FINAL EXECTUTIVE SUMMARY REPORT

AIR QUALITY AND VISIBILITY IMPACTS OF POWDER RIVER BASIN COAL MINING AT BADLANDS NATIONAL PARK

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By

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1.0 INTRODUCTION

Proposals for expansion of coal mining and coal bed methane production in the Powder River Basin (PRB) frequently require preparation of an Environmental Impact Statement (EIS), which includes a projection of future impacts on air quality at regional National Parks and Wilderness Areas (Class I Areas). Methodologies for assessment of impacts on Air Quality Related Values (AQRVs) have been recommended by the U.S. Environmental Protection Agency and Federal Land Managers (FLMs) responsible for management of the Parks and Wilderness Areas. These methodologies involve use of a long-range pollutant transport computer model (CALPUFF) to predict pollutant concentrations in the air, and subsequent calculation of the effect on visibility (regional haze) of these pollutant concentrations. Recent EIS analyses have suggested the potential for significant visibility impacts at National Parks from projected increases in PRB coal production.

The present study was conducted to examine the methodologies and implications for PRB coal mining of current Class I Area visibility analyses. The Class I Area most likely to be affected by PRB pollutant emissions is Badlands National Park, SD, (BNP) approximately 200 kilometers to the southeast. Data on air pollution and visibility at BNP have been collected since 1989. This analysis examined trends in observed pollution and visibility at BNP over recent years, for comparison to trends in PRP air pollutant emissions. The recommended CALPUFF modeling methods were used to predict impacts of coal mining and other pollution-generating activities at BNP over the same time periods. The study objectives were to determine whether mining and other emissions relate to any observed air quality changes at BNP, and to analyze how predicted impacts vary with modeling assumptions and input data.

2.0 MODELING OF POLLUTANT AND VISIBILITY IMPACTS

The recommended atmospheric dispersion modeling system is comprised of the CALMET/CALPUFF models. CALMET is a meteorological data processing system. It utilizes observations form fixed weather monitoring stations and computations by meso-scale meteorological models to generate a three-dimensional, time varying definition of wind, temperature, humidity, and precipitation conditions over the region and year(s) to be modeled. It includes consideration of the elevations and land use of the underlying ground surface. The CALPUFF model then uses this meteorological information to simulate the transport and dispersion of pollutants from multiple point and area sources in the modeling domain. CALPUFF accounts for transport and dispersion by atmospheric motions, chemical reactions that modify the form and composition of pollutants, and deposition of pollutants on the ground by settling or precipitation washout. The output of the CALPUFF model gives airborne concentration and surface deposition of relevant pollutants on an hourly and annual basis at receptor locations in the Class I or other areas of interest.

For the present study, CALMET/CALPUFF was applied to an area of approximately 500 x 700 kilometers, extending from west of the Powder River Basin east through Badlands National Park in South Dakota; meteorological data consisted of conditions observed throughout the year 1990.

Pollutant emissions from the modeling area were estimated using data available from Wyoming and South Dakota regulatory agencies and the U.S. EPA. Detailed evaluations of emissions from PRB coal mining operations were carried out using recent air permit application data and coal production statistics. Emission inventory data were compiled for the years 1990 and 1997, to allow quantification of the temporal trend in air emissions, and comparison to changes observed at BNP from 1989 through 1998.

Emissions were quantified and modeled for sulfur dioxide (SO_2), oxides of nitrogen (NO_x) and small particulate matter (PM10). The total emissions of PM10 were subdivided into elemental carbon particles (generated by diesel fuel combustion), organic carbon particles, and other PM10 (primarily made up of soil and mineral constituents). These pollutants are those primarily responsible for visibility effects in the atmosphere.

After release from a source, SO_2 and NO_x gases typically undergo reactions that result in the formation of ammonium sulfate and ammonium nitrate particles. These sulfate and nitrate particles can cause haze by scattering light, thereby increasing "light extinction" and reducing visibility. Sulfate and nitrate particles are "hygroscopic", meaning that they absorb water vapor from the atmosphere and increase in size. Thus, their effect on light extinction and visibility increases with increasing relative humidity.

The CALPUFF model output provided estimates of the hourly, daily, and annual concentrations of PM10, sulfate, and nitrate particles at BNP for the years 1990 and 1997. These concentrations were used with standard equations to calculate the light extinction produced by their presence in the air. The magnitude of light extinction caused by various modeled pollution sources, relative to a reference (background) extinction, provides a measure of the visibility impact of the modeled sources.

The IMPROVE monitoring data from BNP were analyzed to define average and maximum pollutant concentrations in the Park, determine whether there were significant trends over the monitoring period, and to quantify visibility conditions and any systematic changes in visibility with time. Results of the CALMET/CALPUFF modeling were compared to the data recorded by BNP monitoring. Sensitivity tests were also conducted to clarify the dependence of model results on input assumptions and assessment methodology.

3.0 RESULTS

The pollutant monitoring data from BNP for the period 1989 through 1998 indicate average concentrations of visibility-related pollutants to be relatively low, with no obvious or major trend over the period. Median concentrations were about 1.4 micrograms per cubic meter ($\mu g/m^3$) for ammonium sulfate particles, 0.2 $\mu g/m^3$ for ammonium nitrate, 0.15 $\mu g/m^3$ for elemental carbon, 1.0 $\mu g/m^3$ for organic carbon, and 8.0 $\mu g/m^3$ for total PM10. The median visual range was about 100 kilometers (km), and the 20% cleanest days had a visibility of 140 km or more.

Though average pollutant concentrations are relatively low and visibility is very good on many days, the BNP data indicate a significant existing impact of man-made air pollution. A Federal Land Managers' workgroup on Air Quality Related Values in Class I Areas has estimated "natural" conditions at National Parks (in the absence of any anthropogenic pollution). For BNP, their estimate of natural visibility is on the order of 240 km.

The BNP data were divided into two portions corresponding to 1989 through 1993, and 1994 through 1998, to better define any changes over time. The analysis revealed a small increase in observed nitrate and organic carbon concentrations in the park, and a small reduction in visual range from 1989-93 to 1994-98.

The CALPUFF model results predicted lower pollutant concentrations at BNP than were actually observed, for both 1990 and 1997. The model predictions of nitrate particles accounted for more than 50% of the observed concentrations; for other pollutants the model predictions were much lower than observed concentrations. This result is not surprising, since modeled sources represent only a part of all sources that can ultimately impact the Park. Measured pollutant concentrations are clearly a result of emissions from far distant sources, sources in other directions, and probably some very localized sources in addition to the PRB, Rapid City and other Wyoming/South Dakota sources that were modeled. Other unconsidered sources include forest and range fires, wind erosion of unvegetated surfaces, and natural background pollution.

In no cases did the modeled concentrations exceed observed values, and the model results appeared reasonable in relationship to meteorology, source distances, and pollutant type. There was no evidence that the model significantly over-predicts impacts or produces unrealistic results.

Only nitrate particle concentrations showed significant increase between 1990 and 1997 for both predictions and BNP measurements. Nitrate concentrations increased by slightly more than 20% at BNP; CALPUFF model results explain about one-third of the observed increase. Coal mining and related coal transportation (coal trains) account for only a small fraction of predicted increases in sulfate and PM10 at BNP, but they represented 78% of the predicted increase in nitrate, This model-predicted coal-related increase can account for 26% of the actual measured change at BNP.

The model predictions would imply a small degradation in visibility at the Park. The Federal Land Managers' recommended methods for assessment of visibility impacts call for a comparison of light extinction due to the modeled sources to natural (unpolluted) background on a day-by-day basis. Relative changes on any day at any Park receptor of greater than 5% are considered to be of concern. Even though modeled impacts at BNP are low on an average basis, the model results indicate that coal-related emissions could have produced greater than a 5% visibility impact, relative to unpolluted conditions, on 34 additional days per year in 1997 compared to 1990. However, the model-predicted visibility impacts of coal mining sources, and all modeled sources, account for only a small fraction of the apparent change in actual visibility at BNP.

4.0 CONCLUSIONS AND RECOMMENDATIONS

- Except for nitrate, more than 80% of average ambient pollutant concentrations in BNP are the result of natural background and sources other than those inventoried in northeastern Wyoming, western South Dakota, and northwestern Nebraska. However, approximately 63% of observed nitrate can be accounted for by the sources included in the inventory.
- Maximum observed 24-hour concentrations at BNP are also much larger (except for nitrate) than model-predicted concentrations. This finding implies that nearby sources and/or major man-made or natural sources not included in the inventory can have a major effect on BNP air quality.

- Model results indicate that on an annual basis PRB coal mines contribute two percent of observed nitrate concentrations in BNP, and less than one percent of observed sulfate, PM10, and carbon particle concentrations. Rail transport of coal contributes about six percent of observed nitrate, one percent of elemental carbon, and much less than one percent for the other pollutants.
- On a 24-hour basis, coal trains can contribute up to 18% of measured nitrate at BNP, up to five percent of observed elemental carbon, and less than one percent of other pollutant concentrations. Coal mines can contribute up to eight percent of 24-hour nitrate in BNP, up to four percent of observed 24-hour elemental carbon, and much smaller fractions for other pollutants.
- Culpability results suggest that the most effective mitigation of coal mining impacts on BNP air quality would be through control of diesel emissions from mine equipment and locomotives. Existing federal regulations will result in some reduction in emissions from these sources in future years.
- Analysis of IMPROVE monitoring data at BNP for the period 1989 – 1998 indicates only small changes in air quality. However, nitrate concentrations appear to have increased by about 24%; average visibility has tended to decrease slightly over the same period. The increase in light extinction on the cleanest days at BNP is on the order of seven percent. The latter half of the period has experienced an increase in the number of days with visibility in the range of 75 to 100 km, and fewer days with visual range exceeding 100 km.
- The cause of the apparent slight visibility degradation at BNP cannot be determined from the present analysis. Model results suggest that about 14% of

the change could be explained by the modeled emissions sources. The remainder may be a result of increased emissions elsewhere, or natural factors such as differences in meteorology, forest fires, and wind erosion.

- Visibility impacts of PRB coal mines and coal transportation represent approximately 80% of the total model-predicted incremental impact from 1990 to 1997, but only about 10% of the actual observed increase in light extinction at BNP.
- Application of FLM recommended procedures for assessment of visibility impacts by comparison to natural reference conditions indicates that coal mine/coal train emissions could have a visibility impact exceeding five percent on a number of days per year. The model-predicted change in impacts from 1990 to 1997 indicates an additional 34 days per year of a five percent increase in light extinction compared to natural conditions.
- Very small predicted changes in pollutant concentration can translate into significant visibility impacts under the stringent FLM procedures. If predicted visibility is compared to existing visibility in BNP (rather than natural background visibility), much smaller percentage changes and many fewer days of impact are indicated.
- It is recommended that determination of visibility impacts using FLAG recommendations utilize hourly relative humidity data when they are available, rather than seasonal average values. Use of hourly data should provide more realistic results; for the typical case where the major impacts are due to hygroscopic particles, there will be less likelihood of overpredicting impacts.

- CALPUFF model results are not highly sensitive to most user-specified model inputs. However, sulfate and nitrate predictions can vary with the assumed background ozone and ammonia concentrations. Because projected visibility impacts can change dramatically for small changes in predicted concentrations, it is important that appropriate input parameters and background concentrations be used. Site-specific data, where available, should be used in preference to conservative default values.