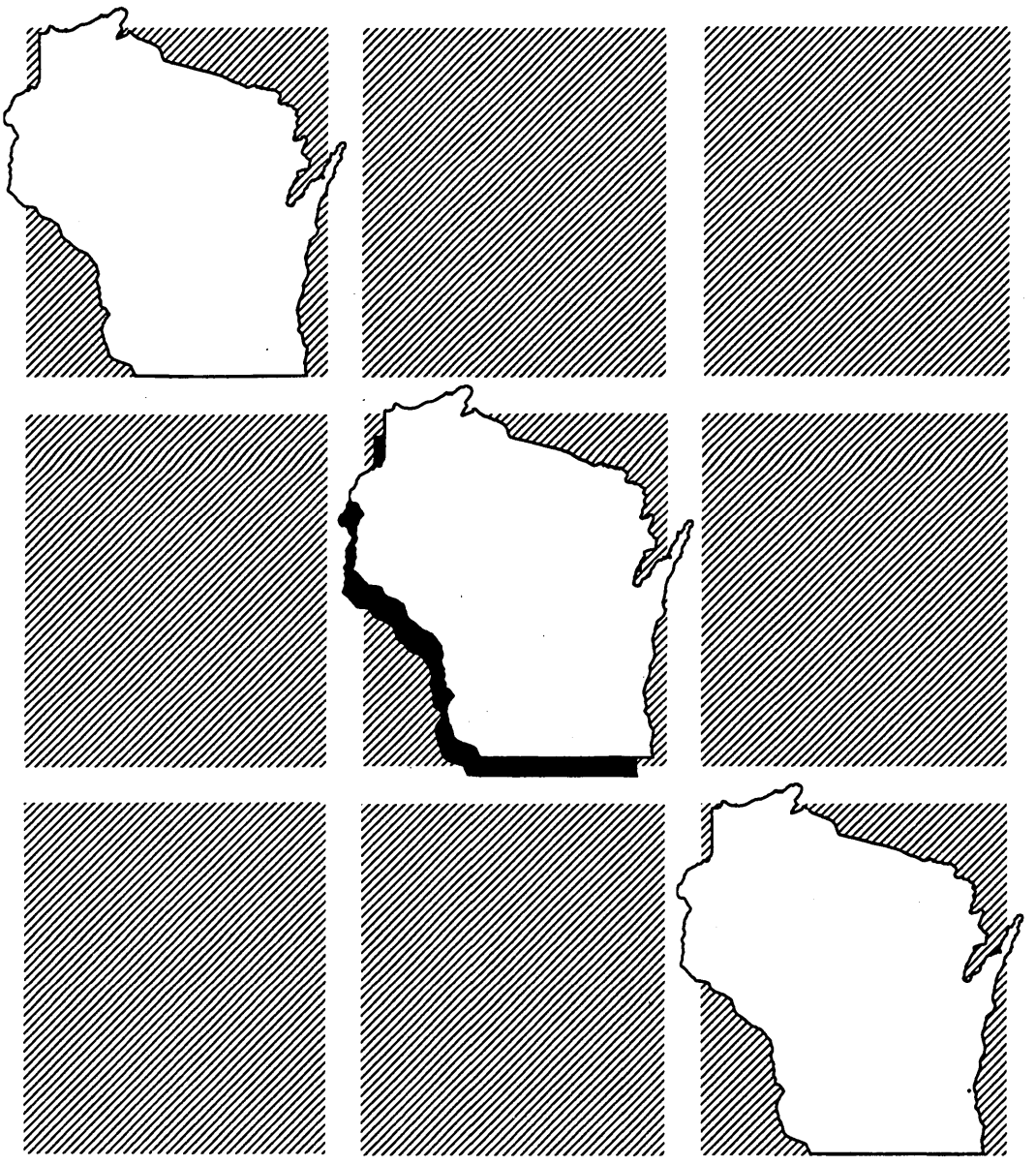
WISCONSIN

A Summary of Cooperative Water-Resources Investigations

U.S. Geological Survey and
Wisconsin Department of Natural Resources



1998

USGS
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A SUMMARY OF COOPERATIVE WATER-RESOURCES INVESTIGATIONS

U.S. GEOLOGICAL SURVEY
Water Resources Division
8505 Research Way
Middleton, Wisconsin 53562

and

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
P.O. Box 7921
Madison, Wisconsin 53707

1998

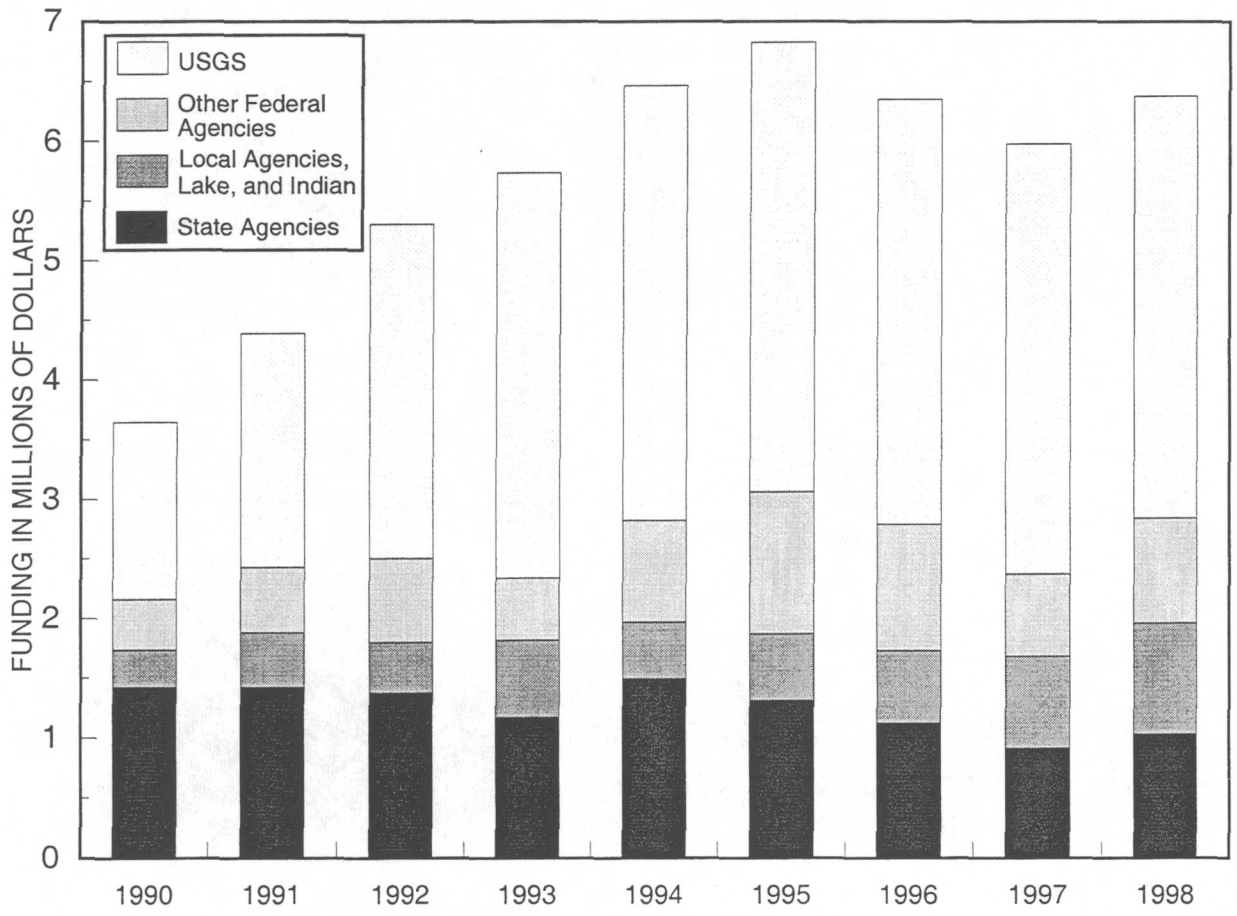
A Summary of Cooperative Water-Resources Investigations U.S. Geological Survey and Wisconsin Department of Natural Resources

1998

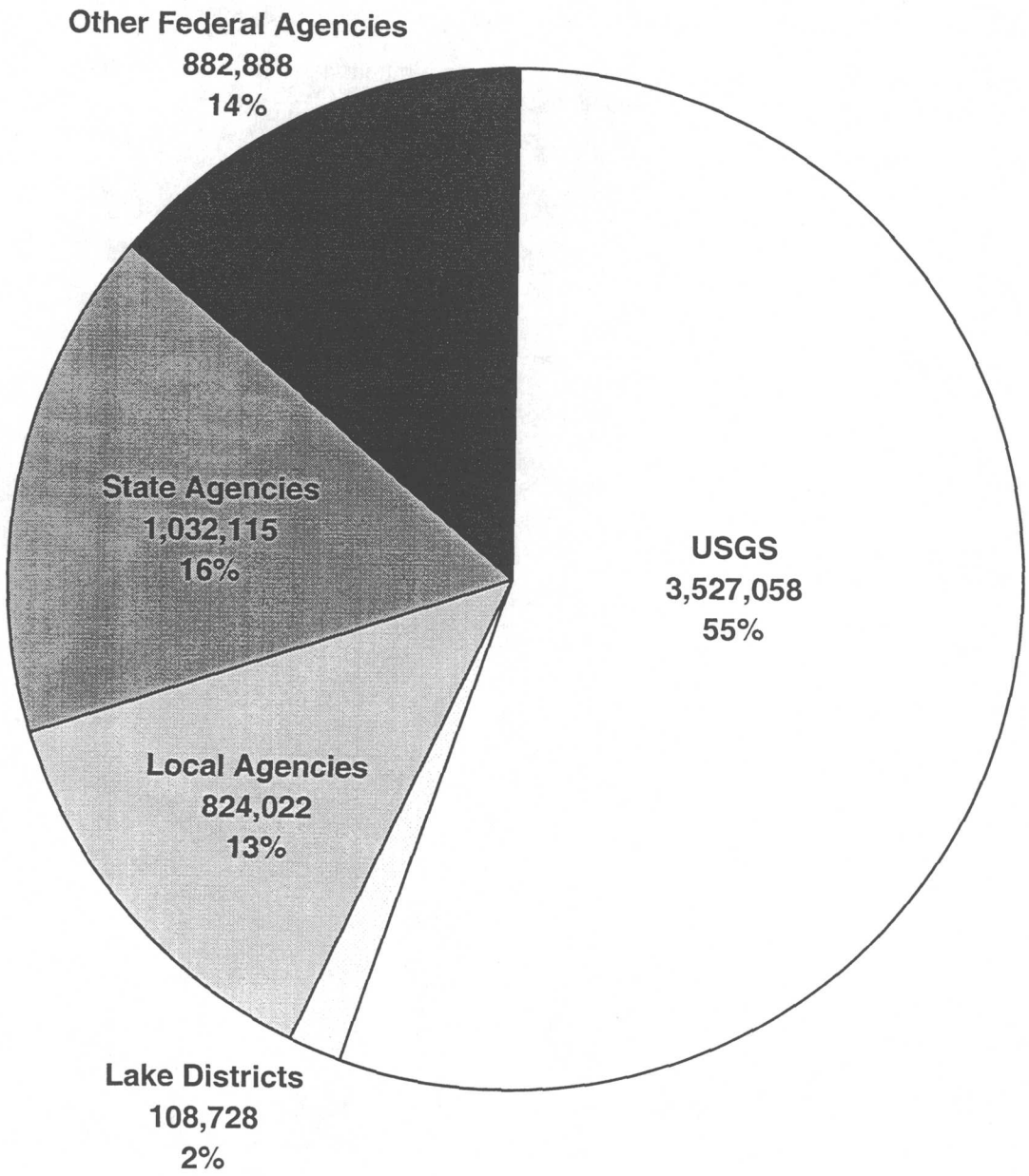
The cooperative program of water-resources investigations between the U.S. Geological Survey and the Wisconsin Department of Natural Resources began as a continuation of cooperative programs with the various State agencies which were merged to form the Wisconsin Department of Natural Resources. These investigations involve various aspects of research, resource evaluations, and water-quantity- and water-quality-monitoring activities.

This is a brief summary report of the activities and plans for the cooperative projects during the July 1997 through June 1998 fiscal year. Each project summary includes a brief description of the objectives, approach, and progress during the 1998 fiscal year, and plans for the 1999 fiscal year.

The appendixes include a detailed listing of proposed stream-monitoring stations for 1999. Also included is the proposed funding summary for the 1998-99 fiscal year.

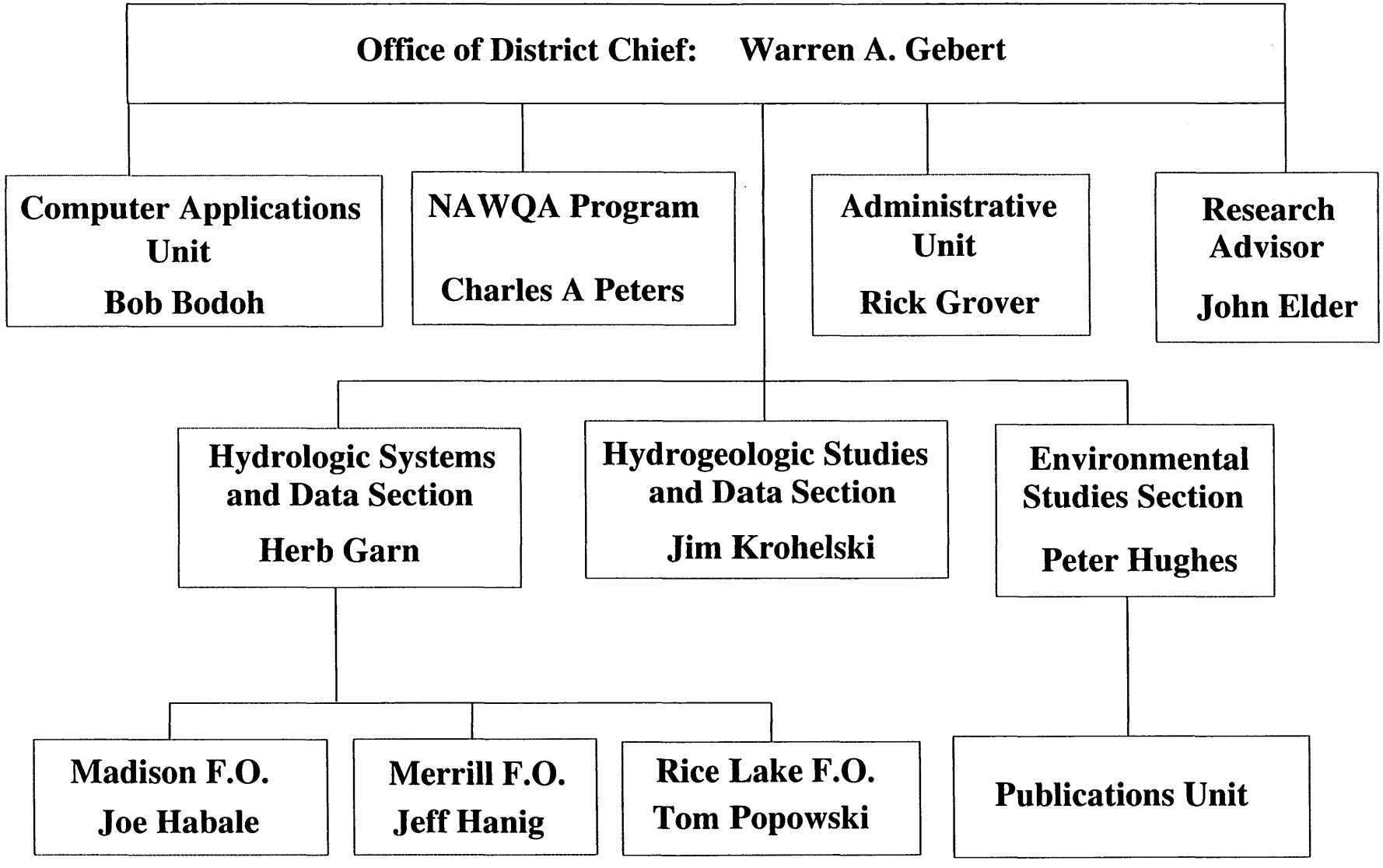


Funding sources for the Wisconsin District program for FY 1998 are shown on the following chart:



Total Funding = 6,374,811

Water Resources Division, Wisconsin District



CONTENTS

COLLECTION OF BASIC RECORDS–SURFACE WATER, WI 001

COOPERATORS:

Wisconsin Department of Natural Resources
Wisconsin Department of Tourism
U.S. Army Corps of Engineers
Southeastern Wisconsin Regional Planning Commission
Federal (Regular)
Madison Metropolitan Sewerage District
Dane County Department of Planning and Development
Dane County Regional Planning Commission
Federal Energy Regulatory Commission Licensees
- Dairyland Power Cooperative
- Niagara of Wisconsin Paper Corporation
- Northern States Power Company
- Wisconsin Electric Power Company
- Wisconsin Power and Light Company
- Wisconsin Public Service Corporation
- Wisconsin Valley Improvement Company

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
Walworth County Metropolitan Sewerage District
Bad River Band of Lake Superior Chippewa Indians

LOCATION:

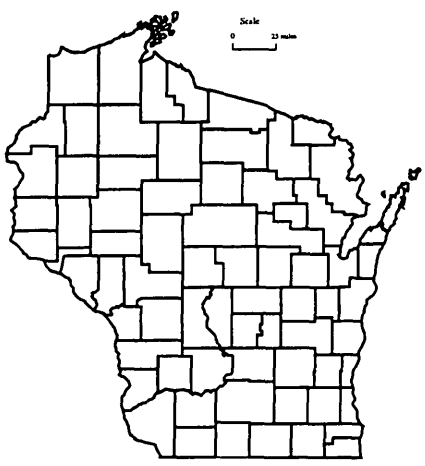
Statewide

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 1997 to June 1998): During the current fiscal year, streamflow data were collected at a total of 98 sites: 32 sites for the Wisconsin Department of Natural Resources (WDNR), 17 sites for the Corps of Engineers, 14 sites for the Southeastern Wisconsin Regional Planning Commission, 6 sites for the Federal program, 3 sites for the Madison Metropolitan Sewerage District, and 1 site each for the Bad River Band of Lake Superior Chippewa Indians, 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, Rock County, Fontana/ Walworth Water Pollution Control Commission, Dane County Department of Planning and Development, Walworth County Metropolitan Sewerage District, Dane County Regional Planning Commission, Wisconsin Department of Tourism, Federal Energy Commission Licensees, and cities of Barron, Beaver Dam, Brookfield, Hillsboro, Peshtigo, Sparta, Thorp, Waupun, and village of Wittenberg. Streamflow data were also collected at four sites for agencies working jointly with the USGS. Lake-level data were collected at two sites for the Dane County Department of Planning and Development, at two sites for the Corps of Engineers, at one site for the Rock County Public Works Department, and one site for the WDNR.

A map showing the location of all continuous-record streamflow-gaging stations in Wisconsin is shown on page 5.

Computation of streamflow and lake-level records for all the network stations for the 1997 water year was completed, stored in our WATSTORE computer data base, and published in the annual report "Water Resources Data–Wisconsin, water year 1997". More than 100 requests for streamflow information were answered.

PLANS (July 1998 to June 1999): Data will be collected at 101 continuous-streamflow stations (see the following list) and lake levels at 6 stations. Streamflow records will be computed and data published for the 1998 water year. Requests for streamflow information will be answered.

Real-time data can be accessed on the World Wide Web at http://wwwdwimdn.er.usgs.gov

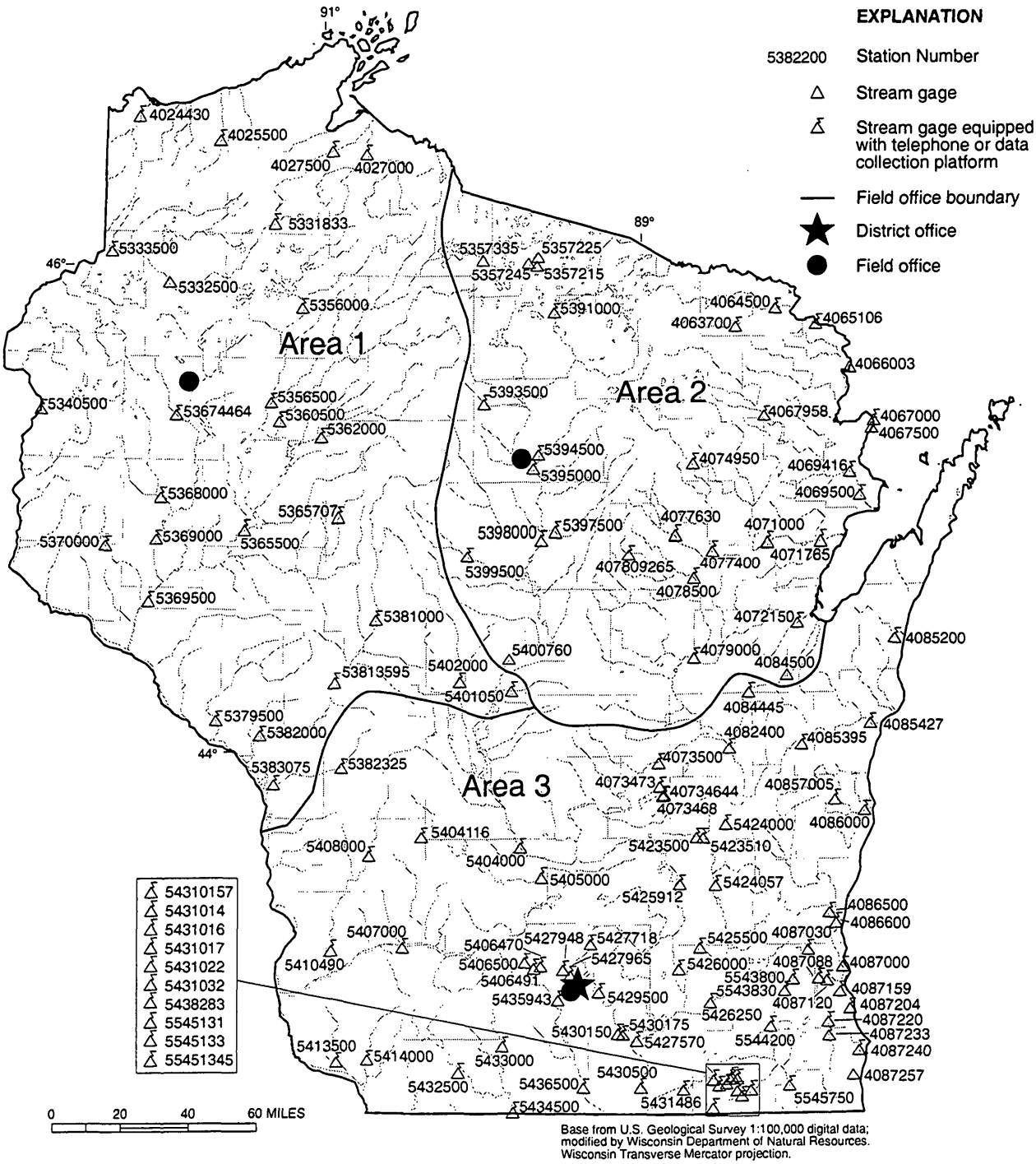
SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1999 FY

Station number	Name and location	Drainage Area	Period of record (water year)	Cooperator
04024430	Nemadji River - South Superior	420	1974-	WDNR
04025500	Bois Brule River - Brule	118	1943-81, 1984-	Fed.
04027000	Bad River - Odanah	597	1914-22, 1948-	Bad River Band of Lake Superior Chippewa Indians
04027500	White River - Ashland	301	1948-	WDNR
04029990	Montreal River - Saxon Falls	262	1987	WDNR
04063700	Popple River - Fence	139	1964-	Fed.
04064500	Pine River - Pine River Powerplant - Florence	533	1924-76, 1996-	WDNR
04065106	Menominee River - Niagara	2470	1993-	FERC
04066003	Menominee River - Pembine	3140	1950-	WDNR
04067000	Menominee River - Koss, MI	3,720	1907-09, 1913-81, 1998-	FERC
04067500	Menominee River - McAllister	3,930	1945-61, 1979-86 1988-90, 1993-95, 1998-	WDNR
04067958	Peshtigo River - Wabeno	447	1998-	WDNR
04069416	Peshtigo River - Porterfield		1998-	FERC
04069500	Peshtigo River - Peshtigo	1080	1953-	City of Peshtigo
04071000	Oconto River - Gillett	705	1906-09, 1914-	Fed.
04071765	Oconto River - Oconto	966	1989-90, 1998-	WDNR
04072150	Duck Creek - Howard	108	1988-	Oneida Tribe of Indians of WI
04073500	Fox River - Berlin	1340	1898-	C of E, Detroit
04074950	Wolf River - Langlade	463	1966-79, 1981-	Menominee Indian Tribe of WI
04077400	Wolf River - Shawano	816	1907-09, 1911-	WDNR
04077630	Red River - Morgan	114	1993	Stockbridge-Munsee Band of Mohican Indians
0407809265	Middle Branch Embarrass River - Wittenberg	76.3	1990-	Village of Wittenberg
04079000	Wolf River - New London	2260	1896-	C of E, Detroit
04082400	Fox River - Oshkosh	5310	1991	WDNR
04084445	Fox River - Appleton	5950	1986-	C of E, Detroit
04084500	Fox River - Rapide Croche Dam - Wrightstown	6010	1896-	WDNR
04085200	Kewaunee River - Kewaunee	127	1964-96, 1998-	WDNR
04085427	Manitowoc River - Manitowoc	526	1972-96, 1998-	WDNR
04086000	Sheboygan River - Sheboygan	418	1916-24, 1951-	WDNR
04086500	Cedar Creek - Cedarburg	120	1930-70, 73-81, 1983-87, 1991 -	WDNR
04086600	Milwaukee River - Pioneer Road - Cedarburg	607	1982-	SEWRPC
04087000	Milwaukee River - Milwaukee	696	1914-	SEWRPC
04087030	Menomonee River - Menomonee Falls	34.7	1975-77, 1979-	SEWRPC
04087088	Underwood Creek - Wauwatosa	18.2	1975-	SEWRPC
04087120	Menomonee River - Wauwatosa	123	1962-	SEWRPC
04087160	Kinnickinnic River - Milwaukee	20.4	1976-	SEWRPC
04087204	Oak Creek - South Milwaukee	25	1964-	SEWRPC
04087220	Root River - Franklin	49.2	1964-	SEWRPC
04087233	Root River Canal - Franklin	57	1964-	SEWRPC
04087240	Root River - Racine	190	1963-	SEWRPC
04087257	Pike River - Racine	38.5	1972-	SEWRPC
05332500	Namekagon River - Trego	488	1928-70, 1988	WDNR
05340500	St. Croix River - St. Croix Falls	6240	1902-	WDNR
05341500	Apple River - Somerset	579	1901-70, 1987	WDNR
05356000	Chippewa River - Winter	790	1912-	WDNR
05356500	Chippewa River - Bruce	1650	1914-	WDNR
05357335	Bear River - Manitowish Waters	81.3	1991	Lac du Flambeau Band of Lake Superior Chippewa
05360500	Flambeau River - Bruce	1860	1951-	WDNR, FERC
05362000	Jump River - Sheldon	576	1915-	Fed.
05365500	Chippewa River - Chippewa Falls	5650	1888-1983, 1987	WDNR
05365707	North Fork Eau Claire River - Thorp	51	1986	City of Thorp
053674464	Yellow River - Barron	153	1991	City of Barron
05368000	Hay River - Wheeler	418	1951-	Fed.
05369000	Red Cedar River - Menomonie	1770	1907-08, 1913-	WDNR
05369500	Chippewa River - Durand	9010	1928-	C of E, St. Paul
05370000	Eau Galle River - Spring Valley	64.1	1944-	C of E, St. Paul
05379500	Trempealeau River - Dodge	643	1914-19, 1934	C of E, St. Paul
05382000	Black River - Galesville	2080	1932-	C of E, St. Paul, WDNR
05382325	La Crosse River - Sparta	167	1992-	City of Sparta
05391000	Wisconsin River - Lake Tomahawk	757	1936-	WDNR

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1999 FY

Station number	Name and location	Drainage Area	Period of record (water year)	Cooperator
05393500	Spirit River - Spirit Falls	81.6	1942-	WDNR
05394500	Prairie River - Merrill	184	1914-31, 1939	WDNR
05395000	Wisconsin River - Merrill	2760	1903-	WDNR
05397500	Eau Claire River - Kell	375	1914-27, 1939-	WDNR
05398000	Wisconsin River - Rothschild	4020	1945-	WDNR
05399500	Big Eau Pleine River - Stratford	224	1914-26, 1937-	WDNR
05400760	Wisconsin River - Wisconsin Rapids	5420	1914-50, 1958-	WDNR
05401050	Tenmile Creek - Nekoosa	73.3	1963-79, 1988-94 1998-	WDNR
05402000	Yellow River - Babcock	215	1944-	WDNR
05404000	Wisconsin River - Wisconsin Dells	8090	1935-	WDNR
05404116	S. Br. Baraboo River - Hillsboro	39.1	1988-	City of Hillsboro
05405000	Baraboo River - Baraboo	609	1914-22, 1943-	Fed.
05406500	Black Earth Creek - Black Earth	45.6	1954-	DCRPC
05407000	Wisconsin River - Muscoda	10400	1903-04, 1914-	C of E, St. Paul
05408000	Kickapoo River - LaFarge	266	1939-	WI Dept. Tourism
05410490	Kickapoo River - Steuben	687	1933-	C of E, St. Paul
05413500	Grant River - Burton	269	1935-	C of E, R. Island
05414000	Platte River - Rockville	142	1935-	C of E, R. Island
05423500	S. Br. Rock River - Waupun	63.6	1948-69, 1987	City of Waupun
05425500	Rock River - Watertown	969	1931-70, 1977-	C of E, R. Island
05425912	Beaverdam River - Beaver Dam	157	1984-	City of Beaver Dam
05426000	Crawfish River - Milford	762	1931-	Rock County, Jefferson County
05426250	Bark River - Rome	122	1980-	SEWRPC
05427570	Rock River - Indianford	2630	1975-	Rock County
05429500	Yahara River - McFarland	327	1930-	DCDP&D
05430150	Badfish Creek - Cooksville	82.6	1977-	MMSD
05430175	Yahara River - Fulton	517	1977	MMSD
05430500	Rock River - Afton	3340	1914-	C of E, R. Island
05431032	Turtle Creek - Delavan	83.3	1996-	WALCOMET
05431486	Turtle Creek - Clinton	199	1939-	C of E, Rock Island, WALCOMET
05432500	Pecatonica River - Darlington	273	1939-	C of E, R. Island
05433000	E. Br. Pecatonica River - Blanchardville	221	1939-1986, 1988	C of E, R. Island
05434500	Pecatonica River - Martintown	1034	1940-	C of E, R. Island
05435943	Badger Mill Creek - Verona	20.3	1997-	MMSD
05436500	Sugar River - Brodhead	523	1914-	C of E, Rock Island
05438283	Piscasaw Creek - Walworth	9.58	1992-	Fontana/Walworth WPCC
05543800	Fox River - Watertown Road - Waukesha	77.4	1993-	City of Brookfield
05543830	Fox River - Waukesha	126	1963-	SEWRPC
05544200	Mukwonago River - Mukwonago	74.1	1973-	SEWRPC
05545750	Fox River - New Munster	811	1940-	IL. DOT
		LAKES		
04082500	Lake Winnebago - Oshkosh	5880	1882-	C of E, Detroit
04084255	Lake Winnebago - Stockbridge	5880	1983-	C of E, Detroit
05404500	Devil's Lake - Baraboo	4.79	1922-30, 1932, 1934-81, 1985-	WDNR
05427235	Lake Koshkonong - Newville	2560	1987	Rock County
05428000	Lake Mendota - Madison	233	1903, 1916-	DCDPW
05429000	Lake Monona - Madison	279	1915-	DCDPW

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
DCDP&D – Dane County Department of Planning and Development
DCRPC - Dane County Regional Planning Commission
Fed. – USGS Federal Program
FERC – Federal Energy Regulatory Commission Licensees
Fontana/Walworth WPCC – Fontana/Walworth Water Pollution Control Commission
IL. DOT – Illinois Department of Transportation
MMSD – Madison Metropolitan Sewerage District
SEWRPC – Southeastern Wisconsin Regional Planning Commission
WALCOMET – Walworth County Metropolitan Sewerage District
WDNR – Wisconsin Department of Natural Resources
WI Dept. Tourism – Wisconsin Department of Tourism



Location of continuous-record data-collection stations.

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
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
Peshtigo River at High Falls near Crivitz, WI	04068000	537	1912-57
Pensaukee River near Pensaukee, WI	04071858	134	1973-96
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
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
East Twin River at Mishicot, WI	04085281	110	1972-96
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

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
North Branch Milwaukee River near Fillmore, WI	04086340	148	1968-81
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	05358000	688	1914-39
Pine Creek near Oxbo, WI	05358300	38.9	1971-75
Flambeau River at Babbs Island near Winter, WI	05358500	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	1962-63
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
Eau Galle River at low water bridge at Spring Valley, WI	05369945	47.9	1982-83, 1986-96
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

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
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
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	05400853	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 Creek nr Barneveld, WI	05406573	8.37	1976-78
Trout Creek at Twin Parks Dam 8 nr Barneveld, WI	05406574	9.02	1976-79
Trout Creek at County Highway T nr Barneveld, 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

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
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
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
Jackson Creek at Petrie Road near Elkhorn, WI	05431014	8.96	1984-95
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

CRANDON GROUND WATER, WI 00201

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Forest County, Wisconsin

PROJECT CHIEF:
James T. Krohelski

PERIOD OF PROJECT:
October 1994-Continuing

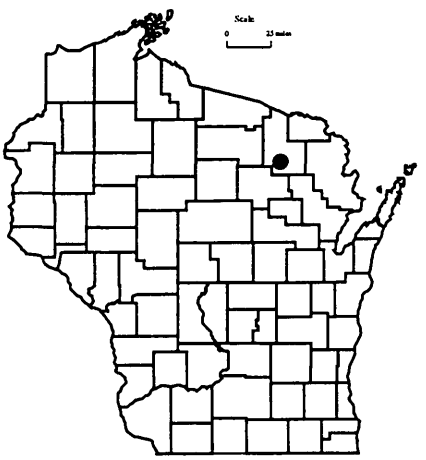
PROBLEM: A large underground zinc-copper mine is being proposed at a site about five miles south of Crandon, Wisconsin, in Forest County. The Wisconsin Department of Natural Resources (WDNR) requested that District staff review the development of a ground-water flow model and associated hydrologic documents as part of a permitting process for the proposed mine.

OBJECTIVE: The objective is to review documents related to water resources submitted to WDNR from the Crandon Mining Company (CMC) and their consultants and to make suggestions to WDNR on studies and approaches that will improve the understanding of the hydrology and effects of mining on the water resources in the vicinity of the proposed mine.

APPROACH: The schedule for review of documents will be mutually agreed upon between WDNR and USGS.

PROGRESS (July 1997 to June 1998): Review of the ground-water flow model was completed and resulted in a revised model, which was submitted in December. Review of the revised model was initiated. Several other issues such as lakebed vertical hydraulic conductivity, reinterpretation of the glacial and saprolite pump tests to determine hydraulic parameters and the functioning of the LAK2 Code developed by GeoTrans have been addressed. Also a field investigation in the vicinity of the proposed mine to determine ambient levels of mercury in ground and surface waters was completed. Monitoring of lake stage and shallow ground-water levels adjacent to Little Sand Lake was continued.

PLANS (July 1998 to June 1999): Documents will be reviewed and meetings attended at the request of the WDNR. Review of the LAK2 Code will be completed. Initial review of the revised flow model and a revised contaminant transport model will be completed. Possibly the flow model will be revised and selected simulations run. Monitoring of lake stage and shallow ground-water levels adjacent to Little Sand Lake will be continued.



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, store data in the State Water-Use Data System (SWUDS), and 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 SWUDS. Efforts will be made to upgrade the accuracy of the water-use data.

PROGRESS (July 1997 to June 1998): 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. The report "Water use in Wisconsin, 1995" was published as a hydrologic atlas.

PLANS (July 1998 to June 1999): Plans include: (1) continue to update and maintain SWUDS with current water-use data, (2) supply water-use data for water-resources studies currently being conducted in the State and (3) estimate 1995 water use by aquifer as part of the national water-use summary.

REPORTS:

Ellefson, B.R., Fan, C.H., and Ripley, J.L., 1995, Water use in Wisconsin, 1995: U.S. Geological Survey Open-File Report 97-356, 1 sheet, scale 1:5,000,000.

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:
Bernard R. Ellefson

PERIOD OF PROJECT:
March 1978-Continuing

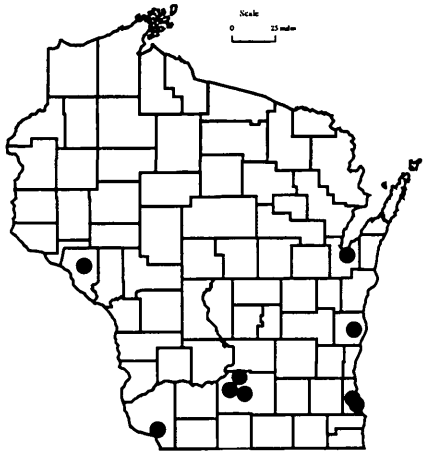
TRENDS IN WATER QUALITY AND STREAM HABITAT FOR PRIORITY WATERSHEDS, WI 17202-17205, 17213

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

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 1997 to June 1998): Streamflow and water-quality monitoring were continued at three sites in the priority watersheds. Dissolved oxygen was monitored at two sites in the priority watersheds. All the data were summarized and will be published in the report "Water-Resources Data–Wisconsin". Water-quality loads were calculated for selected parameters and storm periods. Land-use inventories were completed for each basin

PLANS (July 1998 to June 1999): Streamflow and water quality will be continued at two sites until October 1998 and then discontinued. 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 best-management plans. A report will be prepared. At one site water-quality samples will be collected weekly during the period of April-October, bi-weekly in March and November, and monthly during December, January, and February. Land use will be updated for each basin.

REPORTS:

Wierl, J.A., Giddings, E.M., and Bannerman, R.T., 1998, Comparison of annual loads of phosphorus in storm runoff from barnyard and cropland sources to the Otter Creek Watershed, Wisconsin, U.S. Geological Survey Fact Sheet (in press).

Corsi, S.R., Graczyk, D.J., Owens, D.W., and Bannerman, R.T., 1997, Unit-area loads of suspended sediment, suspended solids, and total phosphorus from small watersheds in Wisconsin: U.S. Geological Survey Fact Sheet 195-97, 4 p.

Greb, Steven R., and Graczyk, David J., 1995, Frequency-duration analysis of dissolved-oxygen concentrations in two southwestern Wisconsin streams, Water Resources Bulletin v. 31, no. 3, p. 431-438.

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

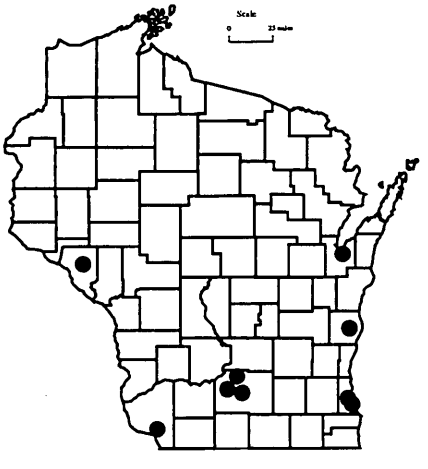
PROBLEM: To date, the effectiveness of best management practices (BMPs) in Wisconsin has not been determined. The natural variability of water-quality data complicates the detection of changes due to BMP implementation. Research is needed to identify techniques for detecting changes due to BMP implementation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

PROGRESS (July 1997 to June 1998): Results from unit-area load analysis was published as a fact sheet and distributed. Results from investigation of sources of phosphorus load in Otter Creek were reviewed and approved for publication as a fact sheet. Annual progress report describing data collected through water year 1997 was reviewed and approved. Analysis synthesizing physical, chemical and biological data for one evaluation-monitoring watershed was begun. All data through water year 1997 was included in the Oracle database.

PLANS (July 1998 to June 1999): Otter Creek phosphorus load fact sheet will be published and distributed. Annual progress report describing data collected through water year 1997 will be completed and published. BMP synthesis open-file report will be published and distributed. Work incorporating snowmelt loads into regression analysis will be completed.



REPORTS:

Walker, J.F., Corsi, S.R., Graczyk, D.J., and Wierl, J.A., 1998, Evaluation of nonpoint-source contamination, Wisconsin: selected data for water year 1997, U.S. Geological Survey Open-File Report (in press).

Corsi, S.R., Graczyk, D.J., Owens, D.W., and Bannerman, R.T., 1997, Unit-area loads of suspended sediment, suspended solids, and total phosphorus from small watersheds in Wisconsin, U.S. Geological Survey Fact Sheet 195-97.

Walker, J.F., Corsi, S.R., Graczyk, D.J., and Wierl, J.A., 1997, Evaluation of nonpoint-source contamination, Wisconsin: selected data for water year 1996, U.S. Geological Survey Open-File Report (in press).

Owens, D.W., Corsi, S.R., and Rappold, K.F., 1997, Evaluation of nonpoint-source contamination, Wisconsin: selected data for water year 1995, U.S. Geological Survey Open-File Report 96-661A.

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-watershed quality assurance and quality control, constituent loads in rural streams, and snowmelt-runoff analysis, water year 1994: U.S. Geological Survey Open-File Report 95-320, 21 p.

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, water year 1993: U.S. Geological Survey Open-File Report 94-707, 57 p.

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

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.

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.

SINGLE SOURCE SITES, WI 17214

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
State of Wisconsin

PROJECT CHIEF:
Todd D. Stuntebeck

PERIOD OF PROJECT:
March 1994-Continuing

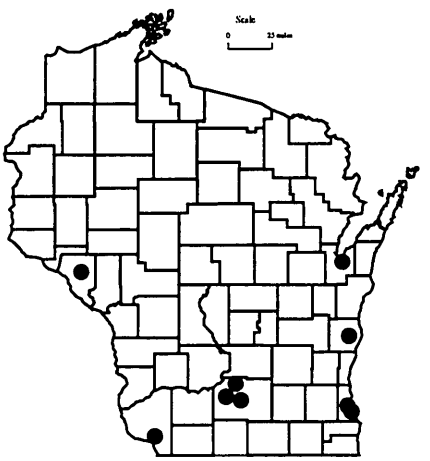
PROBLEM: Much work has been done to assess the effectiveness of nonpoint-source pollution-control strategies known as best management practices (BMPs). Most of this work to date has had a basin-wide scope and is focused on evaluating the cumulative effectiveness of several different types of BMPs. Research targeted at evaluating the effectiveness of a single type of BMP would assist resource managers responsible for planning BMP implementation programs.

OBJECTIVE: The objective is to determine the significance of a single nonpoint-pollution source and evaluate the effectiveness of BMPs in treating that same source.

APPROACH: Water-quality samples will be collected upstream and downstream from a single nonpoint-pollution source before and after implementation of BMPs. Water-quality samples are generally collected bi-weekly during open-water periods, and monthly during the winter months. In addition, water-quality samples are collected with automated water samplers during selected periods of storm runoff. Water-surface levels are continuously monitored at the sites, and a continuous discharge record is determined from water-surface/discharge relations.

Two barnyard-runoff sites have been investigated—Otter Creek in the Sheboygan River Priority Watershed and Halfway Prairie Creek in the Black Earth Creek Priority Watershed. Parsons Creek, an additional single-source site that is currently under investigation in the Lake Winnebago Priority Watershed, is targeted at evaluating both a barnyard BMP system and a streambank erosion BMP.

PROGRESS (July 1997 to June 1998): Samples were collected for 12 storm-runoff periods at Otter Creek and 11 storm-runoff periods at Halfway Prairie Creek before BMP implementation. After BMP implementation, samples were collected for 15 storm-runoff periods at Otter Creek and 11 storm-runoff periods at Halfway Prairie Creek. The results from these two investigations have been published in a USGS fact sheet.



Results from statistical tests revealed that, for the pre-BMP period at both Otter and Halfway Prairie Creeks, downstream loads of total phosphorus, ammonia, biochemical oxygen demand (BOD), and microbial loads of fecal coliform bacteria were significantly greater than upstream loads. At Otter Creek, pre-BMP downstream loads of suspended solids also were significantly greater than those upstream.

Since implementation of barnyard BMPs, the data collected have shown significant reductions in the loadings of most constituents coming from each barnyard. At both creeks, post-BMP loads of total phosphorus, ammonia, and BOD contributed by the barnyard were statistically lower than pre-BMP loads. In addition, post-

BMP loads of suspended solids and microbial loads of fecal coliform bacteria at Otter Creek were also statistically lower than in the pre-BMP period. The barnyard BMP system at Otter Creek has reduced loads of suspended solids by 85 percent, total phosphorus by 85 percent, ammonia by 94 percent, BOD by 83 percent, and microbial loads of fecal coliform bacteria by 81 percent; the respective loads at Halfway Prairie Creek have been reduced by 47, 87, 95, 92, and 9 percent.

Data collection for the project at Parsons Creek began in October 1997. To date, water samples for five storm-runoff periods have been collected, and eight base flow samples have been collected.

PLANS (July 1998 to June 1999): Bi-weekly baseflow and storm-runoff samples will be collected at Parsons Creek. We will search for more potential single-source sites.

REPORTS:

Stuntebeck, T.D., and Bannerman, R.T., 1998, Effectiveness of barnyard best management practices in Wisconsin: U.S. Geological Survey Fact Sheet 051-98, 4 p.

Stuntebeck, T.D., 1995, Evaluating barnyard best management practices in Wisconsin using upstream-downstream monitoring: U.S. Geological Survey Fact Sheet 221-95, 4 p.

DISTRIBUTION OF LOADING, WI 17222

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Statewide

PROJECT CHIEF:
David J. Graczyk

PERIOD OF PROJECT:
July 1997 to June 1998

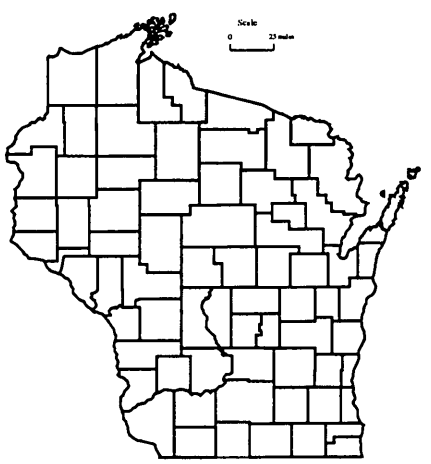
PROBLEM: The distribution of daily constituent loading throughout the year is important for design and evaluation of best management practices. Is most of the annual constituent load generated by snowmelt runoff during a few days in spring of the year or is most of the annual constituent load generated by intense thunderstorms during the summer? How much does the distribution of daily constituent load vary from year to year and from site to site? Does the portion of the annual constituent load vary seasonally from year to year and from site to site?

OBJECTIVE: Objectives are to (1) determine the cumulative distribution of daily constituent loadings and examine the differences over time and between sites and (2) determine the seasonal distribution of annual loads.

APPROACH: Daily constituent loads from the evaluation monitoring sites will be used as the data set. Loads have been calculated at 8 rural evaluation monitoring sites with 6-8 years of data at each site. The cumulative distribution of daily constituent loadings will be determined for each site and for each year. The portion of annual load attributed to seasons selected will be determined and compared over time and between sites.

PROGRESS (July 1997 to June 1998): Data was compiled for the eight rural evaluation monitoring sites. Cumulative distribution of daily constituent loadings for each site and year was determined.

PLANS (July 1998 to June 1999): Analyses will be completed and final report prepared. Results will be published as a U.S. Geological Survey fact sheet.



MULTI-STREAM EXPERIMENTAL DESIGN, WI 17223

PROBLEM: The amount of best management practice (BMP) implementation at evaluation monitoring sites is currently much less than anticipated, and implementation is taking longer than expected. Results on a shorter time scale are needed to evaluate the overall nonpoint-source program.

OBJECTIVE: Objective is to investigate feasibility of sampling a large number of sites (20-60) for a short period of time (1-2 years) to determine the effectiveness of BMPs.

APPROACH: The sites to be considered are chosen to cover a wide range of BMP implementation. For selected evaluation-monitoring sites, annual loads will be computed with a reduced data set and compared to the actual load to determine uncertainty in annual loads for a particular sampling scheme. A statistical analysis will determine the minimum number of sites needed to demonstrate a significant relation between load reduction and BMP implementation.

PROGRESS (July 1997 to June 1998): Feasible sites were selected and the overall watershed characteristics, including BMP implementation status, were summarized. Uncertainty in annual loads based on various sampling strategies was determined for selected evaluation-monitoring sites. The overall statistical analysis was begun.

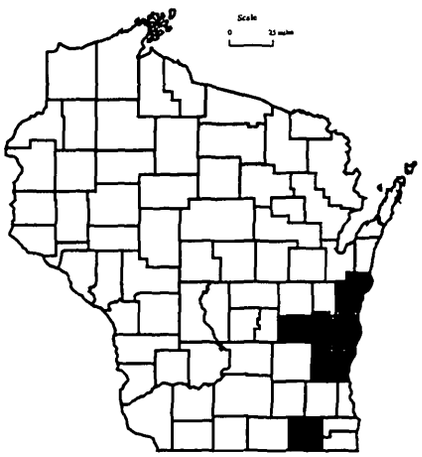
PLANS (July 1998 to June 1999): Statistical analysis will be completed. Results will be published in an open-file report.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Fond du Lac, Manitowoc, Ozaukee, Sheboygan, Washington, and Walworth Counties

PROJECT CHIEF:
John F. Walker

PERIOD OF PROJECT:
October 1997 to June 1999



EVALUATION OF SIPHON SAMPLERS, WI 17225

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Dane County, Wisconsin

PROJECT CHIEF:
David J. Graczyk

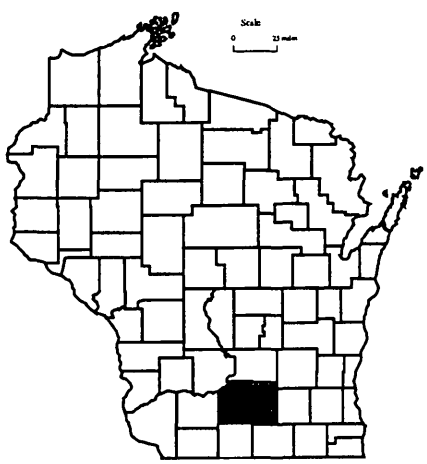
PERIOD OF PROJECT:
July 1997 to June 1998

PROBLEM: Nonpoint water-quality studies have used automatic water samplers to collect samples for laboratory analysis. These analyses are subsequently used to calculate constituent-load and are used to evaluate the effectiveness of best management practices. Intense sampling during both the rising and falling limbs of the hydrograph are needed to calculate accurate storm loads. This approach is cost-effective for a limited number of evaluation sites. For evaluation work at a large number of sites, use of automatic water-quality samplers and estimation of storm loads would be cost prohibitive. Thus for evaluation work at numerous sites the use of single-stage (siphon) samplers and estimation of annual loads is more realistic.

Siphon samplers have been used and tested in other parts of the country. A test in New Mexico under controlled conditions found that suspended-sediment concentrations were all less than 5 percent different from actual stream concentrations. Concentrations of the suspended sediment were less than 30,000 mg/L and 90 percent of the material being transported was in the silt and clay-size fraction (Dewey, U.S. Geological Survey written communication, 1979). Several siphon samplers can be installed at a site to collect samples at varying stream stages. Siphon samplers have been used in Wisconsin but have not been rigorously tested for accuracy.

OBJECTIVE: The objectives are to test the accuracy of siphon samplers to collect samples in Wisconsin and determine if concentrations of suspended sediment, total phosphorus and ammonia nitrogen at nearly concurrent times and stream stages for siphon samplers are the same as the concentrations for samples collected with automatic samplers

APPROACH: Siphon samplers will be installed at three sites: Garfoot, Brewery, and Pheasant Branch Creeks. Automatic water-quality samplers are operating and collecting water-quality samples for other studies at these sites. Samples collected by the siphon samplers will be compared to samples collected by the automatic water-quality samplers. Concentrations of suspended sediment, total phosphorus and ammonia nitrogen at nearly concurrent times and stream stages for the siphon samplers will be compared to concentrations for the automatic samplers. Additional evaluation of siphon samplers will be accomplished by employing a hand-held siphon sampler. This sampler will be used to collect samples manually, and compared to concurrent equal-width increment and automatic sampler samples. The concentrations of these three samples will then be compared.



PROGRESS (July 1997 to June 1998): Siphon samplers were installed at three sites, Garfoot Creek, Brewery Creek and Pheasant Branch Creek. Eighteen samples were collected at the three sites. For one storm at Pheasant Branch Creek, a sample collected by the siphon sampler had a concentration of 0.354 mg/L for ammonia nitrogen and 0.419 mg/L for total phosphorus. The concurrent samples from the automatic sampler had concentrations of 0.345 mg/L for ammonia nitrogen and 0.457 mg/L for total phosphorus. Another sample collected by the siphon sampler had a concentration of 0.188 mg/L for ammonia nitrogen and 0.321 mg/L for total phosphorus. The sample collected concurrently with the automatic sampler had an ammonia nitrogen concentration of 0.207 mg /L and a total phosphorus concentration of 0.471 mg/L.

PLANS (July 1998 to June 1999): Continue to collect samples until July 1, 1998. Results of the study will be summarized in a USGS fact sheet. Constituent concentration will be published in the report, "Water Resources Data–Wisconsin", and archived in the USGS water-quality and streamflow data bases.

CONCENTRATION OF SOLIDS AND PHOSPHORUS IN STREET GUTTERS, MADISON, WISCONSIN, WI 17227

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Dane County, south-central Wisconsin

PROJECT CHIEF:
Robert J. Waschbusch

PERIOD OF PROJECT:
July 1997 to September 1998

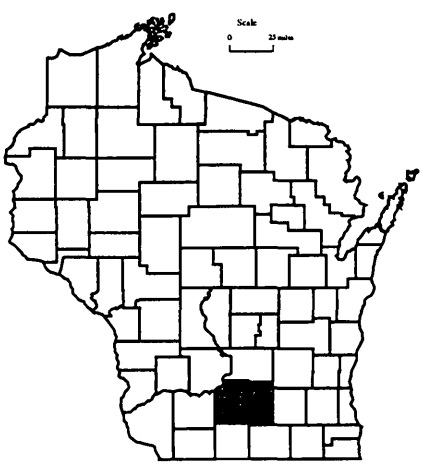
PROBLEM: Previous studies conducted by the Wisconsin district utilized source-area samplers that were installed about 6 feet from street curbs to determine concentrations in street runoff. These samplers collected runoff that ran from the crown of the street to about 6 feet from the curb. Because of this placement, the runoff from the curb to 6 feet into the street was not monitored. Previous studies, visual inspections and modeling efforts have indicated that the area within a few feet of the curb could contain significantly higher pollutant levels. If the near-curb areas do contain higher amounts of pollutants, then the previous studies may be significantly underestimating the contributions from streets.

OBJECTIVE: The objectives of the investigation are to compare the solids and phosphorus concentrations found in street runoff collected using source-area samplers installed 6 feet out from street curbs to those collected using an ISCO sampler which collects water directly from street curbs and determine if source-area samplers located away from street curbs underestimate concentrations for the entire street.

APPROACH: Stormwater runoff samples will be collected from 12 storms at 5 street sites in Madison, Wisconsin. Each of these storms will have samples from an ISCO sampler collecting water directly from the gutter and from a source-area sampler collecting water from about 6 feet from the curb. The concentration values obtained from each of these samplers will be compared.

PROGRESS (July 1997 to February 1998): The sampling equipment was installed at all sites. Two event samples were collected at two of the sites, one sample was collected at one of the sites and no samples were collected at two of the sites before the sites were shut down for the winter.

PLANS (March 1998 to September 1998): Reactivate the sites, collect the remaining runoff samples and compile the data in an Excel spreadsheet. The concentration data with a short description of the sampling equipment and locations will be provided to WDNR at the conclusion of the study.



HYDROLOGY AND WATER QUALITY OF THREE PASTURES IN SOUTHWESTERN WISCONSIN, WI 17229

PROBLEM: Nonpoint source pollution is a major concern in Wisconsin. There are approximately 24,000 dairy farms in Wisconsin which may be a source of sediment, nutrients and pesticides to surface and ground water. Managed Intensive Rotational Grazing (MIRG) is a system that uses pastures as a major source of feed for milking cows (Jackson-Smith and others, 1996). MIRG farmers rely on pastures for their dairy herds' forage needs and move their cows to a new pasture at least once a week (Jackson-Smith and others, 1996). In 1992, roughly 7 percent of Wisconsin dairy farms used MIRG but, in 1994, 14 percent of Wisconsin dairy farms used MIRG (Jackson-Smith and others, 1996). MIRG can be used as a best management practice (BMP) and may reduce the amount of sediments, nutrients and pesticides to receiving waters. In a study in Oklahoma, there was a difference between rotational grazed pastures in average annual runoff and sediment discharges when compared to continuously grazed basin (Menzel and others, 1978).

This study will compare surface-water runoff and water quality from three small pastured watersheds. The pastures will be located at the USDA Dairy Forage Research Center at Prairie du Sac.

OBJECTIVE: The overall objective of this study is to determine differences in quantity and quality of surface-water runoff from three different pasture-management strategies. These strategies consist of a variety of practices which are available to pasture managers, both during the growing and dormant seasons. Combinations of management practices have been chosen to represent commonly used strategies. In addition to examining differences in overall management strategies, differences related to individual seasonal practices will be determined. A secondary objective will be to determine a water budget for each pasture. The water budget will be determined by measuring surface-water runoff and precipitation. Evaporation and transpiration will be estimated by using empirical equations and ground-water flow will be estimated as a residual.

APPROACH: The management practices to be examined include (1) intensive rotational grazing and continuous grazing during the growing season; (2) pasture "stockpiling" during late summer and continued grazing throughout the summer; and (3) two outwintering practices and no outwintering.

An artificial hydraulic control will be installed at each pasture outlet. The control will be a three-inch Parshall flume. Each site will use a pressure transducer to measure stage and a CR-10 data recorder. Daily, monthly and annual surface-water runoff will be calculated at each pasture.

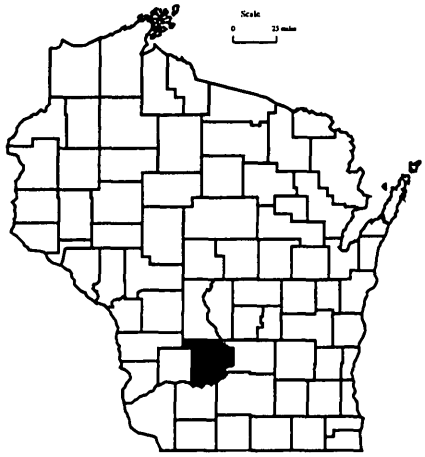
A tipping-bucket raingage will be installed at each site. Evapotranspiration will be estimated at one of the pastures. Empirical equations will be used to estimate evapotranspiration. The input data to these equations will be air temperature and solar radiation and will be collected at one of the pastures. Meteorological data collected at

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION
Sauk County, Wisconsin

PROJECT CHIEF:
David J. Graczyk

PERIOD OF PROJECT:
October 1997 to September 1999



the USDA Research Station will supplement data collected at this pasture. Ground-water flow will be calculated as a residual. An ISCO automatic water-quality sampler will be installed at each site. The sampler will collect discrete samples. These samples will be composited on a flow-weighted basis. One composite sample per rainfall or snowmelt event will be sent to the Wisconsin State Laboratory of Hygiene for analysis. All events will be monitored. A gravity lysimeter will be installed in each pasture. This lysimeter will be sampled after recharge events. Approximately 5-10 samples per pasture will be collected. All samples will be analyzed for soluble reactive phosphorus, total phosphorus, ammonia nitrogen, nitrate and nitrite nitrogen, total kjeldahl nitrogen, total suspended solids, and volatile suspended solids.

PROGRESS (October 1997 to June 1998): Three continuous streamflow and rain gages were installed and operated. No runoff samples were collected because of below-normal snowfall.

PLANS (July 1998 to June 1999): Collect water-quality samples at the three sites for all storms. Determine a water budget for each site and calculate the nutrient and suspended solids loads for each site. All data will be summarized and published in the report, "Water Resources Data–Wisconsin".

MISSISSIPPI RIVER SEDIMENT LOADING, POOLS 7 AND 8, WI 17316

PROBLEM: Tributary streams dump tons of sand into the Mississippi River, contributing to the gradual decline of side channels and backwaters that act as nurseries for river wildlife. As large quantities of sediment enter the river, permanently inundated areas will slowly be converted to shallow, sandy deltas or silty marshes.

Sediments also block the light aquatic plants need for photosynthesis, and can affect organisms that must see to locate prey, avoid predators, or find other members of their species to mate or care for offspring. Navigation is also impacted by the large amount of sand contributed by tributaries in the Upper Mississippi River basin.

OBJECTIVE: The objective is to collect sediment samples and quantify the annual sediment loads at selected locations on the Mississippi River and two of its tributaries. Annual loads will be calculated for the outflow from Pools 7 and 8, the LaCrosse and Black Rivers near LaCrosse, Wisconsin, and the Root River near Houston, Minnesota.

APPROACH: Bridge-mounted sediment samplers will be installed at bridges over the Mississippi River downstream from Lock and Dam 7, over the Black River, and over the Root River. Samples will be collected by an observer at regular intervals during base-flow conditions and more frequently during high flow. An observer will collect samples upstream of Lock and Dam 8 using a P61 sampler from a boat. An automated sediment sampler will be installed on the LaCrosse River to collect samples during storm runoff periods. The sediment samples will be analyzed by the USGS sedement lab in Iowa and the data will be used to compute the annual sediment loads at each of the monitored locations. The loads from the three tributaries and from Pool 7 will be compared to the load calculated leaving Pool 8 at Lock and Dam 8.

PROGRESS (October 1997 to June 1998): Equipment has been installed and sampling was started in October 1997. Initial calibration measurements for the bridge-mounted samplers have been completed. Data is being stored in the QWDATA system in the Wisconsin District office.

PLANS (June 1998 to July 1999): Data collection will end on September 30, 1998, unless funding is received to continue for another year. The data will be summarized and published in the report, "Water Resources Data–Wisconsin", and stored in the QWDATA system.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
LaCrosse to Genoa, Wisconsin

PROJECT CHIEF
Peter E. Hughes

PERIOD OF PROJECT:
October 1997 - Continuing

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 1996

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 μeq/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 μeq/L.

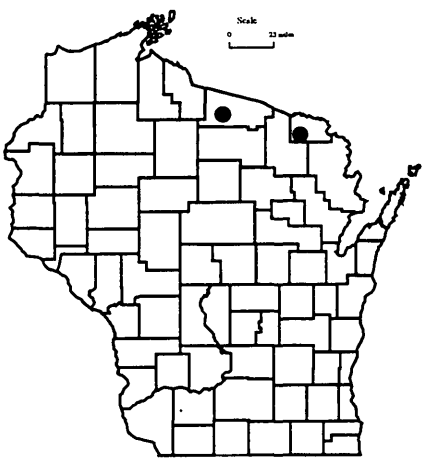
OBJECTIVE: Objectives are to determine the hydrologic and chemical budgets for Honeysuckle, Max, and Morgan Lakes in northern Wisconsin to provide information about mechanisms of acid loadings to these lakes, investigate differences between bog lakes and clear-water lakes, evaluate the feasibility of, 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 1997 to June 1998): 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.

PLANS (July 1998 to June 1999): Routine data collection will continue at Vandercook and Morgan Lakes.



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: Limnology and Oceanography, v. 41, no. 5, p. 977-984.

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 in the states of Wisconsin, Michigan, and Indiana to act as a baseline for evaluation of future remediation activities; estimate loads of PCBs, 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 four Wisconsin tributaries, including 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 PCBs 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 1997 to June 1998): Sample collection was completed for all 11 stations in October 1995. Sample analyses were completed in October 1997. Analyses included congener-specific PCBs, 14 pesticides and pesticide degradation products, trace metals, nutrients, and major ions. Loads of atrazine, nutrients, and major ions have been computed for the monitored tributaries. A method that will be used to estimate contaminant loads from unmonitored tributaries is in draft. A USGS open-file report describing cross-sectional field data is in review.

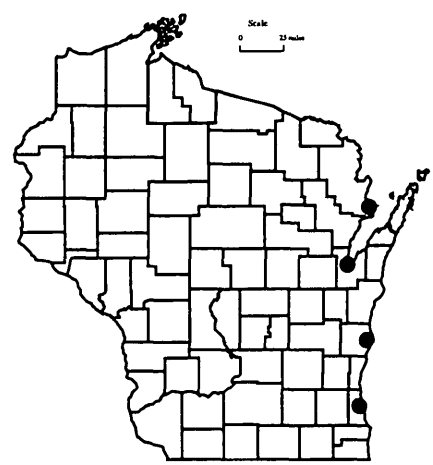
PLANS (July 1998 to June 1999): Contaminant loads from the monitored tributaries will be completed. The method by which to estimate loads of contaminants from unmonitored tributaries will be reviewed and finalized. All load data from both monitored and unmonitored tributaries will be transmitted to the Environmental Protection Agency (EPA) for use in the Lake Michigan Mass Balance model. USGS water-resources investigations reports and USGS sections of EPA reports will be drafted and submitted 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 September 1997



TRACE METAL LOADING TO LAKES MICHIGAN AND SUPERIOR, WI 18301

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
United States portion of Lake Michigan and Lake Superior Basins

PROJECT CHIEF:
Dale M. Robertson

PERIOD OF PROJECT:
October 1997-Continuing

PROBLEM: The delivery of trace metals via tributaries from point and nonpoint sources poses serious concerns for the coastal and offshore ecosystem of the Great Lakes. Though point-source loadings can be significant, evidence suggests that nonpoint source contributions of metals exceed that of point sources. The tributary monitoring component of the Lake Michigan Mass Balance study will provide total loads of selected metals from the selected tributaries, but will not support source reconciliation and will not provide regional load estimates of the selected metals.

OBJECTIVE: Objectives are to (1) develop tributary load estimates of selected metal constituents to Lake Michigan and the U.S. portion of Lake Superior from both monitored and unmonitored watersheds, (2) describe what factors influence the relative loading, and (3) separate the load into the urban and nonurban components.

APPROACH: The approach used will be as follows: (1) Develop GIS coverages of the environmental factors thought to influence the distribution of the selected metals; (2) subdivide the entire basin into areas of relatively homogeneous environmental characteristics; (3) sample areas that have not been previously sampled; (4) compute loads for selected metals for the main tributaries and daily loads (high flow and base flow) for smaller indicator streams from relatively homogeneous areas; (5) use GIS to determine environmental characteristics of main tributary basins and smaller indicator streams; (6) use multiple regression to relate loads from indicator sites to environmental characteristics; (7) use loads from smaller indicator areas with regression relations to estimate loading from ungaged areas and total regional loading; and (8) subtract watershed load from tributary load to estimate the urban inputs.

PROGRESS (July 1997 to June 1998): GIS data were partially obtained for land use, surficial deposits, bedrock types for the complete Lake Michigan and U.S. part of Lake Superior. Michigan was preliminarily stratified into areas of relatively homogeneous units. Indicator sites were chosen from the Michigan RHUs. The indicator sites were sampled for a suite of trace elements by the University of Wisconsin-Madison in December base flow and spring high flow.

PLANS (July 1998 to June 1999): Complete basin characteristics will be obtained using GIS for all the tributaries (integrator sites) sampled in the Lake Michigan Mass Balance study. The entire area will be subdivided into Relatively Homogeneous Units. Each of the drainage areas of the tributaries sampled during the Lake Michigan Mass Balance Study will be divided into downstream urban areas and the rest of the basin. GIS will be used to describe the percentages of each land use, surficial deposits, and bedrock type in the basins of the tributaries sampled during the Lake Michigan Mass Balance Study. The new indicator sites in Michigan will be sampled during the summer of 1998 for a suite of trace elements by the University of Wisconsin-Madison.

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 District 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 1997 to June 1998): Gaging station operations were continued for the year. Several PCB samples were taken during this period using the Infiltrex samplers controlled by the flow-proportional sampling program. AVM data from the sites were calibrated with Doppler measurements to estimate discharge. Discharge data for Duluth and Superior AVM sites and the Nemadji River were published in the report, "Water Resources Data–Wisconsin".

PLANS (July 1998 to June 1999): The gaging stations will be operated through September 1998. Operation beyond September 1998 will depend on finding alternative funding sources. Flow data will be finalized and published in the report, "Water Resources Data–Wisconsin".

COOPERATORS:

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

LOCATION:

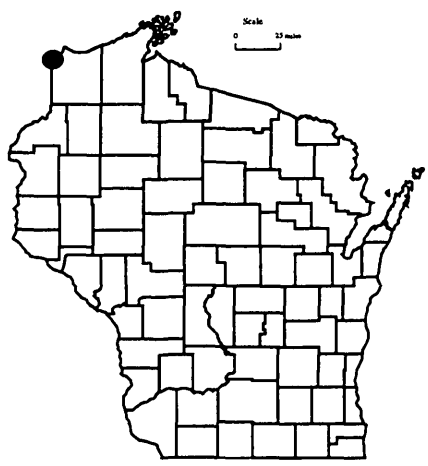
Cities of Duluth, Minnesota and Superior, Wisconsin

PROJECT CHIEF:

Peter E. Hughes

PERIOD OF PROJECT:

July 1993 to September 1998



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:

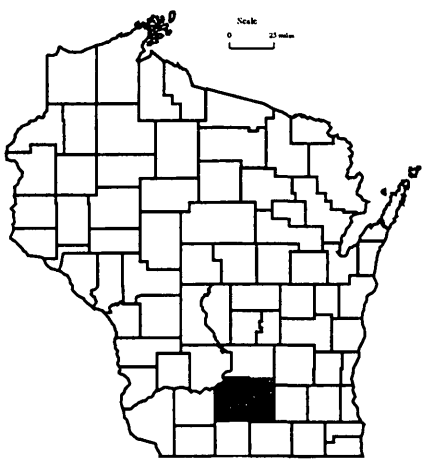
Dane County and parts of surrounding counties

PROJECT CHIEF:

James T. Krohelski

PERIOD OF PROJECT:

October 1992 to September 1996



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.

OBJECTIVE: The objective is to provide a better understanding of the regional ground-water system in relation to surface water and to provide a tool (ground-water flow model) that will be useful in water-resource management decision making on a continuing basis.

APPROACH: The study is divided into three phases: (1) establish conceptual framework of the ground-water system and data base, (2) develop and calibrate three-dimensional ground-water flow model, and (3) determine how land-use and management strategies effect water resources.

PROGRESS (July 1997 to June 1998): A report describing phase 2 of the Dane County Hydrologic Study, a calibrated three-dimensional flow model, was completed and approved for publication. A report describing phase 1 of the Dane County Hydrologic Study, the hydrogeologic framework, was completed and is in review. Simulations incorporating potential land-use and management strategies were run and the results given to the Dane County Regional Planning Commission.

PLANS: Project is complete except for publication of report.

REPORTS:

Krohelski, J.T., Bradbury, K.R., Hunt, R.J., and Swanson, S.K., 1997, Numerical simulation of ground-water flow in Dane County, Wisconsin: Wisconsin Geological and Natural History Survey Information Circular (in press).

Bradbury, K.R., Swanson, S.C., Krohelski, J.T., and Fritz, A.K., 1997, Hydrogeology of Dane County, Wisconsin: Wisconsin Geological and Natural History Survey (in review)

TRANSPORT AND BIOGEOCHEMICAL CYCLING OF PCBs IN THE HAYTON MILLPOND, WISCONSIN, 19101

PROBLEM: High concentrations of polychlorinated biphenyls (PCBs) have been found in the Hayton Millpond bed sediments and fish tissues. Consequently, a plan is being developed to restore and revive the surface waters of this area. Knowledge of the processes that control cycling and transport of PCBs is essential to the remediation effort. Algal incorporation of PCBs 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 PCBs and concentration of PCBs in TSS and resuspendable surficial bottom sediments. PCB loading will be determined at the millpond outlet.

APPROACH: The millpond outlet will be monitored for two years during event and base-flow 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. Eighteen manual organic samples (80 liters) 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.

Three water-column PCB samples will be collected at two Pine Creek sites.

PROGRESS (July 1997 to June 1998): The data-collection effort is complete. Water-column PCB concentrations ranged from 38 to 564 ng/L, producing transported PCB loads of 4 to 136 grams per day. The algal identification effort and laboratory PCB uptake experiments are complete.

PLANS (July 1998 to June 1999): A report detailing the PCB loading, partitioning, algal PCB uptake and suspended-solids classification will be published. Continuous streamflow and temperature monitoring will be continued.

REPORTS:

Steuer, Jeffrey, Fitzgerald, Sharon, and Hall, David, Distribution and transport of polychlorinated biphenyls in Hayton Millpond, Wisconsin (in process).

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

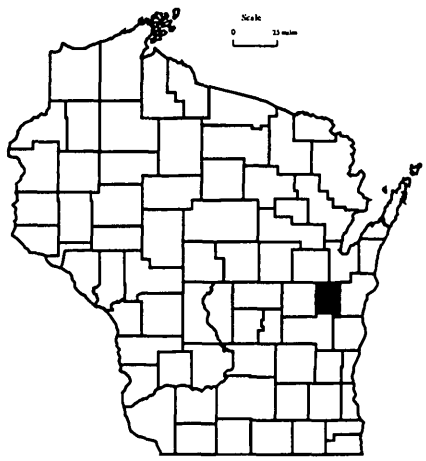
Calumet County, eastern Wisconsin

PROJECT CHIEF:

Jeffrey J. Steuer

PERIOD OF PROJECT:

February 1993 to July 1999



WILD ROSE STATE FISH HATCHERY AQUIFER TEST AND GROUND WATER FLOW MODEL, WI 19200

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Waushara County, Wisconsin

PROJECT CHIEF:
Charles Dunning

PERIOD OF PROJECT:
August 1997 to September 1998

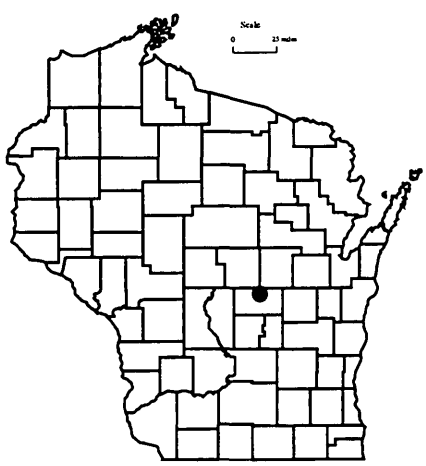
PROBLEM: The Wild Rose State Fish Hatchery is the state's largest cold-water fish hatchery, specializing in raising brown trout and chinook salmon. The hatchery also raises a large variety of cool-water species, including northern pike, muskellunge, hybrid muskellunge, walleye, suckers and sturgeon. All the water for the hatchery is supplied by ground water. Because the quality and quantity of this water is critical to the continued success of the hatchery, there is a need to characterize the ground-water aquifer in the vicinity of the hatchery. The ability of the aquifer to support high-capacity supply wells for future hatchery operations must be known. The effect on local and regional water resources of pumping high capacity wells must also be known.

OBJECTIVE: The objective of this project is to characterize the ground-water aquifer in the vicinity of the Wild Rose Fish Hatchery in order to predict the local and regional effect of supplying hatchery water needs with one or several high-capacity wells.

APPROACH: A pump test of a newly installed high-capacity well on the hatchery grounds will provide measured values for aquifer parameters which will be used in constructing a regional ground-water flow model. This model will be used to predict the effects of high capacity pumping rates and configurations.

PROGRESS (August 1997 to June 1998): At the end of August, a high-capacity pump test was conducted. The USGS collected data to evaluate the response of the aquifer to 24 hours of pumping (at 1500 gpm) and 6 hours of recovery. The test results were used to determine values for aquifer parameters and applied to a regional ground-water-flow model. This model has been delivered to the WDNR for their use in planning future activities at the Wild Rose State Fish Hatchery

PLANS: Project is completed.



NORTH FISH CREEK SEDIMENT, WI 193

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.

OBJECTIVE: 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 1997 to June 1998): Laboratory analyses on particle size were completed and radiocarbon sample analyses was semi-completed. A select number of organic material samples were analyzed for macrofossils. A WRIR containing significant results was begun as analyses of causes of geomorphic change continued. Modeling of the effects of detention basin storage on sediment transport continued. The streamflow-gaging station at Moquah, Wisconsin, continued to operate. The introduction and methods section of the planned dissertation was written.

Preliminary analyses of core and streambank data indicate that approximately 1 to 2 meters of sediment has accumulated in the flood plain and channel in the lower reach during the past 125 years. This human-influenced sedimentation rate is almost 10 times greater than pre-1870 rates. In addition, channel incision and slope steepening have occurred in the upper reach due to past increases in runoff caused by forest clearing. Since the mid 1940s, the channel has incised 1-3 meters in the upper reach and many of the eroded bluffs that also are sources for sediment have retreated 11 to 28 meters. Sedimentation appears to be decreasing since approximately 1950, corresponding to the decrease in agricultural activity and increase in extent and maturity of forested land.

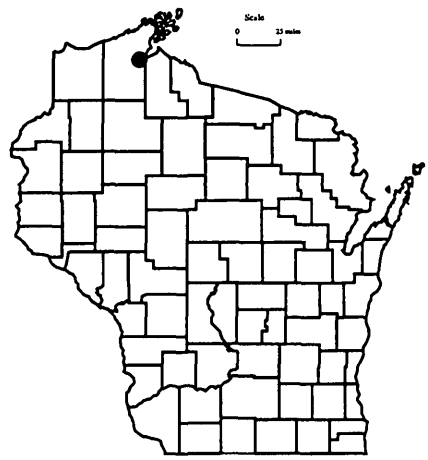
PLANS (July 1998 to June 1999): The radiocarbon analyses will be completed; modeling effects of detention basin storage on sediment transport will be completed. Water-resources investigations report and dissertation will be approved and published.

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 1997



REPORTS:

Fitzpatrick, F.A., and Knox, J.C., Effects of Long-Term Land-Use Changes on Flooding and Sedimentation, North Fish Creek, Wisconsin: U.S. Geological Survey Water Resources Investigations Report (in preparation).

Fitzpatrick, F.A., Effects of Changes in Vegetation, Climate, and Isostatic Rebound on Sedimentation and Hydrology of a Northern Wisconsin Stream, Ph.D. dissertation, University of Wisconsin-Madison (in preparation).

OPTIMUM MANAGEMENT OF GROUND-WATER RESOURCES IN THE LOWER FOX RIVER VALLEY, WI 198

PROBLEM: Recent water-level measurements indicate that the cones of depression from two pumping centers, the Green Bay Metropolitan area and the Fox Cities area, have merged so that pumping in one area effects the other area. Water-use projections, used in a previously developed ground-water-flow model, indicate water levels near the center of the cone of depression at Green Bay will decline more than 250 feet below the top of the sandstone aquifer by the year 2015 and leave about 330 feet of saturated aquifer thickness. This would result in increased pumpage costs and a reduction in the amount of water that can be pumped from the sandstone aquifer. In response to the concern over declining water levels in the aquifer, proposals to build a pipeline to Lake Michigan have been discussed.

OBJECTIVE: The objective of this study is to determine whether ground water, under managed pumping conditions, is an alternative to Lake Michigan water for future water supply in the Lower Fox River Valley. An optimization model will be used to determine ground-water-management plans so that water yields are maximized, while water-level declines in the sandstone aquifer are constrained to remain within reasonable ranges.

APPROACH: A three-dimensional regional ground-water-flow model encompassing the entire Lower Fox River Valley was developed as part of an ongoing ground-water study. The flow model will provide the head response resulting from various management solutions. The goal of the optimization modeling will be to maximize well yield while maintaining reasonable water levels in the aquifer. Optimization modeling will be applied to several management scenarios, addressing relevant issues and questions concerning ground-water resources of the Lower Fox River Valley. Potential issues include ground-water availability in the sandstone aquifer, well placement and pumping strategies, quality of the water supply, and relation between ground and surface water.

PROGRESS (July 1997 to June 1998): Results of computer simulations of management plans were presented to the appropriate planning agencies for the two main pumping centers, the Green Bay Metropolitan area and the Fox Cities area. The management plans were revised slightly and final simulations were completed. The final report was completed and distributed.

PLANS: Project is completed.

REPORTS:

Walker, J.F., Saad, D.A., and Krohelski, J.T., 1998, Optimization of ground-water withdrawal in the lower Fox River communities, Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 97-4218.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

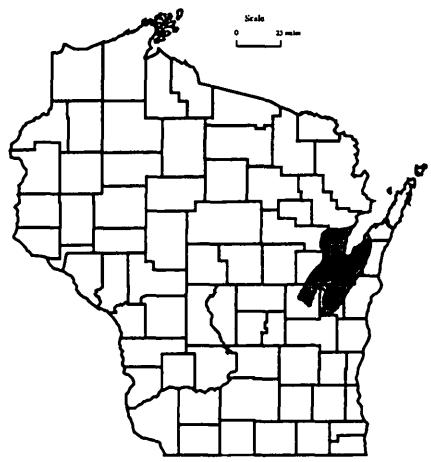
Lower Fox River Valley (Green Bay Metropolitan and Fox Cities area)

PROJECT CHIEF:

John F. Walker

PERIOD OF PROJECT:

October 1995 to September 1997



Completed Projects

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

WI171 Application of habitat-suitability index models to assess effects of fine-grained sediment on brook trout and brown trout habitat

WI17217 Evaluation of total phosphorus load determination methods applied to three major tributaries to Lake Mendota, Dane County, Wisconsin, 1994-95

WI 18901 Simulation of the effects of operating Lakes Mendota, Monona, and Waubesa as multi-purpose reservoirs to maintain low flow

WI191 Distribution and transport of polychlorinated biphenyls in Milwaukee River, Wisconsin

APPENDIX A

STREAM-GAGING STATIONS PROPOSED FOR 1999 FISCAL YEAR

COOPERATOR:
Wisconsin Department of Natural Resources

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 project are to provide continuous-discharge records for selected rivers at specific sites to supply the need for regulation, analytical studies, definition of statistical properties, trends analysis, and 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 flood and 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-gaging 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 periodic stage readings 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 1997 to June 1998): Twenty-six continuous-record gaging stations were operated in cooperation with the Wisconsin Department of Natural Resources (WDNR) during the 1998 fiscal year. Data were analyzed and published for one station that was partially funded by the U.S. Army Corps of Engineers and one by a FERC licensee. Partial-record data were collected and published at six stations. More than 100 requests for streamflow data were answered; WDNR, other State, Federal, and county agencies, consultants, municipalities, and the general public requested data. Streamflow records for the 1997 water year were published in the annual report, "Water Resources Data–Wisconsin".

PLANS (July 1998 to June 1999): Streamflow records for the 1998 water year will be computed and published in the annual report, "Water Resources Data–Wisconsin". Present plans are to operate the same stations that were operated in the 1998 fiscal year plus one station that will be added to the streamflow for hydropower program. Requests for streamflow information will be answered.

PROPOSED PROGRAM FOR THE PERIOD 7/1/98-6/30/99

USGS Gaging Stations
Wisconsin Department of Natural Resources

STREAMFLOW FOR HYDROPOWER DATA		Record began (water year)
04027500	1/ White River near Ashland	1948
04029990	1/ Montreal River at Saxon Falls	1987
04064500	2/ Pine River below Pine River powerplant near Florence	1924-76, 1996
04066003	2/ Menominee River near Pembine	1950
04067958	5/ Peshtigo River near Wabeno	1998
04077400	3/ Wolf River near Shawano	1907-09, 1911
05332500	1/ Namekagon River near Trego	1928-70, 1987
05340500	1/ St. Croix River at St. Croix Falls	1902
05341500	1/ Apple River near Somerset	1901-70, 1987
05356000	1/ Chippewa River at Bishops Bridge near Winter	1912
05356500	1/ Chippewa River near Bruce	1914
05360500	1/ Flambeau River near Bruce	1951
05365500	1/ Chippewa River at Chippewa Falls	1888-1983, 1987
05369000	1/ Red Cedar River at Menomonie	1913
05391000	4/ Wisconsin River near Lake Tomahawk	1936
05393500	4/ Spirit River at Spirit Falls	1942
05394500	4/ Prairie River near Merrill	1914-31, 1939
05395000	4/ Wisconsin River at Merrill	1903
05397500	4/ Eau Claire River near Kelly	1914-27, 1939
05398000	4/ Wisconsin River at Rothschild	1945
05399500	4/ Big Eau Pleine River near Stratford	1914
05400760	4/ Wisconsin River at Wisconsin Rapids	1914
05402000	4/ Yellow River at Babcock	1944
05404000	4/ Wisconsin River near Wisconsin Dells	1935

1/ WDNR cooperates with Northern States Power Company
2/ WDNR cooperates with Wisconsin Electric Power Company
3/ WDNR cooperates with Wisconsin Power and Light Company
4/ WDNR cooperates with Wisconsin Valley Improvement Company
5/ WDNR cooperates with Wisconsin Public Service

Wisconsin Electric Power Company (WEPCO) funds two stations at a cost of $9,200. Complete records are collected at nine stations and partial records at one station for the Wisconsin Valley Improvement Company (WVIC); total cost of the WVIC program is $43,710. Partial records are collected at some of the Northern States Power Company stations; total cost of Northern States Power Company program is $35,650. Wisconsin Power and Light Company funds one station at a cost of $4,600. Wisconsin Public Service funds one station at a cost of $4,965.

CONTINUOUS-RECORD MONITORING–RIVERS	Cost
04024430 Nemadji River near South Superior	$ 4,600
04067500 Menominee River near McAllister	3,490
04071765 Oconto River near Oconto	3,490
04085200 Kewaunee River near Kewaunee	3,490
04085427 Manitowoc River at Manitowoc	3,490
04086000 Sheboygan River at Sheboygan	3,490
04086500 Cedar Creek near Cedarburg	4,600*
05401050 Tenmile Creek near Nekoosa	4,600
TOTAL	$31,250

* Funding uncertain

DEVIL'S LAKE NEAR BARABOO

05404500	Devil's Lake near Baraboo (stage-precipitation data)	1,800

FOX RIVER AT OSHKOSH

04082400	Fox River at Oshkosh (WDNR cooperates with Mercury Marine)	5,830

FOX RIVER AT RAPIDE CROCHE DAM NEAR WRIGHTSTOWN

04084500	Fox River at Rapide Croche Dam near Wrightstown (WDNR cooperates with Appleton Papers)	1,900

ANALYZE AND PUBLISH DATA FOR STATIONS PARTIALLY FUNDED BY U.S. ARMY CORPS OF ENGINEERS

05382000	Black River near Galesville	1,200
	TOTAL	$10,730

APPENDIX B

FUNDING SUMMARY PROPOSED FOR GENERAL COOPERATIVE PROGRAM WITH WISCONSIN DEPARTMENT OF NATURAL RESOURCES 1999 FISCAL YEAR

	Actual 97-98	Proposed 98-99		
	DNR Share	DNR Share	Total	Remarks
Streamflow for Hydropower Data (WI 00-001) Holmstrom/Addis	104,890	98,125	196,250	DNR receives 43,710 from WVIC, 9,200 from WEPCO, 35,650 from NSP, 4,600 from WP&L and 4,965 from WPSC.
Corps of Engineers shortfall-Galesville (WI 00-001) Holmstrom/Larry Lester	1,150	0	0	As per Bill Evans, will be zero.
Wrightstown Gage (LFRDA) (WI00-001) Holmstrom/Patterson	1,850	1,900	3,800	DNR receives funds from LFRDA.
Fox River at Oshkosh (AVM) (WI 00-001) Holmstrom/Rasman, Weisensel	5,660	5,830	11,660	DNR receives funds from Mercury Marine.
Cedar Cr nr Cedarburg and Hayton Millpd (WI 00-001) (WI19101) Holmstrom/Patterson/Talbot	8,900	4,600	9,200	
Devils Lake (WI 00-001) Holmstrom/	1,750	1,800	3,600	
Tenmile Creek (WI00-001) Garn/Zimmerman)	3,360	4,600	9,200	
Sheboygan River near Sheboygan (WI00-001) Holmstrom/Patterson	6,225	3,490	6,980	For period 9/30/98-6/30/99.
Kewaunee River at Kewaunee (WI00-001) Holmstrom/Patterson	9,450	3,490	6,980	For period 9/30/98-6/30/99.
Manitowoc River at Manitowoc (WI00-001) Holmstrom/Patterson	6,015	3,490	6,980	For period 9/30/98-6/30/99.
Menominee River at McAllister (WI00-001) Holmstrom/Patterson	4,900	3,490	6,980	For period 9/30/98-6/30/99.
Oconto River near Oconto (WI00-001) Holmstrom/Patterson	9,450	3,490	6,980	For period 9/30/98-6/30/99.
Crandon (WI 00-201) Krohelski/Tans	202,000	170,000	170,000	
Water-Use Data (WI 78-007) Ellefson/Baker	75,000	75,000	150,000	75,000 direct state services.

	Actual 97-98	Proposed 98-99		
	DNR Share	DNR Share	Total	Remarks
Nonpoint Trends (WI 91-172) Hughes/Bannerman				
17202 - Bower/Otter	9,000	11,000	22,000	
17205 - Black Earth	25,000	17,000	34,000	
17206 - Evaluation BMP	38,000	31,000	62,000	
17210 - Lincoln Creek	5,000	0	0	
17213 - GIS Data Base	60,000	62,000	112,000	
17214 -Single-Source Site	50,000	47,500	95,000	
17222 - Distribution of Loading	7,200	0	0	
17223 - Multi-Stream Exp. Design	23,000	79,000	158,000	
17225 - Siphon Samplers	16,000	0	0	
17227 - Gutter Flow	20,000	0	0	
17228 - C/E Urban BMP	11,000	0	0	
17236 - Clean Water Diversion	0	10,000	20,000	
18701 - Storm Ceptor, Madison	0	4,600	11,200	
17233 - Urban Conservancy Design	0	30,000	60,000	
17220 - Ruby Street Report Milwaukee	0	4,000	8,000	
17235 - Polk County Deer Lake	0	5,000	10,000	
Little Rock Lake (WI 92-18001) Rose/Knauer, Webster	4,300	0	0	
Brownfields Assessment Sites (WI00-00203) Krohelski/Parker	10,000	0	0	
Rotational Grazing (WI 17229) Hughes/Greb	19,000	14,500	29,000	
BOD Loading (WI 109) Hughes/Bannerman	4,000	0	0	
Regional Trace Metal (WI 18301) Robertson/Hurley	11,500	27,000	54,000	
Wild Rose Fish Hatchery (WI 192) Dunning/Burney, Ives	20,000	0	0	
Mississippi River (WI 17316) Hughes/				
Temperature Modeling (WI 17234) Owens/Greb	0	33,000	46,000	$20,000 unmatched.

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

Kammerer, P.A., Jr., and Krug, W.R., 1993, Wisconsin stream water quality, in U.S. Geological Survey, National water summary 1990–91—Hydrologic events and stream water quality: U.S. Geological Survey Water-Supply Paper 2400, p. 561–568.

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.

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Kammerer, Phil A., Jr., Trotta, Lee C., Krabbenhoft, David P., and Lidwin, R.A., 1998, Geology, ground-water flow, and dissolved-solids concentrations in ground water along hydrogeologic sections through Wisconsin aquifers, U.S. Geological Survey Hydrologic Investigations Atlas, HA-731, 4 sheets.

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.

Hindall, S.M., and Borman, R.G., 1974, Water resources of Wisconsin—lower Wisconsin River basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-479, 3 sheets.

Young, H.L., and Borman, R.D., 1973, Water resources of Wisconsin—Trempealeau-Black River basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-474, 4 sheets.

Oakes, E.L., and Hamilton, L.J., 1973, Water resources of Wisconsin—Menominee-Oconto-Peshtigo River basin, U.S. Geological Survey Hydrologic Investigations Atlas HA-470, 4 sheets.

Hindall, S.M., and Skinner, E.L., 1973, Water resources of Wisconsin—Pecatonica-Sugar River basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-453, 3 sheets.

Young, H.L., and Hindall, S.M., 1973, Water resources of Wisconsin—St. Croix River basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-451, 4 sheets.

Skinner, E.L., and Borman, R.G., 1973, Water resources of Wisconsin—Lake Michigan basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-432, 4 sheets.

Shearman, J.O., and Holmstrom, B.K., 1971, Floods on Rock River in southwestern Jefferson County, Wisconsin: U.S. Geological Survey Hydrologic Investigations Atlas HA-413, 1 sheet.

_____1971, Floods on Rock River in northeastern Jefferson County, Wisconsin: U.S. Geological Survey Hydrologic Investigations Atlas HA-394, 1 sheet.

Sherman, J.O., 1970, Floods on Rock River in northern Rock County, Wisconsin: U.S. Geological Survey Hydrologic Investigations Atlas HA-393, 1 sheet.

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