BPU Nearman – Alternative Visibility Analysis Using the CAMx PSAT Modeling System

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January 30, 2007
Amended March 10th, 2007

Executive Summary

Board of Public Utilities (BPU) Nearman Creek Power Station Unit 1 (Nearman) is a coal fired electric generating unit that was determined to be a Best Achievable Retrofit Technology (BART) source in Kansas under the Regional Haze Rule. In November 2007 the Kansas Department of Health and Environment (KDHE) discovered a potential issue with the hourly emission rates used in the initial modeling determination making Nearman a BART source. KDHE informed BPU of this potential issue and BPU revised both the 24 hour maximum emission rates and the BART determination modeling they had performed.

On December 19, 2007 the KDHE received revised 24 hour maximum emission rates from BPU for Nearman. Along with the revised emissions rate, BPU also submitted additional CALPUFF modeling for purposes of a BART determination. This new modeling indicated Nearman should not have been included as a BART source. The modeling BPU performed was based on the already approved CALPUFF modeling protocol. BPU also requested that Nearman no longer be considered a BART source. After receiving the new modeling and request, KDHE reviewed both the revised emissions rate and the modeling and agreed that the CALPUFF modeling did indicate that Nearman should not be a BART source. However, KDHE did note that the revised emissions rate still included substituted hourly CEM data which may still be an overestimation of the actual maximum 24 hour emissions. KDHE did a separate analysis showing slightly lower emissions rates would likely be more appropriate.

Once this revised BART determination was made, KDHE began the process of evaluating Nearman as a “reasonable further progress” source. Following the already established SIP methodology for a source in this category, KDHE calculated the cost benefit on a $/ton/del-dv of $9,502 for SO_2 and $12,383 for NO_x. Control costs below 15,000 are considered reasonable, and this was the line established in the RH SIP. During the course of this evaluation BPU indicated that there were still some uncertainties in the costs, particularly on the SO_2 controls. Because of this uncertainty, specifically in the modeling results, KDHE decided to complete a more refined modeling analysis of the potential impacts associated with the SO_2 emissions specifically.

In consultation with EPA Region 7, KDHE determined that CAMx PSAT was the most accurate available tool to help inform a decision on whether SO_2 controls would be warranted for reasonable progress in the case of BPU Nearman. As was done in the CALPUFF modeling for reasonable progress, actual emission rates were used to determine the baseline impact which would then be compared to the control case. The actual emissions rates are much lower than the maximum rates used in the BART determination. Because CAMx is a refined model and only 1 year is being run, KDHE determined that the 3rd high modeling result would be used. The CAMx analysis with lower actual emission rates resulted in a 0.6 delta-deciview impact on the Hercules-Glades Class I area. Therefore, KHDE concluded that Nearman should remain a BART unit.

Introduction

Board of Public Utilities (BPU) Nearman Creek Power Station Unit 1 (Nearman) is a coal fired electric generating unit that was determined to be a Best Achievable Retrofit Technology (BART) source in Kansas under the Regional Haze Rule. In November 2007 the Kansas Department of Health and Environment (KDHE) discovered a potential issue with the hourly emission rates used in the initial modeling determination making Nearman a BART source. BPU subsequently revised both the 24 hour maximum emission rates and the BART determination modeling they had performed and showed they should not be considered a BART source.

Once this revised BART determination was made, KDHE began the process of evaluating Nearman as a “reasonable further progress” source. Following the already established SIP methodology for a source in this category, KDHE calculated the cost benefit on a \$/ton-dv of \$9,502 for SO2 and \$12,383 for NO_x. Control costs below 15,000 \$/ton-dv are considered reasonable. During the course of this evaluation BPU indicated that there were still some uncertainties in the costs, particularly on the SO_2 controls. KDHE also looked at an alternative approach using the refined modeling that BPU had submitted to KDHE. Using this refined modeling the costs of controls were \$26,987 for SO_2 and \$20,081 for NO_x. Because of this cost uncertainty and varied modeling results between KDHE and BPU runs, it became apparent that potential controls for SO_2 were likely close to the established cost benefit decision line that KDHE had in its SIP for the purposes of reasonable progress. Because of this uncertainty, specifically in the modeling results, KDHE decided to complete a more refined modeling analysis of the potential impacts associated with the SO_2 emissions specifically.

In consultation with EPA Region 7, KDHE determined that CAMx PSAT was the most accurate available tool to help inform a decision on whether SO_2 controls would be warranted for reasonable progress in the case of BPU Nearman. As was done in the CALPUFF modeling for reasonable progress, actual emission rates were used to determine the baseline impact which would then be compared to the control case. The actual emissions rates are much lower than the maximum rates used in the BART determination. Because CAMx is a refined model and only 1 year is being run, KDHE in consultation with EPA Region 7, determined that the 3rd high modeling result would be used in the analysis.

The remainder of this document describes KDHE's alternative modeling analysis performed using the CAMx modeling system and the subsequent factors that led to the decision to keep Nearman a BART source.

Overview of the reasonable progress analysis methodology for Nearman

The Regional Haze Rule stipulates that each state "must address regional haze in each mandatory Class I Federal area located within the state and in each mandatory Class I Federal area located outside the state which may be affected by emissions from within the state." [40 CFR 51.308(d)] Although there are no Class I areas located within Kansas, the State is still required to address reasonable progress goals for regional haze by determining any Class I area(s) that may be significantly impacted by emissions from sources within the State. Kansas developed a six-step process to address reasonable progress. The steps are as follows:

1. Identify all Kansas emission units that had greater than or equal to 500 tons for NO_x and/or SO_2
2. Identify the most effective control technologies and screen for excessive cost
3. Model visibility impacts and screen for low-impact facilities
4. Calculate, screen, and rank based on cost per ton per deciview
5. Screen for non-cost statutory factors, i.e., time necessary for compliance, energy and non-air quality environmental impacts of compliance, and remaining useful life
6. Re-sort and make final list of beyond-BART facilities

The Nearman facility was initially excluded from this analysis because at the time it was considered a BART source. KDHE has gone back and applied the steps above to Nearman. A summary of the analysis follows:

Step 1: Identify all Kansas emission units that had greater than or equal to 500 tons for NOx and/or SO2. In 2002 Nearman had 7625 tons SO2 emissions and 3,860 tons of NOx emissions, thus both pollutants need to be considered.

Step 2: Identify the most effective control technologies and screen for excessive cost. In the BART analysis provided to KDHE, multiple cost effective controls for both pollutants were identified. The Department also has cost estimates from EPA's AirControlNet program and from CENRAP through a contract with Alpine Geophysics. The Department screened out any control costing more than $10,000/ton reduced. In this analysis the cost and control efficiency information provided by BPU will be considered the most representative.

Step 3: Model visibility impacts and screen for low-impact facilities. The Department set a highest pre-control 98th percentile impact of 0.100 dv as the threshold to be screened out. The modeling indicates that Nearman's pre-control 98th percentile impact is 0.378 dv occurring at Hercules-Glades Class I area, thus Nearman can't be screened out in this step.

Step *4: Calculate, screen, and rank based on cost per ton per deciview.* The Department used a cost per ton of unit change in deciview to rank the sources for meeting reasonable progress goals. The Department established a $2002/ton-dv (cost per ton per dv) of $15,000 as the break point for selecting candidate facilities for controls. Based on the Department's analysis, the cost per ton per dv for Nearman are as follows:

> 98th percentile dv calculations at Hercules-Glades
> Base Run - 0.378 dv impact
> SO2 control (0.15 lbs/MMBtu, 81% control efficiency) - 0.198 dv (0.18 dv difference)
> NOx control (0.23 lbs/MMBtu, 44% control efficiency) - 0.318 dv (0.06 dv difference)

Using the cost numbers provided with the BPU BART analysis report, the $/ton-dv at Hercules-Glades are:

SO2 – $11,244/ton-dv ($9,502/ton-dv at Caney Creek)
NOx - $12,383/ton-dv

This would make Nearman a reasonable progress source subject to both NO_x and SO_2 controls.

Costs and controls for all sources are found in the table below.

These results are from calpuff run based on BPU domain

		Max. 1st highest (dv)					Max. 98th percentile (dv)					Cost Information	
Facilities	**Class I areas**	**Base run**	**SO2 control**	**NOx control**	**Difference of base run and SO2 control**	**Difference of base run and NOx control**	**Base run**	**SO2 control**	**NOx control**	**Difference of base run and SO2 control**	**Difference of base run and Nox control**	**SO2 control**	**NOx control**
Kansas City BPU - Nearman	**Hercles-Glades**	0.67	**0.305**	0.577	0.365	0.093	**0.165**	**0.09**	**0.128**	0.075	0.037	$26,987	$20,081
	Caney Creek	0.282	0.19	0.213	0.092	0.069	0.109	0.055	0.093	0.054	0.016	$37,481	$46,438
	Mingo	0.459	0.243	0.376	0.216	0.083	0.088	0.044	0.075	0.044	0.013	$46,000	$57,154
	Upper Buffalo	**0.676**	0.26	**0.608**	0.416	0.068	0.152	0.084	0.122	0.068	0.03	$29,765	$24,767
	Wichita Mountain	0.608	0.222	0.551	0.386	0.057	0.076	0.034	0.063	0.042	0.013	$48,190	$57,154

These results are from calpuff run based on KDHE domain

		Max. 1st highest (dv)					Max. 98th percentile (dv)						
Facilities	**Class I areas**	**Base run**	**SO2 control**	**NOx control**	**Difference of base run and SO2 control**	**Difference of base run and NOx control**	**Base run**	**SO2 control**	**NOx control**	**Difference of base run and SO2 control**	**Difference of base run and Nox control**	**SO2 control**	**NOx control**
Kansas City BPU - Nearman	**Hercles-Glades**	**1.124**	**0.538**	**0.965**	0.586	0.159	**0.378**	**0.198**	**0.318**	0.18	0.06	$11,244	$12,383
	Caney Creek	1.015	0.452	0.885	0.563	0.13	0.349	0.136	0.311	0.213	0.038	$9,502	$19,553
	Mingo	0.929	0.377	0.827	0.552	0.102	0.255	0.108	0.233	0.147	0.022	$13,769	$33,773
	Upper Buffalo	1.017	0.479	0.874	0.538	0.143	0.306	0.151	0.269	0.155	0.037	$13,058	$20,081
	Wichita Mountain	0.819	0.329	0.73	0.49	0.089	0.263	0.116	0.232	0.147	0.031	$13,769	$23,968

Input data:

	SO2 (tons/year)	**NOx (tons/year)**
Base run	7625	3860
SO2 control	1412	3860
NOx control	7625	2165

Because Nearman is again being considered a BART source, KDHE is no longer pursuing this analysis as part of a reasonable progress determination.

CAMx overview and datasets used

CAMx version 4.42, available freely from Environ Corporation www.camx.com, was used in this modeling analysis. CAMx is a photochemical grid model an Eulerian photochemical dispersion model that allows for an integrated “one-atmosphere” assessment of gaseous and particulate air pollution (ozone, PM2.5, PM10, air toxics, mercury) over many scales, ranging from sub-urban to continental (Environ 2006a). CAMx simulates the emission, dispersion, chemical reaction, and removal of pollutants in the troposphere by solving the pollutant continuity equation for each chemical species modeled on a system of nested three-dimensional grids.

This version of CAMx includes the implementation of the particulate source apportionment technology (PSAT) within the full-science plume in grid (PiG). This version of CAMx also uses a full-chemistry PiG module for near-source plume chemistry and dynamics and a three-dimensional grid model for plume chemistry, transport, and dispersion at further downwind distances and contains all of the scientific advantages of both CALPUFF and a photochemical grid model. Because of the full chemistry treatment and source apportionment, this modeling is scientifically much more accurate than CALPUFF at replicating actual impacts. This especially holds true in this case where the source receptor distance is large.

To gain the accuracy in solution of haze forming secondary particulate aerosols, CAMx requires a very data and resource intensive meteorological and emissions inventory dataset. KDHE relied heavily on the work and datasets developed by the Central Air Planning Association (CENRAP) for the Regional Haze Rule. The KDHE obtained the 2002 MM5 meteorological data and 2002 base F emissions inventory from EPA Region 7. This emissions inventory data was then augmented with average hourly rates based on 2002 actual annual emissions from Nearman. This emissions estimation followed the methodology used in the Kansas SIP for reasonable progress. Please see Environ 2006b for addition description of the MM5 and emissions datasets used.

For those wishing to recreate the PSAT setup, KDHE used the PSAT/OSAT “point source override” feature (Environ 2006b). This was done by having a source region map with one source region for the entire domain and assigning a separate source region value in the point source input file that will override the source region that the point source resides in. In addition, a negative flag was set for BPU Nearman stack diameter in order for this point source to receive the PiG treatment. An example of the CAMx script used is provided in Appendix A.

Emissions Rates and Stack Parameters

As outlined in the draft regional haze SIP regarding reasonable progress, both a base inventory and a control inventory were determined for all sources analyzed. In the case of Nearman, the base inventory was set to the average actual 2002 emissions. The controlled inventory contained controls only on SO_2, as this was the pollutant in question for the purposes of Nearman and reasonable progress. SO_2 control was set at 0.15 lbs/MMBtu as this is the presumptive limit of control for this pollutant. The emissions for the two cases are summarized below.

It is important to note that the average actual emissions rate used in this study is less than what would be expected on a worst case day. KDHE analyzed the 2002 CEM data for BPU Nearman, and determined the worst case 24 hour emissions were 2849 lbs/hr for SO_2 and 1356lbs/hr for NO_x. It is important to note that these rates reflect valid CEM measurements and exclude all periods with replacement CEM data regardless of the reason for the replacement. If this actual worst case emissions rate were used in CAMx PSAT, the results would show additional visibility impacts due to the higher emissions rates. This worst-case normal operating rate from the KDHE analysis also appears to exclude startups, shutdowns, malfunctions, and maintenance activities.

It was determined that the emissions rates used for the purposes of reasonable progress would be 1741 lbs/hr for SO2 and 881 lbs/hr for NOx. These hourly rates were derived based on the actual annual 2002 emissions. Because these two pollutants dominate the visibility impacts no other pollutants were modeled. CAMx requires emissions to be speciated and expressed in moles/hr (Environ 2006a), therefore, the emissions rates used in CAMx inputs were NO – 7,821 moles/hr, NO2 – 869 moles/hr, and SO2 – 12,325 moles/hr. A SO2 control run was also modeled with a 0.15 lb/MMBtu limit, resulting in an emissions rate of 2,282 moles/hr.

Additional information on the Nearman source characteristics can be found in BPU's BART Engineering Analysis (BPU 2007).

Visibility Impacts - Methodology

Visibility impacts were calculated at all surrounding Class I areas. The area that experienced the largest visibility impacts was the Hercules-Glades Class I area in Missouri. To calculate the visibility impacts, the PSAT tool in CAMx is first used to estimate the pollutant concentrations resulting from Nearman emissions. Visibility impacts were then calculated following the procedures based on the Federal Land Managers' Air Quality Related Values Workgroup report (FLAG, 2000). The FLAG (2000) procedures were developed to estimate visibility impacts at Class I areas from proposed new sources as part of the Prevention of Significant Deterioration (PSD) and New Source Review (NSR) process.

The IMPROVE reconstructed mass extinction equation is used to estimate visibility at Class I areas using IMPROVE monitoring data, and has also been used for evaluating visibility impacts at Class I areas due to new sources using modeling output of a single source or group of sources. The total light extinction due to a source (bsource), in units of inverse megameters (Mm-1), is assumed to be the sum of the light extinction due to the source's individual species concentration impacts times an extinction efficiency coefficient:

$\mathrm{bsource = bSO4 + bNO3 + bOC + bEC + bsoil + bcoarse}$
$\mathrm{bSO4 = 3\ [(NH4)2SO4]f(RH)}$
$\mathrm{bNO3 = 3\ [NH4NO3]f(RH)}$
$\mathrm{bOC = 4\ [OMC]}$
$\mathrm{bEC = 10\ [EC]}$
$\mathrm{bSoil = 1\ [Soil]}$
$\mathrm{bcoarse = 0.6\ [Coarse\ Mass]}$

Here f(RH) are relative humidity adjustment factors. The concentrations in the square brackets are in µg/m3 and are based on the PSAT results. For Hercules-Glades the f(RH) values used are 3.19 2.88 2.61 2.61 2.99 3.01 2.96 3.03 3.15 2.91 2.98 3.21 for January through December, respectively (EPA, 2003)

The following species mappings are used to map the CAMx species to those used in the IMPROVE reconstructed mass extinction equation given above (Environ, 2006b):

$[(NH4)2SO4] = 1.375 \times PSO4$
$[NH4NO3] = 1.290 \times PNO3$
$[OMC] = POA + SOA1 + SOA2 + SOA3 + SOA4 + SOA5$
$[EC] = PEC$
$[Soil] = FPRM + FCRS$
$[Coarse\ Mass] = CPRM + CCRS$

Here PSO4 and PNO3 are the CAMx particulate sulfate and nitrate species. POA is the CAMx primary particulate organic aerosol species, whereas SOA1-5 is the five secondary organic aerosol species carried in CAMx. Primary elemental carbon is represented by PEC in CAMx. CAMx carries two species that represent the other PM2.5 components (i.e., fine particles that are not SO4, NO3, EC or OC), one for the crustal (FCRS) and the other for the remainder of the primary emitted PM2.5 species (FPRM). Similarly, CAMx carries two species to represent coarse mass (PM2.5-10), one for crustal (CCRS), and one for other coarse PM (CPRM). For the this project only PSO4 and PNO3 were evaluated.

The haze index (HI) for the source is calculated in deciviews (dv) from the source's extinction plus natural background using the following formula:

$$HIsource = 10 \ln[(bsource + bnatural)/10]$$

Here, bnatural is the Class I area specific clean natural visibility background, and EPA's default values were used in this analysis. For Hercules-Glades the natural visibility background value used were bnatural = 21.02 (EPA 2003).

The source's HI was compared against natural conditions to assess the significance of the source's visibility impact. EPA guidance lists natural conditions (bnatural) by Class I area in terms of Mm-1 (Environ, 2006) and assumes clean conditions with no man-made or weather interference. The visibility significance metric for evaluating visibility impact is the change in deciview (del-dv) from the source's and natural conditions haze indices:

$$del\text{-}dv = HIsource - HInatural = 10 \ln[(bsource + bnatural)/10] - 10 \ln[bnatural/10]$$
$$= 10\ln[(bsource + bnatural)/bnatural]$$

Using CAMx PSAT, Nearman's emissions were modeled as a source group and the sulfate and nitrate species impacts were determined. Using the above methodology the species were reconstructed for visibility and the del-dv was calculated. A threshold of 0.5 del-dv maximum is the FLM recommended threshold to use when doing a BART analysis. In this case, the analysis was for reasonable progress and did not use a maximum 24 hour emissions rate for BART, thus the 0.5 del-dv threshold is not directly applied. KDHE proposes to use the 3rd high visibility impacts from both the base and control cases with the difference of the 3rd high being used in the cost benefit assessment documented in the Kansas SIP for reasonable progress.

Visibility Impacts – Results

The visibility impacts from Nearman were calculated at all surrounding Class I areas. The maximum modeled impacts were observed at Hercules-Glades Class I area and only included the impacts of sulfate and nitrate formation. The sulfate and nitrate impacts are expected to represent the great majority of the visibility impairment from this source.

Using the methodology described above, the visibility impacts due to sulfate and nitrate on a daily basis (sorted by descending del-dv) are found in the excel attachment included with this document. Also included is an excel file containing the raw visibility results for all Class I areas. For the Hercules-Glades area the base case results of the ten highest impact days are:

ClassIArea	Date	bSO4	bNO3	Del-dv
HEGL1	20	1.72%	0.71%	1.065
HEGL1	348	0.71%	0.30%	0.588
HEGL1	299	0.62%	0.73%	0.550
HEGL1	6	1.52%	0.36%	0.506
HEGL1	258	1.14%	0.33%	0.491
HEGL1	259	1.02%	0.10%	0.437
HEGL1	146	1.53%	0.49%	0.357
HEGL1	309	0.44%	0.27%	0.321
HEGL1	308	0.42%	0.23%	0.318
HEGL1	340	0.43%	0.14%	0.299

Where:
Date – Julian day modeled
bSO_4 – Nearman's percent of total sulfate extinction modeled at Hercules-Glades
bNO_3 - Nearman's percent of total nitrate extinction modeled at Hercules-Glades
Del-dv – Nearman modeled visibility impact above natural conditions

These results indicate that for the majority of the highest visibility impacting days, sulfate impacts are two to three times that of nitrate on a total percentage basis. These higher modeled days generally occurred in the fall and winter months when the weather patterns take the plume from Nearman's location toward Hercules-Glades Class I areas. On the day with maximum modeled del-dv (1.065), Julian day 20 (January 20, 2002), the sulfate impact was approximately 2.5 times that of the nitrate on a percentage basis. If we look at the overall modeled impacts of visibility from all sources on this day, nitrates are a largest percentage of the total visibility extinction.

From the visibility monitoring done in the Hercules-Glades Class I area, we can see that the predominant impairing pollutant is sulfate, especially during the summer. You can see from Figure 1, that sulfate is also present in the winter months, especially on many of the worst visibility days. Overall, on the worst monitored days, sulfate represents 71% of the extinction from the visibility monitoring performed in 2002. This indicates that sulfate is a concern, and therefore, SO_2 controls are likely warranted for improving the visibility in the Hercules-Glades Class I area.

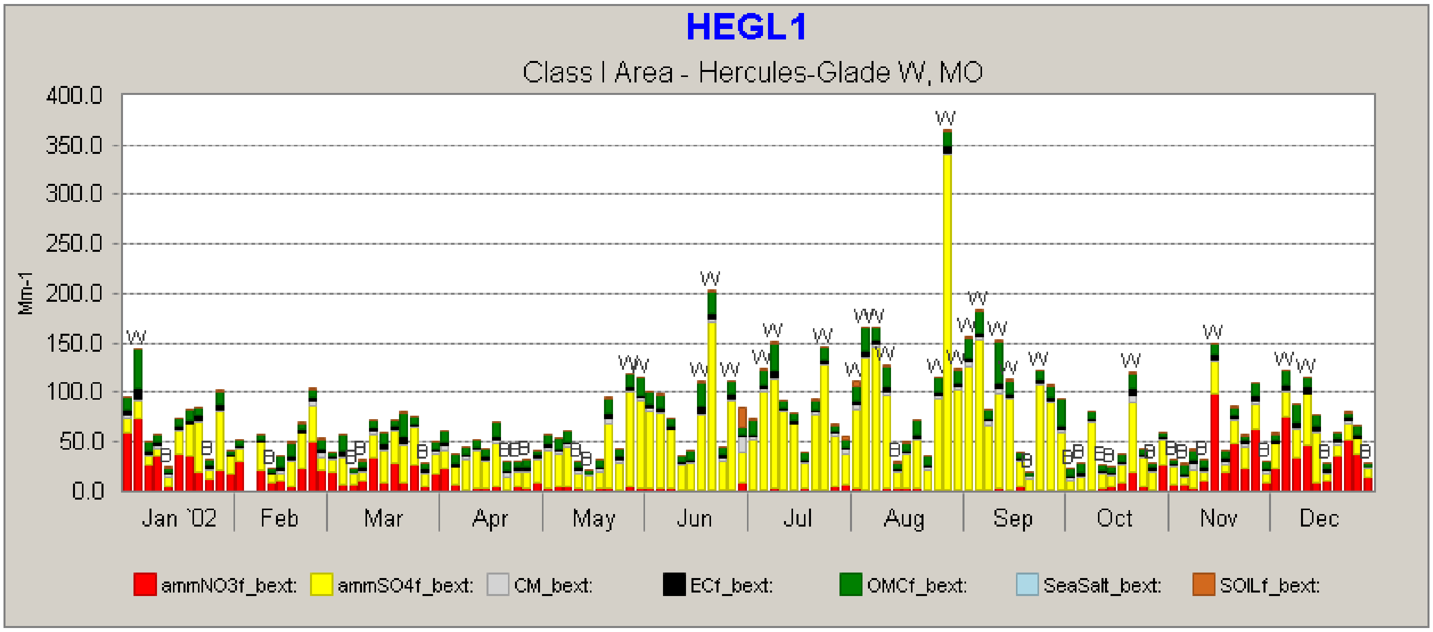

Figure 1. Monthly monitored visibility species impacts in 2002 for Hercules-Glades.

After completing the modeling and reviewing the results, the base case visibility impacts on Hercules-Glades indicate that Nearman should remain a BART source due to the four impacts exceeding the 0.5 del-dv threshold, while using an emissions rate less than the 24-hour worst case that would be used in a BART analysis. It is also apparent that sulfate is an important pollutant of concern for Hercules-Glades, which further justifying pursuing SO_2 controls.

Conclusion

Nearman has been evaluated for visibility impacts using the alternative CAMx model utilizing PSAT and PiG. The results indicate that Nearman emissions do impact Class I areas, predominantly the Hercules-Glades Class I area in Missouri. Based on this analysis the Nearman facility has impacts above the BART source threshold, as the modeling indicates visibility impacts greater than 0.5 del-dv for four days in 2002 when using average actual emissions in the CAMx model. If the highest 24-hour actual emissions were evaluated with CAMx the visibility impacts would be greater because the 24-hour highest emission rates for SO_2 and NO_x are both significantly higher than the average emission rates used in this analysis. KDHE also considers CAMx to be a more refined and accurate model than CALPUFF and therefore gives more weight to CAMx results. The Hercules-Glades area is also predominantly impacted by sulfates on the worst visibility days according to actual monitoring data. After weighing all the available information, KDHE has determined that Nearman should remain a BART source and both NO_x and SO_2 controls are necessary to meet the BART requirements of the regional haze rule.

References

EPA. 2003. Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule. EPA-454/B-03-005. U.S. Environmental Protection Agency, Research Triangle Park, NC.

ENVIRON. 2006a. “User’s Guide – Comprehensive Air-quality Model with extensions, Version 4.40.” ENVIRON International Corporation, Novato, California. (Available at http://www.camx.com). September 2006

ENVIRON. 2006b. Guidance for the Application of the CAMx Hybrid Photochemical Grid Model to Assess Visibility Impacts of Texas BART Sources at Class I Areas. Prepared for Texas Commission of Environmental Quality, Austin Texas. Prepared by ENVIRON International Corporation, Novato, CA. September 27.

FLAG. 2000. “Federal Land Managers’ Air Quality Related Values Workgroup (FLAG)”: Phase I Report. USDI – National Park Service, Air Resources Division, Denver, CO.

BPU. 2007. Kansas City Board of Public Utilities BART Engineering Analysis for Nearman Creek Power Station – Unit 1. Prepared by Black and Veatch. February 2007.

Appendix A - CAMx Script Used for BPU-Nearman PSAT Analysis using the SO4 and NO3 PSAT Tracers

```
#!/bin/csh
#
# CAMx 4.31
#
setenv NCPUS 4
setenv MPSTKZ 128M
limit stacksize unlimited
set EXEC      = "/modeling/cenrap_psat/src.fixed/CAMx.sunflower.pg_linuxomp"
#

set run = revised_psat.Q1
set STARTDATE = 2001356
set ENDDATE   = 2002365
set JDATE = 2001356
#
set RUN     = "v4.42.bpu"
set CHEM    = "/mnt/usb2/modeling/inputs/inputs"
set LUSE    = "/mnt/usb2/modeling/inputs/landuse"
set AHOMAP  = "/mnt/usb2/modeling/inputs/ahomap"
set PHOT    = "/mnt/usb2/modeling/inputs/tuv"
set ICBC    = "/mnt/usb2/modeling/inputs/icbctc"
set MET     = "/mnt/usb2/modeling/inputs/met_new/36"
set EMIS    = "/modeling/cenrap_psat/merged"
set EMIS2   = "/mnt/usb2/modeling/cenrap02f/area_uam"
set OUTPUT  = "/modeling/cenrap_psat/outputs/$run"
#
mkdir -p $OUTPUT $run
#
#  --- set the dates and times ----
#
while ( $JDATE <= $ENDDATE )

set RESTART = "true"
if ( $JDATE == $STARTDATE ) set RESTART = "false"

@ YESTERDAY = $JDATE - 1
if ( $YESTERDAY == 2002000 ) set YESTERDAY = 2001365
set YYYY = `./j2g $JDATE | awk '{print $1}'`
set Y2 = `echo $YYYY | awk '{printf("%2.2d",$1-2000)}'`
set MM = `./j2g $JDATE | awk '{print $2}'`
set DD = `./j2g $JDATE | awk '{print $3}'`
```

```
echo '---- Copying Files -----'

cp -v $EMIS/final.${YYYY}${MM}${DD}.RPO_US36.Base02f.pt.revised.bin
$EMIS/final.${YYYY}${MM}${DD}.RPO_US36.Base02f.pt
.revised.bin.copy >> & $OUTPUT/CAMx.$RUN.$JDATE.stdout
cp -v $EMIS2/camx.ar.bart.36km.$JDATE.bin
$EMIS2/camx.ar.bart.36km.$JDATE.bin.copy >> &
$OUTPUT/CAMx.$RUN.$JDATE.stdo
ut


#
#  --- Create the input file (always called CAMx.in)
#
cat << ieof > CAMx.in

 &CAMx_Control

 Run_Message      = 'CAMx 4.41 --Mech4 CF $RUN',

!--- Model clock control ---

 Time_Zone        = 0,                 ! (0=UTC,5=EST,6=CST,7=MST,8=PST)
 Restart          = .${RESTART}.,
 Start_Date_Hour  = ${YYYY},${MM},${DD},0000,   ! (YYYY,MM,DD,HHHH)
 End_Date_Hour    = ${YYYY},${MM},${DD},2400,   ! (YYYY,MM,DD,HHHH)

 Maximum_Timestep    = 15.,            ! minutes
 Met_Input_Frequency = 60.,            ! minutes
 Ems_Input_Frequency = 60.,            ! minutes
 Output_Frequency    = 60.,            ! minutes

!--- Map projection parameters ---

 Map_Projection           = 'LAMBERT',  ! (LAMBERT,POLAR,UTM,LATLON)
 UTM_Zone                 = 0,
 POLAR_Longitude_Pole     = 0.,        ! deg (west<0,south<0)
 POLAR_Latitude_Pole      = 0.,        ! deg (west<0,south<0)
 LAMBERT_Central_Meridian = -97.,      ! deg (west<0,south<0)
 LAMBERT_Center_Longitude = -97.,      ! deg (west<0,south<0)
 LAMBERT_Center_Latitude  =  40.,      ! deg (west<0,south<0)
 LAMBERT_True_Latitude1   =  45.,      ! deg (west<0,south<0)
 LAMBERT_True_Latitude2   =  33.,      ! deg (west<0,south<0)

!--- Parameters for the master (first) grid ---
```

```
 Number_of_Grids      = 1,
 Master_Origin_XCoord = -2736.,       ! km or deg, SW corner of cell(1,1)
 Master_Origin_YCoord = -2088.,       ! km or deg, SW corner of cell (1,1)
 Master_Cell_XSize    = 36.,          ! km or deg
 Master_Cell_YSize    = 36.,          ! km or deg
 Master_Grid_Columns  = 148,
 Master_Grid_Rows     = 112,
 Number_of_Layers(1)  = 19,

!--- Parameters for the second grid ---

 Nest_Meshing_Factor(2) = 3,          ! Relative to master grid
 Nest_Beg_I_Index(2)    = 31,         ! Relative to master grid
 Nest_End_I_Index(2)    = 69,         ! Relative to master grid
 Nest_Beg_J_Index(2)    = 29,         ! Relative to master grid
 Nest_End_J_Index(2)    = 72,         ! Relative to master grid
 Number_of_Layers(2)    = 14,

!--- Model options ---

 Diagnostic_Error_Check = .false.,      ! True = will stop after 1st timestep
 Advection_Solver       = 'PPM',        ! (PPM,BOTT)
 Chemistry_Solver       = 'CMC',        ! (CMC,IEH)
 PiG_Submodel           = 'GREASD',       ! (None,GREASD,IRON)
 Probing_Tool           = 'PSAT',       ! (None,OSAT,GOAT,APCA,DDM,PA,RTRAC)
 Chemistry              = .true.,
 Dry_Deposition         = .true.,
 Wet_Deposition         = .true.,
 Staggered_Winds        = .true.,
 Gridded_Emissions      = .true.,
 Point_Emissions        = .true.,
 Ignore_Emission_Dates  = .true.,

!--- Output specifications ---

 Root_Output_Name         = '$OUTPUT/camx.$RUN.$JDATE',
 Average_Output_3D        = .false.,
 HDF_Format_Output        = .false.,
 Number_of_Output_Species = 35,
 Output_Species_Names(1)  = 'NO',
 Output_Species_Names(2)  = 'NO2',
 Output_Species_Names(3)  = 'O3',
 Output_Species_Names(4)  = 'PAN',
 Output_Species_Names(5)  = 'NXOY',
 Output_Species_Names(6)  = 'CO',
 Output_Species_Names(7)  = 'HONO',
```

```
 Output_Species_Names(8)  = 'HNO3',
 Output_Species_Names(9)  = 'NTR',
 Output_Species_Names(10)  = 'SO2',
 Output_Species_Names(11)  = 'SULF',
 Output_Species_Names(12)  = 'NH3',
 Output_Species_Names(13)  = 'HCL',
 Output_Species_Names(14)  = 'CG1',
 Output_Species_Names(15)  = 'CG2',
 Output_Species_Names(16)  = 'CG3',
 Output_Species_Names(17)  = 'CG4',
 Output_Species_Names(18)  = 'CG5',
 Output_Species_Names(19)  = 'PNO3',
 Output_Species_Names(20)  = 'PSO4',
 Output_Species_Names(21)  = 'PNH4',
 Output_Species_Names(22)  = 'POA',
 Output_Species_Names(23)  = 'SOA1',
 Output_Species_Names(24)  = 'SOA2',
 Output_Species_Names(25)  = 'SOA3',
 Output_Species_Names(26)  = 'SOA4',
 Output_Species_Names(27)  = 'SOA5',
 Output_Species_Names(28)  = 'PEC',
 Output_Species_Names(29)  = 'FPRM',
 Output_Species_Names(30)  = 'FCRS',
 Output_Species_Names(31)  = 'CPRM',
 Output_Species_Names(32)  = 'CCRS',
 Output_Species_Names(33)  = 'NA',
 Output_Species_Names(34)  = 'PCL',
 Output_Species_Names(35)  = 'PH2O',

!--- Input files ---

 Chemistry_Parameters = '$CHEM/CAMx4.4.chemparam.4_CF',
 Photolyis_Rates      = '$PHOT/tuv.wrap36km.${YYYY}${MM}.20051013.txt',
 Initial_Conditions   = '$ICBC/ic.wrap36km.CAMx',
 Boundary_Conditions  = '$ICBC/bc.wrap36km.CAMx.$JDATE',
 Top_Concentrations   = '$ICBC/topc.wrap36km.CAMx',
 Albedo_Haze_Ozone    = '$AHOMAP/ahomap.${YYYY}${MM}.20051013.txt',
 Point_Sources        =
'$EMIS/final.${YYYY}${MM}${DD}.RPO_US36.Base02f.pt.revised.bin',
 Master_Grid_Restart  = '$OUTPUT/camx.$RUN.$YESTERDAY.inst',
 Nested_Grid_Restart  = ' ',
 PiG_Restart          = '$OUTPUT/camx.$RUN.$YESTERDAY.pig ',

 Emiss_Grid(1)   = '$EMIS2/camx.ar.bart.36km.$JDATE.bin',
 Landuse_Grid(1) = '$LUSE/CAMx.wrap36km.luse.bin',
 ZP_Grid(1)      = '$MET/camx.zp.${Y2}${MM}${DD}.36k.bin',
```

```
 Wind_Grid(1)    = '$MET/camx.uv.${Y2}${MM}${DD}.36k.bin',
 Temp_Grid(1)    = '$MET/camx.tp.${Y2}${MM}${DD}.36k.bin',
 Vapor_Grid(1)   = '$MET/camx.qa.${Y2}${MM}${DD}.36k.bin',
 Cloud_Grid(1)   = '$MET/camx.cr.${Y2}${MM}${DD}.36k.bin',
 Kv_Grid(1)      = '$MET/camx.kv.OB70.${Y2}${MM}${DD}.36k.bin',
 Emiss_Grid(2)   = ' ',
 Landuse_Grid(2) = ' ',
 ZP_Grid(2)      = ' ',
 Wind_Grid(2)    = ' ',
 Temp_Grid(2)    = ' ',
 Vapor_Grid(2)   = ' ',
 Cloud_Grid(2)   = ' ',
 Kv_Grid(2)      = ' ',

 &
!-------------------------------------------------------------------------------

 &SA_Control

 SA_File_Root                = '$OUTPUT/camx.$RUN.$run.$JDATE',
 SA_Summary_Output           = .true.,
 SA_Master_Sfc_Output        = .true.,
 SA_Stratify_Boundary        = .false.,
 SA_Number_of_Source_Regions =  2,
 SA_Number_of_Source_Groups  =  1,
 Use_Leftover_Group          = .false.,
 Number_of_Timing_Releases   =  0,
 SA_Receptor_Definitions     =
'/mnt/usb2/modeling/camx/sa/receptor.nebraska.classI.txt',
 SA_Source_Area_Map(1)       =
'/mnt/usb2/modeling/cenrap_psat/camx/srcmap/srcmap.dat',
 SA_Master_Restart           = '$OUTPUT/camx.$RUN.$run.$YESTERDAY.sa.inst',
 SA_Nested_Restart           = ' ',
 SA_Points_Group(1)          =
'$EMIS/final.${YYYY}${MM}${DD}.RPO_US36.Base02f.pt.revised.bin.copy',
 SA_Emiss_Group_Grid(1,1)    = '$EMIS2/camx.ar.bart.36km.$JDATE.bin.copy',
 PSAT_Treat_SULFATE_Class    = .true.,
 PSAT_Treat_NITRATE_Class    = .true.,
 PSAT_Treat_SOA_Class        = .false.,
 PSAT_Treat_PRIMARY_Class    = .true.,
 PSAT_Treat_MERCURY_Class    = .false.,
 PSAT_Treat_OZONE_Class      = .false.,

  &

ieof
```

```
#
#  --- Execute the model ---
#

echo '---- Running for Date ',$JDATE

cp CAMx.in $run/camx.$RUN.$run.$JDATE.in
/usr/bin/time $EXEC >& $run/camx.$RUN.$run.$JDATE.stdout

rm -fv $EMIS/final.${YYYY}${MM}${DD}.RPO_US36.Base02f.pt.revised.bin.copy
>> & $OUTPUT/camx.$RUN.$JDATE.stdout
rm -fv $EMIS2/camx.ar.bart.36km.$JDATE.bin.copy >> &
$OUTPUT/camx.$RUN.$JDATE.stdout

@ JDATE++
if ( $JDATE == 2001366 ) set JDATE = 2002001

end
```