

Water Resources Data Montana Water Year 2005

Volume 2. Yellowstone and Upper Columbia River Basins and Ground-Water Levels

By Wayne R. Berkas, Melvin K. White, Patricia B. Ladd, Fred A. Bailey, and Kent A. Dodge

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PREFACE

In the act that established the U.S. Geological Survey more than a century ago, the agency was charged by Congress with the responsibility for "...classification of the public lands, and examination of the geologic structure, mineral resources, and products of the national domain." This charge was simple recognition of the principle that factual information is essential to sound development and management decisions involving natural resources. In keeping with this principle, the U.S. Geological Survey publishes annually, by state, hydrologic records for water resources thought to be of particular usefulness to the public and to the scientific community.

This report is the culmination of a concerted effort by dedicated personnel of the U.S. Geological Survey, who collected, compiled, analyzed, verified, and organized the data, and who typed, edited, and assembled the report. In addition to the authors, who had primary responsibility for assuring that the information contained herein is accurate, complete, and adheres to Geological Survey policy and established guidelines, the following individuals contributed significantly to the collection, processing, and tabulation of the data:

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SURFACE-WATER AND GROUND-WATER STATIONS, IN DOWNSTREAM ORDER,
FOR WHICH RECORDS ARE PUBLISHED IN THIS VOLUME

[Letter after station name designates types of data: (d) discharge, (c) chemical, (b) biological, (m) microbiological, (t) water temperature, (s) sediment, (e) elevations or contents]

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ARE PUBLISHED IN THIS VOLUME

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| Ravalli County: | | |
| Well 10N20W13BBA 01 | 463750114033001 | 542 |
| Well 06N20W19CCCC02 | 461518114090802 | 543 |
| Rosebud County: | | |
| Well 06S43E19DDBA02 | 451746106301101 | 544 |
| Sanders County: | | |
| Well 23N24W34ADAA01 | 474251114385201 | 545 |
| Sheridan County: | | |
| Well 33N58E17ADDD01 | 483650104084001 | 546 |
| Well 32N58E04DBBD02 | 483318104105402 | 547 |
| Teton County: | | |
| Well 22N03W15BAAD03 | 474005111583803 | 548 |

WELLS IN WHICH WATER LEVELS WERE MEASURED PERIODICALLY ONLY

| | | |
|-------------------------------|-----------------|-----|
| Mineral County: | | |
| Well 18N28W24DCBA01 | 471804115060501 | 549 |
| Well 18N27W19CBBD01 | 471814115052901 | 549 |
| Well 18N27W30ABBA01 | 471751115045001 | 549 |
| Well 17N26W30DAAD01 | 471207114555401 | 549 |
| Sanders County: | | |
| Well 26N34W03BDAD01 | 480248115574901 | 549 |
| Well 25N31W30DCCC01 | 475316115381901 | 549 |
| Well 22N29W32ACDD01 | 473717115201501 | 549 |
| Well 20N26W22CBBA01 | 472837114540201 | 549 |
| Well 19N25W07CDDA01 | 472448114495201 | 549 |
| Well 19N25W28BABB01 | 472257114473701 | 549 |

QUANTITY OF PRECIPITATION

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM/NATIONAL TRENDS NETWORK

| | | |
|--|-----------------|-----|
| McBeath Residence near Clancy | 462905112035401 | 550 |
| Northern Montana Agricultural Research Center near Havre | 482958109475101 | 552 |

Water Resources Data, Montana, Water Year 2005

By Wayne R. Berkas, Melvin K. White, Patricia B. Ladd, Fred A. Bailey, and Kent A. Dodge

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with other Federal, State, and local agencies and Tribal governments, collects a large amount of data pertaining to the water resources of Montana each water year. These data, accumulated over many years, constitute a valuable database for developing an improved understanding of the water resources of the State. To make these data readily available to interested parties outside the USGS, the data are published annually, by water year, in this report series entitled, "Water Resources Data, Montana."

This report, volumes 1 and 2, includes records of both surface and ground water from stations within the State and selected stations near the Montana border in adjacent states and Canada. Specifically, this report contains (1) discharge records for 245 streamflow-gaging stations; (2) stage or content records for 39 reservoirs or lakes; (3) water-quality records for 154 stream sites (69 ungaged), 12 reservoir or lake sites, and 13 wells; (4) water-level records for 27 wells; and (5) precipitation records for 2 atmospheric-deposition stations. Volume 1 contains discharge records for 125 streamflow-gaging stations; stage or content records for 17 reservoirs or lakes; and water-quality records for 68 stream sites (37 ungaged), 12 reservoir or lake sites, and 13 wells. Volume 2 contains discharge records for 120 streamflow-gaging stations; stage or content records for 22 reservoirs or lakes; water-quality records for 86 stream sites (32 ungaged), water-level records for 25 observation wells; and precipitation records for 2 atmospheric-deposition stations. The locations of streamflow-gaging and reservoir stations are shown in figure 6, locations of water-quality and precipitation stations are shown in figure 7, and locations of observation wells are shown in figure 8.

Additional data for water year 2005 were collected at crest-stage gage and miscellaneous-measurement sites but are not published in this report. These data are stored in the USGS Montana Water Science Center in Helena and are available on request.

Records pertaining to the discharge of streams and contents of lakes and reservoirs were first published in a series of USGS Water-Supply Papers entitled "Surface Water Supply of the United States." These Water-Supply Papers were published in an annual series for water years 1899-1960 and then in a 5-year series for water years 1961-65 and 1966-70. Records of chemical quality, water temperature,

and suspended-sediment concentration were published from 1941 to 1970 in an annual series of Water-Supply Papers entitled "Quality of Surface Waters of the United States." Records of ground-water levels were published from 1935 to 1974 in a series of Water-Supply Papers entitled "Ground-Water Levels in the United States." Water-Supply Papers may be reviewed in the libraries of the principal cities of the United States. The annual Water-Supply Papers were compiled and may be purchased by writing to USGS Information Services, Box 25286, Denver, Colo. 80225 (<http://ask.usgs.gov>). For water years 1961 through 1970, streamflow data were published by the USGS in annual reports for each State. Water-quality records for water years 1964 through 1970 were similarly published either in separate reports or in conjunction with streamflow records. Beginning with the 1971 water year, data for surface and ground water are published as a single or multi-volume USGS annual water-data report for each State. These reports carry an identification number consisting of the two-letter State abbreviation, the last two digits of the water year, and the volume number. For example, volume 1 is identified as "U.S. Geological Survey Water-Data Report MT-05-1." The water-data reports published prior to 2003 are for sale, in paper copy or on microfiche, by the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22161 (<http://www.ntis.gov>). Reports published from 2003 to present are located on the Web at <http://water.usgs.gov/pubs/wdr>.

Water-resources information for Montana and the rest of the Nation are available through the Web as part of the USGS National Water-Information System (NWIS) at <http://waterdata.usgs.gov/nwis>. For Montana, this information includes surface-water, water-quality, and ground-water data. Surface-water information available from the USGS includes provisional real-time streamflow data for stations with satellite telemetry, provisional daily data for the previous 18 months, and daily data for the period of record at each site. Daily, monthly, and annual streamflow statistics also are available as well as annual peak-streamflow data. In addition, flood-frequency and basin-characteristics information for selected sites in Montana is available at <http://mt.water.usgs.gov/freq>.

Water-quality information available from the USGS includes provisional real-time specific-conductance and water-temperature data for selected sites with satellite telemetry. Historical water-quality data also are available for many surface- and ground-water sites in Montana.

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Ground-water information available from the USGS includes descriptive information for wells, springs, and test holes such as location (latitude and longitude), well depth, site use, water levels, and aquifer.

Additional information, including current prices, for ordering specific reports may be obtained from the Director, USGS Montana Water Science Center, at the address given on the back of the title page or by telephone at 1-888-ASK-USGS.

COOPERATION

The USGS has had cooperative agreements with other agencies and organizations for the systematic collection of streamflow records since 1906, for water-quality records since 1946, and for ground-water levels since 1964. In water year 2005, agencies and organizations that supported data collection through cooperative agreements with the USGS were:

Federal Agencies

- Department of Energy, Bonneville Power Administration
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Department of State, International Joint Commission
- Federal Emergency Management Agency
- National Park Service
- National Oceanic and Atmospheric Administration, National Weather Service
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture, Forest Service
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

Tribal Governments

- Blackfeet Nation
- Confederated Salish and Kootenai Tribes of the Flathead Nation
- Fort Peck Tribes
- Northern Cheyenne Tribe

State Agencies

- Montana Bureau of Mines and Geology
- Montana Department of Environmental Quality
- Montana Fish, Wildlife and Parks
- Montana Department of Natural Resources and Conservation
- Montana Department of Transportation
- Wyoming Department of Environmental Quality
- Wyoming State Engineer

- Federal Energy Regulatory Commission Licensees
- Avista Corporation
- PPL—Montana

Local Agencies

- Cascade County Conservation District
- City of Bozeman
- East Bench Irrigation District
- Lewis and Clark County Water Quality Protection District
- Lower Musselshell Conservation District
- Meagher County Conservation District
- North Powell Conservation District
- Stillwater Conservation District
- Teton County Conservation District
- Tongue and Yellowstone Irrigation District

GENERAL HYDROLOGIC SETTING

Montana, with an area of about 147,200 square miles (mi²), is the fourth largest State in the Nation (fig. 1). The major drainage basins in the State are the Hudson Bay basin (465 mi²) and the upper Missouri River basin (120,700 mi²) east of the Continental Divide, and the upper Columbia River basin (26,000 mi²) west of the divide. The Hudson Bay and upper Missouri River basins drain about 82 percent of the State and provide about 40 percent of the total annual streamflow (1971-2000 average). The upper Columbia River basin drains about 18 percent of the State and provides about 60 percent of the total annual streamflow (1971-2000 average).

The western and southwestern parts of the State are in the Northern and Middle Rocky Mountains.¹ The central and eastern parts are in the Great Plains. The Northern and Middle Rocky Mountains are characterized by rugged mountains and intermontane valleys, whereas the Great Plains consists of rolling to dissected plains and small mountain ranges. Altitude in Montana ranges from more than 12,000 feet above the National Geodetic Vertical Datum of 1929 (NGVD 29) in the mountains northeast of Yellowstone National Park to about 1,850 feet above NGVD 29 where the Kootenai River flows from the northwestern part of the State.

Climate and hydrologic conditions differ substantially across the State. Annual precipitation varies considerably throughout the basins, from about 100-120 inches along the Continental Divide in Glacier National Park to about 8-10 inches in parts of south-central Montana and in some of the

¹Fenneman, N.M., and Johnson, D.W., 1946, Physical divisions of the United States: U.S. Geological Survey, scale 1:7,000,000, 1 sheet.

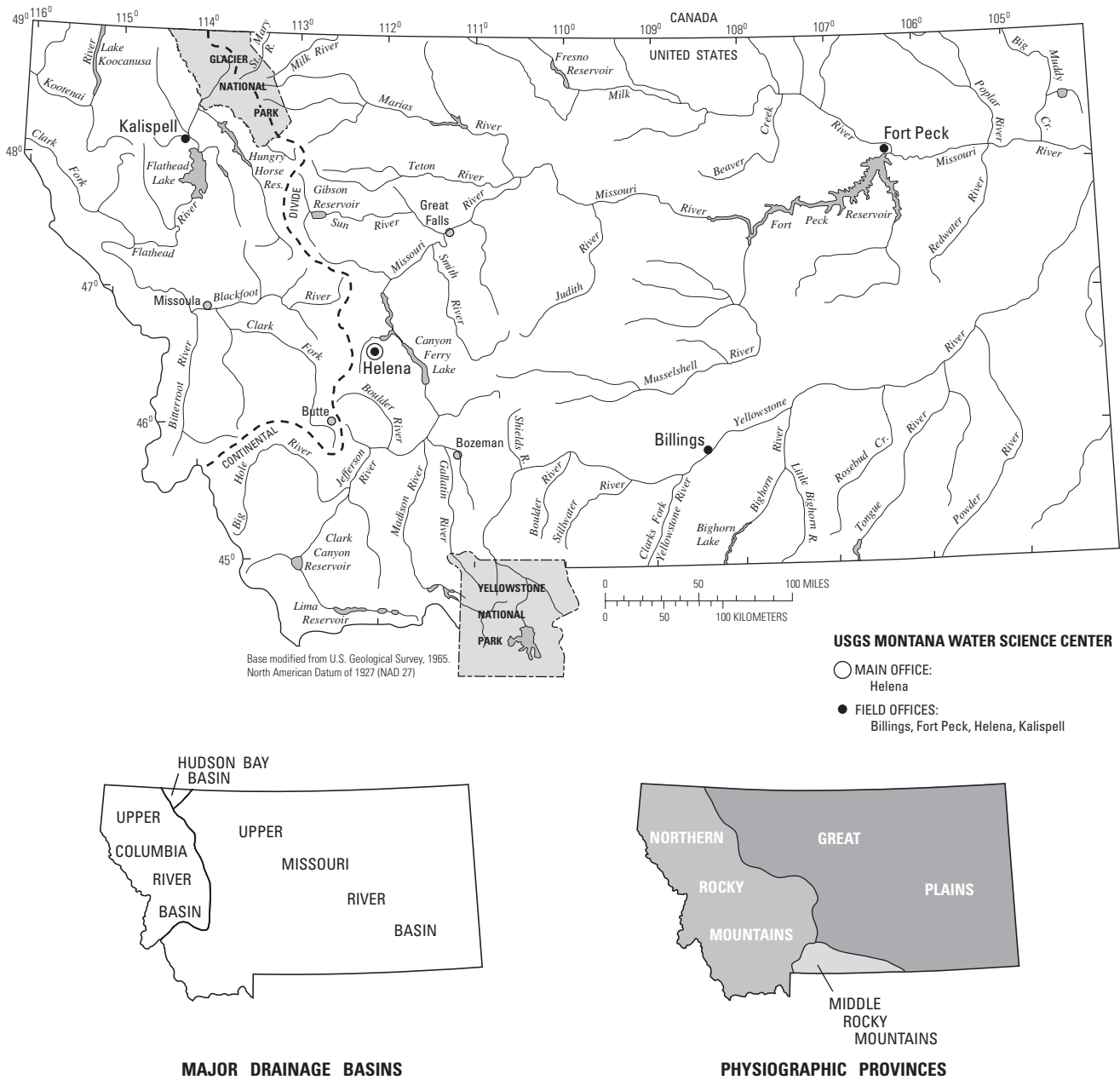


Figure 1. General geographic features of Montana.

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western intermontane valleys.² The diverse precipitation patterns in Montana result from the effects of geographic and topographic features on warm, moist air from either the Gulf of Mexico or the Pacific Ocean. In mountainous areas, much of the annual precipitation falls as snow during the winter. Although much of the annual precipitation on the Great Plains also falls as snow during the winter, intense rainstorms during the summer can add substantial quantities of precipitation to the annual totals in a short time. In areas east of the mountains, generally one-half of the annual precipitation falls from May through July.

Peak runoff can result from snowmelt, snowmelt mixed with rain, or intense rainfall. In addition, backwater from ice jams commonly creates flooding in many rivers throughout the State. The record flood of April 1952 in northeastern Montana is an example of spring snowmelt flooding. The flood of May 1981 in west-central Montana is an example of flooding caused by snowmelt mixed with rain. The floods of June 1964, June 1975, and May 1978 are examples of flooding predominantly caused by intense rainfall. Flash floods, although restricted in areal extent, are common at times in the north-central and eastern parts of the State. In many areas, peak runoff is stored in reservoirs to decrease flooding. The stored water is used for irrigation (the predominant consumptive use of water statewide), power generation, and recreation.

Surface water throughout the State generally is suitable for most uses except in parts of eastern Montana where, because of large concentrations of dissolved solids and some individual constituents, water-quality standards or recommended guidelines for protecting human health, agricultural irrigation, and freshwater-aquatic life may be exceeded. The ionic composition of surface water is largely influenced by geology and can vary markedly between the western mountains and the eastern plains. In addition, dissolved-solids concentrations can vary substantially between runoff conditions and base flow. In the western mountains, where the rocks generally are older and resistant to weathering, the streamflow characteristically is a calcium bicarbonate type. The dissolved-solids concentrations in mountain streams commonly are less than 100 milligrams per liter (mg/L) and seldom exceed 500 mg/L, even during base flow. In the eastern plains, where sedimentary rocks are less resistant to weathering, streamflow commonly is a sodium sulfate type, with dissolved-solids concentrations ranging from about 100 mg/L during runoff to several thousand mg/L during base flow. In the northeastern part of the State, streamflow typically is a sodium bicarbonate type. Snowmelt and intense rainstorms sometimes produce large quantities of runoff that can dilute concentrations of

dissolved solids, modify chemical compositions, and increase concentrations of suspended sediment.

The availability and quality of ground water in Montana are largely controlled by the diverse hydraulic and geochemical properties of the various rocks, sediments, and hydrologic settings in which it occurs. In western Montana, ground water of good quality for most uses is available from alluvium along streams and rivers, from basin fill in intermontane valleys, from glacial deposits, and from fractured consolidated rocks. In eastern Montana, ground water is available from alluvial deposits along larger rivers and streams and from sedimentary rocks. Outside of the alluvial valleys, ground-water availability in sedimentary rock is variable. Quality of ground water in eastern Montana ranges from good quality for most uses to water with large amounts of dissolved solids that is not suitable for irrigation, public-water supply, and domestic uses. Throughout Montana, alluvial deposits along streams generally are the most productive aquifers, and wells completed in alluvium along the major streams may produce several hundred gallons per minute. Alluvium can be readily recharged by precipitation, by streams during periods of high flow, and by applied irrigation water. The particle-size distribution and sorting of glacial deposits largely determines their potential for water development. Where coarse, well-sorted outwash gravels are present, the potential for developing large-yield wells is good, whereas yields from wells completed in poorly sorted glacial till generally are limited to a few gallons per minute. Many fractured consolidated-rock formations are tapped for ground water but, because of the complexity of the geology, fractured rocks might not provide an adequate water supply in all areas. Wells completed in consolidated rocks generally yield only a few gallons per minute. However, several hundred gallons per minute can be obtained from highly fractured or cavernous formations in some areas. The well depth required to reach a given aquifer varies with location.

HYDROLOGIC-MONITORING ACTIVITY

Six streamflow-gaging stations were established during water year 2005 to aid in the assessment of the Nation's water resources:

- 05013900 Grinnell Creek at Grinnell Glacier, near Many Glacier
- 06076560 Smith River below Newlan Creek, near White Sulphur Springs
- 06307990 Tongue River above T and Y Diversion Dam, near Miles City
- 12323670 Mill Creek near Anaconda
- 12323710 Willow Creek near Anaconda
- 12323840 Lost Creek near Anaconda

²Cannon, M.R. and Johnson, D.R., 2004, Estimated water use in Montana in 2000: U.S. Geological Survey Scientific Investigations Report 2004-5223, 50 p.

One streamflow-gaging station (12331500 Flint Creek near Drummond) was discontinued at the end of water year 2005.

Water-quality and bottom-sediment samples were collected one or more times from April 2004 through September 2005 in a cooperative study with Montana Fish, Wildlife and Parks. These samples were analyzed for organic carbon, mercury, and related geothermal constituents in order to evaluate the occurrence of mercury within the Madison River and adjacent watersheds. The laboratory results for samples collected in August and September 2004 were not available in time for publication in the water year 2004 data report and are, therefore, included in this report. The 28 stations sampled as part of this investigation were:

06036650 Jefferson River near Three Forks
 06036905 Firehole River near West Yellowstone
 06037100 Gibbon River at Madison Junction, Yellowstone National Park
 06037500 Madison River near West Yellowstone
 06038500 Madison River below Hebgen Lake, near Grayling
 06038800 Madison River at Kirby Ranch, near Cameron
 06039200 West Fork Madison River near Cameron
 06040000 Madison River near Cameron
 06040800 Madison River above powerplant, near McAllister
 06041300 Hot Springs Creek near Norris
 06042600 Madison River at Three Forks
 06052500 Gallatin River at Logan
 06054500 Missouri River at Toston
 443406110500701 Firehole River below Lower Geysers Basin, Yellowstone National Park
 443824110531601 Madison River near Madison Junction, Yellowstone National Park
 444349111081901 Hebgen Lake, Madison Arm near Grayling
 444548111144401 Upper Hebgen Lake near Grayling
 444710111102301 Hebgen Lake, Grayling Arm near Grayling
 444909111161201 Middle Hebgen Lake near Grayling
 444950111251201 Lower Quake Lake near Grayling
 445107111214501 Upper Quake Lake near Grayling
 445122111193501 Lower Hebgen Lake near Grayling
 445220111213601 Beaver Creek near mouth, near Grayling
 452518111412201 Upper Ennis Lake near Ennis
 452702111393001 Lower Ennis Lake near Ennis
 460719111243201 Lower Toston Reservoir near Toston
 462334111311701 Upper Canyon Ferry Lake near Townsend
 463811111420001 Lower Canyon Ferry Lake near Townsend

A one-time sampling of selected biota and major ions was conducted during 2005 to characterize the aquatic biology and habitat of streams in an area of coal-bed methane development at the following stations; the biological data will not be available for publication until next year. The 13 stations sampled as part of this investigation are:

06306100 Squirrel Creek near Decker
 06307570 Hanging Woman Creek below Horse Creek, near Birney
 06324710 Powder River at Broadus
 06325000 Little Powder River at Biddle
 445832106551401 Youngs Creek above mouth, near Decker
 445957106524701 Tongue River below Youngs Creek, near Decker
 450047106514201 Squirrel Creek above mouth, at Decker
 450137106595101 Youngs Creek near reservation boundary, near Decker
 451340106295501 Hanging Woman Creek below Hay Gulch, near Birney
 451607106372801 Tongue River at Prairie Dog Creek, near Birney
 451732106085001 Otter Creek below Taylor Creek, near Otter
 452642106091201 Otter Creek below Tenmile Creek, near Ashland
 453209105201201 Powder River below Little Powder River, near Broadus

A one-time reconnaissance sampling for major ions and trace elements was conducted to characterize water quality of inflows to the Tongue River upstream from Tongue River Reservoir. The seven sites sampled as part of this investigation are:

445700106563101 Ash Creek at mouth, near Acme, Wyo.
 445817106544601 Youngs Creek at mouth, near Decker
 445949106524801 Discharge from coal-bed methane production facilities, Permit MT-0030457-009
 445955106515801 Discharge from coal-bed methane production facilities, Permit MT-0030457-005
 450007106495201 Discharge from coal-bed methane production facilities, Permit MT-0030457-013
 450011106522501 Discharge from coal-bed methane production facilities, Permit MT-0030457-004
 450017106494001 Discharge from coal-bed methane production facilities, Permit MT-0030457-015

Three new stations were established and one former station was reestablished in the upper Clark Fork basin for determining greater spatial resolution of metal sources in areas where remediation is occurring. These stations are:

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12323230 Blacktail Creek at Harrison Avenue, at Butte
 12323670 Mill Creek near Anaconda
 12323710 Willow Creek near Anaconda
 12323840 Lost Creek near Anaconda

Water-quality data collection was discontinued at two stations during or at the end of water year 2005. These stations are:

06132000 Missouri River below Fort Peck Dam
 06177000 Missouri River near Wolf Point

SUMMARY OF HYDROLOGIC CONDITIONS

Temperature and Precipitation

For most of Montana, temperatures from October 2004 through April 2005 were warmer than normal. In many areas, the above-normal temperatures in March caused valley and prairie snow to melt earlier than usual. Warmer-than-normal temperatures in April caused mountain snow to begin to melt earlier than usual, but cooler-than-normal temperatures in May and June slowed the melting of the remaining mountain snowpack. Temperatures generally remained above normal across the State for the rest of the water year.³

Data for precipitation, departure from normal precipitation, and percentage of normal precipitation for seven climatological divisions of the State are presented in table 1. The precipitation data listed in table 1 are averages of the total monthly precipitation for the National Weather Service (NWS) reporting stations within each of the climatological divisions. No attempt was made to area-weight the division totals. As shown in table 1, for October 2004 through March 2005, precipitation in all climatological divisions was less than normal, ranging from 64 percent of normal in the western division to 92 percent of normal in the north-central division. For April through September 2005, precipitation ranged from 96 percent of normal in the north-central division to 130 percent of normal in the southeastern division. Percentage of normal precipitation for water year 2005 varied across the State from 82 percent of normal in the western division to 118 percent of normal in the southeastern division. Total average precipitation for water year 2005 ranged from 12.66 inches in the north-central division to 16.37 inches in the southeastern division (table 1).

³U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, 2005, Climatological Data, Montana, v. 106, no. 10 through v. 107, no. 9.

Table 1. Precipitation and departure from normal, in inches, and percentage of normal, Montana, water year 2005.¹

| Climatological division (number of stations) | October 2004 through March 2005 | | | April through September 2005 | | | Water year 2005 | | |
|--|---------------------------------|----------------------------------|----------------------|------------------------------|----------------------------------|----------------------|-----------------------------|----------------------------------|----------------------|
| | Total monthly precipitation | Departure from normal, 1971-2000 | Percentage of normal | Total monthly precipitation | Departure from normal, 1971-2000 | Percentage of normal | Total average precipitation | Departure from normal, 1971-2000 | Percentage of normal |
| Western (45) | 6.29 | -3.49 | 64 | 9.72 | 0.01 | 100 | 15.98 | -3.48 | 82 |
| Southwestern (22) | 3.76 | -1.63 | 70 | 10.21 | -.25 | 98 | 13.97 | -1.88 | 88 |
| North Central (42) | 2.98 | -.26 | 92 | 9.68 | -.45 | 96 | 12.66 | -.71 | 95 |
| Central (35) | 3.33 | -.82 | 80 | 10.89 | -.04 | 100 | 14.22 | -.86 | 94 |
| South Central (26) | 4.24 | -1.24 | 77 | 12.06 | 1.04 | 109 | 16.30 | -.20 | 99 |
| Northeastern (27) | 2.08 | -.54 | 79 | 11.79 | 1.55 | 115 | 13.87 | 1.01 | 108 |
| Southeastern (22) | 2.96 | -.67 | 82 | 13.41 | 3.12 | 130 | 16.37 | 2.45 | 118 |

¹Data from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, 2005, Climatological Data, Montana, v. 106, no. 10 through v. 107, no. 9. Normals of precipitation are determined from the base period 1971-2000.

Most NWS stations in Montana measure precipitation in valley or non-mountainous locations. Data for precipitation falling as snow in the mountainous parts of the State during the winter are published by the U.S. Department of Agriculture, Natural Resources Conservation Service (available at <http://www.wcc.nrcs.usda.gov/snow/snotel-reports.html>). Snow-water equivalents of mountain snowpack, determined from SNOpack TELEmetry (SNOTEL) information, for various basins in Montana are presented in table 2.

By March 1, 2005, snow-water equivalent of the snowpack in all basins ranged from 0 (Lower Milk drainage basin) to 78 percent of average. During March, the snowpack continued to increase, but all drainages remained less than average on April 1. Between April 1 and May 1, some drainage basins increased in snowpack and others decreased in snowpack, but all drainage basins had less than average snowpack on May 1.

Table 2. Snow-water equivalent and percent of average snow-water equivalent of mountain snowpack in selected basins in Montana, March 1-May 1, 2005.¹

| Drainage basin | March 1, 2005 | | | April 1, 2005 | | | May 1, 2005 | | |
|--------------------------------------|---|---|-----------------------|---|---|-----------------------|---|---|-----------------------|
| | Basin-wide snow-water equivalent, in inches | Basin-wide average snow-water equivalent, in inches | Percentage of average | Basin-wide snow-water equivalent, in inches | Basin-wide average snow-water equivalent, in inches | Percentage of average | Basin-wide snow-water equivalent, in inches | Basin-wide average snow-water equivalent, in inches | Percentage of average |
| Hudson Bay drainage basin | | | | | | | | | |
| St. Mary | 13.7 | 26.8 | 51 | 17.5 | 30.2 | 58 | 15.9 | 26.2 | 61 |
| Missouri drainage basin | | | | | | | | | |
| Upper Missouri | 9.4 | 14.0 | 67 | 12.8 | 17.4 | 74 | 13.6 | 17.4 | 78 |
| Sun, Teton, Marias | 6.8 | 16.1 | 42 | 10.4 | 19.1 | 54 | 10.2 | 17.7 | 58 |
| Smith, Judith, Musselshell | 6.4 | 10.6 | 60 | 10.5 | 13.1 | 80 | 10.6 | 11.4 | 93 |
| Lower Milk | .0 | 4.3 | 0 | 2.4 | 4.4 | 55 | .4 | 1.2 | 33 |
| Upper Yellowstone | 10.3 | 15.7 | 66 | 13.7 | 19.2 | 71 | 13.2 | 19.2 | 69 |
| Bighorn | 7.4 | 11.6 | 64 | 9.8 | 14.3 | 68 | 9.6 | 15.2 | 63 |
| Tongue | 6.2 | 8.9 | 70 | 9.3 | 11.6 | 80 | 9.2 | 12.2 | 75 |
| Powder | 5.8 | 7.4 | 78 | 8.5 | 9.6 | 88 | 6.9 | 10.0 | 69 |
| Upper Columbia drainage basin | | | | | | | | | |
| Kootenai | 12.5 | 22.7 | 55 | 16.3 | 26.3 | 62 | 12.3 | 23.8 | 52 |
| Flathead | 12.0 | 22.8 | 53 | 16.3 | 26.7 | 61 | 14.8 | 23.8 | 62 |
| Clark Fork | 9.1 | 18.8 | 48 | 12.2 | 22.1 | 55 | 11.8 | 19.9 | 59 |

¹SNOTEL data from Natural Resources Conservation Service (NRCS) National Water and Climate Center, accessed January 31, 2006 at <http://www.wcc.nrcs.usda.gov/snow/snotel-reports.html>. Averages were determined from the base period 1971-2000.

SURFACE WATER

Streamflow

Streamflow data for water year 2005 can be compared to long-term data for water years 1971-2000 and maximum and minimum monthly mean discharge for the period of record at seven streamflow-gaging stations (fig. 2). Compared to the mean annual discharge (average of the annual mean discharges) for water years 1971-2000, the annual mean discharge (fig. 2) during water year 2005 was 86 percent of average at Middle Fork Flathead River near West Glacier (station 12358500); 74 percent of average at Clark Fork at St. Regis (station 12354500); 68 percent of average at Missouri River at Toston (station 06054500); 83 percent of average at Yellowstone River at Corwin Springs (station 06191500); 79 percent of average at Yellowstone River at Billings (station 06214500); 31 percent of average at Rock Creek below Horse Creek, near international boundary (station 06169500); and 58 percent of average at Marias River near Shelby (station 06099500).

The annual departure from mean annual discharge at two streamflow-gaging stations on unregulated streams is shown in figure 3. At both Yellowstone River at Corwin Springs and Middle Fork Flathead River near West Glacier, the annual mean discharge during water year 2005 was less than the long-term average for the period of record.

A comparison of instantaneous peak discharge for water year 2005 at 25 selected streamflow-gaging stations to instantaneous peak discharge for the period of record is presented in table 3. Record peak discharges were not recorded for any of these stations. The recurrence intervals for peak discharges during water year 2005 were less than 2 years at 22 gaging stations and 2-5 years at the other 3 stations.

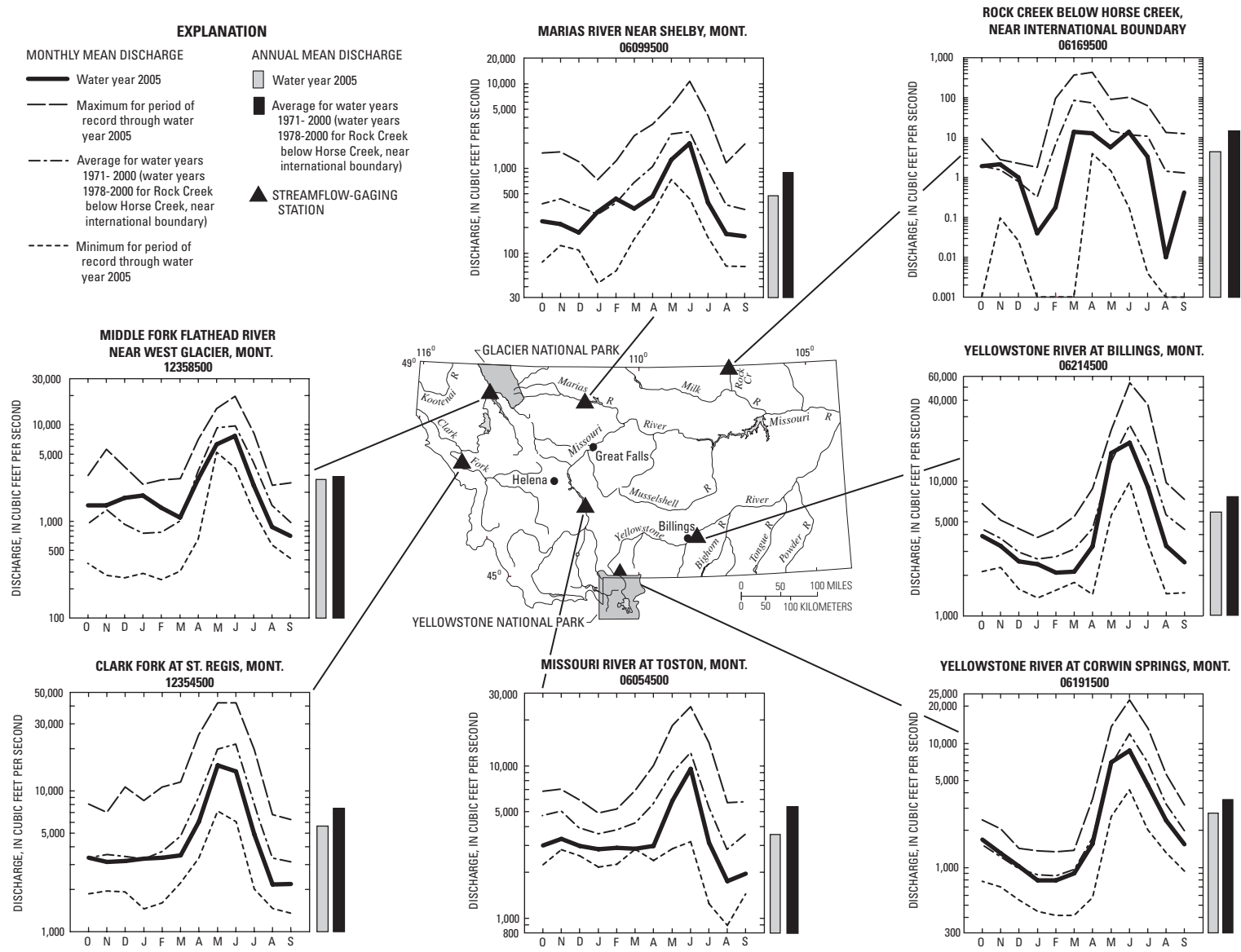


Figure 2. Streamflow data for water year 2005 compared to long-term data at selected streamflow-gaging stations in Montana.

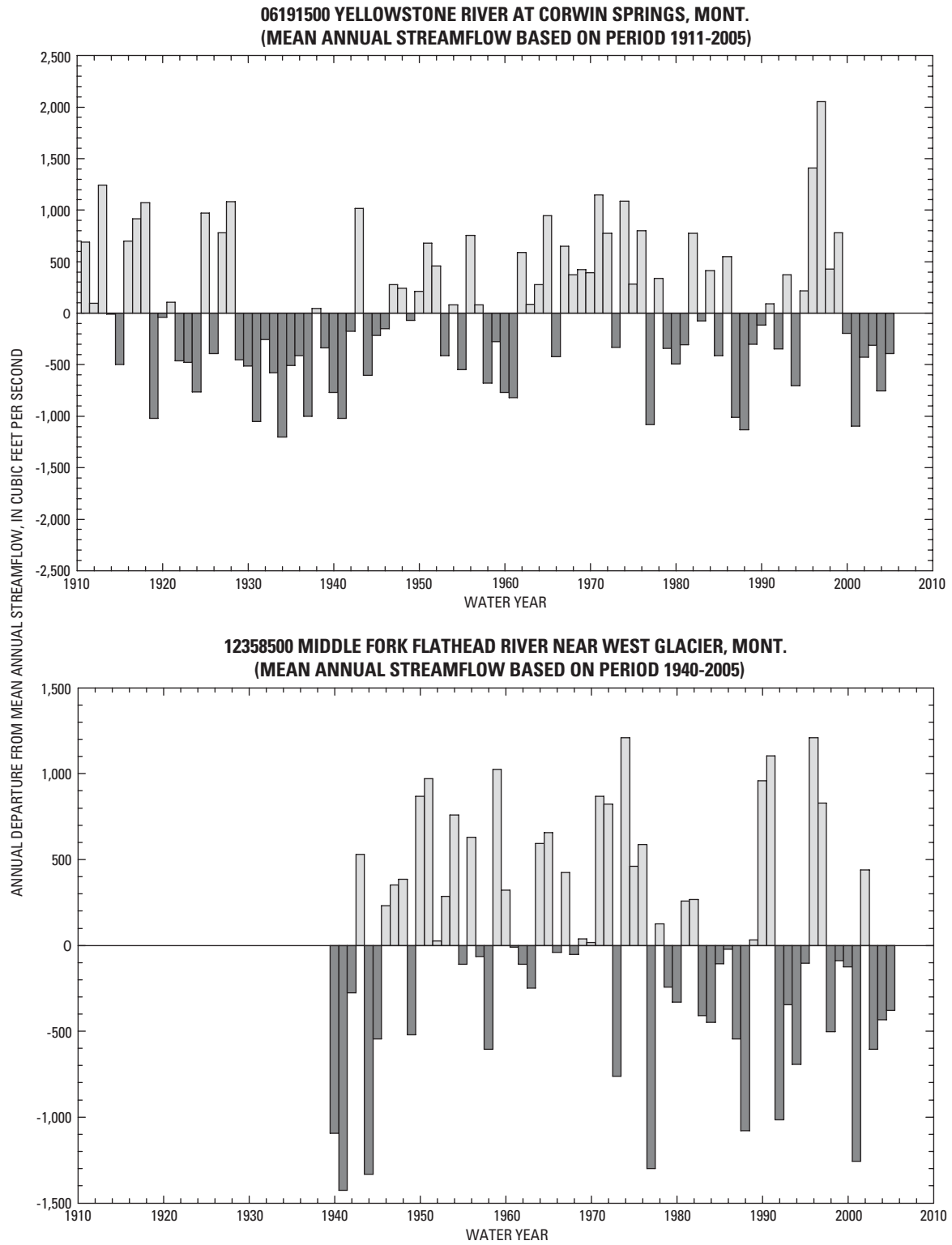


Figure 3. Annual departure from mean annual discharge at two streamflow-gaging stations on unregulated streams in Montana.

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Table 3. Comparisons of instantaneous peak discharge for water year 2005 to instantaneous peak discharge for period of record at selected stations in Montana.

[Symbols: <, less than; --, not determined; *, outside period of record]

| Station number | Station name | Drainage area (square miles) | Peak discharge, water year 2005 | | | Peak discharge, period of record through water year 2004 | |
|----------------|--|------------------------------|---------------------------------|-----------------------|-----------------------------|--|-----------------------|
| | | | Date | Cubic feet per second | Recurrence interval (years) | Date | Cubic feet per second |
| 05014500 | Swiftcurrent Creek at Many Glacier | 30.9 | 06/04 | 894 | <2 | 06/08/64 | 6,700 |
| 05017500 | St. Mary River near Babb | 276 | 06/07 | 2,530 | <2 | 06/09/64 | 16,500 |
| 06025500 | Big Hole River near Melrose | 2,476 | 05/21 | 3,430 | <2 | 06/10/72 | 14,300 |
| 06054500 | Missouri River at Toston | 14,669 | 06/18 | 12,500 | <2 | 06/12/97 | 34,000 |
| 06089000 | Sun River near Vaughn | 1,854 | 05/18 | 3,850 | <2 | 06/09/64 | 53,500 |
| 06099500 | Marias River near Shelby | 3,242 | 06/06 | 5,160 | <2 | 06/09/64 | 241,000 |
| 06115200 | Missouri River near Landusky | 40,987 | 06/06 | 17,700 | <2 | 06/03/53 | 137,000 |
| 06120500 | Musselshell River at Harlowton | 1,125 | 05/21 | 1,070 | 2-5 | 06/20/75 | 7,270 |
| 06154400 | Peoples Creek near Hays | 220 | 06/28 | 49 | <2 | 06/08/72 | 8,460 |
| 06174500 | Milk River at Nashua | 22,332 | 06/11 | 4,540 | <2 | 04/18/52 | 45,300 |
| 06181000 | Poplar River near Poplar | 3,174 | 06/15 | 230 | <2 | 04/06/54 | 37,400 |
| 06191500 | Yellowstone River at Corwin Springs | 2,623 | 05/21 | 16,800 | <2 | 06/10/96 06/06/97 | 32,200 32,200 |
| 06200000 | Boulder River at Big Timber | 523 | 06/23 | 5,160 | <2 | 06/05/97 | 9,940 |
| 06214500 | Yellowstone River at Billings | 11,795 | 05/22 | 35,900 | <2 | 06/12/97 | 82,000 |
| 06289000 | Little Bighorn River at State line, near Wyola | 193 | 05/20 | 1,180 | 2-5 | 06/03/44 | 2,730 |
| 06308500 | Tongue River at Miles City | 5,397 | 06/09 | 3,750 | 2-5 | 06/15/62 | 13,300 |
| 06329500 | Yellowstone River near Sidney | 69,103 | 06/29 | 48,100 | <2 | 06/21/21 | 159,000 |
| 12301300 | Tobacco River near Eureka | 440 | 06/09 | 943 | <2 | 05/13/91 | 3,180 |
| 12304500 | Yaak River near Troy | 766 | 12/11 | 2,550 | <2 | 05/17/97 * 05/54 | 12,600 *13,400 |
| 12332000 | Middle Fork Rock Creek near Philipsburg | 123 | 05/19 | 535 | <2 | 06/16/74 | 1,680 |
| 12335500 | Nevada Creek above reservoir, near Helmville | 116 | 06/04 | 268 | <2 | 06/02/53 | 1,800 |
| 12340000 | Blackfoot River near Bonner | 2,290 | 05/17 | 5,360 | <2 | 06/10/64 | 19,200 |
| 12354500 | Clark Fork at St. Regis | 10,709 | 05/21 | 22,700 | <2 | 05/24/48 05/18/97 | 68,900 68,900 |
| 12358500 | Middle Fork Flathead River near West Glacier | 1,128 | 06/04 | 12,800 | <2 | 06/09/64 | 140,000 |
| 12370000 | Swan River near Bigfork | 671 | 06/05 | 4,860 | <2 | 06/20/74 | 8,890 |

A comparison of minimum daily mean discharge for water year 2005 to minimum daily mean discharge for the period of record through water year 2004 at 24 selected long-term streamflow-gaging stations is presented in table 4. No record minimum daily mean discharges were recorded

during water year 2005. The recurrence intervals for minimum daily discharges were less than 2 years at 9 sites, 2-5 years at 12 sites, and 10-20 years at 3 sites.

Table 4. Comparisons of minimum daily mean discharge for water year 2005 to minimum daily mean discharge for period of record at selected stations in Montana.

[Symbol: <, less than]

| Station number | Station name | Drainage area (square miles) | Minimum daily mean discharge, water year 2005 | | | Minimum daily mean discharge, period of record through water year 2004 | |
|----------------|--|------------------------------|---|-----------------------|-----------------------------|--|-----------------------|
| | | | Date | Cubic feet per second | Recurrence interval (years) | Date | Cubic feet per second |
| 05014500 | Swiftcurrent Creek at Many Glacier | 30.9 | 02/25 | 25 | <2 | 11/14,16/76 | 0 |
| 05017500 | St. Mary River near Babb | 276 | 03/07 | 103 | <2 | 01/03/53 | 27 |
| 06025500 | Big Hole River near Melrose | 2,476 | 09/04 | 169 | 2-5 | 08/17/31 | 49 |
| 06054500 | Missouri River at Toston | 14,669 | 07/28 | 1,530 | 2-5 | 01/12/63 | 700 |
| 06089000 | Sun River near Vaughn | 1,854 | 01/15 | 100 | 2-5 | 05/26/41 | 23 |
| 06099500 | Marias River near Shelby | 3,242 | 08/08 | 83 | 2-5 | 08/20/19 | 10 |
| 06115200 | Missouri River near Landusky | 40,987 | 12/26 | 3,700 | 2-5 | 12/13/36 | 1,220 |
| 06120500 | Musselshell River at Harlowton | 1,125 | 01/15 | 13 | 2-5 | (¹) | 0 |
| 06174500 | Milk River at Nashua | 22,332 | 04/08 | 26 | 2-5 | (¹) | 0 |
| 06181000 | Poplar River near Poplar | 3,174 | 01/16 | 3.5 | <2 | (¹) | 0 |
| 06191500 | Yellowstone River at Corwin Springs | 2,623 | 01/06 | 700 | <2 | 02/05/89 | 380 |
| 06200000 | Boulder River at Big Timber | 523 | 01/14 | 60 | 2-5 | 08/26/61 | 12 |
| 06214500 | Yellowstone River at Billings | 11,795 | 01/14 | 1,700 | <2 | 12/12/32 | 450 |
| 06289000 | Little Bighorn River at State line, near Wyola | 193 | 12/23 | 24 | 10-20 | 02/02/89 | 18 |
| 06308500 | Tongue River at Miles City | 5,397 | 05/05 | 12 | 2-5 | 07/09/40 | 0 |
| 06329500 | Yellowstone River near Sidney | 69,103 | 01/08 | 1,500 | 10-20 | 05/17/61 | 570 |
| 12301300 | Tobacco River near Eureka | 440 | 09/08 | 46 | 2-5 | 01/11/63 | 20 |
| 12304500 | Yaak River near Troy | 766 | 09/09 | 103 | <2 | 09/19/01 | 49 |
| 12332000 | Middle Fork Rock Creek near Philipsburg | 123 | 02/16 | 9.0 | 10-20 | 02/09/53 | 5.3 |
| 12335500 | Nevada Creek above reservoir, near Helmville | 116 | 01/05 | 5.0 | <2 | 01/11/44 | 2.0 |
| 12340000 | Blackfoot River near Bonner | 2,290 | 01/04 | 300 | 2-5 | 01/04/50 | 200 |
| 12354500 | Clark Fork at St. Regis | 10,709 | 01/06 | 1,600 | 2-5 | 02/03/89 | 800 |
| 12358500 | Middle Fork Flathead River near West Glacier | 1,128 | 09/09 | 541 | <2 | 11/27/52 | 189 |
| 12370000 | Swan River near Bigfork | 671 | 09/27 | 352 | <2 | 01/26-29/30 | 193 |

¹On various dates.

The percentage of average storage (based on water years 1971-2000), by month, for selected major reservoirs is presented in table 5. At the end of water year 2005, storage was within 10 percent of average in five of the six major reservoirs used to supply water primarily for hydroelectric-power generation. Storage was within 20 percent of average

at the end of water year 2005 in two of the four reservoirs used to supply water primarily for irrigation. Gibson Reservoir was 17 percent of average at the end of water year 2005.

Table 5. Percentage of average storage, by month, during water year 2005 for selected major reservoirs in Montana used to supply water principally for hydroelectric-power generation and irrigation.

| Reservoir | Usable capacity (acre-feet) | Percentage of average storage based on 1971-2000 period of record | | | | | | | | | | | |
|---------------------------------------|-----------------------------|---|------|------|------|------|------|------|-----|------|------|------|-------|
| | | 2004 | | | 2005 | | | | | | | | |
| | | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
| Hydroelectric-power generation | | | | | | | | | | | | | |
| Canyon Ferry Lake | 1,993,000 | 81 | 81 | 84 | 87 | 91 | 94 | 94 | 96 | 103 | 100 | 97 | 92 |
| Fort Peck Lake | 18,910,000 | 55 | 56 | 56 | 56 | 57 | 58 | 57 | 55 | 56 | 57 | 56 | 57 |
| Bighorn Lake | 1,356,000 | 71 | 80 | 76 | 78 | 80 | 80 | 84 | 103 | 108 | 99 | 106 | 102 |
| Lake Koocanusa | 5,748,000 | 118 | 122 | 119 | 154 | 190 | 182 | 172 | 148 | 119 | 102 | 92 | 94 |
| Hungry Horse Reservoir | 3,451,000 | 111 | 115 | 125 | 139 | 151 | 168 | 160 | 128 | 109 | 101 | 97 | 101 |
| Flathead Lake | 1,791,000 | 98 | 108 | 105 | 120 | 136 | 156 | 156 | 111 | 101 | 100 | 99 | 100 |
| Irrigation | | | | | | | | | | | | | |
| Lima Reservoir | 84,050 | 103 | 108 | 110 | 108 | 108 | 108 | 113 | 113 | 124 | 122 | 112 | 103 |
| Clark Canyon Reservoir | 255,600 | 23 | 26 | 30 | 35 | 37 | 38 | 39 | 39 | 40 | 32 | 31 | 37 |
| Gibson Reservoir | 99,050 | 75 | 69 | 77 | 89 | 95 | 104 | 119 | 108 | 99 | 56 | 16 | 17 |
| Fresno Reservoir | 103,000 | 76 | 75 | 74 | 73 | 72 | 53 | 60 | 59 | 84 | 116 | 91 | 89 |

WATER QUALITY

The USGS operates water-quality stations throughout Montana in cooperation with numerous Federal, State, and local agencies and Tribal governments. The stations change from year to year as objectives are achieved or modified, or funding levels change. Some stations are operated for only a few years and commonly are part of a short-term investigation to examine water quality related to a specific condition. Other stations have been in operation for many years and provide a basis for description of long-term water-quality conditions or trends that represent a wide range of hydrologic or land-use variability. Long-term stations typically are located on major streams that represent an important water resource in the area and require data on an ongoing basis for various management concerns.

Two of the most intensively sampled networks of water-quality stations are in the upper Clark Fork basin of western Montana and in the Yellowstone River tributary basins of Rosebud Creek, Tongue River, and Powder River in southeastern Montana (fig. 7). The primary constituents of concern in the upper Clark Fork basin are trace elements associated with historical mining of metals. In the basins of southeastern Montana, dissolved solids and sodium associated with coal-bed methane development are of concern. Other large sampling networks with small to moderate sampling frequencies are in the Tenmile Creek and Boulder River basins of southwestern Montana where trace elements associated with historical mining are of concern. Small to moderate-sized networks of sampling stations are operated in the Bitterroot River, Sun River, Muddy Creek,

Teton River, and Flathead River basins. Numerous sites are equipped with continuous monitoring for water temperature and a smaller number of sites are equipped with continuous monitors for specific conductance.

Various water-quality measurements are made, either onsite or by laboratory analysis of samples, depending on the objective of the investigation. Several types of water-quality data that describe physical and chemical characteristics are routinely obtained in many sampling programs. Examples of commonly measured water-quality characteristics are dissolved solids, dissolved oxygen, dissolved nitrite plus nitrate, total phosphorus, and suspended sediment. Guideline concentrations and standards have been established by the State of Montana (<http://www.deq.state.mt.us/wqinfo/Circulars/WQB-7.PDF>) and U.S. Environmental Protection Agency (USEPA) (<http://epa.gov/waterscience/standards/wqcriteria.html>) to provide values protective of human health and aquatic organisms.

The concentration of dissolved solids, which represents the mass (milligrams) of all constituents dissolved in a unit volume (liter) of water, can be determined either from the weight of dry residue that remains after evaporation of a known volume of water that has been filtered to remove particulate material, or estimated from the sum of the individual dissolved major-ion concentrations. An excessive concentration of dissolved solids can render the water unsuitable for certain uses such as human consumption, irrigation of crops, or livestock watering. Recommended guidelines compiled by the U.S. Department of Agriculture⁴ indicate that water might not be suitable when dissolved-

solids concentrations exceed 500 mg/L if used for human consumption, 1,000 mg/L if used for crop irrigation, and 10,000 mg/L if used for livestock watering.

Dissolved oxygen in surface water is essential for most aquatic organisms and is an indicator of the biochemical condition of the stream or lake. The solubility of oxygen in water is a function of water temperature and barometric pressure; therefore, the oxygen content in surface water is subject to considerable daily and seasonal change. Biological activities such as photosynthesis and decomposition also can cause rapid and large changes in dissolved-oxygen concentration. Dissolved-oxygen concentrations less than 5.0 mg/L for warm-water fish or less than 8.0 mg/L for cold-water fish may be detrimental to early life stages.⁵

Nitrogen (N) is an essential plant nutrient that occurs in several forms in water. Common sources of nitrogen are atmospheric deposition, soils, plant fertilizer, animal waste, and sewage or septic effluent. Nitrite and nitrate are inorganic forms of nitrogen that can occur in water, although nitrite is seldom present in large amounts in oxygenated water. Dissolved nitrate is a major nutrient for plants; consequently, large concentrations of nitrate in streams and lakes can cause rapid growth of aquatic plants. Nitrate concentrations in excess of 0.30 mg/L as N have the potential to stimulate growths of algae in the presence of adequate phosphorus.⁶ In addition, human health can be adversely affected if the nitrate concentration exceeds 10 mg/L as N in drinking water.^{5,7}

Phosphorus (P) is an essential plant nutrient that can stimulate excessive growth of aquatic plants. Total phosphorus includes the inorganic and organic forms of dissolved and suspended phosphorus and is commonly analyzed as an indicator of eutrophication potential. Although phosphorus can originate naturally from igneous and sedimentary rock formations, more common sources include sewage, detergents, fertilizer, and livestock waste. Total phosphorus concentrations to limit nuisance aquatic plant growth in streams should not exceed 0.03 mg/L as P in

western Montana and 1.0 mg/L as P in eastern Montana.⁴ Water-quality criteria established by the USEPA⁸ also indicate that total phosphorus should not exceed 0.05 mg/L as P in streams discharging directly to lakes or 0.025 mg/L as P within lakes.

Suspended sediment is particulate material eroded from the land surface by either wind or water and maintained in suspension in streams by hydraulic energy. The quantity of suspended sediment in streams typically increases during periods of increased runoff, when large amounts of rainfall or snowmelt can rapidly erode soil and the increased streamflow can scour channel sediments. Although large suspended-sediment concentrations can occur naturally in areas underlain by easily erodible geologic materials, land use that disturbs soils also can contribute substantial quantities of sediment to streams and lakes. The quantity of sediment in suspension has important physical and chemical implications for aquatic life. Sediment in suspension during high flow may be deposited in stream channels or lakes where water velocities decrease. In areas of sediment deposition, aquatic insects or fish eggs can be smothered, thereby rendering the bottom habitat unsuitable for their survival. Many chemical constituents such as some metals, phosphorus, and some pesticides tend to sorb strongly to sediment. As a result, chemicals may be readily transported from land sources into river systems where aquatic organisms could be exposed to toxic concentrations.

Statistical summaries of selected water-quality measurements made at eight long-term water-quality stations in Montana are presented in table 6. The range of values for each type of measurement is described by the minimum and maximum values. To compare current and long-term water-quality conditions, the range of values are summarized for both water year 2005 and the period of record through water year 2004. In addition, the central tendency of data collected over the period of record is described by the median (50th percentile).

⁴U.S. Department of Agriculture, 2002, Natural Resources Conservation Service, Assessing water quality for agriculture and aquatic life uses: Environment Technical Note No. MT-1, 27 p.

⁵Montana Department of Environmental Quality, 2004, Montana numeric water quality standards: Circular WBQ-7, 38 p., Administrative Rules of Montana 17.30.619.

⁶Mackenthun, K.M., 1969, The practice of water pollution biology: U.S. Department of the Interior, Federal Water Pollution Control Administration, Division of Technical Support, 281 p.

⁷U.S. Environmental Protection Agency, 1991, Maximum Contaminant Levels (section 141.62 of subpart G of part 141, National Revised Primary Drinking Water Regulations): U.S. Code of Federal Regulations Title 40, Parts 100 to 149, revised as of July 1, 1991, p. 673.

⁸U.S. Environmental Protection Agency, 1986, Quality criteria for water, 1986: Washington, D.C., Office of Water Regulations and Standards, EPA 440/5-86-001, unpagged.

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Table 6. Statistical summaries of selected water-quality measurements for long-term water-quality stations in Montana for water year 2005 and the period of record through water year 2004.

[Symbols: <, less than; --, no data]

| Station number | Station name | Water year 2005 | | | Period of record through water year 2004 | | | |
|--|---|-------------------|---------|---------|--|---------|---------|--------|
| | | Number of samples | Minimum | Maximum | Number of samples | Minimum | Maximum | Median |
| Dissolved solids, in milligrams per liter | | | | | | | | |
| 06089000 | Sun River near Vaughn | 0 | -- | -- | 306 | 155 | 1,100 | 462 |
| 06178500 | East Poplar River at international boundary | 4 | 770 | 975 | 271 | 97 | 1,480 | 941 |
| 06185500 | Missouri River near Culbertson | 7 | 343 | 403 | 247 | 221 | 579 | 401 |
| 06308500 | Tongue River at Miles City | 18 | 204 | 693 | 219 | 155 | 1,330 | 562 |
| 06326500 | Powder River near Locate | 12 | 522 | 2,060 | 229 | 408 | 3,450 | 1,470 |
| 06329500 | Yellowstone River near Sidney | 0 | -- | -- | 297 | 142 | 863 | 467 |
| 12340000 | Blackfoot River near Bonner | 0 | -- | -- | 26 | 78 | 156 | 128 |
| 12352500 | Bitterroot River near Missoula | 2 | 42 | 62 | 35 | 26 | 107 | 56 |
| Dissolved oxygen, in milligrams per liter | | | | | | | | |
| 06089000 | Sun River near Vaughn | 0 | -- | -- | 47 | 7.4 | 13.2 | 10.9 |
| 06178500 | East Poplar River at international boundary | 4 | 5.5 | 8.1 | 267 | .9 | 17.2 | 9.2 |
| 06185500 | Missouri River near Culbertson | 7 | 7.0 | 12.9 | 285 | 6.0 | 14.2 | 9.3 |
| 06308500 | Tongue River at Miles City | 17 | 6.8 | 13.2 | 208 | 6.5 | 15.6 | 8.8 |
| 06326500 | Powder River near Locate | 9 | 8.3 | 13.7 | 265 | 2.7 | 15.7 | 8.8 |
| 06329500 | Yellowstone River near Sidney | 6 | 8.5 | 13.7 | 430 | 4.4 | 15.0 | 9.1 |
| 12340000 | Blackfoot River near Bonner | 6 | 8.0 | 12.3 | 5 | 7.2 | 10.6 | 9.0 |
| 12352500 | Bitterroot River near Missoula | 0 | -- | -- | 33 | 8.2 | 15.2 | 10.6 |
| Dissolved nitrite plus nitrate, in milligrams per liter as nitrogen | | | | | | | | |
| 06089000 | Sun River near Vaughn | 9 | .139 | .922 | 355 | <.01 | 4.7 | .61 |
| 06178500 | East Poplar River at international boundary | 4 | <.016 | .127 | 69 | <.01 | .29 | .07 |
| 06185500 | Missouri River near Culbertson | 7 | <.016 | .155 | 173 | <.005 | .38 | .006 |
| 06308500 | Tongue River at Miles City | 7 | <.016 | .594 | 151 | <.02 | .97 | .04 |
| 06326500 | Powder River near Locate | 12 | <.016 | .771 | 167 | <.01 | 1.8 | .26 |
| 06329500 | Yellowstone River near Sidney | 6 | <.06 | .710 | 257 | <.005 | .73 | .20 |
| 12340000 | Blackfoot River near Bonner | 6 | <.016 | .040 | 26 | <.005 | .03 | <.05 |
| 12352500 | Bitterroot River near Missoula | 4 | <.016 | .047 | 44 | <.005 | .17 | .03 |
| Total phosphorus, in milligrams per liter as phosphorus | | | | | | | | |
| 06089000 | Sun River near Vaughn | 9 | .007 | .08 | 129 | <.01 | .64 | .03 |
| 06178500 | East Poplar River at international boundary | 4 | .043 | .10 | 273 | <.01 | .40 | .03 |
| 06185500 | Missouri River near Culbertson | 7 | .089 | .34 | 233 | .01 | 1.0 | .09 |
| 06308500 | Tongue River at Miles City | 7 | .011 | 2.7 | 177 | <.01 | 2.6 | .04 |
| 06326500 | Powder River near Locate | 12 | .011 | 5.4 | 230 | .005 | 26 | .17 |
| 06329500 | Yellowstone River near Sidney | 6 | .010 | .84 | 388 | <.01 | 2.7 | .09 |
| 12340000 | Blackfoot River near Bonner | 6 | .006 | .06 | 26 | .003 | .17 | .02 |
| 12352500 | Bitterroot River near Missoula | 4 | .016 | .09 | 44 | .004 | .18 | .02 |
| Suspended sediment, in milligrams per liter | | | | | | | | |
| 06089000 | Sun River near Vaughn | 9 | 16 | 62 | 130 | 8 | 910 | 57 |
| 06178500 | East Poplar River at international boundary | 4 | 58 | 95 | 237 | 4 | 322 | 56 |
| 06185500 | Missouri River near Culbertson | 7 | 110 | 1,890 | 194 | 19 | 2,370 | 244 |
| 06308500 | Tongue River at Miles City | 18 | 31 | 8,110 | 194 | 5 | 14,000 | 84 |
| 06326500 | Powder River near Locate | 12 | 36 | 18,700 | 259 | 8 | 41,400 | 1,040 |
| 06329500 | Yellowstone River near Sidney | 13 | 23 | 4,670 | 379 | 10 | 15,500 | 296 |
| 12340000 | Blackfoot River near Bonner | 6 | 2 | 66 | 147 | 1 | 271 | 9 |
| 12352500 | Bitterroot River near Missoula | 4 | 2 | 178 | 46 | 1 | 186 | 11 |

GROUND WATER

Ground-Water Levels

Water levels were measured in 27 observation wells during water year 2005 (fig. 8). Water levels in most of these wells primarily reflect the response of the ground-water system in the area to natural climatic conditions. However, several wells are within the zone of influence of human activities, and water levels in these wells can be affected by pumping or infiltration of applied irrigation water. Water levels commonly fluctuate throughout the year and from year to year as a result of changes in climatic conditions or human activities.

Seventeen of the observation wells are equipped with continuous water-level recorders and have varying lengths of record. One of the continuous recorders also provides near real-time data delivery, with water level data collected hourly and transmitted every 4 hours via satellite for display as part of the USGS National Water Information System program website: <http://waterdata.usgs.gov/mwis>. Individual data values from the continuous recorders are not presented in this report but are available at the USGS Montana Water Science Center. Hydrographs are included for the 17 wells equipped with continuous recorders and periodic water-level data for all 27 wells are presented.

EXPLANATION OF THE RECORDS

The surface-water and ground-water records published in this report are for water year 2005 that began October 1, 2004, and ended September 30, 2005. A calendar of the water year is provided on the inside of the front cover. The records contain streamflow data, stage and content data for lakes and reservoirs, water-quality data for surface and ground water, and ground-water-level data. The locations of the stations and wells where the data were collected are shown in figures 6 through 8. The following sections of the introductory text are presented to provide users with a more detailed explanation of how the hydrologic data published in this report were collected, analyzed, computed, and arranged for presentation

DOWNSTREAM ORDER AND STATION NUMBER

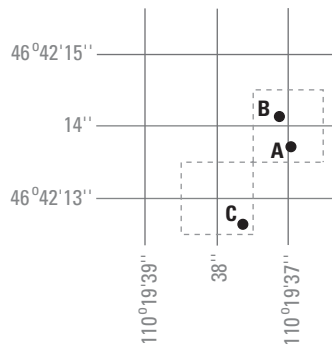
Since October 1, 1950, hydrologic-station records in USGS reports have been listed in order of downstream direction along the main stream. All stations on a tributary entering upstream from a main-stream station are listed before that station. A station on a tributary entering between two main-stream stations is listed between those stations. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries. The rank of any

tributary on which a station is located with respect to the stream to which it is immediately tributary is indicated by an indentation in that list of stations in the front of this report. Each indentation represents one rank. This downstream order and system of indentation indicates which stations are on tributaries between any two stations and the rank of the tributary on which each station is located.

As an added means of identification, each hydrologic station and partial-record station has been assigned a station number. These station numbers are in the same downstream order used in this report. In assigning a station number, no distinction is made between partial-record stations and other stations; therefore, the station number for a partial-record station indicates downstream-order position in a list composed of both types of stations. Gaps are consecutive. The complete 8-digit (or 10-digit) number for each station such as 09004100, which appears just to the left of the station name, includes a 2-digit part number "09" plus the 6-digit (or 8-digit) downstream order number "004100." In areas of high station density, an additional two digits may be added to the station identification number to yield a 10-digit number. The stations are numbered in downstream order as described above between stations of consecutive 8-digit numbers.

NUMBERING SYSTEM FOR WELLS AND MISCELLANEOUS SITES

The USGS well and miscellaneous site-numbering system is based on the grid system of latitude and longitude. The system provides the geographic location of the well or miscellaneous site and a unique number for each site. The number consists of 15 digits. The first 6 digits denote the degrees, minutes, and seconds of latitude, and the next 7 digits denote degrees, minutes, and seconds of longitude; the last 2 digits are a sequential number for wells within a 1-second grid. In the event that the latitude-longitude coordinates for a well and miscellaneous site are the same, a sequential number such as "01," "02," and so forth, would be assigned as one would for wells (see fig. 4). The 8-digit, downstream order station numbers are not assigned to wells and miscellaneous sites where only random water-quality samples or discharge measurements are taken.



LATITUDE AND LONGITUDE
 Coordinates for site A: (464214110193701)
 Coordinates for site B: (464214110193702)
 Coordinates for site C: (464213110193801)

Figure 4. System for numbering wells and miscellaneous sites (latitude and longitude).

In addition to the well number that is based on latitude and longitude given for each well, another well number may be provided which in many states is based on the Public Land Survey System, a set of rectangular surveys that is used to identify land parcels. The well-numbering system used by the Geological Survey in Montana consists of a location number of as many as 14 characters. The first three characters specify the township and its position south (S) or north (N) of the Montana Base Line. The next three characters specify the range and its position east (E) or west (W) of the Montana Principal Meridian. The next two characters are the section number. The letters following the section number indicate the well location within the section: the first letter designates the 160-acre tract (quarter section), the second the 40-acre tract (quarter-quarter section), the third the 10-acre tract (quarter-quarter-quarter section), and the fourth letter designates the 2.5-acre tract (quarter-quarter-quarter-quarter tract). The four subdivisions of the section are designated A, B, C, and D in a counter-clockwise direction, beginning in the northeastern quadrant. The last two characters in the location number specify a sequence number to distinguish between multiple wells in a single tract. For example, as shown in figure 5, well 30N33W05ABAB01 is the first well inventoried in the NW¹/₄ (B) of the NE¹/₄ (A) of the NW¹/₄ (B) of the NE¹/₄ (A) of section 5, in township 30 north, range 33 west.

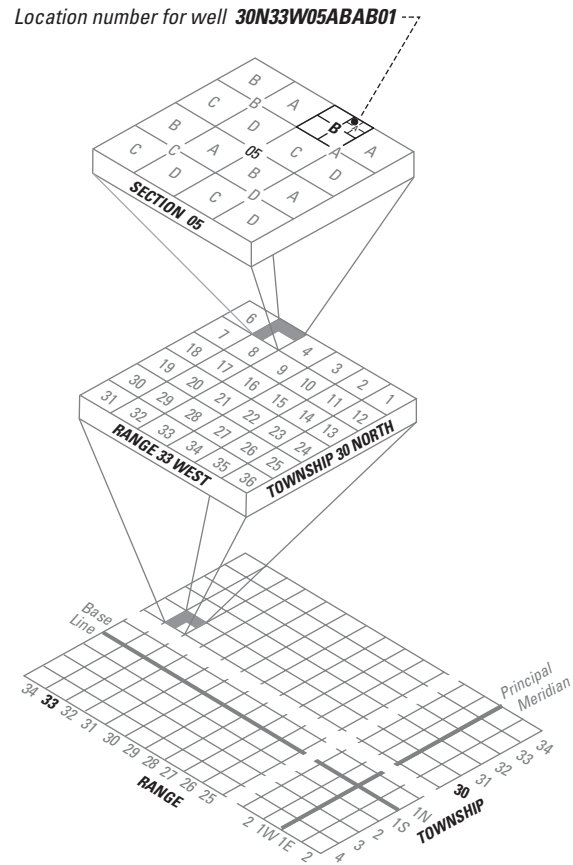


Figure 5. System for numbering wells and miscellaneous sites (township and range).

SPECIAL NETWORKS AND PROGRAMS

Hydrologic Benchmark Network is a network of 61 sites in small drainage basins in 39 States that was established in 1963 to provide consistent streamflow data representative of undeveloped watersheds nationwide, and from which data could be analyzed on a continuing basis for use in comparison and contrast with conditions observed in basins more obviously affected by human activities. At selected sites, water-quality information is being gathered on major ions and nutrients, primarily to assess the effects of acid deposition on stream chemistry. Additional information on the Hydrologic Benchmark Program may be accessed from <http://ny.cf.er.usgs.gov/hbn/>.

National Stream-Quality Accounting Network (NASQAN) is a network of sites used to monitor the water quality of large rivers within the Nation's largest river basins. From 1995 through 1999, a network of approximately 40 stations was operated in the Mississippi, Columbia, Colorado, and Rio Grande River basins. For the period 2000

through 2004, sampling was reduced to a few index stations on the Colorado and Columbia Rivers so that a network of five stations could be implemented on the Yukon River. Samples are collected with sufficient frequency that the flux of a wide range of constituents can be estimated. The objective of NASQAN is to characterize the water quality of these large rivers by measuring concentration and mass transport of a wide range of dissolved and suspended constituents, including nutrients, major ions, dissolved and sediment-bound heavy metals, common pesticides, and inorganic and organic forms of carbon. This information will be used (1) to describe the long-term trends and changes in concentration and transport of these constituents; (2) to test findings of the National Water-Quality Assessment (NAWQA) Program; (3) to characterize processes unique to large-river systems such as storage and re-mobilization of sediments and associated contaminants; and (4) to refine existing estimates of off-continent transport of water, sediment, and chemicals for assessing human effects on the world's oceans and for determining global cycles of carbon, nutrients, and other chemicals. Additional information about the NASQAN Program may be accessed from <http://water.usgs.gov/nasqan/>.

The National Atmospheric Deposition Program/ National Trends Network (NADP/NTN) is a network of monitoring sites that provides continuous measurement and assessment of the chemical constituents in precipitation throughout the United States. As the lead Federal agency, the USGS works together with over 100 organizations to provide a long-term, spatial and temporal record of atmospheric deposition generated from this network of 250 precipitation-chemistry monitoring sites. The USGS supports 74 of these 250 sites. This long-term, nationally consistent monitoring program, coupled with ecosystem research, provides critical information toward a national scorecard to evaluate the effectiveness of ongoing and future regulations intended to reduce atmospheric emissions and subsequent impacts to the Nation's land and water resources. Reports and other information on the NADP/NTN Program, as well as data from the individual sites, may be accessed from <http://bqs.usgs.gov/acidrain/>.

The USGS National Water-Quality Assessment (NAWQA) Program is a long-term program with goals to describe the status and trends of water-quality conditions for a large, representative part of the Nation's ground- and surface-water resources; to provide an improved understanding of the primary natural and human factors affecting these observed conditions and trends; and to provide information that supports development and evaluation of management, regulatory, and monitoring decisions by other agencies.

Assessment activities are being conducted in 42 study units (major watersheds and aquifer systems) that represent a

wide range of environmental settings nationwide and that account for a large percentage of the Nation's water use. A wide array of chemical constituents is measured in ground water, surface water, streambed sediments, and fish tissues. The coordinated application of comparative hydrologic studies at a wide range of spatial and temporal scales will provide information for water-resources managers to use in making decisions and a foundation for aggregation and comparison of findings to address water-quality issues of regional and national interest.

Communication and coordination between USGS personnel and other local, State, and Federal interests are critical components of the NAWQA Program. Each study unit has a local liaison committee consisting of representatives from key Federal, State, and local water-resources agencies, Indian nations, and universities in the study unit. Liaison committees typically meet semiannually to discuss their information needs, monitoring plans and progress, desired information products, and opportunities for collaboration among the agencies. Additional information about the NAWQA Program may be accessed from <http://water.usgs.gov/nawqa/>.

The USGS National Streamflow Information Program (NSIP) is a long-term program with goals to provide framework streamflow data across the Nation. Included in the program are creation of a permanent Federally funded streamflow network, research on the nature of streamflow, regional assessments of streamflow data and databases, and upgrades in the streamflow information delivery systems. Additional information about NSIP may be accessed from <http://water.usgs.gov/nsip/>.

EXPLANATION OF STAGE- AND WATER-DISCHARGE RECORDS

Data Collection and Computation

The base data collected at gaging stations (fig. 6) consist of records of stage and measurements of discharge of streams or canals, and stage, surface area, and volume of lakes or reservoirs. In addition, observations of factors affecting the stage-discharge relation or the stage-capacity relation, weather records, and other information are used to supplement base data in determining the daily flow or volume of water in storage. Records of stage are obtained from a water-stage recorder that is either downloaded electronically in the field to a laptop computer or similar device or is transmitted using telemetry such as GOES satellite, land-line or cellular-phone modems, or by radio transmission. Measurements of discharge are made with a current meter or acoustic Doppler current profiler, using the general methods adopted by the USGS. These methods are described in standard textbooks, USGS Water-Supply Paper

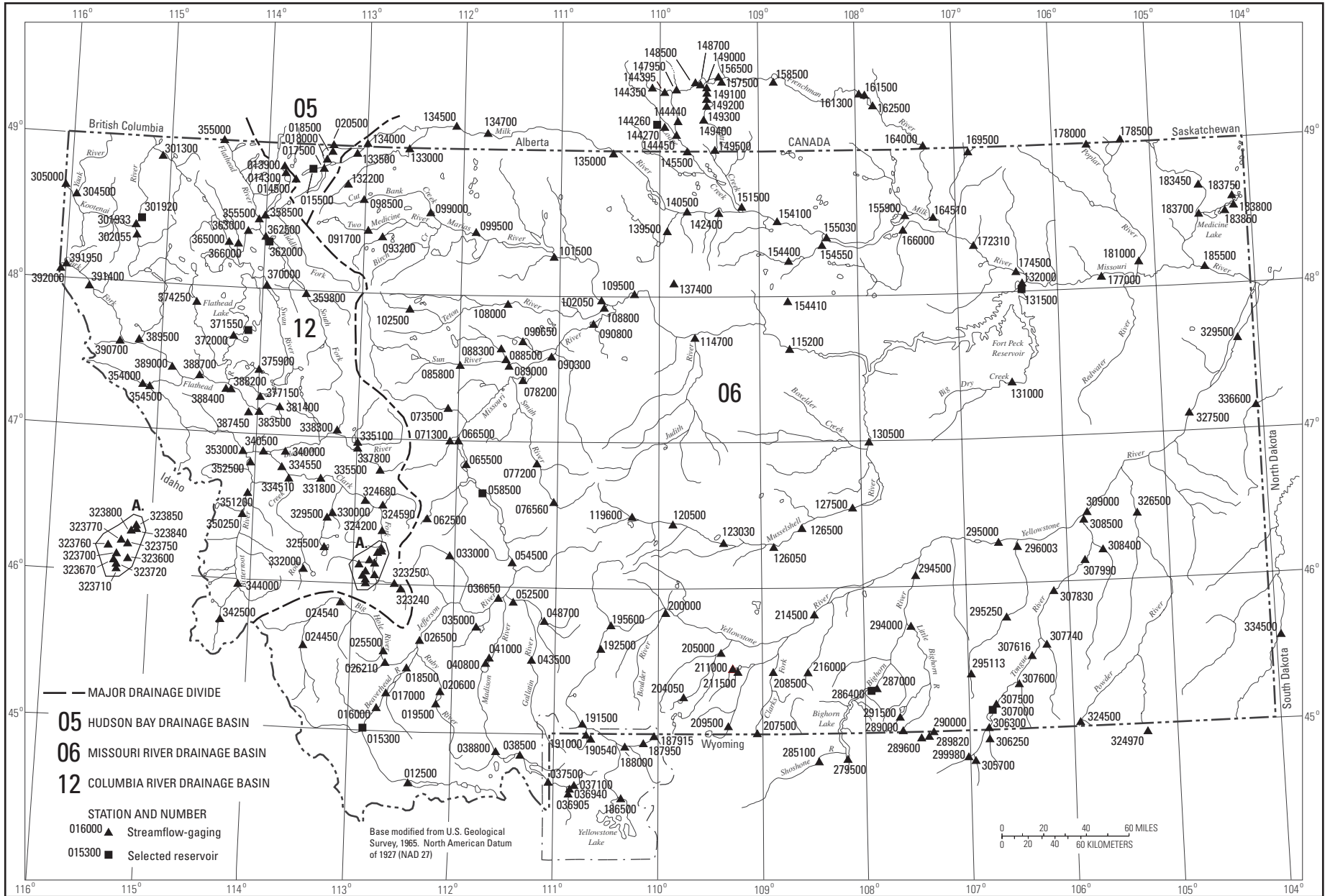


Figure 6. Location of streamflow-gaging and selected reservoir stations in Montana and adjacent areas, water year 2005.

2175, and the Techniques of Water-Resources Investigations of the United States Geological Survey (TWRIs), Book 3, Chapters A1 through A19 and Book 8, Chapters A2 and B2, which may be accessed from <http://water.usgs.gov/pubs/twri/>. The methods are consistent with the American Society for Testing and Materials (ASTM) standards and generally follow the standards of the International Organization for Standardization (ISO).

For stream-gaging stations, discharge-rating tables for any stage are prepared from stage-discharge curves. If extensions to the rating curves are necessary to express discharge greater than measured, the extensions are made on the basis of indirect measurements of peak discharge (such as slope-area or contracted-opening measurements, or computation of flow over dams and weirs), step-backwater techniques, velocity-area studies, and logarithmic plotting. The daily mean discharge is computed from gage heights and rating tables, then the monthly and yearly mean discharges are computed from the daily values. If the stage-discharge relation is subject to change because of frequent or continual change in the physical features of the stream channel, the daily mean discharge is computed by the shifting-control method in which correction factors that are based on individual discharge measurements and notes by engineers and observers are used when applying the gage heights to the rating tables. If the stage-discharge relation for a station is temporarily changed by the presence of aquatic growth or debris on the controlling section, the daily mean discharge is computed by the shifting-control method.

The stage-discharge relation at some stream-gaging stations is affected by backwater from reservoirs, tributary streams, or other sources. Such an occurrence necessitates the use of the slope method in which the slope or fall in a reach of the stream is a factor in computing discharge. The slope or fall is obtained by means of an auxiliary gage at some distance from the base gage.

An index velocity is measured using ultrasonic or acoustic instruments at some stream-gaging stations, and this index velocity is used to calculate an average velocity for the flow in the stream. This average velocity along with a stage-area relation is then used to calculate average discharge.

At some stations, the stage-discharge relation is affected by changing stage. At these stations, the rate of change in stage is used as a factor in computing discharge.

At some stream-gaging stations in the northern United States, the stage-discharge relation is affected by ice in the winter; therefore, computation of the discharge in the usual manner is impossible. Discharge for periods of ice effect is computed on the basis of gage-height record and occasional winter-discharge measurements. Consideration is given to the available information on temperature and precipitation,

notes by gage observers and hydrologists, and comparable records of discharge from other stations in the same or nearby basins.

For a lake or reservoir station, capacity tables giving the volume or contents for any stage are prepared from stage-area relation curves defined by surveys. The application of the stage to the capacity table gives the contents, from which the daily, monthly, or yearly changes are computed.

If the stage-capacity curve is subject to changes because of deposition of sediment in the reservoir, periodic resurveys of the reservoir are necessary to define new stage-capacity curves. During the period between reservoir surveys, the computed contents may be increasingly in error due to the gradual accumulation of sediment.

For some stream-gaging stations, periods of time occur when no gage-height record is obtained or the recorded gage height is faulty and cannot be used to compute daily discharge or contents. Such a situation can happen when the recorder stops or otherwise fails to operate properly, the intakes are plugged, the float is frozen in the well, or for various other reasons. For such periods, the daily discharges are estimated on the basis of recorded range in stage, prior and subsequent records, discharge measurements, weather records, and comparison with records from other stations in the same or nearby basins. Likewise, lake or reservoir volumes may be estimated on the basis of operator's log, prior and subsequent records, inflow-outflow studies, and other information.

Data Presentation

The records published for each continuous-record surface-water discharge station (stream-gaging station) consist of five parts: (1) the station manuscript or description; (2) the data table of daily mean values of discharge for the current water year with summary data; (3) a tabular statistical summary of monthly mean flow data for a designated period, by water year; (4) a summary statistics table that includes statistical data of annual, daily, and instantaneous flows as well as data pertaining to annual runoff, 7-day low-flow minimums, and flow duration; and (5) a hydrograph of discharge.

Station Manuscript

The manuscript provides, under various headings, descriptive information, such as station location; period of record; historical extremes outside the period of record; record accuracy; and other remarks pertinent to station operation and regulation. The following information, as appropriate, is provided with each continuous record of discharge or lake content. Comments follow that clarify

information presented under the various headings of the station description.

LOCATION.—Location information is obtained from the most accurate maps available. The location of the gaging station with respect to the cultural and physical features in the vicinity and with respect to the reference place mentioned in the station name is given. River mileages, given for most stations, were determined by methods given in Montana Department of Natural Resources and Conservation River Mile Index.^{9,10,11}

DRAINAGE AREA.—Drainage areas are measured using the most accurate maps available. Because the type of maps available varies from one drainage basin to another, the accuracy of drainage areas likewise varies. Drainage areas are updated as better maps become available.

PERIOD OF RECORD.—This term indicates the time period for which records have been published for the station or for an equivalent station. An equivalent station is one that was in operation at a time that the present station was not and whose location was such that its flow reasonably can be considered equivalent to flow at the present station.

REVISED RECORDS.—If a critical error in published records is discovered, a revision is included in the first report published following discovery of the error.

GAGE.—The type of gage in current use, the datum of the current gage referred to a standard datum, and a condensed history of the types, locations, and datums of previous gages are given under this heading.

REMARKS.—All periods of estimated daily discharge either will be identified by date in this paragraph of the station description for water-discharge stations or flagged in the daily discharge table. (See section titled Identifying Estimated Daily Discharge.) Information is presented relative to the accuracy of the records, to special methods of computation, and to conditions that affect natural flow at the station. In addition, information may be presented pertaining to average discharge data for the period of record; to extremes data for the period of record and the current year; and, possibly, to other pertinent items. For reservoir stations, information is given on the dam forming the reservoir, the capacity, the out-

let works and spillway, and the purpose and use of the reservoir.

COOPERATION.—Records provided by a cooperating organization or obtained for the USGS by a cooperating organization are identified here.

EXTREMES OUTSIDE PERIOD OF RECORD.—Information here documents major floods or unusually low flows that occurred outside the stated period of record. The information may or may not have been obtained by the USGS.

REVISIONS.—Records are revised if errors in published records are discovered. Appropriate updates are made in the USGS distributed data system, NWIS, and subsequently to its Web-based national data system, NWISWeb (<http://water.usgs.gov/nwis/nwis>). Users are encouraged to obtain all required data from NWIS or NWISWeb to ensure that they have the most recent data updates. Updates to NWISWeb are made on an annual basis.

Although rare, occasionally the records of a discontinued gaging station may need revision. Because no current or, possibly, future station manuscript would be published for these stations to document the revision in a REVISED RECORDS entry, users of data for these stations who obtained the record from previously published data reports may wish to contact the USGS Water Science Center (address given on the back of the title page of this report) to determine if the published records were revised after the station was discontinued. If, however, the data for a discontinued station were obtained by computer retrieval, the data would be current. Any published revision of data is always accompanied by revision of the corresponding data in computer storage.

Manuscript information for lake or reservoir stations differs from that for stream stations in the nature of the REMARKS and in the inclusion of a stage-capacity table when daily volumes are given.

Data Table of Daily Mean Values

The daily table of discharge records for stream-gaging stations gives mean discharge for each day of the water year. In the monthly summary for the table, the line headed TOTAL gives the sum of the daily figures for each month; the line headed MEAN gives the arithmetic average flow in cubic feet per second for the month; and the lines headed MAX and MIN give the maximum and minimum daily mean discharges, respectively, for each month. Discharge for the month is expressed in cubic feet per second per square mile (line headed CF5M); or in inches (line headed IN); or in acre-feet (line headed AC-FT). Values for cubic feet per second per square mile and runoff in inches or in acre-feet may be omitted if extensive regulation or diversion is in

⁹Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Helena, Mont., 61 p.

¹⁰Montana Department of Natural Resources and Conservation, 1979, River mile index of the Missouri River: Helena, Mont., 142 p.

¹¹Montana Department of Natural Resources and Conservation, 1984, River mile index of the Columbia River basin: Helena, Mont., p. 1-76.

effect or if the drainage area includes large noncontributing areas. At some stations, monthly and (or) yearly observed discharges are adjusted for reservoir storage or diversion, or diversion data or reservoir volumes are given. These values are identified by a symbol and a corresponding footnote.

Statistics of Monthly Mean Data

A tabular summary of the mean (line headed MEAN), maximum (MAX), and minimum (MIN) of monthly mean flows for each month for a designated period is provided below the mean values table. The water years of the first occurrence of the maximum and minimum monthly flows are provided immediately below those values. The designated period will be expressed as FOR WATER YEARS __-__, BY WATER YEAR (WY), and will list the first and last water years of the range of years selected from the PERIOD OF RECORD paragraph in the station manuscript. The designated period will consist of all of the station record within the specified water years, including complete months of record for partial water years, and may coincide with the period of record for the station. The water years for which the statistics are computed are consecutive, unless a break in the station record is indicated in the manuscript.

Summary Statistics

A table titled SUMMARY STATISTICS follows the statistics of monthly mean data tabulation. This table consists of four columns with the first column containing the line headings of the statistics being reported. The table provides a statistical summary of yearly, daily, and instantaneous flows, not only for the current water year but also for the previous calendar year and for a designated period, as appropriate. The designated period selected, WATER YEARS __-__, will consist of all of the station records within the specified water years, including complete months of record for partial water years, and may coincide with the period of record for the station. The water years for which the statistics are computed are consecutive, unless a break in the station record is indicated in the manuscript. All of the calculations for the statistical characteristics designated ANNUAL (see line headings below), except for the ANNUAL 7-DAY MINIMUM statistic, are calculated for the designated period using complete water years. The other statistical characteristics may be calculated using partial water years.

The date or water year, as appropriate, of the first occurrence of each statistic reporting extreme values of discharge is provided adjacent to the statistic. Repeated occurrences may be noted in the REMARKS paragraph of the manuscript or in footnotes. Because the designated period may not be the same as the station period of record published in the manuscript, occasionally the dates of

occurrence listed for the daily and instantaneous extremes in the designated-period column may not be within the selected water years listed in the heading. When the dates of occurrence do not fall within the selected water years listed in the heading, it will be noted in the REMARKS paragraph or in footnotes. Selected streamflow duration-curve statistics and runoff data also are given. Runoff data may be omitted if extensive regulation or diversion of flow is in effect in the drainage basin.

The following summary statistics data are provided with each continuous record of discharge. Comments that follow clarify information presented under the various line headings of the SUMMARY STATISTICS table.

ANNUAL TOTAL.—The sum of the daily mean values of discharge for the year.

ANNUAL MEAN.—The arithmetic mean for the individual daily mean discharges for the year noted or for the designated period.

HIGHEST ANNUAL MEAN.—The maximum annual mean discharge occurring for the designated period.

LOWEST ANNUAL MEAN.—The minimum annual mean discharge occurring for the designated period.

HIGHEST DAILY MEAN.—The maximum daily mean discharge for the year or for the designated period.

LOWEST DAILY MEAN.—The minimum daily mean discharge for the year or for the designated period.

ANNUAL 7-DAY MINIMUM.—The lowest mean discharge for 7 consecutive days for a calendar year or a water year. Note that most low-flow frequency analyses of annual 7-day minimum flows use a climatic year (April 1-March 31). The date shown in the summary statistics table is the initial date of the 7-day period. This value should not be confused with the 7-day 10-year low-flow statistic.

MAXIMUM PEAK FLOW.—The maximum instantaneous peak discharge occurring for the water year or designated period. Occasionally the maximum flow for a year may occur at midnight at the beginning or end of the year, on a recession from or rise toward a higher peak in the adjoining year. In this case, the maximum peak flow is given in the table and the maximum flow may be reported in a footnote or in the REMARKS paragraph in the manuscript.

MAXIMUM PEAK STAGE.—The maximum instantaneous peak stage occurring for the water year or designated period. Occasionally the maximum stage for a year may occur at midnight at the beginning or end of the year, on a recession from or rise toward a higher peak in the adjoining year. In

this case, the maximum peak stage is given in the table and the maximum stage may be reported in the REMARKS paragraph in the manuscript or in a footnote. If the dates of occurrence of the maximum peak stage and maximum peak flow are different, the REMARKS paragraph in the manuscript or a footnote may be used to provide further information.

INSTANTANEOUS LOW FLOW.—The minimum instantaneous discharge occurring for the water year or for the designated period.

ANNUAL RUNOFF.—Indicates the total quantity of water in runoff for a drainage area for the year. Data reports may use any of the following units of measurement in presenting annual runoff data:

Acre-foot (AC-FT) is the quantity of water required to cover 1 acre to a depth of 1 foot and is equivalent to 43,560 cubic feet or about 326,000 gallons or 1,233 cubic meters.

Cubic feet per square mile (CFSM) is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming the runoff is distributed uniformly in time and area.

Inches (INCHES) indicate the depth to which the drainage area would be covered if all of the runoff for a given time period were uniformly distributed on it.

10 PERCENT EXCEEDS.—The discharge that has been exceeded 10 percent of the time for the designated period.

50 PERCENT EXCEEDS.—The discharge that has been exceeded 50 percent of the time for the designated period.

90 PERCENT EXCEEDS.—The discharge that has been exceeded 90 percent of the time for the designated period.

Identifying Estimated Daily Discharge

Estimated daily-discharge values published in the water-discharge tables of annual State data reports are identified. This identification is shown either by flagging individual daily values with the letter “e” and noting in a table footnote, “e—Estimated,” or by listing the dates of the estimated record in the REMARKS paragraph of the station description.

Accuracy of Field Data and Computed Results

The accuracy of streamflow data depends primarily on (1) the stability of the stage-discharge relation or, if the control is unstable, the frequency of discharge measurements, and (2) the accuracy of observations of stage, measurements of discharge, and interpretations of records.

The degree of accuracy of the records is stated in the REMARKS in the station description. “Excellent” indicates that about 95 percent of the daily discharges are within 5 percent of the true value; “good” within 10 percent; and “fair,” within 15 percent. “Poor” indicates that daily discharges have less than “fair” accuracy. Different accuracies may be attributed to different parts of a given record.

Values of daily mean discharge in this report are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft³/s; to the nearest tenths between 1.0 and 10 ft³/s; to whole numbers between 10 and 1,000 ft³/s; and to three significant figures above 1,000 ft³/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharge values listed for partial-record stations.

Discharge at many stations, as indicated by the monthly mean, may not reflect natural runoff due to the effects of diversion, consumption, regulation by storage, increase or decrease in evaporation due to artificial causes, or to other factors. For such stations, values of cubic feet per second per square mile and of runoff in inches are not published unless satisfactory adjustments can be made for diversions, for changes in contents of reservoirs, or for other changes incident to use and control. Evaporation from a reservoir is not included in the adjustments for changes in reservoir contents, unless it is so stated. Even at those stations where adjustments are made, large errors in computed runoff may occur if adjustments or losses are large in comparison with the observed discharge.

Other Data Records Available

Information of a more detailed nature than that published for most of the stream-gaging stations such as discharge measurements, gage-height records, and rating tables is available from the USGS Water Science Center. Also, most stream-gaging station records are available in computer-usable form and many statistical analyses have been made.

Information on the availability of unpublished data or statistical analyses may be obtained from the USGS Water Science Center (see address that is shown on the back of the title page of this report).

Publications

The annual series of Water-Supply Papers that give information on quantity of surface waters in Montana are given in table 7. Data for the Hudson Bay basin is given in Part 5, for the Missouri River basin in Part 6, and for the Columbia River basin in Part 12.

Table 7. Water-Supply Paper numbers and parts for surface-water stations, 1899-1970.

| Year | Part 5 | Part 6 | Part 12 | Year | Part 5 | Part 6 | Part 12 |
|------|-----------|--------|---------|---------------------|--------|--------|---------|
| 1899 | | 36,37 | 38 | | | | |
| 1900 | 49 | 49 | 51,52 | | | | |
| 1901 | 66,75 | 66,75 | 66,75 | 1926 | 625 | 626 | 632 |
| 1902 | 83,85 | 84 | 85 | 1927 | 645 | 646 | 652 |
| 1903 | 98,99,100 | 99 | 100 | 1928 | 665 | 666 | 672 |
| 1904 | 130 | 130 | 135 | 1929 | 685 | 686 | 692 |
| 1905 | 171 | 172 | 178 | 1930 | 700 | 701 | 707 |
| 1906 | 207 | 208 | 214 | 1931 | 715 | 716 | 722 |
| 1907 | 245 | 246 | 252 | 1932 | 730 | 731 | 737 |
| 1908 | 245 | 246 | 252 | 1933 | 745 | 746 | 752 |
| 1909 | 265 | 266 | 272 | 1934 | 760 | 761 | 767 |
| 1910 | 285 | 286 | 292 | 1935 | 785 | 786 | 792 |
| 1911 | 305 | 306 | 312 | 1936 | 805 | 806 | 812 |
| 1912 | 325 | 326 | 332A | 1937 | 825 | 826 | 832 |
| 1913 | 355 | 356 | 362A | 1938 | 855 | 856 | 862 |
| 1914 | 385 | 386 | 392 | 1939 | 875 | 876 | 882 |
| 1915 | 405 | 406 | 412 | 1940 | 895 | 896 | 902 |
| 1916 | 435 | 436 | 442 | 1941 | 925 | 926 | 932 |
| 1917 | 455 | 456 | 462 | 1942 | 955 | 956 | 962 |
| 1918 | 475 | 476 | 482 | 1943 | 975 | 976 | 982 |
| 1919 | 505 | 506 | 512 | 1944 | 1005 | 1006 | 1012 |
| 1920 | 505 | 506 | 512 | 1945 | 1035 | 1036 | 1042 |
| 1921 | 525 | 526 | 532 | 1946 | 1055 | 1056 | 1062 |
| 1922 | 545 | 546 | 552 | 1947 | 1085 | 1086 | 1092 |
| 1923 | 565 | 566 | 572 | 1948 | 1115 | 1116 | 1122 |
| 1924 | 585 | 586 | 592 | 1949 | 1145 | 1146 | 1152 |
| 1925 | 605 | 606 | 612 | 1950 | 1175 | 1176 | 1182 |
| 1951 | 1208 | 1209 | 1216 | 1961-65 | 1913 | 1916 | 1933 |
| 1952 | 1238 | 1239 | 1246 | 1966-70 | 2113 | 2116 | 2133 |
| 1953 | 1278 | 1279 | 1286 | | | | |
| 1954 | 1338 | 1339 | 1346 | 1950 Compilation | 1308 | 1309 | 1316 |
| 1955 | 1388 | 1389 | 1396 | | | | |
| 1956 | 1438 | 1439 | 1446 | 1960 Compilation | 1728 | 1729 | 1736 |
| 1957 | 1508 | 1509 | 1516 | | | | |
| 1958 | 1558 | 1559 | 1566 | | | | |
| 1959 | 1628 | 1629 | 1636 | | | | |
| 1960 | 1708 | 1709 | 1716 | | | | |

EXPLANATION OF PRECIPITATION RECORDS

Data Collection and Computation

Rainfall data generally are collected using electronic data loggers that measure the rainfall in 0.01-inch increments every 15 minutes using either a tipping-bucket rain gage or a collection well gage. Twenty-four hour rainfall totals are tabulated and presented. A 24-hour period extends from just past midnight of the previous day to midnight of the current day. Snowfall-affected data can result during cold weather when snow fills the rain-gage funnel and then melts as temperatures rise. Snowfall-affected data are subject to errors. Missing values are indicated by this symbol “---” in the table.

Data Presentation

Precipitation records collected at surface-water gaging stations are identified with the same station number and name as the stream-gaging station. Where a surface-water daily-record station is not available, the precipitation record is published with its own name and latitude-longitude identification number.

Information pertinent to the history of a precipitation station is provided in descriptive headings preceding the tabular data. These descriptive headings give details regarding location, period of record, and general remarks.

The following information is provided with each precipitation station. Comments that follow clarify information presented under the various headings of the station description.

LOCATION.—See Data Presentation in the EXPLANATION OF STAGE- AND WATER-DISCHARGE RECORDS section of this report (same comments apply).

PERIOD OF RECORD.—See Data Presentation in the EXPLANATION OF STAGE- AND WATER-DISCHARGE RECORDS section of this report (same comments apply).

INSTRUMENTATION.—Information on the type of rainfall collection system is given.

REMARKS.—Remarks provide added information pertinent to the collection, analysis, or computation of records.

EXPLANATION OF WATER-QUALITY RECORDS

Collection and Examination of Data

Surface-water samples for analysis usually are collected at or near stream-gaging stations. The quality-of-water records are given immediately following the discharge records at these stations.

The descriptive heading for water-quality records gives the period of record for all water-quality data; the period of daily record for parameters that are measured on a daily basis (specific conductance, water temperature, sediment discharge, and so forth); extremes for the current year; and general remarks.

For ground-water records, no descriptive statements are given; however, the well number, depth of well, sampling date, or other pertinent data are given in the table containing the chemical analyses of the ground water.

Water Analysis

Most of the methods used for collecting and analyzing water samples are described in the TWRIIs, which may be accessed from <http://water.usgs.gov/pubs/twri/>.

One sample can define adequately the water quality at a given time if the mixture of solutes throughout the stream cross section is homogeneous. However, the concentration of solutes at different locations in the cross section may vary considerably with different rates of water discharge, depending on the source of material and the turbulence and mixing of the stream. Some streams must be sampled at several verticals to obtain a representative sample needed for an accurate mean concentration and for use in calculating load.

Chemical-quality data published in this report are considered to be the most representative values available for the stations listed. The values reported represent water-quality conditions at the time of sampling as much as possible, consistent with available sampling techniques and methods of analysis. In the rare case where an apparent inconsistency exists between a reported pH value and the relative abundance of carbon dioxide species (carbonate and bicarbonate), the inconsistency is the result of a slight uptake of carbon dioxide from the air by the sample between measurement of pH in the field and determination of carbonate and bicarbonate in the laboratory.

For chemical-quality stations equipped with digital monitors, the records consist of daily maximum and minimum values (and sometimes mean or median values) for

each constituent measured and are based on 15-minute or 1-hour intervals of recorded data beginning at 0000 hours and ending at 2400 hours for the day of record.

SURFACE-WATER-QUALITY RECORDS

Records of surface-water quality ordinarily are obtained at or near stream-gaging stations because discharge data are useful in the interpretation of surface-water quality. Records of surface-water quality in this report involve a variety of types of data and measurement frequencies.

Classification of Records

Water-quality data for surface-water sites are grouped into one of three classifications. A *continuous-record station* is a site where data are collected on a regularly scheduled basis. Frequency may be one or more times daily, weekly, monthly, or quarterly. A *partial-record station* is a site where limited water-quality data are collected systematically over a period of years. Frequency of sampling is usually less than quarterly. A *miscellaneous sampling site* is a location other than a continuous- or partial-record station, where samples are collected to give better areal coverage to define water-quality conditions in the river basin.

A careful distinction needs to be made between *continuous records* as used in this report and *continuous recordings* that refer to a continuous graph or a series of discrete values recorded at short intervals. Some records of water quality, such as temperature and specific conductance, may be obtained through continuous recordings; however,

because of costs, most data are obtained only monthly or less frequently. Locations of stations for which records on the quality of surface water appear in this report are shown in figure 7.

Accuracy of the Records

One of four accuracy classifications is applied for measured physical properties at continuous-record stations on a scale ranging from poor to excellent (table 8). The accuracy rating is based on data values recorded before any shifts or corrections are made. Additional consideration also is given to the amount of publishable record and to the amount of data that have been corrected or shifted.

Arrangement of Records

Water-quality records collected at a surface-water daily record station are published immediately following that record, regardless of the frequency of sample collection. Station number and name are the same for both records. Where a surface-water daily record station is not available or where the water quality differs significantly from that at the nearby surface-water station, the continuing water-quality record is published with its own station number and name in the regular downstream-order sequence. Water-quality data for partial-record stations and for miscellaneous sampling sites appear in separate tables following the table of discharge measurements at miscellaneous sites.

Table 8. Rating the accuracy of continuous water-quality records.

[≤, less than or equal to; ±, plus or minus value shown; °C, degree Celsius; >, greater than; %, percent; mg/L, milligram per liter; pH unit, standard pH unit]

| Measured field parameter | Ratings of accuracy (Based on combined fouling and calibration drift corrections applied to the record) | | | |
|--------------------------|--|--|---|--|
| | Excellent | Good | Fair | Poor |
| Water temperature | ≤ ± 0.2 °C | > ± 0.2 – 0.5 °C | > ± 0.5 – 0.8 °C | > ± 0.8 °C |
| Specific conductance | ≤ ± 3% | > ± 3 – 10% | > ± 10 – 15% | > ± 15% |
| Dissolved oxygen | ≤ ± 0.3 mg/L or ≤ ± 5%, whichever is greater | > ± 0.3 – 0.5 mg/L or > ± 5 – 10%, whichever is greater | > ± 0.5 – 0.8 mg/L or > ± 10 – 15%, which- ever is greater | > ± 0.8 mg/L or > ± 15%, whichever is greater |
| pH | ≤ ± 0.2 units | > ± 0.2 – 0.5 units | > ± 0.5 – 0.8 units | > ± 0.8 units |
| Turbidity | ≤ ± 0.5 turbidity units or ≤ ± 5%, whichever is greater | > ± 0.5 – 1.0 turbidity units or > ± 5 – 10%, whichever is greater | > ± 1.0 – 1.5 turbidity units or > ± 10 – 15%, whichever is greater | > ± 1.5 turbidity units or > ± 15%, whichever is greater |

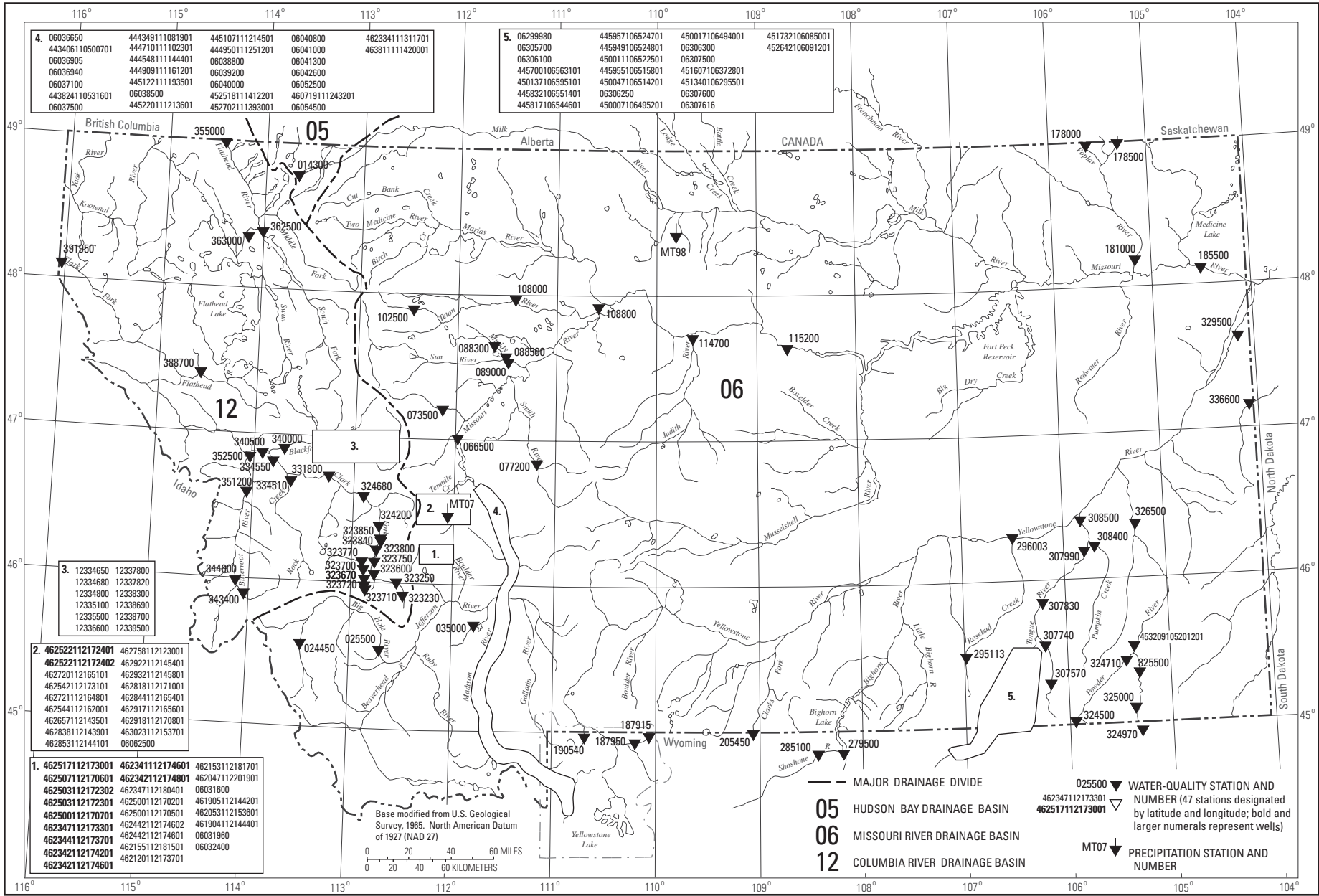


Figure 7. Location of water-quality and precipitation stations in Montana and adjacent areas, water year 2005.

Onsite Measurements and Sample Collection

In obtaining water-quality data, a major concern is assuring that the data obtained represent the naturally occurring quality of the water. To ensure this, certain measurements, such as water temperature, pH, and dissolved oxygen, must be made onsite when the samples are collected. To assure that measurements made in the laboratory also represent the naturally occurring water, carefully prescribed procedures must be followed in collecting the samples, in treating the samples to prevent changes in quality pending analysis, and in shipping the samples to the laboratory. Procedures for onsite measurements and for collecting, treating, and shipping samples are given in TWRI Book 1, Chapter D2; Book 3, Chapters A1, A3, and A4; and Book 9, Chapters A1-A9. Most of the methods used for collecting and analyzing water samples are described in the TWRI, which may be accessed from <http://water.usgs.gov/pubs/twri/>. Also, detailed information on collecting, treating, and shipping samples can be obtained from the USGS Water Science Center (see address that is shown on the back of title page in this report).

Water Temperature

Water temperatures are measured at most of the water-quality stations. In addition, water temperatures are taken at the time of discharge measurements for water-discharge stations. For stations where water temperatures are taken manually once or twice daily, the water temperatures are taken at about the same time each day. Large streams have a small diurnal temperature change; shallow streams may have a daily range of several degrees and may follow closely the changes in air temperature. Some streams may be affected by waste-heat discharges.

At stations where recording instruments are used, either mean temperatures or maximum and minimum temperatures for each day are published. Water temperatures measured at the time of water-discharge measurements are on file in the USGS Water Science Center.

Sediment

Suspended-sediment concentrations are determined from samples collected by using depth-integrating samplers. Samples usually are obtained at several verticals in the cross section, or a single sample may be obtained at a fixed point and a coefficient applied to determine the mean concentration in the cross section.

During periods of rapidly changing flow or rapidly changing concentration, samples may be collected more frequently (twice daily or, in some instances, hourly). The published sediment discharges for days of rapidly changing

flow or concentration are computed by the subdivided-day method (time-discharge weighted average). Therefore, for those days when the published sediment discharge value differs from the value computed as the product of discharge times mean concentration times 0.0027, the reader can assume that the sediment discharge for that day was computed by the subdivided-day method. For periods when no samples were collected, daily discharges of suspended sediment were estimated on the basis of water discharge, sediment concentrations observed immediately before and after the periods, and suspended-sediment loads for other periods of similar discharge.

At other stations, suspended-sediment samples are collected periodically at many verticals in the stream cross section. Although data collected periodically may represent conditions only at the time of observation, such data are useful in establishing seasonal relations between quality and streamflow and in predicting long-term sediment-discharge characteristics of the stream.

In addition to the records of suspended-sediment discharge, records of the periodic measurements of the particle-size distribution of the suspended sediment and bed material are included for some stations.

Laboratory Measurements

Samples for biochemical oxygen demand (BOD) and indicator bacteria are analyzed locally. All other samples are analyzed in the USGS laboratory in Lakewood, Colorado, unless otherwise noted. Methods used in analyzing sediment samples and computing sediment records are given in TWRI, Book 5, Chapter C1. Methods used by the USGS laboratories are given in the TWRI, Book 1, Chapter D2; Book 3, Chapter C2; and Book 5, Chapters A1, A3, and A4. The TWRI publications may be accessed from <http://water.usgs.gov/pubs/twri/>. These methods are consistent with ASTM standards and generally follow ISO standards.

Data Presentation

For continuing-record stations, information pertinent to the history of station operation is provided in descriptive headings preceding the tabular data. These descriptive headings give details regarding location, drainage area, period of record, type of data available, instrumentation, general remarks, cooperation, and extremes for parameters currently measured daily. Tables of chemical, physical, biological, radiochemical data, and so forth, obtained at a frequency less than daily are presented first. Tables of “daily values” of specific conductance, pH, water temperature, dissolved oxygen, and suspended sediment then follow in sequence.

In the descriptive headings, if the location is identical to that of the discharge gaging station, neither the LOCATION nor the DRAINAGE AREA statements are repeated. The following information is provided with each continuous-record station. Comments that follow clarify information presented under the various headings of the station description.

LOCATION.—See Data Presentation information in the EXPLANATION OF STAGE- AND WATER-DISCHARGE RECORDS section of this report (same comments apply).

DRAINAGE AREA.—See Data Presentation information in the EXPLANATION OF STAGE- AND WATER-DISCHARGE RECORDS section of this report (same comments apply).

PERIOD OF RECORD.—This indicates the time periods for which published water-quality records for the station are available. The periods are shown separately for records of parameters measured daily or continuously and those measured less than daily. For those measured daily or continuously, periods of record are given for the parameters individually.

INSTRUMENTATION.—Information on instrumentation is given only if a water-quality monitor temperature record, sediment pumping sampler, or other sampling device is in operation at a station.

REMARKS.—Remarks provide added information pertinent to the collection, analysis, or computation of the records.

COOPERATION.—Records provided by a cooperating organization or obtained for the USGS by a cooperating organization are identified here.

EXTREMES.—Maximums and minimums are given only for parameters measured daily or more frequently. For parameters measured weekly or less frequently, true maximums or minimums may not have been obtained. Extremes, when given, are provided for both the period of record and for the current water year.

REVISIONS.—Records are revised if errors in published water-quality records are discovered. Appropriate updates are made in the USGS distributed data system, NWIS, and subsequently to its Web-based national data system, NWISWeb (<http://waterdata.usgs.gov/nwis>). Users of USGS water-quality data are encouraged to obtain all required data from NWIS or NWISWeb to ensure that they have the most recent updates. Updates to the NWISWeb are made on an annual basis.

The surface-water-quality records for partial-record stations and miscellaneous sampling sites are published in

separate tables following the table of discharge measurements at miscellaneous sites. No descriptive statements are given for these records. Each station is published with its own station number and name in the regular downstream-order sequence.

Remark Codes

The following remark codes may appear with the water-quality data in this section:

| Printed Output | Remark |
|----------------|--|
| E | Value is estimated. |
| > | Actual value is known to be greater than the value shown. |
| < | Actual value is known to be less than the value shown. |
| M | Presence of material verified, but not quantified. |
| N | Presumptive evidence of presence of material. |
| U | Material specifically analyzed for, but not detected. |
| A | Value is an average. |
| V | Analyte was detected in both the environmental sample and the associated blanks. |
| S | Most probable value. |

Water-Quality Control Data

The USGS National Water Quality Laboratory collects quality-control data on a continuing basis to evaluate selected analytical methods to determine long-term method detection levels (LT-MDLs) and laboratory reporting levels (LRLs). These values are re-evaluated each year on the basis of the most recent quality-control data and, consequently, may change from year to year.

This reporting procedure limits the occurrence of false positive error. Falsely reporting a concentration greater than the LT-MDL for a sample in which the analyte is not present is 1 percent or less. Application of the LRL limits the occurrence of false negative error. The chance of falsely reporting a nondetection for a sample in which the analyte is present at a concentration equal to or greater than the LRL is 1 percent or less.

Accordingly, concentrations are reported as less than LRL for samples in which the analyte either was not detected or did not pass identification. Analytes detected at concentrations between the LT-MDL and the LRL and that pass identification criteria are estimated. Estimated concentrations will be noted with a remark code of "E." These data should be used with the understanding that their

uncertainty is greater than that of data reported without the E remark code.

Data generated from quality-control (QC) samples are a requisite for evaluating the quality of the sampling and processing techniques as well as data from the actual samples themselves. Without QC data, environmental sample data cannot be adequately interpreted because the errors associated with the sample data are unknown. The various types of QC samples collected by a USGS Water Science Center are described in the following section. Procedures have been established for the storage of water-quality-control data within the USGS. These procedures allow for storage of all derived QC data and are identified so that they can be related to corresponding environmental samples. These data are not presented in this report but are available from the USGS Montana Water Science Center.

Blank Samples

Blank samples are collected and analyzed to ensure that environmental samples have not been contaminated in the overall data-collection process. The blank solution used to develop specific types of blank samples is a solution that is free of the analytes of interest. Any measured value signal in a blank sample for an analyte (a specific component measured in a chemical analysis) that was absent in the blank solution is believed to be due to contamination. Many types of blank samples are possible; each is designed to segregate a different part of the overall data-collection process. The types of blank samples collected by this USGS Water Science Center are:

Field blank—A blank solution that is subjected to all aspects of sample collection, field processing preservation, transportation, and laboratory handling as an environmental sample.

Trip blank—A blank solution that is put in the same type of bottle used for an environmental sample and kept with the set of sample bottles before and after sample collection.

Equipment blank—A blank solution that is processed through all equipment used for collecting and processing an environmental sample (similar to a field blank but normally done in the more controlled conditions of the office).

Sampler blank—A blank solution that is poured or pumped through the same field sampler used for collecting an environmental sample.

Filter blank—A blank solution that is filtered in the same manner and through the same filter apparatus used for an environmental sample.

Splitter blank—A blank solution that is mixed and separated using a field splitter in the same manner and through the same apparatus used for an environmental sample.

Preservation blank—A blank solution that is treated with the sampler preservatives used for an environmental sample.

Reference Samples

Reference material is a solution or material prepared by a laboratory. The reference material composition is certified for one or more properties so that it can be used to assess a measurement method. Samples of reference material are submitted for analysis to ensure that an analytical method is accurate for the known properties of the reference material. Generally, the selected reference material properties are similar to the environmental sample properties.

Replicate Samples

Replicate samples are a set of environmental samples collected in a manner such that the samples are thought to be essentially identical in composition. Replicate is the general case for which a duplicate is the special case consisting of two samples. Replicate samples are collected and analyzed to establish the amount of variability in the data contributed by some part of the collection and analytical process. Many types of replicate samples are possible, each of which may yield slightly different results in a dynamic hydrologic setting, such as a flowing stream. The types of replicate samples collected by the USGS Montana Water Science Center are:

Concurrent samples—A type of replicate sample in which the samples are collected simultaneously with two or more samplers or by using one sampler and alternating the collection of samples into two or more compositing containers.

Sequential samples—A type of replicate sample in which the samples are collected one after the other, typically over a short time.

Split sample—A type of replicate sample in which a sample is split into subsamples, each subsample contemporaneous in time and space.

Spike Samples

Spike samples are samples to which known quantities of a solution with one or more well-established analyte concentrations have been added. These samples are analyzed to determine the extent of matrix interference or degradation on the analyte concentration during sample processing and analysis.

Publications

The annual series of Water-Supply Papers that gives information on quality of surface waters in Montana is shown in the following table. Data for Hudson Bay and Missouri River basins are given in parts 5-6 and data for Upper Columbia River basin are given in part 12.

Table 9. Water-Supply Paper numbers and parts for water-quality stations, 1947-70.

| Year | Parts 5-6 | Part 12 | Year | Parts 5-6 | Part 12 |
|------|--------------|------------|------|---------------|------------|
| 1946 | 1050 | --- | 1961 | 1883 | 1885 |
| 1947 | 1102 | --- | 1962 | 1943 | 1945 |
| 1948 | 1132 | --- | 1963 | 1949 | 1951 |
| 1949 | 1162 | 1163 | 1964 | 1956 | 1959 |
| 1950 | 1187 | 1189 | 1965 | 1963 | 1966 |
| 1951 | 1198 | 1200 | 1966 | 1993 | 1996 |
| 1952 | 1251 | 1253 | 1967 | 2013 | 2016 |
| 1953 | 1291 | 1293 | 1968 | 2094, 2095 | 2100 |
| 1954 | 1351 | 1353 | 1969 | 2145 | 2150 |
| 1955 | 1401 | 1403 | 1970 | 2155 | 2160 |
| 1956 | 1451 | 1453 | | | |
| 1957 | 1521 | 1523 | | | |
| 1958 | 1572 | 1574 | | | |
| 1959 | 1643 | 1645 | | | |
| 1960 | 1743 | 1745 | | | |

EXPLANATION OF GROUND-WATER-LEVEL RECORDS

Generally, only ground-water-level data from selected wells with continuous recorders from a basic network of observation wells are published in this report. This basic network contains observation wells located so that the most significant data are obtained from the fewest wells in the most important aquifers.

Site Identification Numbers

Each well is identified by means of (1) a 15-digit number that is based on latitude and longitude and (2) a local number that is produced for local needs. (See NUMBERING SYSTEM FOR WELLS AND MISCELLANEOUS SITES in this report for a detailed explanation.)

Data Collection and Computation

Measurements are made in many types of wells, under varying conditions of access and at different temperatures;

hence, neither the method of measurement nor the equipment can be standardized. At each observation well, however, the equipment and techniques used are those that will ensure that measurements at each well are consistent.

Most methods for collecting and analyzing water samples are described in the TWRI's referred to in the Onsite Measurements and Sample Collection and the Laboratory Measurements sections in this report. In addition, TWRI Book 1, Chapter D2, describes guidelines for the collection and field analysis of ground-water samples for selected unstable constituents. Procedures for onsite measurements and for collecting, treating, and shipping samples are given in TWRI's Book 1, Chapter D2; Book 3, Chapters A1, A3, and A4; and Book 9, Chapters A1 through A9. The TWRI publications may be accessed from <http://water.usgs.gov/pubs/twri/>. The values in this report represent water-quality conditions at the time of sampling, as much as possible, and that are consistent with available sampling techniques and methods of analysis. These methods are consistent with ASTM standards and generally follow ISO standards. Trained personnel collected all samples. The wells sampled were pumped long enough to ensure that the water collected came directly from the aquifer and had not stood for a long time in the well casing where it would have been exposed to the atmosphere and to the material, possibly metal, comprising the casings.

Water-level measurements in this report are given in feet with reference to land-surface datum (lsd). Land-surface datum is a datum plane that is approximately at land surface at each well. If known, the elevation of the land-surface datum above sea level is given in the well description. The height of the measuring point (MP) above or below land-surface datum is given in each well description. Water levels in wells equipped with recording gages are reported for every fifth day and the end of each month (EOM).

Water levels are reported to as many significant figures as can be justified by the local conditions. For example, in a measurement of a depth of water of several hundred feet, the error in determining the absolute value of the total depth to water may be a few tenths of a foot, whereas the error in determining the net change of water level between successive measurements may be only a hundredth or a few hundredths of a foot. For lesser depths to water the accuracy is greater. Accordingly, most measurements are reported to a hundredth of a foot, but some are given only to a tenth of a foot or a larger unit.

Data Presentation

Water-level data are presented in alphabetical order by county. The primary identification number for a given well is the 15-digit site identification number that appears in the upper left corner of the table. The secondary identification

number is the local or county well number. Well locations are shown and each well is identified by its local well or county well number on a map in this report (fig. 8)

Each well record consists of three parts: the well description, the data table of water levels observed during the water year, and, for most wells, a hydrograph following the data table. Well descriptions are presented in the headings preceding the tabular data.

The following comments clarify information presented in these various headings.

LOCATION.—This paragraph follows the well-identification number and reports the hydrologic-unit number and a geographic point of reference. Latitudes and longitudes used in this report are reported as North American Datum of 1927 unless otherwise specified.

HYDROGEOLOGIC UNIT.—This entry designates by name and geologic age the aquifer that the well taps.

WELL CHARACTERISTICS.—This entry describes the well in terms of depth, casing diameter and depth or screened interval, method of construction, use, and changes since construction.

INSTRUMENTATION.—This paragraph provides information on both the frequency of measurement and the collection method used, allowing the user to better evaluate the reported water-level extremes by knowing whether they are based on continuous, monthly, or some other frequency of measurement.

DATUM.—This entry describes both the measuring point and the land-surface elevation at the well. The altitude of the land-surface datum is described in feet above the altitude datum; it is reported with a precision depending on the method of determination. The measuring point is described physically (such as top of casing, top of instrument shelf, and so forth), and in relation to land surface (such as 1.3 ft above land-surface datum). The elevation of the land-surface datum is described in feet above National Geodetic Vertical Datum of 1929 (NGVD 29); it is reported with a precision depending on the method of determination.

REMARKS.—This entry describes factors that may affect the water level in a well or the measurement of the water level, when various methods of measurement were begun, and the network (climatic, terrane, local, or areal effects) or the special project to which the well belongs.

PERIOD OF RECORD.—This entry indicates the time period for which records are published for the well, the month and year at the start of publication of water-level records by the USGS, and the words “to current year” if the

records are to be continued into the following year. Time periods for which water-level records are available, but are not published by the USGS, may be noted.

EXTREMES FOR PERIOD OF RECORD.—This entry contains the highest and lowest instantaneously recorded or measured water levels of the period of published record, with respect to land-surface datum or sea level, and the dates of occurrence.

Water-Level Tables

A table of water levels follows the well description for each well. Water-level measurements in this report are given in feet with reference to either sea level or land-surface datum (lsd). Missing records are indicated by dashes in place of the water-level value.

For wells not equipped with recorders, water-level measurements were obtained periodically by steel or electric tape. Tables of periodic water-level measurements in these wells show the date of measurement and the measured water-level value.

Hydrographs

Hydrographs are a graphic display of water-level fluctuations over a period of time. In this report, current water year and, when appropriate, period-of-record hydrographs are shown. Hydrographs that display periodic water-level measurements show points that may be connected with a dashed line from one measurement to the next. Hydrographs that display recorder data show a solid line representing the mean water level recorded for each day. Missing data are indicated by a blank space or break in a hydrograph. Missing data may occur as a result of recorder malfunctions, battery failures, or mechanical problems related to the response of the recorder’s float mechanism to water-level fluctuations in a well.

GROUND-WATER-QUALITY DATA

Data Collection and Computation

The ground-water-quality data in this report were obtained as a part of special studies in specific areas. Consequently, a number of chemical analyses are presented for some wells within a county but not for others. As a result, the records for this year, by themselves, do not provide a balanced view of ground-water quality statewide.

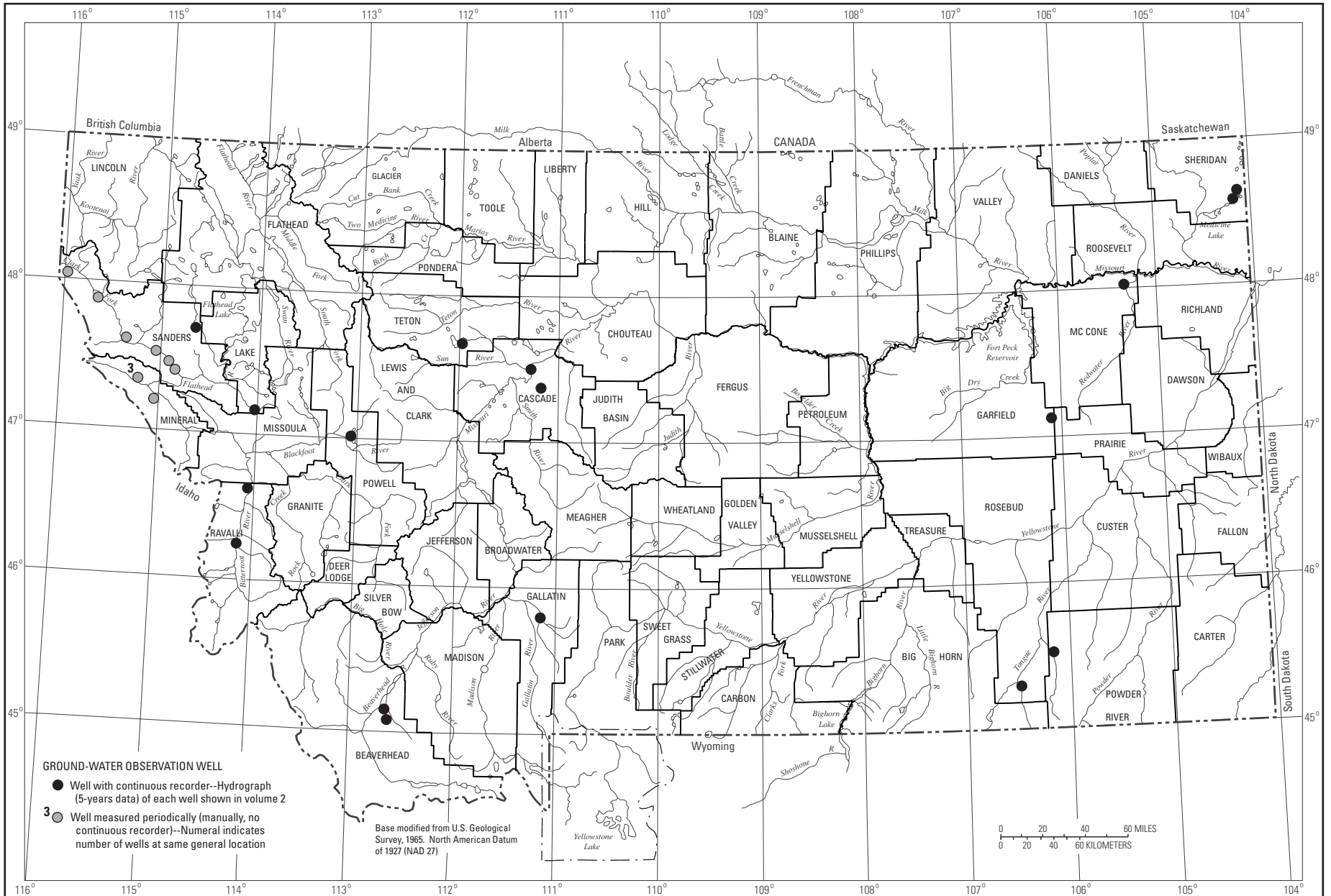


Figure 8. Location of ground-water observation wells in Montana, water year 2005.

Most methods for collecting and analyzing water samples are described in the TWRI, which may be accessed from <http://water.usgs.gov/pubs/twri/>. Procedures for onsite measurements and for collecting, treating, and shipping samples are given in TWRI, Book 1, Chapter D2; Book 5, Chapters A1, A3, and A4; and Book 9, Chapters A1-A6. Also, detailed information on collecting, treating, and shipping samples may be obtained from the USGS Water Science Center (see address shown on back of title page in this report).

Laboratory Measurements

Analysis for sulfide and measurement of alkalinity, pH, water temperature, specific conductance, and dissolved oxygen are performed onsite. All other sample analyses are performed at the USGS laboratory in Lakewood, Colorado, unless otherwise noted. Methods used by the USGS laboratory are given in TWRI, Book 1, Chapter D2 and Book 5, Chapters A1, A3, and A4, which may be accessed from <http://water.usgs.gov/pubs/twri/>.

Publications

Publication of ground-water level data for the United States in Water-Supply Papers was begun by the USGS in 1935. From 1935 through 1939, a single Water-Supply Paper for each year covering the entire nation was issued (Water-Supply Papers 777, 817, 840, 845, and 886). From 1940 through 1974, separate Water-Supply Papers were issued for 6 sections of the United States. Water-level data for Montana are in the Water-Supply Papers listed in the following table, each report containing one or more calendar years (January-December) of data. Data in this report are for the 12-month water year ending September 30. Information about reports and other data on ground water in Montana may be obtained from the USGS Water Science Center, at the address given on the back of the title page.

Table 10. Water-Supply Paper numbers and parts for ground-water stations, 1940-74.

| Year | WSP No. Pt. 5 | Year | WSP No. Pt. 5 | Year | WSP No. Pt.5 |
|------|---------------|------|---------------|---------|--------------|
| 1940 | 910 | 1947 | 1100 | 1954 | 1325 |
| 1941 | 940 | 1948 | 1130 | 1955 | 1408 |
| 1942 | 948 | 1949 | 1160 | 1956-60 | 1760 |
| 1943 | 990 | 1950 | 1169 | 1961-65 | 1845 |
| 1944 | 1020 | 1951 | 1195 | 1966-70 | 1980 |
| 1945 | 1027 | 1952 | 1225 | 1971-74 | 2161 |
| 1946 | 1075 | 1953 | 1269 | | |

ACCESS TO USGS WATER DATA

The USGS provides near real-time stage and discharge data for many of the gaging stations equipped with the necessary telemetry and historic daily mean and peak-flow discharge data for most current or discontinued gaging stations through the World Wide Web (WWW). These data may be accessed from <http://water.usgs.gov>.

Water-quality data and ground-water data also are available through the WWW. In addition, data can be provided in various machine-readable formats on various media. Information about the availability of specific types of data or products, and user charges, can be obtained locally from each USGS Water Science Center. (See address that is shown on the back of the title page of this report.)

DEFINITION OF TERMS

Specialized technical terms related to streamflow, water-quality, and other hydrologic data, as used in this report, are defined below. Terms such as algae, water level, and precipitation are used in their common everyday meanings, definitions of which are given in standard dictionaries. Not all terms defined in this alphabetical list apply to every State. See also table for converting English units to International System (SI) Units. Other glossaries that also define water-related terms are accessible from <http://water.usgs.gov/glossaries.html>.

Acid neutralizing capacity (ANC) is the equivalent sum of all bases or base-producing materials, solutes plus particulates, in an aqueous system that can be titrated with acid to an equivalence point. This term designates titration of an “unfiltered” sample (formerly reported as alkalinity).

Acre-foot (AC-FT, acre-ft) is a unit of volume, commonly used to measure quantities of water used or stored, equivalent to the volume of water required to cover 1 acre to a depth of 1 foot and equivalent to 43,560 cubic feet, 325,851 gallons, or 1,233 cubic meters. (See also “Annual runoff”)

Adenosine triphosphate (ATP) is an organic, phosphate-rich compound important in the transfer of energy in organisms. Its central role in living cells makes ATP an excellent indicator of the presence of living material in water. A measurement of ATP therefore provides a sensitive and rapid estimate of biomass. ATP is reported in micrograms per liter.

Adjusted discharge is discharge data that have been mathematically adjusted (for example, to remove the effects of a daily tide cycle or reservoir storage).

Algal growth potential (AGP) is the maximum algal dry weight biomass that can be produced in a natural water sample under standardized laboratory conditions. The growth potential is the algal biomass present at stationary phase and is expressed as milligrams dry weight of algae produced per liter of sample. (See also “Biomass” and “Dry weight”)

Alkalinity is the capacity of solutes in an aqueous system to neutralize acid. This term designates titration of a “filtered” sample.

Annual runoff is the total quantity of water that is discharged (“runs off”) from a drainage basin in a year. Data reports may present annual runoff data as volumes in acre-feet, as discharges per unit of drainage area in cubic feet per second per square mile, or as depths of water on the drainage basin in inches.

Annual 7-day minimum is the lowest mean value for any 7-consecutive-day period in a year. Annual 7-day minimum values are reported herein for the calendar year and the water year (October 1 through September 30). Most low-flow frequency analyses use a climatic year (April 1-March 31), which tends to prevent the low-flow period from being artificially split between adjacent years. The date shown in the summary statistics table is the initial date of the 7-day period. (This value should not be confused with the 7-day, 10-year low-flow statistic.)

Aroclor is the registered trademark for a group of polychlorinated biphenyls that were manufactured by the Monsanto Company prior to 1976. Aroclors are assigned specific 4-digit reference numbers dependent upon molecular type and degree of substitution of the biphenyl ring hydrogen atoms by chlorine atoms. The first two digits of a numbered aroclor represent the molecular type, and the last two digits represent the percentage weight of the hydrogen-substituted chlorine.

Artificial substrate is a device that purposely is placed in a stream or lake for colonization of organisms. The artificial substrate simplifies the community structure by standardizing the substrate from which each sample is collected. Examples of artificial substrates are basket samplers (made of wire cages filled with clean streamside rocks) and multi-plate samplers (made of hardboard) for benthic organism collection, and plexiglass strips for periphyton collection. (See also “Substrate”)

Ash mass is the mass or amount of residue present after the residue from a dry-mass determination has been ashed in a muffle furnace at a temperature of 500 °C for 1 hour. Ash mass of zooplankton and phytoplankton is expressed in grams per cubic meter (g/m^3), and periphyton and benthic

organisms in grams per square meter (g/m^2). (See also “Biomass” and “Dry mass”)

Aspect is the direction toward which a slope faces with respect to the compass.

Bacteria are microscopic unicellular organisms, typically spherical, rodlike, or spiral and threadlike in shape, often clumped into colonies. Some bacteria cause disease, whereas others perform an essential role in nature in the recycling of materials; for example, by decomposing organic matter into a form available for reuse by plants.

Bankfull stage, as used in this report, is the stage at which a stream first overflows its natural banks formed by floods with 1- to 3-year recurrence intervals.

Base discharge (for peak discharge) is a discharge value, determined for selected stations, above which peak discharge data are published. The base discharge at each station is selected so that an average of about three peak flows per year will be published. (See also “Peak flow”)

Base flow is sustained flow of a stream in the absence of direct runoff. It includes natural and human-induced streamflows. Natural base flow is sustained largely by ground-water discharge.

Bed material is the sediment mixture of which a streambed, lake, pond, reservoir, or estuary bottom is composed. (See also “Bedload” and “Sediment”)

Bedload is material in transport that primarily is supported by the streambed. In this report, bedload is considered to consist of particles in transit from the bed to the top of the bedload sampler nozzle (an elevation ranging from 0.25 to 0.5 foot). These particles are retained in the bedload sampler. A sample collected with a pressure-differential bedload sampler also may contain a component of the suspended load.

Bedload discharge (tons per day) is the rate of sediment moving as bedload, reported as dry weight, that passes through a cross section in a given time. NOTE: Bedload discharge values in this report may include a component of the suspended-sediment discharge. A correction may be necessary when computing the total sediment discharge by summing the bedload discharge and the suspended-sediment discharge. (See also “Bedload,” “Dry weight,” “Sediment,” and “Suspended-sediment discharge”)

Benthic organisms are the group of organisms inhabiting the bottom of an aquatic environment. They include a number of types of organisms, such as bacteria, fungi, insect larvae and nymphs, snails, clams, and crayfish. They are useful as indicators of water quality.

Biochemical oxygen demand (BOD) is a measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by micro-organisms, such as bacteria.

Biomass is the amount of living matter present at any given time, expressed as mass per unit area or volume of habitat.

Biomass pigment ratio is an indicator of the total proportion of periphyton that are autotrophic (plants). This also is called the Autotrophic Index.

Blue-green algae (*Cyanophyta*) are a group of phytoplankton and periphyton organisms with a blue pigment in addition to a green pigment called chlorophyll. Blue-green algae can cause nuisance water-quality conditions in lakes and slow-flowing rivers; however, they are found commonly in streams throughout the year. The abundance of blue-green algae in phytoplankton samples is expressed as the number of cells per milliliter (cells/mL) or biovolume in cubic micrometers per milliliter ($\mu\text{m}^3/\text{mL}$). The abundance of blue-green algae in periphyton samples is given in cells per square centimeter (cells/cm²) or biovolume per square centimeter ($\mu\text{m}^3/\text{cm}^2$). (See also “Phytoplankton” and “Periphyton”)

Bottom material (See “Bed material”)

Bulk electrical conductivity is the combined electrical conductivity of all material within a doughnut-shaped volume surrounding an induction probe. Bulk conductivity is affected by different physical and chemical properties of the material including the dissolved-solids content of the pore water, and the lithology and porosity of the rock.

Canadian Geodetic Vertical Datum 1928 is a geodetic datum derived from a general adjustment of Canada’s first order level network in 1928.

Cell volume (biovolume) determination is one of several common methods used to estimate biomass of algae in aquatic systems. Cell members of algae are used frequently in aquatic surveys as an indicator of algal production. However, cell numbers alone cannot represent true biomass because of considerable cell-size variation among the algal species. Cell volume (μm^3) is determined by obtaining critical cell measurements or cell dimensions (for example, length, width, height, or radius) for 20 to 50 cells of each important species to obtain an average biovolume per cell. Cells are categorized according to the correspondence of their cellular shape to the nearest geometric solid or combinations of simple solids (for example, spheres, cones, or cylinders). Representative formulae used to compute biovolume are as follows:

$$\text{sphere } \frac{4}{3} \pi r^3 \quad \text{cone } \frac{1}{3} \pi r^2 h \quad \text{cylinder } \pi r^2 h.$$

pi (π) is the ratio of the circumference to the diameter of a circle; pi = 3.14159....

From cell volume, total algal biomass expressed as biovolume ($\mu\text{m}^3/\text{mL}$) is thus determined by multiplying the number of cells of a given species by its average cell volume and then summing these volumes for all species.

Cells/volume refers to the number of cells of any organism that is counted by using a microscope and grid or counting cell. Many planktonic organisms are multicelled and are counted according to the number of contained cells per sample volume, and generally are reported as cells or units per milliliter (mL) or liter (L).

Cfs-day (See “Cubic foot per second-day”)

Channel bars, as used in this report, are the lowest prominent geomorphic features higher than the channel bed.

Chemical oxygen demand (COD) is a measure of the chemically oxidizable material in the water and furnishes an approximation of the amount of organic and reducing material present. The determined value may correlate with BOD or with carbonaceous organic pollution from sewage or industrial wastes. [See also “Biochemical oxygen demand (BOD)”]

***Clostridium perfringens* (*C. perfringens*)** is a spore-forming bacterium that is common in the feces of human and other warmblooded animals. Clostridial spores are being used experimentally as an indicator of past fecal contamination and the presence of microorganisms that are resistant to disinfection and environmental stresses. (See also “Bacteria”)

Coliphages are viruses that infect and replicate in coliform bacteria. They are indicative of sewage contamination of water and of the survival and transport of viruses in the environment.

Color unit is produced by 1 milligram per liter of platinum in the form of the chloroplatinate ion. Color is expressed in units of the platinum-cobalt scale.

Confined aquifer is a term used to describe an aquifer containing water between two relatively impermeable boundaries. The water level in a well tapping a confined aquifer stands above the top of the confined aquifer and can be higher or lower than the water table that may be present in the material above it. In some cases, the water level can rise above the ground surface, yielding a flowing well.

Contents is the volume of water in a reservoir or lake.

Unless otherwise indicated, volume is computed on the basis of a level pool and does not include bank storage.

Continuous-record station is a site where data are collected with sufficient frequency to define daily mean values and variations within a day.

Control designates a feature in the channel that physically affects the water-surface elevation and thereby determines the stage-discharge relation at the gage. This feature may be a constriction of the channel, a bedrock outcrop, a gravel bar, an artificial structure, or a uniform cross section over a long reach of the channel.

Control structure, as used in this report, is a structure on a stream or canal that is used to regulate the flow or stage of the stream or to prevent the intrusion of saltwater.

Cubic foot per second (CFS, ft³/s) is the rate of discharge representing a volume of 1 cubic foot passing a given point in 1 second. It is equivalent to approximately 7.48 gallons per second or approximately 449 gallons per minute, or 0.02832 cubic meters per second. The term “second-foot” sometimes is used synonymously with “cubic foot per second” but is now obsolete.

Cubic foot per second-day (CFS-DAY, Cfs-day, [(ft³/s)/d]) is the volume of water represented by a flow of 1 cubic foot per second for 24 hours. It is equivalent to 86,400 cubic feet, 1.98347 acre-feet, 646,317 gallons, or 2,446.6 cubic meters. The daily mean discharges reported in the daily value data tables numerically are equal to the daily volumes in cfs-days, and the totals also represent volumes in cfs-days.

Cubic foot per second per square mile [CFSM, (ft³/s)/mi²] is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming the runoff is distributed uniformly in time and area. (See also “Annual runoff”)

Daily mean suspended-sediment concentration is the time-weighted mean concentration of suspended sediment passing a stream cross section during a 24-hour day. (See also “Sediment” and “Suspended-sediment concentration”)

Daily record station is a site where data are collected with sufficient frequency to develop a record of one or more data values per day. The frequency of data collection can range from continuous recording to data collection on a daily or near-daily basis.

Data collection platform (DCP) is an electronic instrument that collects, processes, and stores data from various

sensors, and transmits the data by satellite data relay, line-of-sight radio, and/or landline telemetry.

Data logger is a microprocessor-based data acquisition system designed specifically to acquire, process, and store data. Data usually are downloaded from onsite data loggers for entry into office data systems.

Datum is a surface or point relative to which measurements of height and/or horizontal position are reported. A vertical datum is a horizontal surface used as the zero point for measurements of gage height, stage, or elevation; a horizontal datum is a reference for positions given in terms of latitude-longitude, State Plane coordinates, or Universal Transverse Mercator (UTM) coordinates. (See also “Gage datum,” “Land-surface datum,” “National Geodetic Vertical Datum of 1929,” and “North American Vertical Datum of 1988”)

Diatoms (*Bacillariophyta*) are unicellular or colonial algae with a siliceous cell wall. The abundance of diatoms in phytoplankton samples is expressed as the number of cells per milliliter (cells/mL) or biovolume in cubic micrometers per milliliter ($\mu\text{m}^3/\text{mL}$). The abundance of diatoms in periphyton samples is given in cells per square centimeter (cells/cm²) or biovolume per square centimeter ($\mu\text{m}^3/\text{cm}^2$). (See also “Phytoplankton” and “Periphyton”)

Diel is of or pertaining to a 24-hour period of time; a regular daily cycle.

Discharge, or flow, is the rate that matter passes through a cross section of a stream channel or other water body per unit of time. The term commonly refers to the volume of water (including, unless otherwise stated, any sediment or other constituents suspended or dissolved in the water) that passes a cross section in a stream channel, canal, pipeline, and so forth, within a given period of time (cubic feet per second). Discharge also can apply to the rate at which constituents, such as suspended sediment, bedload, and dissolved or suspended chemicals, pass through a cross section, in which cases the quantity is expressed as the mass of constituent that passes the cross section in a given period of time (tons per day).

Dissolved refers to that material in a representative water sample that passes through a 0.45-micrometer membrane filter. This is a convenient operational definition used by Federal and State agencies that collect water-quality data. Determinations of “dissolved” constituent concentrations are made on sample water that has been filtered.

Dissolved oxygen (DO) is the molecular oxygen (oxygen gas) dissolved in water. The concentration in water is a function of atmospheric pressure, temperature, and dissolved-solids concentration of the water. The ability of

water to retain oxygen decreases with increasing temperature or dissolved-solids concentration. Photosynthesis and respiration by plants commonly cause diurnal variations in dissolved-oxygen concentration in water from some streams.

Dissolved-solids concentration in water is the quantity of dissolved material in a sample of water. It is determined either analytically by the “residue-on-evaporation” method, or mathematically by totaling the concentrations of individual constituents reported in a comprehensive chemical analysis. During the analytical determination, the bicarbonate (generally a major dissolved component of water) is converted to carbonate. In the mathematical calculation, the bicarbonate value, in milligrams per liter, is multiplied by 0.4917 to convert it to carbonate. Alternatively, alkalinity concentration (as mg/L CaCO₃) can be converted to carbonate concentration by multiplying by 0.60.

Diversity index (H) (Shannon index) is a numerical expression of evenness of distribution of aquatic organisms. The formula for diversity index is:

$$\bar{d} = - \sum_{i=1}^s \frac{n_i}{n} \log_2 \frac{n_i}{n},$$

where n_i is the number of individuals per taxon, n is the total number of individuals, and s is the total number of taxa in the sample of the community. Index values range from zero, when all the organisms in the sample are the same, to some positive number, when some or all of the organisms in the sample are different.

Drainage area of a stream at a specific location is that area upstream from the location, measured in a horizontal plane, that has a common outlet at the site for its surface runoff from precipitation that normally drains by gravity into a stream. Drainage areas given herein include all closed basins, or noncontributing areas, within the area unless otherwise specified.

Drainage basin is a part of the Earth’s surface that contains a drainage system with a common outlet for its surface runoff. (See “Drainage area”)

Dry mass refers to the mass of residue present after drying in an oven at 105 °C, until the mass remains unchanged. This mass represents the total organic matter, ash and sediment, in the sample. Dry-mass values are expressed in the same units as ash mass. (See also “Ash mass,” “Biomass,” and “Wet mass”)

Dry weight refers to the weight of animal tissue after it has been dried in an oven at 65 °C until a constant weight is

achieved. Dry weight represents total organic and inorganic matter in the tissue. (See also “Wet weight”)

Embeddedness is the degree to which gravel-sized and larger particles are surrounded or enclosed by finer-sized particles. (See also “Substrate embeddedness class”)

Enterococcus bacteria commonly are found in the feces of humans and other warmblooded animals. Although some strains are ubiquitous and not related to fecal pollution, the presence of enterococci in water is an indication of fecal pollution and the possible presence of enteric pathogens. Enterococcus bacteria are those bacteria that produce pink to red colonies with black or reddish-brown precipitate after incubation at 41 °C on mE agar (nutrient medium for bacterial growth) and subsequent transfer to EIA medium. Enterococci include *Streptococcus feacalis*, *Streptococcus feacium*, *Streptococcus avium*, and their variants. (See also “Bacteria”)

EPT Index is the total number of distinct taxa within the insect orders Ephemeroptera, Plecoptera, and Trichoptera. This index summarizes the taxa richness within the aquatic insects that generally are considered pollution sensitive; the index usually decreases with pollution.

Escherichia coli (*E. coli*) are bacteria present in the intestine and feces of warmblooded animals. *E. coli* are a member species of the fecal coliform group of indicator bacteria. In the laboratory, they are defined as those bacteria that produce yellow or yellow-brown colonies on a filter pad saturated with urea substrate broth after primary culturing for 22 to 24 hours at 44.5 °C on mTEC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample. (See also “Bacteria”)

Estimated (E) value of a concentration is reported when an analyte is detected and all criteria for a positive result are met. If the concentration is less than the method detection limit (MDL), an E code will be reported with the value. If the analyte is identified qualitatively as present, but the quantitative determination is substantially more uncertain, the National Water Quality Laboratory will identify the result with an E code even though the measured value is greater than the MDL. A value reported with an E code should be used with caution. When no analyte is detected in a sample, the default reporting value is the MDL preceded by a less than sign (<). For bacteriological data, concentrations are reported as estimated when results are based on non-ideal colony counts.

Euglenoids (*Euglenophyta*) are a group of algae that usually are free-swimming and rarely creeping. They have the ability to grow either photosynthetically in the light or heterotrophically in the dark. (See also “Phytoplankton”)

Extractable organic halides (EOX) are organic compounds that contain halogen atoms such as chlorine. These organic compounds are semivolatile and extractable by ethyl acetate from air-dried streambed sediment. The ethyl acetate extract is combusted, and the concentration is determined by microcoulometric determination of the halides formed. The concentration is reported as micrograms of chlorine per gram of the dry weight of the streambed sediment.

Fecal coliform bacteria are present in the intestines or feces of warmblooded animals. They often are used as indicators of the sanitary quality of the water. In the laboratory, they are defined as all organisms that produce blue colonies within 24 hours when incubated at 44.5 °C plus or minus 0.2 °C on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample. (See also “Bacteria”)

Fecal streptococcal bacteria are present in the intestines of warmblooded animals and are ubiquitous in the environment. They are characterized as gram-positive, cocci bacteria that are capable of growth in brain-heart infusion broth. In the laboratory, they are defined as all the organisms that produce red or pink colonies within 48 hours at 35 °C plus or minus 1.0 °C on KF-streptococcus medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 mL of sample. (See also “Bacteria”)

Filtered pertains to constituents in a water sample passed through a filter of specified pore diameter, most commonly 0.45 micrometer or less for inorganic analytes and 0.7 micrometer for organic analytes.

Filtered, recoverable is the amount of a given constituent that is in solution after the part of a representative water-suspended sediment sample that has passed through a filter has been extracted. Complete recovery is not achieved by the extraction procedure and thus the analytical determination represents something less than 95 percent of the total constituent concentration in the sample. To achieve comparability of analytical data, equivalent extraction procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results.

Fire algae (*Pyrrhophyta*) are free-swimming unicells characterized by a red pigment spot. (See also “Phytoplankton”)

Flow-duration percentiles are values on a scale of 100 that indicate the percentage of time for which a flow is exceeded. For example, the 90th percentile of river flow is the streamflow exceeded 90 percent of the time in the period of interest.

Gage datum is a horizontal surface used as a zero point for measurement of stage or gage height. This surface usually is located slightly below the lowest point of the stream bottom such that the gage height is usually slightly greater than the maximum depth of water. Because the gage datum is not an actual physical object, the datum is usually defined by specifying the elevations of permanent reference marks such as bridge abutments and survey monuments, and the gage is set to agree with the reference marks. Gage datum is a local datum that is maintained independently of any national geodetic datum. However, if the elevation of the gage datum relative to the national datum (North American Vertical Datum of 1988 or National Geodetic Vertical Datum of 1929) has been determined, then the gage readings can be converted to elevations above the national datum by adding the elevation of the gage datum to the gage reading.

Gage height (G.H.) is the water-surface elevation, in feet above the gage datum. If the water surface is below the gage datum, the gage height is negative. Gage height often is used interchangeably with the more general term “stage,” although gage height is more appropriate when used in reference to a reading on a gage.

Gage values are values that are recorded, transmitted, and/or computed from a gaging station. Gage values typically are collected at 5-, 15-, or 30-minute intervals.

Gaging station is a site on a stream, canal, lake, or reservoir where systematic observations of stage, discharge, or other hydrologic data are obtained.

Gas chromatography/flame ionization detector (GC/FID) is a laboratory analytical method used as a screening technique for semivolatile organic compounds that are extractable from water in methylene chloride.

Geomorphic channel units, as used in this report, are fluvial geomorphic descriptors of channel shape and stream velocity. Pools, riffles, and runs are types of geomorphic channel units considered for National Water-Quality Assessment (NAWQA) Program habitat sampling.

Green algae (*Chlorophyta*) are unicellular or colonial algae with chlorophyll pigments similar to those in terrestrial green plants. Some forms of green algae produce mats or floating “moss” in lakes. The abundance of green algae in phytoplankton samples is expressed as the number of cells per milliliter (cells/mL) or biovolume in cubic micrometers per milliliter ($\mu\text{m}^3/\text{mL}$). The abundance of green algae in periphyton samples is given in cells per square centimeter (cells/cm²) or biovolume per square centimeter ($\mu\text{m}^3/\text{cm}^2$). (See also “Phytoplankton” and “Periphyton”)

Habitat, as used in this report, includes all nonliving (physical) aspects of the aquatic ecosystem, although living components like aquatic macrophytes and riparian vegetation also are usually included. Measurements of habitat typically are made over a wider geographic scale than are measurements of species distribution.

Habitat quality index is the qualitative description (level 1) of instream habitat and riparian conditions surrounding the reach sampled. Scores range from 0 to 100 percent with higher scores indicative of desirable habitat conditions for aquatic life. Index only applicable to wadable streams.

Hardness of water is a physical-chemical characteristic that commonly is recognized by the increased quantity of soap required to produce lather. It is computed as the sum of equivalents of polyvalent cations (primarily calcium and magnesium) and is expressed as the equivalent concentration of calcium carbonate (CaCO_3).

High tide is the maximum height reached by each rising tide. The high-high and low-high tides are the higher and lower of the two high tides, respectively, of each tidal day. See NOAA Web site: <http://www.csc.noaa.gov/text/glossary.html> (see “High water”)

Hilsenhoff’s Biotic Index (HBI) is an indicator of organic pollution that uses tolerance values to weight taxa abundances; usually increases with pollution. It is calculated as follows:

$$HBI = \frac{\sum(n)(a)}{N},$$

where n is the number of individuals of each taxon, a is the tolerance value of each taxon, and N is the total number of organisms in the sample.

Horizontal datum (See “Datum”)

Hydrologic index stations referred to in this report are continuous-record gaging stations that have been selected as representative of streamflow patterns for their respective regions. Station locations are shown on index maps.

Hydrologic unit is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as defined by the former Office of Water Data Coordination and delineated on the State Hydrologic Unit Maps by the USGS. Each hydrologic unit is identified by an 8-digit number.

Inch (IN., in.), in reference to streamflow, as used in this report, refers to the depth to which the drainage area would be covered with water if all of the runoff for a given time

period were distributed uniformly on it. (See also “Annual runoff”)

Instantaneous discharge is the discharge at a particular instant of time. (See also “Discharge”)

International Boundary Commission Survey Datum refers to a geodetic datum established at numerous monuments along the United States-Canada boundary by the International Boundary Commission.

Island, as used in this report, is a mid-channel bar that has permanent woody vegetation, is flooded once a year, on average, and remains stable except during large flood events.

Laboratory reporting level (LRL) generally is equal to twice the yearly determined long-term method detection level (LT-MDL). The LRL controls false negative error. The probability of falsely reporting a nondetection for a sample that contained an analyte at a concentration equal to or greater than the LRL is predicted to be less than or equal to 1 percent. The value of the LRL will be reported with a “less than” (<) remark code for samples in which the analyte was not detected. The National Water Quality Laboratory (NWQL) collects quality-control data from selected analytical methods on a continuing basis to determine LT-MDLs and to establish LRLs. These values are reevaluated annually on the basis of the most current quality-control data and, therefore, may change. The LRL replaces the term ‘non-detection value’ (NDV).

Land-surface datum (lsd) is a datum plane that is approximately at land surface at each ground-water observation well.

Latent heat flux (often used interchangeably with latent heat-flux density) is the amount of heat energy that converts water from liquid to vapor (evaporation) or from vapor to liquid (condensation) across a specified cross-sectional area per unit time. Usually expressed in watts per square meter.

Light-attenuation coefficient, also known as the extinction coefficient, is a measure of water clarity. Light is attenuated according to the Lambert-Beer equation:

$$I = I_o e^{-\lambda L},$$

where I_o is the source light intensity, I is the light intensity at length L (in meters) from the source, λ is the light-attenuation coefficient, and e is the base of the natural logarithm. The light-attenuation coefficient is defined as

$$\lambda = -\frac{1}{L} \log_e \frac{I}{I_o}.$$

Lipid is any one of a family of compounds that are insoluble in water and that make up one of the principal components of living cells. Lipids include fats, oils, waxes, and steroids. Many environmental contaminants such as organo-chlorine pesticides are lipophilic.

Long-term method detection level (LT-MDL) is a detection level derived by determining the standard deviation of a minimum of 24 method detection limit (MDL) spike-sample measurements over an extended period of time. LT-MDL data are collected on a continuous basis to assess year-to-year variations in the LT-MDL. The LT-MDL controls false positive error. The chance of falsely reporting a concentration at or greater than the LT-MDL for a sample that did not contain the analyte is predicted to be less than or equal to 1 percent.

Low tide is the minimum height reached by each falling tide. The high-low and low-low tides are the higher and lower of the two low tides, respectively, of each tidal day. See NOAA Website: <http://www.csc.noaa.gov/text/glossary.html> (see “Low water”)

Macrophytes are the macroscopic plants in the aquatic environment. The most common macrophytes are the rooted vascular plants that usually are arranged in zones in aquatic ecosystems and restricted in the area by the extent of illumination through the water and sediment deposition along the shoreline.

Mean concentration of suspended sediment (Daily mean suspended-sediment concentration) is the time-weighted concentration of suspended sediment passing a stream cross section during a given time period. (See also “Daily mean suspended-sediment concentration” and “Suspended-sediment concentration”)

Mean discharge (MEAN) is the arithmetic mean of individual daily mean discharges during a specific period. (See also “Discharge”)

Mean high or low tide is the average of all high or low tides, respectively, over a specific period.

Mean sea level is a local tidal datum. It is the arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; for example, monthly mean sea level and yearly mean sea level. In order that they may be recovered when needed, such datums are referenced to fixed points known as benchmarks. (See also “Datum”)

Measuring point (MP) is an arbitrary permanent reference point from which the distance to water surface in a well is measured to obtain water level.

Megahertz is a unit of frequency. One megahertz equals one million cycles per second.

Membrane filter is a thin microporous material of specific pore size used to filter bacteria, algae, and other very small particles from water.

Metamorphic stage refers to the stage of development that an organism exhibits during its transformation from an immature form to an adult form. This developmental process exists for most insects, and the degree of difference from the immature stage to the adult form varies from relatively slight to pronounced, with many intermediates. Examples of metamorphic stages of insects are egg-larva-adult or egg-nymph-adult.

Method code is a one-character code that identifies the analytical or field method used to determine a value stored in the National Water Information System (NWIS).

Method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the analyte concentration is greater than zero. It is determined from the analysis of a sample in a given matrix containing the analyte. At the MDL concentration, the risk of a false positive is predicted to be less than or equal to 1 percent.

Method of Cubatures is a method of computing discharge in tidal estuaries based on the conservation of mass equation.

Methylene blue active substances (MBAS) indicate the presence of detergents (anionic surfactants). The determination depends on the formation of a blue color when methylene blue dye reacts with synthetic anionic detergent compounds.

Micrograms per gram (UG/G, $\mu\text{g/g}$) is a unit expressing the concentration of a chemical constituent as the mass (micrograms) of the element per unit mass (gram) of material analyzed.

Micrograms per kilogram (UG/KG, $\mu\text{g/kg}$) is a unit expressing the concentration of a chemical constituent as the mass (micrograms) of the constituent per unit mass (kilogram) of the material analyzed. One microgram per kilogram is equivalent to 1 part per billion.

Micrograms per liter (UG/L, $\mu\text{g/L}$) is a unit expressing the concentration of chemical constituents in water as mass (micrograms) of constituent per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. One microgram per liter is equivalent to 1 part per billion.

Microsiemens per centimeter (US/CM, $\mu\text{S}/\text{cm}$) is a unit expressing the amount of electrical conductivity of a solution as measured between opposite faces of a centimeter cube of solution at a specified temperature. Siemens is the International System of Units nomenclature. It is synonymous with mhos and is the reciprocal of resistance in ohms.

Milligrams per liter (MG/L, mg/L) is a unit for expressing the concentration of chemical constituents in water as the mass (milligrams) of constituent per unit volume (liter) of water. Concentration of suspended sediment also is expressed in milligrams per liter and is based on the mass of dry sediment per liter of water-sediment mixture.

Minimum reporting level (MRL) is the smallest measured concentration of a constituent that may be reliably reported by using a given analytical method.

Miscellaneous site, miscellaneous station, or miscellaneous sampling site is a site where streamflow, sediment, and/or water-quality data or water-quality or sediment samples are collected once, or more often on a random or discontinuous basis to provide better areal coverage for defining hydrologic and water-quality conditions over a broad area in a river basin.

Most probable number (MPN) is an index of the number of coliform bacteria that, more probably than any other number, would give the results shown by the laboratory examination; it is not an actual enumeration. MPN is determined from the distribution of gas-positive cultures among multiple inoculated tubes.

Multiple-plate samplers are artificial substrates of known surface area used for obtaining benthic invertebrate samples. They consist of a series of spaced, hardboard plates on an eyebolt.

Nanograms per liter (NG/L, ng/L) is a unit expressing the concentration of chemical constituents in solution as mass (nanograms) of solute per unit volume (liter) of water. One million nanograms per liter is equivalent to 1 milligram per liter.

National Geodetic Vertical Datum of 1929 (NGVD 29) is a fixed reference adopted as a standard geodetic datum for elevations determined by leveling. It formerly was called “Sea Level Datum of 1929” or “mean sea level.” Although the datum was derived from the mean sea level at 26 tide stations, it does not necessarily represent local mean sea level at any particular place. See NOAA Web site: <http://www.ngs.noaa.gov/faq.shtml#WhatVD29VD88> (See “North American Vertical Datum of 1988”)

Natural substrate refers to any naturally occurring immersed or submersed solid surface, such as a rock or tree, upon which an organism lives. (See also “Substrate”)

Nekton are the consumers in the aquatic environment and consist of large, free-swimming organisms that are capable of sustained, directed mobility.

Nonfilterable refers to the portion of the total residue retained by a filter.

North American Datum of 1927 (NAD 27) is the horizontal control datum for the United States that was defined by a location and azimuth on the Clarke spheroid of 1866.

North American Datum of 1983 (NAD 83) is the horizontal control datum for the United States, Canada, Mexico, and Central America that is based on the adjustment of 250,000 points including 600 satellite Doppler stations that constrain the system to a geocentric origin. NAD 83 has been officially adopted as the legal horizontal datum for the United States by the Federal government.

North American Vertical Datum of 1988 (NAVD 88) is a fixed reference adopted as the official civilian vertical datum for elevations determined by Federal surveying and mapping activities in the United States. This datum was established in 1991 by minimum-constraint adjustment of the Canadian, Mexican, and United States first-order terrestrial leveling networks.

Open or screened interval is the length of unscreened opening or of well screen through which water enters a well, in feet below land surface.

Organic carbon (OC) is a measure of organic matter present in aqueous solution, suspension, or bottom sediment. May be reported as dissolved organic carbon (DOC), particulate organic carbon (POC), or total organic carbon (TOC).

Organic mass or **volatile mass** of a living substance is the difference between the dry mass and ash mass and represents the actual mass of the living matter. Organic mass is expressed in the same units as for ash mass and dry mass. (See also “Ash mass,” “Biomass,” and “Dry mass”)

Organism count/area refers to the number of organisms collected and enumerated in a sample and adjusted to the number per area habitat, usually square meter (m^2), acre, or hectare. Periphyton, benthic organisms, and macrophytes are expressed in these terms.

Organism count/volume refers to the number of organisms collected and enumerated in a sample and adjusted to the

number per sample volume, usually milliliter (mL) or liter (L). Numbers of planktonic organisms can be expressed in these terms.

Organochlorine compounds are any chemicals that contain carbon and chlorine. Organochlorine compounds that are important in investigations of water, sediment, and biological quality include certain pesticides and industrial compounds.

Parameter code is a 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to uniquely identify a specific constituent or property.

Partial-record station is a site where discrete measurements of one or more hydrologic parameters are obtained over a period of time without continuous data being recorded or computed. A common example is a crest-stage gage partial-record station at which only peak stages and flows are recorded.

Particle size is the diameter, in millimeters (mm), of a particle determined by sieve or sedimentation methods. The sedimentation method uses the principle of Stokes Law to calculate sediment particle sizes. Sedimentation methods (pipet, bottom-withdrawal tube, visual-accumulation tube, sedigraph) determine fall diameter of particles in either distilled water (chemically dispersed) or in native water (the river water at the time and point of sampling).

Particle-size classification, as used in this report, agrees with the recommendation made by the American Geophysical Union Subcommittee on Sediment Terminology. The classification is as follows:

| Classification | Size (mm) | Method of analysis |
|----------------|------------------|---------------------|
| Clay | >0.00024 - 0.004 | Sedimentation |
| Silt | >0.004 - 0.062 | Sedimentation |
| Sand | >0.062 - 2.0 | Sedimentation/sieve |
| Gravel | >2.0 - 64.0 | Sieve |
| Cobble | >64 - 256 | Manual measurement |
| Boulder | >256 | Manual measurement |

The particle-size distributions given in this report are not necessarily representative of all particles in transport in the stream. For the sedimentation method, most of the organic matter is removed, and the sample is subjected to mechanical and chemical dispersion before analysis in distilled water. Chemical dispersion is not used for native water analysis.

Peak flow (peak stage) is an instantaneous local maximum value in the continuous time series of streamflows or stages, preceded by a period of increasing values and followed by a period of decreasing values. Several peak values ordinarily occur in a year. The maximum peak value in a year is called the annual peak; peaks lower than the annual peak are called secondary peaks. Occasionally, the annual peak may not be the maximum value for the year; in such cases, the maximum value occurs at midnight at the beginning or end of the year, on the recession from or rise toward a higher peak in the adjoining year. If values are recorded at a discrete series of times, the peak recorded value may be taken as an approximation of the true peak, which may occur between the recording instants. If the values are recorded with finite precision, a sequence of equal recorded values may occur at the peak; in this case, the first value is taken as the peak.

Percent composition or percent of total is a unit for expressing the ratio of a particular part of a sample or population to the total sample or population, in terms of types, numbers, weight, mass, or volume.

Percent shading is a measure of the amount of sunlight potentially reaching the stream. A clinometer is used to measure left and right bank canopy angles. These values are added together, divided by 180, and multiplied by 100 to compute percentage of shade.

Periodic-record station is a site where stage, discharge, sediment, chemical, physical, or other hydrologic measurements are made one or more times during a year but at a frequency insufficient to develop a daily record.

Periphyton is the assemblage of microorganisms attached to and living upon submerged solid surfaces. Although primarily consisting of algae, they also include bacteria, fungi, protozoa, rotifers, and other small organisms. Periphyton are useful indicators of water quality.

Pesticides are chemical compounds used to control undesirable organisms. Major categories of pesticides include insecticides, miticides, fungicides, herbicides, and rodenticides.

pH of water is the negative logarithm of the hydrogen-ion activity. Solutions with pH less than 7.0 standard units are termed "acidic," and solutions with a pH greater than 7.0 are termed "basic." Solutions with a pH of 7.0 are neutral. The presence and concentration of many dissolved chemical constituents found in water are affected, in part, by the hydrogen-ion activity of water. Biological processes including growth, distribution of organisms, and toxicity of the water to organisms also are affected, in part, by the hydrogen-ion activity of water.

Phytoplankton is the plant part of the plankton. They usually are microscopic, and their movement is subject to the water currents. Phytoplankton growth is dependent upon solar radiation and nutrient substances. Because they are able to incorporate as well as release materials to the surrounding water, the phytoplankton have a profound effect upon the quality of the water. They are the primary food producers in the aquatic environment and commonly are known as algae. (See also “Plankton”)

Picocurie (PC, pCi) is one-trillionth (1×10^{-12}) of the amount of radioactive nuclide represented by a curie (Ci). A curie is the quantity of radioactive nuclide that yields 3.7×10^{10} radioactive disintegrations per second (dps). A picocurie yields 0.037 dps, or 2.22 dpm (disintegrations per minute).

Plankton is the community of suspended, floating, or weakly swimming organisms that live in the open water of lakes and rivers. Concentrations are expressed as a number of cells per milliliter (cells/mL) of sample.

Polychlorinated biphenyls (PCBs) are industrial chemicals that are mixtures of chlorinated biphenyl compounds having various percentages of chlorine. They are similar in structure to organochlorine insecticides.

Polychlorinated naphthalenes (PCNs) are industrial chemicals that are mixtures of chlorinated naphthalene compounds. They have properties and applications similar to polychlorinated biphenyls (PCBs) and have been identified in commercial PCB preparations.

Pool, as used in this report, is a small part of a stream reach with little velocity, commonly with water deeper than surrounding areas.

Primary productivity is a measure of the rate at which new organic matter is formed and accumulated through photosynthetic and chemosynthetic activity of producer organisms (chiefly, green plants). The rate of primary production is estimated by measuring the amount of oxygen released (oxygen method) or the amount of carbon assimilated (carbon method) by the plants.

Primary productivity (carbon method) is expressed as milligrams of carbon per area per unit time [$\text{mg C}/(\text{m}^2/\text{time})$] for periphyton and macrophytes or per volume [$\text{mg C}/(\text{m}^3/\text{time})$] for phytoplankton. The carbon method defines the amount of carbon dioxide consumed as measured by radioactive carbon (carbon-14). The carbon-14 method is of greater sensitivity than the oxygen light- and dark-bottle method and is preferred for use with unenriched water samples. Unit time may be either the hour or day, depending on the incubation period. (See also “Primary productivity”)

Primary productivity (oxygen method) is expressed as milligrams of oxygen per area per unit time [$\text{mg O}/(\text{m}^2/\text{time})$] for periphyton and macrophytes or per volume [$\text{mg O}/(\text{m}^3/\text{time})$] for phytoplankton. The oxygen method defines production and respiration rates as estimated from changes in the measured dissolved-oxygen concentration. The oxygen light- and dark-bottle method is preferred if the rate of primary production is sufficient for accurate measurements to be made within 24 hours. Unit time may be either the hour or day, depending on the incubation period. (See also “Primary productivity”)

Radioisotopes are isotopic forms of elements that exhibit radioactivity. Isotopes are varieties of a chemical element that differ in atomic weight but are very nearly alike in chemical properties. The difference arises because the atoms of the isotopic forms of an element differ in the number of neutrons in the nucleus; for example, ordinary chlorine is a mixture of isotopes having atomic weights of 35 and 37, and the natural mixture has an atomic weight of about 35.453. Many of the elements similarly exist as mixtures of isotopes, and a great many new isotopes have been produced in the operation of nuclear devices such as the cyclotron. There are 275 isotopes of the 81 stable elements, in addition to more than 800 radioactive isotopes.

Reach, as used in this report, is a length of stream that is chosen to represent a uniform set of physical, chemical, and biological conditions within a segment. It is the principal sampling unit for collecting physical, chemical, and biological data.

Recoverable is the amount of a given constituent that is in solution after a representative water sample has been extracted or digested. Complete recovery is not achieved by the extraction or digestion and thus the determination represents something less than 95 percent of the constituent present in the sample. To achieve comparability of analytical data, equivalent extraction or digestion procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results. (See also “Bed material”)

Recurrence interval, also referred to as return period, is the average time, usually expressed in years, between occurrences of hydrologic events of a specified type (such as exceedances of a specified high flow or nonexceedance of a specified low flow). The terms “return period” and “recurrence interval” do not imply regular cyclic occurrence. The actual times between occurrences vary randomly, with most of the times being less than the average and a few being substantially greater than the average. For example, the 100-year flood is the flow rate that is exceeded by the annual maximum peak flow at intervals whose average length is 100 years (that is, once in 100

years, on average); almost two-thirds of all exceedances of the 100-year flood occur less than 100 years after the previous exceedance, half occur less than 70 years after the previous exceedance, and about one-eighth occur more than 200 years after the previous exceedance. Similarly, the 7-day, 10-year low flow ($7Q_{10}$) is the flow rate below which the annual minimum 7-day-mean flow dips at intervals whose average length is 10 years (that is, once in 10 years, on average); almost two-thirds of the nonexceedances of the $7Q_{10}$ occur less than 10 years after the previous nonexceedance, half occur less than 7 years after, and about one-eighth occur more than 20 years after the previous nonexceedance. The recurrence interval for annual events is the reciprocal of the annual probability of occurrence. Thus, the 100-year flood has a 1-percent chance of being exceeded by the maximum peak flow in any year, and there is a 10-percent chance in any year that the annual minimum 7-day-mean flow will be less than the $7Q_{10}$.

Replicate samples are a group of samples collected in a manner such that the samples are thought to be essentially identical in composition.

Return period (See “Recurrence interval”)

Riffle, as used in this report, is a shallow part of the stream where water flows swiftly over completely or partially submerged obstructions to produce surface agitation.

River mileage is the curvilinear distance, in miles, measured upstream from the mouth along the meandering path of a stream channel in accordance with Bulletin No. 14 (October 1968) of the Water Resources Council and typically is used to denote location along a river.

Run, as used in this report, is a relatively shallow part of a stream with moderate velocity and little or no surface turbulence.

Runoff is the quantity of water that is discharged (“runs off”) from a drainage basin during a given time period. Runoff data may be presented as volumes in acre-feet, as mean discharges per unit of drainage area in cubic feet per second per square mile, or as depths of water on the drainage basin in inches. (See also “Annual runoff”)

Salinity is the total quantity of dissolved salts, measured by weight in parts per thousand. Values in this report are calculated from specific conductance and temperature. Seawater has an average salinity of about 35 parts per thousand (for additional information, refer to: Miller, R.L., Bradford, W.L., and Peters, N.E., 1988, Specific conductance: theoretical considerations and application to analytical quality control: U.S. Geological Survey Water-Supply Paper 2311, 16 p.)

Sea level, as used in this report, refers to one of the two commonly used national vertical datums (NGVD 1929 or NAVD 1988). See separate entries for definitions of these datums.

Sediment is solid material that originates mostly from disintegrated rocks; when transported by, suspended in, or deposited from water, it is referred to as “fluvial sediment.” Sediment includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are affected by environmental and land-use factors. Some major factors are topography, soil characteristics, land cover, and depth and intensity of precipitation.

Sensible heat flux (often used interchangeably with latent sensible heat-flux density) is the amount of heat energy that moves by turbulent transport through the air across a specified cross-sectional area per unit time and goes to heating (cooling) the air. Usually expressed in watts per square meter.

Seven-day, 10-year low flow ($7Q_{10}$) is the discharge below which the annual 7-day minimum flow falls in 1 year out of 10 on the long-term average. The recurrence interval of the $7Q_{10}$ is 10 years; the chance that the annual 7-day minimum flow will be less than the $7Q_{10}$ is 10 percent in any given year. (See also “Annual 7-day minimum” and “Recurrence interval”)

Shelves, as used in this report, are streambank features extending nearly horizontally from the flood plain to the lower limit of persistent woody vegetation.

Sodium adsorption ratio (SAR) is the expression of relative activity of sodium ions in exchange reactions within soil and is an index of sodium or alkali hazard to the soil. Sodium hazard in water is an index that can be used to evaluate the suitability of water for irrigating crops.

Soil heat flux (often used interchangeably with soil heat-flux density) is the amount of heat energy that moves by conduction across a specified cross-sectional area of soil per unit time and goes to heating (or cooling) the soil. Usually expressed in watts per square meter.

Soil-water content is the water lost from the soil upon drying to constant mass at 105 °C; expressed either as mass of water per unit mass of dry soil or as the volume of water per unit bulk volume of soil.

Specific electrical conductance (conductivity) is a measure of the capacity of water (or other media) to conduct an electrical current. It is expressed in microsiemens per centimeter at 25 °C. Specific electrical conductance is a

function of the types and quantity of dissolved substances in water and can be used for approximating the dissolved-solids content of the water. Commonly, the concentration of dissolved solids (in milligrams per liter) is from 55 to 75 percent of the specific conductance (in microsiemens). This relation is not constant from stream to stream, and it may vary in the same source with changes in the composition of the water.

Stable isotope ratio (per MIL) is a unit expressing the ratio of the abundance of two radioactive isotopes. Isotope ratios are used in hydrologic studies to determine the age or source of specific water, to evaluate mixing of different water, as an aid in determining reaction rates, and other chemical or hydrologic processes.

Stage (See “Gage height”)

Stage-discharge relation is the relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.

Streamflow is the discharge that occurs in a natural channel. Although the term “discharge” can be applied to the flow of a canal, the word “streamflow” uniquely describes the discharge in a surface stream course. The term “streamflow” is more general than “runoff” as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Substrate is the physical surface upon which an organism lives.

Substrate embeddedness class is a visual estimate of riffle streambed substrate larger than gravel that is surrounded or covered by fine sediment (<2 mm, sand or finer). Below are the class categories expressed as the percentage covered by fine sediment:

| | | | |
|---|-------------------------------|---|---------------|
| 0 | no gravel or larger substrate | 3 | 26-50 percent |
| 1 | > 75 percent | 4 | 5-25 percent |
| 2 | 51-75 percent | 5 | < 5 percent |

Surface area of a lake is that area (acres) encompassed by the boundary of the lake as shown on USGS topographic maps, or other available maps or photographs. Because surface area changes with lake stage, surface areas listed in this report represent those determined for the stage at the time the maps or photographs were obtained.

Surficial bed material is the upper surface (0.1 to 0.2 foot) of the bed material that is sampled using U.S. Series Bed-Material Samplers.

Surrogate is an analyte that behaves similarly to a target analyte, but that is highly unlikely to occur in a sample. A surrogate is added to a sample in known amounts before extraction and is measured with the same laboratory procedures used to measure the target analyte. Its purpose is to monitor method performance for an individual sample.

Suspended is the amount (concentration) of undissolved material in a water-sediment mixture. Most commonly refers to that material retained on a 0.45-micrometer filter.

Suspended, recoverable is the amount of a given constituent that is in solution after the part of a representative water-suspended sediment sample that is retained on a 0.45-micrometer filter has been extracted or digested. Complete recovery is not achieved by the extraction or digestion procedures and thus the determination represents less than 95 percent of the constituent present in the sample. To achieve comparability of analytical data, equivalent extraction or digestion procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results. (See also “Suspended”)

Suspended sediment is sediment carried in suspension by the turbulent components of the fluid or by the Brownian movement (a law of physics). (See also “Sediment”)

Suspended-sediment concentration is the velocity-weighted concentration of suspended sediment in the sampled zone (from the water surface to a point approximately 0.3 foot above the bed) expressed as milligrams of dry sediment per liter of water-sediment mixture (mg/L). The analytical technique uses the mass of all of the sediment and the net weight of the water-sediment mixture in a sample to compute the suspended-sediment concentration. (See also “Sediment” and “Suspended sediment”)

Suspended-sediment discharge (tons/d) is the rate of sediment transport, as measured by dry mass or volume, that passes a cross section in a given time. It is calculated in units of tons per day as follows: concentration (mg/L) x discharge (ft³/s) x 0.0027. (See also “Sediment,” “Suspended sediment,” and “Suspended-sediment concentration”)

Suspended-sediment load is a general term that refers to a given characteristic of the material in suspension that passes a point during a specified period of time. The term needs to be qualified, such as “annual suspended-sediment load” or “sand-size suspended-sediment load,” and so on. It is not synonymous with either suspended-sediment discharge or concentration. (See also “Sediment”)

Suspended solids, total residue at 105 °C concentration is the concentration of inorganic and organic material retained on a filter, expressed as milligrams of dry material per liter of water (mg/L). An aliquot of the sample is used for this analysis.

Suspended, total is the total amount of a given constituent in the part of a water-sediment sample that is retained on a 0.45-micrometer membrane filter. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent determined. Knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to determine when the results should be reported as “suspended, total.” Determinations of “suspended, total” constituents are made either by directly analyzing portions of the suspended material collected on the filter or, more commonly, by difference, on the basis of determinations of (1) dissolved and (2) total concentrations of the constituent. (See also “Suspended”)

Synoptic studies are short-term investigations of specific water-quality conditions during selected seasonal or hydrologic periods to provide improved spatial resolution for critical water-quality conditions. For the period and conditions sampled, they assess the spatial distribution of selected water-quality conditions in relation to causative factors, such as land use and contaminant sources.

Taxa (Species) richness is the number of species (taxa) present in a defined area or sampling unit.

Taxonomy is the division of biology concerned with the classification and naming of organisms. The classification of organisms is based upon a hierarchical scheme beginning with Kingdom and ending with Species at the base. The higher the classification level, the fewer features the organisms have in common. For example, the taxonomy of a particular mayfly, *Hexagenia limbata*, is the following:

| | |
|----------|--------------------------|
| Kingdom: | Animal |
| Phylum: | Arthropoda |
| Class: | Insecta |
| Order: | Ephemeroptera |
| Family: | Ephemeridae |
| Genus: | <i>Hexagenia</i> |
| Species: | <i>Hexagenia limbata</i> |

Thalweg is the line formed by connecting points of minimum streambed elevation (deepest part of the channel).

Thermograph is an instrument that continuously records variations of temperature on a chart. The more general term “temperature recorder” is used in the table

descriptions and refers to any instrument that records temperature whether on a chart, a tape, or any other medium.

Time-weighted average is computed by multiplying the number of days in the sampling period by the concentrations of individual constituents for the corresponding period and dividing the sum of the products by the total number of days. A time-weighted average represents the composition of water resulting from the mixing of flow proportionally to the duration of the concentration.

Tons per acre-foot (T/acre-ft) is the dry mass (tons) of a constituent per unit volume (acre-foot) of water. It is computed by multiplying the concentration of the constituent, in milligrams per liter, by 0.00136.

Tons per day (T/DAY, tons/d) is a common chemical or sediment discharge unit. It is the quantity of a substance in solution, in suspension, or as bedload that passes a stream section during a 24-hour period. It is equivalent to 2,000 pounds per day, or 0.9072 metric ton per day.

Total is the amount of a given constituent in a representative whole-water (unfiltered) sample, regardless of the constituent’s physical or chemical form. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent present in both the dissolved and suspended phases of the sample. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to judge when the results should be reported as “total.” (Note that the word “total” does double duty here, indicating both that the sample consists of a water-suspended sediment mixture and that the analytical method determined at least 95 percent of the constituent in the sample.)

Total coliform bacteria are a particular group of bacteria that are used as indicators of possible sewage pollution. This group includes coliforms that inhabit the intestine of warmblooded animals and those that inhabit soils. They are characterized as aerobic or facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35 °C. In the laboratory, these bacteria are defined as all the organisms that produce colonies with a golden-green metallic sheen within 24 hours when incubated at 35 °C plus or minus 1.0 °C on M-Endo medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 milliliters of sample. (See also “Bacteria”)

Total discharge is the quantity of a given constituent, measured as dry mass or volume, that passes a stream cross section per unit of time. When referring to constituents other than water, this term needs to be qualified, such as

“total sediment discharge,” “total chloride discharge,” and so on.

Total in bottom material is the amount of a given constituent in a representative sample of bottom material. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent determined. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to judge when the results should be reported as “total in bottom material.”

Total length (fish) is the straight-line distance from the anterior point of a fish specimen’s snout, with the mouth closed, to the posterior end of the caudal (tail) fin, with the lobes of the caudal fin squeezed together.

Total load refers to all of a constituent in transport. When referring to sediment, it includes suspended load plus bed load.

Total organism count is the number of organisms collected and enumerated in any particular sample. (See also “Organism count/volume”)

Total recoverable is the amount of a given constituent in a whole-water sample after a sample has been digested by a method (usually using a dilute acid solution) that results in dissolution of only readily soluble substances. Complete dissolution of all particulate matter is not achieved by the digestion treatment, and thus the determination represents something less than the “total” amount (that is, less than 95 percent) of the constituent present in the dissolved and suspended phases of the sample. To achieve comparability of analytical data for whole-water samples, equivalent digestion procedures are required of all laboratories performing such analyses because different digestion procedures may produce different analytical results.

Total sediment discharge is the mass of suspended-sediment plus bed-load transport, measured as dry weight, that passes a cross section in a given time. It is a rate and is reported as tons per day. (See also “Bedload,” “Bedload discharge,” “Sediment,” “Suspended sediment,” and “Suspended-sediment concentration”)

Total sediment load or **total load** is the sediment in transport as bedload and suspended-sediment load. The term may be qualified, such as “annual suspended-sediment load” or “sand-size suspended-sediment load,” and so on. It differs from total sediment discharge in that load refers to the material, whereas discharge refers to the quantity of material, expressed in units of mass per unit time. (See also “Sediment,” “Suspended-sediment load,” and “Total load”)

Transect, as used in this report, is a line across a stream perpendicular to the flow and along which measurements are taken, so that morphological and flow characteristics along the line are described from bank to bank. Unlike a cross section, no attempt is made to determine known elevation points along the line.

Turbidity is an expression of the optical properties of a liquid that causes light rays to be scattered and absorbed rather than transmitted in straight lines through water. Turbidity, which can make water appear cloudy or muddy, is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms, organic acids, and dyes (ASTM International, 2003, D1889–00 Standard test method for turbidity of water, *in* ASTM International, Annual Book of ASTM Standards, Water and Environmental Technology, v. 11.01: West Conshohocken, Pennsylvania, 6 p.). The color of water, whether resulting from dissolved compounds or suspended particles, can affect a turbidity measurement. To ensure that USGS turbidity data can be understood and interpreted properly within the context of the instrument used and site conditions encountered, data from each instrument type are stored and reported in the National Water Information System (NWIS) using parameter codes and measurement reporting units that are specific to the instrument type, with specific instruments designated by the method code. The respective measurement units, many of which also are in use internationally, fall into two categories: (1) the designations NTU, NTRU, BU, AU, and NTMU signify the use of a broad spectrum incident light in the wavelength range of 400-680 nanometers (nm), but having different light detection configurations; (2) The designations FNU, FNRU, FBU, FAU, and FNMU generally signify an incident light in the range between 780-900 nm, also with varying light detection configurations. These reporting units are equivalent when measuring a calibration solution (for example, formazin or polymer beads), but their respective instruments may not produce equivalent results for environmental samples. Specific reporting units are as follows:

NTU (Nephelometric Turbidity Units): white or broadband [400-680 nm] light source, 90 degree detection angle, one detector.

NTRU (Nephelometric Turbidity Ratio Units): white or broadband [400-680 nm] light source, 90 degree detection angle, multiple detectors with ratio compensation.

BU (Backscatter Units): white or broadband [400-680 nm] light source, 30 ± 15 degree detection angle (backscatter).

AU (Attenuation Units): white or broadband [400-680 nm] light source, 180 degree detection angle (attenuation).

NTMU (Nephelometric Turbidity Multibeam Units): white or broadband [400-680 nm] light source, multiple light sources, detectors at 90 degrees and possibly other angles to each beam.

FNU (Formazin Nephelometric Units): near infrared [780-900 nm] or monochrome light source, 90 degree detection angle, one detector.

FNRU (Formazin Nephelometric Ratio Units): near infrared [780-900 nm] or monochrome light source, 90 degree detection angle, multiple detectors, ratio compensation.

FBU (Formazin Backscatter Units): near infrared [780-900 nm] or monochrome light source, 30±15 degree detection angle.

FAU (Formazin Attenuation Units): near infrared [780-900 nm] light source, 180 degree detection angle.

FNMU (Formazin Nephelometric Multibeam Units): near infrared [780-900 nm] or monochrome light source, multiple light sources, detectors at 90 degrees and possibly other angles to each beam.

For more information please see http://water.usgs.gov/owq/FieldManual/Chapter6/6.7_contents.html.

Ultraviolet (UV) absorbance (absorption) at 254 or 280 nanometers is a measure of the aggregate concentration of the mixture of UV absorbing organic materials dissolved in the analyzed water, such as lignin, tannin, humic substances, and various aromatic compounds. UV absorbance (absorption) at 254 or 280 nanometers is measured in UV absorption units per centimeter of path length of UV light through a sample.

Unconfined aquifer is an aquifer whose upper surface is a water table free to fluctuate under atmospheric pressure. (See “Water-table aquifer”)

Unfiltered pertains to the constituents in an unfiltered, representative water-suspended sediment sample.

Unfiltered, recoverable is the amount of a given constituent in a representative water-suspended sediment sample that has been extracted or digested. Complete recovery is not achieved by the extraction or digestion treatment and thus the determination represents less than 95 percent of the constituent present in the sample. To achieve comparability of analytical data, equivalent extraction or digestion procedures are required of all laboratories performing such analyses because different procedures are likely to produce different analytical results.

Vertical datum (See “Datum”)

Volatile organic compounds (VOCs) are organic compounds that can be isolated from the water phase of a sample by purging the water sample with inert gas, such as helium, and, subsequently, analyzed by gas chromatography. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, adhesives, petroleum products, pharmaceuticals, and refrigerants. They often are components of fuels, solvents, hydraulic fluids, paint thinners, and dry-cleaning agents commonly used in urban settings. VOC contamination of drinking-water supplies is a human-health concern because many are toxic and are known or suspected human carcinogens.

Water table is that surface in a ground-water body at which the water pressure is equal to the atmospheric pressure.

Water-table aquifer is an unconfined aquifer within which the water table is found.

Water year in USGS reports dealing with surface-water supply is the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2005, is called the “2005 water year.”

Watershed (See “Drainage basin”)

WDR is used as an abbreviation for “Water-Data Report” in the REVISED RECORDS paragraph to refer to State annual hydrologic-data reports. (WRD was used as an abbreviation for “Water-Resources Data” in reports published prior to 1976.)

Weighted average is used in this report to indicate discharge-weighted average. It is computed by multiplying the discharge for a sampling period by the concentrations of individual constituents for the corresponding period and dividing the sum of the products by the sum of the discharges. A discharge-weighted average approximates the composition of water that would be found in a reservoir containing all the water passing a given location during the water year after thorough mixing in the reservoir.

Wet mass is the mass of living matter plus contained water. (See also “Biomass” and “Dry mass”)

Wet weight refers to the weight of animal tissue or other substance including its contained water. (See also “Dry weight”)

WSP is used as an acronym for “Water-Supply Paper” in reference to previously published reports.

Zooplankton is the animal part of the plankton.

Zooplankton are capable of extensive movements within the water column and often are large enough to be seen with the unaided eye. Zooplankton are secondary consumers feeding upon bacteria, phytoplankton, and detritus. Because they are the grazers in the aquatic environment, the zoo-plankton are a vital part of the aquatic food web. The zoo-plankton community is dominated by small crustaceans and rotifers. (See also “Plankton”)