3.0 APPROACH TO SURFACE WATER MODEL

3.1 Discussion of Proposed Standards

A major beneficial use of surface water in the Project Area is the production of irrigated crops. Therefore, this document focuses on the potential effects to the suitability for irrigation of surface waters in the PRB from proposed discharges of CBM produced water. The effects of the quantity and quality of CBM produced waters on other resources are discussed in relevant sections of the FEISs.

The key water quality parameters for predicting the potential effects of CBM development on irrigated agriculture are sodicity (as measured in the sodium adsorption ratio, or SAR) and salinity (as measured by electrical conductivity, EC). In-stream numerical targets for these parameters, therefore, would facilitate modeling and interpreting impacts under the various alternatives. Ideally, those numerical targets would be in the form of numerical water quality standards — in other words, values backed by regulatory authority. At this time, with the exception of waters that flow from Wyoming into South Dakota, no regulatory water quality standards for these parameters are applicable to the water bodies addressed in this analysis, or for the water bodies downstream in Montana that are likely to receive flows of CBM produced water from Wyoming.

Therefore, because of the importance of this issue, the regulatory entities with jurisdiction for the potentially affected water bodies have begun to quantify the SAR and EC values they believe will be needed to ensure protection of irrigated agriculture in and downstream of the Project Area. In May 2002, for example, the Northern Cheyenne Tribe adopted numerical water quality limits for SAR and EC that are applicable to waters within the reservation, which receives flows in the Tongue River from Wyoming. These tribal limits will not have regulatory status under the Clean Water Act (CWA) until they are approved by the U.S. Environmental Protection Agency (EPA). Still, the adopted numerical limits clearly set out the tribe's considered determination of the water quality needed to protect irrigated agriculture on the reservation.

Wyoming's current permitting process incorporates the numeric water quality standards for EC and SAR adopted in water bodies downstream in South Dakota, specifically the drainages in the Upper Cheyenne and Upper Belle Fourche River sub-watersheds. Wyoming and Montana have entered an interim memorandum of cooperation (MOC) to protect the downstream water quality in the Powder and Little Powder River sub-watersheds in Montana while continuing to allow for CBM development in both states. Interim thresholds are established for EC in the Powder River at the state line, based on monitoring data collected at the gauging station in Moorhead, Montana. The criteria for EC are expressed in monthly maximum values that are not to be exceeded. The two states are also concerned with SAR and bicarbonate but lack sufficient data to establish threshold criteria. Under the MOC, monitoring of the Little Powder River will include EC, SAR, and total dissolved solids (TDS) to evaluate whether these levels change appreciably from historical records. The State of Wyoming would be required to undertake a cause investigation in the event significant changes from baseline conditions are detected in order to determine if CBM discharge is responsible. Wyoming may be required to adjust its regulatory position with the permitting process to ensure compliance with the spirit of the agreement.Wyoming is restricting the amount of CBM discharge water that reaches the main stems through its National Pollutant Discharge Elimination System (NPDES) permitting process to meet the short-term goal of the MOC. Discharge has been restricted through such mechanisms as pond storage, channel loss, and other consumptive uses. Furthermore, as a matter of policy, the Wyoming Department of Environmental Quality (WDEQ) has elected to impose its anti-degradation policy on all CBM discharges. This policy results in effluent limitations in NPDES permits for discharges of CBM produced water that equate to 20 percent of the available increment between low-flow pollutant concentrations and the relevant standards (assimilative capacity) for critical constituents. A separate anti-degradation policy for barium, that sets a basin-specific assimilative capacity, is also applied to discharges of CBM produced waters. Montana has accepted Wyoming's anti-degradation policies as protective of Montana's water quality.

Montana has initiated a process for developing and adopting water quality standards for SAR and EC as well, with the goal of a final decision by the Montana Board of Environmental Review (MBER) by December 2002. MDEQ has proposed two approaches in Montana: one would assign a single set of SAR and EC values to each of the potentially affected water bodies (option 1), and the second would assign a series of values that would be applicable to the main stem of the Tongue River (option 2). MDEQ lists a range of values to be considered by the board for each approach. In addition, a coalition of environmental and irrigation interest groups, collectively known as the "Petitioners," has proposed its own set of numerical SAR and EC limits. The Petitioners include the Tongue River Water Users; the Tongue and Yellowstone Irrigation District; the Buffalo Rapids Irrigation Project; and the Northern Plains Resource Council. The Petitioners' proposal takes an approach similar to MDEQ's option 2. Finally, some time ago, South Dakota's Department of Environment and Natural Resources (SDDENR) adopted numerical SAR and EC standards that are applicable statewide.

There are, then, five sets of numerical limits for SAR and EC now under consideration or applicable to the water bodies addressed in this analysis: the Northern Cheyenne Tribe's adopted water quality limits; Montana's option 1; Montana's option 2; the Petitioners' proposal; and South Dakota's adopted statewide water quality standards. Together, these five sets of values present a wide range of numerical values. Table 3-1 displays the full range of values, including both the lowest and highest possible upper limits, where applicable, for SAR and EC. The water quality standards development process is still under way for key water bodies addressed in this analysis, however. Therefore, it would be inappropriate for the lead or cooperating agencies to this document and the relevant FEISs to select specific numerical values within the range and to apply only those selected values in evaluating potential impact scenarios. Instead, this document uses the full range of potential SAR and EC values as the guideposts to display the outputs of surface water modeling.

The information displayed should be applied only mindful of the three following considerations: First, it should not be assumed that any SAR or EC value within the displayed range will be determined to provide an appropriate level of protection for the existing or anticipated irrigated agricultural uses in these basins. Second, the process of developing water quality standards involves adoption by a state or tribe followed by EPA review and approval, and state- or tribally adopted limits will not assume CWA regulatory status until they have been approved by EPA. Third, the process of developing water quality standards is still under way, and it is not possible to predict the outcome.

Nevertheless, although the eventual outcome of this process for setting water quality standards is uncertain at present, it may be useful to note the specific SAR and EC values adopted by the Northern Cheyenne Tribe and the SDDENR, and those proposed by the MDEQ and the Petitioners. It may further be useful to include those values in the specific impact scenarios evaluated. These SAR and EC values were developed with assistance from advisors with expertise in the areas of the effects of salinity and sodicity on irrigated agriculture. Therefore, it would not be unreasonable to view these values for SAR and EC as a fair estimate of the range that may eventually be judged as providing an appropriate level of protection for irrigated agriculture in the sub-watersheds addressed in this analysis. The specific SAR and EC values proposed or adopted for these sub-watersheds are presented in Appendix A, allowing for application of specific, proposed or adopted numerical standards in the evaluation of various impact scenarios.

The second factor to be considered in applying the information displayed is the significant distinction between the surface water modeling approach applied to alternatives analyzed in this EIS and the approach that eventually will be used in calculating discharge limits for future, specific CBM development projects. The modeling approach used in this document begins with an assumed water management method for the proposed development under each alternative and, applying a series of assumptions (see discussion below), predicts a resulting in-stream water quality. The predicted output of the water quality modeling is then displayed against the full range of potential limits on SAR and EC for each sub-watershed, with no assessment as to the appropriateness of any specific value within the range. The water quality-based approach that will be used to calculate future NPDES permitting requirements, conversely, will begin with appropriate and specific in-stream water quality targets. These targets may include approved water quality standards and, through the total maximum daily load (TMDL) process, those standards may be translated into discharge limits for specific CBM development projects.

The standards will serve as the regulatory basis for controlling CBM discharges. The water quality-based permitting approach that will implement those standards is, therefore, different from the predictive modeling approach used in this analysis. That is, the water quality-based approach will begin with a desired in-stream water quality and, using that level as the target, will calculate the limits on CBM discharge needed to ensure the desired in-stream water quality. Finally, assimilative capacity identified through the TMDL process for a water body will have to be allocated among the appropriate governmental entities along the water body. EPA has a trust responsibility to ensure that a fair and meaningful portion of the available assimilative capacity is reserved for a tribe that is one of the appropriate governmental entities.

3.2 Evaluation Criteria

3.2.1 Most Restrictive Proposed Limit/Least Resrictive Proposed Limit

Table 3-1 summarizes the highest and lowest standards for EC and SAR proposed for or applicable to the sub-watersheds addressed in the analysis. Construction of this table considered the full range of values proposed in the Montana standards process now underway, the adopted Northern Cheyenne standards, South Dakota standards, and the limits applied by the WDEQ to waters that flow downstream into South Dakota. A more detailed summary of the proposed standards under consideration in the Montana standards process and the limits adopted by South Dakota is included in Appendix A. The proposed limits apply to individual sub-watersheds and have been suggested for various seasons of the year. For example, different limits have been proposed for the irrigation season, and the length of the irrigation season often differs for each sub-watershed. The Montana limits were compiled for this analysis as a range of values and were evaluated under a single irrigation season. South Dakota applies water quality standards for EC and SAR year-round. The limits shown in 3-1 are compared with EC and SAR values for resulting mixtures of existing stream flows and CBM discharges under various flow conditions projected under each alternative. CBM discharges to the Upper Powder River, Clear Creek, Crazy Woman Creek, and Salt Creek sub-watersheds in Wyoming have the potential to flow into the Middle Powder River sub-watershed in Montana. Therefore, the limits proposed in Montana for the Powder River have also been applied to these sub-watersheds. WDEQ applies limits in the Upper Cheyenne, Antelope Creek, and the Upper Belle Fourche sub-watersheds in authorizing discharge permits for CBM produced waters to protect the most sensitive crop (alfalfa) that may be grown downstream (Beach 2002).

3.2.2 Ayers and Westcot Irrigation Suitability Diagram

The evaluation of impacts to water quality considers the potential changes in levels of EC and SAR in irrigation water and the implications for production of agricultural crops. The evaluation was based on a criterion of no impact on soils from infiltration. The Ayers and Westcot (1985) irrigation suitability diagram was used to compare water quality before and after it has mixed with discharges of CBM produced water using the diagonal line on the diagram as a no-impact threshold for SAR and EC values of the water. Below and to the right of the irrigation threshold line, water quality would be expected to cause "no reduction in the rate of infiltration" as a result of the dispersion of soils by SAR (Ayers and Westcot 1985). To the left and above the line, waters would be likely to cause "slight to moderate reduction in the rate of infiltration" (Ayers and Westcot 1985). Elevated SAR values may reduce permeability in clayey soils, thereby reducing the rate of water infiltration. The significance of the effects from reduced

Table 3-1
Summary of Proposed Limits for Surface Water Impact Analysis

Sub-Watershed	Most Restrictive Proposed Limit (MRPL)		Least Restrictive Proposed Limit (LRPL)	
	SAR	EC (µS/cm)	SAR	EC (µS/cm)
Tongue, Bighorn, Little Bighorn, Yellowstone	0.5	500	10	2,500
Rosebud	1.0	500	10	2,500
Little Powder	3.0	1,000	10	3,000
Powder, Clear Creek, Crazy Woman Creek, Salt Creek, Mizpah	2.0	1,000	10	3,200
Belle Fourche	10 (1)	2,000 (1)	10 (2)	2,500 (2)
Cheyenne, Antelope Creek	10 (1)	2,000 (1)	10 (2)	2,500 (2)

(1) WDEQ limit applied to waters that flow downstream into South Dakota
(2) South Dakota's existing water quality standard

NOTE: The Tongue River standards proposals are being utilized to assess impacts to the Bighorn, Little Bighorn, and Yellowstone River sub-watersheds, although there are not any petitions before the MBER on these streams for this purpose.

infiltration vary with soil type, and increases on clay and clay-loam soils. Although some soil sealing may occur, at the surface, following one irrigation event in combination with a rain event, soils are more likely to be affected by the quality of a number of irrigation events in sequence. For this reason, potential changes in the quality of irrigation water were analyzed on a monthly basis..

The Ayers-Westcot diagram incorporates a relationship between SAR and EC, which recognizes that as salinity increases the potential impacts of SAR decrease. This relationship is not unbounded, however, because of the potential impact of rainfall on sodic soils. Rainfall can cause SAR problems in surface soil because of the differential way in which EC and SAR respond to a rain event (significant lowering of the EC and little change in the SAR). This rain-on-sodic-soil problem is addressed in a number of the standards proposals (see Appendix A) through adoption of an absolute maximum SAR (i.e., the standard "caps" the Ayers-Westcot EC/SAR relationship). It will be important to be mindful of an upper bound on the Ayers-Westcot relationship in reviewing the conclusions reached in the alternatives analyses in this document. This may help explain situations where the MRPL (or perhaps, the LRPL) shows a potential effect, where the Ayers-Westcot diagram indicates no reduction in infiltration.

3.2.3 Percent of CBM Discharge

The Ayers-Westcot diagram was also used to evaluate the proportion of CBM discharge that could reasonably occur under various flow conditions without causing potential impacts to infiltration.