ASSESSMENT OF SELECTED GROUND-WATER-QUALITY DATA IN MONTANA

By Robert E. Davis and Gary D. Rogers

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 84-4173

Helena, Montana
September 1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, SECRETARY

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CONVERSION FACTORS

The following factors can be used to convert inch-pound units in this report to the International System of units (SI).

Multiply inch-pound unit	By	To obtain SI unit
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09290	meter squared per day
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	25.40	millimeter
mile (mi)	1.609	kilometer

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ABSTRACT

This study was conducted to assess the existing, computer-accessible, ground-water-quality data for Montana. All known sources of ground-water-quality data were reviewed. Although the estimated number of analyses exceeds 25,000, more than three-fourths of the data were not suitable for this study. The only data used were obtained from the National Water Data Storage and Retrieval System (WATSTORE) of the U.S. Geological Survey, because the chemical analyses generally are complete, have an assigned geohydrologic unit or source of water, and are accessible by computer.

The data were assessed by geographic region of the State because of climatic and geologic differences. These regions consist of the eastern plains region and the western mountainous region. Within each region, the data were assessed according to geohydrologic unit. The number and areal distribution of data sites for some groupings of units are inadequate to be representative, particularly for groupings stratigraphically below the Upper Cretaceous Fox Hills Sandstone and Hell Creek Formation in the eastern region and for Quaternary alluvium, terrace deposits, glacial deposits, and associated units in the western region. More than one-half the data for the entire State are for the Tertiary Wasatch, Fort Union, and associated units in the eastern region. The results of statistical analyses of data in WATSTORE indicate that the median dissolved-solids concentration for the groupings of geohydrologic units ranges from about 400 to 5,000 milligrams per liter in the eastern region and from about 100 to 200 milligrams per liter in the western region.

Concentrations of most trace constituents do not exceed the primary drinking-water standards of the U.S. Environmental Protection Agency. The data in WATSTORE for organic constituents presently are inadequate to detect any organic effects of man's activities on ground-water quality.

INTRODUCTION

Disposal of hazardous wastes is a major environmental problem confronting the United States. The quantity of hazardous waste is increasing annually, so the magnitude of the problem probably will increase in the future. An initial approach to the assessment of present or potential effects of hazardous waste on the quality of the ground-water resources is to compile existing data and assess ambient conditions.

In Montana, most ground-water-quality problems related to hazardous wastes are generally associated with solid-waste-disposal landfills, municipal and industrial wastewater disposal, oil production, mining, septic tanks and drainfields, and accidental spills and leakage (Montana Department of Health and Environmental Sciences, 1982). Areas subject to these activities are susceptible to water-quality effects both laterally and vertically. The magnitude of the effects depends on many factors, including geologic and hydrologic conditions in the area.

Many ground-water-quality data exist in numerous reports of the geology and hydrology of Montana. Most studies were restricted to specific sites and encompassed a variety of geologic and hydrologic conditions. The coal hydrology program of the U.S. Geological Survey has produced reports mainly on the Paleocene Fort Union Formation in the eastern part of the State. The Northern Great Plains Regional Aquifer System Analysis project studied aquifers in the stratigraphic section from the Middle and Upper Jurassic Ellis Group through the Fort Union Formation. Several studies of the Mississippian Madison Group have been completed by Feltis (1980a, 1980b) and by Downey (1982). Although many of these studies have considered ground-water quality, none have evaluated all existing data on a statewide basis.

The purpose of this report is to assess existing water-quality data for aquifers in Montana. To achieve this objective, computer-accessible water-quality data were evaluated by aquifer or grouping of aquifers with respect to inorganic, trace, and organic constituents. General information on aquifer geometry and lithology, and direction of ground-water flow is included where available from previous studies.

METHOD OF STUDY

Selection of geohydrologic regions and units

A variety of climatic and geologic conditions exists in Montana. The climate ranges from semiarid in the eastern plains to generally humid in the western mountains. In the east, average annual precipitation ranges from about 6 to 24 in., with most areas receiving 12 to 16 in. (fig. 1). Average annual precipitation in the west ranges from about 12 to 60 in. In general, winters are milder and summers are cooler in the west than in the east.

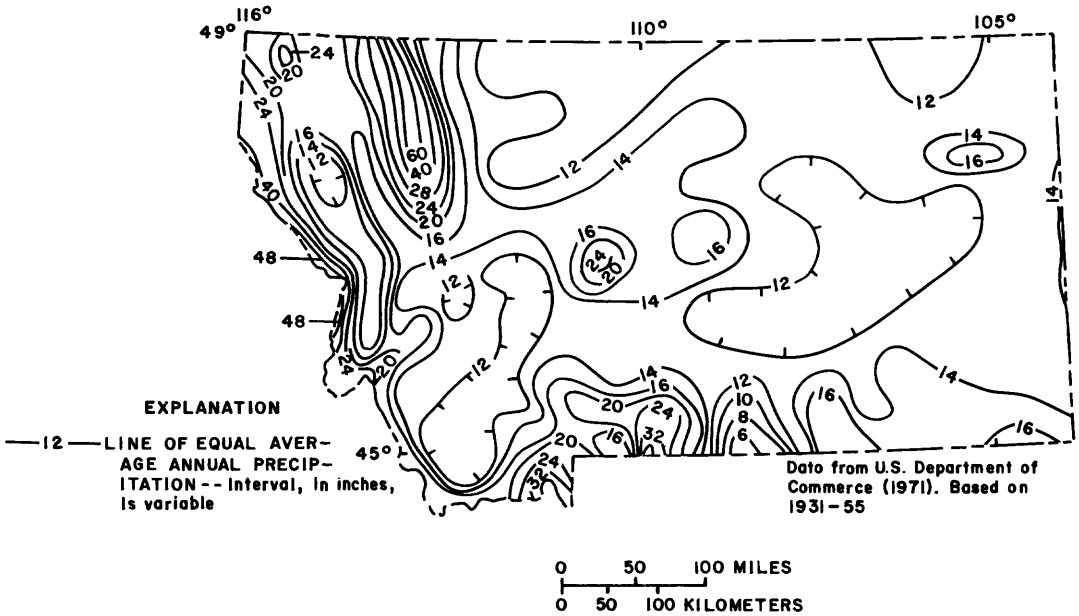

Figure 1.--Average annual precipitation.

About 75 different rock units, ranging from Precambrian metamorphic schist and gneiss to Holocene alluvium, are exposed in Montana. The eastern part of the State primarily consists of Cretaceous and Tertiary sedimentary rocks at the surface that dip regionally to the east. Locally, small mountain ranges interrupt the sequence, exposing rocks of Precambrian and Paleozoic age. Quaternary alluvium is present along major stream courses. In some areas of the northeastern part, a surficial cover of continental glacial deposits occurs.

The western mountainous part of the State primarily consists of Precambrian metasedimentary rocks and Cretaceous and Tertiary igneous rocks, with Tertiary basin-fill deposits and Quaternary alluvium in the valleys. Glacial deposits also are found in valleys in parts of the region.

Because of the basic climatic and geologic differences, the State was studied as two separate regions (fig. 2). The eastern region generally coincides with a combination of the Glaciated and Nonglaciated Central Geohydrologic Regions and the western region generally coincides with the Western Mountain Ranges Geohydrologic Region as described by Heath (1982, p. 399).

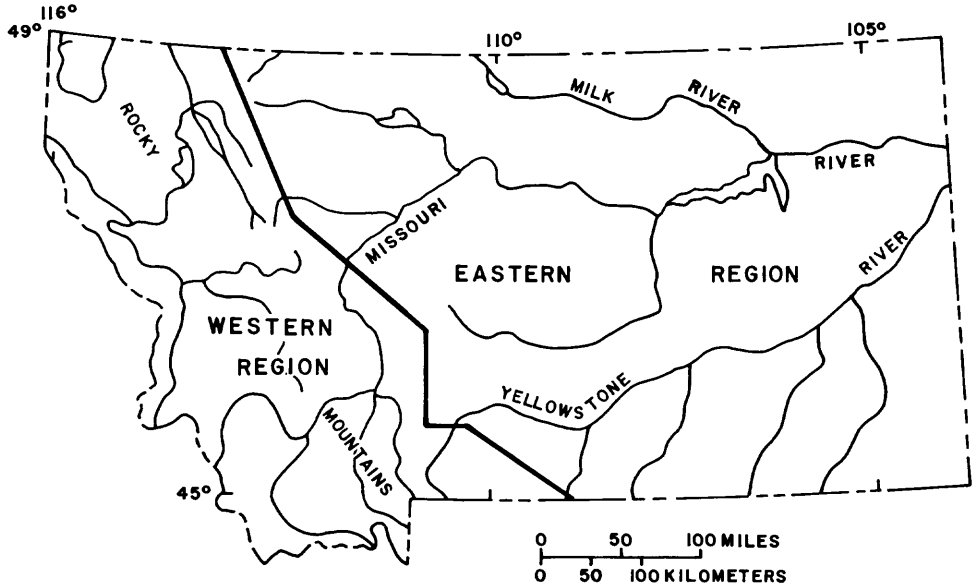

Figure 2.--Geohydrologic regions used for this study.

All major aquifers or geohydrologic units for which water-quality data exist were included in this study. The geohydrologic units were either grouped together or treated separately based on age, depositional environment, stratigraphic position, or lithology.

Availability of ground-water-quality data

All known sources of data on ground-water quality in Montana were reviewed (table 1). (Note that all tables are in the Supplemental Data section at the back of the report.) Although the estimated number of analyses exceeds 25,000, more than three-fourths of the data were not suitable for use in this study because the analyses: (1) Contained information for only a few chemical constituents, making calculation of ionic balance for the analysis impossible; (2) did not contain information on the water source or geohydrologic unit; or (3) were not computer accessible. The only computer-accessible data with assigned geohydrologic units are contained in the National Water Data Storage and Retrieval System (WATSTORE) computer file, which is operated and maintained by the U.S. Geological Survey. Therefore, only data contained in WATSTORE were used for most aspects of this study. Major contributors of data to WATSTORE include both the U.S. Geological Survey and the Montana Bureau of Mines and Geology.

Data analysis and statistical methods

Within each of the eastern and western regions, the data in WATSTORE were verified by rejecting any chemical analysis for which the ionic-balance error for common constituents was greater than 5 percent, thereby eliminating most incomplete analyses and large analytical errors for common constituents. The ionic-balance error was calculated as the difference between the sum of calcium, magnesium, sodium, and potassium concentrations and the sum of bicarbonate, carbonate, sulfate, and chloride concentrations, and the result divided by the total sum of common-constituent concentrations, with all concentrations expressed in milliequivalents per liter. For this study, common constituents are considered to be calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, and chloride. Missing bicarbonate data were calculated if the pH was 8.3 or less, using the value for alkalinity, if available. Similarly, missing dissolved-solids concentrations were calculated from the sum of constituents.

Much of the analysis of the data was accomplished using procedures in programs of the Statistical Analysis System[1] (SAS) (SAS Institute, Inc., 1982a, 1982b). Because most of the data are not normally distributed, nonparametric statistical methods generally were used.

The SAS procedure GLM, with the Duncan multiple-range-test option performed on the ranks of the data for common constituents, was used to test for significant differences between similar geohydrologic units. For each variable, geohydrologic units classified by the same arbitrary letter are not significantly different with respect to the variable at the 0.05 significance level. Thus, for each variable in the tables of data, all mean rank values assigned the same letter (such as A) could be considered to be similar. If two letters are assigned (such as A, B), the values could be considered to be similar to other units assigned A or B.

The SAS procedure UNIVARIATE was used to determine quartile values, the range, mean, and standard deviation for each common chemical constituent and other selected parameters within a geohydrologic unit or grouping of similar units. The mean and standard deviation are included as an aid to the reader who may not desire to use the nonparametric values.

The SAS procedure CORR, using the Spearman option, was used to compute rank correlation coefficients between constituents within a unit or grouping of similar

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[1]The use of trade names in this report is for identification only and does not constitute endorsement by the U.S. Geological Survey.

units. Only correlation coefficients with a level of significance less than or equal to 0.10 are included. The most significant correlations are those for which the absolute value of the coefficient is closest to 1. Positive correlations indicate the concentration of one constituent tends to increase as the concentration of the other constituent increases. Negative correlations indicate the concentration of one constituent tends to increase as the concentration of the other constituent decreases. To determine the most significant correlations in water from the various geohydrologic units, the reader needs to look for the largest coefficients in the tables of data. Then the corresponding variables can be determined from table headings.

Relatively few data were available for some of the geohydrologic units. Statistical evaluations based on a small number of data may or may not be representative of actual conditions. For evaluations in this report, the number of data values is included. Evaluation based on a small number of data values needs to be done with caution.

The form of the data stored in the computer file can affect the treatment of that data in the statistical evaluations. For water analyses with pH values less than 8.3, carbonate-ion concentrations can be stored as zero values or not entered. Missing values were not considered in the evaluation procedures but zero values were, although both values represent virtually the same chemical conditions. Therefore, the statistical evaluations for carbonate need to be considered with caution. Some concentrations of some trace constituents, particularly cadmium and lead, were determined and stored as being less than some detectable value, owing to the sensitivity of the analytical procedure. However, these data were considered to be equal to the detectable value in the evaluation procedures. If the detectable value is larger than the standard or limit to which the value is compared, an erroneous statistical evaluation may result. Therefore, the statistical evaluations for trace constituents also need to be considered with caution.

Diagrams of the composition of water are shown for each geohydrologic unit or grouping of geohydrologic units. The diagrams do not represent any single chemical analysis but represent the quartile values for the data, expressed in milliequivalents per liter, for each combination of the constituents presented. Therefore, the diagrams generally show which constituents tend to be predominant at each quartile value.

Concentrations of selected constituents are compared to the maximum allowable concentrations of the primary drinking-water regulations of the U.S. Environmental Protection Agency (1977). These regulations relate to the safety of drinking water and apply only to public water supplies, although they also are useful in evaluating the quality of other water supplies. Comparisons for cadmium and lead need to be considered with caution, owing to possible contamination of some samples. Comparisons with the secondary drinking-water regulations of the U.S. Environmental Protection Agency (1979) are not included because these regulations relate only to esthetic quality. Concentrations of three organic constituents (dissolved organic carbon, total organic carbon, and phenols) are evaluated because they can be an indicator of the effect of man's activities on water quality. Comparisons of specific organic constituents with the primary drinking-water standards are not included because the data generally are not included in WATSTORE.

GENERAL GEOCHEMICAL PROCESSES

The quality of water in a hydrologic system, if unaltered by man's activities, depends on the hydrological, geochemical, and biological processes that predominate in an area. Some of the general geochemical processes that effect the quality of much of the ground water in Montana are as follows: water containing carbon dioxide percolates below ground surface, dissolves carbonate minerals and possibly gypsum, and exchanges calcium and magnesium ions for sodium ions. The following reactions illustrate these processes more specifically. In a near-surface environment, carbon dioxide gas (CO_2) from the atmosphere and from organic decay reacts with water (H_2O):

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \tag{1}$$

The resulting carbonic acid (H_2CO_3) dissociates:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \tag{2}$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \tag{3}$$

The effect of reactions 1, 2, and 3 is to produce a slightly acidic environment conducive to the dissolution of carbonate minerals such as calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$):

$$CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-} \tag{4}$$

$$CaMg(CO_3)_2 \rightleftharpoons Ca^{2+} + Mg^{2+} + 2CO_3^{2-} \tag{5}$$

Reactions 4 and 5 result in an increase in the concentration of calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}), and an increase in the concentration of carbonate ions (CO_3^{2-}), which causes a decrease in hydrogen-ion (H^+) concentration and an increase in bicarbonate-ion (HCO_3^-) concentration. The adsorption of calcium and magnesium ions and the release of sodium ions (Na^+) by exchange reactions with clays also causes a decrease in H^+ concentration and an increase in HCO_3^- concentration. The net result of the above reactions is a moderately alkaline water containing mainly calcium, magnesium, sodium, and bicarbonate ions.

If present, chloride (Cl) minerals such as halite (NaCl) may be dissolved:

$$NaCl \rightleftharpoons Na^+ + Cl^- \tag{6}$$

Mixing at depth with connate water also may result in increases in Na^+ and Cl^- concentrations.

If sulfide minerals such as pyrite (FeS_2) are present in the oxidizing near-surface environment, sulfate minerals such as gypsum ($CaSO_4$) can be formed:

$$4FeS_2 + 15O_2 + 14H_2O \rightleftharpoons 4Fe(OH)_3 + 8SO_4^{2-} + 16H^+ \tag{7}$$

$$Ca^{2+} + SO_4^{2-} \rightleftharpoons CaSO_4 \tag{8}$$

The sulfate ions (SO_4^{2-}) in reaction 7 either are transported in solution to the aquifer or are precipitated as sulfate minerals such as gypsum near the surface as in reaction 8. The precipitated gypsum may be redissolved later and transported to the aquifer by deeply percolating recharge water. If present, gypsum deposited in ancient sedimentary environments also may be dissolved, thus contributing calcium and sulfate ions.

Under anaerobic conditions, sulfate may be reduced to sulfide by bacteria:

$$SO_4^{2-} + CH_4 \text{ (organic matter)} \xrightarrow[\text{bacteria}]{\text{sulfate-reducing}} HS^- + HCO_3^- + H_2O \qquad (9)$$

Sulfate reduction is common in coal-bearing areas of eastern Montana. Therefore, the quality of near-surface ground water in Montana is dependent on the prevailing conditions and is mainly controlled by the dissolution of carbonate, chloride, sulfide, or sulfate minerals.

ASSESSMENT OF GROUND-WATER-QUALITY DATA

Eastern Montana

Ground-water-quality data are available for several water-yielding geohydrologic units in eastern Montana. A generalized correlation of the stratigraphic sequence in Montana is given in table 2. In eastern Montana, the major geohydrologic units capable of producing significant quantities of water are, in general descending order, the Quaternary alluvium and terrace deposits; the Quaternary glacial deposits; the Eocene and Paleocene units mainly of the Wasatch and Fort Union Formations; the Cretaceous Hell Creek Formation and Fox Hills Sandstone (including the Fox Hills-lower Hell Creek aquifer), Judith River Formation and associated units, Eagle Sandstone and Telegraph Creek Formation, and Kootenai Formation and associated units; the Middle and Upper Jurassic Ellis Group; and Paleozoic units consisting mainly of the Mississippian Madison Group. Many of these major geohydrologic units contain smaller units.

Alluvium, terrace deposits, and associated units

Holocene alluvium, terrace deposits, and colluvium primarily consist of unconsolidated clay, silt, sand, and gravel. Generally, these deposits are located along existing streams and probably are less than several hundred feet thick. The Miocene or Pliocene Flaxville Formation consists of fluvial sand and gravel which caps many of the upland areas in northeastern Montana. Thickness of the Flaxville generally is less than 100 ft and averages about 30 ft (Howard, 1960).

Where they are in contact with one another, these four deposits probably are hydraulically connected; on the basis of the hydrology, they can be considered to be one aquifer. However, the Flaxville generally is higher topographically than the alluvium, terrace deposits, and colluvium and, therefore, generally is not physically or hydraulically connected.

Water in the aquifers generally is unconfined, although clay lenses locally may result in confined conditions. Recharge results from infiltration of precipitation and streamflow, from lateral flow from adjacent aquifers, and from vertical flow from underlying aquifers. The hydraulic gradient generally trends in a downstream direction or from topographically high areas to topographically low areas. Discharge is to streamflow, evapotranspiration, and vertical and lateral flow to adjoining aquifers.

WATSTORE contains data from 378 chemical analyses of water from wells completed in the alluvium, terrace-deposits, colluvium, or Flaxville geohydrologic unit. The location of the data sites is shown in figure 3. Although the data sites are fairly evenly distributed throughout the region, the coverage is relatively sparse along some rivers.

The results of tests for significant differences between chemical data for water from the four units are listed in table 3. Considering data from all depths for the alluvium and terrace units, no significant difference exists between the units at the 0.05 significance level for any of the listed constituents except for chloride. Therefore, on the basis of the data, the alluvium and terrace-deposits geohydrologic units are considered to have similar water quality. However, for most constituents, the colluvium and Flaxville are significantly different, although relatively few analyses are available for each unit. The colluvium and Flaxville units are treated separately in this report. Statistical data are available for the combined alluvium and terrace deposits (table 4), colluvium (table 5), and Flaxville (table 6). The number of analyses and distribution of depth data are insufficient to differentiate water quality by depth.

Diagrams of the composition of water are shown for the combined alluvium and terrace deposits (fig. 4), for the colluvium (fig. 5), and for the Flaxville (fig. 6). For the combined alluvium and terrace deposits, the concentrations of the constituent pairs are relatively equal based on first-quartile values. However, based on median and third-quartile values, sulfate plus chloride tend to be the predominant anion pair. For the colluvium, calcium plus magnesium tend to be the predominant cation pair and sulfate plus chloride are the predominant anion pair. For the Flaxville, calcium plus magnesium tend to be the predominant cation pair and bicarbonate plus carbonate are the predominant anion pair. Maximum values are not included for the combined alluvium and terrace deposits and the colluvium owing to large concentrations which plot off scale.

Spearman-rank correlation coefficients were determined for selected variables in water from the alluvium and terrace deposits (table 7). Owing to the small number of analyses available for the colluvium and Flaxville, correlation coefficients for these units are not shown. For the alluvium and terrace deposits, the most significant correlation (largest coefficient) is between dissolved solids and sulfate (0.98 based on 364 data values) and is positive. Other significant correlations are between dissolved solids and calcium, magnesium, and sodium. These correlation coefficients range from 0.78 to 0.89 and are positive. Based on these correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of sulfate minerals.

Data for concentrations of many trace constituents in water from the alluvium, terrace-deposits, colluvium, or Flaxville unit are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given for the alluvium and terrace deposits (table 8), colluvium (table 9), and Flaxville (table 10). For the alluvium and terrace deposits, 30 percent of 83 data values exceeded the standard for cadmium, 25 percent of 110 data values exceeded the standard for lead, and 11 percent of 71 data values exceeded the standard for selenium. For the colluvium, all six data values for cadmium and lead and all seven data values for selenium exceeded the standards. A lesser percentage of exceedances for other constituents also is shown. The number of data values for water from the Flaxville is small; no concentrations exceeded the standards.

WATSTORE contains data from only two analyses for dissolved organic carbon, one analysis for total organic carbon, and no analyses for phenols in water from the alluvium and terrace deposits. No data are available for the colluvium and Flaxville. The paucity of data for organic constituents indicates that the data file is inadequate to detect any organic effects of man's activities in this hydrologic system.

Glacial deposits

Pleistocene glacial deposits, including drift, Great Falls Lake sands, glaciolacustrine deposits, outwash, and till, are composed of unconsolidated clay, silt, sand, and gravel. These deposits are located in the northern one-half of the eastern region of Montana and, where present, probably are less than several hundred feet thick. These deposits can transmit significant quantities of water, at least in some areas, and, therefore, are considered to be aquifers.

Water in the aquifers generally is unconfined, although locally confined conditions may exist. Recharge results from infiltration of precipitation and from vertical and lateral flow from adjoining aquifers. The direction of the hydraulic gradient is unknown, although it probably varies locally depending on topography and aquifer geometry. Discharge primarily is to streamflow, evapotranspiration, and vertical and lateral flow to adjoining aquifers.

WATSTORE contains data from 88 chemical analyses of water from wells completed in the glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, or glacial-till geohydrologic units. The location of the data sites is shown in figure 7. Most of the data sites are located in the northwestern part of the eastern region.

The results of tests for significant differences between chemical data for water from the five units are listed in table 11. Considering data from all depths for all units, no significant difference exists between the units at the 0.05 significance level for most of the listed constituents. Therefore, on the basis of the data, the five geohydrologic units can be considered to have similar water quality. Statistical data are available for the combined glacial units (table 12). The number of analyses and distribution of depth data are insufficient to differentiate by depth.

A diagram (fig. 8) shows the composition of water from the glacial units. Based on first-quartile and median values, calcium plus magnesium and sulfate plus chloride tend to be the predominant ion pairs. Based on third-quartile values, sodium plus potassium and sulfate plus chloride tend to be the predominant ion pairs. Maximum values are not included owing to large concentrations which plot off scale.

Spearman-rank correlation coefficients were determined for selected variables in water from the glacial units (table 13). For the glacial units, the most significant correlation (largest coefficient) is between dissolved solids and sulfate (0.99 based on 87 data values) and is positive. Other significant correlations are between dissolved solids and calcium, magnesium, sodium, potassium, and chloride. These correlation coefficients range from 0.74 to 0.88 and are positive. Based on these correlations the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of sulfate and chloride minerals.

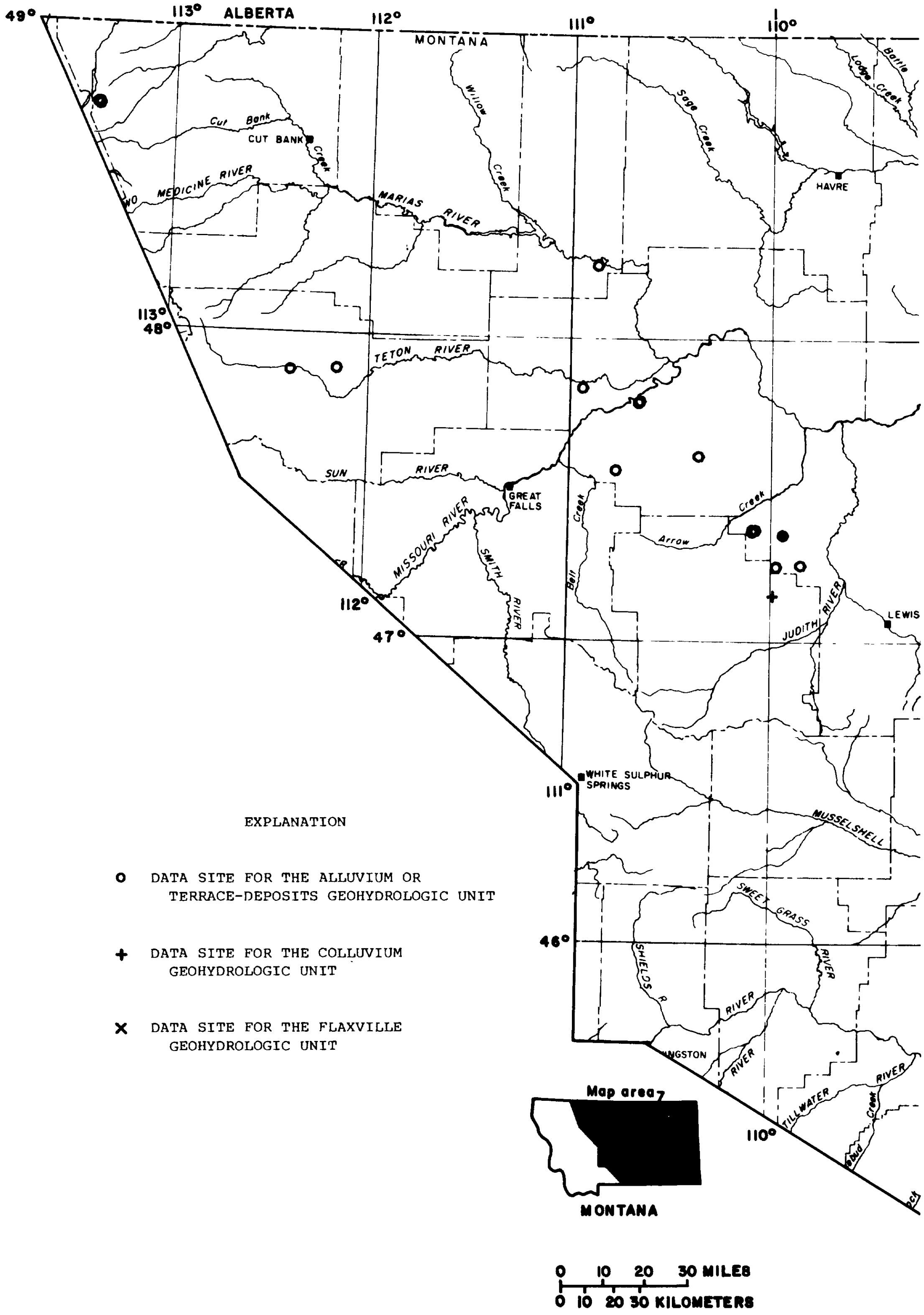
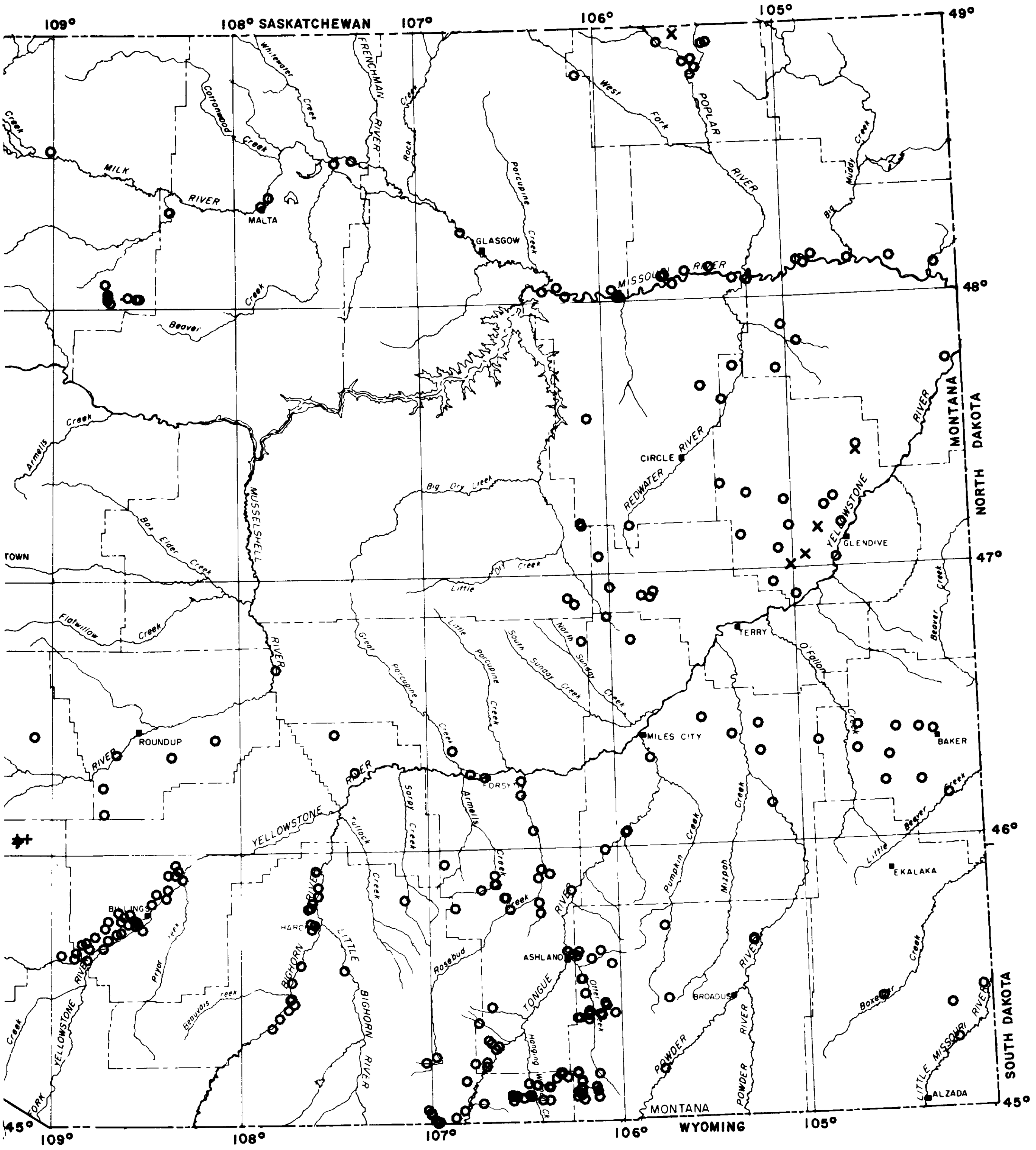


Figure 3.--Location of water-quality data sites in WATSTORE for the alluvium, terrace-deposits, colluvium, and Flaxville geohydrologic units, eastern Montana.


109°
108° SASKATCHEWAN
107°
106°
105°
49°
48°
47°
46°
45°
MILK RIVER
MALTA
GLASGOW
MISSOURI RIVER
POPLAR RIVER
West Fork
FRENCHMAN RIVER
Whitewater Creek
Cottonwood Creek
Rock Creek
Porcupine Creek
Big Muddy Creek
Beaver Creek
Armells Creek
Box Elder Creek
Flatwillow Creek
MUSSELSHELL RIVER
Big Dry Creek
Little Dry Creek
CIRCLE
REDWATER RIVER
GLENDIVE
YELLOWSTONE RIVER
MONTANA
NORTH DAKOTA
TERRY
O'Fallon Creek
Beaver Creek
BAKER
MILES CITY
ROUNDUP
FORSYTH
Great Porcupine Creek
Little Porcupine Creek
South Sunday Creek
North Sunday Creek
Sarpy Creek
Tullock Creek
Armells Creek
Rosebud Creek
TONGUE RIVER
ASHLAND
Otter Creek
Hanging Woman Ck.
Pumpkin Creek
Mizpah Creek
POWDER RIVER
BROADUS
EKALAKA
Little Beaver Creek
Boxelder Creek
LITTLE MISSOURI RIVER
ALZADA
SOUTH DAKOTA
BILLINGS
HARDIN
BIGHORN RIVER
LITTLE BIGHORN RIVER
Pryor Creek
Beauvais Creek
YELLOWSTONE RIVER
CLARKS FORK
TOWN
MONTANA
WYOMING

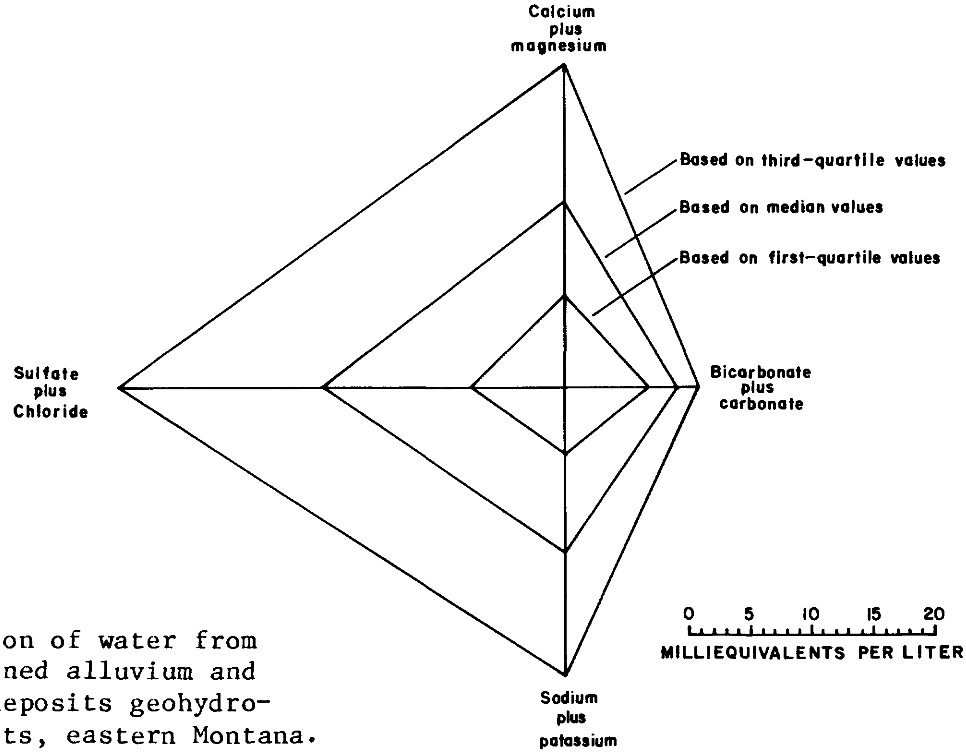


Figure 4.--Composition of water from the combined alluvium and terrace-deposits geohydrologic units, eastern Montana.

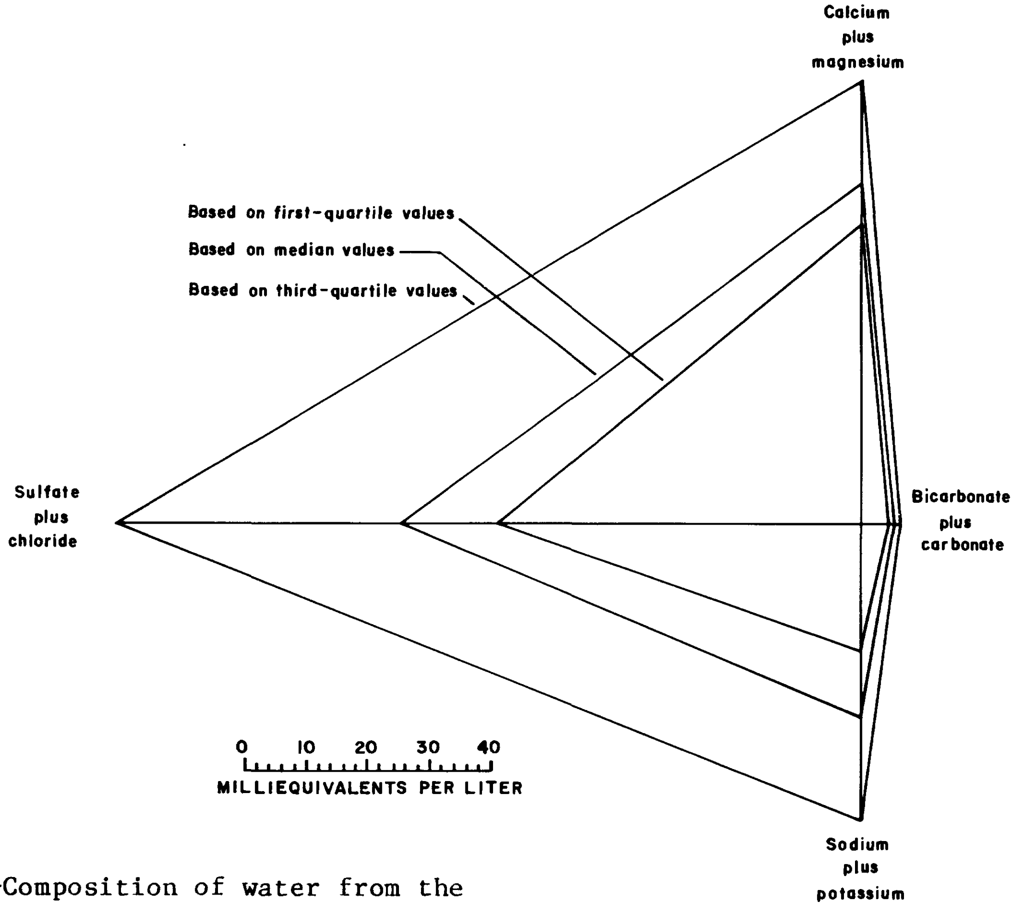


Figure 5.--Composition of water from the colluvium geohydrologic unit, eastern Montana.

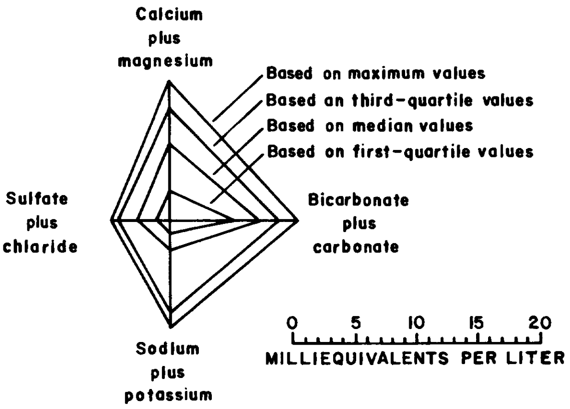


Figure 6.--Composition of water from the Flaxville geohydrologic unit, eastern Montana.

Data for concentrations of trace constituents in water from the glacial geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given for the combined glacial units (table 14). Twenty-eight percent of 87 data values exceeded the standard for nitrate, 69 percent of 32 data values exceeded the standard for cadmium, 34 percent of 47 data values exceeded the standard for lead, and 38 percent of 45 data values exceeded the standard for selenium.

WATSTORE contains data from only one analysis for dissolved organic carbon, no data for total organic carbon, and data from one analysis for phenols in water from the glacial units. The paucity of data for organic constituents indicates that the data file is inadequate to detect any organic effects of man's activities in this hydrologic system.

Wasatch and Fort Union Formations

The Eocene Wasatch Formation and Paleocene Fort Union Formation primarily consist of continental tan to gray shale, siltstone, very fine to fine-grained sand and sandstone, and coal. The Fort Union Formation is composed of the Tongue River Member, the Lebo Shale Member, and the Tullock Member. In extreme eastern Montana, the Lebo and Tullock are lumped as the Ludlow Member (Brown, 1962, p. 6.). Thickness of the members varies considerably. However, in southeastern Montana and northeastern Wyoming, the combined thickness of the Tongue River Member and the Wasatch Formation averages about 1,400 ft, the thickness of the Lebo Shale Member averages about 700 ft, and the thickness of the Tullock Member averages about 800 ft (Lewis and Hotchkiss, 1981, sheet 1).

Hydrologic flow systems within the Wasatch and Fort Union Formations are complex. Shallow flow systems generally are localized and flow is from topographically high areas to local surface drainages; in deeper systems, flow generally is toward the major surface drainages, such as the Tongue, Powder, Redwater, Yellowstone, and Missouri Rivers. Yields from wells for domestic and livestock supply average 15 to 25 gal/min. Greater yields are available in some areas of fractured clinker, which

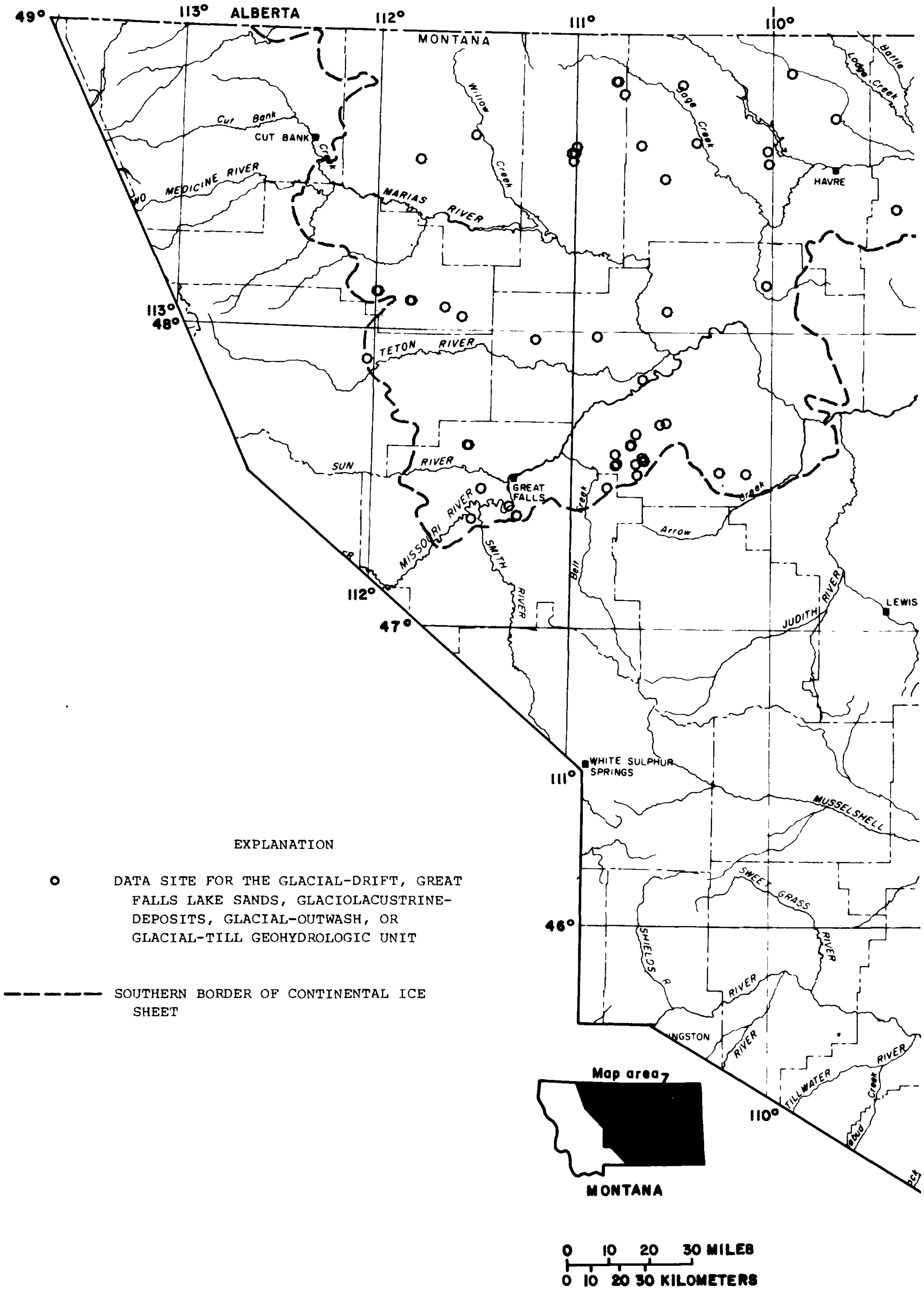
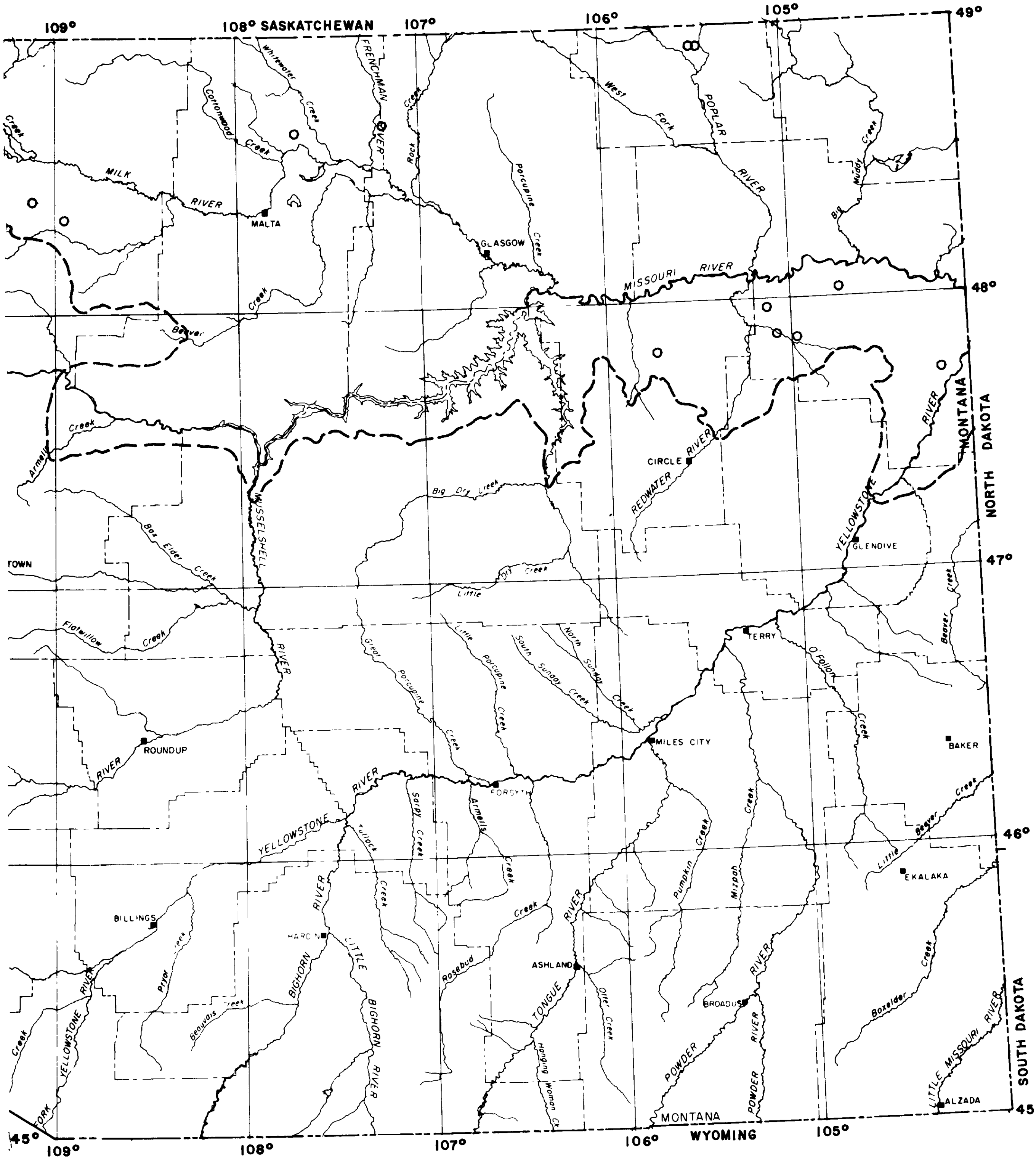


Figure 7.--Location of water-quality data sites in WATSTORE for the glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, and glacial-till geohydrologic units, eastern Montana.


109°
108° SASKATCHEWAN
107°
106°
105°
49°
48°
47°
46°
45°
MILK RIVER
MALTA
GLASGOW
MISSOURI RIVER
POPLAR RIVER
FRENCHMAN RIVER
CIRCLE
REDWATER RIVER
MUSSELSHELL RIVER
YELLOWSTONE RIVER
GLENDIVE
TERRY
MILES CITY
ROUNDUP
FORSYTH
BILLINGS
HARDIN
ASHLAND
BROADUS
BAKER
EKALAKA
ALZADA
BIGHORN RIVER
LITTLE BIGHORN RIVER
TONGUE RIVER
POWDER RIVER
LITTLE MISSOURI RIVER
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING

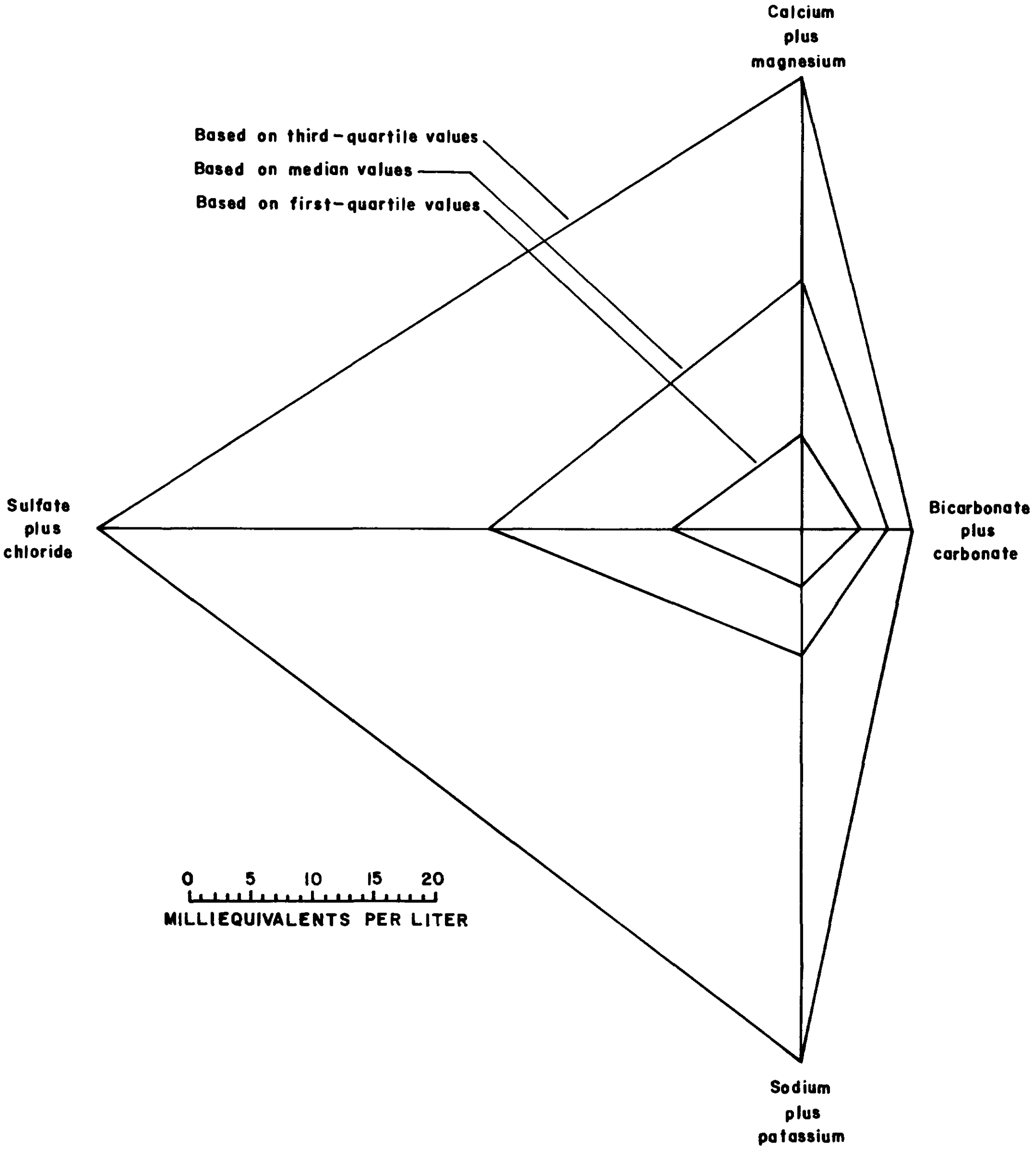


Figure 8.--Composition of water from the combined glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, and glacial-till geohydrologic units, eastern Montana.

is rock that has been baked and fused as a result of the burning of underlying coal beds. Hydraulic conductivity of sandstones in the Fort Union Formation of Montana, North Dakota, Wyoming, and Alberta, Canada has a geometric mean of about 0.3 ft/d. Hydraulic conductivity of coal beds in the same area has a geometric mean of about 0.9 ft/d (Rehm and others, 1980, p. 552). Confining beds tend to preclude significant vertical flow between permeable sandstone and coal layers. However, based on regional hydrology, the Wasatch and Fort Union Formations can be considered to be one aquifer system.

WATSTORE contains data from 1,777 chemical analyses of water from wells completed in the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon [Harmon lignite bed (of Leonard and Smith, 1909, p. 22) of the Tongue River Member], or Ludlow geohydrologic unit. The location of the data sites is shown in figure 9. The data sites are fairly evenly distributed throughout the areas of the Wasatch and Fort Union Formations except in the two westernmost areas where there are no data.

Geochemical relationships exist between the units, particularly if depth is considered. The results of tests for significant differences between data from each of the geohydrologic units are listed in table 15. Considering all units and all depths, no significant difference exists between the units at the 0.05 significance level for sulfate, silica, and dissolved solids. However, if the Ludlow, for which only one analysis is available, is omitted, the remaining units show no significant difference for sodium and bicarbonate. Furthermore, if the Wasatch, for which only nine analyses are available, is omitted, the remaining units show no significant difference for calcium, magnesium, potassium, and carbonate.

If the data are sorted by well depth, a closer relationship exists. For analyses of water from wells 200 ft deep or less, no significant difference exists between units at the 0.05 significance level for pH, sulfate, silica, and dissolved solids (table 16). If the one analysis for the Ludlow is omitted, the remaining units show no significant difference for sodium, potassium, bicarbonate, carbonate and chloride. For analyses from wells with depth known to be greater than 200 ft, no significant difference exists between the units at the 0.05 significance level for pH, calcium, magnesium, sodium, potassium, sulfate, silica, and dissolved solids (table 17), although no data are available for the Wasatch or Ludlow. Therefore, on the basis of the data, the geohydrologic units can be considered to have similar water quality, particularly when differentiated by depth. Statistical descriptions of the data from the combined geohydrologic units are given for well depths of 200 ft or less (table 18) and for well depths greater than 200 ft (table 19).

Diagrams of the composition of water are shown for the combined Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units (fig. 10). The diagrams show that quartile values for the ion pairs in water from wells 200 ft deep or less are relatively evenly distributed, although at the maximum values calcium plus magnesium and sulfate plus chloride tend to be the predominant ion pairs. Quartile values for analyses of water from wells greater than 200 ft show sodium plus potassium and, at maximum values, sulfate plus chloride to be the predominant ion pairs.

Spearman-rank correlation coefficients were determined for selected variables in water from the combined Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow (tables 20 and 21). Considering depths of 200 ft or less, the most significant correlation (largest coefficient) is between dissolved solids and sulfate (0.92 based on 930 data values) and is positive. Another significant correlation is between dissolved solids and sodium (0.68 based on 929 data values). On the basis of these correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of sulfate minerals.

Considering depths greater than 200 ft, the most significant correlation is between calcium and magnesium (0.95 based on 396 data values). Other significant correlations are between dissolved solids and sodium (0.80 based on 386 data values) and dissolved solids and sulfate (0.70 based on 386 data values) and are positive. On the basis of the latter two correlations, the observed dissolved-solids concentrations can be inferred to be largely affected by dissolution of sulfate minerals.

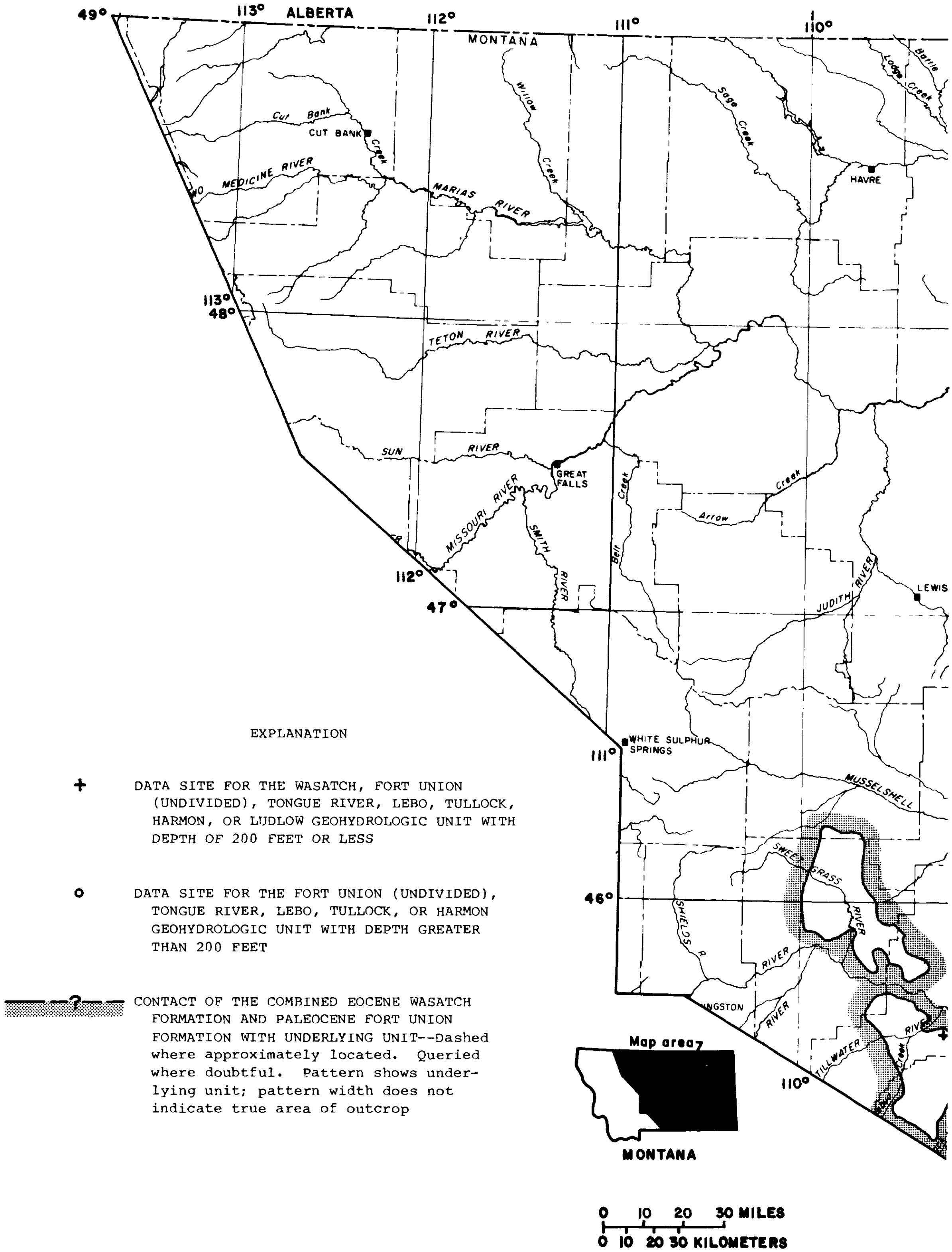
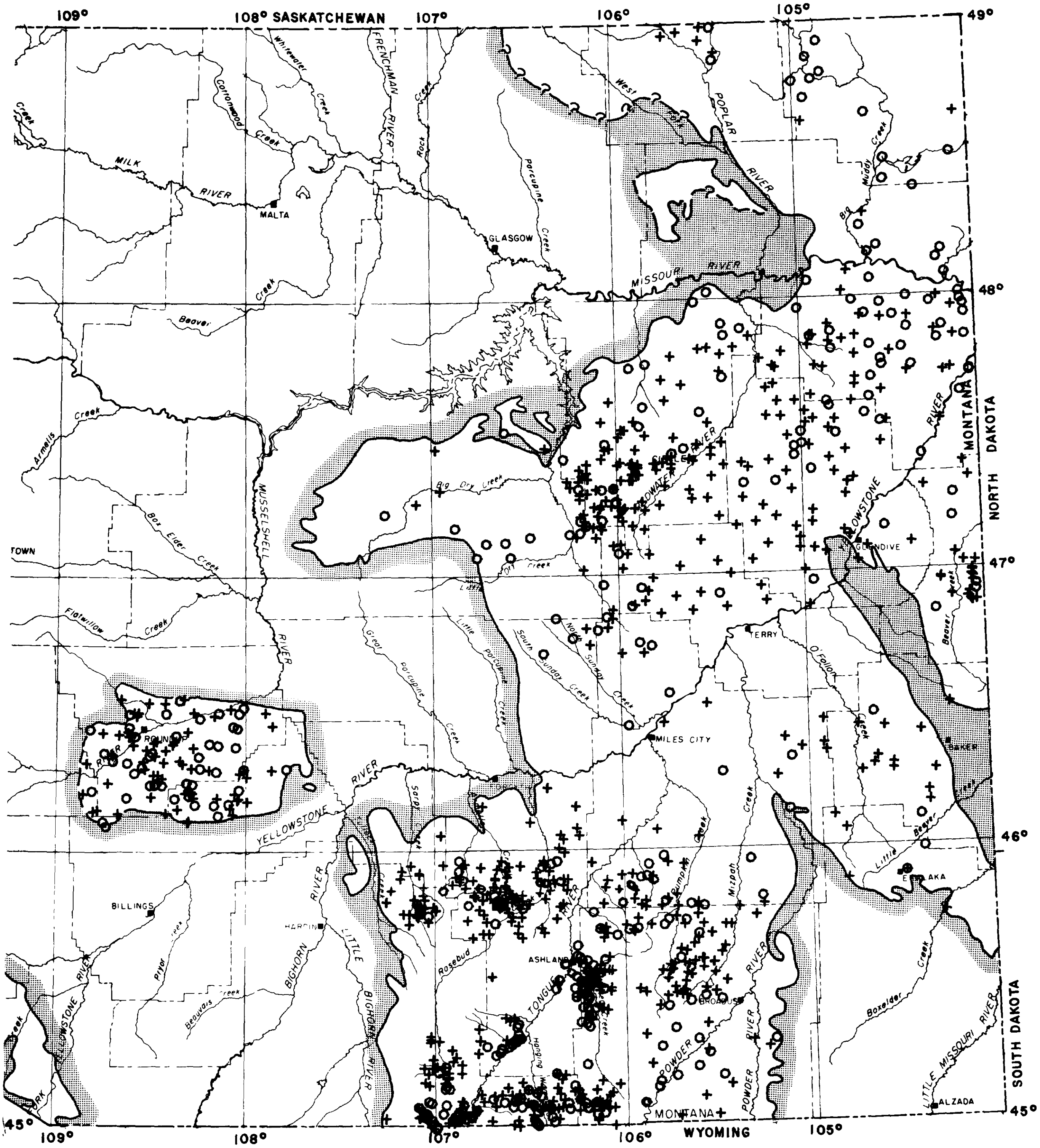


Figure 9.--Location of water-quality data sites in WATSTORE for the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units, eastern Montana.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FRENCHMAN RIVER
Rock Creek
West Fork
POPLAR RIVER
Big Muddy Creek
MILK RIVER
MALTA
GLASGOW
Porcupine Creek
MISSOURI RIVER
Beaver Creek
Armells Creek
Big Dry Creek
REDWATER RIVER
SIDNEY
YELLOWSTONE RIVER
GLENDIVE
TOWN
Box Elder Creek
MUSSELSHELL RIVER
Flatwillow Creek
Great Porcupine Creek
Little Porcupine Creek
South Sunday Creek
North Sunday Creek
TERRY
O'Fallon Creek
Beaver Creek
MILES CITY
BAKER
ROUNDUP
YELLOWSTONE RIVER
BILLINGS
HARDIN
BIGHORN RIVER
LITTLE BIGHORN RIVER
Pryor Creek
Beauvais Creek
Rosebud
ASHLAND
TONGUE RIVER
Hanging Woman Creek
Pumpkin Creek
Mizpah Creek
BROADUS
POWDER RIVER
Little Beaver Creek
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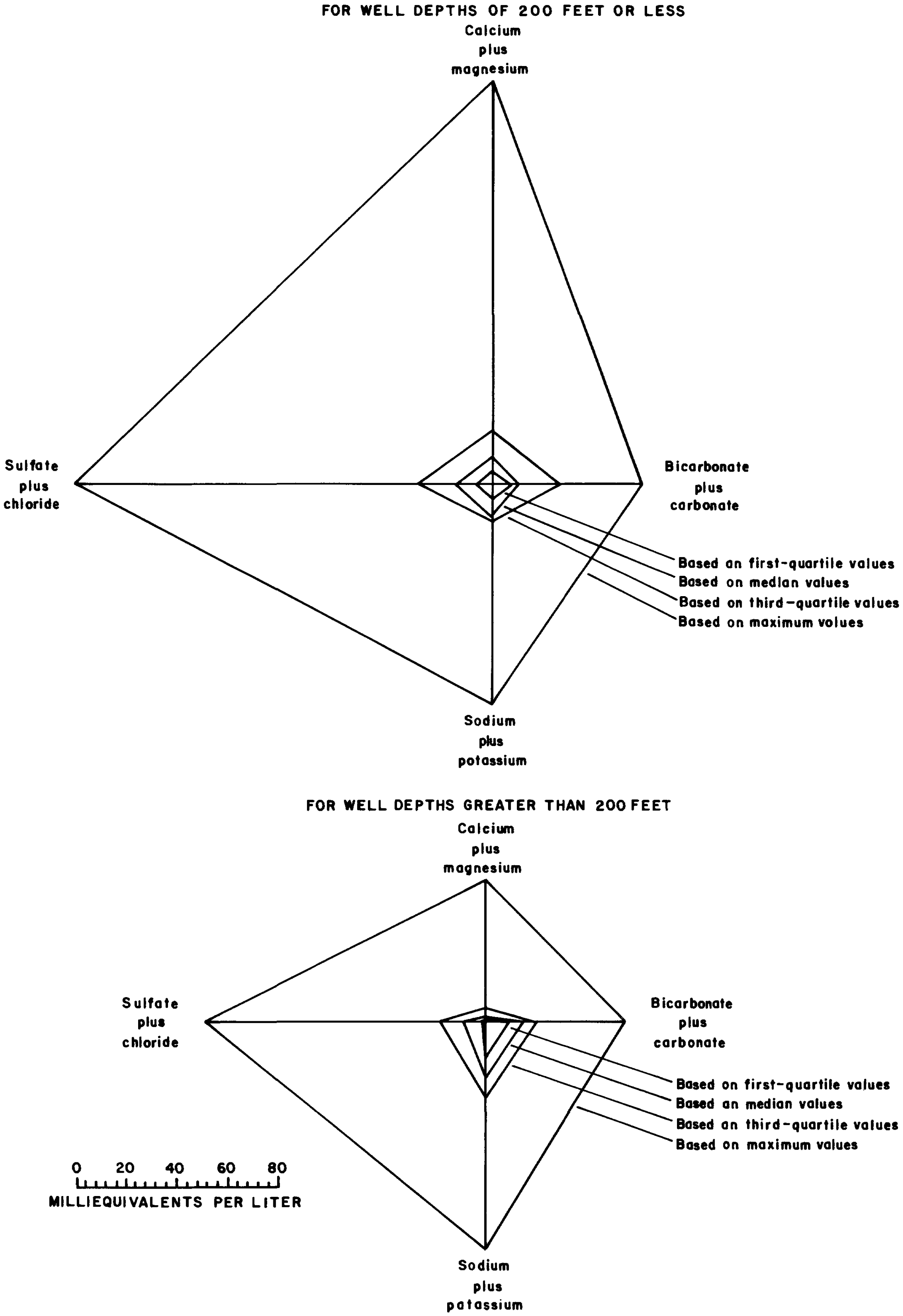


Figure 10.--Composition of water from the combined Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units, eastern Montana. Data are not available for wells completed in the Wasatch and Ludlow geohydrologic units at depths greater than 200 feet.

Data for concentrations of many trace constituents in water from the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, or Ludlow geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (tables 22 and 23). For water from wells 200 ft deep or less, 6 percent of 845 available data values exceeded the maximum standard for fluoride, 39 percent of 188 available data values exceeded the standard for cadmium, and 29 percent of 309 available data values exceeded the standard for lead. The percentage of exceedances for other constituents is minor. For water from wells greater than 200 ft deep, 32 percent of 374 available data values exceeded the maximum standard for fluoride, 23 percent of 73 available data values exceeded the standard for cadmium, 9 percent of 70 available analyses exceeded the standard for chromium, and 9 percent of 97 available data values exceeded the standard for lead. The percentage of exceedances for other constituents is minor.

For the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units WATSTORE contains data from 66 analyses for total organic carbon, 40 analyses for dissolved organic carbon, and 2 analyses for phenols. The concentrations of total organic carbon range from 1.2 to 108 mg/L (milligrams per liter) and have a median value of 7.1 mg/L. The concentrations of dissolved organic carbon range from 0.0 to 36 mg/L and have a median value of 5.6 mg/L. The concentrations of phenols from the two analyses are 3 and 4 µg/L (micrograms per liter). Many of the analyses are for water from wells completed in or near coal beds within the Fort Union Formation.

A representative median value of total organic carbon or dissolved organic carbon for water from most unpolluted aquifers probably is about 1 mg/L. However, the alkaline ground-water condition in these units is conducive to solution of organic material from the coal, and even the 108-mg/L value is not considered unusual under the prevailing natural ground-water system conditions (Ronald L. Malcolm, U.S. Geological Survey, oral commun., 1983).

Hell Creek Formation and Fox Hills Sandstone

The Upper Cretaceous Hell Creek Formation is a fluvial and deltaic deposit primarily consisting of lenticular sandstone with intertonguing siltstone and shale. The conformably underlying Upper Cretaceous Fox Hills Sandstone was deposited during the last marine regression in Montana and primarily consists of sandstone, with lesser amounts of siltstone and shale. The lower part of the Hell Creek Formation and the Fox Hills Sandstone are directly hydraulically connected and compose the Fox Hills-lower Hell Creek aquifer, which is 800 to 1,000 ft thick in southeastern Montana and progressively thins to less than 200 ft thick in northeastern Montana. Cumulative sandstone thickness ranges from about 500 ft in the southeastern part to about 100 ft in the northeastern part. The regional structure of the top of the Fox Hills-lower Hell Creek dips north-northwest in the general area north of Miles City and dips south in areas south of Miles City (Feltis, 1982p,q,r,s).

The upper part of the Hell Creek Formation consists of as much as 800 ft of interbedded shale, siltstone, and sandstone. Sandstone beds may be as thick as 50 ft in the southern areas and generally thinner northward. The regional structural configuration of the upper part of the Hell Creek is similar to that of the Fox Hills-lower Hell Creek aquifer.

Both unconfined and confined ground-water conditions exist in the Fox Hills-lower Hell Creek aquifer. Recharge to the aquifer occurs primarily from infiltration of precipitation on outcrops, with lesser amounts of recharge occurring as leakage from streamflow across outcrops and as vertical leakage across confining beds. The regional hydraulic gradient is to the north and northeast along the regional dip. Discharge from the aquifer is to the Yellowstone River (fig. 2) in some areas and to wells used mainly for stock, domestic, and public supply. Yields to wells completed in the Fox Hills-lower Hell Creek aquifer are as much as 200 gal/min, although most yields are about 20 gal/min or less (Levings, 1982c). Wells completed in the upper part of the Hell Creek Formation yield as much as 40 gal/min, although most yields range from 5 to 12 gal/min. Measurements of transmissivity of the Fox Hills-lower Hell Creek aquifer range from 3 to 640 ft^2/d. Two measurements of transmissivity of the upper part of the Hell Creek Formation show values of 200 and 630 ft^2/d. Estimates of transmissivity from specific-capacity tests are less but of the same order of magnitude (Miller, 1979, 1981). Confining beds tend to preclude significant vertical flow between the Fox Hills-lower Hell Creek aquifer and the upper part of the Hell Creek Formation. However, based on regional hydrology, the Fox Hills-lower Hell Creek and the upper part of the Hell Creek can be considered to be one aquifer system.

WATSTORE contains data from 257 chemical analyses of water from wells completed in the Fox Hills, Hell Creek, or Fox Hills-lower Hell Creek geohydrologic unit. The location of the data sites is shown in figure 11. Although the data sites are fairly evenly distributed, most of the sites are in the southeastern part of this region.

Geochemical relationships exist between the units, particularly if depth is considered. The results of tests for significant differences between data from each of the three geohydrologic units are listed in table 24. Considering all depths, only pH has no significant difference between the units at the 0.05 significance level. However, if the data are sorted by depth, a closer relationship exists. For analyses of water from wells with depths of 200 ft or less, no significant difference exists at the 0.05 significance level for calcium, magnesium, potassium, carbonate, and silica (table 25). If the Fox Hills data, for which only four analyses are available, are omitted, then the remaining units show no significant difference for all other listed constituents. For analyses of water from wells with depth greater than 200 ft, no significant difference exists at the 0.05 significance level for potassium, bicarbonate, sulfate, and dissolved solids (table 26). Therefore, on the basis of the data, the geohydrologic units can be considered to have similar water quality, particularly when differentiated by depth. A statistical description of the combined data from all three geohydrologic units is given for well depths of 200 ft or less (table 27) and for well depths greater than 200 ft (table 28).

Diagrams (fig. 12) show the composition of water from the combined Fox Hills, Hell Creek, and Fox Hills-lower Hell Creek units. The diagrams show that for quartile values for the ion pairs in water from wells 200 ft deep or less, sodium plus potassium tend to be the predominant cation pair and, at third-quartile and maximum values, sulfate plus chloride tend to be the predominant anion pair. Quartile values for water from wells greater than 200 ft show that sodium plus potassium tend to be the predominant cation pair. At first-quartile, median, and third-quartile values, bicarbonate plus carbonate tend to be the predominant anion pair, although at the maximum values, sulfate plus chloride tend to be the predominant anion pair.

Spearman-rank correlation coefficients were determined for selected variables in water from the combined Fox Hills, Hell Creek, and Fox Hills-lower Hell Creek units (tables 29 and 30). Considering depths of 200 ft or less, the most significant correlations (largest coefficients) are between calcium and magnesium (0.96 based on 63 data values) and pH and nitrate (-1.00 based on three data values). However, owing to the small number of data values, the correlation between pH and nitrate may not be statistically valid. Other significant correlations are between dissolved solids and sodium (0.91 based on 63 data values) and dissolved solids and sulfate (0.92 based on 63 data values) and are positive. On the basis of the latter two correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of sulfate minerals.

Considering well depths greater than 200 ft, the most significant correlation is between dissolved solids and sodium (0.96 based on 180 data values) and is positive. The correlation coefficients between dissolved solids and bicarbonate, sulfate, and chloride have similar values and range from 0.43 to 0.57. Based on these latter three correlations, the dissolved-solids concentrations cannot be inferred to be largely affected by the dissolution of any one chemical type of mineral.

Data for concentrations of many trace constituents in water from the Fox Hills, Hell Creek, or Fox Hills-lower Hell Creek unit are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (tables 31 and 32). For water from wells 200 ft deep or less, 11 percent of 63 available data values exceeded the maximum standard for fluoride and 24 percent of 21 available data values exceeded the standard for lead. The percentage of exceedances for other constituents is minor. For water from wells greater than 200 ft deep, 25 percent of 179 available data values exceeded the maximum standard for fluoride.

For the Fox Hills, Hell Creek, and Fox Hills-lower Hell Creek units, WATSTORE contains data from 3 analyses for total organic carbon, 19 analyses for dissolved organic carbon, and no analyses for phenols. The paucity of data for organic constituents indicates that the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer system.

Judith River Formation and associated units

The Upper Cretaceous Judith River Formation consists of marine and nonmarine sandstone interbedded with siltstone, shale, lignite, and coal seams. The formation is as much as 900 ft thick and generally thins from west to east, where the thickness is 200 ft or less. Cumulative sandstone thickness within the Judith River Formation ranges from 350 ft in central Montana to 25 ft or less in eastern Montana. The regional dip is toward the east, although locally the dip may differ (Feltis, 1982b,c,m). The formation generally is overlain by the Bearpaw Shale and underlain by the Claggett Shale or the Parkman Sandstone, which is a marine beach and barrier bar deposit that generally is underlain by the Claggett. The Two Medicine Formation is at least in part equivalent to the Judith River and Claggett and occurs in the northwestern part of the eastern geohydrologic region.

The Judith River, Two Medicine, and Parkman units are relatively sandy sediments that probably are directly hydraulically connected. The overlying Bearpaw Shale may be as much as 700 ft thick, and the underlying Claggett Shale may be as

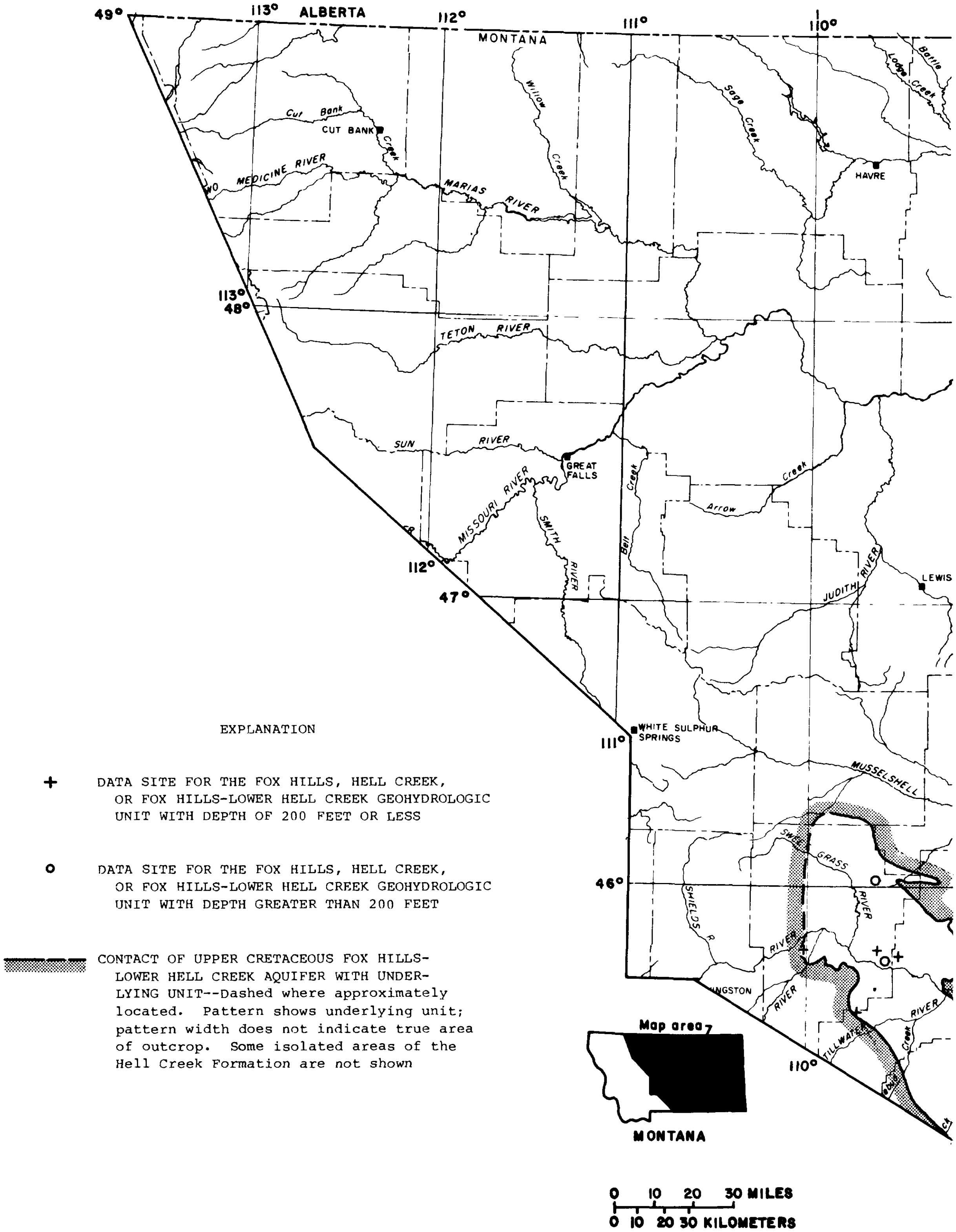
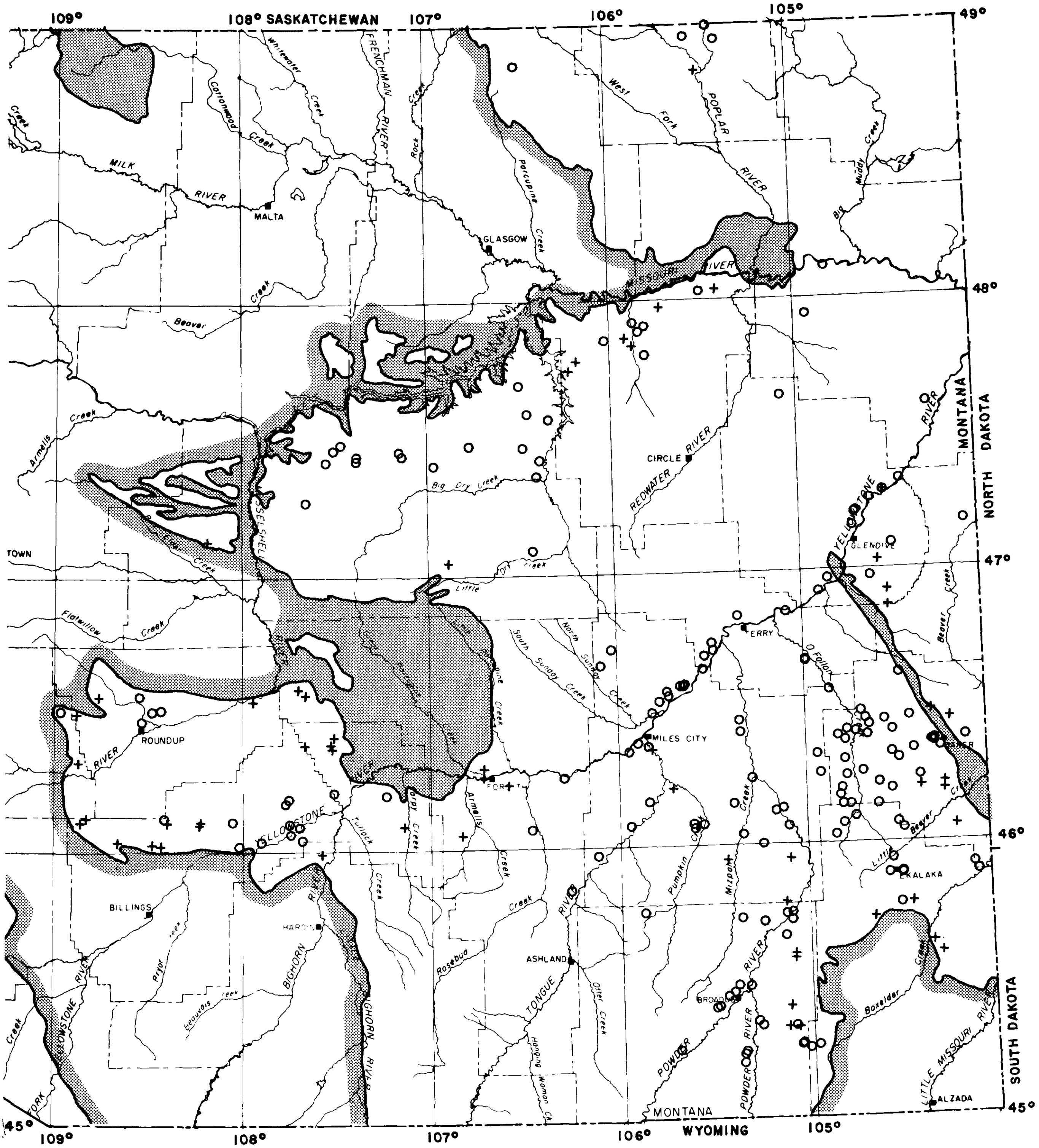


Figure 11.--Location of water-quality data sites in WATSTORE for the Fox Hills, Hell Creek, and Fox Hills-lower Hell Creek geohydrologic units, eastern Montana.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Big Dry Creek
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POWDER RIVER
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WYOMING
NORTH DAKOTA
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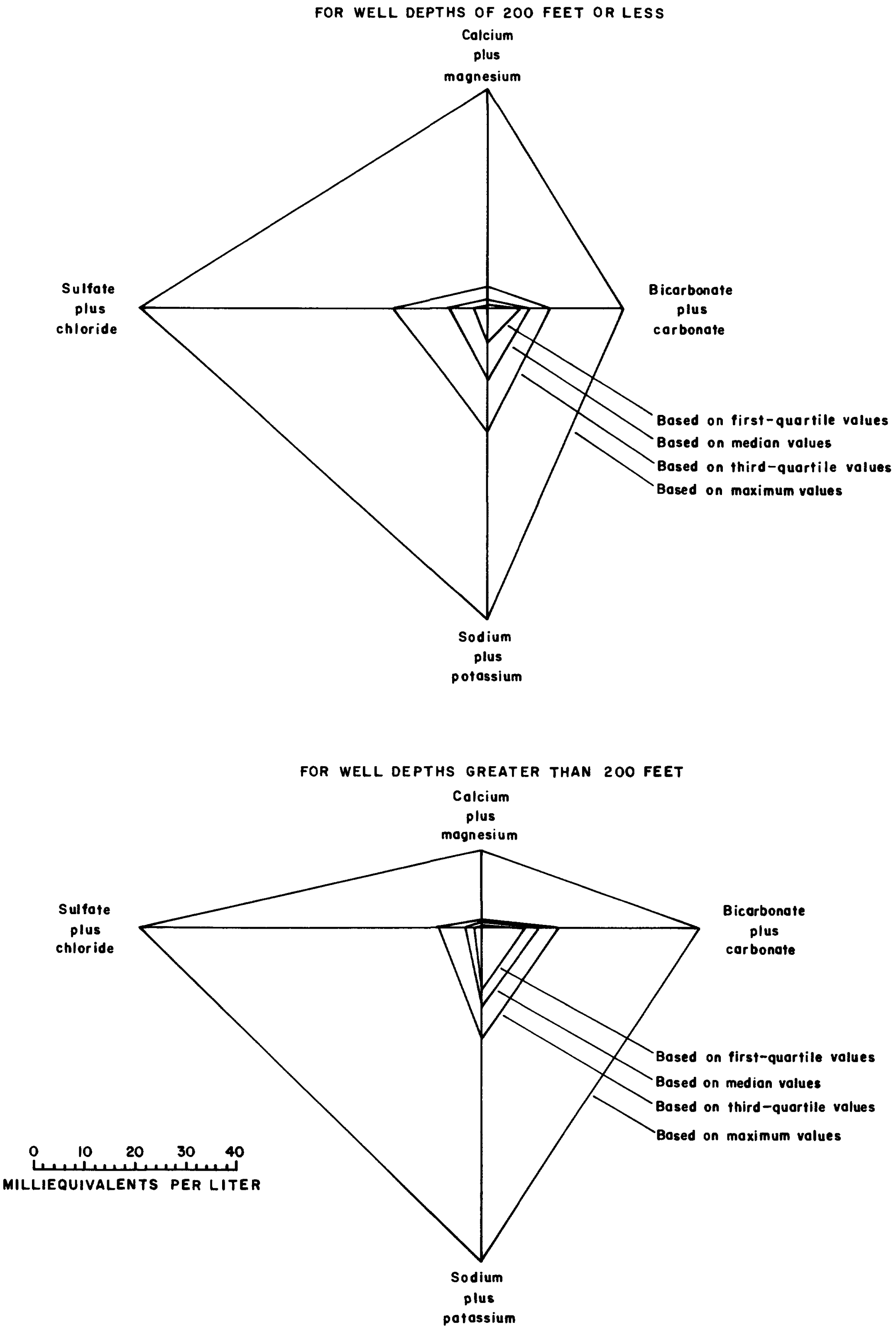


Figure 12.--Composition of water from the combined Fox Hills, Hell Creek, and Fox Hills-lower Hell Creek geohydrologic units, eastern Montana.

much as 400 ft thick. Therefore, based on the regional hydrology, the Judith River, Two Medicine, and Parkman are considered to be one aquifer in this report.

Both unconfined and confined ground-water conditions exist in the aquifer. Recharge is mainly from infiltration of precipitation on the outcrops, which occur along the western edge of the aquifer and also along the flanks of mountain ranges that interrupt the general stratigraphic sequence. Recharge may also occur from infiltration of streamflow across outcrops and from vertical leakage across the confining beds. The regional hydraulic gradient is from west to east. Discharge is to the Milk and Missouri Rivers. Yields to wells completed in the aquifer range from 1 to 100 gal/min and average about 10 gal/min (Levings, 1982a).

WATSTORE contains data from 194 chemical analyses of water from wells completed in the Judith River, Two Medicine, or Parkman geohydrologic unit. The location of the data sites is shown in figure 13. Very few of the sites are located in the eastern or southern parts of the area of the Judith River or Two Medicine Formations.

The results of tests for significant differences between data from the three units in the aquifer system are listed in tables 33-35. No significant difference exists at the 0.05 significance level between data from the three units considering water from all well depths and when considering only water from wells 200 ft or less in depth. For well depths greater than 200 ft, no data are available for the Parkman unit. No significant difference exists between the Judith River and Two Medicine units, although only one analysis was available for the Two Medicine. Therefore, on the basis of the data, all three geohydrologic units can be considered to have similar water quality. Statistical data are available for the combined units considering all well depths (table 36) and for analyses differentiated by well depth (tables 37 and 38).

Diagrams (fig. 14) show the composition of water from the combined Judith River, Two Medicine, and Parkman units. Based on all quartile values for both depth intervals, sulfate plus chloride and sodium plus potassium tend to be the predominant ion pairs. The maximum values for sodium and sulfate concentrations for well depths of 200 ft or less are much larger than normally observed in near-surface aquifers in eastern Montana. The cause or source of these large concentrations is unknown.

Spearman-rank correlation coefficients were determined for selected variables in water from the Judith River, Two Medicine, and Parkman units (tables 39-41). Considering all depths, the most significant correlation (largest coefficient) is between calcium and magnesium (0.96 based on 193 data values) and is positive. Another significant correlation is between dissolved solids and sodium (0.92 based on 177 data values) and is positive. Considering depths of 200 ft or less, the most significant correlation is between calcium and magnesium (0.96 based on 56 data values) and is positive. Other significant correlations are between dissolved solids and sodium (0.90 based on 52 data values) and dissolved solids and sulfate (0.89 based on 53 data values) and are positive. Considering depths greater than 200 ft, the most significant correlation is between calcium and magnesium (0.94 based on 128 data values) and is positive. Another significant correlation is between dissolved solids and sodium (0.90 based on 117 data values) and is positive. On the basis of these correlations, the dissolved-solids concentrations in water from wells 200 ft deep or less can be inferred to be largely affected by dissolution of sulfate minerals. However, considering all depths and depths greater than 200 ft, such an inference cannot be made.

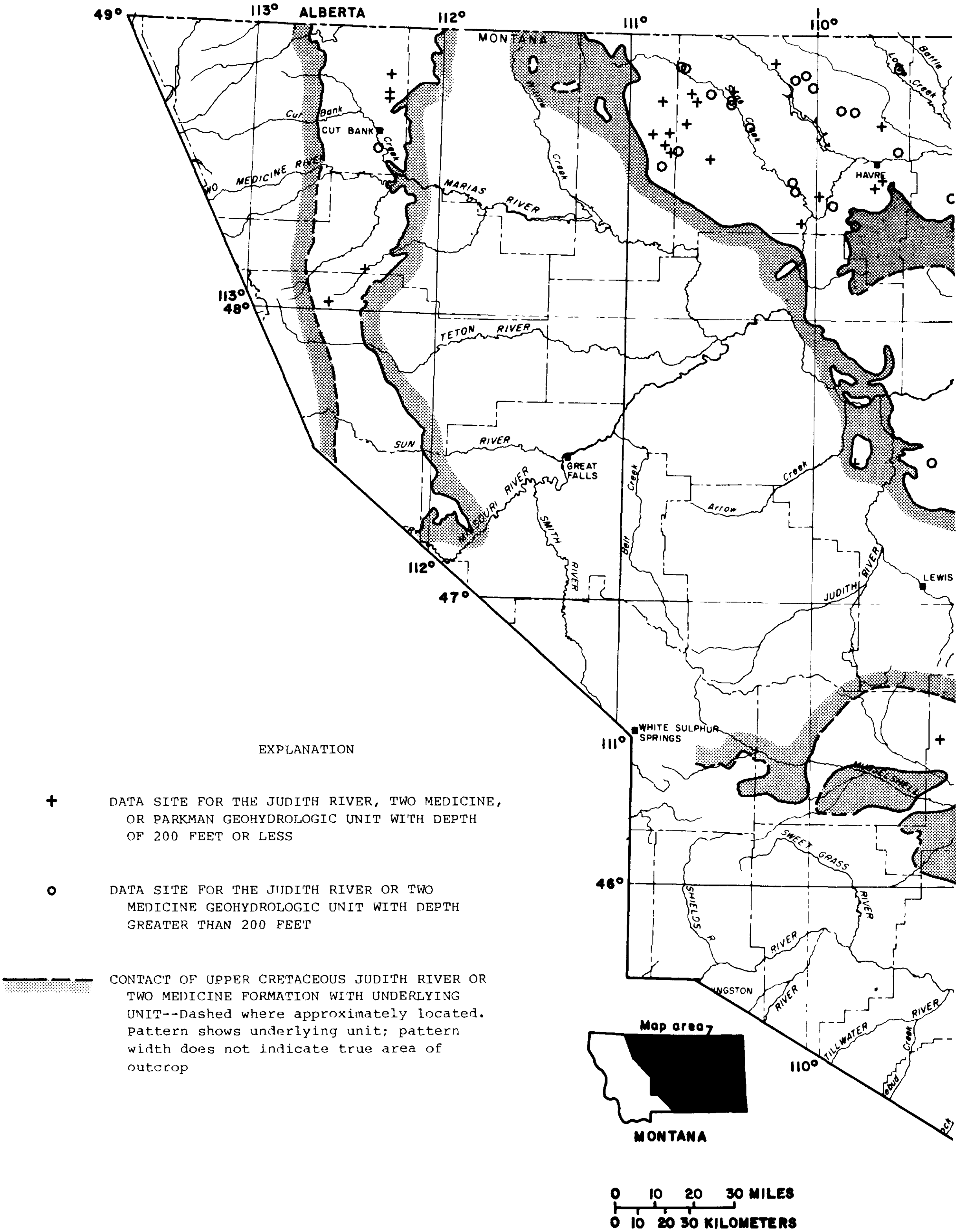
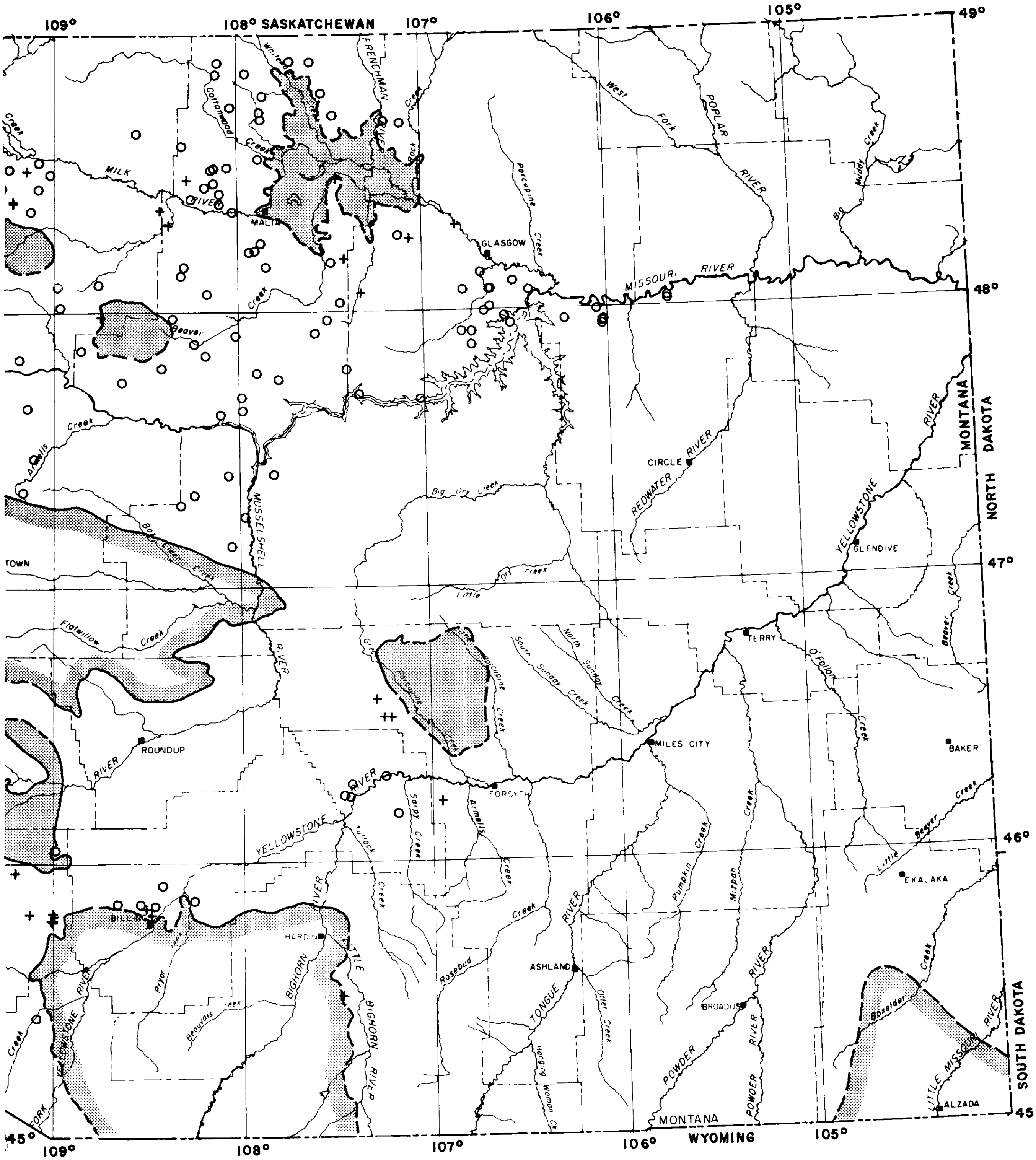


Figure 13.--Location of water-quality data sites in WATSTORE for the Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana.



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FRENCHMAN RIVER
POPLAR RIVER
West Fork
Porcupine Creek
Big Muddy Creek
Beaver Creek
CIRCLE
REDWATER RIVER
Big Dry Creek
MUSSELSHELL RIVER
YELLOWSTONE RIVER
GLENDIVE
MONTANA
NORTH DAKOTA
Box Elder Creek
Flatwillow Creek
ROUNDUP
TERRY
O'Fallon Creek
South Sunday Creek
North Sunday Creek
MILES CITY
BAKER
FORSYTH
Sarpy Creek
Armells Creek
Tullock Creek
Little Beaver Creek
EKALAKA
HARDIN
BILLINGS
Pryor Creek
Beauvais Creek
BIGHORN RIVER
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ASHLAND
Rosebud Creek
TONGUE RIVER
Pumpkin Creek
Mizpah Creek
Otter Creek
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SOUTH DAKOTA
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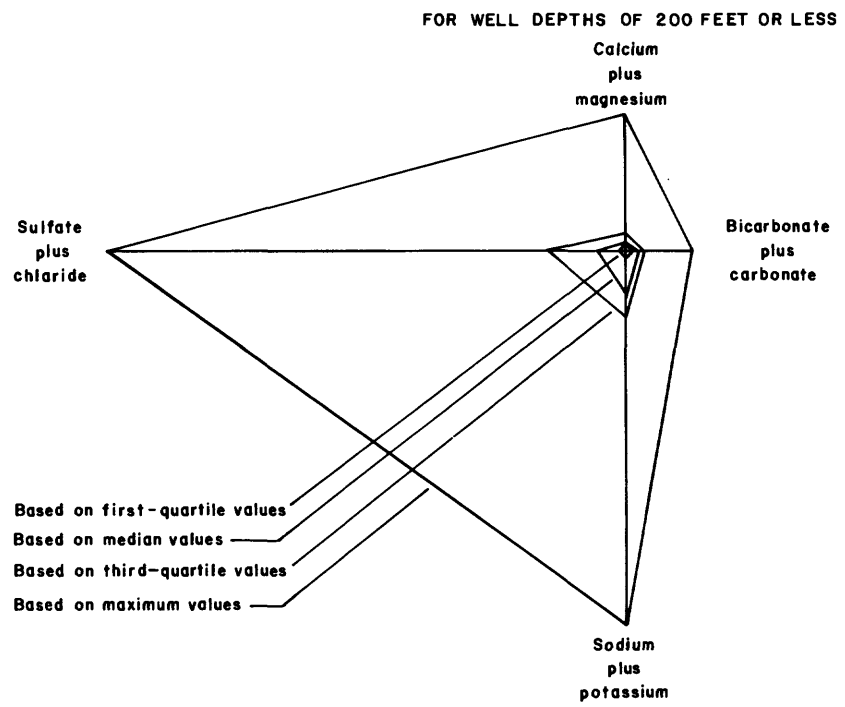


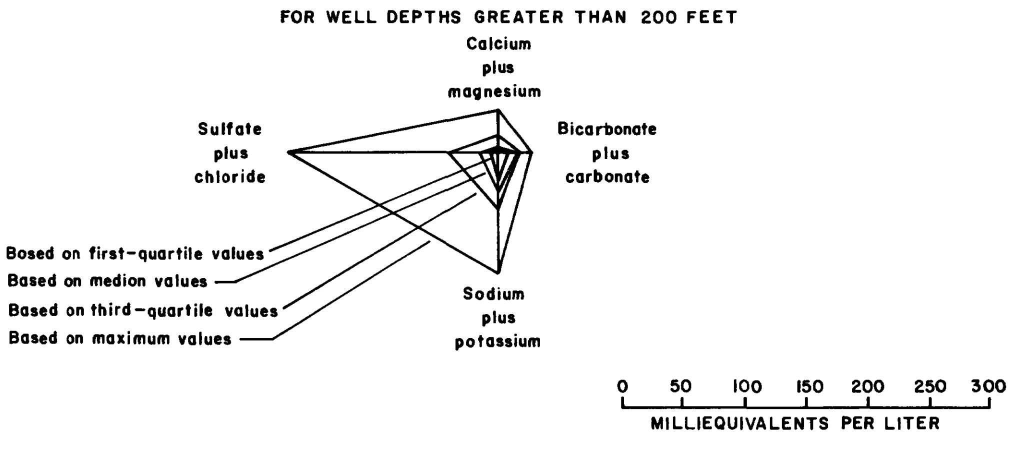


Figure 14.--Composition of water from the combined Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana. Data are not available for wells completed in the Parkman geohydrologic unit at depths greater than 200 feet.

Data for concentrations of many trace constituents in water from the Judith River, Two Medicine, and Parkman units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (tables 42 and 43). For water from wells 200 ft deep or less, 22 percent of 23 available data values exceeded the standard for lead, and 29 percent of 24 available data values exceeded the standard for selenium. For water from wells greater than 200 ft deep, 31 percent of 128 available data values exceeded the maximum standard for fluoride. The percentage of exceedances for other constituents from both depth intervals is less.

For the combined Judith River, Two Medicine, and Parkman units, WATSTORE contains data from five analyses for dissolved organic carbon but no data for total organic carbon or phenols. The paucity of data on organic constituents indicates that the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer.

Eagle Sandstone and associated units

The Upper Cretaceous Eagle Sandstone consists of as much as 1,200 feet of alternating beds of thin-bedded shale and sandstone, and two thin coal beds (Levings, 1982d). The thickness of the Eagle increases from west to east, where it is generally more than 600 ft thick. The regional dip of the Eagle is toward the east, although locally the dip may differ. The Virgelle Sandstone Member of the Eagle Sandstone is a beach barrier-bar deposit. The Telegraph Creek Formation underlies the Eagle and is of shallow-marine origin. The Shannon Sandstone Member of the Gammon Shale (of subsurface usage) is stratigraphically equivalent to part of the Eagle.

The Eagle, Virgelle, Telegraph Creek, and Shannon are relatively sandy sediments that probably are directly hydraulically connected, although in some areas the Shannon may be hydraulically isolated. They generally are overlain by the Claggett Shale or its equivalents and underlain by shales of the Colorado Group. Therefore, on the basis of the regional hydrology, they are considered to be one aquifer in this report.

Both unconfined and confined ground-water conditions exist in the aquifer. Recharge is mainly from infiltration of precipitation on the outcrops, which occur along the western edge of the aquifer and along the flanks of mountain ranges that interrupt the general stratigraphic sequence. Recharge may also occur from infiltration of streamflow across outcrops and from vertical leakage across confining beds. The general hydraulic gradient is from south to north in the northwest part of the aquifer and from west to east in the southern part. Discharge from the aquifer is mainly to the Missouri River. Yields to wells completed in the Eagle range from 0.5 to 200 gal/min and average about 23 gal/min (Levings, 1982d).

WATSTORE contains data from 73 chemical analyses of water from wells completed in the Eagle, Virgelle, Shannon, or Telegraph Creek geohydrologic unit. The location of the data sites is shown in figure 15. Most of the sites are located in the western part of the region near outcrop areas. The eastern part of the area of the Eagle Sandstone is essentially devoid of data sites.

The results of tests for significant differences between data from the four units are listed in tables 44-46. Considering data from all depths, no significant

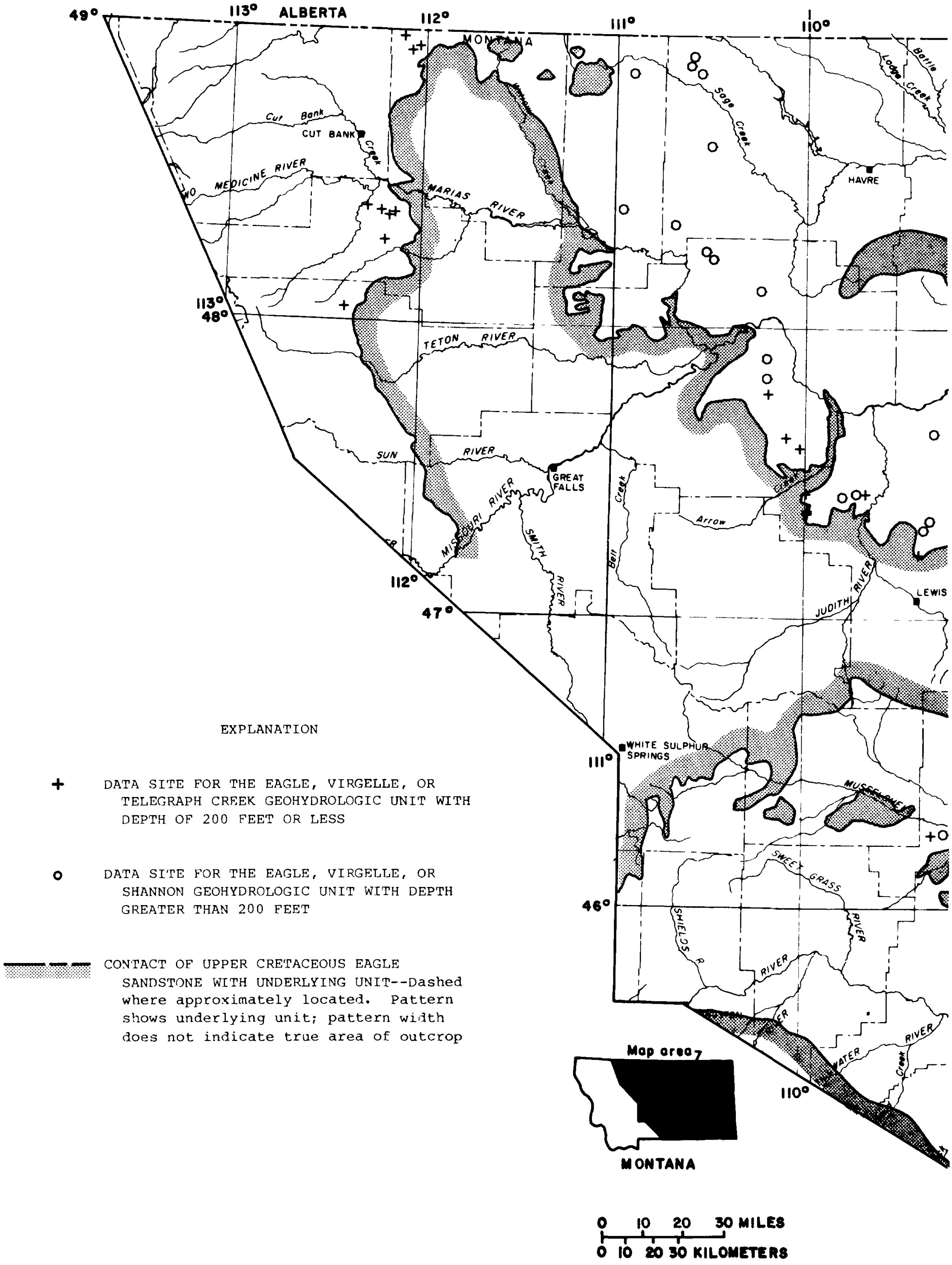
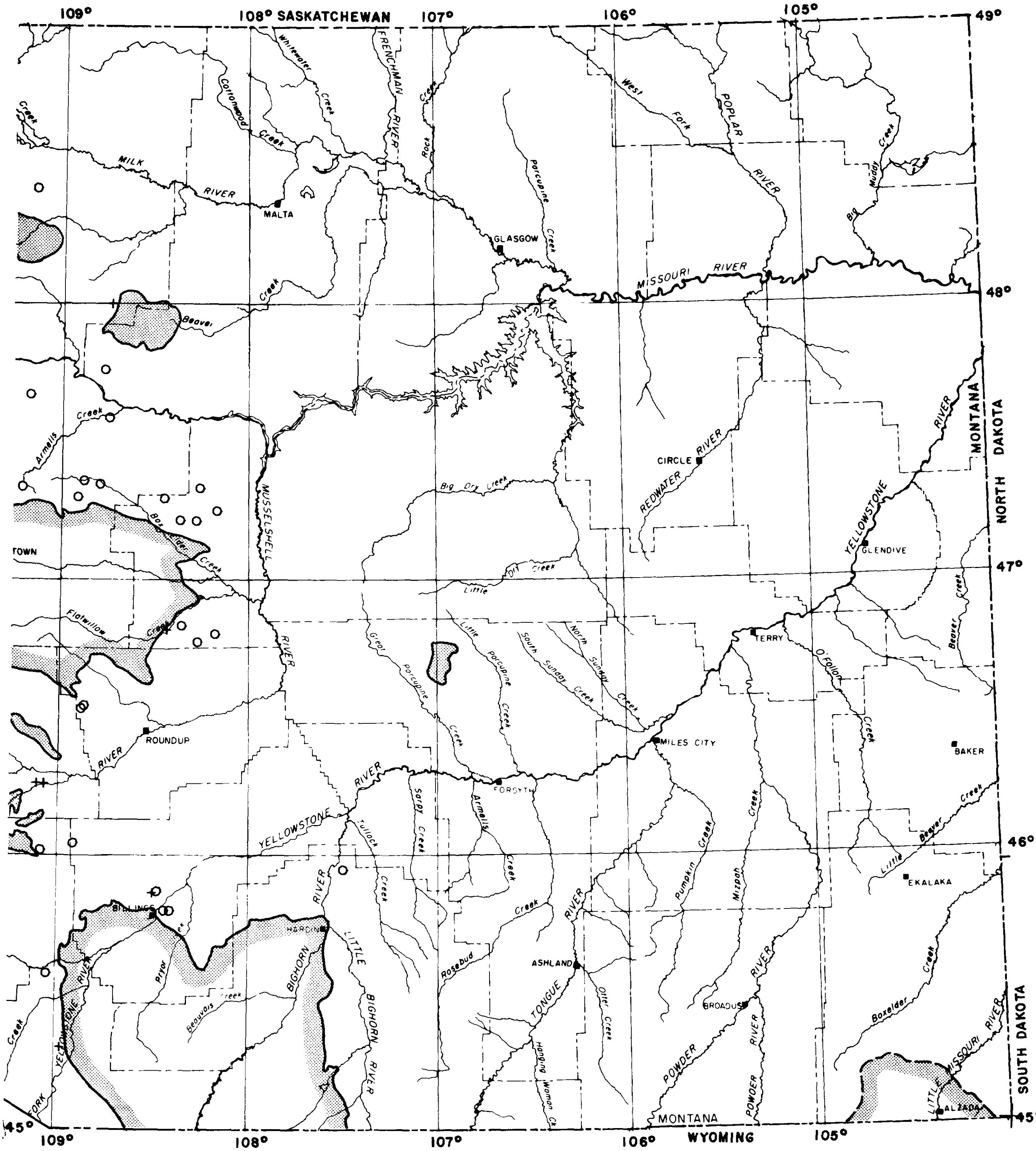


Figure 15.--Location of water-quality data sites in WATSTORE for the Eagle, Virgelle, Shannon, and Telegraph Creek geohydrologic units, eastern Montana.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FRENCHMAN RIVER
POPLAR RIVER
West Fork
Big Muddy Creek
Porcupine Creek
Rock Creek
Cottonwood Creek
Whitewater Creek
Beaver
Armells Creek
MUSSELSHELL RIVER
Big Dry Creek
Little Dry Creek
CIRCLE
REDWATER RIVER
YELLOWSTONE RIVER
GLENDIVE
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MILES CITY
FORSYTH
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HARDIN
ASHLAND
BROADUS
BAKER
EKALAKA
ALZADA
TOWN
Flatwillow Creek
Great Porcupine Creek
Little Porcupine Creek
South Sunday Creek
North Sunday Creek
O'Fallon Creek
Beaver Creek
Little Beaver Creek
Sarpy Creek
Armells Creek
Tullock Creek
Rosebud Creek
TONGUE RIVER
Pumpkin Creek
Mizpah Creek
POWDER RIVER
Otter Creek
Hanging Woman Ck.
BIGHORN RIVER
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Pryor
Beauvais Creek
Boxelder Creek
LITTLE MISSOURI RIVER
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING

difference exists between the units at the 0.05 significance level for pH, calcium, magnesium, carbonate, sulfate, and silica. If the Shannon, for which only one analysis is available, is omitted, then no significant difference exists for all listed constituents. Considering only data from well depths of 200 ft or less, no significant difference exists between the units for all constituents, although no data are available for the Shannon. Considering only data from well depths greater than 200 ft, no significant difference exists between the units for pH, magnesium, bicarbonate, carbonate, sulfate, chloride, and silica, although no data are available for the Telegraph Creek. No significant difference exists for all constituents if only the Eagle and Virgelle are considered. Therefore, on the basis of the data, all four geohydrologic units are considered to have similar water quality, although the one analysis for the Shannon is significantly different for some constituents. Statistical data are available for analyses, differentiated by well depth (tables 47 and 48).

Diagrams (fig. 16) show the composition of water from the combined Eagle, Virgelle, Shannon, and Telegraph Creek geohydrologic units. Based on the quartile values for water from wells 200 ft or less in depth, sodium plus potassium and sulfate plus chloride tend to be the predominant ion pairs. For water from wells greater than 200 ft deep, sodium plus potassium are the predominant cation pair. Bicarbonate plus carbonate tend to be the predominant anion pair at smaller quartile values, and sulfate plus chloride tend to be the predominant anion pair at larger quartile values. The relative largeness of maximum values for sulfate plus chloride and sodium plus potassium for water from wells deeper than 200 ft is due mainly to large sodium and chloride values for the analysis of water from the Shannon.

Spearman-rank correlation coefficients were determined for selected variables in water from the Eagle and associated units (tables 49 and 50). Considering depths of 200 ft or less, the most significant correlation (largest coefficient) is between calcium and magnesium (0.95 based on 26 data values) and is positive. Another significant correlation exists between dissolved solids and sulfate (0.93 based on 26 data values) and is positive. Considering depths greater than 200 ft, the most significant correlation is between calcium and magnesium (0.91 based on 44 data values) and is positive. On the basis of these correlations, the dissolved-solids concentrations in water from wells 200 ft deep or less can be inferred to be largely affected by the dissolution of sulfate minerals. However, considering depths greater than 200 ft, such an inference cannot be made.

Data for concentrations of trace constituents in water from the Eagle, Virgelle, Shannon, and Telegraph Creek geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (tables 51 and 52). For water from wells 200 ft deep or less, 27 percent of 15 available data values exceeded the standard for lead and 21 percent of 19 available data values exceeded the standard for selenium. For water from wells greater than 200 ft deep, 34 percent of 44 available data values exceeded the standard for fluoride. The percentage of exceedances for other constituents from both depth intervals is less.

WATSTORE contains data for seven analyses for dissolved organic carbon in water from the Eagle, but no data for total organic carbon or phenols from any of the four geohydrologic units. The paucity of data for organic constituents indicates that the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer.

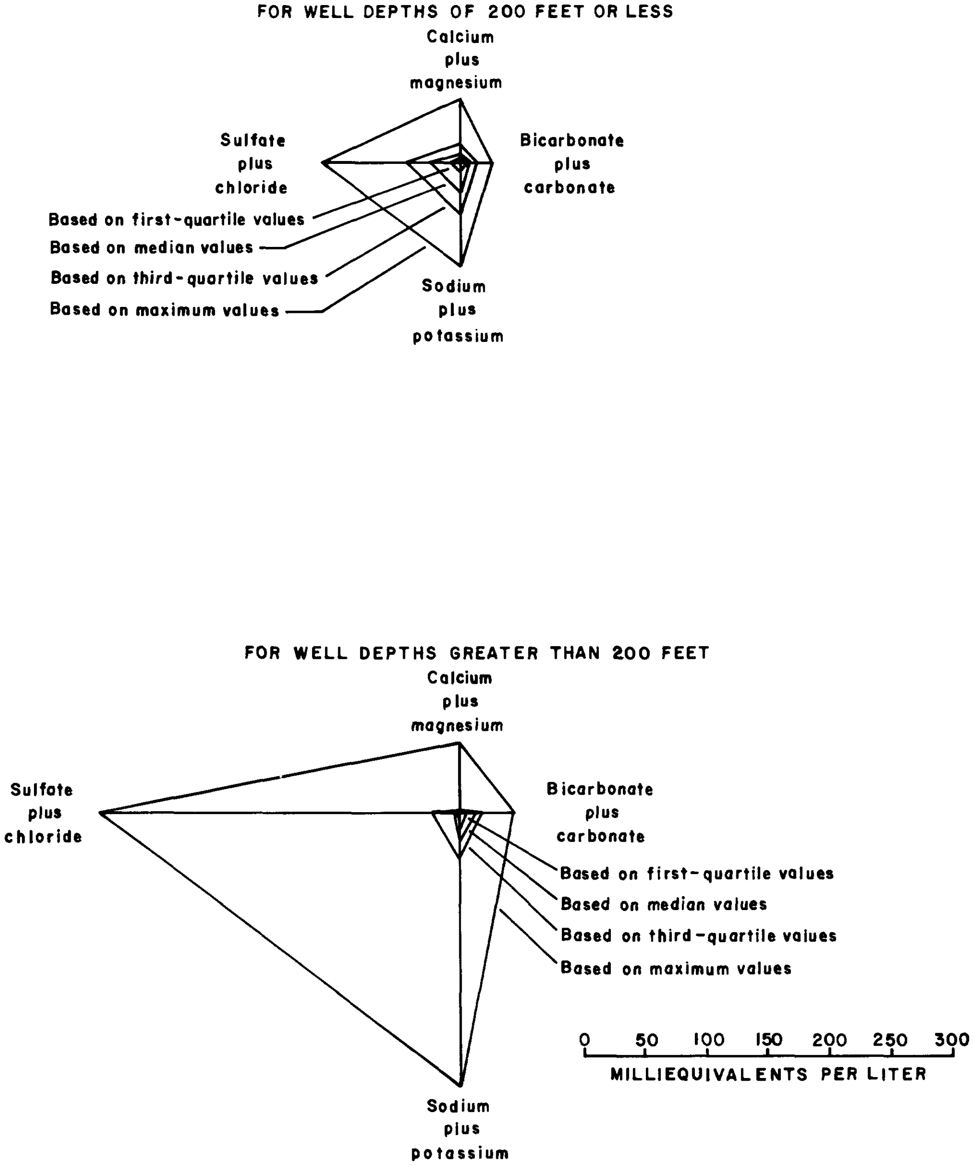


Figure 16.--Composition of water from the combined Eagle, Virgelle, Shannon, and Telegraph Creek geohydrologic units, eastern Montana. Data are not available for wells completed in the Shannon geohydrologic unit at depths of 200 feet or less or in the Telegraph Creek geohydrologic unit at depths greater than 200 feet.

Kootenai Formation and associated units

The Lower Cretaceous Kootenai Formation consists of as much as 580 ft of fluvial sandstone, conglomerate, siltstone, and shale (Levings, 1983). The lower part of the Kootenai consists primarily of thick crossbedded "salt and pepper" fluvial sandstone and chert-pebble conglomerate, and is referred to as the Third Cat Creek sandstone in local subsurface terminology. The lower part is equivalent to the Lakota Sandstone of eastern and southeastern Montana. The middle part of the Kootenai consists of sandstone lenses interspersed with siltstone and shale and is generally referred to as the Second Cat Creek sandstone in local subsurface terminology. The upper part of the Kootenai consists primarily of shale and siltstone and is overlain by the Lower and Upper Cretaceous Colorado Group. Near the base of the Colorado Group is a very fine grained sandstone generally referred to as the First Cat Creek sandstone in local subsurface terminology or as the Fall River Sandstone.

The Kootenai Formation and First Cat Creek sandstone are overlain by shales of the Colorado Group and are underlain by the Upper Jurassic Morrison Formation, which consists primarily of shale, siltstone, thin limestone beds, and lenticular sandstone. Although the First Cat Creek sandstone and the sandstones within the Kootenai Formation may or may not be directly hydraulically connected, they lie between the thick confining beds of the Colorado Group and the Morrison Formation. Therefore, on the basis of the hydrology, the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River are considered as one aquifer in this report.

Both unconfined and confined ground-water conditions exist in the aquifer, although confined conditions predominate. Recharge is from infiltration of precipitation in outcrop areas, infiltration of streamflow across outcrops, and vertical leakage across confining beds. The general hydraulic gradient in the Lakota Sandstone is to the east and north. Discharge probably occurs primarily as vertical leakage across confining beds and as yields to wells. Yields from wells completed in the Lakota Sandstone range from 1 to about 90 gal/min and average 29 gal/min (Levings, 1982b).

WATSTORE contains data from 158 chemical analyses of water from wells completed in the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, or Fall River geohydrologic unit. The location of data sites is shown in figure 17. Most of the data sites are located in the west-central part of the area of the Kootenai Formation. The rest of the area is essentially devoid of data sites.

The results of tests for significant differences between data from these units are listed in tables 53-55. Considering data from all well depths, no significant difference exists between the five units at the 0.05 significance level for calcium, magnesium, silica, and dissolved solids. If the Second Cat Creek and Fall River units, each of which have only one available analysis, are omitted, then no significant difference exists for all the listed constituents. Considering only data from well depths of 200 ft or less, no significant difference exists between the units for all constituents, although no data are available for the Second Cat Creek and Fall River units. Considering only data from well depths greater than 200 ft, the results are the same as when considering data from all depths. Therefore, on the basis of the data, all five geohydrologic units can be considered to have similar water quality. Statistical data are available for the analyses, differentiated by depth (tables 56 and 57).

Diagrams (fig. 18) show the composition of water from the combined Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River units. Based on all quartile values for water from wells 200 ft or less in depth, calcium plus magnesium and bicarbonate plus carbonate tend to be the predominant ion pairs. For water from wells greater than 200 ft deep, sodium plus potassium tend to be the predominant cation pair and bicarbonate plus carbonate tend to be the predominant anion pair, although for maximum values sulfate plus chloride are the predominant anion pair.

Spearman-rank correlation coefficients were determined for selected variables in water from the Kootenai and associated units (tables 58 and 59). Considering well depths of 200 ft or less, the most significant correlation (largest coefficient) is between dissolved solids and sulfate (0.78 based on 36 data values) and is positive. Considering well depths greater than 200 ft, the most significant correlation is between calcium and magnesium (0.90 based on 120 data values) and is positive. Another significant correlation is between calcium and sodium (-0.80 based on 118 data values) and is negative. The correlation between dissolved solids and sulfate (0.72 based on 120 data values) is not quite as significant as for depths of 200 ft or less. Based on the correlations, the dissolved-solids concentrations for both depth intervals can be inferred to be affected by the dissolution of sulfate minerals. For depths greater than 200 ft, cation exchange can be inferred to be a predominant process.

Data for concentrations of trace constituents in water from the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (tables 60 and 61). For water from wells 200 ft deep or less, 11 percent of the 27 available data values exceeded the standard for lead and 7 percent of 27 available data values exceeded the standard for cadmium. Two of five data values exceeded the standard for mercury, but owing to possible contamination during sampling and analysis, these exceedances may or may not be representative of the aquifer. For water from wells greater than 200 ft deep, 7 percent of 121 available data values exceeded the standard for fluoride. The percentage of exceedances for other constituents is less.

WATSTORE contains data for 12 analyses from the Kootenai, 1 from the First Cat Creek, and 1 from the Third Cat Creek for dissolved organic carbon, but no data for total organic carbon or phenols from any of the five geohydrologic units. The paucity of data for organic constituents indicates that the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer.

Ellis Group

The Upper and Middle Jurassic Ellis Group consists of the Swift, Rierdon, Piper, and Sawtooth Formations. The Swift Formation primarily consists of marine glauconitic sandstone and shale that become calcareous eastward (Imlay and others, 1948). The Swift ranges in thickness from about 100 ft in the west to about 800 ft at some locations in the east; the average thickness probably is less than 200 ft (Feltis, 1982f). The cumulative sandstone thickness ranges from about 25 ft to 200 ft, increasing westward (Feltis, 1982e). The regional dip of the Swift is generally eastward, although many local variations exist (Feltis, 1982d). The Rierdon Formation underlies the Swift and consists of as much as 240 ft of calcareous gray shale and gray limestone (Imlay and others, 1948). The Piper Formation underlies the Rierdon in most of eastern Montana and consists of as much as 300 ft of gypsum, gray shale, limestone, dolomite, siltstone, and sandstone (Imlay and others, 1948). The Sawtooth Formation is equivalent to the Piper and underlies the Rierdon in the western part of eastern Montana. The Sawtooth consists of as much as 230 ft of limestone, shale, and sandstone (Imlay and others, 1948).

Existing data are insufficient to show whether or not the formations of the Ellis Group are directly hydraulically connected. However, the entire Ellis Group

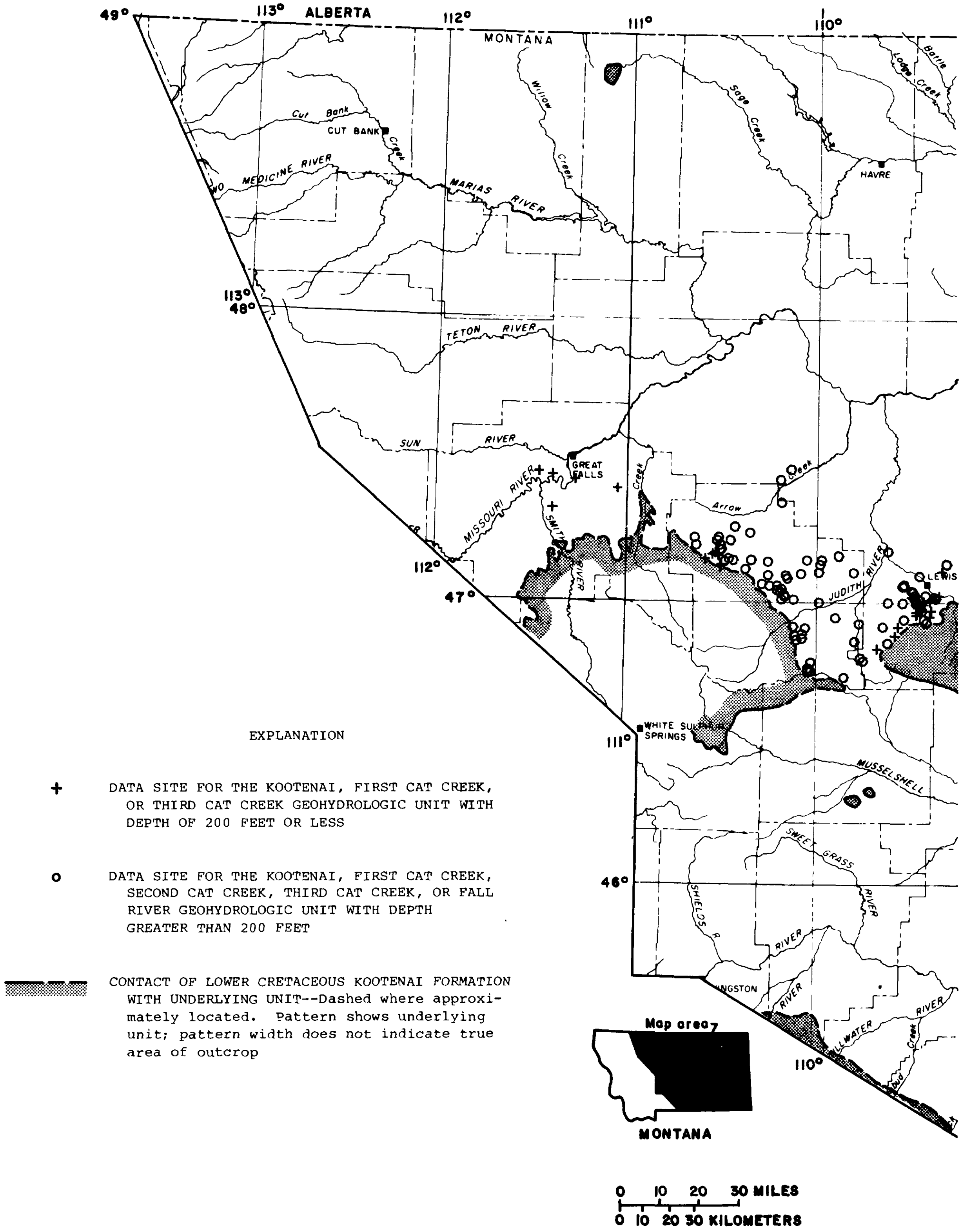
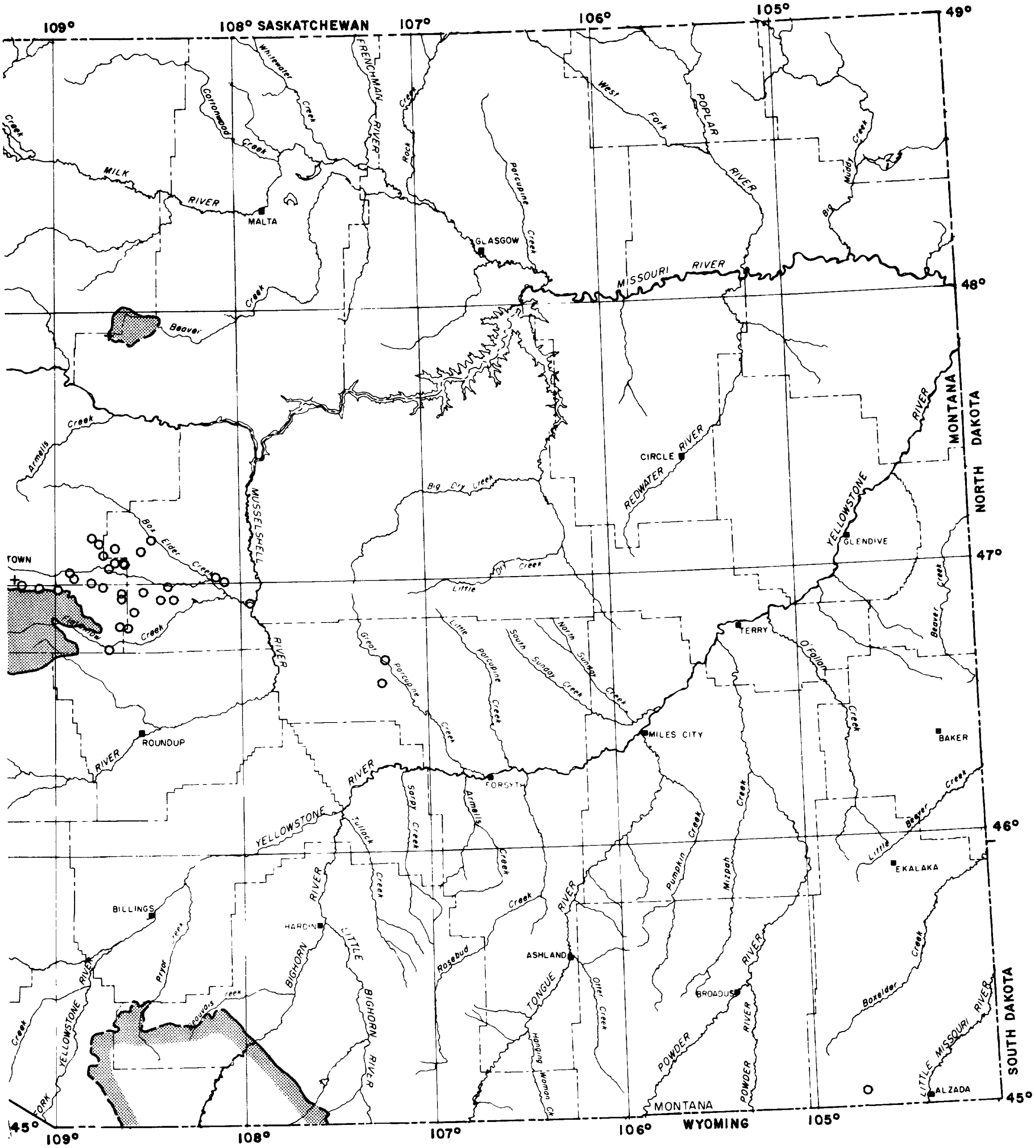


Figure 17.--Location of water-quality data sites in WATSTORE for the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana.


SASKATCHEWAN
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
MILK RIVER
MALTA
GLASGOW
MISSOURI RIVER
POPLAR RIVER
FRENCHMAN RIVER
MUSSELSHELL RIVER
REDWATER RIVER
CIRCLE
YELLOWSTONE RIVER
GLENDIVE
TERRY
MILES CITY
FORSYTH
ROUNDUP
BILLINGS
HARDIN
ASHLAND
BROADUS
BAKER
EKALAKA
ALZADA
BIGHORN RIVER
LITTLE BIGHORN RIVER
TONGUE RIVER
POWDER RIVER
LITTLE MISSOURI RIVER

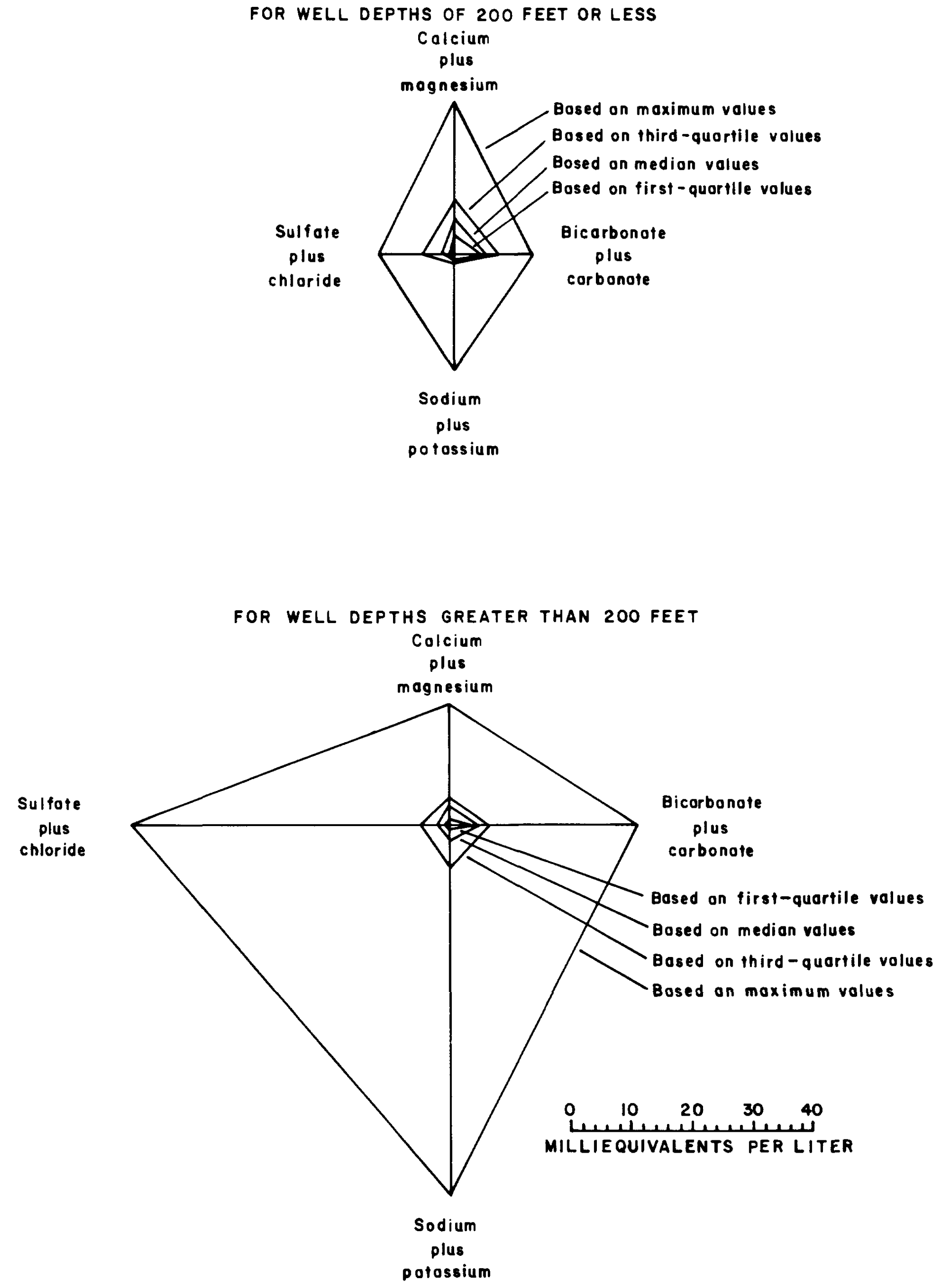


Figure 18.--Composition of water from the combined Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana.

is considered as one aquifer in this report. The Ellis Group is overlain by the Upper Jurassic Morrison Formation, which functions as a confining bed in most areas.

Both unconfined and confined conditions exist in the aquifer. Recharge probably occurs from infiltration of precipitation on the outcrops, streamflow across outcrops, and from vertical leakage across confining beds. The direction of the hydraulic gradient is unknown, but probably trends in a general west to east direction somewhat resembling the direction of dip. Discharge from the aquifer has been shown to be by upward vertical leakage in some areas (Levings, 1983).

WATSTORE contains data from 22 chemical analyses of water from wells completed in the Ellis, Swift, Rierdon, or Piper geohydrologic unit. No data are available for the Sawtooth. The location of the data sites is shown in figure 19. Most of the data sites are located in the west-central part of the area of Jurassic formations. The rest of the area is essentially devoid of data sites.

The results of tests for significant differences between data from the four units are listed in table 62. Considering data from all well depths, no significant difference exists between the units at the 0.05 significance level for any of the listed constituents. Therefore, on the basis of the data, all four geohydrologic units can be considered to have similar water quality, although only two analyses are available for the Ellis, one analysis for the Rierdon, and two analyses for the Piper geohydrologic units. Statistical data are available for all analyses combined (table 63). The number of analyses is insufficient to differentiate by depth.

A diagram (fig. 20) shows the composition of water from the combined geohydrologic units. Based on first-quartile and median values, calcium plus magnesium and bicarbonate plus carbonate tend to be the predominant ion pairs. Based on third-quartile and maximum values, calcium plus magnesium and sulfate plus chloride tend to be the predominant ion pairs.

Spearman-rank correlation coefficients were determined for selected variables in water from the combined Ellis, Swift, Rierdon, and Piper geohydrologic units (table 64). The most significant correlation (largest coefficient) is between calcium and magnesium (0.87 based on 22 data values) and is positive. Other significant correlations are between calcium and sulfate (0.83 based on 22 data values), sodium and fluoride (0.81 based on 19 data values), and dissolved solids and sulfate (0.81 based on 22 data values). On the basis of the correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of sulfate minerals; one of the sulfate minerals probably consists of calcium sulfate.

Data for concentrations of trace constituents in water from the Ellis, Swift, Rierdon, and Piper geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (table 65). Fourteen percent of 21 available data values exceeded the maximum standard for fluoride, and 25 percent of 8 available data values exceeded the standard for cadmium.

WATSTORE contains no data for concentrations of dissolved organic carbon, total organic carbon, or phenols in water from the Ellis, Swift, Rierdon, or Piper geohydrologic units. Therefore, the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer.

Madison Group

The Mississippian Madison Group consists primarily of the Charles Formation, Mission Canyon Limestone, and the Lodgepole Limestone. The Charles Formation consists primarily of the marine evaporites anhydrite and halite, interbedded with

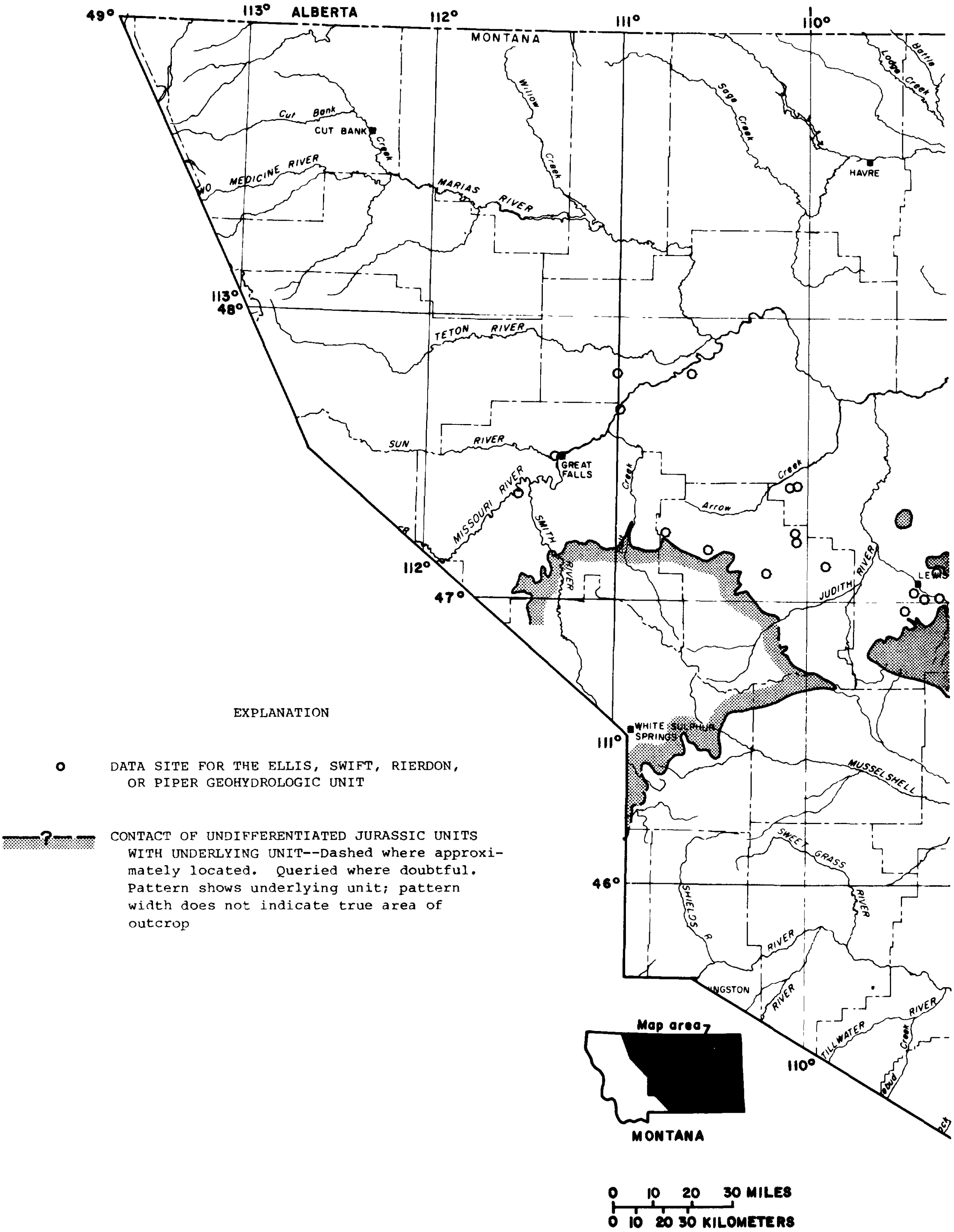
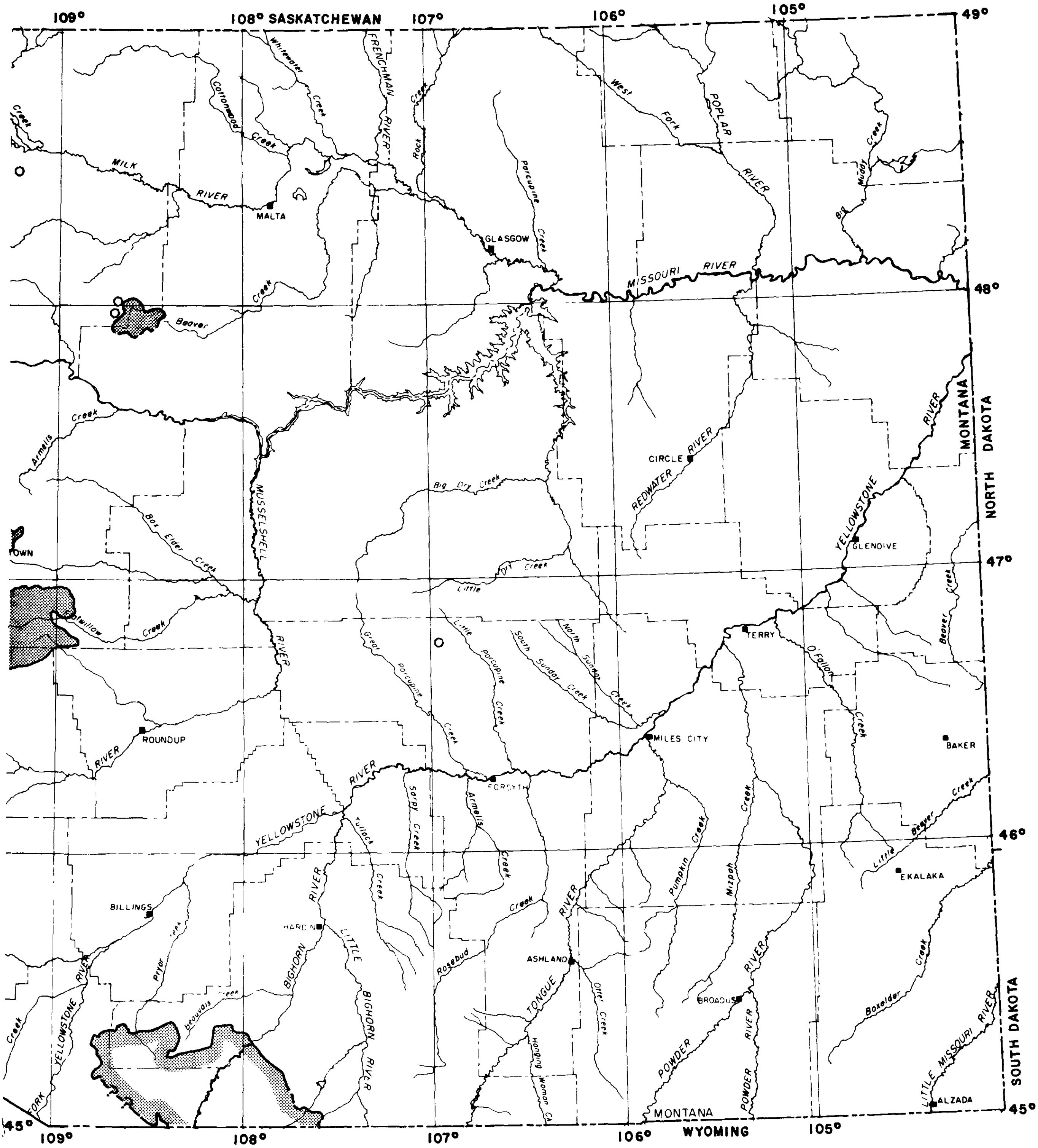


Figure 19.--Location of water-quality data sites in WATSTORE for the Ellis, Swift, Rierdon, and Piper geohydrologic units, eastern Montana.


109°
108° SASKATCHEWAN
107°
106°
105°
49°
48°
47°
46°
45°
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
MILK RIVER
MALTA
GLASGOW
MISSOURI RIVER
FRENCHMAN RIVER
Whitewater Creek
Cottonwood Creek
Rock Creek
Porcupine Creek
West Fork POPLAR RIVER
Big Muddy Creek
Beaver Creek
Armells Creek
MUSSELSHELL RIVER
Big Dry Creek
Little Dry Creek
CIRCLE
REDWATER RIVER
YELLOWSTONE RIVER
GLENDIVE
TERRY
Box Elder Creek
Flatwillow Creek
Great Porcupine Creek
Little Porcupine Creek
South Sunday Creek
North Sunday Creek
O'Fallon Creek
Beaver Creek
ROUNDUP
MILES CITY
BAKER
FORSYTH
Sarpy Creek
Armells Creek
Tullock Creek
Little Beaver Creek
EKALAKA
BILLINGS
HARDIN
BIGHORN RIVER
LITTLE BIGHORN RIVER
Rosebud Creek
TONGUE RIVER
ASHLAND
Pumpkin Creek
Mizpah Creek
POWDER RIVER
BROADUS
Otter Creek
Hanging Woman Cr.
Boxelder Creek
LITTLE MISSOURI RIVER
ALZADA
Pryor Creek
Beauvais Creek
YELLOWSTONE RIVER
Creek
FORK
MONTANA
OWN

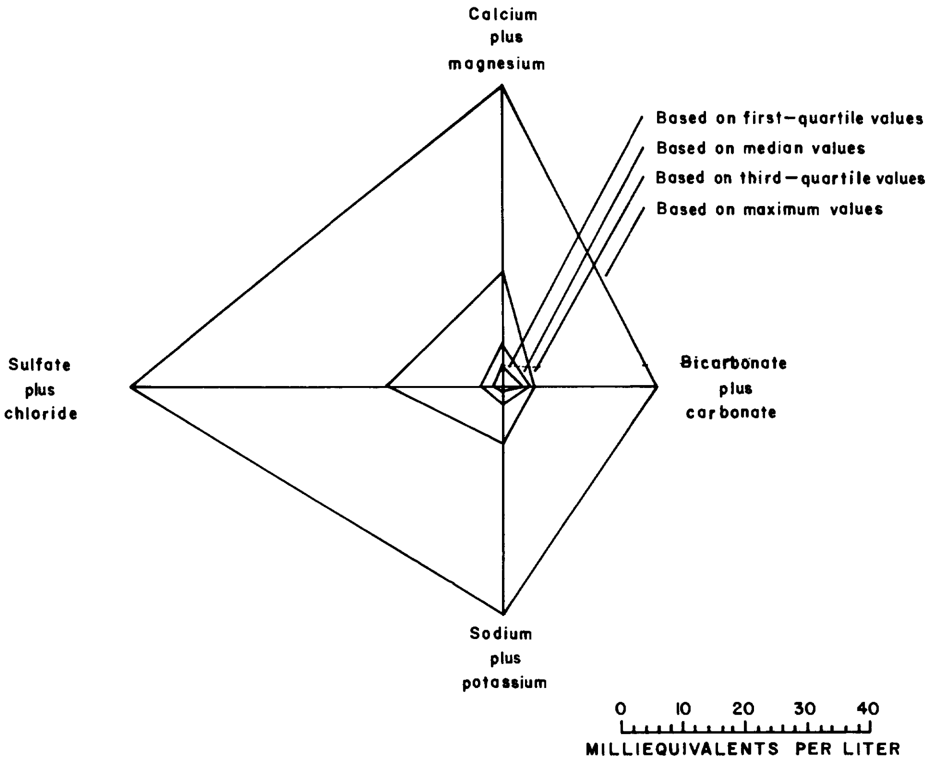


Figure 20.--Composition of water from the combined Ellis, Swift, Rierdon, and Piper geohydrologic units, eastern Montana.

limestone, dolomite, and argillaceous layers. The Mission Canyon Limestone consists of massive fine to coarse crystalline limestone with evaporites near the top. The Lodgepole Limestone is primarily limestone and dolomite interbedded with thin argillaceous layers. The thickness of the Madison Group generally ranges from about 800 to 2,000 ft (Downey, 1982). Although the lithology changes both vertically and laterally within the State, the Madison Group is considered as one aquifer in this report.

Both unconfined and confined conditions exist in the aquifer. Recharge occurs from infiltration of precipitation on outcrop areas, which occur mainly in mountain areas, from infiltration of streamflow across outcrops, and from vertical leakage across confining beds. The general directions of the hydraulic gradient are north and east. Flow through the aquifer is by primary, or intergranular, permeability and by secondary permeability resulting from fractures and solution cavities. Discharge from the aquifer is to wells, springs, and streams; to adjacent aquifers by vertical leakage; and by horizontal flow out of the State.

WATSTORE contains data from 82 chemical analyses of water from wells completed in the Madison, Charles, and Mission Canyon geohydrologic units. No data are available for the Lodgepole. Location of the data sites is shown in figure 21. Although the data sites are distributed throughout the area of Mississippian formations, the density of coverage is sparse. Statistical data for all analyses from the three geohydrologic units are listed in table 66. Because large variations in the chemical quality of water exist both laterally and vertically within the aquifer and because only 20 of the analyses contain information on the depth of the well, no attempt was made to differentiate between the geohydrologic units that comprise the aquifer or to differentiate analyses by depth.

A diagram (fig. 22) shows the composition of water from the combined geohydrologic units. Based on first-quartile and median values, calcium plus magnesium and sulfate plus chloride tend to be the predominant ion pairs. Based on third-quartile values, sodium plus potassium and sulfate plus chloride tend to be the predominant ion pairs. Maximum values are not included, owing to the very large concentrations of sodium and chloride, which plot off scale.

Spearman-rank correlation coefficients were determined for selected variables in water from the Madison, Charles, and Mission Canyon units (table 67). The most significant correlation (largest coefficient) is between sodium and chloride (0.95 based on 64 data values) and is positive. Other significant correlations include those between calcium and sulfate (0.87 based on 82 data values), dissolved solids and calcium (0.92 based on 81 data values), dissolved solids and sodium (0.88 based on 64 data values), and dissolved solids and sulfate (0.87 based on 81 data values). Based on these correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of sulfate and chloride minerals. The sulfate minerals probably consist largely of calcium sulfate and the chloride minerals probably consist largely of sodium chloride.

Data for concentrations of trace constituents in water from the Madison, Charles, and Mission Canyon geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (table 68). Thirty-four percent of 58 available data values exceeded the maximum standard for fluoride and 21 percent of 34 available data values exceeded the standard for cadmium. The percentage of exceedance for lead is 3 percent of 34 available data values.

WATSTORE contains data from only one analysis for dissolved organic carbon from the combined Madison, Charles, and Mission Canyon geohydrologic units and no data for total organic carbon or phenols. The paucity of data on organic constituents in WATSTORE indicates that the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer system.

Western Montana

Ground-water-quality data are available for selected water-yielding geohydrologic units in western Montana. The western part of Montana primarily consists of Precambrian metasedimentary rocks and Cretaceous and Tertiary igneous rocks, with Tertiary basin-fill deposits and Quaternary alluvium and terrace deposits in the valleys (table 2). Glacial deposits are also found in valleys in parts of the region. The metasedimentary and igneous rocks are not widely used as a source of water, although small supplies can be obtained in some areas. The basin-fill deposits generally are not used as a source of water because of the great depth of occurrence and poor water-yielding characteristics, although exceptions occur. In western Montana, the alluvium and terrace and glacial deposits are the most widely used sources of ground water, owing to near-surface occurrence and generally favorable water-yielding characteristics.

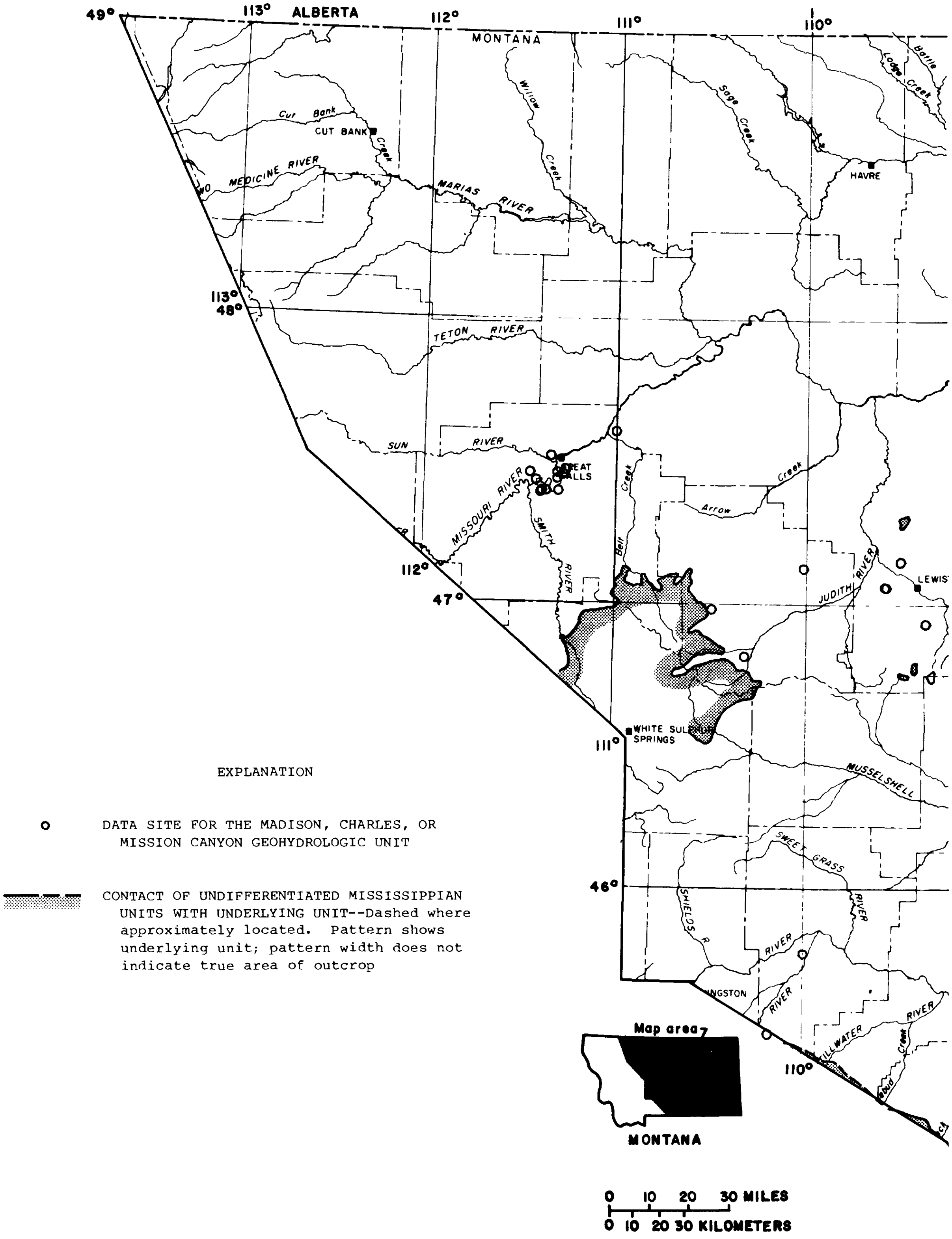
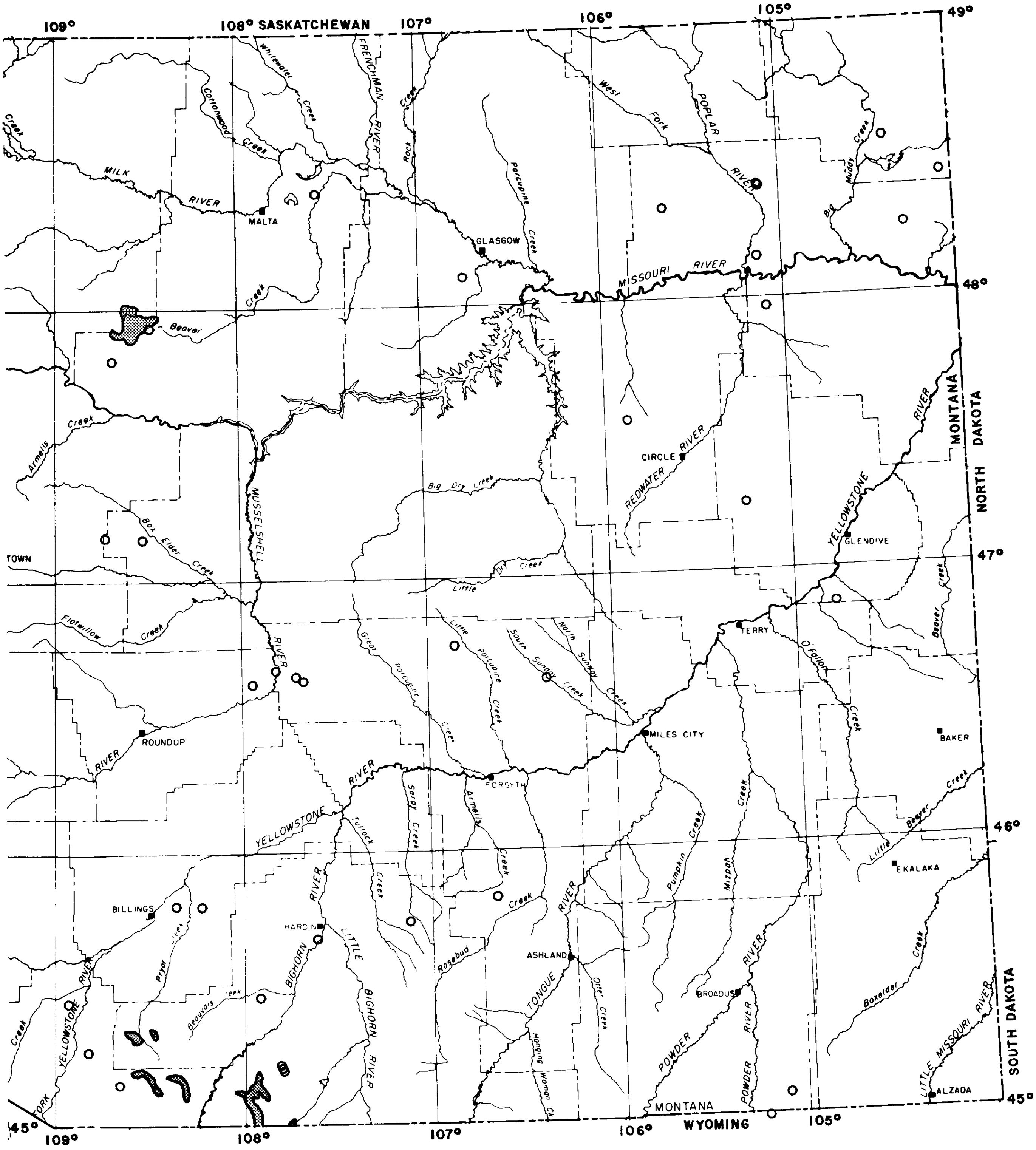


Figure 21.--Location of water-quality data sites in WATSTORE for the Madison, Charles, and Mission Canyon geohydrologic units, eastern Montana.



109°
108° SASKATCHEWAN
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48°
47°
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MILK RIVER
MALTA
GLASGOW
MISSOURI RIVER
FRENCHMAN RIVER
POPLAR RIVER
West Fork
Porcupine Creek
Rock Creek
Whitewater Creek
Cottonwood Creek
Big Muddy Creek
Beaver Creek
Armells Creek
MUSSELSHELL RIVER
Box Elder Creek
Flatwillow Creek
ROUNDUP
TOWN
Big Dry Creek
Little Dry Creek
CIRCLE
REDWATER RIVER
YELLOWSTONE RIVER
GLENDIVE
MONTANA
NORTH DAKOTA
TERRY
O'Fallon Creek
Beaver Creek
BAKER
MILES CITY
Great Porcupine Creek
Little Porcupine Creek
South Sunday Creek
North Sunday Creek
FORSYTH
Sarpy Creek
Armells Creek
Tullock Creek
Rosebud Creek
BILLINGS
HARDIN
BIGHORN RIVER
LITTLE BIGHORN RIVER
Pryor Creek
Beauvais Creek
ASHLAND
TONGUE RIVER
Otter Creek
Hanging Woman Cr.
Pumpkin Creek
Mizpah Creek
POWDER RIVER
BROADUS
Little Beaver Creek
EKALAKA
Boxelder Creek
LITTLE MISSOURI RIVER
ALZADA
SOUTH DAKOTA
MONTANA
WYOMING
CLARKS FORK YELLOWSTONE RIVER

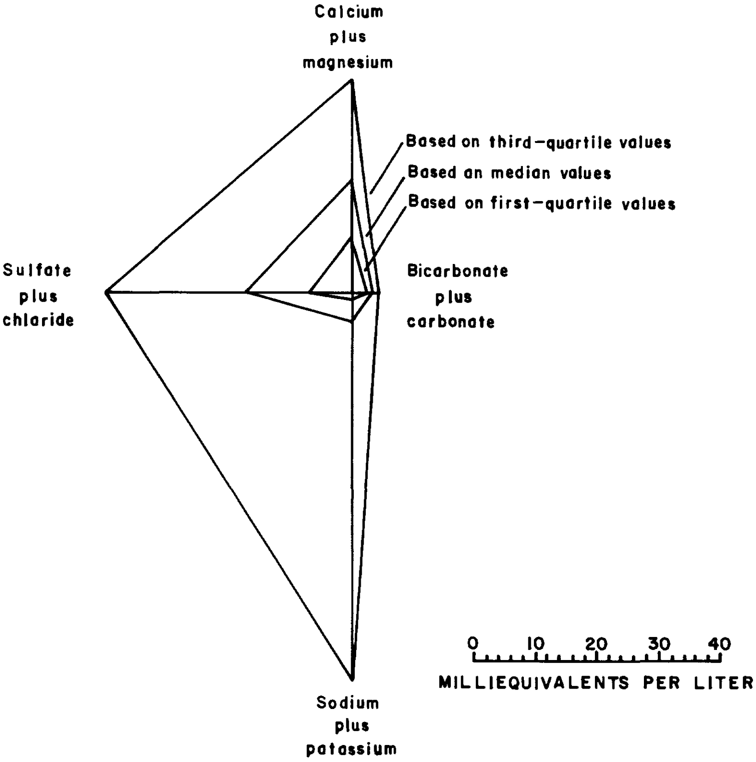


Figure 22.--Composition of water from the combined Madison, Charles, and Mission Canyon geohydrologic units, eastern Montana.

Alluvium and terrace deposits

Holocene alluvium and terrace deposits primarily consist of unconsolidated clay, silt, sand, and gravel. Generally, they are located along existing streams and probably are less than several hundred feet thick.

Where physically connected, the alluvium and terrace deposits probably are hydraulically connected and can be considered as one aquifer. Water in the aquifers generally is unconfined, although clay lenses may result in locally confined conditions. Recharge results from infiltration of precipitation and streamflow, lateral flow from adjacent aquifers, and vertical flow from underlying aquifers. The hydraulic gradient generally trends in a downstream direction or from topographically high areas to topographically low areas. Discharge is to streamflow, evapotranspiration, and vertical and lateral flow to adjoining aquifers.

WATSTORE contains data from 212 chemical analyses of water from wells completed in the alluvium or terrace-deposits geohydrologic units. The location of data sites is shown in figure 23. Most of the data sites are located near the cities of Helena and Missoula.

The results of tests for significant differences between chemical data for water from the two units are listed in table 69. Considering data from all well depths, no significant difference exists between the units at the 0.05 significance level for any of the listed constituents, although only one analysis is available for the terrace-deposits unit. Therefore, on the basis of the data, the two geohydrologic units can be considered to have similar water quality. Statistical data are available for water from the combined alluvium and terrace-deposits geohydrologic units (table 70). The number of analyses and distribution of depth data are insufficient to differentiate by depth.

A diagram (fig. 24) shows the composition of water for the combined units. Based on first-quartile, median, and third-quartile values, calcium plus magnesium and bicarbonate plus carbonate tend to be the predominant ion pairs. Based on maximum values, calcium plus magnesium and sulfate plus chloride tend to be the predominant ion pairs.

Spearman-rank correlation coefficients were determined for selected variables in water from the combined alluvium and terrace-deposits units (table 71). The most significant correlation (largest coefficient) is between calcium and bicarbonate (0.94 based on 204 data values) and is positive. Other significant correlations include those between sodium and chloride (0.88 based on 212 data values), and dissolved solids and calcium, sodium, bicarbonate, sulfate, and chloride (0.78 to 0.89 based on from 204 to 212 data values each). Based on the correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of carbonate, sulfate, and chloride minerals.

Data for concentrations of trace constituents in water from the alluvium and terrace geohydrologic units are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given (table 72). Ten percent of 39 data values exceeded the standard for lead and 1 percent of 181 data values exceeded the standard for nitrate.

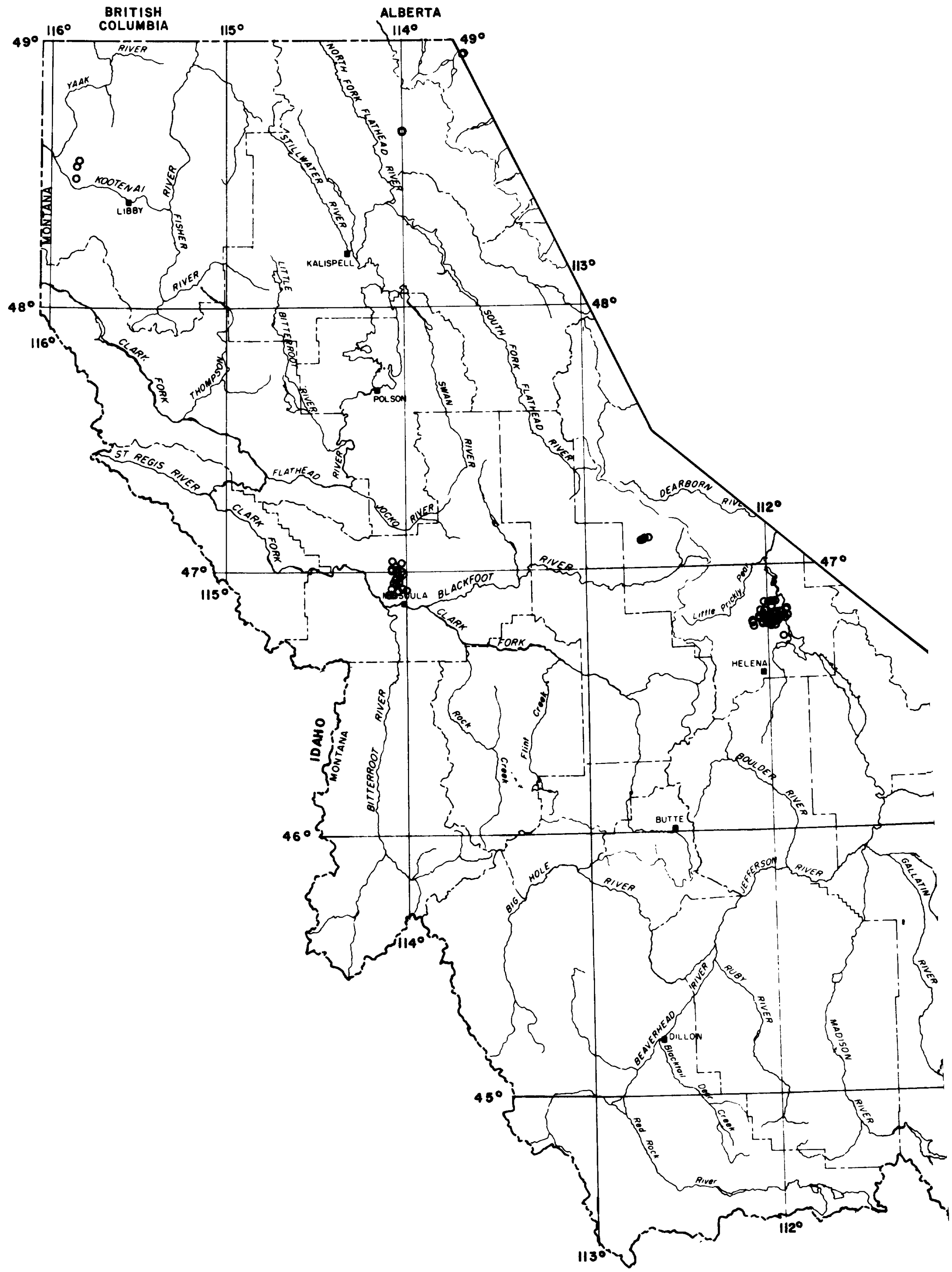
WATSTORE contains no data on the concentrations of dissolved organic carbon, total organic carbon, or phenols for the alluvium and terrace geohydrologic units. Therefore, the data file is inadequate to detect any organic effects of man's activities on the water quality in this aquifer.

Glacial deposits

Pleistocene glacial deposits are composed of unconsolidated clay, silt, sand, and gravel. These deposits generally are located in the intermontane areas of western Montana and generally are less than several hundred feet thick. All these deposits can transmit significant quantities of water, at least in some areas, and therefore are considered to be aquifers.

Water in the aquifers generally is unconfined, although locally confined conditions may exist. Recharge results from infiltration of precipitation and streamflow and from vertical and lateral flow from adjoining aquifers. The direction of the hydraulic gradient is unknown, although it probably varies locally depending on topography and aquifer configuration. Discharge is to streamflow, evapotranspiration, and vertical and lateral flow to adjoining aquifers.

WATSTORE contains data from 94 chemical analyses of water from wells completed in glacial deposits, namely the glacial-till and glaciolacustrine-deposits geohydrologic units. The location of the data sites is shown in figure 25. Most of the data sites for the glacial till are located near Polson and most of the sites for the glaciolacustrine deposits are located near Libby.


BRITISH COLUMBIA
ALBERTA
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49°
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46°
45°
116°
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114°
113°
112°
YAAK RIVER
KOOTENAI RIVER
FISHER RIVER
LIBBY
NORTH FORK FLATHEAD RIVER
STILLWATER RIVER
KALISPELL
LITTLE BITTERROOT RIVER
POLSON
SOUTH FORK FLATHEAD RIVER
SWAN RIVER
CLARK FORK
THOMPSON
ST REGIS RIVER
FLATHEAD RIVER
JOCKO RIVER
DEARBORN RIVER
MISSOULA
BLACKFOOT RIVER
Little Prickly Pear
HELENA
BITTERROOT RIVER
Rock Creek
Flint Creek
BOULDER RIVER
BUTTE
BIG HOLE RIVER
JEFFERSON RIVER
GALLATIN RIVER
RUBY RIVER
MADISON RIVER
BEAVERHEAD RIVER
DILLON
Blacktail Deer Creek
Red Rock River

EXPLANATION

o DATA SITE FOR THE ALLUVIUM OR TERRACE-DEPOSITS GEOHYDROLOGIC UNIT

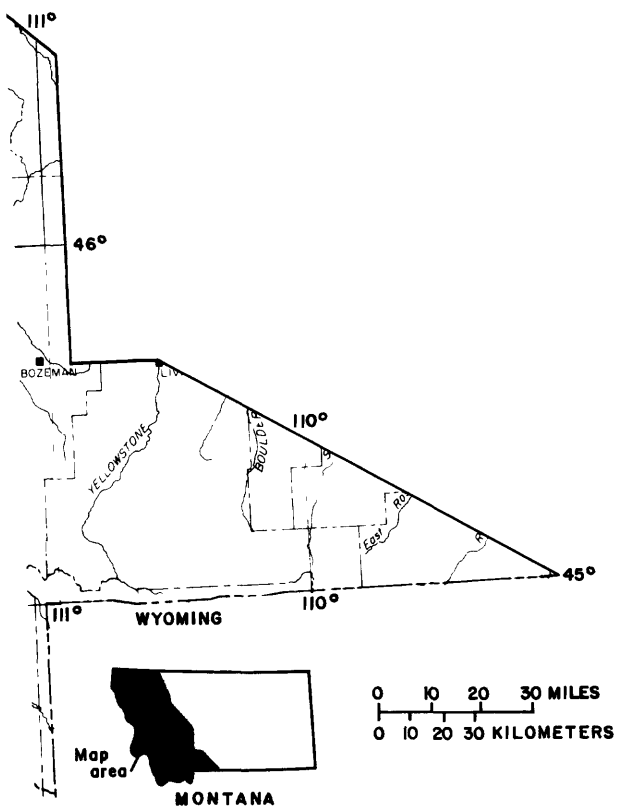


Figure 23.--Location of water-quality data sites in WATSTORE for the alluvium and terrace-deposits geohydrologic units, western Montana.

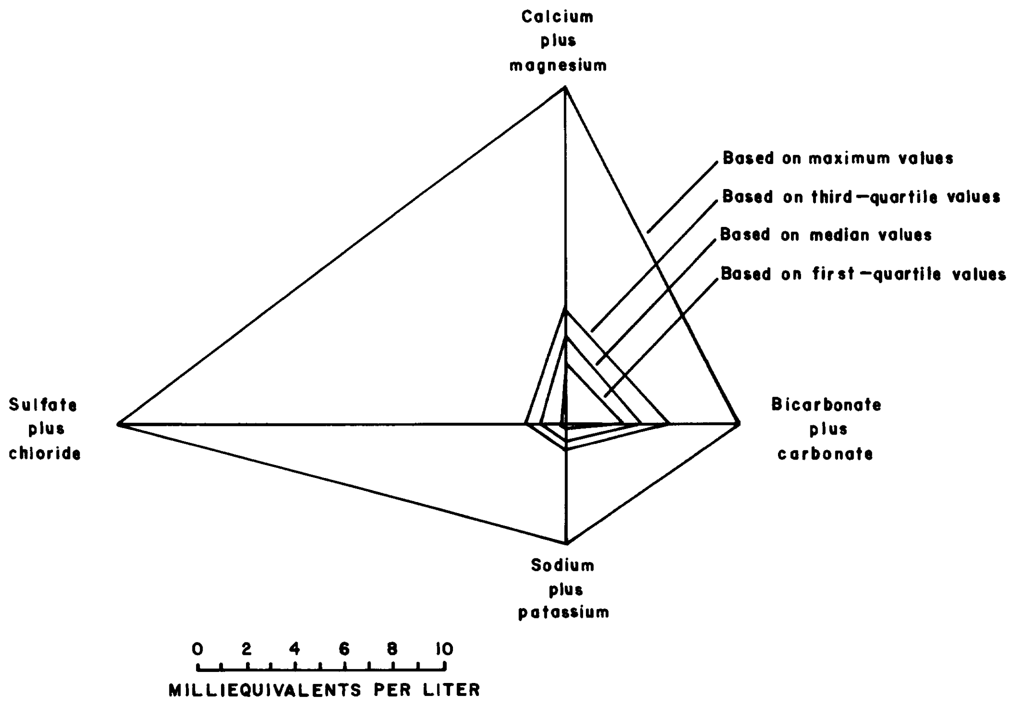


Figure 24.--Composition of water from the combined alluvium and terrace-deposits geohydrologic units, western Montana.

The results of tests for significant differences between chemical data for water from the two units are listed in table 73. Considering data from all well depths, a significant difference exists between the units at the 0.05 significance level for pH, sodium, potassium, bicarbonate, chloride, silica, and dissolved solids. Therefore, based on the data, the glacial-till and glaciolacustrine-deposits geohydrologic units will be considered as having dissimilar water quality. Statistical data are available for the glacial till (table 74) and the glaciolacustrine deposits (table 75). The number of analyses and distribution of depth data are insufficient to differentiate by depth.

Diagrams (fig. 26) show the composition of water from each of the units. Based on first-quartile, median, and third-quartile values for the glacial till, calcium plus magnesium and bicarbonate plus carbonate tend to be the predominant ion pairs. Based on maximum values, the combinations of ions presented are relatively equally distributed. Based on all quartile values for the glaciolacustrine deposits, calcium plus magnesium and bicarbonate plus carbonate tend to be the predominant ion pairs.

Spearman-rank correlation coefficients were determined for selected variables in water from the glacial till (table 76) and the glaciolacustrine deposits (table 77). For the glacial-till unit, the most significant correlation (largest coefficient) is between dissolved solids and bicarbonate (0.90 based on 62 data values) and is positive. Other significant correlations include those between sodium and chloride (0.80), dissolved solids and sodium (0.82), and dissolved solids and chloride (0.77), all based on 62 data values. On the basis of these correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of carbonate and chloride minerals.

For the glaciolacustrine-deposits unit the most significant correlation is between calcium and bicarbonate (0.97 based on 32 data values) and dissolved solids and bicarbonate (0.97 based on 31 data values). Other significant correlations include those between dissolved solids and calcium (0.92), dissolved solids and magnesium (0.89), dissolved solids and sodium (0.85), and dissolved solids and sulfate (0.84), all based on 31 data values. Based on these correlations, the dissolved-solids concentrations can be inferred to be largely affected by the dissolution of carbonate and sulfate minerals.

Data for concentrations of trace constituents in water from the glacial deposits are contained in WATSTORE. In this report, only summaries of constituents included in the primary drinking-water standards of the U.S. Environmental Protection Agency are given for the glacial till (table 78) and the glaciolacustrine deposits (table 79). For the glacial till, 11 percent of 62 data values exceeded the standard for fluoride. For the glaciolacustrine deposits unit, 17 percent of 29 data values exceeded the standard for lead and 3 percent of 29 data values exceeded the standard for cadmium.

WATSTORE contains no data on the concentrations of dissolved organic carbon, total organic carbon, or phenols for either the glacial-till or the glaciolacustrine-deposits geohydrologic units. Therefore, the data file is inadequate to detect any organic effects of man's activitives on the water quality in either aquifer.

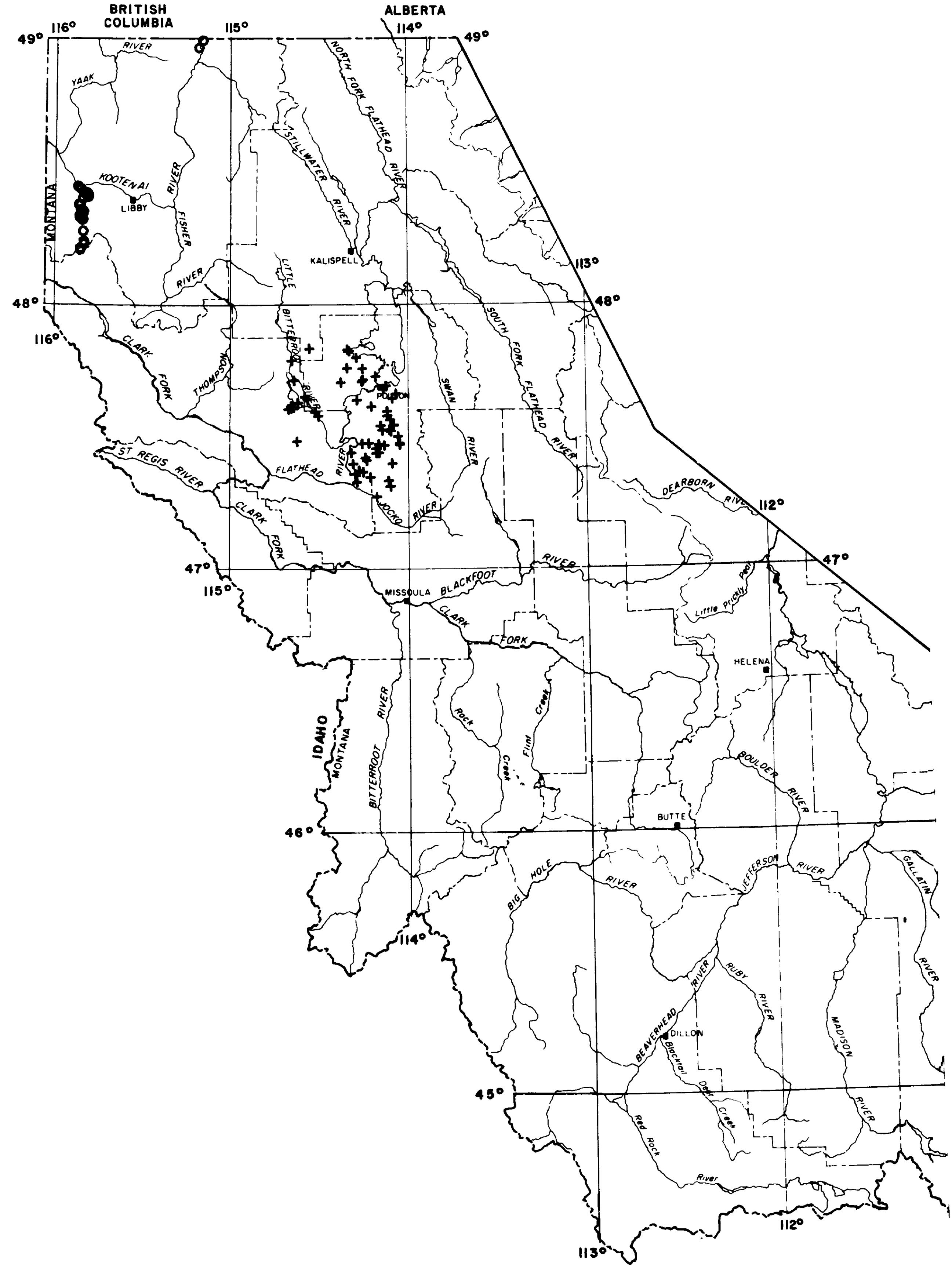
SUMMARY

All known sources of ground-water-quality data for Montana were reviewed. Although the estimated number of analyses exceeds 25,000, more than three-fourths of the data were not suitable for this study. The only data used were obtained from the computer file WATSTORE, because those chemical analyses are generally complete, have an assigned geohydrologic unit or source of water, and are accessible by computer.

The data for Montana were divided geographically into data from the eastern region, generally east of the Rocky Mountains, and data from the western mountainous region of the State because of climatic and geologic differences. Within the eastern region, the data were subdivided as belonging to one of nine general groupings of geohydrologic units. Within the western region, the data were subdivided as belonging to one of two general groupings of geohydrologic units. Data for inorganic, trace, and organic constituents for each grouping of units were assessed if available.

The number and distribution of the data sites for some groupings of geohydrologic units are inadequate to be representative, particularly for groupings stratigraphically below the Fox Hills Sandstone and Hell Creek Formation in the eastern region and, to some extent, for alluvium, terrace deposits, glacial deposits, and associated units in the western region. More than one-half of the data are for the Wasatch, Fort Union, and associated geohydrologic units in the eastern region.

The results of statistical analyses of data for the eastern region indicate the median dissolved-solids concentrations for the groupings of geohydrologic units range from about 400 to 5,000 mg/L. Similarly, the median dissolved-solids concentrations for the groupings of units in the western region range from about 100 to 200 mg/L.


BRITISH COLUMBIA
ALBERTA
MONTANA
IDAHO
49°
48°
47°
46°
45°
116°
115°
114°
113°
112°
YAAK RIVER
KOOTENAI
LIBBY
FISHER RIVER
KALISPELL
NORTH FORK FLATHEAD RIVER
STILLWATER RIVER
LITTLE BITTERROOT RIVER
POLSON
SWAN RIVER
SOUTH FORK FLATHEAD RIVER
CLARK FORK
THOMPSON
ST REGIS RIVER
FLATHEAD RIVER
JOCKO RIVER
DEARBORN RIVER
BLACKFOOT RIVER
MISSOULA
Little Prickly Pear
HELENA
Rock Creek
Flint Creek
BITTERROOT RIVER
BOULDER RIVER
BUTTE
BIG HOLE RIVER
JEFFERSON RIVER
GALLATIN RIVER
BEAVERHEAD RIVER
RUBY RIVER
DILLON
Blacktail Deer Creek
MADISON RIVER
Red Rock River

EXPLANATION

+ DATA SITE FOR THE TILL GEOHYDROLOGIC UNIT

o DATA SITE FOR THE GLACIOLACUSTRINE-DEPOSITS GEOHYDROLOGIC UNIT

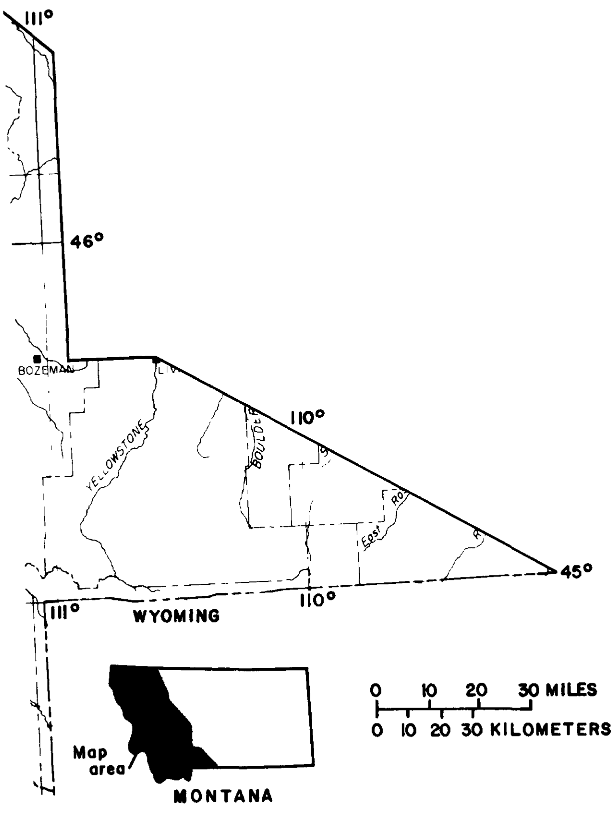


Figure 25.--Location of water-quality data sites in WATSTORE for the glacial-till and glaciolacustrine-deposits geohydrologic units, western Montana.

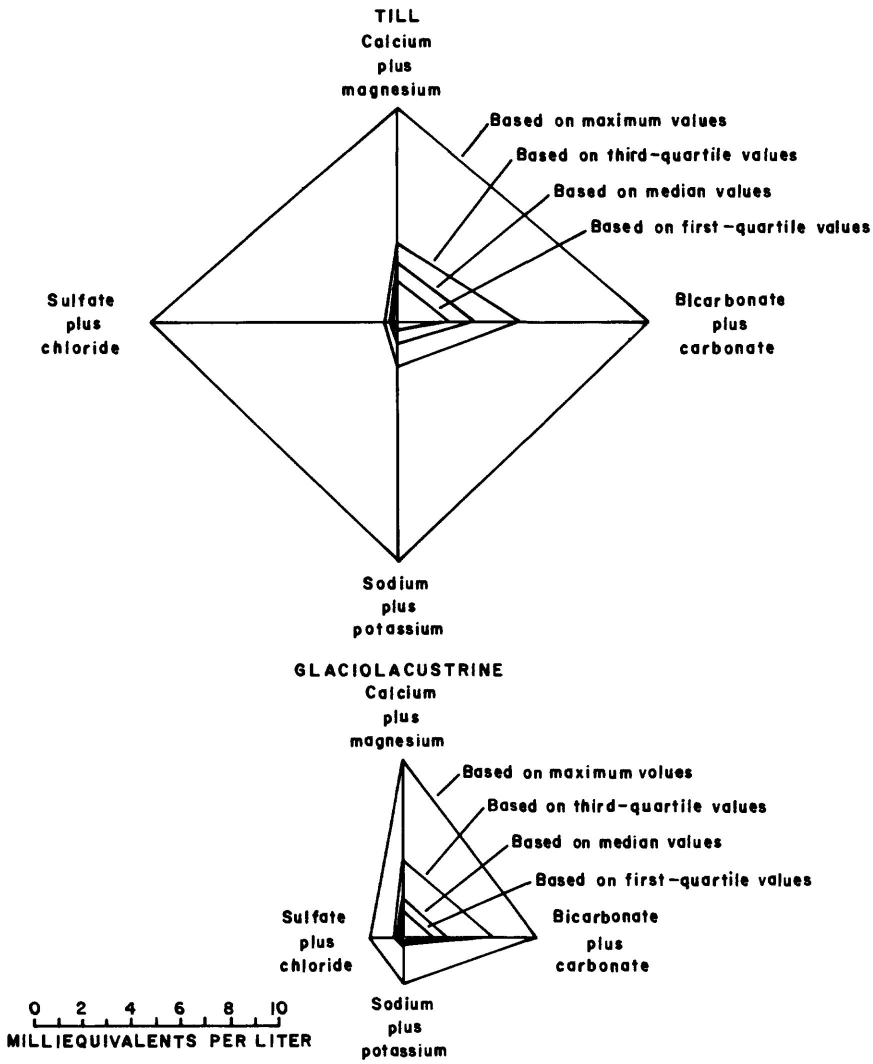


Figure 26.--Composition of water from the glacial-till and glaciolacustrine-deposits geohydrologic units, western Montana.

The dissolved-solids concentrations primarily result from dissolution of carbonate, chloride, and sulfate minerals and cation exchange. However, based on correlation coefficients, the dissolved-solids concentrations throughout the ranges of data values can only be inferred to be largely affected by the dissolution of sulfate minerals for most of the grouping of units.

Concentrations of most trace constituents generally do not exceed the primary drinking water standards of the U.S. Environmental Protection Agency, although exceptions occur. Most exceptions are for lead, cadmium, fluoride, and selenium. Some of the exceptions for lead and cadmium may be erroneous, because of possible sample contamination or because the analytical methods used in some analyses may have been less sensitive than the established standard. The amount of data in WATSTORE for organic constituents presently is inadequate to detect any organic effects of man's activities on ground-water quality.

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SUPPLEMENTAL DATA

Table 1.--*Availability of ground-water-quality data in Montana*

Source	Number of wells sampled	Number of analyses	Types of analyses	Geographical distribution	Remarks
U.S. Geological Survey	3,823	5,150	Common and trace inorganic constituents, organic constituents, and nutrients	Statewide, with emphasis on project areas	Data mostly well documented with geohydrologic unit assigned; data all computer accessible in WATSTORE.
Montana Bureau of Mines and Geology			Common and trace inorganic constituents	Statewide, with emphasis on project areas	Data mostly well documented; many have geohydrologic unit assigned; data through 1978 computer accessible in WATSTORE.
U.S. Environmental Protection Agency	705	2,540	Common inorganic constituents; some trace inorganic constituents	Statewide, with emphasis on project areas	Data stored in STORET; geohydrologic unit not assigned.
Montana Department of Health and Environmental Sciences, Water Quality Bureau	---	2,500 (estimated)	Single constituents; common inorganic constituents	Statewide	Mostly private wells, sampled to determine suitability of water for domestic use. Geohydrologic unit not assigned.
Montana Department of Health and Environmental Sciences, Solid Waste Management Bureau	136	450 (estimated)	Selected common and trace inorganic constituents; organic constituents	Localized near potential problem areas	Data from 1979 to present.
Montana Department of State Lands	50 (estimated)	200 (estimated)	Common inorganic constituents and (or) other parameters to meet specific monitoring needs	Localized mining areas	Data not computer accessible. Monitoring of potential problem areas expected to expand in the future.
U.S. Department of Energy, National Uranium Resource Evaluation (NURE) Program	15,000 (estimated maximum)	15,000 (estimated maximum)	Various common and trace inorganic constituents; radiochemical parameters	Statewide	Geohydrologic unit not assigned for most data for Montana. Data available on magnetic tape or paper copy from Bendix Field Engineering Corp., Grand Junction, Colo.
Lewis and Clark County Health Department	30 (estimated)	50 (estimated)	Specific conductance, chloride, and nitrate, plus some common inorganic constituents	Helena valley area	Data not computer accessible at present. Wells inventoried by U.S. Geological Survey.

page 15 follows

Table 3.--*Results of statistical tests for significant differences between alluvium, terrace-deposits, colluvium, and Flaxville geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of data values. Lower numeral is number of data values]

Variable	Geohydrologic unit			
	Alluvium	Terrace deposits	Colluvium	Flaxville
pH, in units	-- 111 A,B 201	-- 176 A 12	-- 39 B,C 7	-- 16 C 2
Calcium, dissolved as Ca	150 185 A 337	210 222 A 29	420 353 B 7	52 68 C 5
Magnesium, dissolved as Mg	150 188 A 337	130 188 A 29	520 358 B 7	39 66 C 5
Sodium, dissolved as Na	360 185 A 337	584 234 A,B 29	880 296 B 7	85 71 C 5
Potassium, dissolved as K	9 191 A 336	7 162 A 29	13 294 B 7	3 44 C 5
Bicarbonate, as HCO_3	560 189 A 323	510 150 A,B 29	350 64 B 7	430 116 A,B 5
Carbonate, as CO_3	3 95 A 169	1 97 A 18	0 87 A 1	0 87 A 2
Sulfate, dissolved as SO_4	1,200 185 A 337	1,800 229 A 29	4,400 352 B 7	120 36 C 5
Chloride, dissolved as Cl	28 179 A 337	65 285 B 29	160 339 B 7	7.9 105 A 5

Table 3.--*Results of statistical tests for significant differences between alluvium, terrace-deposits, colluvium, and Flaxville geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit			
	Alluvium	Terrace deposits	Colluvium	Flaxville
Silica, dissolved as SiO_2	17 187 A 333	20 227 A 29	8.5 40 B 7	16 185 A 5
Dissolved solids	2,230 184 A 335	3,150 229 A 29	6,610 350 B 7	535 42 C 5

Table 4.--*Statistical data for the combined alluvium and terrace-deposits geohydrologic units, eastern Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	213	6.0	7.3	7.5	7.8	9.1	--	--
Calcium, dissolved as Ca	366	3.2	69	120	200	560	150	110
Magnesium, dissolved as Mg	366	1.0	53	110	200	740	150	130
Sodium, dissolved as Na	366	1.3	120	300	530	2,100	380	340
Potassium, dissolved as K	365	.1	5	8	11	110	9	8
Bicarbonate, as HCO_3	352	80	420	560	670	1,560	560	200
Carbonate, as CO_3	187	0	0	0	0	180	3	15
Sulfate, dissolved as SO_4	366	.6	370	940	1,730	7,300	1,300	1,200
Chloride, dissolved as Cl	366	.2	6.9	13	22	1,400	31	87
Silica, dissolved as SiO_2	362	1.6	12	17	22	36	17	6.8
Dissolved solids	364	163	994	1,910	3,170	11,100	2,310	1,810
Depth of well, in feet	324	10	22	33	45	300	40	30

Table 5.--*Statistical data for the colluvium geohydrologic unit, eastern Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	7	6.7	6.9	7.2	7.2	7.5	--	--
Calcium, dissolved as Ca	7	200	380	460	470	510	420	100
Magnesium, dissolved as Mg	7	320	360	390	590	1,100	520	270
Sodium, dissolved as Na	7	160	460	720	1,100	2,300	880	700
Potassium, dissolved as K	7	8	9	14	15	16	13	3
Bicarbonate, as HCO_3	7	220	310	330	390	500	350	86
Carbonate, as CO_3	1	0	0	0	0	0	0	--
Sulfate, dissolved as SO_4	7	2,700	2,800	3,500	5,400	8,600	4,400	2,100
Chloride, dissolved as Cl	7	24	26	73	300	390	160	150
Silica, dissolved as SiO_2	7	7.1	7.4	7.8	8.9	12	8.5	1.7
Dissolved solids	7	3,970	4,630	5,110	7,860	12,900	6,610	3,070
Depth of well, in feet	7	18	23	33	34	53	31	12

Table 6.--*Statistical data for the Flaxville geohydrologic unit, eastern Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	2	6.9	6.9	7.0	7.0	7.0	--	--
Calcium, dissolved as Ca	5	12	22	57	80	98	52	32
Magnesium, dissolved as Mg	5	9.3	16	43	61	77	39	26
Sodium, dissolved as Na	5	21	22	50	170	200	85	78
Potassium, dissolved as K	5	2	3	3	4	4	3	.7
Bicarbonate, as HCO_3	5	290	310	440	550	640	430	140
Carbonate, as CO_3	2	0	0	0	0	0	0	0
Sulfate, dissolved as SO_4	5	17	46	120	190	210	120	74
Chloride, dissolved as Cl	5	3.4	3.8	7.2	12	17	7.9	5.4
Silica, dissolved as SiO_2	5	13	13	15	20	22	16	3.8
Dissolved solids	5	403	404	429	718	729	535	168
Depth of well, in feet	3	20	20	58	102	102	60	41

Table 7.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined alluvium and terrace-deposits geohydrologic units, eastern Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 213	-0.33 213	-0.15 213	-- 213	-- 213	0.13 199	0.22 136	-- 213	-0.15 213	-- 209	-0.28 211	-- 213	-0.21 70	-- 190
Calcium	-.33 213	1.00 366	.79 366	.51 366	.42 365	.27 352	-.36 187	.81 366	.56 366	-- 360	.14 362	.78 364	-- 127	-.13 324
Magnesium	-.15 213	.79 366	1.00 366	.56 366	.59 365	.39 352	-.21 187	.87 366	.42 366	-- 360	.17 362	.83 364	-- 127	-.17 324
Sodium	-- 213	.51 366	.56 366	1.00 366	.47 365	.65 352	-- 187	.84 366	.59 366	.31 360	-- 362	.89 364	-- 127	-- 324
Potassium	-- 213	.42 365	.59 365	.47 365	1.00 365	.40 351	-.14 187	.58 365	.30 365	.14 359	.37 361	.56 363	-.22 127	-- 323
Bicarbonate	.13 199	.27 352	.39 352	.65 352	.40 351	1.00 352	-- 187	.47 352	.31 352	.34 346	-- 348	.56 350	-- 127	-.11 313
Carbonate	.22 136	-.36 187	-.21 187	-- 187	-.14 187	-- 187	1.00 187	-.17 187	-- 187	-- 184	-- 183	-- 185	-- 37	-- 168
Sulfate	-- 213	.81 366	.87 366	.84 366	.58 365	.47 352	-.17 187	1.00 366	.58 366	.11 360	.09 362	.98 364	-- 127	-- 324
Chloride	-.15 213	.56 366	.42 366	.59 366	.30 365	.31 352	-- 187	.58 366	1.00 366	.22 360	.14 362	.61 364	-- 127	-.18 324
Fluoride	-- 209	-- 360	-- 360	.31 360	.14 359	.34 346	-- 184	.11 360	.22 360	1.00 360	.22 358	.16 358	-- 123	-- 319
Silica	-.28 211	.14 362	.17 362	-- 362	.37 361	-- 348	-- 183	.09 362	.14 362	.22 358	1.00 362	-- 362	-- 127	-- 320
Dissolved solids	-- 213	.78 364	.83 364	.89 364	.56 363	.56 350	-- 185	.98 364	.61 364	.16 358	-- 362	1.00 364	-- 127	-- 322
Nitrate, as N	-.21 70	-- 127	-- 127	-- 127	-.22 127	-- 127	-- 37	-- 127	-- 127	-- 123	-- 127	-- 127	1.00 127	-.18 109
Depth of well	-- 190	-.13 324	-.17 324	-- 324	-- 323	-.11 313	-- 68	-- 324	-.18 324	-- 319	-- 320	-- 322	-.18 109	1.00 324

Table 8.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the alluvium or the terrace-deposits geohydrologic unit, eastern Montana, considering all depths*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	10	9	360	316
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	7	7	127	114
Nitrate, total as N	10 mg/L	8	8	182	162
Arsenic, dissolved	50 μg/L	1	1	55	50
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	0	0	32	32
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	[3]25	[3]22	82	78
Cadmium, total	10 μg/L	0	0	1	1
Chromium, dissolved	50 μg/L	0	0	92	87
Chromium, total	50 μg/L	0	0	1	1

Table 8.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the alluvium or the terrace-deposits geohydrologic unit, eastern Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]27	[3]25	109	100
Lead, total	50 µg/L	0	0	1	1
Mercury, dissolved	2 µg/L	0	0	13	13
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	8	8	71	64
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	69	67
Silver, total	50 µg/L	0	0	1	1

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 9.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the colluvium geohydrologic unit, eastern Montana, considering all depths*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	0	0	7	6
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	2	2	6	6
Nitrate, total as N	10 mg/L	1	1	1	1
Arsenic, dissolved	50 μg/L	0	0	6	6
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	--	--	0	0
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	[3]6	[3]6	6	6
Cadmium, total	10 μg/L	--	--	0	0
Chromium, dissolved	50 μg/L	0	0	6	6
Chromium, total	50 μg/L	--	--	0	0

Table 9.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the colluvium geohydrologic unit, eastern Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 μg/L	[3]6	[3]6	6	6
Lead, total	50 μg/L	--	--	0	0
Mercury, dissolved	2 μg/L	0	0	1	1
Mercury, total	2 μg/L	--	--	0	0
Selenium, dissolved	10 μg/L	7	6	7	6
Selenium, total	10 μg/L	--	--	0	0
Silver, dissolved	50 μg/L	--	--	0	0
Silver, total	50 μg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 10.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Flaxville geohydrologic unit, eastern Montana, considering all depths*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	0	0	5	5
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	--	--	0	0
Nitrate, total as N	10 mg/L	0	0	1	1
Arsenic, dissolved	50 µg/L	0	0	1	1
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	1	1
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	0	0	2	2
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	2	2
Chromium, total	50 µg/L	--	--	0	0

Table 10.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Flaxville geohydrologic unit, eastern Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 μg/L	0	0	2	2
Lead, total	50 μg/L	--	--	0	0
Mercury, dissolved	2 μg/L	0	0	1	1
Mercury, total	2 μg/L	--	--	0	0
Selenium, dissolved	10 μg/L	0	0	1	1
Selenium, total	10 μg/L	--	--	0	0
Silver, dissolved	50 μg/L	0	0	1	1
Silver, total	50 μg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases apply as annual average of the maximum daily air temperature increases.

Table 11.--*Results of statistical tests for significant differences between the glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, and glacial-till geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit				
	Glacial drift	Great Falls Lake sands	Glacio-lacus-trine deposits	Glacial outwash	Glacial till
pH, in units	-- 30 A 42	-- 40 A 4	-- 38 A 1	-- 26 A 9	-- 27 A 3
Calcium, dissolved as Ca	260 47 A,B 59	78 18 B 4	94 25 A,B 1	220 39 A,B 21	360 65 A 3
Magnesium, dissolved as Mg	1,100 49 A,B 59	36 14 B 4	49 25 A,B 1	85 35 A,B 21	1,300 66 A 3
Sodium, dissolved as Na	1,400 51 A 59	270 40 A 4	450 56 A 1	140 26 A 21	1,700 48 A 3
Potassium, dissolved as K	15 47 A 59	5 28 A 4	14 64 A 1	6 36 A 21	22 62 A 3
Bicarbonate, as HCO_3	490 49 A 58	430 45 A 4	450 49 A 1	350 31 A 21	550 46 A 3
Carbonate, as CO_3	3 9 A 10	0 7 A 4	0 7 A 1	0 7 A 1	-- -- --
Sulfate, dissolved as SO_4	7,300 51 A 59	520 23 A 4	1,000 41 A 1	840 30 A 21	8,300 60 A 3

Table 11.--*Results of statistical tests for significant differences between the glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, and glacial-till geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit				
	Glacial drift	Great Falls Lake sands	Glacio-lacus-trine deposits	Glacial outwash	Glacial till
Chloride, dissolved as Cl	130 51 A,B 59	22 33 A,B 4	52 55 A,B 1	19 26 B 21	290 68 A 3
Silica, dissolved as SiO_2	15 42 A,B 59	15 52 A,B 4	6.4 8 A 1	16 55 B 21	8.0 24 A,B 3
Dissolved solids	10,800 50 A 58	1,150 23 A 4	1,890 41 A 1	1,500 29 A 21	12,200 57 A 3

Table 12.--*Statistical data for the combined glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, and glacial-till geohydrologic units, eastern Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	59	3.7	7.0	7.4	7.7	9.8	--	--
Calcium, dissolved as Ca	88	7.2	86	210	410	540	250	170
Magnesium, dissolved as Mg	88	1.9	45	120	200	6,700	810	1,800
Sodium, dissolved as Na	88	8.0	110	230	990	9,800	1,100	1,800
Potassium, dissolved as K	88	1	5	7	15	100	13	16
Bicarbonate, as HCO_3	87	2	300	430	550	1,580	460	280
Carbonate, as CO_3	16	0	0	0	0	15	2	4
Sulfate, dissolved as SO_4	88	29	490	1,200	2,600	37,000	5,400	10,000
Chloride, dissolved as Cl	88	3.3	16	32	130	970	100	180
Silica, dissolved as SiO_2	88	1.6	8.9	12	19	70	15	9.3
Dissolved solids	87	195	1,100	2,110	4,110	53,200	8,040	14,600
Depth of well, in feet	79	10	20	41	59	250	51	47

Table 13.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, and glacial-till geohydrologic units, eastern Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal- cium	Mag- ne- sium	So- dium	Po- tas- sium	Bi- car- bo- nate	Car- bon- ate	Sul- fate	Chlo- ride	Fluo- ride	Sil- ica	Dis- solved solids	Ni- trate, as N	Depth of well
pH	1.00 59	-0.64 59	-0.62 59	-- 59	-0.44 59	0.40 58	-- 15	-0.40 59	-0.33 59	-- 59	-0.25 59	-0.31 58	-0.51 32	0.37 57
Calcium	-.64 59	1.00 88	.85 88	.46 88	.66 88	-- 87	-- 16	.79 88	.68 88	-- 88	-- 88	.76 87	.57 58	-.57 79
Magne- sium	-.62 59	.85 88	1.00 88	.63 88	.80 88	-- 87	-- 16	.87 88	.69 88	.22 88	-- 88	.84 87	.64 58	-.63 79
Sodium	-- 59	.46 88	.63 88	1.00 88	.63 88	.53 87	-- 16	.85 88	.71 88	.45 88	-- 88	.88 87	.51 58	-.35 79
Potas- sium	-.44 59	.66 88	.80 88	.63 88	1.00 88	.26 87	-- 16	.75 88	.67 88	-- 88	-- 88	.74 87	.49 58	-.45 79
Bicar- bonate	.40 58	-- 87	-- 87	.53 87	.26 87	1.00 87	.45 16	.25 87	-- 87	-- 87	-.19 87	.34 87	-- 57	-- 78
Carbo- nate	-- 15	-- 16	-- 16	-- 16	-- 16	.45 16	1.00 16	-- 16	.47 16	-- 16	-- 16	-- 16	-- 2	-- 14
Sul- fate	-.40 59	.79 88	.87 88	.85 88	.75 88	.25 87	-- 16	1.00 88	.81 88	.34 88	-- 88	.99 87	.61 58	-.60 79
Chlo- ride	-.33 59	.68 88	.69 88	.71 88	.67 88	-- 87	.47 16	.81 88	1.00 88	.31 88	-- 88	.82 87	.67 58	-.55 79
Fluo- ride	-- 59	-- 88	.22 88	.45 88	-- 88	-- 87	-- 16	.34 88	.31 88	1.00 88	-- 88	.34 87	.34 58	-- 79
Silica	-.25 59	-- 88	-- 88	-- 88	-- 88	-.19 87	-- 16	-- 88	-- 88	-- 88	1.00 88	-- 87	-- 58	-- 79
Dis- solved solids	-.31 58	.76 87	.84 87	.88 87	.74 87	.34 87	-- 16	.99 87	.82 87	.34 87	-- 87	1.00 87	.59 57	-.54 78
Nitrate, as N	-.51 32	.57 58	.64 58	.51 58	.49 58	-- 57	-- 2	.61 58	.67 58	.34 58	-- 58	.59 57	1.00 58	-.48 50
Depth of well	.37 57	-.57 79	-.63 79	-.35 79	-.45 79	-- 78	-- 14	-.60 79	-.55 79	-- 79	-- 79	-.54 78	-.48 50	1.00 79

Table 14.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, or glacial-till geohydrologic unit, eastern Montana, considering all depths*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	2	2	88	68
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	16	12	58	42
Nitrate, total as N	10 mg/L	8	8	29	28
Arsenic, dissolved	50 μg/L	0	0	40	39
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	0	0	7	7
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	[3]20	[3]20	25	25
Cadmium, total	10 μg/L	[3]2	[3]2	7	7
Chromium, dissolved	50 μg/L	3	3	42	41
Chromium, total	50 μg/L	1	1	7	7

Table 14.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the glacial-drift, Great Falls Lake sands, glaciolacustrine-deposits, glacial-outwash, or glacial-till geohydrologic unit, eastern Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]12	[3]12	41	40
Lead, total	µg/L	[3]4	[3]4	6	6
Mercury, dissolved	2 µg/L	1	1	4	4
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	17	16	45	43
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	6	6
Silver, total	50 µg/L	1	1	7	7

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 15.--*Results of statistical tests for significant differences between the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit						
Variable	Wasatch	Fort Union (undivided)	Tongue River	Lebo	Tullock	Harmon	Ludlow
pH, in units	-- 293 C 3	-- 583 A,B 103	-- 447 A,B,C 736	-- 315 C 15	-- 631 A 56	-- 400 B,C 25	-- -- 0
Calcium, dissolved as Ca	230 1,529 A 9	58 650 B,C 251	110 954 A,B 1,364	89 854 B,C 43	30 465 B,C 84	96 1,001 A,B 25	5.9 240 C 1
Magnesium, dissolved as Mg	170 1,398 A 9	47 620 B,C 251	120 971 A,B 1,364	54 715 B,C 43	23 430 B,C 84	56 814 A,B 25	1.7 168 C 1
Sodium, dissolved as Na	260 684 B 9	500 1,069 A,B 250	360 840 B 1,364	350 855 B 43	550 1,197 A,B 84	370 821 B 25	770 1,563 A 1
Potassium, dissolved as K	8 1,135 A 9	5 590 A,B,C 249	7 971 A,B 1,355	5 643 A,B,C 43	4 460 B,C 84	6 850 A,B 25	2 123 C 1
Bicarbonate, as HCO_3	490 568 B 9	820 1,028 A,B 250	680 792 A,B 1,298	590 680 B 42	850 1,041 A,B 62	730 961 A,B 4	1,000 1,362 A 1
Carbonate, as CO_3	0 254 C 3	25 592 A,B 61	9 366 B,C 659	5 380 B,C 19	22 571 A,B 41	11 375 B,C 4	20 656 A 1
Sulfate, dissolved as SO_4	1,400 1,262 A 9	690 822 A 245	940 905 A 1,363	680 823 A 43	640 752 A 84	660 851 A 25	800 1,014 A 1
Chloride, dissolved as Cl	9.8 803 A,B 9	25 855 A,B 249	15 873 A,B 1,361	17 879 A,B 43	58 1,320 A 84	8.5 580 B,C 25	.5 6 C 1
Silica, dissolved as SiO_2	11 993 A 9	11 796 A 250	12 918 A 1,349	11 852 A 43	8.5 521 A 83	11 888 A 25	8.9 628 A 1
Dissolved solids	2,390 1,161 A 9	1,750 879 A 243	1,930 884 A 1,355	1,510 769 A 43	1,720 878 A 84	1,580 789 A 25	2,110 1,197 A 1

Table 16.--*Results of statistical tests for significant differences between the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range tests on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit						
	Wasatch	Fort Union (undivided)	Tongue River	Lebo	Tullock	Harmon	Ludlow
pH, in units	-- 175 A 3	-- 278 A 25	-- 227 A 373	-- 182 A 13	-- 273 A 22	-- 215 A 23	-- -- 0
Calcium, dissolved as Ca	230 763 A 9	81 367 B,C 115	130 489 A,B 717	90 410 B,C 31	48 294 B,C 35	100 495 A,B 23	5.9 76 C 1
Magnesium, dissolved as Mg	170 698 A 9	66 343 B,C 115	140 501 A,B 717	55 332 B,C 31	39 276 B,C 35	61 381 A,B,C 23	1.7 49 C 1
Sodium, dissolved as Na	260 364 B 9	420 482 A,B 114	380 457 B 717	330 437 B 31	600 657 A,B 35	370 420 B 23	770 809 A 1
Potassium, dissolved as K	8 573 A 9	5 328 A,B 114	8 497 A 711	5 328 A,B 31	5 325 A,B 35	6 419 A 23	2 44 B 1
Bicarbonate, as HCO_3	490 280 B 9	740 483 A,B 114	680 421 A,B 676	580 328 B 30	770 507 A,B 20	730 503 A,B 4	1,000 725 A 1
Carbonate, as CO_3	0 111 B 3	11 198 A,B 13	9 158 A,B 278	4 150 B 14	19 233 A,B 7	11 159 A,B 4	20 275 A 1
Sulfate, dissolved as SO_4	1,400 619 A 9	710 385 A 115	1,100 480 A 717	660 380 A 31	960 511 A 35	700 411 A 23	800 475 A 1
Chloride, dissolved as Cl	9.8 441 A 9	13 388 A 115	16 474 A 717	15 473 A 31	39 665 A 35	8.6 316 A 23	.5 3 B 1
Silica, dissolved as SiO_2	11 483 A 9	11 435 A 115	12 478 A 710	11 424 A 31	8.9 272 A 34	11 441 A 23	8.9 274 A 1
Dissolved solids	2,390 572 A 9	1,670 398 A 115	2,130 479 A 716	1,460 355 A 31	2,050 520 A 35	1,620 399 A 23	2,110 589 A 1

Table 17.--*Results of statistical tests for significant differences between the Fort Union, Tongue River, Lebo, Tullock, and Harmon geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of data values. Lower numeral is number of data values]

Variable	Geohydrologic unit: Fort Union (undivided)	Tongue River	Lebo	Tullock	Harmon
pH, in units	-- 134 A 74	-- 97 A 125	-- 114 A 1	-- 154 A 30	-- 110 A 2
Calcium, dissolved as Ca	35 204 A 111	37 205 A 227	88 231 A 11	15 144 A 45	12 227 A 2
Magnesium, dissolved as Mg	31 210 A 111	34 206 A 227	52 215 A 11	8.1 127 A 45	6.3 215 A 2
Sodium, dissolved as Na	580 222 A 111	520 189 A 227	420 153 A 11	530 200 A 45	440 154 A 2
Potassium, dissolved as K	5 175 A 110	5 225 A 226	4 174 A 11	3 118 A 45	5 237 A 2
Bicarbonate, as HCO_3	910 184 A 111	980 197 A 216	620 102 A 11	880 177 B 38	-- -- 0
Carbonate, as CO_3	27 147 A 47	15 90 B 135	9 107 A,B 4	21 132 A,B 30	-- -- 0
Sulfate, dissolved as SO_4	650 230 A 106	530 183 A 226	790 239 A 11	400 166 A 45	230 166 A 2
Chloride, dissolved as Cl	41 192 A,B 109	18 182 A,B 225	23 183 A,B 11	75 287 A 45	7.6 117 B 2
Silica, dissolved as SiO_2	9.7 209 A 110	9.3 195 A 223	10 241 A 11	7.9 152 A 45	9.4 263 A 2
Dissolved solids	1,840 224 A 104	1,660 185 A 224	1,750 221 A 11	1,470 164 A 45	1,140 113 A 2

Table 18.--*Statistical data for the combined Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units, eastern Montana, considering depths of 200 feet or less*

		Concentration (except as indicated), in milligrams per liter						
Parameter	Number of data values	Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
›H, in units	459	6.1	7.2	7.6	8.0	10.5	--	--
;alcium, dissolved as Ca	931	1.0	32	85	160	540	120	120
lagnesium, dissolved as Mg	931	.1	26	77	160	1,600	120	160
;odium, dissolved as Na	930	3.1	120	310	590	1,900	390	340
'otassium, dissolved as K	924	.6	4	6	9	110	7	5
3icarbonate, as HCO_3	854	20	440	610	810	2,990	690	370
;arbonate, as CO_3	320	0	0	0	10	230	9	22
;ulfate, dissolved as SO_4	931	.1	310	780	1,400	7,600	1,000	990
;hloride, dissolved as Cl	931	.1	5.7	9.6	17	210	16	23
;ilica, dissolved as SiO_2	923	.1	8.5	11	15	52	12	5.4
issolved solids	930	112	1,030	1,715	2,610	10,400	2,040	1,420
)epth of well, in feet	931	10	60	103	144	200	105	50

Table 19.--*Statistical data for the combined Fort Union, Tongue River, Lebo, Tullock, and Harmon geohydrologic units, eastern Montana, considering depths greater than 200 feet*

		Concentration (except as indicated), in milligrams per liter						
Parameter	Number of data values	Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	232	6.4	7.7	8.1	8.4	9.3	--	--
Calcium, dissolved as Ca	396	.8	3.6	8.8	45	380	35	57
Magnesium, dissolved as Mg	396	.1	1.5	4.4	34	450	31	59
Sodium, dissolved as Na	396	14	360	508	670	2,000	530	280
Potassium, dissolved as K	394	.5	2	4	6	81	5	5
Bicarbonate, as HCO_3	376	150	590	890	1,170	2,500	940	430
Carbonate, as CO_3	216	0	0	6	23	440	18	38
Sulfate, dissolved as SO_4	390	.1	10	380	870	4,400	550	640
Chloride, dissolved as Cl	392	0	6.5	14	26	710	31	63
Silica, dissolved as SiO_2	391	3.0	7.6	8.4	10	28	9.3	3.0
Dissolved solids	386	397	1,100	1,460	2,040	6,810	1,690	911
Depth of well, in feet	396	202	238	280	369	1,240	338	169

Table 20.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, and Ludlow geohydrologic units, eastern Montana, considering depths of 200 feet or less*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 459	-0.60 459	-0.52 459	0.29 459	-0.30 455	0.10 382	0.50 254	-0.16 459	-- 459	0.34 449	-0.36 452	-- 459	-- 228	0.17 459
Calcium	-.60 459	1.00 931	.91 931	-.24 930	.57 924	-.16 854	-.62 320	.62 931	.13 931	-.56 846	.49 923	.46 930	-- 571	-.37 931
Magnesium	-.52 459	.91 931	1.00 931	-.22 930	.64 924	-.16 854	-.52 320	.65 931	.16 931	-.55 846	.50 923	.48 930	-- 571	-.39 931
Sodium	.29 459	-.24 930	-.22 930	1.00 930	.16 924	.65 853	.14 319	.47 930	.44 930	.45 846	-.46 922	.68 929	-- 570	.26 930
Potassium	-.30 455	.57 924	.64 924	.16 924	1.00 924	.11 847	.36 316	.57 924	.15 924	-.20 841	.36 916	.53 923	-- 565	-.13 924
Bicarbonate	.10 382	-.16 854	-.16 854	.65 853	.11 847	1.00 854	-- 319	.13 854	.31 854	.39 769	-.26 846	.43 853	-- 571	.29 854
Carbonate	.50 254	-.62 320	-.52 320	.14 319	-.36 316	-- 319	1.00 320	-.31 320	-- 320	.26 308	-.35 313	-.19 320	-- 151	.28 320
Sulfate	-.16 459	.62 931	.65 931	.47 930	.57 924	.13 854	-.31 320	1.00 931	.44 931	-.22 846	-- 923	.92 930	-- 571	-.17 931
Chloride	-- 459	.13 931	.16 931	.44 930	.15 924	.31 854	-- 320	.44 931	1.00 931	.20 846	-.19 923	.54 930	-- 571	-- 931
Fluoride	.34 449	-.56 846	-.55 846	.45 846	-.20 841	.39 769	.26 308	-.22 846	.20 846	1.00 846	-.31 846	-- 846	-.10 502	.23 846
Silica	-.36 452	.49 923	.50 923	-.46 922	.36 916	-.26 846	-.35 313	-- 923	-.19 923	-.31 846	1.00 923	-- 923	-.13 570	-.31 923
Dissolved solids	-- 459	.46 930	.48 930	.68 929	.53 923	.43 853	-.19 320	.92 930	.54 930	-- 846	-- 923	1.00 930	-- 570	-- 930
Nitrate, as N	-- 228	-- 571	-- 571	-- 570	-- 565	-- 571	-- 151	-- 571	-- 571	-.10 502	-.13 570	-- 570	1.00 571	-0.9 571
Depth of well	.17 459	-.37 931	-.39 931	.26 930	-.13 924	.29 854	.28 320	-.17 931	-- 931	.23 846	-.31 923	-- 930	-.09 571	1.00 931

Table 21.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Fort Union, Tongue River, Lebo, Tullock, and Harmon geohydrologic units, eastern Montana, considering depths greater than 200 feet*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal-cium	Mag-ne-sium	So-dium	Po-tas-sium	Bi-car-bo-nate	Car-bon-ate	Sul-fate	Chlo-ride	Fluo-ride	Sil-ica	Dis-solved solids	Ni-trate, as N	Depth of well
pH	1.00 232	-0.71 232	-0.70 232	-- 232	-0.66 231	-- 212	0.69 155	-0.40 227	0.18 230	0.57 230	-0.24 228	-0.26 225	-0.21 120	0.29 232
Calcium	-.71 232	1.00 396	.95 396	-- 396	.78 394	-.26 376	-.47 216	.69 390	-.21 392	-.75 374	.33 391	.45 386	.35 233	-.31 396
Magne-sium	-.70 232	.95 396	1.00 396	-- 396	.80 394	-.22 376	- .46 216	.69 390	-.24 392	-.71 374	.29 391	.45 386	.37 233	-.29 396
Sodium	-- 232	-- 396	-- 396	1.00 396	.15 394	.54 376	-.16 216	.35 390	.30 392	.16 374	-.20 391	.80 386	-- 233	-- 396
Potas-sium	-.66 231	.78 394	.80 394	.15 394	1.00 394	-- 374	-.35 215	.48 388	-.17 390	-.50 373	.35 390	.47 384	.28 231	-.25 394
Bicar-bonate	--- 212	-.26 376	-.22 376	.54 376	-- 374	1.00 376	-- 216	-.34 370	.30 372	.43 354	-- 371	.28 366	-.18 233	-- 376
Carbo-nate	.69 155	-.47 216	-.46 216	-.16 216	-.35 215	-- 216	1.00 216	-.24 214	-- 212	.34 213	-- 212	-.34 210	-- 110	.19 216
Sul-fate	-.40 227	.69 390	.69 390	.35 390	.48 388	-.34 370	-.24 214	1.00 390	-.17 386	-.57 368	-- 385	.70 386	.48 228	-.21 390
Chlo-ride	.18 230	-.21 392	-.24 392	.30 392	-.17 390	.30 372	-- 212	-.17 386	1.00 392	.28 370	-- 387	.14 386	-- 229	.18 392
Fluo-ride	.57 230	-.75 374	-.71 374	.16 374	-.50 373	.43 354	.34 213	-.57 368	.28 370	1.00 374	-.27 372	-.22 364	-.34 214	.25 374
Silica	-.24 228	.33 391	.29 391	-.20 391	.35 390	-- 371	-- 212	-- 385	-- 387	-.27 372	1.00 391	-- 381	-- 231	-- 391
Dis-solved solids	-.26 225	.45 386	.45 386	.80 386	.47 384	.28 366	-.34 210	.70 386	.14 386	-.22 364	-- 381	1.00 386	.28 224	-- 386
Nitrate, as N	-.21 120	.35 233	.37 233	-- 233	.28 231	-.18 233	-- 110	.48 228	-- 229	-.34 214	-- 231	.28 224	1.00 233	-.21 233
Depth of well	.29 232	-.31 396	-.29 396	-- 396	-.25 394	-- 376	.19 216	-.21 390	.18 392	.25 374	-- 391	-- 386	-.21 233	1.00 396

Table 22.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, or Ludlow geohydrologic unit, eastern Montana, considering depths of 200 feet or less*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	50	40	845	698
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	13	13	571	469
Nitrate, total as N	10 mg/L	1	1	145	140
Arsenic, dissolved	50 µg/L	0	0	165	133
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	1	1	112	107
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	[3]74	[3]55	188	162
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	5	5	187	162
Chromium, total	50 µg/L	--	--	0	0

Table 22.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Wasatch, Fort Union, Tongue River, Lebo, Tullock, Harmon, or Ludlow geohydrologic unit, eastern Montana, considering depths of 200 feet or less*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]70	[3]41	279	204
Lead, total	50 µg/L	[3]21	[3]17	30	23
Mercury, dissolved	2 µg/L	0	0	52	46
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	7	6	172	147
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	1	1	163	140
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 23.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Fort Union, Tongue River, Lebo, Tullock, or Harmon geohydrologic unit, eastern Montana, considering depths greater than 200 feet*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	118	105	374	339
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	4	4	233	219
Nitrate, total as N	10 mg/L	1	1	77	73
Arsenic, dissolved	50 µg/L	0	0	59	47
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	48	40
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	[3]17	[3]14	73	61
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	6	4	70	59
Chromium, total	50 µg/L	--	--	0	0

Table 23.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Fort Union, Tongue River, Lebo, Tullock, or Harmon geohydrologic unit, eastern Montana, considering depths greater than 200 feet*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]9	[3]7	96	82
Lead, total	50 µg/L	0	0	1	1
Mercury, dissolved	2 µg/L	0	0	35	26
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	0	0	51	47
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	66	57
Silver, total	µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 24.--*Results of statistical tests for significant differences between the Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless, for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit		
	Fox Hills-lower Hell Creek	Fox Hills	Hell Creek
pH, in units	-- 68 A 58	-- 53 A 13	-- 55 A 50
Calcium, dissolved as Ca	10 103 B 147	13 150 A 20	25 166 A 90
Magnesium, dissolved as Mg	7.4 106 B 147	5.0 112 B 20	16 170 A 90
Sodium, dissolved as Na	380 126 A,B 147	330 103 B 20	490 140 A 90
Potassium, dissolved as K	2 112 B 146	3 128 A,B 19	3 155 A 90
Bicarbonate, as HCO_3	680 130 A 135	540 97 B 20	650 110 A,B 84
Carbonate, as CO_3	35 75 A 66	12 42 B 15	23 62 A 51
Sulfate, dissolved as SO_4	270 115 B 147	290 127 A,B 20	560 152 A 90
Chloride, dissolved as Cl	27 135 A 147	7.1 63 B 19	38 131 A 90

Table 24.--*Results of statistical tests for significant differences between the Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit		
	Fox Hills-lower Hell Creek	Fox Hills	Hell Creek
Silica, dissolved as SiO_2	11 / 145 A / 145	9.2 / 109 B / 19	9.4 / 103 B / 90
Dissolved solids	1,060 / 119 A,B / 146	983 / 105 B / 20	1,480 / 149 A / 90

Table 25.--*Results of statistical tests for significant differences between the Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit		
	Fox Hills-lower Hell Creek	Fox Hills	Hell Creek
pH, in units	-- 17 A,B 13	-- 28 A 2	-- 14 B 16
Calcium, dissolved as Ca	38 29 A 19	17 28 A 4	39 34 A 40
Magnesium, dissolved as Mg	39 31 A 19	6.6 25 A 4	27 33 A 40
Sodium, dissolved as Na	370 32 A,B 19	160 15 B 4	440 34 A 40
Potassium, dissolved as K	3 33 A 19	6 34 A 4	3 32 A 40
Bicarbonate, as HCO_3	680 30 A 11	390 15 B 4	590 25 A,B 35
Carbonate, as CO_3	5 10 A 4	4 11 A 2	8 12 A 16
Sulfate, dissolved as SO_4	510 30 A 19	88 11 B 4	610 35 A 40
Chloride, dissolved as Cl	41 36 A 19	3.3 9 B 4	35 32 A 40

Table 25.--*Results of statistical tests for significant differences between the Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*--Continued

Variable	Geohydrologic unit		
	Fox Hills-lower Hell Creek	Fox Hills	Hell Creek
Silica, dissolved as SiO_2	10 33 A 19	14 45 A 4	9.9 30 A 40
Dissolved solids	1,310 31 A 19	491 13 B 4	1,460 35 A 40

Table 26.--*Results of statistical tests for significant differences between the Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit		
Variable	Fox Hills-lower Hell Creek	Fox Hills	Hell Creek
pH, in units	-- 49 A 45	-- 27 B 10	-- 44 A 33
Calcium, dissolved as Ca	6.1 79 B 120	12 115 A 15	12 116 A 46
Magnesium, dissolved as Mg	2.6 82 B 120	4.5 73 B 15	7.4 120 A 46
Sodium, dissolved as Na	390 88 A,B 120	360 74 B 15	550 104 A 46
Potassium, dissolved as K	1 83 A 119	2 91 A 14	2 107 A 46
Bicarbonate, as HCO_3	680 93 A 116	560 70 A 15	690 83 A 45
Carbonate, as CO_3	37 59 A 62	13 31 B 13	31 57 A 34
Sulfate, dissolved as SO_4	250 83 A 120	340 104 A 15	570 107 A 46
Chloride, dissolved as Cl	25 94 A 120	7.8 47 B 14	42 94 A 46

Table 26.--*Results of statistical tests for significant differences between the Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*--Continued

	Geohydrologic unit		
Variable	Fox Hills-lower Hell Creek	Fox Hills	Hell Creek
Silica, dissolved as SiO_2	11 103 A 118	7.8 64 B 14	9.0 59 B 46
Dissolved solids	1,050 86 A 119	1,040 81 A 15	1,570 106 A 46

Table 27.--*Statistical data for the combined Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, considering depths of 200 feet or less*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter: Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	31	7.0	7.6	7.8	8.2	8.6	--	--
Calcium, dissolved as Ca	63	1.6	5.1	21	45	270	37	50
Magnesium, dissolved as Mg	63	.1	1.7	10	29	360	30	59
Sodium, dissolved as Na	63	7.1	160	360	570	1,400	400	300
Potassium, dissolved as K	63	.1	1	2	4	15	3	3
Bicarbonate, as HCO_3	50	83	390	530	750	1,550	590	310
Carbonate, as CO_3	22	0	0	0	14	29	7	9
Sulfate, dissolved as SO_4	63	6.5	110	340	860	2,800	540	590
Chloride, dissolved as Cl	63	1.2	4.5	11	35	360	35	68
Silica, dissolved as SiO_2	63	.8	6.6	9.2	14	24	10	4.5
Dissolved solids	63	126	601	1,130	2,010	4,830	1,350	973
Depth of well, in feet	63	45	109	155	175	200	143	43

Table 28.--*Statistical data for the combined Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, considering depths greater than 200 feet*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	88	6.9	8.2	8.5	8.9	10.1	--	--
Calcium, dissolved as Ca	181	0	1.3	2.3	5.7	170	8.2	20
Magnesium, dissolved as Mg	181	0	.2	.4	1.5	86	4.0	12
Sodium, dissolved as Na	181	16	280	360	505	1,500	430	250
Potassium, dissolved as K	179	.1	.8	1	2	8	2	1
Bicarbonate, as HCO_3	176	150	490	620	830	1,960	680	300
Carbonate, as CO_3	109	0	12	24	42	310	32	36
Sulfate, dissolved as SO_4	181	.1	66	150	360	2,700	340	480
Chloride, dissolved as Cl	180	0	5.7	13	30	380	28	49
Silica, dissolved as SiO_2	178	1.6	8.3	9.9	11	23	10	3.1
Dissolved solids	180	340	748	899	1,330	4,600	1,180	762
Depth of well, in feet	181	202	337	520	765	1,280	567	269

Table 29.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, considering depths of 200 feet or less*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 / 31	-0.68 / 31	-0.62 / 31	-- / 31	-- / 31	-- / 18	-- / 13	-- / 31	-- / 31	0.71 / 31	-- / 31	-- / 31	-1.00 / 3	-- / 31
Calcium	-.68 / 31	1.00 / 63	.96 / 63	-- / 63	.67 / 63	-.48 / 50	-.67 / 22	.25 / 63	-- / 63	-.59 / 63	-- / 63	-- / 63	-- / 25	-- / 63
Magnesium	-.62 / 31	.96 / 63	1.00 / 63	-- / 63	.72 / 63	-.37 / 50	-.71 / 22	.31 / 63	-- / 63	.54 / 63	-- / 63	-- / 63	-- / 25	-- / 63
Sodium	-- / 31	-- / 63	-- / 63	1.00 / 63	-- / 63	.76 / 50	-- / 22	.76 / 63	.62 / 63	-.33 / 63	-.53 / 63	.91 / 63	-- / 25	-- / 63
Potassium	-- / 31	.67 / 63	.72 / 63	-- / 63	1.00 / 63	-- / 50	-- / 22	.44 / 63	.27 / 63	-- / 63	-- / 63	.39 / 63	-- / 25	-- / 63
Bicarbonate	-- / 18	-.48 / 50	-.37 / 50	.76 / 50	-- / 50	1.00 / 50	-- / 22	.39 / 50	.40 / 50	.51 / 50	-- / 50	.65 / 50	-- / 25	-- / 50
Carbonate	-- / 13	-.67 / 22	-.71 / 22	-- / 22	-- / 22	-- / 22	1.00 / 22	-- / 22	-- / 13	-- / 22	-.59 / 22	-- / 22	-- / 8	-- / 22
Sulfate	-- / 31	.25 / 63	.31 / 63	.76 / 63	.44 / 63	.39 / 50	-- / 22	1.00 / 63	.51 / 63	-- / 63	-.52 / 63	.92 / 63	-- / 25	-- / 63
Chloride	-- / 31	-- / 63	-- / 63	.62 / 63	.27 / 63	.40 / 50	-- / 13	.51 / 63	1.00 / 63	.45 / 63	-.59 / 63	.66 / 63	-- / 25	-- / 63
Fluoride	.71 / 31	-.59 / 63	-.54 / 63	-.33 / 63	-- / 63	.51 / 50	-- / 22	-- / 63	.45 / 63	1.00 / 63	-- / 63	-- / 63	-- / 25	-- / 63
Silica	-- / 31	-- / 63	-- / 63	-.53 / 63	-- / 63	-- / 50	-.59 / 22	-.52 / 63	-.59 / 63	-- / 63	1.00 / 63	-.53 / 63	-- / 25	-- / 63
Dissolved solids	-- / 31	-- / 63	-- / 63	.91 / 63	.39 / 63	.65 / 50	-- / 22	.92 / 63	.66 / 63	-- / 63	-.53 / 63	1.00 / 63	-- / 25	-- / 63
Nitrate, as N	-1.00 / 3	-- / 25	-- / 25	-- / 25	-- / 25	-- / 25	-- / 8	-- / 25	-- / 25	-- / 25	-- / 25	-- / 25	1.00 / 25	-- / 25
Depth of well	-- / 31	-- / 63	-- / 63	-- / 63	-- / 63	-- / 50	-- / 22	-- / 63	-- / 63	-- / 63	-- / 63	-- / 63	-- / 25	1.00 / 63

Table 30.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Fox Hills-lower Hell Creek, Fox Hills, and Hell Creek geohydrologic units, eastern Montana, considering depths greater than 200 feet*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 88	-0.77 88	-0.60 88	-0.24 88	-0.58 88	-- 83	0.61 72	-0.41 88	-- 88	0.22 88	-- 88	0.43 179	-0.42 33	0.49 88
Calcium	-.77 88	1.00 181	.75 181	.41 181	.69 179	-- 176	-.50 109	.56 181	-- 180	-.16 179	-.15 178	.53 180	.54 57	-.50 181
Magnesium	-.60 88	.75 181	1.00 181	.48 181	.77 179	.22 176	-.29 109	.47 181	-- 180	-- 179	-- 178	.59 180	.42 57	-.55 181
Sodium	-.24 88	.41 181	.48 181	1.00 181	.61 179	.57 176	-- 109	.46 181	.48 180	.44 179	-.21 178	.96 180	.36 57	-.21 181
Potassium	-.58 88	.69 179	.77 179	.61 179	1.00 181	.35 174	-- 107	.40 179	.23 179	.19 177	-- 178	.71 178	.47 55	-.36 179
Bicarbonate	-- 83	-- 176	.22 176	.57 176	.35 174	1.00 176	.28 109	-.17 176	.41 175	.64 174	.21 173	.50 175	.27 57	-- 176
Carbonate	.61 72	-.50 109	-.29 109	-- 109	-- 107	.28 109	1.00 109	-.44 109	.43 108	.43 108	-- 106	--- 108	-.57 42	.22 109
Sulfate	-.41 88	.56 181	.47 181	.46 181	.40 179	-.17 176	-.44 109	1.00 181	-.20 180	-.34 179	-.25 178	.57 180	.41 57	-.29 181
Chloride	-- 88	-- 180	-- 180	.48 180	.23 179	.41 175	.43 108	-.20 180	1.00 180	.67 178	-- 178	.43 179	-- 56	-- 180
Fluoride	.22 88	-.16 179	-- 179	.44 179	.19 177	.64 174	.43 108	-.34 179	.67 178	1.00 179	-- 176	.35 178	-- 55	-- 179
Silica	-- 88	-.15 178	-- 178	-.21 178	-- 178	.21 173	-- 106	-.25 178	-- 178	-- 176	1.00 178	-.22 178	-.38 55	.29 178
Dissolved solids	.43 179	.53 180	.59 180	.96 180	.71 178	.50 175	-- 108	.57 180	.43 179	.35 178	-.22 178	1.00 180	.42 57	-.28 180
Nitrate, as N	-.42 33	.54 57	.42 57	.36 57	.47 55	.27 57	-.57 42	.41 57	-- 56	-- 55	-.38 55	.42 57	1.00 57	-.27 57
Depth of well	.49 88	-.50 181	-.55 181	-.21 181	-.36 179	-- 176	.22 109	-.29 181	-- 180	-- 179	.29 178	-.28 180	-.27 57	1.00 181

Table 31.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Fox Hills-lower Hell Creek, Fox Hills, or Hell Creek geohydrologic unit, eastern Montana, considering depths of 200 feet or less*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	7	7	63	62
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	1	1	25	25
Nitrate, total as N	10 mg/L	0	0	15	15
Arsenic, dissolved	50 µg/L	0	0	6	6
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	14	13
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	0	0	6	6
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	6	6
Chromium, total	50 µg/L	--	--	0	0

Table 31.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Fox Hills-lower Hell Creek, Fox Hills, or Hell Creek geohydrologic unit, eastern Montana, considering depths of 200 feet or less*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]5	[3]5	21	21
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	0	0	1	1
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	1	1	14	13
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	5	5
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 32.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Fox Hills-lower Hell Creek, Fox Hills, or Hell Creek geohydrologic unit, eastern Montana, considering depths greater than 200 feet*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	44	43	179	175
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	57	57
Nitrate, total as N	10 mg/L	0	0	47	47
Arsenic, dissolved	50 µg/L	0	0	5	5
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	30	30
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	0	0	5	5
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	5	5
Chromium, total	50 µg/L	--	--	0	0

Table 32.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Fox Hills-lower Hell Creek, Fox Hills, or Hell Creek geohydrologic unit, eastern Montana, considering depths greater than 200 feet*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	0	0	17	17
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	0	0	2	2
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	0	0	31	31
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	5	5
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

Table 33.--*Results of statistical tests for significant differences between the Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit		
Variable	Judith River	Two Medicine	Parkman
pH, in units	-- 83 A 159	-- 67 A 5	-- 141 A 1
Calcium, dissolved as Ca	53 97 A 187	110 115 A 6	4.8 46 A 1
Magnesium, dissolved as Mg	44 97 A 187	38 113 A 6	1.3 46 A 1
Sodium, dissolved as Na	910 97 A 185	500 59 A 5	640 64 A 1
Potassium, dissolved as K	5 97 A 185	3 80 A 5	2 33 A 1
Bicarbonate, as HCO_3	760 96 A 181	580 66 A 6	440 31 A 1
Carbonate, as CO_3	25 43 A 80	27 39 A 3	12 31 A 1
Sulfate, dissolved as SO_4	1,200 94 A 179	810 87 A 6	940 106 A 1
Chloride, dissolved as Cl	320 97 A 185	32 53 A 5	26 45 A 1

Table 33.--*Results of statistical tests for significant differences between the Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit		
	Judith River	Two Medicine	Parkman
Silica, dissolved as SiO_2	10 96 A 184	8.1 59 A 5	9.2 100 A 1
Dissolved solids	2,810 92 A 174	1,740 56 A 6	1,850 61 A 1

Table 34.--*Results of statistical tests for significant differences between the Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit: Judith River	Geohydrologic unit: Two Medicine	Geohydrologic unit: Parkman
pH, in units	-- 21 A 35	-- 20 A 5	-- 39 A 1
Calcium, dissolved as Ca	110 30 A 50	74 21 A 5	4.8 4 A 1
Magnesium, dissolved as Mg	110 30 A 50	38 21 A 5	1.3 5 A 1
Sodium, dissolved as Na	1,100 29 A 49	500 20 A 5	640 22 A 1
Potassium, dissolved as K	6 29 A 49	3 18 A 5	2 6 A 1
Bicarbonate, as HCO_3	730 29 A 49	580 25 A 5	440 16 A 1
Carbonate, as CO_3	6 11 A 20	41 19 A 2	12 18 A 1
Sulfate, dissolved as SO_4	2,000 29 A 50	860 22 A 5	940 27 A 1
Chloride, dissolved as Cl	210 30 A 50	32 19 A 5	26 17 A 1

Table 34.--*Results of statistical tests for significant differences between the Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*--Continued

Variable	Geohydrologic unit		
	Judith River	Two Medicine	Parkman
Silica, dissolved as SiO_2	11 28 A 48	8.1 19 A 5	9.2 31 A 1
Dissolved solids	3,880 28 A 47	1,820 19 A 5	1,850 21 A 1

Table 35.--*Results of statistical tests for significant differences between the Judith River and Two Medicine geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit	
	Judith River	Two Medicine
pH, in units	-- 60 117	-- -- 0
Calcium, dissolved as Ca	25 65 A 128	320 128 A 1
Magnesium, dissolved as Mg	15 65 A 128	43 118 A 1
Sodium, dissolved as Na	860 65 127	-- -- 0
Potassium, dissolved as K	4 65 127	-- -- 0
Bicarbonate, as HCO_3	780 63 A 123	580 34 A 1
Carbonate, as CO_3	31 29 A 55	0 3 A 1
Sulfate, dissolved as SO_4	830 61 A 120	550 58 A 1
Chloride, dissolved as Cl	380 64 125	-- -- 0

Table 35.--*Results of statistical tests for significant differences between the Judith River and Two Medicine geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*--Continued

Variable	Geohydrologic unit	
	Judith River	Two Medicine
Silica, dissolved as SiO_2	9.5 65 127	-- -- 0
Dissolved solids	2,430 60 A 118	1,300 15 A 1

Table 36.--*Statistical data for the combined Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, considering all depths*

Variable	Number of data values	Concentration (except as noted), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	164	7.0	7.8	8.2	8.5	9.7	--	--
Calcium, dissolved as Ca	193	.7	5.0	14	58	460	55	92
Magnesium, dissolved as Mg	193	.1	1.4	4.4	31	1,100	44	110
Sodium, dissolved as Na	190	48	550	810	1,100	6,900	890	700
Potassium, dissolved as K	190	.4	2	3	5	51	5	5
Bicarbonate, as HCO_3	187	250	510	700	930	3,070	750	350
Carbonate, as CO_3	83	0	7	19	38	93	25	24
Sulfate, dissolved as SO_4	185	.2	190	720	1,500	18,000	1,200	1,800
Chloride, dissolved as Cl	190	.7	27	96	340	3,000	310	500
Silica, dissolved as SiO_2	189	3.5	8.0	9.0	11	72	10	5.6
Dissolved solids	180	258	1,580	2,270	3,280	27,100	2,770	2,530
Depth of well, in feet	184	12	184	305	642	1,430	429	354

Table 37.--*Statistical data for the combined Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, considering depths of 200 feet or less*

Variable	Number of data values	Concentration (except as noted), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	41	7.0	7.6	7.8	8.2	9.7	--	--
Calcium, dissolved as Ca	56	.7	15	51	140	460	110	130
Magnesium, dissolved as Mg	56	.2	6.5	30	130	1,100	110	190
Sodium, dissolved as Na	55	48	200	800	1,200	6,900	1,000	1,100
Potassium, dissolved as K	55	.4	3	5	8	26	6	5
Bicarbonate, as HCO_3	55	260	430	570	830	3,070	710	490
Carbonate, as CO_3	23	0	0	3	12	72	9	16
Sulfate, dissolved as SO_4	56	1.9	240	960	2,800	18,000	1,900	2,900
Chloride, dissolved as Cl	56	.7	18	78	220	1,700	190	340
Silica, dissolved as SiO_2	54	4.7	7.6	8.9	11	72	11	9
Dissolved solids	53	288	1,170	2,140	4,910	27,100	3,650	4,250
Depth of well, in feet	56	12	75	120	159	200	116	55

Table 38.--*Statistical data for the combined Judith River and Two Medicine geohydrologic units, eastern Montana, considering depths greater than 200 feet*

Variable	Number of data values	Concentration (except as noted), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	117	7.1	8.1	8.3	8.6	9.2	--	--
Calcium, dissolved as Ca	128	.8	4.1	7.9	21	380	28	55
Magnesium, dissolved as Mg	128	.1	1.1	2.4	8.3	210	15	35
Sodium, dissolved as Na	127	71	610	820	1,100	2,300	860	390
Potassium, dissolved as K	127	.7	2	3	4	19	4	3
Bicarbonate, as HCO_3	123	250	550	780	940	1,460	780	270
Carbonate, as CO_3	55	0	15	24	43	93	31	23
Sulfate, dissolved as SO_4	120	.2	160	620	1,300	4,200	840	810
Chloride, dissolved as Cl	125	.8	33	110	480	3,000	380	570
Silica, dissolved as SiO_2	127	3.5	8.0	8.9	11	20	9.5	2.6
Dissolved solids	118	513	1,650	2,280	2,930	6,860	2,420	1,100
Depth of well, in feet	128	203	291	429	802	1,430	565	342

Table 39.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 164	-0.78 164	-0.78 164	0.16 164	-0.63 164	0.20 158	0.63 64	-0.18 156	-- 162	0.58 163	-0.42 164	-- 153	-0.17 117	0.45 158
Calcium	-.78 164	1.00 193	.96 193	-- 190	.80 190	-.39 187	-.57 83	.49 185	-- 190	-.70 190	.23 189	.31 180	.31 125	-.60 184
Magnesium	-.78 164	.96 193	1.00 193	-- 190	.79 190	-.37 187	-.46 83	.45 185	-.15 190	-.70 190	.21 189	.25 180	.30 125	-.63 184
Sodium	.16 164	-- 190	--- 190	1.00 190	.26 190	.28 184	-- 80	.49 182	.55 188	-- 189	-.27 188	.92 177	-- 123	-- 182
Potassium	-.63 164	.80 190	.79 190	.26 190	1.00 190	-.23 184	-.31 80	.48 182	-- 188	-.58 189	.15 188	.44 177	.26 123	-.37 182
Bicarbonate	.20 158	-.39 187	-.37 187	.28 184	-.23 184	1.00 187	.29 83	-- 179	.12 184	.32 184	-- 183	.16 174	-- 125	.31 178
Carbonate	.63 64	-.57 83	-.46 83	-- 80	-.31 80	.29 83	1.00 83	-- 81	-- 81	.24 80	-- 79	-- 77	-.34 44	.45 78
Sulfate	-.18 156	.49 185	.45 185	.49 182	.48 182	-- 179	-- 81	1.00 185	-- 182	-.32 182	-.18 181	.70 180	.45 118	-.27 176
Chloride	-- 162	-- 190	-.15 190	.55 188	-- 188	.12 184	-- 81	-- 182	1.00 190	.38 188	-- 187	.47 179	-.28 123	.29 181
Fluoride	.58 163	-.70 190	-.70 190	-- 189	-.58 189	.32 184	.24 80	-.32 182	.38 188	1.00 190	-.18 187	-- 177	-.25 124	.55 181
Silica	-.42 164	.23 189	.21 189	-.27 188	.15 188	-- 183	-- 79	-.18 181	-- 187	-.18 187	1.00 189	-.20 178	-- 124	-- 181
Dissolved solids	-- 153	.31 180	.25 180	.92 177	.44 177	.16 174	-- 77	.70 180	.47 179	-- 177	-.20 178	1.00 180	.21 115	-- 171
Nitrate, as N	-.17 117	.31 125	.30 125	-- 123	.26 123	-- 125	-.34 44	.45 118	-.28 123	-.25 124	-- 124	.21 115	1.00 125	-21 120
Depth of well	.45 158	-.60 184	-.63 184	-- 182	-.37 182	.31 178	.45 78	-.27 176	.29 181	.55 181	-- 181	-- 171	-.21 120	1.00 184

Table 40.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Judith River, Two Medicine, and Parkman geohydrologic units, eastern Montana, considering depths of 200 feet or less*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal-cium	Mag-ne-sium	So-dium	Po-tas-sium	Bi-car-bo-nate	Car-bon-ate	Sul-fate	Chlo-ride	Fluo-ride	Sil-ica	Dis-solved solids	Ni-trate, as N	Depth of well
pH	1.00 41	-0.65 41	-0.68 41	-0.32 41	-0.43 41	-- 40	0.90 14	-- 41	-- 41	0.46 40	-0.50 41	-- 40	-- 20	-- 41
Calcium	-.65 41	1.00 56	.96 56	-- 55	.76 55	-.23 55	-.70 23	.60 56	.31 56	-.39 54	-- 54	.44 53	.42 25	-.33 56
Magne-sium	-.68 41	.96 56	1.00 56	--- 55	.71 55	-.29 55	-.69 23	.52 56	-- 56	-.34 54	-- 54	.33 53	.38 25	-.39 56
Sodium	.32 41	-- 55	-- 55	1.00 55	.36 55	.51 54	-- 22	.72 55	.57 55	-- 54	-.49 53	.90 52	-- 24	-- 55
Potas-sium	-.43 41	.76 55	.71 55	.36 55	1.00 55	-- 54	-.56 22	.61 55	.30 55	-.31 54	-- 53	.50 52	-- 24	-.28 55
Bicar-bonate	-- 40	-.23 55	-.29 55	.51 54	-- 54	1.00 55	-- 23	.28 55	-- 55	-- 53	-- 53	.39 52	-- 25	.36 55
Carbo-nate	.90 14	-.70 23	-.69 23	-- 22	-.56 22	-- 23	1.00 23	-- 23	-- 23	-- 21	-.37 21	-- 20	-- 7	-- 23
Sul-fate	-- 41	.60 56	.52 56	.72 55	.61 55	.28 55	-- 23	1.00 56	.37 56	-.30 54	-.37 54	.89 53	-- 25	-- 56
Chlo-ride	-- 41	.31 56	-- 56	.57 55	.30 55	-- 55	-- 23	.37 56	1.00 56	-- 54	-.25 54	.60 53	-- 25	-- 56
Fluo-ride	.46 40	-.39 54	-.34 54	-- 54	-.31 54	-- 53	-- 21	-.30 54	-- 54	1.00 54	-- 52	-- 51	-- 24	-- 54
Silica	-.50 41	-- 54	-- 54	-.49 53	-- 53	-- 53	-.37 21	-.37 54	-.25 54	-- 52	1.00 54	-.43 53	-- 25	-- 54
Dis-solved solids	-- 40	.44 53	.33 53	.90 52	.50 52	.39 52	-- 20	.89 53	.60 53	-- 51	-.43 53	1.00 53	-- 24	-- 53
Nitrate, as N	-- 20	.42 25	.38 25	-- 24	-- 24	-- 25	-- 7	-- 25	-- 25	-- 24	-- 25	-- 24	1.00 25	-- 25
Depth of well	-- 41	-.33 56	-.39 56	-- 55	-.28 55	.36 55	-- 23	-- 56	-- 56	-- 54	-- 54	-- 53	-- 25	1.00 56

Table 41.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Judith River and Two Medicine geohydrologic units, eastern Montana, considering depths greater than 200 feet*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 117	-0.70 117	-0.69 117	-- 117	-0.64 117	-- 112	0.53 48	-- 109	-- 115	0.52 117	-0.38 117	-- 107	-- 93	0.31 117
Calcium	.70 117	1.00 128	.94 128	.24 127	.84 127	-.32 123	.32 55	.45 120	-- 125	-.71 127	-.21 127	.45 118	.31 95	-.48 128
Magnesium	-.69 117	.94 128	1.00 128	.18 127	.82 127	-.26 123	-- 55	.42 120	-- 125	-.70 127	.15 127	.39 118	.30 95	-.54 128
Sodium	-- 117	.24 127	.18 127	1.00 127	.29 127	-- 122	-- 54	.34 119	.58 125	-- 127	-- 127	.90 117	-- 95	.18 127
Potassium	-.64 117	.84 127	.82 127	.29 127	1.00 127	-.19 122	-- 54	.40 119	-- 125	-.59 127	.16 127	.48 117	.30 95	-.30 127
Bicarbonate	-- 112	-.32 123	-.26 123	-- 122	-.19 122	1.00 123	-- 55	-.21 115	-- 120	.33 122	-- 122	-- 113	-- 95	-- 123
Carbonate	.53 48	-.32 55	-- 55	-- 54	-- 54	-- 55	1.00 55	-- 53	-- 53	-- 54	-- 54	-- 52	-.44 35	-- 55
Sulfate	-- 109	.45 120	.42 120	.34 119	.40 119	-.21 115	-- 53	1.00 120	-.30 117	-.27 119	-- 119	.59 118	.51 88	-.23 120
Chloride	-- 115	-- 125	-- 125	.58 125	-- 125	-- 120	-- 53	-.30 117	1.00 125	.40 125	-- 125	.41 117	-.37 93	.36 125
Fluoride	.52 117	-.71 127	-.70 127	-- 127	-.59 127	.33 122	-- 54	-.27 119	.40 125	1.00 127	-- 127	-- 117	-.29 95	.51 127
Silica	-.38 117	.21 127	.15 127	-- 127	.16 127	-- 122	-- 54	-- 119	-- 125	-- 127	1.00 127	-- 117	-- 95	.23 127
Dissolved solids	-- 107	.45 118	.39 118	.90 117	.48 117	-- 113	-- 52	.59 118	.41 117	-- 117	-- 117	1.00 118	.25 86	-- 118
Nitrate, as N	-- 93	.31 95	.30 95	-- 95	.30 95	-- 95	-.44 35	.51 88	-.37 93	-.29 95	-- 95	.25 86	1.00 95	-.31 95
Depth of well	.31 117	-.48 128	-.54 128	.18 127	-.30 127	.18 123	-- 55	-.23 120	.36 125	.51 127	.23 127	-- 118	-.31 95	1.00 128

Table 42.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Judith River, Two Medicine, or Parkman geohydrologic unit, eastern Montana, considering depths of 200 feet or less*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	3	3	54	47
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	3	3	25	25
Nitrate, total as N	10 mg/L	10	6	29	22
Arsenic, dissolved	50 µg/L	0	0	20	20
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	2	2
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	--	--	0	0
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	20	20
Chromium, total	50 µg/L	--	--	0	0

Table 42.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Judith River, Two Medicine, or Parkman geohydrologic unit, eastern Montana, considering depths of 200 feet or less*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]5	[3]5	23	23
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	--	--	0	0
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	7	7	24	24
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	--	--	0	0
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 43.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Judith River or Two Medicine geohydrologic unit, eastern Montana, considering depths greater than 200 feet*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	40	37	128	124
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	4	4	95	94
Nitrate, total as N	10 mg/L	0	0	22	22
Arsenic, dissolved	50 µg/L	0	0	10	10
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	1	1	14	13
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	0	0	1	1
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	10	10
Chromium, total	50 µg/L	--	--	0	0

Table 43.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Judith River or Two Medicine geohydrologic unit, eastern Montana, considering depths greater than 200 feet*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 μg/L	[3]1	[3]1	11	11
Lead, total	50 μg/L	--	--	0	0
Mercury, dissolved	2 μg/L	--	--	0	0
Mercury, total	2 μg/L	--	--	0	0
Selenium, dissolved	10 μg/L	1	1	20	18
Selenium, total	10 μg/L	--	--	0	0
Silver, dissolved	50 μg/L	0	0	1	1
Silver, total	50 μg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 44.--*Results of statistical tests for significant differences between the Eagle, Virgelle, Shannon, and Telegraph Creek geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit			
Variable	Eagle	Virgelle	Shannon	Telegraph Creek
pH, in units	-- 34 A 53	-- 24 A 7	-- -- 0	-- 24 A 4
Calcium, dissolved as Ca	59 35 A 61	110 51 A 7	87 59 A 1	89 45 A 4
Magnesium, dissolved as Mg	40 34 A 61	66 54 A 7	29 50 A 1	72 49 A 4
Sodium, dissolved as Na	660 37 A,B 60	710 38 A,B 7	5,200 72 B 1	400 23 A 4
Potassium, dissolved as K	3 34 A 60	4 47 A,B 7	17 72 B 1	5 47 A,B 4
Bicarbonate, as HCO_3	750 36 A,B 60	810 44 A 7	0 1 B 1	680 36 A,B 4
Carbonate, as CO_3	28 21 A 40	38 34 A 1	41 36 A 1	29 24 A 1
Sulfate, dissolved as SO_4	780 34 A 58	1,300 47 A 7	30 17 A 1	730 39 A 4
Chloride, dissolved as Cl	230 37 A 61	26 31 A 7	7,900 73 B 1	32 36 A 4

Table 44.--*Results of statistical tests for significant differences between the Eagle, Virgelle, Shannon, and Telegraph Creek geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

	Geohydrologic unit			
Variable	Eagle	Virgelle	Shannon	Telegraph Creek
Silica, dissolved as SiO_2	10 37 A 59	8.7 27 A 7	12 55 A 1	8.4 24 A 4
Dissolved solids	2,110 34 A,B 57	2,640 41 A,B 7	13,300 69 B 1	1,690 29 A 4

Table 45.--*Results of statistical tests for significant differences between the Eagle, Virgelle, and Telegraph Creek geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit		
	Eagle	Virgelle	Telegraph Creek
pH, in units	-- / 12 A / 14	-- / 12 A / 5	-- / 12 A / 4
Calcium, dissolved as Ca	130 / 14 A / 17	86 / 14 A / 5	89 / 11 A / 4
Magnesium, dissolved as Mg	96 / 13 A / 17	59 / 15 A / 5	72 / 12 A / 4
Sodium, dissolved as Na	650 / 13 A / 16	870 / 16 A / 5	400 / 10 A / 4
Potassium, dissolved as K	5 / 13 A / 16	5 / 13 A / 5	5 / 13 A / 4
Bicarbonate, as HCO_3	560 / 11 A / 16	840 / 18 A / 5	680 / 14 A / 4
Carbonate, as CO_3	6 / 4 A / 7	-- / -- / 0	29 / 7 A / 1
Sulfate, dissolved as SO_4	1,400 / 14 A / 17	1,500 / 16 A / 5	730 / 10 A / 4
Chloride, dissolved as Cl	120 / 13 A / 17	27 / 13 A / 5	32 / 16 A / 4

Table 45.--*Results of statistical tests for significant differences between the Eagle, Virgelle, and Telegraph Creek geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*--Continued

	Geohydrologic unit		
Variable	Eagle	Virgelle	Telegraph Creek
Silica, dissolved as SiO_2	11 16 A 16	8.2 9 A 5	8.4 9 A 4
Dissolved solids	2,650 14 A 17	3,030 16 A 5	1,690 10 A 4

Table 46.--*Results of statistical tests for significant differences between the Eagle, Virgelle, and Shannon geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit		
	Eagle	Virgelle	Shannon
pH, in units	-- 20 A 39	-- 36 A 1	-- -- 0
Calcium, dissolved as Ca	30 23 A,B 42	.8 2 A 1	87 41 B 1
Magnesium, dissolved as Mg	20 22 A 42	.9 20 A 1	29 41 A 1
Sodium, dissolved as Na	670 22 A,B 42	390 10 A 1	5,200 44 B 1
Potassium, dissolved as K	3 22 A,B 42	1 11 A 1	17 44 B 1
Bicarbonate, as HCO_3	810 23 A 42	940 29 A 1	0 1 A 1
Carbonate, as CO_3	32 16 A 31	38 25 A 1	41 27 A 1
Sulfate, dissolved as SO_4	530 22 A 39	.1 1 A 1	30 16 A 1
Chloride, dissolved as Cl	290 22 A 42	15 16 A 1	7,900 44 A 1

Table 46.--*Results of statistical tests for significant differences between the Eagle, Virgelle, and Shannon geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*--Continued

Variable	Geohydrologic unit		
	Eagle	Virgelle	Shannon
Silica, dissolved as SiO_2	9.9 / 22 A / 41	8.7 / 17 A / 1	12 / 36 A / 1
Dissolved solids	1,890 / 20 A,B / 38	920 / 6 A / 1	13,300 / 40 B / 1

Table 47.--*Statistical data for the combined Eagle, Virgelle, and Telegraph Creek geohydrologic units, eastern Montana, considering depths of 200 feet or less*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter: Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	23	7.2	7.3	7.7	8.1	9.0	--	--
Calcium, dissolved as Ca	26	1.4	39	73	150	420	120	130
Magnesium, dissolved as Mg	26	.5	25	52	120	420	85	99
Sodium, dissolved as Na	25	15	200	560	970	2,000	660	530
Potassium, dissolved as K	25	1	2	4	8	12	5	3
Bicarbonate, as HCO_3	25	240	410	500	850	1,530	640	370
Carbonate, as CO_3	8	0	0	0	24	34	9	14
Sulfate, dissolved as SO_4	26	15	320	1,200	2,100	3,900	1,300	1,100
Chloride, dissolved as Cl	26	1.8	9.4	24	56	1,200	88	230
Silica, dissolved as SiO_2	25	7.1	7.8	9.2	13	16	10	2.9
Dissolved solids	26	287	975	2,280	3,810	6,370	2,570	1,720
Depth of well, in feet	26	7	62	116	176	200	114	60

Table 48.--*Statistical data for the combined Eagle, Virgelle, and Shannon geohydrologic units, eastern Montana, considering depths greater than 200 feet*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	40	6.5	8.1	8.4	8.9	9.4	--	--
Calcium, dissolved as Ca	44	.2	1.5	4.0	9.6	490	31	91
Magnesium, dissolved as Mg	44	.1	.5	1	4.4	420	19	69
Sodium, dissolved as Na	44	15	410	610	920	5,200	770	800
Potassium, dissolved as K	44	.6	1	2	3	17	3	4
Bicarbonate, as HCO_3	44	0	390	690	1,060	2,130	800	520
Carbonate, as CO_3	33	0	12	24	38	250	33	43
Sulfate, dissolved as SO_4	41	.1	2.0	100	890	3,500	500	750
Chloride, dissolved as Cl	44	2.6	7.6	57	200	7,900	460	1,300
Silica, dissolved as SiO_2	43	2	7.9	9.6	11	18	9.9	3.7
Dissolved solids	40	153	1,030	1,770	2,580	13,300	2,150	2,110
Depth of well, in feet	44	235	441	766	1,570	2,564	1,000	683

Table 49.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Eagle, Virgelle, and Telegraph Creek geohydrologic units, eastern Montana, considering depths of 200 feet or less*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower number is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 23	-0.80 23	-0.74 23	-- 23	-0.60 23	-- 22	0.92 6	-- 23	-- 23	0.63 23	-0.67 23	-- 23	-- 15	-- 23
Calcium	-.80 23	1.00 26	.95 26	-- 25	.73 25	-- 25	-.76 8	.46 26	-- 26	-.55 26	.62 25	-- 26	.73 16	-.44 26
Magnesium	-.74 23	.95 26	1.00 26	-- 25	.81 25	-- 25	-.85 8	.59 26	.38 26	-.60 26	.57 25	.42 26	.56 16	-.41 26
Sodium	-- 23	-- 25	-- 25	1.00 25	.36 25	.82 24	-- 7	.65 25	.46 25	-- 25	-.39 25	.82 25	-- 15	-- 25
Potassium	-.60 23	.73 25	.81 25	.36 25	1.00 25	-- 24	-- 7	.83 25	.68 25	-.43 25	.40 25	.78 25	.50 15	-.52 25
Bicarbonate	-- 22	-- 25	-- 25	.82 24	-- 24	1.00 25	.76 8	.34 25	.36 25	-- 25	-.49 24	.55 25	-.49 16	-- 25
Carbonate	.92 6	-.76 8	-.85 8	-- 7	-- 7	.76 8	1.00 8	-- 8	-- 8	.76 8	-- 7	-- 8	-- 3	-- 8
Sulfate	-- 23	.46 26	.59 26	.65 25	.83 25	.34 25	-- 8	1.00 26	.58 26	-- 26	-- 25	.93 26	-- 16	-- 26
Chloride	-- 23	-- 26	.38 26	.46 25	.68 25	.36 25	-- 8	.58 26	1.00 26	-- 26	-- 25	.71 26	-- 16	-- 26
Fluoride	.63 23	-.55 26	-.60 26	-- 25	-.43 25	-- 25	.76 8	-- 26	-- 26	1.00 26	-- 25	-- 26	-- 16	-- 26
Silica	-.67 23	.62 25	.57 25	-.39 25	.40 25	-.49 24	-- 7	-- 25	-- 25	-- 25	1.00 25	-- 25	.58 15	-.37 25
Dissolved solids	-- 23	--- 26	.42 26	.82 25	.78 25	.55 25	-- 8	.93 26	.71 26	-- 26	-- 25	1.00 26	-- 16	-- 26
Nitrate, as N	-- 15	.73 16	.56 16	-- 15	.50 15	-.49 16	-- 3	-- 16	-- 16	-- 16	.58 15	-- 16	1.00 16	-.46 16
Depth of well	-- 23	.44 26	-.41 26	-- 25	-.52 25	-- 25	-- 8	-- 26	-- 26	-- 26	-.37 25	-- 26	-.46 16	1.00 26

Table 50.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Eagle, Virgelle, and Shannon geohydrologic units, eastern Montana, considering depths greater than 200 feet*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal-cium	Mag-ne-sium	So-dium	Po-tas-sium	Bi-car-bo-nate	Car-bon-ate	Sul-fate	Chlo-ride	Fluo-ride	Sil-ica	Dis-solved solids	Ni-trate, as N	Depth of well
pH	1.00 40	-0.60 40	-0.58 40	-- 40	-0.81 40	-- 40	0.84 29	-- 37	-- 40	-- 40	-- 39	-- 36	-- 21	-- 40
Calcium	-.60 40	1.00 44	.91 44	-- 44	.77 44	-.54 44	-.60 33	.44 41	-- 44	-.50 44	-.35 43	.32 40	-- 21	-.26 44
Magne-sium	-.58 40	.91 44	1.00 44	-- 44	.73 44	-.48 44	-.63 33	.34 41	-- 44	-.46 44	-.40 43	.33 40	-- 21	-.28 44
Sodium	-- 40	-- 44	-- 44	1.00 44	-- 44	.40 44	-- 33	-- 41	.78 44	.32 44	-- 43	.82 40	-- 21	-- 44
Potas-sium	-.81 40	.77 44	.73 44	-- 44	1.00 44	-- 44	-.47 33	-- 41	-- 44	-- 44	-- 43	.41 40	-- 21	-- 44
Bicar-bonate	-- 40	-.54 44	-.48 44	.40 44	-- 44	1.00 44	-- 33	-.50 41	.50 44	.78 44	.30 43	-- 40	-- 21	.30 44
Carbo-nate	.84 29	-.60 33	-.63 33	-- 33	-.47 33	-- 33	1.00 33	-- 32	-- 33	-- 33	-- 32	-- 31	-- 13	-- 33
Sul-fate	-- 37	.44 41	.34 41	-- 41	-- 41	-.50 41	-- 32	1.00 41	-.47 41	-.53 41	-.28 40	.29 40	-- 18	-.30 41
Chlo-ride	-- 40	-- 44	-- 44	.78 44	-- 44	.50 44	-- 33	-.47 41	1.00 44	.61 44	-- 43	.58 40	-- 21	-- 44
Fluo-ride	-- 40	-.50 44	-.46 44	.32 44	-- 44	.78 44	-- 33	-.53 41	.61 44	1.00 44	.31 43	-- 40	-- 21	-- 44
Silica	-- 39	-.35 43	-.40 43	-- 43	-- 43	.30 43	-- 32	-.28 40	-- 43	.31 43	1.00 43	-- 40	-- 20	.74 43
Dis-solved solids	-- 36	.32 40	.33 40	.82 40	.41 40	-- 40	-- 31	.29 40	.58 40	-- 40	-- 40	1.00 40	-- 17	-- 40
Nitrate, as N	-- 21	-- 21	-- 21	-- 21	-- 21	-- 21	-- 13	-- 18	-- 21	-- 21	-- 20	-- 17	1.00 21	-- 21
Depth of well	-- 40	-.26 44	-.28 44	-- 44	-- 44	.30 44	-- 33	-.30 41	-- 44	-- 44	.74 43	-- 40	-- 21	1.00 44

Table 51.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Eagle, Virgelle, or Telegraph Creek geohydrologic unit, eastern Montana, considering depths of 200 feet or less*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	1	1	26	25
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	2	2	16	16
Nitrate, total as N	10 mg/L	1	1	8	8
Arsenic, dissolved	50 µg/L	0	0	15	15
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	3	3
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	--	--	0	0
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	15	15
Chromium, total	50 µg/L	--	--	0	0

Table 51.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Eagle, Virgelle, or Telegraph Creek geohydrologic unit, eastern Montana, considering depths of 200 feet or less*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]4	[3]4	15	15
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	--	--	0	0
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	4	4	19	18
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	--	--	0	0
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 52.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Eagle, Virgelle, or Shannon geohydrologic unit, eastern Montana, considering depths greater than 200 feet*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	15	14	44	43
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	21	21
Nitrate, total as N	10 mg/L	0	0	23	22
Arsenic, dissolved	50 µg/L	0	0	7	7
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	1	1	13	13
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	0	0	1	1
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	8	8
Chromium, total	50 µg/L	--	--	0	0

Table 52.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Eagle, Virgelle, or Shannon geohydrologic unit, eastern Montana, considering depths greater than 200 feet*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	0	0	8	8
Lead, total	50 µg/L	0	0	1	1
Mercury, dissolved	2 µg/L	--	--	0	0
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	0	0	18	18
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	1	1
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

Table 53.--*Results of statistical tests for significant differences between the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit				
	Kootenai	First Cat Creek	Second Cat Creek	Third Cat Creek	Fall River
pH, in units	-- / 73 A,B / 104	-- / 113 A / 11	-- / 42 B / 1	-- / 73 A,B / 34	-- / -- / 0
Calcium, dissolved as Ca	66 / 90 A / 108	14 / 32 A / 12	61 / 98 A / 1	38 / 62 A / 35	5.0 / 24 A / 1
Magnesium, dissolved as Mg	28 / 92 A / 109	4.6 / 30 A / 12	18 / 80 A / 1	14 / 60 A / 35	1.9 / 21 A / 1
Sodium, dissolved as Na	58 / 64 A / 106	220 / 123 A,B / 12	60 / 93 A,B / 1	210 / 101 A,B / 35	450 / 150 B / 1
Potassium, dissolved as K	4 / 80 A,B / 104	2 / 45 B / 12	3 / 75 A,B / 1	4 / 79 A,B / 35	6 / 138 A / 1
Bicarbonate, as HCO_3	330 / 69 A,B / 94	490 / 104 A / 12	190 / 14 B / 1	370 / 71 A,B / 35	380 / 103 A / 1
Carbonate, as CO_3	2 / 58 A / 92	7 / 86 A,B / 12	0 / 50 A / 1	5 / 79 A,B / 22	14 / 119 B / 1
Sulfate, dissolved as SO_4	130 / 74 A,B / 109	83 / 49 B / 12	190 / 112 A,B / 1	200 / 104 A,B / 35	640 / 158 A / 1
Chloride, dissolved as Cl	5.0 / 74 A,B / 109	18 / 100 A,B / 12	1.2 / 12 B / 1	62 / 89 A,B / 35	7.5 / 130 A / 1

Table 53.--*Results of statistical tests for significant differences between the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit				
	Kootenai	First Cat Creek	Second Cat Creek	Third Cat Creek	Fall River
Silica, dissolved as SiO_2	7.7 / 66 A / 105	9.0 / 97 A / 12	12 / 138 A / 1	10 / 101 A / 35	11 / 131 A / 1
Dissolved solids	453 / 70 A / 108	601 / 92 A / 12	440 / 85 A / 1	726 / 99 A / 35	1,330 / 152 A / 1

Table 54.--*Results of statistical tests for significant differences between the Kootenai, First Cat Creek, and Third Cat Creek geohydrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

Variable	Geohydrologic unit		
	Kootenai	First Cat Creek	Third Cat Creek
pH, in units	-- 19 A 30	-- 12 A 2	-- 7 A 2
Calcium, dissolved as Ca	77 18 A 32	53 13 A 2	94 27 A 2
Magnesium, dissolved as Mg	41 19 A 32	16 10 A 2	32 18 A 2
Sodium, dissolved as Na	47 18 A 31	49 28 A 2	8.4 12 A 2
Potassium, dissolved as K	4 18 A 31	2 12 A 2	4 23 A 2
Bicarbonate, as HCO_3	360 17 A 29	310 16 A 2	170 8 A 2
Carbonate, as CO_3	1 17 A 29	0 16 A 2	0 16 A 2
Sulfate, dissolved as SO_4	160 19 A 32	48 10 A 2	210 24 A 2
Chloride, dissolved as Cl	6.4 18 A 32	4.9 22 A 2	17 23 A 2

Table 54.--*Results of statistical tests for significant differences between the Kootenai, First Cat Creek, and Third Cat Creek geohyrologic units, eastern Montana, by chemical variable considering depths of 200 feet or less*--Continued

	Geohydrologic unit		
Variable	Kootenai	First Cat Creek	Third Cat Creek
Silica, dissolved as SiO_2	8.4 17 A 31	10 28 A 2	11 28 A 2
Dissolved solids	516 19 A 32	336 12 A 2	458 20 A 2

Table 55.--*Results of statistical tests for significant differences between the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit				
Variable	Kootenai	First Cat Creek	Second Cat Creek	Third Cat Creek	Fall River
pH, in units	-- 55 A,B 74	-- 98 A 9	-- 28 B 1	-- 55 A,B 32	-- -- 0
Calcium, dissolved as Ca	61 71 A 76	6.0 20 A 9	61 81 A 1	35 49 A 33	5.0 20 A 1
Magnesium, dissolved as Mg	22 71 A 77	2.4 21 A 9	18 69 A 1	13 49 A 33	1.9 19 A 1
Sodium, dissolved as Na	62 47 A 75	210 96 A,B 9	60 63 A,B 1	220 77 A,B 33	450 115 B 1
Potassium, dissolved as K	4 62 A,B 73	2 28 A 9	3 59 A,B 1	4 60 A,B 33	6 107 B 1
Bicarbonate, as HCO_3	310 50 A,B 65	430 84 A 9	190 10 B 1	380 58 A,B 33	380 82 A 1
Carbonate, as CO_3	2 42 A 63	3 62 A,B 9	0 34 A 1	6 58 A,B 20	14 87 B 1
Sulfate, dissolved as SO_4	110 54 A 77	97 40 A 9	190 84 A,B 1	200 80 A,B 33	640 121 B 1
Chloride, dissolved as Cl	4.4 56 A,B 77	10 73 A,B 9	1.2 12 A 1	65 70 A,B 33	7.5 101 B 1

Table 55.--*Results of statistical tests for significant differences between the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana, by chemical variable considering depths greater than 200 feet*--Continued

Variable	Geohydrologic unit				
	Kootenai	First Cat Creek	Second Cat Creek	Third Cat Creek	Fall River
Silica, dissolved as SiO_2	7.4 / 49 A / 74	8.3 / 68 A / 9	12 / 106 A / 1	10 / 77 A / 33	11 / 102 A / 1
Dissolved solids	427 / 51 A / 76	554 / 73 A / 9	440 / 64 A / 1	742 / 76 A / 33	1,330 / 116 A / 1

Table 56.--*Statistical data for the combined Kootenai, First Cat Creek, and Third Cat Creek geohydrologic units, eastern Montana, considering depths of 200 feet or less*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	34	5.9	7.3	7.5	7.7	8.9	--	--
Calcium, dissolved as Ca	36	1.1	48	62	96	230	77	49
Magnesium, dissolved as Mg	36	.2	16	35	54	160	39	31
Sodium, dissolved as Na	35	2.6	6.6	12	36	450	45	100
Potassium, dissolved as K	35	1	2	3	4	14	4	3
Bicarbonate, as HCO_3	33	48	260	300	470	690	350	150
Carbonate, as CO_3	33	0	0	0	0	42	1	7
Sulfate, dissolved as SO_4	36	14	34	95	250	530	160	160
Chloride, dissolved as Cl	36	.2	2.2	3.4	6.6	58	6.9	11
Silica, dissolved as SiO_2	35	4.5	6.7	8.1	9.9	16	8.7	2.4
Dissolved solids	36	193	312	401	580	1,220	503	293
Depth of well, in feet	36	46	106	130	164	200	131	39

Table 57.--*Statistical data for the combined Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana, considering depths greater than 200 feet*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	116	6.0	7.4	7.7	8.1	9.1	--	--
Calcium, dissolved as Ca	120	.6	9.4	48	68	190	49	42
Magnesium, dissolved as Mg	121	0	4.0	15	26	130	18	18
Sodium, dissolved as Na	119	1.3	18	55	160	1,400	120	180
Potassium, dissolved as K	117	1	2	3	4	16	3	2
Bicarbonate, as HCO_3	109	80	250	300	380	1,830	340	220
Carbonate, as CO_3	94	0	0	0	2	38	3	7
Sulfate, dissolved as SO_4	121	.1	40	92	210	640	140	130
Chloride, dissolved as Cl	121	.2	1.8	2.7	4.8	1,900	21	170
Silica, dissolved as SiO_2	118	0	6.7	7.4	9.7	24	8.3	3.4
Dissolved solids	120	150	320	430	629	3,590	531	407
Depth of well, in feet	121	203	524	900	1,355	3,942	999	648

Table 58.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Kootenai, First Cat Creek, and Third Cat Creek geohydrologic units, eastern Montana, considering depths of 200 feet or less*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 34	-0.35 34	-- 34	-- 34	-- 34	-- 31	0.31 33	-0.40 34	-- 34	-- 34	-- 34	-- 34	-- 1	-- 34
Calcium	-.35 34	1.00 36	.60 36	-- 35	.36 35	-- 33	-.30 33	.50 36	-.35 36	-.36 36	-- 35	.49 36	-- 2	-- 36
Magnesium	-- 34	.60 36	1.00 36	-- 35	.60 35	.42 33	-.30 33	.32 36	-- 36	-- 36	-- 35	.54 36	-- 2	-- 36
Sodium	-- 34	-- 35	-- 35	1.00 35	-- 35	.38 32	.30 32	-- 35	.50 35	.48 35	.36 35	.47 35	-- 1	-- 35
Potassium	-- 34	.36 35	.60 35	-- 35	1.00 35	.42 32	-.30 32	.34 35	-- 35	-- 35	.29 35	.49 35	-- 1	-- 35
Bicarbonate	-- 31	-- 33	.42 33	.38 32	.42 32	1.00 33	.30 33	-- 33	.35 33	.48 33	-- 32	.61 33	-- 2	-- 33
Carbonate	.31 31	-.30 33	-.30 33	.30 32	-.30 32	.30 33	1.00 33	-- 33	-- 33	-- 33	-- 32	-- 33	-- 2	-- 33
Sulfate	-.40 34	.50 36	.32 36	-- 35	.34 35	-- 33	-- 33	1.00 36	-- 36	-- 36	-- 35	.78 36	-- 2	-- 36
Chloride	-- 34	.35 36	-- 36	.50 35	-- 35	.35 33	-- 33	-- 36	1.00 36	.38 36	-- 35	-- 36	-- 2	-- 36
Fluoride	-- 34	-.36 36	-- 36	.48 35	-- 35	.48 33	-- 33	-- 36	.38 36	1.00 36	.31 35	-- 36	-- 2	-- 36
Silica	-- 34	-- 35	-- 35	.36 35	.29 35	-- 32	-- 32	-- 35	-- 35	.31 35	1.00 35	-- 35	-- 1	-- 35
Dissolved solids	-- 34	.49 36	.54 36	.47 35	.49 35	.61 33	-- 33	.78 36	-- 36	-- 36	-- 35	1.00 36	-- 2	-- 36
Nitrate, as N	-- 1	-- 2	-- 2	-- 1	-- 1	-- 2	-- 2	-- 2	-- 2	-- 2	-- 1	-- 2	1.00 2	-- 2
Depth of well	-- 34	-- 36	-- 36	-- 35	-- 35	-- 33	-- 33	-- 36	-- 36	-- 36	-- 35	-- 36	-- 2	1.00 36

Table 59.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, and Fall River geohydrologic units, eastern Montana, considering depths greater than 200 feet*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal- cium	Mag- ne- sium	So- dium	Po- tas- sium	Bi- car- bo- nate	Car- bon- ate	Sul- fate	Chlo- ride	Fluo- ride	Sil- ica	Dis- solved solids	Ni- trate, as N	Depth of well
pH	1.00 116	-0.72 116	0.66 116	0.66 116	-0.30 115	0.58 104	0.65 91	-0.23 116	0.19 116	0.50 116	-- 115	0.22 115	-- 25	0.30 116
Calcium	-.72 116	1.00 120	.90 120	-.80 118	.43 117	-.51 108	-.65 93	.26 120	-.18 120	-.60 119	-.22 118	-- 119	-- 28	-.34 120
Magne- sium	-.66 116	.90 120	1.00 121	-.67 119	.57 117	-.40 109	-.64 94	.26 121	-- 121	-.50 120	-.21 118	-- 120	-- 29	-.30 121
Sodium	.66 116	-.80 118	-.67 119	1.00 119	-- 117	.68 107	.68 93	.24 119	.42 119	.68 119	.37 117	.63 118	-- 27	.46 119
Potas- sium	-.30 115	.43 117	.57 117	-- 117	1.00 117	-- 105	-.30 91	.30 117	-- 117	-- 117	-- 116	.16 116	-- 25	.18 117
Bicar- bonate	.58 104	-.51 108	-.40 109	.68 107	-- 105	1.00 109	.44 94	-- 109	.47 109	.59 108	.36 106	.62 108	-- 29	.17 109
Carbo- nate	.65 91	-.65 93	-.64 94	.68 93	-.30 91	.44 94	1.00 94	-- 94	.30 94	.46 94	.20 91	.43 93	-- 18	.29 94
Sul- fate	-.23 116	.26 120	.26 121	.24 119	.30 117	-- 109	-- 94	1.00 121	.30 121	-- 120	.24 118	.72 120	-- 29	.33 121
Chlo- ride	.19 116	-.18 120	-- 121	.42 119	-- 117	.47 109	.30 94	.30 121	1.00 121	.36 120	.33 118	.54 120	.42 29	.19 121
Fluo- ride	.50 116	-.60 119	-.50 120	.68 119	-- 117	.59 108	.46 94	-- 120	.36 120	1.00 120	.24 117	.40 119	-- 28	.35 120
Silica	-- 115	-.22 118	-.21 118	.37 117	-- 116	.36 106	.20 91	.24 118	.33 118	.24 117	1.00 118	.35 118	-- 27	.29 118
Dis- solved solids	.22 115	-- 119	-- 120	.63 118	.16 116	.62 108	.43 93	.72 120	.54 120	.40 119	.35 118	1.00 120	-- 29	.32 120
Nitrate, as N	-- 25	-- 28	-- 29	-- 27	-- 25	-- 29	-- 18	-- 29	.42 29	-- 28	-- 27	-- 29	1.00 29	.33 29
Depth of well	.30 116	-.34 120	-.30 121	.46 119	.18 117	.17 109	.29 94	.33 121	.19 121	.35 120	.29 118	.32 120	.33 29	1.00 121

Table 60.--*Exceedances in WATSTORE of the drinking-water standards*[1] *for water from wells completed in the Kootenai, First Cat Creek or Third Cat Creek geohydrologic unit, eastern Montana, considering depths of 200 feet or less*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	0	0	36	35
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	2	2
Nitrate, total as N	10 mg/L	0	0	31	31
Arsenic, dissolved	50 µg/L	0	0	5	5
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	0	0	3	3
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	[3]2	[3]2	27	27
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	26	26
Chromium, total	50 µg/L	--	--	0	0

Table 60.--*Exceedances in WATSTORE of the drinking-water standards*[1] *for water from wells completed in the Kootenai, First Cat Creek or Third Cat Creek geohydrologic unit, eastern Montana, considering depths of 200 feet or less*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]3	[3]3	27	27
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	2	2	5	5
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	0	0	3	3
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	22	22
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 61.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, or Fall River geohydrologic unit, eastern Montana, considering depths greater than 200 feet*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	8	8	121	112
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	1	1	29	26
Nitrate, total as N	10 mg/L	0	0	81	81
Arsenic, dissolved	50 μg/L	0	0	7	7
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	0	0	20	20
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	[3]1	[3]1	62	61
Cadmium, total	10 μg/L	--	--	0	0
Chromium, dissolved	50 μg/L	0	0	62	61
Chromium, total	50 μg/L	--	--	0	0

Table 61.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Kootenai, First Cat Creek, Second Cat Creek, Third Cat Creek, or Fall River geohydrologic unit, eastern Montana, considering depths greater than 200 feet*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]1	[3]1	63	62
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	0	0	7	7
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	0	0	21	21
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	55	55
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 62.--*Results of statistical tests for significant differences between the Ellis, Swift, Rierdon, and Piper geohydrologic units, eastern Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit			
Variable	Ellis	Swift	Rierdon	Piper
pH, in units	-- 2 A 1	-- 8 A 13	-- -- 0	-- 12 A 2
Calcium, dissolved as Ca	270 16 A 2	130 10 A 17	110 15 A 1	270 16 A 2
Magnesium, dissolved as Mg	94 16 A 2	59 11 A 17	29 8 A 1	66 14 A 2
Sodium, dissolved as Na	120 11 A 2	130 10 A 14	7.3 5 A 1	360 10 A 2
Potassium, dissolved as K	19 10 A 2	9 10 A 14	4 5 A 1	40 10 A 2
Bicarbonate, as HCO_3	240 7 A 2	370 12 A 17	240 5 A 1	320 14 A 2
Carbonate, as CO_3	0 8 A 1	1 9 A 14	14 16 B 1	0 8 A 1
Sulfate, dissolved as SO_4	1,000 17 A 2	450 10 A 17	180 12 A 1	1,300 16 A 2
Chloride, dissolved as Cl	67 15 A 2	36 12 A 17	2.4 4 A 1	120 12 A 2

Table 62.--*Results of statistical tests for significant differences between the Ellis, Swift, Rierdon, and Piper geohydrologic units, eastern Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit			
	Ellis	Swift	Rierdon	Piper
Silica, dissolved as SiO_2	9.8 10 A 2	9.9 9 A 14	11 12 A 1	18 17 A 2
Dissolved solids	1,730 16 A 2	1,000 11 A 17	476 10 A 1	2,340 14 A 2

Table 63.--*Statistical data for the combined Ellis, Swift, Rierdon, and Piper geohydrologic units, eastern Montana, considering all depths*

		Concentration (except as indicated), in milligrams per liter						
Variable	Number of data values	Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	16	5.9	7.2	7.5	7.7	8.3	--	--
Calcium, dissolved as Ca	22	2.3	52	82	230	650	150	170
Magnesium, dissolved as Mg	22	.7	17	34	86	200	62	61
Sodium, dissolved as Na	19	2.8	7.3	63	210	800	150	230
Potassium, dissolved as K	19	2	4	7	9	79	13	19
Bicarbonate, as HCO_3	22	45	240	280	350	1,550	350	290
Carbonate, as CO_3	17	0	0	0	0	14	2	5
Sulfate, dissolved as SO_4	22	5.8	72	180	860	2,500	560	790
Chloride, dissolved as Cl	22	1.1	3.3	6.2	39	310	45	82
Silica, dissolved as SiO_2	19	3.2	6.5	9.8	12	26	11	5.7
Dissolved solids	22	176	377	515	2,020	4,300	1,160	1,200
Depth of well, in feet	20	80	326	853	2,340	5,732	1,524	1,574

Table 64.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Ellis, Swift, Rierdon, and Piper geohydrologic units, eastern Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal-cium	Mag-ne-sium	So-dium	Po-tas-sium	Bi-car-bo-nate	Car-bon-ate	Sul-fate	Chlo-ride	Fluo-ride	Sil-ica	Dis-solved solids	Ni-trate, as N	Depth of well
pH	1.00 16	-0.51 16	-0.45 16	-- 15	-- 15	-- 16	-- 12	-- 16	-- 16	-- 15	-- 15	-- 16	-- 5	-- 16
Calcium	-.51 16	1.00 22	.87 22	-- 19	.62 19	-- 22	-- 17	.83 22	-- 22	-- 21	.42 19	.68 22	-- 8	-- 20
Magne-sium	-.45 16	.87 22	1.00 22	-- 19	.64 19	-- 22	-- 17	.73 22	-- 22	-- 21	-- 19	.65 22	-- 8	-- 20
Sodium	-- 15	-- 19	-- 19	1.00 19	.68 19	.55 19	-- 14	.44 19	.69 19	.81 19	-- 19	.76 19	-- 6	.76 17
Potas-sium	-- 15	.62 19	.64 19	.68 19	1.00 19	.53 19	-- 14	.76 19	-- 19	.47 19	-- 19	.78 19	-- 6	-- 17
Bicar-bonate	-- 16	-- 22	-- 22	.55 19	.53 19	1.00 22	-- 17	-- 22	-- 22	-- 21	-- 19	-- 22	-.65 8	-- 20
Carbo-nate	-- 12	-- 17	-- 17	-- 14	-- 14	-- 17	1.00 17	-- 17	-- 17	-- 16	-- 14	-- 17	-- 4	-- 16
Sul-fate	-- 16	.83 22	.73 22	.44 19	.76 19	-- 22	-- 17	1.00 22	-- 22	-- 21	-- 19	.81 22	-- 8	-- 20
Chlo-ride	-- 16	-- 22	-- 22	.69 19	-- 19	-- 22	-- 17	-- 22	1.00 22	.65 21	.41 19	.54 22	-- 8	.43 20
Fluo-ride	-- 15	-- 21	-- 21	.81 19	.47 19	-- 21	-- 16	-- 21	.65 21	1.00 21	-- 19	.59 21	-- 8	.50 19
Silica	-- 15	.42 19	-- 19	-- 19	-- 19	-- 19	-- 14	-- 19	.41 19	-- 19	1.00 19	.57 19	-- 6	-- 17
Dis-solved solids	-- 16	.68 22	.65 22	.76 19	.78 19	-- 22	-- 17	.81 22	.54 22	.59 21	.57 19	1.00 22	-- 8	.43 20
Nitrate, as N	-- 5	-- 8	-- 8	-- 6	-- 6	-.65 8	-- 4	-- 8	-- 8	-- 8	-- 6	-- 8	1.00 8	-- 7
Depth of well	-- 16	-- 20	-- 20	.76 17	-- 17	-- 20	-- 16	-- 20	.43 20	.50 19	-- 17	.43 20	-- 7	1.00 20

Table 65.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Ellis, Swift, Rierdon, or Piper geohydrologic unit, eastern Montana, considering all depths*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	3	3	21	21
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	8	8
Nitrate, total as N	10 mg/L	0	0	13	13
Arsenic, dissolved	50 μg/L	0	0	4	4
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	0	0	1	1
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	[3]2	[3]2	8	8
Cadmium, total	10 μg/L	--	--	0	0
Chromium, dissolved	50 μg/L	0	0	10	10
Chromium, total	50 μg/L	--	--	0	0

Table 65.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Ellis, Swift, Rierdon, or Piper geohydrologic unit, eastern Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 μg/L	0	0	10	10
Lead, total	50 μg/L	--	--	0	0
Mercury, dissolved	2 μg/L	0	0	2	2
Mercury, total	2 μg/L	--	--	0	0
Selenium, dissolved	10 μg/L	0	0	2	2
Selenium, total	10 μg/L	--	--	0	0
Silver, dissolved	50 μg/L	0	0	6	6
Silver, total	50 μg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 66.--*Statistical data for the combined Madison, Charles, and Mission Canyon geohydrologic units, eastern Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	58	6.4	7.0	7.3	7.6	8.1	--	--
Calcium, dissolved as Ca	82	37	120	250	490	12,400	640	1,700
Magnesium, dissolved as Mg	82	16	37	68	120	1,600	120	210
Sodium, dissolved as Na	65	1.4	26	95	1,400	113,000	11,000	30,000
Potassium, dissolved as K	65	.4	4	13	99	4,200	270	790
Bicarbonate, as HCO_3	77	59	150	200	260	760	230	120
Carbonate, as CO_3	46	0	0	0	0	0	0	0
Sulfate, dissolved as SO_4	82	10	330	780	1,700	4,400	1,100	940
Chloride, dissolved as Cl	81	.1	5.6	39	180	199,000	14,400	44,300
Silica, dissolved as SiO_2	54	.1	9.7	15	28	74	21	18
Dissolved solids	81	200	664	1,610	3,820	325,000	25,500	73,200
Depth of well, in feet	20	140	558	864	3,310	7,980	2,290	2,650

Table 67.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined Madison, Charles, and Mission Canyon geohydrologic units, eastern Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 58	-0.52 58	-0.45 58	-0.43 51	-0.50 51	-- 54	-- 37	-0.37 58	-0.48 57	-0.77 38	-0.65 38	-0.47 57	-- 1	-- 14
Calcium	-.52 58	1.00 82	.87 82	.71 65	.78 65	-- 77	-- 46	.87 82	.63 81	.65 58	.54 54	.92 81	-.73 7	.51 20
Magnesium	-.45 58	.87 82	1.00 82	.61 65	.61 65	-- 77	-- 46	.79 82	.59 81	.51 58	-- 54	.79 81	-- 7	-- 20
Sodium	-.43 51	.71 65	.61 65	1.00 65	.89 65	-- 61	-- 37	.67 65	.95 64	.63 52	.39 52	.88 64	-- 2	-- 16
Potassium	-.50 51	.78 65	.61 65	.89 65	1.00 65	-- 61	-- 37	.70 65	.88 64	.78 52	.57 52	.90 64	-- 2	.54 16
Bicarbonate	-- 54	-- 77	-- 77	-- 61	-- 61	1.00 77	-- 46	-- 77	-- 76	-- 54	-- 50	-- 76	-- 7	-- 17
Carbonate	-- 37	-- 46	-- 46	-- 37	-- 37	-- 46	1.00 46	-- 46	-- 46	-- 40	-- 38	-- 46	-- 3	-- 12
Sulfate	-.37 58	.87 82	.79 82	.67 65	.70 65	-- 77	-- 46	1.00 82	.62 81	.66 58	.48 54	.87 81	-.77 7	.52 20
Chloride	-.48 57	.63 81	.59 81	.95 64	.88 64	-- 76	-- 46	.62 81	1.00 81	.71 57	.45 53	.81 81	-- 7	-- 20
Fluoride	-.77 38	.65 58	.51 58	.63 52	.78 52	-- 54	-- 40	.66 58	.71 57	1.00 58	.60 52	.72 57	-- 7	.61 18
Silica	-.65 38	.54 54	-- 54	.39 52	.57 52	-- 50	-- 38	.48 54	.45 53	.60 52	1.00 54	.53 53	-- 2	.68 16
Dissolved solids	-.47 57	.92 81	.79 81	.88 64	.90 64	-- 76	-- 46	.87 81	.81 81	.72 57	.53 53	1.00 81	-.83 7	.58 20
Nitrate, as N	-- 1	-.73 7	-- 7	-- 2	-- 2	-- 7	-- 3	-.77 7	-- 7	-- 7	-- 2	-.83 7	1.00 7	-- 4
Depth of well	-- 14	.51 20	-- 20	-- 16	.54 16	-- 17	-- 12	.52 20	-- 20	.61 18	.68 16	.58 20	-- 4	1.00 20

Table 68.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the Madison, Charles, or Mission Canyon geohydrologic unit, eastern Montana, considering all depths*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	20	18	58	48
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	7	6
Nitrate, total as N	10 mg/L	0	0	21	20
Arsenic, dissolved	50 μg/L	0	0	33	31
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	0	0	23	21
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	[3]7	[3]7	32	30
Cadmium, total	10 μg/L	0	0	2	2
Chromium, dissolved	50 μg/L	0	0	33	31
Chromium, total	50 μg/L	0	0	2	2

Table 68.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells in the Madison, Charles, or Mission Canyon geohydrologic unit, eastern Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 μg/L	[3]1	[3]1	34	32
Lead, total	50 μg/L	[3]1	[3]1	2	2
Mercury, dissolved	2 μg/L	0	0	31	29
Mercury, total	2 μg/L	--	--	0	0
Selenium, dissolved	10 μg/L	0	0	25	22
Selenium, total	10 μg/L	--	--	0	0
Silver, dissolved	50 μg/L	0	0	1	1
Silver, total	50 μg/L	0	0	2	2

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 69.--*Results of statistical tests for significant differences between the alluvium and terrace-deposits geohydrologic units, western Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit	
Variable	Alluvium	Terrace deposits
pH, in units	-- 47 A 91	-- 12 A 1
Calcium, dissolved as Ca	50 106 A 211	59 153 A 1
Magnesium, dissolved as Mg	16 107 A 211	13 104 A 1
Sodium, dissolved as Na	16 106 A 211	25 182 A 1
Potassium, dissolved as K	3 106 A 211	5 191 A 1
Bicarbonate, as HCO_3	200 102 A 203	210 126 A 1
Carbonate, as CO_3	0 102 A 202	0 98 A 1
Sulfate, dissolved as SO_4	44 106 A 211	62 162 A 1
Chloride, dissolved as Cl	12 106 A 211	11 144 A 1

Table 69.--*Results of statistical tests for significant differences between the alluvium and terrace-deposits geohydrologic units, western Montana, by chemical variable considering all depths*--Continued

	Geohydrologic unit	
Variable	Alluvium	Terrace deposits
Silica, dissolved as SiO_2	15 106 A 211	26 198 A 1
Dissolved solids	256 106 A 211	306 152 A 1

Table 70.--*Statistical data for the combined alluvium and terrace-deposits geohydrologic units, western Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	92	6.0	7.4	7.6	7.7	9.8	--	--
Calcium, dissolved as Ca	212	5.8	35	50	61	150	50	.23
Magnesium, dissolved as Mg	212	1.7	10	13	18	75	16	10
Sodium, dissolved as Na	212	.5	2.1	14	21	110	16	18
Potassium, dissolved as K	212	.1	.9	3	4	8	3	2
Bicarbonate, as HCO_3	204	27	150	190	260	420	200	82
Carbonate, as CO_3	203	0	0	0	0	6	0	1
Sulfate, dissolved as SO_4	212	.6	6.8	41	62	350	44	44
Chloride, dissolved as Cl	212	.1	1.2	5.5	14	390	12	32
Silica, dissolved as SiO_2	212	.1	6.9	15	22	41	15	8.5
Dissolved solids	212	54	170	220	338	901	256	138
Depth of well, in feet	199	8	22	24	39	287	35	30

Table 71.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the combined alluvium and terrace-deposits geohydrologic units, western Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 92	-- 92	-- 92	-- 92	-- 92	-- 84	0.27 83	0.25 92	-- 92	0.18 92	-- 92	-- 92	-- 22	-- 79
Calcium	-- 92	1.00 212	.67 212	.61 212	.43 212	.94 204	-.20 203	.61 212	.53 212	.36 212	.51 212	.86 212	-- 22	-.23 199
Magnesium	-- 92	.67 212	1.00 212	.72 212	.53 212	.76 204	-- 203	.70 212	.68 212	.37 212	.36 212	.80 212	-- 22	-- 199
Sodium	-- 92	.61 212	.72 212	1.00 212	.80 212	.63 204	-- 203	.88 212	.88 212	.75 212	.59 212	.89 212	.41 22	.14 199
Potassium	-- 92	.43 212	.53 212	.80 212	1.00 212	.37 204	-- 203	.76 212	.76 212	.76 212	.48 212	.70 212	-- 22	.21 199
Bicarbonate	-- 84	.94 204	.76 204	.63 204	.37 204	1.00 204	-.18 203	.56 204	.51 204	.31 204	.47 204	.84 204	-- 22	-.20 197
Carbonate	.27 83	-.20 203	-- 203	-- 203	-- 203	-.18 203	1.00 203	-- 203	.16 203	-- 203	-.23 203	-- 203	-- 21	-- 196
Sulfate	.25 92	.61 212	.70 212	.88 212	.76 212	.56 204	-- 203	1.00 212	.79 212	.67 212	.55 212	.86 212	-- 22	-- 199
Chloride	-- 92	.53 212	.68 212	.88 212	.76 212	.51 204	.16 203	.79 212	1.00 212	.66 212	.37 212	.78 212	.41 22	.17 199
Fluoride	.18 92	.36 212	.37 212	.75 212	.76 212	.31 204	-- 203	.67 212	.66 212	1.00 212	.54 212	.64 212	-- 22	.12 199
Silica	-- 92	.51 212	.36 212	.59 212	.48 212	.47 204	-.23 203	.55 212	.37 212	.54 212	1.00 212	.65 212	-- 22	-- 199
Dissolved solids	-- 92	.86 212	.80 212	.89 212	.70 212	.84 204	-- 203	.86 212	.78 212	.64 212	.65 212	1.00 212	-- 22	-- 199
Nitrate, as N	-- 22	-- 22	-- 22	.41 22	-- 22	-- 22	-- 21	-- 22	.41 22	-- 22	-- 22	-- 22	1.00 22	-- 17
Depth of well	-- 79	-.23 199	-- 199	.14 199	.21 199	-.20 197	-- 196	-- 199	.17 199	.12 199	-- 199	-- 199	-- 17	1.00 199

Table 72.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the alluvium or terrace-deposits geohydrologic unit, western Montana, considering all depths*

[mg/L, milligrams per liter; μg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	0	0	212	93
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	22	22
Nitrate, total as N	10 mg/L	2	2	181	62
Arsenic, dissolved	50 μg/L	0	0	1	1
Arsenic, total	50 μg/L	--	--	0	0
Barium, dissolved	1,000 μg/L	--	--	0	0
Barium, total	1,000 μg/L	--	--	0	0
Cadmium, dissolved	10 μg/L	0	0	39	16
Cadmium, total	10 μg/L	--	--	0	0
Chromium, dissolved	50 μg/L	0	0	39	16
Chromium, total	50 μg/L	--	--	0	0

Table 72.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the alluvium or terrace-deposits geohydrologic unit, western Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	[3]4	[3]4	39	16
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	0	0	2	2
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	0	0	1	1
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	0	0	39	16
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.

Table 73.--*Results of statistical tests for significant differences between the glacial-till and glaciolacustrine-deposits geohydrologic units, western Montana, by chemical variable considering all depths*

[Upper numeral is mean concentration, in milligrams per liter, except as noted. Middle numeral is the mean of the ranks of data values, dimensionless; for each variable, geohydrologic units classified by the same letter are not significantly different at the 0.05 significance level based on Duncan's multiple-range test on the ranks of the data values. Lower numeral is number of data values]

	Geohydrologic unit	
Variable	Glacial till	Glaciolacustrine deposits
pH, in units	-- 39 A 62	-- 61 B 30
Calcium, dissolved as Ca	31 50 A 62	28 43 A 32
Magnesium, dissolved as Mg	14 50 A 62	11 42 A 32
Sodium, dissolved as Na	39 60 A 62	4.9 23 B 32
Potassium, dissolved as K	2 55 A 62	1 32 B 32
Bicarbonate, as HCO_3	230 54 A 62	140 34 B 32
Carbonate, as CO_3	1 48 A 62	0 46 A 31
Sulfate, dissolved as SO_4	17 49 A 62	8.6 45 A 32
Chloride, dissolved as Cl	9.7 56 A 62	1.0 30 B 32

Table 73.--*Results of statistical tests for significant differences between the glacial-till and glaciolacustrine-deposits geohydrologic units, western Montana, by chemical variable considering all depths*--Continued

Variable	Geohydrologic unit: Glacial till	Geohydrologic unit: Glaciolacustrine deposits
Silica, dissolved as SiO_2	18 55 A 62	11 32 B 31
Dissolved solids	245 54 A 62	138 32 B 31

Table 74.--*Statistical data for the glacial-till geohydrologic unit, western Montana, considering all depths*

Variable	Number of data values	Concentration (except as indicated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	62	6.0	7.2	7.9	8.0	9.1	--	--
Calcium, dissolved as Ca	62	1.1	22	31	39	80	31	16
Magnesium, dissolved as Mg	62	.1	6.6	11	16	60	14	12
Sodium, dissolved as Na	62	1.3	9.0	20	40	220	39	51
Potassium, dissolved as K	62	.4	1	2	3	8	2	2
Bicarbonate, as HCO_3	62	44	130	190	310	580	230	120
Carbonate, as CO_3	62	0	0	0	0	22	1	4
Sulfate, dissolved as SO_4	62	.2	2.7	5.5	13	360	17	47
Chloride, dissolved as Cl	62	.1	1.2	2.6	7.6	90	9.7	18
Silica, dissolved as SiO_2	62	1.1	11	16	22	59	18	11
Dissolved solids	62	46	148	194	292	1,070	245	166
Depth of well, in feet	53	10	90	241	366	1,000	258	212

Table 75.--*Statistical data for the glaciolacustrine-deposits geohydrologic unit, western Montana, considering all depths*

Variable	Number of data values	Concentration (except as inidcated), in milligrams per liter						
		Minimum	First quartile	Median	Third quartile	Maximum	Mean	Standard deviation
pH, in units	30	6.3	7.8	8.1	8.2	8.5	--	--
Calcium, dissolved as Ca	32	5.4	17	21	38	79	28	17
Magnesium, dissolved as Mg	32	1.3	4.3	6.6	15	40	11	10
Sodium, dissolved as Na	32	.3	1.3	1.8	3.2	41	4.9	9.5
Potassium, dissolved as K	32	.2	.7	1	2	3	1	.7
Bicarbonate, as HCO_3	32	25	74	110	220	330	140	87
Carbonate, as CO_3	31	0	0	0	0	0	0	0
Sulfate, dissolved as SO_4	32	.2	2.5	4.6	9.1	64	8.6	14
Chloride, dissolved as Cl	32	.1	.3	1.0	1.4	3.0	1.0	.7
Silica, dissolved as SiO_2	31	4.9	8.9	9.7	12	21	11	3.6
Dissolved solids	31	27	76	104	226	289	138	80
Depth of well, in feet	31	23	43	115	200	300	126	90

Table 76.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the glacial-till geohydrologic unit, western Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Silica	Dissolved solids	Nitrate, as N	Depth of well
pH	1.00 62	-- 62	-- 62	0.30 62	-- 62	0.29 62	0.37 62	-- 62	0.31 62	0.29 62	0.22 62	0.37 62	-- 62	-- 53
Calcium	-- 62	1.00 62	.74 62	-- 62	-- 62	.63 62	-.37 62	.30 62	-- 62	-.28 62	-- 62	.46 62	.44 62	-.33 53
Magnesium	-- 62	.74 62	1.00 62	.24 62	-- 62	.73 62	-.37 62	.38 62	.27 62	-- 62	-- 62	.58 62	.42 62	-.23 53
Sodium	.30 62	-- 62	.24 62	1.00 62	.59 62	.63 62	.22 62	.26 62	.80 62	.79 62	.51 62	.82 62	-- 62	-- 53
Potassium	-- 62	-- 62	-- 62	.59 62	1.00 62	.37 62	-- 62	-- 62	.59 62	.49 62	.22 62	.52 62	-- 62	-.25 53
Bicarbonate	.29 62	.63 62	.73 62	.63 62	.37 62	1.00 62	-.29 62	-- 62	.60 62	.31 62	-- 62	.90 62	.22 62	-.25 53
Carbonate	.37 62	-.37 62	-.37 62	.22 62	-- 62	-.29 62	1.00 62	-- 62	-- 62	.36 62	-- 62	-- 62	-.21 62	.23 53
Sulfate	-- 62	.30 62	.38 62	.26 62	-- 62	-- 62	-- 62	1.00 62	.28 62	-- 62	.30 62	.38 62	.52 62	-.26 53
Chloride	.31 62	-- 62	.27 62	.80 62	.59 62	.60 62	-- 62	.28 62	1.00 62	.61 62	.51 62	.77 62	-- 62	-- 53
Fluoride	.29 62	-.28 62	-- 62	.79 62	.49 62	.31 62	.36 62	-- 62	.61 62	1.00 62	.59 62	.54 62	-.24 62	-- 53
Silica	.22 62	-- 62	-- 62	.51 62	.22 62	-- 62	-- 62	.30 62	.51 62	.59 62	1.00 62	.41 62	-- 62	-- 53
Dissolved solids	.37 62	.46 62	.58 62	.82 62	.52 62	.90 62	-- 62	.38 62	.77 62	.54 62	.41 62	1.00 62	-- 63	-.26 53
Nitrate, as N	-- 62	.44 62	.42 62	-- 62	-- 62	.22 62	-.21 62	.52 62	-- 62	-.24 62	-- 62	-- 62	1.00 62	-.31 53
Depth of well	-- 53	-.33 53	-.23 53	-- 53	-.25 53	-.25 53	.23 53	-.26 53	-- 53	-- 53	-- 53	-.26 53	-.31 53	1.00 53

Table 77.--*Spearman-rank correlation coefficients for selected chemical and physical variables for the glaciolacustrine-deposits geohydrologic unit, western Montana, considering all depths*

[Chemical constituents are dissolved. Upper numeral is Spearman-rank correlation coefficient, shown only if the correlation has a level of significance less than or equal to 0.10. Lower numeral is number of data values]

	pH	Cal-cium	Mag-ne-sium	So-dium	Po-tas-sium	Bi-car-bo-nate	Car-bon-ate	Sul-fate	Chlo-ride	Fluo-ride	Sil-ica	Dis-solved solids	Ni-trate, as N	Depth of well
pH	1.00 30	-0.38 30	-- 30	-- 30	-0.37 30	-0.35 30	-- 30	-- 30	-- 30	-- 30	-- 29	-0.39 29	-- 0	-- 29
Calcium	-.38 30	1.00 32	.85 32	.75 32	.68 32	.97 32	-- 31	.75 32	.38 32	.58 32	.54 31	.92 31	-- 0	.53 31
Magne-sium	-- 30	.85 32	1.00 32	.71 32	.57 32	.89 32	-- 31	.85 32	.35 32	.61 32	-- 31	.89 31	-- 0	.59 31
Sodium	-- 30	.75 32	.71 32	1.00 32	.92 32	.80 32	-- 31	.80 32	.44 32	.51 32	.57 31	.85 31	-- 0	.67 31
Potas-sium	-.37 30	.68 32	.57 32	.92 32	1.00 32	.71 32	-- 31	.65 32	.39 32	.45 32	.60 31	.77 31	-- 0	.62 31
Bicar-bonate	-.35 30	.97 32	.89 32	.80 32	.71 32	1.00 32	-- 31	.81 32	.47 32	.61 32	.46 31	.97 31	-- 0	.56 31
Carbo-nate	-- 30	-- 31	-- 31	-- 31	-- 31	-- 31	1.00 31	-- 31	-- 31	-- 31	-- 30	-- 30	-- 0	--- 30
Sul-fate	-- 30	.75 32	.85 32	.80 32	.65 32	.81 32	-- 31	1.00 32	.41 32	.54 32	-- 31	.84 31	-- 0	.66 31
Chlo-ride	-- 30	.38 32	.35 32	.44 32	.39 32	.47 32	-- 31	.41 32	1.00 32	.30 32	.41 31	.53 31	-- 0	--- 31
Fluo-ride	-- 30	.58 32	.61 32	.51 32	.45 32	.61 32	-- 31	.54 32	.30 32	1.00 32	.35 31	.63 31	-- 0	.34 31
Silica	-- 29	.54 31	-- 31	.57 31	.60 31	.46 31	-- 30	-- 31	.41 31	.35 31	1.00 31	.50 31	-- 0	-- 30
Dis-solved solids	-.39 29	.92 31	.89 31	.85 31	.77 31	.97 31	-- 30	.84 31	.53 31	.63 31	.50 31	1.00 31	-- 0	.57 30
Nitrate, as N	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0	-- 0
Depth of well	-- 29	.53 31	.59 31	.67 31	.62 31	.56 31	-- 30	.66 31	-- 31	.34 31	-- 30	.57 30	-- 0	1.00 31

Table 78.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the glacial-till geohydrologic unit, western Montana, considering all depths*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	7	7	62	62
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	0	0	62	62
Nitrate, total as N	10 mg/L	--	--	0	0
Arsenic, dissolved	50 µg/L	--	--	0	0
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	--	--	0	0
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	--	--	0	0
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	--	--	0	0
Chromium, total	50 µg/L	--	--	0	0

Table 78.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the glacial-till geohydrologic unit, western Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 µg/L	--	--	0	0
Lead, total	50 µg/L	--	--	0	0
Mercury, dissolved	2 µg/L	--	--	0	0
Mercury, total	2 µg/L	--	--	0	0
Selenium, dissolved	10 µg/L	--	--	0	0
Selenium, total	10 µg/L	--	--	0	0
Silver, dissolved	50 µg/L	--	--	0	0
Silver, total	50 µg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

Table 79.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the glaciolacustrine-deposits geohydrologic unit, western Montana, considering all depths*

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Fluoride, dissolved	[2]2.4 mg/L	0	0	32	28
Fluoride, total	[2]2.4 mg/L	--	--	0	0
Nitrate, dissolved as N	10 mg/L	--	--	0	0
Nitrate, total as N	10 mg/L	0	0	29	25
Arsenic, dissolved	50 µg/L	--	--	0	0
Arsenic, total	50 µg/L	--	--	0	0
Barium, dissolved	1,000 µg/L	--	--	0	0
Barium, total	1,000 µg/L	--	--	0	0
Cadmium, dissolved	10 µg/L	[3]1	[3]1	29	25
Cadmium, total	10 µg/L	--	--	0	0
Chromium, dissolved	50 µg/L	0	0	29	25
Chromium, total	50 µg/L	--	--	0	0

Table 79.--*Exceedances in WATSTORE of the primary drinking-water standards*[1] *for water from wells completed in the glaciolacustrine-deposits geohydrologic unit, western Montana, considering all depths*--Continued

Variable	Primary drinking-water standard	Number of data values exceeding the standard	Number of sites at which standard was exceeded	Total number of data values	Total number of sites
Lead, dissolved	50 μg/L	[3]5	[3]5	29	25
Lead, total	50 μg/L	--	--	0	0
Mercury, dissolved	2 μg/L	0	0	4	4
Mercury, total	2 μg/L	--	--	0	0
Selenium, dissolved	10 μg/L	--	--	0	0
Selenium, total	10 μg/L	--	--	0	0
Silver, dissolved	50 μg/L	0	0	29	25
Silver, total	50 μg/L	--	--	0	0

[1]Established by the U.S. Environmental Protection Agency (1977).

[2]Maximum limit. Standard decreases as annual average of the maximum daily air temperature increases.

[3]May be erroneously large because of sensitivity of analytical methods or sample contamination.