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

Potentiometric Surface Map of the Deep Aquifer, Kalispell Valley: Flathead County, Montana

by

John I. LaFave

Note - this map was originally published at a scale of 1:63,360 but the page sizes have been modified to fit the size of the paper in your printer. A full sized 36" X 48" 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.
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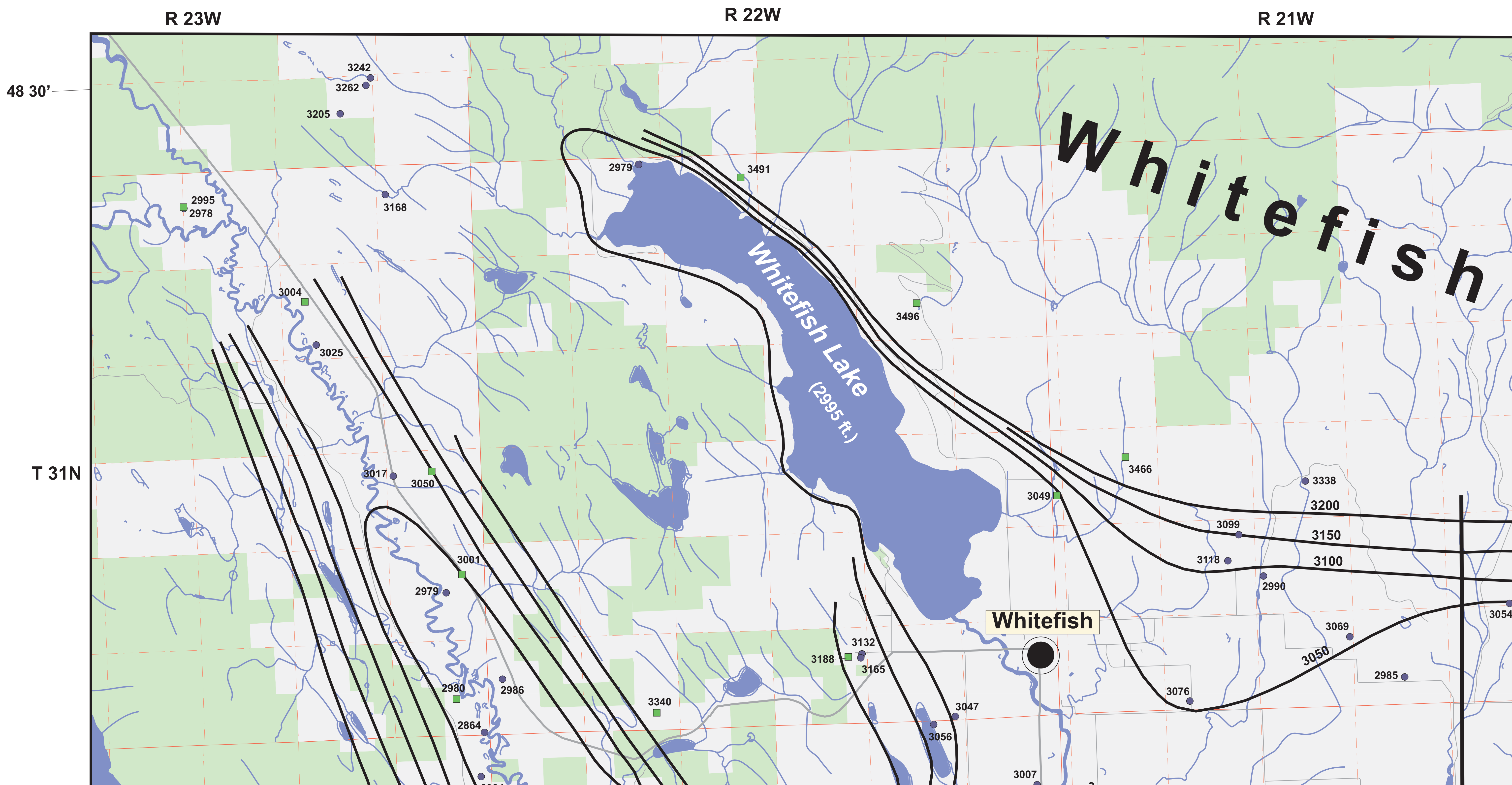
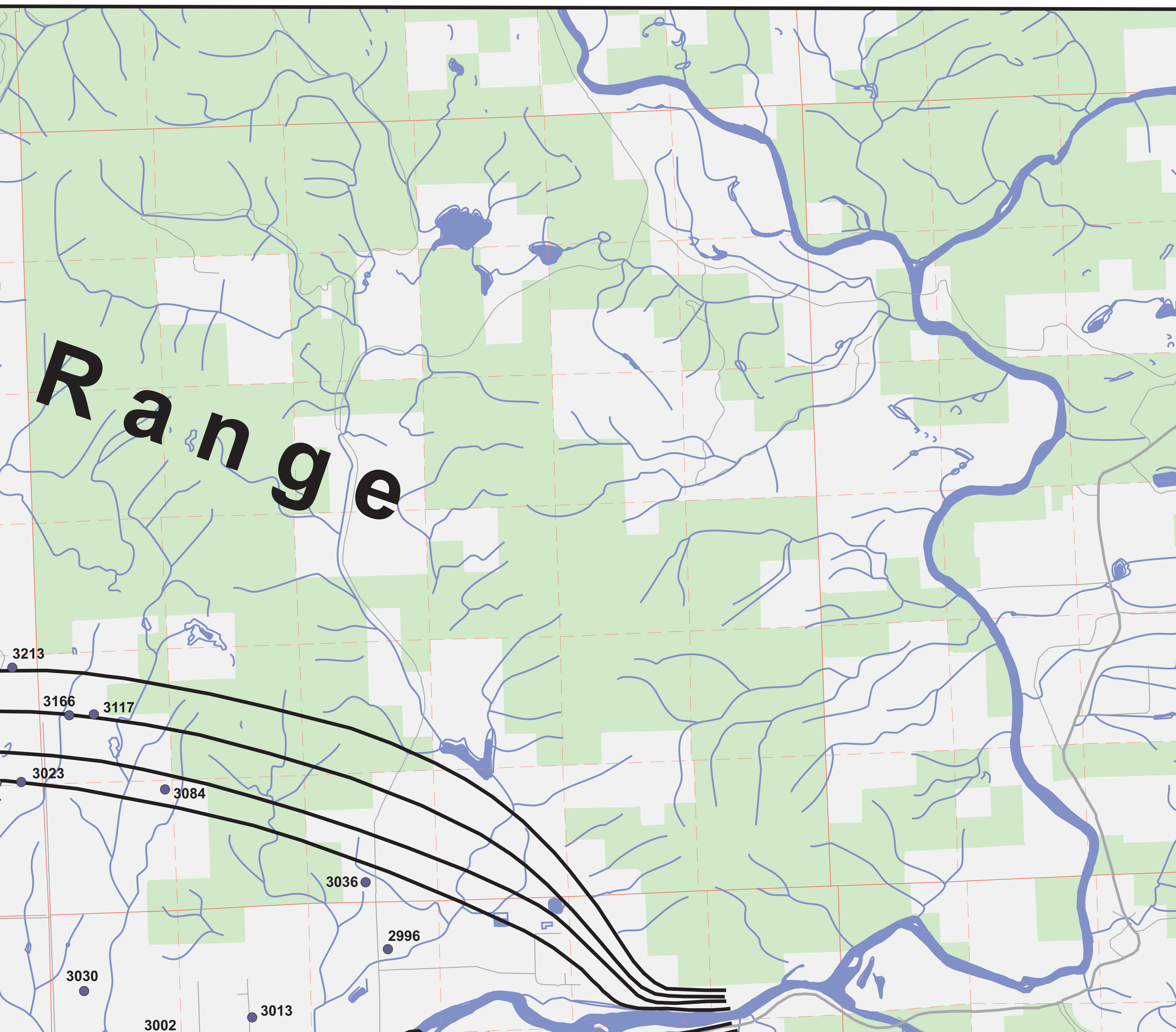




EXPLANATION

2800 — Potentiometric surface contour showing line of equal water-level altitude for the deep aquifer. Contour interval: 25 feet in the valley 50 feet along the valley margins.

Generalized direction of ground-water flow

2968 — Well completed in the deep alluvium with water-level altitude.

Well completed in the bedrock (Belt Supergroup)

Township boundary

Section boundary

Major road

Secondary road

Stream

Area where water levels in the deep aquifer are generally within 10 feet of, or above, land surface.

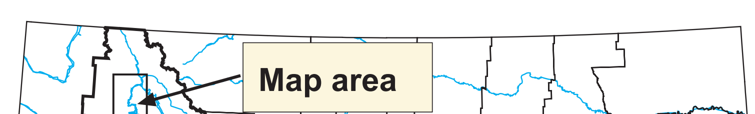
Federal/State lands

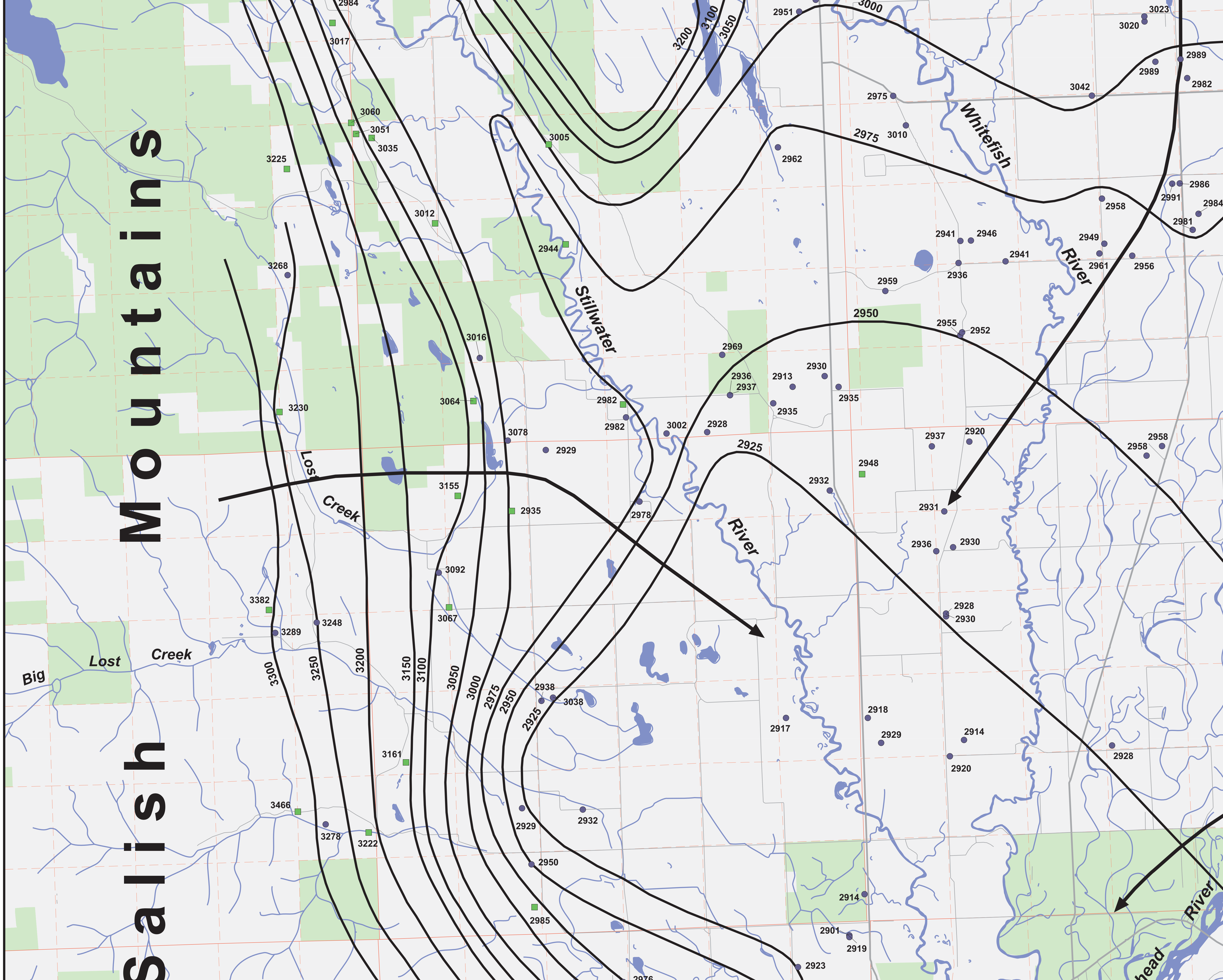
Other lands

1 0 1 2 Miles

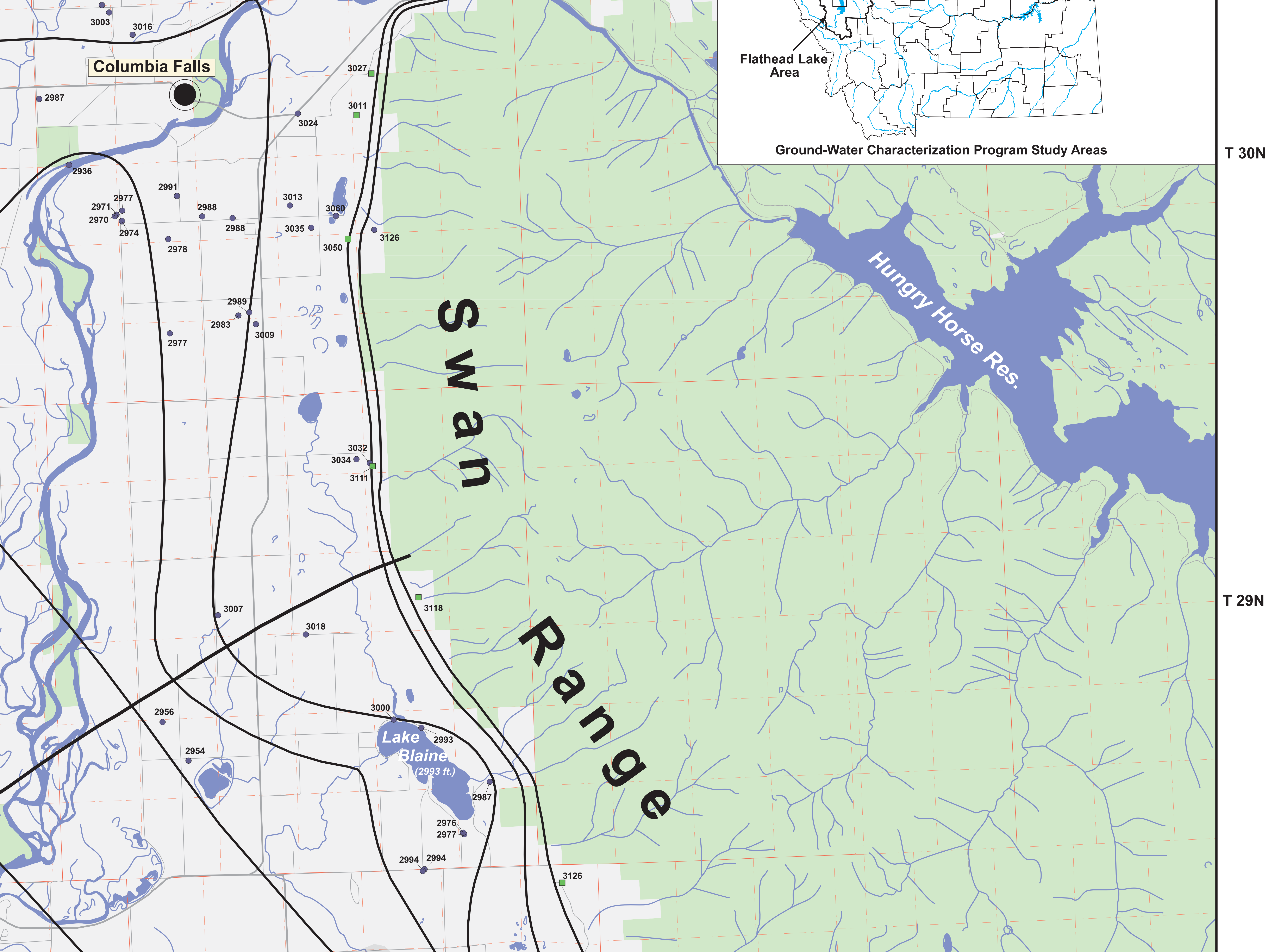
Scale 1:63,360
1 inch on the map represents 1 mile on the ground
UTM Projection Zone 11 NAD27

N W E S

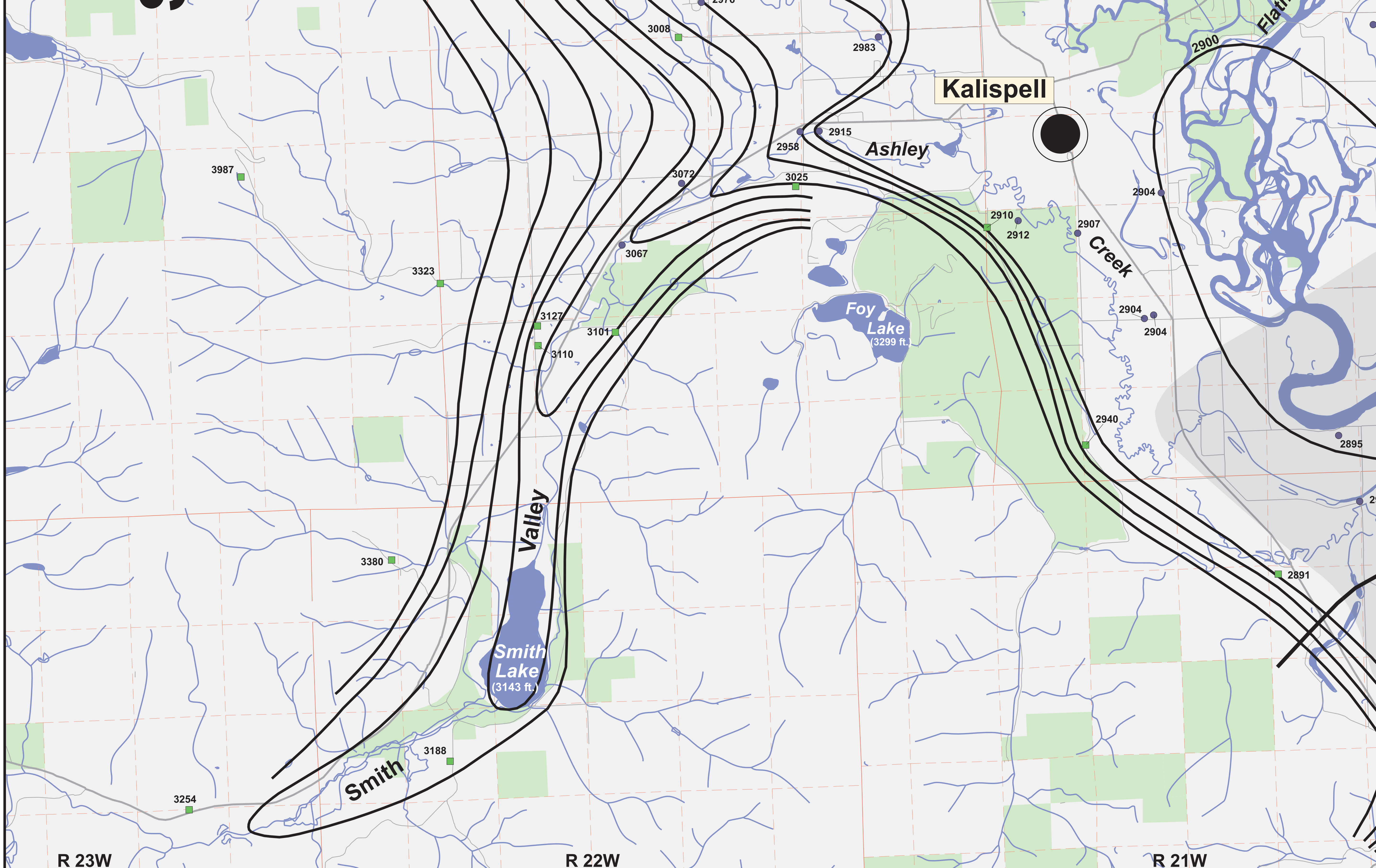




T 30N
T 29N
Salish Mountains
Big Lost Creek
Lost Creek
Stillwater River
Whitefish River
River
3300
3250
3200
3150
3100
3050
3000
2975
2950
2925



Columbia Falls
3003
3016
2987
3027
3011
3024
2936
2991
2977
2971
2970
2974
2988
2988
2978
3013
3060
3035
3050
3126
2989
2983
3009
2977
3032
3034
3111
3007
3018
3118
2956
2954
3000
Lake Blaine
2993
(2993 ft.)
2987
2976
2977
2994
2994
3126
Swan Range
Hungry Horse Res.
Flathead Lake Area
Ground-Water Characterization Program Study Areas
T 30N
T 29N



Potentiometric Surface Map of the Deep Aquifer, Kalispell Valley: Flathead County, Montana

by
John I. LaFave

Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Characterization Open-File Map Series intended to describe specific hydrogeologic features in the Flathead Lake Area. Each map is intended to stand alone, describing a single hydrogeologic aspect; however, many of the hydrogeologic features are interrelated. For an integrated view of

most of the deep aquifer are widespread beneath the valley, but there are some areas where they are separated by low-permeability lenses of silt and clay, especially near the upper part of the aquifer. For example, south of Whitefish, near the intersection of highways 93 and 40 (T. 30 N., R. 22 W. sec. 12), there may be three to four discrete water-bearing sand and gravel horizons separated by layers silt and clay. Where these "intermediate" alluvial layers occur, relationships between subsurface units are complex. On a regional, valley-wide scale, however, there is sufficient hydraulic continuity between the sand and gravel layers to be considered a single entity in terms of ground-water flow.

Across most of the valley the aquifer is covered by layers of till and/or glaciolacustrine deposits. The cover is variable in thickness, however, and in places, such as near Columbia Falls (T. 31 N., R.20 W.) and Lost Creek (T. 20 N., R. 22 W.), it may

to the ground-water system occurs primarily during spring runoff. Fractures within the bedrock help transfer mountain-front recharge to the deep aquifer. Topographic relief has a strong effect on determining the direction of ground-water flow. The potentiometric surface mimics the surface topography with steeper gradients along the side of the valley and flatter gradients in the valley proper. Ground-water flow paths are generally away from the mountains toward the center of the valley and then south toward Flathead Lake. West of the valley ground water flows toward the Ashley Creek (Smith valley) and the Stillwater River valleys before entering the main valley. On the southeast side of the map ground water moves toward the center of the Swan valley before moving into the Kalispell valley. The flat gradient (wide-spaced contour lines) in the central part of the Kalispell valley also reflects the higher permeability of the sand and gravel that form the aquifer in this area as opposed to the lower permeability of the bedrock

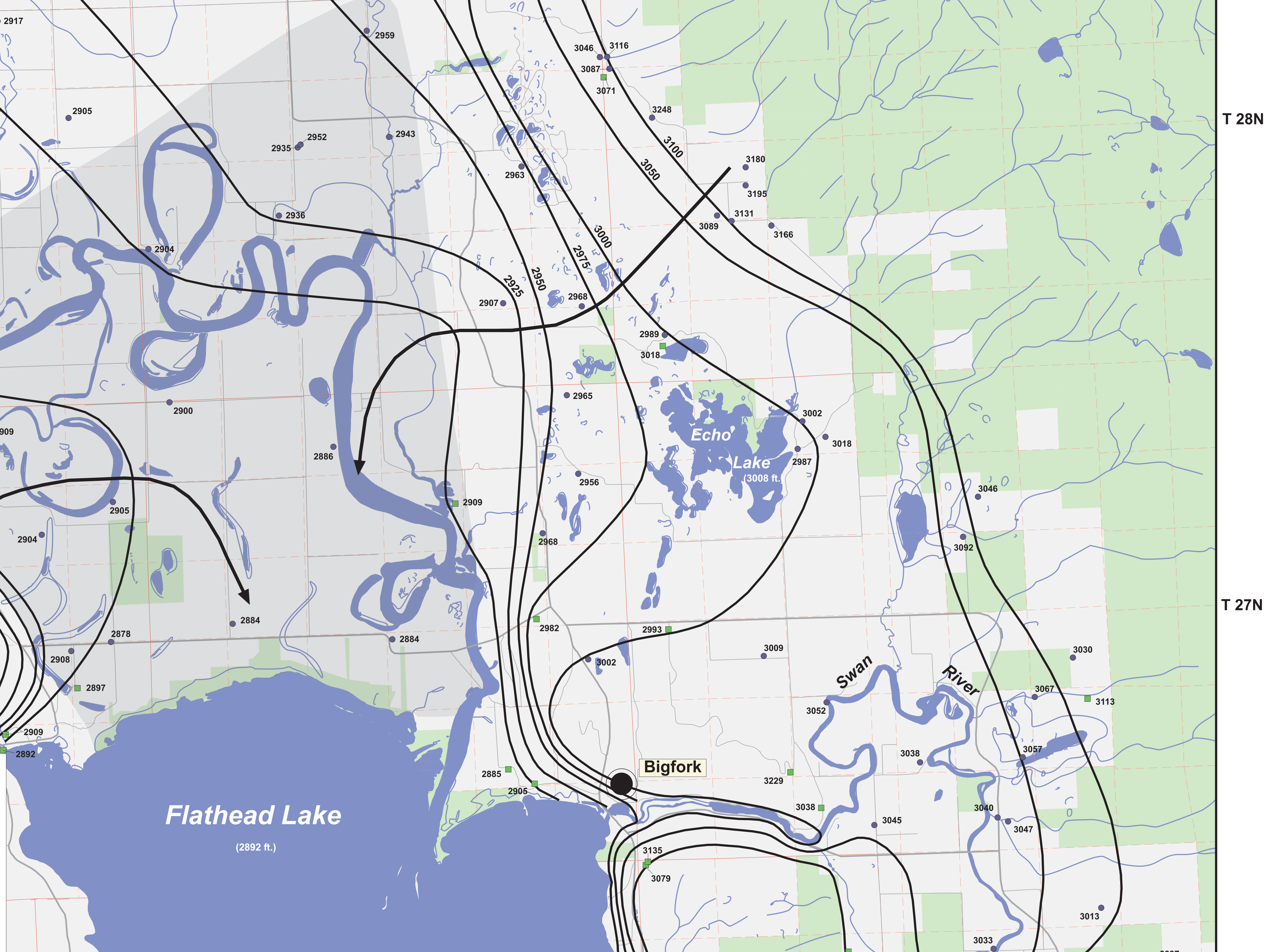
on 10- and 20-ft contour intervals). The potentiometric surface has a contour interval of 25 feet in the valley and 50 feet near the valley margins. The potentiometric contours are expected to be accurate to within one-half of the contour interval (12.5 feet in the valley, 25 feet near the valley margins).

ACKNOWLEDGMENTS

Well owners who allowed collection of the data necessary for the map, and the people who collected the data are all gratefully acknowledged. Reviews of this report by Tom Patton, Wayne VanVoast, and Bob Bergantino improved its clarity.

DATA SOURCES

Geographic Features



T 28N
T 27N
Flathead Lake
(2892 ft.)
Echo
Lake
(3008 ft.)
Swan
River
Bigfork
3100
3050
3000
2975
2950
2925
2917
2959
3046
3116
3087
3071
3248
2905
2952
2935
2943
2963
3180
3195
3131
3089
3166
2936
2904
2907
2968
2989
3018
2965
3002
3018
2987
2900
2886
2909
2956
3046
2905
2904
2968
3092
2884
2878
2884
2982
2993
3009
3030
2908
3002
2897
3052
3067
3113
2909
2892
3038
3057
2885
2905
3229
3038
3040
3045
3047
3135
3079
3013
3033

the hydrogeology of the area the reader is referred to the other maps in the series and the "Ground-Water Atlas of the Flathead Lake Area: Montana Bureau of Mines and Geology, Ground-Water Assessment Report No. 2."

INTRODUCTION

The Kalispell valley (upper Flathead River valley) occupies part of a structurally controlled intermontane basin that is bounded by the Salish Mountains to the west, the Whitefish Range to the north, and the Swan Range to the east; Flathead Lake marks the southern boundary. The valley is characterized by a relatively flat floor whose surface elevation ranges from about 2,900 feet above sea level at Flathead Lake, to 3,000 feet above sea level near Whitefish and Columbia Falls. The Swan Range rises abruptly from the east side of the valley floor with peaks reaching more than 7,000 feet above sea level; mountain peaks in the Whitefish Range are generally between 5,500 and 6,500 feet above sea level; whereas the peaks in the more subdued Salish Mountains west of the valley are generally less than 5,000 feet above sea level. The south-flowing Flathead River and its tributaries are the principal streams within the valley.

The mountains surrounding the valley are formed mostly by metamorphosed sedimentary rocks of the Proterozoic Belt Supergroup (bedrock) and include metacarbonates, argillites and quartzites (Johns, 1970). Normal faults on the east and west sides of the valley have down-dropped the valley floor relative to the surrounding mountains, and the valley has been filled with about 4,000 feet of Tertiary and Quaternary sediment (Smith, 2000a). Quaternary deposits cover most of the valley floor, for a more detailed discussion of the surficial geology the reader is referred to Smith (2000b).

During the Pleistocene Epoch (the last ice age), the upper 600 to 1,000 feet of the valley-fill material was deposited. It is composed of layers of alluvium (silt, sand and gravel) most likely deposited by glacial meltwater streams, and later covered by glacial till (poorly sorted clayey gravel) deposited directly by glaciers, and by glaciolacustrine deposits (clay and silt deposited in glacial lakes). Konizeski and others (1968) first studied the principal aquifer in the valley, calling it the "deep artesian aquifer," and mapped part of its potentiometric surface at a scale of 1:70,000. Briar and others (1996) presented a much smaller scale (1:750,000) potentiometric surface map of the aquifer, and a summary description of the aquifer is presented in Kendy and Tresh (1996). For this map the aquifer is called the "deep aquifer" and is defined as sand and gravel deposits (deep alluvium) generally found at depths greater than 100 feet below the land surface and in the bedrock along the fringe of the valley.

Aquifers are saturated geologic materials that yield sufficient water to supply wells and springs. Non-aquifer materials (also known as confining beds) also may be saturated but have low permeability and do not produce usable amounts of water to wells or springs. The permeable layers of sand and gravel that form

be absent. Typically, water levels in wells will rise above the top of the aquifer due to artesian pressure, and in low areas--such as immediately north of Flathead Lake (shaded area)--flowing wells may occur. Other areas, such as north of Columbia Falls and near Lost Creek, do not exhibit artesian conditions.

The Belt Supergroup bedrock around the fringe of the valley contains sufficient fracture permeability (the primary openings through which water moves are fractures or "cracks" in the rock) to yield water to wells and is included as part of the deep aquifer because it appears, based on the potentiometric surface, to be in hydraulic communication with the deep sand and gravel deposits. It should be noted that ground water in the Belt bedrock occupies and moves through fractures and voids within the rock rather than through intergranular spaces as in the sand and gravel deposits. Because of the irregular distribution of fractures within the bedrock, ground-water occurrence can be unpredictable, and well yields can vary widely between locations.

The deep aquifer is the most dependable potable-water aquifer in the Kalispell valley. Ground water from the aquifer is used for municipal, domestic, irrigation and stock-water purposes; it is the most utilized water source in the valley. Records from the Montana Bureau of Mines and Geology's Ground-Water Information Center (GWIC) data base show that about 8,200 wells are completed in the Kalispell valley; approximately 5,500 of them are completed in the deep aquifer (roughly 67 percent). Water from the aquifer is a calcium-magnesium-bicarbonate (Ca-Mg-HCO3) type with total dissolved solids generally less than 500 milligrams per liter (mg/L).

Reported yields for wells completed in the sand and gravel (alluvium) range up to 3,500 gallons per minute (gpm) and average 25 gpm. Yields for wells completed in the bedrock are slightly lower, ranging up to 600 gpm, with an average of 18 gpm. Reported well depths are as much as 2,000 feet, however, the average depth for wells in the deep aquifer is 200 feet. Wells completed in the bedrock are, on average, slightly deeper (average= 260 feet) than wells completed in the sand and gravel deposits (average = 180 feet). The distribution of well depths within the sand and gravel deposits is variable. Depths, however, are generally greater in the southern part of the valley. The average well depth in the shaded area on the map is 370 feet.

GROUND-WATER FLOW

The potentiometric surface represents the altitudes to which water will rise in wells penetrating the aquifer. Ground water moves down the slope of the potentiometric surface, from higher altitude to lower altitude, perpendicular to the contours. This map shows the potentiometric surface of the deep aquifer based on water-level measurements from the spring and summer of 1996.

The mountains that surround the Kalispell valley serve as the major recharge area to the deep aquifer. Most of the precipitation in the mountains falls during the winter months, hence recharge

along the valley margins. Most of the high-yield wells (reported yields greater than 300 gpm) are found northwest of Kalispell in the southeast part of T. 29 N., R. 22 W. (between the 2,900 and 2,925-foot contours) and between Lake Blaine and the Flathead River in the southwest part of T. 29 N., R. 20 W., where the gradient is relatively flat.

On this map, ground-water flow in the deep aquifer appears to be horizontal, but there also are important vertical components. Vertical ground-water flow is indicated by differing water-level altitudes in closely spaced wells that are completed at different depths. Vertical flow may be upward or downward, depending on position in the flow system and the geologic framework. Recharge areas, discharge areas, and places where low-permeability layers separate more permeable units are settings where vertical flow can occur. Typically, in recharge areas shallow wells have higher water levels; this indicates a downward gradient and downward flow. An example can be seen near the base of the Swan Range (a recharge area) in T. 28 N., R. 19 W. Sec. 7 where three closely spaced wells are completed in the alluvium at different depths. The highest water-level altitude is in the shallowest well (3,116 feet, well depth = 132 feet) and the lowest water-level altitude is in the deepest well (3,046 feet, well depth = 280 feet), indicating a downward component of ground-water flow. Upward flow occurs in the discharge area, which coincides with the shaded area on the map. In this area water-level altitudes increase with depth, indicating an upward component of ground-water flow.

MAP USE

This potentiometric surface map is useful for estimating the general direction of ground-water flow, identifying areas where flowing artesian wells might occur, and estimating the water-level altitude in a non-flowing well. Ground water flows from high altitude to low altitude; the general direction of ground-water flow is indicated by the flow arrows on the map. If the approximate land-surface altitude at a location is known (for example, determined from a topographic map), the corresponding point on the potentiometric surface map can be found and the altitude of the potentiometric surface estimated. Subtracting the potentiometric surface altitude from the land surface altitude yields the approximate level at which water will stand in, or rise above, a well.

MAP CONSTRUCTION

This map was constructed by hand-contouring 281 water-level altitudes measured in wells between February 1996 and September1996 (most were measured between March and July). Map accuracy is affected by data distribution, field measurement errors, accuracy of well locations, and errors in interpretation. Points at which water levels have been measured are distributed unevenly across the map, and map accuracy is greater near points of measurement. Well locations are accurate to the 2.5-acre level (to within about 300 feet). Land-surface altitudes at well locations were interpreted from U.S. Geological Survey (USGS) 1:24,000 topographic maps and are generally accurate to 5 to 10 ft based

Population centers 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 the U.S. Forest Service.

Point Data

Well location and water-level altitude data were obtained by Ground-Water Characterization Program and Department of Natural Resources and Conservation personnel, altitudes of the points were determined from USGS 1:24,000 topographic 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, Montana. Lake-level altitudes were obtained from USGS1:24,000 topographic maps.

REFERENCES

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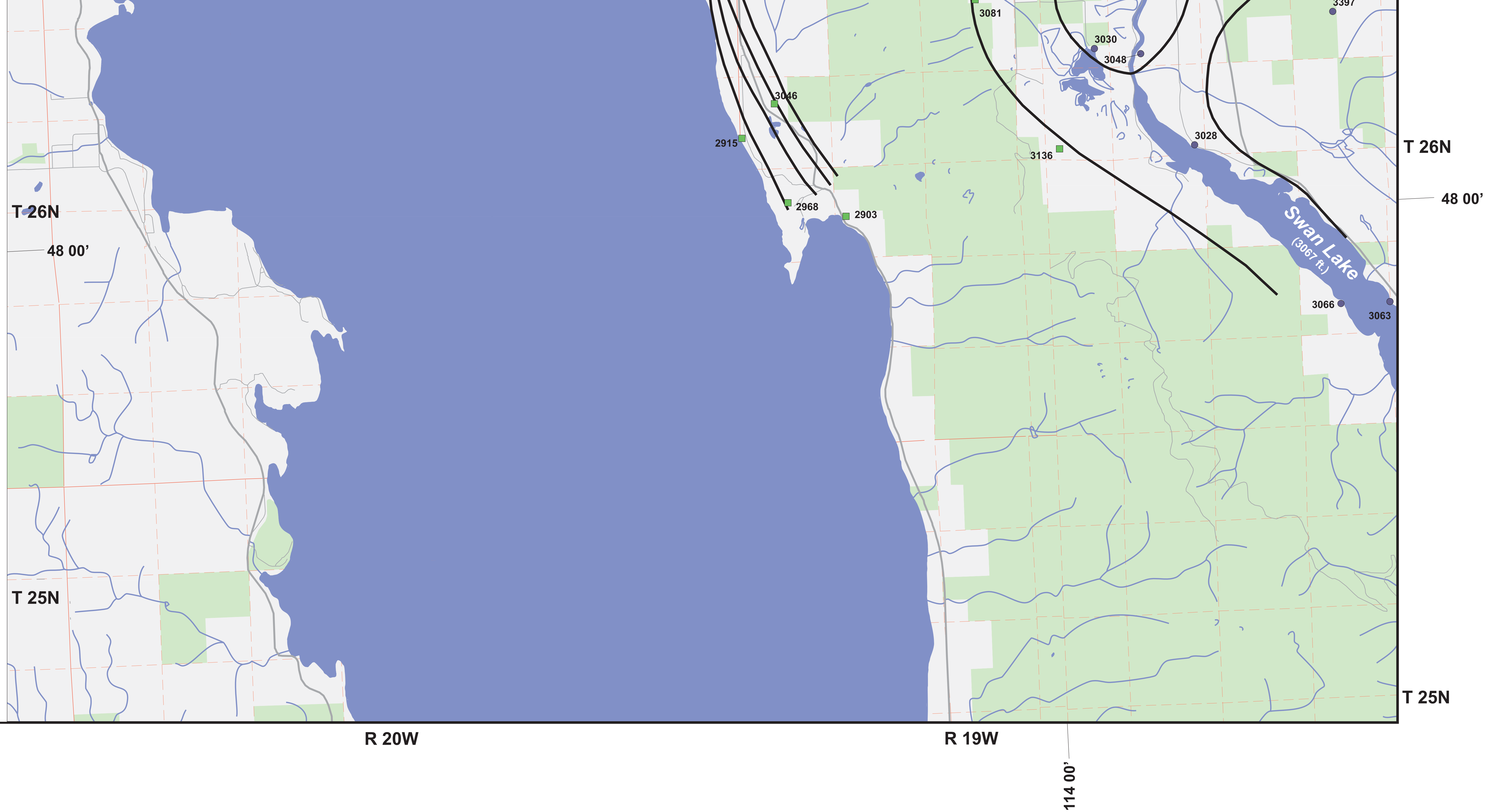

3397
3081
3030
3048
3046
2915
3136
3028
T 26N
48 00'
2968
2903
Swan Lake
(3067 ft.)
3066
3063
T 26N
48 00'
T 25N
T 25N
R 20W
R 19W
114 00'