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

Montana Ground-Water Assessment Atlas No. 2, Part B, Map 3
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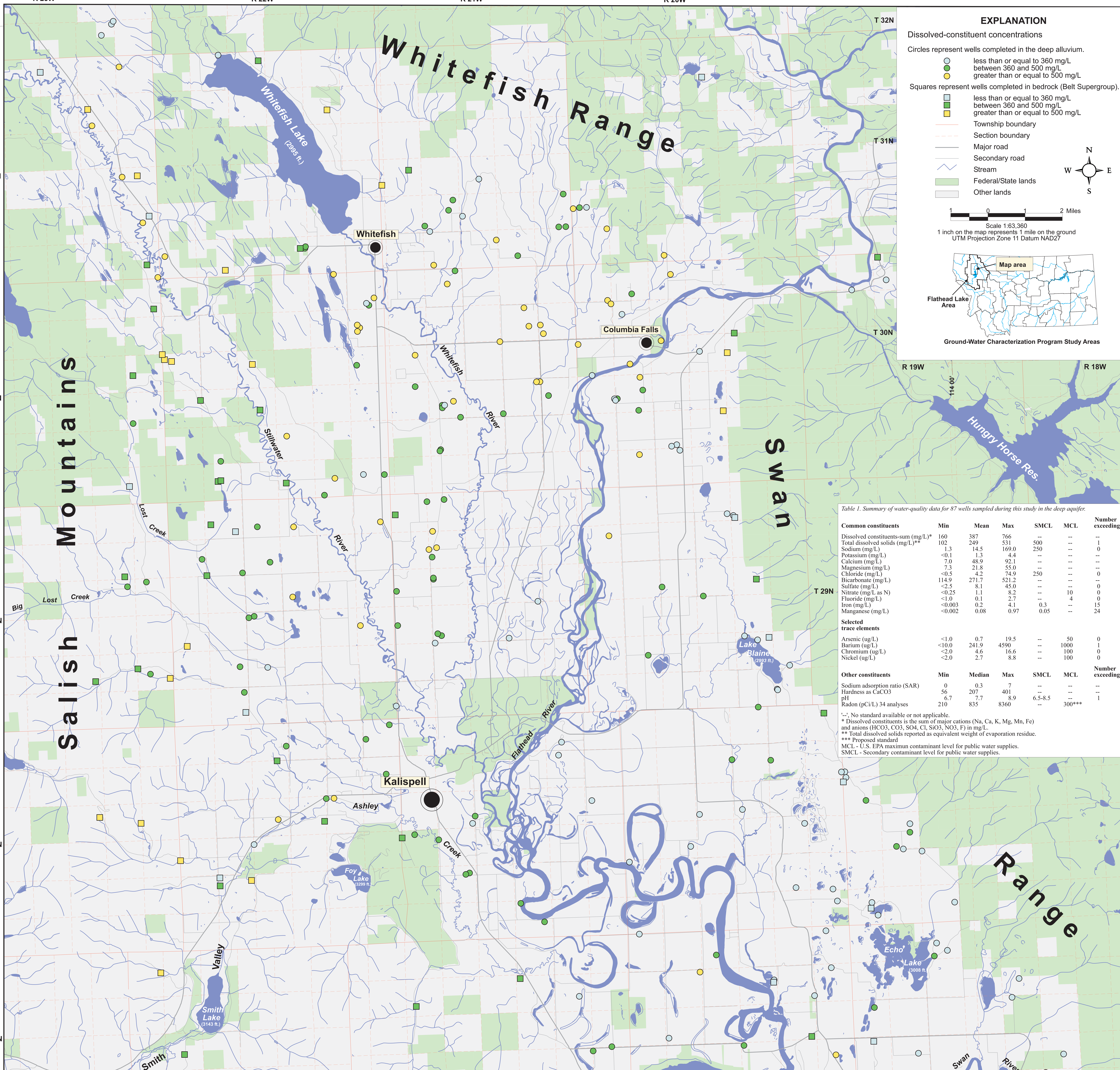
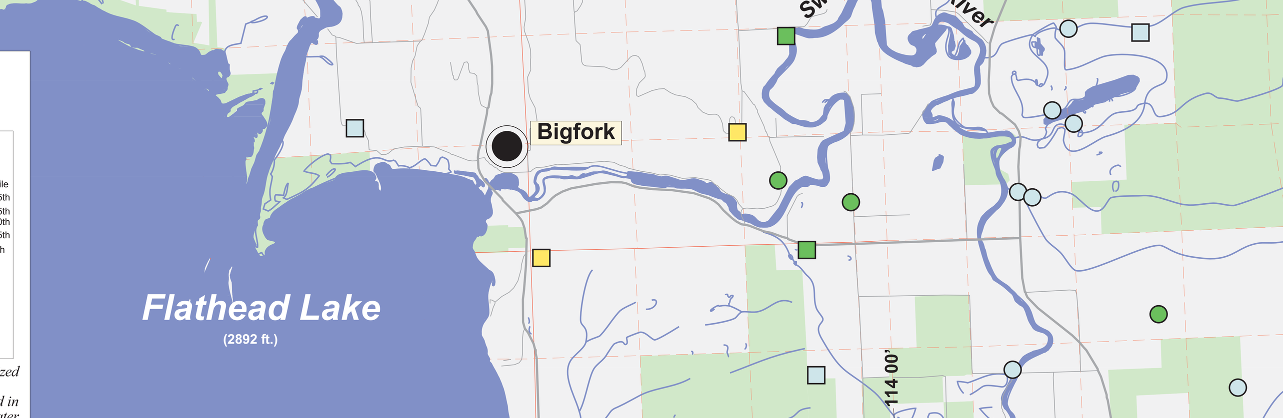


Table 1. Summary of water-quality data for 87 wells sampled during this study in the deep aquifer.

Common constituents	Min	Mean	Max	SMCL	MCL	Number exceeding
Dissolved constituents-sum (mg/L)*	160	387	766	--	--	--
Total dissolved solids (mg/L)**	102	249	531	500	--	1
Sodium (mg/L)	1.3	14.5	169.0	250	--	0
Potassium (mg/L)	<0.1	1.3	4.4	--	--	--
Calcium (mg/L)	7.0	48.9	92.1	--	--	--
Magnesium (mg/L)	7.3	21.8	55.0	--	--	--
Chloride (mg/L)	<0.5	4.2	74.9	250	--	0
Bicarbonate (mg/L)	114.9	271.7	521.2	--	--	--
Sulfate (mg/L)	<2.5	8.1	45.0	--	--	0
Nitrate (mg/L as N)	<0.25	1.1	8.2	--	10	0
Fluoride (mg/L)	<1.0	0.1	2.7	--	4	0
Iron (mg/L)	<0.003	0.2	4.1	0.3	--	15
Manganese (mg/L)	<0.002	0.08	0.97	0.05	--	24
Selected trace elements						
Arsenic (ug/L)	<1.0	0.7	19.5	--	50	0
Barium (ug/L)	<10.0	241.9	4590	--	1000	1
Chromium (ug/L)	<2.0	4.6	16.6	--	100	0
Nickel (ug/L)	<2.0	2.7	8.8	--	100	0
Other constituents	**Min**	**Median**	**Max**	**SMCL**	**MCL**	**Number exceeding**
Sodium adsorption ratio (SAR)	0	0.3	7	--	--	--
Hardness as CaCO3	56	207	401	--	--	--
pH	6.7	7.7	8.9	6.5-8.5	--	1
Radon (pCi/L) 34 analyses	210	835	8360	--	300***	

'--', No standard available or not applicable.
* Dissolved constituents is the sum of major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO3, CO3, SO4, Cl, SiO3, NO3, F) in mg/L.
** Total dissolved solids reported as equivalent weight of evaporation residue.
*** Proposed standard
MCL - U.S. EPA maximun contaminant level for public water supplies.
SMCL - Secondary contaminant level for public water supplies.



Dissolved-Constituents 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 Assessment Atlas for the Flathead Lake 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 Flathead Lake Area the reader is referred to Part A (descriptive overview) and other Part B maps of the Montana Ground-Water Assessment Atlas No. 2.

INTRODUCTION

The Kalispell valley (upper Flathead River valley) occupies part of an 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 covers roughly 325 square miles and is home to about 55,000 people. 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 as much as 4,800 feet of Tertiary and Quaternary sediment (Smith, 2000a). 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).

Although some surface water and shallow ground water are used within the Kalispell valley, ground water obtained from the deep aquifer is the most utilized source of water for municipal, domestic and agricultural needs. For this map, the deep aquifer is defined as sand and gravel deposits generally found at depths greater than 100 feet below the land surface, and fractured bedrock along the fringe of the valley (LaFave, 2000). The purpose of this map is to show the areal distribution of dissolved constituents in the ground water of the deep aquifer and to identify the major solutes.

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. Konizeski and others (1968) first studied the deep aquifer in the Kalispell valley, calling it the "deep artesian aquifer". Summary descriptions of the aquifer are also presented in Briar and others (1996), and Kendy and Tresh (1996); Ground-water levels and water-quality data from an east-west transect across the northern part of the deep aquifer are presented in Uthman and others (2000). The permeable layers of sand and gravel that form most of the deep aquifer are widespread beneath the valley, and are 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 be absent. The bedrock (Belt Supergroup) around the fringe of the valley contains sufficient fracture permeability 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. Ground-water flow in the deep aquifer is generally away from the mountains towards the center of the valley and then southward towards Flathead Lake (LaFave, 2000).

SAMPLE SITES AND WATER QUALITY DATA

Ground-water samples from 87 domestic, stock, municipal, and monitor wells were analyzed for major-ion, and trace-metal concentrations between April 1994 and September 1996. Field measurements of water specific conductance, pH, and temperature also were obtained at the sampled wells. To ensure acquisition 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. The laboratory data were supplemented by dissolved-constituents concentrations estimated from field measurements of specific conductance at an additional 188 wells.

DISSOLVED CONSTITUENTS

Water quality may be characterized by the type and concentrations 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, SiO3, NO3, F) expressed in milligrams per liter (mg/L).

Dissolved constituents in ground water are a result of the initial chemistry of the recharge water and subsequent interactions of that water with soils and aquifer materials. Their total concentration provides a general indicator of water quality, the lower the total the better the water quality. Typically, water does not become too salty to drink until the concentration of dissolved constituents reaches about 2,000 mg/L. All of the ground water tested from the deep aquifer was well below this threshold; the water is of good quality for drinking and other uses. Based on the set of 275 ground-water measurements used in this study, dissolved-constituent concentrations averaged 416 mg/L. Ground water from wells completed in the bedrock (average = 435 mg/L) was slightly higher in dissolved constituents than wells completed in the alluvium (average = 410 mg/L); the difference however (less than 10 percent) is not significant (figure 1).

To highlight areal patterns of dissolved constituents within the aquifer the concentrations are presented in three categories. Values less than 360 mg/L are plotted in blue symbols; those between 360 and 500 mg/L are in green; and those greater than 500 mg/L are in orange. Higher concentrations of dissolved constituents are generally found in the north and northwest part of the valley; most of the orange symbols (highest dissolved solids) plot northwest of a line between Bad Rock Canyon (30N 20W sec. 12) and the terminus of Lost Creek (29N 22W sec. 5). The lowest dissolved constituent concentrations are generally found in the southern part of the valley southeast of a line between Lake Blaine (29N 20W sec. 26) and Kalispell (28N 21W sec. 18). Intermediate concentrations occur in the middle of the valley between the areas of high and low concentrations.

Two factors most likely account for the dissolved-constituent distribution, 1) The aquifer in the north part of the valley, especially between Whitefish and Columbia Falls, is characterized by alluvium with interbeds of till and glaciolacustrine silt and clay (Smith, 2000b). Thus, more dissolved constituents may be leached from the finer grained sediments in this part of the aquifer than in other parts where the aquifer is composed primarily of alluvium, and 2) a great deal of recharge enters the ground-water flow system from the east side of the valley. The Swan Range receives more than 60 inches of precipitation per year, and south of Lake Blaine highly permeable outwash deposits are common along the base of the range (Smith, 2000c). These conditions are favorable for ground-water recharge. The "fresh" water (blue symbols) from the Swan Range appears to extend out into the center of the valley.

GROUND-WATER QUALITY

The overall water chemistry in the deep aquifer is uniform. The major ions consist predominantly of calcium, magnesium and bicarbonate; sodium, sulfate, and chloride contents are low (figure 2). There is no discernable difference in chemical composition between ground water from wells completed in the alluvium (ALVM) and from wells completed in the bedrock (BELT) which surrounds the valley. Nor were there any discernable evolution trends down the ground-water flow path. A sodium-bicarbonate signature is apparent for 4 of the analyses, however the wells where the samples were obtained do not appear to be related hydrologically (they are not close together or along a similar flow path) or by geology (3 of the wells are completed in alluvium, 1 in bedrock).

MAJOR IONS AND SUITABILITY FOR WATER USE

Table 1 summarizes the results of the 87 ground-water analyses performed for this study. For reference, the U. S. Environmental Protection Agency's recommended maximum contaminant levels (MCL) and secondary maximum contaminant levels (SMCL) 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.

Ground water in the deep aquifer is suitable for domestic and stock consumption as well as for irrigation. In the 87 samples, only barium, in one sample, was detected above its health standard; no other constituents exceeded established MCL's. The secondary level for total dissolved solids (TDS), reported as equivalent weight of evaporation residue, was exceeded in one sample and nuisance levels of iron and manganese were common.

Iron and manganese are essential to plants and animals, but may cause unpleasant taste, odor 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. The secondary level of 0.3 mg/L for iron was exceeded in 15 samples, and 24 samples had manganese concentrations above the secondary level of 0.05 mg/L.

The sodium adsorption ratio (SAR) describes the suitability of water for irrigation. SAR values below 10 are desirable for irrigation waters. The results from the 87 samples analyzed as part of this study suggest that water from the deep aquifer is well suited for irrigation. Only one SAR value was greater than 10, and most were less than 1.0 indicating that the potential for sodium or salinity hazards is low.

NITRATE

Nitrate (NO3) is an essential nutrient for plant life, yet is potentially toxic to humans (especially infants) when present in drinking water at excessive concentrations. High levels of nitrate in well water typically indicate seepage from septic tanks, fertilizers, land application of animal wastes or other nonpoint sources. None of the sampled wells had nitrate concentrations above the health standard of 10 milligrams per liter-nitrogen (mg/L-N); in general nitrate was not detected in the deep aquifer at concentrations greater than 1.5 mg/L-N (see inset map). The wells where nitrate was detected at concentrations (greater than 3.0 mg/L-N) that would suggest possible surface sources are clustered northwest of Kalispell. The wells are completed beneath the Lost Creek Fan, a relatively thick accumulation of outwash deposited by glacial melt water (Smith, 2000). These data suggest that the protective layer(s) of till and glaciolacustrine deposits may be absent beneath the Lost Creek Fan and that the deep aquifer may be vulnerable to surface contamination in this area.

RADON

Radon is a colorless, odorless gas produced from the radioactive decay of uranium that occurs naturally in rocks and soil, and has been linked to lung cancer in humans (EPA, 1999). Radon in indoor air poses the greatest health risk. Most of the radon in indoor air seeps inside from the soil and rock beneath a dwelling. Water that contains radon can also be a minor source of radon in indoor air. The EPA estimates that radon released from drinking water accounts for less than 2 percent of radon in indoor air. Currently there is no drinking water standard for radon, however the EPA is proposing a MCL of 300 picoCuries per liter (pCi/L) for community water systems, and an alternative MCL of 4,000 pCi/L for states or community systems that have an EPA-approved Multimedia Mitigation Program (EPA, 1999). The proposed MCL's for radon will not apply to private wells.

Radon was sampled in 16 wells for this study. In addition, the results from 18 other wells sampled between 1992 and 1995 are presented on the inset map. Of the 34 samples, only 3 had concentrations less than the proposed MCL of 300 pCi/L; most were greater than 500 pCi/L. On a state-wide basis, 73 percent of wells that were tested for radon had concentrations greater than 300 pCi/L (Miller and Coffey, 1998). The radon concentrations in the Kalispell valley show a strong correlation to aquifer materials. Those in water from wells completed in the Belt bedrock (average = 1,298 pCi/L) were about twice as high as those in water from wells completed in the alluvium (average = 655 pCi/L).

For more information about radon and possible home treatment options the reader is referred to Miller and Coffey (1998), EPA (1999), and the U.S. Environmental Protection Agency web site (internet: www.epa.gov, search on "radon").

MAP CONSTRUCTION

This map was constructed by plotting "low," "intermediate" and "high" concentrations of dissolved constituents of 87 ground-water samples. The laboratory data were supplemented by estimates of dissolved-constituent concentrations derived from specific-conductance measurements made at an additional 188 wells. The specific-conductance (SC) measurements were used to estimate dissolved constituents (DC) according to the equation: DC = A x SC (Hem, 1992). Based on a straight-line regression of data from the Kalispell valley, a value of A = 0.92 was used in the above equation.

ACKNOWLEDGMENTS

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

SOURCES OF DATA

Geographic Features:

Population centers 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 U.S. Forest Service.

Point Data:

Well-location and water-quality data were obtained by Ground-Water Characterization Program and Department of Natural Resources and Conservation personnel. Well locations are accurate to the 2.5-acre level (to +/- 300 feet). All water-quality data used on this map are available from the Ground- Water Information Center (internet: http://mbmggwic.mtech.edu) at the Montana Bureau of Mines and Geology, Montana Tech of The University of Montana, Butte, Montana.

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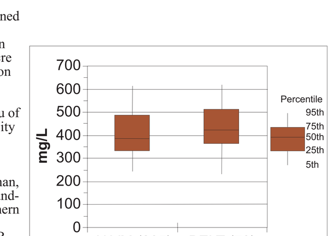


Figure 1. Water from the deep aquifer is characterized by low dissolved constituent concentrations (generally less than 500 mg/L). Wells completed in the bedrock produce slightly more mineralized water but the difference is not significant.

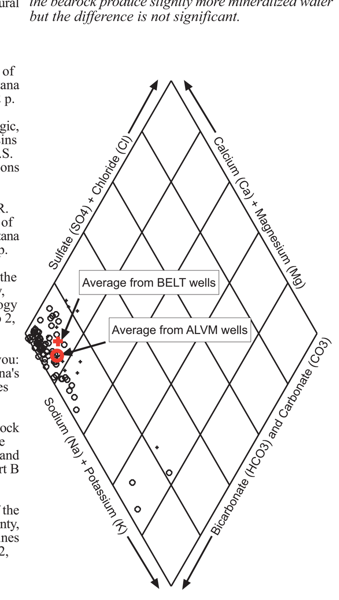
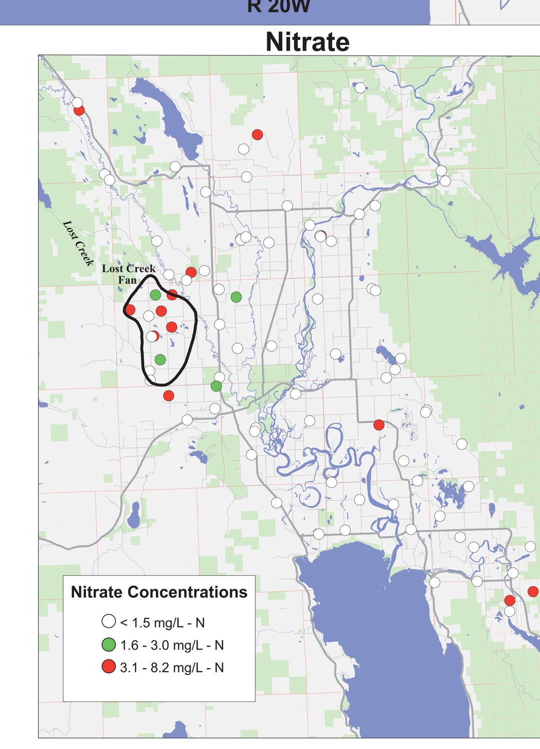


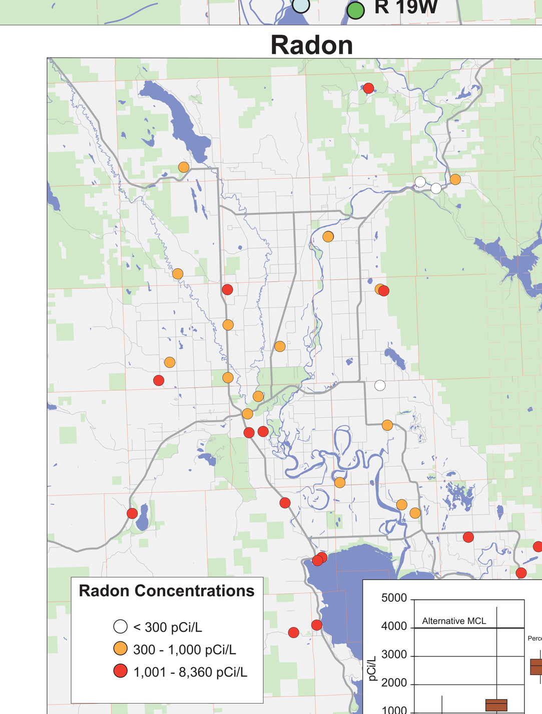
Figure 2. Ground water from the deep aquifer is predominately a calcium-magnesium-bicarbonate type: there is no discernible difference between ground water from wells completed in the alluvium and wells completed in the bedrock.

Nitrate



Elevated nitrate concentrations are clustered in the vicinity of the Lost Creek Fan.

Radon



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Water from wells completed in the Belt bedrock has higher radon concentrations than water from the deep alluvium.