6.0 SUMMARY AND CONCLUSIONS

The objectives of the present study were to compare CALPUFF model predictions to observed trends in pollutant concentration and visibility at Badlands National Park, and to evaluate the variation in projected impacts with model input parameters, pollutant source categories, and assessment methodology. It did not prove possible to obtain a quantitative measure of model accuracy; observed impacts at BNP, on either a day-to-day or an average annual basis, are clearly the result of pollutant sources, both natural and anthropogenic, that are often beyond the boundaries of the study emission inventory and/or not included in the inventory. Nonetheless, information was obtained on the apparent long-term trends in emissions and impacts, and the relative effects of different types of emission sources.

The results obtained by the CALMET/CALPUFF modeling system appear to be relatively robust. By this it is meant that results are not highly sensitive to the input modeling parameters or the precise source parameters assigned to each emission source. Predicted concentrations, on both hourly and long-term bases, appear to be realistic and appropriately associated with the magnitude and characteristics of upwind source emissions. Though no direct correlation between predicted and observed impacts could be demonstrated, the relationship of model predictions to observed concentrations and trends is plausible. No indication was found that the model systematically over-predicts impacts or produces anomalous or unrealistic results.

The modeling results indicate that impacts of sources in northeast Wyoming are generally low at BNP in terms of the actual magnitude of pollutant concentrations. The effects of PRB mining emissions are in turn a relatively small fraction of total predicted impacts. However, it appears that increased emissions from mining-related sources during the period 1990- 1997 could have contributed to small increases in nitrate concentrations and light extinction at BNP.

Despite the small magnitude of observed concentration changes, IMPROVE data from BNP suggest a measurable decrease in visibility during the period. The model results only account for about 14% of the observed visibility degradation on the 20% cleanest days. It is not known whether the observed change is a result of a long-term trend in regional pollutant emissions, or reflects a short-term anomaly due to meteorological conditions, fires, or other natural phenomena.

The apparent visibility effect of very small changes in particle concentrations is a reflection of the sensitivity of visual range to particle concentration, particularly for hygroscopic particles. This sensitivity is readily apparent when applying the Federal Land Managers' (FLAG) visibility assessment methods. New FLAG guidance calls for comparison of new source impacts to natural background conditions; i.e., to conditions in the absence of man-made pollution. When this comparison is performed on a day-to-day basis over a full year, the CALPUFF model results indicate that increased coal production in the PRB from 1990 to 1997 had visibility impacts exceeding a five percent degradation from natural conditions on 34 days per year.

Specific findings and conclusions of the study are summarized in the following paragraphs.

- Except for nitrate, more than 80% of <u>average</u> 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 per unit 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 2.5 Mm^{-1}. 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 observed increase in light extinction at BNP.
- Application of the FLAG 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 FLAG 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 of relative humidity factor. 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.