Water Year 2005
Overview of Surface Water Monitoring Data for SC, SAR and Flow in the Powder River Watershed

This cover photo shows an aerial photograph of the confluence of the Powder River with the Yellowstone River near Terry, MT

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Introduction

When Coal Bed Natural Gas (CBNG) is developed it is necessary to cause the methane to desorb from the coal, and flow to production wells. This is typically achieved by pumping groundwater from the coal bed aquifer being developed, since this reduces the hydrostatic pressure within the coal seam (allowing the methane to desorb) and creates a pressure gradient within the aquifer that causes methane to flow towards the pumping wells. This coal seam water in the Powder River Basin is typically moderately saline, having a Specific Conductance (SC; which is proportional to salinity) on the order of 2,000 microSiemens per centimeter (µS/cm). High salinity irrigation water may result in decreased crop yields depending on the crop being grown (See Fig. 1). Since the MDEQ regulations define Electrical Conductivity (EC) as "the ability of water to conduct an electrical current at 25ºC. The electrical conductivity of water represents the amount of total dissolved solids in the water and is expressed as microSiemens/centimeter (µS/cm) or micromhos/centimeter (µmhos/cm) or equivalent units and is corrected to 25ºC" the SC values discussed in this report are directly comparable to the EC standards. CBNG water is a sodium-bicarbonate (Na-HCO3) type water, while surface waters are typically relatively balanced. This dominance of sodium cations cause CBNG water to have a high Sodium Adsorption Ratio (SAR; which is a complex ratio of Na to Ca+Mg); typically between 20 and 60. High SAR values may cause impacts to soil structure, and impair the ability for clay rich soils to infiltrate water (see Fig. 2). There is also little sulfate in the water in productive coal seams (VanVoast, 2003). Much of the produced water is managed through treated or untreated discharge to surface waters under National Pollutant Discharge Elimination System (NPDES) permits.

In Montana, NPDES permitting is conducted by the Montana Department of Environmental Quality (MDEQ) under the Montana Pollutant Discharge Elimination System (MPDES) permit program. There are currently no permits for CBNG discharge to the Powder River in Montana.

In Wyoming, NPDES discharge permitting is conducted by the Wyoming Department of Environmental Quality (WDEQ) under the Wyoming Pollutant Discharge Elimination System (WYPDES). Surface discharge, either with or without treatment, and to on and off channel impoundments are the major methods of water management in the Wyoming portion of the Powder River watershed (McKinley, pers com. 2006).

Large scale CBNG development began in Wyoming and Montana, in approximately 1999; within the first CBNG discharge in Montana occurring in September, 1999. In response to the potential for CBNG development in the Powder River Basin, the MDEQ has developed surface water quality standards for EC and SAR in the Powder River watershed. These standards provide criteria against which to compare the monitoring data. These standards are summarized in Table 1 below. The MDEQ standards have been reviewed and approved by the United States Environmental Protection Agency (EPA), and therefore have Clean Water Act standing. Also, note that irrigation season standards are different from the non-irrigation season. MDEQ standards are applicable at the Wyoming-Montana state line; however they are not applicable in Wyoming. It

should be noted that these values are used solely as a point of comparison; the comparisons in this report do not constitute regulatory determinations.

The Montana Board of Environmental Review (BER) has modified the standards which apply to CBNG in Montana; however this report only considers those standards which were in place in water year 2005. The most substantial change adopted by the BER was to designate EC and SAR "harmful" parameters, which causes non-degradation rules to apply.

Table 1. MDEQ Standards for EC and SAR in the Powder River Watershed

	Irrigation Season (March-October)				**Non-Irrigation Season (November-February)**			
Stream	Mean Monthly EC (uS/cm)	NTE EC (uS/cm)	Mean Monthly SAR	NTE SAR	Mean Monthly EC (uS/cm)	NTE EC (uS/cm)	Mean Monthly SAR	NTE SAR
Powder River	2000	2500	5	7.5	2500	2500	6.5	9.75
Little Powder River	2000	2500	5	7.5	2500	2500	6.5	9.75
Tributaries	500	500	3	4.5	500	500	5	7.5

NTE = Not to Exceed EC = Electrical Conductance uS/cm = microSiemens per centimeter SAR = Sodium Adsorption Ratio

The Interagency working group for CBNG has identified regional surface water monitoring stations for the Powder River watershed. These stations, with their status for water year 2005 (10/1/05-9/30/06) are listed on Table 2 below. The locations of the active stations are shown on Map 1. Data collected at these stations included continuous flow, continuous specific conductance (SC), and analytical sampling. Analytical sampling includes the measurement of flow, field parameters (SC, pH, temperature, etc) and includes the collection of water-quality samples. Although these samples were analyzed by the USGS for many parameters, this report will focus on SC, SAR, and flow. SC and SAR are considered to be the parameters most likely to be affected by CBNG development (MDEQ, 2003b), and SC and SAR in the natural system fluctuate significantly with flow. The monitoring at these stations was funded by the USGS, WDEQ, WSEO, MDEQ, and MDNRC. An expanded set of analytical data are available from the USGS at http://waterdata.usgs.gov/nwis.

Table 2: Regional USGS Stations in the Powder River Watershed

Station #	Station Name	Status
06313500	Powder River at Sussex, WY	Flow and QW
06313605	Powder River below Burger Draw, near Buffalo, WY	QW
06317000	Powder River at Arvada, WY	Flow and QW
06324500	Powder River near Moorhead, MT	Flow and QW
06324710	Powder River at Broadus, MT	Inactive
06325650	Powder River at Powderville	Inactive
06326500	Powder River near Locate, MT	Flow and QW
06316400	Crazy Woman at Upper Station, near Arvada, WY	Flow and QW
06324000	Clear Creek near Arvada, WY	Flow and QW
06324970	Little Powder River above Dry Creek near Weston, WY	Flow and QW
06325500	Little Powder River near Broadus, MT	QW
06326300	Mizpah at Mizpah	Inactive

QW = Water Quality

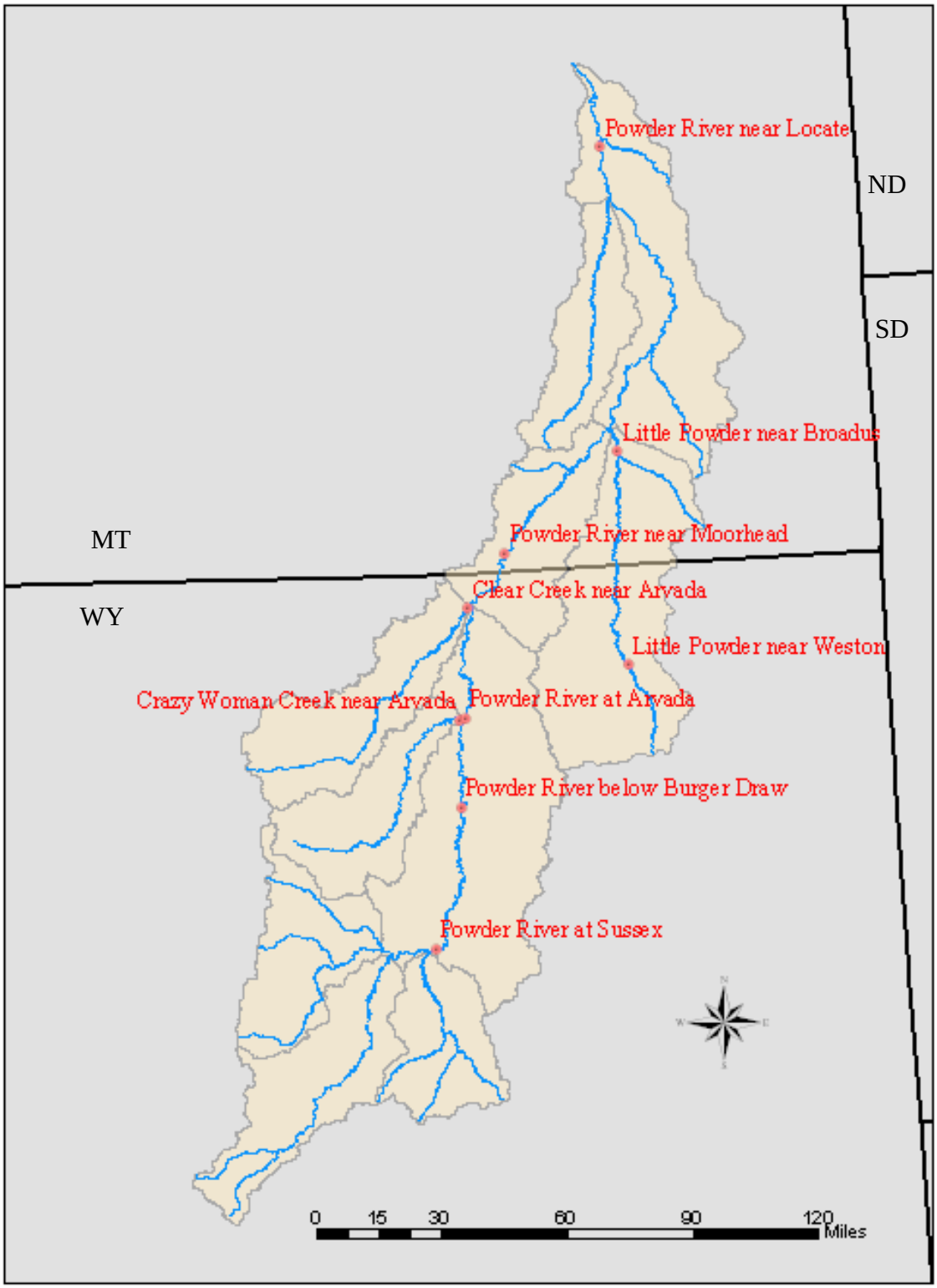
Data Review

For all sites, please see the figures section for graphical display of the data. Tabulated summary statistics for the sites are provided on Tables 3 and 4 below. Note that much of this data is preliminary so there may be slight differences between this data and the final data eventually released by the USGS.

For each station a summary of the mean daily flow, SC, and SAR data collected during water year 2005 is presented. Analytical Flow, SC and SAR data are also presented. Analytical results are compared to the MDEQ "not to exceed" (NTE) surface water standards for EC and SAR where they are applicable. For comparison to the mean monthly EC and SAR standards the mean monthly values are calculated as the simple average of all the mean daily and analytical measurements recorded during each calendar month. For several stations only monthly analytical samples are collected, so the mean monthly values are the same as the analytical values. Note that within the figures section the daily mean and analytical data are combined when discussing the range of values recorded. SC vs. Flow, SAR vs. Flow, and SC vs. SAR with historical data are presented in graphical form to allow evaluation of 2005 data in context.

Since SC and SAR are dependent on flow, it is important to recognize up front that water year 2005 was substantially wetter than 2004, with flows near long-term averages. Therefore, it is believed that data from 2005 may provide a better representation of "normal" conditions. If comparison is made between water quality data from different years, it is important to also take flow into account.

Map 1



Map 1 shows the Powder River Watershed as it extends from Wyoming into Montana. The locations of the 11 surface water monitoring sites (6 in Wyoming, 3 in Montana), which are the subject of this report, are also shown.

Main Stem Sites

Powder River at Sussex

Flow was measured continuously at this site. Water-quality samples were also collected. Mean daily flow values ranged from 5.6 to 2400 cfs, with the mean being 121 cfs (see Fig. 3).

Analytical SC values at this site ranged from 1020 to 6140 µS/cm, with the mean being 2926 µS/cm. Analytical SAR values at this site ranged from 3.4 to 21 with the mean being 7.9 (see Figs. 4-7).

SC vs. Flow, SAR vs. Flow, and SC vs. SAR charts in the figures section present the 2005 data along with historical data (see Figs. 5-7).

Powder River below Burger Draw

Flow was measured during sampling events at this site. Water-quality samples were also collected. Measured flow values ranged from 4.6 to 293 cfs, with the mean being 103 cfs (see Fig. 8).

Analytical SC values at this site ranged from 1780 to 4480 µS/cm, with the mean being 2848 µS/cm. Analytical SAR values at this site ranged from 5.0 to 14 with the mean being 7.8 (see Figs. 9-12).

SC vs. Flow, SAR vs. Flow, and SC vs. SAR charts in the figures section present the 2005 data along with historical data (see Figs. 10-12).

Powder River at Arvada

Flow was measured continuously at this site. Water-quality samples were also collected. Mean daily flow values ranged from 0 to 3080 cfs, with the mean being 176 cfs (see Fig. 13).

Analytical SC values at this site ranged from 916 to 3640 µS/cm, with the mean being 2393 µS/cm. Analytical SAR values at this site ranged from 2.8 to 8.5 with the mean being 5.9 (see Figs. 14-17).

SC vs. Flow, SAR vs. Flow, and SC vs. SAR charts in the figures section present the 2005 data along with historical data (see Figs. 15-17).

Recorded SC values were above the EC instantaneous maximum standard on three occasions (12/1/04, 1/4/05 and 7/25/05). SAR values did not exceed the instantaneous maximum standard. Mean monthly SC values were in excess of the mean monthly EC standard during March and April. Mean monthly SAR values were in excess of the mean monthly SAR standard during March and April (see Fig. 19).

SC vs. Flow, SAR vs. Flow, and SC vs. SAR charts in the figures section present the 2005 data along with historical data (see Figs. 20-22).

Powder River near Locate

Flow was measured continuously at this site. Water-quality samples were also collected. Mean daily flow values ranged from 25 to 3390 cfs, with the mean being 390 cfs (see Fig. 23).

Analytical SC values at this site ranged from 838 to 2870 µS/cm, with the mean being 2025 µS/cm. Analytical SAR values at this site ranged from 3.7 to 6.4 with the mean being 5.1 (see Figs. 24-27).

Recorded SC values were above the EC instantaneous maximum standard for 2 of the 12 samples collected. SAR values did not exceed the instantaneous maximum standard. Mean monthly SC values were in excess of the mean monthly EC standard during December, January, March, April May, August, and September; however there was only one SC sample collected in each month. Mean monthly SAR values were in excess of the mean monthly SAR standard during March, April, May, and August; however there was only one SAR sample collected in each month (see Fig. 24).

SC vs. Flow, SAR vs. Flow, and SC vs. SAR charts in the figures section present the 2005 data along with historical data (see Figs. 25-27).

Tributary Sites

Crazy Woman Creek near Arvada

Flow was measured continuously at this site. Water-quality samples were also collected. Mean daily flow values ranged from 0.36 to 559 cfs, with the mean being 40 cfs (see Fig. 28).

Analytical SC values at this site ranged from 442 to 2840 µS/cm, with the mean being 1527 µS/cm. Analytical SAR values at this site ranged from 0.9 to 3.1 with the mean being 1.8 (see Figs. 29-32).

SC vs. Flow, SAR vs. Flow, and SC vs. SAR charts in the figures section present the 2005 data along with historical data (see Figs. 30-32).