Origins of Seasonal Variations of Salinity of the Tongue River

Preliminary Research

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Introduction

Geologists at the Wyoming State Geological Survey (WSGS) and the University of Wyoming (UW) conducted a one-year water quality investigation to determine if an increase in salinity recorded from water samples collected near the Wyoming/Montana border was the result of coalbed natural gas (CBNG) production in the area.

Preliminary results show that the origin of the elevated salinity is the result of natural seasonal flow from snowmelt and runoff during February and March into the Tongue River and is likely related to the build up of salts in the arid soils of the Powder River Basin as well as from the underlying geology where the river flows.

The Tongue River is the primary water source for agriculture in the Powder River Basin. It also serves as the municipal water supply for several communities in Wyoming and Montana. As part of its water monitoring efforts the Wyoming Department of Environmental Quality (DEQ) requested an investigation on the source of the elevated salinity of the Tongue River. Because the river and its tributaries pass through areas of CBNG production in both states it was important to test for the presence of CBNG produced water.

The headwaters of the Tongue River are in the Bighorn Mountains in Wyoming. The river passes through the northern portion of the state into southeastern Montana and empties into the Yellowstone River in Montana. The river flows through a varied landscape that includes the Tongue River Canyon, the hills of southern Montana, and the buttes and grasslands of the Powder River Basin. The study area for this research included parts of the Tongue River and its associated tributaries that drain the northeast portion of the Powder River Basin. These include the Tongue River and Goose Creek tributaries (montane drainages), and the Prairie Dog Creek and Dutch Creek tributaries (basin interior drainages).

Methods

The scientists conducted a series of water quality tests to determine the cause of the elevated salinity or total dissolved solid (TDS) concentrations recorded in the Tongue River in early spring (Figure 1). TDS is

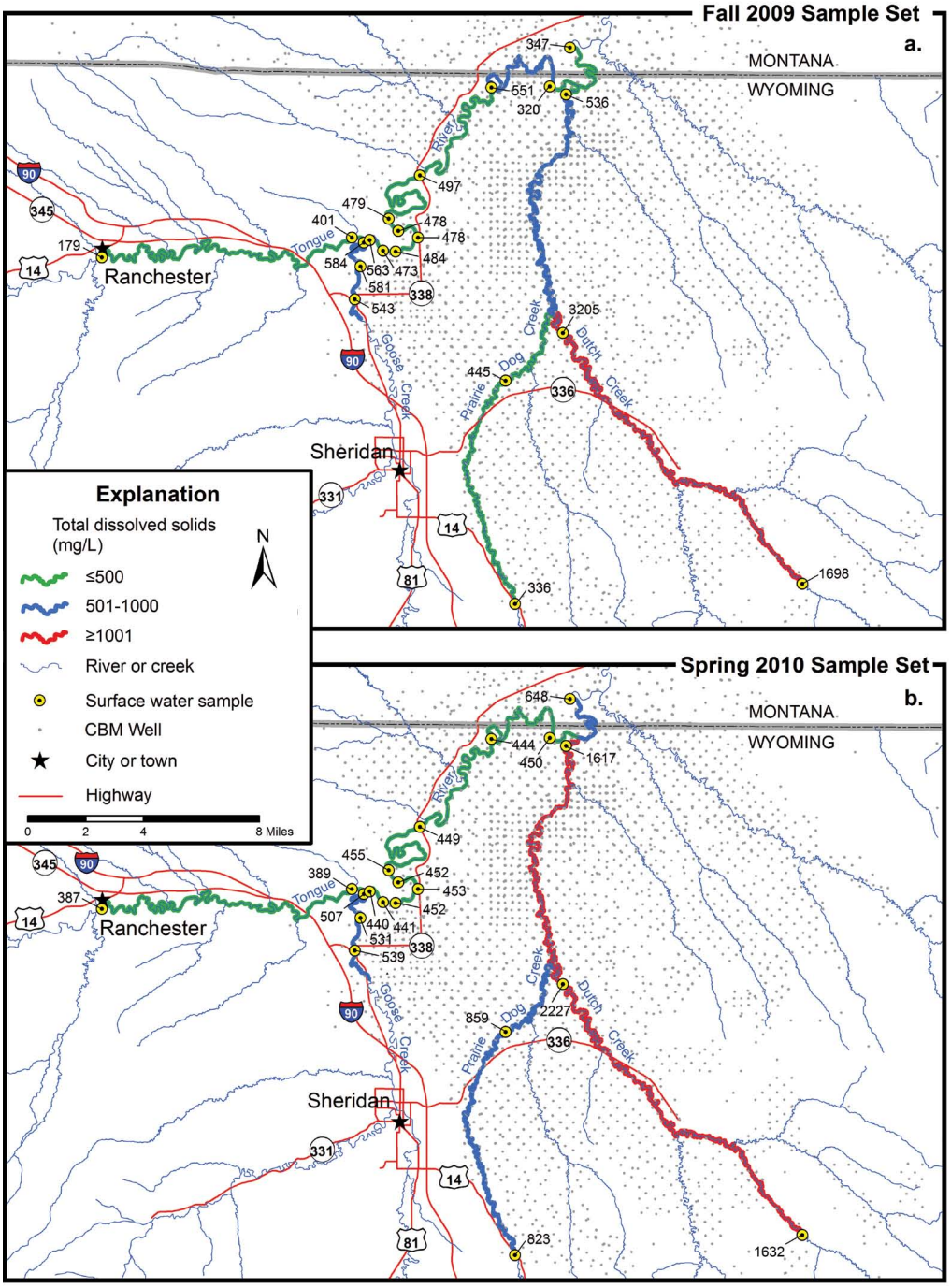

Figure 1. Total dissolved solid concentrations for the fall and spring measured within the Tongue River drainage (figure from report).

Three Water Types

Water flowing in the Tongue River comes from two distinct sources: 1) water that contains calcium-magnesium-bicarbonate minerals derived from mountain snowpack (from headwaters in the Bighorn Mountains), which represents the majority of the flow, and 2) water that contains calcium-magnesium-sulfate, which in part is caused by early runoff that occurs on the basin interior. The third type of water analyzed in this study is water produced from CBNG development.

CBNG produced water is geochemically distinct from river water in the Powder River Basin: CBNG produced waters are strongly sodium-bicarbonate whereas surface waters contain considerably greater sulfate. CBNG produced water also has enriched carbon isotopes.

Characteristics of Flows

The preliminary findings of this research shows that during the months of February and March the water chemistry of the Tongue River changes because of natural water flow processes, which is affecting the type of water draining from the basin interior.

a measure of salinity, which includes all inorganic and organic substances contained in the water. Samples were collected from rivers and streams as well as CBNG wells. Water samples were collected in the fall of 2009 to provide baseline data and again in the spring of 2010 during the period of elevated salinity.

Isotopic analyses were conducted at the UW Stable Isotope Facility and water chemistry samples were analyzed at the Wyoming Department of Agriculture Analytical Services Laboratory in Laramie.

Spring Flows

The lower elevations of the Powder River Basin are subject to snowmelt earlier in the season than the surrounding high snow-capped peaks. As the snow melts on the basin floor, evidence from the water samples suggest that the water runoff collects minerals from the soils in the basin as it drains into the Tongue River. The scientists noted that the minerals in the water are characteristic of the geology on the surface of the land. Consequently, the spring water samples collected in February and March,

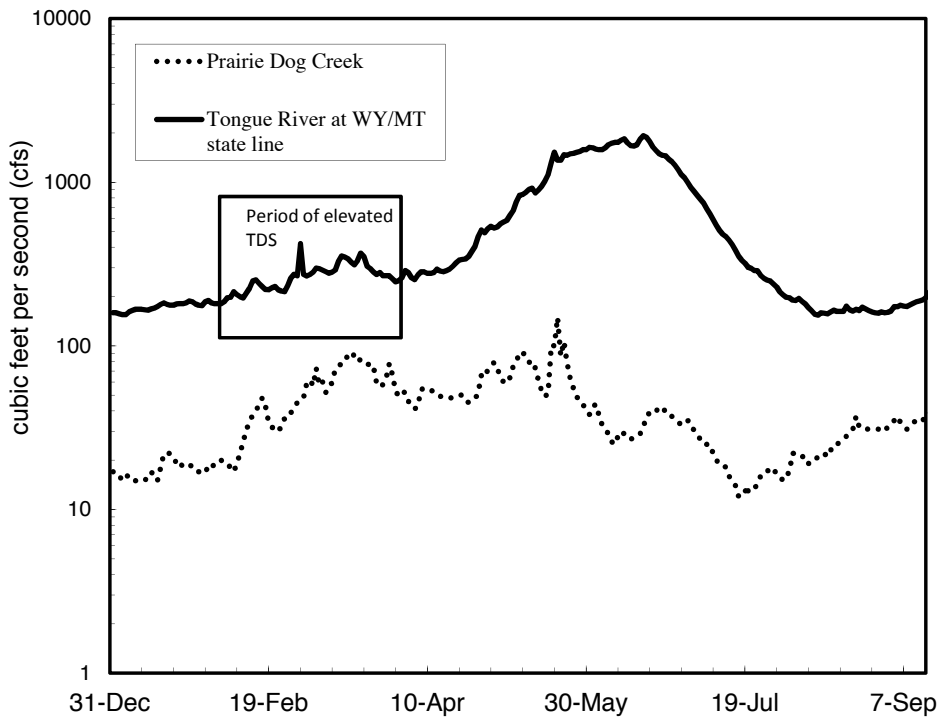

Figure 2. Average flow rates for the Tongue River and Prairie Dog Creek (figure from report).

during the early runoff process in the lower elevation of the basin, also record higher salinity. Peak runoff from mountain snowpack for the Tongue River occurs from May to July (Figure 2). By contrast, peak flow in the basin interior tributaries, such as Prairie Dog Creek, occurs earlier in the spring, between February and March. As a result, the more saline, sulfate-rich type runoff from the Prairie Dog Creek drainage occurs in advance of the mountain snowpack runoff. Based on the initial research findings, the higher TDS water in Prairie Dog Creek, which flows into the Tongue River, may be the result of the elevated TDS (calcium-magnesium-sulfate water type) resulting from the early spring flow.

Fall Flow

The scientists compared these results to the baseline water samples collected during the fall, during low flow. TDS measurements in the fall along the Tongue River remains under the levels recorded for the same areas measured/collected for the spring samples.

Coalbed natural gas produced water is not the cause of the elevated salinity in the Tongue River in early spring.

CBNG produced water is being ruled out as the source because it has a distinct water chemistry and isotopic signature. CBNG produced waters have water compositions that are strongly sodium bicarbonate and have a unique carbon isotopic signature. The isotopic compositions of most CBNG water samples are much higher than normal surface water. This isotopic fingerprint is a by-product of the microbes that have generated the gas that resides within the coal beds. The scientists tested for CBNG produced water, the composition that is high in sodium bicarbonate with a unique carbon isotopic signature; neither of which was observed in the surface water of the Tongue River. As a result, the preliminary findings indicate that the elevated TDS in the water in the Tongue River was not caused from discharged CBNG produced waters.

Conclusion

The preliminary results of this study show that CBNG produced water is not the cause of the elevated salinity in the Tongue River in early spring. The scientists indicate that the elevated TDS measured at the Wyoming/Montana border in February and March is a natural process, which was likely caused by the underlying geology of the Powder River Basin and watershed, and related to the earlier snowmelt in the basin interior.

The Wyoming DEQ and Montana DEQ can use this research as a basis for future inquiry on the water quality of the Tongue River. Geologists can also apply this research and water sampling methods to better characterize other watersheds in the state and study whether rivers in other basins are also affected by the underlying geology of the region.

This public information document is intended to highlight the preliminary results of this collaborative study. The WSGS will publish a Report of Investigation on this research in 2012, after its full editorial review process. Copies can be purchased or downloaded at www.wsgs.uwyo.edu.

WYOMING STATE GEOLOGICAL SURVEY
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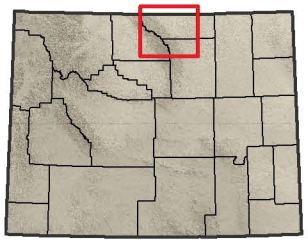

Location map

EXPLANATION

- City or town
- Interstate highway
- County boundary
- River or creek

0 2 4 8 Miles

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The Impact of Geology on the Water Quality of the Tongue River: An Investigation on Seasonal Variations of Salinity

Map design and layout by Phyllis Ranz 12/2011

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