Final Report

Erosion Potential Model Development and Channel Monitoring

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Problem and Research Objectives:

Coal bed methane (CBM) development in the Powder River (structural) Basin (PRB), located in northeast Wyoming, has been increasing since about 1990 (WOGCC, 2000). As of March 2001, about 4,900 CBM gas wells were in production; about 9,600 wells have been drilled (600 of which have been plugged); and about 10 new wells are drilled every day (Bleizeffer, 2001).

CBM extraction involves pumping methane and ground water out of coal seams. The gas and water separate in the well and the gas is sent to a pipeline. On average, water from CBM wells is produced at a rate of 12 gpm per well (BLM, 1999).

In June 2000 the U.S. Bureau of Land Management (BLM) held public scoping meetings to facilitate development of a new resource management plan for oil and gas development in Johnson, Campbell, Sheridan, and Converse counties (Tollefson, 2000). At that time, the BLM was considering the development of up to 35,000 wells in a 10-year period (although as many as 70,000 wells may be constructed over the lifetime of the development). Assuming 33% of the 35,000 anticipated CBM wells are producing 12 gpm of water at a given time, surface water would be produced at an average rate of 140,000 gpm (312 cfs or 225,000 ac-ft/yr). For comparison, the storage capacities of Keyhole Reservoir and Lake de Smet Reservoir, in northeast Wyoming, are 340,000 acre-ft and 239,000 acre-ft, respectively.

Legally, CBM product water can be discharged on the surface only at National Pollution Discharge Elimination System (NPDES) permitted points (BLM, 1999). It is expected that much of the water will be discharged from pipelines into existing surface drainages. It is impossible to know with certainty how much CBM produced water will be discharged into surface drainages since, in some areas, product water will be either reinjected or contained in surface reservoirs. Disposal into surface drainages is by far the least expensive alternative, and as the estimated productive life of a CBM well is 10 to 20 years (BLM, 1999), there is great potential for CBM produced water to cause erosion in affected stream channels and tributaries.

The State of Wyoming Department of Environmental Quality (DEQ) regulates erosion and other issues affecting the quality of water in Wyoming (BLM, 1999). The DEQ is also responsible for granting NPDES permits to discharge produced water. Recognizing the need to manage CBM product water, the DEQ asked the University of Wyoming to evaluate the erosion vulnerability of drainages in the PRB. **The primary objective of this study was to develop a computer program that would help DEQ policy managers formulate appropriate management decisions associated with the NPDES permitting process. This study had three components: (1) development of an analytical model for predicting the erosion potential of channels in the PRB, (2) channel monitoring, and (3) model verification.** The computer program and all data derived from this effort have been made available to the public so that others responsible

for or concerned about watersheds affected by CBM development can use it to evaluate alternative CBM product water management development scenarios.

Methodology:

Model development and implementation

An analysis of hydrologic data published by the U.S. Geological Survey (Lowham, 1988) was performed to develop regression equations for estimating the erosion potential of channels in the PRB. The equations have been integrated into "Erosion Potential (EP) Modeler," a computer program that runs inside of ArcView GIS (Version 3.2). EP Modeler utilizes USGS digital elevation models (DEMs), digital line graphs (DLGs), and other themes that collectively describe the geographic features of the basin. As such, users of EP Modeler must be familiar with ArcView GIS and procedures for working with ArcView GIS compatible themes. After selecting a point in the channel that is of interest and inputting an estimate of the CBM product water discharge in the watershed above the selected point, the erosion potential for the selected point is computed. To date, the erosion potential index has not been calibrated, that is, a threshold value of the erosion potential index at which increased erosion is imminent has not been determined.

Channel monitoring

The second component of this project consisted of monitoring erosion in two channels within the Powder River Basin: Deadhorse Creek and Burger Draw. Six reaches along Deadhorse Creek and its tributaries, and two reaches along Burger Draw were established. The reach lengths ranged from 500 ft to 1,200 ft. The study reaches were surveyed in 2000, 2001, and 2002 using a Sokkia SET 3110 total station. The channel thalweg and four to eight cross-sections were surveyed in each reach**.** The data provided by these surveys characterize the channels in their present (pre-CBM development) state.

Model verification and calibration

To achieve the third objective of this study, model verification and calibration, data from the channel monitoring effort was used. To date, the data has been used to correlate 2-year peak discharges and bankfull discharges—this calibration was required to get the model to yield reasonable predictions of post-CBM development, equilibrium channel widths.

Principal Findings and Significance:

Data from Lowham (1988) was used to develop a model for computing an index that reflects the potential for accelerated erosion because of CBM product water discharges. The model is applicable to channels located in the PRB and has been implemented as an ArcView GIS application called EP Modeler. The benefit to running EP Modeler within ArcView is that it facilitates access to geographic data that is required as input for EP Modeler. The EP Modeler program, and the corresponding reference and technical manuals are available, free of charge, via the Internet, at:

http://wwweng.uwyo.edu/civil/research/water/epmodeler.html

Data from three annual surveys, of reaches along Deadhorse Creek have been evaluated and will serve as baseline data for future studies of the basin. A comparison of the data indicated that one of the reaches is degrading and another is aggrading. The degrading reach is near the center of the basin and the aggrading reach is at the lower end of the basin. It is concluded that discharging significant volumes of CBM product water

into Deadhorse Creek would accelerate the rate of change, respectively, in the degrading and aggrading reach.

It is intended that the model and data derived from this study will to policy managers charged with formulating resource management strategies, particularly in regards to managing CBM product water. In addition to policy managers, others concerned about the effects of CBM development will be able to use EP Modeler and the data derived over the course of this project since that information either is or will be made available to the public.

Student Support and Training:

Undergraduate: Jessica McGahan, Diana Coronado, Diana Coronado, Hillary Hawthorne, Brady Lewis, Justin Montgomery, and Robert Hood.

Graduate: Chris Brown, Robert Hood, Jeff Baxter, and Ray Moores.

Post-Doctoral Associate: Sarah Konrad

Publications:

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Baxter, J. C., Wilkerson, G. V., and Johnson, J. H. (2002). Erosion potential modeler (Version 3.0): Reference manual. Laramie: University of Wyoming.

Wilkerson, G. V., Baxter, J. C., and Johnson, J. H. (2002). Erosion potential modeler (Version 3.0): Technical manual. Laramie: University of Wyoming.

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Wilkerson, G. V., 2002. A GIS model for evaluating the impacts of coal bed methane surface water discharges. Abstracts with Programs - 2002 Annual Meeting of the Geological Society of America, Boulder, CO. Wilkerson, G. V., 2002. A GIS model for evaluating the impacts of coal bed methane surface water discharges. Abstracts with Programs - 2002 Annual Meeting of the Geological Society of America, Boulder, CO.

Publications in Preparation and Presentations:

Wilkerson, G. V., Baxter, J. C., Johnson, J. H., and Konrad, S. K. (2003). A GIS model for assessing the impact of increased channel discharges on hydraulic geometry. Manuscript in preparation.

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Wilkerson, G.V. (May 2003). Modeling CBM Surface Water Impacts Using Erosion Potential Modeler. Invited presentation to the State Water Forum, Cheyenne, WY.

Wilkerson, G.V. (Jan. 2003). Modeling CBM Surface Water Impacts Using Erosion Potential Modeler. Invited presentation to the Niobrara Conservation District and the U.S. Natural Resources Conservation Service, Lusk, WY.

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