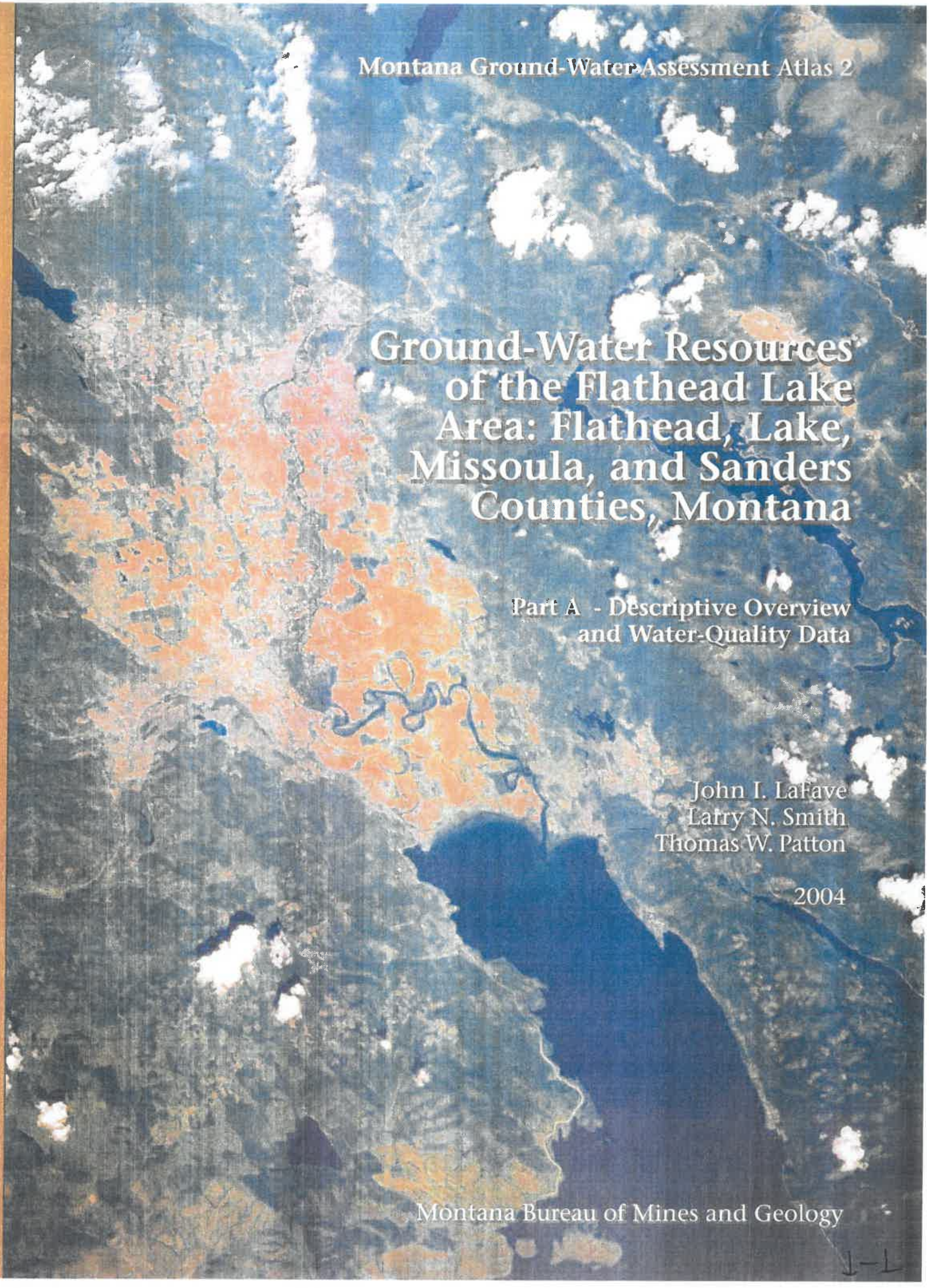

Montana Ground-Water Assessment Atlas 2

# Ground-Water Resources of the Flathead Lake Area: Flathead, Lake, Missoula, and Sanders Counties, Montana

## Part A - Descriptive Overview and Water-Quality Data

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ments from the valleys. Downcutting through the Polson moraine by the Flathead River occurred shortly after deglaciation. Consequently, modern streams have locally removed some glacial-lake deposits north of Flathead Lake, exposing glacial till along the Flathead and Stillwater Rivers. As downcutting streams widened they deposited alluvium along their channels and floodplains. Most stream valleys in the area are lined with alluvial materials that range from 10 ft to several tens of feet in thickness. The shallow alluvium between the Whitefish and Flathead Rivers in the Kalispell subarea is generally more than 50 ft thick, and is an example of deposition that has occurred since deglaciation (Part B, map 11). Stream levels south of the Polson moraine also dropped rapidly during deglaciation. The Flathead River in the Mission valley cut a canyon almost 500 ft in depth soon after the glaciers retreated (Levish, 1997). South of Polson significant recent bodies of alluvium have been deposited along Mud and Post Creeks (Part B, map 11).

## Hydrogeologic Setting

Ground water is a plentiful and vital resource throughout the Flathead Lake area. Although a general hydrogeologic setting applicable to all subareas is discussed here, detailed descriptions of hydrogeologic conditions (water-level fluctuations, water-quality summaries, and aquifer-development statistics) are included in individual subarea sections throughout the atlas. In this atlas "basin fill" refers to unconsolidated Quaternary deposits and to Tertiary sedimentary deposits within the intermontane valleys; "bedrock" refers to Belt Supergroup rocks.

The occurrence and movement of ground water is controlled by the geologic framework and topography. Multiple aquifers occur in the basin-fill materials and in the surrounding bedrock of each subarea. The Quaternary portions of basin-fill materials contain the most widely used and prolific aquifers in the Flathead Lake area. Figure 19 uses the geologic framework introduced in fig. 8 to show how geologic units relate to the important aquifers. The five main hydrogeologic units in most subareas are: (1) shallow alluvium exposed at or occurring just below the land surface (shallow aquifers); (2) clayey and silty till and glacial-lake sediments (non-aquifers or confining units); (3) alluvium within or below the confining units (intermediate or deep alluvial aquifers); (4) Tertiary sedimentary deposits; and (5) fractured bedrock. The generalized vertical and horizontal relationships among the hydrogeologic units are shown in fig. 20. This suggested hydrogeologic framework fits all but the Flathead Lake perimeter subarea, where the primary aquifer is fractured bedrock; in that subarea aquifers developed in other materials occur only locally.

### Shallow Aquifers

Shallow aquifers occur in unconsolidated alluvial deposits (shallow alluvium) along stream valleys, in areas of surficial outwash, or in water-saturated bedrock near land surface (figs. 8, 21). Beach and deltaic sediment of the ancestral Flathead Lake and stabilized wind-blown sand may also support shallow aquifers. Shallow alluvial deposits consist primarily of permeable sand and gravel with lesser amounts of silt and clay, and are generally at or near land surface. The areal distribution of shallow alluvium is shown in Part B, map 11. The median thickness of shallow alluvium as described from well logs is 40 ft, but individual values range to more than 200 ft (see Part B, map 11).

Shallow aquifers are present in all the subareas. Ground water in these aquifers occurs under unconfined conditions and the water table is typically within 50 ft of the land surface. Shallow aquifers are important sources of water locally, but are generally limited in areal extent to floodplains associated with rivers and streams, and to glacial outwash (see Part B, maps 6, 11). In topographically low areas where bedrock is at the surface, typical of small valleys along the foothills, ground water may occur in the bedrock within 50 ft of the land surface and be under unconfined conditions; in these locations the fractured bedrock also is considered a shallow aquifer.

Ground water in the shallow aquifers is characterized by localized flow where water moves from local drainage divides (topographic highs) toward nearby valley bottoms. Water enters (recharges) the aquifers by direct infiltration of precipitation, leakage from irrigation ditches, and stream losses—especially along mountain fronts. It is common for high-gradient, entrenched mountain streams to lose water at the point where they enter the valleys because of decreased gradients and the change in geologic materials as they traverse from bedrock (relatively impermeable) onto basin fill (relatively permeable). The Swan and Mission Range fronts are examples where this occurs.

Ground water leaves (discharges) the shallow aquifers through springs and seeps along valley bottoms, gaining reaches of perennial streams, transpiration by plants, and pumpage from wells. In places along the east side of the Kalispell valley, the Lost Creek fan area, and the Mud Creek drainage east of Pablo, shallow alluvium is interlayered with underlying deep alluvium, providing a hydrologic connection between shallow and deep alluvial aquifers.



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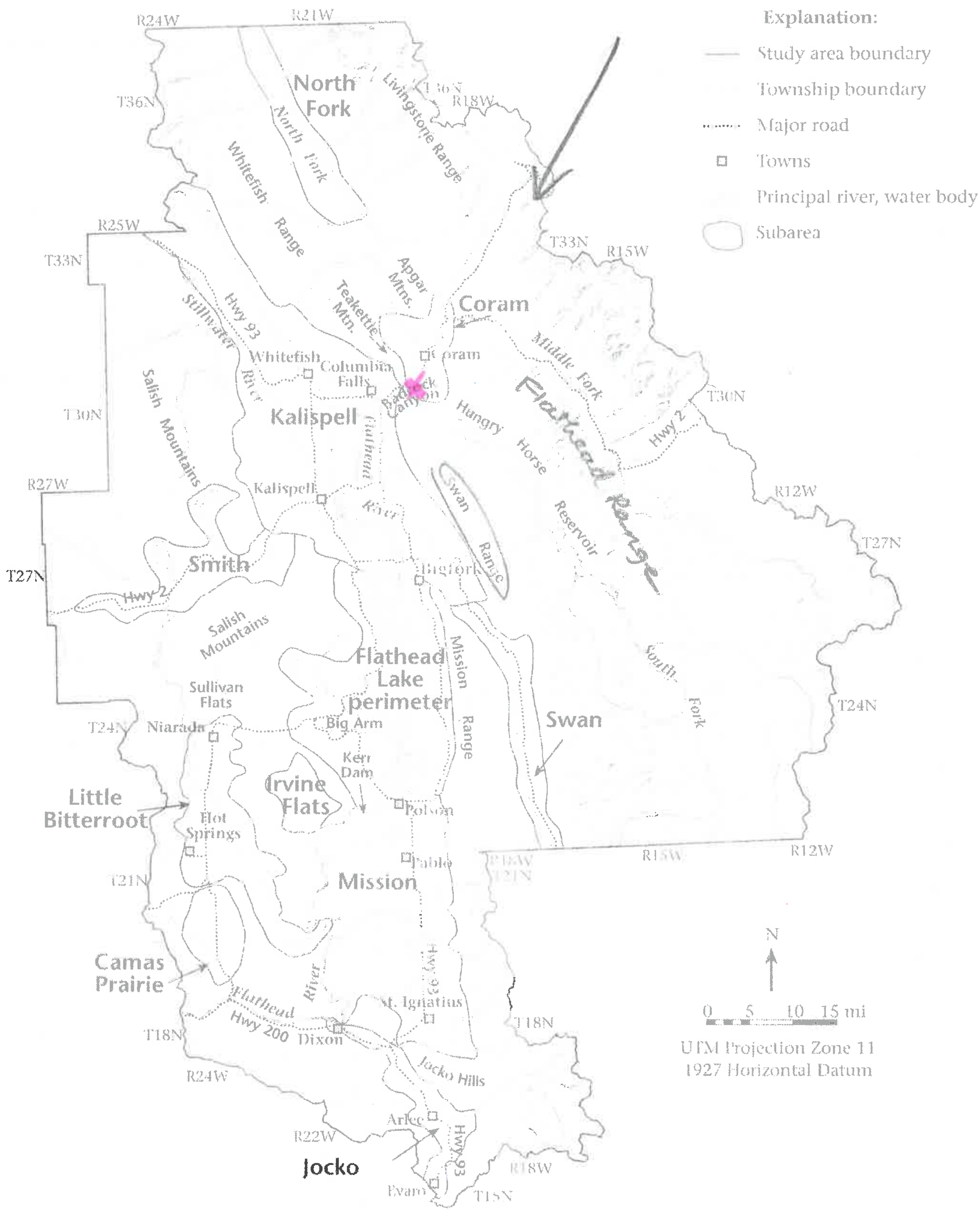


Figure 2. The Flathead Lake area ground-water characterization study covers all of Flathead and Lake Counties, and the parts of Missoula and Sanders Counties within the Flathead Indian Reservation. The 11 hydrogeologic subareas described in the atlas are shown, as are geographic names used in the text.

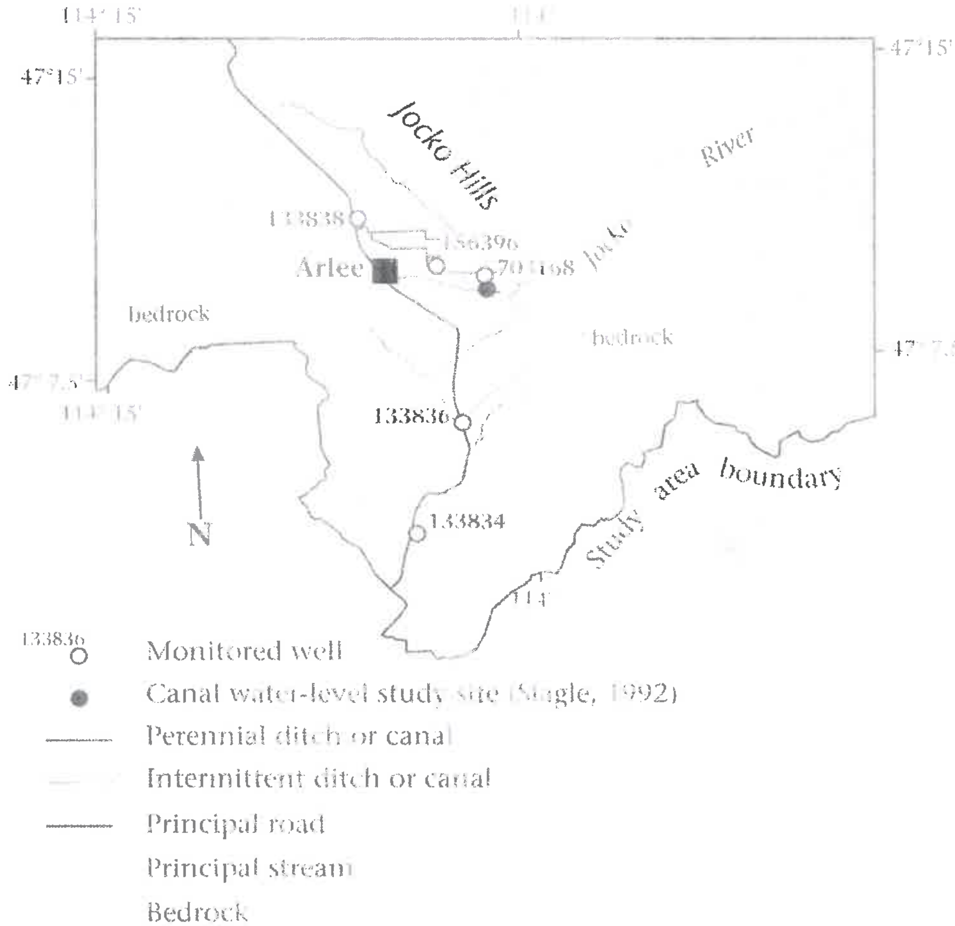


Figure 63. Four of the five wells monitored in the Jocko subarea are within the network of irrigation canals.

Water levels in the shallow aquifers rise from lows in late winter or early spring to peaks in mid-summer, and then fall slowly during the fall and winter months (fig. 62). The magnitude of the annual fluctuation varies from less than 5 ft (wells 133836 and 133838) to as much as 20 ft (well 156396). The slow decline in water levels during the late summer and fall and the proximity of the monitored wells to irrigation canals (fig. 63) suggests that canal leakage is an important source of recharge. None of the available records show long-term water-level increases or decreases.

Annual water-level fluctuations in a deep aquifer (well 703168, fig. 62) occur at the same time as those observed in shallow aquifers, but are as much as 40 ft. This well is completed in alluvial fan deposits <0.25 mi north of the Jocko River near where it enters the valley. Correspondence between water-level changes and flow in the river indicates that leakage from the stream may influence water levels in this well.

Water levels in an intermediate aquifer upgradient from the irrigation canal network (well 133834, fig. 62) peak in the spring and early summer and then drop sharply in the fall; the magnitude of the annual fluctuations is less than 5 ft (fig. 62).

## Water Quality

Based on the results of 28 complete ground-water analyses (10 from shallow aquifers, 10 from intermediate and deep alluvial aquifers, 7 from bedrock aquifers, and 1 from a Tertiary aquifer), ground water in the Jocko subarea is of good quality and meets U.S. EPA standards for natural constituents in drinking water supplies (appendix C). The predominant ions are calcium, bicarbonate, and magnesium; dissolved-constituents concentrations in water from all the aquifers are generally less than 500 mg/L (fig. 64). Water from bedrock aquifers appears to be the least mineralized, with a median dissolved-constituents concentration of about 150 mg/L. Shallow aquifers are slightly more mineralized, with a median dissolved-constituents concentration of 230 mg/L. The concentrations of major ions are consistent between the different aquifers but are most variable in water from bedrock. None of the samples exceeded the secondary standards for sodium, chloride, or sulfate or the primary health standard for nitrate.

## * Coram

The Coram subarea includes the Flathead River valley east of Bad Rock Canyon and south of the Apgar Mountains and Glacier National Park (fig. 2). This subarea encompasses intersecting down-faulted valleys of the South and North Forks of the Flathead River and an erosional valley where the Middle Fork of the Flathead River cuts through bedrock. The valleys of the South and North Forks locally contain Tertiary sedimentary rocks and conglomerates of the Kishenehn Formation.

## Aquifers

Sand and gravel (shallow aquifers) are at the surface along floodplains and terraces near the Flathead



1-4

River and its various tributaries. Glacial outwash also underlies broad terraces about 100 ft above the Flathead River valley. About 30 percent of logs for wells drilled in the Coram subarea encounter shallow alluvium at land surface. The sand and gravel deposits have a median thickness of about 30 ft.

Till was deposited by glaciers that flowed down the valleys of the South, Middle, and North Forks of the Flathead River. The glaciers met east of Teakettle Mountain (fig. 2) and flowed west–southwest around and over the mountain into the Kalispell valley. Most of the Coram subarea is covered by till; 60 percent of the area well logs report it. The till, with a median thickness of 30 ft, overlies Tertiary sedimentary rocks or bedrock in most parts of the valleys, but locally overlies deep alluvium.

Alluvium (deep aquifers) occurs locally below the till in a few exposures along the Flathead River, and is also reported on well logs from west of Hungry Horse to Martin City, and locally north of Coram. The deep alluvium appears to rest on Tertiary rocks. It may have been deposited as outwash in front of a glacier advancing down the valley, along a distinct channel cut in Tertiary sedimentary rocks.

In the Coram subarea, the deep alluvium is the primary source of ground water and hosts about half of the reported 571 wells (fig. 65). The remainder of the wells are completed in shallow alluvium (25 percent), intermediate aquifers within till (11 percent), bedrock aquifers (9 percent), and Tertiary rock (4 percent).

The deep alluvial aquifer is the most productive, with reported well yields of as much as 1,200 gpm and a median yield of 25 gpm. Shallow aquifers have a median well yield of 20 gpm. Intermediate aquifers are generally associated with till, and their highest reported yields are only about 50 gpm with a median reported yield of 12 gpm. Wells in bedrock reportedly produce as much as 75 gpm and have a median of 12 gpm. Yields from wells completed in Tertiary rocks are the lowest reported in the Coram subarea but are still sufficient for domestic purposes; most yields are less than 15 gpm and the median is 10 gpm. Figure 66a summarizes the reported yields from wells.

The deep alluvial and intermediate aquifers in the Coram subarea are generally encountered within 200 ft of the land surface (fig. 65). The median static water level is 35 ft below the land surface for intermediate aquifer wells and 45 ft for deep alluvial wells. Shallow aquifers are generally within 50 ft of the land surface (median well depth in shallow aquifers is 37 ft); the median

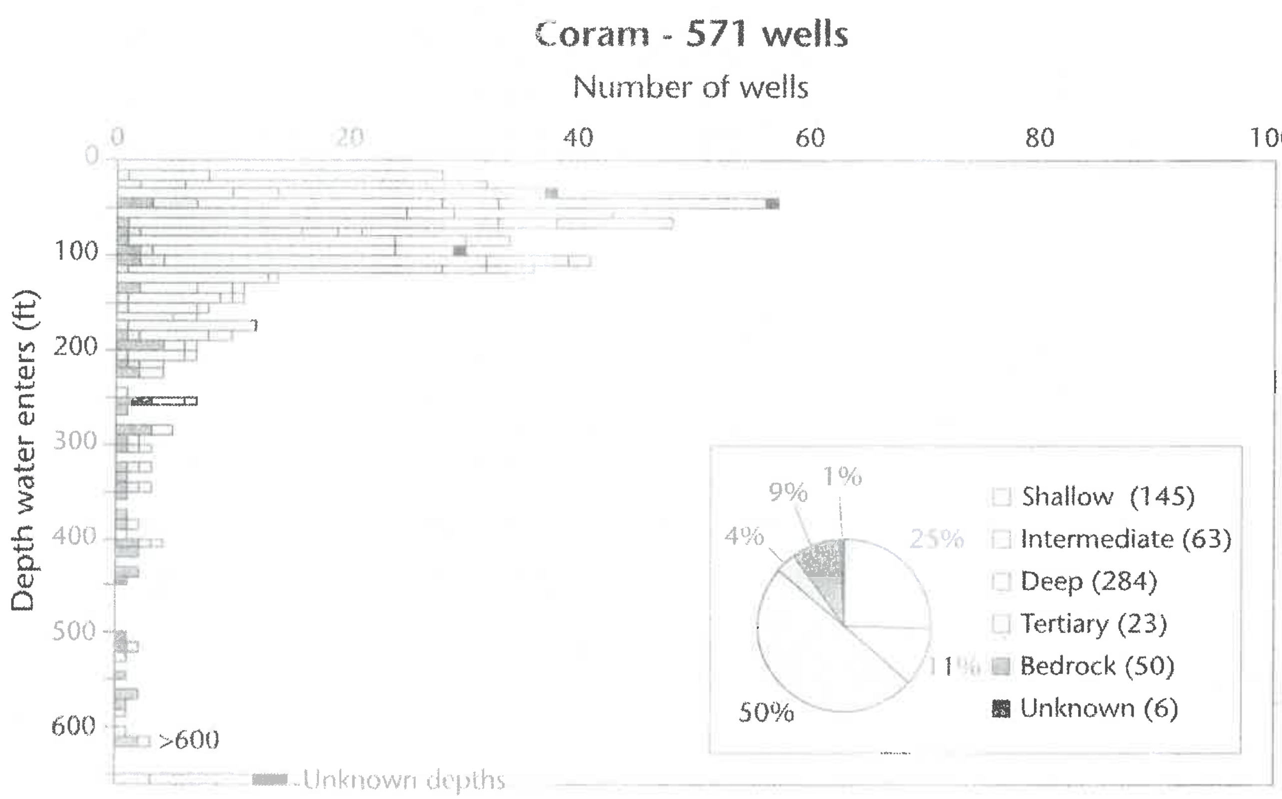


Figure 65. Most of the wells in the Coram subarea are less than 150 ft deep. Depths of those completed in bedrock show the most variability, ranging from less than 50 to more than 500 ft. The inset pie chart shows that 75 percent of wells in the subarea are completed in shallow aquifers or deep alluvial aquifers.

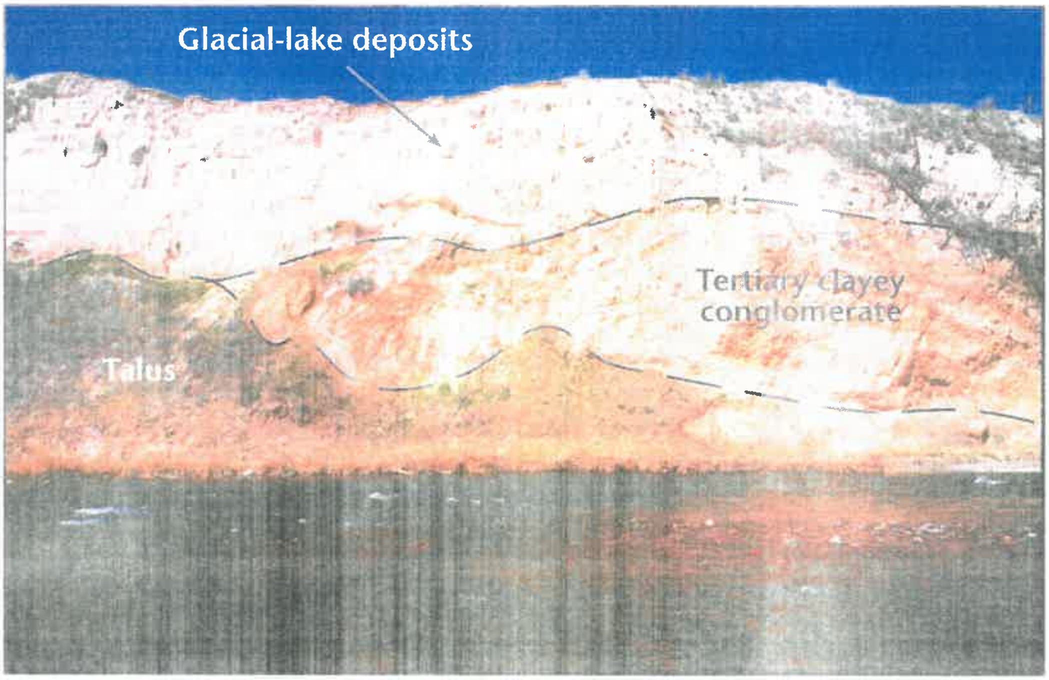


Figure 13. Tertiary sedimentary rocks in the Valley Creek area of the Jocko subarea include conglomerate, siltstone, and volcanic ash. Volcanic ash from a nearby exposure (near the confluence of Valley Creek and the Jocko River, T. 17 N., R. 20 W., sec. 8) yielded a radiometric age of 37 m.y. before present and is similar to the age of rocks in the Hog Heaven volcanic field in northwestern Lake County (P.C. Ryan, written commun., 1998).


Figure 14. Sand and gravel exposed beneath till along the Flathead River north of Hungry Horse likely were deposited by streams in front of the advancing glacier and are the deep alluvium of the Coram subarea. These deposits are analogous to the deep alluvium in the Kalispell subarea and the deep alluvium in the Mission and the Little Bitterroot subareas. At this location, the deposits are saturated below the white dashed line; a quarter dollar for scale is shown by the white and black arrow (location T. 30 N., R. 19 W., sec. 5).

1-6

This would be the N boundary of HH abutting the river, main stem at the foot of Teakettle Mtn

Same composition as my yard.

that is under pressure. To be classified as artesian, the pressure must be adequate to cause the water level in a well to rise above the top of the aquifer (fig. G-2). Flowing wells, or flowing artesian conditions, occur in areas where the potentiometric surface is higher than the land surface (fig. G-3).

**Bedrock** A general term for consolidated geologic material (rock) that underlies soil or other unconsolidated material.

**Carbon-14** A naturally occurring radioactive isotope of carbon, denoted as $^{14}C$, with a half-life of 5,730 yr. Carbon-14, with six protons and eight neutrons, is heavy compared with the most common isotope of carbon ($^{12}C$). See *Environmental Isotopes*.

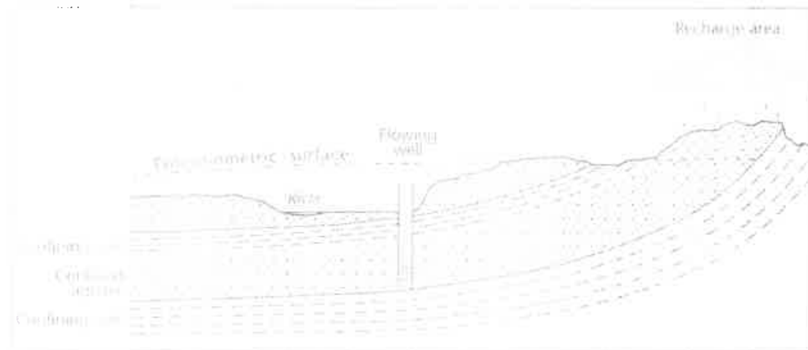

Figure G-3. Artesian conditions develop in confined aquifers when the aquifer, overlain by a low-permeability unit, dips or tilts away from its recharge area. Water percolates down to the water table in the recharge area and moves beneath the confining unit. The artesian pressure is caused by the difference in the level of the water table in the recharge area and at the top of the aquifer. Flowing wells, or flowing artesian conditions, occur in areas where the potentiometric surface is higher than the land surface.

**Cation** See *Ion.*

**Cone of Depression** See *Well Hydraulics.*

**Confined Aquifer** See *Aquifer.*

**Cumulative Departure** Cumulative departure from average precipitation is calculated by determining the cumulative difference between the measured precipitation for a month and the average precipitation for that month for the entire period of record. Increasing (positive) cumulative departure indicates periods of greater than average monthly precipitation.

**Deuterium** A stable isotope of hydrogen, with one neutron and one proton, denoted as D or $^2H$. Deuterium has approximately twice the mass of the most common isotope of hydrogen, protium ($^1H$). See *Environmental Isotopes.*

**Discharge Area** An area where ground water is released from an aquifer, generally characterized by water moving toward the land surface. Springs or *gaining streams* (fig. G-4) may occur in ground-water discharge areas.

**Environmental Isotopes** Globally distributed isotopes that occur in nature are called environmental isotopes. See related sidebar.

* **Flow System** The aquifers and confining beds that control the flow of ground water from a recharge area to a discharge area constitute a ground-water flow system (fig. G-3). Ground water flows through aquifers from recharge areas, which commonly coincide with areas of high topography, to discharge areas in the topographically low areas. The relative length and duration of the ground-water flow paths are used to classify ground-water systems. A regional system generally consists of deep ground-water circulation between the highest

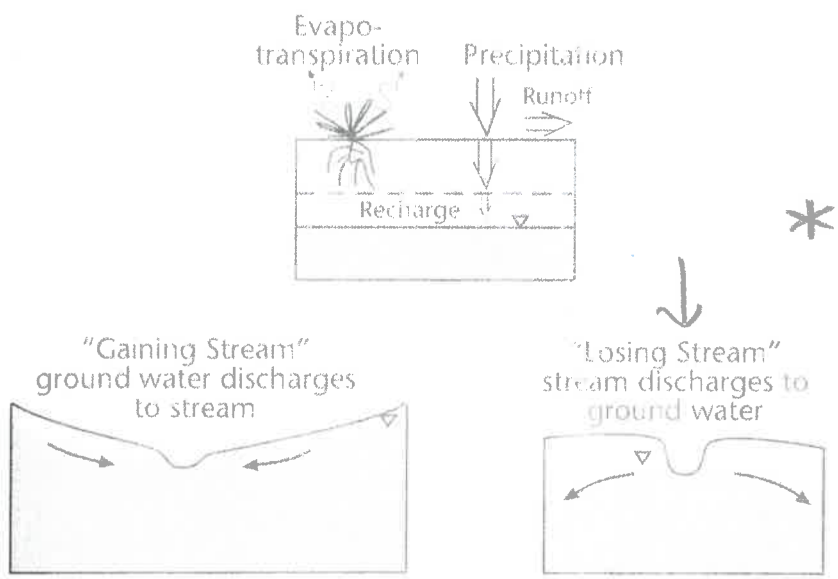

Figure G-4. Water that percolates through the unsaturated zone to the water table is said to recharge an aquifer. Recharge can also occur from surface water bodies (losing streams) where the water levels are higher than those in neighboring aquifers. In contrast, in a gaining stream water levels in the aquifer are above those in the stream and flow is maintained by ground-water discharge.

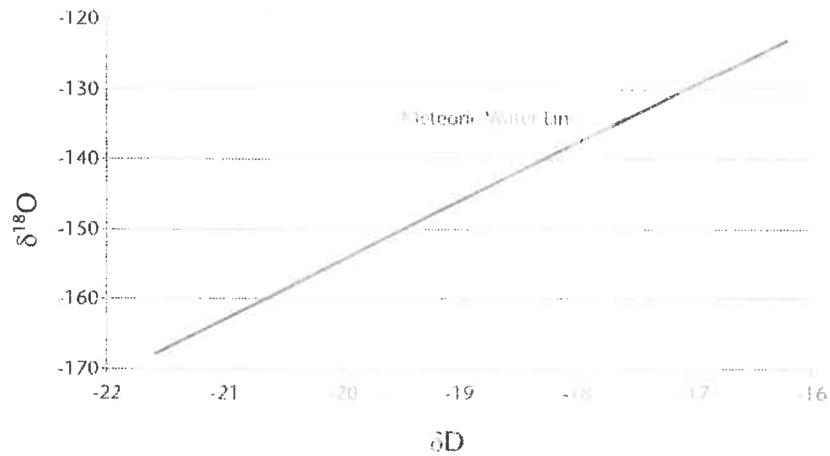


Figure G-5. Values of δ18O and δD in precipitation from around the world plot linearly along a line known as the global meteoric water line (Craig, 1961). Ground water that originates as precipitation should also plot along the global meteoric water line.

surface drainage divides and the largest river valleys. Local and intermediate flow systems consist of shallow ground-water flow between adjacent recharge and discharge areas superimposed on or within a regional flow system.

**Ground Water** Strictly speaking, all water below land surface is "ground water." The water table defines the boundary between the unsaturated (air in pores) and saturated (water in pores) zones (fig. G-1). It is the water from saturated zones that supplies water to wells (and springs) that is called ground water in this atlas.

**GWIC** Ground Water Information Center—repository for water-well logs and ground-water information at the Montana Bureau of Mines and Geology, http://mbmggwic.mtech.edu; 1300 W. Park St., Butte, MT 59701; (406) 496-4336; E-mail: GWIC@mtech.edu.

**Hydraulic Conductivity** Measure of the rate at which water is transmitted through a unit cross-sectional area of an aquifer under a unit gradient; commonly called *permeability*. The higher the hydraulic conductivity (the more permeable the materials) of the aquifer, the higher the well yields will be. The hydraulic conductivity of geologic material ranges over 14 orders of magnitude (fig. G-6).

**Hydrologic Cycle** The constant circulation of water between the ocean, atmosphere, and land is called the hydrologic cycle. The notion of the hydrologic cycle provides a framework for understanding the occurrence and distribution of water on the earth. The important features of the hydrologic cycle are highlighted in fig. G-7. The hydrologic cycle is a natural system powered by the sun and is quantified by the hydrologic budget. Evaporation from the ocean and other surface bodies of water and shallow ground water, and transpiration from plants, bring "clean" water (because most dissolved constituents are left behind) into the atmosphere where clouds may form. The clouds return water to the land and ocean as precipitation (rain, snow, sleet, and hail). The precipitation may subsequently follow many

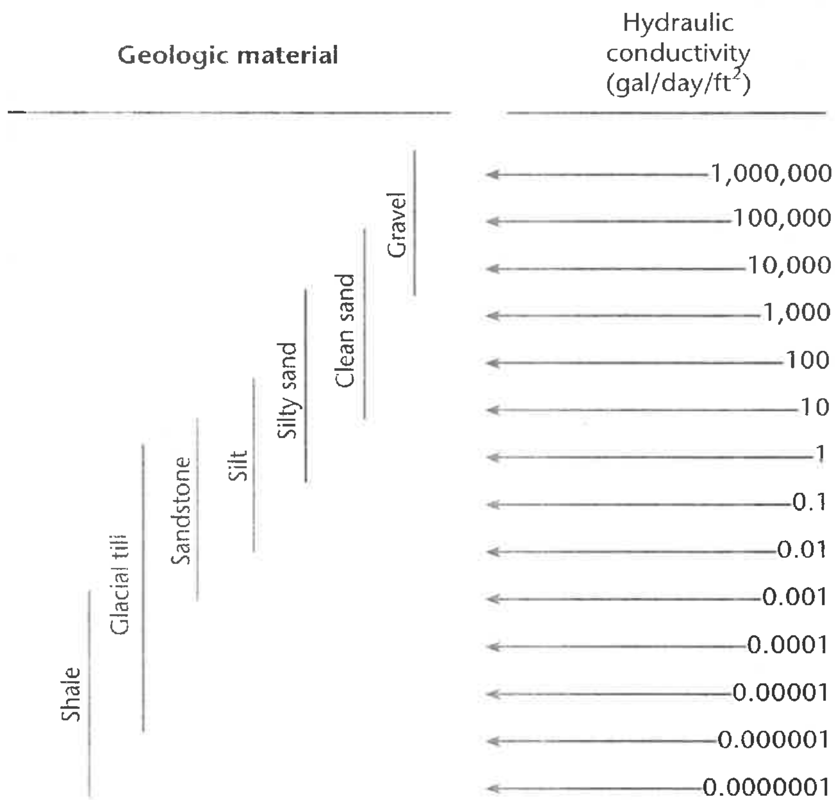


Figure G-6. The range of hydraulic conductivity values for typical geologic materials ranges over several orders of magnitude. Hydraulic conductivities not only differ in different rock types but may also be different from place to place in the same rock (modified from Freeze and Cherry, 1979).