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A Department of Montana Tech of The University of Montana

Thickness of the Fox Hills—Lower Hell Creek Aquifer,
Lower Yellowstone River Area: Dawson, Fallon, Prairie,
Richland, and Wibaux Counties, Montana

by
Larry N. Smith

Note - this map was originally published at a scale of 1:250,000 but the page sizes have been modified to fit the size of the paper in your printer. A full sized 36” X 45” colored print of this map can be ordered from the Office of Publications and Sales of the Montana Bureau of Mines and Geology, 1300 West Park Street, Butte, MT 59701.
Phone: 406-496-4167 E-mail: http://mbmgsun.mtech.edu
Explanation

- ☐ > 0-100 feet
- ☐ 100-200 feet
- ☐ 200-300 feet
- ☐ 300-400 feet
- ☐ 400-500 feet

Well location showing aquifer thickness in feet:

- • 322 Water well log
- ♦ 270 Geophysical log

- ● Location of geophysical log examples
-  County boundary
-  Township boundary
-  County seat
-  Major road
-  Principal stream
- ☐ Area where the Pierre Shale is at or near the surface
- ☐ Outcrop area of the Fox Hills Formation
Thickness of the Fox Hills—Lower Hell Creek Aquifer, Lower Yellowstone River Area: Dawson, Fallon, Prairie, Richland, and Wibaux Counties, Montana

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Introduction

This map illustrates the thickness of the Fox Hills–lower Hell Creek aquifer in the Lower Yellowstone River Area. The top of the aquifer is at the top of a sandstone-dominated sequence of sandstones (aquifer materials) and mudstones (non-aquifer materials) near the middle or base of the Hell Creek Formation (Figure 1, Smith and LaFave 1995). The base of the aquifer is defined at the top of the Pierre Shale, which was picked from geophysical well logs at the uppermost shale marker in the upper Pierre, below the sandstones or siltstones of the overlying Fox Hills Formation (Smith 1995; Smith and LaFave 1995). Sandstone beds in the Fox Hills Formation are continuous across the study area, except where eroded near the Cedar Creek Anticline and the Poplar Dome.

About 11% of the water wells in the area are completed in the Fox Hills–lower Hell Creek aquifer. Many wells yield large volumes of water compared with wells completed in the other bedrock aquifers in the area (aquifers in the Fort Union Formation and upper parts of the Hell Creek Formation). Well yields from the Fox Hills–lower Hell Creek aquifer are up to 400 gallons per minute (gpm), as reported on drillers’ logs; the median yield is 12 gpm. Water in the aquifer is generally a sodium-bicarbonate type with dissolved constituents ranging from 1,000 to 2,500 milligrams per liter (mg/L).

Methods of Map Construction

The thickness of the Fox Hills–lower Hell Creek aquifer was mapped mostly from geophysical logs (primarily spontaneous potential and resistivity) in wells drilled for oil and gas exploration and production (e.g., Figure 1) and from a few drillers’ lithologic logs of water wells. Separate maps were converted to grids of values, and then the altitude of the top was subtracted from the altitude of the base of the aquifer to calculate the thickness, using geographic information system software. The contours were evaluated and then redrawn by hand to fit most of the 170 data points of thickness and the outercrop areas of the Fox Hills Formation (Vuke-Foster et al. 1986; Colton et al. 1994; Wilde and Vuke 1994; Bergantino and Wilde 1998a, b). Of the interpretations used from geophysical logs, about 23% are from Felts et al. (1981), 12% were reported by Comps et al. (1988), and the remaining were made for this study; a total of 9% of the data were from water well logs. Contours fit most data points.

Map Use

This map can be used to estimate the thickness of the Fox Hills–lower Hell Creek aquifer at locations where new wells may be drilled or where older wells may be deepened. Most water wells in the area penetrate less than 10 feet of the aquifer thickness, so increased well productivity may be obtained by deepening a well and increasing the open interval to the total thickness of the aquifer.

The aquifer is more than 450 feet thick in parts of Fallon, Prairie, and Wibaux counties. Recent erosion near the Cedar Creek Anticline and the Poplar Dome and changes in thickness of sandstone units in the lower Hell Creek Formation and the Fox Hills Formation due to depositional and erosional patterns, cause the aquifer to vary in thickness across the map. The coincidence of aquifer thickness along the Cedar Creek Anticline and Poplar Dome indicates that less sediment was preserved in these areas due to uplift; on these structures relative to the surrounding areas.

Map Accuracy

Map accuracy is affected by data availability, accuracy of well locations, errors in interpretation of log data, and smoothing during contouring. Well-log data are distributed unevenly across the map; accuracy is greatest near the data points shown. Water well locations are typically accurate to within a 40-acre area; those visited by agency personnel are accurate to within a 2.5-acre area. Oil and gas well locations are typically accurate to 10 feet. Inconsistency in determining the top of the aquifer is a significant source of error, especially in areas of few data points, because the aquifer interfingers with non-aquifer materials. Error in selecting the base of the aquifer is much less than that in verifying the top because of the greater lithologic and physical differences between the Pierre Shale and the Fox Hills Formation. Correlation error and inconsistency in interpretation can be responsible for between 50 and 100 feet of difference where the top of the aquifer is picked from logs. Contour smoothing may have introduced errors in depth on the order of 50 feet. It is estimated that the accuracy of the map is between 50 and 100 feet in most of the areas, but in some areas with fewer control points the accuracy may be reduced.

Data Sources

Geographic features: 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. Hydrography has been simplified from the 1:100,000 digital line graph files. Township boundaries are from 1:250,000-scale USGS maps and are available from NRIS.

Point data:

Water well drillers’ logs, well locations, and water-quality data are stored in the Ground-Water Information Center data base at Montana Bureau of Mines and Geology (MBMG). Geophysical logs and interpreted tops are stored at MBMG; logs are also in the files of the Montana Board of Oil and Gas Conservation in Billings, Montana.

References


Figure 1. Correlations between drilled for oil and gas and show a hard spot on the thickness of the Fox Hills–lower Hell Creek aquifer and relative potential and resistivity borehole logs. The log of the filled sandstone, mudstone, or sandstone bed in the lower Hell Creek aquifer is represented by a shaded interval, below a 10 ohm-m interval.
geophysical logs from two wells. Low well logs were used to map the lower Hell Creek aquifer. Spontaneous
role logs are commonly used to are scaled so that porous, fresh-
represented by wider areas, and clayey are represented by narrower areas each well. Contacts between different were chosen by comparing adjacent logs to mapped contacts.

rupt change in lithology from the dominated Fox Hills Formation. Fox Hills are generally thin. Shale Hell Creek Formation are common, the upper contact of the Fox Hills – tucked at the top of the sandstone-30 to 300 ft thick mudstone-dominated

Author’s Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Assessment Atlas for the Lower Yellowstone River Area ground-water characterization. It is intended to stand alone and describe a single hydrogeologic aspect of the study area, although many of the area’s hydrogeologic features are interrelated. For an integrated view of the hydrogeology of the Lower Yellowstone River Area the reader is referred to Part A (descriptive overview) and Part B (maps) of the Montana Ground-Water Assessment Atlas No. 1.

Geographic information system production by Joel Hall and Larry Smith. Digital cartography by Don Mason.