



Introduction

The purpose of this map is to show the distribution of dissolved constituents in the ground water of the Deep Hydrologic Unit (DHU). The unit is defined as all aquifers and non-aquifers that occur at depths greater than 200 feet below land surface and lie stratigraphically above the regionally extensive claystone and shale in the upper Hell Creek Formation. The DHU encompasses mostly the lower part of the Fort Union Formation and, in places, the upper part of the Hell Creek Formation. The Fort Union and upper Hell Creek formations are a complex sequence of aquifer and non-aquifer materials.

Aquifers are saturated geologic materials that have sufficient permeability to yield usable quantities of water to wells and springs; non-aquifers (confining beds) are composed of less-permeable geologic materials that restrict the movement of water between aquifers and do not yield water to wells. Most of the aquifers are sandstones and coals in the Fort Union Formation and sandy zones in the upper part of the Hell Creek Formation. Aquifers vary in thickness, are laterally discontinuous, and are separated by non-aquifer shale and claystone layers. Despite of the complex stratigraphy, there is sufficient hydraulic continuity on a regional scale to consider the DHU a single entity in terms of ground-water flow.

The top of the DHU is not delimited by a continuous geologic or hydrogeologic marker but is transitional beneath the Shallow Hydrologic Unit, which consists of all aquifers and non-aquifers within 200 feet of the land surface (Paton *et al.*, 1997). The two units were differentiated to facilitate hydrogeologic interpretations given the scale of this investigation and the available data. Differences in water quality and ground-water flow were used to justify separating the units at 200 feet below land surface.

In the five-county Lower Yellowstone River Area, about 900 wells are completed in the DHU and compose approximately 12% of all wells in the area. Ground water from this unit is used primarily for domestic- and stock-water purposes. Most reported well yields are less than 15 gallons per minute.

Three sets of data on dissolved constituents in ground water are presented on the map: laboratory analyses obtained as part of this study, laboratory analyses from earlier studies, and values estimated from field data. Water samples from 28 domestic, stock, and monitoring wells were analyzed for major ions and trace metals between April 1995 and October 1995. Field measurements of specific conductance, pH, and water temperature also were obtained from each of the sampled wells. To ensure collection of a representative sample, each well was pumped prior to sample collection until the field parameters stabilized and at least three well-casing volumes were removed. Analyses were performed by the Montana Bureau of Mines and Geology's (MBMG) Analytical Laboratory. In addition to the samples collected for this study, 55 ground-water samples collected by the MBMG or the U.S. Geological Survey prior to this study were also used. These laboratory data were supplemented by estimated dissolved-

constituents concentrations derived from field measurements of specific conductance from an additional 112 inventoried wells. The laboratory analysis and field measurements presented on this map are available from the Montana Ground-Water Information Center data base.

Ground-Water Quality

Dissolved Constituents

Water may be characterized by the type and concentration of its dissolved constituents. The dissolved-constituents value is the sum of the major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO₃, CO₃, SO₄, Cl, SiO₂, NO₃, F) expressed in milligrams per liter (mg/L). This map shows the general distribution of dissolved constituents in the deep unit based on chemical analyses of ground-water samples and field measurements of specific conductance.

The concentration of dissolved constituents provides a general indicator of water quality. Typically, water does not become too salty to drink until the concentration of dissolved constituents reaches about 2,000 mg/L. Therefore, for this map a dissolved-constituents concentration of 2,000 mg/L was used to differentiate between water having low-dissolved constituents (blue symbols) and that having high-dissolved constituents (red symbols). Most ground water in the Lower Yellowstone River Area has relatively high concentrations of dissolved constituents; of the 83 ground-water analyses used in this study, the average was about 2,100 mg/L.

Note: 95% of the samples in each set had concentrations low (less than or equal to the values indicated by the 5th percentile); 5% of each sample set had concentrations less than or equal to the values indicated by the 95th percentile.

Major Ions and Suitability for Water Use

This table summarizes the results of 28 ground-water analyses performed as part of this study. For reference, the U.S. Environmental Protection Agency's recommended maximum contaminant levels and secondary maximum contaminant levels for public water supplies are also presented. Constituents for which maximum levels have been set may pose a health threat at elevated concentrations. Secondary levels are set for aesthetic reasons—elevated concentrations of these constituents may be a nuisance (bad taste or odor, or staining) but do not normally pose a health risk.

Despite the relatively high concentration of dissolved constituents (average = 2,080 mg/L), ground water from the Deep Hydrologic Unit is generally suitable for domestic and stock consumption. Recommended maximum fluoride levels were exceeded in some samples, while exceedences of nuisance levels of total dissolved solids, sulfate, sodium, iron, and manganese were common.

Fluoride concentrations ranged from non-detectable (14 samples) to 5 mg/L; the maximum contaminant level of 4.0 mg/L was exceeded in 3 of the samples (about 10%). Small amounts of fluoride (usually less than 2.5 mg/L) in drinking water are beneficial, and it is added to many water supplies in the United States. However, chronic exposure to high concentrations of fluoride may cause mottling of tooth enamel or skeletal damage (Driscoll, 1986).

Sulfate is a natural constituent in eastern Montana ground water, especially in the bedrock aquifers of the Fort Union Formation. Dissolved sulfate is derived from the oxidation of pyrite in shales and coal common in the Fort Union and Hell Creek formations, and the dissolution of gypsum (CaSO₄). Excessive sulfate can produce a laxative effect and, in

combination with other ions, give water a bitter taste. Ground water from aquifers with high sulfate concentrations may also have a "rotten egg" odor due to hydrogen sulfide (H₂S) gas which is formed by the bacterial reduction of sulfate in ground water. Hydrogen sulfide can corrode iron and steel and form ferrous sulfide or "black water."

A high concentration of sodium may give water a salty taste, but for most other domestic purposes has little effect on the water use. Ion exchange reactions within aquifers are an important source of sodium in eastern Montana ground water. Clays interbedded in the aquifer material act as a natural water softener, removing calcium and magnesium from solution and exchanging it for sodium. Commonly, elevated concentrations of sodium are associated with low concentrations of calcium and magnesium. Sodium salts may cause foaming in boilers and high sodium concentrations may limit use of water for irrigation by destroying soil structures and impairing plant growth. The sodium hazard for irrigation is measured by the sodium-adsorption ratio (SAR), which indicates the abundance of sodium relative to calcium and magnesium, and provides an indication of the suitability of water for irrigation use. High SAR values indicate a greater abundance of sodium relative to calcium and magnesium and indicate that the water may present a sodium hazard to soils. SAR values below 10 are desirable for irrigation waters. The results from the 28 samples analyzed as part of this study suggest that most water from the Deep Hydrologic Unit is unsuitable for irrigation. The SAR values ranged from less than 1 to 75 with a mean of 45; only 5 of the samples were less than 10.

Iron and manganese are essential to plants and animals but may cause unpleasant taste, odors and staining of plumbing fixtures. The primary source of iron and manganese in ground water is dissolution of minerals in the bedrock. Iron concentrations in well water may also be elevated (increased) by corrosion of iron well casings and from bacterial activity in and around the well screen. About 40% of the samples had iron concentrations above the secondary level of 0.3 mg/L, and about 25% of the samples had manganese concentrations above the secondary level of 0.05 mg/L.

Map Construction

This map was constructed by classifying concentrations of dissolved constituents of ground-water samples into low or high groupings. A concentration of 2,000 mg/L was used to differentiate between low and high concentrations because this is generally the upper limit of water potability. Three separate data sets are plotted on the map. More than 80 wells are shown from which samples were collected for laboratory analysis. Of these, 28 were sampled as part of this study between April 1995 and October 1995 and represent the primary data set; 55 wells sampled between 1947 and 1985 (49 were sampled since 1975) represent the historic data set. These analytical data were supplemented by estimates of dissolved constituent concentrations derived from specific-conductance measurements made at an additional 112 wells during the current study. These estimated values represent the inventory data set. The specific conductance (SC) measurements were used to estimate dissolved constituents (DS) according to the equation: DS = A × SC. A plot of dissolved constituents against specific conductance shows a well-defined relationship for ground-water samples from the Lower Yellowstone River Area. The data set closely fits a straight-line regression ($r^2 = 0.92$) when the value of A in the above equation is equal to 0.90 (Smith *et al.*, in preparation). Therefore, field specific-conductance measurements were multiplied by 0.90 to estimate the dissolved constituents concentrations in water from wells that were not sampled for laboratory analysis.

Well locations visited during the current study are accurate to the 2.5-acre level.

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References

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Dakota, Montana Bureau of Mines and Geology. Geologic Map No. 1, 1989.

Fetter, R. W. 1994. Applied Hydrogeology. Prentice Hall:Upper Saddle River, New Jersey, 691 p.

Hem, J. D. 1982. Study and interpretation of the chemical characteristics of natural water. U.S. Geological Survey Water Supply Paper 2254, 203 p.

Patton, T. Rose, J. C., LaFave, J. I., and Smith, L. N. 1998. Potentiometric surface map for the Shallow Hydrologic Unit, Lower Yellowstone River Area, Montana. MBMG Ground-Water Assessment Atlas No. 1, Part B, Map 5. Scale 1:250,000.

Smith, L. N., LaFave, J. I., Patton, T., Rose, J. C., and McKenna, D. 2000. Ground-water resources of the Lower Yellowstone River Area: Dawson, Fallon, Prairie, Richland, and Wibaux counties, Montana. Montana Bureau of Mines and Geology Ground-Water Assessment Atlas No. 1, 41 p.

Vake-Foster, S. M., Colon, R. B., Sackey, M. C., Wilde, E. M., Roberson, J. J., and Christensen, K. C. 1986. Geology of the Baker and Wibaux 30 x 60-min. quadrangles, eastern Montana and adjacent North Dakota. Montana Bureau of Mines and Geology Map No. 341, Scale 1:100,000.

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Aquifers

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Geographic features: Hydrography, population center locations, and roads are from 1:100,000-scale USGS Digital Line Graph files available from the Natural Resources Information System (NRIS) at the Montana State Library, Helena, Montana. Township boundaries digitized from 1:250,000 USGS mapping also are available from NRIS.

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