Prepared in cooperation with the Lake St. Clair Regional Monitoring Project; Michigan Department of Environmental Quality; and Macomb, Oakland, St. Clair, and Wayne Counties, Michigan

Stream-Water Quality during Storm-Runoff Events and Low-Flow Periods in the St. Clair River/Lake St. Clair Basin, Michigan

Open-File Report 2007-1201

U.S. Department of the Interior
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Cover photographs:
Photographs showing potential urban and combined-sewer sources from U.S. Geological Survey Water-Quality Image Library. Photograph showing agricultural storm-runoff source taken by T. L. Weaver.

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Conversion Factors, Datum, and Abbreviations

Multiply	By	To obtain
Length		
mile (mi)	1.609	kilometer (km)
Flow rate		
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius

(µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Abbreviations

DWSD – Detroit Water and Sewerage Department

LSCRMP – Lake St. Clair Regional Monitoring Project

MDEQ – Michigan Department of Environmental Quality

NASQAN – National Stream Quality Accounting Network

NAWQA – National Water-Quality Assessment Program

USGS – U.S. Geological Survey

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Abstract

This report, a product of the Lake St. Clair Regional Monitoring Project, describes four water-quality studies in the St. Clair River/Lake St. Clair Basin from the early 1970's through 2005. All the studies examined water quality of streams in the basin; the most recent studies focused primarily on water quality during high- and low-streamflows. This report explains how storm-runoff and low-flow periods affect water quality in the basin. Included is a summary of stream-water quality findings from the National Stream Quality Accounting Network (1973–95); the National Water-Quality Assessment (1996–98); the Oakland County Land-Use Change study (2001–03); and the Lake St. Clair Regional Monitoring Project (2004–05).

Introduction

The goal of the Lake St. Clair Regional Monitoring Project (LSCRMP) was to conduct a comprehensive water-quality assessment of Lake St. Clair and its surface-water sources in southeastern Michigan (Macomb County, Blue Ribbon Commission, 1997; fig. 1). As the population of the basin has steadily grown, formerly rural and agriculturally dominated areas have become more urban. This changing land use has had a profound effect on stream-water quality during storm-runoff and low-flow periods.

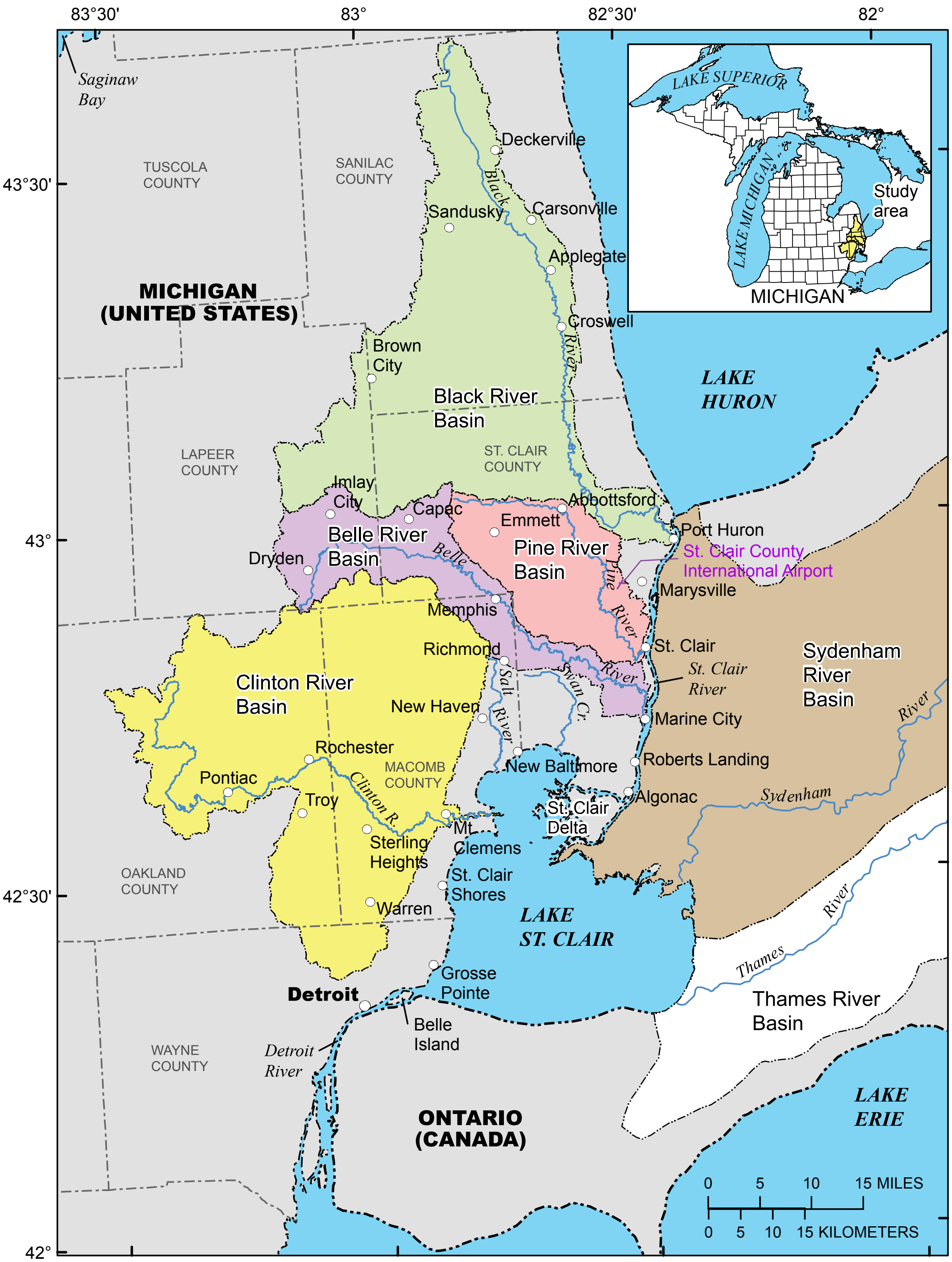
For purposes of this report, "storm-runoff events" are defined as times during and after rainfall when precipitation exceeds infiltration into the soil, resulting in direct runoff. During such events, excess water moves directly to streams or lakes as overland flow. Many factors influence whether a particular storm results in runoff that dilutes or concentrates a particular chemical constituent in the surface-water body receiving the runoff. Commonly, concentrations of some constituents decrease while concentrations of others increase. A photograph of the North Branch Clinton River near Mt. Clemens during a storm-runoff event is shown in figure 2.

Low flows occur in streams and rivers during extended periods of little or no precipitation or snowmelt. Streamflow during low-flow periods is derived mostly from ground water, but flow in some streams can include inputs from septic tanks and point discharges such as tile drainage from agricultural fields, sewage-treatment effluent, and industrial cooling or processing water. A photograph of the Clinton River near Fraser during a low-flow period is shown in figure 2.

This summary of stream-water quality during storm-runoff events and low-flow periods was initiated by the LSCRMP in 2003, in cooperation with the Michigan Department of Environmental Quality (MDEQ), the Counties of Macomb, Oakland, St. Clair, and Wayne; and the U.S. Geological Survey (USGS). This report explains how storm-runoff events and low-flow periods affect water quality in the St. Clair River/Lake St. Clair Basin. Included is a summary of stream-water-quality findings from four studies that published data over the course of 32 years: National Stream Quality Accounting Network (1973–95), National Water-Quality Assessment (1996–98), Oakland County Land-Use Change study (2001–03), and Lake St. Clair Regional Monitoring Project (2004–05).

What Defines Water Quality?

The quality of water is determined by its chemical, physical, and biological characteristics. The same water can be considered bad or good on the basis of its intended use. For example, water-quality standards for drinking water are considerably more stringent than standards for water that will be used for cooling in industrial processing. In some cases, water discharged to streams can meet quality standards at one location but result in human-health-related problems downstream,



Base from U.S. Geological Survey Digital Line Graphics, 1:2,000,000, 1998

Figure 1. Lake St. Clair, the St. Clair River, and major tributary drainage basins.

Figure 2. Examples of high and low streamflow on the Clinton River. The photograph on the left is an example of a storm-runoff event at USGS station 04164500 (North Branch Clinton River near Mt. Clemens, Mich.) on April 5, 2003, when the daily mean streamflow on this day was the highest recorded in water year 2003. The photograph on the right is an example of low flow at USGS station 04164000 (Clinton River near Fraser, Mich.) on June 20, 2005, when the daily mean streamflow was only about 35 percent of the 1947–2005 June monthly mean streamflow for this site. File photographs from U.S. Geological Survey Water-Quality Image Library.

such as microbial contamination near swimming beaches or public-water-supply intakes (U.S. Army Corps of Engineers, 2003).

Chemical characteristics of natural water derive from many sources, among which are gases and aerosols from the atmosphere, weathering and erosion of rocks and soil, solution or precipitation reactions at or below the land surface, and chemical inputs from human activities (Hem, 1985).

Some physical characteristics of surface water can be easily measured in the field. These include temperature, dissolved oxygen, pH (a measure of hydrogen ion activity), specific conductance (a measure of the ability of water to transmit electric current), and turbidity (a measure of how much suspended material is in the water). A multiparameter water-quality monitor can be configured to measure all five characteristics.

Biological characteristics of water are determined by the diversity of the flora and fauna in the water body. Chemical and physical quality determines to a large degree what types of plants and animals can survive. As water quality changes, the diversity and numbers of plants and animals changes. Generally, diversity increases as water quality improves.

What Factors Determine Volume And Quality Of Storm Runoff?

Two main factors in determining the amount and quality of runoff from a particular storm event are land-surface conditions and land-use type. Storm runoff increases when the ground is frozen or saturated. During these times, little or none of the rainfall or snowmelt infiltrates the soil and the water moves rapidly into nearby surface-water bodies as overland flow. Likewise, urban areas that have large areas of the land surface covered by pavement and buildings will have rapid storm runoff throughout the year.

Typically, storm runoff contains solids such as soil particles and other particles small enough to be entrained within overland flow. Storm runoff also carries nutrients and pesticides/herbicides (which are dissolved or carried intact and found in rural as well as urban settings), trace elements, and pathogens (microorganisms that cause disease). In rural areas, where agriculture is prevalent, animal wastes can—and often do—enter surface-water bodies as a result of storm runoff; in urban areas, insufficient wastewater-treatment capacity and combined-sewer overflows often result in entry of untreated or only partially treated human waste to adjacent surface-water bodies. In urban areas, such as southern Oakland and Macomb Counties, large areas of ground covered by pavement and buildings promote rapid runoff, which can pick up and transport automotive antifreeze, fuel, lubricants and many other potential contaminants into nearby surface-water bodies.

Storm runoff is reduced in areas where the ground surface is mostly grassland or forested, and rainfall has a better chance to infiltrate into the ground. A photograph of two adjacent fields in eastern Michigan is shown in figure 3. The field on the left has a buffer strip of rough vegetation in the area adjacent to the drainage ditch, whereas the field on the right has a row crop planted to the edge of the ditch. Creating agricultural buffer strips in the riparian zone near streams,

Figure 3. Contrasting agricultural practices–planted buffer strip adjacent to drainage ditch compared to buffer strip. The field on the left has a buffer strip of rough vegetation planted in the area adjacent to the drainage ditch, whereas the field on the right has a row crop planted down into the edge of the ditch. Photograph by T.L. Weaver, U.S. Geological Survey.

ditches, and ponds or lakes, or practicing no-till field preparation techniques can slow storm runoff that might otherwise flow directly into adjacent surface-water bodies. Buffer strips serve as a transitional zone between agricultural fields and surface water bodies, stabilizing banks, filtering out sediments and reducing water turbidity, recharging aquifers, and protecting aquatic habitat. Establishing buffer strips has been effective at mitigating some potential contaminants, including sediment and pesticides, and is particularly useful when fields are barren.

Historically, headwater areas of the Clinton River Basin (northern Oakland and Macomb Counties) were largely rural or agricultural, whereas downstream areas were heavily urbanized. Downstream industrial and municipal point discharges were the primary factors in the designation of the Clinton River as an Area of Concern in 1985 (Clinton River RAP Public Advisory Council, 2000). Today (2007) however, contamination problems in the Clinton River are largely the result of nonpoint-source runoff. Even though urbanization increased in the Clinton River Basin by 15 percent from 1978 to 2001 (Syed and Fogarty, 2005), major industrial discharges for the most part have ceased, and most municipal sewage-treatment facilities have adequate pretreatment programs and combined sewer-control plans for most streamflow conditions. Yet, some severe storms in the Clinton River Basin can still cause excessive runoff, resulting in overflows of sewers and sewage-retention basins directly into the river. These occasional overflows are blamed for degraded water quality in the Clinton River and excessive weed growth along the Lake St. Clair shoreline. As a result of these overflows and other nonpoint-source inputs, storm runoff is listed as the largest single source of stream-water-quality degradation in the Clinton River Basin (Clinton River RAP Public Advisory Council, 2000).

What Causes Low-Flow Periods, And How Do They Affect Stream-Water Quality?

Periods of low streamflow also can profoundly affect stream-water quality. Although direct runoff of dissolved and suspended constituents into streams typically ceases during low-flow periods, water quality commonly deteriorates as a result of increased concentrations of some chemical constituents, increased water temperatures and conductance, and low dissolved-oxygen concentrations. The combination of lower than normal dissolved-oxygen concentrations and higher than normal water temperatures can be harmful or fatal to aquatic life, particularly if such conditions are sustained for long periods.

In headwaters of the Clinton River Basin, flow in some tributaries can cease entirely if a dry period is sustained or severe. Cessation of flow is most prevalent where streams originate and/or flow through areas of clay-rich surficial geologic materials, such as northern Macomb County. In areas where surficial sand and gravel deposits are more common (eastern Oakland County), streamflow is typically sustained by ground-water inflow. Low streamflow in the Clinton River Basin can also be affected by diversion into lakes to maintain levels. Aichele (2005b) showed that for two tributary streams to the upper Clinton, more than 90 percent of the total streamflow in August and September is derived from ground-water discharge. In downstream parts of the Clinton River Basin, effluent from municipal sewage-treatment plants and cooling water from industrial plants probably composes a significant proportion of the Clinton River's flow during extended dry periods, because many of the municipal water supplies use surface water obtained from outside of the Clinton River Basin and discharge their effluent into the Clinton River. During the drought in the early 1960s, the Detroit Water and Sewerage Department (DWSD) began supplying Oakland County water from Lake Huron and the Detroit River to communities south and east of Pontiac. By 2000, 10 townships in Macomb County also were being supplied by water from DWSD, and nearly all of the same areas were sewered as well (Detroit Water and Sewerage Department, 2000a,b). With the replacement of septic systems by sanitary sewers since the 1960s, water that was formerly discharged back into the ground and recharged aquifers is instead piped to sewage-treatment plants, where it is then released as a point-source discharge into the adjacent river system (Aichele, 2005b). As a result, the total amount of water in the Clinton River Basin at any given time has slowly increased because of the addition of out-of-basin DWSD water returned to the river from treatment plants. Aichele (2005b) also noted that the water in the Clinton River now has a higher nutrient content and higher temperature than the river typically would have if the water had come predominantly from ground-water sources.

What Has Monitoring Of Storm Runoff And Low Flow Taught Us About Changing Water Quality In The St. Clair River/Lake St. Clair Basin?

Since the early 1970s, several studies have been done to assess water-quality status and trends in the St. Clair River/Lake St. Clair Basin. These studies have involved periodic sampling efforts over various flow regimes, including storm-runoff events and low-flow periods. The purpose and findings of four of these studies (National Stream Quality Accounting Network, National Water-Quality Assessment, Oakland County Land-Use Change Study, and the Lake St. Clair Regional Monitoring Project) are described in the following sections.

National Stream Quality Accounting Network (NASQAN)

The major impetus for establishing the NASQAN program in 1974 was to develop a baseline surface-water chemistry data set that was long term and systematically collected throughout the Nation. NASQAN samples were collected at the Clinton River site at Mt. Clemens (USGS station 04165500) from 1974 to 1995 (fig. 4), primarily in response to the Clean Water Act of 1972 (Alexander and others, 1996). During that period, more than 140 water samples were collected at the site.

A trend analysis was done on the Clinton River NASQAN data (Syed and Fogarty, 2005) to assist the MDEQ in evaluating the effectiveness of water-pollution-control efforts and the identification of water-quality concerns. The trend analysis clearly showed the benefits of sampling the same site for the same chemical constituents for an extended period and documented the effect of rapid urbanization on water quality over a two-decade period. Concentrations of 30 constituents over time were examined for trends. A negative trend indicated a decrease in concentration of a particular constituent, which generally meant an improvement in water quality, whereas a positive trend meant an increase in concentration and possible degradation of water quality. A large part of the variance of constituent concentrations may be the result of the variations in the associated discharges (streamflow) (Schertz and others, 1991). Some constituents could show a combination of streamflow-affected concentration and dilution. For example, concentration of suspended solids typically increases with increasing streamflow because overland flow results in particle transport to streams; in contrast, concentrations of many dissolved constituents decrease because of dilution as streamflow increases. The removal of streamflow as a source of variance from the data makes trend-testing techniques more powerful by increasing the probability of detecting a trend and decreases the chances of detecting a trend that is only an artifact of streamflow (Syed and Fogarty, 2005). Trend results of selected constituents are summarized in table 1.

Decreasing concentrations of sulfate, fluoride, total phosphorus and nitrogen compounds, were measured over time at the Clinton River at Mt. Clemens site from 1974 to 1995. These negative trends (decreasing concentrations) could indicate an overall improvement in agricultural practices, municipal and industrial wastewater-treatment processes, and effectiveness of regulations.

Increasing concentrations of major ions such as calcium, magnesium, and chloride were measured over time at the Clinton River at Mt. Clemens site from 1974 to 1995. Of the major ions, the most widespread significant positive trends were for sodium and chloride, and increasing concentration indicates a slight decrease in surface-water quality. Human-related sources that result in sodium and chloride entering streams include road-deicing salt; sewage effluent including water softener chemicals; industrial waste; and, in some places, oil- and gas-field waste. The maximum chloride concentration measured was 270 mg/L, which exceeds U.S. Environmental Protection Agency aquatic-life thresholds for chloride concentrations in surface water (chronic and acute exposure values are 226.5 mg/L and 1,720 mg/L, respectively) (U.S. Environmental Protection Agency, 1988). The trend for pH also was positive at the Clinton River at Mt. Clemens site from 1974 to 1995, but the cause is difficult to determine; the increase in pH could be related to a combination of human activities and natural processes occurring simultaneously in the environment.

Although concentrations of several common ions increased, results of the 1974–95 trend analyses, in general, showed an overall improvement in water quality at the Clinton River site, primarily because of decreasing concentrations of all nutrients sampled for.

National Water-Quality Assessment (NAWQA)

The NAWQA Program's goal is to improve scientific and public understanding of water quality in the Nation's major river basins and ground-water systems. As part of the Lake Erie-Lake St. Clair Basin NAWQA study, surface-water sampling was done in the St. Clair River/Lake St. Clair Basin

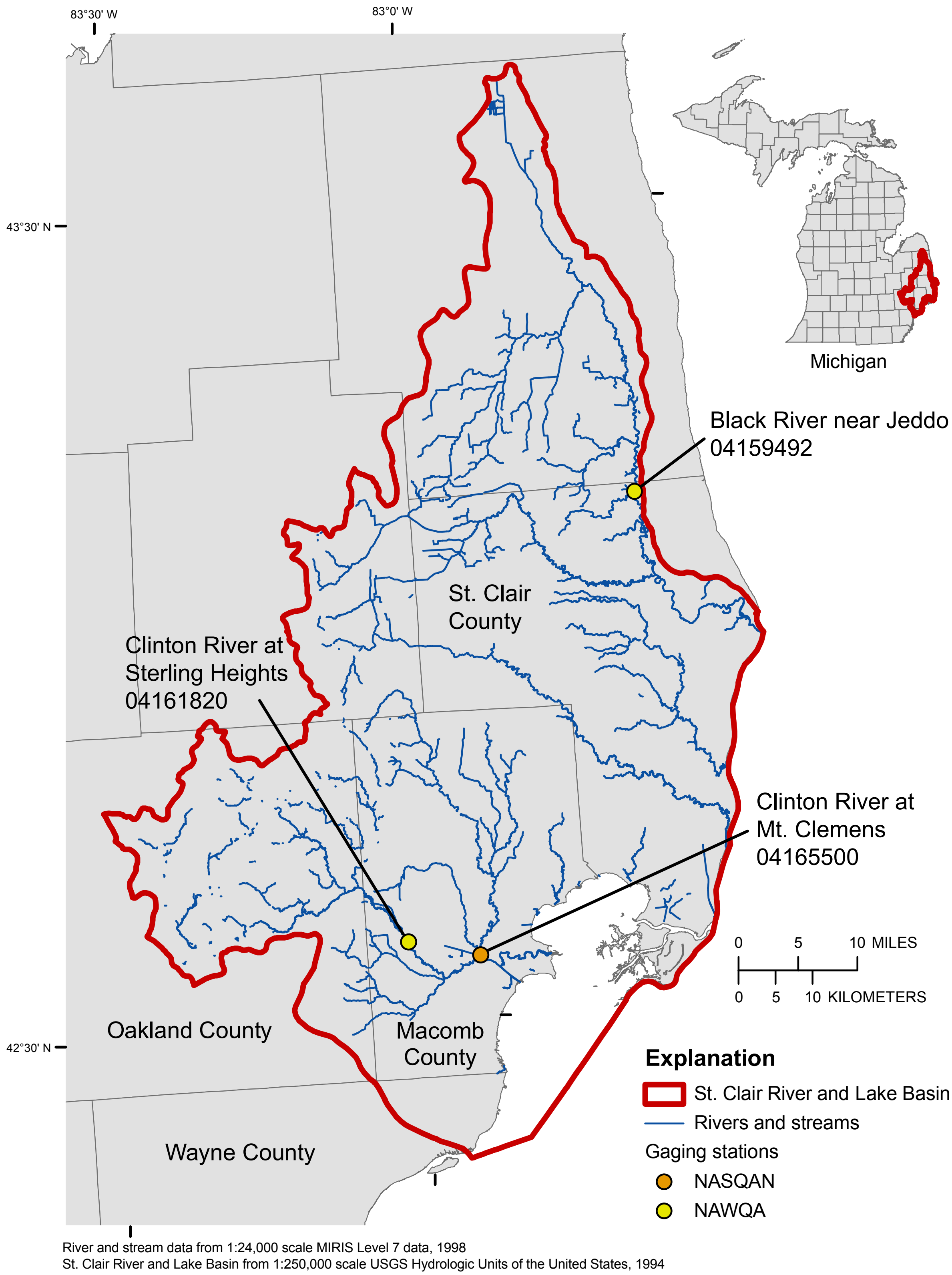


Figure 4. St. Clair River/Lake St. Clair Basin and selected streamflow-gaging stations.

Table 1. Selected summary statistics and trend results for pH, major dissolved ions, and nutrients at Clinton River at Mt. Clemens, Michigan.

[Table modified from Syed and Fogarty (2005); mg/L, milligrams per liter; ▲, positive upward trend; ▼, negative downward trend]

Property or constituent	Period of record	Number of observations	Maxi-mum	Minimum	Median	Trend
pH	1973—95	141	8.4	7.2	8	▲
Dissolved calcium (mg/L)	1974—95	139	90	45	70	▲
Dissolved magnesium (mg/L)	1974—95	139	26	12	21	▲
Dissolved chloride (mg/L)	1973—95	141	270	40	92	▲
Dissolved sulfate (mg/L)	1973—95	141	89	32	58	▼
Dissolved fluoride (mg/L)	1974—95	140	0.9	0.1	0.4	▼
Total ammonia (mg/L as N)	1977—92	70	0.73	0.01	0.14	▼
Ammonia + organic nitrogen (mg/L as nitrogen)	1974—95	136	4.9	0.19	1	▼
Total nitrogen (mg/L)	1974—95	135	12	0.75	3.6	▼
Total organic nitrogen (mg/L)	1978—95	99	4.8	0.35	0.82	▼
Dissolved nitrite + nitrate (mg/L as nitrogen)	1979—95	82	5	0.25	2.4	▼
Total phosphorus (mg/L)	1974—95	138	0.76	0.01	0.175	▼

during 1996-98 at the Clinton River at Sterling Heights (USGS station 04161820) and at a site on the Black River near Jeddo (USGS station 04159492) and again in 2005-06 at the Clinton River at Sterling Heights (fig. 4). Intense sampling emphasizing organic compounds, pesticides, and mercury—as well as major ions, nutrients, biota, and chemistry of bed sediments—took place 18–32 times per year. Data from the 1996–98 study are described in detail in a USGS Circular 1203 (Myers and others, 2000); data for the 2005–06 study are currently being analyzed.

Although the 1996–98 NAWQA study showed that pesticide and fertilizer applications to crops in the Lake Erie-Lake St. Clair Basin were among the highest in the Nation, concentrations of atrazine and phosphorus (known to cause algae growth resulting in reduction of dissolved oxygen) in samples from the Clinton River at Sterling Heights were the lowest of the 10 rivers sampled (Meyers and others, 2000). The NAWQA study did note that rainfall and runoff affected the concentrations of atrazine in the wet years of 1996–97, compared to 1998, which was relatively drier. The highest concentrations of the most heavily used herbicides—metalochlor, atrazine, cyanizine, and acetochlor—were detected for 4 to 6 weeks after significant rainfall and spring runoff. The NAWQA study also showed that the highest concentrations of PCBs, DDT, and chlordane were detected in fish and bed sediment from streams flowing through urban and mixed-use lands, such as the Clinton River Basin (Rheaume and others, 2000). Concentrations of total mercury and PCB were greatest in the nearshore areas of Lake St. Clair, Detroit River, and Lake Erie. The highest concentrations of DDT were found in whole fish (as opposed to filets) from the Clinton River and the Cuyahoga River at Cleveland. The study showed that stream habitat in some urban streams, including the Clinton River site at Sterling Heights, was rated as high quality; however, fish communities were less diverse than expected. Lack of fish community diversity may be an indication that contaminants detected in water and streambed sediment were affecting the Clinton River in spite of the availability of suitable habitat (Myers and others, 2000).

The 1996–98 Lake Erie-Lake St. Clair Basin NAWQA study also showed that agricultural runoff appears to be affecting fish communities in streams with abundant row-crop acreage, such as the Black River near Jeddo. As the amount of runoff containing agricultural pesticides, nutrients, and sediments into a stream increases, fish-community diversity decreases. In contrast, greater numbers of "pollution-intolerant" fish species were found in streams draining areas with lower percentages of row crops and higher percentages of forested land in their basins.

USGS Oakland County Land-Use Change Study

The USGS (Aichele, 2005b) compared low-flow water-quality data from 1966 to 1970 to data collected as part of a 2001–03 study in the Clinton River Basin. For purposes of the study, low-flow periods were defined as those with three or more consecutive days of declining streamflow and an instantaneous streamflow less than the 75^{th} percentile of annual daily streamflow. Chemical analyses of samples from the Clinton River, where wintertime spikes in specific conductance occurred, were shown to have increasing sodium and chloride concentrations associated with snowmelt, possibly a result of road salt in the runoff. Aichele (2005a) showed that specific conductance in the Clinton River had roughly doubled since the 1960s. As noted previously, in two tributary streams to the upper Clinton River, more than 90 percent of the total streamflow in August and September is derived from ground-water discharge (Aichele, 2005b). In downstream parts of the Clinton River Basin, however, effluent from municipal sewage-treatment plants probably composes a significant proportion of the flow during extended dry periods. Low-flow samples for analyses of “emerging contaminants” such as personal-care products, detergents, pharmaceuticals, flame retardants, caffeine, and hormones were collected in 2002 and 2003 at five sites in the Clinton River Basin, and many of the analytes were found—particularly at the Clinton River at Auburn Hills (USGS station 04161000) and Sterling Heights (USGS station 04161820, where 7 of 10 human-waste-stream products and 4 of 5 fire retardants were found). At the time of this report (2007), environmental effects of emerging contaminants are poorly understood in either the human-health or the ecosystem context, although investigative studies are currently underway.

The USGS also sampled the Clinton River for the presence of the bacterium *Escherichia coli (E. coli*; a bacteria found in the feces of warm-blooded creatures, including humans) and found concentrations that frequently exceeded MDEQ standards for partial-body contact (activities such as wading, canoeing, and fishing) as well as full-body contact (swimming). At the Clinton River at Sterling Heights, nine samples were collected; five exceeded full-body-contact standards and two exceeded even the less stringent partial-contact standard (Aichele, 2005b).

Lake St. Clair Regional Monitoring Project (LSCRMP)

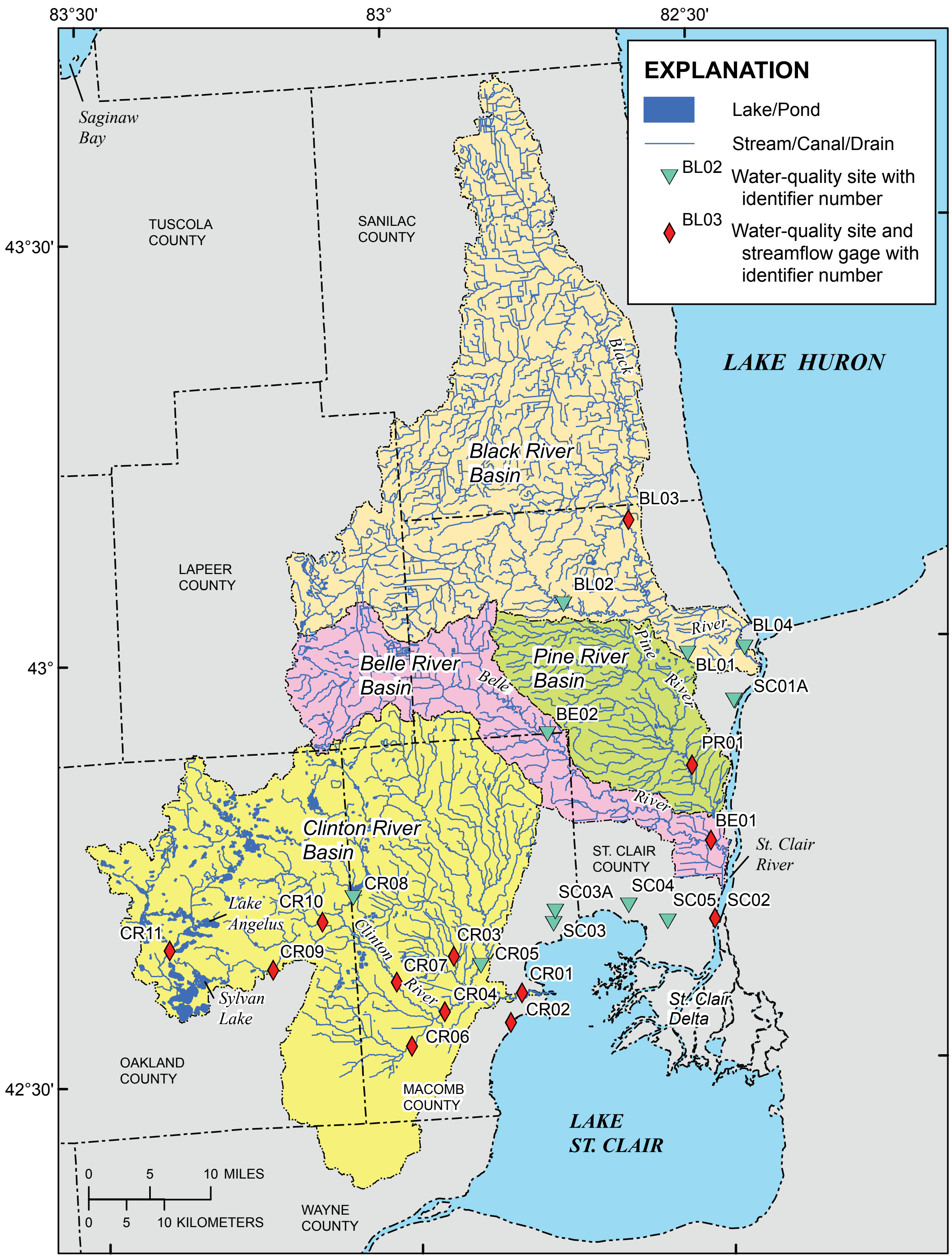
The LSCRMP consisted of a two-year water-quality assessment (2004–05) of the United States side of the St. Clair River/Lake St. Clair Basin. This project was a comprehensive assessment of the hydrological, biological, chemical, and physical state of the surface water of the study area. The study included streamflow and water-quality monitoring, collection of discrete (grab) and automatic water-quality samples, and analysis of previously collected water-quality and bed-sediment data in the basin.

During the LSCRMP, the USGS and its project partners operated 13 continuous streamflow-gaging and water-quality monitoring stations. Environmental Consulting & Technology Incorporated (ECT) collected and analyzed water samples during 19 low-flow periods at 24 stream locations and 14 storm-runoff events at the 13 continuous-monitoring stations in the St. Clair River/Lake St. Clair Basin (fig. 5; table 2) (DeMaria and others, 2006).

For the LSCRMP wet- and dry-weather sampling effort (2004–05), ECT found that sites located at the Clinton River at Auburn Hills (USGS station 04161000), Clinton River at Clinton Township (USGS station 04164000), Red Run at Warren (USGS station 04163030), and Middle Branch Clinton River near Waldenburg (USGS station 04164980) had the most degraded water quality (increased concentrations of *E. coli,* aluminum, total phosphorus, total suspended solids (TSS), and biochemical and chemical oxygen demand (BOD and COD) during storm-runoff events of any of the sites sampled (DeMaria and others, 2006). ECT attributed the increased concentrations to storm runoff carrying constituents from impervious areas, eroding upland soils, and re-suspended sediment from detention ponds and streams (DeMaria and others, 2006). These sites also had relatively poor water quality during low-flow periods as well. The Salt River in Chesterfield Township and Beaubian Creek in Cottrellville Township were found to have the poorest water quality during low-flow periods of all 24 LSCRMP sites. The Clinton River at the mouth (USGS station 04165559), Red Run at Warren, and Clinton River at Clinton Township were the sites ranked third through fifth most degraded during low-flow periods (DeMaria and others, 2006).

At most other LSCRMP sampling sites in both urban and rural settings, *E. coli*, aluminum, total phosphorus, total suspended solids (TSS), and biochemical and chemical oxygen demand (BOD and COD) concentrations also increased significantly during storm-runoff events. The Clinton, Black, Belle, and Pine Rivers did not meet full-body contact standards because of *E. coli* contamination during wet-weather conditions. At most LSCRMP Clinton River sampling sites in urban areas, chloride and some of the nutrients were found at highest concentrations during storm-runoff events, whereas at most LSCRMP sites in rural areas, dissolved oxygen, nitrate, and chloride generally decreased during storm-runoff events, indicating that dilution was reducing concentrations of these constituents. During storm-runoff events, phosphorus concentrations were generally double the concentrations measured during dry-weather concentrations, and nitrate concentrations and dissolved oxygen generally decreased (DeMaria and others, 2006).

For the LSCRMP water-quality monitoring effort (2004–05), the USGS measured water temperature, dissolved oxygen, specific conductance, and pH at 15-minute intervals at all 13 continuous-monitoring stations. Dissolved-oxygen concentrations measured at the Red Run at Warren, the Clinton River Bypass Channel (USGS station 04165557), and the Clinton River at the mouth were very low during summer low-flow periods. At the Clinton River at the mouth site, dissolved-oxygen concentrations were near 4 mg/L frequently during summer 2005, dipping to 2.8 mg/L on June 14, 2005. Low concentrations of dissolved oxygen at the Clinton River sites are probably related to low velocities in the main channel



Base from U.S. Geological Survey Digital Line Graphics, 1:2,000,000, 1998

Figure 5. Streamflow and water-quality data-collection sites of the Lake St. Clair Regional Monitoring Project, Michigan.

Table 2. Site number, name, and location of Lake St. Clair Regional Monitoring Project water-quality sites in the St. Clair River/Lake St. Clair Basin, Michigan.

[ECT, Environmental Consulting & Technology, Inc.; USGS, U.S. Geological Survey; —, not applicable; map numbers shown on figure 5]

ECT water-quality site and map number	USGS streamflow and monitoring site number	Site name	Latitude	Longitude
BL01	—	Black River near Port Huron	42.9900	-82.5378
BL02	—	Mill Creek near Avoca	43.0544	-82.7347
BL03	04159492	Black River near Jeddo	43.1525	-82.6242
BL04		Black River at Port Huron	42.9944	-82.4450
BE01	04160625	Belle River near Marine City	42.7683	-82.5122
BE02	—	Belle River at Memphis	42.9008	-82.7692
SC01A	—	Bunce Creek (A) near South Park	42.9322	-82.4658
SC01	—	Bunce Creek near South Park	42.9314	-82.4639
SC02	04160635	St. Clair River near Roberts Landing	42.4032	-82.3039
SC03A	—	Salt Creek at 24 Mile Road near New Baltimore	42.6903	-82.7673
SC03	—	Salt Creek at 23 Mile Road near New Baltimore	42.6758	-82.7708
SC04	—	Swan Creek at Shortcut Road near Fairhaven	42.6939	-82.6486
SC05	—	Beaubien Creek near Starville	42.6733	-82.5875
PR01	04160398	Pine River near Marysville	42.8586	-82.5381
CR01	04165559	Clinton River near Mt. Clemens	42.5964	-82.8261
CR02	04165557	Clinton River Bypass at Mouth at Mt. Clemens	42.5614	-82.8453
CR03	04164980	Middle Branch Clinton River near Waldenburg	42.6428	-82.9333
CR04	04164000	Clinton River near Fraser	42.5772	-82.9514
CR05	—	North Branch Clinton River near Mt. Clemens	42.6292	-82.8903
CR06	04163030	Red Run at Warren	42.5378	-83.0058
CR07	04161820	Clinton River at Sterling Heights	42.6144	-83.0267
CR08	—	Stony Creek near Washington	42.7153	-83.0919
CR09	04161000	Clinton River at Auburn Hills	42.6333	-83.2244
CR10	04161540	Paint Creek at Rochester	42.6883	-83.1431
CR11	04160900	Clinton River near Drayton Plains	42.6603	-83.3903

and possibly almost no velocity in the bypass channel, which would be typical when the inflatable weir in Mt. Clemens is deployed across the channel. Studies have shown that a combination of low concentrations of dissolved oxygen and high water temperatures are extremely stressful to fish. Erichsen Jones (1964) reports that concentrations of dissolved oxygen of 3.0 to 4.9 mg/L will support some tolerant fish species for varying periods; however, concentrations of 5 mg/L and greater will supply ample and favorable conditions for prolonged fish life.

Most water-quality monitoring at LSCRMP sites was discontinued during the winter by project design; however,

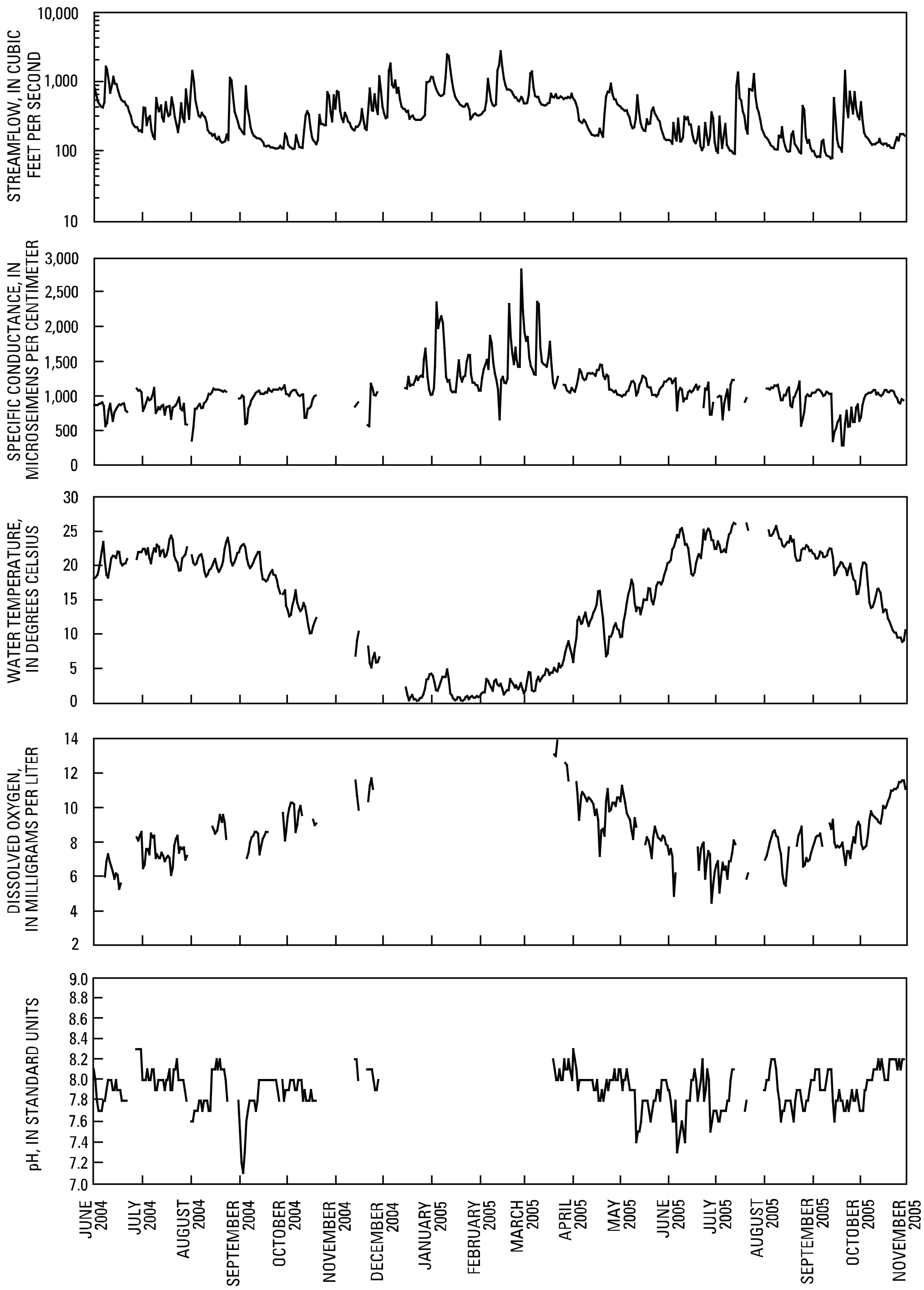


Figure 6. Continuous streamflow, specific conductance, and water temperature and seasonal dissolved oxygen and pH for the Clinton River near Fraser, Michigan, 2004–05.

water temperature and specific conductance were measured year round by the USGS at Red Run at Warren and the Clinton River in Clinton Township during 2004–05. Continuous streamflow, specific conductance, and water temperature, and seasonal dissolved oxygen and pH for the Clinton River in Clinton Township during the LSCRMP (2004–05) are shown in figure 6. The figure and similar data for Red Run shows that specific conductance doubles or triples during the winter, indicating that significant water-quality variation takes place during the winter period when water-quality monitors at the other 11 USGS sites were not in operation. The high specific conductance during the winter may be the result of runoff of salt applied to roads and parking lots. Although monthly mean streamflows for November 2004 and March 2005 were about the same as the long-term means (1947–2005), monthly mean streamflow during December 2004 and January and February 2005 were 150–200 percent of the long-term means. Above-normal precipitation and attendant runoff may have resulted in higher than typical specific conductance during winter 2004–05.

Data from the LSCRMP (2004–05) streamflow-gaging and water-quality monitoring stations, together with extensive dry- and wet weather sampling—including *E. coli*, total organic carbon, chemical oxygen demand, biochemical oxygen demand, total suspended and dissolved solids, hardness, orthophosphate, total phosphorus, ammonia-N, nitrate-N, total Kjeldahl nitrogen, chloride, aluminum, and oil and grease—are available at the LSCRMP Website at *http://www.lakestclairdata.net/*.

How Will This Information Be Used In The Future?

Data collected previously by USGS (NASQAN, NAWQA, and the Oakland County Land-Use Change Study) are an invaluable documentation of past water-quality trends within the rapidly urbanizing St. Clair River/Lake St. Clair Basin. Data from the LSCRMP (2004–05) confirm and quantify suspected water-quality problems in surface water entering into the St. Clair River and Lake St. Clair (DeMaria and others, 2006).

Water-quality data collected for the LSCRMP can be used to focus local remediation efforts in Macomb, Oakland, and St. Clair Counties by identifying the most heavily affected parts of the basin. The data can help identify sources of water-quality degradation, including sanitary-sewer overflows, failing septic fields, and illegal discharges; the data may also document water-quality effects from storm runoff containing urban-related constituents, animal feces, and fertilizers. By analyzing data from specific sampling points within the basin, reaches of streams contributing to water-quality degradation can be identified and corrective actions undertaken. The LSCRMP data can also serve as a baseline for measuring the success of remediation efforts and determining when and where future monitoring should take place.

Summary

Much of the St. Clair River/Lake St. Clair Basin has undergone significant hydrologic change as a result of rapid urbanization over the past several decades. Several cooperative water-quality studies have been conducted in the St. Clair River/Lake St. Clair Basin over much of the same period. These studies examined the changes in water quality during high- and low-streamflow conditions, and as expected, documented long-term trends in concentrations of some chemical constituents. Although point-source industrial discharges have been largely eliminated from the basin and nitrogen, phosphorus, and sulfate concentrations are decreasing, concentrations of sodium and chloride have both increased. Storm runoff in urbanized areas is typically rapid, resulting in a flush of potential contaminants into adjacent surface-water bodies. Storm runoff also often results in combined-sewer overflows.

Streamflows during dry periods in the St. Clair River/Lake St. Clair Basin are sustained primarily by ground-water discharge, although some locations may also receive some of their sustained flow from waste-water treatment plants. Low-flow conditions often result in elevated water temperatures, depressed dissolved-oxygen concentrations, and increased concentrations of some chemical constituents. Specific conductance doubled or tripled at two sites within the St. Clair River/Lake St. Clair Basin during winter conditions at the only sites monitored year round. At least one study suggested that the lack of fish community diversity in the Clinton River Basin may be an indication that contaminants detected in water and streambed sediment are affecting the aquatic health of the river in spite of the presence of suitable habitat.

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