Montana Ground-Water Assessment Atlas No. 1, Part B, Map 5
October 1998
Revision 1 - Dec. 16, 1998

Montana Bureau of Mines and Geology
A Department of Montana Tech of The University of Montana

Potentiometric Surface Map for the Shallow Hydrologic Unit, Lower Yellowstone River Area: Dawson, Fallon, Prairie, Richland, and Wibaux Counties, Montana

by

Thomas W. Patton, James C. Rose, John I. LaFave, and 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

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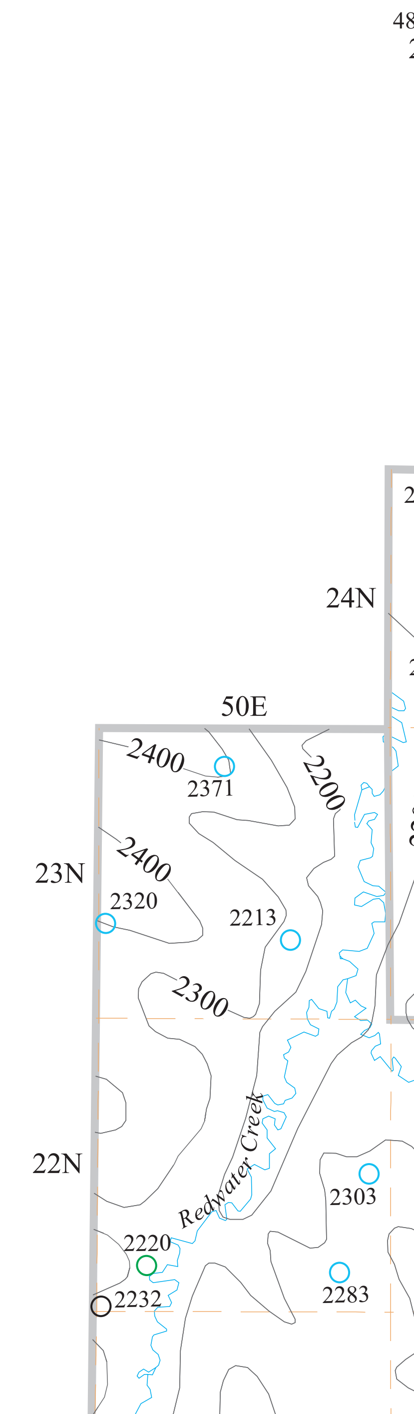
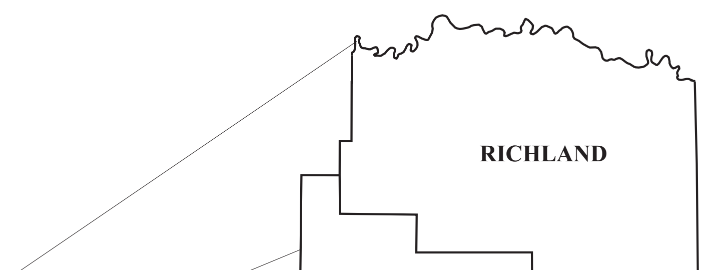
Explanation

- Water-level altitude in well completed within 50 ft of the land surface
- Water-level altitude in well completed between 50 and 100 ft of the land surface
- Flowing well
- Water-level altitude in well completed greater than 100 ft below land surface—may not be honored by contours
- 2200 Potentiometric surface contour for the upper part of the Shallow Hydrologic Unit
- County boundary
- Township boundary
- County seat
- Major road
- Principal stream
- Outcrop of the Pierre Shale
- Outcrop of the Fox Hills Formation





Ground-Water Characterization Study Areas

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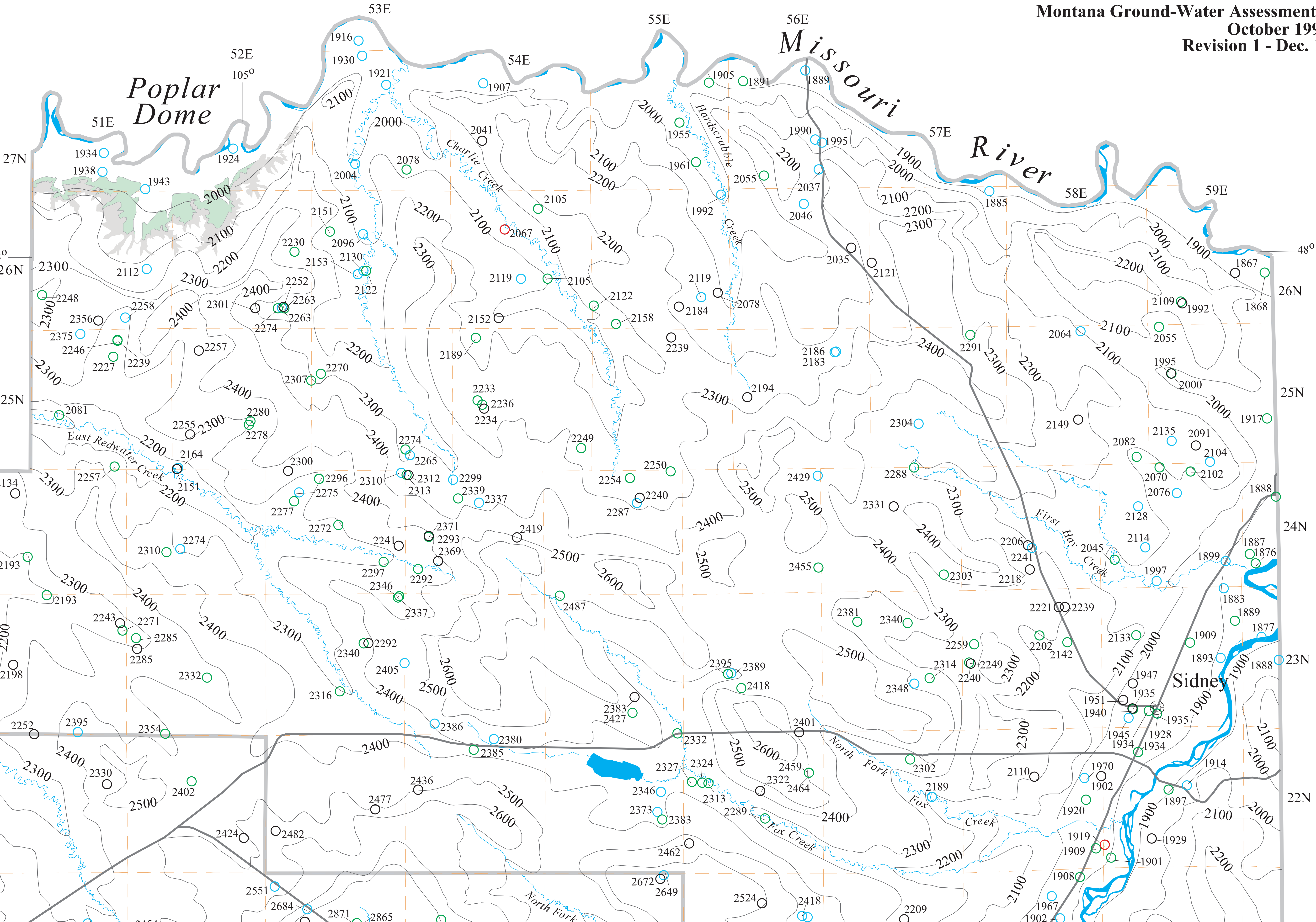
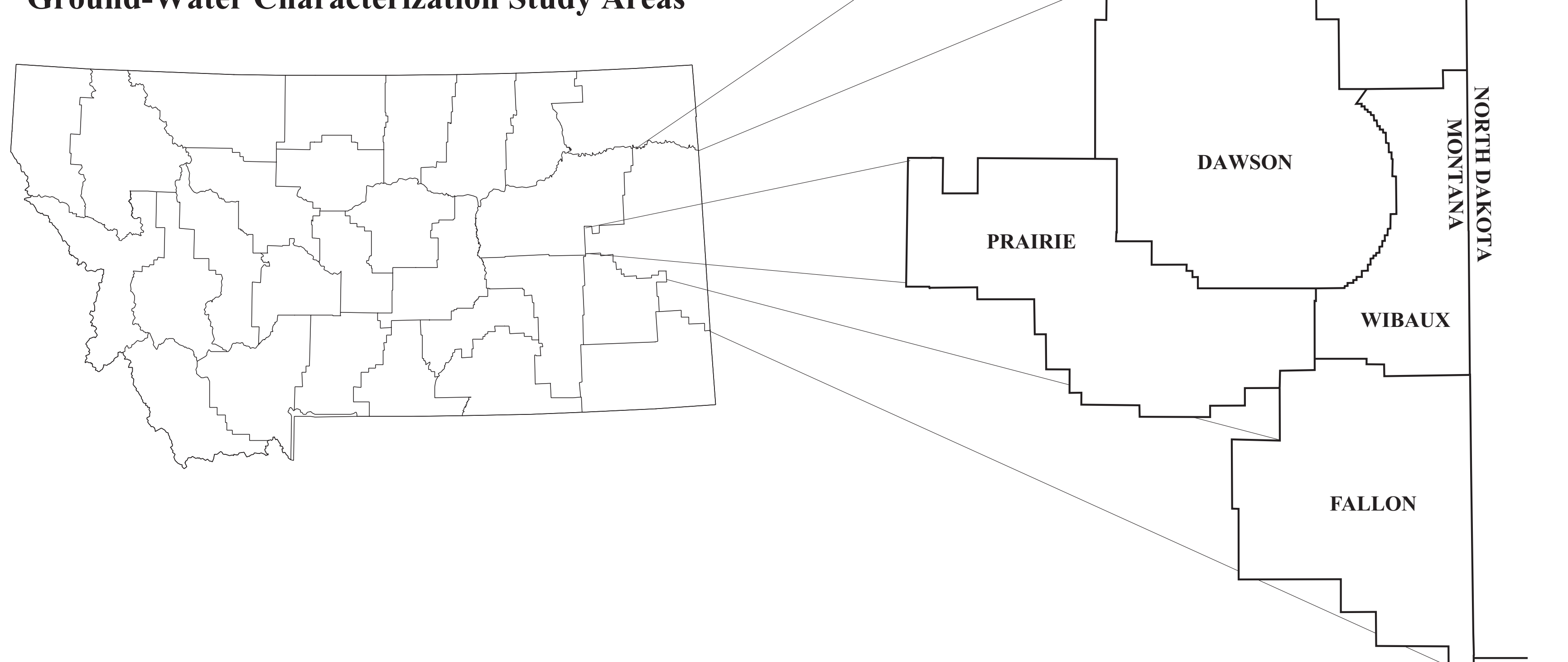
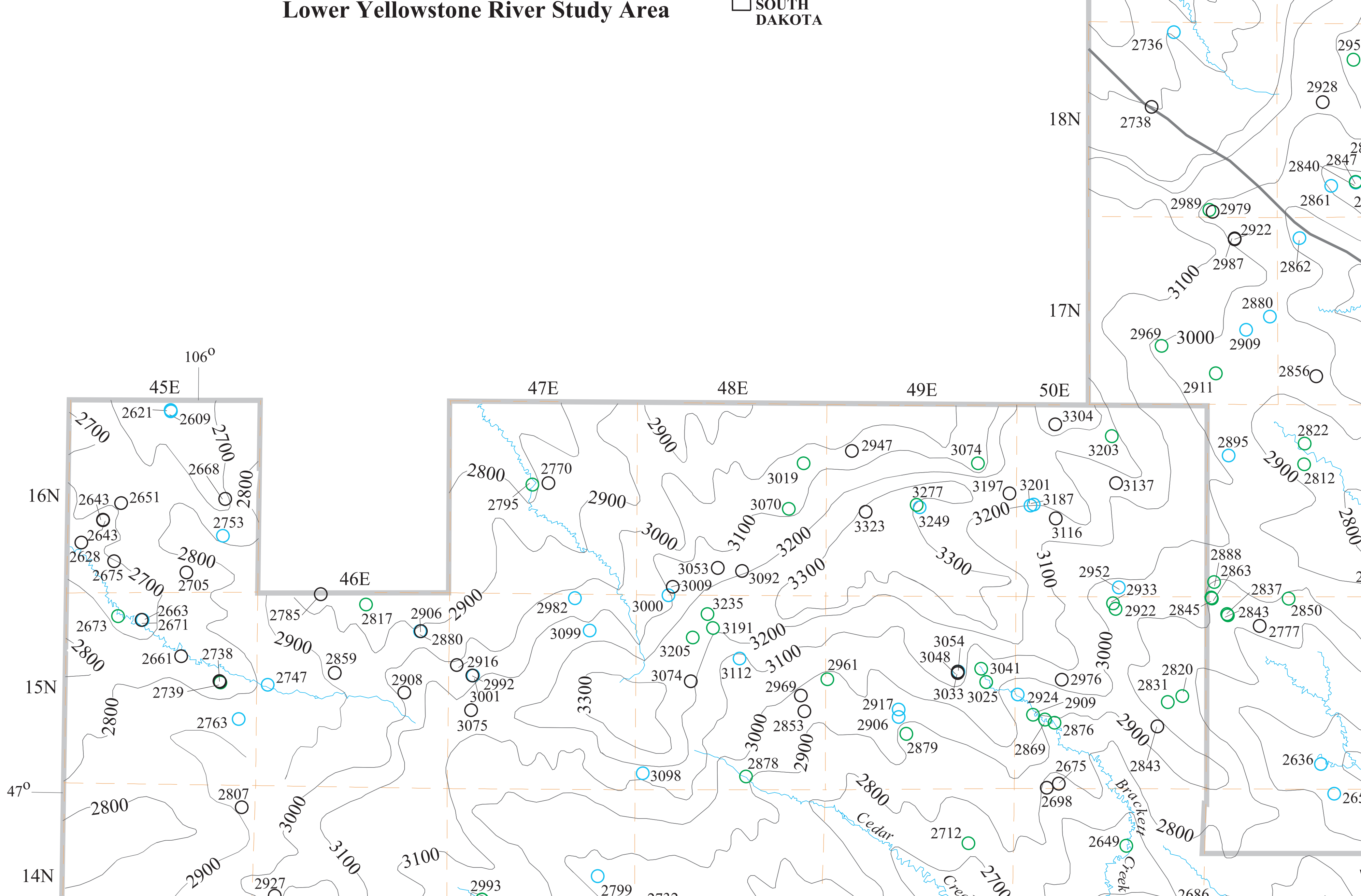
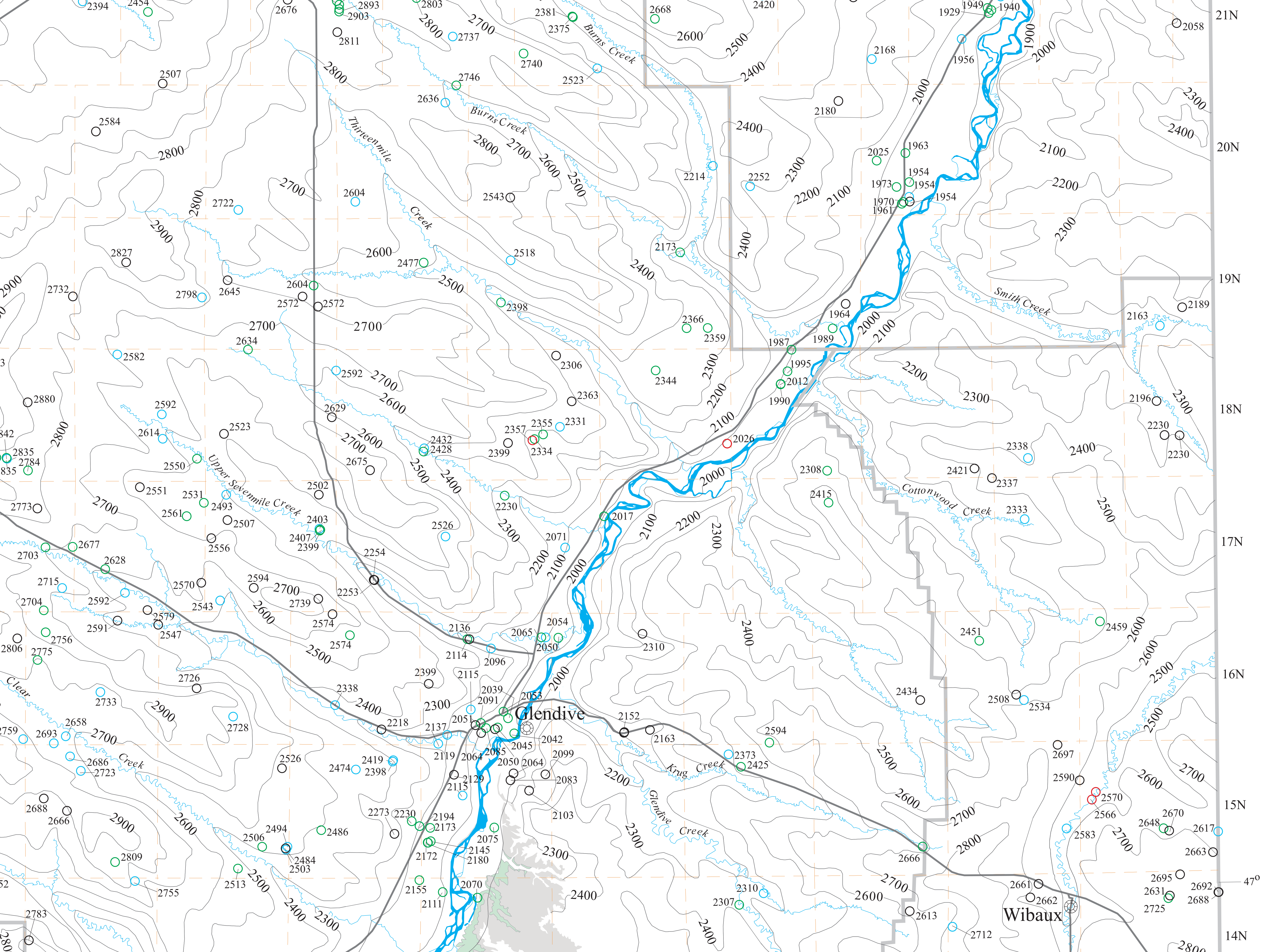


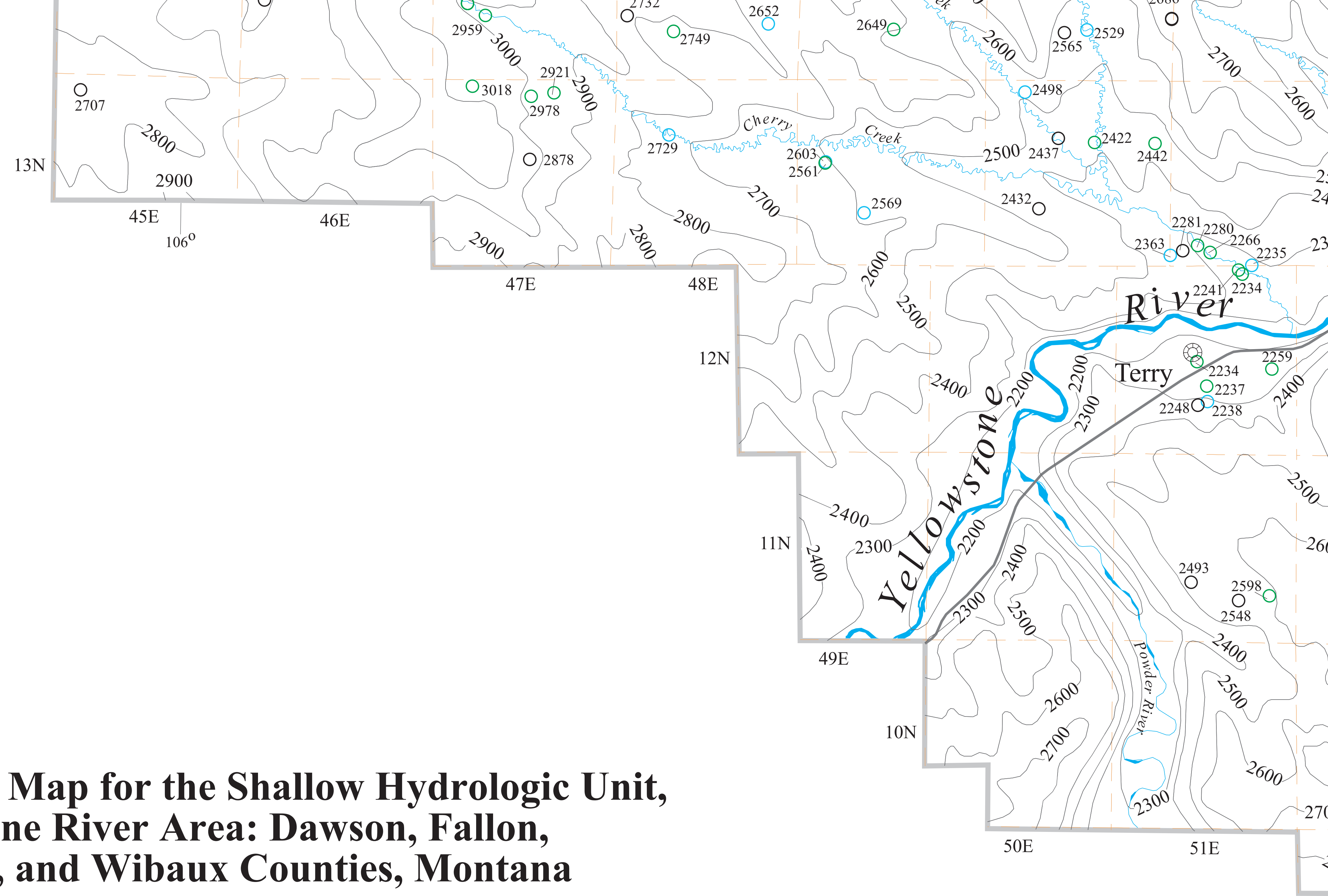
Ground-Water Characterization Study Areas



Lower Yellowstone River Study Area




Glendive
Wibaux
Burns Creek
Thirteenmile Creek
Upper Sevenmile Creek
Smith Creek
Cottonwood Creek
Krug Creek
Glendive Creek
Clear Creek
21N
20N
19N
18N
17N
16N
15N
14N
47°



Potentiometric Surface Map for the Shallow Hydrologic Unit, Lower Yellowstone River Area: Dawson, Fallon, Prairie, Richland, and Wibaux Counties, Montana

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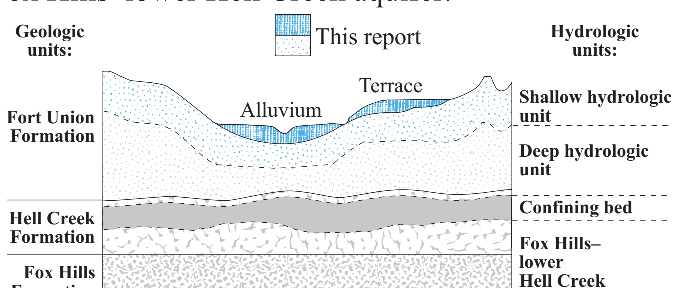
Introduction

The Shallow Hydrologic Unit (SHU) comprises all aquifers and non-aquifers within 200 feet of the land surface, excluding the Fox Hills–lower Hell Creek aquifer.

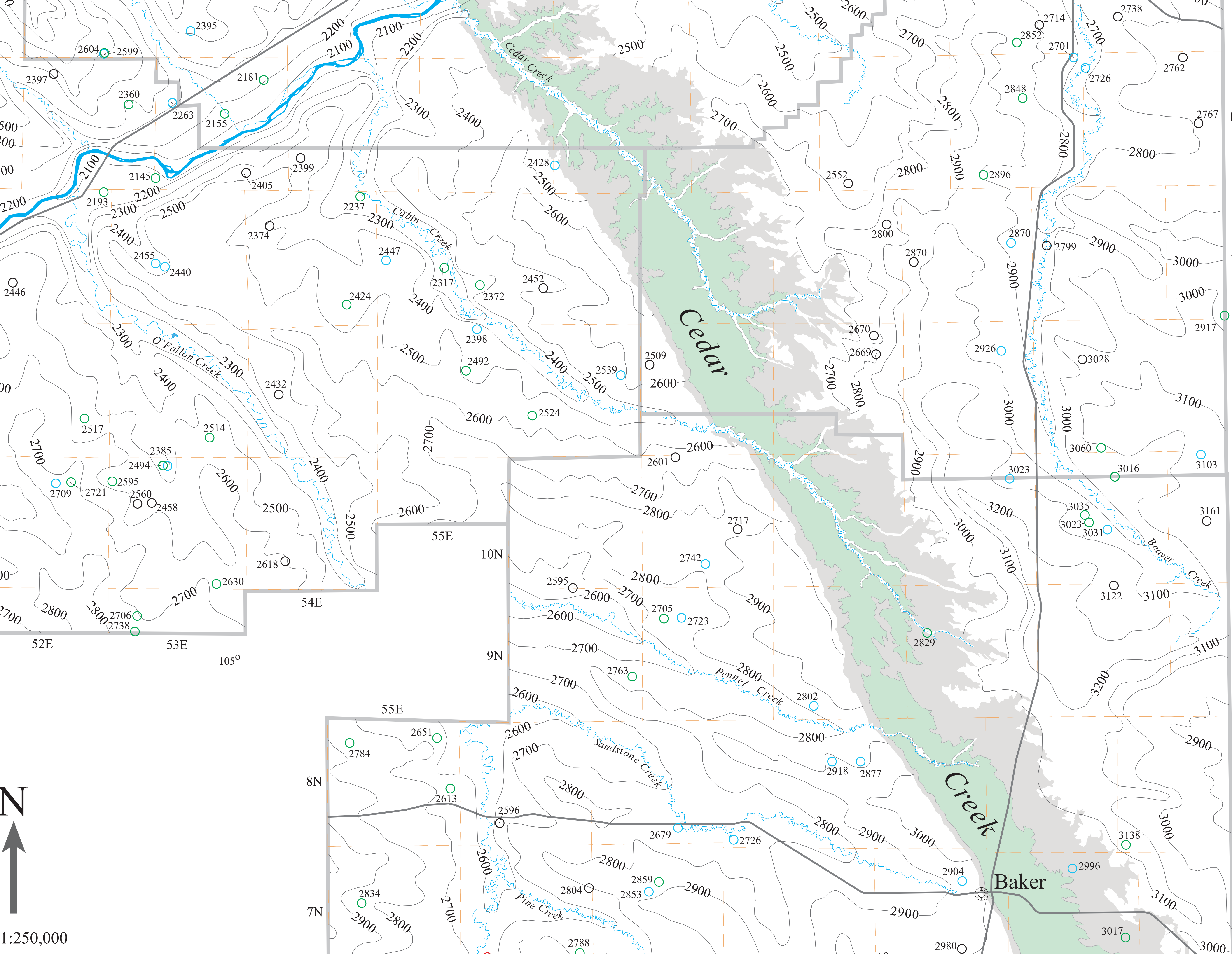


Ground-Water Flow

This map shows the potentiometric surface of the shallow flow system based on water-level measurements in wells completed within 50 feet of the land surface (green circles). This uppermost potentiometric surface, also referred to as the water table, is a muted representation of the land-surface topography. Ground water moves down the slope of the potentiometric surface, from higher altitude to lower altitude, perpendicular to the contours. The flow patterns are characterized by numerous local flow systems where ground water moves from local drainage divides (topographic highs) toward nearby valley bottoms. In the valley bottoms, flow is down valley and toward the Yellowstone and Missouri rivers.

below land surface and 135 measurements for wells completed at depths between 100 and 200 feet also were used. There are 156 water-level measurements for wells completed more than 50 feet below land surface that are not honored by the contours. All measurements were made between October 1993 and November 1995. Locations where the water levels were measured are distributed unevenly across the map. Land-surface topography at a scale of 1:250,000 and a contour interval of 100 feet were used to extrapolate the potentiometric surface between measured water-level altitudes. Well locations are accurate to the 2.5-acre level, and all locations shown have been visited in the field. Land-surface altitudes at well locations were interpreted from U.S. Geological Survey 1:24,000 topographic maps and are generally accurate to ± 5–10 feet (based on 10- and 20-foot contour intervals). The

Scale



Cedar Creek
Cedar Creek
Cabin Creek
O'Fallon Creek
Pennel Creek
Sandstone Creek
Pine Creek
Beaver Creek
Baker
13N
12N
11N
10N
9N
8N
7N
10N
9N
8N
7N
52E
53E
54E
55E
55E
105°
N
1:250,000

Aquifers are saturated geologic materials that yield sufficient water to supply wells and springs. Non-aquifer materials also may be saturated but have low permeability and do not produce usable amounts of water to wells or springs. The aquifers vary in thickness and are laterally and vertically discontinuous over distances of 10s to 100s of feet where they are separated by non-aquifer materials or by topography. The bottom of the SHU is not defined by a continuous geologic or hydrologic marker but is transitional with the underlying Deep Hydrologic Unit (DHU) (LaFave 1998). Differentiating the two hydrologic units simplifies 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 about 200 feet below land surface. Ground-water flow paths in the SHU are relatively short extending from local drainage divides to local valley bottoms. Flow paths in the DHU often extend from regional drainage divides to regional topographic lows.

Geologic deposits within the SHU that generally are aquifers when saturated with water are

- Sand and gravel deposits in the flood plain, low-lying benches, and terraces adjacent to and along the Yellowstone and Missouri rivers and their tributaries;
- Sandstone, clinker, and coal of the Fort Union Formation; and
- Sandstone in the upper Hell Creek Formation.

Non-aquifer materials include

- Glacial till and glacial lake–bed deposits in the northern part of the area;
- Silt and clay deposits within the flood plain and low-lying benches of the Yellowstone and Missouri rivers and their tributaries; and
- Shale of the Fort Union Formation.

Although the SHU consists of a variable sequence of aquifers and non-aquifers, there is sufficient hydraulic continuity to consider it a single entity in terms of ground-water flow.

Records in the Montana Bureau of Mines and Geology's Ground-Water Information Center data base show that almost 7,400 wells (about 70% of total wells) obtain water from the SHU, making it the most utilized ground-water source in the study area. Of these wells, about 4,700 (65%) are completed within 100 feet of the land surface. Reported water-level altitudes range from 58 feet above to 180 feet below land surface. Water quality is highly variable with dissolved-constituent concentrations ranging from less than 500 to more than 5,000 mg/L. Reported well yields are also variable, reflecting the variable nature of the aquifers. In the sand and gravel aquifers, yields average about 35 gallons per minute (gpm).

Water enters (recharges) the ground-water system from infiltration of precipitation, losses from streams, and irrigation water lost by percolation through fields and leakage from ditches. As ground water, it moves away from the recharge area to where it can leave the aquifer (discharge). While in transit, the ground water is considered to be stored. Places where water discharges are springs and seeps along valley bottoms and sides, reaches of perennial streams that gain water, and areas where water becomes available to plants for transpiration. Ground-water flow is not only horizontal but may have vertical components as well. Downward vertical movement (characterized by decreasing water-level altitudes with increasing well depths) represents discharge to deeper systems. Upward vertical movement (characterized by increasing water-level altitudes with increasing well depth) shows areas where shallower aquifers are recharged from deeper systems.Flowing wells, depicted by red circles, document areas where there is upward vertical movement of ground water.

Examples of vertical ground-water flow can be seen at numerous locations on the map where measured water levels are not honored by the potentiometric contours. On this map, about 20% of water levels from wells completed between 50 and 100 feet (blue circles) and 45% of wells completed at depths greater than 100 feet below land surface (black circles) are not honored by the contours. They are shown, however, because they help document vertical components of ground-water flow.

Map Use

The potentiometric surface map is useful in estimating the distance to water below the land surface and the general direction of ground-water flow. If the approximate land-surface altitude at a location is known, the corresponding point on the potentiometric-surface map can be found and the altitude of the potentiometric surface estimated. Subtraction of the potentiometric-surface altitude from the land-surface altitude yields approximate distances to water. The depth to the water level in a completed well should be near the estimated value.

To estimate the direction of ground-water flow near a location, draw lines on the map that cross potentiometric contours at right angles. Ground water flows from high altitude to low altitude along these lines. The example to the right illustrates how ground-water flow directions can be interpreted.

Map Construction

This map was constructed by contouring measured water-level altitudes from 312 wells completed within 50 feet of the land surface by hand. Another 177 water-level measurements for wells completed between 50 and 100 feet

contoured potentiometric surface is expected to be accurate to ± 50 feet at any given point.

Acknowledgements

Well owners who allowed collection of the data necessary for this map, and the people who collected the data are all gratefully acknowledged. Reviews of this report by Kate Miller and Wayne Van Voast improved its clarity.

Data Sources

Geographic features:

Population center locations and roads are from 1:100,000-scale U.S. Geological Survey (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 U.S. Geological Survey maps and are available as digital data from NRIS.

Point data:

Well-location and water-level altitude data were obtained by Ground-Water Characterization Program personnel; land-surface altitudes were determined from U.S. Geological Survey 7.5-min. quadrangle maps. All point data used on this map are available from the Ground-Water Information Center (GWIC) at the Montana Bureau of Mines and Geology, Montana Tech of The University of Montana, Butte.

References

Bergantino, R. N., and Wilde, E. M. 1998a. The preliminary geologic map of the Culbertson 30 x 60-min. quadrangle, Montana. Butte:Montana Bureau of Mines and Geology Open-File Report 359. Scale 1:100,000.

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Colton, R. B., Vuke-Foster, S. M., and Fullerton, D. S. 1994. Preliminary geologic map of the Glendive 30 x 60-min. quadrangle. Montana Bureau of Mines and Geology Open-File Report 276. Scale 1:100,000.

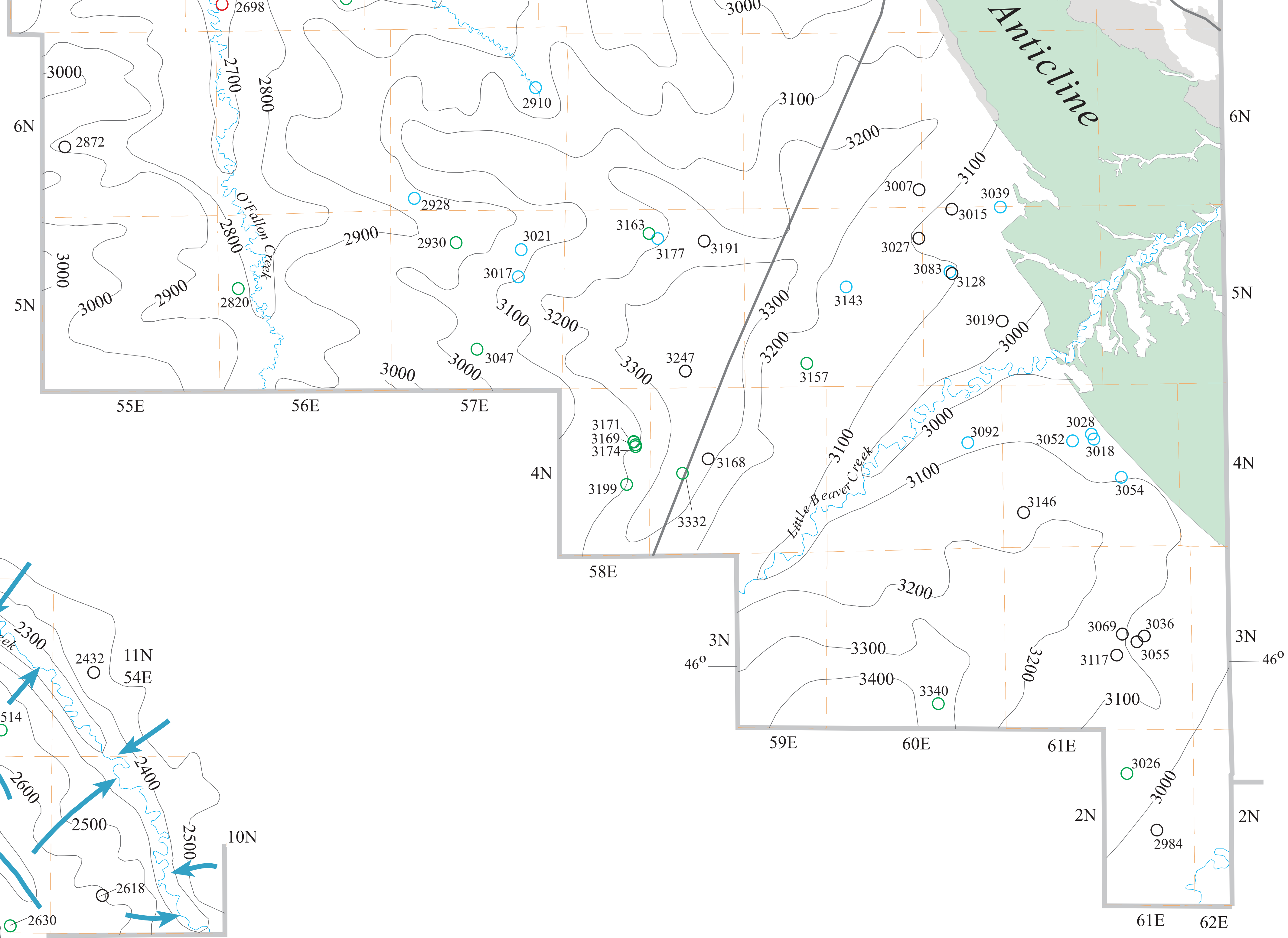
LaFave, J. L. 1998. Potentiometric surface map for the Deep Hydrologic Unit Lower Yellowstone River Area, Montana. Butte:Montana Bureau of Mines and Geology Ground-Water Assessment Atlas No. 1, Part B, Map 6. Scale 1:250,000.

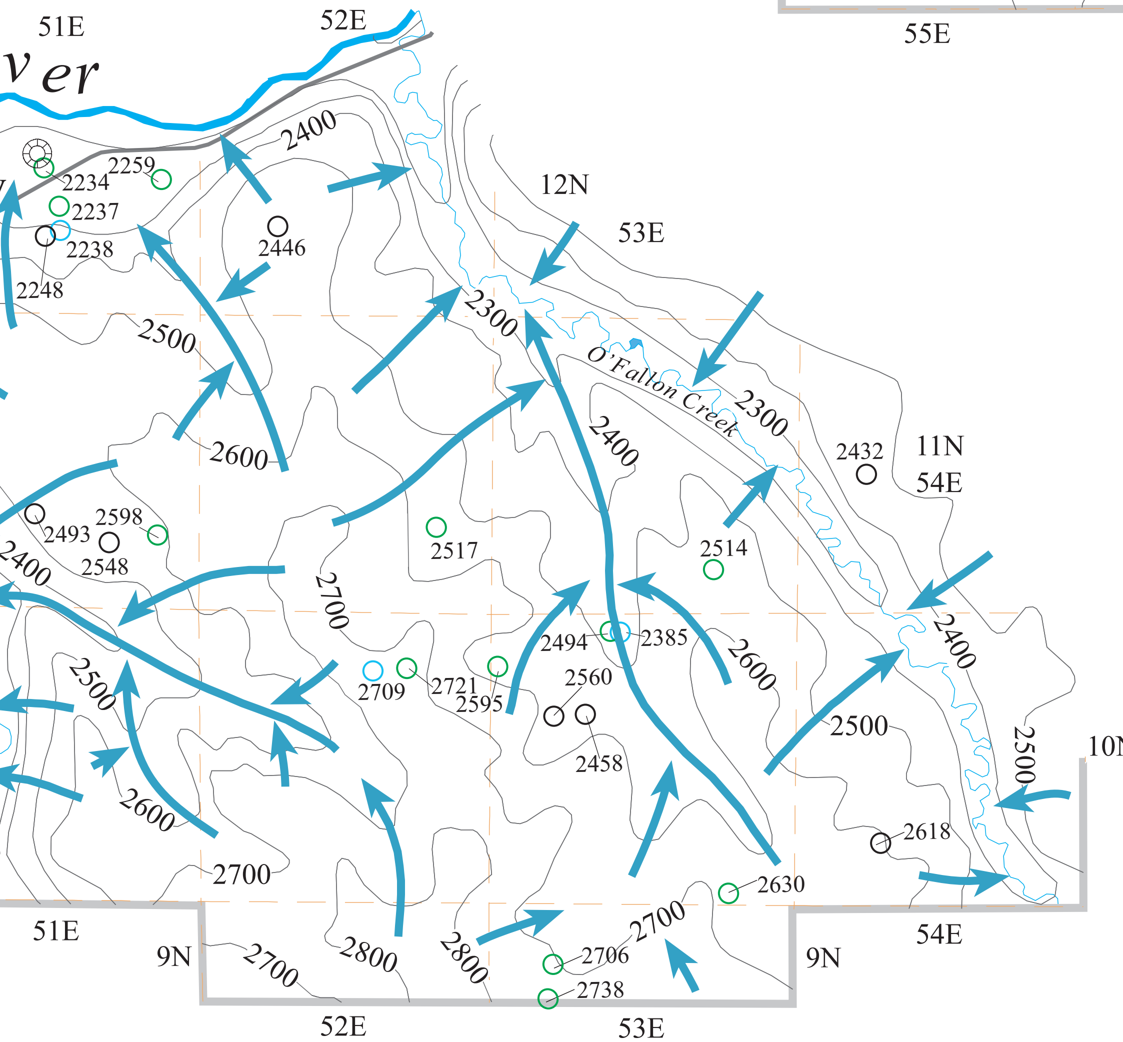
Vuke-Foster, S. M., Colton, R. B., Stickney, M. C., Wilde, E. M., Robocker, J. E., and Christensen, K. C. 1986. Geology of the Baker and Wibaux 30 x 60-min. quadrangles, eastern Montana and adjacent North Dakota. Butte:Montana Bureau of Mines and Geology Geologic Map 41. Scale 1:100,000.

The area south of Terry provi
general directions of ground-
water moves from upland are

10 15 miles

Mercator Projection
dian -105 Degrees
rizontal Datum
erval = 100 feet
m is mean sea level





...tion of ground-water flow

...des an example of how the potentiometric-surface map can be used to estimate ...water flow. Flow arrows drawn perpendicular to the contours show that ground ...as toward the Powder River, O'Fallon Creek, and the Yellowstone River.

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.