WATER-RESOURCES INVESTIGATIONS IN WISCONSIN

Compiled by D.E. Maertz

U.S. GEOLOGICAL SURVEY
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1995

U.S. DEPARTMENT OF THE INTERIOR

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BASIC MISSION AND PROGRAMS

U.S. Geological Survey

The U.S. Geological Survey was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain." An integral part of that original mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of the U.S. Geological Survey (USGS) has grown and has been modified to meet the changing needs of the Nation it serves. As part of the evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian map-making agency, the primary source of data on the Nation's surface-water and ground-water resources, and the employer of the largest number of professional earth scientists in the Nation. Today's programs serve a diversity of needs and users. Programs include:

Conducting detailed assessments of the energy and mineral potential of land and offshore areas.

Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.

Conducting research on the geologic structure of land and offshore areas.

Studying the geologic features, structure, processes, and history of the other planets of our solar system.

Conducting topographic surveys and preparing topographic and thematic maps and related cartographic products.

Developing and producing digital cartographic data bases and products.

Collecting data on a routine basis to determine the quantity, quality, and use of surface water and ground water.

Conducting water-resource appraisals to describe the consequences of alternative plans for developing land and water resources.

Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.

Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural resources planning and management.

Providing earth-science information through an extensive publications program and a network of public access points.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the USGS remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation—providing "Earth science in the public service."

Water Resources Division

The mission of the Water Resources Division (WRD) is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States. This mission is accomplished, in large part, through cooperation with other Federal and non-Federal agencies, by:

Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.

Conducting analytical and interpretive water-resource appraisals describing the occurrence, availability, and physical, chemical, and biological characteristics of surface water and ground water.

Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress.

Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.

Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground water.

Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the U.S. Department of State.

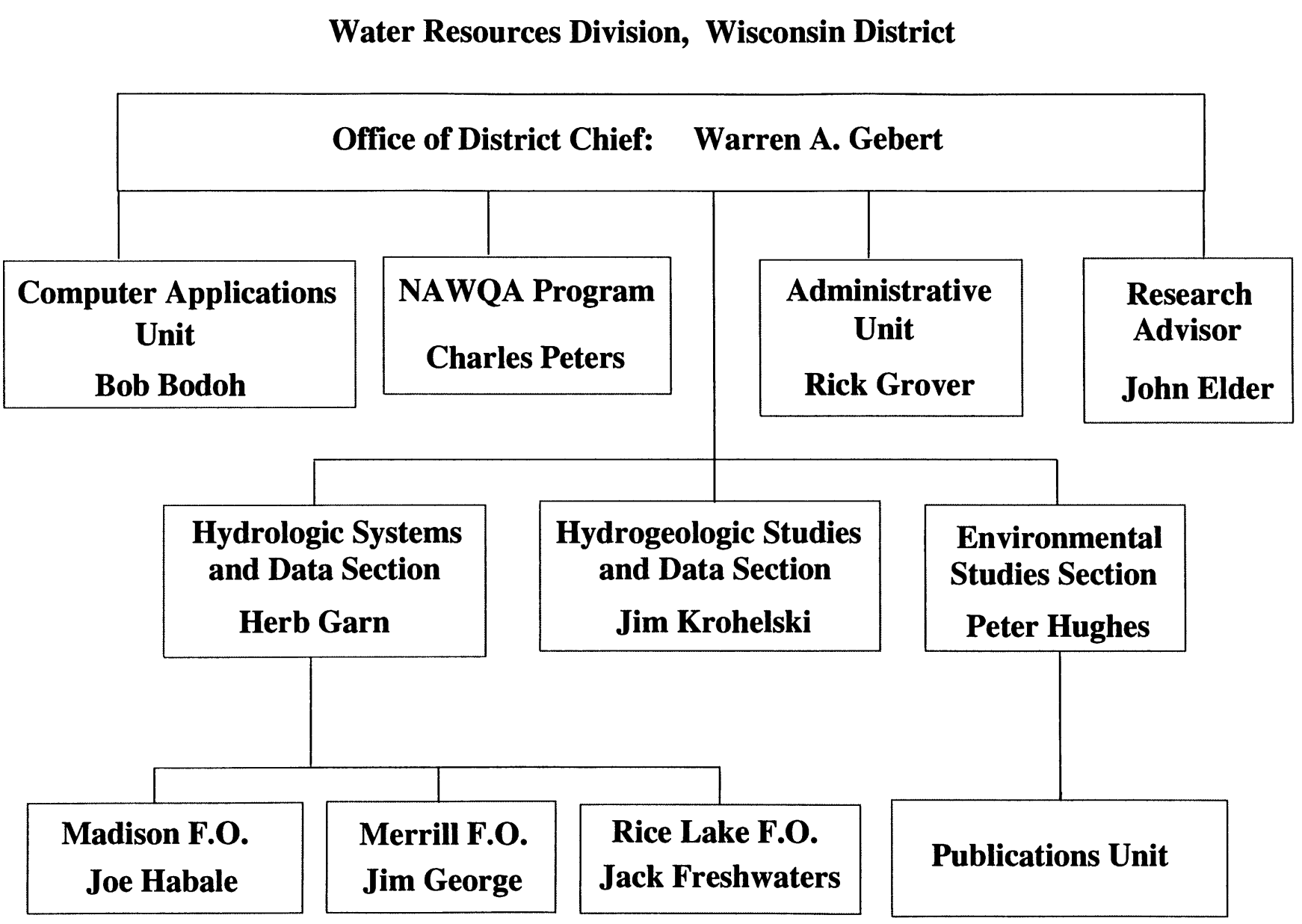

Figure 1. Organization chart of the U.S. Geological Survey, Water Resources Division, Wisconsin District.

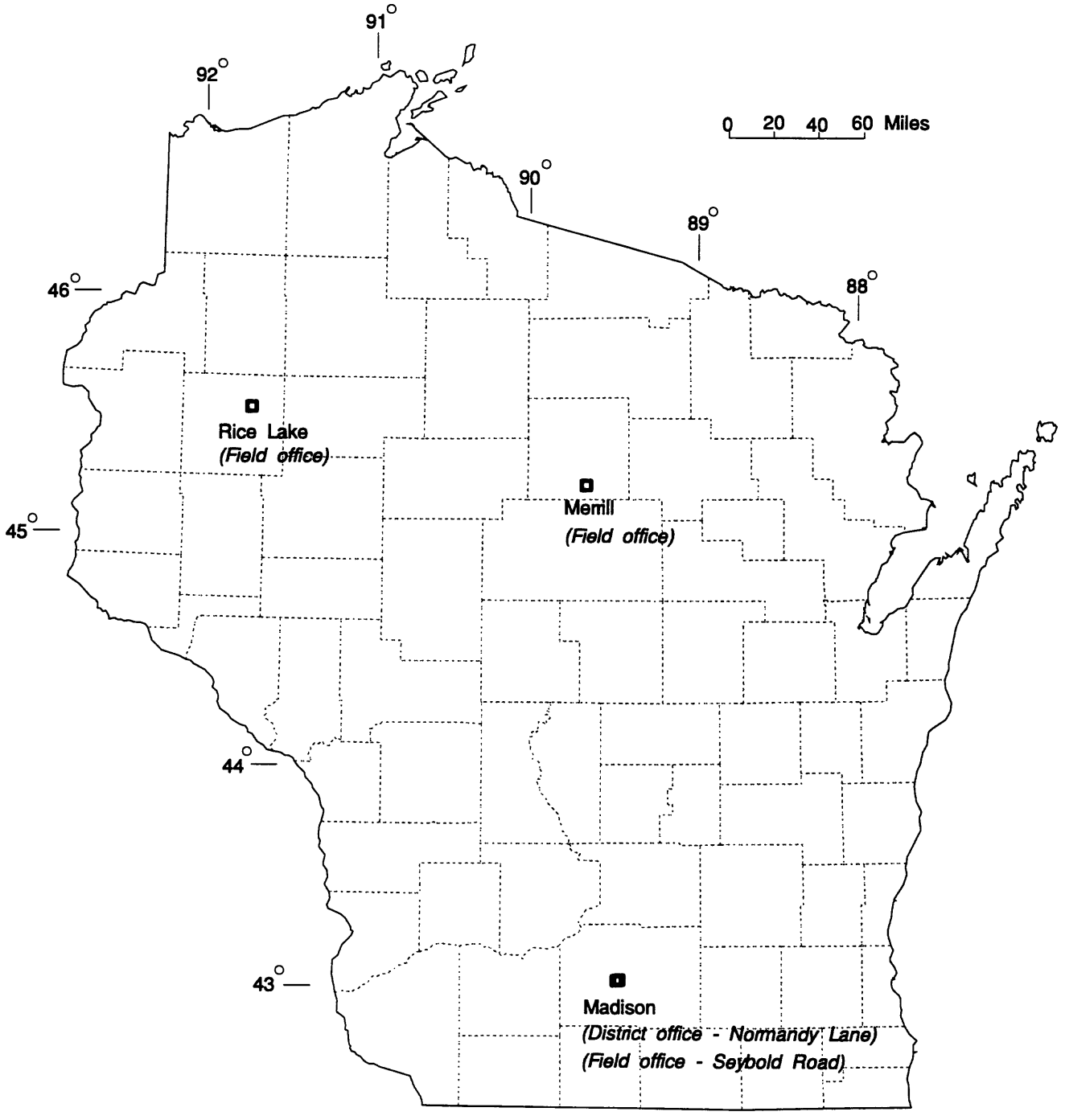

Figure 2. Location of offices in the Wisconsin District.

COOPERATORS

State Agencies

Wisconsin Department of Justice
Wisconsin Department of Natural Resources
Wisconsin Department of Transportation
Wisconsin Geological and Natural History Survey

Local Agencies

Brown County Planning Commission
City of Barron
City of Beaver Dam
City of Brookfield
City of Fond du Lac
City of Hillsboro
City of Madison
City of Peshtigo
City of Sparta
City of Thorp
City of Waupun
Dane County Regional Planning Commission
Dane County Department of Public Works
Fontana/Walworth Water Pollution Control Commission
Green Bay Metropolitan Sewerage District
Kaukauna Electric and Water Utilities
Kimberly Water Works Department
Madison Metropolitan Sewerage District
Rock County Public Works Department
Southeastern Wisconsin Regional Planning Commission
Town of Menasha Sanitary District #4
Village of Little Chute
Village of Wittenberg

Other Federal Agencies

U.S. Army Corps of Engineers,
  Detroit District
  Rock Island District
  St. Paul District
  Vicksburg, MS
U.S. Army, Department of Defense, Ft. McCoy
Federal Emergency Management Agency
Federal Energy Regulatory Commission licensees
U.S. Environmental Protection Agency

Indian Tribes

Lac du Flambeau Band of Lake Superior Chippewa
Menominee Indian Tribe of Wisconsin
Oneida Tribe of Indians of Wisconsin
Stockbridge-Munsee Band of Mohican Indians

Lake Districts

Alma/Moon Lake District
Big Muskego Lake District
City of Muskego
Dane County Lakes and Watershed Commission
Druid Lake Protection and Rehabilitation District
Eagle Spring Lake Management District
Elkhart Lake Improvement Association
Fowler Lake Management District
Green Lake Sanitary District
Lake Keesus Management District
Lauderdale Lakes Management District
Little Arbor Vitae Lake District
Little Green Lake Protection and Rehabilitation District
Little Muskego Lake District
Montello Lake Inland Protection and Rehabilitation District
Okauchee Lake District
Park Lake Management District
Potters Lake Rehabilitation and Protection District
Powers Lake Management District
Pretty Lake Protection and Rehabilitation District
Twin Lakes Protection and Rehabilitation District
Upper Nemahbin Lake Management District
Wolf Lake Management District
Town of Auburn
Town of Delavan
Town of Kansasville
Town of Mead
Town of Norway
Town of St. Germain
Town of Summit
Town of Waterford
Village of Lake Nebagamon
Village of Oconomowoc Lake
Wind Lake Management District

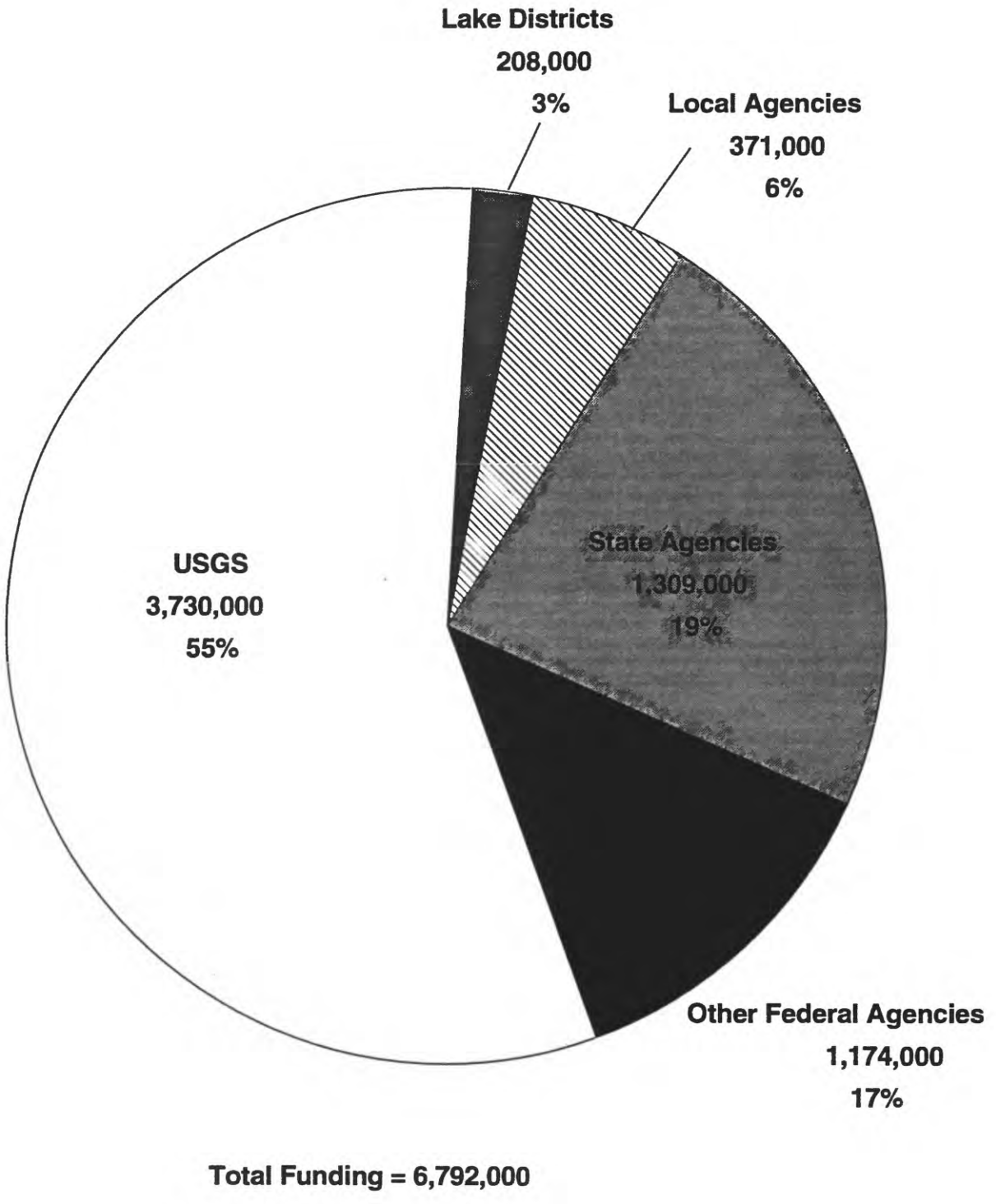

Figure 3. Funding sources for the water-resources program in Wisconsin for the 1995 fiscal year.

SUMMARY OF 1994 HYDROLOGIC CONDITIONS

Streamflow

The statewide average precipitation of 30.66 inches for the 1994 water year was 96 percent of the normal annual precipitation of 31.79 inches for water years 1961-90. Average precipitation values ranged from 81 percent of normal in southeastern Wisconsin to 103 percent of normal in west-central Wisconsin (Pamela Naber Knox, UW-Extension, Geological and Natural History Survey, written commun., 1994).

Runoff was variable for rivers throughout the State ranging from 60 percent in southeast Wisconsin to 142 percent in west-central Wisconsin. Runoff was lowest (60 percent of the average annual runoff from 1972-94) for the Pike River near Racine. Runoff was highest (142 percent of the average annual runoff from 1915-19, 1935-94) for the Trempealeau River at Dodge. Departure of runoff in the 1994 water year as a percent of long-term average runoff in the State are shown in Figure 4.

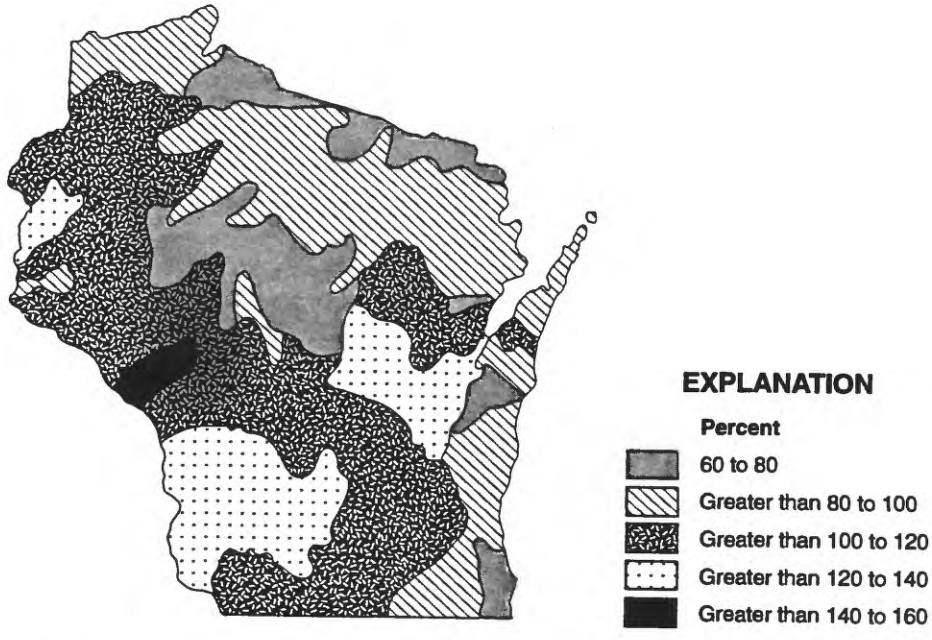

Figure 4. 1994 runoff as percent of long-term average runoff.

Annual discharge for the individual water years (1916-94) at the Oconto River near Gillett, Jump River at Sheldon, and Sugar River near Brodhead is shown in figure 5. The comparisons of monthly and annual discharges for the 1994 water year to discharge for a 79-year base period at the same three gaging stations are shown in figure 6.

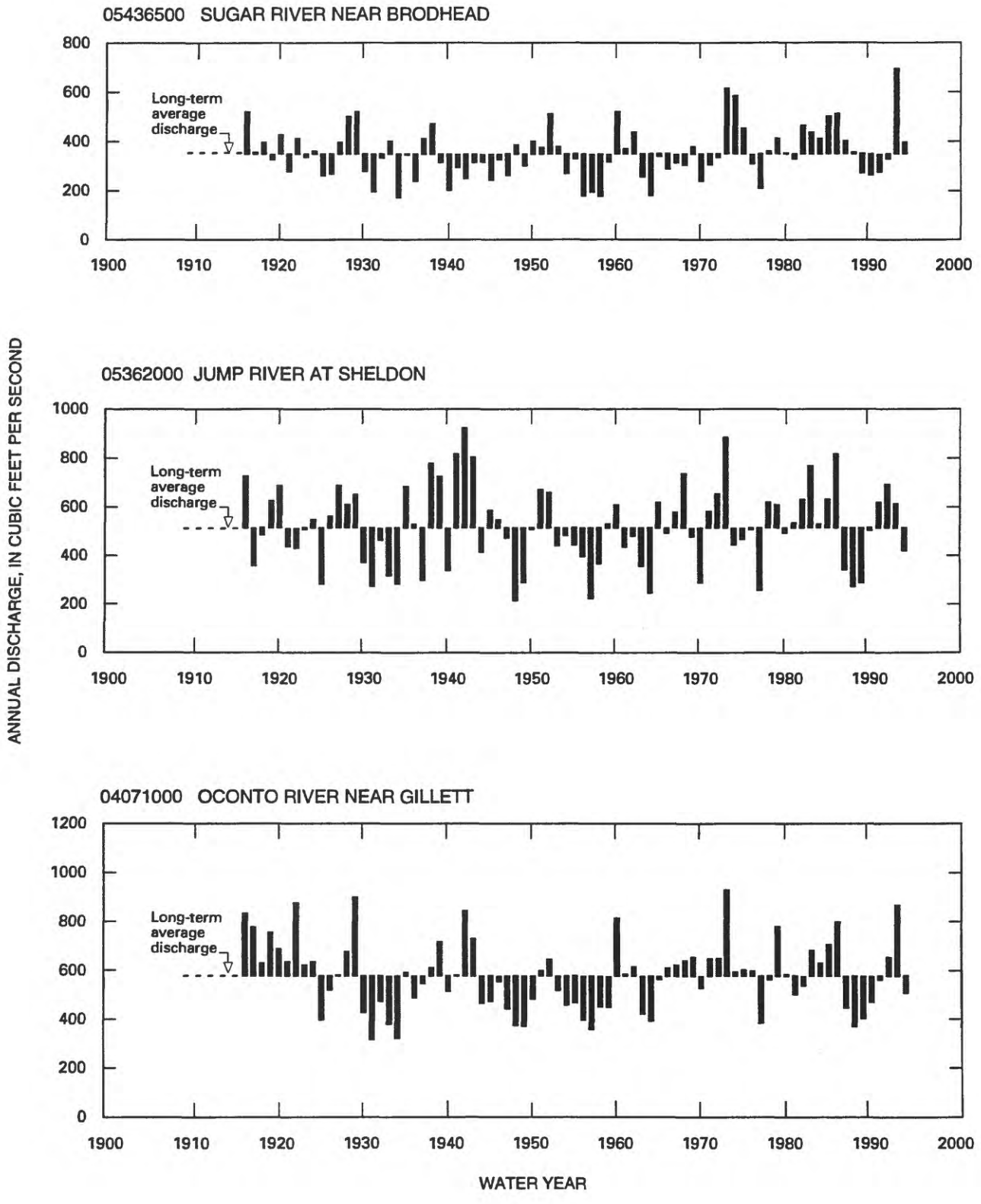

Figure 5. Comparison of annual discharge at representative gaging stations to the long-term average discharge for water years 1916-94.

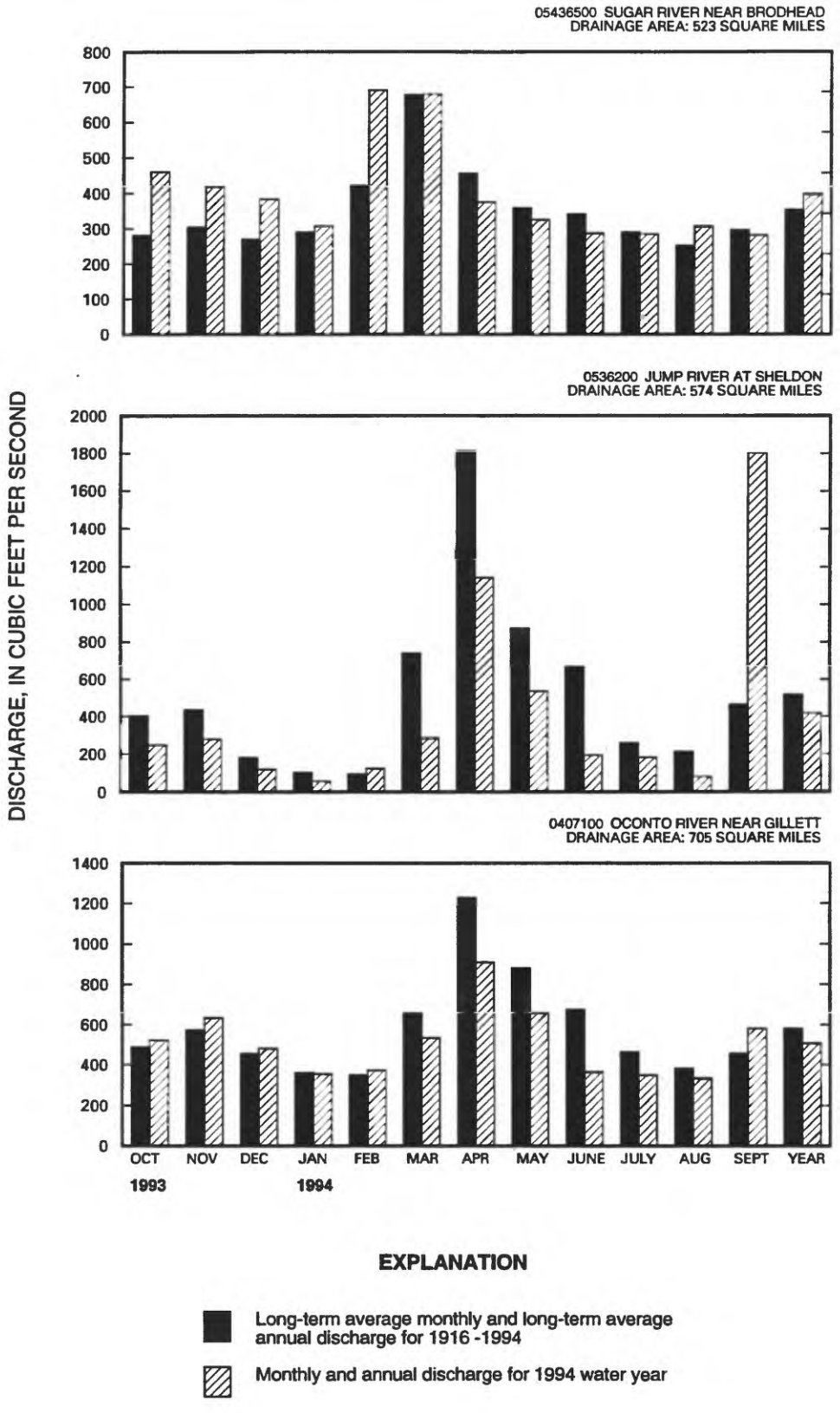

Figure 6. Comparison of discharge at representative gaging stations during water year 1994 with discharge for 1916-94.

The annual precipitation in the State was slightly below normal for the 1994 water year, and low flows occurred at 13 gaging stations where the annual minimum 7-consecutive day average flows (Q_7) had recurrence intervals of 2 or more years. Seven of the stations were located in southeastern Wisconsin where precipitation values were about 81 percent of normal. The Q_7 values and recurrence intervals for gaging stations that equalled or exceeded 2 years are listed in the following table:

Station number	Station name	Date	Q7 (ft3/s)	Recurrence interval (years)
04024430	Nemadji River near South Superior	Feb. 4-10	52	2
04085427	Manitowoc River at Manitowoc	Sept. 19-25	25	2
04087030	Menomonee River at Menomonee Falls	June 16-22	2.7	4
04087120	Menomonee River at Wauwatosa	Jan. 15-21	12	2
04087159	Kinnickinnic River at South 11th Street at Milwaukee	Feb. 6-12	3.6	15
04087220	Root River near Franklin	Jan. 16-22	3.4	3
04087240	Root River at Racine	Sept. 18-24	4.3	3
05332500	Namekagon River near Trego	Aug. 15-21	295	2
05356500	Chippewa River near Bruce	Sept. 6-12	450	2
05365500	Chippewa River at Chippewa Falls	Aug. 15-21	1,180	3
05395000	Wisconsin River at Merrill	July 1-7	1,370	2
05544200	Mukwonago River at Mukwonago	Sept. 13-19	15	4
05545750	Fox River near New Munster	Sept. 24-30	121	2

Spring runoff from snowmelt and localized rainfall in February, scattered showers in April, May, and July, along with a major storm in September caused floods with discharges that equalled or exceeded those with a recurrence interval of 5 years (Krug and others, 1991) at a number of crest-stage gage and gaging stations.

A widespread storm occurred on September 12-16 in northwestern and north-central Wisconsin that totaled up to 13 inches of precipitation. Heavy rain in Sawyer, Rusk, and Washburn Counties in north-central Wisconsin produced rainfall amounts that exceeded the 100-year return frequency. Flood damages to homes and roads in Price County alone amounted to more than $1 million. Several dams in the Phillips and Ladysmith areas were required to be sandbagged due to flooding (Midwestern Climate Center, September 1994). A 70-foot portion of the north embankment of a dam on the Flambeau River at Ladysmith was breached on September 15. Damages caused by flooding on the Chippewa and Flambeau Rivers in Rusk County will also likely exceed $1 million (Ladysmith News, September 22, 1994).

Peak discharges which had recurrence intervals that equalled or exceeded 5 years are summarized in the following table:

Station number	Station name	Date	Peak discharge (cubic feet per second)	Recurrence interval (years)
04026200	Sand River tributary near Red Cliff	April 24	195	5
04069700	North Branch Oconto River near Wabeno	Sept. 16	250	10
04074850	Lily River near Lily	Sept. 15	173	20
04079700	Spaulding Creek near Big Falls	April 25	66	5
04087030	Menomonee River at Menomonee Falls	July 4	996	12
04087100	Honey Creek at Milwaukee	July 14	615	11
05332500	Namekagon River near Trego	Sept. 17,18	3,060	80
05333500	St. Croix River near Danbury	Sept. 16	6,900	7
05356000	Chippewa River at Bishops Bridge near Winter	Sept. 15	6,070	14
05356500	Chippewa River near Bruce	Sept. 17	29,000	>100
05357360	Bear River near Powell	Sept. 23	620	5
05359600	Price Creek near Phillips	Sept. 15	552	>100
05360500	Flambeau River near Bruce	Sept. 16	23,200	70
05361400	Hay Creek near Prentice	Sept. 16	1,650	>100
05361420	Douglas Creek near Prentice	Sept. 15	1,620	>100
05362000	Jump River at Sheldon	Sept. 16	14,300	8
05364000	Yellow River at Cadott	Apr. 26	7,750	6
05365500	Chippewa River at Chippewa Falls	Sept. 17	52,300	5
05370900	Spring Creek near Durand	July 7	450	11
05382200	French Creek near Ettrick	Sept. 14	1,440	30
05391950	Squaw Creek near Harrison	Sept. 15	45	10
05393500	Spirit River at Spirit Falls	Sept. 15	3,990	>100
05393640	Little Pine Creek near Irma	Sept. 15	194	9
05395000	Wisconsin River at Merrill	Sept. 16	19,700	6
05400025	Johnson Creek near Knowlton	Apr. 24	1,850	8
05427948	Pheasant Branch at Middleton	Feb. 20	615	10
05430150	Badfish Creek near Cooksville	Feb. 20	1,210	>10
05430175	Yahara River near Fulton	Feb. 20	2,730	>10
05431486	Turtle Creek near Clinton	Feb. 20	4,600	9
05432300	Rock Branch near Mineral Point	May 24	1,570	>100
05548150	North Branch Nippersink Creek near Genoa City	Feb. 19	350	30

References cited

Krug, W. R., Conger, D. H., and Gebert, W. A., 1991, Flood-frequency characteristics of Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Report 91-4128, 185 p.

Ladysmith News, Repairs begin on Ladysmith dam: Ladysmith, Wis., Sept. 22, 1994.

_____, Flooding hits Flambeau, Chippewa: Ladysmith, Wis., Sept. 22, 1994.

Midwestern Climate Center, 1994, Weather and Climate Impacts in the Midwest--Major Climate Conditions for September, 1994-Regional Impacts-Wisconsin: Champaign, Ill., v. 4, no. 10, p. 3, 4.

Water Quality

Suspended-sediment and total phosphorus yields for streams in southern Wisconsin for water year 1994 ranged from 58 to 83 percent of long-term annual average. The suspended-sediment yield at the Grant River at Burton in southwestern Wisconsin was 219 tons/mi^2 (tons per square mile), or 83 percent of the average annual yield for 1978-94. The suspended-sediment yield for Jackson Creek Tributary near Elkhorn in southeastern Wisconsin for water year 1994 was 50 tons/mi^2, which was 68 percent of the average annual yield for the period 1984-94. The total phosphorus yield for Jackson Creek Tributary was 291 lbs/mi^2 (pounds per square mile), or 58 percent of the 1984-94 annual average. At Silver Creek near Ripon suspended sediment yield was 14.8 tons/mi^2, or 58 percent of the 1988-94 annual average, and total phosphorus yield was 283 lbs/mi^2, or 76 percent of the 1988-94 annual average.

Ground-Water Levels

Maps showing the seasonal ground-water trends for the year (fig. 7) are based on water-level data from 26 shallow-aquifer wells, each having at least 15 years of record. Water-level measurements from each well are grouped so that FALL consists of measurements from October through December 1993; WINTER consists of measurements from January through March 1994; SPRING consists of measurements from April through June 1994; and SUMMER consists of measurements from July through September 1994. Mean seasonal water levels were compared to the long-term mean seasonal water levels. The 1994 water level was considered normal if it was within one-half of the standard deviation on the long-term mean.

In general, shallow ground-water levels during the 1994 water year were normal to above normal for most of the wells in the State. The only counties having below normal ground-water levels at the beginning of the water year were Taylor and Door Counties. Several counties in the northeast and southeast part of the State reported below normal levels during the remainder of the water year. The large extent of the normal and above-normal ground-water levels can be attributed to near normal rainfall during the 1994 water year and above normal rainfall during the previous water year.

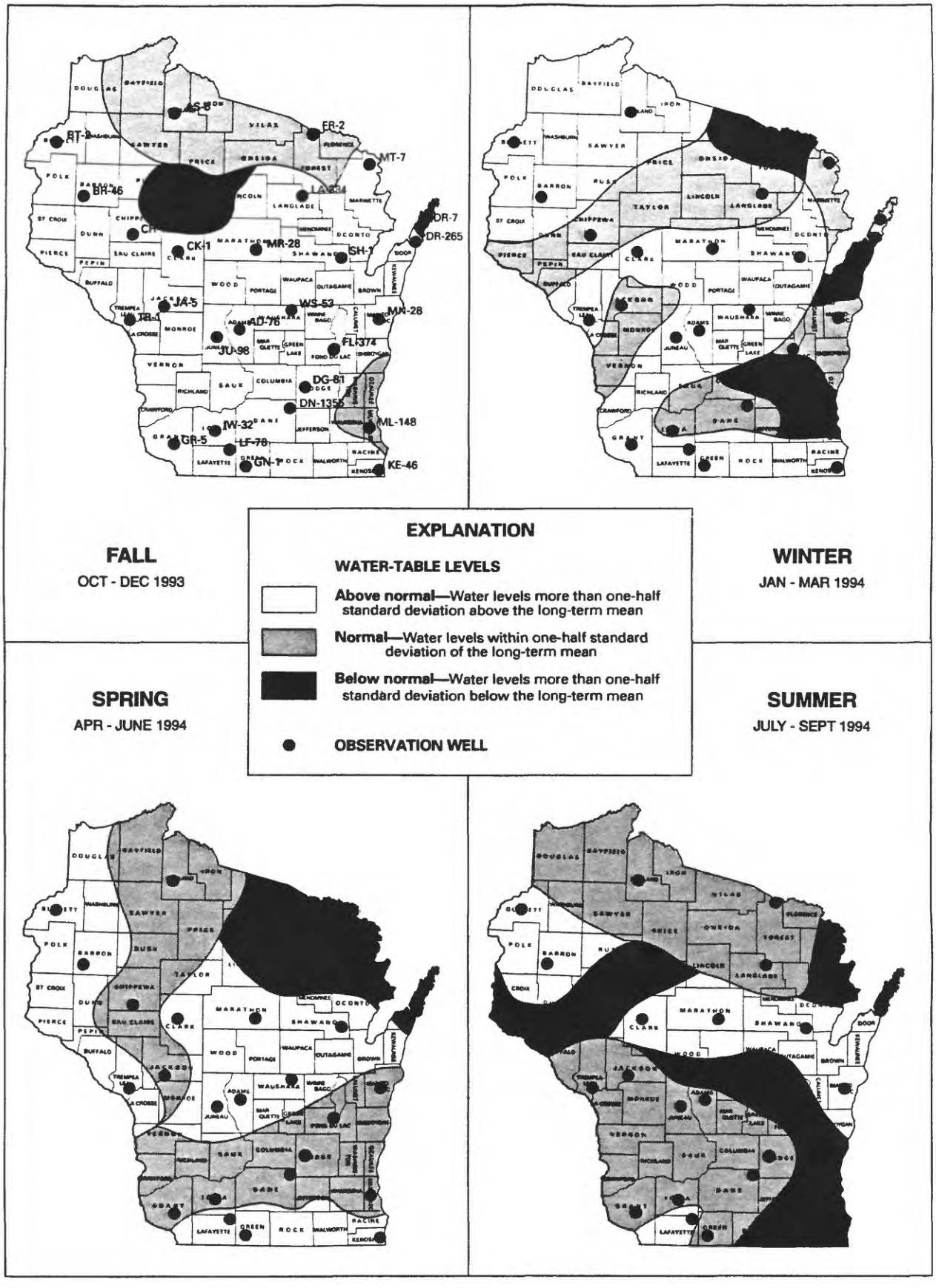

Figure 7. Relation of seasonal water-table levels to long-term means.

COLLECTION OF BASIC RECORDS–SURFACE WATER, WI 001

COOPERATORS:

Wisconsin Department of Natural Resources
U.S. Army Corps of Engineers
Southeastern Wisconsin Regional Planning Commission
Federal (Regular)
Madison Metropolitan Sewerage District
Dane County Department of Public Works
Federal Energy Regulatory Commission Licensees
Lac du Flambeau Band of Lake Superior Chippewa
Illinois Department of Transportation
City of Barron
City of Beaver Dam
City of Brookfield
City of Hillsboro
City of Peshtigo
City of Sparta
City of Thorp
City of Waupun
Village of Wittenberg
Fontana/Walworth Water Pollution Control Commission
Rock County Public Works Department
Menominee Indian Tribe of Wisconsin
Oneida Tribe of Indians of Wisconsin
Stockbridge-Munsee Band of Mohican Indians

LOCATION:

Statewide

PROJECT CHIEF:

Barry K. Holmstrom

PERIOD OF PROJECT:

July 1913-Continuing

PROBLEM: Surface-water information is needed for surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. An appropriate data base is necessary to provide this information.

OBJECTIVE: The objectives of this study are to provide continuous discharge records for selected rivers at specific sites to supply the needs for regulation, analytical studies, definition of statistical properties, trends analysis, determination of the occurrence, and distribution of water in streams for planning. The project is also designed to determine lake levels and to provide discharge for floods, low-flow conditions, and for water-quality investigations. Requests for streamflow data and information relating to streamflow in Wisconsin are answered. Basic data are published annually in the report "Water Resources Data–Wisconsin."

APPROACH: A network of streamflow stations and lake-level stations will be maintained throughout Wisconsin. This includes operating the equipment at the gaging station to record river or lake

stage, making periodic discharge measurements at each streamflow station to establish or verify a stage-discharge rating curve, reducing the stage records to instantaneous and daily discharges, compilation of monthly and annual discharges, and preparing data for publication in the annual report "Water Resources Data–Wisconsin".

Requests for streamflow data from other government agencies, consultants, and private parties will be processed.

PROGRESS (July 1994 to June 1995): During the current fiscal year, streamflow data were collected at a total of 98 sites: 40 sites for the Wisconsin Department of Natural Resources (WDNR), 7 sites for the Corps of Engineers, 14 sites for the Southeastern Wisconsin Regional Planning Commission, 6 sites for the Federal program, 2 sites for Federal Energy Commission Licensees, 2 sites for the Madison Metropolitan Sewerage District, and 1 site each for the Lac du Flambeau Band of Lake Superior Chippewa, Menominee Indian Tribe of Wisconsin, Oneida Tribe of Indians of Wisconsin, Stockbridge-Munsee Band of Mohican Indians, Illinois Department of Transportation, cities of Barron, Beaver Dam, Brookfield, Hillsboro, Peshtigo, Sparta, Thorp, Waupun, village of Wittenberg, and Fontana/Walworth Water Pollution Control Commission. Streamflow data were also collected at 12 sites for agencies working jointly with the USGS. Lake-level data were collected at two sites for the Dane County Department of Public Works, at two sites for the Corps of Engineers, at one site for Rock County Public Works Department, and one site for the WDNR.

Two gaging stations from the Federal program and one Corps of Engineers station were discontinued October 1, 1994.

04086360 Milwaukee River at Waubeka
05403500 Lemonweir River at New Lisbon
05426031 Rock River at Jefferson

Computation of streamflow and lake-level records for all the network stations for the 1994 water year was completed, stored in our WATSTORE computer data base, and published in the annual report "Water Resources Data–Wisconsin, water year 1994: Volume 1, St. Lawrence River Basin and Volume 2, Upper Mississippi River Basin." More than 100 requests for streamflow information were answered.

PLANS (July 1995 to June 1996): Data will be collected at 96 continuous-streamflow stations (see the following list) and lake levels at 6 stations. Streamflow records will be computed and data published for the 1995 water year. Requests for streamflow information will be answered.

Due to budget constraints by the WDNR, the operation of the following stations will have to be reduced. All stations will be operated at a reduced level for the period July 1, 1995 to September 30, 1995. For the period October 1, 1995 to June 30, 1996, only nine stations will be operated as part of the USGS/WDNR agreement. If funding arrangements can be made with other cooperators, it would be desirable to operate all 20 stations. Which nine stations will be funded by the USGS/WDNR agreement is dependent upon pending arrangements with other cooperators.

04071858 Pensaukee River near Pensaukee
04078500 Embarrass River near Embarrass
04084500 Fox River at Rapide Croche Dam near Wrightstown
04085200 Kewaunee River near Kewaunee
04085281 East Twin River at Mishicot
04085427 Manitowoc River at Manitowoc
04086000 Sheboygan River at Sheboygan
05333500 St. Croix River near Danbury
05362000 Jump River at Sheldon
05381000 Black River at Neillsville
05394500 Prairie River near Merrill
05397500 Eau Claire River at Kelly
05404000 Wisconsin River near Wisconsin Dells
05406500 Black Earth Creek at Black Earth
05408000 Kickapoo River at LaFarge
05427570 Rock River at Indianford
05429500 Yahara River at McFarland
05430500 Rock River at Afton
05431486 Turtle Creek at Carvers Rock Road nr Clinton
05436500 Sugar River near Brodhead

Partial funding for the publication of data may also be lost due to budget constraints in the WDNR for the following stations as of July 1, 1995:

04073500 Fox River at Berlin
04079000 Wolf River at New London
05369500 Chippewa River at Durand
05379500 Trempealeau River at Dodge
05382000 Black River near Galesville
05407000 Wisconsin River at Muscoda
05410490 Kickapoo River at Steuben
05413500 Grant River at Burton
05414000 Platte River near Rockville
05425500 Rock River at Watertown
05426000 Crawfish River at Milford

For the period July 1, 1995 to June 30, 1996, only seven stations will be continued as part of the USGS/WDNR agreement. If funding arrangements can be made with other cooperators, it would be desirable to continue all 11 stations.

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1996 FY

Station number	Name and location	Period of record (water year)	Cooperator
04024430	Nemadji River - South Superior	1974	WDNR
04025500	Bois Brule River - Brule	1943-81, 1984-	Fed.
04027500	White River - Ashland	1948-	WDNR
04029990	Montreal River - Saxon Falls	1987	WDNR
04063700	Popple River - Fence	1964-	Fed.
04065106	Menominee River - Niagara	1993-	FERC
04066003	Menominee River - Pembine	1950-	WDNR
04069500	Peshtigo River - Peshtigo	1953-	City of Peshtigo
04071000	Oconto River - Gillett	1906-09, 1914-	Fed.
04071858	Pensaukee River - Pensaukee	1973-	WDNR
04072150	Duck Creek - Howard	1988-	Oneida Tribe of Indians of WI
04073500	Fox River - Berlin	1898-	C of E, Detroit
04074950	Wolf River - Langlade	1966-79, 1981-	Menominee Indian Tribe of WI
04077400	Wolf River - Shawano	1907-09, 1911-	FERC
04077630	Red River - Morgan	1993	Stockbridge-Munsee Band of Mohican Indians
04078500	Embarrass River - Embarrass	1919-85, 1994-	Fed.
04079000	Wolf River - New London	1896-	C of E, Detroit
04082400	Fox River - Oshkosh	1991	WDNR
04084445	Fox River - Appleton	1986-	C of E, Detroit
04084500	Fox River - Wrightstown	1896-	WDNR
04085200	Kewaunee River - Kewaunee	1964-	WDNR
04065281	East Twin River - Mishicot	1972-	WDNR
04085427	Manitowoc River - Manitowoc	1972-	WDNR
04086000	Sheboygan River - Sheboygan	1916-24, 1951	WDNR
04086500	Cedar Creek - Cedarburg	1930-70, 73-81, 1983-87, 1991 -	WDNR
04086600	Milwaukee River - Pioneer Road	1982-	SEWRPC
04087000	Milwaukee River - Milwaukee	1914-	SEWRPC
04087030	Menomonee River - Menomonee Falls	1975-77, 1979-	SEWRPC
04067088	Underwood Creek - Wauwatosa	1975-	SEWRPC
04087120	Menomonee River - Wauwatosa	1962-	SEWRPC
04087160	Kinnickinnic River - Milwaukee	1976-	SEWRPC
04087204	Oak Creek - South Milwaukee	1964-	SEWRPC
04087220	Root River - Franklin	1964-	SEWRPC
04087233	Root River Canal - Franklin	1964-	SEWRPC
04087240	Root River - Racine	1963-	SEWRPC
04087257	Pike River - Racine	1972-	SEWRPC
05332500	Namekagon River - Trego	1928-70, 1988	WDNR
05333500	St. Croix River - Danbury	1914-81, 1985-	WDNR
05340500	St. Croix River - St. Croix Falls	1902-	WDNR
05341500	Apple River - Somerset	1901-70, 1987	WDNR
05356000	Chippewa River - Winter	1912-	WDNR
05356500	Chippewa River - Bruce	1914-	WDNR
05357335	Bear River - Manitowish Waters	1991	Lac du Flambeau Band of Lake Superior Chippewa
05360500	Flambeau River - Bruce	1951-	WDNR, FERC
05362000	Jump River - Sheldon	1915-	WDNR
05365500	Chippewa River - Chippewa Falls	1888-1983, 1987	WDNR
05365707	North Fork Eau Claire River - Thorp	1986	City of Thorp
053674464	Yellow River - Barron	1991	City of Barron
05368000	Hay River - Wheeler	1951-	Fed.
05369000	Red Cedar River - Menomonie	1907-08, 1913-	WDNR
05369500	Chippewa River - Durand	1928-	C of E, St. Paul
05369945	Eau Galle River - low water bridge	1982-83, 1986-	C of E, Vicksburg
05370000	Eau Galle River - Spring Valley	1944-	C of E, St. Paul
05379500	Trempealeau River - Dodge	1914-19, 1934	C of E, St. Paul
05381000	Black River - Neillsville	1905-09, 1914-	WDNR

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1996 FY

Station number	Name and location	Period of record (water year)	Cooperator
05382000	Black River - Galesville	1932-	C of E, St. Paul
05382325	La Crosse River - Sparta	1992-	City of Sparta
05391000	Wisconsin River - Lake Tomahawk	1936-	WDNR
05393500	Spirit River - Spirit Falls	1942-	WDNR
05394500	Prairie River - Merrill	1914-31, 1939-	WDNR
05395000	Wisconsin River - Merrill	1903-	WDNR
05397500	Eau Claire River - Kelly	1914-27, 1939-	WDNR
05398000	Wisconsin River - Rothschild	1945-	WDNR
05399500	Big Eau Pleine River - Stratford	1914-26, 1937-	WDNR
05400760	Wisconsin River - Wisconsin Rapids	1914-50, 1958-	WDNR
05401050	Tenmile Creek - Nekoosa	1963-79, 1987	WDNR
05402000	Yellow River - Babcock	1944-	WDNR
05404000	Wisconsin River - Wisconsin Dells	1935-	WDNR
05404116	S. Br. Baraboo River - Hillsboro	1988-	City of Hillsboro
05405000	Baraboo River - Baraboo	1914-22, 1943-	Fed.
05406500	Black Earth Creek - Black Earth	1954	WDNR
05407000	Wisconsin River - Muscoda	1903-04, 1914-	C of E, St. Paul
05408000	Kickapoo River - LaFarge	1939-	WDNR
05410490	Kickapoo River - Steuben	1933-	C of E, St. Paul
05413500	Grant River - Burton	1935-	C of E, R. Island
05414000	Platte River - Rockville	1935-	C of E, R. Island
05423500	S. Br. Rock River - Waupun	1948-69, 1987	City of Waupun
05425500	Rock River - Watertown	1931-70, 1977-	C of E, R. Island
05425912	Beaverdam River - Beaver Dam	1984-	City of Beaver Dam
05426000	Crawfish River - Milford	1931-	C of E, R. Island
05426250	Bark River - Rome	1980-	SEWRPC
05427570	Rock River - Indianford	1975-	Rock County
05429500	Yahara River - McFarland	1930-	DCDPW
05430150	Badfish Creek - Cooksville	1977-	MMSD
05430175	Yahara River - Fulton	1977	MMSD
05430500	Rock River - Afton	1914-	Rock County
05431486	Turtle Creek - Clinton	1939-	Rock County
05432500	Pecatonica River - Darlington	1939-	C of E, R. Island
05433000	E. Br. Pecatonica River - Blanchardville	1939-1986, 1988	C of E, R. Island
05434500	Pecatonica River - Martintown	1940-	C of E, R. Island
05436500	Sugar River - Brodhead	1914-	Rock County
05438283	Piscasaw Creek - Walworth	1992-	Fontana/Walworth WPCC
05543800	Fox River -Watertown Road - Waukesha	1993-	City of Brookfield
05543830	Fox River - Waukesha	1963-	SEWRPC
05544200	Mukwonago River - Mukwonago	1973-	SEWRPC
05545750	Fox River - New Munster	1940-	IL. DOT
	LAKES		
04082500	Lake Winnebago - Oshkosh	1882-	C of E, Detroit
04084255	Lake Winnebago - Stockbridge	1983-	C of E, Detroit
05404500	Devil's Lake - Baraboo	1922-30, 1932, 1934-81, 1985-	WDNR
05427235	Lake Koshkonong - Newville	1987	Rock County
05428000	Lake Mendota - Madison	1903, 1916-	DCDPW
05429000	Lake Monona - Madison	1915-	DCDPW

WDNR – Wisconsin Department of Natural Resources
C of E, Detroit – Corps of Engineers, Detroit, Michigan
C of E, R. Island – Corps of Engineers, Rock Island, Illinois
C of E, St. Paul – Corps of Engineers, St. Paul, Minnesota
SEWRPC – Southeastern Wisconsin Regional Planning Commission
Fed. – USGS Federal Program
FERC – Federal Energy Regulatory Commission Licensees
MMSD – Madison Metropolitan Sewerage District
DCDPW – Dane County Department of Public Works
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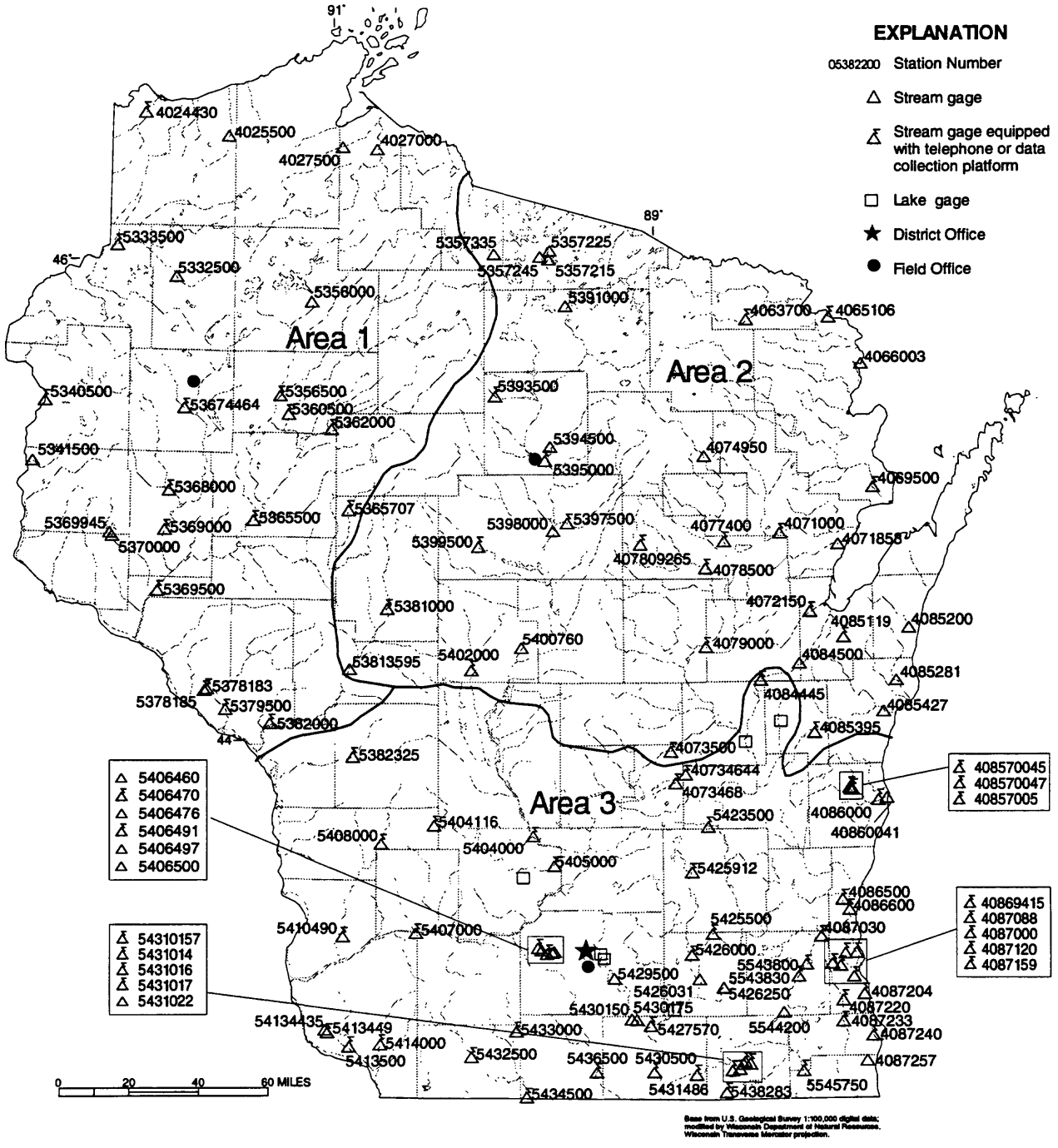

Figure 8. Location of continuous-record data-collection stations.

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1996 FY

Station number	Name and location	Period of record (water year)	Cooperator
05382000	Black River - Galesville	1932-	C of E, St. Paul
05382325	La Crosse River - Sparta	1992-	City of Sparta
05391000	Wisconsin River - Lake Tomahawk	1936-	WDNR
05393500	Spirit River - Spirit Falls	1942-	WDNR
05394500	Prairie River - Merrill	1914-31, 1939-	WDNR
05395000	Wisconsin River - Merrill	1903-	WDNR
05397500	Eau Claire River - Kelly	1914-27, 1939-	WDNR
05398000	Wisconsin River - Rothschild	1945-	WDNR
05399500	Big Eau Pleine River - Stratford	1914-26, 1937-	WDNR
05400760	Wisconsin River - Wisconsin Rapids	1914-50, 1958-	WDNR
05401050	Tenmile Creek - Nekoosa	1963-79, 1987	WDNR
05402000	Yellow River - Babcock	1944-	WDNR
05404000	Wisconsin River - Wisconsin Dells	1935-	WDNR
05404116	S. Br. Baraboo River - Hillsboro	1988-	City of Hillsboro
05405000	Baraboo River - Baraboo	1914-22, 1943-	Fed.
05406500	Black Earth Creek - Black Earth	1954	WDNR
05407000	Wisconsin River - Muscoda	1903-04, 1914-	C of E, St. Paul
05408000	Kickapoo River - LaFarge	1939-	WDNR
05410490	Kickapoo River - Steuben	1933-	C of E, St. Paul
05413500	Grant River - Burton	1935-	C of E, R. Island
05414000	Platte River - Rockville	1935-	C of E, R. Island
05423500	S. Br. Rock River - Waupun	1948-69, 1987	City of Waupun
05425500	Rock River - Watertown	1931-70, 1977-	C of E, R. Island
05425912	Beaverdam River - Beaver Dam	1984-	City of Beaver Dam
05426000	Crawfish River - Milford	1931-	C of E, R. Island
05426250	Bark River - Rome	1980-	SEWRPC
05427570	Rock River - Indianford	1975-	Rock County
05429500	Yahara River - McFarland	1930-	DCDPW
05430150	Badfish Creek - Cooksville	1977-	MMSD
05430175	Yahara River - Fulton	1977	MMSD
05430500	Rock River - Afton	1914-	Rock County
05431486	Turtle Creek - Clinton	1939-	Rock County
05432500	Pecatonica River - Darlington	1939-	C of E, R. Island
05433000	E. Br. Pecatonica River - Blanchardville	1939-1986, 1988	C of E, R. Island
05434500	Pecatonica River - Martintown	1940-	C of E, R. Island
05436500	Sugar River - Brodhead	1914-	Rock County
05438283	Piscasaw Creek - Walworth	1992-	Fontana/Walworth WPCC
05543800	Fox River -Watertown Road - Waukesha	1993-	City of Brookfield
05543830	Fox River - Waukesha	1963-	SEWRPC
05544200	Mukwonago River - Mukwonago	1973-	SEWRPC
05545750	Fox River - New Munster	1940-	IL. DOT
	LAKES		
04082500	Lake Winnebago - Oshkosh	1882-	C of E, Detroit
04084255	Lake Winnebago - Stockbridge	1983-	C of E, Detroit
05404500	Devil's Lake - Baraboo	1922-30, 1932, 1934-81, 1985-	WDNR
05427235	Lake Koshkonong - Newville	1987	Rock County
05428000	Lake Mendota - Madison	1903, 1916-	DCDPW
05429000	Lake Monona - Madison	1915-	DCDPW

WDNR – Wisconsin Department of Natural Resources
C of E, Detroit – Corps of Engineers, Detroit, Michigan
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SEWRPC – Southeastern Wisconsin Regional Planning Commission
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DCDPW – Dane County Department of Public Works
IL. DOT – Illinois Department of Transportation
Fontana/Walworth WPCC – Fontana/Walworth Water Pollution Control Commission

DISCONTINUED SURFACE-WATER DISCHARGE STATIONS

The following continuous-record surface-water discharge stations in Wisconsin have been discontinued. Daily streamflow records were collected and published for the period of record, expressed in water years, shown for each station. Those stations with an asterisk (*) after the station number are currently operated as crest-stage partial-record stations. Some of the discontinued project stations with less than three years of record have not been included. Information regarding these stations may be obtained from the District Office at the address given on the back side of the title page of this report.

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
STREAMS TRIBUTARY TO LAKE SUPERIOR			
Little Balsam Creek at Patzau, WI	04024314	4.89	1976-78
Little Balsam Creek near Patzau, WI	04024315	5.05	1976-78
Little Balsam Creek Tributary near Patzau, WI	04024318	0.60	1976-78
Little Balsam Creek near Foxboro, WI	04024320	3.27	1977-78
Amnicon River near Poplar (Amnicon Falls), WI	04025000	110	1914-16
Bois Brule (Brule) River near Brule, WI	04026000	160	1914-17
Sioux River near Washburn, WI	04026300*	33.9	1965-66
Pine Creek at Moquah, WI	04026347	6.20	1976-78
Pine Creek Tributary at Moquah, WI	04026348	0.48	1976-78
Pine Creek near Moquah, WI	04026349	19.9	1976-78
North Fish Creek near Moquah, WI	040263491	65.4	1990-91
Bad River near Mellen, WI	04026450*	82.0	1971-75
Bad River at Mellen, WI	04026500	98.3	1948-55
Alder Creek near Upson, WI	04026870	22.2	1972-77
Bad River near Odanah	04027000	597	1914-23, 1948-95
Montreal River near Kimball, WI	04028500	100	1924-26
West Fork Montreal River at Gile, WI	04029000	75.0	1918-26, 1943-47
West Fork Montreal River near Kimball, WI	04029500	86.2	1924-26
STREAMS TRIBUTARY TO LAKE MICHIGAN			
North Branch Pine River at Windsor Dam nr Alvin, WI	04063640*	27.8	1967-68
Pine River near Florence, WI	04064000	510	1914-23
Pine River below Pine River Power Plant near Florence, WI	04064500	533	1924-76
Pike River at Amberg, WI	04066500	255	1914-70
Menominee River near McAllister, WI	04067500	3,930	1945-61, 1979-86, 1988-90
Peshtigo River at High Falls near Crivitz, WI	04068000	537	1912-57
Suamico River at Suamico, WI	04072000	60.7	1951-52
Lawrence Creek near Westfield, WI	04072750	13.4	1968-73
Grand River near Kingston, WI	04073050	73.5	1968-75
West Branch White River near Wautoma, WI	04073405	38.9	1964-75
White Creek at Forest Glen Beach near Green Lake, WI	04073462	3.05	1982-88
Swamp Creek above Rice Lake at Mole Lake, WI	04074538	46.3	1977-83, 1985-87
Swamp Creek below Rice Lake at Mole Lake, WI	04074548	56.8	1977-79, 1982-85
Wolf River near White Lake, WI	04075000	485	1935-38
Evergreen Creek near Langlade, WI	04075200*	8.09	1964-73
Wolf River above West Branch Wolf River, WI	04075500	616	1928-62
West Branch Wolf River at Neopit, WI	04076000	93.2	1911-17
West Branch Wolf River near Keshena, WI	04076500	163	1928-32
Middle Branch Embarrass River near Wittenberg	0407809265	76.3	1990-95
Little Wolf River near Galloway, WI	04079602	22.6	1974-79
Spaulding Creek near Big Falls, WI	04079700*	5.57	1964-66
Little Wolf River at Royalton, WI	04080000	507	1914-70, 1983-85
Emmons Creek near Rural, WI	04080950	25.1	1977
Storm Sewer to Mirror Lake at Waupaca, WI	04080976	0.04	1971-74
Waupaca River near Waupaca, WI	04081000	265	1916-66, 1983-85
Daggets Creek at Butte Des Morts, WI	04081800	10.6	1977
West Branch Fond du Lac River at Fond du Lac, WI	04083000	83.1	1939-54
East Branch Fond du Lac River near Fond du Lac, WI	04083500	78.4	1939-54
Brothertown Creek at Brothertown, WI	04084200	5.10	1976-77
Onion River at Hingham, WI	04085813	37.2	1979-80
Onion River near Sheboygan Falls, WI	04085845	94.1	1979-82
Milwaukee River at Kewaskum, WI	04086150	138	1968-81
East Branch Milwaukee River near New Fane, WI	04086200	54.1	1968-81
North Branch Milwaukee River near Fillmore, WI	04086340	148	1968-81

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
Milwaukee River at Waubeka, WI	04086360	432	1968-81, 1994
Mud Lake Outlet near Decker Corner, WI	04086488	7.36	1983-84
Milwaukee River above North Ave Dam at Milwaukee, WI	04087010	702	1982-84
Menomonee River at Germantown, WI	04087018	19.0	1975-77
Jefferson Park Drainageway at Germantown, WI	04087019	1.82	1976-78
Menomonee River at Butler, WI	04087040	60.6	1975-79
Little Menomonee River near Freistadt, WI	04087050*	8.0	1975-79
Noyes Creek at Milwaukee, WI	04087060	1.94	1975-80, 1990
Little Menomonee River at Milwaukee, WI	04087070	19.7	1975-77
Honey Creek at Wauwatosa, WI	04087119	10.3	1975-81
Schoonmaker Creek at Wauwatosa, WI	04087125	1.94	1975-79
Hawley Road Storm Sewer at Milwaukee, WI	04087130	1.83	1975-77
Menomonee River at Milwaukee, WI	04087138	134	1982-84
Kinnickinnic River at Milwaukee, WI	04087160	20.4	1976-83
ST. CROIX RIVER BASIN			
Namekagon River at Trego, WI	05332000	433	1914-27
Loon Creek near Danbury, WI	05335010	17.6	1970-71
Bashaw Brook near Shell Lake, WI	05335380*	26.6	1964-66
Clam River near Webster, WI	05335500	361	1941-42
St. Croix River near Grantsburg, WI	05336000	2,980	1923-70
Wood River near Grantsburg, WI	05339000	185	1939-40
Rice Creek near Balsam Lake, WI	05341375	12.5	1988-89
Balsam Branch at Balsam Lake, WI	05341402	52.8	1988-90
Kinnickinnic River near River Falls, WI	05342000	165	1917-21
CHIPPEWA RIVER BASIN			
West Fork Chippewa River at Lessards, nr Winter, WI	05355500	474	1912-16
Couderay River near Couderay, WI	05356121	169	1981-83
Flambeau River at Flambeau Flowage (Flambeau Reservoir), WI	05357500	622	1927-61
Flambeau River near Butternut, WI	05356000	688	1914-39
Pine Creek near Oxbo, WI	05356300	38.9	1971-75
Flambeau River at Babbs Island near Winter, WI	05356500	967	1929-75
South Fork Flambeau River near Phillips, WI	05359500	609	1929-75
Price Creek near Phillips, WI	05359600*	16.9	1964-66
Flambeau River near (at) Ladysmith, WI	05360000	1,790	1903-06, 1914-61
Chippewa River near Holcombe, WI	05361000	3,720	1944-49
South Fork Jump River near Ogema, WI	05361500	327	1944-54
Chippewa River at Holcombe, WI	05362500	4,680	1943-49
Fisher River at (near) Holcombe, WI	05363000	81.5	1944-45
O'Neil Creek near Chippewa Falls, WI	05363500	78.1	1944-45
Yellow River near Hannibal, WI	05363700	86.7	1982-63
Yellow River at Cadott, WI	05364000*	364	1943-61
Duncan Creek at Bloomer, WI	05364500*	50.3	1944-52
Duncan Creek Tributary near Tilden, WI	05364850	4.17	1987-89
Duncan Creek at Chippewa Falls, WI	05365000	117	1943-55
Eau Claire River near Augusta, WI	05366000	509	1914-26
Bridge Creek at Augusta, WI	05366300	35.0	1980
Eau Claire River near Fall Creek, WI	05366500*	760	1943-55
Chippewa River at (near) Eau Claire, WI	05367000	6,620	1903-09, 1944-54
Red Cedar River near Cameron, WI	05367425	442	1966-70
Red Cedar River near Cameron, WI	05367426	443	1971-73
Red Cedar River near Colfax, WI	05367500	1,100	1914-80, 1989-90
Eau Galle River near Woodville, WI	05369900	39.4	1978-83
French Creek near Spring Valley, WI	05369955	6.03	1981-83
Lousy Creek near Spring Valley, WI	05369970	5.97	1981-83
Lohn Creek near Spring Valley, WI	05369985	2.53	1981-83
Eau Galle River at Elmwood, WI	05370500	91.6	1943-54
BUFFALO RIVER BASIN			
Buffalo River near Tell, WI	05372000	406	1933-51
TREMPEALEAU RIVER BASIN			
Bruce Valley Creek near Pleasantville, WI	05379288	10.1	1980
Elk Creek near Independence, WI	05379305	108	1980
Trempealeau River at Arcadia, WI	05379400	553	1960-77
Trempealeau River near Trempealeau, WI	05380000	719	1932-34

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
BLACK RIVER BASIN			
Black River at Medford, WI	05380806	48.1	1984-87
Poplar River near Owen, WI	05380900*	155	1964-66
LA CROSSE RIVER BASIN			
Little LaCrosse River near Leon, WI	05382500	76.9	1934-61, 1979-81
LaCrosse River near West Salem, WI	05383000	396	1914-70
COON CREEK BASIN			
Spring Coulee Creek near Coon Valley, WI	05386490	9.01	1979-81
Coon Creek at Coon Valley, WI	05386500	77.2	1934-40, 1978-81
Coon Creek near Stoddard, WI	05386999	120	1934-40, 1979-81
BAD AXE RIVER BASIN			
North Fork Bad Axe River near Genoa, WI	05387100*	80.8	1964-66
WISCONSIN RIVER BASIN			
Wisconsin River at Conover, WI	05390180	177	1967-71
Pelican River near Rhinelander, WI	05391226	101	1976-79
Wisconsin River at Whirlpool Rapids, near Rhinelander, WI	05392000	1,220	1906-61
Bearskin Creek near Harshaw, WI	05392350*	31.1	1964-66
Tomahawk River near Bradley, WI	05392400	422	1915-27, 1929
Tomahawk River at Bradley, WI	05393000	544	1930-73
New Wood River near Merrill, WI	05394000	82.2	1953-61
Rib River at Rib Falls, WI	05396000	303	1925-57
Little Rib River near Wausau, WI	05396500	79.1	1914-16
East Branch Eau Claire River near Antigo, WI	05397000	81.5	1949-55
Eau Claire River near Antigo, WI	05397110	185	1975-81
Bull Junior Creek (Bull Creek Junior) near Rothschild, WI	05398500	27.4	1944-52
Big Eau Pleine River near Colby, WI	05399000	78.1	1941-54
Hamann Creek near Stratford, WI	05399431	11.3	1977-79
Wisconsin River at Knowlton, WI	05400000	4,530	1921-42
Plover River near Stevens Point, WI	05400500	145	1914-20, 1944-52
Little Plover River near Arnott, WI	05400600	2.24	1959-75
Little Plover River at Plover, WI	05400650	19.0	1959-87
Fourmile Creek near Kellner, WI	05400840	75.0	1964-67
Buena Vista Creek near Kellner, WI	05400653	53.1	1964-67
Tenmile Creek Ditch 5 near Bancroft, WI	05401020	9.73	1964-73
Fourteenmile Creek near New Rome, WI	05401100	91.1	1964-79
Wisconsin River near Necedah, WI	05401500	5,990	1903-14, 1944-50
Big Roche a Cri Creek near Hancock, WI	05401510	9.61	1964-67
Big Roche a Cri Creek near Adams, WI	05401535	52.8	1964-78
Yellow River at Sprague, WI	05402500	392	1927-40
Yellow River at Necedah, WI	05403000	491	1941-57
Lemonweir River at New Lisbon, WI	05403500	507	1944-87, 1994
Hulbert Creek near Wisconsin Dells, WI	05403630*	11.2	1971-77
Dell Creek near Lake Delton, WI	05403700*	44.9	1957-65, 1971-80
Narrows Creek at Loganville, WI	05404200*	40.1	1964-66
Wisconsin River at Prairie du Sac, WI	05406000	9,180	1946-54
Trout Creek at Confluence with Ameson Crk nr Bameveld, WI	05406573	8.37	1976-78
Trout Creek at Twin Parks Dam 8 nr Bameveld, WI	05406574	9.02	1976-79
Trout Creek at County Highway T nr Bameveld, WI	05406575	12.1	1976-78
Trout Creek near Ridgeway, WI	05406577	13.5	1976-79
Knight Hollow Creek near Arena, WI	05406590	7.57	1976-78
Otter Creek near Highland, WI	05406640	16.8	1968-69, 1970-75
Kickapoo River at Ontario, WI	05407500	151	1939, 1973-77
Knapp Creek near Bloomingdale, WI	05408500	8.44	1955-69
West Fork Kickapoo River near Readstown, WI	05409000	106	1939
Kickapoo River at Soldiers Grove, WI	05409500	530	1939
North Fork Nederlo Creek near Gays Mills, WI	05409830	2.21	1968-79
Nederlo Creek near Gays Mills, WI	05409890	9.46	1968-80
Kickapoo River at Gays Mills, WI	05410000	617	1914-34, 1964-77
GRANT RIVER BASIN			
Pigeon Creek near Lancaster, WI	05413400*	6.93	1964-66
Rattlesnake Creek near Beetown, WI	05413451	45.2	1990-91

Discontinued surface-water discharge stations

Station Station name	Drainage area number	(square miles)	Period of record
GALENA RIVER BASIN			
Little Platte River near Platteville, WI	05414213	79.7	1987-90
Sinsinawa River near Hazel Green, WI	05414800	24.9	1987-90
Pats Creek near Belmont, WI	05414894	5.42	1981-82
Madden Branch Tributary near Belmont, WI	05414915*	2.83	1981-82
Madden Branch near Meekers Grove, WI	05414920	15.04	1981-82
Galena River at Buncombe, WI	05415000	125	1939-92
APPLE RIVER BASIN			
Apple River near Shullsburg, WI	05418731	9.34	1981-82
ROCK RIVER BASIN			
West Branch Rock River near Waupun, WI	05423000	40.7	1949-70, 1978-81
West Branch Rock River at County Trunk Highway D near Waupun, WI	05423100	43.9	1978-81
East Branch Rock River near Mayville, WI	05424000	179	1949-70
Rock River at Hustisford, WI	05424082	511	1978-85
Johnson Creek near Johnson Creek, WI	05425537	1.13	1978-80
Johnson Creek near Johnson Creek, WI	05425539	13.3	1978-80
Pratt Creek near Juneau, WI	05425928	3.54	1978-80
Rock River at Jefferson, WI	05426031	1,850	1978-94
Whitewater Creek near Whitewater, WI	05426500	11.8	1926-28, 1946-54
Whitewater Creek at Millis Road near Whitewater, WI	05426900	20.6	1978-81
Whitewater Creek at Whitewater, WI	05427000	22.8	1926-28, 1946-54
Koshkonong Creek near Rockdale, WI	05427507	150	1977-82
Token Creek near Madison, WI	05427800*	24.3	1964-66, 1976-81
Sixmile Creek near Waunakee, WI	05427900	41.1	1976-82
Pheasant Branch at Airport Road near Middleton, WI	05427943	9.61	1977-81
South Fork Pheasant Branch at Highway 14 near Middleton, WI	05427945	5.74	1978-81
Pheasant Branch at Century Avenue at Middleton, WI	05427950	20.8	1977-81
Pheasant Branch at mouth at Middleton, WI	05427952	24.5	1978-81
Willow Creek at Madison, WI	05427970	3.15	1974-83
Olbrich Park Storm Ditch at Madison, WI	05428665	2.57	1976-80
Manitou Way Storm Sewer at Madison, WI	05429040	0.23	1971-77
Nakoma Storm Sewer at Madison, WI	05429050	2.30	1972-77
Lake Wingra Outlet at Madison, WI	05429120	6.00	1971-77
Door Creek near Cottage Grove, WI	05429580	15.3	1976-79
Yahara River near Edgerton, WI	05430000	430	1917-18
Oregon Branch at Oregon, WI	05430030	9.93	1979-81
Badfish Creek at County Highway A near Stoughton, WI	05430095	41.9	1956-66, 1986-88
Badfish Creek near Stoughton, WI	05430100	41.3	1956-66
Livingston Branch, Pecatonica River near Livingston, WI	05432055	16.4	1987-91
Yellowstone River near Blanchardville, WI	05433500*	28.5	1954-65, 1978-79
Pecatonica River at Dill, WI	05434000	944	1914-19
Steiner Branch near Waldwick, WI	05433510	5.9	1978-79
Skinner Creek at Skinner Hollow Road near Monroe, WI	05434235	32.6	1978-81
Skinner Creek at Klondyke Road near Monroe, WI	05434240	35.0	1978-81
West Branch Sugar River near Mount Vernon, WI	05435980	32.7	1979-80
Mount Vernon Creek near Mount Vernon, WI	05436000	16.4	1954-65, 1976-80
ILLINOIS RIVER BASIN			
White River near Burlington, WI	05545300	110	1964-66, 1973-78

COLLECTION OF BASIC RECORDS–GROUND WATER, WI 002

PROBLEM: Ground-water data are needed to better determine short-term changes and long-term trends in ground-water levels in the State. It is important to know if these changes are natural or man-induced and how these changes are effecting storage in the ground-water reservoirs.

OBJECTIVE: The objective is to maintain records of ground-water-level fluctuations from a network of observation wells representative of Wisconsin's principal aquifers.

APPROACH: A basic network of about 195 wells is being maintained. The network will be constantly modified and improved to provide the best possible coverage of our ground-water resource. A subnetwork of key wells is included in this network. Key wells have long periods of record and are measured weekly or are equipped with continuous recorders.

PROGRESS (July 1994 to June 1995): Additional computer programs were written and are being used to make data entry of water levels more efficient. Local observers were visited and hired to collect water-level data. Several wells were destroyed or discontinued from the network and were replaced with new ones. Data for the annual report, "Water Resources Data-Wisconsin, water year 1994", was completed. Several digital recorders were replaced with state-of-the-art data loggers. Slug tests and geophysical logs were completed for selected network wells to improve the quality of the network.

PLANS (July 1995 to June 1996): Plans include: (1) Continue measurements on observation-well network, (2) replace and hire new observers and make quality-assurance checks when possible, (3) have water-level information available on computer disk for individuals requesting these types of data, (4) install observation wells where needed, (5) replace all remaining digital recorders with state-of-the-art data loggers, and (6) slug test and geophysically log about 60 network wells.

REPORTS:

Patterson, G.L., and Zaporozec, A., 1988, Analysis of water-level fluctuations in Wisconsin wells: Wisconsin Geological and Natural History Survey Information Circular 63.

Erickson, R.M., and Cotter, R.D., 1983, Trends in ground-water levels in Wisconsin through 1981: Wisconsin Geological and Natural History Survey Information Circular No. 43.

Erickson, R.M., 1972, Trends in ground-water levels in Wisconsin, 1967-71: Wisconsin Geological and Natural History Survey Information Circular No. 21.

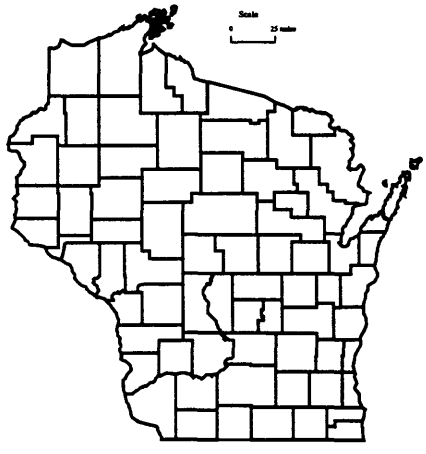
Devaul, R.W., 1967, Trends in ground-water levels in Wisconsin through 1966: Wisconsin Geological and Natural History Survey Information Circular No. 9.

COOPERATOR:
Wisconsin Geological and Natural History Survey

LOCATION:
Statewide

PROJECT CHIEF:
Bernie R. Ellefson

PERIOD OF PROJECT:
July 1946-Continuing



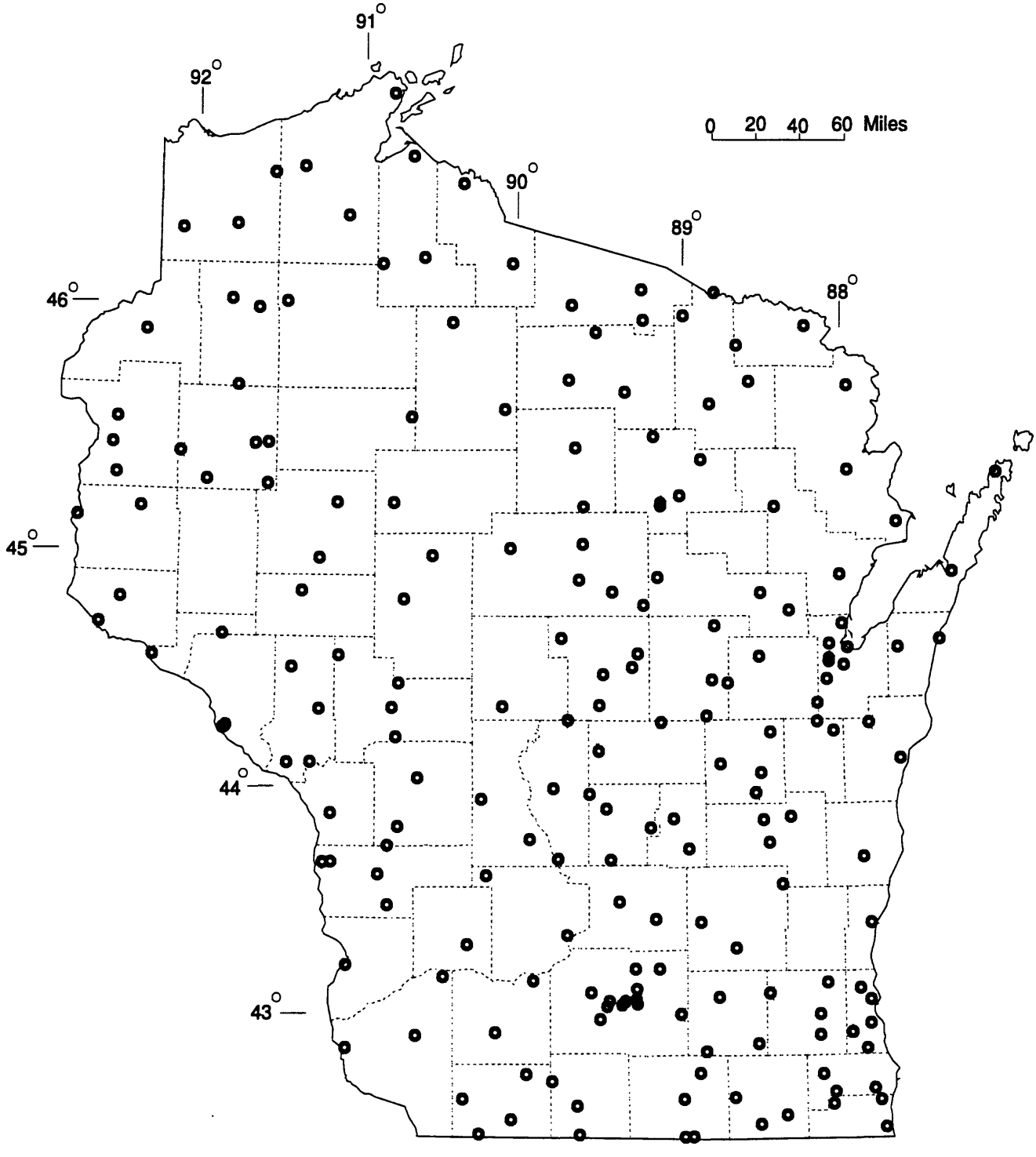


Figure 9. Location of network observation wells.

COLLECTION OF BASIC RECORDS–WATER QUALITY, WI 003

PROBLEM: A long-term base of water-quality data is needed for regional water-quality assessment and water-resource planning.

OBJECTIVE: The Federal program consists of the National Stream Quality Accounting Network (NASQAN) and the Hydrologic Benchmark Network (HBMN). The objectives of the NASQAN program are to (1) account for the quantity and quality of water moving within and from the United States, (2) depict areal water-quality variability, and (3) detect changes in stream quality with time. The objective of the HBMN program is to monitor hydrologic characteristics at sites where they are relatively unaffected by man's activities and will remain unaffected for the foreseeable future.

APPROACH: Chemical, bacteriological, and physical water-quality data are systematically collected at fixed-time intervals at stations for NASQAN and HBMN. Data collected is the same for both programs and includes measurements of water temperature, specific conductance, pH, and concentrations of dissolved oxygen, plant nutrients, common mineral constituents, trace constituents, fecal bacteria, and suspended sediment.

PROGRESS (July 1994 to June 1995): Data were collected bimonthly at NASQAN stations on the Wisconsin and Grant Rivers, five times annually at stations on the Chippewa and Black Rivers, and quarterly at stations on the Fox (Green Bay), Manitowoc, and Milwaukee Rivers through the end of the 1994 water year (September 30, 1994). Data were collected quarterly at the HBMN station on the Popple River. Radiochemical data were collected semiannually at the Chippewa and Popple River stations.

A redesign of the NASQAN program that emphasizes mass transport of dissolved and suspended material and water-quality conditions for a considerably-reduced number of stations was implemented at the beginning of the 1995 water year. The redesigned network includes mostly coastal and large river basins and does not include any stations in Wisconsin. All NASQAN stations in Wisconsin were discontinued at the end of the 1994 water year.

Data collected during the 1994 water year were processed for publication in the annual data release "Water Resources Data-Wisconsin, water year 1994."

Work began on a report that will summarize historical data from the NASQAN network and the Wisconsin Department of Natural Resources' ambient monitoring stations.

PLANS (July 1995 to June 1996): Data collection will continue at the HBMN station on the Popple River. The summary of historical water-quality monitoring data will be completed.

COOPERATOR:
Federal Program

LOCATION:
Statewide

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
July 1964-Continuing

INTERGOVERNMENTAL TASK FORCE ON MONITORING–WISCONSIN WATER RESOURCES COORDINATION PILOT PROJECT, WI 00301

COOPERATOR:
Federal Program
(Interagency Personnel Agreement with the Wisconsin Department of Natural Resources)

LOCATION:
Statewide

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
August 1993 to March 1996

PROBLEM: Protocols for water-sample collection and processing for USGS and the Wisconsin Department of Natural Resources water-quality monitoring programs in Wisconsin differ, and samples from each agency are analyzed by different laboratories. There are no data available to show whether or not the differences in sample collection and processing protocols cause differences in monitoring results.

OBJECTIVE: The objective of this study is to identify interagency differences in monitoring results caused by differences in sample collection and processing protocols.

APPROACH: Concurrent samples are collected by both agencies at visits to three stream sites and one lake site, split between laboratories, and analyzed in triplicate for concentrations of a suite of constituents common to their respective monitoring programs. The constituents chosen for analysis are total phosphorus, dissolved orthophosphate, dissolved chloride and suspended sediment/ suspended solids for streams and total phosphorus, dissolved orthophosphate and chlorophyll *a* for the lake. For streams, two sample-collection methods (flow-integrated sampling and grab sampling) were compared for a range of flow conditions. Laboratories used in the study are the USGS National Water Quality Laboratory and the Wisconsin State Laboratory of Hygiene.

PROGRESS (July 1994 to June 1995): Data collection was completed.

For streams, there were no statistically significant (p=0.05) concentration differences between sampling methods for total phosphorus, dissolved orthophosphorus, or dissolved chloride for any of the flow conditions sampled. There were significant concentration differences between sampling methods for suspended sediment and total suspended solids for some high-flow samples. Where there were differences, concentrations were higher in flow-integrated samples than in grab samples. Concentrations of total phosphorus, dissolved orthophosphorus, and dissolved chloride differed significantly and consistently between laboratories. Differences in concentrations of dissolved orthophosphorus between samples filtered in the field and samples filtered in the laboratory were not significant.

PLANS (July 1995 to June 1996): Data analysis will be completed and an interpretive report describing the results of the study will be prepared.

COLLECTION OF BASIC RECORDS–DANE COUNTY PROGRAM, WI 00302

PROBLEM: A long-term base of water-quality data is needed for water-resource planning and assessment of water quality in the lakes and streams of Dane County.

OBJECTIVE: The objectives of this program are to determine suspended-sediment and phosphorus loads on selected tributaries to Lake Mendota and to collect data to identify long-term changes in base-flow water quality in selected streams in Dane County.

APPROACH: Streamflow-monitoring stations with automatic water-quality samplers are operated on three tributaries to Lake Mendota. Samples for analysis of suspended-sediment and phosphorus concentrations are collected at low flow and during periods when surface runoff is entering the streams. The concentration and streamflow data are used to compute annual suspended-sediment and total-phosphorus load for selected stations.

PROGRESS (July 1994 to June 1995): Suspended-sediment loads for Spring Harbor Storm Sewer at Madison and Pheasant Branch at Middleton, and suspended-sediment and total-phosphorus loads for the Yahara River at Windsor were computed for the 1994 water year. Continuous-streamflow data were collected at all three stations.

Streamflow, load and concentration data were published in the annual data report "Water Resources Data-Wisconsin, water year 1994."

Collection of water-quality data at base flow at sites on two streams began in April 1995.

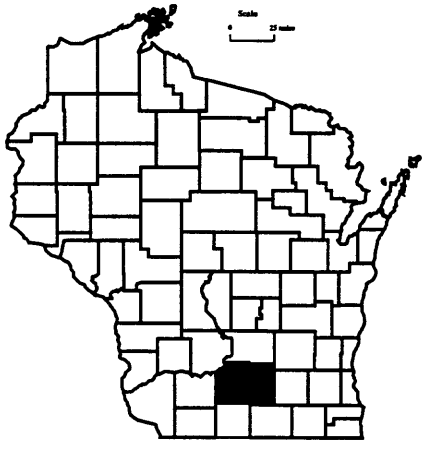
PLANS (July 1995 to June 1996): Continue data collection and processing at the three stations on tributaries to Lake Mendota and the two base-flow sampling sites.

COOPERATOR:
Dane County Regional Planning Commission

LOCATION:
Dane County, Wisconsin

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
Continuing



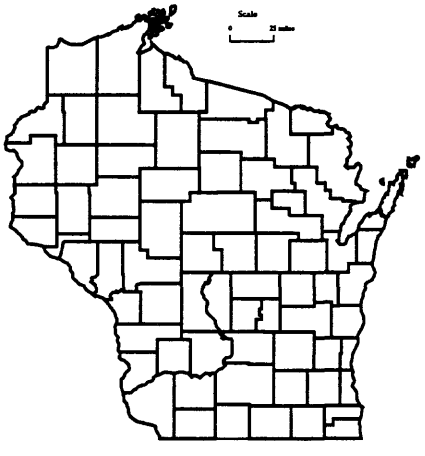
COLLECTION OF BASIC RECORDS–SEDIMENT, WI 004

COOPERATORS:
Wisconsin Department of Natural Resources
U.S. Army Corps of Engineers
Dane County Regional Planning Commission

LOCATION:
Statewide

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
March 1968-Continuing



PROBLEM: Water-resources planning and water-quality assessment require a knowledge of the quantity and quality of sediment being transported in rivers and streams in Wisconsin.

OBJECTIVE: This project will provide sediment data for use in specific planning and action programs and will develop a data base for determining trends in sediment discharge and yield. Streams will be characterized according to range of concentration and particle size of suspended sediment.

APPROACH: Sediment-monitoring stations will be operated at selected stream sites throughout the State, including sites of specific interest to cooperating agencies.

The extent of monitoring at a given site will depend on the characteristics of the basin and the needs of the cooperating agency. Some sites will be sampled manually at infrequent intervals; other sites, where flow responds rapidly to precipitation, will be sampled by automatic samplers.

At sites where bedload or unmeasured sediment discharge may be a significant part of the total sediment discharge, suspended- and bed-sediment particle size will be determined from samples collected concurrently with hydraulic data. These data will be used to estimate total sediment discharge using one of several techniques such as the modified Einstein procedure.

PROGRESS (before July 1993): Sediment data have been collected at more than 200 stream sites in Wisconsin since 1968. The sampling intensity and length of sampling period varies considerably from site to site. At some sites, only a few samples a year were collected at irregular intervals for concentration analysis; at other sites, hundreds of samples per year were collected with stage-activated automatic samplers. Suspended and bed-material particle-size data are available for many of the sites. Except for data collected as part of the National Stream Quality Accounting Network program, data collection at most sites has been of relatively short (less than 4 years) duration. Most sediment data collection has been in the southern one-third of the State and associated with local special problem studies except for about a five-year period in the early 1970's when there was a Statewide network of sediment monitoring stations. All data have been published annually in the data report, "Water Resources Data-Wisconsin."

PROGRESS (July 1994 to June 1995): The 1994 monitoring program is as follows:

CORPS OF ENGINEERS–Suspended sediment was sampled at the Grant River at Burton. Daily loads were determined from these data.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES (WDNR)–A study whose objective was to estimate the coarse-material sediment load at three sites on North Fork Fish Creek near Ashland, Wisconsin, began on July 1, 1989. Monitoring for this study was completed in October 1991. Preliminary load estimates have been provided to the WDNR. The report summarizing the study is in the review stage.

PLANS (July 1995 to June 1996):

CORPS OF ENGINEERS–Operation of the Grant River monitoring station will continue.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES–The brief report summarizing the results of the North Fork Fish Creek study will be completed.

Efforts will continue to establish a long-term sediment-monitoring network. About 10 sites areally distributed to sample runoff from the major geographic provinces would provide an adequate network.

REPORTS:

Rose, William J., 1992, Sediment transport, particle sizes, and loads in the lower reaches of the Chippewa, Black, and Wisconsin Rivers in western Wisconsin, U.S. Geological Survey Water-Resources Investigations Report 90-4124, 38 p.

Rose, William J., and Graczyk, David J., Sediment transport, particle size, and loads in North Fish Creek in Bayfield County, Wisconsin, 1989-91 (in review).

FEMA FLOOD-INSURANCE STUDY, WI 006

COOPERATOR:
Federal Emergency Management Agency

LOCATION:
Statewide

PROJECT CHIEF:
Todd D. Stuntebeck

PERIOD OF PROJECT:
March 1984-Continuing

PROBLEM: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide for the operation of a flood-insurance program. The Federal Emergency Management Agency (FEMA) needs flood studies in selected areas to determine applicable flood-insurance premium rates.

OBJECTIVE: Hydrologic and hydraulic analyses will be performed in order to complete flood-insurance studies at communities selected by FEMA.

APPROACH: Flood-discharge frequency relations will be determined from local historical information, gaging station records, or other applicable information. Water-surface profiles will be produced by using step-backwater models or by other acceptable methods and the results will be published in reports prepared according to FEMA specifications.

PROGRESS (July 1994 to June 1995): Limited map maintenance (LMM) restudy was completed for the city of LaCrosse. Surveying for Fond du Lac County study was started and the initial budget proposal for LaCrosse County was submitted.

PLANS (July 1995 to June 1996): Respond to review comments on completed studies and answer data requests as needed. Work will be continued on Fond du Lac County study, and hydrologic analyses and surveying for LaCrosse County will begin.

WISCONSIN WATER-USE DATA FILE, WI 007

PROBLEM: The need for reliable water-use data by State and Federal planning agencies is increasing as the competition for use of the State's water resources increases. Water-use data in a standardized format needs to be available to assist in making decisions on future water use.

OBJECTIVE: The purpose of this project is to collect accurate and complete data on Wisconsin's water use, to store data in the State Water-Use Data System (SWUDS), and to prepare periodic reports on water use in the State.

APPROACH: Sources of water-use information will be evaluated. The best available data will be entered into the SWUDS. Efforts will be made to upgrade the accuracy of the water-use data.

PROGRESS (July 1994 to June 1995): The SWUDS was updated with current water-use information. These data included high-capacity well data and information on discharge from sewage-treatment plants in the State. Reformatting programs were written or updated as needed for entering data from other agencies into SWUDS.

PLANS (July 1995 to June 1996): Plans include (1) continue to update and maintain the SWUDS data base with current water-use data, (2) explore the possibility of a cooperative project with Wisconsin Department of Natural Resources to meter selected industrial users to better estimate consumptive water use, (3) supply water-use data for water-resources studies currently being conducted in the State, and (4) start data collection for the 1995 water-use publication, "Water use in Wisconsin, 1995".

REPORTS:

Ellefson, B.R., Sabin, T.J., Krohelski, J.T., 1993, Water use in Wisconsin, 1990: U.S. Geological Survey Open-File Report 93-118, 1 sheet, scale 1:5,000,000.

Ellefson, B.R., Rury, K.S., and Krohelski, J.T., 1988, Water-use in Wisconsin, 1985: U.S. Geological Survey Open-File Report 87-699, 1 sheet, scale 1:5,000,000.

U.S. Geological Survey, 1990, National Water Summary, 1987–Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

Krohelski, J.T., Ellefson, B.R., and Storlie, C.A., 1987, Estimated use of ground water for irrigation in Wisconsin, 1984: U.S. Geological Survey Water-Resources Investigations Report 86-4079, 12 p., 1 pl.

Lawrence, C.L., and Ellefson, B.R., 1984, Public-supply pumpage in Wisconsin, by aquifer: U.S. Geological Survey Open-File Report 83-931, 40 p.

____,1982, Water use in Wisconsin, 1979: U.S. Geological Survey Open-File Report 82-444, 98 p.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Statewide

PROJECT CHIEF:
Bernie R. Ellefson

PERIOD OF PROJECT:
March 1978-Continuing

LOW FLOW AT OUTFALL SITES, WI 035

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Selected sites throughout Wisconsin

PROJECT CHIEF:
Barry K. Holmstrom

PERIOD OF PROJECT:
April 1972-Continuing

PROBLEM: Water-quality standards have been adopted for all surface waters of the State. To implement these standards, the Wisconsin Department of Natural Resources (WDNR) has to evaluate the sewage effluent from all waste sources in relation to the low-flow characteristics of the receiving stream. Water-quality standards in Wisconsin are based on a number of streamflow characteristics. These include the annual minimum 7-day consecutive mean flow that occurs on the average of once every 2 years ($Q_{7,2}$) and once every 10 years ($Q_{7,10}$), the annual minimum 30-day consecutive mean flow that occurs on the average of once every 5 years ($Q_{30,5}$), $Q_{7,10}$ values for selected months ($Q_{7,10}$-month), 10-year low mean monthly flows for October, November, April, and May, and the mean annual discharge.

OBJECTIVE: The purpose of this study is to determine the following streamflow characteristics:

1. $Q_{7,10}$ for receiving streams at sewage-treatment plants and industrial plants discharging wastes.
2. $Q_{7,2}$ for selected streams.
3. The 10-year low mean monthly flows for October (Oct. MMQ_{10}), November (Nov. MMQ_{10}), April (Apr. MMQ_{10}), and May (May MMQ_{10}) for sites at fill-and-draw wastewater-treatment lagoons or waste-stabilization ponds.
4. $Q_{30,5}$ for selected streams.
5. The mean annual discharge (MAQ) for selected streams.
6 $Q_{7,10}$ for selected months for selected streams.

APPROACH: Low-flow characteristics of selected streams will be determined by drainage-area/discharge relations, graphical-regression methods, regression equations, Log-Pearson Type III frequency analysis, and other statistical and graphical methods.

PROGRESS (July 1994 to June 1995): Low-flow estimates were determined at approximately 65 sites in response to requests for information from the Surface Waters and Monitoring Section of the WDNR.

PLANS (July 1995 to June 1996): Low-flow characteristics at approximately 50 sites will be determined in response to DNR requests for information. The low-flow characteristics, in most instances, will be determined by drainage-area/discharge relations or by regression equations. Biological design flows and other flow characteristics may also be determined.

REPORTS:

Holmstrom, B.K., 1979, Low-flow characteristics of Wisconsin streams at sewage-treatment plants and industrial plants: U.S. Geological Survey Water-Resources Investigations 79-31, 123 p.

Gebert, W.A., and Holmstrom, B.K., 1974, Low-flow characteristics of Wisconsin streams at sewage-treatment plants: U.S. Geological Survey Water-Resources Investigations 45-74, 101 p.

REGIONAL FLOOD-FREQUENCY STUDY FOR URBAN AND RURAL STREAMS IN WISCONSIN, WI 109

PROBLEM: Flood-frequency estimates are required at many sites for bridge and culvert design, as well as for flood-plain management and flood-insurance studies. Most sites at which such estimates are required do not have records of flood peaks.

OBJECTIVES:

1. Develop improved regression equations for the State of Wisconsin.
2. Analyze and improve the network of crest-stage gages to obtain better data for developing improved regression equations.

APPROACH: The GLSNET program will be used to analyze the crest-stage-gage network. The goal of this analysis will be to determine how to get the most regional flood information from a network of about 100 crest-stage gages. Some stations have been dropped from the network and new stations will be added as a result of this analysis and discussions with the cooperators about areas where the information is most needed.

PROGRESS (July 1994 to June 1995): A journal article was published giving the results of the model study on the Coon Creek basin. Annual flood peaks were computed and published in the annual data report at 66 crest-stage stations. New stations are being installed in areas where the cooperator indicated the greatest need for more information on flooding. Significant effort has been made in measuring flood discharges at crest gages and improving ratings at crest gages. Flood frequency was recomputed using data through 1993.

PLANS (July 1995 to June 1996): The crest-stage-gage network will be monitored with changes starting this year. New gages will have ratings developed for them as measurements and surveys are available. Significant effort will be made to improve ratings at all of the gages.

REPORTS:

Krug, W.R., 1992, Simulation of temporal changes in rainfall-runoff characteristics, Coon Creek Basin, Wisconsin.

Krug, W.R., Conger, D.H., and Gebert, W.A., 1992, Flood-frequency characteristics of Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Report 91-4128, 185 p., 2 pls.

Conger, D.H., 1986, Estimating magnitude and frequency of floods for Wisconsin urban streams: U.S. Geological Survey Water-Resources Investigations Report 86-4005, 18 p.

Conger, D.H., 1981, Techniques for estimating magnitude and frequency of floods for Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Open-File Report 80-1214, 116 p., 2 pls.

Conger, D.H., 1971, Estimating magnitude and frequency of floods in Wisconsin: U.S. Geological Survey Open-File Report, 200 p.

COOPERATOR:

Wisconsin Department of Transportation-Highways

LOCATION:

Statewide

PROJECT CHIEF:

William R. Krug

PERIOD OF PROJECT:

July 1985-Continuing

LIST OF CREST-STAGE GAGES

CHIPPEWA RIVER BASIN

05357360 Bear River near Powell, WI
05359600 Price Creek near Phillips, WI
05361400 Hay Creek near Prentice, WI
05361420 Douglas Creek near Prentice, WI
05364000 Yellow River at Cadott, WI
05364100 Seth Creek near Cadott, WI
05364500 Duncan Creek at Bloomer, WI
05366500 Eau Claire River near Fall Creek, WI
05367030 Willow Creek near Eau Claire, WI
05367700 Lightning Creek at Almena, WI
05370900 Spring Creek near Durand, WI

CENTRAL WISCONSIN RIVER BASIN

05395020 Lloyd Creek near Doering, WI
05395100 Trappe River Tributary near Merrill, WI
05396300 Wisconsin River Tributary at Wausau, WI
05397600 Big Sandy Creek near Wausau, WI
05400025 Johnson Creek near Knowlton, WI
05401800 Yellow River Tributary near Pittsville, WI
05403700 Dell Creek near Lake Delton, WI

FOX-WOLF RIVER BASIN

04073400 Bird Creek at Wautoma, WI
04074850 Lily River near Lily, WI
04075200 Evergreen Creek near Langlade, WI
04079700 Spaulding Creek near Big Falls, WI
04081900 Sawyer Creek at Oshkosh, WI

LAKE MICHIGAN BASIN

04085400 Killsnake River near Chilton, WI
04087100 Honey Creek at Milwaukee, WI
04087200 Oak Creek near South Milwaukee, WI
04087250 Pike Creek near Kenosha, WI

LAKE SUPERIOR BASIN

04024400 Stony Brook near Superior, WI
04025200 Pearson Creek near Maple, WI
04026200 Sand River Tributary near Red Cliff, WI
04026300 Sioux River near Washburn, WI
04026450 Bad River near Mellen, WI
04027200 Pearl Creek at Grandview, WI

LOWER WISCONSIN RIVER BASIN

05405600 Rowan Creek at Poynette, WI
05407200 Crooked Creek near Boscobel, WI

MENOMINEE-OCONTO-PESHTIGO RIVER BASIN

04059900 Allen Creek Tributary near Alvin, WI
04063640 North Branch Pine River at Windsor Dam near Alvin, WI
04067760 Peshtigo River near Cavour, WI
04067800 Armstrong Creek near Armstrong Creek, WI
04069700 North Branch Oconto River near Wabeno, WI
04071700 North Branch Little River near Coleman, WI
04071800 Pensaukee River near Pulaski, WI

PECATONICA-SUGAR RIVER BASIN

05413400 Pigeon Creek near Lancaster, WI
05414213 Little Platte River near Platteville, WI
05414900 Pats Creek near Elk Grove, WI
05432300 Rock Branch near Mineral Point, WI
05433500 Yellowstone River near Blanchardville, WI
05436200 Gill Creek near Brooklyn, WI

ROCK-FOX RIVER BASIN

05430403 Fisher Creek Tributary at Janesville, WI
05431400 Little Turtle Creek at Allens Grove, WI
05545100 Sugar Creek at Elkhorn, WI
05545200 White River Tributary near Burlington, WI
05548150 North Branch Nippersink Creek Tributary near Genoa City, WI

ST. CROIX RIVER BASIN

05340300 Trade River near Frederic, WI
05341900 Kinnickinnic River Tributary at River Falls, WI

TREMPEALEAU-BLACK RIVER BASIN

05371800 Buffalo River Tributary near Osseo, WI
05371920 Buffalo River near Mondovi, WI
05380900 Poplar River near Owen, WI
05380970 Cawley Creek near Neillsville, WI
05382200 French Creek near Ettrick, WI
05387100 North Fork Bad Axe River near Genoa, WI

UPPER WISCONSIN RIVER BASIN

05391260 Gudegast Creek near Starks, WI
05391950 Squaw Creek near Harrison, WI
05392150 Mishonagon Creek near Woodruff, WI
05392350 Bearskin Creek near Harshaw, WI
05393640 Little Pine Creek near Irma, WI
05394200 Devil Creek near Merrill, WI

Figure 10. Location of crest-stage-gage data-collection stations.

LAKE WATER-QUALITY MONITORING, CHEMICAL AND BIOLOGICAL MONITORING OF SELECTED LAKES, WI 133

LOCATION:
Selected lakes in Wisconsin

PROJECT CHIEF:
Stephen J. Field

PERIOD OF PROJECT:
June 1983-Continuing

COOPERATORS:
In the 1994 water year:
Big Muskego, Little Muskego, Fowler, Wind, Okauchee, Alma/Moon, Balsam, Druid, Eagle, Potter, Wolf, Pretty, Little Arbor Vitae, Little Green, Little St. Germain, Loon and Powers Lake Districts; town of Cedar Lake (Balsam, Red Cedar and Hemlock Lakes), village of Oconomowoc Lake (Oconomowoc Lake); Wisconsin Department of Justice (Big Sissabagama Lake); town of Norway (Kee-Nong-Go-Mong and Waubeesee Lakes); Eagle Spring Lake Management District, city of Muskego (Denoon Lake); town of Mead (Mead Lake); town of Merton (Keesus Lake); Marinette County Soil and Water Conservation District (Lake Noquebay); village of Lake Nebagamon (Lake Nebagamon); town of Summit (Silver Lake); town of Troy (Booth Lake); and town of St. Germain (Big St. Germain Lake)

In the 1995 water year:
Big Muskego, Little Muskego, Fowler, Wind, Okauchee, Alma/Moon, Upper Nemahbin, Druid, Eagle, Potter, Wolf, Pretty, Little Arbor Vitae, Little Green, Little St. Germain, Montello, Powers, and Twin (Marie and Elizabeth) Lake Districts; village of Oconomowoc Lake (Oconomowoc Lake); Wisconsin Department of Justice (Big Sissabagama Lake); town of Norway (Kee-Nong-Go-Mong and Waubeesee Lakes); Eagle Spring Lake Management District, city of Muskego (Denoon Lake); town of Mead (Mead Lake); town of Merton (Keesus Lake); village of Lake Nebagamon (Lake Nebagamon); town of Summit (Silver Lake); town of St. Germain (Big St. Germain Lake); town of Auburn (Forest Lake); and town of Waterford (Tichigan Lake)

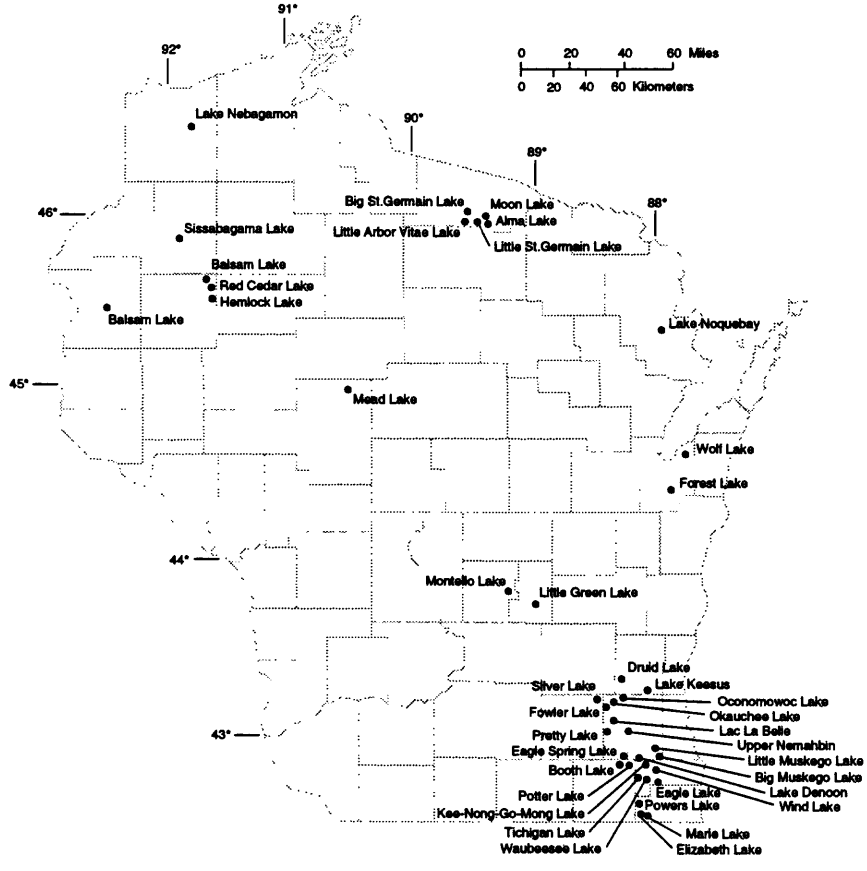
PROBLEM: Lakes are a valuable resource in the State of Wisconsin and their water quality needs documentation.

OBJECTIVE: The objective of this project is to determine lake stage and water quality at selected lakes throughout Wisconsin and, through a continuous monitoring program, provide data to detect chemical or biological changes that may take place.

APPROACH: Water quality at each lake will be monitored in February, April, June, July, and August. Depth profiles of dissolved-oxygen concentration, temperature, pH, and specific conductance will be determined. In April, the lakes will be sampled at the top and bottom for analysis of the major anions and cations, nitrogen, and dissolved phosphorus. Secchi-disc readings will be made for all months (except February), and total phosphorus and chlorophyll *a* samples will be collected and analyzed. Weekly stage readings of the lake level will be obtained at all visits.

PROGRESS (July 1994 to June 1995): In the 1994 water year, total phosphorus, chlorophyll *a*, dissolved oxygen, temperature, pH, specific conductance, and Secchi-depth data were collected and analyzed at Big Muskego, Little Muskego, Fowler, Wind, Okauchee, Powers, Oconomowoc, Big Sissabagama, Kee-Nong-Go-Mong, Waubeesee, Balsam, Eagle Springs, Denoon, Druid, Keesus, Lac La Belle, Little Arbor Vitae, Little Green, Little St. Germain, Loon, Mead, Noquebay, Nebagamon, Moon, Alma, Silver, Booth, Big St. Germain, Eagle, Potter, Wolf, Pretty, Red Cedar, Balsam, Forest, Upper Nemahbin, Tichigan and Hemlock Lakes. A letter evaluating the water quality of each lake was sent to the respective cooperator. In the 1995 water year, Montello and Twin (Marie and Elizabeth) Lakes were added to the program. Balsam, Booth and Noquebay Lakes and the town of Cedar Lake (Balsam, Red Cedar, Hemlock Lakes), discontinued the program. The locations of lakes included in the monitoring program for water years 1994-95 are shown on the following map.

PLANS (July 1995 to June 1996): In the 1995 water year, 35 lakes will be monitored. We will compile the data and transmit it to the respective cooperator after the August monitoring. The data will be prepared for publication in the annual report "Water Resources Data–Wisconsin, water year 1995."



OCCURRENCE, TRANSPORT, AND SIMULATION OF PCB'S IN THE LOWER FOX RIVER, WI 145

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Lower Fox River, East Central Wisconsin

PROJECT CHIEF:
Jeffrey J. Steuer

PERIOD OF PROJECT:
July 1985 to June 1995

PROBLEM: Polychlorinated biphenyls (PCB's) in the Lower Fox River have been identified and classified as "in-place pollutants" by the Wisconsin Department of Natural Resources (WDNR) due to the high concentrations found in the bottom sediments (up to 250 milligrams per kilogram). These PCB deposits are believed to be a significant source of continuing PCB loading to Green Bay and Lake Michigan. The WDNR is developing a remedial action plan to reduce the PCB presence in the Fox River and Green Bay. Information is needed regarding the location of PCB deposits and transport rate of PCB's within the Fox River to support this remedial action effort.

OBJECTIVE: The objectives of this study are to estimate the total mass of PCB's present in the study reach bottom sediments, compute the total PCB load carried by the river, and simulate present and future PCB transport in the river. The study is being coordinated with and will compliment the U.S. Environmental Protection Agency's mass-balance study of PCB's in Green Bay.

APPROACH: Streamflow-monitoring and automated-suspended-sediment sampling equipment is installed on the Fox River between Neenah/Menasha and DePere. Fox River discharge and suspended-sediment data were collected through September 1990.

Acoustical-velocity-meter (AVM) systems were used to determine discharge in the Fox River at Appleton and DePere. Automated sediment samplers were operated at Appleton, Little Rapid, and DePere, and samples were collected on a daily basis.

Water samples were analyzed to obtain PCB concentrations with congener resolution of hundreths of a nano-gram/liter. Dissolved and particulate PCB concentrations were determined separately so the PCB partition coefficients could be computed. Water samples were also analyzed to determine total and dissolved organic carbon and other parameters. Samples were collected every two weeks, except in winter. Winter sampling was done about once per month.

The total mass of PCB's present in the study reach was estimated by use of an unconsolidated sediment thickness contour map and sediment-core analysis. The sediment cores were divided into several sections by visual inspection and analyzed for PCB concentration. Sediment cores were also analyzed to determine density of the bottom deposits.

The Water Analysis Simulation Program (WASP) model has been used to simulate PCB kinetics and transport. This modeling effort is done by a USGS employee on loan to the WDNR. Water-column data collected during the summer and fall of 1992, along with high-flow data collected during the summer of 1993, has been used to validate the transport model.

PROGRESS (July 1994 to June 1995): The WASP4 modeling effort by the USGS/WDNR has been completed, accompanied by model documentation and transference.

PLANS (July 1995 to June 1996): The project is completed. Reports will be published.

REPORTS:

House, Leo B., 1993, Distribution, concentration, and transport of polychlorinated biphenyls in Little Lake Butte des Morts, Fox River, Wisconsin 1987-88, U.S. Geological Survey Open-File Report 93-31 (pending water-supply paper).

Steuer, Jeffrey J., and others, Long-term simulation of PCB export from the Fox River to Green Bay (JA–in review).

Steuer, Jeffrey J., A deterministic PCB transport model for the Fox River between Lake Winnebago and the DePere Dam (in review).

SUPERFUND REMEDIAL RESPONSE SUPPORT, EPA REGION V, WI 164

COOPERATOR:
U.S. Environmental Protection Agency, Office of Superfund

LOCATION:
EPA-Region V (Wisconsin, Illinois, Michigan, Minnesota, Indiana and Ohio)

PROJECT CHIEF:
Ty Sabin

PERIOD OF PROJECT:
November 1988-Continuing

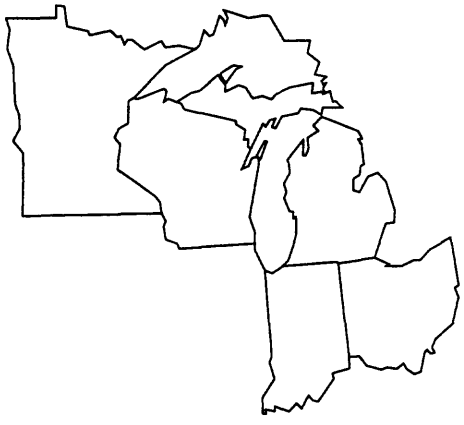
PROBLEM: The U.S. Environmental Protection Agency, Region V, has requested the Wisconsin District to provide technical assistance in the hydrogeological characterization of Superfund sites.

OBJECTIVE: The objectives are to provide the requested assistance and broaden the knowledge of ground-water hydrology in the vicinity of Superfund sites.

APPROACH: The Wisconsin District will provide hydrogeological and geophysical expertise and support to Region V-Superfund. Services, such as drilling and monitor well installation and selective formation packer tests, will be conducted upon request by EPA-Superfund throughout Region V.

PROGRESS (July 1994 to June 1995): Work was done at the following Superfund sites: Parsons Casket, Belvidere, Illinois; Byron Salvage Yard, Byron, Illinois; and Better Brite, De Pere, Wisconsin. Work included packer-testing in selected test wells to collect water-level measurements, water samples for analysis, and to run aquifer tests to determine the hydraulic conductivity at various depths in these test wells. Nested piezometers were also installed in selected test wells to provide wells for further collection of water samples as part of the Superfund efforts at these sites. A draft report of detailed data collected from a test hole at the Better Brite site was written. Included in this report are results of aquifer tests, geologic core analysis, and water-quality sampling.

PLANS (July 1995 to June 1996): Assistance will continue to be provided at sites in EPA Region V upon request. An open-file report of findings at the Better Brite test hole will be completed.



HYDROLOGIC INVESTIGATIONS OF WETLAND RESTORATION AND CREATION PROJECTS, WI 170

PROBLEM: Agencies charged with mitigating wetland acreage losses due to construction projects are increasingly turning to wetland restoration and creation as a means of meeting requirements of Section 404 of the Clean Water Act. However, the hydrology of wetlands is complex and not well understood. This lack of understanding has resulted in a low and unpredictable success rate for wetland mitigation projects.

OBJECTIVE: The overall objective of this study is to gain a better understanding of the hydrology of natural, restored, and created wetlands in order to promote a higher degree of success in wetland restoration and creation projects.

APPROACH: Detailed hydrologic investigations of restoration and creation sites will be coupled with contemporaneous study of adjoining natural wetlands. This study plan will allow us to evaluate how experimental wetlands behave relative to their natural counterparts. Test plots employed in the experimental sites will elucidate the importance of several key parameters in restoration and creation sites, and will aid in the development of guidelines for future wetland mitigation design.

PROGRESS (July 1994 to June 1995): Additional stable isotope sampling of strontium has shown that ground water from the natural wetland is more aggressive than ground water in the developing constructed wetland. Sampling of carbon species (CO_2 and CH_4) also indicate significant differences between the systems, likely due to differences in the type and density of vegetation present on the two sites. Instrumentation at a verification site in Waukesha County was performed in order to test the transferability of techniques developed in the initial study phases. In addition, a journal article describing four methods of measuring ground-water inflow in wetland systems was submitted.

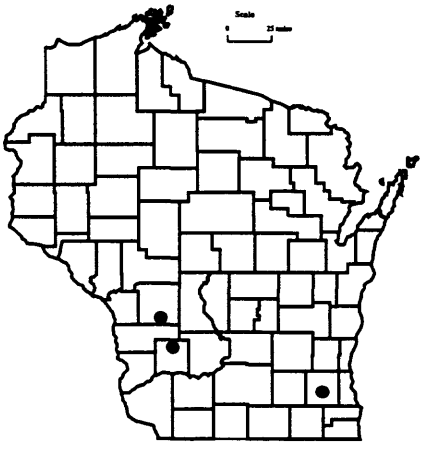
PLANS (July 1995 to June 1996): Two additional journal articles describing project results will be submitted. The verification site in southeastern Wisconsin will be investigated using hydrogeochemical and physical methods to test the transferability of the methods developed to date. In addition, new research aimed at increasing our accuracy in estimating wetland evapotranspiration and delineating small-scale trace-metal chemistry in natural and constructed wetlands will be performed at the initial research sites.

COOPERATOR:
Wisconsin Department of Transportation

LOCATION:
One mile south of Wilton, Wisconsin; one mile north of Hub City, Wisconsin; Waukesha, Wisconsin

PROJECT CHIEF:
Randy J. Hunt

PERIOD OF PROJECT:
November 1989 to September 1997



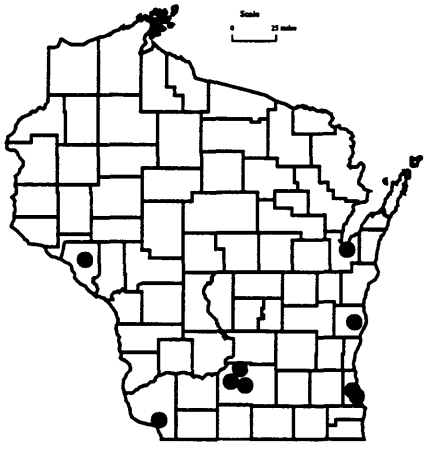
TRENDS IN WATER QUALITY AND STREAM HABITAT FOR PRIORITY WATERSHEDS, WI 17201-17205, 17208-17210, 17213, 17214

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Priority watersheds in Brown, Buffalo, Dane, Grant, Milwaukee and Sheboygan Counties

PROJECT CHIEF:
David J. Graczyk, Steven R. Corsi, David W. Owens, and Todd D. Stuntebeck

PERIOD OF PROJECT:
October 1990 to September 1997



PROBLEM: An evaluation strategy is needed to assess the effectiveness of nonpoint-source pollution control measures in priority watersheds. Several important processes require research including the role of ground water in nonpoint-source contamination, factors leading to dissolved-oxygen reduction in a stream during runoff events, and the impact of management practices on bedload transport. Several techniques need to be developed and/or refined, such as detecting trends in stream-water chemistry, sampling of fish and fish habitat, relation between fish/fish habitat and changes resulting from watershed management practices, and use of habitat models for determining impact of watershed management on fish populations.

OBJECTIVE: The overall objective of this project is to determine the trends in water quality for 10 sites during and after implementation of improved land-management practices in 7 priority watersheds.

APPROACH: Ten streams were selected in seven different priority watersheds. Continuous-record streamflow, water temperature, and dissolved-oxygen gaging stations were installed at each stream site. Water-quality samples will be collected during events and low flows and analyzed for selected constituents. Land-use inventories will be taken each year to help determine the cause of any changes in water quality.

PROGRESS (July 1994 to June 1995): Streamflow and water-quality monitoring was continued at 10 sites in the priority watersheds. Dissolved oxygen was monitored at seven sites in the priority watersheds. All data was summarized and will be published in the report "Water Resources Data-Wisconsin", water year 1994. Water-quality loads were calculated for selected parameters and storm periods for the 10 sites. Land-use inventories were done for each basin.

PLANS (July 1995 to June 1996): Streamflow, water-quality (for the 10 sites), and dissolved-oxygen (at 4 sites) monitoring will be continued. Water-quality loads for selected parameters and storm periods will be calculated and compared to data collected in previous years. The data will be analyzed to determine if there are any apparent trends in water quality during implementation of the best management plans. Land-use inventories will be updated for each basin.

REPORTS:
Walker, J.F., Graczyk, D.J., Corsi, S.R., Owens, D.W., and Wierl, J.A., 1995, Evaluation of nonpoint-source contamination, Wisconsin: Land-use and best management practices inventory, selected streamwater-quality data, urban quality assurance and quality control, constituent loads in rural streams, and snowmelt-runoff analysis: U.S. Geological Survey Open-File Report (in press).

Corsi, S.R., Walker, J.F., Graczyk, D.J., Greb, S.R., Owens, D.W., and Rappold, K.F., 1995, Evaluation of nonpoint-source contamination, Wisconsin: selected streamwater-quality data, land-use and best-management practices inventory, and quality assurance and quality control: U.S. Geological Survey Open-File Report 94-707, 57 p.

Greb, Steven R., and Graczyk, David J., 1995, Frequency-duration analysis of dissolved-oxygen concentrations in two southwestern Wisconsin streams, Water Resources Bulletin (in press).

Graczyk, D.J., Walker, J.F., Greb, S.R., Corsi, S.R., Owens, D.W., 1993, Evaluation of nonpoint-source contamination, Wisconsin: Selected data for 1992 water year: U.S. Geological Survey Open-File Report 93-630, 48 p.

Walker, John F., and Graczyk, David J., 1993, Preliminary evaluation of effects of best management practices in the Black Earth Creek, Wisconsin, priority watershed: Water Science Technology, v. 28, no. 3-5, p. 539-548.

Bannerman, R.T., Owens, D.W., Dodds, R.B., and Hornewer, N.J., 1993, Sources of pollutants in Wisconsin stormwater: Water Science Technology, v. 28, no. 3-5, p. 241-259.

BEST MANAGEMENT PRACTICE EVALUATION, WI 17206

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
State of Wisconsin

PROJECT CHIEF:
John F. Walker

PERIOD OF PROJECT:
October 1989 to September 1997

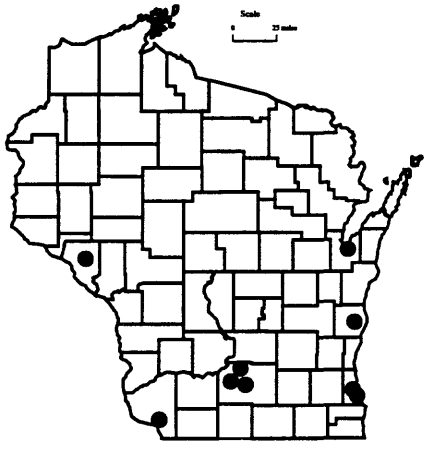
PROBLEM: To date, the effectiveness of best management practices (BMP's) in Wisconsin has not been determined. The natural variability of water-quality data complicates the detection of changes due to BMP implementation. Research is needed to identify techniques for detecting changes due to BMP implementation and applying the techniques to before and after data.

OBJECTIVE: Investigate statistical analysis techniques for assessing trends in water quality due to Best Management Practice (BMP) implementation using data from other States. The effectiveness of BMP's in two urban basins and seven rural basins in Wisconsin will be determined using the identified statistical techniques.

APPROACH: A comprehensive literature search will be conducted to identify viable statistical analysis techniques and identify needs for method modification or development. Data for several rural and urban basins in other States will be compiled and used to test the selected techniques. Storm loads of total-suspended solids and total phosphorus will be computed and used along with rainfall data and land-use information to assess the effectiveness of the BMP's in several basins in Wisconsin.

PROGRESS (July 1994 to June 1995): Publication process for journal article was completed (Walker, 1994). Work continued on incorporating snowmelt events into statistical analyses. Preliminary regression analyses of pre-BMP data for all rural sites were completed. Annual progress report for water year 1994 (Walker and others, 1995) was completed.

PLANS (July 1995 to June 1996): Work on snowmelt events will be continued. Refinement of regression analyses by incorporating additional variables will continue and a closer examination of processes affecting storm and snowmelt loads will be made.



REPORTS:

Walker, J.F., 1994, Statistical techniques for assessing water-quality effects of BMPs, ASCE J. of Irrigation and Drainage Engineering, v. 120, no. 2, p. 334-347.

Walker, J.F., 1993, Techniques for detecting effects of urban and rural land-use practices on stream-water chemistry in selected watersheds in Texas, Minnesota, and Illinois: U.S. Geological Survey Open-File Report 93-130, 16 p.

LAKE SUPERIOR URBAN STORM-WATER DEMONSTRATION PROJECT, WI 17212

PROBLEM: The Lake Superior Binational Program requires an understanding of the sources and amount of urban storm-water pollution in the Lake Superior Basin.

OBJECTIVE: The objective is to provide water-quality data necessary to construct storm-water management plans as required under the Binational Program. In addition to discharge, these data will include nutrients, metals, poly-aromatic hydrocarbons (PAH's) and eight organic bioaccumulative substances identified by the Binational Program.

APPROACH: One storm sewer in each of two cities (Marquette, Michigan and Superior, Wisconsin) will be intensively monitored (15 events) for precipitation, runoff flow and constituent concentrations. Within the Marquette basin, runoff from nine discrete source areas (streets, parking lots, roof tops, driveways and lawns) will be sampled. These data will be used to calibrate an urban model for the Marquette flume site.

One storm sewer in each of eight smaller municipalities will be monitored over four events for constituent concentrations. Constituent concentrations will be monitored (6 events) at two bulk storage piles in the Duluth/Superior area.

In Duluth, Minnesota, and Superior, Wisconsin, water-quality sites will be installed at an urban undeveloped space, recreational park, golf course, and a gas station. The concentration and discharge data collected at these sites will be used to further refine the source-area loading model (SLAMM).

PROGRESS (July 1994 to June 1995): Data collection from storm sewers in Marquette, Michigan, Superior, Wisconsin, and the eight smaller municipalities has been completed and the 2,887 samples analyzed. At Superior, Wisconsin, runoff from the Tower Avenue basin (22 acres), as measured during 63 events, was generally 55 percent. At Marquette, Michigan, runoff from the Tower Avenue basin (288 acres), as measured during 65 events, was generally 15 percent. At Marquette and Superior, event loadings for nutrients, metals, and poly-aromatic hydrocarbons (PAH's) have been calculated based upon flume-measured discharge and flow-weighted composite sampling.

Within the Marquette basin, data collection from 9 source areas has been completed, resulting in 3,186 samples being analyzed. Initial assessment of these source-area data indicate that parking lots generate high concentrations of PAH's. There is also a relation between traffic density on a street and the resulting PAH concentration in street runoff.

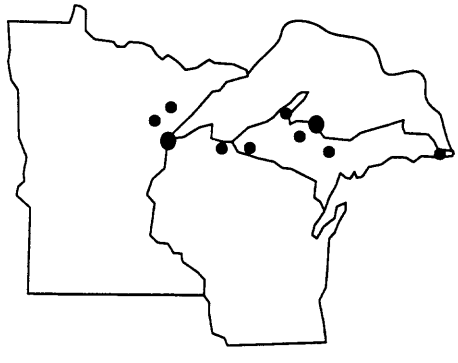
PLANS (July 1995 to June 1996): Data will continue to be collected at the Superior Tower Avenue site. Equipment will be installed and data collected at the urban undeveloped space, recreational park, golf course and gas station sites. Journal articles detailing the storm-sewer and source-area work will be written.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Eleven cities in Lake Superior Basin (Minnesota, Wisconsin, Michigan)

PROJECT CHIEF:
Jeffrey J. Steuer

PERIOD OF PROJECT:
April 1993 to December 1995



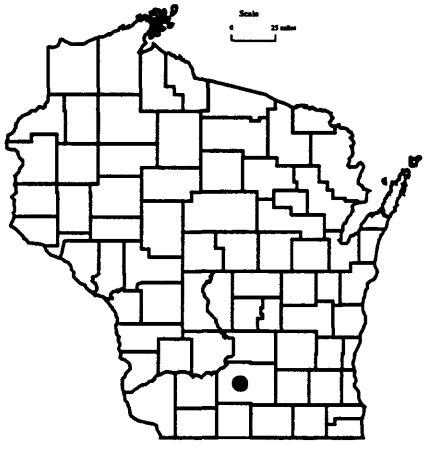
SOURCES OF STORM-WATER POLLUTANTS WASHED OFF CITY STREETS, WI 17215

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Madison, Wisconsin

PROJECT CHIEF:
Robert J. Waschbusch

PERIOD OF PROJECT:
July 1994-September 1995



PROBLEM: High loadings of heavy metals, polycyclic aromatic hydrocarbons (PAH's) and phosphorus have been observed in storm water nationwide. City streets in Madison contribute a large percentage of the heavy metal and phosphorus loadings measured at storm-sewer outfalls. If we know how these pollutants are deposited on the streets, prevention could be an important approach to controlling these pollutants. Controlling the pollutants at their source could be more cost-effective than implementing expensive end-of-pipe practices like detention ponds.

OBJECTIVES: The objectives are to (1) Identify storm-water pollutant loadings that are related to traffic volume, (2) identify the sources of phosphorus to city streets, (3) assess the toxicity of the storm-water pollutants washed off city streets, and (4) estimate storm-water loading reductions by controlling the sources of pollutants to city streets.

APPROACH: Twelve storm-water runoff samples will be collected from each of five streets with different traffic volumes. Sheet-flow samplers will be installed in the streets representing the four lowest traffic volumes of around 500, 6,100, 18,600 and 25,500 cars per day. Samples will also be collected from the Madison beltline which has a traffic volume of about 80,000 cars per day. A sampler will be installed to collect storm water in a storm sewer that collects only water that runs directly from the beltline into the storm sewer. These samples will be analyzed for heavy metals, phosphorus, PAH's and acute toxicity. In addition to storm-water runoff samples, six street dirt samples will be collected from each of the four lowest traffic volume streets. These street dirt samples will be sieved into four different size fractions. Each of these size fractions will be analyzed for phosphorus content and vegetative fraction. Regression analyses will be done to determine if a relation exists between pollutant concentration and traffic volume and also between phosphorus concentration and vegetative content.

PROGRESS (July 1994 to June 1995): Approximately nine runoff samples have been collected and analyzed from each of the five different traffic volume streets. Six street dirt samples have been collected.

PLANS (July 1995 to September 1995): The remaining runoff samples were collected in the spring of 1995. The street dirt samples will be sieved and analyzed. The analyses results will be used to determine if relations exist between pollutant concentration and traffic volume and also between phosphorus concentration and vegetative content. The results will be published in an interpretive report.

TRIBUTARY PHOSPHORUS LOADING TO LAKE MENDOTA AND EVALUATION OF LOAD DETERMINATION METHODS, WI 17217

PROBLEM: Traditionally, monitoring of streamflow and phosphorus loading is done upstream from the lake (sometimes several miles) where the hydraulic gradient is sufficiently steep to employ conventional stream-gaging techniques. These monitoring sites, equipped with automatic samplers, provide data for accurate load determination, but at considerable cost. Usually, the load at the stream's mouth is assumed to be the same as at the monitoring site or adjusted by the ratio of the watershed areas of the two sites. The validity of this assumption is open to question because it is unknown whether the stream reach and watershed between the upstream monitoring site and the lake is a source or a sink for phosphorus. Various data-collection and analysis techniques must be tested to determine the most cost-effective methods for estimating loading at mouths of tributaries to lakes. These methods would then be employed in long-term monitoring on tributaries to selected lakes in priority-watershed projects.

OBJECTIVE: The objectives are to (1) determine the most cost-effective method for estimating total-phosphorus loading at mouths of streams flowing into lakes and (2) determine the annual total-phosphorus loading to Lake Mendota.

APPROACH: Four major tributaries (Yahara River, Pheasant Branch Creek, Sixmile Creek, and Spring Creek) to Lake Mendota will be monitored. These tributaries account for 214 of the 233 square-mile-drainage basin of Lake Mendota. The lower reaches of all these tributaries are low gradient and flow through adjacent wetlands to Lake Mendota. Two of these tributaries, the Yahara River and Pheasant Branch, have continuous-discharge-gaging stations and automatic water-quality samplers upstream of reaches with adjacent wetlands. Water sampling for analysis of total-phosphorus concentration and determination of stream discharge will be done at or very near the mouths of these streams. Annual loads at the four major tributaries will be estimated. The annual loads will be estimated first by using the complete data set of all concentration data. Subsets of the complete data set will be used to estimate annual loads. The annual load estimates by using the subsets will be compared to the annual loads estimated using the complete data sets in order to determine the minimum sampling intensity that still yields sufficiently accurate load estimates. Pollutant loadings to Lake Mendota will be estimated by summing the loads from the four major tributaries and other sources to Lake Mendota. The other sources include loading from storm sewers, other smaller tributaries, ground-water inflow and direct precipitation to the lake. The loads from these sources will be provided by other agencies, programs and from literature reviews.

PROGRESS (July 1994 to June 1995): Water samples were collected and discharge measurements were made weekly at the four tributaries to Lake Mendota. Samples were collected more frequently during storms. The water samples were analyzed for

COOPERATORS:
Wisconsin Department of Natural Resources

LOCATION:
Lake Mendota, Madison, Wisconsin

PROJECT CHIEF:
David J. Graczyk

PERIOD OF PROJECT:
October 1994 to June 1996

total phosphorus and dissolved phosphorus. All data for water year 1994 were summarized and input into the USGS data base. An acoustic-velocity meter (AVM) was installed at the mouth of the Yahara River in September 1994. The AVM was calibrated and appears to be operating reliably.

PLANS (July 1995 to June 1996): Collection of water quality samples and streamflow data will continue through September 1995. Annual loads for the four tributaries will be estimated as outlined in the "approach" above in order to evaluate load calculation methods. Total-phosphorus loading to Lake Mendota will be estimated.

WISCONSIN LAKES, ASSESSMENT OF THE HYDROLOGY AND PHOSPHORUS LOADING TO FISH AND MUD LAKES, DANE COUNTY, WISCONSIN, WI 17301

PROBLEM: Fish and Mud Lakes are seepage lakes separated by about a 200-foot-wide isthmus, but connected by a 5-foot-diameter culvert. Fish Lake is mesotrophic and Mud Lake is eutrophic. Eurasian water milfoil has become a nuisance macrophyte in much of the lake's littoral zone in recent years. A study of Fish Lake in the late 1970's showed significant internal phosphorus loading from the littoral sediment during summer stratification. Extensive row crop farming and large animal feed lots in the western part of the watershed may generate most external loading to both Fish and Mud Lakes. The Wisconsin Department of Natural Resources (WDNR) will be evaluating the lakes' water chemistry and trophic status and testing various means of controlling macrophytes. Identification of the amounts and sources of phosphorus entering the lakes is needed to evaluate phosphorus loading in relation to the lakes' trophic status. This information is needed for developing and assessing lake- and land-management alternatives for maintaining or improving water quality of the lakes.

OBJECTIVE: The objectives of this study are to define the hydrology of Fish and Mud Lakes and to identify and quantify major sources of phosphorus entering the lakes.

APPROACH: The study will be done in two phases. The first phase is data collection and providing the data to the cooperator. The second phase is to interpret the data and publish a summary report. The study will have a one-year (November 1, 1990 to October 31, 1991) data-collection period. Hydrology and phosphorus loading will be evaluated using the following techniques:

Water Budget: The equation describing the water budget for Fish and Mud Lakes is as follows:

$$DS = P - E + S + GI + LE - GO$$

where

DS is change in lake storage volume,
P is precipitation,
E is evaporation,
S is surface runoff into the lake,
GI is ground-water discharge to the lake,
LE is lake exchange or net flow through the culvert separating the lakes,
and GO is ground-water recharge from the lake.

The study emphasis will be on only the most significant (with regard to phosphorus loading) water-budget components owing to funding constraints. These are DS, P, and S. The remaining components (GI, E, LE, and GO) will be evaluated and, if possible, estimated on the basis of minimal data.

Phosphorus loading: An automatic water sampler at a tributary gaging station will collect storm-runoff samples for total-phosphorus

COOPERATOR:
Dane County Lakes and Watershed Commission

LOCATION:
Northwest Dane County near Roxbury, Wisconsin

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
October 1990 to March 1993

analysis. Forty to sixty samples will be collected--the number of samples will depend on the number of storms. Phosphorus load will be calculated by the streamflow and phosphorus-integration techniques described by Porterfield (1972).

Surface runoff in many small gullies and drainageways will be sampled with siphon samplers for phosphorus-concentration analysis. These data will be the basis for estimating the phosphorus concentration of ungaged storm runoff entering the lake.

PROGRESS (July 1994 to June 1995): Water-budget and phosphorus-loading data were provided to the WDNR for their use in a lake-response model.

PLANS: Obligations to the cooperator have been met and a final summary report probably is not needed. Data have been provided to Dane County and to the WDNR for preparation of a lake and watershed management plan. Formal consent must be obtained from the county to cancel plans for a final report.

WISCONSIN LAKES, SILVER CREEK, WI 17303

PROBLEM: Silver Creek has been documented as the primary phosphorus source to Green Lake. Continued documentation of these loads helps to explain the lake's water quality. The station also serves as an indicator of annual phosphorus loading variability to help explain regional lake-water-quality problems.

OBJECTIVE: The objective of this project is to define the water quality in relation to streamflow in stream basins where nonpoint-source pollution exists.

APPROACH: Streamflow will be monitored continuously at two sites. Water-sediment samples will be collected manually on a monthly basis and by automatic samplers during storm runoff. Suspended-sediment and nutrient concentrations will be determined. Daily, monthly, and annual mean suspended-sediment and nutrient loads will be computed.

PROGRESS (July 1994 to June 1995): Streamflow and water quality were monitored at Silver Creek near Ripon, and Green Lake inlet near Green Lake.

Loads for the 1994 water year were computed for suspended sediment and total phosphorus for Silver Creek near Ripon. Annual yields were: total phosphorus, 283 pounds per square mile; suspended sediment, 14.8 tons per square mile. At Green Lake inlet near Green Lake, annual yields were: total phosphorus, 252 pounds per square mile; suspended sediment, 13.3 tons per square mile.

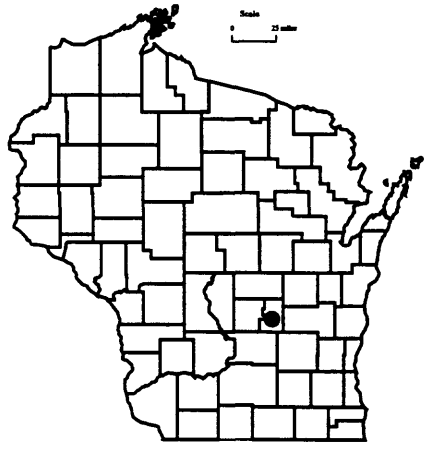
PLANS (July 1995 to June 1996): Continue monitoring streamflow and water quality at Silver Creek near Ripon and Green Lake inlet near Green Lake. All data will be published in the annual report, "Water Resources Data–Wisconsin".

COOPERATOR:
Green Lake Sanitary District

LOCATION:
Green Lake County,
south-central Wisconsin

PROJECT CHIEF:
Stephen J. Field

PERIOD OF PROJECT:
October 1977-Continuing



WISCONSIN LAKES, ASSESSMENT OF THE WATER QUALITY AND TROPHIC STATUS OF PARK LAKE, COLUMBIA COUNTY, WISCONSIN, WI 17306

COOPERATOR:
Park Lake Management District

LOCATION:
Pardeeville, Columbia County

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
October 1992 to September 1995

PROBLEM: Local residents on Park Lake perceive deteriorating water quality in the lake due to excessive algae and aquatic plants. No measurements have been made of factors affecting the lake's quality, and measurement of the lake's condition are limited to two years of in-lake data collection in 1986-87.

The Park Lake Management District plans to prepare a lake management plan to limit input of phosphorus, which contributes to excessive algae and plant growth, to the lake. An understanding of the hydrology of the lake and determination of the sources and amounts of phosphorus entering and leaving the lake are needed to develop a management plan. The trophic status of the lake needs to be determined to evaluate the effectiveness of the management plan.

OBJECTIVE: The objectives of this study are to describe the hydrology of the lake, determine a phosphorus budget for the lake, describe present in-lake water quality, and determine the trophic status of the lake.

APPROACH: The study will consist of a year of data collection followed by data analysis and report preparation. Hydrologic and water-quality data will be collected to describe the hydrology of the lake, compute an annual phosphorus budget to determine the sources and amounts of phosphorus that are available for algae and plant growth, and describe the lake's trophic status and seasonal changes in its water quality. Components of the hydrologic budget for the lake that will be measured directly include precipitation, lake stage, and surface inflow. Surface outflow, evaporation from the lake surface, and net ground-water flow will be estimated from other budget components or taken from the literature. The Fox River is assumed to be the major source of phosphorus entering the lake. Phosphorus input and surface-water inflow to the lake will be measured at a monitoring station on the Fox River upstream from the lake.

In-lake water quality will be measured at four locations in the lake to describe seasonal water-quality characteristics of the lake and to provide data needed to evaluate the lake's trophic status. The trophic status of the lake will be evaluated using empirical models.

PROGRESS (July 1994 to June 1995): Analysis of data collected during the monitoring period (November 1992-October 1993) confirmed that the Fox River is the principal source of phosphorus entering the lake. The phosphorus load at the monitoring station on the Fox River, which includes 90 percent of the lake's 54-square-mile surface drainage basin, was approximately 17,000 pounds, or about 320 pounds per square mile. Mathematical models commonly used to evaluate phosphorus loading to lakes indicate that the measured phosphorus loading was approximately six times greater than phosphorus loadings considered "excessive." In-lake water-quality measurements made during 1993 were used to compute trophic-state index (TSI) values used to evaluate the lake's trophic condition. TSI values based on total phosphorus concentration, water clarity, and chlorophyll *a* concentration all indicate that the lake was highly enriched (eutrophic) during the monitoring period.

Preparation of an interpretive report describing the results of the study was begun.

PLANS (July 1995 to June 1996): The interpretive report will be completed.

ELKHART LAKE HYDROLOGY, WI 17307

PROBLEM: Maintaining the excellent water quality in Elkhart Lake is important to both residents and visitors using the lake. Increased use from daily visitors and residents from new developments on the lake point to the need for studies to understand the lake hydrology and chemical processes. This study will provide some of the necessary technical background for the development of effective lake-management strategies.

OBJECTIVE: The objective is to understand the hydrology and chemical processes of Elkhart Lake. The Center for Great Lakes Studies is responsible for determining chemical processes. The USGS will monitor discharge at the outlet and determine ground-water inflow and outflow areas of the lake.

APPROACH: Establish a stage-discharge relation and maintain a continuous-recording gaging station at the outlet. Conduct a piezometer survey along the shoreline to determine the direction of ground-water flow.

PROGRESS (July 1994 to September 1994): A gaging station, consisting of a pressure-transducer system to monitor lake stage and a tipping-bucket rain gage, was installed in late June 1993.

For the period July 1, 1993 to September 1994, the maximum daily lake stage was 17.44 on July 9 and the minimum was 16.88 on July 3, 1994. Eleven discharge measurements, made during the period of record, range from 2.40 to 6.31 cubic feet per second. The maximum daily discharge was 26 cubic feet per second on July 9, 1993, and the minimum was 0.87 on July 3, 1994. The maximum precipitation event was 3.03 inches and occurred on July 5, 1993. Precipitation amounts were monitored only during non-freezing periods. Increases in lake stage correlate very well to precipitation events.

Piezometers were installed in the lake bed near shore and water levels measured during four periods: August 8 and October 19, 1993, and March 15-17 and June 29, 1994. Within measurement error, positive gradients (indicating ground-water inflow to the lake) were measured along the entire shoreline for all periods. At depth, it is assumed that fine-grained lake sediment precludes ground-water flow.

Measurements of lake storage, precipitation, surface-water discharge, and evaporation are available from data collected at the lake or nearby weather stations. Precipitation for freezing periods was measured at Plymouth, Wisconsin, and evaporation was estimated using data collected at Marshfield, Wisconsin. The monthly estimates of the hydrologic-budget components indicate that, during periods of no evaporation from the lake surface, outflow is approximately equal to ground-water inflow. Because of the lake-stage control structure, changes in monthly lake storage will always be small.

Hydrologic data has been submitted to the Center for Great Lakes for inclusion in a report.

PLANS: Project has ended.

COOPERATOR:

Elkhart Lake Improvement Association (Center for Great Lakes Studies is collaborating on project).

LOCATION:

Elkhart Lake, Wisconsin

PROJECT CHIEF:

Jim Krohelski

PERIOD OF PROJECT:

April 1993 to September 1994

ASSESSMENT OF THE HYDROLOGY AND WATER QUALITY OF LAUDERDALE LAKES,WALWORTH COUNTY, WISCONSIN, WI 17310

COOPERATOR:
Lauderdale Lakes Lake Management District

LOCATION:
La Grange, Walworth County, Wisconsin

PROJECT CHIEF:
Herbert S. Garn

PERIOD OF PROJECT:
October 1993 to September 1996

PROBLEM: Lauderdale Lakes are a chain of three interconnected lakes with a surface area of about 824 acres that are located in the more populated southeastern part of Wisconsin north of Elkhorn. The area is experiencing much population growth and development. Members of the lake district have expressed concern over the deteriorating water quality of the lakes. The lakes also have had problems with increasing macrophyte growth in the past 5 years, and the district has had to harvest macrophytes. The lake-management district plans to prepare a waste-management plan to limit the input of phosphorus, which contributes to excessive algae and aquatic plant growth. An understanding of the hydrology of the lakes and determination of the sources and amounts of phosphorus entering and leaving the lakes is needed to develop a management plan. The present trophic condition of the lakes needs to be determined to evaluate the effectiveness of the management plan.

OBJECTIVE: The objectives of the study are to determine the hydrologic and phosphorus budgets for the Lauderdale chain of lakes, to describe and quantify present in-lake water quality, and to evaluate the trophic status of the lakes.

APPROACH: The study will consist of a year of data collection followed by data analysis and report preparation. Data collection will begin in October 1993 and go through October 1994 with emphasis on the open-water period. Hydrologic and water-quality data will be collected to describe the hydrology of the lake, to calculate an annual phosphorus budget for the lakes to determine major sources, and to describe the lakes' trophic status and seasonal changes in water quality. Major components of the hydrologic budget that will be measured directly include precipitation and evaporation, lake outflow (continuously), and lake stage (continuously). No perennial streams flow into the lake. Groundwater inflow and outflow will be estimated from head-difference values measured in piezometers installed around the lakes. Water samples for phosphorus analysis will be collected from ephemeral drainages entering the lake, from the piezometers, from lake outflow, and from within the lakes to define the phosphorus budget. In-lake water quality will be measured at three locations to describe the seasonal water-quality characteristics of the lakes and to evaluate the lakes' trophic status. The trophic status of the lakes will be evaluated using various indices and empirical models.

PROGRESS (July 1994 to June 1995): In-lake water-quality sampling continued twice a month through the summer. Piezometers were measured and sampled monthly for water level and phosphorus. The recording gages for lake level and lake outflow were operated into the fall. Operation of the recording gages and sampling of the lakes and piezometers was discontinued as scheduled in November 1994, which was the end of the data-collection phase of the study. The continuous-recording lake gage, piezometers, and instruments from the continuous-recording

outflow gage were removed. Provisional data were summarized and presented to the lake district by letter and by a presentation at the annual meeting on September 3. All data were reviewed, finalized, and prepared for publication in the annual data report "Water Resources Data–Wisconsin, water year 1994." Water-quality, discharge, and phosphorus load data for the lakes were summarized and analyzed; figures and tables were prepared. Work on the first draft of the interpretive report describing the results of the study was begun. Provisional data indicate that the water quality of Lauderdale Lakes is very good compared to other southeastern Wisconsin lakes and that the lakes are classified as oligo-mesotrophic.

PLANS (July 1995 to June 1996): Prepare draft of the water-resources investigation report (WRIR) for Lauderdale Lakes for colleague review. Respond to comments from the colleague reviews, prepare final draft, submit WRIR for approval, prepare final copy and print report.

HYDROLOGIC INVESTIGATION OF THE PRETTY LAKE WATERSHED, WI 17311

COOPERATOR:
Pretty Lake Protection and Rehabilitation Lake District

LOCATION:
Near Ottawa, Wisconsin

PROJECT CHIEF:
Randy J. Hunt

PERIOD OF PROJECT:
April 1994 to September 1995

PROBLEM: Since 1977, the citizens in the vicinity of Pretty Lake have attempted to evaluate, protect and enhance the lake's water quality. However, a better understanding of the ground-water system and the surrounding watershed is required to attain the project objectives.

OBJECTIVE: The objectives of this study are to delineate ground-water recharge areas and ground-water divides, and to quantify water and solute loading rates as a means to assess the effects of surrounding land-use and lake-management plans.

APPROACH: A ground-water-flow model of the area will be constructed. The model will encompass hydrologic features in the lake vicinity (e.g., ditches, wells) and features important to the regional system. Particle-tracking will be used to assess the capture zone of the lake. The model will also quantify ground-water flux into the lake given model parameters and will allow prediction of hydrologic response to future system stresses and to possible management alternatives.

PROGRESS (July 1994 to June 1995): An analytic element ground-water-flow model of the site was completed and calibrated to ground-water elevations and fluxes. The recharge area for the lake was delineated using the model, and model results were submitted to the cooperator.

PLANS (July 1995 to September 1995): A journal article detailing the modeling approach, construction, and its application to lake problems will be published.

WESTERN LAKE MICHIGAN DRAINAGES NATIONAL WATER-QUALITY ASSESSMENT (NAWQA), WI 174

PROBLEM: Growing populations throughout the United States have resulted in increased development and use of our water resources. As our water resources become stressed, decisions on how to effectively utilize and manage these resources will need to be made. These decisions must be based on accurate assessments of the quality of the water resource and the factors affecting its use.

OBJECTIVE: The long-term goals of the NAWQA project are to determine the water quality of the streams and aquifers in the Western Lake Michigan Drainages, determine the presence or absence of any trends in the water quality, and provide an understanding of the link between natural and anthropogenic factors and observed water quality. Specific goals are (1) to determine the occurrence and spatial distribution of a broad array of water-quality constituents in water and stream-bed sediments, (2) determine the occurrence of contaminants in selected target taxa, (3) evaluate the aquatic habitat and community structure of streams in the study unit, (4) assess the surface- to ground-water interaction and the effects of land use on base-flow water quality in selected stream reaches, (5) evaluate the sources and transport of selected hydrophilic compounds in agricultural settings, and (6) assess the influence of land use on shallow ground-water quality in selected land-use settings.

APPROACH: The foundation of the study approach is based upon identifying relatively homogenous areas of specific land-use and environmental characteristics. Identification of these areas is accomplished by overlaying digital coverages of land use and various environmental variables using a geographical information system. Sampling sites completely contained in these relatively homogeneous areas (indicator sites) will be incorporated into a nested design of surface-water, streambed sediment, and biological sampling. The sampling strategy consists of a retrospective analysis of available water-quality data, followed by extensive data collection. Monitoring of basic fixed sites in selected areas (indicator sites), as well as downstream sites draining heterogeneous land uses and environmental characteristics (integrator sites), will be conducted for two years beginning in March 1993. These sites will be sampled monthly and augmented with event-related samples. Three of these sites will be extensively sampled for pesticides for a 15-month period. Pesticide samples will be collected approximately weekly during the early to mid-summer period and less frequently during the rest of the year. Synoptic studies will be conducted during high- and low-flow conditions (spring and summer of 1994) to better delineate the sources of nutrients throughout the basins and describe the seasonal variability of these sources. Other program components include an ecological survey (spring 1993) at approximately 40 sites to evaluate the relationship between community (fish and invertebrates), habitat structure, land-use practices, and environmental factors. Selected ground-water studies also will occur including a study-unit survey, a flow-path study and two land-use studies. The flow-path study will examine transformations in various constituents through time and space. Surface-water/ground-water interactions will be examined using shallow wells and

COOPERATOR:

U.S. Geological Survey
Reston, Virginia

LOCATIONS:

Upper peninsula of Michigan from the Menominee River basin in the west to the Fishdam River basin in the east; and the eastern portion of Wisconsin to include the Menominee, Oconto, Peshtigo, Fox- Wolf River basins discharging to Green Bay, and in Wisconsin that directly drain into Lake Michigan from the west which include the Manitowoc, Sheboygan, Milwaukee, Root, and Pike River basins.

PROJECT CHIEF:

Charles A. Peters

PERIOD OF PROJECT:

December 1990-Continuing

lysimeters installed adjacent to the nearby stream. Effects of land use on ground-water quality will be assessed through sampling in specific relatively homogenous areas (1994 and 1995).

PROGRESS (July 1994 to June 1995): Surface-water-quality field work included continued monthly water-quality sampling and stream measurement at the 11 Basic Fixed Sites (BFS). Weekly water-quality sampling was done at six of the BFS during the growing season. High-flow synoptic studies were conducted in three indicator basins and in the Fox/Wolf River basin. These studies involved water-quality sampling at between 6 and 12 tributary sites in each basin during storm runoff. Low-flow synoptic sampling was done in six indicator basins and in the Fox/Wolf River basin. This involved water-quality sampling at between 5 and 11 tributary sites in each of these basins during low-flow conditions. An automatic water-sampling system was installed at Duck Creek to provide for collection of water samples during four storm events in the spring. These samples were analyzed for nutrients, suspended sediment and triazine herbicides.

Biology field work included sampling for trace elements and organics in bed sediment and in plant and invertebrate tissues at the eight indicator BFS sites. Ecological assessments in the third year were conducted at single reaches of each of the indicator BFS. These assessments include collection of algae, invertebrates and fish populations for community analyses and habitat descriptions. Tissue, blood, and organ samples were obtained from carp at two sites in the Milwaukee River basin as part of a national endocrine disruption study. The Wisconsin Department of Natural Resources (WDNR) and NAWQA sampled six streams for macroinvertebrates in the spring, using two sampling methods to compare results obtained by the different methods.

Ground-water field work during 1994 included the installation of 10 wells, 1 mini-piezometer, and 3 lysimeters along the flow-path transect. Water-quality samples were collected at 8 of the flow-path wells, the mini-piezometer and one of the lysimeters. Forty-three wells were installed and sampled for water quality in the two land-use study areas. The well-selection process for the study-unit survey was begun.

The data base for surface- and ground-water quality and QA/QC for those data are complete through September 1994 samples. The data base for trace elements and organics in bed sediments and tissues is complete through August 1994. The habitat and fish community databases are complete through the present. No algae or invertebrate community data have been received from contract labs.

Geographic information system (GIS) data-base development is ongoing. A coverage containing all surface-water-quality, biology and ground-water collection sites has been completed. The drainage basin boundaries for all the basic fixed surface-water sites, except the Menominee River, have been digitized and basin digitizing of the synoptic surface-water sites is 51 percent (53 of 104) complete. Land-cover data for the indicator BFS (except for the Popple and Peshekee Rivers) and for the ground-water land-use and flow-path study locations are complete. Current land-cover layers are being developed for the surface-water synoptic basins and are 86 percent (90 of 104) complete.

Ten abstracts were prepared and presentations were made at five conferences on those results. A poster was prepared and presented at four conferences. A Fact Sheet on retrospective data on nitrates in ground water was published. Two proceedings papers were prepared and presented at conferences. A newsletter was prepared, published and distributed. A retrospective report on nutrients and suspended sediment was prepared and is currently in the final stages of the review process. Eleven presentations were prepared and presented at the 1994 liaison committee meeting; summaries of these presentations were released as an Open-File Report.

PLANS (July 1995 to June 1996): Water-quality and flow will be measured at a limited number of the BFS beginning in May as a part of the low-intensity phase of the study. A synoptic study will be conducted to provide information concerning how well the BFS represent water-quality conditions throughout the Western Lake Michigan drainages. In this survey, 5 sites within each of the 8 indicator BFS and 3 sites within each of the 20 relatively homogeneous units (RHUs) that don't have a BFS associated with them will be sampled at low flow for field parameters, nutrients and suspended sediment. A collection-method data-comparability study may be continued with the WDNR at three sites in the basin at high and low flow.

Biology field work will include sampling for trace elements and organics in bed sediment and biotic tissues at three indicator and three integrator BFS. A synoptic survey will be completed at 20 relatively pristine streams in agricultural areas. This survey will include the collection of fish population information and water-quality samples. Coordinated sampling with the WDNR of benthic invertebrate communities at either the BFS or the synoptic sites may be conducted for comparison of sampling methods. Vegetation plots will be established and surveyed at each of the eight indicator BFS. Elevation surveys will be conducted at each of the indicator sites.

Ground-water field work will include completing work in the flow-path and land-use areas and beginning work on a study-unit survey. Work at 56 agricultural land-use wells will include performing slug tests to determine horizontal hydraulic conductivity and well removal if necessary. Field work at the flow-path study area will include the installation of seven mini-piezometers, and several suction lysimeters and the sampling of these

installations and the eight previously installed PVC wells. Seepage runs will be conducted in the stream at the end of the flow path to determine ground-water input to the stream. A geoprobe will be used to collect four sets of cores along the flow path transect and several of these cores will be analyzed for mineralogic composition. Additionally, water levels will be determined in all wells and elevation levels will be run to all wells. The study-unit survey will be conducted to determine water-quality conditions in the most used aquifer in the study unit. Thirty wells will be randomly selected for sampling to represent this aquifer. The selected wells will be sampled for determination of numerous water-quality parameters.

The data base for surface- and ground-water quality and QA/QC for those data will be completed through September 1995 samples. The bed-sediment and tissue data base will be completed through September 1995. The habitat and fish community data bases will be completed through September 1995. Algae and invertebrate data bases will be completed through September 1994.

Geographic information system (GIS) database development will continue. The site location coverage will be updated to include all new RHU synoptic sites and new ground-water study-unit survey and flow-path sites. The drainage-basin coverage will be completed for all surface-water sites. A land-cover layer will be completed for all the surface-water synoptic basins. A pilot study to identify the best process for compiling cropping and pesticide/fertilizer application rates over the three-year high-intensity phase of the study will be initiated and completed for an agricultural subbasin. This process will be extended to the five agricultural indicator sites if feasible. Soils and elevation coverages will be examined for their utility for water-quality interpretation. Coverages for other anthropogenic features (landfill, sewage treatment plant, underground storage tank, etc., locations) will be compiled where available.

The environmental setting report will be published. Six Water Resources Investigations reports will be written. A Fact Sheet, an Open File report and a journal article are also planned. Another edition of the newsletter will be prepared and distributed.

HYDROLOGIC AND BIOGEOCHEMICAL BUDGETS IN TEMPERATE LAKES AND THEIR WATERSHEDS, NORTHERN WISCONSIN, WI 175

COOPERATOR:
Global Change Hydrology Program, WRD, U.S. Geological Survey

LOCATION:
North-central Wisconsin

PROJECT CHIEFS:
John F. Elder,
David P. Krabbenhoft and
John F. Walker

PERIOD OF PROJECT:
October 1990-Continuing

PROBLEM: There has been expanding evidence that rates of global changes are increasing. There is a need for research to identify, describe, and quantify the processes that control the Water, Energy, and Biogeochemical Budgets (WEBB) of aquatic ecosystems in order to understand and predict their responses to global changes. Promotion of such research is the function of the Water Resources Division's WEBB program. In the northern highlands lakes district of north-central Wisconsin, five lakes and two bog lakes have been the site of long-term ecological research conducted by University of Wisconsin scientists for the past decade. These studies have provided extensive information about biological and chemical features of the lake systems, but understanding of interactions among the lakes, streams, ground-water system, and wetlands is still limited. Research is urgently needed to describe these interactions and basin-wide processes that influence the character of the lakes.

OBJECTIVE: Objectives are to (1) describe processes controlling water and solute fluxes in northern Wisconsin lake watersheds, (2) examine interactions among those processes and their relations to climatic variables, and (3) improve the capability to predict changes in water and solute fluxes for a range of spatial and temporal scales. Fulfillment of these objectives in Wisconsin will contribute to meeting the overall objective of the federal global change program: to understand processes underlying the responses of hydrologic, biologic, and chemical systems to climate variations and human activities.

APPROACH: Selected streamflow/recharge sites on tributaries of Trout Lake are the sites for detailed research of hydrologic processes. Most of the current research effort is concentrated at Allequash Creek, one of four inflowing tributaries of Trout Lake. Analyses of hydrologic connections among precipitation, streamflow, and ground water are conducted at three cross sections of the Allequash Creek basin. Monitoring and sampling equipment installed at these sites include piezometer nests, lysimeters, tensiometers, precipitation collectors, and thermocouple nests. Analyses of stable isotopes (C-13, O-18, Sr-86, and deuterium) are also used to determine water exchange pathways and sources of stream water. The site-specific hydrologic research is supported by data from several rain gages throughout the study area, and a complete climatological station in the vicinity.

Stream-water and ground-water samples, collected at each of the Trout Lake tributaries and at different points in the Allequash system, undergo analysis for nitrogen species, phosphorus, silica, organic carbon, major ions, and metals. Tributary sampling is done on a monthly basis, supplemented with more intense sampling of particular storms. Coupled with hydrologic data, the water sampling provides a basis for describing chemical budgets.

Investigation of geochemical processes that control transport of important chemical species across stream and lake sediments involves fine-scale sampling at the sediment/water interface. This is done by a variety of techniques, including membrane equilibrators, core squeezing, microprobes, and seepage meters.

PROGRESS (July 1994 to June 1995): Data collection and analyses proceeded at the three intensive monitoring sites on Allequash Creek. Analyses of stable isotope composition have been used to distinguish between sources of water in the stream. Water from precipitation that percolates through nearby hillslopes has isotopic signatures different from water that travels through relatively long flow paths, often from lakes several kilometers distant from the stream. The data show an overall picture of the Allequash Creek flow system as a progression from a pure ground-water source at the headwaters to a mixture of relatively deep ground water, relatively shallow ground water, and evaporative (surface) water. Examination of strontium isotope ratios (87Sr/86Sr) provides further detail to the flow system on a smaller spatial scale, and indicates that the "shallow" flow paths are still quite distant from the stream and do not predominantly originate as recharge on the adjacent hillslopes.

Sampling of Trout Lake tributaries and various sites along Allequash Creek continued, with collections approximately bimonthly. Analytical data from these samples indicate some seasonal differences in nutrient and carbon loads, with higher loads generally characterizing the late summer and fall seasons. The seasonal variation is probably associated with nutrient cycling mediated by biological growth and decomposition in the basin and wetland.

The nature of the carbon pools and transport pathways is the subject of much of the current research effort. The Allequash wetland contains large expanses of peat, up to six meters in depth, representing an extremely large carbon reservoir. The significance of this carbon pool as a factor in the overall carbon cycle is being examined by data collected from a transect of wetland wells, vegetation surveys, and determinations of areal extent and thickness of peat deposits. Other procedures to provide more information about carbon pools and fluxes in the system were continued and expanded, including measurement of greenhouse gases (carbon dioxide and methane) in ground water and stream samples, collection of leaf-litter samples in different forest types, and increased sampling and characterization of dissolved organic carbon. This type of data collection is now ongoing, and analyses of early results are in progress.

PLANS (July 1995 to June 1996): Data collection at hillslope monitoring sites will continue. Intensity of sampling will decrease and more effort will be directed toward analyses, interpretation, and write-up of existing data. Stream-water and ground-water monitoring will continue for further examination of seasonal and spatial variability. Measurements of gas-phase and aquatic-phase transport of carbon and nutrients through the system will continue. Additional field work will emphasize investigation of carbon budget.

REPORTS:

Elder, John F., Krabbenhoft, David P., and Walker, John F., 1992, Water, Energy, and Biogeochemical Budgets (WEBB) program: data availability and research at the Northern Temperate Lakes site, Wisconsin: U.S. Geological Survey Open-File Report 92-48.

Krabbenhoft, D.P., Walker, J.F., Kendall, Carol, and Bullen, T.D., Definition of water flow paths by stable isotope analysis of ground water, rainfall, and stream water in temperate lake watersheds, northern Wisconsin (journal article, planned).

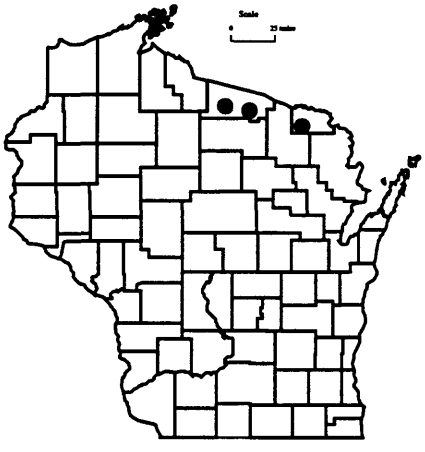
MERCURY CYCLING IN LAKES, WI 18001

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Florence and Vilas Counties, northern Wisconsin

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
March 1987 to September 1991



ACIDIC LAKES

PROBLEM: Acid deposition has damaged lakes in Canada and in the northeastern United States. The pH of precipitation in northern Wisconsin averages 4.6 to 4.7, and Wisconsin has more susceptible lakes than any state east of the Mississippi. Many of these lakes are seepage lakes, whose chemistry is closely associated with precipitation chemistry. Previous studies addressing hydrologic and chemical budgets in northern Wisconsin have concentrated on lakes with alkalinities greater than 20 ueq/L; however, to truly address the potential effects of acid deposition on sensitive lake ecosystems, it is necessary to study lakes with alkalinities less than 20 ueq/L.

OBJECTIVE: Objectives are to determine the hydrologic and chemical budgets for Honeysuckle, Max, and Morgan Lakes in northern Wisconsin to provide information about mechanisms of acid loadings to these lakes, investigate differences between bog lakes and clear-water lakes, evaluate the feasibility of, and develop an approach for, pumping ground water in an acid lake to raise its pH and alkalinity, and continue limited hydrologic monitoring at Vandercook Lake, which has a data base going back to October 1980.

APPROACH: Lake inflows from precipitation and ground-water discharge, and lake outflows from evaporation and ground-water recharge will be quantified. Alkalinity, pH, major cations and anions, nutrients, and mercury plus other trace elements in selected flow paths will be quantified. The lakes will be evaluated for their potential for acidification.

The ground-water-pumping study will be done at Max Lake where a well will be installed to draw water from the lower part of the sand and gravel aquifer adjacent to the lake. The chemical quality and quantity of pumped water will be monitored as well as the effects of the pumping on the lake.

PROGRESS (July 1994 to June 1995): Most monitoring emphasis was at Max Lake; lake stage and a single recorder-equipped well were monitored at Morgan Lake; and lake stage, precipitation, and the ground-water-well network were monitored at Vandercook Lake.

Ground water was pumped into Max Lake to raise and maintain its pH to 7.0. Ground water was pumped from May 5 to August 2, and from September 19 to November 11 at a 25 gallons-per-minute pumping rate. Preliminary water budgets were computed for the lake.

PLANS (July 1995 to June 1996): Routine data collection will continue at approximately the same level as last year. Max Lake's pH will be maintained at 7.0 by intermittent ground-water pumping. Preliminary water budgets will be computed for Max Lake.

REPORTS:

Webster, Katherine E., Kratz, Timothy K., Bowser, Carl J., Magnuson, John J., and Rose, William J., The influence of landscape position on lake chemical responses to drought in northern Wisconsin, USA (in review).

HYDROLOGIC CONSIDERATIONS ASSOCIATED WITH THE ARTIFICIAL ACIDIFICATION OF LITTLE ROCK LAKE IN VILAS COUNTY, WI

PROBLEM: A multi-agency group will study biological chemical responses to artificial acidification of one basin of two-basin Little Rock Lake by artificially lowering the pH incrementally over an 8-year period. The basins will be separated by a barrier; one basin will be acidified, the other will function as a control. A detailed understanding of the lake hydrology is needed by the group to (1) determine which of the basins to acidify, (2) estimate the amount of acid required to achieve a given pH level, (3) characterize the lake hydrologically to increase the transfer value of the study's results to other lakes, (4) monitor the effects of the acidification on the local ground water, and (5) provide basic hydrologic information on lake hydrology that would be input to any acidification models that may be tested.

OBJECTIVE: The goals of this project are to determine monthly water budgets for each basin (the control and acidified basins) of Little Rock Lake, define ground-water-flow paths, and monitor ground-water quality.

APPROACH: Inflow to the lake from precipitation, overland flow, and ground-water discharge, and outflow from the lake from evaporation and ground-water recharge will be determined. Ground-water gradients determined from a piezometer network will be evaluated to define flow paths of ground water discharging to and recharging from the lake. Ground water discharging to and recharging from the lake will be sampled from piezometers situated in the appropriate flow paths. Concentrations of major chemical constituents, including hydrogen ion and alkalinity, nutrients, and trace elements, including aluminum and lead, will be determined. Monthly water budgets will be calculated.

PROGRESS (July 1994 to June 1995): Routine hydrologic monitoring continued. Some instrumentation and equipment from previous periods of more intensive monitoring than the present were removed from the study area.

PLANS (July 1995 to June 1996): A skeleton hydrologic monitoring network will be maintained to track the exchange of lake and ground water. This network consists of continuous measurement of lake stage and precipitation and intermittent measurement of about six piezometers.

REPORTS:

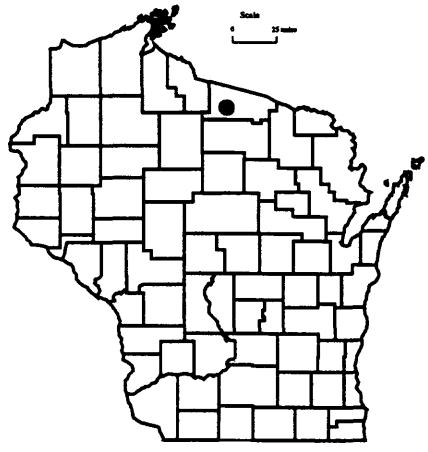
Rose, William J., 1993, Hydrology of Little Rock Lake in Vilas County, north-central Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 93-4139, 22 p.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Florence and Vilas Counties, northern Wisconsin

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
March 1987 to September 1997



MERCURY ACCUMULATION, PATHWAYS, AND PROCESSES, WI 18003

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
North-central Wisconsin

PROJECT CHIEF:
David P. Krabbenhoft

PERIOD OF PROJECT:
January 1992 to June 1995

PROBLEM: Analytical data from the waters and biota of many Wisconsin lakes has indicated that there is a statewide problem of mercury contamination in natural water systems. Elevated concentrations of mercury, coupled with the high toxicity of the element, has led to issuance of fish consumption advisories for many Wisconsin lakes. The causes of mercury contamination and processes affecting mercury cycling within the lake systems are not well understood. An intensive study of mercury biogeochemistry in the lakes is needed to provide information that can be applied to develop appropriate management practices.

OBJECTIVE: The project will be one part of a team research program whose overall objective is to understand the processes responsible for aquatic transport and transformation of mercury. Goals of this subproject are to determine net accumulation rates of mercury in lake sediments, qualify advective and diffusive fluxes of mercury from sediments, determine spatial and temporal variations in mercury accumulation and remineralization below the sediment-water interface, and assess the role of complexation and precipitation in controlling the fate of mercury.

APPROACH: The approaches used in this study will be novel, as no previous methods can yield samples without contamination. Methods developed will focus on various near-sediment, sediment, pore-water, and ground-water-sampling techniques.

PROGRESS (July 1994 to June 1995): Sampling of pore waters at small scale (centimeter) and small volume (about 50 ml) were carried out on about a monthly basis for the ice-free season (May-October) and once during ice cover. Samples were analyzed for total mercury and methylmercury content as well as other important ancillary parameters. Results show that the littoral-zone pore waters have some of the highest concentrations of methylmercury anywhere at the study site, and that the sediment/water interface is a primary site for methylmercury production in lake systems.

PLANS (July 1995 to June 1996): Results from this study will be written and published as two journal papers. One paper describing the importance of wetlands in the aquatic Hg cycle is completed and a second paper on methylation processes at the sediment/water interface is being prepared.

REPORTS:

Krabbenhoft, D.P., 1995, Mercury cycling in the Allequash Creek Watershed, northern Wisconsin (approved to publish as a journal article)

ASSESSMENT OF THE HYDROLOGY, WATER QUALITY, AND BIOLOGY OF DELAVAN LAKE, WI 18101

PROBLEM: Delavan Lake was a hypereutrophic lake where severe blue-green algae blooms occurred. Nutrient sources and loads were identified and a comprehensive management plan was developed and implemented to improve the water quality of the lake. Monitoring is continuing to determine the effectiveness of the plan.

OBJECTIVE:

1. Determine nutrient and suspended-sediment discharge at Jackson Creek near Elkhorn, Jackson Creek tributary near Elkhorn, Jackson Creek at Mounds Road (wetland outlet), and Delavan Lake inlet. Determine phosphorus discharge from the lake at Delavan Lake outlet. Continuous streamflow will be determined at all sites.
2. Determine lake stage.
3. Determine phosphorus characteristics of the lake water and other physiochemical characteristics.
4. Determine the phytoplankton and zooplankton populations, May through September.

APPROACH: Nutrients and suspended sediments will be monitored at Jackson Creek, Jackson Creek tributary, Jackson Creek wetland outlet, and Delavan Lake inlet. Phosphorus will be monitored at Delavan Lake outlet. Streamflow will be monitored at all sites. Lake stage will be monitored continuously. Phosphorus concentration of the lake water and dissolved oxygen, water temperature, pH, and specific conductance will be monitored. Phytoplankton and zooplankton will be monitored.

PROGRESS (July 1994 to June 1995): Streamflow was monitored continuously at four inflow sites and at one outflow site from Delavan Lake. Water samples were collected monthly at all stream sites. During storm runoff, samples were collected by an automatic sampler or by an observer. Water samples were analyzed for nutrients and suspended sediment. Three sites within the lake were monitored to determine the physiochemical characteristics of the water. The 1994 water-year data was compiled for publication in the report, "Water Resources Data-Wisconsin." The final phase of the lake rehabilitation plan was completed in the 1993 water year with the construction of the wetland to decrease nutrients and sediments to the lake. Despite the rehabilitation of Delavan Lake to improve its water quality, summer phosphorus concentrations in 1994 were similar to those prior to rehabilitation. However, summer water clarity is greater and chlorophyll *a* concentrations are less than prior to lake rehabilitation.

PLANS (July 1995 to June 1996): Continue monitoring program as scheduled. Compile data for publication.

REPORTS:

Field, Stephen J., and Duerk, Marvin D., 1988, Hydrology and water quality of Delavan Lake in southeastern Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 87-4168, 61 p.

COOPERATOR:

Delavan Lake Town Board

LOCATION:

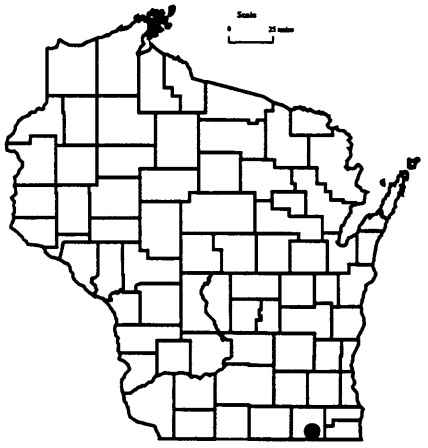
Walworth County, southeast Wisconsin

PROJECT CHIEF:

Stephen J. Field

PERIOD OF PROJECT:

August 1983-Continuing



WETLAND RETENTION OF SURFACE-WATER NUTRIENT AND SUSPENDED-SEDIMENT LOADS INFLOWING TO A EUTHOPHIC LAKE IN SOUTHEASTERN WISCONSIN, WI 18102

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Delavan Lake and Jackson Creek, southeast Wisconsin

PROJECT CHIEF:
John F. Elder

PERIOD OF PROJECT:
October 1991 to September 1996

PROBLEM: Jackson Creek is the major inflowing tributary to Delavan Lake in southeastern Wisconsin. An artificial wetland has been constructed on the creek as a means of trapping nutrients and sediments that would otherwise flow to the lake and contribute to its eutrophication. Other studies have shown that the trapping function of wetlands is not consistent and depends on little-known processes and particular conditions of the system. More information about the wetland functions is needed to assess and predict the effectiveness of the Jackson Creek wetland construction as a management strategy.

OBJECTIVE: Objectives are to assess the effectiveness of the Jackson Creek wetland as a nutrient and sediment-retention system, with emphasis on retention of phosphorus; quantify nutrient and suspended-sediment loads in surface-water inflows and outflows of the wetland; characterize effects of water flow through the wetland on variability of these loads; and describe phosphorus cycling processes and dominant phosphorus partitioning reservoirs in the wetland.

APPROACH: Phosphorus partitioning and transformation are investigated in mesocosms--enclosures containing sediments and water from the wetland and set in the wetland environment to simulate natural conditions. Phosphorus partitioning and retention in the mesocosms, and the roles of sediments and vegetation in such processes, are investigated. Additional samples from selected points within the wetland are analyzed for phosphorus and other constituents to provide comparisons between observations in the natural system and in the mesocosms.

PROGRESS (July 1994 to June 1995): Results of the mesocosm experiments, completed in the previous year, were analyzed. Reports in the literature of similar work were studied and compared with the current study. This information was collected and written in a report.

PLANS (July 1995 to June 1996): The review will be completed, revisions made, and the report finalized.

REPORTS (planned; subject to change):

Elder, J.F., and Manion, B.J., Phosphorus retention and partitioning in mesocosms of a constructed wetland in southeastern Wisconsin.

DELAVAN LAKE INLET MONITORING, WI 18103

PROBLEM: Delavan Lake, a eutrophic lake in southeastern Wisconsin, has been a site of extensive lake rehabilitation for several years to control problems related to excessive algal growth. Jackson Creek, a major tributary contributing 75 percent of the phosphorus to Delavan Lake, flows through a 1.8-mile-long, 0.2-mile-wide shallow inlet (Delavan Lake Inlet) before entering Delavan Lake. Prior to lake rehabilitation, this inlet was devoid of macrophytes due to turbidity caused by large populations of rough fish. The rough fish were eradicated as one of the lake-rehabilitation measures. After the rough-fish eradication, dense macrophytes formed in the inlet. Median summer total-phosphorus concentrations after lake rehabilitation almost doubled to about 0.6 mg/l from those prior to lake rehabilitation. It is suspected that this additional phosphorus is from phosphorus release from the inlet sediments which are enriched in phosphorus from prior sewage effluent. This release is expected to occur associated with high pH during daytime and anoxia at night due to photosynthesis of the macrophytes.

OBJECTIVE: The overall objective is to determine the primary causes of high internal phosphorus loadings from Delavan Lake inlet. Part of this study involves a laboratory analysis to measure phosphorus pools, speciation and flux rates under different ambient conditions. Field data will be collected to describe existing conditions with respect to the factors that are most likely to affect phosphorus releases and will be used in combination with laboratory rates to estimate loading from the sediments.

APPROACH: (1) Laboratory experiments to measure the effects of dissolved-oxygen concentration and pH on phosphorus flux from sediment cores sampled from the inlet; (2) measurements of diurnal changes of water temperature, dissolved oxygen, and pH in the inlet with a continuous water-quality monitor will be made; (3) measurements of diurnal changes of total and soluble reactive phosphorus, iron and manganese in the inlet will be made; and (4) installation of four experimental enclosures, two containing macrophytes and two with vegetation removed, to measure the effects of macrophytes on diurnal cycles of DO, pH, and water temperature. The enclosures will be moved monthly to five different sites within the inlet.

PROGRESS (July 1994 to June 1995): Phosphorus release from Delavan Inlet sediment cores under anoxic and varying pH conditions were determined by the U.S. Army Corps of Engineers in their laboratory. Continuous diurnal changes of water temperature, dissolved oxygen, and pH in the inlet were measured with a water-quality monitor. Diurnal changes of total and soluble reactive phosphorus, iron and manganese in the inlet were measured monthly. The experimental enclosures were monitored to measure differences between vegetated and unvegetated enclosures. A phosphorus budget was prepared for the inlet. From April to September 1994, 56 percent of the phosphorus was released from the sediments primarily caused by high pH. On an annual basis, however, this sediment release accounted for only 16 percent of the phosphorus budget.

PLANS (July 1995 to June 1996): A report will be written.

COOPERATOR:
Delavan Lake Town Board

LOCATION:
Walworth County, southeast Wisconsin

PROJECT CHIEF:
Stephen J. Field

PERIOD OF PROJECT:
April 1994 to September 1995

HYDROGEOLOGY AND GROUND-WATER USE AND QUALITY, FOX CITIES AREA, WISCONSIN, WI 182

COOPERATORS:

East Central Wisconsin Regional Planning Commission
Darboy Sanitary District #4
Kaukauna Electrical and Water Utilities
Town of Menasha Sanitary District #4
Kimberly Water Works Department
Wisconsin Geological and Natural History Survey

LOCATION:

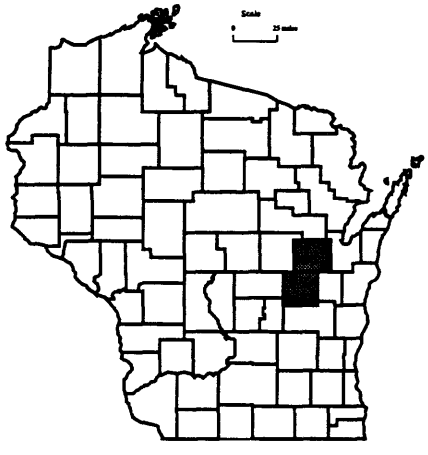
East-central Wisconsin

PROJECT CHIEF:

Terrence Conlon

PERIOD OF PROJECT:

January 1992 to September 1995



PROBLEM: Declining water levels in the sandstone aquifer due to pumping is a regional water-quantity management issue for the Fox Cities, the area along the Fox River between Neenah and Kaukauna, and for the Green Bay area. This study will provide hydrogeologic information through developing data bases and models to help in addressing ground-water management issues.

OBJECTIVE: The study will (1) characterize the hydraulic properties and boundaries of the aquifer and confining units, (2) map the past and present potentiometric surfaces of the study area, (3) compile a history of aquifer development; (4) estimate recharge rates, and (5) calibrate a ground-water-flow model that can be used to evaluate aquifer response to future pumping.

APPROACH: The hydraulic properties of the aquifers and confining units will be compiled from a literature review, and geophysical and drillers' logs for wells. Packer testing of wells open to the Sinnipee Group will provide information about recharge in the Fox Cities area. Water samples from selected wells will be analyzed for isotopes to identify flow paths. The USGS ground-water-flow model, calibrated to past and present water levels, will be used to understand the regional hydrogeology and evaluate the aquifer response to future pumping and land-use changes.

PROGRESS (July 1994 to June 1995): Compilation of hydrogeologic data indicate the rocks of the Sinnipee Group, which underlie the Fox Cities area, are a confining unit. Analyses of well logs and isotope data reveal that the Sinnipee Group does not extend as far west as previously thought and that the recharge area for the sandstone aquifer is close to the Fox Cities.

Hydrogeologic data and model parameters were compiled in a geographic information system and data files written for input to the ground-water-flow model. The simulated steady-state heads before aquifer development compare favorably with measured heads for 1915.

Historic ground-water withdrawals were compiled and used in simulating the response of water levels to pumping over time.

PLANS (July 1995 to September 1995): Simulation and particle tracking to help understand the regional flow system and determine recharge area for selected areas of aquifer beneath the Fox Cities will be run. The calibrated model will be used to predict the effect on water levels of future pumping in the area. Results of the study will be published in a report.

LAKE MICHIGAN TRIBUTARY LOADING, WI 183

PROBLEM: Concern about the potential negative health and biologic effects of toxic chemicals and heavy metals being transported into Lake Michigan has increased with growing evidence of links between the presence of these contaminants and carcinogens in fish, genetic defects in fish-eating birds, and reproductive disorders in biota. Adequate management of chemical loads requires that the total contribution of contaminants from atmospheric, ground water, and tributary rivers be quantified.

OBJECTIVE: Objectives of this project are to build a streamflow and water-quality data base for 11 Lake Michigan tributaries to act as a baseline for evaluation of future remediation activities; estimate loads of PCB's, transnonachlor, atrazine, trace metals, nutrients, and suspended solids to Lake Michigan; compare loads between tributaries to target basins of major concern; identify contaminants of greatest concern; and describe the mobility of contaminants.

APPROACH: The Wisconsin District will install acoustic-velocity-metering (AVM) stations at the mouths of the Milwaukee, Sheboygan, Fox, and Menominee Rivers to provide real-time flow and water-quality data. Field sampling will be scheduled to obtain approximately 75 percent of the samples during non-baseflow periods. Composited samples for analyses of congener-specific PCB's and pesticides will be field filtered and processed through XAD-2 resin columns. Composited samples for analyses of particulate and dissolved trace metals will be obtained using clean sampling protocols. Data will be entered into the WATSTORE and ADAPS data bases.

PROGRESS (July 1994 to June 1995): The Quality Assurance Project Plan was granted conditional approval by EPA Region V and field sampling began in March 1994. As of May 1995, approximately 375 samples have been collected from 11 tributaries to Lake Michigan for analysis of congener-specific PCB's, 11 pesticides and pesticide-degradation products, trace metals, nutrients, and major ions. Approximately 3,700 samples have been collected and analyzed for total suspended solids. AVM data from the Fox River were successfully calibrated with Doppler measurements to estimate discharge. Preliminary data summaries and analyses are in progress.

PLANS (July 1995 to June 1996): Plans are being made to extend field sampling through September 1995. Preliminary data analyses will continue as data become available from laboratories, and existing estimates of contaminant loading from the tributaries will be updated. A final report outline will be prepared and sent out for review.

COOPERATORS:
Environmental Protection Agency
Wisconsin Department of Natural Resources

LOCATION:
Cities of Marinette, Green Bay, Milwaukee and Sheboygan

PROJECT CHIEF:
David W. Hall

PERIOD OF PROJECT:
July 1992 to October 1996

TRACE-METAL TRANSPORT TO STREAMS, WI 18301

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
North Branch of the Milwaukee River at Cascade, Wisconsin

PROJECT CHIEF:
David Krabbenhoft

PERIOD OF PROJECT:
October 1992 to September 1995

PROBLEM: Recent investigations on trace-metal concentrations in surface waters have revolutionized scientists' views of the trace-metal cycle in aquatic ecosystems. Ultra-clean methodologies must be employed at all steps of this research, and even then it is difficult to acquire contamination-free samples. Although we now have a better understanding of trace-metal concentrations in the environment, very little is known about how the metals are delivered to the stream and the processes that affect the transport of trace metals once in the stream.

OBJECTIVE: The principal objective of this project is to gain a better understanding of the processes that control trace-metal transport to streams. Under this broad objective, we propose to (1) develop ultra-clean sampling methods for ground water, pore water at the near sediment/water interface, springs, and stream water, and (2) examine the temporal variability of trace-metal concentrations in stream/ground-water ecosystems.

APPROACH: A variety of sampling methods will be employed, all of which adhere to the strict protocols for trace-metal sampling. A site along the North Branch of the Milwaukee River has been chosen as the location for intensive investigations of stream-, ground-, pore- and spring-water concentrations of trace metals (mercury, lead, zinc, copper, cadmium) as well as other chemical ancillary measurements. Stream discharge and ground-water levels will be monitored to relate hydrologic conditions to trace-metal concentrations in each part of the hydrologic system. Sampling will be conducted on about a bimonthly basis.

PROGRESS (July 1994 to June 1995): Samples from the Milwaukee River, ground water, springs, and pore waters have been taken on about a bimonthly basis and analyzed for mercury, copper, and zinc. In addition, a synoptic survey of 10 locations along the first 12 miles of the Milwaukee River basin was conducted to examine potential trace-metal contributing points.

PLANS (July 1995 to June 1996): Results will be presented at professional meetings and written up in two journal papers.

LAKE SUPERIOR TRIBUTARY LOADING, WI 18302

PROBLEM: Concern about the potential negative health and biologic effects of toxic chemicals and heavy metals being transported into Lake Superior has increased with growing evidence of links between the presence of these contaminants and carcinogens in fish, genetic defects in fish-eating birds and reproductive disorders in biota. Adequate management of chemical loads requires that the total contribution of contaminants from atmospheric, ground water, and tributary rivers be quantified.

OBJECTIVE: Objectives of this project are to build a streamflow and water-quality data base for two Lake Superior tributaries to act as a baseline for evaluation of future remediation activities, estimate loads of targeted contaminants to Lake Superior, compare loads between tributaries to target basins of major concern, identify contaminants of greatest concern, and describe the mobility of contaminants.

APPROACH: The Wisconsin and Minnesota Districts will install acoustic-velocity-metering (AVM) stations at the two St. Louis River harbor exits to Lake Superior and instrument the Nemadji River for water-quality sampling. The AVM sites will be calibrated using Doppler discharge measurements. Infiltrex automated organic samplers will be installed to obtain flow-composited samples for organic analyses. Data will be entered into the WATSTORE and ADAPS data bases.

PROGRESS (July 1994 to June 1995): Equipment has been installed and plans established to start water-quality sampling by the end of May 1995. Calibration of the AVM's will continue and storm sampling using automated ISCO suspended-solids samplers will continue.

PLANS (July 1995 to June 1996): Calibration of the AVM's will be completed and the sites operated for water quality and streamflow.

COOPERATORS:

U.S. Environmental Protection Agency
Wisconsin Department of Natural Resources
Minnesota Pollution Control Agency

LOCATION:

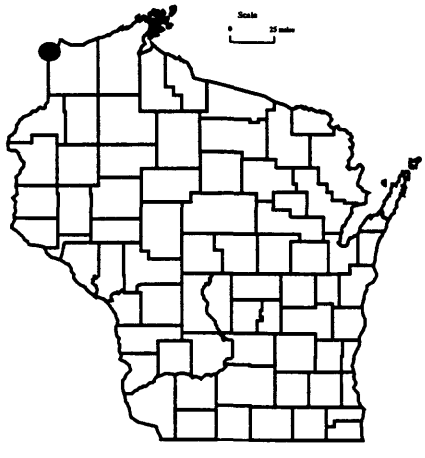
Cities of Duluth, Minnesota and Superior, Wisconsin

PROJECT CHIEF:

Peter E. Hughes

PERIOD OF PROJECT:

July 1993 to October 1996



REGIONALIZED ESTIMATES OF LOADS TO THE UPPER GREAT LAKES, WI 18303

COOPERATOR:
U.S. Environmental Protection Agency

LOCATION:
Drainages to Lake Michigan and Lake Superior

PROJECT CHIEF:
Dale M. Robertson

PERIOD OF PROJECT:
January to September 1994

PROBLEM: In establishing a prioritization of sites for mass-balance studies and remediation, it is desirable to rank the tributaries based upon their relative contributions of sediment-derived contaminants. Prioritization studies have been conducted within small geographic areas; however, a prioritization for the entire area near the Upper Great Lakes has not been performed.

OBJECTIVES: The objectives are to (1) develop methods to estimate frequency-volume relations for streams draining to the Upper Great Lakes, (2) develop methods to compute the suspended-sediment loads for specific flood frequencies (i.e., 10- and 50-year storms), (3) compute suspended sediment loads for the entire 1975-1990 period, (4) develop a method to extrapolate information from well-monitored rivers to rivers with relatively little information, (5) rank the tributaries on the basis of sediment loads for storms and for the entire 1975 to 1990 period, and (6) use sediment chemistry to calculate the relative loads for selected constituents (PCB's) for each tributary for storms and the entire 1975 to 1990 period.

APPROACH: The approach for this project is to conduct a regionalized frequency-volume analysis for 1-, 3-, and 7-day storms with return frequencies of 10 and 50 years for all sites with continuous-discharge measurements and extensive water-quality data (NASQAN sites). Storm and long-term (1975-1990) loads for suspended sediment for these sites will be estimated using constituent-transport models. The constituent-transport models which are being used are based on multiple-regression analyses between constituent load and several variables including discharge and time (seasonal and annual). After calibrating the models (deriving equations to estimate loads), the storm loads will be estimated using the storm discharges from part 1 for two different seasonal periods (spring and summer). Loading from relatively unmonitored rivers will be estimated by determining the "most similar" well-monitored site based on similar surficial deposits, land use, and stream gradient and using the ratio of drainage sizes. The basins will be ranked based on the total storm loads of suspended sediment and PCB's for the design floods and their loads for the 1975 to 1990 period.

PROGRESS (July 1994 to June 1995): The analyses have been completed. The loadings of suspended sediment were highest from rivers with steep gradients located in areas with high clay content. The average total annual inputs of suspended sediment into Lake Michigan and United States part of Lake Superior were 0.8 and 1.4 billion kilograms, respectively. Loadings during storms were a significant portion of this total load, especially for rivers flowing through areas with steep terrains. The largest contributor of suspended sediment over the entire period and during storms was the Bad River draining into Lake Superior. The dominating contributor of PCB's, overall and during storm events, was the Fox River.

PLANS (July 1995 to June 1996): The report summarizing the project results will be published.

WATER-QUALITY MONITORING OF INDUSTRIAL STORM-WATER RUNOFF, WI 185

PROBLEM: The United States Environmental Protection Agency (USEPA) is requiring industries to monitor storm-water runoff for given chemical constituents. Sampling techniques need to be developed for industries with and without well-defined drainage networks.

OBJECTIVE: Objectives are to (1) Compare and evaluate different storm-water sampling schemes, (2) estimate storm-event mean concentrations and annual chemical constituent loads from selected industries using appropriate modeling techniques, (3) design and operate a monitoring program to collect representative storm-water-quality samples, and (4) design and test an electronic impervious source-area sheet-flow sampler.

APPROACH: Paired sampling techniques will be used to determine whether time-composite sampling can be substituted for flow-composite sampling. Furthermore, passive source-area sheet-flow sample results will be used to calculate a loading value which will be compared to the flow-composite loading value. Electronic impervious source-area sheet-flow samplers will be tested to determine whether representative flow-composite samples are taken by the new sampler.

PROGRESS (July 1994 to June 1995): Storm loads and flow data from the first phase of the project have been summarized in a data report. Design and testing of the electronic impervious source-area sheet-flow sampler have been completed at a site in Madison.

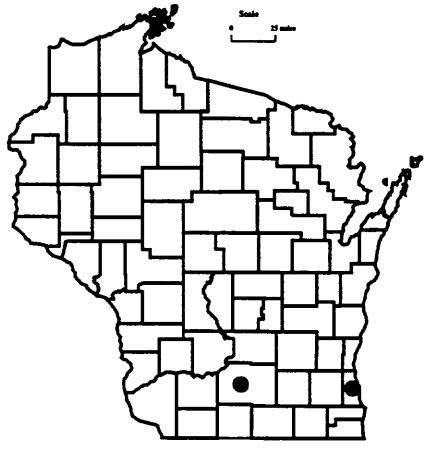
PLANS (July 1995 to June 1996): Results from the electronic impervious source-area sheet-flow sampler tests will be summarized in a data report

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Madison and Milwaukee, Wisconsin

PROJECT CHIEF:
David W. Owens

PERIOD OF PROJECT:
June 1992 to April 1994



WATER QUALITY OF URBAN STORM-WATER RUNOFF IN MADISON, WISCONSIN, WI 187

COOPERATOR:
City of Madison

LOCATION:
Madison, Wisconsin

PROJECT CHIEF:
Robert J. Waschbusch

PERIOD OF PROJECT:
August 1992 to September 1996

PROBLEM: Eutrophication is the most serious impairment to the beneficial uses of Madison lakes. Phosphorus is the nutrient most identified with the cause of eutrophication. Restoration of Madison lakes will require some reduction of phosphorus loadings. Since a few of the sources could produce a disproportionate amount of phosphorus loading, management programs should target the most critical sources of the phosphorus.

Existing urban runoff models need more calibration to more accurately identify the important sources of the phosphorus. Insufficient data has been available to calculate a phosphorus loading from each of the source areas. Runoff concentration data is needed from lawns, streets, roofs, parking lots and driveways.

OBJECTIVES: Objectives are to (1) determine the importance of annual and seasonal phosphorus loadings from lawns in Madison, (2) determine the contribution of lawn and leaf litter to the high phosphorus concentrations observed on Madison streets, (3) determine the amount of phosphorus in each particle-size fraction found on the streets, especially the size fractions most likely to be removed by street sweeping, (4) determine the benefits of improved leaf pick-up programs in the fall, and (5) develop a set of recommendations for reducing phosphorus loading to Madison lakes.

APPROACH: Storm-water-runoff samples will be collected and analyzed for total phosphorus and suspended solids from eight different source areas. The source areas are lawns, residential roofs, flat roofs, driveways, parking lots, feeder streets, collector streets and arterial streets. Up to 25 samples will be collected from each source area. During 1994, the sampling basin was the Monroe Street basin on Madison's west side. During 1995, the sampling basin will be either the Lakeland Avenue basin or the Harper Road basin on Madison's east side. These concentration results will be used to calibrate the Source Loading and Management Model (SLAMM) and estimate the storm, seasonal and annual loads from each source area. In addition to storm-water-runoff samples, six street dirt samples will be collected throughout the year (excluding winter) from each of the three different street types in the two basins. These samples will be sieved into four different size fractions. Each of these size fractions will be analyzed for total phosphorus and microscopically analyzed for percent vegetative versus mineral material.

PROGRESS (July 1994 to June 1995): Source-area sampling apparatus were constructed and installed in each of the eight source areas in the Monroe Street basin in May 1994. Twenty-five runoff events were sampled from May 23 to November 13. Six street dirt samples were collected from April 10 to October 28.

PLANS (July 1995 to June 1996): A basin on the east side of Madison was be selected for source-area sampling and the source-area-sampling equipment was installed in April. Up to 25 storm-water-runoff events will be sampled and six street dirt samples will be collected during the spring, summer and fall of 1995. All concentration data will be compiled and used to calibrate the SLAMM. The SLAMM will then be used to estimate the storm, seasonal and annual loads from each source area. The street dirt samples will be sieved into four size fractions and analyzed for total phosphorus content and vegetative fraction.

DANE COUNTY REGIONAL HYDROLOGIC STUDY, WI 189

COOPERATORS:

City of Middleton
Dane County Regional Planning Commission
Madison Metropolitan Sewerage District
Wisconsin Department of Natural Resources
Wisconsin Geological and Natural History Survey

LOCATION:

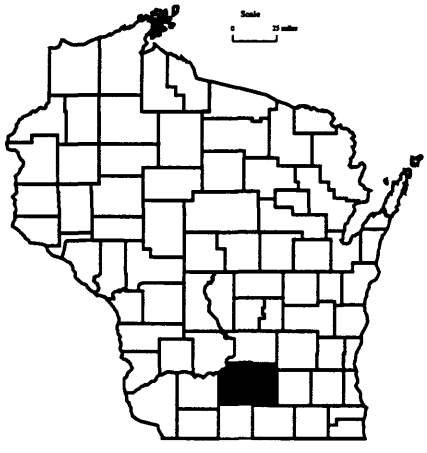
Dane County and parts of surrounding counties

PROJECT CHIEF:

William G. Batten

PERIOD OF PROJECT:

October 1992 to December 1995



PROBLEM: Officials at all levels of government are concerned about the effects of increasing urban growth and development on the surface- and ground-water resources in Dane County. The relation between surface water and ground water must be understood to allow for increased ground-water withdrawals while protecting the quality and quantity of surface-water resources in the county. A comprehensive study that combines existing water data with new data is needed to provide government and planning agencies with a tool to aid in managing the water resources of the Dane County area.

OBJECTIVES: The objective is to provide a better understanding of the regional ground-water system and the effects of urban development, ground-water withdrawals and inter-basin diversions on Dane County's ground- and surface-water resources.

APPROACH: Existing and new data will be compiled to update potentiometric and water-table surfaces, subsurface geology, and aquifer parameters. New data will be collected in areas critical to understanding ground-water flow and direction. A regional ground-water-flow model will be developed to simulate changes in ground-water levels caused by increased pumpage, to identify critical recharge and discharge areas and to show the direction and rate of ground-water flow. The model will then be used as a management tool to simulate and evaluate the effects of management strategies designed to mitigate adverse effects of increased ground-water withdrawals on the surface- and ground-water systems in the Dane County area.

PROGRESS (July 1994 to June 1995): Boundaries of the ground-water-flow system were identified from a screening model. These boundaries plus all existing and new geologic, hydraulic, and pumpage data were then used to construct a three-dimensional ground-water-flow model to simulate ground-water flow in the Dane County area. Water levels and discharges from the aquifers to streams were simulated using this regional model. These water levels and stream discharges were then compared to historical water-level data and stream flow to calibrate the model.

PLANS (July 1995 to June 1996): The calibrated ground-water-flow model will be used with estimates of future ground-water pumpage rates and locations to simulate the effect these changes may have on water levels in the aquifer and on surface water in Dane County. A report that includes water-table and potentiometric-surface maps, hydrogeologic cross sections, values of aquifer parameters, and a conceptual description of the ground-water-flow system will be published. A second report describing the regional ground-water-flow model design, calibration, and results of model simulations of the flow system will also be published.

EFFECTS OF MICROBIAL ACTIVITY ON SEDIMENT/WATER EXCHANGE OF POLYCHLORINATED BIPHENYL CONGENERS IN THE LOWER FOX RIVER, WISCONSIN, WI 190

PROBLEM: The lower Fox River, the principal tributary of Green Bay and Lake Michigan, flows through a heavily industrialized area. More than 100 contaminants have been identified in the system; among the most significant of these are PCB's. To predict possible toxicological effects and downstream transport of these contaminants, it is important to take into account not only their source concentrations, but also the factors that can affect their partitioning, especially their transfer from bottom sediments (the principal repository) to water (the principal medium of transport). There is a scarcity of this kind of information at present.

OBJECTIVE: Objectives are to describe the role of microbial activity in controlling sediment/water exchange of PCB congeners and determine the extent to which microbially-mediated exchange is dependent on total PCB concentration and congener composition.

APPROACH: Sediment and water samples from the lower Fox River are used in controlled microcosm experiments in elution columns, applying an experimental design similar to that used in previous work. A specific PCB congener, labeled with carbon-14, is mixed uniformly into a measured quantity of sediment which is used to fill a vertical column that is connected to a precision metering pump. Ambient river water is pumped through the system, and carbon-14 activity is monitored over time in the outflow water. The results include data that can be used to calculate observed distribution coefficient—a measure of partitioning of the PCB congener between sediments and water mobility. The elution column experiments will be tested under different conditions to assess effects of microbial activity and presence or absence of oxygen.

PROGRESS (July 1994 to June 1995): Experiments with sediment core samples from bottom sediment deposits in the lower Fox River were completed. Results were analyzed to determine rates of sediment-water transfer of 2,2'5,5'-tetrachlorobiphenyl and 2,2',4,4',5,5'-hexachlorobiphenyl and how such transfer is affected by presence or absence of oxygen and presence or absence of bacterial action. Report outlines and parts of report drafts were written.

PLANS (July 1995 to September 1995): Report writing, reviews, and revisions will be completed.

REPORTS (planned; subject to change):

Elder, J.F., James, R.V., Godsy, E.M., and Steuer, J.J., Microbial enhancement of PCB congener mobility at the sediment/water interface in the lower Fox River, Wisconsin.

James, R.V., and Elder, J.R., Procedures for elution column experimentation to determine mobility of polychlorinated biphenyls using carbon-14-labeled congeners.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

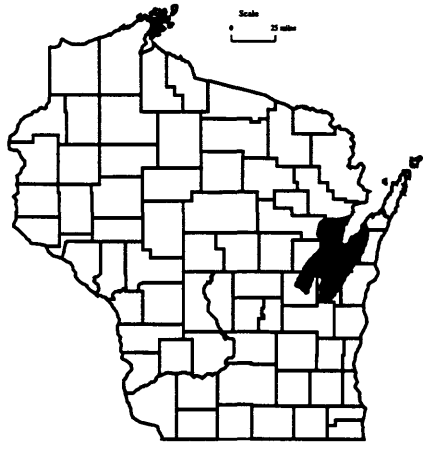
Lower Fox River, East Central Wisconsin

PROJECT CHIEF:

John F. Elder

PERIOD OF PROJECT:

October 1992 to September 1995



TRANSPORT AND BIOGEOCHEMICAL CYCLING OF PCB'S IN THE MILWAUKEE RIVER - THE IMPORTANCE OF ALGAL DYNAMICS, WI 191

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Milwaukee County, eastern Wisconsin

PROJECT CHIEF:
Jeffrey J. Steuer

PERIOD OF PROJECT:
February 1993 to December 1996

PROBLEM: The Milwaukee Harbor is identified as an area of concern by the International Joint Commission because it is highly contaminated by toxic synthetic organic chemicals and trace metals. A plan is being developed to restore and revive the surface waters of this area, but little is known about the upstream transport of contaminated in-place sediments. Knowledge of the processes that control cycling and transport of polychlorinated biphenyls (PCB's) is essential to the remediation effort. Algal incorporation of PCB's may be a quantitatively important process in this transport.

OBJECTIVE: The objective is to determine the link between algal dynamics and PCB transport by characterizing total suspended solids (TSS) in the river as biogenic (algal) and detrital components, determining PCB, organic carbon and lipid concentrations of each fraction, and evaluating the link between algal uptake of PCB's and concentration of PCB's in TSS and resuspendable surficial bottom sediments. Milwaukee River PCB loading will be determined at Estabrook Park, Thiensville, and Pioneer Road. PCB loading will also be determined on Cedar Creek, a tributary entering upstream of Pioneer Road. Due to high bottom sediment and fish PCB concentrations, a fourth site has been selected on the South Branch of the Manitowoc River at Hayton.

APPROACH: The three Milwaukee River sites and one Manitowoc River site will be monitored for two years during event and baseflow conditions. Automated water-quality samplers will be used to obtain daily total suspended solids (TSS) samples; more intensive samples will be obtained on the rising hydrograph limb. Between June 1993 and June 1995, 26 manual organic samples (80 liters) will be collected at the Milwaukee sites and 18 samples will be collected at the Hayton site. Measured water-column characteristics include PCB (dissolved and particulate), TSS, VSS, particulate and dissolved organic carbon, chlorophyll *a*, sand/silt split and chloride.

Water column and bed algae will be seasonally collected and a biomass determined. Dominant algal species will be laboratory cultured and PCB uptake subsequently measured. These data will be used to calculate the algal and detrital PCB fractions.

Seasonal samples will also be collected from the surficial sediment layer at each of the four sites. Total organic carbon, congener-specific PCB, porosity, particle density, bulk density, and chlorophyll *a* will be determined during each of the four seasons.

PROGRESS (June 1994 to July 1995): Seventy-five percent of the field data have been collected. Water-column PCB concentrations on the Milwaukee River range from 3 to 113 ng/L resulting in transported PCB loads of 4 to 260 grams per day. Hayton water-column PCB concentrations range from 44 to 227 ng/L, producing transported PCB loads of 4 to 166 grams per day. The algal identification effort has been completed and laboratory PCB uptake experiments have begun.

PLANS (July 1995 to June 1996): Field data collection and laboratory PCB uptake experiments will be completed. An algal dynamic journal article and a PCB transport data report will be written.

WATER RESOURCES AT WILD ROSE FISH HATCHERY, WAUSHARA COUNTY, WISCONSIN, WI 192

PROBLEM: The Wild Rose State Fish Hatchery is one of the oldest and largest cold-water hatcheries in the State. The water supply for the hatchery consists of scattered springs, seeps, and many small-diameter flowing wells screened in sand and gravel. Combined flow from springs and wells is approximately 3 million gallons per day. Water from these sources requires treatment to remove nitrate. Water is treated at each raceway because of the diffuse nature of the water supply. Water from this supply system is expensive to treat and may be contaminated.

OBJECTIVE: The study will evaluate the ground-water system at the hatchery, provide estimates of the hydraulic properties of the sand and gravel aquifer, and recharge area for water captured by hatchery wells, and provide predictions of the effects of pumping from several large-diameter wells on spring flow and ground-water levels.

APPROACH: Using wells at the hatchery, slug and aquifer tests will be performed to estimate the hydraulic conductivity of the sand and gravel aquifer. Environmental isotopes will be used to estimate the recharge area for the aquifer. Seismic-refraction data will be collected to determine the thickness of the aquifer. A ground-water-flow model, calibrated to ground-water levels and streamflow measured at the hatchery, will predict the effect of pumping from wells on water levels in the sand and gravel aquifer and the effect on spring flow.

PROGRESS (July 1994 to June 1995): The thickness of the glacial aquifer at the hatchery is approximately 200 feet. Seismic velocities of the bedrock indicate that sedimentary rock below the hatchery is thin or not present. An analytic element model was developed to simulate existing flow conditions of the glacial aquifer in the area. Preliminary results of modeling suggest that flow under or from the Pine River is necessary to maintain the discharge of ground-water from springs at the hatchery. Water samples were collected and analyzed for oxygen and hydrogen isotopes which may help in determining the source and age of water flowing to wells at the hatchery.

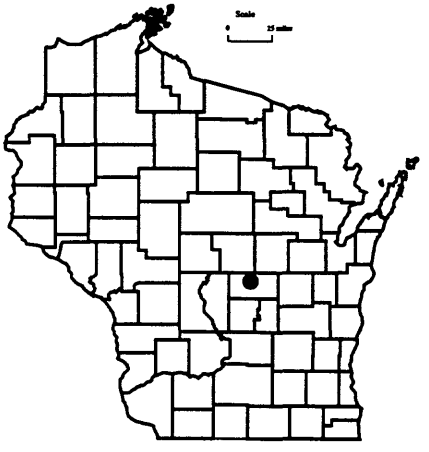
PLANS (July 1995 to June 1996): An aquifer test will be performed to better determine the aquifer properties at the hatchery and the model will be revised, if necessary. The effect of future pumping at the hatchery will be evaluated using distance- and time-drawdown curves and modeling. Results of the study will be published in a report.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
2 miles north of Wild Rose, Waushara County, Wisconsin

PROJECT CHIEF:
Terrence Conlon

PERIOD OF PROJECT:
June 1993 to September 1996



NORTH FISH CREEK SEDIMENT, WI 193

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
East-central Bayfield County near Ashland, Wisconsin

PROJECT CHIEF:
Faith Fitzpatrick

PERIOD OF PROJECT:
June 1994 to September 1996

PROBLEM: North Fish Creek has been identified as having an excessive sediment load that is causing major sedimentation problems in its lower reaches and in Chequamegon Bay. The sediment may be limiting spawning habitat for steelhead, coho salmon, and trout, and also may be impacting important wetland aquatic habitat in the coastal wetland located at the mouth of Fish Creek.

OBJECTIVES: The objectives of this study are to (1) identify sedimentation rates in the floodplain and channel prior to European settlement, (2) identify variations in historical sedimentation rates, (3) identify extrinsic and intrinsic factors leading to destabilization of the fluvial system, and (4) identify the effects of variations in storm runoff on channel hydraulic processes of sediment erosion, transport, and deposition.

APPROACH: Cores of channel, floodplain, and back-water sediment will be examined and dated using indirect and radiometric techniques. Channel geometry of relict cutoff meanders will be compared to channel geometry of the active channel along several reaches of the stream characterized by erosional, transitional, and depositional processes. Historical records such as Government Land Office Surveys, bridge designs, maps, aerial photographs, and field notes will be used to supplement field data. Rates of bluff retreat will be quantified using aerial photographs from 1938, 1950, and 1990.

PROGRESS (July 1994 to June 1995): Approximately 100 cores in the floodplain and 20 stream-bank exposures were examined. Surveying of channel geometry of active and relict channels has begun. Supplemental data from historical records have been collected. A gaging station at Moquah, Wisconsin, was reactivated in October 1994. Preliminary analysis of the data suggests that (1) a pre-European settlement surface can be identified in floodplain deposits, (2) sedimentation is episodic and occurs almost exclusively during large floods, (3) episodic sedimentation in the lower reach of North Fish Creek occurred prior to European settlement but increased after European settlement, and (4) both the texture of the sediment and the rate of historical sedimentation has changed since the area was first settled by Europeans.

PLANS (July 1995 to June 1996): Obtain sediment cores from Chequamegon Slough and relict channels. Complete surveys of channel geometry of active and relict channels. Submit sediment samples for dating and particle-size analysis. Calculate amount of bluff retreat. Begin analysis of relation between runoff and channel hydraulic processes.

REPORTS:
Fitzpatrick, F.A., and Knox, J.C., Effects of variations in vegetation, climate, and isostatic rebound on hydrology and sedimentation of North Fish Creek, Bayfield County, Wis. (in preparation).

FT. McCOY GROUND-WATER QUALITY, WI 194

PROBLEM: Fort McCoy, a military base in north-central Monroe County, Wisconsin, has several sites contaminated with petroleum-based organic compounds which have leaked from underground storage tanks or pipelines.

OBJECTIVE: The objective of this study is to determine the vertical and areal extent of soil and ground-water contamination from leaking underground storage tanks and associated pipelines.

APPROACH: The distribution of contaminant will be determined by collecting soil and ground-water samples with a Geoprobe and analyzing the samples with a field gas chromatograph. Approximately 20 percent of the field-analyzed samples will be sent to a certified lab for verification of field analyses.

PROGRESS (July 1994 to June 1995): Three types of sites were identified and selected for investigation: (1) buildings, (2) petroleum-oil-lubrication stations and (3) selected points along pipelines. Since field work began in July 1994, the District and the Environmental Management Division, Fort McCoy, have purchased a Geoprobe and field gas chromatograph. Contaminant plumes have been delineated at approximately one-half of the selected sites. Field and laboratory analyses have been tabulated along with plots of the site and sampling locations.

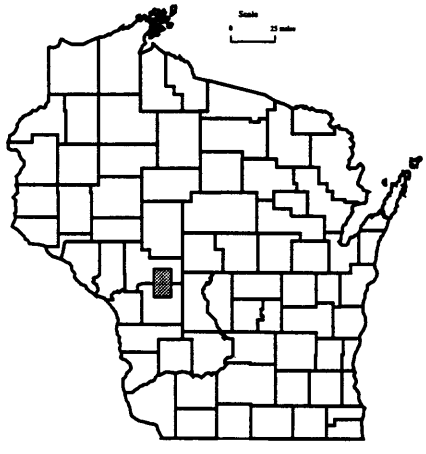
PLANS (July 1995 to October 1995): Sample collection and analyses will continue until all of the selected sites are investigated. A final report listing analyses and site and sampling locations will be written.

COOPERATOR:
Department of Defense, Environmental Management Division, Fort McCoy

LOCATION:
Fort McCoy, Wisconsin

PROJECT CHIEF:
John F. DeWild

PERIOD OF PROJECT:
July 1994 to October 1995



FORT MC COY ENVIRONMENTAL MANAGEMENT DIVISION SUPPORT, WI 195

COOPERATOR:
Department of Defense, Environmental Management Division, Fort McCoy

LOCATION:
Fort McCoy, Wisconsin

PROJECT CHIEF:
Ty Sabin

PERIOD OF PROJECT:
October 1994 to September 1996

PROBLEM: The Fort McCoy Environmental Management Division (EMD) has requested technical assistance from the Wisconsin District to help in the hydrologic, hydrogeologic and geomorphic characterization of Fort McCoy-supported Army Reserve Centers in the six-state area including Iowa, Illinois, Indiana, Michigan, Minnesota and Wisconsin.

OBJECTIVE: The objective is to broaden the knowledge and understanding of hydrology, hydrogeology, and geomorphology in the vicinity of the Fort McCoy-supported Army Reserve Centers in the six-state area.

APPROACH: The Wisconsin District will provide hydrologic, and geomorphologic expertise and support to the Fort McCoy-supported Army Reserve Centers in the six-state area.

PROGRESS (October 1994 to June 1995): A series of products are being created to assist Fort McCoy EMD personnel in managing natural and cultural resources. Products include a geomorphologic and paleoenvironmental history of the Fort. Supporting field work has included sampling bog sediments for pollen analysis, examining soil stratigraphy in trenches, and soil coring along transects to establish the spatial distribution, thickness, and nature of soil strata. The geomorphologic and paleoenvironment information will be incorporated into a three-dimensional digital model created within a Geographic Information System. Literature review and base-map compilation have been completed.

PLANS (July 1995 to June 1996): Field work will be completed in early fall 1995. Model creation will be completed by late fall of 1995 and reports including possible journal article(s) will follow through the spring 1996.

ANTARCTIC HYDROLOGIC STUDIES, WI 196

PROBLEM: The understanding of biogeochemical processes in temperate zone lakes and streams is difficult due to the complex mixing and diversity of the processes involved.

OBJECTIVE: The objective is to enhance the understanding of biogeochemical processes that occur in temperate zone lakes, streams and rivers.

APPROACH: By focusing the study on the lakes and streams in the McMurdo Dry Valleys of Antarctica, we can take advantage of the closed systems with stable water columns, low organic inputs, and polar desert landscapes to conduct research that will lead to the understanding of biogeochemical processes in other, more complex, environments.

PROGRESS (October 1994 to January 1995): Responsibility for operating two gaging stations on the Onyx River in Wright Valley was assumed. Pressure transducers were installed at each site, and the control structure on the Vanda Weir was improved. The Onyx River gaging work will be done in concert with the New Zealand Antarctic Research Program in the future.

An additional gage with a pressure transducer was installed at Lawson Creek. Preliminary site work was conducted at three other locations in Taylor Valleys. These gages were on Harnish Creek, Parker Creek, and the channel reactivation on Von Guerard Stream.

Continuous streamflow data was collected at 16 gages, and intermittent data at an additional 14 sites. An annual data report summarizing the results is planned.

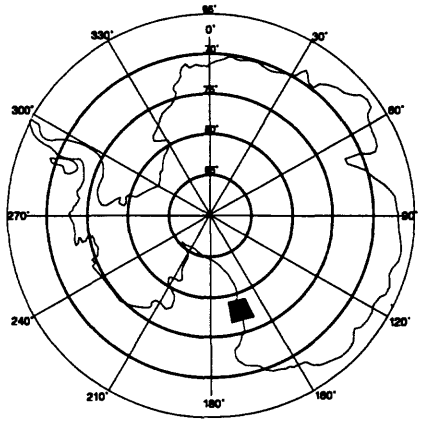
PLANS (February 1995 to September 1995): Data will be reviewed and stored in a relational database, to be made available to the long-term ecological research (LTER) data manager at Desert Research Institute. A variety of analysis will be performed on the data to support LTER researchers in their efforts to publish scientific articles. Logistical preparations for the next field season will be made.

COOPERATOR:
Desert Research Institute,
Reno, Nevada

LOCATION:
McMurdo Dry Valleys, Antarctica

PROJECT CHIEF:
Harry House

PERIOD OF PROJECT:
October 1994-Continuing



FLORIDA EVERGLADES MERCURY CYCLING, WI 197

COOPERATOR:
U.S. Geological Survey
Reston, Virginia

LOCATION:
Florida Everglades

PROJECT CHIEF:
David P. Krabbenhoft

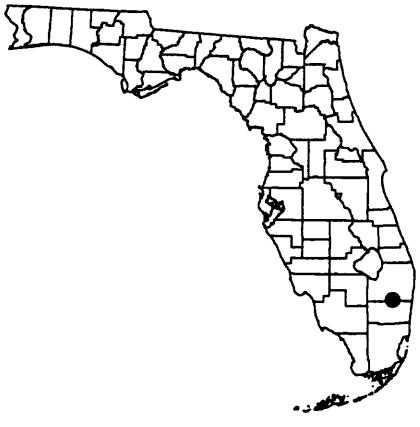
PERIOD OF PROJECT:
January 1995 to September 1999

PROBLEM: Mercury contamination is one of the largest potential health risks to aquatic organisms, predatory animals, and humans. This great concern is the result of two observations: (1) it biomagnifies in the food chain to toxic concentrations even though it is found at very low aqueous concentrations and (2) the principal source to most areas is atmospheric deposition. Thus, almost any aquatic ecosystem with a food chain is potentially susceptible to mercury contamination.

OBJECTIVES: The overall objective of this project is to provide a better understanding of the mercury contamination problem in the Florida Everglades and other aquatic ecosystems. Specific processes will be investigated, including particle and dissolved transport, volatilization, methylation, and interactions with dissolved organic carbon.

APPROACH: The use of ultra-clean sampling techniques are requisite for all aspects of mercury research because of the very low concentrations present in the environment. Samples will be collected for analysis of total mercury, methylmercury, and elemental mercury in water and sediments.

PROGRESS (January 1995 to June 1995): The two primary project objectives for this year were to choose field sites and initiate sampling in the Everglades, and to begin construction of a Mercury Research Lab. Sites were chosen to evaluate the effects of water draining from the northern cropped areas into the Everglades. A transect of seven sites was established (four in the drainage canals and three in the marsh) and intensive sampling for mercury and other important ancillary constituents was performed during March 1995. In addition, reconnaissance surveys were performed by helicopter to extend our network to more distant, less accessible areas in the southern Everglades. A second field trip is planned for July 1995. Most of the necessary equipment for the mercury research lab has been purchased, and it is anticipated the analyses for total mercury in water and sediments will be available by July 1995.



PLANS (July 1995 to June 1996): The areal extent of sampling in the Everglades will be expanded to include areas in the southern Everglades, including the Water Conservation Areas and the Everglades National Park. A synoptic sampling of the entire Everglades system for elemental mercury concentrations in surface water will be conducted in the fall of 1995. Following the establishment of total mercury analysis, instrumentation will be assembled to allow for the analyses of methylmercury and elemental mercury.

VELOCITY PROFILES UNDER AN ICE COVER

PROBLEM: The practice of using a single coefficient to adjust measured velocity at a single point in the vertical under an ice cover is suspect in light of recent evidence in the literature. An evaluation of the present technique and development of alternative techniques for measuring discharge under an ice cover is needed.

OBJECTIVE: The objectives of this project are to determine the variation of coefficients for adjusting point velocity to mean velocity at various locations under an ice cover and to develop recommendations for measuring discharge under an ice cover.

APPROACH: Weekly velocity profiles will be made at 13 sites across the United States. Complete vertical velocity profiles will be made at the usual 20-30 points across the cross section. For each profile, coefficients to adjust point velocity to mean velocity will be computed using an integrated estimate of the mean velocity in the vertical. The coefficients will be analyzed at each site to determine spatial and temporal variations, and for variation across sites. Various computational procedures will be compared to discharge computed using the full profile information.

PROGRESS (July 1994 to June 1995): Publication process for journal article (Walker, 1994) was completed. A journal article describing a joint data base in Canada and the United States was completed, and a paper submitted to the ASCE Journal of Hydraulic Engineering.

PLANS (July 1995 to June 1996): Publication process for journal article (Walker and Wang, 1995) will be completed. This paper constitutes completion of the project.

REPORTS:

Walker, J.F., 1994, Methods for measuring discharge under an ice cover, ASCE J. of Hydraulic Engineering, v. 120, no. 11, p. 1327-1336.

Walker, J.F., and Wang, D., 1995, Measurement of flow under ice cover in North America, submitted to ASCE J. of Hydraulic Engineering.

COOPERATOR:
Office of Surface Water, WRD, U.S. Geological Survey

LOCATION:
Nationwide

PROJECT CHIEF:
John F. Walker

PERIOD OF PROJECT:
January 1987-Continuing

Completed Projects

The following is a list of completed projects with reports that are in various stages of preparation.

WI00101	Discharge ratings for tainter gates and roller gates at Lock and Dam No. 7 on the Mississippi River at La Crescent, Minnesota
WI093	Geology, ground-water flow, and dissolved-solids concentrations along hydrogeologic sections through Wisconsin's aquifers
WI123	Water resources of the Lac du Flambeau Indian Reservation, Wisconsin
	Water resources of the Bad River Indian Reservation of Wisconsin
	Hydrology and water quality of the Stockbridge-Munsee Indian Reservation, Wisconsin
	Distribution of PCB and mercury in sediments of the Apostle Islands/Chequamegon Bay area of Lake Superior, Wisconsin
WI151	Surface-water quality assessment of the upper Illinois River Basin in Illinois, Indiana, and Wisconsin: major and trace elements in water, sediment, and biota, 1978-90
WI15401	Transient hydrogeological controls on the chemistry of a seepage lake
WI167	Mobility of 2,2'5,5' tetrachlorobiphenyl in model systems containing bottom sediments and water from an industrialized river basin in northeastern Wisconsin
WI169	Types and concentrations of contaminants measured in Wisconsin storm sewers and urban streams
WI171	Application of habitat-suitability index models to assess effects of fine-grained sediment on brook trout and brown trout habitat
WI17211	A method for analyzing the effects of storm-water discharge on contaminant concentrations in urban streams
WI17304	Development of a hydrologic budget model to simulate Devils Lake stage, Sauk County, WI (JA)
	Simulation of stage and the hydrologic budget of Devils Lake, Sauk County, WI (OFR)
WI178	Hydrogeology of southwestern Sheboygan County, Wisconsin, in the vicinity of the Kettle Moraine Springs fish hatchery
WI184	The regional ground-water flow system between the Wolf and Fox Rivers near Green Bay, Wisconsin

WISCONSIN DISTRICT PUBLICATIONS

The reports listed below are a partial list of reports prepared by the Wisconsin District in cooperation with other agencies since 1948. The list contains reports that are relevant and contribute significantly to understanding the hydrology of Wisconsin's water resources.

The reports published in a U.S. Geological Survey series are for sale by the U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. Prepayment is required. Remittance should be sent by check or money order payable to the U.S. Geological Survey. Prices can be obtained by writing to the above address or by calling (303) 236-7476. Copies of reports published by the University of Wisconsin, Geological and Natural History Survey, can be obtained from their office at 3817 Mineral Point Road, Madison, WI 53705.

WATER-SUPPLY PAPERS

Melcher, N.B., and Walker, J.F., 1992, Evaluation of selected methods for determining streamflow during periods of ice effect: U.S. Geological Survey Water-Supply Paper 2378, 47 p.

U.S. Geological Survey, 1991, National water summary 1988-89—Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, 591 p.

U.S. Geological Survey, 1990, National water summary 1987—Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

_____,1988, National water summary 1986—Hydrologic events, selected water-quality trends, and ground-water quality: U.S. Geological Survey Water-Supply Paper 2325, 569 p.

_____1986, National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 506 p.

_____1985, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

_____1984, National water summary 1983—Hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

Batten, W.G., and Hindall, S.M., 1980, Sediment deposition in the White River Reservoir, northwestern Wisconsin: U.S. Geological Survey Water-Supply Paper 2069, 30 p.

Sherrill, M.G., 1978, Geology and ground water in Door County, Wisconsin, with emphasis on contamination potential in the Silurian dolomite: U.S. Geological Survey Water-Supply Paper 2047, 38 p.

Hurtgen, D.C., 1975, Summary of floods, June 29-30 in southwestern Wisconsin, in Summary of floods in the United States during 1969: U.S. Geological Survey Water-Supply Paper 2030, p. 116-119.

Bell, E.A., and Sherrill, M.G., 1974, Water availability in central Wisconsin—an area of near-surface crystalline rock: U.S. Geological Survey Water-Supply Paper 2022, 32 p.

Novitzki, R.P., 1973, Improvement of trout streams in Wisconsin by augmenting low flows with ground water: U.S. Geological Survey Water-Supply Paper 2017, 52 p.

Oakes, Edward, Field, S.J., and Seeger, L.P., 1973, The Pine-Popple River basins—hydrology of a wild river area, northeastern Wisconsin: U.S. Geological Survey Water-Supply Paper 2006, 57 p.

Hamilton, L.J., 1971, Water for cranberry culture in the Cranmoor area of central Wisconsin: U.S. Geological Survey Water-Supply Paper 1999-I, 20 p.

Hurtgen, D.C., 1972, Floods of March 27-April 4, 1967, in northwestern and west-central Wisconsin, in Summary of floods in the United States during 1967: U.S. Geological Survey Water-Supply Paper 1880-C, p. 7-10.

Hutchinson, R.D., 1970, Ground-water resources of Racine and Kenosha Counties, Wisconsin: U.S. Geological Survey Water-Supply Paper 1878, 63 p.

Olcott, P.G., 1966, Geology and water resources of Winnebago County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1814, 61 p.

Weeks, E.P., Erickson, D.W., and Holt, C.L.R., Jr., 1965, Hydrology of the Little Plover River basin, Portage County, Wisconsin, and the effects of water-resources development: U.S. Geological Survey Water-Supply Paper 1811, 78 p.

Green, J.H., and Hutchinson, R.D., 1965, Ground-water pumpage and water-level changes in the Milwaukee-Waukesha area, Wisconsin, 1950-61: U.S. Geological Survey Water-Supply Paper 1809-I, 19 p.

Summers, W.K., 1965, Geology and ground-water resources of Waushara County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1809-B, 32 p.

Holt, C.L.R., Jr., and Knowles, D.B., 1963, The water situation in Wisconsin in the role of ground water in the national water situation: U.S. Geological Survey Water-Supply Paper 1800, p. 943-960.

Cline, D.R., 1965, Geology and ground-water resources of Dane County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1779-U, 64 p.

Holt, C.L.R., Jr., 1965, Geology and water resources of Portage County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1796, 77 p.

Berkstresser, C.F., Jr., 1964, Ground-water resources of Waupaca County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1669-U, 38 p.

Knowles, D.B., 1964, Ground-water conditions in the Green Bay area, Wisconsin, 1950-60: U.S. Geological Survey Water-Supply Paper 1669-J, 37 p.

Cline, D.R., 1963, Hydrology of upper Black Earth Creek basin, Wisconsin, with a section on surface water by M.W. Busby: U.S. Geological Survey Water-Supply Paper 1669-C, 27 p.

Collier, C.R., 1963, Sediment characteristics of small streams in southern Wisconsin, 1954-59: U.S. Geological Survey Water-Supply Paper 1669-B, 34 p.

LeRoux, E.F., 1963, Geology and ground-water resources of Rock County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1619-X, 50 p.

Newport, T.G., 1962, Geology and ground-water resources of Fond du Lac County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1604, 52 p.

Knowles, D.B., Dreher, F.C., and Whetstone, G.W., 1964, Water resources of the Green Bay area, Wisconsin: U.S. Geological Survey Water-Supply Paper 1499-G, 66 p.

LeRoux, E.F., 1957, Geology and ground-water resources of Outagamie County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1421, 57 p.

Harger, A.H., and Drescher, W.J., 1954, Ground-water conditions in south-western Langlade County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1294, 39 p.

Foley, F.C., Walton, W.D., and Drescher, W.J., 1953, Ground-water conditions in the Milwaukee-Waukesha area, Wisconsin: U.S. Geological Survey Water-Supply Paper 1229, 96 p.

HYDROLOGIC INVESTIGATIONS ATLASES

Gebert, W.A., Graczyk, D.J., and Krug, W.R., 1987, Average annual runoff in the United States, 1951-80: U. S. Geological Survey Hydrologic Investigations Atlas HA-710, 1 sheet.

Hughes, P.E., Hannuksela, J. S., and Danchuk, W.J., 1981, Flood of July 1-5, 1978, on the Kickapoo River, South-western Wisconsin: U.S. Geological Survey Hydrologic Investigations Atlas HA-653, 7 sheets.

Oakes, E.L., and Cotter, R.D., 1975, Water resources of Wisconsin—upper Wisconsin River basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-536, 3 sheets.

Young, H.L., and Skinner, E.L., 1974, Water resources of Wisconsin—Lake Superior basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-524, 3 sheets.

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