TECHNICAL REPORT NUMBER 17

WATER QUALITY OF LAKES AND STREAMS IN SOUTHEASTERN WISCONSIN: 1964-1975

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Cover Photo courtesy of Milwaukee County Park Commission.

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WATER QUALITY OF LAKES AND STREAMS IN SOUTHEASTERN WISCONSIN: 1964-1975

Prepared by the

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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STATEMENT OF THE EXECUTIVE DIRECTOR

Pursuant to the provisions of Section 208 of the Federal Water Pollution Control Act, the Southeastern Wisconsin Regional Planning Commission on July 1, 1975, undertook an areawide water quality management planning program for the seven-county Southeastern Wisconsin Region. The objective of that program was to identify the most cost-effective means of abating water pollution within the Region and thereby meet established water use objectives and supporting standards. The formulation of sound recommendations for the abatement of water pollution and the attainment of water use objectives requires, among other things, an assessment of existing water quality conditions and the factors affecting those conditions.

The Commission in February 1965 completed an intensive study of stream water quality conditions in the Region. The findings of that study, set forth in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, published in November 1966, provided an important benchmark of stream water quality conditions within the Region. In an effort to monitor long-term changes in stream water quality, the Commission, upon completion of the initial benchmark study, initiated a continuing water quality sampling program. Consequently, at the beginning of the areawide water quality management planning program the Commission had available an unusually complete data base for the assessment of not only existing water quality conditions within the Region but of historic trends in those conditions. These data, together with comparable data from all other available sources, were analyzed and evaluated against established water use objectives and supporting standards presented in this report, and serve to identify and assess existing surface water quality conditions within the Region and long-term trends in such conditions. The results of that analysis and evaluation are presented in this report, and serve to identify the extent of the water pollution problem within the Region for areawide water quality management planning purposes.

The data and analyses presented in this report indicate the relative importance of point and nonpoint sources of water pollution and further indicate that the attainment of the established water use objectives and supporting standards is not possible without significant efforts to control the nonpoint sources of pollution. The data and analyses presented in this report also indicate that the expression and application of water quality standards on the basis that such standards are to be met at all times except periods of extreme low-flow require reevaluation. The analyses presented herein indicate that nonpoint sources of pollution may preclude the achievement of such standards during periods of wet weather and high stream flows, just as point sources of pollution may preclude the achievement of such standards during periods of dry weather and low stream flows.

The data and analyses presented in this report were used in combination with the detailed inventory of pollution sources presented in a companion report, SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin—1975, to assess the impact of these existing sources on water quality conditions. Thus, this report, together with SEWRPC Technical Report No. 21, provides an important basis for the areawide water quality management plan presented in SEWRPC Planning Report No. 30, A Water Quality Management Plan for Southeastern Wisconsin.

In addition to providing an important basis for the preparation of an areawide water quality management plan, it is the hope of the Commission staff that this report will provide a reference of lasting value as a source of information on stream and lake water quality conditions within the Region. As such a reference, and an important part of a larger repository of environmental data, the report should be of value to public and private parties involved in resource management decisions within the Region, particularly with regard to the needs and opportunities for the improvement of surface water quality.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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ERRATA SHEET
for
SEWRPC TECHNICAL REPORT NO. 17,

WATER QUALITY OF LAKES AND STREAMS IN SOUTHEASTERN WISCONSIN: 1964-1975

CHAPTER VI

Page 97, Map 11, caption, last sentence should read: "Samples taken at sampling station DP-3 exhibited . . ."
Page 181, Map 12, all MHD, MMSD, and DNR sampling site locations and designations shown on the 1964 map should also appear on the 1975 map.
Page 185, Map 23, all MHD, MMSD, and DNR sampling site locations and designations shown on the 1968 map should also appear on the 1975 map.
Page 186, Map 24, all MHD, MMSD, and DNR sampling site locations shown on the 1968 map should also appear on the 1975 map.
Page 192, Map 25 and 26, all MHD, MMSD, and DNR sampling site locations shown on the 1964 map should also appear on the 1975 map.
Page 200, Map 28, sampling site SS-Mn-12 located on the 1964 map should appear instead on the 1975 map.
Page 218, Map 39, sampling site SS-Mn-12 located on the 1964 map should appear instead on the 1974 map. The Village of Elm Grove Sanitary District Nos. 1 and 2 Sewage Treatment Facility should appear on the 1964 map as indicated on Map 28.
Page 222, Map 30, sampling site SS-Mn-12 located on the 1964 map should appear instead on the 1974 map. All MMSD sites on the 1974 map should also appear on the 1968 map. The Village of Elm Grove Sanitary District Nos. 1 and 2 Sewage Treatment Facility should appear on the 1968 map as indicated on Map 28.
Page 240, Map 32 and 33 sampling site SS-Mn-12 located on the 1968 map should appear instead on Map 33. The Village of Elm Grove Sanitary District Nos. 1 and 2 Sewage Treatment Facility should appear on Map 32 as indicated on Map 28. Dashed grey line located on the main stem of the Menomonee River near Butler indicating fecal coliforms in excess of 2,000 MFFCC/100 ml; should be located instead on the main stem of the Little Menomonee River upstream from sampling site Mn-7 on Map 32.
Page 244, Map 31, sampling site SS-Mn-12 located on the 1968 map should appear instead on the 1974 map. The Village of Elm Grove Sanitary District Nos. 1 and 2 Sewage Treatment Facility should appear on the 1968 map as indicated on Map 28.
Page 272, Map 36, the West Bend sewage tretment plant should appear on the 1964 map as indicated on Map 35. USGS and MMSD sampling stations designations should appear on the 1965 map, as well as the 1975 map. The title "Milwaukee County Wastewater Discharges" should appear above numbered industries as shown on Map 35.
Page 310, Map 39, the City of West Bend sewage treatment plant should be located above the inlet to Barton Pond on the 1964 map instead of at the indicated 1964 location.
Page 344, Map 49 MMSD sampling sites located on the 1964 map should also be located on the 1975 map.
Page 351, Map 50, the Oakview sewage treatment plant should be located on the 1964 map, as indicated on Map 49, and the MMSD sites located on the 1964 map should also be located on the 1975 map.
Page 353, Map 51, the Oakview sewage treatment plant should be located on the 1968 map as indicated on Map 49. MMSD sampling sites located on the 1964 map should also be located on the 1975 map.
Page 354, Map 52, same changes as noted for page 353, Map 51 should be made.
Page 384, Map 59, caption, first sentence, delete ". . . while station Pk-2 on Pike Creek tributary to the Pike River exhibited an increase in the fecal coliform count . . .".
Page 472, Map 71, all sewage treatment plants as shown for 1964 on Map 70 should also be located for 1964 on Map 71 (1964). The Village of Greendale Sewage Treatment Facility should also be located on the 1964 map as indicated on Map 70. Sampling site DNR Rt-7a should also be located on the 1964 map, as shown on the 1975 map.
Page 476, Map 72, all sewage treatment plants as shown on Map 70 should also be located on the 1968 map. The Village of Greendale sewage treatment plant should be located on the 1968 map as indicated on Map 70. Sampling site DNR Rt-7a should be located on the 1968 map as indicated on Map 70.
Page 478, Map 73, same changes as noted for page 476, Map 72, should be made.
Page 493, Map 74 and Map 75, same changes as noted on Page 472, Map 71 should be made.
Page 521, Map 84, the Village of Belgium sewage treatment plant should be shown on the 1964 map as indicated on the 1975 map. Omit the unnamed industrial discharge symbol from the 1975 map.
Page 526, Map 85, the Belgium sewage treatment plant should be shown on the 1964 map as indicated on Map 84 (1975). Omit the unnamed industrial discharge from the 1974 map. Add "1974" at top of right map.
Page 528, Map 86, the Village of Belgium sewage treatment plant should be shown on the 1968 map as indicated on Map 84 (1975). Add "1979" at top of right hand map. Omit the unnamed industrial discharge from the 1974 map.
Page 530, Map 87, same changes as page 528, Map 86 should be made.
Page 534, Map 88 and Map 89, same changes as page 521, Map 84, should be made.

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Chapter I

INTRODUCTION

The land and water resources of an area are elements vital to its economic development and to its ability to provide a pleasant, habitable environment for human life. Moreover, land and water resources not only affect but are affected by regional growth and urbanization. Accordingly, any meaningful comprehensive regional planning effort must recognize the existence of a limited natural resource base to which both urban and rural development must be properly adjusted if serious environmental problems are to be avoided.

Land and water resources within the Region are limited and subject to grave misuse through improper land use development, short-sighted urban and rural land management, and improper placement and development of both public and private utilities and facilities. Such actions may lead to severe environmental problems which are very expensive to correct and to the deterioration and destruction of the resource base itself. An intelligent selection of the most desirable regional development patterns—and attendant land and water uses—from among the available alternatives must, therefore, be based in part upon a careful assessment of the effects of each development, use, or protection proposal on the underlying and sustaining natural resource base. Such assessment requires the collection of a great deal of information concerning the natural resource base and its ability to sustain proposed land and water uses, including definitive data on water resources.

The streams and lakes of the Region are among its most important resources. The uses of land and water within the Region are closely related. Urban and rural development depend upon surface water resources for the assimilation of treated sewage, for the recharge of groundwater aquifers, for recreational purposes, and in some cases for water supply. The importance of stream and lake water quality to regional development stems from the limitations that are imposed on water use by its flow in streams, and by its area and depth in lakes, and by its chemical and physical characteristics. The chemical and physical characteristics of a stream or lake are determined by the natural mineral content of the water and by the organic and inorganic pollutants introduced into the water by man from domestic, municipal, agricultural, industrial, and natural sources. These limitations decrease the number of uses to which the streams and lakes can be put, depending upon the water quality of the streams and lakes. Consequently, the economic, aesthetic, and recreational potential of the Region is closely dependent upon surface water quality; and, therefore, any meaningful assessment of alternative regional development patterns requires definitive information about the quality and quantity of the water in the major streams and lakes of the Region.

The quantity of water present in streams and lakes is no less important than the quality of that water in evaluating the multipurpose use potential of the streams and lakes of the adjacent land. In southeastern Wisconsin streams are subject to significant changes in seasonal flows. Large differences in flow also occur between the upper and lower reaches of the streams. Water uses that separately or collectively require the withdrawal of large quantities of stream water can induce low-flow conditions. Low-flow conditions, either natural or induced, can adversely affect water uses, such as waste assimilation and recreation. Frequent high-flow conditions also may affect recreational use and shoreland development. Similarly, lakes within the Region are subject to fluctuations in level and area, although the changes which occur in the quantity of lake water are usually less apparent than the changes in stream flow; consequently, the quantitative, as well as the qualitative, aspects of stream flow and lake levels and areas within the Region must be considered in the preparation of regional plans and in the consideration of proposed multipurpose uses of the streams and lakes and adjacent shorelands.

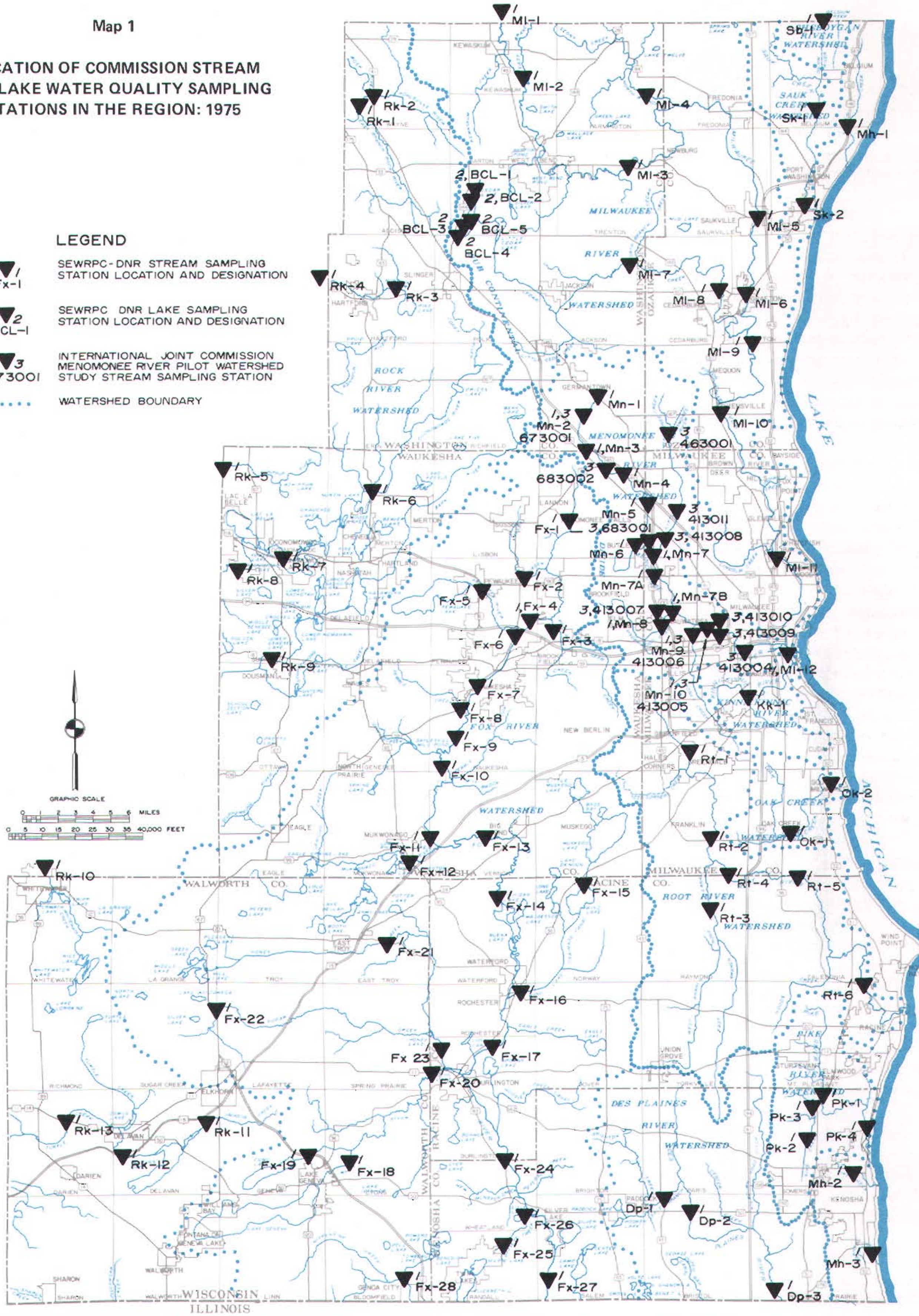
WATER QUALITY AND QUANTITY MONITORING IN THE REGION—AN OVERVIEW

When the Commission began its regional planning program in 1960, little definitive data on surface water quality and quantity in the Region were available, particularly on a uniform, areawide basis. Accordingly, and in recognition of the importance of such data to the preparation of a regional development plan, the Commission, in cooperation with concerned local, state, and federal agencies, undertook certain work efforts designed to develop a regional data base for surface water quality and water quantity.

During a 14-month period extending from January 1964 through February 1965, the Commission conducted an extensive stream water quality sampling program during which nearly 4,000 water samples were collected at 87 sampling stations established on 43 streams in the Region (see Map 1). The samples were analyzed for 32 chemical, physical, biochemical, and bacteriological water quality parameters, or indicators, for the purpose of assessing the then-existing condition of stream water quality in relation to pollution sources, land use, and population distribution and concentration. Data developed during this intensive stream water quality study were used to forecast probable future stream water quality conditions. Regional stream water data of 1965, interpretations of that data, and forecasts of future stream water quality were published in 1966 in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin.

Map 1

LOCATION OF COMMISSION STREAM AND LAKE WATER QUALITY SAMPLING STATIONS IN THE REGION: 1975



Continuing water quality information is needed in order to assess long-term trends in stream and lake water quality and to gage the effectiveness of watershed and sanitary sewerage system plan implementation efforts in improving and restoring high levels of water quality to the surface waters of the Region. For this Region, the Commission, in cooperation with the Wisconsin Department of Natural Resources, maintains a continuing stream and lake water quality monitoring program designed to build upon the bench mark stream water quality data base established by the Commission in 1964.

Source: SEWRPC.

This initial benchmark study of stream water quality in the Region found that the original natural high quality of the streams of the Region had been markedly deteriorated by the activities of man, as evidenced by such key indicators of pollution as the levels of chlorides, dissolved solids, dissolved oxygen, and total coliform bacteria. This deterioration was attributed to the historic failure to properly adjust rural and urban development in the Region to the capability of streams and watercourses to assimilate the pollution loadings attendant to such development. Evidence of occasional or persistent severe stream pollution was found in all of the 12 watersheds contained wholly or partly in the seven-county planning Region. This benchmark study also indicated that not only had stream water quality markedly deteriorated as a result of man's activities, but the deteriorated stream water quality had, in turn, impaired or prohibited certain aesthetic and recreational uses sought by the expanding urban population of the Region. Of the 43 major streams in the Region, 21 were found to be unsuitable for the preservation and enhancement of aquatic life, while 33 were found to be unsuitable for any recreational use in all or portions of the streams.

In 1968 the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources by which that Department and the Commission undertook a continuing stream water quality monitoring program within the Region. The objective of this continuing program was to build upon the benchmark water quality data initially collected under the regional stream water quality study by providing on a continuous basis the water quality information necessary to permit assessment of the long-term trends in stream water quality. This program has been conducted continuously since the signing of the cooperative agreement in 1968 and in 1971 was expanded to include the collection on a very limited basis of some lake water quality data.

As an integral part of a series of comprehensive watershed studies, the Commission also has undertaken intensive short-term stream and lake water quality sampling efforts. Such efforts have been conducted as part of watershed studies for the Fox River,[1] Milwaukee River,[2] and Menomonee River[3] watersheds. The water quality and quantity monitoring efforts under the Commission Menomonee River watershed study were expanded in scope and depth by an intensive short-term research effort under the sponsorship of the International Joint Commission in cooperation with the Commission and other federal and state agencies. Many lakes in each of these watersheds were found to be generally eutrophic as indicated by high phosphorus concentrations, low dissolved oxygen contents, and excessive growth of algae and aquatic weeds. The collection, collation, and analyses of stream water quality data in these watersheds served to supplement the stream water quality data previously collected and analyzed and documented in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin.

With respect to water quantity monitoring, it is important to note that when the Commission began its regional planning program, only two continuously recording stream flow gaging stations were operating on the entire stream network of the Region. One of these was located in Estabrook Park on the Milwaukee River in the City of Milwaukee, the other at Wilmot on the Fox River in Kenosha County. Since 1960 the Commission has been instrumental in establishing through cooperative, voluntary intergovernmental action 13 additional continuous recording stream flow gaging stations in an effort to provide a sound long-term record of stream flow. These additional gages have been established as part of cooperative programs arranged by the Commission among the U. S. Geological Survey; Department of Army Corps of Engineers; Departments of Natural Resources and Transportation; the Metropolitan Sewerage Commission of the County of Milwaukee; the Fond du Lac, Ozaukee, Racine, Washington, and Waukesha County Boards of Supervisors; and the University of Wisconsin-Parkside. Of the 13 new continuously recording stream flow gaging stations, five are located in the Milwaukee River watershed, three in the Root River watershed, three in the Fox River watershed, one in the Oak Creek watershed, and one in the Pike River watershed (see Map 2). All 15 continuous recording stream flow gaging stations in the Region are maintained under contract by the Commission and the U. S. Geological Survey, which publishes the data obtained. The U. S. Geological Survey also maintains 27 additional "partial record" stream flow gaging stations throughout the Region, including one combination wire-weight and crest gage, six crest stage gages, 13 low-flow gages, and seven combination crest stage and low-flow gages, all in cooperation with the Wisconsin Departments of Natural Resources and Transportation (see Map 2).

Two current research studies in which the Regional Planning Commission is cooperating have resulted in the installation of 21 additional continuously recording stream flow gaging stations on selected streams in the Region. Under the International Joint Commission—Menomonee River Pilot Watershed Study already mentioned, 11 such gaging stations have been installed on streams in the Menomonee River watershed. Under the Washington County sediment control research project—a joint effect of the U. S. Environmental Protection Agency and state and local governmental agencies, including the Commission—10 such gaging stations have been installed on selected intermittent streams in the Menomonee and Milwaukee River watersheds. The opera-

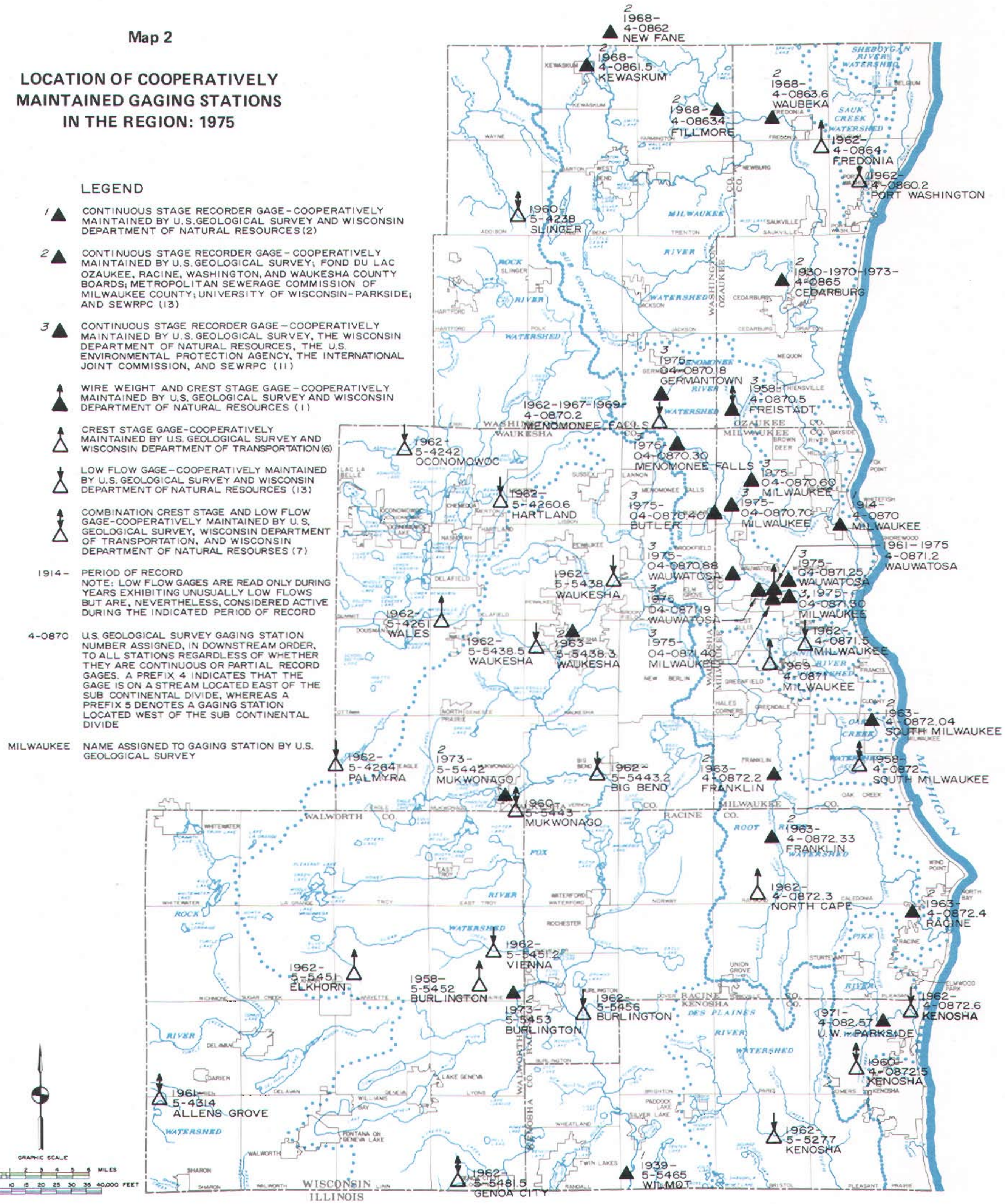
[1] *See SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume One, Inventory Findings and Forecasts.*

[2] *See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume One, Inventory Findings and Forecasts.*

[3] *See SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, Volume One, Inventory Findings and Forecasts.*

Map 2

LOCATION OF COOPERATIVELY MAINTAINED GAGING STATIONS IN THE REGION: 1975



Continuing information on streamflow is essential to both sound water resources and sound land use planning and management within the Region. A total of 42 stream gaging stations are maintained throughout the Region by the U. S. Geological Survey; of these, 15 are continuous flow recording gages. The maintenance of these stations is cooperatively financed by the U. S. Geological Survey; the Metropolitan Sewerage Commission of the County of Milwaukee; the Fond du Lac, Ozaukee, Racine, Washington, and Waukesha County Boards of Supervisors; the Wisconsin Departments of Natural Resources and Transportation; the University of Wisconsin-Parkside; and the Commission. The data collected at each of the 42 gaging stations are analyzed and published annually by the U. S. Geological Survey. In addition, an intensive, short-term stream gaging effort has been established in the Menomonee River watershed under the sponsorship of the International Joint Commission and in cooperation with the Commission and other agencies.

Source: SEWRPC.

tion of these supplementary stream flow gaging stations is complemented by the conduct of stream water quality monitoring efforts at the station locations, thus providing a comprehensive water quality-quantity data base for research and planning purposes.

PURPOSE OF THIS REPORT

In general, the purpose of this report is to present the results of analyses of stream and lake water quality and water quantity data collected to date throughout the Region and thereby to document the existing surface water quality conditions within the Region and to the extent possible to identify long-term trends in water quality. This report is intended to update the data and analyses presented in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin. While the initial 1964-1965 stream water quality data and analyses have been resummarized in this Volume, SEWRPC Technical Report No. 4 will remain a useful document providing detailed historical data on stream water quality and flow conditions in the Region.

Where possible, the water quality analyses in the report will be expanded to include the major inland lakes in the Region. Major inland lakes have been defined by the Commission as lakes having a surface area of 50 acres or greater. Commission inventories indicate that there is a total of 331 inland lakes and ponds within the Region, of which 100 are classified as major. Available water quality and related lake depth and area data for these major lakes also are presented in this technical report under the title of watershed in which the lakes are located. An attempt was made to collate and present in this report all known, pertinent data on the physical, chemical, and biological condition of the surface waters of the Region, together with related stream flow and lake level and area data using not only the Commission data files but all other accessible and known data files. A discussion of the water quality conditions and levels of Lake Michigan was considered beyond the scope of this report.

Specifically, the purposes of this report and of the study effort on which the report is based are:

1. To collate and present in summary form the results of all pertinent water quality and quantity data collection efforts of the Commission to date in the Region.

2. To identify and assess the present condition of stream and lake water quality in the Region in relation to the major types and sources of pollution.

3. To identify and assess long-term trends in stream water quality conditions in the Region in relation to the major types and sources of pollution.

4. To evaluate the existing levels of stream and lake water quality within the Region against established water use objectives and supporting water quality standards to determine the extent to which those objectives and standards are being met, and to assist in identifying the major sources of pollution which may be preventing the attainment of the objectives and standards.

5. To identify appropriate changes in the continuing stream and lake water quality sampling and stream flow gaging programs within the Region—including any needed revision to and expansion of the number of water quality indicators included in the program, modifications in the frequency of sampling, adjustment in the location of sampling stations, and the provision of more extensive stream flow and lake level measurements.

SCHEME OF PRESENTATION

Following this introductory chapter, Chapter II describes the various sources of water quality and quantity data available for the Region, identifying sampling locations, methods, and frequencies. The basic concepts involved in water quality assessment are discussed and the various major sources of water pollution identified in Chapter III, along with the potential effects of such sources on water quality, and on land and water use. Chapter IV presents the water use objectives and supporting water quality standards which have been adopted within the Region. The various water quality parameters are defined and their significance to water uses is discussed in Chapter V. Chapter VI presents the findings of the long-term stream and lake water quality and stream flow and lake level and area monitoring program in the Region, including for each major watershed a discussion of the pertinent hydrologic and hydraulic characteristics of the surface water system; existing water quality conditions and the trends in those conditions over time; existing pollution loadings from private and publicly owned sewage treatment plants, industrial point sources, urban storm water runoff, intensive agricultural activities, and concentrated areas of septic tank use; the trends in such loadings over time; and a comparison of existing water quality conditions against the established water use objectives and supporting water quality standards. Chapter VII describes the method for the development of a water quality index for use within the Region, and in Chapter VIII a discussion is presented on useful changes in the water quality monitoring program. Finally, Chapter IX concludes the report with a summary description of the water quality conditions of streams and lakes in the Region, of the long-term trends in those conditions, and of the major factors determining those conditions and trends.

TOXIC AND HAZARDOUS SUBSTANCES

This report is intended primarily to present the results of the water quality monitoring effort conducted within the Region by the Commission since 1964. The Technical

Advisory Committee on Areawide Wastewater Treatment and Water Quality Management Planning suggested inclusion of available data—from other sources—on the levels of toxic and hazardous substances in the streams and lakes of the Region. Accordingly, the available data were assembled by the Commission. Because these data are not available with the same areawide consistency, nor over the same time span as the Commission monitoring data, they are presented in summary form in Appendix A to this report rather than in the body of the report. The toxic and hazardous substance pollutants include cadmium, chromium, copper, lead, mercury, nickel, zinc, polychlorinated biphenyls (PCB's), dichloro-diphenyl-trichloro-ethane (DDT), dichloro-diphenyl-dichloro-ethylene (DDE), dichloro-diphenyl-dichloro-ethane (DDD), aldrin, heptachlor, heptachlor epoxide, lindane, dieldrin, methoxychlor, phthalate, atrazine, and simazine. In addition to the substances noted above, for which limited amounts of water quality are available, the list of toxic and hazardous substances which find their way into the environment is expanding rapidly, and includes arsenic, asbestos, barium, beryllium, boron, cyanide, manganese, selenium, and silver. Other pesticides include chlordane, demeton, endosulfin, guthion, mirex, and toxophene. As chemical compounds, these and other substances have been included on a list of 164 "hazardous substances"—potentially subject to regulation—by the U. S. Environmental Protection Agency Office of Solid Waste Management Programs. (See Disposal of Hazardous Wastes; Report to Congress. Environmental Protection Agency Publication SW-115 Washington, D. C., U. S. Government Printing Office-1974. 110 pp.)

It is important to note that the list of substances which are considered toxic or hazardous to the health of humans or other animals grows almost daily as new research findings become available. Because no state or federal water quality standards have been adopted for these substances and because controversy exists over the specific levels at which substances are dangerous, the literature does not include any widely accepted recommendations concerning acceptable levels in streams and lakes for each of the relevant substances. The most comprehensive set of recommendations for acceptable levels of these pollutants is presented in Quality Criteria for Water, a document prepared by the U. S. Environmental Protection Agency under a Congressional mandate contained in Section 304(a) of the Federal Water Pollution Control Act Amendments of 1972. This report has been used wherever possible to identify in Appendix A the recommended levels of the substances concerned.

Chapter II

SOURCES OF WATER QUALITY AND QUANTITY DATA

INTRODUCTION

Numeric data describing the quantitative and qualitative characteristics of the waters in the lakes and streams of the Southeastern Wisconsin Region are collected in sampling programs conducted by a number of governmental, educational, and special interest groups. More specifically, water quantity and quality data for regional lakes and streams have been developed through the following sampling programs described in more detail later in this chapter:

1. Commission benchmark stream sampling program.
2. Commission continuing stream and lake monitoring program.
3. Commission streamflow gaging program.
4. Commission Root River watershed stream sampling program.
5. Commission Fox River watershed stream and lake sampling program.
6. Commission Milwaukee River watershed stream and lake sampling program.
7. Commission Menomonee River watershed synoptic water quality surveys.
8. Wisconsin Department of Natural Resources monthly stream sampling program.
9. Wisconsin Department of Natural Resources drainage basin studies.
10. Milwaukee Metropolitan Sewerage District stream water quality sampling program.
11. City of Racine, Department of Health, water quality survey program.
12. Geneva Lake Watershed Environmental Agency stream and lake sampling program.
13. U. S. Environmental Protection Agency national stream and lake eutrophication survey.
14. U. S. Geological Survey streamflow monitoring program.
15. U. S. Geological Survey stream and lake water quality sampling program.
16. Wisconsin Department of Natural Resources quarterly lake monitoring program.
17. City of Milwaukee Health Department study of the water quality at the flushing tunnel at the Kinnickinnic River.
18. City of Milwaukee Health Department water quality sampling program.
19. Lake association limnological surveys and inland lake and stream investigations.

Other studies presently underway—notably the Wisconsin Department of Natural Resources Inland Lake Rehabilitation Program, the Washington County Sediment Control Study, and the International Joint Commission Menomonee River Pilot Watershed Study—were not sufficiently advanced to provide data for consideration in this report.

In addition to the above listed programs, water quality data have been collected by various colleges, universities, and technical institutes within the Region. Water quality studies conducted by the faculty and students of Carroll College, Marquette University, the Milwaukee Area Technical College, and the University of Wisconsin at Madison, Milwaukee, and Whitewater were reviewed by the Commission for consideration in this report. In this review it was noted that the academic studies used a wide variety of sampling techniques, laboratory techniques, and equipment, some quite different from those used in the 19 federal, state, regional and local agency sampling programs cited above. Therefore, it was determined that data from the academic studies would be used only as a secondary source of information to reinforce the water quality data used and the evaluations made in this report.

Because the 19 data collection programs considered for use in this report differed in purpose, scope, timing, sampling parameters, sampling frequencies, and periods of record, the sampling results had to be carefully assembled and evaluated to permit conclusions logically consistent with all available data and reasonably representative of the water quality condition of the water resource being investigated.

U. S. Geological Survey streamflow data and Commission stream-stage measurements were used to correlate water quality sampling results to stream flow on a year to year basis, and to help evaluate any apparent changes in stream water quality over time.

WATER QUALITY AND QUANTITY SAMPLING PROGRAMS

Background and Scope of Water Quality Studies

The continuing surface water quality monitoring program of the Commission was designed to build upon the benchmark stream water quality data base established by the Commission in its initial stream water quality study, the findings of which were published in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, in November 1966. Subsequent to the completion of this initial benchmark water quality monitoring effort, the Commission continued to monitor water quality conditions within the Region in the fall of 1966 and in the spring and fall of 1967. The continuing stream water quality monitoring program was made a cooperative effort with the Wisconsin Department of Natural Resources in 1968. Under this effort water quality samples were collected twice yearly at all 87 sampling stations established in the initial benchmark survey. In 1968 and 1969 samples were collected twice annually, once during a period of high stream flow and once during a period of low stream flow. The samples were analyzed for dissolved oxygen, temperature, fecal coliform, nitrate nitrogen, nitrite nitrogen, soluble orthophosphate, pH, chloride and specific conductance.

To provide additional information on the diurnal fluctuations of stream water quality in the Region, the monitoring program was revised in 1970 to provide for the collection of six water samples over a 24-hour period, once yearly during the period of low stream flow at each sampling station. Each sample was to be analyzed for the following five parameters: dissolved oxygen, temperature, pH, chloride, and specific conductance. In addition, once during the 24-hour period, the following parameters were analyzed: fecal coliform, nitrate nitrogen, nitrite nitrogen, and soluble orthophosphate.

To obtain information on additional water quality indicators, the Commission and the Wisconsin Department of Natural Resources agreed to a further modification of the program beginning with the 1972 survey. The overall continuity of the sampling program was maintained by continuing to monitor those parameters included in previous surveys with the following changes: a decrease from six to four per 24 hours in the frequency of dissolved oxygen, temperature, and specific conductance measurements; a decrease from six to two per 24 hours in the frequency of chloride determinations; an increase from one to two per day in the frequency of fecal coliform, nitrate nitrogen, nitrite nitrogen, and soluble orthophosphate measurements; and the addition of two determinations per day of organic nitrogen, ammonia nitrogen, and total phosphorus. The addition of these latter three parameters was prompted by a perceived need for more information on nutrients, and increased interest in both the oxygen demand exerted by ammonia nitrogen and the toxic effect on fish and other aquatic life of ammonia nitrogen.

Thus, the present continuing stream water quality monitoring program of the Commission, as it has evolved through revisions up to 1972, provides for four measurements over a 24-hour period once yearly. These measurements are made during the period of low flow at each of the 87 stations for each of the following three parameters: dissolved oxygen, temperature, and specific conductance. Two determinations also are made at each station over the same 24-hour period for each of the following nine parameters: pH, chloride, fecal coliform, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, organic nitrogen, soluble orthophosphate, and total phosphorus. Table 1 presents a summary by station of the sampling program from 1964 through the present.

In 1971, the Commission and the Wisconsin Department of Natural Resources agreed to expand the stream water quality sampling program on a pilot basis to include lake water quality sampling. Big Cedar Lake, located in Washington County in the Milwaukee River watershed, was selected for a pilot sampling effort because it was considered representative of the larger lakes in the Region, has a tributary drainage area currently undergoing urbanization, and is experiencing increasing recreational use. Under this pilot program, water samples were taken four times each year—in late winter, early spring, mid-summer, and late fall—and a total of 19 lake water quality parameters evaluated (see Table 1, Big Cedar Lake sites, BCL 1-5).

In 1964, prior to beginning actual field work on the benchmark stream water quality survey, an integrated network of potential sampling station sites was selected by the Commission staff. In the selection, consideration was given to attaining a good geographic dispersal of sampling stations on major streams and tributaries, in keeping with the regional approach to the water quality study. Consideration also was given to achieving a sufficient density of stations along reaches of streams which were believed to be heavily polluted, to permit isolation of major point sources of pollution and assessment of the effect of these sources on water quality conditions. The potential sites were all field inspected to determine the suitability as both stream sampling and streamflow measurement stations. In the interests of efficiency, the sampling station sites had to be readily accessible year around, so all sites were located at points where the streams concerned were crossed by public streets or highways. Favorable conditions for the measurement of stream flow were an important requisite of the potential stream sampling station sites. Therefore, it was of prime importance to avoid selecting a site at which relatively high stream turbulence could be anticipated that would decrease the accuracy of flow measurement.

Once a potential sampling site was field inspected and approved, the sampling site was given an identifying designation and was referred to as a sampling station. The designations consist of a two-letter prefix, identifying the watershed in which the sampling station is located, and a number, identifying the particular sampling station within the watershed. The numbering sequence is arranged in downstream order in accordance with standard usage. The numbers were also marked on the bridges at each sampling station site in an inconspicuous manner and according to a convention which is described on page 5 of Chapter II in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin. The sampling stations were designated not only by watershed and number but also by the stream and the traversing street or highway and were located according to the U. S. Public Land Survey System. Stream flow measurements were made by the Commission as a part of the initial benchmark stream water quality survey by using a Price current meter where streams were too deep for wading or were more than 75 feet wide, and by using a Pygmy current meter where streams were too shallow for accurate use of a Price current meter. The stream flow measurement techniques as well as the stream water sampling techniques used are fully described in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin. Table 2 lists the designations and locations of the established Commission stream sampling stations. These stations are shown on Map 1, inclusive of the five Big Cedar Lake sampling sites.

Water Quantity Monitoring and Stream Gaging Program Commission Streamflow and Stream Stage Measurement Monitoring Stations: Water quantity data for streams are important to water quality analyses for two reasons. First, the known concentrations of water pollutants in a stream cannot be converted to known loading rates, unless quantity data are available. Secondly, the relative rates of streamflow are very useful indicators of the active mechanism—such as storm water runoff or groundwater contribution or the scouring of bottom sediments—which are affecting the water quality conditions. For these reasons, the Commission has always considered the acquisition of accurate and time-correlated streamflow data to be critical to the conduct of a sound and useful water quality sampling program. As shown on Map 2, a variety of stream stage and discharge monitoring stations has been constructed and is in operation within the Region.

Streamflow is not measured directly, but is derived from measurements of "stage," that is, of water surface elevation at monitoring stations along a stream. To convert a measured stage to its corresponding discharge, a stage-discharge relationship must be developed for each monitoring site. Such relationships are normally constructed by making field measurements of discharge for a wide range of river stages. For each such stage, discharge is determined by partitioning the total flow cross section into subareas, using a meter to measure the flow velocity in each subarea, multiplying velocity times area for each subarea to obtain subarea discharge, and integrating overall subareas to estimate the total discharge.

Stage is determined by various types of indicators with the readings taken manually at intervals by an observer or recorded by automatic instruments. Stage indicators are classified according to the method by which the stage is measured and by the manner in which it is read. The principal types are staff gages, crest stage indicators, wire weight gages, and continuous recording gages. All have been, or are, used in the Southeastern Wisconsin Region. Only data from staff gages and continuous recording gages were used for this study, however.

A staff gage is used to measure the water level by direct observation. It consists simply of a graduated scale established in a stream—usually vertically—on a bridge pier or abutment, a wall or other structure, or stable support. It is read by observing the elevation of the water surface in contact with the scale.

A wire weight gage consists of a steel wire or cable with a weight at one end wound on a drum and with the entire assembly enclosed within a protective housing that is mounted above the stream on a bridge or other structure. To measure river stage, a hand crank is used to unwind the drum so as to lower the weight to the water surface. The stage is determined by means of a combination of a mechanical counter driven by the revolving drum and a graduated scale on the periphery of the drum. For the kind of information obtained, the wire weight gage is similar to the staff gage in that it does not automatically record either the peak stage of a flood event or the time at which that stage occurred.

A continuous recording gage is considered an automated device that permits the sensing and recording of river stage on a continuous basis or by very short time increments such as five or 15 minutes. Continuous recording stations consist of three major elements: a stage sensing device, a stage recording device, and a protective structure to house the equipment. The stage sensing device may be a float set in a stilling well and connected to the stage recording device by a tape or wire, or the stage may be sensed by the pressure required to maintain a flow of gas through a small orifice submerged in the stream. The signal from the stage sensing device is relayed to the stage recording device, which may consist of a strip chart recorder on which a pen plots a continuous record of stage or a punch tape recorder on which stage is recorded at predetermined intervals in the form of holes punched in a tape. The punched tape recording device permits direct translation of the digited data for computer processing of the stage data. The continuous recording gage, which is the most costly of the three basic types of stage monitoring installations, provides superior data in that both stage and time are continuously recorded for the full spectrum of flow conditions.

Through a cooperative effort with various governmental agencies, as noted in Chapter I, the Commission has increased the number of continuous recorder stream flow gages in the Region from two to 15 since 1960. Of the 13 new continuous flow recorder stream gages, five are located in the Milwaukee River watershed, three in the Root River watershed, three in the Fox River watershed, one in the Oak Creek watershed, and one in the Pike Creek watershed.

The U. S. Geological Survey also maintains 27 additional gaging stations throughout the Region, including one combination wire weight and crest gage, six crest stage gages,

Table 1

NUMBER OF STREAM SAMPLING AND STREAMFLOW MEASUREMENTS UNDER ANNUAL SEWRPC MONITORING PROGRAM

Stream Sampling Station	Sampled by SEWRPC								Funded by SEWRPC—Sampled by DNR															
	1964		1965		1966		1967		1968		1969		1970		1971		1972		1973		1974		1975	
	Flow	Chem.[a,b,e]	Flow	Chem.[a,b,e]	Flow	Chem.[a,b]	Flow	Chem.[a,b]	Flow	Chem.[a,b,c]	Flow	Chem.[a,b,c]	Flow	Chem.[a,c,h]	Flow	Chem.[a,c,h]	Flow	Chem.[a,c,d,h]	Flow	Chem.[a,c,d,h]	Flow	Chem.[a,c,d,h]	Flow	Chem.[a,c,d,f,h]
Dp-1	2	2				1		1		2		2		1		1		1		1		1		1
Dp-2	1	12				1		1		2		2		1		1		1		1		1		1
Dp-3	3	12		2		1		1		2		2		1		1		1		1		1		1
Fx-1	5	11		2		1		1		2		2		1		1		1		1		1		1
Fx-2	2	11				1		1		2		2		1		1		1		1		1		1
Fx-3	2	3				1		1		2		2		1		1		1		1		1		1
Fx-4	4	11		2		1		1		2		2		1		1		1		1		1		1
Fx-5		3				1		1		2		2		1		1		1		1		1		1
Fx-6	5	12		2		1		1		2		2		1		1		1		1		1		1
Fx-7	--[g]	10	--[g]	2	--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
Fx-8	1	12		2		1		1		2		2		1		1		1		1		1		1
Fx-9		11				1		1		2		2		1		1		1		1		1		1
Fx-10						1		1		2		2		1		1		1		1		1		1
Fx-11		12		2		1		1		2		2		1		1		1		1		1		1
Fx-12		11		2		1		1		2		2		1		1		1	--[g]	1	--[g]	1	--[g]	1
Fx-13		11		2		1		1		2		2		1		1		1		1		1		1
Fx-14		3				1		1		2		2		1		1		1		1		1		1
Fx-15		2				1		1		2		2		1		1		1		1		1		1
Fx-16		2				1		1		2		2		1		1		1		1		1		1
Fx-17		11		2		1		1		2		2		1		1		1		1		1		1
Fx-18		2				1		1		2		2		1		1		1		1		1		1
Fx-19	1	2				1		1		2		2		1		1		1		1		1		1
Fx-20	1	3				1		1		2		2		1		1		1		1		1		1
Fx-21		2				1		1		2		2		1		1		1		1		1		1
Fx-22		2				1		1		2		2		1		1		1		1		1		1
Fx-23	1	4				1		1		2		2		1		1		1		1		1		1
Fx-24		12		2		1		1		2		2		1		1		1		1		1		1
Fx-25		2				1		1		2		2		1		1		1		1		1		1
Fx-26	1	2				1		1		2		2		1		1		1		1		1		1
Fx-27	--[g]	11	--[g]	2	--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
Fx-28	1	2				1		1		2		2		1		1		1		1		1		1
Kk-1	1	2				1		1		2		2		1		1		1		1		1		1
Mn-1	1	11		2		1		1		2		2		1		1		1		1		1		1
Mn-2		2				1		1		2		2		1		1		1		1		1	--[g]	1
Mn-3	1	3				1		1		2		2		1		1		1		1		1		1
Mn-4		2				1		1		2		2		1		1		1		1		1		1
Mn-5	1	3				1		1		2		2		1		1		1		1		1		1
Mn-6		11		2		1		1		2		2		1		1		1		1		1		1
Mn-7	1	4				1		1		2		2		1		1		1		1		1		1
Mn-7a						1		1		2		2		1		1		1		1		1		1
Mn-7b						1		1		2		2		1		1		1		1		1		1
Mn-8	2	3				1		1		2		2		1		1		1		1		1		1
Mn-9	2	7		2		1		1		2		2		1		1		1		1		1	--[g]	1
Mn-10	13[g]	11	--[g]	2	--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
Mh-1	2	2				1		1		2		2		1		1		1		1		1		1
Mh-2		5		2		1		1		2		2		1		1		1		1		1		1
Mh-3	2	2				1		1		2		2		1		1		1		1		1		1

Stream Sampling Station	Sampled by SEWRPC								Funded by SEWRPC—Sampled by DNR															
	1964		1965		1966		1967		1968		1969		1970		1971		1972		1973		1974		1975	
	Flow	Chem.[a,b,e]	Flow	Chem.[a,b,e]	Flow	Chem.[a,b]	Flow	Chem.[a,b]	Flow	Chem.[a,b,c]	Flow	Chem.[a,b,c]	Flow	Chem.[a,c,h]	Flow	Chem.[a,c,h]	Flow	Chem.[a,c,d,h]	Flow	Chem.[a,c,d,h]	Flow	Chem.[a,c,d,h]	Flow	Chem.[a,c,d,f,h]
MI-1	2	11		2		1		1		2		2		1		1		1		1		1		1
MI-2		3				1		1		2		2		1		1		1		1		1		1
MI-3	2	3				1		1		2		2		1		1		1		1		1		1
MI-4	2	3				1		1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
MI-5		10		2		1		1		2		2		1		1		1		1		1		1
MI-6		3				1		1		2		2		1		1		1		1		1		1
MI-7		2				1		1		2		2		1		1		1		1		1		1
MI-8	12	12	--[g]	2	--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
MI-9	2	3				1		1		2		2		1		1		1		1		1		1
MI-10		3				1		1		2		2		1		1		1		1		1		1
MI-11		12		2		1		1		2		2		1		1		1		1		1		1
MI-12		2				1		1		2		2		1		1		1		1		1		1
Ok-1		2				1		1		2		2		1		1		1		1		1		1
Ok-2	2			2		1		1		2		2		1		1		1		1		1		1
Pk-1	2	3				1		1		2		2		1		1		1		1		1		1
Pk-2	2	2				1		1		2		2		1		1		1		1		1		1
Pk-3	2	10		2		1		1		2		2		1		1		1		1		1		1
Pk-4	3	12		2		1		1		2		2		1		1		1		1		1		1
Rk-1	3	10		2		1		1		2		2		1		1		1		1		1		1
Rk-2	2	2				1		1		2		2		1		1		1		1		1		1
Rk-3		3				1		1		2		2		1		1		1		1		1		1
Rk-4	3	11		2		1		1		2		2		1		1		1		1		1		1
Rk-5	2	3				1		1		2		2		1		1		1		1		1		1
Rk-6	2	2				1		1		2		2		1		1		1		1		1		1
Rk-7		3				1		1		2		2		1		1		1		1		1		1
Rk-8	3	11		2		1		1		2		2		1		1		1		1		1		1
Rk-9	2	2				1		1		2		2		1		1		1		1		1		1
Rk-10	2	2				1		1		2		2		1		1		1		1		1		1
Rk-11	2	2				1		1		2		2		1		1		1		1		1		1
Rk-12	2	3				1		1		2		2		1		1		1		1		1		1
Rk-13	2	10		2		1		1		2		2		1		1		1		1		1		1
Rt-1		5				1		2		2		1		1		1		1		1		1		1
Rt-2	12[g]	3	--[g]		--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
Rt-3	12[g]	3	--[g]		--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
Rt-4		10		2		1		1		2		2		1		1		1		1		1		1
Rt-5		3				1		1		2		2		1		1		1		1		1		1
Rt-6	12[g]	12	--[g]	2	--[g]	1	--[g]	1	--[g]	2	--[g]	2	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1	--[g]	1
Sk-1		2				1		1		2		2		1		1		1		1		1		1
Sk-2	2	11		2		1		1		2		2		1		1		1		1		1		1
Sb-1	2	2				1		1		2		2		1		1		1				1		1
Lake Sampling																								
BCL-1																4		4		4		4		4
BCL-2																4		4		4		4		4
BCL-3																4		4		4		4		4
BCL-4																4		4		4		4		4
BCL-5																4		4		4		4		4

[a] *Chemical sampling for major parameters was conducted to include analysis for temperature, dissolved oxygen, specific conductance, nitrate nitrogen, nitrite nitrogen, dissolved phosphorus, pH, and chloride. This table, and these footnotes generally depict the locations, years, and parameters of sampling. However, due to budgetary constaints or sampling and analysis irregularities, some samples taken during the same year were examined for subsets of the parameters presented here. These detailed differences can be identified by inspection of Appendix D, containing the actual data results. For additional parameters sampled and analyzed during the 11-year study period, consult Appendix B of SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin for 1964-1965 data, and Appendix D of SEWRPC Technical Report No. 17, Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975 for all data collected subsequent to 1966.*

[b] *Complete chemical sampling was conducted as above but, in addition, total coliform was sampled and analyzed.*

[c] *Complete chemical sampling was conducted as above but, in addition, fecal coliform was sampled and analyzed.*

[d] *Complete chemical sampling was conducted as above but, in addition, ammonia nitrogen, organic nitrogen, total nitrogen, and total phosphorus were sampled and analyzed.*

[e] *Dissolved phosphorus was not analyzed.*

[f] *Sampling parameters included turbidity.*

[g] *Streamflow measurement was performed by U. S. Geological Survey on a continuous basis. Refer to Map 2 for the locations of 15 additional cooperative stream gaging stations which do not coincide with the 87 SEWRPC-DNR stream sampling station locations.*

[h] *Diurnal Sampling conducted.*

Source: SEWRPC.

Table 2

DESIGNATIONS AND LOCATIONS OF SEWRPC STREAM SAMPLING STATIONS BY THE U. S. PUBLIC LAND SURVEY SYSTEM

Sampling Station Designation	Sampling Station Location	Township	Range	Section	Quarter Section	Quarter-Quarter Section
DP-1	Brighton Creek at USH 45	01	21	05	2	C
DP-2	Des Plaines River at STH 50	01	21	09	1	B
DP-3	Des Plaines River at CTH ML	01	22	32	3	A
Fx-1	Fox River at Mill Road	08	20	29	1	A
Fx-2	Sussex Creek at STH 164	07	19	12	1	B
Fx-3	Poplar Creek at Barker Road	07	20	30	1	A
Fx-4	Fox River at CTH SS	07	19	24	4	B
Fx-5	Pewaukee River at CTH SS	07	19	15	2	B
Fx-6	Pewaukee River at STH 164	07	19	26	1	D
Fx-7	Fox River at Prairie Avenue	06	19	03	3	C
Fx-8	Fox River at Sunset Drive	06	19	16	2	B
Fx-9	Fox River at CTH HI	06	19	20	3	A
Fx-10	Fox River at CTH I	06	19	31	4	C
Fx-11	Fox River at STH 15	05	18	24	4	A
Fx-12	Mukwonago River at STH 83	05	18	35	1	A
Fx-13	Fox River at Center Drive	05	19	22	3	B
Fx-14	Fox River at Tichigan Drive	04	19	10	1	C
Fx-15	Muskego Canal at STH 36	04	20	04	1	C
Fx-16	Wind Lake Drainage Canal at STH 20	03	19	01	3	B
Fx-17	Fox River at CTH W	03	19	22	3	A
Fx-18	White River at Sheridan Springs Road	02	18	20	3	D
Fx-19	Como Creek at CTH NN	02	17	23	4	D
Fx-20	White River at STH II	03	18	25	4	D
Fx-21	Honey Creek at Carver Road	04	18	22	3	C
Fx-22	Sugar Creek at USH 12	03	16	12	4	A
Fx-23	Honey Creek at Spring Prairie Road	03	19	30	1	B
Fx-24	Fox River at CTH J	02	19	26	2	B
Fx-25	Bassett Creek at CTH F	01	19	15	4	D
Fx-26	Bassett Creek at CTH W	01	19	12	2	A
Fx-27	Fox River at CTH C	01	20	30	3	D
Fx-28	Nippersink Creek at Darling Road	01	18	26	4	C
Kk-1	Kinnickinnic River at 29th Street	06	21	12	4	D
Mn-1	Menomonee River at STH 145	09	20	15	3	D
Mn-2	Menomonee River at CTH F	09	20	28	2	A
Mn-3	Menomonee River at CTH Q	08	20	04	1	B
Mn-4	Menomonee River at Lilly Road	08	20	12	3	B
Mn-5	Menomonee River at Good Hope Road	08	21	19	2	B
Mn-6	Menomonee River at Silver Spring Road	08	20	36	1	B
Mn-7	Little Menomonee River at STH 100	08	21	31	4	C
Mn-7A	Menomonee River at Capitol Drive	07	21	07	1	B
Mn-7B	Menomonee River at North Avenue	07	21	20	1	B
Mn-8	Underwood Creek near N. 106th Street	07	21	20	2	B
Mn-9	Honey Creek at Honey Creek Parkway	07	21	27	2	B
Mn-10	Menomonee River at N. 70th Street	07	21	27	2	A

Table 2 (continued)

Sampling Station Designation	Sampling Station Location	Township	Range	Section	Quarter Section	Quarter-Quarter Section
Ml-1	Milwaukee River North of Kewaskum	13	19	33	2	B
Ml-2	Milwaukee River at CTH H	12	19	23	2	A
Ml-3	Milwaukee River at STH 33 near West Bend	11	20	14	2	B
Ml-4	North Branch Milwaukee River at CTH M	12	20	25	2	B
Ml-5	Milwaukee River at STH 33 at Saukville	11	21	36	2	B
Ml-6	Milwaukee River at STH 57 at Grafton	10	21	24	1	D
Ml-7	Cedar Creek at CTH M	10	20	12	2	D
Ml-8	Cedar Creek at STH 60	10	21	23	2	A
Ml-9	Milwaukee River at CTH C	09	22	06	2	B
Ml-10	Milwaukee River at Mequon Road	09	21	26	2	B
Ml-11	Milwaukee River at Hampton Avenue	07	22	05	2	B
Ml-12	Milwaukee River at STH 32	07	22	33	2	B
Mh-1	Sucker Creek at CTH P	11	22	02	2	A
Mh-2	Pike Creek at 43rd Street	02	23	30	3	D
Mh-3	Barnes Creek at Lake Shore Drive	01	23	20	2	C
Ok-1	Oak Creek at Shepard Avenue	05	22	21	4	C
Ok-2	Oak Creek at STH 32	05	22	02	4	C
Pk-1	Pike River at STH 31	02	22	02	3	B
Pk-2	Pike Creek at 18th Street	02	22	15	3	C
Pk-3	Pike Creek at STH 31	02	22	02	3	C
Pk-4	Pike River at STH 32	02	23	18	4	C
Rk-1	East Branch Rock River at CTH D	12	18	30	4	A
Rk-2	Kohlsville River at USH 41	12	18	29	1	A
Rk-3	Rubicon River at Slinger Road	10	18	15	4	C
Rk-4	Rubicon River at Goodland Road	10	17	13	3	A
Rk-5	Ashippun River at CTH CW	08	17	07	2	B
Rk-6	Oconomowoc River at STH 83	08	18	16	2	D
Rk-7	Oconomowoc River at USH 16	08	17	34	4	C
Rk-8	Oconomowoc River at CTH BB	07	17	06	4	D
Rk-9	Bark River at USH 18	07	17	33	4	A
Rk-10	Whitewater Creek at N. Fremont Street	05	15	32	1	D
Rk-11	Jackson Creek at Mound Road	02	16	14	1	A
Rk-12	Delavan Lake Outlet at CTH O	02	16	19	4	C
Rk-13	Turtle Creek at STH II	02	15	10	3	A
Rt-1	Root River at Grange Avenue	06	21	33	1	B
Rt-2	Root River at Ryan Road	05	21	27	1	A
Rt-3	Root River Canal at Six Mile Road	04	21	10	4	D
Rt-4	Root River at County Line Road	04	21	02	1	A
Rt-5	Root River at Nicholson Road	05	22	34	3	C
Rt-6	Root River at STH 38	03	23	06	1	C
Sk-1	Sauk Creek at CTH A	12	22	33	1	B
Sk-2	Sauk Creek at STH 33	11	22	28	3	A
Sb-1	Tributary of Sheboygan River at CTH BH	13	22	34	3	C

Source: SEWRPC.

13 low flow gages, and seven combination crest stage and low flow gages, all in cooperation with the Wisconsin Departments of Natural Resources and Transportation.

In addition, two research studies in which the Regional Planning Commission is cooperating resulted in the installation of 25 additional continuous flow recorder gages on selected streams in the Region. Under the International Joint Commission-Menomonee River Pilot Watershed Study, 11 such gages were installed on streams in the Menomonee River watershed in the fall of 1974. Under the Washington County sediment control project, 12 gages were installed on selected intermittent streams in the Menomonee and Milwaukee River watersheds in the fall of 1975 and spring of 1976.

Descriptions of the stream flow gages according to type and history, location, equipment installed, drainage area, and period of record are given in Water Resources Data for Wisconsin, published annually by the United States Department of the Interior, Geological Survey. The number, type, and location of stream flow gaging stations within the Region are shown on Map 2.

Commission Stream-Stage Measurements: Stream-stage measurements were made in conjunction with the stream sampling program by the Commission prior to 1968. These measurements involved the establishment of an arbitrary but "permanent" reference benchmark for water level observations on bridge railings or bridge decks, and on culverts from which the distance to stream level was measured at each station at the time of each water quality sampling. The stream level reading could then be related to a stream rating curve prepared by the Commission to obtain an estimate of stream flow. These flow estimates were an integral part of the regular monthly sampling program from June 1964 through December 1964. The purpose of the stream-stage measurements was to obtain information regarding the stream flow from one time period to another, in the absence of continuous flow measurements at each station, and to permit the calculation of stream depth at each station.

Commission Water Quality Sampling Programs

Numerous and varied water quality data were collected and analyzed by the eight agencies and two consultants conducting the 19 water quality sampling programs previously cited and reviewed by the Commission under the water quality analysis reported here. Some of the parameters analyzed were critical to the major objective of each individual study, but extraneous to the whole of this study of overall water quality conditions. Thus, to provide consistency in the data from the various lake and stream sampling programs, only those parameters common to most studies and most years were considered for comparison, and are cited in each of the following program descriptions. Similarly, the evolving technology of sampling and water chemistry laboratory analysis have made a stable and comparable sampling program difficult to achieve, except for a core of basic parameters which utilize well established techniques for laboratory analysis.

Commission Bench Mark Stream Sampling Program

Nine major parameters were selected to determine the existing chemical and physical water quality conditions of the streams and lakes in southeastern Wisconsin under the Commission benchmark stream water quality sampling program. These nine parameters were temperature, specific conductance, hydrogen ion concentration (pH), dissolved oxygen, nitrite nitrogen, nitrate nitrogen, five-day biochemical oxygen demand, phosphorus, and chloride. As set forth in Chapter II (page 10) of SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, the chemical laboratory determinations were made in part by the Commission staff and in part by the Wisconsin State Laboratory of Hygiene.

In addition to the chemical, biochemical, and physical water quality analyses performed monthly from January 1964 through February 1965 on the stream and lake water samples collected under the Commission water quality sampling program, bacteriological analyses were performed by the Wisconsin State Laboratory of Hygiene in Madison, Wisconsin. The parameters measured were membrane filter coliform counts (total coliform) from 1964 through 1969 and membrane filter fecal coliform counts (fecal coliform) from 1968 to present.

The analytical methods used by the Department of Natural Resources Delafield Laboratory and the Wisconsin State Laboratory of Hygiene for the physical, chemical, and bacteriological testing are described in Appendix B to this report, and sample collection procedures are described in Appendix C. The complete tabulation of the physical, chemical, and bacteriological water quality data used in this study is presented in Appendix D.

Commission Root River Stream Sampling Program: A total of 77 monthly water quality samples were collected during the period of January 1964 through February 1965 under the Commission bench mark study and analyzed for 34 parameters including the major parameters of chloride, nitrite nitrogen, nitrate nitrogen, pH, phosphorus, total coliform bacteria, specific conductance, five-day biochemical oxygen demand, dissolved oxygen, and temperature. The samples were collected by the Commission staff. The procedures used by the laboratories performing the work are described in Appendix A and Appendix B of Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin.

Commission Milwaukee River Watershed Stream and Lake Sampling Program: Water quality sampling was conducted in 1967-1968 by the Wisconsin Department of Natural Resources under contract to the Southeastern Wisconsin Regional Planning Commission, the Milwaukee Sewerage Commission, the City of Milwaukee, and also by the Commission through its consultant, Harza Engineering Company, Chicago, Illinois. The water quality sampling was conducted at 36 locations on major perennial streams and on 21 major lakes (50 acres or larger) within the Milwaukee River watershed as a part of the Commission Milwaukee River watershed study. As a part of the lake investigations and following publications of SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, individual lake use reports were published for the Commission by the Wisconsin Department of Natural Resources and discussed in the comprehensive water quality planning program for the Milwaukee River watershed. The major parameters considered in evaluating the watersheds streams and lakes were temperature, dissolved oxygen, pH, chloride, nitrite nitrogen, nitrate nitrogen, total phosphorus, soluble orthophosphate, biochemical oxygen demand, specific conductance, and total coliform bacteria.

Commission Fox River Watershed Stream and Lake Sampling Program: Water quality sampling under the Commission Fox River watershed study was conducted in 1966-1968 by the Wisconsin Department of Natural Resources and by the Commission, through its consultant Harza Engineering Company, at 32 perennial stream locations and on 45 major lakes within the Fox River watershed. Individual lake use reports also were published by the Department of Natural Resources for each lake studied and discussed in the comprehensive water quality planning program for the Fox River watershed. Major chemical parameters considered under this program of study were temperature, pH, dissolved oxygen, five-day biochemical oxygen demand, nitrite nitrogen, nitrate nitrogen, total phosphorus, soluble orthophosphate, specific conductance, chloride, and total coliform bacteria.

Commission Menomonee River Watershed Synoptic Water Quality Surveys: Three synoptic surveys of water quality were conducted for the Commission by the Wisconsin Department of Natural Resources on April 4, 1973; July 18, 1973; and August 6, 1974 as part of the Commission Menomonee River watershed study. The purpose of the surveys was to supplement existing water quality data by collecting samples and measuring flows during a spring snowmelt runoff event, a rainfall storm event and a low flow event in order to evaluate existing water quality conditions throughout the Menomonee River watershed at a single time. Samples were collected at 17 instream sampling stations, at two industrial-commercial discharge sampling stations, and at four land use runoff sampling stations. The samples were analyzed for temperature, dissolved oxygen, pH, fecal coliform, chloride, specific conductance, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, dissolved phosphorus, total phosphorus, and five-day carbonaceous biochemical oxygen demand.

As stated above, numerous agencies and groups other than the Commission have conducted water quality sampling programs. The following section summarizes the water quality sampling programs conducted by agencies other than the Commission and used as sources of supporting data for this report.

Other Agency Water Quality Sampling Programs

Wisconsin Department of Natural Resources Monthly Stream and Lake Sampling Program: The Wisconsin Department of Natural Resources monthly sampling program was initiated in 1961 to document and assess long-term trends in the surface water quality of the State. The purpose of this program was to determine the level of water pollution and the subsequent potential for municipal, industrial, agricultural, and recreational water uses within the State. Since there was a particular interest in determining the level of water quality in surface waters leaving the State, most of the 42 sample sites were located at or near the state boundaries. Of the above mentioned 42 sites, nine are located within the seven-county Southeastern Wisconsin Region. The data from eight of these sites, as shown on Map 3 and in Table 3, were used in the preparation of this report.

Table 3

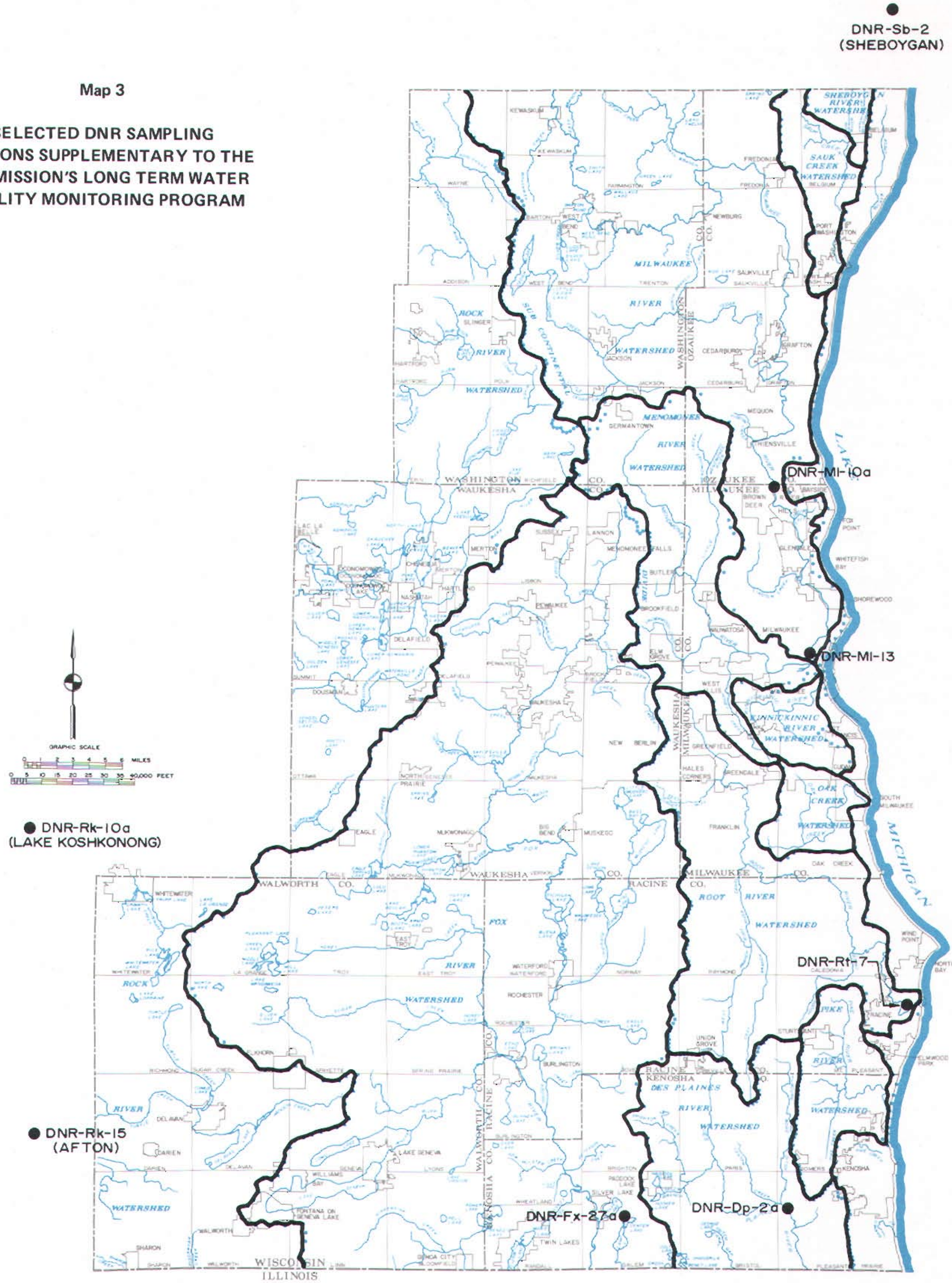
LOCATIONS OF DNR STREAM SAMPLING STATIONS BY THE U. S. PUBLIC LAND SURVEY SYSTEM

Sampling Station Designation	DNR Sampling Station Location	Township	Range	Section	Quarter Section	Quarter-Quarter Section
DNR-Dp-2a	Des Plaines River—CTH "C" near Pleasant Prairie	01	22	18	2	NW
DNR-Fx-27a	Fox (Illinois River)—CTH "C" at Wilmot (Same location as Fx-27)	01	20	30	3	NW
DNR-Ml-10a	Milwaukee River at Brown Deer Road	08	21	12	2	NE
DNR-Ml-13	Milwaukee River at Machinery Bay near mouth in Milwaukee	07	22	33	3	SE
DNR-Rk-10a	Rock River one mile above Lake Koshkonong	05	13	13	1	SW
DNR-Rk-15	Rock River at Afton—Town Road Bridge	02	12	28	1	NW
DNR-Rt-7	Root River at Racine—Marquette Street Bridge	03	23	09	3	SW
DNR-Sb-2	Sheboygan River at Sheboygan—8th Street Bridge	15	23	26	2	NE

Source: SEWRPC.

Map 3

SELECTED DNR SAMPLING STATIONS SUPPLEMENTARY TO THE COMMISSION'S LONG TERM WATER QUALITY MONITORING PROGRAM



Eight stations sampled by the Department of Natural Resources were included in the regional analysis of the 11 years of water quality data. These stations were supplementary to the Commission's long term water quality monitoring program which consists of 87 sampling stations located in the 12 major watersheds in the Region.

Source: SEWRPC.

Data from the ninth station, located at the Peter Cooper Corporation on Oak Creek at Lake Michigan, was not directly considered since the backwater influence of the Lake dilutes the streamflow.

Although 21 sample parameters were collected and analyzed at the eight sample sites, the Commission evaluated and applied the following 15 parameters which correlate to the sample parameters collected for the Commission's 87 sampling stations: temperature, specific conductance, dissolved oxygen, pH, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, organic nitrogen, total nitrogen, soluble orthophosphate, total phosphorus, chloride, total coliform (1961 to 1968), fecal coliform (1968 to present), and five-day biochemical oxygen demand.

Wisconsin Department of Natural Resources Drainage Basin Surveys: The Wisconsin Department of Natural Resources drainage basin surveys are designed to ascertain the surface water quality of each drainage basin and compare that quality to the state-established water quality standards. This program is coordinated with the Wisconsin Pollution Discharge Elimination System (WPDES) under which the Department of Natural Resources issues discharge permits for, and monitors the quantity and quality of waste waters discharged to lakes and streams in each drainage basin. Through the administration of the discharge permits program, coordination of the basin surveys, and the associated compliance monitoring, the causes and effects of water quality conditions can be determined within each of the basins.

The first river basin surveys were conducted in 1950 by the Committee on Water Pollution, the earliest forerunner agency of the Department of Natural Resources. Since 1965, drainage basin surveys have been completed in southeastern Wisconsin for the Des Plaines River watershed, Fox River watershed, Kinnickinnic River watershed, Milwaukee River watershed, Oak Creek watershed, Pike River watershed, and the Rock River watershed. The water quality monitoring stations within each of these watersheds were selected on the basis of land uses, point sources, and limnological characteristics of the stream system. For the period of each basin survey, samples are collected monthly and analyzed for each of the following parameters: temperature, dissolved oxygen, pH, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, organic nitrogen, total nitrogen, soluble orthophosphate, total phosphorus, total coliform (1965-1968), fecal coliform (1968-1975), and five-day biochemical oxygen demand.

Milwaukee Metropolitan Sewerage District Stream Water Quality Sampling Program: The Metropolitan Sewerage District of Milwaukee County has conducted water quality analysis of samples collected from various stream locations within Milwaukee County in an effort to determine general stream water quality conditions and to identify the effects of sources of pollution such as the combined sewer overflows and to document improving or declining water quality conditions in the Menomonee, Milwaukee, Kinnickinnic, and Root Rivers and in Oak Creek.

In addition, sampling programs were conducted in the lower reaches of the Milwaukee and Kinnickinnic Rivers to determine the effects of the operation of the flushing tunnels. With these flushing tunnels, the low flow of each stream is augmented during the dry seasons of the year by pumping water from Lake Michigan into the rivers. Sampling usually was conducted during the spring and summer months, and the samples were analyzed for temperature, pH, dissolved oxygen, total coliform, fecal coliform, five-day biochemical oxygen demand, and chloride.

City of Racine Department of Health Water Quality Survey Program: The Department of Health, City of Racine, has undertaken various water quality programs in response to citizen complaints and upon the direction of City and County Boards. These water quality sampling activities are individually designed to address various problem areas or are undertaken at the request of the City or County Board. Water quality parameters analyzed from samples at various locations within the Fox River, Pike River, and Root River watersheds include the following: total phosphorus, fecal coliform, and total coliform.

Geneva Lake Watershed Environmental Agency Sampling Programs: Because of its large size, its uniquely oligotrophic water quality conditions, and its proximity to major urban population concentrations, Geneva Lake in Walworth County is a recreational water resource important not to only the Southeastern Wisconsin Region but also to the Northeastern Illinois Region. For these reasons, the Geneva Lake Watershed Environmental Agency initiated a water quality sampling program in 1972 to evaluate water quality conditions in the lake; to help determine the level and sources of water pollution in Geneva Lake; and to develop a pollution abatement program for Geneva Lake. On a continuing basis the Agency collects samples from tributary stream and lake water quality monitoring sites twice a year. Each sample is analyzed for temperature, specific conductance, dissolved oxygen, pH, nitrite nitrogen, nitrate nitrogen, organic nitrogen, ammonia nitrogen, total nitrogen, soluble orthophosphate, chlorides, total coliform, fecal coliform, and five-day biochemical oxygen demand.

U. S. Environmental Protection Agency National Eutrophication Survey: The U. S. Environmental Protection Agency, acting on an administrative commitment to study eutrophication in freshwater lakes and reservoirs of the United States, organized the National Eutrophication Survey in 1972. The Survey was intended to develop, in conjunction with state agencies, a data base on nutrient sources and concentrations and their subsequent environmental impact on selected freshwater lakes and reservoirs. The objective in developing the aforementioned data base was to assist in the formulation of comprehensive and coordinated lake management efforts on federal and state levels, particularly for abatement of point sources and diffuse sources of pollution in lake watersheds. A total of 240 lakes was sampled nationwide: 50 were located in Wisconsin and, of those 50, 12 were located in the Southeastern Wisconsin Region.

Sampling sites within each lake system were selected to characterize the water quality of the major tributaries and of the deepest point of the lake. The inlake samples were collected three times a year and the tributary samples were collected monthly. A major proportion of the samples was collected with helicopters of the Wisconsin National Guard. In addition, special efforts were made to obtain effluent quality and quantity data from any sewage treatment facilities located on the lake or on tributaries entering the lake. The samples collected from each lake system were analyzed for the following parameters: temperature, specific conductance, dissolved oxygen, pH, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, organic nitrogen, soluble orthophosphate, and total phosphorus.

U. S. Geological Survey Water Quality and Quantity Sampling Program: The U. S. Geological Survey water quality and quantity sampling program is a cooperative effort with various federal, state, and local units of government. This ongoing program has incorporated a systematic collection of streamflow records since 1913 and selected water quality records since 1955 in an effort to characterize hydrologic and water quality conditions. In addition to the daily discharge information collected at the 23 instream locations in seven major watersheds within the Region, water quality parameters are analyzed on a monthly basis at the Milwaukee River Station (M1-11) located at Estabrook Park in Milwaukee, one of the five stations located within the State of Wisconsin, which are within the National Stream-Quality Accounting Network. This National Network is intended to depict areal water-quality conditions on an annual basis, and to provide data for assessment of long-term changes in stream water quality. Of the 63 parameters sampled at Station M1-11, eight parameters were utilized in this analysis: temperature, specific conductance, dissolved oxygen, organic nitrogen, total nitrogen, chloride, total coliform, and fecal coliform.[1]

The following water quality parameters are analyzed on an annual basis at the Root River Station near Franklin, Wisconsin (Rt-3): temperature, specific conductance, pH, nitrite nitrogen, nitrate nitrogen, and soluble orthophosphate. At the remaining 21 sites, samples are collected by the U. S. Geological Survey on a quarterly basis, and are analyzed for temperature and specific conductance. The results have been published annually since 1965 in Water Resources Data for Wisconsin, Part 2, "Water Quality Records."

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[1] *For a complete listing of the 63 parameters sampled by the U. S. Geological Survey at this station, see Water Resources Data for Wisconsin, Part 2, "Water Quality Records," 1975, pp. 231-240.*

Department of Natural Resources Quarterly Lake Monitoring Program: The quarterly lake monitoring program, initiated in 1966 by the Department of Natural Resources, is designed to determine the water quality conditions of Wisconsin lakes and to compare these conditions with the established water quality standards. These data are useful in evaluating the potential for applying and assessing the accomplishments of techniques for inland lake rehabilitation. A total of 185 lakes, 42 of them within the seven-county Southeastern Wisconsin Region, were selected for monitoring. Their selection was based on the extent of public use and local interest, the aesthetic and scientific characteristics, and the potential for water quality degradation. The lakes are monitored on a quarterly basis, during winter, during summer stratification, and during the spring and fall turnovers. For the period of study, samples are collected and analyzed for temperature, dissolved oxygen, pH, nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, organic nitrogen, total nitrogen, specific conductance, chloride, soluble orthophosphate, and total phosphorus.

City of Milwaukee Health Department Flushing Tunnel Study on the Kinnickinnic River: A November 1970 publication entitled, Report on the Operation of the Kinnickinnic River Flushing Station and Its Effects on Downstream Water Quality, included an analysis of the water quality conditions in the Kinnickinnic River at the Flushing Tunnel outlet, located at South Chase Avenue, upstream from the outlet and downstream from the outlet. Water quality measurements were recorded during the months of June, July, August, and September of 1967, 1969, and 1970 for dissolved oxygen, five-day biochemical oxygen demand, pH, turbidity, chlorides, total coliform, and fecal coliform .

City of Milwaukee, Health Department, Water Quality Sampling Program: In 1974 and 1975, the City of Milwaukee's Health Department carried out a water quality study. In this study temperature, dissolved oxygen, and fecal coliform counts were determined at five locations in 1974 and at seven locations in 1975 in the lower reaches of the Milwaukee River and at six locations in 1974 and 1975 in Lincoln Creek, tributary to the Milwaukee River, within the City of Milwaukee. A total of 713 analyses were conducted over the two year sampling period.

Lake Association Limnological Surveys and Inland Lake and Stream Inventories: Two private consultants have conducted the following inland lake and stream water quality surveys in Waukesha and Walworth Counties since August 1970, under contract to individual lake associations, lake districts, and sportsmen's clubs:

A Limnological Survey of Lower Nashotah Lake for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Lower Nashotah Lake Association from August through October 1970 to evaluate the existing water quality and to identify the sources of pollution to Lower Nashotah Lake in the Rock River watershed in Waukesha County.

A Limnological Survey of Upper Nemahbin Lake for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Nemahbin Conservation Club from August through September 1970 to assess the type and magnitude of possible sources of pollution to the Lake and to establish indices for the basis of an annual or seasonal water quality protection program for Upper Nemahbin Lake in the Rock River watershed in Waukesha County.

A Limnological Survey of Pewaukee Lake for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Pewaukee Lake Sanitary District to analyze seasonal changes in the water conditions of Pewaukee Lake in the Fox River watershed in Waukesha County over the period from September 1971 through October 1975.

A Limnological Survey of Pine Lake for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Pine Lake Committee from June 1971 through June 1973 to assess seasonal water quality conditions and identify pollution sources contributing to Pine Lake in the Rock River watershed in Waukesha County.

A Survey of the Bark River for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Village of Hartland in the Rock River watershed in Waukesha County to evaluate the water quality both upstream and downstream from the Hartland Sewage Treatment Plant in December 1970.

A Survey of Lake Beulah for the Determination of Bacteriological Quality and Chloride Ion Concentration was conducted by Aqua-Tech, Incorporated, for Sanitary District Number One, East Troy, from September 1970 through February 1975 to analyze the fecal coliform and chloride ion distribution within Lake Beulah located in the Fox River watershed in Waukesha County.

A Limnological Survey of Booth Lake for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Booth Lake Property Owners Association in August 1973 to assess existing water quality conditions within Booth Lake in the Fox River watershed in Walworth County.

A Limnological Survey of Turtle Lake for the Determination of Water Quality was conducted by Aqua-Tech, Incorporated, for the Turtle Lake Improvement and Protection Association in July 1971 to analyze existing water quality conditions and locate sources of pollution within Turtle Lake in the Rock River watershed in Walworth County.

Lake Delavan Limnological Survey was conducted by CDM Limnetics for the Delavan Fish and Game Association, Incorporated, to evaluate water quality conditions from July through December 1968 within Lake Delavan in the Rock River watershed in Walworth County.

Sampling frequencies varied depending upon the specifications of the sponsoring organization; however, in most cases the same physical, chemical, bacteriological, and biological parameters were measured, including temperature, dissolved oxygen, turbidity, five-day biochemical oxygen demand, pH, total and fecal coliform, total dissolved phosphates, nitrates, chlorides alkalinity, zooplankton, phytoplankton, benthos, and a rooted aquatic plant (macrophytes) survey.

In addition, the Army Lake Water Quality Analyses have been conducted by Aqua-Tech, Incorporated, for Voss' Resort, a private recreational resort, to test the water quality for levels of fecal coliform, nitrate nitrogen, phosphorus, algae, and macrophyte identification, in August 1973. The lake is located in the Fox River watershed in Walworth County.

SUMMARY

To provide the best possible basis for an analysis of the long-term trends in stream and lake water quality within southeastern Wisconsin, an evaluation was made of all known water quality and related stream flow data sources. These programs, all described in this chapter, discuss the sponsoring agencies, the purposes and scope of each program, the sampling sites, the parameters sampled, the period of sampling for which results are available, and the laboratories performing chemical analyses. More specific information concerning the methods of water quality analysis, the methods of sample collection, and water quality data, is given in Appendices B, C, and D, respectively, of this report. Although other individual sampling efforts have been conducted from time to time within the Region, they were utilized in this analysis by the Commission staff only as a secondary source for confirmation of the interpretive results of this report. The primary data sources utilized were as follows:

1. Commission benchmark stream sampling program.
2. Commission continuing stream and lake monitoring program.
3. Commission streamflow gaging program.
4. Commission Root River stream sampling program.
5. Commission Fox River watershed stream and lake sampling program.
6. Commission Milwaukee River watershed stream and lake sampling program.
7. Commission Menomonee River watershed synoptic water quality surveys.
8. Wisconsin Department of Natural Resources monthly stream sampling program.
9. Wisconsin Department of Natural Resources drainage basin studies.

10. Milwaukee Metropolitan Sewerage District stream water quality sampling program.

11. City of Racine, Department of Health, water quality survey program.

12. Geneva Lake Watershed Environmental Agency stream and lake sampling program.

13. U. S. Environmental Protection Agency national stream and lake eutrophication survey.

14. U. S. Geological Survey streamflow monitoring program.

15. U. S. Geological Survey stream and lake water quality sampling program.

16. Wisconsin Department of Natural Resources quarterly lake monitoring program.

17. City of Milwaukee Health Department study of the water quality at the flushing tunnel at the Kinnickinnic River.

18. City of Milwaukee Health Department water quality sampling program.

19. Lake association limnological surveys and inland lake and stream investigations.

Chapter III

WATER POLLUTION SOURCES

INTRODUCTION

Pure water in the chemical sense is not known to exist in nature. Foreign substances, originating from the natural environment or from the activities of man, are always present in naturally occurring water, making it chemically impure. Water is said to be impure, or polluted, when those foreign substances are in such a form and concentration as to render the water unsuitable for a desired beneficial use such as preservation and enhancement of fish and other aquatic life, water-based recreation, public water supply, industrial water supply, or aesthetic enjoyment.

The inorganic and organic matter that occurs in streams and lakes comes from two sources—nature and man. The natural quality of stream and lake water depends upon the flow of the stream or the size of the lake, the physical environment of soil and rock, and the natural assemblage of plants and animals that live in the tributary watershed. The natural flow of a stream, or the level of a lake is supported by direct precipitation, surface runoff during and following rainfall, snowmelt, and groundwater seepage into the stream channel or lake bed. Although rainfall is the result of atmospheric condensation of water vapor derived from the natural distillation process of evapotranspiration, it is not free from dissolved gases, such as nitrogen, oxygen, and carbon dioxide. Once rainfall, or melt water, is in contact with the earth and runs into the natural drainage system, this surface runoff dissolves and suspends rock particles and organic matter derived from living or decaying plants and animals. These substances affect the water quality of the main stream, or lake, and of the tributaries that drain into it. The natural water quality of a stream or lake is determined further by the seepage of groundwater into the stream channels or lake bed. The ultimate source of groundwater is precipitation. The prolonged contact of groundwater with its subterranean rock environment, however, increases the mineralization of groundwater and contributes much to the chemical quality of streams and lakes. This natural geological and biological environment imparts to a stream or lake a more or less characteristic water quality—the natural stream or lake water quality.

Natural stream and lake water quality is not constant but varies with depth; with the location in the bed of the stream or lake; with time; and in response to a number of interrelated factors. These factors include the geographic or spatial distribution and intensity of rainfall, surface runoff, streamflow, groundwater conditions, daily and seasonal temperature changes, seasonal growth and decay of plants, and diurnal and seasonal changes in photosynthetic processes of plant life in the stream proper.

Human activities comprise the second major source of inorganic and organic matter that affects the water quality of streams and lakes. Municipal, industrial, domestic, agricultural, and commercial wastewater discharges can profoundly affect the water quality of streams and lakes. These discharges can transform a once clear, attractive brook, creek, or river into an open sewage trough that is disgusting to the senses and useless except as a sewer. These discharges can also transform a once clear, attractive lake into a foul smelling, weed-choked, slime-covered, opaque nuisance. Between such an extreme condition of waste loading and the natural condition of a stream or lake that is not used for waste disposal, there is a complete spectrum of quality conditions determined by the impact of human activities within the tributary watershed. The deleterious effects on water uses of wastes discharged into a watercourse constitute pollution. It is important to note, however, that whether or not such effects are considered deleterious ultimately depends upon what use is to be made of the stream or lake water.

Most definitions of pollution make no reference to the sources of the foreign substances, contamination, or discharges causing the undesirable water quality condition; yet the sources may significantly affect the meaning and use of the term. The Commission defines water pollution as the presence of substances which did not originate from natural sources and are present in such quantities as to adversely affect certain beneficial water uses. The Commission, therefore, regards water pollution as being exclusively related to human activity. Such activity may be the direct cause of pollution as, for example, through the discharge of domestic sewage or industrial wastes into a stream. Although less directly associated with human activity, the introduction into a stream of soil particles from eroded land must also be included under this definition.

A broader definition of the term pollution is one that not only describes human activities as the sources of pollution but also includes natural processes. These processes may contribute substances that affect the uses that can be made of water and, therefore, must be considered in the establishment of water use objectives and standards. Such processes include the decay of vegetation, the dissolution of minerals from rock, the leaching of organic matter from soils, and the dissolution of gases from the atmosphere. Thus, a stream having a natural minimum chloride concentration of about 2,000 ppm, and consequently being unsuited for many uses, is "naturally polluted" in the broader, more inclusive sense of the term. According to the usage adopted by the Commission, however, this stream would not be considered polluted with respect to its chloride content, but would be described as having a natural chloride concentration making the stream unsuited for certain uses.

TYPES OF POLLUTION

Water pollution, as defined above, is the direct result of human activities in the watershed. Water pollution may be classified into one or more of the following seven types, depending on the nature of the substance that causes the pollution. Although the water quality problems of a specific body of water may be associated with more than one of the categories, they are presented here for their value in depicting the recurring relationships between pollution sources and their water quality impacts within the Region:

1. Organic pollution—this type of pollution is caused by certain organic compounds (carbonaceous and nitrogenous) in domestic sewage and in industrial wastes which exert a high oxygen demand in the receiving waters and thereby adversely affect aquatic life.

2. Nutrient pollution—this type of pollution is caused primarily by certain nitrogenous and phosphorous compounds in domestic sewage and in urban and agricultural runoff which may cause excessive aquatic plant growths, the subsequent death and decay of which may deplete the dissolved oxygen content of the receiving waters.

3. Inorganic pollution—this type of pollution is caused by certain inorganic compounds—other than nitrogen and phosphorus—such as minerals, heavy metals, and polychlorinated biphenels and pesticides in domestic sewage and industrial wastes, some of which may be toxic to humans and other terrestial life as well as to aquatic animal and plant life.

4. Pathogenic pollution—this type of pollution is caused by a wide variety of bacteria, protozoa, fungi, yeast, and viruses in domestic sewage or in runoff from animal feedlots which may cause infectious diseases in humans and other animals.

5. Thermal pollution—this type of pollution is caused by cooling water discharges, which may adversely affect aquatic animal and plant life.

6. Aesthetic pollution—this type of pollution is caused by one or more of the other forms of pollution, along with the presence of floating objects and unsightly accumulation of trash and debris along stream banks and lake shores.

7. Radiological pollution—this type of pollution is caused by the presence of radioactive substances in sewage or cooling water discharges and may adversely affect human and other animal life. is caused by the presence of radioactive substance

The first six of the foregoing seven types of water pollution occur regularly in surface waters of the Southeastern Wisconsin Region. The seventh type is not known to occur to any significant degree in the Region. Because there are no storage sites for unspent or spent nuclear fuels in the Region, the only possible sources of radioactive contamination are transportation of such materials through and within the Region, the use of such materials within the Region in research or medical institutions, and atmospheric fallout from weapons testing. Water sample results for gross alpha and beta radioactivity collected by the Wisconsin Department of Natural Resources and analyzed by the Wisconsin Department of Health and Social Services since 1961 indicate only background levels to be present.[1] The three pertinent sampling sites included the Milwaukee River at Brown Deer Road and in the estuary at the confluence with the Kinnickinnic River, and at the Rock River at Afton.

SOURCES OF POLLUTION

The major sources of pollution include municipal sewage, septic tank effluent, industrial wastes, and urban and agricultural runoff. Each pollution source is discussed below in light of its characteristic effects on water quality.

Municipal Sewage

Municipal sewage is the spent water of a community and consists of a combination of liquid wastes and waterborne solid wastes from residences, commercial buildings, industrial plants, and institutions, together with ground and surface water infiltration. In temperate climates, the normal discharge point for the sewage or treated effluent is usually the nearest watercourse. All natural bodies of water have the ability to oxidize the organic matter contained in the municipal wastes without the development of nuisance conditions, provided the organic load is kept in balance with the oxygen content of the receiving water.

Many treatment processes have been developed for reducing the pollution load of municipal sewage. Commonly the treatment of municipal sewage involves three steps: primary treatment, secondary treatment, and sludge processing and disposal. Tertiary treatment is employed in sewage treatment when additional removal of oxygen-demanding matter is warranted. Advanced waste treatment is added to the traditional sewage treatment procedures for the removal of additional constituents such as phosphorus and nitrogen compounds. Auxiliary treatment is used in combination with all other treatment methods to effect, for example, effluent aeration and effluent

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[1] *Personal communications of July 11, 1977, with Mr. Larry McDonnell, Chief of the Radiation Protection Section, Wisconsin Department of Health and Social Services, Madison, Wisconsin, the agency recognized as the cognizant body by the U. S. Nuclear Regulatory Commission.*

disinfection. Thus, the nature and contents of sewage effluent vary with the types of sewage treatment provided as well as with the water uses in the area served by the sewer system. A more detailed description of sewage treatment plant processes can be found in Chapter IX, of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. The treated effluent from a secondary sanitary sewage treatment plant typically contains soluble organic and inorganic compounds, suspended solids, and potential pathogenic organisms, all of which affect the water quality of the receiving water.

Soluble Organic Compounds: Efficient secondary sewage treatment employing biological processes removes a high proportion of the soluble, biologically degradable organic material in municipal wastewaters. Generally the net removal of biodegradable organics ranges from 75 to 95 percent of the sewage influent content for secondary treatment plants and from 95 to 97 percent for tertiary treatment plants. The remaining degradable organics will exert a demand on the oxygen resources of the receiving body of water. In streams in which the flow is small relative to the quantity of the waste discharged, even with secondary treatment of the wastewater, there may still be an excessive demand on the dissolved oxygen, and an attendant suppression or depletion of the dissolved oxygen content of the stream.

Nondegradable or slowly degradable organics, such as lignin or synthetic detergents, are not completely removed by secondary biological treatment. These organics can cause taste and odor problems in downstream watercourses, and also impart color to the effluent which may make it unsuitable for certain direct reuse applications and may make the receiving stream aesthetically unacceptable for recreation. In some cases, the organisms may cause objectionable taste in fish living in the receiving watercourse.

Soluble Inorganic Compounds: The soluble inorganic compounds present in municipal sewage and in the treated effluent include phosphorous and nitrogen compounds. These compounds are required for algae and other forms of plant growth, and are not significantly removed by the secondary treatment processes but they can be reduced by advanced wastewater treatment processes. The growth of algae in a receiving body of water may create aesthetically unacceptable conditions for recreation, may create taste and odor problems downstream, and may cause operating problems in water supply filtration plants. In addition, some species of algae and protozoa have been found in laboratory studies to be toxic to livestock and poultry. The growth of algae may also cause marked diurnal variations in dissolved oxygen which may be sufficient at some locations to adversely affect fish and other desirable forms of aquatic life. Advanced sewage treatment employing physical and chemical processes may remove from 90 percent or more of the raw influent phosphorous and nitrogen compounds.

Suspended Solids: Primary treatment employing physical processes may remove from 50 to 60 percent of the raw influent suspended solids and, thereby, from 25 to 35 percent of the raw influent oxygen-demanding materials. An efficient and complete secondary treatment plant may be expected to remove overall up to 90 percent of the raw influent suspended solids. The level of suspended solids in the effluent, however, is usually inadequate for many direct reuse applications. Suspended solids can interfere with disinfection of the effluent, thereby leading to the discharge of pathogenic organisms into the stream. In cases of gross secondary plant failure, or bypassing of raw sewage through various flow relief devices in the sewage systems, sludge deposits may accumulate on stream and lake beds and may cause a long-term oxygen demand and an aesthetic nuisance as well.

Pathogenic Organisms: Pathogens present in municipal wastewater include bacteria, protozoa, fungi, yeast, and viruses. Secondary processes provide substantial but not complete reduction in incoming viral and bacterial concentrations. Chlorination, ozonation of the effluent, and the normal die-off of bacteria in streams eliminate most of the problems that could result from the presence of pathogens in any recreational use of water. Although not much is known about the pathogenic viruses, some viruses have been found to survive disinfection by chlorination.

Carcinogenic Materials: Preliminary research findings of the recent past have implicated the general use of chemicals in the environment as a possible factor in the occurrence of cancers. The specific substances, or combinations of substances, associated with specific diseases are unknown. What is clear, however, is the fact that except for those substances which are not burned, buried, or stored, all the substances utilized in an industrialized society, or the untreated residuals thereof, are eventually included in the wastewater effluent streams of municipal sewage treatment plants. Ultimately, even the very materials and equipment used in wastewater treatment processes may not be above suspicion. Certain compounds formed during chlorination of sewage treatment plant effluent have already been shown to have carcinogenic properties.

Municipal Sewage Flow Relief Discharges

In addition to the pollution of water by the effluent from sewage treatment facilities, sewage flow relief devices that include bypasses, crossovers, and portable and permanent relief pumping stations, which ultimately carry the excess untreated sewage into the surface waters, result in gross forms of organic, nutrient, chemical, pathogenic, and aesthetic pollution. See Chapter V, SEWRPC Planning Report No. 16, A Regional Sanitary Sewer System Planning for Southeastern Wisconsin for a detailed description of each type of flow relief device. From such municipal sanitary flow relief devices, raw sewage is discharged into a receiving body of water or into storm sewers which, in turn, discharge the sewage into the receiving water. Since the sanitary and combined sewer flow relief devices carry untreated sewage directly or indirectly into a receiving body of water, the concentrations of pollutants that are carried by these devices are normally much higher than the concentration in sewage treatment plant effluents, and the aesthetic effects alone can be highly offensive to the potential users of the lakes or streams.

Septic Tank Effluents

Continuing trends within the Region for residents to live in the rural-urban fringe areas and to participate increasingly in water oriented recreational activities are resulting in extensive scattered rural development along lakes and streams and throughout the countryside in areas not served by public sanitary sewerage systems. Full-scale sewage treatment facilities are not economical for much of this scattered rural development. The most commonly used alternative is the individual onsite, septic tank-soil absorption system for disposal of human and domestic wastes.

A septic tank sewage disposal system consists of a house sewer; a septic tank made of metal or concrete; and the absorption field, also known as the filter field or percolation field. With this system, the liquid domestic wastes are discharged into the septic tank where the heavier suspended solids sink to the bottom of the tank to be reduced to stable solid, liquid, and gaseous compounds by the action of anaerobic organisms. The remaining effluent is discharged through a series of perforated pipes into a soil absorption field where anaerobic and aerobic organisms further reduce the solids and destroy the pathogenic organisms.

Contrary to popular belief, a septic tank does not accomplish a high degree of pathogenic bacterial removal. Although the sewage undergoes treatment in passing through the tank, all infectious agents are not removed. Therefore, septic tank effluent cannot be considered bacteriologically safe. The primary purpose of a septic tank is to reduce the total solids of the sewage so that it will cause less clogging of soil pores in the disposal field. Further treatment of the septic tank effluent, including the removal of pathogens, is accomplished by percolation through the soil. Disease-producing bacteria will, in time, die out in the unfavorable environment afforded by soil. In addition, bacteria also are removed by some physical forces during filtration through the soil. This combination of factors is intended to result in the eventual disinfection of the sewage effluent.

There are many causes for a septic tank sewage disposal system to malfunction and contaminate the soil, groundwater, and surface water. Most frequently, a septic tank system fails to operate in areas with soils of low percolation rate, high groundwater, or near-surface bedrock. Even correctly functioning systems may discharge bacteria, viruses and nutrients into the groundwater, and dangerous concentrations may develop in high intensity land use areas. Septic tank systems, especially the filter field, also have a limited life and must be maintained and periodically replaced. Unfortunately, proper maintenance is rare, and little attention usually is paid until functional failures develop. Then, the discharge of untreated wastes onto the ground surface may cause odor nuisances, hazards to health of nearby residents, and water pollution.

Holding Tanks: Holding tanks are concrete or metal devices used as temporary onsite storage facilities in locations where public sewers are not available and where the lot size, the soil type, or the groundwater table prohibits the use of septic tanks and the filter fields required as part of private onsite sewage disposal systems. No treatment is intended to be achieved by holding tanks, since they serve only for temporary storage of the sanitary sewage until a licensed sanitary hauler pumps the waste into a tank truck for transport to a point of disposal, such as a municipal or private sanitary sewage treatment facility. Depending upon the time of storage of the sanitary sewage in the holding tanks, partial anaerobic degradation of the organic fraction of the sewage may occur. The anaerobic nature of the wastes from the holding tanks can create difficulties in treating these wastes with the aerobic processes of the smaller municipal or private treatment facilities to which they may be discharged. This is generally true only in smaller treatment facilities where the volume of anaerobic waste added from holding tanks can be relatively large when compared to the volume of aerobic waste in the receiving facility. Although the vast majority of the raw sewage from holding tanks is disposed of properly by the haulers, a small portion of it is illegally discharged onto the fields or into roadside ditches. Should the wastes reach surface waters, there is an attendant adverse effect on the levels of dissolved oxygen, suspended solids, turbidity, and fecal coliform of the natural waters.

Industrial Wastes

Industrial wastes are the liquid wastes containing dissolved and suspended solids and generated as the byproducts of an industrial process. Industrial wastes differ only slightly in composition from sanitary wastewaters but are generated in small amounts and, in the conduct of a business operation, generally are considered commercial wastes, and are treated as a component of sanitary wastes. Although industrial wastes may be amenable to the same sewage treatment processes as domestic wastes, the strength, volume, or unique composition may require pretreatment before discharge to a municipal sewage collection and treatment system or special treatment prior to discharge to a watercourse. Industrial wastes must, therefore, receive special consideration. Industrial wastes may cause deterioration of sewers and treatment plant structures, increased difficulties and cost in sewage treatment plant operation, health and safety hazards in the operation of sewage systems, and stream pollution of such magnitude as to render the streams unfit for domestic, commercial, or recreational purposes.

The diversity of industry renders the industrial waste treatment problem local and sectional, and it is intensified where many industries of diverse types are concentrated. The uniqueness of each industrial waste type and the potential for rapid change with changing products makes this wastewater management problem particularly difficult to address in categorical terms. For purposes of this analysis, however, industrial wastes can be classified into the following four groups: (1) cooling water, (2) rinse and wash water, (3) organic wastewater, and (4) chemical wastewater.

Cooling Water: The facilities used for electric power generation, primary metal manufacturing, and other industrial activities may discharge cooling water into the nearby streams and lakes. The cooling water or thermal discharge differs from other forms of "pollution" in that it is energy rather than matter which is wasted to the environment. Because of the dynamic nature and magnitude of the heat budgets of aqueous environments, thermal energy can be readily dissipated. However, temperature increases resulting from the discharge of the cooling waters may affect water quality of the receiving stream especially in the vicinity of the thermal plume. In general, the temperature dependence of the chemical constituents of the surface waters of the Region is such that increasing the temperature a few degrees above normal ambient temperatures, for a few minutes to a few hours, will not have a deleterious effect on the water quality of receiving waters. On the other hand, increasing the temperature of a substantial part of the receiving waters 5^{o} to 10^{o} centrigrade above normal ambient temperatures for extended periods of time (days or longer) may induce greater water quality deterioration, or increased frequency of algal blooms in the receiving water. Of particular concern is the reduced dissolved oxygen concentration in heavily polluted receiving waters, since the solubility of oxygen decreases when water temperature is increased. For the lakes and streams of southeastern Wisconsin, it can also be expected that if the temperature of a natural water is increased from below 10^{o} to 15^{o} centrigrade, to above 15^{o} to 20^{o} centigrade, increased numbers of blue green algae will be present.

Rinse and Wash Water: Car and truck washing operations of the Region frequently discharge wash and rinse waters into nearby streams. The wastewater from rinse and wash operations contains dirt, oil, grease, and detergents, and may cause taste and odor problems on bathing beaches, and an aesthetic nuisance from the deposition of a slimy scum. The waste also causes difficulties in sewage treatment plants because of the thick scum on the surface of tanks and the clogging of filters. The high phosphate content of the detergents can increase the algal production and deteriorate the receiving water quality.

Organic Wastewater: Food processing industries, meat rendering companies, and cheese and milk producing factories produce wastewaters high in the content of organic matter. These wastes have high biochemical oxygen demand, high total and suspended solids, and some organic matter which is not biologically degradable and therefore may cause an aesthetic problem if discharged to receiving waters.

Chemical Wastewater: Industries such as electroplating companies, companies producing metal parts, and manufacturers of paint produce wastes containing heavy metals and other toxic compounds. These wastes, when discharged into the receiving water, may cause conditions toxic to human and other animal life and to plant life.

Urban Runoff

Street litter, gasoline and diesel fuel combustion products, ice control chemicals, rubber and metals lost from vehicles, decaying vegetation, domestic pet wastes, fallout from industrial and residential combustion products, and chemical fertilizers, pesticides, and herbicides applied to lawns and parks may be sources of contaminants in urban runoff. Lead from the exhaust of internal combustion engines also may be found in urban runoff.

A portion of the urban runoff may drain to storm and combined sewerage systems, while the remainder may reach surface waters through natural drainage ways. Storm water runoff does not presently receive any treatment by design. Some urban runoff will, however, reach sewage treatment plants through combined sewers and through unintended inflow into sanitary sewers. The discharge of urban runoff to streams or to sewage treatment plants results in an intermittent waste loading that may be excessive for the receiving water. Besides the conventional water pollution parameters, constituents such as chlorinated hydrocarbon and organic phosphate compounds, a number of heavy metals, and polychlorinated biphenyls have also been found in urban runoff. The major constituent of street surface contaminants is inorganic, mineral-like matter. The greatest portion of the potential pollution is associated with the fine solids contained in street surface runoff.

Urban runoff is carried by storm waters which may contain significant levels of pollutants. Precipitation characteristics are influenced by man-made and natural events. Fuel burning, automobiles, manufacturing operations, and wind erosion are examples of activities that contribute to the constituents of precipitation, which will ultimately return to the earth at other locations. Precipitation is a variable and intermittent source of potential contaminants to surface waters. Little is currently known about the quality of precipitation or its effects on surface waters. Once the contaminants have been taken up by atmospheric precipitation, the available control measures are far more limited. Man, however, can exert some control over the contaminants that are released to the atmosphere through management practices that minimize particulate and gaseous air pollutants emitted from combustion processes, particulates from disturbing the land, and volatiles from industrial operations.

Agricultural Runoff

In recent decades, agricultural production has become more labor-efficient as a result of mechanization, increased use of agricultural chemicals, application of modern business methods to farm management, and the application of research results to production. During the same period, the potential has increased for water quality problems associated with runoff from crop and pasture lands and animal feedlots and with leachate from fertilized and manured fields. These problems are not new to agriculture, but have become more noticeable because of increased agricultural productivity, specialization, and intensification. Constituents contained in the runoff from rural land originate in rainfall; in wastes from wildlife; in leaf and plant residue decay; in applied nutrients, herbicides, and pesticides; in nutrients and organic matter initially in the soil; and in wastes from domestic animals.

One of the requirements for satisfactory crop production is the timely availability of nutrients to growing crops. Intensive farming operations are designed to satisfy this requirement, either by the addition of fertilizers or by the incorporation into the soil of readily decomposable organic material, such as manures. Therefore, precipitation runoff or leaching may cause a nitrate loss. Pasture land may be used for manure disposal, as may croplands. The runoff from pasture or croplands may, therefore, carry contaminants from animal wastes. Where animals have direct access to streams, animal urine and feces may be discharged directly to these waters.

The constituents of runoff from rural land vary with the type of soil and the topography, as well as with the type of cropping and animal husbandry practices. The natural weathering of rocks and minerals and the oxidation and leaching of organic matter contribute organic and inorganic matter to runoff, even in the absence of human activities. Subsurface tile drainage systems may be used in areas of poorly drained soils to speed the flow of water from the cultivated fields and to lower the groundwater table. The soil particles which may be carried by the surface runoff from naturally drained agricultural lands serve to transport absorbed organic material and clay and high concentrations of nitrogen, phosphorus, fecal coliform, and pesticides. The chemical composition of surface runoff may vary with soil type, season, land slope, intensity and duration of storm events, and crop cover. By contrast, runoff from subsurface tile drainage systems has higher loads of soluble constituents including chlorides or nitrates and lower loads of clay and organic matter than the surface runoff from naturally drained land. Especially in areas of lighter soils or steeper topography, erosion can be a major contributor of organics and nutrients to surface waters. Soil erosion is a selective process in that the fine particles are more vulnerable to erosion than are the coarser soil fractions. Eroded material may have three to five times as much organic nitrogen content as the original soil.

Silvicultural Runoff

Forested areas have not generally been grossly contaminated by human activities. The runoff from these areas may serve as one of the better indicators of the background levels of chemical constituents that result from natural conditions. The increased world demand for wood fiber has accelerated cultural production practices in managed forested areas. Forest management practices such as forest fertilization and "block" cutting, or "clear" cutting, of mature trees will alter the characteristics of runoff from forested lands by removing or disturbing the rooted terrestrial vegetation which covers and retains the soil particles, and by removing the effect of the forest canopy as a shelter for the soil against the eroding physical forces exerted by the pelting effect of precipitation. Although improperly conducted forest fertilization can result in excessive loss of nutrients to watercourses, there is very little intensively managed and fertilized forest land in southeastern Wisconsin.

SUMMARY

The naturally occurring waters in the lakes and streams of southeastern Wisconsin contain many substances which are not introduced by the activities of man. Soils, underlying rock, plants and animals, precipitation and storm runoff all affect the background water quality. Human activities can pollute the water by adding more or different substances to those which occur naturally and can impair the water uses which would be desirable and possible under the precultural water quality conditions. More specifically, treated sanitary sewage effluent; untreated or partially treated sewage; septic tank wastes; industrial wastewaters; rain and snowmelt runoff from streets, highways, and urbanized areas; rain and snowmelt runoff from croplands, livestock operations, and other rural land uses; and rain and snowmelt runoff from woodlands all contribute to water quality degradation. These various sources introduce organic pollution which consumes the oxygen needed by aquatic life; nutrient pollution which stimulates undesirable plant growth; chemical pollution which can cause an unhealthy environment for flora and fauna, humans included; thermal pollution which affects the balance and dynamics of natural chemical and biological processes; aesthetic pollution which interferes with the highest economic uses of the lakes and streams, and radiological pollution which may be hazardous to all forms of life.

Chapter IV

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

INTRODUCTION

A diversity of uses of the waters of the lakes and streams of southeastern Wisconsin is required in order to maintain a sound economy in the Region, as well as a pleasant, healthful, and attractive physical setting for life. As a dominant force in the ecology of the seven counties, man has long recognized that the presence and quality of surface water are important factors affecting the physical, social, and economic development of the Region. The lakes and streams of the Region throughout its history have attracted land use development of various kinds. Because of the powerful natural forces involved in the cyclic replenishment of water resources, specific water uses can provide an essential and highly stable component of the processes, activities, and structures which support modern human society.

For all beneficial water uses, the quality of the water, as expressed in terms of its physical, biological, and chemical characteristics, must be within a certain range, in order not to impair the intended use. Water quality standards are established to define this range. Without such standards, there would be no way to measure and, consequently, no way to predict the suitability of a given water resource for any particular use.

Water quality standards are of two types, depending on whether the standards apply to the condition of a receiving stream or body of surface water or groundwater, or whether they apply to the composition and strength of the waste discharges from a given source, such as the effluent from a municipal sewage treatment plant or from an industrial plant. These two types of standards often are referred to as "Receiving Water Standards" and "Effluent Standards," respectively. Effluent standards have been promulgated for more than 41 industrial and municipal discharge categories by the State of Wisconsin and by the federal government, as supporting regulations for the national discharge permit system. Since the effluent standards are invoked as a means of attaining stream and lake water quality standards, and since each effluent standard is applicable only to the discharge from a facility of a specified type, age, size, and technical character, effluent standards are of only indirect interest to any study of surface water quality. Receiving water quality standards, because they directly express the suitability of a given stream or lake for a particular use—and therefore relate directly to water use objectives—are of much more direct interest to a study of surface water quality.

At the time the Commission conducted the benchmark survey of regional water quality, no water use objectives or supporting water quality standards had been legally established for the streams and lakes of the Region. The Commission has never had, and does not seek, the authority to establish, regulate, or enforce water quality standards in the Region. However, in order to evaluate the possible impacts on water quality—and therefore on water use—of the alternative land use and transportation plans under consideration at that time, it was necessary for the Commission to identify water quality standards which, if met, would assure the suitability of a lake or stream for a given use or set of uses. Through a careful review of the technical literature and with the assistance of a technical advisory committee, water quality standards were identified for the following major uses: 1) municipal (public) water supply; 2) industrial water supply; 3) cooling; 4) aesthetic enjoyment; 5) livestock and wildlife watering; 6) irrigation; 7) preservation and enhancement of aquatic life; 8) recreation; 9) navigation (commercial); and 10) waste assimilation.

After the publication in November 1966 of SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, water quality standards were established by the State of Wisconsin, in accordance with the provisions of the Federal Water Pollution Control Act of 1965 and the Wisconsin Water Resources Act of 1966. In the 1972 Amendments to the Federal Water Pollution Control Act, it was further required that the State review the water quality standards every three years, and revise the standards as necessary. At this writing, the second such revision is in process. The Wisconsin Department of Natural Resources has been designated by the U. S. Environmental Protection Agency to administer the National Pollutant Discharge Elimination System which requires the issuance of permits for all effluent discharges to surface waters. The regulation of water levels, water flows, and drainage patterns of navigable streams and lakes in Wisconsin also falls under the purview of the Wisconsin Department of Natural Resources and is thereby considered by that Department in the establishment of water quality standards. The Metropolitan Sewerage Commissions of the County and the City of Milwaukee are empowered to establish and maintain reasonable effluent standards within their geographic jurisdiction and may act jointly or separately to enforce these standards.

The interest of the Commission in water quality standards stems from the fact that water quality and pollution affect and, in turn, are affected by regional development patterns. Land and water use are inextricably interrelated and must be considered together in any meaningful comprehensive planning effort. Numerical expressions of water quality, that is, of the concentrations of dissolved or suspended foreign matter in water, have no significance as such in planning. Only where water quality has been related to potential land and water uses and specific permissible maximum and minimum levels of concentrations of the several parameters established in the form of standards can pollution be defined, land and water uses be related, future conditions and needs be forecast, and plans be prepared to meet these needs. In the following pages, the water uses occurring within the Region and the attendant state and federally adopted water quality standards are presented and discussed in detail to provide a basis for the evaluation of water quality conditions and long-term trends in water quality.

WATER USE ACTIVITIES

Municipal (Public) Water Supply Use

The most important use of water is to sustain animal and plant life. Living organisms are largely composed of water, which they require for vital biological processes and for maintaining moisture sufficient for their internal environment. Any marked reduction in the intake of water to meet the normal water requirements of an animal or plant can result in severe symptoms of water starvation or in death. The prime function of a municipal water supply is to provide potable and palatable drinking water to meet the essential biological water need in human beings.

The use of water for drinking purposes requires that the municipal supply be afforded sanitary protection to ensure the health and well-being of individuals and the community. The U. S. Public Health Service promulgates quality standards for drinking water on interstate common carriers subject to the federal quarantine regulations. These quality standards apply to the water after treatment and historically have been accepted by the American Water Works Association and by state public health agencies as minimum standards for all public water supplies. The most recent version succeeding the original standards was published by the U. S. Environmental Protection Agency under the requirements of the Safe Drinking Water Act.[1]

Quality standards that apply to the source of water for drinking purposes, that is, to raw water quality, were not promulgated by the U. S. Public Health Service in the 1962 revision of Drinking Water Standards. The Wisconsin Administrative Code Section NR111.22, which became effective late in 1974, requires that raw surface intake waters should be the highest quality reasonably available and, with appropriate treatment and adequate safeguards, will meet drinking water standards.

The established drinking water quality standards for the chemical and bacteriological parameters are based on health, aesthetic, and economic considerations. Iron or manganese in concentrations higher than the established standard may impart a brownish color to laundry or adversely affect the taste of drinking water or beverages. Water containing higher sulfate or chloride concentrations than the recommended maxima may have a temporary laxative effect upon persons not accustomed to this higher concentration. Fluoride in excess of the maximum permissible concentration may cause discoloration of teeth. Nitrate concentrations exceeding 45 ppm may induce fatal methemoglobinemia in infants. Chlorides are not physiologically harmful except at high concentrations or to people with health problems requiring low chloride ingestion. Taste is the principal consideration in establishing the standard for chloride. The pH of raw water to be used for municipal supply affects the taste and corrosiveness of the water and the treatment processes of chlorination and coagulation. Color and turbidity are aesthetically undesirable and must be reduced by pretreatment.

Water utilities are charged with the responsibility of collecting water for municipal supply at the source, treating the water as conditions may require, and distributing it to the users. In southeastern Wisconsin, the populated areas served by municipal water supply systems provide water, not only for drinking and culinary purposes, but also for a variety of other uses, including waste disposal, bathing, washing, laundering, heating, air conditioning, lawn sprinkling, gardening, industries, business establishments, and fire protection. Within southeastern Wisconsin, the temporary curtailment of water use due to water shortages during seasonal periods of high water demand is often the result of an inadequate municipal system of water treatment or distribution capacity rather than of a physical shortage of water at the source.

The municipal water supplies of the Region are presently obtained both from surface water and groundwater sources. The Cities of Milwaukee, Wauwatosa, Greenfield, St. Francis, West Allis, Glendale, Oak Creek, Cudahy, South Milwaukee, Racine, Kenosha, and Port Washington, and the Villages of Brown Deer, West Milwaukee, Whitefish Bay, Fox Point, Shorewood, Greendale, Wind Point, Sturtevant, North Bay and Elmwood Park, and parts of the Towns of Mt. Pleasant, Somers, Caledonia, and Pleasant Prairie use Lake Michigan water for municipal supply. All other cities, villages, and towns within the Region use groundwater obtained from public or private wells tapping the deep-lying sandstone aquifer, the Niagara aquifer, or the surficial glacial drift.

None of the many streams or inland lakes of the Region is used presently as a source of municipal water supply, nor is it likely that these streams or lakes will be used for this purpose within the foreseeable future. The ready availability of water from Lake Michigan and the thick and extensive subterranean groundwater reservoirs that underlie the Region can be expected, with proper planning and management, to meet the water needs of the Region for many decades, both with respect to water quantity and water quality.

The consideration of stream and inland lake water quality standards for municipal water supply is thus more

[1] *See "Environmental Protection Agency National Interim Primary Drinking Water Regulations," as presented in 40 CFR 141; 40 FR 59565, December 24, 1975; amended by 41 FR 28402, July 9, 1976.*

academic than practical in southeastern Wisconsin. The consistently low mineralization of Lake Michigan water and the relatively uniform chemical and physical characteristics of groundwater, coupled with the greater reliability and predictability of these sources of supply as compared to the variable chemical, physical, and bacteriological qualities and available quantities of stream water, exclude streams and inland lakes from serious consideration as a potential source in the foreseeable future.

Although the streams and inland lakes of the Region are not used as a source of municipal water supply, it is common practice for municipalities and industries to use the streams and stream channels and, therefore, the inland lakes into and through which these streams may flow, for the discharge of treated sewage and occasionally untreated sewage consisting largely of the spent municipal water supply after it has been fouled by use. During low-flow conditions in the Root River watershed, for example, the flow of the Root River Canal apparently is sustained exclusively by liquid wastes of municipal and industrial origin.

Industrial Water Supply Use

The industrial water supply category includes a wide variety of uses and a corresponding wide range of quality requirements. At one extreme, for example, quality is not a consideration in water supply for use as sprays to scrub stack gases to decrease air pollution, whereas, at the other extreme, distilled or demineralized water is required in several processes applied in the manufacturing of television tubes. Not only do water quality requirements vary with the type of industry but they vary also within a single industrial plant where water may be used for multiple purposes, each having different quality requirements.

For the purposes of the regional surface water quality study, industrial water supply, exclusive of cooling water, can be classified into three major use categories: 1) boiler feed water, that is, water used to produce steam for heating and power production; 2) process water, that is water used as an ingredient in the preparation of a finished manufactured product, including foods and beverages; and, 3) general purpose water, that is water used for cleaning and for disposal of industrial wastes.

The process water and general purpose water include such subcategories as baking, boiler feed at four ranges of pressure, brewing, carbonate beverages, daily industry, food canning and freezing, food equipment washing, laundering, processing (general), and tanning. Water use for hydropower generation is an important industrial use in many parts of the country, but in southeastern Wisconsin the low topographic relief, the availability of land and water based shipping routes, and the headwaters nature of the surface water systems have all propagated against hydropower generation as a major water use, except in the earliest days of settlement and industrialization. In addition, the quality of water available is not the important factor, but rather quantity determined possible hydropower generation use. Water for cooling is not included in industrial water use, although a large part of industrial water is used for cooling purposes. Cooling water standards are discussed under the following separate headings in order to facilitate a more detailed consideration of this important water use.

Cooling Water Use

Engine jacket systems, condensers, air conditioning, refrigeration systems, and a large number of industrial operations require water in the cooling process. The water is circulated through the machinery or equipment to reduce temperatures by absorbing heat and carrying it away. There are three principal types of cooling systems in use: 1) the once-through system, 2) the open recirculating system, and 3) the closed recirculating system. The chemical and physical suitability of water for cooling purposes depends on the type of cooling system involved.

In the once-through cooling system, water moves through the heat-exchange units and is discharged into the receiving water. No evaporation of the cooling water takes place in the heat-exchange units. The increase in the temperature decreases the solubility of calcium carbonate in the cooling water and the deposition of the precipitated calcium carbonate and other salts occurs. This deposition of salts is commonly known as scale formation, which decreases the capacity and efficiency of the heat-exchange units. If the cooling water contained high dissolved oxygen, corrosion might occur if the circulating system were made of metal.

In the open recirculating system, the cooling water is passed through the heat-exchange units and is discharged to the atmosphere over structures that facilitate heat dissipation by partial evaporation of the used cooling water. Upon completion of this process, the reconditioned cooling water is recirculated to the heat-exchange system; and the cycle is repeated. This method of cooling causes progressive increase in the total dissolved solids and decrease in the volume of water through evaporation requiring the addition of makeup water. In addition to the calcium carbonate precipitation, as seen in the once-through system, other salts precipitate due to evaporation thus increasing the scale formation and decreasing the heat exchange efficiency and capacity.

In the closed recirculating system, the cooling water is passed through the heat-exchange units and is reconditioned in an enclosed cooling tower that dissipates absorbed heat by convection. Makeup water is added, and the cooling water is recirculated through the heat-exchange equipment. This method of cooling involves little evaporation loss, and makeup water is used normally in small quantities to replace loss from leakage. The problems of corrosion and scale formation in the cooling water system demand high quality water for cooling purposes. The availability of a multitude of treatment methods to chemically condition the water helps the industries in using the raw water of quality lower than required, if the temperature and volume requirements are fulfilled.

Aesthetic Use

The aesthetic value of streams relates to man's emotional and intellectual response to nature. Human appreciation of the scenic beauty of a stream is both intangible and indefinable, but nonetheless real. This appreciation of the beauty of a brook, creek, and river is in contrast to human appraisal of the usefulness of water as expressed in physical or economic terms.

Increased population and urbanization which generally increase the water use of nearby lakes and streams have adverse effects on water quality of these lakes and streams. In southeastern Wisconsin, where 40 percent of the population lives in 5 percent of the land area of the State, the activities of man have caused undesirable changes in both the number and kind of fish that occur in the streams, occasional severe fish kills, accelerated nutrient enrichment giving rise to unsightly or odoriferous algae blooms, and increased pollution loads that adversely affect extensive reaches of many streams. Moreover, the aesthetic value of the streams of the Region have been decreased markedly or in some cases entirely destroyed.

In contrast to the technical appraisal of streams in terms of their usefulness as sources of water supply or for waste disposal, the aesthetic values of a stream involve parameters for which numerical concentrations are physically meaningless. Aesthetic values involve man's sight, scent, sound, and touch. The aesthetic use of a stream may immediately be impaired by the mere presence of any one of a wide variety of materials or substances that are offensive to eye and nose or to body contact. At many locations throughout the Region, refuse heaps litter on the banks of streams and extend into their channels. Discarded automobile and truck tires, tin cans, glass bottles, metallic and wood scrap, paper, and waste material of all varieties are to be observed locally on all streams and watercourses. Floating or suspended garbage, oils, sewage wastes, algal slime, detergent foam, offensive odors, and a wide array of unpleasant matter can preclude the aesthetic enjoyment of a reach of stream. Maximum permissible concentrations are not meaningful in relationship to the aesthetic use of streams unless one arbitrarily states that the concentration should be zero for all unsightly and odoriferous materials. Quality standards for the aesthetic use of streams are descriptive and qualitative rather than quantitative.

Livestock and Wildlife Watering Use

Water used for agricultural purposes is commonly separated into two categories: irrigation water that is applied to the cultivated soil by various methods of spreading to sustain the growth of plants, and nonirrigation water that is used for watering livestock and poultry and for cleansing and other general purposes related to farm activities.

Of the theoretical factors that should have a bearing on the suitability of a water source, those for livestock, poultry, and wildlife are the animal species, age, sex, physiology, and inherent adaptability to water quality conditions. Factors that pertain to the water source are its chemical composition, in terms of the many possible types and concentrations of organic and inorganic substances in solution or suspension, the toxic nature of these substances, pH, synergic and antagonistic effects, water temperature, and the pathogenic microorganisms that may be present. An external factor of importance may be the season of the year.

Water of high mineralization may have sufficiently severe physiologic effects to cause death of animals. Lactation and ovulation are known to decrease and possibly terminate due to continuous ingestion of highly mineralized water. Concentrations of up to 7,000 ppm dissolved solids may be safe for temporary and short-term use. Although animals can adjust to the use of highly mineralized water, the change in concentration should be gradual because sudden large increases in mineralization may cause acute poisoning and death.

Bacteriologically polluted water may be expected to transmit disease to livestock, poultry, and wildlife as well as to humans. Studies have shown that cattle and swine which had been fed water highly polluted with both treated sewage and untreated sewage for periods ranging from six months to two years remained without symptoms of bacterial infection although virulent disease organisms were known to occur in the polluted water. This, however, is not to be considered final in the matter; and water known to contain bacteria pathogenic to livestock and wildlife generally should not be used for watering or animal care. Beef tapeworms may be transmitted through sewage, and waste waters from dairies and slaughterhouses are suspect but not proven sources of animal disease. Toxic algae and protozoa are known to be fatal to livestock and poultry; oils and oily substances could be detrimental to livestock and by adhering to the feathers of water fowl may reduce their buoyancy.

Irrigation Use

The suitability of water for irrigation depends on soil characteristics, on the types of plants to be irrigated, and on the quality of the irrigation water. As with human beings and farm animals, the water quality should contribute to the health of the plants. Successful irrigation is not possible, even with water of excellent quality, if the soil is poorly drained.

Agricultural irrigation in southeastern Wisconsin is applied during the growing season primarily to supplement rainfall and to provide protection against frost damage. Supplemental irrigation is also practiced to control wind erosion, to increase crop yield, to provide earlier maturity of crops, and to produce crops of a higher quality. The feasibility of establishing agricultural irrigation systems is determined by economics, legal considerations associated with the right to use either the surface or ground water, soil characteristics, topography, and the quantity and quality of water available for irrigation. Not all soils within the southeastern Wisconsin area are irrigable. Some soils, because of their slope, permeability, water-holding capacity, or impaired drainage characteristics, cannot be economically irrigated. Surface water also is used for lawn watering, golf courses, cemeteries, and nurseries. Generally, stream and lake water is the cheapest source of irrigation water; but it is the least dependable and the right to its use by riparians may be denied, if the use conflicts with public interests. Such a water use conflict is apt to occur since peak irrigation demands occur during hot, dry weather and thus conflict with recreational water demands and waste dilution needs.

The total volume of irrigation water applied per acre during any one year will vary with the total amount of precipitation, the distribution of precipitation, the rate at which the soil drains, and the type of crop being irrigated. In southeastern Wisconsin 10 to 20 inches of irrigation water are applied to most crops in an average year. This is equivalent to approximately 407,000 gallons per irrigated acre per year.

Use of Preserving and Enhancing Aquatic Life

Although some, very limited, commercial fishing may still take place within the Region, the primary significance of the fish and related aquatic life in southeastern Wisconsin lies in the aesthetic and recreational values that they offer to the sport fisherman, the vacationer, and to the adult and child who enjoy nature in the course of their daily experiences. The fish of stream and lake thus have an intrinsic value to man which is intangible, difficult to define, and incalculable in terms of money. Although an economic value of fish to man can be approximated in terms of what sportsmen spend annually on equipment, licenses, and sports-related travel, such approximation in no way measures the human values derived. Sportsmen, vacationers, and people engaged in the everyday routine of living appear to be more consciously seeking the natural beauty of their environment and attempting, through public and private action, to decrease the unfavorable impacts of changing land uses on fish and other aquatic life.

Fish and other aquatic life belong to a food chain and, even if one link in the chain is eliminated, it will produce highly unfavorable conditions for fish sustenance. The organic matter that enters a stream or lake is changed, by bacterial action, into nitrates and phosphates. These compounds are assimilated by the algae and result in the growth of these plants. The algae are consumed as food by the larger zooplankton, which in turn are eaten by fishes. Any change in the aquatic environment as a result of human activities may have an effect on the organic load, on the algae growth or on the zooplankton concentration. These and other factors may affect the fish life of a stream that range from undetectability through mild effects, to severe effects and death.

The physiological characteristics of fish ultimately determine what effect various pollutants will have upon their health and survival. Important variables within this category are the species, stage of growth (egg, fry, adult, old age), sex, activity phase (vegetative versus propagative), adaptability to adverse conditions of the aquatic environment, and the condition of health prior to exposure to pollution. Water that is of favorable quality to one species of fish may not be adequate for another. Eggs and fry have high oxygen requirements, because of high metabolic rates, making them vulnerable to low dissolved oxygen levels in a stream. Fish may build up a tolerance to certain toxic substances if they are continuously exposed to gradually increasing concentrations. In streams, lakes, and impoundments, the type of organisms and their population density provide a good indication of the prevailing level of the water quality since these reflect directly and indirectly the chemical and physical properties within that particular environment, the extent and degree of pollution, the degree of self-purification, and the water use potential. As a rule, unpolluted waters usually support a large number of different species with relatively few individuals representing a particular species. In contrast, surface waters subjected to excessive loads of oxygen-demanding substances and nutrients are usually characterized by relatively few species but large populations of the more pollution-tolerant forms. Therefore, the degree of pollution may be measured by the number of individual organisms per number of species per unit area or volume, depending on the habitat in question.

Fish life and other aquatic organisms comprising their food chain depend upon the concentration of dissolved oxygen in the aquatic environment. Dissolved oxygen is vital to fish for the same reason that oxygen in the atmosphere is vital to human beings. Whereas air at sea level contains about 20 percent oxygen by weight, or about 200,000 ppm, the maximum dissolved oxygen content of water is 14.6 ppm (under conditions of saturation at 32°F). Although extremely small as compared to the oxygen content of the air, this maximum dissolved oxygen concentration is more than enough to meet the physiologic oxygen requirements of fish and of the organisms which make up the food chain.

There are two principal sources of dissolved oxygen that occur in streams: the atmosphere and the photosynthetic plants. Atmospheric oxygen is taken up by the stream through the process of diffusion and solubilization at the water-air interface. Wave action in the main channel, along the stream embankments, and at and near obstructions, together with the agitation and dispersal in stream rapids, waterfalls, and at dam spillways, results in atmospheric aeration of the stream. This process of stream aeration is further augmented by wind action.

The second important source of oxygen in streams is derived from the photosynthetic processes of both microscopic and macroscopic plants. The photosynethesis occurring during daylight hours releases oxygen into the stream. The amount of oxygen released into the stream from aquatic plants, principally algae, depends on many factors, including the temperature of the water, the amount of light, and amount of nutrients present.

A number of naturally occurring processes oppose the aeration or oxygenation of streams. Rather than adding oxygen to the rivers and creeks, these processes remove the oxygen from solution and thus reduce the amount of dissolved oxygen available in the stream. Algae and other aquatic organisms use oxygen in respiratory processes during day and night, resulting in varying amounts of reduction in dissolved oxygen, depending on the plant population, the temperature, and the net effect of processes of aeration. During a day, changes in the dominance of the photosynthetic over the respiratory processes result in a diurnal change in the dissolved oxygen content of the streams. This diurnal change may vary from a condition of supersaturation to a condition of critically low dissolved oxygen concentration. Supersaturation is a condition in which the dissolved oxygen concentration is higher than the saturation level at the prevailing equilibrium of temperature and pressure. Theoretically, the dissolved oxygen content should not be higher than the saturation concentration for a particular temperature and pressure. The physical principle that accounts for the buildup of dissolved oxygen to levels of supersaturation is the low diffusion rate of dissolved gases in water. As the aquatic plants release oxygen, the low diffusion rate permits the buildup of the dissolved oxygen content to supersaturation at the prevailing equilibrium of temperature and pressure. There is no instantaneous diffusion of the excess dissolved oxygen from the plant source through the water to the stream surface where the excess quantities can be immediately released to the atmosphere.

The second process that removes the oxygen of a stream is the biological oxidation of organic matter in water. The organic wastes discharged into streams from municipal, industrial, or domestic sources are decomposed to stable substances by bacteria and other microorganisms. These organisms require oxygen in the processes of decomposition of organic wastes and may cause the marked lowering or complete depletion of the dissolved oxygen content of the stream.

Fish life and the organisms comprising their food chain depend upon the concentration of dissolved oxygen in their aquatic environment. The opposing processes of oxygenation and deoxygenation have at all times a net effect that controls the absolute amounts of oxygen available to sustain fish life. The minimum dissolved oxygen concentration of the stream must at all times be adequate for those species of fish and for those stages of fish development that require the most dissolved oxygen, and adequate for the food chain organisms. The various species of fish have different dissolved oxygen requirements and are classified as tolerant, facultative, or intolerant to low dissolved oxygen levels. Tolerant fish species include carp, catfish, goldfish, and suckers. Facultative species include alewives, shiners, walleyes, crappies, bluegills, northern pike, and perch. Intolerant fish include trout, chubs, and whitefish.

Recreation Use

The recreational use of streams and lakes in southeastern Wisconsin involves such activities as swimming, bathing, fishing, boating, sailing, water skiing, picnicking in park areas adjacent to water, skating, and ice boating. The predominant recreational use of the streams of the Region is fishing, which is done frequently from bridges and stream banks. Although swimming and bathing in the streams are now uncommon within the Region, picnic areas adjacent to streams are becoming increasingly numerous. Because of relatively narrow channels, shallow depths, and frequent meander bends, streams within the Region offer poor competition to lakes for summer boating and water skiing and winter ice boating and ice fishing. Skating on the ice of river and creek is not a popular sport because of the solid materials that can project through the ice, the frequently unsafe ice conditions near the stream banks, and the tension and heave fractures that readily develop under changing weather conditions.

Navigation (Commercial) Use

In southeastern Wisconsin there are four port cities that serve users of the upper Great Lakes and the St. Lawrence Seaway: Milwaukee, Racine, Kenosha, and Port Washington. The harbors of these cities are deep enough to accommodate oceangoing vessels of moderate size. The navigation of such vessels as ore boats, coal boats, barges, tugs, and large pleasure craft is possible only in the very lower reaches of those streams that enter the harbors at Milwaukee, Racine, and Kenosha. At Milwaukee the Milwaukee River, the Menomonee River, and the Kinnickinnic River are navigable by large commercial vessels for distances of approximately one to three miles upstream from the Milwaukee River estuary. At Racine the Root River is navigable by large pleasure craft for a distance of about one mile upstream from its mouth. At Kenosha, Pike Creek is navigable by large pleasure craft for about one-half mile upstream from its mouth.

The pollutants that are deleterious to the use of streams for navigation are acids or alkalies that corrode metal or cause the deterioration of wood, floating debris, and suspended solids that can be a hazard to ships and floating oil that could ignite and cause fire damage.

Waste Assimilation Use

The disposal of human and industrial wastes has always constituted a serious problem. For aesthetic as well as public health considerations it has become the practice to provide sewer systems to carry such wastes away from the area of use. The normal repository for the disposal of human and industrial waste has usually been the nearest surface watercourse. It is said, and to a certain extent correctly, that flowing water "purifies itself," but there is a finite limit to the purification capacity, since the rivers and other receiving bodies of water have only a limited ability to handle waste material without creating nuisance conditions.

The capacity of a stream to assimilate wastes may be measured in terms of the amount of degradable and nondegradable wastes that can be carried in solution or suspension by the stream without exceeding the limits of concentration—that is, the water quality standards—established for those stream water uses that are deemed necessary or desirable. This assimilative capacity depends, in part, directly upon the extent of dilution of nondegradable wastes that occur in streams. Nondegradable wastes such as chloride are not subject to decomposition, chemical change, or physical removal. Primarily, however, the capacity of the stream to assimilate wastes is a dynamic variable that is a function of a multitude of interacting physical, chemical, biochemical, and biological, processes that occur naturally in streams. These processes decompose, precipitate, and absorb the degradable wastes from solution or suspension, thus making the streams capable of self-purification.

All natural bodies of water have the ability to oxidize degradable, organic matter without the development of nuisance conditions, provided the organic loading is kept within the limits of the oxygen resources of the water. The major interrelated factors that determine whether extensive water pollution will occur are the quantity and quality of water available in the stream to dilute the wastes relative to the quantity and concentration of the wastes. Although no one water quality indicator can be used to determine the extent to which a stream has assimilated wastes, the biochemical oxygen demand is a commonly applied measure of the stream assimilative capacity and of the pollutional load of organic wastes. For other industrial wastes which contain both organic and inorganic wastes, other water quality indicators must be used to evaluate the stream's resource for waste carriage and disposal.

Of special interest within the Region, there are many headwater streams which receive wastewater discharges, but may have only limited flow during the drier periods of the year to assimilate current waste discharges or the wasteloads anticipated by the year 2000. Moreover, even in those cases where a quantifiable excess assimilative capacity exists, its complete use may be disallowed under state and federal "antidegradation" policies which propose the continuing maintenance of existing water quality levels. Similarly, certain minimum treatment standards, such as those calling for secondary treatment or phosphorus removal by municipalities, or "best practical treatment" by industries may preclude the complete use of the physical capacity of a stream to transport and assimilate wastes.

WATER QUALITY STANDARDS

Water quality standards are statements of the characteristics of a water which must be maintained to make it suitable for specific uses. The standards, when applied to specific waters, such as lakes or rivers, are meaningful for achieving, maintaining or upgrading, and documenting the quality of the water. The Federal Water Pollution Control Act of 1965 required that each state adopt water quality criteria and a plan for applying them to interstate waters within the state. Standards for interstate waters were adopted and became effective on June 1, 1967. Section 144.025(2)(6), Wisconsin Statutes, authorizes and directs the adopting of rules setting standards of water quality. It recognizes that different standards may be required for different waters or portions thereof. The intent is set forth: ". . . standards of quality shall be such as to protect the public interest, which includes the protection of the public health and welfare and the present and prospective future use of such waters for public and private water supplies, propagation of fish and aquatic life and wildlife, domestic and recreational purposes, and agricultural, commercial, industrial, and other legitimate uses. In all cases where the potential uses of water are in conflict, water quality standards shall be interpreted to protect the general public interest." Standards for intrastate waters were adopted and became effective on September 1, 1968. The Federal Water Pollution Control Act Amendments of 1972 were added to restore and maintain the chemical, physical, and biological integrity of the nation's waters. In order to achieve this objective, the national goal seeks to eliminate the discharge of pollutants into navigable waters by 1985. Furthermore, it is the national goal that wherever attainable, an interim goal of water quality be achieved by July 1, 1983, to protect and propagate fish and wildlife and provide for recreation in and on the water. The Amendments further require the establishment of water quality standards for all waters, consistent with the applicable requirements of the Act. A review of water quality standards every three years is also required.

The water quality standards for all surface waters of the State (interstate and intrastate) were revised in September 1973. The revised water quality standards of 1973 have been formulated for the following major water uses: restricted use, public water supply, maintenance of a warm water fishery, and recreational use. The water use related to aesthetic considerations provides minimum standards for all waters. Water quality standards have not been formulated for commercial shipping and navigation since suitability for these uses depends primarily on quality, depth, and elevation.

Public Water Supply

The principal consideration with respect to quality standards for raw water to be used for public water supply is that the water, after appropriate treatment, meet the standards cited in the Wisconsin Administrative Code, Section NR 111.22, published in November 1974. The water quality standards of raw water to be used for water supply include an allowable pH range and maximum limits on temperature, dissolved solids, and fecal coliform. A revised set of drinking water standards as required by the Federal Safe Drinking Water Act of 1974 is now being prepared by the Environmental Protection Agency and the new National Interim Drinking Water standards will be effective from June 1977.

Fish and Aquatic Life

Standards for water to be used for the preservation and enhancement of fish and aquatic life are generally specified in terms of parameters that affect the physiologic condition of the fish, the food chain that sustains the fish, and the aquatic environment. The DNR standards for fish and aquatic life, including the specific subcategories of salmon spawning and trout fishery, are set forth in Table 4, and it is apparent that key factors include temperature, dissolved oxygen, and pH, in addition to other substances that may be harmful to the aquatic ecosystem. The adopted standards for the preservation and enhancement of fish and aquatic life include Lake Michigan thermal discharge standards which are only applicable to those facilities discharging heated water directly to Lake Michigan. The standards exclude municipal water and sewage treatment plants, as well as vessels or ships.

Recreation

Waters to be used for recreational purposes should be aesthetically attractive, free of substances that are toxic upon ingestion or irritating to the skin upon contact, and

Table 4

WISCONSIN DEPARTMENT OF NATURAL RESOURCES WATER QUALITY STANDARDS FOR MAJOR WATER USES: MARCH 1973

Water Quality Parameters	Water Uses[a,b,c]										
		Fish and Aquatic Life									
	Public Water Supply	Fishery	Salmon Spawning	Trout Fishery	Recreational Use	Restricted Use	Irrigation	Livestock and Wildlife Watering	Waste Assimilation	Navigation	Aesthetics
Temperature (^{o}F)	--[d]	89[d]	--[d]	--[d,e]	--[d]		See Table 5 for water quality standards for specific streams in the Region	See Table 5 for water quality standards for specific streams in the Region	See Table 5 for water quality standards for specific streams in the Region	No water quality standards; suitability depends upon quantity, depth, and elevation	See footnote b
Total Dissolved Solids (mg/l)	500-700[f]	--	--	--	--						
Dissolved Oxygen (mg/l)		5.0 min.	5.0[g] min.	6.0[h] min.	--	2.0 min.					
pH (units)	6.0-9.0[i]	6.0-9.0[i]	6.0-9.0[i]	6.0-9.0[i]	--	6.0-9.0[i]					
Fecal Coliforms MFFCC/100 ml	-- 200-400[j]	--	--	--	-- 200-400[j]	1,000-2,000[k]					
Miscellaneous Parameters[l]	--[m,n]	--[m]	--[m]	--[m,o]	--[m,p]	--[m]					

[a] *Standards are expressed in mg/l except as indicated. Single numbers are maximum permissible values except where minimum limits are denoted by the subscript Min. Waters shall meet the following conditions at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life. The standards shall apply at all times except (a) during periods when flows are less than the average minimum seven-day low flow, which occurs once in 10 years (seven-day Q_{10}) and (b) in channels which convey a treated effluent to natural surface waters. In determining the seven-day Q_{10} flow, consideration will be given to streams subject to hydraulically altered flow regimes.*

[b] *MIXING ZONES. Water quality standards must be met at every point outside of a mixing zone. The size of the mixing zone cannot be uniformly prescribed, but shall be based on such factors as effluent quality and quantity, available dilution, temperature, current, type of outfall, channel configuration, and restrictions to fish movement.*

[c] *Except for natural conditions, all surface waters (lakes and streams) classified for fish and aquatic life shall meet the required water quality standards of the State.*

[d] *There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 5^{o}F for streams and 3^{o}F for lakes.*

[e] *There shall be no significant artificial increases in temperature where natural trout reproduction is to be protected.*

[f] *Not to exceed 500 mg/l as a monthly average nor 750 mg/l at any time.*

[g] *The dissolved oxygen in the Great Lakes tributaries used by stocked salmonids for spawning runs shall not be lowered below natural background during the period of habitation.*

[h] *Dissolved oxygen shall not be lowered to less than 7.0 mg/l during the spawning season.*

[i] *The pH shall be within the range of 6.0-9.0 with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.*

[j] *Shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.*

[k] *Shall not exceed a monthly geometric mean of 1,000 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 2,000 per 100 ml in more than 10 percent of all samples during any month.*

[l] *Lake Michigan thermal discharge standards, which are intended to minimize the effects on aquatic biota, apply to facilities discharging heated water directly to Lake Michigan excluding that from municipal waste and water treatment plants and vessels or ships. Such discharges shall not raise the temperature of Lake Michigan at the boundary of the mixing zone established by the Wisconsin Department of Natural Resources by more than 3^{o}F and, except for the Milwaukee and Port Washington Harbors, thermal discharges shall not increase the temperature of Lake Michigan at the boundary of the established mixing zones during the following months above the following limits:*

January, February, March	*45^{o}F*
April	*55^{o}F*
May	*60^{o}F*
June	*70^{o}F*
July, August, September	*80^{o}F*
October	*65^{o}F*
November	*60^{o}F*
December	*50^{o}F*

All owners utilizing, maintaining, or presently constructing thermal discharge sources exceeding a daily average of 500 million BTU per hour shall submit monthly temperature and flow data on forms prescribed by the Department of Natural Resources and shall on or before February 1, 1974, submit to the Department a report on the environmental and ecological impact of such thermal discharges in a manner approved by the Department. After a review of the ecological and environmental impact of the discharge, mixing zones shall be established by the Department. New thermal discharge facilities (construction commenced after February 1, 1972 and prior to August 1, 1974) shall be so designed as to avoid significant thermal discharges to Lake Michigan. Any plant or facility, the construction of which is commenced on or after August 1, 1974, shall be so designed that the thermal discharges from it to Lake Michigan comply with mixing zones established by the Department. In establishing a mixing zone, the Department will consider ecological and environmental information obtained from studies conducted pursuant to February 1, 1974, and any requirements of the Federal Water Pollution Control Act Amendments of 1972.

[m] *Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. Questions concerning the permissible levels, or changes in the same, of a substance or combination of substances of undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria, report of the National Technical Advisory Committee to the Secretary of the Interior, April 1, 1968. The Committee's recommendations will also be used as guidelines in other aspects where recommendations may be applicable.*

[n] *The intake water supply shall be such that, by appropriate treatment and adequate safeguards, it will meet the Public Health Service Drinking Water Standards established in 1962.*

[o] *Streams classified as trout waters by the DNR (Wisconsin Trout Streams, publication 213-72) shall not be altered from natural background by effluents that influence the stream environment to such an extent that trout populations are adversely affected.*

[p] *A sanitary survey and/or evaluation to assure protection from fecal contamination is the chief criterion in determining the suitability of a surface water for recreational use.*

Source: SEWRPC.

void of pathogenic organisms. The first two conditions are satisfied if the water meets the minimum standards for all waters as previously described, whereas the third condition requires that a standard be set to ensure the safety of a water from the standpoint of health. The concentration of fecal coliform bacteria is the parameter now used for this purpose. Since the fecal coliform counts is only an indicator of a potential public health hazard, the Wisconsin Standards, as set forth in Table 4, specify that a thorough sanitary survey to assure protection from fecal contamination be the chief criterion for determining recreational suitability.

Restricted Use

As indicated in Table 4, the restricted use category is intended to result in water quality which exceeds minimum standards. The most significant characteristics of the restricted use category are the inclusion of a requirement for minimum dissolved oxygen concentration and an upper limit on fecal coliform bacteria.

Water Use Objectives and Supporting Water Quality Standards Applied in the Southeastern Wisconsin Region

The water use objectives for the surface waters of the Region are shown on Map 4. The combined water use objectives applicable to the southeastern Wisconsin and the water quality standards required to attain these objectives are presented in Table 5. In the Southeastern Wisconsin Region, all of the interstate and most of the intrastate surface waters (lakes and streams) are required to meet the standards for recreational use and maintenance of fish and aquatic life, except where the possibility is precluded by natural background conditions, in-place pollutants, low natural streamflow, or irretrievable cultural alterations. Variances and additions applicable to the streams of the Region are discussed below.

Some streams or segments of some streams of the Region are in the restricted use category and, therefore, less stringent water quality standards are applicable to them. These include Underwood Creek in Milwaukee and Waukesha Counties below Juneau Boulevard; Barnes Creek in Kenosha County; Pike Creek, a tributary of the Pike River, in Kenosha County; Pike River in Racine County; Indian Creek in Milwaukee County; Honey Creek in Milwaukee County; Menomonee River in Milwaukee County below the confluence with Honey Creek; Kinnickinnic River in Milwaukee County; Lincoln Creek in Milwaukee County; and Sussex Creek in Waukesha County. These streams are required to meet the water quality standards for fish and aquatic life except that the dissolved oxygen shall not be lowered to less than 2 mg/l at any time, nor shall the membrane filter fecal coliform count exceed 1,000 per 100 ml as a monthly geometric mean based on not less than five samples per month nor exceed 2,000 per 100 ml in more than 10 percent of all samples during any month.

The water quality of the Milwaukee River in Milwaukee County downstream from the North Avenue Dam and South Menomonee Canal and Burnham Canal in Milwaukee County is required to meet the standards for fish and aquatic life except that the dissolved oxygen shall not be lowered to less than 2 mg/l at any time, nor shall the membrane filter fecal coliform count exceed 1,000 per 100 ml as a monthly geometric mean based on not less than five samples per month nor exceed 2,000 per 100 ml in more than 10 percent of all samples during any month. Furthermore, the temperature should not exceed 89^{o}F at any time at the edge of the mixing zones established by the Department of Natural Resources.

In addition, Palmer Creek in Kenosha County, Bluff Creek in Walworth County, Allenton Creek in Washington County, and Scuppernong Creek in Waukesha County are classified as trout waters by the Department of Natural Resources. For these waters the required water quality standards are those of fish and aquatic life except for a higher dissolved oxygen minimum of 6.0 mg/l and, during spawning season, a minimum of 7.0 mg/l of dissolved oxygen. The effluents entering the trout streams must be such that the trout populations are not adversely affected.

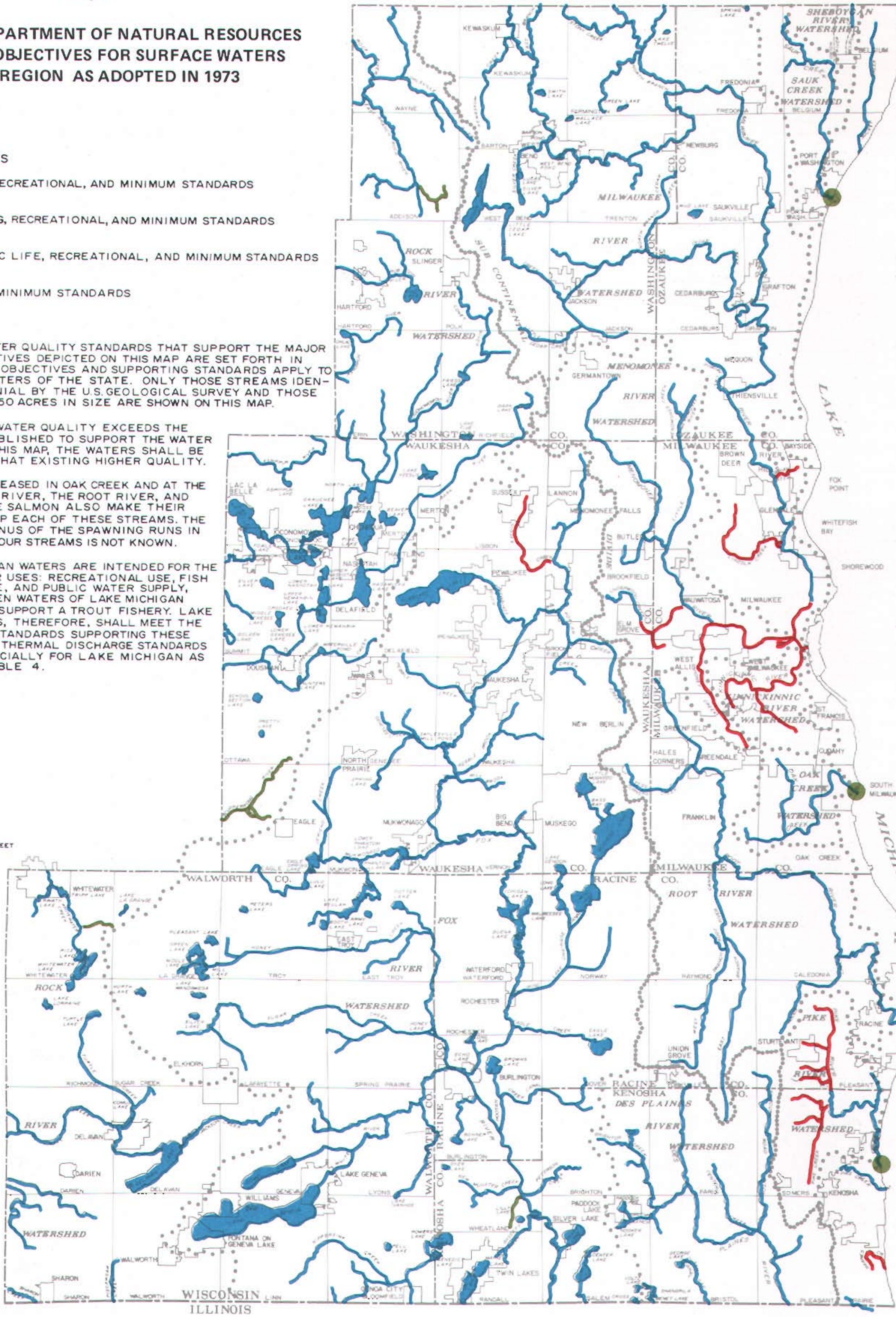
Variances for Small Streams

In September 1976 the Department of Natural Resources revised the official regulation containing identification of water uses and designated standards for intrastate waters to provide for a system of variances for small streams with inherently limited water quality attributable to the presence of inplace pollutants, low natural streamflow, natural background conditions, and irretrievable cultural alterations. Under this system of variances, streams are classified according to their hydrologic characteristics into the following categories: lakes or flowages; diffused surface waters, such as intermittent streams and surface flows across the land; wetlands; wastewater effluent channels, not including agricultural drainage ditches; noncontinuous streams having a natural seven-day 10-year low flow of less than 0.1 cfs; and continuous streams. As presented in Table 6, these hydrologic categories are then assigned a water quality classification which provides for a water quality standards variance from the fish and aquatic life standard. The two variance categories are termed "intermediate aquatic life," which applies to surface waters which cannot support a balanced aquatic community, and "marginal surface waters" which is essentially a categorization for minimum stndards. There are 39 municipal and industrial wastewater discharges in southeastern Wisconsin located near streams which have a hydrologic classification which may be affected by these new promulgated regulations.

In addition to these special variance categories, a classification was devised for the protection of surface waters significant to the environmental integrity of the State or Region. Regardless of the hydrologic categories, this classification provides for the establishment of effluent limitations—including allocation of waste loads—for protecting and maintaining water quality in lakes and streams which are important to the overall environmental integrity of an area. Such resources as trout streams, scientific areas, wild and scenic areas, and areas which provide habitat for endangered species or exceptionally high potential for recreation are to be considered on a case-by-case basis under this category. In addition to

Map 4

WISCONSIN DEPARTMENT OF NATURAL RESOURCES WATER USE OBJECTIVES FOR SURFACE WATERS IN THE REGION AS ADOPTED IN 1973



LEGEND

WATER USE OBJECTIVES

TROUT FISHERY, RECREATIONAL, AND MINIMUM STANDARDS

SALMON SPAWNING, RECREATIONAL, AND MINIMUM STANDARDS

FISH AND AQUATIC LIFE, RECREATIONAL, AND MINIMUM STANDARDS

RESTRICTED AND MINIMUM STANDARDS

NOTES:

1. THE ADOPTED WATER QUALITY STANDARDS THAT SUPPORT THE MAJOR WATER USE OBJECTIVES DEPICTED ON THIS MAP ARE SET FORTH IN TABLE 4. THESE OBJECTIVES AND SUPPORTING STANDARDS APPLY TO ALL SURFACE WATERS OF THE STATE. ONLY THOSE STREAMS IDENTIFIED AS PERENNIAL BY THE U.S. GEOLOGICAL SURVEY AND THOSE LAKES AT LEAST 50 ACRES IN SIZE ARE SHOWN ON THIS MAP.

2. WHERE EXISTING WATER QUALITY EXCEEDS THE STANDARDS ESTABLISHED TO SUPPORT THE WATER USES SHOWN ON THIS MAP, THE WATERS SHALL BE MAINTAINED AT THAT EXISTING HIGHER QUALITY.

3. SALMON ARE RELEASED IN OAK CREEK AND AT THE MOUTHS OF PIKE RIVER, THE ROOT RIVER, AND SAUK CREEK. THE SALMON ALSO MAKE THEIR SPAWNING RUNS UP EACH OF THESE STREAMS. THE UPSTREAM TERMINUS OF THE SPAWNING RUNS IN EACH OF THESE FOUR STREAMS IS NOT KNOWN.

4. ALL LAKE MICHIGAN WATERS ARE INTENDED FOR THE FOLLOWING WATER USES: RECREATIONAL USE, FISH AND AQUATIC LIFE, AND PUBLIC WATER SUPPLY, WHEREAS THE OPEN WATERS OF LAKE MICHIGAN ARE INTENDED TO SUPPORT A TROUT FISHERY. LAKE MICHIGAN WATERS, THEREFORE, SHALL MEET THE WATER QUALITY STANDARDS SUPPORTING THESE USES AS WELL AS THERMAL DISCHARGE STANDARDS ESTABLISHED ESPECIALLY FOR LAKE MICHIGAN AS SET FORTH IN TABLE 4.

GRAPHIC SCALE

0 1 2 3 4 5 6 MILES

0 5 10 15 20 25 30 35 40,000 FEET

Revised water use objectives for all surface waters in the Region, as well as for Lake Michigan, were adopted by the Wisconsin Natural Resources Board effective October 1, 1973. Most of the surface waters of southeastern Wisconsin are now designated for a combination of recreational and fishery use under these adopted objectives. These water use objectives served as the basis for the evaluation in this report of the adequacy of existing levels of water quality in the lakes and the streams of the Region.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 5

WATER QUALITY STANDARDS FOR SOUTHEASTERN WISCONSIN INLAND LAKES AND STREAMS

Name of the Stream	Water Use Objectives[a,b,c,d] Restricted Use	Fishery	Recreation	Water Quality Standards Temperature °F	Total Dissolved Solids mg/l	Dissolved Oxygen mg/l	pH Standard Units	Fecal Coliform MFFCC/100 ml	Misc. Parameters mg/l
Interstate Waters									
Des Plaines River	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Piscasaw Creek	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Nippersink Creek	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Turtle Creek (upstream of the Rock-Walworth County)	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Dutch Gap Canal	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Trevor Creek	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Fox River	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Benet/Shangrila Lakes	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Cross Lake	--	X	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]
Elizabeth Lake	--	X	X	--[e,f]	--	5.0 min	6.0-9.0[g]	200-400[h]	--[i,j]
Rock River	--	X	X	--[e,f]	--	5.0 min	6.0-9.0[g]	200-400[h]	--[i,j,k]
Intrastate Waters									
Underwood Creek in Milwaukee and Waukesha Counties below Juneau Boulevard	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Barnes Creek in Kenosha County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Pike Creek in Kenosha County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Pike River in Racine County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Indian Creek in Milwaukee County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Honey Creek in Milwaukee County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Menomonee River in Milwaukee County below the confluence with Honey Creek	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Kinnickinnic River in Milwaukee County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Lincoln Creek in Milwaukee County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Sussex Creek in Waukesha County	X	--	--	--[e]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Milwaukee River in Milwaukee County downstream from North Avenue from North Avenue Dam	X	--	--	--[e,f]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
South Menomonee Canal and Burnham Canal in Milwaukee County	X	--	--	--[e,f]	--	2.0 min.	6.0-9.0[g]	1,000-2,000[l]	--[i]
Palmer Creek in Kenosha County	--	X[m]	X	--[e,f,h]	--	6.0 min.[o]	6.0-9.0[g]	--	--[i]
Bluff Creek T4N, R15E, S. 13 and S. 14 in Walworth County	--	X[m]	X	--[e,f,n]	--	6.0 min.[o]	6.0-9.0[g]	--	--[i,p]
Allenton Creek, above S. 2, T11N, R18E, Washington County	--	X[m]	X	--[e,f,n]	--	6.0 min.[o]	6.0-9.0[g]	--	--[i,p]
Scuppernong Creek and tributaries, above Hwy. 2, Waukesha County	--	X[m]	X	--[e,f,n]	--	6.0 min.[o]	6.0-9.0[g]	--	--[i,p]
Mouths of Pike River, Root River, Oak Creek, and Sauk Creek	--	X[q]	X	--[e,f]	--	5.0[a] min.	6.0-9.0[g]	--	--[i,j]
All other streams and lakes in the Region	--	X[q]	X	--[e,f]	--	5.0 min.	6.0-9.0[g]	200-400[h]	--[i,j]

Table 5 (continued)

[a] *Single numbers are maximum permissible values except where minimum limits are denoted by the subscript Min.*

[b] *All waters shall meet the following conditions at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life. The standards shall apply at all times except (a) during periods when flows are less than the average minimum seven-day low flow, which occurs once in 10 years (seven-day Q_{10}), and (b) in channels which convey a treated effluent to natural surface waters. In determining the seven-day Q_{10} flow, consideration will be given to streams subject to hydraulically altered flow regimes.*

[c] *Lake Michigan thermal discharge standards, which are intended to minimize the effects on aquatic biota, apply to facilities discharging heated water directly to Lake Michigan excluding that from municipal waste and water treatment plants and vessels or ships. Such discharges shall not raise the temperature of Lake Michigan at the boundary of the mixing zone established by the Wisconsin Department of Natural Resources by more than 3°F and, except for the Milwaukee and Port Washington Harbors, thermal discharges shall not increase the temperature of Lake Michigan at the boundary of the established mixing zones during the following months above the following limits:*

January, February, March	*45°F*
April	*55°F*
May	*60°F*
June	*70°F*
July, August, September	*80°F*
October	*65°F*
November	*60°F*
December	*50°F*

[d] *Except for natural conditions, all surface waters (lakes and streams) classified for fish and aquatic life shall meet the required water quality standards of the State.*

[e] *There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 5°F for streams and 3°F for lakes.*

[f] *The temperature shall not exceed 89°F for warm water fish.*

[g] *The pH shall be within the range of 6.0-9.0 with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.*

[h] *Shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.*

[i] *Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. Questions concerning the permissible levels, or changes in the same, of a substance or combination of substances of undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria, report of the National Technical Advisory Committee to the Secretary of the Interior, April 1, 1968. The Committee's recommendations will also be used as guidelines in other aspects where recommendations may be applicable.*

[j] *A sanitary survey and/or evaluation to assure protection from fecal contamination is the chief criterion in determining the suitability of a surface water for recreational use.*

[k] *Hydropower.*

[l] *Shall not exceed a monthly geometric mean of 1,000 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 2,000 per 100 ml in more than 10 percent of all samples during any month.*

[m] *Stream classified as trout waters by the DNR (Wisconsin Trout Streams, publication 213-72).*

[n] *There shall be no significant artificial increases in temperature where natural trout reproduction is to be protected.*

[o] *Dissolved oxygen shall not be lowered to less than 7.0 mg/l during the spawning season.*

[p] *Streams classified as trout waters by the DNR (Wisconsin Trout Streams, publication 213-72) shall not be altered from natural background by effluents that influence the stream environment to such an extent that trout populations are adversely affected.*

[q] *The dissolved oxygen in the Great Lakes tributaries used by stocked salmonids for spawning runs shall not be lowered below natural background during the period of habitation.*

Source: SEWRPC.

these classifications and the classification for fish and aquatic life, a classification for wastewater treatment lagoons as surface waters of the State was identified in the standards revisions of September 1976. Although these new classifications of streams and the attendant water quality criteria may reduce the requirements to be imposed upon dischargers, the analysis of this report, which reviews water quality data for the period from the Commission's benchmark water quality monitoring survey up to the water quality data collected during 1975, must consider the applicable water quality standards of the time of the study and therefore do not include the variances cited here. For that reason they have not been analyzed, and their impact on the dischargers' performance has not been analyzed in this report but is addressed under the Commission's Planning Report 30 entitled, An Areawide Water Quality Management Plan for Southeastern Wisconsin.

As noted above, the revisions establish a two-step classification system, by which a stream is classified according to its value as an aquatic life resource. The greater a stream's inherent potential for supporting diverse aquatic organisms, the more restrictive the effluent requirements would be. Where deemed necessary, a full-scale allocation of waste loading would be provided on the basis of detailed field investigations by the Wisconsin Department of Natural Resources staff. The first step in the classification would identify a reach of stream as a member of one of the following hydrologic categories:

Table 6

APPLICABLE WATER QUALITY STANDARDS FOR SMALL STREAMS WITH INHERENTLY LIMITED WATER QUALITY

Category	Hydrologic Classification	Water Quality Standards			
		Dissolved Oxygen mg/l—Minimum Daily Average	Chlorine mg/l—Maximum Permissible	Ammonia N mg/l	Other Parameters
Intermediate Aquatic Life (surface waters not supporting a balanced aquatic community)	Continuous Streams Noncontinuous Streams	3.0	0.75	3-6[a]	--[b,c,d]
Marginal Uses (surface waters supporting only the most tolerant life forms)	Continuous Streams Noncontinuous Streams Waste Effluent Channel Wetland or Diffuse Surface Waters	2.0	0.75	--[e]	--[b,d,f]

NOTES: [a] *Ammonia nitrogen (as N) at all points shall not be greater than 3 mg/l during warm temperature and shall not be greater than 6 mg/l during cold temperature.*

[b] *(a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State.*

(b) Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in waters of the State.

(c) Materials producing color, odor, taste, or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the State.

(d) Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.

[c] *The effluent limitations determined necessary to meet the water quality standard is given below.*

Parameter	*Monthly Average (mg/l)*	*Weekly Average (mg/l)*	*Minimum (mg/l)*
BOD_5	20	30	--
Total Suspended Solids	20	30	--
Dissolved Oxygen	--	--	4

[d] *In addition to the effluent limitations above, any other effluent limitations necessary to protect assigned uses shall be met.*

[e] *No standards.*

[f] *The effluent limitations determined necessary to meet the water quality standard is given below.*

Parameter	*Monthly Average (mg/l)*	*Daily Maximum (mg/l)*	*Weekly Average (mg/l)*	*Minimum (mg/l)*
BOD_5	15	30	--	--
Total Suspended Solids	20	30	--	--
NH^3-N				
(May-October)	--	--	3	--
NH^3-N				
(November-April)	--	--	6	--
Dissolved Oxygen	--	--	--	4

Source: SEWRPC.

a. Lakes or flowages—This proposed classification includes bodies of water in which current is generally stagnant or which lack a unidirectional current.

b. Diffused surface waters—This classification includes any water from rains, intermittent springs or melting snow which flows on the land surface, or through ravines which are usually dry except at times of storm water runoff. This category does not include waters on the land surface in the vicinity of agricultural or wastewater irrigation disposal systems.

c. Wastewater effluent channels—This classification includes discharge conveyances constructed for the transport of wastes from a treatment facility to a point of discharge. Drainage ditches constructed primarily for the purpose of relieving excess waters on agricultural lands are explicitly excluded from this category, as are modifications made to natural watercourses for the purpose of increasing or enhancing the natural flow characteristics of a stream.

d. Noncontinuous streams—This classification includes watercourses with a defined stream channel, but with a natural seven-day Q_{10} flow of less than 0.1 cfs and would not be continuously met without the wastewater flow contribution.

e. Continuous streams—This classification includes watercourses which have a natural one-in-10-years, seven-day average, low flow ($Q_{7,10}$) of greater than 0.1 cfs, which exhibit characteristics of a perpetually wet environment, and are capable of supporting diverse aquatic biota and flow in a defined stream channel.

The second step in stream classification is the assignment of one of three additional levels of water quality based upon the ability of the stream to support various types of aquatic life. One category (intermediate aquatic life) permits a variance for those surface waters which can support some aquatic life, but which will not support the more intolerant organisms, such as trout. This category applies to either the continuous or noncontinuous stream hydrologic classification. The water quality criteria applicable to this category of surface waters are presented in Table 6. The minimum dissolved oxygen concentration required (3.0 mg/l) will support a variety of insect life and forage fishes. Ammonia levels, a critical toxicant below wastewater effluent discharge points, must be controlled to prevent acute toxicity and to reduce the amount of chloramine formation. Chloramines retain their toxicity for a longer period of time and therefore the zone of influence will be reduced by the removal of the ammonia. The second category (marginal uses) does not envision the sustenance of other than the most tolerant life forms. The primary criterion in this case is to maintain a level of water quality adequate to protect public rights. This category applies to the continuous or noncontinuous stream hydrologic classification, as well as all surface waters classified as effluent channel, wetland or diffuse surface waters. Table 6 presents the water quality standards applicable to this category of surface waters. The third category includes the continuous streams and lakes or flowages which can support fish and aquatic life. For this category, the effluent criteria is determined by the wasteload allocation for organic material, toxicants, and chlorine residuals.

The municipal effluent discharges to streams which have been identified as appropriate for water quality standards changes in accordance with the 1976 water quality standards revisions are listed below:

City of Muskego Sewage Treatment Plant
Salem Utility District No. 1
Village of Slinger Sewage Treatment Plant
Village of Sturtevant Sewage Treatment Plant
Village of Union Grove Sewage Treatment Plant

In addition 34 municipal and industrial wastewater receiving streams may eventually be affected by this variance technique. They are presented on Map 5.

Nutrient Concentrations Used for Assessment of Water Quality

The official water quality standards set forth by the State of Wisconsin Department of Natural Resources in the Wisconsin Administrative Code do not identify numeric criteria for the acceptable levels of nitrogen or phosphorus. Instead, the state rules say that Water Quality Criteria, a 1968 report by the National Technical Advisory Committee to the Secretary of the Interior, will be used as the basis for standards. In practice, the DNR staff has also used succeeding versions of this report, prepared by the National Academy of Sciences (1973) and the U. S. Environmental Protection Agency (1976) under the mandates of PL 92-500. The reference documents contain the best available scientific assessment of the effects of different levels of individual water pollutants on aquatic organisms and public health. For each pollutant addressed, the most reliable research findings are reported in those documents. In order to develop a meaningful trend analysis of the available water quality data, it was necessary for the Commission staff to specify numeric criteria for those pollutants.

Stated in the reference document as "a desired goal" for flowing streams is the maintenance of total phosphorus concentrations at or below 0.1 mg/l.[2] For nitrogen, no specific value is given for flowing streams: total inorganic nitrogen concentrations—including nitrate, nitrite, and ammonia—of 0.3 mg/l or greater in lakes are noted to be associated with nuisance aquatic growth if other necessary nutrients are present.[3] Because flowing waters

[2] *Water Quality Criteria, p. 53.*

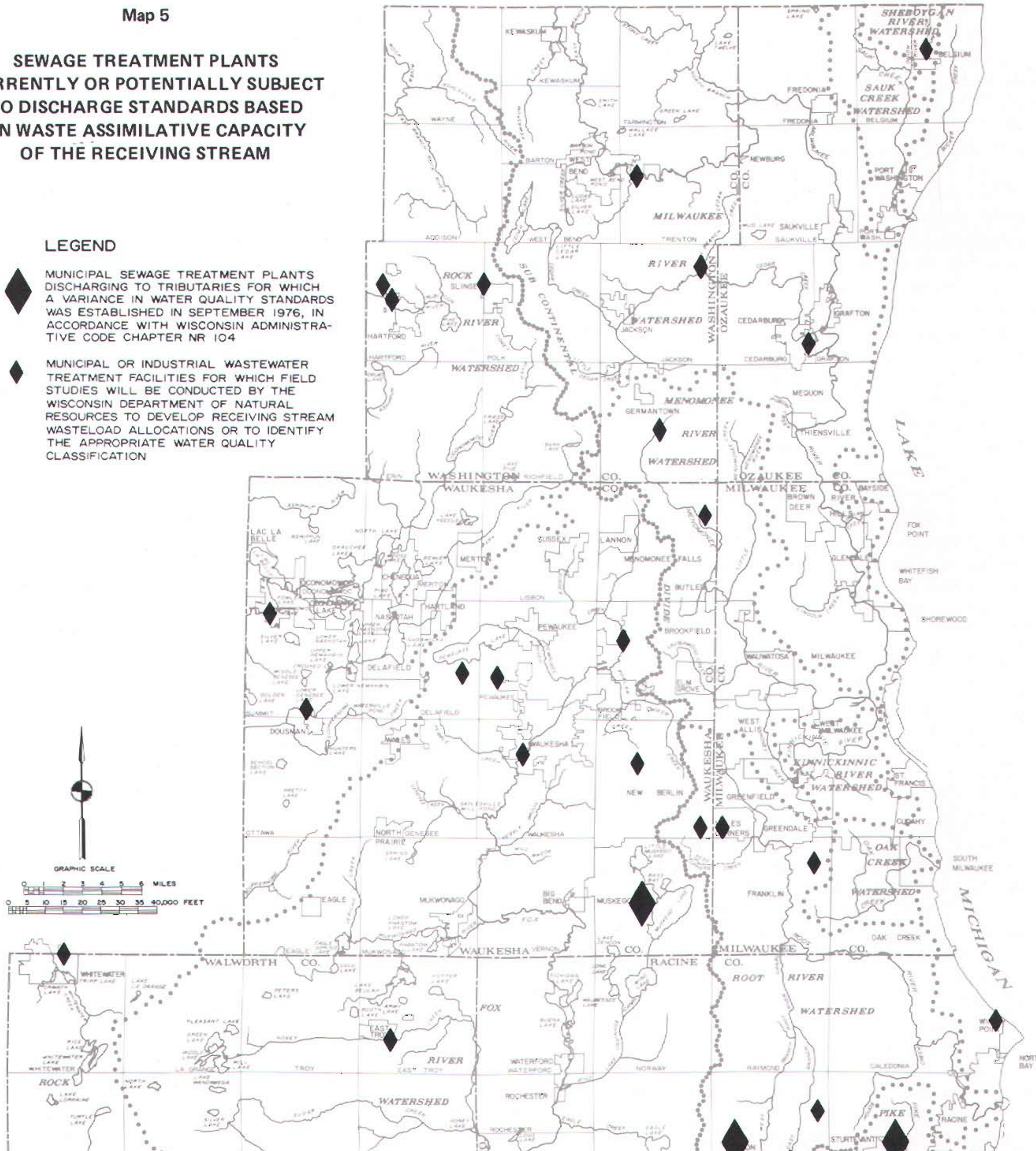
[3] *C. N. Sawyer; "Fertilization of Lakes by Agricultural and Urban Drainage," Journal New England Water Works Association, Vol. 61, 1947.*

Map 5

SEWAGE TREATMENT PLANTS CURRENTLY OR POTENTIALLY SUBJECT TO DISCHARGE STANDARDS BASED ON WASTE ASSIMILATIVE CAPACITY OF THE RECEIVING STREAM

LEGEND

- (large diamond) MUNICIPAL SEWAGE TREATMENT PLANTS DISCHARGING TO TRIBUTARIES FOR WHICH A VARIANCE IN WATER QUALITY STANDARDS WAS ESTABLISHED IN SEPTEMBER 1976, IN ACCORDANCE WITH WISCONSIN ADMINISTRATIVE CODE CHAPTER NR 104
- (small diamond) MUNICIPAL OR INDUSTRIAL WASTEWATER TREATMENT FACILITIES FOR WHICH FIELD STUDIES WILL BE CONDUCTED BY THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES TO DEVELOP RECEIVING STREAM WASTELOAD ALLOCATIONS OR TO IDENTIFY THE APPROPRIATE WATER QUALITY CLASSIFICATION



In September 1976 the Department of Natural Resources developed a system of variances in water quality standards suitable for small streams with water quality limited by the presence of inplace pollutants, low natural streamflow, natural background conditions, and irretrievable cultural alterations. In addition to the variance categories, a classification was established for the protection of surface waters significant for the environmental integrity of the State or Region. Effluent limitations were established for such surface waters as trout streams, scientific areas, wild and scenic areas, and areas that provide endangered species habitat or exceptionally high recreation potential. There are 39 municipal and industrial wastewater dischrges in southeastern Wisconsin located near streams that are potentially subject to these regulations.

Source: SEWRPC.

are held to be less sensitive than quiescent waters to the stimulation of aquatic plant growth by high nutrient levels, and because nitrate-nitrogen was the dominant nitrogen form present and was more generally reported in the Commission sampling program results than was total inorganic nitrogen, the Commission staff compared only the nitrate-nitrogen component of the total inorganic nitrogen to this recommended maximum concentration in assessing stream water quality conditions. This was also deemed reasonable since the nitrite form is rapidly converted to nitrate in most natural waters and constituted generally a very small proportion of total nitrogen when the sample results were available for total nitrogen and its constituents. Nitrite was usually about 5 to 10 percent of total nitrogen. Ammonia, on the other hand, typically constituted about 20 to 50 percent of the total nitrogen, but was not available for plant growth until it was oxidized to nitrite and nitrate. Ammonia is also known to be rendered unavailable in some circumstances through the formation of chloramines, when free residual chlorine is present. In lakes the longer residence time of the water assures that this eventually will occur, but in streams only the existing nitrate is immediately available to plant growth.

SUMMARY

The 10 major water uses of the Region are municipal water supply, industrial water supply, cooling water, aesthetics, livestock and wildlife watering, irrigation, preservation and enhancement of aquatic life, recreation, commercial navigation, and waste assimilation. The municipal water supplies of the Region are presently obtained both from Lake Michigan and groundwater sources. The industrial water supply of the Region can be classified into three major use categories of (a) boiler feed water, (b) process water and (c) general purpose water. The major water using industries in the Region include baking, brewing, carbonate beverage manufacturing, dairy, food canning and freezing, laundering and tanning. The wide variety of industrial water uses correspondingly includes a wide range of quality requirements for water supply. The principal types of cooling water systems in use in the Region are (1) the once-through system, (2) the open recirculating system, and (3) the closed recirculating system. Engine jacket systems, condensers, air conditioning, refrigeration systems, and a large number of industrial operations require water in the cooling process. The waste assimilative capacity of the streams of the Region may be measured in terms of the amount of degradable and nondegradable wastes that can be carried in solution or suspension by the stream. The suitability of water for irrigation depends on soil characteristics, on the types of plants to be irrigated, and on the quality of the irrigation water. In southeastern Wisconsin four to six inches of irrigation water are applied to most crops in an average year. This is equivalent to approximately 136,000 gallons per irrigated acre per year. The factors that affect the water source for its use in livestock and wildlife watering are its chemical composition, the toxic nature of the organic and inorganic substances present, pH, temperature, and pathogenic microorganisms that may be present. In addition, the high concentration of total dissolved solids, the presence of certain species of algae and protozoa, and oily substances may affect the use of water for livestock and wildlife watering. The significance of use of surface water in the Region for fish and related aquatic life lies in the aesthetic and recreational values that they offer to the sports fisherman, the vacationer, and to the adult and child who enjoy nature in the course of their daily experiences. In streams, lakes, or impoundments, the type of organism and their population density in a river provide a good condition of the prevailing level of the water quality since it reflects the extent and degree of pollution, the degree of self-purification, and the water use potential. Surface waters subjected to excessive loads of oxygen demanding substances and nutrients usually have a large population of a few species and unpolluted waters usually support a large number of different species, with relatively few individuals representing a particular species. The predominant recreational use of the streams of the Region is fishing. While swimming and bathing in the streams is now uncommon within the Region, picnic areas adjacent to streams are becoming increasingly numerous. The four port cities namely, Milwaukee, Racine, Kenosha, and Port Washington serve users of the Upper Great Lakes and the St. Lawrence Seaway. The Milwaukee River, the Menomonee River and the Kinnickinnic River are navigable by large commercial vessels, and the Root River and Pike River are navigable by large pleasure crafts for about one-half to one mile upstream from their mouths. In southeastern Wisconsin, where 40 percent of the state population lives in 5 percent of the land area of the State, the activities of man have caused undesirable changes in both the number and kind of fish that occur in the streams, occasional severe fish kills, accelerated nutrient enrichment giving rise to unsightly or odoriferous algal blooms and increased pollution loads that adversely affect extensive reaches of many streams.

The Federal Water Pollution Control Act of 1965 and the Federal Water Pollution Control Act Amendments of 1972 require that all the states establish water quality standards for interstate waters. The 1972 Amendments to the Act also require that the water quality standards be reviewed at least every three years and revised if necessary. Although the Commission has no authority to establish, or enforce the water quality standards in the Region, the technical information provided by the Commission in Water Quality and Flow of Streams in Southeastern Wisconsin, Technical Report No. 4, was considered and utilized by the State in the preparation of the receiving water quality standards. The revised water quality standards of 1972 have been formulated for the restricted water use, public water supply, maintenance of a warm water fishery, and recreational use. The water use related to aesthetics provides minimum standards for all waters. No water quality standards have been formulated for commercial shipping and navigation. In southeastern Wisconsin, except for natural conditions, all of the interstate and most of the intrastate surface waters (lakes and streams) are required to meet the standards for recreational use and maintenance of fish and aquatic life. Less stringent, restricted water use standards are applicable to Underwood Creek in Milwaukee and Waukesha Counties below Juneau Boulevard, Barnes Creek, and Pike Creek in Kenosha County, Pike River in Kenosha County, Indian Creek, Honey Creek, Kinnickinnic River, and Lincoln Creek in Milwaukee County, Menomonee River in Milwaukee County below the confluence with Honey Creek and Sussex Creek in Waukesha County. The water quality of the Milwaukee River in Milwaukee County downstream from North Avenue Dam should meet the restricted water use standards and in addition, the temperature of the mixing zones should not exceed 89°F at any time.

The streams of the Region that are classified as trout waters are Palmer Creek in Kenosha County, Bluff Creek in Walworth County, Allenton Creek in Washington County and Scuppernong River in Waukesha County. For these waters the required water quality standards are those of fish and aquatic life except for a higher dissolved oxygen minimum of 6.0 mg/l and during spawning season, a minimum of 7.0 mg/l of dissolved oxygen. The effluents entering the trout streams must be such that the trout populations are not adversely affected.

In September of 1976, the Department of Natural Resources established a classification of these small streams to identify their hydrologic characteristics and the water quality classification which can be achieved in these streams when natural background conditions, in-place pollutants, low streamflows and irretrievable cultural commitments are considered. This allows for a reduction in the required levels of water quality standards where necessary, and establishes effluent criteria for dischargers whose wastes enter watercourses not able to achieve fish and aquatic life use standards. As of September 1976, five streams receiving municipal wastewater discharges had been assigned to water quality classifications less stringent than fish and aquatic life, and 34 receiving streams had been identified by the Department of Natural Resources as being potentially affected in similar fashion.

Chapter V

WATER QUALITY PARAMETERS

INTRODUCTION

Chemical, physical, and bacteriological tests of representative water samples are used to evaluate the water quality of lakes and streams. These tests, or analyses, are developed for the specific purpose of measuring the quantity or concentration of a given element or compound, physical property, or organism present in a given quantity of sampled water. The elements or compounds in solution or suspension in water, the macroscopic and microscopic organisms, and the chemical and physical properties of water are commonly referred to as "parameters"; and the quantity or concentration of the parameters is expressed on a numerical scale.

There are hundreds of possible water quality parameters available for study; and this number can be expected to increase as new processes, products, and materials are developed by a highly industrialized and technological society. Water quality analyses generally are expensive to perform and often time consuming. A water quality surveillance must, therefore, of necessity select for determination from the hundreds of possible parameters those specific parameters which best meet the objectives of the study and the numeric values of which are most useful as indicators of the suitability of the water quality for the intended water uses.[1]

STREAM QUALITY PARAMETERS SELECTED IN 1964-1965 STUDY

A study of the water quality and flow of streams in southeastern Wisconsin was undertaken by the Commission in 1964 to evaluate the then-existing condition of stream water quality in relation to pollution sources, land use, and population distribution and concentration. To describe the physical, chemical, and bacteriological stream water quality, 34 parameters were chosen, and are listed below:

1. Silica
2. Iron
3. Manganese
4. Chromium
5. Hexavalent chromium
6. Calcium
7. Magnesium
8. Sodium (and potassium)
9. Bicarbonate
10. Carbonate
11. Sulfate
12. Chloride
13. Fluoride
14. Nitrite
15. Nitrate
16. Total Phosphorus
17. Cyanide
18. Oil
19. Detergents (alkyl benzene sulfonate)
20. Dissolved solids
21. Hardness
22. Noncarbonate hardness
23. Calcium hardness
24. Magnesium hardness
25. Alkalinity P
26. Alkalinity M
27. Specific conductance at 25°C
28. Hydrogen ion (pH)
29. Color
30. Turbidity

[1] *As a result of the application of new techniques, the number of water quality laboratory analyses is constantly growing. Gas chromatography, electron microscopy, spectrophotometry, and many other techniques are finding increased use in water quality testing. However, unless a newly developed water quality parameter has been shown to correlate significantly not only with in-stream water quality conditions but also with water use objectives related to those conditions, it cannot be considered appropriate in a long-range monitoring program.*

31. Dissolved oxygen

32. Temperature

33. Biochemical oxygen demand

34. Total coliform count

After one year of intensive monthly sampling of the streams of the Region, the background concentrations of the 34 parameters in the streams of the Region were evaluated. The decision was then made to discontinue testing for some of the parameters in the Commission's long-term water quality monitoring program. The total hardness in the streams of the Region was found to lie within the range that would be expected for the Region given its physiographic characteristics. Therefore, the measurement of total hardness, noncarbonate hardness, calcium hardness, magnesium hardness, calcium, magnesium, alkalinity P, alkalinity M, bicarbonate and carbonate—all of which are interrelated with hardness—was discontinued. Since there is a close relationship between specific conductance and dissolved solids, and since specific conductance is more readily measurable, the testing for dissolved solids also was discontinued. The average and maximum values observed for chromium and fluoride concentrations over the one year period of the Commission's benchmark study were less than the 1962 drinking water standards which were applicable at the time, and were expected to remain low unless there was a change in the external sources. Chromium and fluoride were therefore dropped from the list of parameters for the long-term water quality monitoring program. Although no water quality standards were available to compare, the range and average concentrations of silica, hexavalent chromium, and oil were sufficiently low in the streams of the Region to discontinue their monitoring for a period of time. In addition, the following nine water quality parameters had to be discontinued due to the lack of availability of laboratory space and due to the relatively high cost of analysis: iron, manganese, sulfate, color, turbidity, cyanide, detergents, sodium, and biochemical oxygen demand.

STREAM QUALITY PARAMETERS SELECTED IN THE LONG-TERM MONITORING PROGRAM

Of the 34 water quality parameters chosen for study in the 1964-1965 benchmark study, the following nine continued to be measured under the continuing regional stream water quality monitoring program:

1. Temperature

2. Dissolved oxygen

3. Hydrogen ion concentration (pH)

4. Specific conductance at 25°C

5. Total phosphorus

6. Nitrate

7. Nitrite

8. Chloride

9. Total coliform count

From 1964 through 1969, total coliform counts were made on water samples as a measure of the bacteriological characteristics of the stream samples. An improved method for the measurement of bacteriological characteristics of water was introduced in 1968. The test, which determines fecal coliform counts, has since replaced the total coliform counts in the stream water quality monitoring program. The fecal coliform counts indicate the presence of fecal materials from warm blooded animals, and consequently provide a more direct indication of the possible presence of pathogenic bacteria.

Of the nine water quality parameters that were selected for measurement in the continuing stream water quality monitoring program, four—temperature, dissolved oxygen, pH and fecal coliform counts—were selected to permit comparison of the concentrations in the streams of southeastern Wisconsin with water quality standards associated with water use objectives as adopted by the State of Wisconsin. The other five parameters—specific conductance, phosphorus, nitrate, nitrite, and chloride—were selected in order to permit identification of changes in water quality related to other water use objectives and associated water pollution problems identified by the Commission. As stated above, specific conductance was included in the monitored parameters as an indicator of the dissolved solids concentration in the stream waters. Any drastic change in a dissolved constituent will be reflected in the specific conductance value and consequently in the total dissolved solids concentration. Such a change in dissolved solids concentrations would be indicative of additional pollution and of the need for more detailed investigation of the sources.

Chlorides are generally nonreactive ions, the concentrations of which should remain unchanged in stream and lake water over time, if more chlorides are not added externally. Any change in chloride concentration would be an indication of additional pollution, particularly from domestic wastes, municipal sewage, and certain industrial wastes and from agricultural drainage and urban runoff containing salts applied to roads for winter maintenance.

Nitrogen and phosphorus compounds are cited as the primary cause of eutrophication problems in lakes and streams. These compounds, known as nutrients, are necessary for the growth of plants. While a certain amount of these nutrients is desirable to produce a balanced aquatic flora and fauna, excessive fertilization produces large growths of algae, rooted aquatic plants, and other organisms which inhibit desirable forms of aquatic life (including fish), limit recreational activities, and create an aesthetic nuisance.

In addition to the continuation of measurement of nitrate and nitrite nitrogen and measurement of total phosphorus, analyses for the following four parameters were added to the monitoring program in 1972 in order to permit a better evaluation of the total nutrient input into the surface waters of the Region: ammonia nitrogen, organic nitrogen, total nitrogen, and soluble orthophosphate.

Thus, the 10-year stream water quality monitoring program of the Commission included the measurement of 13 water quality parameters. In the following section, each of the 13 parameters is defined and its significance is described in the determination of water quality and its relationship to the beneficial use of the streams and lakes of the Region. Although the Commission long-term stream water quality monitoring program did not include the analysis of biochemical oxygen demand (BOD), a discussion on BOD also is included in the following section. The five-day BOD test results from the Wisconsin Department of Natural Resources basin surveys and monthly monitoring programs were available and provide another measure useful in better understanding surface water quality conditions and particularly sources of pollution within the Region.

WATER QUALITY PARAMETERS

Temperature

The temperature of a stream or lake is a measure of its heat energy as expressed in degrees Fahrenheit or degrees Centigrade. Natural stream and lake temperatures in southeastern Wisconsin ultimately are controlled by climatic conditions through the heat exchange between a stream or lake and its land and atmospheric environment, rather than by subterranean thermal sources.

The most important natural factor affecting stream and lake water temperature is sunlight. The direct penetration of sun rays into a stream or lake results in the conversion of electromagnetic waves to heat energy, facilitated by turbidity. The width, depth, volume, and velocity of a stream and the area and depth of a lake determine to a large extent how the stream or lake temperature will be affected by sunshine. The warming of a stream or lake depends upon the quantity of water being exposed to a given intensity of sunshine over a given area of exposure. Trees growing at and near the water's edge and extending leaf-filled branches over the stream or lake may intercept sunshine, which is then unavailable to warm the stream or lake water. Cloud cover and haze may weaken solar radiation. Daily and seasonal changes in radiation intensities result in diurnal and seasonal fluctuations in water temperatures under the influence of other environmental factors.

Significant among other environmental factors is the temperature of groundwater that is discharged by seepage and by springs into the stream channel or lake bed from intersected water-bearing rock units or from temporary bank storage built up during periods of higher stream or lake stage at the then prevailing water temperature. Groundwater makes up part or almost all the waters of the stream or lake, depending upon the frequency and intensity of precipitation and surface runoff that would not only add to the flow but also affect the stream temperature. Groundwater temperatures in the glacial drift and Niagara aquifer, which contribute flow to the streams and water to the lakes of southeastern Wisconsin, generally range from 48°F to 52°F with an average of 51°F.

Air temperature, humidity, and velocity also affect stream and lake temperatures. Wave action caused by air in motion creates a larger contact surface between the water and the atmosphere, facilitating more rapid heat exchange. Air humidity affects vapor pressure and the rates of evaporation from the stream surface which, in turn, affect water temperature.

In addition to the climatic conditions that affect the natural stream and lake temperature, hot liquid wastes from industry, and spent cooling water discharges can affect stream and lake temperatures. The effluent from sewage treatment plants also may affect stream temperature; although, because of the relatively low temperature of municipal sewage, this effect is not normally severe.

Temperature is an important water quality parameter for several water uses. The suitability of water for general industrial processing, for cooling purposes, and for sustenance of aquatic life depends, in part, upon the temperature of water. Water for drinking purposes usually is satisfactory at 50°F but generally causes complaints at 66°F or above.

The elevation of stream and lake water temperature causes many pollution problems. Increased water temperature stimulates growth of taste and odor producing organisms. Higher temperatures diminish the solubility of dissolved oxygen and thus decrease the availability of this essential gas in the stream and lake water. Elevated temperatures increase the metabolism and respiration of fish and other aquatic life, approximately doubling the respiration rate for every 10°C rise in temperature. Hence, the demand for oxygen is increased at higher temperatures under conditions where the oxygen supply is low because of decreased solubility of this gas. Many toxic substances such as cyanide phenol, xylene, and zinc exhibit increased toxicity at elevated temperatures. Higher temperatures favor the growth of sewage bacteria and putrefaction of sludge deposits and work against the maintenance of desirable forms of aquatic life. Even with adequate dissolved oxygen and absence of any toxic substance, there is a maximum temperature that each species of fish or other aquatic organism can tolerate; the exposure of an organism to the temperature in excess of this maximum usually results in the death of the organism within 24 hours. For each organism there is not only a thermal death point but also a range of temperature for optimum growth. Thus, temperature is one of the important environmental factors that determines which organisms will thrive and which will diminish in number and size.

Increased temperature may be beneficial to the recreational use of a stream or lake by lengthening the swimming period. Elevated temperatures stimulate the decomposition of sludge, multiplication of bacteria and fungi, and the consumption of oxygen by the decomposition of organic materials, thus affecting the aesthetic value of the watercourse.

The maximum, average, and minimum water temperatures found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 90°, 72.2°, and 46°F, respectively. The maximum temperature of 90°F occurred on the Des Plaines River at station Dp-3 on August 10, 1970, in the Des Plaines River watershed. The minimum temperature of 46°F occurred on the Pike Creek at station Pk-2 on August 17, 1968, in the Pike River watershed. The ranges in water temperatures by watersheds are listed in Table 7.

Specific Conductance: The specific conductance of water is a measure of its ability to conduct an electric current. Conductance is the reciprocal of electric resistance and is expressed in micromhos, the reciprocal of the units of electric resistance, which is expressed in ohms. The specific conductance of water is expressed in micromhos because of the very low conductivity of most natural water, one micromho being one-millionth of a mho. The property of electrical conductance is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made. The nature of the various dissolved substances and their actual and relative concentrations affect the specific conductance values. Natural water contains inorganic and organic substances, both in ionized and un-ionized forms. It is the ionized substances that conduct electric current. Any increase in mineralization, ionization, or water temperature causes an increase in electrical conductivity. To obtain comparable results in the measurement of specific conductance of stream samples, specific conductance is most commonly referred to at a "standard" temperature of 25°C (77°F).

Specific conductance provides a means for quickly estimating the amount of dissolved ionic substances present in water samples. By multiplying the specific conductance value by an empirical factor, the amount of dissolved ionic substances can be estimated. This factor may vary from 0.55 to 0.90, depending on the soluble components of a particular water and the temperature of the measurement of specific conductance. Any significant change in the inflow of wastewater into the stream or lake water, will change the dissolved solid input into the stream or lake and will be reflected in the specific conductance values.

All dissolved substances in stream and lake water collectively exert osmotic pressure on the organisms living in it, and the aquatic life adapts itself to the conditions imposed by the dissolved constituents. Most species tolerate some changes in the relative amounts of dissolved constituents normally present, if the total concentration is not exceeded. However, wide variations in the total dissolved solids or in the concentrations of individual salts can have adverse effects upon stream flora and fauna, sometimes resulting in the elimination of some species.

Most raw and finished waters in the United States exhibit a specific conductance from 50 to 500 micromhos per centimeter (micromhos cm), with highly mineralized water being in the range of 500 to 1,000 micromhos/cm and even higher. Some industrial wastes may have specific conductance values in excess of 10,000 micromhos/cm.

The maximum, average, and minimum specific conductance found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 3,000, 791, and 119 micromhos/cm at 25°C, respectively. The maximum specific conductance of 3,000 micromhos/cm at 25°C occurred on the Rubicon River at station Rk-4 on August 13, 1970, in the Rock River watershed. The minimum specific conductance of 119 micromhos/cm occurred on the Wind Lake Drainage Canal at station Fx-16 on August 13, 1968, at 25°C in the Fox River watershed. The ranges in specific conductance by watersheds are listed in Table 8.

Table 7

TEMPERATURE OF STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Temperature in °F			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	90.0	70.1	51.0	90
Fox River	88.0	72.6	57.0	839
Kinnickinnc River. . .	86.0	75.9	70.0	30
Menomonee River. . .	88.0	73.5	59.0	359
Milwaukee River . . .	86.0	74.2	62.0	359
Minor Streams.	81.0	70.5	60.0	90
Oak Creek	81.0	73.4	66.5	60
Pike River	81.5	69.5	46.0	124
Rock River.	84.5	73.4	61.0	390
Root River.	87.0	74.4	59.5	180
Sauk Creek.	81.0	69.8	61.0	60
Sheboygan River . . .	80.0	69.1	64.0	30
Total Samples				2,611

Source: SEWRPC.

Table 8

SPECIFIC CONDUCTANCE IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Specific Conductance in Micromhos/cm at 25°C			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	1,300	858	553	87
Fox River	1,516	725	119	838
Kinnickinnc River. . .	962	744	560	30
Menomonee River. . .	1,605	881	229	359
Milwaukee River . . .	1,550	638	401	346
Minor Streams.	963	669	155	88
Oak Creek	1,720	1,067	609	60
Pike River	1,455	725	313	120
Rock River.	3,000	688	210	390
Root River.	1,614	953	607	48
Sauk Creek.	1,460	816	522	59
Sheboygan River . . .	1,041	735	569	30
Total Samples				2,455

Source: SEWRPC.

Hydrogen Ion Concentration (pH)

The hydrogen ion concentration of a solution is expressed in pH units which are equal to the logarithm of the reciprocal of the hydrogen ion concentration. This system of denotation was devised to avoid negative coefficients and numbers with many decimal places. The p stands for potenz, which is the German word for "power," and H is the chemical symbol for hydrogen. Thus a pH value of 7.0 is equal to a numerical value of 0.0000001 hydrogen ion concentration in grams per liter of solution. The pH scale ranges from 0 to 14, with 7.0 marking the neutral point between acids, with values of less than 7.0, and bases, with values of more than 7.0.

The value of the pH should not be confused with acidity and alkalinity. While pH is a measure of the hydrogen ion concentration, alkalinity is the sum of the bases present in water. Alkalinity is caused by the presence of carbonates, bicarbonates, hydroxides and, to a lesser extent, by the presence of borates, silicates, phosphates, and organic substances. Highly alkaline water need not have a high pH and vice versa. Thus, a water might have a pH value of 7.0, a neutral value, but a low total alkalinity; or a water might have a pH value of 6.0, acidic, but a high total alkalinity. Similarly, acidity, and pH are differentiated by the fact that the pH is a measure of the hydrogen ion concentrations and acidity is caused by the presence of free carbon dioxide, mineral acids such as sulphuric, weakly dissociated acids such as phosphoric, and salts of strong acids and weak bases.

The pH of water is one of the water quality parameters that is linked to the biological composition of communities and their life processes. Biological activities and the distribution of carbonic acid species (such as carbonates, bicarbonates) are the two important factors which affect the pH of water. For the streams containing calcareous sediments—sediments containing calcium carbonate, such as the streams of southeastern Wisconsin—the stream water may be expected to have carbonates and bicarbonates in solution. The pH of the stream water is determined by the uptake of hydrogen ions principally by bicarbonates to form carbonic acid and free carbon dioxide, and by the hydroxyl ions arising from the hydrolysis of the bicarbonate.

Carbonate-bicarbonate-carbonic acid mixtures share a remarkable and, for living organisms, important property of preventing major fluctuation in the pH of water. These mixtures of a weak acid and a salt (such as carbonic acid-bicarbonate-carbonate mixture) are known as "buffers" because of their ability to "absorb" pH effects of changed concentrations of other ions.

If a strong acid is added to distilled water, the pH of the distilled water would drop significantly. On the other hand, if a strong acid is added to a water containing a buffer such as a carbonate-bicarbonate-carbonic acid mixture, the pH of the water is altered very little. This is because the hydrogen ions added in the form of acid combine with the carbonate and bicarbonate in the stream water, reducing the amount of added hydrogen ion concentrations in the stream water. The carbonic acid formed in these reactions is only weakly dissociated and increases the number of hydrogen ions by only a slight amount, and therefore the pH of the solution is altered very little. The decrease in the pH value thus brought about is very small in proportion to the amount of acid added. This is another way of saying that the concentration of free ions is not greatly changed.

Biological activities, such as respiration and photosynthesis, also influence the pH of water. Respiration involves uptake of oxygen by the organisms and release of carbon dioxide. Photosynthesis involves uptake of carbon dioxide for the manufacture of food by plants and the release of oxygen. Both these processes influence the carbon dioxide present in water. The change in the carbon dioxide concentrations would increase or decrease the hydrogen ion concentration as shown in the equations 1, 2, and 3, and consequently affect the pH of water. An increase in carbon dioxide in water, such as through the respiration process, thus decreases the pH of water. Conversely, photosynthesis, which decreases the concentration of carbon dioxide in water, increases the pH of water.

Most natural waters have a pH in the range of five to nine units, and most sanitary wastewaters have neutral or slightly alkaline pH values. Many industrial wastes, on the other hand, can either be strongly alkaline or acidic. Among the acid wastes may be included tan liquors, acid dyes, coal mine drainage, sulphite waste liquors, pickling liquors, and some brewery wastes. Among the strongly alkaline wastes are soda- and sulphate-pulp rinse waters, laundry wastes, and bottle wash waters. The pH value of domestic water is important because it affects taste, corrosivity, efficiency of chlorination, and water supply treatment processes such as coagulation. The disinfecting efficiency of chlorine is known to diminish with increase in the pH of water, while high pH values favor corrosion control.

$$HCO_3^- + H^+ \rightleftharpoons H_2CO_3 \quad \ldots\ldots\ldots\ldots (1)$$

Bicarbonate/Hydrogen ions — Carbonic Acid

$$H_2CO_2 \rightleftharpoons H_2O + CO_2 \quad \ldots\ldots\ldots\ldots (2)$$

Carbonic Acid — Carbon Dioxide

$$CO_3^= + H_2O \rightleftharpoons HCO_3^- + OH^- \quad (3)$$

Carbonate — Bicarbonate + Hydroxyl ion

It has been found that direct lethal effects of pH on aquatic life are not produced within the range of five to 9.5 units. The permissible range of pH for fish and other aquatic organisms depends upon many other factors such as temperature, dissolved oxygen, prior acclimatization, and the content of various anions and cations. The toxicity of the compounds present in water may also vary with the change in the pH value.

The pH may affect swimming and other recreational uses of streams and lakes. The number of cases of eye irritation among swimmers in a controlled pool has been observed to increase when the pH of the water decreased from eight to seven units.

The maximum, average, and minimum pH values found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 9.3, 8.1, and 5.8, respectively. The maximum pH of 9.3 occurred on the Milwaukee River at station Ml-9 on August 12, 1970, in the Milwaukee River watershed. The minimum pH of 5.8 occurred on the Kinnickinnic River at station Kk-1 on August 12, 1970, in the Kinnickinnic River watershed. The ranges in pH values by watersheds are listed in Table 9.

Dissolved Oxygen

The natural dissolved oxygen concentration in a lake or stream is determined by a large number of interacting factors, which may be divided into three major categories: 1) physical, 2) chemical, and 3) biological. Important physical factors pertain to: the volume of water in the stream as evidenced by stream depth, cross-sectional area, and flow rate; stream turbulence induced by wind action or resulting from channel characteristics; stream temperature; atmospheric pressure; and the oxygen content of surface runoff, groundwater, and direct precipitation that contribute to the flow of the stream.

Table 9

HYDROGEN ION CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Hydrogen Ion (pH) Concentration in Units			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	8.7	8.1	7.6	66
Fox River	9.2	8.1	7.0	615
Kinnickinnic River . .	8.8	7.9	5.8	22
Menomonee River. . .	9.1	8.0	7.1	264
Milwaukee River . . .	9.3	8.3	7.4	264
Minor Streams.	8.8	8.1	7.3	66
Oak Creek	8.2	8.0	7.6	44
Pike River	9.0	8.0	7.5	92
Rock River.	9.2	8.1	6.0	286
Root River.	9.1	8.1	7.6	48
Sauk Creek.	9.0	8.2	7.6	44
Sheboygan River . . .	8.9	8.1	7.6	22
Total Samples				1,833

Source: SEWRPC.

Similarly the dissolved oxygen of a lake is affected by its volume and depth, its area, wave action, water temperature, and direct precipitation. Chemical factors affecting the dissolved oxygen concentration in a lake or a stream include: the dissolved solids content of the water and those chemical reactions that may occur in a stream or lake between the dissolved oxygen and the inorganic and organic substances in solution or suspension. The biological factors affecting the dissolved oxygen content include: the oxygen consumed in the respiration of aquatic animals and plants, and the daily variation of the dissolved oxygen content in the photosynthetic processes of aquatic plants. Dissolved oxygen concentration also is affected by the decomposition of organic matter by microorganisms.

Atmospheric oxygen is a major source of dissolved oxygen in streams and lakes. The solubility of oxygen in water is dependent upon its partial pressure, the temperature of water, and the presence of other salts in water. The solubility of oxygen in fresh waters decreases with an increase in temperature. The saturation value for dissolved oxygen in distilled water is 14.6 mg/l at $0^{\circ}C$ ($32^{\circ}F$), and the saturation concentration at $25^{\circ}C$ ($77^{\circ}F$) is only 8.4 mg/l. In lake waters the saturation value for dissolved oxygen is less than in distilled water, due to the presence of salts in the lake water.

The oxygen solubility varies directly with the atmospheric pressure at any given temperature. As the rates of biological oxidation increase with temperature and the solubility of dissolved oxygen decreases with increasing temperature, the most critical conditions related to dissolved oxygen deficiency occur during the summer months when temperatures are high and solubility of oxygen is at a minimum. However, dissolved oxygen depletion can also occur during winter, when ice cover with extensive snow accumulation interferes with the diffusion of oxygen from the atmosphere and prevents penetration of solar radiation for photosynthesis.

The presence of salts in water inversely affects the solubility of oxygen. Thus, a water having a high dissolved solids content will have a lower dissolved oxygen concentration at a particular temperature and atmospheric pressure than a water having a low dissolved solids content at the same temperature and pressure.

In addition to the atmosphere, as a source, photosynthesis by aquatic plants may represent a major source of dissolved oxygen in streams, lakes, and impoundments. The photosynthetic process of plants involves the combination of carbon dioxide with water in the presence of light energy, to form carbohydrate, and the reaction involves release of oxygen according to the following formula:

$$CO_2 + H_2O \xrightarrow{\text{light}} \text{Organic matter} + O_2$$

The release of oxygen during photosynthesis by aquatic plants increases the dissolved oxygen content of the stream significantly. The dissolved oxygen concentrations in streams are affected simultaneously by photosynthesis of plants and respiration of animals and plants. Photosynthesis is restricted to the green aquatic plants, and occurs during the daylight hours when the light energy is available. On the other hand, all animals and plants respire and the process goes on 24 hours a day regardless of the presence or absence of sunlight. The photosynthetic process releases oxygen and therefore increases the dissolved oxygen concentration in water, while the respiration process takes up oxygen from water, thus decreasing the dissolved oxygen concentration in water. There is a significant change in the dissolved oxygen concentrations of streams during a 24-hour period due to respiration and photosynthetic processes in the stream water. An example of the diurnal fluctuation of dissolved oxygen concentration is shown in Table 10, by data collected at station Rt-2 under the Commission's continuing water quality program.

It is sometimes possible for dissolved oxygen levels in surface water to exceed the saturation concentrations. Such a condition is known as supersaturation. Supersaturation occurs when the rate of photosynthetic oxygen production temporarily exceeds the rate at which oxygen is either consumed by biochemical process in the water or diffused into the atmosphere. Supersaturation is, however, a transient condition and disappears with mixing of the stream or lake water.

In addition to the process of respiration, bacterial degradation of organic matter decreases the dissolved oxygen concentrations in streams and lakes. The organic matter could originate from within stream or lake, as would dead fish or algae. Organic wastes from sewage treatment plants and other industries could provide an external source of oxidizable materials for growth of bacteria in water. The presence or the introduction of organic substances increases the bacterial activity in the stream or lake and decreases the concentration of dissolved oxygen. If the organic substances continue to enter the water in sufficient concentration, the dissolved oxygen content can be lowered to levels that are inadequate to sustain the normal aquatic life of the stream. Such a situation would occur if the organic wastes introduced decrease the dissolved oxygen concentrations to such a level that the atmospheric reaeration, dilution of wastes by the receiving water, and photosynthetic action by algae cannot sufficiently replenish the dissolved oxygen concentrations.

Table 10

DIURNAL DISSOLVED OXYGEN VARIATIONS AT SAMPLING STATION RT-2 ON THE ROOT RIVER ON AUGUST 11, 1970

Time	Dissolved Oxygen Concentration in mg/l
8:10 a.m.	6.9
12:25 p.m.	8.9
3:30 p.m.	10.5
7:15 p.m.	9.5
11:35 p.m.	8.0
3:05 a.m.	7.7

Source: SEWRPC.

The decrease of dissolved oxygen concentration in the water causes many problems. Inadequate dissolved oxygen in a stream or lake may contribute toward an unfavorable environment for fish and other aquatic life. Where natural waters contain no dissolved oxygen, decay of organic wastes is carried on by anaerobic bacteria causing putrefaction. Organic acids and foul odors are the end products of this anaerobic decay. Life forms that inhabit the streams under this condition of deoxygenation are useless to man and unpleasant to behold. Supersaturation with dissolved oxygen has also been reported as detrimental to fish. High dissolved oxygen concentrations in industrial water supplies might also increase corrosion, especially in waters used for cooling.

The maximum, average, and minimum dissolved oxygen concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 26.8, 6.7, and 0.1 mg/l, respectively. The maximum dissolved oxygen concentration of 26.8 mg/l occurred on the Fox River at station Fx-24 on August 3, 1971, in the Fox River watershed. The minimum dissolved oxygen concentration of 0.1 mg/l occurred on the Menomonee River at station Mn-2 on August 13, 1969, in the Menomonee River watershed. The ranges in dissolved oxygen concentration by watersheds are listed in Table 11.

Nitrogen

The compounds of nitrogen are important water quality parameters because of the significance of nitrogen as nutrients in the life processes of all plants and animals. The growth rate of plants is limited by the nitrogen concentration, provided all other nutrients are present

Table 11

DISSOLVED OXYGEN CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Dissolved Oxygen Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	13.7	6.5	1.9	90
Fox River	26.8	7.2	0.3	836
Kinnickinnic River . .	14.1	7.9	3.4	30
Menomonee River. . .	20.1	6.1	0.1	359
Milwaukee River . . .	21.3	7.0	0.3	360
Minor Streams.	18.2	7.4	0.8	90
Oak Creek	13.1	7.1	1.5	60
Pike River	16.1	6.5	1.5	123
Rock River.	25.1	6.1	0.3	389
Root River.	13.4	6.4	1.5	48
Sauk Creek.	14.6	6.2	0.3	60
Sheboygan River . . .	13.6	6.0	1.1	30
Total Samples				2,475

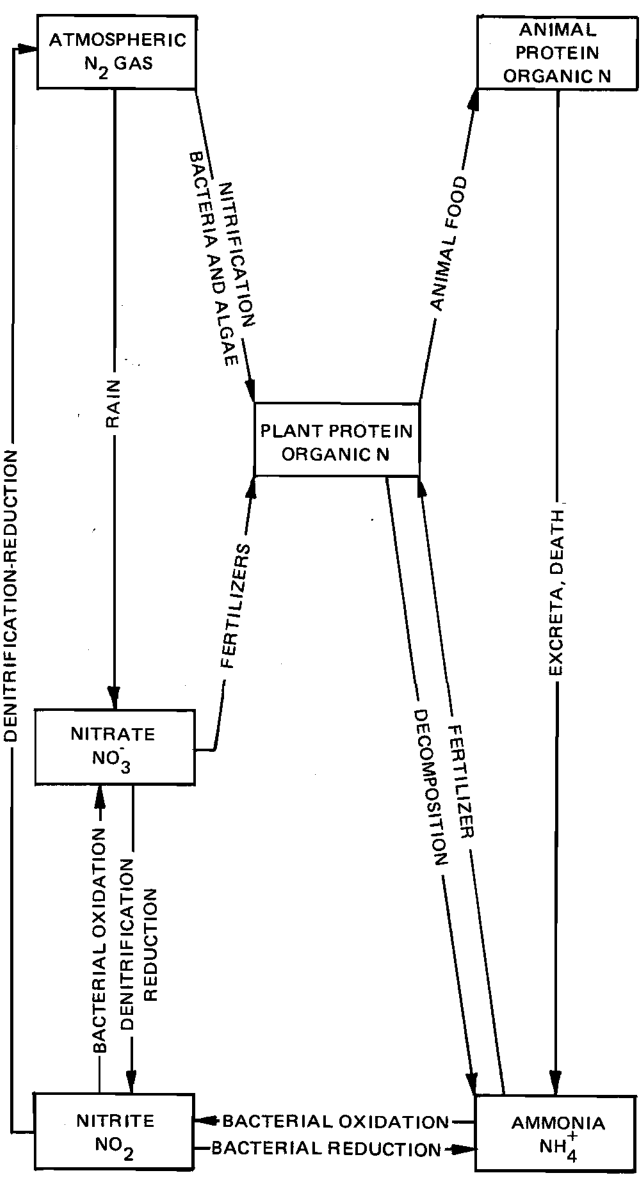
Source: SEWRPC.

above the critical concentrations. The relationships that exist among the various forms of nitrogen compounds and the changes that can occur in nature are illustrated in Figure 1.

The atmosphere serves as a reservoir from which nitrogen gas is constantly removed by the action of electrical discharge and nitrogen fixing bacteria and algae. Nitrogen gas is brought down from the atmosphere in the form of nitric acid and nitrates during rain and electrical discharges. The nitrates so formed serve as nutrients of plant life and are converted to proteins. Atmospheric nitrogen gas can also be converted to proteins by nitrogen fixing bacteria and algae. The plants, or animals that feed upon the plants, provide the protein to animals, including human beings, that are incapable of utilizing nitrogen directly from the atmosphere. Nitrogen compounds are released in the human and animal excreta. Urine contains urea resulting from metabolic breakdown of proteins. The feces of animals contain appreciable amounts of unassimilated protein matter. The protein matter remaining in the bodies of dead animals and plants as well as from the excreta is converted to ammonia by the action of bacteria. The ammonia released by bacterial action on urea and proteins may be used by plants directly to produce plant protein. The ammonia can also be oxidized by nitrifying bacteria and be converted to nitrite and further into nitrates. The nitrates thus formed may serve as nutrients for plants. Under anerobic conditions, nitrites and nitrates are both reduced by bacteria to form ammonia and nitrogen gas which escape to the atmosphere. Produced in excess, the highly soluble nitrates are carried away and percolate into the soil. This may result in relatively high concentrations of nitrates in groundwaters.

Figure 1

NITROGEN CYCLE



Source: SEWRPC.

In the sewage treatment facilities, in both the aerobic system (i.e.—activated sludge, trickling filter) and anaerobic system (i.e.—septic tank, sludge digestion), many of the aforementioned reactions take place. Bacterial degradation of protein from the raw sewage into ammonia and its oxidation to nitrate through the formation of nitrite occur in the aerobic system. In the anaerobic system, degradation of protein into ammonia and further bacterial reduction into nitrite and nitrogen gas occur.

The maximum, average, and minimum total nitrogen concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 19.07, 2.45, and 0.12 mg/l, respectively. The maximum total nitrogen concentration of 19.07 mg/l occurred on the Fox River at station Fx-10 on August 12, 1974, in the Fox River watershed. The minimum total nitrogen concentration of 0.12 mg/l occurred on Brighton Creek at station Dp-1 on August 20, 1975, in the Des Plaines River watershed. The ranges in total nitrogen concentration by watersheds are listed in Table 12.

Table 12

TOTAL NITROGEN CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Total - N Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	4.61	2.03	0.12	24
Fox River	19.07	3.03	0.63	224
Kinnickinnic River . .	2.00	1.28	0.68	8
Menomonee River. . .	7.50	2.77	0.33	96
Milwaukee River . . .	3.55	2.12	0.53	96
Minor Streams.	10.14	2.75	0.44	24
Oak Creek	3.46	1.38	0.29	16
Pike River	7.28	2.80	0.95	32
Rock River.	7.85	2.38	0.29	104
Root River.	7.34	3.17	0.47	24
Sauk Creek.	3.69	2.44	0.56	16
Sheboygan River . . .	8.74	3.31	1.15	8
Total Samples				696

Source: SEWRPC.

Nitrates: In addition to atmospheric sources, nitrates are produced as the end product of the aerobic degradation of proteinaceous materials and, therefore, occur as the end product in the aerobic treatment process of municipal wastes, food and milk wastes. Surface runoff from fields where there has been application of natural or artificial fertilizers also may contribute significant quantities of nitrates to the streams and lakes of the Region. Excessive growth of algae and other aquatic plants may occur, giving rise to unsightly scum and unpleasant odors, when nitrate is present along with phosphate in water above a minimum level.

In spite of their many sources, nitrates are seldom abundant in natural surface waters, for they serve as an essential nutrient for all types of plants, from phytoplankton to trees. Photosynthetic action is constantly utilizing nitrates and converting them to organic nitrogen in plant cells. Methemoglobinemia, a disease characterized by specific blood changes may be caused by high nitrate concentration in the drinking water.

The maximum, average, and minimum nitrate nitrogen concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 8.22, 0.87, and 0.02 mg/l, respectively. The maximum nitrate nitrogen concentration of 8.22 mg/l occurred on the Sucker Creek at station Mh-1 on August 26, 1975, in the minor streams tributary to the Lake Michigan watershed. The minimum nitrate nitrogen concentration of 0.02 mg/l occurred on the Honey Creek at station Mn-9 on August 12, 1968, in the Menomonee River watershed. The ranges in nitrate nitrogen by watersheds are listed in Table 13.

Nitrite: Nitrite occurs in nature as a chemically unstable substance readily oxidized to nitrate, and for this reason is normally present in very low concentrations in surface waters. Nitrites are often byproducts of bacteriological action upon ammonia and nitrogenous substances.

Nitrites are toxic, but rarely occur in large enough concentrations to cause a health hazard. The brewing and dairy industries require that water contain no nitrites. Nitrites are nutrients and stimulate the growth of algae and other phytoplankton. In association with ammonia and nitrate, nitrites in water are often indicative of pollution.

The maximum, average, and minimum nitrite nitrogen concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 0.70, 0.07, and 0.00 mg/l, respectively. The maximum nitrate nitrogen concentration of 0.70 mg/l occurred on the Rock River at station Rk-4 on August 13, 1969, in the Rock River watershed. The minimum nitrite nitrogen concentration of 0.00 mg/l occurred at seven stations in the Region. The ranges in nitrite nitrogen by watersheds are listed in Table 14.

Ammonia: Ammonia is the chief decomposition product from plant and animal proteins and is used as chemical evidence of pollution from sanitary wastes. In the presence of oxygen, however, ammonia is transformed by the nitrifying bacteria into nitrate. Ammonia may also result from the discharge of industrial wastes or from scouring and cleaning operations where ammonia water is used. Streams and lakes known to be unpolluted have very low ammonia concentrations, generally less than 0.2 mg/l expressed as nitrogen. In groundwater, however, ammonia generally occurs in higher concentration, as a result of natural reduction processes.

The toxicity of ammonia to aquatic animals is related to the pH of water. A high concentration of ammonium ions in water at a low pH may not be toxic but, if the pH is raised, toxicity increases with the formation of ammonium hydroxide. Algae which live on high nitrate concentrations, appear to be harmed or inhibited when the nitrogen is in the form of ammonia.

Table 13

NITRATE NITROGEN CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Nitrate Nitrogen Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	2.00	0.48	0.04	36
Fox River	5.52	1.24	0.04	336
Kinnickinnic River . .	0.66	0.30	0.09	12
Menomonee River. . .	3.37	0.97	0.02	144
Milwaukee River . . .	1.59	0.58	0.07	144
Minor Streams.	8.22	0.98	0.08	36
Oak Creek	1.77	0.34	0.04	24
Pike River	4.90	1.74	0.37	52
Rock River.	3.37	0.69	0.04	156
Root River.	3.36	1.07	0.13	48
Sauk Creek.	1.93	0.84	0.12	24
Sheboygan River . . .	3.75	1.16	0.09	12
Total Samples				1,024

Source: SEWRPC.

Table 14

NITRITE NITROGEN CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Nitrite Nitrogen Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	0.19	0.05	0.00	35
Fox River	0.59	0.07	0.00	336
Kinnickinnic River . .	0.16	0.05	0.01	12
Menomonee River. . .	0.55	0.09	0.00	141
Milwaukee River . . .	0.36	0.04	0.00	144
Minor Streams.	0.28	0.07	0.01	36
Oak Creek	0.10	0.03	0.00	24
Pike River	0.33	0.10	0.02	52
Rock River.	0.70	0.07	0.00	152
Root River.	0.38	0.13	0.01	48
Sauk Creek.	0.20	0.05	0.00	23
Sheboygan River . . .	0.32	0.07	0.01	12
Total Samples				1,015

Source: SEWRPC.

The maximum, average, and minimum ammonia nitrogen concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 5.83, 0.268, and 0.03 mg/l, respectively. The maximum ammonia nitrogen concentration of 5.83 mg/l occurred on the Bassett Creek at station Fx-25 on August 8, 1972, in the Fox River watershed. The minimum ammonia nitrogen concentration of 0.03 mg/l occurred at all of the watersheds with the exception of the Kinnickinnic River watershed. The ranges in ammonia nitrogen concentration by watersheds are listed in Table 15.

Organic Nitrogen: The organic nitrogen content of a water contributed by amino acids, proteins, and polypeptides—all products of biological processes. Increase in the organic nitrogen content may often be related to the sewage or industrial waste pollution of a given water supply. In water supply treatment plants practicing free residual chlorination, the presence of organic nitrogen and ammonia increases the amount of free chlorine required for chlorination due to the formation of chloramines, by the reaction of chlorine with the organic nitrogen or ammonia. Organic nitrogen exerts a certain amount of biochemical oxygen demand. The oxidation of organic nitrogen takes up the oxygen present in the surface water, reducing the dissolved oxygen concentrations in water, which is vital for the aquatic life.

The ratio of various forms of nitrogen can be used as an index of domestic pollution. For an example, the presence of ammonia in water would indicate a pollution of recent origin and the presence of nitrate would indicate that the pollution occurred some time ago.

The maximum, average, and minimum organic nitrogen concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 15.08, 1.16, and 0.08 mg/l, respectively. The maximum organic nitrogen concentration of 15.08 mg/l occurred on the Fox River at station Fx-10 on August 12, 1974, in the Fox River watershed. The minimum organic nitrogen concentration of 0.08 mg/l occurred on Brighton Creek at station Dp-1 on August 20, 1975, in the Des Plaines River watershed. The ranges in organic nitrogen concentration by watersheds are listed in Table 16.

Phosphorus

Phosphorus does not occur in its free elemental form in nature, but is found in the form of phosphates in several minerals and is a constituent of fertile soils and plants, and of the protoplasm, nervous tissue, and bones of animal life. It is an essential nutrient for plant and animal growth. Phosphorus combines with oxygen, sulfur, hydrogen, halides, and many metals and can be found in inorganic or organic forms.

Domestic sewage is relatively rich in phosphorus compounds. Most of the inorganic phosphorus is contributed by human wastes as a result of the metabolic breakdown of proteins and elimination of the liberated phosphates in the urine. The amount of phosphorus released is a function of protein intake and, for the average person, this release is considered to be 1.5 grams of phosphorus per day. Most heavy duty synthetic detergents designed for the household market contain large amounts of polyphosphates. The use of these materials as a substitute for soap has greatly increased the phosphorus content of domestic sewage. It has been estimated that domestic sewage probably contains two to three times as much inorganic phosphates at the present time as it did before synthetic detergents became available.

All polyphosphates gradually hydrolyze in aqueous solution and revert to the orthophosphate form. The rate

Table 15

AMMONIA NITROGEN CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Ammonia Nitrogen Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River	0.44	0.11	0.03	24
Fox River	5.83	0.24	0.03	219
Kinnickinnic River	0.63	0.27	0.11	8
Menomonee River	3.61	0.34	0.03	93
Milwaukee River	0.77	0.15	0.03	88
Minor Streams	0.29	0.12	0.03	24
Oak Creek	0.44	0.20	0.03	16
Pike River	1.49	0.23	0.03	32
Rock River	5.69	0.39	0.03	104
Root River	3.74	0.54	0.03	24
Sauk Creek	0.45	0.12	0.03	14
Sheboygan River	1.12	0.26	0.03	7
Total Samples				653

Source: SEWRPC.

Table 16

ORGANIC NITROGEN CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Organic Nitrogen Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River	2.98	1.35	0.08	24
Fox River	15.08	1.35	0.12	224
Kinnickinnic River	0.87	0.60	0.25	8
Menomonee River	2.30	1.24	0.24	96
Milwaukee River	1.98	1.25	0.18	96
Minor Streams	3.34	1.29	0.21	24
Oak Creek	1.32	0.74	0.18	16
Pike River	2.22	0.84	0.20	32
Rock River	3.20	1.23	0.28	104
Root River	2.71	1.39	0.13	24
Sauk Creek	2.23	1.21	0.19	16
Sheboygan River	3.55	1.37	0.62	8
Total Samples				672

Source: SEWRPC.

of hydrolysis is a function of temperature and increases rapidly as the temperature approaches the boiling point. The rate is also increased by lowering the pH. A third factor that influences the rate of hydrolysis of polyphosphates is the presence of organisms. In a period of days or weeks, polyphosphates can be hydrolyzed to orthophosphate in water and wastewater by enzymatic degradation by microorganisms, making the polyphosphate available for aquatic plants as nutrients.

The concentration of phosphorus in surface water depends upon many factors. The solubility of phosphate in surface water is governed by the presence or absence of elements such as calcium, magnesium, iron, and aluminum with which phosphorus forms insoluble compounds. The solubility of phosphorus compounds with calcium, magnesium, iron, and aluminum is dependent upon the pH and dissolved oxygen of water. For example, iron can exist in the form of ferrous or ferric compounds. The oxidation of ferrous iron to ferric iron occurs in the presence of oxygen. While ferrous phosphates are soluble in water, ferric phosphates are insoluble in water. When ferrous iron is converted to ferric iron by the oxidation process, in the presence of oxygen, phosphorus changes from the soluble to insoluble form. The insoluble phosphorus compound is precipitated and is removed from water. Similarly, the solubility of phosphorus compounds with calcium, magnesium, iron, and aluminum are affected by the pH of water. Aluminum phosphate has low solubility at pH 6, and the solubility increases with a change in the pH. In addition, phosphorus also may exist in colloidal form which is an intermediate stage between a soluble and a precipitated form. Depending upon the size of the colloidal particle, phosphorus could be measured as soluble or insoluble phosphorus.

Another factor that affects the concentration of soluble phosphorus in water is the sediment. Phosphorus, which is in the insoluble form due to precipitation or sorption on solid particles, settles on the sediment. Under anaerobic condition (in the absence of oxygen) ferric iron is reduced to ferrous iron and phosphorus associated with iron is released to water. In addition to the solubilization of phosphorus under anaerobic conditions, there also exists a reaction known as desorption: lake or stream sediments may act as a buffer for the phosphorus in the water above, releasing phosphorus into water, by dissolution or desorption.

The presence of phosphate in soluble form, when there is no dissolved oxygen present in water, and the presence of phosphate in the insoluble form, when dissolved oxygen is present, is an important reaction in the phosphorus cycle in eutrophic lakes. During summer months in eutrophic lakes, when little or no dissolved oxygen is present in the hypolimnion, high concentrations of soluble phosphorus may be present in the hypolimnion. During the spring and fall turnover when the water temperature is uniform at all depths of the lakes, the lakes become thoroughly mixed by wind action under these conditions. This high concentration of soluble phosphorus is brought up to the surface of the lakes, and it then may be consumed by the aquatic plants at rates higher than actually required by these plants. As indicated by many laboratory studies, aquatic plants and algae are able to store more than 10 times as much phosphorus as they normally need, through the process referred to as "luxury consumption."

High phosphate concentrations in water are associated with unpleasant algae or other aquatic plant growths. Algae frequently have been cited as responsible for taste and odor in drinking water supplies. Algae growths can impart color and turbidity to water. Algae also interfere with the water treatment processes of filtration, disinfection. Algae reduce the useful capacity of reservoirs by concentrating at certain depths in the water or along the shallow margins or bottom. Other problems caused by algae in domestic water supply include clogging of intake screens and reduction of the flow capacity. Algae also are undesirable in water for a variety of industrial uses, including cooling towers, paper manufacture, laundry, photography, and chemical industries. Algae can cause heavy fish mortality through direct poisoning or by the depletion of oxygen as a result of the death and decay of excessive growths. Algae, both fresh and decaying, have also been reported toxic to livestock and wildlife. Deaths of a great variety of animals, after drinking water containing high concentrations of bluegreen algae such as Aphanizomenon, Anabena and Anacystis, have been reported from many parts of the world. Excessive growth of algae destroy recreational and aesthetic values of lakes and also cause inconvenience to the recreational users. Wave action may concentrate a large amount of algae on shore where, if not removed immediately, decomposition will cause foul odors and other offensive conditions.

The maximum, average, and minimum total phosphorus concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 3.23, 0.423, and 0.01 mg/l, respectively. The maximum total phosphorus concentration of 3.23 mg/l occurred on the Root River Canal at station Rt-3 on August 25, 1975, in the Root River watershed. The minimum total phosphorus concentration of 0.01 mg/l occurred on the Oconomowoc River at station Rk-7 on August 28, 1975, on the Fox River at station Fx-1, and on the Mukwonago River at station Fx-12 on August 18, 1975, in the Fox River watershed. The ranges in total phosphorus by watersheds are listed in Table 17.

The maximum, average, and minimum soluble orthophosphate concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 7.27, 0.39, and 0.01 mg/l, respectively. The maximum soluble orthophosphate concentrations of 7.27 mg/l occurred on the Bassett Creek at station Fx-25 on July 28, 1970, in the Fox River watershed. The minimum soluble orthophosphate concentration of 0.01 mg/l occurred on six watersheds. The ranges in soluble orthophosphate concentration by watersheds are listed in Table 18.

Table 17

TOTAL PHOSPHORUS CONCENTRATIONS
IN STREAMS IN SOUTHEASTERN WISCONSIN
IN AUGUST OF YEARS 1968-1975

Watershed	Total Phosphorus Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	0.62	0.25	0.05	24
Fox River	2.35	0.41	0.01	224
Kinnickinnic River . .	0.34	0.13	0.01	8
Menomonee River. . .	2.82	0.61	0.03	96
Milwaukee River . . .	0.44	0.28	0.07	93
Minor Streams.	2.97	0.41	0.03	24
Oak Creek	0.23	0.10	0.02	16
Pike River	0.80	0.25	0.05	32
Rock River.	2.83	0.45	0.01	104
Root River.	3.23	0.61	0.07	48
Sauk Creek.	1.25	0.54	0.05	16
Sheboygan River . . .	1.41	0.65	0.06	8
Total Samples				670

Source: SEWRPC.

Table 18

DISSOLVED PHOSPHORUS CONCENTRATIONS
IN STREAMS OF SOUTHEASTERN WISCONSIN
IN AUGUST OF YEARS 1968-1975

Watershed	Dissolved Phosphorus Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	0.46	0.17	0.03	36
Fox River	7.27	0.50	0.01	335
Kinnickinnic River . .	0.25	0.10	0.02	12
Menomonee River. . .	4.35	0.70	0.01	141
Milwaukee River . . .	2.38	0.30	0.03	141
Minor Streams.	2.35	0.27	0.01	36
Oak Creek	0.31	0.09	0.01	24
Pike River	1.24	0.30	0.05	52
Rock River.	4.15	0.51	0.01	157
Root River.	4.72	0.66	0.05	38
Sauk Creek.	1.43	0.55	0.07	24
Sheboygan River . . .	1.13	0.49	0.01	11
Total Samples				1,007

Source: SEWRPC.

Chlorides

Chlorides of commonly occurring elements are highly soluble in water and, therefore, chlorides are present in high concentrations in practically all surface and groundwaters. The chloride content of the streams of southeastern Wisconsin is derived from seven principal sources: leaching of rock minerals by groundwater and surface runoff, human sewage, water softening processes, industrial wastes, salt applications for winter road maintenance, animal waste, and solid waste leachates. The leaching of rock minerals by groundwater and the movement of groundwater into a stream channel establishes a "background" chloride concentration that is characteristic of the stream, providing that bank storage has been dissipated and that streamflow is maintained by groundwater discharge into the stream channel.

Chloride is referred to as a "conservative" element, since the concentration is directly related to the extent of dilution; the substance is not decomposed, chemically altered, or removed as a result of natural processes. It is, therefore, possible to predict from the measured chloride concentration at a known streamflow, the concentration that would occur at other streamflows, provided there are no external sources of chloride to the stream, or provided the chloride concentration of the external sources is known.

During the period of time when streamflow is sustained exclusively by discharge from the groundwater reservoir, the prevailing chloride concentration is usually referred to as the background concentration. Occasional or persistent concentrations higher than the background chloride concentration indicate the influence of human activities on water quality of the ground and surface waters.

Chlorides in drinking water are generally not harmful to human beings until relatively high concentrations are reached. Restrictions on chloride concentration in drinking water generally are based on palatability requirements rather than on health. Concentrations of 250 to 400 mg/l of chloride impart a salty taste to water, render it unsuitable for many industrial uses, and inhibit growth of certain aquatic plants. Corrosion of all metals used in the water handling system has been reported at 45-50 mg/l of chlorides.

The maximum, average, and minimum chloride concentrations found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 897, 60.5 and 3.0 mg/l, respectively. The maximum chloride concentration of 897 mg/l occurred on the Rubicon River at station Rk-4 on August 12, 1971, in the Rock River watershed. The minimum chloride concentration of 3.0 mg/l occurred on the Ashippun River at station Rk-5 on August 12, 1971, in the Rock River watershed. The ranges in chloride concentration by watersheds are listed in Table 19.

Coliform and Fecal Coliform

The term "coliform bacteria" refers to a group of bacteria which are rod shaped, aerobic and facultative anaerobic, Gram-negative, nonspore-forming, and ferment lactose with gas formation within 48 hours after incubation at 35°C. This combination of structural and physiological characters exists in the genera Escherichia, Erwinia, Salmonella, Shigella, Serratia, and Enterobacter, a large and ecologically somewhat diverse group. The coliform group is subdivided into two bacterial categories.

Erwinia, Serratia, and Enterobacter genera are found in soil and on plants and are of nonfecal origin. The genera Escherichia, Salmonella, and Shigella are inhabitants of the intestinal tract of man and higher animals and are classified as fecal coliform. Escherichia is nonpathogenic, and the Salmonella and Shigella groups consist exclu-

Table 19

CHLORIDE CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Chloride Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	168.0	46.1	6.0	66
Fox River	245.0	52.3	5.0	615
Kinnickinnic River . .	135.0	53.2	26.0	22
Menomonee River. . .	341.0	84.0	12.0	252
Milwaukee River . . .	324.2	40.9	6.0	262
Minor Streams.	92.0	41.5	18.0	66
Oak Creek	221.0	114.4	27.0	44
Pike River	90.0	36.1	16.0	92
Rock River.	897.0	58.4	3.0	286
Root River.	281.0	86.0	38.0	48
Sauk Creek.	230.0	65.9	33.0	44
Sheboygan River . . .	63.0	25.5	9.0	22
Total Samples				1,819

Source: SEWRPC.

sively of intestinal parasites and pathogens of man and animal. Escherichia, Salmonella and Shigella are found in fecal matter, due to their intestinal origin. Salmonella and Shigella are found in the feces of humans and other animals affected by the intestinal diseases, while the group Escherichia is found in the feces of healthy and affected animals.

The genera Salmonella and Shigella include most of the important causative agents of intestinal disease in man: the agents of bacillary dysentery, infectious hepatitis, typhoid and paratyphoid fevers, and the most common and serious kinds of food poisoning. These pathogens are transmitted almost exclusively by the fecal contamination of water, food, and milk. Transmission through water is by far the greatest source of infection and has been invariably the source of mass epidemics. Today typhoid fever is a very rare disease in most civilized countries, and its disappearance has been achieved largely by the sanitary control of water supplies.

It is seldom possible to isolate intestinal pathogens directly from water that has undergone fecal contamination unless the water has been recently and massively contaminated. However, any water supply that is contaminated with fecal matter is a potential source of intestinal disease, and hence the recognition of such contamination is essential to sanitary control.

Coliform bacteria, both fecal and nonfecal, usually are prevalent in streams and are especially common during periods following rainfall when there are large amounts of surface runoff. These bacteria enter streams in runoff from rural and urban areas, including flow relief discharges and sewage treatment plant effluents. These bacteria may also be present in contaminated bottom sediments and sludge deposits. During dry weather it is usually possible to relate coliform counts to wastewater discharges because of the small number of bacteria entering a stream from runoff.

In routine bacteriological analyses of water samples, specific bacterial species or viruses are not determined. Instead, the fecal coliform count is taken as a measure of the concentration of bacteria of the coliform group that occur in a given amount of sample, commonly 100 ml. The "total coliform bacterial county" includes the fecal and nonfecal (plant and soil origin) bacteria. Although bacteria contamination of water is indicated by the "total coliform counts," the fecal origin of the contamination cannot be ascertained. The fault of the total coliform test is not in its inability to detect unsafe samples, but that safe samples may show up as unsafe samples. Therefore, because some coliforms are present in nature outside the feces of warm-blooded animals, the samples containing these nonfecal organisms only will also be considered unsafe. This results in declaring water unsuitable for contact recreation when there are no harmful organisms present in the water. It is generally accepted, however, that absence of the coliform indicates water is safe for human consumption and use.

The "fecal coliform counts" identify the fecal origin of the contamination of water. The success in recognizing fecal contamination of waters depends upon a correct method of identifying the bacteria that are of true fecal origin. The genera Escherichia of coliform group are of fecal origin since they are constant inhabitants of the human intestinal tract. Even though they are not a cause of intestinal disease, their presence in water is a good indicator of the occurrence of fecal contamination. Hence, the use of Escherichia as an indicator organism for fecal contamination of water has found wide acceptance. The use of an enriched lactose medium and an incubation temperature of 44.5°C plus or minus 0.2°C selectively differentiates fecal coliform group from total coliform bacteria.

The maximum, average, and minimum total coliform counts found in streams of the Region in the samples collected in August of the years 1968 and 1969 were 2,800,000, 60,188, and 100 MFCC/100 ml, respectively. The maximum total coliform of 2,800,000 MFCC/100 ml occurred on the Fox River at station Fx-17 on August 12, 1969, in the Fox River watershed. The minimum total coliform of 100 MFCC/100 ml occurred at Waukesha on Sunset Drive at station Fx-8 on August 12, 1968, in the Fox River watershed and on the Oconomowoc River at station Rk-7 on August 14, 1968, in the Rock River watershed. The ranges in total coliform counts by watershed are listed in Table 20.

The maximum, average, and minimum fecal coliform counts found in streams of the Region in the samples collected in August of the years 1968 through 1975 were 420,000, 3443.0, and 5.0 MFFCC/100 ml, respectively. The maximum fecal coliform of 420,000 MFFCC/100 ml occurred on the Fox River at station Fx-17 on August 12, 1969, in the Fox River watershed. The minimum fecal coliform of 5.0 MFFCC/100 ml occurred on the Fox River at station Fx-8 on August 12, 1968, in the Fox River watershed and on the Oconomowoc River at station Rk-7 on August 14, 1969 in the Rock River watershed. The ranges in fecal coliform counts by watersheds are listed in Table 21.

Table 20

COLIFORM COUNTS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Total Coliform Count in MFFCC/100 ml			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	26,000	16,333	11,000	6
Fox River	2,800,000	113,320	100	56
Kinnickinnic River . .	73,000	53,500	34,000	2
Menomonee River. . .	190,000	51,550	1,300	6
Milwaukee River . . .	490,000	49,208	2,100	24
Minor Streams.	190,000	46,555	26,000	6
Oak Creek	21,000	16,250	13,000	4
Pike River	57,000	33,000	15,000	4
Rock River.	2,500,000	185,519	100	26
Root River.	390,000	84,333	16,000	12
Sauk Creek.	--	--	--	--
Sheboygan River . . .	17,000	12,500	8,000	2
Total Samples				148

Source: SEWRPC.

Table 21

FECAL COLIFORM COUNTS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1968-1975

Watershed	Fecal Coliform Count in MFFCC/100 ml			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River . . .	7,600	784	30	36
Fox River	420,000	4,613	5	335
Kinnickinnic River . .	72,000	8,117	30	12
Menomonee River. . .	400,000	4,346	10	144
Milwaukee River . . .	40,000	2,431	10	143
Minor Streams.	64,000	6,491	100	36
Oak Creek	1,800	499	130	24
Pike River	12,000	1,047	10	52
Rock River.	60,000	2,693	5	157
Root River.	32,000	3,062	30	48
Sauk Creek.	54,000	4,020	10	24
Sheboygan River . . .	14,000	2,088	100	12
Total Samples				1,023

Source: SEWRPC.

Biochemical Oxygen Demand

The myriad of microscopic and macroscopic plants and animals found in the streams range from minute algae and protozoa, to large aquatic plants and fishes of many species. These organisms constitute a biological community in which the many life forms are mutually interdependent. An important aspect of this interdependence is the natural purification of the stream which occurs when dead organisms such as fish and algae are fed upon and ultimately decomposed by bacteria to chemically stable inorganic salts, such as nitrates or sulfates. This process of self-purification is biological principally in that saprophytic bacteria attack dead organic matter and produce simpler stable substances that do not foul the aquatic environment.

The entire biological community living in a stream depends upon the availability of dissolved oxygen, which is not only vital to fish but to aerobic bacteria. This normal assemblage of organisms places a demand upon the dissolved oxygen content of the stream. This demand commonly is met by natural processes of stream aeration. The biological community of a stream is balanced in terms of the general population densities of the many animal and plant species and the availability of oxygen to support this life. Events causing mass deaths of individual species or of large parts of the community are usually brief and temporary, and the original favorable conditions are restored naturally with time.

When organic wastes from sewage treatment plants enter streams, these wastes can provide a massive addition to the normal food supply for bacteria. The bacterial population increases in response to this artificially increased food supply, and the dissolved oxygen demand of the entire biological community also increases. If the organic sewage wastes continue to enter the stream in sufficient concentration, the dissolved oxygen content can be lowered to a level inadequate to sustain the normal aquatic life of the stream. A complete change then takes place in the type of organisms living in the stream; and instead of having, for example, bluegill fish, clams, and normal aerobic decay bacteria that produce stable inorganic end products, the stream becomes the habitat of bloodworms, sludge worms, leeches, rattailed maggots, and anaerobic bacteria that produce unstable organic acids and foul odors.

Five-day biochemical oxygen demand (BOD_5) is a determination of the oxygen used over a five-day period at 20^oC in the aerobic bacterial decomposition of the organic wastes in a water sample. Thus, BOD_5 may be thought of as a measure of the concentration of decomposable organic substances. It should be noted that BOD_5 is not a pollutant, the reason being that it is not a specific chemical substance, physical property, or an organism or group of organisms; and it is measurable only in the presence of aerobic decay bacteria under a standard set of controlled test conditions of internal physical, chemical, and biological environment that does not prevail in nature. BOD_5 is a measure of the biochemical processes as determined by the amount of oxygen required by aerobic decay bacteria to decompose organic substances in the test sample over a given length of time at a given constant temperature without being exposed to the many external influences that prevail in nature.

BOD_5 determinations are important in water quality studies because they indicate levels of organic pollution and the attendant potential decrease in dissolved oxygen concentration. Without the knowledge of the reaeration characteristics of a stream, BOD_5 values cannot be used, except in a very general way, to determine where dissolved oxygen concentrations may reach critically low levels for the preservation of fish life. The maximum, average, and minimum five-day biochemical oxygen demand values (BOD_5) in 29 stream samples collected in August of the years 1968 through 1975 at four sampling stations in four of the watersheds of the Region by the Wisconsin Department of Natural Resources were 15.0, 5.2, and 2.0 mg/l, respectively. The maximum concentration of 15.0 mg/l BOD_5 occurred at station DNR-Rt-7 on the Root River on August 27, 1969, in the Root River watershed. The minimum concentration of 2.0 mg/l of BOD_5 occurred at station DNR-Ml-10a on the Milwaukee River on August 11, 1971, in the Milwaukee River watershed and at station DNR-Dp-2a on the Des Plaines River on August 30, 1971 in the Des Plaines River watershed. Ranges in BOD_5 values by watershed are listed in Table 22.

SUMMARY

Water quality parameters, measured on a numerical scale, can be used to evaluate the chemical, physical, and bacteriological characteristics of lakes and stream waters. Although many parameters can be measured, the costs of sampling and the physical significance of various parameters tend to limit the measures which are utilized in continuing water quality sampling programs. A study of the water quality and flow of streams in the Region was undertaken by the Commission in 1964 to evaluate the then-existing condition of the stream water quality in relation to pollution sources, land use, and population distribution and concentration. To describe the chemical, physical, and bacteriological stream water quality, 34 parameters were analyzed for a one-year period. A water quality monitoring program evolved from this study which included collection of water samples once a year during the month of August from the 87 sampling stations established by the Commission in the initial study and analyses of nine parameters from the year 1968 through 1971 and 13 parameters from the year 1972 through 1975. For the years 1968 and 1969, water samples were collected during the months of April and August. Among the parameters discontinued in the long-term monitoring program, 10 were dropped since their average concentrations were within the expected range for the Region, given its physiographic characteristics, and two of them were discontinued as the maximum values found were less than the state water quality standards. The other parameters were discontinued due to the unavailability of funds and space for the laboratory analysis.

Table 22

BIOCHEMICAL OXYGEN DEMAND CONCENTRATIONS IN STREAMS IN SOUTHEASTERN WISCONSIN IN AUGUST OF YEARS 1964-1975

Watershed	Five-Day Biochemical Oxygen Demand Concentration in mg/l			Number of Samples
	Maximum	Average	Minimum	
Des Plaines River at Pleasant Prairie	8.5	4.4	2.0	8
Milwaukee River at Brown Deer Road	5.0	3.7	2.0	5
Root River in Racine (Marquette Street Bridge)	15.0	5.7	2.5	8
Fox River (Illinois) at Wilmot	13.8	7.0	3.0	8
Total Samples				29

Source: SEWRPC.

The 13 water quality parameters, temperature, specific conductance, dissolved oxygen, hydrogen ion concentration, total and soluble phosphorus, the nitrite-, nitrate-, organic-, ammonia-, and total-nitrogen, chloride, and fecal coliform counts tested in the long-term water quality monitoring program discussed in detail in this chapter are useful in assessing the water quality of the lakes and streams of the Region and its suitability for various uses.

Temperature is an important water quality parameter for water to be used for general industrial cooling, and for the maintenance of aquatic life. Water for drinking purposes usually is unsatisfactory at 66°F or above. Specific conductance provides an estimate of the amount of dissolved ionic substances present in the water samples and is a parameter sensitive to any significant change in the dissolved solid input into a lake or stream. The pH (hydrogen ion concentration) of water is one of the water quality parameters that is linked to the species composition of communities and their life processes. The natural dissolved oxygen concentration in a stream is determined by a large number of interacting physical, chemical, and biological factors. Low or inadequate dissolved oxygen concentrations may impair or preclude the maintenance of conditions suitable for fish and other aquatic life. High phosphate concentrations in water are associated with unpleasant algae or other aquatic plant growth. The components of nitrate, nitrite, ammonia, and organic components of nitrogen are important water quality parameters because of their significance as nutrients in the life processes of all plants and animals and their ability to stimulate excessive growth of algae and other aquatic plants. When nitrate is present in water along with phosphate above the minimum required levels, this excessive growth may occur, causing unsightly scum and unpleasant odors as well as depleted dissolved oxygen conditions. In association with ammonia and nitrate, nitrites in water are often indicative of pollution. Chlorides in drinking water are generally not harmful to human beings or fish and aquatic life until high concentrations are reached. Restrictions on the chloride concentration in drinking water are generally based on palatability requirements, rather than on health. Both fecal and nonfecal coliform counts indicative of the presence of pathogenic bacteria may be high in streams which receive runoff from urbanized areas, sewage which overflows or is bypassed untreated, runoff from soil and certain vegetation, or sewage treatment plant effluents, and may be present from contaminated bottom sediments and sludge deposits. Five-day biochemical oxygen demand (BOD_5) measures the potential consumption of dissolved oxygen that may occur through the natural aerobic biological degradation of organic matter present in streams and lakes.

Chapter VI

CONDITION OF STREAM QUALITY AND STREAMFLOW IN THE MAJOR WATERSHEDS OF THE REGION

INTRODUCTION

Lakes and streams constitute an extremely valuable part of the natural resource base of southeastern Wisconsin. Inasmuch as they are focal points for water-related recreational activities popular with the inhabitants of the Region, they provide extremely attractive sites for properly planned residential development and, when viewed in the context of open space areas, they greatly enhance the aesthetic aspect of the environment.

Streams

The streams of southeastern Wisconsin are relatively small and, therefore, subject to a relatively large variability in natural water quality. This variability is evident when comparing one stream with another and when comparing quality of different reaches of the same stream. Large streams, such as the Mississippi River, typically have a high degree of uniformity in water quality. Because of the relatively small variation between quality extremes over extensive reaches of such large streams, consideration of average water quality conditions may be adequate for planning purposes. In southeastern Wisconsin stream quality conditions vary over relatively wide ranges, and average values of water quality indicators are not sufficient for planning purposes. Careful consideration must also be given to extremes in the ranges.

Of the 43 streams studied by the Commission, 41 rise in southeastern Wisconsin. Only the Milwaukee River and the North Branch of the Milwaukee River have their sources outside the seven-county Region. Five of the 12 watersheds of the Region are contained entirely within the regional boundaries. Twenty-six streams have their watershed areas entirely inside the Region. The longest stream is the Milwaukee River, with 82 miles of its total 101-mile length lying within the Region. According to U. S. Geological Survey records to September 1975, the maximum mean daily flow of any stream in the Region was 15,100 cubic feet per second (cfs) or about 6.8 million gallons per minuite (gpm). This flow occurred on the Milwaukee River in 1918. Minimum flows of zero (0) cfs probably have occurred on a number of streams in the Region as well as on the Des Plaines River and the Milwakee River for which such flows have been observed at flow gaging stations.

Lakes

The lakes of southeastern Wisconsin are almost exclusively of glacial origin, formed by depressions in outwash deposits, terminal and interlobate moraines, and ground moraines. Some lakes, such as Green Lake in northeastern Washington County or Browns Lake in southwestern Racine County, owe their origins to kettles, that is, depressions formed in the glacial drift as a result of the melting of ice blocks that became separated from the melting continental ice sheet, and the subsequent subsidence of sand and gravel contained on and within those blocks. Because of their origin, glacially formed lakes are fairly regular in shape, with their deepest points located predictably near the center of the basin, or near the center of each of several connected basins. There are 100 lakes within the Region which have 50 acres or more of surface water area and are defined in this report as major lakes. The major lakes in the Region have a combined surface water area of 57 square miles, or about 2 percent of the area of the Region, and provide a total of 448 miles of shoreline. The number of major lakes per county ranges from none in Milwaukee County to 33 in Waukesha County. The remaining five counties of Walworth, Kenosha, Washington, Racine, and Ozaukee each contain, respectively, 25, 15, 15, 10, and two major lakes. Lake Geneva is by far the largest lake in southeastern Wisconsin, having a surface area of 5,262 acres, an area 2.1 times as large as Pewaukee Lake which, with an area of 2,493 acres, is the second largest lake in the Region. In addition to the 100 major lakes, there are 228 lakes and ponds in the Region of less than 50 acres of surface water area, considered in this report as minor lakes. These minor lakes have a combined surface water area of four square miles, or about 0.15 percent of the area of the Region, and provide 141 miles of shoreline. The recently completed studies on the two major watersheds of the Region, the Milwaukee and Fox River watersheds, contain 58 of the 100 major lakes in the Southeastern Wisconsin Region. At least 13 of the 58 major regional lakes in these two watersheds were found to be eutrophic as indicated by high phosphorus concentrations, low dissolved oxygen contents, and excessive growths of algae and aquatic weeds. Many other major lakes within the Fox and Milwaukee River watersheds were found to be receiving nutrients at levels above the recommended concentrations for the control of algae and weeds.

Types of Lakes

A lake can be (1) oligotrophic, (2) mesotrophic, (3) eutrophic, or (4) dystrophic, depending upon the biological productivity associated with the nutrient levels of the lake. An oligotrophic lake has low levels of such aquatic plant nutrients as phosphorus and nitrogen and therefore has low levels of biological activity and production. This low biological production is associated with low turbidity and resultant high water clarity, making the lake the most attractive for recreational or aesthetic use. A eutrophic lake has high levels of such aquatic plant nutrients as phosphorus and nitrogen, and therefore has high levels of biological production. The large-scale growth of aquatic plants and weeds causes nuisances such as odors and other aesthetic problems, interference with swimming and boating, and such health hazards as the presence of toxicants and infectious organisms that harbor in the aquatic weeds. In addition, the death and decay of the aquatic plants and weeds cause a decrease in the dissolved oxygen, especially in the bottom of the lake, where the dead plants settle. Sometimes the dissolved oxygen in the bottom of the lake becomes depleted, causing fish to migrate to other, more amenable portions of the lake, and causing the growth of anaerobic organisms and the production of hydrogen sulfide and methane. A highly eutrophic lake is, therefore, the least attractive lake for public use due to the presence of nuisance algae and weed growths and various attendant problems. A mesotrophic lake lies between an oligotrophic and eutrophic lake in its nutrient levels and, therefore, has many of the problems of a eutrophic lake, but at a reduced intensity. Many of the major lakes in the Region can be classified as mesotrophic lakes. A dystrophic lake has brown water with much humic material in solution, low pH levels, low dissolved oxygen levels, and a unique small bottom fauna.

THE WATERSHED AS A STUDY UNIT

In an effort to relate the regional stream water quality evaluation to a meaningful geographic planning unit, the available data have been analyzed, interpreted, and presented by watershed. The selection of the watershed as the basic geographic area of study and reference was made only after careful consideration of the comprehensive planning as well as of the hydrologic, hydraulic, and geologic factors involved. Water resource and water resource-related studies and planning efforts conceivably can be carried out on the basis of various geographic areas, including areas delineated by governmental jurisdictions, socioeconomic linkages, common areawide development problems, and topography, the latter type of area including the natural surface watershed. None of these geographic areas is perfect for selection as a water resource planning unit. There are many advantages, however, to selecting the topographically defined watershed as a study and planning unit since many water resource problems are surface water oriented.

A natural stream channel network forms a system into which overland runoff from rainfall or snowmelt drains and moves downstream under the influence of gravity. The land area which contributes the overland runoff comprises the tributary watershed, the boundary of which is defined by the topographic divide separating those land areas where overland runoff flows to the stream system under consideration from those land areas where runoff flows to other stream systems. Thus, the watershed may be defined as a geographic area, the topographic boundaries of which delimit the catchment area contributing overland runoff to a given stream system.

The watershed forms a meaningful geographic planning unit, not only for the consideration of storm water drainage and flood control problems which must be considered on a watershed basis but also for the consideration of other land and water use problems closely related to drainage and flood control, including flood plain utilization, wetlands preservation, inland lakes protection and rehabilitation, park and open space preservation, fish and wildlife conservation, soil conservation, and stream and lake pollution.

Water supply and sewerage facility planning may involve problems that cross watershed boundaries, but the watershed must be recognized as a planning unit if surface streams are utilized as the source of supply or if the sewerage systems discharge pollutants into the stream system. Changes in land use and transportation requirements are ordinarily not controlled primarily by watershed factors, but can greatly influence watershed development. The land use and transportation pattern determines the amount and spatial distribution of the hydraulic and pollution loadings to be accommodated by the stream system of a watershed. In turn, the drainage and flood control, as well as the effects of urban and rural land management practices upon the water quality control facilities and their effects upon the historic floodways and flood plains and upon surface water quality determine to a considerable extent the use of riverine areas of the watershed. Finally, it should be noted that the related physical problems of a watershed tend to create a strong community of interest among the residents of the watershed, and citizen action groups can readily be formed to assist in solving water-related problems. It may be concluded, therefore, that the watershed is a suitable unit of area to be selected for water resource planning purposes, provided that the relationships existing between watershed and Region are recognized. Accordingly, the results of the stream quality study were analyzed and interpreted utilizing watersheds as the basic geographic area of study and reference.

In considering stream quality within the context of a watershed, however, it must always be recognized that, in addition to direct precipitation and overland runoff, groundwater seepage and artificial discharges from human sources—such as from sewage treatment plants and industries—also contribute to the total flow of the stream system. In southeastern Wisconsin the base flow of perennial streams is determined largely by groundwater seepage into the stream channels. Runoff contributes to the flow of streams only during and immediately following rainfall or snowmelt. During periods of heavy runoff, stream stages rise, temporary bank storage occurs, and normal groundwater gradients may be reversed so that groundwater recharge may occur. Dissipation of the runoff may require only two to four days following rainfall or snowmelt. Water in temporary bank storage moves back into the stream channels until groundwater gradients are reestablished toward the channels, and groundwater basin storage again contributes to the perennial streamflow.

The gravitational movement of groundwater is determined by the hydraulic gradients established by the net effect of the temporal and geographical distribution of groundwater recharge and discharge. Where groundwater occurs under water table conditions in relatively permeable surficial deposits, such as sands and gravels, or in the underlying Niagara aquifer, the configuration of this water table tends to be a subdued image of the surface topography. Under this condition the topographic divides that form the watershed boundaries generally will coincide with the underlying groundwater divides. Where surficial deposits are composed of relatively impermeable deposits, such as clay or till, these deposits may tend to absorb relatively little precipitation, thereby augmenting surface runoff and providing relatively little local groundwater storage to maintain base flows. The groundwater divide under these conditions generally does not coincide with the watershed divide.

In studies and applications in which water quality and stream and lake pollution are matters of primary concern, the significance of any incongruities between watershed and groundwater divides is more than academic. Stream base flow conditions provide the best available data on the background quality conditions of the streams, because it is under base flow conditions that the water in a stream is composed almost entirely of groundwater seepage into the channel, together with whatever artificial discharges may occur from man-made sources. If the groundwater divides extend far beyond the watershed boundaries, groundwater may be moving into or out of the watershed under the influence of subterranean hydraulic gradients; and the water quality of the stream system may be affected by groundwater originating outside the watershed.

The inorganic chemical quality of the streams of southeastern Wisconsin is determined to a considerable extent by the geochemistry of the soil and geologic terrain in relation to precipitation and runoff. Soil types also determine to a very large degree the runoff characteristics of a watershed, and thus ultimately affect streamflow, flooding, basin storage, groundwater recharge rates, and water quality changes. In the presentation and discussion of the stream water quality trend and the present lake water quality within each of the 12 watersheds of the Region, the available information on the groundwater flow and surface runoff characteristics have been used for the interpretation of the chemical and bacteriological data.

The discussions of the present stream water quality and pollution conditions as well as the discussion of the long-term changes in water quality as presented in this chapter are based upon data obtained from: (1) the bench mark stream water quality study of the Commission; (2) the continuing stream and lake water quality monitoring program of the Commission; (3) the continuous streamflow monitoring program of the Commission; (4) the monthly stream and lake water quality sampling program of the Wisconsin Department of Natural Resources; (5) the basin surveys of the Wisconsin Department of Natural Resources; (6) the Milwaukee Metropolitan Sewerage Commission stream water quality sampling program; (7) the Geneva Lake Watershed Environmental Agency stream and lake water quality sampling program; (8) the City of Racine, Department of Health, water quality survey program; (9) the U. S. Geological Survey continuous stream flow monitoring program; (10) the U. S. Geological Survey stream water quality sampling program; (11) the U. S. Environmental Protection Agency-National Lake Eutrophication Survey; and (12) the Wisconsin Department of Natural Resources quarterly lake monitoring program. A detailed description of these data sources is given in Chapter II. As previously noted, the Commission regards water pollution by definition to be related to human activity. Where a parameter concentration in a stream or a lake is increased by human activity to more than the presumed natural "background" levels of concentration but below the standard for a designated water use, there is considered to be an impact upon the stream or lake from a human source.

DES PLAINES RIVER WATERSHED

Regional Setting

The Des Plaines River watershed is a surface water drainage unit located in the southeast portion of the Region. The watershed is only partly contained in the Southeastern Wisconsin Region and the State of Wisconsin, the other part being located in the State of Illinois. The boundaries of the basin within the Region, together with the locations of the main channels of the Des Plaines River and its principal tributaries, are shown on Map 6.

The Des Plaines River rises south of Union Grove near the Racine-Kenosha County line and drains 122.85 square miles of central Kenosha County and 10.74 square miles of Racine County. It flows in a general southeasterly course for 20.7 river miles, leaving the State about 1.5 miles east of Interstate Highway 94. The Wisconsin section of the Des Plaines River basin is bounded on the west by the Fox River watershed, on the north by the Root River watershed, and on the east by the Pike River watershed and other Lake Michigan drainage. The east watershed boundary marks the subcontinental divide which separates surface waters flowing west and south through the Mississippi River to the Gulf of Mexico from surface waters flowing north and east through Lake Michigan and the St. Lawrence River to the Atlantic Ocean.

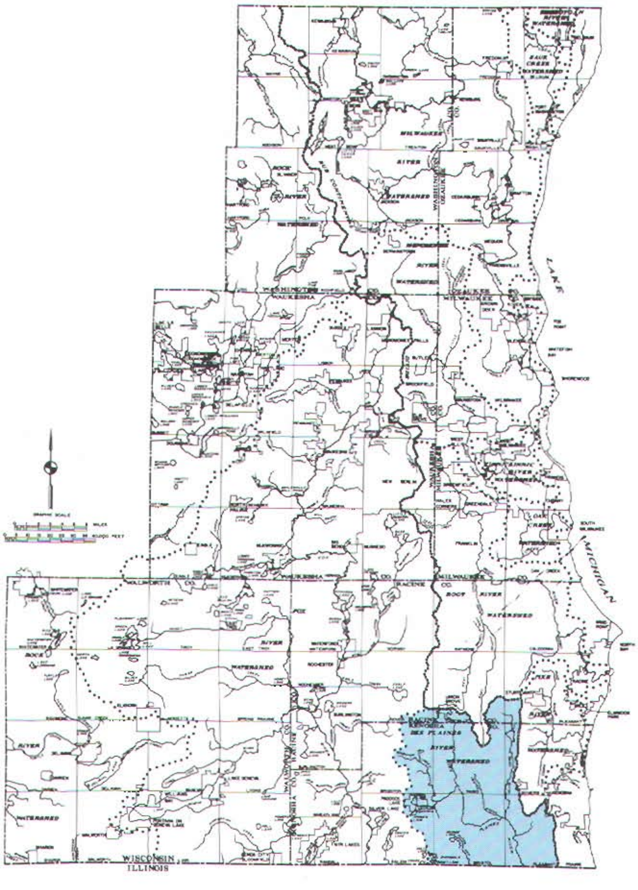
Although the Des Plaines River basin approaches as close as three miles to Lake Michigan, its eventual drainage is to the Mississippi River. The tributaries to the Des Plaines River, which drains the watershed, consist of the North Branch of the Des Plaines River, Brighton Creek, Salem Branch, Center Creek, Kilbourn Road Ditch, and Dutch Gap Canal, all within the Region. Table 23 lists each stream reach, the location, the source, and the length of each stream reach in miles within the Region for the Des Plaines River watershed. The portion of the watershed contained in the Region ranks tenth in population and sixth in size as compared to the 12 watersheds of the Region. The watershed has a total area of 133.98 square miles and an average population density of 118 people per square mile.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries is a rectilinear pattern of local political boundaries, as shown on Map 6. The watershed lies in

Map 6

LOCATION OF THE DES PLAINES RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Des Plaines River watershed has a total area of about 134 square miles and comprises about 5 percent of the total 2,689 square mile area of the Region. The portion of the watershed contained in the Region ranks tenth in population and sixth in size as compared to the 12 watersheds of the Region.

Source: SEWRPC.

two counties—Kenosha and Racine—and in two villages, one city, and nine towns. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 24.

Population

Population Size: The 1975 resident population of the watershed is estimated at 15,811 persons, or about 1.0 percent of the total resident population of the Region of 1,789,871 persons. Table 25 presents the population distribution in the Des Plaines River watershed by civil division. The population of the watershed has increased since 1963, reflecting primarily the increase in population of the Village of Paddock Lake and the Towns of Salem and Pleasant Prairie.

Population Distribution: Presently, about 10 percent of the residents of the watershed live in incorporated villages. The Des Plaines River watershed is predominantly rural, with the exception of some scattered medium density development around Paddock Lake and in the Towns of Bristol and Pleasant Prairie.

Quantity of Surface Water

The landscape of the Des Plaines River Basin consists of gently sloping glacial ground moraine. A maximum difference in elevation of about 260 feet exists within the Wisconsin portion of the watershed. The morainal deposits consist largely of glacial till with much clay content giving rise to gently rolling silty clay loams over silty clay. The soils and underlying parental till cause more rapid runoff of rainfall and snowmelt than the soils of areas west of the morainal ridges. Moreover, these soils and till presumably decrease the vertical recharge potential of underlying water-bearing units. The perennial flow of the Des Plaines River and its tributaries is presumably sustained largely by groundwater seepage from glacial drift having relatively low storage capacity, which would account for the seasonally low flows of streams in this watershed. There are nine lakes—four major (surface area greater than 50 acres) and five minor—in the Des Plaines River watershed. The four major lakes, George Lake, Hooker Lake, Paddock Lake, and Benet/Shangrila

Table 23

STREAMS IN THE DES PLAINES RIVER WATERSHED

Stream or Watercourse	Source		Length in Miles
	By Civil Division	By U. S. Public Land Survey	
Brighton Creek	Town of Brighton	T2N, R20E, Section 11, NW	9.0
Center Creek	Town of Paris	T2N, R21E, Section 27, NW	7.9
Des Plaines River.	Town of Yorkville	T3N, R21E, Section 33, SW	20.7
Dutch Gap Canal.	Town of Bristol	T1N, R21E, Section 20, SE	4.1
Kilbourn Road Ditch	Town of Mt. Pleasant	T3N, R22E, Section 30, SE	12.1
Salem Branch	Village of Paddock Lake	T1N, R20E, Section 2, SE	2.3

Source: SEWRPC.

Table 24

AREAL EXTENT OF CIVIL DIVISIONS IN THE DES PLAINES RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
City			
Kenosha	0.11	0.08	0.74
Village			
Paddock Lake	1.71	1.28	98.28
Towns			
Brighton	15.30	11.42	42.61
Bristol	36.20	27.02	100.00
Paris	33.79	25.22	93.94
Pleasant Prairie	21.88	16.33	59.67
Salem	6.97	5.20	21.10
Somers	6.65	4.96	19.35
County Subtotal	122.61	91.51	44.06
RACINE COUNTY			
Village			
Union Grove	0.48	0.36	52.17
Towns			
Dover	2.49	1.86	6.88
Mount Pleasant	2.85	2.13	7.61
Yorkville	5.55	4.14	15.72
County Subtotal	11.37	8.49	3.34
Total	133.98	100.00	--

Source: SEWRPC.

Lake have a total surface area of 411.4 acres in the watershed. The maximum depth of the deepest lake, Paddock Lake, is 32 feet; Benet/Shangrila and Hooker Lakes have maximum depths of 24 feet each, and George Lake has a maximum depth of 16 feet. Of the four major lakes, Benet/Shangrila is a kettle lake and the other three are headwater lakes. The five minor lakes together occupy a total surface area of 98.6 acres in the watershed. The location by civil division and by the U. S. Public Land Survey system, as well as the physical characteristics of the major lakes in the Des Plaines River watershed, are presented in Table 26.

Streamflow characteristics for the Des Plaines River as measured at Russell, Illinois, the water quality station established by the Commission in cooperation with the U. S. Geological Survey approximately 1.5 miles downstream from sampling station Dp-3, are summarized in Table 27. High streamflow occurs principally in the late winter and early spring, usually associated with melting snow. Low flows persist for most of the remainder of the year with occasional rises caused by rainfall.

Surface runoff, the portion of precipitation which flows overland contributing directly to streamflow, is variable both in season and in location within the watershed. The ratio of runoff from winter rains and melting snow, usually occurring when the soil is frozen or saturated, can be very high. However, runoff is generally a very small fraction of the causative rainfall during the later spring, summer, and fall seasons.

Pollution Sources

An evaluation of water quality conditions in Des Plaines River watershed must include an identification, categorization and, where feasible, quantification of known pollution sources. The following types of pollution sources have been identified in the watershed and are discussed below: municipal sewage treatment facilities, sanitary sewerage system overflow points, industrial wastewater discharges, urban storm water runoff, and agricultural and other runoff. The principal intent is to identify the type and location of the various pollution sources and to quantify the pollution discharge from those sources in terms of rate or amount of discharge and concentration and total transport of pollutants.

Table 25

ESTIMATED RESIDENT POPULATION OF THE DES PLAINES RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
KENOSHA COUNTY	
City	
Kenosha (Part)	0
Village	
Paddock Lake (Part)	1,875
Towns	
Brighton (Part)	733
Bristol	3,067
Paris	1,720
Pleasant Prairie (Part)	3,774
Salem	1,678
Somers (Part)	721
Kenosha County (Part) Subtotal	13,568
RACINE COUNTY	
Village	
Union Grove	1,268
Towns	
Dover	438
Mount Pleasant	143
Yorkville	394
Racine County (Part) Subtotal	2,243
Des Plaines River Watershed Total	15,811

Source: Wisconsin Department of Administration and SEWRPC.

Sewage Treatment Facilities: Five sewage treatment facilities are municipally owned or operated in the Des Plaines River watershed: Village of Paddock Lake sewage treatment facility; Town of Salem Sewer Utility District No. 1; Town of Bristol Utility District No. 1; Town of Pleasant Prairie Sewer Utility District "D," and Town of Pleasant Prairie Sanitary District 73.1.[1] Selected information for the municipal sewage treatment plants in the Des Plaines River watershed is set forth in Table 28 and the plant locations are shown on Map 7.[2] In addition to the public sewage treatment facilities, there are six nonindustrial private sewage treatment facilities present in the Des Plaines River watershed: Fonk's Mobile Home Park No. 2 in Racine County and Brightondale County Park, George Connolly Development, Howard Johnson Motor Lodge, Wisconsin Tourist Information Center, and Paramski Mobile Home Park in Kenosha County. Activated sludge and extended aeration are the principal types of treatment provided by the private and public sewage treatment facilities. The Wisconsin Tourist Infor-

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[1] *Town of Pleasant Prairie Sanitary District 73-1 went into operation in October 1975 and therefore does not affect the analysis of water quality trends for 1964-1975.*

[2] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 7. The map also identifies the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 26

MAJOR LAKES IN THE DES PLAINES RIVER WATERSHED

Name	Location: Municipality	Location: U. S. Public Land Survey Section Town and Range	Surface Width[a] (miles)	Surface Length[a] (miles)	Surface Area[a] (acres)	Maximum Depth[b] (feet)	Shoreline Length (miles)	Shore Development[c] (ratio)	Public Frontage Length (miles)
Benet/Shangrila Lake	Towns of Salem and Bristol	31-1-20 36-1-20	0.60	1.00	153.60	24	5.40	3.11	0.12
George Lake	Town of Bristol	20, 29-1-21	0.30	0.40	58.80	16	1.18	1.10	0.05
Hooker Lake	Town of Salem	11-1-20	0.20	0.40	87.00	24	1.90	1.41	0.02
Paddock Lake	Village of Paddock Lake	2-1-20	0.50	0.60	112.00	32	2.00	1.35	0.04

[a] *Lake lengths, widths and areas, used in this comparison were taken from aerial photographs dated September and October 1956 for Kenosha County.*

[b] *Maximum depth was measured from the surface elevation existing on date sampled.*

[c] *Shore development ratio (SDR) is a convenient expression of the degree of regularity or irregularity of shoreline. Generally, the higher the ratio, the greater the biological productivity of the lake. SDR = length of shoreline of lake of given area divided by circumference of circle with same area. An SDR of 1.00 indicates a circular lake.*

Source: SEWRPC.

mation Center uses a septic sand filter tank, and flow-through lagoon treatment process. The available data on the private sewage treatment facilities is presented in Table 29. Among the five publicly operated sewage treatment facilities and six privately operated sewage treatment facilities, three discharge effluent to the main stem of the Des Plaines River, four to unnamed tributaries of the Des Plaines River, two to Brighton Creek, one to Mud Lake, and one uses a soil absorption system for effluent disposal.

Domestic Onsite Sewage Disposal Systems: Although certain areas of the watershed lie within existing and proposed service areas of public sanitary sewerage systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points: In addition to private and public sewage treatment facility effluents, raw sanitary sewage enters the surface water system of the Des Plaines River watershed directly via three known bypasses from the Village of Paddock Lake, and Towns of Bristol and Pleasant Prairie. Of the three known bypasses, two discharge raw sewage directly to the main stem of the Des Plaines River and one discharges to Brighton Creek.

Industrial Waste Discharges: As shown on Map 7, there are eight locations in the Des Plaines River watershed at which industrial wastewaters consisting of spent process

Table 27

FLOW MEASUREMENTS AT THE DES PLAINES RIVER NEAR RUSSELL, ILLINOIS: OCTOBER 1968 THROUGH SEPTEMBER 1975

Water Year	Des Plaines River Near Russell, Illinois: Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1968-1969	71.3	7.81	270	0.94
1969-1970	64.9	7.11	504	0
1970-1971	92.2	10.10	853	0.24
1971-1972	143.0	15.74	809	1.1
1972-1973	149.0	16.35	1,060	0.90
1973-1974	177.0	19.53	1,590	2.0
1974-1975	53.5	5.91	397	1.8

Source: U. S. Geological Survey.

Table 28

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE DES PLAINES RIVER WATERSHED: 1975

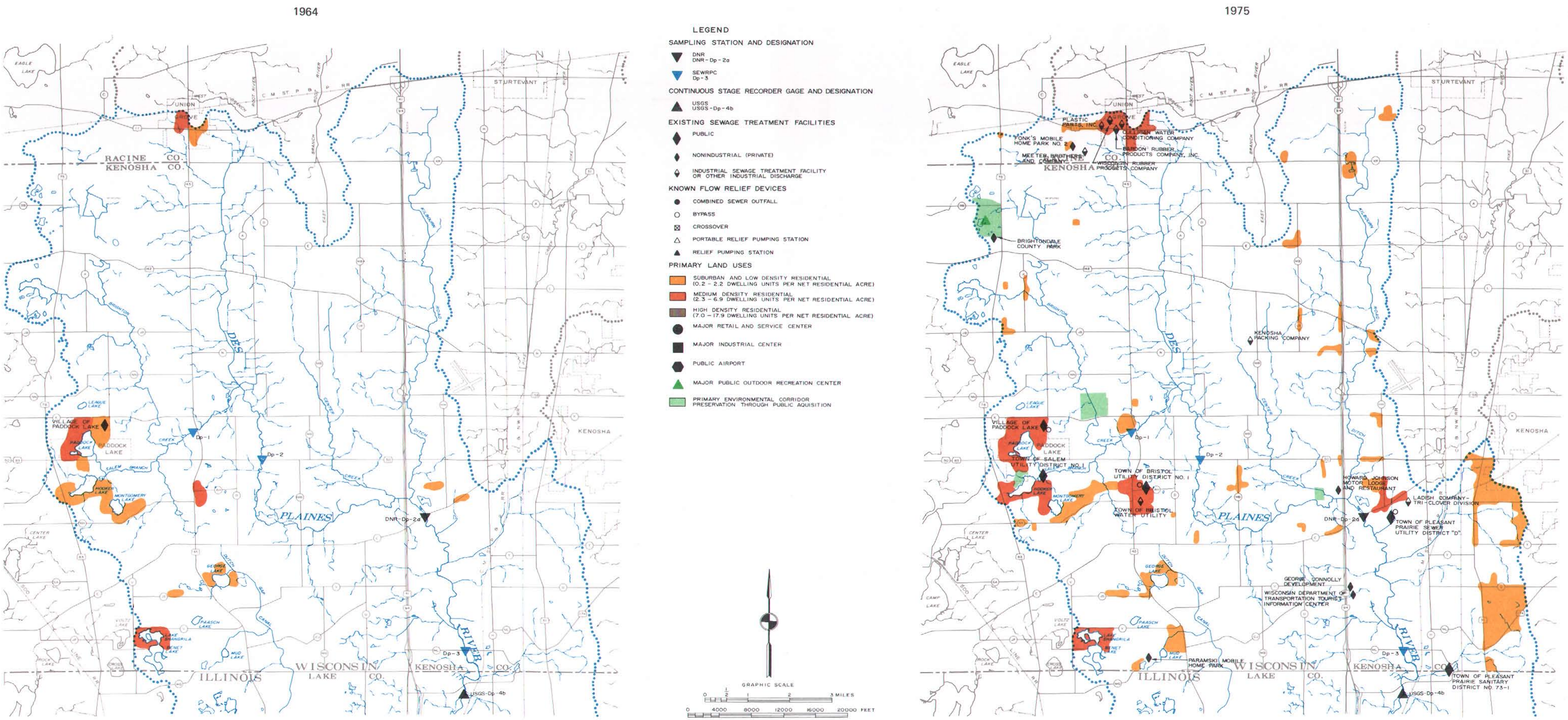
							Design Capacity					Existing Loading	
Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Average Organic	Population[a] Equivalent	Average Hydraulic (mgd)	Average Per Capita (gpd)
Village of Paddock Lake	0.79	1,900	1958, 1967	Activated Sludge	Secondary	Marsh Drained by Brighton Creek	3,200	0.32	0.64	544	2,600	0.17	89
Town of Bristol Utility District No. 1	0.72	800	1965, 1971	Activated Sludge	Secondary	Tributary of Des Plaines River	1,600	0.16	0.27	270	1,290	0.07	87
Town of Pleasant Prairie Sewer Utility District "D"	0.68	1,000	1966	Activated Sludge	Secondary	Des Plaines River	1,200	0.13	0.25	213	1,000	0.10	102
Town of Salem Sewer Utility District No. 1	0.37	1,000	1968	Activated Sludge	Secondary	Salem Branch of Brighton Creek	3,000	0.30	0.60	510	2,430	0.08	80
Town of Pleasant Prairie Sanitary District No. 73-1	0.09	100	1975	Activated Sludge Filter	Tertiary	Des Plaines River	4,000	0.40	0.80	800	3,800	0.03	300

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the Table.*

Source: SEWRPC.

Map 7

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES AND LAND USE IN THE DES PLAINES RIVER WATERSHED: 1964 AND 1975



Stream water quality data was obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at four sampling stations located in the Des Plaines River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by discharges from five municipal sewage treatment facilities, three sanitary sewer system bypasses, six nonindustrial private sewage treatment facilities, and eight industrial or commercial facilities discharging wastewater through eight outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 29

SELECTED CHARACTERISTICS OF NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES IN THE DES PLAINES RIVER WATERSHED: 1975

Name	Civil Division Location	Type of Land Use Served	Type of Wastewater	Type of Treatment Provided	Disposal of Effluent	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Average Hydraulic Design Capacity (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
Brightondale County Park	Town of Brighton	Recreational	Sanitary	Activated Sludge and Lagoon	Groundwater	9,700 (May through September)	10,000	N/A
George Connolly Development	Town of Pleasant Prairie	Residential	Sanitary	Extended Aeration and Sand Filter	Tributary of the Des Plaines River	N/A	34,000	N/A
Howard Johnson Motor Lodge and Restaurant	Town of Bristol	Commercial	Sanitary	Activated Sludge and Lagoon	Des Plaines River	49,000	18,300	77,000
Paramski Mobile Home Park	Town of Bristol	Residential	Sanitary	Extended Aeration and Lagoon	Marsh Tributary to Mud Lake	11,500	40,000	N/A
Wisconsin Department of Transportation Tourist Information Center	Town of Pleasant Prairie	Institutional	Sanitary	Septic Tank, Sand Filter, and Lagoon	Tributary of the Des Plaines River	4,500	9,250	5,800
Fonk's Mobile Home Park No. 2	Town of Dover	Residential	Sanitary	Extended Aeration and Lagoon	Tributary of the Des Plaines River	2,880[b]	15,000[b]	N/A

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data was obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rate was estimated from the available monthly discharge data or from the flow data as reported in the permit.*

[b] *Data obtained from a Department of Natural Resources compliance monitoring survey conducted on October 29 and 30, 1975.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

waters, cooling waters, filter backwash, or sanitary wastewater are discharged directly or indirectly to the surface water system. The industrial wastewaters enter the Des Plaines River and its major tributaries as direct discharge or reach the surface water by drainage ditches and storm sewers. Data and information provided by Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR 101 of the Wisconsin Administrative Code were used to determine the type and location of industrial waste discharges in the Des Plaines River watershed. Table 30 summarizes, by receiving stream and by civil division, the types of industrial waste discharge in the watershed and the types of treatment. Three of the industries—Plastic Parts, Inc., Bardon Rubber Products Company, and Wisconsin Rubber Products Company—discharge cooling water into the Des Plaines River via storm sewers. In addition, the Meeter Brothers Company and Ladish Company discharge cooling and process water into tributaries of the Des Plaines River. The Culligan Water Conditioning Company and the Bristol Water Utility discharge filter backwash to the Des Plaines River. The Kenosha Packing Company discharges cooling, process, and sanitary wastewater to ground waters of the Des Plaines River.

Pollution from Urban Runoff: Separate storm sewers which convey the runoff from rainfall carry the pollutants and contaminants from the urbanized areas into a receiving water. Urban storm waters can contribute suspended solids, nitrogen, phosphorus, chlorides, fecal coliform, oxygen-demanding substances, metals, floating solids, and debris to these receiving lakes and streams. Existing land use information taken from the Commission 1970 Land Use Inventory is presented in Table 31 and indicates that 7,860 acres, or about 9 percent of the Des Plaines River watershed is devoted to urban land uses; 68,928 acres, or about 81 percent of the watershed, is devoted to agriculture; and 8,244 acres, or about 10 percent of the watershed, is occupied by lakes, rivers, streams, and wetlands. A shoreline development survey conducted by the Wisconsin Department of Natural Resources indicates that a similar ratio of urban and rural land uses exists in the shoreline areas of the watershed within 1,000 feet of the Des Plaines River and its tributaries, if the shorelines of the lakes in the watershed are excluded. For the lakes, 72 percent of the shoreline area within 1,000 feet is presently in some urban land use. This data indicates a high concentration of population around the lakes, a typical situation in the Region and one that affects stream and lake water quality.

Pollution from Rural Land: Agricultural land uses are known to contribute high concentrations of suspended solids, total nitrogen, and total phosphorus to surface waters through contribution of storm water runoff. Since 90 percent of the total area of the Des Plaines River watershed is in agricultural use, agricultural runoff is a significant factor affecting the water quality of the Des Plaines River stream system.

Other Pollution Sources: The Commission 1970 Land Use Inventory indicated, in addition to the pollution sources described above, the presence in the watershed of four sanitary landfill sites and one auto salvage yard

Table 30

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE DES PLAINES RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
KENOSHA COUNTY								
Kenosha Packing Company	2011	Town of Paris	Cooling, Process, and Sanitary	Ridge and Furrow	1	Groundwater	23,200	23,700
Ladish Company-Tri-Clover Division	3551	Town of Pleasant Prairie	Process and Cooling	Neutralization Filtration and Lagoon	1	Tributary of the Des Plaines River	94,800	105,300
Town of Bristol Water Utility	4952	Town of Bristol	Filter Backwash	N/A	1	Tributary of the Des Plaines River	Intermittent	Intermittent
RACINE COUNTY								
Bardon Rubber Products Company, Inc.	3069	Village of Union Grove	Cooling	N/A	1	Des Plaines River via Storm Sewer	64,700	86,000
Culligan Water Conditioning Company	7399	Village of Union Grove	Filter Backwash	N/A	1	Des Plaines River via Storm Sewer	1,100	1,300
Meeter Brothers and Company	2033	Town of Dover	Process and Cooling	Lagoon	1	Tributary of the Des Plaines River	66,500	71,200
Plastic Parts, Inc.	3079	Village of Union Grove	Cooling	N/A	1	Des Plaines River via Storm Sewer	192,000	214,500
Wisconsin Rubber Products Company	3069	Village of Union Grove	Cooling	N/A	1	Des Plaines River via Storm Sewer	130,000	173,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rate was estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 31

LAND USE IN THE DES PLAINES RIVER WATERSHED: 1963 AND 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	2,536.32		3,266.64	
Commercial	88.04		130.60	
Industrial	45.93		66.05	
Transportation and Utilities	3,463.86		3,517.37	
Government	179.52		243.58	
Recreation	178.07		568.20	
Landfill and Dump	12.79		68.40	
Total	6,504.53	7.65	7,860.84	9.24
Rural Land Uses				
Open Land	5,955.07		5,729.93	
Agricultural Lands	64,256.95		63,198.30	
Total	70,212.02	82.57	68,928.23	81.06
Water Covered Lands				
Lakes, Rivers, and Streams	905.61		1,202.92	
Wetlands, etc.	7,410.80		7,041.20	
Total	8,316.41	9.78	8,244.12	9.69
Watershed Totals	85,032.96	100.00	85,033.19	100.00

Source: SEWRPC.

in the Des Plaines River watershed. Seepage and runoff from these sources may contain suspended solids, oxygen-demanding materials, chlorides, toxic substances, and nutrients, and may contribute to the pollution of the River system.

Water Quality Conditions of Des Plaines River Watershed

Water Quality Data: Of the total data sources available, the following eight were used in the analysis of water quality trends in the Des Plaines River watershed: (1) bench mark study of the Commission; (2) continuing monitoring program of the Commission; (3) streamflow gaging program of the Commission; (4) Wisconsin Department of Natural Resources monthly stream sampling program; (5) Wisconsin Department of Natural Resources drainage basin surveys; (6) Wisconsin Department of Natural Resources quarterly lake monitoring program; (7) U. S. Geological Survey streamflow monitoring program; and (8) U. S. Geological Survey Water Quality Sampling Program. A detailed description of these data sources is given in Chapter II.

Three sampling stations, two on the Des Plaines River and one on Brighton Creek were established by the Commission. Tables 32 and 33 present the Commission stations, locations, and their distances from the Wisconsin-Illinois State line. Table 34 presents stations other than those established by the Commission. Map 7 illustrates

Table 32

DESIGNATIONS AND LOCATIONS OF SEWRPC SAMPLING STATIONS IN THE DES PLAINES RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from the State Line (in miles)
SEWRPC	Dp-2	Des Plaines River at STH 50; NE ¼, Section 9, T1N, R21E	12.3
SEWRPC	Dp-3	Des Plaines River at CTH ML; SW ¼, Section 32, T1N, R22E	0.7

Source: SEWRPC.

Table 33

DESIGNATION AND LOCATION OF THE SEWRPC SAMPLING STATION ON THE TRIBUTARY OF THE DES PLAINES RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from the State Line (in miles)
SEWRPC	Dp-1	Brighton Creek at USH 45, NW ¼, Section 5, T1N, R21E (Tributary)	16.0

Source: SEWRPC.

Table 34

DESIGNATIONS AND LOCATIONS OF STREAM SAMPLING STATIONS OF OTHER SOURCES IN THE DES PLAINES RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from the State Line (in miles)
DNR.	DNR Dp-2a	Des Plaines River on CTH C, 1 mile west of Pleasant Prairie; NW ¼, Section 18, T1N, R22E	5.7
USGS	USGS Dp-4b	Bridge on Des Plaines River at Russell, Illinois; SE ¼, Section 3, T46N, R11E	−0.8[a]

[a] *Located in the State of Illinois.*

Source: SEWRPC.

the location of the sampling stations in the Des Plaines River watershed.

Surface Water Quality of Des Plaines River and Its Tributaries 1964-1965: Water quality conditions in the Des Plaines River watershed, as determined by the 1964-65 sampling survey at two stations along the length of the Des Plaines River and one on Brighton Creek, are summarized in Table 35. The water quality data obtained at the DNR Dp-2a by the Wisconsin Department of Natural Resources is summarized in Table 36. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to the assessment of trends in surface water quality.

Chloride: During 1964-1965, chloride concentrations throughout the watershed varied from 15 to 105 mg/l. The average values for the Des Plaines River and Brighton Creek were 50 and 22 mg/l, respectively. The water samples collected at the DNR Dp-2a on the Des Plaines River by the Wisconsin Department of Natural Resources also showed a range of seven mg/l to 124 mg/l with the average value of 52 mg/l. The chloride content of the Des Plaines River and Brighton Creek in the 1964 to 1965 monthly samples was higher than that of the groundwater—10 mg/l—as measured from well samples taken in the area.[3] A likely source of the higher chloride concentration is the discharge of backwash waters from Culligan Water Conditioning Company. In addition, the cooling in the headwater area of the Des Plaines River may add chloride to the surface water. The higher chloride concentrations in Brighton Creek probably are related to sewage effluent from the residential development in the Paddock Lake area.

Dissolved Oxygen: During 1964-1965, the dissolved oxygen levels in the watershed ranged from 2.1 to 13.9 mg/l, with the average values for the Des Plaines River and the Brighton Creek 8.6 and 9.7 mg/l, respectively. The water samples collected at the DNR Dp-2a

[3] *C. L. R. Holt, Jr. and E. L. Skinner, Groundwater Quality in Wisconsin Through 1972, U. S. Geological Survey and University of Wisconsin-Extension, Information Circular Number 22, 1973.*

Table 35

WATER QUALITY CONDITIONS OF THE DES PLAINES RIVER AND TRIBUTARIES: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Des Plaines River Main Stem— Dp-2, Dp-3	Chloride (mg/l)	105	50	20	16
	Dissolved Solids (mg/l)	825	700	430	16
	Dissolved Oyxgen (mg/l)	13.9	8.6	2.1	25
	Total Coliform Counts (MFCC/100 ml)	32,000	8,100	< 100	25
	Temperature (°F)	81	51	32	25
Brighton Creek Dp-1	Chloride (mg/l)	30	22	15	2
	Dissolved Solids (mg/l)	615	577	460	2
	Dissolved Oyxgen (mg/l)	13.3	9.7	5.5	11
	Total Coliform Counts (MFCC/100 ml)	56,000	5,900	100	11
	Temperature (°F)	84	55	32	10

Source: SEWRPC.

Table 36

WATER QUALITY CONDITIONS OF THE DES PLAINES RIVER AT SAMPLING STATION DP-2A: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
DNR Dp-2a Des Plaines River	Chloride (mg/l)	124	52	7	12
	Dissolved Solids (mg/l)	1,026	760	613	12
	Dissolved Oyxgen (mg/l)	15.3	6.9	2.6	12
	Total Coliform Counts (MFCC/100 ml)	18,000	5,091	100	12
	Temperature (°F)	77.9	50.9	32.0	12

Source: Wisconsin Department of Natural Resources.

on the Des Plaines River by the Wisconsin Department of Natural Resources had dissolved oxygen concentrations in the range of 2.6 to 11.9 mg/l with the average value of 6.9 mg/l. Although the average concentration of dissolved oxygen was greater than 5.0 mg/l for the Des Plaines River, water samples had the dissolved oxygen levels lower than 5.0 mg/l during four out of 14 sampling periods at sampling station Dp-3 and four out of 12 at sampling periods at DNR Dp-2a. The low dissolved oxygen content and associated presence of oxygen-demanding materials in those portions of the watershed where the predominant land use is agricultural indicates that the pollution source is nonurban in nature. Because the watershed is covered by soils that are generally poorly drained, agricultural drainage systems are used. As discussed in Chapter III, water from such drainage systems usually is high in dissolved solids with both organic and inorganic constituents. The oxidizable portion of the drainage water may account for most of the oxygen demand in the streams of the Des Plaines River watershed.

Biochemical Oxygen Demand: The range of five-day biochemical oxygen demand (BOD_5) in the Des Plaines River watershed during the sampling years of 1964-1965 ranged from a low of 0.5 mg/l to a high of 15.1 mg/l at the three sampling stations, with the average values for the Des Plaines River and Brighton Creek of 3.0 and 3.0 mg/l, respectively. The range and the average of BOD_5 values obtained at the DNR Dp-2a sampling station by the Wisconsin Department of Natural Resources were 0.6 to 9.4 mg/l and 2.8 mg/l, similar to the data obtained at the Commission sampling stations on the Des Plaines River. The high BOD_5 values were obtained in the September and January samples collected at the Des Plaines River and Brighton Creek sampling stations. Since the water samples with high BOD_5 were collected on the days with heavy rain as indicated by the precipitation data from the precipitation gaging station located in the City of Racine, City of Kenosha, Villages of Union Grove and Antioch, Illinois, and since the water samples were collected from those portions of the watershed where the land use is predominantly agricultural, the source of the high BOD_5 is likely to be runoff from the agricultural and rural land.

Total Coliform Bacteria: During 1964-1965, membrane filter coliform counts varied from less than 100 to 56,000 MFCC/100 ml, with the average values for the Des Plaines River and the Brighton Creek being, respectively, 8,100 and 5,900 MFCC/100 ml. The highest total coliform counts occurred during the months of September and January at all three sampling locations. The water samples collected at the DNR Dp-2a on the Des Plaines River by the Wisconsin Department of Natural Resources had total coliform counts in the range of 100 to 18,000 MFCC/100 ml with an average value of 5,091 MFCC/100 ml. The high total coliform counts at DNR Dp-2a were found in July and September samples. The fact that the high coliform counts occur during times of average flow in the streams rules out the possibility of spring runoff as the major source of the total coliform bacteria; and, since the high coliform counts did not occur throughout the year, the source is not continuous. The high total coliform counts therefore are probably due to such noncontinuous sources as agricultural runoff and wastes from wildlife and domestic animals.

Specific Conductance: During the 1964-1965 sampling period, the specific conductance for the Des Plaines River ranged from 572 to 1,220 umhos/cm at 25°C, with the average values of 974 and 655 umhos/cm at 25°C for the Des Plaines River and Brighton Creek, respectively. The highest specific conductance value was found at sampling station Dp-3 on the Des Plaines River located 0.7 miles upstream from the State line. The specific conductance value at sampling station Dp-3 remained high all through the year except for one sample, indicating a consistently high dissolved solids content at this location. Since agricultural runoff, and especially tile drainage water, is known to have high soluble constituents, the high dissolved solids content would tend to corroborate the theory of agricultural runoff being a significant source of high specific conductance levels in the Des Plaines River watershed.

Hydrogen Ion Concentration (pH): The pH values at all sampling stations in the Des Plaines River watershed ranged from 7.2 to 8.6 standard units during 1964-1965. At no location within the watershed was the pH found to be outside the range of 6.0 to 9.0 standard units, as prescribed for recreational uses as well as for the maintenance of fish and aquatic life.

Temperature: During 1964-1965, the temperature of water samples from the Des Plaines and Brighton Creek ranged between 32°F and 43°F during the months of December through April and ranged between 46°F and 84°F during the months of May through November. The temperature variations, therefore, were attributable mainly to the seasonal change.

Surface Water Quality of Lakes in the Des Plaines River Watershed 1964-1965: No chemical data for evaluating the water quality of the major and minor lakes are available for the lakes in the Des Plaines River watershed for the year 1964-1965.

Water Quality Trends from 1965 to 1975: Water quality data from 1965 to 1975 for eight summer sampling programs, three spring sampling programs, and one fall sampling program are presented in tabular form in Appendix D of this report. The summer sampling surveys began in August 1968 and involved collection of samples on one day in August every year during low flow conditions. An analysis of the flow data from Water Resources Data for Wisconsin, published by the U. S. Geological Survey indicates that, for the streams in southeastern Wisconsin, low flow generally occurs during the months of August and September. Although the collection and analysis of one sample per station per year cannot represent water quality conditions for the whole year, it may be assumed to reasonably represent the water quality conditions of the stream at that location during the low flow period, which is generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life. The summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of the three stations sampled in the Des Plaines River watershed by the Commission since 1968 is set forth in Tables 37 through 39, and the summary of water quality data obtained from DNR Dp-2a by the Wisconsin Department of Natural Resources on the Des Plaines River is set forth in Table 40. Streamflow data for the Des Plaines River near Russell, Illinois, located 0.8 mile downstream from the State line and 1.5 miles downstream from Dp-3, was available from the U. S. Geological Survey records, and streamflow data at this location for the years 1968 through 1975 on the days the water samples were collected is presented in Figure 2.

Table 37

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard/ Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	38.0	17.5	6.0	22	--
Dissolved Oxygen (mg/l)	5	13.7	6.7	2.5	30	10[a]
Ammonia-N (mg/l)	2.5	0.44	0.14	0.03	8	0
Organic-N (mg/l)	--	2.27	1.01	0.08	8	--
Total-N (mg/l)	--	2.68	1.36	0.12	8	--
Specific Conductance (umhos/cm at 25°C)	--	875.0	671.0	553.0	29	--
Nitrite-N (mg/l)	--	0.19	0.03	0.00	11	--
Nitrate-N (mg/l)	0.30	0.34	0.18	0.04	12	1
Soluble Orthophosphate-P (mg/l)	--	0.36	0.22	0.03	12	--
Total Phosphorus (mg/l)	0.10	0.50	0.25	0.05	8	7
Fecal Coliform (MFFCC/100 ml)	400	7,600	1,185	30	12	8
Temperature (°F)	89	80.0	64.2	51.0	29	0
Hydrogen Ion Concentrations (standard units)	6-9	8.5	8.0	7.6	16	0

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 38

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard/ Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	168.0	65.7	7.0	22	--
Dissolved Oxygen (mg/l)	5	13.7	6.7	3.1	30	8[a]
Ammonia-N (mg/l)	2.5	0.24	0.09	0.03	8	0
Organic-N (mg/l)	--	2.98	1.52	0.72	8	--
Total-N (mg/l)	--	4.61	2.32	0.95	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,300.0	981.7	686.0	29	--
Nitrite-N (mg/l)	--	0.118	0.045	0.012	12	--
Nitrate-N (mg/l)	0.30	1.340	0.525	0.110	12	7
Soluble Orthophosphate-P (mg/l)	--	0.461	0.25	0.137	12	--
Total Phosphorus (mg/l)	0.10	0.59	0.33	0.17	8	8
Fecal Coliform (MFFCC/100 ml)	400	2,300	774	200	12	8
Temperature (°F)	89	86.0	71.7	60.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.4	8.0	7.7	16	0

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Dissolved Oxygen: For the watershed as a whole, the dissolved oxygen concentrations in the Des Plaines River stream system during August for the period 1968 through 1975 were 2.6 to 13.2 mg/l. The average dissolved oxygen concentrations for the eight year period were 7.1 and 6.9 for the Des Plaines River stations Dp-2 and Dp-3; the average dissolved oxygen concentration for Brighton Creek was 7.1 mg/l. Although the eight year summer average dissolved oxygen concentrations were above 5.0 mg/l for all three locations, the dissolved oxygen concentrations were lower than 5.0 mg/l at Dp-1, Dp-2, and Dp-3 on several occasions during 1968-1975. Substandard levels of dissolved oxygen concentrations occurred in 10, eight, and 13 of the 30 samples collected at each sampling station Dp-1, Dp-2, and Dp-3.

The 11 year (1965-1975) monthly sample data provided by the Wisconsin Department of Natural Resources at CTH C one mile west of Pleasant Prairie, between Dp-2 and Dp-3 of the Commission stations, indicates that

Table 39

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard/ Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	85.0	55.0	30.0	22	--
Dissolved Oxygen (mg/l)	5	12.6	5.9	1.9	30	13[a]
Ammonia-N (mg/l)	2.5	0.26	0.09	0.03	8	0
Organic-N (mg/l)	--	2.42	1.52	0.99	8	--
Total-N (mg/l)	--	4.17	2.40	1.34	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,100	920	708	29	--
Nitrite-N (mg/l)	--	0.13	0.06	0.03	12	--
Nitrate-N (mg/l)	0.30	2.0	0.72	0.23	12	10
Soluble Orthophosphate-P (mg/l)	--	0.61	0.38	0.09	12	--
Total Phosphorus (mg/l)	0.10	0.62	0.41	0.15	8	8
Fecal Coliform (MFFCC/100 ml)	400	880	391	70	12	7
Temperature (°F)	89	90.0	74.4	62.0	30	2
Hydrogen Ion Concentrations (standard units)	6-9	8.6	8.1	7.6	16	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 40

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-2A: 1968-1975

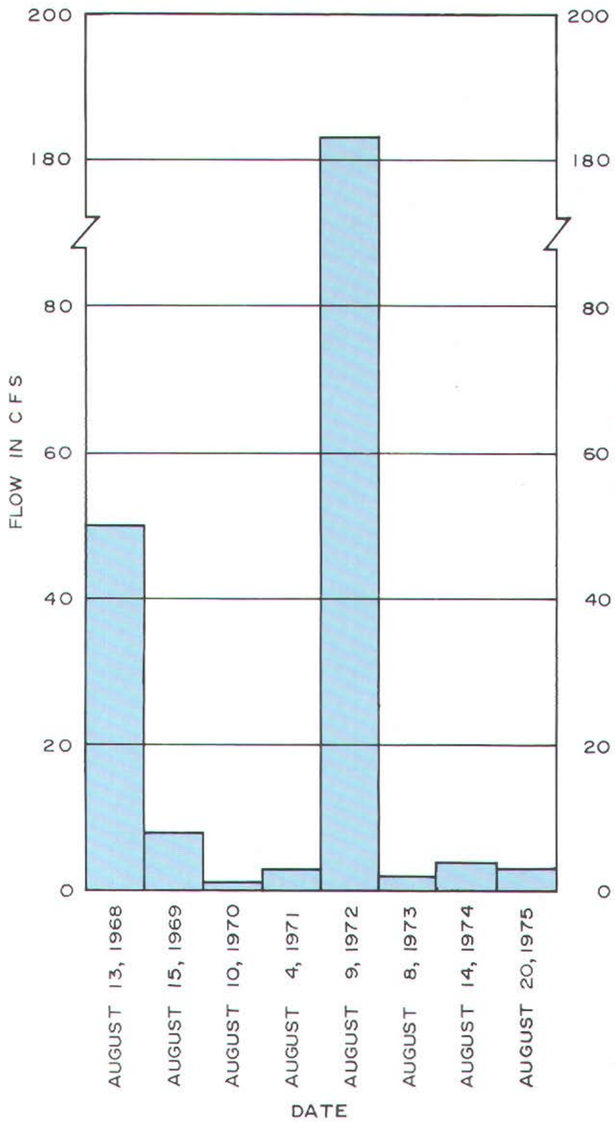
Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard/ Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	114	53	26	8	--
Dissolved Oxygen (mg/l)	5.0	9.5	6.1	4.3	8	2[a]
Ammonia-N (mg/l)	2.5	1.11	0.29	0.03	7	0
Organic-N (mg/l)	--	1.50	1.00	0.15	7	--
Total-N (mg/l)	--	--	--	--	--	--
Specific Conductance (umhos/cm at 25°C)	--	--	--	--	--	--
Nitrite-N (mg/l)	--	--	--	--	--	--
Nitrate-N (mg/l)	0.30	0.26	0.11	0.01	5	0
Soluble Orthophosphate-P (mg/l)	--	--	--	--	--	--
Total Phosphorus (mg/l)	0.10	0.44	0.26	0.12	7	7
Fecal Coliform (MFFCC/100 ml)	400	2,300	520	50	8	2
Temperature (°F)	89.0	82.4	73.4	60.8	8	0
Hydrogen Ion Concentrations (standard units)	6-9	8.2	7.9	7.7	8	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Figure 2

FLOW MEASUREMENT IN THE DES PLAINES RIVER WATERSHED AT USGS STATION DP-4b ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: U. S. Geological Survey.

the dissolved oxygen concentrations are generally lower during the months of June and July than during August. Similar results, i.e., lower dissolved oxygen concentrations in the months of June and July than in August, were observed in the samples collected by the Commission during the 1964-1965 bench mark study. These results from the Wisconsin Department of Natural Resources and the Commission bench mark study indicate that, for the years 1968 through 1975, the concentrations of dissolved oxygen at stations Dp-1 through Dp-3 could have been lower in June or July than those measured in August.

Map 8 presents the average dissolved oxygen concentrations that were found in August 1964 and August 1975 in the Des Plaines River watershed. The graphs included on the map illustrate the change in the average dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at each location. On August 6, 1964, as indicated on the map, substandard dissolved oxygen levels were observed in the Des Plaines River at Dp-3. Similar results, i.e., substandard levels of dissolved oxygen, were observed at Dp-3 on August 20, 1975. The graph inserts on Map 8 present the daily average dissolved oxygen concentration and the three year moving averages at stations Dp-1 through Dp-3 in the August samples during the period for the years 1964 through 1975. The dissolved oxygen concentrations remained fairly constant at Dp-1 and Dp-3 and showed a slight increase at Dp-2. The data obtained by the Wisconsin Department of Natural Resources at DNR Dp-2a also indicates a similar generally stable dissolved oxygen concentration for the period of 11 years.

A comparison of dissolved oxygen concentrations found in April and August of the years 1964, 1968, and 1969, indicates higher dissolved oxygen concentrations in April of each year than in August. The August dissolved oxygen concentration levels were 1 to 10 mg/l less than found in the April samples. The lower flow and higher temperatures, accompanied by the organic load from sewage effluents and agricultural runoff, probably account for the decreased dissolved oxygen concentrations in the August samples.

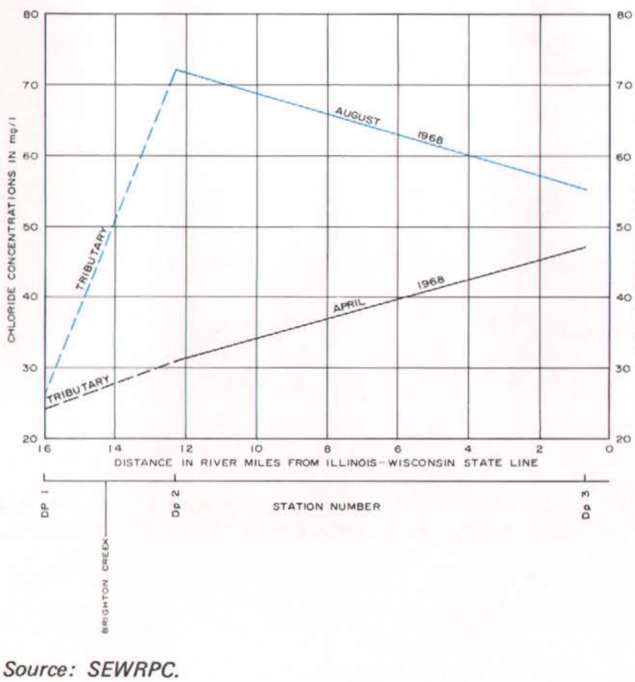
Chloride: The chloride concentrations were found in the range of seven to 168 mg/l for the stations on the Des Plaines River in the samples collected during the period for the years 1968 through 1975. The water samples collected by the Wisconsin Department of Natural Resources at DNR Dp-2a had chloride concentrations in the range of 32 to 114 mg/l. The chloride concentrations at the sampling station located on Brighton Creek, Dp-1, were found in the range of six to 38 mg/l. The average chloride concentrations of the samples collected over the past eight years at sampling stations Dp-2, DNR Dp-2a, and Dp-3 were 62, 53, and 51 mg/l, significantly higher than the area groundwater chloride concentration of approximately 10 mg/l. The high chloride concentrations at sampling station Dp-2 indicate that the source of chloride was located upstream from the sampling location. Brighton Creek, which meets the Des Plaines River upstream from the sampling station Dp-2, was found to have an average chloride concentration of 18 mg/l and therefore accounts for only a third of the chloride levels found in the Des Plaines River at sampling station Dp-2. The other possible sources of chloride located upstream from the sampling station Dp-2 are the four industries: Culligan Water Conditioning Company discharging backwash water, Bardon Rubber Products Company, Wisconsin Rubber Products Company, and Plastic Parts, Inc., discharging cooling waters, and the deicing road salt which percolates and is discharged into the stream water through tile drainage from the agricultural land. A comparison of the chloride concentrations in April 1968 with August 1968, and in April 1969 with August 1969, as presented in

Figures 3 and 4, indicates a trend towards higher chloride concentrations in the August samples of the Des Plaines River and Brighton Creek. Assuming the flow at Dp-3 was similar to that found at Russell, Illinois, which is 1.5 miles downstream from the sampling station Dp-3, chloride loadings were calculated for the August and April 1968 and 1969 data and plotted in Figure 5. A comparison of Figures 3, 4, and 5 indicates that although the chloride concentrations were higher in the August samples in 1968 and 1969 at Dp-3, the chloride loadings were significantly higher in the April samples. The higher chloride loadings during high flow in April at Dp-3 is related to the spring runoff from the pasture land and from deicing salt from the highways located near the sampling station. Map 9 presents the chloride concentrations in the Des Plaines River sampling stations on August 1968 and August 25, 1975, with graphs illustrating the changes in chloride concentrations found at Dp-1 through Dp-3 during the sampling days of intermediate years. No change in chloride concentrations is seen when the August 1968 and 1975 data are compared for the samples collected from stations Dp-1 and Dp-3, and a decrease in chloride concentrations is observed at Dp-2. The graphs illustrate the changes in the chloride concentrations in August for the Des Plaines River stations Dp-1 through Dp-3 for the years 1964 through 1975. At sampling station Dp-1 on Brighton Creek and Dp-3 on the Des Plaines River, the chloride concentrations generally remained constant over the past decade. At sampling stations Dp-2 and DNR Dp-2a no specific trend in chloride concentrations was observed. Figure 6 presents the chloride loadings and flow on the days water samples were collected from the sampling station Dp-3, indicating a direct correlation between the flow and chloride loadings. If it is assumed that the chloride contribution from the sewage treatment plants is constant, then the chloride loadings in the stream would not be expected to vary with the flow of the River. The fact that the chloride loading does vary with the flow at Dp-3 indicates that the chloride has significant sources other than sewage effluent and that these sources may lie in the area tributary to Dp-2. The higher flow in 1972 was associated with rain, raising the possibility of the origin of chloride being associated with storm water runoff. The background chloride loadings, assuming a maximum background chloride concentration of 10 mg/l, are included in Figure 6 and illustrate the fact that the increased chloride loadings in all the samples at Dp-3 are three to 10 times higher than the background loadings assumed.

Fecal Coliform Bacteria: The fecal coliform counts were found to be in the range of 70 to 2,300 MFFCC/100 ml for the two stations of the Des Plaines River in the samples collected during the period 1968 through 1975. The water samples collected by the Wisconsin Department of Natural Resources at DNR Dp-2a had fecal coliform counts in the range of 50 to 2,300 MFFCC/100 ml. The fecal coliform counts at the sampling station Dp-1, located on Brighton Creek, were found to be in the

Figure 3

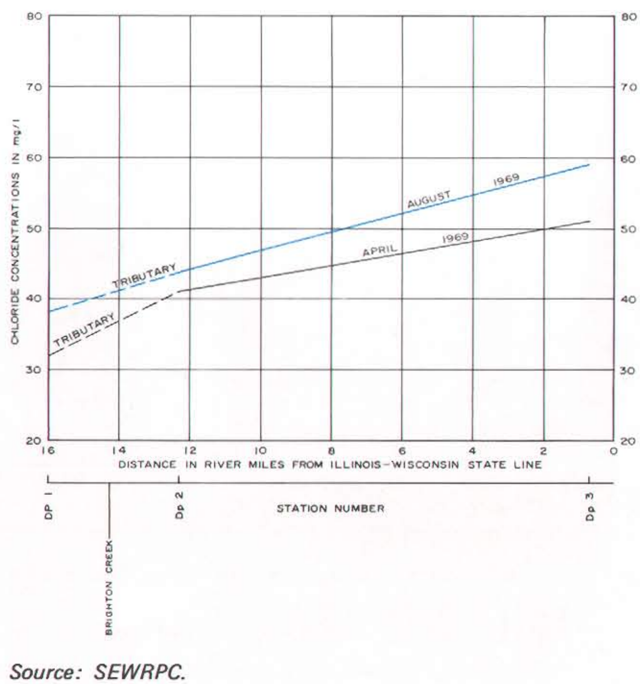
CHLORIDE CONCENTRATIONS IN THE DES PLAINES RIVER WATERSHED APRIL AND AUGUST 1968



Source: SEWRPC.

Figure 4

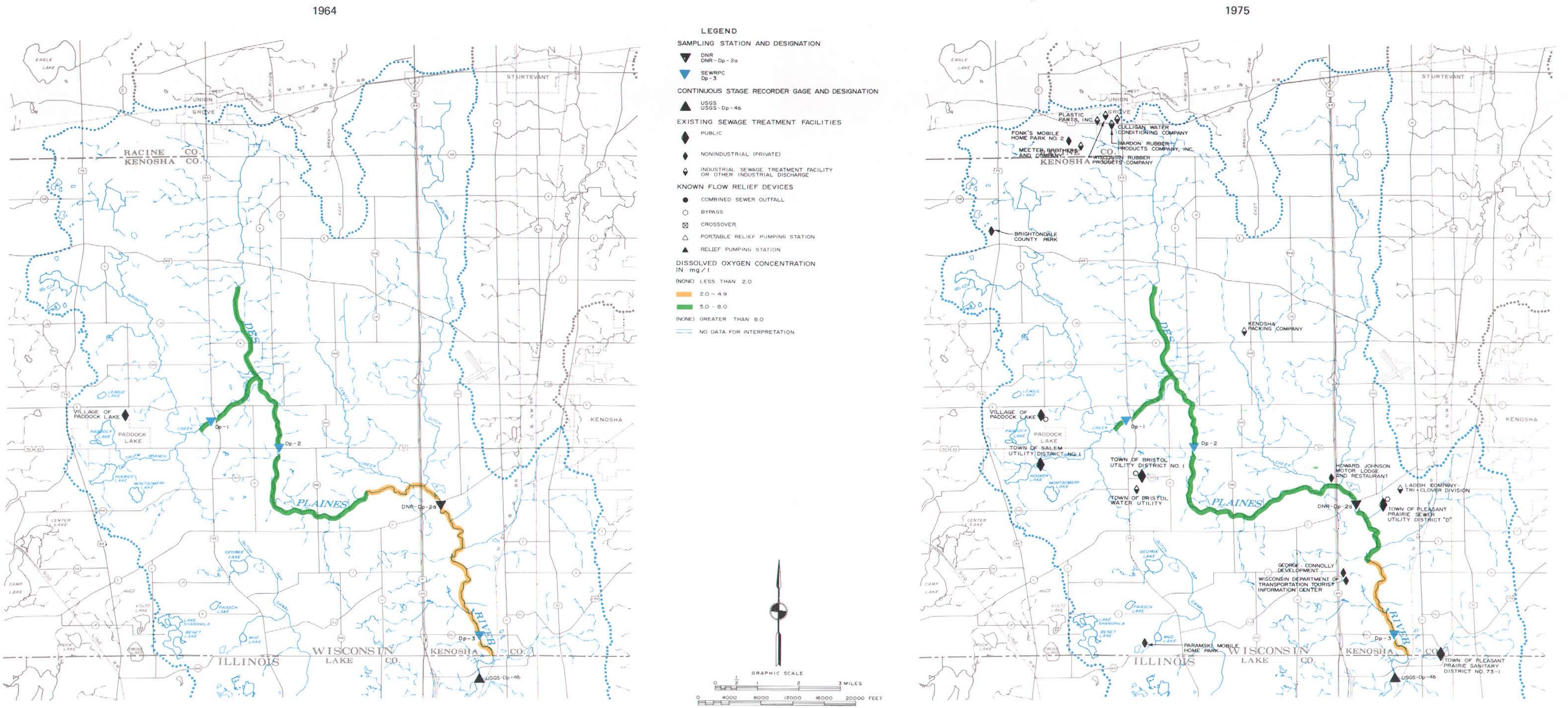
CHLORIDE CONCENTRATIONS IN THE DES PLAINES RIVER WATERSHED APRIL AND AUGUST 1969



Source: SEWRPC.

Map 8

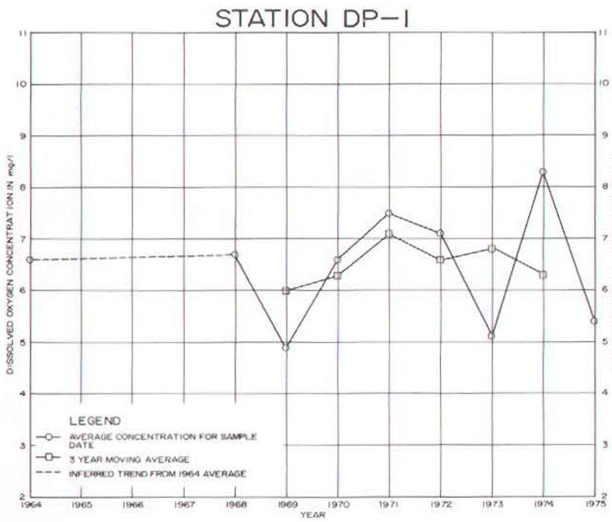
COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST OF THE YEARS 1964-1975 IN THE DES PLAINES RIVER WATERSHED

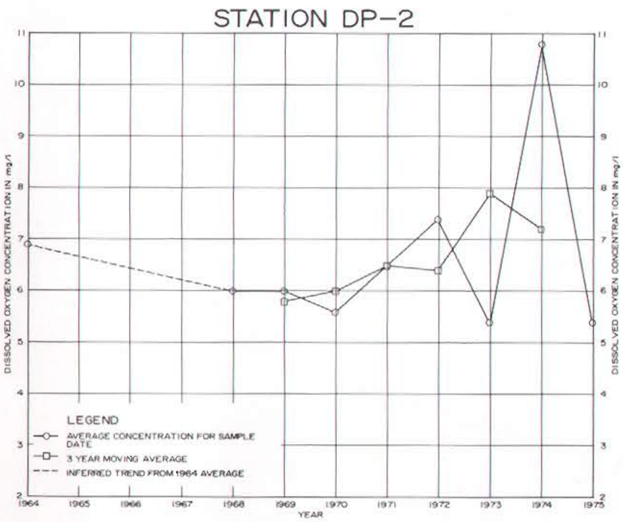


A comparison of the dissolved oxygen levels recorded in 1964 and 1975 in the Des Plaines River watershed indicated that dissolved oxygen concentrations remained fairly constant at sampling stations Dp-1 and Dp-3 and showed a slight increase at sampling station Dp-2. The data obtained by the Wisconsin Department of Natural Resources at sampling station DNR-Dp-2a also indicates a similar generally stable dissolved oxygen concentration for the period of 10 years. The maximum dissolved oxygen sample taken during the 10 year period was 13.7 mg/l recorded at both sampling stations Dp-1 and Dp-2 and the minimum sample of 1.9 mg/l was recorded at sampling station Dp-3.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 8 (continued)





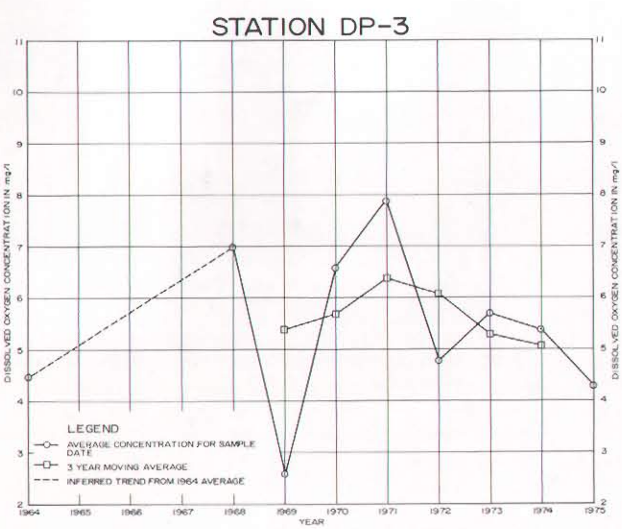
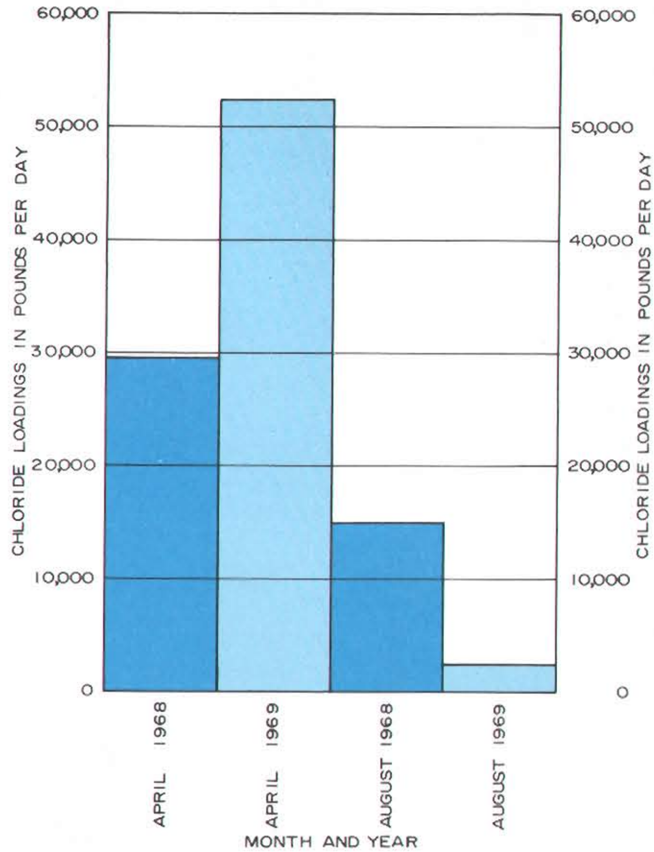


Figure 5

CHLORIDE LOADINGS AT SAMPLING STATION DP-3 IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968-1969

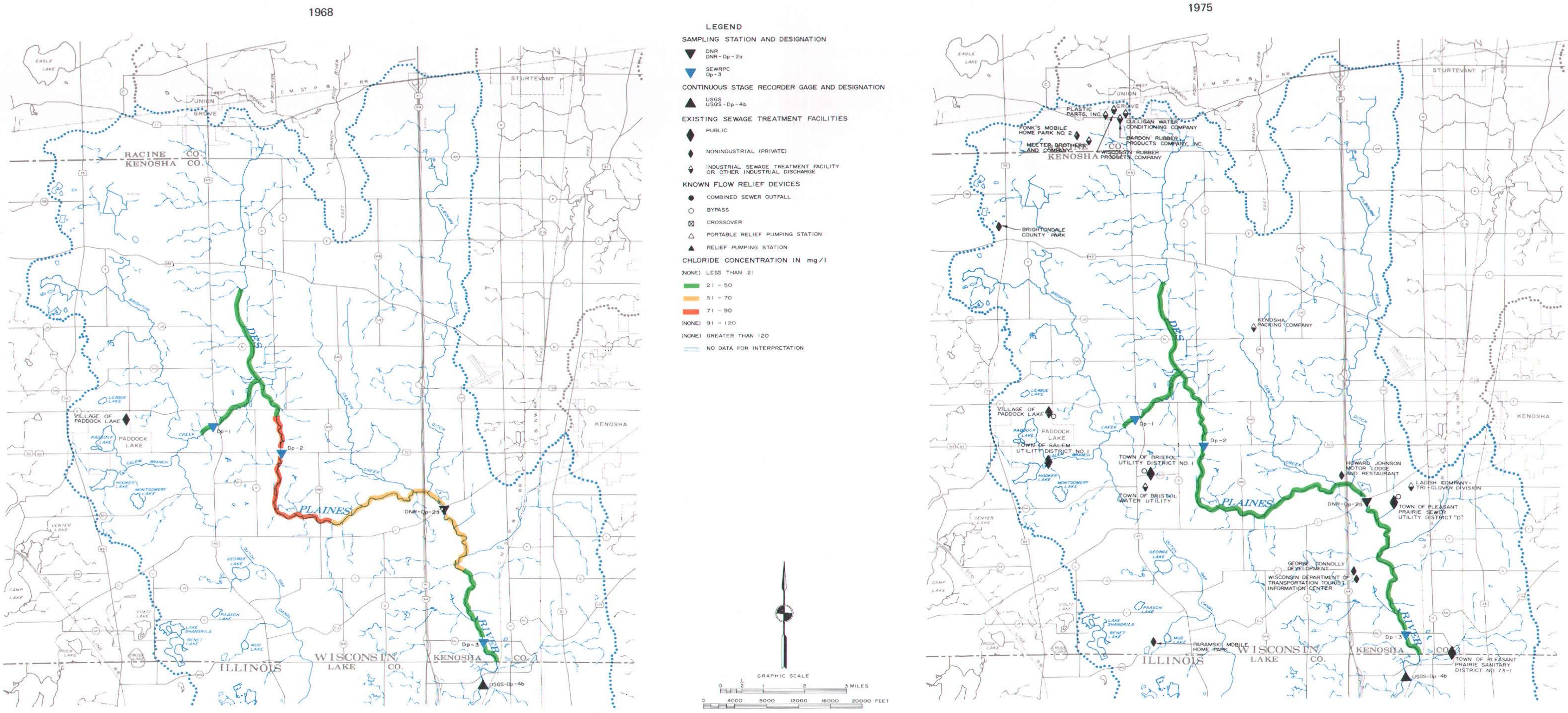


Source: SEWRPC.

range of 30 to 7,600 MFFCC/100 ml. The average fecal coliform counts at sampling stations Dp-1, Dp-2, Dp-3, and DNR Dp-2a were 1,185, 774, 391, and 520 MFFCC/ 100 ml. Map 10 and the graphs drawn thereon present the fecal coliform counts found at the sampling stations Dp-1 through Dp-3 in the Des Plaines River watershed during Augusts of the years 1968 through 1975. The water samples collected in August 1968 showed fecal coliform counts of 1,200 and 700 MFFCC/100 ml at sampling stations Dp-2 and Dp-3 on the Des Plaines River and 7,000 MFCC/100 ml at sampling station Dp-1 on Brighton Creek. On the other hand, the water samples collected in 1975 had fecal coliform counts in the range of 465 to 835 MFFCC/100 ml at all three sampling locations. At the sampling station DNR Dp-2a, the fecal coliform counts were 2,300 MFFCC/100 ml on August 27, 1968, and decreased to 480 MFFCC/100 ml in the sample collected on August 27, 1975. Thus, when 1968 and 1975 samples are compared, a decrease in the fecal coliform counts is observed at sampling stations Dp-1, Dp-2, and DNR Dp-2a and the water quality remained

Map 9

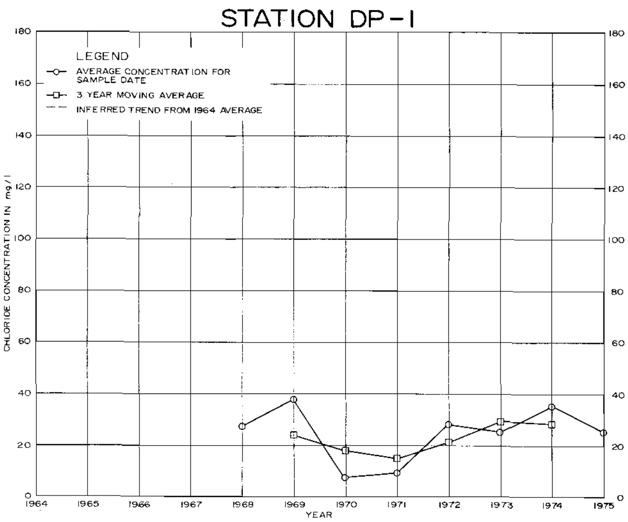
COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST OF THE YEARS 1968-1975 IN THE DES PLAINES RIVER WATERSHED

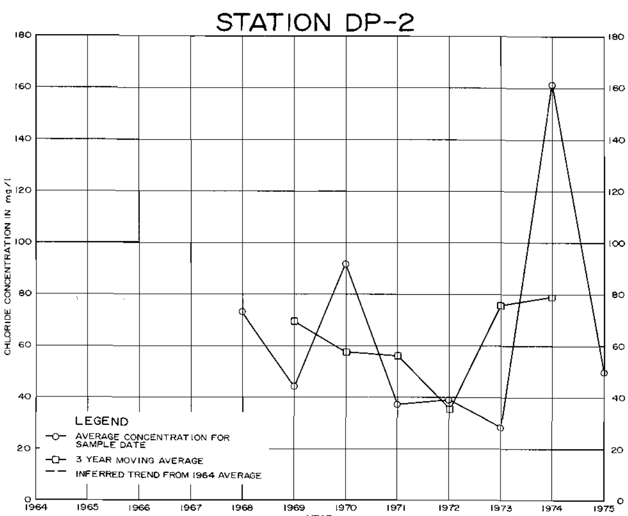


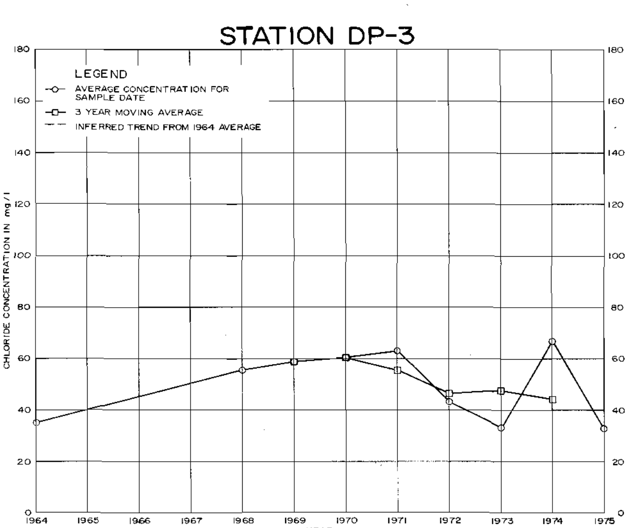
No change in chloride concentrations is evident when the August 1968 and 1975 data are compared for the samples collected from sampling stations Dp-1 and Dp-3, and a decrease in chloride concentrations was observed at sampling station Dp-2. The maximum observed sample of 168.0 mg/l was recorded at sampling station Dp-2 and the minimum observed sample of 6.0 mg/l was recorded at sampling station Dp-1.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 9 (continued)







the same at Dp-3. The graphs on Map 10 illustrate the decreasing trend of fecal coliform counts over time for the sampling stations Dp-1 on Brighton Creek and Dp-2 and DNR Dp-2a on the Des Plaines River. No significant change in the fecal coliform counts is noted at sampling station Dp-3 over the past eight years. The decrease in the fecal coliform counts at sampling station Dp-1 is most probably associated with the improvement of the sewage treatment plant at the Village of Paddock Lake and the installation of sewage collection and treatment facilities of the Town of Salem Sewer Utility District No. 1 in 1966.

Hydrogen Ion Concentrations (pH): As indicated in Tables 37 to 40, the pH values of the watershed surface water system have generally been within the range of 6.0 to 9.0 standard units prescribed for recreational use and maintenance of fish to aquatic life. No trend in pH variation of the samples collected in August 1964 through 1975 was observed.

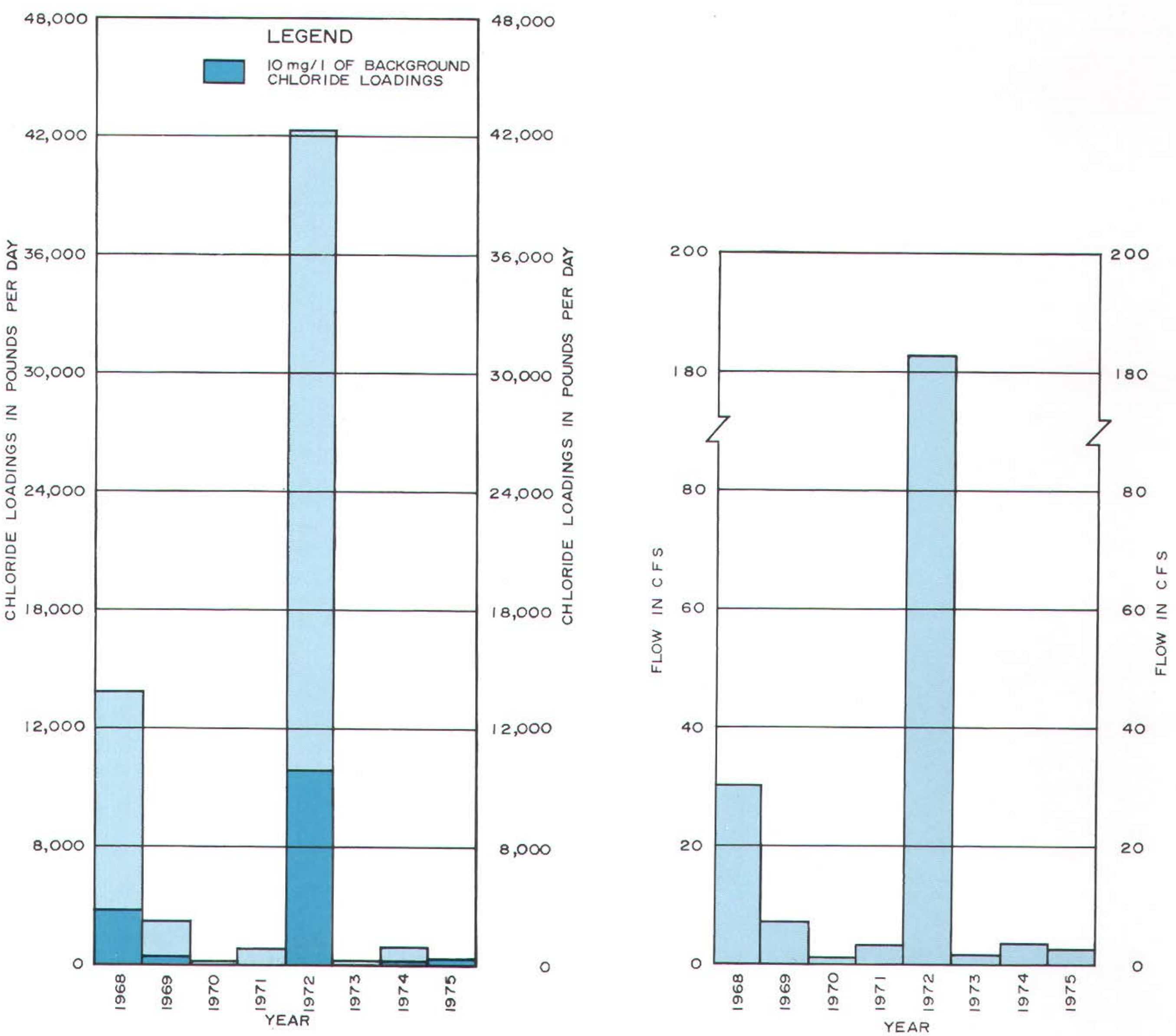
Specific Conductance: Specific conductance, a measure of total dissolved ions in water, was in the range of 553-1,250 µmhos/cm at 25°C for the three locations on the Des Plaines River on the days sampled between 1968 and 1975 in August. The highest specific conductance value was found at sampling station Dp-2 in August 1974. No specific pattern of change in the conductance values was seen at sampling stations Dp-2 and Dp-3 over the years 1968 through 1975, although the variation with time generally followed a similar pattern for sampling stations Dp-2 and Dp-3. At the Brighton Creek sampling station Dp-1, a decreasing trend over the past decade was observed in the specific conductance levels. This, in association with the total phosphorus and total nitrogen values, which also decreased over time at sampling station Dp-1, located on Brighton Creek, indicate a favorable effect on water quality of the increased capacity of the Paddock Lake Sewage Treatment Plant and the 1966 installation of the sewage treatment plant of the Town of Salem Sewer Utility District No. 1.

Temperature: As indicated in Tables 37-40, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life except during one sampling date, that of August 10, 1970. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the two Des Plaines River sampling locations and one sampling station on Brighton Creek during August of 1968 through August 1975 were analyzed for soluble orthophosphate concentrations. A range of 0.02 to 0.23 mg/l of soluble orthophosphate as P was obtained for the eight samples at the three locations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.05 to 0.52 mg/l as P was obtained. The high ratio of soluble orthophosphate—ranging from 0.5 to 1.0—to total phosphorus in the water samples indicates that most of the phosphorus is in a form readily available for the growth of aquatic plants in the Des Plaines River

Figure 6

COMPARISON OF FLOW MEASUREMENTS AND CHLORIDE LOADINGS IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



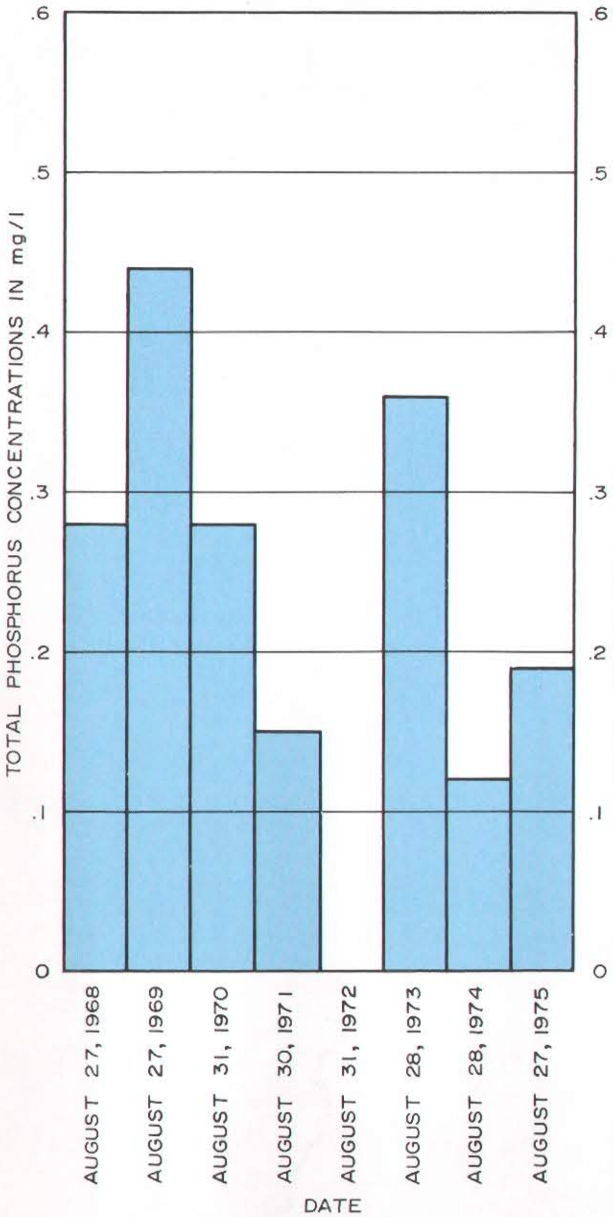
Source: SEWRPC.

and Brighton Creek. Although not enough samples were available in the four years of data to characterize the trends in the total phosphorus concentrations with time, especially with the 1972 sample having been taken soon after a heavy rain, it is evident from the data that the concentrations are many times higher than required for excessive algal growth. A level of total phosphorus of 0.10 mg/l as P generally is held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants in flowing waters. All water samples from the Des Plaines River had total phosphorus levels higher than 0.10 mg/l as P. In Brighton Creek seven of eight samples had total phosphorus levels higher than 0.10 mg/l. The August 1968 through 1975 data from the Des Plaines River water samples at DNR Dp-2a also had total phosphorus values higher than 0.10 mg/l as P, with a range of 0.12 to 0.44 mg/l as P. As indicated in Figure 7, no specific trend in the total phosphorus data obtained in August for the years 1968 through 1975 at DNR Dp-2a was observed.

Figure 8 presents the total phosphorus loadings and flow for the samples collected in August 1972, 1973, 1974, and 1975 at sampling station Dp-3. Since the total phosphorus loadings followed the flow pattern—in that the high flow of 1972 had increased total phosphorus

Figure 7

TOTAL PHOSPHORUS CONCENTRATIONS AT SAMPLING STATION DNR DP-2a IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975

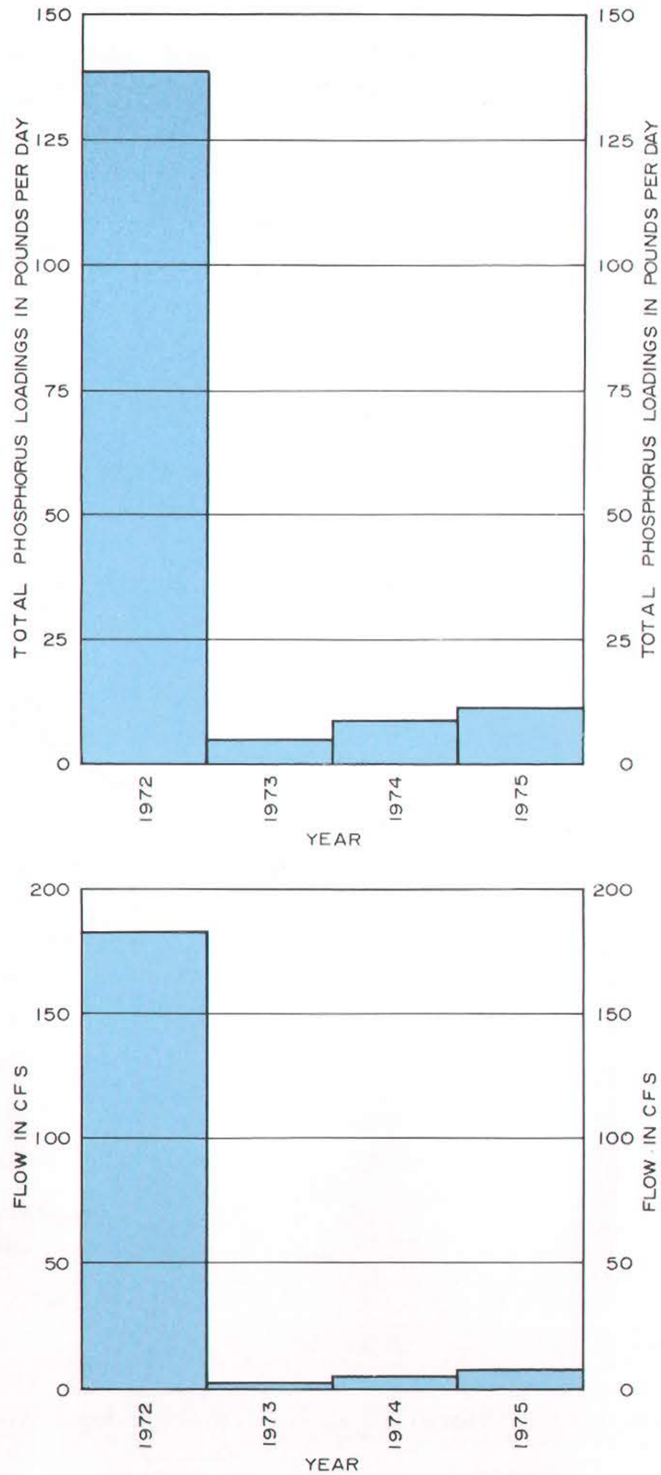


Source: SEWRPC.

loadings in the River—and the remaining three years of data are so few, no attempt is made to characterize the trend in the total phosphorus loadings in the River. However, the soluble orthophosphate data which is available for the years 1968-1975 and presented in Figure 9 indicates soluble orthophosphate loadings of less than 10 pounds per day except for the year 1972 with high flow. Since the soluble orthophosphate concentrations were 0.5 to 1.0 part of total phosphorus, it is likely the total phosphorus loadings also remained low over the past eight years. The increase in phosphorus

Figure 8

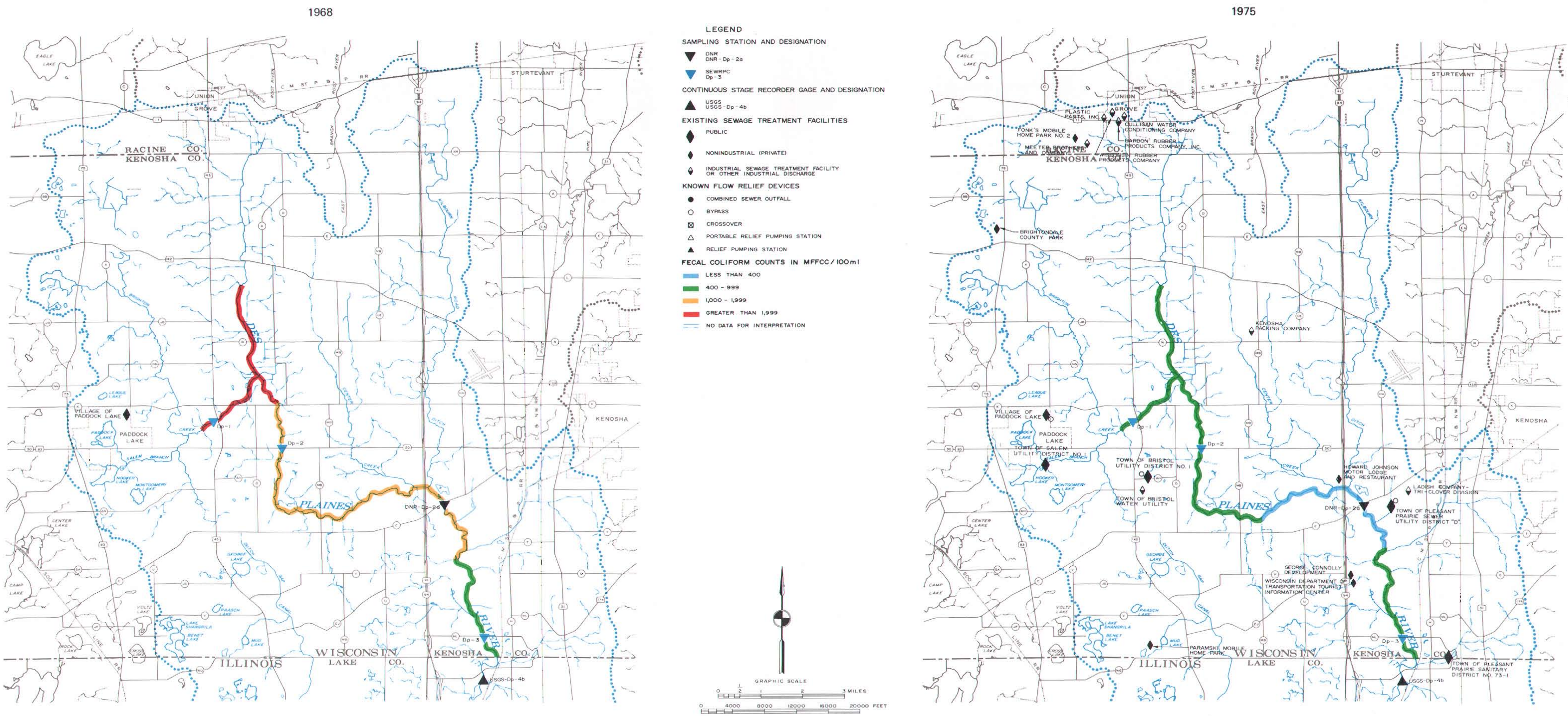
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT SAMPLING STATION DP-3 ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Map 10

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST OF THE YEARS 1968-1975 IN THE DES PLAINES RIVER WATERSHED

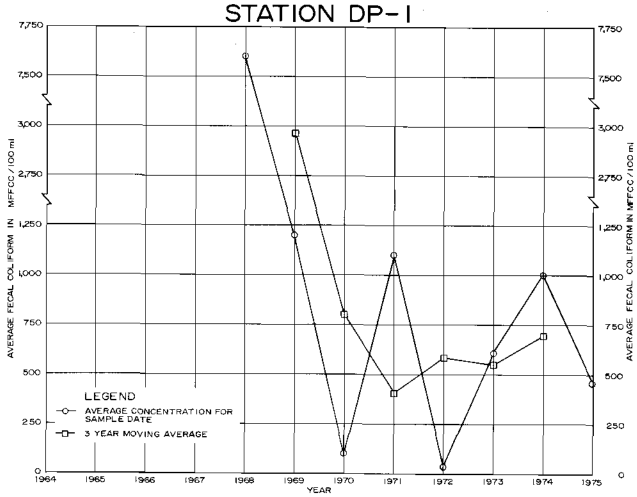


Based on the analysis of 44 stream water quality samples collected in the Des Plaines River watershed from 1968-1975, the fecal coliform counts ranged from a maximum of 7,600 MFFCC/100 ml to a minimum of 30 MFFCC/100 ml. When the 1968 and 1975 samples were compared, a decrease in the fecal coliform counts was observed at sampling stations Dp-1, Dp-2, and DNR-Dp-2a while the bacteria levels remained the same at sampling station Dp-3.

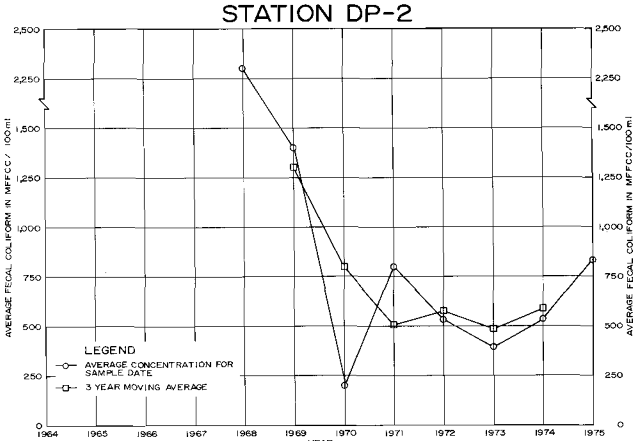
Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 10 (continued)

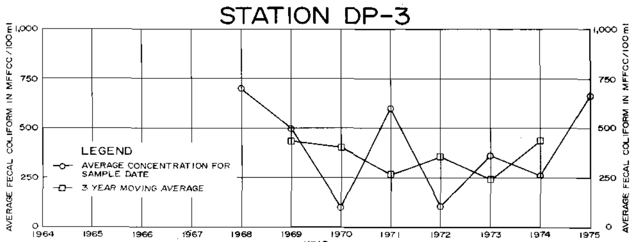
STATION DP-1



STATION DP-2



STATION DP-3



in conjunction with the increase in flow indicates that the increased phosphorus load is probably due to the agricultural runoff.

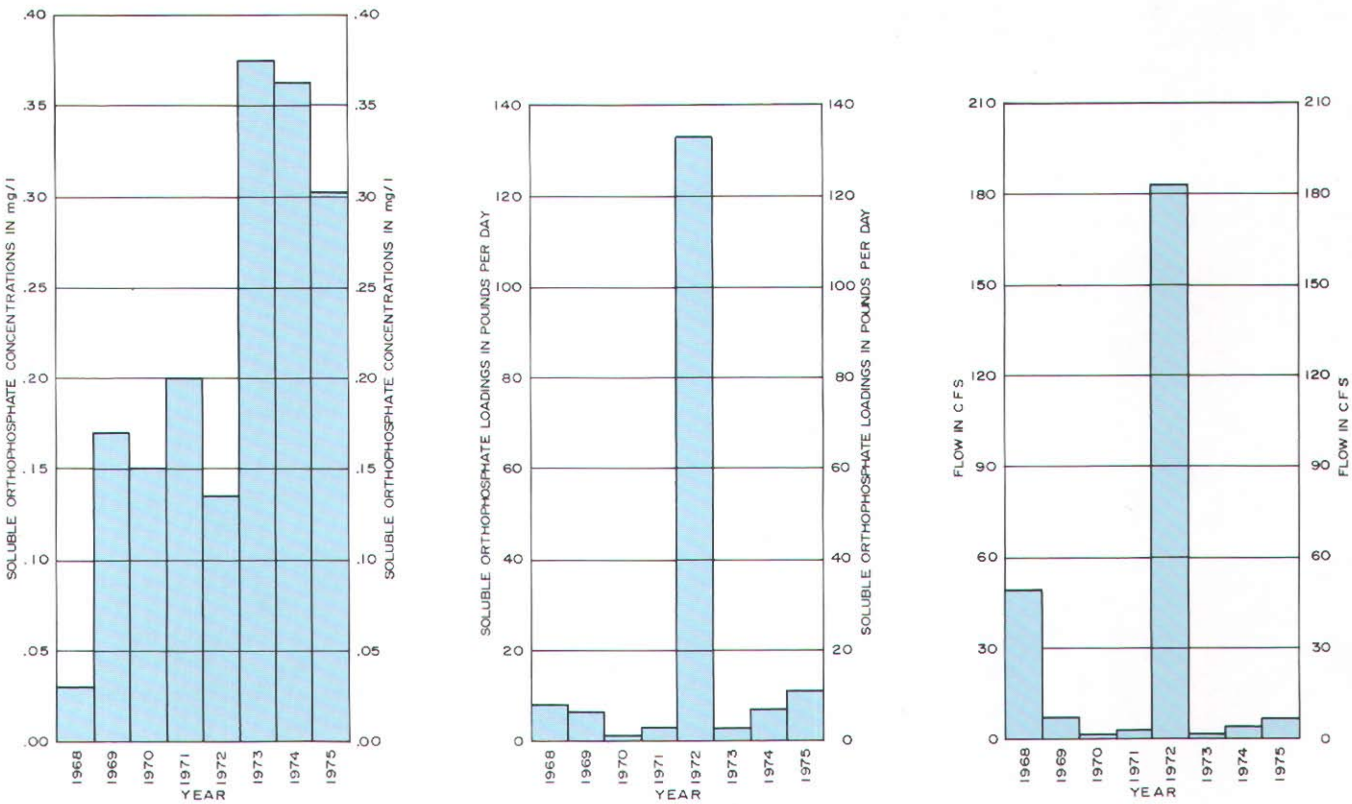
Nitrogen: The total nitrogen concentrations in the Des Plaines River water samples collected during August of 1972 through 1975 were in the range of 0.11 to 3.70 mg/l as N and, of these, 1 to 9 percent was in the form of nitrite-nitrogen, 0 to 25 percent as ammonia-nitrogen, 6 to 50 percent as nitrate-nitrogen, and 48 to 85 percent as organic-nitrogen, with 18 to 45 percent of the total nitrogen present in the readily available form of nitrate and ammonia-nitrogen. Nitrates are obtained as the end product of aerobic degradation of protenaceous materials (organic nitrogen), nitrites are the byproducts of bacteriological action upon ammonia and nitrogenous substances, and ammonia is the chief decomposition product from plant and animal proteins. The presence of ammonia-nitrogen in the stream water is chemical evidence of pollution of recent origin. In the presence of oxygen, ammonia is transformed into nitrite and ultimately into nitrate. The concentrations of ammonia-nitrogen in the Des Plaines River and Brighton Creek sampling sites ranged from 0.03 to 0.44 mg/l as N, well below the known toxic level of 2.5 mg/l for ammonia-nitrogen as N. Similarly, the ammonia-nitrogen at DNR Dp-2a was low and in the range of 0.03 to 0.57 mg/l as N. On five of the 24 sampling dates the ammonia-nitrogen levels did exceed the 0.2 mg/l as N, generally held to be indicative of lakes and streams which have been affected by pollution.

Nitrate-nitrogen concentrations in the Des Plaines River watershed ranged from 0.03 to 2.2 mg/l as N. Surface runoff from fields where there have been excessive or improper applications of natural or artificial fertilizers can contribute significant quantities of nitrate to streams. Nitrates are also present in treated municipal wastes and enter the receiving streams with the discharged effluent. For the samples collected at station Dp-1 in Brighton Creek during the years 1968-1975, all but one had a nitrate concentration of less than the recommended level of 0.30 mg/l of nitrate-nitrogen expressed as N. On the other hand, at sampling stations Dp-2 and Dp-3 the concentration of nitrate-nitrogen remained higher than 0.30 mg/l during more than 50 percent of the sampling events. The major land use upstream from sampling station Dp-2 is agricultural and, therefore, the major source of nitrate-nitrogen in the Des Plaines River watershed is likely to be fertilizers and wastes from domestic animals and wildlife.

Organic-nitrogen accounts for 48 to 85 percent of the total nitrogen in the samples collected in the Des Plaines River watershed and is contributed by amino acids, proteins and polypeptides, all products of biological processes. The presence of organic-nitrogen is directly related to the discharge of organic wastes such as sewage or plant and animal decay products. The organic-nitrogen content was in the range of 0.08 to 2.98 mg/l with the higher concentrations being found at sampling stations Dp-2 or Dp-3. At sampling station DNR Dp-2a the

Figure 9

COMPARISON OF SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS, LOADINGS, AND FLOW AT SAMPLING STATION DP-3 IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

organic-nitrogen concentrations were in the range of 0.15 to 1.43 mg/l as N. The relatively high organic-nitrogen concentrations probably contributed to the reduction of dissolved oxygen concentrations at sampling station Dp-3, since the oxidation step in the decomposition of organic-nitrogen compounds utilizes the oxygen present in the water. Figure 10 presents the total nitrogen loadings and flow for sampling station Dp-3 for the samples of August 1972, 1973, 1974, and 1975. The total nitrogen loadings followed the flow pattern, in that the high flow of 1972 was associated with increased total nitrogen loadings in the Des Plaines River and Brighton Creek. Four years of data being insufficient, no attempt is made to characterize a trend in the total nitrogen loading in the River. However, the increase in total nitrogen along with the increase in total phosphorus and flow in the River reaches draining rural areas probably result from agricultural runoff and runoff from other rural lands such as woodlands, wetlands, and unused lands. Accordingly, it may be assumed that intensification of agricultural practices over the last decade probably has increased the effects of these sources.

Water Quality of Lakes in the Des Plaines River Watershed: 1965-1975

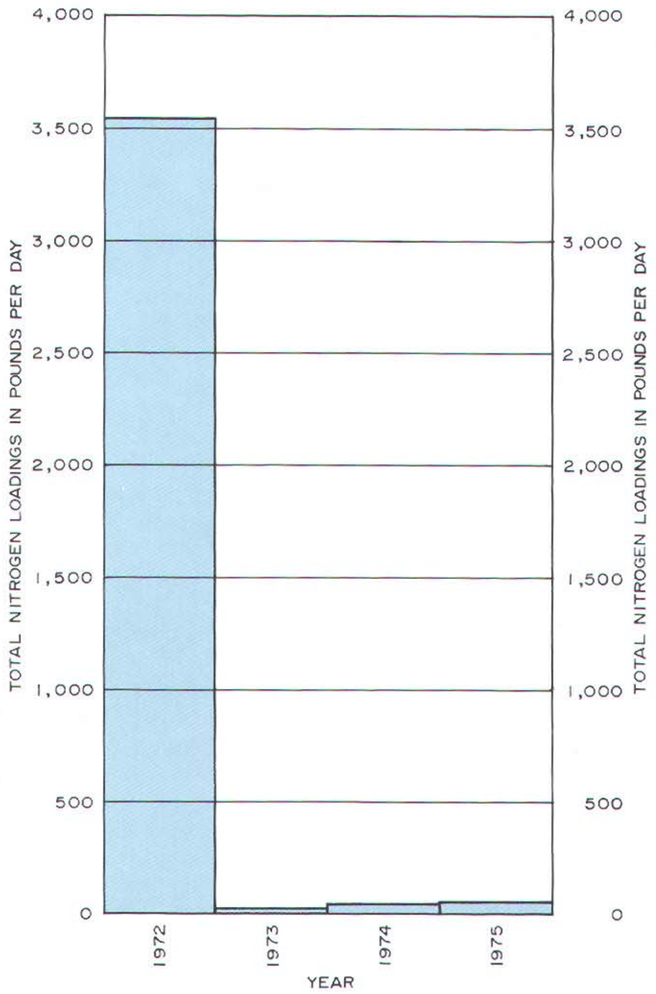
The data sources that were used for the analysis of the lake water quality in the Des Plaines River watershed included: 1) Wisconsin Department of Natural Resources quarterly Lake monitoring program, 2) Wisconsin Department of Natural Resources, Southeast District Headquarters, Lake Investigation Program, 1973, and Paul D. Uttormark and J. Peter Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Water Resources Center, University of Wisconsin, Madison, and U. S. Environmental Protection Agency, June 1975, EPA 660/3-75-033.

The variation of water quality in a lake depends on the depth of the lake, as well as the season of the year. In shallow lakes the water is well mixed, and water quality is fairly uniform throughout the entire depth. In lakes deeper than 15 to 25 feet, however, thermal and chemical stratification occur during summer. In the chemically stratified lakes, the water quality of the lakes vary with the depth as shown in Table 41. Of the four major lakes in the Des Plaines River watershed, only one, Paddock Lake, has a maximum depth of greater than 30 feet. Table 41 presents the available data on the major lakes in the Des Plaines River watershed. Chemical data are available for Hooker and Paddock Lakes, which are likely to stratify during the summer months. The data indicate that both lakes show between zero and less than 1.0 mg/l of dissolved oxygen in the hypolimnion, indicating a possible anaerobic condition during summer, thus adversely affecting the fish and other aquatic life in the lakes. The concentration of dissolved oxygen in the epilimnion generally remained higher than 7.0 mg/l in all four major lakes.

Temperature and dissolved oxygen levels in the shallow lakes of the Des Plaines River watershed are generally similar to the conditions existing in the epilimnion of the stratified lakes during the summer months, with oxygen levels near or above saturation. Of the four major lakes, two have been classified by the Uttormark's trophic status classification. While Benet/Shangrila Lake is defined as "very eutrophic," Paddock Lake is classified as a "mesotrophic" lake. Complete data are not available for the other lakes for their classification of their trophic status. These general categorizations and assessments of lake water quality conditions rely on the interpretation of detailed physical, chemical, and biological data for inland lakes of the Region. Water quality samples collected during specific conditions must be interpreted with regard to the general lake characteristics, seasonal cycles, and shorter-term meteorological phenomena. An example of the types of detailed data displays utilized in these analyses is presented in Figure 11, as dissolved oxygen-temperature profiles for the major inland lakes of the Des Plaines River watershed. Due to the short-term water quality characterization presented by such figures, and the voluminous nature of the figures if presented for each of the 84 major lakes for which data are available in the Region, these profiles have been represented instead by the use of summary tables for the other watersheds.

Figure 10

TOTAL NITROGEN LOADINGS AT SAMPLING STATION DP-3 IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Diurnal Water Quality Changes: Figures 12 through 15 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low flow conditions on August 10, 1970, at the Des Plaines River sampling stations. The rate of flow on August 10, 1970, was 1.1 cfs in the Des Plaines River, or about 11 times the seven day-10 year low flow (0.1 cfs).

Water temperature ranged from a low of 51°F and 68°F during the early morning hours on August 10 to a high of 65°F and 90°F during the early evening hours of that day for Brighton Creek and Des Plaines River, respectively. The difference in the temperature between Brighton Creek and Des Plaines River, measured at approximately the same time of the day, is significant. The water in Brighton Creek has its source in densely vegetated marshes, and sampling station Dp-1 is located in a wooded and consequently shaded area. These factors combine to keep the water temperature significantly lower at samping station Dp-1 than at sampling stations Dp-2 or Dp-3 which are located on the Des Plaines River on agricultural land downstream from the confluence of Brighton Creek with the Des Plaines River. The recorded diurnal water temperature fluctuations at all three stations were probably due to corresponding diurnal variations in air temperature and solar radiation.

Chloride concentrations ranged from a high of nine and 92 mg/l during the early morning hours to a low of six and 89 mg/l during the evening of that day at Brighton Creek and Des Plaines River, respectively. There was a significant difference in the chloride concentrations between the samples taken at Brighton Creek and the samples taken on the Des Plaines River, indicating that the predominant source of chloride for Brighton Creek is probably the groundwater, while some external sources are the cause of significantly increased concentrations in the main stem of the Des Plaines River.

Table 41

AVAILABLE DATA ON THE MAJOR LAKES IN THE DES PLAINES RIVER WATERSHED

Lake	County	Maximum Depth	Type of Lake	WDNR Data	EPA[c] Data	Lake Use[d] Data	Trophic[e] Status	Summer Stratification	Anaerobic Condition in Hypolimnion
Benet/Shangrila	Kenosha	24	kettle	Yes[a]	N/A	N/A	very eutrophic	No	No
George	Kenosha	16	headwater	Yes[b]	N/A	N/A	N/A	No	No
Hooker	Kenosha	24	headwater	Yes[a]	N/A	N/A	N/A	Yes	Yes
Paddock	Kenosha	32	headwater	Yes[b]	N/A	N/A	mesotrophic	Yes	Yes

NOTE: N/A = Not Available.

[a]*Wisconsin Department of Natural Resources, Southeast District Headquarters, Lake Investigation Program, 1973.*

[b]*Wisconsin Department of Natural Resources, Bureau of Research, Quarterly Inland Lake Monitoring Program, 1973-1977.*

[c]*National Eutrophication Survey Methods for Lakes Sampled in 1972, Working Paper No. 1, Pacific Northwest Environmental Research Laboratory, Environmental Protection Agency, October 1974.*

[d]*Lake Use Reports prepared by the Wisconsin Department of Natural Resources for the Southeastern Wisconsin Regional Planning Commission and financed in part by the U. S. Department of Housing and Urban Development under provisions of Section 701 of the Housing Act of 1954 as amended, 1968-1974.*

[e]*Paul D. Uttormark and J. Peter Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Water Resources Center, University of Wisconsin-Madison and U. S. Environmental Protection Agency, June 1975, EPA 660/3-75-033.*

Source: SEWRPC.

The concentrations of dissolved oxygen varied from a low of 3.8 mg/l during the early morning hours to a high of 12.5 mg/l in the late evening hours at sampling station Dp-1 in Brighton Creek. In view of the extreme diurnal variations, the low early morning dissolved oxygen concentrations must be attributed to respiration by algae and other aquatic plants as well as to the biochemical oxygen demand from organic sources entering Brighton Creek. The early morning hour dissolved oxygen concentrations at sampling stations Dp-1, Dp-2, and Dp-3 sampled within half an hour were 3.8, 3.5, and 2.0 mg/l, respectively. The lower dissolved oxygen concentrations at sampling stations Dp-2 and Dp-3 compared to sampling station Dp-1 indicates a source of oxygen-demanding substances between sampling stations Dp-1 and Dp-2. The dissolved oxygen content at all three stations increased considerably during the daytime and can be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants as well as to the atmospheric reaeration of the stream water.

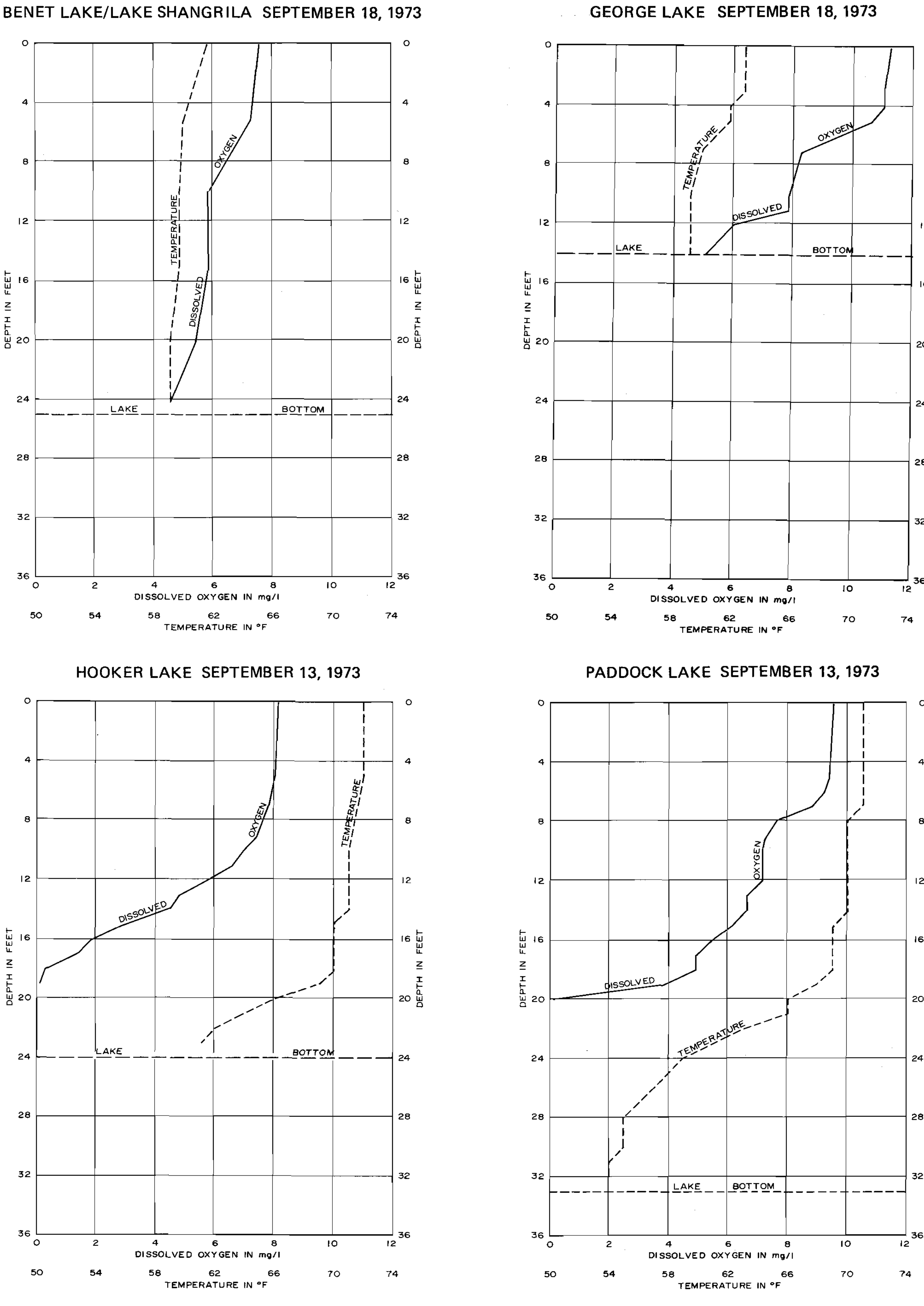
The hydrogen ion concentration (pH) varied from a low of 7.8 standard units during the early morning hours of August 10 to a high of 8.6 standard units in the late evening. The uptake of carbon dioxide during photosynthesis and the release of carbon dioxide during respiration by algae and aquatic plants probably accounts for the higher pH in the late evening samples and for the lower pH during the early morning hours.

A practical consequence of diurnal water quality fluctuations is that, while the average level of concentrations of key parameters may meet the established water quality standards for recreational use and for preservation of fish and aquatic life, the lower levels during the daily cycle do not meet the standards. For example, the average of six dissolved oxygen concentration values on August 10, 1970, was 6.7, 5.6, and 6.7 for Dp-1, Dp-2, and Dp-3, well above the minimum standard of 5.0 mg/l for recreational use and the preservation of fish and aquatic life. However, substandard oxygen levels of less than 4.0 mg/l were measured in the early morning and late evening samples taken.

Spatial Water Quality Changes: The water quality surveys clearly indicate that the water quality conditions change from one location to another in the watershed stream system in response to a combination of man's activities and natural phenomena. Figures 16 through 21 show the spatial water quality variations along the main stem of the Des Plaines River as recorded under low flow hydrologic conditions in August of the years 1964 through 1975. The illustrations include the profiles of the average values of chloride, specific conductance, dissolved oxygen, total phosphorus, total nitrogen, and fecal coliform counts at the two sampling stations. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter.

Figure 11

TEMPERATURE AND DISSOLVED OXYGEN PROFILES FOR MAJOR LAKES IN THE DES PLAINES RIVER WATERSHED



Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 12

DIURNAL VARIATIONS IN TEMPERATURES RECORDED AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 10 AND 11, 1970

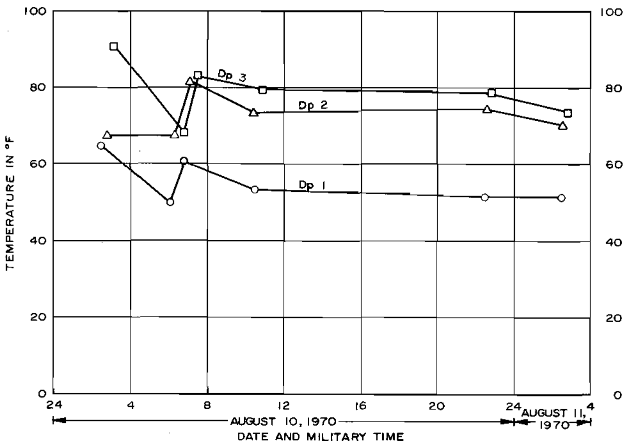
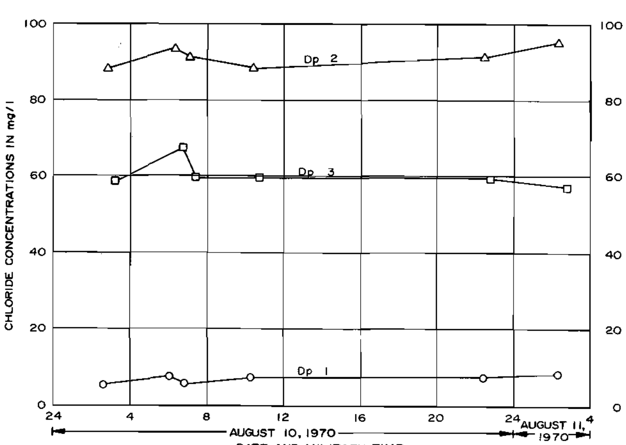


Figure 13

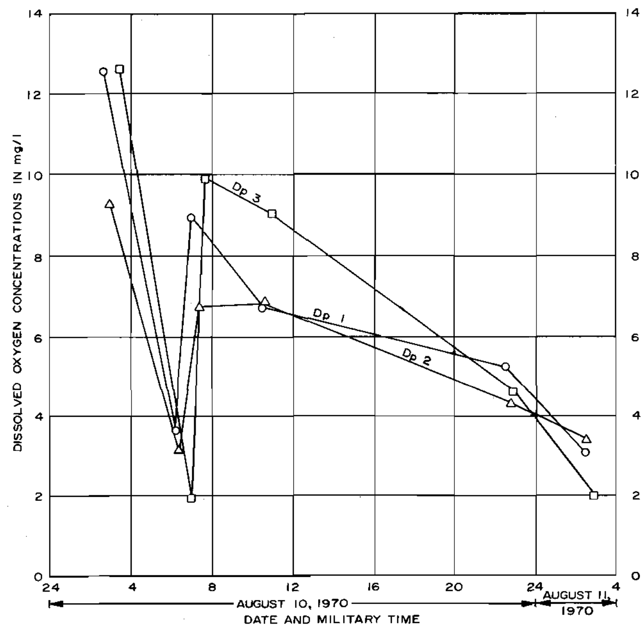
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED: AUGUST 10 AND 11, 1970



Source: SEWRPC.

Figure 14

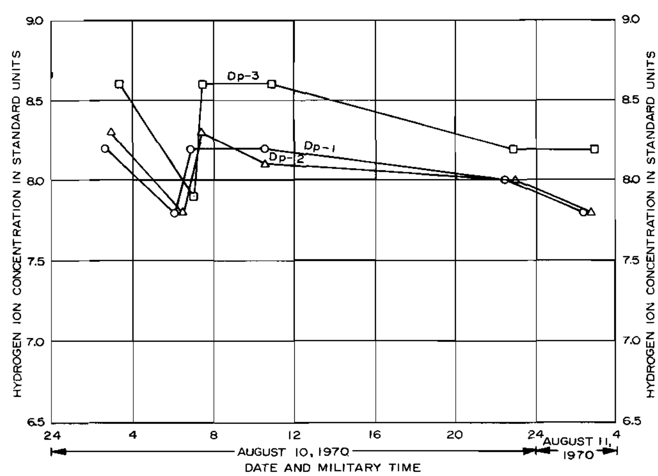
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATION DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED: AUGUST 10 AND 11, 1970



Source: SEWRPC.

Figure 15

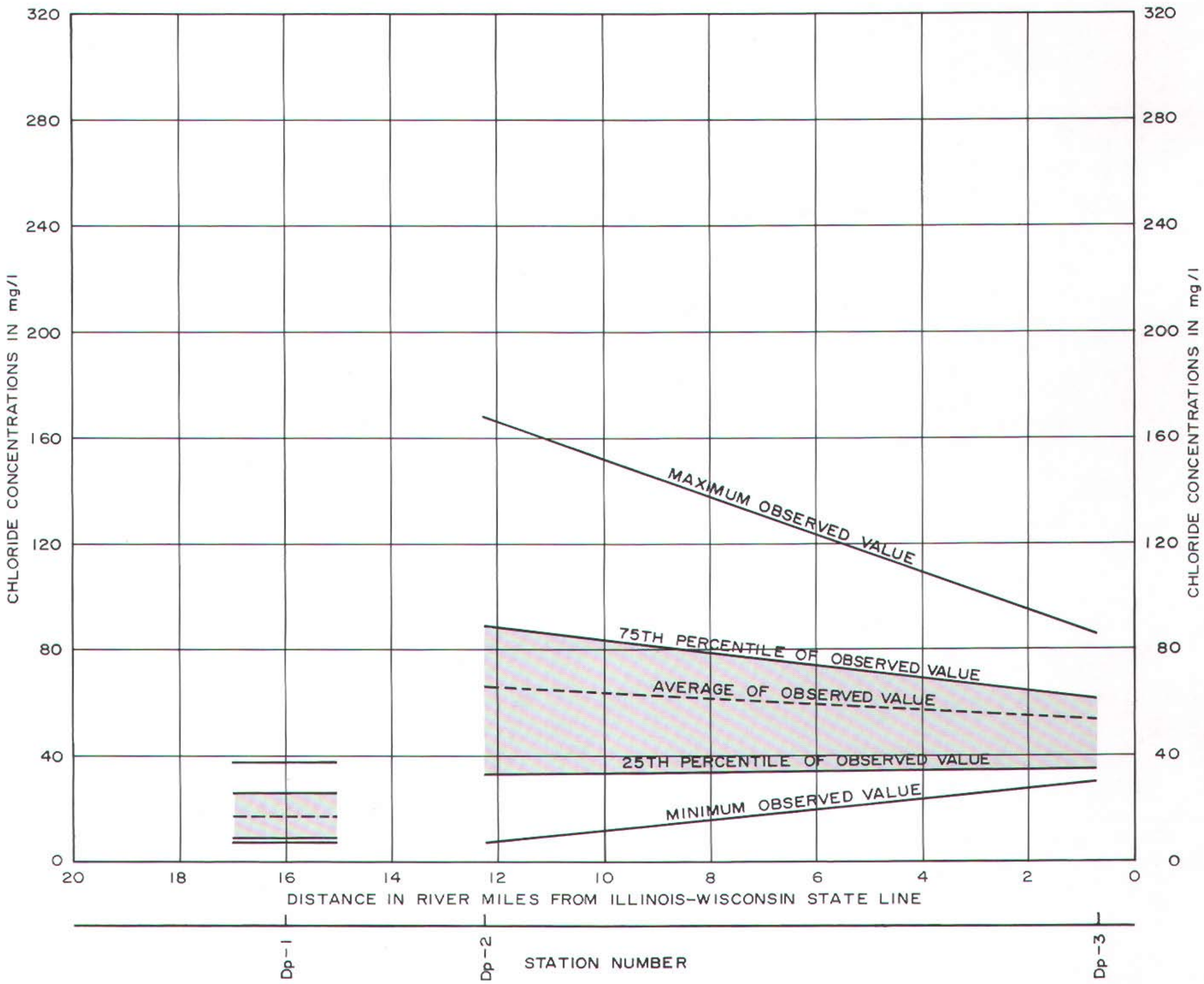
DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS (PH) RECORDED AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 10 AND 11, 1970



Source: SEWRPC.

Figure 16

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE DES PLAINES RIVER WATERSHED: 1964, 1968-1975



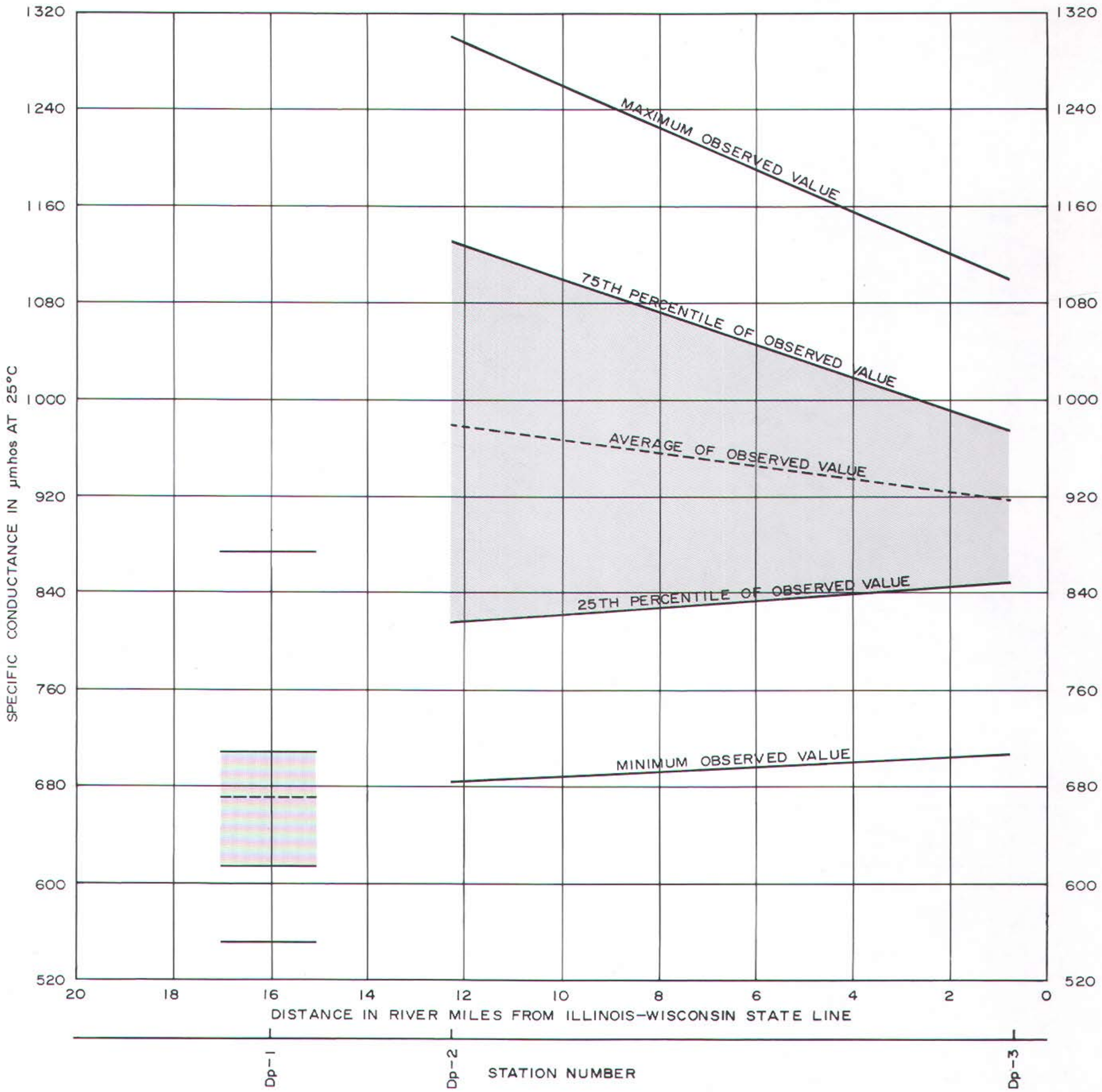
Source: SEWRPC.

thus dividing the data into three categories: (1) the range of the 25 percent of the samples near the minimum values, (2) the range of the middle 50 percent of the samples, and (3) the range of the 25 percent of the samples near the maximum.

A comparison of the average and 25 to 75 percentile data for the sampling stations Dp-2 and Dp-3 indicates a decrease in the specific conductance, chlorides, total nitrogen, and fecal coliform counts reflecting an improvement in water quality from sampling station Dp-2 to Dp-3 on the main stem of the Des Plaines River. However, the average and 25 to 75 percentile range for the total phosphorus indicated an increase from sampling station Dp-2 to sampling station Dp-3 and a decrease in the average concentration of dissolved oxygen from sampling station Dp-2 to sampling station Dp-3. Thus, the overall water quality improvement at sampling station Dp-3 over Dp-2 is negated by the total phosphorus and dissolved oxygen data. A comparison of the water quality data at sampling station Dp-1 on Brighton Creek and at sampling station Dp-2 on the Des Plaines River located downstream from the confluence point of Brighton Creek with the Des Plaines River indicates a decreasing trend, as measured by the specific conductance, chlorides, and total nitrogen concentrations. The decreasing trend in water quality from Dp-1 in Brighton Creek to Dp-2 in the Des Plaines River in an area of low population density

Figure 17

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE DES PLAINES RIVER WATERSHED: 1964, 1968-1975



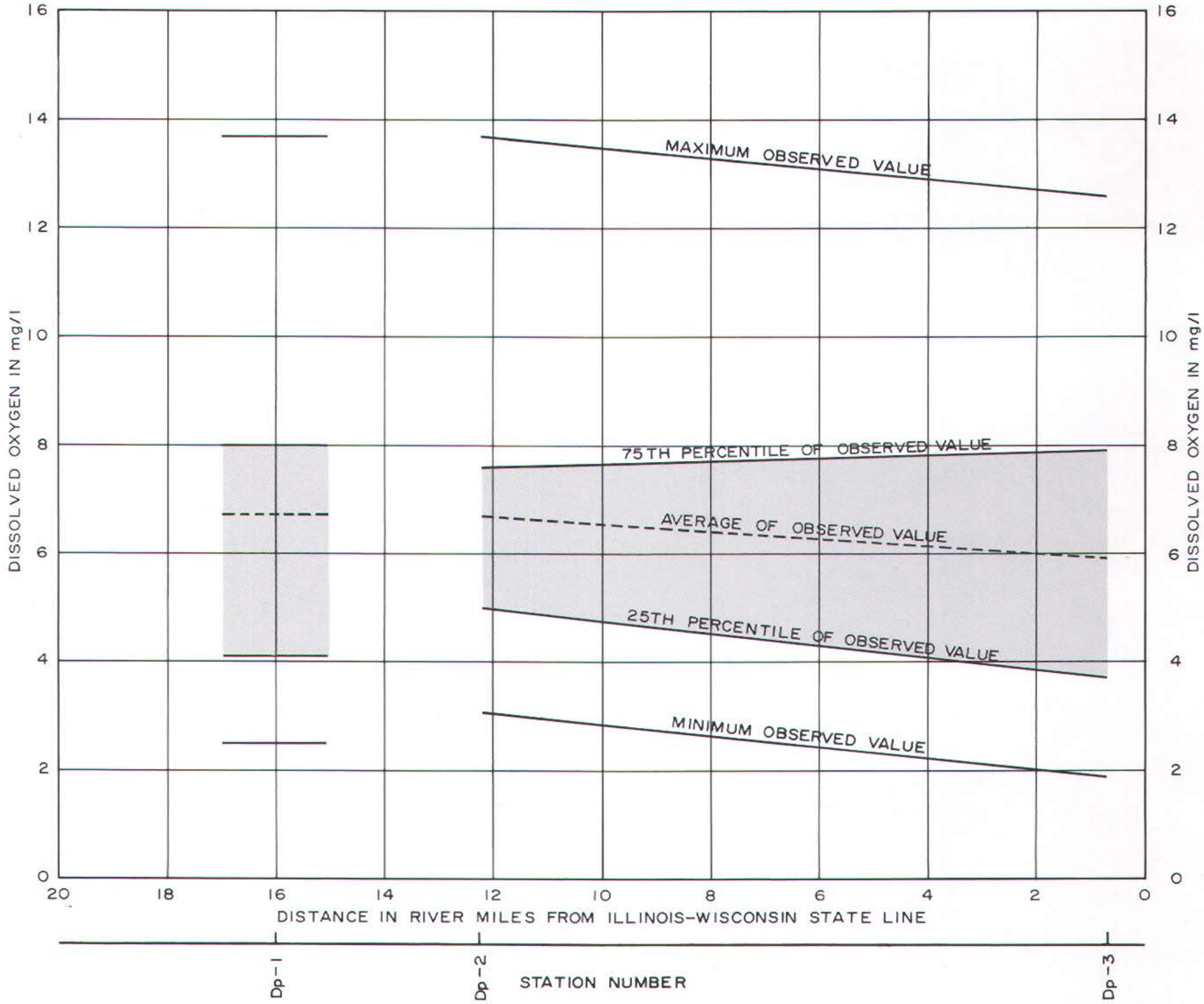
Source: SEWRPC.

and with predominantly agricultural land use indicates that the pollution sources are probably agricultural, including runoff from crop and pasturelands and animal feedlots, wastes from domestic animals, decay of leaf and plant residue, and nutrients, herbicides, and pesticides applied to the land. Since the soil in the Des Plaines River watershed is poorly drained, subsurface tile drainage systems are used extensively to speed the flow of water from the cultivated fields; the runoff from these systems carries relatively high loads of soluble compounds such as chlorides and nitrogen compounds.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low flow samples between 1964 and 1975 were used to assess the quality of the

Figure 18

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATONS IN THE DES PLAINES RIVER WATERSHED: 1964, 1968-1975



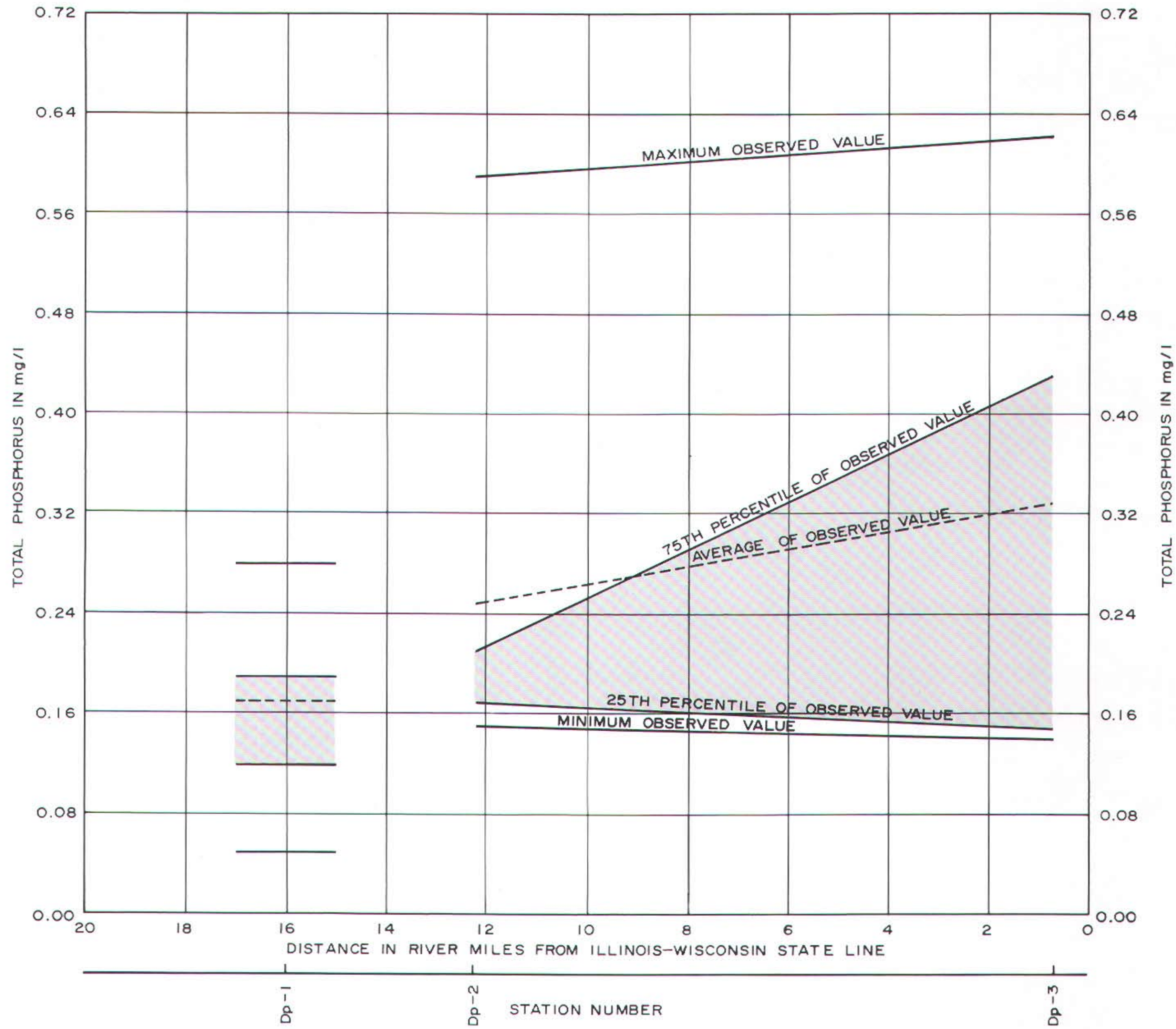
Source: SEWRPC.

Des Plaines River stream network. This provides an assessment of water quality as it existed on the days sampled between 1964 and 1975, and allows for an evaluation of the water quality changes compared to the water quality standards that support the recreational use objectives, as well as the fish and aquatic life use objectives established for the streams of the Des Plaines River watershed. Comparative analysis must consider the concurrent hydrologic conditions since the water quality standards are not intended to be satisified under all streamflow conditions. The data for the daily streamflow at Russell, Illinois, on the Des Plaines River indicates that watershed streamflows during all surveys were in excess of the seven day-10 year low flow; and therefore the water quality standards are to have been met.

The comparison of observed water quality and the adopted water quality standards were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels which have been adopted by the Commission. In the analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24 hour sampling period, did not fall within the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged

Figure 19

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE DES PLAINES RIVER WATERSHED: 1972-1975



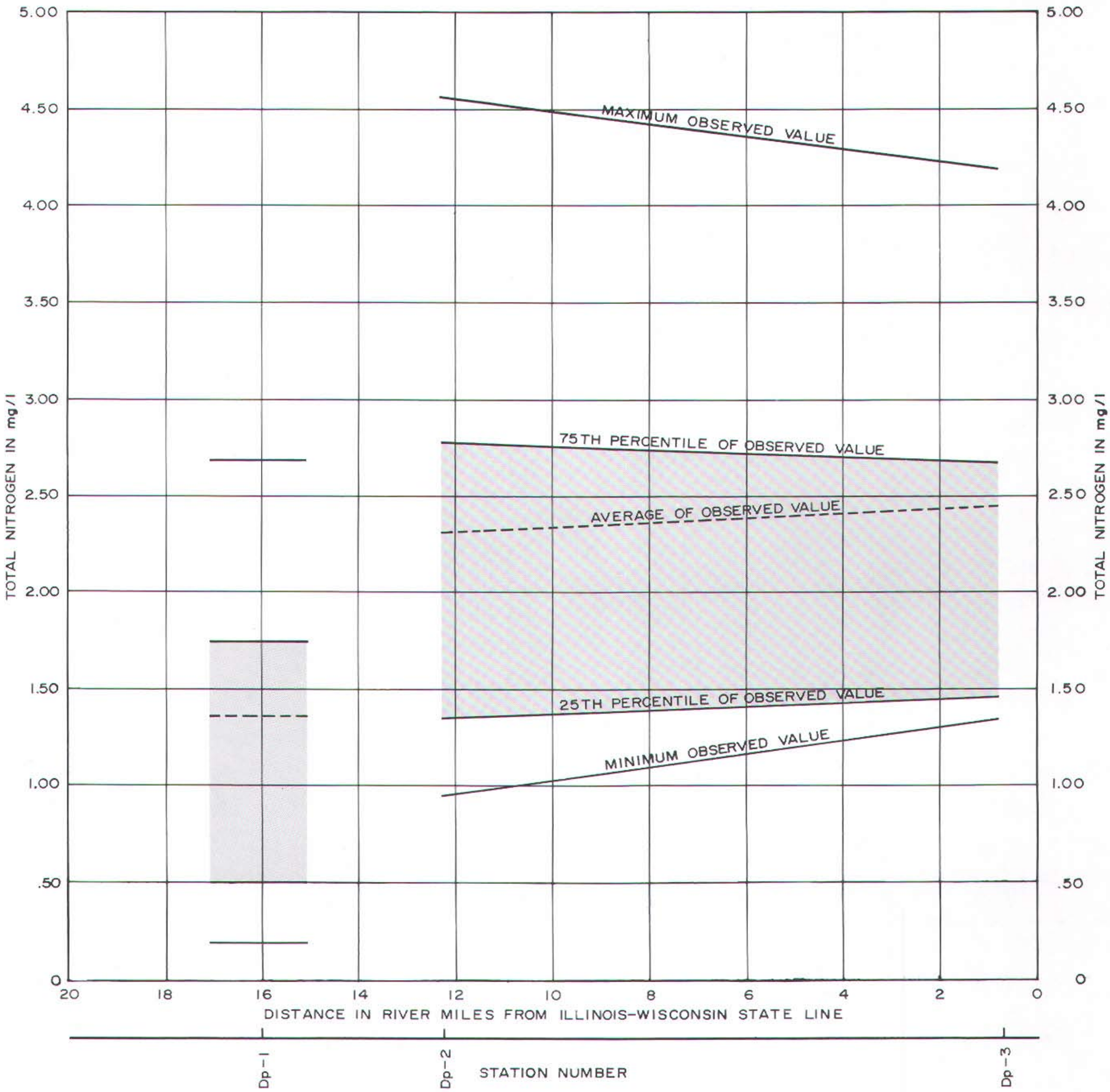
Source: SEWRPC.

over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one month period, the fecal coliform bacteria standards associated with the recreational use objective were assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 11. A color coding scheme is used on Map 11 to indicate which of the standards are exceeded and along what stream reaches.

Figure 20

SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE DES PLAINES RIVER WATERSHED: 1972-1975

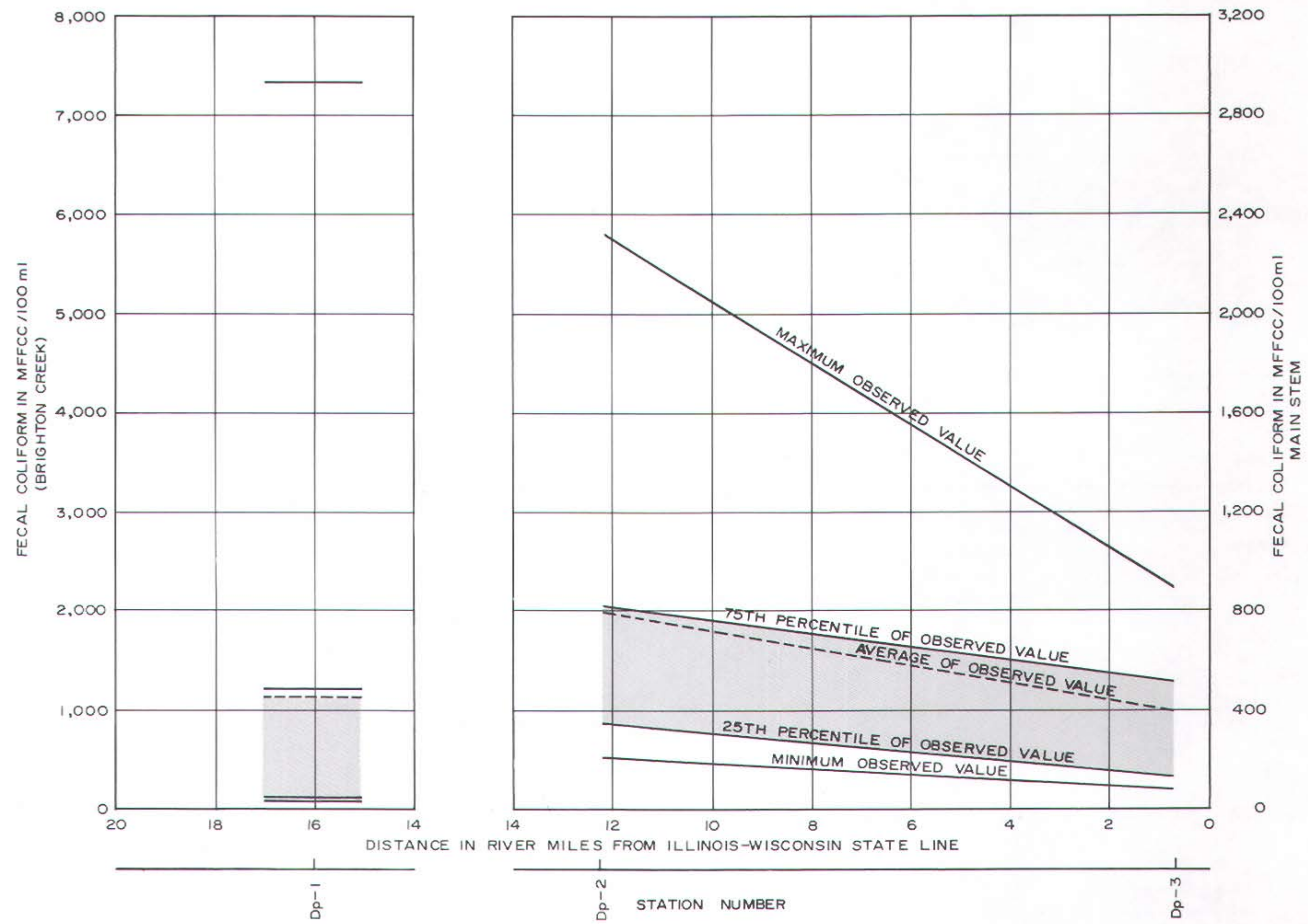


Source: SEWRPC.

For the Des Plaines River main stem, intended for recreational use and preservation of fish and aquatic life, the water quality conditions during the survey satisfied the temperature and pH standards throughout the watershed. Substandard dissolved oxygen levels were found at Dp-3, located 0.7 mile upstream from the State line. For Brighton Creek, also intended for recreational use and for preservation of fish and aquatic life, the water quality conditions during the August 1964 survey satisfied the temperature, pH, and dissolved oxygen standards. Since no fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made in the 1964 samples, no comparison can be made to the nutrient contents and bacteriological safety of the Des Plaines River and

Figure 21

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE DES PLAINES RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Brighton Creek waters for 1964. However, since the total coliform counts in the Des Plaines River and Brighton Creek were in the range of 600-6,000 MFCC/100 ml with an average of 2,200 MFCC/100 ml for 12 months, it is probable that the fecal coliform counts were lower than the permissible limits.

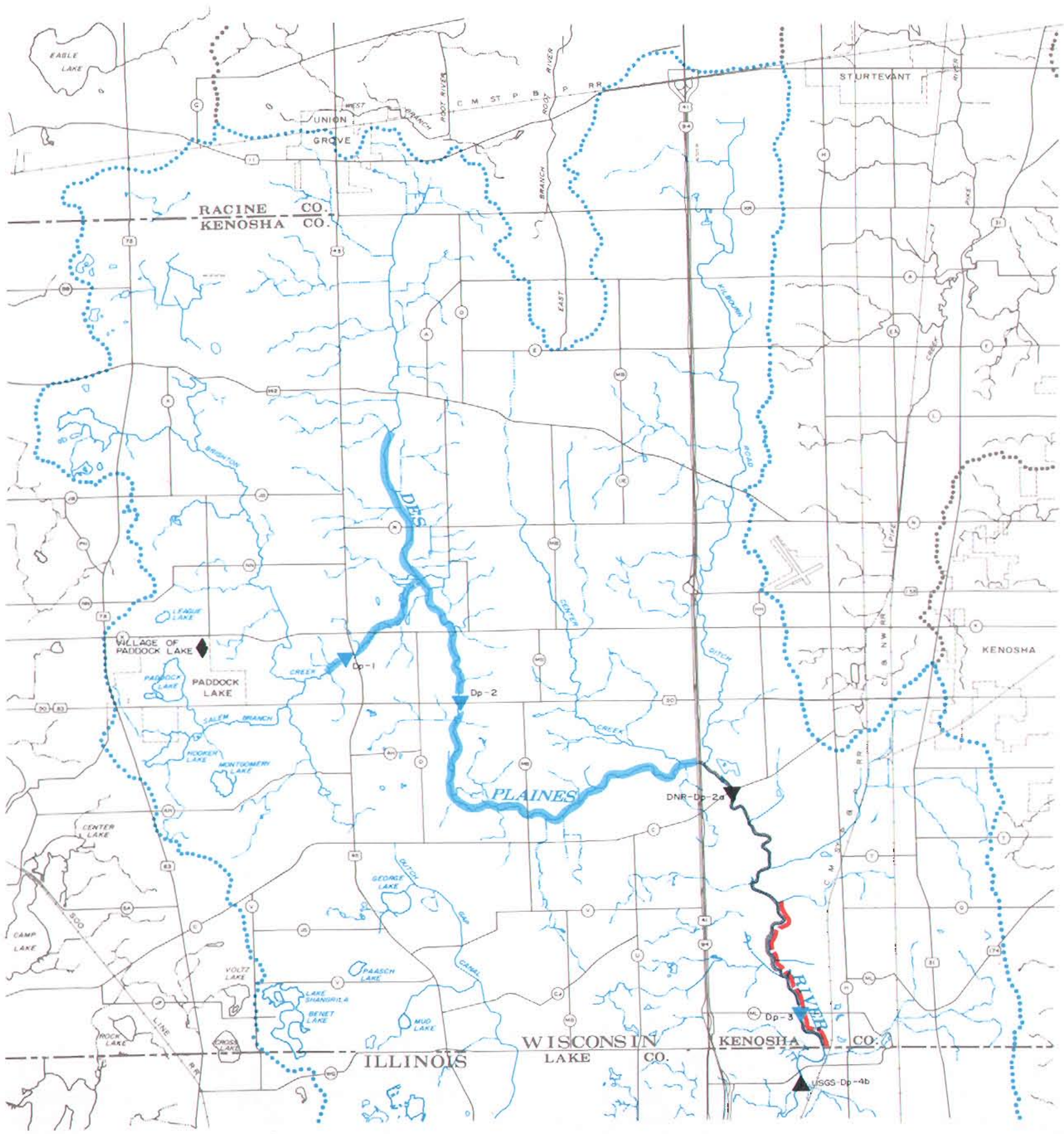
Water Quality-1975: Map 12 indicates that water quality conditions during August 1975 were such that the ammonia, temperature, and pH standards were satisfied throughout the watershed while substandard levels of dissolved oxygen, nitrate, total phosphorus, and fecal coliform observations were recorded. Substandard dissolved oxygen concentrations—less than 5.0 mg/l at sampling station Dp-2 and less than 2.0 mg/l at sampling station Dp-3—occurred on the Des Plaines River. The fecal coliform limit of 400 colonies per 100 ml was exceeded at the two sampling locations on the main stem. For Brighton Creek, substandard dissolved oxygen and fecal coliform counts greater than 400 MFFCC/100 ml were observed. Total phosphorus concentrations were in excess of the level recommended by the Commission—0.10 mg/l as P—applicable throughout the entire length of the Des Plaines River and Brighton Creek. Total phosphorus levels in excess of 0.10 mg/l on the Des Plaines River may be traced in part to the agricultural runoff and in part to the discharges from the municipal sewage treatment plants located between the sampling stations Dp-2 and Dp-3. Nitrate-nitrogen in excess of 0.30 mg/l as N existed at Dp-3. The high nitrate-nitrogen and high total phosphorus concentrations at Dp-2 and Dp-3 generally can be traced to the runoff from agricultural land use.

Concluding Remarks—Des Plaines River Watershed

The Des Plaines River watershed is located in the southeasterly portion of the Region. The watershed is only partly contained within the Region, the Des Plaines River rising in Racine County, flowing approximately 22 miles southerly and easterly in Kenosha County before crossing the State line into Illinois. The Des Plaines River watershed ranks tenth in population and sixth in size among

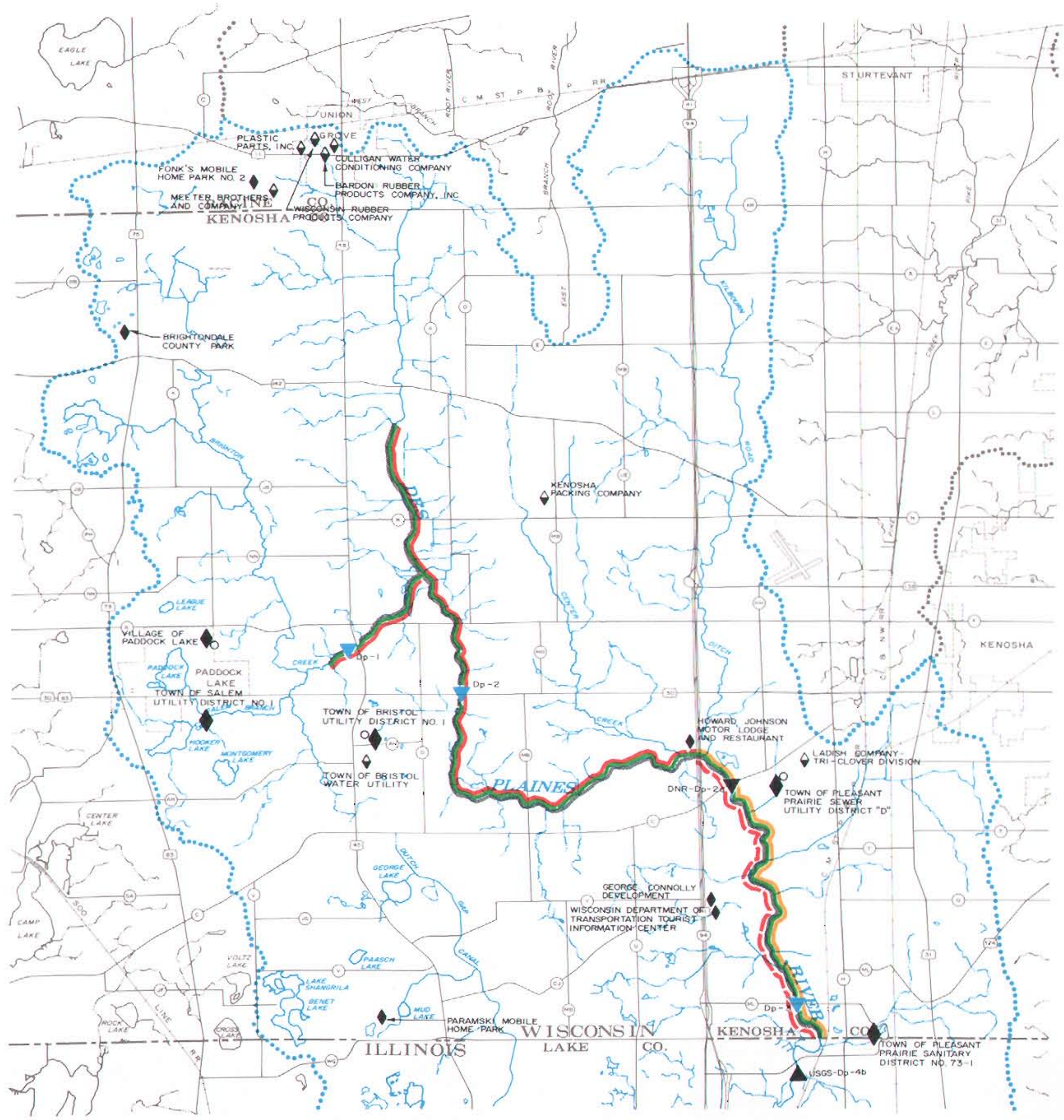
Map 11

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE DES PLAINES RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



Map 12

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE DES PLAINES RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Des Plaines River watershed as sampled in August 1964 to the adopted water quality standards indicated that standards for dissolved oxygen levels were exceeded at sampling station Dp-3 located 0.7 mile upstream from the State line. Samples taken at the three sampling stations Dp-1, Dp-2, and Dp-3 exhibited total coliform levels which are estimated to include fecal coliforms in excess of the standards for recreational use.

Source: Wisconsin Department of Natural Resources and SEWRPC.

A comparison of the stream water quality in the Des Plaines River watershed as sampled in August 1975 to the adopted water quality standards indicated that the ammonia, temperature, and pH standards were satisfied at the three Commission sampling stations in the watershed while substandard levels of dissolved oxygen and fecal coliform observations were recorded. In addition, total phosphorus concentrations exceeded the levels recommended by the Commission throughout the watershed. Nitrate concentrations sampled at station Dp-3 also exceeded the recommended levels.

Source: Wisconsin Department of Natural Resources and SEWRPC.

the 12 watersheds of the Region. In 1975 an estimated 15,811 persons resided within this watershed, which then had a total area of 133.98 square miles and an average population density of 118 people per square mile.

There are five publicly owned and six nonindustrial privately owned sewage treatment plants located within the watershed. All of them discharge treated effluent into the stream system of the watershed. In addition, there are three known sanitary sewer bypasses that discharge raw sewage into the streams during times of sewer surcharge. Of the eight waste discharging industries located within the watershed, one discharges process cooling and sanitary wastewaters to the groundwater while two discharge cooling and process waters, two discharge filter backwash and three discharge cooling waters into the Des Plaines River. The Commission 1970 Land Use Inventory indicates 81 percent of the watershed is devoted to agricultural use, 9 percent to urban use, and the remaining 10 percent is occupied by lakes, rivers, streams, wetlands, and woodlands. There is a total of nine lakes within the watershed, four of which have a surface area of 50 acres or more. About 72 percent of the area within 1,000 feet of the shorelines of these lakes is presently in some urban land use. Runoff from this urban area may be expected to have a significant effect on the lake water quality.

The 1964-1965 bench mark stream water quality study of the Commission included three sampling stations in the watershed, one on Brighton Creek and two on the Des Plaines River. The water quality data for 1964-1965 from the two sampling stations on the Des Plaines River indicated that the chloride levels were higher than the normal background concentration and reflected a chloride impact upon the stream from human sources. Substandard concentrations of dissolved oxygen were found during the summer months at both sampling station locations on the main stem of the Des Plaines River. The sampling station situated on Brighton Creek, a first rank tributary to the Des Plaines River, also exhibited chloride concentrations higher than background levels. These higher chloride concentrations and loads may be attributable to the effluent from the Village of Paddock Lake sewage treatment plant, the Town of Salem Sewer Utility District No. 1, and to runoff of septic tank effluent from unsewered areas such as the Montgomery Lake community. High total coliform counts were found at all three sampling station locations. Drainage from agricultural land and wastes from malfunctioning private onsite sewage disposal systems, from wildlife, and from domestic animals are some of the probable sources for this indicated contamination. The specific conductance values were found to be high at all three sampling locations, with the highest values found at the downstream sampling station located on the Des Plaines River near the State line.

The 1965-1975 water quality monitoring effort by the Commission included continued sampling at the three stations established in the watershed. The observed dissolved oxygen levels indicate that the water quality remained essentially unchanged over the decade. Review of the chloride and fecal coliform data indicated essentially no change over the past eight years at the two sampling stations on the main stem of the Des Plaines River. As measured by nitrate-nitrogen and total phosphorus, the nutrient concentrations remained in excess of the levels recommended by the Commission—0.30 mg/l as N and 0.10 mg/l as P—in most of the samples collected over the past eight years. The water quality of Brighton Creek remained better than that of the Des Plaines River as measured by the dissolved oxygen, chloride, total phosphorus, and nitrate-nitrogen concentrations. As indicated by the dissolved oxygen and chloride, the water quality of Brighton Creek remained essentially unchanged over the decade and even showed a slight improvement in the fecal coliform counts, total phosphorus, and nitrate-nitrogen levels.

The diurnal water quality data for the Des Plaines River and Brighton Creek shows a broad range of dissolved oxygen concentrations from a low of 3.8 to a high of 12.5 mg/l over a 24 hour period, and reflects the dissolved oxygen reductions due to respiration by the aquatic plants and decomposition of organic matter in the stream and dissolved oxygen supersaturation effects of algal photosynthesis. In addition to exhibiting marked diurnal fluctuations, water quality in the Des Plaines River watershed exhibits spatial variation. The water quality of Des Plaines River near the State line was generally better than that in the headwater area as measured by the lower concentration in specific conductance, chloride, and fecal coliform counts.

There are four major lakes in the Des Plaines River watershed. Paddock Lake in Kenosha County is the deepest with a maximum depth of 32 feet. Hooker and Paddock Lakes showed 1.0 mg/l or less of dissolved oxygen in the hypolimnion indicating that anaerobic conditions probably occur during summer with resulting adverse effects on the fish habitat of these lakes. The trophic status of two of the four major lakes have been evaluated and Benet/Shangrila being classified as "very eutrophic" and Paddock as "mesotrophic."

Although generally constant over the past decade, the water quality of the Des Plaines River and Brighton Creek, which are intended for recreational use and for the preservation of fish and aquatic life, does not currently meet the water quality standards set by the Wisconsin Department of Natural Resources for dissolved oxygen and fecal coliform counts. In addition, the plant nutrients, total phosphorus, and nitrate-nitrogen concentrations were found to be significantly higher than the recommended levels adopted by the Commission.

FOX RIVER WATERSHED

Regional Setting

The Fox River watershed is a natural surface water drainage unit, 934.31 square miles in areal extent, located in the central and south central portion of the Southeastern Wisconsin Region. The watershed is the largest of the 12 natural surface water drainage units within the Region and constitutes 35 percent of the regional land and water area. The watershed occupies a broad basin of irregular topography and extends into six counties of the Southeastern Wisconsin Region, namely, Milwaukee, Kenosha, Racine, Walworth, Waukesha, and Washington Counties.[4] The watershed is bounded along much of its eastern side by the subcontinental divide, which separates surface waters flowing westerly and southerly through the Mississippi River system to the Gulf of Mexico from surface waters flowing northerly and easterly through Lake Michigan and the St. Lawrence River system to the North Atlantic Ocean. In Kenosha County the watershed is bounded on the east by the Des Plaines River watershed, also part of the Mississippi River system. Much of the watershed is bounded on the west and northwest by the Kettle Moraine, the unique interlobate deposits that were formed between the Green Bay lobe and the Lake Michigan lobe of the continental glacier. The watershed, as it lies within the Region, is bounded on the south by the Wisconsin-Illinois State line.

The northern headwater portion of the basin lies in rapidly urbanizing Waukesha County; and the central and southern portions lie in important agricultural and recreational areas of Kenosha, Racine, and Walworth Counties. The watershed also includes 0.31 square miles in Washington County in the Town of Richfield and 0.47 square miles in Milwaukee County in the City of Franklin.

The Fox River system, which drains the watershed, consists of 24 named first rank tributaries which rise and join the Fox River within the Region and two named tributaries which rise within the Region and join the Fox River in the State of Illinois. There also exist 21 named streams which meet the first rank tributaries of the Fox River. Within the watershed there are approximately 300 lineal miles of perennial streams. Table 42 lists each stream reach and the location, the source, and the length of each stream reach in miles for the Fox River watershed. Thirteen streams and watercourses were studied by the Commission in the Fox River watershed, inclusive of the Fox River itself, and the following first, second, and third rank tributaries: Sussex Creek, Poplar Creek, Pewaukee River, Mukwonago River, Muskego Canal, Wind Lake Drainage Canal, White River, Como Creek, Honey Creek, Sugar Creek, Bassett Creek, and Nippersink Creek. The Fox River rises in the Region near the Village of Lannon in northeastern Waukesha County and meanders approximately 81 miles southward before entering the State of Illinois. The watershed is the fourth largest in population as compared to the 12 watersheds of the Region. As stated above, it is the largest watershed in the Region and comprises 35 percent of the total land and water area of the seven-county area.

Political Boundaries

Superimposed upon the natural, meandering watershed boundary is a rectilinear pattern of local political boundaries, as shown on Map 13. The Fox River watershed occupies portions of six of the seven counties within the Southeastern Wisconsin Region—Kenosha, Milwaukee, Racine, Walworth, Washington, and Waukesha—and portions or all of nine cities, 19 villages, and 36 towns. The area and proportion of the watershed lying within the jurisdiction of each local unit of government as of January 1, 1976, are set forth in Table 43.

Population

Population Size: The 1975 resident population of the watershed is estimated at 225,335 persons, or about 13.0 percent of the total resident population of the Region. Table 44 presents the population distribution in the Fox River watershed by civil division. The population of the watershed has increased steadily since 1900, and since 1940 the rate of population increase generally has exceeded the regional growth rate.

Population Distribution: The Fox River watershed, like much of the Region, is becoming increasingly urban, particularly in its headwater area, upstream from the confluence with Pebble Creek. In 1975 about 63 percent of the residents of the watershed lived in incorporated cities and villages, comprising 14 percent of the total area of the watershed. In addition to the headwater area, the subwatersheds of many lakes, including Bohner Lake, Echo Lake, Elizabeth Lake, Geneva Lake, Marie Lake, Pell Lake, Pewaukee Lake, and Silver Lake (Kenosha County) are highly urbanized, while the rest of the watershed is predominantly rural.

Quantity of Surface Water

Surface water in the Fox River watershed is made up almost entirely of streamflow and lake storage. A few minor ponds, wetlands, and flooded gravel pits provide the balance, but are negligible compared to the total surface water quantity. The quantity of streamflow varies widely from season to season and from year to year, responding to variations in precipitation, temperature, soil moisture conditions, agricultural operations, the growth cycle of vegetation, and groundwater levels.

Streamflow measurements for the Fox River stream system are available from 1963 for the Fox River at Waukesha; and from 1939 for the Fox River at Wilmot. Streamflow characteristics for the years 1964 through 1975 for the Fox River at Waukesha and at Wilmot are summarized in Table 45. High streamflows occur principally in the late winter and early spring, usually associated with melting snow. Lower flows persist for

[4] *Included in the watershed area is a 3.64 square mile area within Jefferson County, Wisconsin, which lies outside the seven-county Southeastern Wisconsin Region.*

Table 42

STREAMS IN THE FOX RIVER WATERSHED

Stream or Watercourse	By Civil Division	By U. S. Public Land Survey System	Length[a] (in miles)
Beulah Lake Outlet	Town of East Troy	NW ¼, Section 18, T4N, R18E	1.1
Sussex Creek	Village of Sussex	SE ¼, Section 23, T8N, R19E	5.5
Fox River[b]	Town of Menomonee Falls	SE ¼, Section 5, T8N, R20E	81.2
Genesee Creek	Town of Genesee	N ¼, Section 14, T6N, R18E	5.5
Long Lake Channel[c] (Kee Nong Go Mong Lake)	Town of Norway	NE ¼, Section 7, T4N, R20E	0.9
Goose Lake Branch Canal	Town of Norway	SE ¼, Section 4, T4N, R20E	8.7
Hoosier Creek Canal	Town of Burlington	SE ¼, Section 11, T2N, R19E	7.5
Hoosier Creek	Town of Dover	NW ¼, Section 33, T3N, R20E	3.5
New Munster Creek	Town of Wheatland	NE ¼, Section 32, T2N, R19E	5.3
Jericho Creek	Town of Mukwonago	NE ¼, Section 6, T5N, R18E	6.1
Trevor Creek	Town of Salem	NW ¼, Section 34, T1N, R20E	3.3
Mill Brook	Town of Vernon	SE ¼, Section 3, T5N, R19E	8.5
Mill Creek	Town of Waukesha	SE ¼, Section 25, T6N, R19E	5.5
Brandy Brook	Town of Delafield	SW ¼, Section 35, T7N, R18E	4.8
Mukwonago River[d]	Town of Eagle	NE ¼, Section 36, T5N, R17E	16.9
Sugar Creek	Town of Sugar Creek	NW ¼, Section 21, T3N, R16E	25.3
North Branch-Nippersink Creek	Town of Bloomfield	SW ¼, Section 20, T1N, R18E	8.5
East Branch-Nippersink Creek	Town of Bloomfield	NE ¼, Section 1, T1N, R18E NW ¼, Section 14, T1N, R18E	3.5
Nippersink Creek[b]	Town of Bloomfield	SW ¼, Section 26, T1N, R18E	5.2
West Branch-Nippersink Creek	Town of Linn	NE ¼, Section 34, T1N, R17E	7.4
Ore Creek	Town of Geneva	NW ¼, Section 13, T2N, R17E	8.2
Como Creek	Town of Geneva	NW ¼, Section 11, T2N, R17E	3.8
Pebble Creek	Town of Waukesha	SW ¼, Section 8, T6N, R19E	5.0
Pebble Brook	Town of Waukesha	NE ¼, Section 14, T6N, R19E	8.0
Pewaukee River	Town of Pewaukee	SW ¼, Section 4, T7N, R19E	6.4
Honey Creek	Town of Troy	SW ¼, Section 19, T4N, R17E SW ¼, Section 36, T4N, R16E	26.8
Peterson Creek	Town of Brighton	SE ¼, Section 29, T2N, R20E	6.5
Eagle Lake Creek	Town of Dover	SE ¼, Section 21, T3N, R20E	5.5
Poplar Creek	Town of New Berlin	NW ¼, Section 9, T6N, R20E	7.5
Deer Creek	Town of New Berlin	NE ¼, Section 23, T6N, R20E	7.8
Palmer Creek	Town of Wheatland	NW ¼, Section 6, T1N, R19E	3.7
Basset Creek	Village of Twin Lakes	SE ¼, Section 22, T1N, R19E	4.5
Bloomfield Creek	Town of Bloomfield	NW ¼, Section 9, T1N, R18E	3.5
Tichigan Creek	Town of Waterford	SW ¼, Section 9, T4N, R19E	1.6
White River	City of Lake Geneva	NE ¼, Section 36, T2N, R17E	20.0
Spring Brook (Boehner Creek)	Town of Burlington	SW ¼, Section 17, T2N, R19E	3.6
Spring Creek	Town of East Troy	NW ¼, Section 33, T4N, R18E	8.5
Muskego Creek Canal[e] (Wind Lake Drainage Canal)	Town of Muskego	NE ¼, Section 33, T5N, R20E	7.9
First Branch to Ore Creek	Town of Spring Prairie	NW ¼, Section 35, T3N, R18E	2.7
Second Branch to Ore Creek	Town of Spring Prairie	Section 31, T3N, R18E	2.8
Indian Run Creek	Town of Spring Prairie	NW ¼, Section 34, T3N, R18E	2.5
Artesian Brook	Town of Vernon	NW ¼, Section 13, T5N, R19E	2.0
Redwing Creek	Town of Waukesha	Section 6, T6N, R19E	1.5
Upper Creek	Town of New Berlin	NE ¼, Section 33, T6N, R20E	1.5
Spring Valley Creek	Town of Bloomfield	SW ¼, Section 1, T1N, R18E	6.0
Spring Brook	Town of Spring Prairie	NE ¼, Section 24, T3N, R18E	3.5
Lightbody Creek	Town of Linn	SE ¼, Section 9, T1N, R17E	0.6

[a] *Total perennial stream length as shown on U. S. Geological Survey 7 1/2 minute quadrangle maps.*

[b] *Perennial stream length within Wisconsin.*

[c] *Includes 0.5 mile through Waubeesee Lake.*

[d] *Includes 0.5 mile through Lulu Lake, 1.3 miles through Eagle Spring Lake, and 1.8 miles through Lower Phantom Lake.*

[e] *Includes 2.4 miles through Wind Lake and 1.6 miles through Big Muskego Lake.*

Source: SEWRPC.

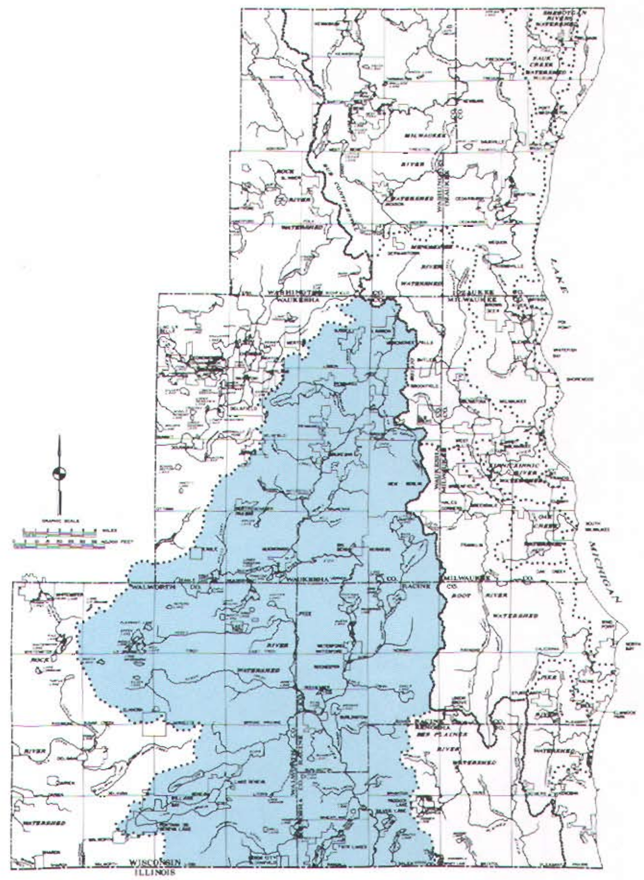
most of the remainder of the year with occasional increases caused by rainfall. The minimum streamflow at Waukesha has remained higher than 7 cfs and at Wilmot higher than 78 cfs for the past 11 years. The mean daily flows at Waukesha have ranged from 30 cfs to 172 cfs and at Wilmot from 219 cfs to 1,152 cfs. The wide range in the mean flow at the two recorded gaging stations indicates the effect of variation in the rainfall and runoff on the flow of the River. Among the tributaries of the Fox River, streamflow measurements are available for the Mukwonago River at Mukwonago and for the White River at Burlington from 1973. Streamflow characteristics for the Mukwonago River and the White River for the years 1973 through 1975 are presented in Table 46.

There are 46 major lakes, each having surface areas of 50 acres or more, and 35 minor lakes and ponds of less than 50 acres in surface area within the watershed. The major lakes have a combined surface water area of 21,825 acres and a total shoreline length of 228 miles. Of the 46 major lakes, the deepest is Lake Geneva with maximum depth of 135 feet; Lake Geneva is also the largest lake in the Region, with a surface area of 5,262 acres. The second largest lake of the Region, Pewaukee Lake, with a surface area of 2,493 acres, also is located in the Fox River watershed. Other major lakes in the Fox River watershed with a maximum depth of 30 feet or more include Benedict Lake, Cross Lake, Center Lake, Elizabeth Lake, Marie Lake, Powers Lake, Rock Lake, and Silver Lake in Kenosha County; Bohner Lake, Browns Lake, Tichigan Lake, Waubeesee Lake, and Wind Lake in Racine County; Beulah Lake, Green Lake, LuLu Lake, Middle Lake, Mill Lake, and Pickerel Lake in Walworth County; and Big Muskego Lake, Denoon Lake, Lannon Pond, and Little Muskego Lake in Waukesha County. The lakes are mostly of glacial origin, being natural, simple, or compound depressions in gravelly outwash, moraine, or ground moraine. The depth of the lakes is sometimes augmented by a low-head dam at the outlet. By virtue of their origin, the lakes are fairly regular in shape, with their deepest points predictably near the center of the basin or near the center of each of several connected basins. The beaches are characteristically gravel or sand on the wind swept north, east, and south shores, while fine sediments and encroaching vegetation are common on the protected west shores and in the bays. Of the 46 major lakes in the Fox River watershed, eight are headwater lakes, nine are kettle lakes, and 29 are flow-through lakes.

The total quantity of surface water that is held in major lakes in the watershed is approximately 482,000 acre feet; the lake levels fluctuate over time, responding primarily to variations in precipitation, surface runoff, evaporation rates, and groundwater levels. High lake levels occur principally in the late winter and spring and are usually associated with melting snow. The location by civil division and by the U. S. Public Land Survey System of the major lakes in the Fox River watershed, together with certain selected physical characteristics, are presented in Table 47.

Map 13

LOCATION OF THE FOX RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Fox River watershed within the Region has an area of 934 square miles and comprises 35 percent of the total 2,689 square mile area of the Region. The Fox River watershed is the fourth largest in population and the largest in area of the 12 watersheds of the Region.

Source: SEWRPC.

Pollution Sources

The following types of pollution sources have been identified in the Fox River watershed and are discussed below: municipal sewage treatment facilities, sanitary sewerage system flow relief points, industrial wastewater discharges, urban storm water runoff, and rural storm water runoff.

Sewage Treatment Facilities: Sixteen municipally owned sewage treatment facilities are operated in the Fox River watershed by the following local units of government: Village of Silver Lake, Village of Twin Lakes, City of Burlington, Western Racine County Sewerage District, City of Lake Geneva, Village of East Troy, Village of Fontana-on-Geneva Lake, Village of Genoa City, Village of Williams Bay, Village of Mukwonago, Village of Pewaukee, Village of Sussex, City of Waukesha, City of

Table 43

AREAL EXTENT OF CIVIL DIVISIONS IN THE FOX RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
Villages			
Paddock Lake	0.03	--[a]	1.72
Silver Lake	1.43	0.15	100.00
Twin Lakes	5.94	0.64	100.00
Towns			
Brighton	20.61	2.21	57.39
Randall	18.18	1.94	100.00
Salem	26.07	2.79	78.90
Wheatland	24.07	2.58	100.00
County Subtotal	96.33	10.31	34.62
MILWAUKEE COUNTY			
City			
Franklin	0.46	0.05	1.33
County Subtotal	0.46	0.05	0.19
RACINE COUNTY			
City			
Burlington	3.15	0.34	100.00
Villages			
Rochester	0.45	0.05	100.00
Waterford	1.67	0.18	100.00
Towns			
Burlington	38.79	4.15	100.00
Dover	31.11	3.33	86.01
Norway	35.69	3.82	99.72
Raymond	1.79	0.19	5.01
Rochester	17.25	1.85	100.00
Waterford	34.44	3.69	100.00
County Subtotal	164.34	17.59	48.29
WALWORTH COUNTY			
Cities			
Elkhorn	1.67	0.18	39.76
Lake Geneva	4.33	0.46	100.00
Villages			
East Troy	1.74	0.19	100.00
Fontana on Geneva Lake	3.48	0.37	94.05
Genoa City	1.00	0.11	100.00
Walworth	0.12	0.01	10.01
Williams Bay	2.66	0.28	91.10
Towns			
Bloomfield	35.06	3.75	100.00
Delavan	0.53	0.06	1.66
East Troy	34.15	3.66	100.00
Geneva	21.09	2.26	64.81
Lafayette	34.75	3.72	99.83
La Grange	28.11	3.01	78.89
Linn	31.41	3.36	93.37
Lyons	35.47	3.80	100.00
Richmond	0.33	0.04	0.92
Spring Prairie	35.90	3.84	100.00
Sugar Creek	26.35	2.82	75.54
Troy	35.58	3.81	100.00
Walworth	2.63	0.28	8.67
Whitewater	1.03	0.11	3.23
County Subtotal	337.39	36.11	58.53

Table 43 (continued)

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
WASHINGTON COUNTY			
Town			
Richfield	0.30	0.03	0.83
County Subtotal	0.30	0.03	0.07
WAUKESHA COUNTY			
Cities			
Brookfield	12.29	1.32	47.62
Delafield	0.20	0.02	1.91
Muskego	32.15	3.44	89.18
New Berlin	27.00	2.89	73.23
Waukesha	13.51	1.45	100.00
Villages			
Big Bend	0.71	0.08	100.00
Eagle	0.94	0.10	95.92
Hartland	0.23	0.02	7.96
Lannon	2.49	0.27	100.00
Menomonee Falls	14.81	1.58	44.38
Mukwonago	2.08	0.22	100.00
North Prairie	1.33	0.14	100.00
Pewaukee	2.77	0.30	100.00
Sussex	2.65	0.28	100.00
Wales	0.89	0.10	39.38
Towns			
Brookfield	6.72	0.72	97.11
Delafield	14.69	1.57	67.05
Eagle	20.45	2.19	57.87
Genesee	28.35	3.03	87.61
Lisbon	21.31	2.28	63.29
Merton	1.43	0.15	4.97
Mukwonago	34.75	3.72	100.00
Ottawa	3.16	0.34	8.84
Pewaukee	28.67	3.07	100.00
Vernon	34.41	3.68	100.00
Waukesha	27.50	2.94	100.00
County Subtotal	335.49	35.91	57.78
Total	934.31	100.00	--

[a] *Less than 0.01 percent.*

Source: SEWRPC.

Brookfield, City of New Berlin, and City of Muskego sewage treatment facilities. The City of Brookfield sewage treatment facility began its operation in 1974 after the abandonment of the "old" Fox River plant and Poplar Creek lagoons in the City of Brookfield in late 1973. Of the remaining 15 public sewage treatment facilities, four plants—Village of Sussex, Village of Pewaukee, the City of Muskego, and New Berlin-Regal Manor sewage treatment plants—are proposed to be abandoned by 1979. In addition to the public sewage treatment facilities, the following 15 nonindustrial privately owned sanitary sewage treatment facilities operate within the Fox River watershed: Brookfield Central High School, Willow Springs Mobile Home Park, Wisconsin Department of Transportation-East Troy, Cleveland Heights Elementary School, New Berlin West High School, Oakton Manor-Tumblebrook Golf Course, Rainbow Springs Resort, Alpine Valley Restor, Inc., Holy Redeemer College County Estates Mobile Home Park, Interlaken Resort Village, Slovak Sokol Camp, Wheatland Mobile Home Park, Playboy Club Hotel, and Steeplechase Inn. Selected data on these 14 private sewage treatment facilities and the 16 public sewage treatment facilities is presented in Tables 48 and 49. The locations of the plants are

Table 44

ESTIMATED RESIDENT POPULATION OF THE
FOX RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
KENOSHA COUNTY	
Villages	
Paddock Lake (Part)	6
Silver Lake	1,317
Twin Lakes	3,115
Towns	
Brighton (Part)	420
Randall	1,869
Salem (Part)	4,969
Wheatland	2,401
Kenosha County (Part) Subtotal	14,097
MILWAUKEE COUNTY	
Cities	
Franklin (Part)	14
Milwaukee County (Part) Subtotal	14
RACINE COUNTY	
City	
Burlington	8,705
Towns	
Burlington	5,167
Dover (Part)	2,715
Norway (Part)	4,623
Raymond (Part)	294
Rochester	1,160
Waterford	3,458
Villages	
Rochester	612
Waterford	2,335
Racine County (Part) Subtotal	29,069

Civil Division	1975 Population
WALWORTH COUNTY	
Cities	
Elkhorn (Part)	2,556
Lake Geneva	5,323
Towns	
Bloomfield	2,772
Delavan (Part)	254
East Troy	3,044
Geneva (Part)	2,428
LaFayette (Part)	986
La Grange (Part	1,240
Linn (Part)	2,113
Lyons	2,379
Richmond (Part)	7
Spring Prairie	1,469
Sugar Creek (Part)	1,846
Troy	1,351
Walworth (Part)	260
Whitewater (Part)	21
Villages	
East Troy	2,168
Fontana on Geneva Lake (Part)	1,631
Genoa City	1,083
Walworth (Part)	53
Williams Bay (Part)	1,651
Walworth County (Part) Subtotal	34,635

shown on Map 14.[5] Of the 16 publicly operated sewage treatment facilities and 15 nonindustrial privately operated sewage treatment facilities, a total of six facilities discharge effluent to the Fox River main stem, and seven facilities have seepage lagoon and soil absorption systems. The remaining 18 facilities discharge effluent to various tributaries of the Fox River or to lakes in the Fox River watershed.

Domestic Onsite Sewage Disposal: Another source of pollution within the Menomonee River watershed is private, onsite soil absorption sewage disposal systems which have the potential of releasing nutrients, fecal coliform bacteria, and other disease producing organisms into the surface waters via both subsurface and overland flow.

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[5] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 14. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 44 (continued)

Civil Division	1975 Population
WASHINGTON COUNTY	
Town	
Richfield	14
Washington County (Part) Subtotal	14
WAUKESHA COUNTY	
Cities	
Brookfield (Part)	14,437
Delafield (Part)	40
Muskego (Part)	9,241
New Berlin (Part)	16,534
Waukesha	47,744
Towns	
Brookfield (Part)	3,944
Delafield (Part)	2,690
Eagle (Part)	1,153
Genesee (Part)	3,099
Lisbon (Part)	5,740
Merton (Part)	55
Mukwonago	2,799
Ottawa (Part)	448
Pewaukee	8,234
Vernon	3,511
Waukesha	4,832
Villages	
Big Bend	1,439
Eagle (Part)	858
Hartland (Part)	476
Lannon	1,161
Menomonee Falls (Part)	6,196
Mukwonago	3,132
North Prairie	793
Pewaukee	4,379
Sussex	4,112
Wales (Part)	199
Waukesha County (Part) Subtotal	147,246
Fox River Watershed Total	225,075

Source: SEWRPC.

Sanitary Sewerage System Flow Relief Points: In addition to private and public sewage treatment facility effluent, raw sanitary sewage enters the surface water system of the Fox River watershed directly from sanitary sewer bypasses and portable pumping stations. There are 20 known sanitary sewerage system flow relief devices in operation within the watershed, as presented in Table 50. Of these, 13 are bypasses and seven are portable pumping stations. Ten of these flow relief devices discharge directly to the Fox River main stem. The remaining 10 discharge to tributaries of the Fox River.

Industrial Wastewater Discharges: At 41 locations in the Fox River watershed industrial wastewaters consisting of cooling and process, waters are discharged directly or indirectly to the surface water system (see Map 14). This industrial wastewater enters the Fox River and its major tributaries directly through industrial waste outfalls or indirectly through drainage ditches and storm sewers.

Data and information provided from the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR 101 of the Wisconsin Administrative Code were used to determine the type and location of industrial waste discharges in the Fox River watershed. Table 51 summarizes by receiving stream and by civil division the types of industrial wastewater discharges and the number of outfalls in the watershed, the types of treatment, and average hydraulic design capacity. A total of 61 industrial and commercial waste discharge points is known to exist in the watershed. Of these, 33 discharge cooling waters, 18 process wastewaters, seven cooling and process wastewaters and three discharge groundwater seepage. Nineteen of the 41 industrial locations discharge the process or cooling waters directly to the Fox River main stem and 14 discharge to tributaries of the Fox River. Of the remaining eight industries seven discharge to the groundwater of the Fox River watershed and one discharges to Muskego Lake.

Pollution from Urban Runoff: Separate urban storm sewers which convey runoff from rainfall carry pollutants and contaminants washed off of the urban areas and drained into receiving surface waters. Urban storm water runoff can cause chemical or inorganic pollution, organic pollution, pathogenic pollution, and aesthetic pollution of the receiving lakes and streams. Existing land use information for the Fox River watershed, taken from the Commission 1970 land use inventory, is presented in Table 52 and indicates that 83,723 acres, or about 14 percent of the Fox River watershed, is devoted to urban land uses, and 439,734 acres, or about 73 percent, is devoted to rural land uses, primarily agricultural. The remaining 13 percent of the watershed is occupied by lakes, streams, and other surface waters. A shoreline development survey by the Wisconsin Department of Natural Resources indicated a similar ratio of urban and rural land uses in the shoreline area within 1,000 feet of the Fox River and its tributaries, if the shorelines of the lakes in the watershed are excluded. For the lakes, about 73 percent of the shoreline area within 1,000 feet of the major lakes in the Fox River watershed is in urban use. Of the remaining shoreland area, about 20 percent is undeveloped and about 7 percent is in agricultural use. The shoreline data indicated a significant concentration of population around the lakes, a typical situation in the Region. Urban development around the lakes may be expected to have a significant effect on water quality.

Table 45

FLOW MEASUREMENTS AT THE FOX RIVER AT WAUKESHA (FX-7) AND WILMOT (FX-27): 1964-1975

Fox River at Waukesha (Fx-7)

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1964	31.6	3.39	314	3.2
1965	83.6	8.92	1,120	7.4
1966	98.3	10.51	915	7.4
1967	37.3	3.98	248	7.0
1968	50.0	5.36	414	7.0
1969	79.3	8.48	573	6.1
1970	62.4	6.67	502	15.0
1971	80.6	8.62	601	4.2
1972	113	12.08	1,010	13.0
1973	172	18.44	2,160	5.7
1974	146	15.64	1,440	9.4
1975	119	12.77	1,140	25

Fox River at Wilmot, Wisconsin (Fx-27)

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1964	219	3.40	1,170	65
1965	501	7.72	2,820	78
1966	647	9.96	3,170	103
1967	403	6.23	2,340	93
1968	394	6.08	1,980	115
1969	569	8.91	2,160	105
1970	458	7.16	1,790	102
1971	550	8.61	2,900	117
1972	713	11.19	3,250	138
1973	1,152	18.02	6,430	222
1974	1,082	16.93	3,880	225
1975	642	10.04	2,820	223

Source: U. S. Geological Survey.

Table 46

FLOW MEASUREMENTS AT THE MUKWONAGO RIVER AT MUKWONAGO (FX-12) AND THE WHITE RIVER NEAR BURLINGTON (FX-20): 1973-1975

Mukwonago River at Mukwonago, Wisconsin (Fx-12)

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1973-1974	90.3	–	275	20
1974-1975	77.5	13.80	236	3.3

White River Near Burlington, Wisconsin (Fx-20)

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1973-1974	159	22.16	849	21
1974-1975	90.2	12.56	662	15

Source: U. S. Geological Survey.

Pollution from Rural Runoff: Storm water runoff from agricultural lands is known to contain high concentrations of suspended solids and nutrients in the form of nitrogen and phosphorus. Since 73 percent of the total area of the Fox River watershed is in agricultural use, pollution from agricultural land is likely to be a significant factor in determining the water quality condition of the Fox River stream system.

Other Pollution Sources: In addition to the pollution sources described above, the Commission 1970 land use inventory indicated that 48 sanitary landfill sites and 17 auto salvage yards are located within the watershed. Seepage and runoff from these sources may contain organic pollutants, inorganic pollutants, and pathogenic organisms and could contribute to the pollution of the river system.

Water Quality Conditions of Fox River Watershed

Water Quality Data: Of the sources of water quality data available within the Southeastern Wisconsin Region, the following five were used in the analyses of water quality conditions in the Fox River watershed: 1) Commission benchmark study, 2) Commission continuing monitoring program, 3) Commission and U. S. Geological Survey cooperative continuous streamflow monitoring program,

Table 47

MAJOR LAKES IN THE FOX RIVER WATERSHED

Name	Municipality	U. S. Public Land Survey Town, Range, Section	Surface Width (miles)	Surface Length[a] (miles)	Surface Area (acres)	Maximum Depth[b] (feet)	Shoreline Length (miles)	Shore Development[c] (ratio)	Public Frontage Length (miles)	Date of Sampling	County
Benedict Lake	Town of Bloomfield Town of Randall	T1N, R18E, Section 19 T1N, R19E Section 24	0.25	0.80	78.00	37	2.50	1.89	0.02	3/19/60	Kenosha
Camp Lake	Town of Salem	T1N, R20E Sections 21, 28, 29	0.97	1.50	461.00	17	3.95	1.28	0.45	3/19/60	Kenosha
Cross Lake	Town of Salem	T1N, R20E Sections 35, 36	0.30	0.50	87.00	35	1.40	1.10	--	3/19/60	Kenosha
Center Lake	Town of Salem	T1N, R20E Sections 15, 16, 21	0.30	0.90	129.00	30	3.16	2.19	0.09	3/19/60	Kenosha
Dyer Lake	Town of Wheatland	T2N, R19E Section 30	0.25	0.40	56.00	13	1.20	1.18	--	3/19/60	Kenosha
Elizabeth Lake	Village of Twin Lakes	T1N, R19E Sections 28, 29, 32	0.80	1.90	638.00	38	5.40	1.55	0.07	3/19/60	Kenosha
Lilly Lake	Town of Wheatland	T1N, R19E Section 11	0.40	0.50	87.00	6	1.30	1.03	0.13	3/19/60	Kenosha
Marie Lake	Village of Twin Lakes	T1N, R19E Sections 21, 28	0.60	1.10	310.00	38	3.40	1.47	0.15	3/19/60	Kenosha
Powers Lake	Town of Randall Town of Bloomfield	T1N, R18E Section 13 T1N, R19E Section 18	0.70	1.30	459.00	34	4.70	1.64	0.15	3/19/60	Kenosha
Silver Lake	Town of Salem	T1N, R20E Sections 8, 9, 16	0.80	1.30	464.00	43	4.10	1.29	0.11	4/15/60	Kenosha
Voltz Lake	Town of Salem	T1N, R20E Section 36	0.38	0.42	52.00	24	1.40	1.62	--	3/19/60	Kenosha
Bohner Lake	Town of Burlington	T2N, R19E Sections 17, 18, 19, 20	0.17	0.60	124.00	30	1.83	1.17	--	4/14/60	Racine
Browns Lake	Town of Burlington	T3N, R19E, Sections 27, 28, 33, 34	0.90	1.10	396.00	44	5.00	1.82	--	4/15/60	Racine
Buena Lake	Town of Waterford	T4N, R19E Sections 14, 23, 26, 35	0.28	0.60	241.00	8	3.90	2.68	--	5/2/60	Racine
Eagle Lake	Town of Dover	T3N, R20E Sections 21, 22, 27	0.83	1.27	520.00	15	4.33	1.37	--	4/15/60	Racine
Echo Lake	Town of Burlington	T3N, R19E Sections 29, 30	--	--	71.00	9	5.60	3.96	--	5/3/60	Racine
Kee Nong Go Mong Lake	Town of Norway	T4N, R20E Sections 6,7	0.33	1.70	87.00	26	2.17	1.58	--	4/14/60	Racine
Long Lake	Town of Burlington Town of Rochester	T3N, R19E Section 16 T3N, R19E Section 21	0.30	0.97	124.00	5	2.50	1.61	--	4/14/60	Racine
Tichigan Lake	Town of Waterford	T4N, R19E Sections 11, 12, 13, 14	0.50	1.40	891.00	63	4.75	2.07	--	5/2/60	Racine
Waubeesee Lake	Town of Norway	T4N, R20E Sections 7, 8, 17, 18	0.40	0.70	129.00	73	2.30	1.70	--	5/3/60	Racine
Wind Lake	Town of Norway	T4N, R20E Sections 3, 4, 8, 9, 10, 16, 17	1.16	1.88	936.00	47	5.75	1.40	--	5/2/60	Racine
Army Lake	Town of East Troy	T4N, R18E Section 16	0.30	0.40	78.00	17	1.40	1.14	0.01	6/9/60	Walworth
Beulah Lake	Town of East Troy	T4N, R18E Sections 4, 8, 9, 17	1.30	2.60	837.00	58	1.53	2.54	0.02	5/13/60	Walworth
Booth Lake	Town of Troy	T4N, R17E Sections 13, 24	0.40	0.60	108.00	24	1.50	1.08	0.30	5/13/60	Walworth
Como Lake	Town of Geneva	T2N, R17E Sections 27, 28, 32	0.60	3.40	2,260.00	8	8.00	1.75	0.01	5/13/60	Walworth

Table 47 (continued)

Name	Municipality	U. S. Public Land Survey Town, Range, Section	Surface Width (miles)	Surface Length[a] (miles)	Surface Area (acres)	Maximum Depth[b] (feet)	Shoreline Length (miles)	Shore Development[c] (ratio)	Public Frontage Length (miles)	Date of Sampling	County
Geneva Lake	City of Lake Geneva	T2N, R17E Sections 35, 36 T2N, R17E Sections 1, 2	--	--	--	--	--	--	--	--	Walworth
	Town of Linn	T1N, R17E Sections 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12	--	--	--	--	--	--	--	--	Walworth
	Village of Williams Bay	T1N, R17E Sections 6, 13, T1N, R16E Section 12	2.10	7.60	5,262.00	135	20.10	2.03	1.50	5/13/60	Walworth
	Village of Fontana	T1N, R16E Sections 11, 12, 13, 14 T1N, R17E Section 18	--	--	--	--	--	--	--	--	Walworth
	Town of Walworth	T1N, R16E Sections 11, 12	--	--	--	--	--	--	--	--	Walworth
Green Lake	Town of LaGrange	T4N, R16E Section 26	0.80	1.20	311.00	57	4.00	1.67	--	6/13/60	Walworth
Lulu Lake	Town of Troy	T4N, R17E Section 2	0.40	0.60	84.00	40	1.50	1.10	--	6/13/60	Walworth
Middle Lake	Town of LaGrange	T4N, R16E Section 35	0.50	1.80	259.00	42	5.30	2.36	--	6/13/60	Walworth
Mill Lake	Town of LaGrange	T4N, R16E Sections 3, 35, 36	0.80	1.10	271.00	44	4.80	2.12	0.02	6/13/60	Walworth
North Lake	Town of Sugar Creek	T3N, R16E Section 5	0.50	1.30	244.00	11	4.80	2.48	0.01	6/09/60	Walworth
Pell Lake	Town of Bloomfield	T1N, R18E Section 15	0.40	0.50	86.00	13	1.80	1.24	1.60	6/20/60	Walworth
Peters Lake	Town of Troy	T4N, R17E Section 17	0.30	0.40	64.00	8	1.20	1.11	--	5/13/60	Walworth
Pleasant Lake	Town of LaGrange	T4N, R16E Section 24	0.50	0.70	155.00	29	2.70	1.65	0.15	6/13/60	Walworth
Potters Lake	Town of East Troy	T4N, R16E Sections 10, 11	0.40	0.80	162.00	26	2.10	1.22	0.05	6/13/60	Walworth
Silver Lake	Town of Sugar Creek	T3N, R16E Section 14	0.30	0.60	85.00	4	1.50	1.15	0.08	--	Walworth
Wandawega Lake	Town of Sugar Creek	T3N, R16E Sections 1, 2	0.30	0.70	119.00	9	2.10	1.37	0.02	6/13/60	Walworth
Big Muskego Lake	City of Muskego	T5N, R20E Sections 13, 14, 22 23, 27	1.47	3.40	2,260.00	26	17.70	2.66	--	10/11/60	Waukesha
Denoon Lake	City of Muskego	T5N, R20E Sections 31, 32	0.45	0.74	162.00	60	2.40	1.35	--	10/18/60	Waukesha
Eagle Spring Lake	Town of Eagle	T5N, R17E Sections 35, 36	0.55	0.85	227.00	12	4.00	1.89	0.03	10/18/60	Waukesha
Little Muskego Lake	City of Muskego	T5N, R20E Sections 4, 9	1.10	1.50	506.00	65	5.70	1.90	0.01	10/18/60	Waukesha
Lower Phantom Lake	Town of Mukwonago	T5N, R18E Sections 26, 35	0.63	0.79	433.00	10	3.30	1.81	0.03	10/18/60	Waukesha
Pewaukee Lake	Village and Town of Pewaukee	T7N, R19E Sections 7, 8									
	Town of Delafield	T7N, R18E Sections 13, 14, 15, 22, 23, 24	1.20	4.50	2,493.00	45	13.20	1.94	0.56	9/22/60	Waukesha
Saylesville Millpond	Town of Genesee	T6N, R18E Sections 24, 25	0.28	0.73	66.00	5	2.20	1.93	--	2/20/63	Waukesha
Spring Lake	Town of Mukwonago	T5N, R18E Sections 4, 9	0.35	0.77	107.00	20	2.20	1.57	--	10/18/60	Waukesha
Upper Phantom Lake	Town of Mukwonago	T5N, R18E Sections 34, 35	0.40	0.73	111.00	29	2.10	1.42	0.04	10/18/60	Waukesha

[a] *Lake lengths, widths and areas, used in this comparison were taken from aerial photographs dated September and October 1956 for Kenosha, Racine, Walworth, and Waukesha Counties.*

[b] *Maximum depth was measured from the surface elevation existing on date sampled.*

[c] *Shore development ratio (SDR) is a convenient expression of the degree of regularity or irregularity of shoreline. Generally, the higher the ratio, the greater the biological productivity of the lake. SDR = length of shoreline of lake of given area divided by circumference of circle with same area. An SDR of 1.00 indicates a circular lake.*

Source: SEWRPC.

Table 48

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE FOX RIVER WATERSHED: 1975

Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[a]	Design Capacity: Average Hydraulic (mgd)	Design Capacity: Peak Hydraulic (mgd)	Design Capacity: Average Organic (pounds BOD_5 per day)	Design Capacity: Population[a] Equivalent	Existing Loading 1975: Average Annual Hydraulic (mgd)	Existing Loading 1975: Average Annual Hydraulic Per Capita (gpd)
Village of Silver Lake	0.47	1,300	1966	Activated Sludge Disinfection	Secondary Auxiliary	Fox River	3,000	0.30	0.50	510	2,429	0.15	115
Village of Twin Lakes	2.31	3,400	1958, 1970	Trickling Filter Activated Sludge Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	Bassett Creek	8,200	0.82	1.64	1,390	6,619	0.41	121
City of Burlington	2.27	10,800	1934, 1938 1962 1970, 1975	Activated Sludge Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	Fox River	N/A	2.50	3.00	N/A	23,809	1.48	137
Western Racine County Sewerage District (includes Rochester and Waterford)	0.94	3,400	1969, 1975	Activated Sludge Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	Fox River	5,000	0.50	1.00	850	4,000	0.24	72
City of Lake Geneva	1.96	5,700	1930, 1966	Trickling Filter Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	White River	9,750	1.1	N/A	1,890	9,000	0.74	129
Village of East Troy	0.82	2,200	1960	Trickling Filter	Secondary	Honey Creek	3,200	0.32	0.64	417	2,000	0.25	112
Village of Fontana-on-Geneva Lake	1.42	1,800	1957	Trickling Filter Disinfection	Secondary Auxiliary	Seepage Lagoon and Lake Geneva	N/A	0.90	1.80	N/A	N/A	0.52	289
Village of Genoa City	0.27	1,100	1923, 1959	Trickling Filter Disinfection	Secondary Auxiliary	Nippersink Creek	N/A	0.12	0.24	200	952	0.07	65
Village of Williams Bay	0.12	1,700	1931, 1968	Activated Sludge Disinfection	Secondary Auxiliary	Seepage Lagoon	6,500	0.80	1.2	1,100	5,238	0.20	118
City of Waukesha	13.59	51,300	1949, 1967	Trickling Filter Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	Fox River	50,000	8.50	12.00	11,500	54,762	9.90	193
Village of Mukwonago	1.26	3,400	1950	Trickling Filter Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	Mukwonago River	1,500	0.22	0.56	485	2,800	0.44	128
Village of Pewaukee	1.31	4,800	1950, 1971	Trickling Filter Disinfection	Secondary Auxiliary	Pewaukee River	7,500	0.80	1.20	1,595	7,595	0.30	63
Village of Sussex	1.06	4,000	1960, 1975	Trickling Filter Disinfection	Secondary Auxiliary	Sussex Creek	3,000	0.30	1.50	510	2,429	0.47	118
City of Brookfield	8.50	16,200	1973	Activated Sludge Phosphorus Removal Disinfection	Secondary Auxiliary Advanced	Fox River	22,000	5.0	7.50	3,665	17,452	2.49	138
City of Muskego	2.15	4,200	1967, 1970	Lagoons Disinfection	Secondary Auxiliary	Big Muskego Lake	6,000	0.70	1.30	1,400	6,667	0.58	56
City of New Berlin Regal Manor	0.54	1,100	1970	Activated Sludge Disinfection	Secondary Auxiliary	Deer Creek	N/A	0.30	N/A	500	2,381	0.12	109

NOTE: N/A indicates data not available.

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5, loading in pounds per day as set forth in the engineering reports by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the study engineer assumed a different daily per capita contribution of BOD_5 the population equivalent design capacity will differ from the population design capacity shown in the table.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

4) Wisconsin Department of Natural Resources monthly manual sampling and 5) Wisconsin Department of Natural Resources basin surveys. The data sources used for the analysis of the lake water quality in the Fox River watershed were: 1) Wisconsin Department of Natural Resources quarterly lake monitoring program, 2) aquatic plant survey of major lakes in the Fox-Illinois-Watershed (1969), 3) U. S. Environmental Protection Agency national eutrophication survey—reports on Browns Lake, Como Lake, Geneva Lake, Middle Lake, Pewaukee Lake and Tichigan Lake, and 4) Southeastern Wisconsin Regional Planning Commission and Wisconsin Department of Natural Resources Lake Use Reports. A detailed description of these data sources is contained in Chapter II of this report.

Twenty-eight water quality sampling stations, 12 on the Fox River and 16 on its primary and secondary tributaries, were established by the Commission in 1964. Tables 53 and 54 list these Commission stations together with their locations and distances from the Fox River at Wilmot dam located 1.2 miles from the Wisconsin-Illinois State line. Map 14 shows the location of the sampling stations in the Fox River watershed. In addition to the

Table 49

SELECTED CHARACTERISTICS OF NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES IN THE FOX RIVER WATERSHED: 1975

Name	Civil Division Location	Type of Land Use Served	Type of Wastewater	Type of Treatment Provided	Disposal of Effluent	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Average Hydraulic Design Capacity (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
KENOSHA COUNTY								
Wheatland Mobile Home Park	Town of Wheatland	Residential	Sanitary	Contact Stabilization and Lagoon	Fox River	37,000[b]	39,000[b]	N/A
RACINE COUNTY								
Holy Redeemer College	Town of Dover	Institutional	Sanitary	Extended Aeration and Lagoon	Tributary of Wind Lake Canal	8,000	15,000	13,000
WALWORTH COUNTY								
Alpine Valley Resort, Inc.	Town of La Fayette	Recreational	Sanitary	Activated Sludge and Lagoon	Groundwater	N/A	40,000	N/A
Country Estates Mobile Home Park	Town of Lyons	Residential	Sanitary	Extended Aeration and Lagoon	White River	15,000	N/A	23,000
Interlaken Resort Village	Town of Geneva	Recreational	Sanitary	Contact Stabilization, Sand Filter and Lagoon	Groundwater	27,000	125,000	72,000
Playboy Club Hotel	Town of Lyons	Recreational	Sanitary	Contact Stabilization and Lagoon	White River	120,000	500,000	278,000
Slovak Sokol Camp	Town of East Troy	Recreational	Sanitary	Activated Sludge	Potters Lake	N/A	20,000	N/A
Wisconsin Department of Transportation—East Troy Rest Area	Town of La Fayette	Recreational	Sanitary	Contact Stabilization and Sand Filter	Tributary of Sugar Creek	N/A	18,000	N/A
WAUKESHA COUNTY								
Brookfield Central High School	City of Brookfield	Institutional	Sanitary	Septic Tank, Sand Filter and Lagoon	Groundwater	N/A	N/A	N/A
Cleveland Heights Elementary School	City of New Berlin	Institutional	Sanitary	Septic Tank, Sand Filter and Lagoon	Tributary of Poplar Creek	5,000	N/A	23,000
New Berlin West High School	City of New Berlin	Instituional	Sanitary	Septic Tank, Sand Filter and Lagoon	Tributary of Poplar Creek	18,000	24,000	23,000
Oakton Manor—Tumblebrook Golf Course	Town of Delafield	Recreational	Sanitary	Activated Sludge and Lagoon	Pewaukee Lake	800[c]	36,000	2,000[c]
Rainbow Springs Resort	Town of Mukwonago	Recreational	Sanitary	Activated Sludge	Tributary of Mukwonago River	N/A	160,000	N/A
Steeplechase Inn	Town of Pewaukee	Commercial	Sanitary	Extended Aeration and Lagoon	Groundwater	N/A	25,000	N/A
Willow Springs Mobile Home Park	Town of Lisbon	Residential	Sanitary	Soil Absorption System	Groundwater	N/A	N/A	36,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data was obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

[b] *Data obtained from a Department of Natural Resources compliance monitoring survey conducted on July 9, 1975.*

[c] *Data obtained from a Department of Natural Resources compliance monitoring survey, 1976.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

28 Commission sampling stations, one Department of Natural Resources' sampling station, DNR-FX-27a was used in the analysis of the Fox River. Sampling station DNR-Fx-27a is located at Wilmot dam.

Surface Water Quality of the Fox River and Its Tributaries 1964-1965: Water quality conditions in the Fox River watershed, as determined by 1964-1965 sampling survey at 12 stations along the entire length of the Fox River and 16 stations on tributary streams, are summarized in Table 55 and presented in tabular form in Appendix D to this report. The results for chloride, dissolved oxygen, and coliform bacteria are particularly relevant to the assessment of the trends in surface water quality.

Table 50

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE FOX RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Crossovers	Other Flow Relief Devices			
				Bypasses	Relief Pumping Stations	Portable Pumping Stations	Total
White River	City of Lake Geneva	0	0	1	0	0	1
Honey Creek	Village of East Troy	0	0	1	0	0	1
Nippersink Creek	Village of Genoa City	0	0	1	0	0	1
Silver Lake Outlet	Village of Silver Lake	0	0	1	0	0	1
Fox River	City of Waukesha	0	0	8	0	2	10
Big Muskego Lake	City of Muskego	0	0	1	0	0	1
Deer Creek	City of Brookfield	0	0	0	0	1	1
Fox River	City of Brookfield	0	0	0	0	1	1
Sussex Creek	Village of Sussex	0	0	0	0	1	1
Fox River	Village of Menomonee Falls	0	0	0	0	2	2
Total	--	0	0	13	0	7	20

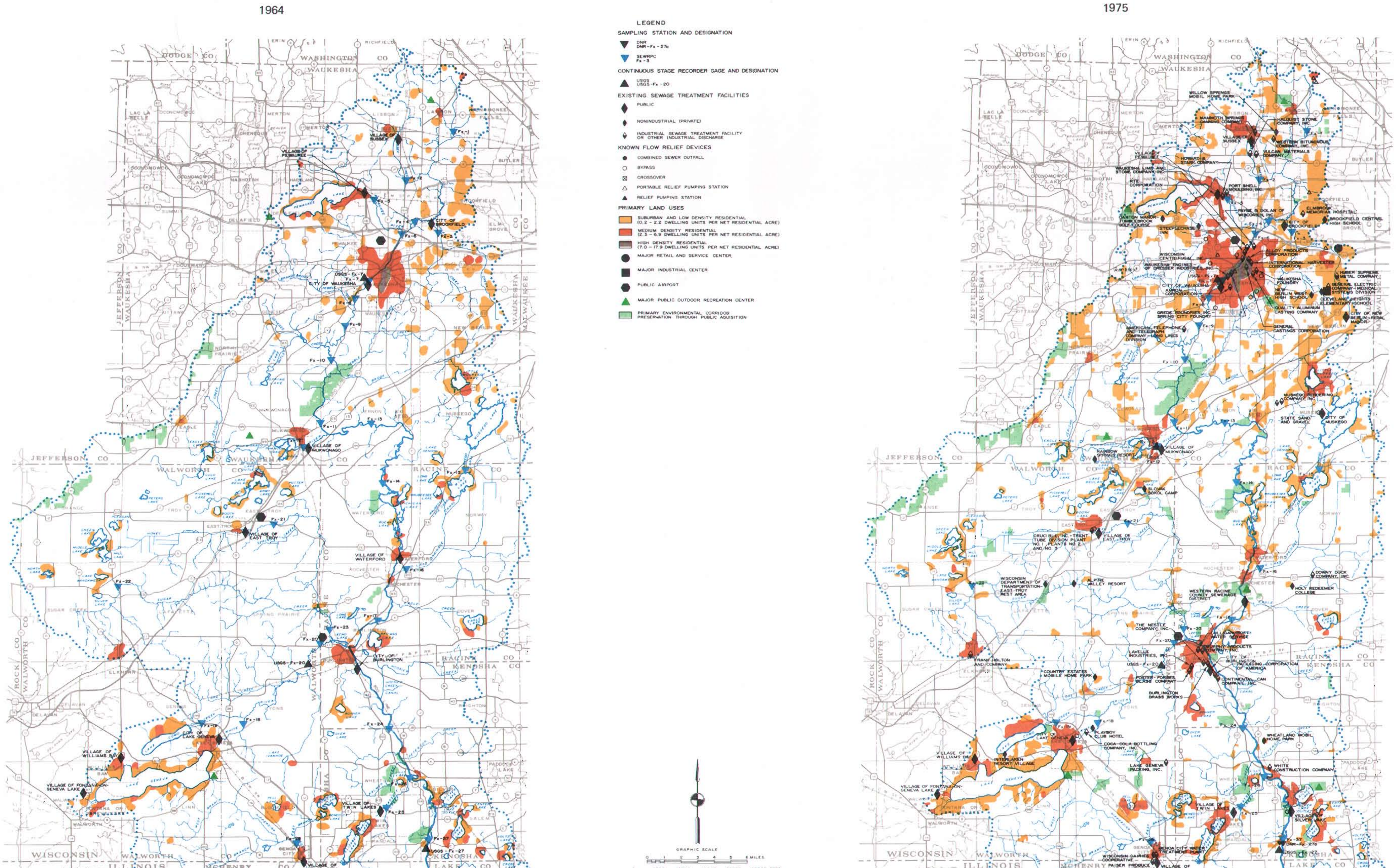
Source: SEWRPC.

Chloride: During the sampling year of 1964-1965, the chloride concentrations throughout the watershed were found to vary from 0 to 445 mg/l with the average values for the Fox River being 50 mg/l. Among the tributaries, the Mukwonago River, Como Creek, and Honey Creek had chloride concentrations in the range of 0 to 15 mg/l; the Muskego Canal, Wind Lake drainage canal, Sugar Creek, White River, and Nippersink Creek had chloride concentrations in the range of 15 to 55 mg/l; and Sussex Creek, Poplar Creek, Pewaukee River, and Bassett Creek had chloride concentrations in the range of 20 to 120 mg/l. With the exception of Mukwonago River, Como Creek and Honey Creek where the chloride concentrations were at about the same level as found in adjacent groundwaters, the Fox River and its tributaries had chloride concentrations higher than the groundwater levels of 10 to 20 mg/l as measured from well water samples in the area. There was no specific seasonal variation observed in the chloride concentrations at various locations in the Fox River and its tributaries in the 1964-1965 sampling survey. A comparison of the flow and the chloride loadings as presented in Figures 22 through 25 at sampling stations Fx-7 and Fx-27—the stations for which flow data are available—indicate no specific relationship between flow and chloride loadings. Although, as a general rule, the chloride loadings increased with an increase in flow, the loadings were not directly proportional to flow. The increase in the chloride loadings with the flow suggests that it is unlikely that the source of chlorides is exclusively sewage treatment plant effluent. The other sources of chloride in the Fox River Watershed include road salts, runoff from feedlot operations, industrial discharges or cooling waters with chlorinated additives, and other diffuse sources of pollutants.

Dissolved Oxygen: During the sampling period of 1964-1965, the dissolved oxygen levels in the watershed were found to range from 0 to 19.0 mg/l in the Fox River main stem. Among the tributaries, Mukwonago River, Sugar Creek, and Nippersink Creek exhibited dissolved oxygen concentrations in the range of 8.5 to 16.5 mg/l with an average of 11.7 mg/l. Como Creek, Honey Creek, Sussex Creek, Bassett Creek, White River, and Wind Lake Drainage Canal exhibited dissolved oxygen concentrations in the range of 4.1 to 16.0 mg/l with an average of 9.6 mg/l. Poplar Creek, Pewaukee River, and Muskego Canal exhibited dissolved oxygen concentrations in the range of 0.1 to 14.3 mg/l with an average of 6.7 mg/l. Although the average concentrations of dissolved oxygen in the Fox River and its tributaries are significantly higher than the applicable dissolved oxygen standard of 5.0 mg/l, many samples showed substandard dissolved oxygen levels in the Fox River and its tributaries. At sampling satations Fx-1 and Fx-4 in the headwaters area of the Fox River, substandard dissolved oxygen levels were observed in 13 of the 27 water samples collected. Other locations in the main stem stations Fx-7 through Fx-27 showed substandard levels of oxygen in two or less of the 14 water samples collected at each sampling station. The substandard dissolved oxygen concentrations encountered in the headwater area are likely to be due primarily to the discharge of wastewater effluents. Among the tributaries, the Pewaukee River and Poplar Creek in

Map 14

LOCATION OF STREAM SAMPLING STATIONS EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES AND LAND USE IN THE FOX RIVER WATERSHED: 1964 AND 1975



Stream water quality data were obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at 29 sampling stations located in the Fox River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by discharges from 16 municipal sewage treatment facilities, 13 sanitary sewerage system bypasses, seven portable pumping stations, 15 nonindustrial private sewage treatment facilities, and 41 industrial or commercial facilities discharging wastewater through 61 outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 14. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.

Source: SEWRPC.

Table 51

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE FOX RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
KENOSHA COUNTY								
White Construction Company	1500	Town of Wheatland	Groundwater Seepage	None	1	Tributary of Fox River	N/A	N/A
RACINE COUNTY								
Burlington Brass Works	3432	City of Burlington	Process and Sanitary	None	2	Fox River via storm sewer	1,700	N/A
Continental Can Company, Inc.	3411	City of Burlington	Process	None	1	Groundwater	N/A	N/A
Culligan Soft Water Service	7399	City of Burlington	Process	None	1	Fox River via storm sewer	1,100	1,300
Downy Duck Company, Inc.	0259	Town of Dover	Process and Sanitary	Lagoon and Spray Irrigation	1	Groundwater	45,000	125,000
Foster-Forbes Glass Company	3221	Town of Burlington	Cooling	Lagoon and Oil Separator	1	Fox River	212,000	370,000
			Cooling	None	2	Fox River	141,000	173,000
			Cooling	None	3	Fox River	228,000	294,000
Lavelle Industries, Inc.	3069	City of Burlington	Cooling and Process	None	1	Fox River via storm sewer	55,000	60,000
Murphy Products Company, Inc.	2048	City of Burlington	Cooling	None	3	Fox River via storm sewer	3,000	3,600
The Nestle Company, Inc.	2066	City of Burlington	Cooling	None	2	Fox River via storm sewer	12,000	16,000
Packaging Corporation of America	2653	Town of Burlington	Process and Sanitary	Extended Aeration and Lagoon	1	Tributary of Fox River	7,500	11,600
WALWORTH COUNTY								
Coca-Cola Bottling Company, Inc.	2086	Town of Lyons	Washwater	None	1	White River via drainage ditch	7,000	10,000
Crucible, Inc.-Trent Tube Division Plant No. 1	3317	Village of East Troy	Cooling and Process	Lagoon	1	Honey Creek	480,000	520,000
Plants No. 2 and No. 3	3317	Village of East Troy	Cooling and Process	N/A	1	Honey Creek	64,000	104,000
Frank Holton and Company	3931	City of Elkhorn	Process	Settling Basin, pH Adjustment and Lagoon	1	Groundwater	15,000	N/A
Genoa City Water Treatment Plant	4952	Village of Genoa City	Filter Backwash	None	1	North Branch Nippersink Creek	Intermittent	Intermittent
Lake Geneva Packing, Inc.	2011	Town of Lyons	Process	None	1	Groundwater	N/A	1,000
Paiser Produce (Not in Operation)	--	Village of Genoa City	Process	Lagoon	1	Groundwater	N/A	N/A
Wisconsin Dairies Cooperative	2026	Village of Genoa City	Process	Activated Sludge	1	Nippersink Creek	6,200	N/A
		Village of Genoa City	Cooling	None	2	Nippersink Creek	3,600	N/A
WAUKESHA COUNTY								
Alloy Products Corporation	3494	City of Waukesha	Process and Cooling	Lagoon	1	Groundwater	34,000	46,000
			Process and Cooling	Lagoon	2	Groundwater	34,000	46,000
American Telephone and Telegraph Company-Long Lines Division	4811	Town of Waukesha	Cooling, Tower Blowdown and Groundwater Seepage	None	1	Fox River	28,000	28,000
Amron Corporation	3489	City of Waukesha	Cooling	N/A	1	Fox River via storm sewer	1,000	7,000
			Cooling and Process	N/A	2	Fox River via storm sewer	1,000	1,000
			Cooling and Process	N/A	3	Fox River via storm sewer	1,000	1,000
			Cooling	N/A	4	Fox River via storm sewer	72,000	288,000

Table 51 (continued)

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
WAUKESHA COUNTY (continued)								
Elmbrook Memorial Hospital	8062	City of Brookfield	Cooling	None	1	Fox River	8,000	N/A
General Casting Corporation	3321	City of Waukesha	Cooling	None	1	Fox River via storm sewer	227,000	270,000
			Cooling	None	2	Fox River via storm sewer	42,000	N/A
			Cooling	None	3	Fox River via storm sewer	180,000	N/A
General Electric Company-Medical Systems Division	–	City of New Berlin	Cooling	None	1	Deer Creek via storm sewer	2,400	N/A
Grede Foundries, Inc.– Spring City Foundry	3321	City of Waukesha	Cooling	None	1	Fox River via storm sewer	70,000	80,000
			Cooling	None	2	Fox River via storm sewer	158,000	179,000
Halquist Stone Company, Inc.	1429	Town of Lisbon	Washwater	Lagoon	1	Sussex Creek	1,035,000	1,186,000
Howard B. Stark Company	2065	Village of Pewaukee	Cooling	Lagoon	1	Pewaukee River	55,000	88,000
Huber Supreme Metal Treating Company	3471	City of New Berlin	Cooling	Oil Separator	1	Poplar Creek via drainage ditch	58,000	64,000
International Harvester Company	3321	City of Waukesha	Cooling	None	1	Tributary of Fox River	8,900	14,900
			Cooling	None	2	Tributary of Fox River	18,000	32,000
			Cooling	None	3	Tributary of Fox River	26,000	72,000
			Cooling	None	5	Tributary of Fox River	112,000	154,000
			Cooling	None	6	Tributary of Fox River	174,000	198,000
Mammoth Springs Canning Company	2033	Town of Lisbon	Cooling	Lagoon	1	Sussex Creek	6,000	9,000
			Cooling	N/A	2	Groundwater	40,000	40,000
			Process	Screening and Spray Irrigation	3	Groundwater	200,000	250,000
Muskego Rendering Company, Inc.	4953	City of Muskego	Process	Lagoon and Aeration	1	Groundwater	N/A	10,000
Payne & Dolan of Wisconsin, Inc.	2951	Town of Pewaukee	Washwater	Lagoon	1	Fox River	95,000	168,000
			Washwater	Lagoon	2	Fox River	922,000	1,723,000
Port Shell Moulding, Inc.	3369	Town of Pewaukee	Cooling	None	1	Pewaukee River	2,700	N/A
RTE Corporation	3612	City of Waukesha	Cooling	Oil Separator	1	Fox River via storm sewer	46,000	52,000
			Cooling	None	2	Fox River via storm sewer	60,000	60,000
Quality Aluminum Casting Company	3341	City of Waukesha	Cooling	None	1	Fox River via storm sewer	2,300	2,400
State Sand and Gravel	1442	Town of Muskego	Process	Seepage Lagoon	1	Muskego Lake	N/A	N/A
Vulcan Materials Company	1442	Town of Lisbon	Groundwater	None	1	Fox River via drainage ditch	498,000	1,468,000
Waukesha Engine– Division of Dresser Industries, Inc.	3519	City of Waukesha	Cooling	N/A	1	Swamp adjacent to the Fox River	418,000	900,000
Waukesha Foundry	3321	City of Waukesha	Cooling	None	1	Fox River via drainage ditch	272,000	272,000
Waukesha Lime and Stone Company, Inc.	1411	Town of Pewaukee	Groundwater	Lagoon	1	Fox River	120,000	N/A
Western Bituminous Company, Inc.	2891	Town of Lisbon	Process	Lagoon	1	Fox River	1,500	N/A
Wisconsin Centrifugal, Inc.	3362	City of Waukesha	Cooling	None	1	Fox River via storm sewer	80,000	102,000
			Cooling	None	2	Fox River via storm sewer	16,000	60,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above cited order of priority. In some cases when 12 months of flow data were not reported, the average annual, and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 52

LAND USE IN THE FOX RIVER WATERSHED: 1963 and 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
A. Urban Land Uses				
Residential	30,710.40		39,282.30	
Commercial	1,535.74		1,985.47	
Industrial	3,653.91		4,367.07	
Transportation and Utilities	23,322.49		26,226.16	
Government	2,059.29		2,670.48	
Recreation	6,226.35		8,778.11	
Landfill and Dump	492.49		413.40	
Total Urban Land Use	68,000.67	11.31	83,722.99	13.92
B. Rural Land Uses				
Open Land	65,748.25		65,144.41	
Agricultural Lands	389,378.86		374,592.93	
Total Rural Land Use	455,127.11	75.66	439,737.34	73.11
C. Water Covered Lands				
Lakes, Rivers, and Streams	24,978.48		25,501.32	
Wetlands	53,403.83		52,547.72	
Total Water Covered Land	78,382.31	13.03	78,049.04	12.97
Watershed Total	601,510.09	100.00	601,509.37	100.00

Source: SEWRPC.

Table 53

DESIGNATIONS AND LOCATION OF SEWRPC SAMPLING STATIONS ON THE FOX RIVER MAIN STEM

Source	Sampling Station Designation	Sampling Station Location	Distance from the Wilmot Dam (in miles)
SEWRPC	Fx-1	Fox River at Mill Road NE ¼, Section 29, T8N, R20E	76.4
	Fx-4	Fox River at CTH SS SE ¼, Secton 24, T7N, R19E	65.5
	Fx-7	Fox River at State Street SW ¼, Section 3, T6N, R19E	60.8
	Fx-8	Fox River at Sunset Drive NW ¼, Section 16, T6N, R19E	58.8
	Fx-9	Fox River at CTH HI SW ¼, Section 20, T6N, R19E	56.2
	Fx-10	Fox River at CTH I SE ¼, Section 31, T6N, R19E	51.4
	Fx-11	Fox River at CTH ES (old STH 15) SE ¼, Section 24, T5N, R18E	44.9
	Fx-13	Fox River at Center Drive SW ¼, Section 22, T5N, R19E	40.0
	Fx-14	Fox River at Tichigan Drive NE ¼, Section 10, T4N, R19E	30.8
	Fx-17	Fox River at CTH W SW ¼, Section 22, T3N, R19E	20.4
	Fx-24	Fox River at CTH JB NW ¼, Section 26, T2N, R19E	11.3
	Fx-27	Fox River at CTH C SW ¼, Section 30, T1N, R22E	0.0

Source: SEWRPC.

Table 54

DESIGNATIONS AND LOCATION OF SEWRPC SAMPLING STATIONS ON FOX RIVER TRIBUTARIES

Source	Sampling Station Designation	Sampling Station Location	Distance from the Wilmot Dam (in miles)
SEWRPC	Fx-2	Sussex Creek at STH 164 NE ¼, Section 12, T7N, R19E	73.3
	Fx-3	Poplar Creek at Barker Road NE ¼, Section 30, T7N, R20E	68.0
	Fx-5	Pewaukee River at CTH SS NW ¼, Section 15, T7N, R19E	69.2
	Fx-6	Pewaukee River at STH 164 NE ¼, Section 26, T7N, R19E	64.3
	Fx-12	Mukwonago River at STH 83 NE ¼, Section 35, T5N, R18E	46.4
	Fx-15	Muskego Canal at Loomis Road NE ¼, Section 4, T4N, R20E	30.4
	Fx-16	Wind Lake Drainage Canal at STH 20 SW ¼, Section 1, T3N, R19E	25.3
	Fx-18	White River at Sheridan Springs Road SW ¼, Section 20, T2N, R18E	33.1
	Fx-19	Como Creek at CTH NN SE ¼, Section 23, T2N, R17E	35.2
	Fx-20	White River at STH 11 SE ¼, Section 25, T3N, R18E	19.7
	Fx-21	Honey Creek at Carver Road SW ¼, Section 22, T4N, R18E	32.9
	Fx-22	Sugar Creek at USH 12 SE ¼, Section 12, T3N, R16E	41.6
	Fx-23	Honey Creek at Spring Prairie Road NE ¼, Section 30, T3N, R19E	18.6
	Fx-25	Basset Creek at CTH F SE ¼, Section 15, T1N, R19E	10.1
	Fx-26	Basset Creek at CTH W NW ¼, Section 12, T1N, R19E	6.5
	Fx-28	Nippersink Creek at Darning Road SE ¼, Section 26, T1N, R18E	--[a]

[a] *Nippersink Creek cannot be measured from the Wilmot Dam since the confluence with the Fox River is located downstream of the point of reference in the State of Illinois.*

Source: SEWRPC.

the headwater area of the watershed, showed substandard dissolved oxygen concentrations in from four to six of the 13 water samples collected at each sampling location. At Bassett Creek three of the 11 water quality samples showed substandard levels of dissolved oxygen concentrations and at other locations on the tributaries of the Fox River, with the exception of the Muskego Canal, substandard dissolved oxygen concentrations were observed in at least one sample of the 12 water samples collected at each sampling location. At the Muskego Canal sampling station Fx-15, six of the 10 samples collected over a one-year period of 1964-1965 showed substandard levels of dissolved oxygen concentrations. The lower dissolved oxygen concentrations at sampling station Fx-15 on the Muskego Canal are likely due to the runoff from the agricultural land uses in the Muskego and Wind Lake Canal subwatersheds.

Total Coliform Bacteria: During the sample period of 1964-1965, membrane filter coliform counts were found to vary from less than 100 to as high as 160,000 MFCC/100 ml, with an average of 12,600 MFCC/100 ml in the Fox River main stem. High total coliform counts were found to exist at all sampling station locations on the Fox River main stem with the exceptions of sampling station Fx-1 in the headwater area and sampling station Fx-14 near the inlet to Tichigan Lake, where in only two of 13 samples were the total coliform counts greater than

Table 55

WATER QUALITY CONDITIONS OF THE FOX RIVER AND TRIBUTARIES: 1964-1965

Sampling Station	Parameter	Numerical Value Maximum	Numerical Value Average	Numerical Value Minimum	Number of Analyses
Fox River Main Stem Fx-1, Fx-4, Fx-7, Fx-8, Fx-9, Fx-10, Fx-11, Fx-13, Fx-14, Fx-17, Fx-24, and Fx-27	Chloride (mg/l)	445	50	5	23
	Dissolved Solids (mg/l)	1,210	510	295	23
	Dissolved Oxygen (mg/l)	19.0	9.6	0	66
	Coliform Count (MFCC/100 ml)	610,000	12,600	100	32
	Temperature (^{o}F)	80	50	32	67
Sussex Creek Fx-2	Chloride (mg/l)	70	60	40	3
	Dissolved Solids (mg/l)	650	590	535	3
	Dissolved Oxygen (mg/l)	12.2	7.7	4.3	12
	Coliform Count (MFCC/100 ml)	85,000	16,000	1,300	11
	Temperature (^{o}F)	70	48	32	11
Poplar Creek Fx-3	Chloride (mg/l)	50	35	20	3
	Dissolved Solids (mg/l)	765	615	480	3
	Dissolved Oxygen (mg/l)	12.1	5.9	0.1	13
	Coliform Count (MFCC/100 ml)	9,000	1,900	300	12
	Temperature (^{o}F)	73	47	32	12
Pewaukee River Fx-5, Fx-6	Chloride (mg/l)	120	65	30	17
	Dissolved Solids (mg/l)	755	520	350	14
	Dissolved Oxygen (mg/l)	12.6	7.3	0.7	27
	Coliform Count (MFCC/100 ml)	3,000,000	197,000	400	25
	Temperature (^{o}F)	74	48	32	25
Mukwonago River Fx-12	Chloride (mg/l)	15	5	0	13
	Dissolved Solids (mg/l)	400	285	240	13
	Dissolved Oxygen (mg/l)	16.5	11.6	9.3	13
	Coliform Count (MFCC/100 ml)	1,000	250	100	12
	Temperature (^{o}F)	77	49	35	12
Muskego Canal Fx-15	Chloride (mg/l)	35	35	35	2
	Dissolved Solids (mg/l)	1,420	1,030	635	2
	Dissolved Oxygen (mg/l)	14.3	6.2	0.8	10
	Coliform Count (MFCC/100 ml)	70,000	33,000	400	10
	Temperature (^{o}F)	72	52	32	10
Wind Lake Drainage Canal Fx-16	Chloride (mg/l)	35	35	30	2
	Dissolved Solids (mg/l)	635	565	495	2
	Dissolved Oxygen (mg/l)	16.0	10.2	4.1	11
	Coliform Count (MFCC/100 ml)	7,000	1,800	100	11
	Temperature (^{o}F)	76	53	32	11
White River Fx-18	Chloride (mg/l)	55	25	15	6
	Dissolved Solids (mg/l)	560	390	265	6
	Dissolved Oxygen (mg/l)	14.1	10.1	5.6	23
	Coliform Count (MFCC/100 ml)	570,000	28,000	400	23
	Temperature (^{o}F)	77	51	32	23
Como Creek Fx-19	Chloride (mg/l)	15	10	5	2
	Dissolved Solids (mg/l)	430	410	390	2
	Dissolved Oxygen (mg/l)	12.3	8.3	4.8	11
	Coliform Count (MFCC/100 ml)	21,000	7,200	300	11
	Temperature (^{o}F)	77	51	32	11

Table 55 (continued)

Sampling Station	Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Honey Creek Fx-21, Fx-23	Chloride (mg/l)	15	15	15	6
	Dissolved Solids (mg/l)	455	420	340	6
	Dissolved Oxygen (mg/l)	14.5	10.2	4.8	23
	Coliform Count (MFCC/100 ml)	40,000	9,400	100	23
	Temperature (^oF)	77	51	32	23
Sugar Creek Fx-22	Chloride (mg/l)	30	25	20	2
	Dissolved Solids (mg/l)	450	445	440	2
	Dissolved Oxygen (mg/l)	13.9	10.9	8.5	10
	Coliform Count (MFCC/100 ml)	13,000	3,100	100	10
	Temperature (^oF)	71	52	32	10
Bassett Creek Fx-25, Fx-26	Chloride (mg/l)	90	50	20	4
	Dissolved Solids (mg/l)	655	575	530	4
	Dissolved Oxygen (mg/l)	19.5	9.2	3.3	23
	Coliform Count (MFCC/100 ml)	250,000	32,000	200	23
	Temperature (^oF)	73	50	32	23
Nippersink Creek Fx-28	Chloride (mg/l)	30	25	20	2
	Dissolved Solids (mg/l)	455	455	450	2
	Dissolved Oxygen (mg/l)	21.6	12.3	8.8	11
	Coliform Count (MFCC/100 ml)	10,000	2,700	100	11
	Temperature (^oF)	77	52	32	11

Source: SEWRPC.

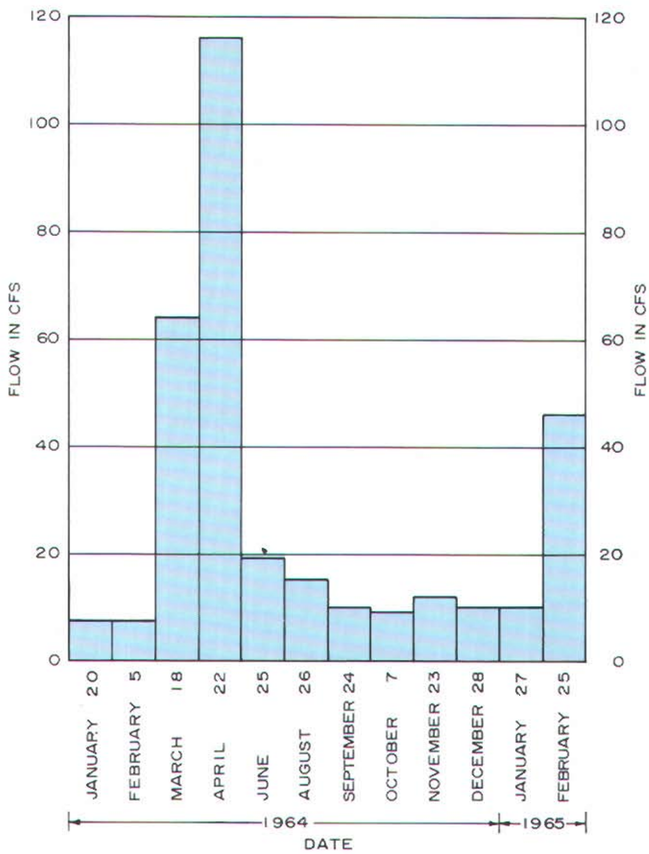
2,000 MFCC/100 ml. At sampling station Fx-10 on the Fox River main stem, located above the confluence with the Mukwonago River, six of the 13 samples showed total coliform counts greater than 2,000 MFCC/100 ml. At the remaining nine sampling locations on the Fox River main stem, the total coliform counts were greater than 2,000 MFCC/100 ml in from nine to 13 samples of the total 13 samples collected at each location.

Total coliform counts for samples collected from the Fox River tributaries were in the range of 100 to 3,000,000 counts/100 ml, with the sample results from station Fx-12 on the Mukwonago River exhibiting a range of from less than 100 to 500 MFCC/100 ml. The low total coliform counts observed in the Mukwonago River in all 13 samples collected during 1964-1965 indicates good water quality in the Mukwonago River at sampling station Fx-12. At sampling stations Fx-2 on Sussex Creek, Fx-5 on the Pewaukee River, Fx-18 on the White River, and Fx-25 on Bassett Creek the total coliform counts were found to range from 1,300 to 3,000,000 MFCC/100 ml. At sampling locations Fx-6 on the Pewaukee River, Fx-20 on the White River, and Fx-26 on Bassett Creek, the total coliform counts were found to range from less than 100 to 160,000 MFCC/100 ml. The high total coliform counts in the Pewaukee River at sampling station Fx-5 can be traced to the discharge of treated effluent from the sewage treatment facility at the Village of Pewaukee. The decreased total coliform counts at sampling station Fx-6 in the Pewaukee River located downstream from sampling station Fx-5 are likely to reflect natural die-off of the coliform bacteria with distance and time. Similarly, high total coliform counts in the White River at sampling station Fx-18 and in Bassett Creek at sampling station Fx-25 may be traced to the discharge of treated effluent from the sewage treatment facilities serving the City of Lake Geneva and the Village of Twin Lakes, respectively. These counts also decreased with distance as indicated in the total coliform counts at sampling station Fx-20 on the White River and sampling station Fx-26 on Bassett Creek. At other locations on the Fox River tributaries including Poplar Creek, Muskego Canal, Wind Lake Drainage Canal, Como Creek, Honey Creek, Sugar Creek, and Nippersink Creek, the total coliform counts were in the range of from less than 100 to 70,000 MFCC/100 ml. The occasional high total coliform counts at these sampling locations on the Fox River tributaries probably result from runoff from feed lots and wastes from wildlife discharged intermittently to the stream.

Specific Conductance: The specific conductance values of the Fox River stream system during the 1964-1965 sampling period were found to range from 500 to 2,000

Figure 22

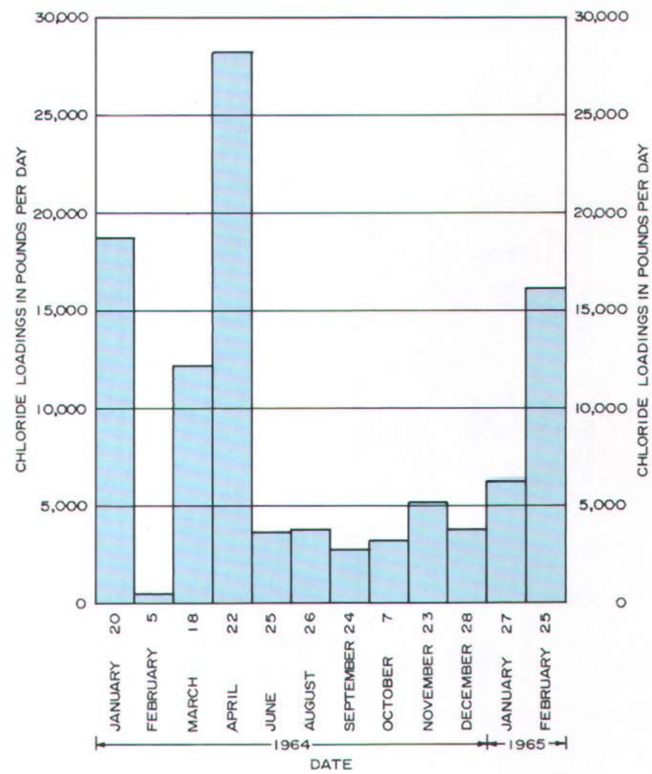
FLOW MEASUREMENTS AT THE FOX RIVER NEAR WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1965



Source: U. S. Geological Survey and SEWRPC.

Figure 23

CHLORIDE LOADINGS AT THE FOX RIVER NEAR WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1965



Source: SEWRPC.

µmhos/cm at 25° for the Fox River main stem and from 390 to 1,560 µmhos/cm at 25°C for the tributaries. The specific conductance remained high all through the year, indicating generally high dissolved solid concentrations in the streams of the watershed. The high dissolved solid concentrations in the Fox River stream system are to be expected since the River is fed by the groundwater which is high in total hardness and therefore contains high levels of dissolved solids.

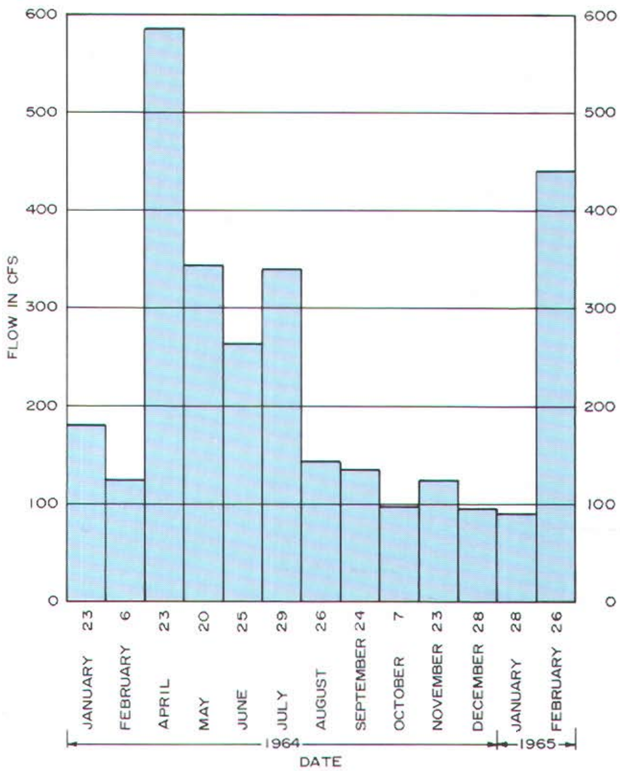
Hydrogen Ion Concentration (pH): The pH values of the water quality samples taken at all sampling stations in the Fox River watershed ranged from 7.1 to 8.8 standard units during the sampling year of 1964-1965. At no location within the watershed was the pH found to be outside the range of 6.0 to 9.0 standard units, prescribed for support of recreational uses, as well as for the maintenance of fish and aquatic life, the established water use objectives for the majority of the streams in the Fox River watershed.

Temperature: During the sample period of 1964-1965, the temperature of water samples from the Fox River and its tributaries ranged between 32°F and 66°F during the months of December through April and ranged between 32°F and 77°F during the months of May through November. The temperature variations, therefore, were mainly due to the seasonal change.

Biochemical Oxygen Demand: The range of five-day biochemical oxygen demand (BOD_5) in the water quality samples taken within the Fox River watershed during the sampling years 1964-1965 ranged from a low of 0.5 mg/l to a high of 21.3 mg/l at the 12 sampling stations. The BOD_5 values at the Fox River main stem sampling locations varied greatly over a 12-month sampling period with no trend apparent. The range of BOD_5 found at the Fox River tributary stations was from 0.4 to 32.8 mg/l during the sampling period of 1964 to 1965. High BOD_5 values, in the range of from 10.0 to 32.8 mg/l, were found at locations situated downstream from sewage treatment

Figure 24

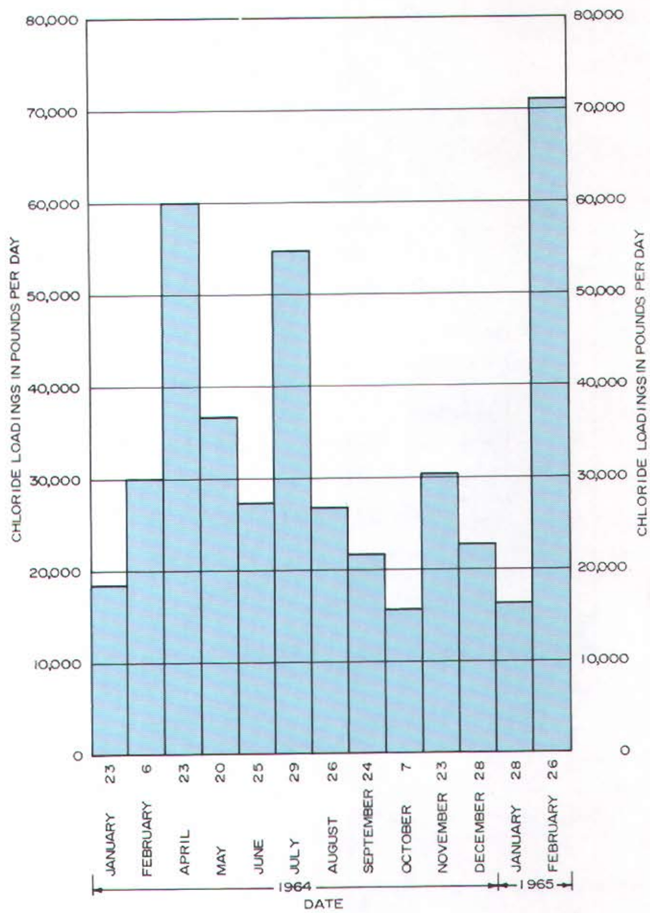
FLOW MEASUREMENTS AT THE FOX RIVER NEAR WILMOT (FX-27) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1965



Source: U. S. Geological Survey and SEWRPC.

Figure 25

COMPARISON OF CHLORIDE LOADINGS AND FLOW IN THE FOX RIVER AT WILMOT (FX-27) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1965



Source: SEWRPC.

facilities such as at sampling station Fx-5 downstream from theVillage of Pewaukee sewage treatment facility, at sampling station Fx-25 downstream from the Village of Twin Lakes sewage treatment facility, and at sampling station Fx-18 downstream from the City of Lake Geneva sewage treatment facility. In addition, high levels of BOD_5 were found at sampling station Fx-16 located in an agricultural area served with an extensive network of tile drainage systems. At sampling station Fx-16, the highest BOD_5 was found in January 1965, possibly indicating the effects of improper application of manure on frozen lands in the tributary drainage area.

Surface Water Quality of Lakes in the Fox River Watershed 1964-1965: No water quality data are available for the lakes in the Fox River watershed.

Water Quality Trends from 1965 to 1975: Water quality data for eight summer sampling programs, three spring sampling programs, and one fall sampling program from 1965 to 1975 are presented in tabular form in Appendix D to this report. The eight summer sampling surveys began in August 1968 and involved collection of samples on one day in August every year during low flow conditions.

Set forth in Table 56 is a summary of the results for specific conductance, hydrogen ion concentration (pH), dissolved oxygen, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen and organic-nitrogen, total phosphorus, chloride, and fecal coliform counts for each of the 28 stations sampled in the Fox River watershed by the Commission during the period 1968 through 1975. The stream flow data for the Fox River at Waukesha and at Wilmot, and for the Mukwonago River and the White River, tributaries of the Fox River, are obtained from records for the stream gaging station operated by the U. S. Geological Survey in cooperation with the Commission and the Counties. The available data for these four locations for the years 1964 through 1975 on the days water quality samples were collected are presented in Figures 26, 27, and 28.

Dissolved Oxygen: For the watershed as a whole, dissolved oxygen concentrations in the Fox River stream system during August for the period 1968 through 1975

Table 56

WATER QUALITY CONDITIONS IN THE FOX RIVER WATERSHED AT SAMPLING STATION FX 1-28: 1968-1975

Station Fx-1

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	62.0	45.9	19.8	22	--
Dissolved Oxygen (mg/l)	5.0	14.7	5.0	0.3	29	17[a]
Ammonia-N (mg/l)	2.5	0.24	0.13	0.04	8	0
Organic-N (mg/l)	--	1.47	1.07	0.51	8	--
Total-N (mg/l)	--	1.97	1.56	0.94	8	--
Specific Conductance (umhos/cm at 25°C)	--	860	758	686	30	--
Nitrite-N (mg/l)	--	0.06	0.03	0.01	12	--
Nitrate-N (mg/l)	0.30	0.51	0.31	0.18	12	6
Soluble Orthophosphate-P (mg/l)	--	0.21	0.08	0.04	12	--
Total Phosphorus (mg/l)	0.10	0.12	0.07	0.01	8	3
Fecal Coliform (MFFCC/100 ml)	400	1,100	385	10	12	5
Temperature (°F)	89.0	85.0	70.0	60.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.6	7.8	7.5	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-2

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	98.0	64.9	37.0	22	--
Dissolved Oxygen (mg/l)	2.0	13.7	7.1	4.4	29	0[a]
Ammonia-N (mg/l)	2.5	0.58	0.22	0.08	8	0
Organic-N (mg/l)	--	1.75	1.12	0.68	8	--
Total-N (mg/l)	--	5.09	3.95	2.56	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,036	825	360	29	--
Nitrite-N (mg/l)	--	0.33	0.17	0.05	12	--
Nitrate-N (mg/l)	0.30	3.23	2.55	0.99	12	12
Soluble Orthophosphate-P (mg/l)	--	1.23	0.65	0.12	12	--
Total Phosphorus (mg/l)	0.10	0.87	0.51	0.02	8	7
Fecal Coliform (MFFCC/100 ml)	2,000	2,500	809	10	12	1
Temperature (°F)	89.0	80.0	65.5	60.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.7	8.0	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-3

Parameter	Recommended Level/Standard	Numerical Value Maximum	Numerical Value Average	Numerical Value Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	89.0	62.7	21.3	22	--
Dissolved Oxygen (mg/l)	5.0	11.7	6.5	3.1	30	11[a]
Ammonia-N (mg/l)	2.5	0.23	0.11	0.03	8	0
Organic-N (mg/l)	--	1.13	0.90	0.54	8	--
Total-N (mg/l)	--	2.25	1.73	1.18	8	--
Specific Conductance (umhos/cm at 25^{o}C)	--	1,110	8.60	625	30	--
Nitrite-N (mg/l)	--	0.06	0.04	0.02	12	--
Nitrate-N (mg/l)	0.30	1.14	0.61	0.29	12	11
Soluble Orthophosphate-P (mg/l)	--	0.10	0.07	0.04	12	--
Total Phosphorus (mg/l)	0.10	0.24	0.10	0.01	8	4
Fecal Coliform (MFFCC/100 ml)	400	2,500	599	120	12	5
Temperature (^{o}F)	89.0	79.0	68.9	61.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.2	7.8	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-4

Parameter	Recommended Level/Standard	Numerical Value Maximum	Numerical Value Average	Numerical Value Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	153.0	116.1	35.7	22	--
Dissolved Oxygen (mg/l)	5.0	9.8	3.8	0.5	30	17[a]
Ammonia-N (mg/l)	2.5	0.96	0.46	0.16	8	0
Organic-N (mg/l)	--	1.92	1.35	0.83	8	--
Total-N (mg/l)	--	4.80	3.55	2.85	8	--
Specific Conductance (umhos/cm at 25^{o}C)	--	1,241	1,042	890	30	--
Nitrite-N (mg/l)	--	0.59	0.36	0.12	12	--
Nitrate-N (mg/l)	0.30	1.86	1.04	0.20	12	11
Soluble Orthophosphate-P (mg/l)	--	2.03	0.92	0.53	12	--
Total Phosphorus (mg/l)	0.10	1.38	0.76	0.32	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,500	366	60	12	3
Temperature (^{o}F)	89.0	79.0	71.3	65.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.2	7.7	7.5	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-5

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	153.0	54.6	14.3	22	--
Dissolved Oxygen (mg/l)	5.0	5.7	2.7	0.4	30	28[a]
Ammonia-N (mg/l)	2.5	2.09	1.34	0.49	8	0
Organic-N (mg/l)	--	2.67	1.76	1.27	8	--
Total-N (mg/l)	--	5.72	4.00	2.34	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,224	638	324	30	--
Nitrite-N (mg/l)	--	0.24	0.11	0.02	12	--
Nitrate-N (mg/l)	0.30	1.32	0.57	0.14	12	8
Soluble Orthophosphate-P (mg/l)	--	1.83	0.71	0.08	12	--
Total Phosphorus (mg/l)	0.10	1.23	0.90	0.50	8	8
Fecal Coliform (MFFCC/100 ml)	400	20,000	5,253	170	12	11
Temperature (°F)	89.0	81.0	73.1	66.0	30	0
Hydrogen Ion Concentrations— Standard Units	6-9	8.5	7.7	7.5	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-6

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	70.0	49.5	18.8	22	--
Dissolved Oxygen (mg/l)	5.0	7.8	5.6	4.1	30	12[a]
Ammonia-N (mg/l)	2.5	0.24	0.12	0.03	8	0
Organic-N (mg/l)	--	2.02	1.13	0.60	8	--
Total-N (mg/l)	--	2.77	2.23	1.80	8	--
Specific Conductance (umhos/cm at 25°C)	--	801	652	545	30	--
Nitrite-N (mg/l)	--	0.16	0.09	0.03	12	--
Nitrate-N (mg/l)	0.30	1.20	0.77	0.20	12	11
Soluble Orthophosphate-P (mg/l)	--	1.77	0.65	0.29	12	--
Total Phosphorus (mg/l)	0.10	1.06	0.56	0.32	8	8
Fecal Coliform (MFFCC/100 ml)	400	3,400	587	1.20	12	3
Temperature (°F)	89.0	81.0	71.4	65.5	30	0
Hydrogen Ion Concentrations— Standard Units	6-9	8.2	7.8	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-7

Parameter	Recommended Level/Standard	Numerical Value Maximum	Average	Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	103.0	79.3	28.7	22	--
Dissolved Oxygen (mg/l)	5.0	15.3	7.9	5.0	30	1[a]
Ammonia-N (mg/l)	2.5	0.15	0.08	0.03	8	0
Organic-N (mg/l)	--	1.52	1.08	0.75	8	--
Total-N (mg/l)	--	3.60	2.56	1.99	8	--
Specific Conductance (umhos/cm at 25°C)	--	991	820	327	30	--
Nitrite-N (mg/l)	--	0.16	0.05	0.02	12	--
Nitrate-N (mg/l)	0.30	2.60	1.10	0.46	12	0
Soluble Orthophosphate-P (mg/l)	--	0.73	0.43	0.25	12	--
Total Phosphorus (mg/l)	0.10	0.64	0.39	0.07	8	7
Fecal Coliform (MFFCC/100 ml)	400	7,300	1,343	70	12	5
Temperature (°F)	89.0	81.0	72.8	67.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	88	8.2	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-8

Parameter	Recommended Level/Standard	Numerical Value Maximum	Average	Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	168.0	103.2	42.7	22	--
Dissolved Oxygen (mg/l)	5.0	7.2	14.8	4.0	30	9[a]
Ammonia-N (mg/l)	2.5	1.11	0.46	0.15	8	0
Organic-N (mg/l)	--	1.69	1.38	0.89	8	--
Total-N (mg/l)	--	6.47	5.01	2.71	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,213	930	560	30	--
Nitrite-N (mg/l)	--	0.20	0.10	0.05	12	--
Nitrate-N (mg/l)	0.30	4.23	2.79	1.21	12	12
Soluble Orthophosphate-P (mg/l)	--	1.73	1.06	0.18	12	--
Total Phosphorus (mg/l)	0.10	1.41	1.04	0.78	8	8
Fecal Coliform (MFFCC/100 ml)	400	3,400	420	5.0	12	2
Temperature (°F)	89.0	82.0	72.3	67.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.6	8.0	7.8	8	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-9

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	123.0	88.1	46.1	22	--
Dissolved Oxygen (mg/l)	5.0	15.5	7.5	2.1	30	7[a]
Ammonia-N (mg/l)	2.5	0.46	0.19	0.06	8	0
Organic-N (mg/l)	--	1.77	1.23	0.72	8	--
Total-N (mg/l)	--	5.75	4.43	3.14	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,065	879	585	30	--
Nitrite-N (mg/l)	--	0.22	0.12	0.08	12	--
Nitrate-N (mg/l)	0.30	4.39	2.76	0.99	12	12
Soluble Orthophosphate-P (mg/l)	--	2.01	1.14	0.79	12	--
Total Phosphorus (mg/l)	0.10	1.20	0.95	0.78	8	8
Fecal Coliform (MFFCC/100 ml)	400	9,700	1,665	10	12	3
Temperature (°F)	89.0	80.0	72.4	66.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.7	8.0	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-10

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	98.0	79.3	49.6	22	--
Dissolved Oxygen (mg/l)	5.0	15.9	8.2	3.6	30	1[a]
Ammonia-N (mg/l)	2.5	0.77	0.24	0.03	8	0
Organic-N (mg/l)	--	15.08	2.98	0.92	8	--
Total-N (mg/l)	--	19.07	5.92	3.33	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,011	845	640	30	--
Nitrite-N (mg/l)	--	0.21	0.10	0.05	12	--
Nitrate-N (mg/l)	0.30	3.10	2.38	1.28	12	12
Soluble Orthophosphate-P (mg/l)	--	1.43	0.84	0.54	12	--
Total Phosphorus (mg/l)	0.10	0.85	0.76	0.62	8	8
Fecal Coliform (MFFCC/100 ml)	400	2,900	475	60	12	2
Temperature (°F)	89.0	82.0	73.5	67.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.8	8.2	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-11

Parameter	Recommended Level/Standard	Numerical Value Maximum	Average	Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	145.0	78.6	38.0	22	--
Dissolved Oxygen (mg/l)	5.0	16.6	8.1	0.6	30	6[a]
Ammonia-N (mg/l)	2.5	0.47	0.14	0.03	8	0
Organic-N (mg/l)	--	2.47	1.30	0.79	8	--
Total-N (mg/l)	--	4.32	3.32	2.19	8	--
Specific Conductance (umhos/cm at 25°C)	--	972	820	600	30	--
Nitrite-N (mg/l)	--	0.15	0.08	0.03	12	--
Nitrate-N (mg/l)	0.30	2.32	1.45	0.40	12	12
Soluble Orthophosphate-P (mg/l)	--	1.17	0.75	0.40	12	--
Total Phosphorus (mg/l)	0.10	0.87	0.68	0.39	8	8
Fecal Coliform (MFFCC/100 ml)	400	500	180	20	12	2
Temperature (°F)	89.0	85.0	74.8	67.5	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.7	8.3	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-12

Parameter	Recommended Level/Standard	Numerical Value Maximum	Average	Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	20.0	10.1	6.09	22	--
Dissolved Oxygen (mg/l)	5.0	10.0	8.1	6.6	30	0[a]
Ammonia-N (mg/l)	2.5	0.17	0.07	0.03	8	0
Organic-N (mg/l)	--	0.96	0.74	0.52	8	--
Total-N (mg/l)	--	1.20	0.89	0.63	8	--
Specific Conductance (umhos/cm at 25°C)	--	464	418	365	30	--
Nitrite-N (mg/l)	--	0.01	0.00	0.00	12	--
Nitrate-N (mg/l)	0.30	0.25	0.09	0.04	12	0
Soluble Orthophosphate-P (mg/l)	--	0.04	0.02	0.01	11	--
Total Phosphorus (mg/l)	0.10	0.08	0.04	0.01	8	0
Fecal Coliform (MFFCC/100 ml)	400	90	33	10	12	--
Temperature (°F)	89.0	85.0	75.8	67.5	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.8	8.4	8.0	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-13

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	81.0	58.3	29.2	22	--
Dissolved Oxygen (mg/l)	5.0	18.1	8.7	2.3	30	3[a]
Ammonia-N (mg/l)	2.5	0.15	0.06	0.03	8	0
Organic-N (mg/l)	--	1.56	1.09	0.74	8	--
Total-N (mg/l)	--	2.90	2.27	1.89	8	--
Specific Conductance (umhos/cm at 25°C)	--	800	707	616	30	--
Nitrite-N (mg/l)	--	0.08	0.05	0.02	12	--
Nitrate-N (mg/l)	0.30	1.64	0.92	0.30	12	11
Soluble Orthophosphate-P (mg/l)	--	0.70	0.46	0.01	12	--
Total Phosphorus (mg/l)	0.10	0.63	0.44	0.22	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,100	201	20	12	1
Temperature (°F)	89.0	85.0	75.4	68.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.9	8.3	7.5	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-14

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	72.0	58.2	31.2	22	--
Dissolved Oxygen (mg/l)	5.0	24.3	9.1	4.0	30	5[a]
Ammonia-N (mg/l)	2.5	0.26	0.10	0.03	8	0
Organic-N (mg/l)	--	2.34	1.22	0.75	8	--
Total-N (mg/l)	--	3.64	2.36	1.73	8	--
Specific Conductance (umhos/cm at 25°C)	--	767	709	610	30	--
Nitrite-N (mg/l)	--	0.08	0.05	0.02	12	--
Nitrate-N (mg/l)	0.30	1.29	0.78	0.10	12	10
Soluble Orthophosphate-P (mg/l)	--	1.23	0.48	0.32	12	--
Total Phosphorus (mg/l)	0.10	0.55	0.41	0.27	8	8
Fecal Coliform (MFFCC/100 ml)	400	900	100	10	12	1
Temperature (°F)	89.0	87.5	75.1	66.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	9.2	8.5	7.9	22	3

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-15

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	56.0	33.8	19.0	22	--
Dissolved Oxygen (mg/l)	5.0	12.4	5.6	1.4	30	17[a]
Ammonia-N (mg/l)	2.5	0.18	0.08	0.03	8	0
Organic-N (mg/l)	--	3.25	2.28	0.70	8	--
Total-N (mg/l)	--	3.54	2.55	0.84	8	--
Specific Conductance (umhos/cm at 25°C)	--	746	580	446	30	--
Nitrite-N (mg/l)	--	0.04	0.02	0.01	12	--
Nitrate-N (mg/l)	0.30	0.40	0.23	0.15	12	2
Soluble Orthophosphate-P (mg/l)	--	0.11	0.06	0.02	12	--
Total Phosphorus (mg/l)	0.10	0.17	0.13	0.07	8	5
Fecal Coliform (MFFCC/100 ml)	400	4,700	658	--	12	4
Temperature (°F)	89.0	85.0	72.2	64.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	9.2	8.0	7.0	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-16

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
Chloride (mg/l)	--	54.0	39.3	13.6	22	--
Dissolved Oxygen (mg/l)	5.0	11.1	6.2	1.6	30	9[a]
Ammonia-N (mg/l)	2.5	0.21	0.11	0.03	7	0
Organic-N (mg/l)	--	3.20	1.76	0.92	8	--
Total-N (mg/l)	--	6.03	2.63	1.05	8	--
Specific Conductance (umhos/cm at 25°C)	--	842	687	119	30	--
Nitrite-N (mg/l)	--	0.08	0.03	0.01	12	--
Nitrate-N (mg/l)	0.30	2.57	0.79	0.04	12	5
Soluble Orthophosphate-P (mg/l)	--	0.27	0.16	0.08	12	--
Total Phosphorus (mg/l)	0.10	0.24	0.19	0.09	8	7
Fecal Coliform (MFFCC/100 ml)	400	60,000	5,464	30	12	4
Temperature (°F)	89.0	84.0	74.4	64.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.8	8.1	7.2	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-17

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	111.0	58.8	30.7	22	--
Dissolved Oxygen (mg/l)	5.0	15.8	7.8	2.3	30	9[a]
Ammonia-N (mg/l)	2.5	0.38	0.19	0.03	7	0
Organic-N (mg/l)	--	2.87	1.70	1.05	8	--
Total-N (mg/l)	--	4.95	2.48	1.10	8	--
Specific Conductance (umhos/cm at 25°C)	--	990	713	584	30	--
Nitrite-N (mg/l)	--	0.34	0.06	0.01	12	--
Nitrate-N (mg/l)	0.30	1.86	0.60	0.08	12	6
Soluble Orthophosphate-P (mg/l)	--	2.51	0.65	0.11	12	--
Total Phosphorus (mg/l)	0.10	0.52	0.35	0.12	8	8
Fecal Coliform (MFFCC/100 ml)	400	420,000	35,471	10	12	5
Temperature (°F)	89.0	83.0	75.3	66.5	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	9.2	8.4	7.7	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-18

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	56.0	40.6	21.0	22	--
Dissolved Oxygen (mg/l)	5.0	17.0	8.0	3.3	30	5[a]
Ammonia-N (mg/l)	2.5	0.32	0.17	0.06	7	0
Organic-N (mg/l)	--	1.05	0.77	0.47	8	--
Total-N (mg/l)	--	3.46	1.96	1.37	8	--
Specific Conductance (umhos/cm at 25°C)	--	842	616	422	30	--
Nitrite-N (mg/l)	--	0.25	0.10	0.03	12	--
Nitrate-N (mg/l)	0.30	2.37	1.15	0.48	12	12
Soluble Orthophosphate-P (mg/l)	--	1.44	0.56	0.26	12	--
Total Phosphorus (mg/l)	0.10	0.57	0.40	0.29	8	8
Fecal Coliform (MFFCC/100 ml)	400	4,800	910	10	12	5
Temperature (°F)	89.0	82.5	72.3	61.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.7	8.2	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-19

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	37.0	20.6	12.0	23	--
Dissolved Oxygen (mg/l)	5.0	10.8	5.9	2.6	31	12[a]
Ammonia-N (mg/l)	2.5	0.19	0.10	0.03	9	0
Organic-N (mg/l)	--	1.30	0.86	0.12	9	--
Total-N (mg/l)	--	1.95	1.40	0.78	9	--
Specific Conductance (umhos/cm at 25°C)	--	950	558	440	31	--
Nitrite-N (mg/l)	--	0.05	0.02	0.01	13	--
Nitrate-N (mg/l)	0.30	0.59	0.40	0.27	13	10
Soluble Orthophosphate-P (mg/l)	--	0.19	0.09	0.03	13	--
Total Phosphorus (mg/l)	0.10	0.23	0.15	0.05	9	6
Fecal Coliform (MFFCC/100 ml)	400	5,400	1,586	80	13	5
Temperature (°F)	89.0	84.0	71.8	61.0	31	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.5	8.0	7.7	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-20

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	31.0	22.7	11.8	22	--
Dissolved Oxygen (mg/l)	5.0	14.2	8.0	4.9	30	1[a]
Ammonia-N (mg/l)	2.5	0.11	0.06	0.03	8	0
Organic-N (mg/l)	--	2.10	0.98	0.38	8	--
Total-N (mg/l)	--	3.12	2.23	1.25	8	--
Specific Conductance (umhos/cm at 25°C)	--	651	598	528	30	--
Nitrite-N (mg/l)	--	0.03	0.02	0.01	12	--
Nitrate-N (mg/l)	0.30	1.59	1.05	0.54	12	12
Soluble Orthophosphate-P (mg/l)	--	0.30	0.17	0.11	12	--
Total Phosphorus (mg/l)	0.10	0.25	0.20	0.15	8	8
Fecal Coliform (MFFCC/100 ml)	400	2,500	913	10	12	9
Temperature (°F)	89.0	86.0	73.7	64.5	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.6	8.3	7.9	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-21

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	17.0	12.6	5.0	22	--
Dissolved Oxygen (mg/l)	5.0	11.2	6.8	2.8	30	4[a]
Ammonia-N (mg/l)	2.5	0.34	0.17	0.03	8	0
Organic-N (mg/l)	--	1.36	1.05	0.63	8	--
Total-N (mg/l)	--	4.75	3.86	2.77	8	--
Specific Conductance (umhos/cm at 25°C)	--	727	614	525	30	--
Nitrite-N (mg/l)	--	0.14	0.06	0.02	12	--
Nitrate-N (mg/l)	0.30	5.52	2.63	0.88	12	12
Soluble Orthophosphate-P (mg/l)	--	0.317	0.17	0.09	12	--
Total Phosphorus (mg/l)	0.10	0.35	0.22	0.13	8	8
Fecal Coliform (MFFCC/100 ml)	400	7,100	2,652	100	11	10
Temperature (°F)	89.0	84.0	73.7	66.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.4	7.9	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-22

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	34.0	21.4	13.0	22	--
Dissolved Oxygen (mg/l)	5.0	13.0	8.4	5.1	30	0[a]
Ammonia-N (mg/l)	2.5	1.04	0.19	0.03	7	0
Organic-N (mg/l)	--	1.62	0.83	0.30	8	--
Total-N (mg/l)	--	5.99	3.67	1.70	8	--
Specific Conductance (umhos/cm at 25°C)	--	797	688	583	30	--
Nitrite-N (mg/l)	--	0.14	0.05	0.01	12	--
Nitrate-N (mg/l)	0.30	3.14	2.20	0.57	12	12
Soluble Orthophosphate-P (mg/l)	--	0.26	0.10	0.03	12	--
Total Phosphorus (mg/l)	0.10	0.40	0.17	0.04	8	5
Fecal Coliform (MFFCC/100 ml)	400	100,000	8,907	40	12	7
Temperature (°F)	89.0	76.0	66.7	57.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.4	8.1	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-23

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	18.0	14.4	12.0	22	--
Dissolved Oxygen (mg/l)	5.0	10.5	7.1	4.8	29	2[a]
Ammonia-N (mg/l)	2.5	0.15	0.08	0.03	8	0
Organic-N (mg/l)	--	2.28	1.18	0.70	8	--
Total-N (mg/l)	--	4.77	3.82	2.78	8	--
Specific Conductance (umhos/cm at 25°C)	--	732	637	578	30	--
Nitrite-N (mg/l)	--	0.06	0.04	0.02	12	--
Nitrate-N (mg/l)	--	3.45	2.01	0.23	12	11
Soluble Orthophosphate-P (mg/l)	--	0.30	0.12	0.06	12	--
Total Phosphorus (mg/l)	0.10	0.23	0.18	0.11	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,500	477	160	12	6
Temperature (°F)	89.0	82.0	72.7	64.0	30	0
Hydrogen Ion Concentrations— Standard Units	6-9	8.3	8.0	7.9	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-24

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	52.0	35.6	14.0	22	--
Dissolved Oxygen (mg/l)	5.0	26.8	9.3	4.2	30	2[a]
Ammonia-N (mg/l)	2.5	0.19	0.10	0.03	7	0
Organic-N (mg/l)	--	2.69	1.50	0.95	8	--
Total-N (mg/l)	--	4.36	2.62	1.28	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,384	677	563	30	--
Nitrite-N (mg/l)	--	0.05	0.03	0.02	12	--
Nitrate-N (mg/l)	0.30	1.52	0.86	0.29	12	10
Soluble Orthophosphate-P (mg/l)	--	0.90	0.28	0.1	12	--
Total Phosphorus (mg/l)	0.10	0.88	0.28	0.11	8	8
Fecal Coliform (MFFCC/100 ml)	400	15,000	2,511	50	12	8
Temperature (°F)	89.0	86.0	75.1	66.0	30	0
Hydrogen Ion Concentrations— Standard Units	6-9	9.0	8.4	7.9	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-25

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	200.0	83.8	36.0	22	--
Dissolved Oxygen (mg/l)	5.0	8.1	4.8	1.2	30	14[a]
Ammonia-N (mg/l)	2.5	5.83	1.18	0.03	8	0
Organic-N (mg/l)	--	6.88	2.05	0.60	8	--
Total-N (mg/l)	--	13.76	4.34	1.72	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,516	905	590	30	--
Nitrite-N (mg/l)	--	0.40	0.10	0.02	12	--
Nitrate-N (mg/l)	0.30	1.42	0.83	0.20	12	10
Soluble Orthophosphate-P (mg/l)	--	7.27	1.84	0.15	12	--
Total Phosphorus (mg/l)	0.10	2.35	0.83	0.04	8	7
Fecal Coliform (MFFCC/100 ml)	400	260,000	55,264	230	12	11
Temperature (°F)	89.0	82.0	71.0	62.0	30	0
Hydrogen Ion Concentrations— Standard Units	6-9	9.1	8.1	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-26

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	245.0	72.3	27.0	22	--
Dissolved Oxygen (mg/l)	5.0	15.0	7.2	3.2	30	6[a]
Ammonia-N (mg/l)	2.5	0.68	0.22	0.03	8	0
Organic-N (mg/l)	--	6.65	2.08	0.77	8	--
Total-N (mg/l)	--	9.26	3.39	1.36	8	--
Specific Conductance (umhos/cm at 25°C)	--	971	808	530	30	--
Nitrite-N (mg/l)	--	0.47	0.13	0.03	12	--
Nitrate-N (mg/l)	0.30	1.84	1.13	0.50	12	12
Soluble Orthophosphate-P (mg/l)	--	3.17	1.15	0.24	12	--
Total Phosphorus (mg/l)	0.10	0.90	0.50	0.07	8	7
Fecal Coliform (MFFCC/100 ml)	400	1,500	690	100	12	7
Temperature (°F)	89.0	88.0	72.6	61.0	30	0
Hydrogen Ion Concentrations— Standard Units	6-9	8.6	8.0	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56 (continued)

Station Fx-27

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	80.0	39.9	20.0	22	--
Dissolved Oxygen (mg/l)	5.0	18.5	10.5	1.6	30	4[a]
Ammonia-N (mg/l)	2.5	0.17	0.08	0.03	8	0
Organic-N (mg/l)	--	2.85	1.54	0.97	8	--
Total-N (mg/l)	--	4.47	2.50	1.34	8	--
Specific Conductance (umhos/cm at 25°C)	--	945	650	506	30	--
Nitrite-N (mg/l)	--	0.04	0.03	0.01	12	--
Nitrate-N (mg/l)	0.30	1.49	0.68	0.19	12	8
Soluble Orthophosphate-P (mg/l)	--	0.47	0.20	0.09	12	--
Total Phosphorus (mg/l)	0.10	0.33	0.25	0.07	8	7
Fecal Coliform (MFFCC/100 ml)	400	1,500	300	10	12	2
Temperature (°F)	89.0	87.0	75.0	65.5	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	9.0	8.4	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Station Fx-28

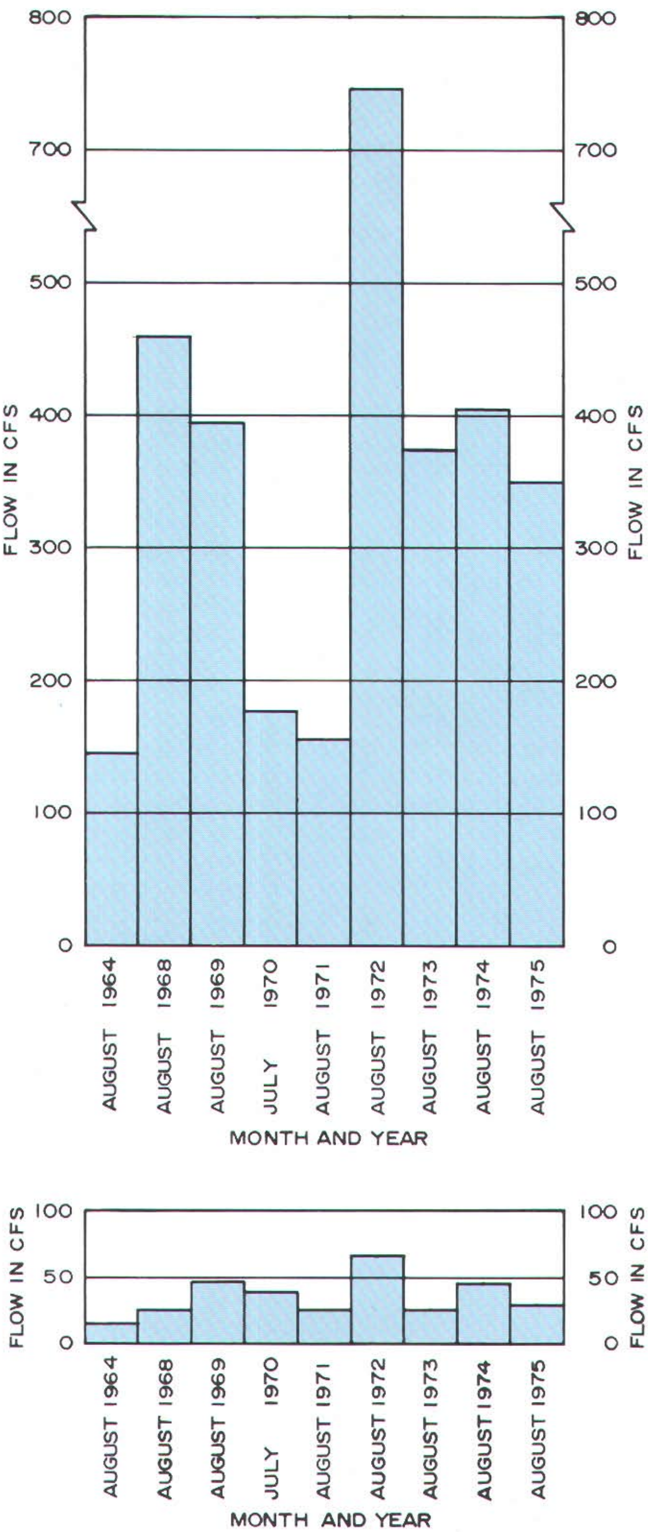
Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standards Were Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	29.0	19.5	11.0	22	--
Dissolved Oxygen (mg/l)	5.0	13.4	8.7	5.2	30	0[a]
Ammonia-N (mg/l)	2.5	0.16	0.07	0.03	8	0
Organic-N (mg/l)	--	1.19	0.87	0.58	8	--
Total-N (mg/l)	--	4.57	3.57	2.54	8	--
Specific Conductance (umhos/cm at 25°C)	--	743	662	553	30	--
Nitrite-N (mg/l)	--	0.10	0.05	0.02	12	--
Nitrate-N (mg/l)	0.30	3.57	2.15	0.75	12	12
Soluble Orthophosphate-P (mg/l)	--	0.13	0.07	0.03	12	--
Total Phosphorus (mg/l)	0.10	0.31	0.12	0.05	8	4
Fecal Coliform (MFFCC/100 ml)	400	6,300	1,113	10	12	6
Temperature (°F)	89.0	82.0	70.3	60.0	30	0
Hydrogen Ion Concentrations—Standard Units	6-9	8.6	8.1	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Figure 26

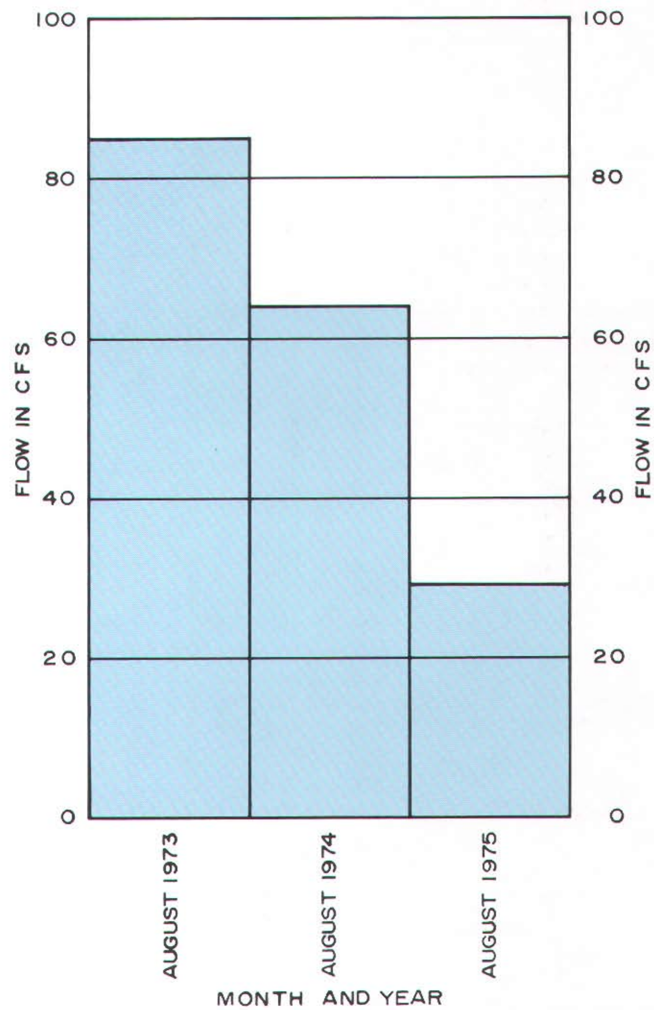
FLOW MEASUREMENTS AT THE FOX RIVER NEAR WILMOT (FX-27) AND WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1975



Source: U. S. Geological Survey and SEWRPC.

Figure 27

FLOW MEASUREMENTS AT THE MUKWONAGO RIVER (FX-12) ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975

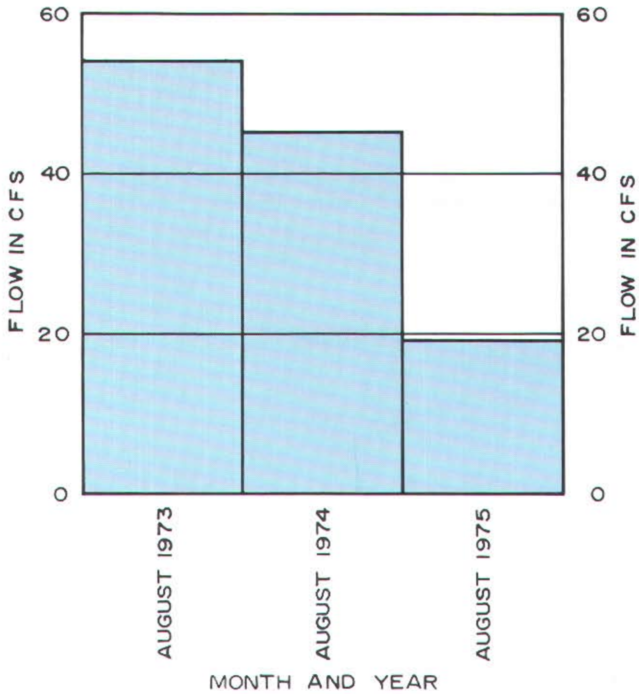


Source: U. S. Geological Survey and SEWRPC.

were found to range from 0.3 to 26.8 mg/l. The average dissolved oxygen concentrations for the eight-year period were in the range of 3.8 to 14.8 mg/l for the stations on the main stem of the Fox River. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l for most sampling stations, the dissolved oxygen concentrations were found to be lower than 5.0 mg/l at some time or another during the period of 1968 through 1975 at all the stations on the Fox River itself. At sampling station Fx-1, the daily average dissolved oxygen concentrations were well below 5 mg/l during all eight sampling periods. Water samples collected at sampling stations Fx-4, Fx-8, and Fx-11 exhibited less than 5.0 mg/l daily average dissolved oxygen concentrations during seven, five, and five of the eight sampling periods, respectively. The daily average concentrations of dissolved oxygen were found to be lower than 5.0 mg/l in samples

Figure 28

FLOW MEASUREMENTS AT THE WHITE RIVER (FX-20) ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975



Source: U. S. Geological Survey and SEWRPC.

collected at sampling stations Fx-9, Fx-13, Fx-14, and Fx-17 during three of eight sampling periods. At sampling stations Fx-10, Fx-24, and Fx-27 one sample each exhibited dissolved oxygen concentrations of less than 5.0 mg/l. At sampling station Fx-7 located upstream from the City of Waukesha sewage treatment plant the dissolved oxygen levels were higher than 5.0 mg/l in all the samples.

Among the tributaries of the Fox River, Sussex Creek, the Mukwonago River, Sugar Creek and Nippersink Creek exhibited dissolved oxygen concentrations greater than the standard of 5.0 mg/l in all of the 30 water samples collected at each location during the eight sampling surveys. Substandard dissolved oxygen levels were observed in all of the remaining tributary water samples at one time or another during the eight sampling surveys. At sampling stations Fx-18 and Fx-20 on the White River and at stations Fx-21 and Fx-23 on Honey Creek, the dissolved oxygen concentrations were found to be less than 5.0 mg/l in at least one but less than six of the 30 water samples collected at each location during the eight sampling surveys. The water samples collected from Como Creek and Poplar Creek were found to have had less than 5.0 mg/l of dissolved oxygen in 10 of the 30 water samples collected at each location during the eight sampling surveys. At sampling station Fx-5 on the Pewaukee River located downstream from the effluent discharge point of the Village of Pewaukee sewage treatment plant; at sampling station Fx-25 on Bassett Creek located downstream from the effluent discharge point from the Village of Twin Lakes sewage treatment plant; and at sampling station Fx-15 on the Muskego Canal which drains an active farming area, the dissolved oxygen levels were found to be lower than 5.0 mg/l in at least 14 but no more than 28 samples of the 30 water samples collected at each location during the eight-year sampling surveys. At sampling station Fx-26 on Bassett Creek located about four miles downstream from the station Fx-25 on Bassett Creek, only six of the 30 water samples exhibited substandard dissolved oxygen concentrations as compared to 14 samples at station Fx-25. Improved dissolved oxygen conditions were also found at sampling station Fx-6 on the Pewaukee River located about five miles downstream from station Fx-5 on the Pewaukee River.

Map 15 shows the dissolved oxygen concentrations found in August 1964 and in August 1975 in the streams of the Fox River watershed. The graph insert illustrates the change in the dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at each location. On August 26 and 27, 1964, as indicated on the map, substandard dissolved oxygen levels were observed at sampling stations Fx-1 and Fx-4 on the main stem of the Fox River in the headwater area. The daily average concentration of dissolved oxygen increased to above the minimum standard of 5.0 mg/l at sampling station Fx-7 and remained high at all the other Fox River main stem sampling stations downstream. Among the tributaries of the Fox River, substandard dissolved oxygen levels were observed in Como Creek at sampling station Fx-19; the Muskego Canal at sampling station Fx-15; and in Bassett Creek at sampling station Fx-25 during the August 1964 sampling survey. The water samples collected at the other tributaries, Sussex Creek, Poplar Creek, Pewaukee River, Mukwonago River, Wind Lake Drainage Canal, White River, Honey Creek, Sugar Creek, and Nippersink Creek all exhibited the daily average dissolved oxygen concentrations greater than 5.0 mg/l.

In the samples collected on August 18-21, 1975, at sampling station Fx-1 on the Fox River itself, substandard dissolved oxygen concentrations were observed. The concentration improved to above the required standard at sampling station Fx-4 and remained higher than 5.0 mg/l at all the other Fox River main stem sampling stations. Among the tributaries of the Fox River, substandard dissolved oxygen concentrations were observed at sampling station Fx-5 on the Pewaukee River, below which the water quality improved to above the minimum standard of 5.0 mg/l at sampling station Fx-6 located downstream from sampling station Fx-5. The daily average dissolved oxygen concentrations of other tributaries—Sussex Creek, Poplar Creek, Mukwonago River, Muskego Canal, Wind Lake Drainage Canal, White River, Como Creek, Honey Creek, Sugar Creek, Bassett Creek, and Nippersink Creek—were all found to be greater than 5.0 mg/l.

The graph inserts on Map 15 present the dissolved oxygen concentrations and the three-year moving averages at stations Fx-1 through Fx-28 for the August samples of 1964 through 1975. Water quality conditions as measured by the dissolved oxygen concentrations were found to be improved over the past decade at all but four Fox River sampling stations—Fx-1, Fx-7, Fx-8, and Fx-14—where the concentrations of dissolved oxygen were found to have decreased slightly. The increasing trend in the dissolved oxygen concentrations over the past decade at all but four of the Commission sampling stations located on the main stem of the Fox River is considered reliable evidence of improved water quality conditions and probably reflects generally improved municipal sewage treatment in the watershed. At the main stem headwater station, Fx-1, the daily average dissolved oxygen concentrations showed a decrease over the past four years in the water samples collected in August of each year. Increased urbanization and associated erosion from new construction areas as well as urban area runoff and effluent from malfunctioning septic tank systems in the tributary area are possible causes of the decrease in the dissolved oxygen concentrations at this location. Similar variations were found in the dissolved oxygen concentration over the past decade in the samples collected at stations Fx-9 and Fx-10. This is a good indication that the pollutants that decrease the dissolved oxygen concentrations—that is, organic and inorganic oxygen-demanding materials—are introduced upstream from station Fx-9. At sampling stations Fx-11, Fx-13, and Fx-14, a similar trend in variation in the dissolved oxygen levels was observed, indicating the sources of oxygen-demanding substances to be upstream from sampling station Fx-11. The variations in the dissolved oxygen concentrations for the years 1971 through 1975 at stations Fx-17 and Fx-24 were also similar, except for the sample results from 1968.

Among the tributaries of the Fox River, the water samples collected at stations Fx-2 on Sussex Creek and station Fx-3 on Poplar Creek exhibited increased daily average dissolved oxygen concentrations over the past decade. The increased daily average dissolved oxygen concentrations in Sussex Creek and Poplar Creek apparently influenced the water quality at sampling station Fx-4 on the main stem of the Fox River downstream from the confluence of Sussex Creek and Poplar Creek, at which similar patterns in the levels of the daily average dissolved oxygen concentrations were exhibited over the past decade. The water quality of the Pewaukee River as measured by the daily average dissolved oxygen concentrations at sampling stations Fx-5 and Fx-6 remained the same over the past decade. The daily averages of dissolved oxygen concentrations during August in the Muskego Canal at sampling station Fx-15 and in the Wind Lake Drainage Canal at sampling station Fx-16 showed improvement over the past decade.

A comparison of the trends in daily average dissolved oxygen at stations Fx-14 and Fx-17 on the Fox River main stem and at station Fx-16 on the Wind Lake Drainage Canal, which joins the Fox River between the two sampling stations Fx-14 and Fx-17, indicates that the dissolved oxygen concentrations at the downstream sampling station Fx-17 remained higher than at sampling station Fx-14 upstream on the main stem, or at the sampling station Fx-16 located on the Wind Lake Drainage Canal. At sampling station Fx-19, on Como Creek, no change was observed in the daily average dissolved oxygen concentrations over the past decade.

The daily average dissolved oxygen concentrations at the sampling stations on the Mukwonago River (Fx-12), the White River (Fx-20), Sugar Creek (Fx-22), Honey Creek (Fx-23), and Nippersink Creek (Fx-28) remained at or near saturation levels in all samples collected over the past decade, indicating a stable and relatively higher water quality in these rivers as measured by the dissolved oxygen contents. The daily average dissolved oxygen concentrations at sampling station Fx-25 on Bassett Creek, downstream from the Village of Twin Lakes sewage treatment facility, remained below 5.0 mg/l for the years 1968 through 1971, but increased significantly after 1972, indicating the favorable effect of major improvements completed in the Village of Twin Lakes sewage treatment facility during the period 1970 to 1972. The daily average dissolved oxygen concentrations at sampling station Fx-26, located 3.6 miles downstream from sampling station Fx-25 on Bassett Creek, were found to be consistently higher than at sampling station Fx-25 during the period from 1968 through 1975. Apparently the natural reaeration process occurring in the stream helps the waters of Bassett Creek recover from the effect of the discharge of the effluent from the sewage treatment facility at the Village of Twin Lakes and improves the dissolved oxygen levels as the stream water moves from the location of station Fx-25 to the location of Fx-26. The difference between the concentrations in the samples collected at sampling stations Fx-25 and Fx-26 on Bassett Creek decreased during the period from 1972 through 1975, since the dissolved oxygen levels at sampling station Fx-25 increased after 1972, due to the effects of completion of the major improvements in the Village of Twin Lakes sewage treatment facility.

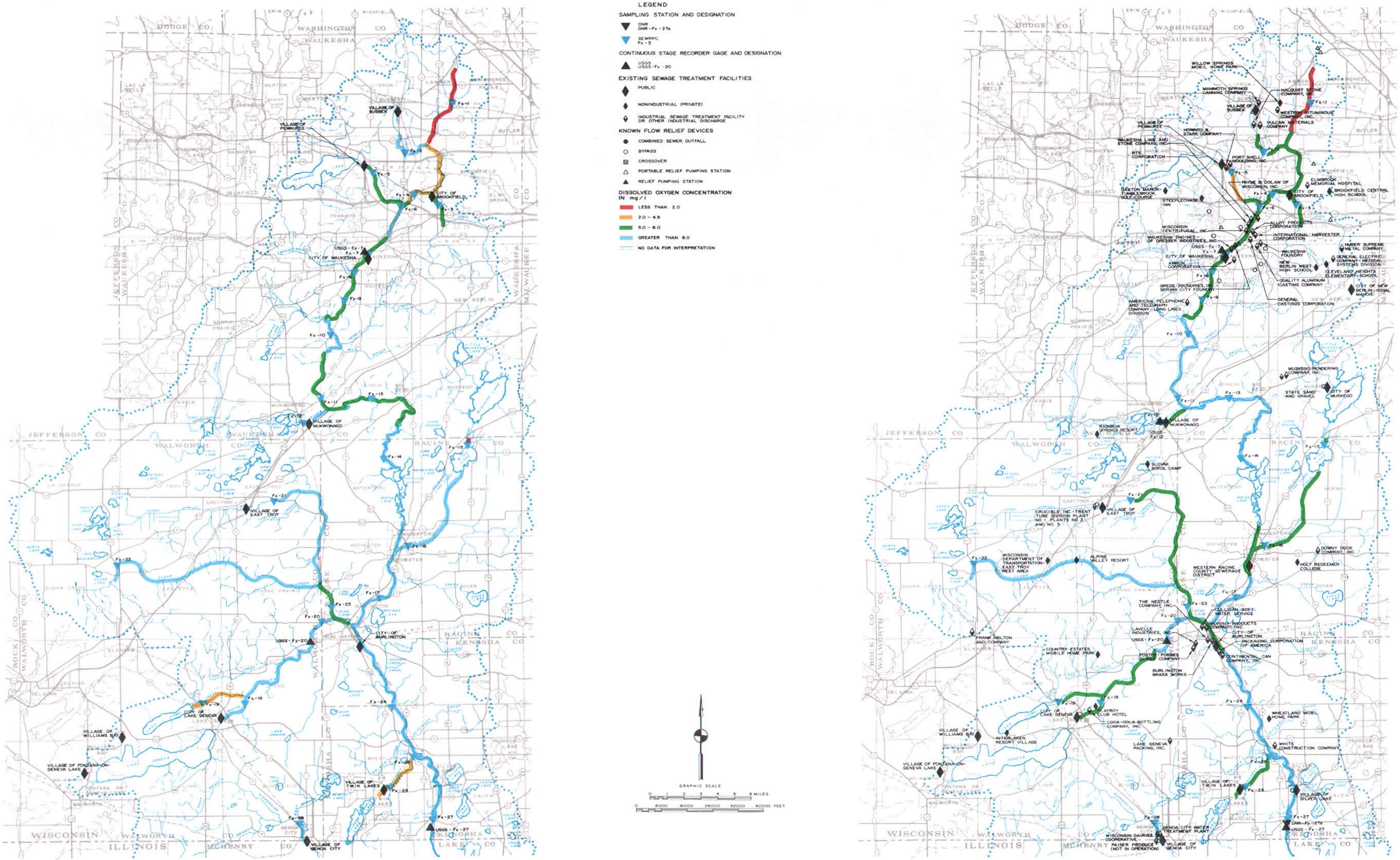
Chloride: The daily average chloride concentrations at the 12 stations on the Fox River main stem were found to range from 15 to 168 mg/l during the eight sampling surveys conducted from 1968 through 1975. A large number of the samples, especially from the headwater area of the Fox River main stem at sampling stations Fx-7 through Fx-11, exhibited chloride concentrations in the range from 30 to 80 mg/l, somewhat higher than the area groundwater chloride concentration of 20 mg/l. At sampling station Fx-27 located at Wilmot dam 1.2 miles from the Wisconsin-Illinois State line, the daily average chloride concentrations during August were lower and in the range of from 25 to 38 mg/l. A comparison of the chloride concentrations in April 1968 with August 1968, and in April 1969 with August 1969, (Figures 29 and 30) indicates that the daily average chloride concentrations generally remained the same in the Fox River main stem samples for the April 1968 and April 1969 samples. The daily average chloride concentrations in the August 1968 samples were lower than in the April 1968 samples at all

Map 15

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST OF THE YEARS 1964-1975 IN THE FOX RIVER WATERSHED

1964

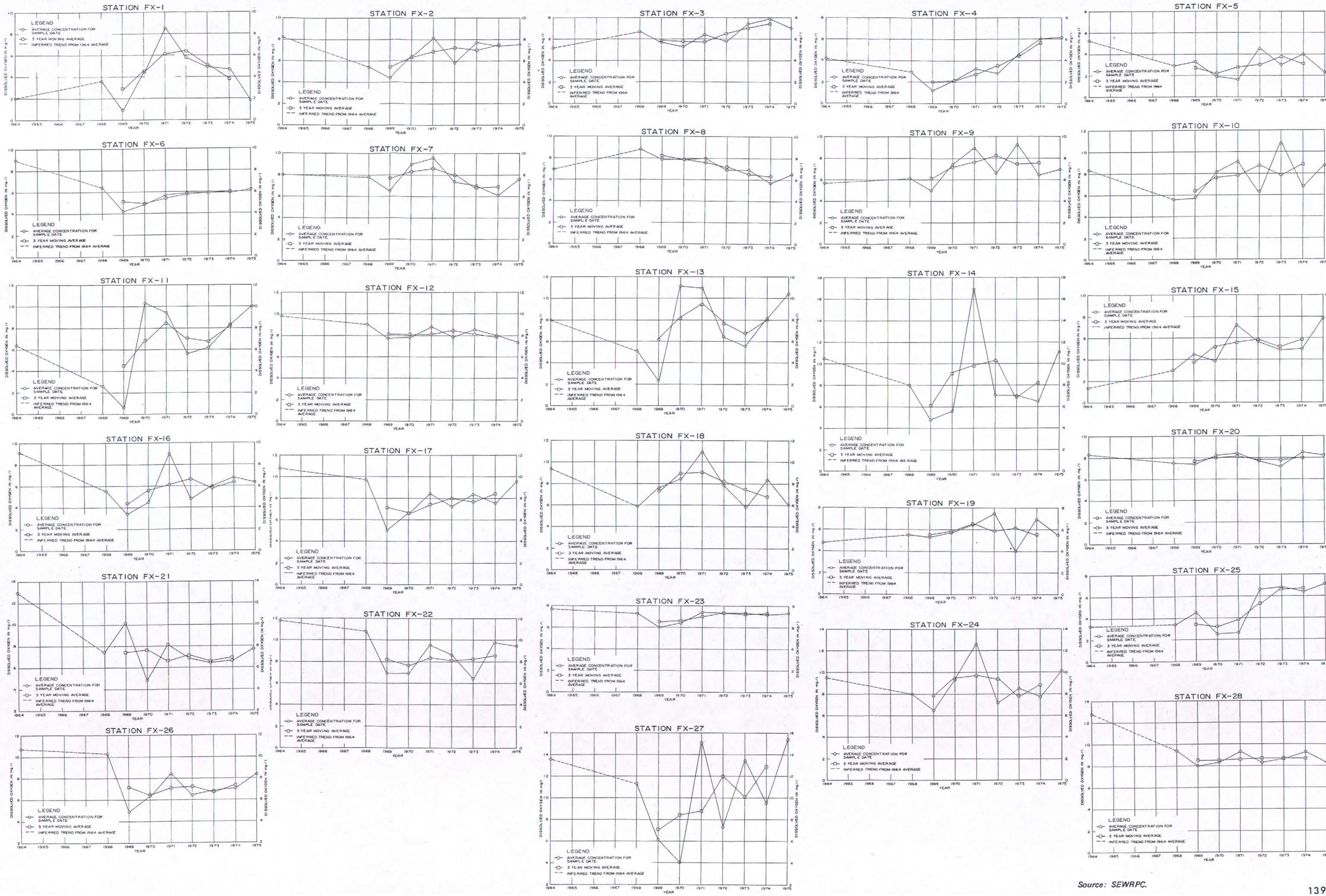
1975



A comparison of the dissolved oxygen levels recorded in 1964 and 1975 in the Fox River watershed indicated that dissolved oxygen concentrations generally remained stable over the past decade. Sampling stations Fx-4, Fx-11, and Fx-13 on the Fox River main stem, station Fx-3 on Poplar Creek, Fx-15 on Muskego Canal, Fx-19 on Como Creek, and Fx-25 on Bassett Creek all recorded an increase in dissolved oxygen levels for the ten year period. Decreased dissolved oxygen levels were observed at Fx-2, Fx-5, Fx-6, Fx-12, Fx-16, Fx-18, and Fx-21, all of which are located on tributaries of the Fox River. The maximum recorded dissolved oxygen concentration was 24.3 mg/l at sampling station Fx-14, while the minimum recorded dissolved oxygen was 0.1 mg/l at station Fx-3.

 Source: SEWRPC.

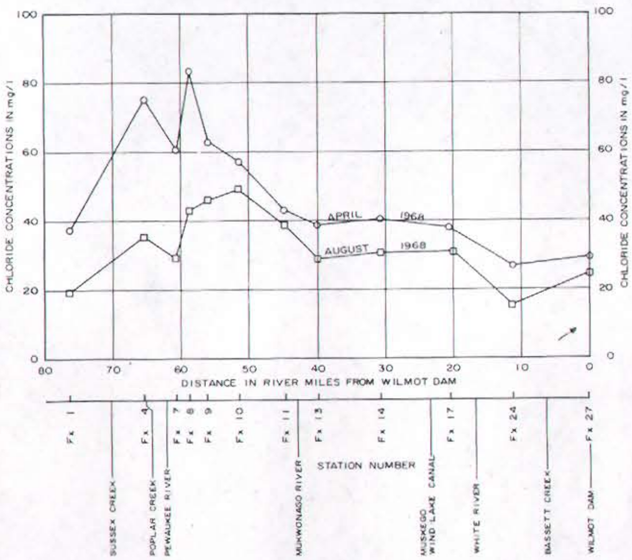
Map 15 (continued)



Source: SEWRPC.

Figure 29

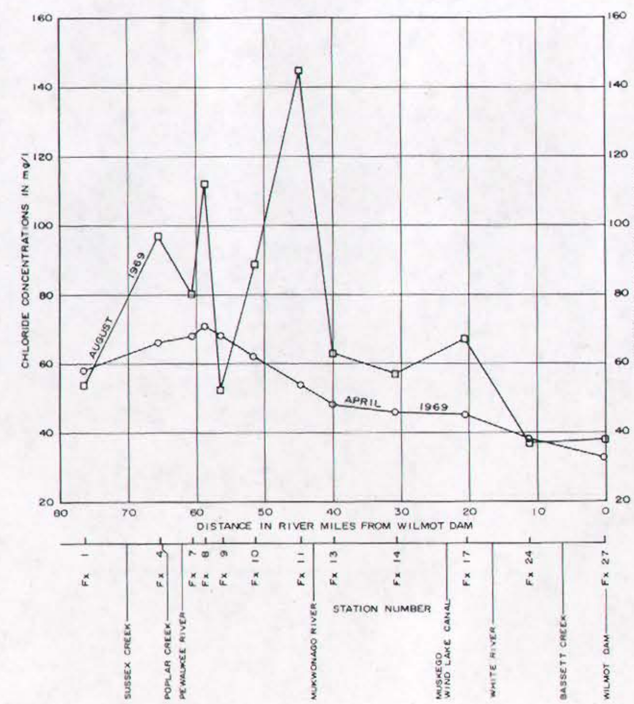
CHLORIDE CONCENTRATIONS IN THE FOX RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968



Source: SEWRPC.

Figure 30

CHLORIDE CONCENTRATIONS IN THE FOX RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1969



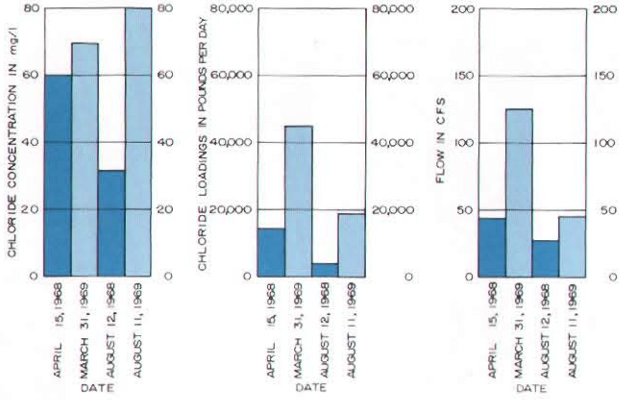
Source: SEWRPC.

of the sampling stations on the Fox River main stem, while the August 1969 samples had higher chloride concentrations than the April 1969 samples.

This anomaly in the chloride concentrations in the spring and summer of 1968 and 1969 was found to be directly related to the flow as indicated in Figures 31 and 32. The figures compare the flow, chloride concentrations and chloride loadings at sampling stations Fx-7 and Fx-27 for which flow information is available. At both sampling stations, Fx-7 and Fx-27, the higher flows were accompanied by increased chloride loadings; at sampling station Fx-7, the flows were higher in the springs of 1968 and 1969 than in the summers of 1968 and 1969 on the sampling days and the chloride loadings were also higher in the samples collected in the spring than in the summer. At sampling station Fx-27, the flow was higher in the summer of 1968 than in the spring of 1968 and the chloride loadings were higher in the summer of 1968 than in the spring of 1968. Map 16 presents the chloride concentrations found at the Fox River sampling stations in August 1968 and August 25, 1975, with the graphs illustrating the changes in the daily average chloride concentrations found during the sampling days of the intermediate years. A comparison of the daily average chloride concentrations found in August 1968 and on August 25, 1975, as presented on Map 16 for the water samples collected from the sampling stations on the Fox River main stem, indicates higher average chloride concentrations for the 1975 samples. The average chloride concentrations in water samples collected over the past eight years at the sampling stations in the headwater area of the Fox River main stem—stations Fx-1 and Fx-9—indicate an increasing trend. For the sampling stations located downstream from station Fx-9 on the Fox River main stem, the average chloride concentrations generally remained constant over the past decade. The increasing trend in chloride concentrations over the past decade, along with the low dissolved oxygen concentrations in the headwater area, is associated with the rapid urbanization taking place in the headwater area. Figure 33 presents the flows and average chloride loadings found at sampling station Fx-7 during the period 1968 through 1975. On all eight sampling days, the chloride loadings and the flow at station Fx-7 increased simultaneously. If it is assumed that the flow from the sewage treatment plants is constant, the chloride loading should remain constant and not vary with the flow. The fact that the chloride loading varies with the flow indicates that the chloride has sources other than sewage effluent. The higher flows in 1972 were associated with rain, raising the possibility of the origin of the chloride being associated with storm water runoff, which washes out chlorides applied for de-icing operations during the winter but temporarily stored in the soil or groundwater. The background loadings, based upon a maximum chloride concentration of 20 mg/l in the groundwater as noted from well samples taken in the area are included in the values given in Figure 33 and indicate that the chloride levels in all the samples taken at station Fx-7 were about three times higher than the background loadings.

Figure 31

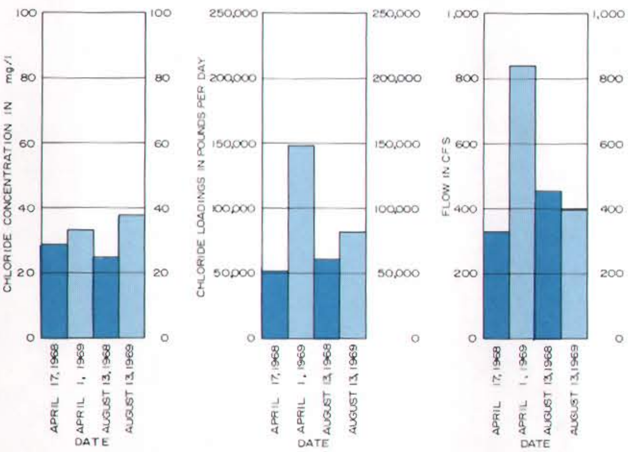
COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE FOX RIVER NEAR WAUKESHA (FX-7) APRIL AND AUGUST 1968 AND 1969



Source: SEWRPC.

Figure 32

COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE FOX RIVER NEAR WILMOT (FX-27) APRIL AND AUGUST 1968 AND 1969



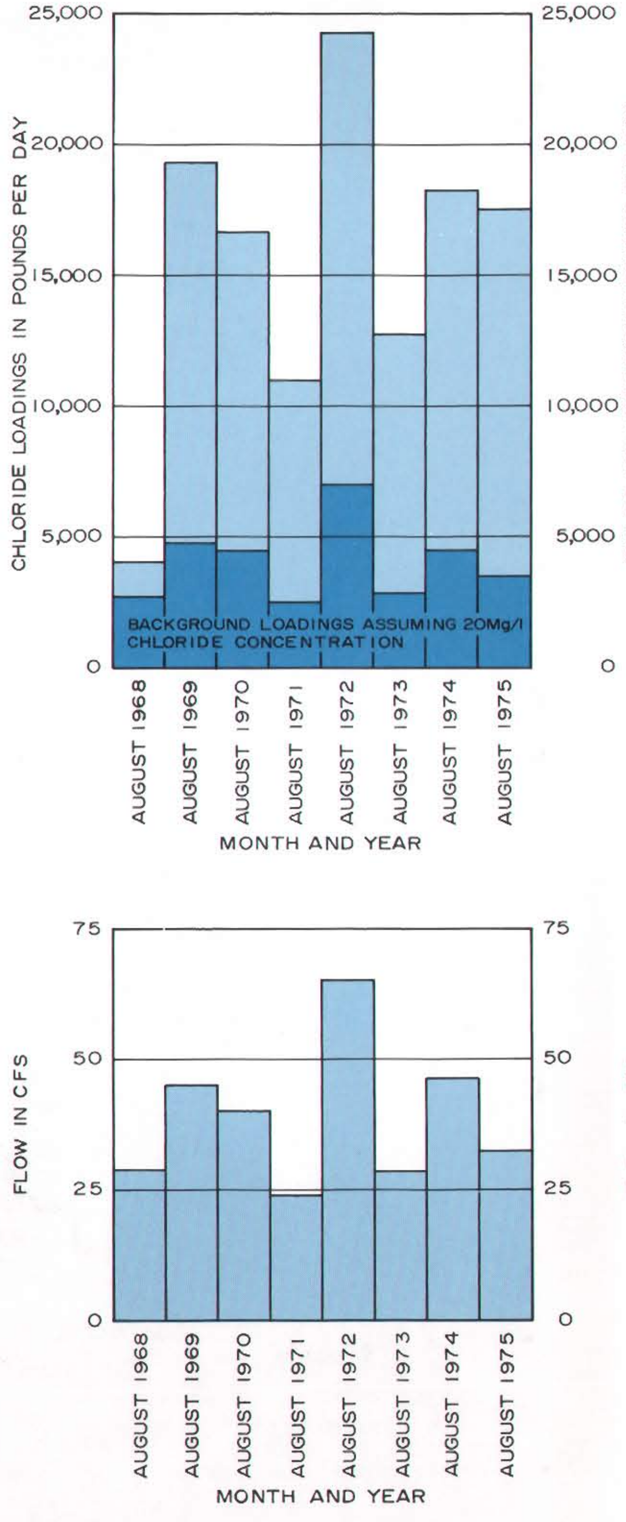
Source: SEWRPC.

Figure 34 presents the chloride loadings and corresponding flow measurements made at sampling station Fx-27 during the sampling period over the years 1968 through 1975. Although the chloride loadings increased with flow in the Fox River at Wilmot station Fx-27, the increases were not proportionate to the flow. The actual chloride loadings at sampling stations Fx-7 and Fx-27 on the Fox River were found to be 200 to 500 percent higher than the background loadings, indicating the effects of human activities on the chloride content of the Fox River.

Among the tributaries of the Fox River, the Mukwonago River and Honey Creek exhibited chloride concentrations in the range of from 5 to 20 mg/l; Como Creek, the

Figure 33

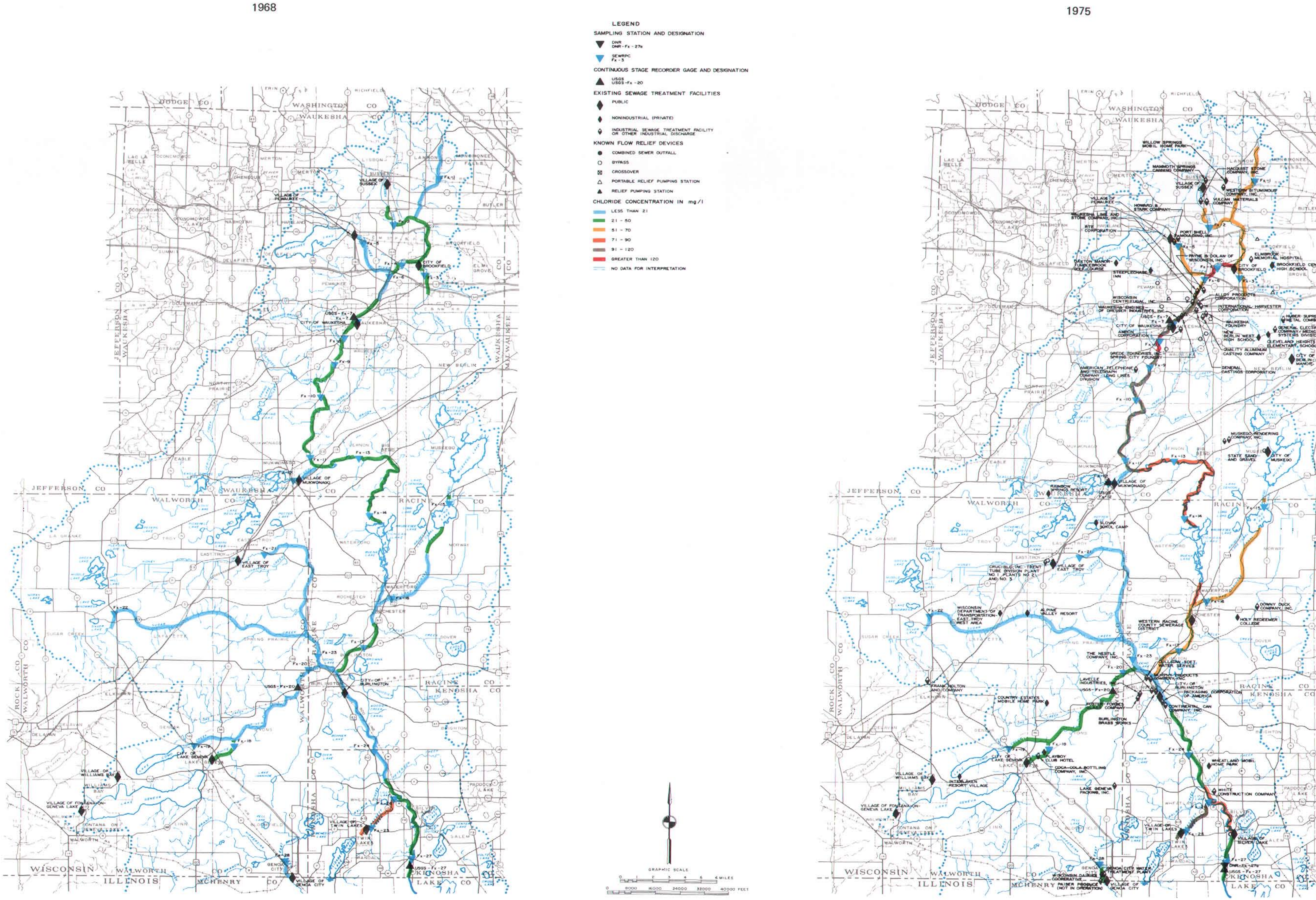
COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE FOX RIVER NEAR WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: U. S. Geological Survey and SEWRPC.

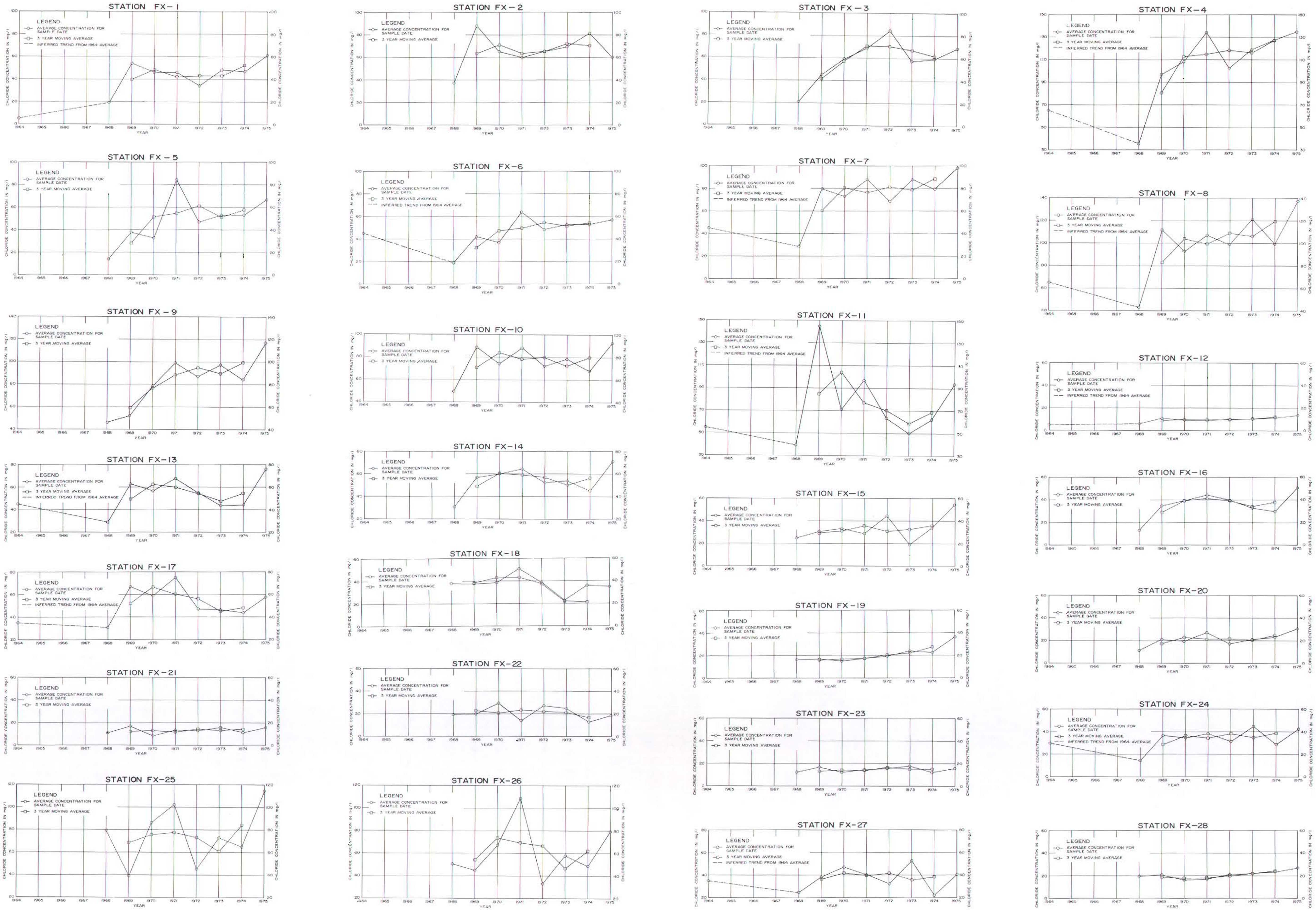
Map 16

COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST OF THE YEARS 1968-1975 IN THE FOX RIVER WATERSHED



Increased chloride concentrations throughout the major portion of the Fox River watershed are evident when the August 1968 and 1975 data are compared. Chloride levels at sampling station Fx-27 on the Fox River main stem and Fx-12 on the Mukwonago River, station Fx-18 on the White River, stations Fx-21 and Fx-23 on Honey Creek and station Fx-22 on Sugar Creek remained constant over the past eight years. The maximum observed concentration of 245.0 mg/l was recorded at Fx-26 and the minimum observed sample of 5.0 mg/l was recorded at Fx-21.

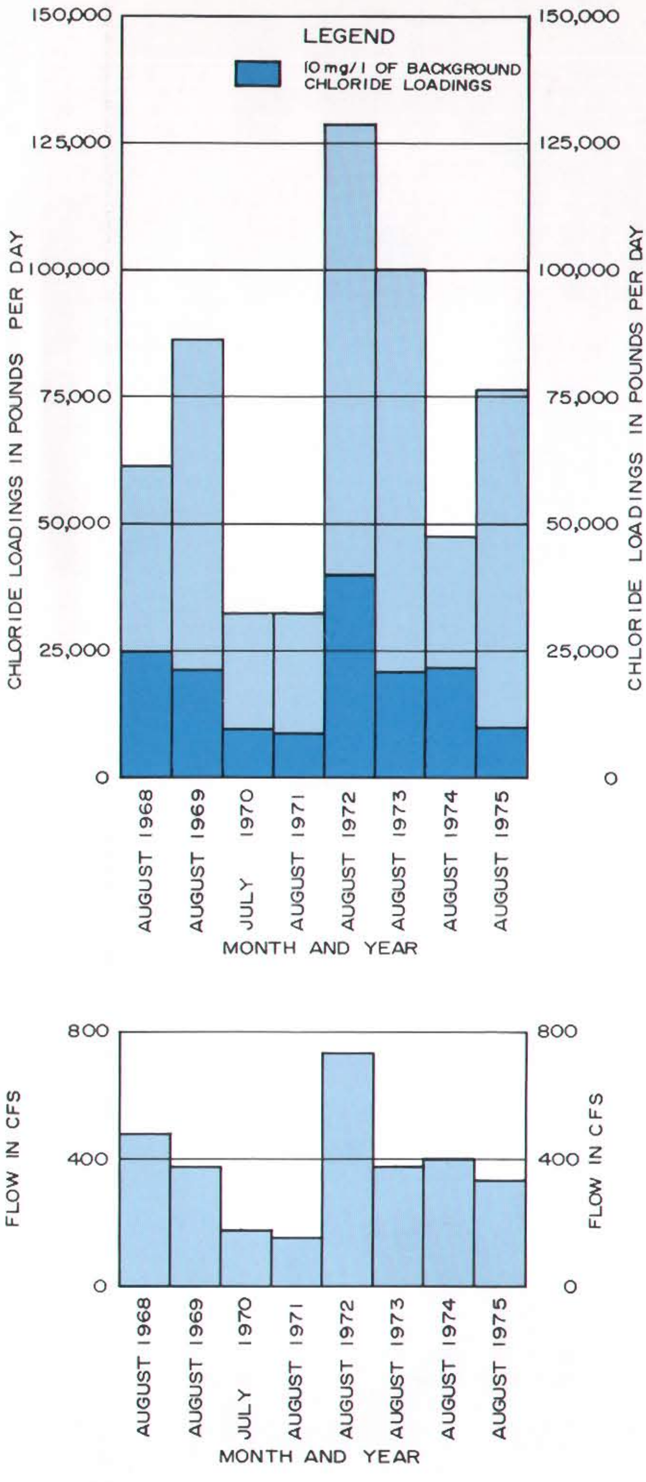
 Source: SEWRPC.



Source: SEWRPC.

Figure 34

COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE FOX RIVER NEAR WILMOT (FX-27) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: U. S. Geological Survey and SEWRPC.

Muskego Canal, the Wind Lake Drainage Canal, Sugar Creek, the White River, and Nippersink Creek exhibited chloride concentrations in the range of from 11 to 55 mg/l; and Sussex Creek, Poplar Creek, the Pewaukee River, and Bassett Creek exhibited chloride concentrations in the range of from 15 to 245 mg/l. With the exception of the Mukwonago River and Honey Creek where the chloride concentrations were at about the levels found in adjacent groundwaters, the Fox River tributaries exhibited chloride concentrations higher than the groundwater concentrations of from 10 to 20 mg/l as measured from the well water samples taken in the area. The ranges in the chloride concentrations on the tributaries of the Fox River for the years 1968 through 1975 were similar to those found in the 1964-1965 sampling survey with the exception of Bassett Creek and the tributaries in the headwater areas of the Fox River. In these streams the maximum chloride concentrations were found to have increased from 120 to 245 mg/l.

The variations of average chloride concentrations on the tributaries of the Fox River differed with time and by location. In the headwaters of the Fox River at the sampling station Fx-3 on Popular Creek and at sampling stations Fx-5 and Fx-6 on the Pewaukee River, there was an increase in the average chloride concentrations over the past eight years. The increase may be attributed to the influences of urbanization in that area over that time period. An increasing trend in the average chloride concentrations also was noted at sampling station Fx-16 on the Wind Lake Drainage Canal. The average chloride concentrations observed in Sussex Creek, the Mukwonago River, Muskego Canal, the White River, Como Creek, Honey Creek, Sugar Creek, and Nippersink Creek remained generally stable over the past eight years. The chloride concentrations found at sampling stations Fx-25 and Fx-26 on Bassett Creek remained greater than 70 mg/l over the past eight years with the exception of the 1972 samples, taken soon after a heavy rainfall. The high chloride concentrations at sampling stations Fx-25 and Fx-26 on Bassett Creek indicate the probable effects of the effluent from the Village of Twin Lakes sewage treatment facility.

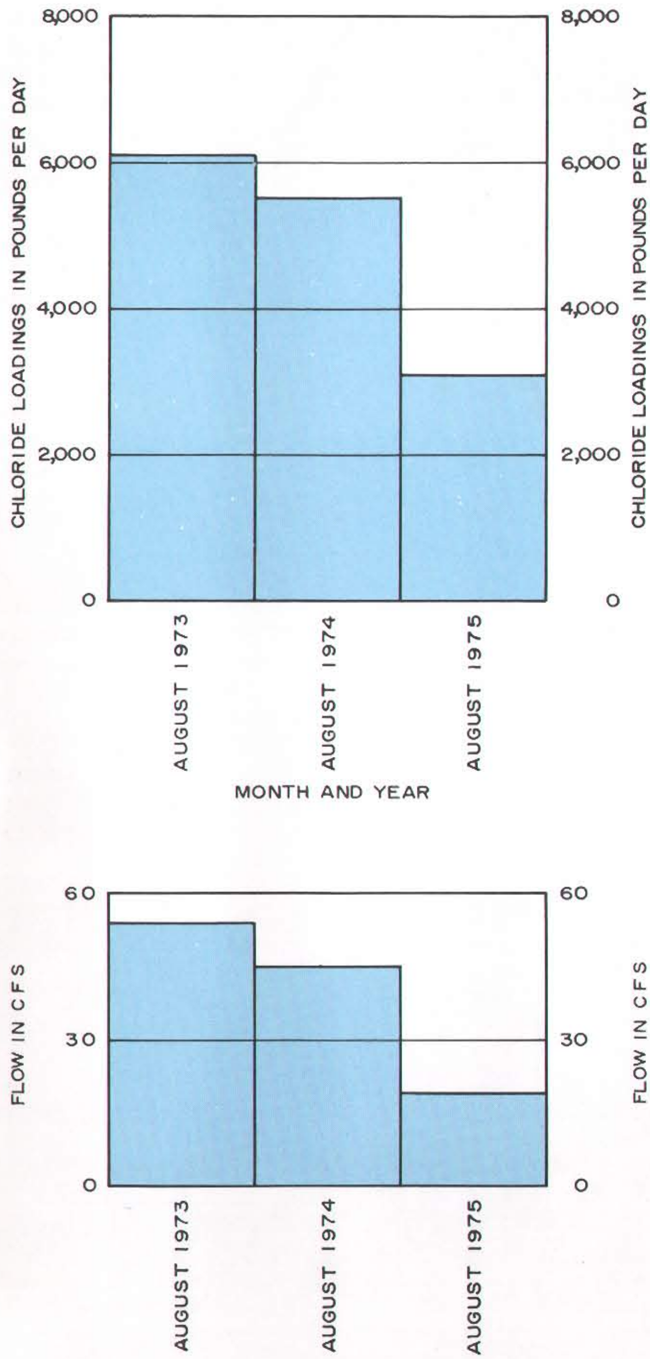
A comparison of chloride loadings at sampling station Fx-20 on the White River, and sampling station Fx-12 on the Mukwonago River are presented in Figures 35 and 36, respectively.

The figures indicate that the chloride loadings ranged from 4,800 to 6,000 lbs/day in the samples collected in August 1973 at station Fx-12 on the Mukwonago River and at station Fx-20 on the White River. On the other hand, the chloride loadings at sampling station Fx-7 on the Fox River main stem in the sample collected in August 1973 were higher, in the range of 13,000 lbs/day.

Fecal Coliform Bacteria: Map 17 presents the fecal coliform counts found at the sampling station locations in August 1968 and August 1975, with the graph inserts showing the changes in the fecal coliform counts found on the sampling days over the period from 1968 through 1975. For the samples collected in August 1968, the fecal

Figure 35

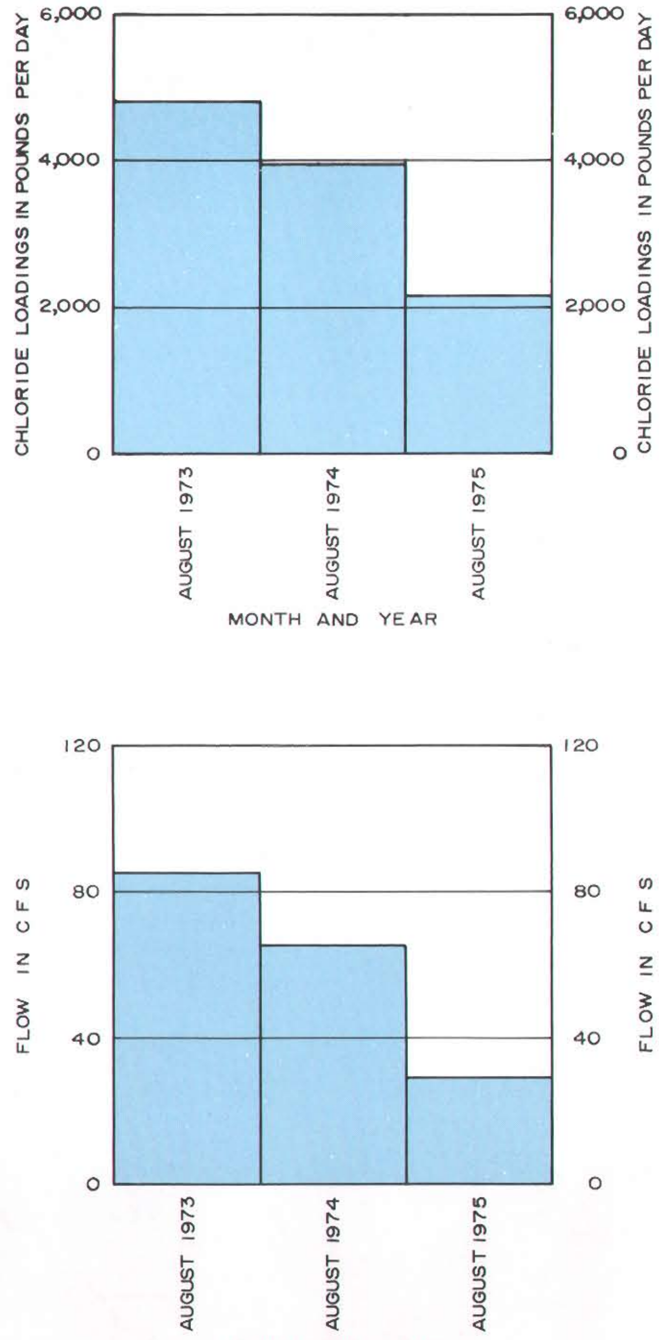
COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE WHITE RIVER (FX-20) ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975



Source: U. S. Geological Survey and SEWRPC.

Figure 36

COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE MUKWONAGO RIVER (FX-12) ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975

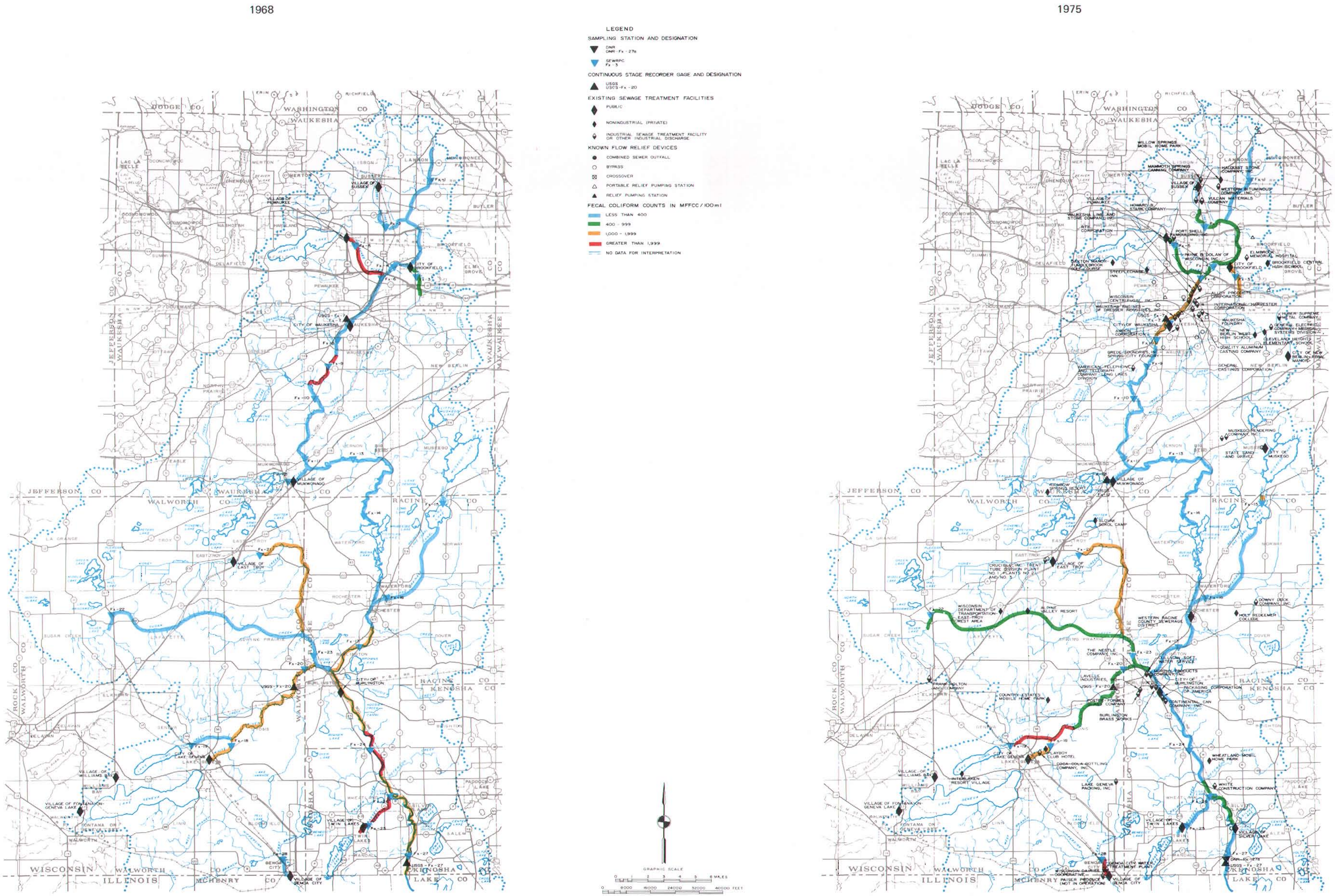


Source: SEWRPC.

coliform counts were greater than 1,000 MFFCC/100 ml at sampling stations Fx-9, Fx-17, Fx-24, and Fx-27; and less than 400 MFFCC/100 ml at sampling stations Fx-1, Fx-4, Fx-7, Fx-8, Fx-10, Fx-11, Fx-13, and Fx-14 on the main stem of the Fox River. For the water samples collected during August 1975, the fecal coliform counts remained less than 400 MFFCC/100 ml at Fx-1 and Fx-8 through Fx-24 and remained between 400-1,000 MFFCC/100 ml at Fx-4. At only one location, Fx-7, were fecal coliform counts greater than 1,000 MFFCC/100 ml. Thus, a trend toward improved water quality, as measured by the average fecal coliform counts, is indicated for stations Fx-17 through Fx-27 on the Fox River main

Map 17

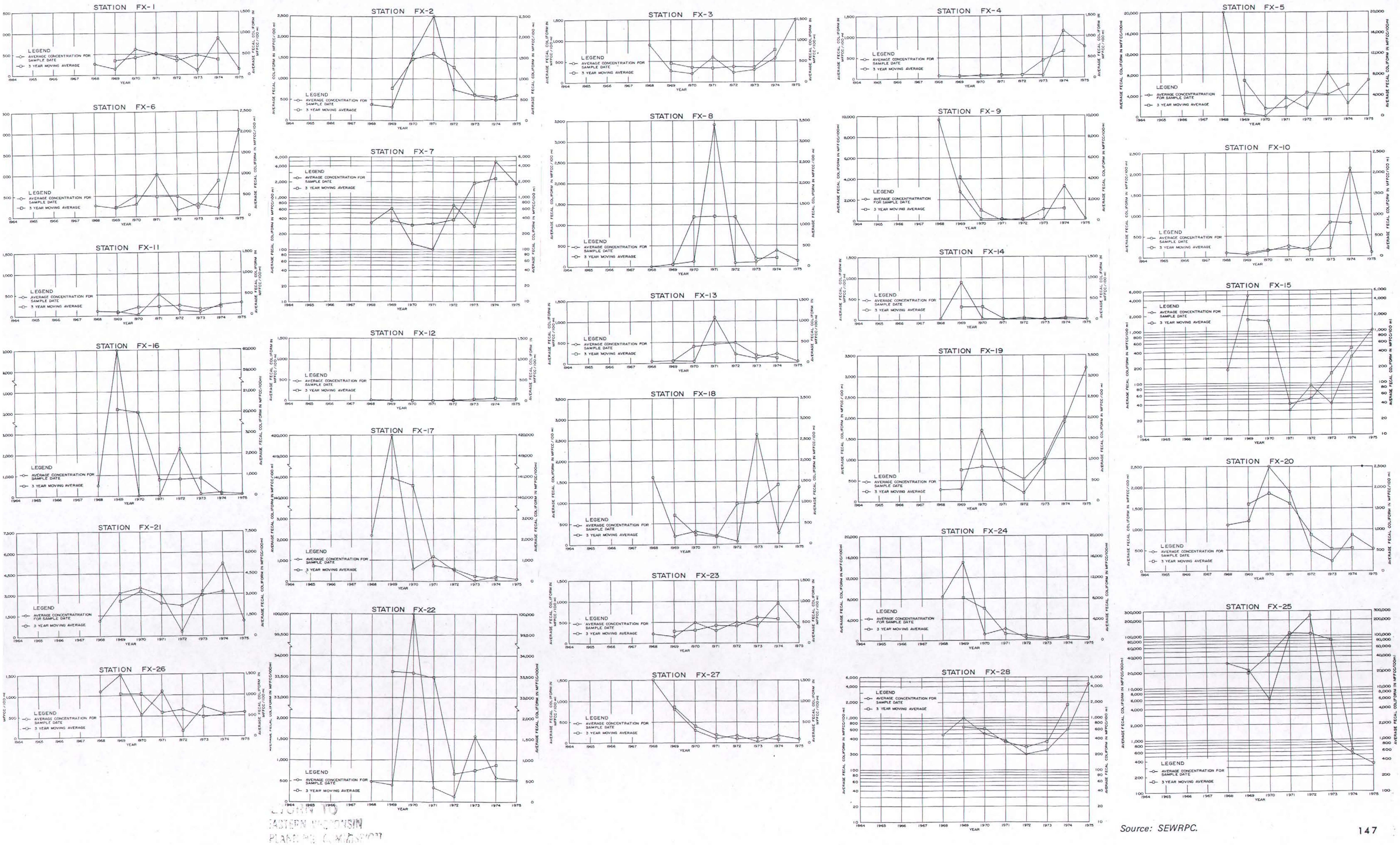
COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST OF THE YEARS 1968-1975 IN THE FOX RIVER WATERSHED



The fecal coliform counts generally remained stable over the past eight years at the Fox River main stem sampling stations Fx-1, Fx-8, Fx-10, Fx-11, Fx-13, and Fx-14 and on the Wind Lake Drainage Canal (Fx-16), the White River (Fx-18), and at Fx-21 on Honey Creek. The fecal coliform counts declined in the samples collected over the past eight years from sampling stations Fx-9, Fx-17, Fx-24, and Fx-27 on the Fox River main stem, and from stations Fx-5 on the Pewaukee River, Fx-20 on the White River, Fx-25 on Bassett Creek, Fx-26 on Bassett Creek, and Fx-28 on Nippersink Creek. Fecal coliform counts increased at sampling stations Fx-4 and Fx-7 on the Fox River main stem and Fx-2 on Sussex Creek, Fx-3 on Poplar Creek, Fx-6 on the Pewaukee River, Fx-15 on the Muskego Canal, Fx-19 on Como Creek, and Fx-22 and Fx-23 on Sugar Creek and Honey Creek, respectively. The maximum fecal coliform counts recorded were 42,000 MFFCC/100 ml at sampling station Fx-17 on the Fox River main stem. The minimum fecal coliform counts were observed at 5 MFFCC/100 ml at stations Fx-8, Fx-9, and Fx-10 on the Fox River main stem and Fx-12 on the Mukwonago River, and Fx-16 on the Wind Lake Drainage Canal.

Source: SEWRPC.

Map 17 (continued)



Source: SEWRPC.

stem. The graph inserts on Map 17 illustrate the temporal trends in the average fecal coliform counts at the sampling stations on the Fox River main stem. A stable count of less than 500 MFFCC/100 ml is exhibited over the past eight years at stations Fx-1, Fx-4, Fx-7, and Fx-10 except for the year 1974 when the average fecal coliform counts at many locations were higher than 500 MFFCC/100 ml. At sampling stations Fx-8 and Fx-11 through Fx-14, also located on the Fox River main stem, the average fecal coliform counts were generally stable and less than 500 MFFCC/100 ml with the exception of the samples collected in 1971. The average fecal coliform counts at sampling station Fx-9 showed no trend over the past eight years, with high counts in the 1968, 1969, and 1974 samples and lower counts in 1970 through 1973 and 1975 samples. For sampling stations Fx-17 through Fx-27 on the Fox River main stem located downstream from the confluence with the Wind Lake Drainage Canal, the fecal coliform counts decreased in the samples collected during the period of 1968 through 1972 and remained low from 1972 onwards.

For the tributaries of the Fox River, the average fecal coliform counts at sampling station Fx-2 on Sussex Creek remained low over the past eight years with the exception of the 1970 and 1971 samples. At Poplar Creek sampling station Fx-3, the fecal coliform counts also remained low over the past eight years. At sampling station Fx-5 located downstream from the Village of Pewaukee sewage treatment plant on the Pewaukee River, fecal coliform counts increased over the past eight years, with levels in excess of 1,000 MFFCC/100 ml. The fecal coliform counts at sampling station Fx-12 located on the Mukwonago River were less than 100 MFFCC/100 ml in all eight sample surveys, indicating high water quality in the river upstream from this sampling location. At sampling station Fx-16 on the Wind Lake Drainage Canal, the fecal coliform counts declined over the past eight years. The area drained by this canal being primarily in agricultural use, the decrease in the fecal coliform counts must be attributed to improved land management in this subwatershed and possible changes in manure handling or grazing practices in the subwatershed. The high fecal coliform counts in the August 1972 samples are associated with the heavy rainfalls recorded at all five gaging stations located in the watershed, and the attendant runoff from fields during the week of the sampling survey in 1972.

The fecal coliform counts at sampling station Fx-19 on Como Creek which is located at the outlet of Lake Como showed an increasing trend over time in the eight years of samples, indicating a possible effect of the septic tank systems serving urban development around Lake Como. At sampling station Fx-18 on the White River, the fecal coliform counts remained high over the past eight years, the water quality at the sampling station being affected by the effluent from the sewage treatment facilities of the City of Lake Geneva and the Lake Geneva Playboy Club. Sampling station Fx-20, also located on the White River, did not show the effect of the high fecal coliform counts at sampling stations Fx-18 and Fx-19, both located upstream from station Fx-20. The distance between sampling stations Fx-20 and Fx-18 or Fx-19 being over 10 miles, the decrease may be attributed to the normal die-off of fecal coliform bacteria.

In Honey Creek and Sugar Creek the fecal coliform counts—as measured at sampling stations Fx-21, Fx-22, and Fx-23—showed a slight general increase over the past eight years. In Bassett Creek the average fecal coliform counts as measured at sampling stations Fx-25 and Fx-26 decreased over time, indicating improved water quality conditions over the eight-year period. At sampling station Fx-28 on Nippersink Creek the fecal coliform counts were found to be consistently low except for the sample collected in 1975.

Hydrogen Ion Concentrations (pH): As indicated in Table 56, the pH values of the stream water of the Fox River watershed system have been found to be generally within the range of the 6.0 to 9.0 standard units prescribed for the applicable recreational use and fish and aquatic life use objectives. At sampling station Fx-14 on the Fox River main stem, the diurnal sample collected in August 1971, at 2:00 p.m., 6:00 p.m., and 10:00 p.m. exhibited a pH of 9.1 standard units. At sampling station Fx-17, also located on the Fox River main stem, the diurnal sample collected at 5:45 p.m. on August 25, 1975, exhibited a pH of 9.2 standard units. At sampling station Fx-15 on the Wind Lake Canal and at station Fx-25 on Bassett Creek, the samples collected on August 25, 1975, at 5:15 p.m. and 4:00 p.m. exhibited a pH greater than 9.0 standard units (9.2 and 9.1). The pH reading of greater than 9.0 at these locations is likely to be the effect of photosynthetic uptake of CO_2 increasing the pH of the stream waters.

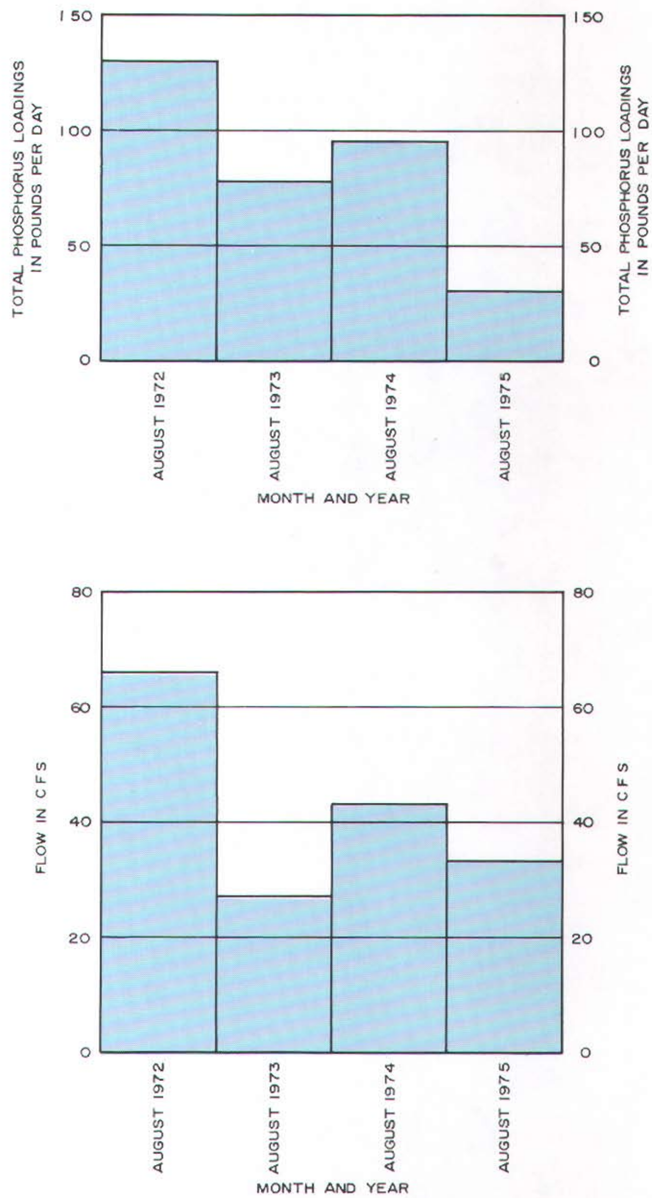
Specific Conductance: Specific conductance was found to be in the range of from 119 to 1,516 μmhos/cm at 25°C for the 28 locations on the Fox River on the days sampled in August of the years 1968 through 1975. The highest specific conductance value for the Fox River main stem stations was found at sampling station Fx-24 in August 1971. In general, higher specific conductance values were found in the headwater area, as were higher chloride levels. The specific conductance values remained greater than 800 μmhos/cm at 25°C over the eight years of sampling. Among the tributaries, Bassett Creek exhibited the highest specific conductance in the August 1976 samples, which also showed a high chloride concentration. Although high specific conductance generally was associated with high chloride concentrations, this was not true in all the cases. This indicates a possible increase in the other ions that increase specific conductance. Since the other ions which were sampled do not show any direct relationship to the high specific conductance values, it is likely that one or more ions not measured in the sampling program could be causing the increased specific conductance values.

Temperature: As indicated in Table 56, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected at the 28 Fox River sampling stations during the months of August 1968 through 1975 were analyzed for soluble orthophosphate concentrations. A range of 0.01 to 7.27 mg/l of soluble orthophosphate as P was found during the eight sampling periods at the 28 locations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.01 to 2.34 mg/l as P was found. The ratio of soluble orthophosphate to total phosphorus in water samples collected indicates that most of the phosphorus was in a form readily available for the growth of aquatic plants. Although not enough samples were analyzed to characterize trends in the total phosphorus concentrations over time, it is evident from the data that the concentrations are many times higher than required for excessive algal growth. A total phosphorus limit of 0.10 mg/l as P is generally held to be the threshold level for preventing nuisance growth of algae and other aquatic plants. All water samples except those from the sampling station Fx-12, located on the Mukwonago River, exhibited total phosphorus levels higher than 0.10 mg/l as P. In addition to the 28 Commission sampling stations, one Department of Natural Resource sampling station, DNR-Fx-27a was used in the analysis of the Fox River. Sampling station DNR-Fx-27a is located at Wilmot dam 1.2 miles upstream from the Wisconsin-Illinois state line. The location of the sampling station is shown on Map 14. The 1968 through 1975 data from sampling station DNR-Fx-27a also exhibited total phosphorus values higher than 0.10 mg/l as P, with a range of from 0.11 to 1.30 mg/l as P. The total phosphorus values were high at headwater stations Fx-4 through Fx-10, indicating the effects of urbanization on the total phosphorus content of the River. Figures 37 and 38 present the total phosphorus loadings and flows for sampling stations Fx-7 and Fx-27 for the samples collected during the period 1972 through 1975. The total phosphorus loadings at sampling stations Fx-7 and Fx-27 on the Fox River main stem were high in the 1972 samples when the flows were the highest of the four data points. Although four years of data are not enough to characterize the trend in the total phosphorus loadings, a decrease in the total phosphorus loadings seems to have occurred over the past four years. The soluble orthophosphate data which are available for the period 1968 through 1975 also showed high loadings with high flow at sampling station Fx-27 on the Fox River main stem but varied independent of the flow at sampling station Fx-7. (Figures 39 and 40.) The soluble orthophosphate loadings indicate a decreasing trend over the past decade, as do the total phosphorus loadings, at sampling stations Fx-7 and Fx-27 on the Fox River main stem. The decreasing trend in the total and soluble orthophosphate loadings may be attributed to the addition of tertiary and advanced waste treatment at the major sewage treatment facilities in the watershed. The high soluble orthophosphate and total phosphorus loadings in the samples collected on August 8, 1972, at sampling stations Fx-7 and Fx-27 are likely to be associated with the antecedent rainfall and consequent runoff from the urban and rural areas.

Figure 37

COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT THE FOX RIVER NEAR WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975

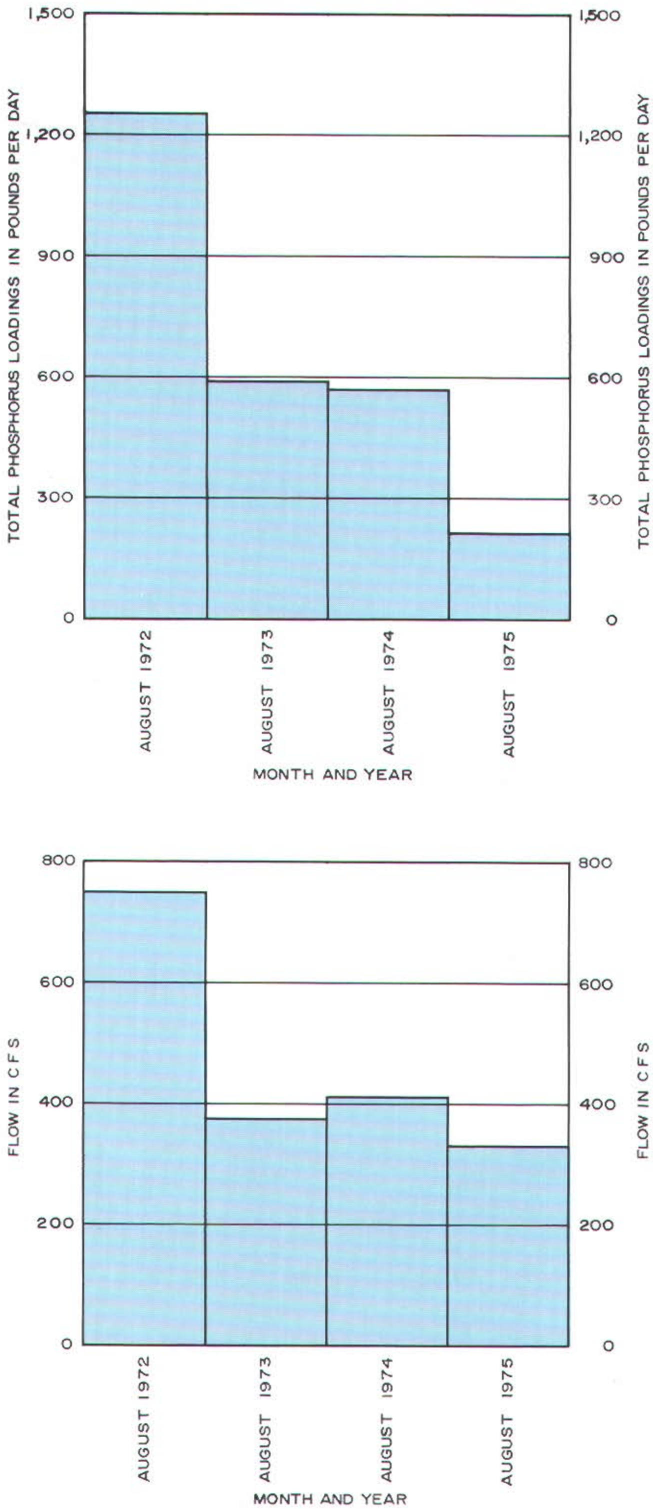


Source: U. S. Geological Survey and SEWRPC.

On the tributary streams the soluble orthophosphate concentrations were found to be in the range of from 0.08 to 7.27 mg/l as P for Sussex Creek, the Pewaukee River, the White River, and Bassett Creek. The range of total phosphorus found in Sussex Creek, the Pewaukee

Figure 38

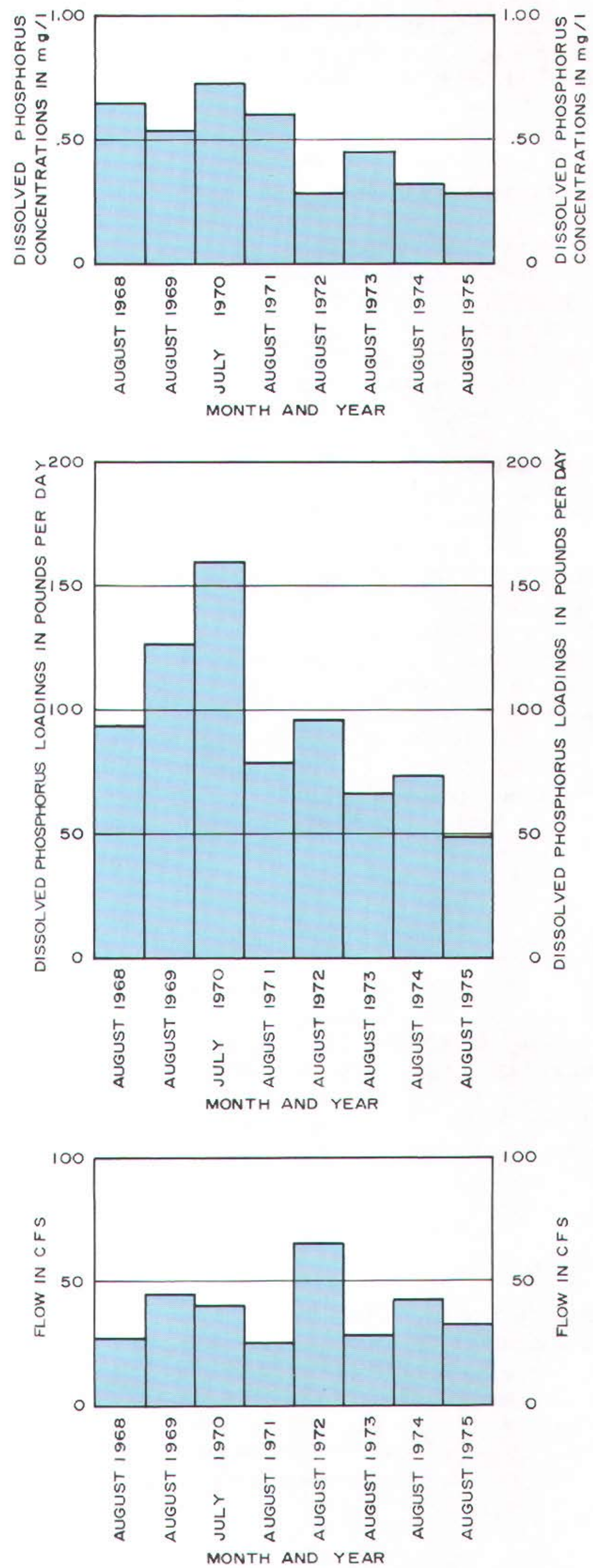
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT THE FOX RIVER NEAR WILMOT (FX-27) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: U. S. Geological Survey and SEWRPC.

Figure 39

COMPARISON OF SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS, LOADINGS, AND FLOW AT THE FOX RIVER NEAR WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: U. S. Geological Survey and SEWRPC.

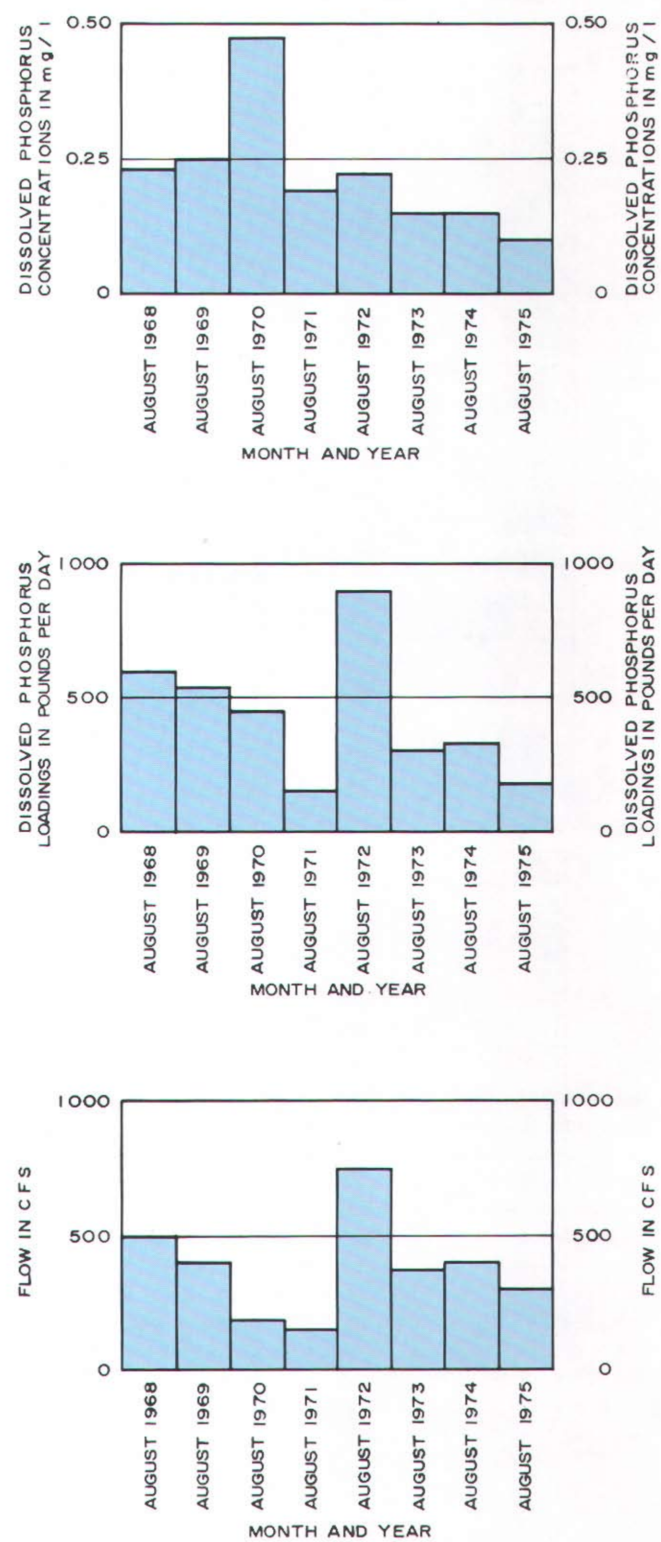
River, the White River, and Bassett Creek for the samples collected during the period 1972 through 1975 was found to be from 0.02 to 2.35 mg/l. The high concentrations of total phosphorus and soluble orthophosphate in these tributaries are probably due to the discharge of effluent from the sewage treatment facilities located upstream from the sampling stations concerned. The chloride concentrations and fecal coliform counts which are also associated with the discharge of effluents from the sewage treatment facilities were also found to be high on these streams. For the other tributaries of the Fox River including Poplar Creek, the Mukwonago River, the Wind Lake Drainage Canal, the Muskego Canal, Sugar Creek, Honey Creek, and Nippersink Creek, which were sampled over the past decade, the soluble orthophosphate concentration was found to range from 0.01 to 0.49 mg/l. The total phosphorus concentration sampled over the past four years was found to range from 0.01 to 0.40 mg/l. These values are significantly lower than those found at sample locations downstream from sewage treatment facilities. The Mukwonago River consistently exhibited high dissolved oxygen, low fecal coliform, and low chloride concentrations in the samples collected over the past eight years. In addition, the River exhibited low total phosphorus loadings for four years with a content of less than 21 lbs/day, despite the high 85 cfs discharge measured in August 1972 (see Figure 41). A comparison of the water quality in the headwater area of the Fox River main stem with the Mukwonago River should leave little doubt of the effects of urbanization on stream water quality conditions and accelerated eutrophication of lakes.

Nitrogen: The total nitrogen concentrations in the Fox River stream systems, as represented by the stream water quality samples collected during August of 1972 through 1975 were found to be in the range of from 0.63 to 19.07 mg/l. One to 16 percent of the nitrogen was found to be in the form of nitrite nitrogen; 27 to 51 percent as ammonia nitrogen; 16 to 57 percent as nitrate nitrogen; and 26 to 67 percent as organic nitrogen. Thus, 14 to 83 percent of the total nitrogen was found to be in the readily available form of nitrate nitrogen and ammonia nitrogen. The concentrations of ammonia nitrogen at the Fox River sampling stations were found to range from less than 0.03 to 5.83 mg/l as N. Only two samples collected exceeded the known toxic level of 2.5 mg/l for ammonia nitrogen as N. Those concentrations were found at station Fx-25, located on Bassett Creek downstream from the Village of Twin Lakes sewage treatment plant. However, on 56 of the 219 sampling dates, the ammonia nitrogen levels did exceed the 0.2 mg/l as N, generally held to be indicative of lakes and streams which have been affected by pollution.

Nitrate nitrogen concentrations in the Fox River watershed ranged from less than 0.07 to 1.59 mg/l as N. The sources of nitrate nitrogen in the Fox River watershed include runoff from agricultural land and sewage treatment effluents. Organic nitrogen was found to account for 26 to 67 percent of the total nitrogen present in the

Figure 40

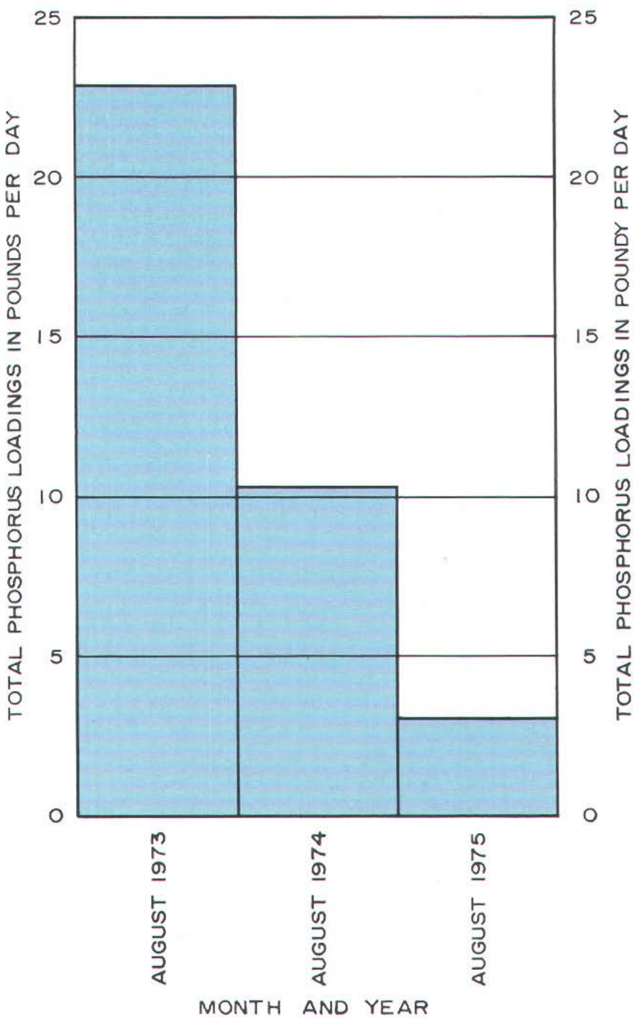
COMPARISON OF SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS, LOADINGS, AND FLOW AT THE FOX RIVER NEAR WILMOT (FX-27) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: U. S. Geological Survey and SEWRPC.

Figure 41

TOTAL PHOSPHORUS LOADINGS AT THE MUKWONAGO RIVER (FX-12) ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975



Source: SEWRPC.

samples collected. The presence of organic nitrogen in such a large concentration accounts for the low dissolved oxygen concentrations present at many of the sampling locations, since the degradation and oxidation of organic nitrogen compounds utilizes the oxygen present in the surface water. Figures 42 and 43 present the total nitrogen loadings and flow for sampling stations Fx-7 and Fx-27 on the Fox River main stem during the period 1972 through 1975. The total nitrogen loadings increased with the increase in flow although the change in loadings was not directly proportional to the change in flow. No trend in the total nitrogen loadings was noted at sampling stations Fx-7 and Fx-27.

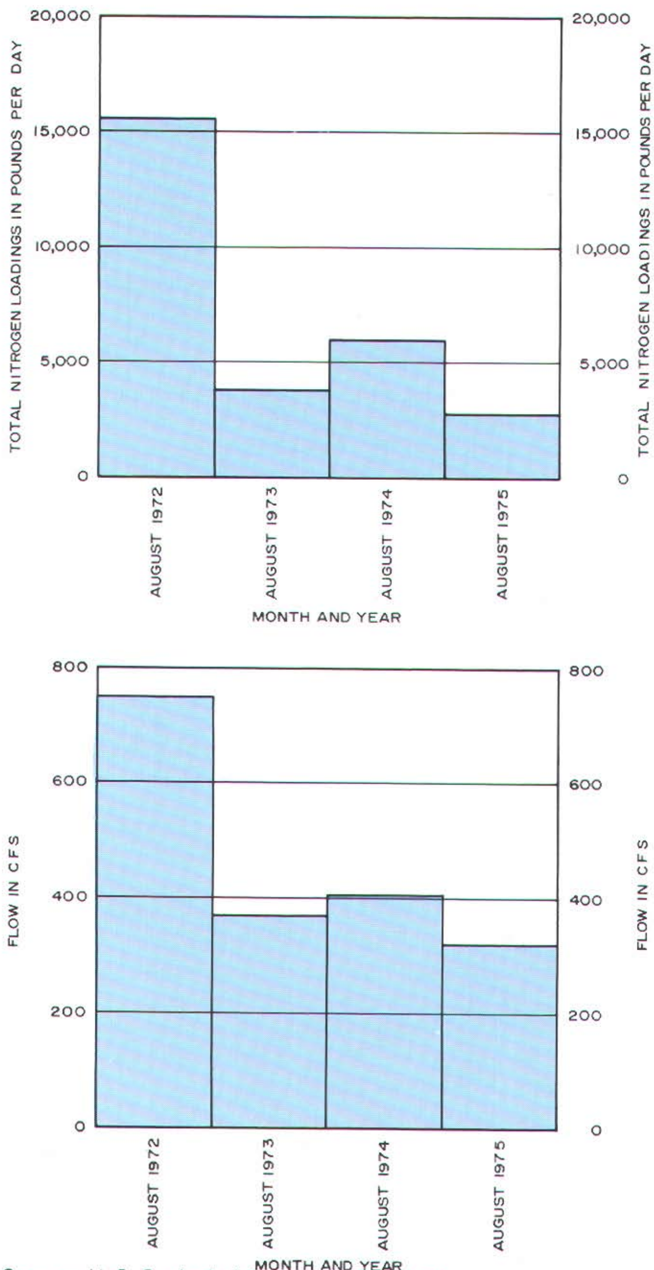
On the tributaries of the Fox River, the range of total nitrogen concentrations was found to be from 0.6 to 13.8 mg/l. The high total nitrogen values were found at sampling station Fx-2 on Sussex Creek with the range of 2.5 to 5.1 mg/l, at sampling station Fx-5 on the Pewaukee River with the range of 2.5 to 5.7 mg/l, at sampling station Fx-15 on the Wind Lake Drainage Canal with the range of 1.0 to 6.0 mg/l, at sampling station Fx-22 on Sugar Creek with the range of 1.7 to 6.0 mg/l, and at sampling stations Fx-25 and Fx-26 on Bassett Creek with a range from 1.3 to 13.8 mg/l. The high total nitrogen concentrations at sampling stations Fx-15 on the Wind Lake Drainage Canal and Fx-22 on Sugar Creek are likely to be associated with the drainage from the agricultural land. The high total nitrogen concentrations at the other locations—stations Fx-2 on Sussex Creek, Fx-5 on the Pewaukee River, and at stations Fx-25 and Fx-26 on Bassett Creek—are likely due to the effluent discharges from the sewage treatment plants located upstream.

Biochemical Oxygen Demand: The Commission water quality monitoring program did not include the measurement of five-day biochemical oxygen demand (BOD_5) for the years 1965 through 1975. However, the monthly sampling program by the Department of Natural Resources at sampling station DNR-Fx-27a did include the measurement of BOD_5 for the years 1964 through 1972 and in 1975. The BOD_5 at this location was found to range from 0.7 to 12.0 mg/l, with six of the 109 samples having a BOD_5 greater than 10.0 mg/l. Five of the six water samples having a BOD_5 greater than 10.0 mg/l were obtained in the summer months of June through August during the years 1965 through 1972 and in 1975, indicating possibly high and constant BOD_5 in the summer months at sampling station DNR-FX-27a.

Water Quality of Lakes in the Fox River Watershed: 1965-1975: The water quality variations of a lake depends upon the depth of the lake, as well as the season of the year. In shallow lakes the water is well mixed, and water quality is fairly uniform throughout the entire depth. In lakes deeper than 15 to 25 feet, however, thermal and chemical stratifications occur during summer. In the chemically stratified lakes, the water quality of the lakes varies with the depth. Of the 46 major lakes in the Fox River watershed, 34 lakes have a minimum depth of greater than 15 feet and therefore are likely to stratify during summer. Of the remaining 12 major lakes, Big Muskego, Echo, Lower Phantom, and Upper Phantom Lakes have a depth of three feet or less for 90 percent or more of the surface area and are therefore likely to freeze out during the winter time. Table 57 presents the available data sources and selected chemical and physical

Figure 42

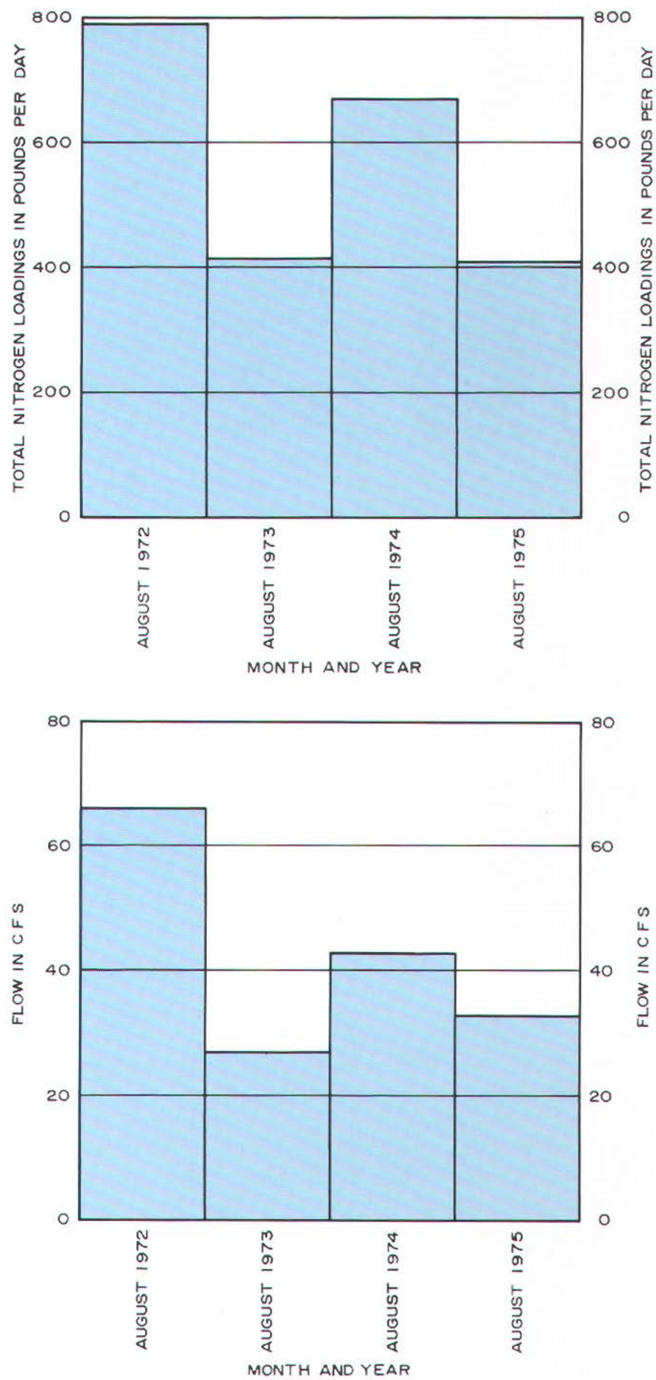
COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT THE FOX RIVER NEAR WILMOT (FX-27) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: U. S. Geological Survey and SEWRPC.

Figure 43

COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT THE FOX RIVER NEAR WAUKESHA (FX-7) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: U. S. Geological Survey and SEWRPC.

characteristics of the major lakes in the Fox River watershed. Among the 34 major lakes that are likely to stratify in the summer because of their depth, chemical data are available for 27. Of the major lakes, 19 are shown by available data to have below 1.0 mg/l of dissolved oxygen in the hypolimnion during summer. It is reasonable to assume that anaerobic conditions do occur in the hypolimnion of these lakes, consequently affecting the fish and other aquatic organisms present. The concentrations of dissolved oxygen in the epilimnion generally remained higher than 7.0 mg/l in the major lakes sampled.

Temperature and dissolved oxygen levels in the shallow lakes of the watershed generally are similar to the conditions existing in the epilimnion of the stratified lakes during the summer months, with oxygen levels near the dissolved oxygen saturation levels, or even supersaturated from aquatic plant photosynthesis. Of the major lakes, 35 have been classified according to Uttormark's trophic status classification systems. Based on hypolimnetic dissolved oxygen, transparency, fish kills, and use and impairment by macrophyte or algal growth, two lakes are classified as oligotrophic, 21 as mesotrophic, four as eutrophic, and eight as very eutrophic lakes. Table 57 presents the trophic status of 35 of the 46 major lakes in the Fox River watershed. Complete data are not available for the other major lakes for their classification according to trophic status.

Diurnal Water Quality Changes: Figures 44 through 49 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low-flow conditions on August 2 and 3, 1971, at sampling stations Fx-7 and Fx-27 on the Fox River. The rates of stream flow in the Fox River at those stations were 24 and 155 cfs, respectively, or four and 15 times the seven-day 10-year low flow of 6.8 and 98 cfs, respectively. Diurnal water quality data also are available at the tributary sampling stations Fx-2 on Sussex Creek, Fx-3 on Poplar Creek, Fx-5 on the Pewaukee River, Fx-12 on the Mukwonago River, Fx-15 on the Wind Lake Drainage Canal, Fx-20 on the White River, Fx-23 on Honey Creek, Fx-26 on Bassett Creek, and Fx-28 on Nippersink Creek and also are discussed. Although no flow data is available for the sampling days at the sampling locations on the tributaries with the exception of the Mukwonago River at sampling station Fx-12 and the White River at sampling station Fx-20, it is believed that the water quality variation in a 24-hour cycle on the tributaries would have a significant effect on the water quality of the main stream during the low-flow periods because these nine tributaries drain a very large portion of the watershed within the Region.

Fox River Main Stem: Water temperature was found to range from a low of 67°F at 3:35 a.m. on August 2, 1971, to a high of 76°F during the afternoon hour of 3:15 p.m. on the same day at station Fx-7. On the Fox River main stem at station Fx-27 located at Wilmot dam 1.2 miles from the Wisconsin-Illinois border, the temperature variations were found to range from 72°F to 75.5°F over a 24-hour period. The recorded diurnal water temperature fluctuation was likely the result of corresponding diurnal variations in air temperature and solar radiation. The higher temperature variation of 9°F at sampling station Fx-7, when compared to the temperature variation of 3.5°F at sampling station Fx-27, is considered reasonable in light of the low flow of water, 24 cfs at station Fx-7 versus 155 cfs at station Fx-27.

Chloride concentrations ranged from a low of 45 mg/l at 3:35 a.m. to a high of 100 mg/l at 3:15 p.m. at station Fx-7. At the other sampling station Fx-27, on the Fox River main stem, the chloride variation was found to range from 38 mg/l at 9:15 a.m. to 43 mg/l at 4:40 p.m. The generally high concentrations during low-flow condition—relative to the background levels of 10 to 20 mg/l of chloride—reflect the effects of pollution. The high diurnal variation of chloride concentrations at sampling station Fx-7 is likely to result from variation in effluent flow from the Village of Pewaukee sewage treatment plant over the 24-hour period, with higher flows and higher chloride concentrations during the daytime than during the nighttime hours.

The dissolved oxygen concentration was found to vary from a low of 6.7 mg/l during the early morning hours to a high of 15.3 mg/l in the late evening hours at sampling station Fx-7 and from 12.8 to 18.5 mg/l at sampling station Fx-27. The diurnal variation in the dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants. The hydrogen ion concentration (pH) was found to vary from a low of 8.0 and 8.6 standard units during the early morning hours to a high of 8.8 and 9.0 standard units in the late evening hours at sampling stations Fx-7 and Fx-27, respectively. The uptake of carbon dioxide by photosynthesis of aquatic plants may account for the higher pH in the late evening hours, and the lower pH during the early morning hours may be accounted for by the release of carbon dioxide during respiration by algae and aquatic plants.

Fox River Tributaries: Diurnal water quality changes also were determined at sampling station Fx-2 on Sussex Creek, at station Fx-3 on Poplar Creek, at station Fx-5 on the Pewaukee River, at station Fx-12 on the Mukwonago River, at station Fx-16 on the Wind Lake Drainage Canal, at station Fx-20 located on the White River below the confluence with Como Creek, at station Fx-23 on Honey Creek, at station Fx-26 on Bassett Creek, and at station Fx-28 on Nippersink Creek and are discussed in this section.

Sussex Creek: At sampling station Fx-2 on Sussex Creek, six water quality samples were collected on August 1 and 2, 1971, at four-hour intervals over a 24-hour period.

Table 57

AVAILABLE DATA ON THE MAJOR LAKES IN THE FOX RIVER WATERSHED

Name of Lake	County	Maximum Depth	Type of Lake	WDNR[a] Data	EPA[b] Data	Lake Use[c] Data	Trophic[d] Status	Summer Stratification	Anaerobic Condition in Hypolimnion
Army	Walworth	17	kettle	N/A	N/A	Yes	N/A	N/A	N/A
Benedict	Kenosha	37	headwater	N/A	N/A	N/A	N/A	N/A	N/A
Beulah	Walworth	58	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Big Muskego	Waukesha	4	flow-through	Yes	N/A	N/A	eutrophic	Yes	N/A
Bohner	Racine	30	flow-through	N/A	N/A	Yes	mesotrophic	Yes	Yes
Booth	Walworth	24	kettle	N/A	N/A	Yes	mesotrophic	Yes	Yes
Browns	Racine	44	headwater	Yes	Yes	Yes	mesotrophic	Yes	Yes
Buena	Racine	8	flow-through	N/A	N/A	N/A	mesotrophic	N/A	N/A
Camp	Kenosha	19	flow-through	Yes	N/A	Yes	very eutrophic	Yes	N/A
Center	Kenosha	28	flow-through	N/A	N/A	Yes	mesotrophic	Yes	Yes
Como	Walworth	9	headwater	Yes	Yes	Yes	very eutrophic	No	N/A
Cross	Kenosha	35	headwater	N/A	N/A	Yes	N/A	Yes	Yes
Denoon	Waukesha	55	flow-through	N/A	N/A	Yes	mesotrophic	Yes	Yes
Dyer	Kenosha	13	flow-through	N/A	N/A	Yes	N/A	N/A	N/A
Eagle	Racine	15	flow-through	Yes	N/A	Yes	very eutrophic	Yes	N/A
Eagle Spring	Waukesha	8	flow-through	Yes	N/A	Yes	mesotrophic	No	N/A
Echo	Racine	11	flow-through	N/A	N/A	Yes	mesotrophic	N/A	N/A
Elizabeth	Kenosha	32	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Geneva	Walworth	135	headwater	Yes	Yes	Yes	mesotrophic	Yes	No
Green	Walworth	57	flow-through	N/A	Yes	Yes	mesotrophic	Yes	Yes
Kee Nong Go Mong	Racine	25	flow-through	N/A	N/A	Yes	N/A	Yes	Yes
Lilly	Kenosha	6	kettle	Yes	N/A	Yes	N/A	No	N/A
Little Muskego	Waukesha	65	flow-through	N/A	N/A	Yes	eutrophic	Yes	Yes
Long	Racine	5	flow-through	N/A	N/A	Yes	eutrophic	N/A	N/A
Lower Phantom	Waukesha	12	flow-through	Yes	N/A	Yes	mesotrophic	No	N/A
Lulu	Walworth	40	flow-through	N/A	N/A	Yes	N/A	Yes	Yes
Marie	Kenosha	33	headwater	Yes	N/A	N/A	mesotrophic	Yes	N/A
Middle	Walworth	42	flow-through	N/A	N/A	N/A	mesotrophic	Yes	N/A
Mill	Walworth	44	flow-through	N/A	N/A	N/A	mesotrophic	Yes	N/A
North	Waukesha	78	kettle	Yes	N/A	N/A	very eutrophic	N/A	N/A
Pell	Walworth	13	headwater	Yes	N/A	Yes	eutrophic	N/A	N/A
Peters	Walworth	8	kettle	N/A	N/A	Yes	N/A	N/A	N/A
Pewaukee	Waukesha	45	headwater	Yes	Yes	Yes	very eutrophic	Yes	Yes
Pleasant	Walworth	29	kettle	N/A	N/A	Yes	oligotrophic	Yes	Yes
Potters	Walworth	26	kettle	Yes	N/A	Yes	eutrophic	Yes	Yes
Powers	Kenosha	33	kettle	N/A	N/A	Yes	mesotrophic	Yes	Yes
Saylesville Millpond	Waukesha	5	flow-through	N/A	N/A	N/A	N/A	N/A	N/A
Silver	Kenosha	44	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Silver	Walworth	3	kettle	N/A	N/A	N/A	N/A	N/A	N/A
Spring	Waukesha	22	flow-through	N/A	N/A	Yes	oligotrophic	N/A	N/A
Tichigan	Racine	63	flow-through	Yes	Yes	N/A	very eutrophic	Yes	N/A
Upper Phantom	Waukesha	29	flow-through	N/A	N/A	Yes	mesotrophic	Yes	Yes
Voltz	Kenosha	24	headwater	N/A	N/A	N/A	N/A	N/A	N/A
Wandawega	Walworth	9	kettle	N/A	N/A	N/A	very eutrophic	N/A	N/A
Waubeesee	Racine	73	flow-through	N/A	N/A	N/A	mesotrophic	N/A	N/A
Wind	Racine	47	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes

NOTE: N/A indicates data not available.

[a] *Wisconsin Department of Natural Resources, Bureau of Research, Quarterly Inland Lake Monitoring Program, 1973-1977.*

[b] *National Eutrophication Survey Methods for Lakes Sampled in 1972, Working Paper No. 1, Pacific Northwest Environmental Research Laboratory, Environmental Protection Agency, October 1974.*

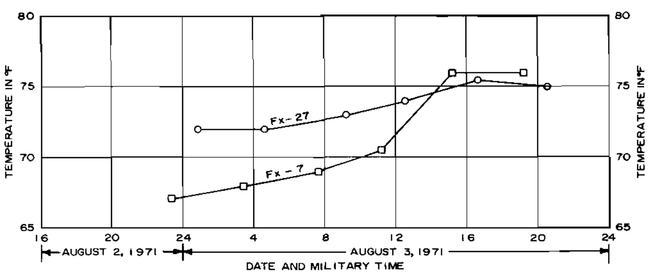
[c] *Lake Use Reports prepared by the Wisconsin Department of Natural Resources for the Southeastern Wisconsin Regional Planning Commission and financed in part by the U. S. Department of Housing and Urban Development under provisions of Section 701 of the Housing Act of 1954 as amended, 1968-1974.*

[d] *Paul D. Uttormark and J. Peter Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Water Resources Center, University of Wisconsin-Madison and U. S. Environmental Protection Agency, June 1975, EPA 660/3-75-033.*

Source: SEWRPC.

Figure 44

DIURNAL VARIATIONS IN TEMPERATURE IN THE FOX RIVER WATERSHED AT SAMPLING STATIONS FX-7 AND FX-27 AUGUST 2-3, 1971



Source: SEWRPC.

Water temperature at this location was found to vary from a low of 65°F to a high of 74°F at 2:55 p.m. and 6:50 p.m., respectively. The recorded diurnal water temperature fluctuation was likely the result of corresponding diurnal variation in the air temperature and incident solar radiation. Chloride concentrations were found to range from 65 to 71 mg/l on August 2, 1971, in the six samples collected at four-hour intervals. A comparison of August 1971 data with those of August of the years 1970 and 1972 through 1975 indicates that the 1971 data were unusually constant. In the other years the daily chloride concentrations were found to vary from 29 to 61 units, indicating the presence of an intermittent source of chloride. The higher chloride concentrations often were associated with higher fecal coliform counts, indicating sewage effluent and wastes from animals as likely sources.

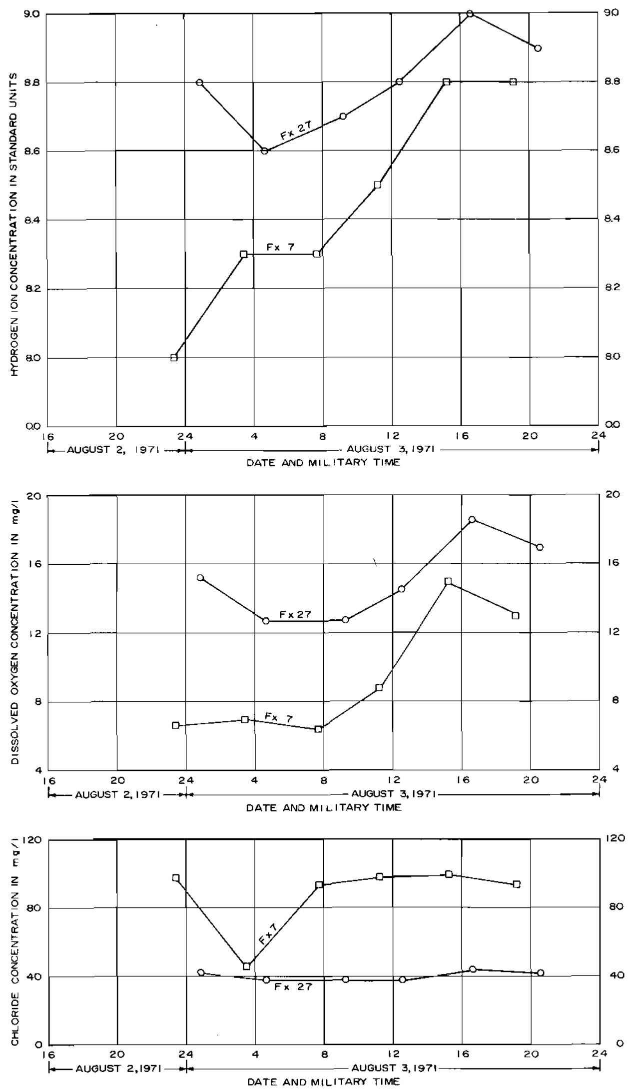
The concentration of dissolved oxygen at sampling station Fx-2 on Sussex Creek was found to vary from a low of 5.0 mg/l during the early morning hours to a high of 13.7 mg/l during the afternoon hours. The hydrogen ion concentration (pH) was found to vary from a low of 7.8 to a high of 8.7 standard units during the late evening hours. The pH and dissolved oxygen variations generally can be attributed to the aquatic plant respiration and photosynthesis.

Poplar Creek: At sampling station Fx-3 on Poplar Creek, water quality data were collected on August 2, 1971, at four-hour intervals over a 24-hour period. Water temperature at this location was found to vary from a low of 65°F at 8:00 a.m. to a high of 74°F at 2:55 p.m. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in the air temperature and incident solar radiation.

Chloride concentrations were found to range from 65 to 73 mg/l in six samples collected over a 24-hour period on August 2, 1971. A comparison of August 1971 chloride data with those of August of the years 1970 and 1972 through 1975 shows diurnal variations of less than 10 units over a 24-hour period except for the year 1970

Figure 45

DIURNAL VARIATIONS IN HYDROGEN ION (PH), DISSOLVED OXYGEN, AND CHLORIDE CONCENTRATIONS IN THE FOX RIVER WATERSHED AT SAMPLING STATIONS FX-7 AND FX-27 AUGUST 2-3, 1971



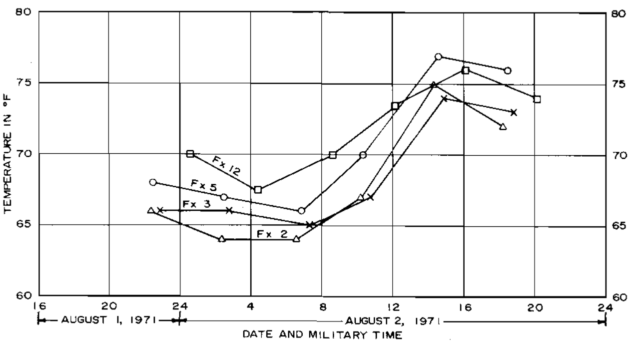
Source: SEWRPC.

when the chloride concentration varied by 25 mg/l over a 24-hour period. The high, but fairly constant, chloride concentrations in six daily samples indicate a continuous chloride input from human sources such as sewage treatment plant effluent.

The concentration of dissolved oxygen at sampling station Fx-3 on Poplar Creek was found to vary from a low of 3.1 mg/l at 7:20 a.m. to a high of 10.4 mg/l at 2:55 p.m. The diurnal variation in dissolved oxygen concentrations can be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants.

Figure 46

DIURNAL VARIATIONS IN TEMPERATURE IN THE FOX RIVER WATERSHED AT SAMPLING STATIONS FX-2, FX-3, FX-5, AND FX-12: AUGUST 1-2, 1971



Source: SEWRPC.

The hydrogen ion concentration (pH) was found to vary from a low of 7.7 at 7:20 a.m. to 8.2 standard units at 2:55 p.m. The 0.5 standard unit change over a 12-hour period is normal where high rates of respiration and photosynthesis occur in the presence of high counts of algae and other aquatic plants.

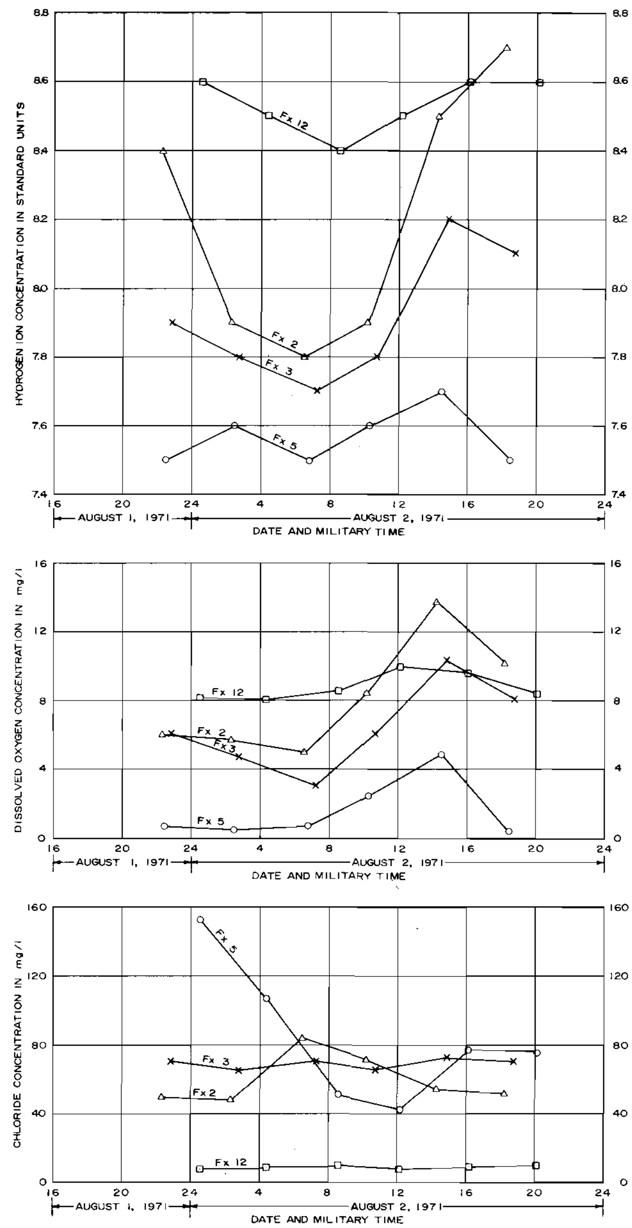
Pewaukee River: At sampling station Fx-5 on the Pewaukee River, water quality data were collected on August 1 and 2, 1971, at four-hour intervals over a 24-hour period. Water temperature at this location was found to vary from a low of 66°F at 8:00 a.m. to a high of 77°F at 6:30 p.m. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in the air temperature and incident solar radiation.

Chloride concentrations were found to range from 153 mg/l at 10:30 p.m. on August 1, 1971, to 43 mg/l at 10:00 a.m. on August 2, 1971. A comparison of the 1971 chloride data with those of August 1970 and of the years 1972 through 1975 indicates less than a 10-unit change over a 24-hour period for the years 1972 and 1975, and less than a 20-unit change for the other years. Thus, the high chloride concentration of 153 mg/l in the sample taken at 10:30 p.m. is likely to result from a temporary diffuse source such as animal waste. The high chloride concentrations—greater than 40 to 50 mg/l—are likely to be associated with a pollution source such as a sewage treatment plant discharge. Sampling station Fx-5 is located downstream from the sewage outfall of the Village of Pewaukee Sewage Treatment Plant.

The concentration of dissolved oxygen at sampling station Fx-5 was found to vary from a low of 0.5 mg/l at 2:30 a.m. to a high of 4.8 mg/l at 2:35 p.m. The low dissolved oxygen concentrations in all the six samples collected on August 1 and 2, 1971, reflect the effect of the effluent from the Village of Pewaukee Sewage Treatment Plant. Similar results of 0.0 to 5.0 mg/l of dissolved oxygen in a 24-hour survey during the month of August

Figure 47

DIURNAL VARIATIONS IN HYDROGEN ION (PH), DISSOLVED OXYGEN, AND CHLORIDE CONCENTRATIONS IN THE FOX RIVER WATERSHED AT SAMPLING STATIONS FX-2, FX-3, FX-5, AND FX-12: AUGUST 1-2, 1971

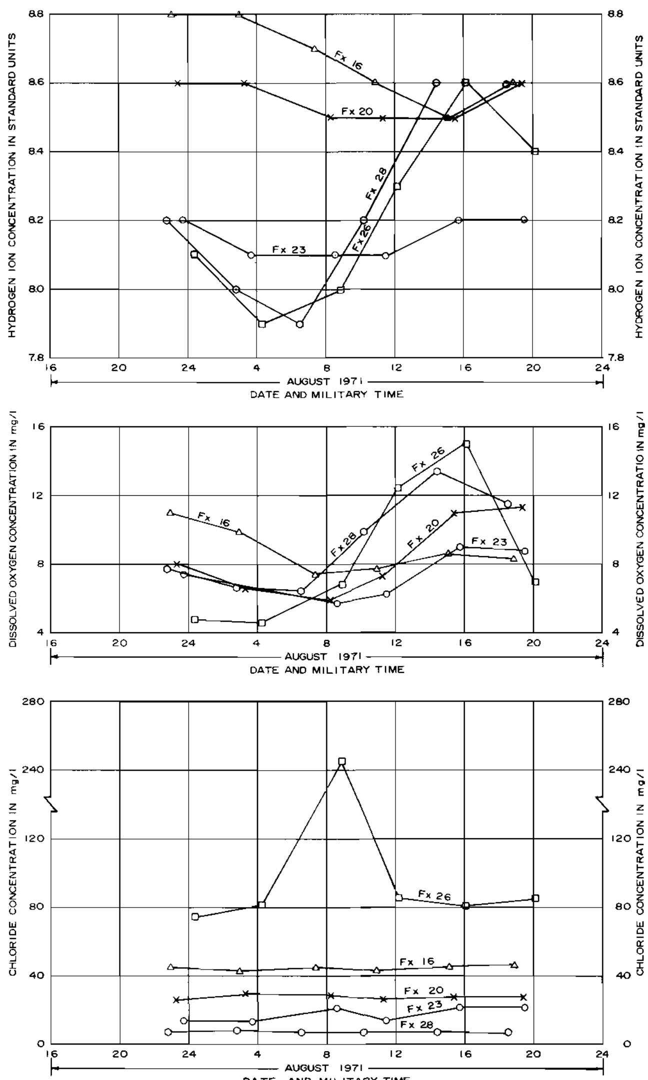


Source: SEWRPC.

in the years 1970 and 1972 through 1975 were observed at this location. The diurnal variation in dissolved oxygen concentrations can be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants. However, the stream clearly reflects the adverse water quality impacts of the sewage effluent discharged into it.

Figure 48

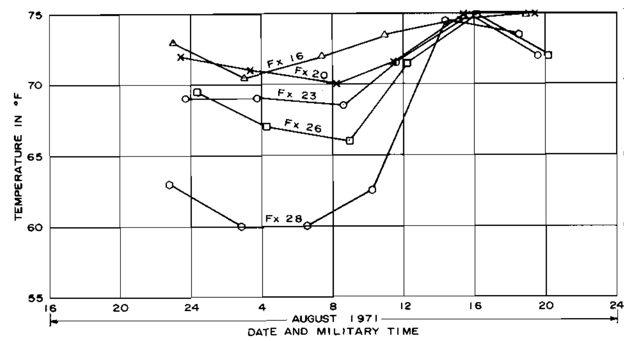
DIURNAL VARIATIONS IN HYDROGEN ION (PH), DISSOLVED OXYGEN, AND CHLORIDE CONCENTRATIONS IN THE FOX RIVER WATERSHED AT SAMPLING STATIONS FX-16, FX-20, FX-23, FX-26, AND FX-28: AUGUST 2-3, 1971



Source: SEWRPC.

Figure 49

DIURNAL VARIATIONS IN TEMPERATURE RECORDED IN THE FOX RIVER WATERSHED AT SAMPLING STATIONS FX-16, FX-20, FX-23, AND FX-26: AUGUST 4-5, 1971



Source: SEWRPC.

The hydrogen ion concentration (pH) was found to vary from a low of 7.5 at 6:55 a.m. to 7.7 standard units at 2:35 p.m. The 0.2 standard unit change over a 24-hour period is well within the range attributable to the effects of respiration and photosynthesis of aquatic plant life.

Mukwonago River: At sampling station Fx-12 on the Mukwonago River, water quality data were collected on August 1 and 2, 1971, at four-hour intervals over a 24-hour period. Water temperature at this location was found to vary from a low of 67.5°F at 4:20 a.m. to a high of 76.0°F at 4:05 p.m. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in the air temperature and incident solar radiation.

Chloride concentrations were found to range from eight to 10 mg/l in six samples collected over a 24-hour period on August 1 and 2, 1971. A comparison of August 1971 chloride data with those of August of the years 1970 and 1972 through 1975 indicates similar low concentrations of chloride and little or no diurnal variation. The low and constant chloride concentrations in the six daily samples indicate that the primary source of chloride in the Mukwonago River is groundwater inflow. The water quality as measured by the chloride content is very good and does not appear to be affected by pollution from human activities.

The concentration of dissolved oxygen at sampling station Fx-12 was found to vary from a low of 8.1 mg/l at 4:20 a.m. to a high of 10.0 mg/l at 12:10 p.m. This diurnal variation in dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants. The high dissolved oxygen levels throughout the days observed in August low-flow conditions over the past six years correlate well with the low chloride concentrations and indicate good water quality conditions in the Mukwonago River at station Fx-12.

The hydrogen ion concentration (pH) was found to vary from a low of 8.4 at 8:40 a.m. to a high of 8.6 standard units at 8:10 p.m. The 0.2 standard unit change observed over a 24-hour period is normal with respiration and photosynthesis of algae and other aquatic plants.

Wind Lake Drainage Canal: At sampling station Fx-16 located on the Wind Lake Drainage Canal, water quality data were collected on August 2 and 3, 1971, at four-hour intervals over a 24-hour period. Water temperature at this location was found to vary from a low of 70.5°F at 3:00 a.m. to a high of 75.0°F during the afternoon hour of 3:05 p.m. The recorded diurnal water temperature fluctuation was likely the result of corresponding diurnal variations in the air temperature and solar radiation.

Chloride concentrations were found to range from 43 to 46 mg/l in the six samples collected over a 24-hour period on August 2 and 3, 1971. A comparison of August 1971 chloride data with those of August of the years 1970 and 1972 through 1975 indicates changes of 3 mg/l or less over a 24-hour period, except in the year 1970 when the chloride concentration varied by 21 mg/l over a 24-hour period. The concentration of chloride in the Wind Lake Drainage Canal being consistently higher than the area groundwater chloride concentration of less than 10 mg/l indicates the presence of a continuing chloride source in the tributary drainage area of the canal.

The concentration of dissolved oxygen at sampling station Fx-16 was found to vary from a low of 7.5 mg/l at 7:30 a.m. to a high of 9.3 mg/l at 7:00 p.m. The diurnal variation in dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen by the algae and other aquatic plants.

The hydrogen ion concentration (pH) was found to vary from a high of 8.8 standard units at 3:00 a.m. to a low of 8.5 standard units at 3:05 p.m. In the afternoon hours when the photosynthetic activity of algae is at a maximum, thus decreasing the carbon dioxide in water to a minimum, the pH should be at a maximum. At sampling station Fx-15 on the Wind Lake Canal the pH in the sample collected at 3:05 p.m. was lower than in the early morning sample.

White River: At sampling station Fx-20 on the White River, water quality data were collected on August 1 and 2, 1971, at four-hour intervals over a 24-hour period. Water temperture at this location was found to vary from a low of 70°F at 3:25 a.m. to a high of 75°F at 3:30 p.m. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in the air temperature and incident solar radiation.

Chloride concentrations were found to range from 26 to 30 mg/l in the six samples collected over a 24-hour period on August 1 and 2, 1971. The concentration of chloride in the White River being higher than the area groundwater chloride concentration of 10 mg/l indicates a continuing chloride input from the effluent of the Lake Geneva Sewage Treatment Plant.

The concentration of dissolved oxygen at sampling station Fx-20 was found to vary from a low of 5.9 mg/l at 8:15 a.m. to a high of 11.6 mg/l at 7:20 p.m. The low early morning dissolved oxygen concentrations may be attributed to respiration by aquatic plants. The dissolved oxygen concentration increased considerably during the daytime, and this may be attributed to the net photosynthetic production of oxygen. The hydrogen ion concentration (pH) varied only minimally from 8.5 to 8.6 standard units during the 24-hour survey.

Honey Creek: At sampling station Fx-23 on Honey Creek, water quality data were collected on August 2 and 3, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of 69.0°F at 5:45 a.m. to a high of 74.5°F during the afternoon hour of 3:45 p.m. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in the air temperature and solar radiation.

Chloride concentrations were found to range from 13 to 16 mg/l in the six samples collected over a 24-hour period on August 2 and 3, 1971. A comparison of August 1971 chloride data with those of August of the years 1970 and 1972 through 1975 indicates changes of less than 11 mg/l during the 24-hour period for all six years. The high but fairly constant chloride concentrations in the six daily samples indicate a continuing chloride input from the effluent of the Village of Twin Lakes Sewage Treatment Plant.

The concentration of dissolved oxygen at sampling station Fx-26 was found to vary from a low of 4.6 mg/l at 4:15 a.m. to a high of 15.0 mg/l at 4:10 p.m. The low early morning dissolved oxygen concentration may be attributed to respiration of aquatic plants. The net photosynthetic production of oxygen is considered the reason for the considerable increase in the dissolved oxygen concentration during the daytime.

The hydrogen ion concentration (pH) was found to vary from a low of 7.9 at 4:15 a.m. to 8.6 standard units at 4:10 p.m. The observed range of 0.7 standard units over a 24-hour period is considered normal where high rates of respiration and photosynthesis occur as a result of observed high levels of aquatic plant activity.

Nippersink Creek: At sampling station Fx-28 on Nippersink Creek, water quality data were collected on August 4 and 5, 1971, at four-hour intervals over a 24-hour period. Water temperature at this location was found to vary from a low of 60.0°F at 6:30 a.m. to a high of 74.5°F during the afternoon hour of 2:55 p.m. The wide range of recorded diurnal water temperature values was the likely result of corresponding diurnal variations in the air temperature and incident solar radiation on the relatively small amount of flow present in the stream.

Chloride concentrations were found to range from 17 to 18 mg/l in the six samples collected over a 24-hour period on August 4 and 5, 1971. A comparison of August 1971 chloride data with those of August of the years 1970 and 1972 through 1975 indicates less than 7 mg/l change during all 24-hour periods observed. The low and constant chloride concentrations found in the 24-hour sampling surveys indicate good water quality conditions in the stream.

The concentration of dissolved oxygen at sampling station Fx-28 was found to vary from a low of 6.5 mg/l at 6:30 a.m. to a high of 13.4 mg/l at 2:25 p.m. The diurnal variation of dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen.

The hydrogen ion concentration (pH) was found to vary from a low of 7.9 at 6:30 a.m. to 8.6 standard units at 2:25 p.m. The slight variation is considered a normal result of high rates of respiration and photosynthesis of algae and other aquatic plants.

The diurnal fluctuations in water quality on this stream are such that the average levels of the concentrations of key parameters meet the established water quality standards while high or low levels during the daily cycle do not meet the standards. For example, the average of six dissolved oxygen concentration values over the 24-hour period sampled on August 2-3, 1971, were 6.5 and 8.9 mg/l for stations Fx-3 on the Fox River main stem and Fx-26 on Bassett Creek, respectively. Although these levels are well above the minimum standard of 5.0 mg/l for recreational use and preservation of fish and aquatic life, substandard oxygen levels of 3.1 and 4.6 mg/l were measured in samples taken at each location in the early morning hours of the same day.

Spatial Water Quality Changes on the Main Stem of the Fox River: The water quality surveys clearly indicate water quality changes from one location to another within the watershed stream system in response to a combination of human activities and natural phenomena. Figures 50 through 55 show the spatial water quality variation along the entire main stem of the Fox River as recorded under low-flow hydrological conditions during the period for the years 1968 through 1975. The illustrations present the range of chloride, specific conductance, dissolved oxygen, total phosphorus, total nitrogen concentrations, and fecal coliform counts obtained over the past eight-year sampling survey at each Fox River main stem sampling station. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter, thus dividing the data into three categories: (1) the range of the 25 percent of the samples near the minimum values, (2) the range of the middle 50 percent of the samples, and (3) the range of the 25 percent of the samples near the maximum.

Figure 52, which presents the range of spatial dissolved oxygen variation in the Fox River main stem, indicates a general increasing trend from the source (Fx-1) to the mouth (Fx-27) of the Fox River, although the dissolved oxygen concentrations decreased at some of the intermediate sampling stations. The samples collected at station Fx-4 showed a decrease in dissolved oxygen concentrations when compared to the data from sampling station Fx-1. At station Fx-4 the 25 percent of the samples which are near the maximum (see Figure 52) were obtained during the 1974 and 1975 sampling surveys and reflect the abandonment of the old Fox River sewage treatment plant and Poplar Creek lagoons in the City of Brookfield in 1973 and construction and operation of the new City of Brookfield sewage treatment facility in early 1974. Since sampling station Fx-4 is located downstream from Poplar Creek to which the wastewater effluents from the then-existing two sewage treatment facilities were discharged, the improved water quality is directly associated with the improved waste treatment facility at the City of Brookfield. The dissolved oxygen concentrations increased from sampling station Fx-4 to station Fx-7 and decreased slightly from station Fx-7 to station Fx-8. The dissolved oxygen concentrations at sampling station Fx-8, located downstream from the City of Waukesha Sewage Treatment Plant, indicates the effect of the wastewater effluent on the water quality. The dissolved oxygen concentrations increased from sampling stations Fx-8 through Fx-27 on the Fox River main stem, as indicated in Figure 52.

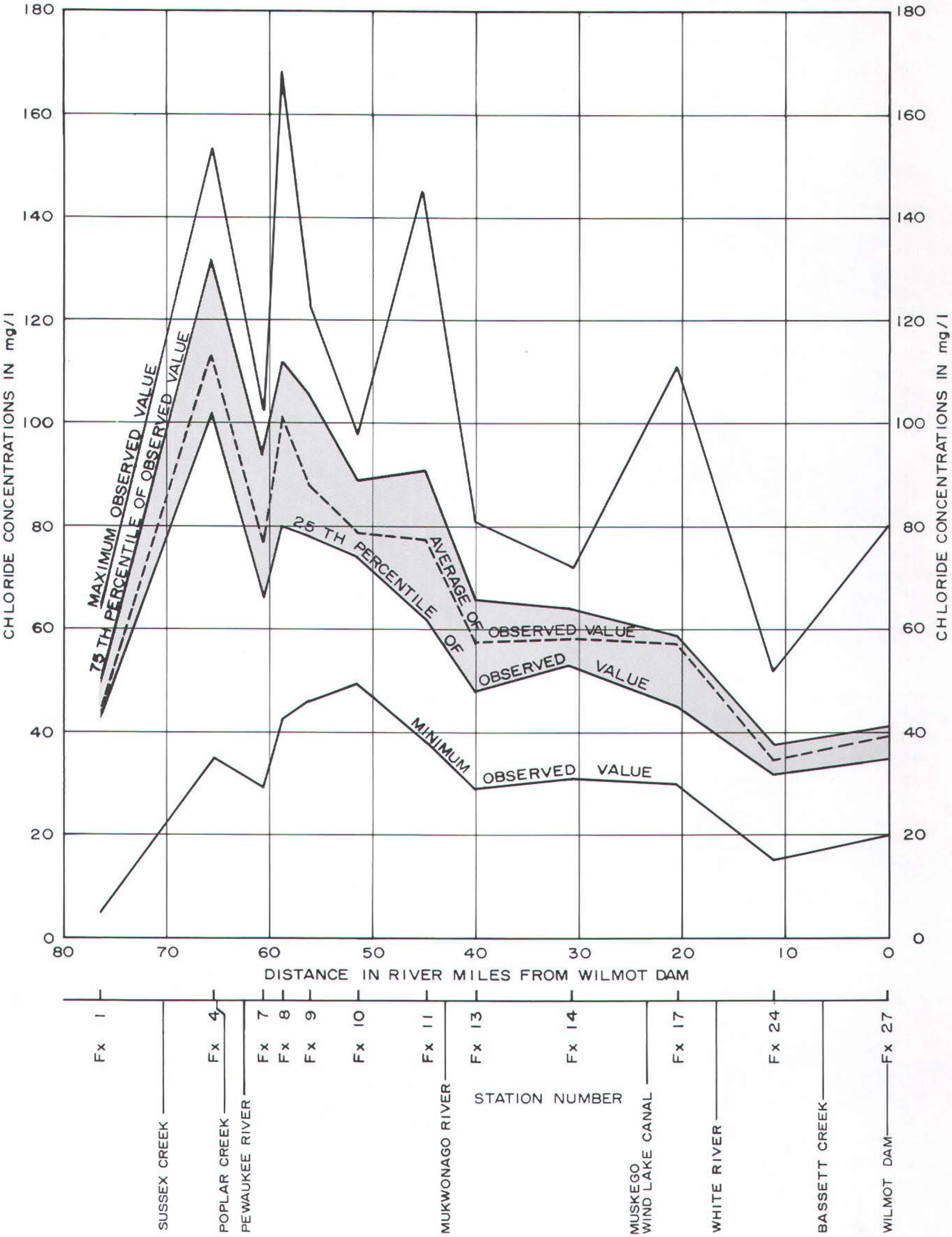
The range of chloride concentrations observed along the main stem of the Fox River showed a generally inverse relationship to the dissolved oxygen concentrations (Figure 50). The chloride concentrations increased from sampling station Fx-1 to sampling station Fx-4, decreased from station Fx-4 to station Fx-7, increased from station Fx-7 to station Fx-8, and significantly decreased from station Fx-8 through sampling station Fx-27. This inverse relationship between chloride and dissolved oxygen concentrations, especially at locations downstream from sewage treatment effluents—such as sampling station Fx-4 downstream from the City of Brookfield sewage treatment facilities and station Fx-8 downstream from the City of Waukesha sewage treatment facility—indicate the adverse effect of the waste effluents on the water quality of the Fox River main stem. The total nitrogen, total phosphorus, and the specific conductance levels followed the same pattern as that of the chlorides, with an increase from sampling station Fx-1 to station Fx-4, decrease from station Fx-4 to station Fx-7, increase from station Fx-7 to station Fx-8, and then a decrease downstream through station Fx-27 located at Wilmot dam 1.2 miles from the Wisconsin-Illinois State line.

The average fecal coliform counts and the fecal coliform counts of 75 percent of the samples collected over the eight-year period at each location on the Fox River main stem were less than 500 MFFCC/100 ml with the exception of samples at sampling stations Fx-7, Fx-9, Fx-17, and Fx-24. Counts of fecal coliform, the indicator of bacteriological pollution, were higher at station Fx-7 than at station Fx-4. High fecal coliform counts, an average of 1,000 MFFCC/100 ml, were found at sampling station Fx-7, located downstream from the Village of Pewaukee sewage treatment plant. At sampling stations Fx-9 and Fx-17 the high fecal coliform counts are likely to be associated with animal feeding operations in the area since there are no known municipally or privately owned sewage treatment facilities located near these sampling stations. The high fecal coliform counts found at sampling station Fx-24 are likely to be associated with the effluent from the City of Burlington sewage treatment plant located upstream from the station.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples between 1964 and

Figure 50

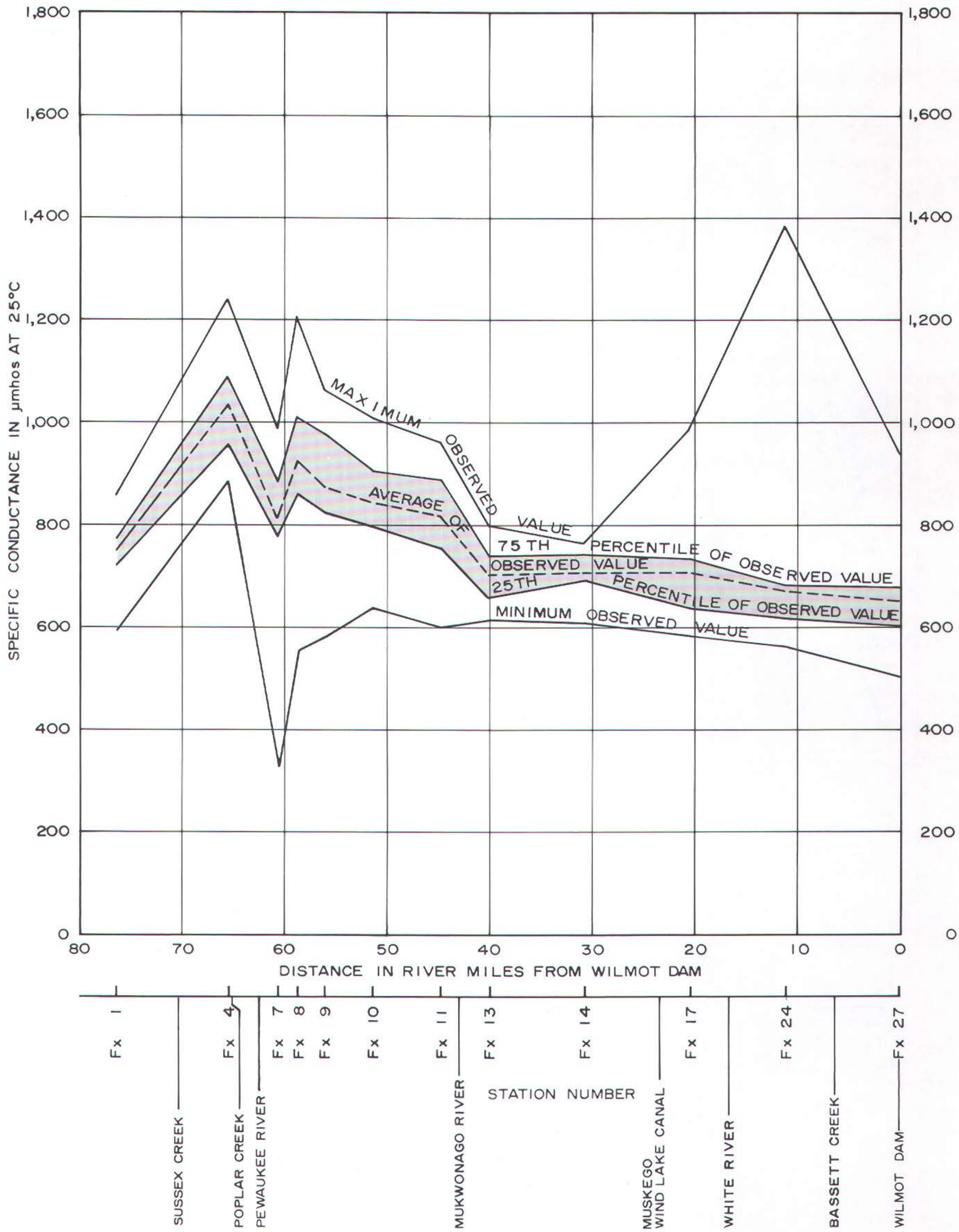
SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE FOX RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 51

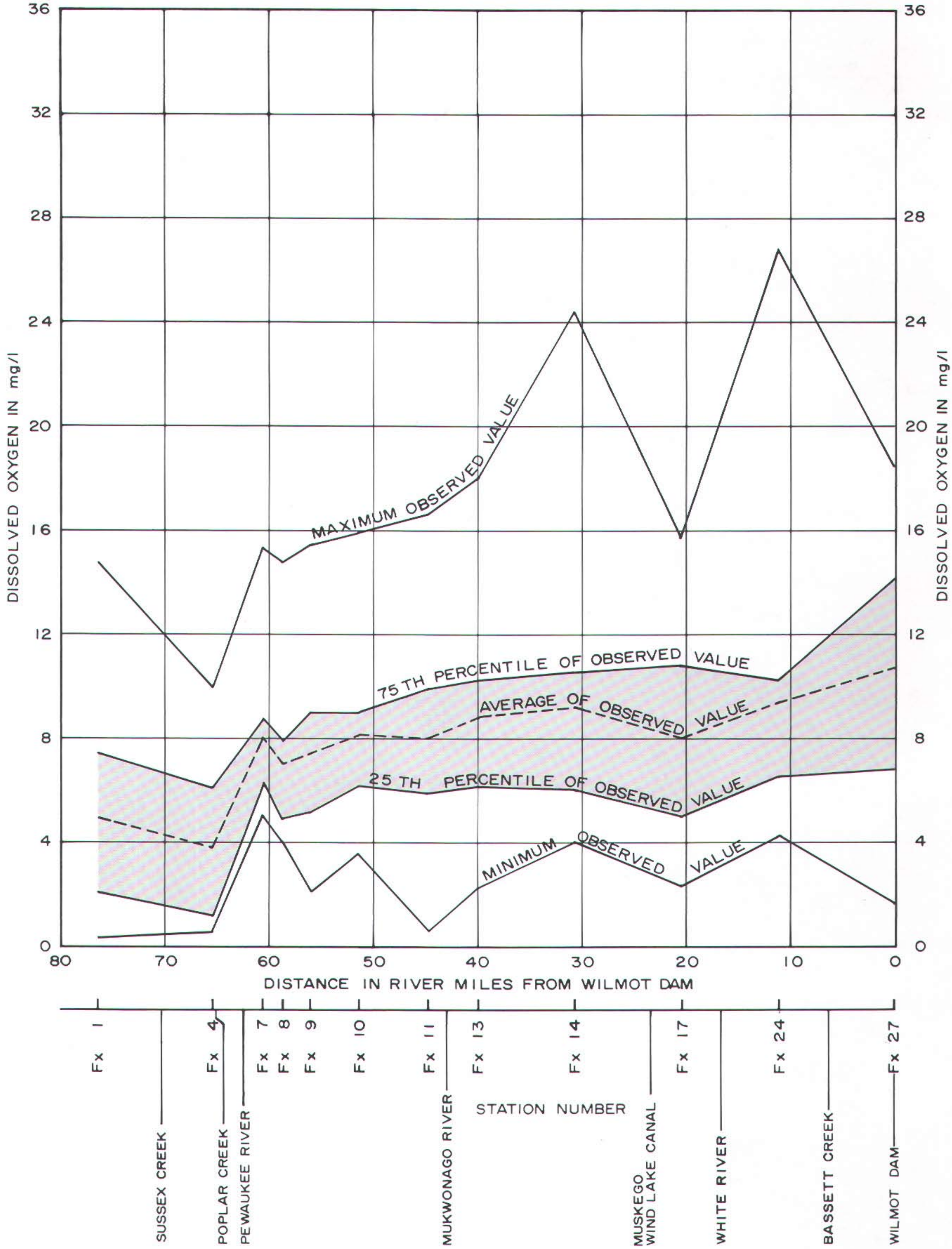
SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE FOX RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 52

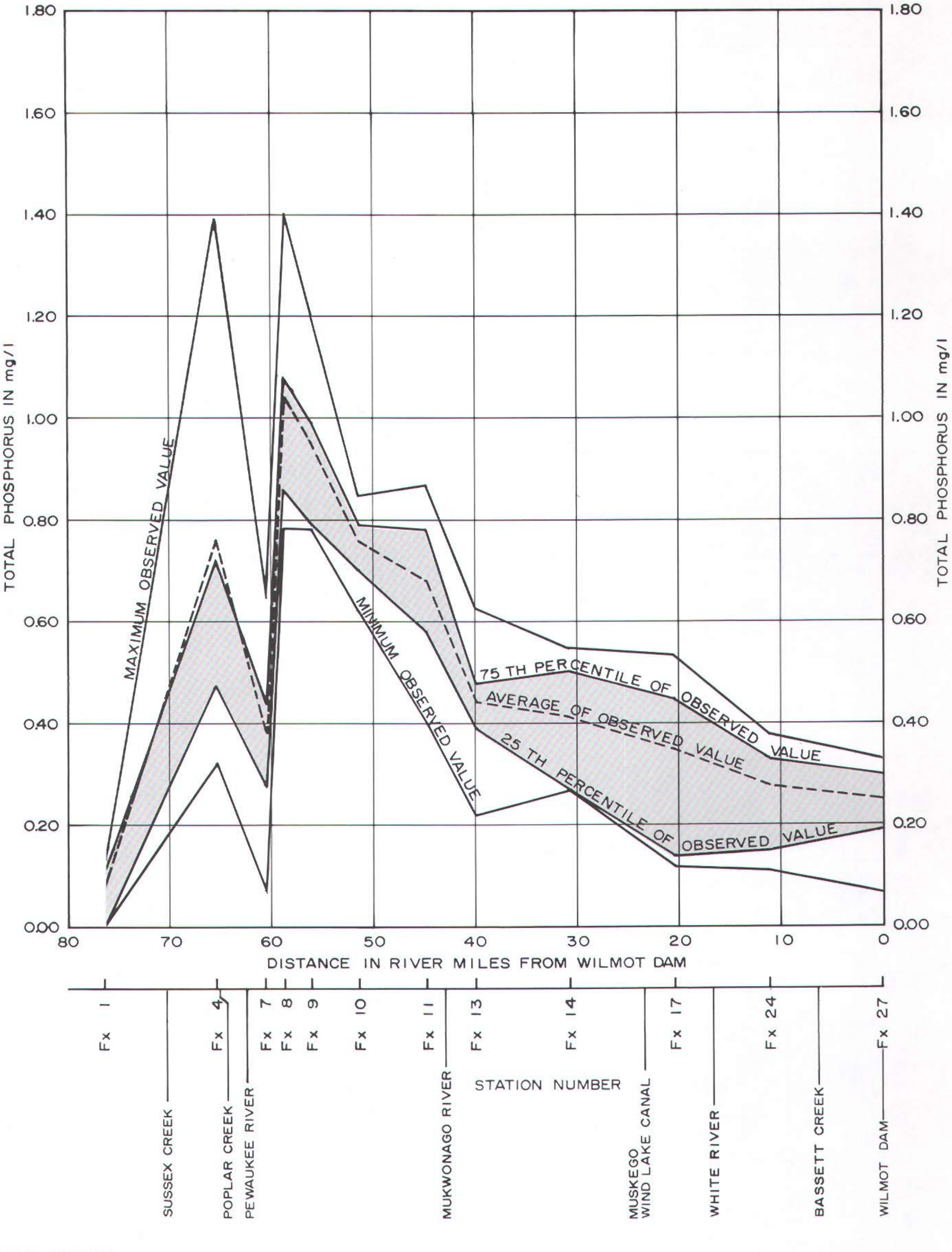
SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN TH FOX RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 53

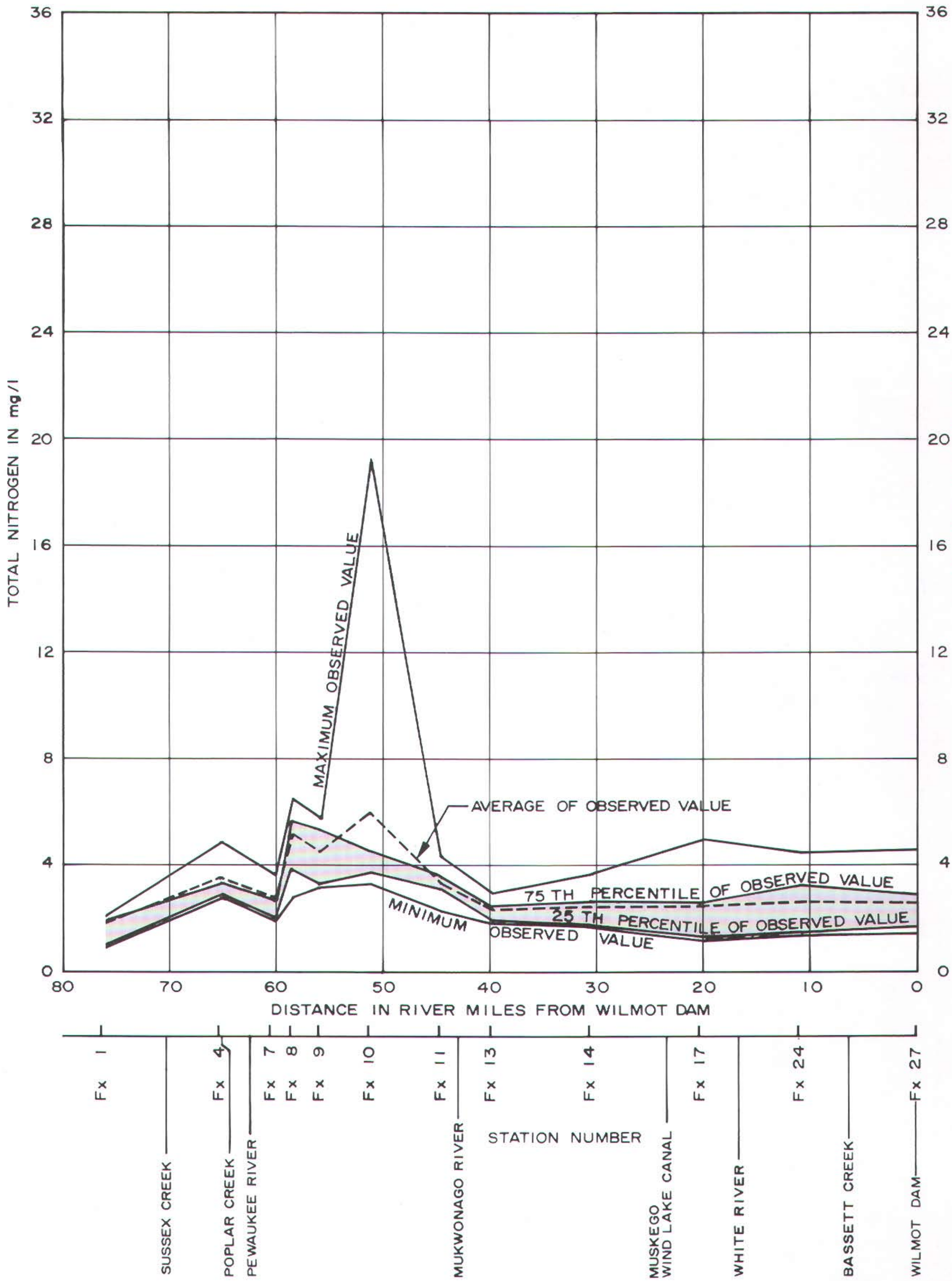
SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE FOX RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 54

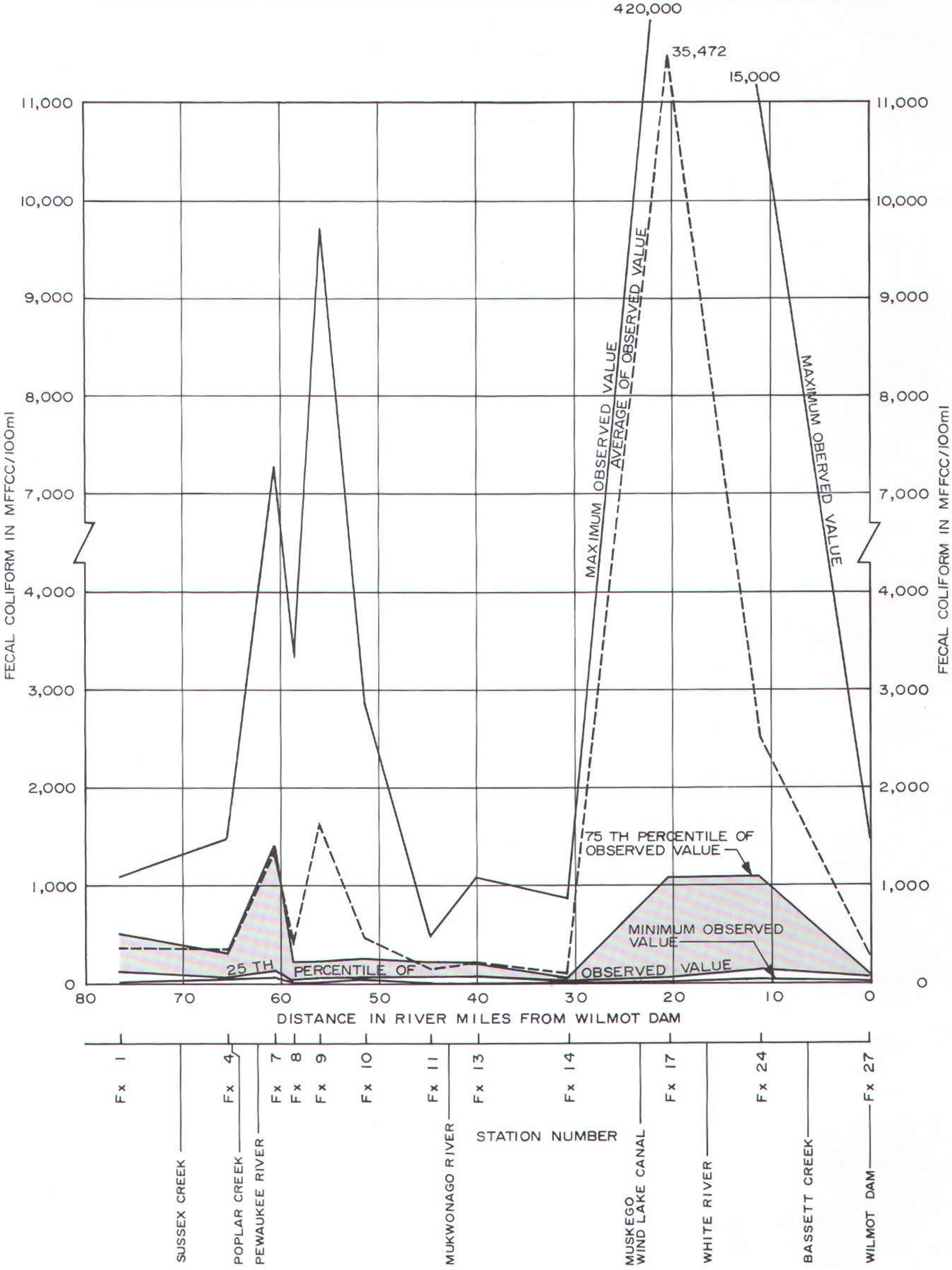
SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE FOX RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 55

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE FOX RIVER WATERSHED: 1968-1975



Source: SEWRPC.

1975 were used to assess the quality of the Fox River stream network and changes in that quality over time by comparison to the water quality standards that support the established water use objectives. Those objectives are for recreation and the maintenance of fish and aquatic life for the Fox River main stem and all tributaries except Sussex Creek designated for restricted use and for Palmer Creek for maintenance of a trout fishery. The comparative analysis of the water quality data must consider the concurrent hydrologic conditions, since the water quality standards are not intended to be satisifed under all streamflow conditions. The data from the two daily streamflow gages on the Fox River indicate that the streamflows during all the surveys were in excess of the seven-day average "one in ten year" low-flow, above which the water quality standards are to be met.

The comparative analysis of observed water quality and the standards were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are the recommended levels which have been adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month, nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the recreational use objective standard for fecal coliform bacteria was assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the stream water quality conditions in the Fox River watershed as these conditions existed during August 1964 and the adopted water quality standards are summarized on Map 18. A color coding scheme is used on Map 18 to indicate which of the standards are exceeded and along what stream reaches.

For the main stem of the Fox River within the Region designated for recreational use and preservation of fish and aquatic life, the water quality during the survey satisfied the temperature and pH standards throughout the watershed. Substandard dissolved oxygen levels were found at two locations, sampling stations Fx-1 and Fx-4 in the headwater area. Water quality conditions in tributaries of the Fox River satisifed the temperature and pH standards. The dissolved oxygen concentrations, however, were below the recommended level of 5.0 mg/l in Como Creek, Bassett Creek, and the Muskego Canal as determined by the samples collected at sampling stations Fx-19, Fx-25, and Fx-15, respectively. In the Muskego Canal, station Fx-15, the dissolved oxygen did not meet even the restricted use standard of 2.0 mg/l.

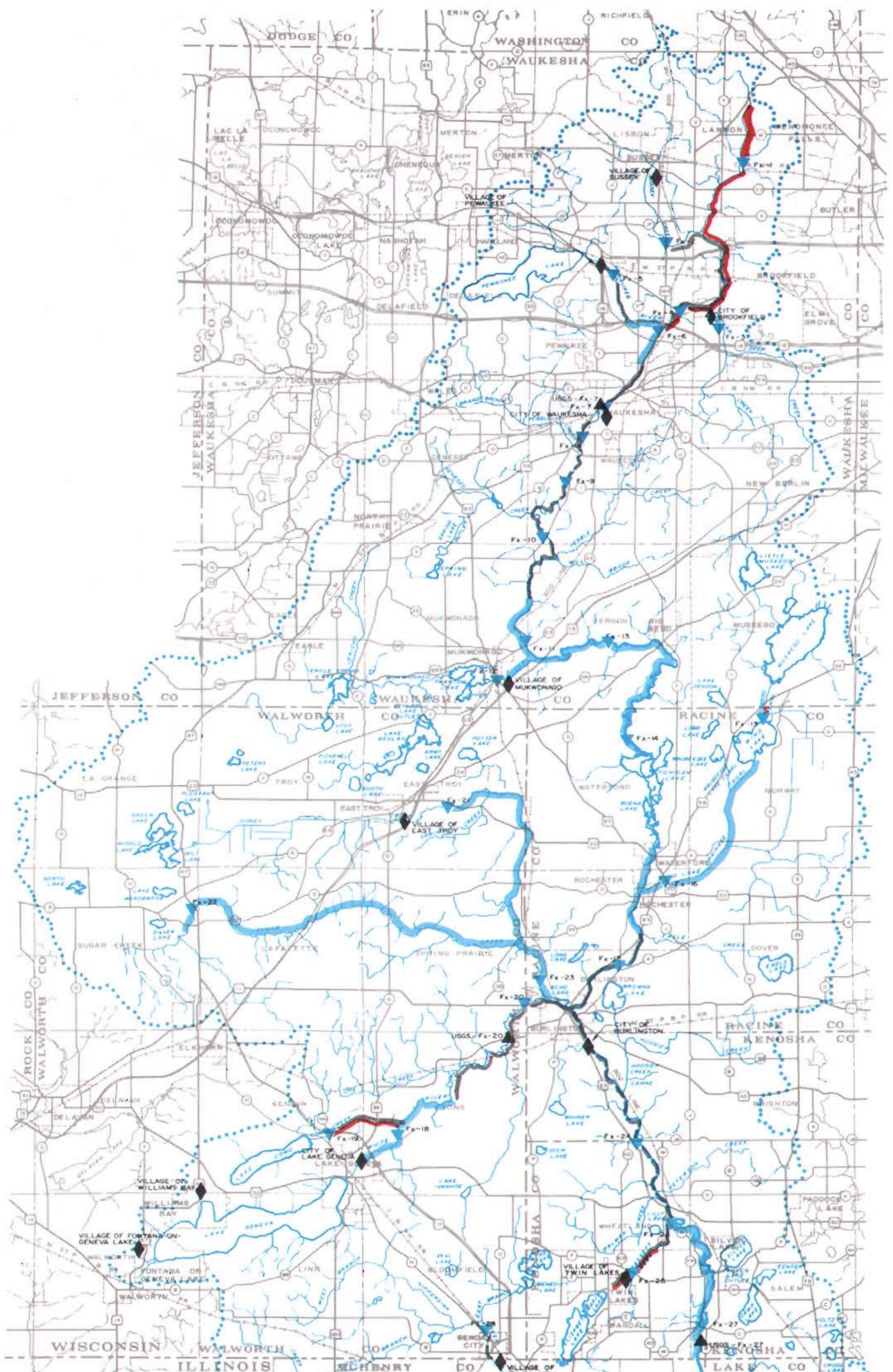
In Sussex Creek, where the restricted use standards of 2.0 mg/l are required to be met, the dissolved oxygen levels were higher than 5.0 mg/l. No data on Palmer Creek were available for comparison with the water quality standards for trout streams. Since no fecal coliform counts and no nitrate, total phosphorus, or ammonia analyses were carried in the 1964 samples, no comparison can be made for 1964 to the nutrient contents and bacteriological safety of the Fox River and its tributary waters. However, since the total coliform counts in the Fox River and its tributaries were less than 2,000 MFCC/ 100 ml in a third of the locations sampled, in the August 1964 survey, there is a high probability of the fecal coliform counts being lower than the permissible limit at these locations, which include Poplar Creek, the Mukwonago River, the Wind Lake Drainage Canal, Honey Creek, Sugar Creek, and portions of the main stem of the Fox River.

Water Quality-1975: For the main stem of the Fox River, designated for recreational use and preservation of fish and aquatic life, Map 19 indicates that water quality conditions during August 1975 were such that the temperature standard and the recommended level for ammonia were satisfied throughout the watershed. Substandard dissolved oxygen levels were observed at sampling stations Fx-1, Fx-8, and Fx-17 on the main stem of the Fox River. A substandard level of pH, 9.1 standard units, also was observed at sampling station Fx-17. The fecal coliform standards were not met at sampling stations Fx-4, Fx-7, and Fx-24 on the main stem of the Fox River. Levels of total phosphorus and nitrate nitrogen were in excess of the recommended level of 0.10 mg/l as P, and 0.30 mg/l as N, throughout the entire length of the Fox River.

For the tributaries of the Fox River, the water quality conditions were such that the ammonia temperature and pH standards were met at all the sampled locations in August 1975. Substandard levels of dissolved oxygen were observed at sampling station Fx-3 located on Poplar Creek, sampling stations Fx-5 and Fx-6 on the Pewaukee River, sampling station Fx-15 on the Muskego Canal, sampling station Fx-16 on the Wind Lake Drainage Canal, sampling station Fx-18 on the White River, and sampling station Fx-19 on Como Creek. Fecal coliform counts were above the water quality standard of 400 MFFCC/ 100 ml intended for the fish and aquatic life and recreational use in all but two of the tributaries, the Mukwonago River and the Wind Lake Drainage Canal. Of the 16 sta-

Map 18

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE FOX RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Fox River watershed as sampled in August 1964 to the adopted water quality standards indicates that temperature and pH standards were met throughout the watershed. Substandard dissolved oxygen levels were reported at two locations, Fx-1 and Fx-4, on the main stem of the Fox River and at three locations, Fx-19, Fx-25, and Fx-15, on the tributaries of the Fox River. Samples at 14, or one-half of the sampling stations, exhibited total coliform levels which are estimated to include fecal in excess of the standards for recreational use.

Source: SEWRPC.

LEGEND

SAMPLING STATION AND DESIGNATION

- DNR DNR-Fx-27a
- SEWRPC Fx-3

CONTINUOUS STAGE RECORDER GAGE AND DESIGNATION

- USGS USGS-Fx-20

EXISTING SEWAGE TREATMENT FACILITIES

- PUBLIC
- NONINDUSTRIAL (PRIVATE)
- INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION

STANDARD VS. CONCENTRATION 1964

- DISSOLVED OXYGEN BELOW 5.0mg/l
- FECAL COLIFORM COLONIES IN EXCESS OF 400 MFFCC/100ml (AS BASED ON 9 PERCENT OF THE TOTAL COLIFORM COUNT)
- FECAL COLIFORM IN EXCESS OF 2,000 MFFCC/100ml (AS BASED ON 9 PERCENT OF THE TOTAL COLIFORM COUNT)
- (NONE) DISSOLVED OXYGEN BELOW 2.0mg/l
- (NONE) TEMPERATURE IN EXCESS OF 89°F
- (NONE) pH OUTSIDE THE 6.0 – 9.0 RANGE
- NO DATA FOR INTERPRETATION
- STREAM REACHES WHERE WATER QUALITY STANDARDS WERE MET FOR ALL PARAMETERS

STANDARD VS. CONCENTRATION 1975

- TOTAL PHOSPHORUS (P) IN EXCESS OF 0.1mg/l
- DISSOLVED OXYGEN BELOW 5.0mg/l
- FECAL COLIFORM COLONIES IN EXCESS OF 400 MFFCC/100ml
- (NONE) AMMONIA (NH_3) IN EXCESS OF 2.5mg/l
- FECAL COLIFORM COLONIES IN EXCESS OF 2,000 MFFCC/100ml
- NITRATE (NO_3) IN EXCESS OF 0.3mg/l
- DISSOLVED OXYGEN BELOW 2.0mg/l
- (NONE) TEMPERATURE IN EXCESS OF 89°F
- pH OUTSIDE THE 6.0 – 9.0 RANGE
- NO DATA FOR INTERPRETATION
- STREAM REACHES WHERE WATER QUALITY STANDARDS WERE MET FOR ALL PARAMETERS

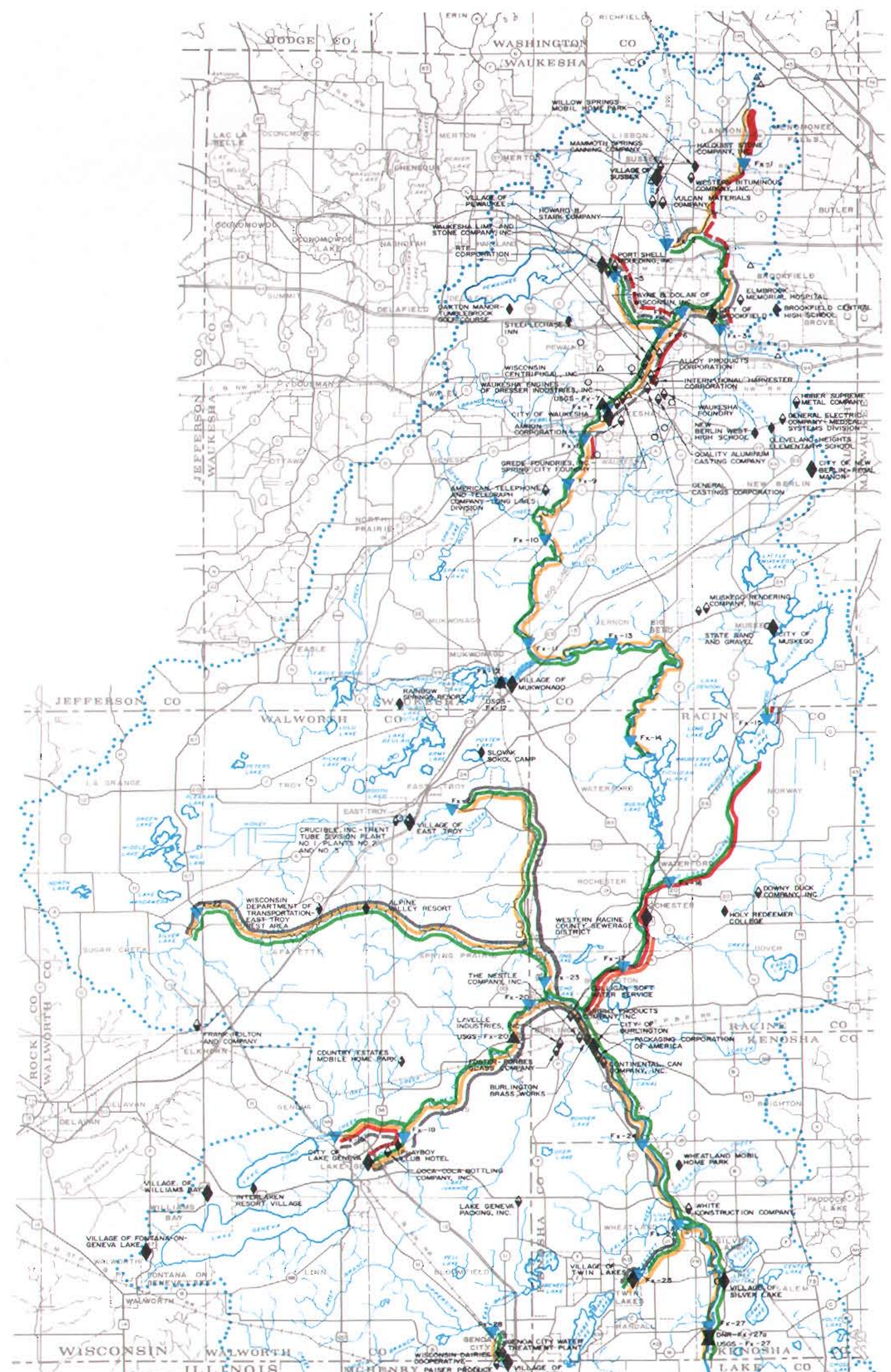
GRAPHIC SCALE

0 1 2 3 4 5 6 MILES

0 8000 16000 24000 32000 40000 FEET

Map 19

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE FOX RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Fox River watershed, as sampled in August 1975, to the adopted water quality standards indicated that the temperature standard and recommended level for ammonia were satisfied throughout the watershed. The hydrogen ion concentration (pH) standard was satisfied throughout the watershed with the exception of sampling station Fx-17 on the main stem of the Fox River. Substandard dissolved oxygen levels were recorded at three locations on the main stem and at seven locations in the tributaries of the Fox River. The fecal coliform standards were not met at three sampling stations on the main stem—Fx-4, Fx-7, and Fx-24—and at all the sampling stations on the tributaries with the exception of Fx-12 and Fx-16. Levels of total phosphorus and nitrate-nitrogen were in excess of the recommended levels throughout the watershed with the exception of Fx-12 located on the Mukwonago River and Fx-1 on the main stem where total phosphorus levels exceeded the levels recommended by the Commission.

Source: SEWRPC.

tions on the Fox River tributaries, only the samples taken at one location met the recommended nitrate nitrogen level of 0.30 mg/l as N: station Fx-12 located on the Mukwonago River. Levels of total phosphorus were in excess of 0.10 mg/l as P along all the tributaries of the Fox River except station Fx-12, located on the Mukwonago River. Sussex Creek, which is designated for restricted use and the maintenance of fish and other aquatic life, met the water quality standards for temperature, pH, dissolved oxygen, fecal coliform, and ammonia at sampling station Fx-2. The levels recommended by the Commission for nitrate nitrogen and total phosphorus were exceeded in Sussex Creek in August 1975.

Since no data are available, the water quality at Palmer Creek cannot be compared with the water quality standards for a trout fishery.

Concluding Remarks—Fox River Watershed

The Fox River watershed is only partly contained in the Region and is located in the central and south central portion of the Region. The watershed is the largest of the 12 watersheds of the Region, and comprises 35 percent of the regional land and water area and extends into Milwaukee, Washington, Waukesha, Walworth, Racine, and Kenosha Counties of the Region. The Fox River, which is the main stream of the watershed, flows through three counties, rising in Waukesha County and flowing 81 miles southward through Racine and Kenosha Counties before crossing the State line into Illinois. The watershed ranks fourth in population among the 12 watersheds of the Region. In 1975 an estimated 225,075 persons lived within this watershed which then had a total area of 934.31 square miles and an average population density of 241 people per square mile.

There are 16 publicly owned and 15 nonindustrial privately owned sewage treatment plants located within the watershed, all of which discharge treated effluent into the stream system of the watershed. In addition, there are 20 known sanitary sewer flow relief devices that discharge raw sewage into the stream system during times of sewer surcharge. A total of 61 industrial and commercial waste discharge points from 41 industries are known to exist in the watershed. Of these waste discharge points, 33 discharge cooling waters, 18 process wastewaters, seven cooling and process wastewaters, and three discharge groundwater seepage. The Commission 1970 land use inventory indicates that 73 percent of the watershed is devoted to agricultural use, 14 percent to urban use, and the remaining 13 percent is occupied by lakes, rivers, streams, wetlands, and woodlands. There is a total of 81 lakes within the watershed, of which 46 have a surface area of 50 acres or more. Of the 46 major lakes, the deepest is Lake Geneva, which is also the largest lake in the Region. The second largest lake of the Region, Pewaukee Lake, also is located in the Fox River watershed. About 73 percent of the area within 1,000 feet of the shorelines of these lakes is presently in some urban land use. Runoff from this urban area may be expected to have a significant effect on the lake water quality.

The 1964-1965 benchmark stream water quality study of the Commission included 28 sampling stations in the watershed, 12 on the Fox River main stem and 16 on the tributaries of the Fox River. The water quality data for 1964-1965 from the 12 sampling stations on the Fox River indicated that the chloride levels were higher than the normal background concentration and reflected a chloride impact upon the stream from human sources. In the tributaries of the Fox River the chloride concentrations were high and reflected the effect of human activities. This is true with the exceptions of the Mukwonago River, Como Creek, and Honey Creek where the chloride concentrations were 0-15 mg/l—above the levels found in adjacent groundwaters. Substandard concentrations of dissolved oxygen were found during the 1964-1965 survey at the headwater area sampling stations on the main stem of the Fox River. Among the tributaries the Pewaukee River, Poplar Creek, Bassett Creek, the Muskego Canal, Sussex Creek, the Wind Lake Drainage Canal, Como Creek, and Honey Creek showed substandard dissolved oxygen levels at one time or another during the 1964-1965 sampling survey. The substandard dissolved oxygen levels observed in the headwater area of the Fox River main stem were likely results of pollution from both rural and urban runoff, while pollution from agricultural runoff probably depressed the dissolved oxygen levels in the Muskego-Wind Lake Drainage Canal area. During the 1964-1965 monthly sampling survey, high total coliform counts of greater than 200 MFCC/100 ml were found in many samples at all sampling stations on the Fox River main stem and at all stations on the tributaries with the exception of the Mukwonago River. Effluents from sewage treatment plants, sewer overflows, drainage from agricultural land, and wastes from malfunctioning private onsite sewage disposal systems, from wildlife, and from domestic animals are some of the probable sources for this indicated contamination. The specific conductance values were found to be high at all 28 sampling locations during the 1964-1965 survey, with a range of from 390-2000 umhos/cm at 25°C. The BOD_5 values were found in the range of from 0.5 mg/l to 21.3 mg/l on the Fox River main stem and from 0.4 mg/l to 32.8 mg/l, with the higher values found at sampling station locations downstream from sewage treatment facilities and in the Wind Lake Drainage Canal located downstream of an extensively farmed area having a tile drainage system.

The 1965-1975 water quality monitoring effort by the Commission included continued sampling at the 28 stations established in the watershed. The observed dissolved oxygen levels indicate that water quality generally improved over the past decade in the Fox River main stem with the exception of conditions at sampling stations Fx-1, Fx-7, Fx-8, and Fx-14, respectively, where the dissolved oxygen concentrations decreased slightly over the decade, apparently as a result of increased loadings from municipal sewage treatment plants and from the effects of increased urbanization.

Among the tributaries of the Fox River, the dissolved oxygen concentrations increased over the past decade on Sussex Creek, Poplar Creek, the Muskego Canal, the

Wind Lake Drainage Canal, and Bassett Creek, and remained essentially unchanged in the Pewaukee River and Como Creek. The dissolved oxygen concentrations of the other tributaries, the Mukwonago River, the White River, Sugar Creek, Honey Creek, and Nippersink Creek remained at or near saturation in all samples collected over the past decade.

The chloride concentrations in the headwater area of the Fox River main stem increased over the past eight years, and remained constant at sampling stations located downstream from station Fx-9. Among the tributaries of the Fox River, there was an increase in chloride concentrations over the past eight years on the Pewaukee River and Poplar Creek and on the Wind Lake Drainage Canal. The chloride concentrations remained constant over the past eight years for the other tributaries. The fecal coliform counts generally remained low and stable over the past eight years at the Fox River main stem sampling stations and on Sussex Creek, Poplar Creek, the Mukwonago River, and Nippersink Creek. The fecal coliform counts declined on the samples collected over the past eight years from the Muskego Canal, the Wind Lake Canal, and Bassett Creek. On the samples collected from the White River the fecal coliform counts remained high over the past eight years and on the samples collected from the Pewaukee River and Como Creek the fecal coliform counts increased during the eight sampling surveys. A modest increase in fecal coliform counts was noted in samples collected on Honey Creek and Sugar Creek. As measured by nitrate nitrogen and total phosphorus, the nutrient concentrations remained in excess of recommended water quality levels of 0.30 mg/l as N, and 0.10 mg/l as P in most of the samples collected on the Fox River main stem and its tributaries over the past eight years.

The diurnal water quality data for the Fox River shows a broad range of dissolved oxygen concentrations from a low of 0.5 to a high of 18.5 mg/l over a 24-hour period and reflects the dissolved oxygen reductions because of respiration by aquatic plants, decomposition of organic matter in the stream, and dissolved oxygen supersaturation effects of algal photosynthesis. The diurnal water quality data for the tributaries of the Fox River showed greater than 5.0 mg/l of dissolved oxygen in all six samples collected over a 24-hour period, with the exception of Poplar Creek, Pewaukee River, and Bassett Creek where the range of dissolved oxygen concentrations over a 24-hour period was 0.5-15.0 mg/l on August 2 and 3, 1971.

In addition to exhibiting marked diurnal fluctuations, water quality in the Fox River watershed exhibited spatial variation. The water quality of the Fox River near the State line generally was better than that in the headwater area as measured by the lower concentrations in specific conductance, chloride, and fecal coliform counts and higher concentrations in the dissolved oxygen.

As already noted, there are 46 major lakes in the Fox River watershed. Of these, 19 were shown to have dissolved oxygen concentrations of less than 1.0 mg/l in the hypolimnion, causing anaerobic conditions during summer and adversely affecting fish and other aquatic organisms. Of the major lakes, 35 have been classified according to Uttormark's trophic status classification systems. Based on consideration of hypolimnetic dissolved oxygen concentration, transparency, fish kills, and use impairment by macrophytes or algal growth, two lakes are classified as disotrophic, 21 as mesotrophic, four as eutrophic, and eight as very eutrophic lakes.

Although generally constant over the past decade, the stream water quality conditions of the Fox River watershed currently do not meet established water use objectives of recreation use and preservation of fish and other aquatic life. Supporting standards for dissolved oxygen, pH, and fecal coliform counts generally are exceeded on the Fox River main stem. Among the tributaries of the Fox River, Sussex Creek is intended for restricted use and the maintenance of fish and aquatic life; Palmer Creek is intended for recreational use and the maintenance of trout fishery; and other tributaries are intended for recreational use and the maintenance of fish and aquatic life. The water quality of the Fox River tributaries was such that pH and temperature standards were met at all the sampling locations while dissolved oxygen standards were met only on Sussex Creek, the Mukwonago River, Sugar Creek, Honey Creek, and Nippersink Creek. Fecal coliform counts were higher than the water quality standards of 400 MFFCC/100 ml at all but the Mukwonago River and the Wind Lake Drainage Canal sampling stations. No water quality data are available for Palmer Creek to compare with the standards set for trout fishery. In addition, the plant nutrients, total phosphorus, and nitrate nitrogen concentrations at all sampling stations on the Fox River main stem and its tributaries, with the exception of the Mukwonago River, and the Wind Lake Drainage Canal, and the Muskego Canal were found to be higher than the levels noted by the Commission for the avoidance of nuisance aquatic plant growth in the stream system.

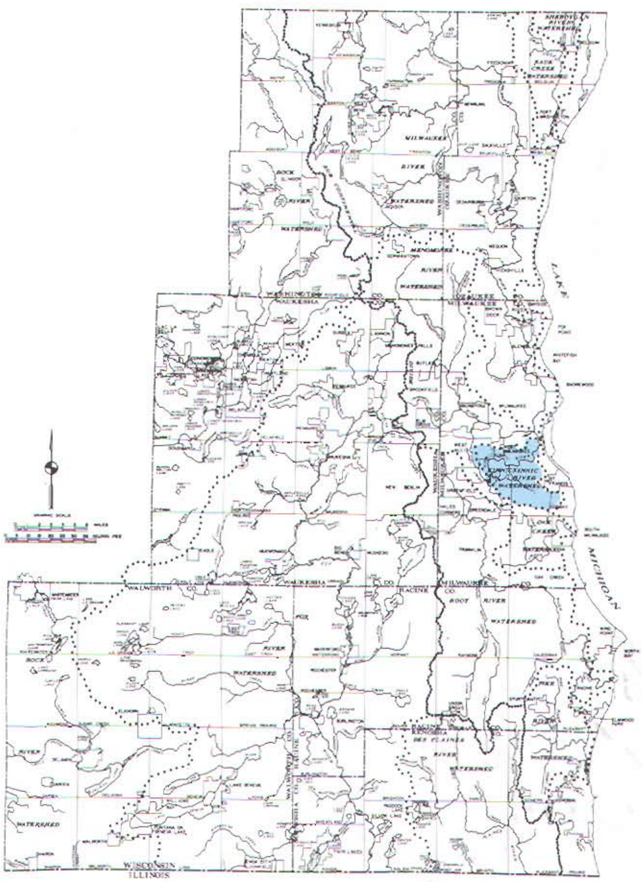
KINNICKINNIC RIVER WATERSHED

Regional Setting

The Kinnickinnic River watershed is a natural surface water drainage unit, 24.85 square miles in areal extent, located in the east central portion of the Southeastern Wisconsin Region. The boundaries of this basin, together with the locations of the main channels of the Kinnickinnic River and its principal tributaries, are shown on Map 20. The watershed lies largely in the southern portion of the City of Milwaukee and directly in the path of the major Milwaukee-to-Chicago transportation routes. The entire watershed is included in the Milwaukee urbanized area and discharges to Lake Michigan through the estuary portion of the Milwaukee Harbor. The southeastern portion of the watershed is occupied by General Mitchell Field airport, while the remainder of the watershed is devoted almost entirely to intense urban land uses, including some heavy industrial land uses in the northern portions of the watershed.

Map 20

LOCATION OF THE KINNICKINNIC RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Kinnickinnic River watershed located entirely within the seven county Southeastern Wisconsin Region, has an area of about 25 square miles, or about 1 percent of the total (2,689 square miles) land and water area of the Region. The watershed is the fifth largest in resident population and the eleventh largest in size of the 12 major watersheds of the Region.

Source: SEWRPC.

The Kinnickinnic River watershed lies within the Lake Michigan drainage system and is bounded by the Menomonee River watershed on the north and west and the Oak Creek watershed on the south. The Kinnickinnic River system, which drains the watershed, consists of the Lyons Park Creek, S. 43rd Street ditch tributary, Wilson Park Creek, Cherokee Park Creek, Villa Mann Creek, Holmes Avenue Creek, and the Kinnickinnic River main stem. Table 58 lists each stream reach, the location, the source, and the length of each stream reach in miles for the Kinnickinnic River watershed. The watershed is the fifth largest in resident population and the eleventh largest in size of the 12 major watersheds of the Region. It comprises 1 percent of the total land and water area of the Region.

Political Boundaries

Superimposed on the irregular watershed boundaries is a rectilinear pattern of local political boundaries as shown on Map 20. The watershed lies entirely in Milwaukee County and in parts of five cities and one village. None of the six civil divisions lies entirely within the boundaries of the watershed, but all of the watershed lies within incorporated cities and villages. The portions of the watershed area lying within each of the six civil divisions involved as of January 1, 1976, are shown in Table 59.

Population

Population Size: The 1975 resident population of the watershed is estimated at 165,088 persons, or about 9 percent of the total estimated residential population of the Region of 1,789,871 persons. The population of the watershed increased steadily from 1900 to the early 1960's. However, during the period from 1960 to 1975, there has been a slight decrease in population.

Population Distribution: The entire population within the watershed lives in five incorporated cities and one incorporated village. The distribution of residents by civil division is set forth in Table 60.

Quantity of Surface Water

The surface water system of the Kinnickinnic River watershed is made up almost entirely of flowing streams. A few minor ponds and wetlands still exist within the watershed but are negligible in terms of total water quantity. The quantity of streamflow varies widely from season to season and from year to year responding to variations in precipitation, temperature, and groundwater levels. Soil moisture conditions and vegetation growth cycles play a greatly reduced role in the hydrology of this highly urbanized watershed as compared with other watersheds having a less urbanized land cover. During the period of this study, there was no continuous flow recording gage in the Kinnickinnic River watershed. Streamflow measurements were made, however, at various locations on the Kinnickinnic River during August through October of 1975 and are set forth in Table 61. High streamflows in this relatively small, highly urbanized watershed are generally associated with heavy rainfalls and may occur throughout all but the winter months. Low flows persist for most of the year except as affected by rainfall and, to a lesser extent, snowmelt events.

The lower reaches of the Kinnickinnic River and other first rank tributaries to Lake Michigan are subject to a phenomenon known as a seiche. A seiche, also known as a standing wave, is an oscillation of water at the surface or within a lake lasting from a few minutes to several hours. The forces that generate seiches include variations in atmospheric pressure and wind. The flow condition and the water quality in the lower reaches of the Kinnickinnic River can temporarily be affected by the dilution effects of the Lake Michigan water during a seiche.

Table 58

STREAMS IN THE KINNICKINNIC RIVER WATERSHED

Stream or Watercourse	Source		Length (in miles)[a]
	By Civil Division	By U. S. Public Land Survey System	
Kinnickinnic River.	City of Milwaukee	NE ¼, Section 10, T6N, R21E	8.0
Wilson Park Creek	City of Milwaukee	NE ¼, Section 29, T6N, R22E	3.7
Cherokee Park Creek[b] . . .	City of Greenfield	NW ¼, Section 24, T6N, R21E	1.8
Villa Mann Creek.	City of Greenfield	NW ¼, Section 24, T6N, R21E	0.9
	City of Milwaukee	SW ¼, Section 19, T6N, R22E	
Holmes Avenue Creek . . .	City of Milwaukee	NW ¼, Section 29, T6N, R22E	1.2
S. 43rd Street Creek.	Village of West Milwaukee	SE ¼, Section 2, T6N, R21E	1.1
Lyons Park Creek	City of Milwaukee	NW ¼, Section 14, T6N, R21E	1.3

[a] *Total perennial stream length as shown on U. S. Geological Survey quadrangle maps.*

[b] *Intermittent stream.*

Source: SEWRPC.

Table 59

AREAL EXTENT OF CIVIL DIVISIONS IN THE KINNICKINNIC RIVER WATERSHED

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
MILWAUKEE COUNTY			
Cities			
Cudahy.	1.49	6.00	31.43
Greenfield.	2.37	9.54	20.38
Milwaukee.	18.76	75.49	19.41
St. Francis.	0.11	0.44	4.30
West Allis	1.67	6.72	14.67
Village			
West Milwaukee	0.45	1.81	40.54
County Subtotal	24.85	100.00	10.24
Total	24.85	100.00	--

Source: SEWRPC.

Pollution Sources

The following principal sources of water pollution have been identified in the Kinnickinnic River watershed and are discussed below: sanitary and combined sewerage system flow relief devices, industrial wastewater discharges, and urban storm water runoff. Presently there are no known municipal or private sewage treatment facilities in the watershed.

Domestic Onsite Sewage Disposal: Another source of pollution within the Region is private, onsite soil absorption sewage disposal systems. However, as the total area of the Kinnickinnic River watershed is served by sanitary sewers, no domestic onsite disposal systems are in operation within the watershed.

Sanitary and Combined Sewerage System Flow Relief Devices: Raw sanitary sewage enters the surface water system of the Kinnickinnic River watershed directly from both combined and separate sanitary sewer overflow devices or indirectly through storm sewer outfalls which are cross-connected to separate sanitary sewers. There are 52 known flow relief devices in the Kinnickinnic River watershed as shown in Table 62. Of these 52 flow relief devices, 23 are combined sewer outfalls, four are bypasses, 19 are crossovers, two are relief pumping stations, and four are portable pumping stations. Forty of these flow relief devices and combined sewer outfalls discharge directly to the Kinnickinnic River main stem, two discharge to the Lyons Park Creek tributary, seven discharge to the Wilson Park Creek tributary, two

Table 60

ESTIMATED RESIDENT POPULATION OF KINNICKINNIC RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	Estimated Population
MILWAUKEE COUNTY	
Cities	
Cudahy (Part)	5,534
Greenfield (Part)	12,800
Milwaukee (Part)	128,568
St. Francis (Part)	670
West Allis (Part)	16,959
Village	
West Milwaukee	557
Milwaukee County Subtotal (Part)	165,088
Kinnickinnic River Watershed Total	165,088

Source: Wisconsin Department of Administration and SEWRPC.

discharge to the S. 43rd Street ditch, and one discharges to the Cherokee Park tributary.

Industrial Waste Discharges: There are 28 locations in the Kinnickinnic River watershed at which industrial wastewaters consisting primarily of process and cooling waters are discharged directly or indirectly to the surface water system (see Map 21).[6] This industrial wastewater enters the Kinnickinnic River and its major tributaries as direct discharge from industrial wastewater outfalls or reaches the surface water by way of drainage ditches, storm sewers, and other flow relief devices connected to industrial outfalls.

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[6] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 21. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964. In addition, all known Metropolitan Sewerage Commission and Milwaukee Health Department water quality sites shown on the above map were sampled during the period of 1965-1970 and therefore did not necessarily exist in 1964.*

Table 61

FLOW MEASUREMENTS IN THE KINNICKINNIC RIVER WATERSHED: AUGUST TO OCTOBER 1975

Stream Segment	Location	Distance in River Miles from the Lake Michigan Shoreline	Date	Flow in Cubic Feet per Second (cfs)
Kinnickinnic River	S. 43rd Street	6.5	10-22-75	0.249
Kinnickinnic River	S. 31st Street	5.1	8-05-75	9.860
Kinnickinnic River	S. 31st Street	5.1	9-15-75	12.920
Kinnickinnic River	S. 31st Street	5.1	10-14-75	6.437
Kinnickinnic River	S. 31st Street	5.1	10-22-75	6.464
Kinnickinnic River	W. Cleveland Avenue and S. 18th Street	3.8	10-22-75	10.299
Kinnickinnic River	S. 6th Street	2.8	10-14-75	11.688
Kinnickinnic River	S. 6th Street	2.8	10-22-75	10.144
Kinnickinnic River	S. 6th Street	2.8	11-11-75	10.488
Wilson Park Creek	W. Layton Avenue (50 feet north)	3.5	10-23-75	2.160
Wilson Park Creek	S. 13th Street	2.4	10-23-75	2.091
Wilson Park Creek	W. Howard Avenue	1.3	10-23-75	1.533
Wilson Park Creek	S. 30th Street and W. Oklahoma Avenue	0.1	10-22-75	2.004
Wilson Park Creek	S. 30th Street and W. Oklahoma Avenue	0.1	10-24-75	1.599
Holmes Avenue Creek	W. Layton Avenue (150 feet north)	0.1	10-23-75	0.343
S. 43rd Street Ditch	At the Confluence with the Main Stem	0.0	10-22-75	5.428

Source: Wisconsin Department of Natural Resources.

Map 21

LOCATION OF STREAM SAMPLING STATIONS, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND URBAN DEVELOPMENT IN THE KINNICKINNIC RIVER WATERSHED: 1964 AND 1975

Stream water quality data were obtained from chemical, physical, biochemical, and bacteriological analyses of water samples collected from the 15 sampling stations located in the Kinnickinnic River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by 23 combined sewer outfalls, four bypasses, 19 crossovers, two portable pumping stations and two relief pumping stations, and 30 industrial or commercial facilities which discharge wastewater into the Kinnickinnic River watershed through 60 outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964. In addition, all known Department of Natural Resources, Milwaukee Metropolitan Sewerage Commission, and Milwaukee Health Department water quality sites shown on the above map were sampled during the period of 1965-1970 and therefore did not necessarily exist in 1964.

Source: SEWRPC.

Table 62

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE KINNICKINNIC RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Other Flow Relief Devices				Total
			Bypasses	Relief Pumping Stations	Portable Pumping Stations	Crossovers	
Kinnickinnic River	City of Milwaukee	23	2	1	0	8	34
Kinnickinnic River	City of West Allis	0	0	0	4	2	6
Wilson Park Creek	City of Milwaukee	0	1	1	0	5	7
Cherokee Park Creek	City of Milwaukee	0	0	0	0	1	1
South 43rd Street Ditch	City of Milwaukee	0	1	0	0	1	2
Lyons Park Creek	City of Milwaukee	0	0	0	0	2	2
	Totals	23	4	2	4	19	52

Source: SEWRPC.

Data and information provided from the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR 101 of the Wisconsin Administrative Code were used to determine the type and location of industrial waste discharges in the Kinnickinnic River watershed. Table 63 summarizes, by receiving stream and by civil division, the number and types of industrial waste discharges and the number of outfalls in the watershed, the types of treatment, and average hydraulic design capacity. A total of 60 industrial and commercial waste discharge points is known to exist in the watershed (see Map 21). Of these, 33 discharge cooling waters, seven discharge process wastewater, 15 cooling and process wastewater, four swimming pool overflow, and one discharges oil-contaminated storm water. Six of the 30 industries discharge wastewater directly to the Kinnickinnic River main stem and three discharge to the Kinnickinnic River via a drainage ditch. Of the remaining 21 industrial wastewater discharges, 18 are contributed through the storm sewer system, two through the storm sewer systems and the drainage ditches and one discharges to Wilson Park Creek through a storm sewer system.

Pollution from Urban Runoff: Separate storm sewers which convey storm water runoff carry pollutants and contaminants from the urbanized areas into a receiving water. Urban storm water runoff, even when separated from sanitary sewage, can cause chemical or inorganic pollution, organic pollution, pathogenic pollution, and aesthetic pollution of the recovery streams from such sources as de-icing salts, decaying vegetation, domestic animal wastes, and soil erosion. Existing land use information taken from the 1970 Commission land use inventory is presented in Table 64 and indicates that 14,866 acres, or 89 percent of the total area of the Kinnickinnic River watershed, is devoted to urban land uses, and only 1,664 acres, or 10 percent, to rural land uses, primarily unused open lands. An additional 195 acres, or 1 percent of the total area of the watershed, is composed of wetlands, ponds, rivers, and streams. A shoreland development survey conducted by the Wisconsin Department of Natural Resources indicates that virtually all of the shoreland area within 1,000 feet of the Kinnickinnic River and its tributaries is of an urban character.

Pollution from Rural Land: Runoff from agricultural land is known to contribute nitrogen and phosphorus to the receiving water courses. Since only 10 percent of the total area of the Kinnickinnic River watershed is devoted to rural land uses, and consists primarily of unused open lands, and since none of the shoreland areas within 1,000 feet of the Kinnickinnic River and its tributaries is used for agricultural purposes, pollution from rural land uses is not considered to be a significant source of water pollution within the watershed.

Other Pollution Sources: There is one known sanitary landfill site and seven auto salvage yards within the Kinnickinnic River watershed as based on the Commission's 1970 land use inventory.

Water Quality Conditions in the Kinnickinnic River Watershed

Water Quality Data: Of the data sources listed in Chapter II, the following six were used in analyzing the water quality conditions of the Kinnickinnic River watershed: 1) Commission benchmark study, 2) Commission continuing monitoring program, 3) Wisconsin Department of Natural Resources basin surveys, 4) Wisconsin Department of Natural Resources waste loading survey of the Kinnickinnic River, 5) Milwaukee-Metropolitan Sewerage District stream water quality sampling program, and 6) City of Milwaukee Health Department report on the water quality effects of the Kinnickinnic River flushing tunnel. A detailed description of these data sources is given in Chapter II.

As part of the regional stream water quality survey conducted by the Commission in 1964, one sampling station, Kk-1, was established in the Kinnickinnic River watershed. This sampling station is located on the main

Table 63

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE KINNICKINNIC RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY								
Allied Smelting Corporation	3341	City of West Allis	Process and Cooling	pH Adjustment	1	Kinnickinnic River via Storm Sewer	121,000	144,000
Badger Die Casting Corporation	3369	City of Milwaukee	Cooling	None	1	Kinnickinnic River via Storm Sewer	43,500	N/A
Briggs and Stratton Corporation	3714	City of West Allis	Cooling	N/A	1	Kinnickinnic River via Storm Sewer	1,026,000	1,026,000
			Cooling	N/A	3	Kinnickinnic River via Storm Sewer	308,000	308,000
			Cooling	N/A	4	Kinnickinnic River via Storm Sewer	20,000	108,000
			Cooling	N/A	5	Kinnickinnic River via Storm Sewer	25,000	25,000
			Cooling	N/A	6	Kinnickinnic River via Storm Sewer	99,000	99,000
Caterpillar Tractor Company	3531	City of Milwaukee	Cooling	N/A	5	Kinnickinnic River via Storm Sewer	1,000	2,400
			Process	N/A	6	Kinnickinnic River via Storm Sewer	1,900	4,800
			Cooling	N/A	13	Kinnickinnic River via Storm Sewer	4,300	5,300
			Process	N/A	16	Kinnickinnic River via Storm Sewer	600	1,200
Eaton Corporation	3462	City of West Allis	Process, Cooling, and Boiler Blowdown	Oil Separator	1	Kinnickinnic River via Storm Sewer and Drainage Ditch	128,800	233,500
			Process, Cooling, and Boiler Blowdown	N/A	2	Kinnickinnic River via Storm Sewer and Drainage Ditch	2,800	3,200
Froedtert Malt Corporation	2083	Village of West Milwaukee	Cooling	None	1	Kinnickinnic River via Storm Sewer	19,900	36,200
General Electric Company—Diswasher and Disposal Products Department	3639	Village of West Milwaukee	Cooling	N/A	1	Kinnickinnic River via Storm Sewer and Drainage Ditch	72,000	N/A
			Cooling	N/A	2	Kinnickinnic River via Storm Sewer and Drainage Ditch	34,000	N/A
			Cooling	N/A	3	Kinnickinnic River via Storm Sewer and Drainage Ditch	2,000	N/A
			Cooling	N/A	4	Kinnickinnic River via Storm Sewer and Drainage Ditch	1,000	N/A
General Electric Company—Medical Systems Division	3829	City of Milwaukee	Cooling and Cooling Tower Blowdown	None	1	Kinnickinnic River via Drainage Ditch	475,700	967,600
General Electric Company—West Edgerton Avenue		City of Milwaukee	Cooling	None	1	Kinnickinnic River via Storm Sewer	300	N/A
The Heil Company Bulk Trailer Division (Tank)	3713	City of Milwaukee	Test and Cooling	N/A	1	Kinnickinnic River via Storm Sewer	10,800	20,400
			Test and Cooling	N/A	2	Kinnickinnic River via Storm Sewer	300	300
The Heil Company—Solid Waste Systems and Truck Equipment Division	3713	City of Milwaukee	Cooling	None	1	Kinnickinnic River	82,400	120,500
			Cooling	N/A	14	Kinnickinnic River	1,000	5,000
Howmet Turbine Components Corporation	3324	City of Milwaukee	Cooling	None	1	Kinnickinnic River	323,900	481,000
			Cooling and Process	None	2	Kinnickinnic River	201,400	258,400
			Process	Settling Pond	3	Kinnickinnic River	111,500	176,000
Kurth Malting Corporation—Plant No. 1	2083	Village of West Milwaukee	Cooling	None	3	Kinnickinnic River via Drainage Ditch	20,000	30,000
			Cooling	None	4	Kinnickinnic River via Drainage Ditch	130,000	450,000
Ladish Company	3462	City of Cudahy	Cooling	N/A	2	Kinnickinnic River	176,600	246,200
			Cooling	N/A	3	Kinnickinnic River	288,900	465,000
Maynard Steel Casting Company	3325	City of Milwaukee	Process and Cooling	Settling Basin, Lagoon and Chemical Precipitation	1	Kinnickinnic River	110,400	123,400
Milwaukee County Park Commission—Holler Park	7999	City of Milwaukee	Swimming Pool Overflow and Emptying	None	1	Kinnickinnic River via Storm Sewer	Intermittent	Intermittent

Table 63 (continued)

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY (continued)								
Milwaukee County Park Commission—Jackson Park	7999	City of Milwaukee	Swimming Pool Overflow	None	1	Kinnickinnic River via Storm Sewer	Intermittent	Intermittent
Milwaukee County Park Commission—Kosciuszko Park	7999	City of Milwaukee	Swimming Pool Overflow	None	1	Kinnickinnic River via Storm Sewer	Intermittent	Intermittent
Milwaukee County Park Commission—Wilson Park	7999	City of Milwaukee	Swimming Pool Overflow	None	1	Kinnickinnic River via Storm Sewer	Intermittent	Intermittent
Milwaukee Solvay Coke Company	3312	City of Milwaukee	Cooling, Process, and Boiler Blowdown	None	1	Kinnickinnic River via Storm Sewer	2,120,800	3,158,100
			Cooling, Process, and Boiler Blowdown	None	2	Kinnickinnic River via Storm Sewer	2,700,000	2,700,000
Milwaukee Spring Company		City of Milwaukee	Cooling	N/A	1	Kinnickinnic River via Storm Sewer	78,000	N/A
Milwaukee Waterworks Howard Avenue Plant	4941	City of Milwaukee	Filter Backwash	None	1	Wilson Park Creek via Storm Sewer	415,800	430,000
Murphy Diesel Company	3519	City of West Allis	Cooling	None	1	Kinnickinnic River via Storm Sewer	5,500	5,800
			Cooling	None	2	Kinnickinnic River via Storm Sewer	8,900	15,100
			Cooling	None	3	Kinnickinnic River via Storm Sewer	6,200	12,400
			Cooling	None	4	Kinnickinnic River via Storm Sewer	19,600	30,300
Oilgear Company	3561	City of Milwaukee	Cooling	None	1	Kinnickinnic River	1,000	2,000
Pelton Casteel, Inc.	3325	City of Milwaukee	Process and Cooling	Settling Basin, Oil Separator and pH Adjustment	1	Kinnickinnic River via Drainage Ditch	79,800	92,600
Perfex, Inc.	3433	City of Milwaukee	Cooling and Test	None	1	Kinnickinnic River via Storm Sewer	130,000	140,000
Rexnord, Inc.—Nordberg Machinery Group	3532	City of Milwaukee	Cooling, Process, and Boiler Blowdown	None	1	Kinnickinnic River via Storm Sewer	145,500	220,000
			Cooling and Process	None	2	Kinnickinnic River via Storm Sewer	246,600	300,000
			Process	None	3	Kinnickinnic River via Storm Sewer	4,000	10,000
			Cooling and Process	None	4	Kinnickinnic River via Storm Sewer	52,700	77,500
Teledyne Wisconsin Motor	3519	City of West Allis	Cooling and Process	N/A	1	Kinnickinnic River via Storm Sewer	3,800	5,500
			Process and Cooling	N/A	2	Kinnickinnic River via Storm Sewer	22,500	30,000
			Process and Cooling	N/A	4	Kinnickinnic River via Storm Sewer	1,200	1,500
			Process and Cooling	N/A	5	Kinnickinnic River via Storm Sewer	8,500	14,000
Union Oil Company of California—General Mitchell Field	5170	City of Milwaukee	Oil-Contaminated Storm Water	Oil-Water Separator	1	Kinnickinnic River via Storm Sewer	Intermittent	Intermittent
Wehr Steel Company	3325	City of Milwaukee	Cooling	N/A	2	Kinnickinnic River	182,000	239,000
			Cooling	N/A	3	Kinnickinnic River	23,000	24,000
			Process	N/A	6	Kinnickinnic River	31,000	50,000
			Cooling	N/A	7	Kinnickinnic River	17,000	49,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rate was estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 64

LAND USE IN THE KINNICKINNIC RIVER WATERSHED: 1963 and 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	5,256.93	31.43	5,551.36	33.2
Commercial	670.72	4.01	785.33	4.7
Industrial	603.03	3.61	604.77	3.6
Transportation and Utilities	5,506.72	32.93	5,949.93	35.6
Government	1,020.03	6.10	1,142.61	6.8
Recreation	817.70	4.89	831.74	5.0
Landfill and Dump	8.77	0.05	0.23	0.1
Total Urban Land Use	13,883.90	83.01	14,865.97	88.9
Rural Land Uses				
Wooded and Unused Lands	2,162.95	12.93	1,406.34	8.4
Agricultural Lands	452.34	2.70	257.17	1.5
Total Rural Land Use	2,615.29	15.64	1,663.51	9.9
Water Covered Lands				
Lakes, Rivers, and Streams	167.90	1.00	159.93	1.0
Wetlands	57.86	0.35	35.56	0.2
Total Water Covered Land	225.76	1.35	195.49	1.2
Watershed Totals	16,724.95	100.00	16,724.97	100.1

Source: SEWRPC.

stem of the Kinnickinnic River upstream from the combined sewer service area, the seiche effect of the lake and the flushing tunnel. Specifically, Kk-1 is located at the S. 29th Street bridge which is approximately five river miles upstream from the confluence of the Kinnickinnic and Milwaukee Rivers. Table 65 indicates the location of the water quality sampling stations in the watershed. Map 21 shows the location of the sampling stations within the Kinnickinnic River watershed.

Surface Water Quality of the Kinnickinnic River and Its Tributaries in 1964-1965: Water quality conditions in the Kinnickinnic River watershed, as determined by 1964-1965 sampling survey at the single station on the main stem of the Kinnickinnic River, are summarized in Table 66. The results for chloride, dissolved oxygen, and coliform bacteria are particularly relevant to the assessment of the trends in the surface water quality.

Chloride: During the sampling year 1964-1965, chlorides were analyzed from two samples, once in April 1964 and again in September 1964, at the sampling survey station. The chloride concentration of 115 mg/l, which occurred during April 1964, was high when compared to a background level of 20 mg/l as measured from the average groundwater chloride concentrations. A significant decrease in the chloride concentration to 20 mg/l was noted in the sample of September 1964. The high chloride level in the Kinnickinnic River during April is most likely due to street salting operations conducted during winter but affecting the River during spring runoff as these residual chemicals are flushed from the streets and highways by snowmelt and spring rains. The low chloride level occurring in September reflects the background chloride concentration expected during low flow conditions.

Dissolved Oxygen: During the sampling year 1964-1965, the dissolved oxygen levels at the sampling station ranged from 7.3 to 13.3 mg/l, with an average value of 10.6 mg/l. An analysis of the average and minimum dissolved oxygen values obtained at this station indicates levels well above the restricted use and minimum standard category assigned to the Kinnickinnic River and its tributaries. With the location of all combined sewer overflows downstream from the sample site, it may be expected that the dissolved oxygen levels in that reach of stream would exhibit a considerable reduction, possibly violating the restricted use objective and minimum standard criteria. The operation of a flushing station at S. Chase Avenue and the Kinnickinnic River main stem, however, provides water from Lake Michigan for river flow augmentation, which reportedly prevents anaerobic conditions from occurring in the lower reaches of the River.[7]

Table 65

DESIGNATIONS AND LOCATION OF THE SAMPLING STATIONS IN THE KINNICKINNIC RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance in River Miles from the Lake Michigan Shoreline
SEWRPC	Kk-1	S. 29th Street Bridge SE ¼, Section 12, T6N, R12E	5.0
Wisconsin Department of Natural Resources	DNR-Kk-Oa	S. 43rd Street Bridge NW ¼, Section 12, T6N, R21E	6.5
	DNR-Kk-Ob	W. Forest Home Avenue Bridge SW ¼, Section 12, T6N, R21E	5.6
	DNR-Kk-1a	S. 27th Street Bridge SE ¼, Section 12, T6N, R21E	4.8
	DNR-Kk-1b	S. 13th Street Bridge NE ¼, Section 7, T6N, R22E	3.3
	DNR-Kk-1f	S. Chase Avenue Bridge NE ¼, Section 8, T6N, R22E	2.4
	DNR-Kk-1h	W. Becher Street Bridge SE ¼, Section 5, T6N, R22E	1.6
	DNR-Kk-Oc	W. Oklahoma Avenue Bridge (Wilson Park Creek) NE ¼, Section 13, T6N, R21E	5.3
Sewerage Commission of Milwaukee	MMSD-Kk-1e	S. Chase Avenue Bridge NE ¼, Section 8, T6N, R22E	2.4
	MMSD-Kk-1i	W. Becher Street Bridge SE ¼, Section 5, T6N, R22E	1.7
	MMSD-Kk-1k	Milwaukee River and Kinnickinnic River Harbor NE ¼, Section 33, T7N, R22E	0.3
City of Milwaukee Health Department	MHD-Kk-1d	The flushing tunnel outlet east of the S. Chase Avenue Bridge NE ¼, Section 8, T6N, R22E	2.4
	MHD-Kk-1c	S. 6th Street Bridge SW ¼, Section 8, T6N, R22E	2.8
	MHD-Kk-1g	W. Lincoln Avenue Bridge SW ¼, Section 5, T6N, R22E	2.0
	MHD-KK-1j	W. Becher Street Bridge SE ¼, Section 5, T6N, R22E	1.7

Source: SEWRPC.

Total Coliform Bacteria: During the year 1964-1965, the membrane filter coliform count (MFCC) ranged from 4,000 to 340,000 MFCC/100 ml with an average value of 77,000 MFCC/100 ml. The highest total coliform counts, 230,000 MFCC/100 ml and 340,000 MFCC/100 ml, occurred during the months of May and September 1964, respectively. These counts corresponded to the spring runoff and to a runoff which occurred in September due to rain which fell during the week prior to the sample collection. The correlation between these runoff periods and the total coliform counts points to the sources as storm water runoff and the discharge of raw sewage from the flow relief devices located upstream from the sampling station, or both. The total coliform counts can be expected to increase downstream from the sampling station as the stream passes through the combined sewer overflow area.

Specific Conductance: The specific conductance at the Kinnickinnic River watershed sampling station was analyzed twice during the year 1964-1965 and ranged from 426 to 1,040 µmhos/cm at 25°C with an average of 733 µmhos/cm at 25°C. The highest specific conductance value was obtained during the month of April at the time of the highest chloride concentration. Specific conductance is an approximate measure of the dissolved

[7] *E. R. Krumbiegel and Roger H. Hulbert, "Report on the Operation of the Kinnickinnic River Flushing Station and Its Effect on Downstream Water Quality," Milwaukee Health Department, November 1, 1970.*

Table 66

WATER QUALITY CONDITIONS OF THE KINNICKINNIC RIVER AND TRIBUTARIES AT SAMPLING STATION KK-1: 1964-1965

Parameter	Numerical Value			Number of Analyses
	Maximum	Average	Minimum	
Chloride (mg/l)	115	65	20	2
Dissolved Solids (mg/l)	680	485	290	2
Dissolved Oxygen (mg/l)	13.3	10.6	7.3	11
Coliform Count (MFCC/100 ml)	340,000	77,000	4,000	11
Temperature (^{o}F)	82	57	32	11

Source: SEWRPC.

ions present in water, and the high specific conductance value during the spring months indicates the effect of the spring runoff on the dissolved ion concentration.

Hydrogen Ion Concentrations (pH): The pH values obtained at the Kinnickinnic River sampling station were 8.0 and 7.3 as recorded in April and September 1964, respectively. These two values were within the range of 6.0 and 9.0 standard units prescribed for streams of restricted use and minimum standards.

Temperature: During the year 1964-1965, the temperature of water samples from the Kinnickinnic River ranged between 32^{o}F and 42^{o}F during the months of December through April and ranged between 54^{o}F and 82^{o}F during the months of May through November. The temperature variations at the sampling station reflected the expected seasonal changes. In addition, the discharge of cooling waters into the storm sewer system's tributary to the main stem of the Kinnickinnic and the S. 43rd Street ditch from 12 industries located upstream from the sampling station may also have contributed to the temperature variations, particularly during warm weather, low flow conditions.

Biochemical Oxygen Demand: No biochemical oxygen demand data are available at sampling station Kk-1 for the year 1964-1965 to evaluate the water quality for biochemical oxygen demand on the Kinnickinnic River.

Water Quality Trends from 1965 to 1975: The water quality data recorded from 1965 to 1975 for eight summer sampling programs, three spring sampling programs, and one fall sampling program are presented in tabular form in Appendix D of this report. The eight summer sampling surveys began in August 1968 and involved collection of samples on one day in August every year during the periods of relatively low flow conditions. An analysis of the flow data from "Water Resources Data for Wisconsin" published by the U. S. Geological Survey indicates that the streams in southeastern Wisconsin generally experience periods of lowest flow during the months of August and September.

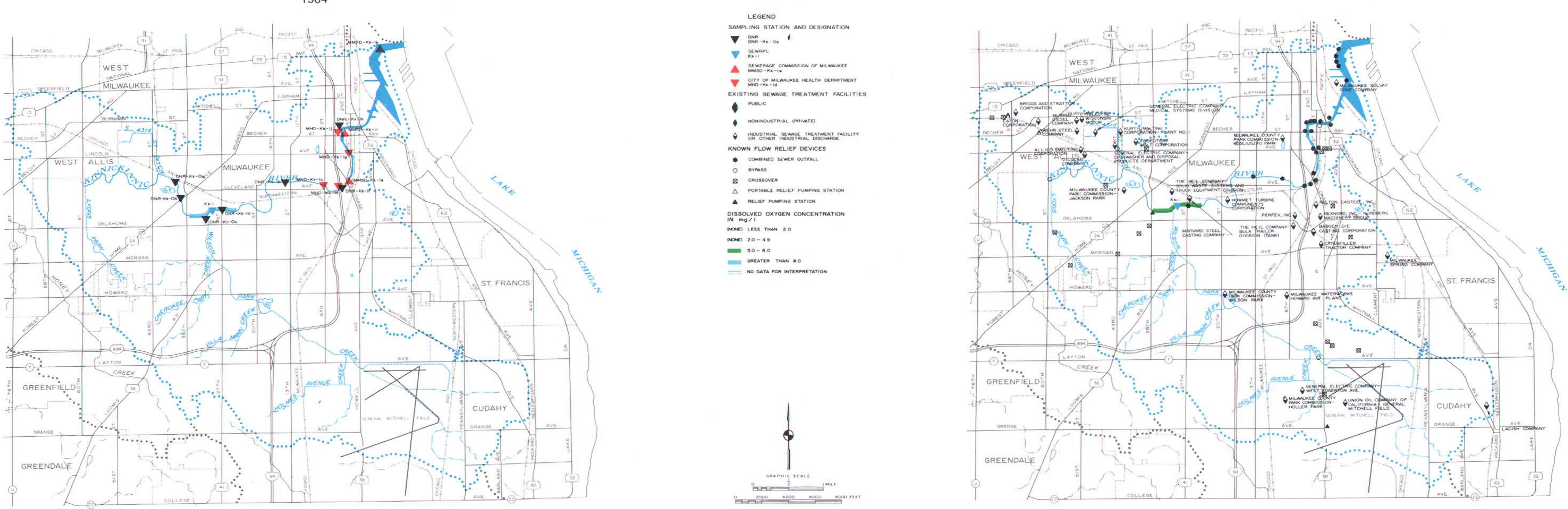
Although the analysis of samples collected from one station and taken once a year is not representative of water quality conditions for the entire year, it may be assumed to reasonably represent the water quality conditions of the stream at that location during relatively low flow periods, which are generally considered the most critical period for the maintenance of dissolved oxygen levels sufficient to meet the restricted use and minimum standards criteria.

A tabular summary of the results for chloride, dissolved oxygen, total coliform bacteria, fecal coliform bacteria, specific conductance, hydrogen ion concentration (pH), temperature, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, and organic nitrogen and soluble and total phosphorus for the single Kinnickinnic River watershed station sampled by the Commission during the periods of relatively low flow each year since 1968, is set forth in Table 67. As discussed earlier in this chapter, the streamflow data for the Kinnickinnic River are available only for the year 1975 for the months of August through October. The data for the 10 streamflow recording locations on the Kinnickinnic River for the dates immediately prior to the August 25, 1975, water sampling collection are presented in Table 61.

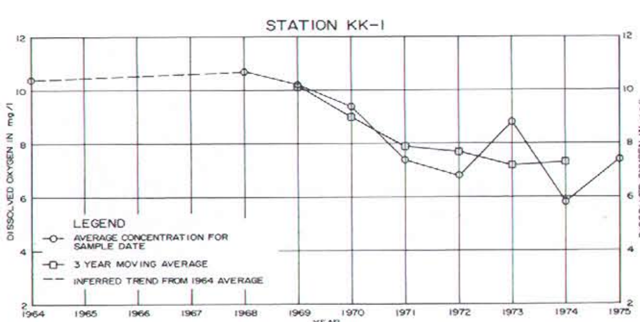
Dissolved Oxygen: The dissolved oxygen concentrations for the eight sampling surveys conducted at the Kinnickinnic River sampling station during August 1968-1975 ranged from 3.4 mg/l to 14.1 mg/l with an average concentration of 7.9 mg/l. The low as well as the average dissolved oxygen levels at the Kinnickinnic River sampling station are well above the established 2.0 mg/l for restricted use; and Map 22 with its insert graph shows the average dissolved oxygen levels at the Kinnickinnic River sampling station in August from 1964 through 1975. As indicated previously, it is quite likely that the dissolved oxygen levels exhibit a considerable decline in concentration as the stream flows through the combined sewer service area, particularly when the diurnal cycles are considered. That the combined sewer service area affects dissolved oxygen concentrations is supported by the results of studies conducted by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department.

Map 22

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE KINNICKINNIC RIVER WATERSHED



A comparison of the dissolved oxygen levels recorded in 1964 and 1975 indicated that dissolved oxygen concentrations decreased at the one sampling station in the watershed. The maximum recorded dissolved oxygen concentration was 14.1 mg/l, while the recorded minimum was 3.4 mg/l.



Source: SEWRPC.

Table 67

WATER QUALITY CONDITIONS IN THE KINNICKINNIC RIVER WATERSHED AT SAMPLING STATION KK-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	135.00	53.0	26.00	22	--
Dissolved Oxygen (mg/l)	2.0	14.1	7.9	3.4	30	0[a]
Ammonia N (mg/l)	2.5	0.63	0.27	0.11	8	0
Organic N (mg/l)	--	0.87	0.60	0.25	8	--
Total N (mg/l)	--	2.00	1.28	0.68	8	--
Specific Conductance (umhos/cm at 25°C)	--	962.00	744.0	560.00	30	--
Nitrite N (mg/l)	--	0.155	0.045	0.010	12	--
Nitrate N (mg/l)	0.3	0.66	0.30	0.09	12	6
Soluble Orthophosphate-P (mg/l)	--	0.753	0.103	0.022	12	--
Total Phosphorus (mg/l)	0.1	0.34	0.12	0.01	8	5
Fecal Coliform (MFFCC/100 ml)	2,000	72,000	8,117	30	12	3
Temperature (°F)	89.0	86	76	70	30	0
Hydrogen Ion Concentrations-pH Standard Units	6-9	8.8	7.9	5.8	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

The samples collected by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department also were analyzed for dissolved oxygen from five sites located in the lower reaches of the Kinnickinnic River main stem during the years 1965 through 1970, as discussed above. Figure 56 shows the average dissolved oxygen concentrations obtained at each station. The average dissolved oxygen concentrations for the five-year period exhibited a steady decline between the S. 6th Street bridge and the Harbor except in 1970 when the dissolved oxygen concentrations remained the same between S. Chase Avenue and W. Becher Street.

Of particular interest are the samples collected during the 1969 sampling period when the flushing tunnel was shut down for repairs. A drastic decline occurred in the average of the 14 dissolved oxygen samples collected at each of the four sampling stations, 9.4 mg/l, 5.1 mg/l, 2.6 mg/l, and 1.3 mg/l, respectively. Results from the two lowermost stations at the W. Lincoln Avenue and W. Becher Street bridges both exhibit dissolved oxygen levels below the 2.0 mg/l restricted standard. Four of the total of 14 samples collected during the summer of 1969 were below the 2.0 mg/l standard at the W. Lincoln Avenue bridge, and 13 of the 14 samples collected at the W. Becher Street bridge were below the 2.0 mg/l standard. As can be seen in Figure 56, the data collected from the two studies conducted in 1965 through 1970 indicate that the Kinnickinnic River flushing tunnel appears to maintain dissolved oxygen levels above the 2.0 mg/l standard in the lower reaches of the River when it is in operation.

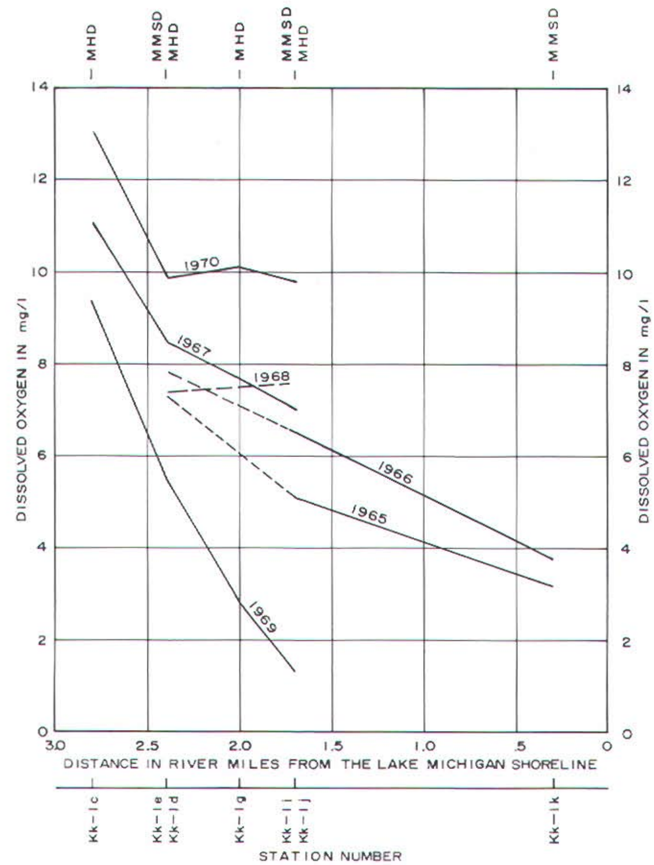
Chloride: Chloride concentrations were found to be in the range of 26 to 135 mg/l with an average of 53 mg/l at the Commission's Kinnickinnic River sampling station in eight August sample surveys conducted during the years 1968 to 1975. Of the 22 samples collected during the eight surveys, all showed chloride concentrations greater than the expected background concentration of 20 mg/l. A comparison of the chloride concentrations recorded in April 1968 with August 1968, and in April 1969 with August 1969 is depicted in Figure 57, and indicates the expected higher chloride concentrations in the April samples. The higher chloride concentrations during the month of April generally are attributed to the spring runoff which may contain de-icing salts applied through the winter to the paved surfaces of this highly urbanized watershed.

In addition, the City of Milwaukee Health Department collected water samples for chloride analysis from four stations in the lower reaches of the Kinnickinnic River during the summer of 1970. The specific locations of these four sampling stations on the Kinnickinnic River main stem were the S. 6th Street bridge, the flushing tunnel outlet, the W. Lincoln Street bridge, and the W. Becher Street bridge. The average chloride concentrations obtained by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department are presented in Figure 58.

The average chloride concentrations recorded in 1967 and 1970 exhibited a reduction between the S. 6th Street bridge and the flushing tunnel locations. The concentra-

Figure 56

DISSOLVED OXYGEN CONCENTRATIONS IN THE KINNICKINNIC RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1965-1970



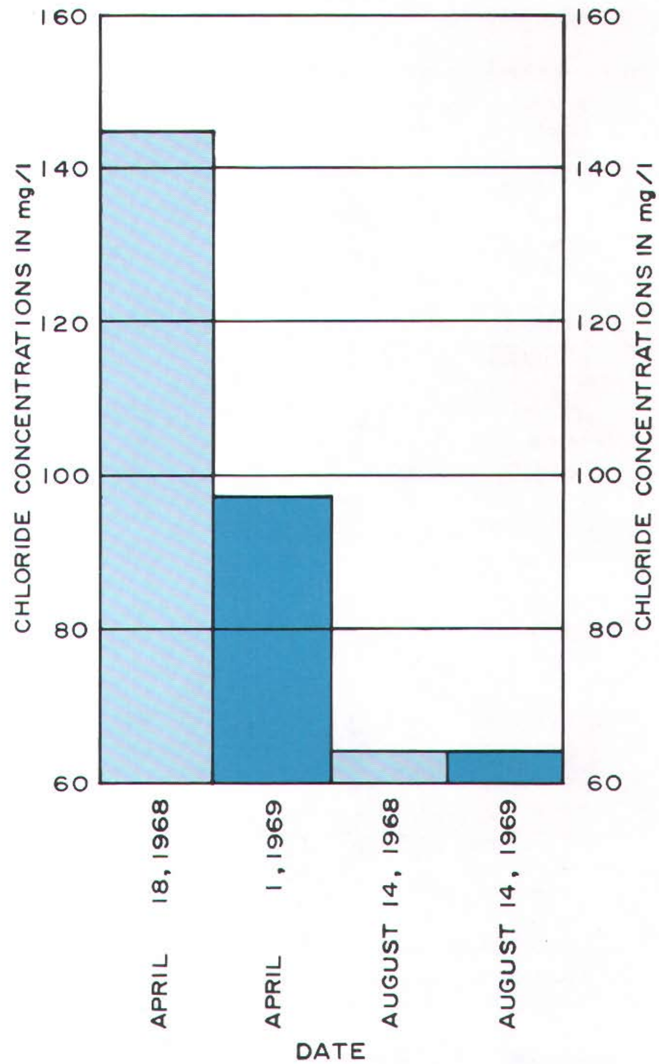
Source: SEWRPC.

tions downstream from the latter point to the Harbor generally are stable. Reductions in the average chloride concentrations also are noted in 1965, 1966, and 1968 between the flushing tunnel near S. Chase Avenue and the W. Becher Street bridge. However, a significant reduction in the chloride concentrations did not occur in 1969 when the flushing tunnel was not in operation. It is clear that the added flow of water pumped from Lake Michigan through the flushing tunnel has a dilution effect on the chloride concentration of the Kinnickinnic River below S. Chase Avenue. Another phenomenon that may have an effect on the chloride concentration near the mouth of the River is the seiche effect of Lake Michigan.

Map 23 shows the average chloride concentrations at the Kinnickinnic River sampling station on August 14, 1968, and August 25, 1975, with a graph insert illustrating the changes in the average chloride concentrations found during the August sampling days of intermediate years. The map indicates a slight increasing trend in the chloride concentrations in the August samples when the 1968 and

Figure 57

CHLORIDE CONCENTRATIONS IN THE KINNICKINNIC RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968-1969

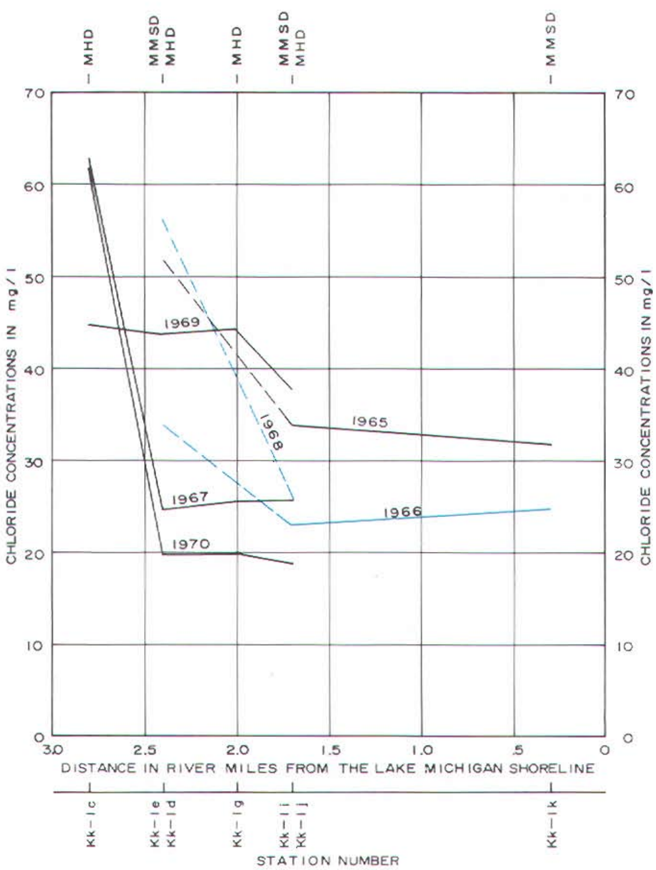


Source: SEWRPC.

1975 data are compared. However, when the chloride concentrations for August 1964 through August 1975 are compared, a more fluctuating trend with time is noted at the sampling station. The fluctuations in chloride concentrations during the August sampling periods were associated with heavy rainfall as recorded at the General Billy Mitchell Field and the City of West Allis weather stations, raising the possibility of the chlorides being associated with storm water runoff from leaching of soil, from sewage discharged through the flow relief devices, or from other diffuse sources. The lack of stream flow data corresponding to the sample dates and locations in the Kinnickinnic River watershed for most of the period of record precludes an analysis of chloride loadings within this watershed.

Figure 58

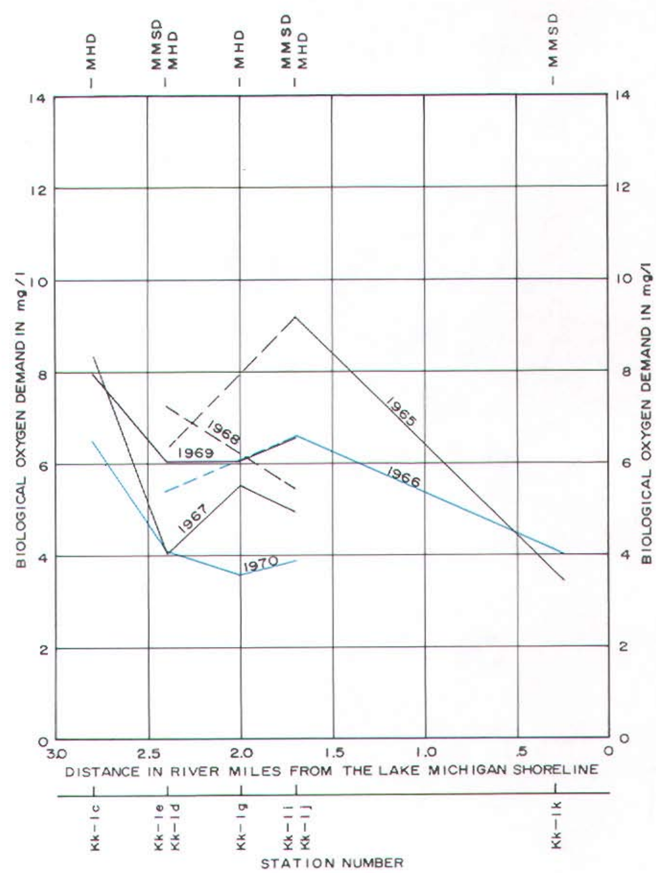
CHLORIDE CONCENTRATIONS IN THE KINNICKINNIC RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1965-1970



Source: SEWRPC.

Figure 59

BIOLOGICAL OXYGEN DEMAND RECORDED IN THE KINNICKINNIC RIVER ON THE DATES OF WATER SAMPLE COLLECTION: 1965-1970



Source: SEWRPC.

The Milwaukee-Metropolitan Sewerage District collected and analyzed samples for chlorides from five sites located in the lower reaches of the Kinnickinnic River main stem during the years 1965 through 1969. More specifically, these sites were located at the S. 6th Street bridge, S. Chase Avenue near the flushing tunnel outlet, the W. Lincoln Street bridge, the W. Becher Street bridge, and the Kinnickinnic River Harbor at E. Mineral Street extended, the latter three sites being located downstream from the flushing tunnel outlet. The samples were collected on a weekly basis beginning in May 1965 and 1966, June 1967, 1968, and 1969, and ending in August 1968, September 1965, 1967, and 1969, and November 1966.

Biochemical Oxygen Demand: The levels of five-day biochemical oxygen demand (BOD_5) are reported for the same stations and the same dates for which the dissolved oxygen levels were reported by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department and are shown in Figure 59. Analysis of the five years of BOD_5 data obtained from these two reports indicates a general decrease in the BOD_5 between S. 6th Street and the Harbor. However, the overall low values, all below 10 mg/l, are probably due to dilution of the River waters by Lake water provided through the flushing tunnel and the seiche effect if occurring at the time of sampling in the lower reaches of the River.

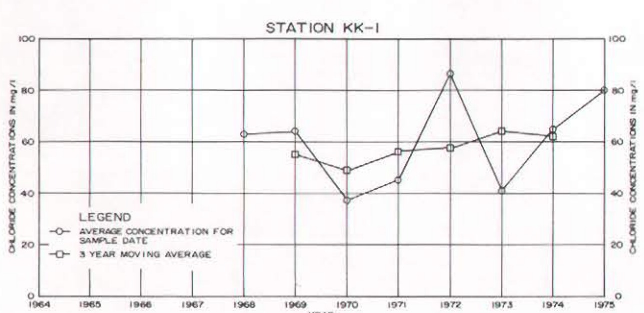
Fecal Coliform Bacteria: The graph insert to Map 24, which presents the fecal coliform counts obtained at the Kinnickinnic River sampling station during the August sampling periods for the years 1968 through 1975, indicates the changes in the fecal coliform bacterial counts. The fecal coliform counts obtained over this eight-year period ranged from 200 MFFCC/100 ml to 72,000 MFFCC/100 ml with an average of 8,117 MFFCC/100 ml. Seasonal variations in the fecal coliform counts ranged from a minimum of 200 MFFCC/100 ml on August 11,

Map 23

COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1975 IN THE KINNICKINNIC RIVER WATERSHED

1968 1975

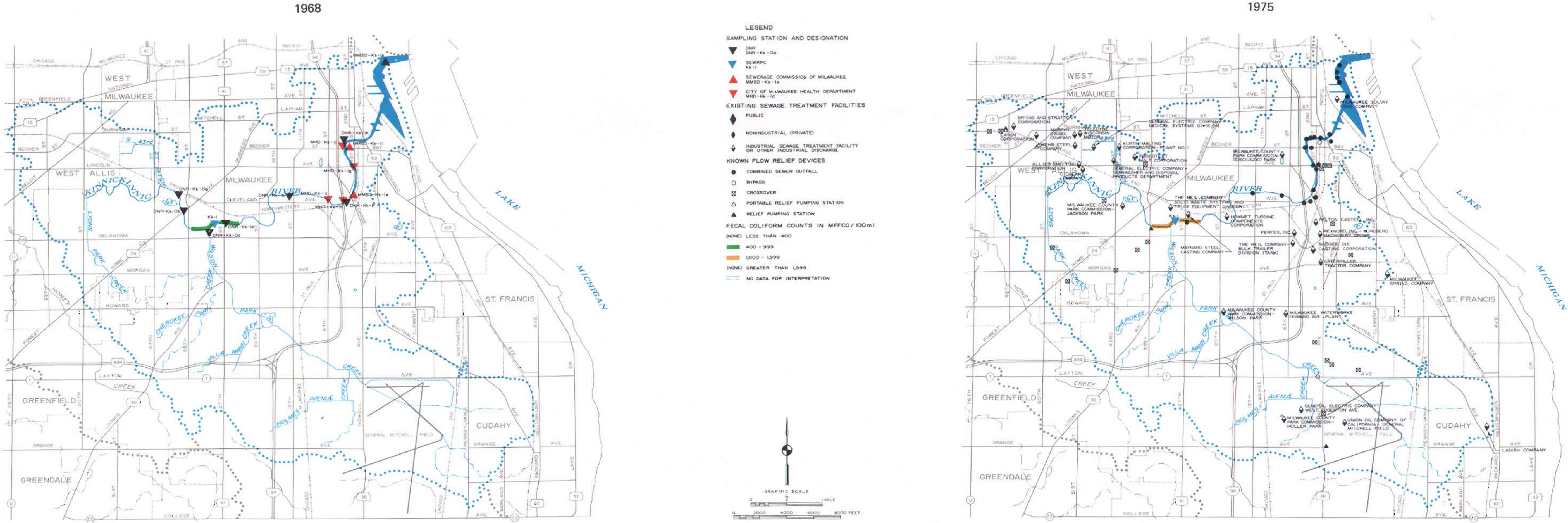
A comparison of the chloride concentrations recorded in 1968 and 1975 in the Kinnickinnic River watershed indicated that chloride concentrations generally remained stable at the one sampling station in the watershed. The maximum recorded chloride concentration was 135 mg/l, while the minimum was 26 mg/l.



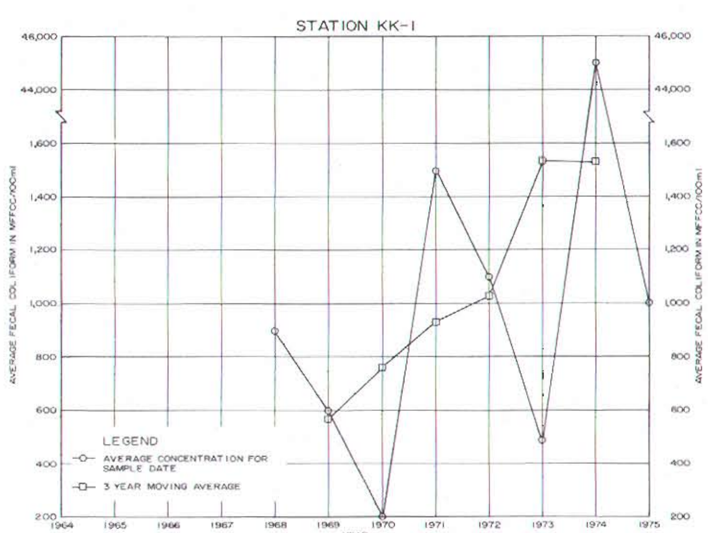
Source: SEWRPC.

Map 24

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1975 IN THE KINNICKINNIC RIVER WATERSHED



The fecal coliform counts obtained over the eight-year period ranged from 200 MFFCC/100 ml to 72,000 MFFCC/100 ml with an average of 8,117 MFFCC/100 ml. The average fecal coliform counts recorded at the Kinnickinnic River sampling station were found to have generally increased over the decade to levels generally exceeding the 2,000 MFFCC/100 ml maximum standard prescribed for the Kinnickinnic River, although the samples collected in August 1975 did satisfy the standard. The maximum recorded fecal coliform count was 72,000 MFFCC/100 ml, while the minimum was 200 MFFCC/100 ml.



Source: SEWRPC.

1970, to a maximum of 260,000 MFFCC/100 ml on April 28, 1968. The high counts of fecal coliform bacteria may be attributed to the raw sewage discharged from the sanitary flow relief devices located upstream from the sampling station and the result of the initial flush of urban storm water runoff from flow relief devices. However, continued flushing of these flow relief devices during a storm event and the associated high stream flows tend to dilute the sanitary wastes initially discharged. Hence, lower fecal coliform counts are observed.

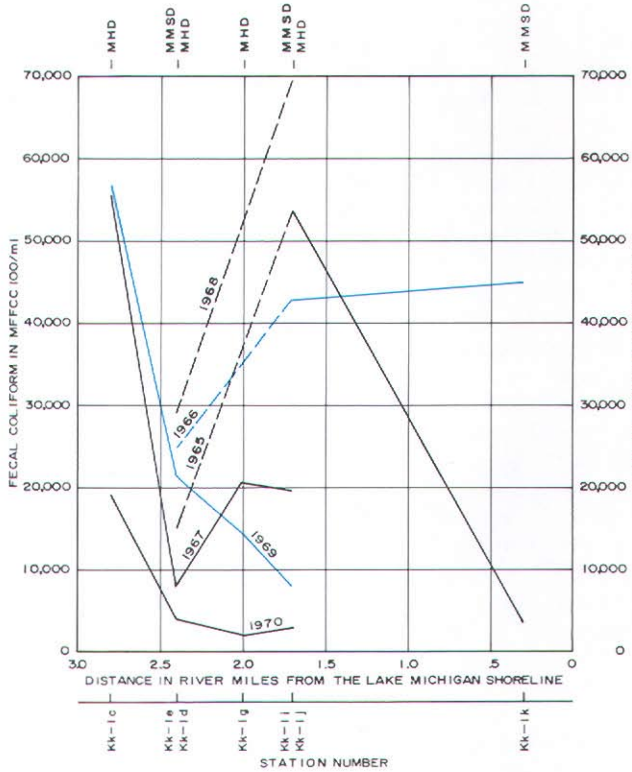
A comparison of the fecal coliform data recorded by the Milwaukee-Metropolitan Sewerage District in the sampling program as described above, with the 2,000 MFFCC/100 ml restricted standard, indicates that 43 of the 59 counts recorded in 1965, 57 of the 75 counts recorded in 1966, 67 of the 115 counts recorded in 1967, 21 of the 26 counts recorded in 1968, and 49 of the 56 counts recorded in 1969 exceeded the standard. It is noteworthy that the highest percentage of recorded values exceeding the applicable standard occurred in 1969, when the flushing tunnel was inoperative.

The City of Milwaukee Health Department recorded the average fecal coliform counts during the summer of 1970 at four sampling stations located at S. 6th Street, the flushing tunnel outlet, W. Lincoln Avenue, and W. Becher Street. The average fecal coliform counts exceeded the 2,000 mg/l restricted standard at all four stations during the study.

Figure 60 shows the average fecal coliform bacteria counts obtained by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department. The elevated fecal coliform counts in the lower reaches of the Kinnickinnic River may be attributed primarily to the combined sewer overflows located immediately upstream.

Figure 60

FECAL COLIFORM COUNTS RECORDED IN THE KINNICKINNIC RIVER ON THE DATES OF WATER SAMPLE COLLECTION: 1965-1970



Source: SEWRPC.

Specific Conductance: The specific conductance, as previously mentioned, is a measure of the total dissolved ion concentration in the water. The samples collected at the Kinnickinnic River sampling station average 744 µmhos/cm at 25°C and ranged from 560 to 962 µmhos/cm at 25°C during the August sampling periods from 1968 through 1975. A comparison of the specific conductance values recorded in April 1968 with those recorded in August 1968, and in April 1969 with those recorded in August 1968, indicates a trend toward a higher specific conductance in the April samples which corresponds to the trend exhibited by the chloride concentrations obtained for the same periods. The higher specific conductance values obtained during the month of April may be attributed to the spring runoff containing de-icing salts applied to the paved surfaces of the watershed during the winter months. As with chloride values, a slight increase in the specific conductance of the August samples was noted when the 1968 and 1975 data are compared.

Hydrogen Ion Concentration (pH): As indicated in Table 67, the pH values obtained at the Kinnickinnic River sampling station generally fell within the 6.0 to 9.0 standard units prescribed for the restricted use and minimum standards criteria and averaged 7.8 standard units for the 11-year period. The pH was observed outside of this range on only one occasion when a value of 5.8 standard units was obtained from a sample collected at 4:20 a.m. during the August 1970 sample survey. This decrease in pH during the early morning hours can probably be accounted for by the discharge of acidic substances to the River rather than the "normal" diurnal pH fluctuations due to algal respiration. The presence of five industries which discharge process waters and 15 industries which discharge both process and cooling waters in the tributary area watershed support this explanation.

Samples collected by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department staffs also were analyzed for pH from five sites located in the lower reaches of the Kinnickinnic River main stem during the years 1965 through 1970, as discussed earlier. The average pH concentrations exhibited insignificant spatial changes in the lower reaches of the Kinnickinnic River. In addition, the pH levels observed were generally within the applicable standard of 6.0 to 9.0 standard units, established for the Kinnickinnic River and its tributaries.

Temperature: As indicated in Table 67, the temperature of the stream water of the watershed has remained below the 89°F standard established for minimum standards. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

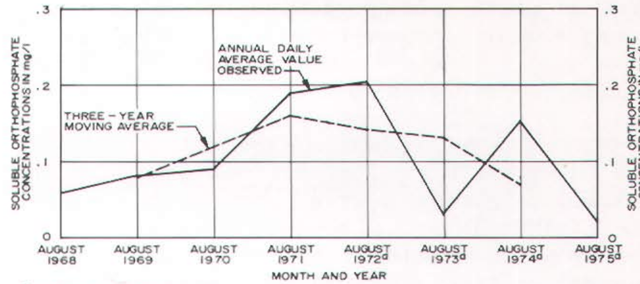
Soluble Orthophosphate and Total Phosphorus: Water samples collected at the Kinnickinnic River sampling station during the low flow periods of August 1968 through August 1975 were analyzed for the concentrations of soluble orthophosphate as phosphorus. Figure 61 shows the average concentrations of soluble orthophosphate-P observed in August samples. The concentrations ranged from a minimum of 0.02 mg/l to a maximum of 0.75 mg/l with an average of 0.10 mg/l during the eight low flow sampling surveys. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus. The results ranged from a minimum of 0.01 mg/l to a maximum of 0.34 mg/l as phosphorus with an average concentration of 0.12 mg/l as phosphorus for the low flow periods over the four years of sampling. The ratio of soluble orthophosphate to total phosphorus was in the range of 0.3 to 1.0. The high ratio of soluble to total phosphorus in the water samples indicates that most of the phosphorus is in a form which is readily available for the growth of aquatic plants in the Kinnickinnic River. Although an insufficient number of samples was analyzed to characterize the trends in the total phosphorus concentrations with time, the data do indicate that, in two of the four years, the available phosphorus concentrations in the water samples are higher than the threshold level of 0.10 mg/l which is generally regarded as sufficiently low for phosphorus as the limiting nutrient to prevent nuisance algae blooms as well as excessive growths of other aquatic plant life in flowing waters. The lack of streamflow data corresponding to the sample dates and locations in the Kinnickinnic River watershed for most of the period of record precludes meaningful analysis of total phosphorus loadings within this watershed.

Nitrogen: The total nitrogen concentrations in the Kinnickinnic River water samples collected during August of the years 1972 through 1975 were within the range of 0.68 to 2.00 mg/l as nitrogen. One to 8 percent of the total nitrogen was in the form of nitrite nitrogen, 9 to 32 percent as ammonia nitrogen, 21 to 32 percent as nitrate nitrogen, and 36 to 55 percent as organic nitrogen. Thus, 27 to 63 percent of the total nitrogen content of the Kinnickinnic River water sample was in the readily available forms of nitrate nitrogen and ammonia nitrogen. As indicated earlier in this report, the presence of any form of nitrogen indicates the presence of organic pollutants in the stream.

The concentrations of ammonia nitrogen at the Kinnickinnic River sampling stations ranged from a minimum of 0.11 mg/l to a maximum of 0.63 mg/l with an average concentration of 0.27 mg/l as nitrogen, well below the known toxic level of 2.5 mg/l for ammonia nitrogen as N. On five of the eight sampling dates the ammonia nitrogen

Figure 61

SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS AT THE KINNICKINNIC RIVER SAMPLING STATION (Kk-1 ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



a AVERAGE OF TWO SAMPLES

Source: SEWRPC.

levels did exceed the 0.2 mg/l as N, generally held to be indicative of lakes and streams which have been affected by pollution.

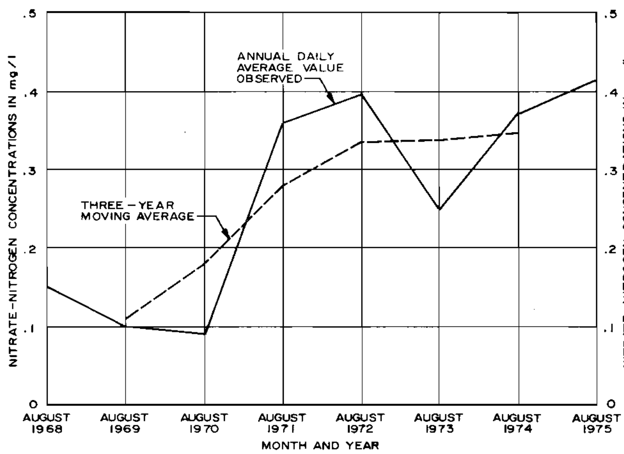
The nitrate nitrogen concentrations at the Kinnickinnic River sampling station, Kk-1, ranged from a minimum of 0.09 mg/l to a maximum of 0.70 mg/l with an average concentration of 0.33 mg/l. Figure 62 shows the average nitrate nitrogen concentrations and a three-year average for the 1968 through 1975 low flow period. The figure indicates an increasing trend in the nitrate nitrogen concentrations over the past eight years in the Kinnickinnic River sampling station, Kk-1. The major source of nitrate nitrogen in the Kinnickinnic River watershed is likely to be sanitary sewage overflows from flow relief devices located upstream from the sampling station.

The organic nitrogen, which ranged from a minimum of 0.33 mg/l to a maximum of 0.87 mg/l with an average of 0.60 mg/l, accounts for 36 to 55 percent of the total nitrogen in the samples collected at the Kinnickinnic River watershed sampling station, Kk-1. The presence of organic nitrogen is directly related to the discharge of organic wastes such as sewage or industrial wastes into the stream. No attempt is made to identify a trend in the total and organic nitrogen levels in the Kinnickinnic River, as the four years of data collected are insufficient for this purpose.

Diurnal Water Quality Changes: Figure 63 through Figure 66 set forth the diurnal changes in chloride, dissolved oxygen, hydrogen ion concentrations (pH), and temperature that occurred during the low flow conditions on August 8-9, 1971, at the Kinnickinnic River sampling station, Kk-1. The chloride concentrations ranged from a minimum of 32 mg/l in the early evening hours to a maximum of 61 mg/l at midnight. However, the trend indicates higher chloride concentrations during the morning hours and somewhat lower chloride concentrations during the afternoon and evening hours for the August 8-9, 1971, 24-hour sample period. The diurnal fluctuation in the chloride concentrations

Figure 62

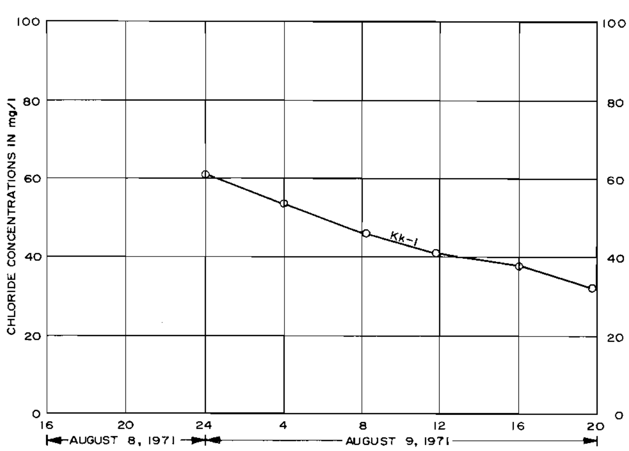
NITRATE NITROGEN CONCENTRATIONS IN THE KINNICKINNIC RIVER WATERSHED AT SAMPLING STATION Kk-1 ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

Figure 63

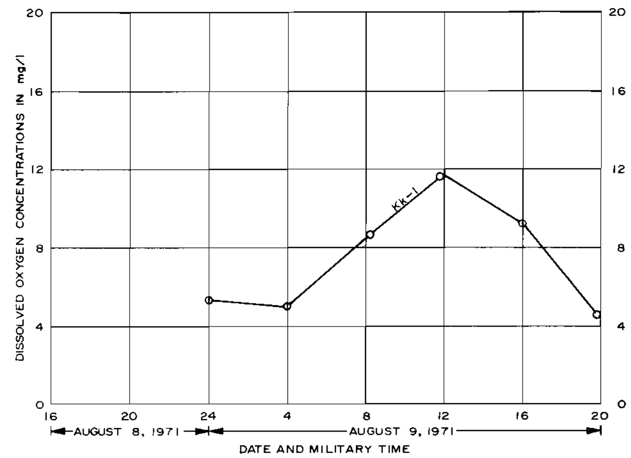
DIURNAL VARIATIONS IN CHLORIDE IN THE KINNICKINNIC RIVER WATERSHED: AUGUST 8-9, 1971



Source: SEWRPC.

Figure 64

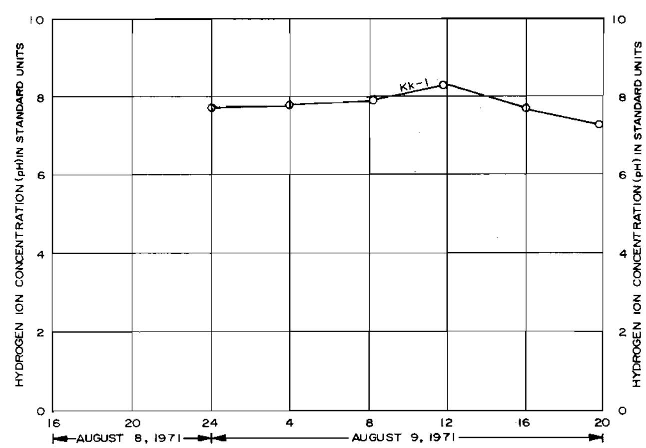
DIURNAL VARIATIONS IN DISSOLVED OXYGEN IN THE KINNICKINNIC RIVER WATERSHED: AUGUST 8-9, 1971



Source: SEWRPC.

Figure 65

DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS (pH) IN THE KINNICKINNIC RIVER WATERSHED AUGUST 8-9, 1971



Source: SEWRPC.

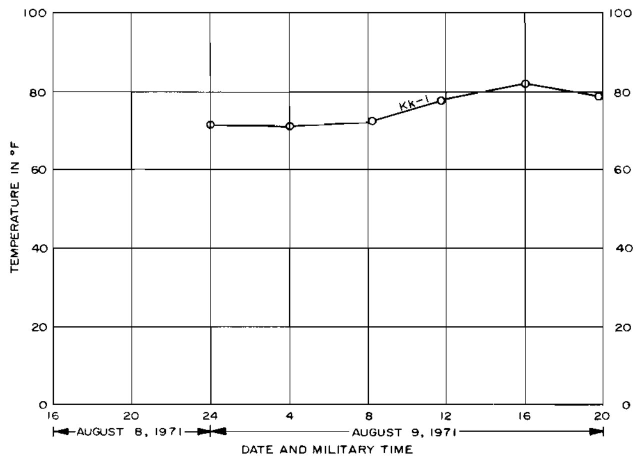
coincides with expected variations in flow of the industrial waste discharges and sanitary sewer overflows over a 24-hour period.

The concentration of dissolved oxygen at the Kk-1 station varied from a midnight minimum of 5.0 mg/l to a midafternoon maximum of 11.7 mg/l. The low dissolved oxygen levels of early morning and evening are attributed to the respiration of algae and, to a lesser extent, other aquatic plants. The dissolved oxygen levels increased considerably during the daytime to a level of supersaturation. These supersaturated conditions are attributed to photosynthetic production of oxygen by algae.

The hydrogen ion concentration (pH) varied from a minimum of 7.3 standard units at 10 p.m. to a maximum of 8.3 standard units at 12 noon on August 9, 1971. Generally, the net uptake of carbon dioxide by the aquatic flora during the daylight hours accounts for the higher pH levels. Conversely, the pH levels are lowered by

Figure 66

DIURNAL VARIATIONS IN TEMPERATURE IN THE KINNICKINNIC RIVER WATERSHED: AUGUST 8-9, 1971



Source: SEWRPC.

0.5 to 1.0 standard units because of the release of carbon dioxide and the attendant liberation of hydrogen ion during the nondaylight hours by the respiration of these same aquatic plants.

The water temperature during the 24-hour survey of August 8-9, 1971, ranged from a minimum of 71.0°F in the early morning hours to a maximum of 82.5°F in the late afternoon. The observed diurnal water temperature fluctuation was probably the result of corresponding diurnal variations in the air temperature and solar radiation.

Spatial Water Quality Changes: The water quality surveys clearly indicate that the water quality conditions change from one location to another in the watershed stream system in response to a combination of human activities and natural phenomena. Figures 67 through 69 show the spatial water quality variations along the main stem of the Kinnickinnic River as recorded under the low flow hydrologic conditions in August of the years 1968 through 1970. The illustrations include profiles of the average values for chloride, dissolved oxygen, and fecal coliform bacteria.

A decrease in the chloride concentration was observed between the Commission water quality sampling station, Kk-1, and the Milwaukee-Metropolitan Sewerage District station located at the W. Becher Street bridge. The lower chloride concentrations may be attributed to the dilution associated with the operation of flushing tunnel and the seiche effect of Lake Michigan.

The dissolved oxygen concentrations increased with distance and remained at or above supersaturation levels from sampling station Kk-1 to S. 6th Street, and exhibited a decreasing trend from S. 6th Street to the mouth of the River. The decrease in the dissolved oxygen concentrations downstream from S. 6th Street could very well result from the discharge of raw sewage during sewer surcharge through 19 combined sewer overflows that are located in the area.

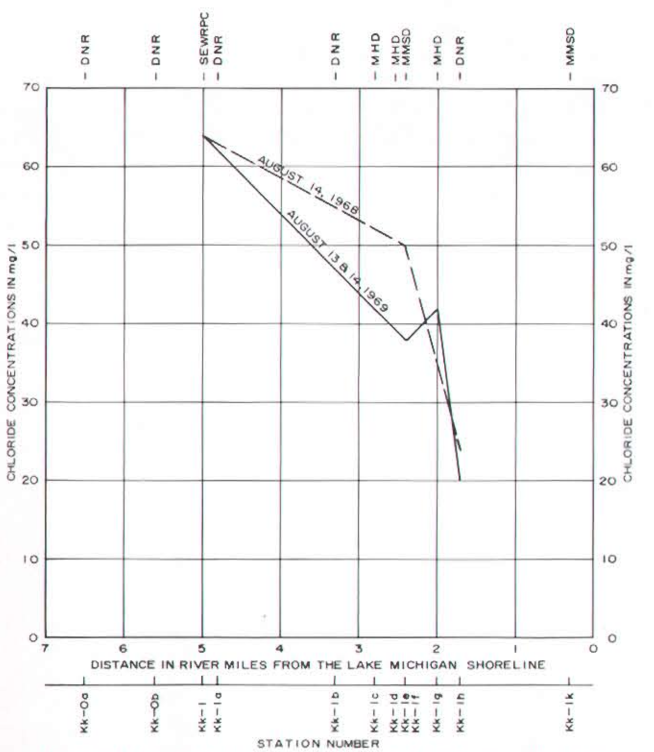
An increase in the fecal coliform bacteria counts is noted between sampling station Kk-1 and the Milwaukee-Metropolitan Sewerage District sampling station located at the flushing tunnel. These high fecal coliform counts are attributable to the location of 22 combined sewer overflows in the lower reaches of the Kinnickinnic River. The lower concentrations observed at other sampling sites downstream from the flushing tunnel reflect the effect of the Lake Michigan seiche as well as the effect of the flushing tunnel operation.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low flow samples between 1964 and 1975 were used to assess the water quality at the Kk-1 station. This procedure provides for an assessment of water quality as it existed on the days sampled between 1964 and 1975 and allows for an evaluation of the water quality standards that support the minimum standards and restricted use objectives established for the Kinnickinnic River watershed stream system. While comparative analysis must consider the concurrent hydrologic conditions—since the water quality standards are not intended to be satisfied under all streamflow conditions—the analysis of the restricted use and minimum standards must be viewed with caution, not only because hydrologic data are lacking for the study period, but also because the water quality samples analyzed have been collected at only one station.

The comparative analysis of observed water quality and the standards was based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits for temperature, dissolved oxygen, pH, and fecal coliform bacteria are explicitly set forth in the standards adopted by the State in 1973, whereas critical values for the remaining three parameters are the recommended levels which have been adopted by the Commission. In the comparative analysis for a given survey, the the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was beyond the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the restricted water use objective and minimum standard states that the fecal coliform count shall not exceed a monthly geometric mean of 1,000 colonies per 100 ml, based on not less than five samples per month, nor shall the count exceed a monthly geometric mean of 2,000 colonies per 100 ml in more than 10 percent of all samples during a month.

Figure 67

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE KINNICKINNIC RIVER WATERSHED: 1968-1970

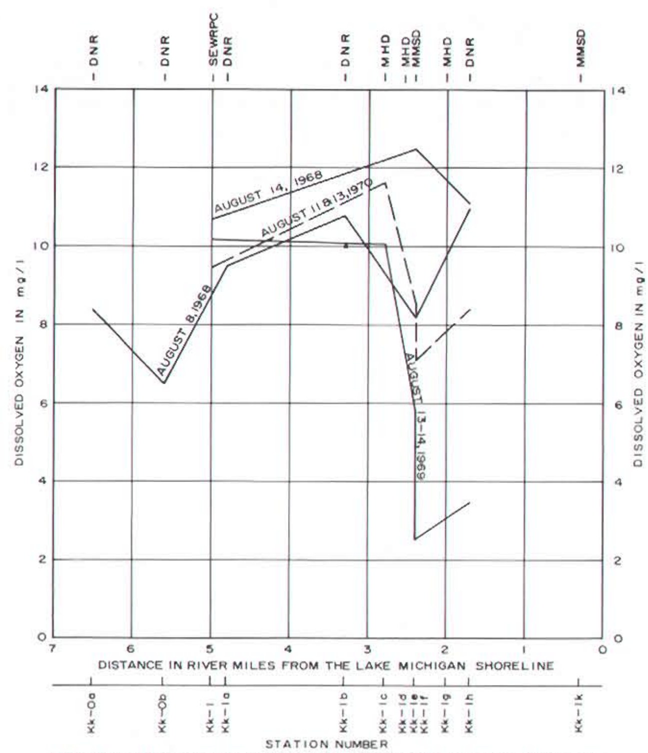


a THE EVALUATION OF THE SPATIAL DISTRIBUTION FOR THE KINNICKINNIC RIVER WATERSHED DIFFERED FROM THE BASIC COMMISSION SPATIAL DISTRIBUTION ANALYSIS DUE TO THE FEWER WATER QUALITY SAMPLES AND THE DIFFERENT DATES ON WHICH THE SAMPLES WERE TAKEN

Source: SEWRPC.

Figure 68

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE KINNICKINNIC RIVER WATERSHED: 1968-1970



a THE EVALUATION OF THE SPATIAL DISTRIBUTION FOR THE KINNICKINNIC RIVER WATERSHED DIFFERED FROM THE BASIC COMMISSION SPATIAL DISTRIBUTION ANALYSIS DUE TO THE FEWER WATER QUALITY SAMPLES AND THE DIFFERENT DATES ON WHICH THE SAMPLES WERE TAKEN

Source: SEWRPC.

Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standard for the restricted use designation was assumed to be violated during a particular survey at a particular location if any of the fecal coliform counts obtained at that location exceeded 2,000 colonies per 100 ml.

Water Quality 1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 25. A color coding scheme is used on Map 25 to indicate which of the standards are exceeded along the main stem of the Kinnickinnic River.

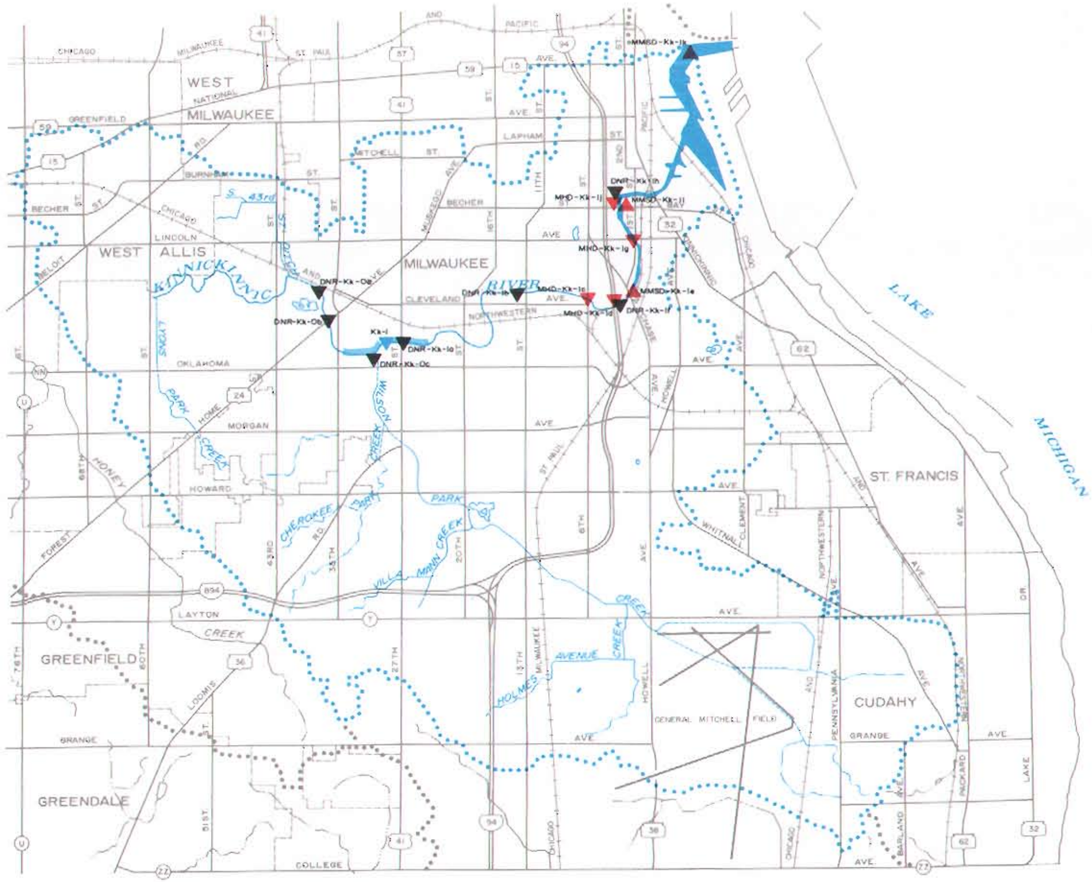
With respect to the Kinnickinnic River and its major tributaries, intended for restricted use and minimum standards, the water quality during the survey at the sampling station satisfied the temperature and dissolved oxygen standards at the single sampling station. The dissolved oxygen concentrations were considerably higher (3.0 to 8.0 mg/l) than the required level of 2.0 mg/l at the sampling station. Estimated fecal coliform counts in August 1964, as based on the percentage of the total coliform counts, were found to be in compliance with the stream standards for restricted use for that portion of the stream reach at sampling station Kk-1.

Since no nitrate, ammonia, total phosphorus, or pH analyses were made in the August 1964 samples, no comparison to the nutrient levels of the Kinnickinnic River waters can be made for 1964.

Water Quality 1975: With respect to the Kinnickinnic River main stem, intended for restricted use and minimum standards, Map 26 indicates that the water quality conditions during August 1975 were such that the temperature, dissolved oxygen, pH, ammonia, and fecal coliform bacteria standards were satisfied at the Commission's Kinnickinnic River sampling station, Kk-1, while substandard levels of nitrate and total phosphorus were recorded. Nitrate nitrogen concentrations in excess of 0.30 mg/l as nitrogen occurred at the sampling station. The high nitrate nitrogen content of the Kinnickinnic River may be reasonably assumed to result from the discharge of this nutrient from the sanitary sewer system

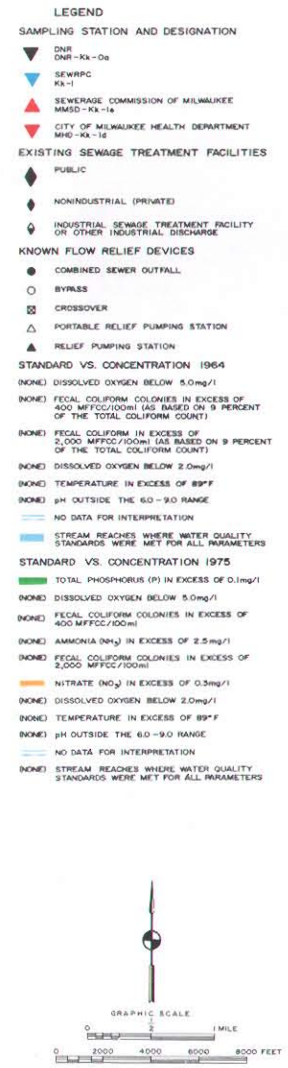
Map 25

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE KINNICKINNIC RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



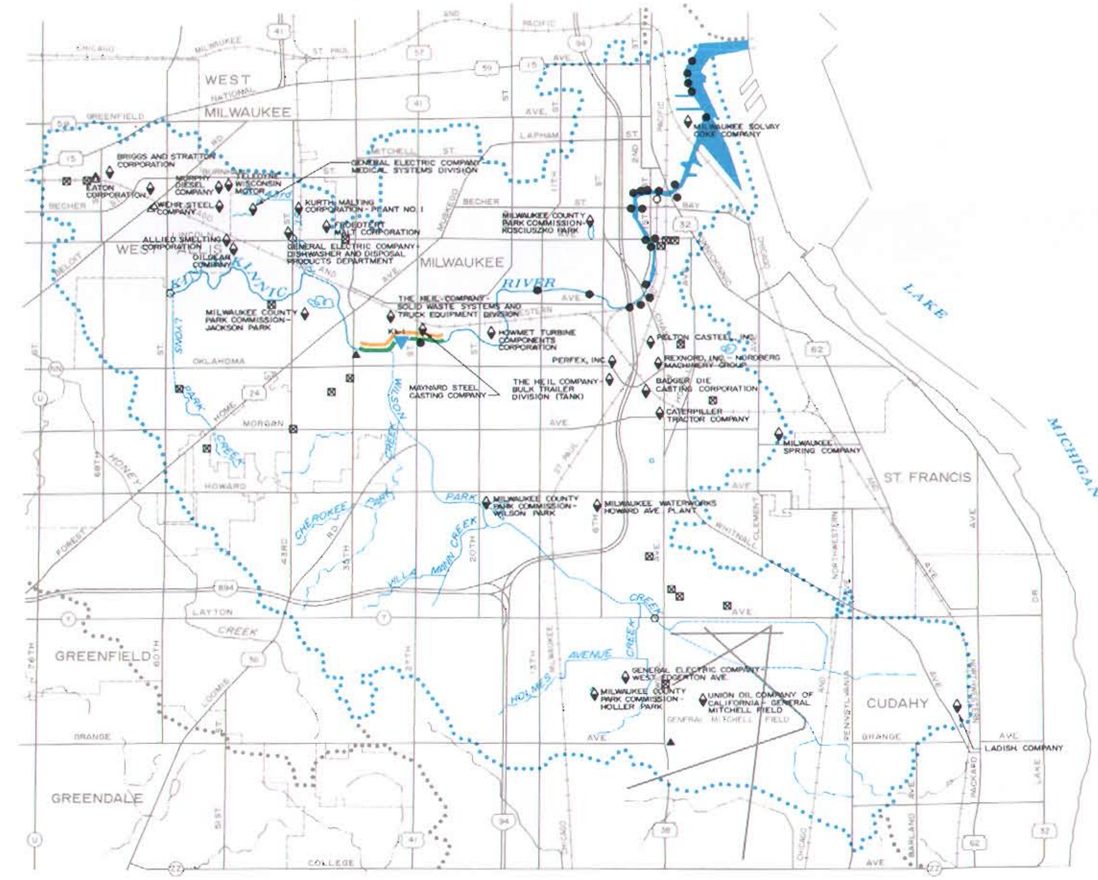
A comparison of the stream water quality in the Kinnickinnic River watershed as sampled in August 1964 to the adopted water quality standards indicated that temperature, dissolved oxygem, pH, and total coliform levels estimated to include fecal coliform standards were satisfied at the single Kinnickinnic River sampling station.

Source: SEWRPC.



Map 26

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE KINNICKINNIC RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

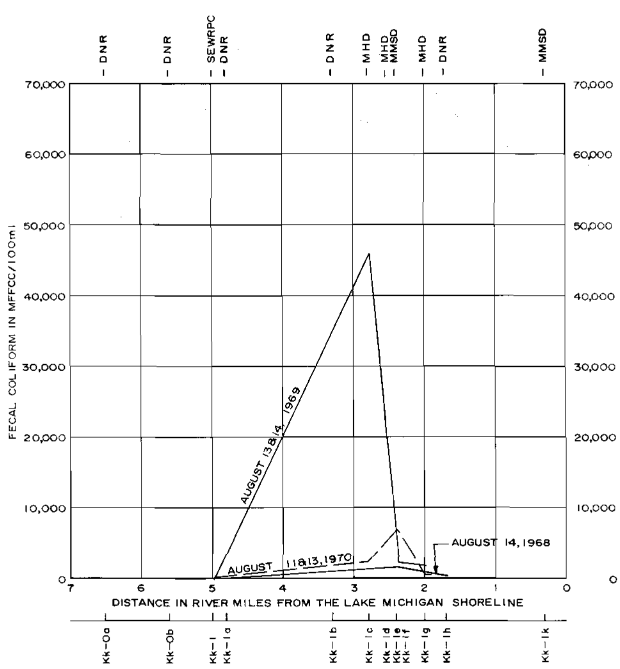


A comparison of the stream water quality in the Kinnickinnic River watershed as sampled in August 1975 to the adopted water quality standards station indicated that temperature, dissolved oxygen, ammonia, pH and fecal coliform bacteria standards were satisfied while substandard levels of nitrate and total phosphorus were recorded. As noted on Map 24, the fecal coliform standard was found generally to be exceeded in the more recent years of sampling.

Source: SEWRPC.

Figure 69

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE KINNICKINNIC RIVER WATERSHED: 1968-1970



a THE EVALUATION OF THE SPATIAL DISTRIBUTION FOR THE KINNICKINNIC RIVER WATERSHED DIFFERED FROM THE BASIC COMMISSION SPATIAL DISTRIBUTION ANALYSIS DUE TO THE FEWER WATER QUALITY SAMPLES AND THE DIFFERENT DATES ON WHICH THE SAMPLES WERE TAKEN

Source: SEWRPC.

flow relief devices. Total phosphorus exceeded the restricted use and minimum level of 0.10 mg/l as phosphorus in the Kinnickinnic River main stem. Although no water quality data are available for Kinnickinnic River downstream from sampling station Kk-1 for the year 1964 and 1975 to compare with the water quality standards, the available data from Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department for the years 1965 through 1970 indicate that the water quality standards generally were met for dissolved oxygen concentrations and hydrogen ion concentrations at the locations downstream from sampling station Kk-1 when the flushing tunnel was in operation. The data also indicate that the fecal coliform counts were not met even when the flushing tunnel was in operation during the sampling years of 1965-1970. However, when the flushing tunnel is not in operation, substandard levels of dissolved oxygen concentrations and fecal coliform counts have been observed at the lower reaches of the River.

Concluding Remarks—Kinnickinnic River Watershed

The Kinnickinnic River watershed is located in the south central portion of Milwaukee County. The Kinnickinnic River, approximately 8.0 miles in length and receiving discharge from approximately 8.2 miles of perennial stream tributaries, discharges to Lake Michigan through the Milwaukee Harbor estuary. The Kinnickinnic River watershed ranks fifth in population and is the eleventh in size of the 12 watersheds located wholly in the Region. In 1975 an estimated 165,088 persons resided within this watershed which has a total area of 24.85 square miles and a resulting population density of 6,596 people per square mile.

There are no publicly or privately owned nonindustrial sewage treatment plants located within the watershed. However, 52 sanitary sewer flow relief devices—23 combined sewer overflows, four bypasses, 19 crossovers, two relief pumping stations, and four portable pumping stations—located in the watershed discharge raw sewage into the stream system during times of sewer surcharge. A total of 60 industrial and commercial waste discharge points from 30 industries is known to exist in the watershed. Of these waste discharge points, 33 discharge cooling waters, seven discharge process wastewater, 15 discharge cooling and process wastewater, four discharge swimming pool overflow, and one discharges oil-contaminated storm water.

The Commission's 1970 land use inventory indicates that 89 percent of the watershed area is devoted to urban uses; 10 percent is devoted to rural use—primarily unused open lands—and the remaining 1 percent is occupied by the River, tributary streams, ponds, and wetlands. The watershed is markedly void of lakes, but has six small ponds, each having a surface area of eight acres or less. Essentially all of the area within 1,000 feet of the shoreline of the ponds and streams within the watershed is presently in urban land use. Runoff from this urban area may be expected to have a significant effect on the surface water quality of the River system.

The 1964-1965 benchmark stream water quality study conducted by the Commission included one sampling station located on the Kinnickinnic River. The water quality data for 1964-1965 from the sampling station indicate that the chloride levels during April were higher than the normal background concentrations, assumedly reflecting a chloride impact on the stream from winter street salting operations and spring runoff. The dissolved oxygen concentrations recorded at the Kinnickinnic River sampling station, Kk-1, at that time indicated levels well above the 2.0 mg/l standard attendant to the restricted use and minimum standards established as the water use objectives for the Kinnickinnic River. However, substandard dissolved oxygen concentrations are assumed to exist downstream in the reaches of the stream affected by combined sewer overflow. High total coliform counts which occurred upstream from the combined sewer outfalls at the sampling station corresponded to spring runoff periods and to runoff occurring after rainfall events recorded at General Billy Mitchell Field weather station during the period from September 19 through 24, 1964. The high coliform counts also are presumed to exist downstream in the reaches of the stream affected by combined sewer overflows. The specific conductance values were found to be highest during the spring runoff period at the sampling station, and thus corresponded to the periods of highest chloride concentrations. The pH values obtained during the study were found to be within the range of from 6.0 to 9.0 standard units prescribed for rivers and streams designated for restricted use and minimum standards. Temperature variations reflected only the expected seasonal changes. However, the discharge of cooling waters to the Kinnickinnic River and its tributaries, particularly during warm weather low flow conditions, may have contributed to localized elevations of the temperature levels.

The continuing water quality monitoring program conducted by the Commission during the period from 1965 through 1975 included sampling at the single station established in the watershed. The dissolved oxygen concentrations observed during the Commission continuing water quality monitoring program were well above the established 2.0 mg/l for restricted use at the Kinnickinnic River sampling station. The daily average dissolved oxygen concentrations in the August samples, collected over the past decade, remained near saturation levels but exhibited a distinct decline over the years of sampling. The dissolved oxygen concentrations can be reasonably assumed to decline downstream from the sampling location, since the stream flows through the combined sewer service area. This is supported by the data obtained by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department in the lower reaches of the Kinnickinnic River where dissolved oxygen concentrations were found to decline between S. 6th Street and the Harbor estuary. The effect of the flushing tunnel on the dissolved oxygen concentrations also was noted particularly in 1969 when the tunnel was inoperative and the average dissolved oxygen concentrations were below the 2.0 mg/l standard at the W. Becher Street bridge. August and September levels of the five-day biochemical oxygen demand (BOD_5) levels, also recorded in the lower reaches of the Kinnickinnic River by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department, were below 10 mg/l. The low levels of BOD_5 are probably attributable to dilution from the flushing tunnel and the seiche effect caused by Lake Michigan. The diurnal water quality data for the Kinnickinnic River exhibit a broad range of dissolved oxygen concentrations from a low of 4.5 mg/l to a high of 11.7 mg/l over a 24-hour period, and reflect dissolved oxygen reductions from respiration by the aquatic flora and the supersaturation effects of algal photosynthesis.

The average chloride concentrations recorded during the August surveys indicate levels significantly exceeding the expected background concentration of 20 mg/l. Chloride concentrations generally increased in the samples obtained over the decade. The highest chloride concentrations continued to occur during the spring runoff periods as well as during runoff periods arising from rainfall events occurring at other times of the year. In addition to de-icing salts, the high chloride levels in the watershed probably are associated with sewage discharge from flow relief devices and in the lower reaches of the watershed combined sewer overflows. Chloride concentrations recorded by the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department exhibited spatially decreasing concentrations between S. 6th Street and the Kinnickinnic River flushing tunnel, from which point the concentrations stabilized downstream to the Harbor estuary. The magnitude of the dilution effect of the flushing tunnel operation was highlighted by the presence of elevated chloride levels during the 1969 sampling period, when the tunnel was inoperative. The seiche effect of Lake Michigan may also cause localized temporary dilution effects on the chloride concentrations of the Kinnickinnic River at its mouth.

The average fecal coliform counts recorded at the Kinnickinnic River sampling station generally increased over the decade and generally exceeded the 2,000 MFFCC/100 ml maximum standard prescribed for the Kinnickinnic River. The high fecal coliform counts may be attributed to the discharge of raw sewage from the sanitary sewer flow relief devices located upstream from the sample station. High fecal coliform counts are assumed to have been present downstream throughout the combined sewer service area, except perhaps during sustained periods of dry weather. This assumption is supported by the fecal coliform counts recorded by the Milwaukee-Metropolitan Sewerage District and City of Milwaukee Health Department for the lower reaches of the Kinnickinnic River, as the average fecal coliform counts exceeded the 2,000 MFFCC/100 ml standard at all of the sampling stations for the six year period of record of that sampling program.

The specific conductance values recorded at the Kinnickinnic River sampling station exhibited a trend toward higher values in the spring samples, corresponding to the trend in chloride concentrations. The higher specific conductance therefore is thought to be attributable to the spring runoff and snowmelt which contain high concentrations of de-icing salts. The pH values generally were within the applicable standard of 6.0 to 9.0 standard units, as established for the Kinnickinnic River, with one exception when the pH fell below the 6.0 standard unit. This decrease is assumed to be accounted for by the discharge of acidic substances to the River from industrial discharges. The nutrient concentrations remained in excess of the recommended levels of 0.30 mg/l as N, and 0.10 mg/l as P, in half of the nitrate nitrogen samples and in all of the total phosphorus samples collected by the Commission during the sampling since 1965.

The water quality of the Kinnickinnic River designated for restricted use and minimum standards at the sample location currently meets water quality standards for dissolved oxygen, pH, and fecal coliform counts. However, the plant nutrient levels, as measured by total phosphorus and nitrate nitrogen concentrations, were found to be significantly higher than the levels recommended for the avoidance of nuisance aquatic plant growth in the receiving waters which ultimately flow to Lake Michigan. The water quality of the River at sampling station Kk-1 does, however, exhibit degradation, as measured by dissolved oxygen, chlorides, and fecal coliform over the period since 1964. Available data from the Milwaukee-Metropolitan Sewerage District and the City of Milwaukee Health Department for the years 1965 through 1970 indicates that the water quality standards generally were met for dissolved oxygen concentrations and pH in the lower reaches of the Kinnickinnic River and its tributaries when the flushing tunnel was in operation. However, when the flushing tunnel was inoperative, the water quality of the lower reaches of the Kinnickinnic River and its tributaries did not meet the water quality standards set forth by the Wisconsin Department of Natural Resources for dissolved oxygen concentrations and fecal coliform counts.

MENOMONEE RIVER WATERSHED

Regional Setting

The Menomonee River watershed is a natural surface water drainage unit, 135.94 square miles in areal extent, located in the east central portion of the Region. The boundaries of the basin, together with the location of the main channel of the Menomonee River and its principal tributaries, are shown on Map 27. The main stem of the Menomonee River originates in the Village of Germantown in Washington County and discharges to Lake Michigan through the Milwaukee Harbor estuary in downtown Milwaukee. The principal tributaries include the Little Menomonee River which drains portions of the Cities of Mequon and Milwaukee; Lilly Creek which drains portions of the Village of Menomonee Falls; Underwood Creek which drains portions of the City of Brookfield, Village of Elm Grove, and City of Wauwatosa; and Honey Creek which drains portions of the City of Greenfield, City of Milwaukee, and City of West Allis. A significant proportion of the northern half of the watershed is still in agricultural use except for the urbanized areas which have developed in and around the Germantown and Menomonee Falls areas. The western boundary of the Menomonee River watershed is marked by the subcontinental divide. The relatively narrow watershed is bounded on the north and east by the Milwaukee River watershed; on the south by the Kinnickinnic River, Root River, and Oak Creek watersheds; and on the west by the Rock and Fox River watersheds.

In addition to the Little Menomonee River, Lilly Creek, Underwood Creek, and Honey Creek, the complex stream network of the watershed includes the North and West Branches of the Menomonee River, Willow Creek, Dousman Ditch, Nor-X-Way Channel, Butler Ditch, Little Menomonee Creek, South Menomonee Canal, Burnham Street Canal, and the South Branch of Underwood Creek. Table 68 lists for the Menomonee River watershed each stream reach, together with the location, the source, and the length in miles. Although the watershed ranks fifth in size of the 12 watersheds within the Region, it ranks second in total resident population.

Political Boundaries

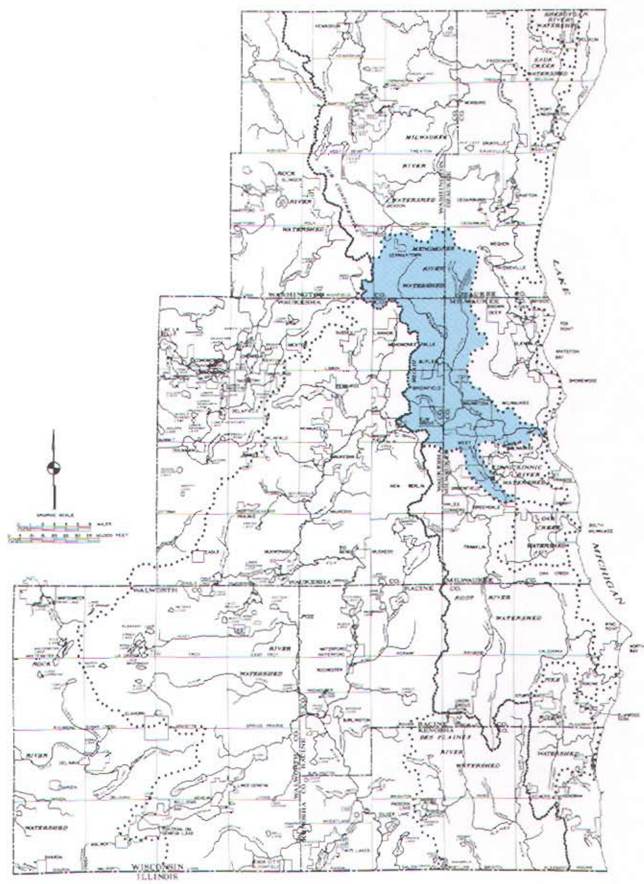
Superimposed upon the natural, meandering watershed boundaries is a rectilinear pattern of local political boundaries, as shown on Map 27. The watershed lies in four counties—Milwaukee, Ozaukee, Washington, and Waukesha—and in parts of seven cities, five villages, and three towns. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 69.

Population

Population Size: The 1975 resident population of the watershed is estimated at 336,824 persons, or about 18.8 percent of the total estimated population of the Region of 1,789,871. Table 70 presents the population distribution in the Menomonee River watershed by civil division. The population of the watershed has increased steadily since 1900, with particularly rapid growth and urbanization occurring after 1950.

Map 27

LOCATION OF THE MENOMONEE RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Menomonee River watershed located entirely within the seven-county Southeastern Wisconsin Region, has a total area of about 136 square miles and comprises about 5 percent of the total 2,689 square mile area of the Region. The Menomonee River watershed ranks second in population and fifth in size as compared to the 12 watersheds of the Region.

Source: SEWRPC.

Table 68

STREAMS IN THE MENOMONEE RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION

Stream or Watercourse	Source		Length (miles)
	By Civil Division	By U. S. Public Land Survey System	
North Branch Menomonee River	Village of Germantown	NW ¼, Section 8, T9N, R20E	1.83
West Branch Menomonee River	Village of Germantown	SE ¼, Section 19, T9N, R20E	2.05
Willow Creek	Village of Menomonee Falls	SW ¼, Section 6, T8N, R20E	1.65
Nor-X-Way Channel	Village of Menomonee Falls	NE and NW ¼, Section 25, T9N, R20E	2.08
Lilly Creek	Village of Butler	SW ¼, Section 35, T8N, R20E	3.29
Butler Ditch	City of Brookfield	NE ¼, Section 10, T7N, R20E	2.37
Little Menomonee Creek	City of Mequon	NW ¼, Section 17, T9N, R21E	2.25
Little Menomonee River	City of Mequon	SW ¼, Section 20, T9N, R21E	10.18
Dousman Ditch	City of Brookfield	SE ¼, Section 28, T7N, R20E	0.64
Honey Creek	City of Greenfield	NW ¼, Section 36, T6N, R21E	7.55
Menomonee River	Village of Germantown	SE ¼, Section 11, T9N, R20E	29.41
Underwood Creek	City of Brookfield	NW ¼, Section 15, T7N, R20E	7.47
South Menomonee Canal	City of Milwaukee	NW ¼, Section 32, T7N, R22E	0.87
Burnham Street Canal	City of Milwaukee	NW ¼, Section 32, T7N, R22E	0.55
South Branch Underwood Creek	City of West Allis	NW ¼, Section 6, T6N, R21E	1.08

[a] *Total perennial stream length as shown on U. S. Geological Survey quadrangle maps.*

Source: SEWRPC.

Population Distribution: About 79 percent of the residents of the watershed now live in Milwaukee County, which occupies 41 percent of the total area of the watershed; 3 percent of the residents of the watershed live in Washington County, which occupies 23 percent of the total area of the watershed; 1 percent of the residents of the watershed live in Ozaukee County, which occupies 9 percent of the total area of the watershed; and 17.5 percent of the residents of the watershed live in Waukesha County, which occupies 27 percent of the total area of the watershed. The percentages indicate that the resident population of the watershed is concentrated in Milwaukee and Waukesha Counties.

Quantity of Surface Water

Surface water in the Menomonee River watershed is made up almost entirely of streamflow. Some small ponds, flooded gravel pits, and wetlands make up the remainder of the surface water. The quantity of streamflow in the Menomonee River watershed, as in the Region, generally varies with seasonal variations in temperature, rainfall, soil moisture, agricultural operations, the growth cycle of vegetation, and groundwater levels.

The streamflow of the Menomonee River has been measured since 1961 at a continuous flow recording gage monitored by the U. S. Geological Survey in cooperation with the Wisconsin Department of Natural Resources at N. 70th Street in the City of Wauwatosa. The streamflow characteristics for the published period of record are summarized in Table 71. Low flows predominate at this station throughout most of the year with the exception of periods of spring runoff associated with the winter snow melt and sporadic periods of rainfall which result in typically higher flows. The streamflow fluctuates considerably as indicated by a peak discharge of 6,380 cubic feet per second recorded on April 21, 1973, and a summer discharge of 2.8 cubic feet per second recorded on January 18, 1964.

Surface runoff, the portion of precipitation which flows overland and contributes directly to streamflow, varies both with the season and with the location within the watershed. The ratio of runoff to precipitation in the spring, occurring when the soil is frozen or saturated, can be very high. Runoff during the summer and fall seasons generally is a very small fraction of the precipitation. In addition to the surface water runoff contribution from rainfall and snowmelt, the major tributaries and main stem of the Menomonee River accept flow in the form of discharges from public and private sewage treatment plants and numerous industries. Groundwater also contributes to the streamflow. Commission simulation model studies indicate, however, that groundwater comprises only about 10 percent of the total yearly flow of the Menomonee River stream system. Unlike the meteorological, municipal, and industrial inputs to the watershed system, the influx of the water from the shallow groundwater reservoir is relatively uniform and constitutes the baseflow of all perennial streams located within the watershed.

The lower reaches of the Menomonee River and other first rank tributaries to Lake Michigan are subject to

Table 69

AREAL EXTENT OF CIVIL DIVISIONS IN THE MENOMONEE RIVER WATERSHED

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
Milwaukee County			
Cities			
Greenfield.	2.77	2.04	23.82
Milwaukee	31.50	23.17	32.60
Wauwatosa	13.28	9.77	100.00
West Allis	6.76	4.97	59.40
Villages			
Greendale	0.11	0.08	1.97
West Milwaukee . .	0.66	0.48	59.46
County Subtotal	55.08	40.52	22.70
Ozaukee County			
City			
Mequon	11.76	8.65	25.00
County Subtotal	11.76	8.65	5.00
Washington County			
City			
Milwaukee	0.02	0.01	100.00
Village			
Germantown	29.41	21.63	85.25
Towns			
Germantown	0.75	0.55	44.38
Richfield	1.57	1.15	4.35
County Subtotal	31.75	23.35	7.29
Waukesha County			
Cities			
Brookfield	13.52	9.94	52.38
New Berlin	0.67	0.49	1.82
Villages			
Butler	0.80	0.59	100.00
Elm Grove	3.30	2.43	100.00
Menomonee Falls .	18.56	13.65	55.62
Towns			
Brookfield	0.20	0.15	2.89
Lisbon.	0.30	0.22	0.89
County Subtotal	37.35	27.48	6.43
Total	135.94	100.00	--

Source: SEWRPC.

Table 70

ESTIMATED RESIDENT POPULATION OF THE MENOMONEE RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
Milwaukee County	
Cities	
Greenfield (part)	8,752
Milwaukee (part)	159,819
Wauwatosa	55,712
West Allis (part).	38,753
Villages	
Greendale (part)	495
West Milwaukee (part)	3,230
Milwaukee County (part)	266,761
Ozaukee County	
City	
Mequon (part).	2,026
Ozaukee County (part)	2,026
Washington County	
City	
Milwaukee (part)	2
Village	
Germantown (part)	8,317
Towns	
Germantown (part)	375
Richfield (part)	383
Washington County (part)	9,077
Waukesha County	
Cities	
Brookfield (part)	18,934
New Berlin	2,657
Villages	
Butler	2,230
Elm Grove	7,692
Menomonee Falls (part)	27,233
Towns	
Brookfield (part)	173
Lisbon (part).	41
Waukesha County (part)	58,960
Menomonee River Watershed	336,824

Source: Wisconsin Department of Administration and SEWRPC.

a phenomenon known as a seiche. A seiche, also known as a standing wave, is an oscillation of the surface of the water mass of a lake lasting from a few minutes to several hours. The forces that generate seiches include variation atmospheric pressure and wind. The flow condition and the water quality in the lower reaches of the Menomonee River can be affected temporarily by the dilution effects of Lake Michigan water during a seiche.

Pollution Sources

Presently no private sewage treatment facilities operate within the Menomonee River watershed. The following types of pollution sources exist within the Menomonee River watershed or operated during the last 10 years and are discussed below: municipal sewage treatment facilities, domestic onsite sewage disposal systems, sanitary and combined sewerage system overflow points, industrial wastewater discharges, urban storm water runoff, rural runoff, and other runoff.

Sewage Treatment Facilities: Three municipal sewage treatment facilities currently discharge treated effluents to the main stem of the Menomonee River: the Old Village of Germantown sewage treatment facility and two sewage treatment facilities serving the Village of

Table 71

FLOW MEASUREMENTS FOR THE MENOMONEE RIVER AT N. 70TH STREET IN THE CITY OF WAUWATOSA (MN-10): 1964-1975

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1964	50.9	5.63	2,870	2.8
1965	96.4	10.64	1,610	6.2
1966	99.5	10.99	2,100	6.2
1967	41.5	4.57	781	6.0
1968	67.3	7.44	1,100	5.0
1969	81.8	9.03	1,180	9.4
1970	68.3	7.54	1,430	11.0
1971	89.5	9.88	1,550	10.0
1972	126	13.93	2,520	13.0
1973	169	18.69	6,380	17.0
1974	134	14.75	1,790	11.0
1975	107	11.76	1,570	14.0

Source: U. S. Geological Survey.

Menomonee Falls, the Pilgrim Road and Lilly Road facilities. Selected information for these municipal sewage treatment plants is set forth in Table 72 and the plant locations are shown on Map 28.[8] The Village of Germantown County Line Road plant serving a resident population of about 1,000 persons was abandoned in November 1973 and its service area connected to the main facility serving the Village.

Domestic Onsite Sewage Disposal: Another source of pollution within the Menomonee River watershed is private, onsite soil absorption sewage disposal systems which have the potential of releasing nutrients, fecal coliform bacteria, and other disease producing organisms into the surface waters via both subsurface and overland flow.

Sanitary Sewerage System Flow Relief Points: Sanitary and combined sewer system flow relief devices consisting of combined sewer outfalls, sanitary sewer overflows, crossovers, bypasses, relief pumping stations, and portable pumping stations contribute to the degradation of water quality in the Menomonee River and its tributaries by the intermittent discharge of raw sanitary sewage during periods of sewer surcharge. A description of the 166 known sewer flow relief devices in the Menomonee River watershed is contained in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. Of these 166 known flow relief devices, 26 are combined sewer outfalls, seven are bypasses, 28 are relief pumping stations, 73 are crossovers, and 32 are portable pumping stations, as shown on Map 28. Of the total, 106 flow relief devices and combined sewer outfalls discharge raw sewage directly to the Menomonee River main stem, one discharges to the Butler Ditch, 15 discharge to Underwood Creek, and 36 discharge to Honey Creek, six discharge to Burnham's Canal Branch, and two discharge to the South Menomonee Canal Branch as shown in Table 73. Included in this total is the Village of Butler overflow chlorination facility which discharges a maximum 400,000 gpd of chlorinated effluent into the Menomonee River. For the purposes of this study, this major discharge will be considered a bypass.

Industrial Wastewater Discharges: At 49 locations in the Menomonee River watershed industrial wastewaters consisting of cooling and process waters are discharged directly or indirectly to the surface water system. Industrial cooling and processing wastewaters enter the surface waters of the watershed directly through industrial waste outfalls or indirectly through drainage ditches and storm sewers.

Data and information provided by the Wisconsin Department of Natural Resources Pollutant Discharge Elimination System, and reports required by Chapter NR 101 of the Wisconsin Administrative Code, were used to determine the type and location of industrial wastewater discharges in the Menomonee River watershed. Table 74 provides selected information for the 79 industrial and commercial waste discharge points known to exist in the watershed. Of these, 41 discharge cooling waters, 15 process wastewaters, 16 cooling and process wastewaters, five swimming pool overflow, and two surface runoff. Thirty-one of the 49 industrial locations discharge wastewaters either directly or indirectly to the Menomonee River main stem, 17 discharge to tributaries of the Menomonee River, and one discharges to a soil absorption system. The locations of the 49 industrial wastewater discharges are shown on Map 28. The S. K. Williams Company operated a small industrial waste treatment facility until April 1975 when it diverted its wastes to the Milwaukee-Metropolitan sanitary sewer system.

Pollution from Urban Runoff: Separate storm sewers which convey rainfall runoff carry pollutants and contaminants from urbanized areas into the stream network. Urban storm waters can cause inorganic pollution, organic pollution, pathogenic pollution, and aesthetic pollution

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[8] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 28. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 72

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE MENOMONEE RIVER WATERSHED: 1975

Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity					Existing Loading	
							Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Average Organic	Population Equivalent[a]	Average Annual Hydraulic (mgd)	Average Annual Per Capita (gpd)
Village of Germantown Old Village Plant	1.88	4,600	1956 1973	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced and Auxiliary	Menomonee River	10,000	1.0	3.0	1,700	8,100	0.80	174
Village of Menomonee Falls Pilgrim Road Plant	6.17	20,400	1954 1961 1973 1975	Trickling Filter Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced and Auxiliary	Menomonee River	N/A	1.9	2.5	935	4,450	1.4	107
Village of Menomonee Falls Lilly Road Plant			1969 1973	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced and Auxiliary	Menomonee River	N/A	1.0	2.0	1,700	8,100	0.78	

NOTE: N/A indicates data not available.

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the table.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

of surface waters. Existing land use data, taken from the Commission's 1970 land use inventory and presented in Table 75, indicate that 46,596 acres, or about 53 percent of the total area of the Menomonee River watershed, is devoted to urban land uses and that 37,363 acres, or about 44 percent, is devoted to rural land uses, primarily agriculture. The remaining 2,843 acres, or about 3 percent, is composed of the stream system itself and associated wetlands. A shoreland development survey by the Wisconsin Department of Natural Resources indicates that about 28 percent of the shoreland area within 1,000 feet of the Menomonee River and its perennial tributaries is used either for agricultural purposes or other rural purposes, while 72 percent is used for urban purposes. Urban development is more intense within 1,000 feet of the perennial stream system than throughout the watershed as a whole, and the extent of this development indicates a potentially adverse impact on the water quality of the Menomonee River system.

Pollution from Rural Land: As indicated by the synoptic water quality surveys conducted by the Commission in 1973 and 1974, concentrations of total nitrogen and total phosphorus in stream flow emanated from the headwater areas of the watershed devoted to agricultural use. Although only 43 percent of the watershed is devoted to agricultural use, most of the farming operations are concentrated in the northern half of the watershed, particularly in the headwater areas of the Menomonee River and the Little Menomonee River. Thus the potential exists for degradation of the water quality of the upper reaches of the Menomonee River and its northernmost tributaries from the runoff of natural and artificial fertilizers applied to the land, various animal wastes from feedlot and grazing operations, and other nutrient contamination from agriculture-related operations.

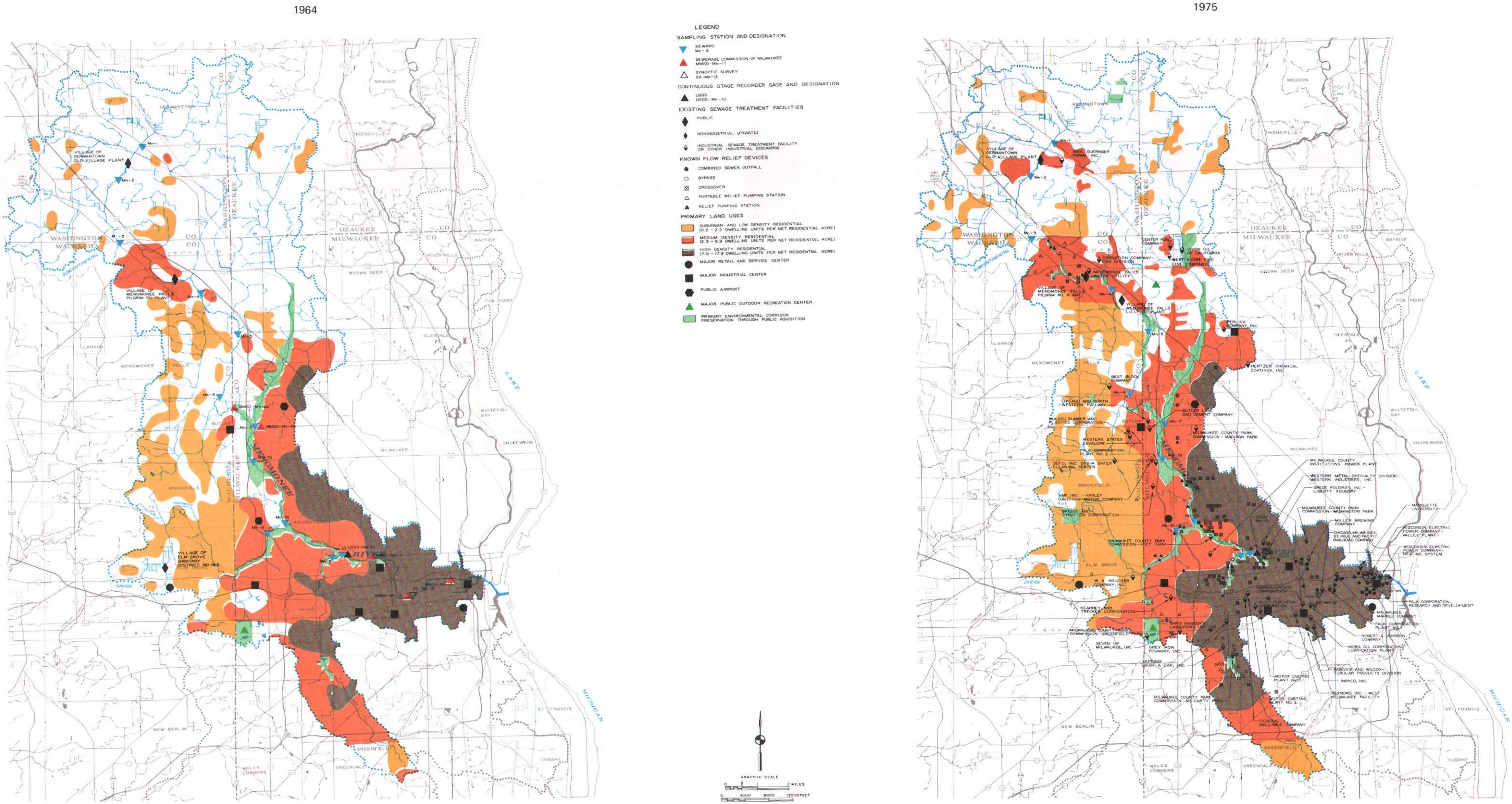
Other Pollution Sources: In addition to the urban and rural land runoff and the municipal and industrial waste discharges, other pollution sources exist within the watershed. Seepage and runoff from six sanitary landfill sites and 16 auto salvage yards contribute to pollution in the watershed through the production and release of organic, inorganic, and pathogenic pollutants. Street and highway construction, land development, and individual residential home construction also contribute to the pollutant loadings of the stream system in both rural and urban areas of the watershed.

Water Quality Conditions of the Menomonee River Watershed

Water Quality Data: Eight of the data sources documented in Chapter II of this report and cited below were used in the analysis and evaluation of water quality of the Menomonee River watershed: (1) Commission benchmark stream sampling study, (2) Commission continuing stream and lake monitoring program, (3) Commission continuous streamflow management program, (4) Commission Menomonee River synoptic water quality surveys, (5) Wisconsin Department of Natural Resources river basin surveys, (6) Milwaukee-Metropolitan Sewerage District stream water quality sampling program, (7) U. S. Geological Survey continuous streamflow monitoring program, and (8) U. S. Geological Survey stream and lake water quality sampling program.

Map 28

LOCATION OF STREAM SAMPLING STATIONS, PUBLIC SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE MENOMONEE RIVER WATERSHED: 1964 and 1975



Stream water quality data were obtained from chemical, physical, biochemical, and bacteriological analyses of water samples collected at twelve sampling stations located in the Menomonee River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by discharges from three municipal sewage treatment facilities, 26 combined sewer outfalls, 73 crossovers, seven bypasses, 28 relief pumping stations, 32 portable pumping stations, and 49 industrial or commercial facilities which discharge wastewater into the Menomonee River watershed through 79 outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Table 73

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE MENOMONEE RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Crossovers	Other Flow Relief Devices			Total
				Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Burnham's Canal Branch	City of Milwaukee	6	0	0	0	0	6
South Menomonee Canal Branch	City of Milwaukee	2	0	0	0	0	2
Menomonee River	City of Milwaukee	18	26	1	0	0	45
Menomonee River	City of Wauwatosa	0	29	1	11	0	41
Menomonee River	Village of Butler	0	0	2	0	0	2
Butler Ditch	City of Brookfield	0	0	0	0	1	1
Underwood Creek	City of Brookfield	0	0	0	0	2	2
Underwood Creek	City of West Allis	0	0	0	0	5	5
Honey Creek	City of West Allis	0	3	0	0	15	18
Menomonee River	Village of Menomonee Falls	0	5	0	4	9	18
Honey Creek	City of Wauwatosa	0	5	3	4	0	12
Underwood Creek	City of Wauwatosa	0	0	0	8	0	8
Subtotal	--	26	68	7	27	32	160
Honey Creek	City of Milwaukee	0	5	0	1	0	6
Total	--	26	73	7	28	32	166

Source: SEWRPC.

Twelve sampling stations, nine on the main stem of the Menomonee River and one each on the Little Menomonee River, Underwood Creek, and Honey Creek were established by the Commission in 1964. Table 76 presents selected data for these stations; Table 77 presents such data for stations other than those established by the Commission; and Map 28 indicates the location of all sampling stations within the Menomonee River watershed.

Surface Water Quality of the Menomonee River and Its Tributaries in 1964-1965: Water quality conditions in the Menomonee River watershed—as determined by the 1964-1965 Commission benchmark survey at nine stations along the main stem of the Menomonee River, one station on the Little Menomonee River, one station on Underwood Creek, and on station on Honey Creek—are summarized in Table 78. The results for chloride, dissolved oxygen, fecal coliform bacteria, and biochemical oxygen demand are critical to the proper assessment of trends of water quality within the Menomonee River and its tributaries.

Chloride: During the sampling period of 1964-1965 the chloride concentration throughout the watershed ranged from 15 mg/l to 425 mg/l. Average values were 10 mg/l for the Menomonee River, 65 mg/l on the Little Menomonee River, and 210 mg/l for Honey Creek. The tributaries to the Menomonee River demonstrated significantly higher average chloride levels than the main stem. Although levels of chloride concentration were found to be typically elevated at the stations located in the urbanized areas of the watershed during the winter months when road de-icing operations were conducted, several fluctuations were noted during the spring, summer,

Table 74

KNOWN INDUSTRIAL WASTE DISCHARGES IN THE MENOMONEE RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)
MILWAUKEE COUNTY								
Allis Chalmers Corporation	3523	City of West Allis	Process	N/A	1	Menomonee River via storm sewer	70,000	140,000
AMF, Inc.— Harley Davidson Motor Company	3751	City of Wauwatosa	Cooling and Process	Settling Pond, Oil Separator, Oil Skimmer, and pH Adjustment	2	Tributary of Menomonee River	40,000	50,000
Babcock and Wilcox-Tubular Products Division	3312	Village of West Milwaukee	Cooling	Oil Separator	1	Menomonee River via storm sewer	825,000	900,000
Briggs and Stratton Corporation	3519	City of Wauwatosa	Cooling	Settling Basin and Oil Separator	1	Menomonee River via storm sewer	25,000	25,000
Butler Lime and Cement Company	3273	City of Milwaukee	Process	Settling Basin and Oil Separator	1	Menomonee River via storm sewer	1,700	2,300
Center Fuel Company	2911	City of Milwaukee	Runoff	Oil and Water Separator	1	Little Menomonee River via storm sewer	Intermittent	Intermittent
Chicago, Milwaukee, St. Paul and Pacific Railroad Company	4013	City of Milwaukee	Process	Oil Separator	1	Menomonee River via drainage ditch	316,800	418,500
			Process	Oil Separator	2	Menomonee River via drainage ditch	3,000	7,000
Chicago and North Western Railway	4013	Village of Butler	Process	Oil and Water Separator	1	Menomonee River via drainage ditch	300	7,500
Chris Hansen's Laboratory, Inc.	2869	City of West Allis	Cooling	None	1	Honey Creek via storm sewer	50,000	63,000
Falk Corporation— Research and Development	3566	City of Milwaukee	Cooling	None	3	Menomonee River	30,000	33,000
			Cooling and Process	None	4	Menomonee River	8,000	11,000
			Cooling	None	5	Menomonee River	17,000	20,000
Falk Corporation— Plant No. 2	3566	City of Wauwatosa	Cooling	None	1	Tributary of Menomonee River	21,000	26,000
			Cooling	None	2	Tributary of Menomonee River	4,000	4,000
Falk Corporation— Plant No. 1	3566	City of Milwaukee	Cooling and Process	N/A	1	Menomonee River	121,100	126,000
			Cooling and Process	N/A	3	Menomonee River	23,000	36,000
			Cooling and Process	N/A	4	Menomonee River	41,000	80,000
			Cooling and Process	N/A	5	Menomonee River	243,000	270,000
Federal Malleable Company	3322	City of West Allis	Cooling	None	1	Menomonee River	9,500	11,500
			Cooling and Boiler Blowdown	None	2	Menomonee River	26,600	40,300
Grede Foundries, Inc.- Liberty Foundry	3321	City of Wauwatosa	Cooling	None	1	Menomonee River via storm sewer	45,000	53,000
			Cooling	None	2	Menomonee River via storm sewer	15,000	18,000
Grey Iron Foundry, Inc.	3321	City of West Allis	Cooling and Process	None	1	Honey Creek	370,000	391,000
			Cooling	None	2	Honey Creek	52,000	56,000
			Cooling	None	3	Honey Creek	52,000	56,000
Harnischfeger Corporation	3536	City of Milwaukee	Cooling and Process	None	1	Menomonee River via storm sewer	360,000	441,000
			Cooling	None	2	Menomonee River via storm sewer	6,000	10,000
			Process	None	3	Menomonee River via storm sewer	14,000	14,000
Hentzen Chemical Coatings, Inc.	2851	City of Milwaukee	Cooling	None	1	Little Menomonee River via storm sewer	49,000	49,000
			Cooling	None	2	Little Menomonee River via storm sewer	5,000	5,000

Table 74 (continued)

Name	Standard Industrial Classification Code	Civil Division	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)
MILWAUKEE COUNTY (continued)								
Inryco, Inc.	3444	City of Milwaukee	Cooling	N/A	3	Menomonee River via storm sewer	211,000	211,000
Kearney and Trecker Corporation	3540	City of West Allis	Cooling	None	1	Underwood Creek via storm sewer	121,900	127,000
Marquette University	8221	City of Milwaukee	Cooling and Steam Condensate	None	1	North Menomonee Canal via storm sewer	56,000	N/A
Miller Brewing Company	2082	City of Milwaukee	Cooling and Drainage	None	1	Menomonee River via storm sewer	7,100	7,200
			Cooling	None	2	Menomonee River via storm sewer	86,400	86,400
			Cooling	None	3	Menomonee River via storm sewer	31,000	31,000
			Cooling and Drainage	None	4	Menomonee River via storm sewer	1,328,400	1,420,800
			Cooling	None	5	Menomonee River via storm sewer	224,000	346,000
Milwaukee County Institutions Power Plant	4911	City of Wauwatosa	Cooling and Process	None	1	Menomonee River via drainage ditch	67,000	N/A
Milwaukee County Park Commission-Greenfield Park	7999	City of West Allis	Swimming Pool Overflow and Drainage	None	1	Menomonee River via storm sewer	Intermittent	Intermittent
Milwaukee County Park Commission-Hoyt Park	7999	City of Wauwatosa	Swimming Pool Overflow and Drainage	None	1	Menomonee River via storm sewer	Intermittent	Intermittent
Milwaukee County Park Commission-Madison Park	7999	City of Wauwatosa	Swimming Pool Overflow and Drainage	None	1	Menomonee River via storm sewer	Intermittent	Intermittent
Milwaukee County Park Commission McCarty Park	7999	City of West Allis	Swimming Pool Overflow and Drainage	None	1	Honey Creek via storm sewer	Intermittent	Intermittent
Milwaukee County Park Commission-Washington Park	7999	City of Milwaukee	Swimming Pool Overflow and Drainage	None	1	Menomonee River via storm sewer	Intermittent	Intermittent
Milwaukee Marble Company	3281	City of Milwaukee	Process	None	1	Menomonee Canal via storm sewer	1,900	1,900
			Process	None	2	Menomonee Canal via storm sewer	1,800	1,800
			Process	None	3	Menomonee Canal via storm sewer	1,800	1,800
Mobil Oil Corporation—Lubrication Plant	2992	City of Milwaukee	Cooling	Oil and Water Separator	1	Menomonee River via storm sewer	4,600	N/A
Motor Casting Plant No. 1	3321	City of West Allis	Cooling	None	1	Woods Creek	119,000	120,000
			Cooling	None	2	Woods Creek	101,000	101,000
Motor Casting Plant No. 2	3321	City of Milwaukee	Cooling	None	1	Honey Creek via storm sewer	18,000	20,000
Perlick Company, Inc.	3585	City of Milwaukee	Cooling	None	1	Little Menomonee River via storm sewer	1,000	N/A
Rexnord, Inc.—West Milwaukee Facility	3566	City of West Milwaukee	Process	None	1	Menomonee River via storm sewer	21,000	26,000
			Cooling and Process	None	2	Menomonee River via storm sewer	159,000	180,000
			Cooling and Process	None	3	Menomonee River via storm sewer	6,600	7,300
			Cooling	None	4	Menomonee River via storm sewer	29,800	36,200
			Cooling	None	5	Menomonee River via storm sewer	3,500	4,000
			Cooling	None	6	Menomonee River via storm sewer	1,700	2,100
			Cooling and Process	None	7	Menomonee River via storm sewer	18,200	20,000
			Cooling	None	8	Menomonee River via storm sewer	24,800	27,000
			Cooling and Process	None	9	Menomonee River via storm sewer	11,000	12,000
Robert A. Johnston Company	2066	City of Milwaukee	Cooling	None	3	Menomonee River via storm sewer	511,600	650,400

Table 74 (continued)

Name	Standard Industrial Classification Code	Civil Division	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)
MILWAUKEE COUNTY (continued)								
Safeway Wash-A-Car, Inc.	7542	City of West Allis	Process	Catch Basin	1	Honey Creek via storm sewer	1,000	1,900
Seven-Up Milwaukee, Inc.	2086	City of West Allis	Process Washwater	None	1	Menomonee River via storm sewer	7,000	10,000
Union Oil of California—N. 107th Street	2911	City of Milwaukee	Runoff	Oil and Water Separator	1	Little Menomonee River via drainage ditch	Intermittent	Intermittent
Western Metal Specialty Division—Western Industries, Inc.	3449	City of Wauwatosa	Cooling	None	1	Menomonee River via storm sewer	10,000 to 50,000	N/A
West Shore Pipe Line Company	N/A	City of Milwaukee	Process	Oil and Water Separator	1	Menomonee River	4,000	N/A
Wisconsin Electric Power Company—Heating System	4911	City of Milwaukee	Steam Condensate and Seepage	None	1	Menomonee River	62,000	80,000
Wisconsin Electric Power Company—Valley Plant	4911	City of Milwaukee	Cooling, Boiler Blowdown, and Drainage	Chlorination	1	South Menomonee Canal	73,510,100	78,467,700
			Cooling, Boiler Blowdown, and Drainage	Chlorination	2	South Menomonee Canal	62,288,400	77,351,600
WASHINGTON COUNTY								
Gehl Guernsey Farms, Inc.	2026	Town of Germantown	Cooling	None	1	Menomonee River via storm sewer	190,000	210,000
WAUKESHA COUNTY								
Best Block Company	3271	Village of Menomonee Falls	Process	Ridge and Furrow	1	Soil Absorption	9,200	12,400
Carnation Company—Can Division	3411	Village of Menomonee Falls	Cooling	None	1	Menomonee River via storm sewer	48,300	64,500
Menomonee Falls Water Utility	4941	Village of Menomonee Falls	Filter Backwash	None	1	Menomonee River	162,900	173,200
Molded Rubber and Plastics Corporation	3069	Village of Butler	Cooling	None	1	Menomonee River via storm sewer	33,100	50,000
SEFO, Inc. D/B/A Safer Cleaning Center	7216	City of Brookfield	Cooling	None	1	Menomonee River via storm sewer	1,000 to 15,000	N/A
W. A. Krueger Company, Inc.	2752	City of Brookfield	Cooling	None	1	Underwood Creek	10,000	32,000
Western States Envelope	2642	Village of Butler	Cooling	None	1	Menomonee River via storm sewer	15,000	N/A

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Department of Natural Resources and SEWRPC.

and fall months of the year indicating that other contributing influences affect the level of chlorides in the Menomonee River network. These high concentrations can be attributed to the presence of sewage treatment facilities and malfunctioning private onsite sewage disposal systems located upstream of the sampling stations which registered the high chloride contents.

Dissolved Oxygen: During the sampling year of 1964-1965, the dissolved oxygen levels in the watershed ranged from 0.0 to 20.4 mg/l, with the average values for the Menomonee River main stem, Little Menomonee River, Underwood Creek, and Honey Creek recorded at 7.6 mg/l, 7.5 mg/l, 12.6 mg/l and 11.9 mg/l, respectively. Although the average concentration of dissolved oxygen was 7.6 mg/l for the Menomonee River main stem, instances of levels below the 5.0 mg/l standard were noted at several of the sampling stations.

At sampling station Mn-1 the concentration of dissolved oxygen was lower than 5.0 mg/l during five of the 12 monthly measurements. Although there are no sewage treatment facilities located upstream from this station, nor any known auto salvage yards or licensed sanitary

Table 75

LAND USE IN THE MENOMONEE RIVER WATERSHED: 1963 and 1970

Categories	1963 Land Use		1970 Land Use	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	19,403.58		21,691.70	
Commercial	1,679.12		2,125.53	
Industrial	1,422.32		1,450.95	
Transportation and Utilities	12,575.41		14,216.91	
Government	2,700.95		3,212.42	
Recreation	3,252.60		3,647.31	
Landfill and Dump	295.09		3,846.30	
Total	41,329.07	47.6	50,191.12	55.5
Rural Land Uses				
Open Land	9,833.14		8,442.74	
Agricultural Lands	32,681.34		28,920.44	
Total	42,514.48	49.0	37,363.18	41.4
Water Covered Lands				
Lakes, Rivers, and Streams	323.60		356.45	
Wetlands	2,634.57		2,486.54	
Total	2,958.17	3.4	2,842.99	3.1
Watershed Totals	86,801.72	100.0	90,397.29	100.0

Source: SEWRPC.

landfill sites, the dissolved oxygen levels were found to be depressed, typically during periods of wet weather, apparently as a result of the heavy loadings of organic material wasted off the agricultural lands in the headwater areas directly above sampling station Mn-1.

Sampling station Mn-2 exhibited dissolved oxygen levels below 5 mg/l during seven of 11 sampling periods. The potential for organic pollution exists from the Village of Germantown sewage treatment facility which is located less than one mile upstream from sampling station Mn-2 and leachate pollution from one auto salvage yard which may release contaminants into the groundwater and/or surface water near the West Branch of the Menomonee River. The effluent from the Germantown sewage treatment facility and the potential leachate from the auto salvage yard coupled with diffuse runoff loadings would account for the dissolved oxygen reductions at sampling station Mn-2.

Sampling station Mn-3, located about 3.0 miles downstream from sampling station Mn-2 on the main stem of the Menomonee River, which meanders through primarily agricutural lands and wetland areas between these two sampling stations, receives no additional sewage treatment plant effluent. There is a sanitary landfill site located directly to the west of the Menomonee River main stem near Willow Creek in the far northwestern section of the watershed. The leachates from this landfill site, coupled with the large acreage of agricultural land in production in this area, probably account for four out of the 11 samples collected in 1964-1965 exhibiting a dissolved oxygen level below the 5.0 mg/l standard. It is important to note that in July 1964, sampling station Mn-3 recorded a dissolved oxygen concentration of 0.0 mg/l, the only zero reading observed at any of the 12 sampling stations throughout the one-year benchmark sampling program. This depleted dissolved oxygen was associated with the six to eight inches of rainfall which fell on the watershed during the five days prior to sampling.

Sampling station Mn-4 is located on the Menomonee River main stem approximately 4.5 miles downstream from sampling station Mn-3 and just slightly downstream from the confluence with the Nor-X-Way Channel. The Village of Menomonee Falls sewage treatment facility Pilgrim Road Plant as well as two industrial waste discharges and one sanitary landfill operation, which may discharge leachate into the stream system, are located upstream from the Mn-4 sampling station. The samples from three sampling periods out of 11 were found to be below the 5.0 mg/l standard, with two of the substandard three readings in the range of 2.0 to 2.5 mg/l and the third near 5.0 mg/l. Also of interest are the increased dissolved oxygen levels during the months of higher flow

Table 76

DESIGNATIONS AND LOCATIONS OF SEWRPC STREAM SAMPLING STATIONS IN THE MENOMONEE RIVER AND TRIBUTARIES OF THE MENOMONEE RIVER

Source	Sampling Station Designation	Menomonee River Sampling Station Location	Distance from River Mouth (miles)
SEWRPC	Mn-1	STH 145, SW ¼, Section 15, T9N, R20E	27.29
SEWRPC	Mn-2	CTH F, NW ¼, Section 28, T9N, R20E	25.93
SEWRPC	Mn-3	CTH Q, NE ¼, Section 4, T8N, R20E	23.47
SEWRPC	Mn-4	Lilly Road SW ¼, Section 12, T8N, R20E	19.74
SEWRPC	Mn-5	Good Hope Road, NW ¼, Section 19, T8N, R21E	17.34
SEWRPC	Mn-6	Silver Spring Road, NE ¼, Section 36, T8N, R20E	14.73
SEWRPC	Mn-7a	Capitol Drive, NE ¼, Section 7, T7N, R21E	11.20
SEWRPC	Mn-7b	North Avenue, NE ¼, Section 20, T7N, R21E	8.50
SEWRPC	Mn-10	N. 70th Street, NW ¼, Section 27, T7N, R21E	6.10

Tributaries to the Menomonee River

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (miles)
SEWRPC	Mn-7	Little Menomonee River at STH 100, SE ¼, Section 31, T8N, R21E	12.60
SEWRPC	Mn-8	Underwood Creek near N. 106th Street, NW ¼, Section 20, T7N, R21E	9.25
SEWRPC	Mn-9	Honey Creek at Honey Creek Parkway, NW ¼, Section 27, T7N, R21E	6.30

Source: SEWRPC.

when values of 11.5 mg/l or greater were recorded. This substantial increase of dissolved oxygen levels at sampling station Mn-4 over those observed at sampling stations Mn-1, Mn-2, and Mn-3 can be attributed to the flow contributions from the tributaries and the distance between sampling stations Mn-3 and Mn-4, which allows for recovery of the dissolved oxygen content of the waters of the Menomonee River main stem through natural reaeration processes. In addition, unusually high concentrations of dissolved oxygen are known to be present in the effluent discharged from the Menomonee Falls Pilgrim Road sewage treatment plant. This high dissolved oxygen content may at times contribute to increased levels of dissolved oxygen within the receiving watercourse.

There are no auto salvage yards, sanitary landfill operations, or industrial discharges located in the drainage area between sampling stations Mn-4 and Mn-5. Dissolved oxygen levels exceeded the 5.0 mg/l standard in 64 percent of the samples taken over the one-year period, with only four monthly measurements below the standard. During these periods the effluent from the second Menomonee Falls sewage treatment facility (Lilly Road Plant) located just upstream from the monitoring station Mn-5, combined with effluent contributions from the two sewage treatment facilities upstream, constitute more than half of the flow in the stream.

Between sampling stations Mn-5 and Mn-6, only storm water runoff and very small intermittent streams are

Table 77

DESIGNATIONS AND LOCATION OF STREAM SAMPLING STATIONS OF OTHER SOURCES IN THE MENOMONEE RIVER

Source	Station Designation	Station Location	Distance from River Mouth
U. S. Geological Survey (USGS)	USGS-Mn-10	Upstream from N. 70th Street bridge NW ¼, Section 27, T7N, R21E	6.20
Milwaukee Metropolitan Sewerage District (MMSD-41) August 1964	MMSD-Mn-6a	Butler sewage treatment plant 124th Street and W. Villard Avenue NE ¼, Section 36, T8N, R20E	13.18
Milwaukee Metropolitan Sewerage District (MMSD-43) August 1964	MMSD-Mn-6b	Little Menomonee River at Highway 100 and Hampton Avenue NW ¼, Section 29, T8N, R21E	12.60
Milwaukee Metropolitan Sewerage District (MMSD-48) August 1964	MMSD-Mn-11	Menomonee River at N. Hawley Road NW ¼, Section 26, T7N, R21E	5.15
Milwaukee Metropolitan Sewerage District (MMSD-49) August 1964	MMSD-Mn-12	Menomonee River at N. 37th Street NW ¼, Section 36, T7N, R21E	2.91
Synoptic Survey (TMN-14) August 6, 1974	SS-Mn-12	Menomonee River at N. 37th Street NW ¼, Section 36, T7N, R21E	2.91
Milwaukee Metropolitan Sewerage District (MMSD-50) August 1964	MMSD-Mn-13	Menomonee River at S. Muskego Avenue SE ¼, Section 30, T7N, R22E	0.92
Synoptic Survey (TMN-15) August 6, 1974	SS-Mn-13	Menomonee River at S. Muskego Avenue SE ¼, Section 30, T7N, R22E	0.92

Source: SEWRPC.

Table 78

WATER QUALITY CONDITIONS OF THE MENOMONEE RIVER AND TRIBUTARIES: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Menomonee River Main Stem Mn-1, Mn-2, Mn-3, Mn-4, Mn-5, Mn-6, Mn-7a, Mn-7b, and Mn-10	Chloride (mg/l)	425	100	15	51
	Dissolved Solids (mg/l)	1,340	705	435	51
	Dissolved Oxygen (mg/l)	18.9	7.6	0	99
	Coliform Count (MFCC/100 ml)	1,100,000	52,000	100	99
	Temperature (^{O}F)	79	49	32	98
Little Menomonee River Mn-7	Chloride (mg/l)	100	65	30	4
	Dissolved Solids (mg/l)	815	675	345	4
	Dissolved Oxygen (mg/l)	13.2	7.5	0.2	12
	Coliform Count (MFCC/100 ml)	16,000	4,700	400	12
	Temperature (^{O}F)	78	49	32	11
Underwood Creek Mn-8	Chloride (mg/l)	340	210	80	4
	Dissolved Solids (mg/l)	1,090	880	550	4
	Dissolved Oxygen (mg/l)	20.4	12.6	4.2	11
	Coliform Count (MFCC/100 ml)	83,000	12,100	100	11
	Temperature (^{O}F)	78	49	32	11
Honey Creek Mn-9	Chloride (mg/l)	1,270	370	50	10
	Dissolved Solids (mg/l)	2,460	985	375	10
	Dissolved Oxygen (mg/l)	15.9	11.9	8.0	11
	Coliform Count (MFCC/100 ml)	430,000	62,000	1,000	11
	Temperature (^{O}F)	67	42	32	11

Source: SEWRPC.

added to the flow in the Menomonee River main stem. The lack of sewage treatment facilities, auto salvage yards, sanitary landfills, and industrial waste discharges accounts for the unusually high dissolved oxygen levels recorded at sampling station Mn-6. Only one reading of 1.8 mg/l, observed in July 1964 and related to the extremely large amount of precipitation recorded prior to the sampling, exhibits a dissolved oxygen content below the 5.0 mg/l standard at sampling station Mn-6.

Sampling station Mn-7 is located on the Little Menomonee River just above its confluence with the main stem near W. Hampton Avenue and is the only station on the Little Menomonee River. Three auto salvage yards, three sanitary landfill sites, and two industrial waste discharges are located upstream from sampling station Mn-7 on the Little Menomonee River and on its tributary, Little Menomonee Creek. Four out of the 12 monthly sampling periods exhibited dissolved oxygen levels of 4.9 mg/l or less. Low dissolved oxygen levels were recorded in February of 1964 and 1965, and these may be accounted for by the spring thaws which occurred in late February of both years.

Sampling station Mn-7a is located on the main stem approximately 2.5 miles downstream from the confluence with the Little Menomonee River. Sampling station 7b is located approximately 2.5 miles downstream from station 7a. The Village of Butler sewage system bypass, eight industrial waste discharges, seven auto salvage yards, and one sanitary landfill operation are located between sampling stations Mn-6 and Mn-7b. Only seven monthly samples were taken at 7a and six monthly samples were taken at 7b during the 1964-1965 benchmark water quality survey, with only one recording of dissolved oxygen levels of less than 5.0 mg/l at each sampling station, Mn-7a and Mn-7b. The two substandard dissolved oxygen readings occurred on July 22, shortly after an unusually heavy rainfall. The reduced dissolved oxygen readings thus were associated with the six to eight inches of rainfall which were measured in the five-day period beginning July 17, 1964, at the U. S. Climatological Weather Station located near sampling stations Mn-7 and Mn-7b. The low readings probably were due to oxygen-demanding organic matter entering the stream from various point and diffuse sources along with the runoff from this heavy rainfall.

Sampling station Mn-8 is located on Underwood Creek. Although located in an area of low- to medium-density residential land use, the dissolved oxygen concentrations at this sampling station were found to be considerably higher than those at other sampling stations. A low reading of 4.2 mg/l was recorded during the July 22, 1964, sampling due to the July 17 rain storm. The remainder of the measurements ranged from a low of 9.7 mg/l to a high of 20.4 mg/l. One sanitary landfill and two industrial discharges are located just upstream of sampling station Mn-8. Two auto salvage yards also exist to the south of Underwood Creek near the Milwaukee County Zoo. Although it is questionable whether these two sites contribute to the degradation of any surface waters because of their distance from any perennial or intermittent streams, indirect surface water pollution from contaminated groundwater is possible and may indirectly affect the quality of Underwood Creek and/or Honey Creek lying farther to the south.

Three industries discharge wastewaters into Honey Creek above sampling station Mn-9. No sewage treatment facilities, auto salvage yards, or sanitary landfill operations exist within this subwatershed which is comprised of predominantly medium-density residential land use. The minimal number of waste discharges in or near this tributary probably account for the relatively high levels of dissolved oxygen concentrations recorded at sampling station Mn-9. Out of 11 monthly sampling periods, the lowest level of dissolved oxygen concentration was recorded in October 1964 as 8.0 mg/l with the maximum for the year recorded as 15.9 mg/l. It should be noted, however, that data for July and August at sampling station Mn-9 are unavailable and lower dissolved oxygen levels may have prevailed during those months due to heavy rainfall.

Sampling station Mn-10, located just downstream from the confluence with Honey Creek on the Menomonee River, also displayed relatively high dissolved oxygen concentrations for the year 1964. Out of a total of 14 sampling dates, only one reading of 4.8 mg/l in July fell below 5.0 mg/l. The applicable standard for this reach calls for only 2.0 mg/l of dissolved oxygen. All other readings showed high dissolved oxygen levels of 10.5 mg/l or greater. Overflow and drainage from Hoyt Park swimming pool and wastewater from one industry are discharged to the Menomonee River between sampling stations Mn-7b and Mn-10. The relatively high concentrations of dissolved oxygen at sampling station Mn-10 probably result from the limited number of point and nonpoint sources, thereby producing water quality improvements through reaeration and the resultant high dissolved oxygen content in the water from Underwood Creek and Honey Creek.

Although no Commission water quality sampling stations are located downstream from sampling station Mn-10, the Milwaukee-Metropolitan Sewerage District conducted a surface water quality study at 11 Menomonee River sites from 1964 to 1966. Three of these sites are located below sampling station Mn-10, in the Menomonee River watershed at Hawley Road (MMSD-Mn-11), at 37th Street (MMSD-Mn-12), and at S. Muskego Avenue (MMSD-Mn-13). The dissolved oxygen concentration declines progressively from sampling station Mn-10 to the N. Hawley Road station to the N. 37th Street station with the addition of the discharges from seven industries. Thirteen industrial waste discharges and two auto salvage yards are located upstream from the S. Muskego Avenue station, and as a result the dissolved oxygen concentrations at this sampling station are further reduced, yielding nine readings below the applicable standard of 2.0 mg/l of dissolved oxygen.

Biochemical Oxygen Demand: The biochemical oxygen demand, as determined from the samples collected by the Commission on the Menomonee River and its tributaries during the years 1964-1965, ranged from a low of 0.5 mg/l to a high of 17.1 mg/l. Sampling station Mn-1 at the headwaters of the Menomonee River recorded a low of 1.0 mg/l in February 1965. This may be attributed to the lack of any form of runoff during the winter months. The high reading of 9.5 mg/l occurred in March and is probably reflective of spring snowmelt and runoff.

High levels of biochemical oxygen demand also were exhibited in the Milwaukee Metropolitan Sewerage District water quality samples taken at stations MMSD-Mn-1, MMSD-Mn-12, and MMSD-Mn-13. Readings for August 11, 1964, were 29 mg/l, 19.5 mg/l, and 30.5 mg/l, respectively, resulting from approximately a one-inch rain which fell in the vicinity of these three intensively urbanized areas, producing large quantities of organically contaminated storm water runoff from the streets, highways, parking lots, rooftops, fertilized lawns, and construction operations in the area.

Total Coliform Bacteria: Membrane filter coliform counts were found to vary from less than 100 to 1,100,000 MFCC/100 ml, with average values of 52,000 MFCC/100 ml on the Menomonee River, 4,700 MFCC/100 ml on the Little Menomonee River, 12,100 MFCC/100 ml on Underwood Creek, and 62,000 MFCC/100 ml on Honey Creek. The highest total coliform counts were recorded during the month of December 1964 at the Menomonee River sampling station Mn-4 and at the Little Menomonee River sampling station Mn-7. The highest total coliform count on Underwood Creek at sampling station Mn-8 was recorded in July 1964 and on Honey Creek at sampling station Mn-9 in November 1964. Elevated readings were found to vary in concentration and time of occurrence, but generally were observed during periods of wet weather.

Fecal coliform bacteria measurements were not a part of the Commission's 1964 benchmark study. However, limited data is available for several of the Milwaukee-Metropolitan Sewerage District stations as listed in Table 77. At the Butler sewage overflow chlorination facility, fecal coliform counts ranged from a low of 1,000 to a high of 27,000,000 MFFCC/100 ml from June to November. This elevated range is typical of effluent from sewage treatment facilities in the years before more stringent disinfection requirements were imposed. Levels of fecal coliform bacteria at station MMSD-Mn-7.1 located at W. Hampton Avenue and STH 100 on the Little Menomonee River ranged from a low of 180 to a high of 1,110,000 MFFCC/100 ml within the sampling period of June through November 1964. The increased reading of 110,000 MFFCC/100 ml at this station on July 28, 1964, can be directly attributed to nonpoint source runoff in the headwaters of the Little Menomonee River as a result of approximately 0.2 of an inch of rainfall which fell within 24 hours prior to sampling.

At station MMSD-Mn-13 at S. Muskego Avenue fecal coliform readings achieved a maximum observed value of 160,000 MFFCC/100 ml on November 17, 1964. The increased fecal coliform count at MMSD-Mn-13 is difficult to assess because only a trace of precipitation was recorded at General Billy Mitchell Field, located approximately 2.5 miles away. However, this increased reading could be attributable to the presence of numerous industries, inclusive of several tanning plants which may occasionally have maintenance problems with pretreatment operations causing a backup and overflow into adjacent surface waters just upstream from the S. Muskego Avenue station.

Specific Conductance: The specific conductance of the Menomonee River watershed during the 1964-1965 sampling period ranged from 295 umhos/cm at 25°C to 2,120 umhos/cm at 25°C on the main stem of the Menomonee River, and 580 µmhos/cm at 25°C to 4,320 µmhos/cm at 25°C on Underwood Creek on December 17, 1964. Specific conductance readings were not available for the above date on the Little Menomonee River or Honey Creek; however, data results for spring runoff months of February, March, and April of 1964 were above normal, typical of the expected data results during spring runoff in which high concentrations of dissolved ions are present. During the late spring, summer, and early fall months, normal specific conductance ranges of 1,200 µmhos/cm at 25°C or less were recorded at all stations.

Hydrogen Ion Concentrations (pH): The pH values at all sampling sites in the Menomonee River watershed generally ranged from 7.0 to 8.9 standard units during the sampling year 1964-1965. Only once during the sampling period did the pH exceed the range of 6.0 to 9.0 standard units prescribed for the major water use objectives of the Menomonee River and its tributaries. The elevated pH reading of 9.2 occurred on November 17, 1964, at the S. Muskego Avenue station MMSD-Mn-13. It is difficult to identify the exact source of the elevated pH, but it is reasonable to conclude that one of the many industries in this area may have discharged caustic wastes into the watercourses.

Temperature: During the years 1964-1965, the temperature of water samples from the Menomonee River and its tributaries ranged from 32°F to 41°F during the months of December through April and from 32°F to 79°F during the months of May through November. All temperature variations were primarily seasonal and not the result of thermal pollution from cooling water discharges. Although it is known that spent cooling waters are discharged to the main stem and to three major tributaries of the Menomonee River, there are no data available to compare the average background water temperatures to the average temperatures with the existing thermal inputs.

Water Quality Trends from 1965 to 1975

Water quality data obtained during the decade from 1965 to 1975 during eight summer water quality sampling programs and three spring water quality sampling programs are presented in tabular form in Appendix D of this report. Seven summer sampling surveys began in August 1968 and involved collection of samples one day in August every year during low flow conditions. A similar low flow sampling effort was conducted in late July—instead of August—in 1970.

An analysis of available streamflow data indicates that, for streams in southeastern Wisconsin, low flow generally occurs during the months of August and September. Although the collection and analysis of one sample per station per year cannot represent water quality conditions for the whole year, if collected in midsummer or late summer it may be reasonably assumed to represent the water quality conditions of the stream at that location during the low flow period, generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life.

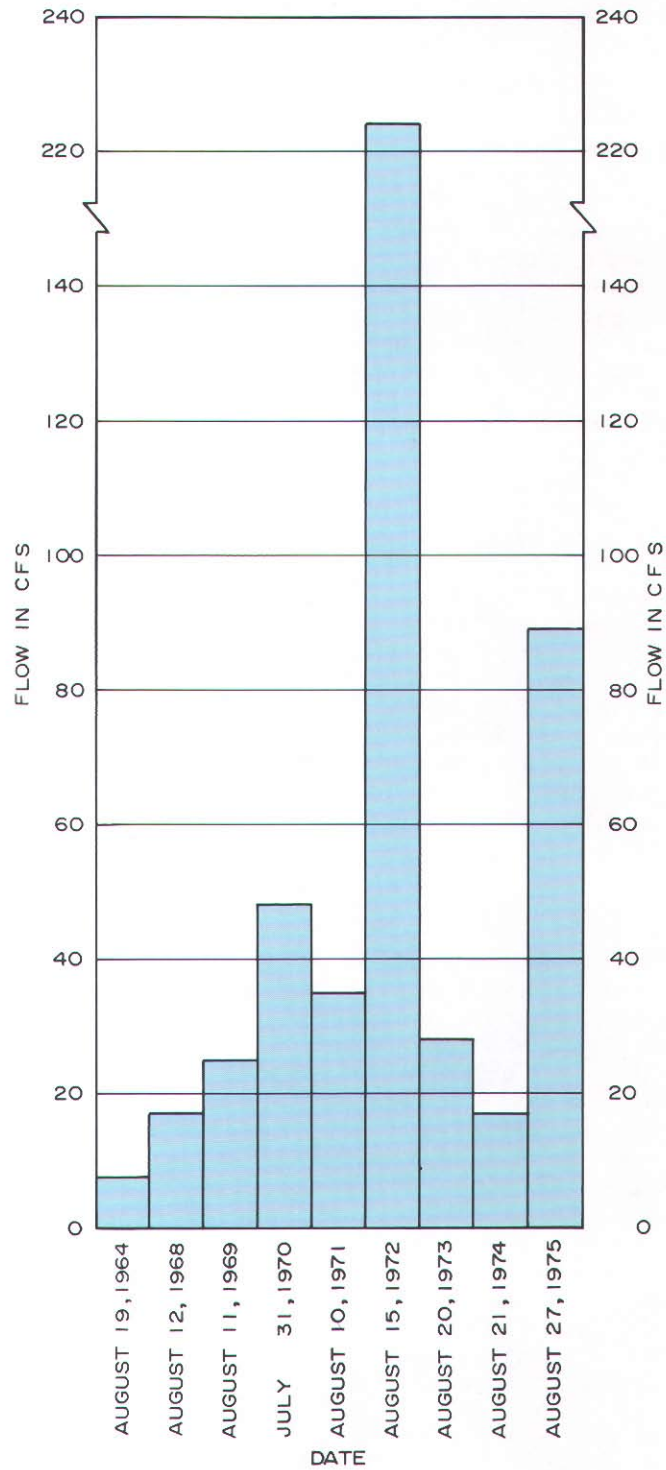
The summary of the results for specific conductance, pH, dissolved oxygen, nitrate, nitrite, ammonia, and organic nitrogen, soluble and total phosphorus, chloride and fecal coliform counts, for each of the 12 SEWRPC sampling stations sampled in the Menomonee River watershed from 1968 through 1975 is set forth in Tables 79 to 90. The streamflow data for the Menomonee River at sampling station Mn-10 in Wauwatosa are obtained from U. S. Geological Survey records. Presented in Figure 70 are the actual flow data for the dates of water quality sampling from 1964 through 1975.

As indicated by the bar graph, sampling years 1972 and 1975 exhibited relatively high flow values when compared to the typical low flow years of 1964, 1968 through 1971, 1973, and 1974. Thus, for the assessment of water quality trends in this report, the sample results from the years 1964 and 1974 will be considered due to comparable measured low flow of 17 cubic feet per second (cfs) at sampling station Mn-10. Although the 1972 and 1975 sampling dates were considered in the analysis, it is important to note that the flows of 224 and 89 cubic feet per second, respectively, resulted in increased loadings to the Menomonee River system and thus offset the normal low flow condition.

Dissolved Oxygen: For the watershed as a whole the range of dissolved oxygen in the Menomonee River stream system during the low flow period for the years 1964 through 1975 was found to range from 0.1 mg/l to 20.1 mg/l. The average dissolved oxygen concentrations are shown in Table 91. Eight year averages of dissolved oxygen from 1968-1975 indicate that during low flow conditions only sampling stations Mn-4 and Mn-5 recorded average readings below the 5.0 mg/l minimum standard. However, some sampling stations, Mn-1 through Mn-7b, did not meet the minimum 5.0 mg/l of dissolved oxygen standard during many of the low flow sampling periods throughout the eight years of data collection. Sampling stations Mn-8, Mn-9, and Mn-10 exhibited relatively high levels of dissolved oxygen concentrations, with sampling station Mn-8 meeting the 5.0 mg/l standard at all times, Mn-9 falling below the minimum standard three times, and Mn-10 only once. Based on the eight years of low flow data, the 1964-1965 one-year benchmark data, and the July 18, 1973, and August 6, 1974, Menomonee River synoptic

Figure 70

FLOW MEASUREMENTS FOR THE MENOMONEE RIVER AT WAUWATOSA (MN-10) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1975



Source: SEWRPC.

Table 79

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	37	26.560	15	21	--
Dissolved Oxygen (mg/l)	5.0	15.5	6.1	1.5	30	12[a]
Ammonia N (mg/l)	2.5	0.230	0.146	0.030	8	0
Organic N (mg/l)	--	2.180	1.353	0.690	8	--
Total N (mg/l)	--	4.320	3.628	2.870	8	--
Specific Conductance (umhos/cm at 25°C)	--	800	703	498	30	--
Nitrite N (mg/l)	--	0.550	0.094	0.015	12	--
Nitrate N (mg/l)	0.3	2.54	1.700	0.550	12	12
Soluble Orthophosphate-P (mg/l)	--	0.338	0.097	0.027	12	--
Total Phosphorus (mg/l)	0.10	0.400	0.162	0.070	8	5
Fecal Coliform (MFFCC/100 ml)	400	7,100	1,214	20	12	7
Temperature (°F)	89	80	71.08	59	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.6	7.9	7.3	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 80

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	79	45.37	15.0	21	--
Dissolved Oxygen (mg/l)	5.0	18.7	6.65	0.1	30	16[a]
Ammonia N (mg/l)	2.5	0.340	0.184	0.060	8	0
Organic N (mg/l)	--	2.240	1.8	1.200	8	--
Total N (mg/l)	--	3.450	2.72	1.430	8	--
Specific Conductance (umhos/cm at 25°C)	--	915	750.4	501	30	--
Nitrite N (mg/l)	--	0.100	0.054	0.020	12	--
Nitrate N (mg/l)	0.30	1.350	0.650	0.100	12	9
Soluble Orthophosphate-P (mg/l)	--	1.613	0.568	0.043	12	--
Total Phosphorus (mg/l)	0.10	1.320	0.55	0.070	8	7
Fecal Coliform (MFFCC/100 ml)	400	400,000	35,454	70	12	9
Temperature (°F)	89	81	73.15	64	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	9.1	7.87	7.2	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 81

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	64	43.81	12	21	--
Dissolved Oxygen (mg/l)	5.0	20.1	5.7	0.7	30	16[a]
Ammonia N (mg/l)	2.5	0.250	0.149	0.05	7	0
Organic N (mg/l)	--	1.850	1.50	1.23	8	--
Total N (mg/l)	--	2.68	2.277	1.46	8	--
Specific Conductance (umhos/cm at 25°C)	--	898	730	545	30	--
Nitrite N (mg/l)	--	0.114	0.054	0.023	12	--
Nitrate N (mg/l)	0.3	0.950	0.498	0.166	12	8
Soluble Orthophosphate-P (mg/l)	--	1.393	0.444	0.088	12	--
Total Phosphorus (mg/l)	0.10	0.870	0.427	0.140	8	8
Fecal Coliform (MFFCC/100 ml)	400	4,300	875	40	12	5
Temperature (°F)	89	86	74	65	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	9.0	7.95	7.4	22	0

[a]The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.

Source: SEWRPC.

Table 82

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-4: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	264	91.68	26	21	--
Dissolved Oxygen (mg/l)	2.5	9.8	5.06	1.0	30	14[a]
Ammonia N (mg/l)	--	3.610	1.14	0.290	8	0
Organic N (mg/l)	--	2.300	1.65	1.230	8	--
Total N (mg/l)	--	7.500	4.744	2.970	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,566	941	540	30	--
Nitrite N (mg/l)	--	0.423	0.205	0.053	12	--
Nitrate N (mg/l)	0.3	3.37	1.43	0.181	12	10
Soluble Orthophosphate-P (mg/l)	--	4.350	1.771	0.011	11	--
Total Phosphorus (mg/l)	0.10	2.820	1.275	0.040	8	6
Fecal Coliform (MFFCC/100 ml)	400	4,800	1,525	80	12	8
Temperature (°F)	89	87	73.4	65	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.5	7.9	7.6	22	0

[a]The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.

Source: SEWRPC.

Table 83

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-5: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	315	139.919	44	21	--
Dissolved Oxygen (mg/l)	5.0	9.9	3.99	0.7	30	17[a]
Ammonia N (mg/l)	2.5	1.980	0.965	0.390	8	0
Organic N (mg/l)	--	2.200	1.488	0.990	8	--
Total N (mg/l)	--	6.010	4.106	3.190	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,605	1,084.83	655.0	30	--
Nitrite N (mg/l)	--	0.548	0.215	0.07	12	--
Nitrate N (mg/l)	0.3	2.400	1.128	0.200	12	10
Soluble Orthophosphate-P (mg/l)	--	3.643	1.582	0.093	11	--
Total Phosphorus (mg/l)	0.10	2.470	1.202	0.320	8	8
Fecal Coliform (MFFCC/100 ml)	400	5,200	1,625	60	12	7
Temperature (°F)	89	83.0	74.77	66.0	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.2	7.855	7.4	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 84

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-6: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	274.000	130.300	46.000	21	--
Dissolved Oxygen (mg/l)	5.0	10.2	5.71	1.7	30	12[a]
Ammonia N (mg/l)	2.5	0.510	0.326	0.100	8	0
Organic N (mg/l)	--	1.540	1.263	0.870	8	--
Total N (mg/l)	--	5.185	3.510	2.720	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,485.0	1,054.47	618.0	30	--
Nitrite N (mg/l)	--	0.190	0.115	0.018	12	--
Nitrate N (mg/l)	0.3	3.340	1.751	0.940	12	12
Soluble Orthophosphate-P (mg/l)	--	3.520	1.631	0.202	11	--
Total Phosphorus (mg/l)	0.10	2.770	1.260	0.230	8	8
Fecal Coliform (MFFCC/100 ml)	400	4,200.0	1,084.17	160.0	12	8
Temperature (°F)	89	83.0	74.07	66.0	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.4	8.04	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 85

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-7: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	145.000	53.524	22.010	21	--
Dissolved Oxygen (mg/l)	5.0	13.0	5.07	0.6	30	16[a]
Ammonia N (mg/l)	2.5	0.290	0.139	0.030	8	0
Organic N (mg/l)	--	1.410	1.048	0.650	8	--
Total N (mg/l)	--	2.920	1.960	0.890	8	--
Specific Conductance (umhos/cm at 25°C)	--	950.0	728.6	389.0	30	--
Nitrite N (mg/l)	--	16.2	0.055	0.007	11	--
Nitrate N (mg/l)	0.3	1.270	0.577	0.090	12	6
Soluble Orthophosphate-P (mg/l)	--	0.843	0.208	0.065	12	--
Total Phosphorus (mg/l)	0.10	0.450	0.226	0.030	8	7
Fecal Coliform (MFFCC/100 ml)	400	2,700.0	790.83	10.0	12	7
Temperature (°F)	89	82.0	73.9	67.0	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.8	7.9	7.4	22	0

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 86

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-7A: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	195.000	102.689	25.000	21	--
Dissolved Oxygen (mg/l)	5.0	13.1	6.0	2.7	30	10[a]
Ammonia N (mg/l)	2.5	0.250	0.184	0.040	8	0
Organic N (mg/l)	--	1.860	1.308	0.840	8	--
Total N (mg/l)	--	3.829	3.143	2.530	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,255.0	949.9	529.0	30	--
Nitrite N (mg/l)	--	1.57	0.076	0.035	12	--
Nitrate N (mg/l)	0.3	2.22	1.386	0.890	12	12
Soluble Orthophosphate-P (mg/l)	--	1.493	0.849	0.191	12	--
Total Phosphorus (mg/l)	0.10	1.940	0.797	0.140	8	8
Fecal Coliform (MFFCC/100 ml)	400	3,700.0	1,024.16	110.0	12	8
Temperature (°F)	89	85.0	74.5	66.0	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.8	8.1	7.6	22	0

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 87

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-7B: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	341.000	105.766	13.000	21	--
Dissolved Oxygen (mg/l)	5.0	11.5	6.0	2.1	30	8[a]
Ammonia N (mg/l)	2.5	0.240	0.155	0.030	8	0
Organic N (mg/l)	--	1.760	1.218	0.840	8	--
Total N (mg/l)	--	3.430	2.849	2.530	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,320.0	930.8	620.0	30	--
Nitrite N (mg/l)	--	0.170	0.065	0.014	12	--
Nitrate N (mg/l)	0.3	1.64	1.245	0.44	12	12
Soluble Orthophosphate-P (mg/l)	--	1.510	0.798	0.156	12	--
Total Phosphorus (mg/l)	0.10	1.150	0.648	0.240	8	8
Fecal Coliform (MFFCC/100 ml)	400	3,900	1,224.16	110.0	12	9
Temperature (°F)	89	81.0	73.83	67.5	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.7	8.1	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 88

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-8: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	269.000	106.888	40.000	21	--
Dissolved Oxygen (mg/l)	2.0	13.7	8.8	5.3	30	0[a]
Ammonia N (mg/l)	2.5	0.160	0.072	0.030	8	0
Organic N (mg/l)	--	0.930	0.659	0.370	8	--
Total N (mg/l)	--	1.440	0.921	0.400	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,320.0	1,019.4	775.0	30	--
Nitrite N (mg/l)	--	0.082	0.026	0.010	11	--
Nitrate N (mg/l)	0.3	0.82	0.238	0.070	12	3
Soluble Orthophosphate-P (mg/l)	--	0.289	0.074	0.010	12	--
Total Phosphorus (mg/l)	0.10	0.200	0.093	0.040	8	2
Fecal Coliform (MFFCC/100 ml)	2,000	14,000	2,595	240	12	3
Temperature (°F)	89	88.0	74.7	62.0	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	9.1	8.2	7.3	22	2

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 89

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-9: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value Maximum	Numerical Value Average	Numerical Value Minimum	Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
Chloride (mg/l)	--	141.000	72.165	25.000	21	--
Dissolved Oxygen (mg/l)	2.0	9.8	7.0	3.9	30	0[a]
Ammonia N (mg/l)	2.5	0.720	0.429	0.030	7	0
Organic N (mg/l)	--	1.070	0.671	0.240	8	--
Total N (mg/l)	--	2.160	1.145	0.330	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,332.0	792.5	229.0	30	--
Nitrite N (mg/l)	--	0.162	0.052	0.003	11	--
Nitrate N (mg/l)	0.3	0.550	0.257	0.015	12	5
Soluble Orthophosphate-P (mg/l)	--	0.364	0.145	0.023	12	--
Total Phosphorus (mg/l)	0.10	0.990	0.283	0.040	8	6
Fecal Coliform (MFFCC/100 ml)	2,000	25,000	3,445	330	12	3
Temperature (°F)	89	81.0	71.0	59.5	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.7	8.1	7.3	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 90

WATER QUALITY CONDITIONS IN THE MENOMONEE RIVER WATERSHED AT SAMPLING STATION MN-10: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value Maximum	Numerical Value Average	Numerical Value Minimum	Number of Analyses	Number of Times the Recommended Level/ Standard Was Not Met
Chloride (mg/l)	--	164.000	89.696	20.000	21	--
Dissolved Oxygen (mg/l)	2.0	12.9	7.403	4.6	30	0[a]
Ammonia N (mg/l)	2.5	0.270	0.108	0.030	8	0
Organic N (mg/l)	--	1.650	0.915	0.330	8	--
Total N (mg/l)	--	3.370	1.912	0.860	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,146.0	884.6	416.0	30	--
Nitrite N (mg/l)	--	0.177	0.055	0.010	12	--
Nitrate N (mg/l)	0.3	1.360	0.726	0.270	12	11
Soluble Orthophosphate-P (mg/l)	--	1.046	0.484	0.163	12	--
Total Phosphorus (mg/l)	0.10	0.890	0.445	0.140	8	8
Fecal Coliform (MFFCC/100 ml)	1,000-2,000	2,800	1,290.83	180	12	3
Temperature (°F)	89	83.0	73.183	65.0	30	0
Hydrogen Ion Concentrations (standard units)	6.0-9.0	8.8	8.06	7.1	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 91

AVERAGE DISSOLVED OXYGEN CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1964-1975

Station Designation	Average Dissolved Oxygen Concentration
1	6.3
2	6.5
3	6.0
4	4.7
5	4.2
6	6.0
7	5.3
8	9.0
9	7.2
10	7.6
7a	5.8
7b	6.2

Source: SEWRPC.

survey, it may be concluded that the average dissolved oxygen concentration at sampling station Mn-10 consistently exceeded the average of sampling station Mn-7b immediately upstream. This is due to the higher dissolved concentrations of the feeder tributaries: Underwood and Honey Creeks, which join the main stem upstream from samping station Mn-10. As expected, the concentrations gradually decreased to a level near the 2.0 mg/l standard adopted for the Menomonee River in the industrial valley area. At no time during the last 10 years did the average daily dissolved oxygen concentrations, as measured in the Commission's continuing stream and lake water quality sampling program, drop below the 2.0 mg/l for any of the stream samples. However, dissolved oxygen concentrations below the minimum 2.0 mg/l standard were recorded in the lower Menomonee River near S. Muskego Avenue. Map 29 presents the dissolved oxygen concentrations that were found in August 1964 and August 1974 in the Menomonee River watershed. The graph insert illustrates the change in the dissolved oxygen concentrations as observed on the sampling dates in August 1964, August 1968 and 1969; July 1970, and August 1971-1975 at each location.

Generally the dissolved oxygen concentrations at sampling stations Mn-1, Mn-2, and Mn-3 have improved from 1964 to 1974. Little change was noted at sampling stations Mn-4 and Mn-5 because of continued operation of the two Village of Menomonee Falls sewage treatment facilities and the Village of Germantown County Line sewage treatment facility which was phased out in November 1973. Based on the dissolved oxygen levels recorded at sampling stations Mn-6 and Mn-7a on the main stem of the Menomonee River, water quality conditions were better in 1975 than in 1964. The farthest downstream sampling station Mn-10 showed no appreciable change in dissolved oxygen levels over the 10-year span of data. Sampling station Mn-7 on the Little Menomonee River shows improvement over the 10-year period, whereas no significant change was noted at the Underwood Creek sampling station Mn-8. Sampling station Mn-9 cannot be evaluated because of the unavailability of data in August 1964.

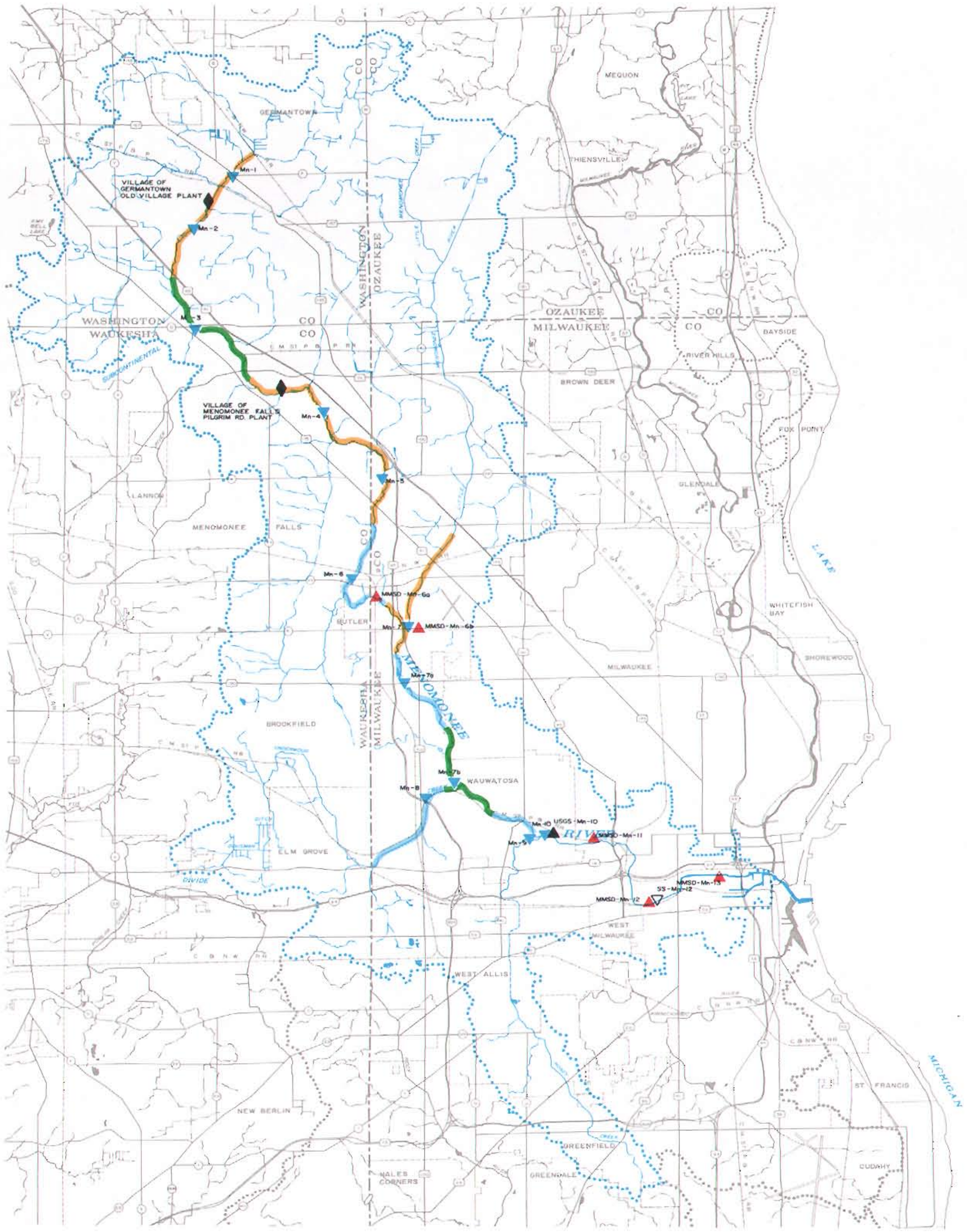
On August 19, 1964, as indicated on Map 29, substandard dissolved oxygen levels were observed at sampling stations Mn-1, Mn-2, Mn-4, and Mn-5 on the upper portion of the Menomonee River above W. Hampton Avenue. At the Milwaukee-Metropolitan Sewerage District stations at S. Muskego Avenue, (MMSD-Mn-13), the dissolved oxygen readings were 0.0 mg/l, 3.6 mg/l, and 0.4 mg/l on July 28, August 11, and August 25, respectively, thus meeting the minimum standard for restricted water use only once during this low flow period in 1964. The dissolved oxygen concentration increased to 10 mg/l at sampling station Mn-6 and remained above the 5.0 mg/l maximum standard at an average of 10.1 mg/l at the remaining three downstream sampling stations, only to drop to very low substandard levels at the S. Muskego Avenue sampling station. On August 21, 1974, as indicated on Map 29, substandard dissolved oxygen levels were observed at least once during the diurnal sampling at all sampling stations on the Menomonee River main stem except for Mn-2. In addition, minimum standards were violated at sampling stations Mn-7 on the Little Menomonee River.

The graph insert in Map 29 presents the dissolved oxygen concentrations and the three-year moving averages at sampling stations Mn-1 through Mn-10 for the August samples of 1964 through 1974. It is difficult to identify a trend over this 10-year period at sampling station Mn-1 due to the fluctuating yearly values of dissolved oxygen with a low recorded in August 1971 of 1.5 mg/l and a high in July 1970 of 15.5 mg/l. The fluctuations may be due to changes in stream flow as a result of precipitation and attendant pollution from diffuse sources in the predominantly rural, agricultural headwater area of the Menomonee River. Based on comparison with the three-year moving averages for sampling stations Mn-1, Mn-2, and Mn-3, the dissolved oxygen content at sampling station Mn-1 remains fairly stable at approximately 6.0 mg/l throughout the 1968 to 1974 period. At sampling stations Mn-2 and Mn-3 just downstream from the Village of Germantown sewage treatment facility, the moving average of the dissolved oxygen content was low at 1.7 mg/l and 5.2 mg/l, respectively, for the 1969 sampling period and increased gradually to 12.1 and 9.3 mg/l, respectively, in 1974. These higher dissolved oxygen concentrations in more recent years may be indicative of an improved effluent from the sewage treatment plants' upgraded wastewater treatment processes. Although an increase in dissolved oxygen was noted at sampling station Mn-4, it is not so high as in the two upstream sampling stations where a moving average of 3.3 mg/l was recorded in the 1969 period, increasing gradually to 5.8 mg/l in the 1974 period. Similarly, a gradual increase was noted at sampling station Mn-5 from 1.6 mg/l to 5.3 mg/l. However, the

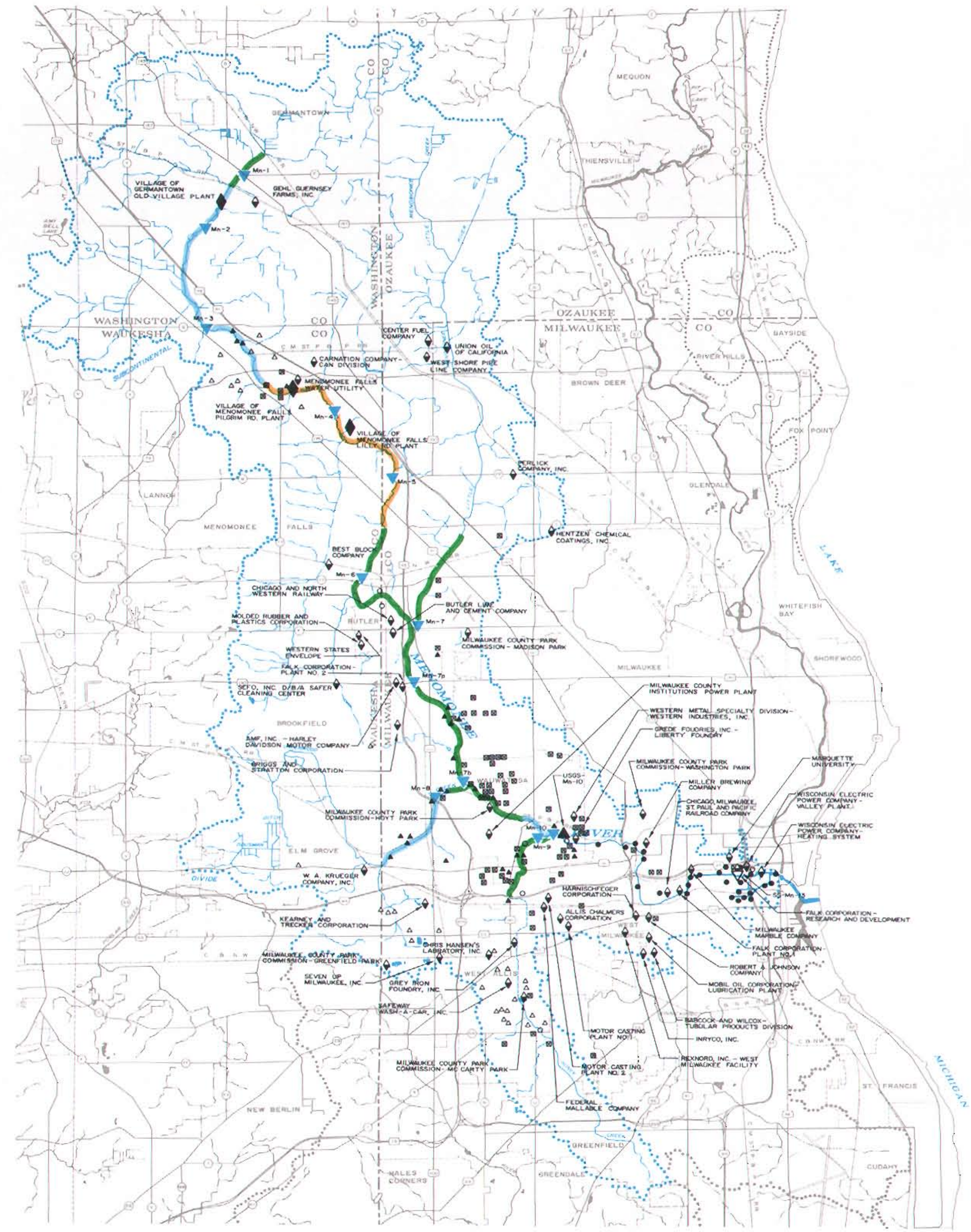
Map 29

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1974 IN THE MENOMONEE RIVER WATERSHED

1964



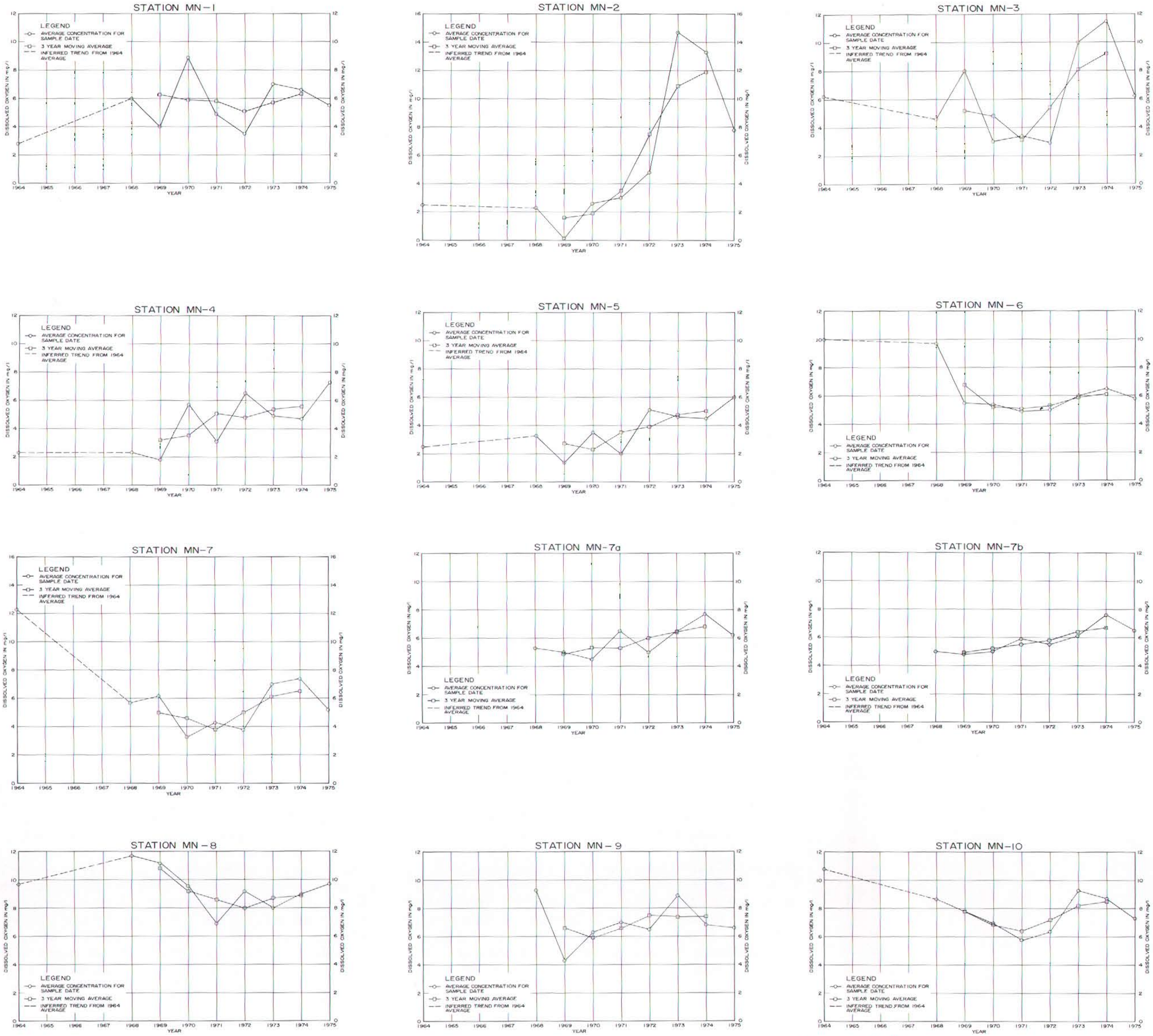
1974



A comparison of the dissolved oxygen levels recorded in 1964 and 1975 indicated that dissolved oxygen concentrations increased at the sampling stations Mn-1, Mn-2, and Mn-3 located in the upstream portion of the watershed and sampling station Mn-7 farther downstream, while sampling stations Mn-6 and Mn-7a located in the downstream portion of the watershed exhibited decreased dissolved oxygen levels. There was no significant change in dissolved oxygen levels from sampling stations Mn-4, Mn-5, Mn-7b, Mn-8, and Mn-10. The maximum dissolved oxygen concentration observed during the 10 year period was 20.1 mg/l recorded at sampling station Mn-3, and the minimum concentration of 0.1 mg/l was recorded at sampling station Mn-2.

Source: SEWRPC.

Map 29 (continued)



Source: SEWRPC.

overall concentrations at both sampling stations, Mn-4 and Mn-5, were lower than the concentration at the upstream headwater sampling station Mn-3, possibly due to the discharge of effluent from the Village of Menomonee Falls Pilgrim Road plant and the Village of Germantown County Line plant located just upstream from sampling station Mn-4 and the Village of Menomonee Falls Lilly Road plant located upstream from sampling station Mn-5. Menomonee River sampling station Mn-6 exhibited relatively stable dissolved oxygen concentrations fluctuating within a 2.0 mg/l range from 5.3 to 7.2 mg/l for the three-year moving averages from 1968-1974. Such stability is normal and expected for this stream reach because there are no effluent discharges from sewage treatment plants or industries between sampling stations Mn-5 and Mn-6. The sampling stations immediately downstream from sampling station Mn-6 on the main stem, sampling stations Mn-7a and Mn-7b, show gradual increases in the dissolved oxygen concentrations and fluctuate only moderately between the 3.0 to 7.0 mg/l range. Once again, the gradual increases in dissolved oxygen content since 1968 may reflect the more stringent requirements placed on the operation of existing sewage treatment plants and industries, resulting in reduced discharges of pollutants into the surface waters of the Region. Stability also is exhibited at sampling station Mn-10 throughout the period of analysis but, unlike the sampling stations upstream, no gradual increase of dissolved oxygen was observed. The modest range of 2.0 mg/l may be accounted for by the diluting effect of the added flow from Underwood Creek and Honey Creek which join the main stem just upstream from sampling station Mn-10. Although both tributaries contribute flows with relatively higher concentrations of dissolved oxygen—9.7 and 7.3 mg/l, respectively—to the main stream of the Menomonee River, it is believed that the increased flow at sampling station Mn-10 accounts for a stabilization of the dissolved oxygen content, making it difficult to detect changes in dissolved oxygen levels.

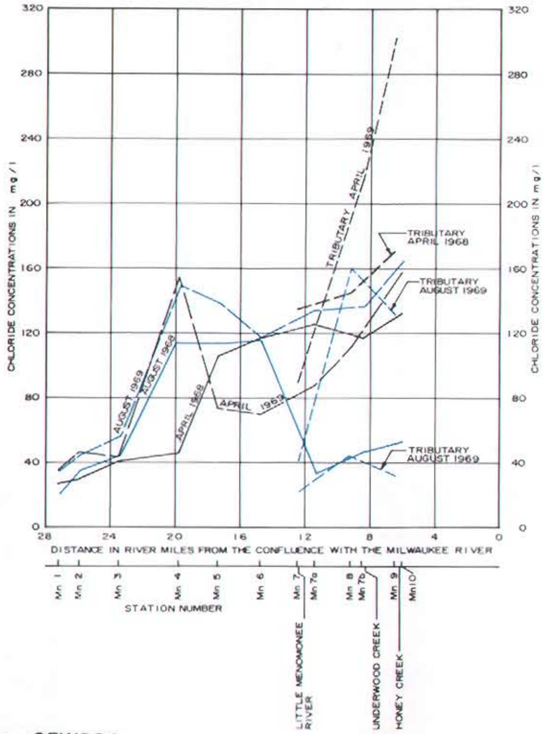
A comparison of dissolved oxygen concentrations found in April and August of the years 1964, 1968, and 1969 indicates consistently higher dissolved oxygen levels in April of each year than during the low flow July and August periods. The August dissolved oxygen concentrations were 0.1 to 11.5 mg/l less than were found in the April samples. The lower flow and higher temperatures, coupled with the organic loading from sewage and industrial effluents, probably account for the decreased dissolved oxygen concentrations of the August samples.

Chloride: Chloride concentrations were found to be in the range of 12 to 1,270 mg/l for the 12 sampling stations on the Menomonee River during the years 1964-1975. The majority of readings far exceeded the normal background levels of 5 to 15 mg/l for chloride concentrations in the groundwater. A comparison of the observed chloride concentrations of April 1968 with those of August 1968, and those of April 1969 with those of August 1969, indicates a trend to higher chloride concentrations in the urbanized downstream areas. Figure 71 presents the sampling results for chloride concentrations for April and August of 1968 and 1969. Higher chloride concentrations were recorded during April 1968 at the more urban stations, the tributary sampling stations Mn-7, the Little Menomonee River; Mn-8, Underwood Creek; Mn-9, Honey Creek; and in 1969 at sampling stations Mn-10, Mn-7a, and Mn-7b. These elevated chloride levels can be attributed to the spring runoff containing street de-icing salts applied throughout the winter. Interestingly enough, sampling stations Mn-1 through Mn-3 exhibit comparably low chloride values in April and August of 1968 and 1969, with abrupt increases in the chloride concentrations beginning at the urban sampling station Mn-4. The lower concentrations at the rural upstream locations may be expected because of the lower density of the road network where salting routinely occurs. Map 30 shows the chloride concentrations for the Menomonee River sampling stations on August 19, 1968, and August 27, 1974, with a graph illustrating the changes in chloride concentrations found during the sampling days of intermediate years. The map indicates an increasing trend in chloride concentrations in the August 1974 samples, as compared to the August 1968 samples at sampling stations on the Menomonee River and three major tributaries. The graphs illustrate the chloride concentrations in August for the Menomonee River sampling stations Mn-1 through Mn-10 for the years 1968 through 1975. When the chloride concentrations for August 1968 through August 1975 are compared, an increase over time may be noted at all sampling stations except Mn-10 which remained stable. The increase in chloride concentrations over the past eight years was more obvious at sampling station Mn-8 than at any other station on the Menomonee River. The chloride concentration increased from about 10 mg/l to about 40 mg/l at all sampling stations during the period from 1968 to 1975 except sampling station Mn-8 which exhibited an increase from 85 mg/l to 150 mg/l. This increase is significant since the location of sampling station Mn-8 lies just downstream from STH 45 (the Zoo Freeway) on Underwood Creek where heavy salting operations are conducted during the winter months. This may result in the release of chloride from chloride saturated soils during periods of rainfall throughout the year and especially chloride concentrated runoff during the winter snow and ice months.

The chloride loadings at sampling station Mn-10 during the sampling days are compared with flow in Figure 72. If it is assumed that the chloride loadings are contributed primarily by the sewage treatment plants, when the chloride loadings should not vary with flow, since the chlorides would be associated with the fixed loadings of organic wastes to the treatment plants. From Figure 71 it can be seen, however, that chloride levels do vary with flow, indicating that the chloride has other sources than sewage effluent. The higher flows in 1972 and 1975 were associated with large amounts of rainfall, raising the possibility of chloride originating with storm water runoff from the leaching of road salt from soil in urban areas or from diffuse agricultural sources. The background chloride loadings, assuming a maximum background chloride level of 15 mg/l from the groundwater in this area and assuming that all the observed flow is from

Figure 71

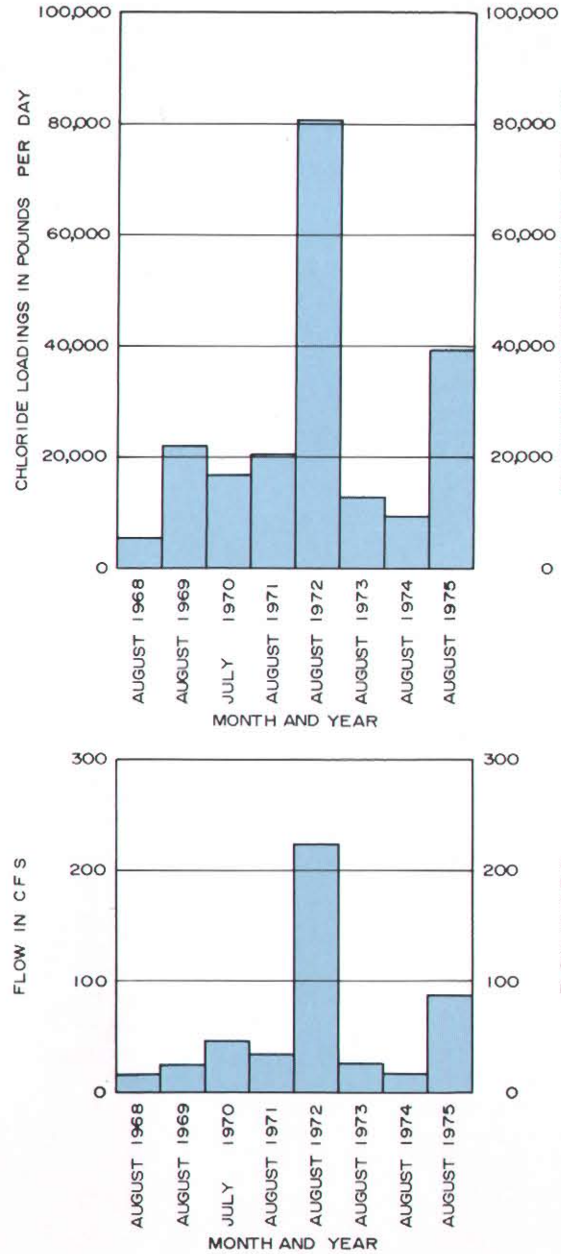
CHLORIDE CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968 AND APRIL AND AUGUST 1969



Source: SEWRPC.

Figure 72

COMPARISON OF CHLORIDE LOADINGS AND FLOW AT THE MENOMONEE RIVER AT WAUWATOSA (MN-10) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

base flow, indicate that the chloride loadings in all samples collected at sampling station Mn-10 were from three to 15 times higher than the background levels.

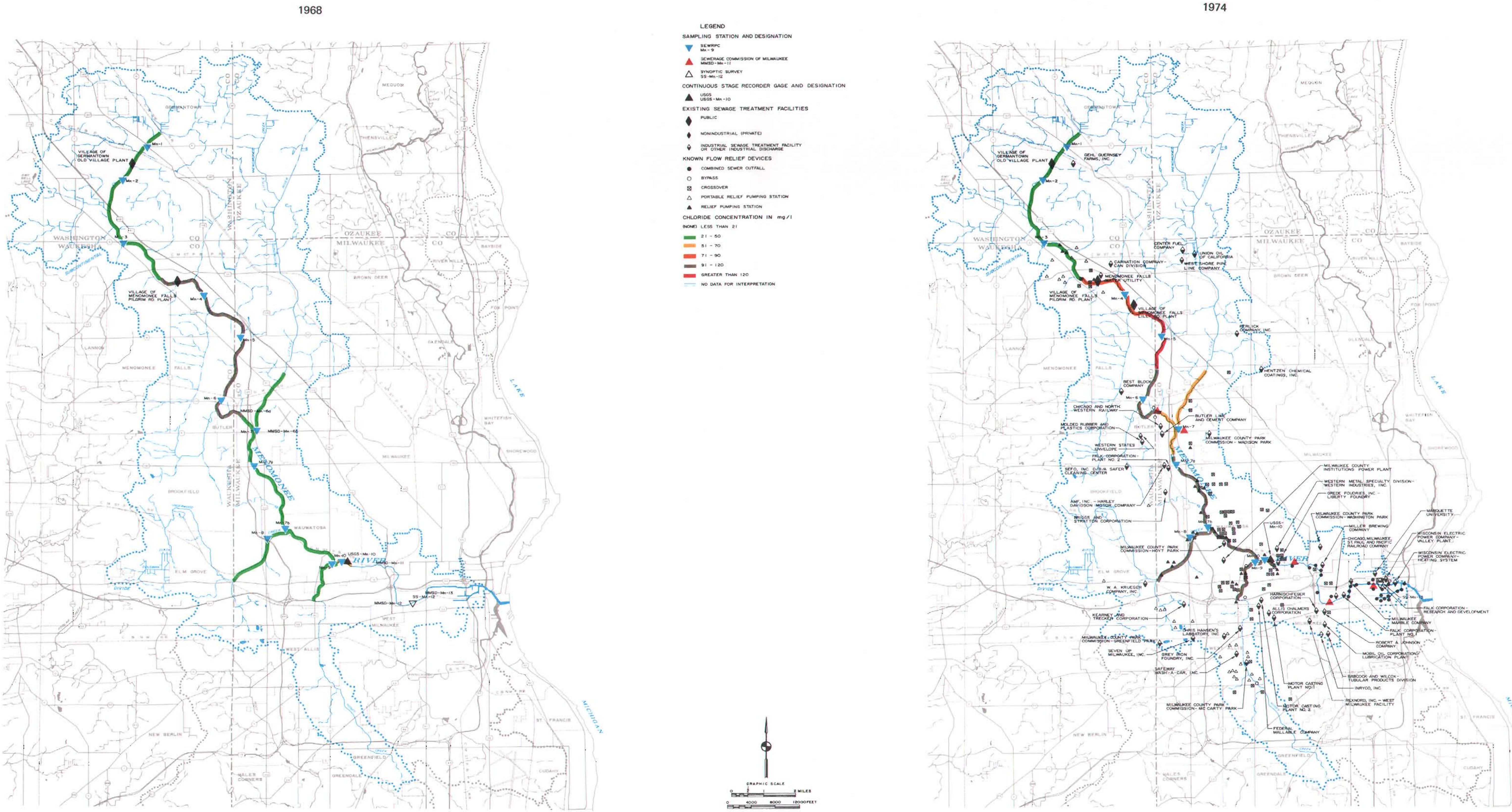
It is apparent, in the plot of chloride concentrations versus month and year, that those stations associated with rural and agricultural land uses display a very gradual increase of chloride levels since 1968. On the other hand, sampling stations reflecting the impact of urban land use exhibit highly fluctuating values and rapid increases in concentrations since 1968.

Fecal Coliform Bacteria: Map 31, with a graph insert presenting fecal coliform counts in the Menomonee River watershed locations during the period of August 1968-August 1974, illustrates changes in fecal coliform counts found on the days of sampling during the intermediate years. The samples collected in August 1968 showed greater than 400 MFFCC/100 ml at five of the 12 sampling stations, with levels of 1,200 MFFCC/100 ml at Mn-1 and Mn-2, 600 MFFCC/100 ml at sampling station Mn-4, 1,700 MFFCC/100 ml at Mn-10, and 1,100 MFFCC/100 ml at Underwood Creek sampling station Mn-8.

All sampling stations on the main stem and tributaries of the Menomonee River demonstrated elevated counts of 400 MFFCC/100 ml or more in August of 1974. Sampling station Mn-8 had the highest reading of 4,400 MFFCC/100 ml of all 12 sampling stations that year. In 1975, sampling station Mn-5 exhibited a count of

Map 30

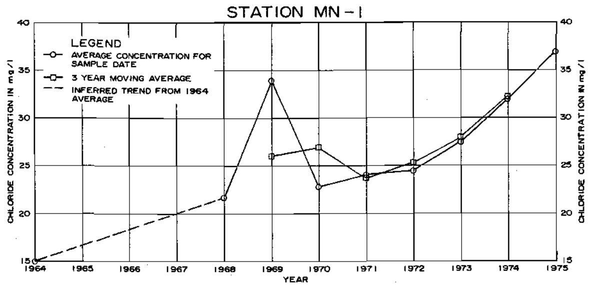
COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1974 IN THE MENOMONEE RIVER WATERSHED

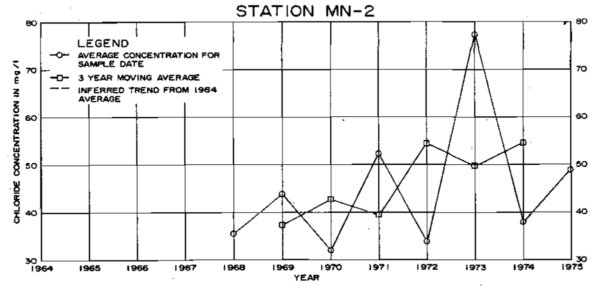


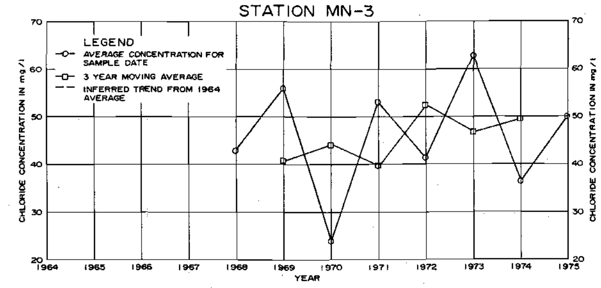
A comparison of the chloride concentrations recorded in 1968 and 1974 in the Menomonee River watershed indicated that chloride concentrations had increased for sampling stations Mn-5, Mn-7, Mn-7a, Mn-7b, Mn-8, Mn-9, and Mn-10, while only sampling station Mn-4 recorded decreased chloride concentration. Observations recorded at sampling stations Mn-1, Mn-2, Mn-3, and Mn-6 exhibited stable chloride levels. The maximum chloride sample taken during the seven year period was 341 mg/l, recorded at station Mn-7b, and the minimum sample of 12 mg/l was recorded at sampling station Mn-3.

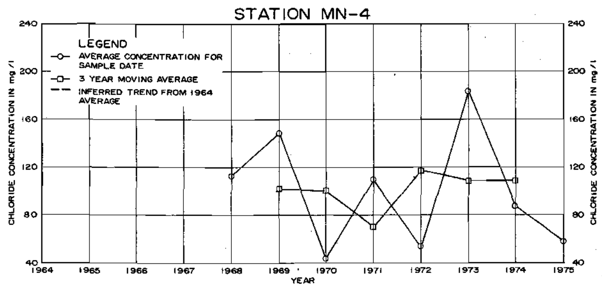
Source: SEWRPC.

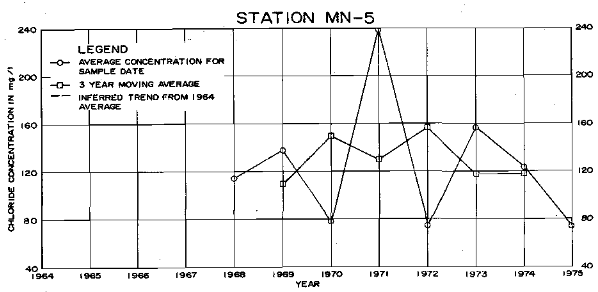
Map 30 (continued)

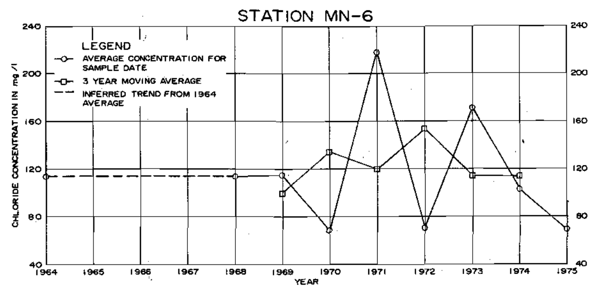


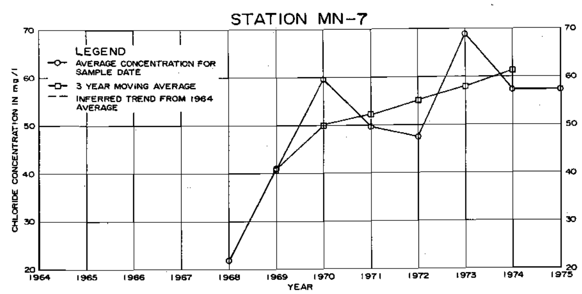


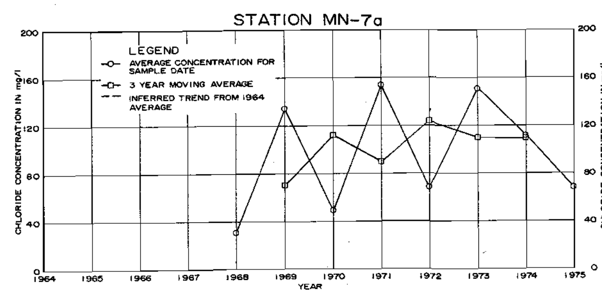


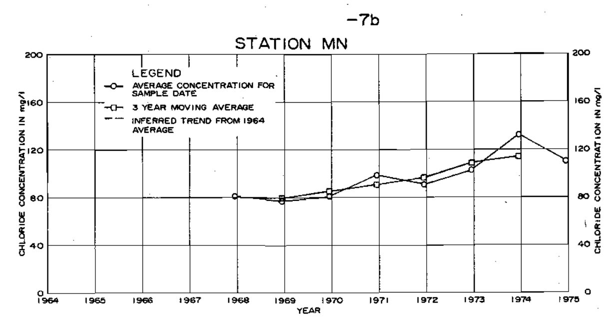


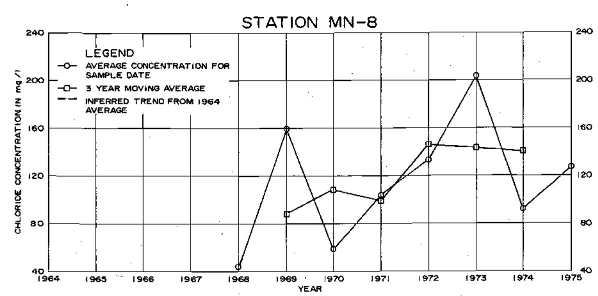


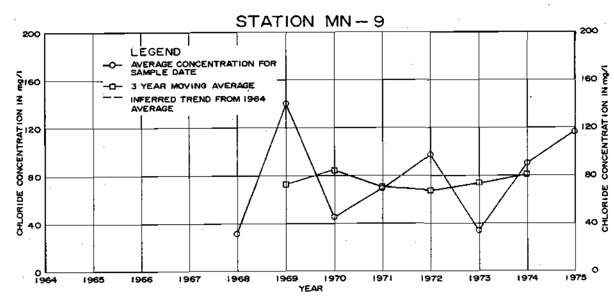


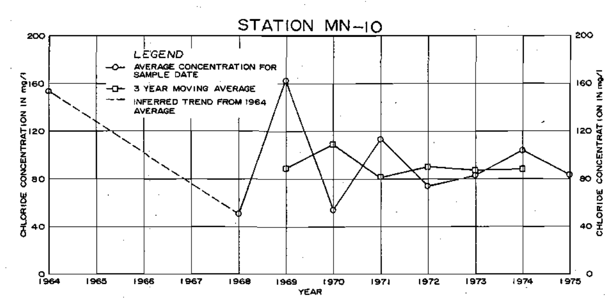








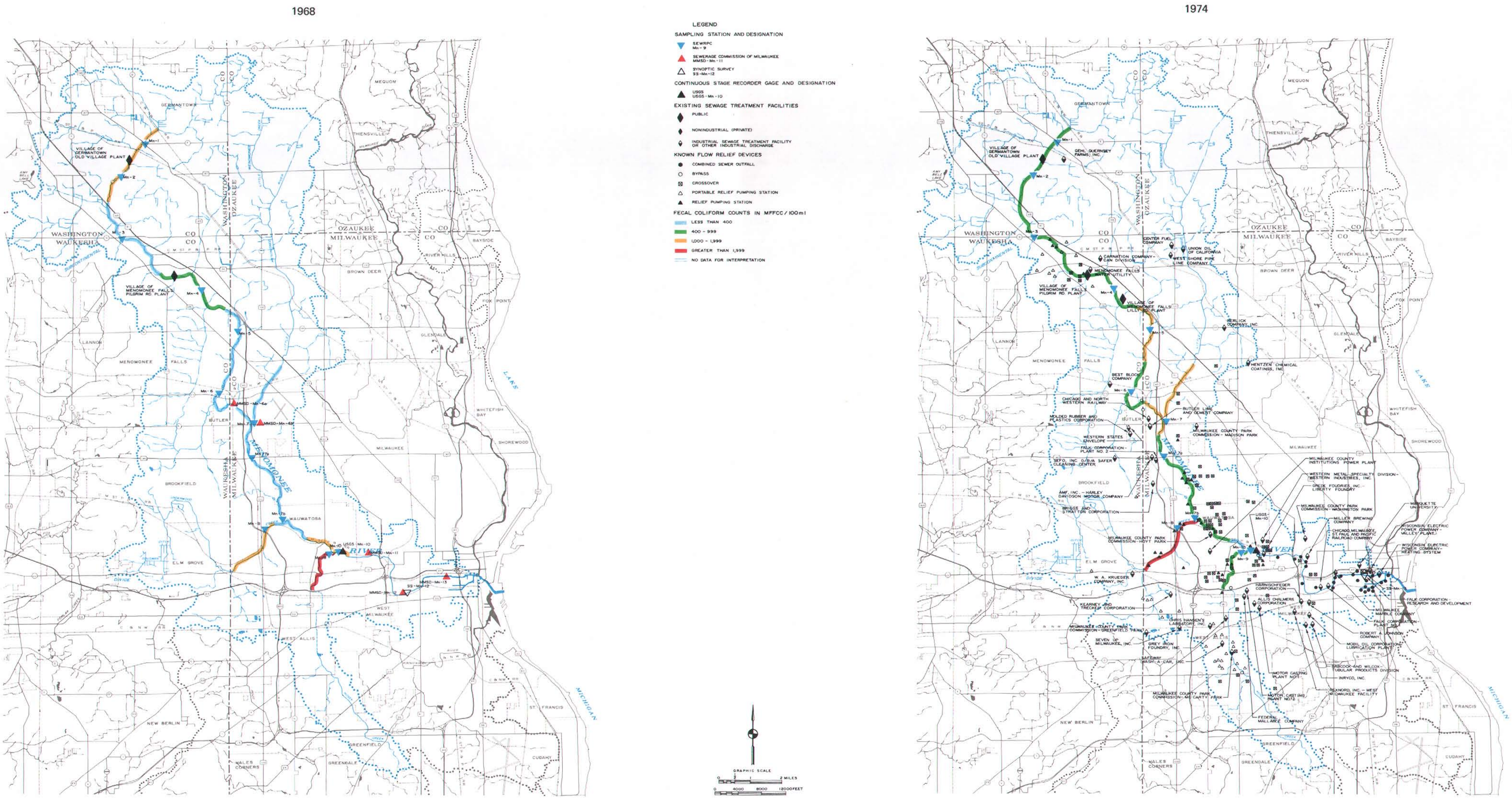




Source: SEWRPC.

Map 31

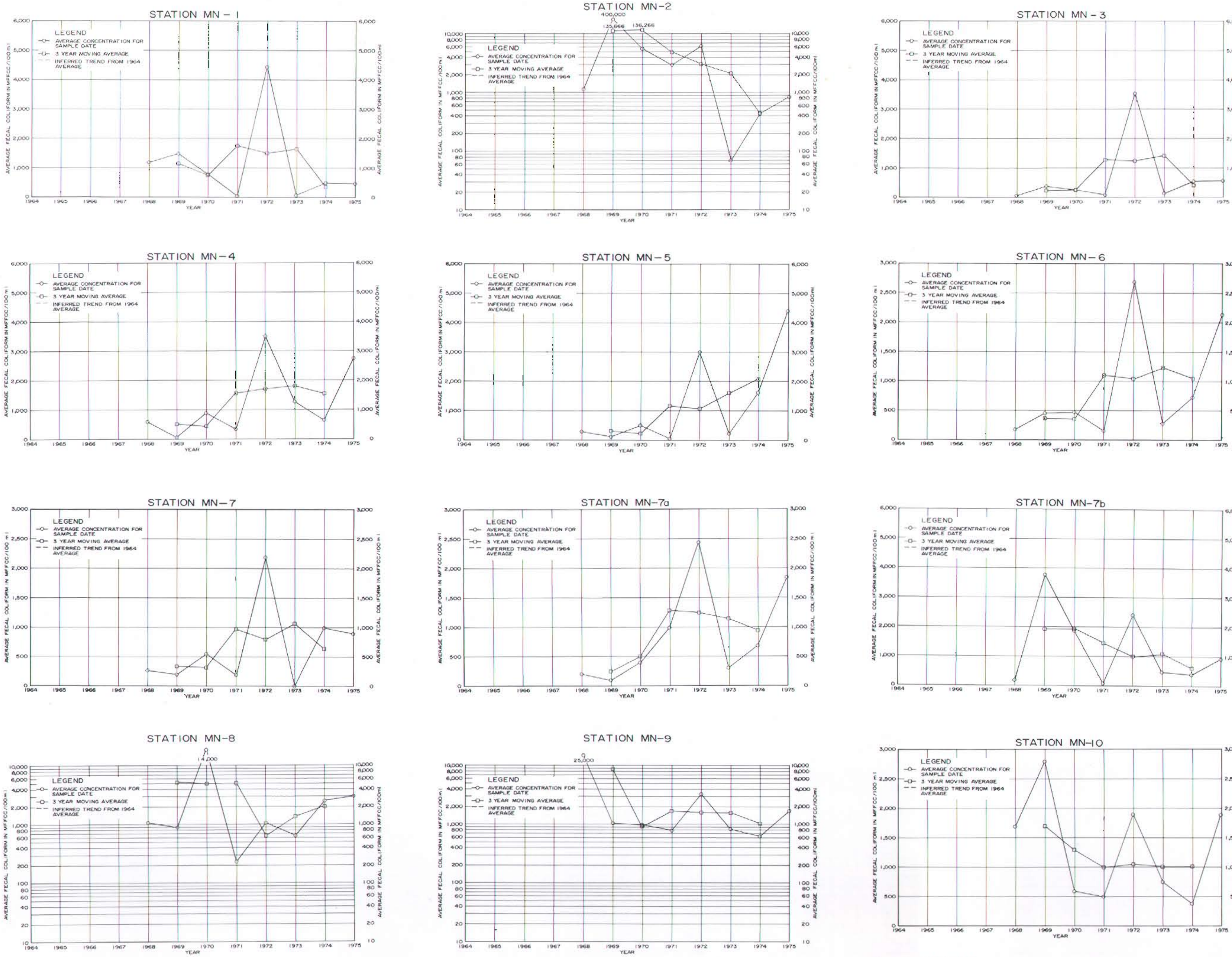
COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1974 IN THE MENOMONEE RIVER WATERSHED



The fecal coliform counts generally increased since 1968 at the Menomonee River main stem sampling stations and those stations on Underwood Creek and the Little Menomonee River. A decrease in fecal coliform counts indicated improved water quality conditions at sampling stations Mn-1, Mn-2, and Mn-10 on the Menomonee River main stem and at sampling station Mn-9 on Honey Creek. Station Mn-4 showed no significant change in fecal coliform counts from 1968 to 1974.

Source: SEWRPC.

Map 31 (continued)



Source: SEWRPC.

5,200 MFFCC/100 ml with slightly lower readings of 3,400 MFFCC/100 ml at sampling station Mn-4 directly upstream and 3,000 MFFCC/100 ml at sampling station Mn-6 directly downstream from sampling station Mn-5. All three sewage treatment plants are located upstream of sampling station Mn-5: the Village of Germantown Old Village plant, the Village of Menomonee Falls Lilly Road plant, and the Village of Menomonee Falls Pilgrim Road plant. Thus, the elevated fecal coliform counts may reasonably be attributed to discharges from the three sewage treatment plants and to raw sewage discharge from flow relief devices as a result of the increased flow in 1975. A review of other diffuse sources of fecal coliform contamination in this part of the watershed indicates no barnyards or other animal feeding operations. Contamination from malfunctioning septic systems may be a contributing factor, although difficult to identify. Analysis of the fecal coliform data indicates significant increases of fecal coliform levels in 1972 for all 12 sampling stations as a result of several days of intensive rainfall preceding the sampling.

Hydrogen Ion Concentration (pH): As indicated in Table 79-90, the pH values of the watershed surface water system generally have been within the range of 6.0 to 9.0 standard units prescribed for recreational use and fish and aquatic life use. The pH was observed to violate this standard only twice, with 9.1 standard units exhibited at sampling station Mn-2 on August 20, 1973, and 9.1 standard units at sampling station Mn-9 on August 21, 1974. No trend in pH variation of the samples collected over the 10-year period was observed.

Specific Conductance: Specific conductance was found to be in the range of 229 to 1,605 µmhos/cm at 25°C for the 12 locations on the Menomonee River on the days sampled between 1968 and 1975. The highest specific conductance value was found at sampling station Mn-5 on August 10, 1971. Approximately one-quarter of an inch of rainfall occurred just before the sampling period, resulting in elevated levels of specific conductance at 10 of the 12 sampling stations, and indicating a direct correlation between rainfall runoff and the total dissolved ions in the water. Interestingly, sampling stations Mn-4, Mn-5, and Mn-6 have continuously exhibited specific conductance values higher than any of the other sampling stations, regardless of precipitation events, and this may be attributed to the dissolved solids contributed by the two Village of Menomonee Falls sewage treatment facilities and the Germantown County Line facility.

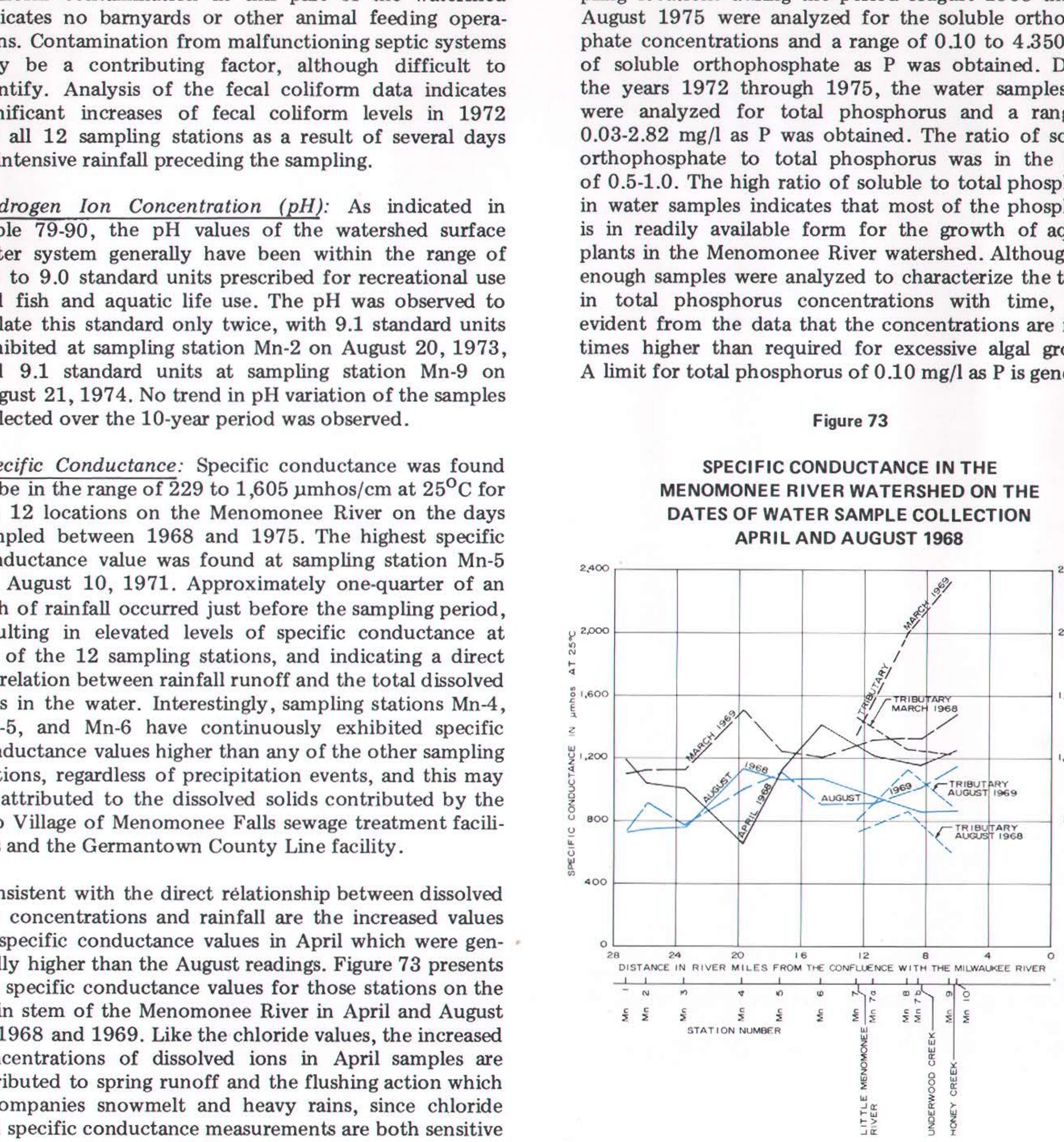
Consistent with the direct relationship between dissolved ion concentrations and rainfall are the increased values of specific conductance values in April which were generally higher than the August readings. Figure 73 presents the specific conductance values for those stations on the main stem of the Menomonee River in April and August of 1968 and 1969. Like the chloride values, the increased concentrations of dissolved ions in April samples are attributed to spring runoff and the flushing action which accompanies snowmelt and heavy rains, since chloride and specific conductance measurements are both sensitive to these events. As expected, the highest readings of specific conductance occur at the urban sampling sites, due to the increased loadings from the winter road salting operations.

Temperature: As indicated in Tables 79 to 90, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the 12 Menomonee River sampling locations during the period August 1968 through August 1975 were analyzed for the soluble orthophosphate concentrations and a range of 0.10 to 4.350 mg/l of soluble orthophosphate as P was obtained. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.03-2.82 mg/l as P was obtained. The ratio of soluble orthophosphate to total phosphorus was in the range of 0.5-1.0. The high ratio of soluble to total phosphorus in water samples indicates that most of the phosphorus is in readily available form for the growth of aquatic plants in the Menomonee River watershed. Although not enough samples were analyzed to characterize the trends in total phosphorus concentrations with time, it is evident from the data that the concentrations are many times higher than required for excessive algal growth. A limit for total phosphorus of 0.10 mg/l as P is generally

Figure 73

SPECIFIC CONDUCTANCE IN THE MENOMONEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968



Source: SEWRPC.

held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants. All sampling stations on the Menomonee River had total phosphorus levels higher than 0.10 mg/l as P.

Figure 74 presents the total phosphorus loadings and flow for sampling station Mn-10 for 1972 through 1975. Since the total phosphorus loadings followed the flow pattern—in that the high flow of 1972 had increased total phosphorus loading into the River system—and the four years of data are so few, no attempt is made to characterize the trend in phosphorus loading in the River. It can be noted, however, that the phosphorus loadings generally increase in high flow years far beyond the proportionate increase in flow. The soluble orthophosphate data which are available for the years 1968-1975 also showed disproportionately increased loadings with the increase in flow (see Figure 75). These data along with the chloride data indicate that the pollution sources are not limited to the sewage treatment plant effluents. In the rural areas the increases in phosphorus with increased flow indicate that part of the phosphorus loading results from rural storm water runoff as well as other diffuse sources. Conversely, in the urbanized areas, a combination of contamination from sewage treatment plant discharges, sewer overflows, malfunctioning onsite sewage disposal systems, industrial wastewater discharges, and storm water runoff all contribute to the phosphorus loadings in the streams within the Menomonee River watershed.

Nitrogen: The total nitrogen concentrations in the Menomonee River water quality samples collected during August of 1972 through 1975 were in the range of 0.33 to 7.50 mg/l as N with about 1.2 to 1.8 percent in the form of nitrite nitrogen, 24.7 to 28.5 percent as nitrate nitrogen, 8.2 to 48.1 percent as ammonia nitrogen, and 21.5 to 65.9 percent as organic nitrogen with 20 to 75 percent of the total nitrogen in the readily available forms of nitrate nitrogen and ammonia nitrogen. Presence of any form of nitrogen is an indicator of organic loadings. Nitrates are obtained as the end product of aerobic degradation of protenaceous materials (organic nitrogen), nitrites are the byproducts of bacteriological action upon ammonia and nitrogenous substances, and ammonia is the chief decomposition product from plant and animal proteins. The presence of ammonia nitrogen in the stream water is a chemical evidence of sanitary pollution of recent origin. In the presence of oxygen, ammonia is transformed into nitrite and ultimately into nitrate. The concentration of ammonia nitrogen at the Menomonee River sampling sites ranged from less than 0.01 to 3.61 mg/l as N. On 44 of the 93 sampling dates, the ammonia nitrogen levels did exceed the 0.2 mg/l as N, generally held to be indicative of lakes and streams which have been affected by pollution. The only sample exceeding the known toxic level of 2.5 mg/l as ammonia nitrogen as N was taken at sampling station Mn-4 downstream from the Village of Menomonee Falls Pilgrim Road sewage treatment facility and at the convergence of the main stem of the Menomonee River with Nor-X-Way Channel, probably attributable to the treatment plant.

Nitrate nitrogen concentrations in the Menomonee River watershed ranged from 0.02 to 3.37 mg/l as N. Nitrate is the end product in the aerobic treatment of municipal sanitary wastes and other organic wastes. Surface runoff from fields where there have been applications of natural and artificial fertilizers also contribute significant quantities of nitrate to the streams. Nitrate nitrogen as a source of pollution is evident in the Menomonee River main stream as demonstrated by the elevated levels of nitrate nitrogen at sampling stations Mn-4, Mn-5, Mn-7a and Mn-7b, each influenced by wastewaters from municipal sewage treatment facilities.

Organic nitrogen accounts for 21.5 to 65.9 percent of the total nitrogen samples collected in the Menomonee River watershed. The organic nitrogen content is contributed by amino acids, proteins, and polypeptides, all products of biological processes. The presence of organic nitrogen is directly related to discharge into the stream of such organic wastes as sewage or industrial wastes. The presence of organic nitrogen in such a large concentration accounts for the low dissolved oxygen concentrations present at many of the sampling locations, since the degradation and oxidation of organic nitrogen compounds utilizes the oxygen present in the surface water. The concentrations or organic nitrogen and nitrate nitrogen have remained high through the years 1972-1975 at all stations on the Menomonee River and especially at those stations corresponding to the existing sewage treatment facilities, indicating that no significant change or decrease in the organic loading has occurred in the past four years. However, sampling stations Mn-8 and Mn-9 on Underwood and Honey Creeks have exhibited significantly lower levels during the four sampling periods than the Menomonee River main stem station.

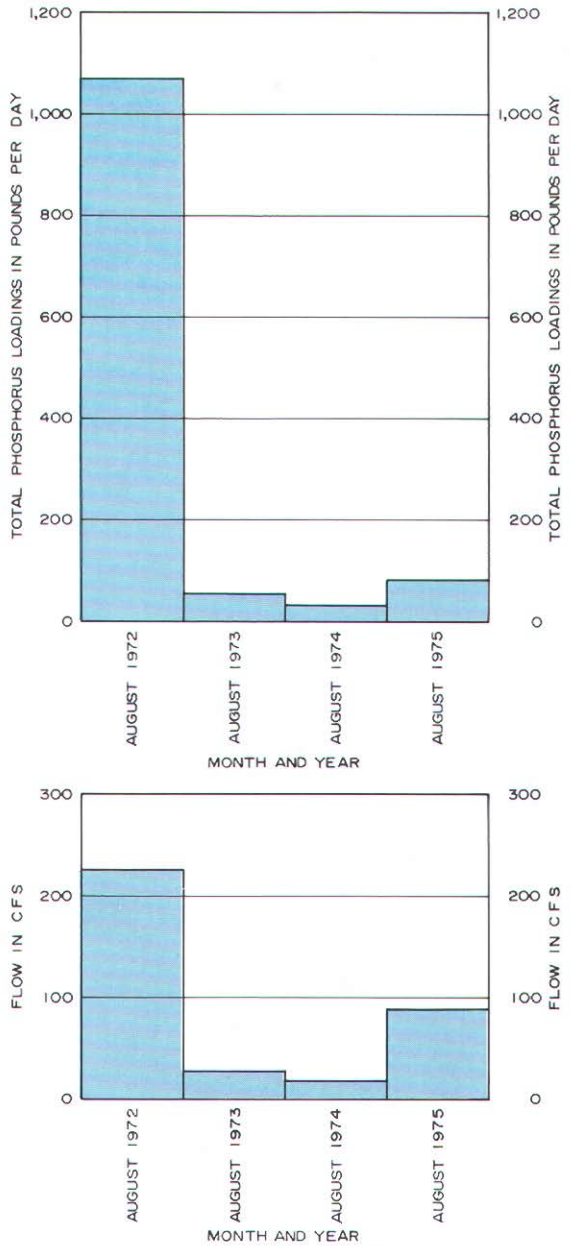
Figure 76 presents the total nitrogen loadings and flow for sampling station Mn-10 for the samples of August 1972, 1973, 1974, and 1975. The total nitrogen loadings followed the flow pattern, in that the high flow in 1972 and the increased flow in 1975 had increased the total nitrogen loading into the River. The four years of data are insufficient for assessing a trend in the total nitrogen loading in the Menomonee River. These data along with the chloride and total phosphorus data indicate various point and diffuse sources of pollution other than sewage treatment plants effluents. The increase in total nitrogen along with the increase in flow and total phosphorus in the headwaters of the Menomonee River watershed are attributed to agricultural runoff and runoff from other rural lands such as woodlands, wetlands, and unused lands.

Biochemical Oxygen Demand: Neither the Commission water quality monitoring program nor other agency programs included the measurement of five-day biochemical oxygen demand (BOD_5) for the years 1965 through 1975.

Diurnal Water Quality Changes: Figures 77-81 illustrate the diurnal changes in temperature specific conductance, chloride, dissolved oxygen, and pH which occurred during low flow conditions on August 10, 1971, at the Menomonee River sampling stations. The rate of flow

Figure 74

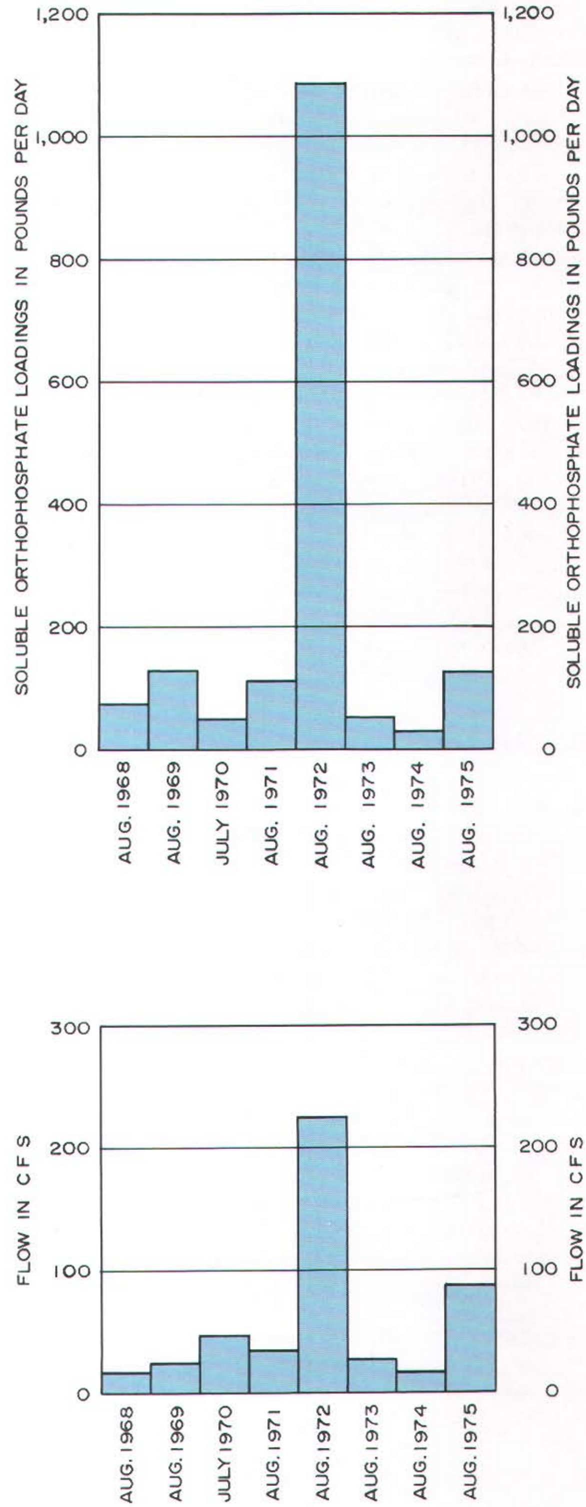
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT THE MENOMONEE RIVER AT WAUWATOSA (Mn-10) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

Figure 75

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW AT THE MENOMONEE RIVER AT WAUWATOSA (Mn-10) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



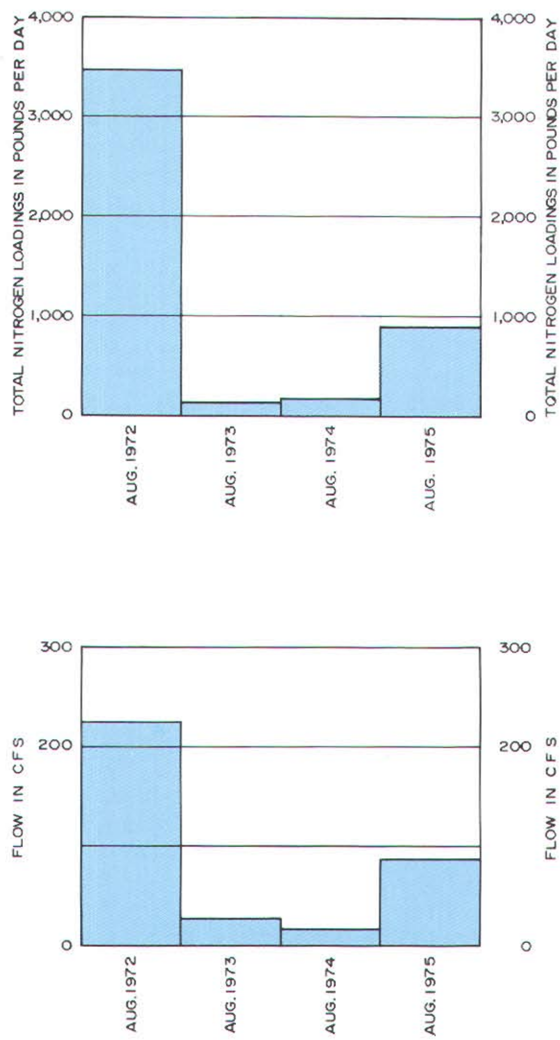
Source: SEWRPC.

on August 10, 1971, was 35 cfs which was 10 times the seven day-10 year low flow of 3.5 cfs.

Water temperatures ranged from a low of 68°F to a high of 81°F at the nine sampling stations on the Menomonee River and the three sampling stations on its tributaries. Chloride concentrations at sampling station Mn-7b ranged

Figure 76

COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT THE MENOMONEE RIVER AT WAUWATOSA (Mn-10) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975

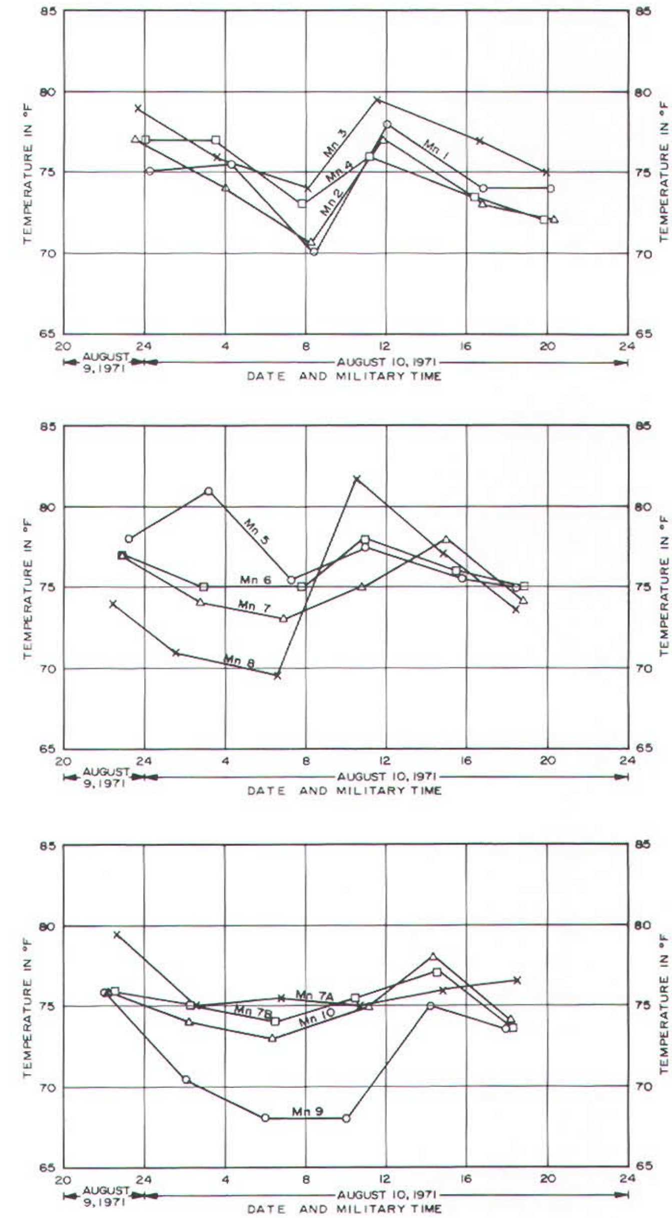


Source: SEWRPC.

from a high of 341 mg/l during the morning hours of August 10, 1971, to a low for the day in the early evening hours of 130 mg/l. Relatively high concentrations of chloride also were recorded at sampling stations Mn-4, Mn-5, and Mn-6, reflecting the possible effects of treated sanitary sewage discharged to the Menomonee River. Headwater stations generally exhibited low chloride concentrations similar to background levels due to the absence of a dense road network which contributes excessive amounts of salt from winter maintenance operations. The concentrations of dissolved oxygen varied from a low of 0.6 mg/l during the early morning hours to a high in excess of 10.0 mg/l at several sampling stations in the late afternoon and early evening hours.

Figure 77

DIURNAL VARIATIONS IN TEMPERATURE IN THE MENOMONEE RIVER WATERSHED: 1971

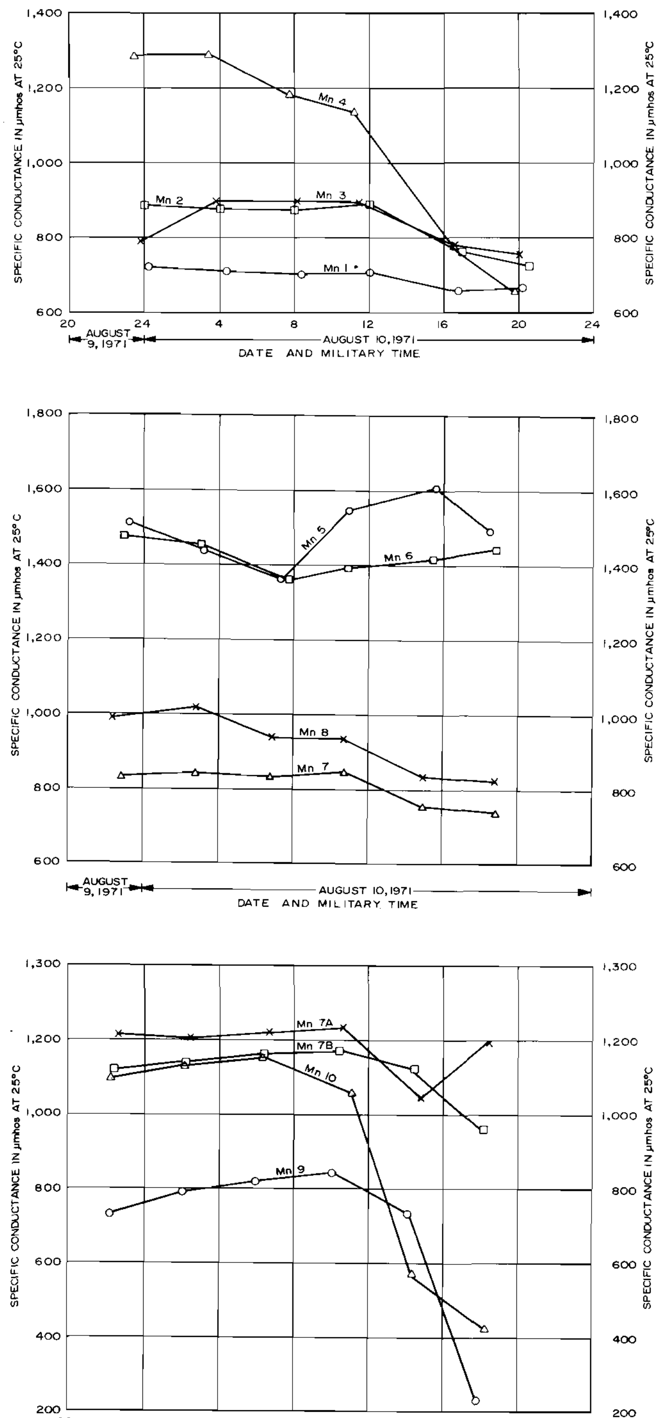


Source: SEWRPC.

The low early morning dissolved oxygen concentrations are typical since oxygen is critical for the respiration of algae and other aquatic plants during hours of darkness as well as the biochemical oxygen demand from increased flow of sewage effluent during the early morning hours, as indicated by higher chloride concentrations at the sampling stations located downstream from existing sewage treatment facilities. One high reading of 10.7 mg/l on the morning of August 10, 1971, at sampling station Mn-8 is difficult to assess. Normally, the daytime dis-

Figure 78

DIURNAL VARIATIONS IN SPECIFIC CONDUCTANCE IN THE MENOMONEE RIVER WATERSHED: 1971



Source: SEWRPC.

solved oxygen content increases considerably until the early evening hours near dusk and may be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants.

The observed hydrogen ion concentration (pH) was found to vary from a low of 7.6 standard units during the early morning hours of August 10, 1971, to a high of 8.8 standard units in the late evening. The uptake of carbon dioxide by photosynthesis process of the aquatic plants probably accounted for the higher pH in the late evening samples, and the lower pH during the early morning hours is attributed to the release of carbon dioxide during respiration by algae and aquatic plants during hours of darkness.

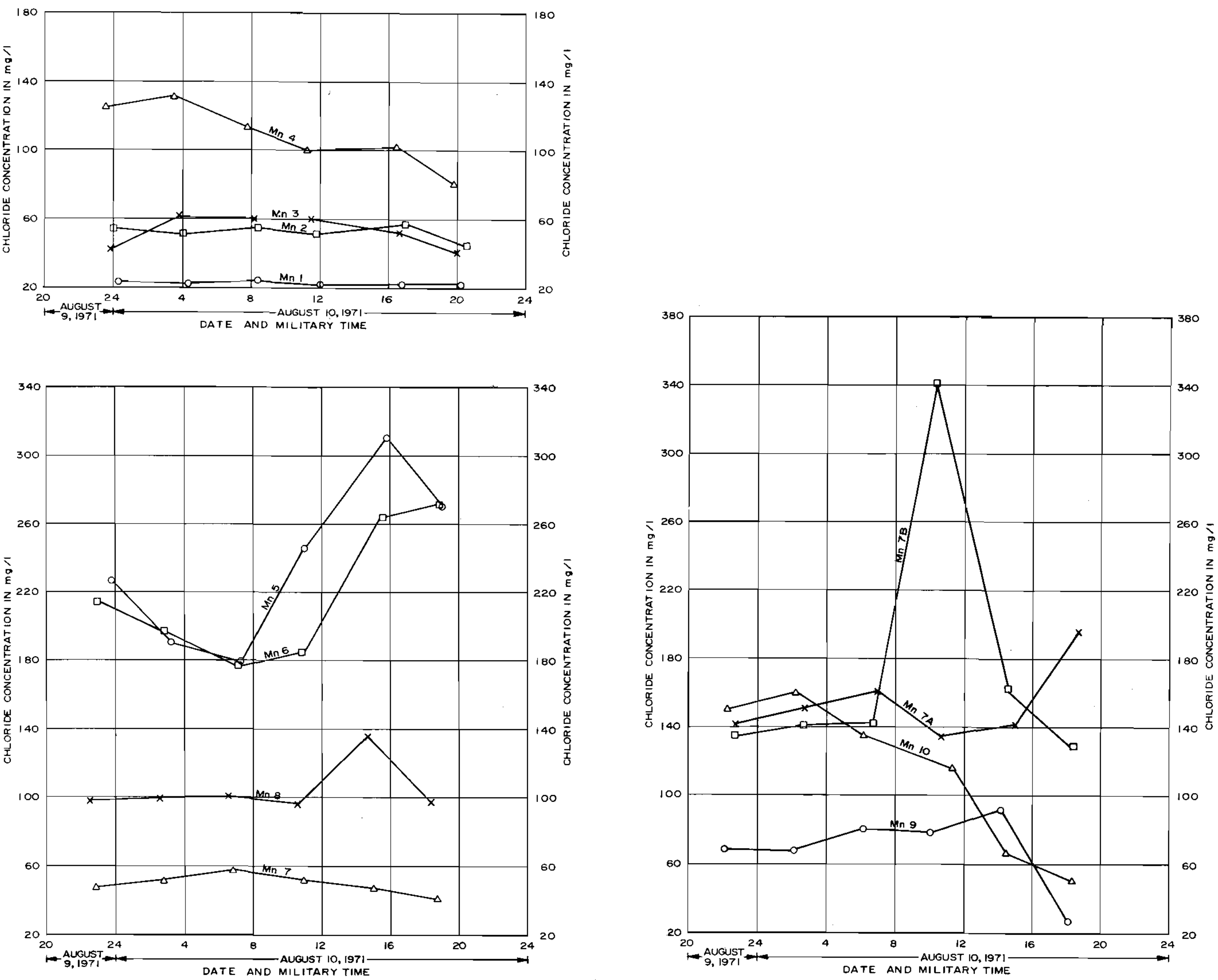
The diurnal fluctuations in water quality may be such that the average level of the concentrations of critical parameters meet the established water quality standards while the instantaneous levels during the daily cycles do not meet the standards. For example, the average of six dissolved oxygen concentration values for sampling station Mn-7a on the Little Menomonee River was 6.6 mg/l. Although this is above the minimum standard of 5.0 mg/l for recreational use and preservation of fish and aquatic life, substandard oxygen levels of less than 5.0 mg/l were measured at three of the six time periods in the predawn morning hours of August 10, 1971.

Spatial Water Quality Changes: The water quality surveys clearly indicate water quality changes from one location to another within the watershed stream system in response to a combination of human activities and natural phenomena. Figures 82 through 87 show the spatial water quality variation along the entire main stem of the Menomonee River as recorded under low flow hydrological conditions during the period for the years 1968 through 1975. The illustrations present the range of dissolved oxygen, chloride, specific conductance, total phosphorus, total nitrogen concentrations, and fecal coliform counts obtained over the past eight-year sampling survey at each Menomonee River main stem sampling station. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter, thus dividing the data into three categories: (1) the range of the 25 percent of the samples near the minimum values, (2) the range of the middle 50 percent of the samples, and (3) the range of the 25 percent of the samples near the maximum.

Figure 82, which presents the range of spatial dissolved oxygen variation in the Menomonee River main stem, indicates a moderately increasing trend from the source (Mn-1) to sampling station Mn-10 located at N. 70th Street of the Menomonee River, although the dissolved oxygen concentrations decreased at three of the intermediate sampling stations. The samples collected at sampling stations Mn-3, Mn-4, and Mn-5 showed a decrease in the dissolved oxygen concentrations when compared to the dissolved data from sampling station Mn-1. These

Figure 79

DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1971



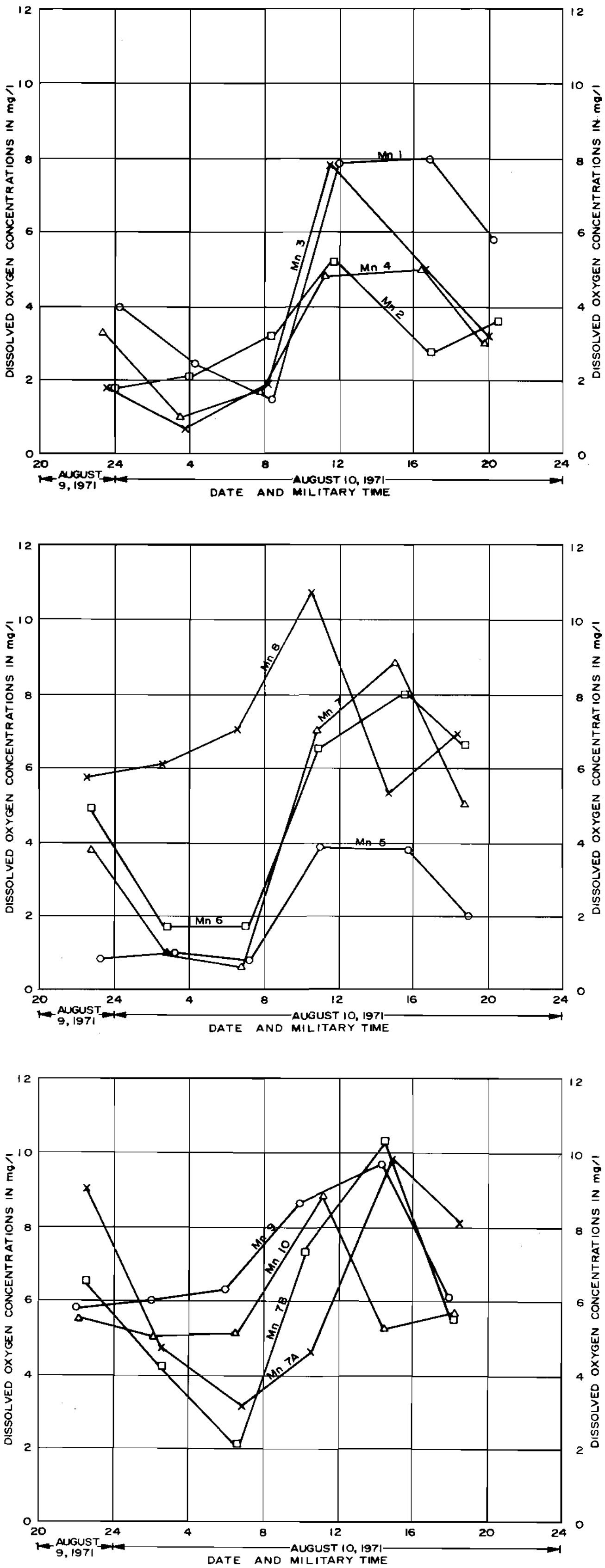
Source: SEWRPC.

decreases in the dissolved oxygen levels may be attributed to the organic loadings discharged by the Village of Germantown (Old Village plant) treatment facility located upstream from sampling station Mn-2; the Village of Germantown (County Line plant) abandoned in November 1973; the Menomonee Falls (Pilgrim Road plant) sewage treatment facility located upstream from sampling station Mn-4; and the Menomonee Falls (Lilly Road plant) sewage treatment facility located upstream from sampling station Mn-5. Menomonee River sampling stations Mn-6, Mn-7, Mn-7a, Mn-7b and Mn-10, all demonstrate increased average dissolved oxygen concentrations above the 5.0 mg/l for two reasons: first, because of the absence of sewage treatment facilities in the lower reaches of the Menomonee River, the stream system is capable of natural reaeration and, second, inflow from the three major tributaries—the Little Menomonee River, Underwood Creek, and Honey Creek—which characteristically demonstrate higher levels of dissolved oxygen, has the potential to increase the average dissolved oxygen concentrations in the Menomonee River main stem.

The range of chloride concentrations observed along the main stem of the Menomonee River showed a generally inverse relation to the dissolved oxygen concentrations (Figure 83). The chloride concentrations increased from sampling stations Mn-1 to Mn-5, and decreased from sampling stations Mn-6 through Mn-10, with only a slight increase in average chloride concentrations noted at sampling station Mn-7b. This inverse relationship between

Figure 80

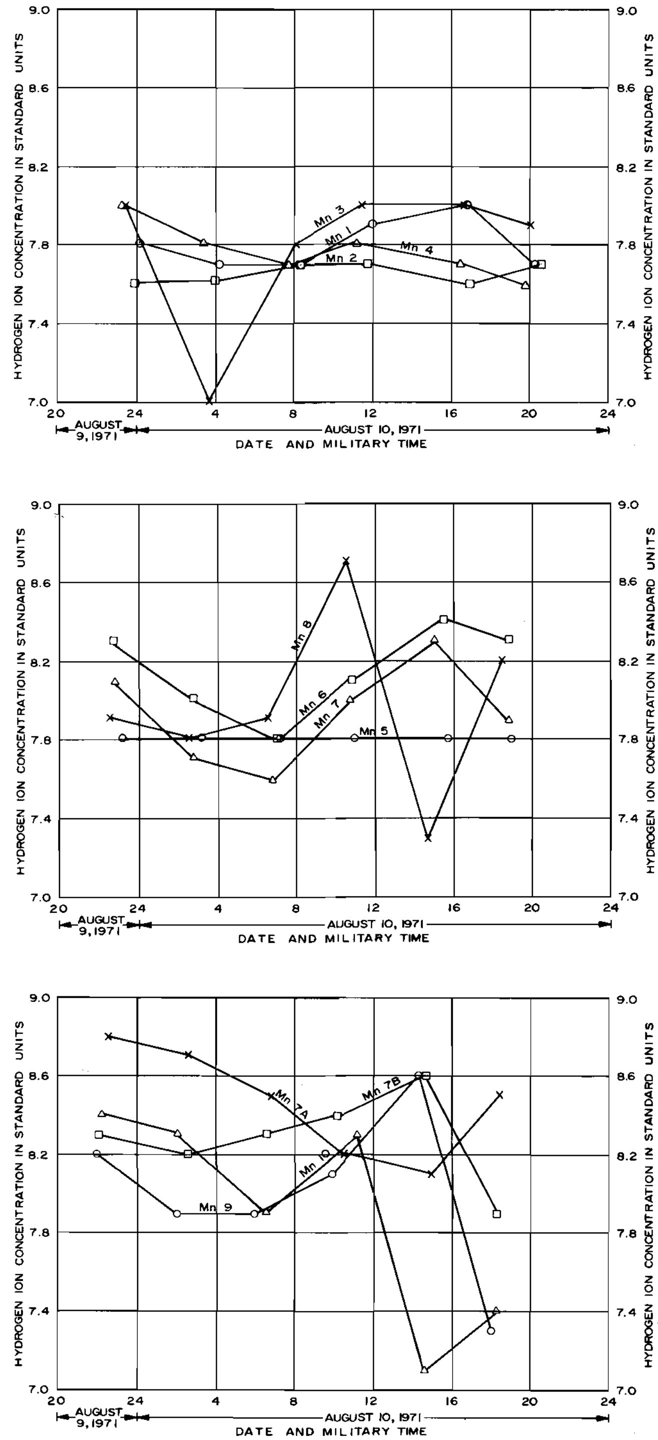
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1971



Source: SEWRPC.

Figure 81

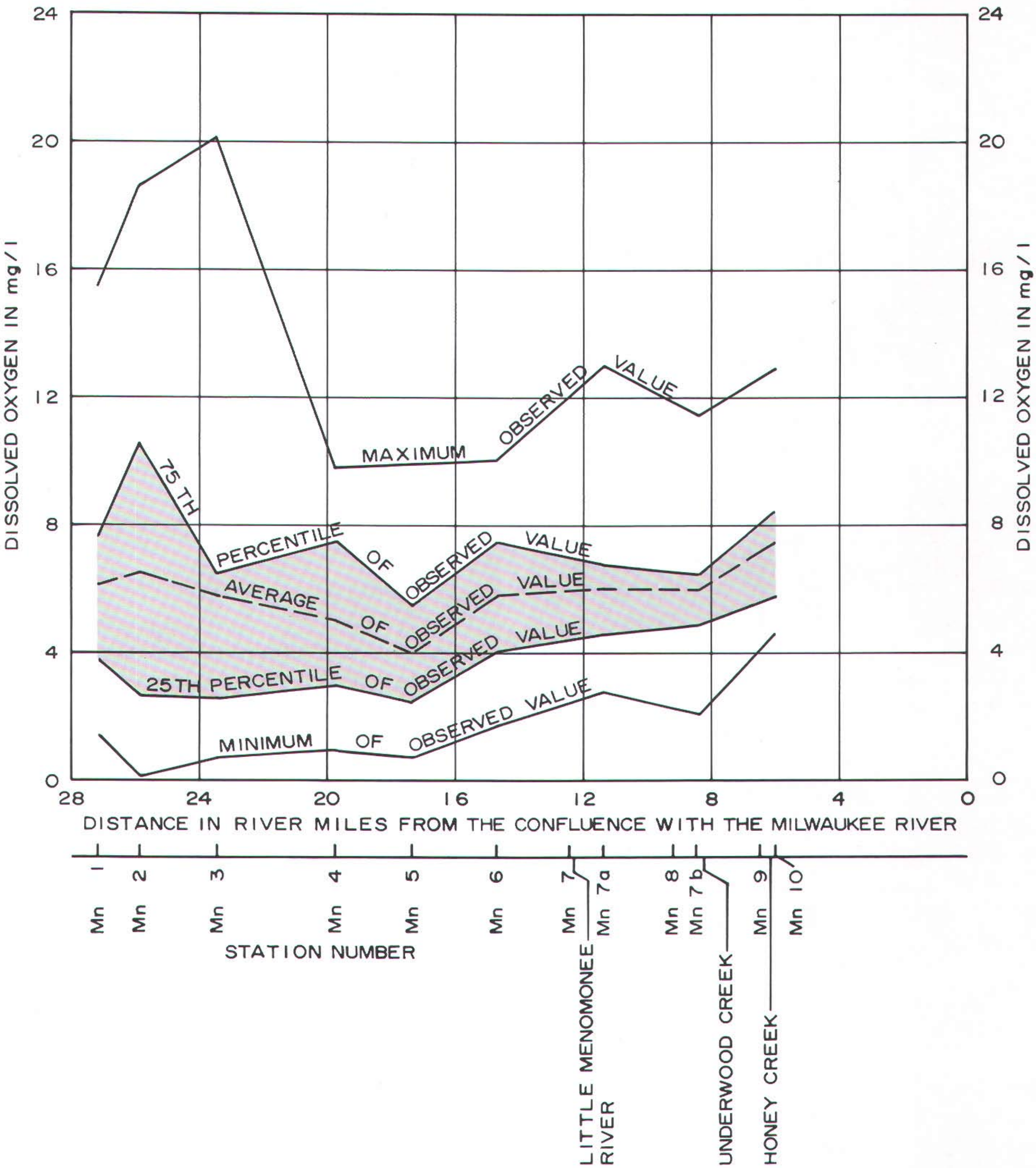
DIURNAL VARIATIONS IN HYDROGEN ION (pH) CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1972



Source: SEWRPC.

Figure 82

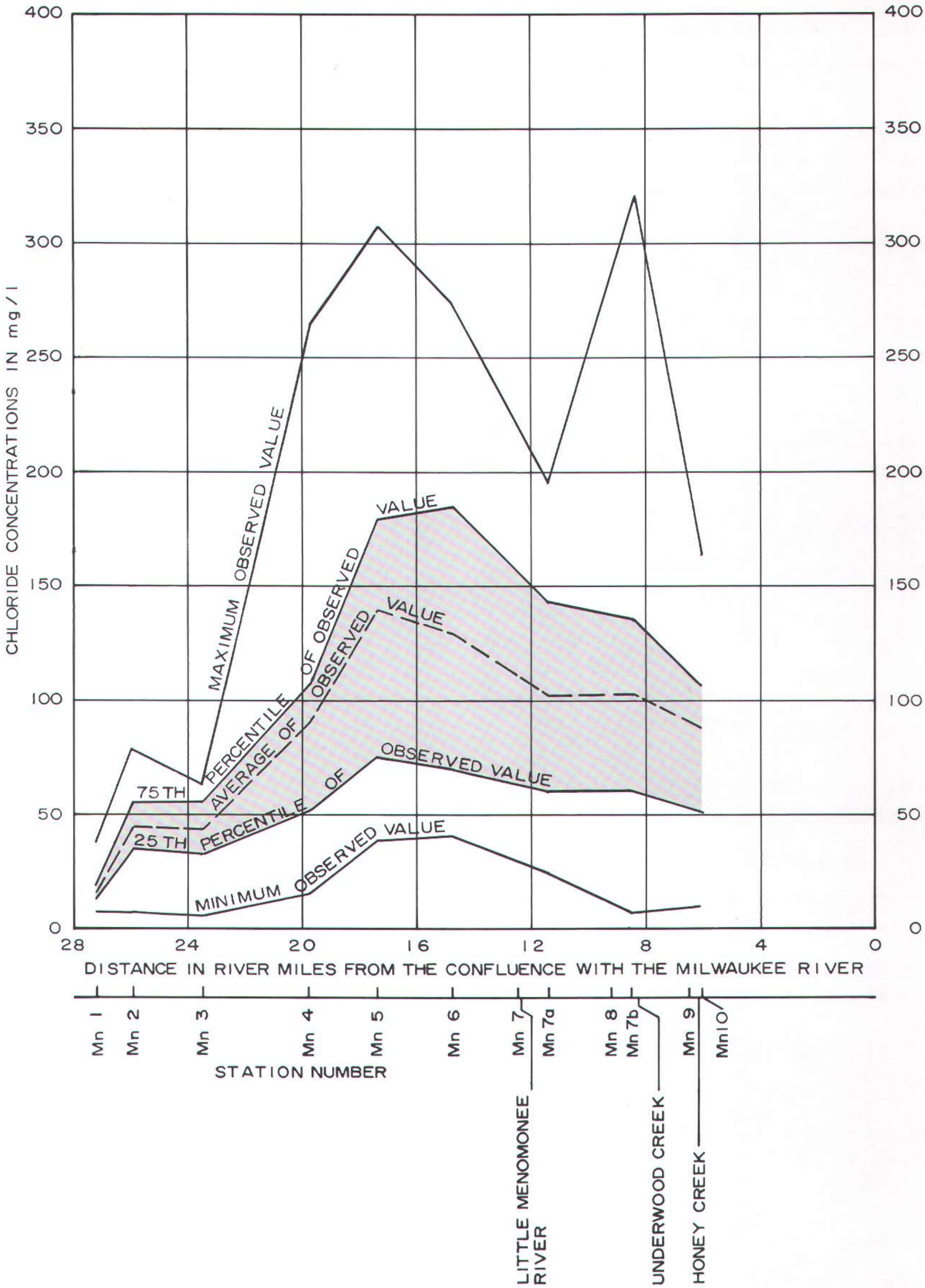
SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 83

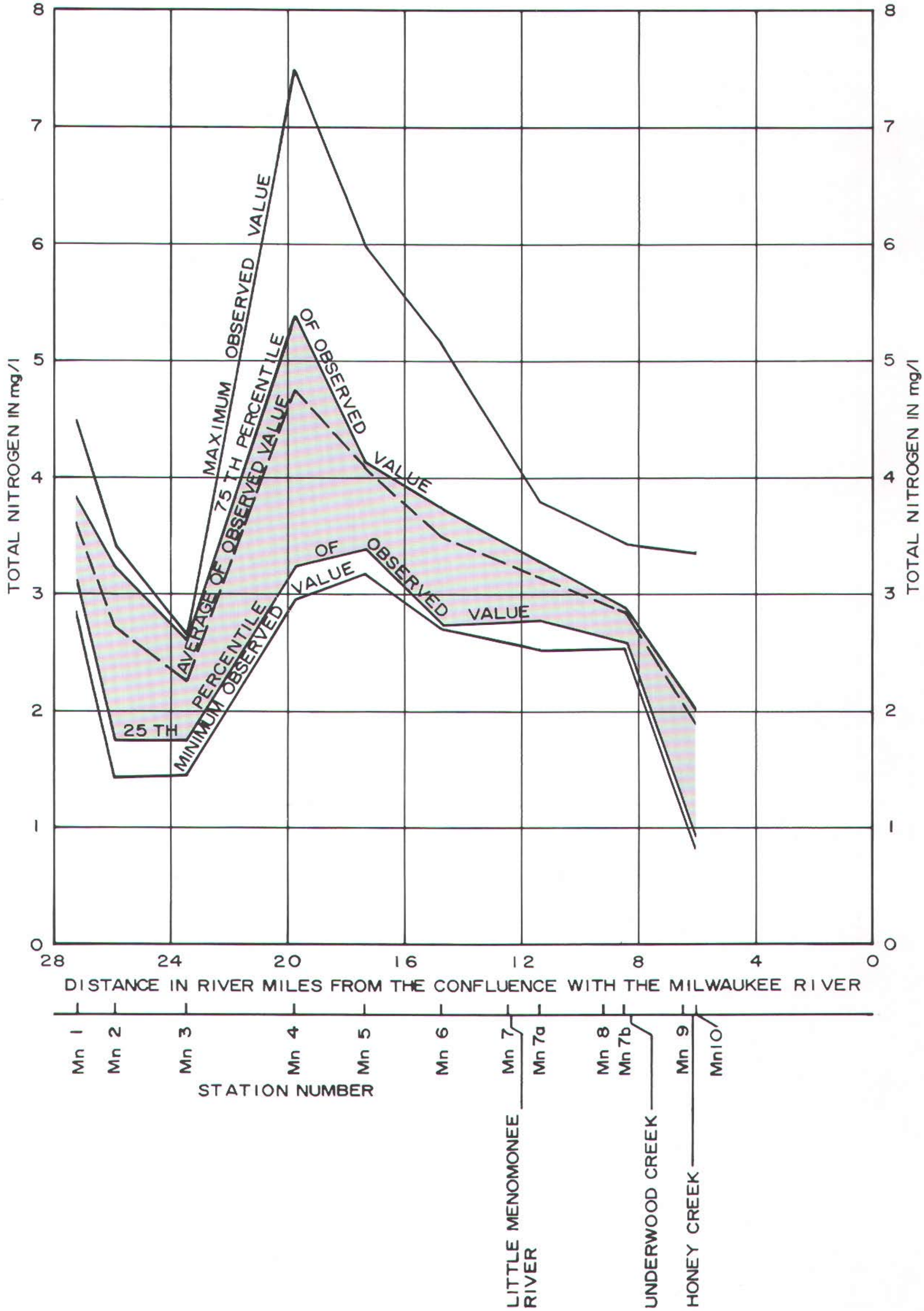
SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 84

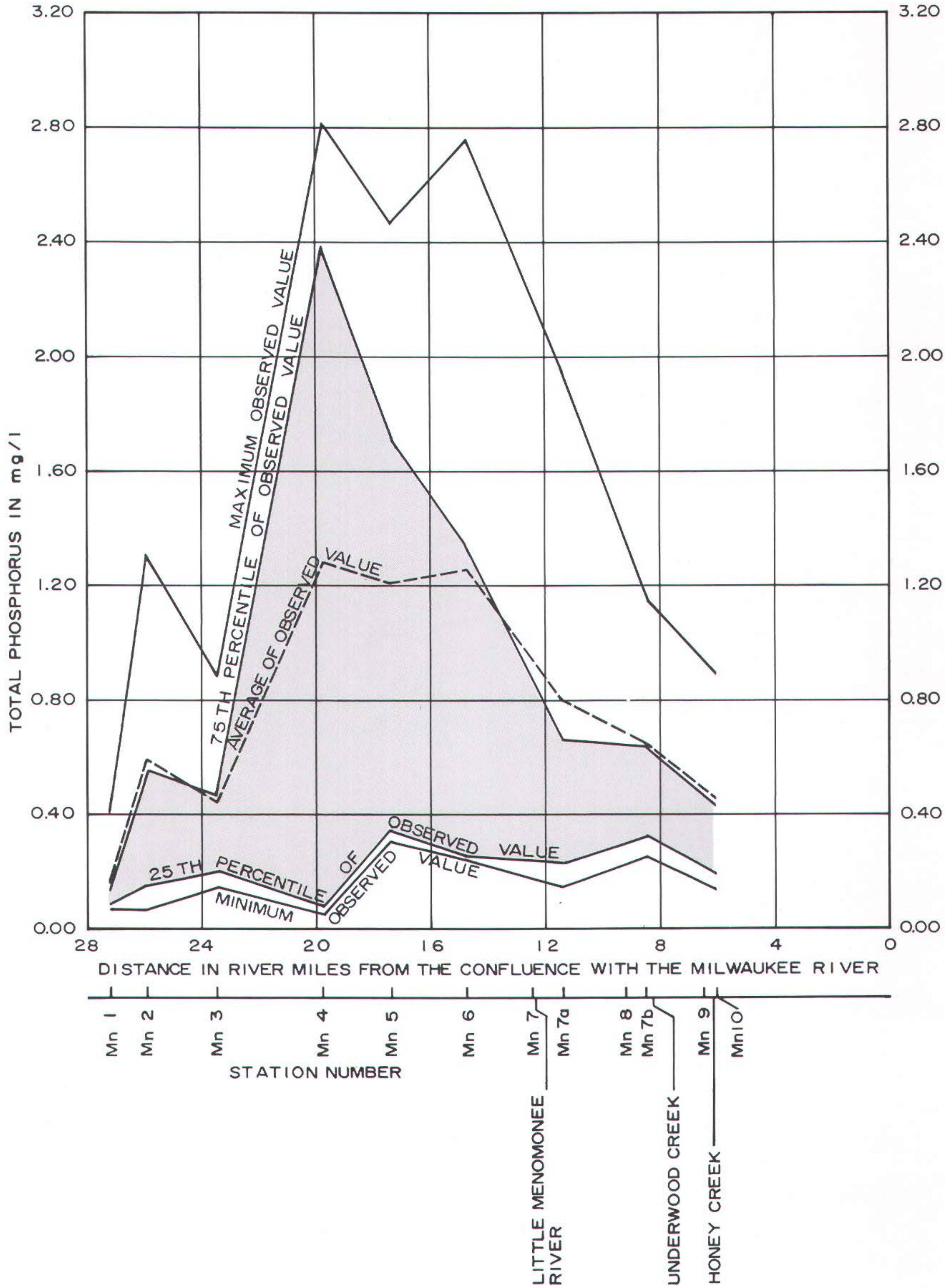
SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 85

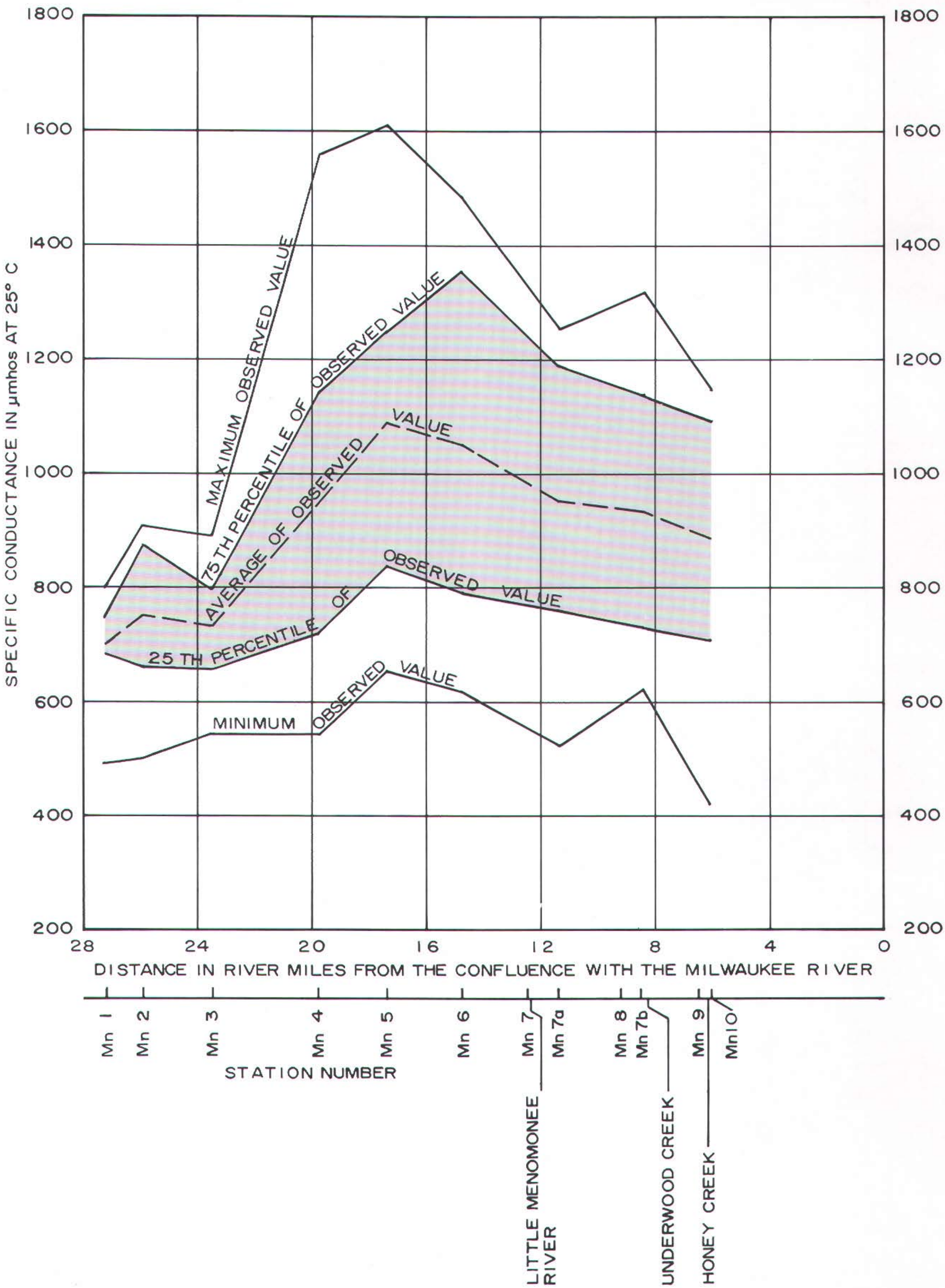
SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE MENOMONEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 86

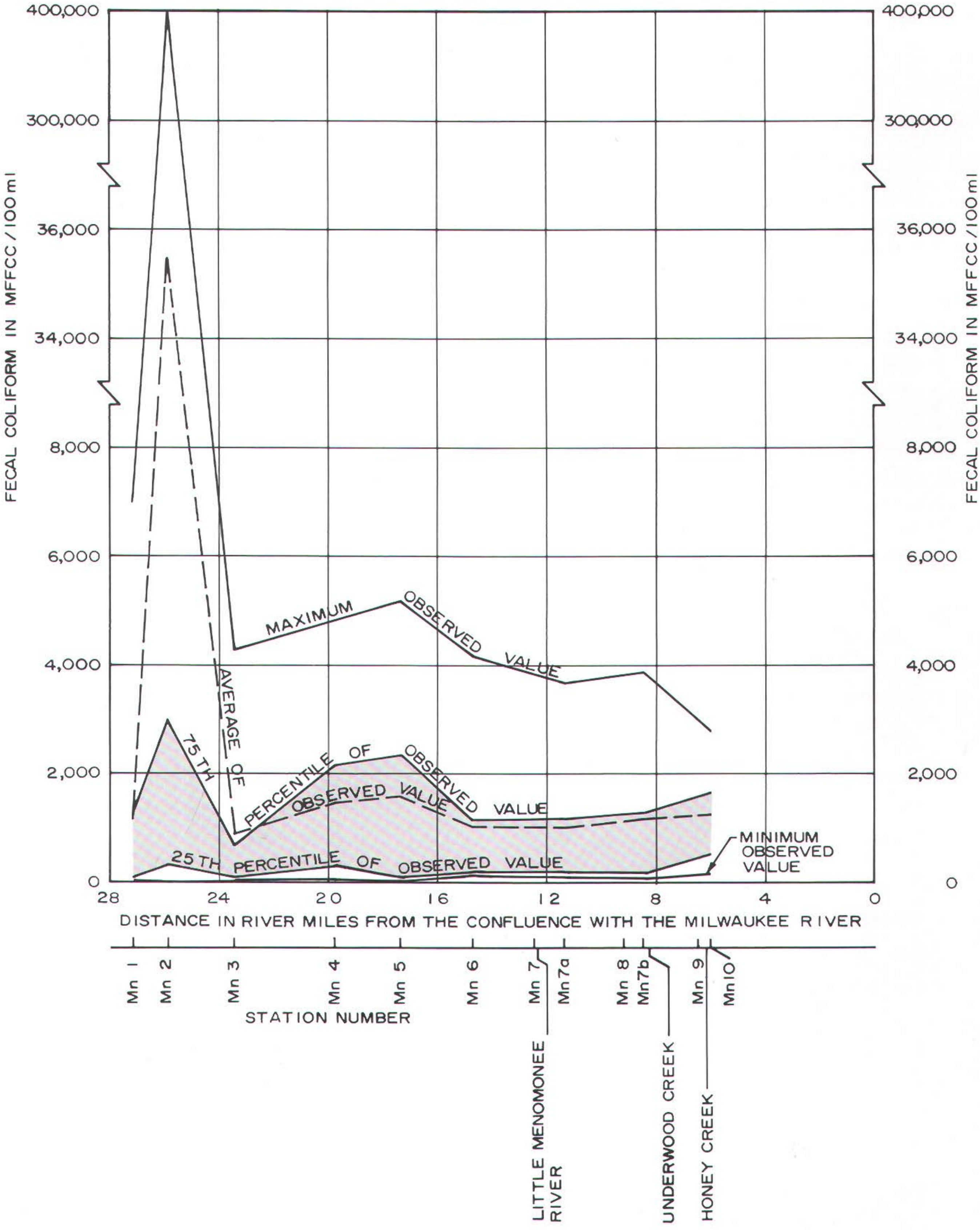
SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE MENOMONEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 87

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE MENOMONEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

chloride and dissolved oxygen concentrations, especially at locations downstream from sewage treatment effluents such as at sampling stations Mn-2, Mn-4, and Mn-5, indicated the adverse effect of the waste effluents on the water quality of the Menomonee River main stem. As shown in Figures 84 to 86, total nitrogen, total phosphorus, and the specific conductance levels followed the same pattern as that of chlorides, with an increase from sampling station Mn-1 to sampling station Mn-5 and a decrease from sampling stations Mn-6 through Mn-10 on the Menomonee River main stem.

The average fecal coliform counts and the fecal coliform counts of 65 percent of the samples collected over the eight-year period at each location on the Menomonee River main stem were greater than 500 MFFCC/100 ml, as shown in Figure 87. Counts of fecal coliform, the indicator of bacteriological pollution, were higher at sampling station Mn-2 than at any other sampling station, although all stations recorded abnormally high averages of fecal coliform bacteria. This can be attributed to the high potential for diffuse source pollution resulting from runoff from barnyard operations, malfunctioning onsite septic disposal systems and fecal coliform loadings of the Village of Germantown (Old Village plant) sewage treatment facility. Sampling station Mn-3 consistently demonstrates lower fecal coliform levels than any other station on the Menomonee River main stem, which may be attributed to the three-mile distance of sampling station Mn-3 from the nearest sewage treatment facility, allowing for natural reaeration of that reach of stream and thereby assimilating some of the fecal coliform bacteria which are present.

Assessment of Water Quality Relative to Water Quality Standards: The data obtained from the summer low flow samples were used to assess the water quality of the Menomonee River stream network on the days sampled between 1964 and 1975 and to provide a comparison with the water quality standards that support the recreational as well as fish and aquatic life use objectives established for the Menomonee River watershed stream system and the restricted use standards as set forth for Underwood Creek, Honey Creek, and the Lower Menomonee River. Comparative analysis must consider the hydrologic conditions during the sampling events since the water quality standards are not intended to be met under the seven-day average, one in 10-year low flow condition.

The comparative analysis of observed water quality and the standards were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels which have been adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml, in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standard for the recreational use objective was assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 32. The color colding scheme used on Map 32 indicates which of the standards were exceeded and along what stream reaches.

On the Menomonee River and its tributaries designated for recreational use and preservation of fish and aquatic life, all sampling stations satisfied the temperature and pH criteria. Substandard dissolved oxygen levels were found at four locations on the main stem of the Menomonee River with the other five sampling stations in compliance with the applicable minimum standard. The dissolved oxygen levels in both Underwood Creek and Honey Creek met the 2.0 mg/l restricted use standard; however, the dissolved oxygen level on Little Menomonee River did not meet the 5.0 mg/l minimum standard. Since no fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made in 1964 samples, no comparisons can be made for the nutrient content or bacteriological safety of the Menomonee River, Little Menomonee River, Underwood Creek, or Honey Creek for 1964. However, since total coliform counts in the Menomonee River were very high, in the range of 100 to 1,100,000 MFCC/100 ml and with an average of 51,058 MFCC/100 ml, the fecal coliform counts on the tributaries probably were above the maximum allowable level of 400 MFFCC/100 ml.

Water Quality-1975: On the Menomonee River and its tributaries intended for recreational use and preservation of fish and aquatic life, the water quality conditions observed during the 1975 sampling satisfied the ammonia, temperature and pH standards throughout the watershed, while substandard levels of dissolved oxygen and fecal coliform were observed during 1975. Nitrate and total phosphorus concentrations were above the levels recommended by the Commission. Substandard dissolved oxygen concentrations of less than 5.0 mg/l were observed at sampling station Mn-1 in the headwaters of the Menomonee River watershed as shown on Map 33. In addition, the fecal coliform standard of 400 MFFCC/100 ml was exceeded at sampling station Mn-1 through sampling station Mn-7b with readings at stations Mn-4 through Mn-7a in excess of 2,000 MFFCC/100 ml. Sampling station Mn-7b reflected a slightly lower level of 1,300 MFFCC/100 ml which is still above the standard set for that stream reach. In addition, both Underwood Creek and Honey Creek exceeded the standards for fecal coliform counts. Levels of total phosphorus were in excess of the recreational use and preservation of fish and aquatic life use objective of 0.10 mg/l as P throughout the entire length of the Menomonee River and its tributaries. Total phosphorus levels in excess of 0.10 mg/l on the Menomonee River may be traced in part to the discharge of this nutrient from the three existing municipal sewage treatment plants. Nitrate nitrogen levels in excess of 0.30 mg/l as N were noted over the entire length of the Menomonee River and its three major tributaries. The high nitrate nitrogen content of the Menomonee River main stem can also be traced to the discharge of this nutrient from the three municipal sewage treatment plants within the watershed. In 1975, samples of the ammonia nitrogen did not exceed the known toxic level of 2.50 mg/l ammonia nitrogen as N which serves as indicators of pollution of recent origin.

Concluding Remarks—Menomonee River Watershed

The Menomonee River watershed is located in the east central portion of the Region. The Menomonee River originates in southeastern Washington County and flows approximately 28 miles through the northeastern corner of Waukesha County and through western and central Milwaukee County to its confluence with the Milwaukee River. The Menomonee River watershed ranks second in population and fifth in size among the 12 watersheds of the Region. In 1975 an estimated 336,824 persons lived in this watershed which then had a total area of 135.94 square miles and an average population density of 2,454 people per square mile.

There are three publicly owned sewage treatment plants located within the watershed; all of them discharge treated effluent to the main stem of the Menomonee River. Currently, there are no private sewage treatment facilities in operation within the watershed. In addition to the three public sewage treatment facilities, there are 166 known combined and separate sewerage system flow relief devices in operation within the watershed that intermittently discharge raw sewage into the streams during time of sewer surcharge. Included in this total is the Village of Butler chlorination facility which discharges through a sewer system bypass. There was, however, one industry which operated a small industrial treatment facility discharging electroplating wastes through March 1975 prior to connecting to the sanitary sewer. A total of 79 industrial and commercial waste water discharge points from 49 industries is known to exist in the watershed. Of the wastewater discharge points, 41 discharge cooling waters, 15 process wastewaters, 16 coding and process wastewaters, five swimming pool overflow, and two discharge surface runoff. The Commission 1970 land use inventory indicates that 53 percent of the watershed is devoted to urban land use, 44 percent is devoted to rural land use, and the remaining 3 percent is occupied by streams, lakes, rivers, and canals within the watershed. Approximately 72 percent of the shoreland within 1,000 feet of the Menomonee River and its tributaries is used for urban purposes. Runoff from this urban area may be expected to have a significant effect on stream water quality.

The 1964-1965 benchmark stream water quality study of the Commission included 12 sampling stations in the watershed, nine on the Menomonee River main stem and one each on the Little Menomonee River, Underwood Creek, and Honey Creek. The water quality data for 1964-1965 from the nine Menomonee River main stem sampling stations indicated that the chloride levels were higher than the normal background concentration and reflected a chloride impact upon the stream from human sources as a result of sewage treatment facilities and malfunctioning domestic onsite sewage disposal systems in the upstream areas of the main stem and from road de-icing activities in the downstream urban areas of the watershed. Higher levels of chloride concentrations also were found on the three major tributaries of the Menomonee River, probably due to malfunctioning private onsite sewage disposal systems, animal barnyards, and road salting operations. Substandard concentrations of dissolved oxygen were recorded at four of the nine main stem stations on the Menomonee River during the August sampling period of 1964. High total coliform counts were found at five of the nine Menomonee River sampling stations. Drainage from agricultural land and wastes from malfunctioning private onsite sewage disposal systems are some of the probable sources for this indicated contamination. The specific conductance values on the Menomonee River were found to be within the normal range of expected values, considering the high level of dissolved solids which exists in the stream system. As a result of spring runoff from snow melting and rainfall events, elevated levels of specific conductance typically were found at the midstream and downstream sampling stations.

The 1965-1975 water quality monitoring effort by the Commission included continued sampling at the 12 sampling stations established in the watershed. The observed dissolved oxygen levels indicate that water quality at upstream sampling stations Mn-1 through Mn-5 has improved since 1964. Water quality conditions have deteriorated, however, at downstream sampling stations Mn-6 through Mn-10. Review of the chloride and fecal coliform data indicated essentially no change in the chloride levels over the past eight years of sampling with generally increased fecal coliform counts throughout the main stem of the Menomonee River since 1968. As measured by nitrate nitrogen and total phosphorus, the nutrient concentrations remained in excess of the recommended levels of 0.3 mg/l as N and 0.10 mg/l as P in 76 percent of the nitrate nitrogen samples and 92 percent of the total phosphorus samples. The water quality of the Little Menomonee River remained equal to or better than the water quality of the main stem as measured by dissolved oxygen, chloride, nitrate nitrogen, and total phosphorus. However, fecal coliform levels on the Little Menomonee River, Honey Creek, and Underwood Creek increased in total counts as compared to the Menomonee River main stem. This may be attributed to the agriculture-related operations located in the headwaters of the major tributaries. When evaluating the range of improvement, no change, or deterioration on the three major tributary streams, the parameters of dissolved oxygen, fecal coliform, chloride, total phosphorus, and nitrate nitrogen yield a net assessment of essentially no change over the past decade.

The diurnal water quality data for the Menomonee River and its three major tributaries show a broad range of dissolved oxygen concentrations from a low of 0.6 to a high of 10.7 mg/l over a 24-hour period and reflect the dissolved oxygen reductions due to respiration by the aquatic plants, decomposition of organic matter in the stream, and the dissolved oxygen supersaturation effects of algal photosynthesis. In addition to exhibiting marked diurnal fluctuations, water quality in the Menomonee River watershed exhibits spatial variation. The water quality of the Menomonee River downstream near 76th Street generally was better than the water quality in the headwater areas of the Menomonee River.

Although generally constant over the past decade, the water quality of the Upper Menomonee River and the Little Menomonee River which are intended for recreational use and the preservation of fish and aquatic life does not currently meet the water quality standards set by the Wisconsin Department of Natural Resources for fecal coliform counts and dissolved oxygen concentrations. In addition, plant nutrients, total phosphorus, and nitrate nitrogen concentrations were found to be significantly higher than the recommended levels adopted by the Commission. When assessing the lower Menomonee River, Underwood Creek, and Honey Creek industrial use standards, violations of fecal coliform counts persist, as well as levels well above the recommended levels for total phosphorus and nitrate nitrogen.

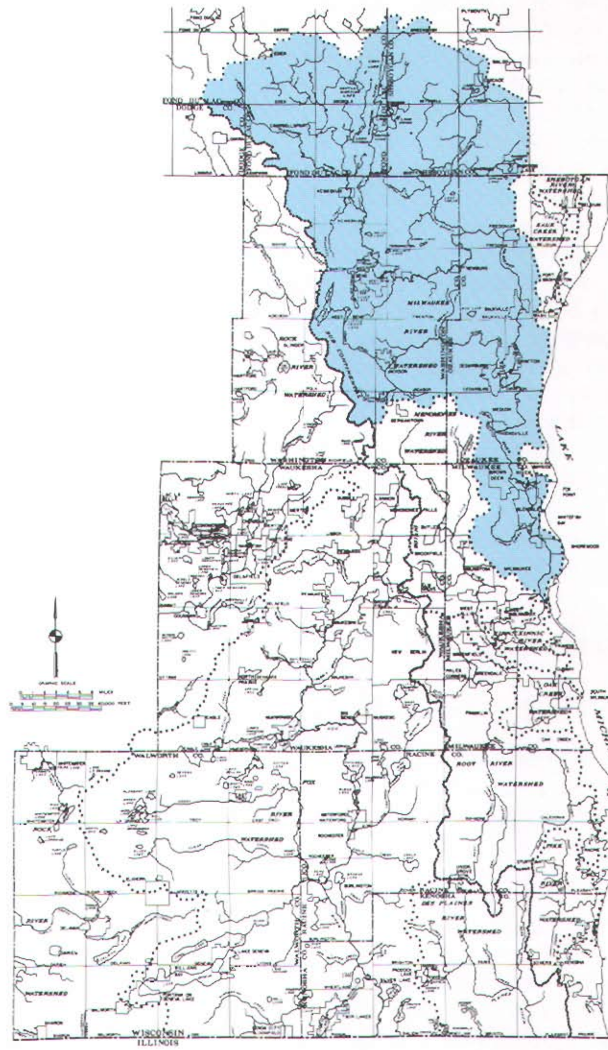
MILWAUKEE RIVER WATERSHED

Regional Setting

The Milwaukee River watershed is a natural surface water drainage unit 693.8 square miles in areal extent. Of this total, approximately 62 percent, or 433.00 square miles, lies within the seven-county Southeastern Wisconsin Region. The remaining 38 percent, consisting of the headwater portions of the watershed, lies adjacent to the Region in adjoining Dodge, Fond du Lac, and Sheboygan Counties. The boundaries of the basin, together with the locations of the main channels of the Milwaukee River and its major tributaries, are shown on Map 34. The watershed lies north of the City of Milwaukee and directly in the path of the major Milwaukee to Green Bay transportation routes. The southeastern portion of the watershed lies within the Milwaukee urbanized area while the remainder of the watershed is composed of agricultural land uses and smaller cities and villages of low- to medium-density urban development scattered throughout the watershed.

Map 34

LOCATION OF THE MILWAUKEE RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Milwaukee River watershed is a natural surface water drainage basin about 693 square miles in extent, of which about 62 percent, or 433 square miles, is located within the jurisdiction of the seven-county Southeastern Wisconsin Planning Region. The remaining 38 percent, or about 264 square miles, is located in Dodge, Fond du Lac, and Sheboygan Counties. The watershed ranks largest in resident population and third largest in size of the 12 major watersheds of the Region.

Source: SEWRPC.

The Milwaukee River watershed lies within the Lake Michigan drainage basin. It is bounded on the northwest by the subcontinental divide which separates surface waters flowing west and south through the Mississippi River to the Gulf of Mexico, from those flowing north and east through Lake Michigan and the St. Lawrence River to the Atlantic Ocean. The watershed is further bounded by the Sauk Creek watershed on the northeast and the Menomonee River watershed on the south and southwest. The Milwaukee River system, which drains the watershed consists of the West Branch of the Milwaukee River, the East Branch of the Milwaukee River, Crooked Lake Creek, Silver Creek (West Bend Township), the North Branch of the Milwaukee River, Silver Creek (Sherman Township), Cedar Creek, Lincoln Creek and the Milwaukee River main stem which discharges to Lake Michigan via the harbor in the City of Milwaukee. Table 92 lists each stream reach, the location of the source, and the length of each stream reach in miles for the Milwaukee River watershed. The watershed ranks first in population and third in size of the other 12 watersheds of the Region.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries is a rectilinear pattern of local political boundaries, as shown on Map 34. The watershed occupies portions of three of the seven counties comprising the Southeastern Wisconsin Region: Milwaukee, Ozaukee, and Washington; parts of three counties outside of the Southeastern Wisconsin Region: Dodge, Fond du Lac, and Sheboygan; and portions or all of the five cities, 18 villages, and 28 towns. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 93.

Table 92

STREAMS IN THE MILWAUKEE RIVER WATERSHED

Stream or Watercourse	Source: By Civil Division	Source: By U. S. Public Land Survey System	Length[a] (in miles)
Batavia Creek	Town of Scott	SW ¼, Section 14, T13N, R20E	5.0
Cedar Creek	Town of West Bend	SW ¼, Section 17, T11N, R19E	31.5
Cedarburg Creek	Town of Jackson	NE ¼, Section 24, T10N, R20E	3.0
Chambers Creek	Town of Mitchell	SW ¼, Section 25, T14N, R20E	2.9
East Branch Milwaukee River	Town of Mitchell	NE ¼, Section 17, T14N, R20E	14.3
Engmon Creek	City of West Bend	SE ¼, Section 15, T11N, R19E	1.5
Evergreen Creek	Town of Jackson	NE ¼, Section 6, T10N, R19E	4.9
Gooseville Creek	Town of Sherman	NW ¼, Section 16, T13N, R21E	1.8
Indian Creek	Village of River Hills	NE ¼, Section 8, T8N, R22E	1.9
Kewaskum Creek	Town of Barton	SE ¼, Section 5, T11N, R19E	6.4
Kressin Brook	Town of Germantown	NW ¼, Section 2, T9N, R20E	4.7
Lake Fifteen Creek	Town of Osceola	NE ¼, Section 26, T14N, R19E	7.4
Lincoln Creek	City of Glendale	NE ¼, Section 23, T8N, R21E	7.1
Little Cedar Creek	Town of Richfield	NE ¼, Section 2, T9N, R19E	6.0
Melius Creek	Town of Scott	SW ¼, Section 11, T13N, R20E	3.3
Milwaukee River	Town of Osceola	NE ¼, Section 7, T14N, R19E	101.0
Mink Creek	Town of Mitchell	NW ¼, Section 26, T14N, R20E	17.3
Myra Creek	Town of Trenton	NE ¼, Section 27, T11N, R20E	2.6
Nichols Creek	Town of Mitchell	SE ¼, Section 12, T14N, R20E	3.3
North Branch Cedar Creek	Town of Saukville	NW ¼, Section 19, T11N, R21E	7.3
North Branch Milwaukee River	Town of Mitchell	SE ¼, Section 12, T14N, R20E	30.0
Pigeon Creek	City of Mequon	SE ¼, Section 10, T9N, R21E	2.4
Quas Creek	Town of West Bend	SE ¼, Section 34, T11N, R19E	5.9
Silver Creek	Town of Sherman	NW ¼, Section 24, T13N, R21E	7.1
Silver Creek	Town of West Bend	NW ¼, Section 34, T11N, R19E	4.0
Stony Creek	Town of Scott	NW ¼, Section 31, T13N, R20E	10.0
Virgin Creek	Town of Osceola	SE ¼, Section 33, T14N, R19E	4.5
Wallace Creek	Town of Farmington	SW ¼, Section 33, T12N, R20E	8.6
Watercress Creek	Town of Greenbush	SW ¼, Section 33, T15N, R20E	6.5
West Branch Milwaukee River	Town of Byron	SW ¼, Section 24, T14N, R17E	20.1

[a] *Total perennial stream length as shown on U. S. Geological Survey quadrangle maps.*

Source: SEWRPC.

Table 93

AREAL EXTENT OF CIVIL DIVISIONS IN THE MILWAUKEE RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
MILWAUKEE COUNTY			
Cities			
Glendale	5.93	1.37	99.33
Milwaukee	38.69	8.94	40.04
Villages			
Bayside	0.35	0.08	15.15
Brown Deer	4.35	1.00	100.00
Fox Point	1.56	0.36	54.17
River Hills	4.21	0.97	79.43
Shorewood	1.58	0.36	92.94
Whitefish Bay	0.73	0.17	34.27
County Subtotal	57.40	13.25	23.65
OZAUKEE COUNTY			
Cities			
Cedarburg	2.84	0.66	100.00
Mequon	31.28	7.22	66.51
Villages			
Fredonia	1.18	0.27	89.39
Grafton	2.25	0.52	100.00
Newburg	0.07	0.02	100.00
Saukville	2.06	0.48	100.00
Thiensville	1.03	0.24	100.00
Towns			
Cedarburg	27.13	6.27	100.00
Fredonia	27.96	6.46	80.04
Grafton	17.96	4.15	82.54
Port Washington	2.46	0.57	12.73
Saukville	34.40	7.94	99.97
County Subtotal	150.62	34.79	64.10
WASHINGTON COUNTY			
City			
West Bend	7.51	1.73	100.00
Villages			
Germantown	5.09	1.18	14.75
Jackson	1.42	0.33	100.00
Kewaskum	1.24	0.29	100.00
Newburg	0.68	0.16	100.00
Towns			
Addison	0.12	0.03	0.33
Barton	19.54	4.51	93.67
Farmington	36.72	8.48	100.00
Germantown	0.94	0.22	55.62
Jackson	35.04	8.09	100.00
Kewaskum	23.10	5.33	100.00
Polk	24.39	5.63	71.02
Richfield	5.66	1.31	15.67
Trenton	34.66	8.00	100.00
Wayne	9.25	2.14	25.70
West Bend	19.62	4.53	95.33
County Subtotal	224.98	51.96	51.64
Total	433.00	100.00	--

Source: SEWRPC.

Population

Population Size: The 1975 resident population of the watershed within the Region is estimated at 483,193 persons, or about 27 percent of the total estimated residential population of the Region as indicated in Table 94. The population of the watershed has increased steadily since 1900. Since 1960, however, the rate of population increase within the Region has exceeded the rate of increase within the watershed.

Population Distribution: The Milwaukee River watershed, like much of the Southeastern Wisconsin Region, is becoming increasingly urban, particularly in the southeastern portions of the watershed. In 1975 approximately 94 percent of the residents of the watershed lived in incorporated cities and villages, the combined areas of which comprised approximately 15 percent of the total area of the watershed. Intensive urban development is concentrated in the lower reaches of the Milwaukee River within Milwaukee County and the River discharges to Lake Michigan through the central business district of Milwaukee. The middle reaches of the watershed are occupied by unused rural and suburban development while the upper reaches of the watershed are still predominantly rural.

Quantity of Surface Water

Surface water in the Milwaukee River watershed is made up almost entirely of streamflow and lake storage. A few minor ponds, wetlands, and flooded gravel pits comprise the balance, but are negligible in terms of the total surface water quantity. The quantity of streamflow varies widely from season to season and from year to year responding to variations in precipitation, temperature, soil moisture conditions, agricultural operations, the growth cycle of vegetation, and groundwater levels. Streamflow measurements have been made at six locations in the Milwaukee River watershed under the cooperative streamflow gaging program of the Commission.

Streamflow characteristics for the years 1964-1975 for the main stem of the Milwaukee River at Kewaskum, Waubeka, and Milwaukee; the East Branch of the Milwaukee River at New Fane; the North Branch of the Milwaukee River at Fillmore; and Cedar Creek near Cedarburg are summarized in Table 95. High streamflows occur principally in the late winter and early spring, usually associated with melting snow. Lower flows persist for most of the remainder of the year with occasional rises caused by rainfall. The streamflow on the main stem of the Milwaukee River at Kewaskum has remained higher than 1.1 cfs and at Waubeka has remained higher than 20.0 cfs over the past six years and at Milwaukee has remained higher than 5.0 cfs for the past 11 years. In addition, streamflows recorded for the last six years on the East Branch of the Milwaukee River at New Fane and the North Branch of the Milwaukee River at Fillmore and for the last eight years on Cedar Creek near Cedarburg have remained higher than 0.8 cfs, 3.2 cfs, and 2.7 cfs, respectively. Over the period of record, the daily mean flow of the Milwaukee River at Kewaskum has ranged from 22.9 cfs to 176.0 cfs; on the Milwaukee River at Waubeka from 110.0 cfs to 488.0 cfs; on the Milwaukee River at Milwaukee from 204.0 cfs to 833.0 cfs; on the East Branch of the Milwaukee River at New Fane from 12.2 cfs to 46.1 cfs; on the North Branch of the Milwaukee River at Fillmore from 39.5 cfs to 145.0 cfs; and on Cedar Creek near Cedarburg from 32.1 cfs to 161 cfs. The range in mean flows at the six continuous stage recorder gages indicate the effects of variation in rainfall and runoff on the flow of the Milwaukee River and its tributaries.

There are 21 major lakes in the watershed which have a combined surface water area of 3,439 acres and a total shoreline length of 59 miles. There are 50 minor lakes in the watershed with a combined surface area of 732 acres and a total shoreline length of 41 miles. Of the 21 major lakes located in the Milwaukee River watershed, Big Cedar Lake in Washington County is the largest and deepest with a total area of 932 acres and a maximum depth of 105 feet. The second largest lake in the watershed is Long Lake which is located in Fond du Lac County and has a total area of 427 acres. Little Cedar Lake, also in Washington County, is the second deepest lake in the watershed with a maximum depth of 56 feet. The other major lakes in the watershed with a maximum depth of 30 feet or more include Forest Lake, Kettle Moraine Lake, and Long Lake in Fond du Lac County; Crooked Lake and Lake Ellen in Sheboygan County; and Green Lake, Silver Lake, and Wallace Lake in Washington County. The lakes are mostly of glacial origin, being natural simple or compound depressions in gravelly outwash moraine, or ground moraine, sometimes augmented by a low-head dam at the outlet. By virtue of their origin, these lakes are fairly regular in shape, with their deepest points predictably near the center of the basin or near the center of each of several connected basins. The beaches are characteristically gravel or sand on the wind-swept north, east, and south shores, while fine sediments and encroaching vegetation are common on the protected west shores and in the bays. The 21 major lakes within the Milwaukee River watershed include six headwater lakes, 10 flow-through lakes, and five kettle lakes.

The total quantity of surface water that is held in major lakes in the watershed is approximately 58, 181 acre feet. The lake levels fluctuate from time to time, responding primarily to variations in precipitation, surface runoff, temperature, and groundwater levels. High lake levels occur principally in the late winter and spring, usually associated with melting snow. The location by civil division and by the U. S. Public Land Survey system as well as the physical characteristics of the major lakes in the Milwaukee River watershed, are listed in Table 96.

Pollution Sources

The following types of pollution sources have been identified in the watershed and are discussed below: municipal sewage treatment facilities, sanitary and combined sewerage system flow relief devices, industrial wastewater discharges, urban storm water runoff, and agricultural runoff.

Table 94

ESTIMATED RESIDENT POPULATION OF MILWAUKEE RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
Dodge County	
Town	
Lomira	160
Dodge County (part)	160[a]
Fond du Lac County	
Village	
Campbellsport	1,857
Towns	
Ashford (part)	1,340
Auburn	1,416
Byron (part)	250
Eden (part)	492
Forest (part)	25
Osceola (part)	1,100
Fond du Lac County (part)	6,480[a]
Milwaukee County	
Cities	
Glendale (part)	13,453
Milwaukee (part)	337,769
Villages	
Bayside (part)	1,010
Brown Deer	13,570
Fox Point (part)	6,032
River Hills (part)	1,170
Shorewood (part)	14,088
Whitefish Bay (part)	6,467
Milwaukee County (part)	393,559
Ozaukee County	
Cities	
Cedarburg	9,766
Mequon (part)	9,860
Villages	
Fredonia (part)	1,269
Grafton	7,983
Newburg (part, Ozaukee County)	82
Saukville	2,483
Thiensville	3,819
Towns	
Cedarburg	4,619
Fredonia (part)	1,713
Grafton (part)	2,889
Port Washington (part)	378
Saukville (part)	1,514
Ozaukee County (part)	46,375
Sheboygan County	
Villages	
Adell	509
Cascade	576
Random Lake	1,233
Towns	
Greenbush (part)	50
Lyndon (part)	510
Mitchell (part)	750
Scott	1,550
Sherman (part)	1,225
Sheboygan County (part)	6,403[a]
Washington County	
City	
West Bend	20,296
Villages	
Germantown (part)	222
Jackson	1,895
Kewaskum	2,329
Newburg (part, Washington County)	562
Towns	
Addison (part)	16
Barton (part)	1,556
Farmington	1,889
Germantown (part)	97
Jackson	3,178
Kewaskum	1,303
Polk (part)	2,379
Richfield (part)	1,319
Trenton	2,956
Wayne (part)	328
West Bend (part)	2,934
Washington County (part)	43,259
Milwaukee River Watershed	496,236

[a] *Indicates county population outside the SEWRPC seven-county Region. In-Region population is estimated at 483,193 persons.*

Source: *Wisconsin Department of Administration and SEWRPC.*

Sewage Treatment Facilities: Thirteen municipally owned sewage treatment plants are located in the Milwaukee River watershed. The seven plants which serve the City of West Bend and the Villages of Kewaskum, Fredonia, Grafton, Saukville, Thiensville, and Newburg discharge treated effluents to the main stem of the Milwaukee River; the two plants which serve the Villages of Adell and Cascade discharge treated effluents to tributaries of the North Branch of the Milwaukee River; the two plants which serve the City of Cedarburg and the Village of Jackson discharge treated effluents directly to Cedar Creek; the plant which serves the Village of Campbellsport

Table 95

FLOW MEASUREMENTS IN THE MILWAUKEE RIVER WATERSHED: 1963-1975

Water Year	Milwaukee River near Kewaskum				Milwaukee River near Waubeka				Milwaukee River near Milwaukee			
	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1963-1964	–	--	--	--	--	--	--	--	204	4.04	2,220	24
1964-1965	--	--	--	--	--	--	--	--	486	9.62	5,600	5
1965-1966	--	--	--	--	--	--	--	--	580	11.47	5,060	37
1966-1967	–	--	--	--	--	--	--	--	314	6.21	2,300	52
1967-1968	--	--	--	--	--	--	--	--	281	5.58	1,620	58
1968-1969	64.5	6,00	578	5.0	225	7.13	1,560	35	382	7.55	3,150	73
1969-1970	22.9	2.13	164	1.1	110	3.49	478	20	213	4.22	1,900	43
1970-1971	79.5	7.40	736	3.2	269	8.54	2,250	26	469	9.28	3,810	17
1971-1972	76.9	7.17	1,040	6.2	256	8.13	1,900	52	455	9.02	3,230	77
1972-1973	176	16.36	1,100	16	488	15.49	2,100	72	833	16.48	7,030	138
1973-1974	104	9.64	1,030	13	433	13.73	3,200	84	760	15.05	5,850	151
1974-1975	108	10.04	2,810	9.0	359	11.40	6,740	49	547	10.83	8,010	84

Water Year	East Branch near New Fane				North Branch near Fillmore				Cedar Creek near Cedarburg			
	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1963-1964	--	--	--	--	--	--	--	--	36.1	4.07	901	2.7
1964-1965	--	--	--	--	--	--	--	--	90.7	10.16	1,870	4.6
1965-1966	--	--	--	--	--	--	--	--	94.4	10.57	825	7.8
1966-1967	--	--	--	--	--	--	--	--	45.6	5.10	600	7.4
1967-1968	--	--	--	--	--	--	--	--	38.7	4.36	290	5.4
1968-1969	25.8	7.68	94	5.1	76.3	6.77	454	10	55.7	6.25	689	7.5
1969-1970	12.2	3.63	64	2.4	39.5	3.50	180	3.2	32.1	3.60	251	5.4
1970-1971	28.4	6.74	180	0.76	85.8	7.62	623	11	--	--	--	--
1971-1972	24.0	5.72	170	4.2	82.9	7.38	910	18	--	--	--	--
1972-1973	46.1	10.95	192	11	144	12.77	865	26	--	--	--	--
1973-1974	41.0	9.74	200	10	145	12.84	1,200	31	161	18.07	1,900	22
1974-1975	40.9	9.71	646	6.5	114	10.14	2,630	21	120	13.42	2,100	19

Source: U. S. Geological Survey.

discharges directly to the West Branch of the Milwaukee River; and the plant which serves the Village of Random Lake discharges directly to Silver Creek, a tributary of the North Branch of the Milwaukee River. Selected information for the municipal sewage treatment plants in the Milwaukee River watershed is set forth in Table 97 and the plant locations are shown on Map 35.[9] In addition to the publicly owned sewage treatment facilities, two nonindustrial private wastewater treatment facilities exist in the Milwaukee River watershed owned and operated

[9] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 35. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exist to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 96

MAJOR LAKES IN THE MILWAUKEE RIVER WATERSHED

Name	Location: Municipality	Location: U. S. Public Land Survey Section, Town, Range	Surface Width[a] (miles)	Surface Length[a] (miles)	Surface Area[a] (square miles)	Maximum Depth[b] (feet)	Shoreline Length (miles)	Shore Development[c] (ratio)	Public Frontage Length (miles)	Date of Sampling	County
Auburn.	Town of Auburn	15-13-19	0.27	1.00	0.167	29	2.40	0.070:1	0.852	1970	Fond du Lac
Barton Pond	Town of Barton	11, 12-11-19	0.24	1.00	0.105	5	3.0	0.035:1	0	1969	Washington
Big Cedar.	Town of Polk City of West Bend	5-10-19; 20, 29, 30, 31, 32-11-19	0.64	3.80	1.456	3.8	11.0	0.132:1	0.1	1970	Washington
Crooked	Kettle Moraine Forest	6, 7, 10-13-20	0.44	0.68	0.143	32	2.25	0.064:1	0.33	1970	Sheboygan and Fond du Lac
Ellen		29, 32-14-21	0.34	0.53	0.190	42	1.9	0.100:1	N/A	1970	Sheboygan
Forest		12-13-19	0.28	0.44	0.08	32	1.33	0.060:1	0.399	1967	Fond du Lac
Green.	Town of Farmington	33-12-20	0.27	0.71	0.111	37	1.8	0.062:1	N/A	1969	Washington
Kettle Moraine . .		27-14-19	0.64	0.87	0.355	30	1.42	0.118:1	0	1969	Fond du Lac
Little Cedar	Town of West Bend	33-11-19	0.50	1.48	0.385	56	4.35	0.089:1	0	1969	Washington
Long	Kettle Moraine State Forest Town of Saukville	13, 24-14-19	0.44	2.65	0.668	47	5.0	0.097:1	1.4	1969	Fond du Lac
Lucas.	Town of West Bend	22-11-19	0.32	0.64	0.121	15	2.39	0.051:1	0	1967	Washington
Mauthe.	Town of Auburn	11, 12-13-19	0.38	0.50	0.122	23	1.55	0.079:1	1.55	1970	Fond du Lac
Mud (Little)	Town of Saukville	32-11-21	0.70	0.95	0.383	4	1.75	0.100:1	1.47	1969	Ozaukee
Mud.	Town of Osceola	27, 28-14-19	0.24	0.46	0.086	17	1.40	0.061:1	0	1969	Fond du Lac
Random	Village of Random Lake	26, 35-13-21	0.48	1.08	0.327	21	3.6	0.091:1	N/A	1969	Sheboygan
Silver	Town of West Bend	27-11-19	0.33	0.95	0.184	47	2.74	0.067:1	0	1969	Washington
Smith.	Town of Barton	26-12-19	0.34	0.65	0.134	5	1.8	0.074:1	0.126	1970	Washington
Spring	Town of Fredonia	2, 3-12-21	0.27	0.48	0.090		1.64	0.055:1	0	1968	Ozaukee and Sheboygan
Twelve	Town of Farmington	12-12-20	0.44	0.27	0.082	20	1.3	0.063:1	0	1969	Washington
Wallace.	Town of Trenton	6-11-20	0.22	0.47	0.081	30	1.5	0.054:1	0.105	1967	Washington
West Bend Pond. .	City of West Bend	13-11-19	0.23	0.91	0.104	14	2.7	0.038:1	0.243	1969	Washington

NOTE: N/A indicates data not available.

[a] *Lake lengths, widths and areas, ussed in this comparison were taken from aerial photographs dated September and October 1956 for Kenosha County.*

[b] *Maximum depth was measured from the surface elevation existing on date sampled.*

[c] *Shore development ratio (SDR) is a convenient expression of the degree of regularity or irregularity of shoreline. Generally, the higher the ratio, the greater the biological productivity of the lake. SDR = length of shoreline of lake of given area divided by circumference of circle with same area. An SDR of 1.00 indicates a circular lake.*

Source: SEWRPC.

by the Cedar Lake Rest Home in the Town of West Bend in Washington County and Justo Foods Company in the Town of Cedarburg in Ozaukee County. Selected data on the two nonindustrial privately owned wastewater treatment facilities are presented in Table 98. Of the 13 publicly operated sewage treatment facilities, a total of seven facilities discharge effluent to the main stem of the Milwaukee River, two to tributaries of the North Branch of the Milwaukee River, two to Cedar Creek, one to Silver Creek, and one to the West Branch of the Milwaukee River.

Domestic Onsite Sewage Disposal Systems: Although certain areas of the watershed lie within existing and proposed service areas of public sanitary sewerage systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points

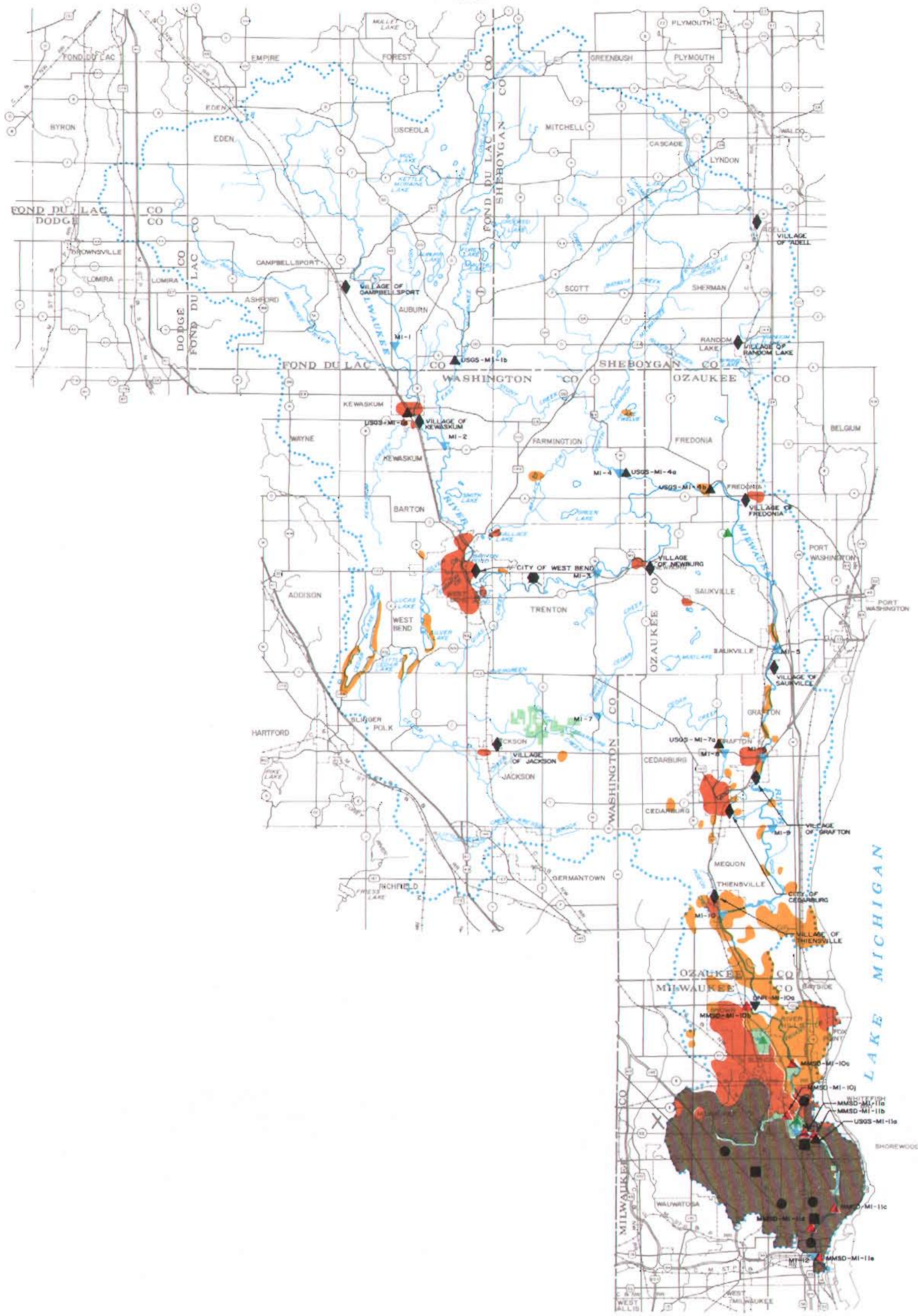
There are 188 known combined sewer outfalls and other flow relief devices in the Milwaukee River watershed as shown in Table 99 and located on Map 35. Of these flow relief devices, 61 are combined sewer outfalls, 77 are crossovers, 27 are sanitary sewerage system bypasses, seven are relief pumping stations, and 16 portable pumping stations. One hundred and nine of these flow relief devices and combined sewer outfalls discharge to the Milwaukee River main stem, four discharge to Cedar Creek, 55 discharge to Lincoln Creek, 13 discharge to Indian Creek, six discharge to Beaver Creek, and one discharges to Pigeon Creek. Map 35 presents the location of the known flow relief devices which discharge to the surface waters of the Milwaukee River watershed.

Industrial Waste Discharges: At 73 locations in the Milwaukee River watershed within the Region, industrial wastewaters consisting of cooling and process waters are discharged directly or indirectly to the surface water

Map 35

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND PRIVATE NONINDUSTRIAL SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND URBAN DEVELOPMENT IN THE MILWAUKEE RIVER WATERSHED

1964



LEGEND

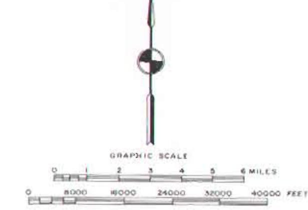
SAMPLING STATION AND DESIGNATION
- DNR DNR-MI-10a
- SEWRPC MI-2
- SEWERAGE COMMISSION OF MILWAUKEE MMSD-MI-10b

CONTINUOUS STAGE RECORDER GAGE AND DESIGNATION
- USGS USGS-MI-4a

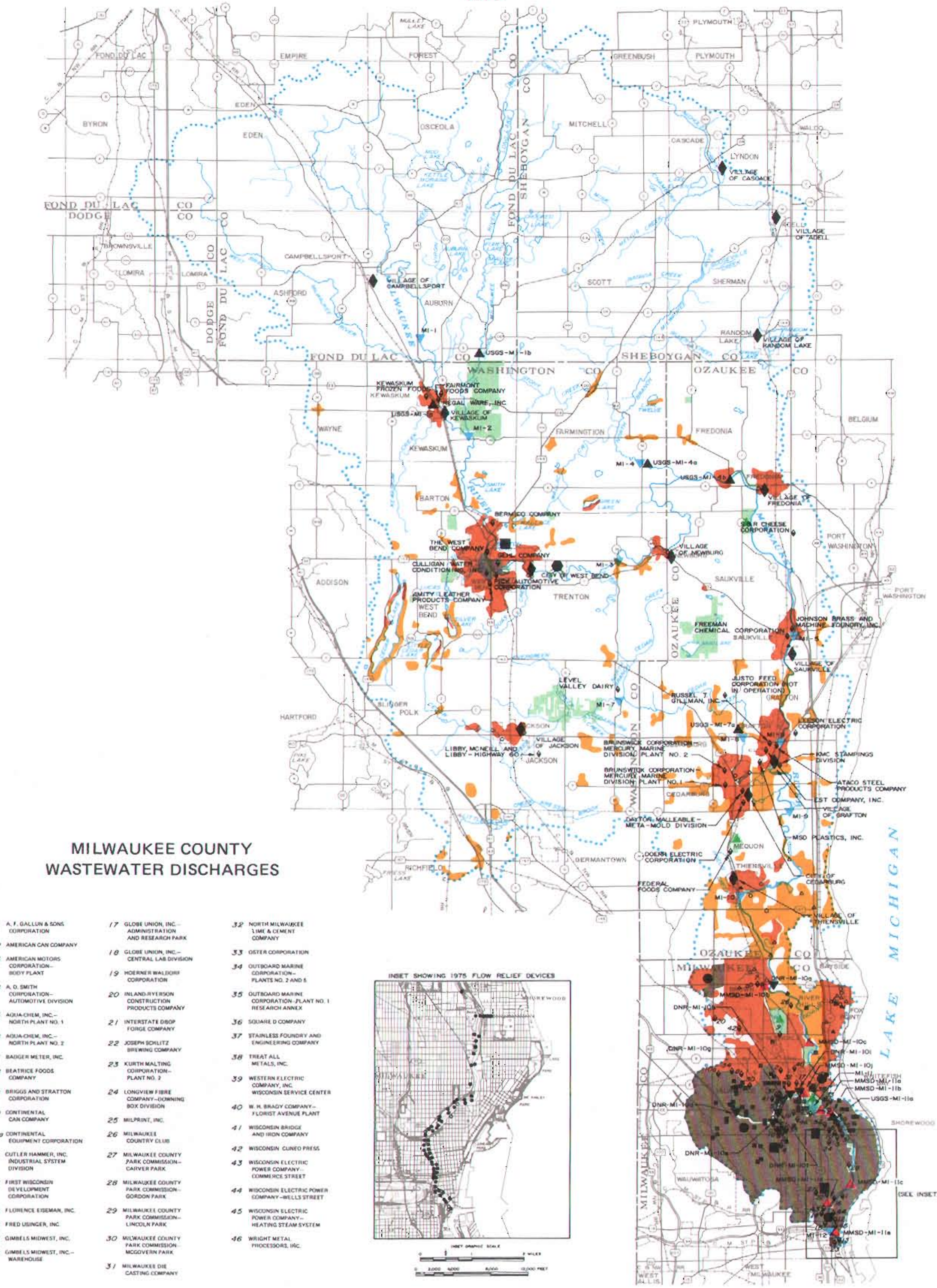
EXISTING SEWAGE TREATMENT FACILITIES
- PUBLIC
- NONINDUSTRIAL (PRIVATE)
- INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES
- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION

PRIMARY LAND USES
- SUBURBAN AND LOW DENSITY RESIDENTIAL (0.2 – 2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY RESIDENTIAL (2.3 – 6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- HIGH DENSITY RESIDENTIAL (7.0 – 17.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MAJOR RETAIL AND SERVICE CENTER
- MAJOR INDUSTRIAL CENTER
- PUBLIC AIRPORT
- MAJOR PUBLIC OUTDOOR RECREATION CENTER
- PRIMARY ENVIRONMENTAL CORRIDOR PRESERVATION THROUGH PUBLIC AQUISITION



1975



MILWAUKEE COUNTY WASTEWATER DISCHARGES

1 A. F. GALLUN & SONS CORPORATION
2 AMERICAN CAN COMPANY
3 AMERICAN MOTORS CORPORATION–BODY PLANT
4 A. O. SMITH CORPORATION–AUTOMOTIVE DIVISION
5 AQUA-CHEM, INC.–NORTH PLANT NO. 1
6 AQUA-CHEM, INC.–NORTH PLANT NO. 2
7 BADGER METER, INC.
8 BEATRICE FOODS COMPANY
9 BRIGGS AND STRATTON CORPORATION
10 CONTINENTAL CAN COMPANY
10a CONTINENTAL EQUIPMENT CORPORATION
11 CUTLER HAMMER, INC. INDUSTRIAL SYSTEM DIVISION
12 FIRST WISCONSIN DEVELOPMENT CORPORATION
13 FLORENCE EISEMAN, INC.
14 FRED USINGER, INC.
15 GIMBELS MIDWEST, INC.
16 GIMBELS MIDWEST, INC.–WAREHOUSE
17 GLOBE UNION, INC.–ADMINISTRATION AND RESEARCH PARK
18 GLOBE UNION, INC.–CENTRAL LAB DIVISION
19 HOERNER WALDORF CORPORATION
20 INLAND-RYERSON CONSTRUCTION PRODUCTS COMPANY
21 INTERSTATE DROP FORGE COMPANY
22 JOSEPH SCHLITZ BREWING COMPANY
23 KURTH MALTING CORPORATION–PLANT NO. 2
24 LONGVIEW FIBRE COMPANY–DOWNING BOX DIVISION
25 MILPRINT, INC.
26 MILWAUKEE COUNTRY CLUB
27 MILWAUKEE COUNTY PARK COMMISSION–CARVER PARK
28 MILWAUKEE COUNTY PARK COMMISSION–GORDON PARK
29 MILWAUKEE COUNTY PARK COMMISSION–LINCOLN PARK
30 MILWAUKEE COUNTY PARK COMMISSION–MCGOVERN PARK
31 MILWAUKEE DIE CASTING COMPANY
32 NORTH MILWAUKEE LIME & CEMENT COMPANY
33 OSTER CORPORATION
34 OUTBOARD MARINE CORPORATION–PLANTS NO. 2 AND 5
35 OUTBOARD MARINE CORPORATION–PLANT NO. 1 RESEARCH ANNEX
36 SQUARE D COMPANY
37 STAINLESS FOUNDRY AND ENGINEERING COMPANY
38 TREAT ALL METALS, INC.
39 WESTERN ELECTRIC COMPANY, INC. WISCONSIN SERVICE CENTER
40 W. H. BRADY COMPANY–FLORIST AVENUE PLANT
41 WISCONSIN BRIDGE AND IRON COMPANY
42 WISCONSIN CUNEO PRESS
43 WISCONSIN ELECTRIC POWER COMPANY–COMMERCE STREET
44 WISCONSIN ELECTRIC POWER COMPANY–WELLS STREET
45 WISCONSIN ELECTRIC POWER COMPANY–HEATING STEAM SYSTEM
46 WRIGHT METAL PROCESSORS, INC.

Stream water quality was obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at 27 sampling stations located in the Milwaukee River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by discharges from 13 municipal sewage treatment facilities, 61 combined sewer outfalls, 75 crossovers, 27 bypasses, seven relief pumping stations, 16 portable relief pumping stations, two private nonindustrial sewage treatment facilities, and 72 commercial or industrial facilities discharging wastewater through 121 outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6 The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treat ment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 97

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE MILWAUKEE RIVER WATERSHED: 1975

Name (in-Region)	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[a]	Design Capacity: Average Hydraulic (mgd)	Design Capacity: Peak Hydraulic (mgd)	Design Capacity: Average Organic (lbs/$CBOD_5$/day)	Design Capacity: Population[a] Equivalent	Existing Loading: Average Annual Hydraulic (mgd)	Existing Loading: Average Annual Per Capita (gpd)
City of Cedarburg	2.58	10,400	1925, 1935 1960, 1971	Trickling Filter Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced Auxiliary	Cedar Creek	20,000	3.00	6.00	5,000	23,800	1.41	136
City of West Bend	6.28	21,000	1967, 1973	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced Auxiliary	Milwaukee River	25,000	2.50	10.00	4,250	20,240	3.70	176
Village of Fredonia	0.66	1,500	1939, 1962	Activated Sludge Disinfection	Secondary Auxiliary	Milwaukee River	1,200	0.12	0.25	200	950	0.28	187
Village of Grafton	2.15	8,800	1934, 1959 1960, 1972	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced Auxiliary	Milwaukee River	9,400	1.00	2.50	1,880	8,950	0.88	100
Village of Jackson	0.43	2,000	1939	Trickling Filter Disinfection	Secondary Auxiliary	Cedar Creek	250	0.03	0.05	40	190	0.26	130
Village of Kewaskum	0.62	2,000	1955, 1972	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced Auxiliary	Milwaukee River	5,000	0.50	1.50	1,800	8,570	0.32	160
Village of Newburg	0.19	600	1964	Activated Sludge Disinfection	Secondary Auxiliary	Milwaukee River	800	0.05	0.10	136	650	0.07	117
Village of Saukville	0.43	2,300	1959	Trickling Filter Disinfection	Secondary Auxiliary	Milwaukee River	1,400	0.28	0.46	430	2,050	0.29	126
Village of Thiensville	1.16	4,200	1951, 1963	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced Auxiliary	Milwaukee River	3,000	0.24	0.36	N/A	N/A	0.57	136

Name (out-of-Region)	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[a]	Design Capacity: Average Hydraulic (mgd)	Design Capacity: Peak Hydraulic (mgd)	Design Capacity: Average Organic (lbs/$CBOD_5$/day)	Design Capacity: Population[a] Equivalent	Existing Loading: Average Annual Hydraulic (mgd)	Existing Loading: Average Annual Per Capita (gpd)
Village of Random Lake	0.43	1,200	1936	Trickling Filter Disinfection	Secondary Auxiliary	Silver Creek	N/A	0.08	0.30	N/A	N/A	0.20	167
Village of Campbellsport	0.42	1,900	1935, 1962	Activated Sludge Disinfection	Secondary Auxiliary	West Branch Milwaukee River	N/A	0.24	N/A	N/A	N/A	0.31	163
Village of Adell	0.16	500	1961	Activated Sludge Disinfection	Secondary Auxiliary	Ground Absorption North Branch Milwaukee River	N/A	0.10	0.16	N/A	N/A	N/A	N/A
Village of Cascade		600	1976	Disinfection	Secondary Auxiliary	North Branch Milwaukee River	N/A	0.17	0.60	N/A	N/A	0.04	67

NOTE: N/A indicates data not available.

[a] The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the table.

Source: SEWRPC.

system. The 73 industrial wastewater discharges are located on Map 35. The industrial wastewater enters the Milwaukee River and its major tributaries directly through drainage ditches and storm sewers.

Data and information provided by the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR 101 of the Wisconsin Administrative Code were used to determine the type and location of industrial wastewater discharges in the Milwaukee River watershed. Table 100 summarizes by receiving stream and by civil division the types of industrial wastewater discharges and the number of outfalls in the watershed within the Region and the types of treatment and average hydraulic design capacity. A total of 122 industrial and commercial discharge points is known to exist within the watershed within the Region. Of these, 13 discharge processing wastewaters, 88 cooling wastewaters, 14 process and cooling wastewaters, four swimming pool overflow, and three discharge groundwater. Forty-five of the 73 industrial locations discharge wastewater directly to the Milwaukee River main stem, 24 discharge to tributaries of the Milwuakee River, and four discharge groundwater.

Table 98

SELECTED CHARACTERISTICS OF NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES IN THE MILWAUKEE RIVER WATERSHED: 1975

Name	Civil Division Location	Type of Land Use Served	Type of Wastewater	Type of Treatment Provided	Disposal of Effluent	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Average Hydraulic Design Capacity (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
Company (not in operation)	Town of Cedarburg	Industrial	Process	Lagoon	Soil Absorption	N/A	N/A	N/A
Cedar Lake Rest Home	Town of West Bend	Institutional	Sanitary	Contact Stabilization and Lagoon	Groundwater	N/A	N/A	35,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rate was estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 99

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE MILWAUKEE RIVER WATERSHED IN THE REGION BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Crossovers	Other Flow Relief Devices			
				Bypasses	Relief Pumping Stations	Portable Pumping Stations	Total
Milwaukee River . .	City of Mequon	0	0	2	0	5	7
Beaver Creek	Village of Brown Deer	0	0	1	0	5	6
Indian Creek.	Village of Fox Point	0	1	3	2	5	11
Indian Creek.	City of Glendale	0	0	0	0	1	1
Milwaukee River . .	Village of River Hills	0	0	0	1	0	1
Lincoln Creek. . . .	City of Milwaukee	1	48	4	2	0	55
Pigeon Creek	Village of Thiensville	0	0	0	1	0	1
Milwaukee River . .	Village of Saukville	0	0	0	1	0	1
Cedar Creek	City of Cedarburg	0	0	2	0	0	2
Cedar Creek	Village of Jackson	0	0	2	0	0	2
Milwaukee River . .	City of West Bend	0	0	1	0	0	1
Milwaukee River . .	Village of Fredonia	0	0	1	0	0	1
Milwaukee River . .	Village of Newburg	0	0	1	0	0	1
Milwaukee River . .	Village of Thiensville	0	0	1	0	0	1
Milwaukee River . .	Village of Brown Deer	0	0	1	0	0	1
Milwaukee River . .	City of Glendale	0	1	1	0	0	2
Milwaukee River . .	City of Milwaukee	60	13	7	0	0	80
Milwaukee River . .	Village of Shorewood	0	8	0	0	0	8
Indian Creek.	Village of River Hills	0	1	0	0	0	1
Milwaukee River . .	Village of Whitefish Bay	0	5	0	0	0	5
Total		61	77	27	7	16	188

Source: SEWRPC.

Table 100

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE MILWAUKEE RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY								
A. F. Gallun & Sons Corporation	3111	City of Milwaukee	Cooling	None	2	Milwaukee River via Storm Sewer	2,800	3,500
			Cooling	None	3	Milwaukee River via Storm Sewer	1,500	1,800
			Cooling	None	4	Milwaukee River via Storm Sewer	1,100	1,300
American Can Company	3411	City of Milwaukee	Cooling	Settling Basin, Screening, and ph Adjustment	1	Lincoln Creek via Storm Sewer	30,000	40,000
American Motors Corporation—Body Plant	3711	City of Milwaukee	Cooling	None	1	Milwaukee River via Storm Sewer	470,400	632,100
			Cooling	None	2	Milwaukee River via Storm Sewer	20,000	37,000
			Cooling	None	3	Milwaukee River via Storm Sewer	25,000	47,300
			Cooling	None	4	Milwaukee River via Storm Sewer	14,700	21,300
A. O. Smith Corporation—Automotive Division	3714	City of Milwaukee	Cooling	Settling Basin and Oil Separator	1	Lincoln Creek via Storm Sewer	1,094,900	1,235,900
			Cooling	Settling Basin and Oil Separator	2	Lincoln Creek via Storm Sewer	591,000	661,000
Aqua-Chem, Inc.—North Plant No. 1	3829	City of Milwaukee	Cooling and Process	None	2	Lincoln Creek via Storm Sewer	11,600	178,500
Aqua-Chem, Inc.—North Plant No. 2	3829	City of Milwaukee	Cooling, Process and Boiler Blowdown	None	2	Lincoln Creek via Storm Sewer	37,500	58,800
Badger Meter, Inc.	3824	Village of Brown Deer	Cooling	None	2	Milwaukee River via Storm Sewer	7,000	14,000
Beatrice Foods Company	2037	City of Milwaukee	Cooling	None	1	Milwaukee River via Storm Sewer	51,000	51,000
Briggs and Stratton Corporation	3499	City of Milwaukee	Cooling	Lagoon	1	Brown Deer Park Creek	5,000	5,000
Continental Can Company	3551	City of Milwaukee	Cooling	None	1	Milwaukee River via Storm Sewer	340,000	500,000
Continental Equipment Company	3551	City of Milwaukee	Cooling	None	1	Lincoln Creek via Storm Sewer and Drainage Ditch	N/A	1,000
Cutler Hammer, Inc. Industrial System Division	3622	City of Milwaukee	Cooling	None	2	Lincoln Creek via Storm Sewer	80,000	100,000
			Cooling	None	3	Lincoln Creek via Storm Sewer	50,000	60,000
			Cooling	None	4	Lincoln Creek via Storm Sewer	15,000	20,000
First Wisconsin Development Corporation	6025	City of Milwaukee	Cooling	None	1	Milwaukee River	660,000	660,000
Florence Eiseman, Inc.	2339	City of Milwaukee	Cooling and Boiler Blowdown	None	1	Milwaukee River	100	N/A
Fred Usinger, Inc.	2013	City of Milwaukee	Cooling	None	1	Milwaukee River	45,000	50,000
Gimbels Midwest, Inc.	5311	City of Milwaukee	Cooling	None	1	Milwaukee River	1,470,000	3,370,000
			Cooling	None	2	Milwaukee River	47,000	73,000
			Process	None	3	Milwaukee River	200	5,000
			Process	None	4	Milwaukee River	2,000	2,500
Gimbels Midwest, Inc.—Warehouse	5311	City of Milwaukee	Boiler Blowdown	None	1	Milwaukee River	100	N/A
Globe Union, Inc.—Administration and Research Park	3691	City of Glendale	Cooling	Cooling Lagoon	1	Lincoln Creek via Storm Sewer	7,100	17,000
Globe Union, Inc.—Central Lab Division	3679	City of Milwaukee	Cooling	N/A	1	Lincoln Creek via Storm Sewer	60,000	80,000
			Cooling	N/A	2	Lincoln Creek via Storm Sewer	60,000	70,000

Table 100 (continued)

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY (continued)								
Hoerner Waldorf Corporation	2653	City of Milwaukee	Cooling and Boiler Blowdown	None	1	Milwaukee River via Storm Sewer	1,200	N/A
Inland-Ryerson Construction Products Company	3444	City of Milwaukee	Cooling	None	1	Lincoln Creek via Storm Sewer	1,100	N/A
Interstate Drop Forge Company	3462	City of Milwaukee	Cooling	None	1	Lincoln Creek via Storm Sewer	60,000	N/A
Joseph Schlitz Brewing Company	2082	City of Milwaukee	Cooling	None	1	Milwaukee River via Storm Sewer	2,274,800	4,110,000
			Cooling	None	2	Milwaukee River via Storm Sewer	2,364,400	3,068,000
			Cooling	None	3	Milwaukee River via Storm Sewer	6,276,500	14,950,800
Kurth Malting Corporation—Plant No. 2	2083	City of Milwaukee	Cooling	None	4	Milwaukee River	46,783,300	54,000,000
Longview Fibre Company—Downing Box Division	2653	City of Milwaukee	Cooling	*Settling Basin*	17	Milwaukee River via Storm Sewer	4,800	4,800
Milprint, Inc.	2649	City of Milwaukee	Cooling	N/A	1	Milwaukee River via Storm Sewer	202,000	259,400
			Cooling	N/A	2	Milwaukee River via Storm Sewer	86,700	111,000
Milwaukee Country Club	7999	City of Milwaukee	Cooling	None	1	Milwaukee River via Storm Sewer	17,600	50,500
			Cooling	None	2	Milwaukee River via Storm Sewer	100	300
Milwaukee County Park Commission—Carver Park	7999	City of Milwaukee	Swimming Pool Overflow and Drainage	None	1	Milwaukee River via Storm Sewer	Intermittent	Intermittent
Milwaukee County Park Commission—Gordon Park	7999	City of Milwaukee	Swimming Pool Overflow and Drainage	None	1	Milwaukee River via Storm Sewer	Intermittent	Intermittent
Milwaukee County Park Commission—Lincoln Park	7999	City of Milwaukee	Swimming Pool Overflow and Drainage	None	1	Milwaukee River via Storm Sewer	Intermittent	Intermittent
Milwaukee County Park Commission—McGovern Park	7999	City of Milwaukee	Swimming Pool Overflow and Drainage	None	1	Lincoln Creek via Storm Sewer	Intermittent	Intermittent
Milwaukee Die Casting Company	3361	City of Milwaukee	Cooling	None	1	Milwaukee River via Storm Sewer	11,000	15,000
North Milwaukee Lime & Cement Company	3273	City of Milwaukee	Process	Settling Pond and pH Adjustment	1	Lincoln Creek via Storm Sewer	2,000	2,500
Oster Corporation	3634	City of Milwaukee	Cooling	None	3	Milwaukee River via Storm Sewer	8,000	13,000
			Cooling	None	4	Milwaukee River via Storm Sewer	33,000	72,000
Outboard Marine Corporation—Plants No. 2 and 5	3519	City of Milwaukee	Cooling	None	1	Lincoln Creek via Storm Sewer	901,300	1,123,500
			Cooling	None	2	Lincoln Creek via Storm Sewer	85,200	179,800
			Cooling	None	3	Lincoln Creek via Storm Sewer	107,000	170,000
Outboard Marine Corporation—Plant No. 1 Research Annex	3519	City of Milwaukee	Cooling	None	1	Lincoln Creek via Storm Sewer	262,200	313,800
Square D Company	3622	Village of Glendale	Cooling	N/A	1	Milwaukee River via Storm Sewer	2,600	3,500
			Cooling	N/A	2	Milwaukee River via Storm Sewer	36,600	62,500
			Cooling	N/A	3	Milwaukee River via Storm Sewer	88,800	153,000
Stainless Foundry and Engineering Company	3325	City of Milwaukee	Cooling	N/A	2	Lincoln Creek via Storm Sewer	110,000	121,000
			Cooling	N/A	3	Lincoln Creek via Storm Sewer	20,000	22,000
Treat All Metals, Inc.	3398	City of Milwaukee	Cooling	N/A	1	Milwaukee River via Storm Sewer	200,000	200,000
Western Electric Company, Inc. Wisconsin Service Center	7629	City of Milwaukee	Cooling	N/A	1	Milwaukee River via Storm Sewer	1,000	2,400

Table 100 (continued)

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY (continued)								
W. H. Brady Company—Florist Avenue Plant	2641	City of Glendale	Cooling	N/A	1	Milwaukee River via Storm Sewer	29,000	52,000
Wisconsin Bridge and Iron Company	3441	City of Milwaukee	Cooling and Drainage	Oil Separator	1	Lincoln Creek via Storm Sewer	5,600	N/A
Wisconsin Cuneo Press	2752	City of Milwaukee	Cooling and Process	None	1	Lincoln Creek via Storm Sewer	135,000	148,000
Wisconsin Electric Power Company—Commerce Street	4911	City of Milwaukee	Boiler Blowdown	None	1	Milwaukee River	200,000	200,000
			Cooling, Process, and Boiler Blowdown	None	4	Milwaukee River	46,521,200	51,887,100
Wisconsin Electric Power Company—Wells Street	4911	City of Milwaukee	Boiler Blowdown	None	1	Milwaukee River	600	700
			Drainage	N/A	2	Milwaukee River	200	250
			Drainage	N/A	3	Milwaukee River	400	500
			Cooling and Boiler Blowdown	None	4	Milwaukee River	24,200	25,000
			Boiler Blowdown	N/A	5	Milwaukee River	7,000	8,700
			Drainage and Boiler Blowdown	N/A	6	Milwaukee River	20	25
			Boiler Blowdown	N/A	7	Milwaukee River	1,200	1,500
			Boiler Blowdown	N/A	8	Milwaukee River	1,200	3,000
			Drainage	N/A	9	Milwaukee River	20	25
			Drainage	N/A	10	Milwaukee River	20	25
			Drainage	N/A	11	Milwaukee River	100,000	125,000
			Tank Overflow	N/A	12	Milwaukee River	100	125
			Cooling, Boiler Blowdown, and Drainage	N/A	13	Milwaukee River	889,500	909,300
Wisconsin Electric Power Company—Heating Steam System	3585	City of Milwaukee	Steam Condensate and Groundwater	None	2	Milwaukee River	300	72,000
			Steam Condensate and Groundwater	None	3	Milwaukee River	62,000	80,000
			Stream Condensate and Groundwater	None	4	Milwaukee River	21,000	72,000
Wright Metal Processors, Inc.	3479	City of Milwaukee	Cooling	None	1	Lincoln Creek via Storm Sewer	3,000	4,000
OZAUKEE COUNTY								
Ataco Steel Products Company	3312	Village of Grafton	Cooling	None	1	Milwaukee River via Storm Sewer	20,000	35,000
Brunswick Corporation—Mercury Marine Division Plant No. 1	3519	City of Cedarburg	Process and Cooling	None	1	Cedar Creek via Storm Sewer	43,000	70,000
Brunswick Corporation—Mercury Marine Division Plant No. 2	3519	City of Cedarburg	Cooling	None	1	Cedar Creek via Storm Sewer	5,000	10,000
Dayton Malleable-Meta-Mold Division	3361	City of Cedarburg	Cooling and Process	None	1	Cedar Creek via Storm Sewer	21,000	35,000
Doerr Electric Corporation	3621	City of Cedarburg	Cooling	None	1	Cedar Creek via Storm Sewer	1,000	1,000
EST Company, Inc.	3361	Village of Grafton	Cooling	None	2	Milwaukee River via Storm Sewer	8,100	14,000
Federal Foods Company	N/A	City of Mequon	Process	Lagoon	1	Groundwater	N/A	N/A
Freeman Chemical Corporation	2821	Village of Saukville	Cooling	None	1	Milwaukee River	344,200	436,700
Johnson Brass and Machine Foundry, Inc.	3362	Village of Saukville	Cooling	None	1	Milwaukee River via Storm Sewer	7,000	N/A
KMC Stampings Division	3469	Village of Grafton	Cooling	None	1	Milwaukee River via Drainage Ditch	125	N/A
Leeson Electric Corporation	3621	Village of Grafton	Cooling	Lagoon	1	Milwaukee River via Storm Sewer	5,000	N/A
MSD Plastics, Inc.	3079	Village of Grafton	Cooling	Settling Tank	1	Milwaukee River via Storm Sewer	25,000	35,000
Russel T. Gillman, Inc.	3545	Village of Grafton	Cooling	None	1	Milwaukee River via Storm Sewer	700	1,300
S & R Cheese Corporation	2022	Town of Fredonia	Process	Septic Tank and Lagoon	1	Groundwater	1,800	N/A

Table 100 (continued)

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
WASHINGTON COUNTY								
Amity Leather Products Company	3172	City of West Bend	Cooling	N/A	1	Milwaukee River via Storm Sewer	N/A	10,000
Bermico Company	2646	City of West Bend	Process and Cooling	N/A	1	Milwaukee River	228,800	295,000
Culligan Water Conditioning, Inc.	7399	City of West Bend	Filter Backwash	None	1	Milwaukee River via Storm Sewer	2,900	3,000
Fairmont Foods Company	2026	Village of Kewaskum	Cooling	None	1	Milwaukee River via Storm Sewer	8,000	10,000
Gehl Company	3523	City of West Bend	Cooling	None	1	Milwaukee River	64,000	94,000
			Cooling	None	2	Milwaukee River	4,000	4,000
			Cooling	None	3	Milwaukee River	17,000	37,000
			Cooling	None	4	Milwaukee River	168,000	456,000
Justo Foods Company	N/A	Town of Cedarburg	Process	Lagoon	1	Soil Absorption	N/A	N/A
Kewaskum Frozen Foods	2011	Village of Kewaskum	Cooling	None	1	Milwaukee River via Storm Sewer	10,000 to 50,000	N/A
Level Valley Dairy	2021	Town of Jackson	Process and Cooling	Aeration and Lagoon	1	Cedar Creek	172,000	218,100
Libby, McNeill and Libby— Highway 60	2033	Town of Jackson	Process and Cooling	Spray, Irrigation, and Lagoon	2	Groundwater	144,000	144,000
				Stabilization Lagoon	3	Cedar Creek	144,000	144,000
Pick Automotive Corporation	3714	City of West Bend	Cooling	None	1	Milwaukee River	1,000	N/A
Regal Ware, Inc.	3631	Village of Kewaskum	Cooling	N/A	1	Milwaukee River	124,300	168,300
The West Bend Company	3634	City of West Bend	Cooling	N/A	1	Milwaukee River	1,000	1,000
			Cooling	N/A	2	Milwaukee River	1,000	1,000
			Cooling	N/A	3	Milwaukee River	45,000	63,000
			Cooling	N/A	4	Milwaukee River	29,000	39,000
			Cooling	N/A	5	Milwaukee River	6,000	8,000
			Cooling	N/A	6	Milwaukee River	3,000	4,000
			Cooling	N/A	8	Milwaukee River	1,000	1,000
			Cooling	N/A	9	Milwaukee River	52,000	72,000
			Cooling	N/A	10	Milwaukee River	1,000	1,000
			Cooling	N/A	11	Milwaukee River	4,000	5,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rate was estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Pollution from Urban Runoff: Separate storm sewers which convey the runoff from rainfall carry the pollutants and contaminants washed from the urbanized areas into the receiving waters. Urban storm waters can cause chemical or inorganic pollution, organic pollution, pathogenic pollution, and aesthetic pollution of the receiving lakes and streams. Existing land use information taken from the Commission 1970 Land Use Inventory is presented in Table 101 and indicates that 62,351 acres, or 23 percent of the Milwaukee River watershed, are devoted to urban land uses and 180,938 acres, or 65 percent, are devoted to rural land uses, primarily agricultural. An additional 32,992 acres, or 12 percent, are classified as surface waters and wetlands. A shoreland development survey by the Wisconsin Department of Natural Resources indicates that 73 percent of the shoreland area within 1,000 feet of the Milwaukee River and its major tributaries is used either for agricultural purposes or other rural purposes, and 27 percent of the shoreland within 1,000 feet of the Milwaukee River and its tributaries is used for urban purposes if the shorelines of the lakes in the watershed are excluded. About 75 percent of the shoreline area within 1,000 feet of the major lakes in the Milwaukee River watershed is in urban use. Of the remaining lake shoreline area, about 15 percent is undeveloped and about 10 percent is in agricultural use. In comparing the land uses within the watershed as a whole with the land uses within 1,000 feet of the shores of the Milwaukee River and its tributaries, it should be noted that a slightly higher percentage of the land use along the shores of the Milwaukee River is urbanized within the watershed as a whole. The urbanized areas of the Milwaukee River watershed, although comprising only 23 percent of the total area of the watershed, are known to have a significant effect on stream water quality.

Table 101

LAND USE IN THE MILWAUKEE RIVER WATERSHED: 1970

Categories	1963 Land Use		1970 Land Use	
	Acres	Percentage	Acres	Percentage
Urban Land Uses				
Residential	23,778.33		28,780.63	
Commercial	1,759.42		2,087.27	
Industrial	1,836.04		2,018.25	
Transportation and Utilities	19,752.72		21,482.34	
Government	2,825.81		3,289.52	
Recreation	3,988.79		4,546.79	
Landfill and Dump	178.23		145.97	
Total Urban Land Use	54,119.34	19.59	62,350.77	22.58
Rural Land Uses				
Wooded and Unused Lands	25,222.59		25,110.82	
Agricultural Lands	163,508.94		155,826.81	
Total Rural Land Use	188,731.53	68.32	180,937.63	65.48
Water Covered Lands				
Lakes, Rivers, and Streams			5,221.50	
Wetlands			27,770.12	
Total Water Covered Land	33,412.85	12.09	32,991.62	11.94
Watershed Totals	276,263.72	100.00	276,280.02	100.00

Pollution from Rural Land: Agricultural land uses are known to contribute high concentrations of suspended solids, total nitrogen, and total phosphorus to lakes and streams through storm water runoff. Since 65 percent of the total area of the Milwaukee River watershed is in rural land uses, pollution from rural lands is likely to be a significant factor determining the water quality of the Milwaukee River stream system.

Other Pollution Sources: The Commission 1970 land use inventory revealed, in addition to the population sources described above, 41 sanitary landfill sites and 10 auto salvage yards located within the Milwaukee River watershed. Seepage and runoff from these sources may contribute to the pollution of the River system.

Water Quality Conditions of the Milwaukee River Watershed

Water Quality Data: Of the total data sources available, the following 10 were used in the analysis of water quality in the Milwaukee River: (1) Commission benchmark study, (2) Commission continuous monitoring program, (3) Commission Milwaukee River watershed study, (4) Wisconsin Department of Natural Resources lake sampling program, (5) Wisconsin Department of Natural Resources basin surveys, (6) City of Milwaukee Health Department, (7) Metropolitan Sewerage Commission of Milwaukee County, (8) Department of Natural Resources aquatic plant survey of major lakes in the Milwaukee River watershed, (9) Commission-Wisconsin Department of Natural Resources lake use reports, and (10) U. S. Geological Survey continuous streamflow monitoring program. A detailed description of these data sources is given in Chapter II of this report.

Twelve sampling stations—nine on the Milwaukee River main stem, two on Cedar Creek, and one on the North Branch of the Milwaukee River—were established by the Commission under its benchmark water quality survey. Table 102 and Table 103 present the Commission Stations, locations, and their distances from the mouth of the Milwaukee River and Table 104 presents the stations other than those established by the Commission. Map 35 illustrates the location of the Milwaukee River watershed sampling stations.

Surface Water Quality 1964-1965: Water quality conditions in the Milwaukee River watershed as measured by 1964-65 sampling surveys at nine stations along the entire length of the main stem of the Milwaukee River, at two stations on Cedar Creek, and at one station on the North Branch of the Milwaukee River are summarized in Tables 105, 106, and 107. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to assessment of the trends in surface water quality.

Table 102

DESIGNATIONS AND LOCATIONS OF SEWRPC SAMPLING STATIONS ON THE MAIN STEM OF THE MILWAUKEE RIVER

Sampling Station Designation	Stream Segment	Sampling Station Location	Distance from the Mouth (miles)
MI-1	Milwaukee River—main stem	North of Kewaskum NW ¼, Section 33, T13N, R19E	81.24
MI-2	Milwaukee River—main stem	CTH H NW ¼, Section 23, T12N, R19E	74.10
MI-3	Milwaukee River—main stem	STH 33 near West Bend NW ¼, Section 14, T11N, R20E	57.5
MI-5	Milwaukee River—main stem	STH 33 near Saukville NW ¼, Section 36, T11N, R21E	36.8
MI-6	Milwaukee River—main stem	STH 57 at Grafton NE ¼, Section 24, T10N, R21E	30.8
MI-9	Milwaukee River—main stem	CTH C NW ¼, Section 6, T9N, R22E	26.3
MI-10	Milwaukee River—main stem	W. Mequon Road NW ¼, Section 26, T9N, R21E	18.8
MI-11	Milwaukee River—main stem	W. Hampton Avenue NW ¼, Section 5, T7N, R22E	7.5
MI-12	Milwaukee River—main stem	STH 32 NW ¼, Section 33, T7N, R22E	0.8

Table 103

DESIGNATIONS AND LOCATIONS OF SEWRPC SAMPLING STATIONS ON TRIBUTARIES OF THE MILWAUKEE RIVER

Sampling Station Designation	Stream Segment	Sampling Station Location	Distance from the Mouth (miles)
MI-4	North Branch of the Milwaukee River	CTH M NW ¼, Section 25, T12N, R20E	2.22
MI-7	Cedar Creek	CTH M NW ¼, Section 12, T10N, R20E	43.8
MI-8	Cedar Creek	STH 60 NW ¼, Section 23, T10N, R21E	48.3

Chloride: During the sampling year of 1964-1965, the chloride concentrations varied from 0 mg/l to 170 mg/l with an average of 32 mg/l on the main stem of the Milwaukee River; from 15 mg/l to 20 mg/l with an average of 18 mg/l on the North Branch of the Milwaukee River; and from 15 mg/l to 130 mg/l with an average of 25 mg/l on Cedar Creek. The chloride levels in the watershed were high compared to the background levels averaging 10 mg/l of chloride as measured from the area groundwater sample concentrations. The highest concentration of 170 mg/l occurred in December 1964 at sampling station Ml-11 on the Milwaukee River main stem. Cedar Creek experienced its maximum chloride concentration of 130 mg/l at sampling station Ml-8 in May 1964. Significant decreases in the chloride concentrations were noted in the ensuing monthly samples collected from both sampling locations. The high chloride level in the Milwaukee River during December is most likely due to the runoff from winter street and highway salting operations. The high chloride concentration at sampling station Ml-8 on Cedar Creek during May 1964 is likely due to a temporary source such as animal wastes,

Table 104

DESIGNATIONS AND LOCATION OF STREAM SAMPLING STATIONS
OF OTHER SOURCES IN THE MILWAUKEE RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from the Mouth (in miles)
DNR[a]	DNR-MI-10a	Milwaukee River—main stem at W. Brown Deer Road, NW ¼, Section 12, T8N, R21E	15.0
DNR	DNR-MI-10i	Lincoln Creek at N. Green Bay Avenue, NE ¼, Section 31, T8N, R22E	0.4
DNR	DNR-MI-10g	Lincoln Creek at N. Teutonia Avenue, SE ¼, Section 36, T8N, R21E	2.0
DNR	DNR-MI-10f	Lincoln Creek at N. 32nd Street, NE ¼, Section 1, T7N, R21E	2.7
DNR	DNR-MI-10e	Lincoln Creek at N. 35th Street, SW ¼, Section 1, T7N, R21E	4.2
DNR	DNR-MI-10d	Lincoln Creek at N. 60th Street, NW ¼, Section 2, T7N, R21E	6.7
DNR	DNR-MI-10h	Lincoln Creek at W. Villard Avenue, NW ¼, Section 31, T8N, R22E	8.0
MMSD[b]	MMSD-MI-10b	Milwaukee River at W. Brown Deer Road, SW ¼, Section 1, T8N, R21E	15.0
MMSD	MMSD-MI-10c	Milwaukee River at W. Green Tree Road, NE ¼, Section 19, T8N, R22E	11.3
MMSD	MMSD-MI-10j	Lincoln Creek at N. Green Bay Avenue, NE ¼, Section 31, T8N, R22E	0.4
MMSD	MMSD-MI-11a	Milwaukee River at N. Port Washington Road, NE ¼, Section 5, T7N, R22E	6.9
MMSD	MMSD-MI-11b	Milwaukee River at Estabrook Park, NE ¼, Section 5, T7N, R22E	6.7
MMSD	MMSD-MI-11c	Milwaukee River at North Avenue Dam, NE ¼, Section 21, T7N, R22E	3.1
MMSD	MMSD-MI-11d	Milwaukee River at E. Cherry Street, SE ¼, Section 20, T7N, R22E	2.0
MMSD	MMSD-MI-11e	Milwaukee River at E. Buffalo Street, SE ¼, Section 28, T7N, R22E	1.0
USGS[c]	USGS-MI-1a	Milwaukee River at Kewaskum, SE ¼, Section 9, T12N, R19E	76.87
USGS	USGS-MI-1b	East Branch Milwaukee River at New Fane, SE ¼, Section 35, T13N, R19E	80.52
USGS	USGS-MI-4a	North Branch Milwaukee River at Filmore, NW ¼, Section 25, T12N, R20E	49.95
USGS	USGS-MI-4b	Milwaukee River at Waubeka, SE ¼, Section 28, T12N, R21E	45.50
USGS	USGS-MI-7a	Cedar Creek at Cedarburg, SW ¼, Section 14, T10N, R21E	34.36
USGS	USGS-MI-11a	Estabrook Park, NE ¼, Section 5, T7N, R22E	6.65

[a] *Wisconsin Department of Natural Resources.*

[b] *This abbreviation refers to Milwaukee Metropolitan Sewerage District, the formal name of which is the Metropolitan Sewerage District of the County of Milwaukee.*

[c] *U. S. Geological Survey.*

Source: SEWRPC.

Table 105

WATER QUALITY CONDITIONS OF THE MILWAUKEE RIVER: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Milwaukee River main stem— MI-1, MI-2, MI-3, MI-5, MI-6, MI-9, MI-10, MI-11, MI-12	Chloride (mg/l)	170	32.1	0	58
	Dissolved Solids (mg/l)	620	415	245	57
	Dissolved Oxygen (mg/l)	24.2	9.4	0.5	111
	Total Coliform Count (MFCC/100 ml)	170,000	17,700	100	112
	Temperature (^{o}F)	87	51	32	112

Table 106

WATER QUALITY CONDITIONS OF THE NORTH BRANCH OF THE MILWAUKEE RIVER: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
North Branch of Milwaukee River— MI-4	Chloride (mg/l	20	18	15	3
	Dissolved Solids (mg/l)	525	440	400	3
	Dissolved Oxygen (mg/l)	13.5	8.8	0.4	12
	Total Coliform Count (MFCC/100 ml)	140,000	15,000	100	12
	Temperature (^{o}F)	86	50	32	12

Table 107

WATER QUALITY CONDITIONS OF CEDAR CREEK: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Cedar Creek— MI-7 and MI-8	Chloride (mg/l)	130	25	15	16
	Dissolved Solids (mg/l)	730	505	330	16
	Dissolved Oxygen (mg/l)	13.4	7.5	0	25
	Total Coliform Count (MFCC/100 ml)	120,000	17,200	100	24
	Temperature (^{o}F)	91	51	32	25

since the chloride levels in the other 13 samples of the total 14 samples collected during 1964-1965 from Cedar Creek showed chloride concentrations of approximately 20 mg/l.

Dissolved Oxygen: During the sampling year 1964-1965, the dissolved oxygen levels in the Milwaukee River watershed ranged from 0.5 mg/l to 24.2 mg/l with an average of 9.4 mg/l in the main stem of the Milwaukee River; 0.4 mg/l to 13.5 mg/l with an average of 8.8 mg/l on the North Branch of the Milwaukee River; and 0.0 mg/l to 13.4 mg/l with an average of 7.5 mg/l in Cedar Creek. Although the average dissolved oxygen concentrations were well above the applicable water use objectives and supporting standards adopted for the Milwaukee River and its major tributaries, several instances of substandard levels were noted over many locations of the stream system. The most notable of such substandard conditions occurred after a 6.57 inch rainfall event at West Bend on July 18, 1964, which caused greatly increased stream flows within the watershed. The dissolved oxygen levels occurring at sampling stations Ml-1 through Ml-8 and sampling station Ml-11 subsequent to the rainstorm found during the July survey all exhibited values significantly less than the 5.0 mg/l standard required for recreational use and the maintenance of fish and aquatic life. The substandard levels may be attributed to the runoff of oxygen-demanding substances caused by the rainstorm and the overflow of sanitary sewage from flow relief devices and overloaded sewage treatment plants. Sporadic dissolved oxygen reductions to substandard levels occurred at sampling stations Ml-1 and Ml-8 on the main stem of the Milwaukee River and on Cedar Creek, respectively. These sporadic low dissolved oxygen concentrations can be attributed in part to sanitary sewage overflow from the Village of Campbellsport sewage treatment plant and the Village of Jackson sewage treatment plant located upstream from sampling stations Ml-1 and Ml-8, respectively. In addition, the deposition of oxygen-demanding substances in the stream by storm water runoff from agricultural lands may contribute to the reduction in dissolved oxygen.

Biochemical Oxygen Demand: The range of five-day biochemical oxygen demand (BOD_5) in the Milwaukee River watershed during the sampling years 1964 to 1965 ranged from a low of 0.5 mg/l to a high of 11.6 mg/l at the 12 sampling stations. The BOD_5 values remained less than 5.0 mg/l at sampling stations Ml-1, Ml-2, Ml-8, and Ml-12 on the Milwaukee River in all 14 samples collected at each location during the year 1964 to 1965. At sampling stations Ml-3, Ml-4, Ml-5, Ml-6, Ml-9, and Ml-10 the water samples collected during the month of August showed BOD_5 greater than 5.0 mg/l. In addition, at sampling station Ml-7 the sample collected on July 24, 1964, had BOD_5 of greater than 5.0 mg/l. At sampling station Ml-11, located downstream from the Village of Mequon sewage treatment plant, the water samples showed BOD_5 values of greater than 5.0 mg/l in five of the 13 samples collected during the year 1964 to 1965. The Village of Mequon sewage treatment plant was abandoned in 1968.

Total Coliform Bacteria: During the sampling period 1964 through 1965, the total membrane filter coliform count varied from 100 MFCC/100 ml to 170,000 MFCC/100 ml with an average of 17,700 MFCC/100 ml at the nine stations located on the Milwaukee River main stem; from 100 MFCC/100 ml to 140,000 MFCC/100 ml with an average of 15,000 MFCC/100 ml at the station on the North Branch of the Milwaukee River; and from 100 MFCC/100 ml to 120,000 MFCC/100 ml with an average of 17,200 MFCC/100 ml at the two Cedar Creek stations. The highest total coliform bacteria counts occurred in the month of July at station Ml-11 on the Milwaukee River main stem; in the month of August at sampling station Ml-4 on the North Branch of the Milwaukee River; and again in the month of August at sampling station Ml-7 on Cedar Creek.

The high total coliform counts at sampling stations in the watershed correspond to the runoff events following heavy rains. The correlation between storm water runoff events and total coliform counts indicates these pollutants are from diffuse sources. In sampling programs conducted by the Commission, storm water runoff from agricultural land and from older residential areas served by combined sewer systems have been found to be high in fecal coliform counts. Accordingly, the high total coliform readings observed in the watershed are probably due to agricultural and urban storm water runoff. The high total coliform counts occurring in the stream samples at times other than following precipitation events can be accounted for by the discharge of sewage treatment plant effluents and the seepage of septic tank effluents.

Specific Conductance: The specific conductance of the stream water of the Milwaukee River watershed during the 1964-65 sampling period ranged from 384 to 964 µmhos/cm at 25°C with an average of 604 µmhos/cm at 25°C for the Milwaukee River main stem; 610 to 690 µmhos/cm at 25°C with an average of 641 µmhos/cm at 25°C, on the North Branch of the Milwaukee River; and 520 to 1,150 µmhos/cm at 25°C with an average of 701 µmhos/cm at 25°C for Cedar Creek. The specific conductance exceeded 1,000 µmhos/cm at 25°C on but one occasion, during the month of May at sampling station Ml-8 located on Cedar Creek. As the specific conductance is an approximate measure of the dissolved ions present in water, the high specific conductance values during the spring months indicate the effects of spring runoff on the dissolved ion concentrations.

Hydrogen Ion Concentrations (pH): The pH values at all of the sampling sites in the Milwaukee River watershed were found to range from 7.0 to 8.6 standard units during the sampling period of 1964-65. At no location within the watershed was the pH found to be outside the range of 6.0 to 9.0 standard units prescribed for support of recreational, fish and aquatic life, and for restricted uses which are the major water use objectives for the Milwaukee River and its tributaries.

Temperature: During the year 1964-1965, the temperature of water samples collected from the Milwaukee River and its tributaries ranged from 32° to 57°F during the months of December through April, and from 32° to 91°F during the months of May through November. The observed temperature variations, therefore, may be attributed primarily to seasonal changes. The discharge of cooling waters into the main stream or the tributaries of the Milwaukee River from 86 industrial outfalls apparently did not modify the normal temperature of the stream water above the prescribed standard of 89°F.

Water Quality Trends from 1965 to 1975: Water quality data from 1965 to 1975 for eight summer sampling programs, three spring sampling programs, and one fall sampling program are presented in tabular form in Appendix D of this report. The eight summer sampling surveys were begun in August 1968 and involved collection of samples one day in August every year during low-flow conditions.

An analysis of the flow data from "Water Resources Data for Wisconsin," published by U. S. Geological Survey, shows that for the streams in southeastern Wisconsin, low flow generally occurs during the months of August and September. Although the collection and analysis of one sample per station per year cannot represent water quality conditions for the whole year, it may be assumed to reasonably represent the water quality conditions of the stream at that location during the low-flow period, which is generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life.

Set forth in Tables 108-119 is a summary of the results of water quality sampling for temperature; specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, and organic nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of the 12 sampling stations maintained in the Milwaukee River watershed by the Commission since 1968. The stream flow data for the Milwaukee River near Kewaskum, Waubeka, and Milwaukee; the East Branch of the Milwaukee River near New Fane; North Branch of the Milwaukee River near Fillmore; and Cedar Creek near Cedarburg were obtained from U. S. Geological Survey records. The data for these six locations for the years 1964 through 1975 on the days the water samples were collected are presented in Figures 88-91.

Dissolved Oxygen: For the watershed as a whole, the dissolved oxygen content in the Milwaukee River system for the years 1968-1975 was found to range from 0.3 mg/l to 21.3 mg/l. The average dissolved oxygen concentrations for the Milwaukee River main stem were 6.8, 6.8, 7.5, 8.2, 9.8, 7.8, 7.0, 9.5, and 2.4 mg/l for stations Ml-1, Ml-2, Ml-3, Ml-5, Ml-6, Ml-9, Ml-10, Ml-11, and Ml-12, respectively. For station Ml-4 on the North Branch of the Milwaukee River, the average dissolved oxygen concentration was 6.4 mg/l. Stations Ml-7 and Ml-8 on Cedar Creek had average dissolved oxygen concentrations of 5.6 and 6.4 mg/l, respectively. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l for sampling stations Ml-1 through Ml-11 and above 2.0 mg/l for sampling station Ml-12 during August, dissolved oxygen concentrations lower than the applicable water quality standards for the Milwaukee River and tributaries were occasionally recorded. For sampling stations Ml-1, 2, 3, 5, 9, and 10, located on the Milwaukee River main stem, the dissolved oxygen concentrations were below 5.0 mg/l in 11 samples at sampling station Ml-3; in eight samples at stations Ml-1 and Ml-9; in seven samples at station Ml-2; in six samples at station Ml-10; and in five samples at station Ml-5 out of 30 dissolved oxygen samples collected at each sampling station during the eight sampling surveys. Sampling station Ml-4, located on the North Branch of the Milwaukee River, exhibited substandard dissolved oxygen levels in seven of the 30 August samples collected during the eight-year

Table 108

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	131.0	62.2	16.0	22	--
Dissolved Oxygen (mg/l)	5.0	11.6	6.8	2.6	30	8[a]
Ammonia-N (mg/l)	2.5	0.120	0.049	0.000	8	0
Organic-N (mg/l)	--	1.470	1.072	0.730	8	--
Total-N (mg/l)	--	2.090	1.732	1.290	8	--
Specific Conductance (μmhos/cm at 25°C)	--	888	741	540	29	--
Nitrite-N (mg/l)	--	0.018	0.011	0.004	12	--
Nitrate-N (mg/l)	0.30	0.960	0.590	0.160	12	10
Soluble Orthophosphate-P (mg/l)	--	0.527	0.303	0.187	12	--
Total Phosphorus (mg/l)	0.10	0.420	0.336	0.240	8	8
Fecal Coliform (MFFCC/100 ml)	400	2,400	517	20	12	6
Temperature (°F)	89.0	81.0	70.7	63.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.6	8.2	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 109

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	50.0	29.7	20.0	22	--
Dissolved Oxygen (mg/l)	5.0	11.3	6.8	2.7	30	6
Ammonia-N (mg/l)	2.5	0.150	0.079	0.000	8	0
Organic-N (mg/l)	--	1.560	1.070	0.660	8	--
Total-N (mg/l)	--	2.041	1.691	1.220	8	--
Specific Conductance (μmhos/cm at 25°C)	--	666	603	525	28	--
Nitrite-N (mg/l)	--	0.061	0.024	0.016	12	--
Nitrate-N (mg/l)	0.30	0.750	0.486	0.240	12	8
Soluble Orthophosphate-P (mg/l) . . .	--	1.030	0.289	0.058	12	--
Total Phosphorus (mg/l)	0.10	0.390	0.232	0.090	8	7
Fecal Coliform (MFFCC/100 ml) . . .	400	760	284	60	11	2
Temperature (°F)	89.0	79.0	72.5	66.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.5	8.1	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 110

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	100.0	55.8	29.0	22	--
Dissolved Oxygen (mg/l)	5.0	20.7	10.2	3.2	30	11[a]
Ammonia-N (mg/l)	2.5	0.540	0.230	0.000	8	0
Organic-N (mg/l)	--	1.860	1.367	0.820	8	--
Total-N (mg/l)	--	2.943	2.452	2.010	8	--
Specific Conductance (μmhos/cm at 25°C)	--	863	692	551	28	--
Nitrite-N (mg/l)	--	0.260	0.136	0.057	12	--
Nitrate-N (mg/l)	0.30	1.350	0.792	0.430	12	12
Soluble Orthophosphate-P (mg/l) . . .	--	1.230	0.440	0.125	11	--
Total Phosphorus (mg/l)	0.10	0.410	0.277	0.170	7	7
Fecal Coliform (MFFCC/100 ml) . . .	400	1,000	307	50	12	6
Temperature (°F)	89.0	84.0	74.3	68.5	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.2	8.4	7.8	22	2

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 111

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-4: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	29.0	16.1	6.0	22	--
Dissolved Oxygen (mg/l)	5.0	10.1	6.5	4.2	30	7[a]
Ammonia-N (mg/l)	2.5	13.000	0.065	0.000	8	0
Organic-N (mg/l)	--	1.570	1.286	0.800	8	--
Total-N (mg/l)	--	2.550	2.109	1.750	8	--
Specific Conductance (μmhos/cm at 25°C)	--	733	614	518	27	--
Nitrite-N (mg/l)	--	0.044	0.029	0.015	12	--
Nitrate-N (mg/l)	0.30	1.160	0.598	0.140	12	10
Soluble Orthophosphate-P (mg/l)	--	0.299	0.170	0.051	12	--
Total Phosphorus (mg/l)	0.10	0.360	0.303	0.230	8	8
Fecal Coliform (MFFCC/100 ml)	400	960	402	50	12	5
Temperature (°F)	89.0	80.5	72.8	68.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.8	8.2	7.9	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 112

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-5: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	45.0	36.7	25.0	22	--
Dissolved Oxygen (mg/l)	5.0	18.1	8.2	4.0	30	5[a]
Ammonia-N (mg/l)	2.5	0.130	0.051	0.000	8	0
Organic-N (mg/l)	--	1.980	1.317	0.730	8	--
Total-N (mg/l)	--	2.323	1.866	1.490	8	--
Specific Conductance (μmhos/cm at 25°C)	--	751	631	510	28	--
Nitrite-N (mg/l)	--	0.034	0.018	0.005	12	--
Nitrate-N (mg/l)	0.30	0.760	0.378	0.110	12	5
Soluble Orthophosphate-P (mg/l)	--	0.573	0.210	0.038	12	--
Total Phosphorus (mg/l)	0.10	0.397	0.292	0.190	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,600	431	20	12	4
Temperature (°F)	89.0	81.0	74.8	69.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.0	8.6	8.2	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 113

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-6: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	44.0	37.8	27.0	22	--
Dissolved Oxygen (mg/l)	5.0	18.5	9.8	5.1	30	0[a]
Ammonia-N (mg/l)	2.5	0.110	0.049	0.030	8	0
Organic-N (mg/l)	--	1.730	1.349	0.920	8	--
Total-N (mg/l)	--	2.070	1.773	1.500	8	--
Specific Conductance (μmhos/cm at 25°C)	--	751	629	541	29	--
Nitrite-N (mg/l)	--	0.046	0.020	0.007	12	--
Nitrate-N (mg/l)	0.30	0.600	0.325	0.140	12	4
Soluble Orthophosphate-P (mg/l)	--	0.467	0.186	0.031	12	--
Total Phosphorus (mg/l)	0.10	0.373	0.259	0.140	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,100	384	10	12	4
Temperature (°F)	89.0	85.0	76.1	71.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.1	8.7	8.2	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 114

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-7: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	324.0	47.5	15.0	22	--
Dissolved Oxygen (mg/l)	5.0	9.5	7.6	2.5	30	14[a]
Ammonia-N (mg/l)	2.5	0.260	0.169	0.100	8	0
Organic-N (mg/l)	--	1.830	1.307	0.740	8	--
Total-N (mg/l)	--	3.550	2.775	1.810	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,550	680	574	29	--
Nitrite-N (mg/l)	--	0.120	0.059	0.033	12	--
Nitrate-N (mg/l)	0.30	1.590	0.942	0.270	12	11
Soluble Orthophosphate-P (mg/l)	0.10	0.386	0.227	0.144	11	11
Total Phosphorus (mg/l)	0.10	0.407	0.275	0.180	7	7
Fecal Coliform (MFFCC/100 ml)	400	27,000	3,962	90	12	10
Temperature (°F)	89.0	84.5	73.2	68.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.5	8.1	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 115

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-8: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	111.0	36.2	13.0	22	--
Dissolved Oxygen (mg/l).	5.0	14.0	6.4	4.1	30	7[a]
Ammonia-N (mg/l)	2.5	0.190	0.081	0.000	8	0
Organic-N (mg/l)	--	1.810	1.215	0.630	8	--
Total-N (mg/l)	--	3.410	2.596	1.710	8	--
Specific Conductance (μmhos/cm at 25^{o}C).	--	830	624	540	27	--
Nitrite-N (mg/l).	--	0.094	0.040	0.007	12	--
Nitrate-N (mg/l)	0.30	1.470	0.896	0.120	12	8
Soluble Orthophosphate-P (mg/l) . . .	--	0.384	0.219	0.143	12	--
Total Phosphorus (mg/l)	0.10	0.423	0.310	0.190	8	8
Fecal Coliform (MFFCC/100 ml) . . .	400	5,300	1,014	140	12	7
Temperature (^{o}F)	89.0	81.0	73.0	68.0	29	0
Hydrogen Ion Concentrations (standard units)	6-9	9.0	8.3	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 116

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-9: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	66.0	44.4	26.0	22	--
Dissolved Oxygen (mg/l).	5.0	21.3	6.8	0.5	30	8[a]
Ammonia-N (mg/l)	2.5	15.000	0.052	0.000	8	0
Organic-N (mg/l)	--	1.570	1.285	0.800	8	--
Total-N (mg/l)	--	3.080	2.335	1.640	8	--
Specific Conductance (μmhos/cm at 25^{o}C).	--	775	663	562	29	--
Nitrite-N (mg/l).	--	0.096	0.040	0.013	12	--
Nitrate-N (mg/l)	0.30	1.450	0.729	0.140	12	10
Soluble Orthophosphate-P (mg/l) . . .	--	1.133	0.400	0.145	11	--
Total Phosphorus (mg/l)	0.10	0.410	0.264	0.140	7	7
Fecal Coliform (MFFCC/100 ml) . . .	400	900	367	10	12	4
Temperature (^{o}F)	89.0	83.5	74.4	67.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.3	8.4	7.8	22	3

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 117

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-10: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	63.0	43.9	20.0	21	--
Dissolved Oxygen (mg/l)	5.0	15.0	6.9	1.5	30	6[a]
Ammonia-N (mg/l)	2.5	0.270	0.192	0.060	8	0
Organic-N (mg/l)	--	1.580	1.350	1.060	8	--
Total-N (mg/l)	--	2.660	2.231	1.660	8	--
Specific Conductance (µmhos/cm at 25°C)	--	788	669	543	29	--
Nitrite-N (mg/l)	--	0.107	0.043	0.024	12	--
Nitrate-N (mg/l)	0.30	1.020	0.508	0.135	12	6
Soluble Orthophosphate-P (mg/l)	--	1.177	0.389	0.102	12	--
Total Phosphorus (mg/l)	0.10	0.387	0.250	0.150	8	8
Fecal Coliform (MFFCC/100 ml)	400	30,000	3,540	150	12	4
Temperature (°F)	89.0	83.5	76.3	72.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.9	8.5	8.2	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 118

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-11: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	120.0	47.1	19.0	21	--
Dissolved Oxygen (mg/l)	5.0	15.7	9.5	5.5	30	0[a]
Ammonia-N (mg/l)	2.5	0.330	0.156	0.030	8	0
Organic-N (mg/l)	--	1.500	1.332	1.020	8	--
Total-N (mg/l)	--	2.660	1.996	1.220	8	--
Specific Conductance (µmhos/cm at 25°C)	--	784	593	471	29	--
Nitrite-N (mg/l)	--	0.088	0.032	0.012	12	--
Nitrate-N (mg/l)	0.30	0.870	0.393	0.100	12	5
Soluble Orthophosphate-P (mg/l)	--	2.380	0.445	0.053	12	--
Total Phosphorus (mg/l)	0.10	0.437	0.242	0.070	8	7
Fecal Coliform (MFFCC/100 ml)	400	40,000	6,630	150	12	9
Temperature (°F)	89.0	85.0	76.7	72.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.1	8.7	8.0	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 119

WATER QUALITY CONDITIONS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-12: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	50.0	33.9	16.0	22	--
Dissolved Oxygen (mg/l)	2.0	5.7	2.4	0.3	30	11[a]
Ammonia-N (mg/l)	2.5	0.770	0.437	0.210	8	0
Organic-N (mg/l)	--	1.540	1.002	0.180	8	--
Total-N (mg/l)	--	2.580	1.827	0.530	8	--
Specific Conductance (μmhos/cm at 25°C)	--	800	499	401	30	--
Nitrite-N (mg/l)	--	0.360	0.064	0.008	12	--
Nitrate-N (mg/l)	0.30	0.670	0.281	0.070	12	5
Soluble Orthophosphate-P (mg/l)	--	0.757	0.254	0.078	12	--
Total Phosphorus (mg/l)	0.10	0.423	0.265	0.150	8	8
Fecal Coliform (MFFCC/100 ml)	2,000	31,000	11,145	80	12	8
Temperature (°F)	89.0	86.0	75.2	62.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	7.9	7.6	7.4	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

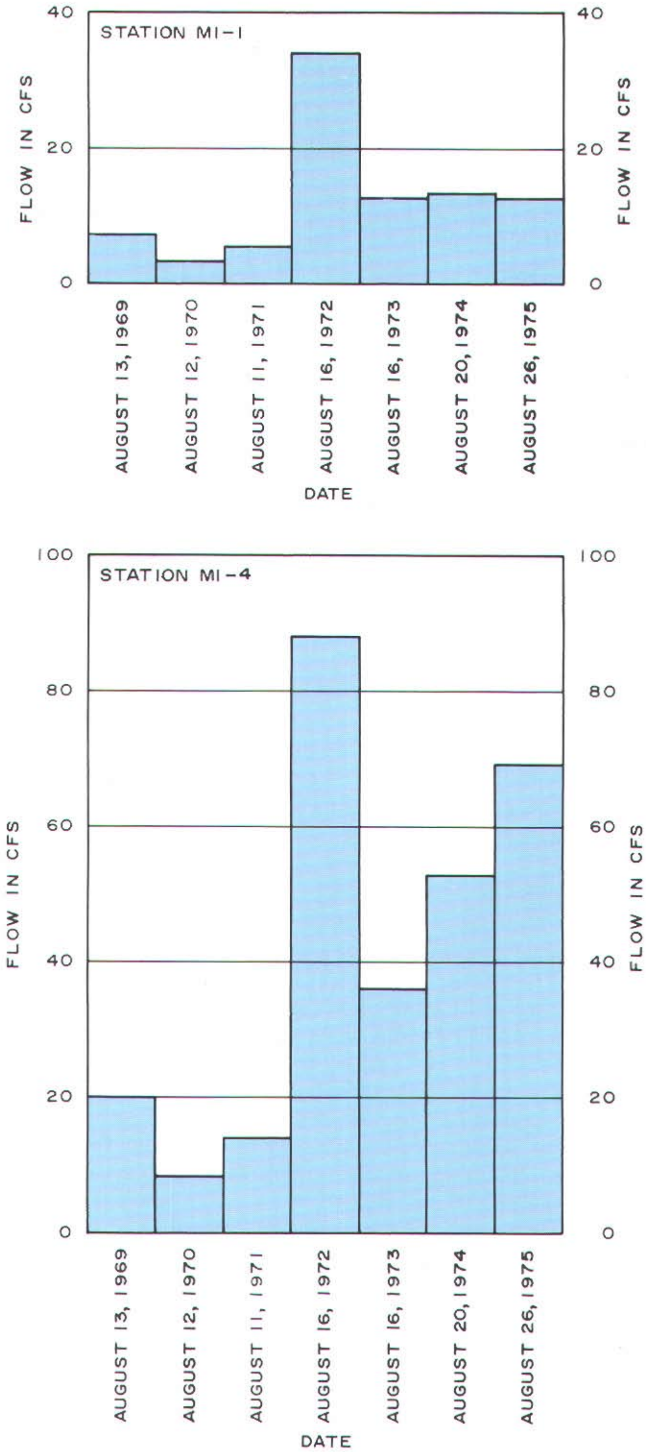
period of record. Samples collected and analyzed for dissolved oxygen at sampling stations Ml-7 and Ml-8, located on Cedar Creek, showed concentrations below 5.0 mg/l in 14 and seven of the 30 samples collected, respectively, at each of the sample sites. Eleven of the 30 samples collected at sampling station Ml-12 during the eight sample surveys were found to be below the 2.0 mg/l dissolved oxygen concentrations standard for the lower reaches of the main stem of the Milwaukee River.

Map 36 presents the dissolved oxygen concentrations that were found in August 1964 and August 1975 in the Milwaukee River watershed. The graph inserts illustrate the change in dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at each location. On August 20-21, 1964, as indicated on the map, no substandard dissolved oxygen levels were observed in the Milwaukee River main stem, the North Branch of the Milwaukee River, or Cedar Creek, with the exception of sampling station Ml-12 on the main stem. In the samples recorded on August 25, 26, and 27, 1975, substandard dissolved oxygen concentrations were noted at sampling stations Ml-1, Ml-3, and Ml-12 on the main stem of the Milwaukee River and at sampling stations Ml-7 and Ml-8 in Cedar Creek. An analysis of the 10 years (1965-1974) of monthly data obtained from samples collected by the Wisconsin Department of Natural Resources at the W. Brown Deer Road bridge in the Village of Brown Deer indicates, however, that the dissolved oxygen concentrations generally were lower during the month of July rather than August. Similar results, i.e., lower dissolved oxygen concentrations in July than in August samples, were recorded from the samples collected by the Commission during the 1964-1965 study; and it may be possible that the lowest dissolved oxygen levels occur red in July in the streams of the Milwaukee River watershed.

The graph inserts on Map 36 present the dissolved oxygen concentrations and the associated three-year moving averages at sampling stations Ml-1 through Ml-12 in the August samples of 1964 through 1975. In August 1972 high streamflows with daily averages of 103 cfs, 299 cfs, 718 cfs, and 107 cfs were recorded at Kewaskum, Waubeka, and Milwaukee—on the main stem of the Milwaukee River—and at Fillmore—on the North Branch of the Milwaukee River—respectively. No streamflow data were collected near Cedarburg on Cedar Creek for this period. Judging from rainfall data collected at Hartford and Germantown, however, and the high streamflows observed elsewhere throughout the watershed, it can be assumed that Cedar Creek also was carrying high flows. High average streamflows of 140 cfs and 650 cfs also were recorded during the August 1975 sample period on Cedar Creek near Cedarburg and on the Milwaukee River at Milwaukee, respectively. The water quality data collected during the aforementioned high streamflow events therefore are not directly comparable with other years. There was a general increase in dissolved oxygen concentrations at sampling station Ml-1 in the samples collected in August from 1970 to 1975. The trend was further noted in sample results from sam-

Figure 88

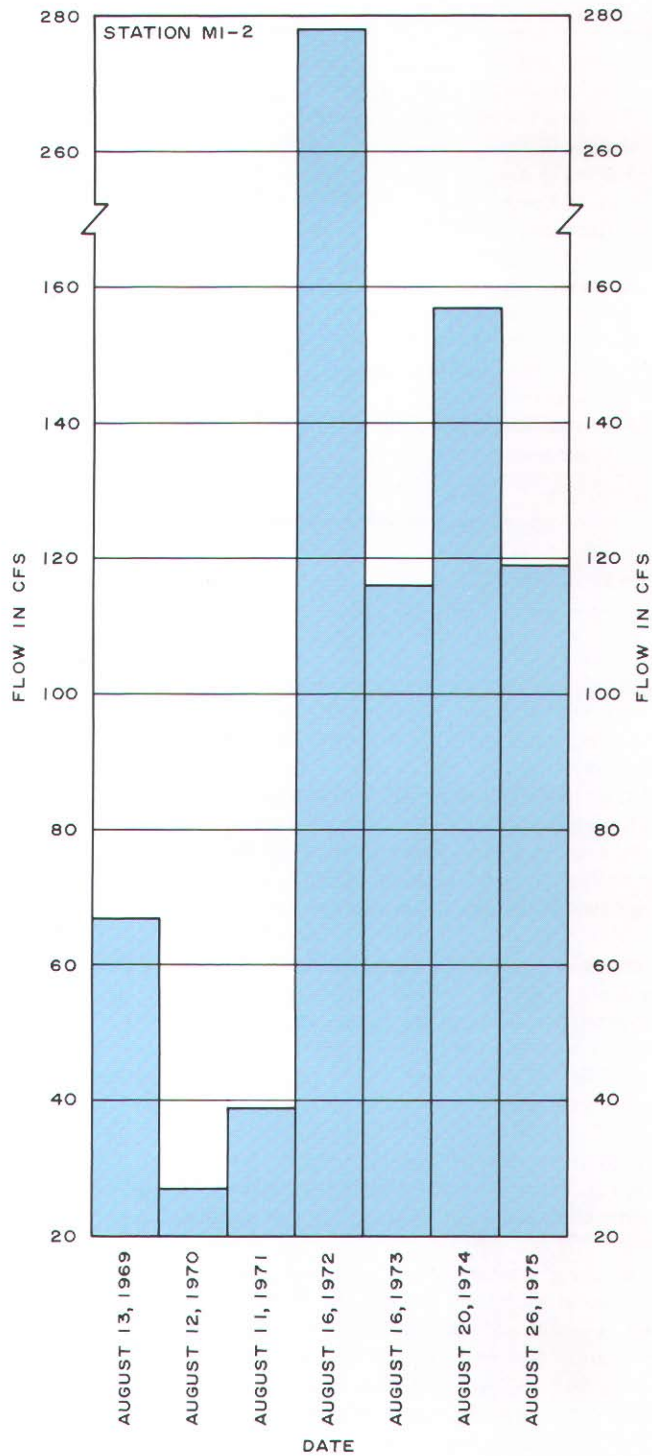
FLOW MEASUREMENTS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATIONS MI-1 AND MI-4 ON THE DATES OF WATER SAMPLE COLLECTION: 1969-1975



Source: SEWRPC.

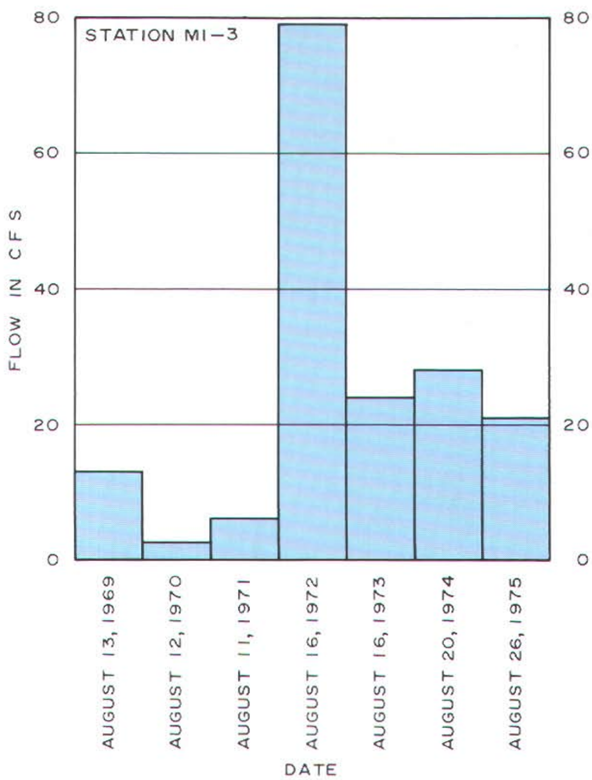
Figure 89

FLOW MEASUREMENTS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATIONS MI-2 AND MI-3 ON THE DATES OF WATER SAMPLE COLLECTION: 1969-1975



Source: SEWRPC.

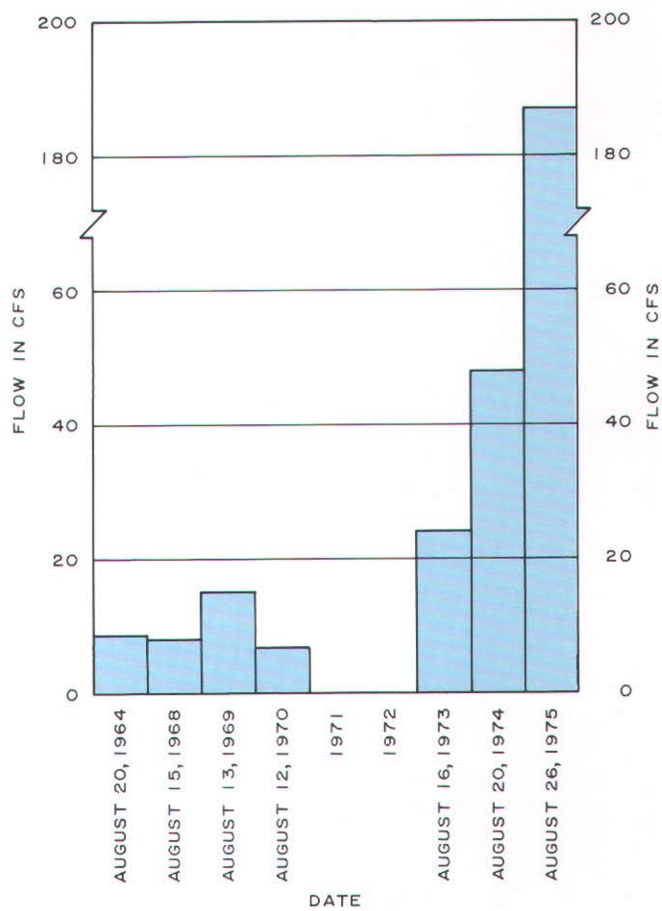
Figure 89 (continued)



Source: SEWRPC.

Figure 90

FLOW MEASUREMENTS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-8 ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1975



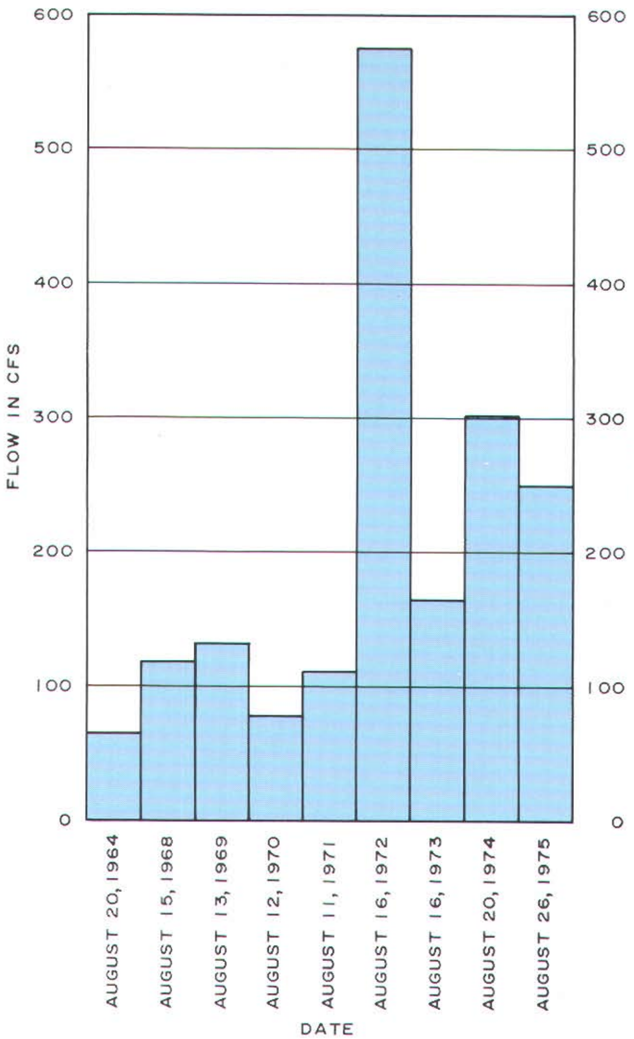
Source: SEWRPC.

pling station MI-2. The dissolved oxygen concentrations recorded at sampling station MI-3 exhibited a declining trend due to increased loadings on the main stem of the Milwaukee River from the City of West Bend sewage treatment plant. The dissolved oxygen concentrations obtained at sampling stations MI-5 and MI-6 both exhibited increasing trends over time. Both of these stations are located above the outfalls of the sewage treatment plants serving the Villages of Saukville and Grafton, respectively. It may, therefore, be possible that the dissolved oxygen concentrations downstream from the two above-mentioned sewage treatment plants exhibit a decreasing trend similar to that seen at sampling station MI-3. This is supported in part by the decreasing trend in dissolved oxygen levels noted at MI-9 located downstream from the Village of Grafton Sewage Treatment Plant and the confluence with Cedar Creek, which receives treated wastewaters from the City of Cedarburg sewage treatment plant. The trend in dissolved oxygen concentrations between 1970 and 1975 at sampling stations MI-10 and MI-12 was increasing, whereas the concentrations decreased at sampling station MI-11. Sampling station MI-11 is located downstream from the confluence of the main stem with Lincoln Creek, which receives sanitary waste loading from 55 separate sanitary sewer flow relief devices during wet weather conditions. The dissolved oxygen concentrations at sampling station MI-12, which is located within the area of the City of Milwaukee served by combined sewers, is greatly affected by the Milwaukee River flushing tunnel, located near the North Avenue dam and used to augment the Milwaukee River streamflow with waters pumped from Lake Michigan. The water quality at sampling station MI-12 also is subject to the dilution effects of Lake Michigan. Therefore, sampling station MI-12 does not always directly reflect the lower Milwaukee River water quality conditions as they are affected by the upstream flow and pollutant contributions.

An analysis of the three-year moving average dissolved oxygen concentrations at sampling station MI-4, which is located on the North Branch of the Milwaukee River, indicates no significant change in the water quality since 1964. A similar trend was noted on Cedar Creek at sampling stations MI-7 and MI-8.

Figure 91

FLOW MEASUREMENTS IN THE MILWAUKEE RIVER WATERSHED AT SAMPLING STATION MI-11 ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1975



Source: SEWRPC.

The staff of the Metropolitan Sewerage District of the County of Milwaukee collected and analyzed samples for dissolved oxygen from eight sites located in the lower reaches of the Milwaukee River and Lincoln Creek during the summers of 1964 through 1966. Specifically, these sites were located at the W. Brown Deer Road bridge, E. Green Tree Road bridge, N. Port Washington Road bridge, Estabrook Park, North Avenue dam, E. Cherry Street bridge, E. Buffalo Street bridges over the main stem of the Milwaukee River, and N. Green Bay Avenue bridge over Lincoln Creek. Samples were also collected and analyzed for dissolved oxygen during the summers of 1967 and 1968 at three sites including the North Avenue dam, E. Cherry Street bridge, and E. Buffalo Street bridge, all located in the lower reaches of the Milwaukee River and affected by the Milwaukee River flushing tunnel and the dilution effect of Lake Michigan. The samples were collected on a weekly basis for the periods from May 6 through November 18, 1964; May 5 through September 29, 1965; May 11 through November 2, 1966; June 14 through September 29, 1967; and June 5 through August 28, 1968. The average dissolved oxygen concentrations recorded during the period from 1964 through 1966 exhibited a fluctuation over time with those at the stations from W. Brown Deer Road to Estabrook Park exhibiting no specific trend. A general decline in the average dissolved oxygen concentrations from 1964 to 1968 is noted at the North Avenue dam and the E. Buffalo Street bridge. No significant trend can be observed at the E. Cherry Street bridge; however, the Milwaukee River flushing tunnel augments the flow of the River at this point, thus aiding in the maintenance of higher dissolved oxygen levels. The average dissolved oxygen concentrations recorded at the N. Green Bay Avenue bridge on Lincoln Creek from 1964 to 1966 fluctuated, thus showing no specific trend. Frequently, the dissolved oxygen concentrations were below the 2.0 mg/l restricted standard adopted by the Wisconsin Department of Natural Resources in 1973 for dissolved oxygen levels on Lincoln Creek during the summer months of June, July, and August during this three-year period of record.

Dissolved oxygen concentrations were recorded for the six stations sampled along Lincoln Creek by the Wisconsin Department of Natural Resources during the 1968-1969 Milwaukee River Basin Survey. As indicated in that Basin Survey report, Lincoln Creek—which lies entirely within a highly urbanized portion of the City of Milwaukee—routinely exhibits substandard dissolved oxygen levels at the N. Green Bay Avenue bridge. On two occasions during the survey—July 31, 1968 and August 21, 1968—the dissolved oxygen concentrations at the N. Green Bay Avenue sampling station were 0.0 mg/l and 0.1 mg/l, respectively—well below the 2.0 mg/l restricted standard. The low dissolved oxygen concentrations noted in the lower reaches of the Milwaukee River and the Lincoln Creek are due to the continued effects of sanitary sewerage system flow relief devices as well as urban runoff.

A comparison of the dissolved oxygen concentrations recorded throughout the watershed in April and August of the years 1964, 1968, and 1969, indicates generally higher dissolved oxygen concentrations in April of each year than in August. The lower flow and higher temperatures, accompanied by continuing organic loading from sewage and industrial effluents, account for the decreased dissolved oxygen concentrations in the August samples.

Chloride: Chloride concentrations were found to be in the range of from 16 mg/l to 131 mg/l at the nine stations located on the main stem of the Milwaukee River; from 6 mg/l to 29 mg/l at the single station located on the North Branch of the Milwaukee River; and from 13 mg/l to 324 mg/l at the two stations located along Cedar Creek for the month of August during the years 1968-1975.

During the sampling program, the average chloride concentrations for the Milwaukee River main stem were 62, 30, 62, 37, 38, 44, 44, 47, and 34 mg/l for stations Ml-1, Ml-2, Ml-3, Ml-5, Ml-6, Ml-9, Ml-10, Ml-11, and Ml-12, respectively. Station Ml-4 on the North Branch of the Milwaukee River had an average chloride concentration of 16 mg/l. Station Ml-7 and Ml-8 on Cedar Creek had average chloride concentrations of 47 and 36 mg/l, respectively. As indicated by the average concentrations, a significant number of the chloride concentrations were higher than the area groundwater chloride concentration of 10 mg/l. The elevation in chloride concentrations within the Milwaukee River watershed is attributed to the effects of runoff from agricultural lands in the middle and upper portions of the watershed, urban runoff in the lower portions of the watershed, and treated and untreated sanitary waste effluents from sewage treatment facilities and flow relief devices distributed throughout the watershed.

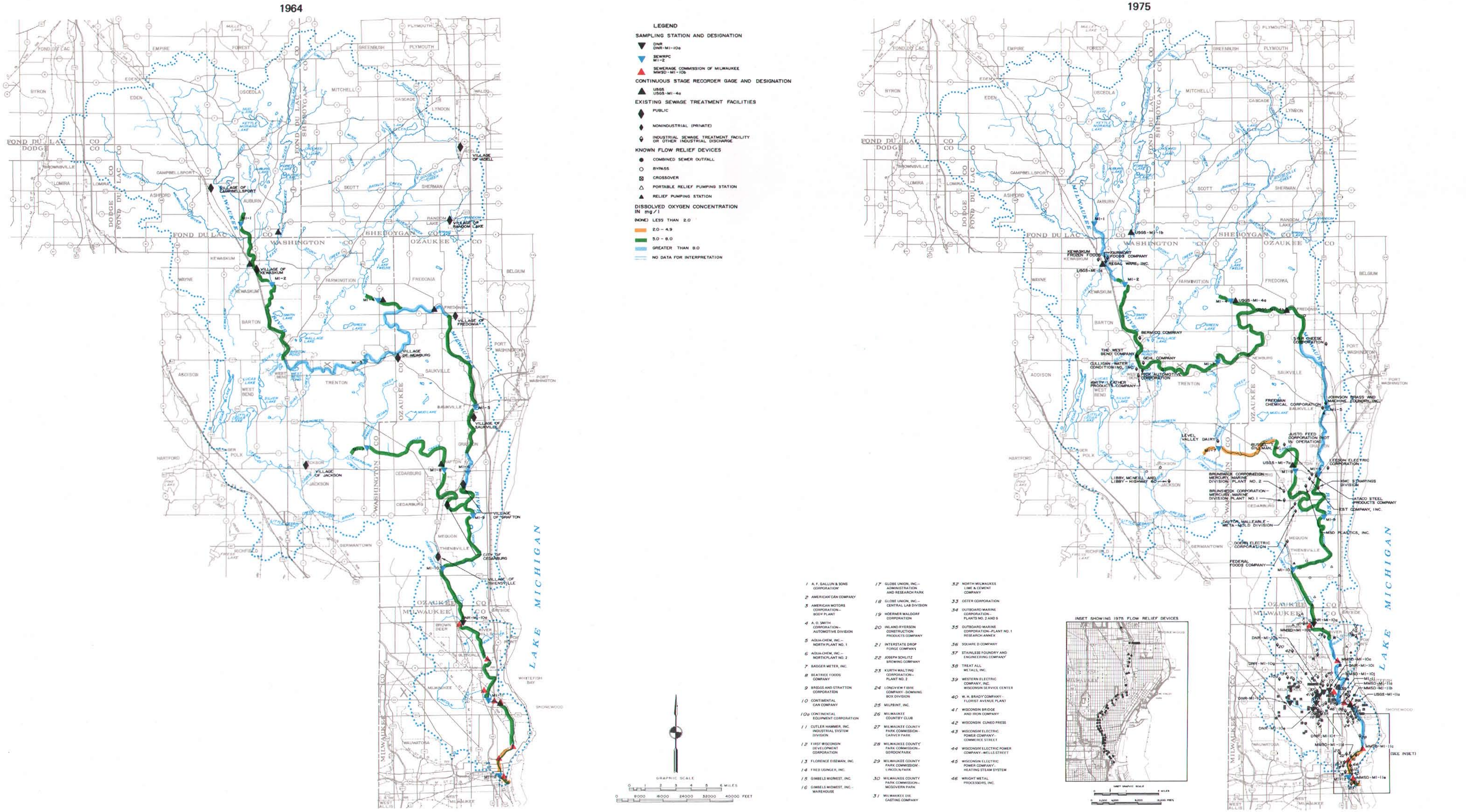
A comparison of the chloride concentrations from April 1968 with those from August 1968 and of chloride concentrations from April 1969 with those from August 1969—as presented in Figure 92 for sampling stations Ml-1, Ml-4, Ml-8, and Ml-11—indicates a trend toward higher chloride concentrations in the August samples collected in the Milwaukee River at Ml-1 and in Cedar Creek collected at Ml-8 and lower chloride concentrations in the August samples at sampling stations Ml-4 and Ml-11. The chloride loadings were calculated for the August and April 1968 and 1969 data and plotted in Figure 93. A comparison of Figures 92 and 93 indicates that although the chloride concentrations were higher in the August samples of 1968 and 1969 at location Ml-1 on the Milwaukee River and at location Ml-8 on Cedar Creek, the chloride loadings calculated with the available flow data were higher in the April samples at sampling stations Ml-1 and Ml-11 on the Milwaukee River, Ml-4 on the North Branch of the Milwaukee River, and Ml-8 on Cedar Creek. The chloride loadings observed in the April samples were approximately double those observed in the August samples at sampling stations Ml-1, Ml-4, and Ml-8 and were five to eight times as high at sampling station Ml-11 on the Milwaukee River located downstream from Lincoln Creek in the highly urbanized area in the City of Milwaukee. The high chloride loadings in the April 1968 and 1969 samples at sampling station Ml-11 are therefore probably attributable to urban runoff from deicing salt from the highways and streets located in the area. At stations Ml-1, Ml-4, and Ml-8, the higher chloride loadings in the April samples are related to a combination of factors inclusive of the runoff from agricultural lands and deicing salt applied to the highways. Map 37 illustrates the chloride concentrations at the Milwaukee River watershed sampling stations on August 20-21, 1964, and August 25-28, 1975, with the graphs illustrating the changes in chloride concentrations found during the sampling days of intermediate years. No change in chloride concentrations is seen when the August 1964 and 1975 data are compared for sampling stations Ml-5, Ml-8, and Ml-11. However, a notable increase occurred at sampling station Ml-1 in August 1975 as compared to August 1964. The graphs illustrate the trend in the average chloride concentrations in August for the Milwaukee River watershed sampling stations Ml-1 through Ml-12 for the years 1968 through 1975. Sampling stations Ml-1 and Ml-2 both exhibit slight increases in the chloride concentrations which are probably associated with increased loading on the Villages of Campbellsport and Kewaskum sewage treatment plants. Sampling station Ml-3 exhibited a decrease in the average chloride concentrations as did sampling station Ml-9. No significant trend was noted at sampling stations Ml-5, Ml-6, and Ml-10 through Ml-12. The sampling station located on the North Branch of the Milwaukee River, Ml-4, also exhibited no significant change in the average chloride concentrations during the period 1968 through 1975. Chloride concentrations recorded on Cedar Creek between 1968 through 1975 exhibited decreases at both sampling stations Ml-7 and Ml-8. The chloride loadings at sampling stations Ml-1 and Ml-11 on the main stem of the Milwaukee River, Ml-4 on the North Branch of the Milwaukee River, and Ml-8 on Cedar Creek are compared with the flow in Figure 94. The direct correlation between the flow and the chloride loading is well illustrated at these stations. If it is assumed that the chloride contribution from the sewage treatment plants is constant, then the chloride loadings in the stream would not be expected to vary with the flow of the River. The fact that the chloride loading does vary with the flow at sampling stations Ml-1, Ml-4, Ml-8, and Ml-11 indicates that the chloride has significant sources other than sewage effluent. The higher flows in 1972 and 1975 were associated with rain, raising the possibility that the origin of chlorides is associated with storm water runoff from the leaching of road salts from upper layers of soil and from pasture land and discharge of raw sewage through overflow points due to surcharges. The background chloride loadings, assuming a maximum background chloride concentration of 10 mg/l, are included in Figure 95 and illustrate the fact that the elevated chloride loadings in all the samples at sampling stations Ml-1, Ml-4, Ml-8, and Ml-11 are two to five times higher than the background loadings assumed.

The staff of the Metropolitan Sewerage District of the County of Milwaukee collected and analyzed samples for chlorides from the eight sites as described above in the lower reaches of the Milwaukee River and Lincoln Creek during the summers of 1964 through 1968. The average chloride concentrations recorded during the four-year sample period exhibited a fluctuating trend at each of the eight stations except at the North Avenue dam and the E. Cherry Street bridge where increasing trends were noted. Approximately 428 of the 654 chloride samples analyzed, exceeded the 10 mg/l background chloride concentration at all of the eight Metropolitan Sewerage District sample sites.

Fecal Coliform: Map 38 and the graphs thereon present the fecal coliform bacteria counts obtained in the Milwaukee River watershed during the sample period from August 1968 through August 1975. The samples collected in August 1968 showed fecal coliform counts slightly greater than 400 MFFCC/100 ml at sampling stations Ml-1, Ml-2, Ml-6, and Ml-9 and two to 10 times greater than 400 MFFCC/100 ml at sampling stations Ml-10,

Map 36

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE MILWAUKEE RIVER WATERSHED

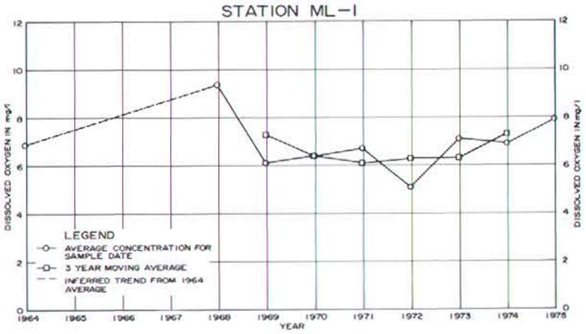


A comparison of the dissolved oxygen levels recorded in 1964 and 1975 indicated that dissolved oxygen concentrations increased at sampling stations MI-1, MI-5, and MI-11 on the main stem of the Milwaukee River while sampling station MI-3 on the main stem and MI-7 on Cedar Creek exhibited decreased dissolved oxygen levels. No significant change was observed at sampling station MI-4 on the North Branch of the Milwaukee River; MI-8 on Cedar Creek; or at sampling stations MI-6, MI-9, MI-10, or MI-12 on the main stem of the Milwaukee River. The maximum observed dissolved oxygen concentration was 21.3 mg/l at sampling station MI-9 on the Milwaukee River main stem. Sampling station MI-12, also on the main stem, recorded the minimum dissolved oxygen concentration of 0.3 mg/l.

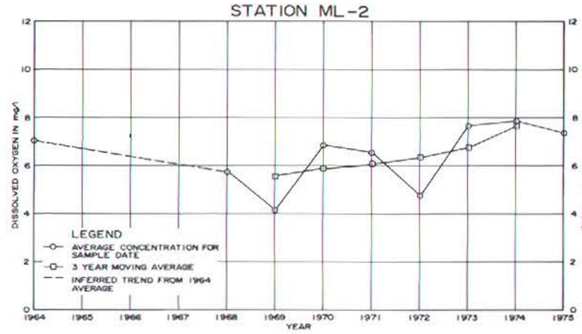
Source: SEWRPC.

Map 36 (continued)

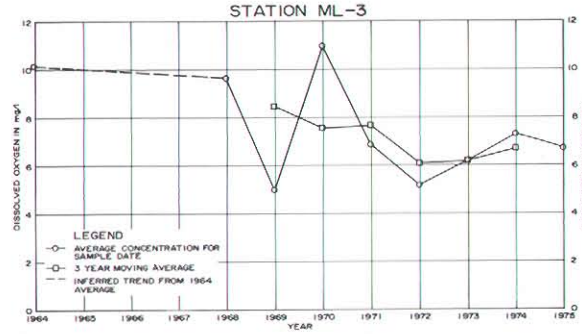
STATION ML-1



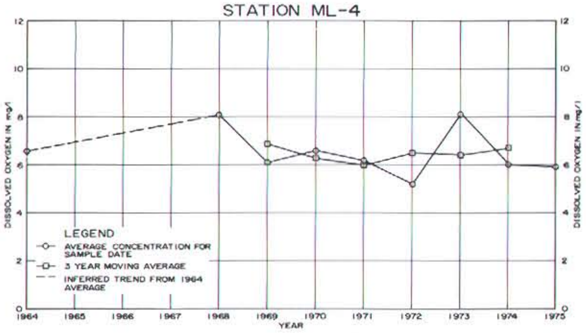
STATION ML-2



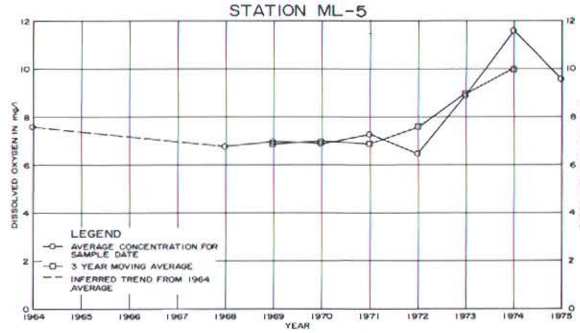
STATION ML-3



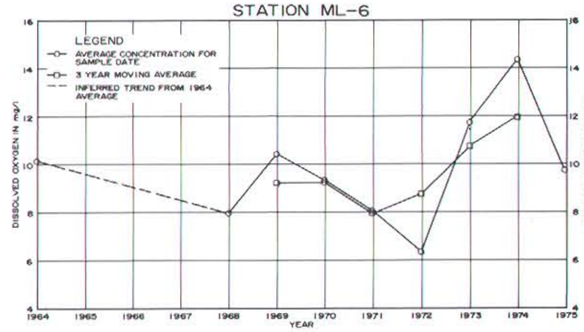
STATION ML-4



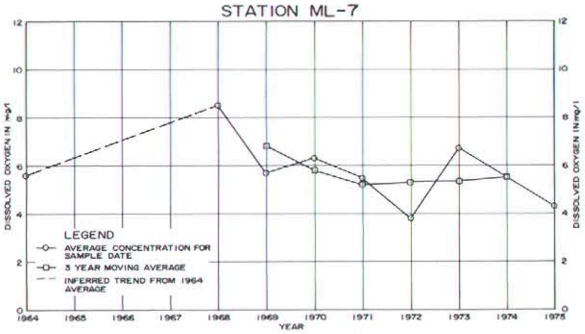
STATION ML-5



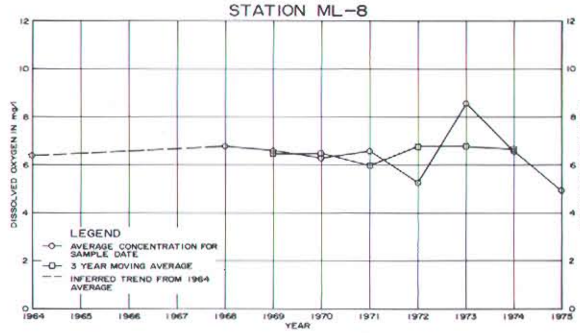
STATION ML-6



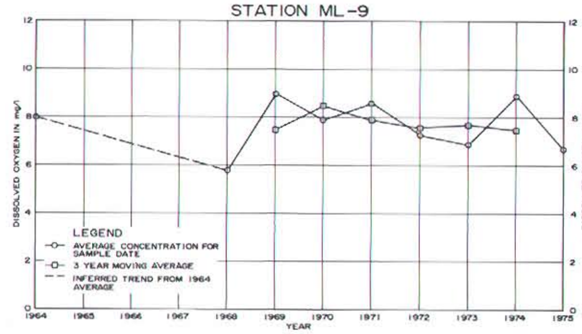
STATION ML-7



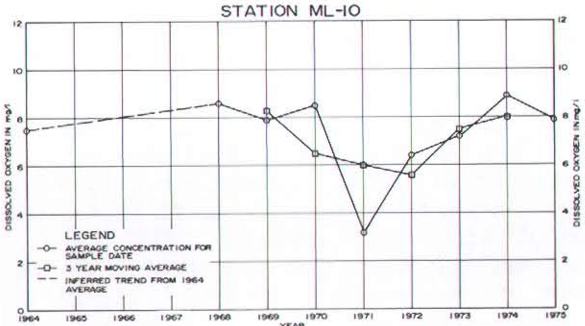
STATION ML-8



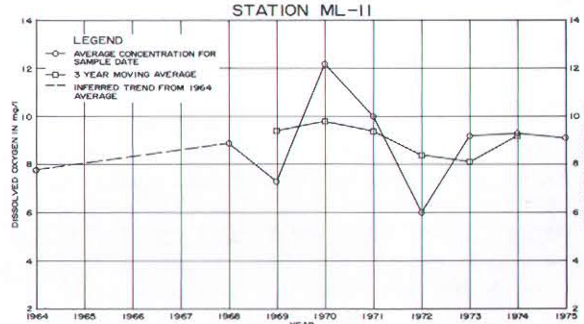
STATION ML-9



STATION ML-10



STATION ML-11



STATION ML-12

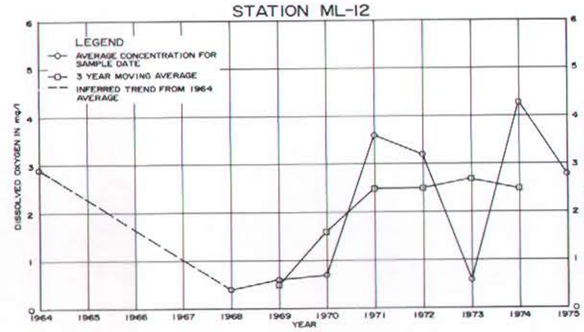
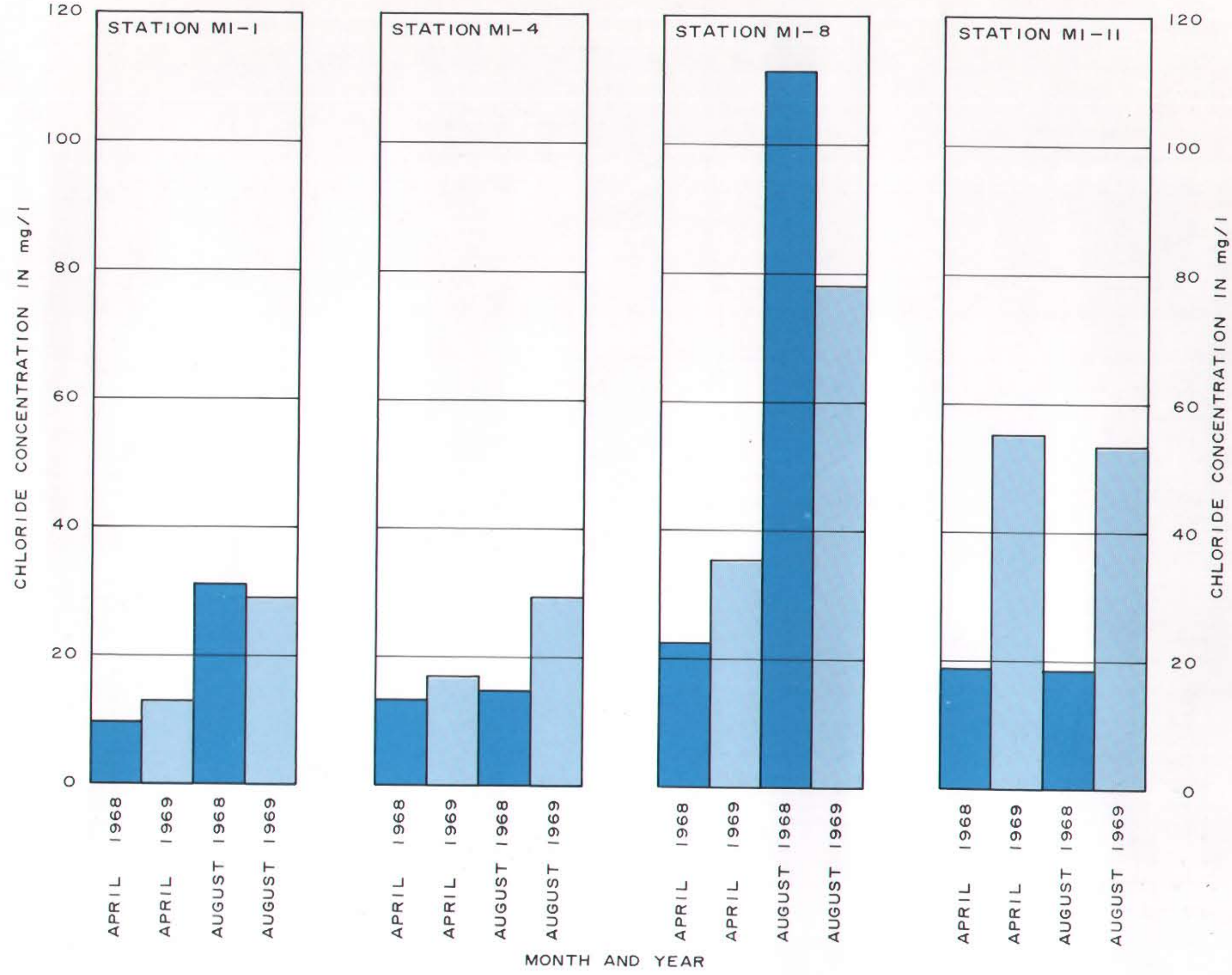


Figure 92

CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS MI-1, MI-4, MI-8, AND MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: APRIL AND AUGUST 1968-1969

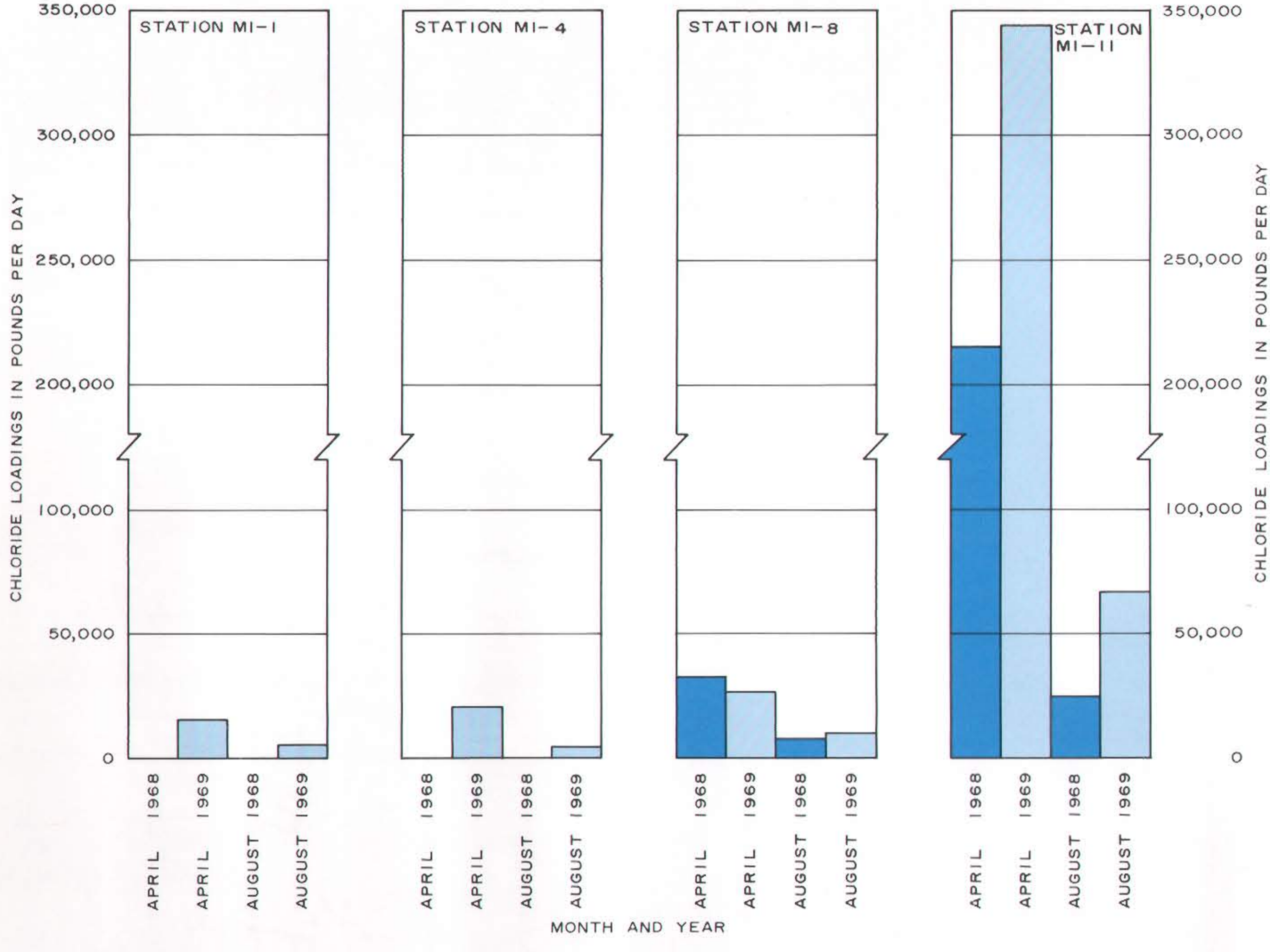


Source: SEWRPC.

Ml-11, and Ml-12 on the main stem of the Milwaukee River and Ml-7 and Ml-8 on Cedar Creek. A similar trend was noted in the August 1975 samples with fecal coliform counts in excess of 400 MFFCC/100 ml at sampling stations Ml-3, Ml-5, Ml-6, Ml-9, and Ml-11 located on the main stem of the Milwaukee River; Ml-4 located on the North Branch of the Milwaukee River; and Ml-7 and Ml-8, both located on Cedar Creek. Also, fecal coliform counts exceeding 2,000 MFFCC/100 ml were recorded at sampling station Ml-12 in August 1975. Thus, when 1968 and 1975 samples were compared, a decrease in the fecal coliform count is observed at sampling stations Ml-1, Ml-2, and Ml-10; an increase in the fecal coliform count is observed at sampling stations Ml-3 and Ml-5; and no change is apparent at sampling stations Ml-4, Ml-6 through Ml-9, Ml-11, and Ml-12. The graph on Map 38 illustrates the eight-year trend in fecal coliform counts at each station in the Milwaukee River watershed. Analysis of the three-year moving averages at each station indicates decreasing trends in the fecal coliform counts at sampling stations Ml-1, Ml-10, and Ml-11, all on the main stem of the Milwaukee River. The declining trend exhibited at sampling stations Ml-1 and Ml-10 may be attributed to the implementation of effluent disinfection through chlorination since 1971 at the Villages of Campbellsport and Thiensville sewage treatment facilities. The declining trend observed at sampling station Ml-11, near the confluence of Lincoln

Figure 93

CHLORIDE LOADINGS AT SAMPLING STATIONS MI-1, MI-4, MI-8, AND MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: APRIL AND AUGUST 1968-1969



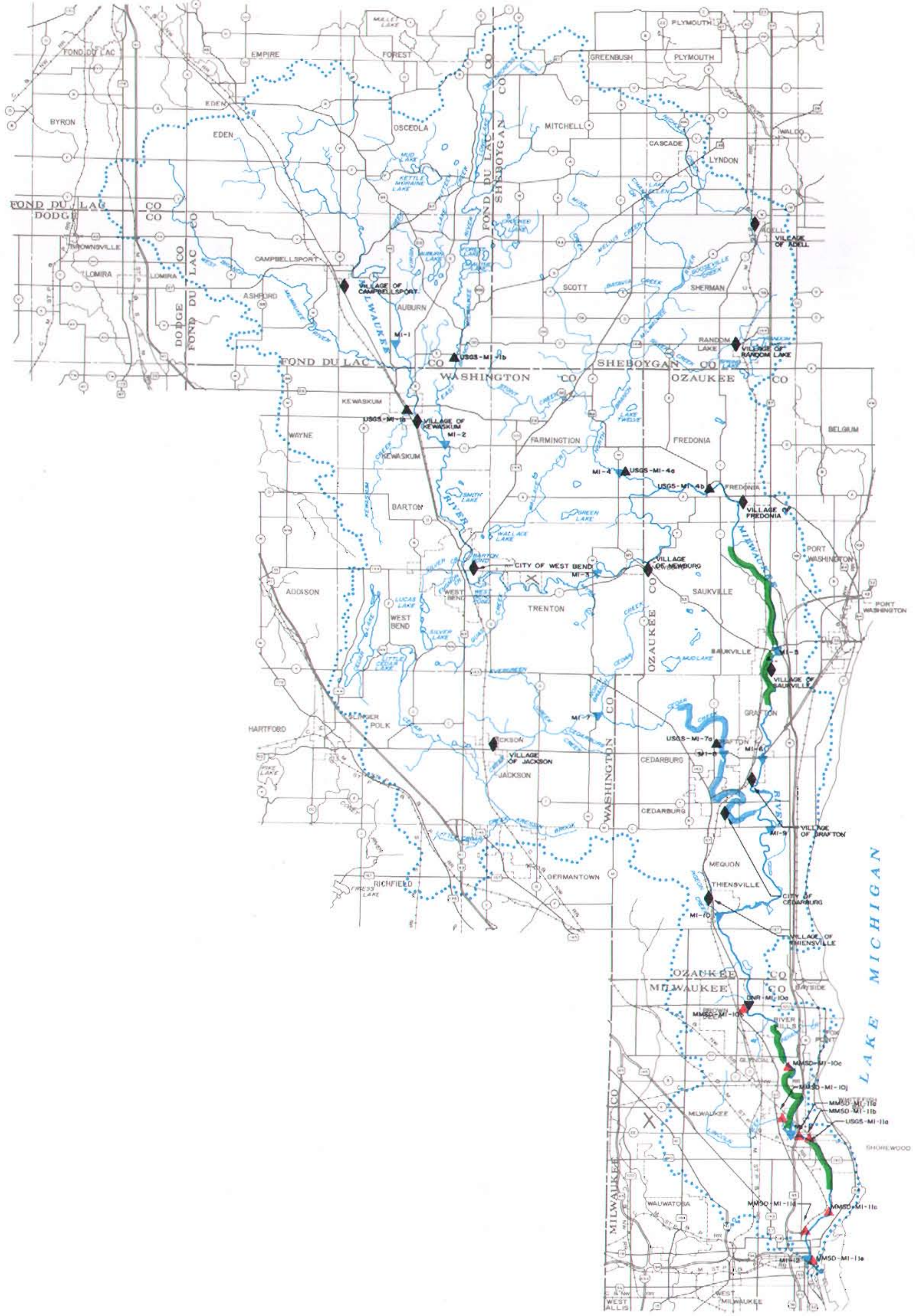
Source: SEWRPC.

Creek with the Milwaukee River, is assumed to be a result of fluctuations in the coliform counts or the test results, rather than a trend, since the two streams receive sanitary waste loadings from flow relief devices immediately upstream from the station, particularly during wet weather. An increasing trend was noted in the three-year moving averages at sampling stations MI-2, MI-3, MI-5, MI-9, and MI-12 on the main stem of the Milwaukee River; MI-4 on the North Branch of the Milwaukee River; and MI-7 and MI-8 on Cedar Creek. The increasing trends in fecal coliform counts recorded on the main stem of the Milwaukee River at sampling stations MI-2 and MI-9 is attributed to increased loading on the sewage treatment facilities located at the Villages of Kewaskum and Grafton and the City of Cedarburg. The trends at sampling stations MI-2 and MI-9 also are affected by runoff from agricultural land uses and onsite sewage disposal systems located on generally unsuitable soils along the River. The increasing trend at sampling station MI-5 may be due to installation of onsite sewage disposal systems on unsuitable soils along the River within and near the Village of Saukville. The sampling station at MI-12 is located in the combined sewer service area of the City of Milwaukee and receives sanitary waste loadings particularly during wet weather periods. Sampling station MI-12 also is affected by the Lake Michigan dilution effects. The increase in fecal coliform counts recorded at sampling station MI-4 can probably be accounted for by runoff from agricultural lands, as the sewage treatment facilities serving the Villages of Adell and Random Lake are considered located too far upstream to have any significant effect at that station. The increasing trend in

Map 37

COMPARISON OF CHLORIDE CONCENTRATIONS IN THE MILWAUKEE RIVER WATERSHED IN AUGUST 1964-1975

1964



LEGEND

SAMPLING STATION AND DESIGNATION

- DNR DNR-MI-10a
- SEWRPC MI-2
- SEWERAGE COMMISSION OF MILWAUKEE MMSD-MI-10b

CONTINUOUS STAGE RECORDER GAGE AND DESIGNATION

- USGS USGS-MI-4a

EXISTING SEWAGE TREATMENT FACILITIES

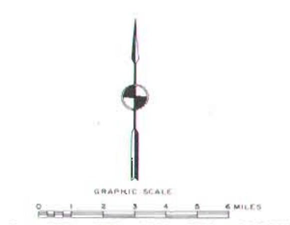
- PUBLIC
- NONINDUSTRIAL (PRIVATE)
- INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES

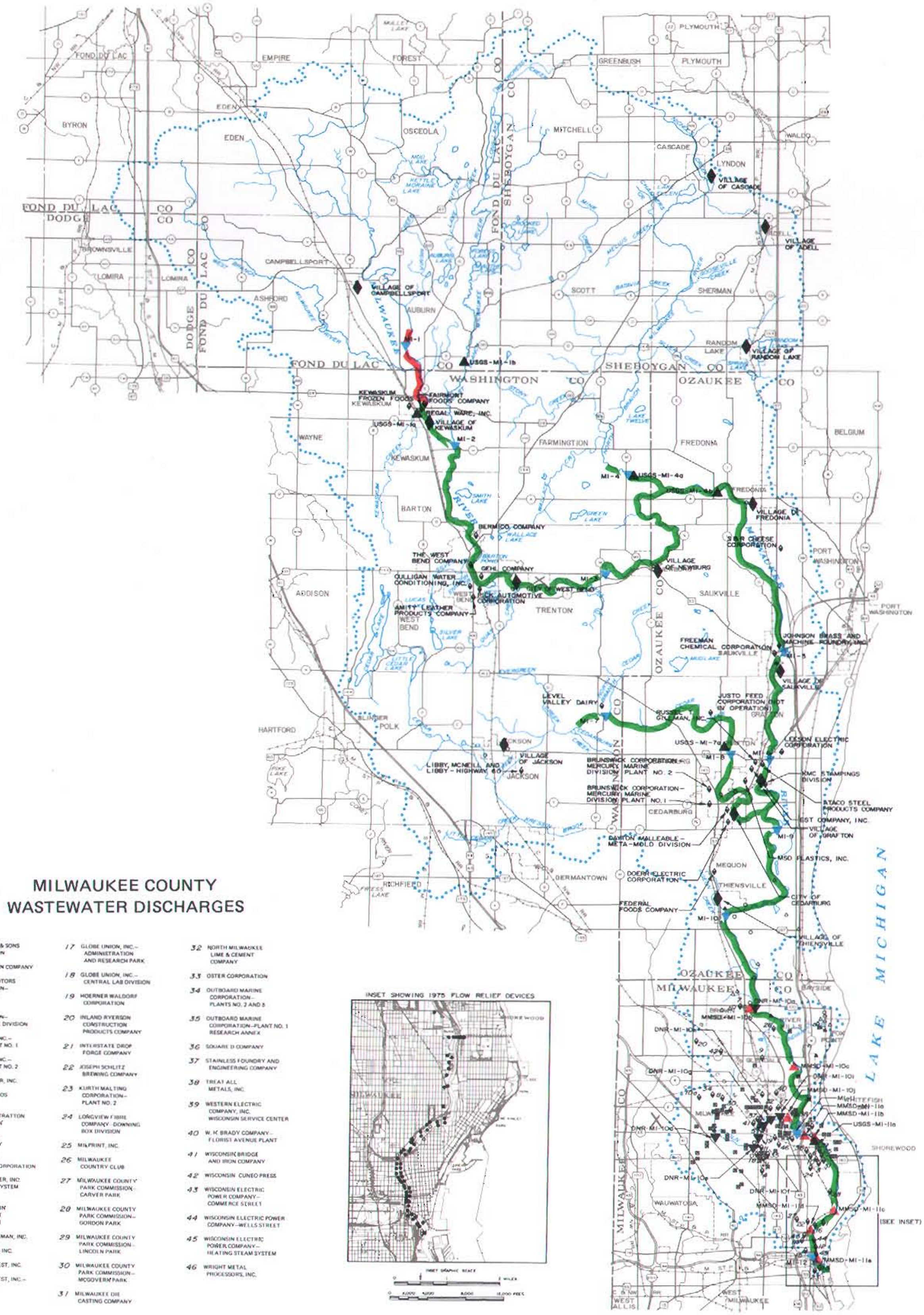
- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION

CHLORIDE CONCENTRATION IN mg/l

- LESS THAN 21
- 21 - 50
- (NONE) 51 - 70
- (NONE) 71 - 90
- (NONE) 91 - 120
- GREATER THAN 120
- NO DATA FOR INTERPRETATION



1975



MILWAUKEE COUNTY WASTEWATER DISCHARGES

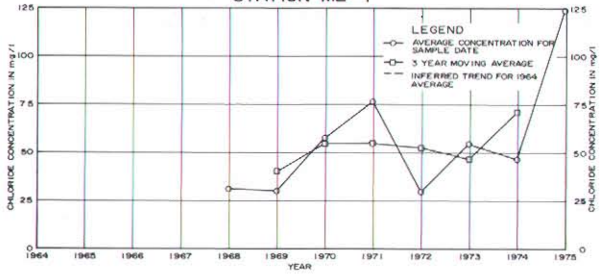
1 A. F. GALLUN & SONS CORPORATION
2 AMERICAN CAN COMPANY
3 AMERICAN MOTORS CORPORATION– BODY PLANT
4 A. O. SMITH CORPORATION– AUTOMOTIVE DIVISION
5 AQUA-CHEM, INC.– NORTH PLANT NO. 1
6 AQUA-CHEM, INC.– NORTH PLANT NO. 2
7 BADGER METER, INC.
8 BEATRICE FOODS COMPANY
9 BRIGGS AND STRATTON CORPORATION
10 CONTINENTAL CAN COMPANY
10a CONTINENTAL EQUIPMENT CORPORATION
11 CUTLER HAMMER, INC. INDUSTRIAL SYSTEM DIVISION
12 FIRST WISCONSIN DEVELOPMENT CORPORATION
13 FLORENCE EISEMAN, INC.
14 FRED USINGER, INC.
15 GIMBELS MIDWEST, INC.
16 GIMBELS MIDWEST, INC.– WAREHOUSE
17 GLOBE UNION, INC.– ADMINISTRATION AND RESEARCH PARK
18 GLOBE UNION, INC.– CENTRAL LAB DIVISION
19 HOERNER WALDORF CORPORATION
20 INLAND RYERSON CONSTRUCTION PRODUCTS COMPANY
21 INTERSTATE DROP FORGE COMPANY
22 JOSEPH SCHLITZ BREWING COMPANY
23 KURTH MALTING CORPORATION– PLANT NO. 2
24 LONGVIEW FIBRE COMPANY DOWNING BOX DIVISION
25 MILPRINT, INC.
26 MILWAUKEE COUNTRY CLUB
27 MILWAUKEE COUNTY PARK COMMISSION– CARVER PARK
28 MILWAUKEE COUNTY PARK COMMISSION– GORDON PARK
29 MILWAUKEE COUNTY PARK COMMISSION– LINCOLN PARK
30 MILWAUKEE COUNTY PARK COMMISSION– MCGOVERN PARK
31 MILWAUKEE DIE CASTING COMPANY
32 NORTH MILWAUKEE LIME & CEMENT COMPANY
33 OSTER CORPORATION
34 OUTBOARD MARINE CORPORATION– PLANTS NO. 2 AND 3
35 OUTBOARD MARINE CORPORATION–PLANT NO. 1 RESEARCH ANNEX
36 SQUARE D COMPANY
37 STAINLESS FOUNDRY AND ENGINEERING COMPANY
38 TREAT ALL METALS, INC.
39 WESTERN ELECTRIC COMPANY, INC. WISCONSIN SERVICE CENTER
40 W. H. BRADY COMPANY– FLORIST AVENUE PLANT
41 WISCONSIN BRIDGE AND IRON COMPANY
42 WISCONSIN CUNEO PRESS
43 WISCONSIN ELECTRIC POWER COMPANY– COMMERCE STREET
44 WISCONSIN ELECTRIC POWER COMPANY–WELLS STREET
45 WISCONSIN ELECTRIC POWER COMPANY– HEATING STEAM SYSTEM
46 WRIGHT METAL PROCESSORS, INC.

A comparison of the chloride concentrations recorded in 1964 and 1975 in the Milwaukee River watershed indicated that chloride concentrations on the main stem of the Milwaukee River increased at sampling station MI-8, while concentrations at sampling stations MI-5 and MI-11 on the main stem remained stable with no significant change. Data are not available for 1964 in order to make a comparison for the remaining stations. The maximum chloride concentration observed was 324.2 mg/l at sampling station MI-7, while a minimum chloride concentration of 5.0 mg/l was observed at sampling stations MI-1, MI-2, MI-4, MI-5, and MI-6.

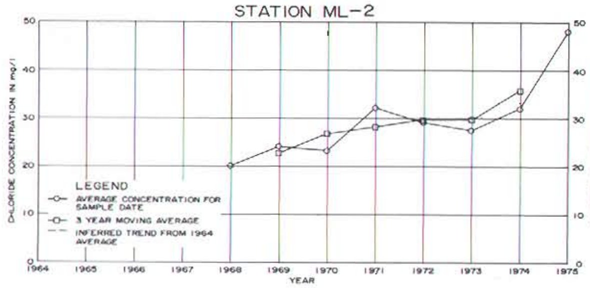
Source: SEWRPC.

Map 37 (continued)

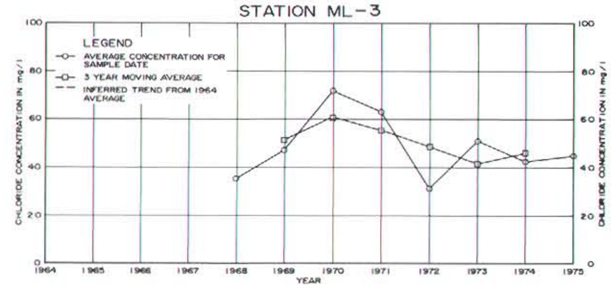
STATION ML-1



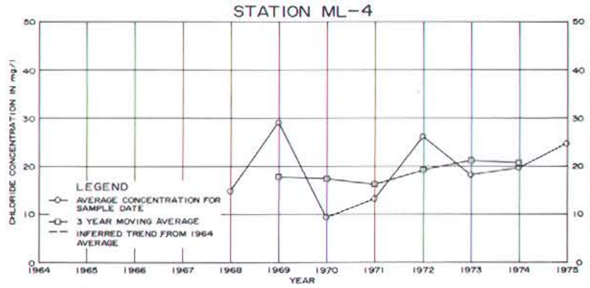
STATION ML-2



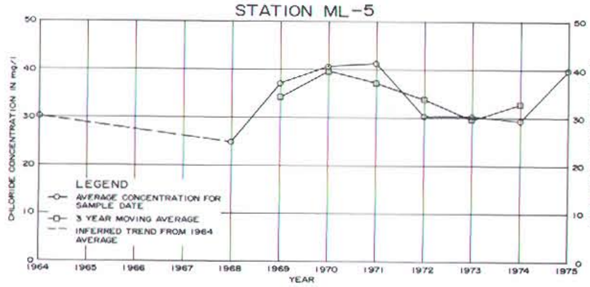
STATION ML-3



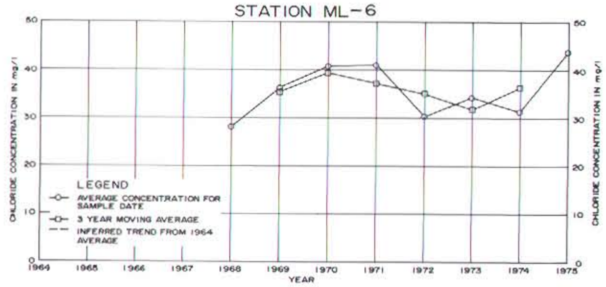
STATION ML-4



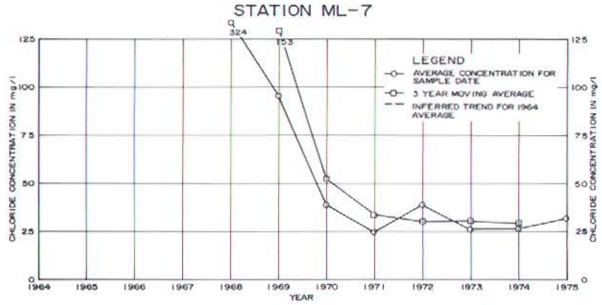
STATION ML-5



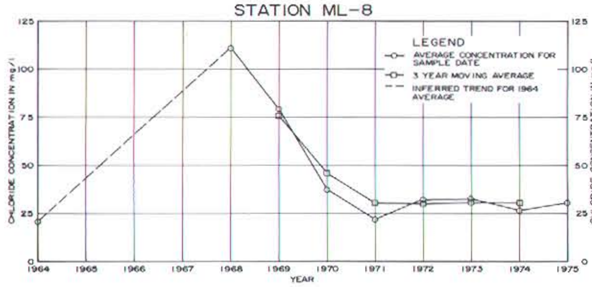
STATION ML-6



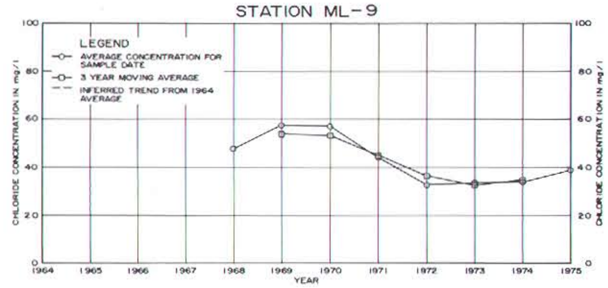
STATION ML-7



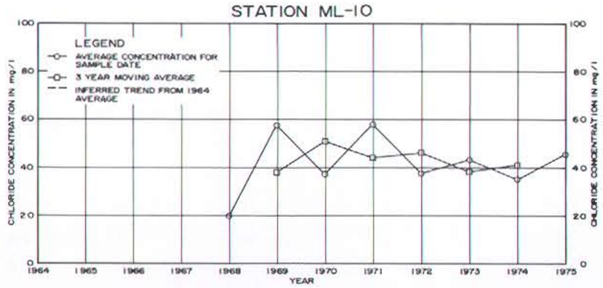
STATION ML-8



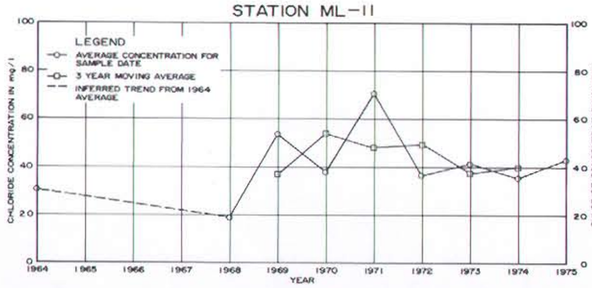
STATION ML-9



STATION ML-10



STATION ML-11



STATION ML-12

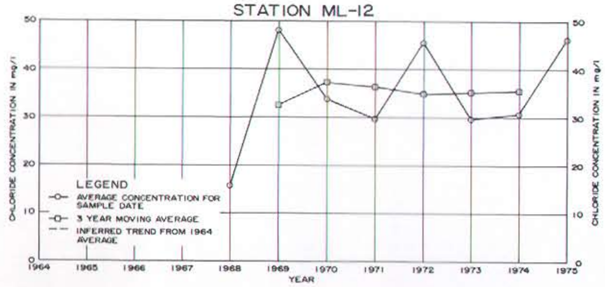
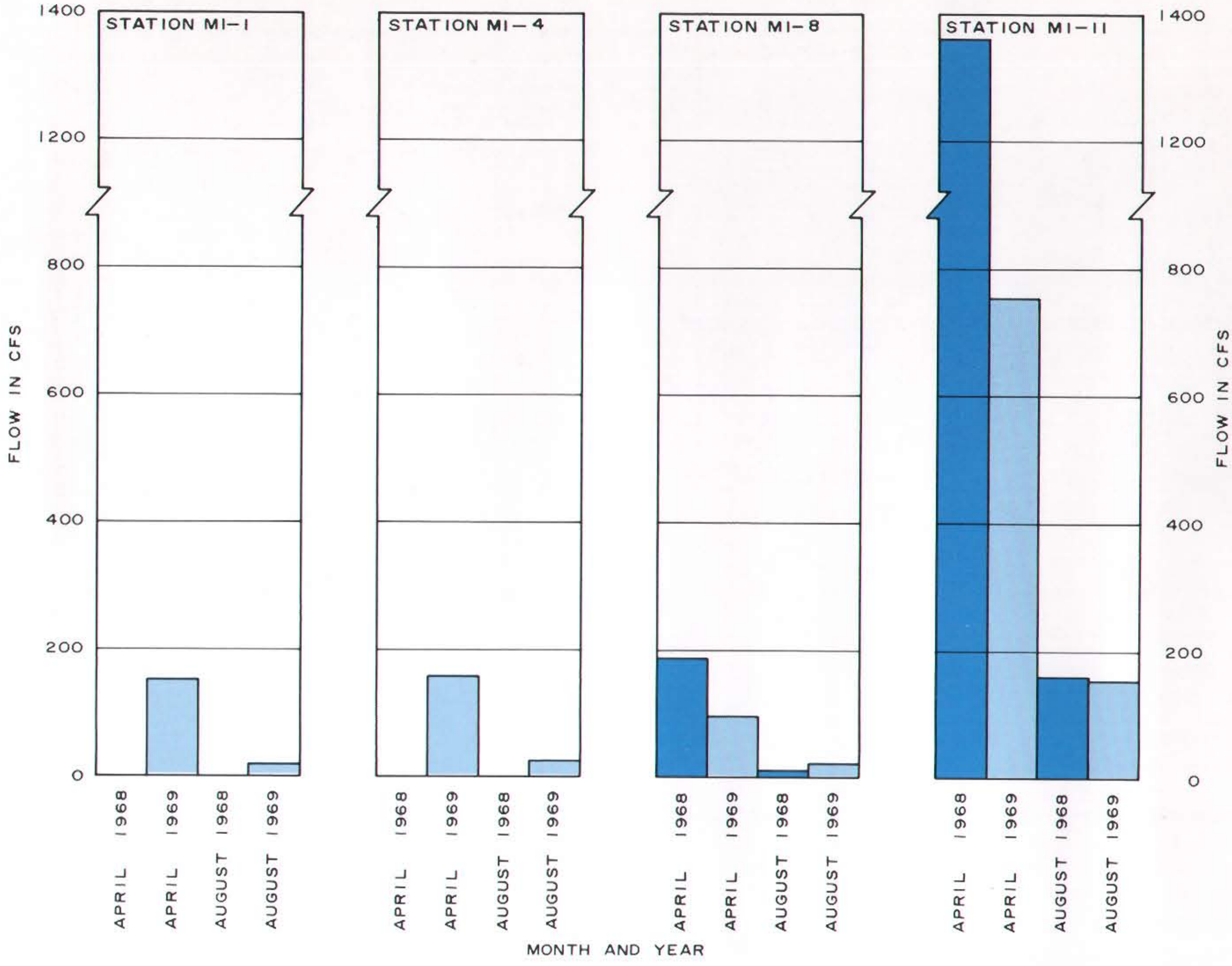


Figure 94

FLOW MEASUREMENTS AT SAMPLING STATIONS MI-1, MI-4, MI-8, AND MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: APRIL AND AUGUST 1968-1969



Source: SEWRPC.

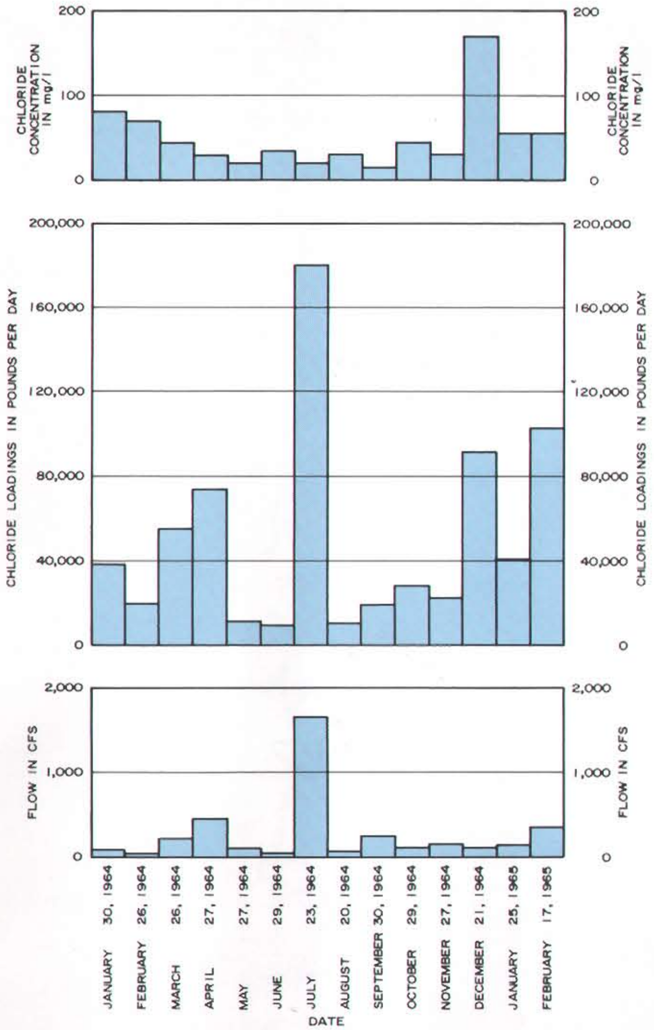
the three-year moving averages for fecal coliform counts recorded at sampling stations MI-7 and MI-8 during the eight surveys reflects increased loadings on the Village of Jackson sewage treatment plant as well as onsite sewage disposal systems located on unsuitable soils along the Creek.

Fluctuating levels in fecal coliform counts were recorded from 1968 to 1975 at sampling stations MI-3 and MI-6 on the main stem of the Milwaukee River. The fluctuating levels at sampling station MI-3 reflect waste loadings which arise from the City of West Bend sewage treatment plant discharge as well as from rural runoff. The waste loading which occurs at the Village of Saukville sewage treatment plant, combined with urban and rural runoff, accounts for fluctuating fecal coliform counts at sampling station MI-6.

Fecal coliforms were recorded by the Metropolitan Sewerage District staff during the summers of 1965 and 1966 at eight sites in the lower reaches of the Milwaukee River and Lincoln Creek. Specifically, samples were collected at the W. Brown Deer Road bridge, E. Green Tree Road bridge, N. Port Washington Road bridge, Estabrook Park, North Avenue dam, E. Cherry Street bridge, and E. Buffalo Street bridge located on the main stem of the Milwaukee River and the N. Green Bay Avenue bridge on Lincoln Creek. Additional samples were collected and

Figure 95

COMPARISON OF CHLORIDE CONCENTRATIONS, LOADINGS, AND FLOW AT SAMPLING STATION MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1965



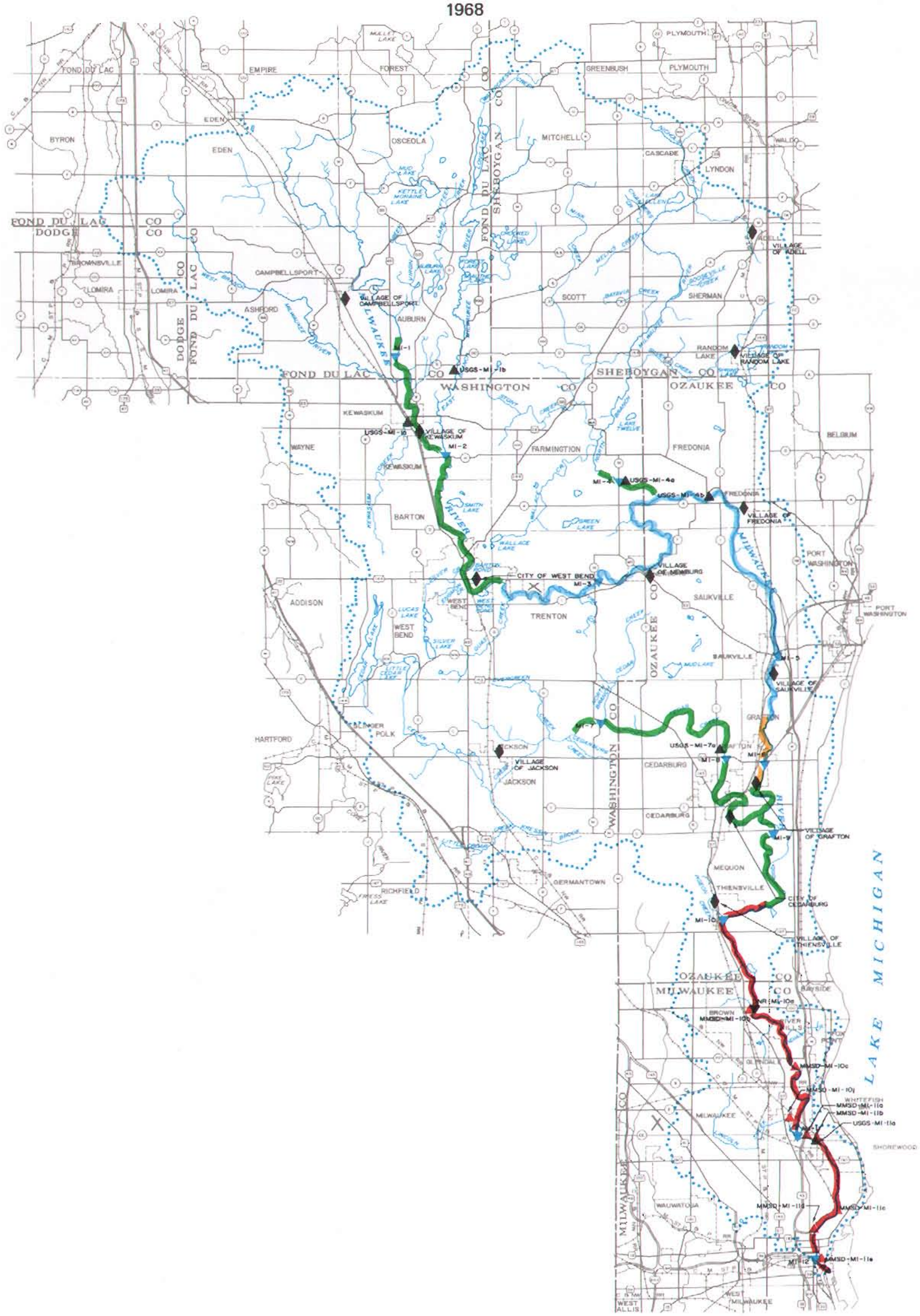
Source: SEWRPC.

analyzed for fecal coliform bacteria during the summers of 1967 and 1968 at three sites—the North Avenue dam, the E. Cherry Street bridge, and the E. Buffalo Street bridge—all located in the lower reaches of the Milwaukee River and affected by the dilution effects of Lake Michigan. The samples were collected on a weekly basis from May 1965 to September 1965, May 1966 to November 1966, June 1967 to September 1967, and June 1968 to August 1968. A comparison of the fecal coliform counts recorded by the Metropolitan Sewerage District staff at the W. Brown Deer Road bridge, E. Green Tree Road bridge, N. Port Washington Road bridge, and Estabrook Park with the applicable standard of 400 MFFCC/100 ml; and a comparison of the fecal coliform counts recorded at the N. Green Bay Avenue bridge, North Avenue dam, E. Cherry Street bridge and E. Buffalo Street bridge with the applicable standard of 2,000 MFFCC/100 ml indicates that the standard levels were exceeded in 104 of the 146 samples analyzed on the Milwaukee River and all of the 21 counts recorded on Lincoln Creek in 1965, 118 of the 175 counts recorded on the Milwaukee River and 24 of the 25 counts recorded on Lincoln Creek in 1966, 26 of the 39 counts recorded on the Milwaukee River in 1967, and 37 of the 39 counts recorded on the Milwaukee River in 1968.

In addition, samples were collected and analyzed for fecal coliform bacteria by the City of Milwaukee Health Department at five locations in the lower reaches of the Milwaukee River in 1975. Fecal coliform counts also were recorded at six locations on Lincoln Creek in 1974 and 1975. Specifically, the samples were collected at W. Silver Spring Drive, E. North Avenue, N. Holton Street, E. Kilbourn Avenue, and the mouth of the Milwaukee River in 1974 and 1975. Two additional samples were collected at N. Commerce Street and E. Pleasant Street in 1975. The six locations along Lincoln Creek for which fecal coliform counts were recorded by the City of Milwaukee Health Department staff in 1974 and 1975 are W. Good Hope Road, W. Silver Spring Drive, N. 42nd Street, N. 35th Street, N. Teutonia Avenue, and N. Green Bay Avenue. The fecal coliform counts were found to range from less than 20 MFFCC/100 ml to 380,000 MFFCC/100 ml in the lower reaches of the Milwaukee River in 1974. Based on these data the 1974 average fecal coliform counts exceeded the standard of 400 MFFCC/100 ml at W. Silver Spring Drive with an average for 23 samples of 2,800 MFFCC/100 ml and the counts exceeded the standard of 2,000 MFFCC/100 ml at E. Kilbourn Avenue with the average of 22 fecal coliform counts being 4,400 MFFCC/100 ml. A total of 130 samples was collected and analyzed for fecal coliform in Lincoln Creek and the results ranged from 20 MFFCC/100 ml to 280,000 MFFCC/100 ml. The standard of 2,000 MFFCC/100 ml established for Lincoln Creek was exceeded by the average counts recorded at three of the six stations. The average fecal coliform counts of 22 samples collected were 2,400 MFFCC/100 ml, 2,000 MFFCC/100 ml, and 2,200 MFFCC/100 ml at the stations at N. 42nd Street, N. 35th Street, and N. Green Bay Avenue, respectively. The fecal coliform counts ranged from less than 20 MFFCC/100 ml to 170,000 MFFCC/100 ml in the lower reaches of the Milwaukee River in 1975. Based on these data, the 1975 average fecal coliform counts exceeded the standard of 400 MFFCC/100 ml for the Milwaukee River at W. Silver Spring Drive, with an average of 800 MFFCC/100 ml computed for the 22 samples. The 1975 average fecal coliform counts for the Milwaukee River also exceeded the standard of 2,000 MFFCC/100 ml at E. Kilbourn Avenue with an average of 3,000 MFFCC/100 ml based on the 22 samples taken there. A total of 124 samples was collected and analyzed for fecal coliforms in the Lincoln Creek and ranged from less than 20 MFFCC/100 ml to 54,000 MFFCC/100 ml. Samples with fecal coliform counts exceeding the applicable standard of 2,000 MFFCC/100 ml were recorded at all six stations on Lincoln Creek.

Map 38

COMPARISON OF FECAL COLIFORM COUNTS IN THE MILWAUKEE RIVER WATERSHED IN AUGUST 1968-1975



LEGEND

SAMPLING STATION AND DESIGNATION

- DNR DNR-MI-10a
- SEWRPC MI-2
- SEWERAGE COMMISSION OF MILWAUKEE MMSD-MI-10b

CONTINUOUS STAGE RECORDER GAGE AND DESIGNATION

- USGS USGS-MI-4a

EXISTING SEWAGE TREATMENT FACILITIES

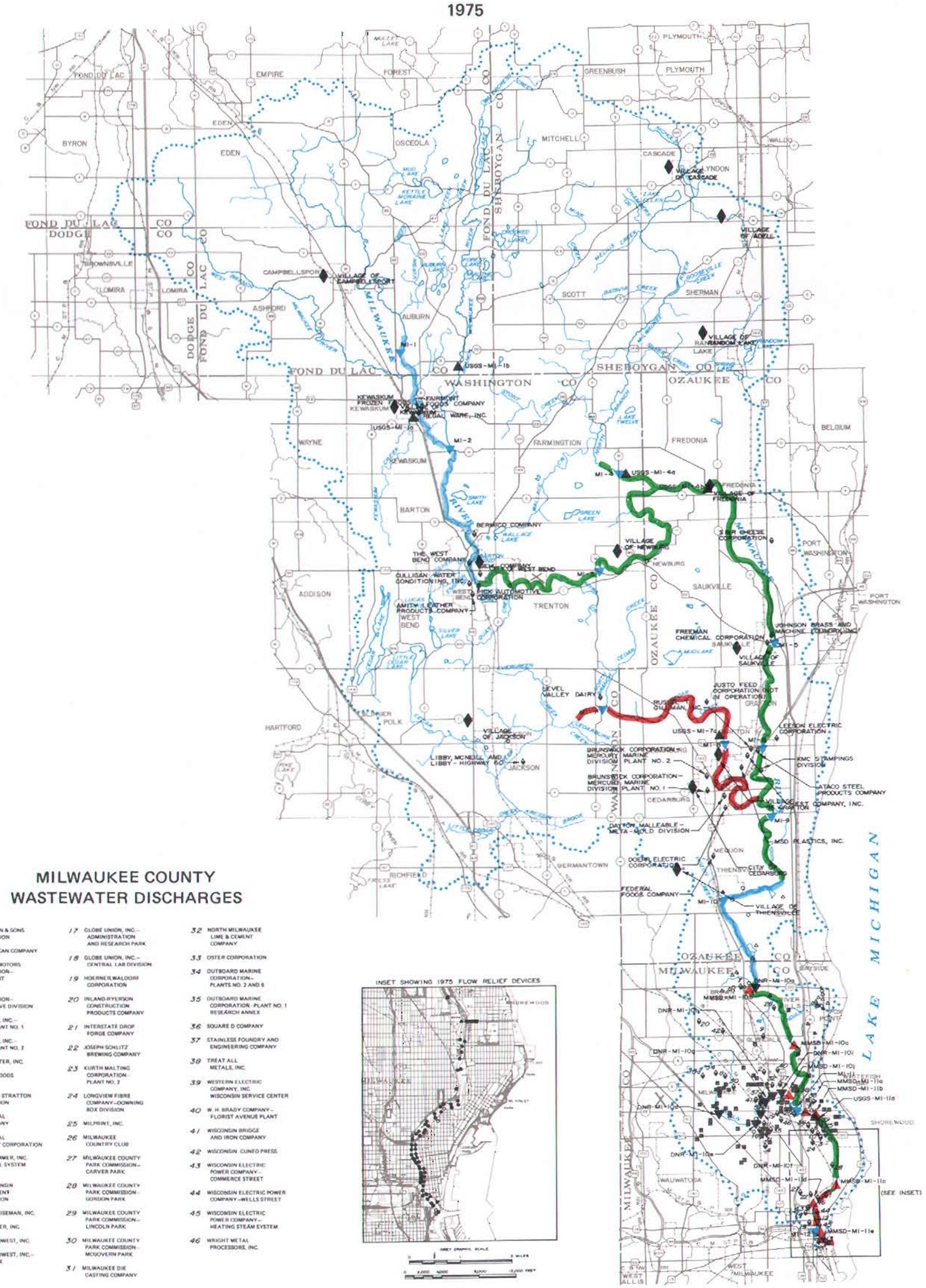
- PUBLIC
- NONINDUSTRIAL (PRIVATE)
- INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION

FECAL COLIFORM COUNTS IN MFFCC/100 ml

- LESS THAN 400
- 400 - 999
- 1,000 - 1,999
- GREATER THAN 1,999
- NO DATA FOR INTERPRETATION



MILWAUKEE COUNTY WASTEWATER DISCHARGES

1 A. F. GALLUN & SONS CORPORATION
2 AMERICAN CAN COMPANY
3 AMERICAN MOTORS CORPORATION–BODY PLANT
4 A. O. SMITH CORPORATION–AUTOMOTIVE DIVISION
5 AQUA-CHEM, INC.–NORTH PLANT NO. 1
6 AQUA-CHEM, INC.–NORTH PLANT NO. 2
7 BADGER METER, INC.
8 BEATRICE FOODS COMPANY
9 BRIGGS AND STRATTON CORPORATION
10 CONTINENTAL CAN COMPANY
10a CONTINENTAL EQUIPMENT CORPORATION
11 CUTLER-HAMMER, INC. INDUSTRIAL SYSTEM DIVISION
12 FIRST WISCONSIN DEVELOPMENT CORPORATION
13 FLORENCE EISEMAN, INC.
14 FRED USINGER, INC.
15 GIMBELS MIDWEST, INC.
16 GIMBELS MIDWEST, INC.–WAREHOUSE
17 GLOBE UNION, INC.–ADMINISTRATION AND RESEARCH PARK
18 GLOBE UNION, INC.–CENTRAL LAB DIVISION
19 HOERNER-WALDORF CORPORATION
20 INLAND-RYERSON CONSTRUCTION PRODUCTS COMPANY
21 INTERSTATE DROP FORGE COMPANY
22 JOSEPH SCHLITZ BREWING COMPANY
23 KURTH MALTING CORPORATION–PLANT NO. 2
24 LONGVIEW FIBRE COMPANY–DOWNING BOX DIVISION
25 MILPRINT, INC.
26 MILWAUKEE COUNTRY CLUB
27 MILWAUKEE COUNTY PARK COMMISSION–CARVER PARK
28 MILWAUKEE COUNTY PARK COMMISSION–GORDON PARK
29 MILWAUKEE COUNTY PARK COMMISSION–LINCOLN PARK
30 MILWAUKEE COUNTY PARK COMMISSION–MCGOVERN PARK
31 MILWAUKEE DIE CASTING COMPANY
32 NORTH MILWAUKEE LIME & CEMENT COMPANY
33 OSTER CORPORATION
34 OUTBOARD MARINE CORPORATION–PLANTS NO. 2 AND 6
35 OUTBOARD MARINE CORPORATION–PLANT NO. 1 RESEARCH ANNEX
36 SQUARE D COMPANY
37 STAINLESS FOUNDRY AND ENGINEERING COMPANY
38 TREAT ALL METALS, INC.
39 WESTERN ELECTRIC COMPANY, INC. WISCONSIN SERVICE CENTER
40 W. H. BRADY COMPANY–FLORIST AVENUE PLANT
41 WISCONSIN BRIDGE AND IRON COMPANY
42 WISCONSIN CUNEO PRESS
43 WISCONSIN ELECTRIC POWER COMPANY–COMMERCE STREET
44 WISCONSIN ELECTRIC POWER COMPANY–WELLS STREET
45 WISCONSIN ELECTRIC POWER COMPANY–HEATING STEAM SYSTEM
46 WRIGHT METAL PROCESSORS, INC.

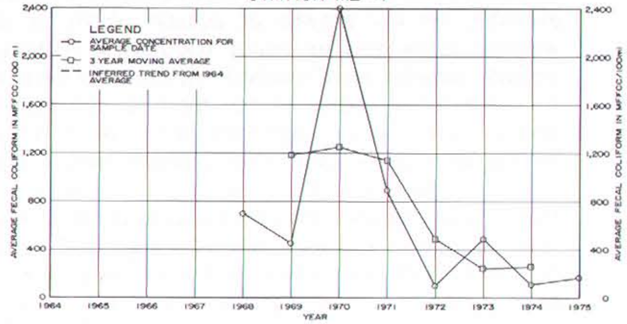
INSET SHOWING 1975 FLOW RELIEF DEVICES

A comparison of fecal coliform counts recorded in 1968 and 1975 in the Milwaukee River watershed indicated that sampling stations MI-7 and MI-8 on Cedar Creek and sampling stations MI-3, MI-5, MI-10, and MI-11 on the Milwaukee River main stem exhibited increased fecal coliform counts, while sampling stations MI-1, MI-2, and MI-6 exhibited a decrease in fecal coliform counts. No significant long-term changes were observed at sampling station MI-4 on Cedar Creek, or sampling stations MI-9 and MI-12 on the Milwaukee River main stem. The maximum fecal coliform count was 40,000 MFFCC/100 ml at sampling station MI-11, while a minimum fecal coliform count of 10 MFFCC/100 ml was observed at sampling stations MI-6 and MI-9.

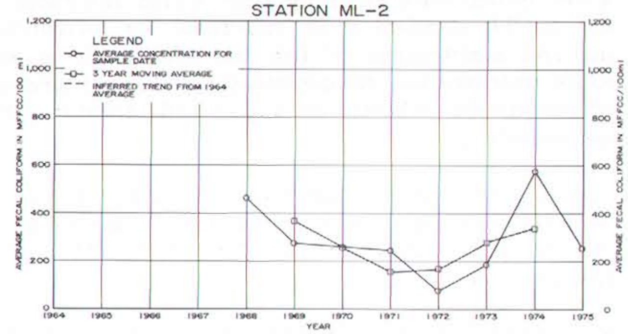
Source: SEWRPC.

Map 38 (continued)

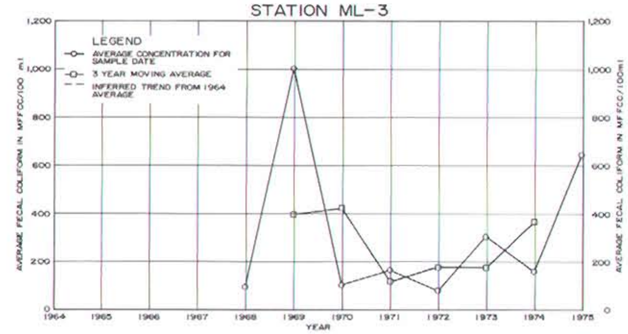
STATION ML-1



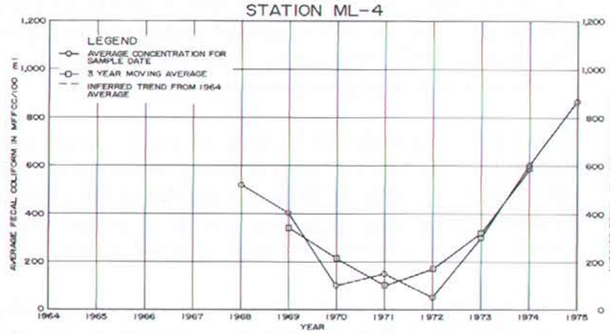
STATION ML-2



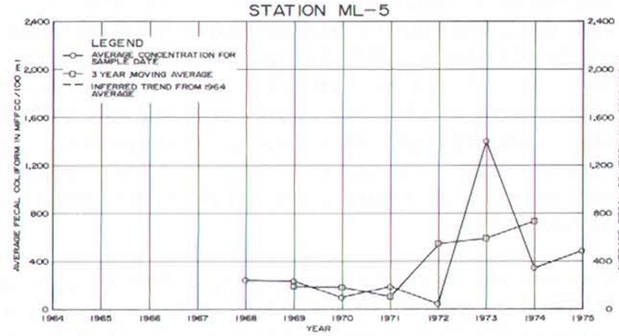
STATION ML-3



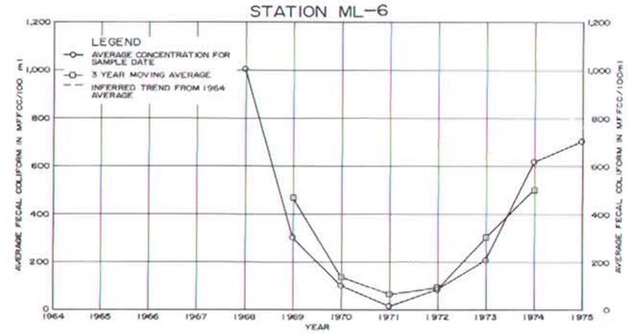
STATION ML-4



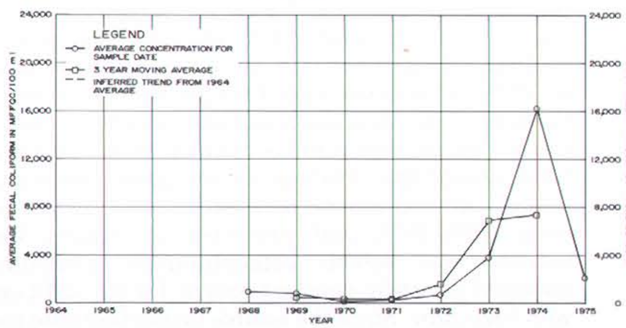
STATION ML-5



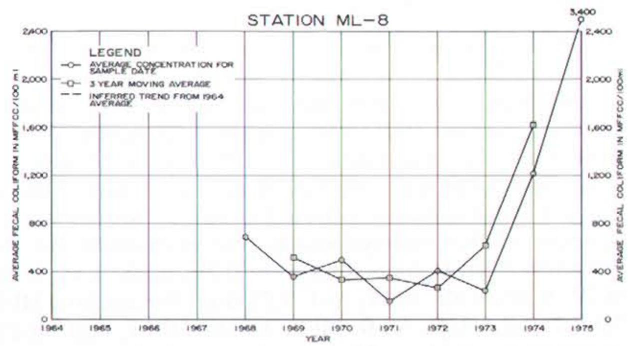
STATION ML-6



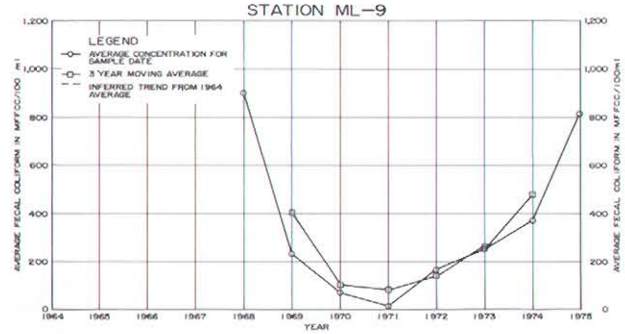
STATION ML-7



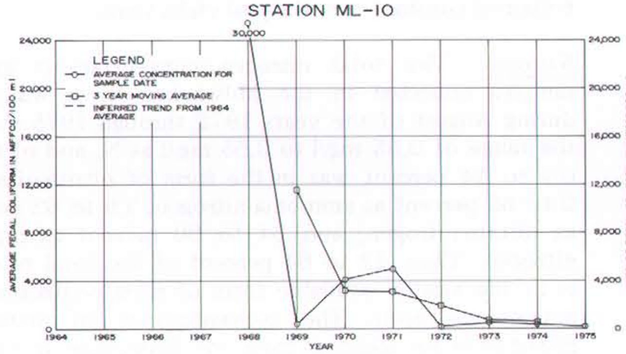
STATION ML-8



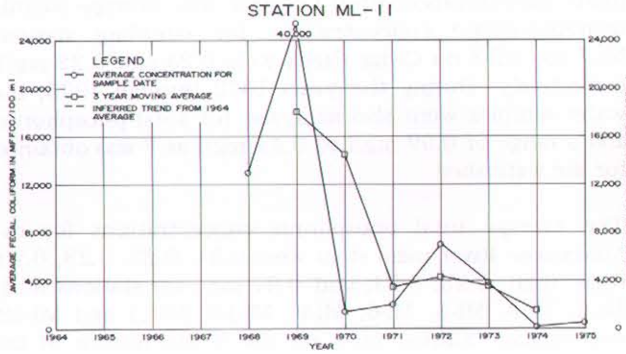
STATION ML-9



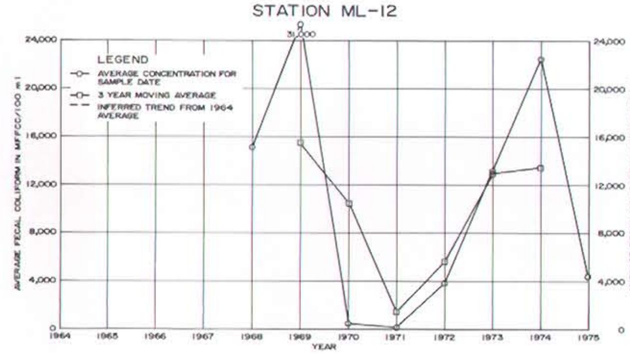
STATION ML-10



STATION ML-11



STATION ML-12



Hydrogen Ion Concentrations (pH): As indicated in Table 108-119, the pH values of the watershed surface water system have generally been within the range of 6.0 to 9.0 standard units prescribed for recreational use and maintenance of fish and aquatic life as well as for restricted use. No detectable trend in pH variation of the samples collected in August 1964 through 1975 was observed.

Specific Conductance: Specific conductance, a measure of total dissolved ions in water, was in the range of 401 to 1,550 μmhos/cm at 25°C in the Milwaukee River watershed.

The average specific conductances at 25°C for the Milwaukee River main stem were 741, 603, 692, 631, 630, 663, 668, 609, and 499 μmhos/cm for sampling stations Ml-1, Ml-2, Ml-3, Ml-5, Ml-6, Ml-9, Ml-10, Ml-11, and Ml-12, respectively. Station Ml-4 on the North Branch of the Milwaukee River had an average specific conductance at 25°C of 614 μmhos/cm. The average specific conductance at 25°C for Cedar Creek stations Ml-7 and Ml-8 were 614 and 624 umhos/cm, respectively. The highest specific conductance value of 1,550 umhos/cm was recorded at sampling station Ml-7 on Cedar Creek in August 1968.

Temperature: As indicated in Tables 108 to 119, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the 12 sampling stations located in the Milwaukee River watershed during August 1968 through August 1975 were analyzed for soluble orthophosphate concentrations. A range of 0.03 mg/l to 2.38 mg/l of soluble orthophosphate as P was obtained for the eight samples collected at the 12 locations. The average soluble orthophosphate concentrations for the Milwaukee River main stem were 0.30, 0.29, 0.44, 0.24, 0.19, 0.40, 0.39, 0.45, and 0.25 mg/l for stations Ml-1, Ml-2, Ml-3, Ml-5, Ml-6, Ml-9, Ml-10, Ml-11, and Ml-12, respectively. Station Ml-4 on the North Branch of the Milwaukee River reported an average soluble orthophosphate concentration of 0.17 mg/l. The average soluble orthophosphate concentrations for sampling stations Ml-7 and Ml-8 on Cedar Creek were 0.23 and 0.22 mg/l, respectively. During the years 1972 through 1975, the water samples were also analyzed for total phosphorus, and a range of 0.09 mg/l to 0.44 mg/l as P was obtained for the watershed.

The average total phosphorus concentrations for the Milwaukee River main stem were 0.34, 0.23, 0.28, 0.29, 0.26, 0.26, 0.25, 0.24, and 0.27 mg/l for stations Ml-1, Ml-2, Ml-3, Ml-5, Ml-6, Ml-9, Ml-10, Ml-11 and Ml-12, respectively. Station Ml-4 on the North Branch of the Milwaukee River reported an average total phosphorus concentration of 0.30 mg/l. The average total phosphorus concentrations for sampling stations Ml-7 and Ml-8 on Cedar Creek were 0.28 and 0.31 mg/l, respectively.

The high ratio—ranging from 0.1 to 1.0—of soluble orthophosphate to total phosphorus in the water samples indicates that most of the phosphorus is in a form readily available for the growth of aquatic plants in the Milwaukee River and its major tributaries. Although not enough samples were available in the four years of data to characterize trends in the total phosphorus concentrations with time, especially with the 1972 sample having been taken soon after a heavy rain, it is evident from the data that the concentrations are many times higher than required for profuse algal growth. A level of total phosphorus of less than 0.10 mg/l as P is generally held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants. All of the water samples collected at the sampling stations on the Milwaukee River, the North Branch of the Milwaukee River, and Cedar Creek exhibited total phosphorus levels higher than 0.10 mg/l as P with the exception of one sample collected at Ml-2 in August 1975 and one sample collected at Ml-11 in August 1972 when the total phosphorus values were 0.09 and 0.08 mg/l, respectively.

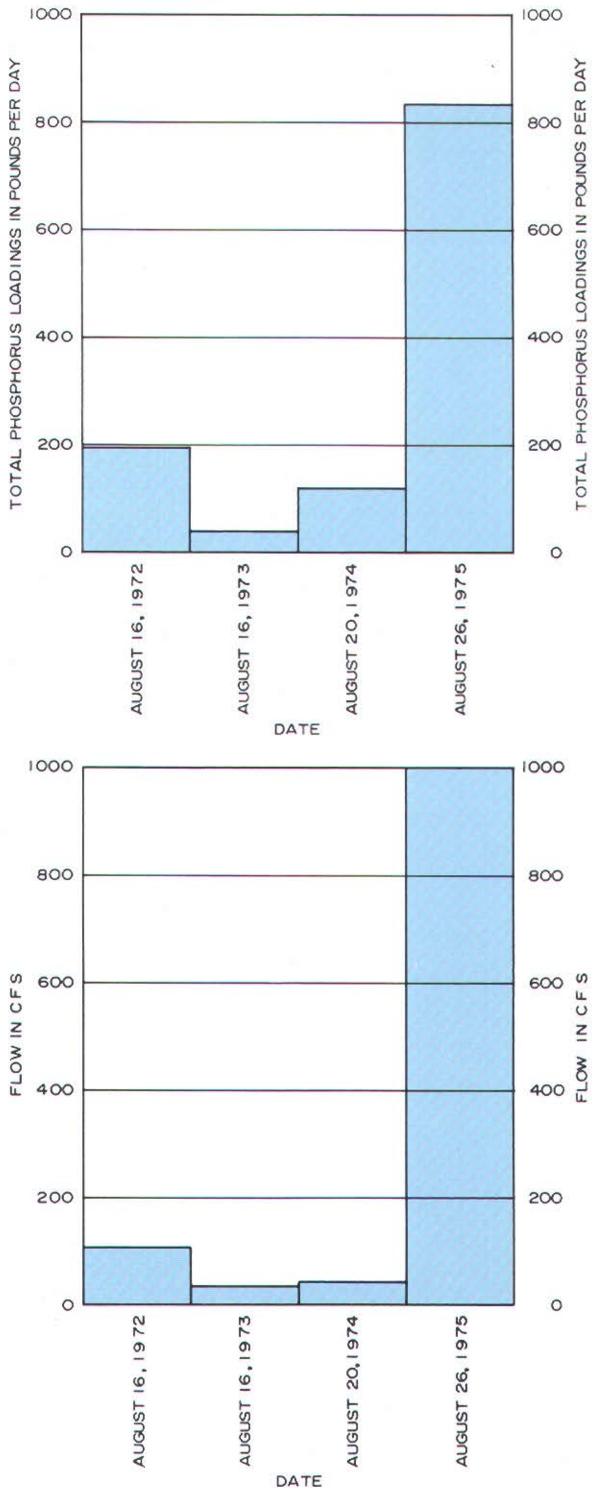
The 1968 through 1975 data obtained from the water samples collected by the Wisconsin Department of Natural Resources at DNR-Ml-10a also exhibited total phosphorus values higher than 0.10 mg/l as P in all but one sample with a range of from 0.09 mg/l to 0.88 mg/l as P.

Figures 96-99 present the total phosphorus loading and flow for sampling stations Ml-2 and Ml-11 on the main stem of the Milwaukee River and Ml-4 on the North Branch of the Milwaukee River, for the samples collected in August 1972, 1973, and 1974, and for sampling station Ml-8 on Cedar Creek for samples collected in August 1973, 1974, and 1975. Since the total phosphorus loadings followed the flow pattern—in that the high flow of 1972 had increased the total phosphorus loading into the River—and since the remaining three years of data are so few, no attempt is made to characterize a trend in the total phosphorus loadings in the River. However, the soluble orthophosphate data which are available for the years 1968-1975 and presented in Figures 100-103 indicate that soluble orthophosphate concentrations remained generally constant except for the 1972 samples with high flow. Since the soluble orthophosphate concentrations constituted between 10 and 100 percent of total phosphorus, it is likely the total phosphorus loadings also remained constant over the past eight years.

Nitrogen: The total nitrogen concentrations in the samples collected in the Milwaukee River watershed during August of the years 1972 through 1975 were in the range of 0.53 mg/l to 3.55 mg/l as N, and of these, 0.4 to 14 percent was in the form of nitrite-nitrogen, 0 to 53 percent as ammonia-nitrogen, 7.9 to 62 percent as nitrate-nitrogen, and 34 to 90 percent as organic-nitrogen. Thus, 12 to 64 percent of the total nitrogen is in the readily available form of nitrate-nitrogen and ammonia-nitrogen. The concentrations of ammonia-nitrogen in the samples from the Milwaukee River, the North Branch of the Milwaukee River, and Cedar Creek ranged from 0.03 mg/l to 0.77 mg/l as N, well below the known toxic level of 2.5 mg/l for ammonia-nitrogen as N. However, on 21 of the 88 sampling dates, the ammonia-

Figure 96

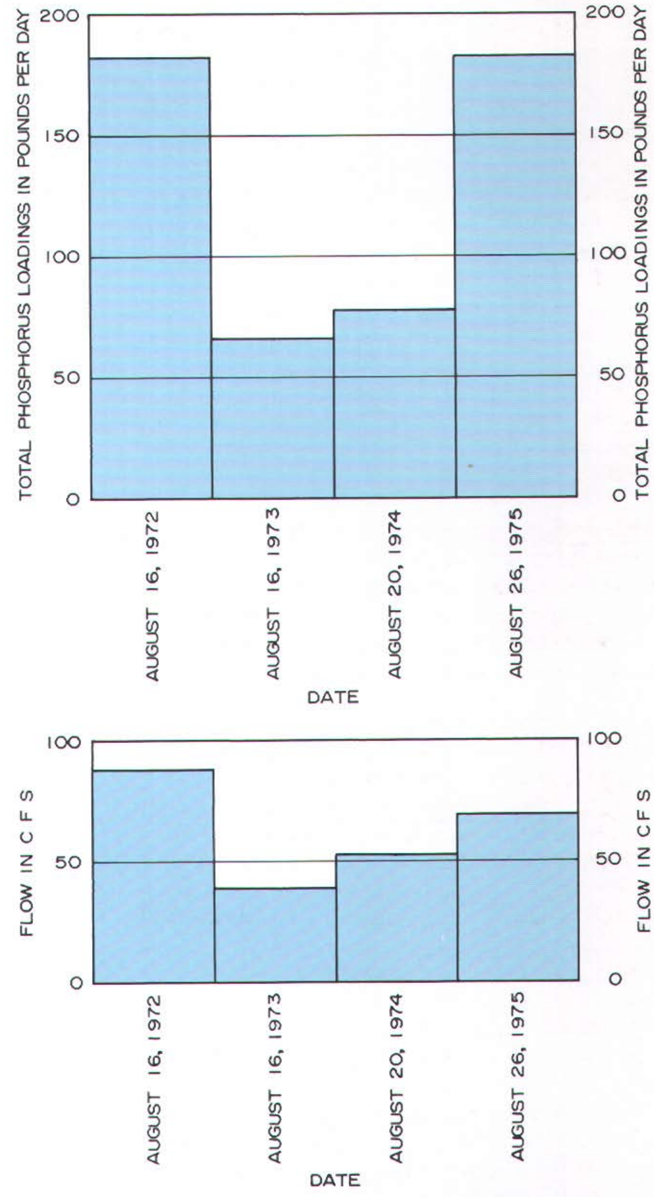
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT SAMPLING STATION MI-2 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 97

COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT SAMPLING STATION MI-4 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



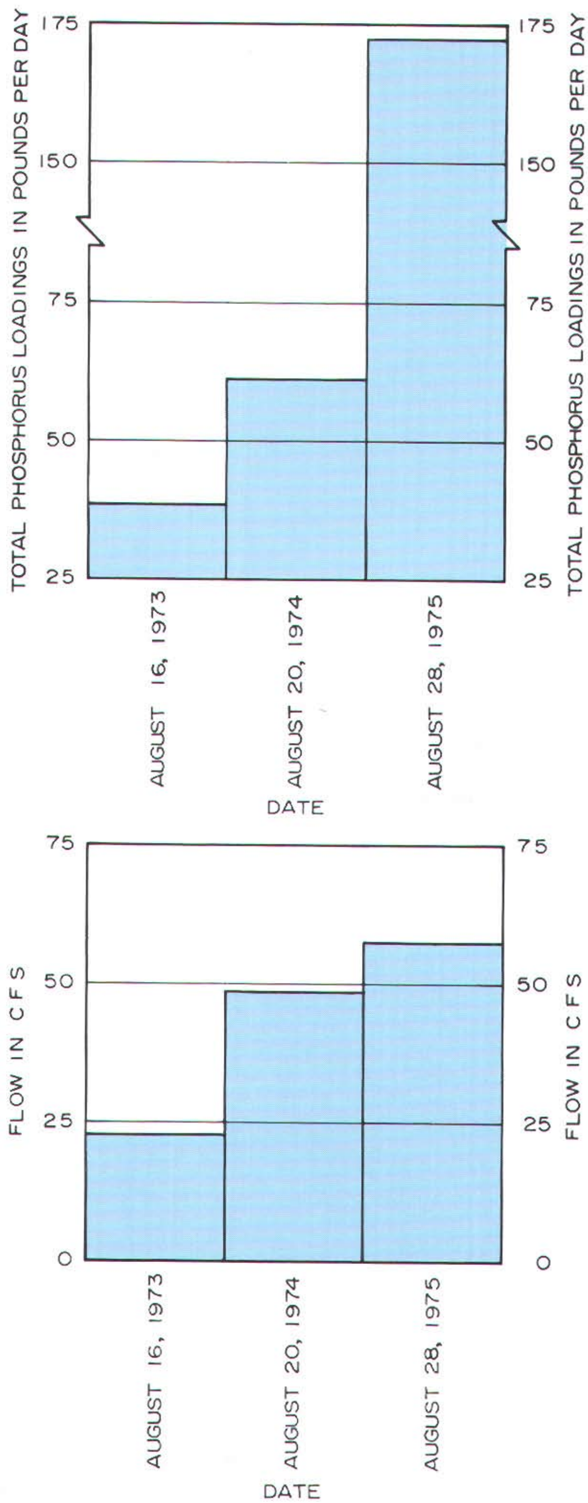
Source: SEWRPC.

nitrogen levels did exceed the 0.2 mg/l as N, generally held to be indicative of lakes and streams which have been affected by pollution.

Nitrate-nitrogen concentrations in the Milwaukee River watershed ranged from 0.07 mg/l to 1.59 mg/l as N. Surface runoff from agricultural fields and urban lands where there have been excessive or improper applications

Figure 98

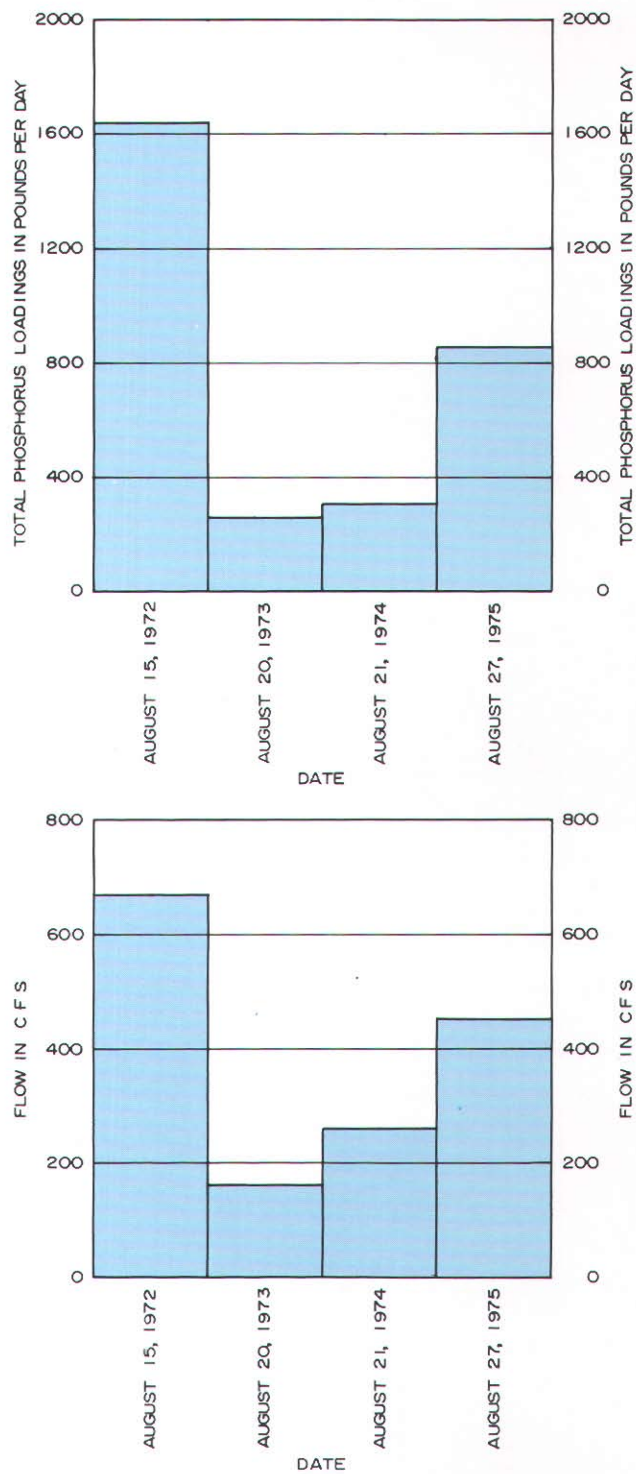
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT SAMPLING STATION MI-8 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975



Source: SEWRPC.

Figure 99

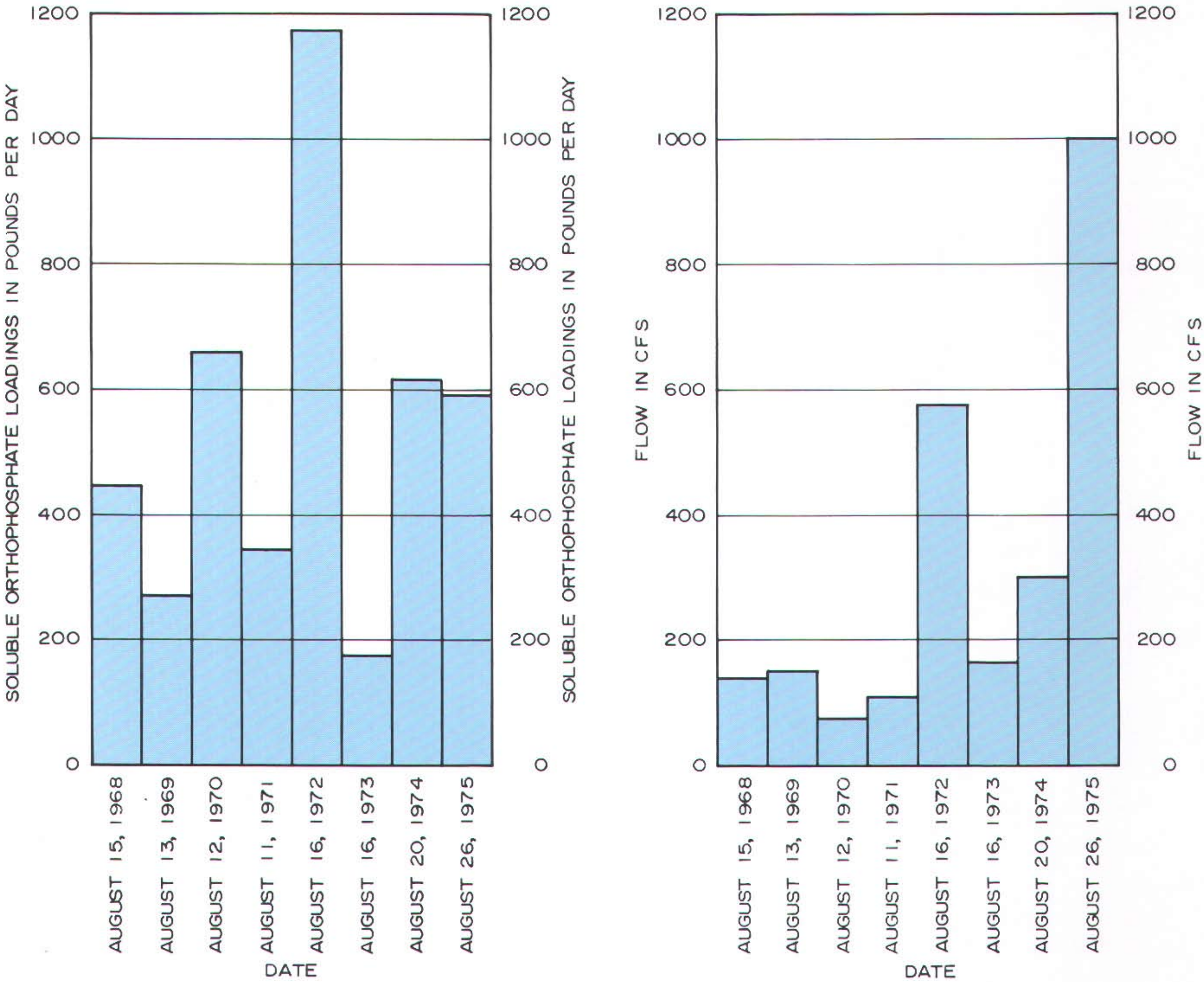
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT SAMPLING STATION MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 100

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW AT SAMPLING STATION MI-2 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

of natural or artificial fertilizers can contribute significant quantities of nitrate to streams. Nitrates also are present in treated municipal wastes and enter the receiving streams with the discharged effluent.

Of the 12 nitrate-nitrogen concentrations recorded in the Milwaukee River watershed during the years 1968 to 1975, the following number of samples equaled or exceeded the 0.30 mg/l recommended level:

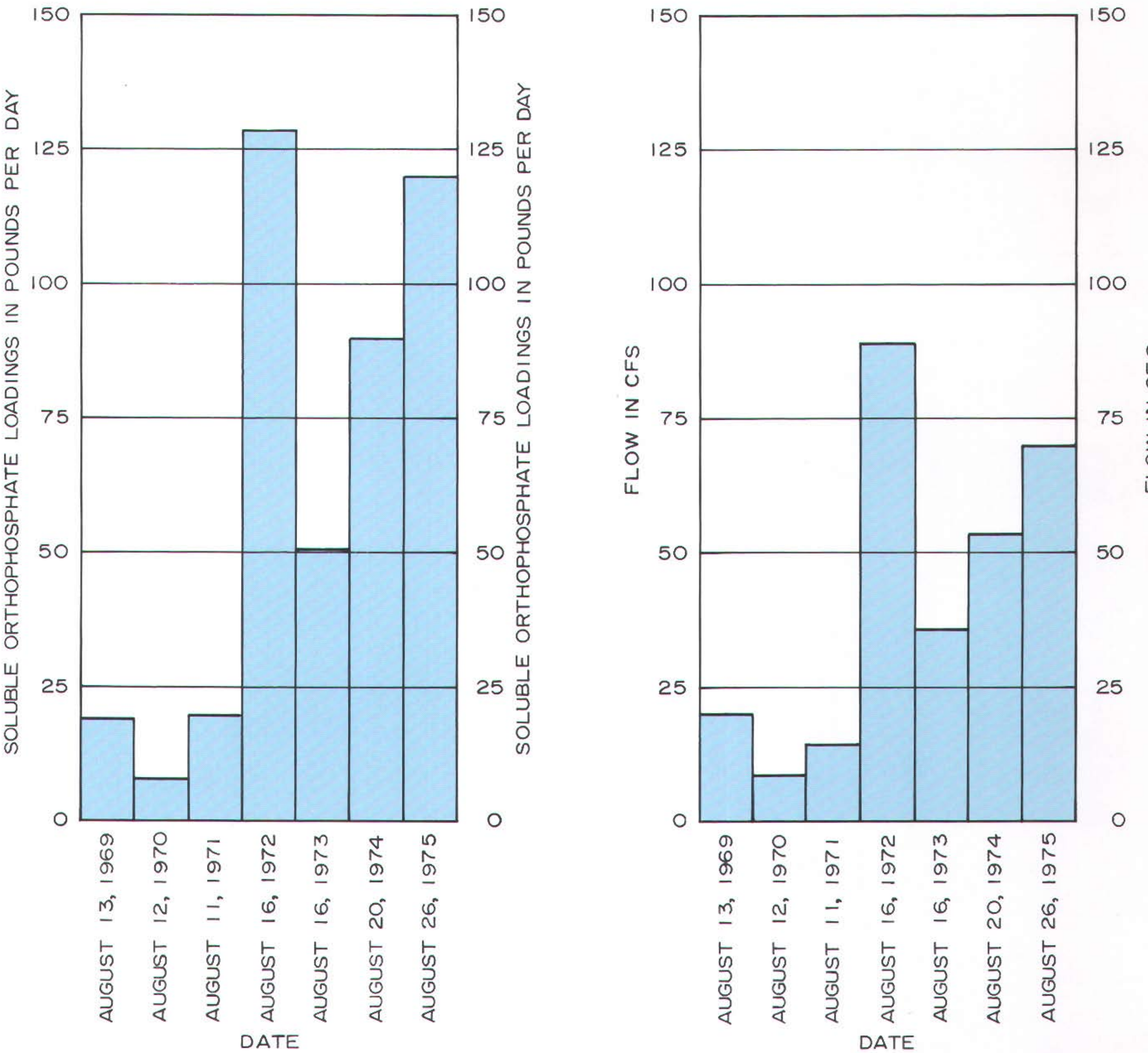
Milwaukee River Main Stem	
Ml-1	10
Ml-2	8
Ml-3	12
Ml-5	5
Ml-6	4
Ml-9	10
Ml-10	6
Ml-11	5
Ml-12	5

North Branch of the Milwaukee River	
Ml-4	10

Cedar Creek	
Ml-7	11
Ml-8	9

Figure 101

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW AT SAMPLING STATION MI-4 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1969-1975



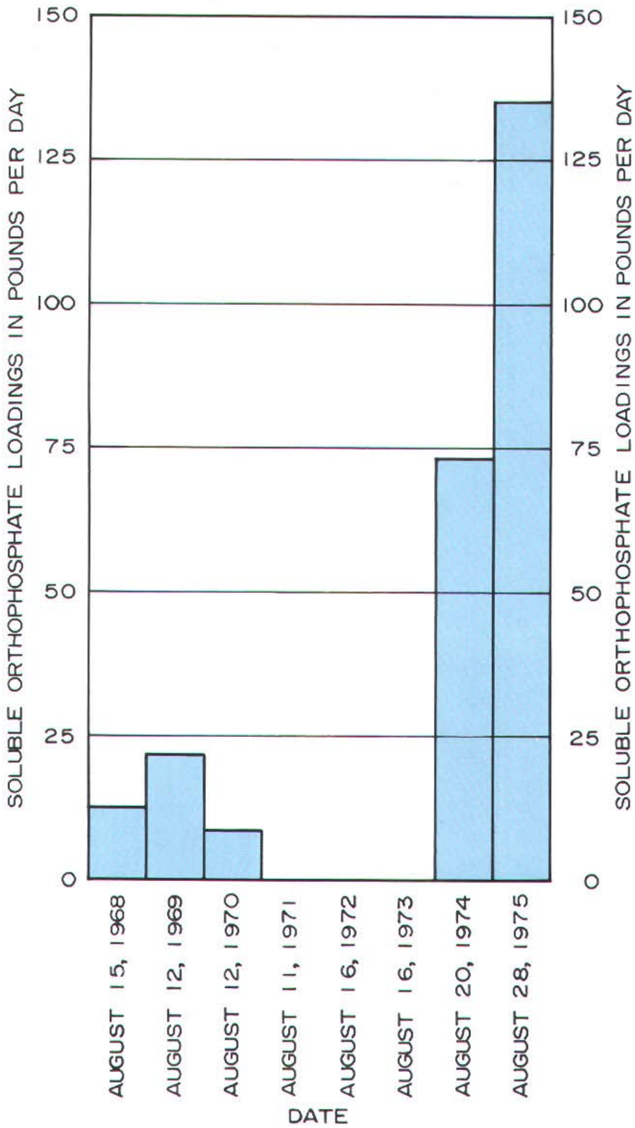
Source: SEWRPC.

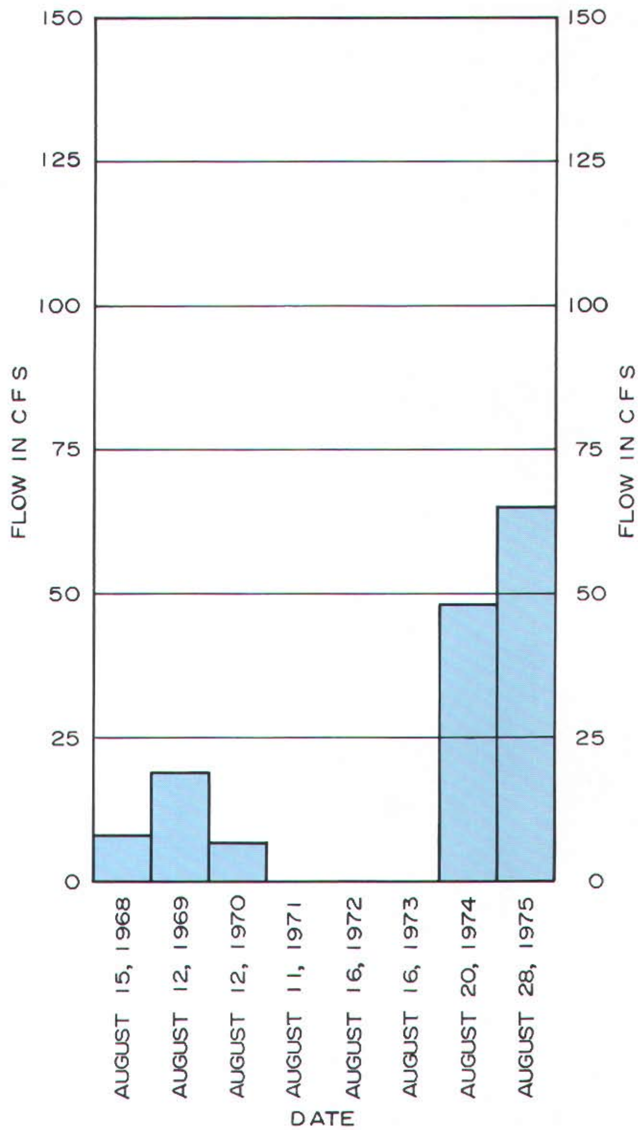
As the predominant land use within the Milwaukee River watershed is rural, particularly in the middle and upper reaches of the watershed, it is therefore likely that the major source of nitrate-nitrogen in the Milwaukee River watershed is fertilizers and wastes from domestic animals and wildlife.

Organic-nitrogen accounts from 34 to 90 percent of the total nitrogen in the samples collected in the Milwaukee River watershed. The presence of organic nitrogen is directly related to the discharge of organic wastes such as sewage or plant and animal decay products. The organic-nitrogen levels observed from 1972 to 1975 were

Figure 102

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW AT SAMPLING STATION MI-8 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



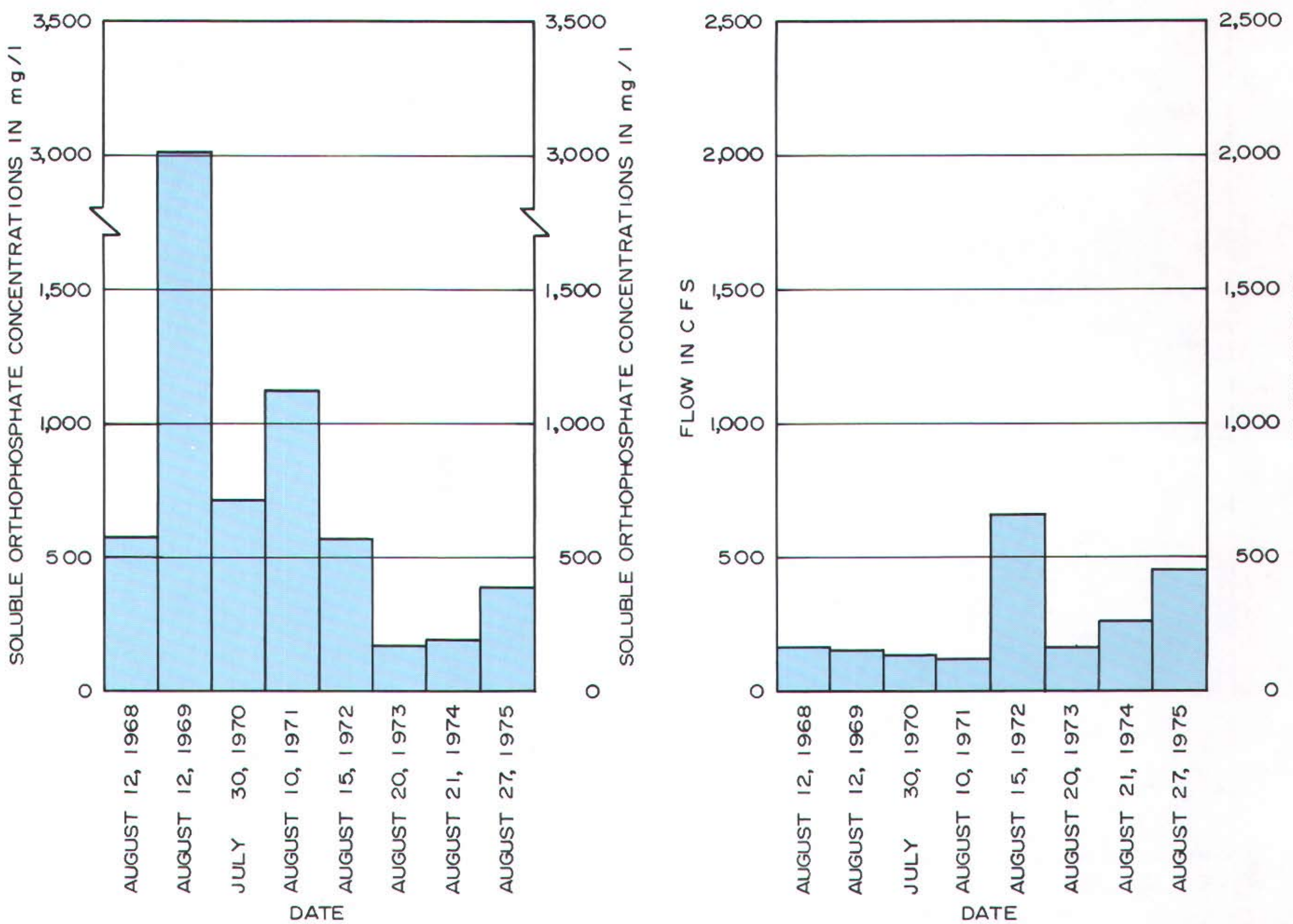


Source: SEWRPC.

generally greater than 0.5 mg/l at all 12 locations, the higher concentrations being found at sampling stations MI-7 and MI-8 on Cedar Creek and sampling station MI-9 on the main stem of the Milwaukee River. The relatively high organic-nitrogen concentrations probably contributed to the reduction of dissolved oxygen concentrations at the same stations, since the oxidation step in the decomposition of organic-nitrogen compounds utilizes the oxygen dissolved in the water. Figures 104-107 present the total nitrogen loadings and flow for sampling stations MI-2 and MI-11 on the main stem of the Milwaukee River and MI-4 on the North Branch of the Milwaukee River, for the samples of August 1972, 1973, 1974, and 1975; and for sampling station MI-8 on Cedar Creek for the samples of August 1973, 1974, and 1975. The total nitrogen loadings followed the flow pattern in that the high flow of 1972 was associated with increased total nitrogen loadings in the Milwaukee River and in the North Branch of the Milwaukee River. Three years of data being insufficient, no attempt is made to characterize a trend in total nitrogen loading in the River. However, the increases in total nitrogen along with the increases in total phosphorus and flow in the reaches of the River draining rural areas probably are due to agricultural runoff and runoff from other rural lands such as woodlands, wetlands, and unused lands.

Figure 103

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW AT SAMPLING STATION MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975

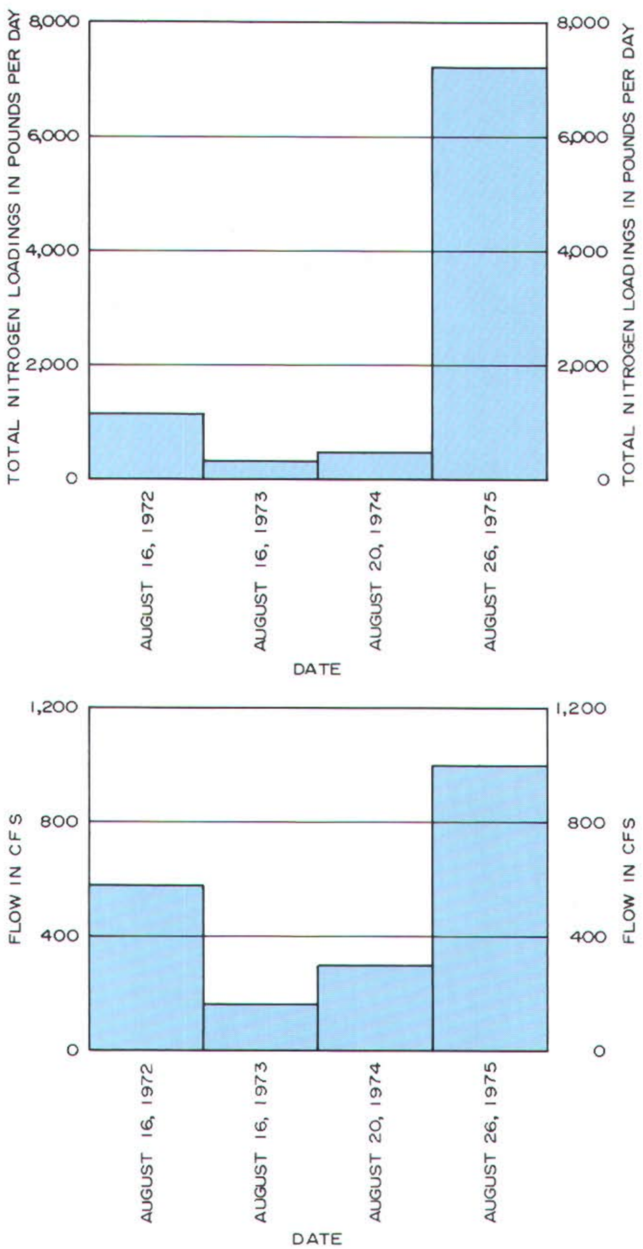


Source: SEWRPC.

Water Quality of Major Lakes in the Milwaukee River Watershed: 1965-1975: The water quality of the 21 major lakes in the Milwaukee River watershed was analyzed from data collected through the Wisconsin Department of Natural Resources quarterly lake monitoring program, the Big Cedar Lake pilot sampling project conducted by the Wisconsin Department of Natural Resources in cooperation with the Commission, and the Lake Use Reports developed by the Wisconsin Department of Natural Resources under the Commission Milwaukee River Watershed comprehensive planning program. In addition, data collected for the Aquatic Plant Survey of Major Lakes in the Milwaukee River Watershed (1970) by the Wisconsin Department of Natural Resources and the Milwaukee River watershed comprehensive planning program were used to assess the aquatic plant conditions and aquatic nuisances in each of the 21 major lakes. Table 120 indicates what data sources and selected chemical and physical characteristics are available for the major lakes in the Milwaukee River watershed.

Figure 104

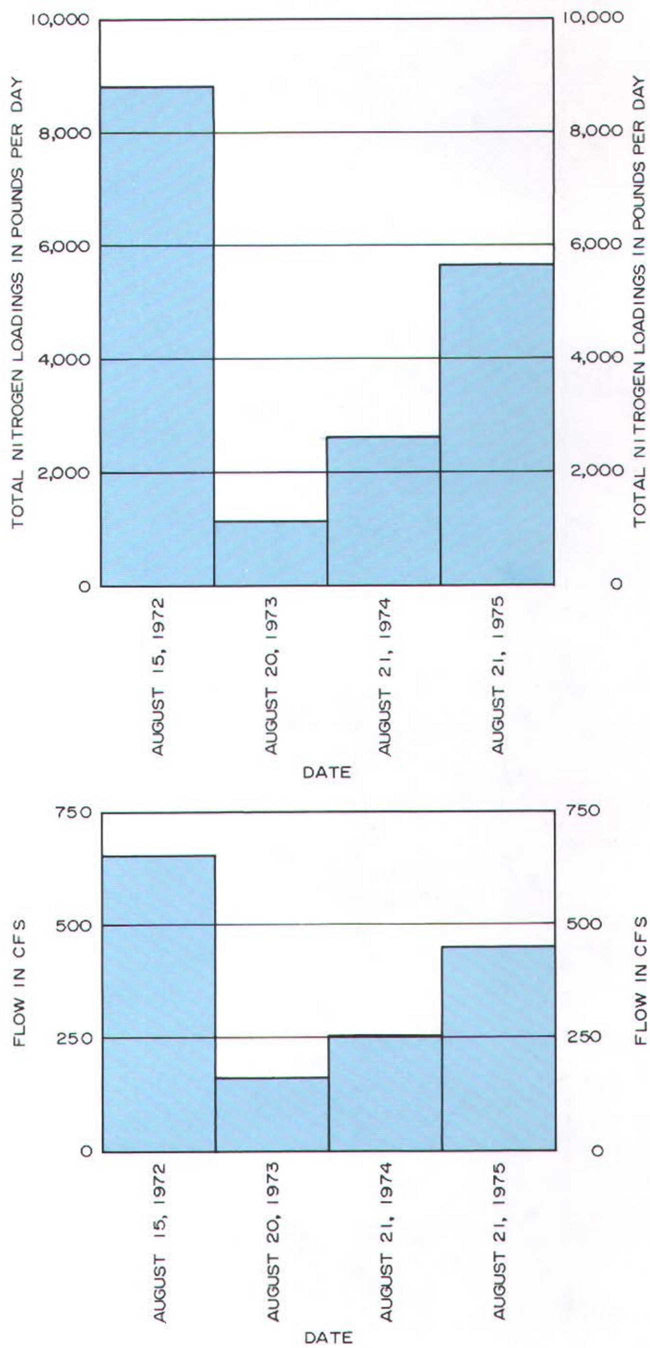
COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT SAMPLING STATION MI-2 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 105

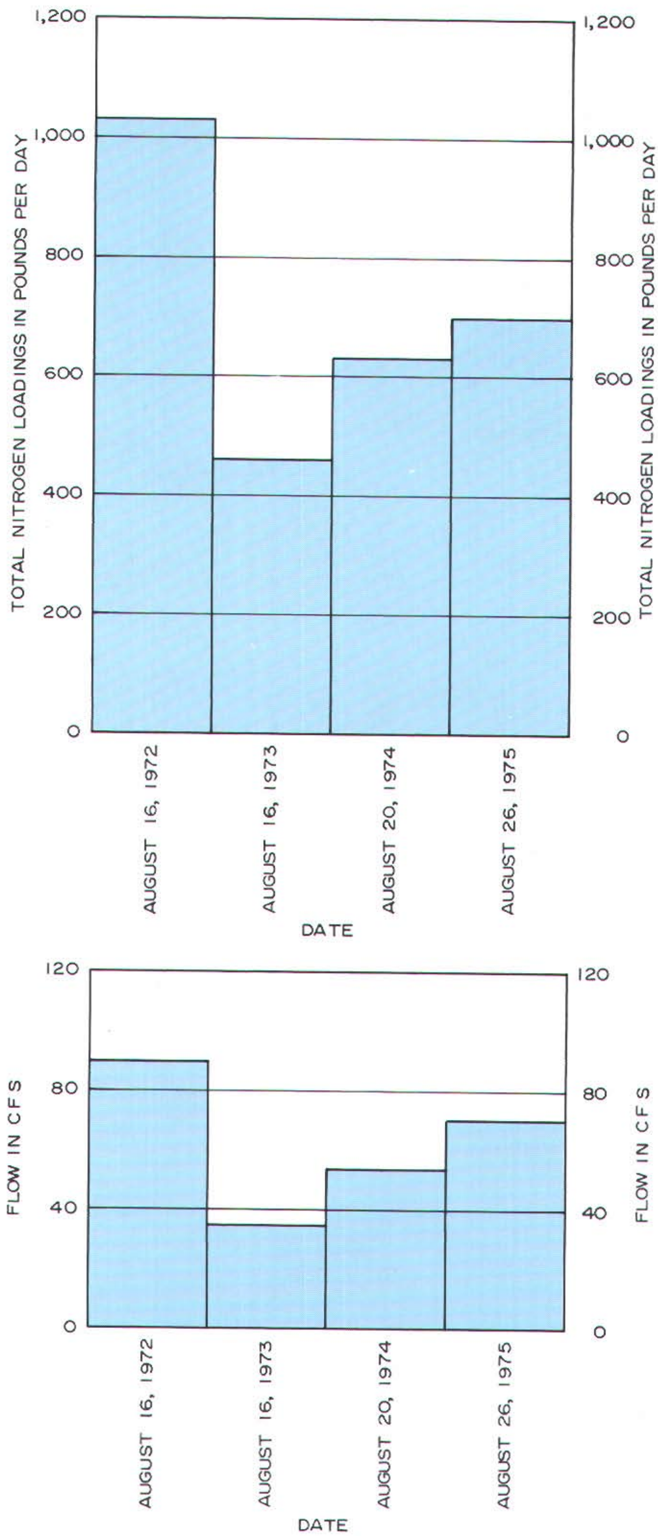
COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT SAMPLING STATION MI-11 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 106

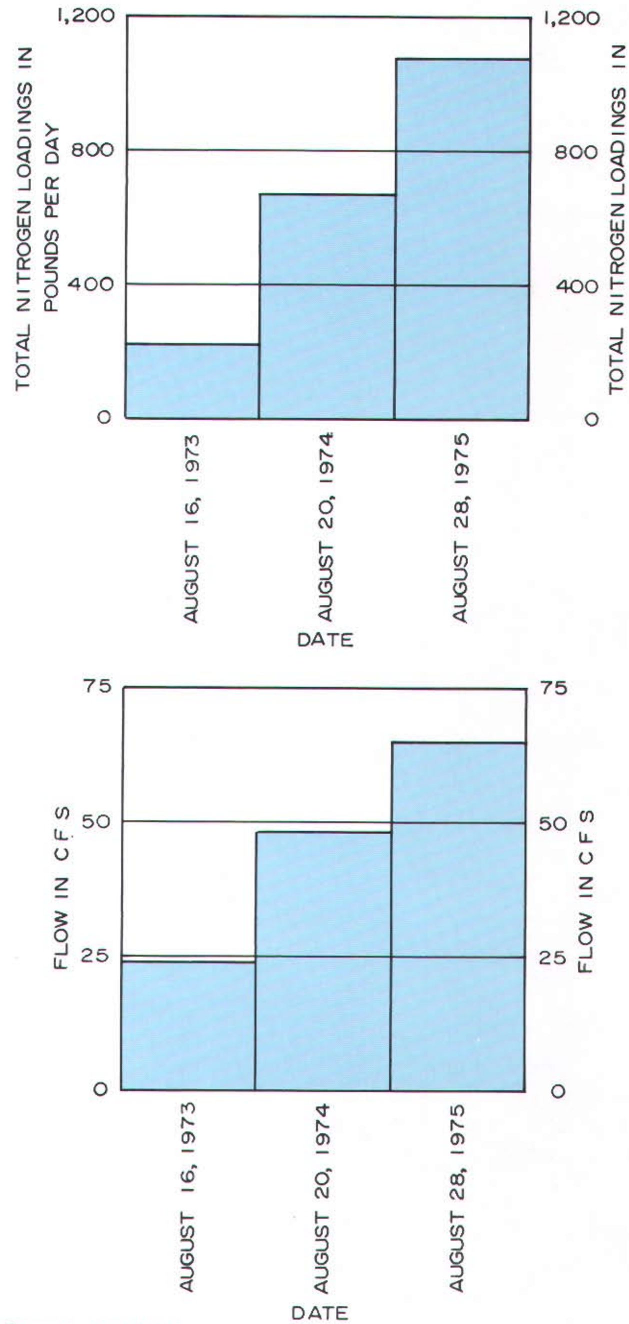
COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT SAMPLING STATION MI-4 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 107

COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT SAMPLING STATION MI-8 IN THE MILWAUKEE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1973-1975



Source: SEWRPC.

Table 120

AVAILABLE DATA ON THE MAJOR LAKES IN THE MILWAUKEE RIVER WATERSHED

Name of Lake	County	Maximum Depth	Type of Lake	WDNR[a] Data	EPA[b] Data	Lake Use[c] Data	Trophic[d] Status	Summer Stratification	Anaerobic Condition in Hypolimnion
Big Cedar	Washington	105	headwater	Yes	N/A	Yes	mesotrophic	Yes	Yes
Long	Fond du Lac	47	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Little Cedar	Washington	56	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Mud	Ozaukee	4	kettle	Yes	N/A	Yes	eutrophic	No	No
Kettle Moraine	Fond du Lac	30	headwater	Yes	N/A	Yes	very eutrophic	Yes	Yes
Random	Sheboygan	21	flow-through	Yes	N/A	Yes	eutrophic	No	No
Ellen	Sheboygan	42	headwater	Yes	N/A	Yes	mesotrophic	Yes	Yes
Silver	Washington	47	headwater	Yes	N/A	Yes	oligotrophic	Yes	Yes
Auburn (Fifteen)	Fond du Lac	29	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Crooked	Sheboygan and Fond du Lac	32	flow-through	Yes	N/A	Yes	N/A	Yes	Yes
Smith	Washington	5	headwater	N/A	N/A	Yes	N/A	No	Yes
Mauthe	Fond du Lac	23	flow-through	Yes	N/A	Yes	N/A	Yes	Yes
Lucas	Washington	15	flow-through	N/A	N/A	Yes	N/A	No	No
Green	Washington	37	kettle	Yes	N/A	Yes	N/A	Yes	Yes
Barton Pond	Washington	5	flow-through	N/A	N/A	Yes	N/A	No	Yes
West Bend Pond	Washington	14	flow-through	Yes	N/A	Yes	N/A	No	Yes
Spring	Ozaukee and Sheboygan	22	headwater	N/A	N/A	Yes	N/A	No	Yes
Mud	Fond du Lac	17	flow-through	N/A	N/A	Yes	N/A	No	Yes
Twelve	Washington	20	kettle	N/A	N/A	Yes	N/A	Yes	Yes
Wallace	Washington	35	kettle	Yes	N/A	Yes	N/A	Yes	Yes
Forest	Fond du Lac	32	kettle	N/A	No	Yes	N/A	Yes	Yes

NOTE: N/A indicates data not available.

[a] *Wisconsin Department of Natural Resources, Bureau of Research, Quarterly Inland Lake Monitoring Program, 1973-1977.*

[b] *National Eutrophication Survey Methods for Lakes Sampled in 1972, Working Paper No. 1, Pacific Northwest Environmental Research Laboratory, Environmental Protection Agency, October 1974.*

[c] *Lake Use Reports prepared by the Wisconsin Department of Natural Resources for the Southeastern Wisconsin Regional Planning Commission and financed in part by the U. S. Department of Housing and Urban Development under provisions of Section 701 of the Housing Act of 1954 as amended, 1968-1974.*

[d] *Paul D. Uttormark and J. Peter Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Water Resources Center, University of Wisconsin-Madison and U. S. Environmental Protection Agency, June 1975, EPA 660/3-75-033.*

Source: SEWRPC.

The variation of water quality in a lake depends to a great degree on the depth of the lake, the season of the year, the meteorological conditions, the geology, the soils, and the land use in the watershed tributary to the lake. In shallow lakes the water is well mixed and water quality is fairly uniform throughout the entire depth. In lakes deeper than 15 to 25 feet, however, thermal and chemical stratification occurs in summer. In the chemically stratified lakes, the water quality of the lakes varies with depth. Of the 21 major lakes located in the Milwaukee River watershed, 16 have a maximum depth greater than 15 feet and therefore are likely to stratify during the summer season. Among the major lakes that are likely to stratify in the summer, chemical data are available for all the major lakes. The data for 13 of the major lakes indicate that the dissolved oxygen in the hypolimnion were between zero and 1.0 mg/l, indicating a possible anaerobic condition during summer in the lowest layers of these lakes, consequently affecting the fish and other aquatic organisms present. The concentration of dissolved oxygen in the epilimnion generally remains higher than 7.0 mg/l in the major lakes.

The conditions of temperature and dissolved oxygen levels in the shallow lakes of the watershed are generally similar to the conditions existing in the epilimnion of the stratified lakes during the summer months, with oxygen levels near or above saturation. Among the major lakes, Mud Lake (Cedarburg bog) has a depth of four feet or less for 100 percent of the surface area and Lucas Lake has a depth of three feet or less for 81 percent of the surface area and therefore, these lakes are likely to freeze out during the winter months. Of the 21 major lakes, nine have been classified in Lake Classification—A Trophic Characterization of Wisconsin Lakes;[10] Kettle Moraine Lake has been categorized as a "very eutrophic lake" and Random Lake as a "eutrophic lake." Auburn, Big Cedar, Ellen, Little Cedar, and Long Lakes have been classified as mesotrophic lakes and Silver Lake (Washington County) as an oligotrophic lake. Application of the Uttormark classification defines Mud Lake (Cedarburg bog) as a eutrophic lake. Complete data are not available to permit classification of the other lakes as to trophic status.

In 1971 the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources to expand the stream water quality sampling program to include a lake water quality sampling program on Big Cedar Lake on a pilot basis. Under this program, samples are collected at five sample sites four times a year (winter, spring, summer, and fall). These samples were originally analyzed for 19 parameters which included temperature, dissolved oxygen, pH, total alkalinity, specific conductivity, nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, organic nitrogen, dissolved phosphates, total phosphorus, sulfate, chloride, calcium, magnesium, sodium, potassium, fecal coliforms, and water clarity (Secchi Disc). Beginning with the survey of March 9, 1972, the total nitrogen parameter was also analyzed. Fecal coliform counts were discontinued as of the November 22, 1972 survey because values obtained from the previous surveys were consistently less than 10 MFFCC/100 ml. Analysis of the samples collected since the July 11, 1974, survey have been expanded to include turbidity.

The Commission and the Department of Natural Resources expanded the pilot program in 1973 and again in 1975 to include Little Cedar and Silver Lakes as well as Big Cedar Lake. Water quality samples have been collected since September 20, 1973, at two sites on Little Cedar Lake and an additional site at the Jackson Creek inlet to the Lake. The Silver Lake water quality sampling program was initiated on February 3, 1975, at one sample site. Analysis of the samples collected from Little Cedar and Silver Lakes includes the same 13 parameters currently evaluated at the 12 stream sampling stations, with the exception of turbidity, which replaces fecal coliform counts. The data collected on these three lakes are summarized in Tables 121-123.

The Wisconsin Department of Natural Resources has prepared Lake Use Reports for the Commission on selected major lakes of southeastern Wisconsin since 1969. Among the major lakes in the Milwaukee River watershed, all 21 lakes have been studied for potential recreational uses and reports have been published. With the exception of Mud Lake (Cedarburg bog), the major lakes in the watershed are used for fishing and other partial body contact recreational use. Swimming as a recreational use of the lakes exists in all the major lakes in the watershed except for Barton Pond, Mud Lake (Cedarburg bog), Mud Lake (Fond du Lac County), Smith Lake, and West Bend Pond, all of which are too shallow to find popular use for swimming.

The amount of aquatic flora and fauna produced in a lake often is limited by the nutrient element present in a limiting concentration. Generally, the elements thought to limit the fertility of a lake are the nitrogen and phosphorus compounds. The rate at which these plant nutrients enter a body of water determines the rate of eutrophication of the lake. Depending upon the source of plant nutrients, the fertilization process causing eutrophication in a lake may be divided into natural and artificial (cultural) sources. Nutrients derived from rainfall, groundwater, and runoff from marshes, forests, and other areas causes natural eutrophication. Nutrients derived from man's activities in the watershed, including such sources as agricultural runoff, wastewater effluents, urban runoff, and septic tank drainage cause cultural eutrophication. While the natural eutrophication of a lake takes place in hundreds or thousands of years, the increased rate of nutrient inflow from man's activities can render a lake eutrophic in a few years.

Lake fertilization is an important surface water problem in the basin. Many of the smaller, shallower lakes experience annual blooms of algae during the warm summer months. Submerged aquatic vegetation is also a major use problem in the shallow areas of most lakes. These growths are often in conflict with the recreational uses of the lakes. Boating, swimming, and other water sports become aesthetically less pleasing when algae and other aquatic floral growths are present in nuisance amounts. Mechanical weed cutting and chemical treatment of many lakes including Big and Little Cedar Lakes, Crooked Lake, Forest Lake, Kettle Moraine Lake, Long Lake, Lucas Lake, and Random Lake have been used in attempts to abate the lake fertilization problems. A more detailed description of the specific problems occurring in each of the major lakes in the Milwaukee River watershed is presented in the individual lake study reports published separately over the past several years.

Diurnal Water Quality Changes: The results of diurnal water quality sampling efforts are presented and discussed below. Figures 108-111 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during the low-flow conditions on August 9, 10, and 11, 1971, at the Milwaukee River watershed sampling stations. The average rates of flow for August 9, 10, and 11, 1971, were 5.4 cfs at Kewaskum, 36 cfs at Waubeka, and 117 cfs at Milwaukee on the main stem of the Milwaukee River, and 13 cfs near Fillmore on the North Branch of the Milwaukee River. The average rates of flow during the August 1971 sampling period were approximately 4.5 times, 1.6 times, and two times the seven-day average, once-in-10-year recurrence interval low flows of 1.2 cfs, 22.1 cfs, and 58 cfs, respectively, at Kewaskum, Waubeka, and Milwaukee on the main stem

[10] *P. D. Uttormark and J. P. Wall, "Lake Classification—A Trophic Characterization of Wisconsin Lakes," EPA 660/3-75-033, June 1975.*

Table 121

WATER QUALITY CONDITIONS OF BIG CEDAR LAKE: 1971-1975

Site I—Surface

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	15	12	8	17
Dissolved Oxygen (mg/l)	14.7	10.6	5.5	17
Ammonia-N (mg/l)	0.20	0.09	0.03	17
Organic-N (mg/l)	1.11	0.66	0.37	17
Total-N (mg/l)	1.32	0.83	0.55	15
Specific Conductance (µmhos/cm at 25°C)	578	390	321	17
Nitrite-N (mg/l)	0.023	0.008	0.002	17
Nitrate-N (mg/l)	0.37	0.11	0.04	17
Dissolved Phosphate-P (mg/l)	0.212	0.102	0.052	17
Total Phosphorus (mg/l)	0.21	0.12	0.06	17
Temperature (°F)	79	51	32	17
Hydrogen Ion Concentration (standard units)	8.8	8.2	7.8	17
Turbidity-Formazin Turbidity Units (FTU)	3.2	2.2	1.4	10

Site IV—Surface

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	16	12	9	17
Dissolved Oxygen (mg/l)	15.5	10.8	8.1	17
Ammonia-N (mg/l)	0.21	0.06	0.00	17
Organic-N (mg/l)	1.02	0.59	0.37	17
Total-N (mg/l)	1.04	0.71	0.49	15
Specific Conductance (µmhos/cm at 25°C)	551	383	300	17
Nitrite-N (mg/l)	0.047	0.007	0.000	17
Nitrate-N (mg/l)	0.24	0.10	0.04	17
Dissolved Phosphate-P (mg/l)	0.199	0.117	0.051	17
Total Phosphorus (mg/l)	0.20	0.13	0.03	17
Temperature (°F)	77	50	32	17
Hydrogen Ion Concentration (standard units)	8.8	8.2	8.0	17
Turbidity-Formazin Turbidity Units (FTU)	3.1	2.0	1.2	10

Site II—Surface

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	17	12	8	17
Dissolved Oxygen (mg/l)	14.8	10.9	7.7	17
Ammonia-N (mg/l)	0.24	0.06	0.03	17
Organic-N (mg/l)	0.99	0.61	0.38	17
Total-N (mg/l)	1.10	0.75	0.49	15
Specific Conductance (µmhos/cm at 25°C)	551	387	312	17
Nitrite-N (mg/l)	0.011	0.004	0.000	17
Nitrate-N (mg/l)	0.33	0.11	0.00	17
Dissolved Phosphate-P (mg/l)	0.192	0.116	0.053	17
Total Phosphorus (mg/l)	0.20	0.13	0.07	17
Temperature (°F)	77	50	32	17
Hydrogen Ion Concentration (standard units)	8.6	8.2	8.0	17
Turbidity-Formazin Turbidity Units (FTU)	4.7	2.4	1.4	10

Site V—Surface

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	16	13	8	20
Dissolved Oxygen (mg/l)	15.7	10.6	7.8	20
Ammonia-N (mg/l)	0.18	0.07	0.00	20
Organic-N (mg/l)	1.02	0.57	0.35	20
Total-N (mg/l)	1.22	0.75	0.39	18
Specific Conductance (µmhos/cm at 25°C)	568	386	311	20
Nitrite-N (mg/l)	0.013	0.004	0.000	20
Nitrate-N (mg/l)	0.34	0.11	0.00	20
Dissolved Phosphate-P (mg/l)	0.195	0.109	0.044	20
Total Phosphorus (mg/l)	0.20	0.12	0.05	20
Temperature (°F)	79	51	32	20
Hydrogen Ion Concentration (standard units)	8.8	8.2	7.8	20
Turbidity-Formazin Turbidity Units (FTU)	4.3	2.1	0.6	13

Site III—Surface

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	17	12	8	17
Dissolved Oxygen (mg/l)	14.2	10.7	7.9	17
Ammonia-N (mg/l)	0.13	0.06	0.03	17
Organic-N (mg/l)	1.28	0.64	0.37	17
Total-N (mg/l)	1.36	0.76	0.55	15
Specific Conductance (µmhos/cm at 25°C)	551	379	287	17
Nitrite-N (mg/l)	0.011	0.005	0.000	17
Nitrate-N (mg/l)	0.39	0.10	0.00	17
Dissolved Phosphate-P (mg/l)	0.156	0.104	0.040	17
Total Phosphorus (mg/l)	0.20	0.12	0.00	17
Temperature (°F)	78	51	32	17
Hydrogen Ion Concentration (standard units)	8.6	8.2	7.9	17
Turbidity-Formazin Turbidity Units (FTU)	6.0	2.3	1.5	10

Site V—30-35 Feet

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	16	12	8	17
Dissolved Oxygen (mg/l)	13.5	10.4	7.7	17
Ammonia-N (mg/l)	0.23	0.07	0.00	17
Organic-N (mg/l)	1.83	0.70	0.42	17
Total-N (mg/l)	1.84	0.85	0.54	15
Specific Conductance (µmhos/cm at 25°C)	568	392	271	17
Nitrite-N (mg/l)	0.013	0.005	0.000	17
Nitrate-N (mg/l)	0.31	0.11	0.00	17
Dissolved Phosphate-P (mg/l)	0.191	0.113	0.058	17
Total Phosphorus (mg/l)	0.19	0.13	0.06	17
Temperature (°F)	66	47	35	17
Hydrogen Ion Concentration (standard units)	8.8	8.2	7.8	17
Turbidity-Formazin Turbidity Units (FTU)	15.0	3.88	1.4	10

Table 121 (continued)

Site V—60-70 Feet

Parameter	Numerical Value			Number of Analyses
	Maximum	Average	Minimum	
Chloride (mg/l)	15	11	3	16
Dissolved Oxygen (mg/l)	12.1	8.6	0.6	16
Ammonia-N (mg/l)	0.14	0.07	0.03	16
Organic-N (mg/l)	0.89	0.59	0.34	16
Total-N (mg/l).	1.37	0.81	0.49	14
Specific Conductance (μmhos/cm at 25°C)	568	409	271	16
Nitrite-N (mg/l)	0.012	0.004	0.000	16
Nitrate-N (mg/l).	0.63	0.17	0.04	16
Dissolved Phosphate-P (mg/l) .	0.207	0.120	0.069	16
Total Phosphorus (mg/l)	0.20	0.13	0.07	16
Temperature (°F).	48	42	35	16
Hydrogen Ion Concentration (standard units)	8.3	8.0	7.7	16
Turbidity-Formazin Turbidity Units (FTU)	3.1	1.9	1.3	9

Site V—90-103 Feet

Parameter	Numerical Value			Number of Analyses
	Maximum	Average	Minimum	
Chloride (mg/l)	17	12	6	20
Dissolved Oxygen (mg/l)	10.7	4.8	0.0	20
Ammonia-N (mg/l)	1.87	0.54	0.03	20
Organic-N (mg/l)	1.40	0.67	0.34	20
Total-N (mg/l).	2.93	1.32	0.43	18
Specific Conductance (μmhos/cm at 25°C)	626	411	33	20
Nitrite-N (mg/l)	0.015	0.006	0.000	20
Nitrate-N (mg/l).	0.98	0.18	0.04	20
Dissolved Phosphate-P (mg/l) .	0.376	0.173	0.062	20
Total Phosphorus (mg/l)	0.45	0.21	0.07	20
Temperature (°F).	45	41	36	20
Hydrogen Ion Concentration (standard units)	8.3	7.8	7.4	20
Turbidity-Formazin Turbidity Units (FTU)	15.0	4.1	1.3	13

Source: SEWRPC.

of the Milwaukee River and 2.7 times the seven-day average, once-in-10-year recurrence interval low flow of 4.8 cfs on the North Branch of the Milwaukee River. No streamflow data were available for Cedar Creek near Cedarburg during this period; however, it is believed that the water quality variation in a 24-hour cycle on this tributary would have a significant effect on the water quality of the main stream during the low-flow period, since the plant nutrient levels are known to be sufficiently high to induce heavy plant growth and attendant photosynthesis and respiration effects on the stream water quality.

Milwaukee River Main Stem: Water temperatures were found to range from 67.5°F during the early morning hours to 74.0°F during the afternoon and evening hours at sampling station Ml-2. At sampling station Ml-11 located in the City of Milwaukee, the temperature variation was found to be from 75.0°F to 79.0°F during the daily cycle of August 10, 1971. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in air temperature and solar radiation. The slightly higher temperature variation of 6.5°F at sampling station Ml-2, when compared to the temperature variation of 4.0°F at sampling station Ml-11, probably is related to the relatively low flow—5.4 cfs at Kewaskum versus 117 cfs at Milwaukee.

Chloride concentrations recorded at sampling station Ml-2 ranged from 30 mg/l at 7:25 a.m. to 35 mg/l at 7:00 p.m. Sampling station Ml-11 exhibited no variation in the chloride level of 60 mg/l in any samples collected except for the 4:45 a.m. sample, which exhibited a concentration of 120 mg/l. The generally high concentrations during low-flow conditions—relative to the background levels of 10 mg/l of chloride—are assumed to reflect the effects of the treated sanitary effluent discharged from the Village of Kewaskum sewage treatment facility located just upstream from sampling station Ml-2 and the discharge of untreated sanitary and industrial wastes from the sanitary sewerage system flow relief devices located upstream from sampling station Ml-11. It also is possible that the discharge of salt brine from the recharging of water softener devices affected the high early morning chloride levels.

The diurnal concentrations of dissolved oxygen recorded at sampling station Ml-2 varied from 3.7 mg/l at 7:25 a.m. to 11.3 mg/l at 7:00 p.m. The low morning dissolved oxygen concentrations are attributed to respiration by algae and other aquatic flora as well as to higher effluent flows and higher levels of biochemical oxygen demand in sewage effluents during the early morning hours. The dissolved oxygen content increased considerably during the daytime and this can be attributed to the net photosynthetic production of oxygen by algae and other aquatic flora. The dissolved oxygen concentrations at sampling station Ml-11 ranged from 7.3 mg/l at 9:05 a.m. to 11.5 mg/l at 12:55 a.m. during the night hours. This is the reverse of what is normally seen. The hydrogen ion concentration (pH) varied from 7.9 standard units at 7:25 a.m. to 8.5 standard units at 7:00 p.m. at sampling station Ml-2. The diurnal variation in pH at sampling station Ml-11 ranged from 8.6 standard units at 5:30 p.m. to 8.9 standard units at 4:45 a.m. The uptake of carbon dioxide by aquatic flora usually accounts for the higher pH levels in the evening samples, and the low pH during the morning hours could, therefore, be accounted for by the release of carbon dioxide during periods of respiration by algae and other aquatic flora. However, the

Table 122

WATER QUALITY CONDITIONS OF LITTLE CEDAR LAKE: 1973-1975

Surface

Parameter	Numerical Value: Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	16	12	2	9
Dissolved Oxygen (mg/l)	13.2	10.8	7.7	9
Ammonia-N (mg/l)	0.43	0.12	0.00	9
Organic-N (mg/l)	0.88	0.59	0.46	9
Total-N (mg/l)	1.10	0.88	0.54	9
Specific Conductance (µmhos/cm at 25°C)	426	387	329	9
Nitrite-N (mg/l)	0.014	0.006	0.000	9
Nitrate-N (mg/l)	0.42	0.16	0.04	9
Dissolved Phosphate-P (mg/l)	0.131	0.085	0.053	9
Total Phosphorus (mg/l)	0.16	0.11	0.07	9
Temperature (°F)	79	45.8	32	9
Hydrogen Ion Concentration (standard units)	8.4	8.1	7.8	9
Turbidity-Formazin Turbidity Units (FTU)	3.7	2.6	1.2	9

50-55 Feet

Parameter	Numerical Value: Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	19	14	1	9
Dissolved Oxygen (mg/l)	10.8	4.7	0.0	8
Ammonia-N (mg/l)	2.79	1.02	0.03	9
Organic-N (mg/l)	2.06	0.79	0.52	9
Total-N (mg/l)	3.80	2.01	0.88	9
Specific Conductance (µmhos/cm at 25°C)	465	419	373	9
Nitrite-N (mg/l)	0.011	0.005	0.00	9
Nitrate-N (mg/l)	0.29	0.12	0.04	9
Dissolved Phosphate-P (mg/l)	0.659	0.240	0.105	9
Total Phosphorus (mg/l)	0.95	0.30	0.09	9
Temperature (°F)	48.5	41.8	37.0	8
Hydrogen Ion Concentration (standard units)	8.1	7.8	7.4	9
Turbidity-Formazin Turbidity Units (FTU)	5.5	3.1	1.8	9

25-30 Feet

Parameter	Numerical Value: Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	17	15	13	6
Dissolved Oxygen (mg/l)	12.8	7.2	1.2	5
Ammonia-N (mg/l)	0.28	0.13	0.03	6
Organic-N (mg/l)	0.84	0.62	0.47	6
Total-N (mg/l)	1.37	0.95	0.736	6
Specific Conductance (µmhos/cm at 25°C)	426	391	361	6
Nitrite-N (mg/l)	0.013	0.006	0.000	6
Nitrate-N (mg/l)	0.62	0.20	0.04	6
Dissolved Phosphate-P (mg/l)	0.10	0.072	0.043	6
Total Phosphorus (mg/l)	0.11	0.09	0.07	6
Temperature (°F)	60	46	36	5
Hydrogen Ion Concentration (standard units)	8.4	8	7.8	6
Turbidity-Formazin Turbidity Units (FTU)	2.95	2.4	1.1	6

Source: SEWRPC.

opposite situation occurred at sampling station Ml-11. This phenomenon may in part be attributed to the discharge of acidic substances to the Milwaukee River main stem through the storm or sanitary sewer system.

Milwaukee River Tributaries: The diurnal water quality changes as measured through the Commission sampling program in 1971 at sampling station Ml-4 on the North Branch of the Milwaukee River and sampling stations Ml-7 and Ml-8 on Cedar Creek are discussed in this section.

North Branch of the Milwaukee River: At sampling station Ml-4, water quality data were collected on August 10-11, 1971, at intervals of approximately four hours during a 24-hour period. Water temperature at this location varied from 68.5°F at 7:10 a.m. to 76.0°F at 3:00 p.m. The recorded diurnal water temperature fluctuation can be attributed to the corresponding diurnal variations in the air temperature and solar radiation. Chloride concentrations ranged from 12 mg/l to 14 mg/l during the 24-hour period, exhibiting a rather insignificant variation. The chloride concentrations at sampling station Ml-4 are only slightly above the 10 mg/l background concentration, indicating little or no effect from human pollution sources at this station.

The dissolved oxygen concentrations at sampling station Ml-4 varied from 4.7 mg/l at 11:05 p.m. on August 10 and 7:10 a.m. on August 11 to 9.9 mg/l at 3:00 p.m., also on August 11. As indicated above, the diurnal fluctuations are attributed to the respiration and photosynthesis of algae and aquatic flora. Biochemical oxygen-demanding substances arising from agricultural land uses may account for the generally depressed levels of dissolved oxygen. The hydrogen ion concentration (pH) varied from 8.1 standard units at 11:05 p.m. on August 10 and 7:10 a.m. on August 11 to 8.3 standard units at 3:00 p.m., also on August 11. The very slight diurnal variation in pH can be attributed to the diurnal uptake and release of carbon dioxide by algae and other aquatic flora.

Cedar Creek: Water samples were collected and analyzed for diurnal variations in water quality at sampling stations Ml-7 and Ml-8 on August 10-11, 1971, at intervals of approximately four hours during a 24-hour period. Water temperatures at sampling stations Ml-7 and Ml-8 ranged from 68.0°F at 6:40 a.m. to 75.5°F at 6:20 p.m. and 68.0°F at 6:25 a.m. and 10:25 a.m. to 74.0°F at 6:10 p.m., respectively. The recorded diurnal fluctuations in

Table 123

WATER QUALITY CONDITIONS OF SILVER LAKE: 1975

Surface

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	10	9	8	4
Dissolved Oxygen (mg/l)	11.8	10.2	8.1	4
Ammonia-N (mg/l)	0.30	0.20	0.03	4
Organic-N (mg/l)	0.40	0.37	0.33	4
Total-N (mg/l)	0.91	0.73	0.43	4
Specific Conductance (μmhos/cm at 25°C)	511	449	390	4
Nitrite-N (mg/l)	0.019	0.010	0.002	4
Nitrate-N (mg/l)	0.29	0.17	0.05	4
Dissolved Phosphate-P (mg/l)	0.015	0.016	0.005	4
Total Phosphorus (mg/l)	0.05	0.03	0.01	4
Temperature (°F)	81.5	50.8	35.0	4
Hydrogen Ion Concentration (standard units)	8.9	8.4	8.1	4
Turbidity-Formazin Turbidity Units (FTU)	2.4	1.8	1.5	4

20-25 Feet

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	13	10	9	4
Dissolved Oxygen (mg/l)	9.7	3.9	0.2	4
Ammonia-N (mg/l)	0.84	0.54	0.30	4
Organic-N (mg/l)	0.63	0.47	0.37	4
Total-N (mg/l)	1.69	1.17	0.74	4
Specific Conductance (μmhos/cm at 25°C)	568	504	503	4
Nitrite-N (mg/l)	0.023	0.015	0.003	4
Nitrate-N (mg/l)	0.20	0.15	0.06	4
Dissolved Phosphate-P (mg/l)	0.014	0.011	0.005	4
Total Phosphorus (mg/l)	0.05	0.03	0.01	4
Temperature (°F)	44.0	41.4	39.0	4
Hydrogen Ion Concentration (standard units)	8.2	7.9	7.7	4
Turbidity-Formazin Turbidity Units (FTU)	3.8	2.4	1.3	4

44-46 Feet

Parameter	Numerical Value Maximum	Average	Minimum	Number of Analyses
Chloride (mg/l)	10	8	5	3
Dissolved Oxygen (mg/l)	11.9	11.0	9.9	3
Ammonia-N (mg/l)	0.34	0.23	0.06	3
Organic-N (mg/l)	0.40	0.37	0.35	3
Total-N (mg/l)	1.10	0.88	0.66	3
Specific Conductance (μmhos/cm at 25°C)	525	477	424	3
Nitrite-N (mg/l)	0.02	0.011	0.009	3
Nitrate-N (mg/l)	0.39	0.27	0.20	3
Dissolved Phosphate-P (mg/l)	0.014	0.008	0.005	3
Total Phosphorus (mg/l)	0.04	0.02	0.01	3
Temperature (°F)	52.5	43.2	37.0	3
Hydrogen Ion Concentration (standard units)	8.2	8.1	8.0	3
Turbidity-Formazin Turbidity Units (FTU)	3.6	2.2	1.3	3

Source: SEWRPC.

the water temperature, as indicated above, are attributed to diurnal variations in the air temperature and solar radiation. Chloride concentrations ranged from 15 mg/l to 35 mg/l at sampling station Ml-7 and from 13 mg/l to 30 mg/l at sampling station Ml-8. The high chloride concentrations recorded for Cedar Creek can be attributed to the discharge of treated sanitary effluent from the Village of Jackson sewage treatment plant. Any diurnal variation noted in the chloride concentration would be the result of changes in domestic and industrial water uses.

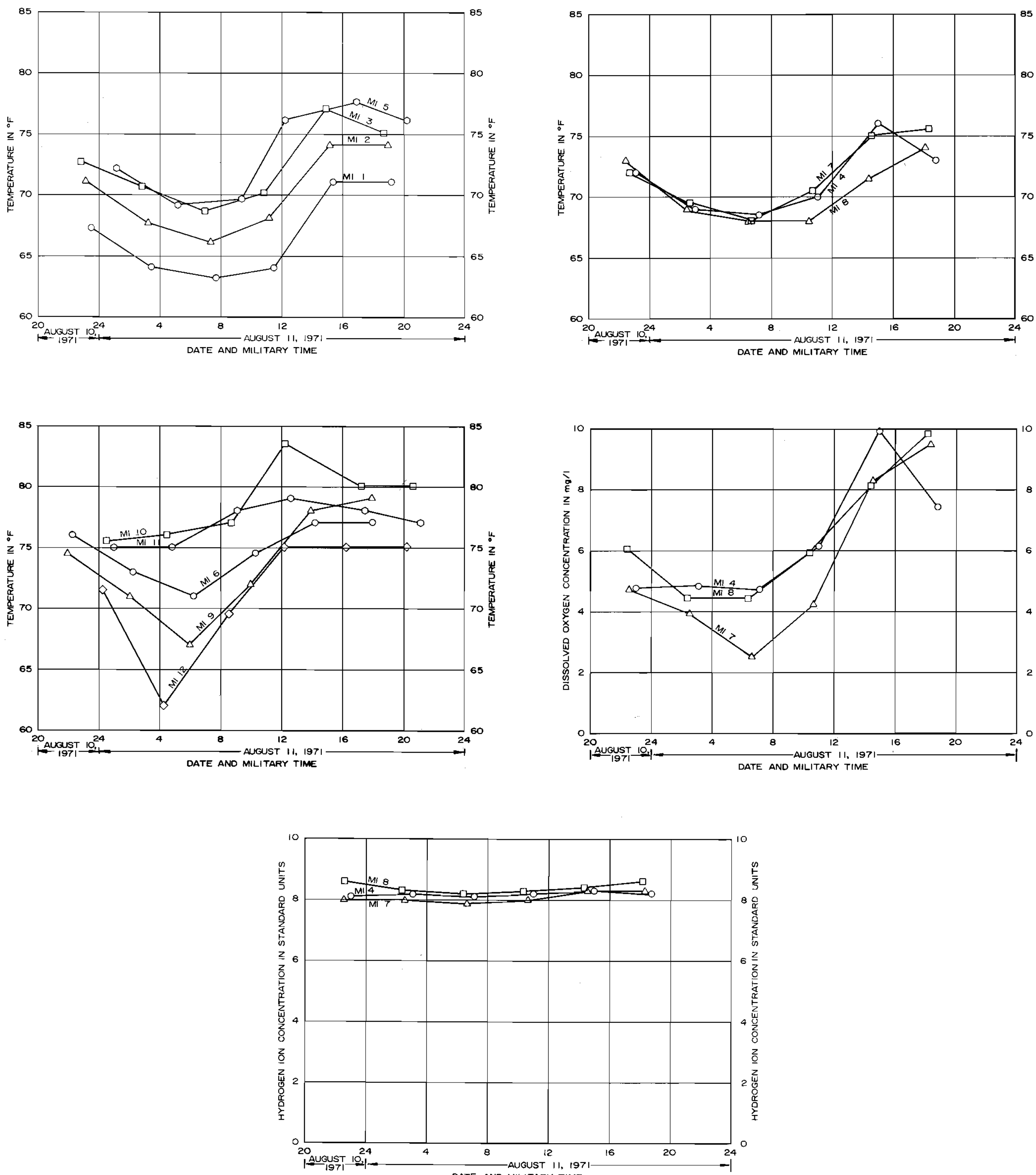
The dissolved oxygen concentrations recorded during the 24-hour diurnal sampling period varied from 2.5 mg/l at 6:40 a.m. to 9.5 mg/l at 6:20 p.m. and reflected both the respiration of algae and other aquatic flora during the night and the loading of biochemical oxygen-demanding substances on Cedar Creek from the Village of Jackson sewage treatment plant. Dissolved oxygen increased considerably during the daytime and can be attributed to the net photosynthetic production of oxygen. A similar situation occurred farther downstream at sampling station Ml-8 where the dissolved oxygen concentrations varied from 4.4 mg/l recorded at 2:25 a.m. and 6:25 a.m. to 9.8 mg/l recorded at 6:10 p.m. on August 11, 1971. The effects of the Village of Jackson sewage treatment plant discharge are not so pronounced this far downstream because the stream undergoes some reoxygenation. Nevertheless, substandard dissolved oxygen concentrations were noted in the early morning sample results.

The hydrogen ion concentration (pH) ranged from 7.9 standard units at 6:40 a.m. to 8.3 standard units at 2:35 p.m. and 6:20 p.m. and from 8.2 standard units at 6:25 a.m. to 8.6 standard units at 10:25 p.m. on August 10 and 6:10 p.m. on August 11 at sampling stations Ml-7 and Ml-8, respectively. The slight changes in pH, as indicated above, represent the uptake and release of carbon dioxide by algae and other aquatic flora.

A practical consequence of diurnal water quality fluctuations is that, while the average level of concentrations of key parameters may meet the established water quality standards for recreational use and for preservation of fish

Figure 108

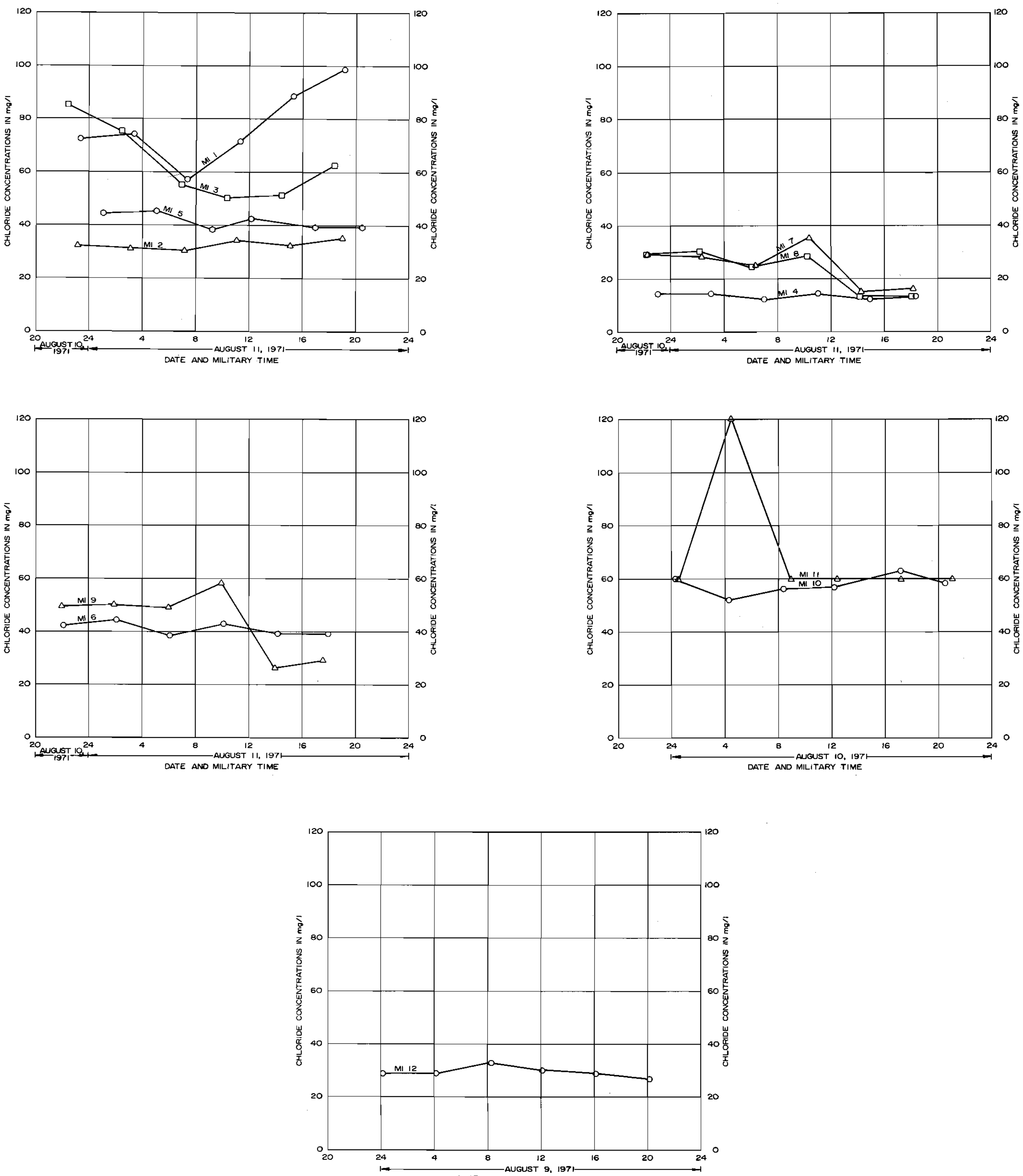
DIURNAL VARIATIONS IN TEMPERATURE IN THE MILWAUKEE RIVER WATERSHED: AUGUST 1971



Source: SEWRPC.

Figure 109

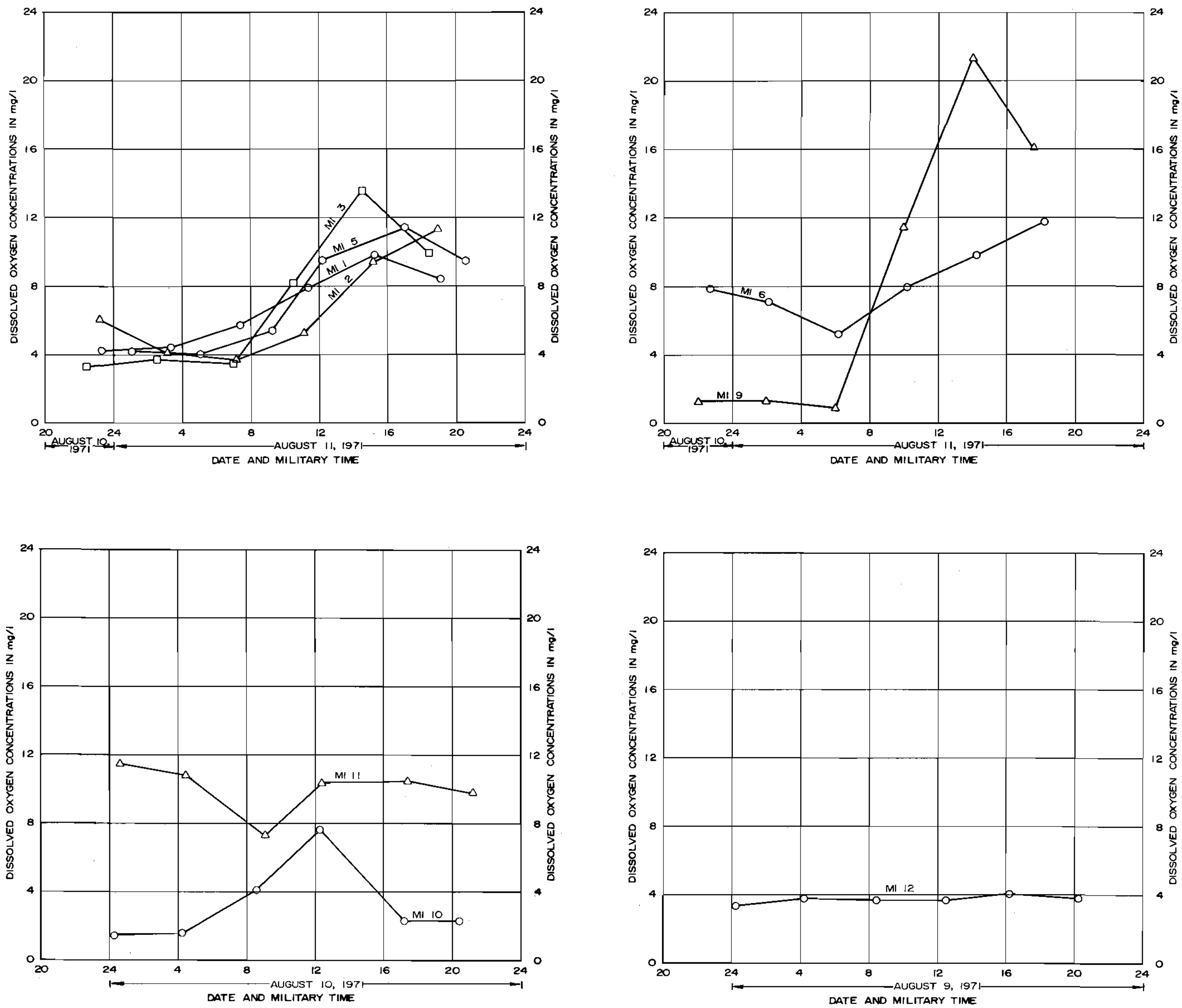
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS IN THE MILWAUKEE RIVER WATERSHED: AUGUST 1971



Source: SEWRPC.

Figure 110

DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS IN THE MILWAUKEE RIVER WATERSHED: AUGUST 1971



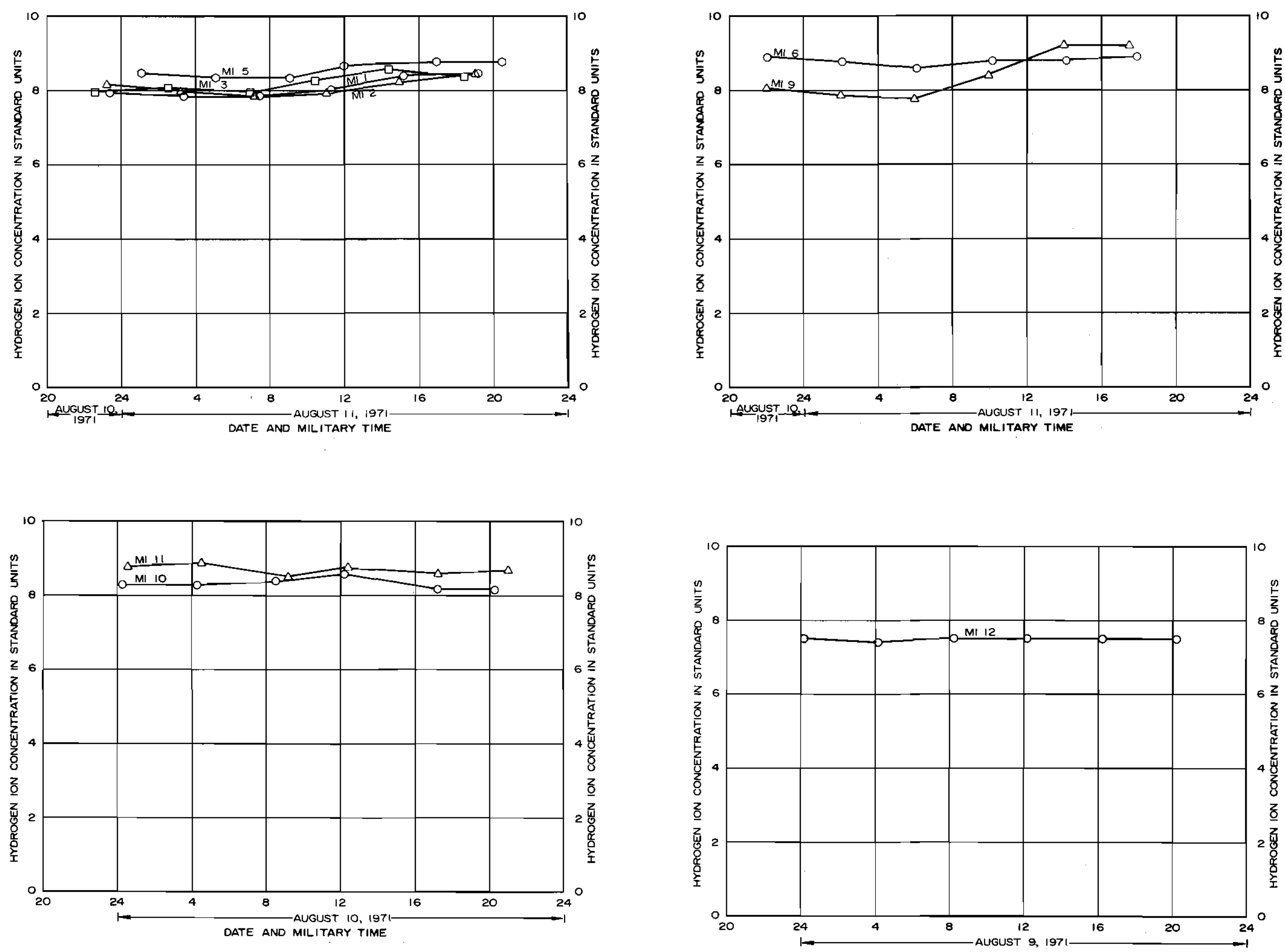
Source: SEWRPC.

and aquatic life, the lower levels during the daily cycle may not meet the applicable standards. For example, the average of six dissolved oxygen concentrations recorded at sampling stations Ml-2, Ml-4, Ml-7, and Ml-8 on August 10 and 11, 1971, were 6.6, 6.3, 5.5, and 6.6 mg/l, respectively, well above the minimum standard of 5.0 mg/l for recreational use and preservation of fish and aquatic life. However, substandard oxygen levels were recorded in three of the six samples collected at sampling stations Ml-2 and Ml-4, in four of the six samples collected at sampling station Ml-7, and in two of the six samples collected at sampling station Ml-8.

Spatial Water Quality Changes: The water quality surveys clearly indicate that water quality changes from one location to another within the watershed stream system in response to a combination of human activities and natural phenomena. Figures 112 through 117 show the spatial water quality variation along the entire main stem of the Milwaukee River as recorded under low-flow hydrological conditions during the period for the years 1968 through 1975. The illustrations present the range of dissolved oxygen, chloride, specific conductance, fecal coliform, total phosphorus, and total nitrogen obtained over the past eight-year sampling survey at

Figure 111

DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS (PH) IN THE MILWAUKEE RIVER WATERSHED: AUGUST 10-11, 1971



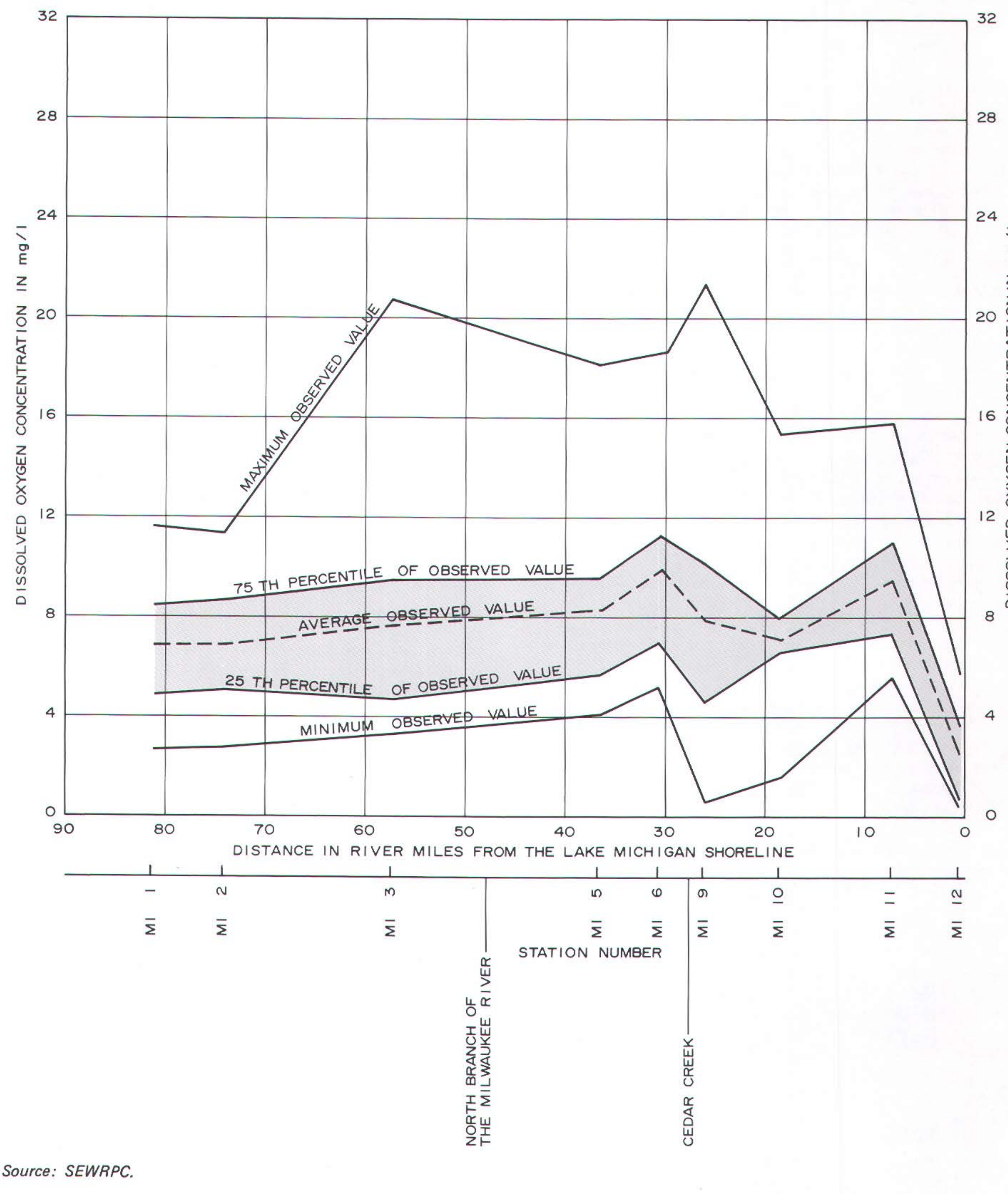
Source: SEWRPC.

each Milwaukee River main stem sampling station. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter, thus dividing the data into three categories: (1) the range of the 25 percent of the samples near the minimum values, (2) the range of the middle 50 percent of the samples, and (3) the range of the 25 percent of the samples near the maximum.

Figure 112, which presents the range of spatial dissolved oxygen variations in the Milwaukee River main stem, indicates a general increasing trend from the source (Ml-1) to near the Village of Grafton (Ml-6), and a decreasing trend from sampling station Ml-6 to sampling station Ml-10. The lower water quality condition, as measured by the lower dissolved oxygen levels at sampling station Ml-10, is due to the effects of effluent loadings from three sewage treatment plants—those serving the Villages of Grafton and Thiensville and the City of Cedarburg—located within the approximately 12 miles of River between sampling stations Ml-6 and Ml-10. Particularly at sampling station Ml-9 downstream from the Village of Grafton and the City of Cedarburg sewage treatment plants, a widened range of observed values and a reduction in the average value of the dissolved oxygen samples indicate an erratic but adverse effect of the effluents discharged from these facilities. The oxygen-demanding substances discharged from these plants appear generally to exceed the River's capability for adequate reoxygenation. From sampling stations Ml-10 to Ml-11 an increasing trend in the dissolved oxygen concentrations is noted,

Figure 112

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE MILWAUKEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

apparently a result of the River's recovery from the upstream sewage treatment plant discharges. However, nutrient contributions from various sources, including runoff and sewer flow relief devices along this stream reach and Lincoln Creek, sustain large algal populations which would appear to contribute to supersaturated dissolved oxygen concentrations. A significant decline in the average dissolved oxygen concentrations was observed from sampling station Ml-11 to Ml-12 due to the effects of the combined sewer overflows which contribute large quantities of oxygen-demanding substances to the River in this reach. The dissolved oxygen concentrations in this reach also are affected by the Milwaukee River flushing tunnel and the Lake Michigan harbor effect. This analysis is supported by data collected by the Metropolitan Sewerage District during the period 1964-1968.

As shown in Figure 113, the chloride concentrations declined from sampling stations Ml-1 to Ml-2 due to dilution from the East Branch of the Milwaukee River. An increase in the chloride concentrations was observed from sampling stations Ml-2 to Ml-3, reflecting the effects of the City of West Bend sewage treatment plant. The spatial trend in the chloride concentrations decreased from sampling stations Ml-3 to Ml-5. The sewage treatment facilities of the Newburg Sanitary District and the Village of Fredonia are located far enough upstream from sampling station Ml-5 that sufficient dilution occurs to explain this decline in the general chloride concentrations relative to sampling station Ml-3. An increase in the August chloride concentrations was noted from sampling stations Ml-5 to Ml-9, reflecting the effects of sewage treatment plant discharges from the Villages of Saukville and Grafton and the City of Cedarburg. The increasing trend continued from sampling stations Ml-9 to Ml-11, due apparently to the discharge of wastewaters from the Village of Thiensville sewage treatment plant and from flow relief devices located along Lincoln Creek which discharge to the Milwaukee River just upstream from sampling station Ml-11. From sampling stations Ml-11 to Ml-12 the chloride concentrations generally declined due to the dilution effect associated with the Milwaukee River flushing tunnel and the effects of Lake Michigan.

The chloride concentrations recorded by the Metropolitan Sewerage Commission support the conclusions derived from the data collected by the Southeastern Wisconsin Regional Planning Commission as the concentrations generally increased from the E. Green Tree Road bridge to the North Avenue dam. A decline in the chloride concentrations was noted from the dam to the E. Cherry Street bridge, a fact that, as indicated above, may be attributable to dilution associated with the Milwaukee River flushing tunnel and the effects of Lake Michigan.

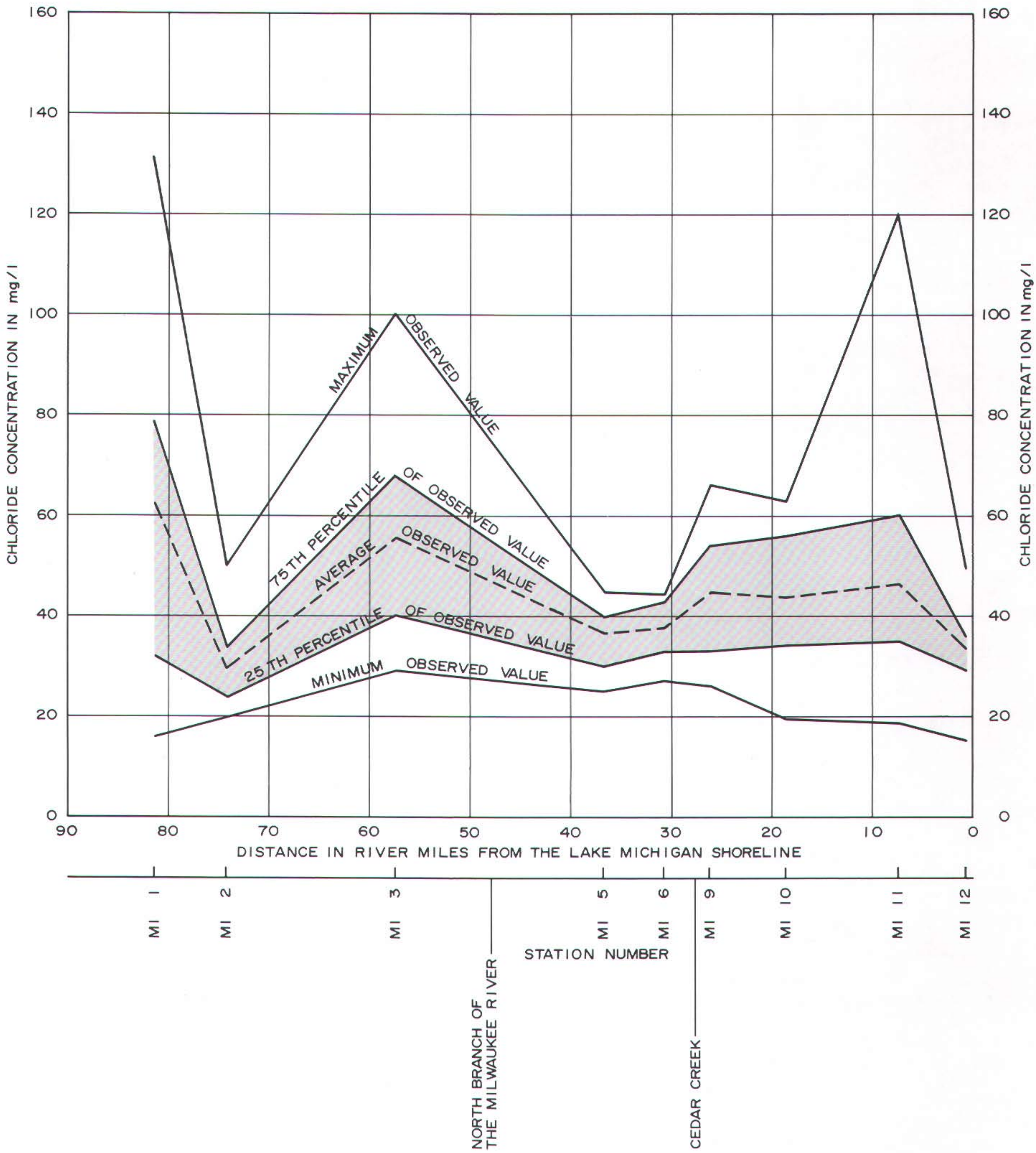
Figure 114 shows the spatial variations in the specific conductance recorded along the main stem of the Milwaukee River. Generally, the spatial variations of specific conductance follow those of the chloride concentrations as shown in Figure 113. Particularly noteworthy is the similarity in spatial fluctuations within the 50 percent range.

The fecal coliform counts recorded along the main stem of the Milwaukee River exhibit fluctuations which generally correspond to the location of sewage treatment plants and sanitary sewer flow relief devices. Spatially, the average coliform counts declined slightly from sampling stations Ml-1 to Ml-2 as the River recovered from the discharges of the Village of Campbellsport and Village of Kewaskum sewage treatment plants, and as the flow from the East Branch of the Milwaukee River tended to dilute the samples recorded at sampling station Ml-2. Between sampling stations Ml-2 and Ml-5, a slight increase in the average fecal coliform counts is noted and may be attributed to high concentrations associated with discharges from the City of West Bend sewage treatment plant and onsite sewage disposal systems installed in unsuitable soils in and near the northern portion of the Village of Saukville during wet weather conditions. Similar increases in fecal coliform counts might be expected downstream from the Newburg Sanitary District and Village of Fredonia sewage treatment facilities. However, they are not reflected in the data recorded from sampling station Ml-5 apparently because of dilution and bacterial dieoff above that sampling station. Although the averages of the observed fecal coliform counts decreased between sampling stations Ml-5 and Ml-9, a broadening range was noted in the counts recorded, as indicated by the increased difference between the 25th and 75th percentiles. This expansion is presumed to be due to an increased fluctuation in the fecal coliform counts recorded at sampling stations Ml-6 and Ml-9 because of the discharge of wastewaters from the sewage treatment facilities located at the Villages of Saukville and Grafton and the City of Cedarburg—particularly during wet weather conditions. From sampling stations Ml-9 to Ml-12, a sharp increase in the average fecal coliform counts is observed. In addition, a very significant expansion in the 25th and 75th percentile ranges recorded is noted at sampling stations Ml-11 and Ml-12. The increased fecal coliform counts observed at Ml-10 are presumed to result from discharges from the Village of Thiensville sewage treatment plant. The greatly expanded ranges in the fecal coliform counts seen at sampling stations Ml-11 and Ml-12 particularly reflect the effect of flow relief devices on Lincoln Creek and in the combined sewer service areas, respectively, during the wet weather periods. Fecal coliform counts recorded by the Metropolitan Sewerage District staff generally increased from the W. Brown Deer Road bridge to the E. Buffalo Street bridge as shown in Figure 115. The dilution effect of the flow from the Milwaukee pumping station, particularly during the summer of 1966, is also detectable in the fecal coliform counts obtained from the samples from the E. Cherry Street bridge.

The spatial variation in the August total phosphorus values recorded on the main stem of the Milwaukee River is shown in Figure 116. From sampling stations Ml-1 to Ml-2 a decrease in the total phosphorus concentrations is noted. The upstream total phosphorus values are considered likely to be contributed by runoff from agricultural lands and the discharge from the Village of Campbellsport sewage treatment plant upstream from sampling station Ml-1. The sewage treatment plant effluent from the Village of Kewaskum, while known

Figure 113

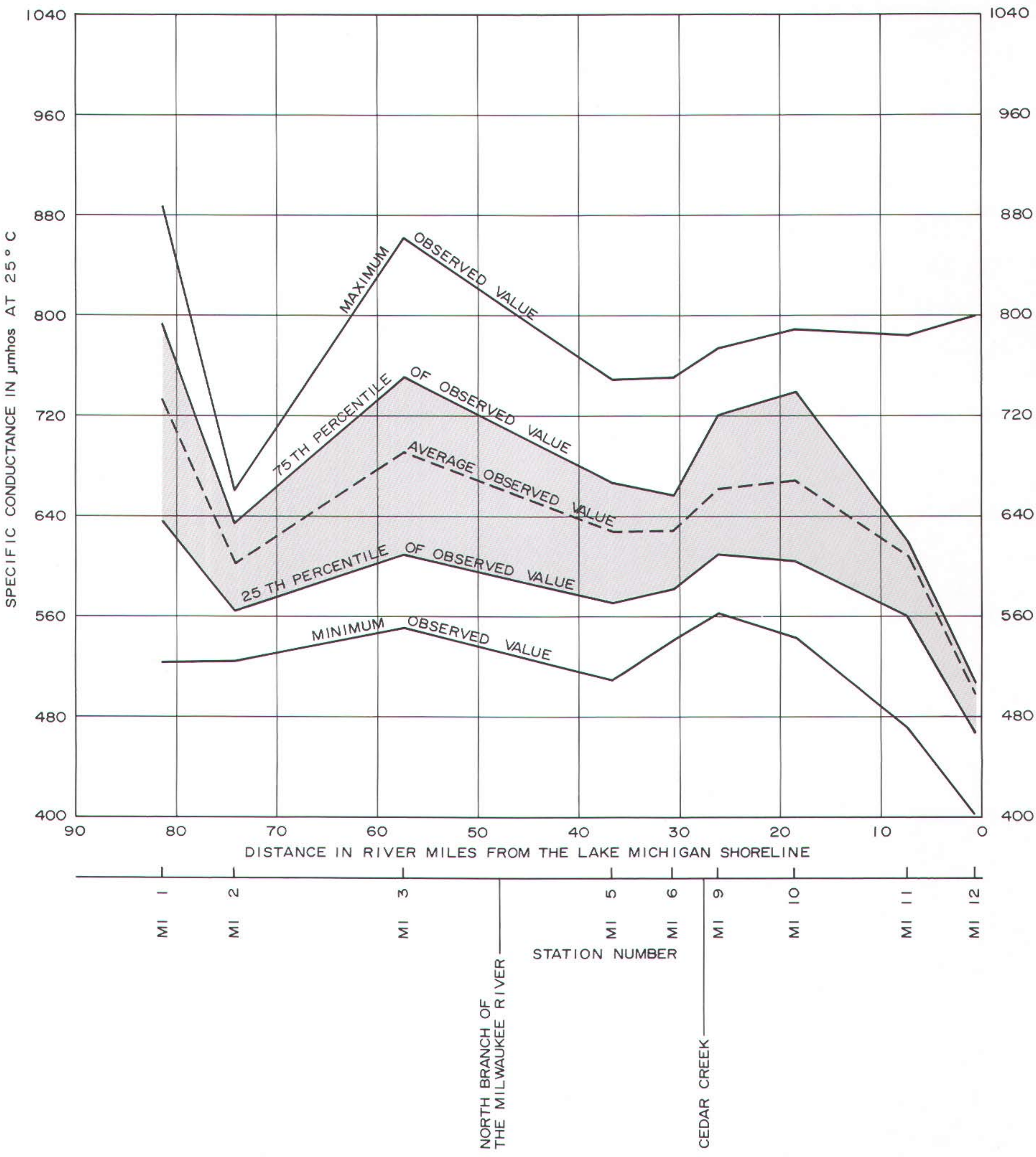
SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE MILWAUKEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 114

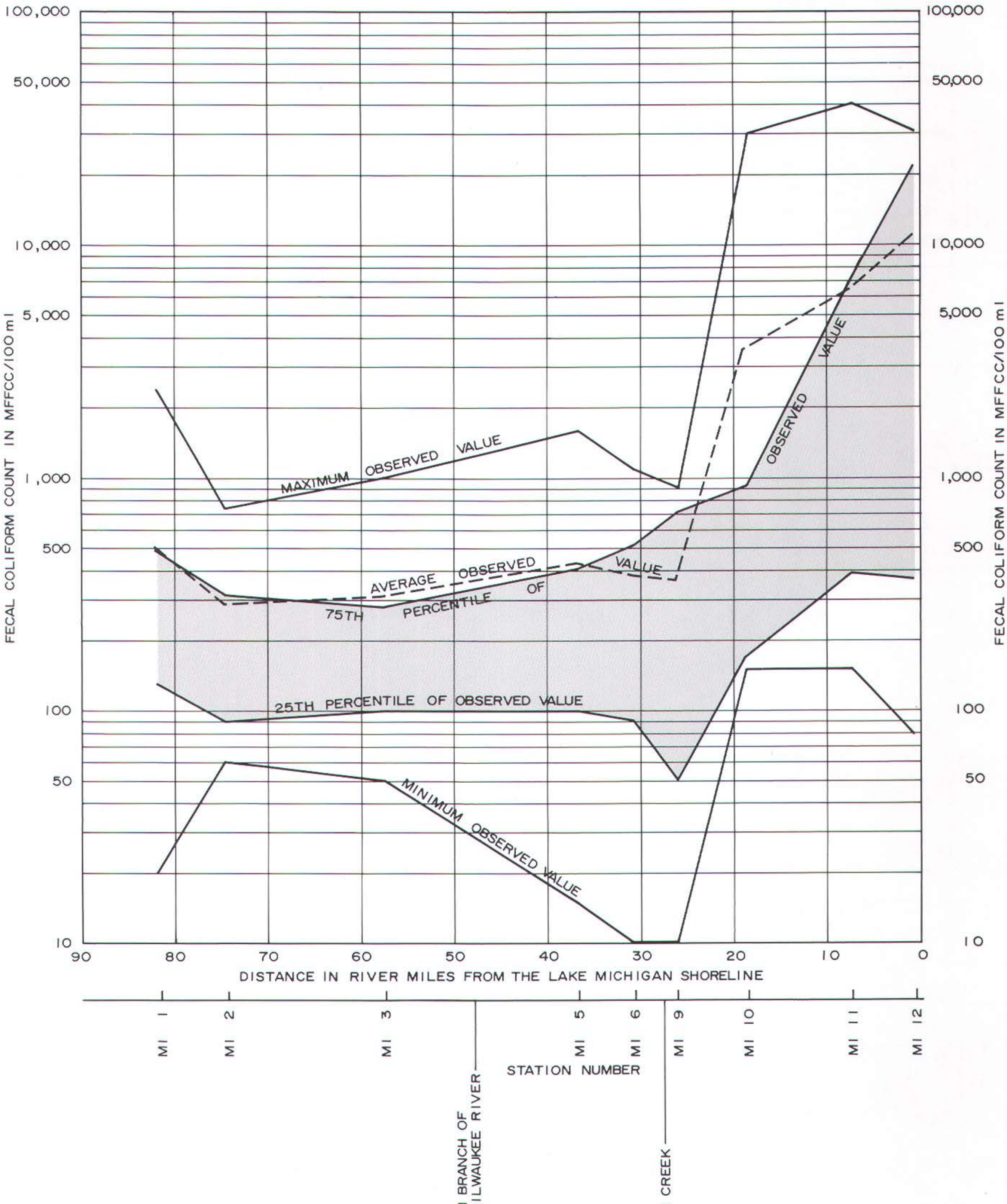
SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE MILWAUKEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 115

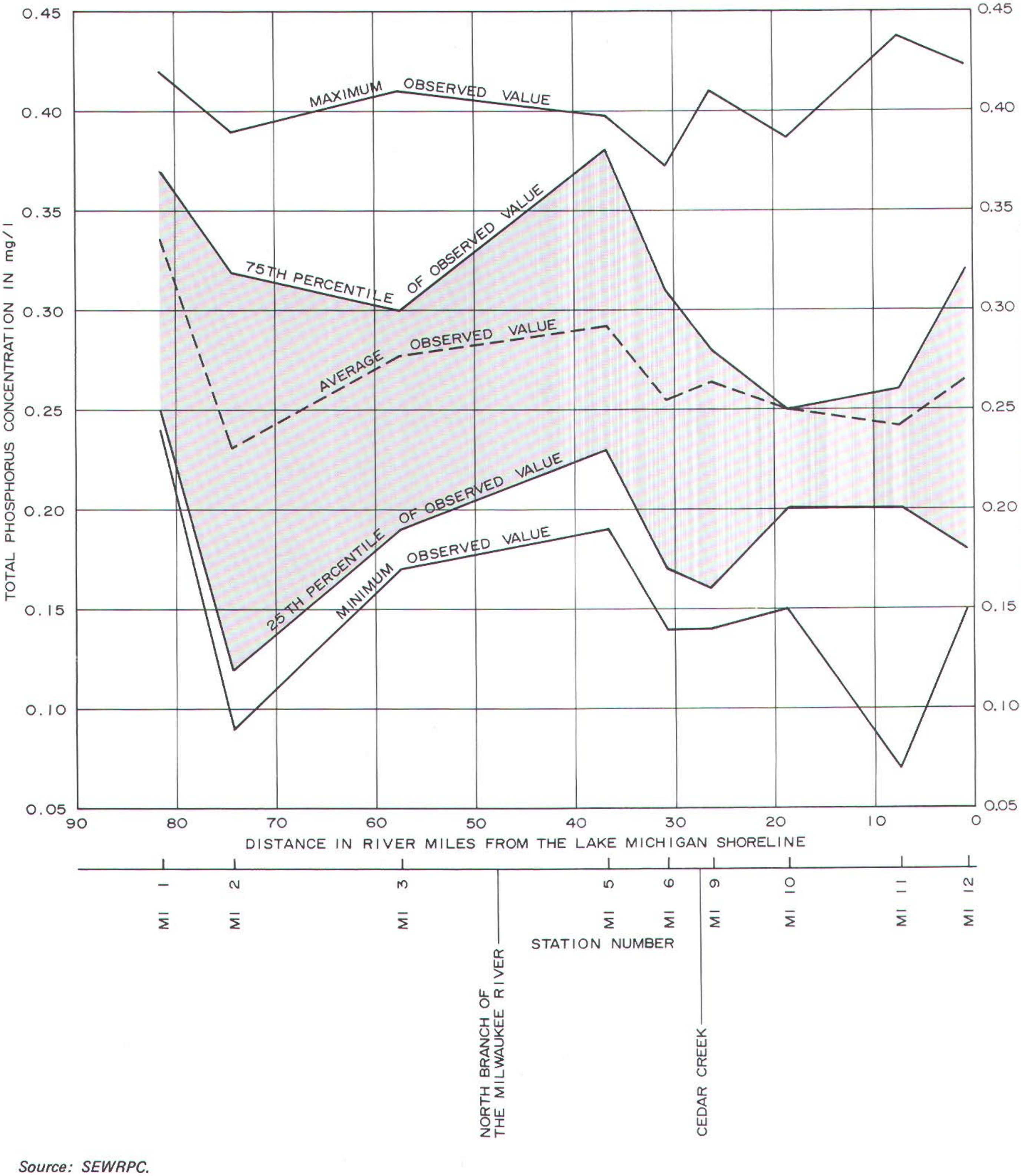
SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE MILWAUKEE RIVER WATERSHED: 1968-1975



Source: SEWRPC.

Figure 116

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE MILWAUKEE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

to contribute significant levels of phosphorus to the River system, is not reflected in the samples recorded because of the dilution effect of the East Branch of the Milwaukee River. A spatial increase in the total phosphorus values is observed from sampling stations Ml-2 to Ml-5, and is considered due largely to runoff from agricultural lands and loadings from the City of West Bend, Newburg Sanitary District, and the Villages of Fredonia and Saukville sewage treatment facilities. Although a slight increase in the average total phosphorus values is noted from sampling stations Ml-6 to Ml-9, the concentrations range between the 25th and 75th pertiles of the observed samples is noted to decrease. During wet weather conditions, the increase in the average concentration is due to high total phosphorus loadings to the River from both agricultural and urban storm water runoff and loadings from the Village of Grafton and City of Cedarburg sewage treatment facilities. However, the general decrease in the total phosphorus which occurs from sampling stations Ml-5 to Ml-10 is probably due to dilution from inflowing streams as well as uptake by algae and other aquatic plants. From sampling stations Ml-10 to Ml-11 the average total phosphorus values continue to show a decline due to continued dilution and biological assimilation; however, the concentrations range for the second and third quantities of the samples collected levels off. The levels of total phosphorus increase between sampling stations Ml-11 and Ml-12. The stabilization and increase of total phosphorus levels between sampling stations Ml-10 and Ml-12 reflect the effects of agricultural and urban storm water runoff, with some contributions of phosphorus from the Village of Thiensville sewage treatment plant and loadings from the various flow relief devices, particularly in the combined sewer service area of the City of Milwaukee.

Spatial fluctuations in the total nitrogen concentrations recorded from the source to the mouth of the main stem of the Milwaukee River for the years 1972 to 1975 are illustrated in Figure 117.

The total nitrogen concentrations exhibited a slight decrease in both the average and range of 50 percent of the concentrations recorded from sampling stations Ml-1 to Ml-2, probably due to the aassimilation of available nitrogen by algae and other aquatic plants and the dilution effect of the East Branch of the Milwaukee River. A significant increase in the total nitrogen levels occurs from sampling stations Ml-2 to Ml-3. The increase is attributable largely to the discharge of treated wastes from the City of West Bend sewage treatment plant. From sampling stations Ml-3 to Ml-6, a steady decline in the total nitrogen values is noted. Contribution of nitrogen by the Newburg Sanitary District and the Villages of Fredonia and Saukville sewage treatment plants appears to occur far enough upstream from each of the sampling stations that recovery through biological assimilation and dilution have occurred sufficiently to account for the lower concentrations. The total nitrogen concentrations exhibit a sharp increase from sampling stations Ml-6 to Ml-9 due to nitrogen loadings from the three sewage treatment facilities outfalls located in the Villages of Saukville and Grafton and the City of Cedarburg between these two sampling stations. A steady decline in the total nitrogen occurs from sampling stations Ml-9 to Ml-12, probably due to biological assimilation and the effects of dilution by inflowing streams located in this reach and Lake Michigan water.

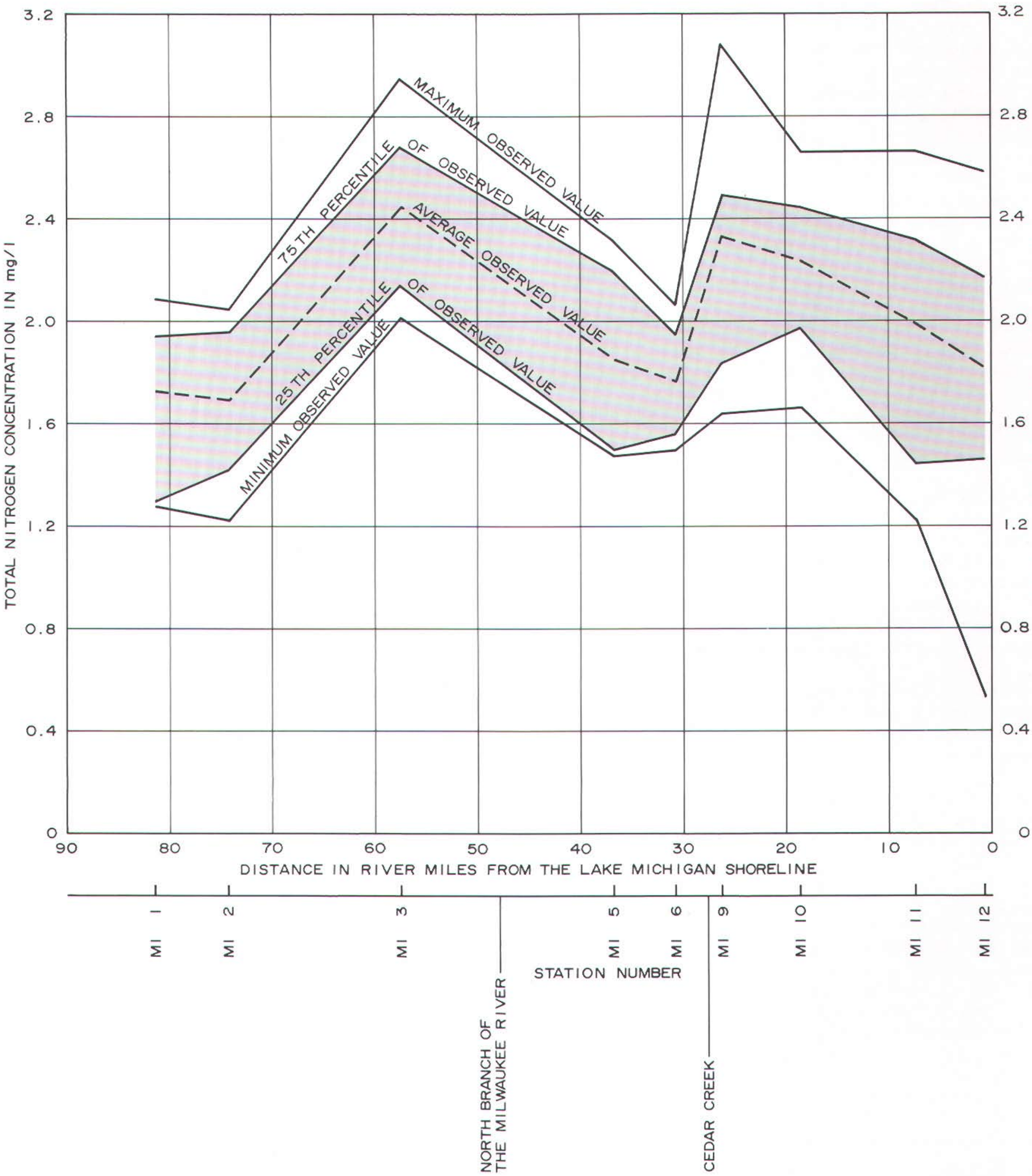
Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples between 1964 and 1975 were used to assess the quality of the Milwaukee River stream network and changes in that quality by comparison to the adopted water quality standards that support the recreational use and preservation of fish and aquatic life in those portions of the Milwaukee River and its tributaries upstream from the North Avenue dam and restricted use and minimum standards downstream from the dam.

Comparative analysis must consider the concurrent hydrologic conditions since the water quality standards are not intended to be satisfied under all streamflow conditions. The data for the daily stream gages on the Milwaukee River indicate that watershed streamflows during all the surveys were in excess of the seven day-10 year low flow above which the water quality standards are to be met.

The comparative analysis of observed water quality and standards was based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are based on recommended levels which have been adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month, nor shall the counts exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the recreational and restricted use objectives for fecal coliform bacteria standard were assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml in reaches designated for recreational uses or 2,000 colonies per 100 ml in reaches designated for restricted uses.

Figure 117

SPATIAL DISTRIBUTION OF TOTAL NITROGEN IN THE MILWAUKEE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Water Quality-1964: The results of a comparative analysis of the water quality conditions that existed during August 1964 and the water quality conditions set forth in the adopted standards are summarized on Map 39. A color coding scheme is used on Map 39 to indicate which of the standards are exceeded and along what stream reaches.

With respect to the Milwaukee River main stem, designated for recreational use and preservation of fish and aquatic life in all but the lower reaches below the North Avenue dam, which is designated for restricted and minimum standards, the water quality during the survey satisfied the applicable temperature and pH standards. Dissolved oxygen concentrations above the applicable 5.0 mg/l standard occurred in August 1964 at all stations along the main stem of the Milwaukee River including sampling stations Ml-12, which is subject to a dissolved oxygen standard of 2.0 mg/l. With respect to the tributaries, the North Branch of the Milwaukee River and Cedar Creek are designated for recreational use and preservation of fish and aquatic life. Lincoln Creek and Indian Creek, however, are designated for restricted use and maintenance of minimum standards. The water quality data collected by the Commission during the August 1964 survey on the North Branch of the Milwaukee River and on Cedar Creek and collected on Lincoln Creek by the Metropolitan Sewage Commission staff, satisfied the temperature and pH standards. Dissolved oxygen concentrations were above the recommended level of 5.0 mg/l at sampling station Ml-4 on the North Branch of the Milwaukee River and at sampling stations Ml-7 and Ml-8 on Cedar Creek. Dissolved oxygen concentrations recorded at the N. Green Bay Road bridge over Lincoln Creek met or exceeded the 2.0 mg/l standard set for that stream reach. No data are available for comparison with the water quality standards for restricted use and minimum standards on Indian Creek. Since no fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were conducted for the 1964 samples, no comparison to the nutrient contents or bacteriological safety of the Milwaukee River and its tributary waters can be made for 1964. However, since the total coliform counts in the Milwaukee River and its tributaries were greater than 2,000 MFCC/100 ml at all of the locations sampled, there is a high probability of the fecal coliform counts being higher than the permissible limit at these locations, which include the North Branch of the Milwaukee River, Cedar Creek, and the main stem of the Milwaukee River.

Water Quality-1975: With respect to the Milwaukee River main stem, designated for recreational use and preservation of fish and aquatic life in those portions upstream from the North Avenue dam and restricted use and minimum standards downstream from the dam, Map 40 indicates that the water quality conditions were such during the August 1975 survey that the temperature and ammonia standards were satisfied throughout the watershed, while substandard dissolved oxygen concentrations were recorded at sampling stations Ml-1 and Ml-3 on the main stem of the Milwaukee River. The fecal coliform standard of 400 MFFCC/100 ml was exceeded at all stations along the Milwaukee River main stem above the North Avenue dam except at sampling stations Ml-1, Ml-2, and Ml-10. Also the 2,000 MFFCC/100 ml restricted standard set for the reach downstream from the North Avenue dam was exceeded at sampling station Ml-12. The average levels of total phosphorus and nitrate nitrogen observed were in excess of the recommended levels for recreational use and fish and aquatic life use objectives of 0.10 mg/l as P and 0.30 mg/l as N which are the same for restricted use and minimum levels throughout the entire length of the Milwaukee River. For the tributaries of the Milwaukee River which are designated for recreational use and preservation of fish and aquatic life, the water quality conditions were such that the temperature, ammonia, and pH standards were met at all of the sample locations during the August 1975 survey. Substandard levels of dissolved oxygen were noted at sampling stations Ml-7 and Ml-8, both located on Cedar Creek. The fecal coliform standard of 400 MFFCC/100 ml was exceeded during the August 1975 survey at the station located on the North Branch of the Milwaukee River and the two stations located on Cedar Creek. The nutrient concentrations of nitrate nitrogen and total phosphorus recorded at the sampling station on the North Branch of the Milwaukee River and at the two stations on Cedar Creek all exceeded the recommended levels of 0.30 mg/l as N and 0.10 mg/l as P.

Since no data are available for August 1975, the water quality on Lincoln and Indian Creeks cannot be compared to water quality standards for restricted use and minimum standards.

Concluding Remarks—Milwaukee River Watershed

The Milwaukee River watershed is located in the northeastern and northcentral portions of the Southeastern Wisconsin Region. The headwater portion of the watershed lies adjacent to the Region in Dodge, Fond du Lac, and Sheboygan Counties. The Milwaukee River, approximately 101 miles in length and receiving discharge from approximately 231 miles of perennial stream tributaries, discharges into Lake Michigan at the Milwaukee River Harbor. The Milwaukee River watershed ranks first in population and third in size among the 12 watersheds located wholly or partly in the Region. In 1975 an estimated 483,193 persons lived within this watershed which has a total area of 693.8 square miles and a resulting population density of 696 people per square mile.

There are 13 public and one nonindustrial privately owned sewage treatment facilities located in the watershed. Seven of these sanitary sewage treatment facilities discharge their effluents to the main stem of the Milwaukee River, two discharge to tributaries of the North Branch of the Milwaukee River, two discharge to Cedar Creek, one discharges to Silver Creek, and one discharges to the West Branch of the Milwaukee River. The remaining one facility discharges to a soil absorption system. A total of 188 flow relief devices—consisting of 61 combined sewer overflow devices, 77 crossovers, 27 bypasses, seven relief pumping stations, and 16 portable pumping stations

Map 39

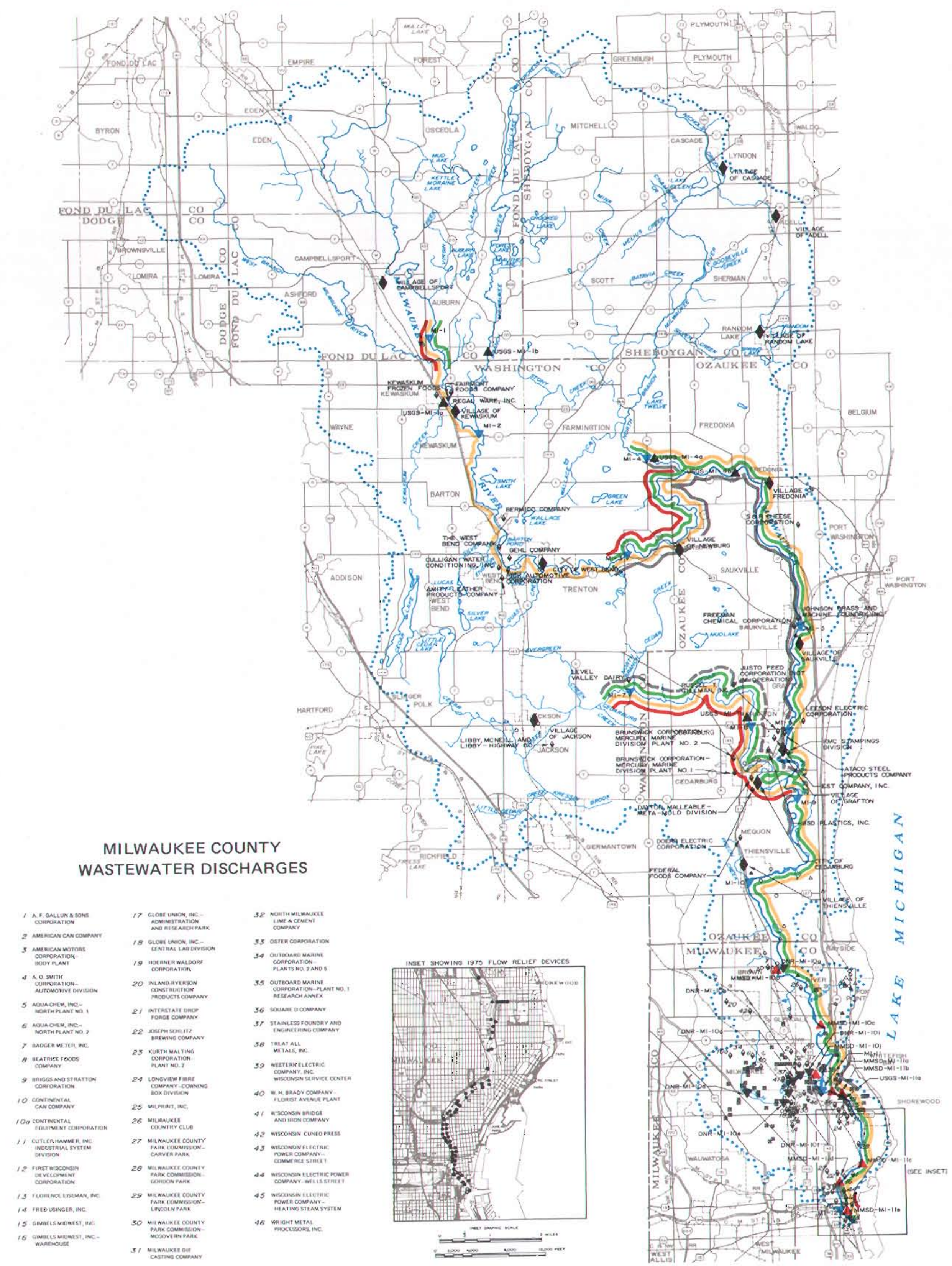
COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE MILWAUKEE RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

A comparison of stream water quality in the Milwaukee River watershed as sampled in August 1964 to the adopted water quality standards indicated that dissolved oxygen, temperature, and pH standards were satisfied throughout the watershed. All of the stations required to meet standards for recreational use exhibited substandard conditions based on total coliform levels and attendant estimated fecal coliform levels. Total coliform levels at sampling station MI-12, designated for restricted use, met the standard based on total coliform levels.

Source: SEWRPC.

Map 40

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE MILWAUKEE RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of stream water quality in the Milwaukee River watershed as sampled in August 1975 to the adopted water quality standards indicated that the temperature standard and the recommended level for ammonia were satisfied throughout the watershed. Substandard dissolved oxygen concentrations were recorded at sampling stations MI-1, MI-3 on the main stem of the Milwaukee River, and MI-7 and MI-8 on Cedar Creek. The fecal coliform standard was exceeded at all the sampling stations on the main stem and the tributaries with the exception of sampling stations MI-1, MI-2, and MI-10, although generally increasing trends were observed since 1964 at MI-10. The concentrations of nitrate-nitrogen and total phosphorus exceeded the levels recommended by the Commission throughout the watershed with the exception of sampling station MI-2 which satisfied the recommended level for total phosphorus.

Source: SEWRPC.

are located in the watershed and discharge raw sewage into the streams during times of sewer surcharge. A total of 122 industrial and commercial waste discharge points from 73 industries are known to exist in the watershed. Of these wastewater discharge points, 88 discharge cooling waters, 13 process wastewaters, 14 process and cooling wastewaters, four swimming pool overflows, and three discharge groundwater.

The Commission 1970 Land Use Inventory indicates that 23 percent of the watershed land area is devoted to urban land uses, 65 percent to rural land uses—primarily agricultural—and 12 percent to surface waters and wetlands. Approximately 68 percent of the shoreland area within 1,000 feet of the lakes, ponds, rivers, and streams of the watershed is presently used for agricultural and other rural purposes. The remaining 32 percent of shoreland is in urban land use. The watershed contains 21 major lakes and ponds.

The 1964-1965 benchmark stream water quality study conducted by the Commission included 12 sampling stations located on the Milwaukee River and its major tributaries. The water quality data for this sampling period indicated that the chloride levels were higher during February, May, and December than those of the normal background concentrations, probably reflecting the impacts of winter street and highway salting operations and spring runoff and snowmelt events.

The dissolved oxygen concentrations recorded at the Milwaukee River watershed sampling stations during the benchmark survey indicated substandard dissolved oxygen concentrations at sampling stations Ml-1 through Ml-8 and at sampling station Ml-11 during July 1964. These substandard conditions may be attributed to treatment plant and sewer overflow as well as to agricultural runoff occurring after a heavy rainfall event in the upper reaches of the watershed. High total coliform counts occurring at the sampling stations corresponded to the low flow months of July and August and are attributed to sewage effluents and seepage of septic tank effluents. The specific conductance values are highest during the spring runoff period and thus corresponded to the highest dissolved ion concentrations. The pH values obtained during the study were within the 6.0 to 9.0 standard units prescribed for rivers and streams designated for recreational, fish and aquatic life, and restricted uses. Temperature variations reflected the expected seasonal changes. The discharge of cooling waters to the Milwaukee River and its major tributaries apparently did not elevate the normal water temperatures significantly.

The 1965-1975 water quality monitoring effort by the Commission included continued sampling at the 12 stations established in the watershed. Analysis of the average chloride concentrations recorded during the August surveys indicates average chloride concentrations which significantly exceed the normal 10 mg/l background concentration except in those areas tributary to the North Branch of the Milwaukee River. The highest chloride loadings continued to occur during the spring runoff periods and during runoff periods arising from rainfall events occurring at other times of the year. As well as being associated with deicing salts, chloride levels in the watershed are associated with sewage treatment plant effluent, sewer overflows, and industrial discharges. Chloride loadings in the Milwaukee River watershed were higher in April than in August due to the spring runoff. The chloride concentrations exhibited increasing trends from 1968 through 1975 at sampling stations Ml-1 and Ml-2 on the main stem of the Milwaukee River due to probable increased loadings from the Villages of Campbellsport and Kewaskum sewage treatment plants. Sampling stations Ml-3 and Ml-9 experienced a decrease and sampling stations Ml-5, Ml-6, and Ml-10 through Ml-12 showed no significant trend in the chloride concentrations over the same time period. No significant change was noted at sampling station Ml-4 on the North Branch of the Milwaukee River. Chloride concentrations at both sampling stations Ml-7 and Ml-8 decreased from 1968 to 1975. The chloride concentrations recorded by the Metropolitan Sewerage District in the lower reaches of the Milwaukee River fluctuated, thus exhibiting no specific trend during the years 1964 through 1975. Chloride concentrations recorded by the Metropolitan Sewerage District exhibited generally increasing spatial trends from the E. Green Tree Road bridge to the North Avenue dam. The chloride concentrations declined downstream from the North Avenue dam due to dilution from the Milwaukee River flushing tunnel and the effects of Lake Michigan. The chloride concentrations in this stream reach are affected by the storm water runoff and sanitary sewage discharge from the combined sewer overflows and flow relief devices located in the area.

The average dissolved oxygen concentrations were above the applicable standard of 5.0 mg/l for sampling stations Ml-1 through Ml-11 and above 2.0 mg/l for sampling station Ml-12 for the Milwaukee River and its major tributaries. However, substandard concentrations were recorded at all stations within the watershed except for sampling stations Ml-6 and Ml-11. The substandard dissolved oxygen concentrations at these stations are attributed to the discharge of sanitary wastes from the sewage treatment facilities and flow relief devices, industrial effluents, and urban and rural runoff. Analysis of the average dissolved oxygen concentrations from 1964 through 1975 indicates an increasing trend at sampling stations Ml-1, Ml-2, Ml-5, Ml-6, Ml-10, and Ml-12. Decreasing trends in the average dissolved oxygen concentrations were noted at sampling stations Ml-3, Ml-9, and Ml-11. Sampling station Ml-4 on the North Branch of the Milwaukee River and sampling stations Ml-7 and Ml-8 on Cedar Creek experienced no significant change from 1964 through 1975.

Substandard dissolved oxygen concentrations were also recorded by the Metropolitan Sewerage District in the results of samples from all but one of the eight sample sites located on the Milwaukee River and Lincoln Creek from 1964 to 1968. The average dissolved oxygen concentrations recorded from 1964 to 1966 upstream from the North Avenue dam fluctuated, showing no specific trend. Downstream from the North Avenue dam a general decline in the average dissolved oxygen is noted from 1964 to 1968 except for those concentrations recorded at the E. Cherry Street bridge which show no change.

The average fecal coliform counts recorded at the 12 Milwaukee River watershed sample sites exceeded the 400 MFFCC/100 ml maximum standard prescribed for the Milwaukee River main stem upstream from the North Avenue dam, for the North Branch of the Milwaukee River, and for Cedar Creek, and exceeded the 2,000 MFFCC/100 ml maximum standard prescribed for the lower reaches of the Milwaukee River downstream from the North Avenue dam. The high fecal coliform counts may be attributed to the discharge of raw sewage from overloaded sewage treatment facilities, sanitary sewer flow relief devices, septic tank effluents, and urban and rural storm water runoff occurring upstream from the sampling stations. This assumption is supported, in part, by fecal coliform counts recorded in the lower reaches of the Milwaukee River and Lincoln Creek by the Metropolitan Sewerage District and the City of Milwaukee Health Department since the observed counts exceeded the applicable standards of 400 MFFCC/100 ml and 2,000 MFFCC/100 ml on more than one occasion at each of the eight sampling stations during the six years of record.

Analysis of the three-year moving averages for the fecal coliform counts obtained on the main stem of the Milwaukee River indicated a decreasing trend at sampling stations Ml-1, Ml-10, and Ml-11. The decreases at sampling stations Ml-1 and Ml-10 are probably a result of effluent chlorination instituted in 1971 at the Villages of Campbellsport and Thiensville sewage treatment plants. The fecal coliform counts recorded at sampling stations Ml-3 and Ml-6 fluctuate greatly and therefore show no specific trend. The remaining sampling stations along the main stem of the Milwaukee River, the North Branch of the Milwaukee River, and Cedar Creek exhibit an increasing trend in their fecal coliform counts. This increasing trend in fecal coliform counts is probably the result of overloading of the sewage treatment plants at the Villages of Grafton, Jackson, and Kewaskum and the Cities of Cedarburg and West Bend, which discharge to the River. The trend in coliform counts is the result additionally of onsite sewage disposal systems located on unsuitable soils, discharge from flow relief devices and stormwater runoff from agricultural lands.

The specific conductance values recorded at the Milwaukee River watershed sampling stations exhibited a trend toward higher values in the spring samples, which corresponds to the trend in chloride concentrations. The higher specific conductance, therefore, is considered attributable to spring runoff and snowmelt which contain high concentrations of deicing salts. The pH values remained within the range of 6.0 to 9.0 standard units prescribed for recreational use and maintenance of fish and aquatic life as well as for restricted use objectives. A stable trend in the pH variation was noted in the samples collected in August samples collected between 1964 and 1975.

All the total phosphorus concentrations recorded remained in excess of the recommended water quality level of 0.10 mg/l as P at all 12 sampling stations in the watershed. Similarly, the nitrate nitrogen concentrations exceeded the recommended water quality level of 0.30 mg/l as N at the 12 sampling stations for many of the samples analyzed for the past eight years.

Of the 21 major lakes located within the Milwaukee River watershed, 16 have a maximum depth greater than 15 feet and therefore are likely to stratify during the summer season. Dissolved oxygen profiles prepared for these major lakes indicate that all 16 lakes exhibit less than 1.0 mg/l dissolved oxygen levels in the hypolimnion, which may adversely affect fish and other aquatic life in the lakes. The dissolved oxygen concentrations in the epilimnion are generally above 7.0 mg/l. Nine of the 21 major lakes located in the watershed have been classified according to their trophic status; one as oligatrophic, five as mesotrophic, two as eutrophic, and one as very eutrophic.

The diurnal water quality data for the Milwaukee River exhibit a broad range of dissolved oxygen concentrations from a low of 3.7 mg/l to a high of 11.3 mg/l at sampling station Ml-2 and a low of 7.3 mg/l to a high of 11.5 mg/l at sampling station Ml-11 on the main stem of the Milwaukee River. The diurnal variations at sampling station Ml-4 located on the North Branch of the Milwaukee River ranged from 4.7 mg/l to 9.9 mg/l. At sampling stations Ml-7 and Ml-8 located on Cedar Creek, the diurnal variations ranged from 2.5 mg/l to 9.5 mg/l and 4.4 mg/l to 9.8 mg/l, respectively. These diurnal variations reflect dissolved oxygen reductions due to respiration by aquatic flora as well as the decomposition of organic matter deposited in the stream and the supersaturation effects of algal photosynthesis on dissolved oxygen levels.

In addition to the marked diurnal fluctuations exhibited at the Milwaukee River watershed sampling stations, the water quality exhibits a predictable pattern of spatial variation. The water quality, as measured by the dissolved oxygen and fecal coliform counts, generally is better upstream than downstream from the sewage treatment facilities, sanitary sewer flow relief devices, and industrial discharges located on the Milwaukee River and its tributaries.

Although for specific parameters the water quality of the Milwaukee River and its major tributaries fluctuated between slightly improved, no change, or slightly worse, the overall trend since 1964 would indicate a slightly degraded water quality condition. When comparing the entire spectrum of the 10 years of water quality data to the water quality standards as adopted by the Wisconsin Department of Natural Resources, dissolved oxygen concentrations and fecal coliform counts are found not to satisfy the minimum standards for recreational use and the preservation of fish and aquatic life set for the reaches of the Milwaukee River and its tributaries upstream from the North Avenue dam nor the minimum standards for restricted use set for the reaches of the main stem of the Milwaukee River downstream from the North Avenue dam and for Lincoln Creek. In addition, the plant nutrients, total phosphorus, and nitrate-nitrogen levels were found to be significantly higher than the recommended levels adopted by the Commission.

MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN

Regional Setting

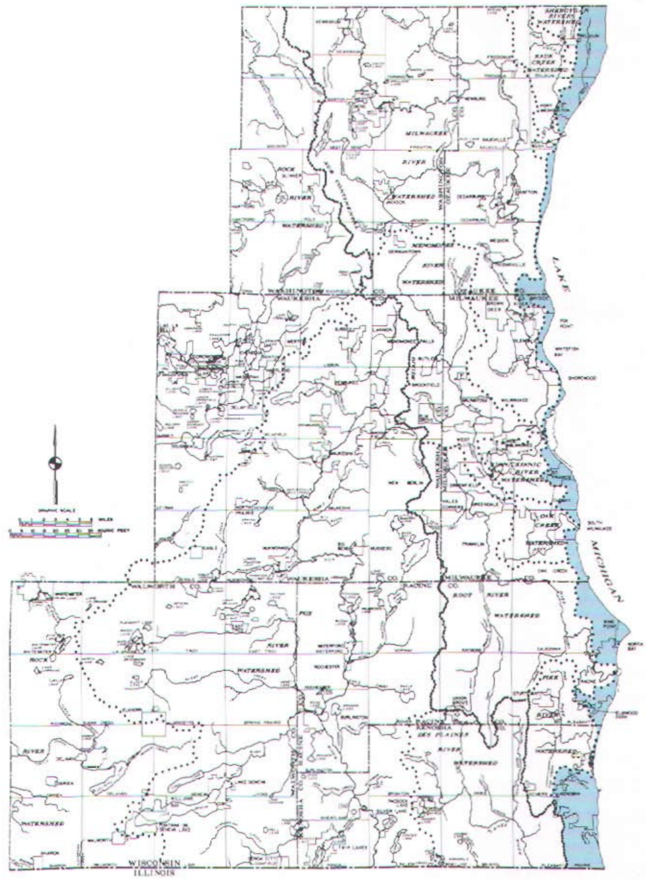
The composite watershed of the streams which are directly tributary to Lake Michigan has a combined area of 95.52 square miles and is located in the eastern portion of the Region along the Lake Michigan shore. The boundaries of the drainage areas, together with the locations of the three perennial streams which drain the composite watershed—Barnes Creek, Pike Creek, and Sucker Creek—are shown on Map 41. The three subwatersheds lie on the western shore of Lake Michigan in the eastern portions of Ozaukee, Milwaukee, Racine, and Kenosha Counties. Barnes Creek rises at a point two miles north of the Illinois State line and less than one mile from Lake Michigan in Kenosha County and flows northeasterly, easterly, and southeasterly to Lake Michigan. Pike Creek rises near the north central portion of the City of Kenosha and flows easterly and southeasterly through the City of Kenosha to Lake Michigan. The lower reaches of Pike Creek flow through a large-diameter subterranean culvert. Sucker Creek rises within the Region, about two miles northeast of the Village of Belgium, and flows generally southerly to its point of discharge into Lake Michigan, about three miles north of the harbor at the City of Port Washington. Barnes Creek flows off the eastern slope of a broad end moraine paralleling Lake Michigan southwest of the City of Kenosha and flows to Lake Michigan. Table 124 lists each stream reach, the location, the source, and the length in miles of each stream reach in the drainage area. The drainage area of these three combined subwatersheds, wholly contained within the Region, is the third largest in population and seventh in size of the 12 watersheds of the Region. Together these three subwatersheds comprise 1.0 percent of the total land and water area of the Region.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries of these three watersheds is a rectilinear pattern of local political boundaries, as shown on Map 41. The subwatersheds lie in four counties—Kenosha, Mil-

Map 41

LOCATION OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The watershed of minor streams directly tributary to Lake Michigan has a total area of 96 square miles and comprises about 3.5 percent of the total 2,689-square-mile area of the Region. The watershed ranks third in population and seventh in size as compared to the 12 watersheds of the Region.

Source: SEWRPC.

Table 124

STREAMS IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

Stream	Source		Length in Miles[a]
	By Civil Division	By U. S. Public Land Survey	
Barnes Creek	Town of Somers	SW ¼, Section 19, T1N, R23E	3.7
Pike Creek	Town of Somers	NE ¼, Section 26, T2N, R22E	4.2
Sucker Creek	Town of Belgium	SW ¼, Section 1, T12N, R22E	8.8

[a] *Total perennial stream length as shown on U. S. Geological Survey quadrangle map.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

waukee, Racine, and Ozaukee—and in 10 cities, 10 villages, and seven towns. The area and proportion of the drainage area lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 125.

Population

Population Size: The 1975 resident population of the drainage area is estimated at 238,414 persons, or about 13.3 percent of the total estimated resident population of the Region of 1,789,871. Table 126 presents by civil division the population distribution in the subwatersheds of the minor streams tributary to Lake Michigan, including the major subwatersheds of Barnes Creek, Pike Creek, and Sucker Creek. The population of these three subwatersheds has increased steadily since 1900, and since 1940 the rate of population increase generally has exceeded the regional growth rate.

Population Distribution: Presently, about 89 percent of the residents of these three subwatersheds live in incorporated cities and villages, the combined areas of which comprise about 25 percent of the combined area of these watersheds.

Quantity of Surface Water

Surface water in these subwatersheds within the Region is made up almost entirely of streamflow. No streamflow data are available to evaluate the seasonal effect on the flow of the streams of the subwatersheds. The available flow information for similar watersheds of the Region indicates that higher streamflows occur principally in the late winter and early spring—usually associated with melting snow—and that lower flows may persist for most of the remainder of the year with occasional increases caused by rainfall.

The lower reaches of the Barnes Creek, Pike Creek, Sucker Creek, and other first rank tributaries to Lake Michigan are subject to a phenomenon known as a seiche. A seiche, also known as a standing wave, is an oscillation of the water mass at the surface or within a lake lasting from a few minutes to several hours. The forces that generate seiches include variation in atmospheric pressure and wind. The flow condition and the water quality in the lower reaches of Barnes Creek, Pike Creek, and Sucker Creek can temporarily be affected by the dilution effects of the Lake Michigan water during a seiche.

Pollution Sources

An evaluation of water quality conditions must include an identification, categorization and, where feasible, quantification of known pollution sources. In the analysis of water quality of the minor streams tributary to Lake Michigan, the pollution sources that discharge into the three perennial minor streams—Barnes Creek, Pike Creek, and Sucker Creek—are largely limited to urban and rural runoff, although some sanitary sewerage systems flow relief devices and industrial waste outfalls exist in some of these subwatersheds.

Sewage Treatment Facilities: No known public or nonindustrial private sewage treatment facilities discharge effluent into the three streams—Barnes Creek, Pike Creek, and Sucker Creek—or into their tributaries.

Domestic Onsite Sewage Disposal Systems: Although certain areas of the watershed lie within existing and proposed sewer service areas of the public sanitary sewerage systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points: There are no known points of sanitary flow relief in either the Barnes Creek or Sucker Creek subwatersheds. There are three known sanitary sewerage system crossovers and two relief pumping stations located in the City of Kenosha in the Pike Creek subwatershed, as shown in Table 127. Map 42 presents the location of these sanitary sewerage system flow relief points. Raw sanitary sewage may enter the surface water system of Pike Creek from these crossovers and relief pumping stations, causing organic, inorganic, and pathogenic pollution of the stream.

In addition, there are 97 points of sanitary flow relief in that portion of the minor streams tributary to Lake Michigan watershed outside the above-mentioned three major subwatersheds. As shown in Table 127, those 95 relief devices consist of 8 combined sewer outfalls, 72 crossovers, 12 bypasses, one relief pumping station, and two portable relief pumping stations from which raw sewage may enter the surface water of Lake Michigan or those minor streams directly tributary to Lake Michigan.

Industrial Waste Discharges: Noncontact cooling waters are discharged to Pike Creek at one location in the Pike Creek subwatershed of the minor streams tributary to Lake Michigan watershed (see Map 42).[11] This industrial wastewater enters Pike Creek through a storm sewer. There are no known industrial discharges to either Barnes Creek or Sucker Creek. Table 128 summarizes by receiving stream and civil division the type of industrial wastewater discharge and the number of outfalls in the watershed, type of treatment, and average hydraulic design capacity. Data and information provided from the Wisconsin Pollutant Discharge Elimination System and reports required

[11] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 42. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 125

AREAL EXTENT OF THE CIVIL DIVISIONS IN THE MINOR STREAM TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1975

Civil Division	Lake Michigan Watershed		
	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
City			
Kenosha	12.63	13.22	85.51
Towns			
Pleasant Prairie	12.13	12.70	33.08
Somers	2.38	2.49	6.93
County Subtotal	27.14	28.41	9.75
MILWAUKEE COUNTY			
Cities			
Cudahy	3.03	3.17	63.92
Glendale	0.04	0.04	0.67
Milwaukee	3.82	4.00	3.95
Oak Creek	3.03	3.17	10.66
St. Francis	2.45	2.56	95.70
South Milwaukee	1.63	1.71	33.61
Villages			
Bayside	1.96	2.05	84.85
Fox Point	1.32	1.38	45.83
Shorewood	0.12	0.12	7.06
Whitefish Bay	1.40	1.46	65.73
River Hills	1.09	1.14	20.57
County Subtotal	19.89	20.82	8.20
OZAUKEE COUNTY			
Cities			
Mequon	3.99	4.17	8.48
Port Washington	1.09	1.14	35.39
Villages			
Bayside	0.09	0.09	100.00
Belgium	0.10	0.10	15.15
Towns			
Belgium	13.27	13.89	35.86
Grafton	2.91	3.05	13.37
Port Washington	6.02	6.30	31.14
County Subtotal	27.47	28.76	11.69
RACINE COUNTY			
City			
Racine	6.83	7.15	50.78
Villages			
Elmwood Park	0.16	0.17	100.00
North Bay	0.11	0.12	100.00
Wind Point	1.27	1.33	100.00
Towns			
Caledonia	10.48	10.97	22.46
Mt. Pleasant	2.17	2.27	5.79
County Subtotal	21.02	22.01	6.18
Total	95.52	100.00	--

Table 125 (continued)

Civil Division	Barnes Creek Subwatershed		
	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
City			
Kenosha	0.11	2.44	0.74
Town			
Pleasant Prairie.	4.39	97.56	11.97
Total	4.50	100.00	--

Civil Division	Pike Creek Subwatershed		
	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
City			
Kenosha	5.32	74.93	36.02
Town			
Somers	1.78	25.07	5.18
Total	7.10	100.00	--

Civil Division	Sucker Creek Subwatershed		
	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
OZAUKEE COUNTY			
Village			
Belgium	0.10	0.96	15.15
Towns			
Belgium	7.64	73.46	20.65
Port Washington.	2.66	25.58	13.76
Total	10.40	100.00	--

Source: SEWRPC.

by Chapter NR 101 of the Wisconsin Administrative Code were used to determine the type and location of industrial wastewater discharges in the minor streams tributary to Lake Michigan watershed. The one discharge point discharges cooling water to a storm sewer which empties into Pike Creek.

Pollution from Urban Runoff: Separate storm sewers which convey the runoff from rainfall carry the pollutants and contaminants washed off of the urbanized areas and drained into receiving waters. Urban storm water runoff can cause chemical, organic, inorganic, pathogenic, and aesthetic pollution of the receiving streams. Existing land use information taken from the Commission 1970 land use inventory is presented in Table 129 and indicates that, in the Barnes Creek watershed, 1,545 acres, or 33 percent of the land, is in urban use; 2,879 acres, or 62 percent, is in rural use; and the remaining 253 acres, or 5 percent, is occupied by streams and wetlands. In the Pike Creek subwatershed, 4,950 acres, or 75 percent of

Table 126

ESTIMATED RESIDENT POPULATION OF MINOR TRIBUTARIES DRAINING TO LAKE MICHIGAN BY CIVIL DIVISION: 1975

Civil Division	1975 Population
KENOSHA COUNTY	
City	
Kenosha (part)	76,358
Towns	
Pleasant Prairie (part)	7,875
Somers (part)	1,453
Kenosha County (part) Subtotal	85,686
MILWAUKEE COUNTY	
Cities	
Cudahy (part)	15,604
Glendale (part)	27
Milwaukee (part)	28,791
Oak Creek (part)	1,046
St. Francis (part)	9,255
South Milwaukee (part)	7,071
Villages	
Bayside (part—Milwaukee County portion)	3,420
Fox Point (part)	1,879
River Hills (part)	377
Shorewood (part)	248
Whitefish Bay (part)	9,733
Milwaukee County (part) Subtotal	77,451
OZAUKEE COUNTY	
Cities	
Mequon (part)	2,934
Port Washington (part)	3,240
Villages	
Bayside (part—Ozaukee County portion)	108
Belgium (part)	182
Towns	
Belgium (part)	967
Grafton (part)	253
Port Washington (part)	465
Ozaukee County (part) Subtotal	8,149
RACINE COUNTY	
City	
Racine (part)	52,334
Villages	
Elmwood Park	415
North Bay	249
Wind Point	1,292
Towns	
Caledonia (part)	9,187
Mt. Pleasant (part)	3,651
Racine County (part) Subtotal	67,128
Minor Tributaries Draining to Lake Michigan	238,414

Civil Division	1975 Population
PIKE CREEK	
City	
Kenosha	30,513
Town	
Somers	747
Kenosha County	31,260
Pike Creek Subwatershed	31,260
BARNES CREEK	
City	
Kenosha	63
Town	
Pleasant Prairie	2,753
Kenosha County	2,816
Barnes Creek Subwatershed	2,816
SUCKER CREEK	
Village	
Belgium	182
Towns	
Belgium	275
Port Washington	96
Ozaukee County	553
Sucker Creek Subwatershed	553

Source: SEWRPC.

the watershed, is devoted to urban land uses; 1,618 acres, or 24 percent, devoted to rural land uses, primarily agricultural; and 93 acres, or 1 percent of the land, is occupied by streams and wetlands. In Sucker Creek subwatershed, 91 percent, or 8,495 acres of the land, is in rural use; 6 percent, or 580 acres, in urban use; and 243 acres, or 3 percent of the land, is occupied by streams and wetlands. The urban land uses comprising 74 percent of the total area of the Pike Creek subwatershed and 33 percent of the total area of the Barnes Creek subwatershed may be expected to have a significant effect on the water quality of the affected stream systems.

Pollution from Rural Land: Agricultural land uses have been determined to provide high concentrations of suspended solids, total nitrogen, and total phosphorus in storm water runoff. Since 62 percent of the total area of the Barnes Creek subwatershed and 91 percent of the total area of the Sucker Creek subwatershed are in agricultural use, pollution from the agricultural land may be expected to be a significant factor in determining the water quality of these stream systems.

Other Pollution Sources: The Commission 1970 Land Use Inventory indicated, in addition to the pollution sources described above, the presence of one auto salvage yard in the Barnes Creek watershed and five auto salvage yards and one sanitary landfill site in the Pike

Table 127

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Other Flow Relief Devices				Total
			Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Lake Michigan	City of Port Washington	0	0	4	0	0	4
Lake Michigan	Village of Bayside	0	2	2	1	2	7
Lake Michigan	Village of Whitefish Bay	0	21	1	0	0	22
Lake Michigan	City of Milwaukee	2	1	0	0	0	3
Lake Michigan	Village of Fox Point	0	7	0	0	0	7
Lake Michigan	City of St. Francis	0	1	0	0	0	1
Fish Creek	Village of Bayside	0	1	0	0	0	1
Lake Michigan	City of Cudahy	0	22	0	0	0	22
Lake Michigan	City of South Milwaukee	0	0	2	0	0	2
Lake Michigan	City of Kenosha	4	11	1	0	0	16
Lake Michigan	Village of North Bay	0	0	1	0	0	1
Lake Michigan	Town of Mt. Pleasant	0	0	1	0	0	1
Lake Michigan	City of Racine	2	6	0	0	0	8
Total		8	72	12	1	2	95

Receiving Stream	Civil Division	Combined Sewer Outfalls	Other Flow Relief Devices				Total
			Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Pike Creek	City of Kenosha	0	3	0	2	0	5

Source: SEWRPC.

Table 128

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1975

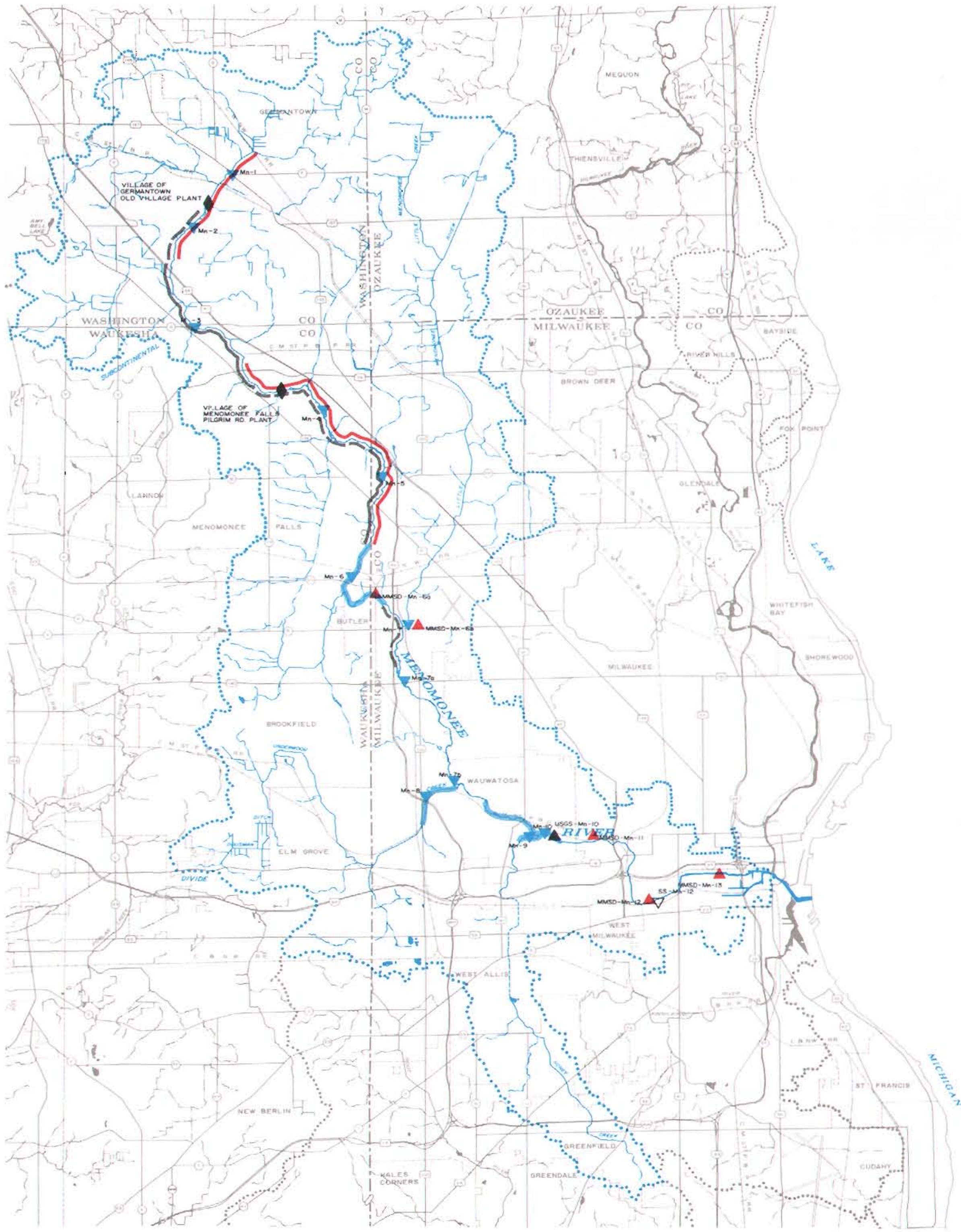
Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
KENOSHA COUNTY American Motors Corporation—Main Plant	3711	City of Kenosha	Cooling	None	1	Pike Creek via Storm Sewer	2,335,000	2,834,000

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rate was estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

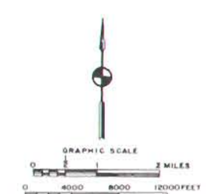
Map 32

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE MENOMONEE RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



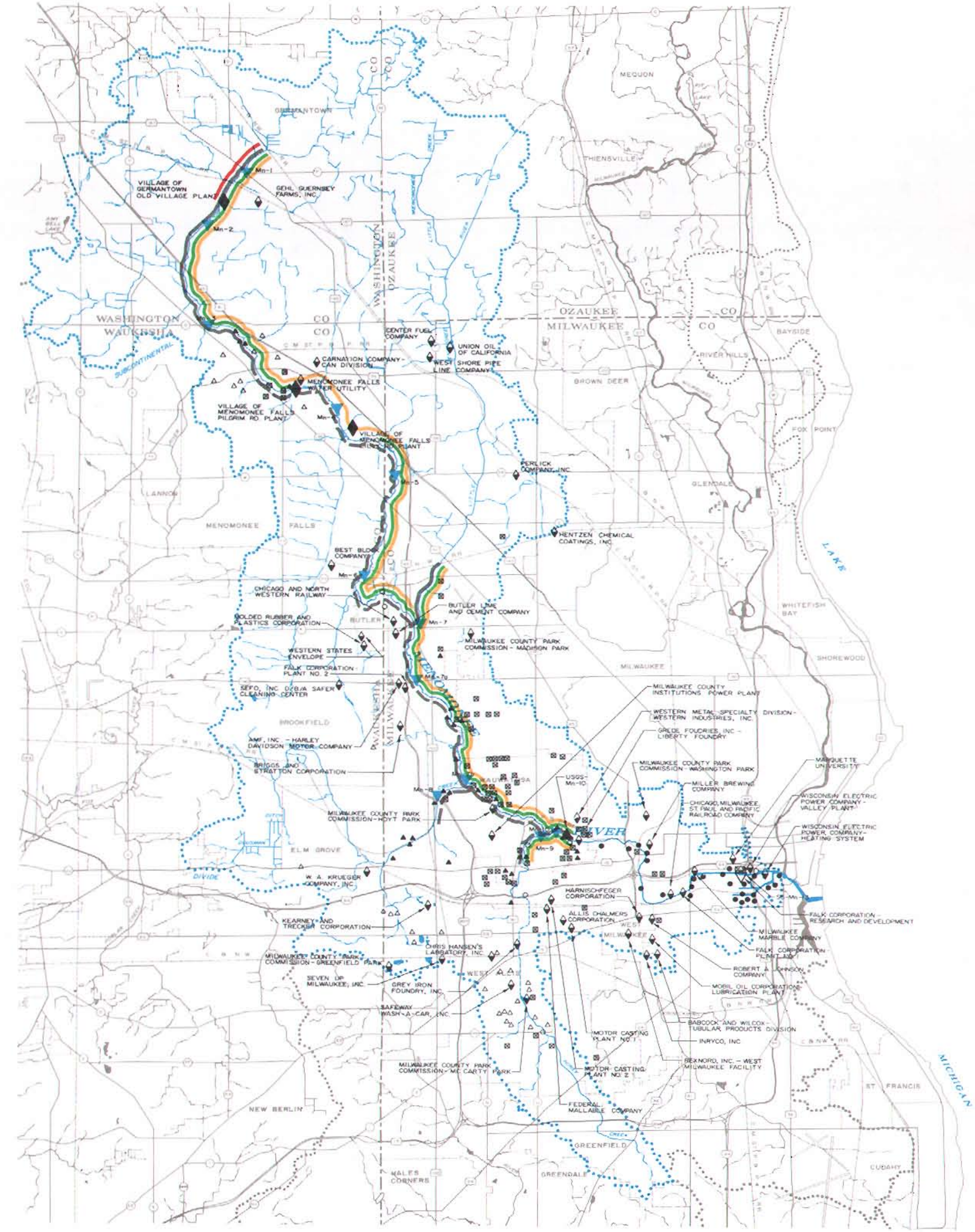
A comparison of the stream water quality in the Menomonee River watershed as sampled in August 1964 to the adopted water quality standards indicated that all sampling stations satisfied the temperature and pH standards. Substandard concentrations of dissolved oxygen were recorded at Mn-1, Mn-2, Mn-4, and Mn-5 on the main stem of the Menomonee River. Samples collected at stations Mn-2, Mn-3, Mn-4, Mn-5, and Mn-7 exhibited coliform levels in excess of standards for recreational use.

Source: SEWRPC.



Map 33

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE MENOMONEE RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

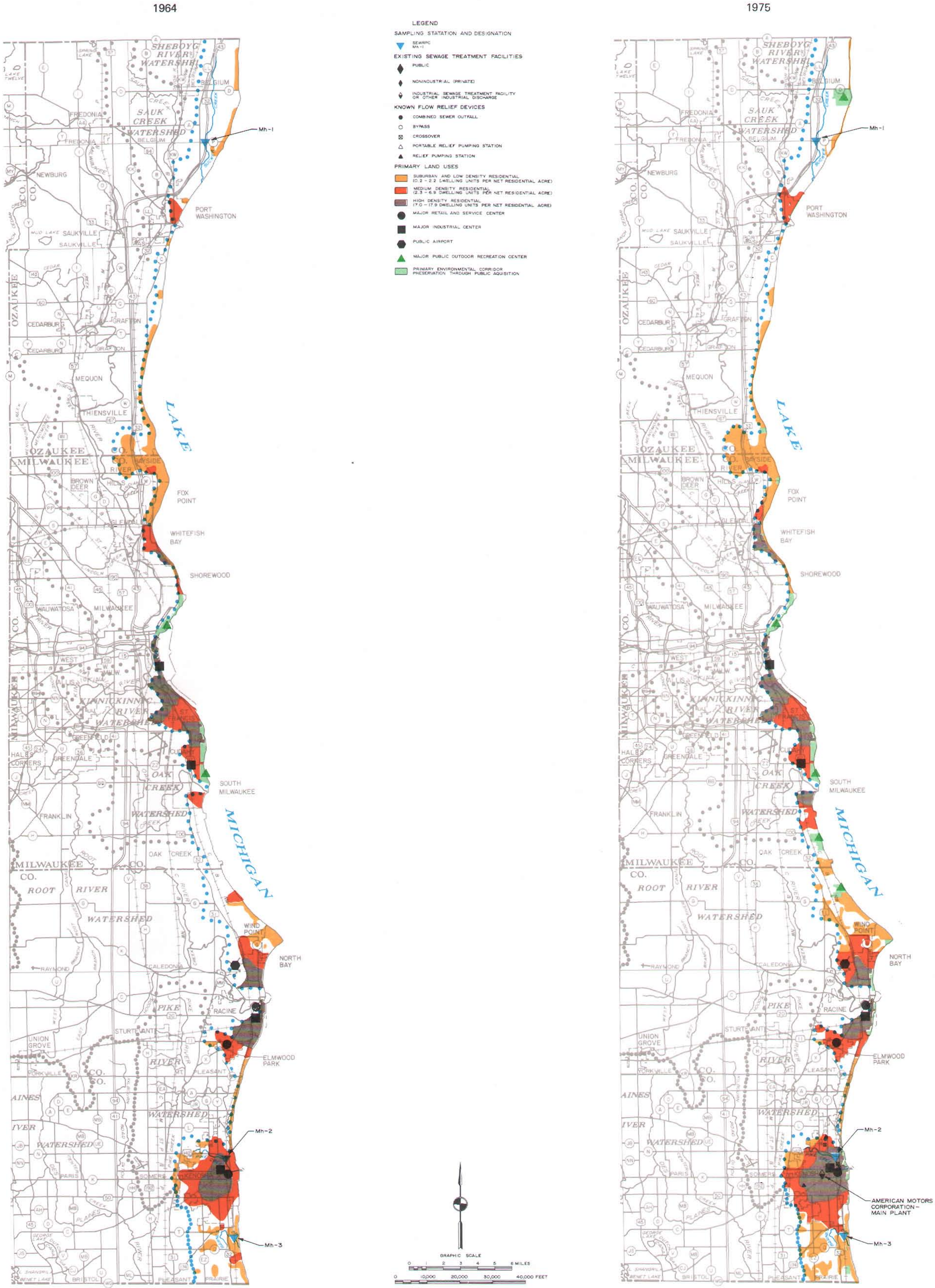


A comparison of the stream water quality in the Menomonee River watershed as sampled in August 1975 to the adopted water quality standards indicated that the ammonia, temperature, and pH standards were satisfied throughout the watershed. Substandard dissolved oxygen concentrations were observed at sampling station Mn-1. Substandard concentrations of fecal coliform were found to exist throughout the entire length of the watershed. Nitrate-nitrogen and total-phosphorus concentrations also exceeded the levels recommended by the Commission throughout the entire length of the Menomonee River and its tributaries, with the exception of sampling stations Mn-4 and Mn-8 where recommended level for total phosphorus was achieved.

Source: SEWRPC.

Map 42

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND URBAN DEVELOPMENT IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN: 1964-1975



Stream water quality was obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at three sampling stations located in the watershed of minor streams tributary to Lake Michigan. These data were analyzed to determine the water quality conditions of the streams over time as affected by discharges from three sanitary sewerage system crossovers, two relief pumping stations, and one industrial waste outfall.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 129

LAND USE IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1963 AND 1970

Lake Michigan Tributaries, including Barnes, Pike, and Sucker Creeks

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	15,273.69		16,015.03	
Commercial	1,268.72		1,466.36	
Industrial	1,074.27		969.59	
Transportation and Utilities	7,551.63		7,948.70	
Government	1,704.62		2,016.97	
Recreation	2,144.20		2,113.59	
Landfill and Dump	33.34		107.38	
Total	29,050.47	48.42	30,637.62	51.01
Rural Land Uses				
Open Land	5,065.80		5,302.21	
Agricultural Lands	24,474.29		22,552.73	
Total	29,540.09	49.24	27,854.94	46.37
Water Covered Lands				
Lakes, Rivers, and Streams	173.78		237.27	
Wetlands	1,231.97		1,335.75	
Total	1,405.75	2.34	1,573.02	2.62
Watershed Totals	59,996.31	100.00	60,065.58	100.00

Barnes Creek

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	590.95		660.38	
Commercial	24,82		26.76	
Industrial	16.94		48.12	
Transportation and Utilities	175.61		170.53	
Government	108.72		130.20	
Recreation	13.82		12.92	
Total	930.86	33.98	1,048.91	38.28
Rural Land Uses				
Open Lands	282.48		360.49	
Agricultural Lands	1,383.14		1,173.52	
Total	1,665.62	60.79	1,534.01	55.99
Water Covered Lands				
Lakes, Rivers, and Streams	0.00		2.82	
Wetlands, Swamps, and Marshes	143.40		154.17	
Total	143.40	5.23	156.99	5.73
Subwatershed Total	2,739.88	100.00	2,739.91	100.00

Table 129 (continued)

Pike Creek

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	1,626.35			
Commercial	270.87			
Industrial	144.05			
Transportation and Utilities.	789.42			
Government	188.49			
Recreation	148.23			
Landfill and Dump.	6.90			
Total	3,174.31	67.36	3,339.71	70.86
Rural Land Uses				
Open Lands	198.33			
Agricultural Lands	1,270.94			
Total	1,469.27	31.17	1,303.77	27.66
Water Covered Lands				
Lakes, Rivers, and Streams.	1.26			
Wetlands, Swamps, and Marshes . . .	68.50			
Total	69.76	1.48	69.90	1.49
Subwatershed Total	4,713.34	100.00	4,713.38	100.00

Sucker Creek

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	94.44			
Commercial	9.31			
Industrial	6.59			
Transportation and Utilities.	201.00			
Government	5.10			
Total	316.44	4.71	315.61	4.70
Rural Land Uses				
Open Lands	355.52			
Agricultural Lands	5,872.07			
Total	6,227.59	92.51	6,234.70	92.61
Water Covered Lands				
Lakes, Rivers, and Streams.	0.00			
Wetlands, Swamps, and Marshes . . .	187.80			
Total	187.80	2.79	181.53	2.69
Subwatershed Total	6,731.83	100.00	6,731.84	100.00

Creek subwatershed. Seepage and runoff from these sources may contribute to the pollution of the affected stream systems.

Water Quality Conditions of Minor Streams Tributary to Lake Michigan Watershed

Water Quality Data: of the total data sources available, the following two were used in the water quality study of the minor tributaries: (1) Commission benchmark study and (2) Commission continuing monitoring program. A detailed description of these data sources is given in Chapter II.

Three sampling stations, one each on Barnes Creek, Pike Creek, and Sucker Creek, were established by the Commission in 1964. Table 130 lists the Commission stations, locations, and their distances from the mouth of the stream. Map 42 shows the location of the sampling stations on the minor streams tributary to Lake Michigan.

Surface Water Quality of Minor Streams Tributary to Lake Michigan: 1964-1965: Water quality conditions in the Barnes Creek, Pike Creek, and Sucker Creek subwatersheds, as determined by 1964-65 sampling survey at three stations, are summarized in Table 131. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to the assessment of trends in surface water quality.

Chloride: During the sampling year of 1964-65, the chloride concentrations in Barnes Creek were found to be 30 and 45 mg/l in the two samples taken; in Pike Creek in the range of 20-285 mg/l in the seven samples taken; and in Sucker Creek 30 mg/l in the two samples taken. The observed chloride concentrations in all three streams were higher than the background levels of 10 mg/l as measured by the average groundwater chloride concentrations. The higher concentrations were found in the Pike Creek samples collected in December 1964-February 1965 at sampling station Mh-2 located in the City of Kenosha. The high chloride levels in the Pike Creek samples collected during the winter months may be attributed to street salting operations. The elevation of chloride above background levels during the rest of the sampling periods may be attributed to other sources of chloride pollution such as overflow from sanitary sewerage systems and from malfunctioning private onsite sewage disposal systems (septic tanks).

Dissolved Oxygen: During the sampling year of 1964-1965, the dissolved oxygen levels in Barnes Creek were found to range from 6.7 to 21.7 mg/l; in Pike Creek from 3.5 to 12.0 mg/l; and in Sucker Creek from 0.3 to 10.0 mg/l, with Pike Creek and Sucker Creek exhibiting several instances of substandard dissolved oxygen levels over the one-year period.

At sampling station Mh-3 on Barnes Creek, all 11 samples collected during 1964-1965 were found to have dissolved oxygen greater than 5.0 mg/l, with nine of the samples showing supersaturated levels. At sampling station Mh-2 on Pike Creek three times during the 11 sampling periods the dissolved oxygen values were found to be less than 5.0 mg/l. The predominant land use in the subwatershed of Pike Creek being urban, the decrease in dissolved oxygen levels is likely to result from urban runoff and discharge from sanitary sewerage system overflows. At sampling station Mh-1 on Sucker Creek, the dissolved oxygen concentrations were found to be less than 5.0 mg/l during six of the 11 sampling periods. Since the predominant land use in the subwatershed is agricultural, the low dissolved oxygen during the majority of sampling periods is likely to be attributable to discharge of oxygen-demanding materials with agricultural storm water runoff. Of the three streams studied, water quality conditions, as measured by the dissolved oxygen, were the worst in Sucker Creek, where the drainage area is predominantly in agricultural use.

Biochemical Oxygen Demand: The five-day biochemical oxygen demand (BOD_5) in the minor streams tributary to Lake Michigan watershed during the sampling years 1964-1965 was found to range from 1.1 mg/l to 25.9 mg/l. Specifically, values within Sucker Creek subwatershed at station Mh-1 ranged from 1.1 mg/l on October 15, 1964, to 24.0 mg/l on February 10, 1965. This higher

Table 130

DESIGNATION AND LOCATIONS OF SEWRPC STREAM SAMPLING STATIONS IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
SEWRPC	Mh-1	Sucker Creek at CTH P, NW ¼, Section 2, T11N, R22E	3.3
SEWRPC	Mh-2	Pike Creek at 43rd Street, SW ¼, Section 30, T2N, R23E	1.4
SEWRPC	Mh-3	Barnes Creek at North Shore Drive, NW ¼, Section 20, T1N, R23E	0.04

Source: SEWRPC.

Table 131

WATER QUALITY CONDITIONS OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Sucker Creek Mh-1	Chloride (mg/l)	30	30	30	2
	Dissolved Solids (mg/l)	790	760	725	2
	Dissolved Oxygen (mg/l)	10.0	4.3	0.3	11
	Total Coliform Count (MFCC/100 ml)	140,000	18,800	100	11
	Temperature (^{o}F)	78	52	32	11
Pike Creek Mh-2	Chloride (mg/l)	285	130	20	7
	Dissolved Solids (mg/l)	780	515	260	7
	Dissolved Oxygen (mg/l)	12.0	7.1	3.5	10
	Total Coliform Count (MFCC/100 ml)	740,000	130,000	10,000	10
	Temperature (^{o}F)	75	57	33	10
Barnes Creek Mh-3	Chloride (mg/l)	45	40	30	2
	Dissolved Solids (mg/l)	585	575	560	2
	Dissolved Oxygen (mg/l)	21.7	13.5	6.7	11
	Total Coliform Count (MFCC/100 ml)	88,000	14,700	100	11
	Temperature (^{o}F)	73	48	32	11

Source: SEWRPC.

value of 24.0 mg/l was recorded after a three-day snowfall and snowmelt period. Concentrations of biochemical oxygen demand in Barnes Creek (Mh-3) subwatershed ranged from a low of 1.6 mg/l to a high of 8.0 mg/l on December 10, 1964, and January 22, 1965, respectively. The upper limit within the highly urbanized Pike Creek subwatershed ranged from 3.0 mg/l to 25.9 mg/l on July 20, 1964, and January 22, 1965, respectively. As noted in other watershed discussions, overall concentrations of biochemical oxygen demand were greater when urbanization was more intense. This is also true with the highly urbanized Pike Creek subwatershed located within the City of Racine. An average value of 11.5 mg/l was recorded at the Pike Creek station during the monthly sampling period from May 1964 through February 1965. In comparison, average values of 7.5 mg/l and 3.3 mg/l were recorded at the stations on Sucker Creek and Barnes Creek, respectively. Thus, indications are that larger concentrations of biochemical oxygen-demanding substances tend to result in greater loadings to urbanized stream reaches as compared to more rural stream reaches.

Total Coliform Bacteria: During the sampling year 1964-1965, membrane filter coliform counts were found to vary from 100 to 88,000 MFCC/100 ml in Barnes Creek; 10,000 to 740,000 MFCC/100 ml in Pike Creek; and less than 100 to 140,000 MFCC/100 ml in Sucker Creek. The total coliform counts at sampling station Mh-3 on Barnes Creek were found to be greater than 2,000 MFCC/100 ml for eight of the 11 sampling periods. At sampling station Mh-2 on Pike Creek, the total coliform counts were found to be greater than 10,000 MFCC/100 ml for all 11 samples, indicating possibly high fecal coliform counts in those samples. At sampling station Mh-1 on Sucker Creek, the total coliform counts remained at 2,000 MFCC/100 ml during six of the 11 sampling periods, indicating possibly low fecal coliform counts in those samples. Of the three streams studied, the highest total coliform counts were found in Pike Creek which drains a highly urbanized watershed and which contains three sanitary sewer crossovers to the storm sewer system.

Specific Conductance: The specific conductance values during the 1964-1965 sampling period were found to be 780 and 840 µmhos/cm at 25^{o}C in two samples collected on Barnes Creek; were found to range from 414 to 1,300 µmhos/cm at 25^{o}C in 10 samples collected on Pike Creek; and were found to be 1,020 and 1,030 µmhos/cm at 25^{o}C in two samples collected on Sucker Creek. The high specific conductance values of Barnes Creek, Pike Creek, and Sucker Creek all were associated with high calcium, bicarbonate and sulfate concentrations, indicating the probable cause of the high specific conductance to be soil erosion with calcium carbonate and calcium sulfate as major constituents of the soil in these areas of the Region.

Hydrogen Ion Concentration (pH): The pH values at sampling station Mh-3 on Barnes Creek were found to be 8.0 and 8.7 standard units in the two samples collected during the 1964-1965 sampling period; in Pike Creek were found to range from 7.2 to 7.9 standard units in 10 samples; and in Sucker Creek were found to be

7.2 and 8.0 standard units in the two samples taken. At all three locations within the three subwatersheds the pH was found to be within the range of 6.0 to 9.0 standard units prescribed for restricted use, recreational use, and for maintenance of fish and aquatic life, the water use objectives established for these three subwatersheds.

Temperature: During the year 1964-1965, the temperature of water samples from Barnes Creek, Pike Creek, and Sucker Creek was found to range from 32°F to 69°F during the months of December through April and from 50°F to 78°F during the months of May through November. The temperature variations may be attributed to the seasonal changes and are not considered indicative of the presence of any thermal pollution resulting from discharges to the streams.

Water Quality Trends from 1965 to 1975: Water quality data obtained from eight summer sampling programs, three spring sampling programs, and one fall sampling program during the period from 1965 to 1975 are presented in tabular form in Appendix D of this report. The eight summer sampling surveys began in August 1968 and involved collection of samples one day in August every year during low-flow conditions.

An analysis of the flow data from Water Resources Data for Wisconsin, published by the U. S. Geological Survey, indicates that, for the streams in southeastern Wisconsin, low flow generally occurs during the months of August and September. Although the collection and analysis of one sample per station per year cannot be considered to represent water quality conditions for the whole year, it may be assumed to reasonably represent the water quality conditions of the stream at that location during the low-flow period, which is generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life.

Sampling results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate, nitrite, ammonia, and organic nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of three stations sampled since 1968 in the minor streams tributary to Lake Michigan watershed are set forth in Table 132.

Dissolved Oxygen: For the watersheds concerned, the range of dissolved oxygen during August for the period 1968 through 1975 was found to be 0.8 to 18.2 mg/l. The average dissolved oxygen concentrations were found to be 10.4, 8.0, and 4.7 for Barnes Creek, Pike Creek, and Sucker Creek, respectively. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l at location Mh-2, and well above the 2.0 mg/l restricted level for station Mh-3, the dissolved oxygen concentrations were lower than 5.0 mg/l at one time or another during 1968-1975 at location Mh-2 on Pike Creek and location Mh-1 on Sucker Creek.

At sampling station Mh-3 on Barnes Creek, the 24-hour average dissolved oxygen concentrations were higher than 2.0 mg/l during all eight sampling surveys. At location Mh-2 on Pike Creek, the 24-hour average dissolved oxygen concentration was greater than 5.0 mg/l during all of the eight sampling sessions, although three of the six diurnal sampling surveys exhibited at least one sampling with dissolved oxygen concentrations of less

Table 132

WATER QUALITY CONDITIONS IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1968-1975

Barnes Creek

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
Chloride (mg/l)	--	68.0	50.6	28.0	22	--
Dissolved Oxygen (mg/l)	2.0	18.2	10.4	4.2	30	0[a]
Ammonia-N (mg/l)	2.5	0.26	0.13	0.03	8	0
Organic-N (mg/l)	--	3.34	1.01	0.32	8	--
Total-N (mg/l)	--	4.82	1.67	0.45	8	--
Specific Conductance (μmhos/cm at 25°C)	--	960	802	699	29	--
Nitrite-N (mg/l)	--	0.05	0.02	0.01	12	--
Nitrate-N (mg/l)	0.3	1.22	0.48	0.08	12	8
Soluble Orthophosphate-P (mg/l)	--	0.14	0.07	0.03	12	--
Total Phosphorus (mg/l)	0.1	0.16	0.11	0.05	8	4
Fecal Coliform (MFFCC/100 ml)	2,000	760	359	100	12	0
Temperature (°F)	89.0	81.0	70.9	60.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.5	8.2	7.8	22	0

Table 132 (continued)

Pike Creek

Parameter	Recommended Level/Standard	Numerical Value Maximum	Average	Minimum	Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
Chloride (mg/l)	--	52.0	25.7	18.0	22	--
Dissolved Oxygen (mg/l)	5.0	12.2	8.0	3.2	30	8[a]
Ammonia-N (mg/l)	2.5	0.29	0.14	0.03	8	0
Organic-N (mg/l)	--	2.49	0.97	0.21	8	--
Total-N (mg/l)	--	3.37	1.86	0.44	8	--
Specific Conductance (µmhos/cm at 25°C)	--	708	411	155	30	--
Nitrite-N (mg/l)	--	0.25	0.80	0.01	12	--
Nitrate-N (mg/l)	0.3	1.47	0.62	0.18	12	8
Soluble Orthophosphate-P (mg/l)	--	0.86	0.15	0.01	12	--
Total Phosphorus (mg/l)	0.1	1.14	0.31	0.03	8	2
Fecal Coliform (MFFCC/100 ml)	400	64,000	17,883	110	12	8
Temperature (°F)	89.0	80.0	69.4	60.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.8	8.0	7.4	22	0

Sucker Creek

Parameter	Recommended Level/Standard	Numerical Value Maximum	Average	Minimum	Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
Chloride (mg/l)	--	92.0	48.2	33.0	22	--
Dissolved Oxygen (mg/l)	5.0	12.5	4.7	0.8	30	21[a]
Ammonia-N (mg/l)	2.5	0.18	0.09	0.03	8	0
Organic-N (mg/l)	--	2.40	1.89	1.44	8	--
Total-N (mg/l)	--	10.14	4.71	2.80	8	--
Specific Conductance (µmhos/cm at 25°C)	--	944	776	543	30	--
Nitrite-N (mg/l)	--	0.28	0.10	0.01	12	--
Nitrate-N (mg/l)	0.3	8.22	1.83	0.14	12	10
Soluble Orthophosphate-P (mg/l)	--	2.35	0.62	0.11	11	--
Total Phosphorus (mg/l)	0.1	2.97	0.81	0.30	8	8
Fecal Coliform (MFFCC/100 ml)	400	4,300	1,229	140	22	7
Temperature (°F)	89.0	80.0	71.4	65.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.4	8.1	7.3	22	0

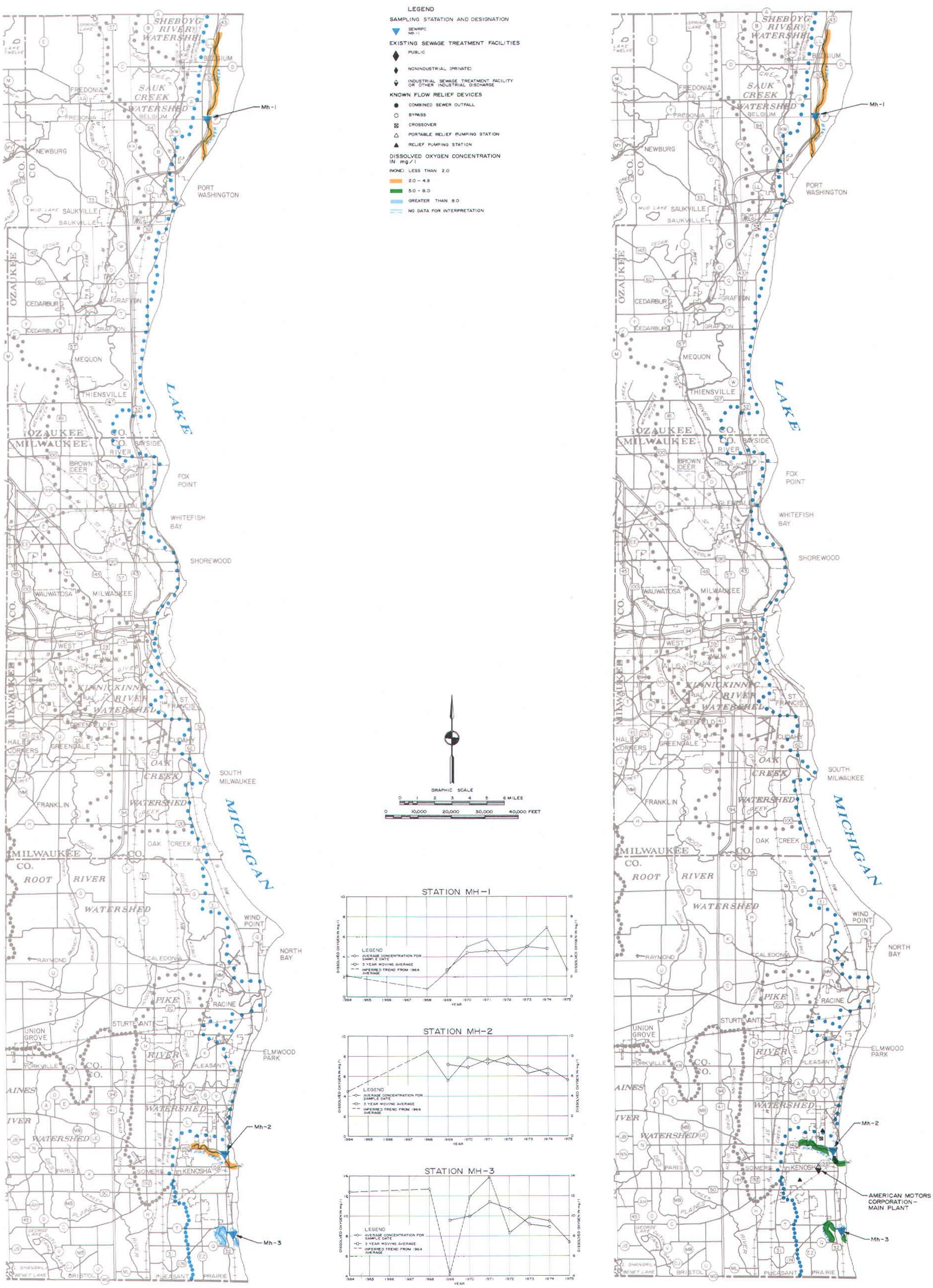
[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

than 5.0 mg/l. For sampling station Mh-1 on Sucker Creek, the 24-hour average dissolved oxygen concentration was well below 5.0 mg/l during five out of eight sampling surveys; and at least one of every diurnal sample in the six sampling surveys in which diurnal samples were taken had less than 5.0 mg/l dissolved oxygen. Map 43 presents the dissolved oxygen concentrations that were found in August 1964 and in August 1975 in the three minor tributaries to Lake Michigan. The graph inserts illustrate the change in dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at each location. On August 12-13, 1964, as indicated on the map, the dissolved oxygen concentration was above the restricted use standard of 2.0 mg/l at sampling station Mh-3 on Barnes Creek and was substandard (below 5.0 mg/l) at sampling station

Map 43

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED



A comparison of the dissolved oxygen levels recorded in 1964 and 1975 indicated that dissolved oxygen concentrations increased at sampling station Mh-2 on Pike Creek, while sampling station Mh-3 on Barnes Creek exhibited decreased dissolved oxygen levels. No significant change was observed at sampling station Mh-1 on Sucker Creek. The maximum observed dissolved oxygen concentration was 21.7 mg/l at sampling station Mh-3 on Barnes Creek. Sampling station Mh-1 on Suckers Creek recorded the minimum dissolved oxygen concentration of 0.8 mg/l.

Source: SEWRPC.

Mh-2 on Pike Creek and sampling station Mh-1 on Sucker Creek. Similarly, in samples collected on August 20-26, 1975, the dissolved oxygen concentrations were greater than 2.0 mg/l at sampling station Mh-3 on Barnes Creek and greater than 5.0 mg/l at sampling station Mh-2 on Pike Creek while substandard dissolved oxygen levels below 5.0 mg/l were observed at sampling station Mh-1 on Sucker Creek. The graph inserts on Map 43 present the average dissolved oxygen concentrations for the 24-hour period and the three-year moving averages at sampling stations Mh-1, Mh-2, and Mh-3 for the August samples collected over the period from 1964 through 1975. At sampling station Mh-3 on Barnes Creek, the dissolved oxygen concentrations were found to be at supersaturated levels with the exception of the 1969 and 1975 samples for which the concentrations of dissolved oxygen were below the supersaturation level. At sampling station Mh-2 on Pike Creek the dissolved oxygen concentrations exhibited no significant change over the past decade while there was a trend toward increase in the dissolved oxygen concentrations in the samples collected at sampling station Mh-1 on Sucker Creek in the August months from 1964 to 1975 except for the data for the years 1972 and 1975. The observed low dissolved oxygen concentrations in the samples collected at sampling station Mh-1 in 1972 and 1975 are likely to be associated with the rain that preceded the sampling surveys.

A comparison of dissolved oxygen concentrations found in April and August of the years 1964, 1968, and 1969 for sampling stations Mh-1 through Mh-3 indicates higher dissolved oxygen concentrations in April of each year than in August. The August dissolved oxygen concentrations were 2.0 to 8.0 mg/l less than those found in the April samples. The lower flow and higher temperatures in the streams, accompanied by the organic load from storm water runoff from the land surface, probably account for the decreased dissolved oxygen concentrations in the August samples.

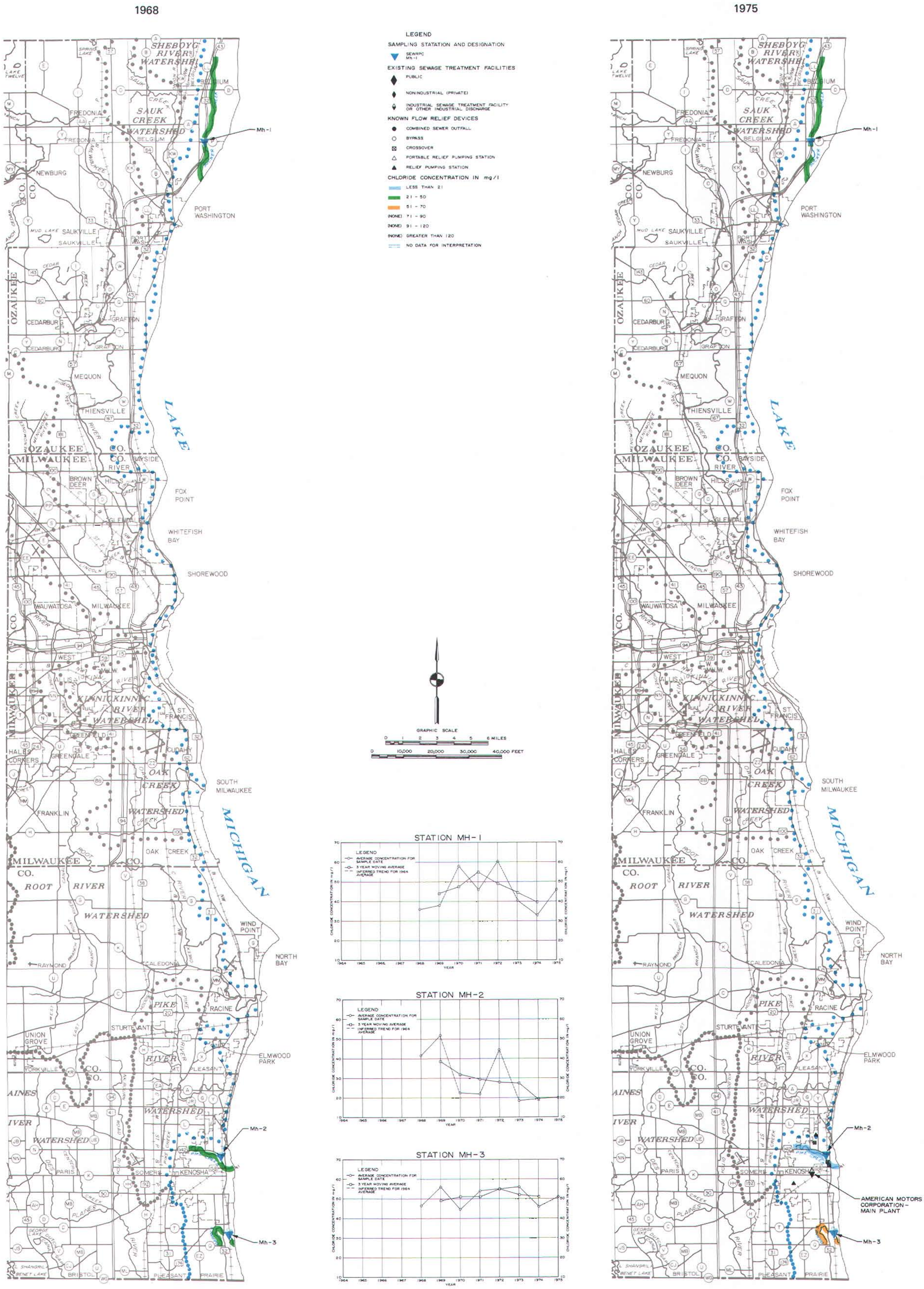
Chloride: The chloride concentrations were in the range of 18 to 92 mg/l for the three sampling stations, Mh-1, Mh-2, and Mh-3, in eight sampling surveys during the period of years 1968 through 1975. A vast majority of these samples showed chloride concentrations between 20 and 50 mg/l, a range higher than the area groundwater chloride concentrations of 10 mg/l. Map 44 presents chloride concentrations for the samples collected at the sampling stations on the three minor streams tributary to Lake Michigan in August 1968 and August 1975, with graphs illustrating the changes in chloride concentrations found during the sampling days of intermediate years. The map indicates that the chloride concentrations remained the same at sampling station Mh-1, decreased at sampling station Mh-2, and increased slightly at sampling station Mh-3 in the August samples for 1968 and 1975 data, respectively. The graphs illustrate the average chloride concentrations and three-year moving averages in the samples collected in August for stations Mh-1 through Mh-3 during the intermediate years from 1968 to 1975. As illustrated in the graph, the chloride concentrations at sampling station Mh-3 on Barnes Creek generally remained constant from 1968 through 1975. At sampling station Mh-2 on Pike Creek, the chloride concentrations remained low and showed a slight decrease in the samples collected in the period 1968 through 1975 with the exception of the 1969 and 1972 samples when rain preceded the sample collection, according to records of the Racine Department of Air Pollution Control. At sampling station Mh-1 on Sucker Creek, a decreasing trend in chloride concentrations from 1970 to 1975 was noted, with the exception of samples collected in 1972 and 1975. The increased chloride concentrations in 1972 and 1975 samples at sampling station Mh-1 may be due to rainfalls which are known to have immediately preceded those sampling surveys. A comparison of the April and August 1968 and 1969 chloride data for sampling stations Mh-1 through Mh-3 shows no specific pattern in the chloride concentrations of the spring as opposed to the summer samples. Since no flow data are available for the three streams studied in the watershed, the total chloride loadings carried by the streams can not be calculated.

Fecal Coliform Bacteria: Map 45 presents the fecal coliform counts found in the three subwatersheds in August 1968 and in August 1975 with graph inserts representing the changes in the fecal coliform counts found on the sampling days during the intermediate years. The fecal coliform counts were found to range from 100 to 640,000 MFFCC/100 ml, with the higher concentrations found at sampling station Mh-2 on Pike Creek. In the samples collected in August 1968, the fecal coliform counts were found to be less than 2,000 MFFCC/100 ml at sampling station Mh-3 on Barnes Creek; 35,000 MFFCC/100 ml at sampling station Mh-2 on Pike Creek; and less than 400 MFFCC/100 ml at sampling station Mh-1 on Sucker Creek. For the samples collected in August 1975, the fecal coliform counts remained less than 2,000 MFFCC/100 ml at sampling station Mh-3 on Barnes Creek increased to 2,800 MFFCC/100 ml at sampling station Mh-1 on Sucker Creek and remained higher than 17,000 MFFCC/100 ml at sampling station Mh-2 on Pike Creek. The Pike Creek subwatershed has 74 percent of its area in urban land uses, indicating the detrimental effect of runoff from the urban land on the bacteriological water quality of the stream system. The graphs on Map 45 illustrate the trend of fecal coliform counts over time for the three stations in the three subwatersheds for the period 1968 through 1975. At sampling station Mh-3 on Barnes Creek, the fecal coliform counts remained stable and low over the past eight years, the highest value recorded being 760 MFFCC/100 ml. At sampling station Mh-2 on Pike Creek and sampling station Mh-1 on Sucker Creek, increases in the fecal coliform counts occurred in the samples collected during the period of August 1968 through August 1975 for a significant decrease in the 1972 sample at satation Mh-2 on Pike Creek, possibly because of the dilution effect by heavy rain that preceded the sampling.

Hydrogen Ion Concentrations (pH): As indicated in Table 132, the pH values of the stream water of the three subwatersheds generally were within the range of 7.3 to 8.8 standard units and therefore within the range of

Map 44

COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1975 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED



A comparison of the chloride concentrations recorded in 1964 and 1975 indicated that chloride concentrations increased at sampling station Mh-3 on Barnes Creek, while sampling station Mh-2 on Pike Creek recorded a decrease in chloride concentrations. No significant change was recorded at Mh-1 on Sucker Creek. The maximum chloride concentration observed was 92 mg/l at sampling station Mh-1 on Sucker Creek, while a minimum chloride concentration of 18 mg/l was recorded at sampling station Mh-2 on Pike Creek.

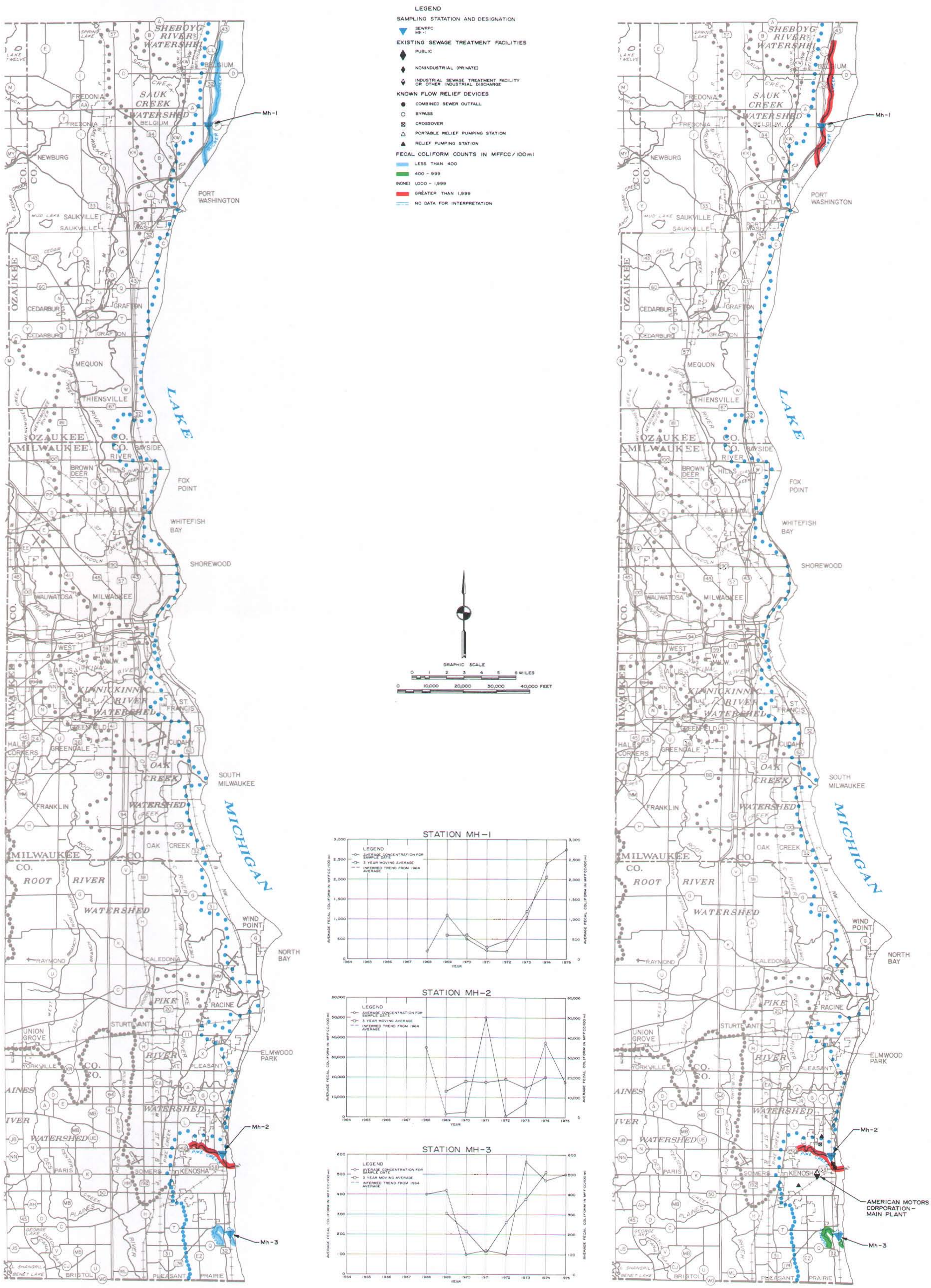
Source: SEWRPC.

Map 45

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1975 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

1968

1975



A comparison of fecal coliform counts recorded in 1968 and 1975 indicated that sampling stations Mh-1 on Sucker Creek and Mh-3 on Barnes Creek both exhibited an increase in fecal coliform counts, while sampling station Mh-2 on Pike Creek showed no significant change in fecal coliform counts. The maximum fecal coliform count was 64,000 MFFCC/100 ml recorded at sampling station Mh-2 on Pike Creek. Sampling station Mh-3 on Barnes Creek recorded the minimum fecal coliform count of 100 MFFCC/100 ml.

Source: SEWRPC.

6.0-9.0 standard units prescribed for restricted use, recreational use, and maintenance of fish and aquatic life. No trend in pH variation of the samples collected in August 1964 through 1975 was observed.

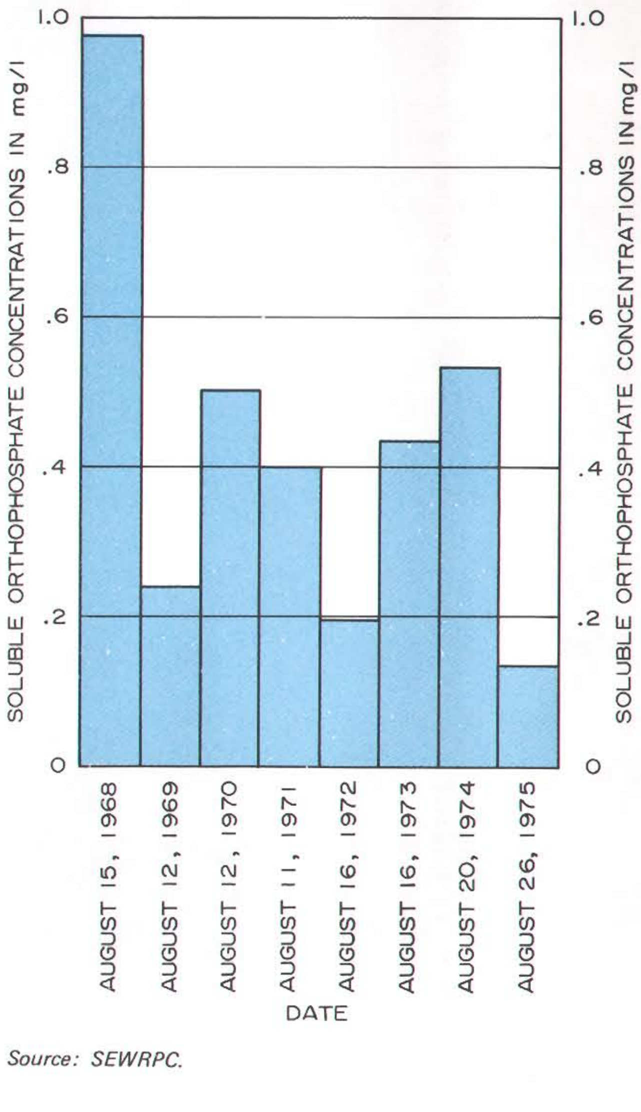
Specific Conductance: Specific conductance, which is a measure of total dissolved ions in water, was found to be in the range of 155 to 960 μmhos/cm at 25°C for the three locations on Barnes Creek, Pike Creek, and Sucker Creek on the days sampled between 1968 and 1975. The higher specific conductance values were found at sampling station Mh-3 on Barnes Creek, with the values for Sucker Creek at sampling station Mh-1 following closely. The higher specific conductance values, observed in samples from Sucker Creek and Barnes Creek—both subwatersheds having a high proportion of land in agricultural use than at Pike Creek which drains a predominately urban area—are conclusive proof of the higher dissolved ion contribution from the agricultural land uses, as compared to the contribution from urban land uses. At sampling station Mh-3 on Barnes Creek, the specific conductance values remained high and unchanged over the past decade. The specific conductance values decreased from 1970 through 1975 at sampling station Mh-2 on Pike Creek with high values in 1968, 1969, and 1972, samples which were collected following rains. At sampling station Mh-1 on Sucker Creek, the specific conductance values decreased slightly from 1970 through 1975 with the exception of the 1972 sample.

Temperature: As indicated in Table 132, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected at the sampling stations during August 1968 through August 1975 were analyzed for the soluble orthophosphate concentrations. A range of 0.01 to 2.35 mg/l of soluble orthophosphate as P was obtained during the eight sampling sessions at three locations, with the higher concentrations being found at sampling station Mh-1 on Sucker Creek. Figure 118 through Figure 120 present the soluble orthophosphate data for the years 1968 through 1975 for stations Mh-1, Mh-2, and Mh-3. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus, and a range of 0.03-297 mg/l as P was obtained. The ratio of soluble orthophosphate to total phosphorus was in the range of 0.5 to 1.0. The high ratio of soluble to total phosphorus in water samples indicates that most of the phosphorus is in the form readily available for the growth of aquatic plants and that the concentrations are many times higher than are required for excessive algal growth. A maximum limit of total phosphorus of 0.10 mg/l as P is generally held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants in flowing waters. Of the eight samples collected at station Mh-3 on Barnes Creek during the period of 1972 through 1975, four samples had total phosphorus concentrations less than 0.10 mg/l. At sampling station Mh-2 on Pike Creek, two of the eight samples had total phosphorus concentrations greater than 0.10 mg/l. On the other hand, all eight samples collected at station Mh-1 on Sucker Creek during the period of 1972 through 1975 had total phosphorus concentrations three to 30 times greater than 0.10 mg/l. Sucker Creek watershed has 91 percent of the land in agricultural use, and the high total phosphorus values in the samples collected from Sucker Creek indicate the probable source of phosphorus to be agricultural runoff. The total phosphorus input from urban land runoff is found to be significantly less than from agricultural runoff when data for the Pike Creek watershed, with 75 percent urban land use, is compared to data for Sucker Creek watershed, with 91 percent agricultural land use. The available four-year data on total phosphorus concentrations indicate that, at sampling stations

Figure 118

SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS AT SAMPLING STATION MH-1 ON THE DATES OF WATER SAMPLE COLLECTION IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1968-1975



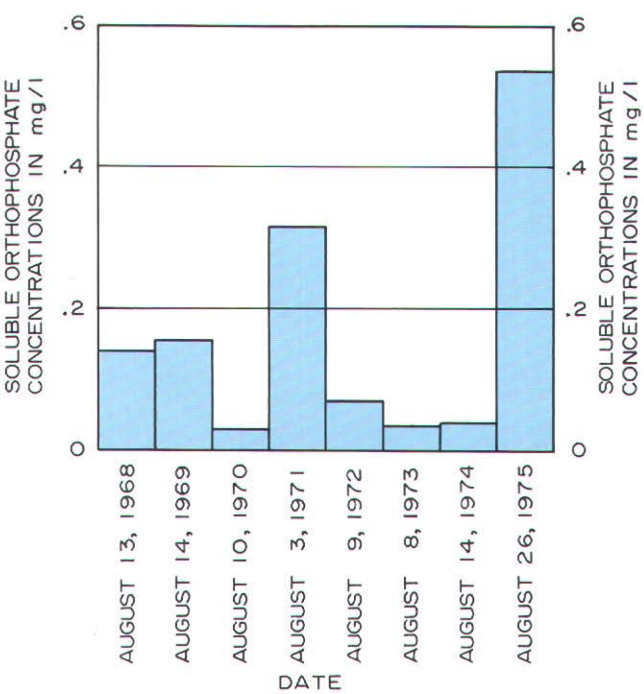
Source: SEWRPC.

Mh-3 on Barnes Creek and Mh-2 on Pike Creek, the levels remained generally constant and, at sampling station Mh-1 on Sucker Creek, the total phosphorus levels increased since 1972.

Nitrogen: The total nitrogen concentrations in the water samples collected during August 1972 through 1975 were found to be in the range of 0.44 to 10.14 mg/l as N; and, of these, 1 to 6 percent was in the form of nitrite-nitrogen, 1 to 15 percent of ammonia-nitrogen, 20 to 66 percent of nitrate-nitrogen, and 30 to 69 percent of organic-nitrogen. Thus 28 to 66 percent of total nitrogen was in the nitrate-nitrogen and ammonia-nitrogen forms readily available for plant growth. The concentrations of ammonia-nitrogen at the sampling sites were found to range from less than 0.03 to 0.29 mg/l ammonia-nitrogen as N, well below the known toxic level of 2.5 mg/l as ammonia-nitrogen as N. However, on five of the 23 sampling dates, the ammonia-nitrogen levels exceeded the 0.2 mg/l ammonia-nitrogen as N generally held to be indicative of lakes and streams which have been affected by pollution. Nitrate-nitrogen concentrations in the watersheds were found to range from 0.08 to 8.20 mg/l as N. The higher nitrate concentrations were found in the Sucker Creek samples. Since the predominant land use in the subwatershed of Sucker Creek is agricultural, surface runoff from fields that have had applications of natural or artificial fertilizers may contribute significant quantities of nitrate to this stream.

Figure 119

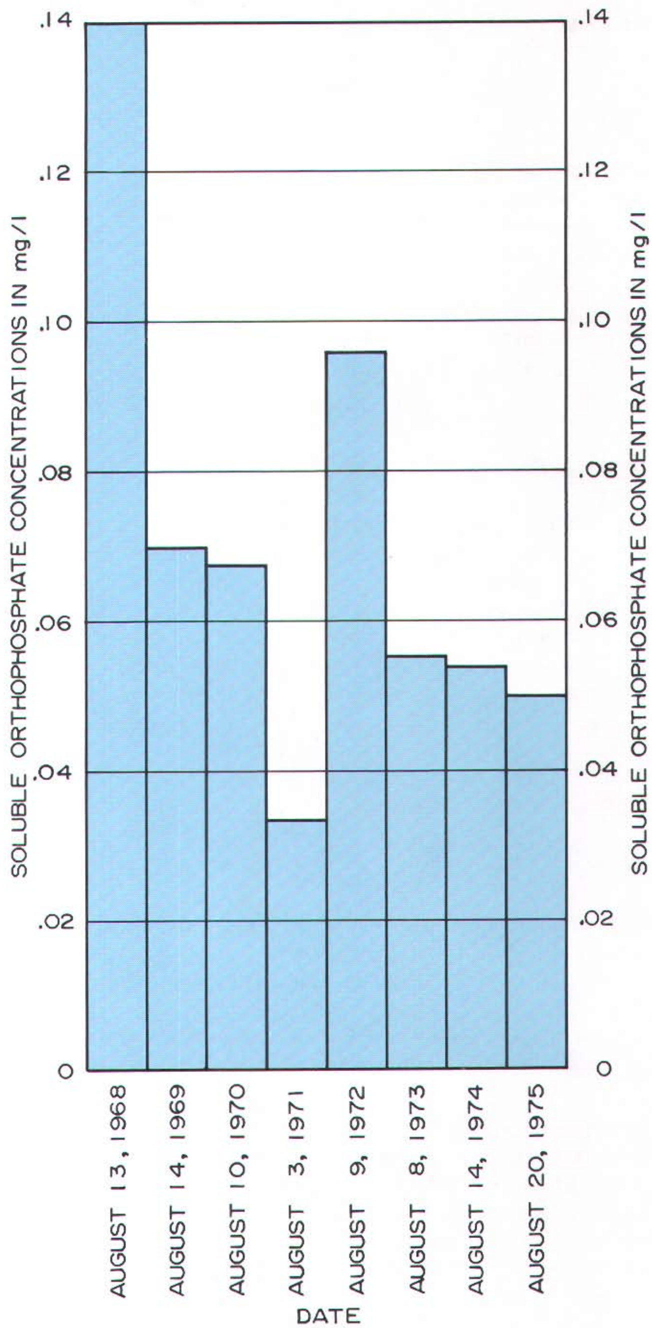
SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS AT SAMPLING STATION MH-2 ON THE DATES OF WATER SAMPLE COLLECTION IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1968-1975



Source: SEWRPC.

Figure 120

SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS AT SAMPLING STATION MH-3 ON THE DATES OF WATER SAMPLE COLLECTION IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1968-1975



Source: SEWRPC.

Organic-nitrogen accounts for 30 to 69 percent of the total nitrogen in the samples collected from the three minor streams tributary to Lake Michigan. At Barnes Creek and Pike Creek, a decrease in the organic-nitrogen and total nitrogen input is noted over the past four years, as observed by the data from sampling stations Mh-3 and Mh-2. The concentrations of organic-nitrogen, nitrate-nitrogen, and total nitrogen were found to have increased at sampling station Mh-1 through the years 1972-1975, indicating that the organic loadings to Sucker Creek have increased over that period. This might be explained by increases in agricultural activity through the increase in cultivated land or an increase in row crops as a proportion of the total cropland cover, or by an increase in livestock populations.

Biochemical Oxygen Demand: The Commission water quality monitoring program did not include measurement of biochemical oxygen demand for the years 1965 through 1975. No other biochemical oxygen demand data are available from the other sources to study the trend in biochemical oxygen demands over the past decade in the minor stream's watershed.

Diurnal Water Quality Changes: Figure 121 through Figure 132 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low-flow conditions on August 4 and 11, 1971 on Barnes Creek, Pike Creek, and Sucker Creek at sampling stations Mh-3, Mh-2, and Mh-1.

At station Mh-3 on Barnes Creek, water temperatures were found to range from a low of 61.0°F during the early morning hours on August 4 to a high of 68.0°F during the early evening hours of that day. The recorded diurnal water temperature fluctuation was probably the result of corresponding diurnal variations in air temperature and solar radiation. Chloride concentrations were found to range from a high of 68 mg/l during the early morning hours to a low of 28 mg/l during the evening hours of the same day. The generally high concentrations—relative to the area background levels of 10 mg/l during low-flow conditions—reflect the effect of human pollution on the water quality of the Barnes Creek.

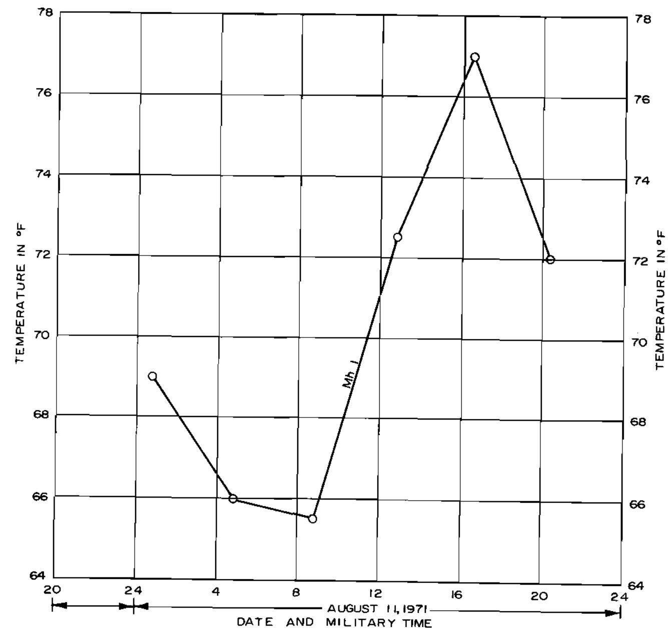
The concentration of dissolved oxygen was found to vary from a low of 9.8 mg/l during the early morning hours to a high of 18.2 mg/l in the late evening hours. The diurnal variation in the dissolved oxygen concentrations can be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants.

The hydrogen ion concentrations (pH) were found to vary from a low of 8.0 standard units during the early morning hours of August 4 to a high of 8.5 standard units in the late evening hours. The uptake of carbon dioxide by the aquatic plants for photosynthesis probably accounted for the higher pH in the late evening samples and the low pH during the early morning hours can therefore probably be accounted for by the release of carbon dioxide during respiration by algae and aquatic plants.

At sampling station Mh-2 on Pike Creek, water temperatures were found to range from a low of 60°F during the early morning hours on August 4 to a high of 67°F during the early evening hours of that day. The recorded diurnal water temperature fluctuation was probably the result of corresponding diurnal variations in air tempera-

Figure 121

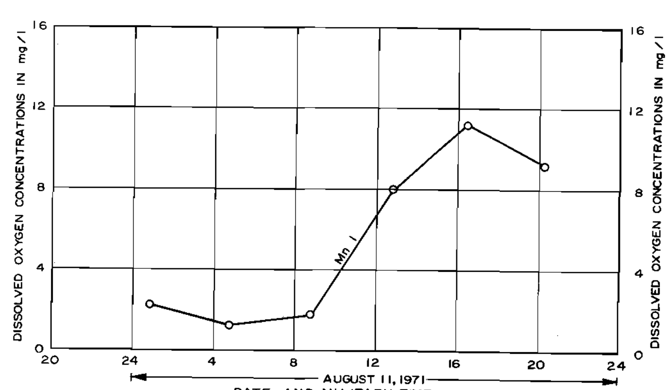
DIURNAL VARIATIONS IN TEMPERATURES RECORDED AT SAMPLING STATION MH-1 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED AUGUST 11, 1971



Source: SEWRPC.

Figure 122

DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATION MH-1 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: AUGUST 11, 1971



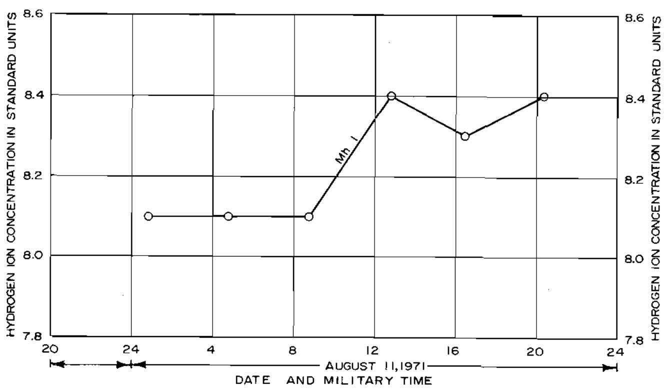
Source: SEWRPC.

ture and solar radiation. Chloride concentrations were found to range from a high of 26 mg/l during the early morning hours to a low of 19 mg/l during the evening hours of the same day. The generally high concentrations—relative to the area background levels of 10 mg/l during low-flow conditions—reflect the effect of human pollution on the water quality on the Pike River.

The concentration of dissolved oxygen was found to vary from a low of 4.0 mg/l during the early morning hours to a high of 11.6 mg/l in the late evening hours. The diurnal variation of dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants.

Figure 123

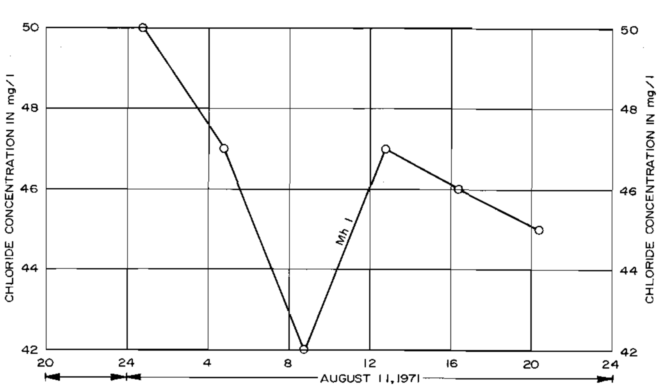
DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS (pH) RECORDED AT SAMPLING STATION MH-1 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED AUGUST 11, 1971



Source: SEWRPC.

Figure 124

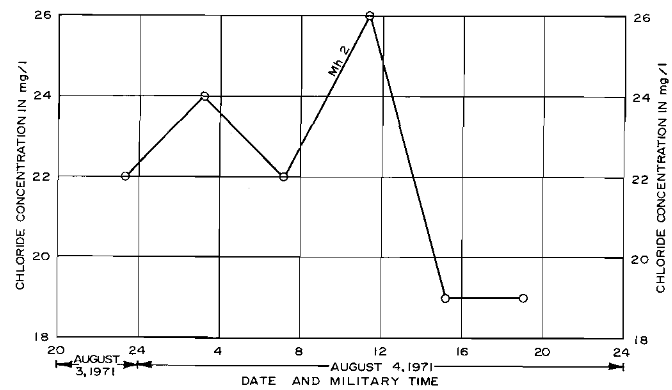
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS RECORDED AT SAMPLING STATION MH-1 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED AUGUST 11, 1971



Source: SEWRPC.

Figure 125

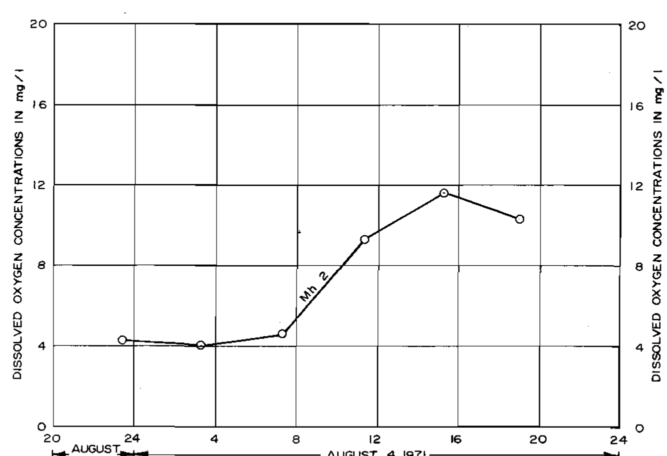
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS RECORDED AT SAMPLING STATION MH-2 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

Figure 126

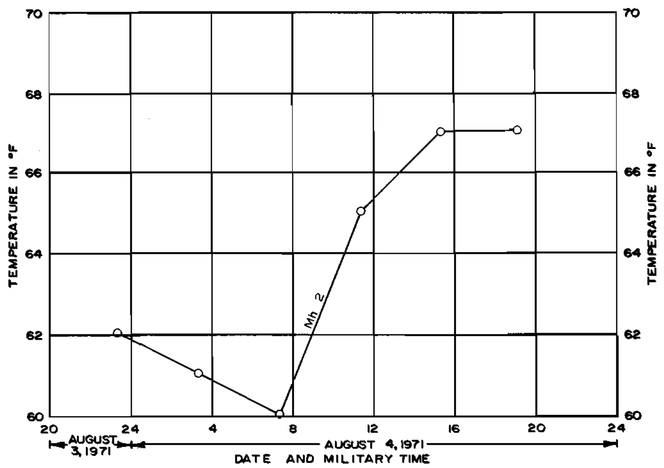
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS RECORDED AT SAMPLING STATION MH-2 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

Figure 127

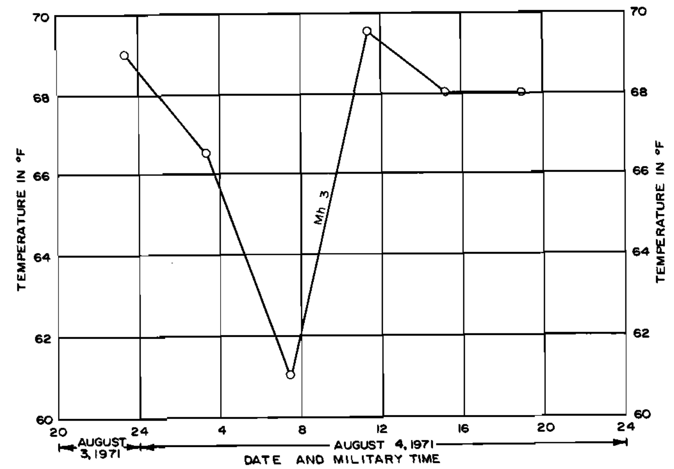
DIURNAL VARIATIONS IN TEMPERATURES RECORDED AT SAMPLING STATION MH-2 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

Figure 129

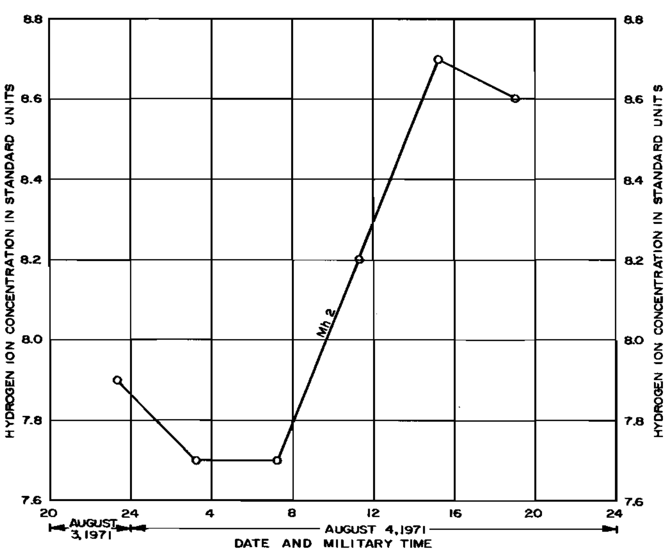
DIURNAL VARIATIONS IN TEMPERATURES RECORDED AT SAMPLING STATION MH-3 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4,1971



Source: SEWRPC.

Figure 128

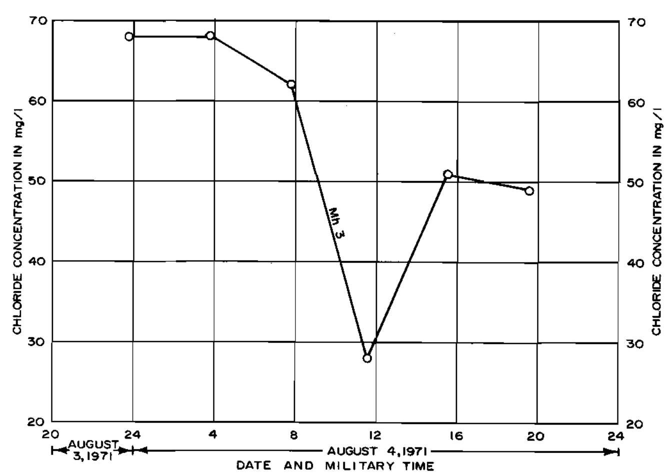
DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS (pH) RECORDED AT SAMPLING STATION MH-2 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

Figure 130

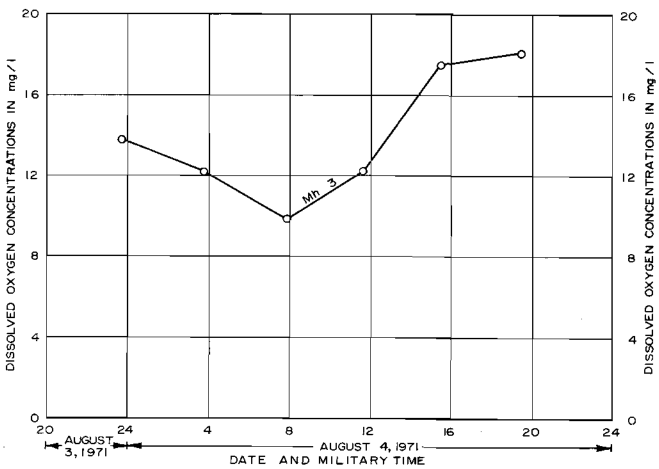
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS RECORDED AT SAMPLING STATION MH-3 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

Figure 131

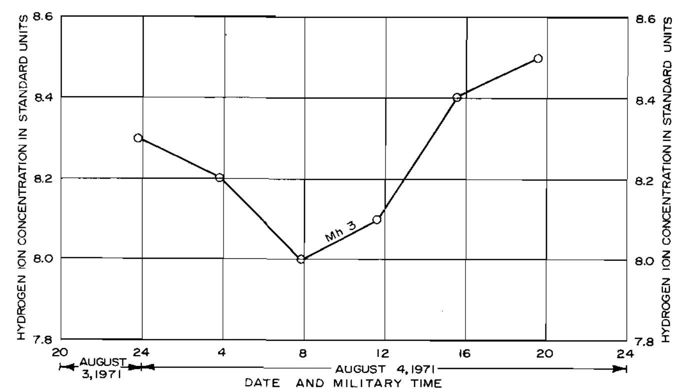
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATION MH-3 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

Figure 132

DIURNAL VARIATIONS IN HYDROGEN ION (pH) CONCENTRATIONS RECORDED AT SAMPLING STATION MH-3 IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION AUGUST 3-4, 1971



Source: SEWRPC.

The hydrogen ion concentration (pH) was found to vary from a low of 7.7 standard units during the early morning hours of August 11 to a high of 8.7 standard units in the late evening hours. The uptake of carbon dioxide for photosynthesis by algae and other aquatic plants probably accounts for the higher pH in the late evening samples; and the low pH during the early morning hours may be accounted for by the release of carbon dioxide during respiration by algae and aquatic plants.

At sampling station Mh-1 on Sucker Creek, water temperatures were found to range from a low of 65.5°F during the early morning hours on August 11 to a high of 77.6°F during the early evening hours of that day. The recorded diurnal water temperature fluctuation was probably the result of corresponding diurnal variations in air temperature and solar radiation. Chloride concentrations were found to range from a high of 50 mg/l during the early morning hours to a low of 42 mg/l during the evening hours of the same day. The generally high concentrations—relative to the area background levels of 10 mg/l during low-flow conditions—reflect the effects of pollution from human activities on the water quality of Sucker Creek.

The concentration of dissolved oxygen was found to vary from a low of 1.8 mg/l during the early morning hours to a high of 11.5 mg/l during the late evening hours. The diurnal variation of dissolved oxygen concentrations may be attributed to the net photosynthetic production of consumption by respiration of oxygen, by algae and other aquatic plants.

The hydrogen ion concentration (pH) was found to vary from a low of 8.1 standard units during the early morning hours of August 11 to a high of 8.4 standard units in the late evening hours. The uptake of carbon dioxide by the aquatic plants for photosynthesis probably accounts for the higher pH in the late evening samples; and the low pH during the early morning hours can be accounted for by the release of carbon dioxide during respiration by algae and aquatic plants.

The diurnal fluctuations in water quality can be such that the average concentration level of key parameters meets the water quality standards established for the streams, while the instantaneous levels during the daily cycle do not meet the standards. For example, the average of six dissolved oxygen concentration values for Sucker Creek at station Mh-1 on August 11, 1971, was 5.8 mg/l, which is well above the minimum standard of 5.0 mg/l for recreational use and preservation of fish and aquatic life. However, substandard dissolved oxygen levels of 1.8-2.5 mg/l were measured in three samples taken in the early morning hours of the same day.

Spatial Water Quality Changes: The water quality monitoring program included only one sampling station on each of the three perennial minor streams of Lake Michigan. Therefore, the spatial water quality changes in Sucker Creek, Barnes Creek, and Pike Creek can not be evaluated. Based on the other water quality observations in the Region, however, it is very likely that the upstream reaches of low flow would exhibit lower levels of water quality and the reaches near the mouth of each stream would display improved or better water quality conditions because of the dilution effects of Lake Michigan waters as well as the increase in flow conditions from within the watershed.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples between 1964 and 1975 were used to assess the quality of the three minor streams directly tributary to Lake Michigan. This procedure provides for an assessment of water quality as it existed on the days sampled in 1964 and 1975 and allows for an evaluation of the water quality changes.

The comparative analysis of observed water quality and the standards were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are based on recommended levels which have been adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the recreational use objective fecal coliform bacteria standard was assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comprehensive analysis of the water quality conditions existing during August 1964 and the water quality conditions prescribed in the adopted standards are summarized on Map 46. A color coding scheme is used on Map 46 to indicate which of the standards are exceeded and along what stream reaches.

For Barnes Creek, intended for restricted use and maintenance of fish and aquatic life, water quality conditions during the survey satisfied the temperature and dissolved oxygen standards at sampling station Mh-3. Since no pH, fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made on the August 1964 samples, no comparison can be made to the pH, nutrient contents, and bacteriological standards for Barnes Creek. For Pike Creek and Sucker Creek, intended for recreational use and preservation of fish and aquatic life, the water temperature at sampling stations Mh-1 and Mh-2 remained within the prescribed limit of 89°F, but dissolved oxygen levels were found to fall below the required standard of 5.0 mg/l at times. Since no pH, fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made on the August 1964 samples, no comparison can be made to the pH, nutrient contents, and bacteriological safety of the Pike Creek and Sucker Creek waters for 1964.

Water Quality-1975: For Barnes Creek, intended for restricted use and maintenance of fish and aquatic life, water quality conditions during August 1975 were such that the temperature, pH, dissolved oxygen, fecal coliform counts, total phosphorus, and ammonia standards all were satisfied while substandard levels of nitrate nitrogen were observed. Two samples were collected at sampling station Mh-3 on Barnes Creek on August 20, 1975—the first during a low-flow period and the other during a heavy rain. The first sample collected in the morning hours contained nitrate in amounts within the recommended level of 0.30 mg/l. The second sample collected in the evening hours during a heavy rain exhibited excessive nitrate levels indicating a significant contribution of nitrate from storm water runoff from the agricultural land. A similar effect also was observed at the Pike Creek sampling location: higher levels of nitrate nitrogen, organic nitrogen, total and soluble phosphate, and fecal coliform counts were present in the sample collected during a heavy rain than in the samples collected during low flow before the precipitation occurred. For Pike Creek and Sucker Creek, intended for recreational use and preservation of fish and aquatic life, Map 47 indicates that water quality conditions during August 1975 were such that the temperature, pH, and ammonia standards all were satisfied while substandard levels of dissolved oxygen, nitrate, total phosphorus, and fecal coliform were recorded. Substandard dissolved oxygen concentrations of less than 5.0 mg/l occurred in one sample taken at sampling station Mh-2 on Pike Creek and less 2.0 mg/l occurred in two of the four diurnal samples from Sucker Creek. The fecal coliform standard of 400 colonies per 100 ml was exceeded in all the samples collected at sampling stations Mh-2 and Mh-1 on Pike Creek and Sucker Creek.

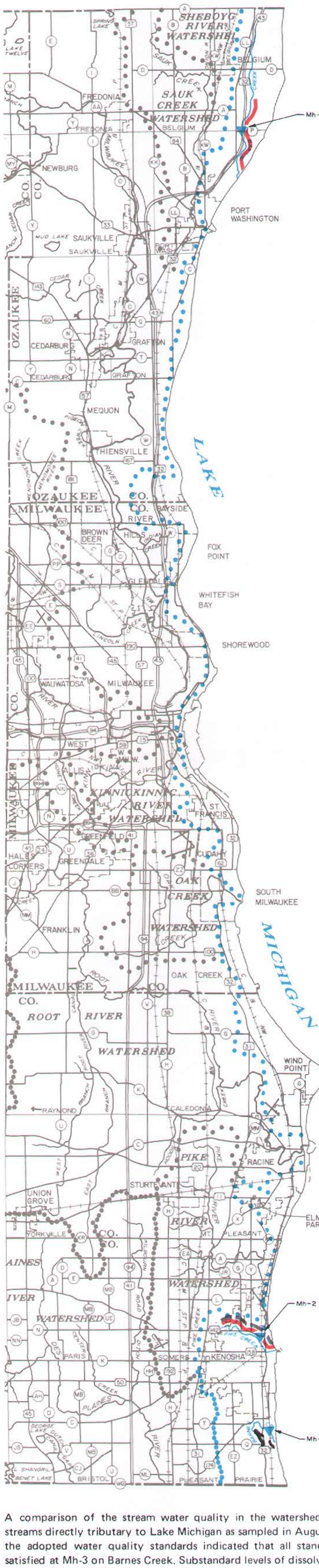
Concluding Remarks—Minor Streams Tributary to Lake Michigan Watershed

The composite watershed of the minor streams tributary to Lake Michigan is located in the eastern portion of the Region and on the western shore of Lake Michigan in the eastern parts of Ozaukee, Milwaukee, Racine, and Kenosha Counties. Three perennial streams—Barnes Creek, Pike Creek, and Sucker Creek—drain the composite watershed, which is the third largest in population and seventh largest in size of the 12 watersheds of the Region.

The Barnes Creek watershed is located in the eastern portion of Kenosha County. In 1975 an estimated 2,816 persons resided within this watershed, which has a total area of 4.5 square miles and a resulting average

Map 46

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

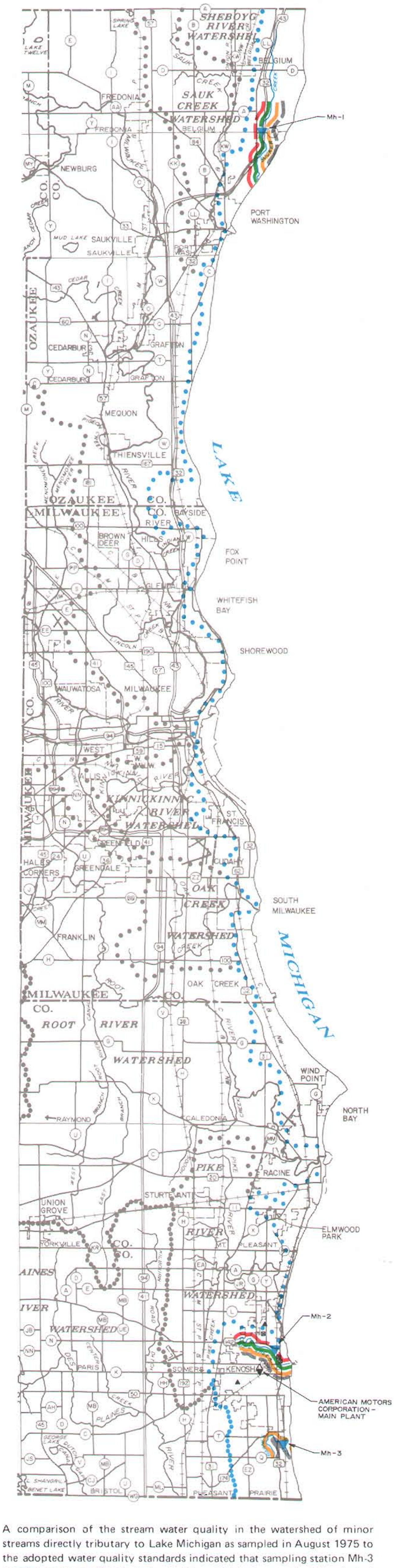


A comparison of the stream water quality in the watershed of minor streams directly tributary to Lake Michigan as sampled in August 1964 to the adopted water quality standards indicated that all standards were satisfied at Mh-3 on Barnes Creek. Substandard levels of dissolved oxygen concentration were noted at sampling stations Mh-2 on Pike Creek and Mh-1 on Sucker Creek. Total coliform levels at sampling station Mh-2 on Pike Creek did not meet the standard.

Source: SEWRPC.

Map 47

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the watershed of minor streams directly tributary to Lake Michigan as sampled in August 1975 to the adopted water quality standards indicated that sampling station Mh-3 located on Barnes Creek, designated for restricted use, met all the desired levels, with the exception of nitrate-nitrogen substandard levels at dissolved oxygen and fecal coliform, as well as levels in excess of those recommended by the Commission for total phosphorus and nitrate-nitrogen, were recorded at Mh-1 and Mh-2 located on Sucker Creek and Pike Creek, respectively.

Source: SEWRPC.

population density of 626 people per square mile. There are no public or nonindustrial privately owned sewage treatment facilities, sanitary sewer flow relief devices, or industrial waste outfalls discharging effluent to Barnes Creek. The Commission 1970 land use inventory indicates that 62 percent of the total area of the Barnes Creek watershed is devoted to agricultural use, 33 percent to urban use, and the remaining 5 percent is occupied by streams and wetlands.

The 1964-1965 benchmark stream water quality study of the Commission included one sampling station on Barnes Creek. The water quality data for 1964-1965 indicated chloride levels higher than the normal background concentration in area groundwater, reflecting a chloride impact upon the stream from cultural sources. The dissolved oxygen concentration remained greater than 2.0 mg/l for all samples taken during the one-year survey. Barnes Creek also exhibited high total coliform counts as compared to the 2,000 MFFCC/100 ml restricted use standard. The specific conductance values were high and were associated with high calcium, bicarbonate, and sulfate concentrations, indicating that the source of the high specific conductance probably is soil erosion.

The 1965-1975 continuing water quality monitoring effort by the Commission included sampling at the same sampling station originally established in the Barnes Creek watershed. The observed dissolved oxygen, chloride, and fecal coliform levels indicate that the water quality remained essentially unchanged in Barnes Creek over the past decade. Nitrate nitrogen concentrations remained in excess of the recommended water quality levels of 0.30 mg/l as N in 10 of the 16 water samples collected over the past decade, and total phosphorus concentrations remained in excess of the recommended water quality levels of 0.10 mg/l as P in four of the eight water samples collected over the past four years. The diurnal water quality data for Barnes Creek indicate the dissolved oxygen concentrations remained greater than saturation levels on all the six samples collected from Barnes Creek over a 24-hour period. The current water quality conditions of Barnes Creek, intended for restricted use and maintenance of fish and aquatic life, do meet the water quality standards for dissolved oxygen, pH, total phosphorus, ammonia, and fecal coliform counts. However, nitrate-nitrogen concentrations were found to be higher than the recommended levels adopted by the Commission for the avoidance of nuisance aquatic plant growth in the receiving stream system which discharges ultimately to Lake Michigan.

The Pike Creek watershed also is located in the eastern portion of Kenosha County, and of the City of Kenosha. In 1975 an estimated 31,260 persons resided within this subwatershed, which has a total area of 7.1 square miles and a resulting average population density of 4,403 people per square mile. There are no public or nonindustrial privately owned sewage treatment facilities discharging effluent into Pike Creek, but three sanitary sewerage system crossovers and two relief pumping stations located in the subwatershed of Pike Creek are known to discharge raw sewage into Pike Creek during times of sewer surcharge. There is one industry which discharges cooling water to Pike Creek at one wastewater discharge point.

The Commission 1970 land use inventory indicates the Pike Creek subwatershed is highly urbanized with 74 percent of the land in urban use, 24 percent devoted to agricultural use, and the remaining 2 percent occupied by streams and wetlands.

The 1964-1965 benchmark stream water quality study of the Commission included one sampling station in the Pike Creek watershed. The water quality data for 1964-1965 indicated chloride levels higher than the normal background concentration in groundwater and reflected a chloride impact upon the stream from cultural sources. Substandard dissolved oxygen levels and high total coliform counts were found during the summer months at the Pike Creek sampling station. Since the watershed is highly urbanized, the apparent source for this contamination is urban runoff. The specific conductance values were also found to be the highest at the sampling station located on Pike Creek when compared with those of Barnes Creek and Sucker Creek. The high specific conductance values were associated with high calcium, bicarbonate, and sulfate concentrations, indicating the probable source of high specific conductance as soil erosion.

The 1965-1975 continuing water quality monitoring effort by the Commission included sampling at the station originally established in the Pike Creek watershed. The observed dissolved oxygen levels indicate that the water quality remained essentially unchanged in Pike Creek over the past decade. The fecal coliform counts increased and the chloride levels showed slight decreases over the past eight years. Nitrate-nitrogen concentrations remained in excess of the recommended water quality levels of 0.30 mg/l as N in 11 of 15 water samples collected over the past decade, and total phosphorus concentrations remained in excess of the recommended level of 0.10 mg/l as P in two of eight water samples collected over the past four years. The diurnal water quality data for Pike Creek showed a broad range of dissolved oxygen concentrations, from a low of 1.8 to a high of 11.6 mg/l over a 24-hour period and reflected the net effect of algal photosynthesis and respiration. Generally unchanged over the past decade, the water quality of Pike Creek, which is intended for recreational use and for the preservation of fish and aquatic life, does not currently meet the established water quality standards for dissolved oxygen and fecal coliform counts. In addition, the plant nutrients, total phosphorus, and nitrate-nitrogen concentrations were found to be significantly higher in the streams than the recommended levels adopted by the Commission for the avoidance of nuisance aquatic plant growth in the receiving stream system which discharges ultimately to Lake Michigan.

The Sucker Creek watershed is located in the eastern portion of Ozaukee County. In 1975 an estimated 553 persons resided within this subwatershed, which has a total area of 10.4 square miles and a resulting average population density of 53 people per square mile.

There are no public or nonindustrial privately owned sewage treatment facilities, sanitary sewerage system flow relief device overflows, or industrial waste outfalls discharging effluent to Sucker Creek. The Commission 1970 land use inventory indicates that 91 percent of the total land area of the Sucker Creek watershed is devoted to agricultural use, 6 percent to urban use, and the remaining 3 percent occupied by streams and wetlands.

The 1964-1965 benchmark stream water quality study of the Commission included one sampling station in the Sucker Creek watershed. The water quality data for 1964-1965 indicated chloride levels higher than the normal background concentration in groundwater and reflected a chloride impact upon the stream from cultural sources. Substandard concentrations of dissolved oxygen and high total coliform counts were found during the summer months at Sucker Creek. The watershed being highly rural, drainage from the agricultural land is the apparent source for this indicated contamination. The high specific conductance values found on Sucker Creek, were associated with high calcium, bicarbonate, and sulfate concentrations, indicating the source of high specific conductance as sediment erosion.

The 1965-1975 continuing water quality monitoring effort by the Commission included sampling at the station originally established in the Sucker Creek watershed. The observed dissolved oxygen levels indicate that water quality conditions improved in Sucker Creek over the past decade. Fecal coliform counts increased, however, while the chloride levels showed a slight decrease over the past eight years. Nitrate nitrogen remained in excess of the recommended water quality levels of 0.30 mg/l as N in 14 of the 16 water samples collected over the past decade and 0.10 mg/l as P in all the eight samples collected at Sucker Creek over the past four years. The diurnal water quality data for the Sucker Creek show a broad range of dissolved oxygen concentrations from a low of 1.8 to a high of 11.6 mg/l over a 24-hour period and reflect the net effect of algal photosynthesis and respiration.

Although generally constant over the past decade, the water quality of Sucker Creek, which is intended for recreational use and for the preservation of fish and aquatic life, does not currently meet the established water quality standards for dissolved oxygen and fecal coliform counts. The plant nutrients, total phosphorus, and nitrate nitrogen concentrations were found to be higher in all three streams than the levels recommended by the Commission for the avoidance of nuisance aquatic plant growth in the receiving stream system which discharges ultimately to Lake Michigan.

An interpretive analysis of the observed trends in the individual parameters indicates water quality conditions marked by high levels of dissolved oxygen and no significant changes in fecal coliform counts or chloride content over the past decade. This analysis considers the types and location of pollution sources in the three watersheds as well as the specific streamflow and precipitation conditions on the sampling dates, and the land use changes over the past decade, with 62 percent of land of the watershed devoted to agricultural land use in 1970. The water quality of Pike Creek, with 74 percent of land in the watershed in urban land use, continued to exhibit the undesirable water quality conditions associated with low levels of dissolved oxygen and high fecal coliform counts in the water samples. In Sucker Creek, which has 91 percent of its watershed land area used for agriculture, the dissolved oxygen content remained higher than in Pike Creek and lower than in Barnes Creek, and the fecal coliform counts remained high and increased over the past decade. The analysis of water quality data from Barnes Creek, Pike Creek, and Sucker Creek—the principal watersheds of that area of the Region which drains directly to Lake Michigan—points to definite effects of urbanization and agricultural runoff on the water quality of Pike Creek and Sucker Creek. Since there are no privately or publicly owned sewage treatment facilities and only one industry in the watershed that discharges wastewaters to Pike Creek, it is pollution from diffuse sources in these urbanized and agricultural areas that affects the water quality of these streams.

OAK CREEK WATERSHED

Regional Setting

The Oak Creek watershed is a natural surface water drainage unit, 26.33 square miles in areal extent located in the east central portion of the Region. The boundaries of the basin, together with the locations of the main channel of Oak Creek and its single principal tributary, are shown on Map 48. The main stem of Oak Creek originates in the City of Franklin in Milwaukee County and discharges to Lake Michigan at Grant Park. The single principal tributary of the watershed is the North Branch of Oak Creek. About 50 percent of the watershed is devoted to rural land uses, with about two-thirds of this area still in agricultural production. Most of the agriculturally related land use is located in the southwestern and southern portions of the watershed. The watershed is bounded on the north by the Kinnickinnic River watershed, on the west and south by the Root River watershed, and on the east by Lake Michigan.

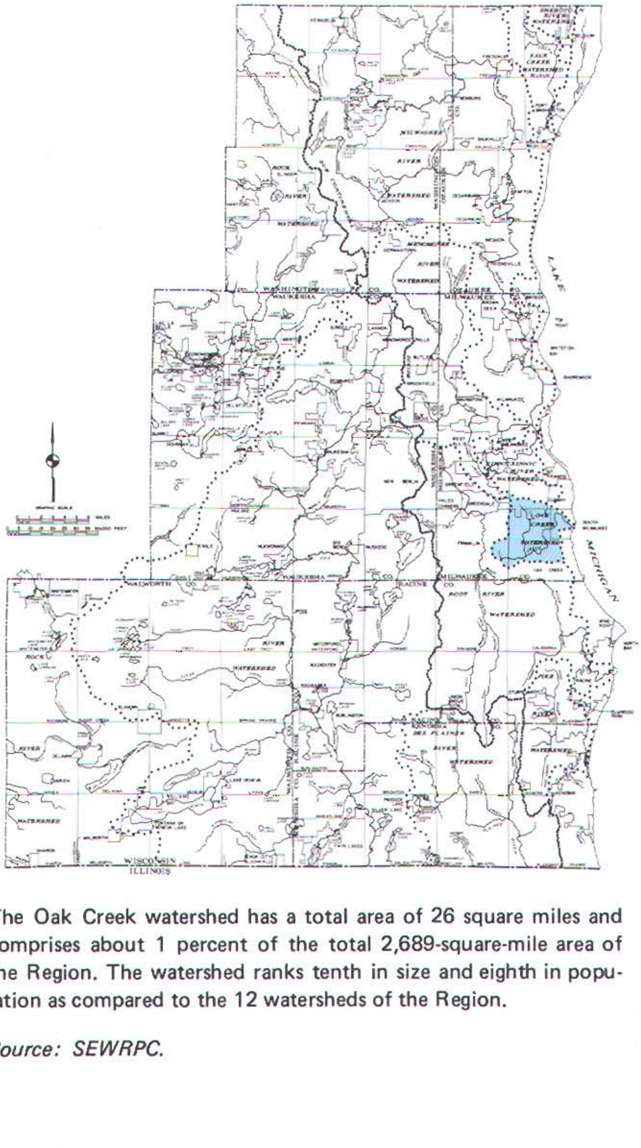
In addition to Oak Creek and the North Branch of Oak Creek, the stream system of the watershed includes the Mitchell Field drainage ditch which drains a portion of the northern end of the watershed but has measurable flow only during or after precipitation events, and therefore was not considered as a major tributary in this water quality study. Table 133 lists for the Oak Creek watershed each stream reach together with the location, source, and length in miles. The watershed ranks tenth in size, but eighth in total resident population among the other watersheds of the Region.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries is a rectilinear pattern of local political boundaries, as shown on Map 48. The Oak Creek water-

Map 48

LOCATION OF THE OAK CREEK WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Oak Creek watershed has a total area of 26 square miles and comprises about 1 percent of the total 2,689-square-mile area of the Region. The watershed ranks tenth in size and eighth in population as compared to the 12 watersheds of the Region.

Source: SEWRPC.

shed lies totally within Milwaukee County and in parts of six cities. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 134.

Population

Population Size: The 1975 resident population of the watershed is estimated at 39,519 persons, or approximately 2 percent of the total resident population of the Region of 1,789,871. Table 135 presents the population distribution in the Oak Creek watershed by civil division. The resident population of the watershed has increased steadily since 1900, with particularly rapid growth and urbanization occurring after 1950.

Population Distribution: Presently, about 30 percent of the residents of the watershed live within the rapidly growing City of Oak Creek, which occupies 65.7 percent of the total area of the watershed. The remaining 70 percent of the watershed population resides in the Cities of Cudahy, Franklin, Greenfield, Milwaukee, and South Milwaukee.

Quantity of Surface Water

Surface water in the Oak Creek watershed consists almost entirely of streamflow. Some small ponds, flooded gravel pits, and wetlands make up the remainder of the surface water. The quantity of streamflow in the Oak Creek watershed, as in the Region generally, varies with seasonal variations in temperature, rainfall, soil moisture, agricultural operation, the growth cycle of vegetation, and groundwater levels. The streamflow of Oak Creek has been measured since 1963 at a continuous flow recording gage operated by the U. S. Geological Survey in cooperation with the Milwaukee Metropolitan Sewerage District and the Commission, at the 15th Avenue bridge in South Milwaukee. The streamflow characteristics for the published period of record are summarized in Table 136. Low flows predominate at the location throughout most of the year with the exception of periods of spring runoff associated with winter snowmelt and periods of rainfall which result in typically higher flows. The streamflow fluctuates considerably as indicated by a peak discharge

Table 133

STREAMS IN THE OAK CREEK WATERSHED

Stream or Watercourse	Source		Length in Miles[a]
	By Civil Division	By U. S. Public Land Survey	
Oak Creek	Franklin	NW ¼, Section 24, T5N, R21E	12.8
North Branch to Oak Creek.	Milwaukee	SE ¼, Section 31, T6N, R22E	15.5

[a] *Total perennial stream length as shown on U. S. Geological Survey quadrangle maps.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 134

AREAL EXTENT OF CIVIL DIVISIONS IN THE OAK CREEK WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Area Within Within Civil Division	Percent of Civil Division Area Within Watershed
MILWAUKEE COUNTY			
Cities			
Cudahy.	0.22	0.84	4.64
Franklin	2.53	9.61	7.29
Greenfield.	0.24	0.91	2.92
Milwaukee.	2.82	10.67	2.91
Oak Creek.	17.30	65.70	60.89
South Milwaukee	3.22	12.27	66.39
County Subtotal	26.33	100.00	10.85
Total	26.33	100.00	--

Source: SEWRPC.

Table 135

ESTIMATED RESIDENT POPULATION OF THE OAK CREEK WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
MILWAUKEE COUNTY	
Cities	
Cudahy (part)	515
Franklin (part).	2,013
Greenfield (part)	1,644
Milwaukee (part)	7,340
Oak Creek (part)	11,688
South Milwaukee (part).	16,319
Milwaukee County (part) Subtotal	39,519
Oak Creek Watershed Total	39,519

Source: SEWRPC.

of 745 cubic feet per second recorded on March 4, 1974, and a minimum discharge of 0.5 cubic feet per second recorded on January 14-18, 1964.

Surface runoff, the portion of precipitation which flows overland and contributes directly to streamflow, varies both with the season and with the location within the watershed. The ratio of runoff to precipitation in the spring, occurring when the soil is frozen or saturated, can be very high. Runoff during the summer and fall seasons generally is a very small fraction of the precipitation. In addition to the surface water runoff contribution from rainfall and snowmelt, the main stem, the North Branch, and the intermittently flowing Mitchell Field Drainage Ditch, accept waste water flows from several industries. The influx of water from the shallow groundwater aquifer is relatively uniform and constitutes a baseflow of all perennial streams located within the watershed.

The lower reach of Oak Creek, like the lower reaches of other first rank tributaries to Lake Michigan is subject to a phenomenon known as a seiche. A seiche, also known as a standing wave, is an oscillation of the surface of the water mass of a lake lasting from a few minutes to several hours. The forces that generate seiches include variations of atmospheric pressure and wind. The flow condition and the water quality in the lower reaches of the Oak Creek River can temporarily be affected by the dilution effects of Lake Michigan water during a seiche.

Pollution Sources

In order to properly analyze the past and present surface water quality conditions in the Oak Creek watershed, all known sources of pollution—inclusive of point and diffuse sources—must be taken into account. The following types of pollution sources exist within the watershed and are discussed below: numerous privately owned onsite sewage disposal systems; two sanitary sewerage system flow relief devices; eight industrial wastewater discharges, urban storm water runoff, and agricultural runoff.

Sewage Treatment Facilities: There are no publicly or privately owned nonindustrial sewage treatment plants discharging to the stream system of the watershed, since the entire watershed lies within the existing and proposed service areas of two public sanitary sewerage systems; the Milwaukee Metropolitan Sewerage System and the City of South Milwaukee sewerage system.

Domestic Onsite Sewage Disposal Systems: Although the entire watershed lies within existing and proposed service areas of six public sanitary sewerage systems, some areas of the watershed still are served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems

Table 136

FLOW MEASUREMENTS AT OAK CREEK NEAR SOUTH MILWAUKEE (OK-2) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1975

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1964	7.4	4.05	215	0.5
1965	21.8	11.86	380	2.6
1966	21.7	11.77	490	1.2
1967	16.6	9.02	450	1.2
1968	14.5	7.88	483	0.8
1969	25.3	13.72	668	1.2
1970	14.9	8.08	310	1.2
1971	19.8	10.75	450	0.8
1972	25.2	13.71	710	0.8
1973	36.1	19.63	639	0.8
1974	41.7	22.63	745	1.5
1975	16.9	9.18	364	0.9

Source: SEWRPC.

and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points: In addition to malfunctioning septic systems, raw sanitary sewage enters the surface water system of the Oak Creek watershed indirectly via sanitary sewer overflows to separate storm sewer systems. There are two known flow relief devices in the Oak Creek watershed as shown in Table 137. Both of these flow relief devices are bypasses which discharge directly into Oak Creek.

Industrial Waste Discharges: Industrial cooling and processing wastewaters enter the surface water system of the watershed directly through industrial waste outfalls and indirectly through drainage ditches and storm sewers at eight locations in the Oak Creek watershed.

Data and information provided by the Wisconsin Department of Natural Resources Pollutant Discharge Elimination System and reports required by Chapter NR101 of the Wisconsin Administrative Code were used to determine the type and location of industrial wastewater discharges in the Oak Creek watershed. Table 138 summarizes by receiving stream and civil division the types of industrial wastewater discharges and the number of outfalls known to exist in the watershed (Map 49), the types of treatment and average hydraulic design capacity.[12] A total of 13 discharge points result from the eight commercial and industrial discharges, eight of which discharge directly to Oak Creek, three of which discharge indirectly to Oak Creek, and two of which discharge indirectly to the North Branch of Oak Creek. Of the 13 discharge points, six discharge cooling waters, three process wastewater, two cooling and process wastewater, one swimming pool overflow, and one surface runoff.

Pollution from Urban Runoff: Separate storm sewers existing within the watershed convey runoff and carry pollutants from urbanized areas into the stream system. Existing land use data taken from the Commission 1970 land use inventory are presented in Table 139 and indicate that 7,536 acres, or about 44 percent of the total area of the Oak Creek watershed, are devoted to urban land uses; and 9,060 acres, or about 53 percent of the total area of the watershed, are devoted to rural land uses, primarily agriculture. The remaining 506 acres, or 3 percent of the total area of the watershed, consist of the stream system itself and associated wetlands. A shoreline development survey by the Wisconsin Department of Natural Resources indicates that approximately 48 percent of the shoreland area within 1,000 feet of Oak Creek and its North Branch tributary is used either for agricultural purposes or other rural purposes, while about 52 percent is used for urban purposes. Urban

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[12] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 49. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exist to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 137

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE OAK CREEK WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Other Flow Relief Devices				
			Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	Total
Oak Creek	City of South Milwaukee	0	0	2	0	0	2
Total		0	0	2	0	0	2

Source: SEWRPC.

Table 138

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE OAK CREEK WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY								
Appleton Electric Company—Lighting Products Division	3643	City of South Milwaukee	Process	None	1	Oak Creek via Storm Sewer	22,600	28,800
			Process	None	3	Oak Creek via Storm Sewer	11,500	14,000
Appleton Electric Company—Foundry Division	3679	City of South Milwaukee	Cooling	None	1	Oak Creek	66,000	84,000
Bucyrus Erie Company	3532	City of South Milwaukee	Cooling	None	1	Oak Creek	42,200	78,000
			Cooling	None	2	Oak Creek	117,000	162,500
			Cooling and Process	None	3	Oak Creek	136,600	300,000
			Cooling and Process	None	5	Oak Creek	468,400	590,000
Harley-Davidson Motor Company	3751	City of Oak Creek	Cooling	N/A	1	North Branch Oak Creek via Storm Sewer	4,400	7,500
Industrial Fuel, Inc.	5093	City of Oak Creek	Process	Holding Pond	1	North Branch Oak Creek via Storm Sewer	600	600
Ladish Company	3462	City of Cudahy	Cooling	N/A	1	Oak Creek	585,000	1,585,000
			Cooling	N/A	12	Oak Creek	171,000	1,013,000
Milwaukee County Park Commission: Oak Creek Park	7032	City of South Milwaukee	Swimming Pool Overflow	None	1	Oak Creek via Storm Sewer	Intermittent	Intermittent
Union Oil Truck Stop	5541	City of Oak Creek	Runoff	Oil Separator	1	Oak Creek	Intermittent	Intermittent

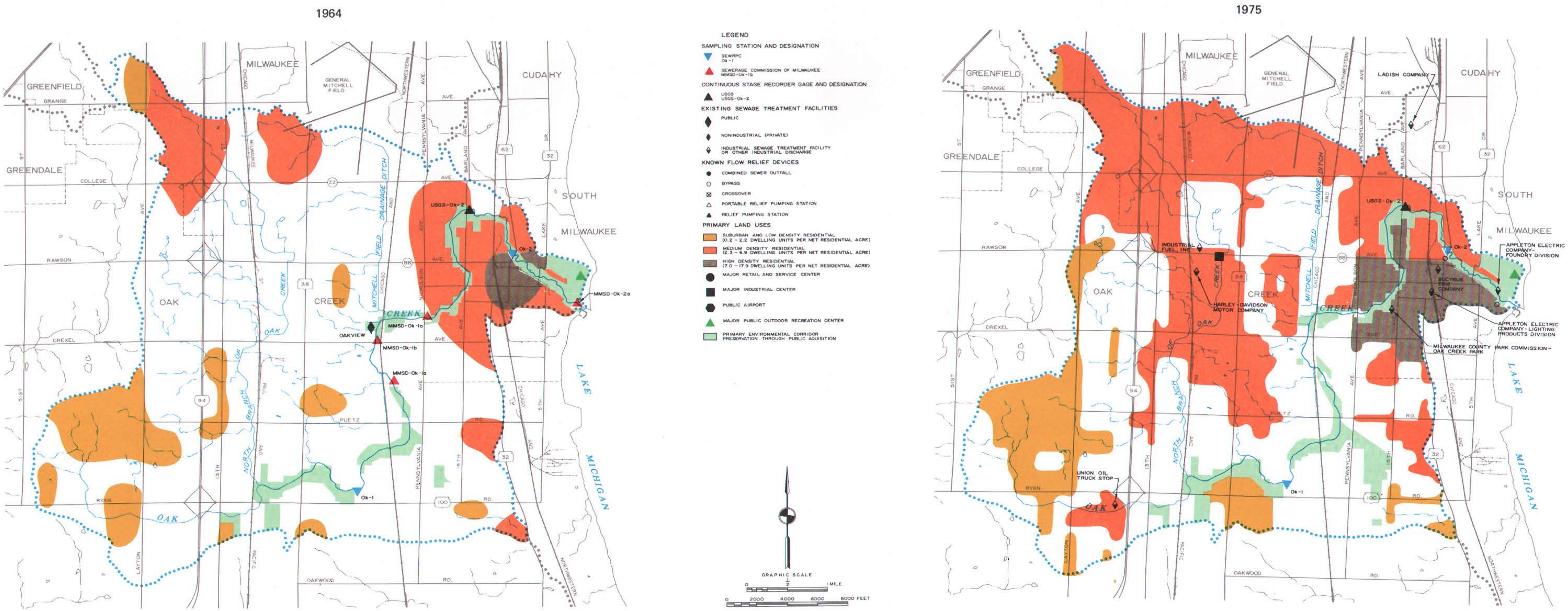
NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 49

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE OAK CREEK WATERSHED: 1964 AND 1975



Stream water quality was obtained from chemical, physical, biochemical, or bacteriological analysis of water samples collected at seven sampling stations located in the Oak Creek watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by two sewer bypasses and eight commercial and industrial facilities which discharge wastewater through 13 outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 139

LAND USE IN THE OAK CREEK WATERSHED: 1963, 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	2,600.76		3,234.41	
Commercial	247.62		356.25	
Industrial	194.19		208.39	
Transportation and Utilities	2,278.41		2,648.12	
Government	322.26		359.62	
Recreation	524.26		650.86	
Landfill and Dump	48.23		78.11	
Total	6,215.73	36.35	7,535.76	44.06
Rural Land Uses				
Open Land	2,222.51		2,405.45	
Agricultural Lands	8,062.78		6,654.05	
Total	10,285.29	60.14	9,059.50	52.97
Water Covered Lands				
Lakes, Rivers, and Streams	19.16		28.48	
Wetlands, etc.	581.45		477.93	
Total	600.61	3.51	506.41	2.96
Watershed Totals	17,101.63	100.00	17,101.67	100.00

Source: SEWRPC.

development is more intense within 1,000 feet of the perennial stream system than throughout the watershed as a whole, and the extent of this development indicates a potential adverse impact on the water quality of the Oak Creek system.

Pollution from Rural Land: About 39 percent of the total area of the watershed is devoted to agricultural uses, with most of the farming operations concentrated in the western and southern portions of the watershed, particularly in the headwater areas of Oak Creek itself. Thus, a potential exists for degradation of the water quality of the upper reaches of Oak Creek by runoff of natural and artificial fertilizers applied to the land, of various animal wastes from barnyard and grazing operations, and of other nutrients as a result of agricultural operations.

Other Pollution Sources: In addition to the pollution from urban and rural runoff and industrial waste discharges, six other potential sources of pollution exist within the watershed; more specifically, one sanitary landfill site and five auto salvage yards. Street and highway construction and land development activities also may contribute to the pollutant loadings of the stream system in both rural and urban areas of the watershed, particularly since urbanization is occurring throughout the watershed—even in the more rural areas.

Water Quality Conditions of the Oak Creek Watershed

Water Quality Data: Six of the data sources discussed in Chapter II of this report were used in the analysis and evaluation of the water quality of the Oak Creek watershed: 1) Commission benchmark stream sampling program; 2) Commission continuing stream and lake monitoring program; 3) Commission streamflow gaging program; 4) Wisconsin Department of Natural Resources drainage basin surveys; 5) Milwaukee Metropolitan Sewerage District stream water quality sampling program; and 6) U. S. Geological Survey streamflow monitoring program.

Two sampling stations, both on the main stem of Oak Creek, were established by the Commission during the 1964-1965 benchmark survey. Table 140 lists the station locations and distances from the mouth of Oak Creek at Lake Michigan. Table 141 presents similar data for stations other than those established by the Commission. Map 49 illustrates the location of all sampling stations within the Oak Creek watershed from which water quality sample results were used in this study.

Surface Water Quality of Oak Creek and Its Tributary 1964-1965: Water quality conditions in the Oak Creek watershed as measured in the 1964-1965 Commission benchmark survey at the two Commission stations on Oak Creek are summarized in Table 142. However, data

Table 140

DESIGNATIONS AND LOCATIONS OF THE SEWRPC SAMPLING STATIONS IN THE OAK CREEK WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
SEWRPC	Ok-1	Shepard Avenue SE ¼, Section 21, T5N, R22E	8.4
	Ok-2	STH 32 SE ¼, Section 2, T5N, R22E	1.6

Source: SEWRPC.

Table 141

DESIGNATIONS AND LOCATION OF STREAM SAMPLING STATIONS OF OTHER SOURCES IN THE OAK CREEK WATERSHED

Source	Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
MMSD[a]	MMSD Ok-1a	Forest Hill at Oak Creek, SW ¼, Section 15, T5N, R22E	6.14
MMSD.	MMSD Ok-1b	Drexel Avenue at Oak Creek, SE ¼, Section 9, T5N, R22E	4.96
MMSD.	MMSD Ok-1c	Pennsylvania Avenue at Oak Creek, SE ¼, Section 10, T5N, R22E	4.12
MMSD.	MMSD Ok-2a	Grant Park, Mouth of Oak Creek SE ¼, Section 12, T5N, R22E	0.00
USGS[b]	USGS Ok-2	Oak Creek at South Milwaukee NW ¼, Section 2, T5N, R22E	2.80

[a] *Milwaukee Metropolitan Sewerage District.*

[b] *U. S. Geological Survey.*

Source: SEWRPC.

Table 142

WATER QUALITY CONDITIONS OF OAK CREEK AND ITS TRIBUTARY: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Oak Creek (Ok-1-Ok-2)	Chloride (mg/l)	135	80	30	16
	Dissolved Solids (mg/l)	755	605	375	16
	Dissolved Oxygen (mg/l)	13.7	10.9	6.4	25
	Total Coliform Count (MFCC/100 ml)	33,000	8,500	500	25
	Temperature (^{o}F)	77	48	32	24

Source: SEWRPC.

are available for September at station Ok-1 and, for purposes of this analysis, comparisons are made assuming that similar low flows occurred during the months of August and September and the streams were likely to have exhibited similar dry weather, low-flow water quality conditions. Supplemental data are available for the low-flow periods of 1964-1966 at four additional sites along the main stem of Oak Creek as collected by the Milwaukee Metropolitan Sewerage Commission as discussed in Chapter II above.

Chloride: During the sampling year 1964-1965 the observed chloride concentrations for the Oak Creek watershed ranged from 7 mg/l to 135 mg/l with the average values for Oak Creek being 77 mg/l. The levels of chloride concentration were typically elevated during the winter months at all stations as a result of runoff contaminated with road salt. The exception was at station MMSD-Ok-2a at Grant Park, reflecting the dilution of the stream water from Lake Michigan at that location.

Dissolved Oxygen: During the sampling period of 1964-1965, the dissolved oxygen levels in the watershed were found to range from 6.4 mg/l to 13.7 mg/l with an average of 10.9 mg/l. Although no samples taken at stations Ok-1 or Ok-2 exhibited an oxygen concentration of below 5.0 mg/l, substandard levels were recorded on 11 occasions during the 1964 summer months at the four Milwaukee Metropolitan Sewerage District stations. Surprisingly, the substandard levels recorded at the MMSD stations were not detected at station Ok-2, 2.2 miles downstream, thus indicating that this stream reach may have undergone natural recovery, thereby increasing dissolved oxygen levels.

Although there are no public or private sewage treatment facilities located within the watershed, the upstream substandard dissolved oxygen levels are a result of the sewerage service area feeding into the Milwaukee metropolitan sewage facility and the South Milwaukee sewage facility, thereby releasing raw sewage through overflows into the River system during periods of significant precipitation. In addition, runoff from both urban and rural land uses may contribute to sporadic reductions in dissolved oxygen levels during periods of wet weather. In most cases, however, dissolved oxygen levels were found to be high throughout the upstream and middle reaches of the entire watershed, with readings of 13.4 mg/l and 10.3 mg/l at stations Ok-1 and Ok-2, respectively, during the August low-flow period in 1964. This is indicative of low amounts of organic loading on this stream system, and probably the supersaturated dissolved oxygen levels indicate the effects of plant growth on the water quality.

It is difficult to assess the impact on the dissolved oxygen concentration of the five auto salvage yards and the two industrial discharges located along the North Branch of Oak Creek, due to the absence of water quality stations on this tributary or near the confluence with the main stream. Generally, the pollution impact of the Mitchell Field Airport is difficult to assess due to the lack of sampling stations on the Mitchell Field drainage ditch.

Biochemical Oxygen Demand: The five-day biochemical oxygen demand (BOD_5) in Oak Creek during the sampling years 1964 and 1965 was found to range from 0.5 mg/l to 9.9 mg/l. The lowest value was recorded at station Ok-1 in May 1964 and the highest at station Ok-2 in August 1964. Higher values, in the range of 10.0 mg/l to 21.5 mg/l, were noted in the supplemental Milwaukee Metropolitan Sewerage Commission samples and were probably associated with precipitation on the day of sampling or within the 24-hour period preceding the sampling. Lower levels of biochemical oxygen demand were found at the farthest upstream station, Ok-1, with gradually increasing levels occurring at each successive station moving downstream through stations MMSD-Ok-1a, MMSD-Ok-1b, MMSD-Ok-1c, and Ok-2. This appears to indicate increasing biochemical oxygen demand levels in the stream reaches tributary to the more intensively urbanized land uses. Biochemical oxygen demand levels in streams draining urban areas are more sensitive to the effect of rainfall than are similar streams draining rural areas because of the relatively large proportion of impervious area drained and the numerous sources of organic material. Consequently, at times of heavy rainfall, urban areas may contribute heavily contaminated runoff directly or indirectly to the surface water system. At station MMSD-Ok-2a, biochemical oxygen demand levels were found to be considerably reduced, falling to levels of 1.0 mg/l because of the pollution effect of Lake Michigan.

Total Coliform Bacteria: Coliform levels in Oak Creek were found to vary from 500 membrane filter coliform counts (MFCC) per 100 ml to 33,000 MFCC/100 ml. The highest coliform count occurred at station Ok-2 on September 23, 1964, with a reading of 22,000 MFCC/100 ml on that same day at station Ok-1. The Milwaukee Metropolitan Sewerage Commission stations exhibited ranges from as low as 100 MFCC/100 ml to as high as 168,000 MFCC/100 ml. Elevated readings occurred generally during periods of wet weather. Coliform counts observed in fall and early winter of the 1964-1965 sampling period at sampling station Ok-2, reflecting the more urbanized areas of the watershed, were generally higher than coliform counts observed upstream at sampling station Ok-1 which is associated with the more rural areas of the watershed. This same pattern was noted as well during summers of some later years of sampling for fecal coliform.

Fecal coliform bacteria measurements were not a part of the Commission's 1964 benchmark study. Thus, it is difficult to determine the levels of fecal coliform pathogens within the total coliform concentration. Generally, however, increased total coliform counts indicate elevated fecal coliform readings. The Milwaukee Metropolitan Sewerage Commission conducted fecal coliform samplings in 1964 at the Grant Park station MMSD-Ok-2a at the mouth of Oak Creek. Although dilution from Lake Michigan waters would tend to reduce the fecal coliform counts at this station, ranges of from 20 to 1,400 fecal coliform counts/100 ml were recorded. These levels indicate the presence of fecal coliform bacteria contamination in Oak Creek from several possible sources, including runoff from animal feeding operations, areas served by malfunctioning onsite sewage disposal systems, sanitary sewer overflows, and urban runoff.

Specific Conductance: The specific conductance of the surface waters of the Oak Creek watershed during the 1964-1965 sampling period were found to range from 544 to 1,020 μmhos/cm at 25°C. As anticipated, higher specific conductance levels were evident during the spring runoff due to the greater concentrations of dissolved solids from the residue of winter street and highway salting operations. During the late spring, summer, and early fall months, specific conductance levels returned to normal levels at stations Ok-1 and Ok-2.

Hydrogen Ion Concentration (pH): The pH values at all sampling stations in the Oak Creek watershed ranged from 7.3 to 9.0 standard units in the 1964-1965 sampling year. The recommended maximum of 9.0 standard units, as prescribed by the Department of Natural Resources for recreational use and the propagation of fish and aquatic life, was exceeded four times, once at station MMSD-Ok-1a, twice at station MMSD-Ok-1c, and once at station MMSD-Ok-2a, with readings of 9.1 at each station. It is difficult to assess the origin of these elevated pH levels, although industrial waste discharges are the most likely cause.

Temperature: During the 1964-1965 sampling period, the temperature of Oak Creek was found to range from 32°F to 79°F. This temperature variation was primarily seasonal.

Water Quality Trends from 1965 to 1975: Water quality data obtained during the period from 1964 through 1975 in eight summer sampling programs, three spring sampling programs, and one fall sampling program are presented in tabular form in Appendix D of this report. All eight summer sampling programs—1964, and 1968 through 1975—involved collection of samples during one day in August of each year during what is typically the low-flow period. An exception to this occurred in 1972 when a high flow of 12 cfs was recorded at the U. S. Geological Survey stream gaging station on Oak Creek as compared to the average low-flow reading of 3.5 cfs for the remaining low-flow years.

The summary of the results for specific conductance; pH; dissolved oxygen; nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble- and total phosphorus; chloride; and fecal coliform counts for both of the Commission sampling stations in the Oak Creek watershed for the period from 1968 through 1975 is set forth in Table 143. Additional data are available for low-flow periods in 1965 and 1966 from samples taken by the Milwaukee Metropolitan Sewerage Commission at stations Ok-1a, Ok-1b, Ok-1c, and Ok-2a. These additional data serve to supplement existing Commission data for those years—1965 and 1966—for which no low-flow samples were obtained under the Commission program. The continuous streamflow data for the U. S. Geological Survey gaging station, located 0.9 mile upstream from sampling station Ok-2, is considered to provide representative data on the relative rates of flow at the station. Flow data are presented for the dates of sampling during the 1964 through 1975 period in Figure 133. As indicated by Figure 133, a relatively high flow was observed during the 1972 sampling. Other than 1972, uniformly low flows were present during the sampling period.

Dissolved Oxygen: The water use objectives for Oak Creek and its tributaries are recreation and maintenance of fish and aquatic life throughout the watershed, except for the mouth of Oak Creek where salmon spawning is intended to be supported. Although the same fecal coliform and pH standards for the rest of the stream system apply to this reach, the dissolved oxygen levels in the reach designated for spawning are not to be degraded below the natural background levels during the spawning periods.

The observed range of dissolved oxygen in the Oak Creek stream system during the low-flow sampling periods for the years 1968 through 1975 was from 1.5 mg/l to 13.1 mg/l at stations Ok-1 and Ok-2 and the three Milwaukee Metropolitan Sewerage Commission stations at Forest Hill Road, Drexel Avenue, and Pennsylvania Avenue. The average dissolved oxygen concentrations were 7.0 and 7.1 mg/l at stations Ok-1 and Ok-2, respectively. The data indicate that, during low-flow conditions, the 5.0 mg/l standard was violated at the Commission sampling station only three times, all on August 25, 1975. The decrease in dissolved oxygen in August 1975 can be attributed to the rainfall which occurred over the four days prior to sampling. During this time period, two inches of rainfall were recorded at the General Mitchell Field weather station, located 3.5 miles north of sampling station Ok-2. Based on the sampling results, there appears to be a more pronounced reduction in dissolved oxygen levels after intensive rainfall events at sampling stations Ok-1, MMSD-Ok-1a, and MMSD-Ok-1b which are located closer to the agricultural subbasin of the watershed than at the more urbanized downstream stations MMSD-Ok-1c and Ok-2. This may be attributed to organic loadings associated with storm water runoff from agricultural lands.

On August 6, 1964, as indicated by Map 50, high concentrations of dissolved oxygen were recorded at sampling station Ok-1 and Ok-2, whereas on August 25, 1975, substandard levels of dissolved oxygen were recorded at sampling station Ok-1 with values improving at Ok-2 sufficiently to exceed the 5.0 mg/l minimum requirement.

The graph inserts on Map 50 present the dissolved oxygen concentrations and three-year moving averages for sampling station Ok-1 and Ok-2 for the August samples of 1964 through 1975. Sampling station Ok-1 exhibits a moving average which is relatively stable during the sampling period 1968 through 1971. In 1972 the dissolved oxygen concentrations exhibit significant reductions through August 1975. The total decrease over the range of this four-year period amounts to approximately 3.0 mg/l. Daily average values fluctuated from a high of

Table 143

WATER QUALITY CONDITIONS OF OAK CREEK AT SAMPLING STATIONS OK-1 AND OK-2: 1968-1975

Station Ok-1

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	221.000	141.745	27.000	22	--
Dissolved Oxygen (mg/l)	5.0	13.1	7.0	1.5	30	3[a]
Ammonia-N (mg/l)	2.5	0.440	0.249	0.030	8	0
Organic-N (mg/l)	--	0.980	0.721	0.180	8	--
Total-N (mg/l)	--	1.750	1.233	0.290	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,720.0	1,235.0	775.0	30	--
Nitrite-N (mg/l)	--	0.050	0.024	0.002	12	--
Nitrate-N (mg/l)	0.3	0.430	0.212	0.040	12	4
Soluble Orthophosphate-P (mg/l) . . .	--	0.176	0.079	0.010	12	--
Total Phosphorus (mg/l)	0.1	0.160	0.102	0.020	8	5
Fecal Coliform (MFFCC/100 ml) . . .	400	1,200	508	130	12	7
Temperature (°F)	89.0	81.0	73.4	66.5	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.2	8.0	7.6	22	0

Station Ok-2

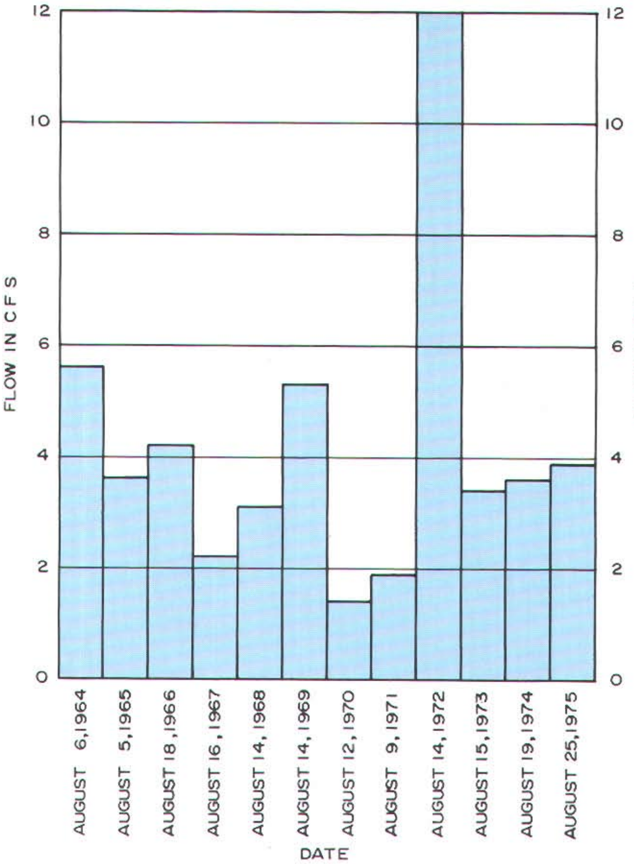
Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	211.000	87.061	48.000	22	--
Dissolved Oxygen (mg/l)	5.0	9.6	7.1	4.1	30	1[a]
Ammonia-N (mg/l)	2.5	0.270	0.144	0.030	8	0
Organic-N (mg/l)	--	1.320	0.767	0.210	8	--
Total-N (mg/l)	--	3.460	1.518	0.510	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,160.0	899.4	609.0	30	--
Nitrite-N (mg/l)	--	0.100	0.030	0.004	12	--
Nitrate-N (mg/l)	0.3	1.770	0.459	0.100	12	8
Soluble Orthophosphate-P (mg/l) . . .	--	0.312	0.099	0.010	12	--
Total Phosphorus (mg/l)	0.1	0.230	0.102	0.050	8	3
Fecal Coliform (MFFCC/100 ml) . . .	400	1,800	490	150	12	3
Temperature (°F)	89.0	80.0	73.3	67.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	89.0	8.0	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Figure 133

FLOW MEASUREMENTS AT OAK CREEK NEAR SOUTH MILWAUKEE (OK-2) ON THE DATES OF WATER SAMPLE COLLECTION: 1964-1975



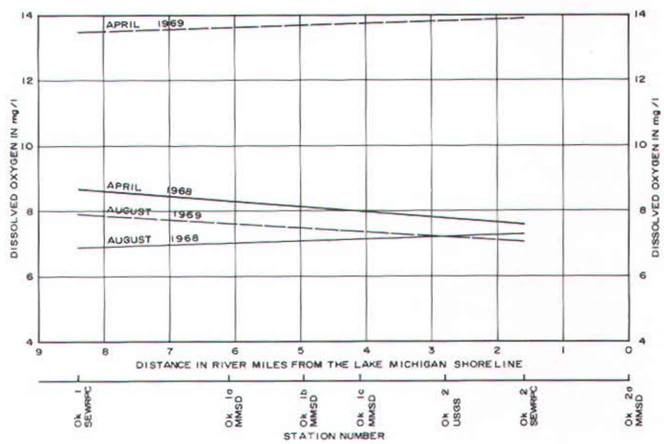
Source: SEWRPC.

13.4 mg/l in August 1964 to a low of 3.9 mg/l in August 1975. The three-year moving averages for sampling station Ok-2 over the eight-year analysis period appear stable. In addition, daily average values fluctuated over a range of approximately 1.7 mg/l with a high of 7.8 mg/l in August 1970 and a low of 6.1 mg/l in August 1975. Thus, it appears that the increased volume of flow, coupled with the natural reaeration capacity of the stream, results in slightly higher and more stable dissolved oxygen conditions in the lower reaches of the Oak Creek watershed near sampling station Ok-2. In addition, the lack of major point sources of pollution, as compared to other watersheds of the Region, appears to provide an enhanced stability of water quality in Oak Creek.

A comparison of dissolved oxygen concentrations found in April and August of the years 1968 and 1969, as shown in Figure 134, indicates consistently higher dissolved oxygen levels in April of each year than during the August low-flow periods. The lower flow and higher temperatures, coupled with the organic loadings from

Figure 134

DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATIONS OK-1 AND OK-2 ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968



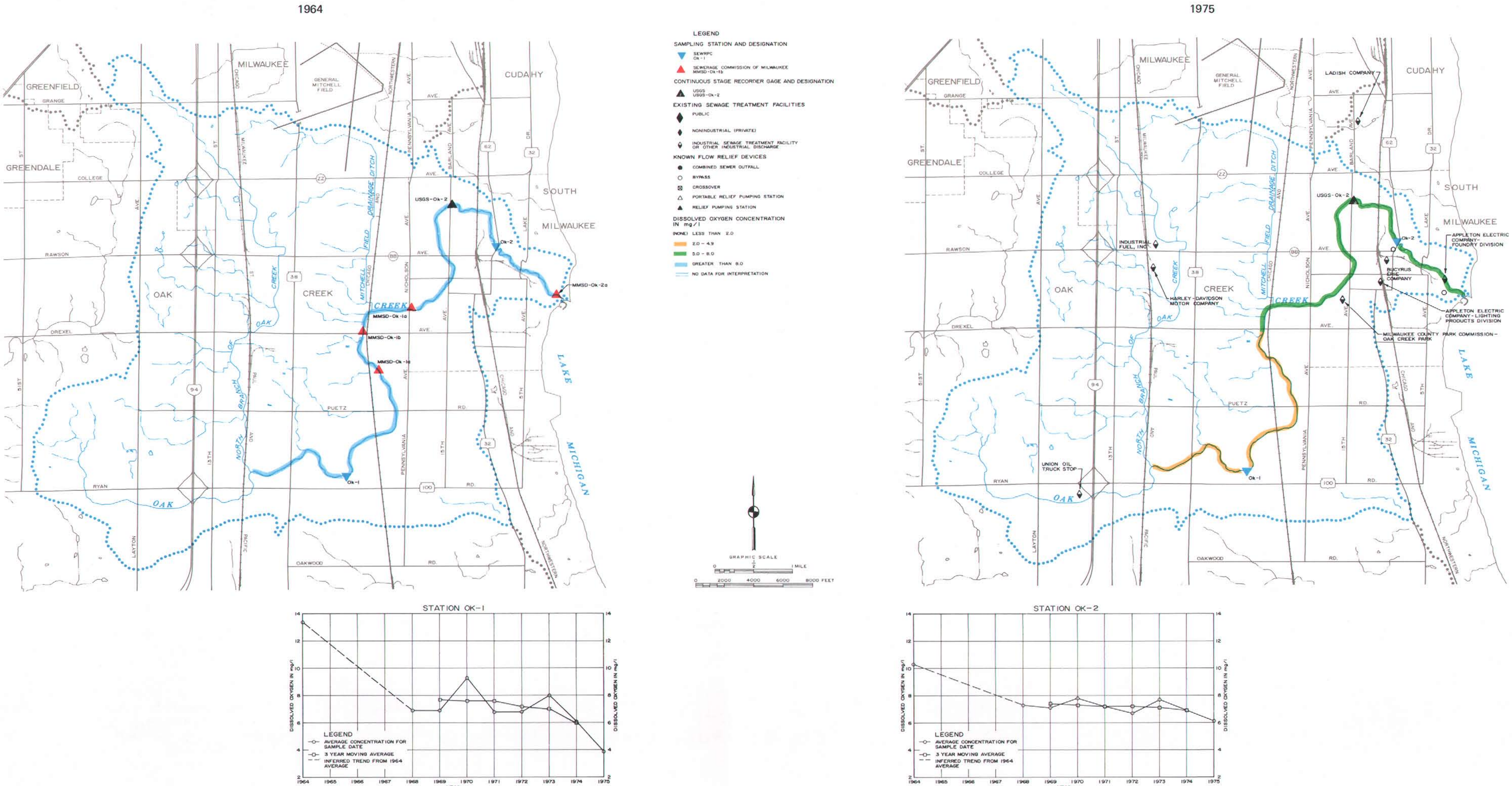
Source: SEWRPC.

agricultural and urban runoff, probably account for the lower dissolved oxygen concentrations of the August samples.

Chloride: Chloride concentrations in Oak Creek were observed to range from 27 mg/l to 221 mg/l at the two Commission stations during the years 1964 through 1975. The majority of the readings exceeded the normal background levels of chloride concentrations in the groundwater of 7 mg/l for the Oak Creek watershed area. A comparison of the chloride concentrations, as presented in Figure 135, for April and August of the years 1968 and 1969 indicates generally higher chloride concentrations in April 1968 as compared to August 1968 at both stations. However, in August 1969 sampling station Ok-2 exhibited chloride concentrations higher than those of April 1969. This reversal is difficult to assess since small amounts of precipitation occurred on several days prior to both the April and August sampling, producing runoff from urban areas potentially contaminated with high levels of chloride. Perhaps another pollution source, such as separate sanitary sewer overflows or industrial discharges, released wastes high in chloride to the surface water system just above sampling station Ok-2 prior to the time of sampling in August. The averages of the four chloride readings taken in April and August of 1968 and 1969 at sampling station Ok-1 are identical to the comparable figures from sampling station Ok-2. It may be assumed from the data that chloride loadings to the stream at both stations are similar, a situation quite different from that in the other watersheds of the Region, where increased chloride concentrations were generally exhibited in the more urbanized areas as a result of winter deicing operations on a higher density street and highway network. This is an anomaly attributed

Map 50

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE OAK CREEK WATERSHED

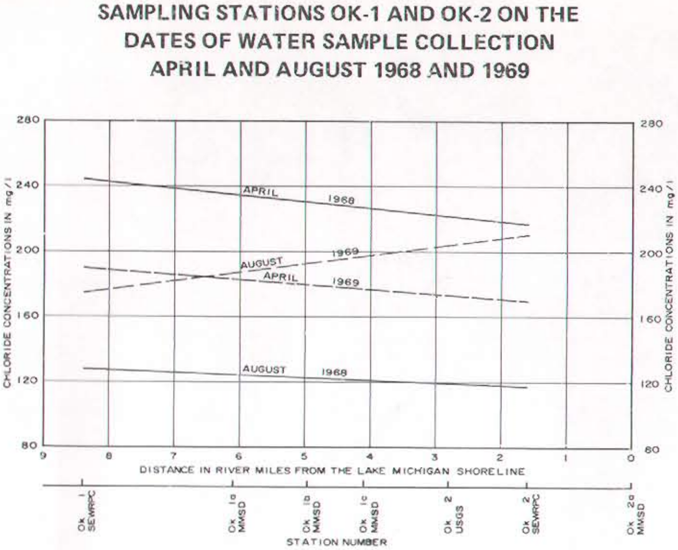


A comparison of the dissolved oxygen levels recorded in 1964 and 1975 indicated that dissolved oxygen concentrations decreased at both sampling stations Ok-1 and Ok-2. The maximum observed dissolved oxygen concentration was 13.4 mg/l at sampling station Ok-1. Station Ok-1 also recorded the minimum dissolved oxygen concentration of 1.5 mg/l.

Source: SEWRPC.

Figure 135

CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS OK-1 AND OK-2 ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968 AND 1969



Source: SEWRPC.

to the close proximity of sampling station Ok-1 to Ryan Road which is salted during snowfall and icing events in winter months.

In 1965 and 1966, the data from sampling stations MMSD-Ok-1a, MMSD-Ok-1b, and MMSD-Ok-1c indicate increasing values of chloride concentrations in the more urbanized areas downstream from sampling station MMSD-OK-1c.

Map 51 depicts the chloride concentrations at sampling stations Ok-1 and Ok-2 on August 14, 1968, and August 25, 1975, with the graph insert illustrating the changes in chloride concentrations found during the sampling days of intermediate years. The map indicates generally stable conditions over time in the chloride levels at sampling station Ok-1. A trend toward lower chloride levels is noted at sampling station Ok-2 from 1968 to 1975. The graphs illustrate the chloride concentrations in the August months for the two Commission stations for the years 1968 through 1975. When the three-year moving average chloride concentrations for August 1968 through 1975 are compared for both stations, a decreasing trend over time may be noted except for the earlier years at sampling station Ok-1. The chloride concentrations exhibited decreases from about 100 mg/l to 200 mg/l at both stations over the eight-year sampling period. These results are consistent with what might be expected since the winter salting operations by the Milwaukee County Highway Department during the same period have decreased due to the installation of computerized salting machines, which use less salt and exhibit a decrease in the frequency and amount of salting because of increased salt and gasoline prices. In addition, decreasing levels of chloride within the Oak Creek watershed may be attributed to a reduced number of animal operations due to urbanization, elimination of malfunctioning domestic onsite sewage disposal systems due to the rapidly expanding sewer service areas, and the gradual elimination of sewage overflow relief devices by the Cities of South Milwaukee and Milwaukee. As shown in Figure 136, the chloride levels of all the samples taken at station Ok-2 are eight to 30 times higher than the reasonably assumed levels of about 10 mg/l.

As discussed above, both Commission sampling stations, the more rural Ok-1 and the more urban Ok-2, exhibited a gradual decrease in chloride concentrations from 1968 through 1975 as shown on the graph inserts to Map 51. The trends in the graphs are remarkably similar for the two stations, indicative of the cause and effect relationship between precipitation events and high levels of chloride concentration in the stream system.

Fecal Coliform Bacteria: Map 52 presents the fecal coliform counts observed at the Commission sampling stations during August 1968 and August 1975. The graph insert presents the changes in fecal coliform counts found on the days of sampling during the intermediate years. The samples collected in August 1968 contained excessive levels of 1,000 MFFCC/100 ml at station Ok-1, and marginally acceptable levels of 400 MFFCC/100 ml at station Ok-2.

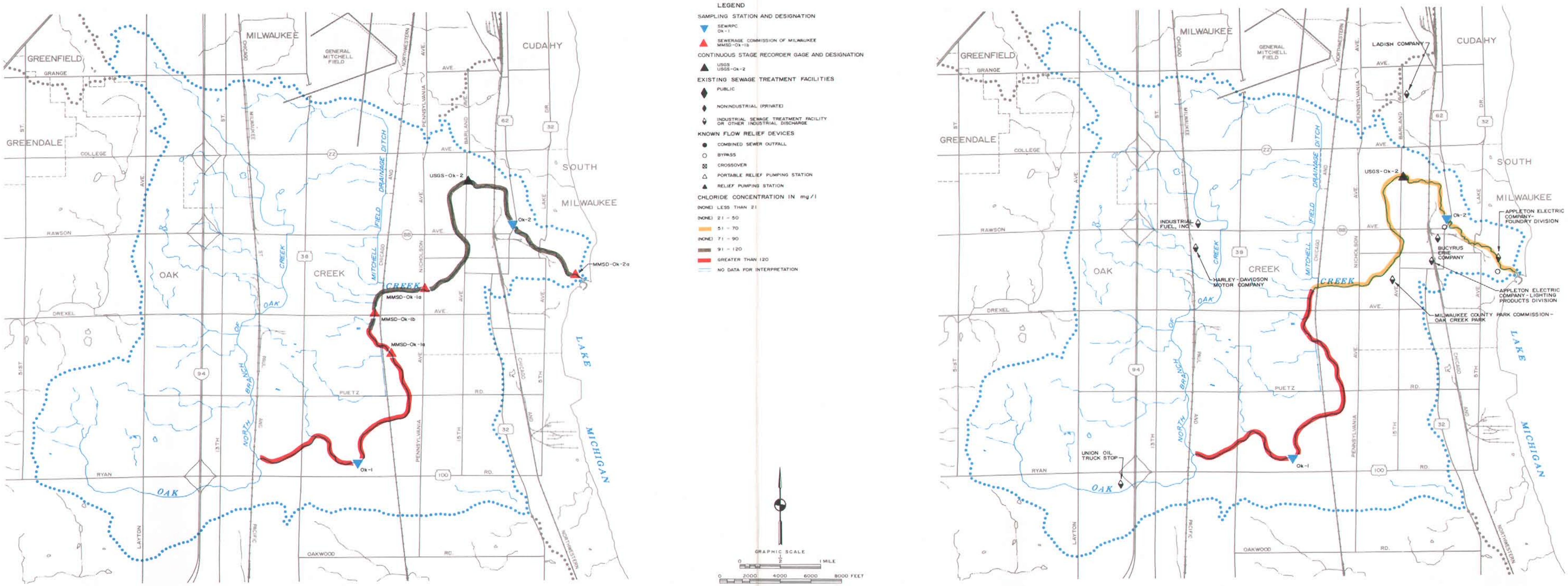
In 1975 fecal coliform levels decreased to an average of 555 and 270 MFFCC/100 ml at sampling stations Ok-1 and Ok-2, respectively. It is difficult, however, to access any trends because of the lack of fecal coliform data for the years prior to 1968 and because of the fluctuations of fecal coliform values as a result of varied precipitation. Milwaukee Metropolitan Sewerage Commission data available for August in the years 1965 and 1966 for sampling stations MMSD-Ok-1a, Ok-1b, and Ok-1c indicate very high counts ranging from 1,200 to 1,900 MFFCC/100 ml in 1965 and lower counts ranging from 400 to 700 MFFCC/100 ml in 1966. Sampling station Ok-2 located in the more urbanized portion of the watershed exhibits a pattern of fecal coliform levels which is more sensitive to the flow rates on the sampling dates than does sampling station Ok-1, which reflects a more rural portion of the watershed.

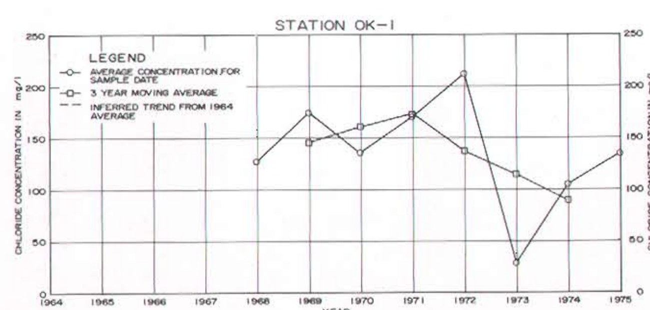
Unlike the other watersheds within the Region, where probable sources of fecal contamination can be identified, the Oak Creek watershed has few probable sources. Only animal feeding operations, of which two are known to exist within the watershed as of 1975, or malfunctioning septic systems, for which numerical data are unavailable, could be the major single type of fecal contamination within this watershed. The two sanitary sewerage system flow relief devices that discharge raw sewage into the streams during times of sewer surcharge may have been the source of high fecal coliform levels during wet weather. In addition, fecal material from pets or other warm blooded animals within the watershed, when washed off during precipitation events, may contribute to the high levels. Generally, however, sampling station Ok-1 shows a gradual decrease in fecal coliform levels

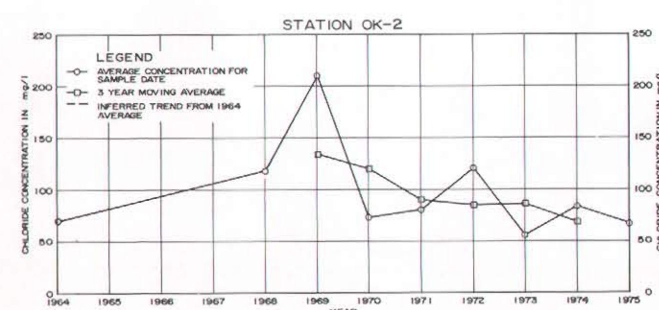
Map 51

COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1975 IN THE OAK CREEK WATERSHED

1968 | 1975







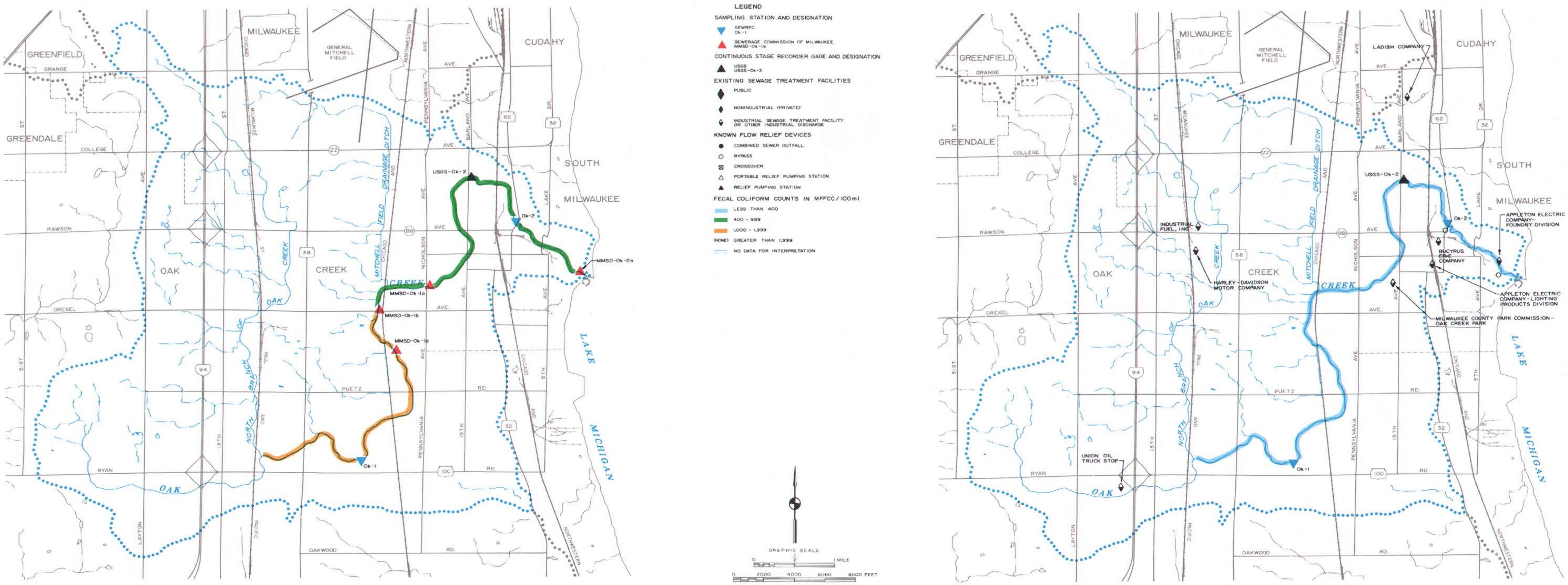
A comparison of the chloride concentrations recorded in 1968 and 1975 indicated that chloride concentrations decreased at sampling station Ok-2 and remained stable at Ok-1. The maximum chloride concentration recorded was 221 mg/l at sampling station Ok-1, while a minimum concentration of 27 mg/l was also recorded at station Ok-1.

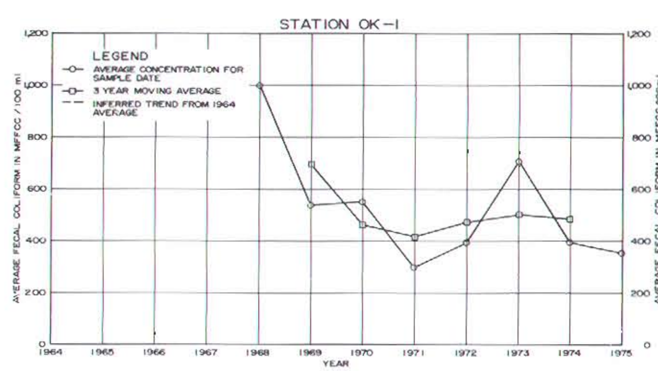
Source: SEWRPC.

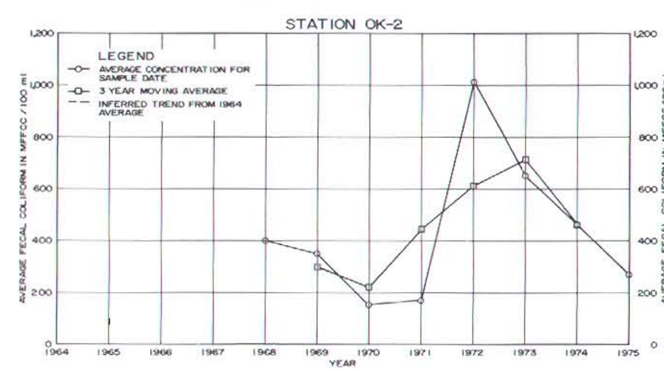
Map 52

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1975 IN THE OAK CREEK WATERSHED

1968 | 1975





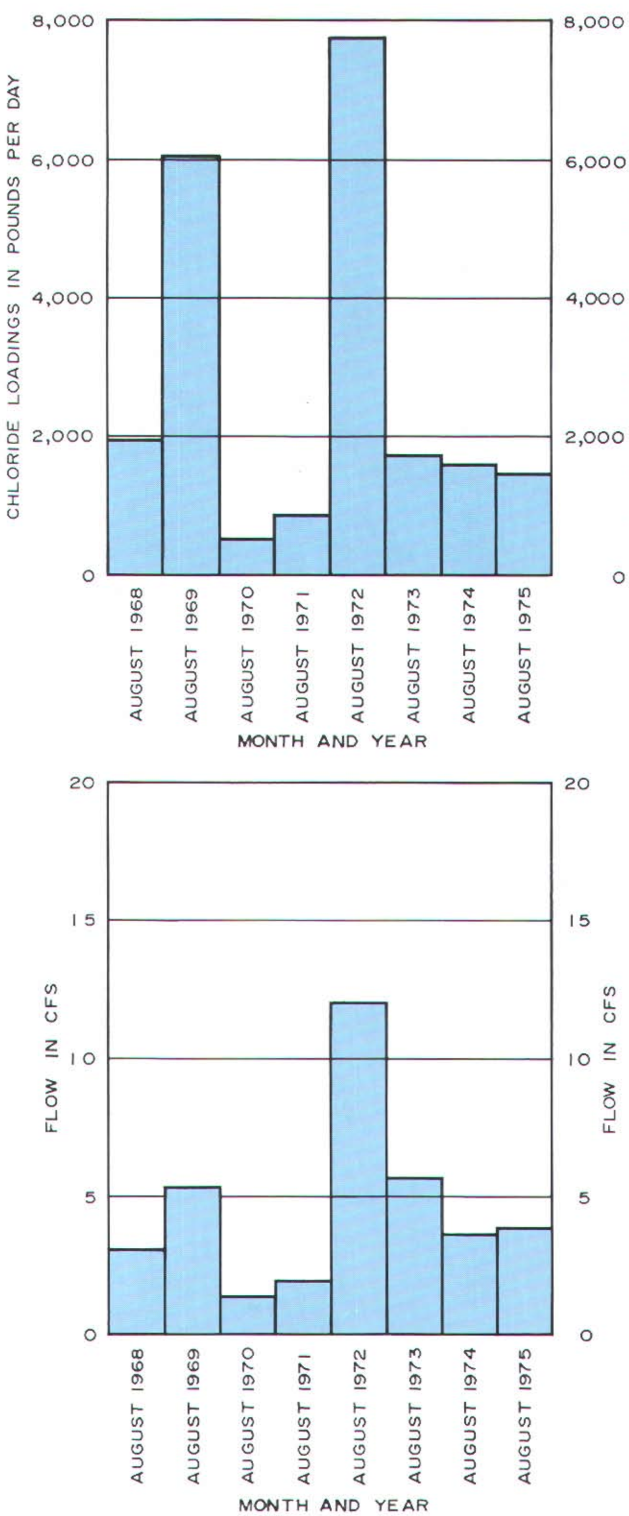


A comparison of fecal coliform counts recorded in 1968 and 1975 indicated that fecal coliform counts decreased for both sampling stations Ok-1 and Ok-2. The maximum fecal coliform count was 1,800 MFFCC/100 ml recorded at station Ok-2, while the minimum fecal coliform count was recorded at station Ok-1 as 70 MFFCC/100 ml.

Source: SEWRPC.

Figure 136

COMPARISON OF CHLORIDE LOADINGS AND FLOW AT OAK CREEK NEAR SOUTH MILWAUKEE (OK-2) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

recorded during August low-flow periods since 1968. Comparing the three-year moving averages with the actual fecal coliform data for sampling station Ok-1, as shown on Map 52, indicates some increased stability in the samples taken since 1970. A review of the data from sampling station Ok-2 indicates the reverse, since the actual values in three-year moving averages are higher for the years since 1971. This may be attributed to the extremely high levels of fecal coliform observed during the August 1972 sampling, which is preceded by a major rainfall event. At both sampling stations, the values from 1968 through 1971 were generally stable, or slightly reduced in direct response to the flow levels in the stream. This may be the most striking result apparent in the data for sampling station Ok-2. The same direct relationship is not reflected at sampling station Ok-1. Generally the data indicate that the overall levels of water quality in the main stem of Oak Creek are somewhat improved—especially at sampling station Ok-1—since 1968, on the basis of fecal coliform levels observed in August 1968 through 1975.

Hydrogen Ion Concentration (pH): As indicated in Table 143, the pH values of the stream system in the Oak Creek watershed have generally been within the range of 6.0 to 9.0 standard units, prescribed for recreational use and maintenance of fish and aquatic life. The pH was observed to be within the 1973 adopted standards for all of the samples taken at both sampling stations Ok-1 and Ok-2. No apparent trend in pH of the samples collected over the 10-year period was observed. Normal ranges for pH of 7.9 to 8.2 standard units were also recorded at sampling stations MMSD-Ok-1a, Ok-1b, and Ok-1c for the years 1965 and 1966.

Specific Conductance: The specific conductance of the stream water was found to be in the range of 544 to 1,720 umhos/cm at 25°C at the two Commission sampling stations on the days of sampling between 1964 and 1975. The highest specific conductance value was found at station Ok-1 on August 11, 1970, and was preceded by four days by a significant rainfall event of sufficient intensity to have carried major amounts of sediment into the water course. The direct relationship between dissolved ion concentrations and antecedent rainfall is supported by the increased values of specific conductance in April, which values were observed to be higher than the August readings in 1968 and 1969. Figure 137 presents the specific conductance values for the two sampling stations on the main stem of Oak Creek. Like the chloride concentrations, the increased concentrations of dissolved ions in the April samples may be attributed to spring runoff and the flushing action which accompanies snowmelt and heavy rainfall. Slightly higher and more persistent values were demonstrated at sampling station Ok-1 which, although affected by runoff from lands which are more rural in nature, is located close to a residential subdivision and close to STH 100 (Ryan Road) which passes 900 feet south of the station and lies within the upstream tributary area. It may reasonably be assumed that street and highway salting operations are responsible for these elevated levels.

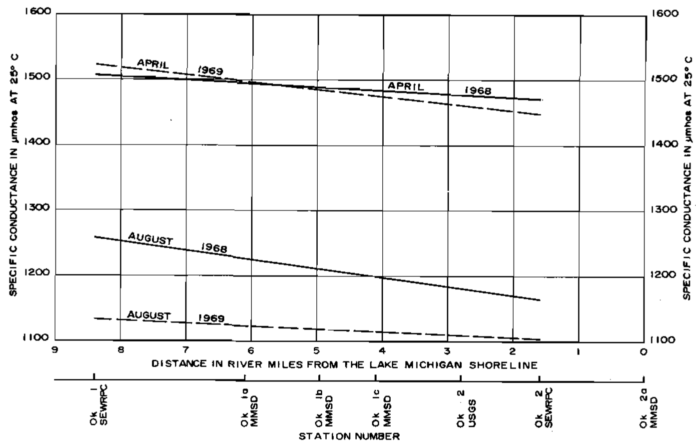
Temperature: As indicated in Table 143, the temperature of the stream water of the watershed has remained below the $89^{o}F$ standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the two Commission sampling stations within the Oak Creek watershed during August 1968 through August 1975 were analyzed for soluble orthophosphate concentrations. A range of 0.01 to 0.38 mg/l of soluble orthophosphate as P was found during eight sampling years at the two stations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus, and a range of 0.02 to 0.23 mg/l as P was found. The ratio of soluble orthophosphate to total phosphorus was found to be approximately 1 to 1; however, at times the ratio was found to range from 0.5 to 1.0. Surface waters with soluble orthophosphate levels equal to total phosphorus levels, as is the case for Oak Creek, are considered to contain excessive amounts of soluble orthophosphate. This high ratio of soluble to total phosphorus in water samples indicates that most of the phosphorus is in the form readily available for the growth of aquatic flora. Although not enough samples were analyzed to characterize the trends in total phosphorus concentrations over time, it is evident from the data that the concentrations are many times higher than required for excessive algal growth. A limit of 0.1 mg/l of total phosphorus as P generally is held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants. Eight of the 16 exhibited total phosphorus levels equal to or higher than 0.10 mg/l.

Figure 138 presents the total phosphorus loadings and flow for sampling station Ok-2 for the August samples from 1972 to 1975. Since the total phosphorus loadings followed the flow pattern—the high flow of 1972 increased total phosphorus loading into the river system by a disproportionally high amount—and the four years of data are so few, no attempt was made to characterize a trend in phosphorus loadings. The soluble orthophosphate data which are also available for the years 1968 through 1975 generally showed increased loadings with increased flow as shown in Figure 139. There were two exceptions, however, one in 1969 and one in 1971. There is no supportable explanation for these two anomalies. The phosphorus data along with the earlier cited chloride data are indicative of the presence of several sources of pollution from both point and diffuse sources within the watershed. The increase in phosphorus with the increase in flow in the rural areas may indicate that part of the phosphorus loading is due to agricultural runoff. Conversely, in the urban areas, a combination of point source contamination from sanitary sewerage system flow relief devices, industrial wastewater discharges, and storm water discharges all may contribute significantly to the phosphorus loadings of the surface waters of the Oak Creek watershed.

Figure 137

SPECIFIC CONDUCTANCE IN THE OAK CREEK WATERSHED APRIL AND AUGUST 1968 AND 1969



Source: SEWRPC.

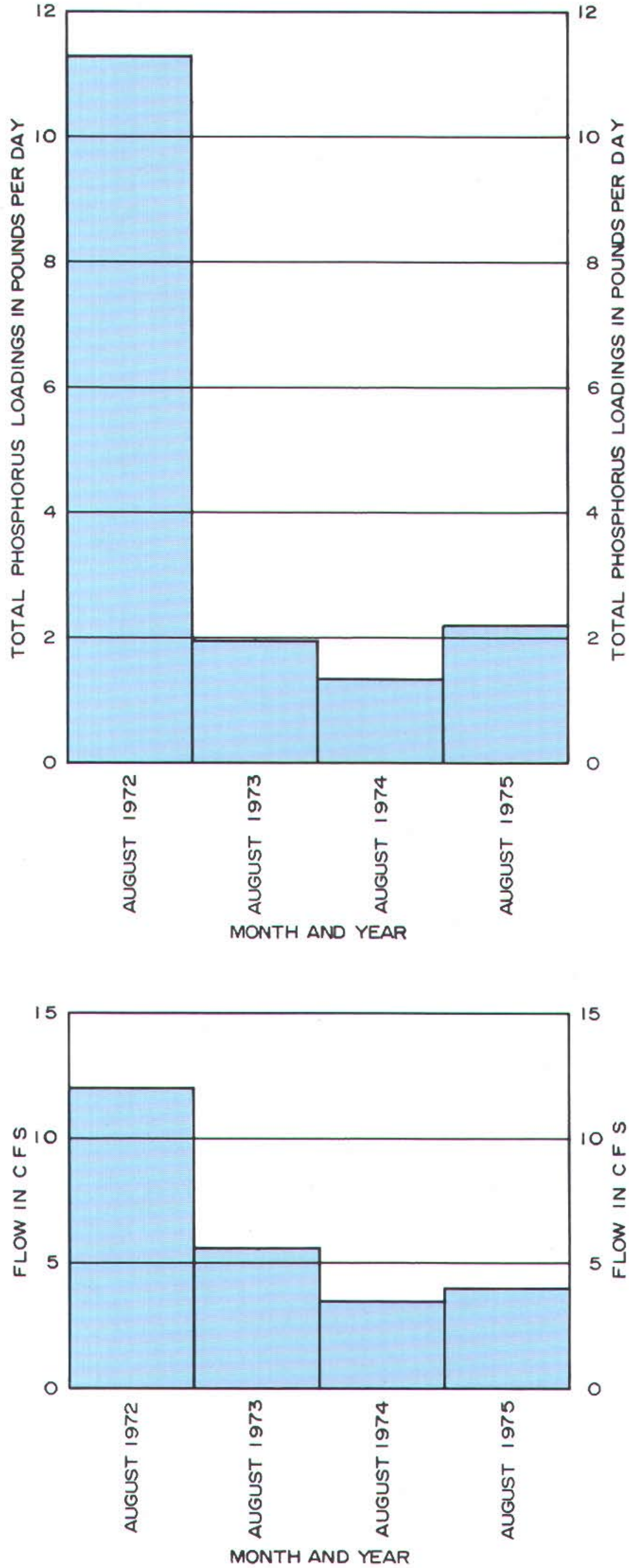
Nitrogen: The total nitrogen concentrations in the water samples collected during August 1972 through 1975 were found to be in the range of from 0.29 to 3.46 mg/l as N. Of this total, 0.6 to 2.8 percent was found to be in the form of nitrite-nitrogen, 7.8 to 10 percent as ammonia-nitrogen, 60 to 51 percent as nitrate-nitrogen, and 38 to 62 percent as organic-nitrogen. The concentrations of ammonia-nitrogen at the sampling stations ranged from 0.03 to 0.44 mg/l as N well below the known toxic level of 2.5 mg/l for ammonia nitrogen as N. On eight of the 16 sampling dates, ammonia-nitrogen did exceed 0.2 mg/l as N, the level generally held to be indicative of lakes and streams which are affected by pollution. The highest concentrations were found at sampling station Ok-1 in 1974 and 1975. These elevated levels may be attributed to the effects of agricultural cropping operations.

Nitrate-nitrogen concentrations in the Oak Creek watershed were found to range from 0.04 to 2.1 mg/l as N. The major source of nitrate-nitrogen in the Oak Creek watershed is likely to be from agriculturally related operations.

Organic-nitrogen was present in the Oak Creek watershed in the range of 0.18 to 1.32 mg/l on the sampling days in 1972 through 1975. Organic-nitrogen levels have remained high over the last four years with 75 percent of the values ranging upward from 0.50 mg/l. Figure 140 presents the total nitrogen loadings and flows for sampling station Ok-2 for August 1972 through 1975. Generally, the total nitrogen loadings increased with flow. The four years of data are insufficient for identifying a trend in the total nitrogen loading of Oak Creek. The nitrogen data, however, when considered along with the chloride and total phosphorus data, do indicate that significant sources of pollution exist within the watershed and are probably diffuse in nature.

Figure 138

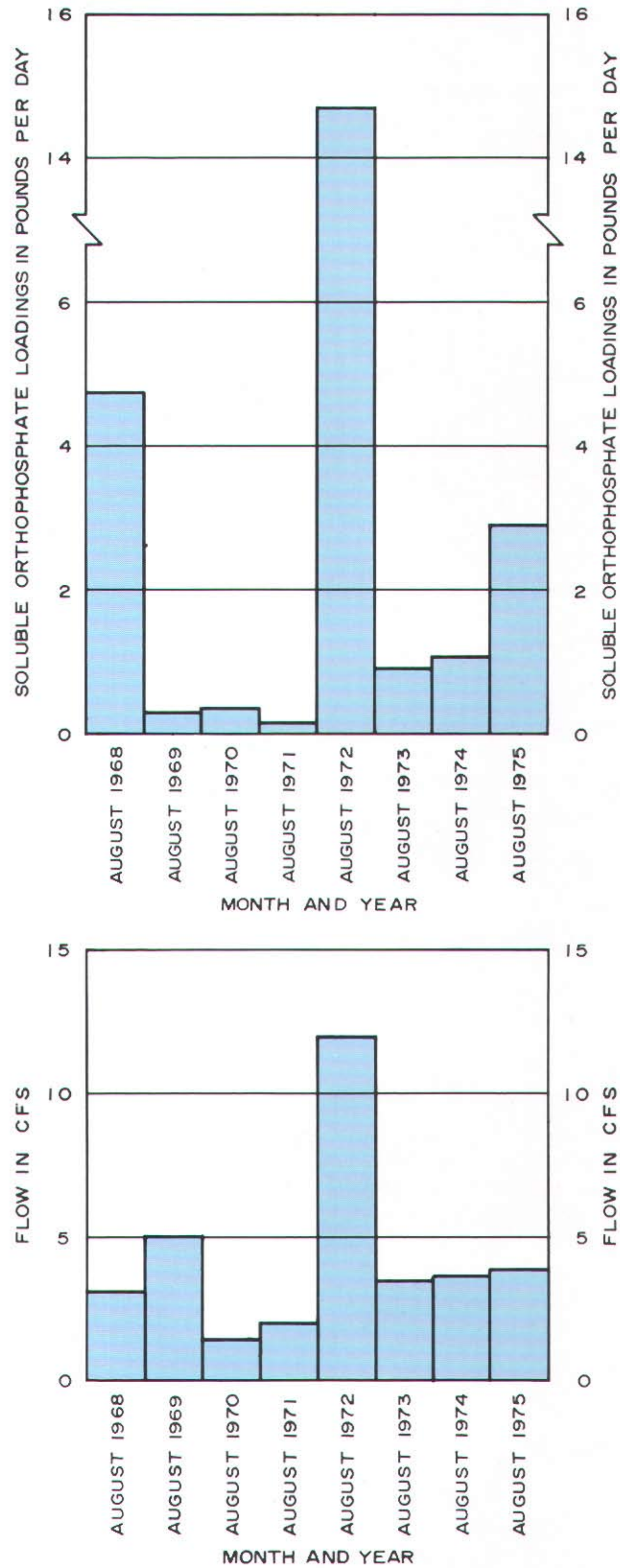
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT OAK CREEK NEAR SOUTH MILWAUKEE (OK-2) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 139

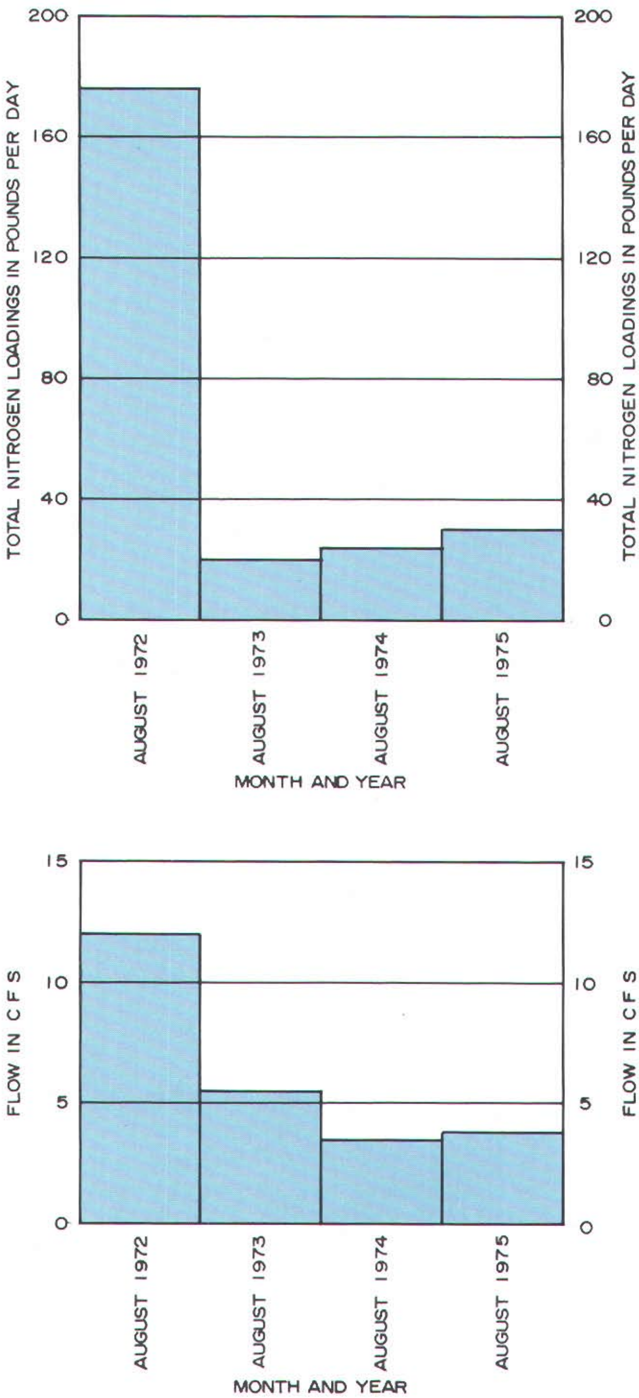
COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW AT OAK CREEK NEAR SOUTH MILWAUKEE (OK-2) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

Figure 140

COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT OAK CREEK NEAR SOUTH MILWAUKEE (OK-2) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Biochemical Oxygen Demand: The Commission water quality monitoring program did not include the measurement of biochemical oxygen demand for the years 1965 through 1975. No other biochemical oxygen demand data are available from the other sources to study the trend in the biochemical oxygen demands over the past decade in the Oak Creek watershed.

Diurnal Water Quality Changes: Figures 141-144 illustrate the diurnal changes in temperature, chloride, dissolved oxygen, and pH that were observed during low-flow conditions on August 9, 1971, at the Commission Oak Creek sampling stations. The rate of flow on August 9, 1976, was 1.9 cfs, which was about two times the seven day-10 year low-flow of 0.9 cfs. Water temperatures were found to range from a low of 70°F to 76°F at the two Oak Creek stations. Chloride concentrations at sampling station Ok-1 were found to range from a high of 188 mg/l during the late evening hours to a low of about 150 mg/l during midday. Lower readings, consistently near 85 mg/l, persisted at sampling station Ok-2 on August 9, 1976. Headwater stations usually exhibit low concentrations of chloride in approximating background levels. This was not the case at sampling station Ok-1, which, although slightly downstream from the headwater area, is greatly influenced by the location of STH 100 (Ryan Road).

The concentration of dissolved oxygen at sampling station Ok-2 was found to vary from a low of 5.7 mg/l during the early morning hours to a high of 8.6 mg/l in the midafternoon hours.

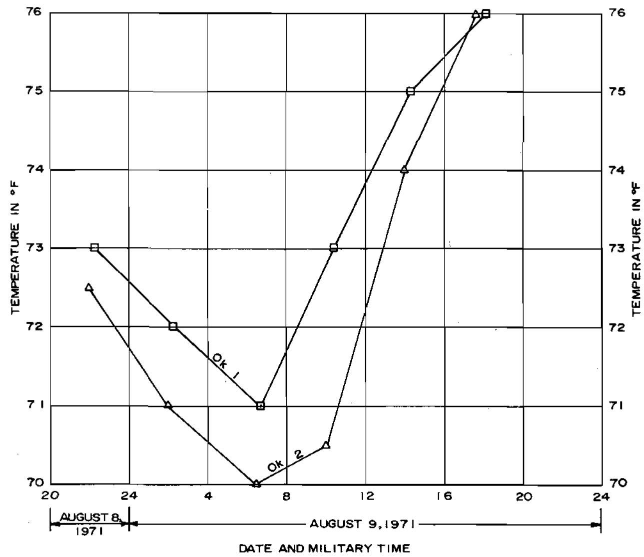
Hydrogen ion concentration (pH) was found to vary from a low of 7.9 standard units in the early morning hours to 8.1 standard units later in the day at both sampling stations. The uptake of carbon dioxide for photosynthesis by the aquatic plants accounts for the higher pH values in the late evening samples; and a lower pH during the early morning hours can be accounted for by the release of carbon dioxide during respiration by algae and aquatic plants.

A practical consequence of diurnal water quality fluctuations is that, although the average level of concentrations of critical parameters may meet the adopted water quality standards for recreational use and for the preservation of fish and aquatic life, the lower levels during the daily cycles may not meet the minimum standards. An example of this occurred on August 25, 1975, at sampling station Ok-1 when the early morning dissolved oxygen readings at 1:20 a.m. and 5:20 a.m. were 1.5 and 2.5 mg/l, respectively. Dissolved oxygen concentrations recorded later in the day at 12:30 p.m. and 4:30 p.m. were 5.6 and 6.1 mg/l, respectively.

Spatial Water Quality Changes: Figure 145, which presents the spatial variation in dissolved oxygen levels in Oak Creek, indicates essentially no change from sampling stations Ok-1 and Ok-2, from 1964 through 1975. Stable conditions also exist for total phosphorus and total nitrogen as exhibited in Figures 146 and 147 for low-flow

Figure 141

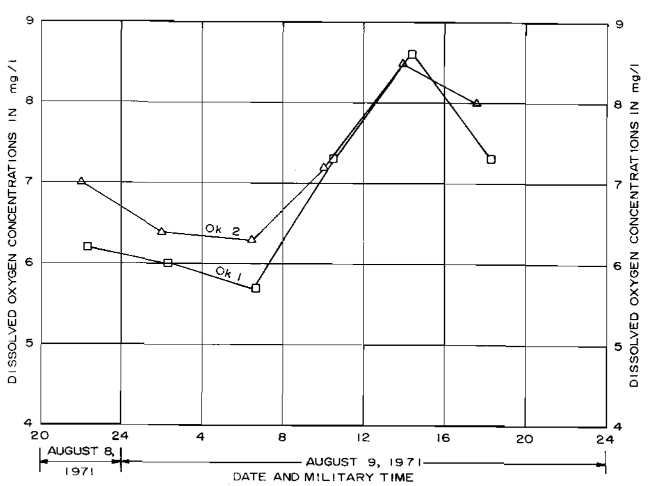
DIURNAL VARIATIONS IN TEMPERATURE RECORDED AT SAMPLING STATIONS OK-1 AND OK-2 IN THE OAK CREEK WATERSHED: AUGUST 9, 1971



Source: SEWRPC.

Figure 142

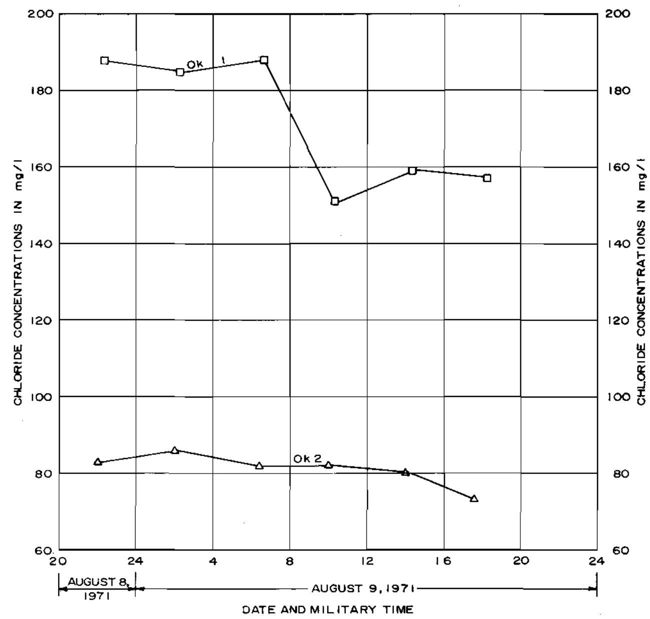
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATIONS OK-1 AND OK-2 IN THE OAK CREEK WATERSHED: AUGUST 9, 1971



Source: SEWRPC.

Figure 143

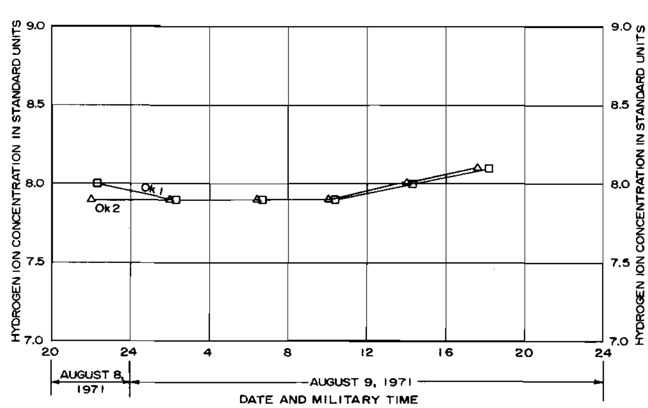
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS OK-1 AND OK-2 IN THE OAK CREEK WATERSHED: AUGUST 9, 1971



Source: SEWRPC.

Figure 144

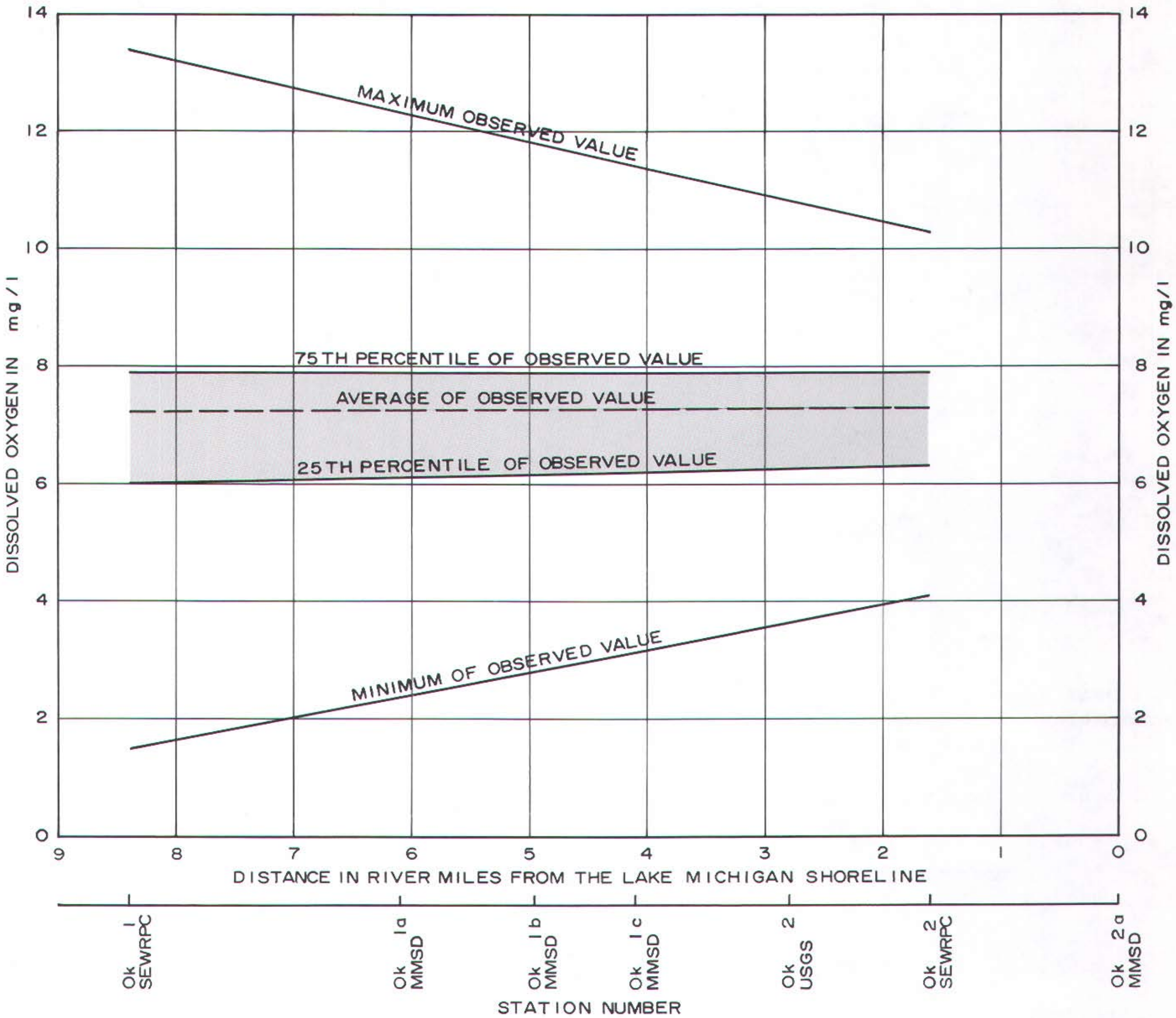
DIURNAL VARIATIONS IN HYDROGEN ION (pH) CONCENTRATIONS AT SAMPLING STATIONS OK-1 AND OK-2 IN THE OAK CREEK WATERSHED: APRIL 9, 1971



Source: SEWRPC.

Figure 145

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE OAK CREEK WATERSHED: 1964-1975



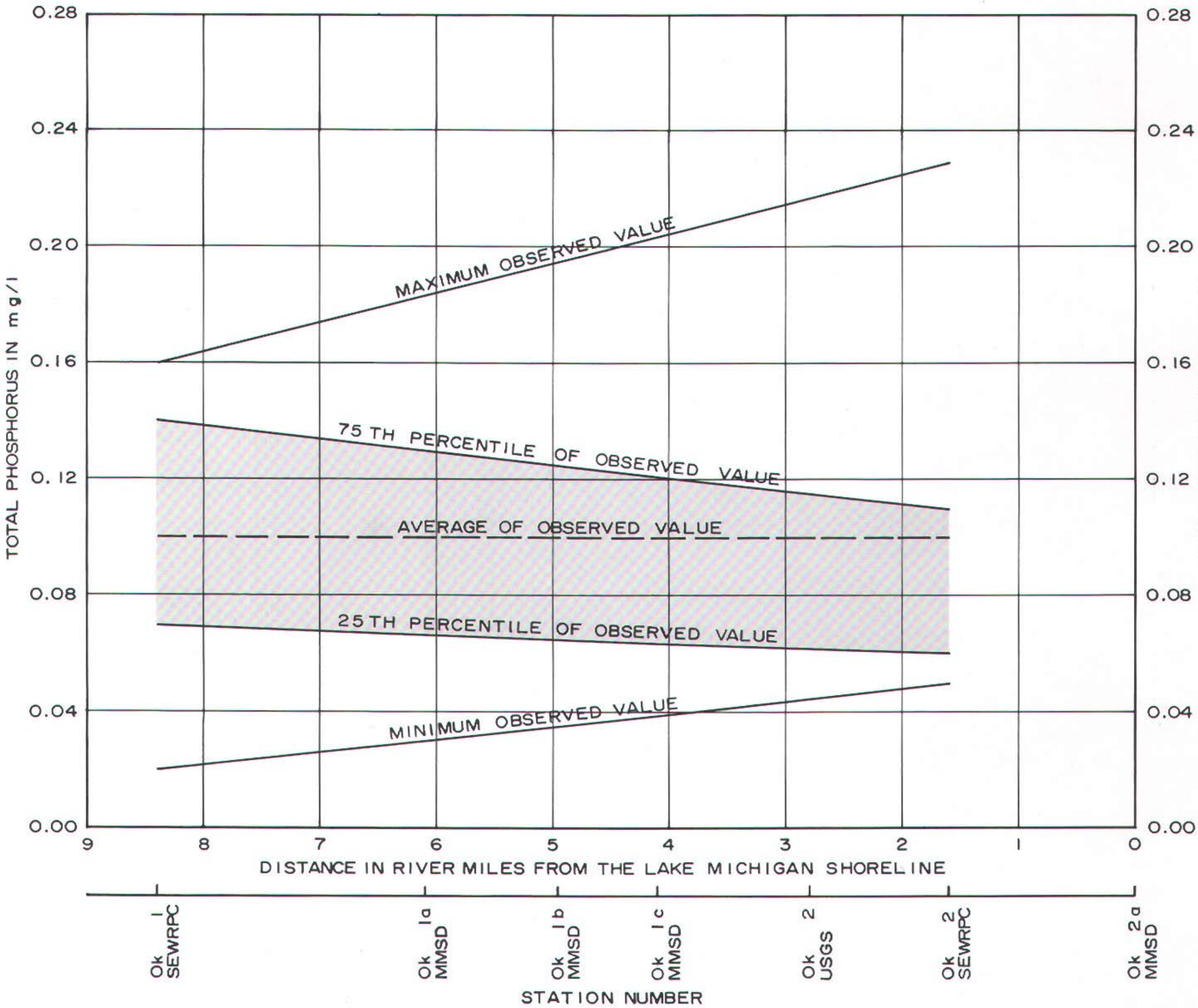
Source: SEWRPC.

hydrologic conditions in August 1972 through 1975. These near stable conditions are indicative of similar levels of pollution upstream from both sampling stations. This stability does not, however, indicate identical pollution sources. The rural areas upstream from sampling station Ok-1 contribute organic material and nutrients through runoff from agricultural operations and domestic onsite sewage disposal systems. The urban areas upstream from sampling station Ok-2 contribute organic material and nutrients in runoff from streets and highways, parking lots, lawns, golf courses, parks, and construction sites. Figures 148 and 149 illustrate a decrease in chloride concentrations and specific conductance from sampling station Ok-1 to Ok-2 during the 11-year sampling period. The higher readings recorded for sampling stations Ok-1 may be expected, considering the location of Ok-1 with respect to STH 100 (Ryan Road).

The data for fecal coliform, as shown in Figure 150, for sampling years 1968 through 1975, indicate a slight increase from sampling stations Ok-1 and Ok-2. This increase can be expected and reflects the greater potential for fecal coliform contamination from washoff in the urbanized areas, adversely affecting the level of pollution during wet weather.

Figure 146

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE OAK CREEK WATERSHED: 1972-1975



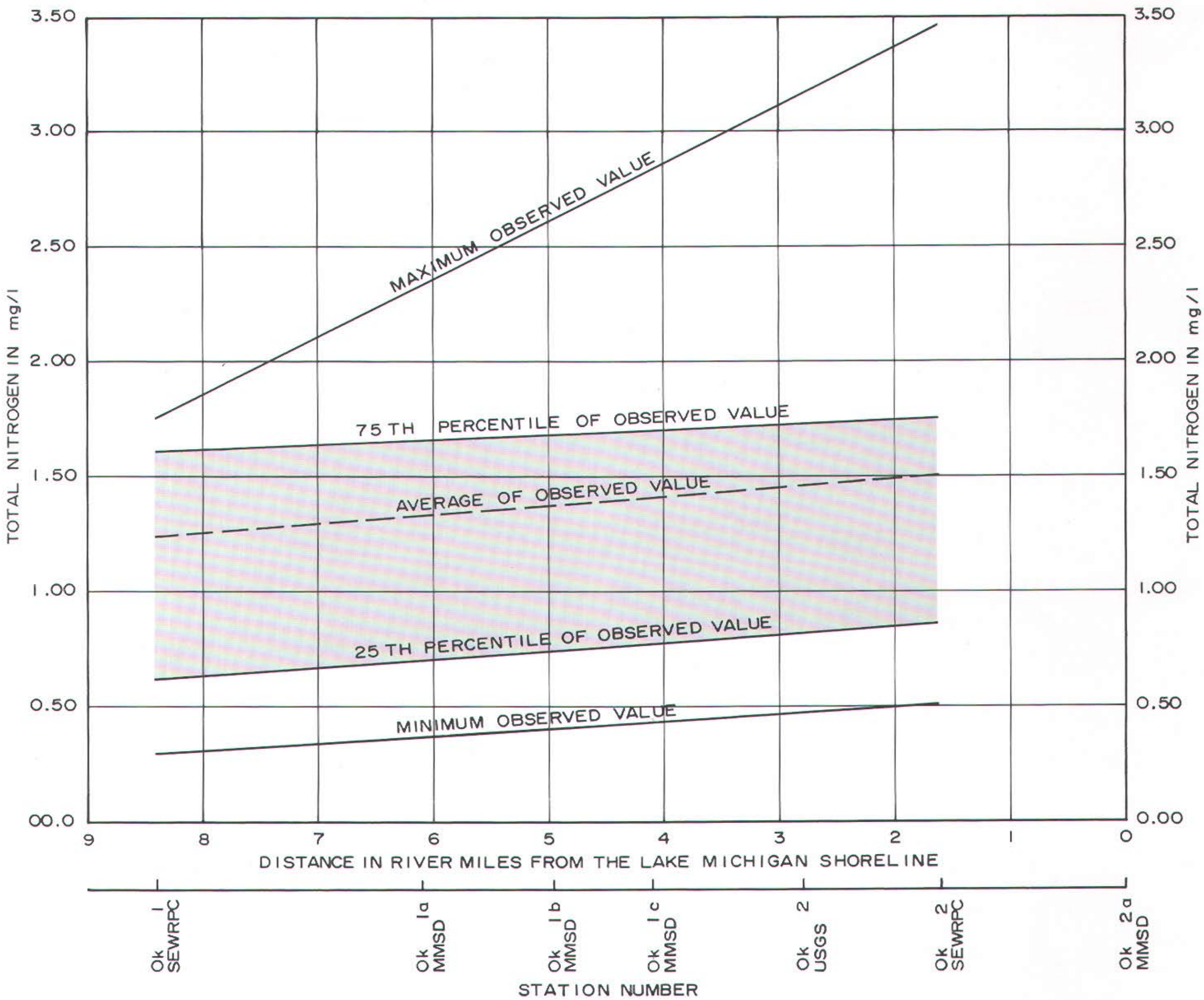
Source: SEWRPC.

Assessment of Water Quality and Comparison with Adopted and Recommended Water Quality Standards: The data obtained from the August low-flow samples between 1964 and 1975 were used to assess the quality of the Oak Creek stream network. These data provide for an assessment of water quality as it existed on the days sampled between 1964 and 1975, and allows for an evaluation of the water quality trends compared to the water quality standards that support the adopted objectives for recreational use and the preservation of fish and aquatic life in the Oak Creek watershed. Comparative analysis must consider hydrologic conditions during the sampling events, since the water quality standards are not intended to be met under the seven-day average, 10-year recurrence interval low-flow conditions.

The comparative analysis of observed water quality and the adopted standards and recommended levels were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels

Figure 147

SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE OAK CREEK WATERSHED: 1972-1975

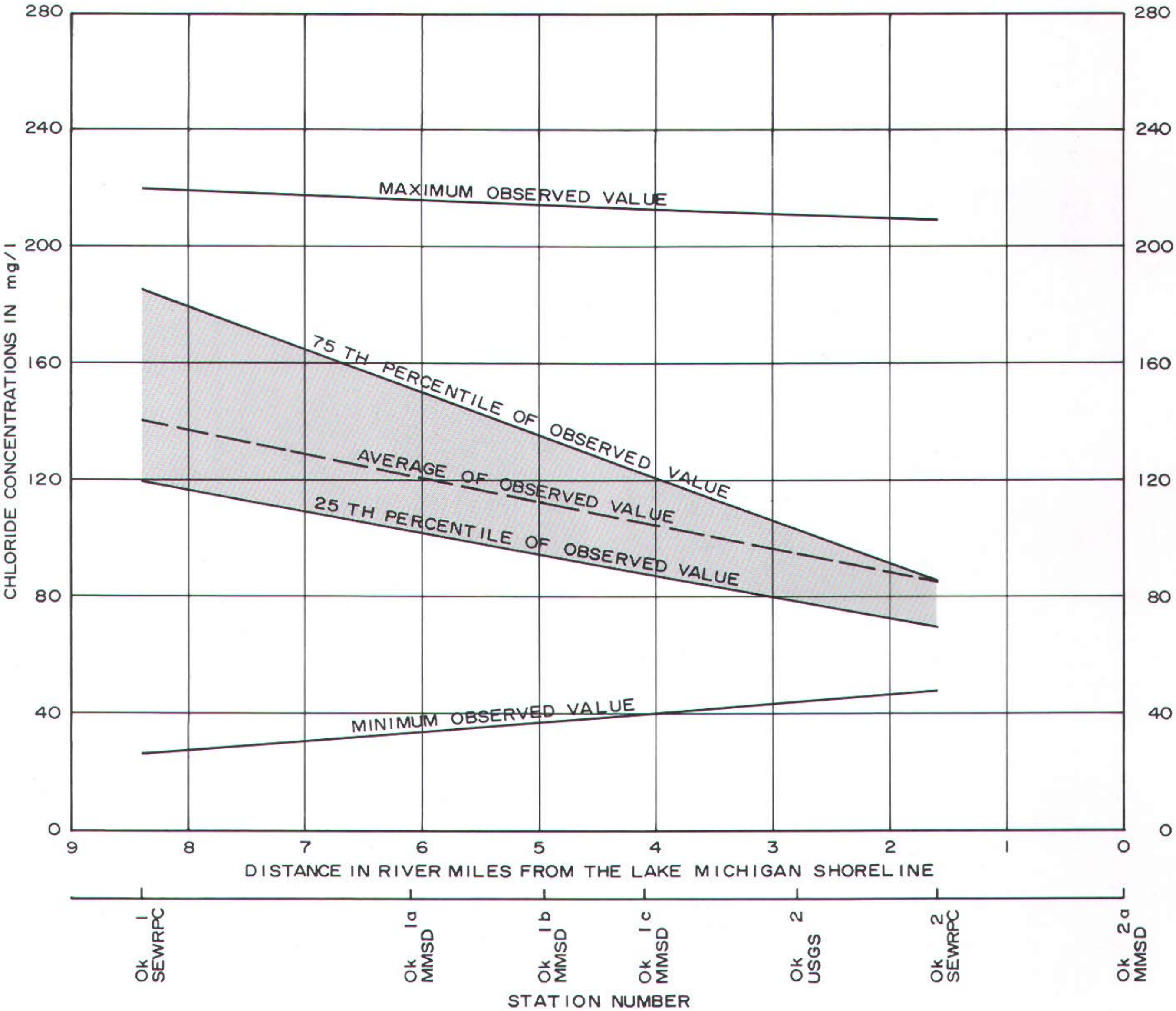


Source: SEWRPC.

which have been adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits depending upon the parameter. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml based on not less than five samples per month, nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standard for the recreational use objective was assumed to be violated during a par-

Figure 148

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE OAK CREEK WATERSHED: 1964-1975



Source: SEWRPC.

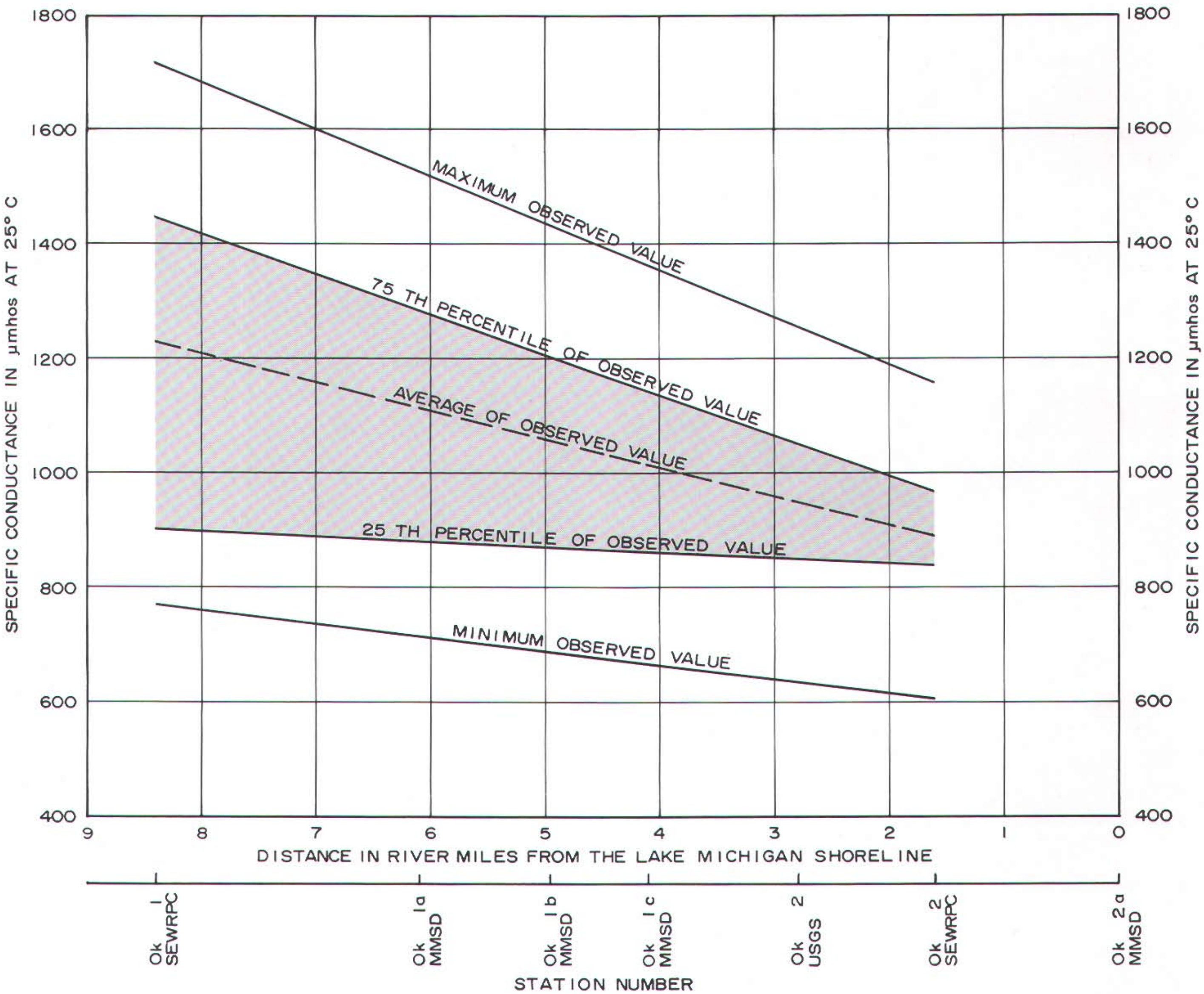
ticular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 53. A color coding scheme is used to indicate which of the standards are exceeded and along what stream reaches.

Water quality in Oak Creek intended for recreational use and preservation of fish and aquatic life satisfied the temperature, pH, and dissolved oxygen standards during the benchmark survey period. Since no fecal coliform counts, nitrate-nitrogen, ammonia-nitrogen, or total phosphorus analyses were made in 1964 samples, no comparison to the nutrient content and bacteriological safety of Oak Creek can be made for 1964. However, since the total coliform counts in Oak Creek were high, in the range of 3,800 to 4,000 MFCC/100 ml, the fecal

Figure 149

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE OAK CREEK WATERSHED: 1964-1975



Source: SEWRPC.

coliform counts probably would have been higher than the permissible limit.

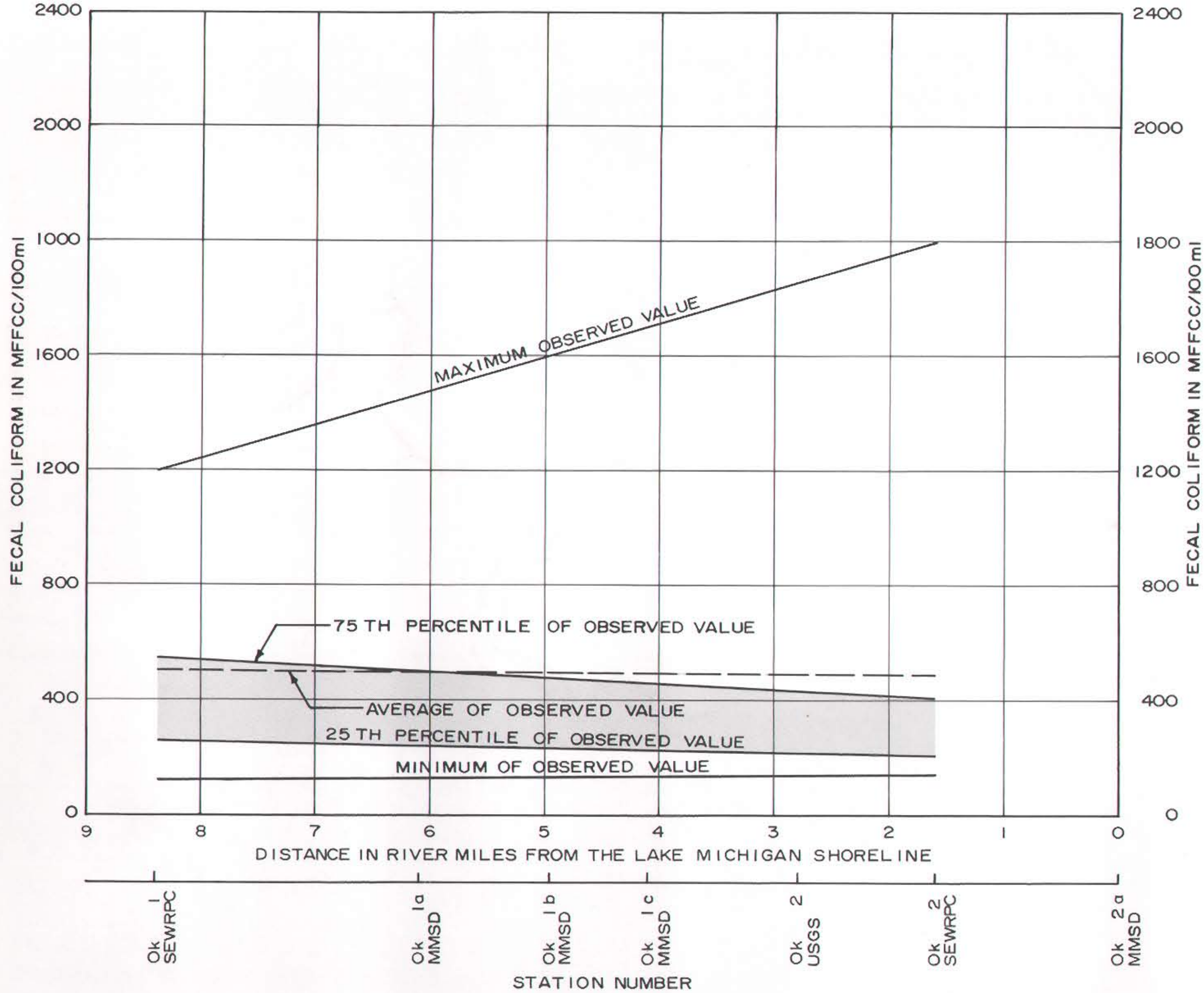
Water Quality-1975: As shown on Map 54, the water quality of Oak Creek, observed during the 1975 survey, satisfied the temperature, ammonia-nitrogen, and pH standards throughout the watershed, while substandard levels of dissolved oxygen, fecal coliform, nitrate-nitrogen, and total phosphorus were recorded. Substandard dissolved oxygen concentrations of less than 5.0 mg/l were exhibited at sampling station Ok-1 in the more rural area of the Oak Creek watershed, and the fecal coliform standard of 400 membrane filter fecal coliform counts per 100 milliters was exceeded at sampling station Ok-1. Nitrate-nitrogen in excess of 0.30 mg/l as N was found in all samples from Oak Creek and may be attributed to urban and agricultural runoff, as may the total phosphorus levels in excess of 0.1 mg/l, since there are no significant point sources of pollution in the watershed.

Concluding Remarks—Oak Creek Watershed

The Oak Creek watershed is located in the east central portion of the Region. The main stem of Oak Creek rises and flows easterly and northerly within Milwaukee

Figure 150

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE OAK CREEK WATERSHED: 1968-1975



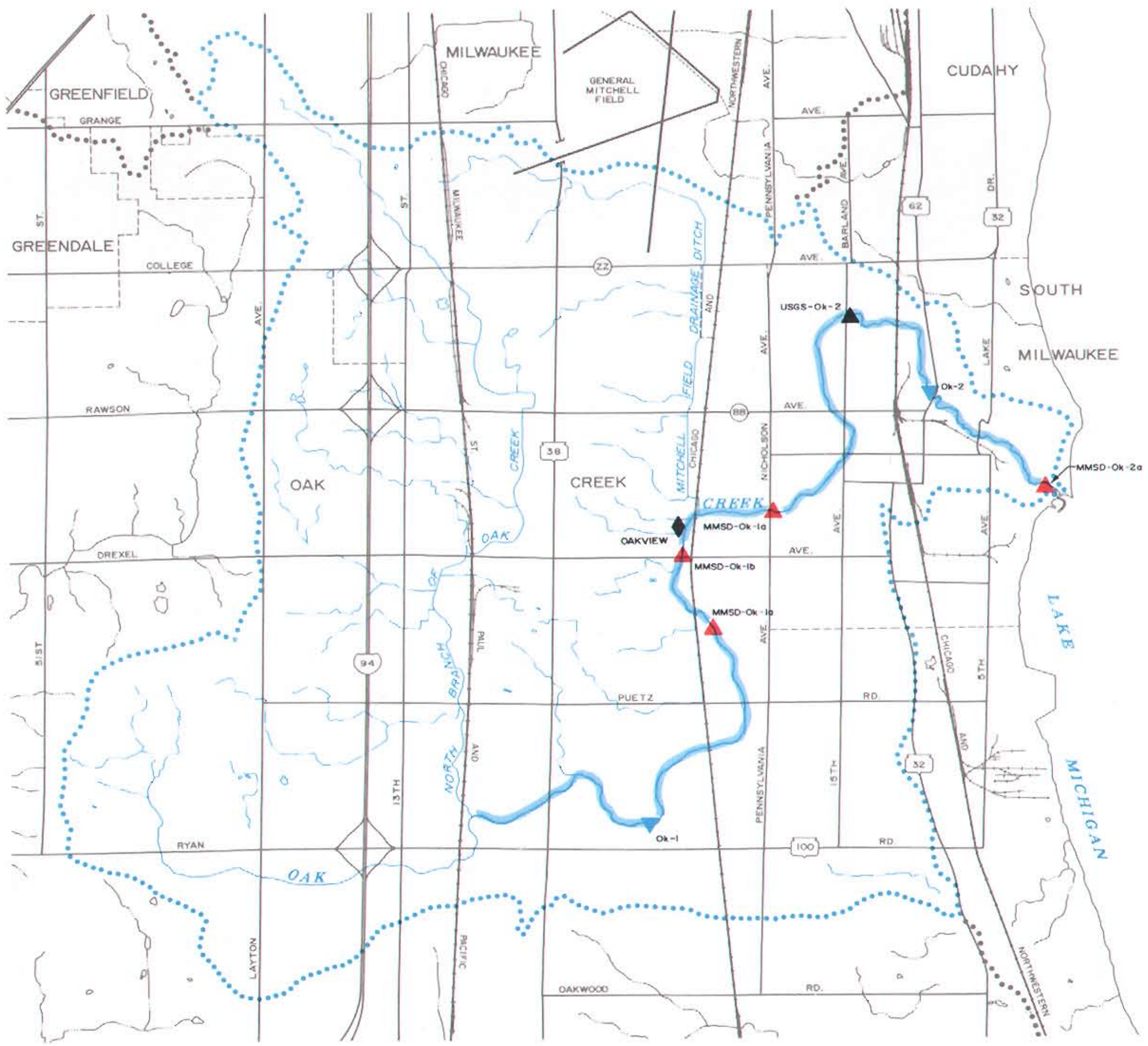
Source: SEWRPC.

County for approximately 13 miles before emptying into Lake Michigan on the eastern border of the watershed. The Oak Creek watershed ranks eighth in population and tenth in areal size among the 12 watersheds in the Region. In 1975, an estimated 39,519 persons resided within this watershed which then had a total area of 26.7 square miles and an average population density of 1,480 people per square mile.

There are currently no known public or nonindustrial privately operated sewage treatment plants operating within the watershed that discharge treated wastes to the surface water system. There are two known sanitary sewer flow relief devices that discharge raw sewage into the streams during times of sewer surcharge. These were eliminated during 1974 and 1975. A total of 13 industrial and commercial waste discharge points from eight industries are known to exist in the watershed. Of these wastewater discharge points, six discharge cooling waters, three process wastewaters, two cooling and process wastewaters, one swimming pool overflow, and one surface runoff. The Commission 1970 land use inventory indicates that 53 percent of the watershed is devoted to agricultural use, 44 percent to urban use, and the remaining 3 percent is occupied by streams, wetlands, and woodlands.

Map 53

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE OAK CREEK WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

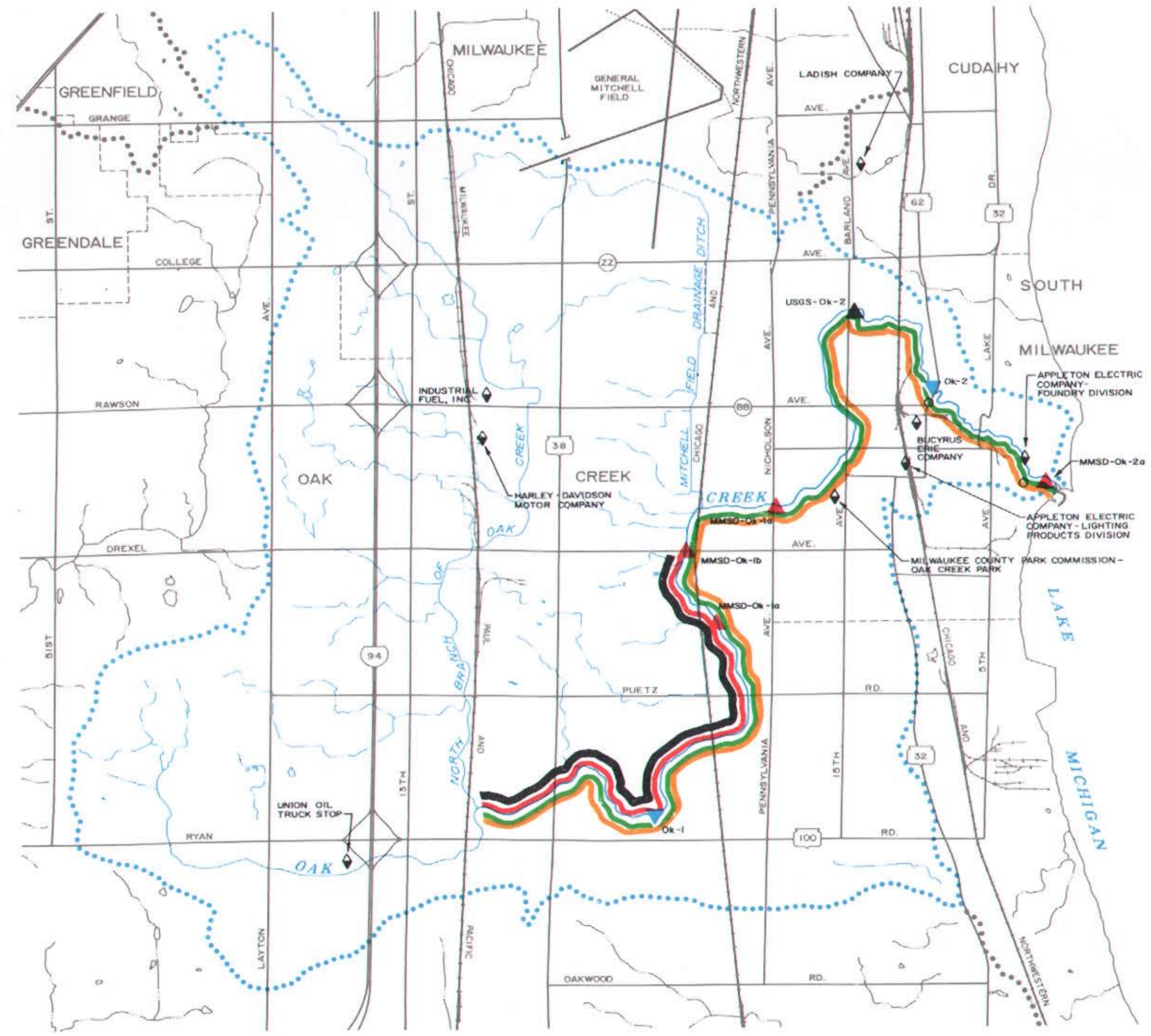


A comparison of the stream water quality in the Oak Creek watershed as sampled in August 1964 to the adopted water quality standards indicated that all standards were satisfied for both sampling stations Ok-1 and Ok-2.

Source: SEWRPC.

Map 54

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE OAK CREEK WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Oak Creek watershed as sampled in August 1975 to the adopted water quality standards indicated that the fecal coliform and dissolved oxygen standards and the recommended levels for total phosphorus and nitrate nitrogen were not met at sampling station Ok-1. The total phosphorus and nitrate-nitrogen levels also were exceeded at station Ok-2, although the dissolved oxygen standard was satisfied on that particular date of sampling despite a general decline in the parameter over the study period.

Source: SEWRPC.

The 1964-1965 benchmark stream water quality study of the Commission included two sampling stations in the watershed, both on the Oak Creek main stream. The water quality data for 1964-1965 from the two sampling stations indicated that the chloride levels were higher than background levels, reflecting a probable chloride impact upon the stream from winter salting operations, urban storm runoff, domestic onsite sewage disposal systems, sewer overflows, and animal feeding operations. High concentrations of dissolved oxygen were noted at both stations during the 1964 summer low-flow sampling period. The specific conductance values were found to be moderately high in August 1964 at both sampling stations.

The 1968-1975 water quality monitoring effort by the Commission included continued sampling at the two stations established in the watershed. Lower dissolved oxygen levels were observed in 1975 than in all of the prior sampling years, indicating that the water quality conditions had declined during the sampling period. Review of the fecal coliform data indicates a general decline in water quality at sampling station Ok-2 and a general improvement at sampling station Ok-1 over the past eight years. This may be attributable to higher flows and possible sanitary sewage bypassing in the later years of sampling at station Ok-2 and to declining livestock numbers within the watershed over the sampling years at sampling station Ok-1. The elimination of three sanitary sewage flow relief devices may, however, be reflected in the lower fecal coliform values observed in 1975 compared to those of 1974 at sampling station Ok-2. Chloride concentrations demonstrated a slight decrease over the time period, which may be attributable to a more careful management of winter street and highway deicing operations. As measured by nitrate-nitrogen and total phosphorus, the nutrient concentrations remained in excess of the recommended water quality levels of 0.30 mg/l of nitrate as N, and 0.1 mg/l of total phosphorus as P in 61 percent of the nitrate samples and all of the phosphorus samples taken over the eight sample years.

The diurnal water quality data for Oak Creek show a broad range of dissolved oxygen concentrations from a low of 4.2 mg/l to a high of 13.1 mg/l, reflecting the dissolved oxygen reductions due to respiration by the aquatic plants and decomposition of organic matter in the stream, and dissolved oxygen supersaturation effects of photosynthesis by algae and other aquatic plants.

In addition to exhibiting marked diurnal fluctuations, water quality in the Oak Creek watershed exhibits spatial variation. The water quality was generally of a higher quality at the downstream sampling station, Ok-2, than at the upstream station, Ok-1, as measured by fecal coliform, dissolved oxygen, chloride, and specific conductance.

Overall water quality conditions of Oak Creek have been slightly degraded since 1968, as indicated by decline in the average dissolved oxygen concentrations from 13.4 mg/l to 3.9 mg/l at sampling station Ok-1 and from 10.3 mg/l to 6.1 mg/l at sampling station Ok-2 in the years 1964 and 1975, respectively. When comparing the entire spectrum of the 10 years of water quality data to the adopted standards proposed by the Wisconsin Department of Natural Resources, dissolved oxygen concentrations and fecal coliform counts are found not to meet the minimum standards for recreational use and the preservation of fish and aquatic life. In addition, the plant nutrients, total phosphorus, and nitrate-nitrogen levels were consistently found to be significantly higher than the recommended levels adopted by the Commission.

In general, however, the water quality levels observed at the two Commission sampling stations and at the sampling sites of other agencies do not reflect any direct improvements as a result of control measures applied to point sources of pollution in the watershed. Rather, the water quality observations reflect pollutant levels which apparently are influenced by the general weather patterns of the sampling periods in this watershed which has been continually subject to an increased degree of urban development during the entire period of the Commission's sampling effort and probably by land washoff mechanisms associated therewith.

PIKE RIVER WATERSHED

Regional Setting

The Pike River watershed is a natural surface water drainage unit, 50.66 square miles in areal extent, located in the southeastern portion of the Region. The boundaries of the basin, together with the locations of the main channels of the Pike River and its principal tributaries, are shown on Map 55. The watershed lies in the southeastern part of Racine County and northeastern part of Kenosha County. The Pike River rises in southeastern Racine County two miles north of the Village of Sturtevant and flows easterly and southerly through the northern part of the City of Kenosha to Lake Michigan. Pike Creek, a major tributary to the Pike River, rises in east central Kenosha County about one mile east of the Kenosha Airport and flows northerly to join the Pike River in the northwestern corner of Petrifying Springs Park at a point 7.2 miles downstream from the source of the Pike River.

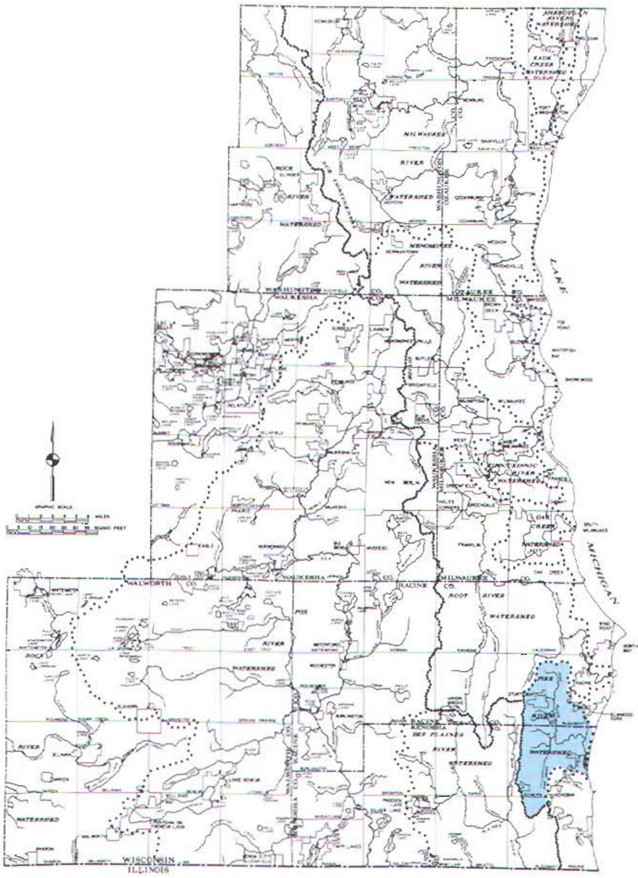
The stream system which drains the watershed consists of the Pike River, Pike Creek, Somers Branch, School tributary, Sturtevant tributary, and Waxdale Creek. Table 144 lists each stream reach, the location, the source, and the length of each stream reach in miles for the Pike River watershed. The watershed, which is wholly contained within the Region, is the ninth largest in population and eighth in size of the 12 watersheds of the Region. It comprises 1.9 percent of the total land and water area of the Region.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries is a rectilinear pattern of local political boundaries, as shown on Map 55. The watershed lies in two counties—Kenosha and Racine; in two cities—

Map 55

LOCATION OF THE PIKE RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Pike River watershed has a total area of 51 square miles and comprises about 1.9 percent of the total 2,689-square-mile area of the Region. The watershed ranks ninth in population and eighth in size as compared to the 12 watersheds of the Region.

Source: SEWRPC.

Racine and Kenosha; in one village—Sturtevant; and in three towns—Mt. Pleasant, Pleasant Prairie, and Somers. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 145.

Population

Population Size: The 1975 resident population of the watershed is estimated at 27,800 persons, or about 8 percent of the total estimated resident population of the Region of 1,789,871. Table 146 presents the population distribution in the Pike River watershed by civil division. The population of the watershed has increased steadily since 1900.

Population Distribution: Presently, about 20 percent of the residents of the watershed live in the City of Kenosha which occupies 3 percent of the total area of the watershed, and 16 percent of the residents of the watershed live in the Village of Sturtevant which also occupies 3 percent of the total area of the watershed. The lower reaches of the Pike River watershed are highly urbanized but the watershed is predominantly rural elsewhere.

Quantity of Surface Water

Surface water in the Pike River watershed is made up almost entirely of streamflow. A few minor ponds, wetlands, and flooded gravel pits comprise the balance, but are negligible in terms of total water quantity. The quantity of streamflow varies widely from season to season and from year to year, responding to variations in precipitation, temperature, soil moisture conditions, agricultural operations, the growth cycle of vegetation, and groundwater levels. Until 1971 there was no recording gage in the Pike River watershed. Streamflows were, however, measured from 1972 by the U. S. Geological Survey in conjunction with the Commission on the Pike River near Racine at a continuous flow gaging station. Streamflow characteristics for the published period of record for the Pike River near Racine are summarized in Table 147. High streamflows occur principally in the late winter and early spring, usually associated

Table 144

STREAMS IN THE PIKE RIVER WATERSHED

Stream or Watercourse	Source by Civil Division	Source by U. S. Public Land Survey	Length (in miles)
Pike River	Town of Mt. Pleasant	NW ¼, Secton 10, T3N, R22E	18.39
Waxdale Creek	Town of Mt. Pleasant	NW ¼, Section 21, T3N, R22E	2.17
Chicory Creek.	Town of Mt. Pleasant	SW ¼, Section 28, T3N, R22E	1.17
School Tributary.	Town of Somers	SE ¼, Section 5, T2N, R22E	2.77
Somers Branch	Town of Somers	SW ¼, Section 9, T2N, R22E	2.22
Pike Creek	Town of Somers	NE ¼, Section 33, T2N, R22E	3.44

Source: SEWRPC.

Table 145

AREAL EXTENT OF CIVIL DIVISIONS IN THE PIKE RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
City			
Kenosha	2.03	4.01	13.74
Towns			
Pleasant Prairie	2.66	5.25	7.25
Somers	25.33	50.00	73.72
County Subtotal	30.02	59.26	10.79
RACINE COUNTY			
City			
Racine	0.35	0.69	2.60
Village			
Sturtevant	1.56	3.08	100.00
Town			
Mt. Pleasant	18.73	36.97	50.01
County Subtotal	20.64	40.74	6.06
Total	50.66	100.00	--

Source: SEWRPC.

Table 146

ESTIMATED RESIDENT POPULATION OF THE PIKE RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
KENOSHA COUNTY	
City	
Kenosha (part)	7,446
Towns	
Pleasant Prairie (part)	641
Somers (part)	5,151
Kenosha County (part) Subtotal	13,238
RACINE COUNTY	
City	
Racine (part)	1,540
Village	
Sturtevant	4,354
Town	
Mt. Pleasant (part)	8,668
Racine County (part) Subtotal	14,562
Pike River Watershed Total	27,800

Source: SEWRPC.

with melting snow. Low flows persist for most of the remainder of the year with occasional rises caused by rainfall. Under the present groundwater conditions, the lowest flows of the River appear to consist almost entirely of sewage treatment plant effluent without which flows probably would drop to zero for considerable periods of time during the year.

Surface runoff, the portion of precipitation which flows overland contributing directly to streamflow, is variable both in season and in location within the watershed. The ratio of runoff from winter rains and melting snow, usually occurring when the soil is frozen or saturated, can be very high. However, runoff during the later spring, summer, and fall seasons is generally a very small fraction of the causative rainfall.

The lower reaches of the Pike River and other first rank tributaries to Lake Michigan, are subject to a phenomenon known as a seiche. A seiche, also known as a standing wave, is an oscillation of the water mass at the surface or within a lake lasting from a few minutes to several hours. The forces that generate seiches include variation in atmospheric pressure and wind. The flow condition and the water quality in the lower reaches of the Pike River can be affected temporarily by the dilution effects of the Lake Michigan water during a seiche.

Pollution Sources

The following types of pollution sources have been identified in the Pike River watershed and are discussed below: municipal sewage treatment facilities, sanitary sewerage system overflow points, industrial wastewater discharges, urban storm water runoff, and agricultural and other runoff.

Sewage Treatment Facilities: Two municipally owned sewage treatment facilities are operated in the Pike River watershed: the Village of Sturtevant sewage treatment facility and the Town of Somers Utility District No. 1. In addition to these two public sewage treatment facilities, St. Bonaventure Seminary in the Town of Mt. Pleasant operates a nonindustrial private sewage treatment facility. Selected information for the private and public municipal sewage treatment plants in the Pike River watershed is set forth in Tables 148 and 149, and the plant locations are shown on Map 56.[13] All three sewage treatment plants provide a secondary level of treatment and the effluents are discharged into tributaries of the Pike River.

Domestic Onsite Sewage Disposal Systems: Although certain portions of the watershed lie within existing and proposed service areas of public sanitary sewerage

[13] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 56. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exist to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 147

FLOW MEASUREMENTS AT THE PIKE RIVER NEAR RACINE (USGS PK-36): 1972-1975

Water Year	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1972	42.0	14.79	560	0.53
1973	36.1	19.63	639	0.84
1974	55.8	19.59	1,010	3.10
1975	23.0	8.08	323	0.70

Source: SEWRPC.

Table 148

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE PIKE RIVER WATERSHED: 1975

Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity					Existing Loading	
							Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Average Organic Pounds BOD_5/Day	Population[a] Equivalent	Average Annual Hydraulic (mgd)	Average Annual Per Capita (gpd)
Town of Somers Utility District No. 1[b]	0.29	700	1964	Activated Sludge, Disinfection	Secondary and Auxiliary	Tributary of Pike River	250	0.03	0.10	N/A	N/A	0.06	87
Village of Sturtevant	0.83	4,400	1959, 1974	Phosphorus Removal, Trickling Filter, Disinfection	Secondary Advanced Auxiliary	Tributary of Pike River	2,500	0.30	0.50	425	2,025	0.53	120

NOTE: N/A indicates data not available.

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the table.*

[b] *Formerly Town of Somers Sanitary District No. 2.*

Source: SEWRPC.

systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points: In addition to private and public sewage treatment facility effluents, raw sanitary sewage enters the surface water system of the Pike River watershed indirectly via sanitary sewer overflows to separate storm sewer systems. There are eight known flow relief devices in the Pike River watershed as shown in Table 150. Of these flow relief devices, five are crossovers and three are bypasses. Seven of these flow relief devices discharge directly into the Pike River main stem and one discharges into Pike Creek.

Although the Pike River includes portions of the urbanized areas of the Cities of Racine and Kenosha, there are no known combined sewer overflows in the watershed.

Industrial Discharges: At five locations in the Pike River watershed cooling waters and treated wastewaters are discharged directly or indirectly to the surface water system (see Map 56). These industrial wastewaters enter the Pike River as direct discharge through industrial waste outfalls or reach the surface water by drainage ditches and storm sewers.

Data and information provided by the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR101 of the Wisconsin Administrative Code were used to determine the type and location of indus-

Table 149

SELECTED CHARACTERISTICS OF NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES IN THE PIKE RIVER WATERSHED: 1975

Name	Civil Division Location	Type of Land Use Served	Type of Wastewater	Type of Treatment Provided	Disposal of Effluent	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Average Hydraulic Design Capacity (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
RACINE COUNTY								
St. Bonaventure Seminary	Town of Mt. Pleasant	Institutional	Sanitary	Contact Stabilization and Lagoon	Waxdale Creek	8,000	15,000	10,000

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 150

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE PIKE RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1976

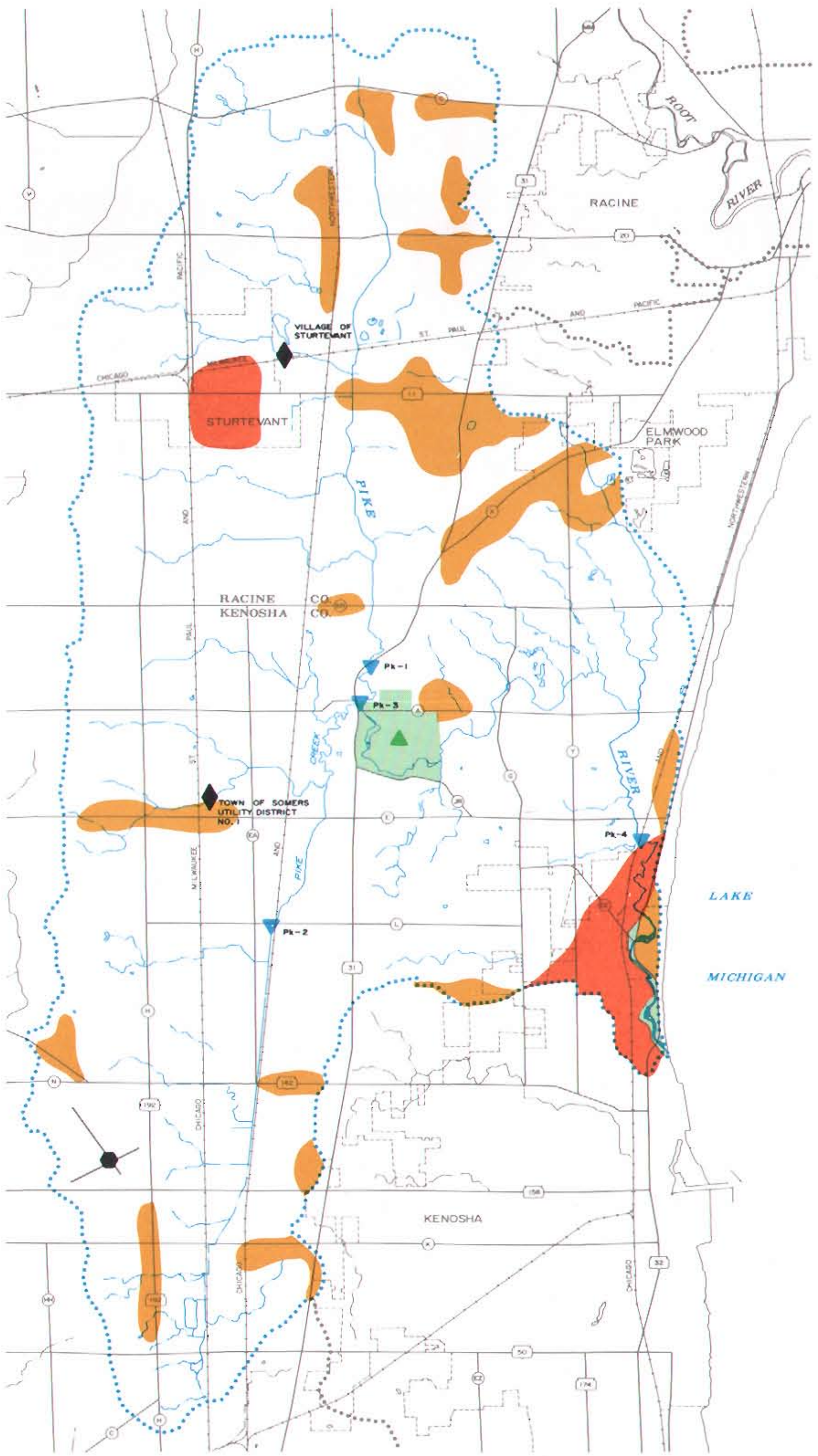
Receiving Stream	Civil Division	Combined Sewer Outfalls	Other Flow Relief Devices				Total
			Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Pike River	City of Kenosha	0	5	0	0	0	5
Pike River	Village of Sturtevant	0	0	1	0	0	1
Pike River	Town of Mt. Pleasant	0	0	1	0	0	1
Pike Creek	Town of Somers	0	0	1	0	0	1
Total	--	0	5	3	0	0	8

Source: SEWRPC.

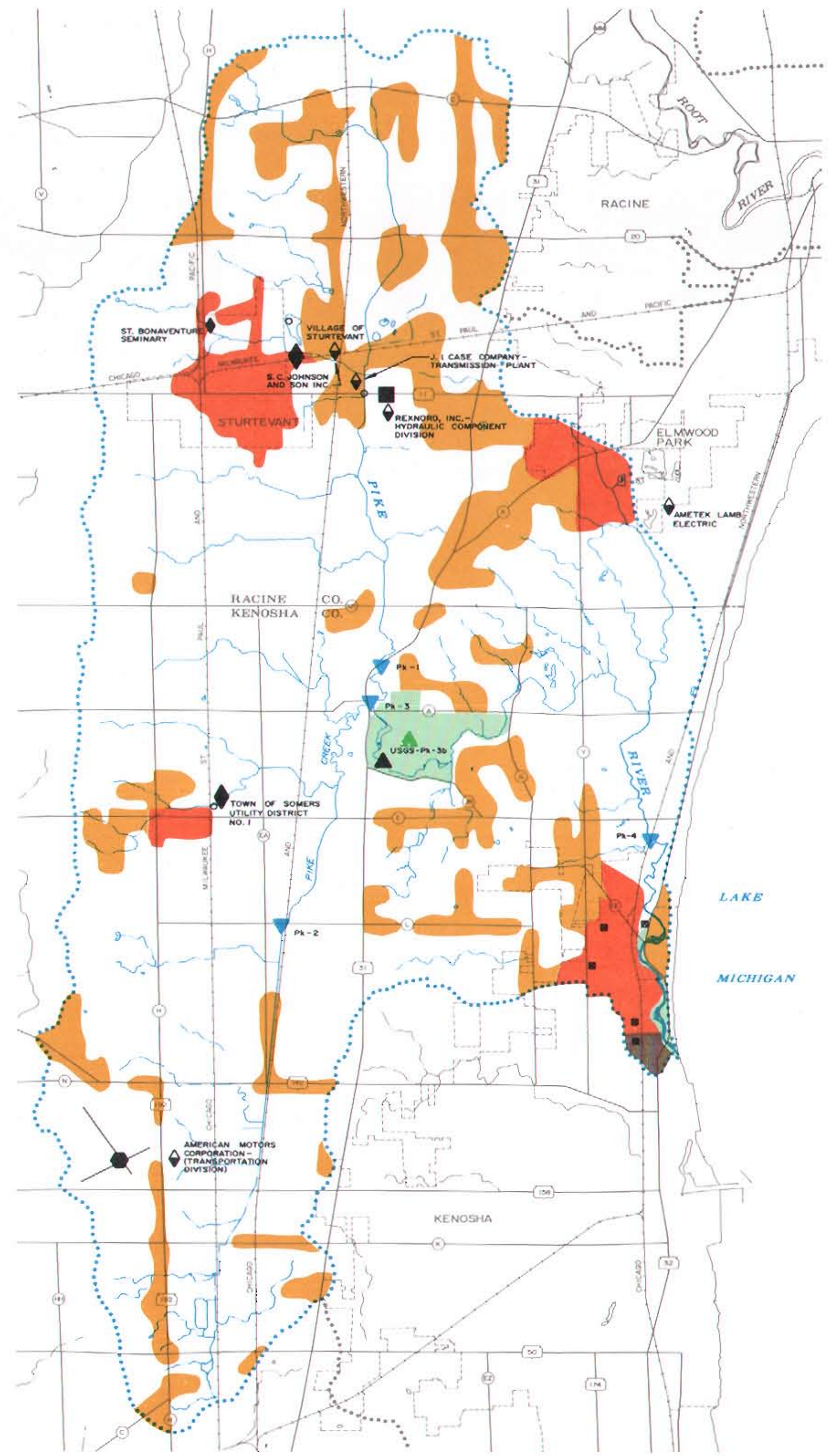
Map 56

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE PIKE RIVER WATERSHED: 1964-1975

1964



1975



Stream water quality was obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at five sampling stations located in the Pike River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by two public sewage treatment facilities, one nonindustrial private sewage treatment facility, five sanitary sewage crossovers, three bypasses and five commercial or industrial facilities dicharging wastewater through seven outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

trial wastewater discharges in the Pike River watershed. Table 151 summarizes by receiving stream and by civil division the types of industrial wastewater discharge in the watershed and the types of treatment and average hydraulic design capacity. Seven industrial and commercial waste discharge points are known to exist in the watershed; six of which discharge cooling waters only. The remaining discharge point discharges process water. Three of the five industrial locations discharge directly to the Pike River and the remaining two locations discharge to tributaries of the Pike River.

Pollution from Urban Runoff: Separate storm sewers which convey the runoff from rainfall carry the pollutants and contaminants from the urbanized areas into the receiving waters. Urban storm waters can cause chemical or inorganic pollution, organic pollution, pathogenic pollution, and aesthetic pollution of these receiving streams. Existing land use information taken from the Commission 1970 land use inventory is presented in Table 152 and indicates that 7,284 acres, or about 22 percent of the Pike River watershed, is devoted to urban land uses; 24,502 acres, or about 75 percent, is devoted to rural land uses, primarily agriculture; and 803 acres, or about 3 percent, is occupied by streams. A shoreland development survey by the Wisconsin Department of Natural Resources indicates that 58 percent of the shoreland area within 1,000 feet of the Pike River and its tributaries is used for agricultural purposes, while 42 percent of the shoreland is used in low-density and high-density residential development. A comparison of the land use within the watershed with the land use within 1,000 feet of the shores of the Pike River and tributaries indicates that a higher percentage of the land along the shores of the Pike River is urbanized than within the watershed as a whole. The urbanized areas of the Pike River watershed, although comprising only about 22 percent of the total area of the watershed, are likely to have a significant effect on the stream water quality.

Pollution from Rural Land: Agricultural land uses are known to contribute high concentrations of suspended solids, nitrogen, and phosphorus to surface waters through storm water runoff. Since 75 percent of the total area of the Pike River watershed is in agricultural use, agricultural runoff is a significant factor affecting the water quality of the Pike River stream system.

Other Pollution Sources: The Commission 1970 land use inventory indicated, in addition to the pollution sources described above, the presence of four sanitary landfill sites and four auto salvage yards in the Pike River watershed. Seepage and runoff from these sources may contain suspended solids, oxygen-demanding materials, chlorides, toxic substances, and nutrients and may contribute to the pollution of the River system.

Water Quality Conditions of Pike River Watershed

Water Quality Data: Of the data sources listed in Chapter II, the following five were used in analyzing the water

Table 151

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE PIKE RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
RACINE COUNTY								
Ametek Lamb Electric	3621	City of Racine	Cooling	N/A	1	Sorenson Creek	3,000	7,000
J. I. Case Company—Transmission Plant	3714	Town of Mt. Pleasant	Cooling	N/A	1	Pike River	70,000	80,000
Rexnord, Inc.—Hydraulic Component Division	3599	Town of Mt. Pleasant	Cooling	N/A	1	Pike River	130,000	231,000
S. C. Johnson and Son, Inc.	2842	Village of Sturtevant	Cooling	N/A	1	Tributary of Pike River	1,291,400	1,550,000
			Cooling	N/A	2	Tributary of Pike River	248,000	320,000
			Cooling	N/A	3	Tributary of Pike River	96,000	120,000
KENOSHA COUNTY								
American Motors Corporation—(Transportation Division)	3711	Town of Somers	Process	Activated Sludge and Sand Filter	1	Pike River	2,000	N/A

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

quality conditions in the Pike River watershed study: (1) Commission benchmark study; (2) Commission continuing monitoring program; (3) Wisconsin Department of Natural Resources basin surveys; (4) City of Racine Department of Health Water Quality Survey Program; and (5) U. S. Geological Survey continuous streamflow monitoring program. A detailed description of these data sources is given in Chapter II.

Four sampling stations, two on the Pike River and two on the Pike Creek, were established by the Commission in the initial water quality benchmark study in 1964-1965. Tables 153 and 154 present the Commission stations, locations, and their distances from the mouth of the Pike River and Table 155 presents the stations other than those established by the Commission. Map 56 illustrates the location of the sampling stations in Pike River watershed.

Surface Water Quality of Pike River and Its Tributaries 1964-1965: Water quality conditions in the Pike River watershed, as determined by the 1964-1965 sampling survey at two stations along the Pike River and two on Pike Creek, are summarized in Table 156. The results for chloride, dissolved oxygen, and coliform bacteria are particularly relevant to assessment of the trends in surface water quality.

Chloride: During the sampling year of 1964-1965, the chloride concentrations throughout the watershed varied from 35 mg/l to 90 mg/l with the average values for the Pike River and Pike Creek being 65 mg/l each. The chloride levels in the watershed were high compared to background levels of 10 mg/l as measured from the average groundwater chloride concentrations.[14] The chloride concentrations remained high throughout the year in the Pike River and Pike Creek. The sustained high chloride concentrations in the streams of the Pike River watershed indicate continuing contribution of chlorides from a source other than groundwater. The Village of Sturtevant sewage treatment facility, St. Bonaventure Seminary sewage treatment facility, and the Town of Somers Utility District No. 1 sewage treatment facility located in the watershed, discharging into the Pike River and Pike Creek, are likely to be major sources of chloride in the stream waters.

[14] *C.L.R. Holts and E. L. Skinner, "Groundwater Quality in Wisconsin Through 1972," UW Extension Information Circular Number 22, 1973.*

Table 152

LAND USE IN THE PIKE RIVER WATERSHED: 1963 and 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	2,490.57		3,370.52	
Commercial	129.70		184.04	
Industrial	185.29		297.66	
Transportation and Utilities	2,141.96		2,142.82	
Government	287.71		520.79	
Recreation	717.14		732.31	
Landfill and Dump	30.38		36.59	
Total	5,982.75	18.36	7,284.73	22.35
Rural Land Uses				
Open Land	999.81		1,790.01	
Agricultural Lands	24,798.39		22,712.63	
Total	25,798.20	79.16	24,502.64	75.18
Water Covered Lands				
Lakes, Rivers, and Streams	126.23		141.47	
Wetlands, etc.	683.68		662.24	
Total	809.91	2.48	803.71	2.47
Watershed Totals	32,590.86	100.00	32,591.08	100.00

Source: SEWRPC.

Table 153

DESIGNATIONS AND LOCATIONS OF SEWRPC STREAM SAMPLING STATIONS ON THE MAIN STEM OF THE PIKE RIVER

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
SEWRPC	Pk-1	STH 31, SW ¼, Section 2, T2N, R22E	9.9
	Pk-4	STH 32, SE ¼, Section 18, T2N, R23E	1.8

Source: SEWRPC.

Table 154

DESIGNATIONS AND LOCATIONS OF SEWRPC STREAM SAMPLING STATIONS ON THE TRIBUTARY OF THE PIKE RIVER

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
SEWRPC	Pk-2	Pike Creek at 18th Street, SW ¼, Section 15, T2N, R22E	12.8
	Pk-3	Pike Creek at STH 31, SW ¼, Section 2, T2N, R22E	9.6

Source: SEWRPC.

Table 155

DESIGNATIONS AND LOCATIONS OF STREAM SAMPLING STATIONS OF OTHER SOURCES IN THE PIKE RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
USGS	Pk-3b	SE ¼ and NE ¼, Section 11, T2N, R22E	9.0

Source: SEWRPC.

Table 156

WATER QUALITY CONDITIONS OF THE PIKE RIVER AND TRIBUTARIES: 1964-1965

Station Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Pike River Pk-1, Pk-4	Chloride (mg/l)	90	65	35	17
	Dissolved Solids (mg/l)	905	600	380	17
	Dissolved Oxygen (mg/l)	11.8	5.3	0.1	27
	Total Coliform Count (MFCC/100 ml)	1,800,000	260,000	2,000	27
	Temperature (^{o}F)	75	49	32	27
Pike Creek Pk-2, Pk-3	Chloride (mg/l)	90	65	35	15
	Dissolved Solids (mg/l)	840	620	505	15
	Dissolved Oxygen (mg/l)	13.2	6.0	0.4	25
	Total Coliform Count (MFCC/100 ml)	300,000	35,000	1,200	25
	Temperature (^{o}F)	71	49	32	25

Source: SEWRPC.

Dissolved Oyxgen: During the sampling period of 1964-1965, the dissolved oxygen levels in the watershed ranged from 0.1 to 13.2 mg/l, with the average values for the Pike River and Pike Creek being 5.3 and 6.0 mg/l, respectively. Although the average concentration of dissolved oxygen was 5.3 mg/l for the Pike River, several instances of substandard levels were noted at the two sampling stations on Pike River. At station Pk-1, the concentration of dissolved oxygen was below 5 mg/l during 10 of the 13 sampling periods. Since the nearest sanitary wastewater discharge is located 5.0 miles upstream from sampling station Pk-1, as indicated on Map 56, the more likely source for the decrease in dissolved oxygen is runoff from the agricultural land which comprises 75 percent of the land use in the watershed. Station Pk-4, located on the Pike River downstream from Pk-1 and Pike Creek, exhibited substandard levels of dissolved oxygen five times during the year 1964-1965, twice during late summer and three times during the months of January and February. The concentration of dissolved oxygen remained higher than at Pk-1 during all sampling surveys. The distance between sampling stations Pk-1 and Pk-4 is 8.1 miles and, apparently, the absence of sewage and industrial waste sources between these two locations allows the stream to reestablish its dissolved oxygen level to some extent, as noted from the increased dissolved oxygen concentrations at Pk-4. In addition, the Lake Michigan seiche effect may have a dilution effect on Pike River water at Pk-4, increasing the dissolved oxygen content.

Pike Creek, which meets the Pike River one-half mile downstream from Pk-1, has two sampling stations, located upstream and downstream from Somers Branch tributary to Pike Creek, which carries the effluent from the sewage treatment plant of the Town of Somers Utility District No. 1. The dissolved oxygen concentrations at Pk-2, located upstream from the confluence of Somers Branch with Pike Creek, were above 5.0 mg/l on 10 occasions and were between 3.0 and 5.0 mg/l on three occasions during the 1964-1965 sampling survey. On the other hand, at Pk-3, located downstream from the Somers Branch, only five out of 13 sampling surveys indicated dissolved oxygen levels above 5.0 mg/l. Five of the 13 samples had less than 3.0 mg/l of dissolved oxygen. This decreased water quality at Pk-3 is likely to be at least partly due to the discharge of the treated effluent from the Town of Somers Utility District No. 1. The 1972 revision of water quality standards by the Wisconsin Department of Natural Resources requires Pike Creek in Kenosha County and the Pike River in Racine County to meet the less stringent water quality standards for restricted use under which the dissolved oxygen concentrations were to exceed 2.0 mg/l. The concentrations of dissolved oxygen were below 2.0 mg/l at Pk-2 on four out of 13 sampling occasions.

Total Coliform Bacteria: During the 1964-1965 sampling, membrane filter average coliform counts varied from 1,200 to 1,800,000 MFCC/100 ml, with the average values for the Pike River and the Pike Creek being, respectively, 260,000 and 35,000 MFCC/100 ml. The highest total coliform counts occurred during the month of December in the Pike River at station Pk-1. Since the high coliform counts observed in the watershed did not occur throughout the year, it is likely that they are from intermittent pollution sources which discharge to the stream, such as wastes from animal operations, effluent from malfunctioning septic tank systems, or wildlife excretion.

Specific Conductance: The specific conductance of the Pike River samples during the 1964-1965 sampling period ranged from 522 to 1,330 µmhos/cm at 25°C. The specific conductance is an approximate measure of the dissolved ions present in the water; and, in the Pike River watershed, the high specific conductance values correlated with high alkalinity. The alkalinity being a measure of the concentration of all of the bases present in water, the increased specific conductance is due to the presence of increased amounts of such substances as sulfates and bicarbonates. The source of the bases in the Pike River is likely to be the result of soil erosion since the watershed has calcareous soils.

Hydrogen Ion Concentration (pH): The pH values at all sampling sites in the Pike River watershed generally ranged from 6.9 to 8.2 standard units during the sampling year of 1964-1965. At no location within the watershed was the pH found to be outside the range of 6.0 to 9.0 standard units prescribed for recreational use, the maintenance of fish and aquatic life, and restricted use, the major water use objectives for the Pike River and its tributaries.

Temperature: During the year 1964-1965, the temperature of water samples from the Pike River and the Pike Creek ranged between 32°F and 40°F during the months of December through April and between 43°F and 75°F during the months of May through November. These temperature variations may be attributed primarily to the seasonal changes. Consequently, the discharges of cooling water into the main stem or the tributaries of Pike River from the J. I. Case Company and Rexnord, Inc., located in the Town of Mt. Pleasant; S. D. Johnson and Sons, Inc. plant, located in the Village of Sturtevant; and the Ametek/Lamb Electric plant, located in the City of Racine, appear to be not increasing the normal temperature of the stream water above the prescribed standard of 89°F.

Biochemical Oxygen Demand: The range of five-day biochemical oxygen demand (BOD_5) on the Pike River and Pike Creek during the sampling period of 1964-1965 recorded a low of 0.9 mg/l and a high of 87.7 mg/l at the four sampling stations. The highest BOD_5 values were found during the month of February at all four sampling locations. Since the watershed is 75 percent in agricultural land use, the high BOD_5 in the samples collected in February indicates the probable source as agricultural runoff and, more specifically, the improper spreading of manure on the frozen lands during winter with subsequent washoff increasing the BOD_5 values in the receiving streams. In addition, inverse correlation generally was found between the dissolved oxygen level and BOD_5 concentrations. The data indicate that a portion of the biochemical oxygen-demanding materials had been exerted, thereby consuming oxygen present in the stream, and hence indicating that high concentrations of BOD_5 may be present even in the upstream reaches.

Water Quality Trends from 1965 to 1975: Water quality data from 1965 to 1975 for eight summer sampling programs, three spring sampling programs, and one fall sampling program are presented in tabular form in Appendix D of this report. The eight summer sampling surveys began in August 1968 and involved collection of samples one day in August every year during low flow conditions.

A summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite, ammonia-, and organic nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of the four stations sampled in the Pike River watershed by the Commission since 1968 is set forth in Tables 157-160. The streamflow data for Pike River near Racine (USGS-Pk-3b) are obtained from the U. S. Geological Survey records. The data for the years 1972 through 1975 on the days that the water samples were collected are presented in Figure 151.

Dissolved Oxygen: For the watershed as a whole, the range of dissolved oxygen in the Pike River stream system during August for the years 1968-1975 was 2.2 to 16.1 mg/l. The average dissolved oxygen concentrations were 5.9, 5.8, 7.4, and 6.9 mg/l for Pike River stations Pk-1, Pk-2, Pk-3, and Pk-4, respectively. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l for all locations during August, the dissolved oxygen concentrations in some samples taken at every sampling location during 1968-1975 were lower than 5.0 mg/l. At the sampling station Pk-1 on Pike River, the daily average dissolved oxygen concentrations were well below 5.0 mg/l during seven out of eight sampling surveys. Samples collected at station Pk-4 on Pike River had less than 5.0 mg/l dissolved oxygen during two out of eight sampling sessions. During six out of eight sampling periods at station Pk-2 and during one of eight sampling periods at station Pk-3, respectively, on Pike Creek, the daily average concentrations of dissolved oxygen were found to be lower than 5.0 mg/l. Although Pike Creek is required to meet only the restricted use standard of 2.0 mg/l of dissolved oxygen at stations Pk-2 and Pk-3, the dissolved oxygen concentrations at station Pk-2 were found to be lower than 2.0 mg/l twice during the eight sampling periods. At station Pk-3 on Pike Creek the dissolved oxygen levels remained higher than 2.0 mg/l during all eight sampling surveys. Map 57 with the graph insert presents the daily average dissolved oxygen concentrations that were found in August 1964 and August 1975 samples from the Pike River watershed. On August 12, 1964, as indicated on the map, the dissolved oxygen levels were below 5.0 mg/l at sampling station Pk-1 and Pk-4 on Pike River. The dissolved oxygen concentrations remained greater than 2.0 at both sampling locations on Pike Creek, Pk-2 and Pk-3, with a dissolved oxygen concentration of 5.4 mg/l at sampling station Pk-3, located 275 feet from the confluence with the Pike River. On August 20, 1975, the dissolved oxygen concentrations in Pike River samples remained below 5.0 mg/l at sampling location Pk-1 but above 5.0 mg/l at sampling location

Table 157

WATER QUALITY CONDITIONS OF THE PIKE RIVER AT SAMPLING STATION PK-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	45.0	24.5	16.0	23	--
Dissolved Oxygen (mg/l)	5.0	11.0	5.9	2.2	30	15[a]
Ammonia-N (mg/l)	2.5	1.49	0.47	0.03	8	0
Organic-N (mg/l)	--	2.22	0.81	0.27	8	--
Total-N (mg/l)	--	6.49	3.33	1.24	8	--
Specific Conductance (umhos/cm at 25°C)	--	928	525	313	29	--
Nitrite-N (mg/l)	--	0.33	0.18	0.04	13	--
Nitrate-N (mg/l)	0.3	3.81	1.84	0.60	13	13
Soluble Orthophosphate-P (mg/l)	--	0.83	0.35	0.07	12	--
Total Phosphorus (mg/l)	0.1	0.80	0.34	0.10	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,700	589	40	12	7
Temperature (°F)	89	80.0	68.9	48.0	31	0
Hydrogen Ion Concentrations (standard units)	6-9	9.0	7.9	7.5	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 158

WATER QUALITY CONDITIONS OF THE PIKE RIVER AT SAMPLING STATION PK-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	90.0	51.1	25.0	23	--
Dissolved Oxygen (mg/l)	2.0	16.1	5.8	1.5	31	3[a]
Ammonia-N (mg/l)	2.5	0.21	0.14	0.03	8	0
Organic-N (mg/l)	--	1.89	0.98	0.51	8	--
Total-N (mg/l)	--	7.28	3.30	1.31	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,455	1,099	840	29	--
Nitrite-N (mg/l)	--	0.28	0.08	0.03	13	--
Nitrate-N (mg/l)	0.3	4.90	2.24	0.66	13	13
Soluble Orthophosphate-P (mg/l)	--	0.46	0.21	0.14	12	--
Total Phosphorus (mg/l)	0.1	0.37	0.22	0.14	8	8
Fecal Coliform (MFFCC/100 ml)	2,000	1,200	593	90	12	0
Temperature (°F)	89.0	81.5	68.8	46.0	31	0
Hydrogen Ion Concentrations (standard units)	6-9	8.3	7.8	7.5	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 159

WATER QUALITY CONDITIONS OF THE PIKE RIVER AT SAMPLING STATION PK-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	82.0	34.1	22.0	23	--
Dissolved Oxygen (mg/l)	2.0	11.7	7.4	3.9	31	0[a]
Ammonia-N (mg/l)	2.5	0.43	0.19	0.03	8	0
Organic-N (mg/l)	--	1.14	0.65	0.20	8	--
Total-N (mg/l)	--	4.08	2.26	0.95	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,069	619	440	29	--
Nitrite-N (mg/l)	--	0.15	0.09	0.04	13	--
Nitrate-N (mg/l)	0.3	3.55	1.47	0.39	13	13
Soluble Orthophosphate-P (mg/l)	--	0.61	0.30	0.10	12	--
Total Phosphorus (mg/l)	0.1	0.54	0.25	0.11	8	8
Fecal Coliform (MFFCC/100 ml)	2,000	12,000	1,541	10	12	2
Temperature (°F)	89.0	76.5	68.5	48.0	31	0
Hydrogen Ion Concentrations (standard units)	6-9	8.7	8.1	7.7	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 160

WATER QUALITY CONDITIONS OF THE PIKE RIVER AT SAMPLING STATION PK-4: 1968-1975

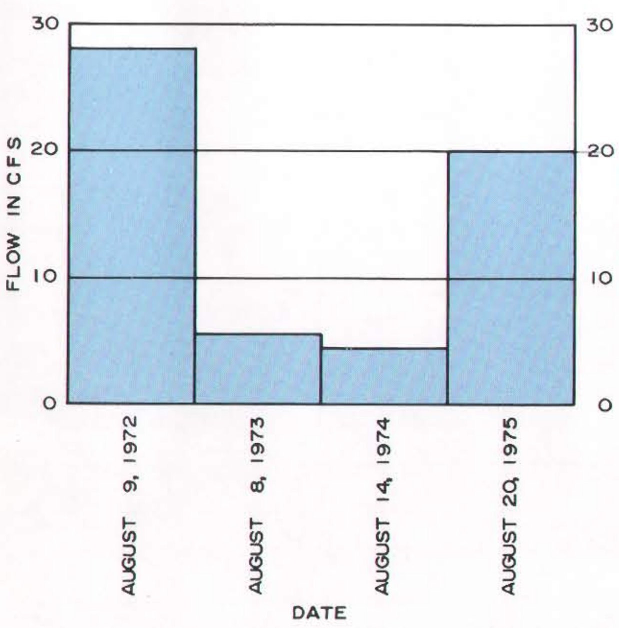
Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	51.0	34.6	24.0	23	--
Dissolved Oxygen (mg/l)	5.0	14.2	6.9	3.2	31	5[a]
Ammonia-N (mg/l)	2.5	0.34	0.13	0.03	8	0
Organic-N (mg/l)	--	1.42	0.94	0.48	8	--
Total-N (mg/l)	--	4.50	2.31	1.15	8	--
Specific Conductance (µmhos/cm at 25°C)	--	956	616	445	29	--
Nitrite-N (mg/l)	--	0.13	0.05	0.02	13	--
Nitrate-N (mg/l)	0.3	2.85	1.43	0.37	13	13
Soluble Orthophosphate-P (mg/l)	--	0.55	0.30	0.06	12	--
Total Phosphorus (mg/l)	0.1	0.34	0.19	0.05	8	6
Fecal Coliform (MFFCC/100 ml)	400	2,100	720	20	12	6
Temperature (°F)	89	81.5	71.4	50.0	31	0
Hydrogen Ion Concentrations (standard units)	6-9	8.9	8.3	7.5	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Figure 151

FLOW MEASUREMENTS IN THE PIKE RIVER AT RACINE (USGS PK-3b) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

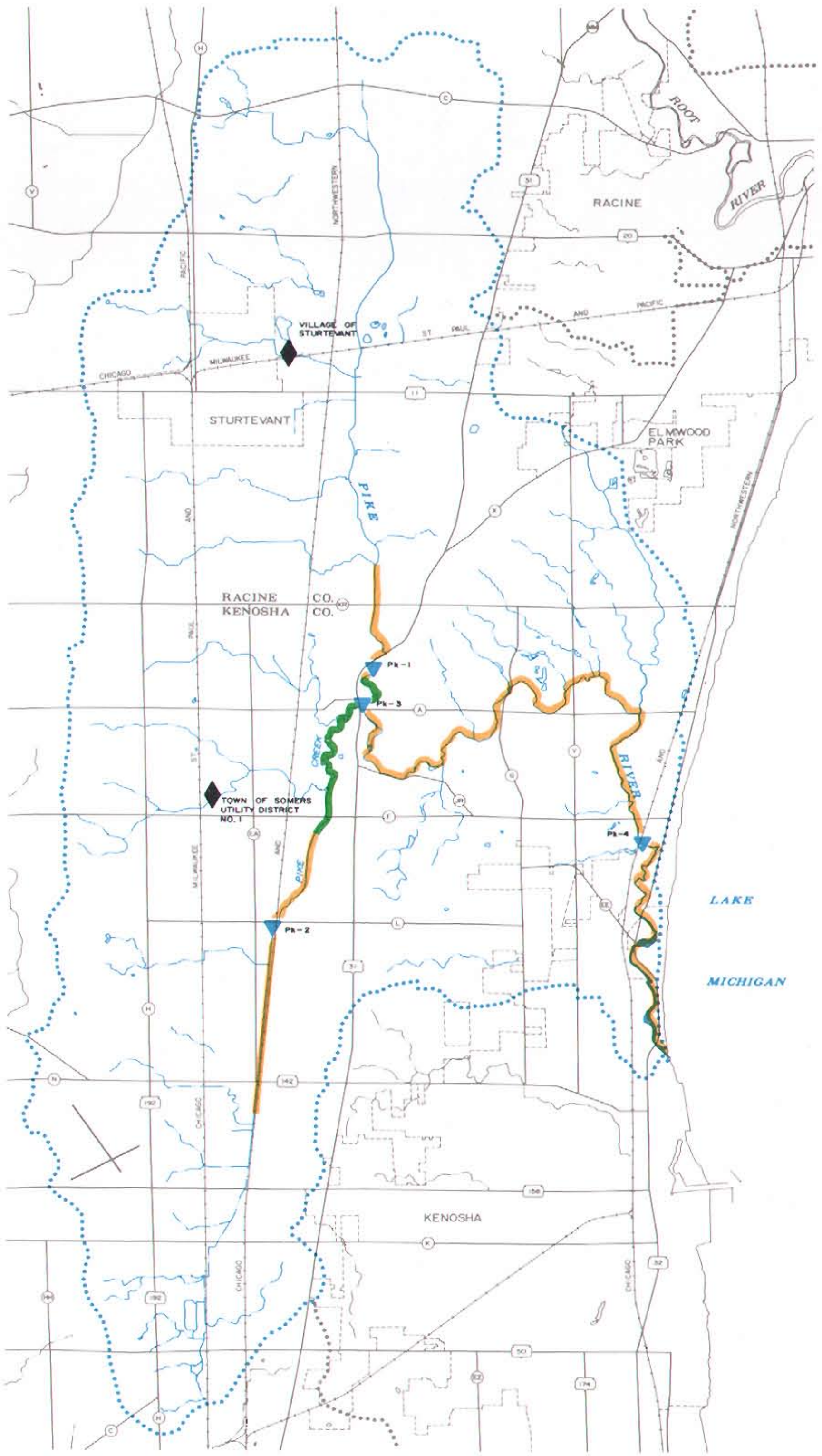
Pk-4, thus meeting the required standard for dissolved oxygen at location Pk-4 but not at location Pk-1. On Pike Creek, the dissolved oxygen concentrations at sampling locations Pk-2 and Pk-3 were greater than 2.0 mg/l, the applicable standard for the restricted use of the stream. The graph inserts on Map 57 present the daily averages of the dissolved oxygen concentrations in sets of four to six samples taken on August sample dates and the moving averages at sample locations Pk-1 through Pk-4 in the samples collected during the period from 1964 through 1975 in the Pike River watershed. The dissolved oxygen concentrations indicate a slight increase over the eight-year sampling surveys at sampling stations Pk-1 and Pk-4. It is assumed that the increase reflects improved operation and maintenance at the Village of Sturtevant sewage treatment plant. At Pike Creek sampling station Pk-2, a modest early increase in dissolved oxygen content was offset by more recent declines over the past eight years. The flow in Pike Creek being generally dependent upon direct precipitation events and with little or no base flow in the stream during the dry summer months, the water quality trend at sampling location Pk-2 cannot be readily assessed by sampling during the summer months. At sampling station Pk-3, the dissolved oxygen concentrations remained fairly constant in the summer samples collected over the past eight years.

A comparison of dissolved oxygen concentrations found in April and August 1964, 1968, and 1969 indicates higher dissolved oxygen concentrations in April of each

Map 57

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE PIKE RIVER WATERSHED

1964



LEGEND

SAMPLING STATION AND DESIGNATION

SEWRPC Pk-2

CONTINUOUS STAGE RECORDER GAGE AND DESIGNATION

USGS USGS-Pk-3b

EXISTING SEWAGE TREATMENT FACILITIES

PUBLIC

NONINDUSTRIAL (PRIVATE)

INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES

COMBINED SEWER OUTFALL

BYPASS

CROSSOVER

PORTABLE RELIEF PUMPING STATION

RELIEF PUMPING STATION

DISSOLVED OXYGEN CONCENTRATION IN mg/l

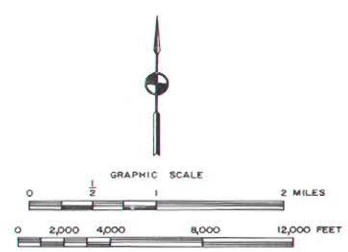
(NONE) LESS THAN 2.0

2.0 – 4.9

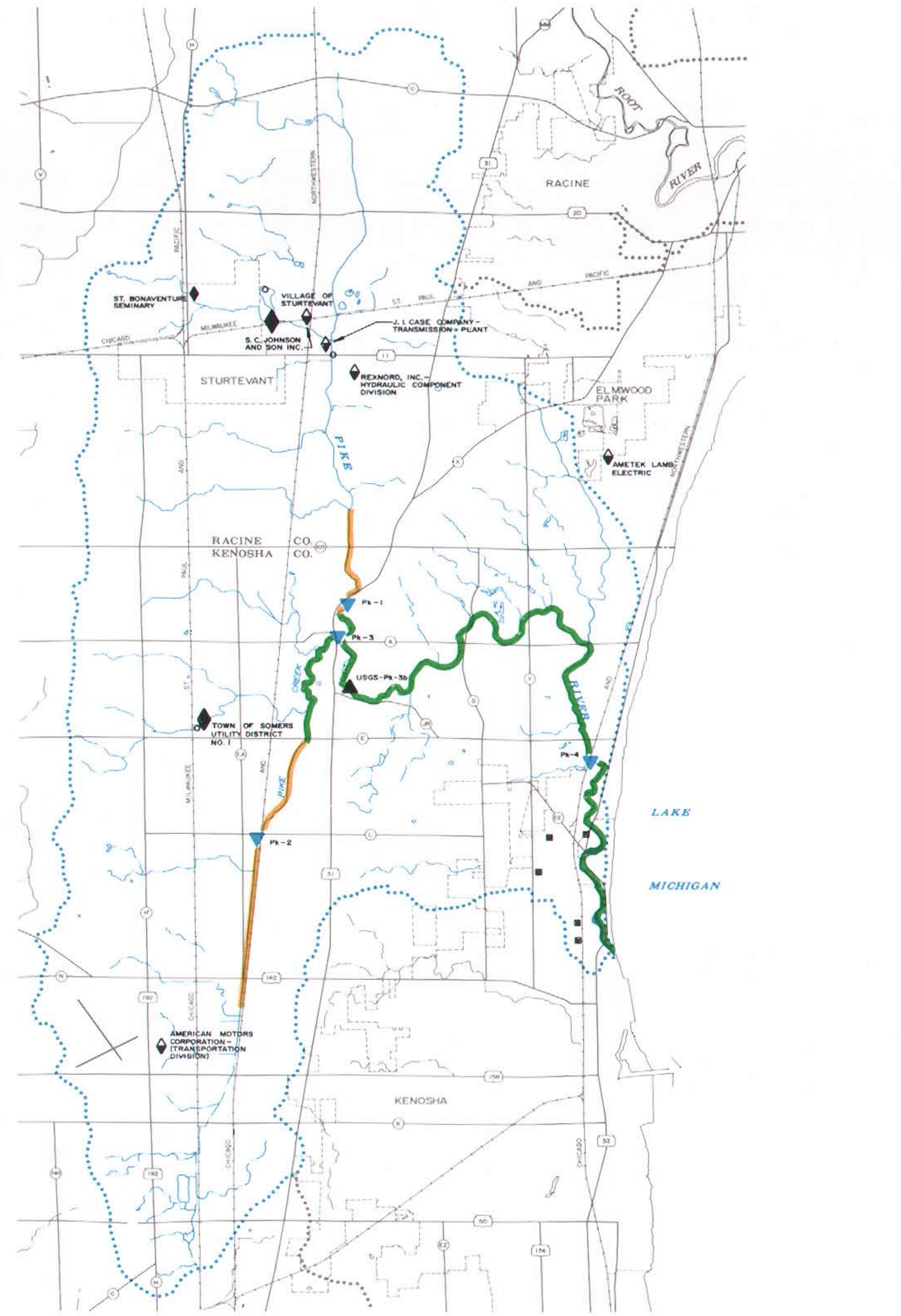
5.0 – 8.0

(NONE) GREATER THAN 8.0

NO DATA FOR INTERPRETATION



1975

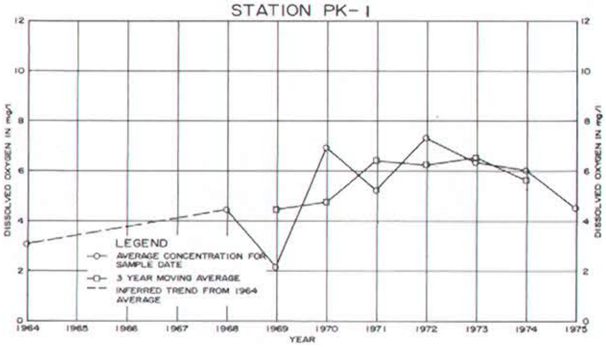


A comparison of the dissolved oxygen levels recorded from 1964 to 1975 indicated that dissolved oxygen concentrations increased at sampling station Pk-4 on the Pike River main stem. No significant change was observed at sampling stations Pk-1 on the Pike River main stem or at Pk-2 or Pk-3 on Pike Creek tributary to the Pike River. The maximum observed dissolved oxygen concentration was 16.1 mg/l at sampling station Pk-2 on Pike Creek tributary to Pike River. Sampling station Pk-2 also recorded the minimum dissolved oxygen concentration of 1.5 mg/l.

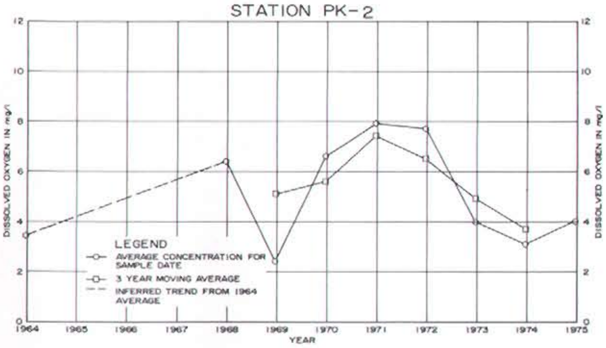
Source: SEWRPC.

Map 57 (continued)

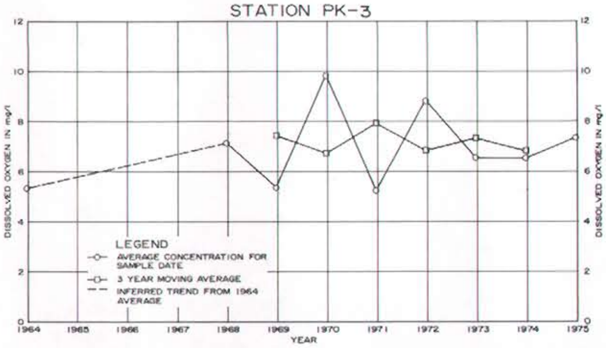
STATION PK-1



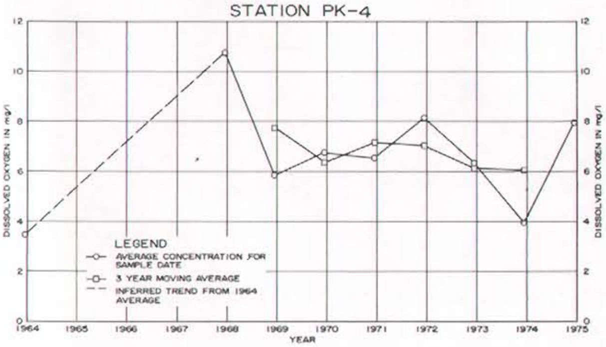
STATION PK-2



STATION PK-3



STATION PK-4



year than in August of the same year. The August dissolved oxygen levels were approximately 8.0 mg/l lower than those found in the April samples.

Chloride: The average chloride concentrations of the multiple samples taken on the sampling dates in eight summer sampling surveys during the years 1968-1975 were in the range of 16 to 90 mg/l for the four stations of the Pike River watershed. The average chloride concentrations of the samples at sampling stations Pk-1 and Pk-4 on Pike River were 25 mg/l and 35 mg/l, respectively, higher than the area groundwater concentration of approximately 10 mg/l. The chloride concentrations at Pike Creek sampling stations Pk-2 and Pk-3, with averages of 51 and 34 mg/l, respectively, were also significantly higher than the groundwater chloride levels and are likely associated with discharges of sanitary wastewater effluents from the sewage treatment plants of the Town of Somers Utility District No. 1, since the dry weather flow at Pike Creek during the summer consists mainly of the sewage treatment plant effluents. A comparison of daily average chloride concentrations in April 1968 with August 1968 and in April 1969 with August 1969 indicates a trend towards higher chloride concentrations in April samples from the main stem of the Pike River. In Pike Creek the April 1968 samples had higher chloride concentrations than the August 1968 samples at stations Pk-2 and Pk-3; and in 1969, the August samples had higher chloride concentrations than the April samples. No flow information is available for Pike Creek on the sampling days to allow a comparison of chloride loadings with the chloride concentrations at Pike Creek sampling stations.

Map 58 illustrates the average chloride concentrations in the Pike River and Pike Creek sampling stations on August 12, 1964, and August 20, 1975, with graphs presenting the changes in average chloride concentrations found during the sampling days of intermediate years. The average chloride concentrations remained within the range of 20-50 mg/l when the August 1964 and 1975 data are compared for stations Pk-1 through Pk-4. The graph inserts illustrate the changes in average chloride concentrations in August for the Pike River watershed sampling stations for the years 1968 through 1975. A decrease in average chloride concentrations was observed at all the Pike River and Pike Creek stations over the past eight years. The concentrations of chloride decreased from the range of 40-50 mg/l at sampling stations Pk-1 and Pk-4 in August 13, 1968, to 20-30 mg/l at the same locations on the Pike River on August 20, 1975. Higher concentrations of chloride in the August samples from 1968, 1969, and 1972 were preceded by rain, according to records of the Racine Department of Air Pollution Control, indicating the effect of runoff on the chloride concentrations. Although no flow measurements are available at the Pike River sampling stations, the available precipitation data on or five days preceding the sampling days, as measured at Racine Department of Air Pollution Control, indicate precipitation events which could cause significantly higher flows in Pike River during the August 1968, 1969, and 1972 sampling days. That higher flows occurred in the Root River watershed

Map 58

COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1975 IN THE PIKE RIVER WATERSHED

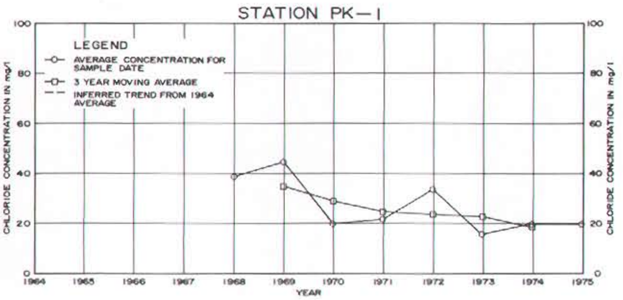
1968

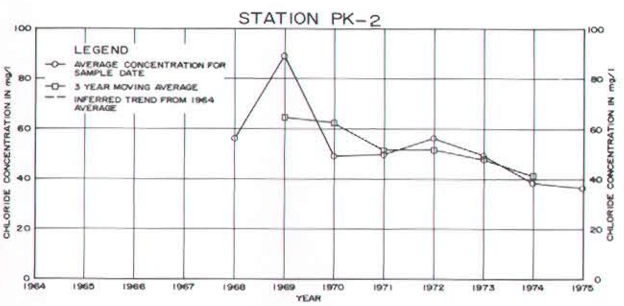
1975

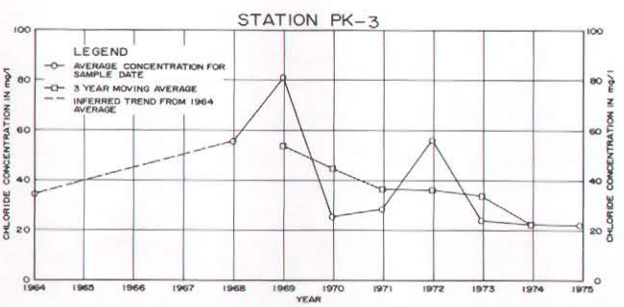
A comparison of the chloride concentrations recorded in 1968 and 1975 indicated that chloride concentrations decreased at sampling stations Pk-2 and Pk-3 on Pike Creek tributary to the Pike River and remained stable with no significant change at stations Pk-1 and Pk-4 on the Pike River main stem. The maximum chloride concentration observed was 90 mg/l at station Pk-2, while a minimum chloride concentration of 16 mg/l was recorded at sampling station Pk-1.

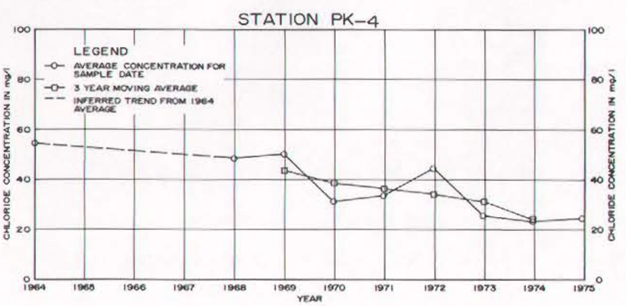
Source: SEWRPC.

Map 58 (continued)









located adjacent to the north edge of the Pike River watershed supports this possibility. The correlation between the precipitation data and high chloride concentrations at sampling stations Pk-1 and Pk-4 on Pike River suggests a direct effect of storm runoff on chloride concentrations. For Pike Creek, the chloride concentrations remained at approximately 50 mg/l at sampling station Pk-2 except in August 1969 when 90 mg/l of chloride was observed. At Pk-3 the average chloride concentration remained between 20 and 30 mg/l during the period from 1970 through 1975 with the exception of 1972 on the sampling days in August. The average chloride concentration was greater than 50 mg/l in the samples collected in August 1968, 1969, and 1972. Apparently the chloride levels in Pike Creek at Pk-3 also were affected by the rains in August 1968, 1969, and 1972; and chloride levels in Pike Creek at Pk-2 were affected by an external source of chloride only in the August 1969 samples.

Fecal Coliform Bacteria: Map 59, with graph inserts, which present the average fecal coliform counts in the Pike River watershed sample locations during August 1968 through August 1975, represents changes in the average fecal coliform counts found on sampling days during the intermediate years. The samples collected in August 1968 indicated a range of 200-600 MFFCC/100 ml at sampling stations Pk-1 on the Pike River and sampling station Pk-2 on Pike Creek and in excess of 1,500 MFFCC/100 ml at sampling station Pk-4 on the Pike River and sampling station Pk-3 on Pike Creek. For the samples collected in August 1975, the fecal coliform counts were in the range of 400 to 1,100 MFFCC/100 ml at all four sampling stations with the higher counts observed at sampling locations Pk-1 and Pk-2, the Pike River and Pike Creek, respectively. When the averages of samples obtained on sampling days in August 1968 and 1975 are compared, a decrease in fecal coliform counts is observed at sampling stations Pk-3 and Pk-4; no change is indicated at sampling station Pk-1; and an increase in counts is noted at sampling station Pk-2. The only specific trend manifested in the changes in fecal coliform counts over the eight sets of samples collected in the month of August during the period from 1968 through 1975 is a general reduction in 1970 and the following years after disinfection facilities were added at the Village of Sturtevant sewage treatment plant, the largest in the watershed. However, the two samples collected at sampling station Pk-1 on August 20, 1975, at 5:50 a.m. and 5:30 p.m. were 210 and 1,700 MFFCC/100 ml, respectively. Interestingly, between the two recorded sampling times there was a heavy rain.[15] Similar high counts were observed at sampling stations Pk-2 through Pk-4 in the evening samples, which were collected during or after the same rainfall.

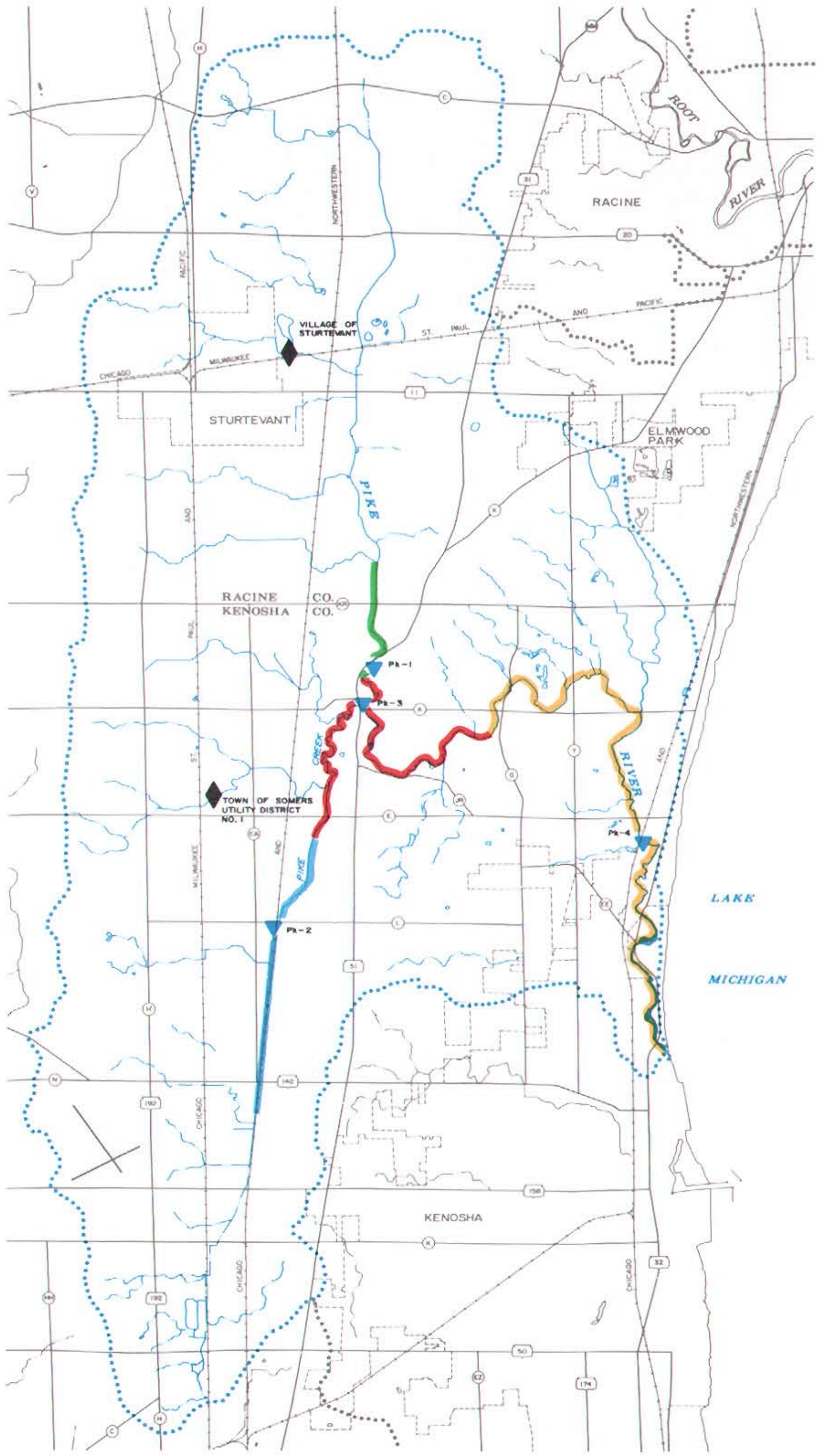
Hydrogen Ion Concentrations (pH): As indicated in Tables 157-160, the pH values of the watershed surface water system have generally been within the range of

[15] *Precipitation as recorded by John W. Mason, Lake and Stream Project, Bureau of Research, Wisconsin Department of Natural Resources.*

Map 59

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1975 IN THE PIKE RIVER WATERSHED

1968



LEGEND

SAMPLING STATION AND DESIGNATION
- SEWRPC Pk-2

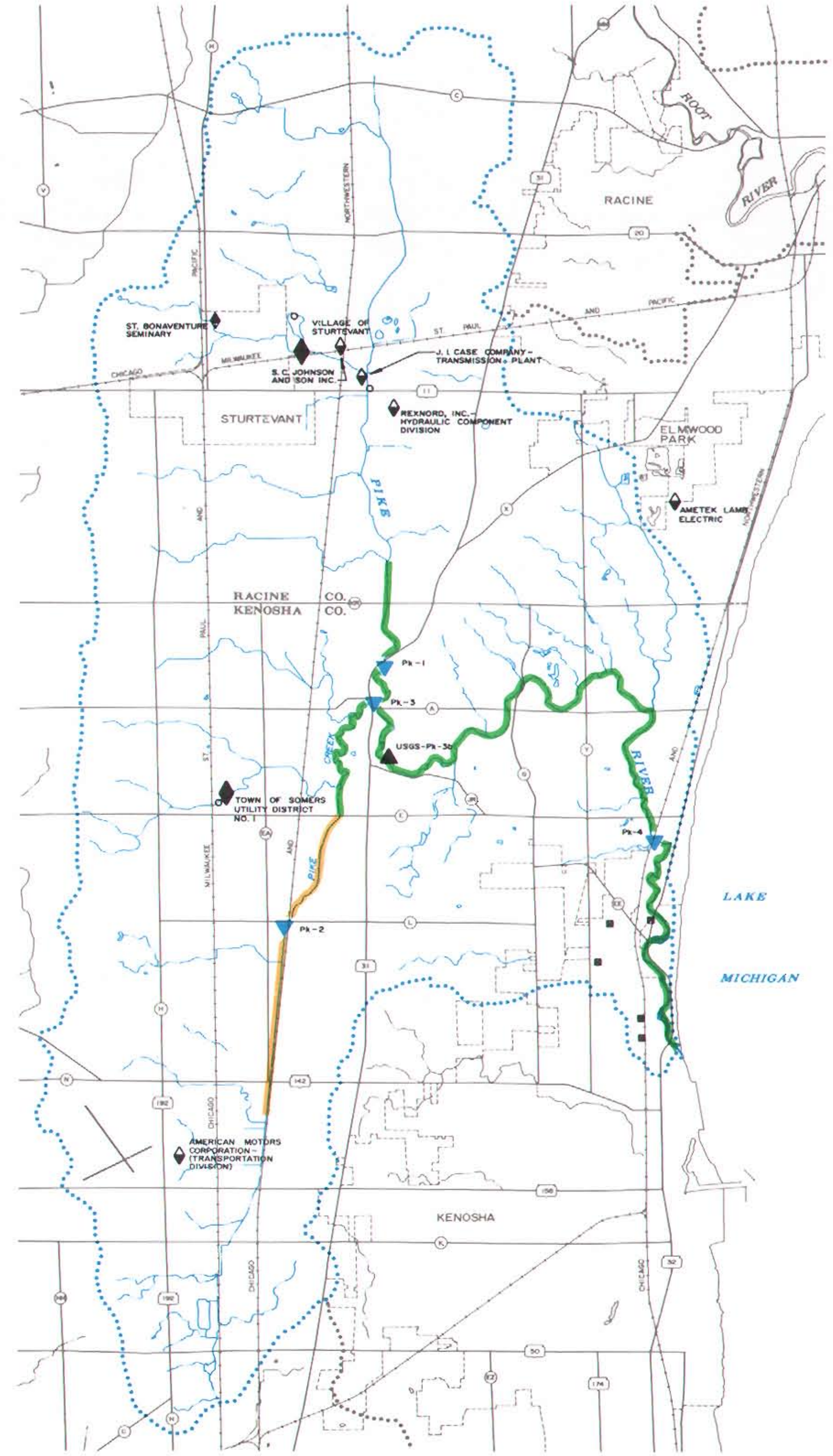
CONTINUOUS STAGE RECORDER GAGE AND DESIGNATION
- USGS USGS-Pk-3b

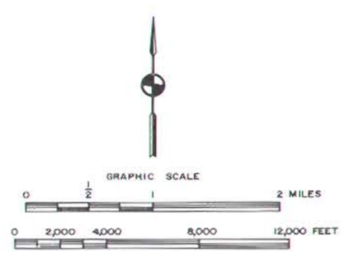
EXISTING SEWAGE TREATMENT FACILITIES
- PUBLIC
- NONINDUSTRIAL (PRIVATE)
- INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES
- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION

FECAL COLIFORM COUNTS IN MFFCC/100ml
- LESS THAN 400
- 400 - 999
- 1,000 - 1,999
- GREATER THAN 1,999
- NO DATA FOR INTERPRETATION

1975

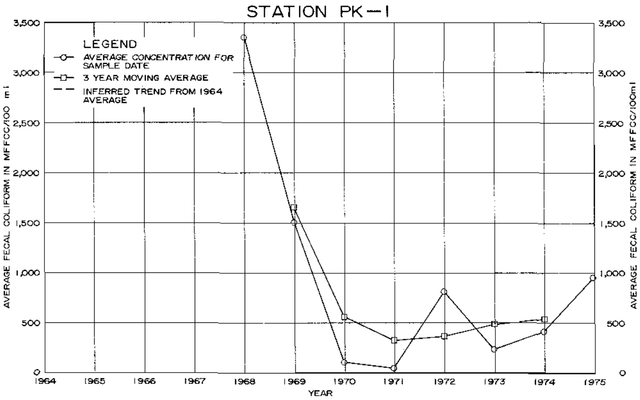


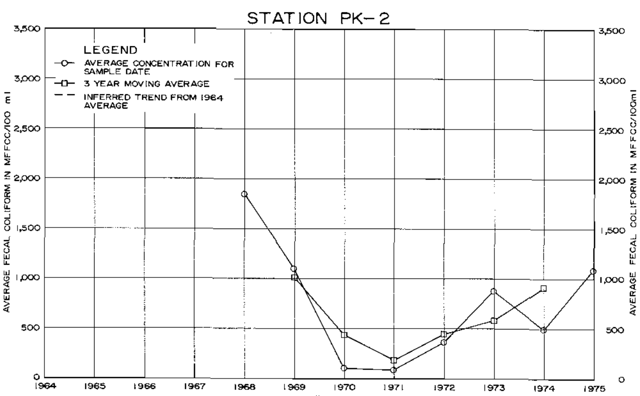


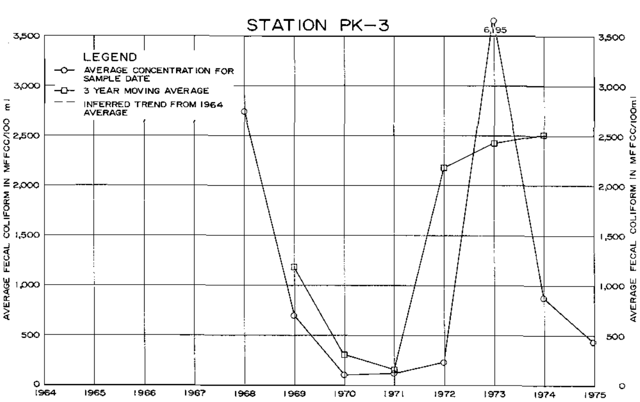
A comparison of fecal coliform counts recorded in 1968 and 1975 indicated that sampling station Pk-2 on Pike Creek tributary to the Pike River exhibited an increase in fecal coliform counts, while station Pk-2 on Pike Creek tributary to the Pike River exhibited an increase in fecal coliform counts, while stations Pk-3 and Pk-4 showed a decrease in fecal coliform counts. No significant change in fecal coliform counts was recorded at sampling station Pk-1. The maximum fecal coliform count recorded was 12,000 MFFCC/100 ml at sampling station Pk-3. The minimum recorded fecal coliform count recorded was 10 MFFCC/100 ml also at station Pk-3.

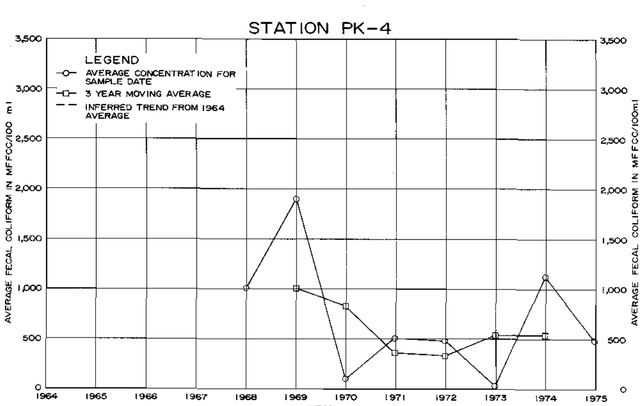
Source: SEWRPC.

Map 59 (continued)









6.0 to 9.0 standard units prescribed for recreational use, maintenance of fish and aquatic life, and restricted use. No trend in pH variation of the samples collected in August 1964 through 1975 was observed.

Specific Conductance: Specific conductance, a measure of total dissolved ions in water, was in the range of 313 to 1,455 umhos/cm at 25°C for the four locations on Pike River and Pike Creek on the August days sampled during the period from 1968 through 1975. The highest specific conductance value was found at sampling station Pk-2 in August 1970. With the exception of the samples collected during or after a rain (i.e., 1968, 1969, and 1972), the water samples indicated a slight decrease in the specific conductance over the past eight years at the Pike River stations Pk-1 and Pk-4 as well as the Pike Creek sampling station Pk-3 located near the confluence point of the Creek with the Pike River. At Pike Creek location Pk-2, the specific conductance values remained the highest when compared to the samples from the other locations in the Pike River watershed for each year. No trend in specific conductance values was found over the past eight years at sampling station Pk-2.

Temperature: As indicated in Tables 157-160, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through August 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected in eight sampling periods from the four Pike River watershed sampling locations during August 1968 through 1975 were analyzed for soluble orthophosphate concentrations, and a range of 0.05 to 0.82 mg/l of soluble orthophosphate as P was obtained. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.08 to 0.80 mg/l as P was obtained. The high ratio—ranging from 0.7 to 1.0—of soluble orthophosphate to total phosphorus in the water samples indicates that most of the phosphorus is readily available for the growth of aquatic plants in Pike River and Pike Creek. Although not enough samples were available in the four years of data to characterize the trends in total phosphorus concentrations with time—especially with the 1972 sample having been taken soon after a heavy rain—the concentrations are many times higher than required for excessive algal growth. A maximum limit of 0.10 mg/l of total phosphorus as P is generally held to be allowable for prevention of nuisance growth of algae and other aquatic plants in flowing waters. Of the 32 water samples collected from Pike Creek and Pike River, 30 samples had total phosphorus levels higher than 0.10 mg/l as P.

Although no flow information is available for the sampling sites on the days water samples were collected, the flow measurement by the U. S. Geological Survey at a location 0.9 miles downstream from sampling station Pk-1 on the Pike River near Racine indicates a significant variation in the flow over the past four years on the sampling days. The flow measurements on the Pike River at USGS-Pk-3b are plotted in Figure 151. Since the relative flow of Pike

Creek to Pike River is not known, it is not possible to calculate loadings of total phosphorus at USGS-Pk-3b with the available chemical data. However, total phosphorus loadings to the watershed as determined by land use information are discussed in Chapter VI of Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin.

Nitrogen: The total nitrogen concentrations in the Pike River water samples collected in August during the period from 1972 through 1975 were found to be in the range of 0.95 to 7.48 mg/l as N; and, of these, 1 to 13 percent was present as nitrite-nitrogen, 2 to 25 percent as ammonia-nitrogen, 36 to 70 percent as nitrate-nitrogen, and 14 to 50 percent as organic-nitrogen. Thus 43 to 77 percent of the total nitrogen content of the Pike River water samples was in the readily available forms of nitrate-nitrogen and ammonia-nitrogen. Nitrates are obtained as the end product of aerobic degradation of proteinaceous materials (organic-nitrogen); nitrites are the byproducts of bacteriological action upon ammonia and nitrogenous substances; and ammonia is the chief decomposition product from plant and animal proteins. The presence of ammonia-nitrogen in the stream water constitutes chemical evidence of organic pollution of recent origin. In the presence of oxygen, ammonia is transformed into nitrite and ultimately into nitrate. The concentrations of ammonia-nitrogen in the Pike River and Pike Creek sampling sites ranged from 0.03 to 1.49 mg/l as N, which is approximately 60 percent of the known toxic level of 2.5 mg/l for ammonia-nitrogen as N. However, on 11 of the 32 sampling dates, ammonia-nitrogen did exceed 0.2 mg/l as N, the level generally held to be indicative of lakes and streams which are affected by pollution.

Nitrate-nitrogen concentrations in the Pike River watershed ranged from 0.37 to 4.9 mg/l as N. Surface runoff from fields where there have been excessive or improper applications of natural or artificial fertilizers contributes significant quantities of nitrate to the streams. Nitrates also are present in the treated municipal wastes and enter the receiving streams with the discharged effluent. For the samples collected at sampling locations Pk-1 through Pk-4 on the Pike River and Pike Creek, the concentrations of nitrate-nitrogen remained higher than 0.30 mg/l in all of the samples collected in August during the periods from 1968 through 1975.

Organic-nitrogen accounts for 14 to 50 percent of the total nitrogen in the samples collected in the Pike River watershed, and is contributed by amino acids, proteins, and polypeptides, all products of biological processes. The presence of organic nitrogen is directly related to the discharge of organic wastes such as sewage or plant and animal decay products. The eight-year average of organic-nitrogen content was approximately 1.0 mg/l at all four locations. The relatively high organic-nitrogen concentrations contributed to the reduction of dissolved oxygen concentrations since the oxidation step in the decomposition of organic-nitrogen compounds utilizes the oxygen present in the water. No attempt was made to evaluate the total nitrogen, since only four years of data (1972-1975) are available, with the 1972 sample having been taken soon after a heavy rain. However, the estimated loadings to the watershed are discussed in Chapter VI of Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin.

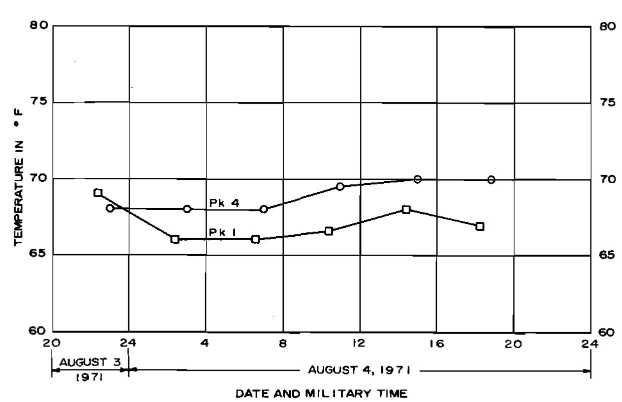
Biochemical Oxygen Demand: The Commission water quality monitoring program did not include the measurement of biochemical oxygen demand for the years 1965 through 1975. No other biochemical oxygen demand data are available from the other sources to study the trend in the biochemical oxygen demands over the past decade in the Pike River watershed.

Diurnal Water Quality Changes: Figures 152-155 illustrate the diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low-flow conditions on August 4, 1971, at the Pike River sampling stations. Water temperature ranged from a low of 66.0°F and 60.5°F during the early morning hours on August 4 to a high of 69.0°F and 70.5°F during the early evening hours at sampling stations Pk-1 and Pk-4, respectively, on Pike River. The recorded diurnal water temperature fluctuations of approximately 10°F were probably due to corresponding diurnal variations in air temperature and solar radiation. Chloride concentrations ranged from a high of 28 and 39 mg/l during the early morning hours to a low of 19 and 31 mg/l during the evening at sampling stations Pk-1 and Pk-4 on the Pike River, respectively. The concentrations of dissolved oxygen varied from a low of 2.4 and 6.0 mg/l during the early morning hours to a high of 9.2 and 7.2 mg/l in the late evening hours at Pk-1 and Pk-4, respectively, on the Pike River.

The variation in dissolved oxygen concentrations can be attributed to the net effects of respiration and photosynthesis by algae and other aquatic plants. The observed diurnal variations of dissolved oxygen concentrations

Figure 152

DIURNAL VARIATIONS IN TEMPERATURE AT SAMPLING STATIONS PK-1 AND PK-4 IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

were greater at sampling station Pk-1 located near the source of the River than at sampling station Pk-4 located near the mouth of the River, indicating probably combined effects of the discharges of oxygen-demanding substances above sampling station Pk-1 and the dilution effect of Lake Michigan seiche.

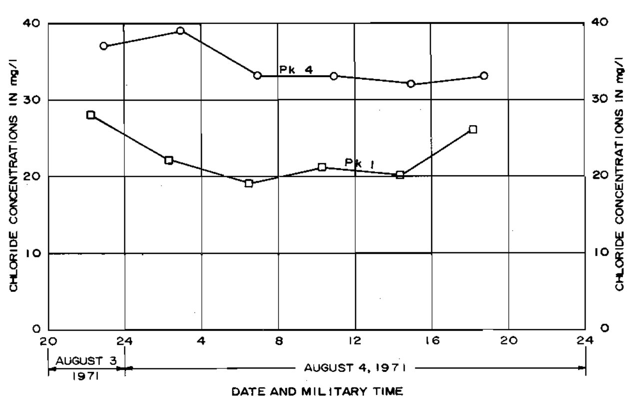
The hydrogen ion concentrations (pH) varied from a low of 7.5 and 8.4 standard units during the morning hours to a high of 8.3 and 8.6 standard units in the late evening of August 10, 1971, at the Pike River stations Pk-1 and Pk-4, respectively. The uptake of carbon dioxide during photosynthesis and the release of carbon dioxide during respiration by aquatic plants accounted for these variations. As was the case with dissolved oxygen, the diurnal variation of pH was higher at sampling station Pk-1 than at sampling station Pk-4, indicating the possibility that sources of the variation of dissolved oxygen and pH, such as photosynthetic organisms, were the same.

In Pike Creek, a tributary to the Pike River (see Figures 156-159), water temperatures ranged from a low of $60.5^{\circ}F$ and $63.5^{\circ}F$ during the early morning hours of August 4, 1971, to a high of $70.5^{\circ}F$ and $75.0^{\circ}F$ during the early evening hours of the same day for sampling stations Pk-2 and Pk-3 at Pike Creek, respectively. The recorded diurnal water temperature fluctuations at these two locations probably were caused by corresponding diurnal variations in air temperature and solar radiation. Chloride concentrations ranged from high values of 61 and 32 mg/l to low values of 25 mg/l during the six sampling surveys at sampling stations Pk-2 and Pk-3, respectively, on August 4, 1971. The diurnal variation of chloride remained within seven units at sampling station Pk-3 located on Pike Creek, 0.05 miles from its confluence with Pike River. On the other hand, there was a change of 36 mg/l of chloride over a 24-hour period at sampling station Pk-2. The diurnal variation of chloride at sampling station Pk-2 is most likely associated with malfunctioning septic tanks and agricultural and livestock operations upstream from the sampling station.

The concentrations of dissolved oxygen varied from lows of 1.5 and 3.9 mg/l during the early morning hours to high values of 14.5 and 7.1 mg/l in the late evening hours at sampling stations Pk-2 and Pk-3 in Pike Creek, respectively. The variation of 13 mg/l of dissolved oxygen at sampling station Pk-2, as compared to 3.0 mg/l at sampling station Pk-3 over a 24-hour period, are once again likely to be due to the effects of low flow and greater concentrations of photosynthetic organisms. The low dissolved oxygen corresponded to the high chloride

Figure 153

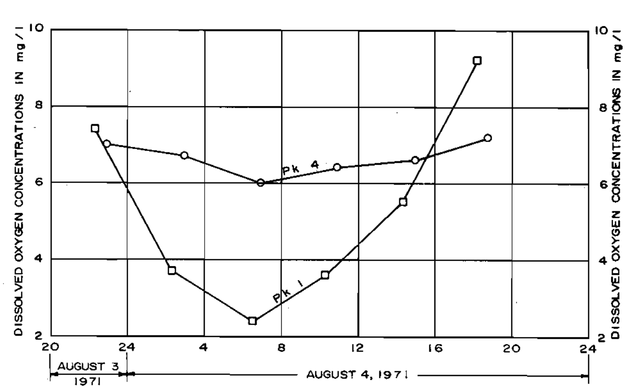
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS PK-1 AND PK-4 IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

Figure 154

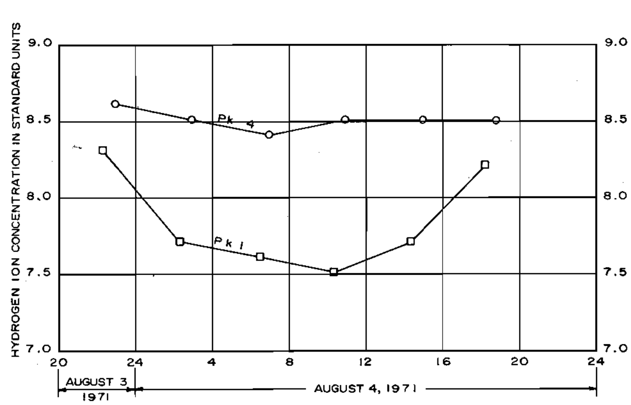
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATIONS PK-1 AND PK-4 IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

Figure 155

DIURNAL VARIATIONS IN HYDROGEN ION (pH) CONCENTRATIONS AT SAMPLING STATIONS PK-1 AND PK-4 IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

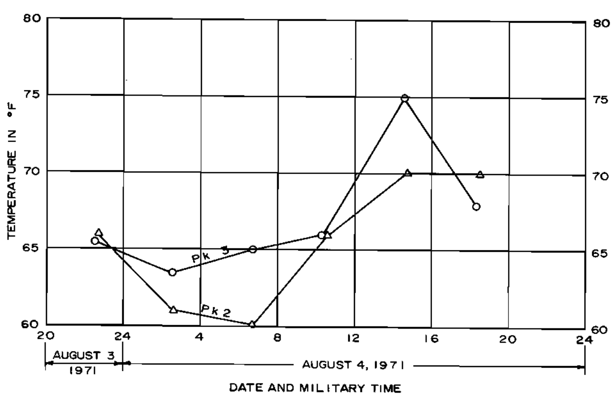
concentration at sampling station Pk-2, buttressing the assumption of significant water quality effects of the upstream agricultural practices in septic tanks.

The hydrogen ion concentrations (pH) on Pike Creek varied from lows of 7.6 and 7.7 standard units to high values of 8.3 and 8.1 standard units at sampling stations Pk-2 and Pk-3, respectively.

The diurnal fluctuations in water quality may be such that the average level of concentrations of key parameters meets the established water quality standards and the instantaneous levels during the daily cycle do not meet the standards. For example, the average of six dissolved oxygen concentration values on August 4, 1971, were 5.3 and 8.0 mg/l at sampling stations Pk-1 and Pk-2 on the Pike River and Pike Creek, respectively, and are above the applicable minimum standard of 5.0 mg/l for recreational use and the preservation of fish and aquatic life at sampling station Pk-1 on Pike River and well above the minimum standard of 2.0 mg/l applicable for restricted use at sampling station Pk-2 on Pike Creek. However, substandard oxygen levels of less than 5.0 and 2.0 mg/l were measured at sampling stations Pk-1 and Pk-2, resptctively, in the early morning samples.

Figure 156

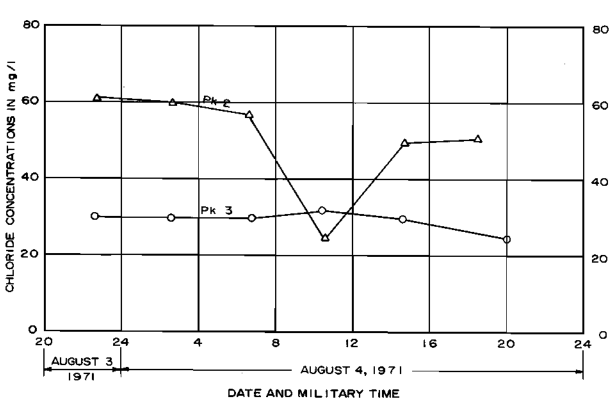
DIURNAL VARIATIONS IN TEMPERATURES AT SAMPLING STATIONS PK-2 AND PK-3 ON PIKE CREEK IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

Figure 157

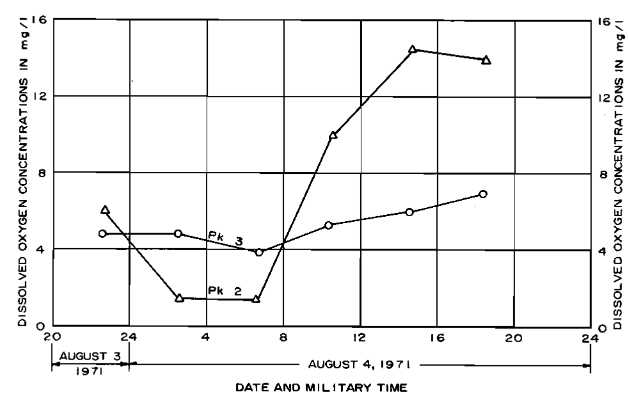
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS PK-2 AND PK-3 ON PIKE CREEK IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

Figure 158

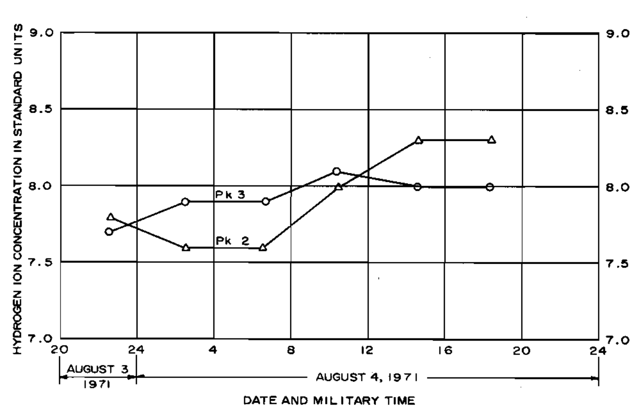
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATIONS PK-2 AND PK-3 ON PIKE RIVER IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

Figure 159

DIURNAL VARIATIONS IN HYDROGEN ION (pH) CONCENTRATIONS AT SAMPLING STATIONS PK-2 AND PK-3 ON PIKE CREEK IN THE PIKE RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 3-4, 1971



Source: SEWRPC.

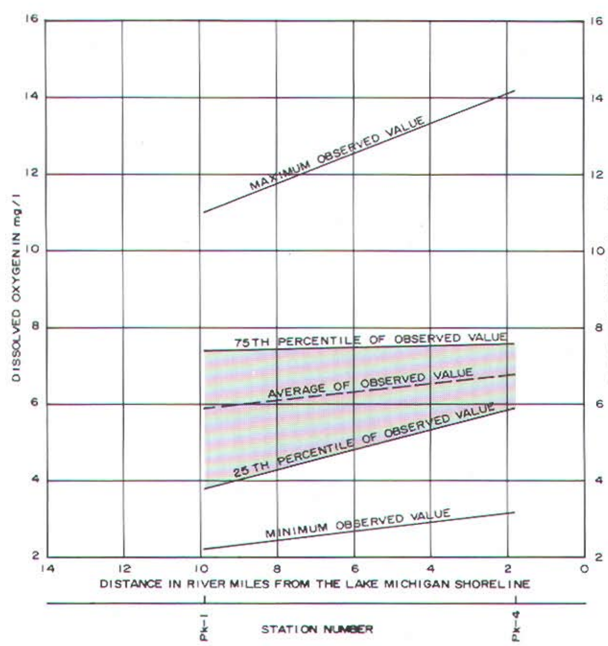
Spatial Water Quality Changes: The water quality surveys clearly indicate water quality changes within the watershed stream system due to a combination of human activities and natural phenomena. Figures 160-165 show the spatial water quality variations along the main stem of the Pike River and Figures 166-171 show spatial water quality variations along Pike Creek as recorded under low-flow hydrologic conditions during August for the period of 1964 through 1975. The illustrations include profiles of the average values of dissolved oxygen, chloride, specific conductance, and fecal coliform counts obtained over the past eight year sampling survey, at two Pike River main stem sampling stations and two Pike Creek sampling stations. Data presented and illustrated profiles for total nitrogen and total phosphorus represent four years of data collection in 1972-1975. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter, thus dividing the data into three categories: (1) the range of the 25 percent of the samples near the minimum values, (2) the range of the middle 50 percent of the samples, and (3) the range of the 25 percent of the samples near the maximum.

Pike River: Figure 160, which presents the range of spatial dissolved oxygen variation in the Pike River main stem, indicates an improved water quality in the downstream reaches (Pk-4) compared to headwater areas (Pk-1). The improved water quality conditions, as measured by the higher dissolved oxygen levels at sampling station Pk-4, are at least partly attributable to the seiche and dilution effects of Lake Michigan waters at this location. The average and the range of 25 to 75 percentile of fecal coliform counts, total-phosphorus, and total-nitrogen concentrations decreased from the sampling station Pk-1 to the sampling station Pk-4. The decrease in the above-mentioned three parameters near the mouth of the River (Pk-4) is once again due to the seiche and dilution effects of Lake Michigan waters on Pike River water quality. Concurrent increases in chloride and specific conductance are noted at sampling station Pk-4 compared with the data at sampling station Pk-1, 8.1 miles upstream. The increased chloride concentrations at sampling station Pk-4, despite possible dilution effect by Lake Michigan waters, are likely due to the Pike Creek flow contributions entering the Pike River between sampling stations Pk-1 and Pk-4. The higher concentrations of chloride in Pike Creek arise from the discharge of municipal and industrial waste effluents into the stream.

Pike Creek: The water quality of Pike Creek as measured by dissolved oxygen concentrations improved from sampling station Pk-2 located near the source of the Creek to sampling station Pk-3 located 0.05 miles upstream from the confluence of Pike Creek with the Pike River. Figures 167 and 169 also indicate the improved water quality

Figure 160

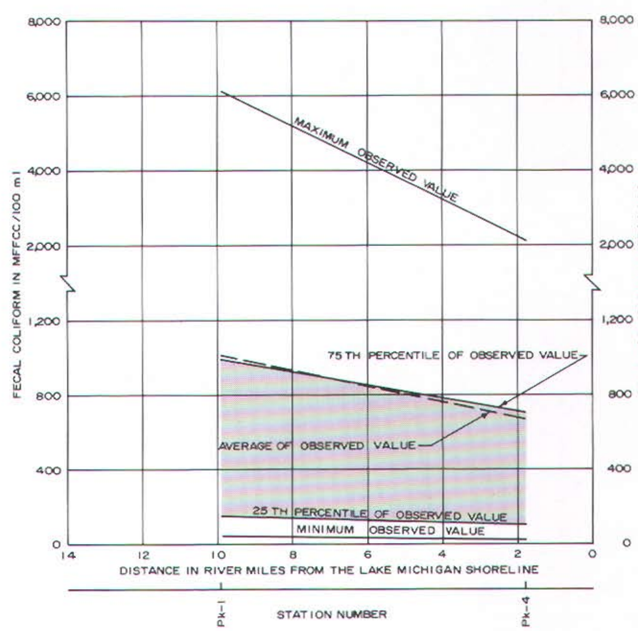
SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 161

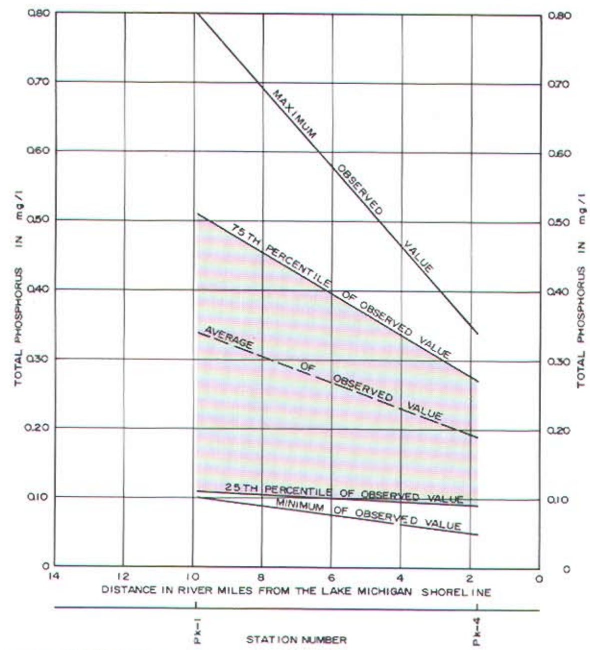
SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 162

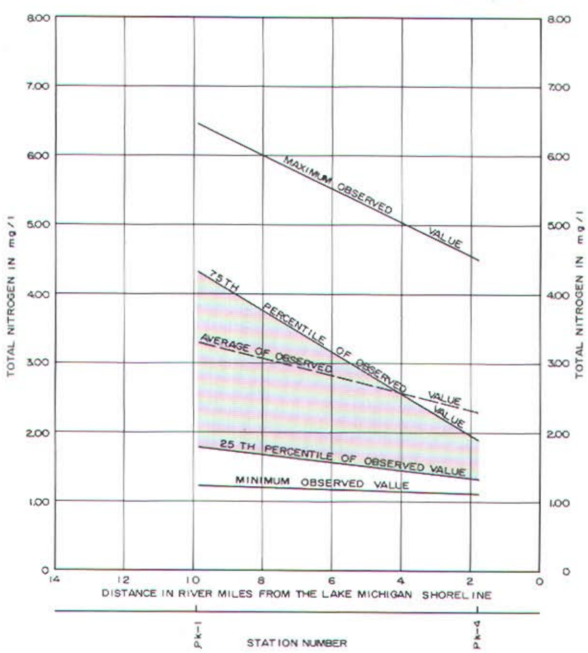
SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE PIKE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 163

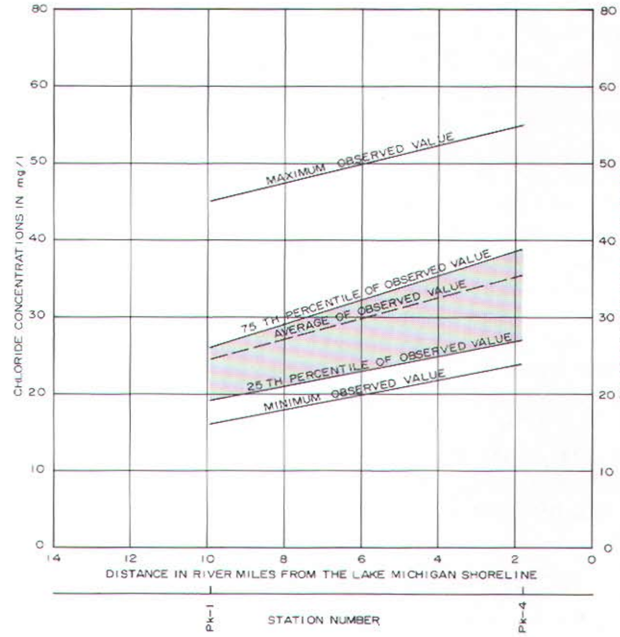
SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE PIKE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 164

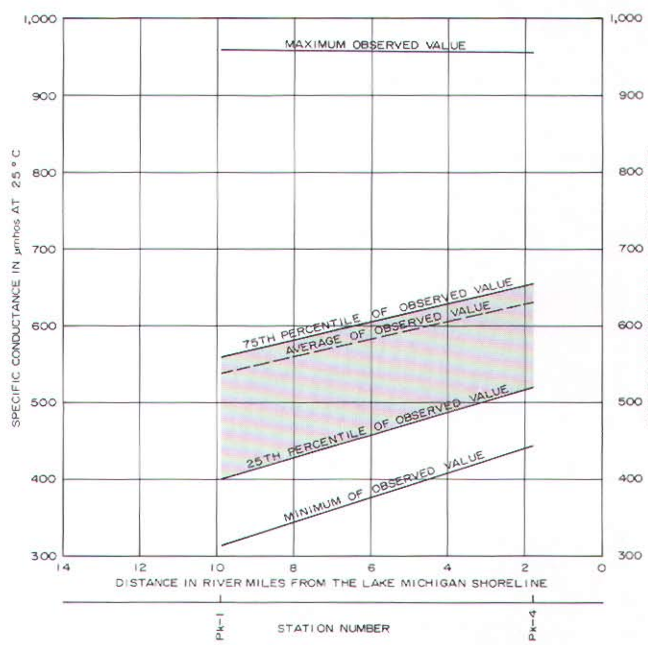
SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 165

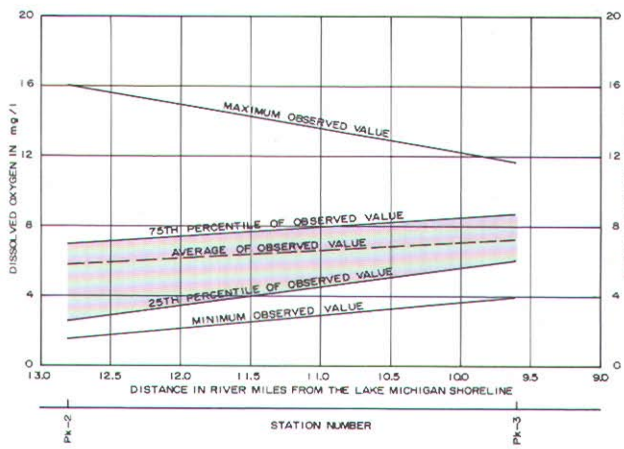
SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 166

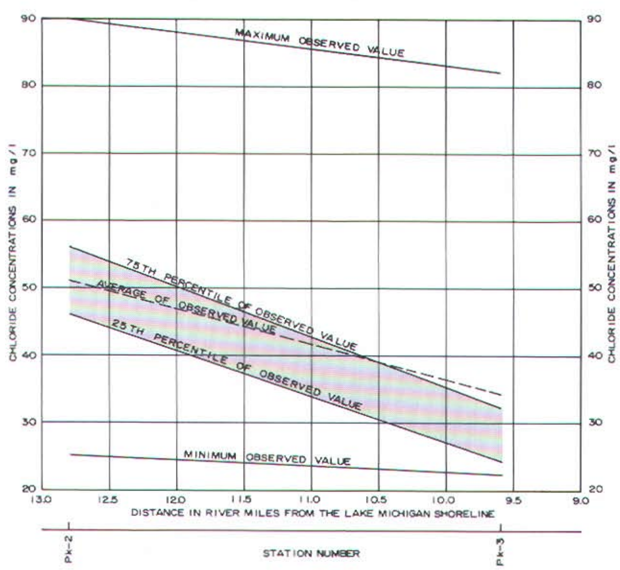
SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN PIKE CREEK IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 167

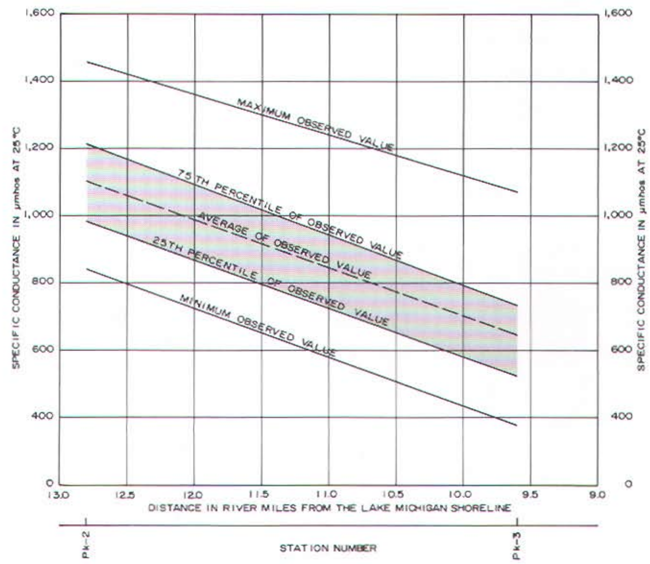
SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN PIKE CREEK IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 168

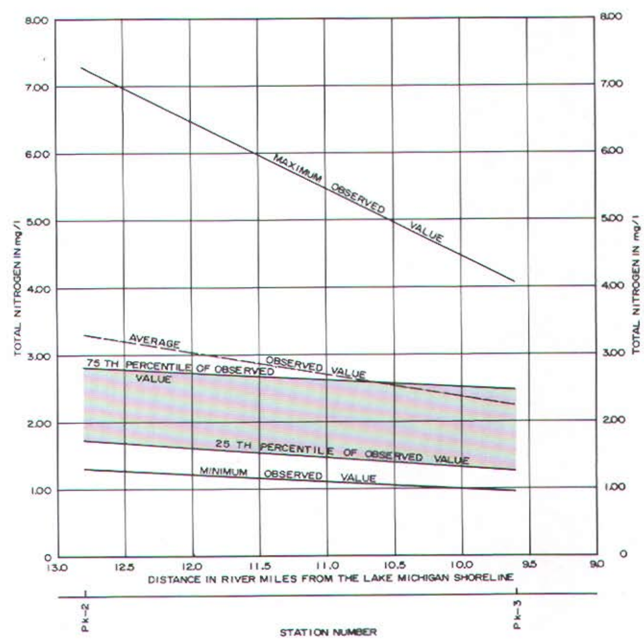
SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN PIKE CREEK IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

Figure 169

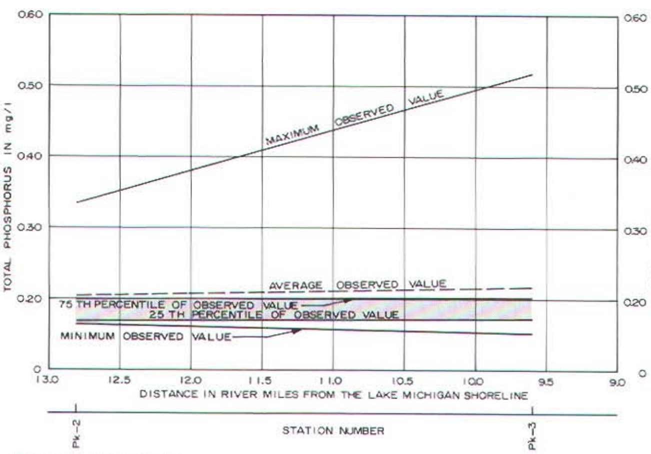
SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN PIKE CREEK IN THE PIKE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 170

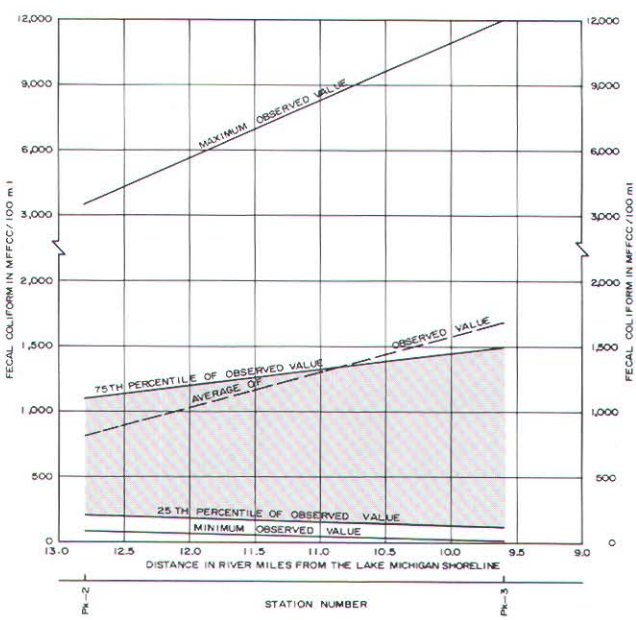
SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN PIKE CREEK IN THE PIKE RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Figure 171

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN PIKE CREEK IN THE PIKE RIVER WATERSHED: 1964-1975



Source: SEWRPC.

of Pike Creek at sampling station Pk-3 when compared to Pk-2, as measured by the concurrent decrease in total nitrogen, chloride, and specific conductance values. The fecal coliform counts and total phosphorus on August 12, 1964, was also somewhat in excess of the seven day-10 year low flow. On August 20, 1975, the flow of Pike River near Racine was 20 cfs, which is considerably higher than 1.2 cfs, the recorded seven-day minimum flow for the period of record of 1972-1975.

The comparison of observed water quality and adopted water quality standards was based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels which have been adopted by the Commission. In the analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained in the four or six samples taken over the approximate 24-hour sampling period, did not fall within the specified limits. That is, water quality was assessed on the basis of individual determinations made of each parameter as opposed to using average values of all samples taken over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month nor increased slightly from sampling station Pk-2 to sampling station Pk-3, despite the indication of improved water quality from Pk-2 to Pk-3 as measured by the other water quality parameters. The inconsistency in fecal coliform counts and total-phosphorus values indicate the possibility of multiple and dispersed sources of these pollutants in Pike Creek between sampling stations Pk-2 and Pk-3.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples between 1964 and 1975 were used to assess the quality of the Pike River stream network. This provides for an assessment of water quality as it existed on the days sampled in 1964 and 1975 and allows for an evaluation of water quality changes compared to the water quality standards that support the recreational use objectives and the fish and aquatic life use objectives established for the Pike River in Kenosha County and the restricted use objectives established for Pike Creek. No data are available for an additional reach of the Pike River in the headwaters area in Racine County to compare with the applicable water quality standards established for restricted use objectives on that reach of stream. A comparative analysis must consider the concurrent hydrological conditions since the water quality standards are not intended to be satisfied under all streamflow conditions. Although no flow data are available at the sampling sites of Pike River and

Pike Creek, flow measurements for the years 1972-1975 at USGS-Pk-3b located on the Pike River downstream from the confluence with Pike Creek indicate that the flow pattern was similar to that of the Root River near Franklin. Since the flow of the Root River at Franklin on the days of sample collection remained low—but somewhat above the seven day-10 year low flow—for the years 1964 and 1975, it was assumed that the flow in Pike River and Pike Creek shall the count exceed a monthly geometric mean of 400 colonies per 100 ml, in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standard associated with the applicable use objective was assumed to be violated during a particular survey at a sampling location if any of the fecal coliform counts obtained at that location exceeded the applicable standard limits.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality requirements of the adopted standards are summarized on Map 60. A color coding scheme is used on Map 60 to indicate which of the standards are exceeded along what stream reaches. For the main stem of the Pike River in Kenosha County, designated for recreational use and preservation of fish and aquatic life, the water quality during the survey satisifed the temperature and pH standards throughout the watershed. Substandard dissolved oxygen levels were found at sampling stations Pk-1 and Pk-4. For Pike Creek, designated for restricted use, the water quality during the August 1964 survey satisfied the temperature, pH, and dissolved oxygen standards. Since no fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made in the 1964 samples, no comparison to the nutrient contents and bacteriological safety of the Pike River and Pike Creek waters for 1964 can be made. However, since the total coliform counts in the Pike River were in the range of 12,000-50,000 MFCC/100 ml, it is probable that the fecal coliform counts were higher than the permissible limit of 400 MFFCC/100 ml. In Pike Creek, it is also probable that the applicable limit of 2,000 MFFCC/ 100 ml was met since the observed levels of total coliform at sampling stations Pk-2 and Pk-3 were 9,000 and 4,000 MFCC/100 ml.

Water Quality-1975: For Pike River in Kenosha County, intended for recreational use and for preservation of fish and aquatic life, Map 61 indicates that water quality conditions during August 1975 were such that the ammonia, temperature, and pH standards were satisfied while substandard levels of dissolved oxygen, nitrate, total phosphorus, and fecal coliform observations were recorded. On Pike Creek, intended for restricted use, Map 61 indicates that water quality conditions during August 1975 were such that the recommended level for ammonia, and the standards for temperature, dissolved oxygen, fecal coliform, and pH were satisfied, while levels of nitrate and total phosphorus were recorded in excess of the levels recommended by the Commission. The total phosphorus concentrations were in excess of 0.10 mg/l as P in Pike Creek and in the Pike River at sampling station Pk-1. The total phosphorus concentrations were less than 0.1 mg/l as P in one of the two samples collected at Pk-4 on August 1975. Total phosphorus levels in excess of 0.10 mg/l as P and nitrate-nitrogen in excess of 0.30 mg/l as N on Pike Creek and portions of the Pike River may be attributed in part to agricultural runoff and in part to the discharges from the two municipal sewage treatment plants located in the watershed.

Concluding Remarks—Pike River Watershed

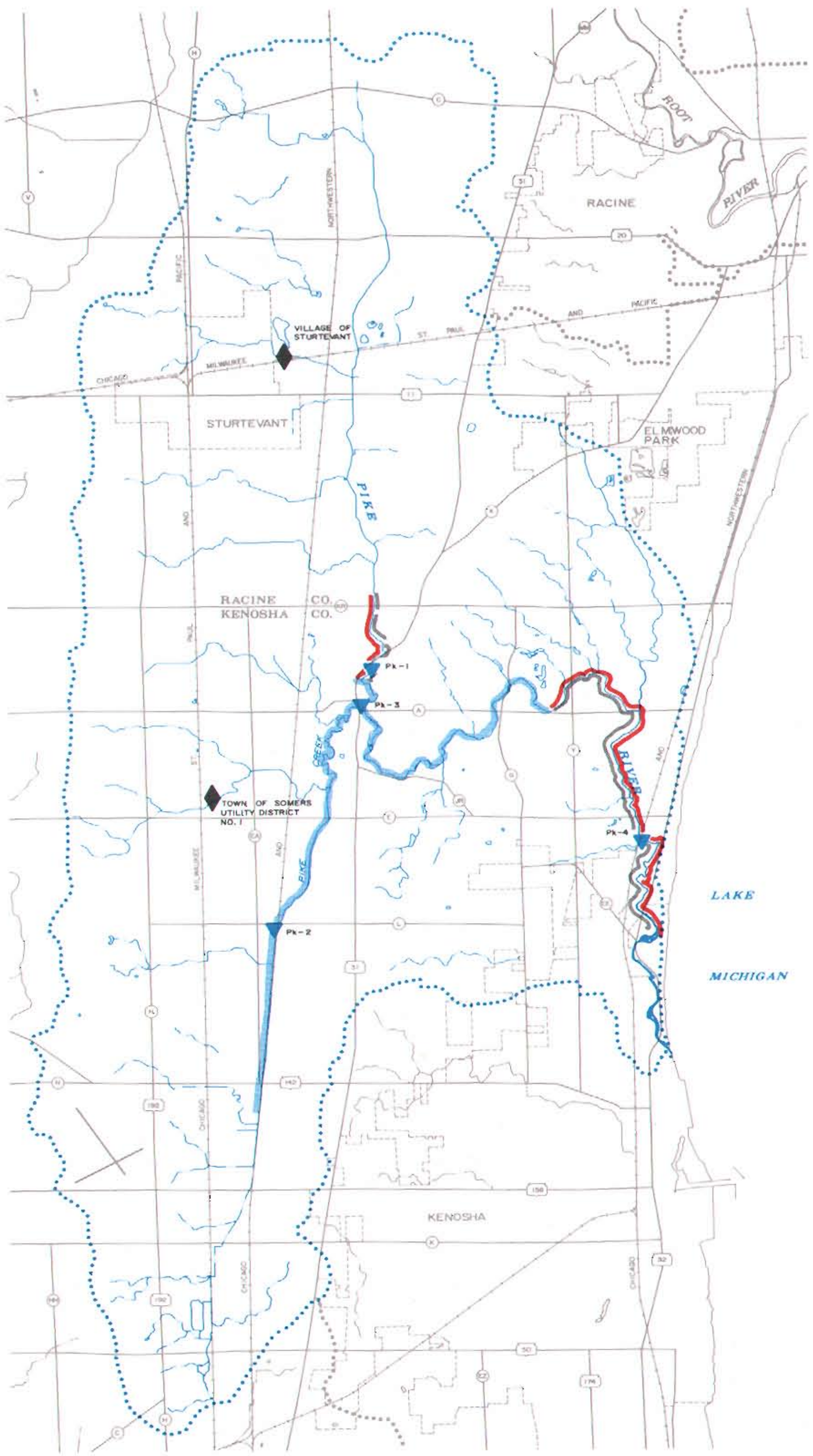
The Pike River watershed is located in the southeast portion of the Region, rising in Racine County and flowing 16.6 miles south and east to enter Lake Michigan in the City of Kenosha in Kenosha County. The Pike River watershed ranks ninth in population and eighth in size of the 12 watersheds in the Region. An estimated 27,800 persons reside within this watershed, which has a total area of 50.66 square miles and an average population density of 546 people per square mile.

One nonindustrial privately owned sewage treatment facility, and two publicly owned sewage treatment facilities are located within the watershed and discharge treated effluents into the streams of the watershed. In addition, there are three known sanitary sewer bypasses and five crossovers that discharge raw sewage into the streams during sewer surcharges. Seven industrial and commercial waste discharge points from five industries are known to exist in the watershed. The Commission 1970 land use inventory indicates that 75 percent of the watershed is devoted to agriculture, 22 percent to urban use, and the remaining 3 percent is occupied by streams and wetlands. Although 42 percent of the shoreline area within 1,000 feet of the streams of the watershed is presently in some urban land use, runoff from the agricultural areas of the watershed is thought to have a significant effect on water quality.

The 1964-1965 Commission water quality benchmark study included four sampling stations on the Pike River watershed. Water quality data for 1964-1965 from the two sampling stations on the Pike River showed the chloride levels were higher than the normal background concentration, and reflected a chloride impact upon the stream from human sources. Substandard concentrations of dissolved oxygen occurred during the summer months at both locations on the main stem of the Pike River. The two sampling stations situated on Pike Creek also exhibited chloride concentrations higher than the background levels. These higher chloride concentrations may be attributed to effluent from the Town of Somers Utility District No. 1. High total coliform counts were found at all four sampling locations. Effluent from the municipal sewage treatment plants, in particular, but also drainage from agricultural land and wastes from domestic animals are some of the probable sources for total coliform contamination in the streams of the watershed. The specific conductance values were high at all four locations, with the highest values at tne Pike River sampling stations during the winter months. The pH

Map 60

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE PIKE RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

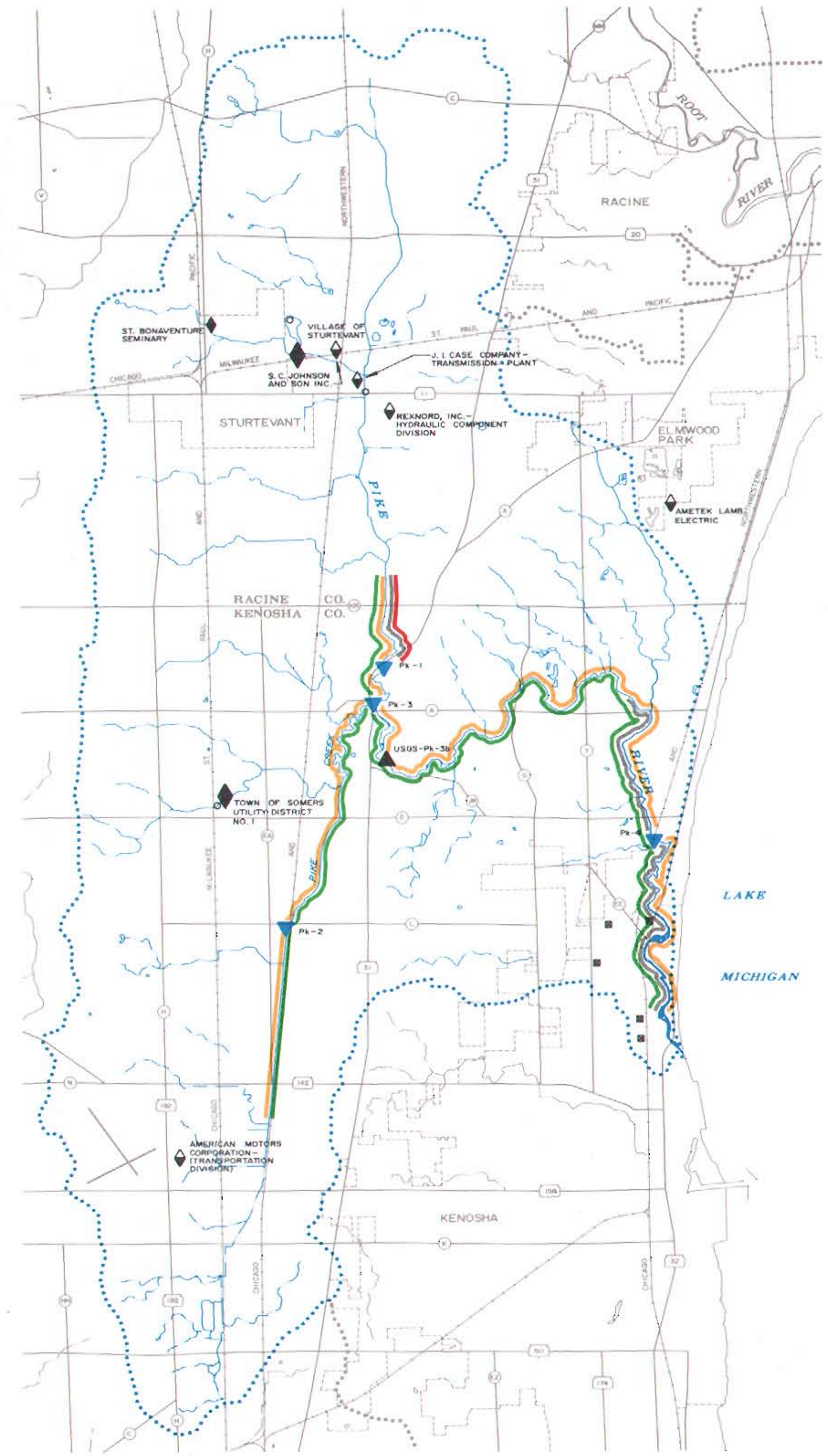


A comparison of stream water quality in the Pike River watershed, as sampled in August 1964, to the adopted water quality standards indicated that all standards were satisfied for sampling stations Pk-2 and Pk-3 on Pike Creek designated for restricted use. Substandard levels of dissolved oxygen and total coliform, which includes fecal coliform, were noted at sampling stations Pk-1 and Pk-4, designated for recreational use.

Source: SEWRPC.

Map 61

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE PIKE RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Pike River watershed, as sampled in August 1975, to the adopted water quality standards indicated that standards for fecal coliform and the recommended levels of total phosphorus and nitrate-nitrogen were not met at sampling station Pk-1 and Pk-4 designated for recreational use. Sampling station Pk-4 also violated the standard for dissolved oxygen. Sampling stations Pk-2 and Pk-3 located on Pike Creek, designated for restricted use, exceeded the recommended levels for total phosphorus and nitrate-nitrogen.

Source: SEWRPC.

remained within the normal range of 6.0-9.0 standard units and the temperature did not deviate from the prescribed standard of 89°F in all of the samples.

The water quality monitoring survey carried out by the Commission from 1965 through 1975 included collection of samples at the four stations originally established in the Pike River watershed. The dissolved oxygen content of samples collected at the Pike River stations indicated that the water quality improved slightly over the past decade, probably reflecting improved operation and maintenance at the Village of Sturtevant sewage treatment facilities. The applicable dissolved oxygen standards, however, still are not being met. In Pike Creek, near its confluence with Pike River, the dissolved oxygen concentrations remained fairly constant. However, near the source of Pike Creek, no trend in the change in dissolved oxygen concentrations was observed. The observed variation in water quality at Pike Creek, as measured by dissolved oxygen, is considered attributable to the variation in flow of Pike Creek which is dependent on precipitation and flow from the industry and municipal treatment facilities located in the subwatershed. The chloride and fecal coliform levels showed a decrease over the past decade at all four locations, with the exception of the samples collected in 1968, 1969, and 1972, which were preceded by rain, according to precipitation records of the Racine Department of Air Pollution control. The nutrient concentrations, as measured by nitrate-nitrogen and total phosphorus, remained high, being in excess of the recommended levels of 0.30 mg/l as N and 0.10 mg/l as P, respectively, in all the samples collected over the past eight years with one exception at station Pk-4 in the August 1975 sample. The diurnal water quality data in Pike River and Pike Creek indicate a spectrum of dissolved oxygen concentrations from a low of 2.4 and 1.5 to a high of 9.2 and 14.5 mg/l over a 24-hour period, reflecting the effects of photosynthesis and respiration by aquatic plants. In addition to exhibiting marked diurnal fluctuations, Pike River water quality is characterized by spatial variations. Water quality improved slightly from the headwaters areas of the Pike River to downstream near the mouth of the River at Lake Michigan as measured by the decrease in fecal coliform counts, total nitrogen, and total phosphorus concentrations and increase in the dissolved oxygen concentrations at sampling station Pk-4 near the mouth when compared to the values observed at sampling station Pk-1 located in the headwaters areas. Similarly, the water quality improved in Pike Creek, as shown by a comparison of Pk-2 near the source and Pk-3 near the confluence of Pike Creek and Pike River.

The water quality of the Pike River in Kenosha County, designated for recreational use and for the preservation of fish and aquatic life, although fairly constant over the past decade does not currently meet the water quality standards set by the Wisconsin Department of Natural Resources for dissolved oxygen and fecal coliform counts. Total phosphorus and nitrate-nitrogen concentrations also were found to be higher than the recommended levels adopted by the Commission with the exception of the total phosphorus values of 0.05 mg/l at sampling station Pk-4 on the Pike River. For Pike River in Racine County, designated for restricted use, no water quality data are available to compare with the established standards. For Pike Creek, also designated for restricted use, water quality levels measured in 1975 did meet the adopted standards for dissolved oxygen, pH, fecal coliform, ammonia, and temperature; and the total phosphorus and nitrate concentrations were higher than the levels of 0.10 mg/l as P and 0.30 mg/l as N adopted by the Commission for the avoidance of nuisance aquatic plant growth in receiving waters which ultimately flow to Lake Michigan.

ROCK RIVER WATERSHED

Regional Setting

The Rock River watershed is a natural surface drainage unit 612.41 square miles in areal extent located in the western portion of the Southeastern Wisconsin Region. The watershed is the second largest of the 12 major natural surface water drainage units within the Region, encompassing about 23 percent of the total land and water area of the Region. The watershed is only partly contained in the Region, the main stem of the Rock River originating in the marshy areas of southern Fond du Lac County, outside of the Region, and flowing southerly through Dodge, Jefferson, and Rock Counties, all outside of the Region. Seventeen tributaries of the Rock River, however, originate in the Region and drain that portion of the Rock River basin located within the Region. The Rock River watershed within the Region occupies a basin of irregular topography and extends into three counties: Walworth, Waukesha, and Washington. The watershed is underlain by glacial deposits of diverse origin.

Eighteen first rank and second rank tributaries of the Rock River arise within the Region and Table 161 lists the location, the source, and the length of each stream reach in miles. Ten streams in the Rock River basin were included by the Commission in its water quality studies: East Branch of the Rock River, Kohlsville River, Rubicon River, Ashippun River, Oconomowoc River, Bark River, Whitewater Creek, Jackson Creek, Delavan Lake Outlet, and Turtle Creek. The East Branch of the Rock River rises at the confluence of Limestone Creek and Allenton Creek in a marshy area located about two miles southeast of the Village of Allenton and flows northwesterly to the Dodge County line. The Kohlsville River, a tributary of the East Branch of the Rock River, originates about four miles northeast of the Village of Kohlsville and flows northwesterly through Kohlsville to join the East Branch of the Rock River near the Dodge County line. The Rubicon River rises in the low marshy areas north of Pike Lake, about two miles east of the City of Hartford, and flows westerly through Hartford into Dodge County. The Ashippun River flows in a general southwesterly direction from its origin about two miles southwest of the City of Hartford. The River flows through Druid Lake and, after traversing part of Dodge County, enters the northwestern corner of Waukesha County and leaves the Region upon passing into Jefferson County. The Oconomowoc River originates in south central Washington County, about two miles northeast of Friess Lake, and flows in a general southwesterly direction through

Table 161

STREAMS IN THE ROCK RIVER WATERSHED

Stream or Watercourse	Source		Length (in miles)
	By Civil Division	By U. S. Public Land Survey	
Allenton Creek	Town of Addison	NW ¼, Section 14, T11N, R18E	2.50
Ashippun River	Town of Hartford	NE ¼, Section 26, T10N, R18E	19.10
Bark River	Town of Richfield	NE ¼, Section 25, T9N, R19E	27.10
Bluff Creek	Town of Whitewater	NE ¼, Section 14, T4N, R15E	2.00
Delavan Lake Outlet	Town of Delavan	SE ¼, Section 20, T2N, R16E	7.00
East Branch Rock River	Town of Wayne	NW ¼, Section 18, T12N, R18E	15.50
Jackson Creek	Town of Geneva	SW ¼, Section 9, T2N, R17E	7.00
Kohlsville River	Town of Barton	NE ¼, Section 7, T11N, R19E	7.90
Limestone Creek	Town of Addison	NE ¼, Section 30, T11N, R18E	5.80
Mason Creek	Town of Erin	NW ¼, Section 30, T9N, R18E	5.20
Oconomowoc River	Town of Richfield	NE ¼, Section 10, T9N, R19E	23.40
Piscasaw Creek	Town of Walworth	SW ¼, Section 19, T1N, R16E	2.20
Rubicon River	Town of Polk	NW ¼, Section 7, T10N, R19E	5.70
Scuppernong Creek	Town of Ottawa	SE ¼, Section 14, T6N, R17E	13.20
Scuppernong River	Town of Ottawa	NE ¼, Section 27, T6N, R17E	5.50
Sharon Creek	--[a]	--[a]	--[a]
Turtle Creek	Town of Richmond	NE ¼, Section 14, T3N, R15E	13.00
Whitewater Creek	Town of Whitewater	NW ¼, Section 26, T4N, R15E	4.30

[a]*Sharon Creek is intermittent in the Region.*

Source: SEWRPC.

Friess Lake, North Lake, Okauchee Lake, Oconomowoc Lake, Fowler Lake, and Lac La Belle into Jefferson County. The Bark River rises at Bark Lake in south central Washington County and flows southwesterly through Nagawicka Lake, Upper and Lower Nemahbin Lakes, and Crooked Lake into Jefferson County. Whitewater Creek originates in Rice Lake, about four miles southeast of the City of Whitewater, and flows northwesterly through Tripp Lake and Cravath Lake and through the City of Whitewater into Jefferson County. Jackson Creek originates about two miles southeast of the City of Elkhorn, flows generally westerly to Delavan Lake. Delavan Lake Outlet flows from Delavan Lake through the City of Delavan to Turtle Creek. Turtle Creek originates at Turtle Lake, located about seven miles northwest of the City of Delavan, and flows southerly and easterly to Comus Lake, past the City of Delavan, and westerly into Rock County.

The Rock River watershed within the Region is the seventh largest watershed in population and second in area of the 12 major watersheds of the Region.

Political Boundaries

Superimposed upon the natural, meandering watershed boundary is a rectilinear pattern of local political boundaries, as shown on Map 62. The Rock River watershed occupies portions of three of the seven counties within the Southeastern Wisconsin Region—Walworth, Washington, and Waukesha—and portions or all of six cities, 15 villages, and 27 towns. The area and proportion of the watershed lying within the jurisdiction of each local unit of government as of January 1, 1976, are set forth in Table 162.

Population

Population Size: The 1975 resident population of the watershed is estimated at 97,334 persons, or about 5.4 percent of the total estimated resident population of the Region. Table 163 presents the population distribution in the Rock River watershed by civil division. The population of the watershed has increased steadily since 1900.

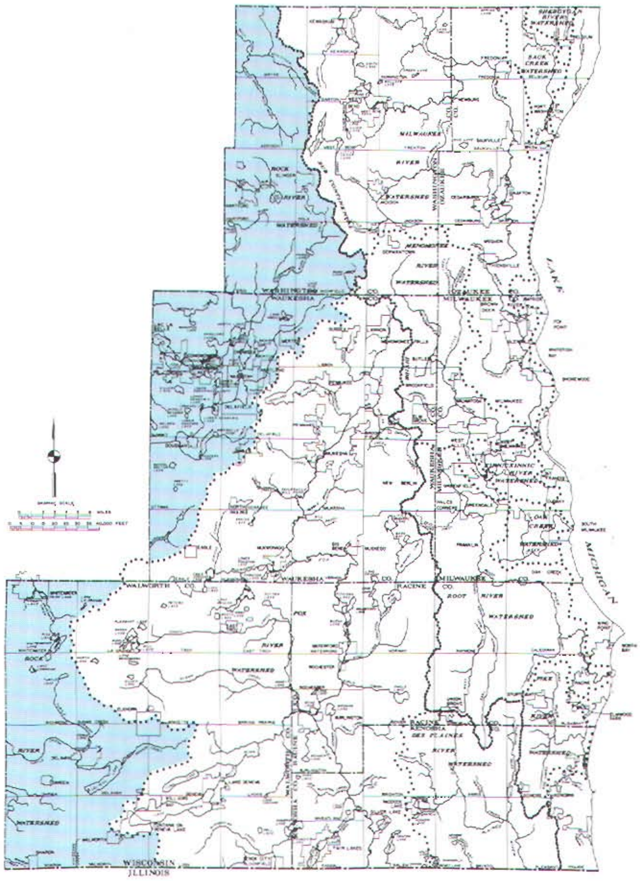
Population Distribution: The Rock River watershed, in common with much of the Region, is becoming increasingly urban, particularly around the many inland lakes located within the watershed. In 1975, about 53 percent of the residents of the watershed lived in incorporated cities and villages, comprising about 8 percent of the total area of the watershed.

Quantity of Surface Water

The surface water resources of the Rock River watershed are composed primarily of streams and lakes. A few minor ponds, wetlands, and flooded gravel pits comprise the balance; but are negligible in terms of total surface water quantity. The quantity of streamflow varies widely from season to season and from year to year, responding to variations in precipitation, temperature, soil moisture conditions, the growth cycle of vegetation, and groundwater levels. No continuous flow recording gages are

Map 62

LOCATION OF THE ROCK RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Rock River watershed within the Region has a total area of 612 square miles and comprises about 22.7 percent of the total 2,689-square-mile area of the Region. The watershed ranks seventh in population and second in size as compared to the 12 watersheds of the Region.

Source: SEWRPC.

located on the tributaries of the Rock River within the Region. The streamflow measurements made on Turtle Creek in Rock County at USGS-Rk-13 are used for evaluation of the streamflow characteristics of Turtle Creek. Table 164 summarizes the streamflow characteristics for Turtle Creek for the years 1964 through 1975. High streamflows occur principally in the late winter and early spring, usually associated with melting snow. Lower flows persist for most of the remainder of the year with occasional rises caused by rainfall.

There are 38 major lakes having surface areas of 50 acres or more located within the watershed. The major lakes have a combined surface water area of 12,167.4 acres and combined total of 140.7 miles of shoreline. Of the 38 major lakes, the deepest is Okauchee Lake in Waukesha County with a maximum depth of 94 feet. Other major lakes in the Rock River watershed with a maximum depth of 30 feet or more include Delavan Lake, Turtle Lake, and Whitewater Lake in Walworth County; Bark Lake, Druid Lake, Friess Lake, and Pike Lake in Washington County; and Ashippun Lake, Beaver Lake, Fowler Lake, Golden Lake, Hunter Lake, Lake Keesus, Lac La Belle, Lower Genesee Lake, Lower Nashotah Lake, Lower Nemahbin Lake, Middle Genesee Lake, Moose Lake, Nagawicka Lake, North Lake, Oconomowoc Lake, Pine Lake, Pretty Lake, Silver Lake, Upper Nashotah Lake, and Upper Nemahbin Lake in Waukesha County. Of the remaining 11 major lakes, LaGrange Lake in Walworth County has a maximum depth of less than four feet and Comus Lake, Cravath Lake, Loraine Lake, Rice Lake, and Tripp Lake in Walworth County have a maximum depth of less than 10 feet.

The lakes are mostly of glacial origin, formed from natural, simple, or compound depressions in the glacial deposits. The effects of the natural topography often are augmented by a low-head dam at the lake outlet. The beaches are characteristically gravel or sand on the windswept north, east, and south shores, while fine sediments and encroaching vegetation are common on the protected west shores and in the bays. Of the 38 major lakes in the Rock River watershed 10 are kettle lakes, 20 are flow-through lakes, and eight are headwater lakes.

The lake levels fluctuate over time, responding primarily to variations in precipitation, surface runoff, temperature, and groundwater levels. High lake levels occur principally in the late winter and spring, usually associated with melting snow. The location by civil division and by U. S. Public Land Survey quarter section and the salient physical characteristics of the major lakes in the Rock River watershed are presented in Table 165.

Pollution Sources

Sewage Treatment Facilities: Twelve municipal sewage treatment facilities exist in the Rock River watershed. These facilities are operated by the following local units of government: City of Delavan, City of Elkhorn, City of Whitewater, City of Hartford, Village of Slinger, Allenton Sanitary District, City of Oconomowoc, Village of Dousman, Village of Hartland, Village of Darien, Village of Sharon, and Village of Walworth. In addition to these 12 public sanitary sewage treatment facilities, there are six nonindustrial privately owned sanitary sewage treatment facilities located in the Rock River watershed; the Pike Lake State Park sewage treatment plant in the Town of Hartford; the Lake Lawn Lodge sewage treatment plant in the Town of Delavan; the Lakeland Nursing Home in the Town of Geneva; the Gigas Hillside Apartments in the Town of Delafield; St. John's Military Academy in the City of Delafield; and the Ethan Allen School in the Town of Delafield. Selected data on the 12 public sewage treatment facilities and the six nonindustrial privately owned sanitary sewage treatment facilities are presented in Tables 166 and 167. The loca-

Table 162

AREAL EXTENT OF CIVIL DIVISIONS IN THE ROCK RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
WALWORTH COUNTY			
Cities			
Delavan	3.19	- 0.52	100.00
Elkhorn	2.53	- 0.41	60.24
Whitewater	4.15	- 0.68	100.00
Villages			
Darien	0.65	- 0.11	100.00
Fontana	0.22	- 0.04	5.95
Sharon	0.87	- 0.14	100.00
Walworth	1.07	- 0.17	89.92
Williams Bay	0.26	- 0.04	8.90
Towns			
Darien	35.14	5.74	100.00
Delavan	31.34	5.12	98.34
Geneva	11.45	1.87	35.19
Lafayette	0.06	0.01	0.17
La Grange	7.52	1.23	21.11
Linn	2.23	0.36	6.63
Richmond	35.58	5.81	99.08
Sharon	35.74	5.83	100.00
Sugar Creek	8.53	1.39	24.46
Walworth	27.71	4.52	91.33
Whitewater	30.82	5.03	96.77
County Subtotal	239.06	39.03	41.47
WASHINGTON COUNTY			
City			
Hartford	2.53	- 0.41	100.00
Village			
Slinger	1.80	- 0.29	100.00
Towns			
Addison	36.21	5.91	99.67
Barton	1.32	0.22	6.33
Erin	36.41	5.94	100.00
Hartford	34.18	5.58	100.00
Polk	9.95	1.62	28.97
Richfield	28.58	4.67	79.15
Wayne	26.74	4.37	74.30
West Bend	0.96	0.16	4.66
County Subtotal	178.68	29.18	41.01

tions of these facilities are shown on Map 63.[16] Of the 18 existing sanitary sewage treatment facilities, three discharge effluent to Turtle Creek and three to the Bark River; two each to Jackson Creek, and the Rubicon River; one each to the East Branch of the Rock River, the Oconomowoc River, Delavan Lake Outlet, Piscasaw Creek, and Whitewater Creek. The remaining three private facilities dispose of the effluent by soil absorption.

Domestic Onsite Sewage Disposal Systems: Although certain portions of the watershed lie within existing and proposed service areas of public sanitary sewerage systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Table 162 (continued)

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
WAUKESHA COUNTY			
Cities			
Delafield	10.29	- 1.68	98.09
Oconomowoc	5.49	- 0.90	100.00
Villages			
Chenequa	4.63	- 0.75	100.00
Dousman	0.77	- 0.13	100.00
Eagle	0.04	- 0.01	4.08
Hartland	2.66	- 0.43	92.04
Lac La Belle	0.48	- 0.08	100.00
Merton	2.27	- 0.37	100.00
Nashotah	1.63	- 0.27	100.00
Oconomowoc Lake	3.13	- 0.51	100.00
Wales	1.37	- 0.22	60.62
Towns			
Delafield	7.22	1.18	32.95
Eagle	14.89	2.43	42.13
Genesee	4.01	0.65	12.39
Lisbon	12.06	1.97	35.82
Merton	27.34	4.46	95.03
Oconomowoc	33.57	5.48	100.00
Ottawa	32.59	5.32	91.16
Summit	30.23	4.94	100.00
County Subtotal	194.67	31.79	33.53
Total	612.41	100.00	--

Source: SEWRPC.

Sanitary Sewerage System Flow Relief Points: In addition to private and public sewage treatment facility effluents, raw sanitary sewage enters the surface water system of the Rock River watershed directly from sanitary sewer overflows or indirectly via such overflows to separate storm sewer systems. There are 16 known flow relief devices located in the Rock River watershed, as listed in Table 168. All of these flow relief devices are bypasses.

Industrial Discharges: At 27 locations in the Rock River watershed industrial wastewaters consisting primarily of cooling and process water are discharged directly or indirectly to the surface water system (see Map 63). This industrial wastewater enters the Rock River tributaries as direct discharge or reaches the surface water by drainage ditches and storm sewers.

Data and information provided by the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR101 of the Wisconsin Administrative Code were used to determine the type and location of industrial wastewater discharges in the Rock River watershed. Table 169 summarizes by receiving stream and civil division the types of industrial wastewater discharges and the number of outfalls in the watershed, the treatment provided, and hydraulic design capacity of the treatment facility. A total of 31 industrial and commercial discharges is known to exist in the watershed. Of these, 13 industries discharge cooling waters, 14 process wastewaters, two cooling and process wastewaters, and two sanitary wastewaters which are treated at an onsite facility. The Oconomowoc River receives discharges from four industries, the Rubicon River from two industries, the Bark River likewise from two industries, while Jackson Creek and Whitewater Creek receive discharges from three. Turtle Creek, Little Turtle Creek, and Swan Creek each receive wastewater from a single industry.

[16] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 63. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exist to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 163

ESTIMATED RESIDENT POPULATION OF THE ROCK RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
WALWORTH COUNTY	
Cities	
Delavan	5,786
Elkhorn (part)	1,789
Whitewater	9,247
Villages	
Darien	1,014
Fontana on Geneva Lake (part)	168
Sharon	1,301
Walworth (part)	1,640
Williams Bay (part)	14
Towns	
Darien	1,461
Delavan (part)	3,935
Geneva (part)	1,124
LaFayette (part)	7
LaGrange (part)	164
Linn (part)	44
Richmond (part)	1,357
Sharon	1,070
Sugar Creek (part)	219
Walworth (part)	1,269
Whitewater (part)	1,267
Walworth County (part) Subtotal	32,876
WASHINGTON COUNTY	
City	
Hartford	7,225
Village	
Slinger	1,548
Towns	
Addison (part)	2,669
Barton (part)	209
Erin	1,950
Hartford	2,619
Polk (part)	777
Richfield (part)	6,149
Wayne (part)	973
West Bend (part)	110
Washington County (part) Subtotal	24,229
WAUKESHA COUNTY	
Cities	
Delafield (part)	3,440
Oconomowoc	10,337
Villages	
Chenequa	547
Dousman	768
Eagle (part)	0
Hartland (part)	3,620
Lac La Belle	216
Merton	799
Nashotah	623
Oconomowoc Lake	563
Wales (part)	982
Towns	
Delafield (part)	893
Eagle (part)	234
Genesee (part)	418
Lisbon (part)	509
Merton	4,782
Oconomowoc	6,194
Ottawa (part)	1,672
Summit	3,632
Waukesha County (part) Subtotal	40,229
Rock River Watershed	97,334

Source: SEWRPC.

Table 164

FLOW MEASUREMENTS ON TURTLE CREEK NEAR CLINTON (USGS-RK-13) IN THE ROCK RIVER WATERSHED: 1964-1975

Water Year (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1964	64.4	4.73	1,430	27
1965	119	8.71	1,300	26
1966	110	8.05	1,520	42
1967	82.1	6.00	450	33
1968	74.4	5.44	236	37
1969	109	7.93	1,000	42
1970	101	7.34	848	34
1971	136	9.96	1,900	45
1972	173	11.63	1,740	42
1973	289	21.12	6,400	94
1974	289	21.09	1,970	108
1975	166	12.13	2,120	53

Source: SEWRPC.

Table 165

MAJOR LAKES IN THE ROCK RIVER WATERSHED IN THE REGION

Name	Municipality	U. S. Public Land Survey Section, Town, Range	Surface Width[a] (miles)	Surface Length[a] (miles)	Surface Area[a] (acres)	Maximum Depth[b] (feet)	Shoreline Length (miles)	Shore Development[c] (ratio)	Public Frontage Length (miles)	Date of Sampling	County
Ashippun.	Town of Oconomowoc	15-8-17	0.35	1.05	84.00	40	1.50	1.17	0.33	2-9-61	Waukesha
Bark	Town of Richfield	26-9-19	0.10	0.70	65.00	32	1.80	1.59	0.10	7-21-60	Washington
Beaver	Town of Merton	27, 28-8-18	0.70	1.09	316.00	49	3.60	1.45	--	2-13-61	Waukesha
Comus	Town and City of Delavan	7, 8, 18-2-16	0.20	2.00	117.00	8	5.10	3.36	0.15	4-20-61	Walworth
Cravath.	City of Whitewater	4, 9-4-15	0.20	0.90	65.00	10	2.50	2.21	0.02	5-20-60	Walworth
Crooked	Town of Summit	23-7-17	0.30	0.60	58.00	16	2.30	2.16	--	9-21-60	Waukesha
Delavan.	Town of Delavan	21, 22, 28-2-16	1.20	5.80	2,072.00	56	17.70	2.77	0.60	5-13-60	Walworth
Druid	Town of Erin	27-9-18	0.20	0.30	16.00	7	0.60	1.07	--	8-16-60	Washington
Fowler	City of Oconomowoc	33-8-17	0.35	0.60	78.00	50	1.70	1.37	0.15	9-22-60	Waukesha
Friess.	Town of Richfield	17-9-19	0.30	0.80	119.00	51	2.30	1.51	0.04	7-21-60	Washington
Golden	Town of Summit	30, 31-7-17	0.43	1.30	250.00	46	3.40	1.53	--	1-23-61	Waukesha
Hunter	Town of Ottawa	11-6-17	0.16	0.60	65.00	36	1.90	1.68	--	1-24-61	Waukesha
Keesus	Town of Merton	11, 14-8-18	0.71	0.90	237.00	42	5.00	2.32	0.04	2-13-61	Waukesha
LaGrange.	Town of LaGrange	7, 18-4-16	--	--	55.00	4	1.80	1.73	--	--	Walworth
Lac La Belle	Village of Lac La Belle; Town of Oconomowoc	29, 30, 32-8-17	1.10	2.65	1,117.00	46	8.70	1.47	0.16	6-27-60	Waukesha
Lake Five	Town of Richfield	32-9-19	0.40	0.70	102.00	23	1.90	1.35	--	7-20-60	Washington
Loraine.	Town of Richmond	9-3-15	0.60	1.00	133.00	8	3.20	1.98	--	6-10-60	Walworth
Lower Genesee . .	Town of Summit	27, 28-7-17	0.32	0.45	66.00	44	1.40	1.23	0.14	10-12-60	Waukesha
Lower Nashotah. .	Town of Summit	12, 13-7-17	0.25	0.83	90.00	43	2.00	1.50	--	9-21-60	Waukesha
Lower Nemahbin .	Town of Summit	24, 25-7-17	0.67	1.00	271.00	36	3.30	1.43	0.03	9-21-60	Waukesha
Middle Genesee . .	Town of Summit	21, 22-7-17	0.43	0.55	102.00	38	1.60	1.13	0.13	10-12-60	Waukesha
Moose	Town of Merton	19, 30-8-18	0.20	0.83	81.00	61	2.30	1.82	--	2-13-61	Waukesha
Nagawicka	City of Delafield	8, 17-7-18	1.05	2.80	957.00	90	8.60	1.98	0.27	10-12-60	Waukesha
North.	Town of Merton	16, 21-8-18	0.67	1.37	437.00	78	5.30	1.81	0.02	10-23-60	Waukesha
Oconomowoc . . .	Village of Oconomowoc Lake	2, 3-7-17	1.05	1.24	767.00	62	7.00	1.80	--	9-22-60	Waukesha
Okauchee	Town of Oconomowoc; Town of Merton	25, 36-8-18; 30-8-18	1.85	1.90	1,187.00	94	15.00	3.20	0.08	10-11-60	Waukesha
Pike.	Town of Hartford	23-10-18	1.10	1.20	522.00	45	3.80	1.19	0.01	6-27-60	Washington
Pine.	Village of Chenequa	28, 29, 32-8-18	0.89	2.37	703.00	85	7.30	1.96	0.01	9-23-60	Waukesha
Pretty.	Town of Ottawa	28-6-17	0.30	0.40	64.00	35	1.20	1.07	0.02	1-24-61	Waukesha
Rice.	Town of Whitewater	26, 27-4-15	0.50	0.90	137.00	8	3.40	2.07	3.40	6-10-60	Walworth
School Section Lake.	Town of Ottawa	16, 17-6-17	0.55	0.60	125.00	12	1.90	1.21	0.05	1-24-61	Waukesha
Silver	Town of Summit	9, 16-7-17	0.56	0.97	222.00	44	2.70	1.29	0.01	10-12-60	Waukesha
Tripp	City of Whitewater	9, 10-4-15	0.40	0.80	115.00	6	2.90	1.93	0.08	5-12-60	Walworth
Turtle.	Town of Richmond	11, 12, 14-3-15	0.30	0.90	140.00	35	2.60	1.73	--	6-10-60	Walworth
Upper Nashotah. .	Town of Summit	12, 13-7-17	0.42	0.80	133.00	53	2.30	1.42	--	9-21-60	Waukesha
Upper Nemahbin .	Town of Summit	13, 24-7-17	0.59	1.10	283.00	61	2.90	1.23	0.09	9-21-60	Waukesha
Waterville Pond . .	Town of Summit	36-7-17	--	0.95	68.40	12	1.87	1.58	--	1-25-63	Waukesha
Whitewater.	Town of Whitewater	34, 35-3, 4-15	0.60	2.60	640.00	38	9.80	2.80	0.80	5-12-60	Walworth

[a] *Lake lengths, widths, and areas used in this comparison were taken from aerial photographs dated September and October 1956 for Kenosha County.*

[b] *Maximum depth was measured from the surface elevation existing on date sampled.*

[c] *Shore development ratio (SDR) is a convenient expression of the degree of regularity or irregularity of shoreline. Generally, the higher the ratio, the greater the biological productivity of the lake. SDR = length of shoreline of lake of given area divided by circumference of circle with same area. An SDR of 1.00 indicates a circular lake.*

Source: SEWRPC.

Table 166

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES OF THE ROCK RIVER WATERSHED IN THE REGION: 1975

Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity						Existing Loading	
							Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Average Organic Pounds $CBOD_5$/Day	Population[a] Equivalent	Average Annual Hydraulic (mgd)	Average Annual Per Capita (gpd)
City of Delavan	2.01	5,800	1930, 1949, 1975	Trickling Filter Disinfection	Secondary Auxiliary	Turtle Creek	10,000	1.0	1.5	N/A	N/A	0.59	102
City of Elkhorn	2.42	4,400	1927, 1949	Trickling Filter Disinfection	Secondary Auxiliary	Jackson Creek	4,500	0.5	N/A	1,510	7,200	0.69	157
City of Whitewater	2.38	11,000	1937, 1956, 1967	Activated Sludge and Trickling Filter Disinfection	Secondary Auxiliary	Whitewater Creek	35,750	2.5	3.75	6,080	28,950	1.14	104
City of Hartford	1.92	7,600	1973	Phosphorus Removal Activated Sludge Disinfection	Advanced Secondary Auxiliary	Rubicon River	10,000	2.00	6.00	10,000	47,620	1.37	180
Village of Slinger	0.45	1,300	1950	Trickling Filter Disinfection	Secondary Auxiliary	Marshland Drained by the Rubicon River	1,900	0.15	0.30	792	3,800	0.15	115
Allenton Sanitary District	0.19	800	1961	Activated Sludge Disinfection	Secondary Auxiliary	Rock River East Branch	1,000	0.10	0.15	170	810	0.08	100
City of Oconomowoc	2.71	11,100	1936	Trickling Filter Disinfection	Secondary Auxiliary	Oconomowoc River	5,000	1.50	3.00	2,500	11,900	1.90	171
Village of Dousman	0.45	1,000	1961, 1972	Activated Sludge Disinfection	Secondary	Bark River	1,500	0.12	0.30	200	950	0.11	110
Village of Hartland	1.16	4,400	1933, 1962	Activated Sludge Disinfection	Secondary Auxiliary	Bark River	3,500	0.35	0.70	700	3,330	0.42	95
Village of Darien	0.47	1,000	1968	Activated Sludge Disinfection	Secondary Auxiliary	Turtle Creek	1,500	0.15	0.30	255	1,210	0.14	140
Village of Sharon	0.53	1,400	1959	Trickling Filter Disinfection	Secondary Auxiliary	Turtle Creek	2,000	0.15	0.30	260	1,240	0.08	57
Village of Walworth	0.47	1,700	1952, 1965, 1975	Trickling Filter Disinfection	Auxiliary Secondary	Piscasaw Creek	7,050	0.15	0.30	1,480	7,050	N/A	N/A

NOTE: N/A indicates data not available.

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the table.*

Source: SEWRPC.

Pollution from Urban Runoff: Separate storm sewers which convey the runoff from rainfall carry pollutants and contaminants from urbanized areas into receiving waters, and may cause chemical or inorganic, organic, pathogenic, and aesthetic pollution of lakes and streams. Existing land use information taken from the Commission 1970 land use inventory is presented in Table 170 and indicates that in the Rock River watershed within the Region 38,057 acres, or about 10 percent of the land, are in urban use; 303,630 acres, or about 77 percent, are in rural use; and the remaining 49,558 acres, or about 13 percent, are occupied by streams and wetlands. A shoreline development survey by the Wisconsin Department of Natural Resources indicated that a similar ratio of urban and rural land uses occurs in the shoreline area within 1,000 feet of the Rock River tributaries, if the shorelines of the lakes in the watershed are excluded. In contrast to the streams, about 74 percent of the shoreline area within 1,000 feet of the lakes in the Rock River watershed is in urban land use. Of the remaining land, only one-quarter percent is in agricultural use, while 12 percent is in other rural open uses. The shoreline

Table 167

SELECTED CHARACTERISTICS OF NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES IN THE ROCK RIVER WATERSHED: 1975

Name	Civil Division Location	Type of Land Use Served	Type of Wastewater	Type of Treatment Provided	Disposal of Effluent	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Average Hydraulic Design Capacity (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
WALWORTH COUNTY								
Lakeland Nursing Home (Walworth County Institutions)	Town of Geneva	Institutional	Sanitary	Activated Sludge and Lagoon	Jackson Creek	80,000	230,000	N/A
Lake Lawn Lodge	Town of Delavan	Recreational	Sanitary	Activated Sludge	Delavan Lake	69,000	100,000	103,000
WASHINGTON COUNTY								
Pike Lake State Park	Town of Hartford	Recreational	Sanitary	Lagoon	Groundwater	N/A	N/A	N/A
WAUKESHA COUNTY								
Gigas Hillside Apartments	Town of Delafield	Residential	Sanitary	Lagoon and Activated Sludge	Groundwater	N/A	20,000	N/A
St.John's Military Academy	City of Delafield	Institutional	Sanitary	Septic System and Lagoon	Bark River	N/A	75,000	N/A
Ethan Allen School	Town of Delafield	Institutional	Sanitary	Contact Stabilization and Lagoon	Groundwater	59,000	165,000	86,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: SEWRPC.

Table 168

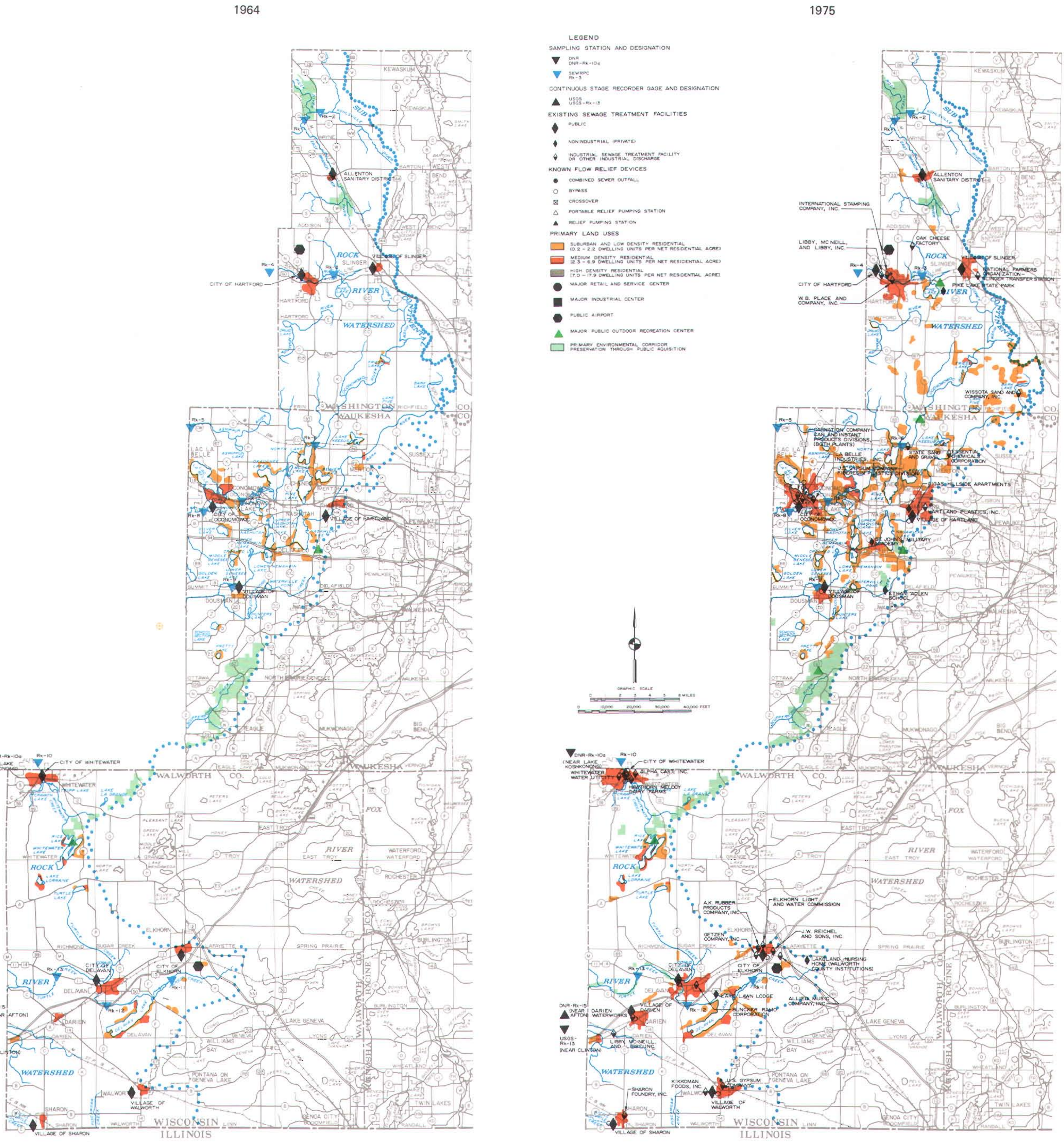
KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE ROCK RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Other Flow Relief Devices: Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	Total
Turtle Creek	City of Delavan	0	0	1	0	0	1
Turtle Creek	Village of Darien	0	0	1	0	0	1
Little Turtle Creek	Village of Sharon	0	0	1	0	0	1
Piscasaw Creek	Village of Walworth	0	0	1	0	0	1
Jackson Creek	City of Elkhorn	0	0	1	0	0	1
Whitewater Creek	City of Whitewater	0	0	5	0	0	5
Bark River	Village of Hartland	0	0	1	0	0	1
Bark River	Village of Dousman	0	0	1	0	0	1
Oconomowoc River	City of Oconomowoc	0	0	1	0	0	1
Lac La Belle	City of Oconomowoc	0	0	2	0	0	2
Fowler Lake	City of Oconomowoc	0	0	1	0	0	1
Total	--	0	0	16	0	0	16

Source: SEWRPC.

Map 63

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE ROCK RIVER WATERSHED: 1964 AND 1975



Stream water quality was obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at 14 sampling stations located in the Rock River watershed. This data was analyzed to determine the water quality conditions of the streams over time as affected by 12 municipal sewage treatment facilities, six nonindustrial private sewage treatment facilities, 16 sanitary sewage system bypasses and 27 industrial or commercial facilities discharging wastewater through 31 outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 169

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE ROCK RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
WALWORTH COUNTY								
A. K. Rubber Products Company, Inc.	3069	City of Elkhorn	Cooling	None	1	Jackson Creek via Storm Sewer	1,600	N/A
Allied Music Corporation	7696	City of Elkhorn	Process	Lagoon	1	Groundwater	3,000	N/A
Alpha Cast, Inc.	3321	City of Whitewater	Cooling	None	1	Whitewater Creek	125,000	150,000
Buncker Ramo Corporation	3829	City of Delavan	Cooling	None	8	Swan Creek via Storm Sewer	2,200	3,300
			Cooling	None	9	Swan Creek via Storm Sewer	2,200	5,500
Darien Waterworks	4941	Village of Darien	Filter Backwash	Sedimentation Tank	1	Turtle Creek via Storm Sewer	Intermittent	Intermittent
Elkhorn Light and Water Commission	4941	City of Elkhorn	Filter Backwash	N/A	1	Jackson Creek via Storm Sewer	40,000	40,000
			Process	N/A	2	Jackson Creek via Storm Sewer	10,000	10,000
Getzen Company, Inc.	3931	City of Elkhorn	Process	Lagoon	1	Groundwater	N/A	10,000
Hawthorn Melody Farms Dairy	2026	City of Whitewater	Cooling	None	1	Whitewater Creek	1,157,000	1,458,000
			Cooling	None	2	Whitewater Creek	123,000	163,000
J. W. Reichel and Sons, Inc.	3369	City of Elkhorn	Cooling	None	1	Jackson Creek via Storm Sewer	3,500	4,500
Kikkoman Foods, Inc.	2035	Town of Walworth	Process Sanitary	Aerobic, Digester Lagoon	1	Groundwater	240,000	264,000
Libby, McNeill, and Libby, Inc.	2037	Town of Darien	Process	Lagoon Spray Irrigation	1	Groundwater	1,100,000	1,700,000
			Sanitary	Septic System	2	Groundwater	10,000	10,000
Sharon Foundry, Inc.	3321	Town of Sharon	Cooling	N/A	1	Little Turtle Creek	750	750
U. S. Gypsum Company	3296	Village of Walworth	Boiler Blowdown	Lagoon	1	Groundwater	35,000	N/A
Whitewater Water Utility	4941	City of Whitewater	Backwash	N/A	1	Whitewater Creek via Storm Sewer	92,000	120,000
WASHINGTON COUNTY								
International Stamping Company, Inc.	3469	City of Hartford	Cooling	None	1	Rubicon River	154,000	217,000
Libby, McNeill, and Libby, Inc.	2033	City of Hartford	Process	Lagoon	1	Hartford Sewage Treatment Plant	458,000	763,000
National Farmers Organization— Slinger Transfer Station	9641	Town of Polk	Washwater	Septic Tanks and Ridge and Furrow	1	Groundwater	N/A	5,500
Oak Cheese Factory	2022	Town of Hartford	Washwater	Septic System and Lagoon	1	Groundwater	N/A	400
W. B. Place and Company, Inc.	3111	City of Hartford	Process	Settling Basin, Screening Sludge, and Dewatering	1	Rubicon River	200	400
Wissota Sand and Company, Inc.	1442	Town of Richfield	Washwater	N/A	1	Bark Creek	50,000	N/A
WAUKESHA COUNTY								
Carnation Company— Can Division	3411	City of Oconomowoc	Cooling	None	1	Oconomowoc River via Storm Sewer	18,200	19,500
Carnation Company— Instant Products Division	2034	City of Oconomowoc	Cooling and Boiler Blowdown	None	1	Oconomowoc River via Storm Sewer	1,234,000	1,554,000
Essential Chemicals Corporation	2841	Town of Merton	Cooling	None	1	Bark Creek via Storm Sewer	500	N/A
Hartland Plastics, Inc.	2821	Village of Hartland	Cooling	Lagoon	1	Groundwater	3,000	3,000
Labelle Industries, Inc.	3651	City of Oconomowoc	Cooling	None	1	Oconomowoc River via Storm Sewer	17,500	21,000
State Sand and Gravel	1442	Village of North Lake	Washwater	Lagoon	1	Tributary of Oconomowoc River	670,000	670,000
U. S. Gypsum Company— Fiberesin Plastics Division	2621	City of Oconomowoc	Cooling and Boiler Blowdown	N/A	1	Groundwater	3,500	5,000

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 170

LAND USE IN THE ROCK RIVER WATERSHED: 1963 AND 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	13,605.24		18,451.96	
Commercial	482.94		582.74	
Industrial	545.19		681.28	
Transportation and Utilities	12,490.68		13,181.29	
Government	1,127.27		1,550.80	
Recreation	2,783.16		3,399.46	
Landfill and Dump	200.08		209.16	
Total	31,234.56	7.98	38,056.69	9.73
Rural Land Uses				
Open Lands	40,403.96		39,613.51	
Agricultural Lands	269,358.83		264,016.61	
Total	309,762.79	79.14	303,630.12	77.61
Water Covered Lands				
Lakes, Rivers, and Streams	14,094.54		14,198.07	
Wetlands, etc.	36,321.62		35,359.61	
Total	50,416.16	12.88	49,557.68	12.67
Watershed Totals	391,413.51	100.00	391,244.49	100.00

Source: SEWRPC.

use data indicated a significantly high concentration of population around the lakes, a situation typical in the Region. Urban land use may be expected, therefore, to have a significant effect on stream and lake water quality in the watershed.

Pollution from Rural Land: Agricultural land uses are known to contribute high concentrations of suspended solids, nitrogen, and phosphorus to surface waters through storm water runoff. Since 77 percent of the total area of the Rock River watershed is in agricultural use, agricultural runoff is likely to be a significant factor affecting the water quality of the Rock River stream system.

Other Pollution Sources: The Commission 1970 land use inventory indicated, in addition to the pollution sources described above, the presence of 16 sanitary landfill sites and 11 auto salvage yards in the watershed. Seepage and runoff from these sources may contribute to the pollution of the surface water system of the watershed.

Water Quality Conditions of the Rock River Watershed

Water Quality Data: Of the available water quality data sources, the following five were used in the Rock River watershed study: 1) Commission benchmark study, 2) Commission continuing monitoring program, 3) Commission and U. S. Geological Survey cooperative continuous streamflow monitoring program, 4) Wisconsin Department of Natural Resources monthly manual sampling, and 5) Wisconsin Department of Natural Resources basin survey. For a detailed description of these data sources, see Chapter II of this report.

Thirteen sampling stations, eight on the upper Rock River and five on lower Rock River watersheds, were established by the Commission under the initial benchmark survey. Table 171 presents selected data on these stations, indicating the location and distances from the mouth of the rivers. Table 172 presents selected data on stations other than those established by the Commission. Map 63 illustrates the location of the water quality sampling stations in the Rock River watershed.

Surface Water Quality of the Tributaries to the Rock River 1964-1965: Water quality conditions in the Rock River watershed as determined by 1964-1965 sampling survey at 13 stations on the tributaries of Rock River within the Region are summarized in Table 173. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to the assessment of trends in surface water quality.

Chloride: During the benchmark survey sampling year of 1964-1965, the chloride concentrations throughout the watershed varied from 0 to 850 mg/l. The average chloride concentrations of the Ashippun River, the Kohls-

Table 171

DESIGNATIONS AND LOCATIONS OF SEWRPC SAMPLING STATIONS ON THE ROCK RIVER TRIBUTARIES

Source	Sampling Station Designation	Sampling Station Location	Distance from the County Line (in miles)
SEWRPC	Rk-3	Rubicon River, SE ¼, Section 15, T10 N, R18E	5.3
SEWRPC	Rk-4	Rubicon River, SW ¼, Section 13, T10N, R18E	1.5
SEWRPC	Rk-6	Oconomowoc River, NW ¼, Section 16, T8N, R18E	17.2
SEWRPC	Rk-7	Oconomowoc River, SE ¼, Section 34, T8N, R17E	8.8
SEWRPC	Rk-8	Oconomowoc River, SE ¼, Section 6, T7N, R17E	2.4
SEWRPC	Rk-1	East Branch of Rock River, SE ¼, Section 30, T12N, R18E	4.5
SEWRPC	Rk-2	Kohlsville River, NE ¼, Section 29, T12 N, R18E	0.6
SEWRPC	Rk-5	Ashippun River, NW ¼, Section 7, T8N, R17E	0.1
SEWRPC	Rk-9	Bark River, SE ¼, Section 33, T7N, R17E	3.8
SEWRPC	Rk-10	Whitewater Creek, NE ¼, Section 32, T5N, R15E	1.0
SEWRPC	Rk-11	Jackson Creek, NE ¼, Section 14, T2N, R16E	20.1
SEWRPC	Rk-12	Delavan Lake Outlet, SE ¼, Section 19, T2N, R16E	14.41
SEWRPC	Rk-13	Turtle Creek, SW ¼, Section 10, T2N, R15E	6.4

Source: SEWRPC.

Table 172

DESIGNATIONS AND LOCATIONS OF STREAM SAMPLING STATIONS OF OTHER SOURCES IN THE ROCK RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from the County Line (in miles)
USGS	Rk-13	Turtle Creek near Clinton, SE ¼, Section 29, T2N, R14E	- 6.54
DNR.	DNR-10a	Rock River, NE ¼, Section 13, T5N, R13E	--[a]
DNR.	DNR-15	Rock River, NE ¼, Section 28, T2N, R12E	--[a]

[a]*Sampling stations DNR-10a and DNR-15 are located on the Rock River outside the Region but have portions of the Region tributary to them.*

Source: SEWRPC.

ville River, and the Bark River at the sampling stations were 10 mg/l or less, and the average chloride concentrations of the East Branch of the Rock River, Whitewater Creek, the Delavan Lake Outlet, and the Rubicon River at sampling station Rk-3, Turtle Creek, and the Oconomowoc River were 15-34 mg/l. At sampling station Rk-11 on Jackson Creek, the average chloride concentration was 98 mg/l and at sampling station Rk-4 on the Rubicon River, the average chloride concentration was 410 mg/l. There was no specific seasonal variation apparent in the chloride concentrations at various locations in the Rock River tributaries in the 1964-1965

Table 173

WATER QUALITY CONDITIONS OF THE ROCK RIVER TRIBUTARIES: 1964-1965

Source	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
East Branch Rock River Rk-1	Chloride (mg/l)	30	15	0	12
	Dissolved Solids (mg/l)	570	440	195	12
	Dissolved Oxygen (mg/l)	12.8	8.0	0.0	12
	Total Coliform Count (MFCC/100 ml)	21,000	3,800	300	12
	Temperature (^{O}F)	71	46	32	12
Kohlsville River Rk-2	Chloride (mg/l)	15	10	5	2
	Dissolved Solids (mg/l)	490	480	470	2
	Dissolved Oxygen (mg/l)	14.5	10.7	6.0	11
	Total Coliform Count (MFCC/100 ml)	6,000	1,700	300	11
	Temperature (^{O}F)	70	46	32	11
Rubicon River Rk-3 and Rk-4	Chloride (mg/l)	850	195	15	16
	Dissolved Solids (mg/l)	1,970	745	275	16
	Dissolved Oxygen (mg/L)	17.1	11.8	4.2	27
	Total Coliform Count (MFCC/100 ml)	270,000	22,000	100	27
	Temperature (^{O}F)	77	47	32	27
Ashippun River Rk-5	Chloride (mg/l)	20	10	5	3
	Dissolved Solids (mg/l)	440	380	320	3
	Dissolved Oxygen (mg/l)	15.9	10.3	5.0	12
	Total Coliform Count (MFCC/100 ml)	10,000	2,500	100	12
	Temperature (^{O}F)	77	50	32	12
Oconomowoc River Rk-6, Rk-7, and Rk-8	Chloride (mg/l)	70	15	0	18
	Dissolved Solids (mg/l)	470	320	240	18
	Dissolved Oxygen (mg/l)	14.1	10.8	4.6	39
	Total Coliform Count (MFCC/100 ml)	2,300,000	128,000	100	39
	Temperature (^{O}F)	80	51	32	39
Bark River Rk-9	Chloride (mg/l)	5	5	5	2
	Dissolved Solids (mg/l)	300	280	255	2
	Dissolved Oxygen (mg/l)	13.5	11.2	9.2	12
	Total Coliform Count (MFCC/100 ml)	100,000	14,700	300	12
	Temperature (^{O}F)	76	51	32	12
Whitewater Creek Rk-10	Chloride (mg/l)	20	20	15	2
	Dissolved Solids (mg/l)	485	395	300	2
	Dissolved Oxygen (mg/l)	11.4	8.7	5.6	11
	Total Coliform Count (MFCC/100 ml)	1,000,000	196,000	17,000	11
	Temperature (^{O}F)	80	56	35	11
Jackson Creek Rk-11	Chloride (mg/l)	150	95	45	2
	Dissolved Solids (mg/l)	570	510	455	2
	Dissolved Oxygen (mg/l)	13.5	6.0	1.6	12
	Total Coliform Count (MFCC/100 ml)	300,000	86,000	4,000	12
	Temperature (^{O}F)	74	50	32	12
Delavan Lake Outlet Rk-12	Chloride (mg/l)	30	25	20	3
	Dissolved Solids (mg/l)	385	300	255	3
	Dissolved Oxygen (mg/l)	14.2	11.6	7.2	13
	Total Coliform Count (MFCC/100 ml)	21,000	3,200	100	13
	Temperature (^{O}F)	75	48	32	13
Turtle Creek Rk-13	Chloride (mg/l)	45	25	15	13
	Dissolved Solids (mg/l)	450	375	220	13
	Dissolved Oxygen (mg/l)	14.6	12.1	7.8	14
	Total Coliform Count (MFCC/100 ml)	70,000	18,800	400	14
	Temperature (^{O}F)	71	48	32	14

Source: SEWRPC.

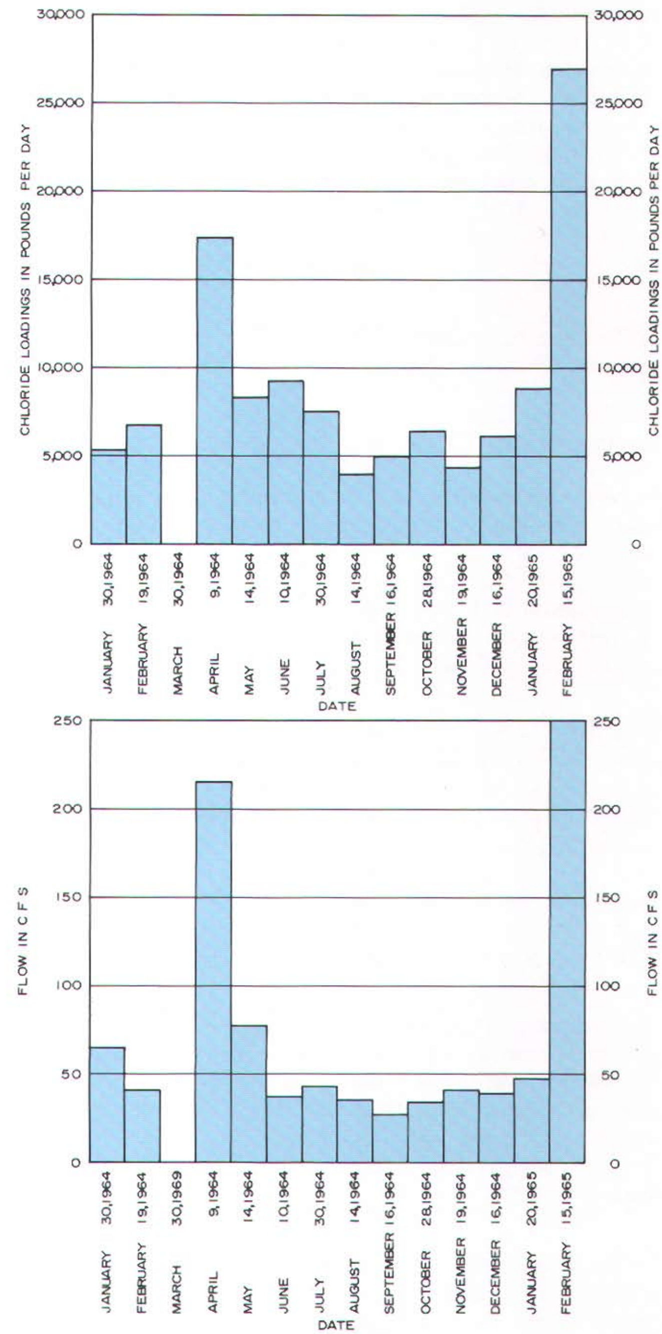
sampling survey. Although no flow data are available at the Rock River sampling stations for the days the water samples were collected, flow data are available on Turtle Creek beyond sampling station Rk-13 in Rock County and were used for the calculation of chloride loadings at sampling station Rk-13. A comparison of the flow and the chloride loadings at sampling station Rk-13 (Figure 172) indicates no specific trend in the relationships of the flow and chloride loadings. Although, as a general rule, the chloride loadings increased with an increase in the flow, this was not true in all cases. At times where the chloride concentrations were high, despite the low flow, the total loadings remained high. Since the chloride loading varied with the flow, and since the loadings did not increase uniformly per unit volume of relative flow in the stream, it is unlikely that the source of chlorides is exclusively sewage effluent. The fact that the Turtle Creek subwatershed is not highly urbanized and that the chloride loadings are, therefore, unlikely to be directly associated with major winter deicing operations indicates the chloride source to be rural in nature, possibly associated with feedlot operations and other diffuse sources of pollutants.

Dissolved Oxygen: During the sampling period of 1964-1965, the dissolved oxygen levels in the watershed were found to range from 0 to 17.1 mg/l within the Region, with the average concentration at all 13 sample locations being greater than 6.0 mg/l. Although the average concentrations of dissolved oxygen in the Rock River tributaries are significantly higher than the recreational use dissolved oxygen standard of 5.0 mg/l, many samples showed substandard dissolved oxygen levels. At sampling station Rk-4 on the Rubicon River and at sampling station Rk-8 on the Oconomowoc River, one sample out of 12 collected at each station showed substandard dissolved oxygen levels. In addition, at sampling station Rk-11 on Jackson Creek, five samples out of 12 showed dissolved oxygen levels of less than 5.0 mg/l in the 1964-1965 sampling survey. Sampling station Rk-4 on the Rubicon River is located downstream from the City of Hartford sewage treatment facility; sampling station Rk-8 on the Oconomowoc River is located downstream from the City of Oconomowoc sewage treatment facility; and sampling station Rk-11 on Jackson Creek is located downstream from the City of Elkhorn sewage treatment plant, indicating the probable source of the dissolved oxygen reductions as the treated effluent from these sewage treatment plants.

Total Coliform Bacteria: During the sampling period of 1964-1965, membrane filter coliform counts were found to vary from less than 100 to 2,300,000 MFCC/100 ml with averages of less than 2,500 MFCC/100 ml at sampling station Rk-2 on the Kohlsville River, sampling station Rk-3 on the Rubicon River, sampling station Rk-5 on Ashippun River, and sampling stations Rk-6 and Rk-7 on the Oconomowoc River. At sampling stations Rk-1, Rk-4, and Rk-8 through Rk-13, the averages of 12 samples were found to be greater than 3,000 MFCC/100 ml. At sampling station Rk-4 on the Rubicon River downstream from the City of Hartford sewage treatment plant; sampling station Rk-8 on the Oconomowoc River down-

Figure 172

FLOW MEASUREMENTS ON TURTLE CREEK NEAR CLINTON (RK-13) ON DATES OF WATER SAMPLE COLLECTION: 1964-1965



Source: SEWRPC.

stream from the City of Oconomowoc sewage treatment plant; sampling station Rk-11 on Jackson Creek downstream from the City of Elkhorn sewage treatment plant, and sampling station Rk-13 on Turtle Creek downstream from the City of Delavan sewage treatment plant and the Delavan conservation area, the total coliform counts remained high all through the year indicating the effect of the treated effluents on the total coliform counts of the stream waters. At sampling station Rk-1 on the East Branch of the Rock River; sampling station Rk-9 on the Bark River; and sampling station Rk-12 on the Delavan Lake Outlet, high total coliform counts were found infrequently and at various times of the year. The fact that the high coliform counts occurred during periods of average streamflow eliminates the possibility of heavy runoff as the predominant source of the total coliform bacteria. Since the high coliform counts did not occur throughout the year, the sources are not continuous. The high total coliform counts must, therefore, be due to sources that discharge intermittently to the streams, such as drainage from agricultural land and wastes from wildlife and animal feeding operations.

Specific Conductance: The specific conductance of the Rock River tributaries in the Region during the 1964-1965 sampling period was found to range from 376 to 3,390 μmhos/cm at 25°C. The specific conductance remained high all through the year at sampling station Rk-4 on the Rubicon River, the range being 924 to 3,390 μmhos/cm at 25°C, indicating a generally high dissolved solids concentration in the waters of the Rubicon River. The specific conductance values at the other sampling station locations were found to range from 376 to 1,010 μmhos/cm at 25°C with the lowest values found at sampling station Rk-7 on the Oconomowoc River.

Hydrogen Ion Concentration (pH): The pH values at all sampling stations in the Rock River watershed were found to range from 6.8 to 8.7 standard units during the sampling year of 1964-1965. At no location within the watershed was the pH found to be outside the range of 6.0 and 9.0 standard units prescribed for recreational uses and for the maintenance of fish and aquatic life, the water use objectives for the majority of streams in the Rock River watershed within the Region.

Temperature: During the sampling period of 1964-1965, the temperatures of water samples from the Rock River tributaries were found to range from 32°F to 48°F during the months of December through April and from 36°F to 80°F during the months of May through November. The temperature variations, therefore, can be ascribed mainly to seasonal change.

Biochemical Oxygen Demand: Biochemical oxygen demand on the Rock River tributaries during the sampling years 1964-1965 was found to range from a low of 0.6 mg/l to a high of 78.6 mg/l at the 13 sampling stations. The high biochemical oxygen demand values were found at locations situated downstream from sewage treatment facilities such as at sampling station Rk-3, located downstream from the Village of Slinger sewage treatment facility; sampling station Rk-8, located downstream from the City of Oconomowoc sewage treatment facility; sampling station Rk-10, located downstream from the City of Whitewater sewage treatment facility; and sampling station Rk-11, located downstream from the City of Elkhorn sewage treatment plant.

Surface Water Quality of Lakes in the Rock River Watershed 1964-1965: No chemical data on which to evaluate water quality are available for the lakes in the Rock River watershed for the sample period of 1964-1965.

Water Quality Trends from 1965-1975: Water quality data for the eight summer sampling programs and three spring sampling programs and one fall program conducted from 1965 to 1975 are presented in tabular form in Appendix D to this report. The eight summer sampling surveys began in August 1968 and involved collection of samples one day in August every year during low-flow conditions.

The summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of the 13 stations at which the streams in this Rock River watershed were sampled by the Commission since 1968 is set forth in Tables 174 through 186. The streamflow data for Turtle Creek near Clinton, located outside of the Region in Rock County, were obtained from the records of the U. S. Geological Survey. The data for this location for the years 1964 through 1975 on the days that water quality samples were collected at sampling station USGS-Rk-13 are presented in Figure 173.

Dissolved Oxygen: For the watershed as a whole, the dissolved oxygen content of the Rock River stream system during August for the years 1968-1975 was found to range from 0.3 to 25.1 mg/l. The average dissolved oxygen concentrations were found to be less than 5.0 mg/l at sampling stations Rk-1 on the East Branch of the Rock River, Rk-4 on the Rubicon River, and Rk-12 on Delavan Lake Outlet, and were found to be greater than 5.0 mg/l at the other sampling station locations. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l at 10 of the 13 sampling stations during August in 1968-1975, the dissolved oxygen concentrations were lower than 5.0 mg/l at times during the period from 1968 through 1975 at all Rock River sampling stations. At sampling stations Rk-2 on the Kohlsville River and Rk-10 on Whitewater Creek, the daily average dissolved oxygen concentrations were below 5.0 mg/l once during the eight sampling surveys. At sampling station Rk-5 on the Ashippun River, two of the eight sampling surveys exhibited dissolved oxygen concentrations below 5.0 mg/l. At sampling stations Rk-3 on the Rubicon River, Rk-11 on Jackson Creek, Rk-12 on the Delavan Lake Outlet, the dissolved oxygen concentrations were below the 5.0 mg/l during three, four, and six of the eight sampling surveys, respectively. At sampling station Rk-1 on the East Branch of the Rock River and Rk-4 on the Rubicon River, five of the eight sampling surveys exhibited dissolved oxygen concentrations of less than 5.0 mg/l.

Table 174

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	30.0	21.2	14.0	22	--
Dissolved Oxygen (mg/l)	5.0	12.7	4.4	0.3	29	14[a]
Ammonia-N (mg/l)	2.5	0.28	0.13	0.03	8	0
Organic-N (mg/l)	--	1.75	1.37	0.86	8	--
Total-N (mg/l)	--	2.38	1.78	0.97	8	--
Specific Conductance (µmhos/cm at 25°C)	--	790	631	417	30	--
Nitrite-N (mg/l)	--	0.05	0.03	0.00	12	--
Nitrate-N (mg/l)	0.3	0.51	0.30	0.10	12	6
Soluble Orthophosphate-P (mg/l)	--	0.41	0.27	0.11	12	--
Total Phosphorus (mg/l)	0.1	0.40	0.32	0.10	8	8
Fecal Coliform (MFFCC/100 ml)	400	600	229	20	12	1
Temperature (°F)	89.0	79.0	72.8	65.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.7	8.0	7.4	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 175

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	25.0	14.3	11.0	22	--
Dissolved Oxygen (mg/l)	5.0	12.4	6.8	3.0	30	24[a]
Ammonia-N (mg/l)	2.5	0.13	0.07	0.03	8	0
Organic-N (mg/l)	--	1.69	1.05	0.36	8	--
Total-N (mg/l)	--	2.67	2.13	1.45	8	--
Specific Conductance (µmhos/cm at 25°C)	--	722	638	580	30	--
Nitrite-N (mg/l)	--	0.04	0.02	0.01	12	--
Nitrate-N (mg/l)	0.3	1.32	0.90	0.32	12	12
Soluble Orthophosphate-P (mg/l)	--	0.20	0.11	0.04	12	--
Total Phosphorus (mg/l)	0.1	0.24	0.14	0.06	8	5
Fecal Coliform (MFFCC/100 ml)	400	2,300	843	70	12	9
Temperature (°F)	89.0	79.0	69.9	61.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.6	8.1	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 176

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	85.0	35.5	21.0	22	--
Dissolved Oxygen (mg/l)	5.0	14.3	5.2	0.7	30	17[a]
Ammonia-N (mg/l)	2.5	0.28	0.11	0.03	8	0
Organic-N (mg/l)	--	1.94	1.38	0.48	8	--
Total-N (mg/l)	--	2.31	1.75	0.61	8	--
Specific Conductance (μmhos/cm at 25°C)	--	862	673	480	30	--
Nitrite-N (mg/l)	--	0.04	0.01	0.00	12	--
Nitrate-N (mg/l)	0.3	0.52	0.27	0.09	12	4
Soluble Orthophosphate-P (mg/l)	--	4.15	0.62	0.04	12	--
Total Phosphorus (mg/l)	0.1	0.59	0.31	0.04	8	6
Fecal Coliform (MFFCC/100 ml)	400	4,300	675	40	12	4
Temperature (°F)	89.0	83.0	71.7	61.5	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.9	8.0	7.7	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 177

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-4: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	897.0	305.9	49.0	22	--
Dissolved Oxygen (mg/l)	5.0	8.9	4.2	0.6	30	15[a]
Ammonia-N (mg/l)	2.5	4.25	1.06	0.03	8	2
Organic-N (mg/l)	--	2.40	1.59	0.57	8	--
Total-N (mg/l)	--	7.19	4.03	1.46	8	--
Specific Conductance (μmhos/cm at 25°C)	--	3,000	1,460	644	30	--
Nitrite-N (mg/l)	--	0.70	0.23	0.03	12	--
Nitrate-N (mg/l)	0.3	2.63	1.04	0.23	12	10
Soluble Orthophosphate-P (mg/l)	--	2.71	1.20	0.13	12	--
Total Phosphorus (mg/l)	0.1	2.45	1.07	0.25	8	8
Fecal Coliform (MFFCC/100 ml)	400	21,000	2,709	50	12	6
Temperature (°F)	89.0	84.0	73.3	65.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.2	7.8	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 178

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-5: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	19.0	12.8	3.0	22	--
Dissolved Oxygen (mg/l)	5.0	9.9	6.1	1.5	30	8[a]
Ammonia-N (mg/l)	2.5	0.13	0.09	0.03	8	0
Organic-N (mg/l)	--	1.37	1.10	0.65	8	--
Total-N (mg/l)	--	1.87	1.48	0.83	8	--
Specific Conductance (μmhos/cm at 25°C)	--	687	594	459	30	--
Nitrite-N (mg/l)	--	0.03	0.02	0.01	12	--
Nitrate-N (mg/l)	0.3	0.55	0.29	0.09	12	6
Soluble Orthophosphate-P (mg/l)	--	0.22	0.15	0.04	12	--
Total Phosphorus (mg/l)	0.1	0.24	0.20	0.15	8	8
Fecal Coliform (MFFCC/100 ml)	400	5,700	1,054	90	12	7
Temperature (°F)	89.0	83.0	73.2	64.5	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.8	8.1	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 179

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-6: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	17.0	11.3	8.0	22	--
Dissolved Oxygen (mg/l)	5.0	8.2	6.5	5.2	30	0[a]
Ammonia-N (mg/l)	2.5	0.28	0.09	0.03	8	0
Organic-N (mg/l)	--	1.34	1.04	0.58	8	--
Total-N (mg/l)	--	1.93	1.55	0.81	8	--
Specific Conductance (μmhos/cm at 25°C)	--	629	546	450	30	--
Nitrite-N (mg/l)	--	0.03	0.02	0.01	12	--
Nitrate-N (mg/l)	0.3	0.73	0.43	0.20	12	10
Soluble Orthophosphate-P (mg/l)	--	0.09	0.05	0.02	12	--
Total Phosphorus (mg/l)	0.1	0.11	0.09	0.06	8	2
Fecal Coliform (MFFCC/100 ml)	400	4,300	896	90	12	5
Temperature (°F)	89.0	84.5	74.0	65.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.4	8.1	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 180

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-7: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	16.0	11.8	9.0	22	--
Dissolved Oxygen (mg/l)	5.0	10.9	8.9	6.7	30	0[a]
Ammonia-N (mg/l)	2.5	0.11	0.05	0.03	8	0
Organic-N (mg/l)	--	1.05	0.72	0.28	8	--
Total-N (mg/l)	--	1.18	0.82	0.29	8	--
Specific Conductance (µmhos/cm at 25°C)	--	508	442	395	30	--
Nitrite-N (mg/l)	--	0.01	0.00	0.00	8	--
Nitrate-N (mg/l)	0.3	0.15	0.09	0.04	11	0
Soluble Orthophosphate-P (mg/l)	--	0.27	0.05	0.01	12	--
Total Phosphorus (mg/l)	0.1	0.030	0.022	0.010	8	0
Fecal Coliform (MFFCC/100 ml)	400	570	72	5	12	1
Temperature (°F)	89.0	81.0	75.4	70.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.8	8.5	8.0	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 181

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-8: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	66.0	37.3	18.4	22	--
Dissolved Oxygen (mg/l)	5.0	25.1	7.6	2.6	30	8[a]
Ammonia-N (mg/l)	2.5	0.44	0.17	0.03	8	0
Organic-N (mg/l)	--	1.42	1.05	0.48	8	--
Total-N (mg/l)	--	2.58	1.58	0.55	8	--
Specific Conductance (µmhos/cm at 25°C)	--	820	570	420	30	--
Nitrite-N (mg/l)	--	0.10	0.04	0.01	12	--
Nitrate-N (mg/l)	0.3	1.12	0.42	0.10	12	6
Soluble Orthophosphate-P (mg/l)	--	2.61	0.65	0.08	12	--
Total Phosphorus (mg/l)	0.1	0.70	0.38	0.16	8	8
Fecal Coliform (MFFCC/100 ml)	400	29,000	3,735	100	12	8
Temperature (°F)	89.0	83.5	75.3	68.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.2	8.1	7.6	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 182

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-9: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	29.0	19.0	12.4	22	--
Dissolved Oxygen (mg/l)	5.0	11.2	6.5	3.4	30	10[a]
Ammonia-N (mg/l)	2.5	5.69	0.77	0.03	8	1
Organic-N (mg/l)	--	1.36	0.93	0.39	8	--
Total-N (mg/l)	--	7.85	1.88	0.39	8	--
Specific Conductance (μmhos/cm at 25°C)	--	572	482	425	30	--
Nitrite-N (mg/l)	--	0.06	0.01	0.00	11	--
Nitrate-N (mg/l)	0.3	0.74	0.19	0.08	12	2
Soluble Orthophosphate-P (mg/l) . . .	--	0.31	0.08	0.02	12	--
Total Phosphorus (mg/l)	0.1	0.34	0.12	0.05	8	3
Fecal Coliform (MFFCC/100 ml) . . .	400	60,000	5,170	40	12	2
Temperature (°F)	89.0	82.0	73.8	68.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.6	8.1	6.0	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 183

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-10: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	62.0	29.5	8.0	21	--
Dissolved Oxygen (mg/l)	5.0	9.9	6.2	2.2	29	8[a]
Ammonia-N (mg/l)	2.5	1.94	0.50	0.03	8	0
Organic-N (mg/l)	--	1.74	1.06	0.33	8	--
Total-N (mg/l)	--	4.68	2.86	1.21	8	--
Specific Conductance (μmhos/cm at 25°C)	--	595	594	210	29	--
Nitrite-N (mg/l)	--	0.11	0.06	0.03	12	--
Nitrate-N (mg/l)	0.3	2.71	1.26	0.34	12	12
Soluble Orthophosphate-P (mg/l) . . .	--	1.03	0.87	0.53	12	--
Total Phosphorus (mg/l)	0.1	9.36	2.00	0.66	8	8
Fecal Coliform (MFFCC/100 ml) . . .	400	37,000	6,510	10	12	7
Temperature (°F)	89.0	83.0	75.0	65.0	29	0
Hydrogen Ion Concentrations (standard units)	6-9	8.4	8.2	7.8	21	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 184

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-11: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	315.0	198.23	69.00	22	--
Dissolved Oxygen (mg/l)	5.0	22.2	5.6	1.5	30	18[a]
Ammonia-N (mg/l)	2.5	3.63	1.59	0.69	8	1
Organic-N (mg/l)	--	3.20	1.91	0.96	8	--
Total-N (mg/l)	--	7.17	5.51	3.85	8	--
Specific Conductance (µmhos/cm at 25°C)	--	1,708	122	715	30	--
Nitrite-N (mg/l)	--	0.40	0.21	0.01	12	--
Nitrate-N (mg/l)	0.3	3.37	1.89	0.50	12	12
Soluble Orthophosphate-P (mg/l)	--	4.15	2.00	0.85	12	--
Total Phosphorus (mg/l)	0.1	2.83	1.80	0.86	8	8
Fecal Coliform (MFFCC/100 ml)	400	41,000	7,678	100	12	10
Temperature (°F)	89.0	83.0	73.2	63.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.1	8.0	7.5	22	1

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 185

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-12: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	49.0	32.5	20.0	21	--
Dissolved Oxygen (mg/l)	5.0	11.5	3.7	1.5	29	22[a]
Ammonia-N (mg/l)	2.5	0.78	0.23	0.03	8	0
Organic-N (mg/l)		2.25	1.35	0.59	8	--
Total-N (mg/l)	--	4.22	2.43	1.64	8	--
Specific Conductance (µmhos/cm at 25°C)	--	675	493	406	29	--
Nitrite-N (mg/l)	--	0.23	0.08	0.00	12	--
Nitrate-N (mg/l)	0.3	2.15	0.62	0.11	12	5
Soluble Orthophosphate-P (mg/l)	--	0.28	0.17	0.09	12	--
Total Phosphorus (mg/l)	0.1	0.28	0.20	0.10	8	8
Fecal Coliform (MFFCC/100 ml)	400	11,000	1,280	10	12	5
Temperature (°F)	89.0	84.0	73.5	61.0	29	0
Hydrogen Ion Concentrations (standard units)	6-9	8.7	8.0	7.5	21	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 186

WATER QUALITY CONDITIONS IN THE ROCK RIVER WATERSHED AT SAMPLING STATION RK-13: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	45.0	30.5	21.0	22	--
Dissolved Oxygen (mg/l)	5.0	17.9	7.7	3.8	29	7[a]
Ammonia-N (mg/l)	2.5	0.32	0.167	0.03	8	0
Organic-N (mg/l)	--	2.03	1.38	0.57	8	--
Total-N (mg/l)	--	4.36	3.09	2.30	8	--
Specific Conductance (μmhos/cm at 25°C)	--	690	567	465	29	--
Nitrite-N (mg/l)	--	0.168	0.09	0.004	12	--
Nitrate-N (mg/l)	0.3	2.64	1.29	0.24	12	11
Soluble Orthophosphate-P (mg/l)	--	0.76	0.34	0.08	12	--
Total Phosphorus (mg/l)	0.1	0.52	0.31	0.19	8	8
Fecal Coliform (MFFCC/100 ml)	400	12,000	4,302	100	12	11
Temperature (°F)	89.0	84.0	72.3	61.0	29	0
Hydrogen Ion Concentrations (standard units)	6-9	8.9	8.1	7.7	21	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

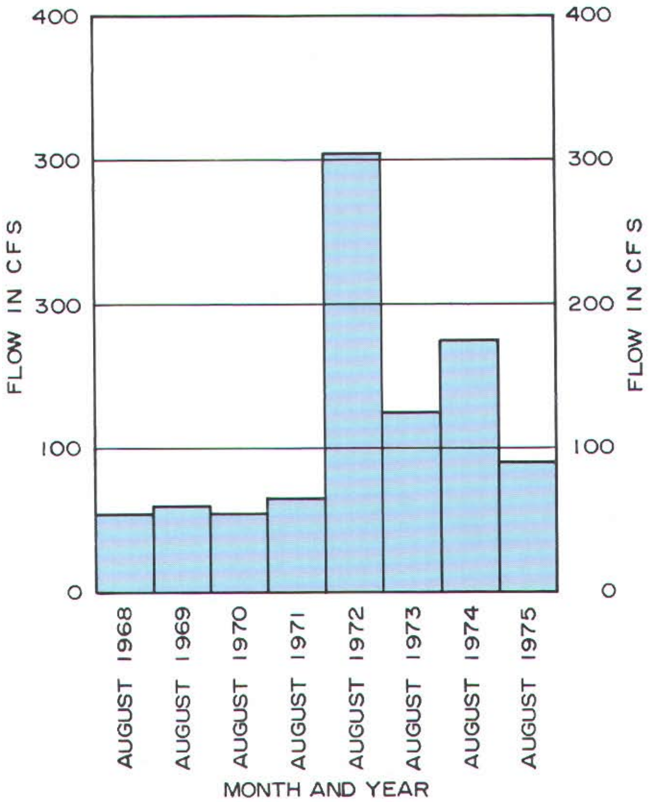
Source: SEWRPC.

Map 64 presents the dissolved oxygen concentrations that were found in August 1964 and August 1975 in the Rock River watershed. The graph inserts illustrate the change in the dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at each location. On August 7, 13, and 14, 1964, as indicated on the map, the dissolved oxygen levels were above the 5.0 mg/l standard at all sampling locations. In the samples collected on August 21 and 28, 1975, substandard levels of dissolved oxygen concentrations were observed at sampling station Rk-1 on the East Branch of the Rock River, sampling station Rk-5 on the Ashippun River, sampling station Rk-11 on Jackson Creek, and sampling station Rk-12 on Delavan Lake Outlet. The graph inserts on Map 64 present the dissolved oxygen concentrations and the three-year moving averages at sampling stations Rk-1 through Rk-13 in the August samples of 1964 through 1975. The water quality as measured by the dissolved oxygen concentrations remained the same over the past eight years at sampling stations Rk-5 on the Ashippun River, Rk-6 and Rk-7 on the Oconomowoc River, Rk-10 on Whitewater Creek and in Jackson Creek, the Delavan Lake Outlet, and Turtle Creek (sampling stations Rk-11, Rk-12, and Rk-13). In addition, the dissolved oxygen concentrations at sampling station Rk-2 on the Kohlsville River and sampling station Rk-9 on the Bark River remained the same in the samples collected for the years 1969-1975, while a decrease in the concentrations of dissolved oxygen was observed when the 1969 samples were compared to the 1968 samples. At sampling station Rk-1 on the East Branch of the Rock River and sampling station Rk-8 on the Oconomowoc River, the dissolved oxygen concentrations decreased over the past eight years in the samples collected in August 1968-1975, while at sampling stations Rk-3 and Rk-4 on the Rubicon River the dissolved oxygen concentrations of the water samples showed an improvement over the past five years. Nine of the 13 sampling stations in the Rock River watershed showed no trend over time in the dissolved oxygen concentrations. Land use data for 1963 and 1970, as presented earlier in Table 170, indicate only a 1 percent change from agricultural land use to urban land use within the watershed; and this fact is consistent with the conclusion that the stability of the water quality conditions is related to the generally unchanged land use in the watershed.

Chloride: The chloride concentrations were found to be in the range of 3 to 897 mg/l for 13 sampling stations in the Rock River watershed during the eight sampling surveys conducted from 1968 through 1975. At three locations, sampling station Rk-5 on the Ashippun River and sampling stations Rk-6 and Rk-7 on the Oconomowoc River, the chloride concentrations were found to be less than 20 mg/l with an eight-year average of 11 to 13 mg/l, thus showing minimal effect of human activities on water quality. At sampling stations Rk-1 on the East Branch of the Rock River, Rk-2 on the Kohlsville River, and Rk-9 on the Bark River, the chloride concentrations were found to be in the range of 11 to 30 mg/l with an average of 18 mg/l. These chloride concentrations indicate some effect of human activities on water quality of the East

Figure 173

FLOW MEASUREMENTS ON TURTLE CREEK NEAR CLINTON (RK-13) ON THE DATES OF WATER SAMPLIE COLLECTION: 1968-1975



Source: SEWRPC.

Branch of the Rock River, the Kohlsville River, and the Bark River. At sampling stations Rk-3 on the Rubicon River, Rk-8 on the Oconomowoc River, Rk-10 on Whitewater Creek, Rk-12 on Delavan Lake Outlet, and Rk-13 on Turtle Creek, the chloride concentrations were found to be in the range of 18 to 85 mg/l with an average of 33 mg/l. All five sampling stations are located downstream from sewage treatment plants. Sampling station Rk-3 is located downstream from the Village of Slinger sewage treatment plant; sampling station Rk-8 is located downstream from the City of Oconomowoc sewage treatment plant; sampling station Rk-12 is located downstream from the Lake Lawn Lodge private sewage treatment plant; and sampling station Rk-13 is located downstream from the City of Delavan sewage treatment plant, indicating the effect of the treated effluent on the chloride concentrations of the stream water samples. At sampling stations Rk-4 on the Rubicon River and Rk-11 on Jackson Creek, the chloride concentrations remained greater than 49 mg/l with eight-year averages of 306 and 198 mg/l, respectively. The reason for the significantly higher concentrations of chloride at these two locations is not clear, although the presence of the City of Elkhorn sewage treatment plant upstream from sampling station Rk-11 would have an effect on the chloride concentrations of Jackson Creek at sampling station Rk-11. A comparison of the chloride concentrations in April 1968 with August 1968 and in April 1969 with August 1969 indicates higher chloride concentrations at all locations in the August samples in 1968 and in 1969.

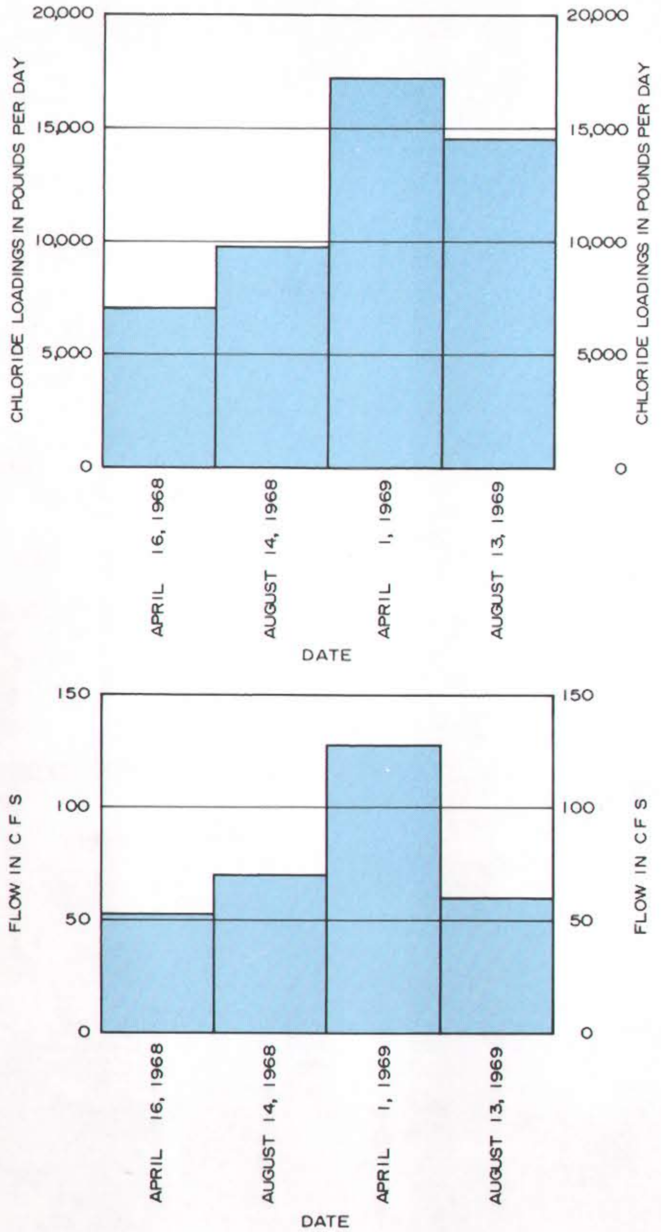
To evaluate the effect of streamflow on chloride levels, a comparison of the flow to the chloride loadings was made as shown in Figure 174 at sampling station Rk-13 using the flow measurements available on Turtle Creek near Clinton, located 12.94 miles downstream from sampling station Rk-13. In 1968, at sampling station Rk-13, when the flow on the sampling dates was lower in April than in August, the chloride loadings also were lower in April. The reverse was true for 1969: the flow and the chloride loadings were higher in August 1969 than in April at sampling station Rk-13. Map 65 presents the chloride concentrations at the Rock River sampling stations on August 13-14, 1968, and August 21-28, 1975, with graphs illustrating the changes in chloride concentrations for the years 1968 through 1975. As illustrated in the graphs, when the chloride concentrations found in August during the period of 1968 through 1975 are compared, no changes were observed in the chloride concentrations over the past eight years at 12 of the 13 sampling locations, with the exception of sampling station Rk-4 on the Rubicon River where a significant decrease in chloride concentrations was observed over the past eight years.

The chloride loadings at sampling station Rk-13 during the sampling days are compared with the flow in Figure 175. For all eight sets of samples, the flow and the chloride loadings increased simultaneously and proportionately. The chloride loadings from the sewage treatment plants should be relatively constant, and not vary with the flow. The fact that the chloride loadings carried in the streams vary with the flow at sampling station Rk-13 on Turtle Creek indicates that the chloride has sources other than sewage effluent. The higher flows in 1972 were associated with rain, raising the possibility of the origin of chloride being associated with storm water runoff. The background chloride loadings, assuming maximum background chloride concentrations of 10 mg/l as noted from the well samples of the test area, are included in Figure 175 and illustrate the fact that chloride loadings in all the samples at sampling station Rk-13 are approximately three times higher than the background loadings.

Fecal Coliform Bacteria: Map 66 presents the fecal coliform counts in the Rock River watershed sampling locations in August during the period from 1968 through 1975 with graph inserts representing the changes in fecal coliform counts found on sampling days during the intermediate years at each sampling location. In August 1968 samples, the fecal coliform counts were greater than 1,000 MFFCC/100 ml at seven sampling station locations:

Figure 174

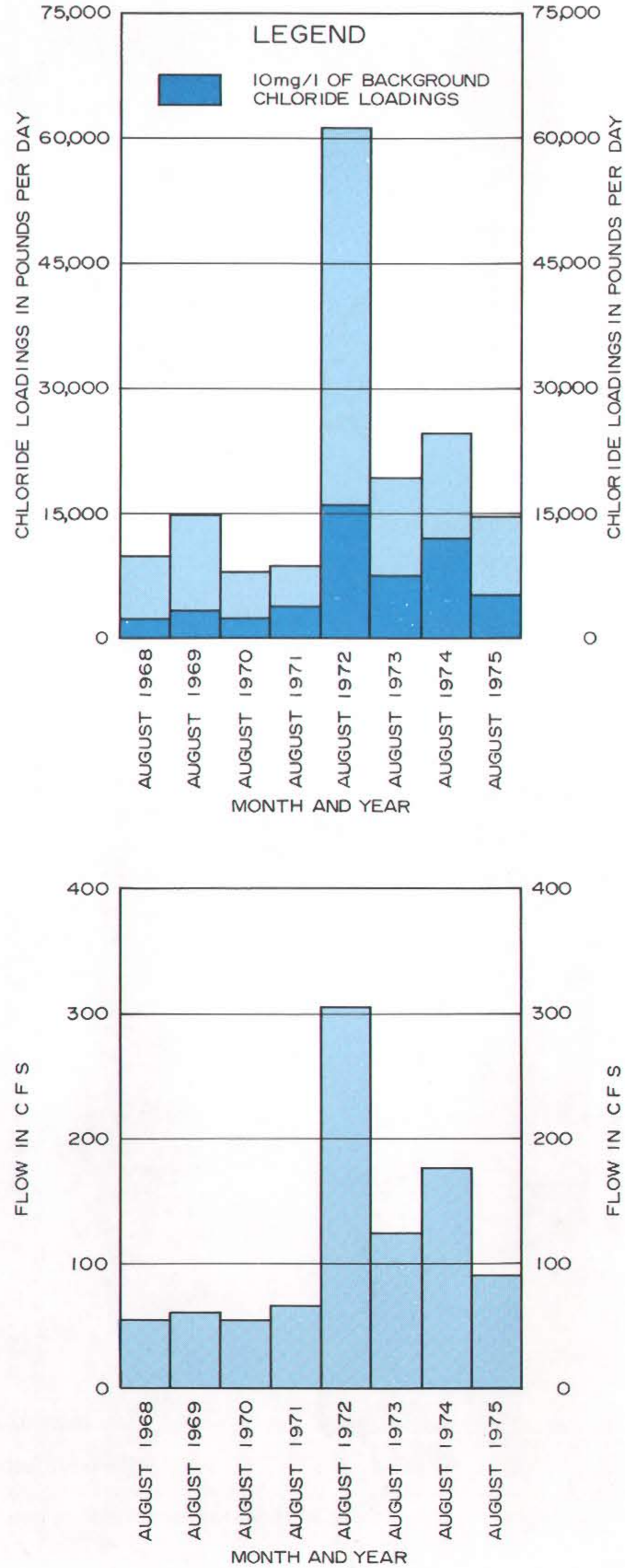
COMPARISON OF CHLORIDE LOADINGS AND FLOW ON TURTLE CREEK NEAR CLINTON (RK-13) ON THE DATES OF WATER SAMPLE COLLECTION APRIL AND AUGUST 1968 AND 1969



Source: SEWRPC.

Figure 175

COMPARISON OF CHLORIDE LOADINGS AND FLOW ON TURTLE CREEK NEAR CLINTON (RK-13) ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975

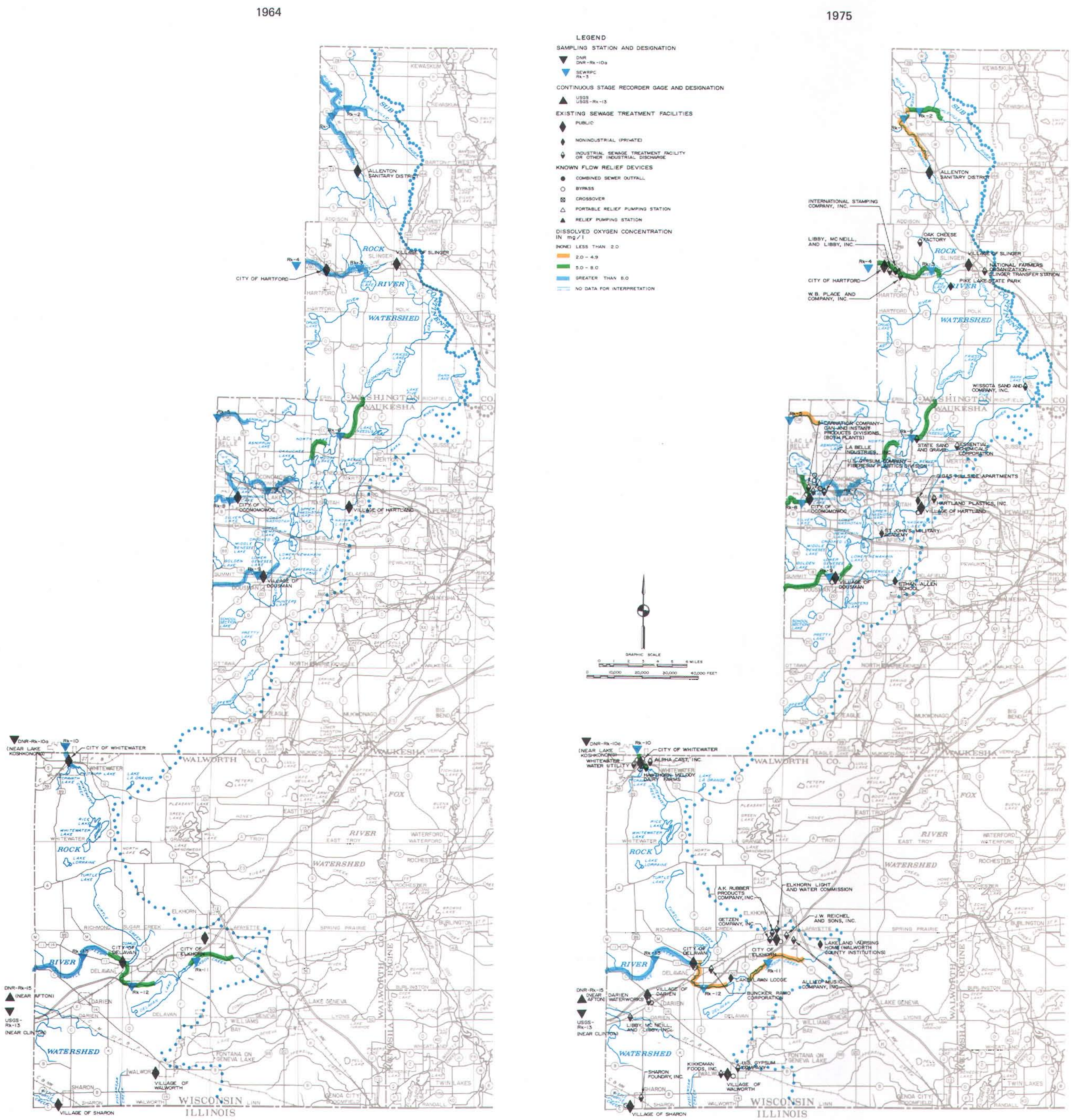


Source: SEWRPC.

Rk-4 on the Rubicon River, Rk-5 on the Ashippun River, Rk-6 and Rk-8 on the Oconomowoc River, and Rk-10 on Whitewater Creek, Rk-11 on Jackson Creek, and Rk-13 on Turtle Creek. Sampling station Rk-4 is located downstream from the City of Hartford sewage treatment plant on the Rubicon River; sampling station Rk-8 is located

Map 64

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE ROCK RIVER WATERSHED

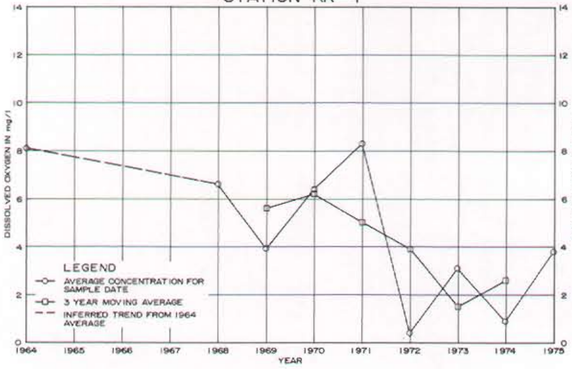


A comparison of the dissolved oxygen levels recorded from 1964 to 1975 in the Rock River watershed indicated that dissolved oxygen concentrations generally decreased over the past decade with the exception of sampling stations Rk-6, Rk-7, and Rk-13 where the dissolved oxygen concentrations remained unchanged. The maximum recorded dissolved oxygen concentration was 25.1 mg/l at sampling station Rk-8. Sampling station Rk-1 recorded the minimum dissolved oxygen concentration of 0.3 mg/l.

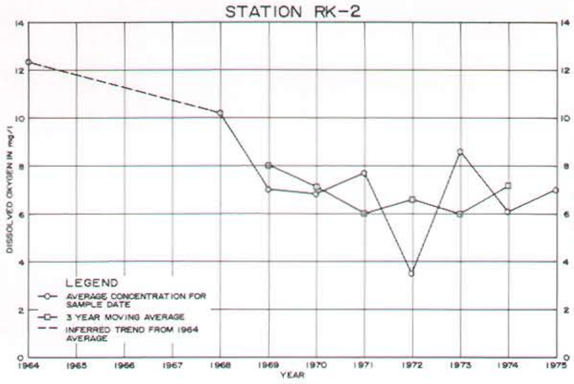
Source: SEWRPC.

Map 64 (continued)

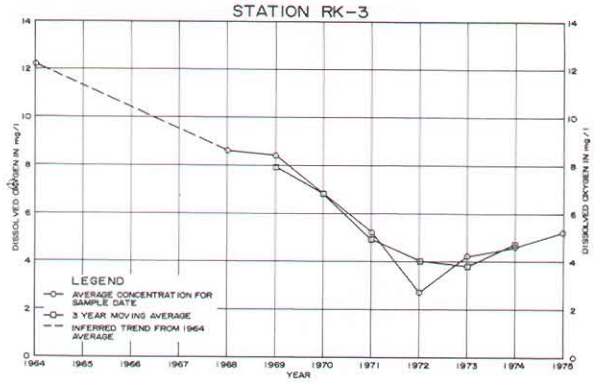
STATION RK-1



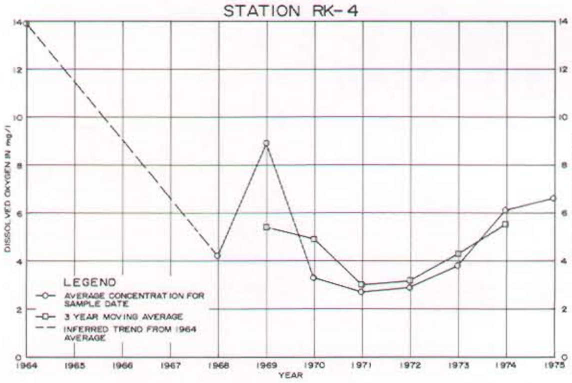
STATION RK-2



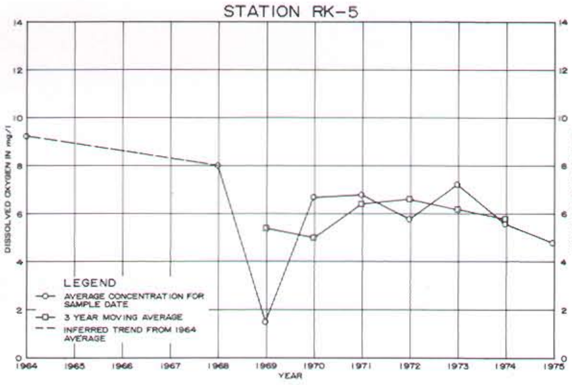
STATION RK-3



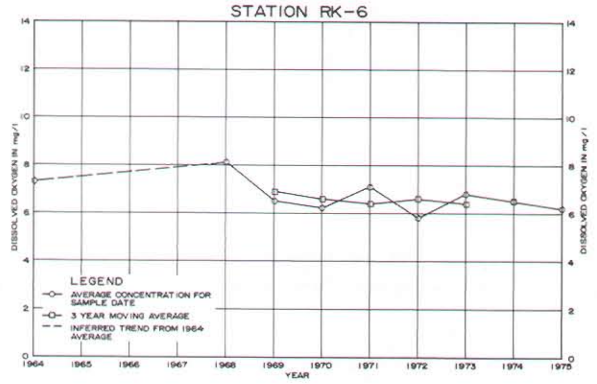
STATION RK-4



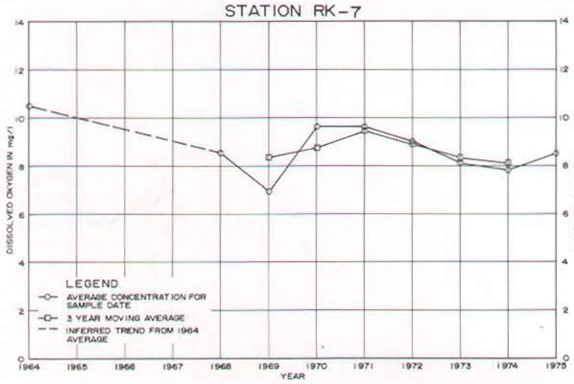
STATION RK-5



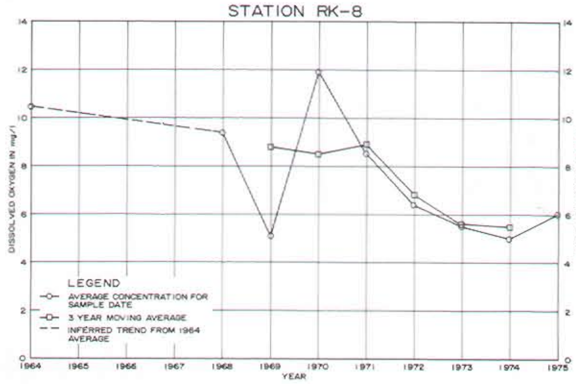
STATION RK-6



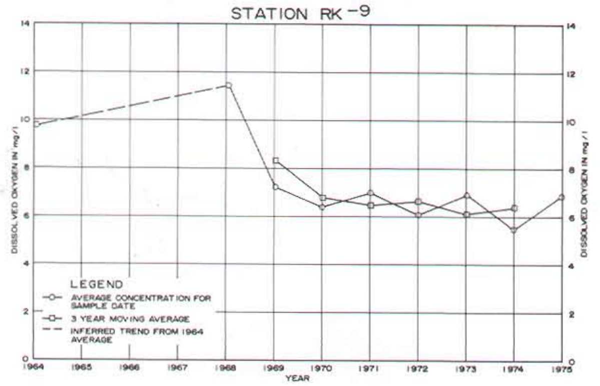
STATION RK-7



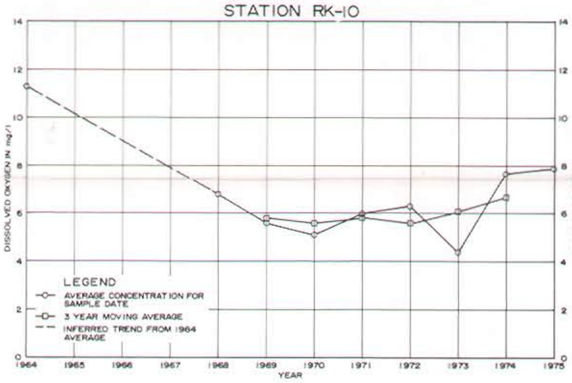
STATION RK-8



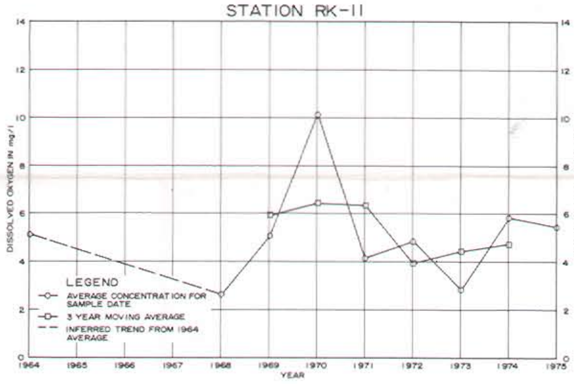
STATION RK-9



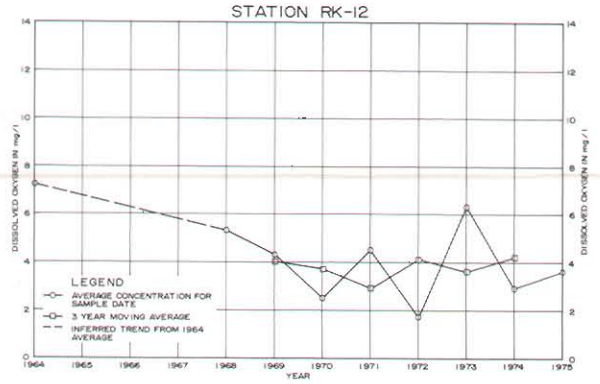
STATION RK-10



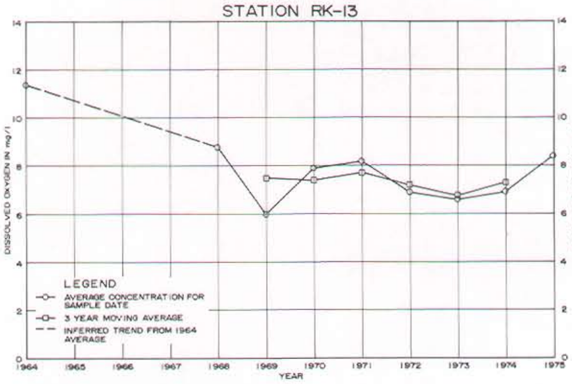
STATION RK-11



STATION RK-12



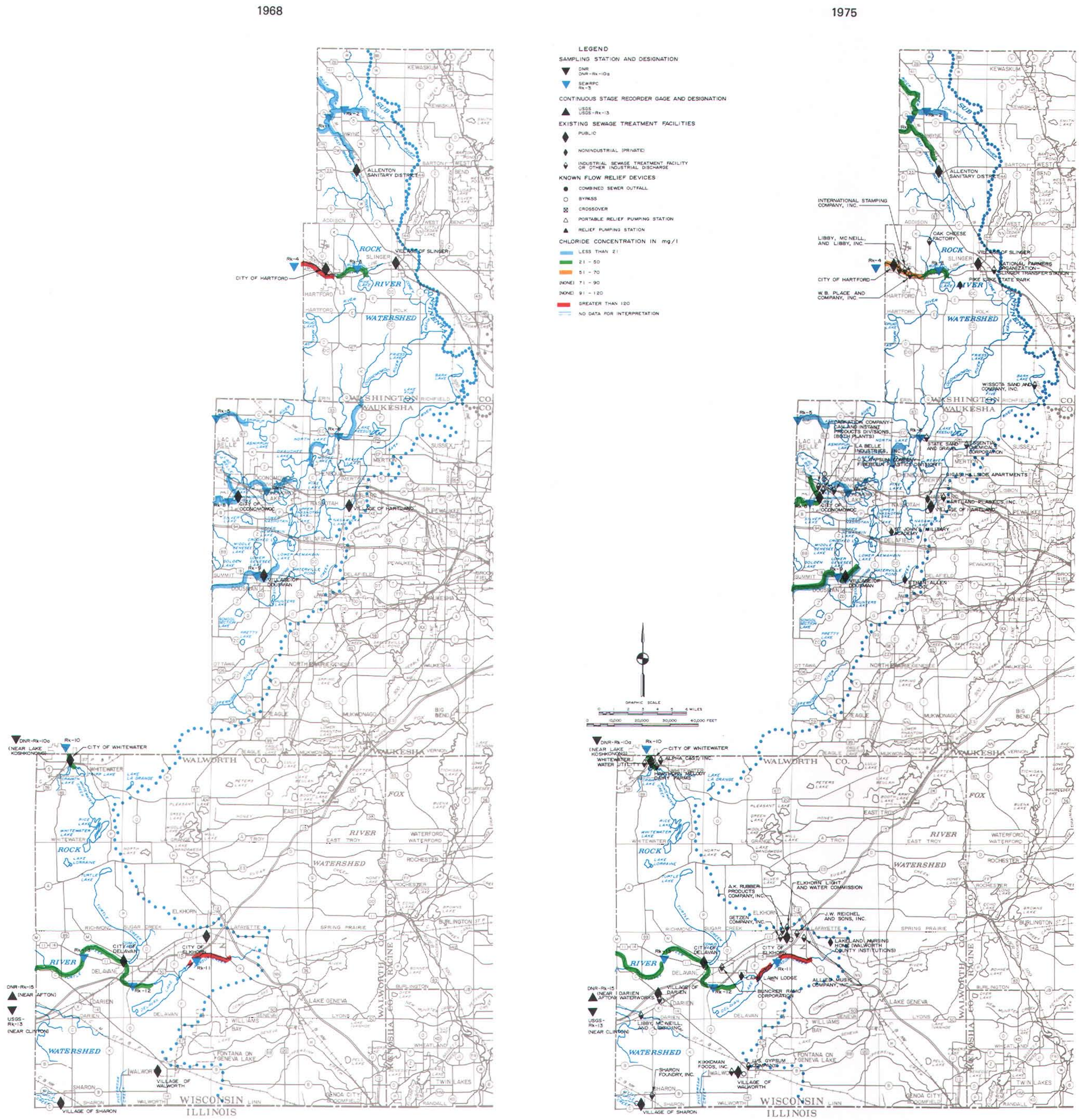
STATION RK-13



Source: SEWRPC.

Map 65

COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1975 IN THE ROCK RIVER WATERSHED

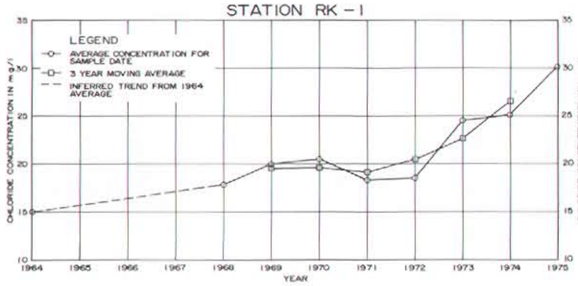


A comparison of the chloride concentrations recorded in 1968 and 1975 generally indicated no significant change throughout the watershed. A decrease in chloride concentration was recorded at sampling station Rk-4, while increases were observed at sampling stations Rk-1, Rk-8, and Rk-9. The maximum recorded chloride concentration was 897 mg/l at sampling station Rk-4. The minimum observed chloride concentration was 3 mg/l.

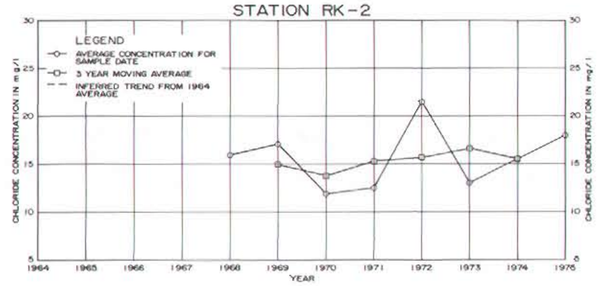
Source: SEWRPC.

Map 65 (continued)

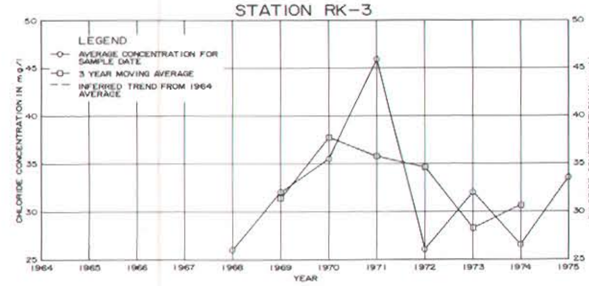
STATION RK-1



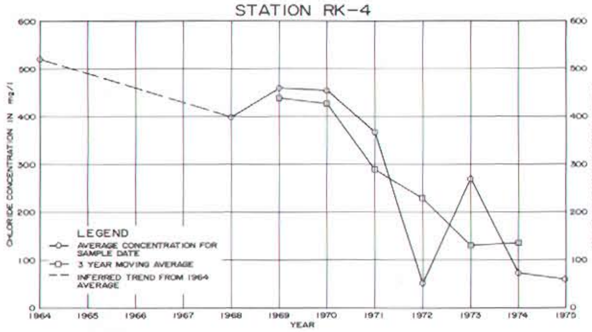
STATION RK-2



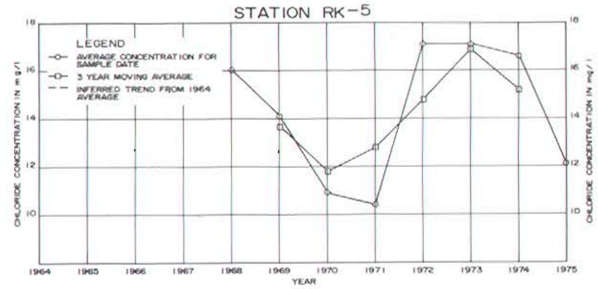
STATION RK-3



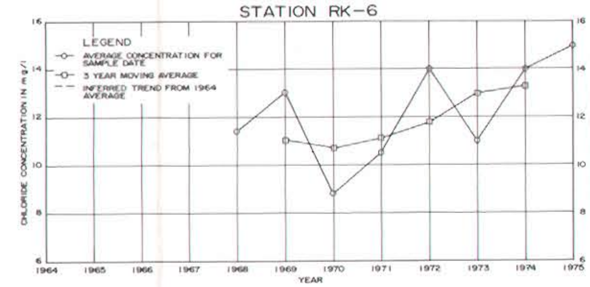
STATION RK-4



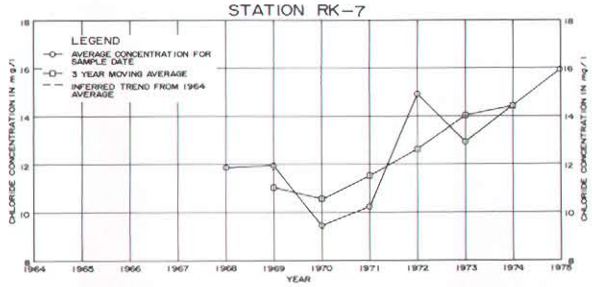
STATION RK-5



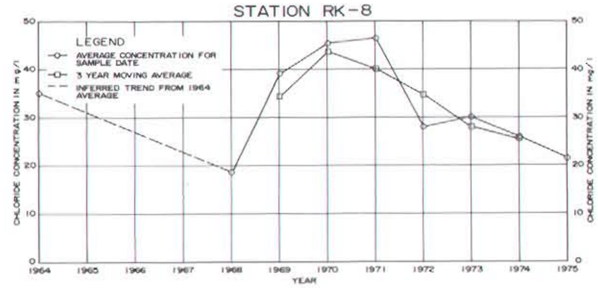
STATION RK-6



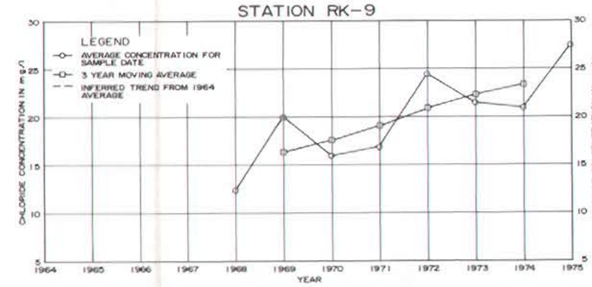
STATION RK-7



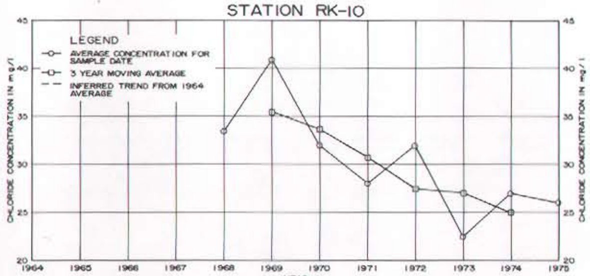
STATION RK-8



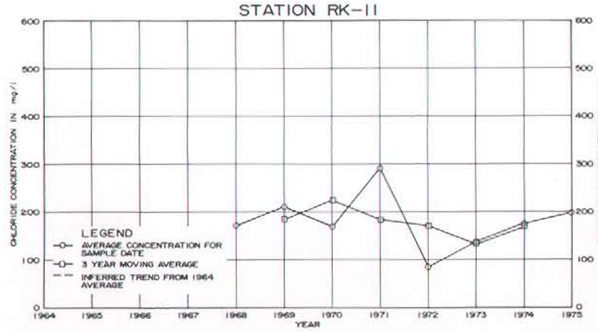
STATION RK-9



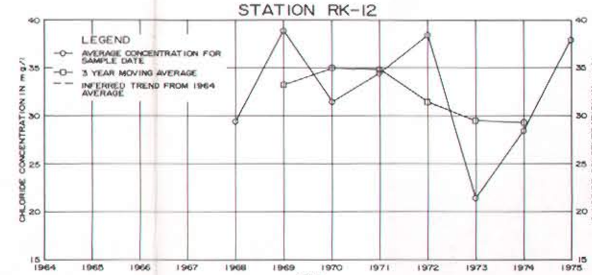
STATION RK-10



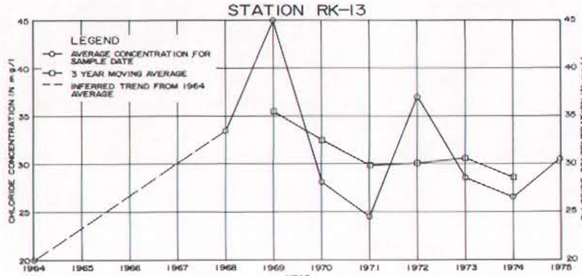
STATION RK-11



STATION RK-12



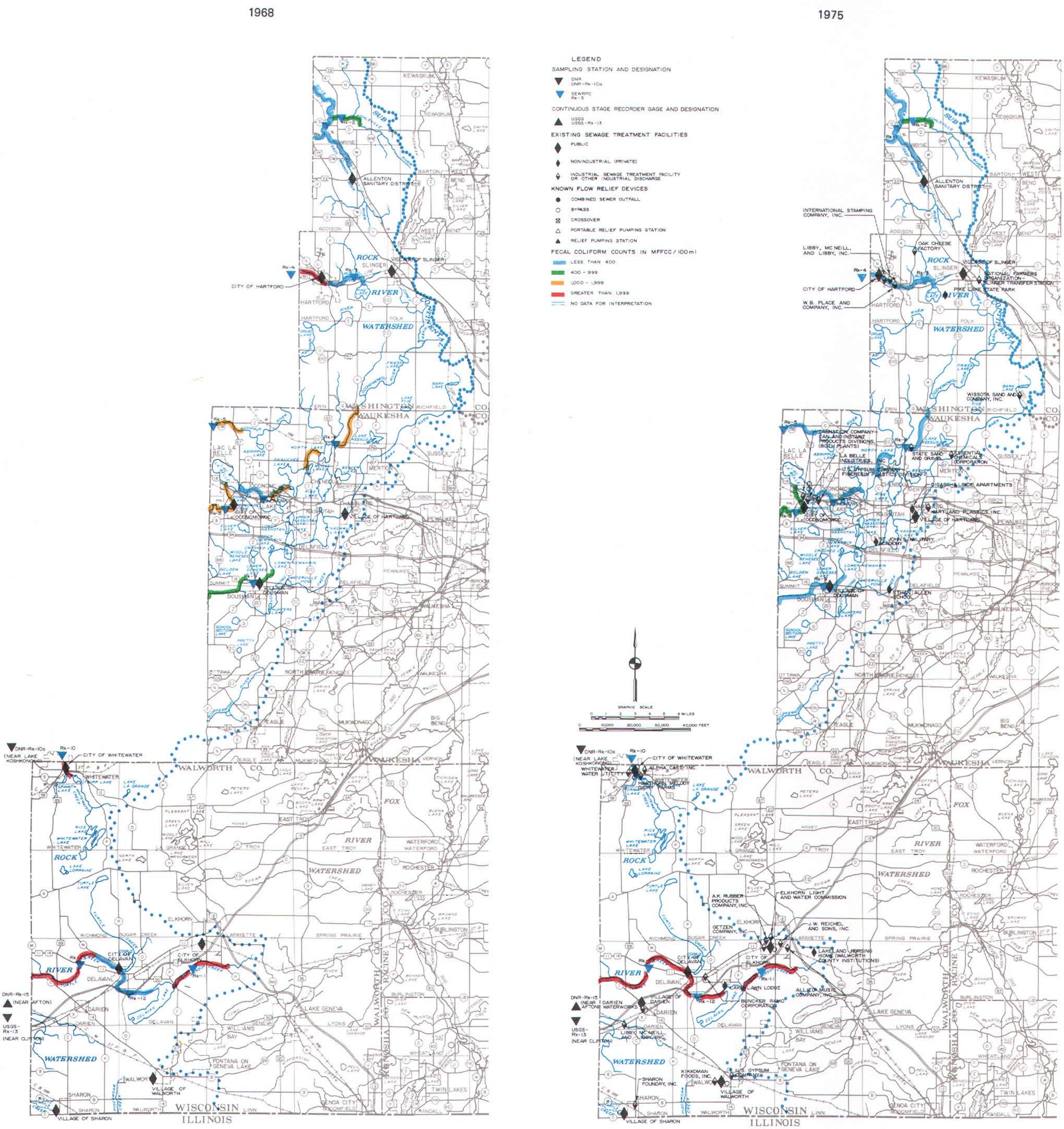
STATION RK-13



Source: SEWRPC.

Map 66

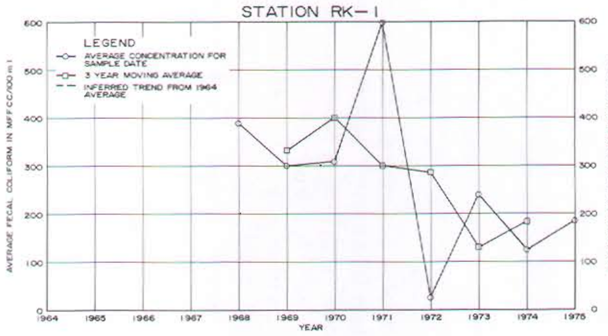
COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1975 IN THE ROCK RIVER WATERSHED

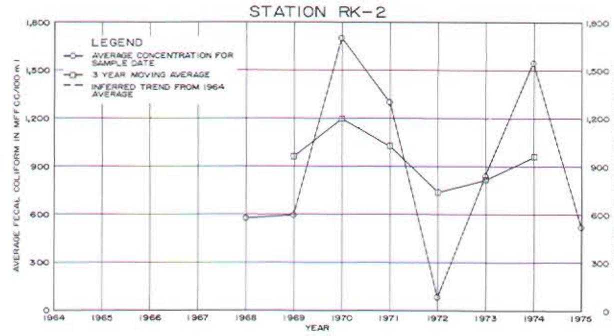


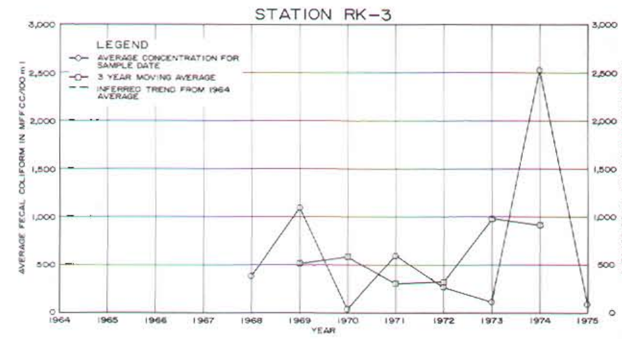
A comparison of fecal coliform levels recorded from 1968 to 1975 in the Rock River watershed indicated that fecal coliform counts generally remained stable or decreased for the period. Only one sampling station, Rk-12, located downstream from the Delavan Lake Outlet, exhibited an increase in fecal coliform counts. The maximum observed fecal coliform count was 60,000 MFFCC/100 ml at sampling station Rk-9. The minimum recorded fecal coliform count was 5 MFFCC/100 ml at station Rk-7.

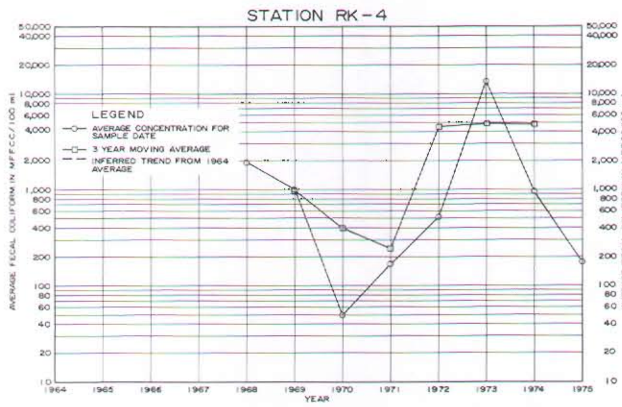
Source: SEWRPC.

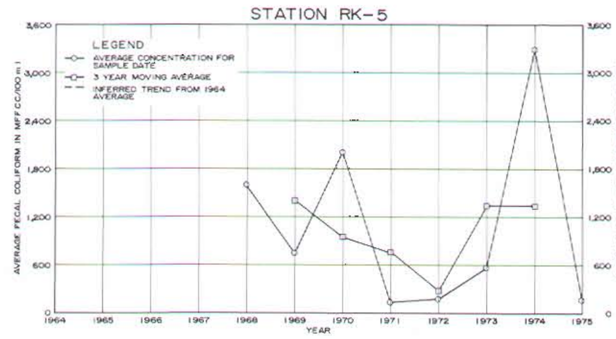
Map 66 (continued)

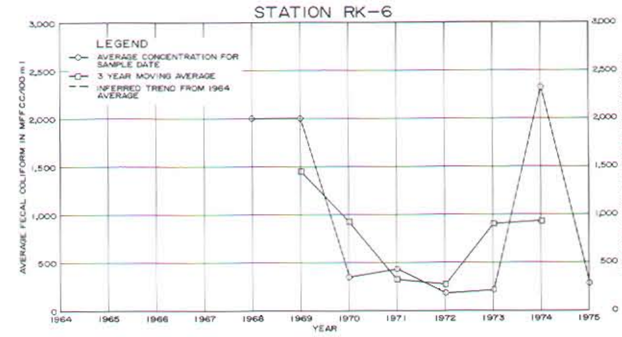


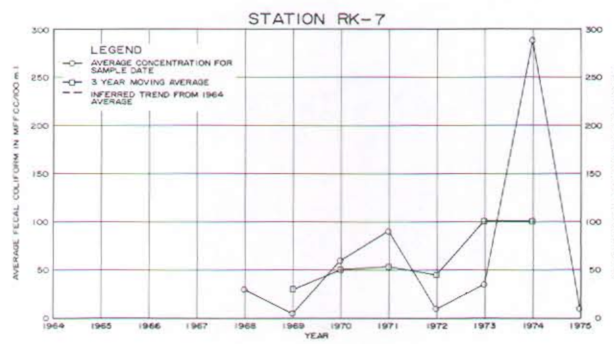


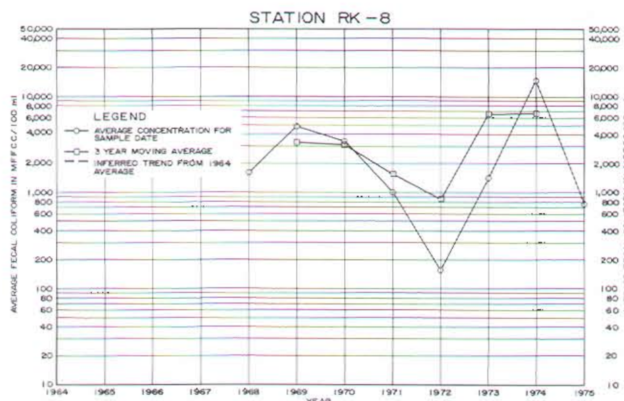


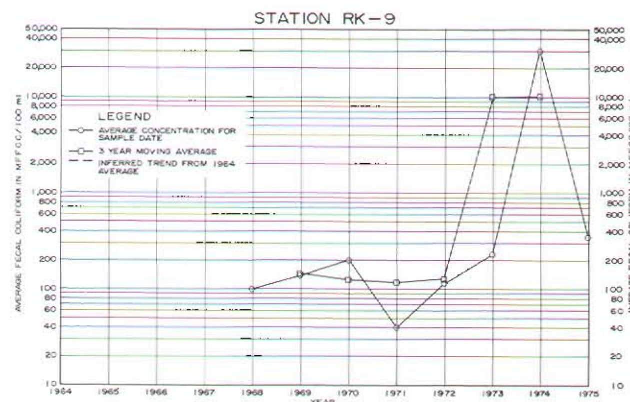


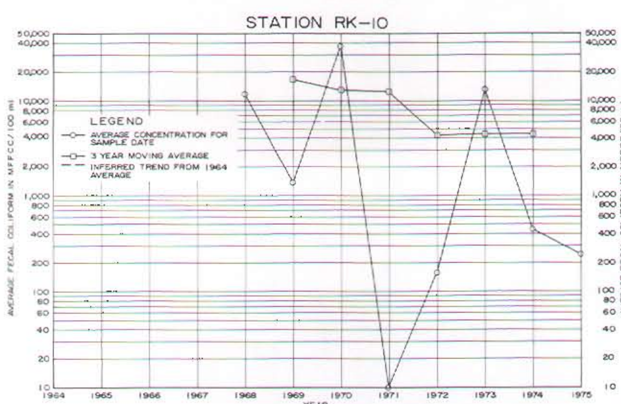


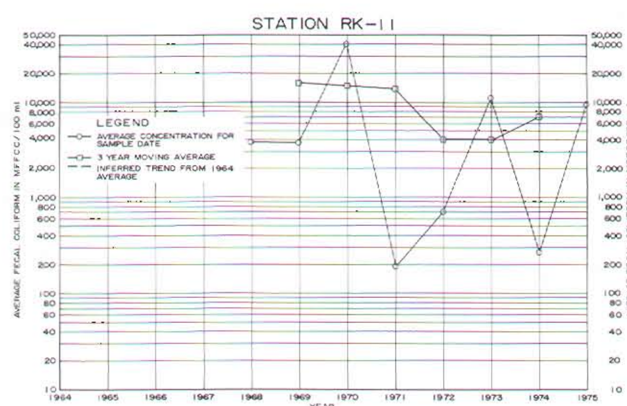


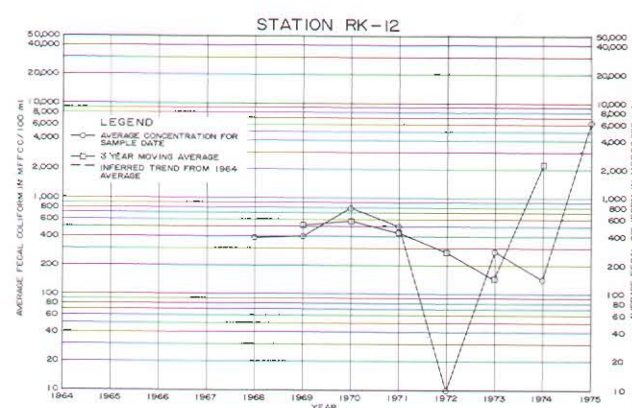


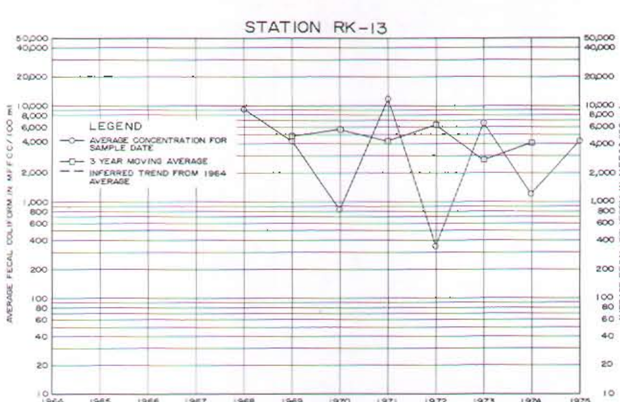












Source: SEWRPC.

downstream from the City of Oconomowoc sewage treatment plant on the Oconomowoc River; sampling station Rk-10 is located downstream from the City of Whitewater sewage treatment plant on Whitewater Creek; sampling station Rk-11 is located downstream from the City of Elkhorn sewage treatment plant on Jackson Creek; and sampling station Rk-13 is located downstream from the City of Delavan sewage treatment plant on Turtle Creek. The high fecal coliform counts at these locations, therefore, are likely to be due to discharge of treated effluent upstream from the sampling locations. The high fecal coliform counts at sampling station Rk-5 on the Ashippun River and sampling station Rk-6 on the Oconomowoc River are likely to be due to runoff from agricultural operations and from malfunctioning private onsite sewage disposal systems (septic tanks). The water samples collected during the August 1975 survey exhibited fecal coliform counts greater than 1,000 MFFCC/100 ml at sampling stations Rk-11 on Jackson Creek, and Rk-13 on Turtle Creek, both of which also showed high fecal coliform counts in the 1968 summer sampling survey. In addition, sampling station Rk-12, located downstream from the Lake Lawn Lodge private sewage treatment plant on the Delavan Lake Outlet, also exhibited high fecal coliform counts in the 1975 summer samples.

The graph inserts on Map 66 illustrate the trend of fecal coliform counts over time at all 13 sampling stations in the Rock River watershed. Five of the 13 sampling stations (Rk-1 on the East Branch of the Rock River, Rk-3 on the Rubicon River, Rk-7 on the Oconomowoc River downstream from Oconomowoc Lake, Rk-9 on the Bark River, and Rk-12 on the Delavan Lake Outlet) exhibited generally stable fecal coliform counts over the past eight years, except for the samples collected in August 1969 and 1974 at sampling station Rk-3 on the Rubicon River; in August 1974 at sampling station Rk-9 on the Bark River; and in August 1975 at sampling station Rk-12 on the Delavan Lake Outlet. For these samples higher fecal coliform counts were exhibited than in the samples collected the other seven years. At three sampling stations (Rk-5 on the Ashippun River, Rk-6 on the Oconomowoc River, and Rk-10 on Whitewater Creek), the fecal coliform counts decreased over the past eight years except for the samples collected in August 1969 and 1974. At Kohlsville River sampling station Rk-2, Rubicon River sampling station Rk-4, Oconomowoc River sampling station Rk-8, Jackson Creek sampling station Rk-11, and Turtle Creek sampling station Rk-13, no trend in the fecal coliform counts over the past eight years was observed.

Hydrogen Ion Concentrations (pH): As indicated in Table 173, the pH values of the Rock River watershed have been found to be generally within the range of 6.0 to 9.0 standard units prescribed for recreational use and fish and aquatic life use. On two occasions, once at sampling station Rk-8 on the Oconomowoc River on August 13, 1970, and once at sampling station Rk-11 on Jackson Creek on August 29, 1970, the pH values were greater than 9.0 standard units (9.1 and 9.2 standard units, respectively). The high pH values were associated with high dissolved oxygen values during the afternoon hours and are therefore likely to be due to the photosynthetic activities by algae and the aquatic plants. No trend in pH variation of the samples collected in August during the period from the years 1968 through the year 1975 were observed.

Specific Conductance: Specific conductance, which is a measure of total dissolved ions in water, was found to be in the range from 210 to 3,000 µmhos/cm at 25°C at the 13 sampling station locations in the Rock River watershed on the days sampled in August during the years 1968 through 1975. The highest specific conductance value of 3,000 µmhos/cm at 25°C was found at sampling station Rk-4 on the Rubicon River in August 1970. The daily average specific conductance values remained greater than 600 µmhos/cm at 25°C at sampling stations Rk-4 on the Rubicon River and Rk-11 on Jackson Creek, which also had high daily average chloride concentrations. At the other locations, specific conductance values remained low and showed no significant change over the past decade. At sampling station Rk-4 on the Rubicon River, the specific conductance values decreased with time, as was also the case with the chloride concentrations at this location. At sampling station Rk-11 on Jackson Creek, specific conductance values remained high but generally unchanged over the past eight years.

Temperature: As indicated in Tables 174-186, the stream water temperature of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through August 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected at the 13 Rock River watershed sampling stations during August 1968 through 1975 were analyzed for the soluble orthophosphate concentrations. A range of 0.01 to 4.15 mg/l of soluble orthophosphate as P was obtained during the eight sampling sessions at 13 locations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.01 to 9.36 mg/l as P was obtained. The ratio of soluble orthophosphate to total phosphorus was in the range of 0.5 to 1.0 and indicates that most of the phosphorus is in the form readily available for the growth of aquatic plants in the Rock River tributaries. Although not enough samples were analyzed to characterize the trends in total phosphorus concentrations with time, it is evident from the data that total phosphorus concentrations at many locations on the Rock River watershed are many times higher than required for excessive algal growth. A limit of total phosphorus 0.10 as P is generally held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants. All water samples collected from the Rubicon River at Rk-4, the Whitewater Creek at Rk-10, Jackson Creek at Rk-11, and the Oconomowoc River at Rk-8 had total phosphorus levels higher than 0.10 mg/l as P. Nine out of 10 samples collected from the East Branch of the Rock River, the Delavan Lake Outlet, and Turtle Creek also had total phosphorus concentration greater than 0.10 mg/l as P. At the Kohlsville River and the Ashippun River sampling stations, five and eight, respectively, of the 10 samples collected had total phosphorus greater than 0.10 mg/l. Total phosphorus concentrations remained generally constant over the past four years at all locations except for sampling station Rk-4 on the Rubicon River, sampling station Rk-10 on Whitewater Creek, and sampling station Rk-11 on Jackson Creek where the samples were found to have high total phosphorus concentrations so varied that no specific trend could be observed in the past four years.

Figure 176 presents the total phosphorus loadings and flow for sampling station Rk-13 on Turtle Creek for the samples collected in August 1972 through 1975. Although the high flow during the 1972 sampling survey showed high total phosphorus loadings at sampling station Rk-13 on Turtle Creek, there was no direct correlation between flow and total phosphorus loadings for the data collected during the period of 1973 through 1975.

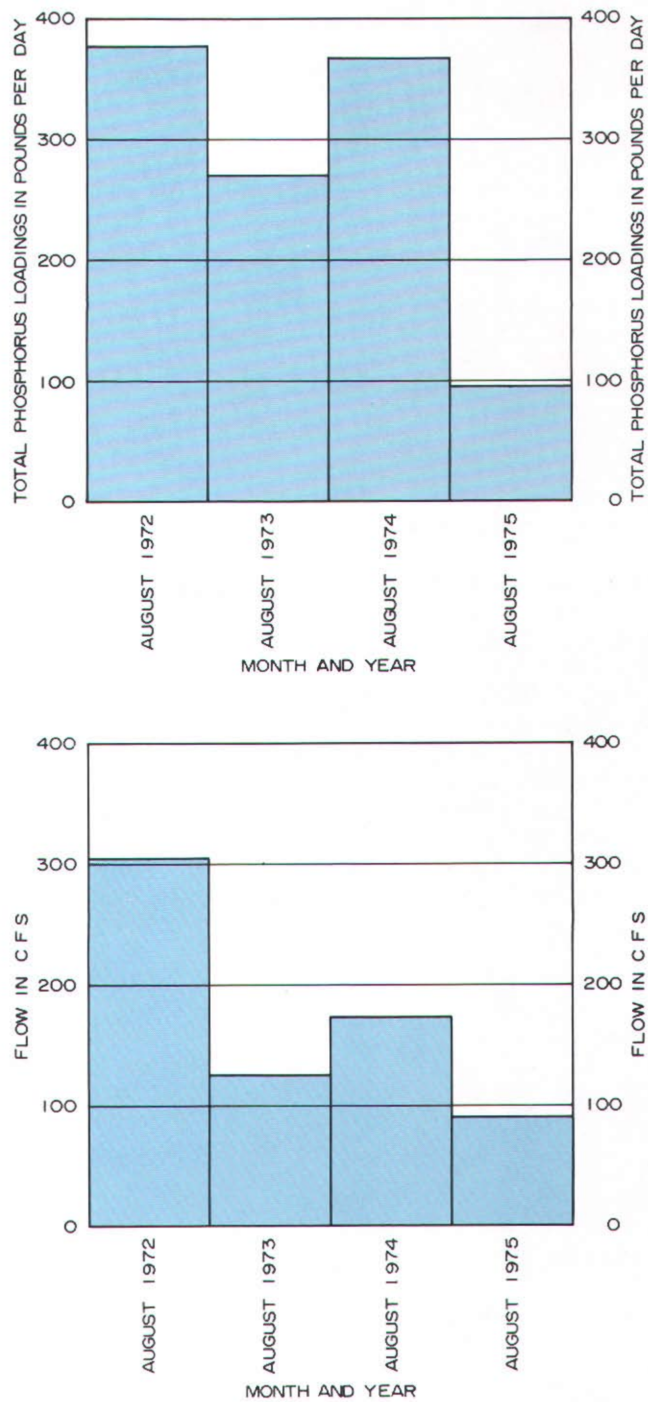
Nitrogen: The total nitrogen concentrations in the Rock River water samples collected during August 1972 through 1975 were found to be in the range of 0.29 to 7.85 mg/l and, of these, 0 to 8.9 percent was in the form of nitrite-nitrogen, 10.3 to 72.4 percent of ammonia-nitrogen, 13.7 to 42.9 percent of nitrate-nitrogen, and 40.7 to 96.5 percent of organic-nitrogen. The concentrations of ammonia-nitrogen in the Rock River sampling sites ranged from less than 0.03 to 5.69 mg/l as N. On 29 of the 105 sampling dates, ammonia-nitrogen did exceed 0.2 mg/l as N, the level generally held to be indicative of lakes and streams which have been affected by pollution. For more than 96 percent of the samples, the ammonia concentrations were below the known toxic level of 2.5 mg/l for ammonia-nitrogen as N. The highest concentrations were found at sampling station Rk-9 on the Bark River.

Nitrate-nitrogen concentrations in the Rock River watershed were found to range from less than 0.04 to 3.37 mg/l as N. Organic-nitrogen was found to account for 24 to 45 percent of the total nitrogen in the samples collected in the Rock River watershed. The presence of organic-nitrogen in such a large concentration accounts for the low dissolved oxygen concentrations present in many of the sampling locations, since the degradation and oxidation of organic-nitrogen compounds utilizes the oxygen present in the surface water. The concentrations of organic-nitrogen and nitrate-nitrogen have remained high through the years 1972-1975 indicating that no significant change or decrease in the organic loading has occurred in the Rock River over the last four years. Figure 177 presents the total nitrogen loadings and flow for sampling station Rk-13 for August 1972 through 1975.

Although the high flow during the 1972 sampling survey showed high total nitrogen loadings at sampling station Rk-13 on Turtle Creek, there was no direct correlation between the flow and the total nitrogen loadings for the data collected during the period of 1973 through 1975.

Figure 176

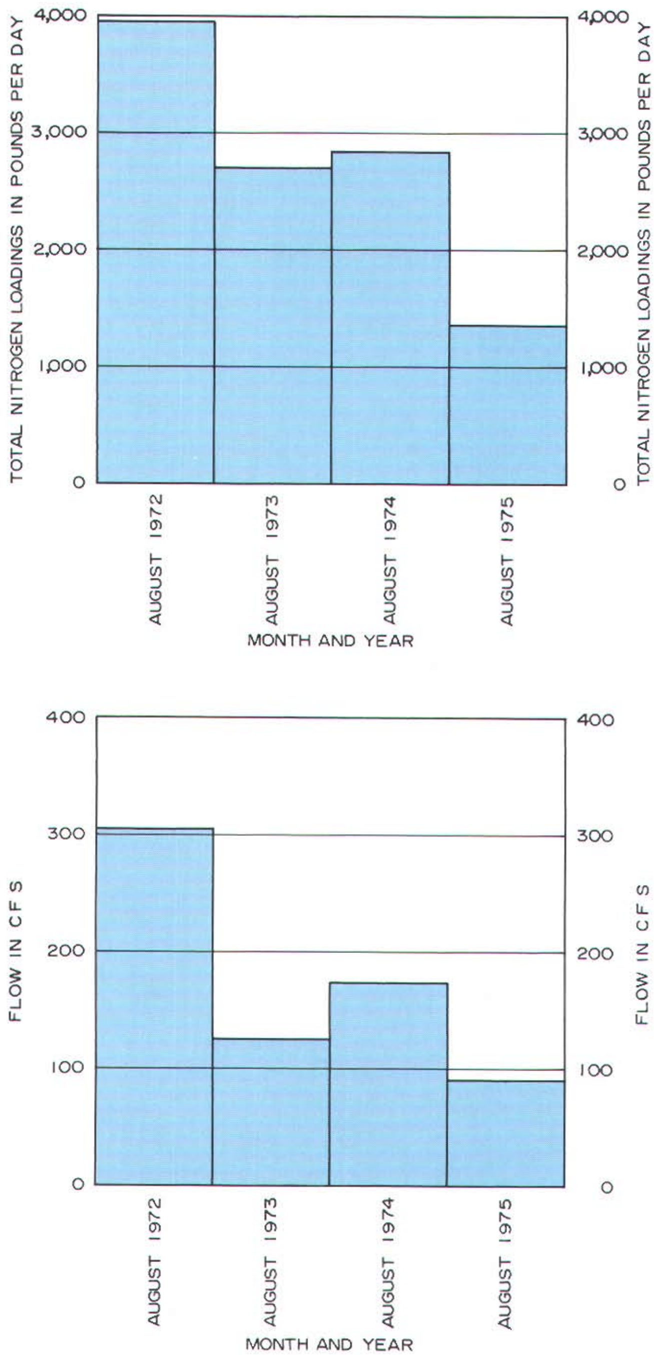
COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT TURTLE CREEK NEAR CLINTON (RK-13) ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975



Source: SEWRPC.

Figure 177

COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW ON TURTLE CREEK NEAR CLINTON (RK-13) ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROCK RIVER WATERSHED: 1972-1975



Source: SEWRPC.

Biochemical Oxygen Demand: The Commission water quality monitoring program did not include the measurement of biochemical oxygen demand for the years 1965 through 1975. No other biochemical oxygen demand data are available from the other sources to study the trend in the biochemical oxygen demands over the past decade in the Rock River watershed.

Water Quality of Lakes in the Rock River Watershed 1965-1975: The data sources used for the analysis of lake water quality in the Rock River watershed included: 1) Wisconsin Department of Natural Resources quarterly lake monitoring program, 2) Lake Association limnological surveys and inland lake inventories, and 3) U. S. Environmental Protection Agency national eutrophication survey-reports on Delavan Lake, Lac La Belle, Oconomowoc Lake, Okauchee Lake, Pine Lake, and Tichigan Lake.

The variation of water quality in a lake depends on the depth of the lake as well as the season of the year. In shallow lakes the water is well mixed, and water quality is fairly uniform throughout the entire depth. In lakes deeper than 15 to 25 feet, however, thermal and chemical stratification occurs during summer. In the chemically stratified lakes, the water quality of the lakes varies with the depth. Of the 38 major lakes in the Rock River watershed, 29 have a maximum depth of greater than 30 feet. Table 187 presents the available data on the major lakes in the Rock River watershed. Among the 29 major lakes that are likely to stratify in the summer, chemical data are available for 28 lakes. The data indicate that all of the major lakes show between zero and less than 1.0 mg/l of dissolved oxygen in the hypolimnion, indicating a possible anaerobic condition during summer, thus adversely affecting the fish and other aquatic life in the lakes. The concentration of dissolved oxygen in the epilimnion generally remained higher than 7.0 mg/l in the major lakes.

Temperature and dissolved oxygen levels in the shallow lakes of the Rock River watershed are generally similar to the conditions existing in the epilimnion of the stratified lakes during the summer months, with oxygen levels near or above saturation. Among the major lakes, LaGrange has a depth of four feet or less for 90 percent or more of the surface area and therefore may freeze solidly during the winter. Of the 38 major lakes, 17 have been classified by the Uttormark's trophic status classification. While Nagawicka Lake in Waukesha County is defined as "very eutrophic," Lac La Belle is classified as "eutrophic"; Beaver, Druid, Fowler, Golden, Keesus, Lower Nemahbin, North, Oconomowoc, Pine, Silver, Upper Nemahbin, and Whitewater Lakes have been classified as "mesotrophic" lakes. Pike Lake in Washington County, and Okauchee Lake and Upper Nashotah Lake in Waukesha County are classified as "oligotrophic" lakes. Complete data are not available for the other lakes for their classification of their trophic status.

A comparison of the water quality data at sampling station Rk-11 and sampling station Rk-12 located on Jackson Creek upstream from Lake Delavan and at

Table 187

AVAILABLE DATA ON THE MAJOR LAKES IN THE ROCK RIVER WATERSHED

Name of Lake	County	Maximum Depth	Type of Lake	WDNR[a] Data	EPA[b] Data	Lake Use[c] Data	Trophic[d] Status	Summer Stratification	Anaerobic Condition in Hypolimnion
Ashippun	Waukesha	40	headwater	Yes	N/A	N/A	N/A	Yes	Yes
Bark	Washington	32	flow-through	Yes	N/A	N/A	N/A	Yes	Yes
Beaver	Waukesha	49	kettle	Yes	N/A	N/A	mesotrophic	Yes	Yes
Delavan	Walworth	56	flow-through	Yes	Yes	Yes	Yes	Yes	Yes
Druid	Washington	40	flow-through	Yes	N/A	N/A	mesotrophic	Yes	Yes
Freiss	Washington	51	flow-through	Yes	N/A	N/A	N/A	Yes	Yes
Fowler	Waukesha	50	flow-through	Yes	N/A	N/A	mesotrophic	Yes	Yes
Golden	Waukesha	46	kettle	Yes	N/A	N/A	mesotrophic	Yes	Yes
Keesus	Waukesha	42	kettle	Yes	N/A	N/A	mesotrophic	Yes	Yes
Lac La Belle	Waukesha	46	flow-through	Yes	Yes	N/A	eutrophic	Yes	Yes
Lower Genesee	Waukesha	44	kettle	Yes	N/A	N/A	N/A	Yes	Yes
Lower Nemahbin	Waukesha	36	flow-through	Yes	N/A	N/A	mesotrophic	Yes	Yes
Middle Genesee	Waukesha	38	kettle	Yes	N/A	N/A	N/A	Yes	Yes
Moose	Waukesha	61	kettle	Yes	N/A	N/A	N/A	Yes	Yes
Nagawicka	Waukesha	90	flow-through	Yes	N/A	N/A	very eutrophic	Yes	Yes
North	Waukesha	78	flow-through	Yes	N/A	N/A	mesotrophic	Yes	Yes
Oconomowoc	Waukesha	62	flow-through	Yes	Yes	N/A	mesotrophic	Yes	Yes
Okauchee	Waukesha	94	flow-through	Yes	Yes	N/A	oligotrophic	Yes	Yes
Upper Nashotah	Waukesha	53	kettle	Yes	N/A	N/A	oligotrophic	Yes	Yes
Lower Nashotah	Waukesha	43	kettle	Yes	N/A	Yes	N/A	Yes	Yes
Pike	Washington	45	kettle	Yes	N/A	N/A	oligotrophic	Yes	Yes
Pine	Waukesha	85	kettle	Yes	Yes	Yes	mesotrophic	Yes	Yes
Pretty	Waukesha	35	kettle	Yes	N/A	N/A	N/A	Yes	Yes
Rice	Walworth	10	flow-through	Yes	N/A	N/A	N/A	No	No
Silver	Waukesha	44	kettle	Yes	N/A	N/A	mesotrophic	Yes	Yes
Turtle	Walworth	35	headwater	Yes	N/A	Yes	N/A	Yes	Yes
Upper Nemahbin	Waukesha	61	flow-through	Yes	N/A	Yes	mesotrophic	Yes	Yes
Whitewater	Walworth	38	headwater	Yes	N/A	Yes	mesotrophic	Yes	Yes

NOTE: N/A indicates data not available.

[a] *Wisconsin Department of Natural Resources, Bureau of Research, Quarterly Inland Lake Monitoring Program, 1973-1977.*

[b] *National Eutrophication Survey Methods for Lakes Sampled in 1972, Working Paper No. 1, Pacific Northwest Environmental Research Laboratory, Environmental Protection Agency, October 1974.*

[c] *Lake Use Reports prepared by the Wisconsin Department of Natural Resources for the Southeastern Wisconsin Regional Planning Commission and financed in part by the U. S. Department of Housing and Urban Development under provisions of Section 701 of the Housing Act of 1954 as amended, 1968-1974.*

[d] *Paul D. Uttormark and J. Peter Wall, Lake Classification—A Trophic Characterization of Wisconsin Lakes, Water Resources Center, University of Wisconsin-Madison and U. S. Environmental Protection Agency, June 1975, EPA 660/3-75-033.*

Source: SEWRPC.

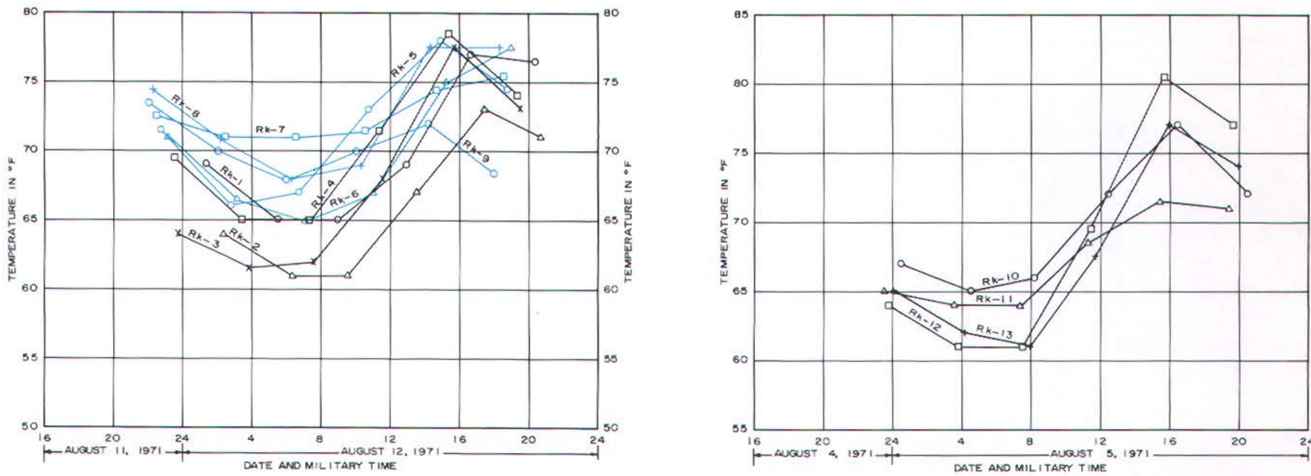
Delavan Lake Outlet, respectively, provides a general indication of the effect of a flow-through lake on the water quality of the streamflow. In general, the dissolved oxygen, soluble orthophosphate, and nitrate increased at the sampling station located downstream from the Lake (Rk-12) while chloride concentrations remained the same. A more detailed description of the specific problems occurring in each of the major lakes in the Rock River watershed is presented in the individual lake study reports published separately over the past several years.

Diurnal Water Quality Changes: Figures 178 through 182 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low-flow conditions on August 4-5 and 11-12, 1971, at the Rock River tributary sampling stations Rk-1, Rk-2, Rk-4, Rk-5, Rk-8, Rk-9, Rk-10, and Rk-13. Although no flow data are available for these sampling station locations, it is believed that the water quality variation in a 24-hour cycle on these tributaries would have a significant effect on the water quality during the low-flow period. The diurnal water quality changes at sampling stations Rk-1 on the East Branch of the Rock River, Rk-2 on the Kohlsville River, Rk-4 on the Rubicon River, Rk-5 on the Ashippun River, Rk-8 on the Oconomowoc River, Rk-9 on the Bark River, Rk-10 on Whitewater Creek, and Rk-13 on Turtle Creek are discussed below.

East Branch of the Rock River: At sampling station Rk-1 on the East Branch of the Rock River, water quality data were collected on August 12, 1971, at four-hour intervals during a 24-hour period. Water temperature at this loca-

Figure 178

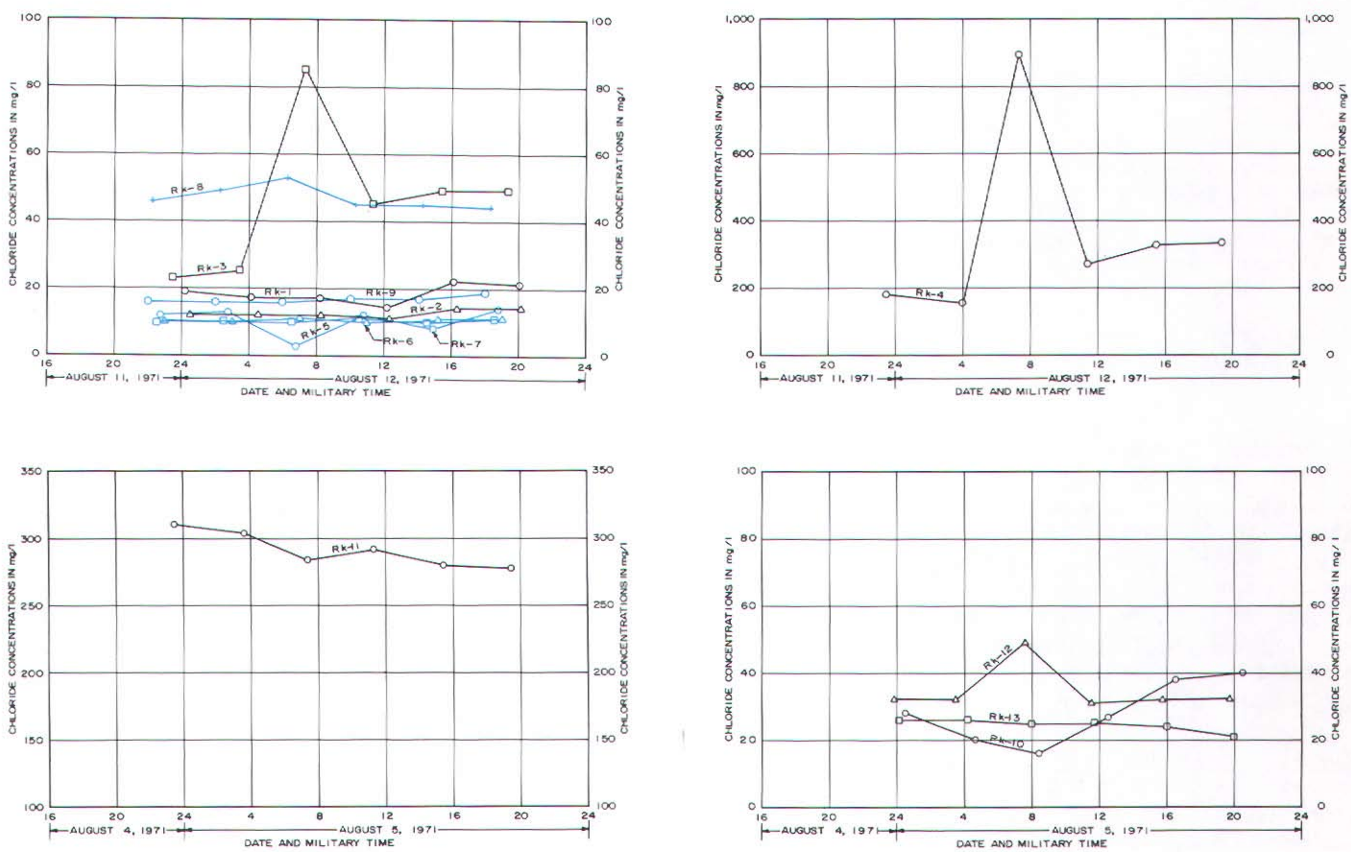
DIURNAL VARIATIONS IN TEMPERATURE AT SAMPLING STATIONS RK-1 THROUGH RK-13 IN THE ROCK RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 1971



Source: SEWRPC.

Figure 179

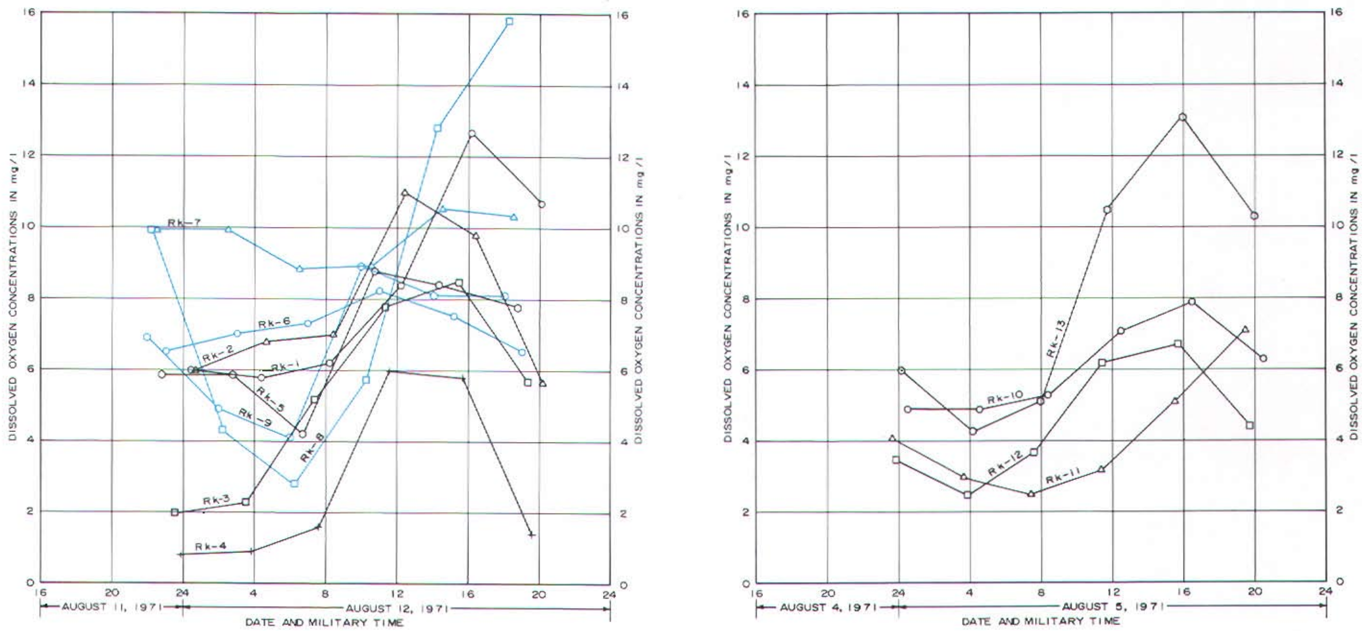
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATION AT SAMPLING STATIONS RK-1 THROUGH RK-13 IN THE ROCK RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 1971



Source: SEWRPC.

Figure 180

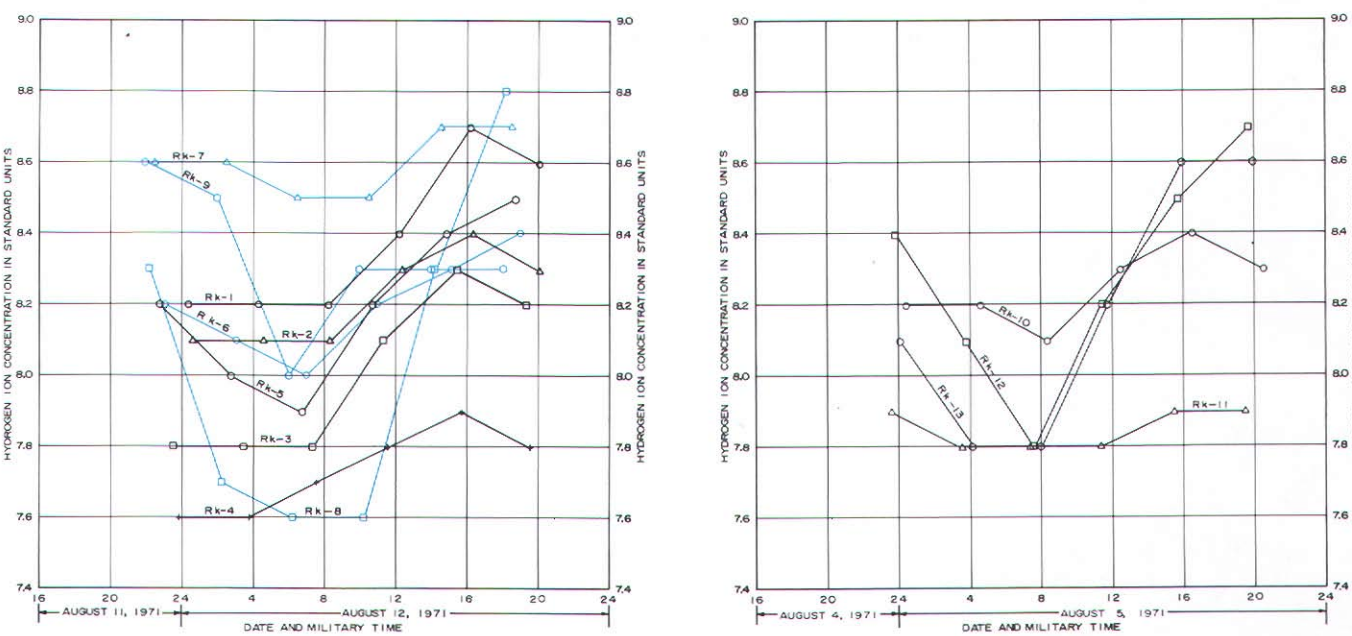
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATION AT SAMPLING STATIONS RK-1 THROUGH RK-13 IN THE ROCK RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 1971



Source: SEWRPC.

Figure 181

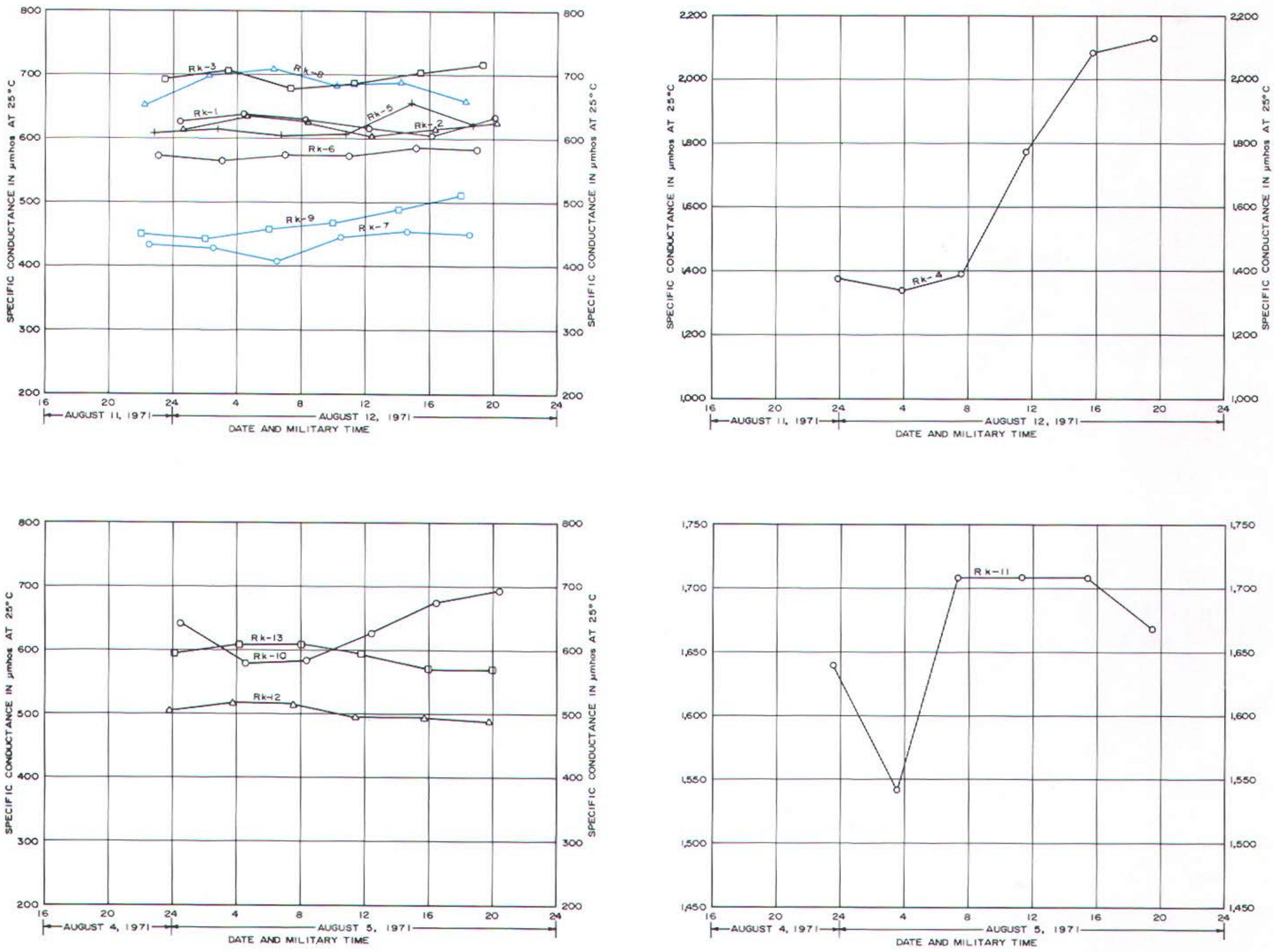
DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATION AT SAMPLING STATIONS RK-1 THROUGH RK-13 IN THE ROCK RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 1971



Source: SEWRPC.

Figure 182

DIURNAL VARIATIONS IN SPECIFIC CONDUCTANCE AT SAMPLING STATIONS RK-1 THROUGH RK-13 IN THE ROCK RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: AUGUST 1971



Source: SEWRPC.

tion varied from a low of 65°F at 4:25 a.m. on August 12, 1971, to a high of 77°F during the evening hours of 4:10 p.m. The recorded diurnal water temperature fluctuation was the likely result of corresponding diurnal variations in the air temperature and solar radiation. Chloride concentrations were found to range from 14 to 22 mg/l. The low and constant chloride concentrations in the six daily samples indicate that the primary source of chloride is groundwater inflow.

The concentration of dissolved oxygen at sampling station Rk-1 was found to vary from a low of 5.8 mg/l during the early morning hours to a high of 12.7 mg/l during the afternoon hours. The hydrogen ion concentration (pH) was found to vary from a low of 8.2 to a high of 8.7 standard units during the late evening hours. The pH and dissolved oxygen variations may be attributed to algal and other aquatic plant respiration and photosynthesis.

Kohlsville River: At sampling station Rk-2 located on the Kohlsville River, water quality data were collected on August 12, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of $61^{o}F$ at 4:35 a.m. to a high of $73^{o}F$ during the evening hour of 4:25 p.m. on August 12, 1971. The recorded diurnal water temperature fluctuation may be attributed to corresponding diurnal variations in the air temperature and solar radiation.

The chloride concentrations were found to range from 11 to 14 mg/l on August 12, 1971, in six samples. The low and constant chloride concentrations in the six daily samples indicate that the primary source of chloride in the Kohlsville River at sampling station Rk-2 is groundwater inflow. The concentration of dissolved oxygen at sampling station Rk-2 was found to vary from a low of 6.0 mg/l at 12:35 a.m. to a high of 11.1 mg/l at 12:25 p.m. The diurnal variations in the dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen. The hydrogen ion concentration (pH) was found to vary from a low of 8.1 in the early morning samples to 8.4 standard units at 4:25 p.m. The 0.3 standard unit change over a 24-hour period is normal where high rates of respiration and photosynthesis go on with the presence of large counts of algae and other aquatic plants.

Rubicon River: At sampling station Rk-4 on the Rubicon River, water quality data were collected on August 12, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of $65^{o}F$ at 3:50 a.m. to a high of $78.5^{o}F$ during the late afternoon hour of 3:45 p.m. on August 12, 1971. The recorded diurnal water temperature fluctuation may be attributed to corresponding diurnal variations in the air temperature and solar radiation.

Chloride concentrations were found to range from 158 to 362 mg/l. A comparison of August 1971 chloride data with those of August 1970 and of August 1972 through 1975 shows a wide variation in chloride concentrations from less than 100 mg/l to greater than 500 mg/l. The high chloride concentrations and a variation of as much as 100 mg/l in a 24-hour period are most likely to be associated with a pollution source such as a sewage treatment effluent. This is especially true at sampling station Rk-4 which is located downstream from the City of Hartford sewage treatment plant.

The concentration of dissolved oxygen at sampling station Rk-4 was found to vary from a low of 0.8 mg/l to a high of 6.0 mg/l. Although the diurnal variations in the dissolved oxygen concentrations may be attributed in part to the net photosynthetic production of oxygen by algae and other aquatic plants, the low dissolved oxygen concentrations in four of the six samples collected within a 24-hour period indicates the effect of the discharge of the effluent from the City of Hartford sewage treatment plant.

The hydrogen ion concentration (pH) was found to vary from a low of 7.6 at 3:50 a.m. to 7.9 standard units at 3:45 p.m. The 0.3 standard unit change over a 24-hour period is normal with the respiration and photosynthesis of algae and other aquatic plants.

Ashippun River: At sampling station Rk-5 located on the Ashippun River, water quality data were collected on August 11-12, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of $66^{o}F$ at 2:45 a.m. to a high of $78^{o}F$ at 2:50 p.m. The recorded diurnal water temperature fluctuation may be attributed to corresponding diurnal variations in the air temperature and solar radiation.

Chloride concentrations were found to range from 3 to 14 mg/l. A comparison of August 1971 chloride data with those of August 1970 and of August 1972 through 1975 showed a similar low concentration of chloride with little or no diurnal variation. The low and constant chloride concentrations in six daily samples indicate the groundwater as the primary source of chloride. The water quality, as measured by the chloride content, is very good and not likely to be affected by pollution from human sources.

The concentration of dissolved oxygen at sampling Rk-5 was found to vary from 4.2 mg/l at 6:45 a.m. to a high of 8.8 mg/l at 10:45 p.m. The diurnal variations in the dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen.

The hydrogen ion concentration (pH) was found to vary from a low of 7.9 at 6:45 a.m. to 8.5 standard units at 6:45 p.m. The 0.6 standard unit change over a 24-hour period is normal with respiration and photosynthesis of algae and other aquatic plants.

Oconomowoc River: At sampling station Rk-8 located on the Oconomowoc River, water quality data were collected on August 11-12, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of $68^{o}F$ at 6:15 a.m. to a high of $77.5^{o}F$ during the evening hour of 4:15 p.m. The recorded diurnal water temperature fluctuation may be attributed to corresponding diurnal variations in the air temperature and solar radiation.

Chloride concentrations were found to range from 41 to 53 mg/l. A comparison of August 1971 chloride data with those of August 1970 and of August 1972 through 1975 indicates that a similar trend in the diurnal variation of chloride was prevalent for the other five years. The chloride concentration in the Oconomowoc River was found to be significantly higher than the area groundwater chloride concentration of 10 mg/l, indicating a continuous chloride contribution from such human sources as sewage treatment plant effluent.

The concentration of dissolved oxygen at sampling station Rk-8 was found to vary from a low of 2.8 mg/l at 6:15 a.m. to a high of 15.8 mg/l at 6:15 p.m. The diurnal variation of dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen.

The hydrogen ion concentration (pH) was found to vary from 7.6 to 8.8 standard units during the 24-hour survey. A similar wide range in the pH was observed at sampling station Rk-8 on the Oconomowoc River in August 1970 when six pH measurements were made during a 24-hour survey. The cause for such a wide range of 1.2 standard units of pH change during a 24-hour period is not known.

Chloride concentrations were found to range from 21 to 26 mg/l. A comparison of August 1971 chloride data with those of August 1970 and of August 1972 through 1975 shows less than a seven-unit change over a 24-hour period. The chloride concentrations are slightly higher than the area groundwater chloride concentrations, indicating a possible continuous chloride input from such human sources as sewage treatment plant effluent.

The concentration of dissolved oxygen at sampling station Rk-13 was found to vary from a low of 4.3 mg/l at 4:10 a.m. to a high of 13.1 mg/l at 4:00 p.m. The diurnal variation in dissolved oxygen concentrations may be attributed to the net photosynthetic production of oxygen.

The hydrogen ion concentration (pH) was found to vary from a low of 7.8 at 4:10 a.m. to 8.6 standard units at 4:00 p.m. The 0.8 standard unit change over a 24-hour period is normal with high rates of respiration and photosynthesis in the presence of large counts of algae and other aquatic plants.

The diurnal water quality fluctuations may be such that while the average level of concentrations of key parameters meets the established water quality standards, the instantaneous levels during the daily cycle do not meet the standards. For example, the average of six dissolved oxygen concentration values at sampling station Rk-3 on the Rubicon River, Rk-5 on the Ashippun River, Rk-8 on the Oconomowoc River, and Rk-9 on the Bark River on August 11 and 12, 1971 were 5.3, 6.8, 8.6, and 6.8 mg/l, respectively, which are all well above the minimum standard of 5.0 mg/l for recreational use and preservation of fish and aquatic life. However, substandard oxygen levels of 2.0, 4.2, 2.8, and 4.1 mg/l were measured at Rk-3, Rk-5, Rk-8, and Rk-9, respectively, in one sample at each location on the same day.

Bark River: At sampling station Rk-9 on the Bark River, water quality data were collected on August 11-12, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of 68°F at 6:00 a.m. to a high of 72°F at 2:05 p.m. The recorded diurnal water temperature fluctuation may be attributed to the corresponding diurnal variations in the air temperature and solar radiation.

Chloride concentrations were found to range from 16 to 19 mg/l. A comparison of August 1971 chloride data with those of August 1970 and of August 1972 through 1975 shows less than a five-unit change over a 24-hour period for all the years. The low and constant chloride concentration found in the 24-hour sampling surveys indicate that the primary source of chloride in the Bark River at sampling station Rk-5 is groundwater inflow.

The concentration of dissolved oxygen at sampling station Rk-9 was found to vary from a low of 4.1 mg/l at 6:00 a.m. to a high of 8.9 mg/l at 10:00 p.m. The low early morning dissolved oxygen concentrations may be attributed to respiration by algae and other aquatic plants. The dissolved oxygen concentration increased considerably during the daytime and can be attributed to the net photosynthetic production of oxygen.

The hydrogen ion concentration (pH) was found to vary from 8.0 at 6:00 a.m. to 8.3 standard units at 6:00 p.m. The 0.3 standard unit change over a 24-hour period is normal where high rates of photosynthesis and respiration go on with the presence of large counts of algae and other aquatic plants.

Whitewater Creek: At sampling station Rk-10 on Whitewater Creek, water quality data were collected on August 4-5, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of 65°F at 2:35 a.m. to a high of 77°F at 4:30 p.m. The recorded diurnal water temperature fluctuation may be attributed to corresponding diurnal variations in the temperature and solar radiation.

Chloride concentrations were found to range from 16 to 40 mg/l. A comparison of August 1971 chloride data with those of August 1970 and of 1972 through 1975 shows a similar variation over a 24-hour period for all the six years. The high chloride concentrations in six daily samples indicate a continuous chloride input from such human sources as sewage treatment effluent.

The concentration of dissolved oxygen at sampling station Rk-10 was found to vary from a low of 4.9 mg/l at 4:35 a.m. to a high of 7.9 mg/l at 4:30 p.m. The diurnal variation in dissolved oxygen concentration may be attributed to the net photosynthetic production of oxygen.

The hydrogen ion concentration (pH) was found to vary from a low of 8.1 at 8:25 a.m. to 8.4 standard units at 4:30 p.m. The 0.3 standard unit change over a 24-hour period is normal where high rates of respiration and photosynthesis go on with the presence of large counts of algae and other aquatic plants.

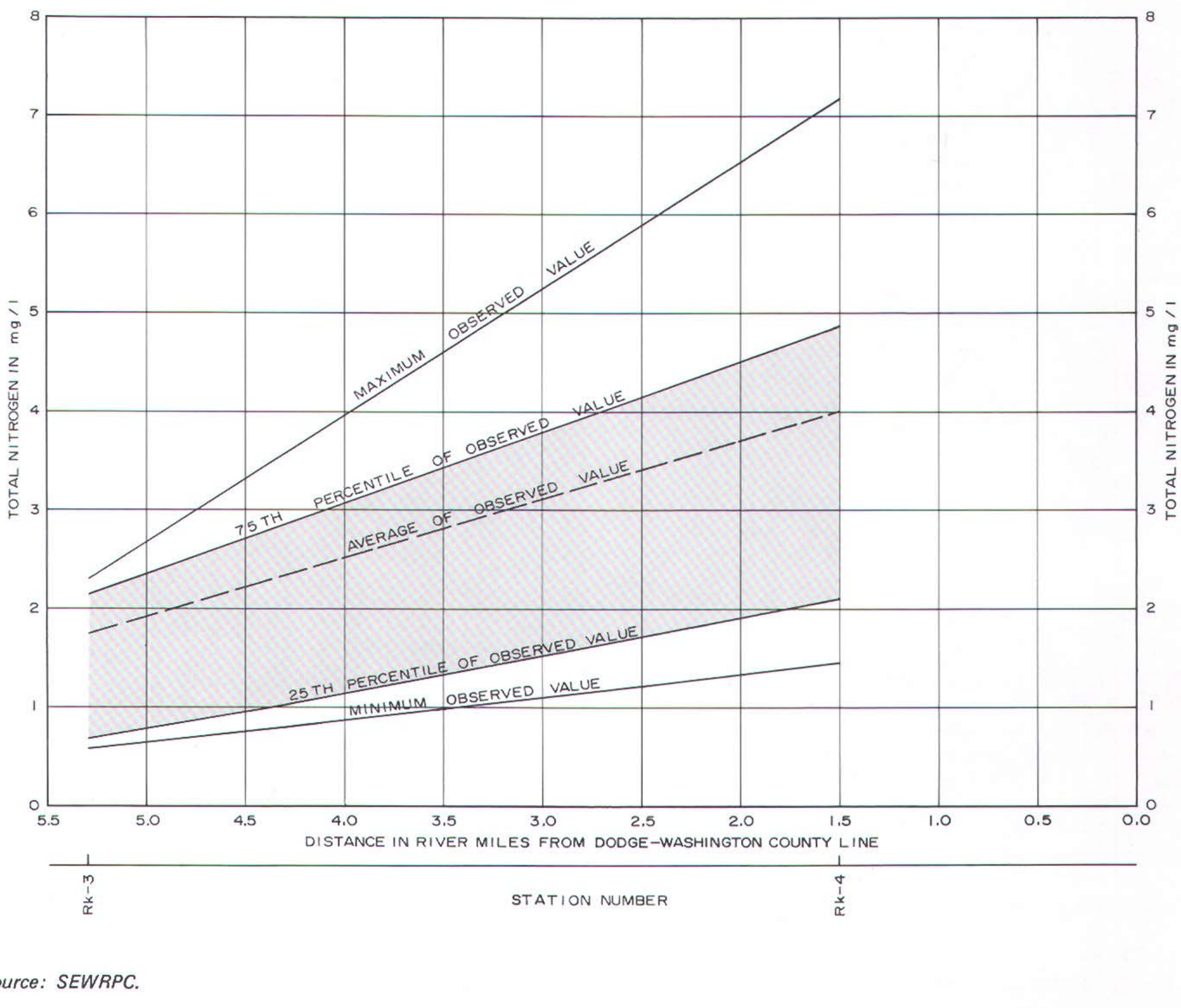
Turtle Creek: At sampling station Rk-13 on Turtle Creek, water quality data were collected on August 5, 1971, at four-hour intervals during a 24-hour period. Water temperature at this location was found to vary from a low of 61°F at 8:00 a.m. to a high of 77°F at 4:00 p.m. The recorded diurnal water temperature fluctuation may be attributed to diurnal variations in the air temperature and solar radiation.

Spatial Water Quality Changes: The water quality surveys clearly indicate that water quality conditions change from one location to another in the watershed stream system in response to a combination of man's activities and natural phenomena. Figure 183 through 200 indicate the spatial water quality variation along Rubicon River, Oconomowoc River, and Jackson Creek/Turtle Creek, as recorded under low-flow hydrological conditions in August 1964 through 1975. The illustrations include profiles of the average values of chloride, specific conductance, dissolved oxygen, total phosphorus, total nitrogen, and fecal coliform counts at the sampling stations. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter, thus dividing the data into three categories: 1) the range of the 25 percent of the samples near the minimum values, 2) the range of the middle 50 percent of the samples, and 3) the range of the 25 percent of the samples near the maximum.

Rubicon River: Two sampling stations, Rk-3 and Rk-4, upstream and downstream from the City of Hartford sewage treatment plant, were established on the Rubicon River. A comparison of the chemical data at sampling station Rk-3 and Rk-4 indicate a generally decreasing trend in the water quality as measured by an increase in fecal coliform counts, specific conductance, chloride,

Figure 183

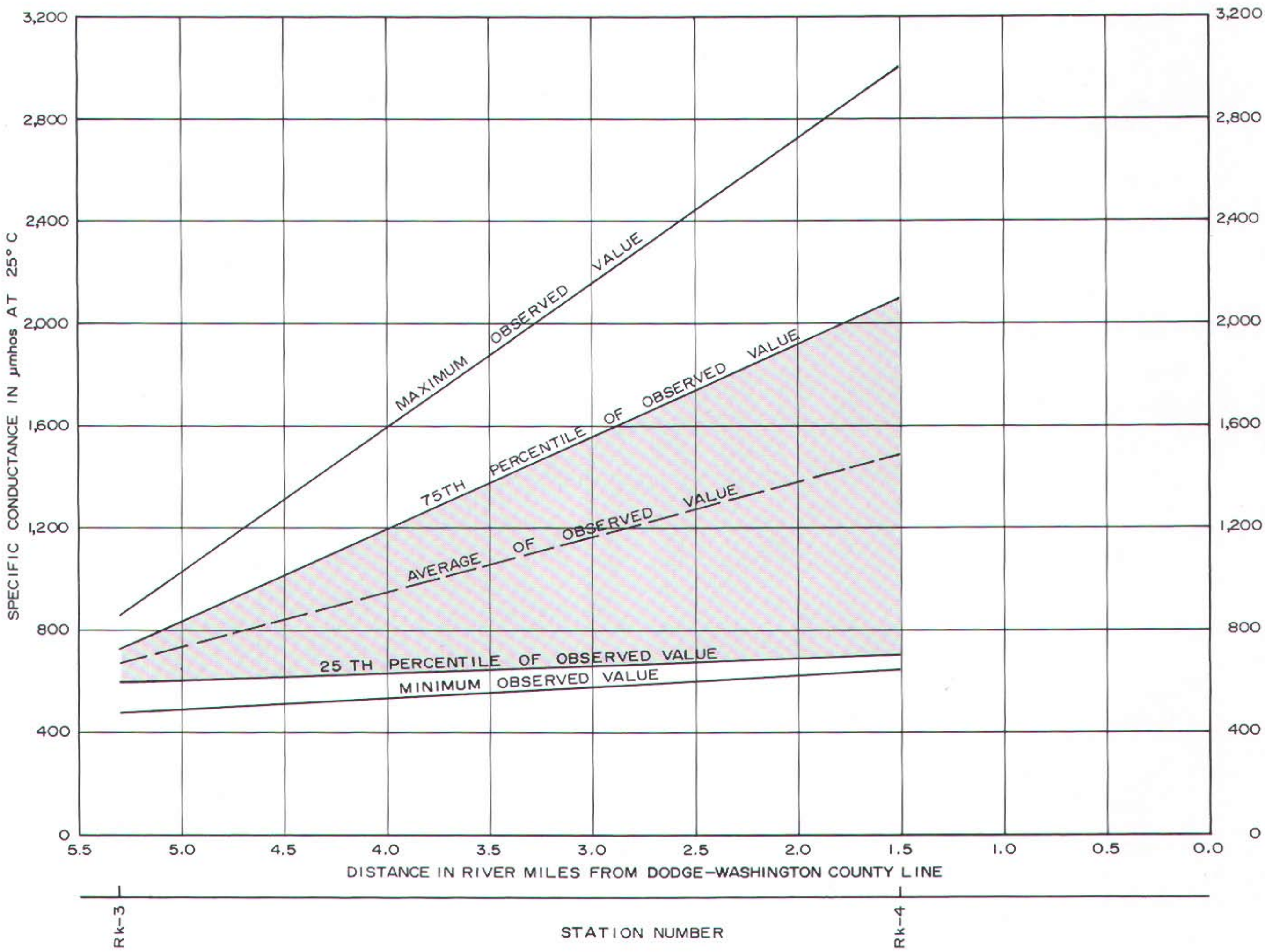
SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE RUBICON RIVER: 1972-1975



Source: SEWRPC.

Figure 184

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE RUBICON RIVER: 1964-1975



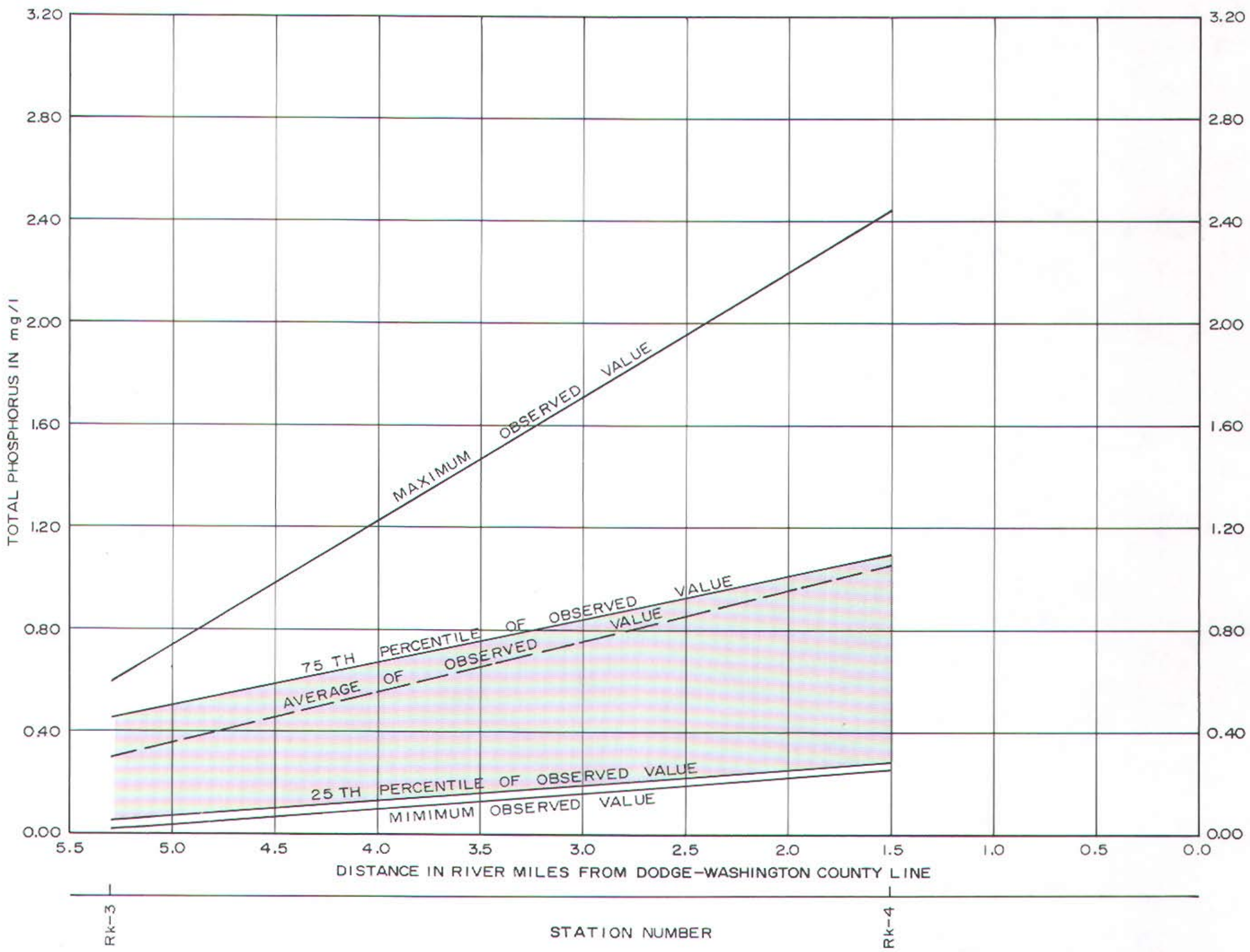
Source: SEWRPC.

total nitrogen, and total phosphorus concentrations and by a decrease in the dissolved oxygen concentrations. The decrease in water quality at sampling station Rk-4, when compared to the water quality at sampling station Rk-3 on the Rubicon River, indicates the effect of effluent from the City of Hartford sewage treatment plant on the water quality of the Rubicon River at sampling station Rk-4.

Oconomowoc River: Three sampling stations were established on the Oconomowoc River: Rk-6, Rk-7, and Rk-8. Sampling station Rk-6 is located on the Oconomowoc River upstream from the inlet to North Lake. The major land use in the subwatershed is agricultural. Sampling station Rk-7 is located downstream from three major lakes—North Lake, Okauchee Lake, and Oconomowoc Lake—through which the Oconomowoc River flows. Despite the fact that the sampling station Rk-7 is located in a highly urbanized area, water quality conditions at this station were found to be generally good. This indicates that the three major Lakes act to improve the water quality of the River downstream from the lakes. Sampling station Rk-8 is located downstream from sampling station Rk-7 and downstream from the City of Oconomowoc sewage treatment plant. A general increasing trend in the water quality—as measured by

Figure 185

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE RUBICON RIVER: 1972-1975



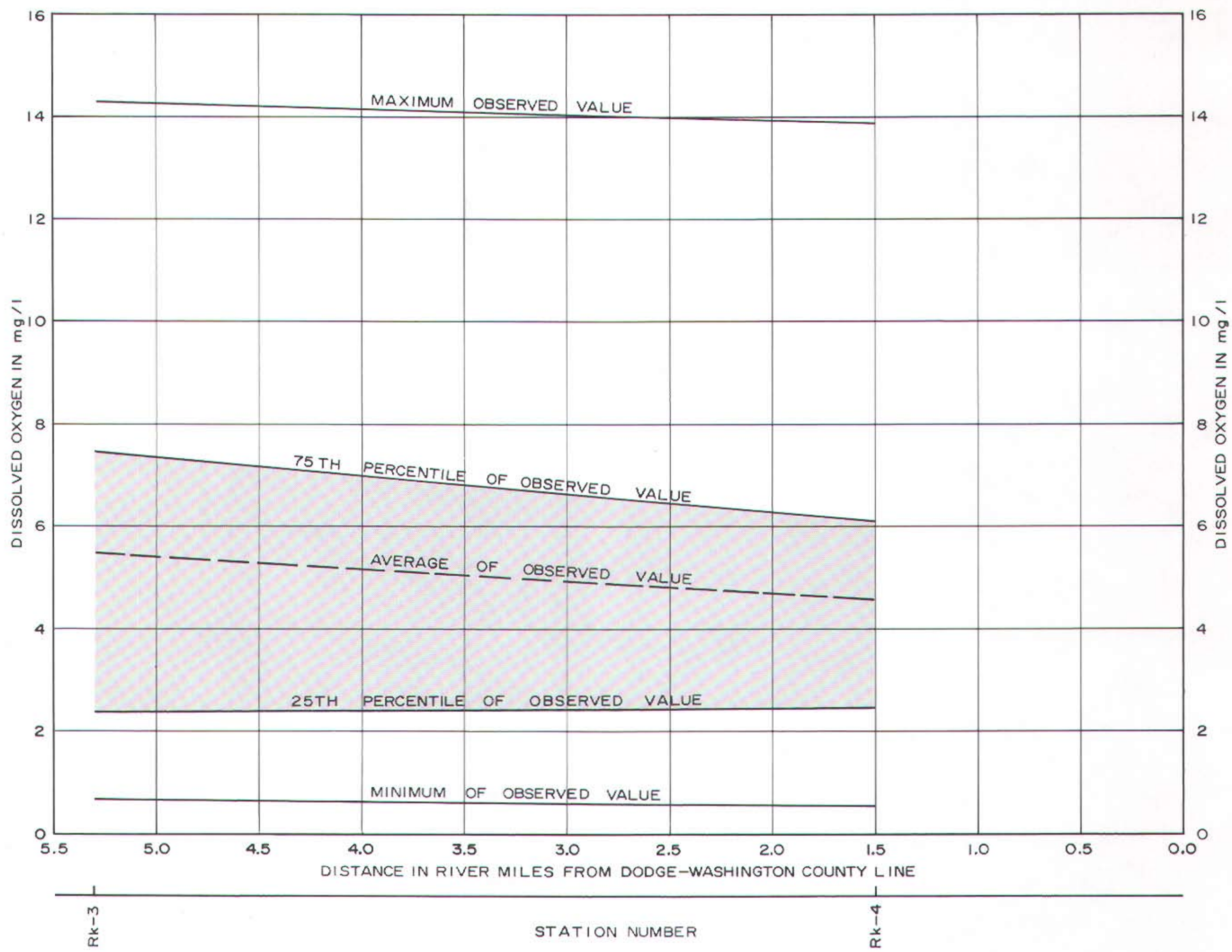
Source: SEWRPC.

the decrease in fecal coliform counts, chloride, specific conductance, total nitrogen, and total phosphorus concentrations and increases in dissolved oxygen concentrations—was observed from sampling station Rk-6 to sampling station Rk-7 on the Oconomowoc River. This improved water quality is directly associated with the presence of North, Okauchee, and Oconomowoc Lakes. Water quality conditions showed a decreasing trend from sampling stations Rk-7 to Rk-8 as measured by the decrease in dissolved oxygen content and increase in chloride, specific conductance, total nitrogen, total phosphorus concentrations, and fecal coliform counts. This is due to the discharge of effluent from the City of Oconomowoc sewage treatment plant upstream from sampling station Rk-8.

Jackson Creek-Delavan Lake Outlet-Turtle Creek: Three sampling stations were established on the Jackson Creek-Delavan Lake Outlet-Turtle Creek stream system: Rk-11, Rk-12, and Rk-13. Sampling station Rk-11 is located on Jackson Creek downstream from the City of Elkhorn sewage treatment plant outfall and two industrial waste outfalls serving J. W. Reichel and Sons, Inc., and The Getzen Company, Inc. Sampling station Rk-12 is located

Figure 186

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE RUBICON RIVER: 1964-1975



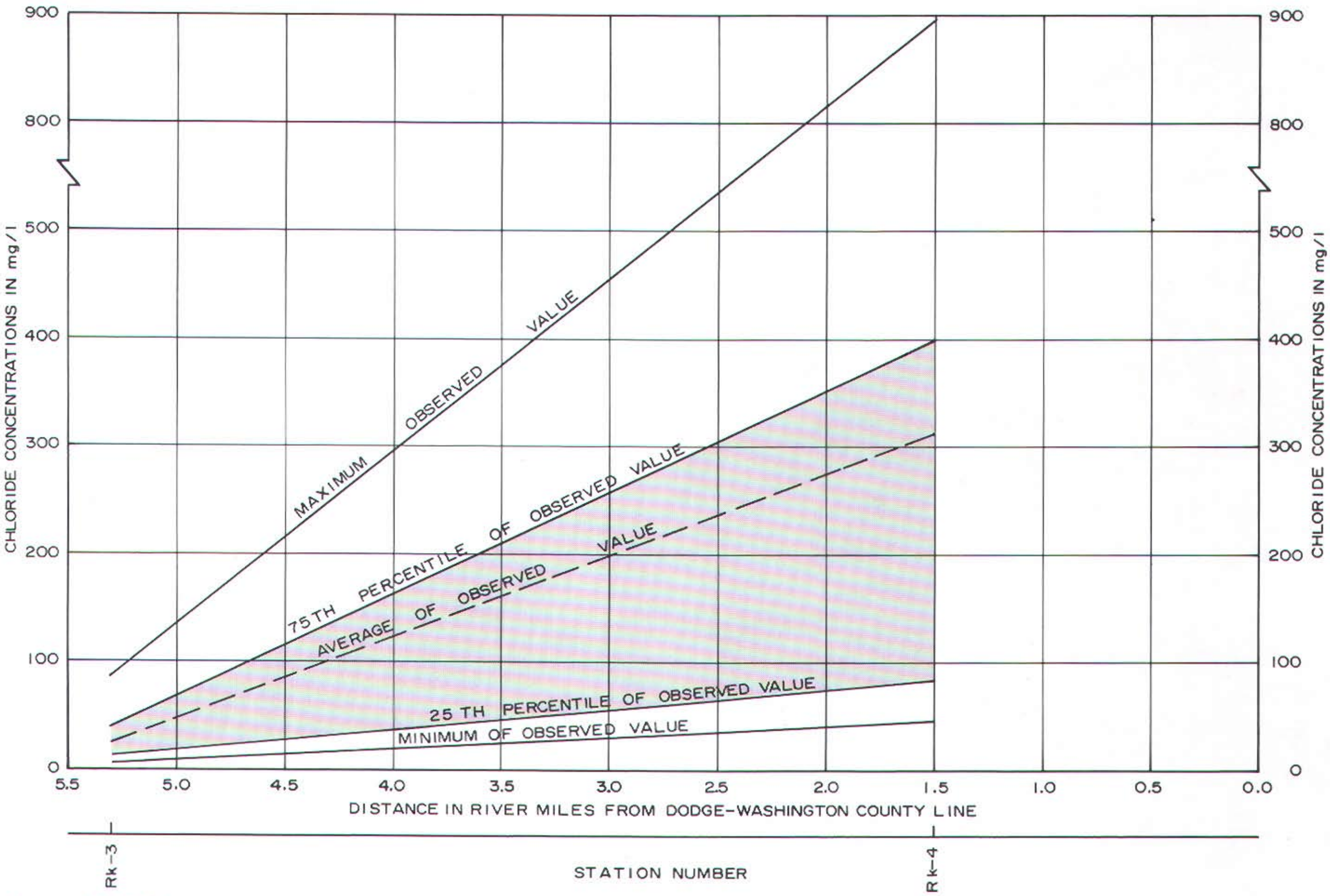
Source: SEWRPC.

on the Delavan Lake Outlet, downstream from Delavan Lake, and may be expected to show an improvement in water quality from sampling station Rk-11 due to the presence of the Lake. Sampling station Rk-13 is located on the Turtle Creek downstream from the sampling stations Rk-11 and Rk-12. The dissolved oxygen concentrations for 75 percent of the samples collected at sampling station Rk-12 on the Delavan Lake Outlet were the same as those for 75 percent of the samples collected at sampling station Rk-11 on Jackson Creek. Significant decreases in the fecal coliform counts, chloride, specific conductance, total nitrogen, and total phosphorus concentrations at sampling station Rk-12 on the Delavan Lake Outlet were observed when compared with the water quality of Jackson Creek at sampling station Rk-11. The improved water quality at sampling station Rk-12 is likely to be associated with the presence of Lake Delavan.

When the water quality at sampling station Rk-12 on the Delavan Lake Outlet and the water quality at sampling station Rk-13 on Turtle Creek were compared, no definite trend in the water quality change was observed between the two locations. The chloride concentrations in 75 percent of the samples collected at sampling station Rk-13 on Turtle Creek remained the same as those of 75 percent

Figure 187

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE RUBICON RIVER: 1964-1975



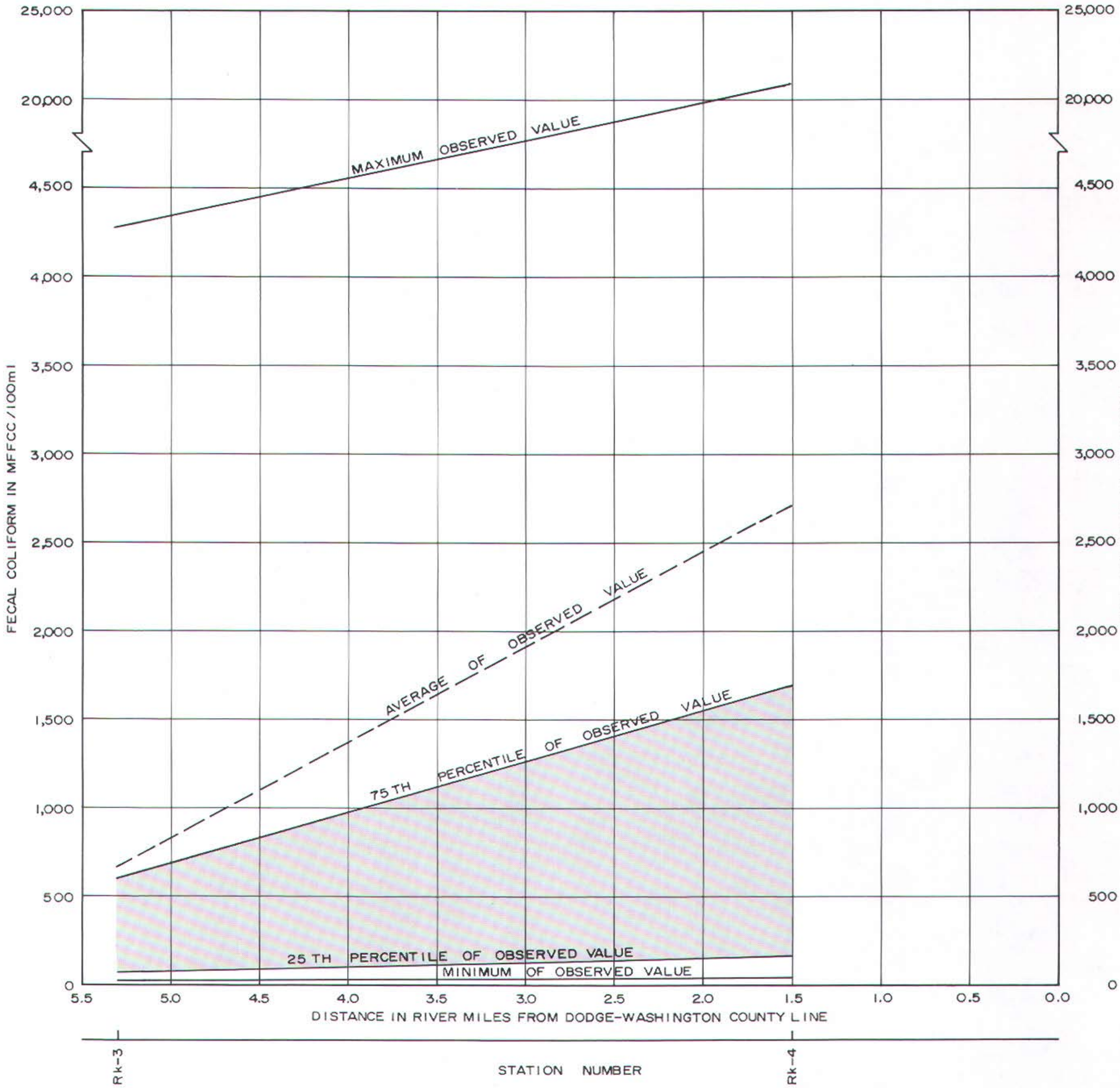
Source: SEWRPC.

of the samples collected at sampling station Rk-12 on the Delavan Lake Outlet. There were slight increases observed in the specific conductance, total phosphorus, and total nitrogen as indicated in Figure 185 and a very significant increase in the fecal coliform counts at sampling station Rk-13 when compared to the fecal coliform counts obtained at sampling station Rk-12. Although these data indicate poorer water quality conditions at sampling station Rk-13 than at sampling station Rk-12, the dissolved oxygen concentrations showed an inverse relationship—i.e., an increase in the dissolved oxygen concentration in 75 percent of the samples collected at sampling station Rk-13 as compared to similar data for sampling station Rk-12. The reason for this apparent discrepancy is not known.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples between 1964 and 1975 were used to assess the quality of the Rock River stream network. These water quality data provided an assessment of water quality as it existed on the days sampled between 1964 and 1975, and allowed for an evaluation of the water quality changes compared to the

Figure 188

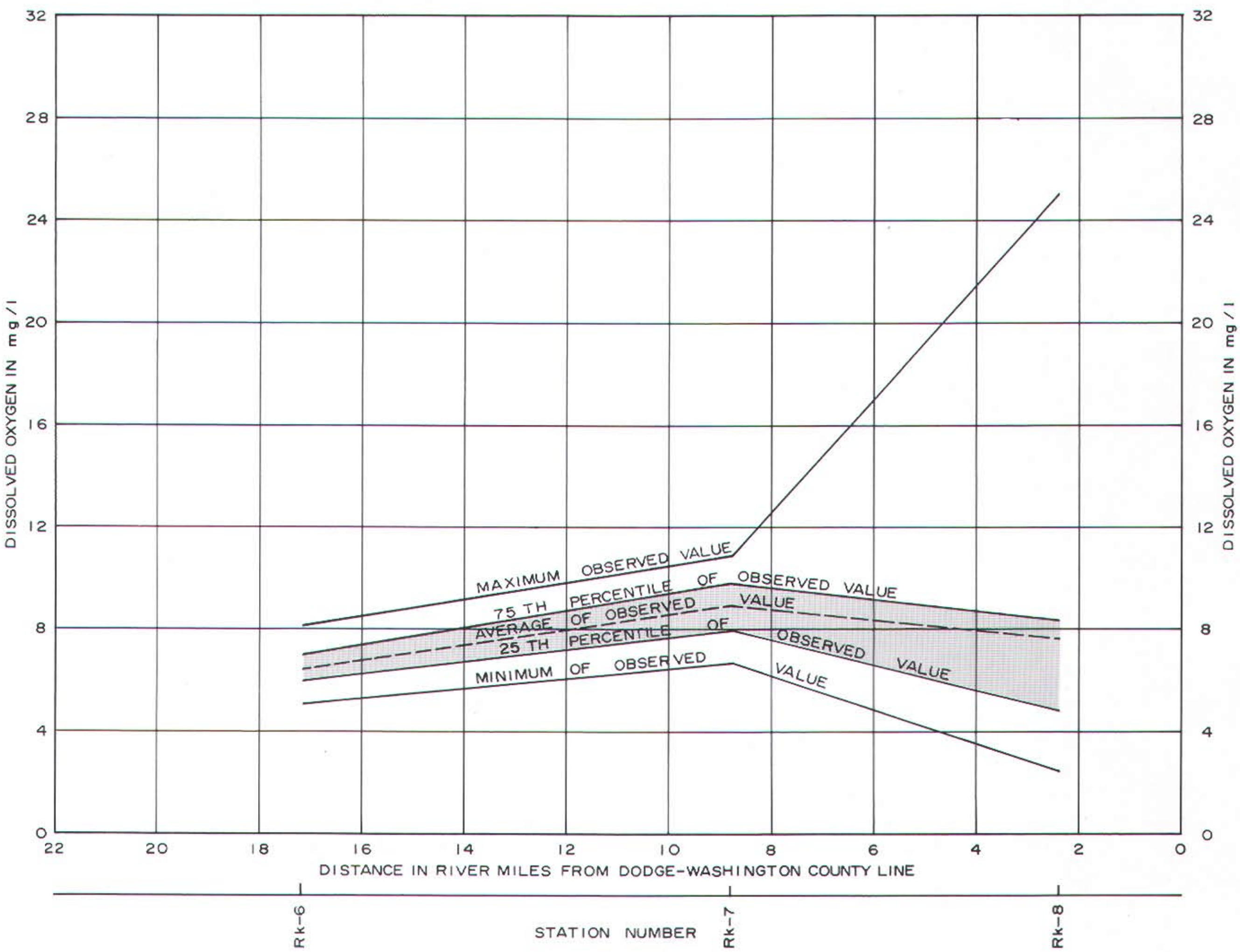
SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE RUBICON RIVER: 1968-1975



Source: SEWRPC.

Figure 189

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE OCONOMOWOC RIVER: 1964-1975



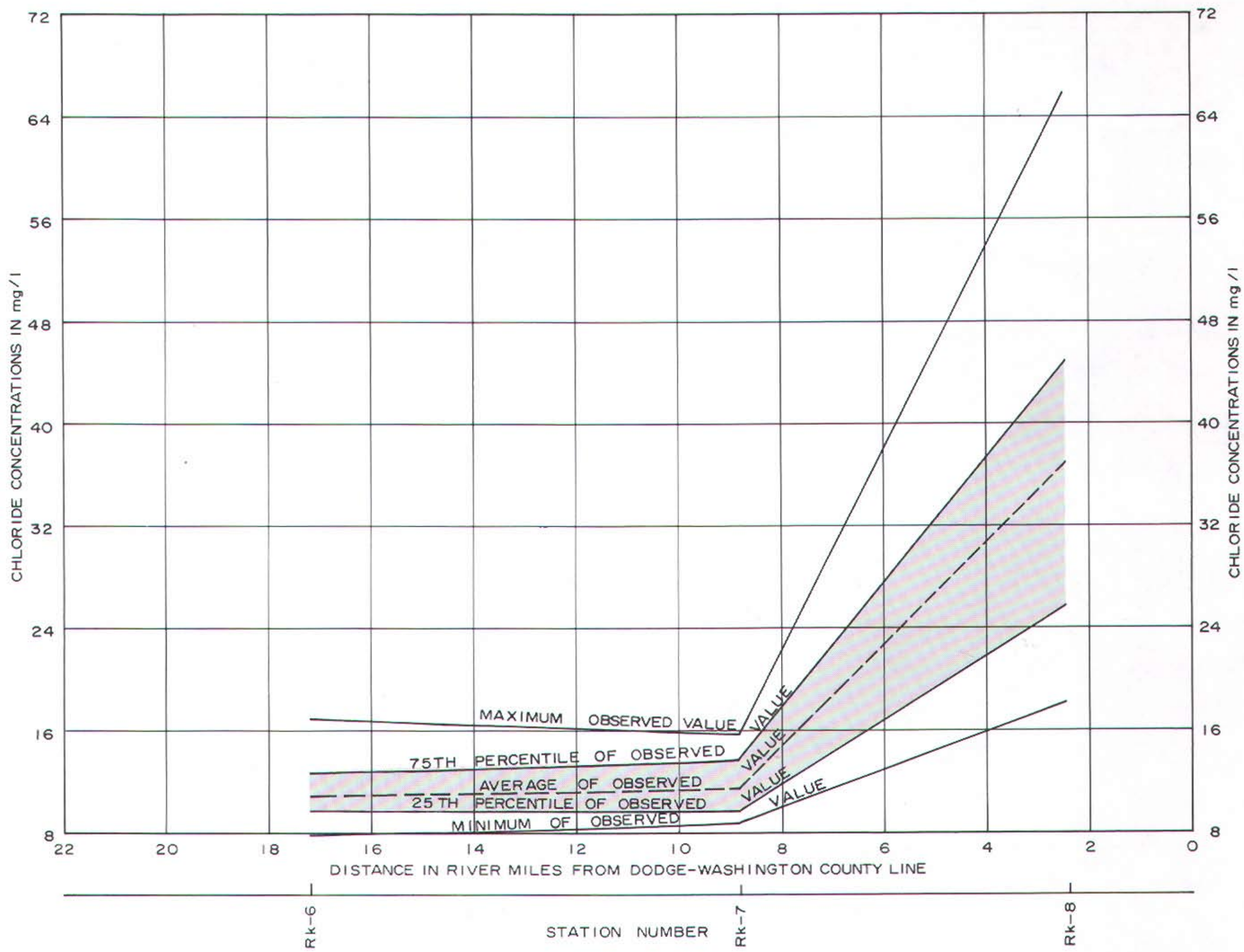
Source: SEWRPC.

water quality standards that support the restricted use, recreational use, and the maintenance of fish and aquatic life objectives established for the Rock River watershed stream system within the Region. Comparative analysis must consider the concurrent hydrologic conditions since the water quality standards are not intended to be satisfied under all streamflow conditions. The data from the partial record stream gage on Turtle Creek indicate that the streamflows during all of the surveys were in excess of the seven day-10 year low flow above which the water quality standards are to be met. It is assumed that the streamflows for the other tributaries of the Rock River within the Region also were in excess of the seven day-10 year low flow.

The comparative analysis of observed water quality and the standards were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are based on recommended levels adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits. That is, water quality was assessed on the basis

Figure 190

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE OCONOMOWOC RIVER: 1964-1975



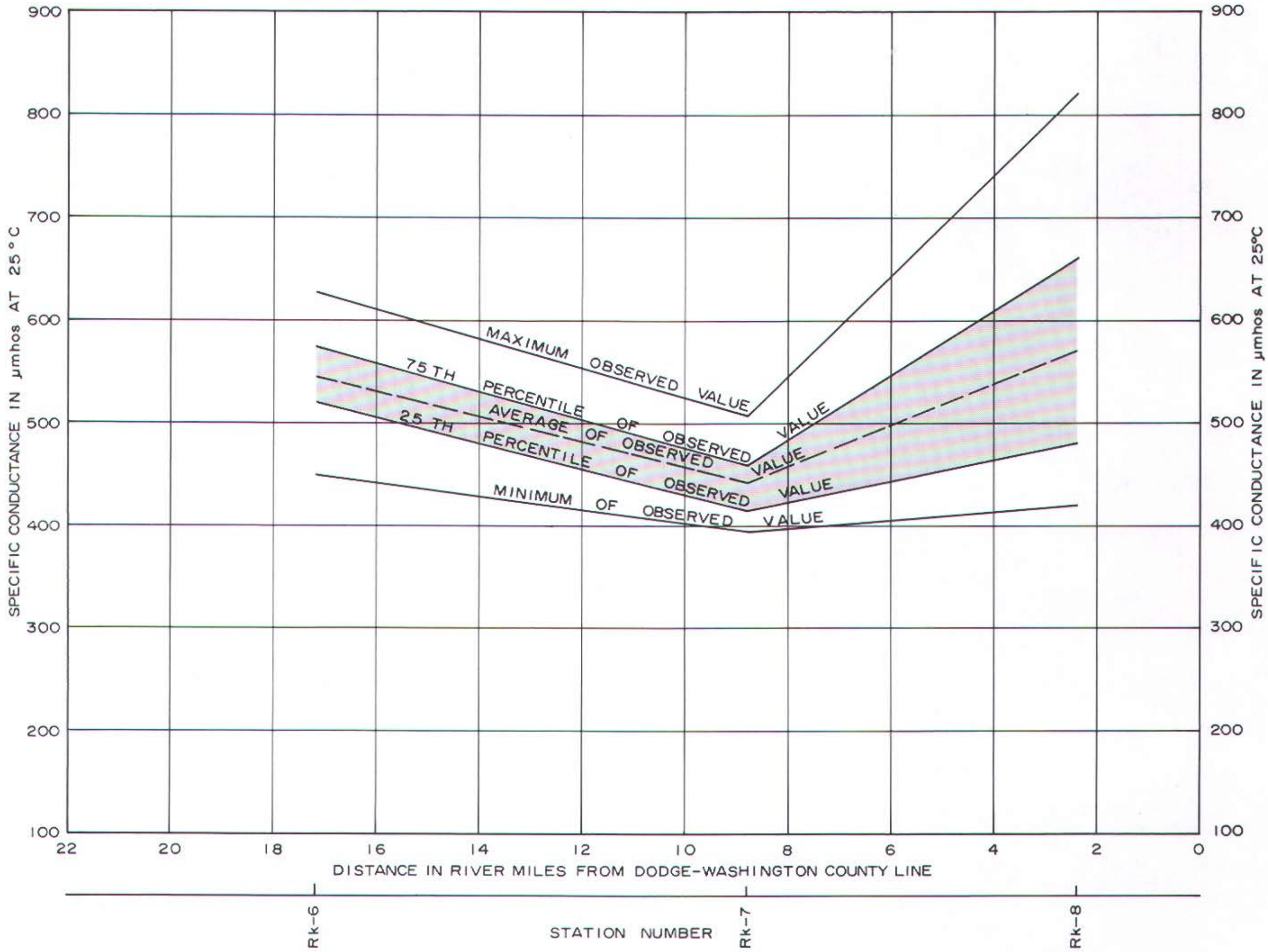
Source: SEWRPC.

of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objectives states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month, nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the recreational use objective fecal coliform bacteria standard was assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 67. A color coding scheme is used on Map 67 to indicate which of the standards are exceeded and along what stream reaches.

Figure 191

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE OCONOMOWOC RIVER: 1964-1975

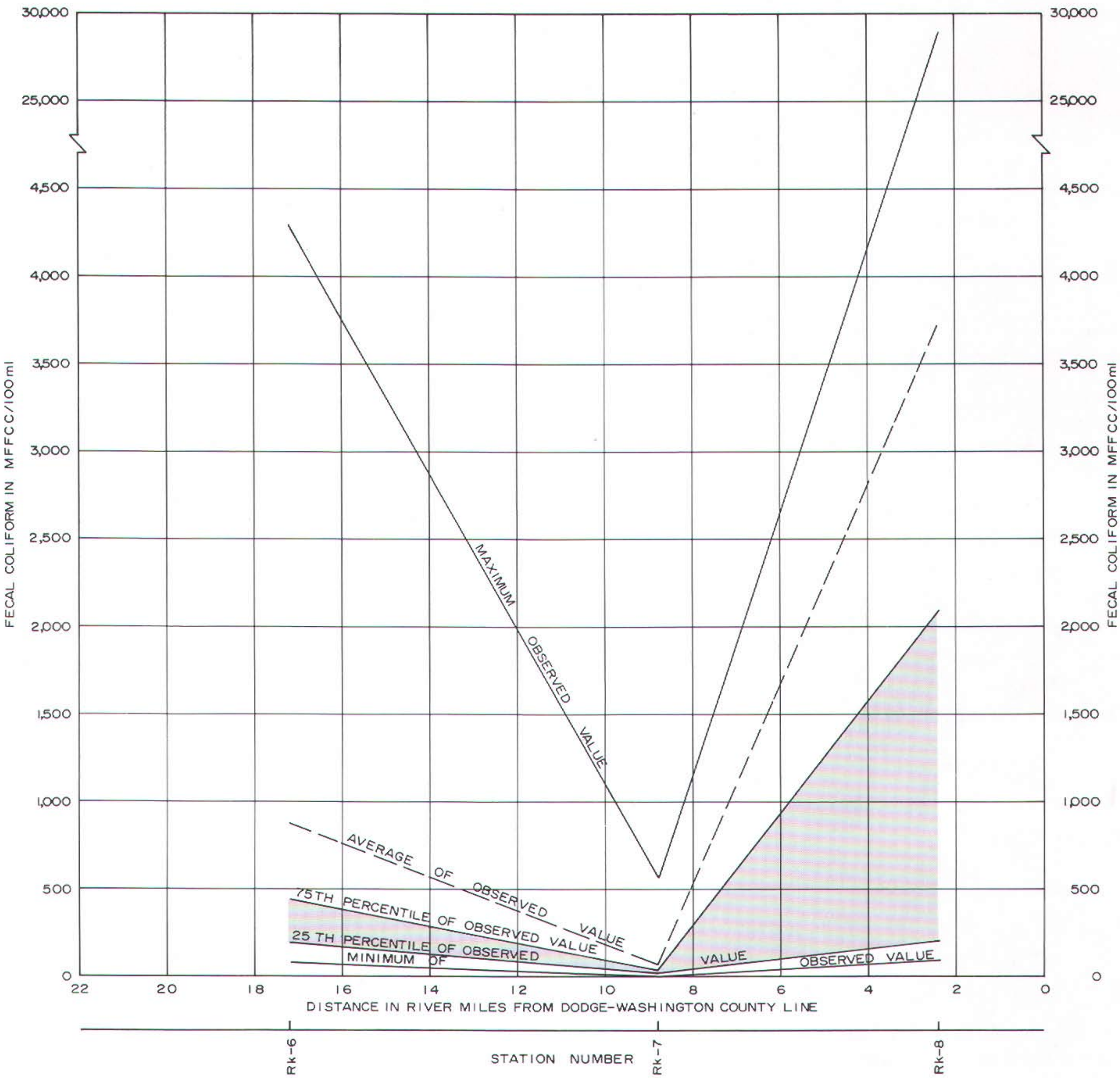


Source: SEWRPC.

For the Rock River tributaries within the Region—with the exception of Allenton Creek, Bluff Creek, and Scuppernong Creek—intended for recreational use and preservation of fish and aquatic life, the water quality during the survey satisfied the temperature and dissolved oxygen standards throughout the watershed. The pH measurements were made in the samples collected at sampling stations Rk-1, Rk-4, Rk-8, and Rk-13 in August 1964 and were found to be within the adopted range of 6.0 to 9.0 standard units. Since no fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made in the 1964 samples, no comparison can be made to the nutrient contents and bacteriological safety of the Rock River tributary waters for 1964. However, the total coliform counts at sampling stations Rk-1 on the East Branch of the Rock River, Rk-2 on the Kohlsville River, Rk-3 on the Rubicon River, Rk-6 and Rk-7 on the Oconomowoc River, and Rk-12 on the Delavan Lake Outlet were less than 2,000 MFCC/100 ml. Therefore, it is probable that the fecal coliform counts also were within the permissible limits at these locations. For Allenton Creek in Washington County, a tributary to the East Branch of the Rock River, and Bluff Creek in Walworth County, a tributary to the Whitewater Creek, which are intended for the restricted use and maintenance of fish and aquatic life, no water quality data are available

Figure 192

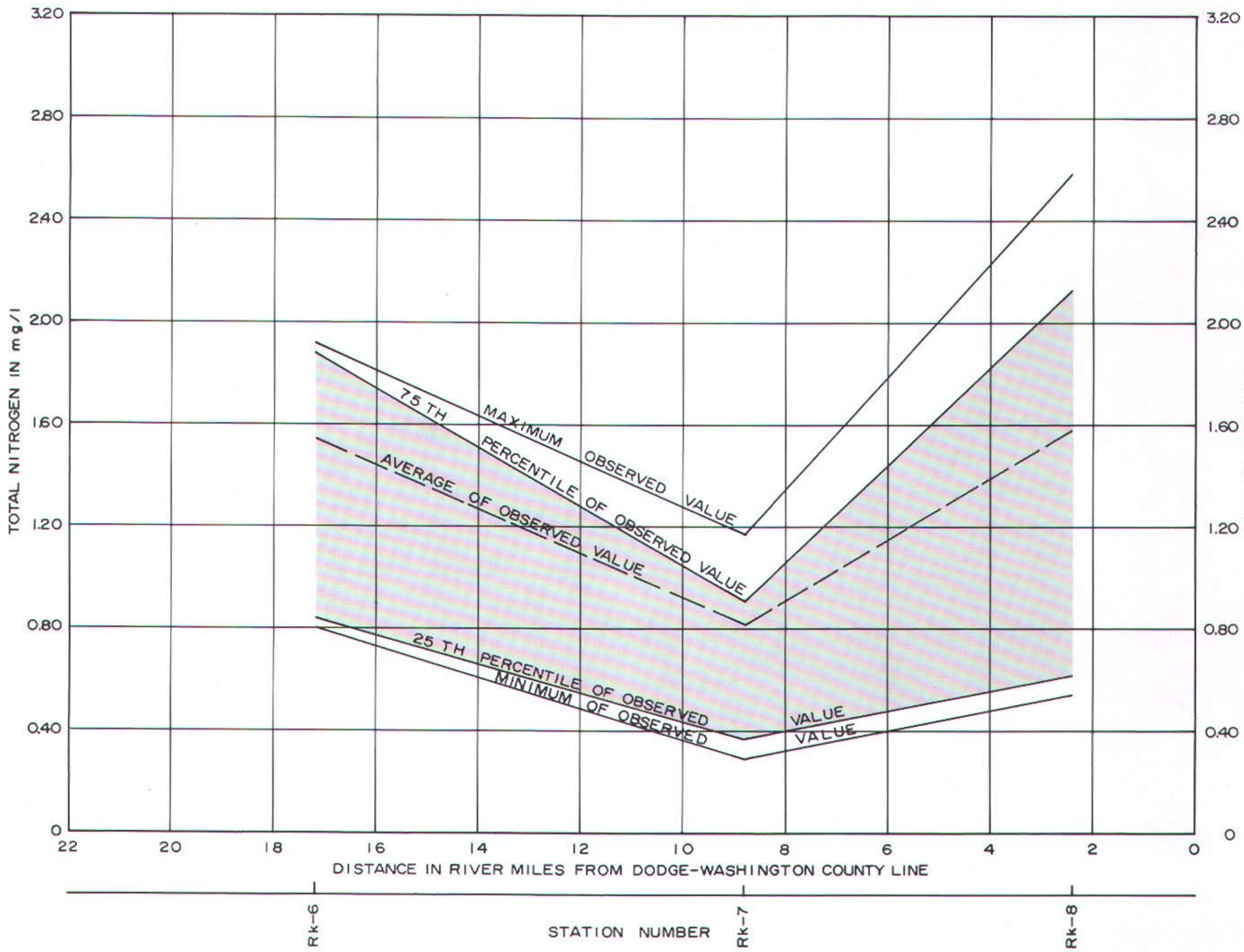
SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE OCONOMOWOC RIVER: 1968-1975



Source: SEWRPC.

Figure 193

SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE OCONOMOWOC RIVER: 1972-1975



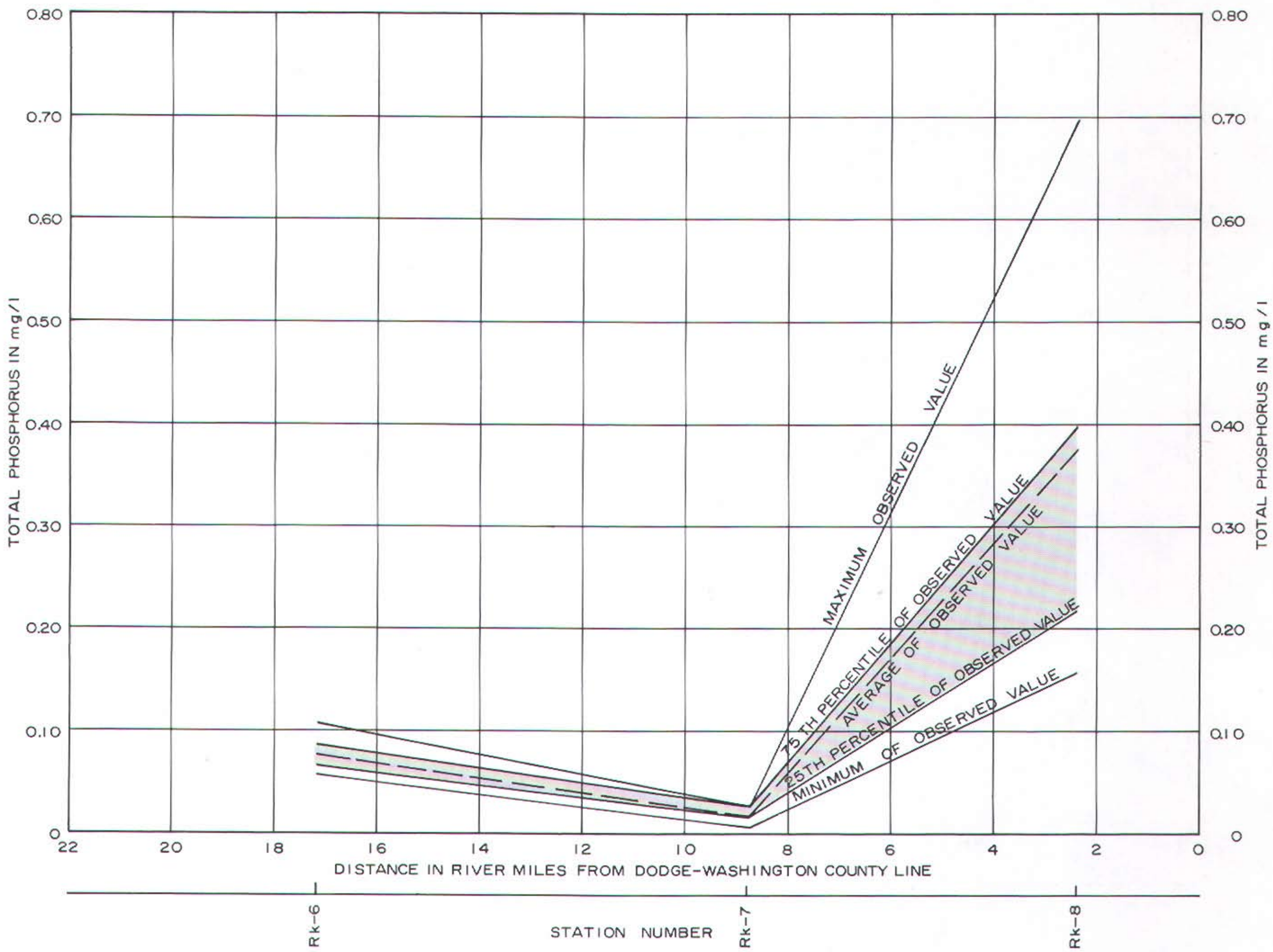
Source: SEWRPC.

for comparison with the water quality standards. For the Scuppernong River and its tributaries in Waukesha County, the streams intended for trout fishery, no water quality data are available for comparison with the water quality standards.

Water Quality-1975: For the Rock River tributaries within the Region—with the exception of Allenton Creek, Bluff Creek, and the Scuppernong River—intended for recreational use and preservation of fish and aquatic life, Map 68 indicates that water quality conditions during August 1975 were such that the temperature and pH standards and the recommended level for ammonia were satisfied throughout the watershed while substandard levels of dissolved oxygen were observed at sampling stations Rk-1 on the East Branch of the Rock River, Rk-5 on the Ashippun River, Rk-11 on Jackson Creek, Rk-12 on Delavan Lake Outlet, and Rk-13 on Turtle Creek. The fecal coliform standards were not met at sampling stations Rk-2 on the Kohlsville River, Rk-8 on the Oconomowoc River, Rk-11 on Jackson Creek, Rk-12 on Delavan Lake Outlet, and Rk-13 on Turtle Creek. Levels of total phosphorus were in excess of the recommended recreational use and fish and aquatic life use

Figure 194

\TIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE OCONOMOWOC RIVER: 1972-1975



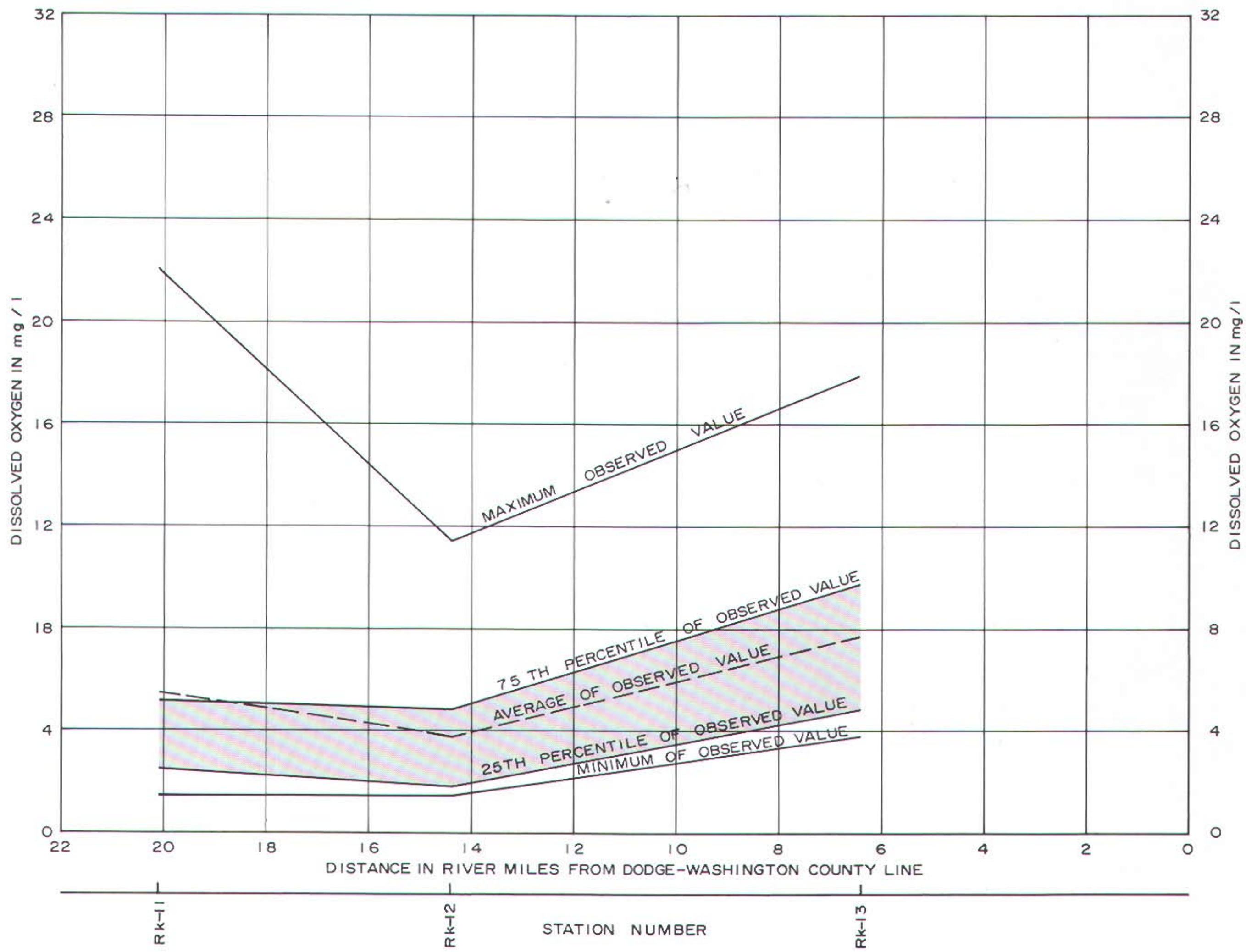
Source: SEWRPC.

level of 0.10 mg/l as P throughout the watershed except at sampling stations Rk-3 on the Rubicon River, Rk-6 and Rk-7 on the Oconomowoc River, and Rk-9 on the Bark River. Nitrate-nitrogen levels in excess of 0.30 mg/l as N existed at all locations with the exception of sampling station Rk-1 on the East Branch of the Rock River, sampling station Rk-3 on the Rubicon River, sampling stations Rk-7 and Rk-8 on the Oconomowoc River and sampling station Rk-9 on the Bark River.

Since no data are available, the water quality at Allenton Creek and Bluff Creek cannot be compared to the water quality standards for the restricted use and for the maintenance of fish and aquatic life. The Scuppernong River and its tributaries in Washington County are intended for the use of trout fishery. Although no water quality data are available for the year 1975, the data obtained in 1971 by the Wisconsin Department of Natural Resources indicate that the streams met the water quality standards

Figure 195

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN JACKSON CREEK-TURTLE CREEK: 1964-1975



Source: SEWRPC.

for pH and temperature during the sampling period. No dissolved oxygen data or fecal coliform data are available on the Scuppernong River to compare with the required standards.

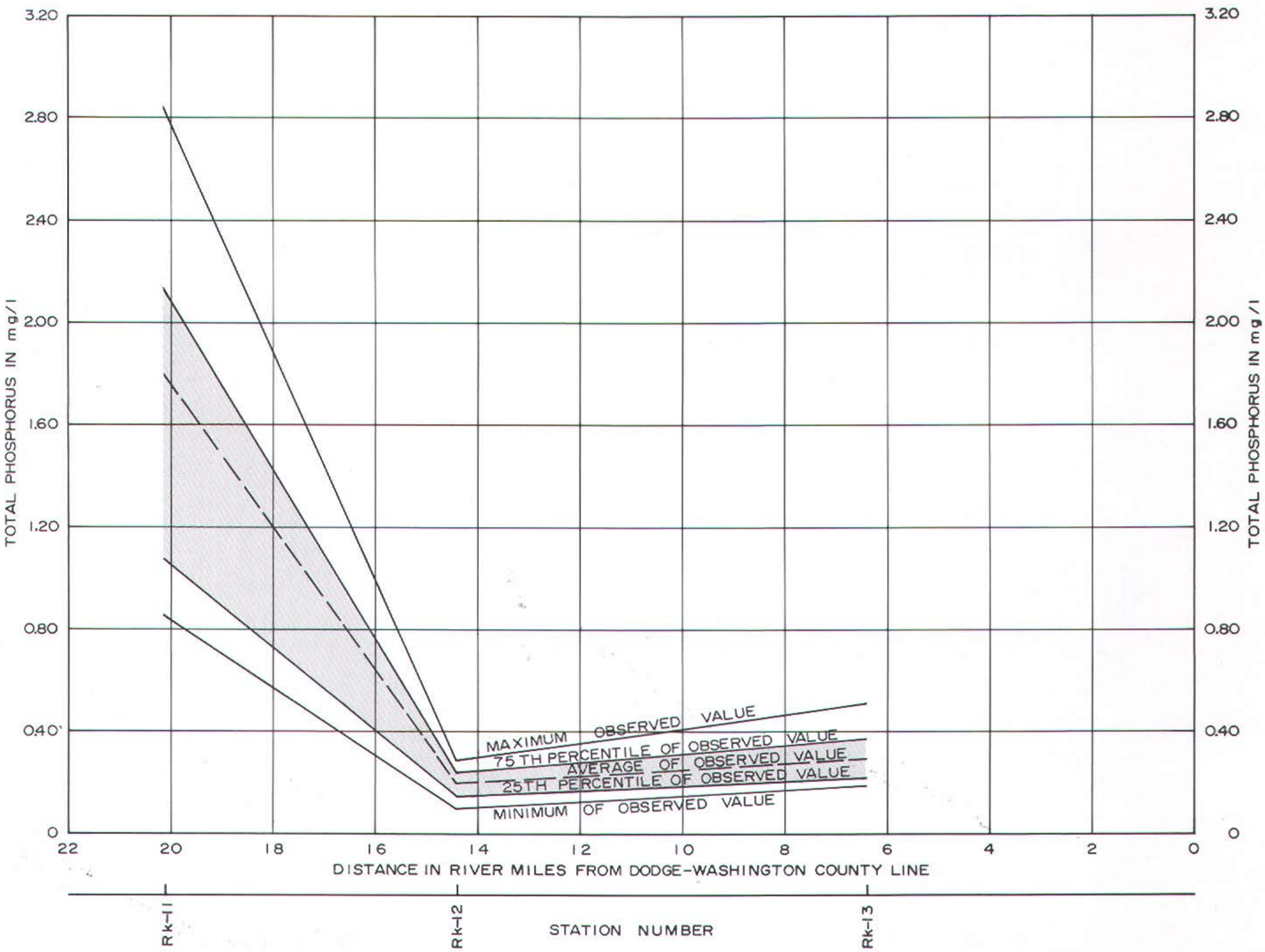
Concluding Remarks—Rock River Watershed

The Rock River watershed is located in the westerly portion of the Region and is only partly contained in the Region, with the Rock River main stem itself arising and flowing outside of the Region. Seventeen tributaries of the Rock River originate in the Region. The composite watershed is the second largest of the 12 drainage areas within the Region and ranks seventh in population. In 1975, an estimated 97,334 persons resided within this composite watershed, which has a total area of 612.41 square miles and an average population density of 159 people per square mile.

There are 12 publicly owned and six nonindustrial privately owned sewage treatment plants located within

Figure 196

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN JACKSON CREEK-TURTLE CREEK: 1972-1975



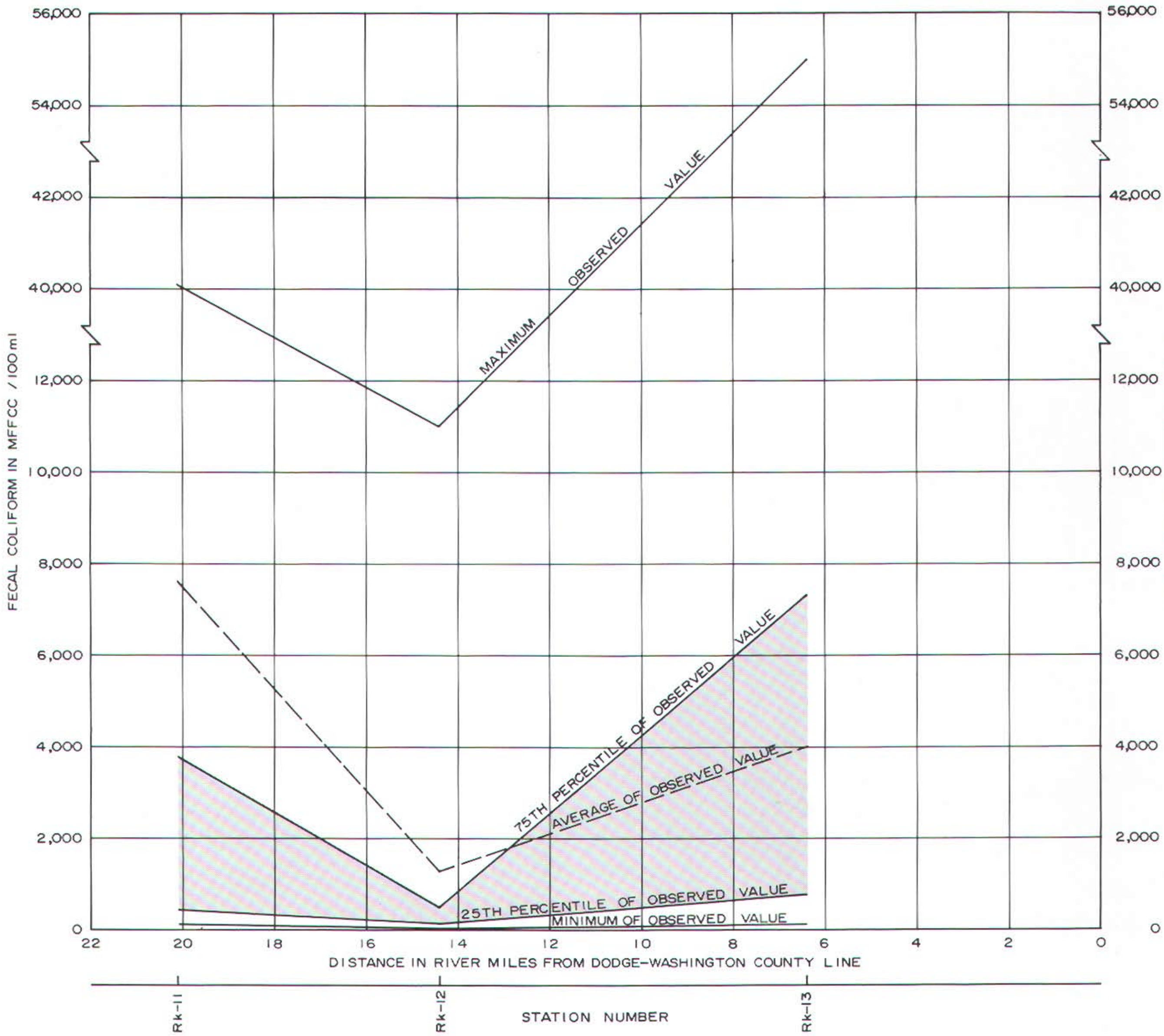
Source: SEWRPC.

the composite watershed, all of which discharge treated effluent into the stream system of the watershed. In addition, there are 16 known sanitary sewer bypasses that discharge raw sewage into the streams during times of sewer surcharge. Of the 27 industries discharging wastewater through 31 outfalls located within the watershed, 14 outfalls discharge process waters, 13 outfalls discharge cooling waters, two outfalls discharge cooling and process wastewaters into the Rock River tributaries, and two outfalls discharge sanitary wastes to onsite treatment facilities before discharging to the groundwater of the watershed. The Commission 1970 land use inventory indicates that in the Rock River watershed within the Region, 38,057 acres, or about 10 percent of the land, is in urban use; 303,630 acres, or about 77 percent, is in rural use; and the remaining 49,558 acres, or about 13 percent, is occupied by streams and wetlands. There is a total of 82 lakes within the watershed, of which 38 are major lakes having a surface area of 50 acres or more. About 74 percent of the land area within 1,000 feet of the shorelines of these lakes is presently in some urban land use. Runoff from this urban area may be expected to have a significant effect on lake water quality.

The 1964-1965 benchmark stream water quality study of the Commission included 13 sampling stations in the

Figure 197

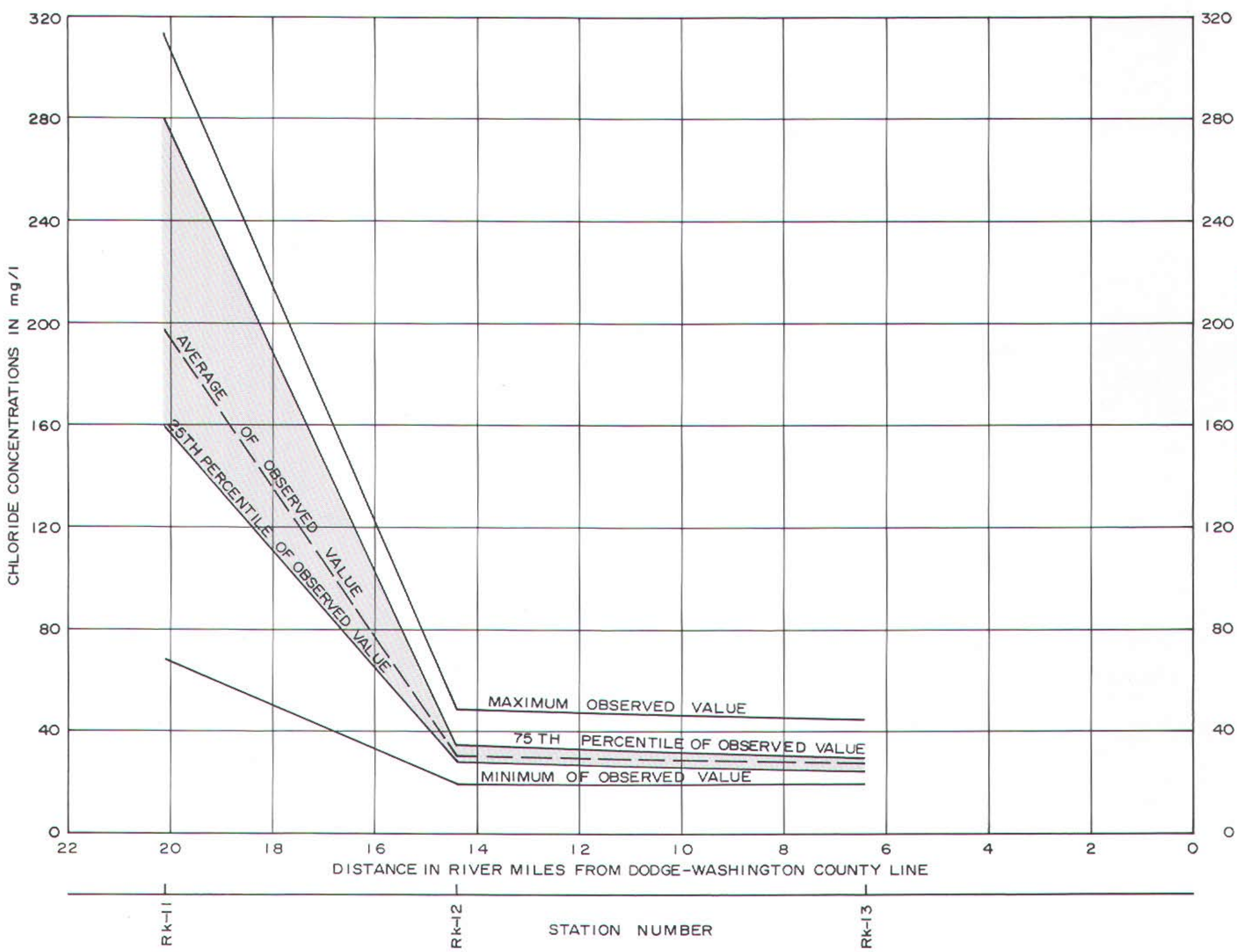
SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN JACKSON CREEK-TURTLE CREEK: 1968-1975



Source: SEWRPC.

Figure 198

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN JACKSON CREEK-TURTLE CREEK: 1964-1975

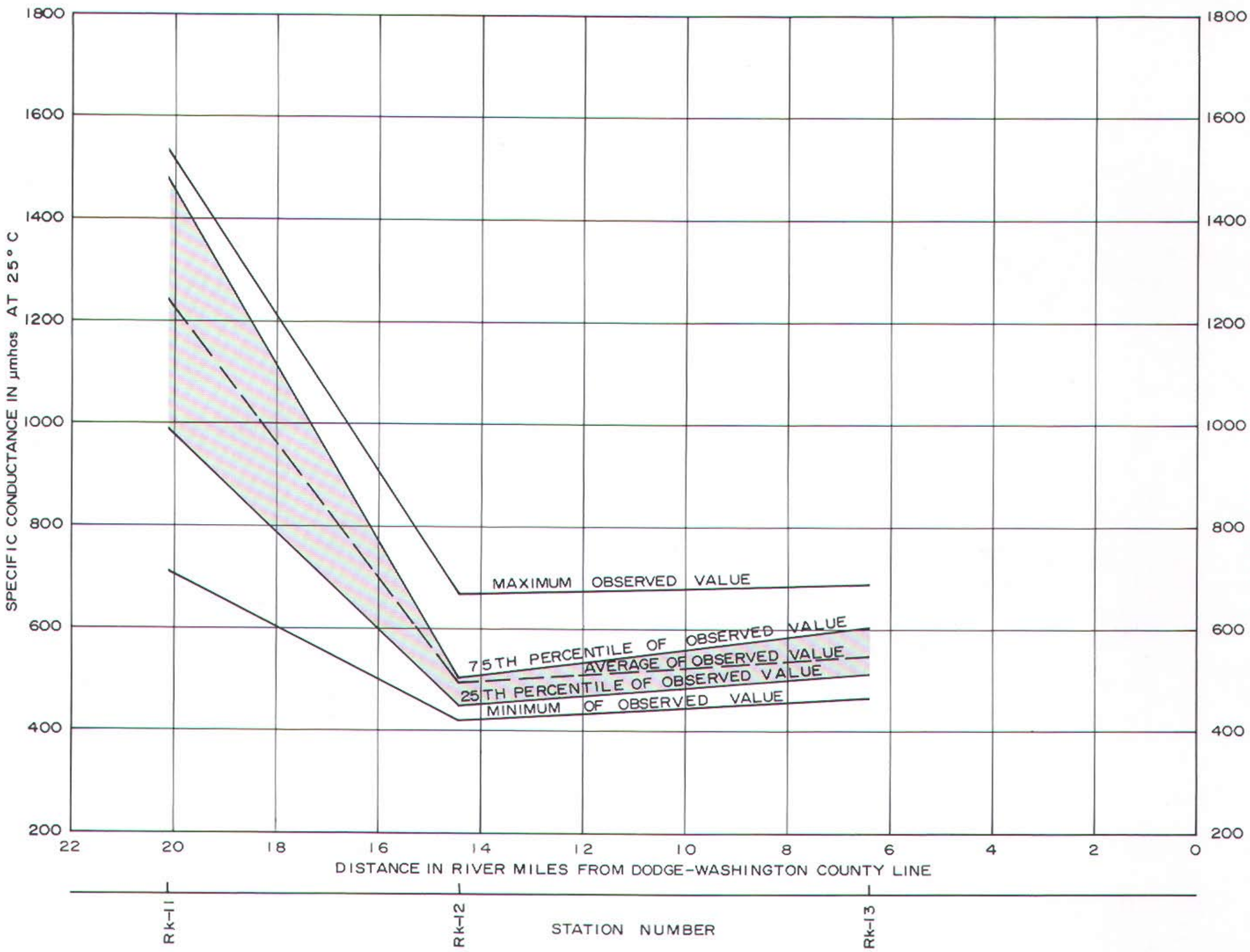


Source: SEWRPC.

watershed, eight on the Upper Rock River, and five on the lower Rock River watershed within the Region. The water quality data for 1964-1965 from the 13 sampling stations on the Rock River tributaries indicated that the chloride levels were higher than the normal background concentration and reflected a chloride impact upon the stream from human activities. The exceptions were the sampling stations on the Ashippun River and the Bark River, at which the chloride concentrations were found to be less than 10 mg/l. Substandard concentrations of dissolved oxygen, total coliform counts greater than 2,000 MFCC/100 ml, and high biochemical oxygen demand values (BOD_5) were found during the summer months at sampling station Rk-4 on the Rubicon River, Rk-8 on the Oconomowoc River, and Rk-11 on Jackson Creek. Human activities, especially the discharge of treated effluent from sewage treatment plants, are the likely sources of organic matter that cause depletion of oxygen and increase fecal coliform counts and BOD_5 at these three locations.

Figure 199

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN JACKSON CREEK-TURTLE CREEK: 1964-1975

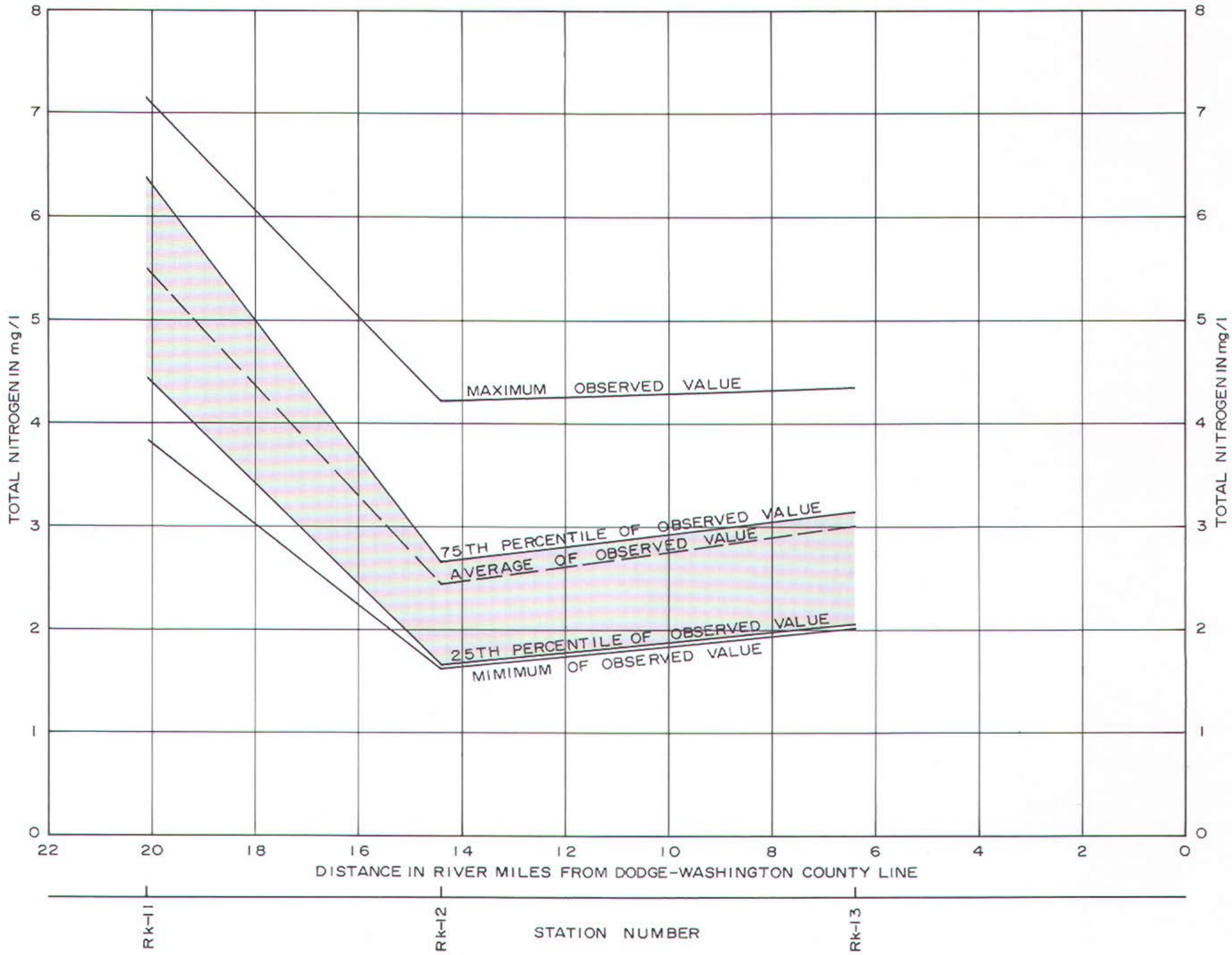


Source: SEWRPC.

The 1965-1975 water quality monitoring effort by the Commission included continued sampling at the 13 stations established in the watershed. The observed dissolved oxygen levels indicate that the water quality remained essentially unchanged at all sampling station locations except for sampling stations Rk-1 on the East Branch of the Rock River, Rk-4 on the Rubicon River, and Rk-8 on the Oconomowoc River. A slight decrease in the dissolved oxygen content over the past decade was observed at sampling station Rk-1 on the East Branch of the Rock River and at sampling station Rk-8 on the Oconomowoc River. The dissolved oxygen content showed an increase over the past decade at sampling station Rk-4 on the Rubicon River. The chloride data indicated essentially no change over the past 10 years at all the sampling stations with the exception of Rk-4 on the Rubicon River where a significant decrease in chloride levels was observed. The fecal coliform counts remained essentially unchanged over the past eight years at sampling stations Rk-1 on the East Branch of the Rock River, Rk-3 on

Figure 200

SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN JACKSON CREEK-TURTLE CREEK: 1972-1975



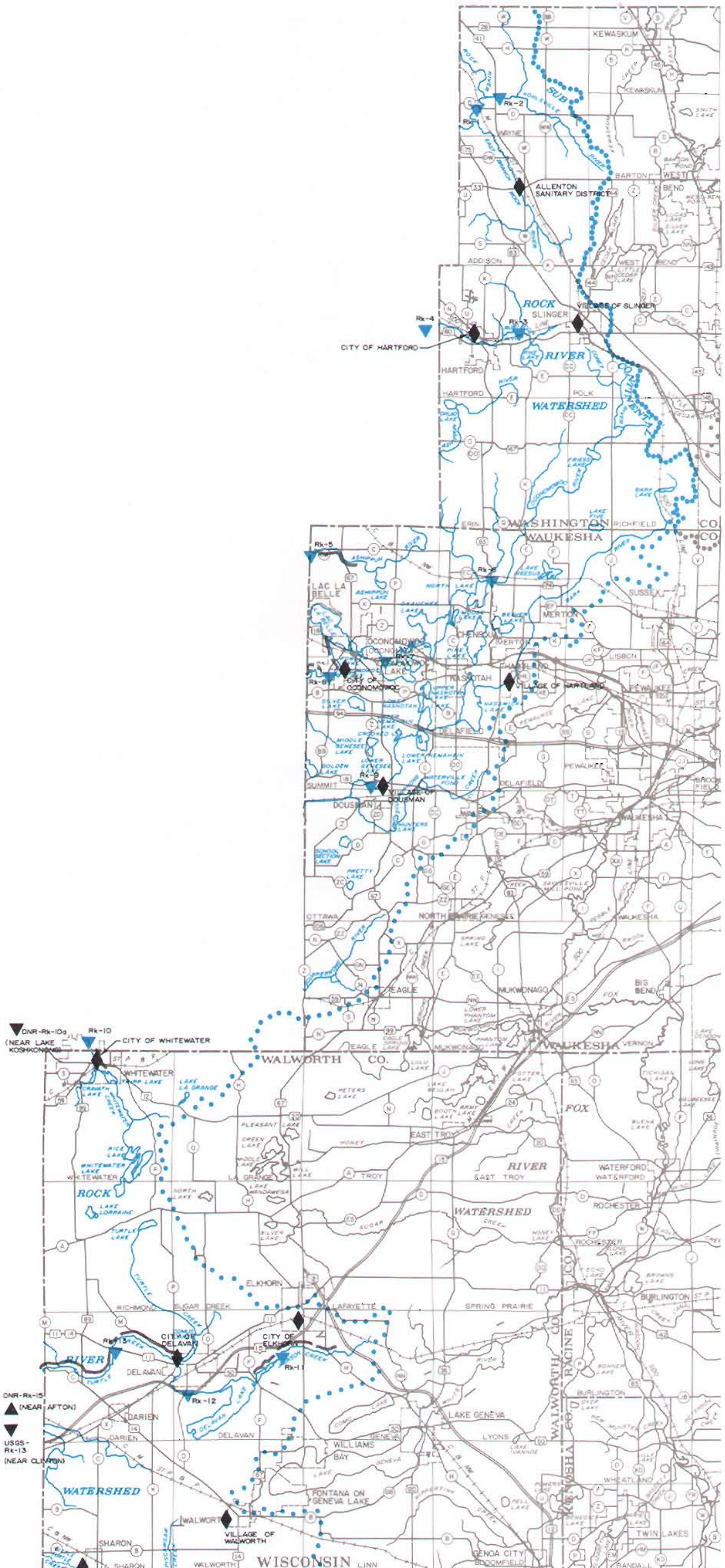
Source: SEWRPC.

the Rubicon River, Rk-7 on the Oconomowoc River, Rk-9 on the Bark River, and Rk-12 on the Delavan Lake Outlet. However, the fecal coliform counts decreased at sampling stations Rk-5 on the Ashippun River, Rk-6 on the Oconomowoc River, and Rk-10 on the Whitewater Creek. At the remaining five locations no trends in the fecal coliform counts were observed. As measured by nitrate-nitrogen and total phosphorus, the nutrient concentrations remained in excess of the recommended water quality standards of 0.30 mg/l as N, and 0.1 mg/l as P in all the samples collected at all of the sampling stations over the past eight years with the exception of samples from sampling station Rk-7 on the Oconomowoc River downstream from Oconomowoc Lake.

The diurnal water quality data for the Rock River tributaries showed a broad range of dissolved oxygen concentrations from a low of 0.8 to a high of 15.8 mg/l over a 24-hour period and reflected the dissolved oxygen reductions due to respiration by aquatic plants and decomposition of organic matter in the stream, and the dissolved oxygen supersaturation effects of algal photosynthesis. In addition to exhibiting marked diurnal fluctuations, water quality in the Rubicon River, the Oconomowoc River, and Jackson Creek-Delavan Lake Outlet-Turtle Creek showed spatial variation. The water quality of the Rubicon River generally declined from sampling station Rk-3 to sampling station Rk-4 located downstream from the City of Hartford sewage treatment

Map 67

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE ROCK RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

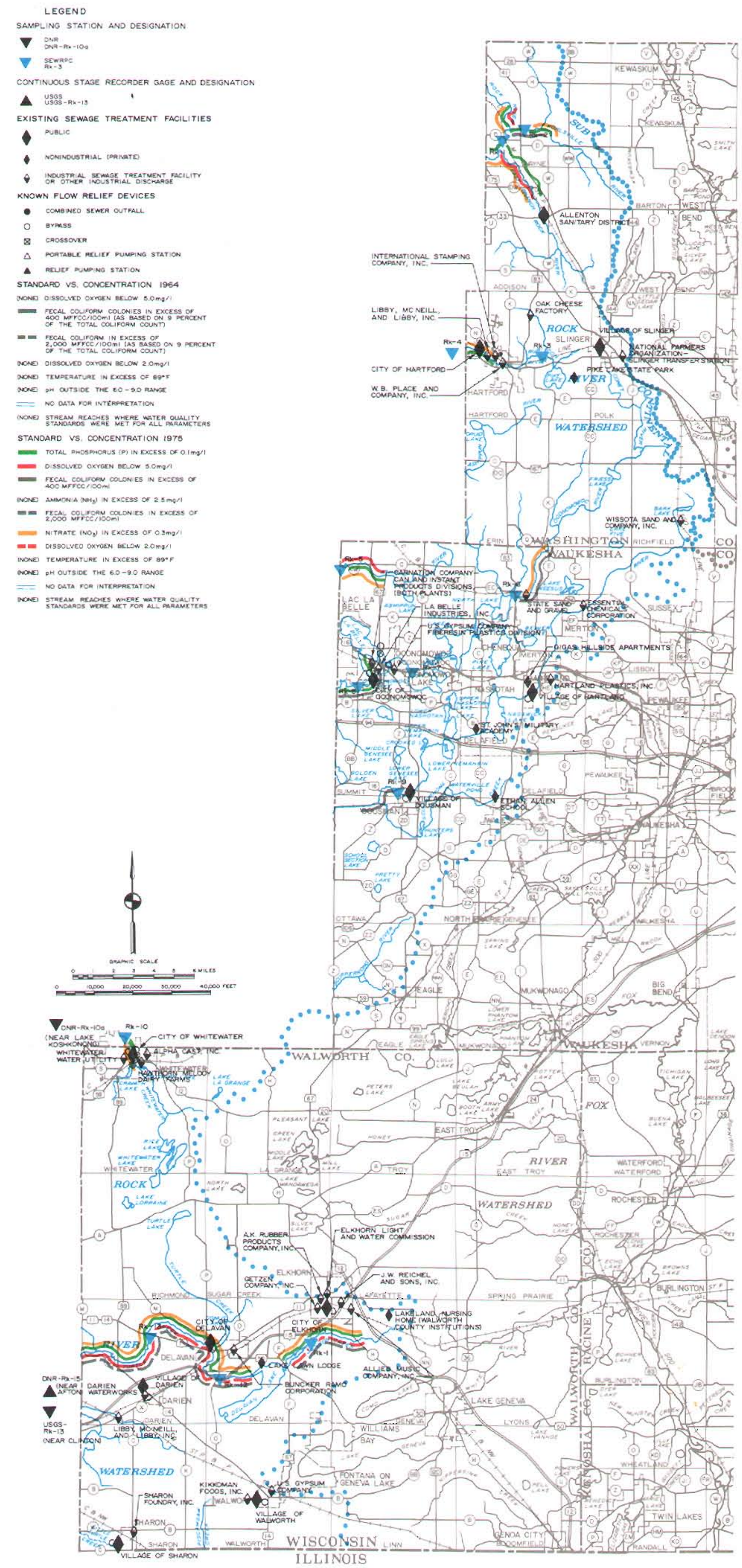


A comparison of the stream water quality in the Rock River watershed as sampled in August 1964 to the adopted water quality standards indicated that all standards at all sampling stations were met with the exception of sampling stations Rk-5, Rk-8, Rk-10, Rk-11, and Rk-13 where the total coliform levels and estimated fecal coliform levels exceeded the standard for recreational use.

Source: SEWRPC.

Map 68

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE ROCK RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Rock River watershed as sampled in August 1975 to the adopted water quality standards indicated that only at sampling stations Rk-3 and Rk-7 were all standards satisfied. The recommended level for total phosphorus was exceeded at stations Rk-1, Rk-4, Rk-5, Rk-8, Rk-10, Rk-11, Rk-12, and Rk-13. Sampling station Rk-1, Rk-5, Rk-11, Rk-12, and Rk-13 violated the established dissolved oxygen standard. The fecal coliform standard was not satisfied at stations Rk-2, Rk-6, Rk-8, Rk-9, Rk-11, Rk-12, and Rk-13. Finally, the recommended level for nitrate-nitrogen was exceeded at stations Rk-2, Rk-4, Rk-5, Rk-6, Rk-10, Rk-11, Rk-12, and Rk-13.

Source: SEWRPC.

plant. The water quality of the Oconomowoc River improved from sampling station Rk-6 to sampling station Rk-7 located downstream from the three major lakes—North, Okauchee, and Oconomowoc Lakes. At sampling station Rk-8, located downstream from sampling stations Rk-6 and Rk-7 and the City of Oconomowoc sewage treatment plant, the water quality declined as compared to the dissolved oxygen levels and fecal coliform counts at sampling stations Rk-6 and Rk-7. The water quality of Jackson Creek improved as the water passed through Delavan Lake, but deteriorated at sampling station Rk-13 on Turtle Creek located downstream from Jackson Creek, Delavan Lake, and the City of Delavan sewage treatment plant.

There are 38 major lakes in the Rock River watershed. Okauchee Lake in Waukesha County is the deepest with a maximum depth of 94 feet. All major lakes showed 1.0 mg/l or less of dissolved oxygen in the hypolimnion indicating that anaerobic conditions probably occur during summer with resulting adverse effects on the fish habitat of these lakes. The trophic status of 17 of the 38 major lakes have been evaluated and, of the 17 lakes, Nagawicka Lake is classified as "very eutrophic,"; Lac La Belle is classified as "eutrophic"; Beaver, Druid, Fowler, Golden, Keesus, Lower Nemahbin, North, Oconomowoc, Pine, Silver (in Waukesha County), Upper Nemahbin, and Whitewater Lakes are classified as "mesotrophic" lakes; and Pike Lake in Washington County and Okauchee and Upper Nashotah Lakes in Waukesha County are classified as "oligotrophic" lakes.

The water quality of the Rock River tributaries within the Region, which are intended for recreational use and for the preservation of fish and aquatic life, does not currently meet the water quality standards set by the Wisconsin Department of Natural Resources for dissolved oxygen and fecal coliform counts. In addition, at many locations the plant nutrients, total phosphorus, and nitrate-nitrogen concentrations were found to be significantly higher than the recommended levels adopted by the Commission for the avoidance of nuisance algal growth in these streams.

An interpretive analysis of the observed trends in the individual parameters, considering the types and location of pollution sources in the Rock River watershed, the specific streamflow and precipitation conditions of the sampling dates, and a general understanding of the land use changes over the past decade, indicates the effect of these sources on the water quality of the 10 streams studied in the Rock River watershed. The water quality of the Kohlsville River showed no significant change over the past decade, with occasionally high fecal coliform counts probably caused by the runoff from agriculture operations in the subwatershed. The portion of the East Branch of the Rock River within the Rock River watershed within the Region showed a slight decrease in water quality with a decreasing trend in the dissolved oxygen over the past decade. The water quality of the Rubicon River at sampling station Rk-3 showed no significant change over the past decade and showed a slight improvement at sampling station Rk-4 with a decrease in chloride concentrations and an increase in dissolved oxygen levels. The improved dissolved oxygen concentration at sampling station Rk-4, located downstream from the City of Hartford sewage treatment plant, reflects improvements made at the sewage treatment plant in the summer of 1973. The water quality of the Ashippun River showed no change over the past decade. The water quality conditions of the Oconomowoc River showed no change at sampling stations Rk-6 upstream from North Lake and Rk-7 downstream from a chain of three lakes—North, Okauchee, and Oconomowoc Lakes. At sampling station Rk-8 on the Oconomowoc River, located downstream from the City of Oconomowoc sewage treatment plant, the water quality showed a slight decrease over the past decade. The Bark River showed no meaningful trend in water quality, and Whitewater Creek showed a slight improvement in water quality with decrease in fecal coliform counts over the past decade. No significant change is demonstrated in the water quality of the Jackson Creek-Delavan Lake Outlet-Turtle Creek chain over the past decade.

ROOT RIVER WATERSHED

Regional Setting

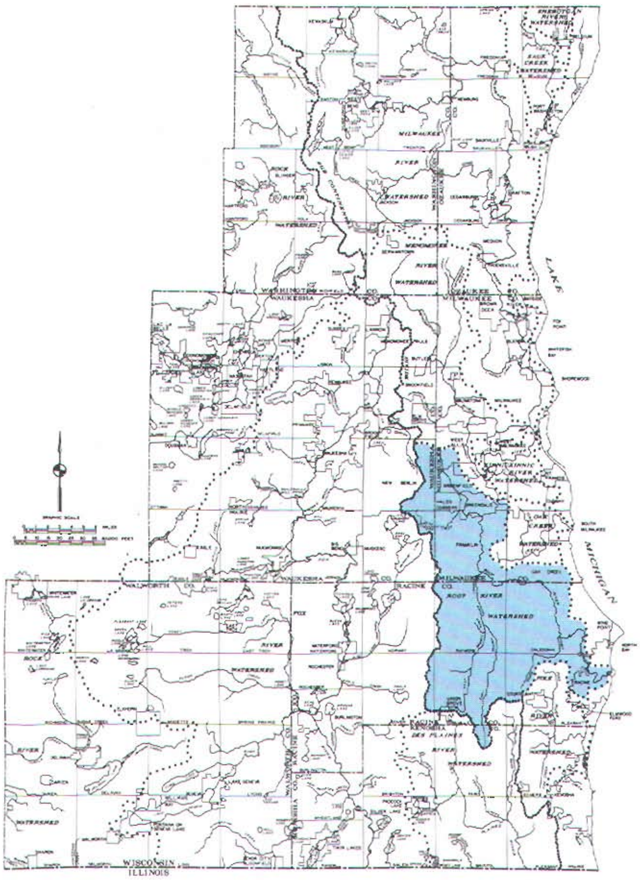
The Root River watershed is a surface water drainage unit, 196.87 square miles in areal extent, located in the east central portion of the Southeastern Wisconsin Region. The boundaries of the basin, together with the locations of the main channels of the Root River and its principal tributaries, are shown on Map 69. The watershed lies south of the City of Milwaukee and directly in the path of the major Milwaukee-to-Chicago transportation routes. The northern headwater portion of the watershed lies in the rapidly expanding Milwaukee urbanized area, while the Racine urbanized area occupies the southeastern portion of the watershed which discharges to Lake Michigan through the City of Racine. The southwestern portion of the watershed is occupied by a singular expanse of rich agricultural land, one of the few remaining large concentrations of such land within the Region. The westerly watershed boundary marks the subcontinental divide which separates surface waters flowing westerly and southerly through the Mississippi River to the Gulf of Mexico from surface waters flowing northerly and easterly through Lake Michigan and the St. Lawrence River to the Atlantic Ocean. The Root River, which drains the watershed, consists of the North Branch of the Root River, Upper Creek, Hales Corners Creek, Tess Corners-Whitnall Creek, Ryan Creek, Root River Canal, the East Branch of the Root River Canal, the West Branch of the Root River Canal, the Root River main stem, and Hoods Creek. Table 188 lists each stream reach, the location, the source, and the length of each stream reach in miles in the Root River watershed. The watershed, which is wholly contained within the Region, is the sixth largest in population and fourth in size of the 12 watersheds of the Region. It comprises 7 percent of the total land and water area of the Region.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries is a rectangular pattern of local political

Map 69

LOCATION OF THE ROOT RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Root River watershed has a total area of 197 square miles and comprises about 7.3 percent of the total 2,689 square mile area of the Region. The watershed ranks sixth in population and fourth in size of the 12 watersheds of the Region.

Source: SEWRPC.

boundaries, as shown on Map 69. The watershed lies in four counties—Kenosha, Milwaukee, Racine, and Waukesha—and in 18 cities, villages, and towns. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 189.

Population

Population Size: The 1975 resident population of the watershed is estimated at 152,431 persons, or about 8 percent of the total estimated resident population of the Region of 1,789,871. Table 190 presents the population distribution in the Root River watershed by civil division. The population of the watershed has increased steadily since 1900; and since 1940 the rate of population increase has generally exceeded the regional growth rate.

Population Distribution: Presently, about 90 percent of the residents of the watershed live in incorporated cities and villages, the combined areas of which comprise about 40 percent of the watershed. The Root River watershed is highly urbanized in the headwater and outlet areas, but is predominantly rural elsewhere.

Quantity of Surface Water

Surface water in the Root River watershed is made up almost entirely of streamflow. A few minor ponds, wetlands, and flooded gravel pits comprise the balance but are negligible in terms of total water quantity. The quantity of streamflow varies widely from season to season and from year to year, responding to variations in precipitation, temperature, soil moisture conditions, agricultural operations, the growth cycle of vegetation, and groundwater levels. Since the quantity of streamflow is the product of many interrelated hydrologic factors, the only practical way to determine streamflow characteristics is to measure the streamflow itself.

Streamflow characteristics for the published period of record, are summarized in Table 191. High streamflows occur principally in late winter and early spring, usually in association with melting snow. Low flows persist for most of the remainder of the year with occasional rises caused by rainfall. Under present groundwater conditions, the lowest flows of the River appear to consist almost entirely of sewage treatment plant effluent, without which flows would probably drop to zero for considerable periods of time during the year.

Surface runoff, the portion of precipitation which flows overland contributing directly to streamflow, is variable both in season and in location within the watershed. The ratio of runoff from winter rains and melting snow, usually occurring when the soil is frozen or saturated, can be very high. However, runoff during the later spring, summer, and fall seasons is generally a very small fraction of the causative rainfall.

Pollution Sources

An evaluation of water quality conditions in the Root River watershed must include an identification, categorization and, where feasible, quantification of known pollution sources. The following types of pollution sources have been identified in the watershed and are discussed below: municipal sewage treatment facilities, sanitary and combined sewerage system overflow points, industrial wastewater discharges, urban storm water runoff, and agricultural and other runoff. The principal purpose is to identify the type and location of various pollution sources and to quantify the pollution discharge from those sources in terms of rate or amount of discharge and concentration and total transport of pollutants.

Sewage Treatment Facilities: Six sewage treatment facilities are municipally owned or operated in the Root River watershed: the Village of Hales Corners sewage treatment facility; City of Muskego Northeast District sewage treatment facility; Rawson Homes Sanitary Trust; Village of Union Grove sewage treatment facility; Caddy Vista Sanitary District; and City of New

Table 188

STREAMS IN THE ROOT RIVER WATERSHED

Stream or Watercourse	Source		Length (in miles)[a]
	By Civil Division	By U. S. Public Land Survey	
North Branch of Root River	City of West Allis	NW ¼, Section 7, T6N, R21E	44.8
Upper Creek[b]	City of New Berlin	SW ¼, Section 13, T6N, R20E	2.3
Hales Corners Creek.	Village of Hales Corners	SE ¼, Section 31, T6N, R21E	0.8
Tess Corners-Whitnall Park	City of Franklin	NW ¼, Section 8, T5N, R21E	3.3
Tributary[a] to West of Root River[b] . . .	City of Franklin	NW ¼, Section 20, T5N, R21E	1.6
Tributary to East of Root River.	City of Franklin	NE ¼, Section 1, T5N, R21E	2.4
Tributary[b] to West of Root River[b] . . .	City of Franklin	NW ¼, Section 22, T5N, R21E	0.6
Ryan Creek[b]	City of Franklin	NE ¼, Section 28, T5N, R21E	3.0
Root River Canal.	Town of Raymond	SW ¼, Section 23, T4N, R21E	2.9
West Branch of Root River Canal	Village of Union Grove	NE ¼, Section 29, T3N, R21E	10.6
Raymond Creek	Town of Raymond	NW ¼, Section 22, T4N, R21E	2.9
East Branch of Root River Canal	Town of Paris	SW ¼, Section 11, T2N, R21E	11.6
Husher Creek	Town of Caledonia	NW ¼, Section 21, T4N, R22E	3.4
Hoods Creek.	Town of Mt. Pleasant	NW ¼, Section 19, T3N, R22E	8.6

[a] *Total perennial stream length as shown on U. S. Geological Survey quadrangle maps.*

[b] *Intermittent streams.*

Source: SEWRPC.

Berlin (Greenridge plant which was abandoned in 1975) sewage treatment facility. Selected information for the municipal sewage treatment plants in the Root River watershed is set forth in Table 192, and the plant locations are shown on Map 70.[17] In addition to the public sewage treatment facilities, there are seven nonindustrial private sewage treatment facilities present in the Root River watershed: the Highway 100 Drive-In Theater; the Union Oil Truck Stop in Milwaukee County; Fonk's Mobile Home Park; Racine County Highway and Park Commission; Wisconsin Southern Colony Training School and Treatment Facility in Racine County; New Berlin Memorial Hospital; and Highway 24 Outdoor Theater in New Berlin in Waukesha County. Five of these nonindustrial private sewage treatment facilities operate a secondary activated sludge treatment process. Highway 24 Outdoor Theater in New Berlin operates a primary sedimentation treatment facility and Highway 100 Drive-In operates a sand filter and flow-through lagoon treatment facility. The available data on the seven nonindustrial private sewage treatment facilities are presented in Table 193. Among the six publicly operated sewage treatment facilities and seven nonindustrial privately operated sewage treatment facilities, a total of four facilities discharge the effluent into the Root River main stem, two into the West Branch of the Root River Canal and two into the East Branch of the Root River Canal, four into Tess Corners Creek, and one into a minor tributary to the Root River.

Domestic Onsite Sewage Disposal Systems: Although certain portions of the watershed lie within existing and proposed service areas of public sanitary sewerage systems, some areas of the watershed still are served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points

In addition to private and public sewage treatment facility effluents, raw sanitary sewage enters the surface water system of the Root River watershed directly from combined or sanitary sewer overflows, or indirectly via

[17] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 70. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 189

AREAL EXTENT OF CIVIL DIVISIONS IN THE ROOT RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
KENOSHA COUNTY			
Town			
Paris	2.18	1.11	6.06
County Subtotal	2.18	1.11	0.78
MILWAUKEE COUNTY			
Cities			
Franklin	31.70	16.10	91.38
Greenfield	6.25	3.17	53.74
Milwaukee	1.04	0.53	1.08
Oak Creek	8.08	4.10	28.44
West Allis	2.95	1.50	25.92
Villages			
Greendale	5.46	2.77	98.02
Hales Corners	3.17	1.61	100.00
County Subtotal	58.66	29.79	24.17
RACINE COUNTY			
City			
Racine	6.27	3.18	46.62
Village			
Union Grove	0.44	0.22	47.83
Towns			
Caledonia	36.18	18.37	77.54
Dover	2.57	1.30	7.11
Mt. Pleasant	13.70	6.96	36.58
Norway	0.10	0.05	0.28
Raymond	33.93	17.23	94.99
Yorkville	29.75	15.11	84.28
County Subtotal	122.94	62.45	36.12
WAUKESHA COUNTY			
Cities			
Muskego	3.90	1.98	10.82
New Berlin	9.20	4.67	24.28
County Subtotal	13.10	6.65	2.26
Total	196.87	100.00	--

Source: SEWRPC.

such overflows to separate storm sewer systems. This direct or indirect conveyance of sanitary sewage to the watershed surface water system occurs as a result of the presence of five types of flow relief devices: combined sewer outfalls, crossovers, bypasses, relief pumping stations, and portable pumping stations. The definition and detailed description of these flow relief devices are given in Chapter V, Planning Report No. 16, Regional Sanitary Sewer System Planning for Southeastern Wisconsin, published in February 1974 by the Commission. There are 61 known combined sewer outfalls and other flow relief devices in the Root River watershed as shown in Table 194. Of these flow relief devices, eight are combined sewer outfalls and 20 are bypasses, 22 are crossovers, and 11 are portable pumping stations. Fifty-six of these flow relief devices and combined sewer outfalls are

Table 190

ESTIMATED RESIDENT POPULATION OF ROOT RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
KENOSHA COUNTY	
Town	
Paris (part)	62
Kenosha County (part) Subtotal	62
MILWAUKEE COUNTY	
Cities	
Franklin (part).	11,923
Greenfield (part)	8,455
Milwaukee (part)	8,376
Oak Creek (part)	3,014
West Allis (part)	13,254
Villages	
Greendale (part)	16,349
Hales Corners.	8,773
Milwaukee County (part) Subtotal	70,144
RACINE COUNTY	
City	
Racine (part)	43,286
Villages	
Union Grove (part)	1,752
Towns	
Caledonia (part)	9,394
Dover (part)	779
Mt. Pleasant (part)	4,276
Norway (part)	31
Raymond (part)	3,583
Yorkville (part)	2,813
Racine County (part) Subtotal	65,914
WAUKESHA COUNTY	
Cities	
Muskego (part).	4,169
New Berlin (part)	12,142
Waukesha County (part) Subtotal	16,311
Root River Watershed Total	152,431

Source: SEWRPC.

directly discharging into the Root River main stream, one discharges into the West Branch of the Root River Canal, two discharge into the East Branch of the Root River, and the remaining two discharge into Hoods Creek. Map 70 presents the location of flow relief devices in the Root River watershed.

Industrial Discharges: At 17 locations in the Root River watershed industrial wastewaters consisting of process and cooling waters are discharged directly or indirectly to the surface water system. This industrial wastewater enters the Root River and its major tributaries as direct discharge through industrial waste outfalls or indirectly through drainage ditches and storm sewers.

Data and information provided by the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR101 of the Wisconsin Administrative Code were used to determine the type and location of industrial wastewater discharges in the Root River watershed. Table 195 summarizes by receiving stream and by civil division the types of industrial wastewater discharges and the number of outfalls in the watershed, the types of treatment, and average hydraulic design capacity. A total of 25 industrial and commercial discharge points is known to exist in the watershed (Map 70). Of these, 14 industries discharge cooling water, four discharge process wastewater, one discharges both cooling and process wastewater, two discharge surface runoff, one discharges swimming pool overflow, and three discharge process and sanitary wastes which are treated at an onsite facility before being released. Eight of the 17 industrial locations discharge the wastes directly into the Root River main stream, six industries discharge the wastes into the tributaries of the Root River, and the remaining three discharge to groundwater.

Pollution from Urban Runoff

Separate storm sewers which convey the runoff from rainfall carry the pollutants and contaminants from urbanized areas into a receiving water. Urban storm waters can cause chemical or inorganic pollution, organic pollution, pathogenic pollution, and aesthetic pollution of these receiving lakes and streams. Existing land use information taken from the Commission 1970 land use inventory is presented in Table 196 and indicates that 32,532 acres of the Root River watershed are devoted to urban land uses and 93,773 acres, or 72 percent, devoted to rural land uses, primarily agriculture. A shoreland development survey by the Wisconsin Department of Natural Resources indicates that 62 percent of the shoreland area within 1,000 feet of the Root River and its tributaries is used either for agricultural purposes or other rural purposes, and 38 percent of the shoreland within 1,000 feet of the Root River and its tributaries is used for urban purposes. In comparing the land use within the watershed with the land use within 1,000 feet of the shores of the Root River and its tributaries, it is noted that a slightly higher percentage of the land along the shores of the Root River is urbanized than within the watershed as a whole. The urbanized areas of the Root River watershed, although comprising only 28 percent of the total area of the watershed, have a significant effect on stream water quality.

Table 191

FLOW MEASUREMENTS FOR THE ROOT RIVER WATERSHED AT SELECTED LOCATIONS

Water Year	Root River Canal at CTH G (Rt-3)				North Branch at Ryan Road (Rt-2)				Root River Near Racine (Rt-6)			
	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)	Mean Daily Flow (cfs)	Equivalent Runoff Depth (inches)	Maximum Daily Flow (cfs)	Minimum Daily Flow (cfs)
1963-1964	7.7	1.83	309	0.3	15.9	4.38	729	1.4	34.4	2.51	997	1.3
1964-1965	39.6	9.37	500	1.2	51.3	14.12	1,600	2.1	121.0	8.76	1,610	3.5
1965-1966	52.5	12.45	763	1.2	40.4	11.12	900	2.2	151.0	10.97	2,400	3.5
1966-1967	34.9	8.31	557	1.2	29.5	8.13	675	2.9	105.0	7.62	1,900	3.0
1967-1968	19.9	4.72	418	1.0	31.5	8.68	820	5.2	84.6	6.16	1,420	8.4
1968-1969	44.4	10.54	436	2.5	56.7	15.63	2,150	8.9	162.0	11.78	1,900	15.0
1969-1970	34.9	8.28	676	1.8	34.0	9.37	768	3.2	131.0	9.49	1,240	9.0
1970-1971	52.4	12.44	720	0.6	38.7	10.67	866	0.44	146.0	10.61	1,460	2.5
1971-1972	59.9	14.26	684	0.7	58.6	16.17	1,380	1.3	189.0	13.77	2,570	3.8
1972-1973	71.4	16.95	706	1.9	78.8	21.70	2,390	7.1	234.0	16.96	2,980	8.0
1973-1974	98.4	23.35	1,410	1.5	84.0	23.13	1,360	3.0	257.0	18.68	4,010	7.7
1974-1975	38.9	10.71	1,100	2.0	38.9	10.71	1,110	2.0	117.0	8.50	1,480	3.6

Source: SEWRPC.

Table 192

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE ROOT RIVER WATERSHED: 1975

Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity					Existing Loading	
							Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Average Organic	Population[a] Equivalent	Average Hydraulic (mgd)	Average Per Capita (gpd)
Hales Corners Plant. .	2.99	8,800	1942, 1957	Phosphorus Removal Trickling Filter Disinfection	Advanced Secondary Auxiliary	Root River	9,000	0.90	N/A	1,333	6,350	0.52	59
Rawson Homes Sewer and Water Trust.	0.16	600	1954	Activated Sludge Disinfection	Secondary Auxiliary	Root River	402	0.04	N/A	67	320	N/A	N/A
Village of Union Grove	0.97	3,200	1937, 1962	Activated Sludge Disinfection	Secondary Auxiliary	West Branch Root River Canal	3,000	0.30	0.72	510	2,400	0.43	134
Caddy Vista Sanitary District. . .	0.29	1,000	1956	Trickling Filter Disinfection	Secondary Auxiliary	Root River	N/A	0.25	0.40	N/A	N/A	0.09	90
City of New Berlin Greenridge Plant, Abandoned 1975 . .	0.12	800	1966	Activated Sludge	Secondary	Root River	1,000	0.10	N/A	200	955	0.10	N/A
City of Muskego, Northeast District . .	2.60	6,000	1972	Activated Sludge Phosphorus Removal Disinfection	Secondary Advanced Auxiliary	Tess Corners Creek	5,000	0.50	1.0	1,000	4,760	0.34	57

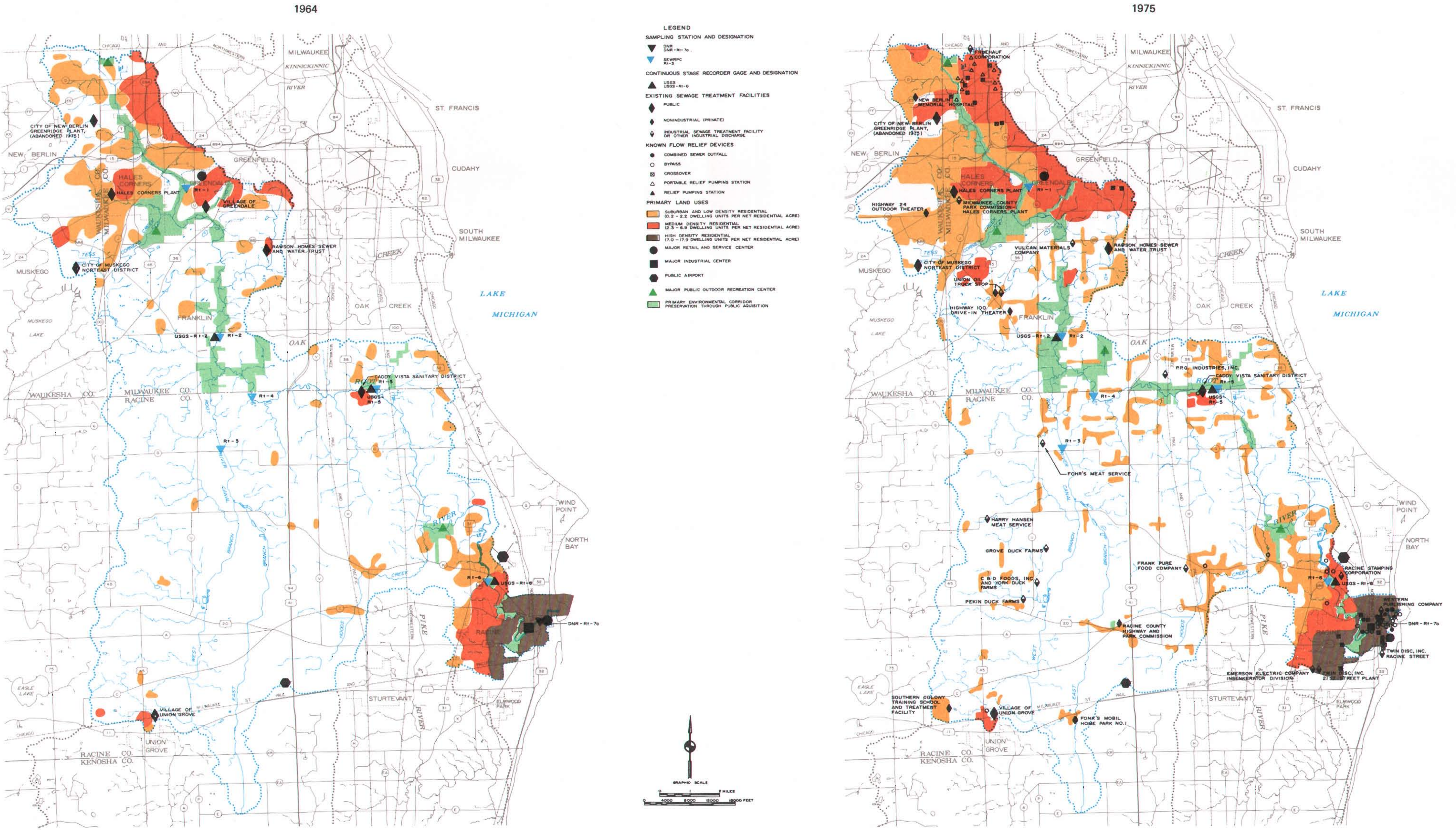
NOTE: N/A indicates data not available.

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the table.*

Source: SEWRPC.

Map 70

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE ROOT RIVER WATERSHED: 1964 AND 1975



Stream water quality data was obtained from chemical, physical, biochemical, and bacteriological analyses of water samples collected at 10 sampling stations located in the Root River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by discharges from six municipal sewage treatment facilities, seven nonindustrial private sewage treatment facilities, eight combined sewer outfalls, 22 crossovers, 20 bypasses, 11 portable pumping stations, and 17 industrial or commercial locations discharging wastewater through 25 outfalls.

NOTE: *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.*

Source: SEWRPC.

Table 193

SELECTED CHARACTERISTICS OF NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES IN THE ROOT RIVER WATERSHED

Name	Civil Division Location	Type of Land Use Served	Type of Wastewater	Type of Treatment Provided	Disposal of Effluent	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Average Hydraulic Design Capacity (gallons per day)	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY								
Highway 100 Drive-in Theater	City of Franklin	Commercial	Sanitary	Septic Tank, Sand Filter, and Lagoon	Groundwater	N/A	N/A	6,000
Union Oil Truck Stop	City of Franklin	Commercial	Sanitary	Extended Aeration	Root River	N/A	10,000	N/A
RACINE COUNTY								
Fonk's Mobile Home Park No. 1	Town of Yorkville	Residential	Sanitary	Extended Aeration and Lagoon	East Branch Root River Canal	13,000	15,000	N/A
Racine County Highway and Park Commission	Town of Yorkville	Commercial	Sanitary	Activated Sludge and Lagoon	Hoods Creek	N/A	10,000	N/A
Southern Colony Training School and Treatment Facility	Town of Dover	Institutional	Sanitary	Contact, Stabilization, and Lagoon	West Branch Root River Canal	180,000	445,000	210,000
WAUKESHA COUNTY								
Highway 24 Outdoor Theater	City of New Berlin	Commercial	Sanitary	Septic Tank, and Soil Absorption	Groundwater	N/A	Intermittent	Intermittent
New Berlin Memorial Hospital	City of New Berlin	Institutional	Sanitary	Activated Sludge and Lagoon	Root River via Drainage Ditch	260,000	19,000	370,000

NOTE: N/A indicates data not available.

[a] Unless specifically noted otherwise, data was obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data for from the flow data as reported in the permit.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Pollution from Rural Land: Based on surveys and studies performed in the Menomonee River watershed, agricultural land uses have been determined to provide high concentrations of total nitrogen and total phosphorus in storm water runoff. Since 72 percent of the total area of the Root River watershed is in agricultural use, pollution from the agricultural land is a significant factor determining the water quality of the Root River stream system.

Other Pollution Sources: The Commission 1970 land use inventory revealed, in addition to the pollution sources described above, 11 sanitary landfill sites and 11 auto salvage yards; two of the former and five of the latter were located on or just outside the boundary of the Root River watershed. Seepage and runoff from these sources would contain organic pollutants, inorganic pollutants, and pathogenic pollutants and contribute to the pollution of the River system.

Water Quality Conditions of the Root River Watershed

Water Quality Data: Of the total data sources, the following eight of 12 were used in the Root River watershed study: (1) the Commission benchmark study, (2) the Commission continuing monitoring program, (3) the Commission continuous streamflow monitoring program, (4) Wisconsin Department of Natural Resources monthly manual sampling, (5) Wisconsin Department of Natural Resources basin surveys, (6) City of Racine, Department of Health water quality survey program, (7) U. S. Geological Survey continuous streamflow monitoring program, and (8) U. S. Geological Survey water quality sampling program. A detailed description of these data sources is given in Chapter II.

Six sampling stations, five on the Root River and one on the Root River Canal, were established by the Commission. Tables 197 and 198 present the Commission stations, locations, and their distances from the source of the

Table 194

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE ROOT RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1976

Receiving Stream	Civil Division	Combined Sewer Outfalls	Crossovers	Other Flow Relief Devices			Total
				Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Root River.	City of West Allis	0	7	0	0	11	18
Root River.	City of Milwaukee	0	2	0	0	0	2
East Branch of Root River.	City of Milwaukee	0	2	0	0	0	2
Root River.	Town of Caledonia	0	0	2	0	0	2
Root River.	City of Racine	8	11	14	0	0	33
Hoods Creek.	Town of Caledonia	0	0	2	0	0	2
Root River.	Town of Mt. Pleasant	0	0	1	0	0	1
West Branch of Root River Canal. .	Village of Union Grove	0	0	1	0	0	1
Total		8	22	20	0	11	61

Source: SEWRPC.

Root River and Table 199 presents the stations other than those established by the Commission. Map 70 illustrates the location of the sampling stations in the Root River watershed.

Surface Water Quality of the Root River 1964-1965: Water quality conditions in the Root River watershed, as determined by the 1964-65 sampling survey at five stations along the entire length of the Root River and one on the Root River Canal, are summarized in Table 200. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to an assessment of the trends in the surface water quality.

Chloride: During the sampling year of 1964-1965, the chloride concentrations throughout the watershed varied from 30 to 240 mg/l with the average values for the Root River and Root River Canal being 115 and 95 mg/l, respectively. The chloride levels in the watershed were high compared to background levels of 20 to 50 mg/l as measured from the average groundwater chloride concentrations. The highest concentration in the range of 170 to 240 mg/l chloride occurred during February and March of 1964 in all six sampling locations. A significant decrease in chloride concentrations was noted in the next monthly samples from all six sampling locations. The high chloride levels in the Root River during February and March are most likely due to street salting operations conducted during winter but affecting the main stream during the spring runoff, as the residual chemicals are flushed from the streets and highways. The high concentrations during the rest of the sampling periods can be attributed to sewage treatment plant effluents and septic tank system discharge.

Dissolved Oxygen: During the sampling year of 1964-1965, the dissolved oxygen levels in the watershed ranged from 0 to 14.6 mg/l, with the average values for the Root River and Root River Canal being 7.2 and 3.4 mg/l, respectively. Although the average concentration of dissolved oxygen was 7.2 mg/l for the Root River, several instances of substandard levels were noted over many locations of the stream. At sampling station Rt-1, the concentration of dissolved oxygen was lower than 5 mg/l during five of the 12 sampling periods. There were two sewage treatment facilities which discharged treated effluents to the North Branch of the Root River upstream from sampling station Rt-1. In addition, a possible leaching of organic materials from the sanitary landfill site and probable discharge of raw sewage through flow relief devices also might cause oxygen depletion in the stream water. A combination of these three sources and

Table 195

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE ROOT RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
MILWAUKEE COUNTY								
Fruehauf Corporation	7539	City of West Allis	Cooling and Process	None	1	South Branch Root River via Storm Sewer and Drainage Ditch	3,200	4,000
Milwaukee County Park Commission Hales Corners Park	7999	Village of Hales Corners	Swimming Pool Overflow and Emptying	None	1	Root River via Storm Sewer	Intermittent	Intermittent
P.P.G. Industries, Inc.	2851	City of Oak Creek	Cooling Boiler and Cooling Tower Blowdown	Oil Separator and pH Adjustment	1	Root River via Drainage Ditch	4,000	6,600
Union Oil Milwaukee Truck Stop	5571	City of Franklin	Runoff	Oil Separator	1	Tributary of Root River	Intermittent	Intermittent
Vulcan Materials Company	1422	City of Franklin	Runoff	N/A	1	Root River	321,000	1,260,000
RACINE COUNTY								
C & D Foods, Inc.	0259	Town of Yorkville	Process and Sanitary	Activated Sludge and Lagoon	1	West Branch Root River	269,900	322,600
Emerson Electric Company	3639	City of Racine	Cooling	None	1	Root River via Storm Sewer	27,200	33,000
			Cooling	None	2	Root River via Storm Sewer	13,400	15,800
Fohr's Meat Service	2033	Town of Raymond	Process and Sanitary	Septic System	1	Groundwater	N/A	1,000
Frank Pure Food Company	2033	Town of Caledonia	Process	Screening and Lagoon	1	Hoods Creek via Drainage Tile	70,000	70,000
			Cooling	None	2	Hoods Creek via Drainage Tile	12,800	16,000
Grove Duck Farms	0259	Town of Raymond	Process and Sanitary	Lagoon	1	West Branch Root River	25,000	40,000
Harry Hansen Meat Service	2011	Town of Raymond	Process	Septic Tank	1	Groundwater	1,400	N/A
Pekin Duck Farms	0259	Town of Yorkville	Process	Spray Irrigation, Settling Basin Screening, and Lagoon	1	Groundwater	6,000	90,000
Racine Stamping Corporation	3467	City of Racine	Cooling	None	1	Root River via Storm Sewer	17,500	N/A
Twin Disc, Inc. Racine Street	3566	City of Racine	Cooling	N/A	1	Root River via Storm Sewer	17,000	30,000
			Cooling	N/A	2	Root River via Storm Sewer	11,000	26,000
			Cooling	N/A	3	Root River via Storm Sewer	29,000	40,000
Twin Disc, Inc. 21st Street Plant	3566	City of Racine	Cooling	N/A	1	Root River via Storm Sewer	45,000	65,000
			Cooling	N/A	2	Root River via Storm Sewer	73,000	94,000
			Cooling	N/A	3	Root River via Storm Sewer	6,000	9,000
Western Publishing Company	2731	City of Racine	Cooling	N/A	1	Root River	154,000	601,300
			Cooling	N/A	2	Root River	108,300	371,000
			Cooling	N/A	3	Root River	96,000	328,000
York Duck Farms	0259	Town of Yorkville	Process	Uses C & D Foods, Inc. Plant	1	West Branch Root River Canal	N/A	N/A

NOTE: N/A indicates data not available.

[a] Unless specifically noted otherwise, data was obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order or priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 196

LAND USE IN THE ROOT RIVER WATERSHED: 1963 AND 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	12,772.60		15,728.80	
Commercial	575.80		711.59	
Industrial	299.60		429.97	
Transportation and Utilities	9,132.33		9,683.58	
Government	1,138.07		1,450.94	
Recreation	2,767.71		3,492.92	
Landfill and Dump	161.21		170.95	
Total	26,847.32	21.46	31,668.75	25.38
Rural Land Uses				
Open Lands	9,363.48		9,222.16	
Agricultural Lands	83,567.61		78,415.95	
Total	92,931.09	74.28	87,638.11	70.24
Water Covered Lands				
Lakes, Rivers, and Streams	639.15		906.88	
Wetlands, etc.	4,684.10		4,562.03	
Total	5,323.25	4.26	5,468.91	4.38
Watershed Totals	125,101.66	100.00	124,775.77	100.00

Source: SEWRPC.

Table 197

DESIGNATIONS AND LOCATIONS OF SEWRPC SAMPLING STATIONS ON THE ROOT RIVER

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
SEWRPC	Rt-1	Bridge on Grange Avenue, northwest of Greendale; NE ¼, Section 33, T6N, R21E	37.2
SEWRPC	Rt-2	Bridge on Ryan Road; NE ¼, Section 27, T5N, R21E	28.4
SEWRPC	Rt-4	Milwaukee-Racine County line; NE ¼, Section 2, T5N, R21E	24.15
SEWRPC	Rt-5	Racine County line; on common boundary of Section 33 and 34; SW ¼, T5N, R22E	17.8
SEWRPC	Rt-6	Bridge on STH 38; NE ¼, Section 6, T3N, R23E	5.9

Source: SEWRPC.

Table 198

DESIGNATION AND LOCATION OF THE SEWRPC SAMPLING STATION ON THE ROOT RIVER CANAL

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
SEWRPC	Rt-3	Bridge on Six Mile Road, 8.7 Miles Southeast of Hales Corners; SE ¼, Section 10, T4N, R21E	29.3

Source: SEWRPC.

Table 199

DESIGNATIONS AND LOCATIONS OF STREAM SAMPLING STATIONS OTHER THAN SEWRPC IN THE ROOT RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from River Mouth (in miles)
USGS	Rt-2	Bridge on Ryan Road, NE ¼, Section 27, T5N, R21E	28.4
USGS	Rt-5	Bridge on Nicholson Road, Milwaukee-Racine County Line; on common boundary of Sections 33 and 34, SW ¼, T5N, R22E	17.8
USGS	Rt-6	Bridge on STH 38; NE ¼, Section 6, T3N, R23E	5.9
WDNR	Rt-7a	Marquette Bridge at Racine; SW ¼, Section 9, T3N, R23E	1.6

Source: SEWRPC.

Table 200

WATER QUALITY CONDITIONS OF THE ROOT RIVER: 1964-1965

Streams Sampled	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Root River main stem— Rt-1, Rt-2, Rt-4, Rt-5, Rt-6	Chloride (mg/l)	240	115	30	37
	Dissolved Solids (mg/l)	955	715	390	37
	Dissolved Oxygen (mg/l)	14.6	7.2	0	64
	Total Coliform Count (MFCC/100 ml) . .	1,100,000	71,000	100	64
	Temperature (^{o}F)	78	52	32	64
Root River Canal— Rt-3	Chloride (mg/l)	170	95	45	3
	Dissolved Solids (mg/l)	790	740	710	3
	Dissolved Oxygen (mg/l)	9.2	3.4	0	13
	Total Coliform Count (MFCC/100 ml) . .	1,700,000	150,000	$<$ 100	13
	Temperature (^{o}F)	72	50	32	13

Source: SEWRPC.

storm water runoff account for the oxygen demand in the stream at location Rt-1, resulting in low dissolved oxygen concentrations. Sampling station Rt-2 had less than 5.0 mg/l of dissolved oyxgen during six of the 12 sampling times. Between Rt-1 and Rt-2, were situated five municipal and industrial treatment facilities in addition to two sanitary landfill sites. The effluent from these treatment facilities or the leachate from the sanitary landfill would account for the increased dissolved oxygen depletion at Rt-2.

The Root River Canal, a tributary to Root River, meets the main stem two miles downstream from Rt-2, between Rt-2 and Rt-4. There were no known sewage or industrial waste treatment facilities, sanitary landfill sites, or sewage flow relief devices in operation along the main stem between Rt-2 and Rt-4. The distance between stations Rt-2 and Rt-4 is about four miles and, apparently, the absence of sewage and industrial waste sources between these two locations allows the stream to reestablish the dissolved oxygen level to some extent, as noted from the increased dissolved oxygen concentrations at Rt-4. As will be seen later, the Root River Canal, which meets the Root River two miles upstream from Rt-4, did have substandard dissolved oxygen concentrations. The ratio of flows of the Root River at Rt-2 and the Root River Canal at Rt-3 ranged from 1.00 to 2.00 for 80 percent of the time sampled. The substandard dissolved oxygen levels of Root River Canal did not significantly affect the dissolved oxygen concentrations of the Root River, as evidenced from station Rt-4. Apparently, the distance from Rt-3 and Rt-4, approximately four miles, was long enough for the reaeration of the stream and consequently the dissolved oxygen concentrations at station Rt-4 were higher than Rt-2 and Rt-3. While sampling station Rt-2 had concentrations of dissolved oxygen less than 5 mg/l, during five out of 12 sampling surveys, only three out of 12 samples of Rt-4 had less than 5 mg/l of dissolved oxygen. Even these three samples had dissolved oxygen concentrations higher than those at Rt-2.

The Caddy Vista sewage effluent discharge point is located between Rt-4 and Rt-5. The oxygen demand from the effluent from Caddy Vista Sanitary District and from rural runoff between Rt-4 and Rt-5 was not high enough to deplete the dissolved oxygen content below 5.0 mg/l at location Rt-5. Location Rt-6 had dissolved oxygen concentrations higher than 5.0 mg/l in all 12 monthly samples.

There were four known sewage and industrial effluents discharged into the Root River Canal, or the West Branch of the Root River Canal. In addition, three sanitary landfill sites were identified in the subwatershed of the West Branch of the Root River Canal. The organic load from the municipal and industrial wastes as well as from the leachate from the sanitary landfills along the West Branch of the Root River Canal had a severe effect on the stream water quality of the Root River Canal. The dissolved oxygen concentration at Rt-3 remained lower than 5.0 mg/l during nine out of 12 sampling surveys for the year 1964-1965.

Biochemical Oxygen Demand: The range of five-day biochemical oxygen demand (BOD_5) on the Root River and Root River Canal during the sampling period of 1964-1965 recorded a low of 1.3 mg/l and a high of 65.3 mg/l at the six sampling stations. The highest BOD_5 values were found during the months of February and March when spring snowmelt and runoff is occurring and high concentrations of organic oxygen-demanding materials are being carried via runoff into the Root River and its tributaries. Since the watershed is 74 percent in agricultural land use, the high BOD_5 in the samples collected the months of February and March indicates the probable source is agricultural runoff and, more specifically, the improper spreading of manure on the frozen farmlands during winter with subsequent washoff, increasing the BOD_5 values in the receiving streams.

Total Coliform Bacteria: During the year 1964-1965, membrane filter coliform count varied from less than 100 to 1,700,000 MFCC/100 ml, with the average values for the Root River and the Root River Canal, respectively, 71,000 and 150,000 MFCC/100 ml. The highest total coliform counts occurred during the month of February in the Root River at locations Rt-2 and Rt-5 and in the Root River Canal at Rt-3.

The high total coliform counts corresponded to high chloride concentration; both in turn corresponded to the spring runoff. The correlation between spring runoff and total coliform counts pointed to their sources being diffuse, and washed into the stream with the snowmelt in the spring. The results from three synoptic surveys conducted on the Menomonee River watershed showed that runoff from agricultural lands and older residential areas served by combined sewer system had high fecal coliform counts. Accordingly, the high total coliform readings may indicate agricultural and urban land runoff in the Root River watershed as the source of total and fecal coliform counts during spring runoff. The other high total coliform counts in the stream samples during the rest of the time could be accounted for, mainly by the discharge of sewage effluents and seepage of septic tank effluents.

Specific Conductance: The specific conductance of the Root River water during the 1964-65 sampling period ranged from 566 to 1,320 µmhos/cm at 25°C. The highest specific conductance values were found during the months of February and March, as were the chloride concentrations. Specific conductance is an approximate measure of the dissolved ions present in water, and the high specific conductance values during the spring months indicate the effect of spring runoff on the dissolved ion concentrations. During the rest of the year, the specific conductance values for the water samples from all the locations in the Root River and Root River Canal were less than 1,000 µmhos/cm at 25°C.

Hydrogen Ion Concentration (ph): The pH values at all sampling sites in the Root River watershed generally ranged from 7.0 to 8.5 standard units during the sampling year of 1964-1965. At no location within the watershed was the pH found to be outside the range of 6.0 to

9.0 standard units, prescribed for recreational as well as fish and aquatic life uses, the major water use objectives of the Root River and its tributaries.

Temperature: During the year 1964-1965, the temperature of water samples from the Root River and the Root River Canal ranged between 32°F and 40°F during the months of December through April, and ranged between 50°F and 77°F during the months of May through November. The temperature variations, therefore, were mainly due to the seasonal change. The discharge of cooling water into the main stream or the tributaries of the Root River from Fruehauf Corporation in the City of West Allis and Twin Disc, Inc., in the City of Racine apparently did not modify the normal temperature of the stream water significantly.

Water Quality Trends from 1965 to 1975: Water quality data from 1965 to 1975 for eight summer sampling programs and three spring sampling programs and one fall sampling program are presented in tabular form in Appendix D of this report. The eight summer sampling surveys began in August 1968 and involved collection of samples one day in August every year during low-flow conditions.

An analysis of the flow data from "Water Resources Data for Wisconsin," published by U. S. Geological Survey, shows that, for the streams in southeastern Wisconsin, low flow generally occurs during the months of August and September. Although the collection and analysis of one sample per station per year cannot represent water quality conditions for the whole year, it may be assumed to reasonably represent the water quality conditions of the stream at that location during the low-flow period, which is generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life.

The summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble and total phosphorus; and chloride and fecal coliform counts for each of the six stations sampled in the Root River watershed by the Commission since 1968 is set forth in Tables 201-206. The stream flow data for the Root River Canal near Franklin and for the Root River at Franklin and at Racine are obtained from U. S. Geological Survey records. The data for these three locations for the years 1964 through 1975 on the days the water samples were collected are presented in Figure 201.

Dissolved Oxygen: For the watershed as a whole, the range of dissolved oxygen in the Root River stream system during August for the years 1968-1975 was 0.2 to 16.1 mg/l. The average dissolved oxygen concentrations were 5.2, 7.1, 5.1, 8.4, 8.4, and 7.6 for Root River stations 1, 2, 3, 4, 5, and 6, respectively. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l for all locations during August, the dissolved oxygen concentrations were lower than 5.0 mg/l at some time or another during 1968-1975 for stations Rt-1 through Rt-5. For Rt-1, the daily average dissolved oxygen concentration was well below 5.0 mg/l during five out of eight sampling surveys. Stations Rt-2, Rt-4, and Rt-5 had less than 5.0 mg/l dissolved oxygen during three, two, and one out of eight sampling sessions, respectively. At station Rt-3, twice during eight sampling periods was the daily average concentration of dissolved oxygen found to be higher than 5.0 mg/l.

The 10-year (1965-1974) monthly data from samples collected at the Marquette Street bridge in Racine by the Wisconsin Department of Natural Resources showed that the dissolved oxygen concentrations were generally lower in the months of June or July than in August. Similar results, i.e., lower dissolved oxygen concentrations in the months of June or July than in August, were observed in the samples collected by the Commission during the 1964-1965 one-year study. These data from the Wisconsin Department of Natural Resources and the Commission's benchmark study indicate that, for the years 1968 through 1975, the concentrations of dissolved oxygen at stations Rt-1 through Rt-6 could have been lower in June or July than those concentrations measured in August by the Commission's sampling program. Map 71 presents the dissolved oxygen concentrations that were found in August 1964 and August 1975 in the Root River watershed. The graph insert illustrates the change in dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at each location. On August 6, 1964, as indicated on the map, substandard dissolved oxygen levels were observed in the Root River Canal at Rt-3, as well as at Rt-2 and Rt-4, in the Root River. The concentration of dissolved oxygen increased to above the minimum standard of 5.0 mg/l at Rt-5 and remained high at Rt-6 of the Root River. In the samples collected on August 25, 1975, Rt-1 through Rt-5 showed substandard dissolved oxygen concentrations which improved to above the minimum standard at Rt-6. The graph insert on Map 71 presents the dissolved oxygen concentrations and the moving averages at stations Rt-1 through Rt-6 in the August samples of 1964 through 1975. In August 1971 the flow of the Root River near Franklin during sampling was 0.44 cfs which is less than the seven day-10 year low flow of 0.90 cfs and, therefore, although the data are presented in the report, they were not compared with the other years. With the exception of 1973, there was a decreasing trend in the dissolved oxygen concentrations at Rt-1 in the samples collected in August from 1970 to 1975. The trend was reemphasized at Rt-2. The dissolved oxygen concentrations of the samples collected at Rt-1 and Rt-2 showed similar variation over the past 11 years. This is a good indication that the sources that decrease the dissolved oxygen concentrations—that is, the organic and inorganic oxygen-demanding materials—at Rt-1 and Rt-2 are introduced upstream from Rt-1. The decreasing dissolved oxygen concentrations at Rt-2 were observed despite the abandonment of three privately owned sewage treatment facilities and one public sewage treatment facility in the subwatershed since 1969.[18] Increased

[18] *Tess Corners Grade School, Mission Hills Water and Sewer and Trust, County farm, and Greendale Sewage Treatment Facilities.*

Table 201

WATER QUALITY CONDITIONS OF THE ROOT RIVER AT SAMPLING STATION RT-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	395	147	48	22	--
Dissolved Oxygen (mg/l)	5.0	9.9	5.2	2.2	30	16[a]
Ammonia-N (mg/l)	2.5	0.44	0.25	0.03	8	0
Organic-N (mg/l)	--	1.19	0.80	0.10	8	--
Total-N (mg/l)	--	2.89	1.62	0.22	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,733	1,103	464	30	--
Nitrite-N (mg/l)	--	0.28	0.11	0.00	12	--
Nitrate-N (mg/l)	0.3	1.08	0.44	0.12	12	6
Soluble Orthophosphate-P (mg/l)	--	0.58	0.32	0.05	12	--
Total Phosphorus (mg/l)	0.1	0.53	0.18	0.07	8	6
Fecal Coliform (MFFCC/100 ml)	400	32,000	3,253	140	12	8
Temperature (°F)	89.0	77.0	69.9	59.5	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.3	7.9	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 202

WATER QUALITY CONDITIONS OF THE ROOT RIVER AT SAMPLING STATION RT-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	158	93	58	22	--
Dissolved Oxygen (mg/l)	5.0	11.6	7.0	2.3	30	4[a]
Ammonia-N (mg/l)	2.5	0.23	0.16	0.03	8	0
Organic-N (mg/l)	--	1.57	1.12	0.63	8	--
Total-N (mg/l)	--	2.70	1.98	0.97	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,188	961	752	30	--
Nitrite-N (mg/l)	--	0.12	0.07	0.01	12	--
Nitrate-N (mg/l)	0.3	0.81	0.56	0.12	12	9
Soluble Orthophosphate-P (mg/l)	--	0.80	0.41	0.16	12	--
Total Phosphorus (mg/l)	0.1	0.55	0.43	0.07	8	8
Fecal Coliform (MFFCC/100 ml)	400	13,000	2,069	80	12	6
Temperature (°F)	89.0	82.0	74.6	67.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.8	8.2	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 203

WATER QUALITY CONDITIONS OF THE ROOT RIVER AT SAMPLING STATION RT-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	194	85	40	22	--
Dissolved Oxygen (mg/l)	5.0	12.4	3.8	0.5	30	23[a]
Ammonia-N (mg/l)	2.5	4.09	1.65	0.15	8	2
Organic-N (mg/l)	--	2.73	2.10	1.70	8	--
Total-N (mg/l)	--	7.58	5.47	3.00	8	--
Specific Conductance (µmhos/cm at 25°C)	--	1,347	841	775	30	--
Nitrite-N (mg/l)	--	0.40	0.24	0.04	12	--
Nitrate-N (mg/l)	0.3	2.86	1.48	0.21	12	11
Soluble Orthophosphate-P (mg/l)	--	4.72	1.41	0.33	12	--
Total Phosphorus (mg/l)	0.1	3.28	1.35	0.61	8	8
Fecal Coliform (MFFCC/100 ml)	400	25,000	2,900	40	12	7
Temperature (°F)	89.0	83.5	73.3	67.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.4	7.8	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 204

WATER QUALITY CONDITIONS OF THE ROOT RIVER AT SAMPLING STATION RT-4: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	114	84	42	22	--
Dissolved Oxygen (mg/l)	5.0	23.0	8.4	4.1	30	21[a]
Ammonia-N (mg/l)	2.5	1.73	0.32	0.03	8	0
Organic-N (mg/l)	--	2.02	1.44	0.72	8	--
Total-N (mg/l)	--	6.01	3.45	1.09	8	--
Specific Conductance (µmhos/cm at 25°C)	--	1,180	956	688	30	--
Nitrite-N (mg/l)	--	0.38	0.16	0.01	12	--
Nitrate-N (mg/l)	0.3	3.43	1.54	0.36	12	12
Soluble Orthophosphate-P (mg/l)	--	1.94	0.63	0.19	12	--
Total Phosphorus (mg/l)	0.1	0.67	0.59	0.45	8	8
Fecal Coliform (MFFCC/100 ml)	400	3,400	843	90	12	9
Temperature (°F)	89.0	86.0	75.6	67.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.0	8.1	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 205

WATER QUALITY CONDITIONS OF THE ROOT RIVER AT SAMPLING STATION RT-5: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	134	89	39	22	--
Dissolved Oxygen (mg/l)	5.0	23.0	8.4	2.2	30	6[a]
Ammonia-N (mg/l)	2.5	0.43	0.21	0.00	8	0
Organic-N (mg/l)	--	1.92	1.45	0.70	8	--
Total-N (mg/l)	--	5.02	3.22	1.14	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,065	896	591	30	--
Nitrite-N (mg/l)	--	0.19	0.11	0.02	12	--
Nitrate-N (mg/l)	0.3	2.86	1.32	0.34	12	12
Soluble Orthophosphate-P (mg/l)	--	0.94	0.58	0.30	12	--
Total Phosphorus (mg/l)	0.1	0.61	0.48	0.30	8	8
Fecal Coliform (MFFCC/100 ml)	400	36,000	6,144	530	12	12
Temperature (°F)	89.0	87.0	76.9	70.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.3	8.5	7.8	22	4

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 206

WATER QUALITY CONDITIONS OF THE ROOT RIVER AT SAMPLING STATION RT-6: 1968-1975

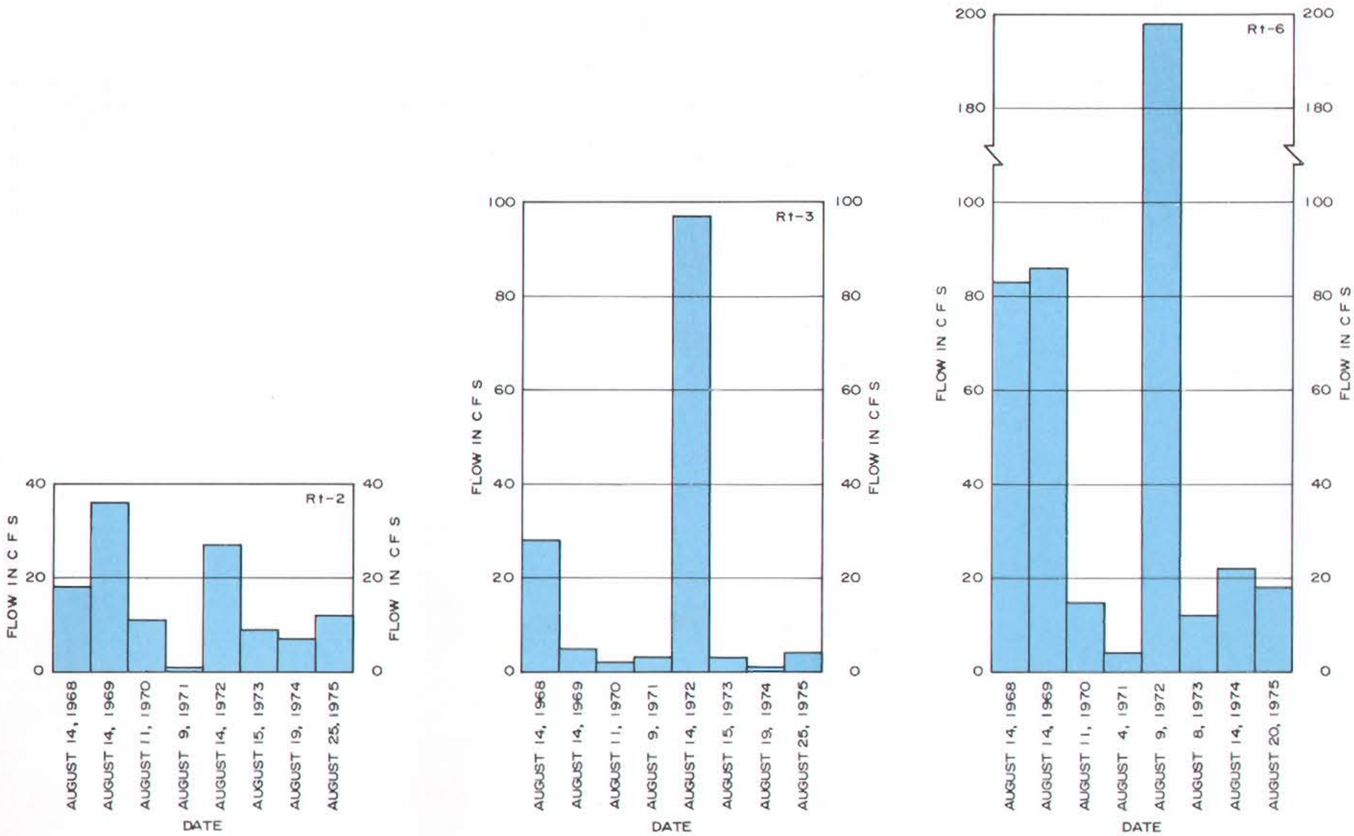
Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	150	89	38	22	--
Dissolved Oxygen (mg/l)	5.0	9.2	7.6	5.4	30	0[a]
Ammonia-N (mg/l)	2.5	2.23	0.38	0.03	8	0
Organic-N (mg/l)	--	2.50	1.42	0.79	8	--
Total-N (mg/l)	--	6.03	2.95	1.32	8	--
Specific Conductance (μmhos/cm at 25°C)	--	1,133	940	585	30	--
Nitrite-N (mg/l)	--	0.15	0.07	0.03	12	--
Nitrate-N (mg/l)	0.3	3.21	1.17	0.17	12	11
Soluble Orthophosphate-P (mg/l)	--	0.67	0.36	0.21	12	--
Total Phosphorus (mg/l)	0.1	0.61	0.43	0.30	8	8
Fecal Coliform (MFFCC/100 ml)	400	1,700	528	30	12	5
Temperature (°F)	89.0	83.0	73.4	62.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.7	8.3	7.8	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Figure 201

FLOW MEASUREMENTS IN THE ROOT RIVER WATERSHED AT SAMPLING STATIONS RT-2, RT-3, AND RT-6 ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

urbanization causing erosion from new construction areas and other urban area runoff, as well as malfunctioning septic tank systems in the area, along with the sewage plant effluent from the City of Muskego Northeast District sewage treatment plant located in the area are likely to be the causes of the decrease in the dissolved oxygen concentrations at these locations.

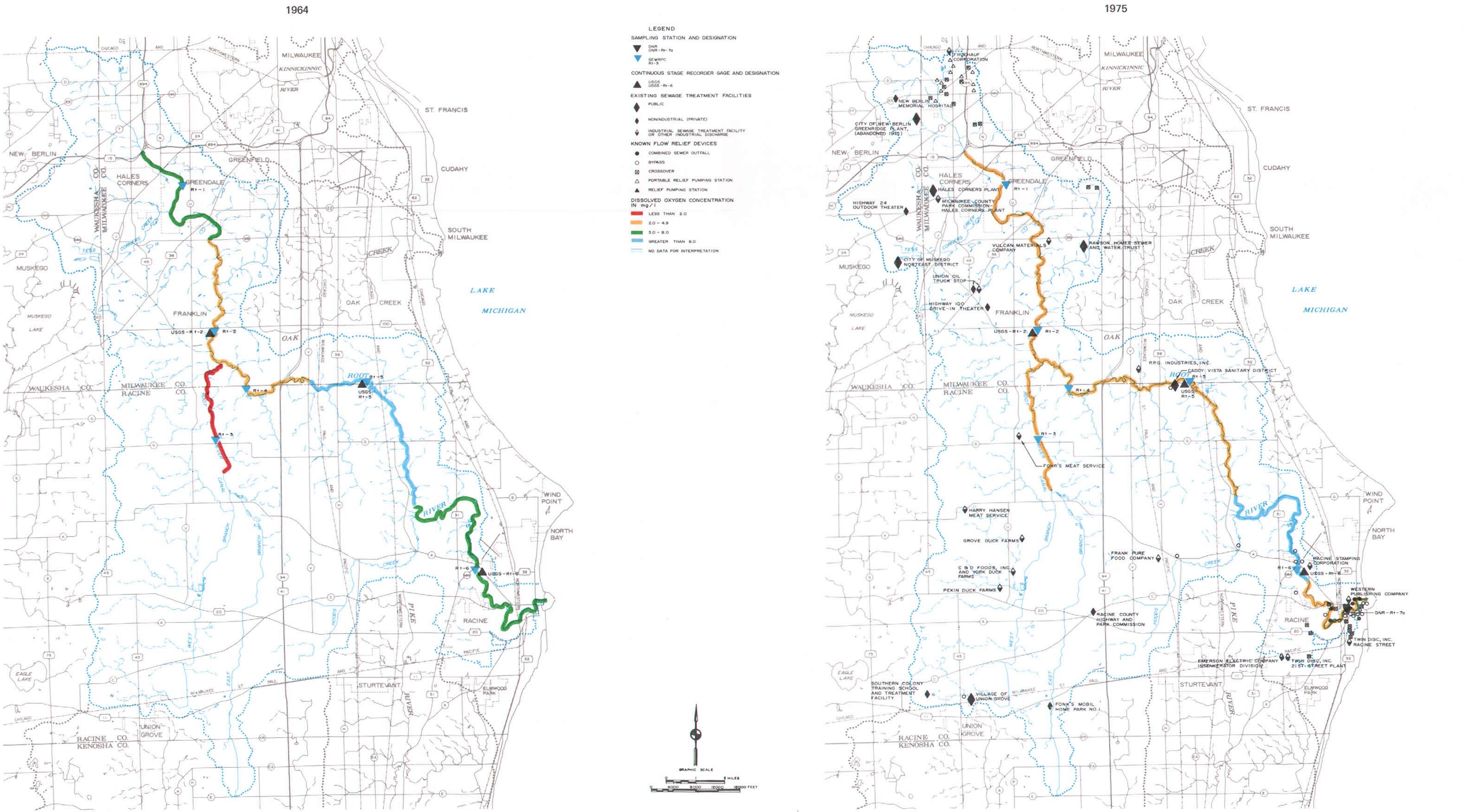
The Root River Canal at Rt-3 showed an increasing trend in dissolved oxygen concentrations in the samples collected in August 1971 through 1975. The improved water quality conditions, as noted by the dissolved oxygen concentrations in samples collected in August 1971 through August 1975 at Rt-3, probably are related to better waste management by the industries present in the subwatershed. For sampling stations Rt-4, Rt-5, and Rt-6, the dissolved oxygen concentrations remained higher than at Rt-1, Rt-2, and Rt-3 and near or above 5.0 mg/l in all the collected samples over the years 1964-1975. There was very little fluctuation in dissolved oxygen concentrations at Rt-6 over the nine August samples. At stations Rt-4 and Rt-5, a decreasing trend in dissolved oxygen concentrations was found in the August samples of 1971 through 1975. The variations in dissolved oxygen content with time at both Rt-4 and Rt-5 were similar, although different from those of Rt-1 and Rt-2.

A comparison of dissolved oxygen concentrations found in April and August 1964, 1968, and 1969 indicates higher dissolved oxygen concentrations in April of each year than in August. The August dissolved oxygen concentrations were 2.0 to 8.0 mg/l less than those found in the April samples. The lower flow and higher temperatures, accompanied by the organic load from sewage and industrial effluents, probably account for the decreased dissolved oxygen concentrations in the August samples.

Chloride: The chloride concentrations were in the range of 38 to 281 mg/l for the six stations of the Root River in 10 sampling surveys during the years 1964-1975. A large number of these samples showed chloride concentrations between 60 and 100 mg/l, the range being higher than the area groundwater chloride concentrations of 20 to 50 mg/l. A comparison of the chloride concentrations in April 1968 with August 1968, and in April 1969 with August 1969, indicates a trend to higher chloride concentrations in April samples in the upstream reaches

Map 71

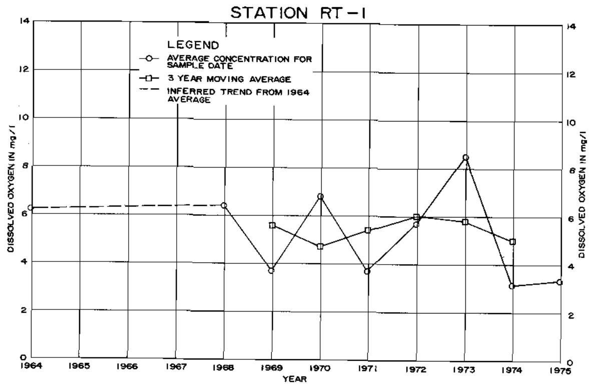
COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1975 IN THE ROOT RIVER WATERSHED

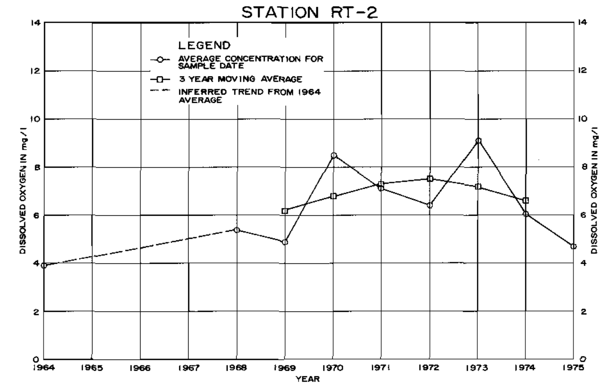


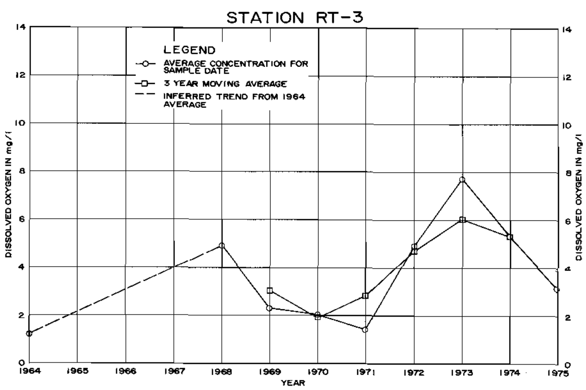
A comparison of the dissolved oxygen levels recorded from 1964 to 1975 indicated that dissolved oxygen concentrations increased at sampling stations Rt-3 and Rt-6 and decreased at stations Rt-1 and Rt-5. No significant change in dissolved oxygen concentration was noted at sampling stations Rt-2 and Rt-4. The maximum recorded dissolved oxygen concentration was 23.0 mg/l at sampling station Rt-4. The minimum concentration recorded was 0.5 mg/l at station Rt-3.

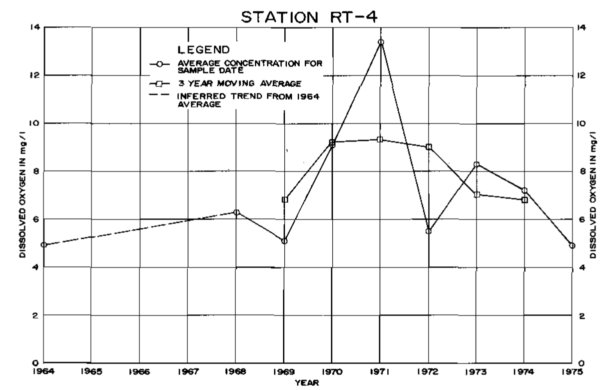
Source: SEWRPC.

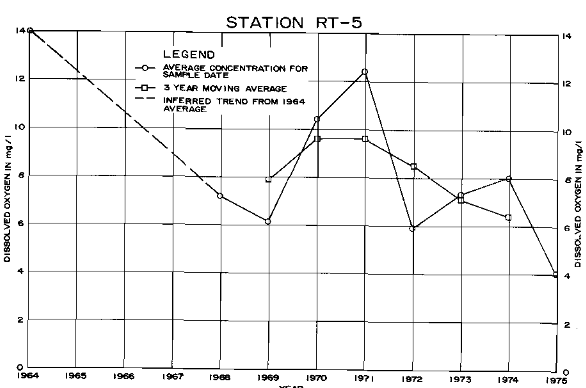
Map 71 (continued)

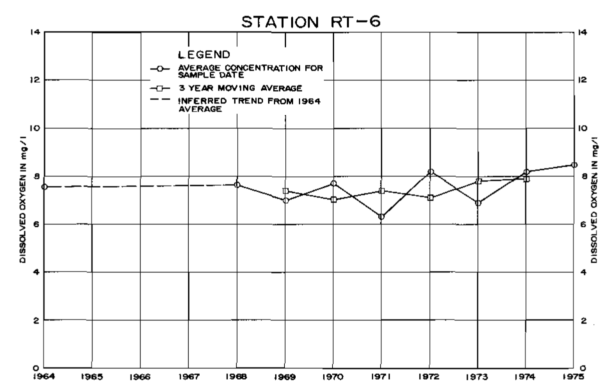












Source: SEWRPC.

of the Root River. Figure 202 presents the results of chloride concentrations for April and August samples from 1968 and 1969. The higher chloride concentrations during April, especially at stations Rt-1 and Rt-2 located in the highly urbanized area, may be attributed to the spring runoff containing street deicing salts applied through the winter. Figure 202 illustrates that the difference in chloride concentrations between April and August samples for 1968—as well as 1969—decreases downstream. In fact, the August 1969 chloride concentrations at Rt-3, Rt-4, Rt-5, and Rt-6 were slightly higher than the April 1969 samples from the same locations. Apparently, the chloride content of spring runoff from land near the source of the River was higher than the chloride concentrations of spring runoff from land south of the station Rt-2. This is conceivable, considering the relatively dense network of streets and highways located in the highly urbanized area of the Root River watershed in Milwaukee County. Map 72 shows the chloride concentrations in the Root River sampling stations on August 12, 1964, and August 25, 1975, with a graph illustrating the changes in chloride concentrations found during the sampling days of intermediate years. The map indicates an increasing trend in chloride concentrations in the August samples when 1964 and 1975 data are compared. The graph illustrates the chloride concentrations in August for the Root River stations Rt-1 through Rt-6 for the years 1964 through 1975. When the chloride concentrations for August 1964 through August 1975 are compared, an increasing trend with time may be noted at all six sampling stations. The increasing trend in chloride concentrations over the past eight years, was more obvious at station Rt-1 than at any other station on the Root River. The chloride concentrations increased from about 50 mg/l to 100 mg/l or less at all sampling locations except at Rt-1, where the increase was from about 70 mg/l to 160 mg/l.

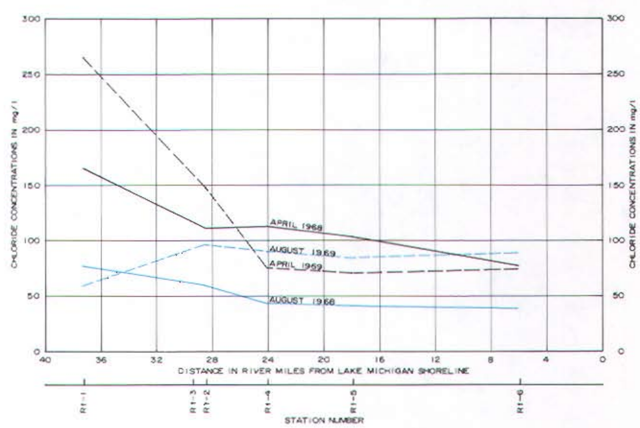
The chloride loadings for Rt-2 during these sampling days are compared with the flow in Figure 203. The direct correlation between the flow and the chloride loading is striking. If it is assumed that the flow from the sewage treatment plants is constant, the chloride input from the effluents would be constant; this would mean that the chloride loading should remain constant and not vary with the flow. The fact that the chloride loading varies with the flow at Rt-2 indicates that the chloride has other sources than sewage effluent. The higher flows in 1969 and 1972 were associated with rain, raising the possibility of the origin of chloride being associated with storm water runoff from the leaching of soil, or from the excess sewage discharged through the sanitary overflow devices or other diffuse sources. Assuming a maximum background chloride concentration of 50 mg/l, results in the finding that the increased chloride loadings in all the samples at Rt-2 are three to 10 times higher than the background loadings.

A comparison of flow versus chloride loadings for Rt-3 at the Root River Canal and for Rt-6 on Root River at Racine, reemphasizes the correlation between the flow and chloride loadings (Figures 203 and 204). The high flow in August 1972 at Rt-3 was preceded by rain, as observed at the Union Grove Weather Bureau. The positive correlation between rain, flow, and chloride loadings at Rt-3 increases the possibility of the origin of chloride being traced to runoff from the soil and other diffuse sources rather than to point sources in the watershed. The chloride loadings at station Rt-6 were significantly higher than the sum of the loadings from Rt-2 and Rt-3. This means that there are chloride sources downstream from stations Rt-2 and Rt-3 but upstream from Rt-6, increasing the flow and chloride concentrations to the River. Since the flow and chloride loadings increase simultaneously and nonproportionately, the increased chloride during high flow should be related to sources other than sewage effluents.

Fecal Coliform Bacteria: Map 73, which presents fecal coliform counts in the Root River watershed locations during August 1968-August 1975 with a graph insert, represents the changes in fecal coliform counts found on the sampling days during the intermediate years. The samples collected in August 1968 showed greater than 1,700 MFFCC/100 ml at all locations except at station Rt-1. On the other hand, for the sample of year 1975, the fecal coliform counts decreased to 375 counts/100 ml for Rt-6 and remained between 500-700 counts at all other locations except at Rt-5. Thus a trend toward improved water quality, as measured by the fecal coliform counts, is observed at stations Rt-1 through Rt-4; at location Rt-6, water quality showed considerable improvement when 1968 and 1975 samples were compared for fecal coliform counts. The graph on Map 73 illustrates the trend of fecal coliform counts with time for all six stations on the Root River. There was a significant decrease in fecal coliform counts from the samples collected in August 1968 to the samples collected in August 1970. A stabilized count of about 500 MFFCC/100 ml seems to be the trend in the past three years at all locations except for Rt-5. At this location (Rt-5) a definite increasing trend is noted from 1971 through

Figure 202

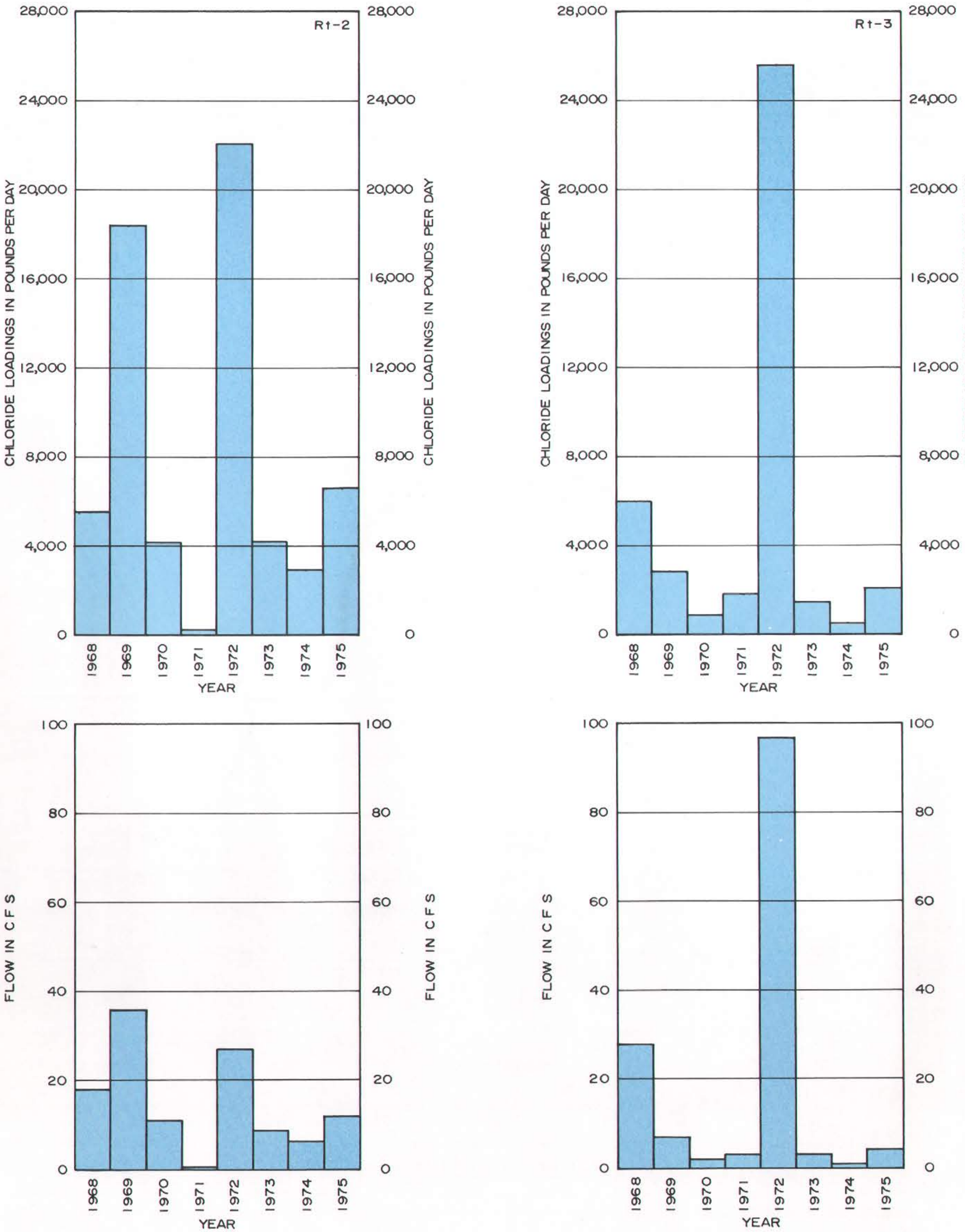
CHLORIDE COMPARISONS IN THE ROOT RIVER WATERSHED
APRIL AND AUGUST 1968 AND 1969



Source: SEWRPC.

Figure 203

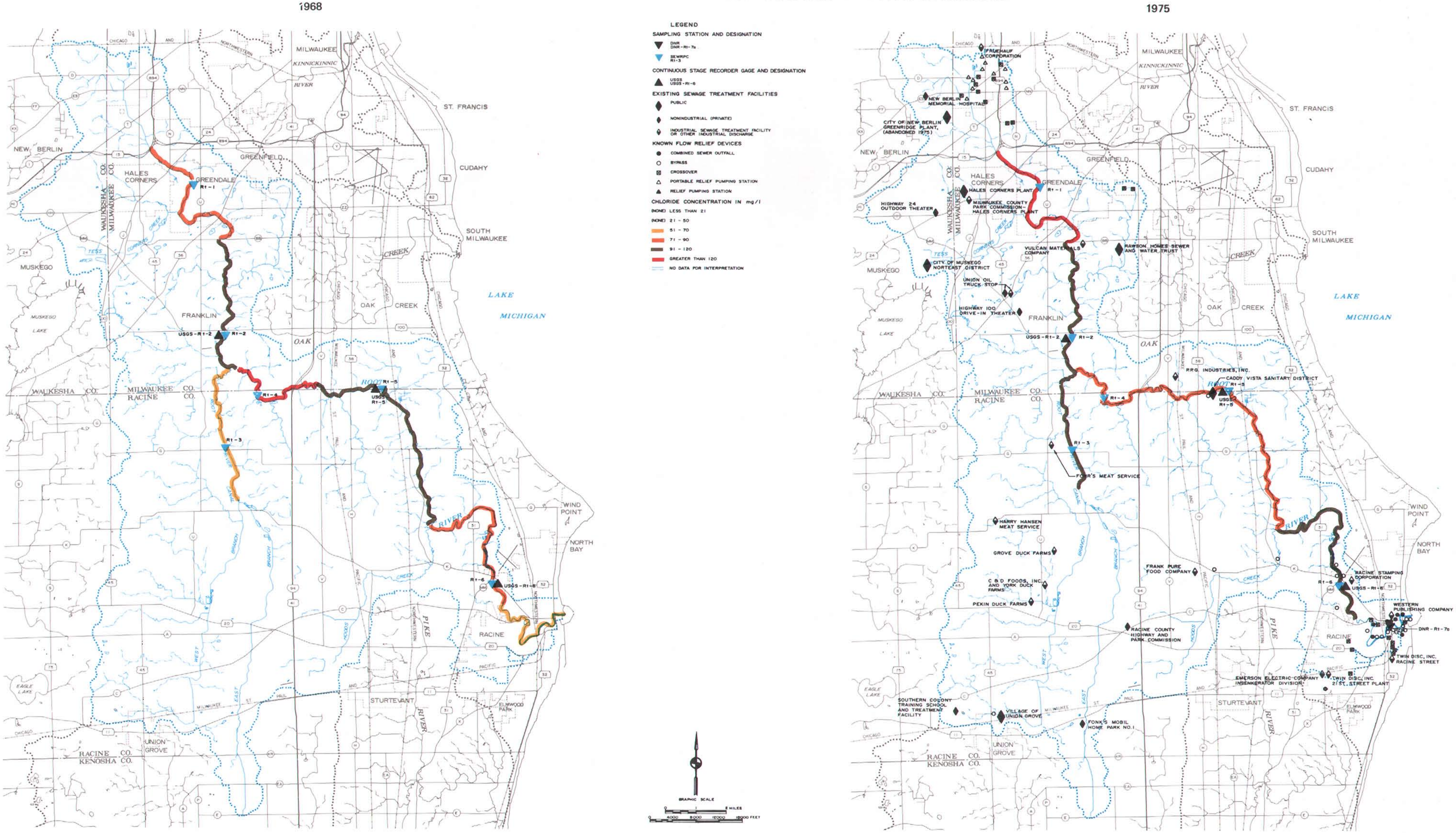
COMPARISON OF FLOW AND CHLORIDE LOADINGS AT SAMPLING STATIONS RT-2 AND RT-3 IN THE ROOT RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

Map 72

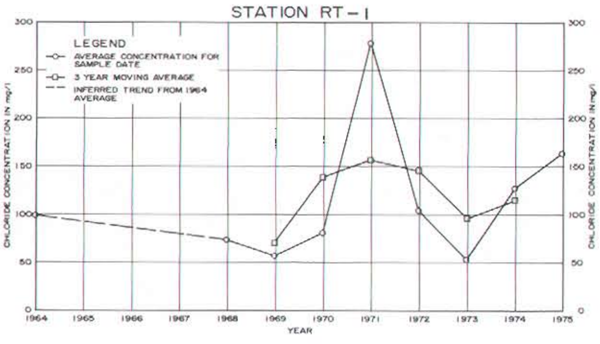
COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1975 IN THE ROOT RIVER WATERSHED

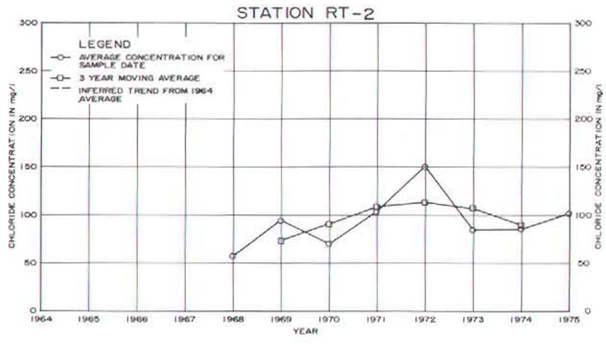


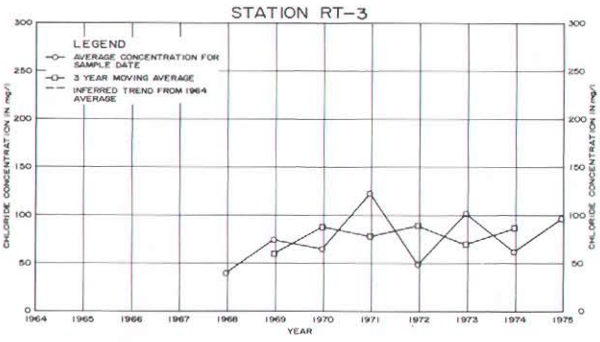
A comparison of the chloride concentrations recorded in 1968 and 1975 indicated that chloride concentration decreased at sampling stations Rt-4 and Rt-5 and increased at stations Rt-1, Rt-3, and Rt-6. No significant change was noted at sampling station Rt-2. The maximum recorded chloride concentration was 395 mg/l at sampling station Rt-1. Station Rt-6 recorded the minimum concentration of 37.8 mg/l.

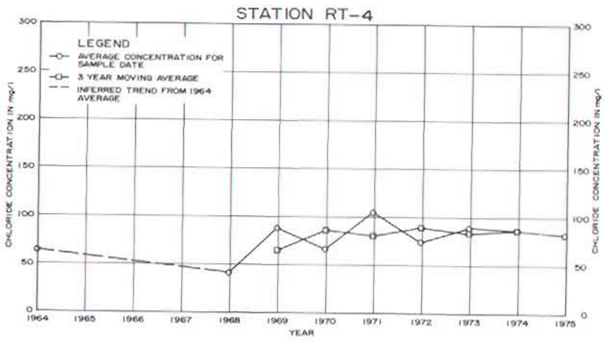
Source: SEWRPC.

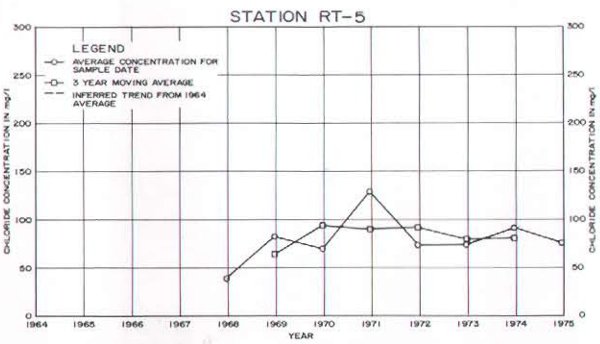
Map 72 (continued)

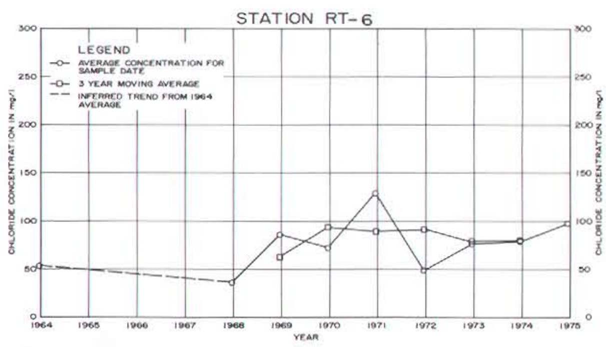












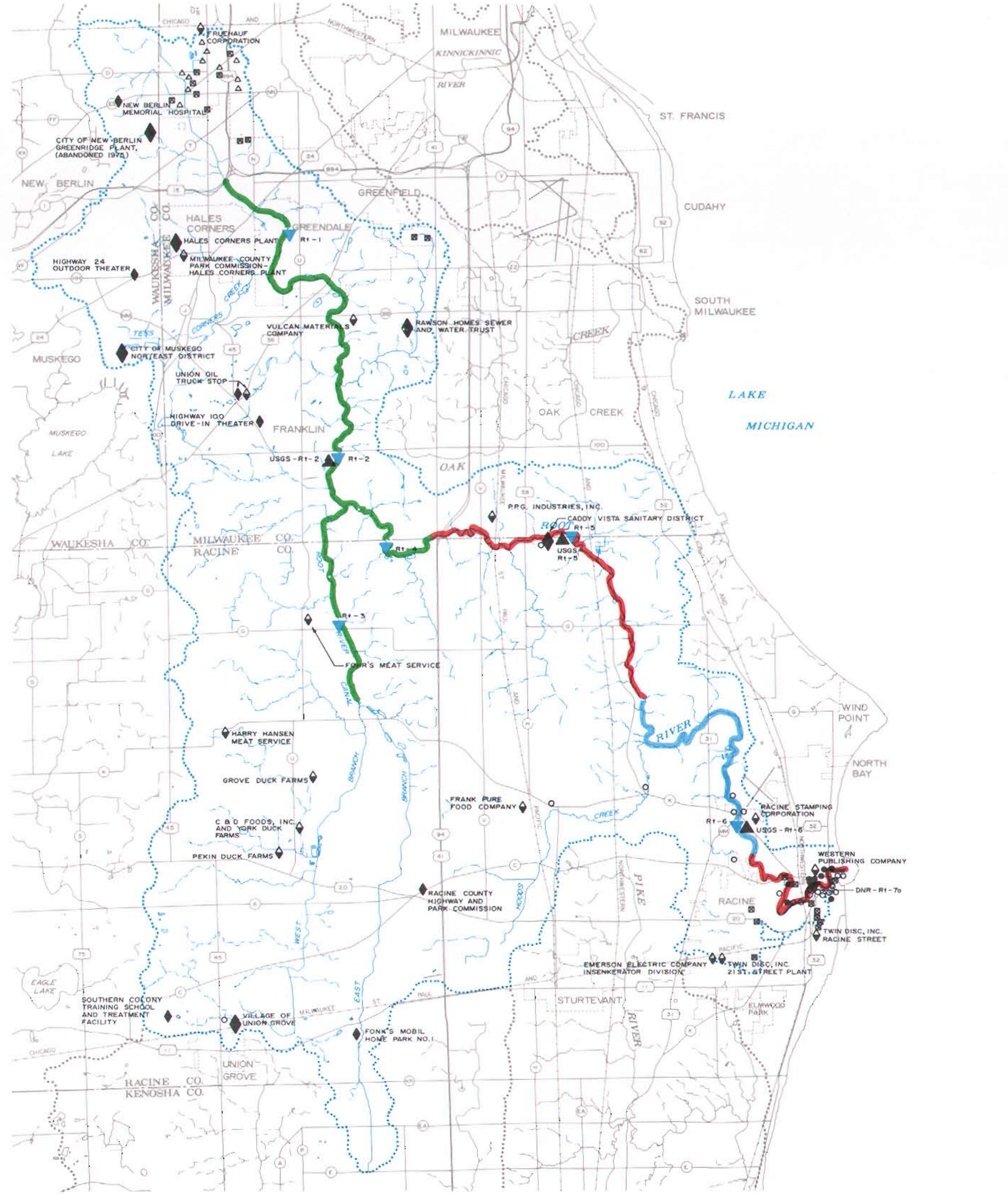
Source: SEWRPC.

Map 73

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1975 IN THE ROOT RIVER WATERSHED

1968

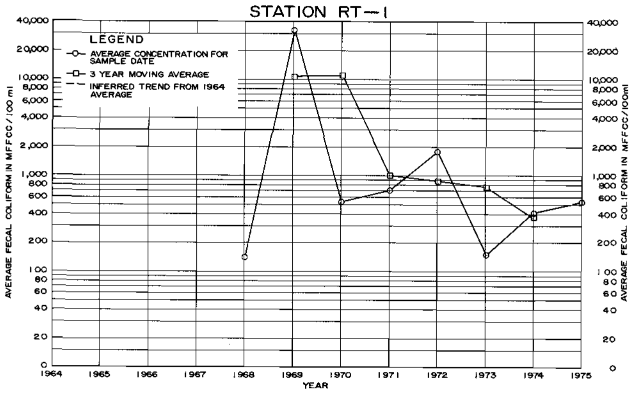
1975

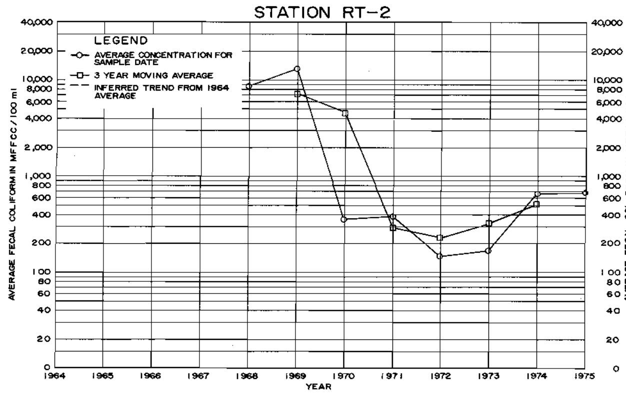


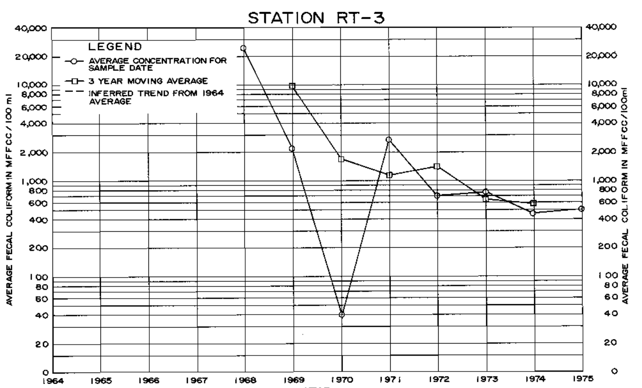
A comparison of the fecal coliform counts in 1968 and 1975 indicated a decrease in fecal coliform counts at sampling stations Rt-2, Rt-3, Rt-4, and Rt-6, while an increase was noted at station Rt-1. No significant change in fecal coliform levels was noted at sampling station Rt-5. The maximum recorded fecal coliform count was 32,000 MFFCC/100 ml at sampling station Rt-1. Station Rt-6 noted the minimum fecal coliform count of 30 MFFCC/100 ml.

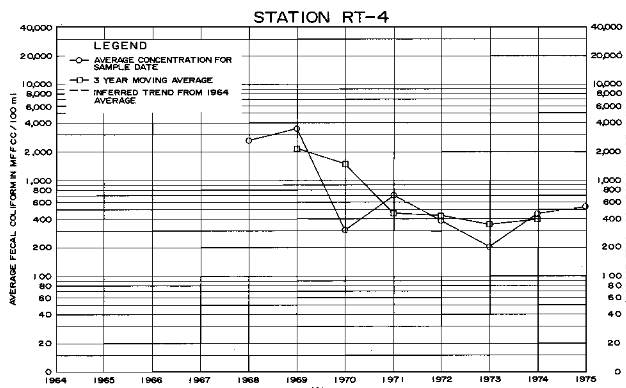
Source: SEWRPC.

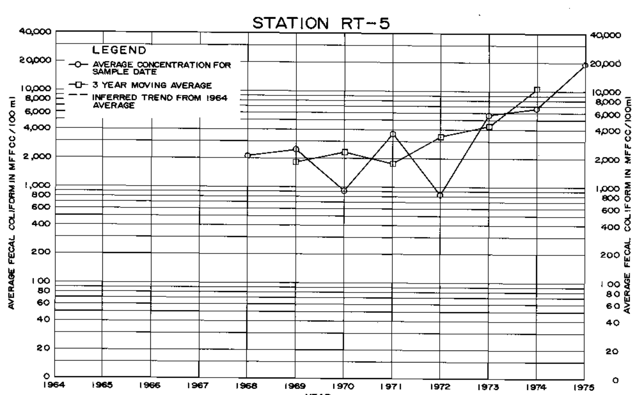
Map 73 (continued)

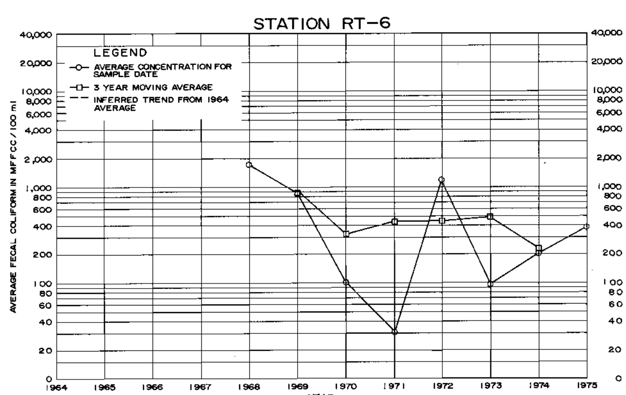








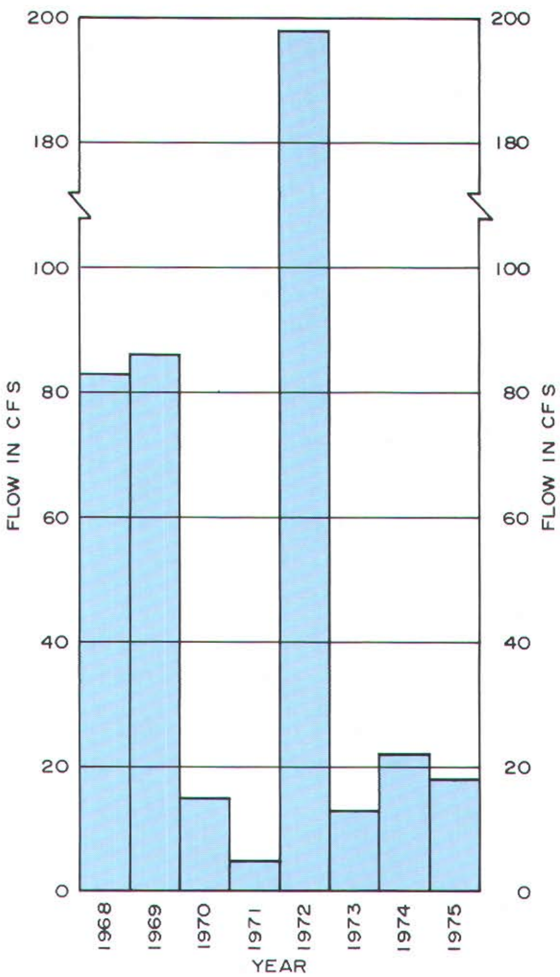


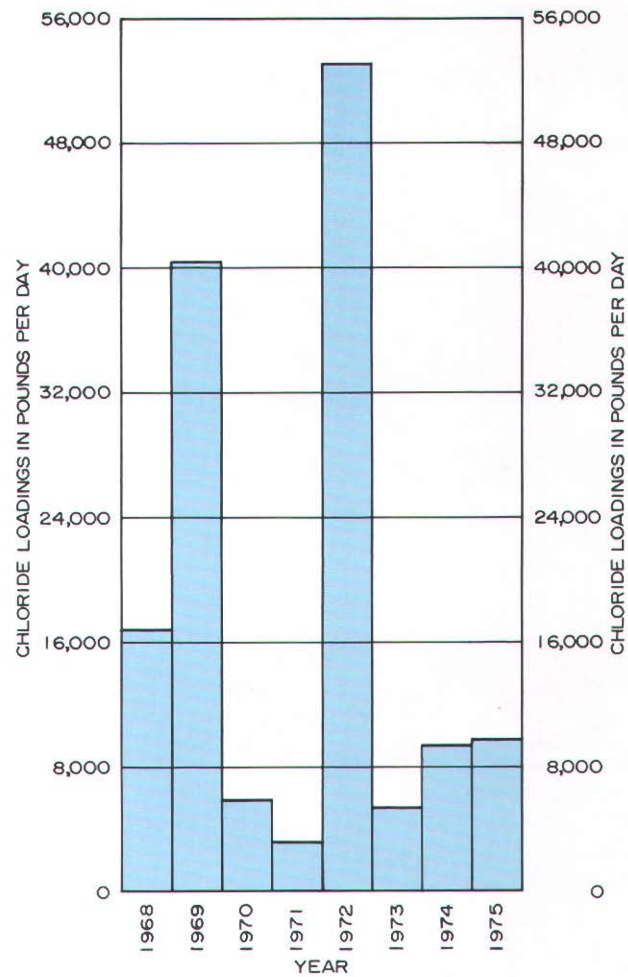


Source: SEWRPC.

Figure 204

COMPARISON OF FLOW AND CHLORIDE LOADINGS AT SAMPLING STATION RT-6 IN THE ROOT RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975





Source: SEWRPC.

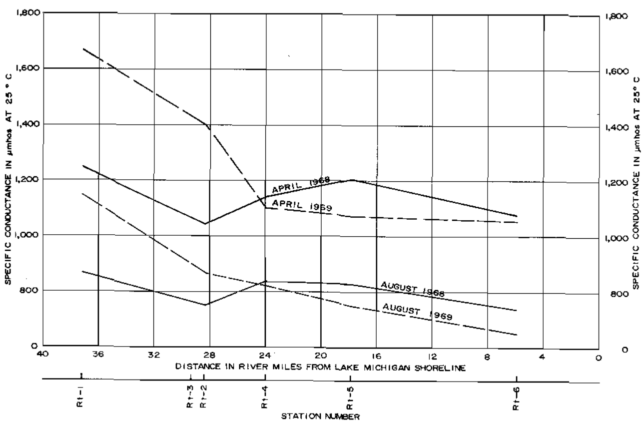
1975 in the collected samples except for the sample collected in 1972. The high counts of fecal coliform at Rt-5 are at least partly due to sewage effluent discharged from the Caddy Vista Sanitary District and may be partly due to agricultural runoffs. The decrease in fecal coliform counts in 1972 samples at Rt-5 is associated with high flow and heavy rain, indicating a possible dilution effect of the fecal coliform counts by rain water.

Hydrogen Ion Concentrations (pH): As indicated in Tables 201-206, the pH values of the watershed surface water system have generally been within the range of 6.0 to 9.0 standard units prescribed for recreational use and fish and aquatic life use. The pH was observed outside of this range (9.1) on four samples at Rt-5 in August 1971. No trend in pH variation of the samples collected in August 1964 through 1971 was observed.

Specific Conductance: Specific conductance, which is a measure of total dissolved ions in water, was in the range of 607-1,614 µmhos/cm at 25°C for the six locations on Root River on the days sampled between 1968 and 1975 in August. The highest specific conductance value was found at Rt-1 in August 1972. Heavy rain preceded this sampling period, indicating a possible effect of surface runoff from the land above Rt-1 increasing the dissolved ion concentrations and, thus, affecting the specific conductance values. No specific pattern of change was seen in the conductance values at any location over the years 1968 through 1975. Figure 205 presents the specific conductance values for stations Rt-1 to Rt-6 on the Root River during the sampling surveys of April and August 1968 and April and August 1969. The specific conductance values were generally higher for the April samples when compared with the August samples, indicating a general decrease in the dissolved

Figure 205

SPECIFIC CONDUCTANCE IN THE ROOT RIVER WATERSHED APRIL AND AUGUST 1968-1969



Source: SEWRPC.

ion concentrations when the flow decreased. Like the chloride values, the increased concentrations of dissolved ions in April samples is attributed to spring runoff and the flushing action which accompanies the snowmelt and heavy rains, since both chlorides and specific conductance are sensitive to these events.

Temperature: As indicated in Tables 201-206, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the six Root River sampling locations during August 1968 through August 1975 were analyzed for the soluble orthophosphate concentrations. A range of 0.10 to 2.22 mg/l of soluble orthophosphate as P was obtained during the eight sampling sessions at six locations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of 0.10 to 2.62 mg/l as P was obtained. The ratio of soluble orthophosphate to total phosphorus was in the range of 0.5 to 1.0. The high ratio of soluble to total phosphorus in water samples indicates that most of the phosphorus was the readily available form for the growth of aquatic plants in the Root River. Although not enough samples were analyzed to characterize the trends in total phosphorus concentrations with time, it was evident from the data that the concentrations are many times higher than required for excessive algal growth. A limit of total phosphorus of 0.10 mg/l as P is generally held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants. All water samples from the Root River, except two samples from station Rt-1, had total phosphorus levels higher than 0.10 mg/l as P. The 1968-74 data from Root River water samples at DNR Rt-7a also had total phosphorus values higher than 0.10 mg/l as P with a range of 0.17 to 0.21 mg/l as P.

Figure 206 presents the total phosphorus loadings and flow for stations Rt-2, Rt-3, and Rt-6 for the samples of August 1972, 1973, and 1974. Since the total phosphorus loadings followed the flow pattern—in that the high flow of 1972 had increased total phosphorus loading into the River—and the three years of data are so few, no attempt is made to characterize the trend in phosphorus loading in the River. The soluble orthophosphate data which are available for the years 1968-1975 also showed increased loadings with the increase in flow (see Figures 207-209). These data along with the chloride data indicate that the pollution sources cannot include the sewage treatment effluents alone. The increase in phosphorus with the increase in flow in the rural areas probably indicates that part of the phosphorus loading is likely attributable to agricultural runoff as well as other diffuse sources.

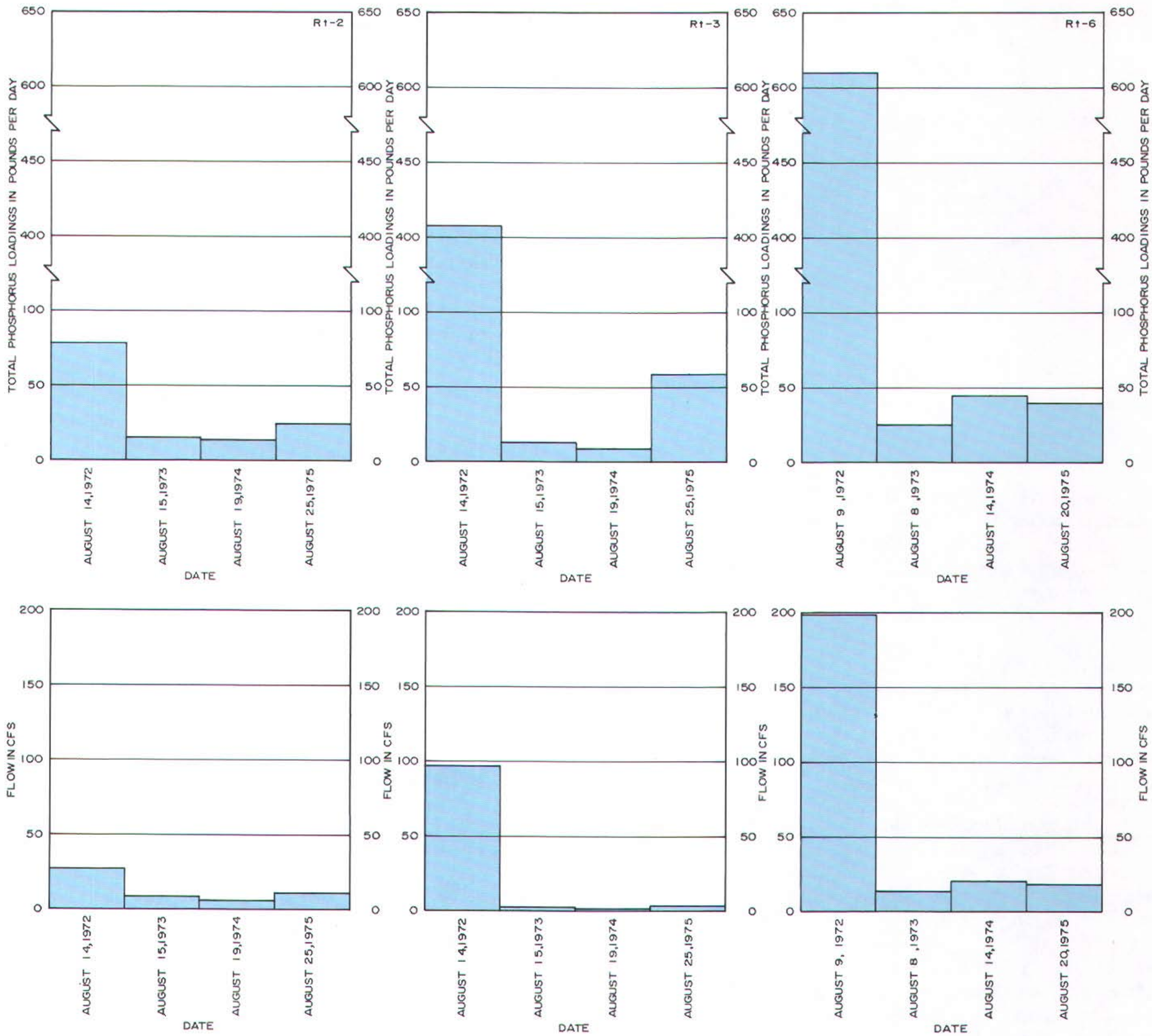
Nitrogen: The total nitrogen concentrations in the Root River water samples collected during August of 1972 through 1975 were in the range of 0.07 to 7.34 mg/l as N and, of these, 1 to 16 percent was in the form of nitrite-nitrogen, 2 to 51 percent as ammonia-nitrogen, 16 to 57 percent as nitrate-nitrogen, and 26 to 67 percent as organic-nitrogen. Presence of any form of nitrogen indicates organic loadings. Nitrates are obtained as the end product of aerobic degradation of proteinaceous materials (organic-nitrogen); nitrites are the byproducts of bacteriological action upon ammonia and nitrogenous substances; and ammonia is the chief decomposition product from plant and animal proteins. The presence of ammonia-nitrogen in the stream water is a chemical evidence of sanitary pollution of recent origin. In the presence of oxygen, ammonia is transformed into nitrite and ultimately into nitrate. The concentrations of ammonia-nitrogen in the Root River sampling sites ranged from less than 0.03 to 3.74 mg/l as N. On 25 of the 47 sampling dates, ammonia-nitrogen did exceed 0.2 mg/l as N, the level generally held as indicative of lakes and streams which are affected by pollution. The concentrations that were in excess of the known toxic level of 2.5 mg/l for ammonia-nitrogen as N were recorded at Rt-3. This is a general indication that the Root River Canal, on which Rt-3 is located, is more polluted by organic wastes than the Root River main stem itself.

Nitrate-nitrogen concentrations in the Root River watershed ranged from 0.13 to 3.4 mg/l as N. Nitrate is the end product in the aerobic treatment of municipal sanitary wastes and food and milk wastes. Surface runoff from fields where there have been applications of natural or artificial fertilizers also contributes significant quantities of nitrate to the streams. The major source of nitrate-nitrogen in the Root River watershed is likely to be municipal sewage effluents.

Organic-nitrogen accounts for 26 to 67 percent of the total nitrogen in the samples collected in the Root River watershed. The organic-nitrogen content is contributed by amino acids, proteins, and polypeptides, all products

Figure 206

COMPARISON OF TOTAL PHOSPHORUS LOADINGS AND FLOW AT SAMPING STATIONS RT-2, RT-3, AND RT-6 IN THE ROOT RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1972-1975

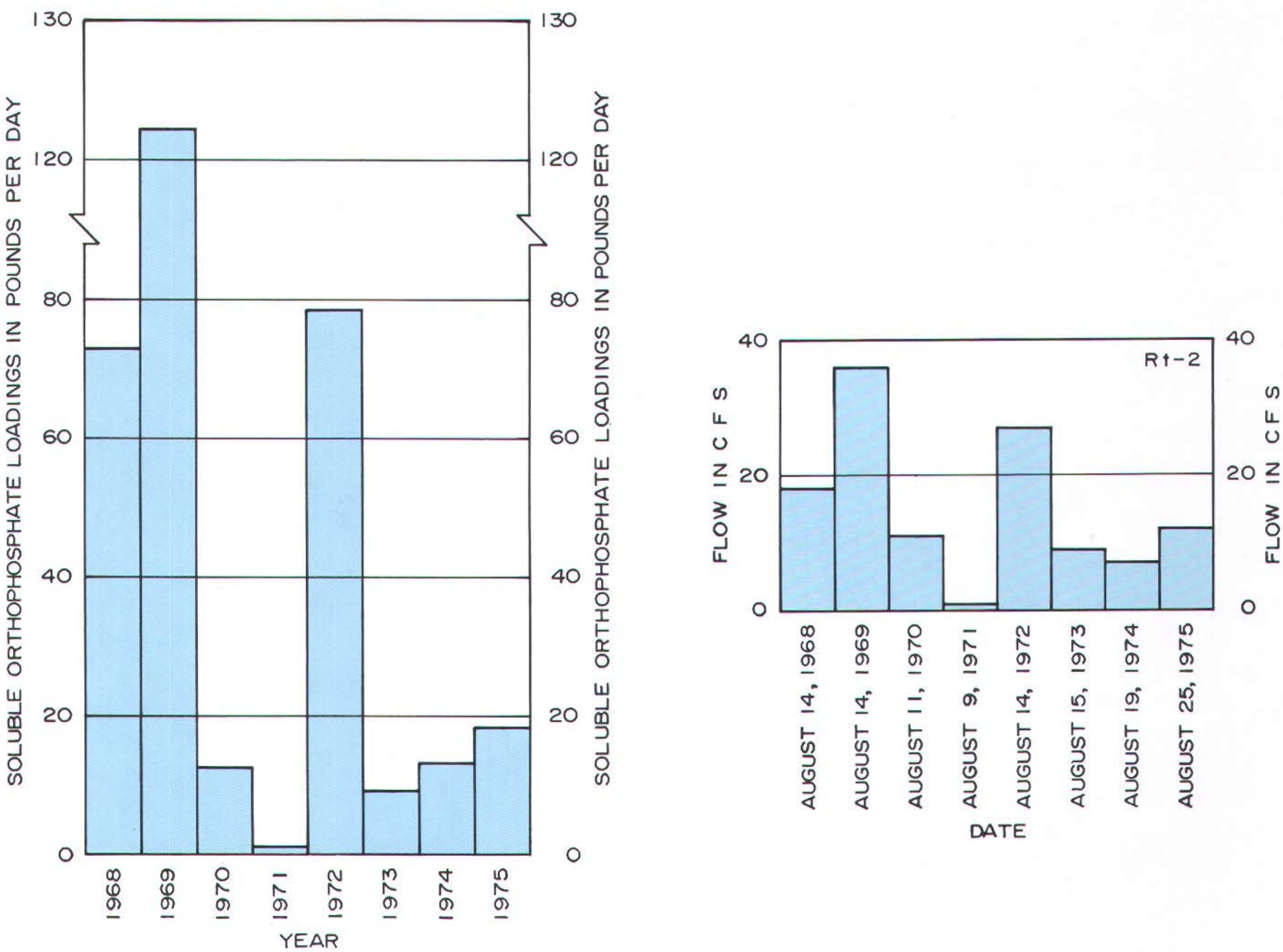


Source: SEWRPC.

of biological processes. The presence of organic-nitrogen is directly related to the discharge of organic wastes such as sewage or industrial wastes into the stream. The presence of organic-nitrogen in such a large concentration accounts for the low dissolved oxygen concentrations present in many of the sampling locations since the degradation and oxidation of organic-nitrogen compounds utilize the oxygen present in surface water. The concentrations of organic-nitrogen and nitrate-nitrogen have remained high through the years 1972-1975 indicating the fact that no significant change or decrease in the organic input has occurred in the Root River over the last four years. Figure 210 presents the total nitrogen loadings and flow for stations Rt-2, Rt-3, and Rt-6 for the samples of August 1972, 1973, and 1974. The total nitrogen loadings followed the flow pattern, in that the high flow of 1972 had increased total nitrogen loadings into the River. The three years of data being insufficient

Figure 207

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS AND FLOW ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROOT RIVER WATERSHED AT SAMPLING STATION RT-2: 1968-1975



Source: SEWRPC.

for this purpose, no attempt is made to characterize the trend in total nitrogen loading into the River. These data along with chloride and total phosphorus data indicate that the River pollution cannot be attributed solely to sewage treatment plant effluents. The increase in total nitrogen along with the increase in flow and total phosphorus in the River reaches draining rural areas are more likely due to agricultural runoff and runoff from other rural lands such as woodlands, wetlands, and unused lands.

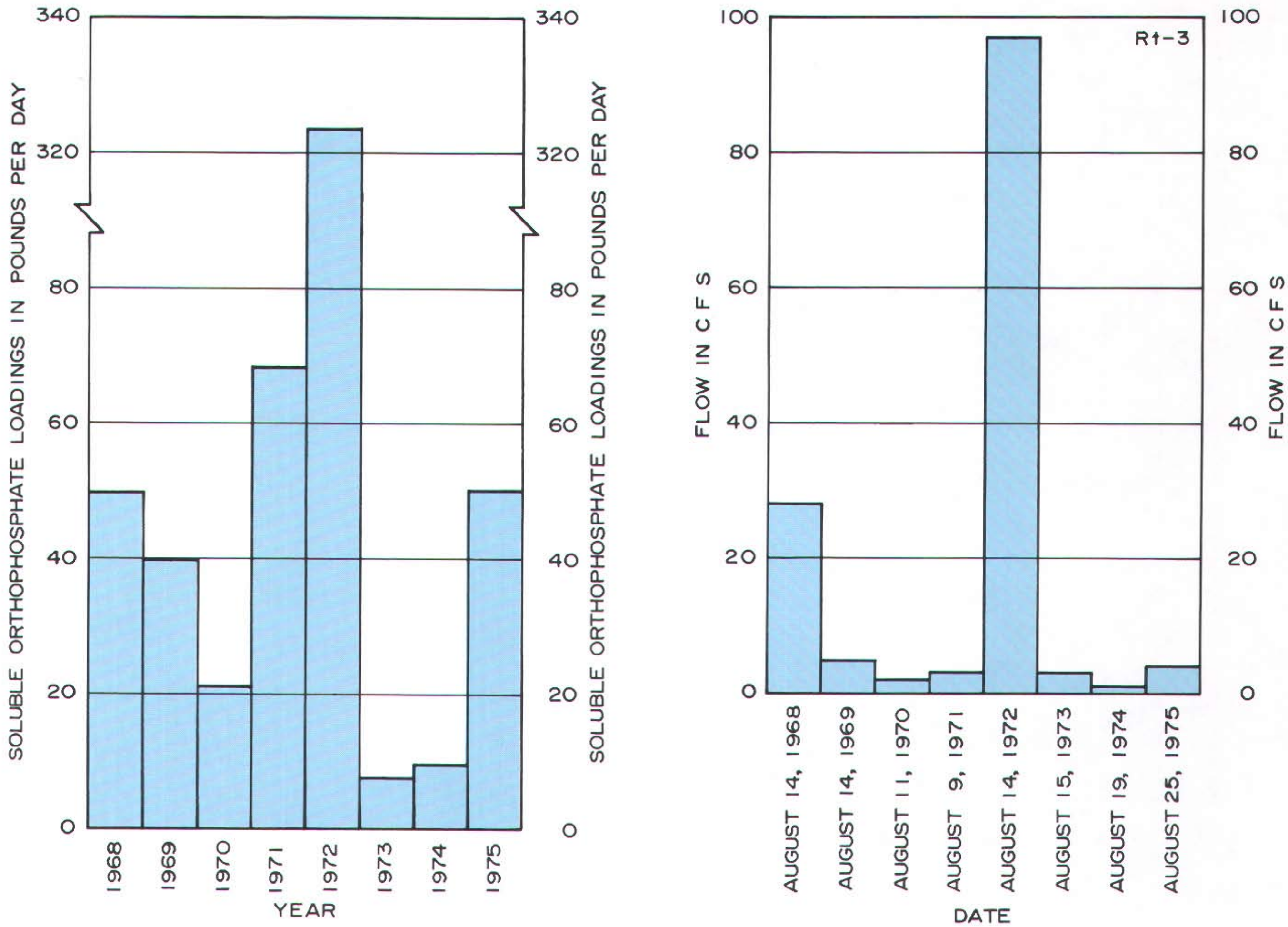
Biochemical Oxygen Demand: The Commission water quality monitoring program did not include measurement of biochemical oxygen demand for the years 1965 through 1975. No other biochemical oxygen demand data are available from the other sources to study the trend in biochemical oxygen demands over the past decade in the Rock River watershed.

Diurnal Water Quality Changes: Figures 211-214 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low-flow conditions on August 11, 1970, at the Root River sampling stations. The rate of flow on August 11, 1970, was 11.0 cfs in the Root River and 2.2 cfs in the Root River Canal, figures that were 12 and five times the seven day-10 year low flow of 0.9 and 0.4 cfs, respectively.

Water temperature ranged from a low of 65.5°F during the early morning hours on August 11 to a high of 73.0°F during the early evening hours of that day. The recorded diurnal water temperature fluctuation probably

Figure 208

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROOT RIVER WATERSHED AT SAMPLING STATION RT-3: 1968-1975



Source: SEWRPC.

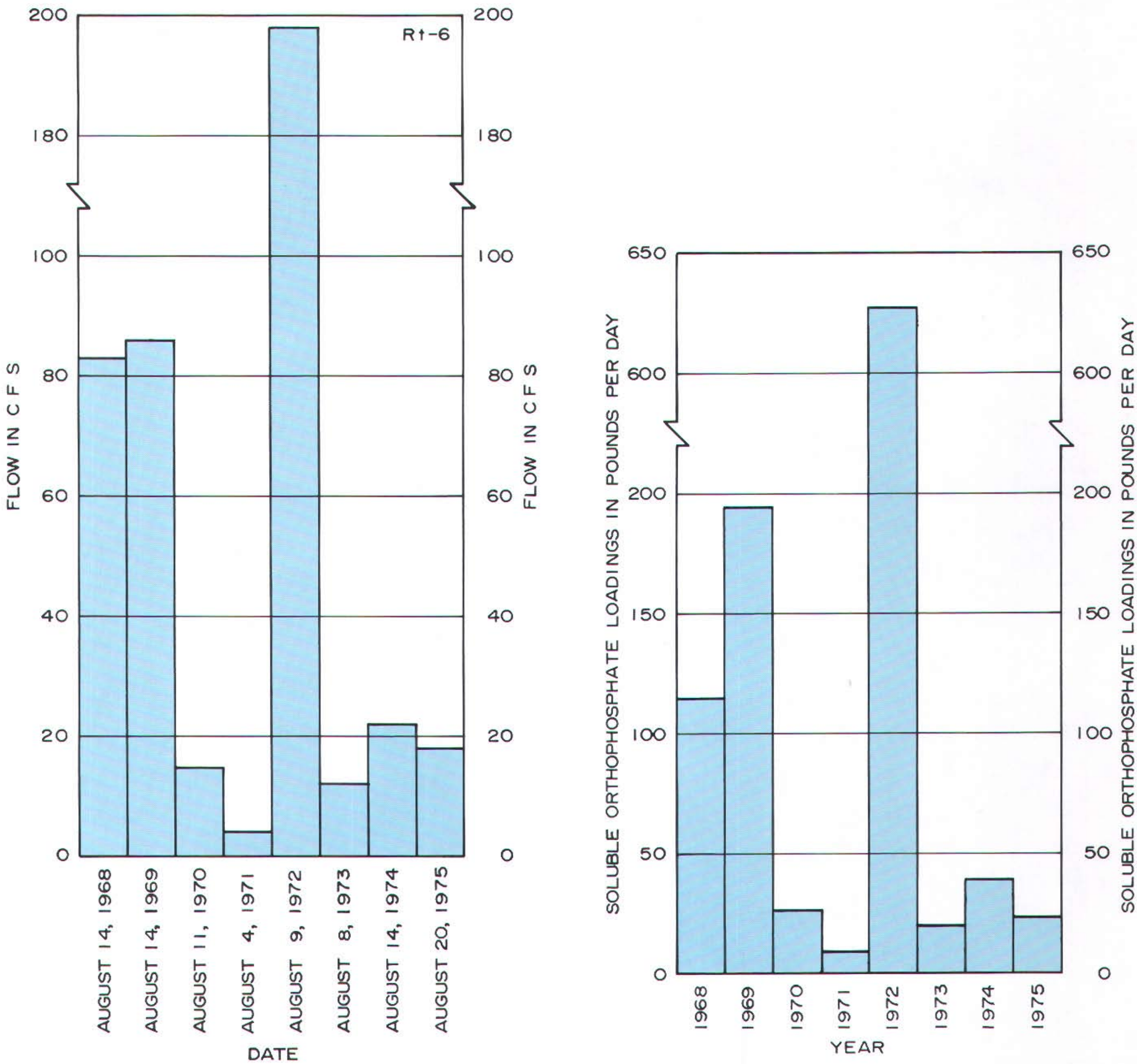
was the result of corresponding diurnal variations in air temperature and solar radiation. Chloride concentrations ranged from a high of 100 mg/l during the early morning hours to a low of 65 mg/l during the evening of that day at Rt-1. The generally high concentrations—relative to headwater area background levels of 20 to 50 mg/l during low-flow conditions—reflect the effect of treated sanitary sewage being discharged to the Root River.

The concentration of dissolved oxygen varied from a low of 4.7 mg/l during the early morning hours to a high of 8.7 mg/l in the late evening hours. The low early morning dissolved oxygen concentrations could be attributed to respiration by algae and other aquatic plants as well as the biochemical oxygen demand from a possibly higher flow of sewage effluent during the early morning hours as evidenced by higher chloride concentrations. The dissolved oxygen content increased considerably during the daytime and can be attributed to the net photosynthetic production of oxygen by algae and other aquatic plants.

The hydrogen ion concentration (pH) varied from a low of 8.0 standard units during the early morning hours of August 11 to a high of 8.3 standard units in the late evening. The uptake of carbon dioxide by the aquatic plants for photosynthesis accounted for the higher pH in the late evening samples, and the low pH during the

Figure 209

COMPARISON OF SOLUBLE ORTHOPHOSPHATE LOADINGS ON THE DATES OF WATER SAMPLE COLECTION IN THE ROOT RIVER WATERSHED AT SAMPLING STATION RT-6: 1968-1975



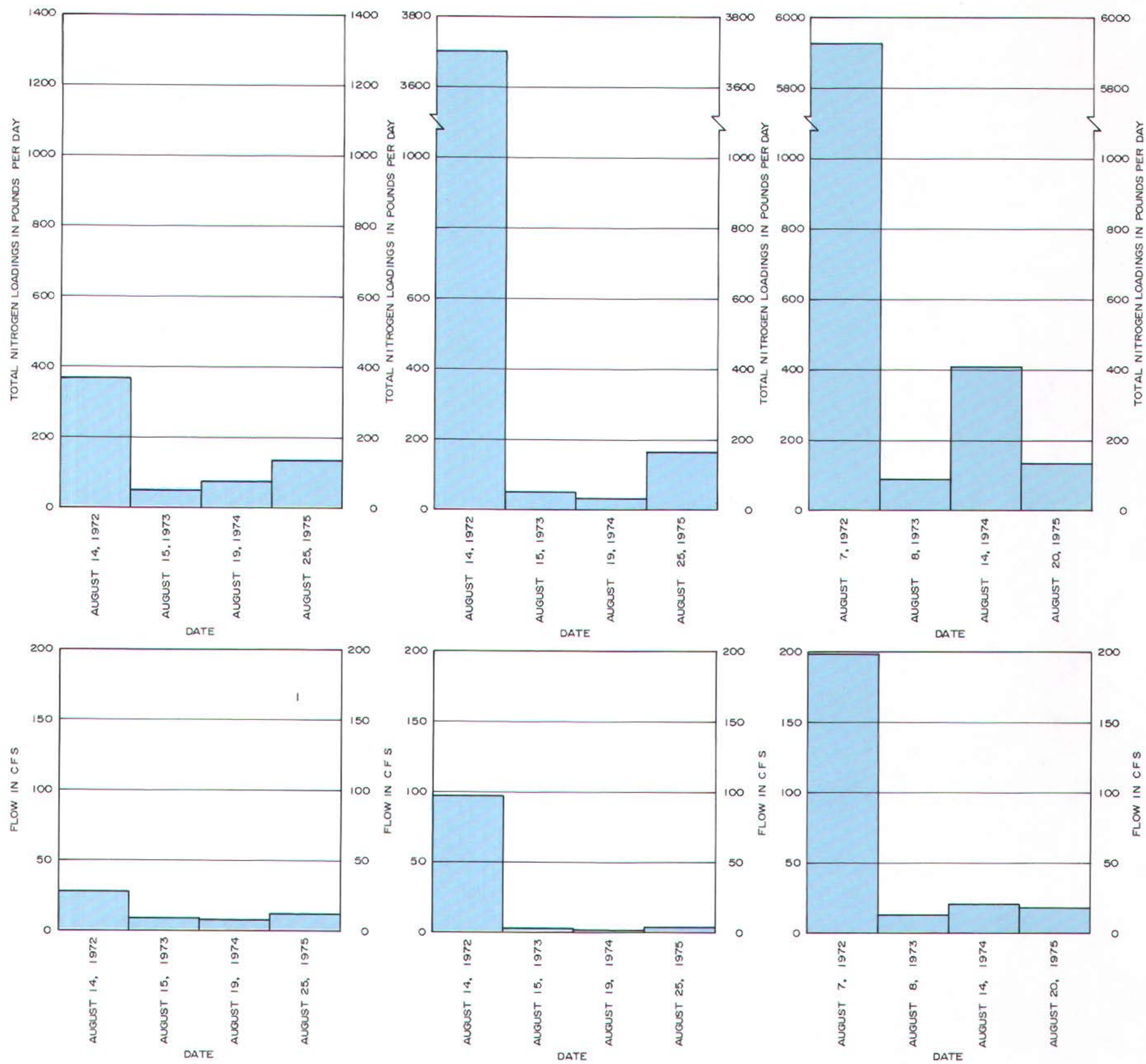
Source: SEWRPC.

early morning hours can therefore be accounted for by the release of carbon dioxide during respiration by algae and aquatic plants.

A practical consequence of diurnal water quality fluctuations is that, while the average level of concentrations of key parameters might meet the established water quality standards for recreational use and for preservation of fish and aquatic life, the lower levels during the daily cycle may not meet the standards. For example, the average of six dissolved oxygen concentration values for station Rt-1 on August 11, 1970, was 6.9 mg/l, which is well above the minimum standard of 5.0 mg/l for recreational use and preservation of fish and aquatic life. However, substandard oxygen level of 4.7 mg/l was measured in one sample taken at 8:25 a.m. on the same day.

Figure 210

COMPARISON OF TOTAL NITROGEN LOADINGS AND FLOW AT SAMPLING STATIONS RT-2, RT-3, AND RT-6 ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975

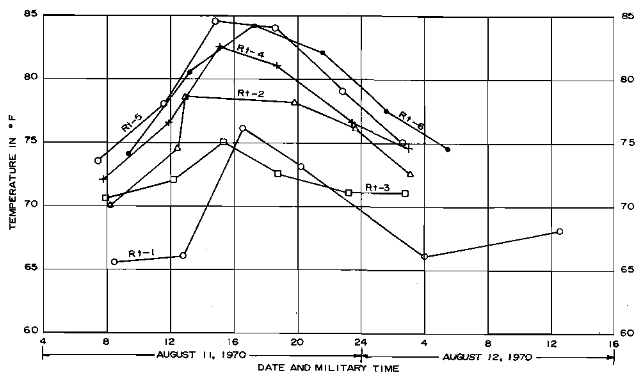


Source: SEWRPC.

Spatial Water Quality Changes: The water quality surveys clearly indicate that water quality conditions change from one location to another in the watershed stream system in response to a combination of man's activities—primarily the discharge of treated and untreated sanitary sewage—and natural phenomena. Figures 215-219 show the spatial water quality variations along the entire main stem of the Root River as recorded under a low-flow hydrologic condition in August of 1964 through August 1975. The illustrations are the profile of the average values of chloride, specific conductance, dissolved oxygen, total phosphorus, total nitrogen, and fecal coliform counts along the River, and the illustrations include the location of the six sampling stations. Water quality conditions, as measured by dissolved oxygen, generally improved from sampling stations Rt-1 to Rt-6. The

Figure 211

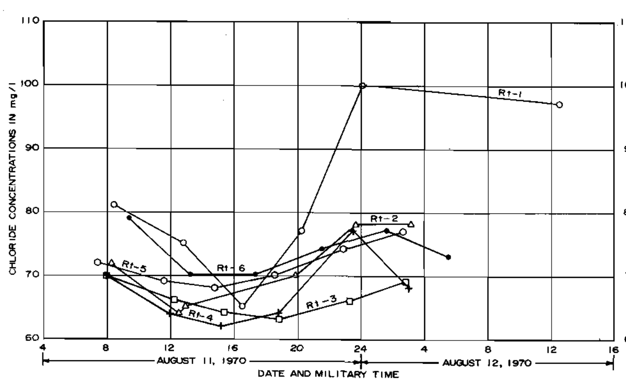
DIURNAL VARIATIONS IN TEMPERATURE AT SAMPLING STATIONS RT-1 THROUGH RT-6 ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROOT RIVER WATERSHED



Source: SEWRPC.

Figure 212

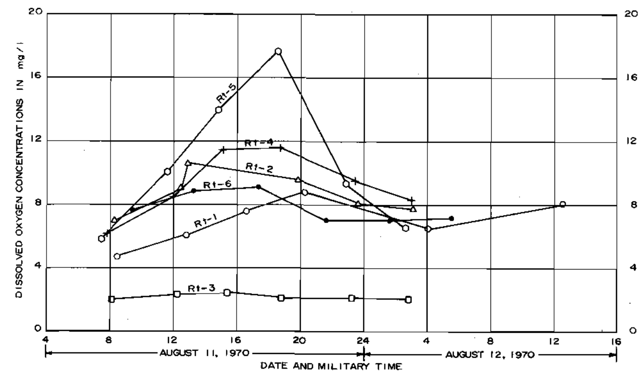
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATION AT SAMPLING STATIONS RT-1 THROUGH RT-6 ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROOT RIVER WATERSHED



Source: SEWRPC.

Figure 213

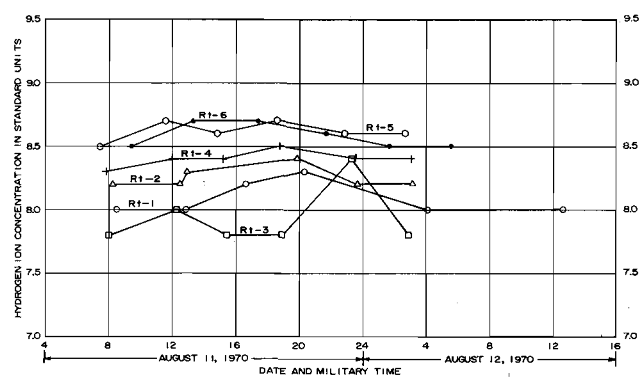
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATION AT SAMPLING STATIONS RT-1 THROUGH RT-6 ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROOT RIVER WATERSHED



Source: SEWRPC.

Figure 214

DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATION SAMPLING STATIONS RT-1 THROUGH RT-6 ON THE DATES OF WATER SAMPLE COLLECTION IN THE ROOT RIVER WATERSHED



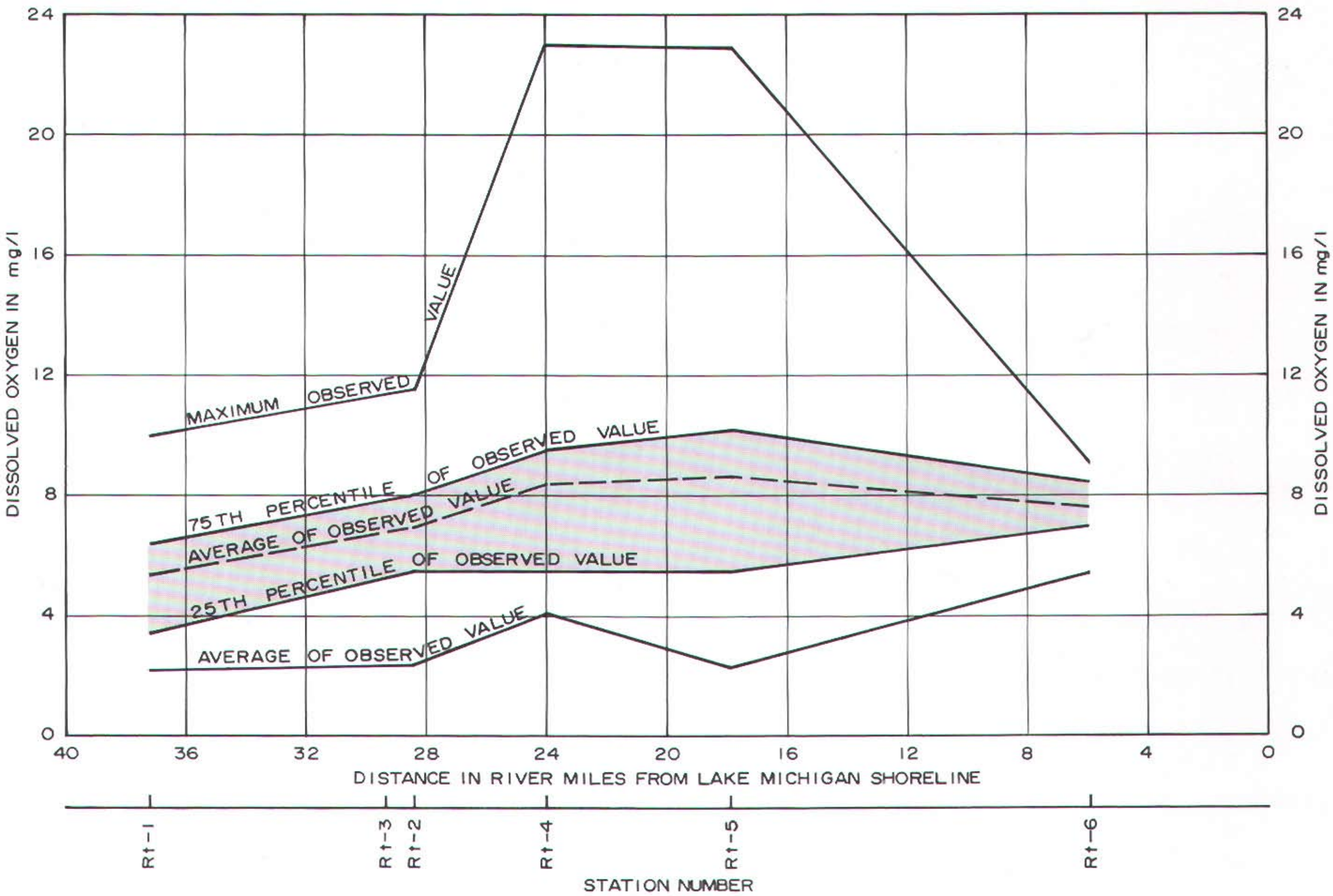
Source: SEWRPC.

exception during the year 1972, when the dissolved oxygen concentration was lower at Rt-4 than at Rt-2, seems to be directly related to the unseasonably high flow of the Root River Canal of 97 cfs. The high flow in the Root River Canal may be traced to the heavy rains as measured by the Union Grove Weather Bureau. The rainwater flow from the rural area may be expected to have washed organic materials into the Canal, in turn increasing the organic load of the Root River downstream from sampling station Rt-2, thus decreasing the dissolved oxygen concentrations of sampling stations Rt-4 and Rt-5. In some samples the dissolved oxygen concentrations were higher at sampling station Rt-5 when compared with Rt-6; in these cases, the concentrations at both the locations were higher than 6 mg/l.

The fecal coliform counts, the indicator of bacteriological pollution, decreased from the source to the mouth of the Root River, with the exception of the samples at sampling station Rt-5. The decrease of the fecal coliform counts from sampling station Rt-1 to Rt-6 was more dramatic in the 1968 and 1969 samples. This means that the fecal coliform input upstream from station Rt-2 decreased significantly from 1968 to 1970; the abandonment of Greendale sewage treatment plant in 1969 and House of Correction sewage treatment plant in 1970 as well

Figure 215

SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATION IN THE ROOT RIVER WATERSHED: 1964-1975



Source: SEWRPC.

as improved sewage treatment by the construction of the Greenridge plant in New Berlin in 1969 probably are responsible for this improved water quality. There was a marked increase in the fecal coliform counts at sampling station Rt-5 in the samples from 1971 through 1975. The exception in the 1972 samples was directly related to the high flow during that sampling time, which was associated with heavy rain. The chloride and specific conductance values from the source to the mouth of the River generally decreased in all the samples analyzed from 1964 through 1975. The total phosphorus and nitrogen concentrations generally increased from sampling station Rt-1 to stations Rt-2, Rt-3, Rt-4, and Rt-5, and remained high at Rt-6.

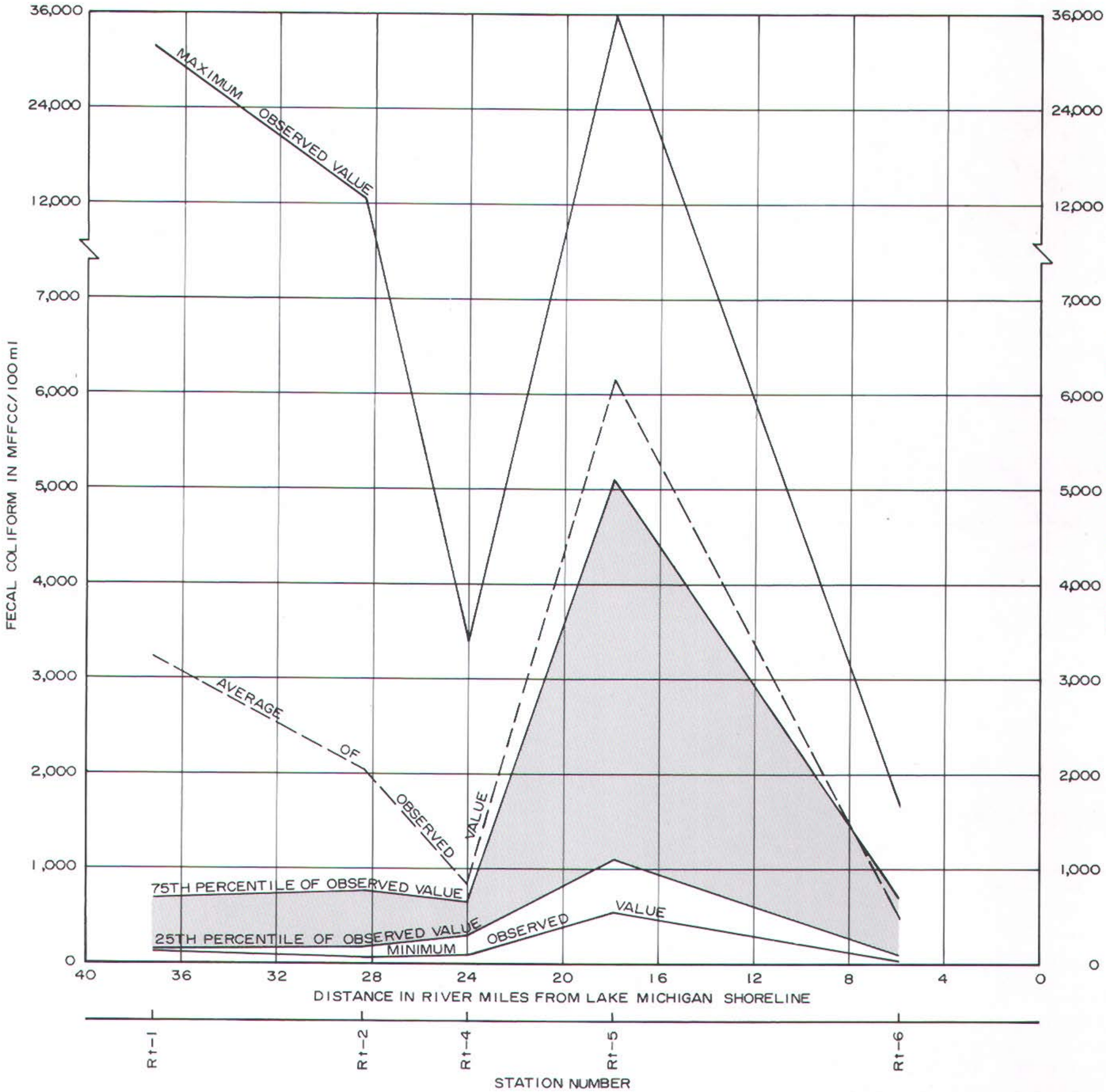
The bacteriological analyses of the samples at DNR Rt-7a by the Wisconsin Department of Natural Resources and at various locations in Racine by the Racine Department of Health indicated a poorer water quality when compared with the values at location Rt-6, situated upstream from the above-mentioned location. Apparently the sewage overflow devices in the City of Racine and other possible rural sources of pollution between Rt-6 and the DNR Rt-7a caused the deterioration in water quality condition in the Root River at Racine.

It should be noted, however, that at DNR Rt-7a and at the Main Street Bridge, the range in fecal coliform counts over the past few years has decreased, indicating the effect of the intensified effort made by the City of Racine to reduce the sewage overflow into the Root River by decreasing the number of sewer overflow devices.

It is evident from the above data and analysis that the individual streams in the watershed exhibit markedly different water quality conditions throughout their length depending on the type and quantity of substances discharged to the stream. It is, therefore, common to find instances where water quality standards are met along some parts of stream while substandard conditions exist along other reaches. For example, the average dissolved oxygen concentration obtained for station Rt-6 was 7.54 mg/l. The lowest of the 30 analyses at that station was 5.40 mg/l, which is above the 5.0 mg/l

Figure 216

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE ROOT RIVER WATERSHED: 1968-1975



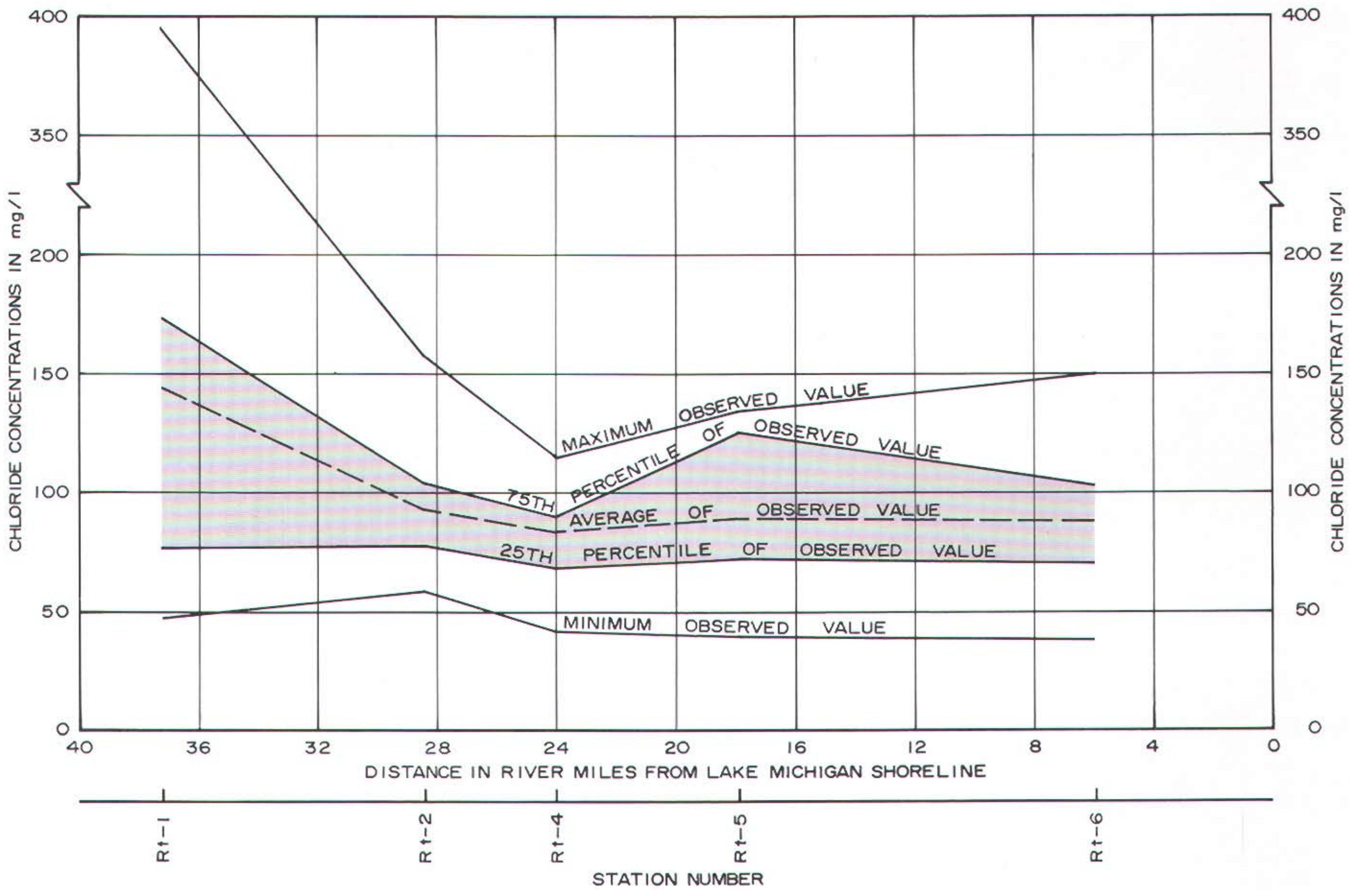
Source: SEWRPC.

minimum standard established for recreational use and preservation of fish and aquatic life. In contrast, the average concentration at station Rt-3 on the Root River Canal was 5.10 mg/l with the lowest of the 30 values at that station being 0.50 mg/l.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from summer low-flow samples between 1964 and 1975 were used to assess the quality of the Root River stream network. These data provide for an assessment of water quality as it existed on the days sampled between 1964 and 1975 and allow for an evaluation of the water quality changes compared to the water quality standards that support the recreational as well as fish and aquatic life use objectives established for the Root River watershed stream system. Comparative analysis must consider the concurrent hydrologic conditions since the water quality

Figure 217

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATION IN THE ROOT RIVER WATERSHED: 1968-1975



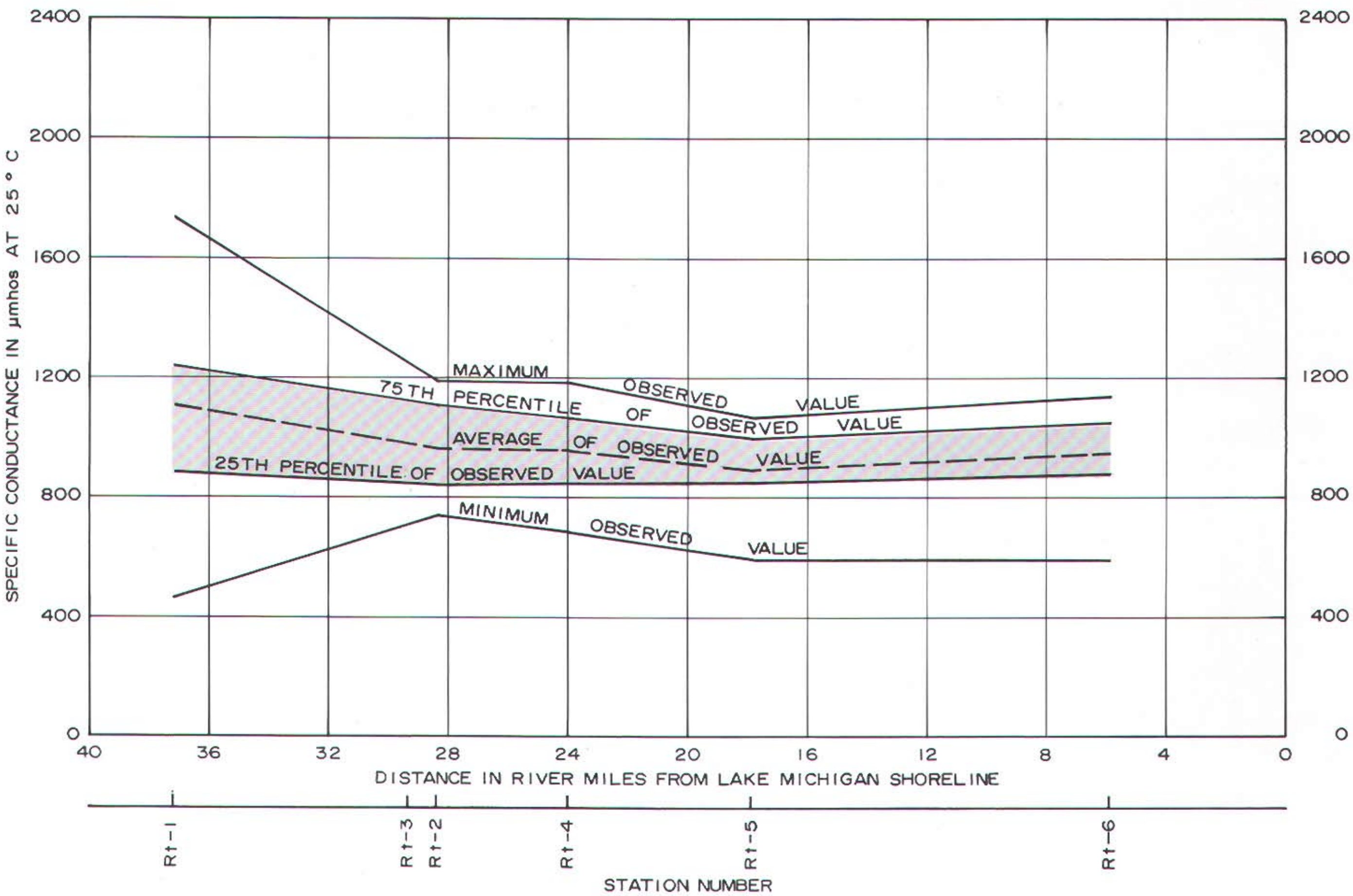
Source: SEWRPC.

standards are not intended to be satisifed under all streamflow conditions. The data for the daily stream gage on the Root River indicate that watershed streamflows during all but one of the surveys were in excess of the seven day-10 year low flow above which the water quality standards are to be met.

The comparative analysis of observed water quality and the standards were based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels which have been adopted by the Commission. In carrying out the comparative analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, was above or below the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month nor shall the count exceed a monthly

Figure 218

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE ROOT RIVER WATERSHED: 1968-1975



Source: SEWRPC.

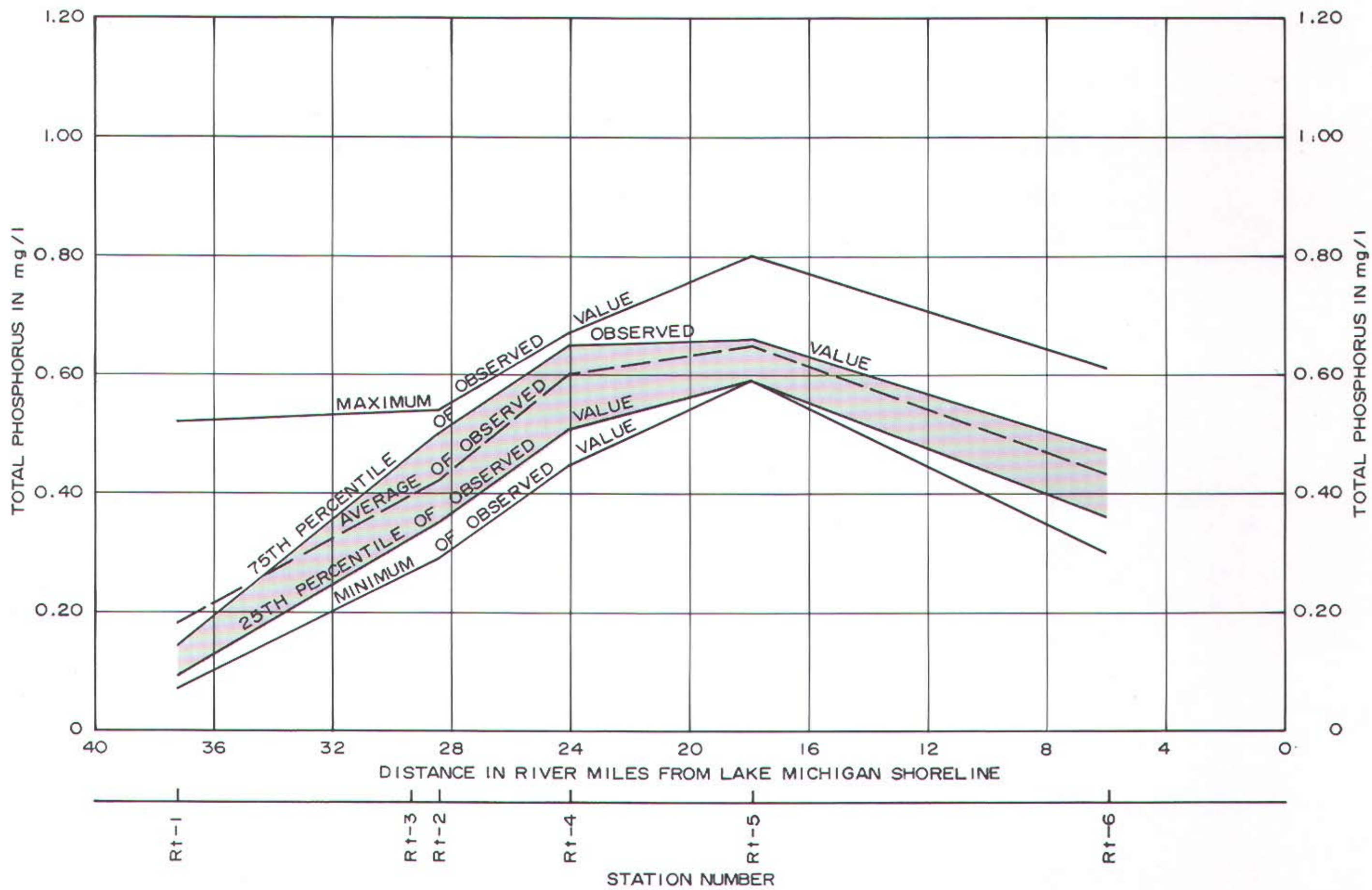
geometric mean of 400 colonies per 100 ml, in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the recreational use objective fecal coliform bacteria standard was assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 74. A color coding scheme is used on Map 74 to indicate which of the standards are exceeded and along what stream reaches.

For the Root River main stream, intended for recreational use and preservation of fish and aquatic life, the water quality during the survey satisfied the temperature and pH standards throughout the watershed. Substandard dissolved oxygen levels were found at two locations, and at the other three locations the dissolved oxygen concentrations were higher than 5.0 mg/l. For the Root River Canal, also intended for recreational use and preservation of fish and aquatic life, the water quality during the August 1964 survey satisfied temperature and pH standards only. Dissolved oxygen concentrations were below the recommended level of 5.0 mg/l at Rt-3. Since no fecal coliform counts or nitrate, total phosphorus, or ammonia analyses were made in the 1964 samples, no comparison can be made to the nutrient contents and bacteriological

Figure 219

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS AND TOTAL NITROGEN IN THE ROOT RIVER WATERSHED: 1972-1975



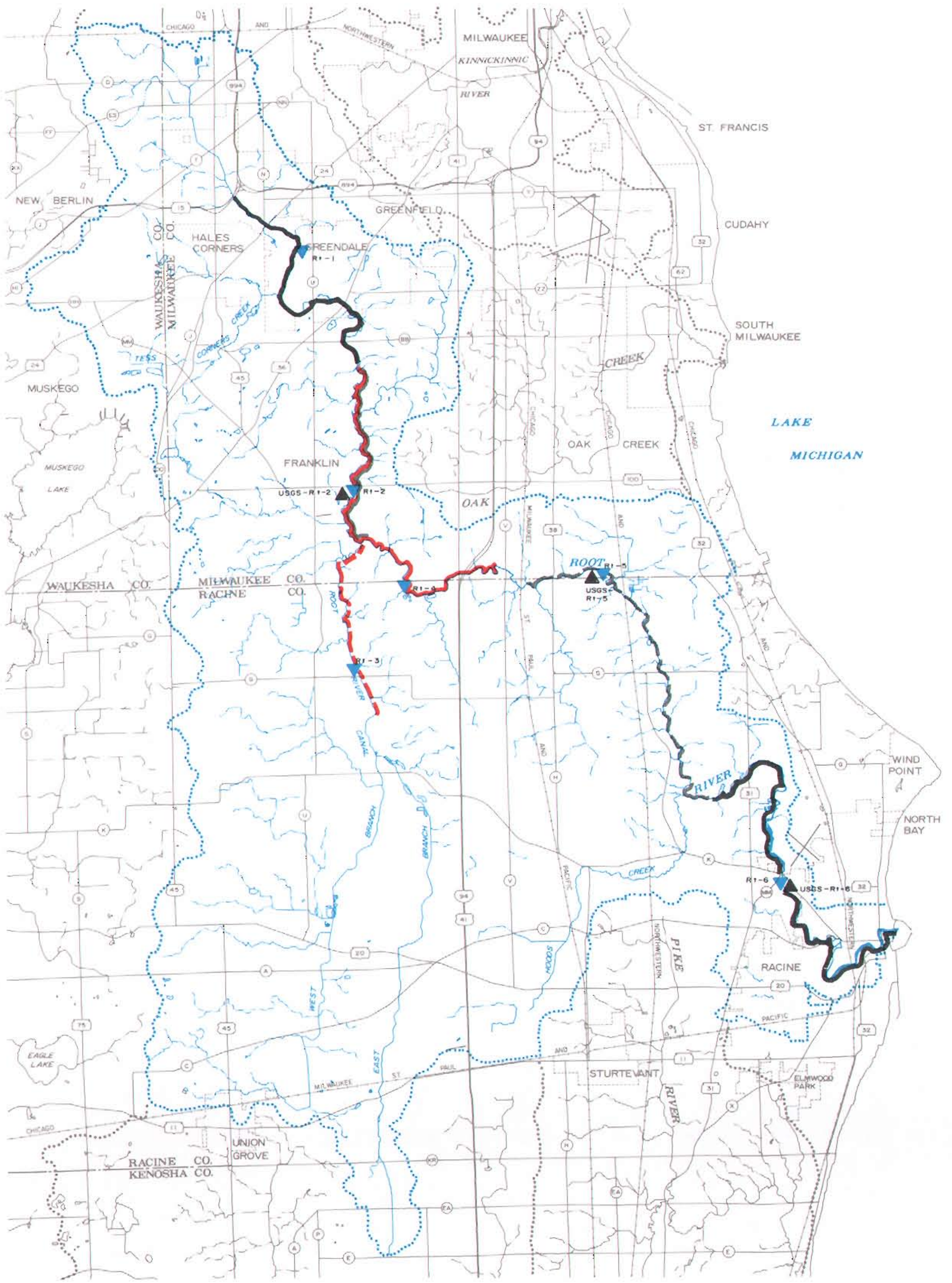
Source: SEWRPC.

safety of the Root river and Root River Canal waters for 1964. However, since the total coliform counts in the Root River and the Root River Canal were very high, in the range of 100-1,700,000 MFCC/100 ml with an average of 105,000 counts/100 ml, they indicate a high probability of the fecal coliform counts being higher than the permissible limit.

Water Quality-1975: For the Root River main stem, intended for recreational use and preservation of fish and aquatic life, Map 75 indicates that water quality conditions during August 1975 were such that the temperature and pH standards were satisfied throughout the watershed while substandard levels of dissolved oxygen, ammonia, nitrate, total phosphorus, and fecal coliform observation were recorded. Substandard dissolved oxygen concentrations—less than 5.0 mg/l—occurred along the main stem of the Root River upstream of the Milwaukee-Racine County line and in the Root River Canal. The fecal coliform standard of 400 colonies per 100 ml was exceeded all along the main stem of the Root River upstream of the Milwaukee-Racine County line and in the Root River Canal. Total phosphorus in excess of the Commission's recommended level of 0.10 mg/l as P was found throughout the entire length of the Root River and along the Root River Canal. Total phosphorus levels in excess of 0.10 mg/l on the Root River may be traced in part to the discharge of this nutrient from the municipal sewage treatment plants. Nitrate-nitrogen in excess of 0.30 mg/l as N existed the entire length of the Root River and along the Root River Canal. The high nitrate-nitrogen content of the Root River and Root River Canal can also be traced to the discharge of this nutrient from the municipal sewage treatment plants. Ammonia-nitrogen in excess of 2.50 mg/l as N was found along the Root River Canal. The high ammonia-

Map 74

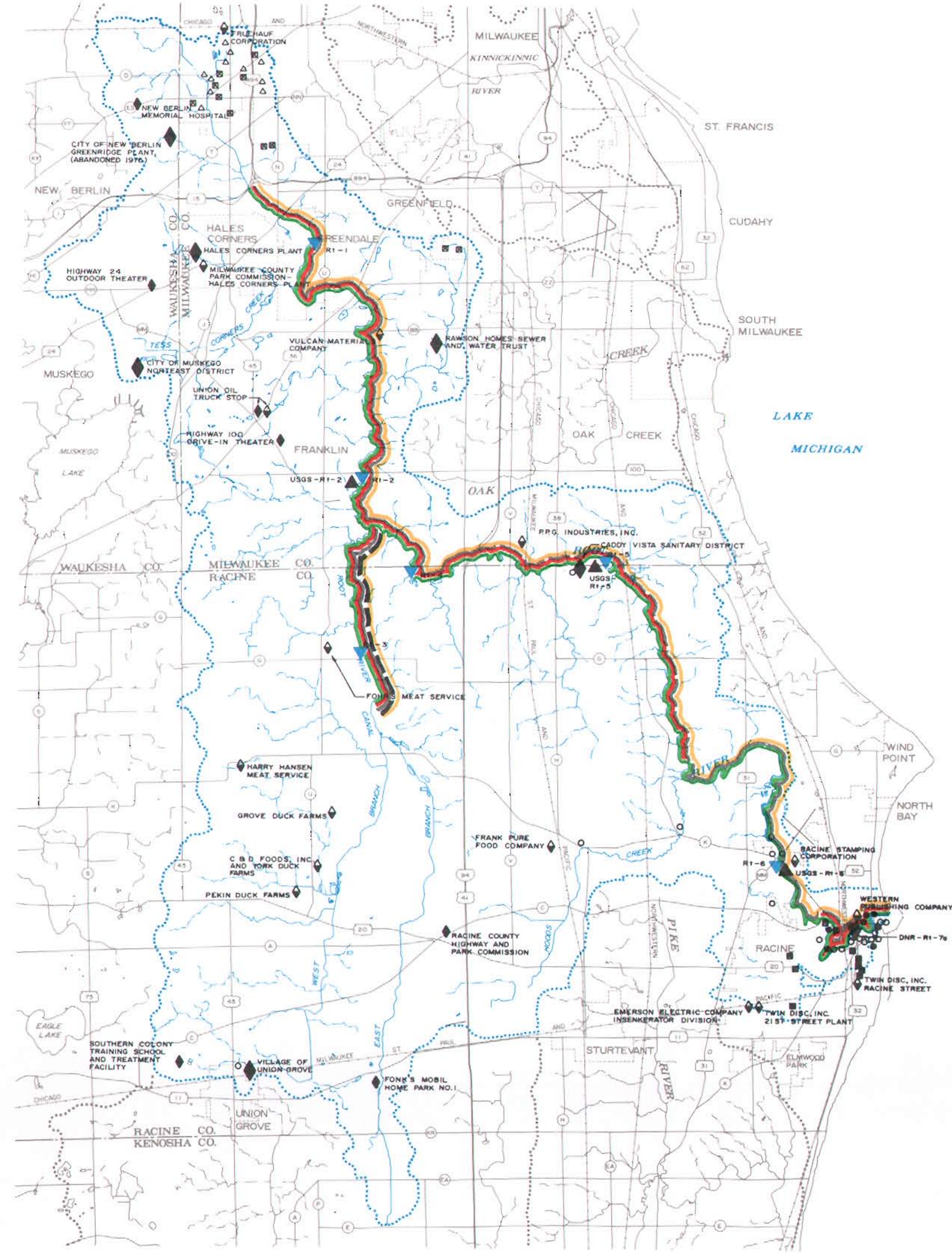
COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE ROOT RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Root River watershed as sampled in August 1964 to the adopted water quality standards indicated that all standards were satisfied at sampling stations Rt-1 and Rt-6. Substandard levels of dissolved oxygen were noted at sampling stations Rt-2, Rt-3, and Rt-4. Sampling stations Rt-2 and Rt-5 exhibited total coliform levels including estimated fecal coliform levels in excess of the standard for recreational use.

Map 75

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE ROOT RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Root River watershed as sampled in August 1975, to the adopted water quality standards and recommended levels indicated fecal coliform, total phosphorus, and nitrate-nitrogen limits were not achieved at any of the six sampling stations in the watershed. The dissolved oxygen standard was exceeded at all the sampling stations with the exception of Rt-6. Further, the recommended maximum ammonia concentration was exceeded at station Rt-3.

nitrogen content indicates pollution of recent origin. The use of land in the watershed for agricultural purposes, especially for livestock operations, may be a major source of this parameter in the Root River Canal.

Concluding Remarks—Root River Watershed

The Root River watershed is located in the east central portion of the Region. The Root River and its tributaries drain approximately 197 square miles and discharge to Lake Michigan within the City of Racine. The Root River watershed is the sixth largest in population and fourth in size of the 12 watersheds, and comprises 7 percent of the total land and water within the Region.

There are six publicly owned and seven nonindustrial privately owned sewage treatment plants located within the watershed. Eleven of the 13 discharge treated effluent into the stream system of the watershed. In addition, there are 61 known sanitary sewer bypasses that discharge raw sewage into the streams during times of sewer surcharge. The 17 waste discharging industries located within the watershed discharge cooling, process, and sanitary wastes through 25 outfalls. The Commission 1970 land use inventory indicates 74 percent of the watershed is devoted to agricultural use and 26 percent is devoted to urban use.

The 1964 water quality benchmark study of the Commission revealed the occurrence of substandard levels of dissolved oxygen at various locations of the Root River watershed. The organic load from the duck farms and the Union Grove sewage treatment plant were significantly high enough to reduce the dissolved oxygen content in the Root River Canal. The specific conductance, chlorides, and total coliform counts in the Root River and its tributaries were high in the spring, indicating their sources were diffuse, and the pollutants washed into the stream with the snowmelt in the spring.

The Root River watershed report, A Comprehensive Plan for the Root River Watershed, published in 1966 by the Commission, recommended that water pollution be controlled by the: 1) abandonment of all existing sewage treatment plants discharging wastes to the North Branch and the export of all Milwaukee County sewage via the Milwaukee metropolitan sewerage system to a new treatment plant on Lake Michigan; 2) abandonment of the Caddy Vista sewage treatment plant and connection of the tributary sewers to the Milwaukee metropolitan sewerage system; 3) connection of the Frank Pure Food Company industrial waste outlet to the City of Racine sanitary sewerage system; 4) improvement in the degree of sewage treatment provided at the Southern Wisconsin Colony, and at the C & D Foods, Inc., duck farm in the Village of Union Grove.

Since their recommendation in the 1966 Root River watershed report, several plans have been implemented. Three privately owned sewage treatment plants—Tess Corners Grade School, Mission Hills Water and Sewer Trust, and Milwaukee House of Correction in the county farm—as well as one public sewage treatment plant from the Village of Greendale, which were discharging their effluents to the North Branch of the Root River or its tributaries have been abandoned since 1969. In addition, improved treatment facilities have been provided at the C & D Foods duck farm in the Root River Canal subwatershed. The C & D Foods duck farm, which is the largest of five duck farms in the Root River Canal subwatershed, has changed its waste treatment facility from aerated lagoons to activated sludge treatment facilities since 1972.

The abandonment of several sewage treatment facilities in the subwatershed area of the North Branch of the Root River and improved waste treatment facilities in the C & D Foods duck farm have favorably affected water quality in the Root River watershed. A comparison of the water quality of the Root River as it existed in August 1964 and in August 1975 shows the positive effects of abandoning the four sewage treatment facilities and decreasing the effluent discharge into the River, as measured by the fecal coliform counts in low-flow periods, except for samples taken at a station located near the Caddy Vista Sanitary District Sewage Treatment Plant. A high fecal coliform count from the effluent from Caddy Vista Sanitary District is not surprising since the treatment process at this location does not include disinfection by chlorination. The Caddy Vista treatment plant is planned to be abandoned in the near future and the proposed project is currently approved for federal funding for sewer connection to the Milwaukee Metropolitan sewerage system. The high fecal coliform problem near the Caddy Vista Sanitary District is expected to be taken care of by the plan. Despite the abandonment of four sewage treatment facilities in the subwatershed of the North Branch of the Root River, the chloride loadings showed an increase and the dissolved oxygen concentration showed a decrease. The increased chloride loadings and decreased dissolved oxygen concentrations at the locations of sampling stations Rt-1 and Rt-2, as well as their occurrence at times of precipitation in the watershed and flow events in the main stem of the Root River, indicate degraded water quality associated with the increased urbanization of the tributary area.

A comparison of the water quality of the Root River Canal as it existed in August 1964 and in August 1975 shows the positive effects of improved wastewater management of C & D Foods duck farm, the largest industry in the subwatershed. The dissolved oxygen concentrations have increased in the past few years from less than 2.0 mg/l to greater than 3.0 mg/l. Also observed in the Root River Canal sampling station was a decrease in fecal coliform counts in the past six years.

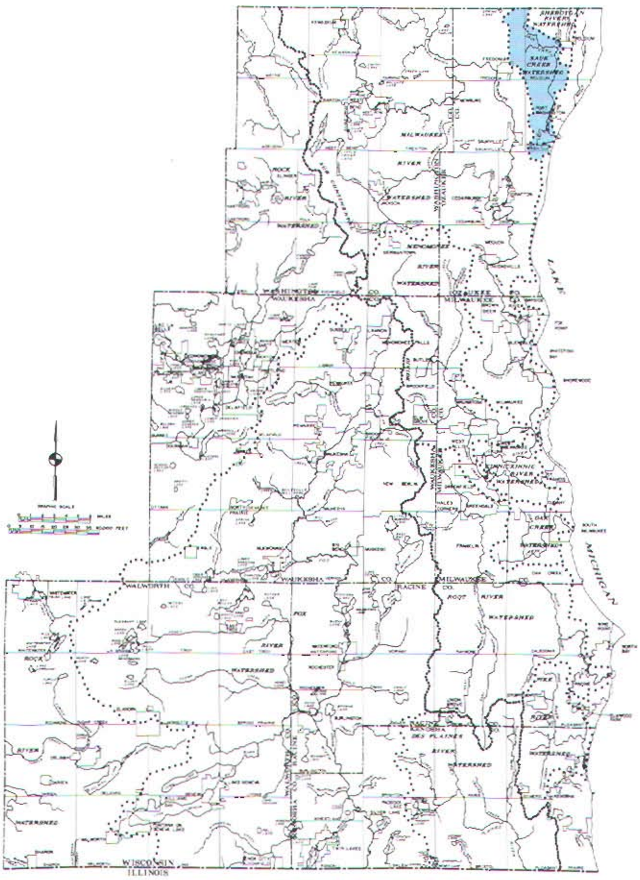
SAUK CREEK WATERSHED

Regional Setting

The Sauk Creek watershed is a natural surface water drainage unit, 33.71 square miles in areal extent, located in the northeast portion of the Southeastern Wisconsin Region. The boundaries of the basin, together with the locations of the main channel of Sauk Creek, are shown on Map 76. The watershed lies in north central Ozaukee County and the main stream, Sauk Creek, is 16.6 miles

Map 76

LOCATION OF THE SAUK CREEK WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Sauk Creek watershed has a total area of 34 square miles and comprises about 1.3 percent of the total 2,689-square-mile area of the Region. The watershed ranks eleventh in population and ninth in size of the 12 watersheds of the Region.

Source: SEWRPC.

long and rises just outside the Region in the Town of Holland in southwest Sheboygan County, flowing southeasterly, easterly, and then southerly to discharge to Lake Michigan in the harbor area of the City of Port Washington. Table 207 lists for the Sauk Creek watershed, each stream reach, together with the location, the source, and length in miles. Sauk Creek drains an area comprised almost exclusively of glacial end and ground moraines. The watershed, which is wholly contained within the Region with the exception of an approximately 0.88-square-mile area in Sheboygan County, is the eleventh largest in population, and ninth in size of the 12 watersheds of the Region. It comprises 1.3 percent of the total land and water area of the Region.

Political Boundaries

Superimposed upon the natural meandering watershed boundary is a rectilinear pattern of local political boundaries as shown on Map 76. The in-Region portion of the watershed lies entirely within Ozaukee County, and lies within one city, two villages, and five towns. The area and proportion of the watershed contained within the jurisdiction of each of these general purpose local units of government as of January 1, 1976, are shown in Table 208.

Population

Population Size: The 1975 resident population of the watershed is estimated at 7,377 persons, or about 1 percent of the total estimated resident population of the Region. Table 209 presents the population distribution in the Sauk Creek watershed by civil division. The population of the watershed has increased steadily since 1900.

Population Distribution: Presently about 85.8 percent of the residents of the watershed live in incorporated cities and villages, the combined areas of which comprise about 6.4 percent of the watershed. The Sauk Creek watershed is highly urbanized in its lower reaches, but predominantly rural elsewhere.

Table 207

STREAMS IN THE SAUK CREEK WATERSHED

Stream or Watercourse	Source		Length (in miles)
	By Civil Division	By U. S. Public Land Survey	
Sauk Creek.	Town of Belgium	NW ¼, Section 6, T21N, R22E	16.58

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 208

AREAL EXTENT OF CIVIL DIVISIONS IN THE SAUK CREEK WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
OZAUKEE COUNTY			
City			
Port Washington.	1.99	5.90	64.61
Villages			
Belgium	0.02	0.06	3.03
Fredonia.	0.14	0.41	10.61
Towns			
Belgium	12.84	38.09	34.70
Fredonia.	6.97	20.68	19.95
Grafton	0.89	2.64	4.09
Port Washington.	10.85	32.19	56.13
Saukville.	0.01	0.03	0.03
County Subtotal	33.71	100.00	14.34
Total	33.71	100.00	--

Source: SEWRPC.

Table 209

ESTIMATED RESIDENT POPULATION OF THE SAUK CREEK WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
OZAUKEE COUNTY	
City	
Port Washington (part) . .	6,194
Villages	
Belgium (part)	15
Fredonia (part)	122
Towns	
Belgium (part)	266
Fredonia (part)	189
Grafton (part)	23
Port Washington (part) . .	565
Saukville (part)	3
Ozaukee County (part) Subtotal	7,377
Sauk Creek Watershed (part) Total	7,377

Source: SEWRPC.

Quantity of Surface Water

Surface water in the Sauk Creek watershed is made up almost entirely of streamflow. There is only one minor lake; and there are no major lakes 50 acres or greater in area within the watershed. No streamflow data are available to evaluate the effect of the flow on the water quality of Sauk Creek. The available flow information in the other watersheds of the Region indicates that higher streamflows probably occur principally in the late winter and early spring, usually associated with melting snow; and lower flows might persist for most of the remainder of the year with occasional rises caused by rainfall.

The lower reaches of Sauk Creek and other first rank tributaries to Lake Michigan are subject to a phenomenon known as a seiche. A seiche, also known as a standing wave, is an oscillation of the water mass at the surface or within a lake lasting from a few minutes to several hours. The forces that generate seiches include variations in atmospheric pressure and wind. The flow condition and the water quality in the lower reaches of Sauk Creek can temporarily be affected by the dilution effects of the Lake Michigan water during a seiche.

Pollution Sources

The following pollution sources have been identified in the Sauk Creek watershed and are discussed below: a single sanitary sewerage system overflow point, three industrial wastewater discharges, urban storm water runoff, and agricultural runoff.

Sewage Treatment Facilities: There are no known public or nonindustrial private sewage treatment facilities located in the Sauk Creek watershed, nor are there any known municipal treatment plant effluent discharges to the stream system of the watershed.

Sanitary Sewerage System Flow Relief Points: There are two flow relief devices, both bypasses, located in the City of Port Washington, which discharge raw sanitary waste into Sauk Creek during periods of sanitary sewer system surcharge as shown in Table 210.

Table 210

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE SAUK CREEK WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Crossovers	Other Flow Relief Devices			Total
				Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Sauk Creek. . . .	City of Port Washington	0	0	2	0	0	2
Total	--	0	0	2	0	0	2

Source: SEWRPC.

Domestic Onsite Sewage Disposal Systems: Although certain areas of the watershed lie within existing and proposed service areas of public sanitary sewerage systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Industrial Waste Discharges: At three locations in the Sauk Creek watershed industrial wastewaters consisting of process and cooling water are discharged directly or indirectly to the surface water system (see Map 77).[19] This industrial wastewater enters Sauk Creek or its tributary directly through industrial waste outfalls or indirectly through drainage ditches and storm sewers.

Data and information provided by the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR101 of the Wisconsin Administrative Code were used to determine the type and location of industrial wastewater discharges in the Sauk Creek watershed. Table 211 summarizes by receiving stream and by civil division the types of industrial wastewater discharge and the number of outfalls in the watershed and the types of treatment and average hydraulic design capacity. Cedar Valley Cheese Factory, in the Town of Fredonia, has a private treatment facility, the effluent from which is discharged to groundwater. Murphy Oil Corporation, in the City of Port Washington, has oil-water separator tanks, the effluent from which is discharged into a tributary of Sauk Creek. In addition, Allis Chalmers, Inc., in the City of Port Washington discharges cooling water into Sauk Creek.

Pollution from Urban Runoff: Separate storm sewers which convey the runoff from rainfall carry pollutants and contaminants from urbanized areas into receiving waters, and may cause chemical or inorganic, organic, pathogenic, and aesthetic pollution of lakes and streams. Existing land use information taken from the Commission 1970 land use inventory is presented in Table 212 and indicates that 2,081 acres, or about 9 percent of the total area of the Sauk Creek watershed, is devoted to urban land uses; 19,364 acres, or about 88 percent, is devoted to rural land uses, primarily agricultural; and 614 acres, or about 3 percent, is occupied by the stream network itself. A shoreland development survey conducted by the Wisconsin Department of Natural Resources indicates that 75 percent of the shoreland area within 1,000 feet of Sauk Creek is devoted to agricultural and other rural uses; and 25 percent is devoted to low- and medium-density urban uses. In comparing land use within the watershed with land use within 1,000 feet of the shores of Sauk Creek, it is noted that a higher percentage of the land along the shores of Sauk Creek is urbanized than within the watershed as a whole. The urbanized areas of the Sauk Creek watershed, although comprising only about 9 percent of the total area of the watershed, therefore, may have a significant effect on stream water quality, especially near the mouth of the stream.

[19] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 77. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed at that time and which have been added since 1964.*

Map 77

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC AND NONINDUSTRIAL PRIVATE SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE SAUK CREEK WATERSHED: 1964-1975

Stream water quality data were obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at two sampling stations located in the Sauk Creek watershed. These data were analyzed to determine the water quality conditions of the streams as affected by discharges from three industrial or commercial facilities discharging wastewater through three outfalls and two sanitary sewer system bypasses.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 211

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE SAUK CREEK WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
OZAUKEE COUNTY								
Allis Chalmers, Inc. Simplicity Manufacturing Company	3524	City of Port Washington	Cooling	None	4	Sauk Creek	47,000	125,000
Cedar Valley Cheese Factory	2022	Town of Fredonia	Cooling and Process	Lagoon, Ridge, Furrow, and Spray Irrigation	1	Groundwater	N/A	25,000
Murphy Oil Corporation	5171	City of Port Washington	Stormwater Runoff	Oil Separator	1	Tributary of Sauk Creek	76,500	26,500

NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Source: SEWRPC.

Table 212

LAND USE IN THE SAUK CREEK WATERSHED: 1963 AND 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	594.53		671.70	
Commercial	51.40		50.16	
Industrial	69.95		63.00	
Transportation and Utilities	1,098.07		1,148.82	
Government	58.26		120.40	
Recreation	29.06		9.57	
Landfill and Dump	0.73		18.29	
Total	1,902,00	8.62	2,081.94	9.44
Rural Land Uses				
Open Land	971.06		1,008.51	
Agricultural Lands	18,562.90		18,355.89	
Total	19,533.96	88.55	19,364.40	87.78
Water Covered Lands				
Lakes, Rivers, and Streams	48.78		51.01	
Wetlands, etc.	575.96		563.37	
Total	624.74	2.83	614.38	2.78
Watershed Totals	22,060.70	100.00	22,060.72	100.00

Source: SEWRPC.

Pollution from Rural Land: Agricultural land uses are known to contribute high concentrations of suspended solids, nitrogen, and phosphorus to surface waters through storm water runoff. Since almost 88 percent of the total area of the Sauk Creek watershed is in agricultural use, agricultural runoff is likely to be a significant factor affecting the water quality of the Sauk Creek stream system.

Other Pollution Sources: The Commission 1970 land use inventory indicated, in addition to the pollution sources described above, the presence of a sanitary landfill site located on the shore of Sauk Creek in the City of Port Washington. Seepage and runoff from this sanitary landfill may contribute to the pollution of the river system.

Water Quality Conditions of Sauk Creek Watershed

Water Quality Data: Of the 19 primary water quality data sources available, only two included useful information for the Sauk Creek watershed water quality analysis: 1) the Commission benchmark study, and 2) the Commission continuing monitoring program. For a detailed description of these sources, see Chapter II of this report. Two sampling stations were established by the Commission on Sauk Creek, as indicated in Table 213. Map 77 shows the location of these sampling stations in the Sauk Creek watershed.

Surface Water Quality of the Sauk Creek Watershed 1964-1965: Water quality conditions in the Sauk Creek watershed, as determined by the Commission 1964-1965 sampling survey at two stations along the main stem, are summarized in Table 214. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to the assessment of trends in surface water quality.

Chloride: During the sampling year of 1964-1965, the chloride concentrations throughout the watershed varied from 20 to 50 mg/l with average values of 30 mg/l. The minimum chloride levels in the watershed are approximately equal to background levels of 20 mg/l as measured from the average groundwater chloride concentrations. The higher concentration of chloride occurred in September 1964 at Sk-1 located in the headwater area. Sampling station Sk-1 having been located in the nonurbanized area, the source of high chloride concentrations is likely to be runoff from rural land, especially from feedlots and malfunctioning septic tank systems and from road salting operations on nearby CTH A. At sampling station Sk-2, chloride concentrations remained in the range of 20-35 mg/l throughout the 13 sampling surveys during 1964-1965, indicating a better water quality at sampling station Sk-2 than at sampling station Sk-1 as measured by chloride.

Table 213

DESIGNATIONS AND LOCATION OF SEWRPC SAMPLING STATIONS ON SAUK CREEK

Source	Sampling Station Designation	Sampling Station Location	Distance from the County Line (in miles)
SEWRPC	Sk-1	CTH A, NE ¼, Section 33, T12N, R22E	7.6
SEWRPC	Sk-2	STH 33, SW ¼, Section 28, T11N, R22E	0.35

Source: SEWRPC.

Table 214

WATER QUALITY CONDITIONS OF SAUK CREEK: 1964-1965

Source	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Sauk Creek— Sk-1, Sk-2	Chloride (mg/l)	55	40	20	15
	Dissolved Solids (mg/l)	770	605	200	15
	Dissolved Oxygen (mg/l)	19.3	10.6	0.1	25
	Total Coliform Count (MFCC/100 ml)	200,000	20,000	400	25
	Temperature (^{o}F)	86	51	32	24

Source: SEWRPC.

Dissolved Oxygen: During the sampling year of 1964 1965, the dissolved oxygen levels in the watershed ranged from 0.1 to 19.3 mg/l, with an average of 10.6 mg/l. At sampling station Sk-1, although the dissolved oxygen concentrations remained greater than 5.0 mg/l during most of the sampling surveys, the dissolved oxygen levels decreased to as low as 0.1 mg/l during the autumn of 1964. The low dissolved oxygen levels occurred in conjunction with high chloride levels, indicating that runoff from feedlots is likely to be the primary source of the pollution. At sampling station Sk-2, the dissolved oxygen concentrations remained greater than 10.9 mg/l throughout the 13 samples taken during 1964-1965. The observed dissolved oxygen concentrations and chloride concentrations indicate generally higher levels of water quality at sampling station Sk-2 than at sampling station Sk-1.

Biochemical Oxygen Demand: The biochemical oxygen demand values found in Sauk Creek during the sampling year of 1964-1965 ranged from a recorded low of 1.0 mg/l to a high of 20.0 mg/l at the two sampling stations. The highest biochemical oxygen demand values were found during the month of February at both sampling locations. Since the watershed had greater than 75 percent agricultural land use, the high biochemical oxygen demand in the samples collected in February indicates agricultural runoff as the probable source of the biochemical oxygen-demanding materials, perhaps from the improper spreading of manure on frozen lands during winter. No correlation between the dissolved oxygen and biochemical oxygen demand level was found, the probable reason being that the bacteria had not had enough time to act upon the oxygen-demanding materials and thus decrease the biochemical oxygen demand and dissolved oxygen concentrations.

Total Coliform Bacteria: During the sampling year 1964-1965, the membrane filter coliform count varied from less than 200 to 200,000 MFCC/100 ml, with the average value of 20,000 MFCC/100 ml. The highest total coliform counts occurred during the month of September in Sauk Creek at sampling station Sk-1. With the exception of the high total coliform counts in September 1964 and a low total coliform count of 200 MFCC/100 ml at sampling station Sk-1 in June 1964, the total coliform counts ranged from 5,000 to 36,000 MFCC/100 ml at sampling station Sk-1; and from 400 to 14,000 MFCC/100 ml at sampling station Sk-2. At sampling stations Sk-1 and Sk-2, respectively, one sample and eight samples having less than 2,000 MFCC/100 were observed out of the 13 samples collected over the one-year period. These results indicate a poorer quality of water at sampling station Sk-1 than at sampling station Sk-2, as was also indicated by the dissolved oxygen and chloride concentrations. The difference is thought to be attributable to livestock operations in the rural areas tributary to sampling station Sk-1.

Specific Conductance: The specific conductance of Sauk Creek water samples taken during the 1964-1965 sampling period ranged from 292 to 992 μmhos/cm at 25°C. The highest specific conductance values were found at sampling station Sk-1 during the month of October, as were the highest chloride concentrations. Specific conductance is an approximate measure of the dissolved ions present in water, and the high specific conductance values at sampling station Sk-1 indicate high dissolved solids at this location.

Hydrogen Ion Concentration (pH): The pH values at all sampling sites in the Sauk Creek watershed generally ranged from 7.1 to 8.6 standard units during the sampling year of 1964-1965. At no location within the watershed was the pH found to be outside the range of 6.0 to 9.0 standard units, prescribed for recreational use as well as for the maintenance of fish and aquatic life, the major water use objectives of Sauk Creek.

Temperature: During the year 1964-1965, the temperature of water samples from Sauk Creek ranged between 32°F and 53°F during the months of December through April and between 47°F and 86°F during the months of May through November. The temperature variations, therefore, may be attributed primarily to seasonal change. The discharge of cooling water from Allis Chalmers, Inc., into Sauk Creek, does not appear to be increasing the normal temperature of the stream water above the prescribed standard of 89°F.

Surface Water Quality of Lakes in the Sauk Creek Watershed 1964-1965: No chemical data are available for Ludowissi Lake, the only Lake present in the watershed in the Region, for the sampling period of 1964-1965 to evaluate the water quality of that time period.

Water Quality Trends from 1965 through 1975:[20] Water quality data from 1965 through 1975 for eight summers and three spring sampling programs and one fall sampling program are presented in tabular form in Appendix D of this report. The eight summer sampling surveys began in August 1968 and involved collection of samples one day in August every year during low-flow conditions.

The summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite-, ammonia- and organic-nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of the two stations sampled in the Sauk Creek watershed by the Commission since 1968 is set forth in Tables 215 and 216.

Dissolved Oxygen: For the watershed as a whole, the range of dissolved oxygen in the Sauk Creek stream system during August 1968-1975 was 0.3 to 14.6 mg/l. The average dissolved oxygen concentrations were 4.9 and 7.3 for Sauk Creek sampling stations 1 and 2, respectively. Although the eight-year average dissolved

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[20] *When evaluating the trends of dissolved oxygen, chloride, and fecal coliform for the sampling period of 1968-1975, the base year 1974 was used instead of 1975 due to the high streamflow that was recorded in 1975 due to approximately 2.5 inches of rain which fell the preceding five days.*

Table 215

WATER QUALITY CONDITIONS IN SAUK CREEK AT SAMPLING STATION SK-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	230.0	85.8	38.0	23	--
Dissolved Oxygen (mg/l)	5.0	14.6	4.9	0.3	30	18[a]
Ammonia-N (mg/l)	2.5	0.45	0.15	0.03	8	0
Organic-N (mg/l)	--	2.23	1.46	0.99	8	--
Total-N (mg/l)	--	3.69	2.66	1.47	8	--
Specific Conductance (umhos/cm at 25°C)	--	1,460	880	522	30	--
Nitrite-N (mg/l)	--	0.20	0.07	0.01	13	--
Nitrate-N (mg/l)	0.3	1.93	0.78	0.12	12	7
Soluble Orthophosphate-P (mg/l)	--	1.43	0.85	0.22	12	--
Total Phosphorus (mg/l)	0.1	1.25	0.77	0.21	8	8
Fecal Coliform (MFFCC/100 ml)	400	54,000	7,061	70	12	9
Temperature (°F)	89.0	81.0	70.7	61.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	9.0	8.4	7.6	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 216

WATER QUALITY CONDITIONS IN SAUK CREEK AT SAMPLING STATION SK-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
		Maximum	Average	Minimum		
Chloride (mg/l)	--	80.0	43.8	33.0	23	--
Dissolved Oxygen (mg/l)	5.0	13.2	7.3	4.0	30	2[a]
Ammonia-N (mg/l)	2.5	0.12	0.07	0.03	6	0
Organic-N (mg/l)	--	1.34	0.96	0.19	8	--
Total-N (mg/l)	--	3.12	2.22	0.56	8	--
Specific Conductance (umhos/cm at 25°C)	--	963	751	585	29	--
Nitrite-N (mg/l)	--	0.08	0.03	0.00	13	--
Nitrate-N (mg/l)	0.3	1.82	0.90	0.12	12	8
Soluble Orthophosphate-P (mg/l)	--	0.51	0.24	0.07	12	--
Total Phosphorus (mg/l)	0.1	0.64	0.32	0.05	8	6
Fecal Coliform (MFFCC/100 ml)	400	4,000	977	10	12	7
Temperature (°F)	89.0	79.5	68.8	62.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.5	8.1	7.8	23	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

oxygen concentration was above 5.0 mg/l for sampling station Sk-2 during August, the dissolved oxygen concentrations were lower than 5.0 mg/l in two diurnal samples in one sampling survey during 1968-1975. For sampling station Sk-1, the daily average dissolved oxygen concentration was well below 5.0 mg/l during six out of eight sampling surveys.

Map 78 presents the dissolved oxygen concentrations that were found in August 1964 and August 1974 in the Sauk Creek watershed. The graph insert illustrates the change in dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year and the three-year moving average at each location. On August 6, 1964, as indicated on the map, the dissolved oxygen levels were greater than 5.0 mg/l, the established standards for the Sauk Creek. The water quality objective of the stream is recreational use and the preservation of fish and aquatic life. Similarly, at sampling station Sk-2, located 0.35 mile above the mouth of the stream, the dissolved oxygen concentrations on August 20, 1974 were greater than the established water quality standard of 5.0 mg/l. At sampling station Sk-1, however, substandard dissolved oxygen concentrations of less than 5.0 mg/l were present on August 20, 1974. The graph insert on Map 78 presents the dissolved oxygen concentration and the moving averages at sampling stations Sk-1 and Sk-2 for the August samples of 1964 through 1974. A decrease over time in the dissolved oxygen concentration at sampling station Sk-1 may be observed when the data for the samples collected in August 1964 and 1968 through 1971 are compared. The dissolved oxygen levels for 1971 through 1974 remained generally low. A similar trend—a decrease in the dissolved oxygen concentrations over time—was observed at sampling station Sk-2, indicating that the source of the decrease in dissolved oxygen is likely to be located upstream from sampling station Sk-1. For the years 1971 through 1974, the dissolved oxygen concentrations at sampling station Sk-2 remained relatively constant, with a slight increase in the 1973 sample as was true also in the samples at sampling station Sk-1.

A comparison of dissolved oxygen concentrations found in April 1968 with August 1968 and in April 1969 with August 1969 indicates higher dissolved oxygen concentrations in April of each year than in August. The August dissolved oxygen concentrations were 3.0 to 5.0 mg/l less than those found in the April samples.

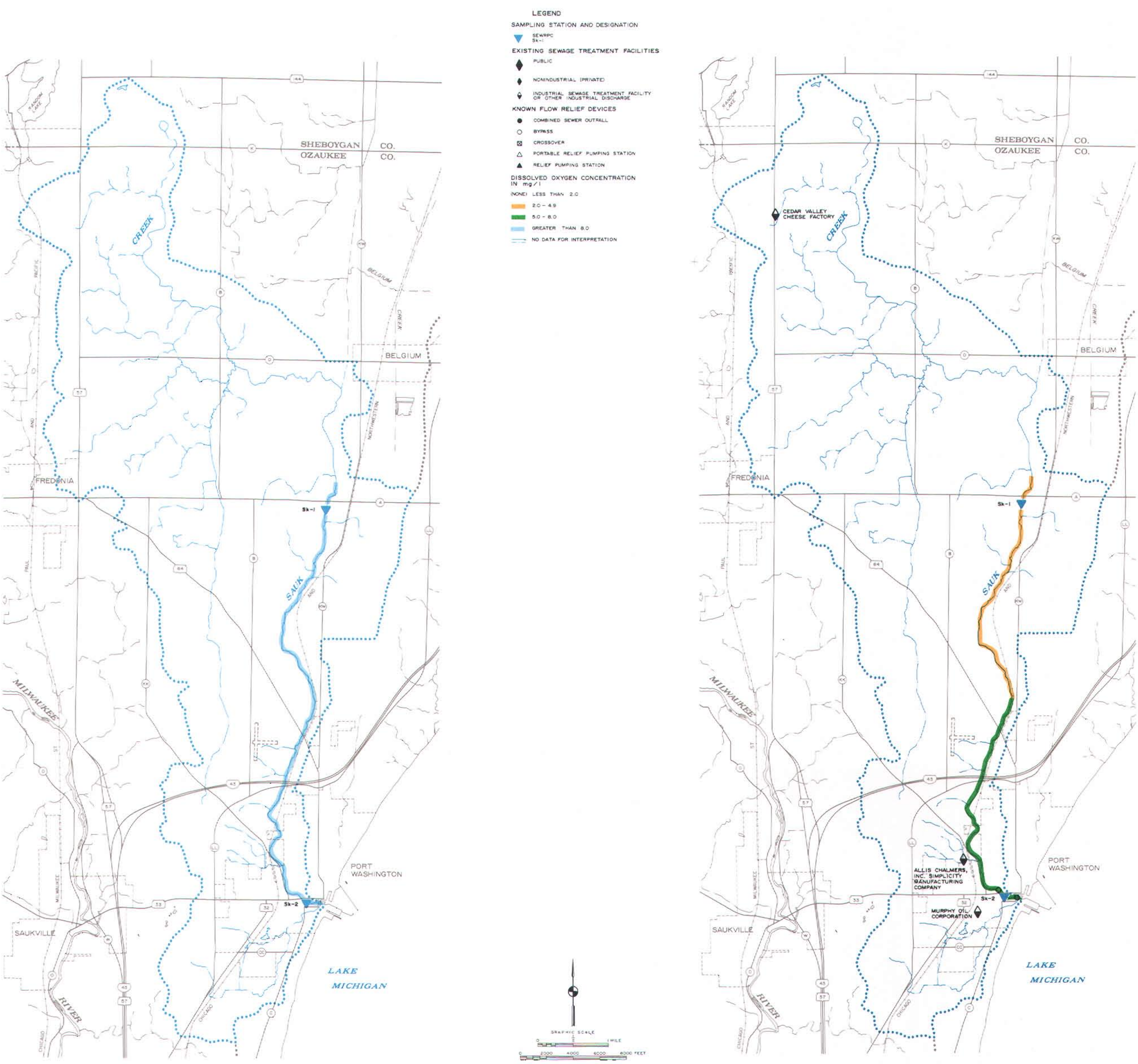
Chloride: The observed chloride concentrations were in the range of 33 to 230 mg/l for the two stations on Sauk Creek for the eight August sampling surveys during the years 1968 through 1975. The average chloride concentrations of the eight samples each at sampling station Sk-1 and sampling station Sk-2 were 86 and 44 mg/l, higher than the area groundwater concentration of approximately 10 mg/l. The higher chloride concentrations at sampling station Sk-1 are likely to be associated with runoff from rural land especially from feedlots and with runoff containing deicing salt. A comparison of the chloride concentrations in April 1968 with August 1968 and in April 1969 with August 1969, as presented in Figure 220, indicates higher chloride concentrations in the August samples. Since no information on flow is available for Sauk Creek, it is not possible to compare the chloride loadings with the chloride concentrations to quantify the dilution effect of the streamflow on the chloride concentrations. Map 79 presents the chloride concentrations at the Sauk Creek sampling stations on August 5, 1968, and August 20, 1974, with a graph illustrating the changes in chloride concentrations found during the sampling days of intermediate years. The range in chloride concentrations remained between 35 and 40 mg/l when only the August 1968 and 1974 data are compared for sampling station Sk-2, while a decrease in the chloride concentrations at sampling station Sk-1 occurred from 74 to 42 mg/l when only the August 1968 and 1974 data are compared. The graph insert on Map 79 illustrates the changes in chloride concentrations at sampling stations Sk-1 and Sk-2 over the past eight years. The data at sampling station Sk-1 located on Sauk Creek 7.6 miles from the mouth indicate a decrease in chloride concentrations over the past eight years, as measured by the samples collected in August 1968 through 1975. On the other hand, the chloride concentrations remained constant at sampling station Sk-2, sampled on the same days as those of sampling station Sk-1 over the past eight years. It might be reasonable to assume a significant increase in the flow at sampling station Sk-2 compared to sampling station Sk-1, considering their locations near the mouth and near the source of the stream, respectively, and to assume that the waters responsible for the increase in flow at sampling station Sk-2 have lower chloride concentrations, thus diluting the high chloride levels at sampling station Sk-1.

Fecal Coliform Bacteria: Map 80, with a graph insert, presents the fecal coliform counts in the Sauk Creek watershed locations during August 1968 through 1974 and illustrates the changes in fecal coliform counts found on the sampling days during the intermediate years. The samples collected in August 1968 showed high levels of more than 2,000 MFFCC/100 ml at sampling station Sk-1 and low levels of less than 400 MFFCC/100 ml at sampling station Sk-2; and, for the samples of the year 1974, the fecal coliform counts remained higher than 4,000 MFFCC/100 ml at station Sk-1 and greater than 400 MFFCC/100 ml at Sk-2. Thus, when only the 1968 and 1974 samples are compared, an increase in fecal coliform counts is observed at sampling station Sk-1 and sampling station Sk-2. The graphs on Map 80 illustrate the variations in fecal coliform counts with time for sampling stations Sk-1 and Sk-2 on Sauk Creek. No trend over time is apparent. The random, but recurring, incidence of levels of 4,000 MFFCC/100 ml and at sampling station Sk-2 suggests diffuse and intermittent sources of bacteriological contamination such as human wastes, animal wastes, and urban storm water runoff resulting from the sanitary sewerage bypass known to exist upstream.

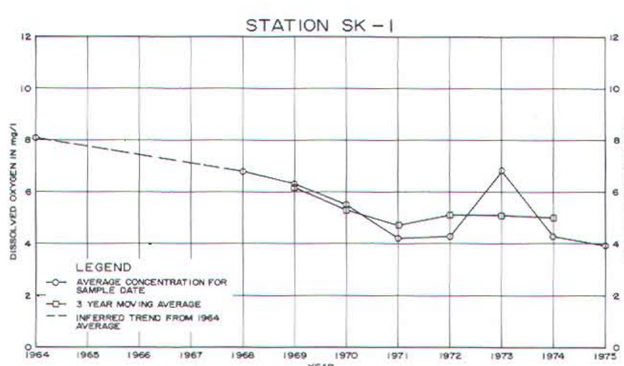
Hydrogen Ion Concentrations (pH): As indicated in Tables 215 and 216, the pH values observed in the watershed have been within the range of 6.0 to 9.0 standard units prescribed for recreational use and maintenance

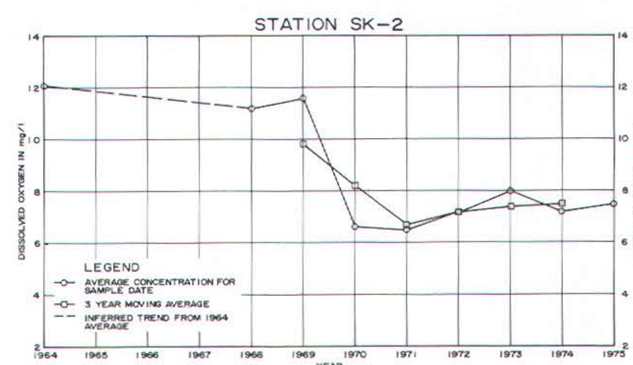
Map 78

COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1974 IN THE SAUK CREEK WATERSHED



A comparison of the dissolved oxygen levels recorded in 1964 and 1974 indicated that dissolved oxygen concentrations decreased at both sampling stations Sk-1 and Sk-2. The maximum observed dissolved oxygen concentration was 14.6 mg/l at sampling station Sk-1. Station Sk-1 also recorded the minimum of 0.3.

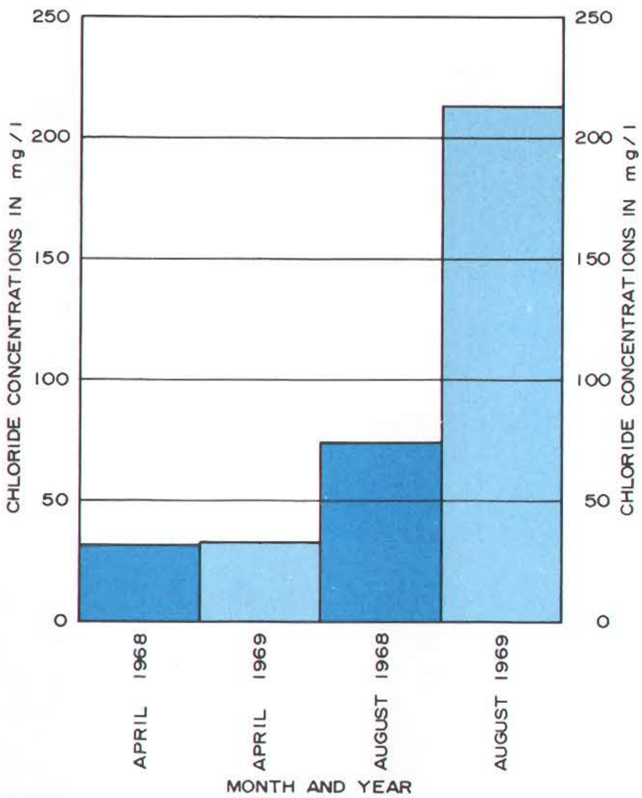




Source: SEWRPC.

Figure 220

CHLORIDE COMPARISONS IN THE SAUK CREEK WATERSHED APRIL AND AUGUST 1968 AND 1969



Source: SEWRPC.

of fish and aquatic life. No trend in pH variation of the samples collected in August 1964 through 1975 is apparent.

Specific Conductance: Specific conductance, a measure of total dissolved ions in water, was found to be in the range of 522 to 1,460 umhos/cm at 25°C for the two locations on Sauk Creek on the days sampled between 1968 and 1975 in August. The highest specific conductance values decreased over the past eight years as did the chloride concentrations. At sampling station Sk-2, the specific conductance values remained the same except for the August 1972 sample, when the concentration increased. During the 1972 sampling survey, heavy rain was recorded in the area, indicating runoff may have increased the dissolved ions in the sampling water. The increased dissolved ions, which are likely to be contributed by agricultural runoff in the area, are reflected in the high specific conductance values at sampling station Sk-2 in 1972.

Temperature: As indicated in Tables 215-216, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through 1975 although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the two Sauk Creek sampling locations during August 1968 through August 1975 were analyzed for soluble orthophosphate concentrations. A range of 0.07 to 1.43 mg/l of soluble orthophosphate as P was obtained during the eight sampling sessions at three locations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of from 0.05 to 1.25 mg/l as P was obtained. A high ratio of from 0.5 to 1.0 of soluble orthophosphate to total phosphorus in water samples indicates that most of the phosphorus is in the form of soluble orthophosphate readily available for the growth of aquatic plants. Although not enough samples were available in the four years of data to characterize trends in the total phosphorus concentrations over time, especially with the 1972 sample having been taken soon after a heavy rain, it is evident from the data that the concentrations are many times higher than required for excessive algal growth. A limit of total phosphorus of 0.10 mg/l as P is generally held to be sufficiently low to prevent nuisance growth of algae and other aquatic plants in flowing waters. All but two water samples from Sauk Creek had total phosphorus and soluble orthophosphate levels substantially higher than 0.10 mg/l as P. A comparison of the concentrations of total and soluble orthophosphate at sampling station Sk-1 and sampling station Sk-2 indicates a lower concentration at sampling station Sk-2, possibly due to sorption of phosphate to sediment particles or to a dilution effect by water of lower total and soluble orthophosphate level occurring between sampling station Sk-1 and sampling station Sk-2.

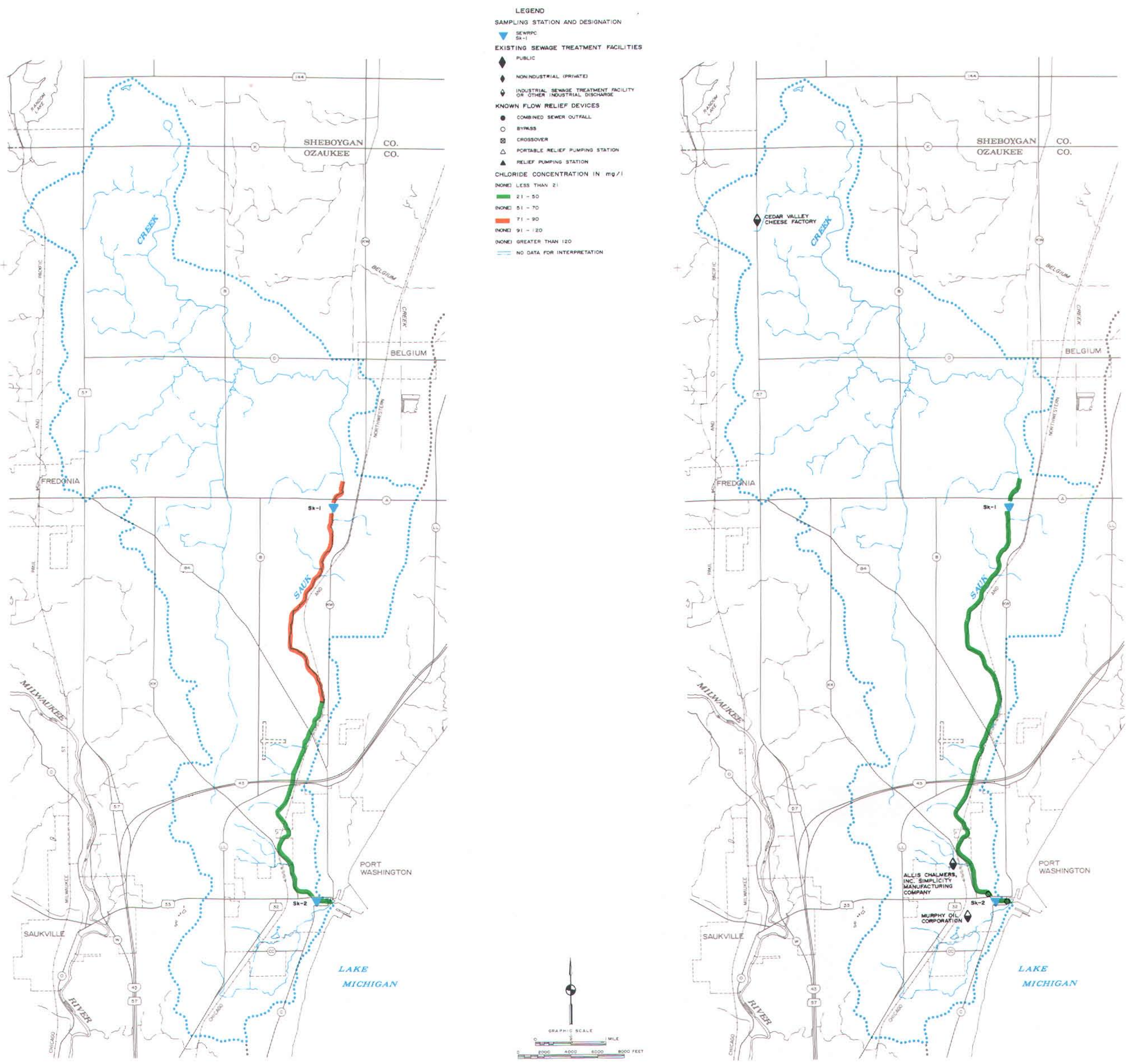
Nitrogen: The total nitrogen concentrations in the Sauk Creek water samples collected during August 1972 through 1975 were in the range of 0.56 to 3.69 mg/l as N. Of this total, 1 to 5 percent was present as nitrite-nitrogen, 0 to 10 percent as ammonia-nitrogen, 10 to 58 percent as nitrate-nitrogen, and 38 to 84 percent as organic-nitrogen. Thus, 10 to 68 percent of the total nitrogen was present in the form of nitrate-nitrogen or ammonia-nitrogen and readily available for plant uptake. The concentration of ammonia-nitrogen in the Sauk Creek samples ranged from 0.03 to 0.45 mg/l as N, well below the known toxic level of 2.5 mg/l ammonia-nitrogen as N. On one of the 14 sampling dates, ammonia-nitrogen did exceed 0.2 mg/l as N, the level generally held to be indicative of lakes and streams which are affected by pollution.

Nitrate concentrations in the Sauk Creek watershed ranged from 0.12 to 1.93 mg/l as N. Surface runoff from fields where there have been excessive or improper applications of natural or artificial fertilizers can contribute significant quantities of nitrate to surface waters. Nitrates are also present as a highly soluble component of the effluent of private, onsite sewage disposal systems. Four out of eight samples collected at sampling station Sk-1 during August 1968 through 1975 contained nitrate

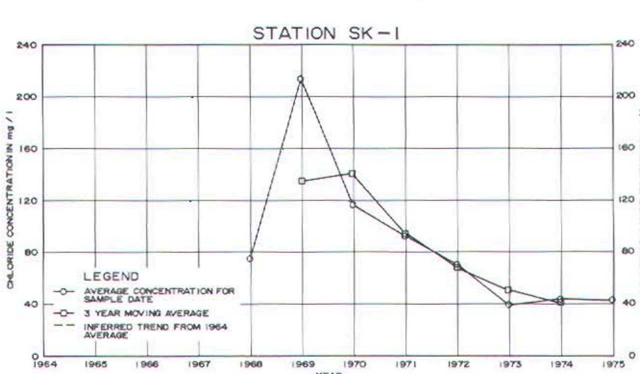
Map 79

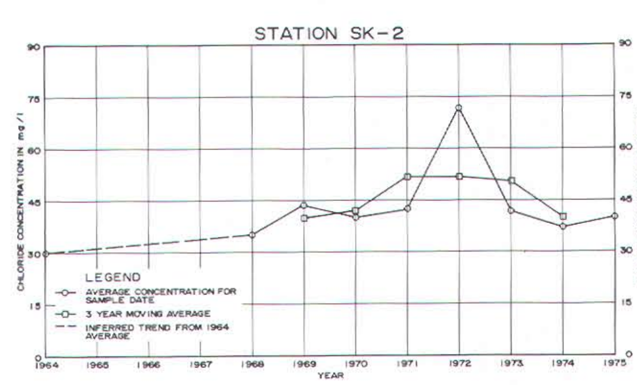
COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1974 IN THE SAUK CREEK WATERSHED

1968 1974



A comparison of the chloride concentrations recorded in 1968 and 1974 indicated that chloride concentrations remained stable at sampling station Sk-2 and decreased at sampling station Sk-1. The maximum observed chloride concentration was 230 mg/l at sampling station Sk-1. The minimum recorded chloride concentration was 30 mg/l at sampling station Sk-2.

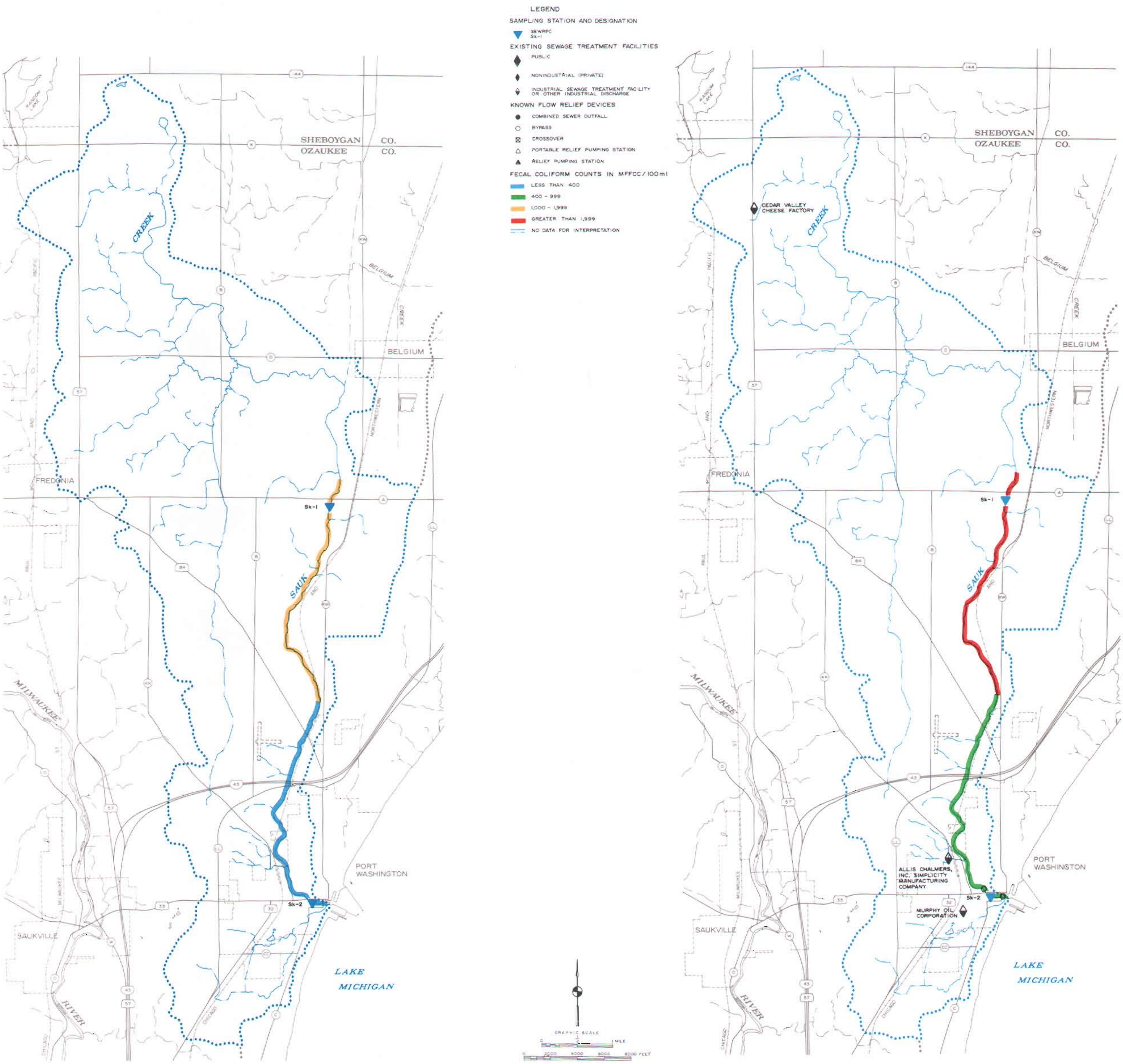




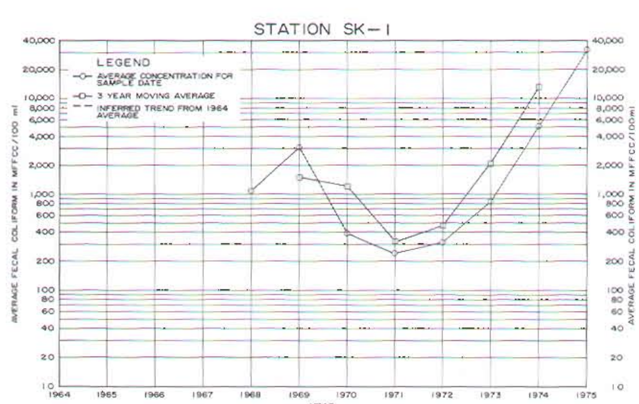
Source: SEWRPC.

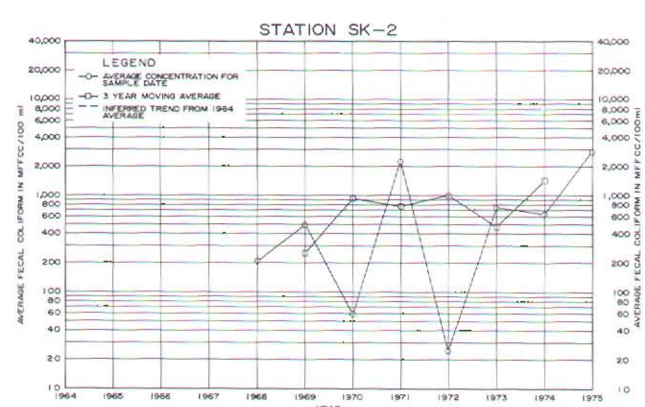
Map 80

COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1974 IN THE SAUK CREEK WATERSHED



A comparison of fecal coliform counts recorded for 1968 through 1974 indicated that sampling stations Sk-1 and Sk-2 exhibited increased fecal coliform counts. The maximum recorded fecal coliform count was 54,000 MFFCC/100 ml at sampling station Sk-1 while the minimum recorded fecal coliform count was 10 MFFCC/100 ml at sampling station Sk-2.





Source: SEWRPC.

levels below the recommended level of 0.30 mg/l expressed as N, while, at sampling station Sk-2, the concentration remained above 0.30 mg/l for three out of eight samples. The major land use in Sauk Creek watershed is agricultural and, therefore, the major source of nitrate-nitrogen is likely to be the fertilizers and wastes from domestic animals.

Organic-nitrogen accounts for 38 to 84 percent of the total nitrogen in the samples collected in the Sauk Creek watershed and is contributed by amino acids, proteins, and polypeptides, all products of biological processes. The presence of organic-nitrogen is directly related to the discharge of organic wastes such as sewage or plant and animal decay products. The organic-nitrogen content was 1.0 mg/l or more in all samples collected at both sampling stations within the watershed, except for one sample at sampling station Sk-2. The total nitrogen concentration, for which data are available for the last four years of the period, remained greater than 2.0 mg/l for the years 1972, 1974, and 1975, but was less than 1.5 mg/l for the samples collected in 1973. The difference in the concentrations of total nitrogen in the samples may be due to differences in streamflow, on which data are not available.

Diurnal Water Quality Changes: Figures 221-224 illustrate diurnal changes observed in temperature, chloride, dissolved oxygen, and pH during low-flow conditions on August 11, 1971, at the Sauk Creek sampling stations. Observed water temperatures ranged from a low of 62°F during the early morning hours on August 11 to a high of 71.5°F during the early evening hours of that day. The recorded diurnal water temperature fluctuations were probably due to corresponding diurnal variations in air temperature and solar radiation.

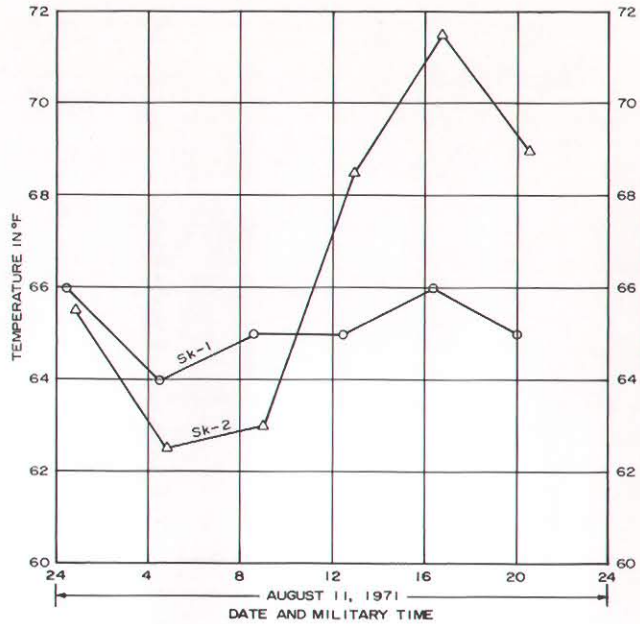
Although changes are not a result of daily sunlight or thermal cycles, chloride concentrations ranged from a low of 84 mg/l during the early morning hours to a high of 100 mg/l during the evening hours of that day at Sauk Creek sampling station Sk-1. At sampling station Sk-2, the range of chloride concentrations was from 33 to 59 mg/l. A significant difference was found in the chloride concentrations in the samples taken at sampling station Sk-1 and sampling station Sk-2, the chloride concentrations being higher at sampling station Sk-1. The lower chloride concentrations at sampling station Sk-2 may be due to a dilution effect by waters of lower chloride concentrations.

The concentrations of dissolved oxygen varied from a low of 3.1 mg/l during the early morning hours to a high of 8.4 mg/l in the early afternoon hours. This variation in dissolved oxygen concentrations can be attributed to the net effects of respiration by algae and other aquatic plants.

The hydrogen ion concentration (pH) varied from a low of 7.8 standard units during the night of August 11 to a high of 9.0 standard units in the early afternoon. The uptake of carbon dioxide during photosynthesis and the release of carbon dioxide during respiration by algae and aquatic plants would be sufficient to account for these variations.

Figure 221

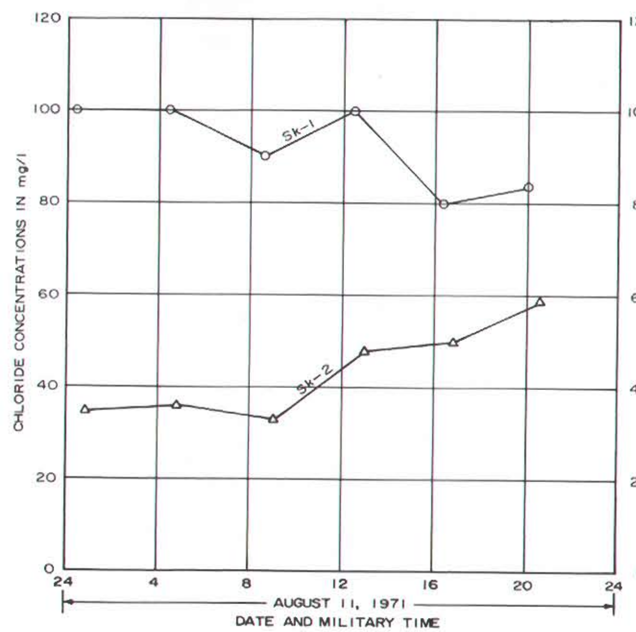
DIURNAL VARIATIONS IN TEMPERATURE RECORDED AT SAMPLING STATIONS SK-1 AND SK-2 IN THE SAUK CREEK WATERSHED: AUGUST 11, 1971



Source: SEWRPC.

Figure 222

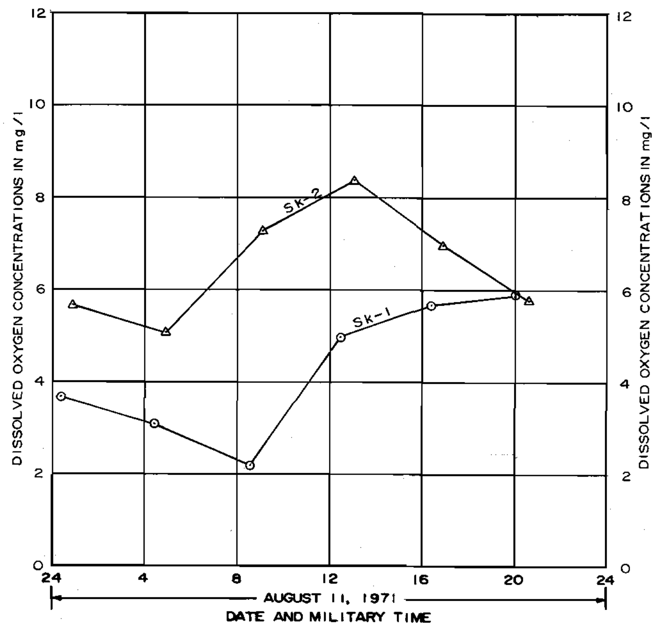
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS RECORDED AT SAMPLING STATIONS SK-1 AND SK-2 IN THE SAUK CREEK WATERSHED: AUGUST 11, 1971



Source: SEWRPC.

Figure 223

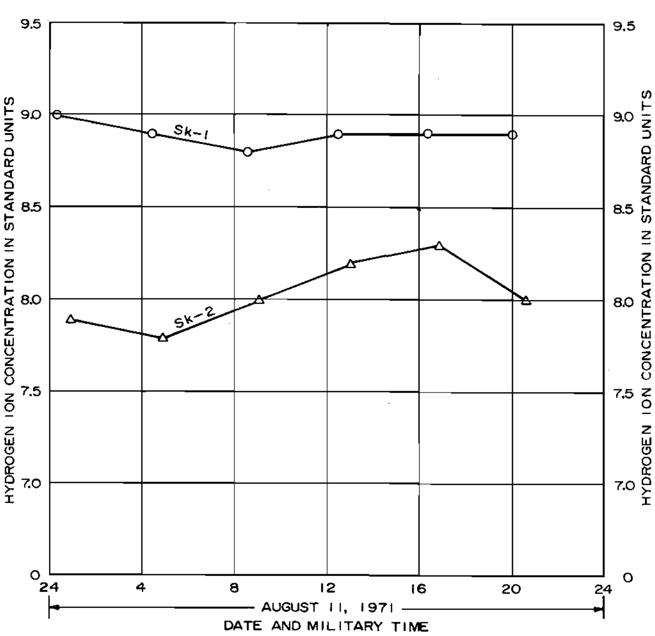
DIURNAL VARIATIONS IN DISSOLVED OXYGEN RECORDED AT SAMPLING STATIONS SK-1 AND SK-2 IN THE SAUK CREEK WATERSHED: AUGUST 11, 1971



Source: SEWRPC.

Figure 224

DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS RECORDED AT SAMPLING STATIONS SK-1 AND SK-2 IN THE SAUK CREEK WATERSHED AUGUST 11, 1971



Source: SEWRPC.

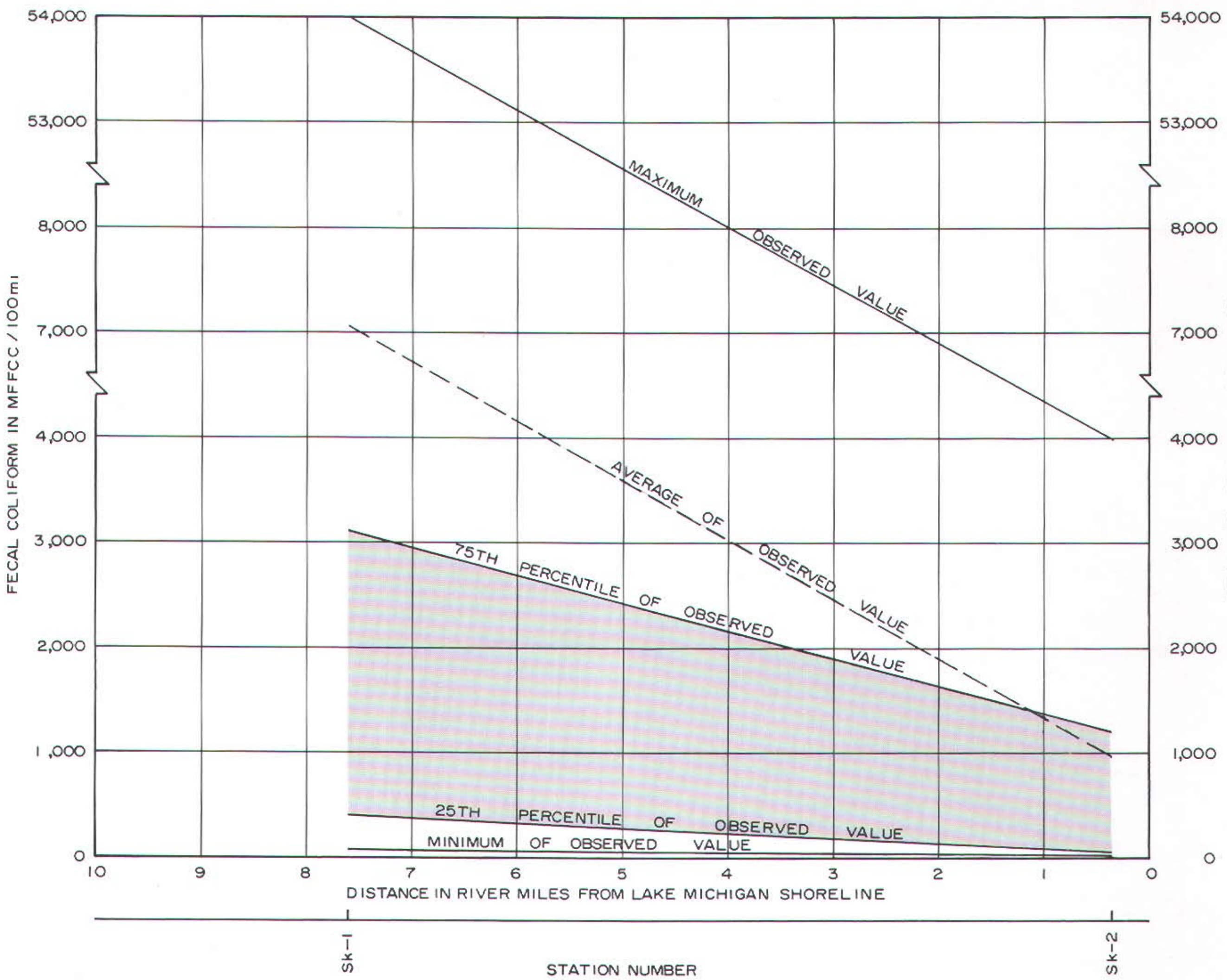
The diurnal fluctuations in water quality may be such that the average level of the concentrations of key parameters meet the established water quality standards while the instantaneous levels during the daily cycle do not meet the standards. For example, the averages of six dissolved oxygen values for August 12, 1970, were 5.5 mg/l and 6.6 mg/l for sampling station Sk-1 and sampling station Sk-2, respectively. Although these are above the minimum standard of 5.0 mg/l for recreational use and the preservation of fish and aquatic life, substandard oxygen levels of less than 4.0 mg/l were measured at both locations in three and one of the six samples at sampling stations Sk-1 and Sk-2, respectively.

Spatial Water Quality Changes: The water quality surveys clearly indicate that the water quality conditions change from one location to another in the watershed stream system in response to a combination of human activities and natural phenomena. Figures 225 through 230 show the spatial water quality variations along the main stem of Sauk Creek. The illustrations include profiles of the average values of chloride, specific conductance, dissolved oxygen, total phosphorus, total nitrogen, and fecal coliform counts obtained over the past eight-year sampling survey at two sampling stations. The figures include the maximum, minimum, and mean values for the water quality parameters. The shaded areas in the figures present the middle 50 percent of the range of each parameter, thus dividing the data into three categories: (1) the range of the 25 percent of the samples near the minimum values, (2) the range of the middle 50 percent of the samples, and (3) the range of the 25 percent of the samples near the maximum. A decrease was observed between sampling station Sk-1 and sampling station Sk-2 in the concentrations of all the parameters studied, with the exception of dissolved oxygen which increased from sampling station Sk-1 to sampling station Sk-2. The decrease in chloride, fecal coliform, and nutrient levels, and the increase in the dissolved oxygen level at sampling station Sk-2 indicate generally better water quality conditions at sampling station Sk-2 located upstream from the Port Washington subwatershed.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples taken between 1964 and 1975 were used to assess the quality of the Sauk Creek stream network. This provides for an assessment of water quality as it existed on the days sampled during the period from 1964 through 1975, and allows for an evaluation of changes in water quality as related to the water quality standards that support the water use objective established for the streams of the Sauk Creek watershed. Comparative analysis must consider the concurrent hydrologic conditions since the water quality standards are not intended to be satisfied under all streamflow conditions. Although no streamflow data are available for Sauk Creek, it is assumed that the flow levels on the sampling days were greater than the seven day-10 year average low flow, and that the water quality data are therefore comparable with the water quality standards.

Figure 225

SPATIAL DISTRIBUTION OF FECAL COLIFORM COUNTS IN THE SAUK CREEK WATERSHED: 1968-1975

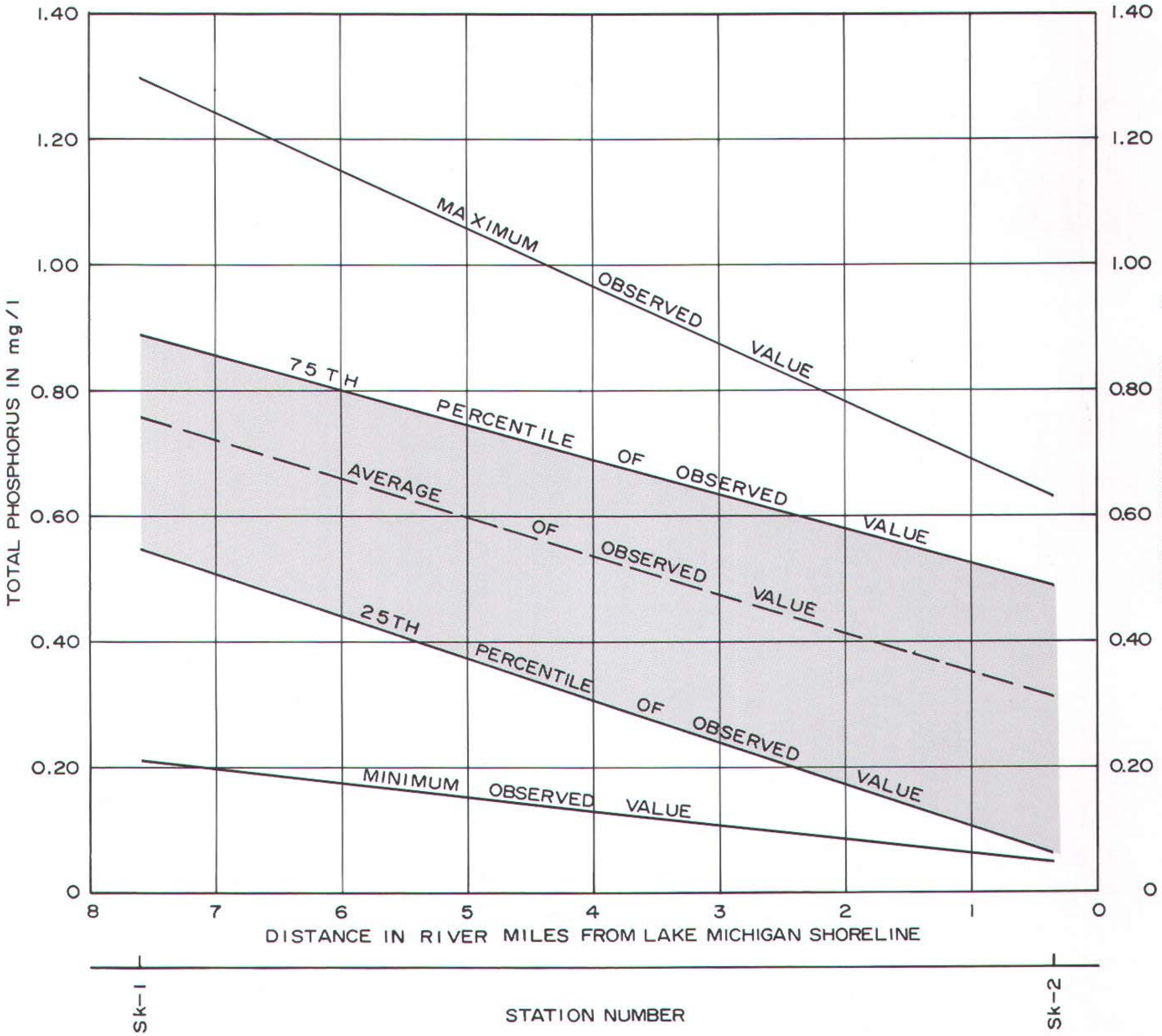


Source: SEWRPC.

The comparison of observed water quality and the adopted water quality standards or recommended levels was based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the adopted standards, whereas critical values of the last three parameters are recommended levels which have been adopted by the Commission. In the analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, did not fall within the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month

Figure 226

SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE SAUK CREEK WATERSHED: 1972-1975



Source: SEWRPC.

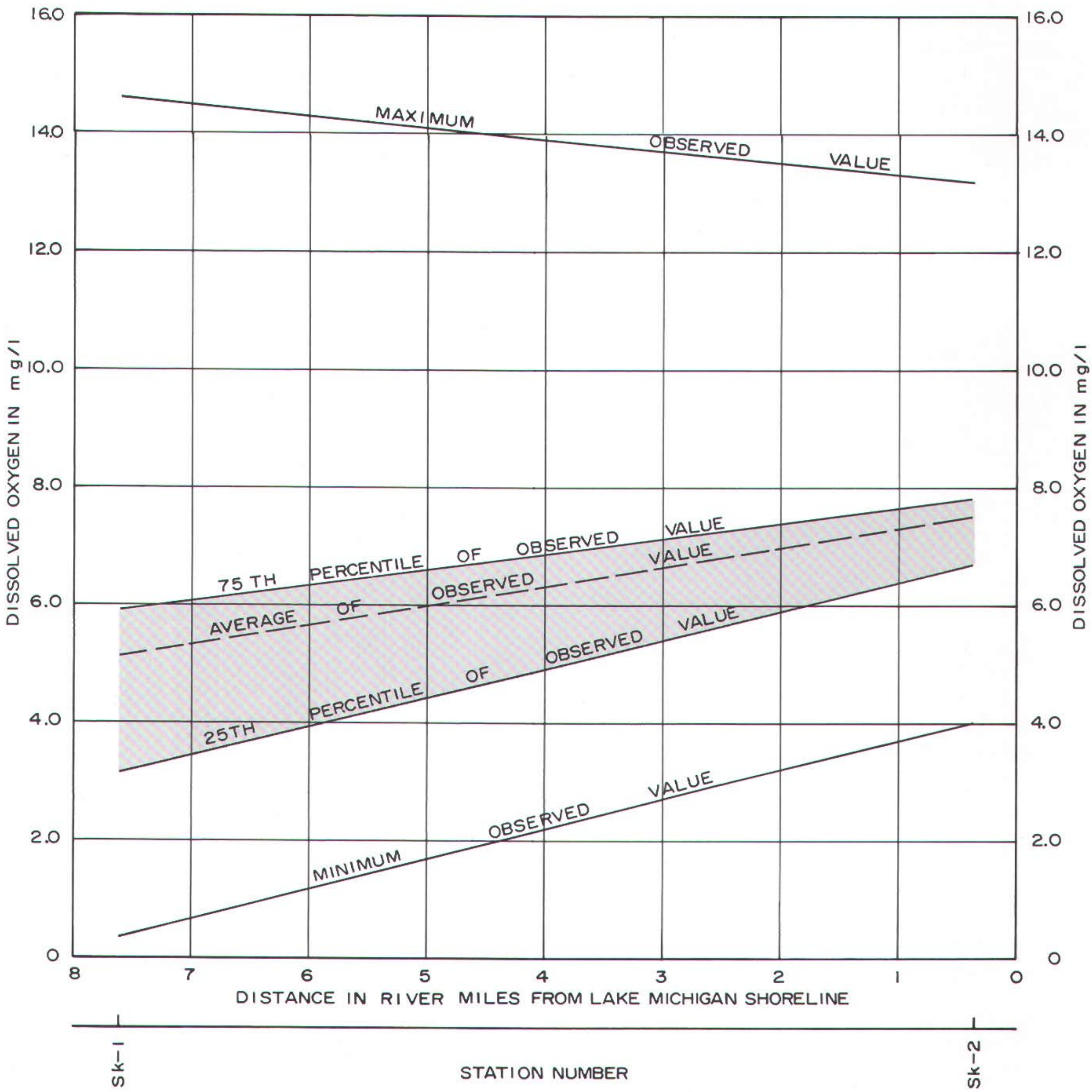
nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standard associated with the recreational use objective were assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 81. A color coding scheme is used on Map 81 to indicate which of the standards are exceeded and where along the stream.

For Sauk Creek, intended for recreational use and preservation of fish and aquatic life, water quality during the

Figure 227

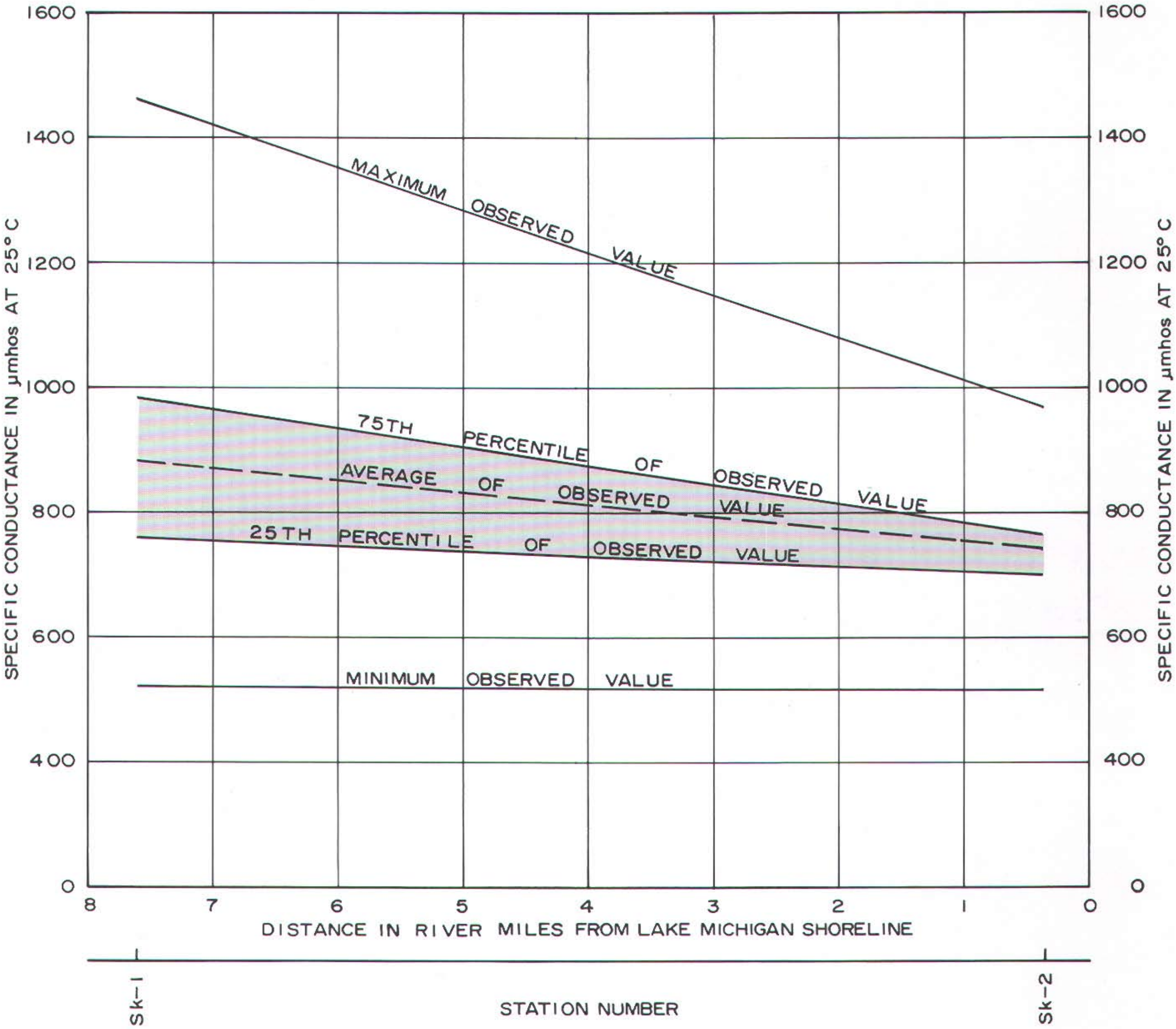
SPATIAL DISTRIBUTION OF DISSOLVED OXYGEN CONCENTRATIONS IN THE SAUK CREEK WATERSHED: 1968-1975



Source: SEWRPC.

Figure 228

SPATIAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN THE SAUK CREEK WATERSHED: 1968-1975



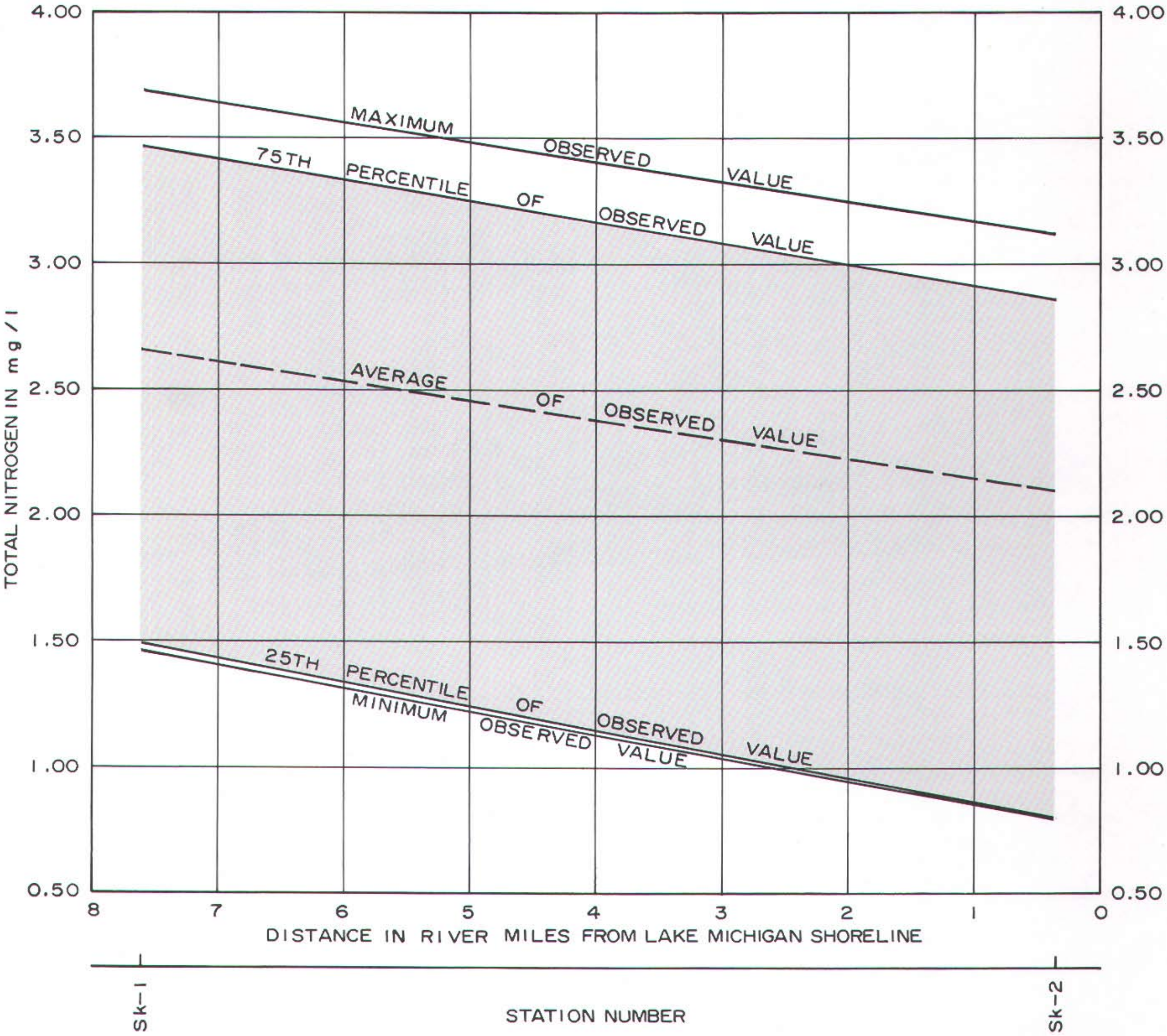
Source: SEWRPC.

survey satisfied the temperature, dissolved oxygen, and pH standards throughout the watershed. Since no fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made for the 1964 samples, no comparison to the nutrient contents and bacteriological safety of the Sauk Creek water for 1964 can be made. However, since the total coliform counts in the Sauk Creek were greater than 3,000 MFCC/100 ml with an average of 20,000 MFCC/100 ml for 12 months, it is probable that the fecal coliform counts were higher than the permissible limit.

Water Quality-1975: Map 82 indicates that water quality conditions during August 1975 were such that the ammonia, temperature, and pH standards or recommended levels were satisfied throughout the watershed, while substandard levels of nitrate, total phosphorus, and fecal coliform were recorded. Substandard dissolved oxygen concentrations—less than 2.0 mg/l occurred at sampling station Sk-1 located 7.6 miles upstream from the mouth. At sampling station Sk-2, the established water quality standards of 5.0 mg/l were met

Figure 229

SPATIAL DISTRIBUTION OF TOTAL NITROGEN CONCENTRATIONS IN THE SAUK CREEK WATERSHED: 1972-1975



Source: SEWRPC.

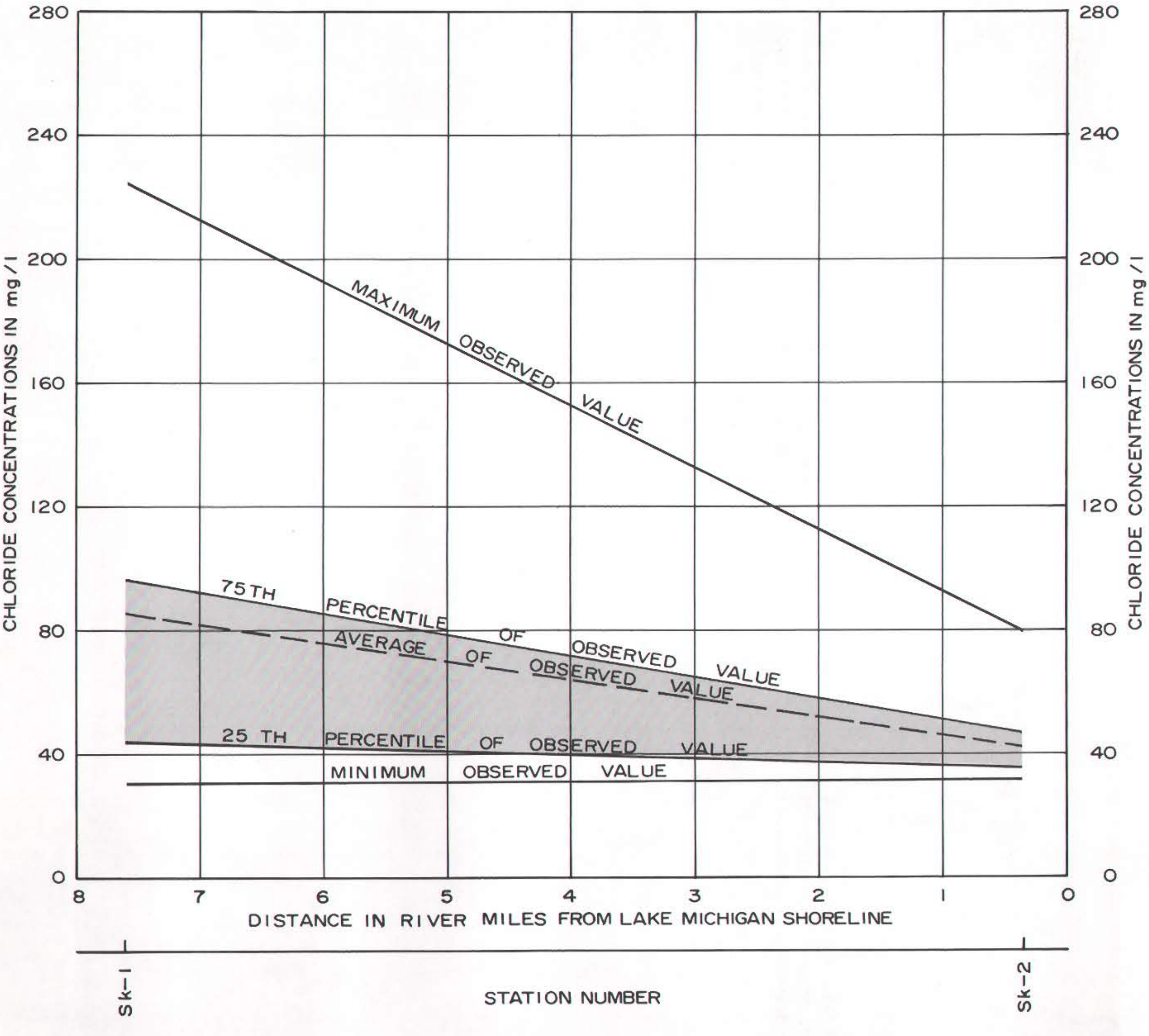
in the August 1975 sample. The fecal coliform limit of 400 MFFCC/100 ml was exceeded all along the main stem of Sauk Creek. Total phosphorus and nitrate-nitrogen were in excess of the levels recommended by the Commission—0.10 mg/l as P and 0.30 mg/l as N, respectively—the entire length of Sauk Creek. The high nitrate and high total phosphorus concentrations at sampling station Sk-1 and sampling station Sk-2 can be attributed to the runoff from the agricultural land use predominant in the watershed.

Concluding Remarks—Sauk Creek Watershed

The Sauk Creek watershed is located in the northeast portion of the Region, and all but 0.88 square miles of the 33.71-square-mile area of the watershed lies within the Region. Sauk Creek, the main stream draining the watershed, rises just outside the Region in the Town of Holland in southwest Sheboygan County, and flows 16.6 miles southerly and easterly to discharge to Lake Michigan in the City of Port Washington. The Sauk Creek watershed ranks eleventh in population and ninth in

Figure 230

SPATIAL DISTRIBUTION OF CHLORIDE CONCENTRATIONS IN THE SAUK CREEK WATERSHED: 1968-1975



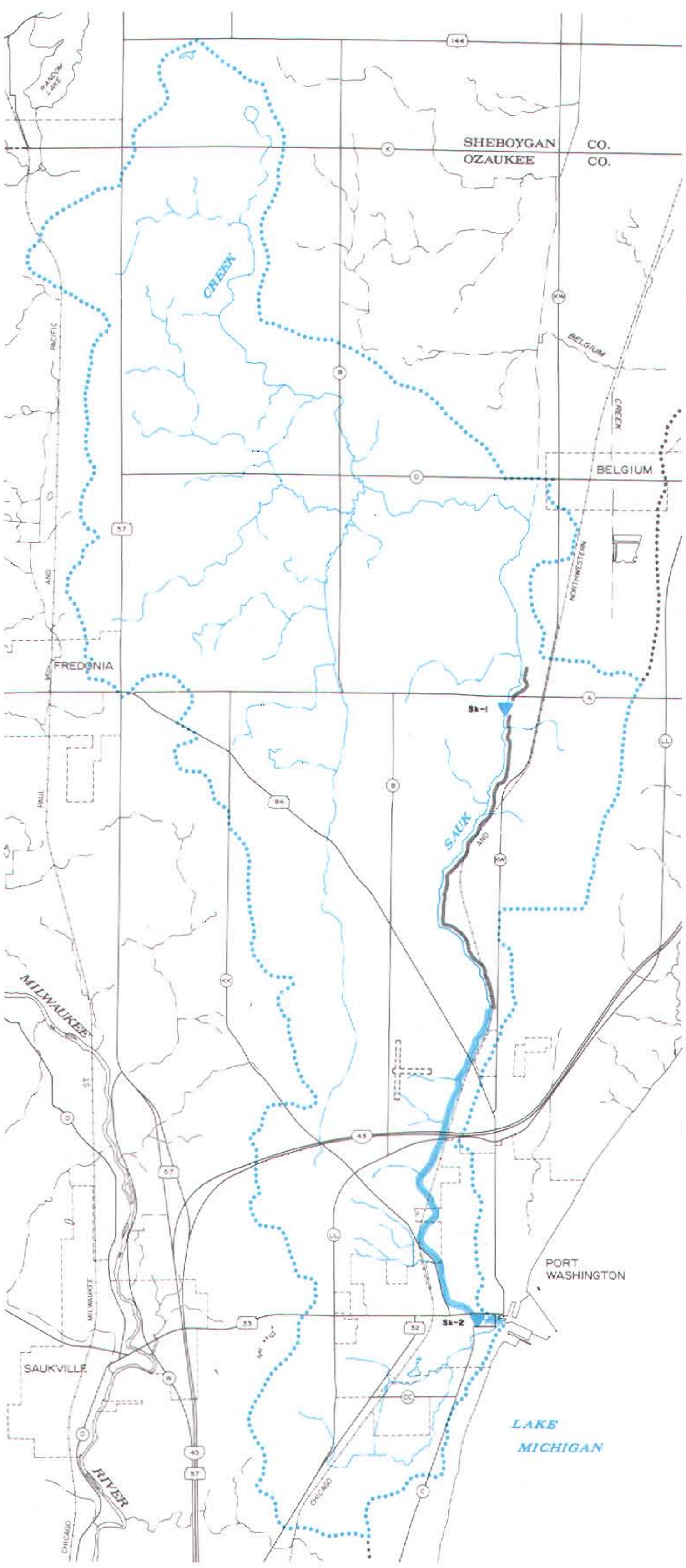
Source: SEWRPC.

size of the 12 watersheds of the Region. An estimated 7,377 persons reside within this watershed, which has an average population density of 214 people per square mile. The principal land use is agricultural, which covers about 88 percent of the total area of the watershed.

There are no known publicly owned or privately owned nonindustrial sewage treatment facilities in the watershed. There are two known sanitary sewer bypasses that discharge raw sewage into Sauk Creek during periods of sanitary sewer system surcharge. Three industrial waste outfalls exist in the watershed. The Cedar Valley Cheese Factory has a private treatment facility and discharges the effluent and cooling waters; the Allis Chalmers, Inc., outfall discharges cooling waters; and the Murphy Oil Corporation discharges wash waters which pass through oil separators into Sauk Creek. The Commission 1970 land use inventory indicates that about 88 percent of the

Map 81

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE SAUK CREEK WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



LEGEND

SAMPLING STATION AND DESIGNATION

- SEWRPC Sk-1

EXISTING SEWAGE TREATMENT FACILITIES

- PUBLIC
- NONINDUSTRIAL (PRIVATE)
- INDUSTRIAL SEWAGE TREATMENT FACILITY OR OTHER INDUSTRIAL DISCHARGE

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION

STANDARD VS. CONCENTRATION 1964

- (NONE) DISSOLVED OXYGEN BELOW 5.0mg/l
- FECAL COLIFORM COLONIES IN EXCESS OF 400 MFFCC/100ml (AS BASED ON 9 PERCENT OF THE TOTAL COLIFORM COUNT)
- (NONE) FECAL COLIFORM IN EXCESS OF 2,000 MFFCC/100ml (AS BASED ON 9 PERCENT OF THE TOTAL COLIFORM COUNT)
- (NONE) DISSOLVED OXYGEN BELOW 2.0mg/l
- (NONE) TEMPERATURE IN EXCESS OF 89°F
- (NONE) pH OUTSIDE THE 6.0 – 9.0 RANGE
- NO DATA FOR INTERPRETATION
- STREAM REACHES WHERE WATER QUALITY STANDARDS WERE MET FOR ALL PARAMETERS

STANDARD VS. CONCENTRATION 1975

- TOTAL PHOSPHORUS (P) IN EXCESS OF 0.1mg/l
- (NONE) DISSOLVED OXYGEN BELOW 5.0mg/l
- (NONE) FECAL COLIFORM COLONIES IN EXCESS OF 400 MFFCC/100ml
- (NONE) AMMONIA (NH_3) IN EXCESS OF 2.5mg/l
- FECAL COLIFORM COLONIES IN EXCESS OF 2,000 MFFCC/100ml
- NITRATE (NO_3) IN EXCESS OF 0.3mg/l
- DISSOLVED OXYGEN BELOW 2.0mg/l
- (NONE) TEMPERATURE IN EXCESS OF 89°F
- (NONE) pH OUTSIDE THE 6.0 – 9.0 RANGE
- NO DATA FOR INTERPRETATION
- (NONE) STREAM REACHES WHERE WATER QUALITY STANDARDS WERE MET FOR ALL PARAMETERS

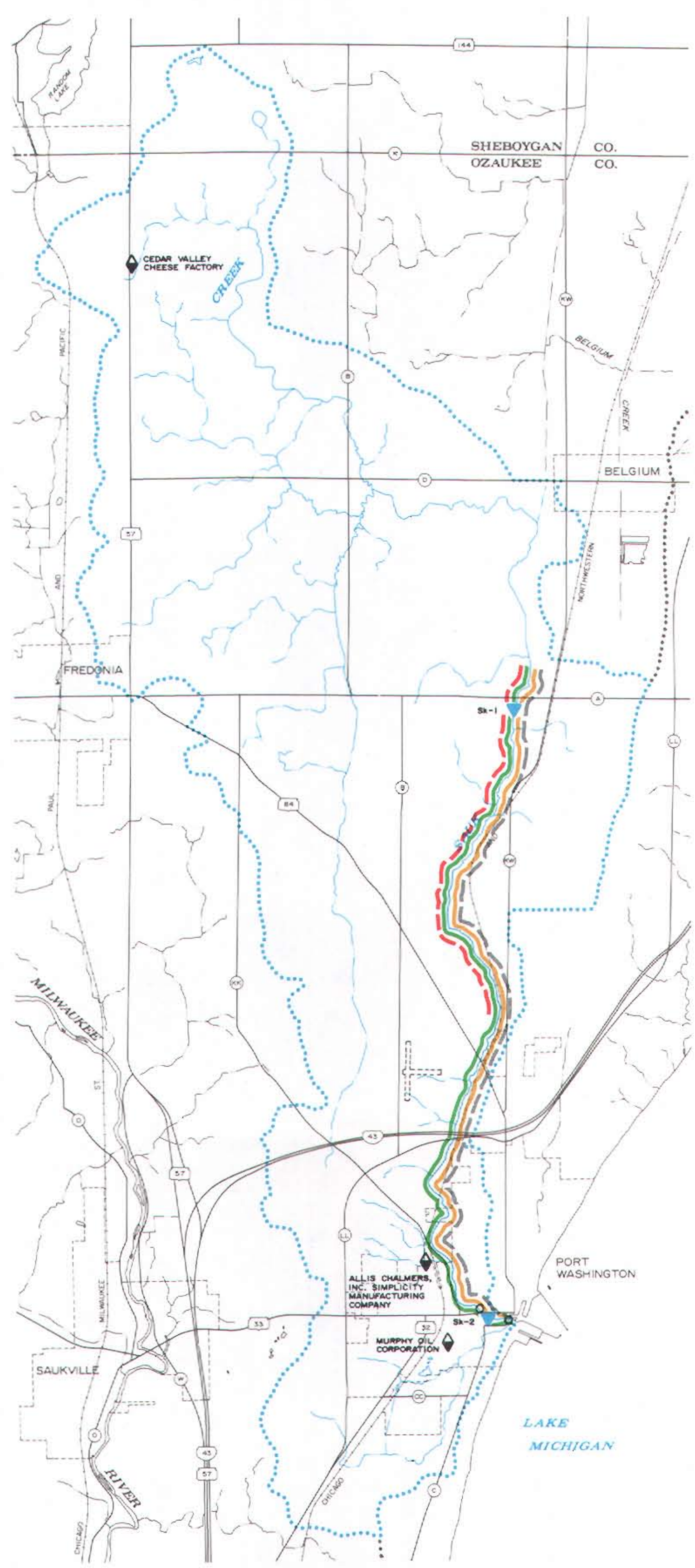
GRAPHIC SCALE

A comparison of the stream water quality in the Sauk Creek watershed as sampled in August 1964 to the adopted water quality standards indicated that all standards were satisfied at sampling station Sk-2 and all standards except total coliform and estimated fecal coliform were met for station Sk-1.

Source: SEWRPC.

Map 82

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE SAUK CREEK WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Sauk Creek watershed as sampled in August 1975 to the adopted water quality standards indicated that the recommended levels for total phosphorus and nitrate-nitrogen and the standard for fecal coliform were exceeded at both sampling stations Sk-1 and Sk-2. In addition, the dissolved oxygen standard was violated at station Sk-1.

Source: SEWRPC.

total area of the watershed is devoted to agricultural use, 9 percent to urban use, and the remaining 3 percent is occupied by the stream network itself. About 75 percent of the shoreline area within 1,000 feet of the streams of the watershed is presently in agricultural use. Therefore, runoff from the agricultural lands of the watershed may be expected to have a significant effect on water quality conditions in the watershed.

The 1964-1965 Commission water quality benchmark study included two sampling stations in the Sauk Creek watershed. The water quality data for 1964-1965 from these two sampling stations indicated that chloride levels were higher than the normal background concentration and reflected a chloride impact upon the stream from human sources. Dissolved oxygen concentrations were found to be greater than 5.0 mg/l during the summer months at both the stations on the main stem of Sauk Creek. High total coliform counts were found at both stations and may be attributed to the drainage from agricultural and urban land and waste from wildlife and domestic animals. The specific conductance values were found to be high at both stations, with the highest values at the sample station located near the headwater area. The pH was found to be within the normal range of 6.0 to 9.0 standard units and the temperature did not exceed the prescribed standard of 89°F for any samples. In general, water quality conditions in Sauk Creek were better at sampling station Sk-2 located in Port Washington, than at sampling station Sk-1 which is located in the rural portion of the watershed and approximately 7.25 miles upstream from sampling station Sk-2.

The water quality monitoring survey carried out by the Commission from 1965 through 1975 included the collection of samples at the two stations originally established in the Sauk Creek watershed. The dissolved oxygen content of the samples collected at the Sauk Creek stations indicated a decline in oxygen content from 1964 to 1971 with a stabilization in that content from 1971 through 1975. The chloride concentrations decreased over the period, and no significant trend in fecal coliform counts was observed at the two sampling stations. The nutrient concentrations, as mreasured by nitrate-nitrogen and total phosphorus, remained high, in excess of the recommended water quality levels of 0.30 mg/l as N and 0.10 mg/l as P, respectively, in all but two of the samples collected over the past eight years. The diurnal water quality data available for Sauk Creek indicated a range of dissolved oxygen concentrations from a low of 3.1 to a high of 8.4 mg/l over a 24-hour period. In addition to exhibiting marked diurnal fluctuations, the water quality conditions of Sauk Creek were characterized by spatial variations. Water quality conditions generally improved from sampling station Sk-1 to Sk-2, as measured by the lower concentrations of specific conductance, chloride, nutrients, and fecal coliform counts and by the increase in the dissolved oxygen concentration at sampling station Sk-2.

The water quality of Sauk Creek, intended for recreational use and for the preservation of fish and aquatic life, as measured at two Commission water quality sampling stations, does not currently meet the water quality standards set by the Wisconsin Department of Natural Resources for dissolved oxygen and fecal coliform counts. Total phosphorus and nitrate concentrations also were found to be higher than the levels recommended by the Commission for the avoidance of nuisance aquatic plant growth in the stream system which discharges to Lake Michigan. The more severe water quality problems were found to be indicated in the samples from sampling station Sk-1 in the rural headwaters area of the watershed and dominated by the effects of agricultural land use.

SHEBOYGAN RIVER WATERSHED

Regional Setting

The Sheboygan River watershed is a natural surface water drainage unit, partially located within the Region, in the northeast portion of Ozaukee County. The major portion of the watershed is located in Sheboygan County outside of the Region. The small portion of the watershed located in the Region is 11.43 square miles in areal extent and encompasses 82 percent of the Village and parts of the Town of Belgium. The boundaries of the basin, together with the locations of the tributaries of the Sheboygan River which are located in the Region, are shown on Map 83. The portion of the Sheboygan River watershed within the Region ranks twelfth in population and twelfth in size as compared to the other 11 watersheds of the Region. The only perennial stream of the Sheboygan River watershed within the Region is Belgium Creek, which is a tributary to the Onion River, a first rank tributary to the Sheboygan River. Table 217 lists the tributary, its location, the source, and the length in miles from the Sheboygan County line.

Political Boundaries

The portion of the watershed within the Region lies in Ozaukee County and, as shown on Map 83, in the Village of Belgium and parts of the Town of Belgium. The area and proportion of the watershed lying within the jurisdiction of each of these three general purpose local units of government as of January 1, 1976, are shown in Table 218.

Population

Population Size: The 1975 resident population of the watershed within the Region is estimated at 1,005 persons, or about 1 percent of the total estimated resident population of the Region of 1,789,871. Table 219 presents the population distribution in the Sheboygan River watershed within the Region by civil division.

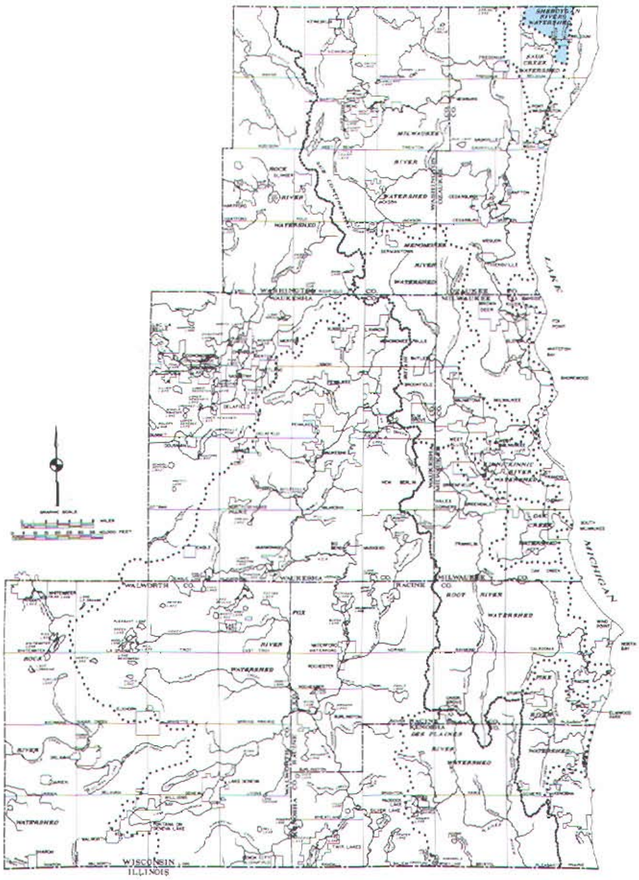
Population Distribution: Presently, about 64.2 percent of the residents of the watershed live in the incorporated Village of Belgium, the area of which comprises about 4.7 percent of the watershed within the Region.

Quantity of Surface Water

Surface water in the Sheboygan River watershed, which consists primarily of portions of Belgium Creek, is made up almost entirely of flowing streams. No streamflow data are available, however, to evaluate the seasonal

Map 83

LOCATION OF THE SHEBOYGAN RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Sheboygan River watershed has a total area of about 11.5 square miles and comprises less than 1 percent of the total 2,689 square mile area of the Region. The portion of the watershed contained in the Region ranks twelfth in population and twelfth in size as compared to the twelve watersheds of the Region.

Source: SEWRPC.

variations of the flow of these streams. The available flow information for the other watersheds of the Region indicates that higher streamflows may be expected to occur principally in the late winter and early spring, usually associated with melting snow, and that lower flows may be expected to persist for most of the remainder of the year with occasional rises caused by rainfall.

Pollution Sources

The following types of pollution sources have been identified in the watershed area within the Region and are discussed below: a municipal sewage treatment facility, a sanitary sewerage system overflow point, an industrial wastewater drainage, urban storm water runoff, and agricultural runoff.

Sewage Treatment Facility: The Village of Belgium operates the only public sewage treatment facility within the watershed, and the effluent from this facility is discharged to Belgium Creek. Selected data relating to this publicly-owned sewage treatment facility, are presented in Table 220 and Map 84. There are no known nonindustrial privately owned sewage treatment facilities in operation within this watershed.

Domestic Onsite Sewage Disposal Systems: Although certain areas of the watershed lie within existing and proposed service areas of public sanitary sewerage systems, some areas of the watershed are still served by septic tanks. These systems may constitute a source of surface water pollution by surface ponding of malfunctioning systems and by groundwater contributions which discharge to the streams.

Sanitary Sewerage System Flow Relief Points: One known sanitary sewerage system flow relief point through which raw sanitary sewage may be discharged to the surface water system exists within the watershed—the Village of Belgium sewage treatment plant bypass. This bypass is designed to discharge to the Onion River, as shown in Table 221.

Table 217

STREAMS IN THE SHEBOYGAN RIVER WATERSHED

Stream or Watercourse	Source		Length (in miles)
	By Civil Division	By U. S. Public Land Survey	
Belgium Creek	Village of Belgium	NW ¼, Section 3, T12N, R22E	0.23

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 218

AREAL EXTENT OF CIVIL DIVISIONS IN THE SHEBOYGAN RIVER WATERSHED: 1975

Civil Division	Area Within Watershed (square miles)	Percent of Watershed Area Within Civil Division	Percent of Civil Division Area Within Watershed
OZAUKEE COUNTY			
Village			
Belgium	0.54	4.72	81.82
Town			
Belgium	10.89	95.28	29.43
County Subtotal	11.43	100.00	4.86
Total	11.43	100.00	--

Source: SEWRPC.

Table 219

ESTIMATED RESIDENT POPULATION OF SHEBOYGAN RIVER WATERSHED BY CIVIL DIVISION: 1975

Civil Division	1975 Population
OZAUKEE COUNTY	
Village	
Belgium (part)	645
Town	
Belgium (part)	360
Ozaukee County (part) Subtotal	1,005
Sheboygan River Watershed (part) Total	1,005

Source: SEWRPC.

Industrial Waste Discharges: Data and information provided by the Wisconsin Pollutant Discharge Elimination System and reports required by Chapter NR101 of the Wisconsin Administrative Code were used to identify the one known industrial waste outfall in the watershed that serves the Krier Preserving Company located in the Town of Belgium. The industry operates a treatment facility, and the available data relating to this privately owned sewage treatment facility which discharges treated wastes through three outfalls to the Onion River via a drainage ditch and groundwater are presented in Table 222.[21]

Pollution from Urban Runoff: Existing land use information relating to the watershed taken from the Commission 1970 land use inventory is presented in Table 223. The urbanized areas of the Sheboygan River watershed within the Region, although comprising only about 6 percent of the total area of the watershed within the Region, may have an effect on the stream water quality due to the discharge of contaminants—organic, inorganic, and pathogenic—from urbanized areas of the Village of Belgium.

Pollution from Rural Land: Existing land use information relating to the watershed taken from the Commission 1970 land use inventory is presented in Table 223. These data indicate that 382 acres, or about 6 percent of the total area of the Sheboygan River watershed area within the Region, are devoted to urban land uses; 6,077 acres, or about 92 percent of the total area of the watershed, are devoted to rural land uses, primarily agriculture; and 139 acres, or about 2 percent of the total area of the watershed, are covered by streams. A shoreland development survey by the Wisconsin Department of Natural Resources indicates that about 94 percent of the shoreland area within 1,000 feet of Belgium Creek is used for agricultural purposes, and about 6 percent of the

[21] *All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on Map 84. The map also identifies only the known municipal sewage treatment facilities that were in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exist to establish which of these pollution sources existed at that time and which have been added since 1964.*

Table 220

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN THE SHEBOYGAN RIVER WATERSHED IN THE REGION: 1975

Name	Total Area Served (square miles)	Estimated Total Population Served	Date of Construction and Major Modification	Type of Treatment	Level of Treatment Provided	Disposal of Effluent	Design Capacity					Existing Loading	
							Population[a]	Average Hydraulic (mgd)	Peak Hydraulic (mgd)	Average Organic	Population[a] Equivalent	Average Hydraulic (mgd)	Average Per Capita (gpd)
Village of Belgium . .	0.36	900	1949, 1970	Activated Sludge Disinfection	Secondary Auxiliary	Tributary of Onion River	1,200	0.07	0.10	N/A	N/A	0.07	78

NOTE: N/A indicates data not available.

[a] *The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design BOD_5 loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of BOD_5 per day. If the design engineer assumed a different daily per capita contribution of BOD_5, the population equivalent design capacity will differ from the population design capacity shown in the table.*

Source: SEWRPC.

Table 221

KNOWN COMBINED SEWER OUTFALLS AND OTHER FLOW RELIEF DEVICES IN THE SHEBOYGAN RIVER WATERSHED BY RECEIVING STREAM AND CIVIL DIVISION: 1975

Receiving Stream	Civil Division	Combined Sewer Outfalls	Crossovers	Other Flow Relief Devices			Total
				Bypasses	Relief Pumping Stations	Portable Pumping Stations	
Onion River . . .	Village of Belgium	0	0	1	0	0	1
Total	--	0	0	1	0	0	1

Source: SEWRPC.

Table 222

KNOWN INDUSTRIAL WASTE DISCHARGES OTHER THAN SEWAGE TREATMENT PLANTS IN THE SHEBOYGAN RIVER WATERSHED: 1975

Name	Standard Industrial Classification Code	Civil Division Location	Type of Wastewater	Known Treatment	Outfall Number	Receiving Water Body	Reported Average Annual Hydraulic Discharge Rate (gallons per day)[a]	Reported Maximum Monthly Hydraulic Discharge Rate (gallons per day)[a]
SHEBOYGAN COUNTY								
Krier Preserving Company	2033	Town of Belgium	Process	Lagoon	1	Onion River via Drainage Ditch	Intermittent	N/A
			Cooling	N/A	2	Onion River via Drainage Ditch	29,600	30,000
			Process	Lagoon and Spray Irrigation	3	Groundwater	550,000	1,100,000

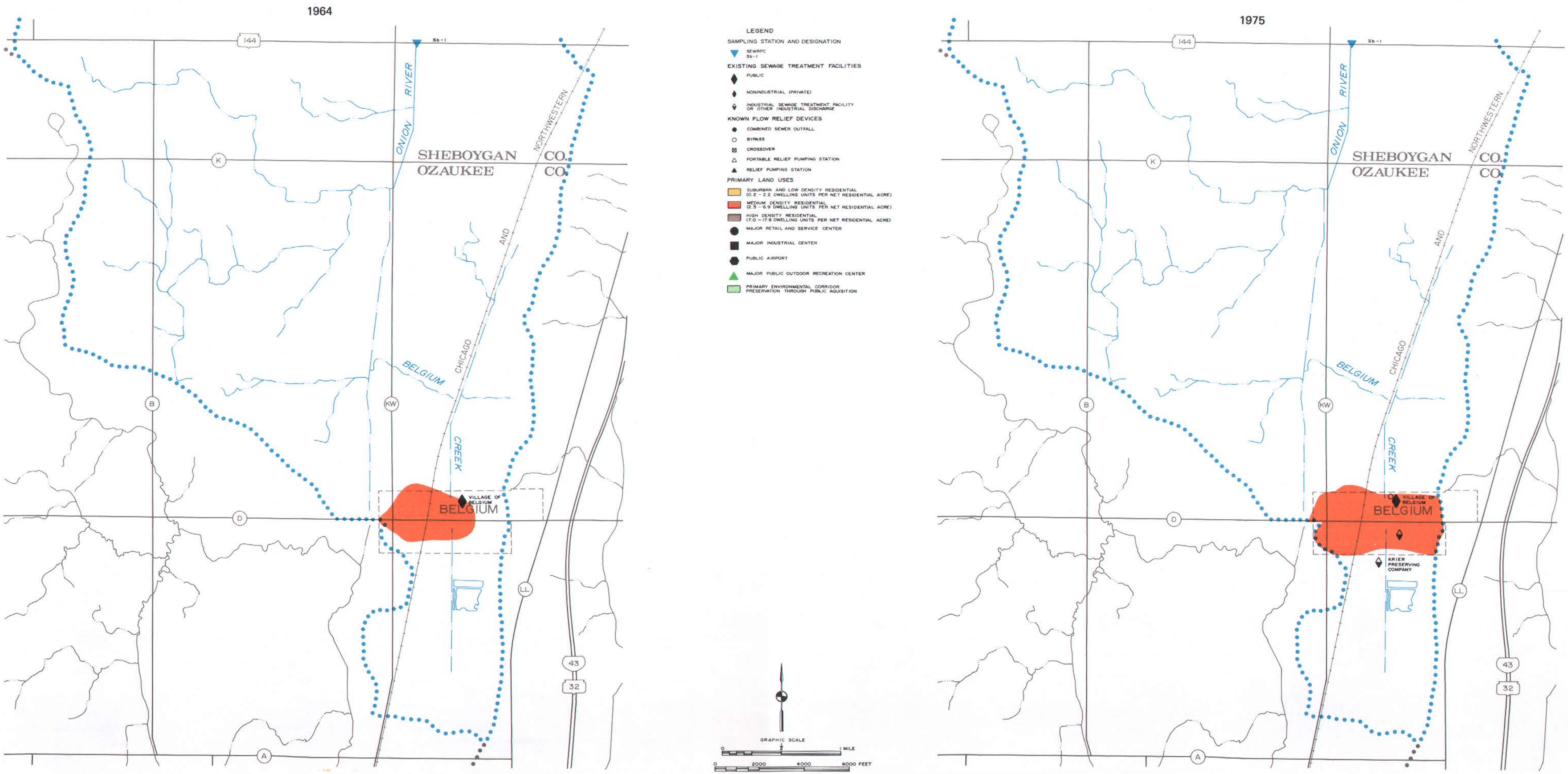
NOTE: N/A indicates data not available.

[a] *Unless specifically noted otherwise, data were obtained from quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code or from the Wisconsin Pollutant Discharge Elimination System permit itself in the above-cited order of priority. In some cases when 12 months of flow data were not reported, the average annual and maximum monthly hydraulic discharge rates were estimated from the available monthly discharge data or from the flow data as reported in the permit.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 84

LOCATION OF STREAM SAMPLING STATIONS, EXISTING PUBLIC SEWAGE TREATMENT FACILITIES, INDUSTRIAL WASTE DISCHARGES, SEWAGE FLOW RELIEF DEVICES, AND LAND USE IN THE SHEBOYGAN RIVER WATERSHED: 1964-1975



Stream water quality was obtained from chemical, physical, biochemical, or bacteriological analyses of water samples collected at the single sampling station located in the Sheboygan River watershed. These data were analyzed to determine the water quality conditions of the streams over time as affected by one public sewage treatment facility, one sewer bypass, and one industrial facility which discharges wastewater through three outfalls.

NOTE: All known municipal sewage treatment plants, nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices in operation as of 1975 are identified on the 1975 map. The 1964 map identifies only the known municipal sewage treatment facilities in operation in 1964 based upon inventories conducted by the Commission and published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin. Inventories of nonindustrial private sewage treatment plants, industrial waste discharges, and sewage flow relief devices were not conducted by the Commission in 1964. Many of the pollution sources inventoried in 1975 existed in 1964; however, no inventory data exists to establish which of these pollution sources existed in 1964 and which have been added since 1964.

Source: SEWRPC.

Table 223

LAND USE IN THE SHEBOYGAN RIVER WATERSHED: 1963 AND 1970

Categories	1963		1970	
	Acres	Percent	Acres	Percent
Urban Land Uses				
Residential	118.44		124.98	
Commercial	9.64		12.90	
Industrial	9.09		9.62	
Transportation and Utilities	205.01		209.24	
Government	13.90		16.55	
Recreation	3.95		3.95	
Landfill and Dump	5.05		5.05	
Total	365.08	5.53	382.29	5.79
Rural Land Uses				
Open Land	610.32		609.80	
Agricultural Lands	5,467.20		5,467.35	
Total	6,077.52	92.10	6,077.15	92.10
Water Covered Lands				
Lakes, Rivers, and Streams	56.32		42.36	
Wetlands, etc.	99.99		97.08	
Total	156.31	2.37	139.44	2.11
Watershed Totals	6,598.91	100.00	6,598.88	100.00

Source: SEWRPC.

shoreland within 1,000 feet of the Belgium Creek is used for low-intensity residential development purposes. The rural areas of the watershed, constituting well over 90 percent of the total land of the watershed, can be expected to have a significant effect on stream water quality.

Other Pollution Sources: The Commission 1970 land use inventory indicated that, in addition to the pollution sources described above, a sanitary landfill site is located on the shore of an intermittent tributary to Belgium Creek in the Town of Belgium. Seepage and runoff from the sanitary landfill may contribute to the pollution of the River system.

Water Quality Conditions of the Sheboygan River Watershed

Water Quality Data: Of the water quality data sources described in Chapter II, two were used in the analysis of water quality trends in the Sheboygan River watershed study: (1) the Commission benchmark study, and (2) the Commission continuing monitoring program.

Belgium Creek was the only stream studied in the Sheboygan River watershed within the Region. Belgium Creek, which rises near the Village of Belgium in northeastern Ozaukee County, is a tributary of the Onion River, which flows into the Sheboygan River in the City of Sheboygan Falls. Sampling station Sb-1 (as presented in Table 224) was established on Belgium Creek, at a point about one-half mile downstream from the perennial source of the stream. Map 84 illustrates the location of the sampling station in the watershed.

Surface Water Quality of the Sheboygan River Watershed 1964-1965: Water quality conditions in the watershed as determined by 1964-1965 sampling survey at sampling station Sb-1 are summarized in Table 225. The results for chloride, dissolved oxygen, and total coliform bacteria are particularly relevant to the assessment of trends in surface water quality.

Chloride: During the sampling year of 1964-1965, two samples were collected at sampling station Sb-1 and analyzed for chloride. The resulting values were 30 and 20 mg/l for April and October 1964, respectively. Although no data on groundwater chloride concentrations are available for the area within the watershed, the groundwater chloride concentrations in adjacent portions of the Milwaukee River watershed area were found to be approximately 10 mg/l, and it is reasonable to assume the same value for the Sheboygan River watershed within the

Table 224

DESIGNATION AND LOCATION OF THE SEWRPC SAMPLING STATION IN THE SHEBOYGAN RIVER WATERSHED

Source	Sampling Station Designation	Sampling Station Location	Distance from the County Line (in miles)
SEWRPC	Sb-1	STH 144 east of CTH KW, SW ¼, Section 27, T13N, R22E	- 1.4

Source: SEWRPC.

Table 225

WATER QUALITY CONDITIONS OF BELGIUM CREEK, A TRIBUTARY OF THE SHEBOYGAN RIVER: 1964-1965

Source	Parameter	Numerical Value			Number of Analyses
		Maximum	Average	Minimum	
Belgium Creek—Sb-1	Chloride (mg/l)	30	25	20	2
	Dissolved Solids (mg/l)	675	635	590	2
	Dissolved Oxygen (mg/l)	16.5	9.7	1.0	11
	Total Coliform Count (MFCC/100 ml)	200,000	24,000	2,000	11
	Temperature (^{O}F)	87	53	32	11

Source: SEWRPC.

Region. Since the observed values are higher than the assumed groundwater chloride concentrations in the surface water, the difference is attributed to the discharge of sewage treatment plant effluents and the contribution of storm water runoff to the stream.

Dissolved Oxygen: During the sampling year of 1964-1965, the dissolved oxygen levels in the watershed ranged from 1.0 to 16.5 mg/l, with an average value of 9.7 mg/l. Once during the 1964-1965 sampling period, on September 30, 1964, the dissolved oxygen was observed to be less than 5.0 mg/l. As discussed below in the section on water quality trends, the data for the years 1971-1975 indicate a significant diurnal variation in the dissolved oxygen at sampling station Sb-1, with three or four of the six samples taken during a 24-hour period being less than 5.0 mg/l.

Biochemical Oxygen Demand: The five-day biochemical oxygen demand (BOD_5) on the Belgium Creek during the sampling period of 1964-1965 was found to range from a low of 1.7 mg/l to a high of 24.0 mg/l. The highest BOD_5 values were found during February at sampling location Sb-1. Since 92 percent of the portion of the watershed within the Region is in agricultural land use, the high BOD_5 in the sample collected in February 1965 indicates the probable source as agricultural runoff from the improper spreading of manure on the frozen lands during winter. Another possible source for the BOD_5 in the stream may be effluent from the sewage treatment facility at the Village of Belgium.

Total Coliform Bacteria: During the year 1964-1965, the membrane filter coliform count was found to vary from less than 2,000 to 200,000 MFCC/100 ml, with an average value of 24,127 MFCC/100 ml. The highest total coliform counts occurred during the month of September, as did the lowest dissolved oxygen content. The high coliform counts coinciding with the low dissolved oxygen concentration observed at sampling station Sb-1 in September, indicate the effect of organic pollution, arising primarily from human and animal wastes. The discharge of sewage effluent from the Village of Belgium sewage treatment facility is the probable cause of the high total coliform and low dissolved oxygen in the sample collected on September 30, 1964. With the exception of the data from September 1964 and February 1965, when the total coliform counts were 200,000 and 19,000 MFCC/100 ml, respectively, the range of the total coliform counts at sampling station Sb-1 was between 2,000 and 10,000 MFCC/100 ml for the 1964-1965 sample period.

Specific Conductance: The two specific conductance values obtained at sampling station Sb-1 in the samples collected in April and October of 1964 were 756 and

800 µmhos/cm at 25°C, respectively. These values are considerably higher than average, however typical of the elevated values for specific conductance throughout the Region.

Hydrogen Ion Concentration (pH): The pH values at sampling station Sb-1 in Belgium Creek were found to range from 7.4 to 8.3 standard units in the three samples collected during the sampling year 1964-1965. The pH was therefore found to be in the range of 6.0 to 9.0 standard units, prescribed for support of recreational use as well as maintenance of fish and aquatic life, the water use objective of Belgium Creek in the Sheboygan River watershed within the Region.

Temperature: During the year 1964-1965, the temperature of water samples from Belgium Creek ranged between 32°F and 52°F during the months of December through April, and ranged between 47°F and 86°F during the months of May through November. The temperature variations, therefore, may be ascribed primarily to the seasonal changes.

Water Quality Trends from 1965 to 1975: Water quality data obtained in the watershed during the period from 1965 to 1975 for eight summer sampling programs, three spring sampling programs, and one fall sampling program, are presented in tabular form in Appendix D of this report. The eight summer sampling surveys began in August 1968 and involved collection of multiple samples each year during one day in August—generally the low-flow season. An analysis of the flow data from "Water Resources Data for Wisconsin," published by U. S. Geological Survey, indicates that, for the streams in southeastern Wisconsin, low flow generally occurs during the months of August and September. Although the collection and analysis of one sample per station per year cannot represent water quality conditions for the whole year, it may be assumed to reasonably represent the water quality conditions of the stream at that location during the low-flow period which is generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life.

The summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for sampling station Sb-1 on Belgium Creek in the Sheboygan River watershed sampled by the Commission since 1968 is set forth in Table 226.

Dissolved Oxygen: The range of dissolved oxygen in Belgium Creek in the Sheboygan River watershed, as measured at sampling station Sb-1 for the years 1968-1975, was 1.1 to 13.6 mg/l, with an average of 6.1 mg/l. Although the eight-year average dissolved oxygen concentrations were above 5.0 mg/l, individual dissolved oxygen concentrations were lower than 5.0 mg/l during six out of eight sampling surveys and all six of the diurnal

Table 226

WATER QUALITY CONDITIONS IN THE SHEBOYGAN RIVER WATERSHED AT SAMPLING STATION SB-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value: Maximum	Numerical Value: Average	Numerical Value: Minimum	Number of Analyses	Number of Times the Recommended Standard/Level Was Not Met
Chloride (mg/l)	--	63.0	25.5	9.0	22	--
Dissolved Oxygen (mg/l)	5.0	13.6	6.1	1.1	30	16[a]
Ammonia-N (mg/l)	2.5	1.12	0.22	0.00	8	0
Organic-N (mg/l)	--	3.55	1.37	0.62	8	--
Total-N (mg/l)	--	8.74	3.31	1.15	8	--
Specific Conductance (µmhos/cm at 25°C)	--	1,041	735	569	30	--
Nitrite-N (mg/l)	--	0.32	0.08	0.01	12	--
Nitrate-N (mg/l)	0.3	3.75	1.16	0.09	12	10
Soluble Orthophosphate-P (mg/l)	--	1.13	0.49	0.01	11	--
Total Phosphorus (mg/l)	0.1	0.92	0.43	0.06	8	7
Fecal Coliform (MFFCC/100 ml)	400	14,000	2,088	100	12	8
Temperature (°F)	89.0	80.0	69.1	64.0	30	0
Hydrogen Ion Concentrations (standard units)	6-9	8.9	8.1	7.6	22	0

[a] *The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

sampling surveys from the year 1970 through 1975. Map 85 presents the average dissolved oxygen concentrations that were found in August 1964 and August 1975 in Belgium Creek of the Sheboygan River watershed. The graph inserts illustrate the change in daily average dissolved oxygen concentrations as observed on the sampling dates in August of each intermediate year at Sb-1. On August 13, 1964, as indicated on the map, the dissolved oxygen levels were greater than 5.0 mg/l. Similar results, i.e., the levels of dissolved oxygen, greater than 5.0 mg/l at Sb-1 were observed on August 26, 1975. The graph insert on Map 85 presents the dissolved oxygen concentration and three-year moving averages at Sb-1 in the August samples during the period from 1964 through 1975. The dissolved oxygen concentrations decreased from 1964 through 1970 and increased from 1970 through 1975 as measured by the daily average concentrations found on the sampling days.

A comparison of dissolved oxygen concentrations found in April and August 1968 and 1969 indicates that the dissolved oxygen concentrations remained high in April and August of each year. The dissolved oxygen concentrations were found to be in the range of 8.3 to 11.8 mg/l—at or above saturation levels—in April and August of the years 1968 and 1969.

Chloride: The chloride concentrations were found to be in the range of 9 to 63 mg/l, with the higher concentrations of 61 and 63 mg/l for the years 1972 and 1975, at sampling station Sb-1 on Belgium Creek in eight sampling surveys during the years 1968 through 1975 (Map 86). The higher concentrations of the 1972 and 1975 samples were attributed to rainfall which occurred prior to sampling, as measured at the Port Washington weather station, about 10 miles distant. With the exception of the 1972 and 1975 chloride data, the range of chloride concentrations in the August samples from 1968 through 1975 was 17 to 25 mg/l, slightly higher than the area groundwater chloride concentrations. The concentrations of chloride in 1972 and 1975 samples were twice the normal summer chloride concentrations and were associated with rain which preceded the sampling period. The significant effect of the runoff from the agricultural land in the watershed is evident from the data of 1972 and 1975, compared with the data of 1968, 1969, 1970, 1971, 1973, and 1974 when there was no rain immediately prior to the sampling. Except for the flow difference, no long-term trend in water quality in the watershed as measured by chloride levels was observed.

Fecal Coliform Bacteria: Map 87, with a graph insert which presents the fecal coliform counts at the sampling location in Belgium Creek during the period from August 1968 through August 1975, represents changes in the daily average fecal coliform counts found on the sampling days during the intermediate years. The range of fecal coliform counts at sampling station Sb-1 for the samples taken from 1968 to 1975 was 100 to 14,000 MFFCC/100 ml with an average of 2,088 MFFCC/100 ml. The average values for five of the eight years of samples were higher than the adopted water quality standard of 400 MFFCC/100 ml. The graph on Map 87 indicates no trend in the fecal coliform counts with time at sampling station Sb-1 on the Belgium Creek. The high fecal coliform counts of greater than 1,000 MFFCC/100 ml in 1974 and 1975, when the chlorination step was in operation in the Village of Belgium sewage treatment plant, indicates possible bacteriological contamination from diffuse sources such as animal wastes disposed of in the subwatershed.

Hydrogen Ion Concentration (ph): As indicated in Table 226, the pH values of Belgium Creek in the Sheboygan River watershed were found to be within the range of 6.0 to 9.0 standard units prescribed for recreational use and maintenance of fish and aquatic life. No trend in pH variation of the August samples collected during the period of 1964 through 1975 were observed.

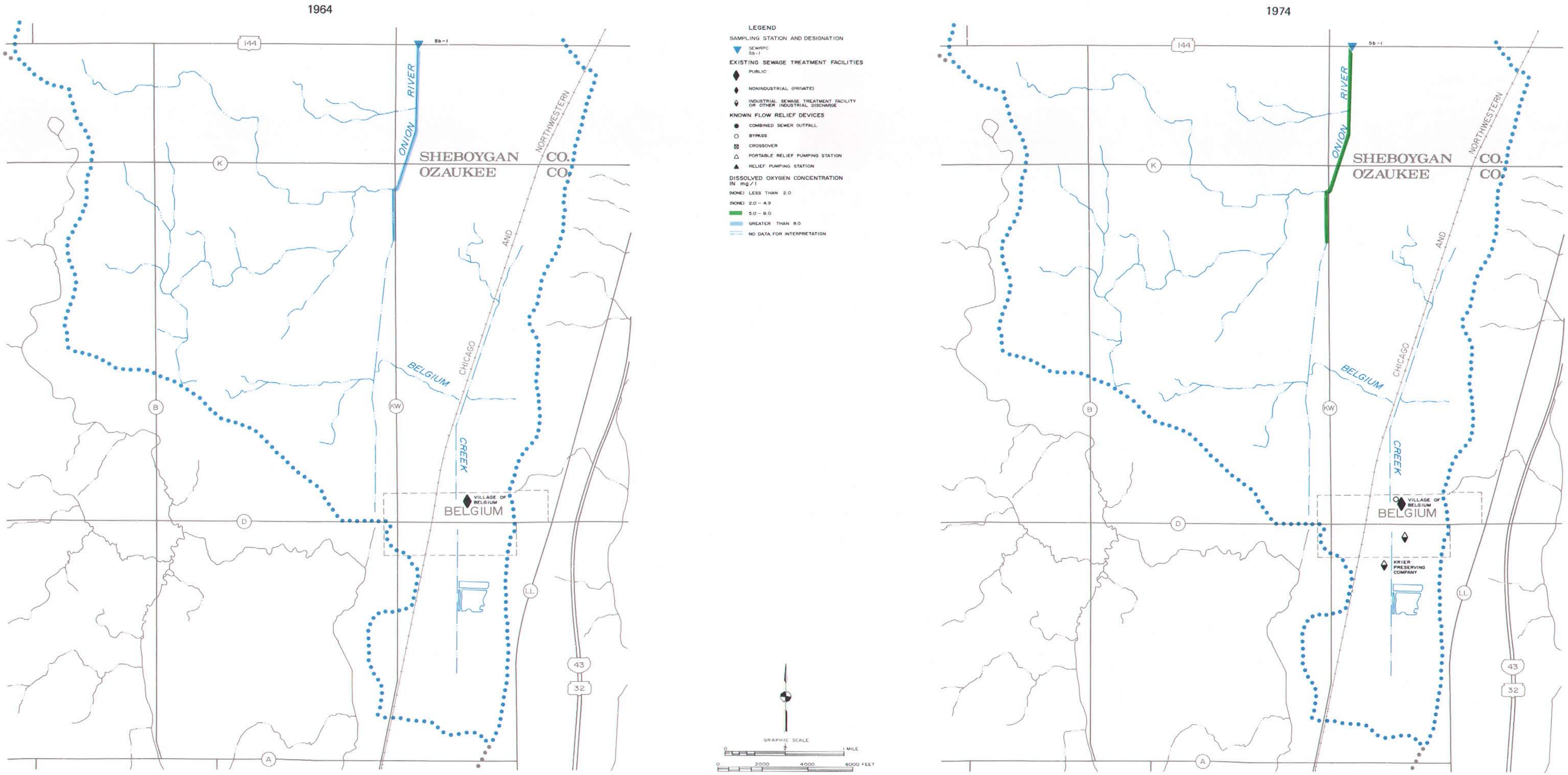
Specific Conductance: Specific conductance, a measure of total dissolved ions in water, was found to be in the range of 561 to 1,041 µmhos/cm at 25°C at sampling station Sb-1 on Belgium Creek on the days sampled during the period of 1968 through 1975. The specific conductance values were fairly constant except for the year 1972, when the sample was collected soon after a heavy rain and when the highest specific conductance value was observed. Since the land use data indicate 92 percent agricultural land in the subwatershed, runoff from these areas is a likely source for the higher specific conductance and consequently high dissolved solids.

Temperature: As indicated in Table 226, the temperature of the stream water of the watershed has remained below the 89°F standard established for fish and aquatic life. No trend in temperature variation was observed from August 1964 through August 1975 although seasonal fluctuations were noted.

Soluble Orthophosphate and Total Phosphorus: Water samples collected from the Belgium Creek sampling location during August from 1968 through 1975 were analyzed for soluble orthophosphate concentrations. A range of 0.01 to 1.13 mg/l of soluble orthophosphate as P was obtained during the eight sampling sessions (Figure 231). During the period from 1972 through 1975, the water samples also were analyzed for total phosphorus, and a range of 0.06-0.92 mg/l as P was obtained. The high ratio—ranging from 0.83 to 1.0—of soluble orthophosphate to total phosphorus in water samples indicates that most of the phosphorus present was in the form of soluble orthophosphate, which is the form most readily available for the growth of aquatic plants. Although not enough samples were available to characterize temporal trends in the total phosphorus concentrations, the soluble orthophosphate concentrations for which data are available for the period of 1968 through 1975, and which generally accounts for more than 83 percent of the total phosphorus, remained in the range of 0.4 to 0.5 mg/l as P with the exception of the sample collected in 1970, which was 1.13 mg/l as P. These values, although constant over the past several years were four to five times higher than 0.10 mg/l

Map 85

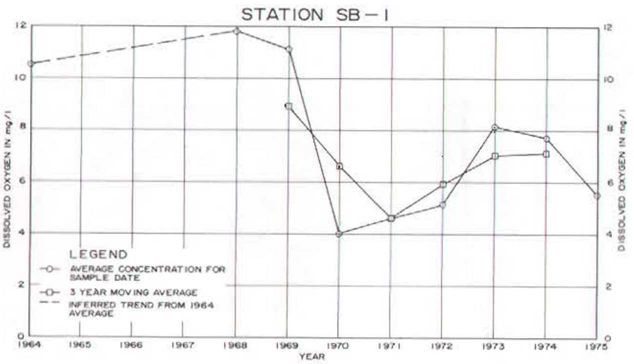
COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN AUGUST 1964-1974 IN THE SHEBOYGAN RIVER WATERSHED



A comparison of the dissolved oxygen levels recorded from 1964 to 1974 indicated that the dissolved oxygen concentration decreased at sampling station Sb-1. The maximum and minimum observed dissolved oxygen concentrations were 13.6 mg/l and 1.1 mg/l, respectively.

Source: SEWRPC.

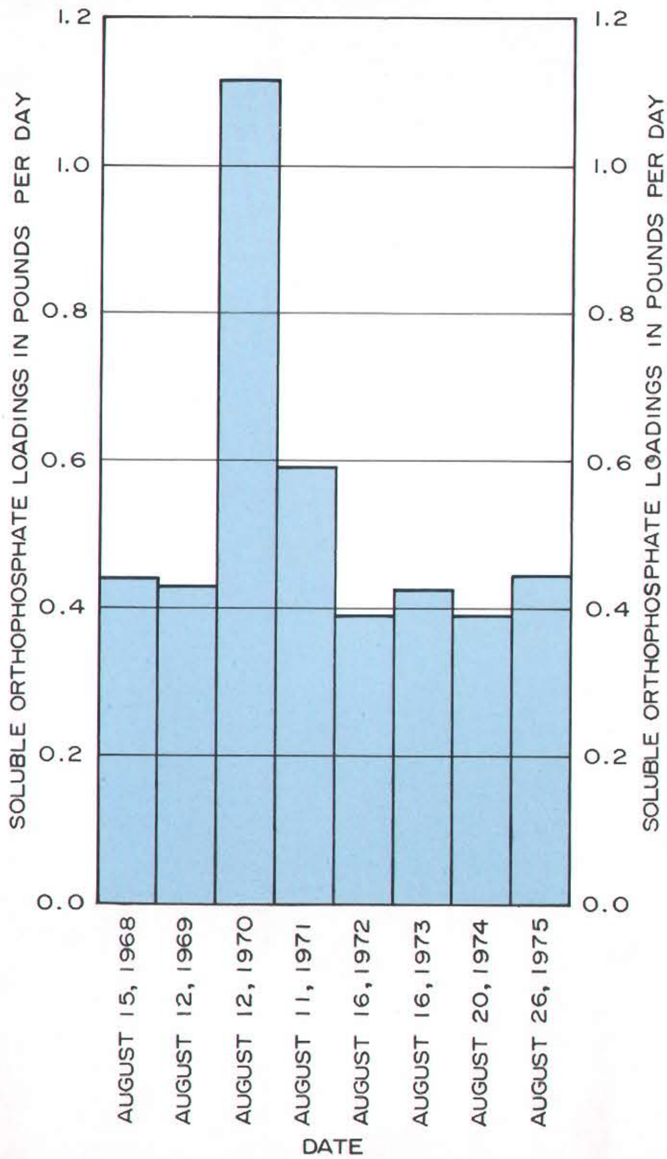
Map 85 (continued)



Source: SEWRPC.

Figure 231

SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS AT SAMPLING STATION SB-1 ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



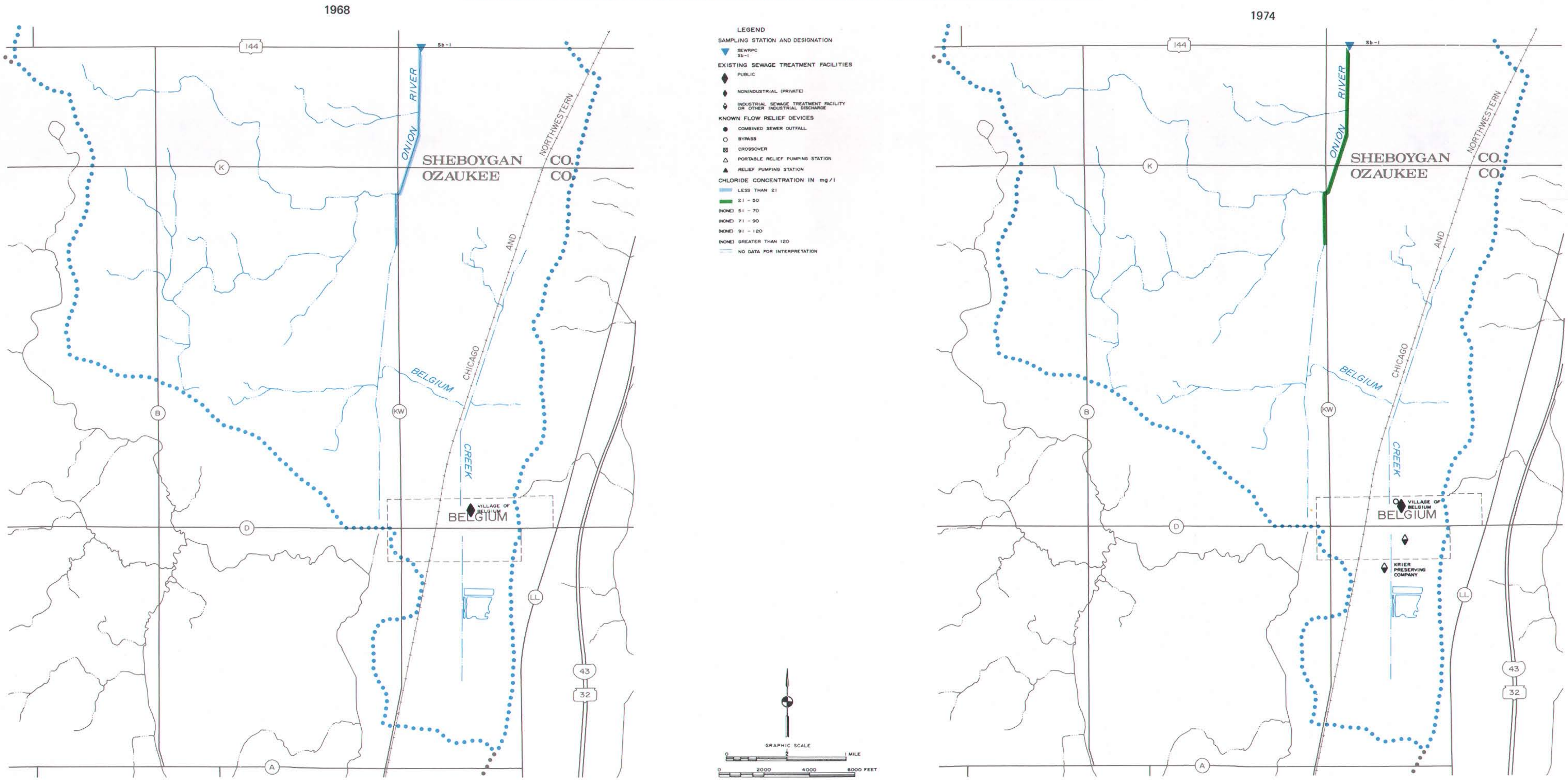
Source: SEWRPC.

total phosphorus as P, which is considered the threshold for nuisance growth of algae and other aquatic plants in flowing waters.

Nitrogen: As shown in Figure 232, the total nitrogen concentrations in Belgium Creek water samples collected during August 1972 through 1975 were in the range of 1.15 to 8.70 mg/l as N. Of the total nitrogen values recorded, 1 to 3 percent was in the form of nitrite nitrogen; 1 to 13 percent ammonia-nitrogen; 41 to 61 percent nitrate-nitrogen; and 36 to 44 percent organic-

Map 86

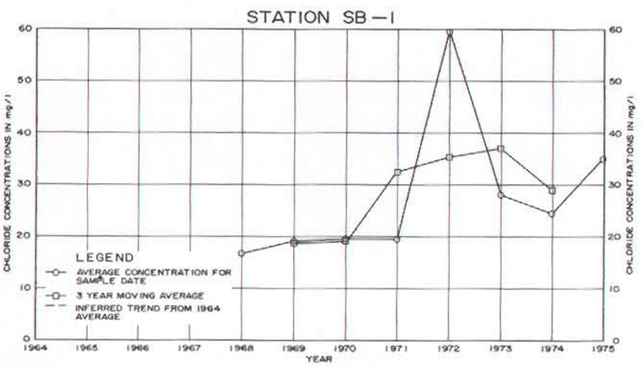
COMPARISON OF CHLORIDE CONCENTRATIONS IN AUGUST 1968-1974 IN THE SHEBOYGAN RIVER WATERSHED



A comparison of the chloride concentrations recorded from 1968 to 1974 indicated that chloride concentrations increased at sampling station Sb-1. The maximum and minimum observed chloride concentrations were 61 mg/l and 9 mg/l, respectively.

Source: SEWRPC.

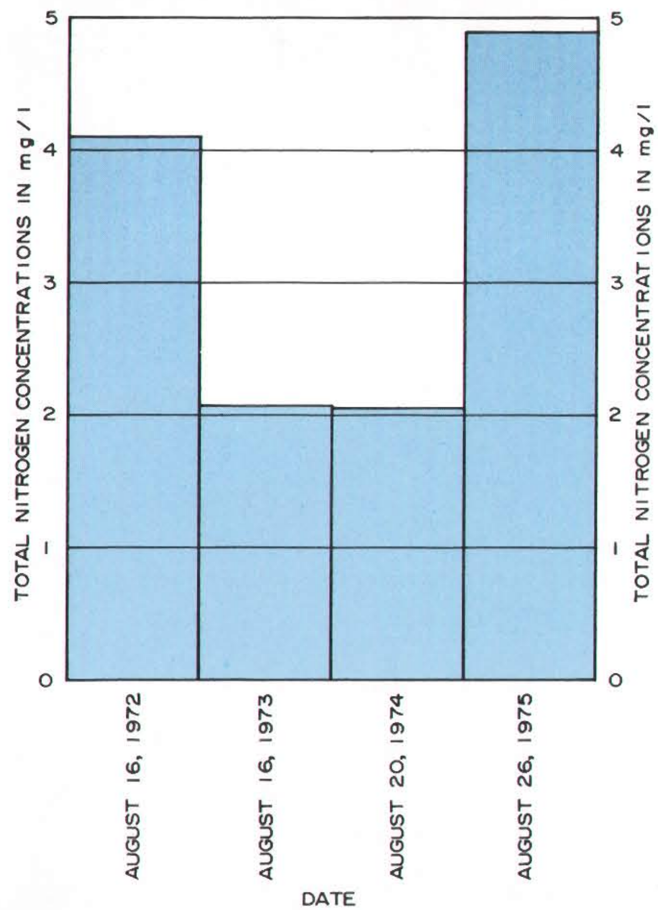
Map 86 (continued)



Source: SEWRPC.

Figure 232

TOTAL NITROGEN CONCENTRATIONS AT SAMPLING STATION SB-1 ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



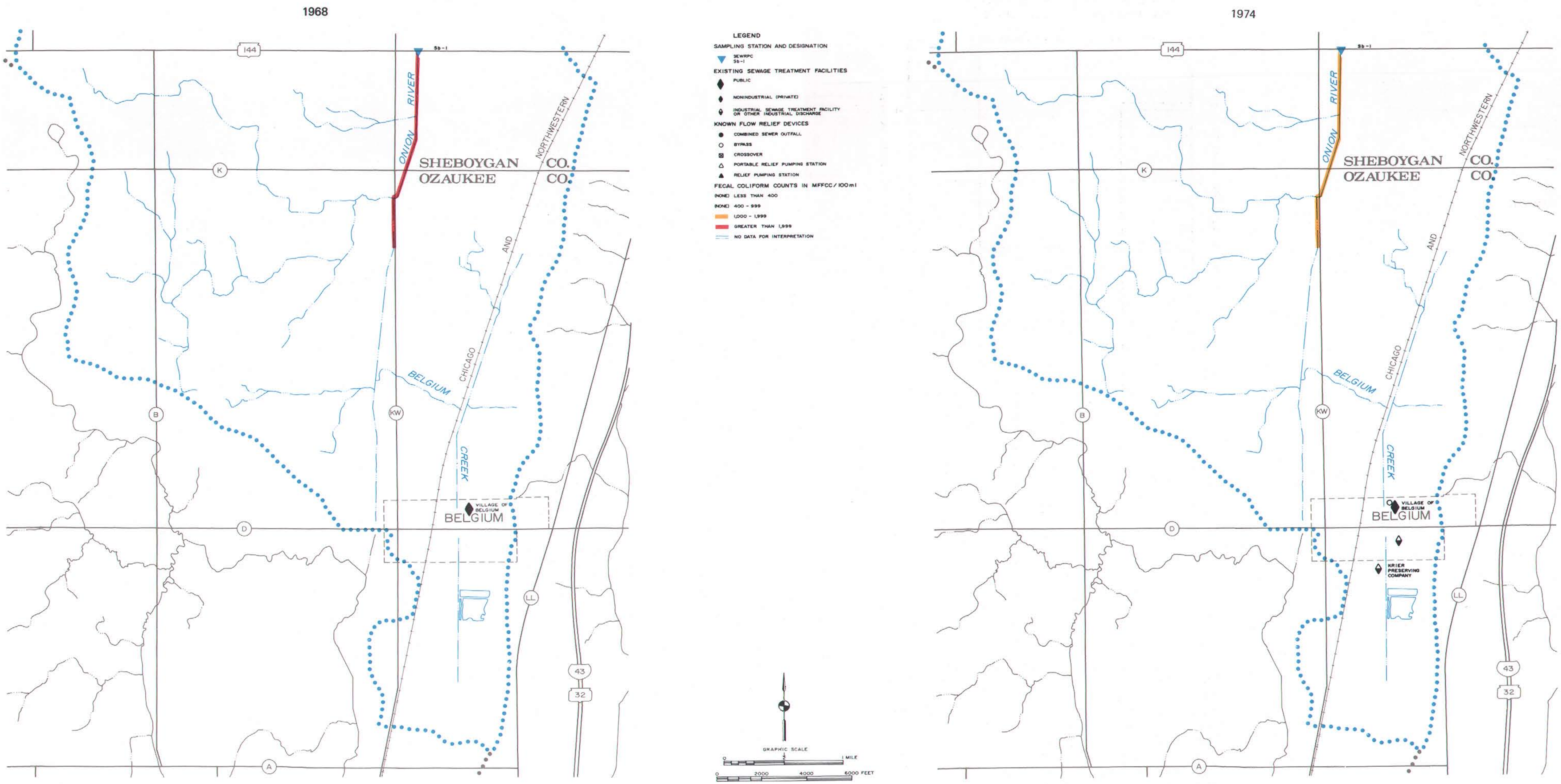
Source: SEWRPC.

nitrogen, with 53 to 62 percent of total nitrogen in the readily available form of nitrate-nitrogen and ammonia-nitrogen. The presence of ammonia-nitrogen in the stream water is chemical evidence of pollution of recent origin. The concentrations of ammonia-nitrogen in the Belgium Creek sampling sites ranged from 0.00 to 1.12 mg/l as N, which is less than the known toxic level of 2.5 mg/l for ammonia-nitrogen as N. On one of the seven sampling dates, ammonia-nitrogen did exceed 0.2 mg/l as N, the level generally held to be indicative of lakes and streams which are affected by pollution.

Nitrate-nitrogen concentrations in Belgium Creek of the Sheboygan River watershed ranged from 0.09 to 3.75 mg/l as N. Surface runoff from fields where there

Map 87

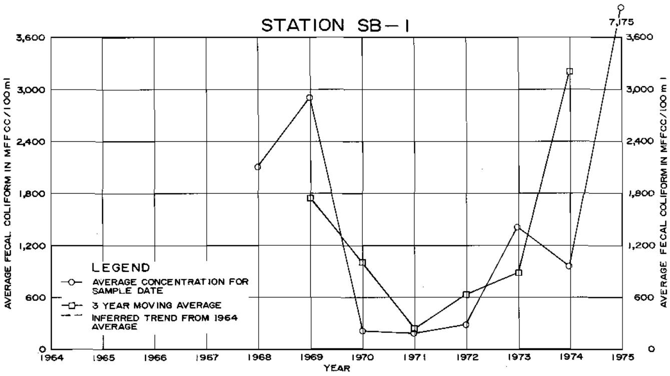
COMPARISON OF FECAL COLIFORM COUNTS IN AUGUST 1968-1974 IN THE SHEBOYGAN RIVER WATERSHED



A comparison of fecal coliform counts recorded from 1968 to 1974 in the Sheboygan River watershed indicated that fecal coliform counts decreased at sampling station Sb-1. The maximum and minimum recorded fecal coliform counts were 14,000 MFFCC/100 ml and 100 MFFCC/100 ml, respectively.

Source: SEWRPC.

Map 87 (continued)



Source: SEWRPC.

have been excessive or improper applications of natural or artificial fertilizers can contribute significant quantities of nitrate to the streams. Nitrates are also present in the treated municipal wastes and enter the receiving streams with the discharged effluent. For the samples collected at Sb-1 in Belgium Creek during the period of 1968 through 1975, all but two had nitrate-nitrogen levels greater than the recommended level of 0.30 mg/l. The major land use in the Belgium Creek subwatershed being agricultural, the source of nitrate-nitrogen in the watershed is likely to be runoff from the agricultural land. The presence of organic-nitrogen is directly related to the discharge of organic wastes, such as sewage or plant and animal decay products. The organic-nitrogen concentration ranged from 0.62 to 3.55 mg/l at sampling station Sb-1. The relatively high organic-nitrogen concentration of 1.0 mg/l or more at sampling station Sb-1 may have contributed to the reduction of dissolved oxygen concentrations since the oxidation step in the decomposition of organic-nitrogen compounds utilizes the oxygen present and reduces the dissolved oxygen content in the water.

Diurnal Water Quality Changes: Figure 233 through Figure 236 illustrate diurnal changes in temperature, chloride, dissolved oxygen, and pH that occurred during low-flow conditions on August 11, 1971, at the Belgium Creek sampling station.

Water temperature ranged from a low of 64°F during the early morning hours on August 11 to a high of 72°F during the early evening hours of that day for Belgium Creek. The recorded diurnal water temperature fluctuations at sampling station Sb-1 were probably due to corresponding diurnal variations in air temperature and solar radiation. Chloride concentrations ranged from a high of 16 mg/l during the early morning hours to a low of 24 mg/l during the evening of that day at Belgium Creek.

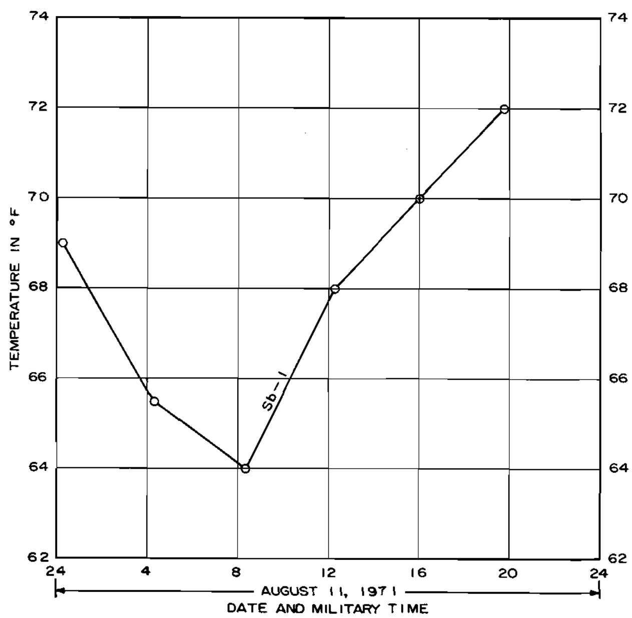
The concentrations of dissolved oxygen in the stream were found to vary from a low of 1.1 mg/l during the early morning hours to a high of 10.4 mg/l in the early evening hours. The variations in dissolved oxygen concentrations can be attributed to respiration and photosynthesis by algae and other aquatic plant.

The hydrogen ion concentration (pH) was found to vary from a low of 7.8 standard units during the early morning hours of August 11 to a high of 8.6 standard units in the late evening. The uptake of carbon dioxide during photosynthesis and the release of carbon dioxide during respiration by algae and aquatic plants probably accounted for the higher pH in the late evening samples and for the lower pH during the early morning hours.

The diurnal fluctuations in water quality may be such that the levels of concentrations of key parameters of some of the samples may meet the established water quality standards for recreational use and for preservation of fish and aquatic life, while the levels of concentrations of other samples collected on the same day may not meet

Figure 233

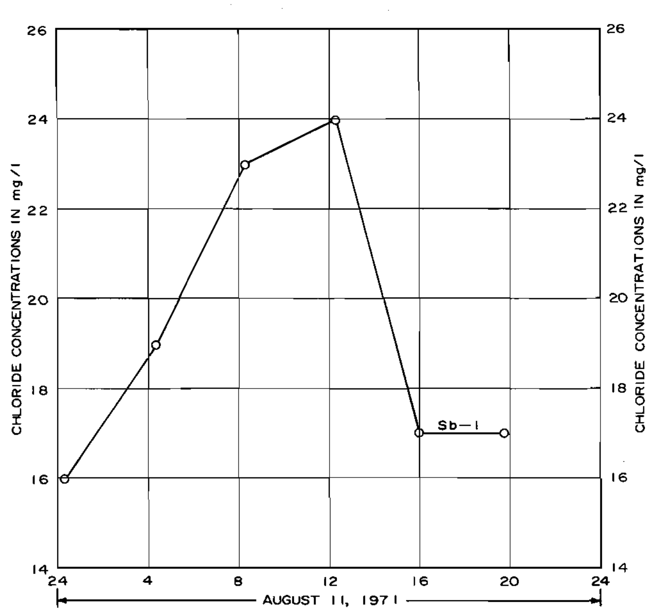
DIURNAL VARIATIONS IN TEMPERATURES RECORDED AT SAMPLING STATION SB-1 IN THE SHEBOYGAN RIVER WATERSHED AUGUST 11, 1971



Source: SEWRPC.

Figure 234

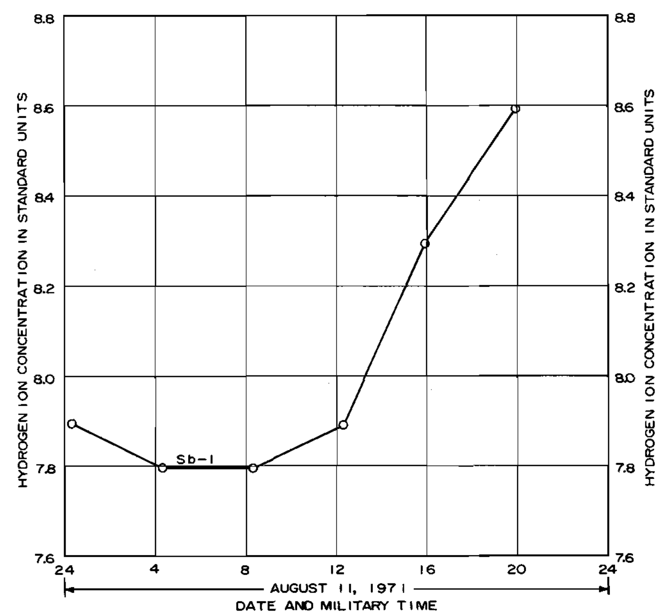
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS RECORDED AT SAMPLING STATION SB-1 IN THE SHEBOYGAN RIVER WATERSHED: AUGUST 11, 1971



Source: SEWRPC.

Figure 235

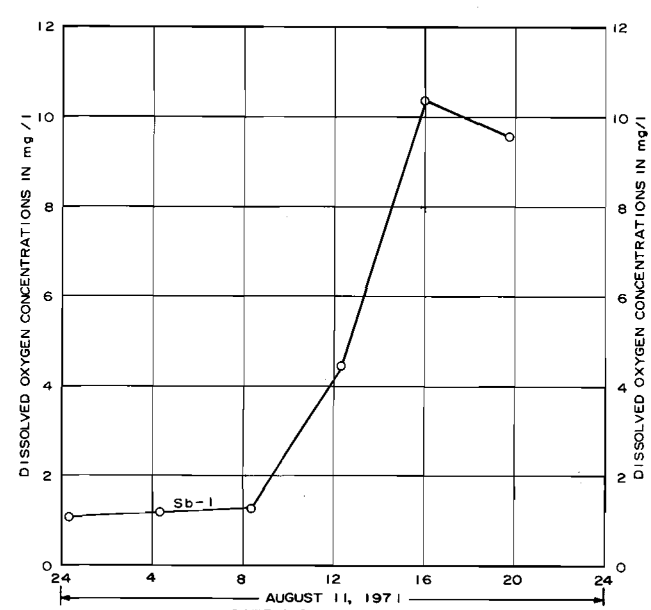
DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS IN THE SHEBOYGAN RIVER WATERSHED AUGUST 11, 1971



Source: SEWRPC.

Figure 236

DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS IN THE SHEBOYGAN RIVER WATERSHED AUGUST 11, 1971



Source: SEWRPC.

the standards. For example, two of six dissolved oxygen concentration values obtained at sampling station Sb-1 on August 11, 1971, were 9.6 and 10.4 mg/l, well above the minimum standard of 5.0 mg/l for recreational use and the preservation of fish and aquatic life. However, substandard oxygen levels of less than 5.0 mg/l were measured in four samples, with three samples having dissolved oxygen levels of less than 2.0 mg/l.

Spatial Water Quality Changes: Water quality monitoring data in the Sheboygan River watershed within the Region are available for only one sampling station, that established by the Commission on Belgium Creek. Therefore, spatial water quality changes in the Belgium Creek cannot be evaluated.

Assessment of Water Quality Relative to Water Quality Standards: The comprehensive water quality data obtained from the summer low-flow samples between 1964 and 1975 were used to assess the quality of Belgium Creek in the Sheboygan River watershed within the Region. This provides for an assessment of water quality as it existed on the days sampled between 1964 and 1975, and allows for an evaluation of the water quality changes compared to the water quality standards that support the recreational use objectives, as well as the fish and aquatic life use objectives established for Belgium Creek within the Region. Comparative analysis must consider the concurrent hydrologic conditions since the water quality standards are not intended to be satisfied under all streamflow conditions.

The comparison of observed water quality and the adopted water quality standards or recommended levels was based on seven parameters: temperature, dissolved oxygen, pH, fecal coliform bacteria, total phosphorus, ammonia, and nitrate. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels which have been adopted by the Commission. In the analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, did not fall within the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated. For example, the fecal coliform bacteria standard for the recreational water use objective states that fecal coliform counts shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml, in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standards associated with the recreational use objective were assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.

Water Quality-1964: The results of a comparative analysis of the water quality existing during August 1964 and the water quality set forth in the adopted standards are summarized on Map 88. A color coding scheme is used on Map 88 to indicate which of the standards are exceeded and along what stream reaches.

Belgium Creek within the Region has been designated for recreational use and preservation of fish and aquatic life. Water quality in this stream during the survey satisfied the temperature and dissolved oxygen standard at sampling station Sb-1. Since no pH, fecal coliform counts, nitrate, total phosphorus, or ammonia analyses were made in the 1964 samples, no comparison can be made to the nutrient contents and bacteriological safety of the waters of Belgium Creek of the Sheboygan River watershed for 1964. However, since the total coliform counts in Belgium Creek at sampling station Sb-1 were 10,000 MFCC/100 ml in the August 1964 samples, a probability exists of the fecal coliform counts being higher than the permissible limit.

Water Quality-1975: Map 89 indicates that water quality conditions during August 1975 were such that the ammonia, temperature, and pH standards were satisfied throughout the watershed while substandard levels of dissolved oxygen, nitrate, total phosphorus, and fecal coliform counts were recorded. Substandard dissolved oxygen concentrations—less than 5.0 mg/l—occurred in the early morning samples at sampling station Sb-1. The fecal coliform limit of 400 colonies per 100 ml was exceeded in the early morning samples at sampling station Sb-1, as was true with dissolved oxygen. Total phosphorus concentrations were in excess of the levels recommended by the Commission of 0.10 mg/l as P and nitrate-nitrogen in excess of 0.30 mg/l as N existed at sampling station Sb-1.

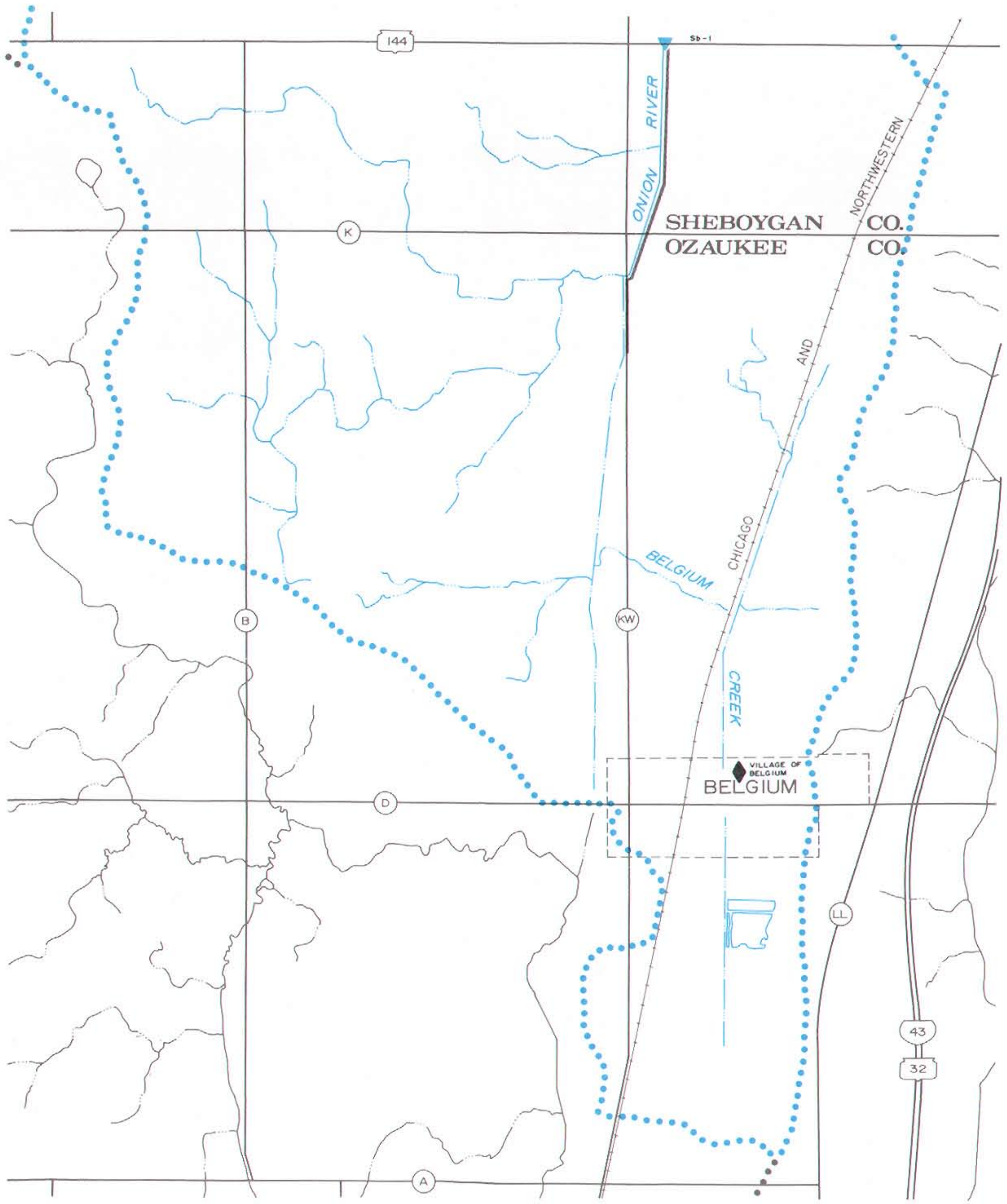
Concluding Remarks—Sheboygan River Watershed

The Sheboygan River watershed is located in the northern portion of Ozaukee County. The watershed is only partly contained in the Region; the major portion of the watershed is located in Sheboygan County. The only perennial stream of the Sheboygan River watershed within the Region is Belgium Creek, with a drainage area of 11.43 square miles. The watershed within the Region is markedly void of lakes. In 1975 an estimated 1,005 persons resided within this subwatershed in the Region with a population density of 87.8 people per square mile.

There is one publicly owned sewage treatment plant located within this watershed. No nonindustrial privately owned sewage treatment plants are located within the watershed. There is one sanitary sewer flow relief point in the watershed, that for the Village of Belgium sewage treatment plant emergency bypass. Krier Preserving Company in the Town of Belgium is the only industry

Map 88

COMPARISON OF AUGUST 1964 SURFACE WATER QUALITY IN THE SHEBOYGAN RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS

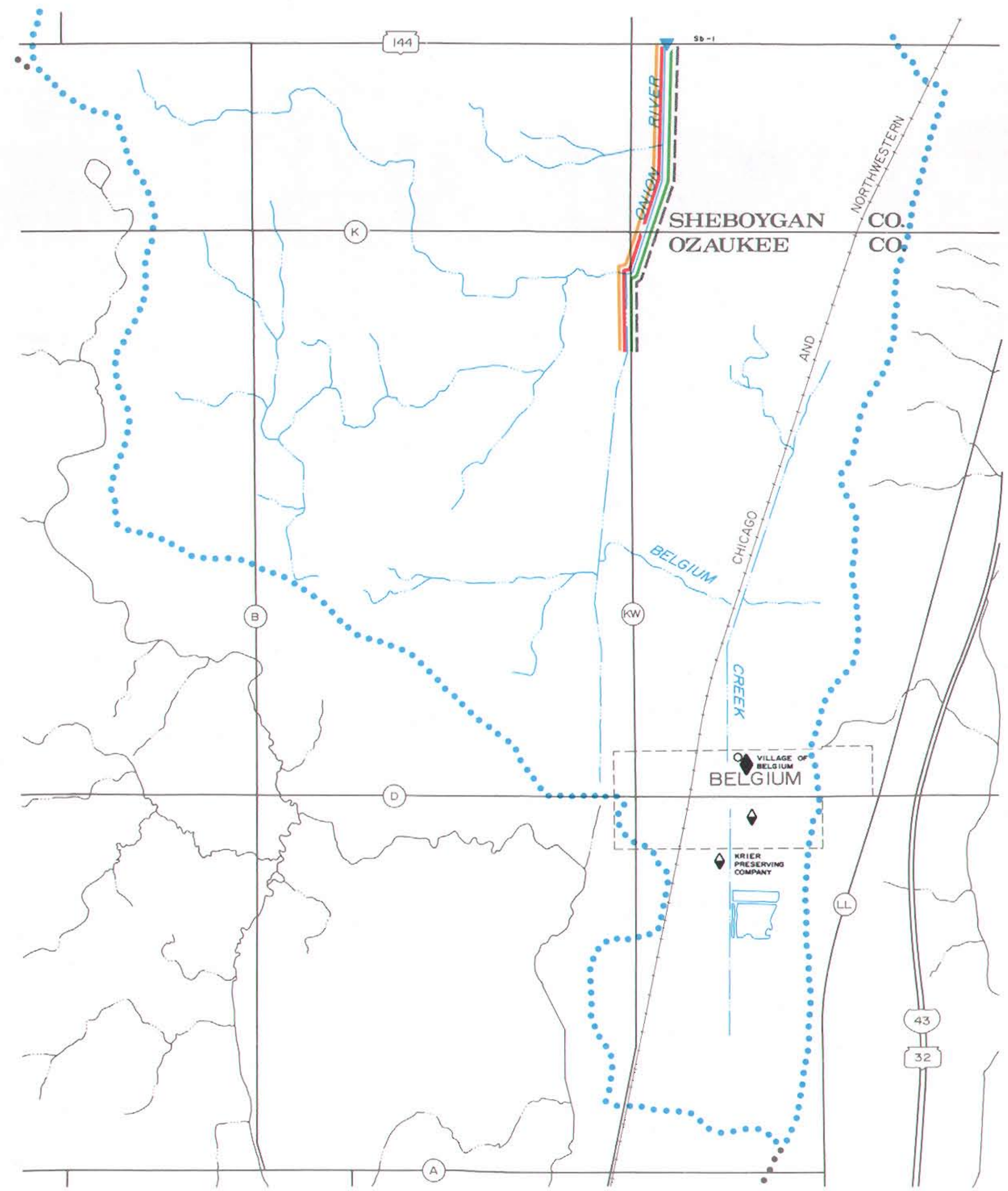


A comparison of the stream water quality in the Sheboygan River watershed as sampled in August 1964 to the adopted water quality standards indicated that all standards were satisfied with the exception of total coliform levels and estimated to include fecal coliform levels in excess of the standard for recreational use.

Source: SEWRPC.

Map 89

COMPARISON OF AUGUST 1975 SURFACE WATER QUALITY IN THE SHEBOYGAN RIVER WATERSHED WITH ADOPTED WATER QUALITY STANDARDS



A comparison of the stream water quality in the Sheboygan River watershed, as sampled in August 1975, to the adopted water quality standards indicated that desired levels of the total phosphorus, dissolved oxygen, nitrate-nitrogen, and fecal coliform standards were not met at sampling station Sb-1.

Source: SEWRPC.

in the Belgium Creek subwatershed. Its industrial waste treatment facility discharges treated wastes via three outfalls to the Onion River and groundwater.

The Commission 1970 land use inventory indicates that 6 percent of the watershed area in the Region is devoted to urban use; 92 percent is devoted to rural use, primarily agriculture; and the remaining 2 percent is occupied by the stream system. Runoff from the agricultural lands of the Belgium Creek subwatershed, which occupies about 92 percent of the land, may be expected to have a significant effect on water quality condition in the watershed within the Region.

The 1964-1965 benchmark stream water quality study conducted by the Commission included one sampling station located on Belgium Creek. The water quality data for 1964-1965 from the sampling station indicated that the chloride levels during April were higher than the normal background concentrations and assumedly reflected a chloride impact upon the stream from sewage treatment plant effluents. Substandard levels of dissolved oxygen concentration were recorded at Belgium Creek in September 1964. The five-day biochemical oxygen demand (BOD_5) remained less than 6.0 mg/l except for the sample collected in February 1965, which exhibited a BOD_5 value of 24.0 mg/l. The total coliform counts remained higher than 2,000 MFCC/100 ml with the highest value found in the September 1964 sample. The two specific conductance values obtained during 1964-1965 were 756 and 800 umhos/cm at 25°C. The pH values obtained during the study were within the 6.0 to 9.0 standard units prescribed for rivers and streams designated for recreational use as well as for fish and aquatic life uses. Temperature variations reflected the expected seasonal changes.

The 1965-1975 water quality monitoring effort by the Commission included continued sampling at the single station established on Belgium Creek. The average chloride concentrations recorded during the August surveys indicate levels significantly exceeding the expected background concentrations of 10 mg/l. High chloride concentrations were found in the 1972 and 1975 samples collected after a heavy rain. The dissolved oxygen concentrations remained higher than 5.0 mg/l in all the samples collected over the past decade with the exception of the sample collected in 1970. No trend was observed in the fecal coliform counts except that fecal coliform levels did drop in 1968 and 1969, the years following the addition of disinfection at the Village of Belgium sewage treatment plant. The specific conductance values recorded at the Belgium Creek sampling station exhibited a trend toward higher values in the samples collected after a rain, which corresponded to the pattern in chloride concentrations. The pH values were found to be within the applicable standard of 6.0 to 9.0 standard units established for Belgium Creek and exhibited no discernible temporal trend. As measured by the nitrate-nitrogen and total phosphorus levels, the nutrient concentrations remained in excess of the recommended water quality standards of 0.30 mg/l as N, and 0.10 mg/l as P, in 10 of the 12 nitrate-nitrogen samples and in seven of the eight total phosphorus samples collected over the past eight years. The diurnal water quality data for Belgium Creek exhibited a broad range of dissolved oxygen concentrations from a low of 1.1 mg/l to a high of 10.4 mg/l over a 24-hour period.

The water quality of Belgium Creek, designated for recreational use and for the preservation of fish and aquatic life, remained fairly constant over the past decade, but does not currently meet the established water quality standards for dissolved oxygen and fecal coliform counts. The plant nutrients, total phosphorus, and nitrate concentrations also were found to be higher than the recommended levels adopted by the Commission for the avoidance of nuisance aquatic plant growth in the stream system which discharges ultimately to Lake Michigan. Adverse water quality effects of treated sewage discharges and agricultural wastes are demonstrated in the available data.

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Chapter VII

WATER QUALITY INDEX

INTRODUCTION

Water quality management decisions can be intelligently shaped and effectively implemented only if accurate and timely information is available on stream and lake water quality. To assist in the development of sound public plans and policies directed at water quality enhancement, the water quality data should be in a form which can be readily comprehended by the general public—the electorate—which ultimately determines the nature of public actions, as well as by the elected and appointed public officials directly responsible for the decisions involved. Many individuals and agencies collect water quality data on the large number of different parameters, over different time spans, and at different geographic locations. The sheer amount of data, together with its complexity, makes it difficult for even trained experts to interpret its meaning—both in terms of changes in stream and lake water quality over long periods of time, and in terms of changes in water quality conditions from one site to another. What is needed to make this complex mass of data more comprehensible is an index of water quality which accurately reflects the composite influence of the most significant physical, chemical, biological, and microbiological parameters of water quality and which can be expressed numerically so that the magnitude and series of the index values have significance in terms of the temporal and spatial variation in water quality. Preceding chapters of this report have presented a profusion of quantitative data on changes in surface water quality conditions at various locations within the Region over time, these data being expressed in terms of a complex of individual water quality indicators. This chapter attempts to aggregate the available water quality data in a more comprehensible form by combining the individual water quality indicators into a single numerical expression or water quality index.

It is important to note the hazards inherent in a generalizing approach of this type. The combining of multiple parameters into a single numerical expression of necessity implies a substitutability of one dimension of water quality for another. For example, an accurate water quality representation could result from data indicating a high dissolved oxygen level in the presence of a high level of biochemical oxygen demand; or the same representation might result if both values were low, each offsetting the effect of the other. The interpretive difficulty lies in an implicit comparison of parameters less directly related, such as dissolved oxygen level and chloride, or nitrogen, or heavy metal content. For this reason, water quality index values are useful only as general indicators of water quality conditions, and then only if the factors involved in the index are logically weighted. Such generalization also may overlook seasonal and other temporal variations in water quality conditions by averaging them together. For the identification and analytical estimation of the effect of various pollutants on water quality, individual parameters must still be evaluated—a difficult and complex task.

In recent years several methods have been developed for the construction of a water quality index. Truett et al, (1975)[1] developed a water quality index for comparing stream water quality to applicable standards, using the prevalence, duration, and intensity of pollution (PDI) within an area. Prevalence was expressed in terms of the number of stream miles within an area over which water quality standards are not met. Duration was expressed in terms of the length of time over which the standards are not met. Intensity was expressed in terms of numbers representing three impacts on desirable water use objectives: ecological, utilitarian, and aesthetic. Ecological impacts include the effects of pollution on the existence or the potential for existence of desirable life forms, including man. Pollution effects causing reductions in the economic or resource utilization values of the water are grouped under utilitarian impacts. Lastly, pollution effects disagreeable to the senses are included in the category of aesthetics. The water quality index (V) was calculated by the formula $V = \frac{PDI}{M}$, with M representing the total stream miles involved. The approach is normative and, since judgment is involved in the assignment of values and their application, the index is in part subjective.

Dinius (1972)[2] developed a water quality index using selected water quality parameters weighted in terms of their importance as measures of water pollution. The water quality index (WQI) was expressed as:

$$WQI = \frac{Q_{DO}\,W_{DO} + Q_{BOD}\,W_{BOD} + \cdots + Q_X\,W_X}{W_{DO} + W_{BOD} + \cdots + W_X}$$

Q_X is the concentration of parameters X, and W_X is the assigned weighting factor given to the parameter X. This system equates zero pollution to distilled water, and the effects of natural sources of pollution are not taken into account. Biological and aesthetic pollution are not taken

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[1] *J. B. Truett, A. C. Johnson, W. D. Rowe, K. D. Feigner and L. J. Manning, "Development of Water Quality Management Indices" in Water Resources Bulletin, Volume 11, No. 3, June 1975, pages 436-448.*

[2] *S. H. Dinius, "Social Accounting System for Evaluating Water Resources," in Water Resources Research, Volume 8, No. 5, October 1972, pages 1,159-1,177.*

into consideration in the water quality index calculation. The Wisconsin Department of Natural Resources uses this system, with some modifications, in the development of the stream reach "segment score" which comprises an element of the priority rating used to administer sanitary sewage collection and treatment system grants-in-aid by the U. S. Environmental Protection Agency.

The National Sanitation Foundation[3] and Landwehr [4] developed a water quality index that includes nine physical, chemical, and microbial factors chosen by 142 individuals with expertise in water quality management. This method, like the one developed by Dinius, also excludes biological or aesthetic aspects. Dornbusch and Falcke[5] developed a water quality index based on popular perception of the importance of certain water quality characteristics, such as the presence of floating debris, murkiness, algae, and odor. The index was used to estimate changes in property values due to water quality improvements. Other water quality indices have also been developed at various levels of sophistication and used for special purposes.

Development of Commission Index

As noted above, the Commission sought a water quality index which would serve the purpose of reducing the data from a multiplicity of water quality parameters to a single indicator which would provide a general measure of the relative quality of the surface waters of the Region. The index has validity only in a relative comparison of the general levels of water quality at different sites in southeastern Wisconsin or the comparison of water quality and changes over time at a specific site. Being a general indicator, the index is not a substitute for a detailed comparison of specific sample results to the established standards for individual water quality parameters, as set forth in the water quality criteria to support specific water uses and as adopted by the state and federal governments.

For example, the water quality index does not substitute for the bacteriological test results in an assessment of the safety of a lake or stream for swimming. The water quality index incorporates all of the parameters for which data are generally available—or can be approximated—for the period addressed by this report, and which relate to some form of human impact on the quality of the water. Only subsets of these might apply to specific water uses. For example, the maintenance of water quality suitable for fish and aquatic life specifically might include consideration of dissolved oxygen, temperature, biochemical oxygen demand, ammonia, chlorine levels, pesticides, and heavy metals. For body contact recreation, the major relevant parameters of suitability might be only fecal coliform and nutrient levels affecting plant growth. To examine the water quality in relation to wastewater treatment, only the nutrients, dissolved oxygen, fecal coliform, and ammonia might be examined. Indeed, for southeastern Wisconsin, no specific standards comparison would be likely to include an assessment of the levels of chlorides, one of the most useful general indicators of human activity in a drainage area. In other words, a general index cannot substitute for the necessary comparison of water quality to the standards applicable for a specific use, nor can the comparison of observed parameter values to criteria for specific uses provide a measure of the general water quality conditions as they may be affected by all human activity in the aggregate. Each approach is necessarily either too detailed or too general to substitute for the other.

For the general assessment of water quality conditions and changes over time within the Region, the Commission sought a water quality index with the following characteristics:

1. A computed index which could be estimated by computation if data for one of the several constituent parameters were unavailable for index computation for a portion of the period of record;

2. An index which allowed comparison of the spatial variation in surface water quality; and

3. An index which allowed comparison of the temporal variations in surface water quality.

Accordingly, the Commission staff developed a water quality index which could express water quality conditions within the Region, and changes in such conditions over space and time utilizing the data available from the continuing water quality monitoring effort of the Commission. The procedure used in developing the water quality index is similar to the one used by the National Sanitation Foundation, with appropriate modifications to reflect the general water quality conditions occurring in southeastern Wisconsin and to make the most effective use of the available data. More specifically, the procedure used in development of the water quality index involved the following steps:

1. Based on careful examination of the data available from the continuing water quality monitoring program of the Commission, initiated in 1964 for the 87 sampling stations established on the major streams of the Region, the following six water quality parameters were chosen for their importance as general indicators of water quality, and for their generally consistent availability over the

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[3] *R. M. Brown and N. I. McClelland, "Up from Chaos: The Water Quality Index as an Effective Instrument in Water Quality Management," National Sanitation Foundation, Ann Arbor, Michigan, 1974, page 27.*

[4] *Jurate Maciunas Landwehr, "Water Quality Indices—Construction and Analysis," Ph.D. thesis, University of Michigan-School of Public Health, Ann Arbor, Michigan, 1974.*

[5] *D. M. Dornbusch and C. O. Falcke, A Generic Methodology to Forecast Benefits from Urban Water Resources Improvement Projects, Department of Interior 14-31-001-4201, November 1974, page 173.*

fulltime span of the regional water quality monitoring effort:

a. Dissolved oxygen expressed as percent of saturation level, thereby incorporating the water temperature at the time of sampling, since the solubility of oxygen in water is a function of water temperature.

b. Fecal coliform counts expressed as MFFCC/100 ml. The measurement of fecal coliform counts was begun during 1968. From 1964 through 1967, water samples were analyzed for total coliform. A comparison was made of total and fecal coliform data for the more than 170 samples collected over a two-year period. For these data both parameters were determined and the frequency of occurrence of concentrations of total and fecal coliform counts (see Figures 237 and 238 below) indicated that, for the streams in southeastern Wisconsin, the ratio of the concentrations of fecal coliform organisms to the concentrations of total coliform organisms generally ranged from 0.015 to 0.426. A selected sample of the observed total coliform and fecal coliform levels and the ratios is set forth in Table 227. Based on this analysis, a factor of 0.09—the mean value—was selected for estimating fecal coliform counts as a proportion of total coliform counts from the data collected during the sampling program for the years 1964 through 1967.

c. pH (hydrogen ion concentration) expressed in Standard Units.

d. Chloride concentrations expressed in mg/l.

e. Nitrate expressed in mg/l as nitrate-nitrogen.

f. Total phosphorus, expressed in mg/l as phosphorus. The measurement of total phosphorus was begun during the sampling year of 1972. In addition, some of the water samples collected during the year 1964 were analyzed for total phosphorus content. To compensate for the missing total phosphorus data, an assumption was made that water samples exhibiting low dissolved oxygen concentrations and high coliform counts also would tend toward high total phosphorus concentrations, based on a review of the available data from the water samples collected in the Region for these parameters. Table 228 presents the values of dissolved oxygen, total phosphorus, and total or fecal coliform observed at those sampling stations where all of the parameters were generally available. The phosphorus concentration and corresponding scores for the missing total phosphorus data were estimated in accordance with Table 229. As noted below, the greater the water quality parameter score for each of the six parameters, the higher the water quality index rating, which is intended to vary in proportion to the water quality conditions.

2. After the selection of the water quality parameters, weighting factors (W_i) indicative of the importance of each of the parameters were selected. The sum of the weighting factors for the six parameters was set at 1.00, so that the weighting factors can be thought of as the percentage of the total weighting assigned to each parameter. Of the six parameters chosen, dissolved oxygen was considered to be the most important in terms of the measurement of the water quality of the lakes and streams. Therefore, a weight of 0.22 was assigned to this parameter. Since a major use of the streams and lakes of the Region is recreational, and since such use requires strict observance of water quality standards for fecal coliform counts, a weight of 0.20 closely following that of dissolved oxygen was assigned to fecal coliform measurements. The hydrogen ion concentration (pH) was selected as the third water quality parameter in order of importance in the Region, also because of its effects on recreational use and on the maintenance of fish and aquatic life. A weight of 0.16 was assigned for this parameter. It should be noted, however, that the pH of water samples collected from the streams and lakes of the Region was generally found to be within the range of 7.3 to 8.5. Therefore, regardless of the weight assigned, pH will tend to affect the overall water quality index less than will those parameters for which a higher variability was observed in the sampling results. The three remaining water quality parameters selected—chloride, total phosphorus, and nitrate-nitrogen—were given equal weights of 0.14, since it was thought that the presence of high concentrations of any one of these three parameters would adversely affect recreational use and the maintenance of a fishery, but not to the same extent as the first three parameters selected. Therefore, it was throught reasonable to set the weights of these three parameters somewhat lower than the weights for dissolved oxygen, fecal coliform, and ph. Table 230 presents the weighting assignments for the six parameters.

3. The available data for each of the six parameters were plotted to show the number of observations equal to or less than the specific values of each parameter. The plots included enough samples so that it is reasonable to assume that the values of the curve referred to the vertical axis of the plot are representative of the probability that a sample would exhibit a parametric value equal to or less than the values of the curve referred to the horizontal axis of the plot. This kind of a plot is referred to as a "cumulative frequency distribu-

Table 227

TOTAL COLIFORM AND FECAL COLIFORM VALUES OBSERVED AT SELECTED WATER QUALITY SAMPLING STATIONS IN THE REGION: 1968

Sampling Station	Total Coliform Organisms (MFCC per 100 ml)	Fecal Coliform Organisms (MFFCC per 100 ml)	Ratio of Fecal Coliform to Total Coliform Organisms
Dp-3	12,000	700	0.058
Fx-1	16,000	270	0.017
Fx-2	3,800	380	0.100
Fx-3	130,000	900	0.007
Fx-4	20,000	70	0.003
Fx-5	230,000	20,000	0.087
Fx-6	1,300	270	0.208
Fx-7	21,000	330	0.016
Fx-8	100	5	0.050
Fx-11	3,600	120	0.033
Fx-12	1,100	20	0.018
Fx-13	1,000	55	0.055
Fx-16	8,000	500	0.063
Fx-17	190,000	2,200	0.012
Fx-19	17,000	290	0.017
Fx-20	14,000	1,100	0.078
Fx-23	4,000	230	0.057
Fx-24	190,000	8,400	0.044
Fx-26	12,000	1,100	0.91
Fx-27	35,000	1,500	0.043
Fx-28	2,600	490	0.188
Kk-1	34,000	900	0.026
Mn-1	9,000	1,200	0.133
Mn-2	14,000	1,200	0.085
Mn-4	26,000	600	0.023
Mn-6	1,900	180	0.095
Mn-7	18,000	270	0.015
Mn-7a	9,000	210	0.023
Mn-8	25,000	1,100	0.044
Mn-9	140,000	25,000	0.178
Mn-10	41,000	1,700	0.041
Mh-1	1,300	190	0.146
Mh-2	190,000	35,000	0.184
Ml-1	3,000	700	0.233
Ml-4	2,200	520	0.236
Ml-5	8,000	240	0.030
Ml-8	12,000	680	0.056
Ml-9	2,100	900	0.426
Ml-11	220,000	1,300	0.059
Ok-2	21,000	400	0.020
Pk-4	--	110	--
Rk-1	3,000	390	0.130
Rk-4	1,500,000	1,900	0.001
Rk-5	23,000	1,500	0.065
Rk-6	6,000	2,000	0.330
Rk-8	34,000	1,600	0.047
Rk-13	--	1,500	--
Rt-4	25,000	2,600	0.104
Rt-5	33,000	2,100	0.064
Rt-6	43,000	1,700	0.040
Sk-1	--	1,100	--
Sk-2	--	210	--
Sb-1	8,000	2,100	0.262

Source: SEWRPC.

Table 228

TEMPERATURE, DISSOLVED OXYGEN, TOTAL PHOSPHORUS, TOTAL COLIFORM, AND FECAL COLIFORM VALUES OBSERVED AT SELECTED WATER QUALITY SAMPLING STATIONS IN THE REGION: SELECTED YEARS 1964-1968

Station Number	1964				1966				1967				1968				
	Temperature (°F)	Dissolved Oxygen (mg/l)	Total Phosphorus (mg/l)	Total Coliform (MFCC per 100 ml)	Temperature (°F)	Dissolved Oxygen (mg/l)	Total Phosphorus (mg/l)	Total Coliform (MFCC per 100 ml)	Temperature (°F)	Dissolved Oxygen (mg/l)	Total Phosphorus (mg/l)	Total Coliform (MFCC per 100 ml)	Temperature (°F)	Dissolved Oxygen (mg/l)	Total Phosphorus (mg/l)	Fecal Coliform (MFFCC per 100 ml)	Total Coliform (MFCC per 100 ml)
Dp-3	66.0	4.5	0.31	6,000	56.0	7.9	0.050	1,000	51.0	6.7	0.020	200	75.0	7.0	--	700	12,000
Fx-1	58.0	2.0	0.16	700	43.0	9.9	--	200	53.0	11.8	--	660	60.0	3.6	--	270	16,000
Fx-2	56.0	8.2	0.66	19,000	41.0	6.5	--	8,300	52.0	15.1	--	8,300	60.0	5.4	--	380	3,800
Fx-3	58.0	5.2	0.20	1,100	42.0	6.1	--	5,900	54.0	13.3	--	19,200	61.0	6.7	--	900	130,000
Fx-4	60.0	4.2	2.00	21,000	43.0	5.9	--	9,800	54.0	9.8	--	11,500	65.0	2.9	--	70	20,000
Fx-5	61.0	5.3	3.2	6,000	44.0	4.2	--	4,800	54.0	9.9	--	1,900,000	71.0	2.9	--	20,000	230,000
Fx-6	58.0	9.0	0.96	400	42.0	9.9	--	14,000	54.0	12.4	--	9,000	66.0	6.4	--	270	1,300
Fx-7	66.0	8.0	0.26	7,000	50.0	7.8	--	14,000	58.0	11.6	--	8,700	72.0	7.8	--	330	21,000
Fx-8	64.0	6.9	2.3	6,000	51.0	8.2	--	97,000	57.0	15.3	--	208,000	69.0	8.8	--	5	100
Fx-11	65.0	6.4	--	4,000	47.0	12.6	--	5,300	58.0	10.6	--	10,000	69.0	2.6	--	120	3,600
Fx-12	68.0	9.8	--	300	48.0	11.3	--	2,300	58.0	9.4	--	5,800	75.0	9.0	--	20	1,100
Fx-13	68.0	8.0	1.12	3,000	47.0	7.8	--	9,700	58.0	9.0	--	20,000	71.0	5.1	--	55	1,000
Fx-16	69.0	9.1	0.38	2,000	47.0	11.8	--	6,300	49.0	9.0	--	8,400	71.0	5.5	--	500	8,000
Fx-17	67.0	10.8	0.46	10,000	51.0	13.9	--	14,000	56.0	11.5	--	17,600	74.0	9.7	--	2,200	190,000
Fx-19	67.0	4.8	0.24	7,000	42.0	9.1	--	19,000	45.0	12.9	--	3,400	71.0	5.5	--	290	17,000
Fx-20	68.0	8.3	0.36	10,000	44.0	10.9	--	21,000	44.0	11.3	--	20,200	69.0	7.5	--	1,100	14,000
Fx-23	68.0	7.7	0.14	2,000	45.0	9.6	--	5,500	45.0	10.9	--	13,200	71.0	7.3	--	230	4,000
Fx-24	69.0	9.5	0.46	50,000	50.0	11.1	--	24,000	58.0	8.7	--	197,000	74.0	8.0	--	8,400	190,000
Fx-26	68.0	10.8	1.90	8,000	42.0	11.8	--	47,000	44.0	14.4	--	12,600	75.0	10.3	--	1,100	12,000
Fx-27	69.0	13.6	0.42	2,000	49.0	15.5	--	9,400	59.0	10.9	--	18,400	74.0	11.3	--	1,500	35,000
Fx-28	71.0	12.8	0.24	3,000	47.0	13.7	--	6,900	47.0	14.9	--	11,400	69.0	9.4	--	490	2,600
Kk-1	77.0	10.4	0.72	8,000	54.0	10.3	0.160	66,000	44.0	10.3	0.140	7,600	70.0	10.7	--	900	34,000
Mn-1	61.0	2.8	0.06	300	48.0	6.1	--	2,500	42.0	8.1	--	100	59.0	6.0	--	1,200	9,000
Mn-2	62.0	2.5	1.44	6,000	51.0	3.1	--	4,000,000	44.0	6.8	--	10,900	64.0	2.3	--	1,200	14,000
Mn-4	64.0	2.3	4.60	80,000	52.0	3.5	--	66,000	49.0	13.1	--	86,000	65.0	2.3	--	600	26,000
Mn-6	64.0	10.0	3.68	3,000	48.0	6.6	--	2,000	46.0	9.9	--	86,000	66.0	9.7	--	180	1,900
Mn-7	65.0	12.3	0.24	60,000	49.0	6.8	--	700	46.0	12.1	--	4,700	68.0	5.7	--	270	18,000
Mn-7a	--	--	--	--	50.0	7.8	--	4,000	47.0	10.2	--	144,000	66.0	5.3	--	210	9,000
Mn-8	66.0	9.7	0.16	11,000	54.0	13.8	--	4,000	50.0	14.9	--	2,200	66.0	11.7	--	1,100	25,000
Mn-9	50.0	8.3	0.32	200,000	48.0	8.6	--	4,000	50.0	10.8	--	56,000	68.0	9.3	--	25,000	140,000
Mn-10	68.0	10.8	--	19,000	49.0	13.1	--	3,000	48.0	14.2	--	60,000	66.0	8.7	--	1,700	41,000
Mh-1	65.0	2.1	0.24	1,700	54.0	--	--	8,000	37.0	10.2	--	1,350	65.0	0.8	--	190	1,300
Mh-2	68.0	4.5	0.80	740,000	63.0	4.2	--	450,000	49.0	10.2	--	21,000	44.0	8.3	--	35,000	190,000
Ml-1	63.0	6.9	0.24	43,000	48.0	8.7	--	5,300	43.0	10.2	--	1,300	64.0	9.4	--	700	3,000
Ml-4	65.0	6.6	0.20	140,000	48.0	9.6	--	5,700	45.0	9.1	--	1,800	68.0	8.1	--	520	2,200
Ml-5	68.0	7.6	0.56	10,000	50.0	10.6	--	10,000	45.0	10.1	--	1,300	70.0	6.8	--	240	8,000
Ml-8	68.0	6.4	0.32	40,000	49.0	9.5	--	6,800	44.0	9.6	--	4,500	69.0	6.8	--	680	12,000
Ml-9	68.0	8.0	0.40	10,000	52.0	16.2	--	5,700	46.0	12.4	--	6,000	70.0	5.8	--	900	2,100
Ml-11	69.0	7.8	0.28	19,000	51.0	7.7	--	33,000	46.0	11.6	--	469,999	74.0	8.9	--	13,000	220,000
Ok-2	71.0	10.3	0.48	4,000	52.0	7.4	--	5,200	43.0	10.6	--	14,000	67.0	7.3	--	400	21,000
Pk-4	66.0	3.5	1.37	12,000	56.0	5.7	--	28,000	45.0	11.3	--	7,300	50.0	14.2	--	110	--
Rk-1	62.0	8.1	0.24	1,600	48.0	8.9	0.120	7,200	41.0	12.7	0.050	430	66.0	6.6	--	390	3,000
Rk-4	64.0	13.9	4.00	2,000	48.0	9.7	2.050	7,100	50.0	14.3	0.280	17,400	68.0	4.2	--	1,900	1,500,000
Rk-5	77.0	9.2	0.24	10,000	49.0	11.0	0.080	5,300	51.0	13.6	0.060	610	72.0	8.0	--	1,500	23,000
Rk-6	77.0	7.3	0.12	700	49.0	10.2	0.070	4,800	41.0	11.9	0.040	780	73.0	8.1	--	2,000	6,000
Rk-8	79.0	10.5	5.30	440,000	50.0	5.6	1.590	9,200	45.0	10.9	0.180	34,000	75.0	9.4	--	1,600	34,000
Rk-13	68.0	11.4	0.64	5,000	48.0	10.3	0.190	8,000	46.0	12.6	0.080	37,000	67.0	8.8	--	1,500	--
Rt-4	72.0	4.9	--	1,200	52.0	5.3	2.630	3,200	45.0	9.9	0.290	8,400	67.0	6.3	--	2,600	25,000
Rt-5	77.0	14.1	1.30	47,000	52.0	8.3	1.820	9,000	44.0	10.2	0.220	6,700	70.0	7.9	--	2,100	33,000
Rt-6	76.0	7.5	--	3,000	54.0	9.5	0.280	22,000	46.0	10.9	0.190	6,800	68.0	7.6	--	1,700	43,000
Sk-1	60.0	8.1	1.92	5,000	52.0	8.9	0.220	15,500	38.0	11.6	0.100	63,000	67.0	6.8	--	1,100	--
Sk-2	59.0	12.1	0.26	1,200	53.0	11.8	1.210	12,000	38.0	13.2	0.100	900	62.0	11.2	--	210	--
Sb-1	61.0	10.5	0.52	10,000	48.0	11.8	--	600	40.0	10.6	--	11,200	65.0	11.8	--	2,100	8,000

Source: SEWRPC.

Table 229

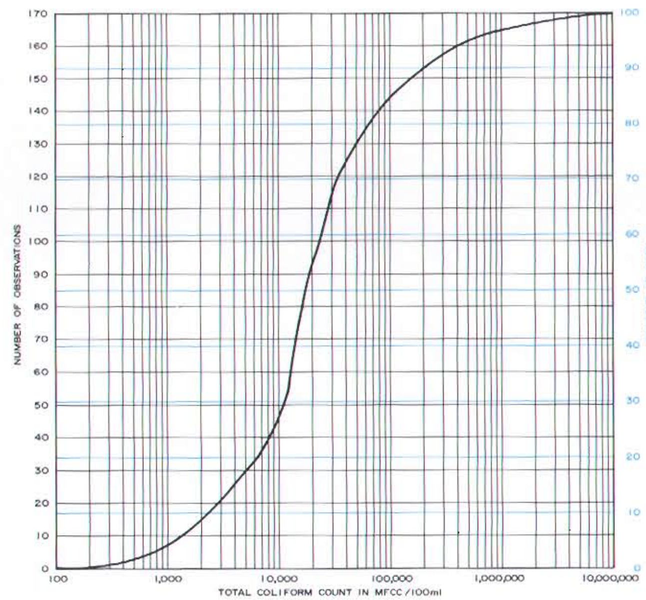
ESTIMATED PHOSPHORUS CONCENTRATIONS FOR WATER QUALITY SAMPLES HAVING KNOWN LEVELS OF DISSOLVED OXYGEN AND FECAL COLIFORM

Dissolved Oxygen Saturation (in percent)	Observed or Estimated Fecal Coliform (in MFFCC per 100 ml)	Estimated Range of Concentration of Total Phosphorus as P (in mg/l)	Resulting Phosphorus Quality Score
Greater than 50	Less than 200 counts	0.05 - 0.20	12
Greater than 50	Greater than 200 counts	0.20 - 0.40	9
Less than 50	Less than 200 counts	0.20 - 0.40	9
Less than 50	Greater than 200 and Less than 2000 counts	0.40 - 0.60	7
Less than 50	Greater than 2000 counts	0.60 - higher	6

Source: SEWRPC.

Figure 237

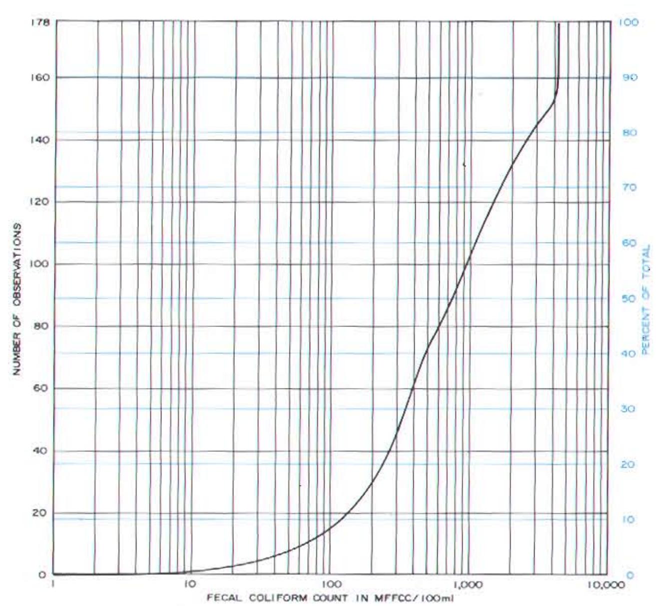
CUMULATIVE FREQUENCY DISTRIBUTION OF TOTAL COLIFORM SAMPLES IN THE REGION: AUGUST 1968-1969



Source: SEWRPC.

Figure 238

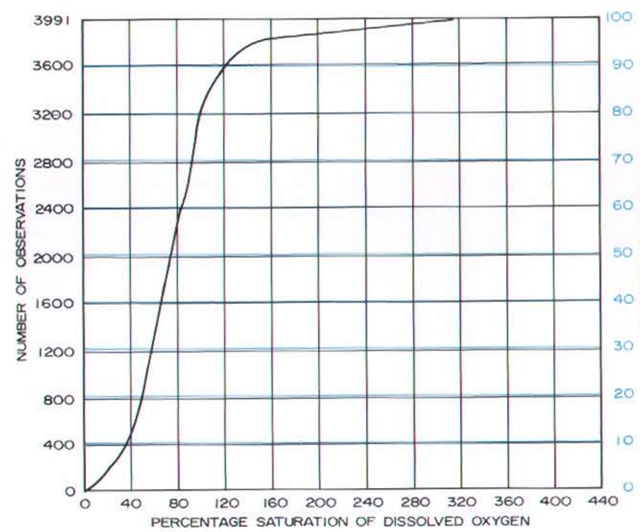
CUMULATIVE FREQUENCY DISTRIBUTION OF FECAL COLIFORM SAMPLES IN THE REGION: AUGUST 1968-1969



Source: SEWRPC.

Figure 239

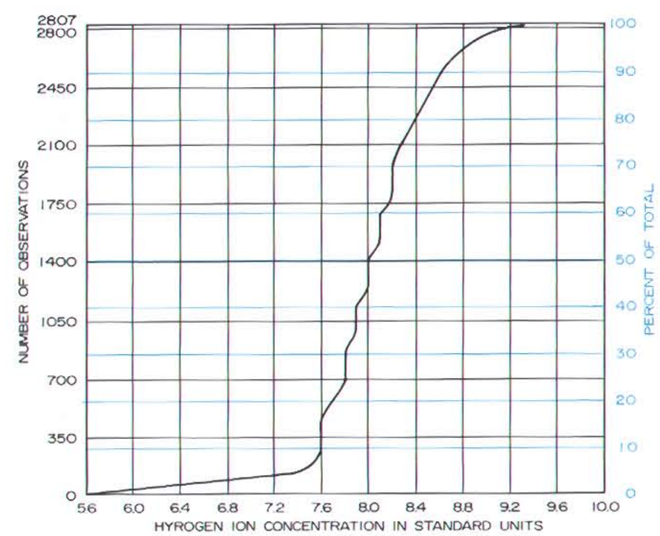
CUMULATIVE FREQUENCY DISTRIBUTION OF PERCENT SATURATION OF DISSOLVED OXYGEN SAMPLES OBSERVED IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 240

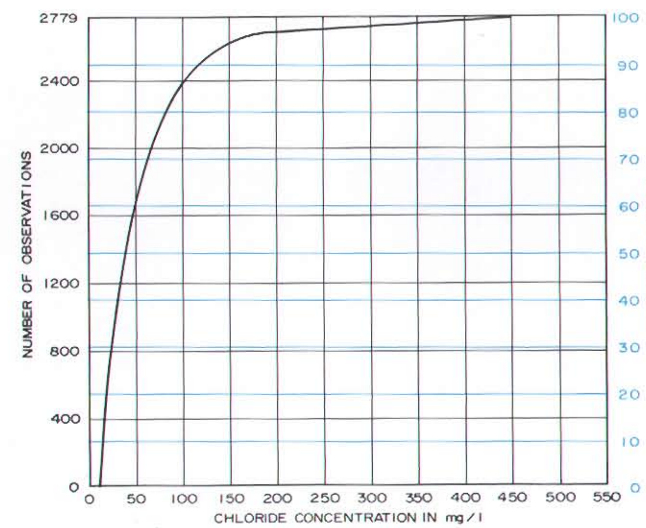
CUMULATIVE FREQUENCY DISTRIBUTION OF OBSERVED HYDROGEN ION CONCENTRATION (pH) SAMPLES IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 241

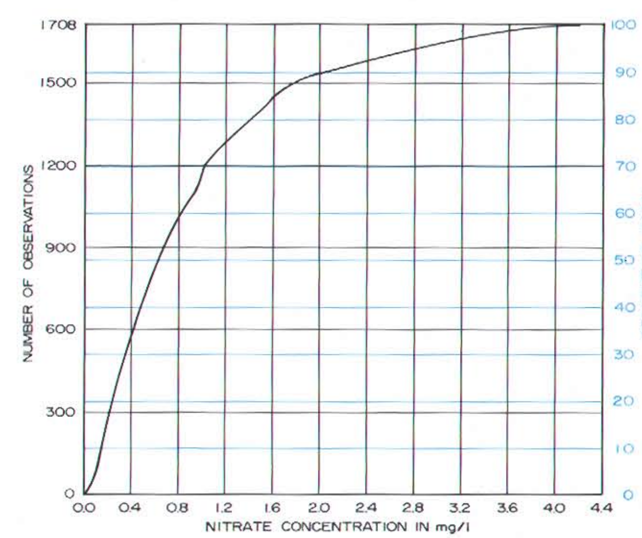
CUMULATIVE FREQUENCY DISTRIBUTION OF OBSERVED CHLORIDE CONCENTRATIONS SAMPLED IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 242

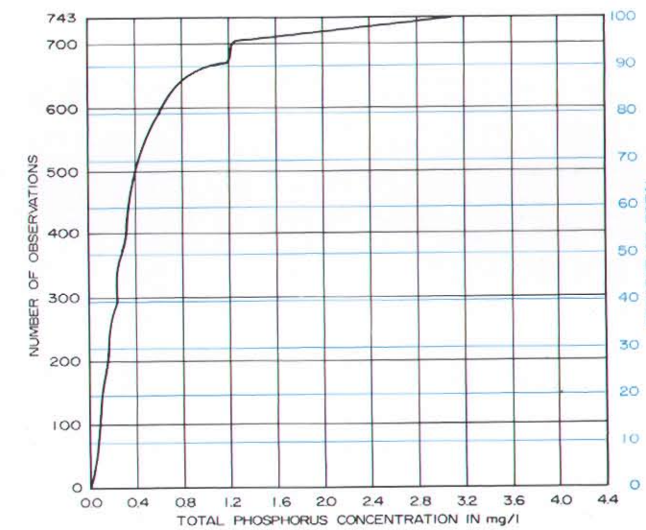
CUMULATIVE FREQUENCY DISTRIBUTION OF OBSERVED NITRATE CONCENTRATIONS SAMPLED IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 243

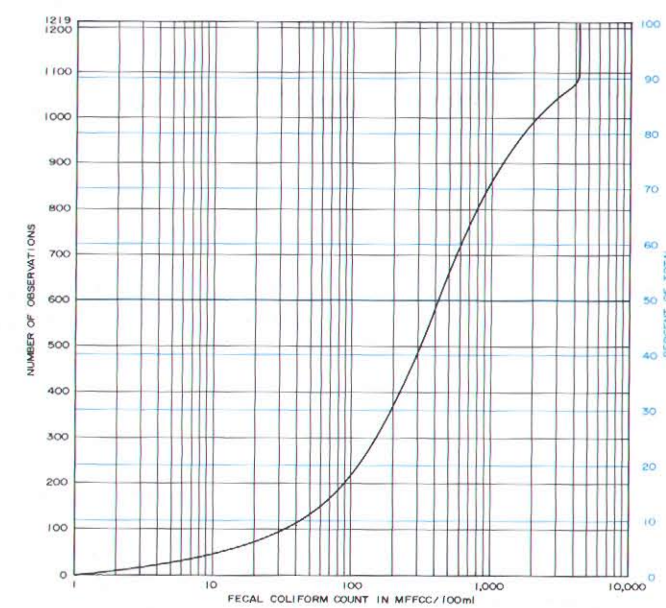
CUMULATIVE FREQUENCY DISTRIBUTION OF OBSERVED TOTAL PHOSPHORUS CONCENTRATIONS SAMPLED IN THE REGION: 1972-1975



Source: SEWRPC.

Figure 244

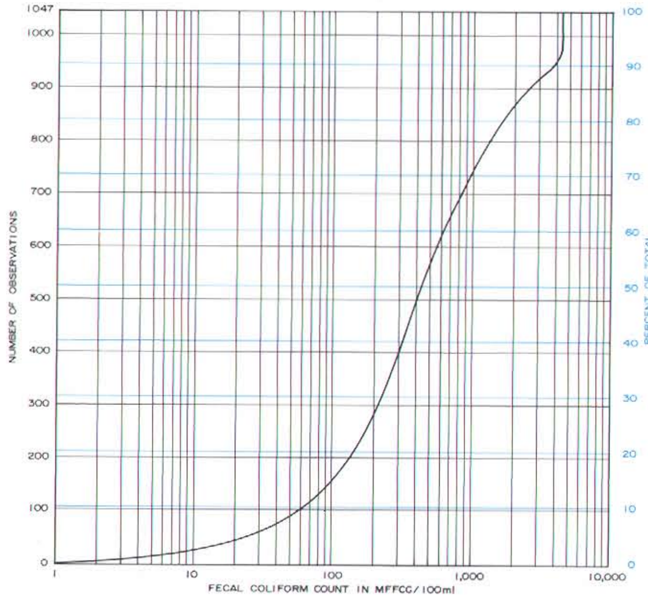
CUMULATIVE FREQUENCY DISTRIBUTION OF FECAL COLIFORM SAMPLED IN THE REGION: 1968-1975



Source: SEWRPC.

Figure 245

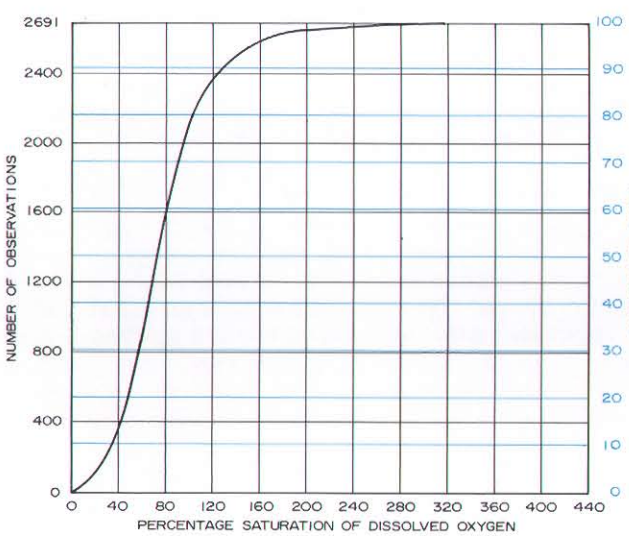
CUMULATIVE FREQUENCY DISTRIBUTION OF FECAL COLIFORM OBSERVED IN AUGUST STREAM SAMPLES IN THE REGION: 1968-1975



Source: SEWRPC.

Figure 246

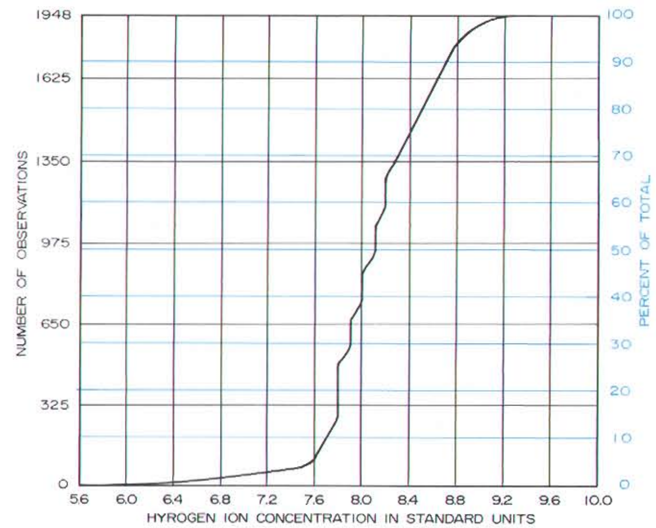
CUMULATIVE FREQUENCY DISTRIBUTION OF PERCENT SATURATION OF DISSOLVED OXYGEN OBSERVED IN AUGUST STREAM SAMPLES IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 247

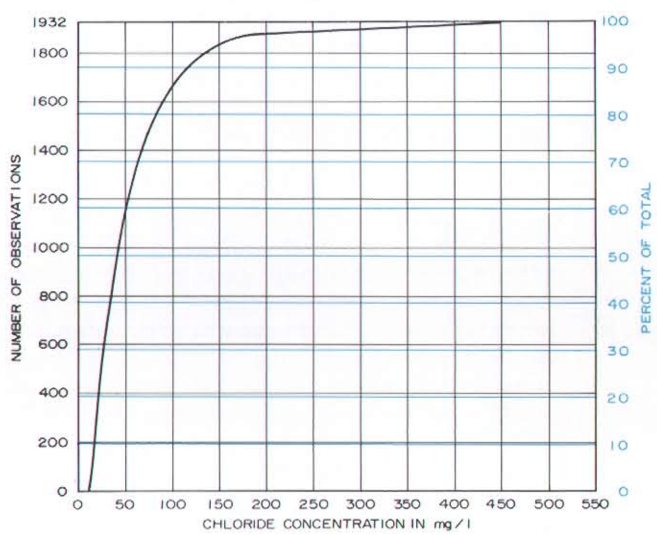
CUMULATIVE FREQUENCY DISTRIBUTION OF HYDROGEN ION CONCENTRATION (pH) OBSERVED IN AUGUST STREAM SAMPLES IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 248

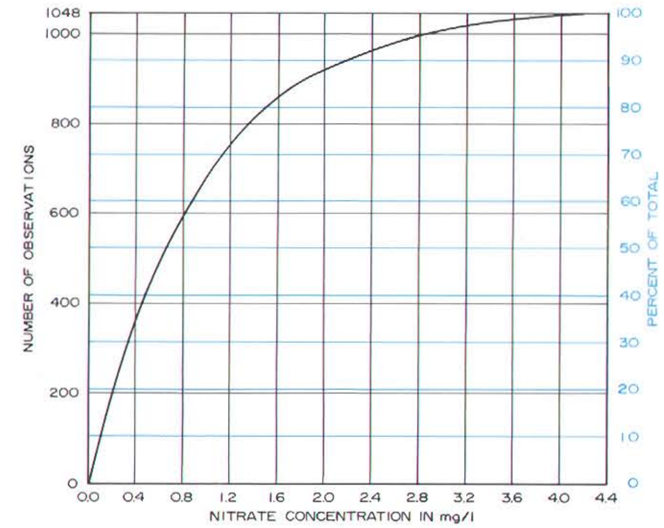
CUMULATIVE FREQUENCY DISTRIBUTION OF CHLORIDE CONCENTRATIONS OBSERVED IN AUGUST STREAM SAMPLES IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 249

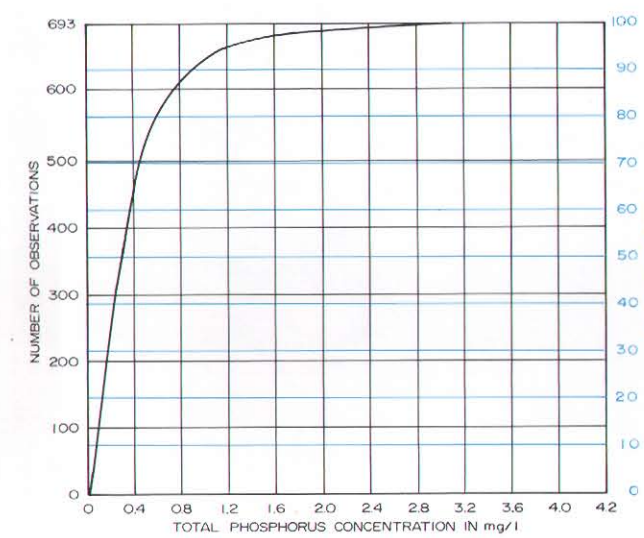
CUMULATIVE FREQUENCY DISTRIBUTION OF NITRATE CONCENTRATIONS OBSERVED IN AUGUST STREAM SAMPLES IN THE REGION: 1964-1975



Source: SEWRPC.

Figure 250

CUMULATIVE FREQUENCY DISTRIBUTION OF TOTAL PHOSPHORUS CONCENTRATIONS OBSERVED IN AUGUST STREAM SAMPLES IN THE REGION: 1972-1975



Source: SEWRPC.

Table 230

WEIGHTING OF WATER QUALITY PARAMETERS

Parameters	Weight
Dissolved Oxygen, Percent Saturation . . .	0.22
Fecal Coliform, MFFCC/100 ml.	0.20
pH, Standard Units	0.16
Chloride, mg/l.	0.14
Nitrate, mg/l N	0.14
Total Phosphorus, mg/l P	0.14
Total	1.00

Source: SEWRPC.

tion," since at any point on the curve the value of the vertical axis represents the accumulated number of occurrences of samples having parametric values less than or equal to the value on the horizontal axis. Since the water quality analyses described in Chapter VI of this report were based on the data collected during August of 1964 and the late summer months of each year since 1968, it was considered useful for two reasons to plot cumulative frequency distributions for the data obtained for each of the six parameters during the August sampling for the years 1964 and 1968 through 1975. First, this should provide an understanding of the general distribution of the values observed. Second, the comparison of August data and data from the late summer months to the distribution of values observed during all seasons of the year provides an opportunity to assess the representativeness of the dry-month sample results. The plots are presented in Figures 237 through 250. A comparison of the August data to all data collected throughout the Region over the past decade indicates that the distribution of the values observed during summer low-flow sampling differed from the distribution of the values collected at other times of the year and did so in the ways which would have been expected for dissolved oxygen, chlorides, and pH. For total coliform, the differences in the seasonal distributions of the observed values were less evident than might have been expected.

4. Using the ranges and the concentrations that were found to occur generally in the Region, a rating curve was developed for each one of the six parameters—dissolved oxygen as percent of saturation level, fecal coliform counts, pH, chlorides, nitrate-nitrogen, and total phosphorus. These rating curves, which are used to assign a water quality score for individual measurements of each of the six parameters, are presented in Figures 251 through 256. This step is especially important because it imparts to the observed water quality sample values a variability resulting from the conversion of these values into a range of scores from zero to 100. This step was accomplished by categorizing the water quality parameter values into ranges to which scores were assigned. The most important aspect of the variability for this discussion is that the parameters with less variability have a reduced effect on the water quality index. For example, if all water quality samples had 30 mg/l of chloride, all chloride ratings would be 85 and would contribute the same number to the water quality index, so the relative values of the computed index at different sampling stations would be unaffected by the chloride parameter. Therefore, this is the step at which the most important subjective decisions were made: the rating of the relative quality and desirability of specific ranges of parametric values. This rating, developed by the Commission staff, was based on the relative value of a water quality condition—as described by a specific parameter—for recreational use and maintenance of fish and other aquatic life. Thus, the variability in the raw data was converted and normalized into ranges—between zero and 100 units—which could be combined—through the use of the selected weighting values—into the water quality index rating. The resulting basis for parameter scoring is set forth for each parameter in Figures 251 through 256.

5. The water quality index was then calculated using the measured value of each of the six parameters, its individual score (qi) from the rating curves, and the final weight (Wi) as presented in Table 230. The overall quality score for each parameter is calculated by multiplying the individual score (qi) by the final weight (Wi). The overall water quality index rating (Q) of a stream at a particular location is then calculated by summing up the overall quality scores (qiWi) found for the six parameters. Table 231 presents a sample calculation for the water quality index development at Fx-26 on Bassett Creek on the Fox River watershed for the year 1974-1975.

Using the method described above, water quality indices were developed for the streams of the Region at the 87 sampling stations for the period 1964-1965 and 1974-1975. The calculation of the water quality index for the period 1964-1965 was based upon all the data provided by analyses of the grab samples collected once during each of the four months of minimum precipitation and low streamflow: July, August, September, and October. The calculation of the water quality index for the period 1974-1975 was based upon the two sets of data from four diurnal samples collected on a single day during the months of August in 1974 and 1975. The comparison was based upon multiple samples in order to reduce the likelihood of any single sampling occasion resulting in a misleading assessment of changes in the water quality over the 10-year period. The comparison of the August data for the years

Table 231

SAMPLE CALCULATION: WATER QUALITY INDEX AT FX-26 DURING 1974-1975 IN THE FOX RIVER WATERSHED

Parameter	Measured Values	Individual Parameter Score q_1 [a]	Weighting Value w_1 [b]	Overall Quality Score $q_1 \times w_1$ [c]
Dissolved Oxygen, Percent Saturation	67.51	65	0.22	14.3
Fecal Coliform, MFFCC/100 ml.	570	20	0.20	4.0
pH, Standard Units	8.23	90	0.16	14.4
Chloride, mg/l.	64.25	50	0.14	7.0
Nitrate, mg/l N	0.77	50	0.14	7.0
Total Phosphorus, mg/l P	0.27	60	0.14	8.4
		Water Quality Index Q =		55.1

[a] *The individual parameter score q_1 is obtained from the individual parameter rating curves developed. See Figures 251 through 256.*

[b] *Weighting value w_1 was obtained from Table 230.*

[c] *The overall water quality index value is equal to the weighted summation of six overall quality scores, rounded to the nearest full unit.*

Source: SEWRPC.

1974-1975 with the data collected during the four driest months of 1964 is justified based on the cumulative frequency analysis discussed earlier in this chapter.

6. Next, the Commission staff reviewed the resulting water quality index ratings to assure that the method resulted in logical results which were reflective of, and consistent with, the general conclusions reached by the detailed professional staff analyses of the same data as presented earlier in this report.

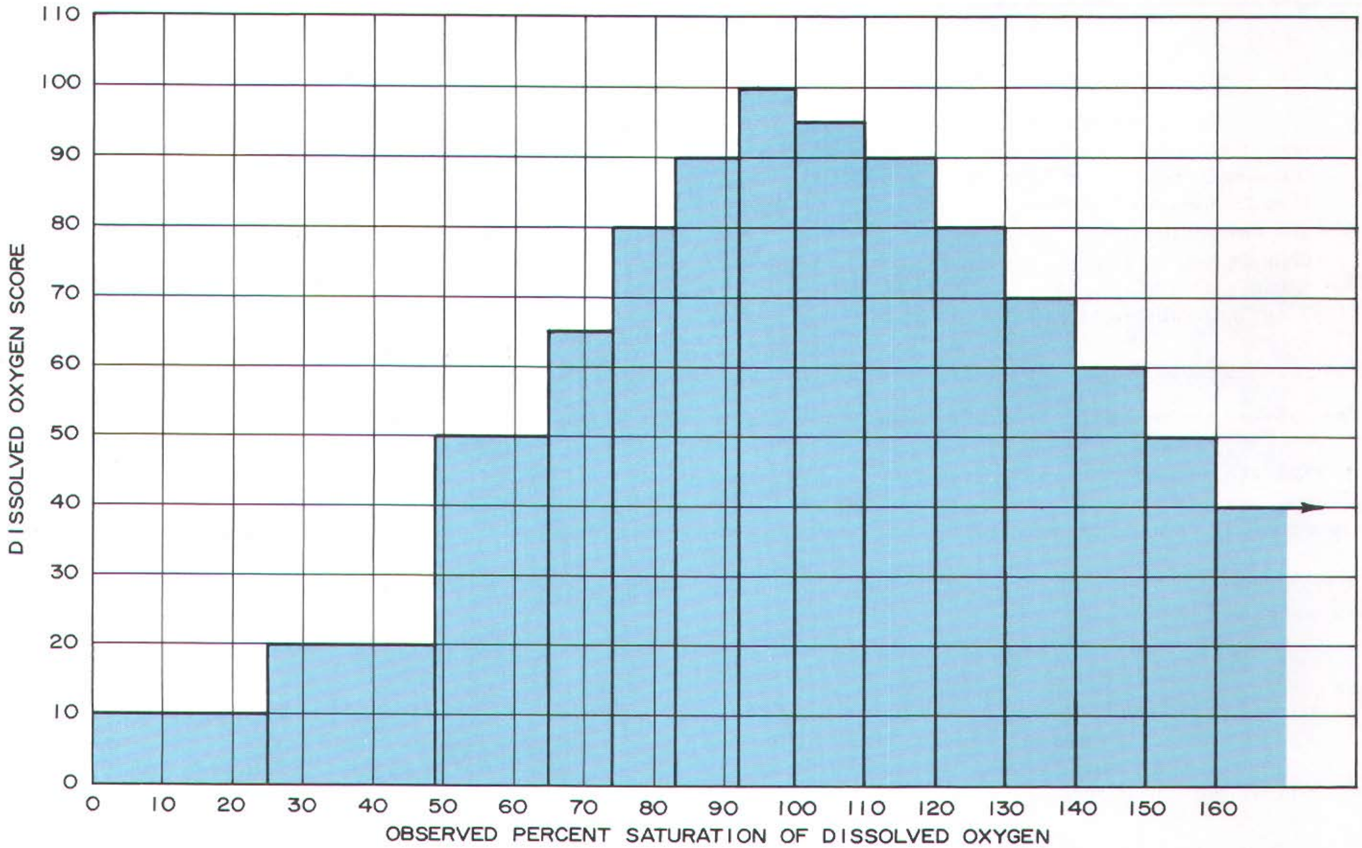
7. The resulting water quality index ratings were compared with subjective judgments of the general water quality of selected streams in southeastern Wisconsin to identify general categories of water quality. Index ratings of 30 or less were categorized as "very poor" water quality. Ratings between 31 and 50 units were termed "poor," between 51 units and 70 units "fair," between 71 and 85 units "good," and between 86 and 100 units "excellent."

   Each category has a range of values of about 15 to 20 index units, which corresponds to about 1½ standard deviations of the distribution of observed index values. A rating of "fair" includes those index values lying about 1 standard deviation above and below the mean of the observed values. The category "good" includes those values lying between about 1 and 2 standard deviations above the mean, while those grouped as "excellent" lie beyond 2 standard deviations above the mean. The category "poor" includes those values lying between about 1 and 2 standard deviations below the mean. Since the midpoint of the categories called "poor" and "good" differs by over 15 units from the midpoint of the category called "fair," these groups in general are significantly different. In addition, they are consistent with the subjective water quality assessments reported in Chapter VI. Like most grouping systems, this does not imply that all the values within a given category are statistically different from those grouped within an adjacent category, since some values will lie near the class limits. However, by using class widths of greater than one standard deviation, the potential overlap between categories is reduced.

It is important to recognize that no matter how carefully conceived, a numerical rating system such as the water quality index here described can represent only those results which can be derived from the technical data on which it is based. Accordingly, conclusions drawn from the more detailed analyses in Chapter VI, and based on more years of data, more sources of data, and more types of data may differ in some specific instances from the conclusions reached through use of the more simplified water quality index alone. Analyses of water quality data by experienced technical personnel can consider many more factors than a mathematical index. These factors may include land use and land management practices in the tributary drainage area, the existence and magnitude of known pollution sources, and sample error, to name but a few.

Figure 251

DISSOLVED OXYGEN SCORE ASSOCIATED WITH OBSERVED PERCENT SATURATION OF DISSOLVED OXYGEN



Source: SEWRPC.

APPLICATION OF COMMISSION INDEX

The water quality index ratings are designed to reflect higher rating values for higher water quality conditions. In theory, the highest possible water quality rating a stream could receive would be 100, and the lowest possible rating would be 22, based on the rating curves and weights given to the individual parameters.

Map 90 presents the water quality index found for the 87 stations in the Region for the four low-flow months of 1964 and presents the same water quality index information for August 1974-1975 water quality data. Based on the water samples taken in four months in 1964 at 87 sampling stations, the water quality ratings were found to be poor, fair, good, and excellent at 17, 42, 22, and 6 stations, respectively. Based on similar samples for August 1974 and 1975, water quality ratings were found to be poor, fair, good, and excellent at 8, 68, 9, and 2 stations, respectively. Table 232 presents the water quality index numbers obtained for the 87 sampling stations in the Region as calculated for the samples from the period of July, August, September, and October 1964 and for the August samples from 1974 and 1975.

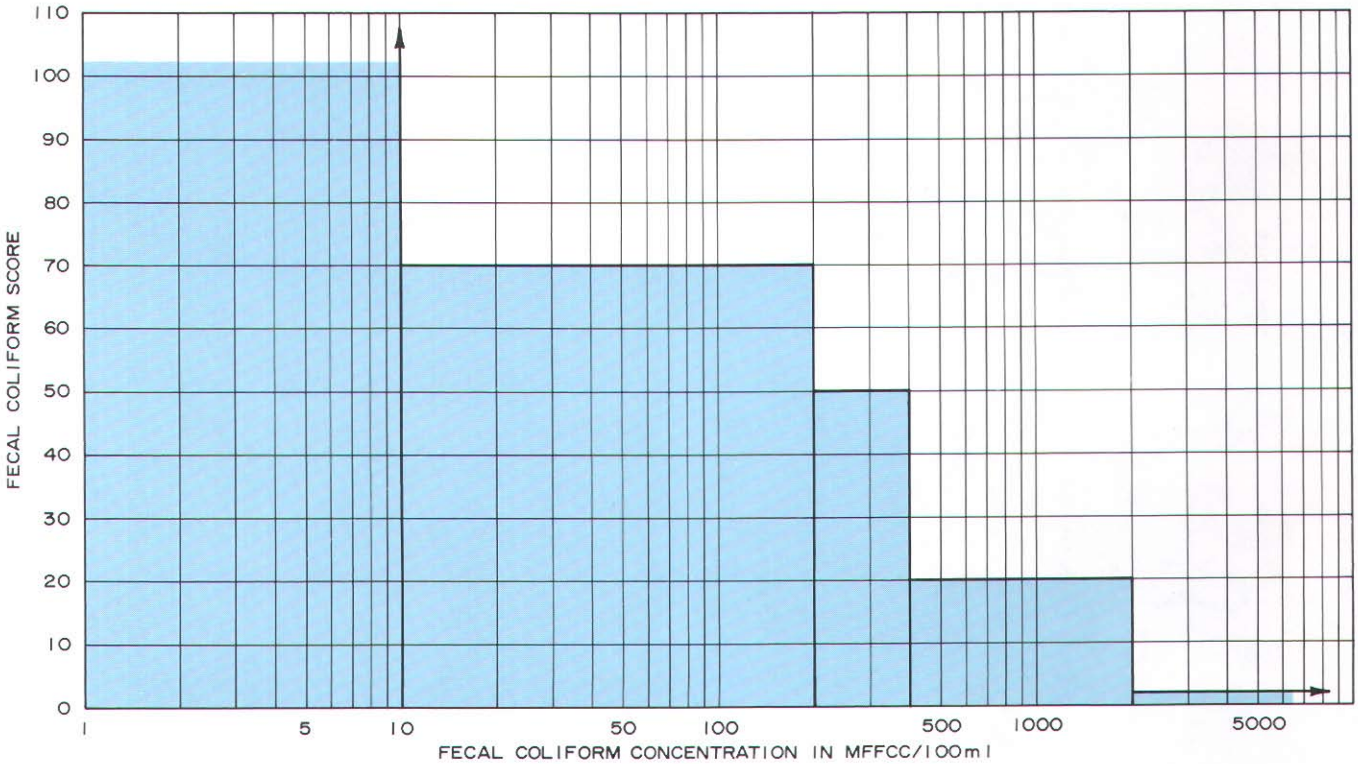
As indicated in Table 232, the two highest water quality index ratings calculated for the streams of the Region were 90 for the August 1974-1975 sampling period at sampling station Rk-7 on the Oconomowoc River at USH 16 and 91 for the July-October 1964 sampling period at sampling station Rk-2 on the Kohlsville River at USH 41. The staff analysis of water quality data for these streams for the period of 1964 through 1975 as presented in Chapter VI above arrived at a similar conclusion. The other sampling stations for which the water quality ratings fell in the category of excellent—a water quality index of 86 units or higher—as presented in Table 232 were as follows:

1964		1974-1975	
Dp-1	89	Fx-12	88
Fx-12	89	Rk-7	90
Rk-1	86		
Rk-2	91		
Rk-3	87		
Rk-6	88		

The staff analysis of the 10 years of water quality data as presented in Chapter VI presented similar conclusions.

Figure 252

FECAL COLIFORM SCORE ASSOCIATED WITH OBSERVED FECAL COLIFORM CONCENTRATION

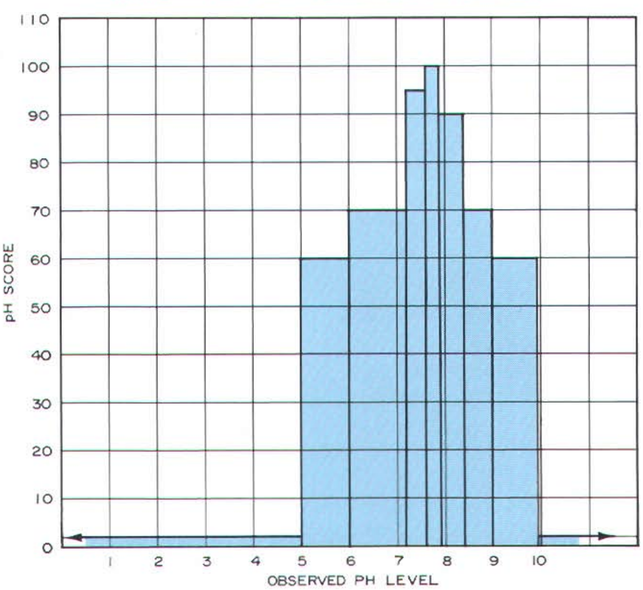


NOTE: FECAL COLIFORM CONCENTRATION ESTIMATED AS NINE PERCENT OF TOTAL COLIFORM BACTERIA

Source: SEWRPC.

Figure 253

HYDROGEN ION CONCENTRATION (pH) SCORES ASSOCIATED WITH OBSERVED pH LEVELS

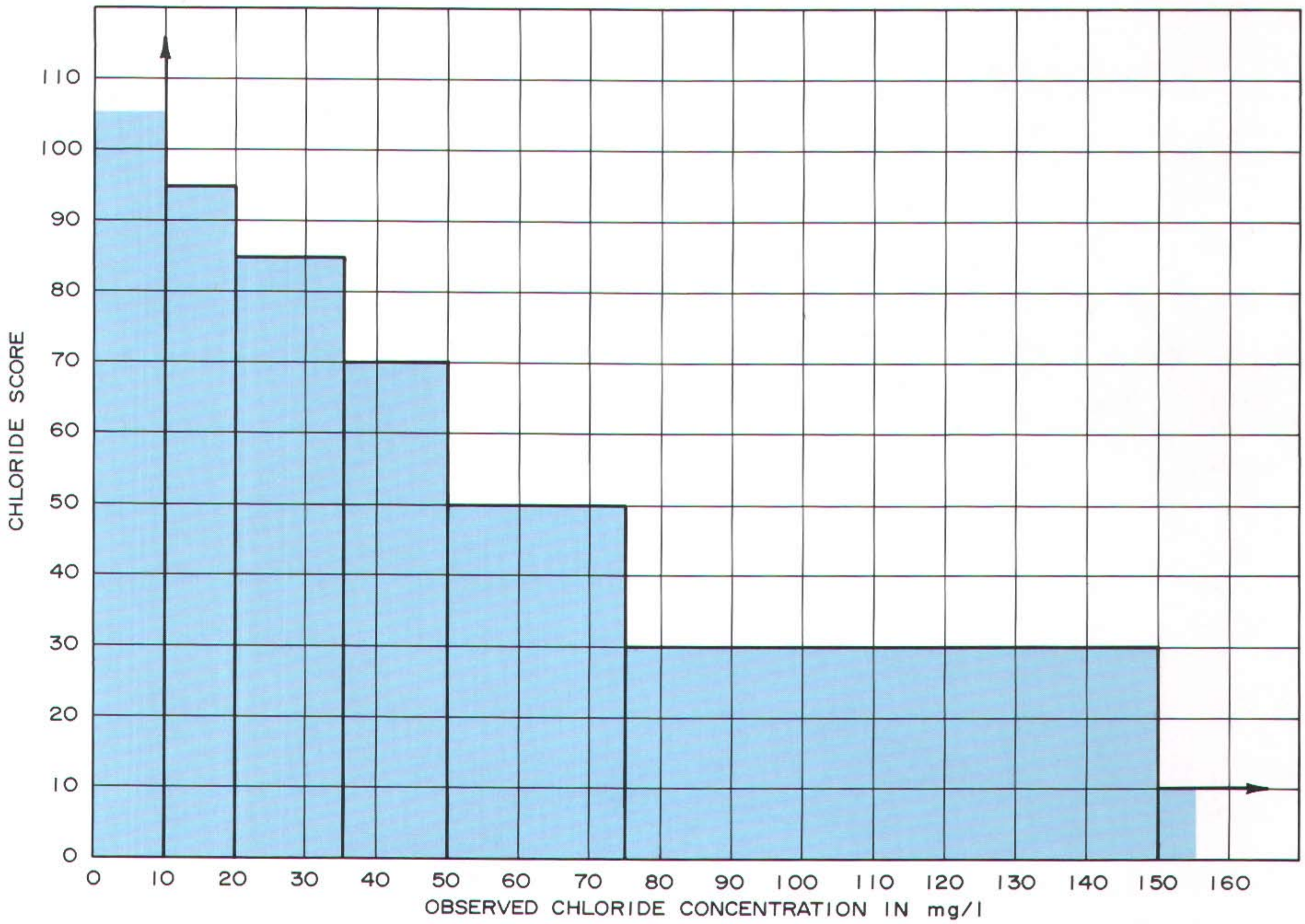


Source: SEWRPC.

The two lowest water quality index ratings calculated for the streams of the Region were 42 for the 1974-1975 sampling period at sampling station Fx-5 on the Pewaukee River at CTH SS; and 34 for the 1964 sampling period at sampling station Rk-11 on Jackson Creek at Mound Road. The other water quality sampling stations for which the water quality ratings are categorized as poor—a water quality index of between 31 to 50 units—were as follows:

Figure 254

CHLORIDE SCORE ASSOCIATED WITH OBSERVED CHLORIDE CONCENTRATIONS



Source: SEWRPC.

1964

Sampling Station	Water Quality Index
Fx-4	40
Fx-5	42
Fx-8	46
Fx-9	37
Fx-10	49
Fx-15	47
Fx-25	38
Mn-2	48
Mn-4	38
Mn-5	40
Pk-1	38
Pk-2	42
Pk-3	47
Rt-2	42
Rt-3	48
Sk-1	49

1974-1975

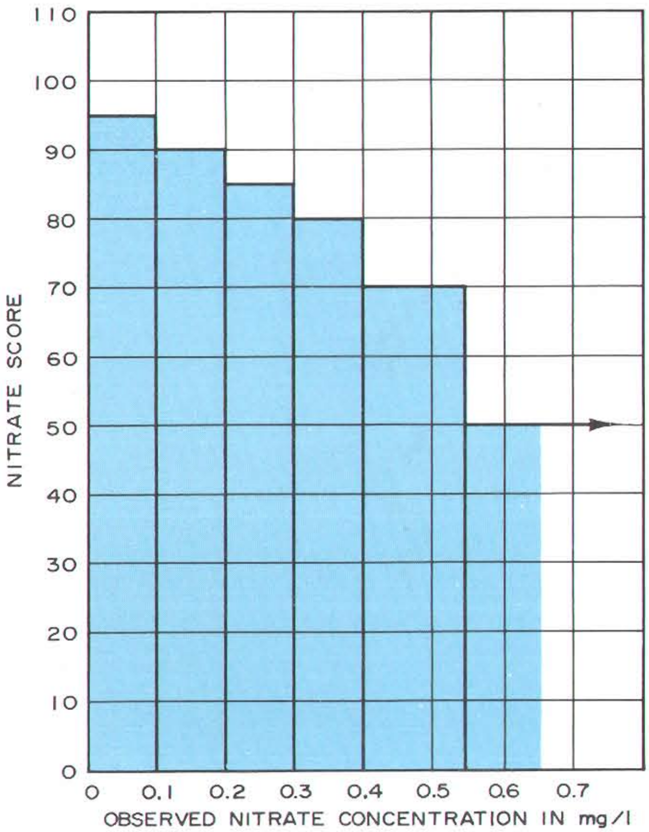
Sampling Station	Water Quality Index
Mn-5	44
Rk-11	45
Rt-1	49
Rt-2	48
Rt-3	49
Rt-5	47
Sk-1	43

The relatively low water quality indicated by the water quality index at these locations is confirmed by the results of the staff analyses of the water quality of individual watersheds as presented in Chapter VI.

Although at many locations the water quality index and the staff analyses of the water quality data indicated the same conclusions about trends over time, there were some locations where the water quality index and the staff analyses of the data did not agree directly. The difference in the results of the two methods can be explained by the fact that in the staff analyses, the trends in the parameters were individually analyzed and deductions were made about water quality as measured by all observations and for each one of the parameters. On the other hand, the water quality index calculation necessarily combines the effect of the six parameters identified as most critical, and does so for the selected months for which comparable data are available.

Figure 255

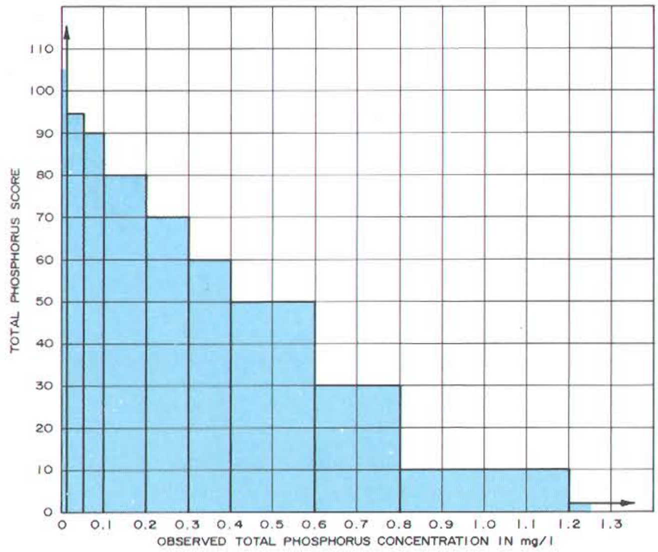
NITRATE SCORE ASSOCIATED WITH OBSERVED NITRATE CONCENTRATIONS



Source: SEWRPC.

Figure 256

TOTAL PHOSPHORUS SCORE ASSOCIATED WITH OBSERVED TOTAL PHOSPHORUS CONCENTRATIONS



Source: SEWRPC.

The cumulative frequency distribution of water quality index ratings for the samples taken at 87 sites in the Commission benchmark water quality survey in 1964 during July, August, September, and October, the four months most representative of the adverse water quality conditions associated with hot and dry summer conditions, are shown in Figure 257 and have a mean of 63, with 50 percent of the ratings between water quality index values of 46.0 and 63.4. Also presented in Figure 258 are the comparable statistics for the water quality index of the average values of the eight samples taken at the same 87 sites in the diurnal sampling of August 1974 and August 1975, as part of the Commission continuing water quality monitoring program. These water quality index ratings have a mean of 62, with 50 percent of the ratings between 41.8 and 62.6 units. A statistical analysis of the differences[6] between the 1964 and the 1974-1975 water quality index values, assessed for each of the 87 sampling stations, produces no statistically significant difference between the water quality index values for the years sampled. The average difference in the water quality index values computed for the sample stations was 1.4 units. Under the same assumptions and methodology, the average difference would have to equal or exceed 2.25 units in order to be statistically significant at the 95 percent confidence level. A graphic analysis using a fractile diagram technique shows the distribution of differences to be normally distributed, thus supporting the most critical assumption of the statistical analysis.

An examination of the water quality index distributions for 1964 and 1974-75 indicates a difference in the range and variance of the distributions, with the 1964 values having a greater range and variance. These differences are attributed to the differences in rainfall during the sampling periods. The total monthly precipitation values, averaged for 15 weather stations in southeastern Wisconsin, ranged from 0.19 inches to 6.29 inches during the four months used for computation of the 1964 water quality index values, while the average total rainfall for August 1974 and August 1975 were 3.81 and 5.50 inches, respectively.

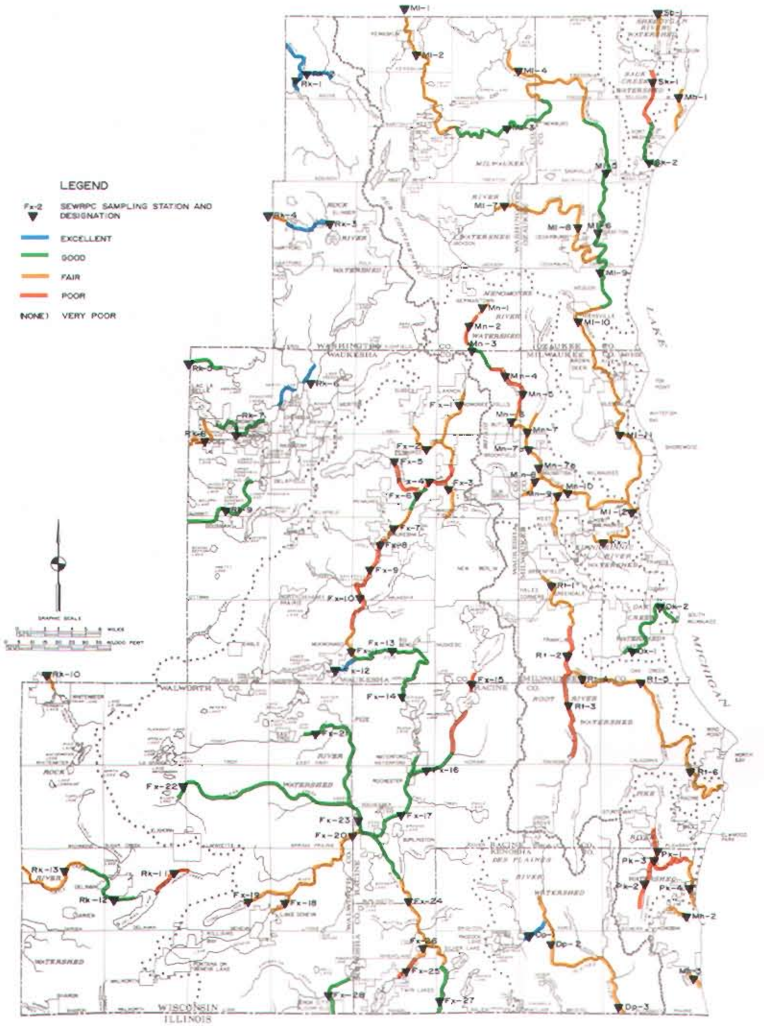
The average water quality index values of 63 units and 62 units for 1964 and 1974-1975, respectively, are of particular interest when compared to a theoretical water quality index of 73, which would correspond to the water quality parameter values associated with water quality standards for recreation and the maintenance of fish and aquatic life. Only 17 stations in 1964 and

[6] *A statistical methodology commonly referred to as the "paired difference" technique was used to evaluate the differences in the water quality index. For a thorough discussion of this methodology, see B. Ostle, Statistics in Research, Iowa State University Press, 1963.*

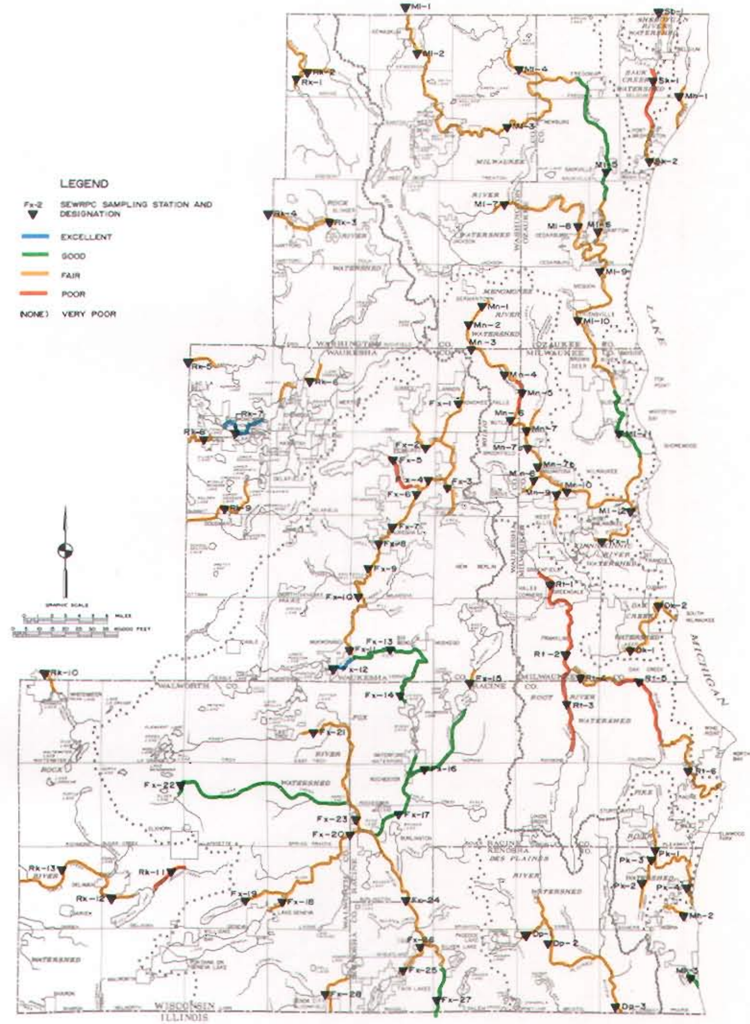
Map 90

WATER QUALITY INDEX SAMPLING RESULTS FOR JULY, AUGUST, SEPTEMBER, AND OCTOBER 1964 AND AUGUST 1974 AND 1975

1964



1974 AND 1975



Only 17 stations in 1964, and five stations in 1974-1975 exhibited water quality index values higher than the theoretical water quality index value of 73, a value corresponding to a level of water quality suitable for full recreational use and for the maintenance of a healthier fishery. This funding is consistent with the water quality analyses presented in Chapter VI, which concluded that established water quality standards are generally not being met in the streams of southeastern Wisconsin.

Source: SEWRPC.

Table 232

WATER QUALITY INDEX VALUES COMPUTED FOR SAMPLES FROM 87 STREAM SAMPLING STATIONS IN THE REGION

	For July, August, September, and October 1964								For August 1974 and 1975							
	Parameter Scores								Parameter Scores							
Station Number	DO	FC	pH	CL	NO_3	TP	Weighted Average Water Quality Index Values	Overall Water Quality Category	DO	FC	pH	CL	NO_3	TP	Weighted Average Water Quality Index Values	Overall Water Quality Category
Des Plaines River Watershed																
Dp-1	90	70	100	95	95	90	89	Excellent	65	20	90	85	90	80	68	Fair
Dp-2	65	20	90	70	90	70	65	Fair	90	20	90	30	70	60	61	Fair
Dp-3	20	20	95	70	90	50	53	Fair	50	20	90	70	80	60	59	Fair
Des Plaines River Watershed Average							69	Fair							63	Fair
Fox River Watershed Main Stem																
Fx-1	20	20	95	95	85	50	56	Fair	20	20	95	50	80	95	55	Fair
Fx-4	20	2	95	50	50	40	40	Poor	65	20	90	30	50	50	51	Fair
Fx-7	65	20	95	50	85	70	62	Fair	80	2	90	30	50	70	53	Fair
Fx-8	50	2	95	30	50	60	46	Poor	65	50	100	30	50	50	59	Fair
Fx-9	20	2	95	30	50	40	37	Poor	80	20	90	30	50	50	54	Fair
Fx-10	65	2	90	30	50	60	49	Poor	90	20	90	30	50	50	56	Fair
Fx-11	65	50	95	50	50	70	63	Fair	95	50	90	30	50	50	64	Fair
Fx-13	80	70	100	70	50	90	77	Good	95	70	90	50	50	60	72	Good
Fx-14	90	70	70	50	70	90	74	Good	95	70	90	50	50	60	72	Good
Fx-17	95	20	90	70	85	70	71	Good	95	70	70	70	85	70	78	Good
Fx-24	100	2	90	85	80	60	68	Fair	95	20	70	85	50	70	65	Fair
Fx-27	80	70	90	85	85	90	82	Good	60	70	90	85	50	80	72	Good
Fox River Watershed Main Stem Average							60	Fair							63	Fair
Fox River Watershed Tributaries																
Fx-2	80	20	90	50	50	70	60	Fair	80	20	90	50	50	50	57	Fair
Fx-3	20	70	95	95	80	70	68	Fair	80	20	90	50	50	95	63	Fair
Fx-5	20	20	95	30	50	50	42	Poor	20	2	100	50	50	50	42	Poor
Fx-6	90	70	100	50	90	90	82	Good	65	20	90	50	50	50	54	Fair
Fx-12	95	70	90	100	95	90	89	Excellent	90	70	90	95	95	95	88	Excellent
Fx-15	20	2	95	85	70	40	47	Poor	65	20	90	70	90	80	66	Fair
Fx-16	80	50	70	85	85	70	72	Good	80	70	90	70	90	80	80	Good
Fx-18	90	2	90	50	50	60	57	Fair	80	20	90	85	50	50	62	Fair
Fx-19	50	20	95	95	80	70	65	Fair	65	2	90	85	70	80	62	Fair
Fx-20	90	20	70	85	90	70	69	Fair	100	20	90	85	50	80	71	Fair
Fx-21	100	20	90	95	50	70	71	Good	80	2	90	95	50	80	64	Fair
Fx-22	95	50	90	95	80	70	80	Good	95	20	90	95	50	80	71	Good
Fx-23	90	50	90	95	80	70	79	Good	80	20	90	95	50	80	66	Fair
Fx-25	20	2	100	30	50	40	38	Poor	80	20	70	30	50	70	54	Fair
Fx-26	100	20	90	50	50	70	64	Fair	90	20	90	50	50	70	62	Fair
Fx-28	70	50	90	85	80	70	73	Good	100	2	90	85	50	80	67	Fair
Fox River Watershed Tributaries Average							66	Fair							64	Fair
Fox River Watershed Average							64	Fair							64	Fair
Kinnickinnic River Watershed																
Kk-1	80	2	95	95	80	60	66	Fair	80	2	100	50	80	90	65	Fair
Kinnickinnic River Watershed Average							66	Fair							65	Fair

Table 232 (continued)

Station Number	For July, August, September, and October 1964								For August 1974 and 1975							
	Parameter Scores						Weighted Average Water Quality Index Values	Overall Water Quality Category	Parameter Scores						Weighted Average Water Quality Index Values	Overall Water Quality Category
	DO	FC	pH	CL	NO_3	TP			DO	FC	pH	CL	NO_3	TP		
Menomonee River Watershed Main Stem																
Mn-1	20	20	95	95	70	50	54	Fair	65	20	90	85	50	90	64	Fair
Mn-2	20	2	95	70	85	40	48	Poor	80	20	90	70	50	70	63	Fair
Mn-3	100	2	95	85	90	60	71	Good	95	20	90	70	50	70	66	Fair
Mn-4	20	2	100	30	50	40	38	Poor	65	20	90	50	50	50	54	Fair
Mn-5	20	20	100	10	50	50	40	Poor	50	2	90	30	50	50	44	Poor
Mn-6	90	50	100	30	50	70	67	Fair	65	20	90	30	50	50	51	Fair
Mn-7a	10	100	2	100	95	70	60	Fair	80	20	90	30	50	60	56	Fair
Mn-7b	10	100	2	100	95	70	60	Fair	80	20	90	30	50	50	54	Fair
Mn-10	100	2	95	30	70	60	60	Fair	90	20	90	30	50	70	59	Fair
Menomonee River Watershed Main Stem Average							55	Fair							57	Fair
Menomonee River Watershed Tributaries																
Mn-7	90	2	90	85	95	60	68	Fair	65	20	90	50	50	80	58	Fair
Mn-8	90	2	90	30	85	60	59	Fair	95	2	70	30	95	95	63	Fair
Mn-9	65	2	95	50	50	60	52	Fair	80	20	90	30	70	70	60	Fair
Menomonee River Watershed Tributaries Average							60	Fair							60	Fair
Menomonee River Watershed Average							56	Fair							58	Fair
Milwaukee River Watershed Tributaries																
Ml-4	50	2	100	95	70	60	60	Fair	65	20	90	85	50	70	61	Fair
Ml-7	50	2	95	95	50	60	55	Fair	50	2	90	85	50	70	55	Fair
Ml-8	80	20	95	85	80	70	70	Fair	65	2	90	85	50	70	58	Fair
Milwaukee River Watershed Tributaries Average							62	Fair							58	Fair
Milwaukee River Watershed Main Stem																
Ml-1	65	20	95	85	80	70	66	Fair	90	70	90	30	50	60	68	Fair
Ml-2	50	20	95	95	80	70	65	Fair	90	20	90	70	50	80	66	Fair
Ml-3	90	20	100	95	70	70	73	Good	80	50	90	70	50	70	69	Fair
Ml-5	80	20	90	95	85	70	71	Good	80	50	70	85	85	70	72	Good
Ml-6	90	20	90	95	70	70	71	Good	60	20	70	70	85	80	61	Fair
Ml-9	100	20	90	85	70	70	72	Good	90	20	90	85	50	70	67	Fair
Ml-10	80	2	90	95	70	60	64	Fair	100	50	70	70	50	70	70	Fair
Ml-11	65	2	100	85	50	60	58	Fair	95	50	70	70	70	70	72	Good
Ml-12	50	2	95	95	70	60	58	Fair	20	2	100	70	80	80	53	Fair
Milwaukee River Main Stem Average							66	Fair							66	Fair
Milwaukee River Watershed Average							65	Fair							64	Fair
Minor Streams Tributary to Lake Michigan																
Mh-1	20	50	95	85	70	50	58	Fair	50	2	100	70	50	50	51	Fair
Mh-2	50	2	95	70	50	60	52	Fair	65	2	100	95	50	70	61	Fair
Mh-3	95	2	90	85	90	60	69	Fair	100	20	90	70	80	90	74	Good
Minor Streams Tributary to Lake Michigan Watershed Average							60	Fair							62	Fair
Oak Creek Watershed																
Ok-1	95	20	95	85	90	70	74	Good	50	50	100	30	85	90	66	Fair
Ok-2	100	20	100	50	85	70	71	Good	80	50	90	30	80	90	70	Fair
Oak Creek Watershed Average							73	Good							68	Fair

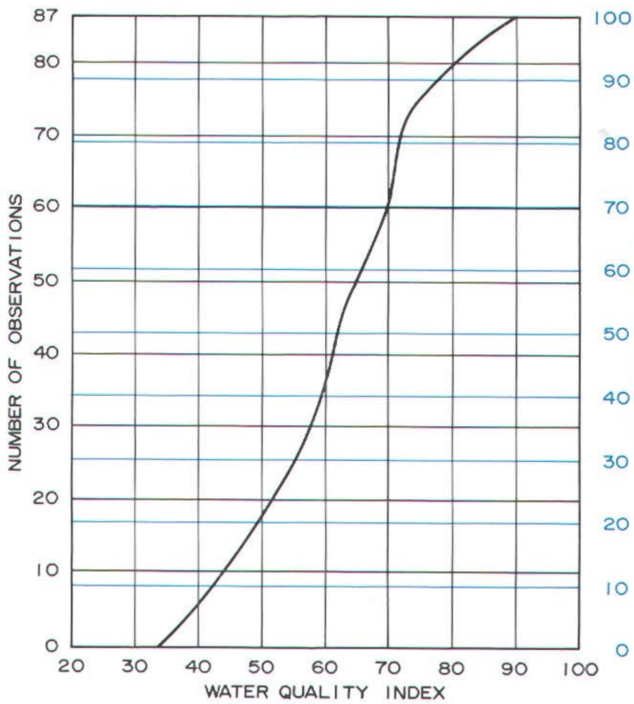
Table 232 (continued)

Station Number	For July, August, September, and October 1964: Parameter Scores DO	FC	pH	CL	NO_3	TP	Weighted Average Water Quality Index Values	Overall Water Quality Category	For August 1974 and 1975: Parameter Scores DO	FC	pH	CL	NO_3	TP	Weighted Average Water Quality Index Values	Overall Water Quality Category
Pike River Watershed																
Pk-1	20	2	70	70	50	40	38	Poor	50	20	100	95	50	80	63	Fair
Pk-2	20	2	95	70	50	40	42	Poor	20	20	100	70	50	70	51	Fair
Pk-3	20	20	95	70	50	50	47	Poor	80	20	90	85	50	80	66	Fair
Pk-4	50	2	100	70	70	60	55	Fair	65	20	100	85	50	90	66	Fair
Pike River Watershed Average							46	Poor							62	Fair
Rock River Upper Subwatershed																
Rk-1	80	70	100	95	90	90	86	Excellent	20	70	95	85	85	70	67	Fair
Rk-2	100	70	100	100	85	90	91	Excellent	65	20	90	95	50	90	66	Fair
Rk-3	90	70	90	95	90	90	87	Excellent	50	20	100	85	90	80	67	Fair
Rk-4	95	20	90	10	50	70	58	Fair	65	20	100	50	50	50	55	Fair
Rock River Upper Subwatershed Average							81	Good							64	Fair
Rock River Middle Subwatershed																
Rk-5	90	20	90	100	90	70	75	Good	50	20	100	95	85	80	67	Fair
Rk-6	90	70	90	100	95	90	88	Excellent	65	20	90	95	80	90	70	Fair
Rk-7	95	70	70	95	95	90	85	Good	100	70	90	95	95	95	90	Excellent
Rk-8	80	2	95	70	50	60	58	Fair	50	2	100	85	80	70	60	Fair
Rk-9	95	50	90	100	85	70	81	Good	65	2	100	85	85	80	66	Fair
Rock River Middle Subwatershed Average							77	Good							71	Good
Rock River Lower Subwatershed																
Rk-10	100	2	90	95	50	60	66	Fair	90	50	90	85	50	50	70	Fair
Rk-11	20	2	95	10	50	40	34	Poor	65	2	90	10	50	50	45	Poor
Rk-12	100	20	95	85	70	70	73	Good	20	2	100	85	70	70	52	Fair
Rk-13	80	20	95	85	50	70	66	Fair	90	2	90	85	50	70	63	Fair
Rock River Lower Subwatershed Average							60	Fair							58	Fair
Rock River Watershed Average							73	Good							64	Fair
Root River Watershed																
Rt-1	50	50	95	30	85	70	62	Fair	20	20	95	30	70	80	49	Poor
Rt-2	20	20	95	30	50	50	42	Poor	50	20	90	30	50	50	48	Poor
Rt-3	10	50	95	50	50	50	48	Poor	50	20	100	30	50	50	49	Poor
Rt-4	50	20	95	30	50	70	51	Fair	65	20	90	30	50	50	51	Fair
Rt-5	100	2	90	30	70	60	59	Fair	65	2	90	30	50	50	47	Poor
Rt-6	90	20	100	30	70	70	64	Fair	100	50	70	30	70	60	66	Fair
Root River Watershed Average							54	Fair							52	Fair
Sauk Creek Watershed																
Sk-1	50	2	95	50	50	60	49	Poor	20	2	90	70	50	50	43	Poor
Sk-2	80	70	90	85	85	90	82	Good	80	20	90	70	50	60	61	Fair
Sauk Creek Watershed Average							66	Fair							52	Fair
Sheboygan River Watershed																
Sb-1	90	2	95	95	70	57	67	Fair	65	2	90	85	50	50	55	Fair
Sheboygan River Watershed Average							67	Fair							55	Fair

Source: SEWRPC.

Figure 257

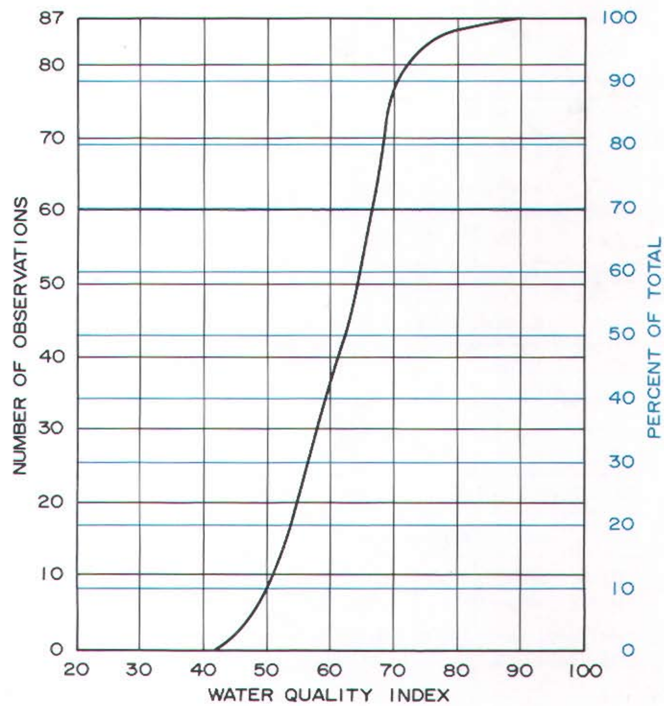
WATER QUALITY INDEX FREQUENCY DISTRIBUTION: JULY-OCTOBER 1964



Source: SEWRPC.

Figure 258

WATER QUALITY INDEX FREQUENCY DISTRIBUTION: AUGUST 1974-1975



Source: SEWRPC.

five stations in 1974-1975 exhibited water quality index values higher than the theoretical standard index. This is consistent with the water quality analysis presented in Chapter VI, which concluded that water quality standards generally are not being met in the streams of southeastern Wisconsin. Although the number of stations with water quality index values above 73 did decrease from 17 to five when comparing the values calculated for 1964-1965 with those calculated for 1974-1975, this cannot be taken to indicate a major shift in water quality in the Region as a whole. Between 1964-65 and 1974-75, the water quality index changed in samples collected at 18, or about 21 percent, of the sampling stations, by 14 units—1½ standard deviations—or more. Of these 18 stations, nine decreased in quality while nine increased in quality.

In the Des Plaines River watershed, the average of the water quality index values for three sampling stations changed from 69 units to 63 units over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. An increase in the water quality index was noted for sampling station Dp-3. This is attributed to differences in streamflow at the times of sampling, as set forth in the flow data presented in Figure 240. A decrease in water quality index was noted at sampling station Dp-1 on Brighton Creek. This is contrary to the generally improved water quality trend noted in the detailed analyses in Chapter VI above, and is attributed to the temporary effects of wet weather immediately preceding the sampling in 1975, and the associated storm water runoff containing pollutants from the land surface.

In the Fox River watershed the average of the water quality index values for 12 sampling stations on the main stem changed from 60 to 63 units over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. Increases in the water quality index were noted for sampling stations Fx-4, Fx-8, Fx-9, Fx-10, and Fx-17 on the Fox River main stem and are attributed to the combined effects of improved wastewater treatment and agricultural management practices. The improved water quality index values at sampling station Fx-4 are attributed to differences in flow at the time of sampling, since both water quality index values compared are relatively very low. At sampling stations Fx-8, Fx-9, and Fx-10 the improved water quality is likely due to the effects of the abandonment of the old City of Brookfield Fox River plant and Poplar Creek lagoon and the improvement of the City of Waukesha sewage treatment plant, including the addition of phosphorus removal facilities. At sampling station Fx-17, below the confluence of the Muskego Canal and Wind Lake Drainage Canal, modest water quality improvements are noted. A possible but improbable factor is the effect of channelization and drainage improvements on the runoff from agricultural land in the tributary areas. It would generally be assumed, however, that improved drainage would increase the storm water runoff rates and the loadings of soluble pollutants, as well as the amounts of pollutants transported with soil particles. The possible counter-argument is that very wet soils, unless artificially drained, might cause high rates of runoff from the saturated surface. The new drainage improvements, therefore, may have allowed for increased storm water infiltration.

Among the major tributaries in the Fox River watershed, the average of the water quality index values for 16 sampling stations changed from 66 to 64 units over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. Increases in the water quality index were noted for sampling stations Fx-15 and Fx-16 on the Muskego Canal and Wind Lake Drainage Canal, Fx-18 on the White River, and Fx-25 on Bassett Creek. The causes of the water quality improvements in the Muskego and Wind Lake Drainage Canals are difficult to identify, as noted above. At sampling stations Fx-18 and Fx-20 the water quality improvement is thought to be a result of the improved facilities serving the City of Lake Geneva. Similarly, the improved treatment facility serving the Village of Twin Lakes has enhanced water quality at sampling station Fx-25 on Bassett Creek. At sampling station Fx-20 on Sussex Creek, improved operations of the Village of Sussex sewage treatment plant are thought to account for the apparent increase in water quality. By contrast, however, at sampling station Fx-3 on Poplar Creek, the improvements at the City of Brookfield Fox River sewage treatment facility and the abandonment of the Poplar Creek lagoons are not reflected in increased water quality index values, perhaps because large portions of the tributary area have been in transition to urban residential land use. Decreases in the water quality index were noted at sampling stations Fx-21 and Fx-23 on Honey Creek, Fx-22 on Sugar Creek, and Fx-28 on Nippersink Creek. These water quality declines may be attributed to the effects of precipitation immediately preceding the sampling in 1975, since the detailed analyses presented in Chapter VI above indicate a generally stable water quality condition at each of these sites. Increased loadings at the sewage treatment facility as well as increased urban development in the tributary area are thought to account for decreased index values at sampling stations Fx-6 on the Pewaukee River and at station Fx-7 below the confluence with the Fox River.

In the Kinnickinnic River watershed the average water quality index value for the single sampling station changed from 66 to 65 units over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. The decrease in the water quality index is attributed to industrial wastewater discharges and increased urban storm water runoff.

On the main stem of the Menomonee River, the average of water quality index values for nine sampling stations changed from 55 to 57 units over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. Significant increases in the water quality index were noted at sampling stations Mn-1, Mn-2, and Mn-4 on the Menomonee River. Decreasing levels of agricultural activity in the upper reaches of the Menomonee River watershed are considered to be factors in the improved water quality at sampling stations Mn-1 and Mn-2. At sampling station Mn-4 the improvement was probably due to abandonment of a small Village of Germantown sewage treatment plant. Although the water quality index shows a slight decline at sampling station Mn-3, the abandonment of the Village of Germantown sewage treatment plant and the improvements made at the Lilly Road and Pilgrim Road plants should have resulted in improved water quality, as noted in Chapter VI, and confirmed by the changes in the water quality index values for sampling stations Mn-1, Mn-2, and Mn-4. A decline in the water quality index at sampling station Mn-6 on the Menomonee River is attributed to the effects of storm water runoff from precipitation immediately preceding the sampling in 1975. Among the three sampling stations on the tributaries of the Menomonee River, the average of the water quality index values was essentially unchanged over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. An increase in the water quality index is noted for sampling station Mn-9 on Honey Creek and is attributed to a significant reduction in the volume of untreated wastes from overflows and crossovers in the sanitary sewer system in the tributary area as a result of actions taken by the City of West Allis and the Metropolitan Sewerage District of Milwaukee County. A decline in the water quality index at sampling station Mn-7 on the Little Menomonee River is attributed to the effects of storm water runoff from agricultural operations in the tributary area.

On the main stem of the Milwaukee River, the average of the water quality index values for nine sampling stations remained at 66 over the period from 1964 to 1974-1975, representing a continuation of a fair water quality condition. Increases were noted in the water quality index values at sampling station Ml-10 and Ml-11 on the Milwaukee River and are attributed to improved operation and maintenance of sewage treatment plants serving the Village of Grafton and Thiensville. Similarly at sampling stations Ml-1 and Ml-5, minor water quality improvements may be attributable to better operation at the sewage treatment plants of the Villages of Fredonia and Campbellsport in Fond du Lac County. A decrease in the water quality index is noted at sampling station Ml-6 on the Milwaukee River and, despite improved operation and maintenance at the treatment plant serving the Village of Saukville, is attributed to the increased amounts of waste discharged from that sewage treatment plant, which is currently in the process of expansion and improvement.

At three sampling stations on the major tributaries of the Milwaukee River, the average of the water quality index values changed from 62 to 58 units over the period from 1964 to 1974-1975. The water quality condition continued to be categorized as fair over this time period. The decline in the water quality index values at sampling stations Ml-7 and Ml-8 on Cedar Creek, as well as the station Ml-9 which is located on the Milwaukee River main stem below its confluence with Cedar Creek, are attributed to increased loadings from the Village of

Jackson sewage treatment plant and the City of Cedarburg, increased urbanization and the installation of more onsite sewage treatment and disposal systems over the period of the study, and may also be influenced by variations in the flow at the times of sampling as demonstrated in Figure 240.

Among the minor streams draining to Lake Michigan, three sampling stations exhibited a change in the average of the water quality index values from 60 to 62 units over the period from 1964 to 1974-1975, representing a continuing water quality condition categorized as fair. Increases in the water quality index were noted for sampling stations Mh-2 and Mh-3 on Pike Creek and Barnes Creek, respectively, while a decrease in the water quality index was noted at sampling station Mh-1 on Sucker Creek. All of these changes are attributed to differences in flow at the times of sampling.

In the Oak Creek watershed the average of the water quality index values for two sampling stations changed from 73 to 68 units during the period from 1964 to 1974-1975, representing a declining water quality condition shifting categories from good to fair. A decline in the water quality index values at station Ok-1 is attributed to the effects of urbanization, development of commercial and industrial lands, and industrial wastewater discharges.

In the Pike River watershed the average of the water quality index values for four sampling stations changed from 46 to 62 units over the period from 1964 to 1974-1975, representing an improvement of water quality conditions from poor to fair. Improvements in the water quality index are noted at all four sampling stations on the Pike River. This improvement—from being the watershed with the lowest computed water quality index value in 1964 to being in the lower third of the water quality index values for watersheds in 1974-1975—is attributed to an enhanced operation and maintenance at the municipal sewage treatment facilities above sampling stations Pk-1 and Pk-3. At sampling station Pk-4 the apparent improvement in water quality probably is due to the dilution effect of Lake Michigan which has been observed more frequently by field sampling crews during the recent years of high lake levels of Lake Michigan. Disinfection at the Town of Somers sewage treatment plant may also have affected water quality index values at sampling station Pk-3 in this watershed.

In the upper subwatershed of the Rock River watershed, the average of the water quality index values for four sampling stations changed from 81 to 64 units over the period from 1964 to 1974-1975, representing a water quality condition declining from good to fair. Decreases in the water quality index values were noted at sampling stations Rk-1, Rk-2, and Rk-3. Despite improved operation and maintenance at the sewage treatment plant of the Allenton Sanitary District since 1972, the decline in water quality may be attributable to the increased total loadings from the sewage treatment facility, or to increased agricultural runoff in the subwatershed—a more likely explanation since the vast majority of the land in the tributary drainage area is in agricultural use, and could engender water quality effects of sufficient magnitude to overshadow the effects of this relatively small sewage treatment plant. In the middle subwatershed of the Rock River watershed, the average of the water quality index values for five sampling stations remained in the category of good with a shift in the average of the water quality index values from 77 to 71 units over the period from 1964 to 1974-1975. An improvement in water quality is noted at sampling station Rk-7 downstream from Oconomowoc Lake and may be a result of differences in precipitation, temperature, and pH due to patterns affecting the photosynthetic activity in Oconomowoc Lake. However, the generally reduced water quality index values from other stations more reflective of water quality in flowing streams, may be attributable to increased urbanization and development activities, as well as to agricultural activity in the subwatershed. In the lower subwatershed of the Rock River watershed, the average of the water quality index values for four sampling stations changed from 60 to 58 units over the period from 1964 to 1974-1975, an indication of a continuing water quality condition categorized as fair. Increased water quality index values at sampling stations Rk-10 and Rk-11 are attributed to improved operation and maintenance of treatment facilities at the Cities of Whitewater and Elkhorn, respectively. The declining water quality index values at sampling stations Rk-12 and Rk-13 may be associated with the effects of agricultural activities, increased loadings at the City of Delavan sewage treatment facility, and the effects of privately owned onsite sewage disposal systems tributary to the sampling points in the areas tributary to the sampling points.

In the Root River watershed the average of the water quality index values for six sampling stations changed from 54 to 52 units over the period from 1964 to 1974-1975, representing a stable water quality condition categorized as fair. The water quality index sampling station Rt-2 showed a noticeable increase directly associated with the abandonment of four sewage treatment facilities—Tess Corners Grade School, Mission Hills Water and Sewer Trust, Milwaukee House of Correction, and the Village of Greendale—in the subwatershed. Similarly the improved water quality at sampling station Rt-3 on the Root River Canal is associated with enhancements in the Cooper-Dixon duck farm waste treatment facility. The decline in water quality, as indicated by significant decrease in the water quality index at sampling station Rt-1, is attributed to the effects of urban storm water runoff. The significant reduction in the water quality index value at sampling station Rt-5 is not explained, but is thought to be associated with a source of chloride loadings as well as possibly other pollutants—perhaps an agricultural pollution source within the watershed.

In the Sauk Creek watershed the average of the water quality index values for two sampling stations changed from 66 to 52 units over the decade, representing a continuing fair water quality condition, despite reductions in the water quality index values for each of the two sites. The decline in water quality is attributed in part to the effects of agricultural activities, and in part to the effects of storm water runoff, and one sanitary sewer bypass.

The water quality index at the single sampling station on Belgium Creek in the Sheboygan River watershed dropped from 67 to 55 units during the period from 1964 to 1974-1975, but continued to be categorized as a fair water quality condition. The apparent decline in water quality is attributed to heavy rains experienced during the 1975 sampling period and may be indicative of the presence of agricultural pollution and the effects of the sewage treatment plant at the Village of Belgium, but cannot be interpreted to represent a significant temporal shift in water quality.

A lake classification index, developed at the University of Wisconsin and used by the Wisconsin Department of Natural Resources, was applied to the available data for major lakes in southeastern Wisconsin. This lake classification index was chosen for use in lieu of the stream water quality index described above because of the differences in the effects of pollution on lakes as opposed to streams. Lakes, especially those which stratify, exhibit marked seasonal changes in water quality; whereas streams, although more highly changeable in their water quality from hour to hour, are affected by the same forces regardless of the season. Because of their different hydraulic characteristics, lakes have the effect of reducing the immediate levels of the pollutants in their inflowing streams; but tend to store these substances in the bottom sediments or even in the lake water itself, thereby receiving cumulative and long-term pollutional impacts, more difficult to reverse than those imposed on a stream. Similarly, bacteriological pollution, so important in stream water quality, is diluted to insignificance in most lakes. Finally, high lake levels can not flush or cleanse a lake, the way flood flows can scour a stream bed.

The lake classification index uses different parameters, inclusive of water clarity, the occurrence of fish kills, and other less quantitative measures of the extent of impairment of human use of the lake, to evaluate the trophic status. In addition, the lake classification index selected provides the potential for comparing water quality in lakes in southeastern Wisconsin to that of the lakes throughout the rest of the State, since more than 1,100 lakes had been rated as of 1976.

The results of the lake classification index are presented in Table 233 and show the most oligotrophic major lakes in the Region to be Friess, Pike, and Silver Lakes in Washington County and Middle Genesee in Waukesha County, and the most eutrophic to be Tichigan Lake in Racine County. Of the 65 lakes for which data were available, eight lakes, or 12 percent, were rated as oligotrophic; 37 lakes, or 57 percent, were rated as mesotrophic; eight lakes, or 12 percent, were rated as eutrophic; and 12 lakes, or 19 percent, were rated as very eutrophic. Since very limited time series data were available for lake water quality, no temporal comparisons were made.

SUMMARY

Different dimensions of water quality can be measured by different parameters. In order to provide a summary form of the sample results from the Commission benchmark water quality survey and the Commission continuing water quality monitoring program, six water quality parameters were identified for use in the water quality index. Dissolved oxygen, fecal coliform, pH, chlorides, nitrate-nitrogen, and total phosphorus were chosen because of their value as general indicators of water quality as discussed in Chapter V of this report; because of the availability of data on these parameters or estimates of these parameters; and because of their likelihood for continued inclusion in water quality sampling programs of the Commission or other agencies and institutions.

From each water quality sample analyzed, the observed level of each of the six selected parameters was assigned a score in the range of from zero to 100. Based on a weighting which was selected by the Commission staff after review of the 11 years of water quality data available for the streams of southeastern Wisconsin, the parameter scores were combined to result in a water quality index rating for each sample. The resulting water quality index ratings were compared with professional judgments of the general water quality of selected streams in southeastern Wisconsin, to identify general categories of water quality. Index ratings of 30 or less were categorized as "very poor" water quality and index ratings between 31 and 50 were categorized as "poor" water quality. Ratings between 51 units and 70 units were termed "fair," between 71 and 85 units "good," and 86 to 100 units were "excellent." The resulting ratings for 1974-1975 ranged from a low of 42 at sampling station Fx-5 on the Pewaukee River, indicative of poor water quality, to a high of 90, indicative of excellent water quality at sampling station Rk-7 on the Oconomowoc River. Based on the July, August, September, and October samples taken in 1964 at 87 sampling stations, the water quality ratings were found to be poor at 17, or 19.5 percent of stations; fair at 42, or 48.3 percent of the stations; good at 22, or 25.3 percent of the stations, and excellent at six, or 6.9 percent of the stations. Based on similar samples for August 1974 and 1975, water quality ratings were found to be poor at 8, or 9.2 percent of the stations; fair at 68, or 78.2 percent of the stations; good at 9, or 10.3 percent of the stations; and excellent at 2, or 2.3 percent of the stations. The samples taken in 1974-1975 exhibited a general shift into the water quality category of "fair" when compared to those samples taken in 1964.

When comparing the average of the water quality index ratings for all samples taken in July, August, September, and October 1964 with the ratings for those taken in August 1974 and 1975, a statistically insignificant reduction over the decade for the Region as a whole is indicated by a decrease from 63 to 62 units. In the two comparison periods, the range of the water quality index values for the August months of 1974 and 1975 were found to be narrower than the range for the four-month period of data used for 1964 index calculations, a result consistent with the variations typically expected in water quality conditions from month to month.

The average values of the water quality indices of the streams of the major watersheds of the Southeastern Wisconsin Region were examined for trends in water quality conditions as indicated by the water quality index values. In the Des Plaines River watershed the water quality was found to have remained in the category of fair, with average index values of 69 and 63 for the years 1964 and 1974-1975, respectively. In the Fox River main stem the average of the water quality index for the 12 stations remained fair, with values of 60 and 63, respectively, for the comparison years. The 16 stations in the Fox River tributaries remained rated as fair, with average index values of 66 and 64, respectively, for the comparison years. In the Kinnickinnic River watershed the single sampling station exhibited average index values of 66 and 65 for the comparison years, a fair water quality. The nine stations on the main stem of the Menomonee River continued to be categorized as fair in their water quality with average index values of 55 and 57, respectively, for the comparison years. The three sampling stations on the tributaries of the Menomonee River continued to be categorized as fair in their water quality with average water quality index values of 60 for both the comparison years. Similarly the nine stations on the main stem of the Milwaukee River continued to be categorized as fair, with average water quality index values of 66 for both the comparison years. At the three sampling stations on the tributaries of the Milwaukee River the average water quality index values were categorized as fair, computing to 62 and 58, respectively, for the years of comparison. Fair water quality continued to be exhibited for the average water quality index values for the three sampling stations on the minor streams tributary to Lake Michigan, and having water quality index values of 60 and 62 for the years of comparison. None of the changes in index values were thought to indicate dramatic shifts in water quality, although locally important shifts in water quality were noted on the basis of both the water quality index and the more specific and detailed analyses presented in Chapter VI above.

In the Oak Creek watershed the two sampling stations exhibited average water quality index values of 73 and 68 for the years of comparison, representing a shift in water quality from good water quality to fair water quality. In the Pike River watershed the water quality apparently increased from poor to fair based on the water quality index values averaged for four sampling stations and computing to 46 and 62 for the years of comparison. For the four stations in the upper Rock River subwatershed, the average water quality index value shifted categories from good to fair water quality, with the average index values of 81 and 64, and the middle Rock River subwatershed exhibiting values of 77 and 71. In the lower Rock River subwatershed the four sampling stations continued to be rated as fair in their water quality with average water quality index values of 60 and 58. In the Root River watershed the water quality index values averaged for the six sampling stations shifted from 54 to 52, but continued to be rated as fair. In the Sauk Creek watershed the water quality index average for the two sampling stations was 66 and 52 in 1964 and 1974-1975, respectively, the water quality continued to be rated as fair based on these values. In the Sheboygan River watershed the water quality index value for a single sampling station was 67 and 55 for each of the years of comparison, and continued to be rated as fair in its water quality.

At many locations the water quality sampling station data indicated improved water quality which could be attributed primarily to the improved waste treatment facilities including chlorination of the treated effluents to decrease the fecal coliform counts; improved operation and maintenance to decrease the organic loadings and thereby increased the dissolved oxygen levels in the streams; and tertiary or advanced waste treatment to reduce the organic waste loadings and the nutrient levels discharged to the receiving streams. These effects generally are reflected in the water quality index developed by the Commission.

A lake classification index developed at the University of Wisconsin and used by the Wisconsin Department of Natural Resources, was applied to the available data for 65 of the 100 major lakes in southeastern Wisconsin, and showed eight to be oligotrophic, 37 to be mesotrophic, eight to be eutrophic, and 12 to be very eutrophic. This was considered to be enough lakes to be taken as generally representative of the major lakes in southeastern Wisconsin, although it is likely that the lakes which have been classified include most, if not all, of the lakes which are most aesthetically appealing because of their oligotrophic characteristics. Accordingly, the cross section may underestimate the proportion of the lakes of the Region which are enriched to various degrees of eutrophication.

Table 233

LAKE CLASSIFICATION INDEX OF SELECTED MAJOR LAKES IN SOUTHEASTERN WISCONSIN: 1975

Watershed	Major Lake Name	County	Lake Classification Index[a]	Category
Des Plaines.	Benet and Shangrila	Kenosha	13	very eutrophic
Des Plaines.	Paddock	Kenosha	9	mesotrophic
Fox	Beulah	Walworth	7	mesotrophic
Fox	Big Muskego	Waukesha	12	eutrophic
Fox	Bohners	Racine	6	mesotrophic
Fox	Booth	Walworth	6	mesotrophic
Fox	Browns	Racine	8	mesotrophic
Fox	Buena	Racine	6	mesotrophic
Fox	Camp	Kenosha	14	very eutrophic
Fox	Center	Kenosha	6	mesotrophic
Fox	Como	Walworth	13	very eutrophic
Fox	Denoon	Waukesha	8	mesotrophic
Fox	Eagle	Racine	20	very eutrophic
Fox	Eagle Spring	Waukesha	5	mesotrophic
Fox	Echo	Racine	6	mesotrophic
Fox	Elizabeth	Kenosha	6	mesotrophic
Fox	Geneva	Walworth	5	mesotrophic
Fox	Green	Walworth	9	mesotrophic
Fox	Little Muskego	Waukesha	12	eutrophic
Fox	Long	Racine	17	very eutrophic
Fox	Lower Phantom	Waukesha	9	mesotrophic
Fox	Marie	Kenosha	8	mesotrophic
Fox	Middle	Walworth	7	mesotrophic
Fox	Mill	Walworth	8	mesotrophic
Fox	North	Walworth	13	very eutrophic
Fox	Pell	Walworth	12	eutrophic
Fox	Pewaukee	Waukesha	15	very eutrophic
Fox	Pleasant	Walworth	4	oligotrophic
Fox	Potters	Walworth	12	eutrophic
Fox	Powers	Kenosha	8	mesotrophic
Fox	Silver	Kenosha	8	mesotrophic
Fox	Spring	Waukesha	4	oligotrophic
Fox	Tichigan	Racine	21	very eutrophic
Fox	Upper Phantom	Waukesha	6	mesotrophic
Fox	Wandawega	Walworth	13	very eutrophic
Fox	Waubeesee	Racine	7	mesotrophic
Fox	Wind	Racine	7	mesotrophic
Milwaukee	Big Cedar	Washington	5	mesotrophic
Milwaukee	Little Cedar	Washington	5	mesotrophic
Milwaukee	Mud	Ozaukee	10	eutrophic
Milwaukee	Silver	Washington	3	oligotrophic

Table 233 (continued)

Watershed	Major Lake Name	County	Lake Classification Index[a]	Category
Rock.	Beaver	Waukesha	7	mesotrophic
Rock.	Comus	Walworth	15	very eutrophic
Rock.	Delavan	Walworth	14	very eutrophic
Rock.	Druid	Washington	6	mesotrophic
Rock.	Five	Washington	12	eutrophic
Rock.	Friess	Washington	3	oligotrophic
Rock.	Golden	Waukesha	8	mesotrophic
Rock.	Keesus	Waukesha	8	mesotrophic
Rock.	Lac La Belle	Waukesha	10	eutrophic
Rock.	Loraine	Walworth	12	eutrophic
Rock.	Lower Nemahbin	Waukesha	5	mesotrophic
Rock.	Middle Genesee	Waukesha	3	oligotrophic
Rock.	Nagawicka	Waukesha	13	very eutrophic
Rock.	North	Waukesha	5	mesotrophic
Rock.	Oconomowoc	Waukesha	8	mesotrophic
Rock.	Okauchee	Waukesha	4	oligotrophic
Rock.	Pike	Washington	3	oligotrophic
Rock.	Pine	Waukesha	7	mesotrophic
Rock.	Silver	Waukesha	5	mesotrophic
Rock.	Tripp	Walworth	6	mesotrophic
Rock.	Turtle	Walworth	5	mesotrophic
Rock.	Upper Nashotah	Waukesha	4	oligotrophic
Rock.	Upper Nemahbin	Waukesha	7	mesotrophic
Rock.	Whitewater	Walworth	7	mesotrophic

[a]*LCI*	*Trophic Classification*
0-1	*very oligotrophic*
2-4	*oligotrophic*
5-9	*mesotrophic*
10-12	*eutrophic*
13-	*very eutrophic*

Source: U. S. Environmental Protection Agency, June 1975, EPA-660/3-75-033.

Chapter VIII

WATER QUALITY MONITORING PROGRAM ENHANCEMENTS

INTRODUCTION

In the analysis of the water quality data collected in the Commission benchmark water quality sampling program and in the Commission continuing water quality monitoring effort, five specific objectives were sought to be achieved. These objectives included identification of temporal water quality changes over the period from January 1964 through August 1975; identification of spatial changes in water quality within the system of lakes and streams in the Region; a complete areawide evaluation of the quality of the surface water network; a comparison of past and present water quality to applicable standards; and identification of major pollution sources wherever possible.

In the conduct of this analytical work the Commission staff has noted specific aspects of the basic data collection effort which, if modified, would enhance the utility of the resulting data for a similar analysis at some future time. The potential enhancements can be divided into three groups. The first group relates to the need for additional stream and lake water quality sampling locations, to provide more complete geographic coverage within the Region. The second group relates to analysis of the samples collected for additional water quality parameters. The third group relates to the periods and frequencies of the sampling activities. The potential enhancements discussed below will be considered in the development of a continuing regional water quality monitoring program, as an element of the recommended areawide water quality management plan for southeastern Wisconsin. The costs, benefits, timing, and responsibilities for water quality sampling will be discussed, alternatives evaluated, and recommendations made as part of this important element of the regional plan.

Stream Sampling Locations

The Commission 1964-1965 benchmark water quality sampling program collected water samples at 87 sampling stations in the 12 watersheds in the Region. The utility of the water quality data would be enhanced by the inclusion of 19 additional sampling stations at sites located on streams draining areas which have been urbanized since the original benchmark survey; on streams draining areas in which new or previously existing industrial or commercial land uses have been found to be potentially important factors in water quality conditions; or on streams for which the State has designated special water quality standards other than the more generally applicable standards supportive of water use objectives for recreation and the maintenance of a warm water fishery. Examples of the latter category include streams designated for the maintenance of a trout fishery or, conversely, streams which have been identified as having exceedingly low water quality and, therefore, requiring wastewater treatment beyond secondary levels.

None of the existing 87 sites of the Commission was deemed appropriate for discontinuation in a sampling program directed at the assessment of long-term water quality trends because of the very important and unique historical value of continued and fully comparable water quality sampling results from specific sites. To relocate or abandon sites imposes severe limitations on the value of the sample results in such a trends analysis.

In the Des Plaines River watershed, one additional sampling station would be helpful on the Des Plaines River in Kenosha County at the CTH N bridge in the Town of Paris, approximately 0.9 miles and 2.8 miles upstream from the confluence with Brighton Creek and the existing sampling station Dp-2, respectively. The upper reaches of the Des Plaines River receive wastewaters discharged by five industries and one private sewage treatment facility and are difficult to analyze for water quality because of the distance between the effluent discharge points and the nearest existing sampling station downstream, Dp-2.

In the Fox River watershed an additional sampling station on Palmer Creek, a first-order tributary of the Fox River, would be useful in estimating the water quality characteristics of undeveloped areas in the Region, as well as assuring that the applicable water use objectives are achieved for Palmer Creek, designated by the Wisconsin Department of Natural Resources as a trout stream and therefore required to meet the criteria applicable to the maintenance of a cold water fishery. In order to provide representative water quality data and samples at a site where streamflow is most likely to be present during dry weather sampling occasions, the sampling station should be located at the STH 50 and 83 crossing in the Town of Wheatland, 0.6 mile above the confluence with the Fox River.

In the Kinnickinnic River watershed, four additional sampling stations are suggested. Two of these would be useful to provide water quality data on streams draining areas containing special land uses—the industrial land use activities which are located in the subwatershed of the 43rd Street ditch, and General Billy Mitchell Field. These two potential sampling stations should be located on the 43rd Street ditch in the City of Milwaukee at the Chicago and North Western Railroad bridge immediately east of S. 43rd Street and on Wilson Park Creek in the City of Milwaukee at the S. 6th Street bridge, where storm water runoff from General Billy Mitchell Field and the effects of the commercial and industrial establishments in the subwatershed of the Holmes Avenue Creek would be reflected in the samples. The third additional station should be located at the streamflow gaging station established in 1976 by the Commission in cooperation with the U. S. Geological Survey and the Metropolitan Sewerage Commission on the Kinnickinnic River at S. 7th Street. The fourth potential sampling site, particularly attractive for the nearly uniform land uses in the tributary area, was at the 72-inch hemispherical storm sewer outlet located about 50 feet to the southeast of the intersection of S. Howell and East Layton Avenues. This storm sewer drains about 1,010 acres of land predominantly devoted to use for runways and terminal areas for General Billy Mitchell Field Airport. Although useful for characterizing the water quality effects of these land uses, the site would be less likely to exhibit measurable flow under dry conditions, has an artificial bottom surface which would not provide favorable habitat for benthic organisms, and drains a far smaller proportion of the Kinnickinnic River watershed than does the downstream site. These differences make the S. 6th Street site more appropriate for the collection of data useful in long-term assessment of water quality trends, as discussed in this report.

In the Menomonee River watershed, four more sampling stations would be useful, two located in the heavily industrialized areas downstream from existing sampling station Mn-10 at the crossing of N. 70th Street, and two located in the upstream areas currently undergoing urbanization. More specifically, two of the sites which appear worthy of consideration were utilized as temporary sampling stations in the synoptic water quality surveys conducted by the Commission as a part of the Menomonee River Watershed Comprehensive Planning Program, and the two were instrumented for continuous streamflow measurement as part of the IJC pilot study of the Menomonee River watershed. The temporary commission sites are designated as TMn-14 in the City of Milwaukee at the 37th Street footbridge, which provides water quality data at the farthest downstream continuously flowing point on the Menomonee River, where the streamflow is not under the influence of the backwater effects of Lake Michigan and the Milwaukee harbor, and TMn-15 in the City of Milwaukee at the Muskego Street bridge, where water quality samples are known to reflect the characteristics of the upper reaches of the Milwaukee inner harbor and the estuary-like portions of the Menomonee River. At this latter site it would be necessary to conduct the field sampling in accordance with special precedures described below to obtain samples representative of deep or stratified lake or estuary water quality conditions.

The other two sites recommended for consideration have been instrumented with continuous flow-gaging equipment as part of the IJC pilot study of the Menomonee River watershed. On the Menomonee River at Pilgrim Road (CTH YY) in the Village of Menomonee Falls, the USGS gaging station has been recommended in the Commission's Menomonee River watershed plan for continued operation. This streamflow data would be an important adjunct to further water quality sample results which could be obtained from this site to characterize conditions below the urbanizing upper subwatershed. At the USGS gaging station on the Little Menomonee River at W. Silver Spring Drive (CTH VV) in the City of Milwaukee, samples reflecting the water quality of this subwatershed also would be useful since there currently is no Commission sampling station on this important tributary and the area drained is urbanizing and is known to include agriculture related water pollution sources for which future controls have been recommended by the Commission.

In the Milwaukee River watershed, one additional sampling station would be desirable on Pigeon Creek, a first-order tributary of the Milwaukee River, at the bridge of STH 57 in the Village of Thiensville south of the Village of Thiensville sewage treatment plant. This station would be useful in assessing the effects of the effluent discharge of this sewage treatment facility.

In the Oak Creek watershed, two additional sampling stations are recommended. The industrial land uses in the subwatershed of the North Branch of Oak Creek would make useful a sampling station on the North Branch of Oak Creek at the Chicago, Milwaukee. St. Paul, and Pacific Railroad bridge, approximately 0.2 mile north of STH 100 (Ryan Road). This station would allow for an assessment of the water quality effects of storm water runoff from the area of industrial and commercial development tributary to the North Branch to Oak Creek. The second site recommended for consideration is in the City of Oak Creek on the Mitchell Field drainage ditch at the Chicago and North Western Railway bridge approximately 0.3 mile north of Drexel Avenue. It would provide information on the water quality effects on Oak Creek of drainage from the urban development immediately to the south of General Billy Mitchell Field as well as from the subwatershed of the Mitchell Field drainage ditch flowing from the airport itself.

In the Pike River watershed two additional sampling stations would be helpful to an analysis of water quality. One should be located at the STH 11 bridge over the Pike River in Racine County, to allow for an evaluation of the water quality in the upper reaches of the Pike River which are designated for restricted water use. The other should be located on the Pike River at the CTH A bridge in the Town of Somers, to provide water quality data from samples undiluted by Lake Michigan waters, and should be located at a point with good hydraulic control to assure accurate flow rating. The existing sampling station, Pk-4, is farther downstream, and the quality of the samples has been influenced by the dilution effects of Lake Michigan, while the flow measurements have been impaired by the backwater effects of Lake Michigan during recent periods of high water on the Lake.

In the Rock River watershed three streams are designated for recreational use and the maintenance of a trout fishery—Allenton Creek in Washington County, Scuppernong River in Waukesha County, and Bluff Creek in Walworth County. Accordingly, these streams should be sampled to assure that their water quality is sufficient to achieve the designated water use objectives. For Allenton Creek the sampling station site recommended for consideration is at the Wildlife Road bridge in the Town of Addison. For Scuppernong River, the CTH Z bridge at the Waukesha-Jefferson County line is recommended as the site. On Bluff Creek, the site recommended for consideration is at the CTH P bridge, in the Town of Whitewater.

In the Root River watershed one additional sampling station is recommended for consideration on the West Branch of the Root River canal at the Four Mile Road bridge in the Town of Raymond. This sampling station is recommended to allow for an evaluation of water quality as it might be affected by the presence of agricultural activities within the subwatershed and the presence of three industries and two sanitary sewage treatment facilities which discharge to the West Branch of the Root River canal.

In addition to the 19 additional stream sampling stations discussed above, it would be ideally desirable to identify additional stream sampling stations on every reach of stream in the Region which manifests limited water quality as a result of limited natural flow, natural background pollutant loadings, or irretrievable cultural development which affects water quality. There are numerous such streams throughout southeastern Wisconsin which have, historically, exhibited a questionable potential for the maintenance of high water quality concurrent with their use as waste receiving bodies. Similarly, there are numerous urban streams which function primarily as urban storm drains and numerous rural drainage channels which serve as agricultural drainage ditches or as drainage swales flowing only during wet weather. In a reevaluation of the applicable water quality standards, the Wisconsin Department of Natural Resources completed the investigation of five such streams of potentially limited water quality within southeastern Wisconsin during 1976, to be followed by the investigation of an additional 34 streams within the Region to evaluate the appropriate wasteload allocations to be made to the streams and the suitability of requiring more stringent levels of wastewater treatment for the existing municipal sanitary sewage effluent discharges to those streams. It is also possible, however, that the State will find the applicable stream water quality standards to be higher than the natural limitations of the stream will allow. In addition, selected segments of 13 streams within the Region have been identified in the water quality standards since 1973 as streams with limited water quality.

It is unlikely that the benchmark and trending analyses sought to be accomplished with the Commission sampling programs would add a significant amount of information to the detailed analyses conducted by the State Department of Natural Resources—in part, to provide specified performance criteria to be met by treatment of the wastewater generated in the tributary area. These surveys entail two- to three-week periods of intensive and time-coordinated, frequent sampling efforts of the discharging point sources, and the in-stream water quality response. Accordingly, the Commission staff has concluded that the establishment of continuing water quality sampling sites on these many stream reaches within the Region would be too expensive for the limited information which would be obtained and would duplicate the intensive effort being expended by the State in analyzing the waste carriage and assimilation capacity of the streams.

It is recognized that the conclusions reached concerning the natural potential for water quality and the recommendations for revised water quality standards or waste treatment levels are very important matters in the evaluation of the extent to which alternative water quality plans could meet the desired water use objectives and supporting standards in the rivers and streams of the Region. Therefore, in developing the official areawide water quality plan for southeastern Wisconsin, to be documented in SEWRPC Planning Report No. 30, the suitability of these streams for certain uses will be examined. The available information will be applied to determine whether there are cost-effective means for achieving water quality standards for recreation and the maintenance of fish and aquatic life in these streams or whether more limited water quality objectives and associated standards and criteria should be considered.

Lake Sampling Stations

The water quality monitoring program, which now includes the streams of the Region, should also be expanded significantly to include in each sampling year all 100 major lakes of the Region. The important sample times would be during fall or spring turnover—when the nutrient concentrations should be representative of fully mixed lake water quality conditions, and during summer stratification, when the most adverse conditions would be expected. Some data on water quality conditions during winter ice cover would also be useful. Although the number of sampling locations would vary depending on the size of the lake, one sampling station at the largest inlet, one at the outlet, and one sampling station at the deepest portion of the lake are recommended to be sampled. Only one sampling point would be needed, however, in each of the 28 kettle lakes, and two on each of the 30 headwaters lakes. This results in an estimated 214 sampling stations proposed for consideration in lakes.

Water Quality Parameters

In addition to the 13 water quality parameters presently included in the continuing monitoring program of the Commission, five additional parameters are suggested to improve the use of the data for characterizing the water quality of streams. Biochemical oxygen demand, both total and carbonaceous, would be useful for all stream samples collected to expand the interpretability of the dissolved oxygen data which are currently provided under the program. Similarly, chemical oxygen demand would be useful. These two parameters together would provide an indication not only of the oxygen stress in the stream at the time and point of sampling, but also an indication of the potential for oxygen utilization by the wastes in the stream. This would extend the domain of the data—

both in the geographic sense by indicating the potential downstream water quality impacts and in the temporal sense by indicating the potential changes in oxygen as the oxygen-demanding substances exert themselves.

Fecal streptococcus analyses are recommended for all samples. The fecal streptococcus analyses are recommended because of their potential utility in combination with fecal coliform data to identify the probable source of the bacteriological contamination. Research has indicated that if the ratio of the fecal coliform concentration to the fecal streptococcus concentration is greater than 4.0, then the likely source of contamination is human sanitary wastes.[1] If that ratio is less than 0.7, then the source of the contamination is thought to be entirely the wastes from livestock, poultry, or other animals. If the ratio is in the range of from 0.7 to 1.0, then the predominant source is the waste from livestock, poultry, and other animals. When the ratio is between 1.0 and 2.0, the conclusions are indeterminate, while the predominant source is human sanitary waste when the ratio is between 2.0 and 4.0.

Suspended solids analyses also are recommended for all samples since the suspended solids concentrations can be related to soil erosion or to urban storm water runoff. Suspended solids cause turbidity in water, thus affecting plant and animal life; and the sediment itself is a pollutant, due to its potential for covering stream and lake bottoms and thereby altering desirable aquatic habitat, reducing storage in reservoirs, and contributing nutrients and pesticides to the water. This parameter is not expensive to measure, and provides another useful indicator of inorganic pollution sources. It also may serve to explain—when considered in conjunction with the several phosphorus forms which are sampled—the potential for stimulation of nuisance aquatic growths.

In the years since the initial Commission benchmark water quality survey, research results have indicated that pesticides and other toxic and hazardous substances are present in potentially harmful amounts in many natural waters and should be considered in any comprehensive water quality monitoring program. For these reasons, and because preliminary research results are now available to relate the levels of these constituents not only to potential health hazards but also to their sources, it is deemed desirable to add analyses for pesticides, toxic substances, and heavy metals at the 23 sampling sites which are located on streams at the most downstream flowing point in the Region, and therefore representative of the largest possible tributary drainage area, but not affected by dilution from Lake Michigan. Grease and oil, which are indicators of pollutants from automobile use, recreational boating, and other activities related to combustion engines, should also be included for all stream and lake water quality samples.

[1] *E. E. Geldreich "Applied Bacteriological Parameters to Recreational Water Quality," Journal of American Water Works Association, Vol. 62, 1970, page 113.*

Finally, the most useful single parameter which could be added to the sampling effort, is the measurement of flow at the times of sample collection. The water quality sampling programs of the Commission, like those of other organizations, have been particularly directed at measuring concentrations of pollutants in the lakes and streams of the Region, since the concentration data provide the indicators of the immediate suitability of the water body for the support of fish and other aquatic life, as well as water-based recreation. For some parameters, however—notably those associated with nutrients which stimulate nuisance plant growth—it would be useful to calculate the pollutant loads in the streamflow. This would require an accurate quantification of the flow rates at the time of sampling. Although continuous streamflow gages serve multiple purposes, the use of simple staff gages, with their associated stage-discharge rating curves, would provide a significantly improved basis for water quality analyses at those sampling stations where continuous streamflow gages are not justified. Several other items of data which are useful and relatively easily obtained are the air temperature, wind direction and velocity, and precipitation conditions, or any other observed event or process which might affect the flow or chemical or biological characteristics of the water.

The analysis of biological data has proven useful in identifying and quantifying water quality impacts in the lakes and streams over a period of time. Aquatic communities react in measurable ways to changes in chemical and physical conditions in the body of water they occupy. The seasonal collection of selected parameters describing the aquatic community should be considered for the potential enhancement of the Commission continuing water quality monitoring program. Specifically, the parameter chlorophyll-a is recommended to be sampled from the periphyton communities in rivers and streams and phytoplankton communities of lakes and impoundments, as it provides a general indicator of the levels of primary production as well as an estimate of the algal biomass. In addition, it is recommended that the ash-free weight of both the periphyton and phytoplankton be determined, because the ratio between the ash-free weight and chlorphyll-a can be used as an index of the proportion of organisms that manufacture their own food as compared to organisms which rely on other natural or pollutant based food sources.[2]

Zooplankton should be collected in lakes and impoundments as well as at the 23 stream sampling sites nearest the mouth of each major tributary in the Region on a seasonal basis. Zooplankton analysis should include species identification, enumeration, and biomass. Likewise benthic macroinvertebrate identification and enumeration at each of the stream sampling sites is recommended with the results being summarized in pollution tolerance

[2] *Weber and McFarland, Periphyton, Biomass-Chlorophyll Ratio as an Index of Water Quality, 1969.*

categories and a diversity index. Benthic macroinvertebrates may be sampled annually in the early spring rather than on a quarterly basis.

The lake water quality monitoring program recommended earlier should include all of the 13 parameters sampled in the Commission continuing water quality sampling program for streams, except for fecal coliform samples, since fecal coliform organisms generally have not been found in the in-lake sites sampled in the inland lake studies conducted as an element of the areawide water quality planning program. The major water quality parameters to be considered for the lake water samples are organic-, nitrate-, ammonia-, nitrogen-, and total nitrogen, total and soluble phosphorus, pesticides, gas and oil, dissolved oxygen, chloride, temperature, secchi disk readings, pH, turbidity, suspended solids, sediment chemistry to determine whether the sediment buildup in the lake is attributable to biological processes or physical soil erosion processes, selected heavy metals wherever chemical treatments have been used in the lakes for weedkillers, and fecal coliform counts near the shore where the residents use septic tank systems for waste disposal . Fish survey results from each of the 100 major lakes would be very useful and should be considered in future analyses of long-term water quality changes, but would be beyond the scope of the one-year, areawide, water quality trends sampling programs proposed below.

Sampling Periods and Frequencies

In the analysis of the water quality data collected over the period since 1964, it was noted that the comparison of temporal changes would have been more readily accomplished with the availability of a quintennial replication of the Commission benchmark monitoring program undertaken in the period from January 1964 through February 1965. Specifically, it would have been desirable to have available for 1970 and 1975 the large numbers of sample results available for 1964-1965, and the ability to estimate average annual values of parameters, compensating for the variability of the seasonal effects on water quality. In addition, year-round sampling would be consistent with research findings over the past decade which have increased the general concern for water quality problems during all seasons of the year, rather than just during periods of low streamflow. At the time the Commission initiated the continuing water quality sampling program, it was generally held that summer or early autumn conditions were the periods of most serious threat to the achievement of water quality standards. One of the important findings of the analyses reported here is that the water quality standards in the Region are in fact not met under many different hydrologic conditions—not just low-flow conditions. Accordingly, redirecting the timing of the water quality sampling would be appropriate to provide sample results for other than dry weather conditions, and to allow for the conduct of a new water quality benchmark survey every five years in lieu of the annual sampling program.

Special surveys would be desirable for stream reaches directly draining areas of activity related to water quality improvement measures, such as modifications in wastewater treatment facilities, the installation of sewage collection systems in previously unsewered areas, the installation of land management practices in agricultural areas, urbanization or construction in extensive areas along with the associated soil disturbance, the addition of parking areas or other impervious surfaces, changes in urban land management practices such as street sweeping and leaf pickup, or other water quality improvement measures. If available, such water quality survey results would be helpful in evaluating and documenting the general water quality improvements associated with these activities and the specific details about the resulting water quality effects of these individual undertakings. Although this information would have been useful in the analysis of the temporal and spatial changes in water quality in the lakes and streams of the Region, its value for inclusion in a continuing water quality monitoring program is more directly associated with evaluation of the effects of categories of pollution sources and various water quality management practices, as discussed above. It is estimated that perhaps as many as three such surveys per year could reasonably be analyzed during the four years intervening between the proposed extensive five-year surveys, and the results and conclusions documented and incorporated into an enhanced capability for water resources management within southeastern Wisconsin. In the analysis of potential sources, the Commission staff has found particularly useful the continuing water quality monitoring samples which were obtained during wet weather conditions, in association with the spring samples obtained during the years 1964, 1968, and 1969, and the collection of scheduled "dry weather samples" which occurred on days of storm events. In future efforts, data collected before, during, and after a specific storm event would be of the highest utility in these surveys, suggested for the analysis and quantification of sources of water pollution.

Summary

In 1964 the Commission initiated a benchmark survey of water quality conditions in the streams of the Region; and during the period from 1967 through 1975, the Commission conducted a continuing water quality monitoring effort at the same 87 sampling stations located on the 43 streams of the Region. The program was expanded in 1971 to include selected major lakes within southeastern Wisconsin. In analyzing the available water quality data collected by the Commission, as well as the data available from other sources, the Commission staff sought to evaluate the water quality of the streams and, wherever possible, the water quality of the major lakes, for the changes over time, the spatial changes, the effects of major sources of pollution, and the degree of satisfaction of the requirements of the applicable water quality standards.

In the analysis of the data, desirable enhancements of the Commission water quality sampling programs were identified, and were recorded for consideration in the development of a continuing planning process as an element of the areawide water quality management planning program for southeastern Wisconsin. Desirable enhancements in the water quality monitoring program include the addition of a total of 19 stream sampling stations throughout the Region: 14 to characterize the water quality impacts of urbanized and industrially or commercially developed areas; four to characterize the water quality conditions of designated trout streams; and one to characterize the water quality conditions in stream reaches which have been adversely affected by cultural changes and accordingly have been identified by the State of Wisconsin as reaches for which special water quality standards are appropriate. Ultimately, an estimated total of approximately 214 lake sampling stations has been identified as desirable to be sampled along with the 19 recommended additional stream sampling stations and the 87 currently established stream sampling stations, during any replication of the Commission benchmark water quality survey.

In all water quality samples taken on flowing streams or rivers, it was found desirable to continue sampling the 13 water quality parameters included in the Commission continuing water quality monitoring program, as well as the additional parameters total biochemical oxygen demand, carbonaceous biochemical oxygen demand, chemical oxygen demand, zooplankton and phytoplankton (at reduced frequencies), chlorophyll-a, suspended solids, grease and oil, fecal streptococcus, and flow. For the 23 sites farthest downstream in each of the watersheds or subwatersheds draining to Lake Michigan, the Wisconsin-Illinois boundary, or one of the county lines which mark the northern or western edges of the Region, the additional analyses for major pesticides, heavy metals, and toxic substances are recommended for consideration in a continuing water quality sampling program.

For the approximately 214 sampling stations in the 100 major lakes which may be sampled in the Region with each major water quality survey, it was found desirable to obtain data for all of the parameters discussed above for stream sampling stations, as well as for secchi disk readings, and the physical and chemical characteristics of bottom sediments. The only exceptions were the elimination of fecal coliform and fecal streptococcus sampling at in-lake sampling sites, and the elimination of heavy metals sampling in lakes where there are not known to have been chemical treatments of the lake for control of nuisance aquatic growth.

Deemed as desirable were certain sampling program designs for sampling frequency and period—more specifically, abandonment of an annual low-flow sampling program, in favor of a replication of the benchmark water quality survey of the lakes and streams every five years, modified to include the 105 stream sampling stations and the parameters noted above; and the availability of three sampling programs per year during the intervening four years for the analysis of specific water quality management measures implemented on major development activities occurring within the Region at specific sites. Despite the utility of the results of the water quality sampling efforts of the Commission and other agencies and groups, these changes in water quality monitoring programs were identified as useful and desirable in light of new technical research results which have identified both additional pollutants and their potential sources. These changes have also become more appropriate in the recent past because of new social and governmental concerns related to the control of diffuse sources of pollution created by urbanization or other changed land use practices, and by the effects of storm processes and snow melt which serve to cleanse the land surface. The recommendations presented are intended for consideration in the development of a continuing planning process, an element of the areawide water quality management plan for southeastern Wisconsin, currently under preparation by the Commission.

Chapter IX

SUMMARY AND CONCLUSIONS

INTRODUCTION

In 1964 the Southeastern Wisconsin Regional Planning Commission undertook a benchmark survey of water quality conditions in the streams of southeastern Wisconsin. The results of 14 months of water quality sampling at 87 sites within the Region were reported in Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin. That analysis concluded that the original naturally high quality of the streams of the Region had been markedly deteriorated through the impact of human activity; that the deterioration had impaired or prohibited certain water uses, particularly recreational and aesthetic uses; that the pollution of the streams was directly related to urbanization and the associated wastewater discharges and stormwater runoff; and that population increases within the Region could be expected to increase the impacts of sewage treatment plants upon the water quality of the receiving streams. That report called for provision of centralized sanitary sewer service rather than onsite sewage disposal to serve the increasing urban development, provision for the export of liquid wastes or of more advanced levels of treatment, and adjustment wherever possible of land use development patterns to the waste assimilation capacities of the streams and watercourses. The report also warned of the danger of assuming that water pollution problems could always be solved economically by the application of technical advances in waste treatment, and proposed instead an increased emphasis on coordinated land and water use planning within the Region in order to abate pollution and control water quality.

In 1967 the Commission initiated the conduct of a continuing water quality monitoring program to provide data on changes in stream water quality within the Region over time. Like the benchmark study, this continuing water quality monitoring program, conducted annually, included the sampling of water quality conditions at 87 sites within the Region. Concurrently, 19 other agencies and organizations collected comparable surface water quality data for various purposes and in various portions of the Region. In 1975 the Commission undertook the task of analyzing water quality data collected in over a decade of continuing monitoring effort, relating the results of these water quality analyses to the pertinent water quality data collection efforts of other groups within the Region. The analysis of the data was intended to identify and assess long-term trends in stream water quality conditions within the Region in relation to the major types and sources of pollution; to identify and assess the present condition of stream and lake water quality in the Region; and to evaluate the existing levels of stream and lake water quality against the established water use objectives and supporting water quality standards to ascertain the extent to which those objectives and standards were being met. The availability and analyses of 10 years of water quality data were particularly timely, as the Commission on July 1, 1975, initiated the preparation of an areawide water quality management plan for southeastern Wisconsin. As the official designated areawide water quality management planning agency for the Region, the Commission is charged with the assessment of existing water quality conditions; the comparison of these conditions to the applicable water use objectives and supporting standards; the identification of the relationships existing between substandard water quality conditions and sources of pollution within the Region; and the recommendation of the best means to abate the identified water pollution problems.

Generic Sources of Water Pollution

The major categories of man-made water pollution sources which can impair desired water uses are sewage treatment plant effluent; separate and combined sewer overflows; septic tank wastes; industrial wastewaters; and storm water and snowmelt runoff from certain rural and urban land uses. These various sources introduce into the Region's streams and watercourses organic pollution which consumes the oxygen needed by aquatic life; nutrient pollution which stimulates undesirable plant growth; inorganic pollution which contributes plant nutrients and causes siltation of the waterways; chemical pollution which can cause an unhealthy environment for flora and fauna, humans included; thermal pollution which affects the balance and dynamics of chemical and biological processes; aesthetic pollution which interferes with a particularly pleasurable use of the lakes and streams; and radiological pollution which may be hazardous to all forms of life.

Water Use Objectives and Water Quality

Ten major uses are currently made of the streams and lakes of the Region: municipal water supply; industrial water supply; cooling water; waste assimilation; livestock and wildlife watering; irrigation; preservation and enhancement of aquatic life; recreation; navigation; and aesthetic enjoyment. Associated with each water use is a level of water quality which makes that use possible. The water use objectives and supporting water quality standards that have been adopted for each stream and lake within the Region to protect the intended uses are promulgated as regulations of the State of Wisconsin as required by state and federal law. These water use objectives are shown in graphic summary form on Map 4 of this report. Most of the streams and lakes in southeastern Wisconsin are designated for recreational use and for the maintenance and enhancement of fish and other aquatic life. More stringent dissolved oxygen standards apply to Palmer Creek in the Fox River watershed; and Allenton

Creek, Scuppernong River, and Bluff Creek in the Rock River watershed for the protection of trout populations in a cold water fishery. Less stringent standards apply to some streams and lakes because of naturally occurring background conditions, low natural streamflow, in-place pollutants, or irreversible cultural conditions. As of 1975, these streams and lakes included the following: Sussex Creek in the Fox River watershed; the Kinnickinnic River; Underwood Creek, Honey Creek, South Menomonee Canal, Burnham Canal, and portions of the Menomonee River in the Menomonee River watershed; Indian Creek, Lincoln Creek, and portions of the Menomonee River in the Milwaukee River watershed; Barnes Creek in the watershed of streams draining directly to Lake Michigan; and Pike Creek and the Pike River in the Pike River watershed.

Water Quality Parameters

Water samples collected by the Commission as a part of its continuing stream water quality monitoring program were tested for 13 water quality parameters or indicators: temperature; specific conductance; dissolved oxygen; hydrogen ion concentration; total and soluble phosphorus; nitrite-, nitrate-, organic-, ammonia-, and total nitrogen; chloride; and fecal coliform counts. These parameters were considered most useful in assessing the water quality of the streams and lakes of the Region and, accordingly, the suitability of the streams and lakes for various uses.

Water Quality Conditions and Trends

Water quality conditions and long-term trends in those conditions within the Region were analyzed for each of the 12 major watersheds in the Region.

Des Plaines River Watershed: In the Des Plaines River watershed, surface water quality conditions as measured at two sampling stations were found to be essentially unchanged over the decade except that a slight reduction in the dissolved oxygen levels was found in the southern reaches of the watershed. Nitrate-nitrogen and total phosphorus concentration levels remained in excess of the recommended water quality levels in most samples collected over the past eight years. The water quality of Brighton Creek remained better than that of the Des Plaines River and showed a slight improvement in fecal coliform counts, total phosphorus, and nitrate-nitrogen levels. Of the four major lakes in this watershed, two showed signs of accelerated eutrophication. Although generally constant over the past decade, the water quality of the Des Plaines River and Brighton Creek, both intended for recreational use and the preservation of fish and aquatic life, does not currently meet the water quality standards set by the Wisconsin Department of Natural Resources for dissolved oxygen and fecal coliform counts. In addition, the concentrations of plant nutrients were found to be above the levels recommended to avoid the stimulation of excessive plant growth.

Fox River Watershed: In the Fox River watershed, surface water quality conditions as measured at 12 sampling stations along the Fox River main stem were found to be slightly improved over the past decade. Increases in dissolved oxygen levels were noted at eight of 12 sampling stations on the main stem of the Fox River. For the major tributaries of the Fox River, dissolved oxygen levels were found to be improved over the past decade on Sussex Creek, Poplar Creek, Muskego Canal, the Wind Lake Drainage Canal, and Bassett Creek; but essentially unchanged in the seven other perennial tributaries sampled. Chloride concentrations were found to have generally increased over the past decade in rapidly urbanizing upper portions of the watershed. In other reaches of the watershed the chloride levels remained generally constant. Fecal coliform levels were observed to decline in the samples collected from the Muskego Canal, the Wind Lake Drainage Canal, and Bassett Creek. High levels of fecal coliform, however, were observed in the White River, the Pewaukee River, and Como Creek, with increases noted for the latter two tributaries. All samples exhibited excessive levels of plant nutrients. Of the 46 major lakes in the watershed, 19 exhibited potentially anaerobic conditions in the hypolimnion in the summer. Thirty-five of the major lakes in the watershed were classified for their trophic status; eight were classified as very eutrophic, four as eutrophic, 21 as mesotrophic, and two lakes in the watershed were considered to be oligotrophic. This general pattern is confirmed by a different analytical procedure used in the Commission comprehensive planning program for the Fox River watershed, under which the levels of phosphorus, dissolved oxygen conditions, and occurrence of nuisance aquatic growth were analyzed and indicated that 37 lakes were in a relatively advanced state of eutrophication.

Although stream water quality conditions were generally unchanged over the past decade, the stream water quality conditions of the Fox River watershed as a whole do not currently meet the established water use objectives for recreational use and the preservation of fish and aquatic life. The dissolved oxygen standards were met on only five tributaries of the Fox River, while the fecal coliform counts exceeded the established standards at all sampling stations except those on the Mukwonago River and Wind Lake Drainage Canal. Nitrogen and phosphorus were observed to be present in concentrations higher than recommended at all sampling stations on the Fox River main stem and all of its tributaries except the Mukwonago River, the Wind Lake Drainage Canal, and the Muskego Canal.

Kinnickinnic River Watershed: In the Kinnickinnic River watershed, surface water quality as measured at a single Commission sampling station was found to be essentially unchanged over the decade. Dissolved oxygen concentrations observed over the past decade were found to be essentially unchanged and continued to be above the established 2.0 mg/l associated with the designated restricted use objective for the Kinnickinnic River at the sampling station. The fecal coliform counts also were found to be essentially unchanged, but generally exceeded the applicable maximum standard prescribed for the Kinnickinnic River. In all samples taken, the plant nutrient levels were found to be significantly higher than the recommended levels. The River generally exhibited degraded water quality in the areas affected by combined sewer overflows, but exhibited improved water quality farther downstream at sampling stations of the Milwaukee Metropolitan Sewerage District, apparently as a result of the dilution effect of Lake Michigan and the direct effects of the flow augmentation from the S. 6th Street flushing tunnel during operation by the Milwaukee Metropolitan Sewerage District.

Menomonee River Watershed: Twelve sampling stations were included in the Commission continuing water quality sampling effort in the Menomonee River watershed. On the Menomonee River itself, the observed dissolved oxygen levels at the five upstream sampling stations showed improvement since 1964, while such levels at the four downstream sampling stations showed a decline since 1964. There was essentially no change in the chloride concentrations over the decade. Fecal coliform counts generally increased within the watershed over time. The plant nutrient concentrations remained in excess of the recommended levels in 76 percent of the nitrate-nitrogen samples and in 99 percent of the total phosphorus samples. Although remaining generally constant over the decade, the water quality of the upper Menomonee River and Little Menomonee River—intended for recreational use and preservation of fish and aquatic life—does not currently meet the established water quality standards for fecal coliform and dissolved oxygen, nor the recommended levels for total phosphorus and nitrate-nitrogen. The Lower Menomonee River, Underwood Creek, and Honey Creek exhibited persistent violations of fecal coliform counts, as well as excess levels of plant nutrients, despite the industrial use standards applicable to these stream reaches, which drain generally urban, commercial, and industrial land uses.

Milwaukee River Watershed: The Milwaukee River and its major tributaries were monitored for their water quality over the past decade at 12 sampling stations within the Region. Both increases and decreases in chloride concentrations were observed over the past decade within the watershed. Similarly, dissolved oxygen levels and fecal coliform levels within the watershed showed both increases and decreases within the watershed. The detectable changes in the dissolved oxygen levels generally occurred at those stations which were near or below sewage treatment plant discharges. On the other hand, at three sampling stations on stream reaches draining agricultural and other rural land uses, no significant changes in dissolved oxygen levels were detected from 1964 through 1975. Fecal coliform counts exhibited a decreasing trend at several sampling stations below sewage treatment plants at which effluent disinfection was instituted during the study period. Wide fluctuations were observed in fecal coliform counts at other stations, while generally increasing trends were observed in many stations along the main stem of the Milwaukee River, the North Branch of the Milwaukee River, and Cedar Creek. These increases were attributed to many sources, including overloaded sewage treatment plants, malfunctioning onsite sewage disposal systems, discharge from sanitary sewer flow relief devices, and storm water runoff from agricultural livestock operations. The plant nutrient levels observed in most samples over the past decade exceeded the recommended levels.

Of the 21 major lakes within the watershed, nine have been classified using the Lake Classification Index according to their trophic status; one as oligotrophic, five as mesotrophic, two as eutrophic, and one as very eutrophic. This is consistent with the conclusions reached in the development of the comprehensive plan for the Milwaukee River watershed, in which a case-by-case analysis of the phosphorus concentrations, the dissolved oxygen levels, and the extent of nuisance aquatic growth in the major lakes indicated that many of the major lakes are in an advanced state of eutrophication. Although fluctuations were observed in specific parameters and at various sampling stations within the Milwaukee River watershed, the water quality since 1964 generally is considered to be slightly degraded from the effects of many factors, despite the observed, localized improvements attributable to specific enhancements in sewage treatment plant facilities and operations effected during the decade. The water quality of the Milwaukee River and its major tributaries within the Region does not generally meet the applicable dissolved oxygen or fecal coliform standards. Neither are the important plant nutrients—nitrogen and phosphorus—found to be below the levels which are likely to stimulate nuisance aquatic growth. Water quality in the upper reaches of the watershed and in minor tributaries of the watershed, however, is considered to be generally higher, as regards all of these parameters.

Lake Michigan Tributaries: Major streams draining directly to Lake Michigan include Barnes Creek, Pike Creek, and Sucker Creek. In the Barnes Creek subwatershed water quality conditions were found to be essentially unchanged over the past decade. The 1975 water quality conditions in the Creek—which is intended for the less stringent restricted use and maintenance of fish and aquatic life—do meet the water quality standards for dissolved oxygen, pH, total phosphorus, and fecal coliform. Nitrate-nitrogen concentrations, however, were found to be higher than the recommended levels. Although total phosphorus met 1975 recommended conditions, one-half of the phosphorus samples obtained in the watershed during the past four years, concentrations exceeded the recommended levels.

In the Pike Creek subwatershed the observed dissolved oxygen levels at the single sampling station indicate essentially unchanged water quality conditions over the past decade, although fecal coliform counts and chloride levels showed slight decreases. Although nitrate-nitrogen concentrations were found to be generally in excess of the recommended levels, the total phosphorus concentrations exceeded those levels in only about one-fourth of the samples. Although the water quality did not change significantly over the decade, the applicable standards for recreational use and preservation of fish and aquatic life are not currently met for dissolved oxygen and fecal coliform counts.

Improvements were noted at the sampling station in the Sucker Creek subwatershed for dissolved oxygen and chloride levels, indicating improvements in water quality conditions over the decade. Fecal coliform counts on the other hand were found to have increased and nitrogen and phosphorus levels both remained in excess of the recommended levels. Like the other two perennial streams which drain directly to Lake Michigan, Sucker Creek exhibits water quality conditions which are not sufficiently high to meet the applicable water quality standards for recreational use and the preservation of fish and aquatic life, particularly for dissolved oxygen and fecal coliform counts. In all three streams the total phosphorus and nitrate-nitrogen concentrations were found to be higher than the levels recommended for the avoidance of nuisance aquatic plant growth in the receiving streams.

Oak Creek Watershed: In the Oak Creek watershed, surface water quality conditions were measured at two sampling stations on the Oak Creek main stem, and were found to be slightly degraded in general, except that fecal coliform levels were somewhat improved during 1975. The nitrogen and phosphorus levels observed during the decade were found to be in excess of the levels recommended to avoid the stimulation of undesirable growth of aquatic plants; and the dissolved oxygen and fecal coliform levels did not meet the applicable water quality standards for recreation and the maintenance of fish and other aquatic life. The upstream station generally exhibited better water quality than that of the downstream sampling station.

Pike River Watershed: Two sampling stations on the Pike River and two sampling stations on Pike Creek of the Pike River watershed were monitored as part of the Commission continuing water quality monitoring program. Although the sampling indicated that the applicable fecal coliform and dissolved oxygen standards are not being met, the dissolved oxygen sample results indicated that the water quality of the Pike River had improved slightly over the decade, probably as a result of improved operations of the sewage treatment facility serving the Village of Sturtevant. The chloride and fecal coliform levels showed general improvement over the decade at both sampling stations in the watershed, except during sampling periods which followed significant precipitation events. In all but one of the samples taken within the watershed, the levels of nitrate-nitrogen and total phosphorus were in excess of the recommended levels. Although the less stringent water quality standards applicable to Pike Creek—which is designated for restricted use—were met, the dissolved oxygen and fecal coliform counts associated with the water quality standards for fish and aquatic life, the designated use for the Pike River in Kenosha County, were not met.

Rock River Watershed: Water quality conditions in the 10 major tributaries of the Rock River which rise and flow through parts of the Region were monitored under the Commission continuing water quality effort at 13 sampling stations, eight in the Upper Rock River subwatershed and five in the Lower Rock River subwatershed within the Region. The Bark and Ashippun Rivers showed no significant change in water quality over the decade, nor did the Kohlsville River, where occasionally high fecal coliform counts were observed, probably due to the runoff from agricultural operations in the subwatershed. A slight decrease in water quality was observed in the East Branch of the Rock River and is attributed to the effects of agricultural activities in the tributary area, since the only sewage treatment plant in the area experienced major improvements in its physical condition and operational performance in 1972. No significant change was observed in the water quality of the Rubicon River except at the sampling station located downstream from the City of Hartford sewage treatment plant, where the sewage treatment plant improvements completed in the summer of 1973 were reflected in improved dissolved oxygen levels. Water quality conditions in the Oconomowoc River showed no change, except at the sampling station located downstream from the City of Oconomowoc sewage treatment plant, where increased loadings from the plant were reflected in decreased water quality conditions. Whitewater Creek showed a slight improvement in fecal coliform counts over the past decade. The water quality of Jackson Creek and Turtle Creek deteriorated somewhat over the decade as measured at the sampling station located downstream from the City of Delavan sewage treatment plant. In general, the water quality of the Rock River tributaries lying within the Southeastern Wisconsin Region, all designated for recreational use and for the preservation of fish and aquatic life, does not currently meet the water quality standards for dissolved oxygen and fecal coliform counts and, in addition, frequently exhibits concentrations of total phosphorus and nitrate-nitrogen which are significantly higher than the levels recommended for the avoidance of nuisance aquatic growth.

Of the 38 major lakes in the Rock River watershed, all exhibited the potential for anaerobic conditions in the hypolimnion during the summer and the potential adverse effects on fish and other aquatic life within these lakes. Of the 24 lakes which have been rated for their trophic status, five were rated as oligotrophic lakes, 13 as mesotrophic, three as eutrophic, and three as very eutrophic.

Root River Watershed: In the Root River watershed, the Commission continuing water quality monitoring program included sampling at six stations. Water quality conditions, as measured by fecal coliform within the middle reaches of the watershed, exhibited improvement as a result of the abandonment of four sewage treatment facilities previously discharging to the streams of the watershed. Water quality conditions, as measured by chloride loadings and dissolved oxygen levels in the upper reaches of the Root River exhibited some decline, however, attributed to the increased urbanization of the tributary area. The improved wastewater mangement practices instituted at the Cooper-Dixon duck farm are manifested in improved water quality conditions in the Root River Canal. Despite these improvements, the water quality of the streams of the Root River watershed does not currently meet the applicable water quality standards for recreational use and preservation of fish and aquatic life as regards dissolved oxygen and fecal coliform, while the ammonia-nitrogen, total phosphorus, and nitrate-nitrogen levels in all of the streams were also found to be higher than the levels recommended.

Sheboygan River Watershed: Water quality conditions in Belgium Creek in the Sheboygan River watershed remained essentially unchanged over the past decade. Those conditions do not meet the established water quality standards for dissolved oxygen and fecal coliform counts, and they exceed the recommended levels for total phosphorus and nitrate-nitrogen concentrations, important plant nutrients which can stimulate nuisance aquatic growths in the stream system which discharges ultimately to Lake Michigan.

Sauk Creek Watershed: In the Sauk Creek watershed, the continuing water quality monitoring program of the Commission included collection of samples at two stations. A slight decline in dissolved oxygen levels over the decade and generally stable levels of chloride and fecal coliform concentrations, as well as nitrate-nitrogen and total phosphorus concentrations, indicate generally stable water quality conditions within the watershed. However, the water quality standards applicable for recreational use and the preservation of fish and aquatic life are not met within this watershed for dissolved oxygen and fecal coliform counts. Recommended levels of total phosphorus and nitrate-nitrogen also were exceeded in the stream which ultimately flows to Lake Michigan.

Toxic and Hazardous Substances

Heavy metals, pesticides, and PCB's may be transported into the surface waters of the Region from a number of sources. Research remains to be accomplished to identify the acceptable levels of these materials, although new chemicals continue to be placed on the market and find their way into the environment. The currently-available criteria were compared to the available stream quality information. Generally the data are not indicative of problems in the streams of the Region of extensive toxic substances. Some localized conditions were noted but should be evaluated carefully because of the very limited number of samples and their associated areas of coverage. These noted situations included: mercury levels in portions of the Pike and Rock River watersheds; levels of mercury and polychlorinated biphenyls (PCB's) in portions of the Milwaukee and Oak Creek watersheds; and some pesticides in portions of the Des Plaines, Kinnickinnic, Milwaukee, Oak Creek, Pike, Rock, and Root River watersheds. Unfortunately, in the analysis of heavy metals, pesticides, and PCB's, it was also difficult to evaluate the impact of these substances on water quality since the recommended criteria frequently are below the most sensitive detectable limits of analysis.

Miles of Stream Meeting Standards

Over the period since 1964, the 87 sampling stations utilized by the Commission have provided information on water quality in the larger, continuously flowing, more intensively used streams which total 459 miles, or 41 percent, of the total 1,118 miles of streams within and tributary to the Southeastern Wisconsin Region. A comparison of the 1964 data to the applicable water quality standards indicates that only 164 miles, or 36 percent of the stream miles for which data are available, met or exceeded the standards. In 1975, by comparison, only 88 miles, or 19 percent, met the same applicable standards for dissolved oxygen and coliform. If the recommended levels of nitrogen and phosphorus are considered, then the number of miles of stream which met or exceeded the applicable standards in 1975 is reduced to only 8.5 miles, or 2 percent. Table 234 presents the number of miles of stream, by watershed, which were characterized by the available water quality data and, of those, the number which met the applicable standards in 1964 and 1975.

Water Quality Index Results

In order to reduce the massive amount of water quality data collected and collated under the Commission water quality monitoring effort to a more readily understandable summary form, the Commission developed a water quality index based upon six water quality parameters. The six parameters—dissolved oxygen content as percent of saturation and fecal coliform, pH, chloride, nitrate, and total phosphorus concentrations—were chosen because of their significance as general indicators of stream water quality, because of the availability of data on these parameters, and because of the likelihood of their continued inclusion in water quality sampling programs of the Commission and other agencies and institutions.

For each water quality sample analyzed, the observed level of each of the six selected parameters was assigned a score in the range of from zero to 100. The parameter scores were then combined through the use of a weighting equation to result in a water quality index rating for each sample. The resulting ratings for 1974-1975 are presented in Table 230 and presented graphically on Map 90, and ranged from a low of 41—at sampling station Fx-5 on the Pewaukee River, an index value indicative of poor water quality conditions—to a high of 90 on the Oconomowoc River—an index value indicative of excellent water quality conditions. For the July, August, September, and October samples taken in 1964 at 87 sampling stations, the averages of the water quality ratings are also presented on Map 90 and were found to be poor, fair, good, and excellent at 17, 42, 22, and six stations, respectively. Based on similar samples for August 1974 and 1975, water quality ratings were found to be poor, fair, good, and excellent at eight, 68, nine, and two stations, respectively.

When comparing the average of the water quality index ratings for all samples taken in July, August, September, and October 1964 with the ratings for those taken in August 1974 and 1975, an insignificant decline in water quality over the decade is indicated by the decrease from 63 to 62 units. This reduction is noted despite substantially improved sanitary wastewater treatment practices within the Region. In evaluating the water quality index values averaged for each watershed or major subwatershed within the Region, it was found that the Des Plaines River, Kinnickinnic River, Root River, Sauk Creek, and Sheboygan River watersheds as well as the major tributaries to the Milwaukee and Fox Rivers exhibited average water quality index values which had dropped over the period from 1964 to 1975 but could continue to be

Table 234

LINEAL EXTENT OF WATER QUALITY STANDARDS VIOLATIONS IN MAJOR STREAMS IN SOUTHEASTERN WISCONSIN: 1964 AND 1975

Watershed	Stream Length (miles)					Total Stream Length Sampled (miles)[a]
	1964		1975			
	Water Quality Standards Met	Water Quality Standards Violated	Water Quality Standards Met	Water Quality Standards Violated	Water Quality Standards Violated Due to Nutrients (NO_3 + TP) Only	
Des Plaines River	9.9	6.4	0	16.3	0	16.3
Kinnickinnic River	4.0	0.0	0	0.0	4.0	4.0
Menomonee River	6.0	33.5	0	39.5	0	39.5
Milwaukee River	0	99.8	0	78.6	21.2	99.8
Fox River	87.5	87.4	2.5	130.2	42.2	174.9
Oak Creek	10.0	0	0	10.0	0	10.0
Pike River	6.0	6.6	0	6.6	6.0	12.6
Rock River	18.3	26.0	6.0	33.3	5.0	44.3
Root River	13.2	24.3	0	37.5	0	37.5
Sauk Creek	3.7	5.3	0	9.0	0	9.0
Sheboygan River	4.0	0	0	4.0	0	4.0
Minor Streams Tributary to Lake Michigan	1.4	5.8	0	5.8	1.4	7.2
Total	164.0	295.1	8.5	370.8	79.8	459.1
Percent of Total	35.7	64.3	1.9	80.7	17.4	100

[a] *Approximately 459, or 41 percent, of the 1,118 total stream miles in the Region were sampled. No data are available for the remaining 659 miles of streams.*

Source: SEWRPC.

classified as fair in water quality. On the main stem and the major tributaries of the Menomonee River and the main stem of the Fox River as well as in the watershed of streams draining directly to Lake Michigan, the fair water quality category was maintained, and slight increases in the water quality index were evident. On the main stem of the Milwaukee River, the water quality index remained fair and stable over the period of record. In the Oak Creek watershed and the Upper Rock River subwatershed, the water quality index values over the decade dropped sufficiently to move the ratings for those drainage areas from the category of good to the category of fair water quality. In the Middle Rock River subwatershed, the declining index values continued to be rated as good. In the Lower Rock River subwatershed the slight decline in average water quality index values from 1964 to 1975 was not sufficient to change the rating of the values from the category of fair. In the Pike River watershed a significant increase in the average water quality index values was observed with the water quality classification shifting from poor to fair over the years of comparison.

A lake classification index developed at the University of Wisconsin and used by the Wisconsin Department of Natural Resources was applied to available data for the major lakes in southeastern Wisconsin and showed the most oligotrophic major lakes in the Region to be Friess, Pike, and Silver Lakes in Washington County and the most eutrophic to be Tichigan Lake in Racine County. Of the 65 lakes for which data were available, eight lakes, or 12 percent, were rated as oligotrophic; 37 lakes, or 57 percent, were rated as mesotrophic; eight lakes, or 12 percent, were rated as eutrophic; and 12 lakes, or 19 percent, were rated as very eutrophic. Since virtually no time series data were available for lake water quality, no comparisons could be made for the changes over time in the quality of the water in the lakes.

Sampling Program Enhancements

In the analysis of the water quality data collected by the Commission since 1964 to identify spatial and temporal trends in water quality and the major sources of water pollution, useful enhancements of the data collection program were identified with respect to (1) sampling sites, (2) water quality parameters, and (3) sampling periods and frequencies. The potential enhancements were noted for consideration in the development of a continuing planning process as an element of the areawide water quality management plan for southeastern Wisconsin. Some subwatersheds of the Region could be more readily analyzed for the water pollution sources within them and their impact on the lakes and streams if 19 additional stream sampling stations and an estimated 214 lake sampling stations on 100 lakes were visited in each sampling period. This would expand the sampling to all of the major lakes in the Region, and would improve the sampling for portions of the Des Plaines, Fox, Kinnickinnic, Menomonee, Milwaukee, Oak Creek, Pike, Rock, and Root River watersheds. Four of these identified sampling stations would be helpful on the streams that have been assigned special use classifications by the Wisconsin Department of Natural Resources as has been done for Palmer Creek, Scuppernong River, Allenton Creek, and Bluff Creek—and for streams for which the restricted water use designation is applicable such as the Pike River in Racine County and Lincoln Creek in Milwaukee County.

Among the traditional water quality parameters for which data would have been helpful are biochemical and chemical oxygen demand, suspended solids, and grease and oil. In addition, flow measurements at all the stream sampling locations; data on heavy metals and toxic substances in samples collected from the streams in urban areas; and data on pesticides in samples collected from the rural areas would have been desirable. Most importantly, the analysis of long-term changes in water quality could be more readily accomplished if the Commission's initial 14-month benchmark survey of water quality were replicated within the Region—with minor modifications—at least once every five years.

CONCLUSIONS

Based on the water quality and streamflow data collected by the Commission and other agencies in southeastern Wisconsin during the decade from 1964 through 1975 and the results of the analysis presented in this report, the following general conclusions can be drawn from the factual findings of this study on stream quality conditions within the Region:

1. The original naturally high quality of the streams and watercourses of the Region has been markedly deteriorated along 40 of the 43 major continuously flowing streams in southeastern Wisconsin through the impact of human activity. Stream water quality conditions within the Region reflect the deleterious effect of human activity as measured by the chloride, dissolved oxygen, fecal coliform counts, and nutrient levels reported in the several monitoring programs. Stream pollution may, therefore, be considered as occasionally or persistently severe and widespread in all of the 12 watersheds within the Region. Particularly severe in 1974-1975 were the water quality conditions of tributaries of the Milwaukee River, the Menomonee River, Belgium Creek, Sauk Creek, the streams of the Root River watershed, and the streams in the lower Rock River subwatershed. For dissolved oxygen, 26 of the 43 streams and watercourses exhibited concentrations of less than 5.0 mg/l at least once during the 10-year monitoring period, and 33 of the 43 streams and watercourses exhibited concentrations greater than 400 fecal coliform counts per 100 ml, with eight exhibiting concentrations greater than 2,000 MFFCC/100 ml in at least one sample. For nutrients, 40 of the 43 streams and watercourses exhibited concentrations greater than 0.10 mg/l total phosphorus and 0.30 mg/l nitrate nitrogen. These findings indicate the extent and severity of the water pollution problem within the Region. Map 91 provides a graphic summary of the water quality conditions as compared to the water quality standards applicable for the years 1964 and 1975, respectively. A more detailed comparison of the existing stream quality conditions to the water quality standards further substantiates the seriousness of the pollution problems within the Region, demonstrating that 451 miles, or 98 percent, of the total major stream mileage sampled within the Region does not meet the applicable water quality criteria for dissolved oxygen, fecal coliform, nitrogen, and phosphorus concentrations. The temperature and pH of the streams of southeastern Wisconsin were found to be virtually always within the ranges specified by the state and federally adopted water quality standards.

2. The pollution of the Fox River headwaters areas, the Kinnickinnic River, the Menomonee River, the lower Milwaukee River, Pike Creek which is directly tributary to Lake Michigan, and the headwater area of the Root River is directly related to urbanization, with the major waste sources in the various watersheds being different combinations of municipal sewage treatment plants, sewer overflows, industries, malfunctioning onsite private sewage disposal systems, and urban storm water runoff.

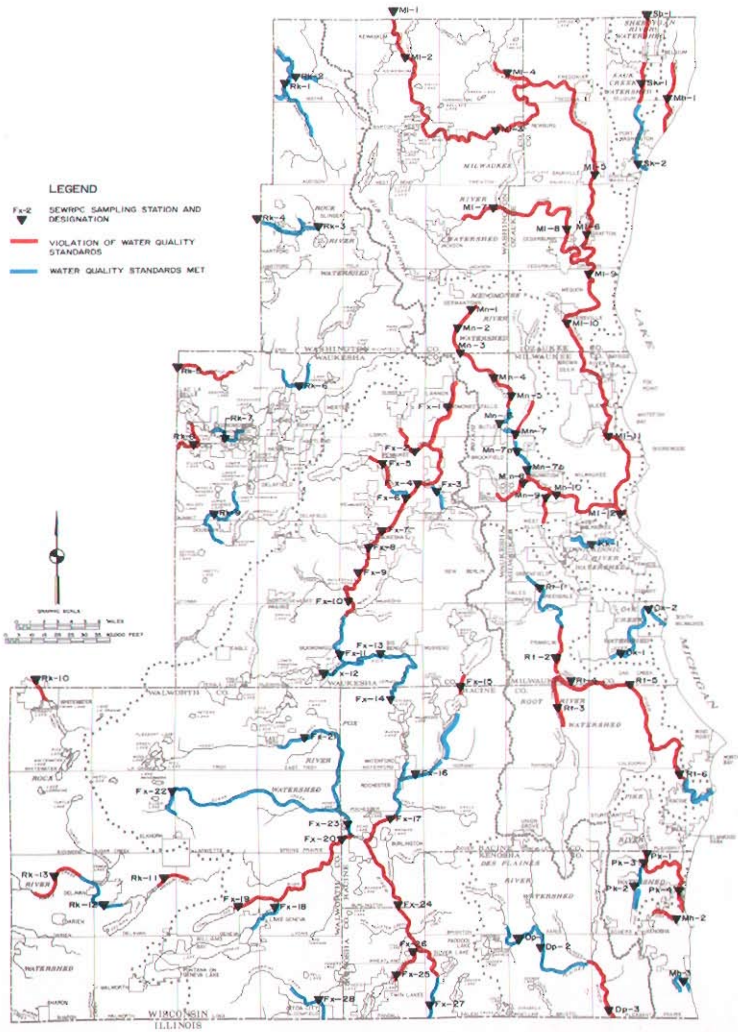
3. Localized improvements in the water quality of 21 streams at 37 sampling locations including the headwater area of the Root River, Pike River, Bassett Creek, and Poplar Creek tributaries of the Fox River were observed over the decade and are directly related to the structural and operational improvements made in the sanitary sewage treatment facilities located in the watersheds cited. These improvements were not necessarily sufficient to assure the achievement of the applicable water quality standards.

4. The pollution of the streams and watercourses of the Region also is related to the development of residential areas served by onsite sewage disposal systems (septic tank systems) which fail to function properly on unsuitable soils. In 1975, nearly 14 percent of the population of the Region, about 247,000 persons, was served by onsite sewage disposal systems. Detailed soil surveys covering the entire Region indicate that over 49 percent of the Region is covered by soils

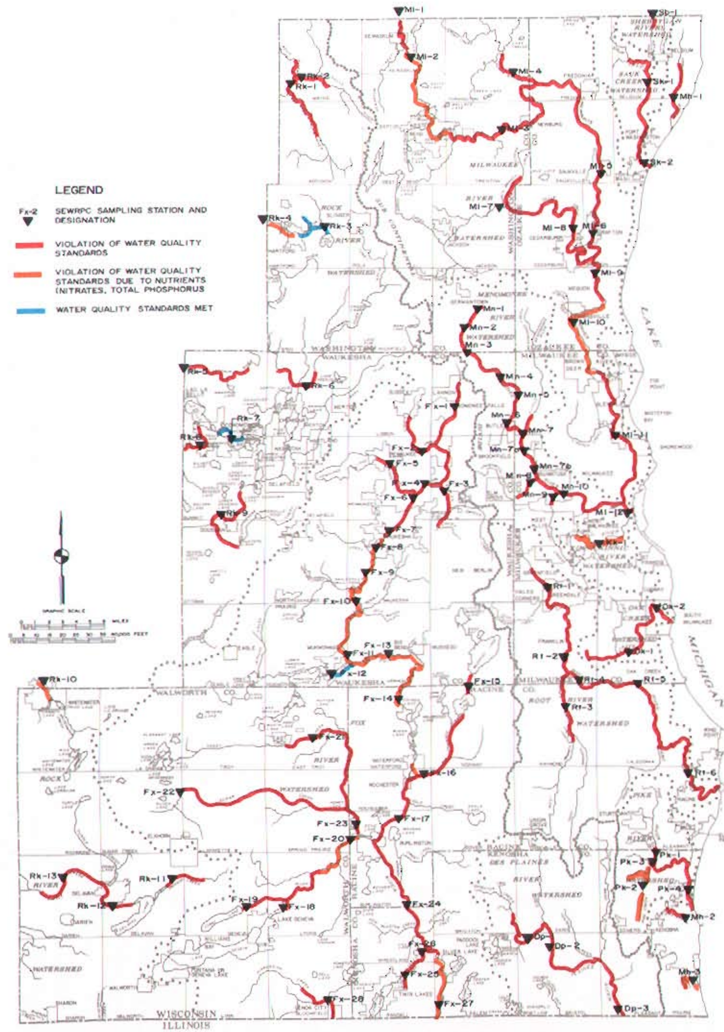
Map 91

COMPLIANCE WITH WATER QUALITY STANDARDS IN SOUTHEASTERN WISCONSIN: 1964 AND 1975

1964



1975



A comparison of the 1964 water quality data to the applicable established water quality standards indicates that only 164 miles, or 36 percent of the stream miles for which data are available, met or exceeded the standards. In 1975, by comparison, only 80 miles or 17 percent met the same applicable standards for dissolved oxygen and coliform. If the recommended levels of nitrogen and phosphorus are considered, then the number of miles of stream which met or exceeded the recommended water quality conditions in 1975 is reduced to only nine miles, or 2 percent of the total stream miles for which data are available.

Source: SEWRPC.

unsuitable for onsite sewage disposal systems. The fecal coliform sample results from the decade of monitoring indicate an extensive problem from these malfunctioning systems in the streams draining their areas of occurrence. Streams draining unsewered residential areas throughout the Region exhibit high levels of fecal coliform, most notably after major precipitation events. Although livestock wastes may account for a portion of this pollution, a component of this pollution is attributable to inadequate onsite sewage disposal.

5. The pollution of the Des Plaines River; Sucker Creek, a minor tributary to Lake Michigan; Sauk Creek; and the Muskego Canal and Wind Lake Drainage Canal, which are tributary to the Fox River, is directly related to the agricultural activities in the areas drained. The presence of high dissolved solids, low dissolved oxygen, and high nutrient contents in these streams appears to be correlated with agricultural land use in the tributary watersheds. Similarly, high dissolved solids, low dissolved oxygen, and high nutrient contents in samples taken during the winter and coincidental with unusually high levels of fecal coliform organisms at some of these sites is an indication of the effects of livestock wastes reaching the streams. In many other watercourses of the Region, the pollutional effects of agricultural operations appear to be significant, but are combined with contaminants from other pollution sources in the tributary drainage areas.

   As noted above, fecal coliform levels which exceed the applicable water quality standards are found in many streams in the Region and are attributed in part to wastes from agricultural livestock.

6. Diffuse sources are an important source of pollution in the streams and watercourses of the Region. This would include runoff from urban and rural land uses, uses that are washed during a rainfall, the "dirty water" draining to the streams carrying contaminants from the surface of the land. The consistently lower water quality of the samples collected from the streams of the Region soon after rainfalls substantiates the seriousness of the pollution problem from these "nonpoint" sources. Even if all the discharge of all wastes from municipalities and industries ceased, it appears that pollution from diffuse sources would have an adverse effect of sufficient magnitude to violate the applicable state and federally adopted water quality standards for many—if not most—streams of the Region.

7. Human activities not only cause degradation in the streams of southeastern Wisconsin, but can improve water quality through the design and execution of measures intended to abate and control water pollution. A subtle but general enhancement of water quality is reflected in fecal coliform levels and has been achieved specifically by the enhanced operation and maintenance and installation of disinfection facilities at many municipal sewage treatment plants, in accordance with the policies adopted by the Wisconsin Department of Natural Resources during the period since 1964. Unfortunately, the adverse water quality effects of diffuse pollution sources overshadow these local improvements, when the Region is considered as a whole.

As noted above, the Commission analysis of the stream water quality data obtained in the 1964-1965 benchmark survey recommended the provision of centralized sanitary sewer service and advanced levels of liquid waste treatment and the adjustment of land use development patterns to the waste assimilation capacities of the stream and watercourses. The continued validity of these recommendations is borne out by the analysis of more than a decade of water quality data for the streams of southeastern Wisconsin. In particular, the importance of land use and its impacts on water quality has been once again demonstrated. If water use objectives are to be achieved, industry, government, and citizens of the Region must seek specific means of establishing land use development patterns and land management practices which will in fact have positive effects on water quality as well as improved means of liquid waste treatment and disposal.

The complex and dynamic characteristics of the water resources of the Region may not allow an immediate or complete reparation of water quality conditions upon implementation of specific advanced sewage treatment techniques. Because of the importance of diffuse sources of pollution, the abatement of water pollution within southeastern Wisconsin may require direct and personal actions by the residents of the Region, actions related to land management in addition to governmental action to improve wastewater treatment. The water quality data currently available indicate that both urban and rural land uses in the Region have important impacts on the water quality of its lakes and streams.

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APPENDICES

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Appendix A

TOXIC AND HAZARDOUS SUBSTANCES IN STREAMS AND LAKES OF THE REGION

Since publication of SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, there has been a growing awareness on the part of both scientists and the general public of the potentially harmful effects on animal life of certain substances, substances not formerly considered in water quality management related studies. Because of this growing awareness, the available data on the levels of toxic and hazardous substances in the streams and lakes of the Region were assembled by the Commission and the concentrations observed, together with comparisons to any recommended acceptable levels are presented in this Appendix. The data are presented in this Appendix rather than in the body of the report because the data are not available with the same areawide consistency nor over the same time span as the Commission monitoring data. The pollutants addressed include cadmium, chromium, copper, lead, mercury, nickel, zinc, polychlorinated biphenyls (PCB's), dichloro-diphenyl-trichloro-ethane (DDT), dichloro-diphenyl-dichloro-ethylene (DDE), dichloro-diphenyl-dichloro-ethane (DDD), aldrin, heptachlor, heptachlor epoxide, lindane, dieldrin, methoxychlor, phthalate, atrazine, and simazine. In addition to the substances noted above, for which limited amounts of water quality data are available, the list of toxic and hazardous substances which find their way into the environment is expanding almost daily, and includes arsenic, asbestos, barium, beryllium, baron, cyanide, manganese, selenium, and silver. Also included are other pesticides: chlordane, demeton, endosulfin, guthion, mirex, and toxophene. As chemical compounds, these and other substances have been included on a list of 164 "hazardous substances"—potentially subject to regulation—by the U. S. Environmental Protection Agency Office of Solid Waste Management Programs. (See "Disposal of Hazardous Wastes," report to Congress, Environmental Protection Agency Publication SW-115, Washington, D. C., U. S. Government Printing Office-1974, 110 pp.)

The general category of toxic and hazardous materials consists of heavy metals, pesticides, and polychlorinated biphenyls (PCB's) which accumulate in nature after their initial production as a result of man's activities. The development and production of industrial chemicals and their ultimate disposal in the environment have presented the ecological systems of the streams and lakes with a complex array of new chemical substances having essentially unpredictable individual or joint impacts on the biological processes occurring in the environment. Heavy metals, pesticides, and PCB's are transported into the surface waters of the Region via several sources of entry inclusive of discharges from sewage treatment plants; industrial wastewater discharges; storm water runoff from streets, highways, parking lots, rooftops, lawns, and other pervious and impervious surfaces; application of wastewater sludge residuals to land surfaces; applications of organic and inorganic fertilizers for agricultural purposes; and the repeated spraying or spreading of pesticides, particularly the persistent chlorinated hydrocarbons.

Heavy metals, pesticides, PCB's, and other toxic and hazardous substances generally do not present the gross, aesthetic, or olfactory offense of some other water pollutants, but may present an unseen health hazard to animal and human populations. Not only are these toxic and hazardous materials taken up by rooted plants, but certain of these materials such as mercury, DDT, and PCB's have the innate ability to enter the food chain at the lowest levels of vegetative growth and thereby gradually move up the food chain and accumulate in fish which in turn are available for human consumption. In addition, other carnivores such as predatory birds may be adversely affected by toxic materials. Evidence exists that populations of peregrine falcons, bald eagles, and gulls have been significatly reduced by the effects of pesticides. Chloroform—linked to cancer in preliminary research results—is another example of hazardous substances. Chlorine, when introduced as a disinfectant in water supply plants, reacts with natural organic substances. Chlorine also is used as a disinfectant in the operation of wastewater treatment plants and as an algaecide by industry and utilities, but is known to be directly toxic to fish and other aquatic life. In addition, the residual chlorine is capable of reacting with the organics in the receiving waters to form the same compounds as in a water supply facility.

Heavy metals such as cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc are those which have a specific gravity greater than four, have several oxidation states, and readily form complex ions. The toxic effects of heavy metals in the aquatic system vary greatly and are thought to be dependent upon such factors as concentration, hardness, pH, and temperature of the receiving waters, and the presence of other compounds with which the heavy metals may react—although the specific toxic effects of each metal on each potentially affected species of plant or animal are not uniformly and readily documentable. Concentrations of heavy metals which are toxic to many forms of aquatic life may not be harmful to man. However, this is not always the case, as numerous incidents of poisoning have been reported following human consumption of fish that had accumulated large concentrations of organic mercury in their flesh as a result of ingesting lower aquatic forms which had assimilated the mercury directly from the water.[1] The 1967 discovery of this

[1] *Quality Criteria for Water, 1976 Ecological Research Series, U. S. Environmental Protection Agency.*

problem in Japan, after scientific studies of the so-called "Minamata Disease," prompted the most recent wave of increase in research and regulation pertaining to these materials. Even in Wisconsin, unacceptable levels of mercury and PCB's in fish flesh have caused the Wisconsin Department of Natural Resources to recommend limiting human consumption of sport fish from stretches of the Wisconsin River and from Lake Michigan; and the commercial fisheries of Lakes Michigan and Superior have been severely constrained by these same findings. The specific effects of heavy metals on man and other forms of life are many and varied. For example, excessive concentrations of cadmium are associated with liver and kidney disorders in man, and are toxic to fish in their food sources. Chromium can be toxic—particularly in its hexavalent form—and is also a possible carcinogen, in addition to being toxic to fish and aquatic life. Although trace amounts of copper are essential to man, large quantities may cause liver damage. Lead and mercury attack the nervous systems and can be toxic to humans as well as to fish and other aquatic life.[2]

Organic pesticides are chemicals that are utilized by man to control or destroy undesirable forms of plant and animal life. Pesticides encompass all forms of insecticides, herbicides, fungicides, fumigants, nematocides, algaecides, and rodenticides. Pesticides and their residues may enter surface waters via surface and ground water runoff from both urban and rural land uses. Some pesticides, such as herbicides used for aquatic weed control, are applied directly to the surface waters. Pesticides, like heavy metals, may accumulate in the tissues of living organisms with the concentration increasing up the food chain and thus presenting a potential threat to the human population.

Pesticides can be generally classified into four groups: chlorinated hydrocarbons, organophosphorus insecticides, carbamate insecticides, and chlorophenoxy herbicides. The chlorinated hydrocarbons, which include DDT, DDD, DDE, aldrin, dieldrin, chlordane, heptachlor, and lindane, are synthetic organic insecticides that are very stable in the environment, and are not easily broken down in the bodies of man or animals. These poisons affect the nervous system—particularly the brain—and in very severe poisonings may cause death. The organophosphorus insecticides, which include approximately 30 types with parathion potentially the most dangerous to man, are synthetic organic compounds that may affect the nervous system in man by inhibiting certain enzymatic reactions necessary for proper neural functions. The carbamate insecticides such as aminocarb, bayer, baygon, carboryl, and zectian are very similar to the organophosphorus insecticides in their toxic mechanisms. The chlorophenoxy herbicides have been widely used to control both aquatic and terrestrial vegetation. Experiments have generally indicated ambiguous toxic effects from chlorophenoxy herbicides.[3] Because of the slow degradation rate of heavy metals and pesticides, adverse and other toxic effects may continue long after the sources have been eliminated.

Polychlorinated biphenyls (PCB's) are a class of compounds produced by the chlorination of biphenyls and are registered in the United States under the trade name aroclor. The degree of chlorination determines the chemical properties, and generally the composition can be identified by the numerical nomenclature; e.g., aroclor 1242. The first two digits of the numeric designation represent the molecular type and the last two digits the average percentage—by weight—of chlorine. Identification of PCB's in the presence of organo-chlorine pesticides such as DDT and DDE has been difficult in the past because of their similar chromotographic characteristics. PCB compounds are slightly soluble in water, soluble in lipids—that is, in compounds that, with proteins and carbohydrates, constitute the principal structural components of living cells, namely fats, waxes—soluble in oils and organic solvents, and are resistant to both health and biological degradation. PCB's are relatively nonflammable, have useful heat exchange and dielectric properties, and are used principally in the electrical industry in capacitors and transformers and formerly in the production of papers used for printed self-copying forms not requiring carbon paper. Parallel to heavy metals and organic pesticides, PCB's are also capable of being taken up at the lowest vegetative food chain and thereby accumulating in the fleshy tissues of fish and eventually the human population that consumes the fish; the amounts being directly related to the amount of fish eaten over a long period of time.

PCB's have been found in the effluents of municipal wastewater treatment plants, industrial discharges, iron, steel, and especially aluminum foundries, pulp and paper mills, and electrical industries; and traces of PCB's have been found in snow samples indicating deposition from the contaminated atmosphere. Polychlorinated biphenyls' entry into the atmosphere may be expected to occur at locations where papers are incinerated, at foundries where imported casting waxes containing PCB's are heated to high temperatures, and in manufacturing facilities. PCB's are adsorbed in fine particulate matter and may also be entering the air as windblown dust.

Excessive exposure to PCB's is known to cause skin lesions[4] and to increase liver enzyme production with potential secondary effects on reproductive processes.[5] It is not clear whether the effects are due to the PCB's or to highly toxic contaminants—as, for example, chlorinated dibenzofurans—present in the PCB's. While chlorinated dibenzofurans are a byproduct of PCB production, it is not known whether they are also produced by the degradation of PCB's.[6]

Although a great deal of research remains to be accomplished in order to identify definitively the acceptable levels of these materials, the best available estimates of acceptable levels have been identified for this analysis. Although new chemicals continue to be placed on the market and find their way into the environment, the currently available recommended criteria for the known toxic and hazardous substances for which field data are available are presented in the following tables.

Tables 1 through 7 present the water quality analysis data for toxic and hazardous materials for the Des Plaines River, Kinnickinnic River, Milwaukee River, Oak Creek, Pike River, Rock River, and Root River watersheds, as collected by the Wisconsin Department of Natural Resources (DNR) in 1973 through 1976 as part of the drainage basin studies program. To date, water quality standards for the toxic and hazardous wastes inclusive of heavy metals, pesticides, and polychlorinated biphenyls have not been established; however, criteria are recommended by the U. S. Environmental Protection Agency (EPA) based upon the available data regarding the effects of toxic and hazardous wastes considered most significant in the aquatic environment for the protection and propagation of fish and other aquatic life, and for recreation in and on the water. These recommended water quality levels do not have a direct regulatory impact; but they are helpful as a basis for identifying actual and projected uses which are reasonable for any given body of water, the natural background levels of particular constituents, the sensitivity of important species which are or were present, the characteristics of the local biological community, and the physical characteristics of the aquatic system which may be adversely affected by excessive concentrations of pollutants.

As shown in the following tables, the EPA-recommended criteria[7] are noted for each substance for which the criteria and technical data are available. The notable omission is for pesticide compounds for which only very limited data are available as a basis for the establishment of recommendations. The other categorical omission is the absence of recommended levels of any of these substances in bottom sediments of lakes or streams. Despite this difficulty, Tables 8, 9, and 10 below report the sediment sample results from the Kinnickinnic, Milwaukee, and Oak Creek watersheds, respectively. This is likely a result of not only the lack of field research in the water chemistry of these pollutants, but also the general scientific ignorance of the mechanisms which govern water-sediment interactions controlling the forms and locations of these pollutants. What is known is that a general tendency exists for these substances to be removed from the water column. Low solubility, high affinity for particulate matter, and their potential to be consumed and stored in the biota all contribute to the accumulation of many of these materials in the bottom sediments. This is reflected in the much higher levels observed in the sediments than found in the streamflow samples themselves.

The recommended criteria were generally established by applying a factor of 0.01 to the concentration of a substance shown to be lethal to 50 percent of the test population of an indicator species after 96 hours (96 hours LC50 value). Procedurally, a controlled laboratory analysis is conducted on a sensitive resident aquatic species at which time a given number of organisms is exposed to predetermined concentrations of a toxic or hazardous material for 96 hours. By increasing the test concentrations of the substance being evaluated during separate 96-hour test periods, the mortality eventually approximates 50 percent of the total population of organisms, and an associated concentration is identified. This is then the level which is adjusted by a safety factor of 0.01, as set forth in Quality Criteria for Water, so that recommended water quality criteria can be established. This procedure does not and cannot consider the long-term cumulative effects, nor the synergistic or compensating interactions of various toxicity factors. The recommended levels presented are based on the reported sensitivities of the fathead minnow (scientific name: Pimephales promelas) which, although categorized as a pollution-tolerant organism, is considered to be reasonably representative of the sensitivity of organisms currently found within the major streams of the Region. In addition, more sensitive species dwell within five salmon spawning areas and 12 small trout streams located within the Region as of 1975; however, they are neither typical of the Region, nor are they the sites of any of the samples, the results of which are reported in the tables below. None of the sensitivity levels based on fish life should be considered necessarily indicative of direct danger to human life.[8]

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[2] *Ibid.*

[3] *Ibid.*

[4] *L. Schwartz and S. M. Peck, 1943 Occupational Acme New York State Medical Society, 43:1711.*

[5] *M. Wasman, et al, 1970. The Effect of Organochlorine Insecticides on Serum Chlorosterol Level in People Occupational Exposed Pollutant Environmental Contamination and Toxicology, 5:368.*

[6] *National Academy of Sciences, National Academy of Engineering, 1974. Water Quality Criteria, 1972. U. S. Government Printing Office, Washington, D. C.*

[7] *Quality Criteria for Water, 1976 Ecological Research Series, U. S. Environmental Protection Agency.*

[8] *It should be noted that newly available EPA criteria for aldrin, dieldrin, DDT, DDD, and DDE, as published in Part 129, amendments to Chapter I of Title 40 of the Code of Federal Regulations, also were incorporated in the analyses presented here.*

Table A-1

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE DES PLAINES RIVER WATERSHED[a]

Location	Date	Cadmium 12 μg/l		Chromium 100 μg/l		Copper 47 μg/l		Lead 4,820 μg/l		Mercury 0.05 μg/l		Nickel 100 μg/l		Zinc 334 μg/l		Polychlorinated Biphenyls (PCB's) 0.001 μg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Des Plaines River at CTH ML Bridge	07/27/73-10/17/73	2.5(2)	--	15.(2)	--	10.(2)	--	20.(2)	--	--	< 0.2*(2)	20.(1)	<10.(1)	17.(2)	--	--	<0.05(3)
Des Plaines at IH 94 Frigate Road	07/27/73-10/17/73	2.5(2)	--	15.(2)	--	9.(2)	--	20.(2)	--	--	< 0.2*(2)	10.(1)	< 10.(1)	16.(2)	--	--	--

Location	Date	DDT[d] 0.001 μg/l		DDE[d] 0.001 μg/l		DDD[d] 1.001 μg/l		Aldrin[d] 0.003 μg/l		Heptachlor 0.001 μg/l		Heptachlor Epoxide 0.001 μg/l		Lindane 0.01 μg/l		Dieldrin[d] 0.003 μg/l		Methoxychlor 0.03 μg/l		Phthalate 3 μg/l		Atrazine[e] __ μg/l		Simazine[e] __ μg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Des Plaines River at CTH ML Bridge	05/29/73-07/27/73	--	<0.005*(2)	--	< 0.005(2)	--	<0.005(2)	--	--	--	<0.005*(2)	0.007(1)	--	--	<0.005(2)	0.002(1)	<0.010*(1)	--	0.010(2)	--	<0.5(2)	--	--	--	--
Kilbourn Road Ditch NR STH 50 Bridge	10/17/73-10/24/73	--	<0.005*(2)	--	<0.005(2)	--	<0.005(2)	--	<0.002(2)	--	<0.002*(2)	--	<0.002*(2)	--	<0.002(2)	--	< 0.002(2)	--	0.010(2)	0.6(1)	<0.5(1)	--	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

By comparison to the fathead minnow, the levels of pollutants which are hazardous to the Daphnia species are noted to be significantly lower. The Daphnia species consists of zooplankton organisms which are commonly found in the waters of the Region and constitute a major portion of the food supply for aquatic vertebrates. Since the recommended concentrations of many of these substances are below the detectable limits for the fathead minnow, it is clear that the same would apply to Daphnia. Accordingly, the more tolerant species was selected for this general assessment of biological acceptability of the water pollutant concentrations.

Generally the data are not indicative of extensive toxicity problems in the water columns of the streams of the Region. Some localized or unique findings are worthy of note, however, and are described here; but these situations should be evaluated carefully because of the very limited number of samples and their associated areas of coverage. As summarized by the following tables in which the available heavy metals data are presented, the recommended levels for mercury were exceeded in 11 out of 114 samples in the Milwaukee River watershed, in two out of 48 samples in the Oak Creek watershed, four out of 73 samples in the Kinnickinnic River watershed, in four out of 78 samples in the Rock River watershed, in one out of five samples in the Pike River watershed, and in none of the samples collected in the Root River or Des Plaines River watersheds. It is important to note that the above-cited percentages represent those sample results that were known to be higher than the recommended criteria. In many cases the level of detection of the substances analyzed was higher than the recommended water quality criteria due to the lack of sensitivity of the laboratory analysis method to detect the substances at the recommended levels. For example, in many of the analyses conducted for mercury, the lowest level of detection of the laboratory conducting the test was 0.2 micrograms per liter (μg/l), whereas the criterion used for comparison is recommended at 0.05 μg/l for mercury. Therefore, the actual mercury concentration present in the sample may be less than 0.2 μg/l but greater than the recommended level. Thus it is impossible to determine the actual number of samples that were above the 0.05 μg/l, yet below 0.2 μg/l, and therefore exceeding the recommended criteria. Levels of concentrations for the other elements in the heavy metals category were all within normal limits of the recommended criteria. Specifically, cadmium, chromium, copper, lead, nickel, and zinc in the water samples from the Milwaukee, Oak Creek, Kinnickinnic, Rock, Root, Pike, and Des Plaines River watersheds all were observed to be below the imputed desirable levels. By contrast, the Kinnickinnic, Milwaukee, and Oak Creek watersheds for which data are available, exhibited detectable levels of heavy metals and PCB's in samples of stream sediments.

Table A-2

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE KINNICKINNIC RIVER WATERSHED[a]

Location	Date	Cadmium 12 μg/l		Chromium 100 μg/l		Copper 145 μg/l		Lead 4,820 μg/l		Mercury 0.05 μg/l		Nickel 100 μg/l		Zinc 334 μg/l		Polychlorinated Biphenyls (PCB's) 0.001 μg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Kinnickinnic River S. 35th Street	05/27/75-04/12/76	0.9(4)	<0.2(9)	9.(7)	<3.(6)	98.(13)	--	101.(12)	--	0.3(1)	<0.2*(12)	--	<20.(13)	134.(13)	--	0.2(1)	<0.1*(2)
Kinnickinnic River Oklahoma at 30th	05/27/75-04/12/76	0.4(4)	<0.4(11)	7.(7)	<3.(7)	6.(12)	<3.(2)	14.(11)	<3.(2)	0.3(1)	<0.2*(13)	20.(1)	<20.(13)	57.(10)	<20.(4)	--	<0.1*(3)
Kinnickinnic River S. Howell Avenue at Layton Airport	05/27/75-04/12/76	0.3(1)	<0.2(11)	3.(4)	<3.(8)	7.(12)	--	10.(10)	<3.(2)	--	<0.2*(12)	--	<20.(12)	44.(9)	<20.(3)	--	<0.1*(3)
Kinnickinnic River Railroad Bridge at Mooring Basin	05/27/75-04/14/76	0.41(4)	<0.7(8)	7.5(11)	<3.(1)	31.9(11)	<3.(1)	16.(12)	--	0.4(1)	<0.2*(11)	50.(1)	<20.(11)	83.(11)	<20.(1)	--	<0.1*(2)
Kinnickinnic River S. 6th Street	05/27/75-04/12/76	0.5(3)	<0.2(9)	15.(8)	<3.(4)	8.7(10)	<3.(2)	34.8(10)	<3.(2)	0.2(1)	<1.1*(11)	--	<20.(12)	57.(12)	--	--	<0.1*(2)
West Branch Kinnickinnic at 43rd Street	10/22/75	--	<0.2(1)	--	<3.(1)	--	<3.(1)	264.(1)	--	--	<0.2*(1)	--	<20.(1)	--	<20.(1)	--	--
Industrial Tributary to Kinnickinnic	10/22/75	--	<0.2(1)	--	<3.(1)	6.(1)	--	15.(1)	--	--	<0.2*(1)	--	<20.(1)	70.(1)	--	--	--
Mainstream Kinnickinnic at Cleveland Avenue	10/22/75	--	<0.2(1)	3(1)	--	--	<3.(1)	16.(1)	--	--	<0.2*(1)	--	<20.(1)	60.(1)	--	--	--
Mainstream Kinnickinnic at 7th Street	10/22/75	--	<0.2(1)	3(1)	--	4.(1)	--	15.(1)	--	--	<0.2*(1)	--	<20.(1)	40.(1)	--	--	--
Kinnickinnic at Mitchell Field	10/23/75	--	<0.2(1)	--	<3.(1)	4.(1)	--	--	<3.(1)	--	<0.2*(1)	20.(1)	--	--	<20.(1)	--	--
Holmes Avenue Creek at Layton	10/23/75	--	<0.2(1)	--	<3.(1)	5.(1)	--	9.(1)	--	--	<0.2*(1)	20.(1)	--	--	<20.(1)	--	--
South Branch Kinnickinnic at 13th Street	10/23/75	--	<0.2(1)	--	<3.(1)	--	<3.(1)	3.(1)	--	--	<0.2*(1)	--	<20.(1)	--	<20.(1)	--	--
Tributary at Wilson Park to South Branch Kinnickinnic	10/23/75	--	<0.2(1)	--	<3.(1)	6.(1)	--	7.(1)	--	--	<0.2*(1)	--	<20.(1)	--	<20.(1)	--	--
Kinnickinnic at Howard Avenue	10/23/75	--	<0.2(1)	--	<3.(1)	--	<3.(1)	3.(1)	--	--	<0.2*(1)	--	<20.(1)	--	<20.(1)	--	--
Tributary Upstream at Morgan Avenue	10/23/75	--	<0.2(1)	--	<3.(1)	6.(1)	--	13.(1)	--	--	<0.2*(1)	--	<20.(1)	--	<20.(1)	--	--

Location	Date	DDT[d] 0.001 μg/l		DDE[d] 0.001 μg/l		DDD[d] 0.001 μg/l		Aldrin[d] 0.003 μg/l		Heptachlor 0.001 μg/l		Heptachlor Epoxide 0.001 μg/l		Lindane 0.01 μg/l		Dieldrin[d] 0.003 μg/l		Methoxychlor 0.03 μg/l		Phthalate 3 μg/l		Atrazine[e] ___ μg/l		Simazine[e] ___ μg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Kinnickinnic River S. 35th Street	05/27/75-12/08/75	--	<0.02*(3)	--	<0.01(3)	--	<0.02(3)	--	<0.005*(3)	--	<0.005*(3)	--	<0.01*(3)	--	<0.005(3)	--	<0.01*(3)	--	<0.1*(3)	--	<0.2(1)	--	--	--	--
Kinnickinnic River Oklahoma at 30th	05/27/75-12/08/75	--	<0.02*(3)	--	<0.01(3)	--	<0.02(3)	--	<0.005*(3)	--	<0.005*(3)	--	<0.02*(3)	--	<0.005(3)	--	<0.01*(3)	--	<0.08*(3)	--	--	--	--	--	--
Kinnickinnic River S. Howell Avenue at Layton Airport	05/27/75-12/08/75	--	<0.02*(3)	--	<0.01(3)	--	<0.02(3)	--	<0.005*(3)	--	<0.005*(3)	--	<0.01*(3)	--	<0.003(3)	--	<0.01*(3)	--	<0.08*(3)	--	<0.2(2)	--	--	--	--
Kinnickinnic River Railroad Bridge at Mooring Basin	05/27/75-12/08/75	--	<0.02*(2)	--	<0.01(2)	--	<0.02(2)	--	<0.01*(2)	--	<0.005*(2)	-	<0.01*(2)	--	<0.003(2)	--	<0.01*(2)	--	<0.08*(2)	--	<0.2(1)	--	--	--	--
Kinnickinnic River S. 6th Street	05/27/75-12/08/75	--	<0.02*(2)	--	<0.01(2)	--	<0.01(2)	--	<0.005*(2)	--	<0.005*(2)	--	<0.02*(2)	--	<0.006(2)	--	<0.01*(2)	--	<0.04*(2)	--	--	--	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

When assessing the impact of polychlorinated biphenyls (PCB's) on the water quality of the major watersheds within the Region for which data were available, the Milwaukee, Oak Creek, and Kinnickinnic watersheds are observed to have one, seven, and one samples, respectively, exceeding the recommended criteria. However, as with heavy metals, the sensitivity of the tests for PCB's—0.05 μg/l—was significantly higher than the recommended level of 0.001 μg/l. Therefore, it is difficult to assess the actual levels of concentrations in the watersheds of the Region.

In regard to the observed pesticide concentrations for which criteria have been specifically recommended—namely, DDT, aldrin, heptachlor, heptachlor epoxide, lindane, dieldrin, methoxychlor, and phthalate—the streams of the Region are observed to have exceeded the recommended levels in from 1 to 5 percent of the sample results. More specifically, the Milwaukee River watershed is observed to have exceeded the recommended known levels for two out of 68 samples for aldrin, one out of 68 samples for heptachlor, one out of 68 samples for heptachlor epoxide, and two out of 50 samples for phthalate. The Rock River watershed exhibited excessive values in one out of 77 values for heptachlor, one out of

Table A-3

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE MILWAUKEE RIVER WATERSHED[a]

Location	Date	Cadmium 12 µg/l		Chromium 100 µg/l		Copper 47 µg/l		Lead 4,820 µg/l		Mercury 0.05 µg/l		Nickel 100 µg/l		Zinc 334 µg/l		Polychlorinated Biphenyls (PCB's) 0.001 µg/l	
		B	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Cedar Creek at STH 60 West of Jackson	04/29/74-10/01/74	3.0(1)	< 0.2(4)	25.0(2)	< 2.0(3)	13.0(3)	< 3.0(2)	12.0(2)	< 20.0(3)	--	< 0.3*(5)	30.0(1)	< 10.0(4)	10.0(2)	< 50.0(3)	--	< 0.05*(5)
Cedar Creek above confluence with Milwaukee River	04/29/74-09/30/74	2.0(1)	< 0.2(4)	11.0(3)	< 2.0(2)	6.1(3)	< 3.0(2)	15.6(3)	< 5.0(2)	0.5(1)	< 0.2*(4)	10.(1)	< 10.0(4)	54.5(2)	< 50.0(3)	0.355(1)	< 0.05*(1)
Mainstream at Milwaukee-Ozaukee County Line	04/30/74-09/30/74	--	< 0.2(5)	5.0(4)	< 0.8(1)	5.0(3)	< 3.0(2)	12.0(2)	< 5.0(3)	--	< 0.2*(5)	10.0(1)	< 10.0(4)	8.5(2)	< 50.0(3)	--	< 0.1*(5)
East Branch Milwaukee River at Washington-Fond du Lac County Line	04/11/74-03/20/75	0.2(1)	<5.0(20)	7.0(4)	<10.0(17)	2.0(6)	< 5.0(15)	20.0(2)	<40.0(19)	0.3(1)	<0.3*(19)	17.0(5)	<20.0(15)	14.0(5)	<50.0(16)	0.16(1)	<0.05*(21)
West Branch Milwaukee River 0.5 mile below Kewaskum in Washington County	04/24/74-09/30/74	0.5(1)	< 2.0(4)	86.0(3)	< 2.0(2)	5.0(3)	< 3.0(2)	20.0(1)	< 20.0(4)	0.3(2)	< 0.2*(3)	22.0(2)	< 10.0(3)	16.0(3)	< 50.0(2)	--	< 0.05*(5)
West Branch Milwaukee River at Riveredge Park Trail off CTH "Y" Washington County	04/25/74-09/30/74	1.3(3)	< 2.0(2)	10.0(3)	< 2.0(2)	6.0(3)	< 3.0(2)	9.0(1)	< 20.0(4)	--	< 0.3*(5)	16.0(2)	< 70.0(3)	20.0(2)	< 50.0(3)	--	< 0.05*(5)
North Branch Milwaukee River above confluence with Mainstream at River Road	04/25/74-09/30/74	--	< 3.0(5)	25.0(2)	< 2.0(3)	10.0(2)	< 3.0(3)	--	< 20.0(5)	--	< 2.0*(5)	10.0(1)	< 70.0(4)	15.0(2)	< 50.0(3)	--	< 0.05*(4)
Milwaukee River Wells Street Bridge	05/28/75-04/13/76	0.7(1)	<0.2(11)	19.0(10)	< 3.0(2)	26.0(12)	--	24.0(12)	--	0.3(1)	<0.2*(11)	--	<20.0(12)	48.0(10)	< 20.0(2)	0.035(2)	--
Milwaukee River North Avenue Dam	05/28/75-04/13/76	0.3(1)	<2.0(11)	5.0(5)	< 3.0(7)	26.0(11)	< 3.0(1)	19.0(11)	< 3.0(1)	0.4(2)	<0.2*(10)	--	<20.0(12)	50.0(9)	< 20.0(3)	0.6(2)	--
North Avenue Flushing Station	07/09/75-02/17/76	--	< 0.2(3)	4.0(1)	< 3.0(2)	12.0(2)	< 3.0(1)	6.0(3)	--	--	< 0.2*(3)	--	< 20.0(3)	--	< 20.0(3)	--	--
Milwaukee River Green Tree Road	05/28/75-10/08/76	--	<0.2(14)	--	< 3.0(14)	14.0(12)	< 3.0(2)	9.0(7)	< 3.0(7)	0.4(2)	<0.2*(10)	--	<20.0(14)	25.0(4)	<20.0(10)	--	< 0.1*(3)
Milwaukee River Brown Deer Road	05/28/75-10/08/76	--	<0.3(14)	--	< 3.0(14)	17.0(9)	< 3.0(5)	17.0(9)	< 3.0(7)	0.2(1)	<2.2*(11)	--	<20.0(14)	88.0(5)	< 20.0(9)	--	< 0.1*(3)
Milwaukee River Capitol Drive	05/28/75-10/08/76	0.4(2)	<0.2(12)	10.(5)	< 3.0(9)	18.0(10)	< 3.0(4)	19.0(11)	< 3.0(3)	0.4(1)	<3.0*(12)	--	<20.0(14)	70.0(5)	< 20.0(9)	0.6(1)	< 0.1*(1)
Milwaukee River Silver Spring Road	05/28/75-10/08/76	0.4(2)	<0.2(13)	38.0(2)	< 3.0(14)	17.0(16)	--	15.0(14)	< 3.0(3)	0.5(1)	<0.2*(11)	--	<20.0(15)	90.0(8)	< 20.0(8)	0.6(1)	< 0.1*(1)
Lincoln Creek Congress at 40th Street	05/28/75-04/13/76	0.4(2)	<0.2(10)	6.0(2)	< 3.0(10)	6.8(12)	--	15.0(11)	< 3.0(1)	0.3(2)	<0.2*(10)	--	<20.0(12)	34.0(7)	< 30.0(5)	--	< 0.1*(2)
Indian Creek at Bradley Road	05/28/75-04/13/76	--	<0.2(10)	--	< 3.0(10)	7.0(10)	--	7.0(7)	< 3.0(3)	2.0(1)	< 0.2*(9)	--	<20.0(10)	46.0(6)	< 20.(4)	--	< 0.1*(2)
Lincoln Creek at Teutonia Avenue	05/29/75-04/13/76	0.2(1)	<0.2(11)	8.0(10)	< 3.0(2)	8.0(12)	--	20.(12)	--	0.2(1)	<0.2*(11)	--	<20.0(12)	40.0(10)	< 20.0(2)	--	< 0.1*(2)
Lincoln Creek Villard at 64th Street	05/29/75-04/13/76	--	<0.2(12)	3.0(2)	< 3.0(10)	8.0(12)	--	12.0(6)	< 3.0(6)	0.3(1)	<0.2*(11)	--	<20.0(12)	46.0(3)	< 20.0(9)	--	< 0.1*(2)

Location	Date	DDT[d] 0.001 µg/l		DDE[d] 0.001 µg/l		DDD[d] 0.001 µg/l		Aldrin[d] 0.003 µg/l		Heptachlor 0.001 µg/l		Heptachlor Epoxide 0.001 µg/l		Lindane 0.01 µg/l		Dieldrin[d] 0.003 µg/l		Methoxychlor 0.03 µg/l		Phthalate —3 µg/l		Atrazine[e] — µg/l		Simazine[e] — µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Cedar Creek at STH 60 West of Jackson	04/29/74-10/01/74	--	< 0.02*(5)	--	< 0.01(5)	--	< 0.01(5)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005(5)	--	< 0.01*(5)	--	< 0.02(5)	2.8(1)	< 0.5(4)	--	<1.(4)	--	--
Cedar Creek above confluence with Milwaukee River	04/29/74-09/30/74	--	< 0.02*(4)	--	< 0.01(4)	--	< 0.01(4)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005(5)	--	< 0.01*(5)	--	< 0.02(5)	--	< 0.5(5)	2.(1)	<2.(4)	--	--
Mainstream at Milwaukee County Line	04/30/74-09/30/74	--	< 0.02*(5)	--	< 0.01(5)	--	< 0.01(5)	--	< 0.005*(4)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005(5)	--	< 0.01*(5)	--	< 0.02(5)	--	< 0.5(5)	1.5(1)	<1.(4)	--	--
East Branch Milwaukee River at Washington-Fond du Lac County Line	04/11/74-03/20/75	--	<0.02*(19)	--	<0.01(19)	--	<0.01(19)	0.019(1)	<0.005*(18)	--	<0.005*(19)	--	<0.005*(19)	--	<0.005(19)	--	<0.01*(19)	--	<0.04*(19)	1.2(2)	<0.5(17)	--	--	--	--
West Branch Milwaukee River 0.5 mile below Kewaskum in Washington County	04/25/74-09/30/74	--	< 0.02*(5)	--	< 0.01(5)	--	< 0.01(5)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005*(5)	0.008(1)	< 0.005(4)	--	< 0.01*(5)	--	< 0.02(5)	1.(1)	< 0.5(4)	1.(1)	<1.(4)	--	--
West Branch Milwaukee River at Riveredge Park Trail off CTH "Y" Washington County	04/25/74-09/30/74	--	< 0.02*(5)	--	< 0.01(5)	--	< 0.01(5)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005*(5)	--	< 0.005(5)	--	< 0.01*(5)	--	< 0.02(5)	4.5(1)	< 0.5(4)	2.5(1)	<1.(4)	--	--
North Branch Milwaukee River above confluence with mainstream at River Road	04/25/74-09/30/74	--	< 0.02*(4)	--	< 0.01(4)	--	< 0.01(4)	0.01(1)	< 0.005*(3)	--	< 0.005*(2)	--	< 0.01*(2)	--	< 0.003(1)	--	< 0.01*(2)	--	< 0.08*(2)	--	< 0.5(4)	--	<1.(4)	--	--
Milwaukee River Wells Street Bridge	05/28/75-04/13/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.02(2)	--	< 0.005*(1)	--	< 0.005*(2)	--	< 0.01*(2)	--	< 0.003(1)	--	< 0.01*(2)	--	< 0.08*(2)	0.2(1)	--	--	--	--	--
Milwaukee River North Avenue Dam	05/28/75-04/13/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.01(2)	--	< 0.005*(1)	0.008(1)	< 0.002*(1)	0.006(1)	< 0.002*(1)	--	< 0.005(1)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--
Milwaukee River Green Tree Road	05/28/75-10/08/76	--	< 0.02*(3)	--	< 0.01(3)	--	< 0.01(3)	--	< 0.005*(3)	--	< 0.005*(3)	--	< 0.005*(3)	--	< 0.005(3)	--	< 0.01*(3)	--	< 0.04*(3)	--	--	--	--	--	--
Milwaukee River Brown Deer Road	05/28/75-10/08/76	--	< 0.02*(3)	--	< 0.01(3)	--	< 0.01(3)	--	< 0.005*(3)	--	< 0.005*(3)	--	< 0.002*(3)	--	< 0.002(3)	--	< 0.01*(3)	--	< 0.05*(3)	--	< 0.2(1)	--	--	--	--
Milwaukee River Capitol Drive	05/28/75-10/08/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.01(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005(2)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--
Milwaukee River Silver Spring Road	05/28/75-10/08/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.01(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005(2)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--
Lincoln Creek Congress at 40th Street	05/28/75-04/13/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.01(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.03*(2)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--
Indian Creek Bradley Road	05/28/75-04/13/76	--	< 0.02*(2)	--	< 0.01(2)	--	<0.005(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.06*(2)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--
Lincoln Creek Teutonia Avenue	05/28/75-04/13/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.01(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.10*(2)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--
Lincoln Creek Villard at 64th Street	05/28/75-04/13/76	--	< 0.02*(2)	--	< 0.01(2)	--	< 0.01(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005*(2)	--	< 0.005(2)	--	< 0.01*(2)	--	< 0.04*(2)	--	--	--	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-4

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE OAK CREEK WATERSHED[a]

Location	Date	Cadmium 12 µg/l		Chromium 100 µg/l		Copper 47 µg/l		Lead 4,820 µg/l		Mercury 0.05 µg/l		Nickel 100 µg/l		Zinc 334 µg/l		Polychlorinated Biphenyls (PCB's) 0.001 µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Oak Creek Puetz Road West of Howell	05/27/75-04/12/76	0.1(1)	< 0.2(11)	6.(3)	< 3.(10)	4.5(7)	< 4.(6)	6.(9)	< 3.(4)	0.3(1)	< 0.2*(12)	--	< 20.(13)	50.(8)	<20.(5)	--	< 0.1*(3)
Oak Creek Marquette Street	05/27/75-04/12/76	--	< 0.2(11)	12.(1)	< 3.(10)	6.8(8)	< 3.(3)	14.(9)	< 3.(2)	0.3(1)	< 0.2*(10)	--	< 20.(11)	80.(9)	< 20.(2)	--	< 0.1*(2)
Oak Creek Parkway 0.3 Miles Below Dam (Mill Road)	05/27/75-04/12/76	--	< 0.2(12)	11.(6)	< 3.(6)	5.(9)	< 3.(3)	6.(7)	< 3.(5)	--	< 0.2*(12)	--	< 20.(12)	17.(4)	< 20.(8)	0.36(1)	< 0.1*(2)
Oak Creek Pennsylvania Avenue	05/27/75-04/12/76	--	< 0.7(12)	33.(8)	< 3.(4)	5.8(5)	< 3.(7)	5.(6)	< 3.(6)	--	< 0.2*(12)	--	< 20.(12)	30.(8)	< 20.(4)	--	< 0.1*(2)

Location	Date	DDT 0.001 µg/l		DDE 0.001 µg/l		DDD 0.001 µg/l		Aldrin 0.003 µg/l		Heptachlor 0.001 µg/l		Heptachlor Epoxide 0.001 µg/l		Lindane 0.01 µg/l		Dieldrin 0.003 µg/l		Methoxychlor 0.03 µg/l		Phthalate 3 µg/l		Atrazine[e] —— µg/l		Simazine[e] —— µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Oak Creek Puetz Road West of Howell	05/27/75-04/12/76	--	<0.02*(3)	--	<0.01(3)	--	<0.01(3)	--	<0.005*(3)	--	<0.005*(3)	--	< 0.03*(3)	--	<0.005(3)	--	<0.01*(3)	--	<0.04*(3)	--	--	--	--	--	--
Oak Creek Marquette Street	05/27/75-04/12/76	--	<0.02*(3)	--	<0.01(3)	--	<0.02(3)	--	<0.005*(3)	--	<0.005*(3)	--	<0.005*(3)	--	< 0.01(3)	--	<0.01*(3)	--	<0.08*(3)	--	< 0.2(1)	--	--	--	--
Oak Creek Parkway 0.3 Miles Below Dam (Mill Road)	05/27/75-04/12/76	--	<0.02*(3)	--	< 0.01(3)	--	<0.02(3)	--	< 0.005*(3)	--	<0.005*(3)	--	< 0.01*(3)	--	<0.005(3)	--	<0.01*(3)	--	<0.08*(3)	--	--	--	--	--	--
Oak Creek Pennsylvania Avenue	05/27/75-04/12/76	--	< 0.02*(2)	--	<0.01(2)	--	<0.02(2)	--	< 0.005*(2)	--	<0.005*(2)	--	< 0.01*(2)	--	<0.003(2)	--	<0.01*(2)	--	<0.08*(2)	--	< 0.2(2)	--	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-5

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE PIKE RIVER WATERSHED[a]

Location	Date	Cadmium 12 µg/l		Chromium 100 µg/l		Copper 145 µg/l		Lead 4,820 µg/l		Mercury 0.05 µg/l		Nickel 100 µg/l		Zinc 334 µg/l		Polychlorinated Biphenyls (PCB's) 0.001 µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Pike Creek 52nd Street	06/06/73-10/23/73	2.0(2)	--	15.(2)	--	15.(2)	--	165.(2)	--	--	<0.2*(2)	20.(1)	<10.(1)	37.(2)	--	--	<0.05*(4)
Pike River at STH 31	10/30/73	--	<0.2(1)	3.(1)	--	2.(1)	--	--	<4.(1)	--	< 0.2*(1)	40.(1)	--	20.(1)	--	--	--
Pike River at STH 32	06/13/73-10/30/73	8.(1)	<0.2(1)	6.5(2)	--	6.(2)	--	40.(1)	<4.(1)	2.2(1)	< 0.2*(1)	27.(2)	--	25.(1)	--	--	<0.05*(1)

Location	Date	DDT[d] 0.001 µg/l		DDE[d] 0.001 µg/l		DDD[d] 0.001 µg/l		Aldrin[d] 0.003 µg/l		Heptachlor 0.001 µg/l		Heptachlor Epoxide 0.001 µg/l		Lindane 0.01 µg/l		Dieldrin[d] 0.003 µg/l		Methoxychlor 0.03 µg/l		Phthalate 3 µg/l		Atrazine[e] —— µg/l		Simazine[e] —— µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Pike Creek 52nd Street West of 16th Avenue	06/05/73-11/06/73	--	<0.010*(4)	--	<0.020(4)	--	<0.010(4)	--	<0.005*(3)	--	<0.005*(4)	--	<0.005*(4)	--	<0.005(4)	--	< 0.50*(4)	--	<0.040*(4)	--	<0.5(3)	--	--	--	--
Pike River at STH 32 Bridge	07/30/73-10/30/73	0.02(1)	< 0.010*(1)	0.007(1)	<0.005(1)	--	< 0.008(2)	--	< 0.001(1)	--	<0.002*(2)	0.045(1)	<0.002*(1)	--	<0.005(2)	0.013(2)	--	--	< 0.020(2)	--	<0.5(2)	--	--	--	--
Pike River at STH 32 and 7th Avenue	06/12/73	--	<0.010*(1)	0.010(1)	--	--	<0.010(1)	--	--	--	<0.005*(1)	0.360(1)	--	--	<0.002(1)	--	<0.010*(1)	--	< 0.010(1)	--	<0.5(1)	--	--	--	--
Sturtevant Tributary NR Willow Road Bridge	06/13/73-10/29/73	--	< 0.040*(2)	--	<0.005(2)	--	<0.040(2)	--	< 0.002(1)	--	<0.010*(2)	--	<0.010*(2)	0.010(1)	< 0.010(1)	0.050(1)	--	0.020(1)	<0.040*(1)	--	--	--	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-6

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE ROCK RIVER WATERSHED[a]

Location	Date	Cadmium 12 µg/l		Chromium 100 µg/l		Copper 47 µg/l		Lead 4,820 µg/l		Mercury 0.05 µg/l		Nickel 100 µg/l		Zinc 334 µg/l		Polychlorinated Biphenyls (PCB's) 0.001 µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Scuppernong River CTH "N"	04/11/74-03/20/75	1.9(3)	< 5.(15)	17.(2)	< 3.(11)	4.(3)	< 4.(15)	20.(2)	< 5.(16)	--	< 0.2*(17)	6.5(2)	< 20.(16)	--	< 50.(18)	--	< 0.05*(18)
Scuppernong River at CTH "Z" Walworth County	04/11/74-03/20/75	1.1(4)	< 5.(14)	21.(3)	< 3.(15)	7.(3)	< 3.(15)	50.(2)	< 40.(16)	--	< 0.4*(17)	7.(3)	< 20.(15)	20.(2)	< 50.(16)	--	< 0.1*(16)
Rubicon River at CTH "P" Bridge	04/26/73-11/02/73	4.0(4)	< 2.(1)	49.(5)	--	21.(5)	--	20.(5)	--	0.3(2)	< 0.2*(3)	35.(3)	< 10.(2)	72.(5)	--	--	< 0.02*(2)
Ashippun River at CTH "CW" Bridge	04/25/73-10/12/73	--	< 2.(1)	--	< 10.(1)	4.0(1)	--	0.(0)	< 20.(1)	--	< 0.2*(1)	--	< 10.(1)	5.(1)	--	--	< 0.02*(2)
Oconomowoc River at CTH "BB" Bridge Below STP	05/03/73-11/02/73	--	< 2.(4)	10.(4)	--	5.0(1)	--	13.(2)	< 20.(2)	--	< 0.2*(4)	25.(2)	< 10.(2)	16.(4)	--	--	< 0.02*(3)
Turtle Creek at Sommerville Road Rock County	04/17/74-08/21/74	--	< 2.(1)	5.(1)	--	5.0(1)	--	--	< 20.(1)	--	< 0.2*(1)	--	< 10.(1)	5.(1)	--	--	< 0.05*(4)
Horton Creek at STH 89 (Represents AG runoff only)	04/11/74-03/20/75	4.5(2)	< 0.3(15)	25.(2)	< 3.(15)	4.5(4)	< 3.(13)	25.(2)	< 5.(15)	0.3(2)	< 0.3*(14)	15.(2)	< 20.(15)	25.(2)	< 50.(15)	--	< 0.1*(18)
Whitewater Creek at Willis Ray Road above Tripp Lake (Walworth County)	04/11/74-03/20/75	0.2(2)	< 5.0(15)	97.(3)	< 3.(14)	4.0(4)	< 3.(13)	11.(3)	< 5.(14)	--	< 0.2*(17)	37.(2)	< 20.(15)	24.(5)	< 20.(12)	--	< 0.05*(16)

Location	Date	DDT[d] 0.001 µg/l		DDE[d] 0.001 µg/l		DDD[d] 0.001 µg/l		Aldrin[d] 0.003 µg/l		Heptachlor 0.001 µg/l		Heptachlor Epoxide 0.001 µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c
Scuppernong River at CTH "N"	04/11/74-12/17/74	--	< 0.02*(13)	--	< 0.01(13)	--	< 0.01(13)	--	< 0.005*(12)	--	< 0.005*(13)	--	< 0.005*(13)
Scuppernong River at CTH "Z"	04/11/74-03/20/75	--	< 0.2*(16)	--	< 0.01(16)	--	< 0.01(16)	--	< 0.01*(15)	--	< 0.01*(16)	--	< 0.01*(16)
Kohlsville River 2 Miles East County Line	07/23/73-08/01/73	--	< 0.005*(2)	--	< 0.005(2)	--	< 0.005(2)	--	--	--	< 0.001(2)	--	< 0.002*(2)
East Branch Rock River at Highway D Bridge	07/23/70-11/02/73	--	< 0.005*(2)	--	< 0.005(2)	--	< 0.005(2)	--	< 0.002(2)	--	< 0.002*(2)	--	< 0.002*(2)
Rubicon River at CTH "P" Bridge	04/26/73-11/02/73	--	< 0.01*(2)	--	< 0.005(2)	--	< 0.005(2)	--	< 0.002(2)	--	< 0.002*(2)	--	< 0.002*(2)
Ashippun River at CTH "CW"	04/25/73-	--	< 0.005*(2)	--	< 0.005(2)	--	< 0.005(2)	--	--	--	< 0.002*(2)	--	< 0.002*(1)
Oconomowoc River at CTH "BB" Bridge below STP	05/03/73-11/02/73	--	< 0.01*(3)	--	< 0.005(3)	--	< 0.005(3)	--	< 0.002(2)	--	< 0.002*(3)	--	< 0.002*(3)
Jackson Creek below confluence with Geneva Tributary below Mound Road (Walworth County)	04/18/74-10/09/74	--	< 0.02*(5)	--	< 0.01(5)	--	< 0.01(5)	--	< 0.005*(5)	0.008(1)	< 0.005*(4)	--	< 0.005*(5)
Turtle Creek at Sommerville Road (Rock County)	04/17/74-08/21/74	--	< 0.02*(4)	--	< 0.01(4)	--	< 0.01(4)	--	< 0.005*(3)	--	< 0.005*(4)	--	< 0.005*(4)
Horton Creek at STH 89 (Represents AG runoff only)	04/11/74-03/20/75	--	< 0.02*(15)	--	< 0.01(15)	--	< 0.01(15)	--	< 0.005*(15)	--	< 0.005*(15)	0.05(1)	< 0.005*(14)
Whitewater Creek at Willis Ray Road above Tripp Lake (Walworth County)	04/11/74-03/20/75	--	< 0.02*(13)	--	< 0.01(13)	--	< 0.01(13)	--	< 0.005*(13)	--	< 0.005*(13)	--	< 0.005*(13)

Location	Date	Lindane 0.01 µg/l		Dieldrin[d] 0.003 µg/l		Methoxychlor 0.03 µg/l		Phthalate 3 µg/l		Atrazine[e] ___ µg/l		Simazine[e] ___ µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c
Scuppernong River at CTH "N"	04/11/74-12/17/74	--	< 0.005(13)	--	< 0.01*(13)	--	< 0.04*(13)	0.8(1)	< 0.5(12)	--	< 1.(10)	--	< 0.2(1)
Scuppernong River at CTH "Z"	04/11/74-03/20/75	--	< 0.01(16)	--	< 0.02*(16)	0.13(1)	< 0.04*(15)	--	< 0.5(16)	--	< 5.(16)	--	--
Kohlsville River 2 Miles East County Line	07/23/73-08/01/73	--	< 0.001(2)	--	< 0.002(2)	--	< 0.01(2)	--	< 0.1(2)	--	--	--	--
East Branch Rock River at Highway D Bridge	07/23/70-11/02/73	--	< 0.002(2)	--	< 0.002(2)	--	< 0.01(2)	--	< 0.5(2)	--	--	--	--
Rubicon River at CTH "P" Bridge	04/26/73-11/02/73	--	< 0.007(2)	--	< 0.002(2)	--	< 0.02(2)	< 0.95(1)	< 0.2(1)	0.2(1)	--	--	--
Ashippun River at CTH "CW"	04/25/73-	--	< 0.001(1)	--	< 0.002(2)	--	< 0.01(2)	--	< 0.5(2)	--	--	--	--
Oconomowoc River at CTH "BB" Bridge below STP	05/03/73-11/02/73	--	< 0.002(3)	--	< 0.005*(3)	0.007(1)	< 0.02(2)	--	< 0.5(3)	--	--	--	--
Jackson Creek below confluence with Geneva Tributary below Mound Road (Walworth County)	04/18/74-10/09/74	--	< 0.01(5)	--	< 0.01*(5)	--	< 0.02(5)	--	< 0.5(5)	1.75(2)	< 1.(3)	--	--
Turtle Creek at Sommerville Road (Rock County)	04/17/74-08/21/74	--	< 0.005(4)	--	< 0.01*(4)	--	< 0.04*(4)	1.(1)	< 0.5(3)	--	< 0.5(4)	--	< 0.2(1)
Horton Creek at STH 89 (Represents AG runoff only)	04/11/74-03/20/75	0.015(1)	< 0.005(14)	--	< 0.01*(15)	--	< 0.04*(15)	6.(2)	< 0.5(13)	0.76(3)	< 1.(5)	--	--
Whitewater Creek at Willis Ray Road above Tripp Lake (Walworth County)	04/11/74-03/20/75	1	< 0.005(13)	--	< 0.01*(13)	--	< 0.01(13)	3.(1)	< 0.5(12)	0.65(2)	< 0.5(7)	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

76 samples for heptachlor epoxide, one out of 76 samples for lindane, one out of 74 samples for methoxychlor, and three out of 77 samples collected for phthalate. The Root River watershed samples exceeded the recommended water quality criteria in one out of 11 samples for heptachlor epoxide, while the Pike River watershed did so in one out of nine samples for DDT, in two out of nine samples for heptachlor epoxide, in one out of nine samples for lindane, and in three out of eight samples for dieldrin. Finally, the Des Plaines River watershed samples exceeded recommended levels of water quality criteria in one out of three of the samples collected for heptachlor epoxide. Unfortunately, as in the case of heavy metals and PCB's, it is extremely difficult to evaluate the impact of pesticides on water quality since both the recommended criteria and the observed values are below the detectable limits of the sample results available.

Table A-7

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED WATER QUALITY SAMPLES FROM THE ROOT RIVER WATERSHED[a]

Location	Date	Cadmium 12 µg/l		Chromium 100 µg/l		Copper 47 µg/l		Lead 4,820 µg/l		Mercury 0.05 µg/l		Nickel 100 µg/l		Zinc 334 µg/l		Polychlorinated Biphenyls (PCB's) 0.001 µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Root River-Oakwood Bridge	03/20/73	--	<2.(1)	5.(1)	--	4.(1)	--	20.(1)	--	--	<0.2*(1)	10.(1)	--	12.(1)	--	--	< 0.05*(3)
Root River-5th Street Yacht Club	05/17/73-10/08/73	6.(1)	<2.(1)	10.(1)	<5.(1)	26.(2)	--	30.(1)	<20.(1)	--	<10.*(2)	10.(1)	<10.(1)	147.(2)	--	--	< 0.02*(2)
West Branch-Root River Canal	03/26/73	2.(1)	--	10.(1)	--	7.(1)	--	20.(1)	--	--	<0.2*(1)	10.(1)	--	14.(1)	--	--	< 0.05*(3)
East Branch-Root River Canal	03/26/73	2.(1)	--	10.(1)	--	5.(1)	--	20.(1)	--	--	<0.2*(1)	10.(1)	--	10.(1)	--	--	< 0.05*(1)
Root River Canal-near Confluence	10/10/73	--	<2.(1)	10.(1)	--	9.(1)	--	--	<20.(1)	--	<0.2*(1)	--	<10.(1)	18.(1)	--	--	< 0.05*(2)

Location	Date	DDT[d] 0.001 µg/l		DDE[d] 0.001 µg/l		DDD[d] 0.001 µg/l		Aldrin[d] 0.003 µg/l		Heptachlor 0.001 µg/l		Heptachlor Epoxide 0.001 µg/l		Lindane 0.01 µg/l		Dieldrin[d] 0.003 µg/l		Methoxychlor 0.03 µg/l		Phthalate 3 µg/l		Atrazine[e] __ µg/l		Simazine[e] __ µg/l	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Root River at Oakwood Road Bridge	03/20/73-09/10/73	--	<0.010*(3)	--	< 0.010(3)	--	<0.010(3)	--	<0.005*(2)	--	<0.005*(2)	--	<0.005*(3)	--	<0.005(3)	--	<0.010*(3)	--	<0.010(3)	--	<1.0(3)	--	--	--	--
Root River at 5th Street Yacht Club	05/17/73-07/17/73	--	<0.005*(2)	--	< 0.005(2)	--	<0.010(2)	--	< 0.002(1)	--	<0.002*(2)	--	<0.002*(2)	--	<0.002(2)	--	<0.005*(2)	--	<0.010(2)	--	<1.0(2)	--	--	--	--
Root River Canal Near Confluence with Root River	05/17/73-11/01/73	--	<0.010*(3)	--	< 0.010(3)	--	<0.005(3)	--	< 0.002(1)	--	<0.002*(3)	0.006(1)	<0.005*(2)	--	<0.003(3)	--	<0.005*(3)	--	<0.020(3)	--	<1.0(3)	--	--	--	--
West Branch Root River Canal at CTH K Bridge	03/26/73	--	<0.005*(1)	--	<0.005*(1)	--	<0.005(1)	--	--	--	<0.005*(1)	--	<0.005*(1)	--	<0.005(1)	--	<0.005*(1)	--	<0.010(1)	--	<0.5(1)	--	--	--	--
East Branch Root River Canal at CTH K Bridge	03/26/73-01/11/73	--	<0.005*(2)	--	< 0.005(2)	--	<0.005(2)	--	< 0.002(2)	--	<0.002*(1)	--	<0.002*(2)	--	<0.002(2)	--	< 0.002(2)	0.025(1)	<0.010(1)	--	<0.5(2)	--	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *Since the publication of Criteria for Water Quality, 1976, the U. S. Environmental Protection Agency has promulgated toxic pollutant effluent standards for ambient water quality criterion in navigable waters for aldrin, dieldrin, DDE, DDD, and DDT at the maximum concentrations as they appear above and as cited in the Federal Register, Volume 42, No. 8, January 12, 1977.*

[e] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-8

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED SEDIMENT SAMPLES FROM THE STREAMS OF THE KINNICKINNIC RIVER WATERSHED[a]

Location	Dates of Sampling	Cadmium[d] __ µg/gm		Chromium[d] __ µg/gm		Copper[d] __ µg/gm		Lead[d] __ µg/gm		Mercury[d] __ µg/gm		Nickel[d] __ µg/gm		Zinc[d] __ µg/gm		Polychlorinated Biphenyls (PCB's)[d] __ µg/Kg	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Industrial Tributary to Kinnickinnic River	02/10/76	3.5	--	22.0	--	49.0	--	670	--	0.31	--	15	--	750	--	2,700	--
30th Street at Kinnickinnic River (1/2 mile above)	02/16/76	1.25	--	1.25	--	16.0	--	375	--	0.025	--	12	--	250	--	110	--
6th Street at Kinnickinnic River (600 yards below)	02/10/76	3.5	--	37.5	--	78.0	--	650	--	0.34	--	26	--	825	--	9,700	--
Mooring Basin at Kinnickinnic River	02/10/76	1.2	--	500	--	11.8	--	670	--	0.55	--	32	--	850	--	--	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-9

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED SEDIMENT SAMPLES FROM THE STREAMS OF THE MILWAUKEE RIVER WATERSHED[a]

Location	Dates of Sampling	Cadmium[d] ___ ug/gm		Chromium[d] ___ ug/gm		Copper[d] ___ ug/gm		Lead[d] ___ ug/gm		Mercury[d] ___ ug/gm		Nickel[d] ___ ug/gm		Zinc[d] ___ ug/gm		Polychlorinated Biphenyls (PCB's)[d] ___ ug/Kg	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Milwaukee River at Brown Deer	02/10/76	0.5	--	6.3	--	8.5	--	35	--	0.07	--	5	--	95	--	150	--
Teutonia Avenue at Lincoln Creek	02/10/76	2.0	--	38.0	--	45.0	--	250	--	0.21	--	20	--	275	--	7,500	--
Capitol Drive at Milwaukee River	02/10/76	7.25	--	172.0	--	272.0	--	625	--	0.69	--	62	--	775	--	345,000	--
North Avenue at Milwaukee River	02/10/76	6.75	--	93.0	--	100.0	--	550	--	0.11	--	28	--	525	--	13,600	--
Wells Street at Milwaukee River	02/10/76	6.25	--	1,650.0	--	125.0	--	775	--	1.06	--	30	--	600	--	9,600	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table A-10

SUMMARY RESULTS OF AVAILABLE DATA FOR TOXIC AND HAZARDOUS MATERIALS IN SELECTED SEDIMENT SAMPLES FROM THE STREAMS OF THE OAK CREEK WATERSHED[a]

Location	Dates of Sampling	Cadmium[d] ___ ug/m		Chromium[d] ___ ug/gm		Copper[d] ___ ug/gm		Lead[d] ___ ug/gm		Mercury[d] ___ ug/gm		Nickel[d] ___ ug/gm		Zinc[d] ___ ug/gm		Polychlorinated Biphenyls (PCB's)[d] ___ ug/Kg	
		b	c	b	c	b	c	b	c	b	c	b	c	b	c	b	c
Marquette at Oak Creek	02/16/76	0.5	--	9.3	--	42	--	80	--	0.025	--	15	--	500	--	250	--
Parkway at Oak Creek	02/16/76	0.75	--	25.0	--	39	--	128	--	0.095	--	10	--	120	--	34,000	--

[a] *Values which are underlined indicate that the recommended criteria were exceeded.*

[b] *Average of determinate sample results (number of samples averaged).*

[c] *Indeterminate sample results (number of samples averaged). Asterisk (*) indicates those sample results of less than detectable (sensitivity) limits of the laboratory analysis.*

[d] *No recommended criteria established.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Appendix B

METHODS OF WATER ANALYSIS

SEWRPC STREAM SAMPLING PROGRAM (1964-1967)

The analytical methods used in determining the physical, chemical, biochemical, and bacteriological parameters are documented in Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, November 1966, Appendix A. The only addition to that appendix is the April 1967 sampling for which the Waukesha County Health Department analyzed the Commission water samples for coliform bacteria by the millipore method, as cited in Standards Methods of Water and Wastewater Analysis, 13th edition.

SEWRPC-DNR STREAM SAMPLING PROGRAM (1968-PRESENT)

Beginning in April of 1968, when the cooperative stream sampling program was initiated between the Wisconsin Department of Natural Resources and the Commission, a methodology was adopted and has since been followed by the DNR Delafield laboratory for analyzing surface water samples under the cooperative program. Under the adopted procedures, specific conductance, hydrogen ion concentration (pH), dissolved oxygen, nitrate-nitrogen, nitrite-nitrogen, soluble orthophosphate, and chlorides all are determined by the current edition of Standard Methods and/or the U. S. Environmental Protection Agency's publication, Methods for Chemical Analysis of Water and Wastes, 1974. The only exceptions are the tests for ammonia-nitrogen, organic-nitrogen, and total phosphorus. For ammonia-nitrogen, the method as described in the 13th and earlier editions of Standard Methods is used, under which the phosphate buffer replaces the borate buffer, and no boric acid is used in the procedure. For organic-nitrogen, the Delafield laboratory uses the method as set forth by the U. S. Geological Survey, Book 5, Chapter A1, "Methods for the Collection and Analysis of Water Samples for Dissolved Minerals and Gases." In the total phosphorus technique, as cited by M. L. Jackson, in Soil Chemical Analysis, 1958, the perchloric/nitric acid digestion method for determining total phosphorus is preferred over the persulfate method as described in Standard Methods, although somewhat more time consuming.

This sampling program includes the techniques established by the U. S. Geological Survey for examination of surface water and is documented in the following three manuals: Methods for Collection and Analysis of Water Samples for Dissolved Minerals and Gases, Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples, and Methods for Analysis of Organic Substances in Water.

ALL OTHER STREAM AND LAKE WATER QUALITY SAMPLING PROGRAMS

The DNR monthly manual sampling program, the DNR basin surveys, the DNR quarterly lake monitoring program, the U. S. Environmental Protection Agency National Stream and Lake Eutrophication Survey, the City of Milwaukee Health Department water quality studies, the City of Racine Department of Health water quality survey, the Geneva Lake Watershed Environmental Agency sampling program, the Milwaukee Metropolitan Sewerage Commission's water quality sampling program, and sampling conducted by Aqua-Tech, Inc., and CDM/Limnetics for the Lake Association Limnological Surveys, use the Wisconsin State Laboratory of Hygiene, Madison, or their own laboratories, all of which apply exclusively the procedures set forth in the latest editions of Standard Methods, or the U. S. Environmental Protection Agency Methods for the Analysis of Water and Wastewater.

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Appendix C

METHODS OF SAMPLE COLLECTION: 1964-1975

SEWRPC AND DNR STREAM AND LAKE SAMPLING METHODS

The methods used to collect stream and lake samples for analysis depend upon the purpose of the water quality study and upon the characteristics of the surface water being sampled. Methodology involves instrumentation, procedure, and sampling location. The stream itself, as the object of study, has variable characteristics such as width, depth, flow, velocities, turbulence, and cross-sectional and longitudinal channel configuration. The lake, on the other hand, encompasses other varied parameters in addition to several of the river characteristics. These characteristics affect the choice of sampling methods to be used. The variety of purposes of water quality studies of streams and lakes and the variety of stream and lake characteristics require that the sampling methods be carefully selected and evaluated as to suitability, particularly during the early period of study.

In considering sampling methods, one of the first questions which must be answered is whether water samples, to be representative of conditions in the stream or lake, must be taken at several locations and depths within the stream or lake at each station and blended to form a composite sample or whether a single "grab" sample can be used to represent conditions at each station location. A primary factor in reaching a decision is the flow characteristics encountered.

In streams, the mixing of waters of different composition and volume is a function of the turbulence of the receiving stream. If a single water sample taken at a point location is to properly represent the water quality of the entire cross-sectional area of the stream through the point, then water entering the receiving stream at one bank must be well dispersed laterally from bank to bank and vertically from surface to bottom; and the diluting flow of the receiving stream must disperse high local concentrations of pollutants throughout the cross-sectional area of the stream. If any pollutants move downstream for many miles in concentrated substreams within the channel, composite samples—rather than the so-called "grab" samples—would be required. A map study of the streams in southeastern Wisconsin was conducted and confirmed by visual field inspection of all sampling sites during the 10 years of monitoring. The results indicated that stream turbulence does adequately mix converging waters above each sampling location, thus indicating use of the "grab" sampling technique at all the sampling sites.

Temperature variations resulting from seasonal changes in lakes create several levels of temperature gradients during certain months of the year, due to the changing water densities which cause vertical stratification of the lake. Thus, grab sampling is indicated for the various levels of the lake. The use of composite sampling in this instance would not serve as a true indicator of the stratified conditions of the lake.

SAMPLING TECHNIQUES FOR ANALYSIS

The following is a description of the methodology used in the actual collection of stream and lake water samples by the Wisconsin Department of Natural Resources in all of its monitoring for the Commission's programs and in its own programs on the lakes and streams within the Region. In the years 1964-1967, in which the Commission initiated and carried out its own sampling program, a similar methodology was followed.

Physical Analysis

Sampling for temperature in degrees Fahrenheit was accomplished in the field at each site location.

Chemical Analysis

The sampling for specific conductance; hydrogen ion concentration (pH); nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble orthophosphate; total phosphorus and chloride were collected in plastic bottles of one-quart capacity. The sample bottles were premarked with grease pencil on the textured bottle surface, indicating sampling station and month of collection. As standard procedure, the bottles were rinsed twice with the sample water at the point of collection at each sampling station. This was done to remove any distilled water remaining in the bottle as the last step of the bottle-cleaning process. The sample bottle was held by its handle and immersed, where possible, to approximately six-tenths of stream depth or just below the lakewater surface. If various lake depths are being sampled, a device was used which takes a sample at the depth required by a pull on a rope attached to a rubber stopper. The bottle was placed into the stream on the upstream side of the person sampling, with the bottle opening tilted upstream and the handle oriented downstream from the opening. Care was taken not to sample water with turbidity resulting from the stream or lake bed being disturbed during sampling.

Sampling for Dissolved Oxygen

Samples for dissolved oxygen determination were collected in 250 ml glass-stoppered bottles. Where stream depths were sufficient to permit use of a sampling device (a sewage sampler), the glass bottle was lowered into the stream in the sampler. The intake tube was kept well below the surface of the stream. Upon filling, the sampler was raised from the stream; and the sample bottle was inspected immediately for air bubbles before being stoppered. If no bubbles appeared floating within the sample or adhering to the inside, the bottle was stoppered immediately and again inspected. If no bubbles were observed, reagents were added to the sample and the analysis was performed.

If air bubbles were observed in the sample upon removal from the sampler, immediate attempts were made to dislodge the bubbles by tapping the bottle. If the bubbles did not rise and escape through the bottle neck, the sample was discarded; and the procedure was repeated until a satisfactory sample was obtained.

Where stream depth was insufficient for use of the sampler, the 250 ml bottle was hand-held well below the water surface. The bottle was tilted upstream; and, as it was filled, it was reoriented progressively toward the vertical. If bubbles adhered to the inside, the bottle was reimmersed without spillage and tapped on the side opposite the bubbles. Bubbles accumulating on the shoulder of the sample bottle were removed by tapping and tilting to permit high-angle rise of the bubbles to the bottle opening. Unsuccessful attempts at removal of entrapped air necessitated resampling.

When successive attempts failed at bubble removal, a small part of the sample was poured out, permitting a larger bubble to enter the upper part of the bottle. This bubble, by tilting and turning the bottle around its long axis, was made to overrun and engulf the smaller bubbles adhering to the bottle shoulder. The larger bubble would then be dispelled by reimmersion. This technique, although used in a number of cases, was avoided and used only as a last solution to the problem of entrapped air.

To obtain the most reliable results, quickness of procedure was required both in the techniques of sample collection and of sample preparation by the addition of reagents. All sampling techniques discussed were applied when appropriate.

Sampling for Total Coliform and Fecal Coliform

Sampling for the determination of total coliform bacteria by the Commission staff was conducted through April 1967. The sample was collected in separate glass bottles furnished by the State Laboratory of Hygiene. Collection was in the same manner as described previously with one exception. The samples for the determination of total coliform count were collected by holding the coliform bottle at its base and lowering it into the stream in the inverted position. At the desired depth of sampling, the bottle opening was pointed upstream, permitting water to enter the bottle. Care was given to avoid touching the bottle and lid when the sample could become contaminated by contact with the hands. The samples were stored in ice in boxes specifically designed for storage and shipment of total coliform samples. At that time, the use of the total coliform parameter and the sampling and test procedures were consistent with the practices used in drinking water supply testing.

Beginning with the Commission-DNR cooperative stream sampling program in 1968, samples were analyzed for fecal coliform bacteria as a more definitive indicator of water pollution than total coliform bacteria. By definition, fecal coliform bacteria are present only when fecal materials are present, and therefore, are considered more indicative of the presence of potential pathogens. The use of the fecal coliform test minimizes the possibility that waters which contain coliforms from natural sources, such as decaying leaves, will be adjudged unsafe for full body-contact recreation, even though the pathogens associated with fecal matter would not be present. With the onset of the first sampling period, in April 1968, fecal coliform bacteria counts were sampled and analyzed by the Wisconsin State Laboratory of Hygiene. Samples were collected in 250 ml plastic bottles and delivered to the Wisconsin State Laboratory in Madison for analysis.

OTHER AGENCY FIELD SAMPLING TECHNIQUES

Grab samples were collected and preserved in a similar fashion for all other studies noted in Chapter II and cited in Appendix B. The only exception to this was in the U. S. Environmental Protection Agency National Eutrophication Survey in which a submersible pump and an interocean Systems sensor was used, capable of making in situ measurements of conductivity, temperature, dissolved oxygen, pH, depth, and several other parameters not incorporated into the Commission's final analysis.[1]

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[1] *U. S. Environmental Protection Agency National Eutrophication Survey: "Working Paper Number 1—Survey Methods for Lakes Sampled in 1972." October 1974, pp. 5-8.*

Appendix D

PHYSICAL, CHEMICAL, AND BACTERIOLOGICAL STREAM SAMPLE ANALYSES BY THE SEWRPC AND THE STATE LABORATORY OF HYGIENE

Due to its voluminous nature, Appendix D is omitted from this report but may be obtained from the following source:

Administrative Officer
Southeastern Wisconsin Regional
Planning Commission
P. O. Box 769
916 N. East Avenue
Waukesha, Wisconsin 53187

Appendix D contains the chemical analyses obtained by SEWRPC and discussed in this report. Additional chemical and biochemical data collected on a more infrequent basis as part of the Commission's Benchmark Study conducted in 1964-1965 are summarized in Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, and reported separately in Appendix C of that report.

For residents of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Waukesha, and Washington Counties, Wisconsin, the purchase price of Appendix D is $5.00. For those persons residing outside this Region, the purchase price is $10.00. All remittances should be paid in advance.

See below for
Appendix D

APPENDIX D

OF

TECHNICAL REPORT NO. 17

WATER QUALITY OF STREAMS AND LAKES
IN SOUTHEASTERN WISCONSIN: 1964-1975

Chemical, Biochemical and Bacteriological Stream Sample Analysis by the Southeastern Wisconsin Regional Planning Commission, the Department of Natural Resources, Bureau of Research, and the State Laboratory of Hygiène.

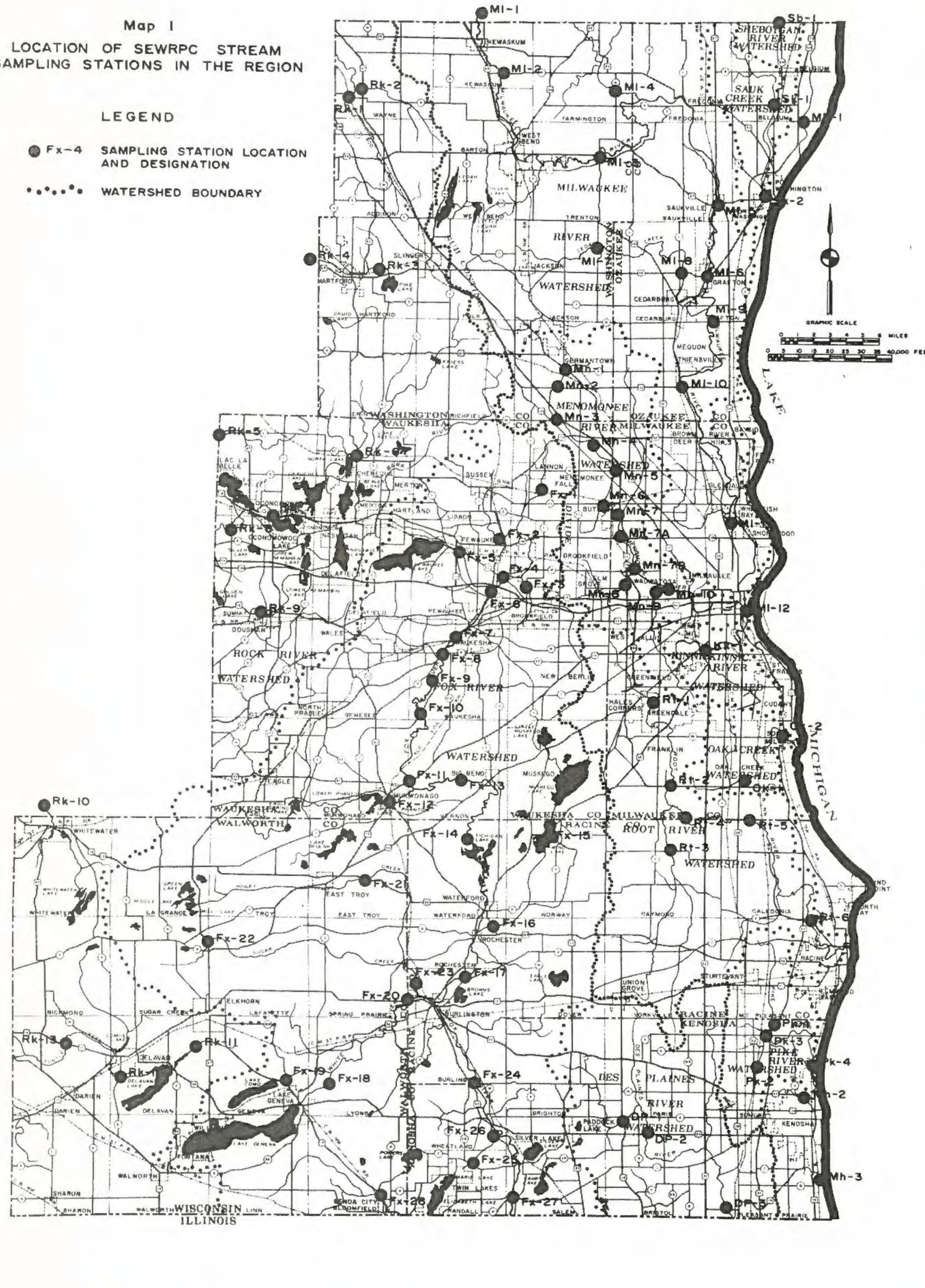
DESIGNATIONS AND LOCATIONS OF SEWRPC STREAM SAMPLING STATIONS BY THE U. S. PUBLIC LAND SURVEY SYSTEM

Sampling Station Designation	Sampling Station Location	Township	Range	Section	Quarter Section	Quarter-Quarter Section
DP-1	Brighton Creek at USH 45	01	21	05	2	C
DP-2	Des Plaines River at STH 50	01	21	09	1	B
DP-3	Des Plaines River at CTH ML	01	22	32	3	A
Fx-1	Fox River at Mill Road	08	20	29	1	A
Fx-2	Sussex Creek at STH 164	07	19	12	1	B
Fx-3	Poplar Creek at Barker Road	07	20	30	1	A
Fx-4	Fox River at CTH SS	07	19	24	4	B
Fx-5	Pewaukee River at CTH SS	07	19	15	2	B
Fx-6	Pewaukee River at STH 164	07	19	26	1	D
Fx-7	Fox River at State Street	06	19	03	3	C
Fx-8	Fox River at Sunset Drive	06	19	16	2	B
Fx-9	Fox River at CTH HI	06	19	20	3	A
Fx-10	Fox River at CTH I	06	19	31	4	C
Fx-11	Fox River at STH 15	05	18	24	4	A
Fx-12	Mukwonago River at STH 83	05	18	35	1	A
Fx-13	Fox River at Center Drive	05	19	22	3	B
Fx-14	Fox River at Tichigan Drive	04	19	10	1	C
Fx-15	Muskego Canal at STH 36	04	20	04	1	C
Fx-16	Wind Lake Drainage Canal at STH 20	03	19	01	3	B
Fx-17	Fox River at CTH W	03	19	22	3	A
Fx-18	White River at Sheridan Springs Road	02	18	20	3	D
Fx-19	Como Creek at CTH NN	02	17	23	4	D
Fx-20	White River at STH II	03	18	25	4	D
Fx-21	Honey Creek at Carver Road	04	18	22	3	C
Fx-22	Sugar Creek at USH 12	03	16	12	4	A
Fx-23	Honey Creek at Spring Prairie Road	03	19	30	1	B
Fx-24	Fox River at CTH J	02	19	26	2	B
Fx-25	Bassett Creek at CTH F	01	19	15	4	D
Fx-26	Bassett Creek at CTH W	01	19	12	2	A
Fx-27	Fox River at CTH C	01	20	30	3	D
Fx-28	Nippersink Creek at Darling Road	01	18	26	4	C
Kk-1	Kinnickinnic River at 29th Street	06	21	12	4	D
Mn-1	Menomonee River at STH 145	09	20	15	3	D
Mn-2	Menomonee River at CTH F	09	20	28	2	A
Mn-3	Menomonee River at CTH Q	08	20	04	1	B
Mn-4	Menomonee River at Lilly Road	08	20	12	3	B
Mn-5	Menomonee River at Good Hope Road	08	21	19	2	B
Mn-6	Menomonee River at Silver Spring Road	08	20	36	1	B
Mn-7	Little Menomonee River at STH 100	08	21	31	4	C
Mn-7A	Menomonee River at Capitol Drive	07	21	07	1	B
Mn-7B	Menomonee River at North Avenue	07	21	20	1	B
Mn-8	Underwood Creek Near N. 106th Street	07	21	20	2	B
Mn-9	Honey Creek at Honey Creek Parkway	07	21	27	2	B
Mn-10	Menomonee River at N. 70th Street	07	21	27	2	A
Ml-1	Milwaukee River North of Kewaskum	13	19	33	2	B
Ml-2	Milwaukee River at CTH H	12	19	23	2	A
Ml-3	Milwaukee River at STH 33 Near West Bend	11	20	14	2	B
Ml-4	North Branch Milwaukee River at CTH M	12	20	25	2	B
Ml-5	Milwaukee River at STH 33 at Saukville	11	21	36	2	B
Ml-6	Milwaukee River at STH 57 at Grafton	10	21	24	1	D
Ml-7	Cedar Creek at CTH M	10	20	12	2	D
Ml-8	Cedar Creek at STH 60	10	21	23	2	A
Ml-9	Milwaukee River at CTH C	09	22	06	2	B
Ml-10	Milwaukee River at Mequon Road	09	21	26	2	B
Ml-11	Milwaukee River at Hampton Avenue	07	22	05	2	B
Ml-12	Milwaukee River at STH 32	07	22	33	2	B
Mh-1	Sucker Creek at CTH P	11	22	02	2	A
Mh-2	Pike Creek at 43rd Street	02	23	30	3	D
Mh-3	Barnes Creek at Lake Shore Drive	01	23	20	2	C
Ok-1	Oak Creek at Shepard Avenue	05	22	21	4	C
Ok-2	Oak Creek at STH 32	05	22	02	4	C

Sampling Station Designation	Sampling Station Location	Township	Range	Section	Quarter Section	Quarter-Quarter Section
Pk-1	Pike River at STH 31	02	22	02	3	B
Pk-2	Pike Creek at 18th Street	02	22	15	3	C
Pk-3	Pike Creek at STH 31	02	22	02	3	C
Pk-4	Pike River at STH 32	02	23	18	4	C
Rk-1	East Branch Rock River at CTH D	12	18	30	4	A
Rk-2	Kohlsville River at USH 41	12	18	29	1	A
Rk-3	Rubicon River at Slinger Road	10	18	15	4	C
Rk-4	Rubicon River at Goodland Road	10	17	13	3	A
Rk-5	Ashippun River at CTH CW	08	17	07	2	B
Rk-6	Oconomowoc River at STH 83	08	18	16	2	D
Rk-7	Oconomowoc River at USH 16	08	17	34	4	C
Rk-8	Oconomowoc River at CTH BB	07	17	06	4	D
Rk-9	Bark River at USH 18	07	17	33	4	A
Rk-10	Whitewater Creek at N. Fremont Street	05	15	32	1	D
Rk-11	Jackson Creek at Mound Road	02	16	14	1	A
Rk-12	Delavan Lake Outlet at CTH O	02	16	19	4	C
Rk-13	Turtle Creek at STH II	02	15	10	3	A
Rt-1	Root River at Grange Avenue	06	21	33	1	B
Rt-2	Root River at Ryan Road	05	21	27	1	A
Rt-3	Root River Canal at Six Mile Road	04	21	10	4	D
Rt-4	Root River at County Line Road	04	21	02	1	A
Rt-5	Root River at Nicholson Road	05	22	34	3	C
Rt-6	Root River at STH 38	03	23	06	1	C
Sk-1	Sauk Creek at CTH A	12	22	33	1	B
Sk-2	Sauk Creek at STH 33	11	22	28	3	A
Sb-1	Tributary of Sheboygan River at CTH BH	13	22	34	3	C

Map 1

LOCATION OF SEWRPC STREAM SAMPLING STATIONS IN THE REGION



STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
DP-01															
4/09/64		43.0	13.3	724.0								8.3	30.000		300.000
5/21/64		64.0	8.9												600.000
6/05/64		67.0	9.9												500.000
7/20/64		84.0	10.1												500.000
8/12/64		63.0	6.6												600.000
9/23/64		61.0	5.5												3400.000
10/20/64		46.0	10.6	586.0		.068						7.8	15.000		100.000
11/11/64		59.0	12.7												2000.000
12/10/64			10.2												100.000
1/22/65		32.0	12.4			.497									56000.000
2/05/65		33.0	6.7			.475									1000.000
10/05/66	1345	56.0	8.3	630.0							.280	7.3	5.000		1000.000
4/03/67	0925	47.0	8.9	590.0	.003	.429					.020	7.6	30.000		300.000
4/17/68	0750	50.0	7.7	875.0	.009	.196				.031		8.0	24.100	70	
8/13/68	1155	73.0	6.7	716.0	.016	.277				.040		8.0	26.740	7,600	11000.000
4/01/69	0755	34.0	13.2	720.0	.013	.700				.020		7.8	32.000	10	400.000
8/13/69	1150	75.0	4.9	660.0	.035	.200				.090		8.1	38.000	1,200	21000.000
8/10/70	0245	65.0	12.5	660.0								8.2	6.000		
8/10/70	0615	51.0	3.6	875.0	.008	.100				.100		7.8	8.000	100	
8/10/70	0705	61.0	8.9	615.0								8.2	6.000		
8/10/70	1030	54.0	6.7	855.0								8.2	8.000		
8/10/70	1040	52.5	5.2	820.0								8.0	8.000		
8/11/70	0230	52.5	3.1	805.0								7.8	9.000		
8/03/71	0040	53.5	3.9	624.0								7.9	14.000		
8/04/71	0440	56.0	2.5	632.0								7.8	11.000		
8/04/71	0845	56.0	5.6	709.0								8.0	8.000		
8/04/71	1240	58.0	9.1	627.0						.120		8.4	9.000		
8/04/71	1620	67.0	13.7	595.0								8.4	7.000	1,100	
8/04/71	2020	63.0	10.6	600.0		.090						8.4	8.000		
8/09/72	0205	62.0	6.1	558.0	.005	.170	.230	2.270	2.680	.119	.170	7.6	27.000	40	
8/09/72	0605	60.0	6.0												
8/09/72	1400	66.0	8.5	661.0											
8/09/72	1800	67.0	8.0	667.0	.188	.310	.120	1.330	1.950	.130	.140	7.9	29.000	30	
8/08/73	0001	74.0	4.0	723.0											
8/08/73	0400	72.0	3.2	634.0	.025	.340	.090	.900	1.360	.257	.280	7.9	24.000	550	
8/08/73	1205	78.5	6.7	730.0											
8/08/73	1601	80.0	6.5	634.0	.018	.260	.040	.990	1.310	.196	.220	8.4	25.000	670	
8/14/74	0001	66.0	5.5	675.0											
8/14/74	0400	66.0	4.5	660.0	.017	.120	.440	1.160	1.745	.138	.190	8.0	38.000	1,400	
8/14/74	1200	73.0	11.4	690.0											
8/14/74	1600	77.0	11.9	700.0	.011	.170	.100	.960	1.250	.086	.120	8.5	31.000	610	
8/20/75	0001	59.0	4.1	619.0											
8/20/75	0401	57.0	3.8	566.0	.004	.040	.030	.080	.120	.027	.050	7.8	13.000	90	
8/20/75	1215	64.0	7.4	553.0											
8/20/75	1545	67.0	6.6	602.0	.012	.120	.030	.420	.500	.140	.180	7.8	32.000	840	
DP-02															
4/09/64		43.0	12.7	896.0								8.6	40.000		800.000
5/21/64		61.0	8.4												6000.000
6/05/64		68.0	13.0												800.000
7/20/64		81.0	5.3												15000.000
8/12/64		66.0	6.9												3000.000
9/23/64		64.0	4.8												31000.000
10/20/64		45.0	11.6	1,080.0		.113						8.0	45.000		6000.000
11/11/64		58.0	10.8												1000.000
12/10/64		33.0	9.8												2000.000
1/22/65		32.0	9.6			.497									31000.000
2/05/65		32.0	6.2			.678									1000.000
10/05/66	1330	55.0	10.4	955.0							.060	7.5	25.000		1000.000
4/03/67	0955	46.0	11.6	680.0	.006	1.017					.070	8.0	35.000		740.000
4/17/68	0740	50.0	7.2	954.0	.017	.193				.030		8.0	31.200	100	
8/13/68	1145	74.0	6.0	1,040.0	.048	.467				.050		7.8	72.510	2,300	26000.000
4/01/69	0810	34.0	12.5	840.0	.015	1.400				.030		7.8	41.000	30	400.000
8/13/69	1140	73.0	6.0	825.0	.027	.200				.080		7.9	44.000	1,400	13000.000
8/10/70	0300	86.0	9.2	910.0								8.3	89.000		
8/10/70	0630	68.0	3.1	1,140.0	.016	.110				.110		7.8	94.000	200	
8/10/70	0720	82.0	6.8	1,100.0								8.3	92.000		
8/10/70	1040	74.0	7.0	1,145.0								8.1	89.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
DP-02															
8/10/70	1050	75.0	4.3	1,135.0								8.0	92.000		
8/11/70	0240	71.0	3.4	1,145.0								7.8	96.000		
8/03/71	0025	68.0	5.7	1,091.0								8.0	90.000		
8/04/71	0425	63.5	5.0	1,025.0								7.8	39.000		
8/04/71	0835	63.0	5.2	1,026.0						.120		7.8	38.000		
8/04/71	1225	68.8	6.8	1,023.0								7.9	7.000		
8/04/71	1610	73.5	8.5	1,013.0	.026							8.0	15.000	800	
8/04/71	2010	71.0	8.3	992.0		.190						8.1	33.000		
8/09/72	0155	62.0	7.3	686.0	.046	1.340	.240	2.980	4.610	.153	.160	7.7	35.000	270	
8/09/72	0555	60.0	7.3												
8/09/72	1350	65.0	7.6	810.0											
8/09/72	1745	67.0	7.6	800.0	.051	1.220	.060	1.450	2.780	.140	.150	7.8	43.000	800	
8/08/73	0015	78.0	4.7	918.0											
8/08/73	0415	75.5	3.5	816.0	.046	.390	.040	.870	1.350	.171	.210	7.8	27.000	440	
8/08/73	1210	79.5	6.0	951.0											
8/08/73	1610	81.0	7.5	951.0	.024	.430	.030	1.080	1.530	.180	.170	8.3	29.000	340	
8/14/74	0010	70.0	9.2	1,230.0											
8/14/74	0410	68.5	8.4	1,190.0	.118	.790	.110	2.060	3.078	.137	.310	8.1	153.000	740	
8/14/74	1210	76.5	12.1	1,250.0											
8/14/74	1610	82.0	13.7	1,300.0	.095	.720	.100	1.780	2.699	.173	.200	8.4	168.000	330	
8/20/75	0010	68.5	4.2	783.0											
8/20/75	0410	65.5	3.5	795.0	.012	.220	.090	1.190	1.520	.229	.590	7.9	47.000	770	
8/20/75	1230	71.0	6.9	692.0											
8/20/75	1555	71.0	7.1	690.0	.031	.220	.030	.720	.950	.166	.190	8.1	52.000	900	
DP-03															
1/30/64		35.0	6.9	1,150.0	.300							7.9	105.000		1000.000
2/19/64		33.0	7.2	990.0								8.0	55.000		100.000
3/25/64		39.0	13.9	1,030.0								8.3	90.000		1300.000
4/09/64		43.0	10.3	796.0								8.0	55.000		1300.000
5/21/64		64.0	10.9	916.0								7.5	50.000		600.000
6/05/64		68.0	7.6	934.0								8.4	45.000		2000.000
7/20/64		79.0	2.2	572.0								7.4	45.000		13000.000
8/12/64		66.0	4.5	910.0								7.4	35.000		6000.000
9/23/64		68.0	3.4	864.0								7.4	20.000		32000.000
10/20/64		46.0	10.8	1,110.0		.136						8.0	85.000		200.000
11/11/64		56.0	9.4	1,050.0		.045						7.8	50.000		1000.000
12/10/64		33.0	9.2	1,220.0		.520						7.3	85.000		1000.000
1/22/65		32.0	11.0	936.0		.723						7.3	50.000		32000.000
2/05/65		32.0	2.1	1,130.0		.701						7.2	55.000		1000.000
10/05/66	1310	56.0	7.9	1,060.0		.045					.050	7.4	25.000		1000.000
4/03/67	1035	51.0	6.7	625.0	.006	.610					.020	7.7	50.000		200.000
4/17/68	0945	50.0	8.0	986.0	.041	.280				.055		8.0	47.100	65	
8/13/68	1120	75.0	7.0	850.0	.089	1.999				.030		7.8	55.600	700	12000.000
4/01/69	0830	34.0	12.6	910.0	.019	2.200				.030		8.0	51.000	10	300.000
8/14/69	0840	79.0	2.6	775.0	.037	.300				.170		8.0	59.000	500	15000.000
8/10/70	0325	90.0	12.6	870.0								8.6	59.000		
8/10/70	0655	69.0	1.9	1,010.0	.054	.310				.150		7.9	68.000	100	
8/10/70	0740	83.0	9.9	975.0								8.6	60.000		
8/10/70	1100	80.0	9.0	970.0								8.6	60.000		
8/10/70	1110	79.0	4.6	920.0								8.2	60.000		
8/11/70	0300	74.0	2.0	940.0								8.2	58.000		
8/03/71	2400	68.0	6.6	1,080.0								8.5	84.000		
8/04/71	0400	62.0	4.7	1,066.0								8.3	85.000		
8/04/71	0815	63.0	5.8	1,063.0						.200		8.1	67.000		
8/04/71	1200	75.0	8.9	1,015.0	.056							8.3	30.000		
8/04/71	1550	80.0	12.3	960.0		.320						8.7	58.000	600	
8/04/71	1950	75.0	9.1	960.0								8.7	55.000		
8/09/72	0135	63.0	4.5	708.0	.032	1.510	.210	2.420	4.170	.125	.150	7.6	45.000	140	
8/09/72	0535	62.0	4.1												
8/09/72	1335	65.0	5.1	828.0											
8/09/72	1730	66.0	5.6	826.0	.041	1.470	.050	1.480	3.040	.143	.140	7.8	41.000	70	
8/08/73	0035	80.0	3.3	963.0											
8/08/73	0435	77.0	2.1	827.0	.127	.910	.030	1.360	2.430	.464	.620	7.9	33.000	480	
8/08/73	1230	85.0	7.9	900.0											
8/08/73	1630	89.5	9.5	785.0	.050	.470	.030	1.540	2.060	.288	.430	8.5	33.000	250	
8/14/74	0030	73.0	3.8	920.0											
8/14/74	0430	69.5	3.0	900.0	.091	.550	.260	1.760	2.663	.336	.440	7.8	61.000	410	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
DP-03															
8/14/74	1230	79.5	6.4	1,010.0											
8/14/74	1625	87.0	8.5	1,100.0	.045	.400	.090	1.540	2.078	.389	.290	8.3	72.000	120	
8/20/75	0025	73.0	3.7	842.0											
8/20/75	0425	69.0	1.9	884.0	.053	.390	.030	.990	1.450	.389	.420	7.8	33.000	880	
8/20/75	1245	70.0	5.5	886.0											
8/20/75	1615	72.0	6.2	851.0	.035	.230	.030	1.070	1.340	.215	.150	8.1	33.000	450	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-01															
1/20/64		32.0	3.7	660.0	.100							7.2	45.000		1000.000
2/05/64		32.0	6.4	670.0								8.2	45.000		100.000
3/18/64		34.0	9.2	716.0											1500.000
4/22/64		50.0	7.6	676.0								8.0	25.000		100.000
5/20/64		59.0	6.2	960.0								8.0	35.000		2400.000
6/25/64		68.0	1.4	528.0								7.4	15.000		1000.000
7/29/64		68.0	1.6	652.0								7.2	20.000		18000.000
8/26/64		58.0	2.0	596.0								7.4	5.000		700.000
9/24/64		56.0	4.0	614.0								7.5	5.000		
10/07/64		42.0	7.0	700.0		.271						7.8	30.000		800.000
11/23/64		34.0	12.0	926.0		.633						7.7	30.000		100.000
12/28/64		32.0	6.1	878.0		.023						7.2	15.000		800.000
1/27/65		32.0	4.1	790.0		.090						7.3	5.000		200.000
2/25/65		32.0	2.1	644.0	.400	.362						6.7	35.000		200.000
10/24/66	0910	43.0	9.9	710.0	.009	.226				.040		7.7	35.000		9900.000
4/17/67	1340	53.0	11.8	785.0		.158				.010		8.2	20.000		660.000
4/15/68	0915	41.0	11.0	1,080.0		.238				.013		7.8	36.800	10	
8/12/68	0800	60.0	3.6	735.0	.034	.214				.047		7.8	19.780	270	16000.000
3/31/69	0715	32.0	10.5	920.0	.015	.500				.020		7.4	58.000	10	300.000
8/11/69	0800	64.0	.9	750.0	.045	.300				.050		7.6	54.000	150	12000.000
7/27/70	0615	71.0	2.0	845.0	.050	.450				.210		7.6	48.000	620	
7/27/70	1030	76.0	5.1	860.0								7.8	46.000		
7/27/70	1500	85.0	9.0	785.0								8.1	43.000		
7/27/70	1820	79.0	4.3	775.0								7.9	41.000		
7/27/70	2235	75.0	2.3	775.0								7.8	45.000		
7/28/70	0230	73.0	2.5	800.0								7.8	53.000		
8/01/71	2200	70.0	9.5	783.0								8.3	49.000		
8/02/71	0200	67.0	4.9	722.0								7.8	44.000		
8/02/71	0620	66.0	3.5	752.0	.023	.180				.090		7.5	47.000	500	
8/02/71	1000	67.5	8.3	757.0								8.0	46.000		
8/02/71	1405	75.0	10.5	762.0								8.4	45.000		
8/02/71	1800	77.0	14.7	729.0								8.6	45.000		
8/07/72	0001	67.0	5.1	754.0	.023	.510	.240	1.160	1.930	.074	.110	7.6	36.000	510	
8/07/72	0400	65.0	4.0	720.0											
8/07/72	1210	62.0	6.6	686.0											
8/07/72	1610	64.5	7.5	714.0	.008	.290	.100	.800	1.200	.093	.117	7.9	33.000	350	
8/06/73	0001	76.5	.9	790.0											
8/06/73	0400	71.5	.7	723.0	.049	.310	.140	.510	1.010	.043	.040	7.8	48.000	210	
8/06/73	1205	76.5	7.3	800.0											
8/06/73	1605	80.0	11.0	703.0	.037	.270	.040	.590	.940	.071	.060	8.4	49.000	10	
8/12/74	0001	65.0	2.9	740.0											
8/12/74	0400	62.0	2.2	700.0	.022	.320	.120	1.430	1.898	.051	.100	7.6	47.000	1,100	
8/12/74	1201	68.0		775.0											
8/12/74	1600	72.0	9.2	800.0	.020	.360	.130	1.450	1.961	.070	.080	7.9	47.000	650	
8/18/75	0001	68.0	.3	774.0											
8/18/75	0401	66.0	.4	758.0	.059	.260	.100	1.120	1.540	.071	.010	7.5	61.000	130	
8/18/75	1130	66.0	3.5	713.0											
8/18/75	1530	66.0	3.0	758.0	.031	.310	.160	1.470	1.970	.081	.010	7.7	62.000	130	
FX-02															
2/05/64		32.0	6.3	968.0								7.7	70.000		85000.000
3/18/64		32.0	9.0												4000.000
4/22/64		50.0	8.9	836.0								7.7	40.000		9000.000
5/20/64		58.0	9.5												2100.000
6/25/64		67.0	5.7												13000.000
7/29/64		70.0	5.7												11000.000
8/26/64		56.0	8.2												19000.000
9/24/64		54.0	7.2												
10/07/64		41.0	12.2	828.0		.814						8.0	65.000		11000.000
11/24/64		32.0	10.8												7000.000
1/27/65			4.7			.633									13000.000
2/25/65		32.0	4.3			.407									1300.000
10/24/66	0930	41.0	6.5	1,080.0	.009	.152				1.420		7.6	90.000		8300.000
4/17/67	1325	52.0	15.1	905.0	.055	.475				.830		8.8	55.000		10600.000
4/15/68	0945	43.0	5.7	1,550.0	.060	.195				.657		8.0	88.200	40,000	
8/12/68	0830	60.0	5.4	890.0	.123	2.710				.820		7.6	37.690	380	3800.000
3/31/69	0800	32.0	9.1	1,100.0	.037	1.900				.390		7.8	46.000	440	21000.000
8/11/69	0820	61.0	4.4	880.0	.180	3.100				.760		7.8	88.000	330	16000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-02															
7/27/70	0315	77.0	7.3	850.0								8.3	58.000		
7/27/70	0650	69.0	6.0	940.0	.120	2.400				1.230		7.9	68.000	1,600	
7/27/70	1050	76.0	8.9	985.0								8.1	72.000		
7/27/70	1840	74.0	6.2	830.0								8.2	44.000		
7/27/70	2315	71.0	5.1	820.0								7.9	50.000		
7/28/70	0240	69.0	5.0	1,020.0								7.8	98.000		
8/01/71	2220	66.0	6.1	857.0								8.4	50.000		
8/02/71	0220	64.0	5.7	826.0								7.9	48.000		
8/02/71	0640	64.0	5.0	950.0	.209	2.860				1.010		7.8	84.000	2,500	
8/02/71	1015	67.0	8.4	918.0								7.9	72.000		
8/02/71	1420	75.0	13.7	808.0								8.5	54.000		
8/02/71	1815	72.0	10.2	797.0								8.7	52.000		
8/07/72	0025	65.0	6.2	960.0	.196	2.050	.240	1.750	4.240	.486	.723	7.8	94.000	400	
8/07/72	0425	65.0	5.2	360.0											
8/07/72	1220	63.0													
8/07/72	1620	64.5	6.2	605.0	.052	.990	.250	1.270	2.560	.211	.373	7.8	37.000	1,100	
8/06/73	0015	73.0	5.1	1,036.0											
8/06/73	0415	70.5	5.1	848.0	.301	3.230	.150	1.070	4.750	.702	.510	7.9	84.000	1,200	
8/06/73	1220	75.0	9.7	879.0											
8/06/73	1620	80.0	11.0	765.0	.094	2.510	.120	.830	3.550	.752	.660	8.6	55.000	10	
8/12/74	0015	69.0	5.2	910.0											
8/12/74	0415	65.5	5.2	850.0	.331	2.900	.580	1.290	5.094	.831	.870	7.9	98.000	980	
8/12/74	1215	66.0	8.2	760.0											
8/12/74	1615	69.5	11.3	770.0	.158	2.800	.120	1.050	4.115	.713	.790	8.3	65.000	10	
8/18/75	0020	67.0	6.3	764.0											
8/18/75	0420	65.0	6.4	726.0	.162	2.350	.240	.990	[illegible]	.119	.110	7.9	65.000	600	
8/18/75	1150	66.0	8.8	684.0											
8/18/75	1545	67.0	8.8	626.0	.079	2.670	.080	.680	3.510	.135	.020	8.0	55.000	600	
FX-03															
2/05/64		32.0	7.5	1,010.0								8.3	35.000		500.000
3/18/64		32.0	10.2												1800.000
4/22/64		51.0	6.4	744.0								7.6	50.000		3600.000
5/20/64		59.0	5.5												900.000
6/25/64		66.0	3.8												1500.000
7/29/64		73.0	.1												2000.000
8/26/64		58.0	5.2												1100.000
9/24/64		54.0	5.5												
10/07/64		42.0	8.2	832.0		.362						7.6	20.000		900.000
11/24/64		33.0	12.1												1100.000
12/28/64		32.0	5.2												400.000
1/27/65			3.6			.407									9000.000
2/25/65		32.0	3.2			1.017									300.000
10/24/66	0950	42.0	6.1	890.0	.003	.181				.120		7.5	45.000		5900.000
4/17/67	1300	54.0	13.3	1,000.0	.003	.271				.010		8.0	55.000		19200.000
4/15/68	1030	46.0	12.2	1,155.0	.019	.950				.313		8.0	62.400	150	
8/12/68	0915	61.0	6.7	858.0	.021	.331				.077		7.6	21.270	900	130000.000
3/31/69	0840	32.0	12.9	1,260.0	.014	.800				.027		7.8	45.000	10	100.000
8/11/69	0900	62.0	5.7	1,110.0	.020	.500				.040		7.6	45.000	270	18000.000
7/27/70	0725	68.0	3.8	910.0	.049	.710				.080		7.7	59.000	210	
7/27/70	1120	74.0	8.8	960.0								7.9	56.000		
7/27/70	1950	74.0	4.6	625.0								7.7	45.000		
7/27/70	2345	72.0	4.0	840.0								7.8	62.000		
7/28/70	0310	71.0	3.4	850.0								7.7	64.000		
7/28/70	1515	79.0	7.3	825.0								7.8	70.000		
8/01/71	2255	66.0	6.4	869.0								7.9	71.000		
8/02/71	0255	66.0	4.7	857.0								7.8	65.000		
8/02/71	0720	65.0	3.1	897.0	.058	.290				.080		7.7	70.000	600	
8/02/71	1045	67.0	6.1	846.0								7.8	66.000		
8/02/71	1455	74.0	10.4	842.0								8.2	73.000		
8/02/71	1850	73.0	8.1	859.0								8.1	71.000		
8/07/72	0100	66.0	4.9	932.0	.042	.540	.130	1.050	1.760	.068	.117	7.7	80.000	340	
8/07/72	0500	65.0	4.8	948.0											
8/07/72	1255	63.0	5.7	988.0											
8/07/72	1655	65.0	8.1	990.0	.037	.390	.100	.980	1.510	.075	.113	7.9	89.000	120	
8/06/73	0045	72.0	5.3	931.0											
8/06/73	0445	71.0	4.4	838.0	.061	1.140	.100	.950	2.250	.101	.240	8.0	60.000	420	
8/06/73	1245	74.5	8.2	936.0											

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-03															
8/06/73	1650	76.5	11.7	827.0	.026	.900	.030	.810	1.740	.082	.080	8.2	55.000	180	
8/12/74	0045	68.5	6.5	790.0											
8/12/74	0445	66.0	5.5	760.0	.027	.740	.160	1.070	1.999	.053	.090	7.9	57.000	810	
8/12/74	1245	68.0	9.1	775.0											
8/12/74	1645	70.0	10.5	810.0	.025	.720	.230	1.130	2.115	.041	.100	8.2	62.000	340	
8/18/75	0050	68.0	5.0	806.0											
8/18/75	0450	65.5	4.6	768.0	.031	.570	.070	.640	1.310	.065	.010	7.8	69.000	400	
8/18/75	1220	67.0	9.0	796.0											
8/18/75	1620	71.0	9.6	747.0	.027	.530	.080	.540	1.180	.044	.030	7.9	69.000	2,600	
FX-04															
2/05/64		32.0	10.9	1,120.0								7.7	85.000		3000.000
3/18/64		33.0	10.1	808.0								8.2	50.000		5000.000
4/22/64		51.0	7.0	794.0								8.3	55.000		10000.000
5/20/64		62.0	6.0	946.0								7.6	55.000		10000.000
6/25/64		71.0	4.0	836.0								8.0	65.000		100.000
7/29/64		73.0		756.0	.100							7.3	30.000		80000.000
8/26/64		60.0	4.2	946.0	.200							7.6	65.000		21000.000
9/24/64		55.0	4.8	932.0								7.3	80.000		
10/07/64		44.0	6.9	1,140.0	.200	.723						7.6	120.000		7000.000
11/23/64		33.0	9.6	1,200.0	.200	1.605						7.6	105.000		45000.000
12/28/64		33.0	5.9	1,090.0	.100	.316						7.3	85.000		1000.000
1/27/65			4.3	956.0		.678						7.3	85.000		10000.000
2/25/65		32.0	2.3	796.0	.100	.452						7.1	50.000		1600.000
10/24/66	1005	43.0	5.9	1,500.0	.064	.339				2.090		7.5	135.000		9800.000
4/17/67	1245	54.0	9.8	980.0	.015	.294				.370		7.9	55.000		11500.000
4/15/68	1015	45.0	10.7	1,253.0	.062	.850				.469		7.8	74.700	500	
8/12/68	0900	65.0	2.9	890.0	.292	.783				.813		7.8	35.700	70	20000.000
3/31/69	0830	32.0	11.7	1,060.0	.015	.600				.190		7.8	66.000	20	1000.000
8/11/69	0845	67.0	1.2	1,010.0	.129	.200				.530		7.6	97.000	60	1900.000
7/27/70	0715	74.0	1.1	1,120.0	.300	.380				2.030		7.7	119.000	90	
7/27/70	1115	75.0	3.7	1,080.0								7.5	102.000		
7/27/70	1545	79.0	5.4	960.0								7.9	78.000		
7/27/70	1935	78.0	1.2	1,035.0								7.6	106.000		
7/27/70	2335	76.0	.7	1,010.0								7.6	124.000		
7/28/70	0300	75.0	.5	1,055.0								7.6	120.000		
8/01/71	2240	68.0	3.3	1,090.0								7.7	132.000		
8/02/71	0240	66.0	1.1	1,090.0								7.6	113.000		
8/02/71	0705	66.5	.8	1,063.0	.123	.690				1.440		7.6	115.000	80	
8/02/71	1035	68.0	1.5	1,147.0								7.5	140.000		
8/02/71	1445	70.0	6.1	1,237.0								7.8	153.000		
8/02/71	1840	72.0	6.7	1,241.0								7.9	152.000		
8/07/72	0050	68.0	1.7	998.0	.283	.970	.310	1.590	3.150	.600	.627	7.6	92.000	60	
8/07/72	0450	68.0	1.2	992.0											
8/07/72	1245	65.0	3.1	1,140.0						.706					
8/07/72	1640	66.5	5.3	1,141.0	.278	.950	.820	1.300	3.350		.723	7.8	113.000	100	
8/06/73	0035	76.0	.5	1,119.0											
8/06/73	0435	75.0	1.1	931.0	.342	.790	.960	.830	2.920	1.200	1.380	7.9	103.000	70	
8/06/73	1235	75.5	6.9	1,151.0											
8/06/73	1640	77.5	9.8	1,033.0	.262	1.390	.280	.920	2.850	1.190	1.130	8.2	135.000	80	
8/12/74	0035	72.5	5.6	990.0											
8/12/74	0435	70.0	4.9	950.0	.560	1.800	.510	1.920	4.796	.607	.710	8.0	123.000	1,500	
8/12/74	1232	70.0	6.4	1,000.0											
8/12/74	1635	72.0	7.4	1,030.0	.591	1.860	.430	1.850	4.737	.672	.700	8.1	132.000	780	
8/18/75	0040	74.0	6.6	899.0											
8/18/75	0440	70.0	5.3	928.0	.583	1.400	.160	1.200	3.350	.554	.470	8.0	135.000	310	
8/18/75	1210	71.0	6.2	992.0											
8/18/75	1610	71.0	6.6	928.0	.538	1.320	.220	1.200	3.280	.678	.320	8.1	135.000	1,200	
FX-05															
2/05/64		34.0	2.2	1,160.0	2.000							6.8	120.000		3000000.000
3/18/64		33.0	9.8												130000.000
4/22/64		51.0	8.9	620.0								7.6	30.000		40000.000
5/20/64		66.0	8.1												70000.000
6/25/64		71.0	5.2												110000.000
7/29/64		74.0	4.3												8000.000
8/26/64		61.0	5.3												6000.000
9/24/64		55.0	3.0												

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-05															
10/07/64		46.0	6.1	960.0	.200	1.853						7.5	90.000		3000.000
11/23/64		32.0	4.9												100000.000
12/28/64		32.0	.7												1000000.000
1/27/65			1.0			.113									1700000.000
2/25/65		34.0	11.0			.294									43000.000
10/24/66	1030	44.0	4.2	985.0	.079	.497				3.740		7.5	70.000		48000.000
4/17/67	1230	54.0	9.9	560.0	.012	.226				.270		8.2	20.000		1900000.000
4/15/68	1000	49.0	10.3	775.0	.042	.725				.282		8.0	35.800	330	
8/12/68	0845	71.0	2.9	324.0	.067	.181				.390		7.8	14.300	20,000	230000.000
3/31/69	0815	36.0	12.9	740.0	.015	.400				.190		8.0	29.000	3,600	56000.000
8/11/69	0830	70.0	3.3	520.0	.039	.200				.230		7.8	38.000	600	16000.000
7/27/70	1100	79.0	3.3	580.0								7.9	29.000		
7/27/70	1530	81.0	4.0	590.0								7.8	42.000		
7/27/70	1905	76.0	1.1	555.0	.072	.220				.080		7.7	31.000	170	
7/27/70	2330	78.0	.7	520.0								7.7	32.000		
7/28/70	0255	76.0	.6	555.0								7.7	30.000		
8/01/71	2230	68.0	.7	1,224.0								7.5	153.000		
8/02/71	0230	67.0	.5	1,100.0								7.6	107.000		
8/02/71	0655	66.0	.7	723.0	.018	.140				1.830		7.5	51.000	3,600	
8/02/71	1025	70.5	2.5	658.0								7.6	43.000		
8/02/71	1435	77.0	4.8	740.0								7.7	78.000		
8/02/71	1830	76.0	.4	819.0								7.5	76.000		
8/07/72	0035	72.0	4.3	432.0	.100	.520	.490	1.450	2.560	.564	.503	8.3	42.000	2,200	
8/07/72	0435	71.0	3.7	480.0											
8/07/72	1230	68.5	4.6	554.0											
8/07/72	1630	71.0	5.7	545.0	.093	.430	.540	1.280	2.340	.384	.527	8.5	53.000	830	
8/06/73	0025	76.0	2.0	638.0											
8/06/73	0425	74.0	1.7	579.0	.235	1.030	1.110	1.270	3.650	.890	.970	7.8	43.000	16,000	
8/06/73	1230	78.5	4.0	679.0											
8/06/73	1630	80.0	4.4	661.0	.164	1.320	1.410	1.460	4.350	1.130	1.110	8.0	64.000	810	
8/12/74	0025	71.0	3.2	590.0											
8/12/74	0425	69.0	2.9	575.0	.082	.370	1.320	1.780	3.554	.512	.710	7.9	47.000	1,000	
8/12/74	1223	71.5	4.5	640.0											
8/12/74	1630	74.5	5.5	690.0	.095	.880	1.950	1.870	4.798	.843	1.090	7.9	60.000	3,900	
8/18/75	0030	72.0	1.3	671.0											
8/18/75	0430	69.0	1.2	662.0	.150	.490	2.090	2.260	5.000	.681	1.230	7.7	65.000	13,000	
8/18/75	1200	70.0	3.2	651.0											
8/18/75	1600	70.0	3.8	616.0	.198	1.030	1.820	2.670	5.720	.996	1.070	7.7	69.000	930	
FX-06															
1/20/64		33.0	1.4	996.0								7.4	90.000		160000.000
2/05/64		32.0	3.5	1,040.0								7.3	85.000		160000.000
3/18/64		32.0	9.8	842.0								8.4	50.000		10000.000
4/22/64		53.0	10.9	700.0								7.8	35.000		15000.000
5/20/64		64.0	11.1	584.0								7.9	30.000		7000.000
6/25/64		71.0	8.4	586.0								7.6	30.000		1100.000
7/29/64		70.0	7.2	596.0								7.6	35.000		3000.000
8/26/64		58.0	9.0	606.0								7.8	45.000		400.000
9/24/64		54.0	8.2	774.0								7.7	70.000		
10/07/64		44.0	12.6	840.0		.181						8.0	65.000		1500.000
11/23/64		33.0	11.8	1,030.0		1.017						7.6	90.000		38000.000
12/28/64		33.0	4.5	1,120.0		.090						7.2	105.000		60000.000
1/27/65			4.4	920.0		.090						7.4	105.000		4000.000
2/25/65		34.0	4.8	634.0	.100	.316						7.2	35.000		24000.000
10/24/66	1045	42.0	9.9	910.0	.018	.587				2.290		7.6	70.000		14000.000
4/17/67	1220	54.0	12.4	690.0	.009	.271				.490		8.5	30.000		9000.000
4/15/68	1100	49.0	12.4	782.0	.036	.813				.219		8.2	38.600	110	
8/12/68	0945	66.0	6.4	569.0	.068	.364				.487		7.6	18.780	270	1300.000
3/31/69	0845	33.0	13.5	895.0	.005	.600				.120		8.0	44.000	170	1900.000
8/11/69	0910	68.0	4.2	570.0	.103	.200				.420		7.6	42.000	200	15000.000
7/27/70	0740	74.0	4.3	645.0	.150	.560				1.130		7.8	43.000	280	
7/27/70	1130	78.0	5.5	670.0								7.8	40.000		
7/27/70	2000	77.0	4.5	590.0								7.9	32.000		
7/28/70	0001	75.0	4.1	610.0								7.9	35.000		
7/28/70	0320	74.0	4.2	625.0								7.8	38.000		
7/28/70	1525	81.0	6.2	645.0								7.9	34.000		
8/01/71	2310	69.0	5.3	801.0								7.9	70.000		
8/02/71	0310	68.0	5.3	759.0								7.8	63.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-06															
8/02/71	0730	65.5	5.1	752.0	.161	.820				1.770		7.8	66.000	1,000	
8/02/71	1100	66.5	5.9	752.0								7.8	62.000		
8/02/71	1505	71.0	6.8	760.0								8.0	63.000		
8/02/71	1905	73.0	5.9	757.0								8.0	60.000		
8/07/72	0115	71.0	5.0	545.0	.049	.440	.210	2.020	2.720	.292	.393	7.8	49.000	120	
8/07/72	0515	69.0	5.0	605.0											
8/07/72	1305	66.0	6.4	590.0											
8/07/72	1700	68.0	7.3	599.0	.059	.410	.200	1.190	1.860	.298	.437	8.0	48.000	160	
8/06/73	0055	75.0	4.9	678.0											
8/06/73	0455	73.0	5.0	620.0	.126	1.080	.030	1.090	2.300	.675	.620	7.9	55.000	250	
8/06/73	1255	77.0	7.0	706.0											
8/06/73	1655	78.5	6.9	619.0	.103	.900	.080	1.140	2.220	.780	1.060	8.2	51.000	330	
8/12/74	0100	71.0	4.9	630.0											
8/12/74	0500	68.5	5.5	630.0	.104	1.190	.090	1.380	2.772	.560	.610	8.0	57.000	200	
8/12/74	1250	70.5	6.4	610.0											
8/12/74	1655	72.0	7.0	630.0	.073	1.120	.240	.600	2.035	.595	.680	8.1	49.000	170	
8/18/75	0100	71.0	4.7	671.0											
8/18/75	0500	68.0	4.9	646.0	.028	1.200	.070	.810	2.100	.389	.370	7.9	56.000	670	
8/18/75	1235	69.0	7.8	640.0											
8/18/75	1635	70.0	7.6	640.0	.031	.950	.040	.790	1.800	.407	.320	8.0	58.000	3,400	
FX-07															
1/20/64		42.0	9.0	2,000.0	.100							7.7	445.000		10000.000
2/05/64		42.0	8.8	930.0								7.4	70.000		1200.000
3/18/64		39.0	13.1	736.0								8.2	35.000		4900.000
4/22/64		53.0	9.3	794.0								7.6	45.000		14000.000
5/20/64		68.0	8.9												20000.000
6/25/64		76.0	6.7	664.0								7.4	35.000		4000.000
7/29/64		76.0													20000.000
8/26/64		66.0	8.0	772.0	.100							7.8	45.000		7000.000
9/24/64		62.0	5.8	800.0								7.4	50.000		
10/07/64		53.0	6.9	880.0	.100	.294						7.9	65.000		5000.000
11/23/64		40.0	14.4	898.0		.588						8.3	80.000		2600.000
12/28/64		40.0	9.5	984.0		.610						7.6	70.000		400.000
1/27/65		39.0	10.2	1,010.0	.100	.565						7.5	115.000		4000.000
2/25/65		33.0	8.4	758.0	.100	.203						7.2	65.000		3200.000
10/24/66	1100	50.0	7.8	865.0	.027	.294				.900		7.7	70.000		14000.000
4/17/67	1200	58.0	11.6	840.0	.006	.271				.250		8.4	45.000		8700.000
4/15/68	1730	54.0	10.2	1,058.0	.062	.694				.456		8.2	60.300	1,300	
8/12/68	1000	72.0	7.8	772.0	.081	.623				.660		8.2	28.730	330	21000.000
3/31/69	0900	34.0	13.9	1,040.0	.012	.700				.160		8.0	68.000	20	900.000
8/11/69	0930	69.0	6.5	800.0	.155	.700				.530		7.7	80.000	640	70000.000
7/27/70	0830	75.0	6.0	900.0	.058	.520				.730		8.1	81.000	140	
7/27/70	1140	78.0	13.4	890.0								8.6	82.000		
7/27/70	2015	78.0	8.8	780.0								8.7	66.000		
7/28/70	0010	77.0	6.3	790.0								8.6	70.000		
7/28/70	0405	73.0	5.7	850.0								8.5	71.000		
7/28/70	1645	81.0	14.0	875.0								8.6	68.000		
8/01/71	2325	67.0	6.7	991.0								8.0	98.000		
8/02/71	0335	68.0	7.1	490.0								8.3	45.000		
8/02/71	0745	69.5	6.6	887.0	.039	.460				.610		8.3	95.000	100	
8/02/71	1115	70.5	8.7	950.0								8.5	97.000		
8/02/71	1515	76.0	15.3	922.0								8.8	100.000		
8/02/71	1920	76.0	13.2	938.0								8.8	94.000		
8/07/72	0135	71.0	6.7	327.0	.048	.790	.150	1.520	2.510	.247	.323	7.9	58.000	1,400	
8/07/72	0535	70.0	6.5	799.0											
8/07/72	1320	67.5	7.9	834.0											
8/07/72	1720	70.0	8.6	833.0	.055	.730	.110	1.110	2.000	.303	.433	8.1	79.000	70	
8/06/73	0110	74.0	5.0	962.0											
8/06/73	0510	73.5	5.1	869.0	.030	2.600	.030	.970	3.600	.459	.530	8.1	88.000	400	
8/06/73	1310	77.0	8.8	968.0											
8/06/73	1715	78.0	9.1	848.0	.032	1.050	.030	.910	1.990	.470	.640	8.3	88.000	150	
8/12/74	0110	72.5	5.3	850.0											
8/12/74	0505	71.0	5.5	850.0	.043	1.600	.120	1.370	3.128	.324	.440	8.0	94.000	2,100	
8/12/74	1305	70.5	7.0	850.0											
8/12/74	1705	74.0	6.6	610.0	.044	1.380	.030	1.200	2.650	.315	.380	8.0	65.000	7,300	
8/18/75	0110	72.0	5.7	847.0											
8/18/75	0510	70.5	10.6	854.0	.021	1.260	.070	.750	2.090	.271	.070	8.0	103.000	190	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-07															
8/18/75	1245	72.0	6.8	724.0											
8/18/75	1645	72.0	7.4	754.0	.034	1.530	.110	.810	2.480	.285	.280	7.9	94.000	3,300	
FX-08															
1/20/64		42.0	7.1	1,680.0	.200							7.4	320.000		70000.000
2/05/64		41.0	8.4	1,120.0								7.6	105.000		24000.000
3/18/64		41.0	13.0	740.0								8.0	50.000		610000.000
4/22/64		57.0	9.0	800.0								7.4	45.000		9000.000
5/20/64		66.0	9.1	850.0								8.0	65.000		19000.000
6/25/64		74.0	3.4	800.0								7.3	65.000		5000.000
7/29/64		76.0	.2	730.0	.200							7.2	35.000		100000.000
8/26/64		64.0	6.9	860.0	.200							7.6	65.000		60000.000
9/24/64		57.0	5.6	944.0								7.4	90.000		
10/07/64		53.0	9.8	1,050.0	.200	1.514						7.8	120.000		140000.000
11/23/64		40.0	12.5	1,060.0	.200	1.921						8.0	105.000		1000.000
12/28/64		36.0	10.9	1,130.0	.200	.136						7.6	105.000		17000.000
1/27/65		32.0	10.5	1,180.0	.400	.949						7.5	155.000		30000.000
2/25/65		32.0	8.8	792.0	.300	.520						7.2	70.000		13000.000
10/24/66	1110	51.0	8.2	995.0	.073	.881				3.140		7.6	100.000		97000.000
4/17/67	1145	57.0	15.3	900.0	.009	.294				.490		8.8	55.000		208000.000
4/15/68	1215	58.0	11.5	1,120.0	.187	2.776				1.198		8.2	82.800	5	
8/12/68	1015	69.0	8.8	885.0	.198	2.439				.180		7.8	42.660	5	100.000
3/31/69	0910	35.0	14.0	1,100.0	.021	.900				.430		8.0	71.000	10	100.000
8/11/69	0940	69.0	7.9	885.0	.099	2.400				.930		7.8	112.000	60	4300.000
7/27/70	0845	72.0	5.4	1,050.0	.060	2.800				1.730		7.9	95.000	130	
7/27/70	1225	80.0	14.0	1,010.0								8.5	104.000		
7/27/70	2030	77.0	5.0	560.0								7.8	60.000		
7/28/70	0420	73.0	4.0	950.0								8.0	99.000		
7/28/70	1228	75.0	4.3	875.0								8.0	100.000		
7/28/70	1700	82.0	14.8	1,030.0								8.6	98.000		
8/01/71	2335	69.0	7.2	1,114.0								8.4	128.000		
8/02/71	0345	67.0	5.1	826.0								8.2	78.000		
8/02/71	0755	68.0	4.4	630.0	.049	1.210				1.020		7.9	69.000	3,400	
8/02/71	1135	70.0	7.3	770.0								8.0	80.000		
8/02/71	1530	77.0	13.1	1,040.0								8.5	121.000		
8/02/71	1930	76.0	11.3	1,213.0								8.4	168.000		
8/07/72	0145	70.0	5.5	777.0	.079	1.810	.380	1.640	3.910	.754	.780	7.8	90.000	170	
8/07/72	0545	69.0	5.3	784.0											
8/07/72	1325	68.0	7.6	884.0											
8/07/72	1725	70.5	9.3	963.0	.098	2.070	.550	1.690	4.410	.981	1.083	8.1	108.000	10	
8/06/73	0120	73.0	4.9	1,093.0											
8/06/73	0520	71.0	4.5	930.0	.053	1.490	.150	1.020	2.710	1.200	1.140	7.9	101.000	180	
8/06/73	1320	78.0	10.4	1,145.0											
8/06/73	1725	78.5	7.8	1,034.0	.116	3.760	1.110	1.260	6.250	1.420	1.410	8.3	142.000	30	
8/12/74	0115	70.0	4.6	920.0											
8/12/74	0515	68.0	4.8	880.0	.073	3.680	.240	1.350	5.347	1.049	.970	7.9	98.000	10	
8/12/74	1315	71.0	7.4	950.0											
8/12/74	1715	74.0	6.3	800.0	.132	3.380	.470	1.600	5.588	.943	1.070	7.9	101.000	770	
8/18/75	0120	72.0	5.1	992.0											
8/18/75	0520	69.0	4.2	972.0	.074	4.230	.210	.890	5.410	1.226	.860	7.8	120.000	10	
8/18/75	1255	72.0	7.9	969.0											
8/18/75	1655	72.0	8.8	960.0	.114	4.220	.580	1.560	6.470	1.285	1.030	8.0	156.000	270	
FX-09															
1/22/64			5.5												58000.000
2/05/64		38.0	8.4												34000.000
3/18/64		36.0	11.4												110000.000
4/22/64		56.0	8.9												10000.000
5/20/64		64.0	8.0												13000.000
6/25/64		74.0	5.3												1400.000
7/29/64		77.0	.5												140000.000
8/26/64		66.0	5.7												500000.000
9/24/64		56.0	5.7												
10/07/64		48.0	7.9	1,050.0	.400	1.853						7.6	115.000		100000.000
11/23/64		34.0	11.5												60000.000
12/28/64		32.0	9.5												30000.000
1/27/65			8.8			1.220									60000.000
2/25/65		32.0	8.2			.723									19000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-09															
10/24/66	1135	48.0	4.7	1,060.0	.116	.610				2.630		7.6	100.000		84000.000
4/17/67	1130	56.0	10.8	870.0	.012	.316				.700		8.4	50.000		158000.000
4/15/68	1230	55.0	11.9	1,059.0	.111	1.626				.704		8.2	63.000	5	
8/12/68	1030	66.0	6.1	848.0	.224	2.041				1.170		7.8	46.140	9,700	50000.000
3/31/69	0920	33.0	12.9	1,060.0	.036	.900				.520		8.0	68.000	240	32000.000
8/11/69	0955	67.0	5.0	845.0	.106	2.200				1.000		7.9	52.000	2,800	13000.000
7/27/70	0855	76.0	6.2	985.0	.130	3.500				1.530		8.2	101.000	140	
7/27/70	1235	80.0	12.5	980.0								8.5	94.000		
7/27/70	2040	78.0	5.8	750.0								7.9	84.000		
7/28/70	0030	76.0	2.8	585.0								7.6	54.000		
7/28/70	0430	74.0	2.1	635.0								7.6	62.000		
7/28/70	1705	80.0	15.5	950.0								8.5	78.000		
8/01/71	2350	68.5	9.4	1,065.0								8.3	110.000		
8/02/71	0355	66.5	4.0	1,040.0								7.8	100.000		
8/02/71	0805	69.0	4.4	1,033.0	.167	2.180				2.010		8.0	120.000	160	
8/02/71	1145	70.0	8.8	1,065.0								8.2	115.000		
8/02/71	1540	76.0	14.8	825.0								8.7	87.000		
8/02/71	1940	75.0	12.2	682.0								8.7	64.000		
8/07/72	0155	71.0	6.7	845.0	.129	.990	.460	1.650	3.230	.860	1.010	7.9	85.000	10	
8/07/72	0555	68.0	5.2	901.0											
8/07/72	1335	66.5	6.4	819.0											
8/07/72	1735	69.0	8.1	885.0	.108	1.030	.230	1.770	3.140	.854	.970	8.0	89.000	70	
8/06/73	0130	77.0	6.9	1,046.0											
8/06/73	0530	74.0	6.0	930.0	.079	3.060	.090	.850	4.080	1.110	.790	8.0	106.000	190	
8/06/73	1330	76.0	11.9	1,046.0											
8/06/73	1735	77.0	12.0	915.0	.077	2.760	.060	.800	3.700	1.170	.990	8.3	89.000	70	
8/12/74	0125	72.0	4.6	690.0											
8/12/74	0525	69.0	3.8	680.0	.115	3.350	.220	1.710	5.399	.790	.860	7.8	79.000	6,500	
8/12/74	1325	69.0	8.1	850.0											
8/12/74	1725	73.0	9.4	890.0	.110	3.690	.340	1.600	5.747	.967	1.200	8.2	89.000	10	
8/18/75	0130	73.0	5.1	888.0											
8/18/75	0530	72.0	5.5	854.0	.086	3.960	.080	.740	4.870	1.173	.970	7.9	110.000	100	
8/18/75	1305	72.0	8.2	950.0											
8/18/75	1705	72.0	9.1	885.0	.118	4.390	.070	.720	5.300	1.085	.780	8.1	123.000	230	
FX-10															
1/22/64			9.6												6400.000
2/05/64		34.0	11.9												700.000
3/18/64		34.0	11.5												8200.000
4/22/64		54.0	8.3												12000.000
5/20/64		68.0	10.4												8000.000
6/25/64		77.0	9.7												700.000
7/29/64		78.0	1.0												41000.000
8/26/64		66.0	8.4												9000.000
9/24/64		56.0	7.4												
10/07/64		50.0	13.7	964.0	.200	1.695						8.3	90.000		18000.000
11/23/64		33.0	12.4												2000.000
12/28/64		32.0													7000.000
1/27/65			10.3			1.220									5000.000
2/25/65		32.0	7.6			.723									12000.000
10/24/66	1150	46.0	8.2	915.0	.094	.723				2.160		7.9	70.000		12000.000
4/17/67	1120	57.0	11.0	840.0	.018	.384				.790		8.4	45.000		50000.000
4/15/68	1245	53.0	13.2	1,028.0	.119	1.875				.625		8.2	57.200	5	
8/12/68	1035	68.0	5.6	735.0	.210	1.313				.940		7.8	49.630	100	8000.000
3/31/69	0930	33.0	13.0	920.0	.031	1.300				.740		8.0	62.000	10	400.000
8/11/69	1005	71.0	5.7	800.0	.091	3.100				.750		7.9	89.000	60	34000.000
7/27/70	0910	76.0	6.7	910.0	.093	2.000				1.430		8.2	79.000	150	
7/27/70	1240	82.0	12.1	885.0								8.0	74.000		
7/27/70	2055	80.0	8.4	770.0								8.4	66.000		
7/28/70	0040	77.0	5.7	900.0								8.3	88.000		
7/28/70	0440	76.0	3.6	835.0								7.9	84.000		
7/28/70	1715	81.0	12.5	700.0								8.5	56.000		
8/01/71	2400	70.0	8.7	906.0								8.5	83.000		
8/02/71	0405	68.5	7.2	907.0								8.4	83.000		
8/02/71	0815	69.5	6.7	950.0	.135	1.280				1.150		8.4	97.000	270	
8/02/71	1150	71.0	8.8	955.0								8.5	91.000		
8/02/71	1550	77.0	11.8	1,011.0								8.5	92.000		
8/02/71	1950	77.0	11.9	1,000.0								8.6	85.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-10															
8/07/72	0205	72.0	6.4	810.0	.096	1.550	.210	1.470	3.330	.626	.793	7.9	67.000	90	
8/07/72	0605	69.0	5.5	851.0											
8/07/72	1340	67.0	6.2	899.0											
8/07/72	1745	68.0	6.6	844.0	.136	2.010	.300	1.360	3.810	.538	.753	7.9	78.000	230	
8/06/73	0140	77.0	9.2	941.0											
8/06/73	0540	75.0	6.0	826.0	.045	2.730	.030	.940	3.720	.970	.770	8.1	77.000	340	
8/06/73	1335	78.5	12.9	931.0											
8/06/73	1745	80.0	15.9	827.0	.069	2.940	.040	.920	3.970	.760	.850	8.8	81.000	70	
8/12/74	0130	71.5	6.3	800.0											
8/12/74	0530	70.0	5.3	750.0	.140	3.080	.770	15.080	19.068	.651	.800	7.8	77.000	2,900	
8/12/74	1335	71.5	6.9	640.0											
8/12/74	1735	74.0	8.3	700.0	.080	2.650	.090	1.460	4.291	.592	.620	8.2	60.000	1,300	
8/18/75	0140	74.0	9.0	858.0											
8/18/75	0540	71.0	7.2	822.0	.083	3.070	.240	1.070	4.460	.902	.780	8.2	98.000	130	
8/18/75	1315	72.0	8.5	828.0											
8/18/75	1715	72.0	10.6	768.0	.054	2.880	.260	1.500	4.690	.823	.700	8.3	89.000	70	
FX-11															
1/22/64		34.0	9.8	1,040.0	.200							7.8	130.000		700.000
2/06/64		32.0	11.9	864.0								8.0	65.000		600.000
3/18/64		34.0	12.2	678.0								8.2	50.000		3300.000
4/22/64		55.0	7.7	776.0								7.6	35.000		18000.000
5/20/64		71.0	6.8	840.0								8.2	45.000		10000.000
6/25/64		77.0	11.9	540.0								8.0	35.000		500.000
7/29/64		80.0	.4	652.0	.600							7.2	35.000		4000.000
8/26/64		65.0	6.4	778.0	.200							7.6	55.000		4000.000
9/24/64		58.0	7.1	840.0								7.5	80.000		
10/07/64		50.0	16.3	840.0	.100	.927						8.5	65.000		300.000
11/23/64		33.0	15.4	964.0	.100	1.220						8.0	90.000		900.000
12/28/64		33.0	10.1	956.0	.100	1.627						7.5	65.000		300.000
1/27/65			6.0	942.0	.200	.994						7.4	100.000		3400.000
2/25/65		32.0	.6	698.0	.300	.407						7.1	55.000		500.000
10/24/66	1220	47.0	12.6	915.0	.058	.475				1.600		8.2	70.000		5300.000
4/17/67	1040	58.0	10.6	845.0	.018	.339				1.450		8.4	50.000		10000.000
4/15/68	1300	52.0	12.0	963.0	.087	1.475				.532		8.2	42.700	35	
8/12/68	1055	69.0	2.6	696.0	.099	.659				.830		7.6	39.680	120	3600.000
3/31/69	0945	34.0	12.5	990.0	.019	.800				.050		7.9	54.000	10	100.000
8/12/69	0815	75.0	.6	720.0	.029	.400				.800		7.7	145.000	100	12000.000
7/27/70	0955	80.0	10.8	865.0	.072	.990				1.030		8.5	77.000	20	
7/27/70	1255	85.0	16.6	855.0								8.7	70.000		
7/27/70	2120	81.0	9.2	750.0								8.6	68.000		
7/28/70	0105	79.0	6.3	785.0								8.4	70.000		
7/28/70	0525	77.0	4.7	810.0								8.2	64.000		
7/28/70	1740	84.0	14.7	930.0								8.5	76.000		
8/01/71	0020	70.0	7.8	933.0								8.4	92.000		
8/02/71	0430	69.0	7.0	907.0								8.4	90.000		
8/02/71	0850	70.0	6.8	944.0	.149	.990				1.170		8.3	104.000	500	
8/02/71	1220	75.5	10.8	966.0								8.6	103.000		
8/02/71	1615	79.0	13.2	972.0								8.7	102.000		
8/02/71	2020	77.0	11.1	912.0								8.7	91.000		
8/07/72	0225	72.0	5.2	778.0	.098	1.280	.470	2.470	4.320	.520	.797	7.8	67.000	50	
8/07/72	0625	70.0	4.8	888.0											
8/07/72	1355	67.5	5.9	834.0											
8/07/72	1800	69.0	6.5	812.0	.086	1.190	.270	1.490	3.040	.552	.577	7.9	60.000	190	
8/06/73	0155	78.0	4.6	910.0											
8/06/73	0555	77.0	3.7	807.0	.061	2.100	.060	.860	3.080	.761	.720	8.0	62.000	20	
8/06/73	1355	79.5	9.1	701.0											
8/06/73	1800	79.5	7.5	600.0	.037	1.320	.030	.800	2.190	.398	.870	8.4	38.000	120	
8/12/74	0145	75.0	8.7	800.0											
8/12/74	0545	71.0	6.9	800.0	.064	2.310	.100	1.600	4.074	.572	.700	8.2	69.000	410	
8/12/74	1400	72.5	8.0	700.0											
8/12/74	1755	75.0	9.6	720.0	.076	2.050	.080	1.330	3.538	.522	.610	8.4	55.000	80	
8/18/75	0200	74.0	9.8	811.0											
8/18/75	0600	71.0	8.0	790.0	.083	2.320	.040	.790	3.230	.911	.390	8.5	101.000	320	
8/18/75	1330	73.0	11.9	837.0											
8/18/75	1735	72.0	10.6	758.0	.062	1.830	.090	1.060	3.050	.879	.780	8.3	86.000	240	
FX-12															
2/06/64		39.0	12.9	492.0								8.0	5.000		100.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-12															
3/19/64		36.0	13.9	394.0								8.3	5.000		100.000
4/22/64		55.0	10.1	440.0								7.9	5.000		100.000
5/20/64		66.0	9.4	390.0								7.9	5.000		500.000
6/25/64		77.0	9.7	404.0								8.0	5.000		400.000
7/29/64			9.3	400.0								8.0			1000.000
8/26/64		68.0	9.8	416.0								8.2	5.000		300.000
9/24/64		59.0	9.7	448.0								8.0	5.000		
10/07/64		51.0	11.9	462.0		.090						8.6	5.000		100.000
11/23/64		35.0	16.5	506.0		.068						8.3	15.000		100.000
12/28/64		37.0	12.6	544.0		.203						7.7	15.000		100.000
1/27/65		35.0	12.2	476.0		.181						7.8	15.000		200.000
2/25/65		35.0	13.0	424.0		.113						7.6	5.000		100.000
10/24/66	1205	48.0	11.3	495.0		.045				.070		8.4	5.000		2300.000
4/17/67	1055	58.0	9.4	435.0	.003	.113				.010		8.2	5.000		5800.000
4/15/68	1330	54.0	9.4	514.0	.009	.120				.038		8.2	6.600	5	
8/12/68	1130	75.0	9.0	406.0	.002	.108				.020		8.0	6.090	20	1100.000
3/31/69	1100	34.0	14.2	520.0	.008	.300				.050		8.4	8.000	10	200.000
8/12/69	0830	80.0	7.7	385.0	.002	.100				.010		8.2	11.000	15	1500.000
7/27/70	0925	80.0	8.4	400.0	.003	.060				.010		8.7	20.000	10	
7/27/70	1320	84.0	9.4	400.0								8.8	8.000		
7/27/70	2110	81.0	7.1	365.0								8.6	8.000		
7/28/70	0055	81.0	6.8	375.0								8.6	8.000		
7/28/70	0455	80.0	6.7	385.0								8.5	7.000		
7/28/70	1730	85.0	8.7	410.0								8.7	7.000		
8/01/71	0035	70.0	8.2	423.0								8.6	8.000		
8/02/71	0420	67.5	8.1	407.0								8.5	9.000		
8/02/71	0840	70.0	8.6	429.0	.001	.090				.010		8.4	10.000	10	
8/02/71	1210	73.5	10.0	438.0								8.5	8.000		
8/02/71	1605	76.0	9.6	424.0								8.6	9.000		
8/02/71	2010	74.0	8.4	424.0								8.6	10.000		
8/07/72	0250	73.0	7.2	445.0	.007	.250	.110	.830	1.200	.009	.040	8.1	10.000	10	
8/07/72	0650	72.0	7.0	464.0											
8/07/72	1420	72.0	9.1	459.0											
8/07/72	1820	71.5	8.3	461.0	.008	.100	.080	.960	1.150		.037	8.1	11.000	10	
8/06/73	0220	78.5	8.5	450.0											
8/06/73	0620	77.0	8.1	392.0	.006	.100	.030	.670	.780	.033	.080	8.3	11.000	60	
8/06/73	1420	78.0	8.6	460.0											
8/06/73	1825	77.5	8.9	393.0	.005	.090	.030	.590	.690	.041	.040	8.6	10.000	30	
8/12/74	0210	74.0	8.0	415.0											
8/12/74	0610	73.0	7.7	420.0	.008	.040	.030	.850	.915	.019	.030	8.0	12.000	50	
8/12/74	1430	74.0	8.1	410.0											
8/12/74	1820	74.5	8.5	430.0	.004	.040	.170	.910	1.126	.007	.030	8.4	11.000	90	
8/18/75	0230	75.0	6.6	424.0											
8/18/75	0630	74.5	6.7	413.0	.004	.060	.040	.520	.630	.010	.020	8.1	14.000	50	
8/18/75	1400	77.0	8.3	428.0											
8/18/75	1800	76.0	7.8	407.0	.004	.040	.030	.560	.640	.007	.010	8.1	14.000	50	
FX-13															
1/22/64		34.0	11.5	504.0	.100							7.7	30.000		100.000
2/06/64		32.0	12.6	724.0								8.2	50.000		10000.000
3/19/64		34.0	12.0	624.0											12000.000
4/23/64		54.0	7.5	760.0								7.7	30.000		5000.000
5/20/64		62.0	7.1	760.0								8.3	45.000		10000.000
6/25/64		76.0	12.2	530.0								7.4	30.000		300.000
7/29/64		80.0	.8	624.0	1.000							7.1	30.000		1000.000
8/26/64		68.0	8.0	700.0	.200							8.0	45.000		3000.000
9/24/64		58.0	8.2	768.0								7.7	55.000		
10/07/64		49.0	14.8	786.0	.100	.746						8.7	55.000		2000.000
11/23/64		34.0	16.5	858.0		.994						8.2	65.000		8000.000
12/28/64		33.0	12.0	818.0	.100	.972						7.7	50.000		22000.000
1/27/65			8.5	824.0	.100	.655						7.5	70.000		4000.000
2/25/65		32.0	4.5	624.0	.100	.610						7.2	45.000		2800.000
10/24/66	1240	47.0	7.8	765.0	.052	.249				1.360		7.8	55.000		9700.000
4/17/67	1025	58.0	9.0	710.0	.018	.294				.450		8.1	35.000		20000.000
4/15/68	1320	52.0	12.2	940.0	.077	1.265				.500		8.2	39.600	100	
8/12/68	1110	71.0	5.1	616.0	.045	.509				.580		7.6	29.230	55	1000.000
3/31/69	1005	33.0	13.0	790.0	.013	.800				.270		8.0	48.000	290	4500.000
8/12/69	0845	77.0	2.3	650.0	.020	.300				.610		7.8	63.000	60	29000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-13															
7/27/70	0940	80.0	8.6	750.0	.064	.800				.010		8.6	66.000	50	
7/27/70	1310	85.0	17.8	745.0								8.9	66.000		
7/27/70	2135	83.0	11.3	670.0								8.8	52.000		
7/28/70	0115	80.0	6.3	650.0								8.6	48.000		
7/28/70	0510	78.0	4.8	665.0								8.4	54.000		
7/28/70	1800	84.0	18.1	800.0								8.8	55.000		
8/01/71	0055	71.0	10.1	786.0								8.8	77.000		
8/02/71	0455	69.0	7.5	777.0								8.6	70.000		
8/02/71	0905	70.5	6.6	770.0	.068	.920				.700		8.4	69.000	1,100	
8/02/71	1245	75.0	10.3	752.0								8.5	60.000		
8/02/71	1635	79.0	15.8	723.0								8.8	64.000		
8/02/71	2040	77.0	15.2	723.0								8.9	69.000		
8/07/72	0235	73.0	6.1	689.0	.065	.790	.150	1.240	2.250	.412	.633	8.0	55.000	120	
8/07/72	0635	70.0	5.1	733.0											
8/07/72	1405	68.0	6.4	770.0											
8/07/72	1810	70.0	8.1	749.0	.068	.990	.100	1.190	2.350	.442	.513	8.0	56.000	310	
8/06/73	0205	78.5	5.1	735.0											
8/06/73	0605	77.5	4.1	641.0	.046	1.090	.030	.870	2.010	.470	.390	8.0	46.000	70	
8/06/73	1410	79.0	6.1	722.0											
8/06/73	1810	78.5	7.0	641.0	.036	.910	.030	.980	1.930	.410	.460	8.1	42.000	140	
8/12/74	0155	72.0	8.4	620.0											
8/12/74	0555	71.0	6.7	620.0	.035	1.240	.070	1.560	2.903	.351	.480	8.1	39.000	220	
8/12/74	1420	73.0	7.7	660.0											
8/12/74	1810	75.5	9.6	690.0	.040	.600	.030	1.220	1.886	.404	.420	7.5	50.000	220	
8/18/75	0215	77.5	11.0	723.0											
8/18/75	0615	73.0	8.4	720.0	.077	1.640	.040	.930	2.690	.560	.220	8.5	81.000	20	
8/18/75	1345	74.0	10.4	733.0											
8/18/75	1745	73.0	11.8	679.0	.055	1.280	.040	.740	2.120	.516	.400	8.5	72.000	50	
FX-14															
1/23/64			15.5												700.000
2/06/64		34.0	15.8	672.0								8.0	35.000		1000.000
3/19/64		34.0	15.9												800.000
4/23/64		54.0	8.0	686.0								7.8	30.000		5900.000
5/20/64		66.0	8.6												900.000
6/25/64		77.0	11.3												400.000
7/29/64		80.0	3.0												1000.000
8/26/64		68.0	10.5												2000.000
9/24/64		59.0	8.9												
10/07/64		49.0	11.4	770.0	.100	.475						8.6	55.000		100.000
11/23/64		35.0	19.0												100.000
12/28/64		33.0	11.0												2000.000
1/28/65		32.0	8.5			.475									9000.000
2/26/65		32.0	3.6			.678									2200.000
10/24/66	1255	48.0	13.6	730.0	.027	.203				1.000		7.9	45.000		4300.000
4/17/67	1010	58.0	8.1	785.0	.015	.316				.460		8.1	35.000		10000.000
4/16/68	0715	49.0	9.8	912.0	.065	.938				.379		8.2	40.500	20	
8/13/68	0845	71.0	8.0	643.0	.036	.331				.510		8.0	31.220	30	1400.000
3/31/69	1015	34.0	14.4	850.0	.017	.800				.160		8.0	46.000	10	200.000
8/12/69	0905	77.0	4.8	610.0	.015	.100				.500		7.9	57.000	900	27000.000
7/28/70	0700	79.0	4.0	730.0	.020	.290				1.230		8.5	60.000	30	
7/28/70	1040	79.0	5.1	750.0								8.6	58.000		
7/28/70	1440	83.0	6.5	745.0								8.8	60.000		
7/28/70	1845	87.5	8.8	695.0								8.5	60.000		
7/28/70	2335	82.0	4.4	710.0								8.5	62.000		
7/29/70	0250	80.0	4.8	700.0								8.5	62.000		
8/02/71	2225	73.0	18.4	735.0								9.1	63.000		
8/03/71	0220	71.5	13.5	742.0								8.9	64.000		
8/03/71	0645	71.5	10.8	762.0	.069	.610				.480		8.9	68.000	10	
8/03/71	1020	73.0	13.2	744.0								8.9	65.000		
8/03/71	1430	75.0	21.2	710.0								9.1	64.000		
8/03/71	1815	77.0	24.3	705.0								9.2	62.000		
8/08/72	0020	69.0	7.1	739.0	.053	.940	.120	2.020	3.130	.541	.500	7.9	53.000	50	
8/08/72	0420	68.0	6.3	741.0											
8/08/72	1230	66.0	7.2	767.0											
8/08/72	1620	66.5	8.1	761.0	.052	1.160	.090	2.340	3.640	.371	.553	8.1	52.000	50	
8/07/73	0001	78.5	7.6	743.0											
8/07/73	0401	76.5	6.2	649.0	.040	.890	.050	.750	1.730	.356	.430	8.1	53.000	10	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-14															
8/07/73	1201	73.0	5.5	727.0											
8/07/73	1601	80.5	8.7	636.0	.035	.940	.110	.880	1.970	.339	.530	8.3	55.000	10	
8/13/74	0001	75.0	6.0	690.0											
8/13/74	0400	73.5	4.4	660.0	.044	1.060	.260	.980	2.350	.321	.360	8.0	44.000	90	
8/13/74	1200	75.0	6.5	670.0											
8/13/74	1600	79.0	9.2	700.0	.039	1.290	.110	1.110	2.551	.333	.360	8.2	46.000	10	
8/19/75	0245	71.5	8.4	700.0											
8/19/75	0645	69.0	7.2	693.0	.065	.900	.030	.840	1.770	.376	.270	8.5	70.000	10	
8/19/75	1400	76.0	12.4	723.0											
8/19/75	1800	77.0	16.6	698.0	.082	.860	.030	.840	1.730	.359	.270	8.8	72.000	10	
FX-15															
4/23/64		52.0	7.9	1,560.0								7.4	35.000		66000.000
5/21/64		59.0	3.6												11000.000
6/26/64		71.0	8.5												70000.000
7/30/64		72.0	3.8												30000.000
8/27/64		67.0	1.4												62000.000
9/25/64		55.0	.8												13000.000
10/08/64		48.0	4.8	884.0		.475						7.4	35.000		17000.000
11/24/64		33.0	14.3												400.000
12/29/64		32.0	3.0												62000.000
1/28/65		32.0	13.9			.452									1400.000
10/25/66	1015	44.0	4.9	640.0	.006	.181				.300		7.6	45.000		17000.000
4/18/67	0850	45.0	9.1	565.0	.003	.294						7.6	20.000		5800.000
4/16/68	0730	48.0	8.0	885.0	.029	.757				.024		7.4	26.200	85	
8/13/68	0915	69.0	3.0	644.0	.019	.361				.060		7.0	25.250	180	2000.000
4/02/69	1240	36.0	12.2	630.0	.018	.600				.040		7.4	17.000	50	7200.000
8/12/69	0945	73.0	4.5	450.0	.034	.400				.060		7.5	31.000	4,700	500000.000
7/28/70	0001	78.0	4.6	585.0								8.2	34.000		
7/28/70	0725	74.0	1.4	600.0	.008	.150				.080		7.6	34.000		
7/28/70	1155	75.0	2.3	620.0								7.8	32.000		
7/28/70	1500	77.0	4.3	620.0								7.9	30.000		
7/28/70	1920	85.0	7.0	540.0								8.4	38.000		
7/29/70	0310	76.5	4.0	580.0								8.0	34.000		
8/02/71	2245	68.0	8.4	731.0								8.6	29.000		
8/03/71	0240	67.5	6.8	730.0								8.4	28.000		
8/03/71	0705	67.5	4.4	746.0	.005	.220				.020		8.2	29.000	30	
8/03/71	1040	64.0	5.4	734.0								8.3	28.000		
8/03/71	1445	71.5	9.1	722.0								8.7	33.000		
8/03/71	1835	70.0	9.6	705.0								8.8	31.000		
8/08/72	0055	66.5	6.2	573.0	.018	.190	.060	3.150	3.420	.062	.073	7.6	45.000	110	
8/08/72	0455	65.5	4.6	619.0											
8/08/72	1245	64.5	4.9	617.0											
8/08/72	1635	65.0	7.2	600.0	.019	.200	.070	3.250	3.540	.044	.080	7.6	45.000	70	
8/07/73	0020	76.0	5.2	565.0											
8/07/73	0420	75.0	3.8	497.0	.030	.270	.090	2.280	2.670	.056	.150	8.1	19.000	40	
8/07/73	1222	76.0	4.2	570.0											
8/07/73	1615	81.0	6.6	481.0	.013	.230	.050	2.620	2.910	.028	.150	8.1	20.000	50	
8/13/74	0020	73.5	4.9	500.0											
8/13/74	0415	73.0	4.0	500.0	.011	.170	.180	2.420	2.783	.035	.160	7.6	35.000	450	
8/13/74	1215	73.0	4.0	500.0											
8/13/74	1615	77.0	7.4	525.0	.008	.200	.120	2.010	2.341	.033	.090	7.9	34.000	180	
8/19/75	0230	68.0	4.6	463.0											
8/19/75	0630	67.5	4.2	472.0	.038	.180	.030	.700	.840	.112	.170	8.3	54.000	1,400	
8/19/75	1345	75.0	10.6	470.0											
8/19/75	1745	76.0	12.4	446.0	.034	.150	.030	1.770	1.880	.092	.130	9.2	56.000	690	
FX-16															
3/19/64		37.0	12.5												1700.000
4/23/64		54.0	9.2	1,120.0								7.5	30.000		200.000
5/21/64		68.0	11.2												100.000
6/26/64		76.0	9.8												1000.000
7/30/64		75.0	4.1												7000.000
8/27/64		69.0	9.1												100.000
9/25/64		57.0	7.0												2000.000
10/08/64		50.0	10.1	700.0		.294						8.4	35.000		200.000
11/24/64		34.0	15.4												100.000
12/29/64		32.0	16.0												300.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-16															
1/28/65		32.0	8.2			.814									7000.000
10/25/66	1040	47.0	11.8	715.0		.045				.100		8.7	30.000		6300.000
4/18/67	0910	49.0	9.0	745.0	.012	.723				.060		7.8	20.000		8400.000
4/16/68	0900	51.0	9.8	1,014.0	.044	.850				.043		8.2	30.600	5	
8/13/68	0930	71.0	5.5	119.0	.055	1.445				.080		7.6	13.560	500	8000.000
4/01/69	1315	37.0	13.4	795.0	.019	1.900				.050		7.8	34.000	250	9100.000
8/12/69	1005	70.0	3.4	620.0	.074	1.500				.190		7.5	35.000	60,000	100000.000
7/28/70	0025	81.0	6.8	735.0								8.3	35.000		
7/28/70	0800	78.0	4.4	770.0	.008	.180				.270		8.1	34.000	30	
7/28/70	1110	78.0	5.6	790.0								8.3	33.000		
7/28/70	1530	78.0	3.0	600.0								7.2	48.000		
7/28/70	1935	84.0	1.6	640.0								7.3	54.000		
7/29/70	0325	80.5	5.9	735.0								8.3	35.000		
8/02/71	2305	73.0	11.1	685.0								8.8	45.000		
8/03/71	0300	70.5	9.9	701.0								8.8	43.000		
8/03/71	0730	72.0	7.5	699.0	.016	.210				.170		8.7	45.000	30	
8/03/71	1055	73.5	7.7	708.0								8.6	43.000		
8/03/71	1505	74.5	8.6	691.0								8.5	45.000		
8/03/71	1855	75.0	9.3	681.0								8.6	46.000		
8/08/72	0100	66.0	4.5	802.0	.066	2.400	.210	3.100	5.780	.204	.200	7.3	41.000	1,900	
8/08/72	0500	65.0	4.5	840.0											
8/08/72	1300	65.0	5.0	840.0											
8/08/72	1650	64.0	5.5	842.0	.081	2.570	.180	3.200	6.030	.110	.200	7.5	40.000	2,600	
8/07/73	0035	76.0	6.2	774.0											
8/07/73	0435	76.0	5.6	713.0	.021	.040	.040	1.310	1.410	.158	.240	7.8	32.000	80	
8/07/73	1230	79.5	5.3	782.0											
8/07/73	1630	80.5	7.1	692.0	.011	.480		1.360	1.850	.134	.210	8.3	34.000	60	
8/13/74	0035	75.0	6.4	680.0											
8/13/74	0430	75.0	5.7	670.0	.016	.140	.200	1.580	1.935	.139	.200	8.0	30.000	240	
8/13/74	1230	76.0	6.5	700.0											
8/13/74	1630	78.5	8.2	720.0	.015	.160	.120	1.620	1.909	.138	.210	8.2	30.000	30	
8/19/75	0215	73.0	5.0	591.0											
8/19/75	0615	72.0	4.5	601.0	.011	.190	.030	.980	1.110	.161	.170	8.3	52.000	70	
8/19/75	1330	76.0	8.0	591.0											
8/19/75	1730	76.0	7.8	602.0	.013	.190	.030	.920	1.050	.112	.090	8.3	50.000	30	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-17															
1/23/64		35.0	12.1	780.0								8.3	40.000		4100.000
2/06/64		40.0	17.3	722.0								7.9	50.000		2800.000
3/19/64		36.0	16.1	500.0								8.2	35.000		4000.000
4/23/64		54.0	14.1	640.0								7.6	30.000		9000.000
5/20/64		66.0	8.2	716.0								8.3	30.000		6000.000
6/25/64		76.0	9.6												2400.000
7/29/64		80.0	11.3	580.0								7.6	20.000		8000.000
8/26/64		67.0	10.8	650.0								8.4	35.000		10000.000
9/24/64		59.0	8.9	658.0								7.8	45.000		
10/07/64		50.0	11.7	698.0		.249						8.6	50.000		8000.000
11/23/64		34.0	13.4	778.0		.475						8.0	65.000		3100.000
12/28/64		33.0	13.4	930.0		.791						7.9	55.000		7000.000
1/28/65		32.0	14.0	846.0		.678						7.9	45.000		14000.000
2/26/65		32.0	8.8	582.0	.100	.497						7.2	35.000		4000.000
10/24/66	1325	51.0	13.9	715.0		.068				.490		8.0	50.000		14000.000
4/17/67	0930	56.0	11.5	680.0	.003	.158				.170		8.8	30.000		17600.000
4/16/68	0915	53.0	13.0	805.0	.020	.238				.273		9.0	38.300	400	
8/13/68	0955	74.0	9.7	650.0	.020	.376				.310		8.2	30.720	2,200	190000.000
4/01/69	1300	38.0	16.0	800.0	.017	.900				.170		8.5	45.000	80	2400.000
8/12/69	1030	78.0	5.0	700.0	.338	1.700				2.510		7.7	67.000	420,000	2800000.000
7/28/70	0810	79.0	4.6	700.0	.012	.210				1.330		8.3	51.000	590	
7/28/70	1135	82.0	11.0	720.0								8.7	52.000		
7/28/70	1545	83.0	11.0	885.0								8.3	72.000		
7/28/70	1945	83.0	7.0	830.0								8.3	74.000		
7/29/70	0045	79.0	3.7	700.0								8.4	54.000		
7/29/70	0345	76.0	2.3	720.0								8.2	52.000		
8/02/71	2320	71.5	7.1	719.0								8.9	55.000		
8/03/71	0315	70.0	4.8	716.0								8.8	56.000		
8/03/71	0800	69.0	4.8	796.0	.021	.170				1.790		8.4	69.000	1,200	
8/03/71	1110	73.0	11.5	710.0								8.9	53.000		
8/03/71	1515	81.0	12.5	946.0								8.6	109.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-17															
8/03/71	1905	75.0	10.0	990.0								8.6	111.000		
8/08/72	0115	68.5	6.1	735.0	.046	1.460	.360	2.750	4.620	.341	.513	7.8	45.000	300	
8/08/72	0515	67.5	5.5	776.0											
8/08/72	1315	67.0	8.5	754.0											
8/08/72	1705	66.5	8.9	749.0	.079	1.860	.140	2.870	4.950	.273	.523	8.1	50.000	700	
8/07/73	0050	77.0	7.8	707.0											
8/07/73	0450	77.0	5.6	600.0	.015	.280	.160	1.120	1.580	.319	.410	8.3	44.000	20	
8/07/73	1240	81.0	8.7	698.0											
8/07/73	1640	82.5	11.2	595.0	.016	.150		1.050	1.220	.114	.140	8.7	49.000	10	
8/13/74	0050	74.5	5.7	640.0											
8/13/74	0445	75.0	5.0	630.0	.084	.380	.380	1.730	2.570	.225	.450	8.0	41.000	310	
8/13/74	1240	76.5	8.6	660.0											
8/13/74	1640	80.5	11.0	700.0	.067	.360	.250	1.840	2.506	.250	.380	8.4	43.000	160	
8/19/75	0205	71.0	4.1	594.0											
8/19/75	0605	69.5	4.2	597.0	.011	.210	.030	1.160	1.320	.174	.230	8.3	57.000	50	
8/19/75	1320	75.0	14.2	584.0											
8/19/75	1720	79.0	15.8	595.0	.013	.080	.030	1.090	1.100	.132	.120	9.2	59.000	120	
FX-18															
4/23/64		50.0	12.6	486.0								8.3	5.000		21000.000
5/21/64		62.0	11.9												10000.000
6/26/64		76.0	9.6												6000.000
7/30/64		72.0	5.9												6000.000
8/27/64		69.0	9.4												2000.000
9/25/64		54.0	10.3												61000.000
10/08/64		50.0	11.8	766.0	.300	1.537						8.0	55.000		83000.000
11/24/64		34.0	12.8												85000.000
12/29/64		33.0	9.4												52000.000
1/29/65		32.0	6.2			.768									310000.000
2/26/65		32.0	6.8			.316									570000.000
10/25/66	1305	46.0	14.4	770.0	.058	.497				1.630		8.2	35.000		60000.000
4/18/67	1125	45.0	14.7	460.0	.003	.203				.140		8.6	5.000		84000.000
4/16/68	1030	49.0	10.0	800.0	.053	1.000				.581		8.2	17.200	17,000	
8/14/68	1045	69.0	5.9	610.0	.055	.482				.330		7.8	38.480	1,600	110000.000
4/01/69	1055	39.0	13.3	525.0	.010	.300				.160		8.3	14.000	520	49000.000
8/12/69	1120	77.0	7.6	640.0	.217	1.800				1.440		8.0	38.000	200	22000.000
7/29/70	0900	75.0	5.9	680.0	.250	1.400				1.130		7.9	37.000	320	
7/29/70	1230	77.0	9.7	690.0								8.1	42.000		
7/29/70	1630	82.0	13.6	675.0								8.5	47.000		
7/29/70	2020	79.0	9.3	655.0								8.6	45.000		
7/30/70	0015	77.0	6.8	625.0								8.5	37.000		
7/30/70	0350	73.5	5.2	500.0								8.1	31.000		
8/04/71	2305	64.0	9.0	786.0								8.4	46.000		
8/05/71	0310	63.0	8.3	730.0								8.4	49.000		
8/05/71	0650	61.0	7.1	825.0	.061	2.370				.910		8.2	50.000	210	
8/05/71	1040	65.0	10.4	840.0								8.4	56.000		
8/05/71	1500	71.0	17.0	809.0								8.7	54.000		
8/05/71	1900	70.5	13.6	842.0								8.6	55.000		
8/10/72	0050	67.0	6.1	487.0											
8/10/72	0450	65.5	5.8	595.0	.041	.480	.300	1.050	1.870	.261	.367	7.7	53.000	120	
8/10/72	1245	69.0	9.5	476.0											
8/10/72	1645	73.0	10.5	488.0	.028	.590	.160	1.040	1.820	.329	.293	8.4	25.000	10	
8/09/73	0050	77.0	3.6	570.0											
8/09/73	0450	75.0	3.4	467.0	.076	1.000	.100	.560	1.740	.330	.340	7.7	21.000	440	
8/09/73	1255	77.0	7.3	529.0											
8/09/73	1650	82.5	9.2	594.0	.025	.930		.590	1.550	.283	.310	8.1	25.000	4,800	
8/15/74	0055	70.0	6.9	530.0											
8/15/74	0455	68.0	4.4	575.0	.238	1.950	.320	.940	3.457	.324	.330	7.9	32.000	330	
8/15/74	1300	72.0	9.7	650.0											
8/15/74	1655	76.5	12.5	610.0	.078	1.290	.090	.950	2.411	.351	.570	8.6	40.000	190	
8/21/75	0030	69.0	3.3	422.0											
8/21/75	0430	69.5	3.3	459.0	.040	.620	.170	.540	1.370	.498	.430	7.7	35.000	2,200	
8/21/75	1120	75.0	7.5	560.0											
8/21/75	1520	79.0	10.0	560.0	.072	.840	.060	.470	1.440	.536	.540	8.1	36.000	500	
FX-19															
4/23/64		51.0	11.3	616.0								7.9	5.000		6700.000
5/21/64		66.0	12.3												5100.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-19															
6/26/64		77.0	7.2												21000.000
7/30/64		70.0	7.0												2000.000
8/27/64		67.0	4.8												7000.000
9/25/64		52.0	5.4												17000.000
10/08/64		50.0	5.3	654.0		.407						7.4	15.000		16000.000
11/24/64		35.0	9.9												3000.000
12/29/64		33.0	9.3												300.000
1/29/65		32.0	8.3			.542									1100.000
2/26/65		33.0	10.3			.542									500.000
10/25/66	1325	42.0	9.1	770.0	.003	.090				.170		7.8	15.000		19000.000
4/18/67	1140	45.0	12.9	705.0	.003	.271				.010		7.8	15.000		3400.000
4/16/68	1045	49.0	12.8	962.0	.013	.757				.012		8.0	16.600	10	
8/14/68	1100	71.0	5.5	523.0	.026	.271				.040		7.8	16.440	290	17000.000
4/01/69	1040	33.0	13.6	570.0	.008	.400				.020		8.2	15.000	10	700.000
8/12/69	1155	80.0	5.3	440.0	.018	.300				.080		8.1	17.000	300	13000.000
7/29/70	0000	77.0	3.5	490.0								8.1	17.000		
7/29/70	0845	76.0	4.7	505.0	.027	.350				.070		7.9	12.000	1,700	
7/29/70	1215	80.0	6.9	510.0								8.0	16.000		
7/29/70	1615	84.0	7.9	465.0								8.5	16.000		
7/29/70	2010	80.0	5.8	470.0								8.4	15.000		
7/30/70	0340	72.0	5.5	485.0								8.0	16.000		
8/04/71	2320	65.0	5.9	547.0								8.1	18.000		
8/05/71	0330	62.5	4.3	540.0								7.8	18.000		
8/05/71	0705	61.0	4.4	540.0	.016	.410				.050		7.7	17.000	500	
8/05/71	1100	65.0	6.6	547.0								7.9	18.000		
8/05/71	1515	73.5	10.8	533.0								8.4	18.000		
8/05/71	1915	72.5	6.4	526.0								8.4	18.000		
8/10/72	0100	65.0	6.6	528.0											
8/10/72	0500	63.0	6.3	538.0	.015	.520	.130	.120	.780	.039	.053	8.0	19.000	320	
8/10/72	1250	65.5	8.4	565.0											
8/10/72	1700	71.0	9.0	534.0	.007	.460	.110	1.300	1.880	.032	.070	8.3	20.000	80	
8/09/73	0100	77.0	2.7	533.0											
8/09/73	0500	76.0	2.6	463.0	.047	.430	.190	.960	1.630	.127	.210	7.7	21.000	130	
8/09/73	1325	76.0	5.0	617.0											
8/09/73	1700	80.0	5.7	558.0	.041	.470	.130	1.050	1.690	.123	.230	7.8	27.000	1,700	
8/15/74	0105	69.0	4.6	950.0											
8/15/74	0505	65.5	4.2	500.0	.022	.590	.160	1.180	1.952	.069	.120	7.8	24.000	2,600	
8/15/74	1310	72.0	9.1	540.0											
8/15/74	1705	78.5	10.0	550.0	.010	.300	.070	.960	1.333	.056	.100	8.3	21.000	1,200	
8/21/75	0020	67.0	4.6	612.0											
8/21/75	0420	69.0	4.9	680.0	.018	.370	.030	.790	1.170	.192	.200	7.9	36.000	5,400	
8/21/75	1130	71.0	5.9	676.0											
8/21/75	1530	74.0	6.9	666.0	.017	.390	.030	.570	.990	.113	.140	8.0	37.000	1,000	
FX-20															
2/06/64		34.0	13.3	640.0								8.0	30.000		400.000
3/19/64		37.0	14.1												1300.000
4/23/64		51.0	9.5	564.0								8.0	15.000		4100.000
5/21/64		62.0	8.4	490.0								7.4	15.000		3800.000
6/26/64		77.0	5.6												20000.000
7/30/64		74.0	5.7												9000.000
8/27/64		68.0	8.3												10000.000
9/25/64		52.0	10.6												3000.000
10/08/64		50.0	12.5	640.0		.203						8.8	35.000		2000.000
11/24/64		37.0	14.1												400.000
12/29/64		33.0	11.7												1800.000
1/29/65		32.0	9.1			.814									2900.000
10/25/66	1110	44.0	10.9	680.0	.006	.181				.370		8.6	20.000		21000.000
4/18/67	0935	44.0	11.3	515.0	.003	.249				.060		8.3	15.000		20200.000
4/16/68	0945	50.0	9.0	795.0	.022	.722				.101		8.2	14.000	180	
8/13/68	1015	69.0	7.5	588.0	.015	.542				.120		8.0	11.820	1,100	14000.000
4/01/69	1235	38.0	14.2	620.0	.013	.800				.130		8.3	15.000	40	8000.000
8/12/69	1100	77.0	7.4	580.0	.022	.900				.110		8.2	21.000	1,200	13000.000
7/28/70	0820	75.0	4.9	590.0	.025	.600				.300		8.2	16.000	2,500	
7/28/70	1150	78.0	6.9	635.0								8.2	19.000		
7/28/70	1605	83.0	10.9	600.0								8.2	19.000		
7/28/70	2000	86.0	14.2	565.0								8.6	19.000		
7/29/70	0100	81.0	7.1	565.0								8.4	23.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-20															
7/29/70	0400	78.0	5.3	575.0								8.3	23.000		
8/02/71	2330	72.0	8.0	650.0								8.6	26.000		
8/03/71	0325	71.0	6.6	647.0								8.6	30.000		
8/03/71	0815	70.0	5.9	651.0	.027	.980				.230		8.5	28.000	1,900	
8/03/71	1125	71.5	7.3	650.0								8.5	26.000		
8/03/71	1530	75.0	11.0	631.0								8.5	27.000		
8/03/71	1920	75.0	11.6	642.0								8.6	27.000		
8/08/72	0130	66.5	7.5	562.0	.007	.930	.080	2.100	3.120	.127	.180	7.9	18.000	500	
8/08/72	0530	65.0	7.5	624.0											
8/08/72	1325	64.5	7.8	605.0											
8/08/72	1720	65.0	8.1	588.0	.009	1.040	.050	1.420	2.520	.129	.180	8.1	17.000	460	
8/07/73	0105	77.0	7.0	601.0											
8/07/73	0505	74.0	6.4	542.0	.022	1.290	.070	.720	2.100	.169	.220	8.3	21.000	480	
8/07/73	1300	77.0	7.3	596.0											
8/07/73	1655	81.0	8.4	528.0	.018	1.120	.030	.600	1.770	.143	.190	8.4	21.000	10	
8/13/74	0100	73.5	7.3	575.0											
8/13/74	0455	72.0	6.3	560.0	.025	1.590	.090	1.090	2.793	.140	.170	8.1	20.000	1,700	
8/13/74	1300	75.0	9.4	610.0											
8/13/74	1700	79.0	11.3	640.0	.025	1.520	.110	1.030	2.683	.112	.150	8.4	26.000	40	
8/19/75	0145	69.0	7.1	576.0											
8/19/75	0545	67.5	7.0	578.0	.029	1.130	.030	.500	1.610	.237	.250	8.5	30.000	890	
8/19/75	1300	71.0	8.3	599.0											
8/19/75	1700	75.0	10.5	601.0	.027	.910	.030	.380	1.250	.224	.250	8.6	31.000	180	
FX-21															
4/24/64		50.0	10.4	784.0								8.0	15.000		34000.000
5/21/64		61.0	7.8												2100.000
6/26/64		76.0	5.2												23000.000
7/30/64		72.0	5.5												8000.000
8/27/64		73.0	12.9												1000.000
9/25/64		52.0	10.4												15000.000
10/08/64		50.0	10.3	630.0		.949						8.0	15.000		3200.000
11/24/64		34.0	14.0												28000.000
12/29/64		33.0	12.2												20000.000
1/29/65		32.0	12.7			1.017									40000.000
2/26/65		32.0	11.1			1.311									9000.000
10/25/66	1415	45.0	11.9	635.0	.009	.362				.490		8.4	5.000		28000.000
4/18/67	1245	48.0	14.0	705.0	.012	.497				.130		8.4	15.000		12900.000
4/16/68	0830	49.0	8.9	848.0	.063	1.763				.125		8.0	10.300	1,800	
8/12/68	1200	71.0	7.4	612.0	.023	.876				.170		8.0	11.070	1,100	8000.000
3/31/69	1045	34.0	15.6	790.0	.032	1.600				.120		8.4	13.000	60	1500.000
8/12/69	1215	84.0	10.1	650.0	.062	2.600				.140		8.0	17.000	3,100	5300.000
7/29/70	0955	79.0	4.0	580.0	.078	1.700				.260		7.8	5.000	3,500	
7/29/70	1330	82.0	4.0	560.0								7.8	8.000		
7/29/70	1725	84.0	8.0	545.0								8.1	8.000		
7/29/70	2110	80.0	2.8	585.0								7.7	10.000		
7/30/70	0130	77.0	5.1	540.0								7.8	10.000		
7/30/70	0530	76.0	5.1	525.0								7.8	12.000		
8/02/71	2200	72.5	8.2	677.0								8.0	16.000		
8/03/71	0200	70.5	6.1	727.0								7.6	15.000		
8/03/71	0610	69.5	4.9	691.0	.135	5.520				.230		7.8	15.000	3,000	
8/03/71	1000	70.0	7.5	658.0								8.0	12.000		
8/03/71	1400	75.0	11.2	631.0								8.3	12.000		
8/03/71	1755	76.0	10.8	607.0								8.3	13.000		
8/08/72	0001	67.0	6.7	696.0	.053	2.150	.340	1.340	3.880	.317	.330	8.0	14.000	100	
8/08/72	0400	66.0	6.4	696.0											
8/08/72	1210	66.0	6.9	708.0											
8/08/72	1600	66.0	7.5	696.0	.067	2.170	.240	1.340	3.820	.147	.230	8.1	13.000	480	
8/07/73	0235	75.0	5.3	683.0											
8/07/73	0635	74.0	5.5	608.0	.063	3.240	.260	1.010	4.570	.165	.350	8.0	15.000	5,100	
8/07/73	1450	80.0	8.0	679.0											
8/07/73	1840	79.0	7.0	592.0	.046	2.930	.160	.730	3.870	.132	.190	8.3	17.000	1,300	
8/13/74	0235	71.0	6.2	530.0											
8/13/74	0635	70.0	6.4	530.0	.037	3.220	.120	1.360	4.746	.092	.190	7.9	11.000	3,300	
8/13/74	1445	74.0	7.0	540.0											
8/13/74	1830	74.5	6.8	525.0	.040	2.370	.170	1.340	3.920	.113	.200	8.0	12.000	7,100	
8/19/75	0001	70.0	6.2	578.0											
8/19/75	0401	67.5	6.2	593.0	.052	2.600	.030	.630	3.300	.189	.160	8.0	16.000	1,100	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-21															
8/19/75	1130	72.0	8.4	589.0											
8/19/75	1530	75.0	10.3	583.0	.041	2.140	.030	.650	2.770	.125	.130	8.4	16.000		
FX-22															
4/24/64		50.0	12.1	694.0								8.4	30.000		1800.000
5/21/64		59.0	9.7												1200.000
6/26/64		71.0	8.5												13000.000
7/30/64		68.0	8.9												5000.000
8/27/64		68.0	11.8												1400.000
9/25/64		52.0	10.3												6000.000
10/08/64		50.0	10.4	636.0		.407						8.0	20.000		1800.000
11/24/64		35.0	13.9												800.000
12/29/64		33.0	12.9												100.000
2/26/65		32.0	10.8			.814									100.000
10/25/66	1355	46.0	12.4	695.0	.006	.158				.120		8.0	5.000		6600.000
4/18/67	1215	48.0	13.5	730.0	.006	.610				.090		8.4	20.000		11200.000
4/16/68	1310	55.0	13.3	812.0	.014	.944				.024		8.4	21.200	20	
8/14/68	1145	67.0	10.8	754.0	.017	.572				.059		8.2	19.950	480	10000.000
4/01/69	0905	37.0	14.4	825.0	.010	1.800				.040		8.2	33.000	10	500.000
8/13/69	0830	65.0	6.9	700.0	.019	1.200				.030		8.1	20.000	400	29000.000
7/29/70	1015	71.0	5.1	625.0	.062	1.100				.150		7.9	29.000	100,000	
7/29/70	1345	76.0	8.5	655.0								8.1	32.000		
7/29/70	1745	75.0	8.3	670.0								8.3	29.000		
7/29/70	2130	72.0	6.8	700.0								8.2	30.000		
7/30/70	0155	70.0	6.4	670.0								8.0	30.000		
7/30/70	0500	69.5	6.5	610.0								7.9	27.000		
8/04/71	2200	61.0	7.9	763.0								8.2	15.000		
8/05/71	0200	59.0	7.7	785.0								8.2	15.000		
8/05/71	0545	57.0	7.9	757.0	.012	2.300				.040		8.1	13.000	350	
8/05/71	0945	59.0	9.8	750.0								8.2	14.000		
8/05/71	1400	68.5	13.0	729.0								8.4	14.000		
8/05/71	1800	67.5	10.8	728.0								8.4	14.000		
8/10/72	0001	64.0	7.9	744.0											
8/10/72	0400	61.0	8.0	755.0	.021	2.570	.100	1.030	3.720	.110	.127	8.2	27.000	230	
8/10/72	1200	61.5	9.3	797.0											
8/10/72	1600	66.5	9.4	761.0	.020	2.440	.070	.980	3.510	.105	.107	8.3	28.000	40	
8/09/73	0001	70.0	6.5	758.0											
8/09/73	0400	69.0	6.4	673.0	.074	3.390	.030	.490	3.950	.123	.100	7.9	16.000	460	
8/09/73	1205	68.5	7.2	675.0											
8/09/73	1600	74.0	5.6	583.0	.106	2.840		1.110	4.060	.257	.400	7.7	34.000	2,700	
8/15/74	0001	63.5	7.5	610.0											
8/15/74	0400	62.0	7.5	600.0	.135	3.190	1.040	1.620	5.991	.238	.390	7.8	13.000	920	
8/15/74	1200	64.0	11.6	650.0											
8/15/74	1600	69.5	12.5	660.0	.026	3.410	.040	.740	4.220	.049	.080	8.3	13.000	250	
8/21/75	0055	63.0	7.1	619.0											
8/21/75	0455	63.5	6.9	625.0	.039	1.930	.030	.300	2.230	.038	.090	8.1	19.000	630	
8/21/75	1245	70.0	11.5	619.0											
8/21/75	1645	74.0	12.3	629.0	.043	1.400	.030	.340	1.700	.037	.040	8.3	18.000	430	
FX-23															
2/06/64		34.0	14.3	588.0								8.3	15.000		100.000
3/19/64		41.0	14.5	664.0											100.000
4/23/64		53.0	8.6	656.0								8.0	15.000		400.000
5/21/64		64.0	7.9	620.0								8.0	15.000		1200.000
6/26/64		77.0	4.8												3000.000
7/30/64		74.0	5.4												7000.000
8/27/64		68.0	7.7												2000.000
9/25/64		55.0	10.2												3000.000
10/08/64		51.0	12.1	542.0		.407						8.0	15.000		3000.000
11/24/64		35.0	13.3												100.000
12/29/64		33.0	12.6												200.000
1/29/65		32.0	9.7			.859									3600.000
10/25/66	1125	45.0	9.6	645.0	.006	.294				.120		7.9	5.000		5500.000
4/18/67	0950	45.0	10.9	695.0	.006	.497				.050		8.2	5.000		13200.000
4/16/68	1000	52.0	8.7	785.0	.023	1.575				.014		8.2	11.400	600	
8/13/68	1030	71.0	7.3	681.0	.022	1.174				.090		8.0	12.310	230	4000.000
4/01/69	1245	38.0	13.2	800.0	.018	1.700				.040		8.3	18.000	10	200.000
8/12/69	1050	79.0	6.0	620.0	.034	1.300				.060		8.1	17.000	160	88000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-23															
7/28/70	0830	75.0	4.8	645.0	.060	1.400				.300		7.9	14.000	500	
7/28/70	1200	77.0	6.7	675.0								8.1	12.000		
7/28/70	1620	81.0	8.5	660.0								8.0	12.000		
7/28/70	2005	82.0	8.1	630.0								8.1	12.000		
7/29/70	0105	78.0	5.7	635.0								8.1	12.000		
7/29/70	0410	77.0	4.9	600.0								8.0	12.000		
8/02/71	2345	69.0	7.5	627.0								8.2	14.000		
8/03/71	0340	69.0		644.0								8.1	13.000		
8/03/71	0825	68.5	5.7	633.0	.032	1.920				.090		8.1	16.000	310	
8/03/71	1135	71.5	6.3	619.0								8.1	13.000		
8/03/71	1545	74.5	9.1	619.0								8.2	16.000		
8/03/71	1935	73.5	8.7	654.0								8.2	16.000		
8/08/72	0140	65.0	6.7	660.0	.048	2.330	.110	1.490	3.980	.194	.197	7.9	16.000	300	
8/08/72	0540	64.0	7.0	732.0											
8/08/72	1335	65.0	7.6	708.0						.084					
8/08/72	1730	64.0	7.9	683.0	.050	2.070	.090	2.280	4.490		.220	8.0	16.000	700	
8/07/73	0115	74.5	6.2	696.0											
8/07/73	0515	73.0	6.4	649.0	.037	2.790	.030	1.000	3.830	.104	.220	8.1	18.000	360	
8/07/73	1310	78.0	8.1	701.0											
8/07/73	1705	79.5	8.8	624.0	.032	2.560	.030	.810	3.400	.071	.130	8.3	18.000	480	
8/13/74	0110	71.0	6.3	590.0											
8/13/74	0505	70.0	6.3	580.0	.040	2.950	.150	1.140	4.283	.128	.120	7.9	13.000	1,500	
8/13/74	1305	74.0	7.8	600.0											
8/13/74	1705	75.5	8.2	610.0	.037	3.450	.150	1.140	4.771	.061	.210	8.1	12.000	410	
8/19/75	0155	68.0	6.0	578.0											
8/19/75	0555	67.0	5.3	585.0	.040	.233	.030	.700	3.010	.152	.230	8.2	16.000	470	
8/19/75	1310	73.0	7.7	581.0											
8/19/75	1710	74.0	10.5	586.0	.035	1.970	.030	.850	2.780	.081	.110	8.3	16.000	310	
FX-24															
1/23/64		35.0	13.1	590.0								8.0	35.000		49000.000
2/06/64		34.0	15.5	680.0								8.2	35.000		14000.000
3/19/64		38.0	13.9	570.0								8.1	20.000		11000.000
4/23/64		53.0	11.0	696.0								7.6	15.000		5000.000
5/20/64		64.0	6.1												11000.000
6/25/64		76.0	7.3	634.0								7.6	30.000		30000.000
7/29/64		80.0	6.7	580.0	.100							7.4	30.000		17000.000
8/26/64		69.0	9.5	624.0								8.6	30.000		50000.000
9/24/64		60.0	8.5	634.0								7.8	20.000		
10/07/64		49.0	12.6	676.0		.339						8.6	45.000		12000.000
11/23/64		34.0	14.3	746.0		.475						8.1	45.000		23000.000
12/28/64		33.0	14.0	860.0		.814						7.9	50.000		30000.000
1/28/65		32.0	13.4	716.0		.610						7.7	35.000		29000.000
2/26/65		32.0	10.7	594.0	.100	.475						7.2	35.000		10000.000
10/24/66	1355	50.0	11.1	700.0	.006	.022				.490		7.9	30.000		24000.000
4/17/67	0905	58.0	8.7	680.0	.006	.361				.090		8.4	20.000		197000.000
4/17/68	0830	53.0	7.1	715.0	.014	.512				.182		8.4	27.000	3,300	
8/13/68	1100	74.0	8.0	624.0	.020	.614				.210		8.2	14.800	8,400	190000.000
4/01/69	1215	36.0	13.9	800.0	.017	1.100				.150		8.4	38.000	800	29000.000
8/13/69	1215	75.0	6.5	615.0	.018	.300				.390		8.1	37.000	15,000	340000.000
7/28/70	0915	75.0	4.2	800.0	.029	.450				.900		8.3	35.000	1,200	
7/28/70	1230	81.0	8.5	670.0								8.5	34.000		
7/28/70	1655	85.0	17.0	665.0								8.6	36.000		
7/28/70	2020	86.0	14.4	625.0								8.6	36.000		
7/29/70	0120	81.0	7.0	620.0								8.5	32.000		
7/29/70	0425	79.5	4.8	655.0								8.4	34.000		
8/02/71	0005	74.0	10.4	662.0								8.8	37.000		
8/03/71	0400	73.0	6.5	691.0								8.6	39.000		
8/03/71	0840	66.5	5.8	693.0	.027	.690				.350		8.6	38.000	2,200	
8/03/71	1200	73.0	10.3	681.0								8.8	37.000		
8/03/71	1600	76.5	26.8	626.0								9.0	38.000		
8/03/71	1955	75.0	16.0	1,384.0								8.9	41.000		
8/08/72	0200	68.0	6.8	673.0	.050	1.480	.130	2.250	3.910	.294	.363	7.9	33.000	440	
8/08/72	0600	67.0	6.7	754.0											
8/08/72	1355	66.5	7.3	702.0											
8/08/72	1750	66.0	8.1	684.0	.043	1.520	.110	2.690	4.360	.192	.300	8.1	30.000	330	
8/07/73	0130	79.0	7.4	701.0											
8/07/73	0530	77.0	6.5	610.0	.022	1.250	.060	1.030	2.360	.198	.330	8.4	38.000	160	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-24															
8/07/73	1325	78.5	8.8	711.0											
8/07/73	1730	82.0	11.4	634.0	.029	.400		.960	1.390	.157	.380	8.6	52.000	50	
8/13/74	0125	74.0	6.5	625.0											
8/13/74	0520	73.5	5.9	610.0	.043	1.470	.150	1.310	2.969	.207	.320	8.0	28.000	850	
8/13/74	1325	76.5	7.9	640.0											
8/13/74	1725	78.5	10.5	660.0	.032	1.260	.190	1.740	3.229	.156	.290	8.3	29.000	550	
8/19/75	0125	72.0	8.0	589.0											
8/19/75	0525	70.5	6.6	587.0	.026	.560	.030	.950	1.450	.141	.150	8.6	43.000	900	
8/19/75	1240	73.0	10.2	563.0											
8/19/75	1640	77.0	15.9	566.0	.027	.290	.030	1.040	1.280	.106	.110	8.9	42.000	60	
FX-25															
4/23/64		52.0	15.8	660.0								8.0	20.000		2300.000
5/21/64		68.0	12.8												14000.000
6/26/64		71.0	7.6												250000.000
7/30/64		66.0	4.1												54000.000
8/27/64		65.0	3.3												22000.000
9/25/64		53.0	4.5												60000.000
10/08/64		50.0	5.3	966.0	.300	1.582						7.8	90.000		7000.000
11/24/64		33.0	10.7												52000.000
12/29/64		33.0	7.7												24000.000
1/28/65		32.0	7.3			.339									120000.000
2/26/65		32.0	7.4			.203									230000.000
10/25/66	1210	43.0	10.0	835.0	.033	.452				2.600		7.9	50.000		96000.000
4/18/67	1035	47.0	14.5	715.0	.024	.475				1.430		8.4	30.000		18000.000
4/17/68	0850	49.0	6.0	735.0	.096	.843				1.054		7.6	27.300	4,300	
8/13/68	1130	69.0	3.4	1,053.0	.402	.376				2.720		7.8	79.480	30,000	400000.000
4/01/69	1130	40.0	12.2	960.0	.033	.900				1.250		8.1	64.000	30,000	449999.872
8/13/69	1045	70.0	4.5	540.0	.041	.200				1.880		7.7	39.000	23,000	600000.000
7/28/70	0945	72.0	1.5	885.0	.015	.290				7.270		7.8	44.000	6,400	
7/28/70	1315	76.0	1.8	1,090.0								7.8	46.000		
7/28/70	1740	80.0	1.6	1,430.0								7.8	190.000		
7/28/70	2105	76.0	1.2	1,100.0								7.7	124.000		
7/29/70	0200	82.0	4.7	650.0								8.3	36.000		
7/29/70	0500	82.0	4.3	650.0								8.3	78.000		
8/02/71	0035	66.0	1.7	1,102.0								7.8	80.000		
8/03/71	0430	65.0	2.1	1,016.0								7.8	55.000		
8/03/71	0900	65.0	2.8	886.0	.090	.580				4.400		7.9	55.000	100,000	
8/03/71	1225	67.0	3.3	918.0								7.9	47.000		
8/03/71	1625	70.0	3.1	1,516.0								7.8	177.000		
8/03/71	2020	67.5	2.6	878.0								8.6	200.000		
8/08/72	0220	63.0	6.0	825.0	.103	.810	3.090	3.470	7.470	2.322	2.347	7.8	51.000	240,000	
8/08/72	0620	62.0	6.5	914.0											
8/08/72	1420	67.0	7.4	916.0											
8/08/72	1810	64.0	6.8	988.0	.170	.880	5.830	6.880	13.760	1.889	2.130	7.9	39.000	260,000	
8/07/73	0205	71.0	6.3	915.0											
8/07/73	0605	69.5	6.4	800.0	.034	1.090	.030	.600	1.720	.371	.350	8.1	77.000	1,000	
8/07/73	1355	78.0	7.7	915.0											
8/07/73	1805	77.0	6.8	776.0	.017	1.290	.140	.600	2.050	.270	.910	8.4	69.000	1,000	
8/13/74	0200	70.5	5.9	800.0											
8/13/74	0600	69.0	6.1	780.0	.067	1.420	.150	1.230	2.860	.321	.370	8.4	69.000	580	
8/13/74	1350	75.0	6.9	840.0											
8/13/74	1800	75.0	6.7	850.0	.055	1.390	.140	1.220	2.808	.333	.340	8.6	60.000	510	
8/19/75	0050	68.0	6.3	785.0											
8/19/75	0450	67.0	6.3	799.0	.076	.800	.030	1.070	1.880	.183	.040	9.0	106.000	460	
8/19/75	1205	72.0	7.7	733.0											
8/19/75	1600	75.0	8.1	788.0	.096	.770	.030	1.360	2.190	.148	.140	9.1	123.000	230	
FX-26															
3/19/64		36.0	12.2												400.000
4/23/64		52.0	9.2	908.0								8.0	30.000		200.000
5/21/64		69.0	19.5												1400.000
6/26/64		73.0	5.6												4000.000
7/30/64		68.0	8.2												13000.000
8/27/64		68.0	10.8												8000.000
9/25/64		51.0	8.4												12000.000
10/08/64		50.0	10.8	762.0	.100	.655						8.0	55.000		10000.000
11/24/64		32.0	10.2												51000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-26															
12/29/64		32.0	6.4												50000.000
1/28/65		32.0	7.0			.542									13000.000
2/26/65		32.0	8.2			.316									1000.000
10/25/66	1155	42.0	11.8	825.0	.021	.407				.410		8.1	50.000		47000.000
4/18/67	1020	44.0	14.4	695.0	.006	.361				2.080		8.3	20.000		12600.000
4/17/68	0840	49.0	8.3	750.0	.021	1.102				.563		7.6	20.600	1,900	
8/13/68	1115	75.0	10.3	901.0	.143	1.843				1.640		8.0	50.620	1,100	12000.000
4/01/69	1200	37.0	12.3	830.0	.020	1.200				.660		8.0	32.000	180	9300.000
8/13/69	1115	72.0	4.9	530.0	.082	.500				2.510		7.9	45.000	1,500	49000.000
7/28/70	0930	74.0	7.0	860.0	.470	.920				3.170		7.9	58.000	530	
7/28/70	1245	83.0	10.5	830.0								8.2	54.000		
7/28/70	1710	88.0	8.4	840.0								8.0	66.000		
7/28/70	2035	80.0	5.8	780.0								7.7	74.000		
7/29/70	0135	77.0	3.2	850.0								7.8	79.000		
7/29/70	0435	74.0	3.6	860.0								7.9	72.000		
8/02/71	0020	69.5	4.8	891.0								8.1	75.000		
8/03/71	0415	67.0	4.6	927.0								7.9	82.000		
8/03/71	0850	66.0	6.9	955.0	.332	1.810				2.810		8.0	245.000	1,100	
8/03/71	1210	71.5	12.4	971.0								8.3	86.000		
8/03/71	1610	75.0	15.0	866.0								8.6	81.000		
8/03/71	2010	72.0	7.0	866.0								8.4	85.000		
8/08/72	0205	62.0	5.8	730.0	.091	1.830	.450	3.420	5.790	.899	.797	7.8	27.000	210	
8/08/72	0605	61.0	5.7	832.0											
8/08/72	1410	64.5	7.1	835.0											
8/08/72	1800	64.0	7.2	793.0	.158	1.770	.680	6.650	9.260	.961	.903	7.9	39.000	100	
8/07/73	0140	73.0	5.0	816.0											
8/07/73	0540	71.0	5.6	722.0	.070	.890	.170	1.110	2.240	.310	.530	8.0	58.000	1,100	
8/07/73	1335	81.0	9.6	826.0											
8/07/73	1740	83.0	7.0	755.0	.054	.870	.030	1.300	2.220	.316	.650	8.3	58.000	360	
8/13/74	0135	73.0	5.9	750.0											
8/13/74	0530	70.0	5.9	750.0	.056	.910	.190	1.180	2.332	.345	.360	7.9	48.000	970	
8/13/74	1335	78.0	8.5	810.0											
8/13/74	1735	79.5	7.7	820.0	.036	.920	.170	1.160	2.291	.336	.370	8.3	50.000	150	
8/19/75	0115	67.0	6.6	723.0											
8/19/75	0515	64.0	6.9	713.0	.034	.600	.030	1.010	1.610	.294	.280	8.2	76.000	160	
8/19/75	1230	69.0	9.8	702.0											
8/19/75	1630	76.0	10.1	730.0	.032	.650	.030	.770	1.360	.236	.070	8.5	83.000	1,000	
FX-27															
1/23/64		35.0	13.2	640.0								8.5	35.000		13000.000
2/06/64		34.0	17.5	674.0								8.2	45.000		100.000
3/19/64		37.0	14.4	568.0											2500.000
4/23/64		55.0	11.9	656.0								8.3	20.000		5800.000
5/20/64		68.0	7.1	676.0								7.8	20.000		2000.000
6/25/64		76.0	12.3	614.0								7.8	20.000		2300.000
7/29/64		80.0	12.9	590.0	.500							7.7	30.000		500.000
8/26/64		69.0	13.6	600.0								8.4	35.000		2000.000
9/24/64		62.0	8.3	598.0								7.9	30.000		
10/07/64		51.0	14.2	664.0		.294						8.8	30.000		200.000
11/23/64		35.0	14.7	748.0		.452						8.2	45.000		400.000
12/28/64		33.0	13.2	820.0		.881						7.8	45.000		7000.000
1/28/65		32.0	9.6	682.0		.610						7.4	35.000		33000.000
2/26/65		32.0	8.2	568.0	.100	.588						7.2	30.000		15000.000
10/24/66	1425	49.0	15.5	700.0	.009	.090				.410		8.1	30.000		9400.000
4/17/67	0835	59.0	10.9	665.0	.006	.294				.090		8.8	20.000		18400.000
4/17/68	0915	53.0	10.4	708.0	.026	.060				.135		8.6	28.900	700	
8/13/68	1145	74.0	11.3	665.0	.028	.422				.230		8.4	24.250	1,500	35000.000
4/01/69	1145	33.0	14.6	730.0	.018	1.200				.160		8.3	33.000	910	30000.000
8/13/69	1100	76.0	6.1	590.0	.016	.300				.250		8.1	38.000	800	16000.000
7/28/70	0940	80.0	3.7	690.0	.022	.190				.470		8.2	34.000	300	
7/28/70	1255	80.0	6.0	710.0								8.4	32.000		
7/28/70	1725	87.0	6.8	645.0								8.2	36.000		
7/28/70	2055	83.0	5.0	660.0								8.3	35.000		
7/29/70	0145	73.0	1.6	945.0								7.7	80.000		
7/29/70	0445	71.0	1.7	870.0								7.7	64.000		
8/02/71	0045	72.0	15.4	622.0								8.8	42.000		
8/03/71	0440	72.0	12.8	622.0								8.6	39.000		
8/03/71	0915	73.0	12.8	630.0	.024	.260				.180		8.7	38.000	100	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
FX-27															
8/03/71	1235	74.0	14.5	574.0								8.8	38.000		
8/03/71	1640	75.5	18.5	605.0								9.0	43.000		
8/03/71	2035	75.0	17.0	605.0								8.9	41.000		
8/08/72	0230	68.0	7.0	656.0	.032	1.440	.080	1.670	3.220	.241	.313	8.0	31.000	160	
8/08/72	0630	67.0	6.7	742.0											
8/08/72	1425	67.0	7.7	696.0											
8/08/72	1820	65.5	8.0	690.0	.040	1.490	.090	2.850	4.470	.209	.300	8.1	33.000	190	
8/07/73	0150	79.5	15.8	681.0											
8/07/73	0550	78.0	12.6	604.0	.029	.210	.050	1.340	1.630	.179	.330	8.7	41.000	30	
8/07/73	1345	78.5	11.6	711.0											
8/07/73	1750	79.5	14.6	619.0	.043	.720	.030	1.300	2.060	.119	.250	8.7	64.000	10	
8/13/74	0150	75.0	9.0	650.0											
8/13/74	0545	74.0	8.1	630.0	.033	1.130	.150	1.450	2.763	.124	.260	8.2	24.000	190	
8/13/74	1400	77.0	9.8	650.0											
8/13/74	1745	77.0	11.4	650.0	.038	1.260	.170	1.320	2.794	.172	.250	8.0	20.000	160	
8/19/75	0100	76.0	16.1	516.0											
8/19/75	0500	75.0	13.9	544.0	.020	.330	.030	1.430	1.720	.110	.190	8.6	40.000	40	
8/19/75	1220	72.0	14.2	506.0											
8/19/75	1620	77.0	17.7	531.0	.011	.420	.030	.970	1.340	.087	.070	8.8	41.000	120	
FX-28															
4/23/64		52.0	12.8	690.0								8.4	20.000		100.000
5/21/64		71.0	11.6												2900.000
6/26/64		77.0	11.2												5000.000
7/30/64		72.0	10.9												3000.000
8/27/64		71.0	12.8												3000.000
9/25/64		54.0	9.5												10000.000
10/08/64		50.0	21.6	620.0	.100	.384						8.0	30.000		1000.000
11/24/64		32.0	14.5												800.000
12/29/64		32.0	11.7												600.000
1/29/65		32.0	9.4			.542									2800.000
2/26/65		32.0	8.8			.475									200.000
10/25/66	1235	47.0	13.7	660.0	.006	.271				.140		8.2	15.000		6900.000
4/18/67	1055	47.0	14.9	685.0	.006	.407				.390		8.3	15.000		11400.000
4/16/68	1030	56.0	13.6	790.0	.031	1.514				.036		8.4	15.000	75	
8/14/68	1015	69.0	9.4	672.0	.028	.753				.080		8.0	19.950	490	2600.000
4/01/69	1115	39.0	14.7	795.0	.024	1.700				.100		8.3	19.000	650	6700.000
8/13/69	1020	70.0	8.0	615.0	.023	.800				.070		8.1	21.000	1,000	11000.000
7/29/70	0925	74.0	9.4	685.0	.064	1.500				.090		8.1	11.000	500	
7/29/70	1250	79.0	11.8	680.0								8.3	18.000		
7/29/70	1655	82.0	11.3	650.0								8.5	18.000		
7/29/70	2040	77.0	6.6	675.0								8.3	17.000		
7/30/70	0045	74.0	5.6	665.0								8.0	18.000		
7/30/70	0410	72.0	5.6	625.0								8.0	16.000		
8/04/71	2245	63.0	7.8	687.0								8.2	17.000		
8/05/71	0245	60.0	6.7	694.0								8.0	18.000		
8/05/71	0630	60.0	6.5	697.0	.045	2.040				.130		7.9	17.000	370	
8/05/71	1015	62.5	9.9	683.0								8.2	17.000		
8/05/71	1425	74.5	13.4	649.0								8.6	17.000		
8/05/71	1830	73.5	11.6	648.0								8.6	17.000		
8/10/72	0030	63.5	7.2	729.0											
8/10/72	0430	61.0	7.4	717.0	.037	2.370	.100	1.190	3.700	.088	.113	8.2	20.000	400	
8/10/72	1230	67.5	9.1	719.0											
8/10/72	1630	71.5	9.5	732.0	.033	2.040	.080	1.050	3.200	.049	.083	8.3	22.000	10	
8/09/73	0025	73.5	5.2	743.0											
8/09/73	0425	72.0	5.4	662.0	.102	2.860	.110	.770	3.840	.040	.150	7.8	23.000	300	
8/09/73	1230	76.0	12.5	711.0											
8/09/73	1625	78.5	11.5	630.0	.098	2.670	.030	.580	3.350	.071	.090	8.3	21.000	180	
8/15/74	0030	62.0	6.5	610.0											
8/15/74	0430	64.0	6.7	600.0	.038	3.570	.160	.810	4.568	.048	.050	8.0	26.000	1,200	
8/15/74	1235	67.0	11.7	660.0											
8/15/74	1630	78.0	12.4	690.0	.025	3.180	.030	.850	4.054	.033	.060	8.5	21.000	10	
8/21/75	0001	66.5	5.9	566.0											
8/21/75	0401	68.0	5.9	553.0	.059	2.180	.030	1.020	3.290	.123	.310	7.8	25.000	6,300	
8/21/75	1100	73.0	9.7	619.0											
8/21/75	1500	79.0	11.9	601.0	.057	1.870	.030	.680	2.540	.062	.110	8.3	29.000	2,600	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
KK-01															
4/09/64		41.0	11.8	1,040.0								8.0	115.000		75000.000
5/15/64		59.0	9.3												230000.000
6/18/64		68.0	7.3												49000.000
7/16/64		82.0	11.6												10000.000
8/06/64		77.0	10.4												8000.000
9/23/64		64.0	8.3	426.0		.316						7.3	20.000		340000.000
10/21/64		69.0	12.9												21000.000
11/04/64		54.0	9.8												80000.000
12/10/64		37.0	13.3												12000.000
1/07/65		42.0	10.3			.407									19000.000
2/03/65		32.0	11.6			.181									4000.000
10/10/66	0925	54.0	10.3	715.0	.030	1.100					.160	7.4	45.000		66000.000
4/04/67	0820	44.0	10.3	1,330.0	.030	.800					.140	7.8	200.000		7600.000
4/18/68	1110	54.0	7.4	1,235.0	.122	.506				.565		7.4	145.100	260,000	
8/14/68	1050	70.0	10.7	722.0	.033	.151				.057		8.0	63.600	900	34000.000
4/01/69	1135	42.0	11.0	920.0	.046	.700				.157		7.8	94.000	16,000	120000.000
8/14/69	1140	86.0	10.2	600.0	.023	.100				.083		8.0	64.000	600	73000.000
8/11/70	0140	82.0	14.1	650.0								8.8	35.000		
8/11/70	0450	82.5	12.0	670.0								8.6	37.000		
8/11/70	0835	78.0	5.8	640.0								7.9	32.000		
8/11/70	1030	77.0	12.7	700.0	.011	.090				.093		8.5	44.000	200	
8/12/70	0420	71.5	6.3	560.0								5.8	31.000		
8/12/70	1245	76.0	6.0	720.0								8.0	44.000		
8/08/71	2355	71.5	5.3	853.0	.035	.360				.187		7.7	61.000	1,500	
8/09/71	0355	71.0	5.0	842.0								7.7	54.000		
8/09/71	0815	72.5	8.7	810.0								7.9	46.000		
8/09/71	1150	78.5	11.7	687.0								8.3	41.000		
8/09/71	1555	82.5	9.2	665.0								7.7	38.000		
8/09/71	1945	78.5	4.5	693.0								7.3	32.000		
8/14/72	0220	75.0	6.4	937.0											
8/14/72	0620	74.0	6.6	962.0	.018	.130	.110	.630	.890	.152	.130	8.1	103.000	30	
8/14/72	1405	78.0	8.3	743.0											
8/14/72	1815	73.0	6.2	663.0	.079	.660	.120	.750	1.610	.253	.340	7.7	70.000	2,200	
8/15/73	0001	73.0	5.3	795.0											
8/15/73	0400	71.5	5.7	851.0	.010	.250	.340	.330	.930	.027	.070	7.6	50.000	810	
8/15/73	1200	77.0	13.1	696.0											
8/15/73	1600	78.5	11.4	717.0	.014	.250	.170	.250	.680	.030	.100	8.0	33.000	160	
8/19/74	0001	72.0	3.4	840.0											
8/19/74	0400	70.0	3.7	840.0	.155	.350	.630	.870	1.995	.183	.230	7.7	72.000	72,000	
8/19/74	1205	77.5	8.3	800.0											
8/19/74	1600	80.5	8.0	800.0	.109	.390	.230	.720	1.451	.118	.120	8.2	58.000	17,000	
8/25/75	0001	75.0	6.6	697.0											
8/25/75	0401	73.0	6.4	740.0	.031	.480	.250	.780	1.540	.036	.030	7.8	135.000	600	
8/25/75	1100	74.0	8.2	710.0											
8/25/75	1500	77.0	8.6	713.0	.019	.350	.300	.440	1.110	.022	.010	7.8	26.000	1,400	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MH-01															
4/16/64		46.0	7.4	1,020.0								8.0	30.000		400.000
5/27/64		61.0	5.2												2900.000
6/30/64		78.0	9.1												100.000
7/15/64		68.0	5.0												200.000
8/13/64		65.0	2.1												1700.000
9/30/64		54.0	.4												6000.000
10/15/64		52.0	3.0	1,030.0		.542						7.2	30.000		1600.000
11/13/64		50.0	.3												140000.000
12/14/64		33.0	4.2												7000.000
1/13/65		32.0	.9			.429									1300.000
2/10/65		32.0	10.0			.520									46000.000
10/11/66	1345	54.0		1,850.0		.362				2.070		7.4	160.000		8000.000
4/11/67	0945	37.0	10.2	660.0	.009	1.605				.060		7.3	35.000		1350.000
4/23/68	0930	44.0	8.0	759.0	.046	5.616				.201		7.2	31.700	5,500	
8/15/68	1030	65.0	.8	720.0	.010	.135				.890		8.0	36.020	190	1300.000
4/02/69	1115	37.0	10.6	830.0	.036	1.500				.217		7.7	42.000	1,100	24000.000
8/12/69	1130	72.0	2.5	730.0	.071	.500				.240		7.8	38.000	1,100	14000.000
8/12/70	0535	78.0	8.1	870.0								8.4	92.000		
8/12/70	0820	72.0	3.6	865.0	.017	.170				.533		8.2	52.000	500	
8/12/70	1030	75.0	6.2	800.0								8.4	50.000		
8/12/70	1255	75.5	6.8	885.0								8.2	52.000		
8/13/70	0410	73.0	3.1	850.0								8.2	52.000		
8/13/70	0655	72.0	2.4	850.0								8.2	52.000		
8/11/71	0040	69.0	2.5	780.0	.035	.390				.400		8.1	50.000	200	
8/11/71	0440	66.0	1.8	793.0								8.1	47.000		
8/11/71	0850	65.5	1.8	798.0								8.1	42.000		
8/11/71	1240	72.5	8.0	842.0								8.4	47.000		
8/11/71	1630	77.0	11.5	773.0								8.3	46.000		
8/11/71	2015	72.0	9.1	766.0								8.4	45.000		
8/16/72	0215	66.0	3.0	944.0											
8/16/72	0615	65.5	2.5	928.0	.065	1.960	.120	1.780	3.930	.110	.300	7.8	58.000	140	
8/16/72	1400	70.5	3.5	924.0											
8/16/72	1800	70.5	4.1	963.0	.051	1.670	.110	1.770	3.600	.280	.340	8.1	63.000	230	
8/16/73	0200	72.0	4.4	785.0											
8/16/73	0600	71.0	3.2	744.0	.279	3.290	.030	2.060	5.630	.495	.980	7.5	45.000	1,700	
8/16/73	1355	77.0	4.7	764.0											
8/16/73	1750	79.0	7.7	688.0	.102	1.400	.030	1.440	2.940	.342	.610	8.2	36.000	390	
8/20/74	0225	67.0	3.6	860.0											
8/20/74	0625	65.0	4.5	680.0	.186	2.080	.180	2.000	4.442	.510	.460	7.9	33.000	3,500	
8/20/74	1430	80.0	12.5	740.0											
8/20/74	1830	75.0	7.0	700.0	.133	1.870	.080	2.130	4.211	.569	.430	8.3	33.000	1,300	
8/26/75	0220	68.0	4.3	543.0											
8/26/75	0620	66.0	4.5	562.0	.280	8.220	.080	1.560	10.140	.295	.380	7.6	35.000	4,300	
8/26/75	1440	74.0	.9	543.0											
8/26/75	1825	71.5	1.2	578.0	.017	.330	.050	2.400	2.800	2.353	2.970	7.3	57.000	1,200	
MH-02															
5/25/64		69.0	8.2												10000.000
6/11/64		70.0	9.8	538.0								7.4	20.000		28000.000
7/20/64		75.0	6.9												16000.000
8/12/64		68.0	4.5												740000.000
9/23/64		66.0	5.8	526.0		1.379						7.2	35.000		290000.000
10/16/64		60.0	4.2	740.0	.400	.452						7.4	45.000		60000.000
11/11/64		53.0	3.5	414.0	.300	.316						7.3	20.000		50000.000
12/10/64		33.0	7.6	1,240.0	.800	.136						7.9	270.000		29000.000
1/22/65		37.0	12.0	894.0		.610						7.3	220.000		60000.000
2/05/65		44.0	8.3	1,300.0	.400	.203						7.4	285.000		17000.000
10/11/66	1215	63.0	4.2	380.0	.030					1.120		7.5	15.000		450000.000
4/03/67	1135	49.0	10.2	770.0	.076	.927				.450		7.4	50.000		21000.000
4/17/68	1045	48.0	9.1	267.0	.074	.542				.188		7.8	28.700	300	
8/13/68	1020	68.0	8.3	741.0	.173	1.144				.140		7.8	41.670	35,000	190000.000
4/01/69	0910	41.0	12.1	960.0	.091	1.200				.080		8.0	75.000	130	17000.000
8/14/69	0920	74.0	5.6	500.0	.104	.400				.150		7.9	52.000	1,800	48000.000
8/10/70	0405	77.0	12.2	375.0								8.8	22.000		
8/10/70	0805	67.0	6.8	450.0	.016	.180				.023		7.9	25.000	2,400	
8/10/70	0830	74.0	8.2	395.0								8.4	21.000		
8/10/70	1150	73.0	11.3	435.0								8.2	26.000		
8/10/70	1200	72.0	4.7	405.0								7.8	20.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MH-02															
8/11/70	0355	72.0	4.5	390.0								7.8	21.000		
8/03/71	2315	62.0	4.3	444.0	.114	.270				.317		7.9	22.000	50,000	
8/04/71	0315	61.0	4.0	451.0								7.7	24.000		
8/04/71	0715	60.0	4.5	474.0								7.7	22.000		
8/04/71	1110	65.0	9.3	450.0								8.2	26.000		
8/04/71	1515	67.0	11.6	405.0								8.7	19.000		
8/04/71	1900	67.0	10.3	405.0								8.6	19.000		
8/09/72	0055	63.0	6.9	617.0	.027	.960	.080	1.840	2.910	.061	.070	7.7	47.000	260	
8/09/72	0455	62.0	7.0												
8/09/72	1300	66.0	8.8	708.0											
8/09/72	1700	68.5	9.4	655.0	.249	.800	.090	.740	1.880	.071	.080	8.1	42.000	230	
8/08/73	0120	76.0	3.2	408.0											
8/08/73	0520	75.0	3.8	348.0	.028	.200	.030	.210	.440	.007	.030	7.7	18.000	110	
8/08/73	1315	79.0	12.2	387.0											
8/08/73	1710	80.5	6.2	374.0	.011	.810	.060	2.490	3.370	.060	1.140	7.4	19.000	14,000	
8/14/74	0120	63.0	5.5	345.0											
8/14/74	0515	62.0	5.6	340.0	.010	.520	.180	.630	1.337	.041	.050	7.6	21.000	64,000	
8/14/74	1310	68.0	8.5	350.0											
8/14/74	1705	69.5	7.8	350.0	.012	.460	.140	.610	1.221	.036	.050	7.8	18.000	11,000	
8/20/75	0105	71.5	4.8	377.0											
8/20/75	0505	71.5	5.0	382.0	.038	.230	.290	.260	.820	.056	.090	7.7	22.000	800	
8/20/75	1335	75.0	5.1	228.0											
8/20/75	1645	72.0	7.5	155.0	.172	1.470	.260	.980	2.870	.862	.980	8.3	18.000	35,000	
MH-03															
4/09/64		43.0	12.5	780.0								8.7	45.000		1100.000
5/25/64		73.0	20.3												2000.000
6/11/64		70.0	21.7												100.000
7/20/64		77.0	7.9												8000.000
8/12/64		65.0	12.4												3900.000
9/23/64		65.0	6.7												88000.000
10/16/64		56.0	15.2	840.0		.158						8.0	30.000		10000.000
11/11/64		57.0	15.9												3000.000
12/10/64		33.0	13.6												9000.000
1/22/65		32.0	12.8			.497									36000.000
2/05/65		33.0	9.2			.362									1000.000
10/11/66	1240	54.0	9.9	735.0	.003	.090				.080		7.6	30.000		3600.000
4/03/67	1105	48.0	11.1	680.0	.009	.678				.070		8.0	35.000		800.000
4/17/68	1020	46.0	10.2	858.0	.009	.217				.063		8.0	32.100	600	
8/13/68	1100	71.0	12.7	790.0	.019	.783				.140		8.2	46.640	400	26000.000
4/01/69	0850	35.0	12.7	945.0	.014	1.500				.073		8.0	46.000	110	200.000
8/14/69	0900	75.0	4.2	740.0	.020	.100				.090		8.0	56.000	420	30000.000
8/10/70	0345	71.0	11.2	960.0								8.2	31.000		
8/10/70	0730	72.0	9.2	840.0	.011	.110				.087		8.2	53.000	100	
8/10/70	0805	71.0	11.7	955.0								8.1	37.000		
8/10/70	1125	77.0	12.2	810.0								8.4	50.000		
8/10/70	1135	77.5	15.3	760.0								8.2	48.000		
8/11/70	0330	76.0	12.2	750.0								8.2	50.000		
8/03/71	2340	69.0	13.9	824.0	.037	.430				.033		8.3	68.000	120	
8/04/71	0340	66.5	12.1	841.0								8.2	68.000		
8/04/71	0750	61.0	9.8	822.0								8.0	62.000		
8/04/71	1135	69.5	12.2	809.0								8.1	28.000		
8/04/71	1530	68.0	17.5	720.0								8.4	51.000		
8/04/71	1920	68.0	18.2	699.0								8.5	49.000		
8/09/72	0115	62.0	7.7	804.0	.031	1.220	.230	3.340	4.820	.097	.160	7.8	55.000	100	
8/09/72	0515	60.0	7.1												
8/09/72	1315	67.5	8.7	909.0											
8/09/72	1715	69.5	9.9	892.0	.031	1.100	.240	1.180	2.550	.095	.100	8.1	55.000	100	
8/08/73	0100	78.0	11.7	811.0											
8/08/73	0500	76.0	9.2	741.0	.050	.350	.260	.710	1.370	.069	.160	7.8	59.000	680	
8/08/73	1255	76.5	10.3	847.0											
8/08/73	1650	81.0	8.7	736.0	.005	.080	.030	.680	.770	.040	.120	8.3	53.000	450	
8/14/74	0050	70.0	9.0	750.0											
8/14/74	0450	69.0	8.1	750.0	.012	.530	.120	.850	1.512	.064	.090	8.0	47.000	560	
8/14/74	1250	70.5	8.5	790.0											
8/14/74	1645	77.0	12.4	820.0	.009	.500	.070	.680	1.258	.044	.070	8.2	45.000	380	
8/20/75	0045	68.5	9.5	702.0											
8/20/75	0445	68.5	7.1	710.0	.013	.160	.030	.340	.450	.075	.090	8.1	52.000	240	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MH-03															
8/20/75	1315	71.0	6.1	837.0											
8/20/75	1630	68.0	7.0	851.0	.012	.350	.030	.320	.630	.025	.050	8.0	50.000	760	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-01															
1/30/64		32.0	7.0	696.0	.300							7.5	45.000		100.000
2/26/64		32.0	5.8	790.0								7.6	70.000		100.000
3/26/64		32.0	11.2	520.0								8.1	20.000		1300.000
4/27/64		56.0	8.5	584.0								8.3	5.000		1400.000
5/27/64		58.0	8.2	576.0								8.2	15.000		200.000
6/29/64		74.0	2.8	654.0								8.2	45.000		3900.000
7/24/64		79.0	2.3	436.0								7.1	5.000		6000.000
8/20/64		63.0	6.9	524.0								7.7			43000.000
9/30/64		51.0	9.9	664.0		.407						7.8	30.000		3000.000
10/30/64		43.0	11.9	676.0		.294						8.0	30.000		1400.000
11/27/64		32.0	11.7	714.0		.452						7.7	35.000		700.000
12/10/64		32.0													
12/21/64			2.8	896.0		.542						7.4	50.000		100.000
1/25/65		32.0	.5	724.0	.400	.339						7.2	50.000		100.000
2/17/65		32.0	8.6	472.0		.294						7.2	20.000		4000.000
10/19/66	1035	48.0	8.7	610.0	.003	.294				.380		7.6	30.000		5300.000
4/10/67	0930	43.0	10.2	465.0	.003	.181				.080		7.9	5.000		1300.000
4/22/68	0820	50.0	8.9	540.0	.010	.211				.038		7.8	9.700	200	
8/15/68	1130	64.0	9.4	683.0	.009	.813				.353		8.0	31.000	700	3000.000
4/02/69	1010	35.0	12.0	585.0	.009	.400				.070		7.9	13.000	140	1100.000
8/13/69	1040	75.0	6.1	565.0	.004	.400				.187		8.0	29.000	450	2600.000
8/12/70	1005	73.0	4.3	590.0	.012	.160				.257		8.0	18.000	2,400	
8/12/70	1415	81.0	11.6	540.0								8.6	16.000		
8/12/70	1635	77.5	10.8	860.0								8.5	80.000		
8/12/70	2135	73.0	5.7	780.0								8.4	79.000		
8/13/70	0310	69.0	2.6	770.0								8.1	79.000		
8/13/70	0610	67.5	3.7	770.0								8.1	74.000		
8/10/71	2335	67.0	4.2	781.0	.017	.840				.527		8.0	72.000	900	
8/11/71	0335	64.0	4.4	786.0								7.9	74.000		
8/11/71	0745	63.0	5.7	788.0								7.9	57.000		
8/11/71	1135	64.0	7.9	816.0								8.1	71.000		
8/11/71	1530	71.0	9.9	845.0								8.4	88.000		
8/11/71	1915	71.0	8.4	888.0								8.5	98.000		
8/16/72	0115	70.5	4.6	605.0											
8/16/72	0515	70.5	4.6	594.0	.009	.490	.120	1.470	2.090	.189	.310	8.1	25.000	140	
8/16/72	1315	70.0	5.2	638.0											
8/16/72	1715	74.0	6.0	624.0	.009	.390	.090	1.450	1.940	.273	.347	8.2	32.000	70	
8/16/73	0055	69.0	5.3	758.0											
8/16/73	0455	66.5	5.6	794.0	.018	.960		.830	1.810	.283	.370	7.7	54.000	480	
8/16/73	1255	72.0	9.3	737.0											
8/16/73	1645	76.5	8.4	714.0	.010	.740	.030	.730	1.480	.283	.360	8.4	53.000	500	
8/20/74	0120	72.0	5.3												
8/20/74	0525	68.5	5.3	880.0	.013	.880	.040	1.080	2.018	.338	.390	8.0	50.000	220	
8/20/74	1330	76.5	9.5	690.0											
8/20/74	1730	76.0	7.5	660.0	.013	.740	.050	1.130	1.930	.315	.420	8.5	42.000	20	
8/26/75	0115	68.0	5.4	887.0											
8/26/75	0515	66.0	4.8	878.0	.013	.450	.030	.820	1.300	.330	.240	8.0	131.000	200	
8/26/75	1320	72.5	11.4	792.0											
8/26/75	1710	73.0	10.3	776.0	.007	.220	.030	1.070	1.290	.297	.250	8.6	115.000	130	
MI-02															
2/26/64		32.0	13.9	600.0								7.9	25.000		400.000
4/27/64		56.0	7.5	616.0								8.0	15.000		2300.000
5/27/64		62.0	6.1												10000.000
6/29/64		75.0	5.8												400.000
7/24/64		79.0	.7												34000.000
8/20/64		64.0	7.1												20000.000
9/30/64		52.0	7.5	696.0		.316						7.6	15.000		22000.000
10/30/64		44.0	10.5												2500.000
11/27/64		33.0	12.6												34000.000
12/21/64		32.0	10.6												8000.000
1/25/65		33.0	8.1			.339									9000.000
2/17/65		33.0	8.0			.316									200.000
10/19/66	1055	48.0	5.8	630.0	.012	.226				.610		7.5	35.000	8,400	8400.000
4/10/67	0950	43.0	8.4	425.0		.090				.030		7.8	5.000	2,600	2600.000
4/22/68	0840		6.6	517.0	.006	.328				.009		7.8	7.800	230	
8/15/68	1100	68.0	5.8	616.0	.061	.485				.450		8.0	19.950	460	49000.000
4/02/69	1025	35.0	11.8	630.0	.011	.700				.090		8.0	16.000	520	22000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-02															
8/13/69	1005	76.0	4.2	525.0	.036	.300				.247		8.0	24.000	270	27000.000
8/12/70	0955	70.0	2.7	640.0	.042	.260				1.030		7.9	28.000		
8/12/70	1410	76.0	6.0	620.0								8.1	26.000		
8/12/70	1625	79.0	10.8	620.0								8.4	26.000		
8/12/70	2115	75.5	10.8	530.0								8.5	21.000		
8/13/70	0255	73.0	6.3	545.0								8.3	21.000		
8/13/70	0600	70.0	5.0	565.0								8.1	21.000		
8/10/71	2320	71.0	6.0	644.0	.021	.590				.370		8.2	32.000	240	
8/11/71	0320	67.5	4.1	624.0								8.0	31.000		
8/11/71	0725	66.0	3.7	646.0								7.9	30.000		
8/11/71	1115	68.0	5.3	653.0								8.0	34.000		
8/11/71	1515	74.0	9.3	618.0								8.3	32.000		
8/11/71	1900	74.0	11.3	637.0								8.5	35.000		
8/16/72	0105	72.0	4.6	562.0											
8/16/72	0505	72.0	4.6	567.0	.027	.250	.140	1.460	1.880	.208	.320	8.1	23.000	60	
8/16/72	1300	72.0	4.8	621.0											
8/16/72	1705	75.0	5.5	618.0	.033	.240	.150	1.560	1.980	.282	.390	8.2	35.000	90	
8/16/73	0040	72.0	8.6	629.0											
8/16/73	0440	70.5	6.8	636.0	.029	.580		1.010	1.620	.127	.180	7.8	28.000	280	
8/16/73	1240	73.0	7.0	649.0											
8/16/73	1635	74.0	8.7	661.0	.017	.700	.030	.700	1.420	.130	.190	8.3	27.000	80	
8/20/74	0110	75.0	7.2												
8/20/74	0515	72.0	5.2		.023	.750	.070	1.200	2.041	.275	.340	8.1	34.000	760	
8/20/74	1310	76.0	8.6	610.0											
8/20/74	1710	76.5	10.6	590.0	.016	.540	.140	1.220	1.916	.211	.230	8.5	30.000	380	
8/26/75	0125	72.0	6.6	553.0											
8/26/75	0525	69.0	5.9	578.0	.035	.680	.070	.660	1.450	.084	.120	8.0	46.000	320	
8/26/75	1330	73.0	7.9	570.0											
8/26/75	1720	74.5	9.4	562.0	.017	.470	.030	.750	1.220	.058	.090	8.3	50.000	190	
MI-03															
2/26/64		32.0	24.2	640.0								8.9	40.000		300.000
3/26/64		32.0	12.6												3300.000
4/27/64		56.0	8.2	578.0								8.3	15.000		700.000
5/27/64		64.0	12.9												900.000
6/29/64		80.0	10.1												100.000
7/23/64		80.0	2.4												14000.000
8/20/64		68.0	10.2												5000.000
9/30/64		54.0	9.1	624.0		.429						7.8	15.000		7000.000
10/30/64		46.0	15.0												100.000
11/27/64		33.0	13.5												5000.000
12/21/64		32.0	14.0												19000.000
1/25/65		32.0	12.7			.475									800.000
2/17/65		33.0	11.3			.520									28000.000
10/19/66	1135	51.0	10.5	645.0	.036	.271				1.130		7.6	45.000		6000.000
4/10/67	1010	43.0	10.2	495.0	.006	.203				.100		8.3	15.000		1100.000
4/22/68	0920	52.0	8.8	600.0	.021	.662				.097		8.0	11.400	700	
8/15/68	1140	71.0	9.7	610.0	.219	.964				.563		8.4	35.010	90	4000.000
4/02/69	1300	39.0	13.6	610.0	.015	.600				.130		7.7	16.000	110	4300.000
8/13/69	0930	79.0	5.0	600.0	.160	.800				.803		8.2	47.000	1,000	12000.000
8/12/70	0930	75.5	10.7	770.0	.260	.880				1.230		8.8	76.000	100	
8/12/70	1350	83.0	20.7	745.0								9.2	69.000		
8/12/70	1600	84.0	18.4	755.0								9.2	63.000		
8/12/70	2045	77.5	8.7	725.0								8.9	54.000		
8/13/70	0230	75.0	4.0	730.0								8.3	100.000		
8/13/70	0535	74.0	4.0	790.0								8.4	68.000		
8/10/71	2250	72.5	3.2	863.0	.149	.850				.930		8.0	85.000	160	
8/11/71	0250	70.5	3.7	824.0								8.1	75.000		
8/11/71	0700	68.5	3.5	790.0								8.0	55.000		
8/11/71	1050	70.0	8.1	751.0								8.3	50.000		
8/11/71	1450	77.0	13.5	741.0								8.6	51.000		
8/11/71	1840	75.0	9.9	785.0								8.4	62.000		
8/16/72	0035	74.0	5.0	614.0											
8/16/72	0435	72.5	4.5	621.0	.126	.430	.540	1.840	2.940			8.0	33.000	100	
8/16/72	1240	71.0	4.9	643.0											
8/16/72	1635	74.0	6.6	624.0	.078	.430	.310	1.860	2.680	.293	.410	8.2	29.000	50	
8/16/73	0015	75.0	6.0	706.0											
8/16/73	0415	73.0	4.8	723.0	.184	1.350		.870	2.400	.232	.330	7.8	61.000	200	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-03															
8/16/73	1220	73.0	6.2	743.0											
8/16/73	1610	78.0	7.9	662.0	.159	.930	.290	.820	2.200	.244	.270	8.2	40.000	400	
8/20/74	0045	76.5	7.2												
8/20/74	0445	73.5	4.6		.093	.900	.340	1.610	2.943	.125	.300	8.4	48.000	200	
8/20/74	1250	73.5	8.2	640.0											
8/20/74	1655	76.0	9.4	610.0	.060	.590	.050	1.600	2.302	.161	.270	8.6	36.000	110	
8/26/75	0050	72.0	4.8	566.0											
8/26/75	0450	70.0	4.5	586.0	.082	.760	.220	1.080	2.140	.141	.170	8.0	51.000	1,000	
8/26/75	1250	70.5	6.9	598.0											
8/26/75	1640	74.0	10.6	551.0	.057	.620	.080	1.260	2.010	.132	.190	8.3	38.000	280	
MI-04															
2/26/64		32.0	13.5	624.0								7.9	20.000		100.000
4/27/64		56.0	8.2	610.0								8.4	15.000		900.000
5/27/64		63.0	7.5												600.000
6/30/64		86.0	11.7												100.000
7/24/64		77.0	.4												23000.000
8/21/64		65.0	6.6												140000.000
9/30/64		52.0	8.0	690.0		.452						7.8	20.000		13000.000
10/30/64		45.0	11.3												600.000
11/27/64		32.0	13.4												3000.000
12/21/64		32.0	11.9												3000.000
1/25/65		32.0	7.6			.316									100.000
2/17/65		32.0	5.1			.497									200.000
10/19/66	1115	48.0	9.6	625.0		.203				.190		7.6	20.000		5700.000
4/10/67	1025	45.0	9.1	535.0	.003	.226				.040		7.9	5.000		1800.000
4/22/68	0900	50.0	7.0	652.0	.015	.903				.038		7.6	13.200	140	
8/15/68	1130	68.0	8.1	570.0	.020	.301				.103		8.2	14.930	520	2200.000
4/02/69	1200	37.0	12.4	680.0	.011	.800				.030		7.8	17.000	340	11000.000
8/13/69	0950	76.0	6.1	565.0	.015	.300				.107		8.2	29.000	400	7000.000
8/12/70	0920	73.0	5.1	615.0	.019	.140				.113		8.8	12.000	100	
8/12/70	1335	79.0	8.7	590.0								8.5	7.000		
8/12/70	1610	80.5	9.4	610.0								8.5	7.000		
8/12/70	2100	77.0	7.7	555.0								8.4	6.000		
8/13/70	0240	74.0	4.6	565.0								8.3	12.000		
8/13/70	0545	72.0	4.2	565.0								8.3	12.000		
8/10/71	2305	72.0	4.7	603.0								8.1	14.000		
8/11/71	0305	69.0	4.8	595.0								8.2	14.000		
8/11/71	0710	68.5	4.7	518.0	.044	.600				.163		8.1	12.000	150	
8/11/71	1100	70.0	6.1	601.0								8.2	14.000		
8/11/71	1500	76.0	9.9	570.0								8.3	12.000		
8/11/71	1845	73.0	7.4	564.0								8.2	13.000		
8/16/72	0050	70.0	4.8	710.0											
8/16/72	0450	69.0	4.9	717.0	.037	.500	.110	1.500	2.150	.051	.353	8.2	24.000	50	
8/16/72	1250	70.0	6.0	733.0											
8/16/72	1650	74.0	5.3	728.0	.035	.450	.130	1.570	2.190	.299	.343	8.2	28.000	50	
8/16/73	0025	71.5	7.4	680.0											
8/16/73	0425	68.5	6.5	671.0	.025	1.160		1.360	2.550	.172	.300	7.9	18.000	300	
8/16/73	1230	72.0	8.6	669.0											
8/16/73	1620	75.5	10.1	592.0	.024	.980	.030	.800	1.800	.171	.280	8.4	18.000	310	
8/20/74	0055	73.0	5.9												
8/20/74	0500	70.5	5.5		.032	.890	.070	1.320	2.307	.228	.270	8.1	20.000	660	
8/20/74	1300	76.0	6.1												
8/20/74	1700	76.5	6.5	650.0	.025	.700	.050	1.350	2.125	.178	.230	8.2	19.000	550	
8/26/75	0140	71.0	5.7	566.0											
8/26/75	0540	69.0	5.5	584.0	.036	.560	.080	1.070	1.750	.202	.290	8.1	24.000	960	
8/26/75	1345	74.5	6.2	591.0											
8/26/75	1735	75.5	6.4	590.0	.031	.600	.050	1.320	2.000	.216	.360	8.2	25.000	770	
MI-05															
1/30/64		32.0	10.9	700.0	.100							7.6	35.000		12000.000
2/26/64		32.0	14.7	660.0	.200							8.2	35.000		900.000
3/26/64		32.0	13.5	524.0											2300.000
4/27/64		54.0	8.5	594.0								8.3	5.000		3400.000
5/27/64		65.0	9.6	604.0								8.4	15.000		1400.000
6/05/64		83.0	5.7	606.0								7.8	30.000		700.000
7/23/64		80.0	4.0	384.0								7.2	5.000		7000.000
8/20/64		68.0	7.6	554.0								8.7	30.000		10000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-05															
9/30/64		58.0	9.9	654.0		.475						7.8	15.000		4000.000
10/29/64		48.0	9.4	660.0		.136						8.4	20.000		1000.000
11/27/64		32.0	13.7	654.0		.362						8.2	30.000		5000.000
12/21/64		33.0	14.6	814.0		.542						7.8	35.000		8000.000
1/25/65		32.0	6.2	696.0		.610						7.4	30.000		800.000
2/17/65		32.0	9.9	488.0	.100	.158						7.2	20.000		1800.000
10/19/66	1240	50.0	10.6	610.0	.003	.090				.500		7.7	20.000		10000.000
4/10/67	1050	45.0	10.1	510.0	.006	.271				.110		8.1	30.000		1300.000
4/23/68	1040	54.0	8.0	588.0	.029	.548				.100		7.8	12.600	290	
8/15/68	0950	70.0	6.8	544.0	.010	.120				.327		8.8	24.970	240	8000.000
4/02/69	1030	36.0	12.7	625.0	.011	.700				.103		8.1	15.000	180	3000.000
8/12/69	1100	74.0	7.0	615.0	.015	.200				.573		8.6	37.000	230	7000.000
8/12/70	0745	73.5	4.5	680.0	.005	.110				.467		8.7	39.000	100	
8/12/70	0830	79.0	8.9	700.0								8.7	40.000		
8/12/70	1750	81.0	10.9	620.0								9.0	38.000		
8/12/70	2255	77.0	8.1	620.0								9.0	40.000		
8/13/70	0435	76.0	4.7	610.0								8.8	43.000		
8/13/70	0725	74.0	4.6	610.0								8.6	42.000		
8/10/71	0110	72.0	4.2	669.0	.006	.210				.193		8.5	44.000	180	
8/11/71	0510	69.0	4.0	681.0								8.4	45.000		
8/11/71	0925	69.5	5.4	691.0								8.4	38.000		
8/11/71	1215	76.0	9.5	675.0								8.7	42.000		
8/11/71	1700	77.5	11.4	638.0								8.8	39.000		
8/11/71	2050	76.0	9.5	658.0								8.8	39.000		
8/16/72	0240	72.5	5.8	642.0											
8/16/72	0640	72.0	5.6	648.0	.034	.660	.130	1.500	2.320	.387	.397	8.2	28.000	20	
8/16/72	1425	74.0	7.1	650.0											
8/16/72	1845	77.0	7.8	650.0	.027	.560	.070	1.540	2.200	.308	.393	8.4	32.000	70	
8/16/73	0220	74.0	6.5	654.0											
8/16/73	0620	71.5	5.5	751.0	.027	.760	.030	.730	1.520	.193	.250	8.2	30.000	1,600	
8/16/73	1420	77.0	11.0	675.0											
8/16/73	1815	79.0	12.6	634.0	.013	.730		.760	1.500	.064	.270	8.6	30.000	1,200	
8/20/74	0250	75.0	7.3												
8/20/74	0645	71.5	5.6		.025	.270	.050	1.980	2.323	.111	.380	8.6	29.000	410	
8/20/74	1455	80.0	18.1	560.0											
8/20/74	1850	80.5	15.5	510.0	.019	.150	.070	1.630	1.872	.043	.230	8.9	29.000	250	
8/26/75	0250	72.0	5.9	598.0											
8/26/75	0650	70.0	5.6	572.0	.017	.640	.030	1.030	1.700	.128	.230	8.2	38.000	610	
8/26/75	1505	77.5	13.4	570.0											
8/26/75	1850	77.0	13.8	551.0	.014	.130	.030	1.370	1.490	.071	.190	8.8	41.000	270	
MI-06															
2/26/64		33.0	14.7	692.0	.200							8.2	35.000		3600.000
3/26/64		33.0	14.1												3200.000
4/27/64		56.0	8.3	594.0								8.0	15.000		2100.000
5/27/64		71.0	5.6												8000.000
6/29/64		84.0	2.8												500.000
7/23/64		80.0	3.1												11000.000
8/20/64		71.0	10.2												5000.000
9/30/64		59.0	10.4	656.0		.497						8.2	15.000		11000.000
10/29/64		50.0	9.6												900.000
11/27/64		32.0													6000.000
12/21/64		33.0	15.0												7000.000
1/25/65		32.0	6.4			.452									7000.000
10/19/66	1255	50.0	10.3	610.0	.003	.068				.350		7.7	20.000		7400.000
4/10/67	1105	45.0	9.8	535.0	.003	.271				.110		8.1	5.000		2000.000
4/23/68	0840	53.0	7.8	559.0	.028	.671				.107		8.0	13.300	100	
8/15/68	0930	73.0	8.0	541.0	.011	.286				.357		8.8	28.990	1,000	13000.000
4/02/69	1000	36.0	12.8	635.0	.012	.500				.117		8.1	18.000	350	3600.000
8/12/69	1030	74.0	10.5	585.0	.008	.200				.323		8.8	36.000	300	2300.000
8/12/70	0715	79.0	6.9	630.0	.007	.210				.467		8.9	44.000	100	
8/12/70	1205	80.0	9.9	670.0								9.0	31.000		
8/12/70	1525	85.0	11.4	630.0								9.0	41.000		
8/12/70	2000	78.0	10.5	695.0								9.0	42.000		
8/13/70	0150	79.5	9.9	650.0								9.0	42.000		
8/13/70	0505	78.5	8.0	660.0								9.0	43.000		
8/10/71	2215	76.0	7.8	622.0	.009	.180				.163		8.9	42.000	10	
8/11/71	0215	73.0	6.9	644.0								8.8	44.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-06															
8/11/71	0615	71.0	5.1	617.0								8.6	38.000		
8/11/71	1015	74.5	7.9	654.0								8.8	43.000		
8/11/71	1415	77.0	9.7	630.0								8.8	39.000		
8/11/71	1800	77.0	11.6	621.0								8.9	39.000		
8/16/72	0001	74.5	6.5	631.0											
8/16/72	0401	74.0	6.6	624.0	.027	.600	.100	1.210	1.940	.039	.373	8.3	27.000	70	
8/16/72	1200	73.0	6.1	647.0											
8/16/72	1600	76.0	6.5	657.0	.021	.530	.110	1.410	2.070	.244	.323	8.4	33.000	90	
8/16/73	0230	74.0	9.6	680.0											
8/16/73	0630	72.5	6.2	751.0	.046	.590	.030	.920	1.560	.193	.290	8.2	33.000	300	
8/16/73	1430	76.5	13.9	690.0											
8/16/73	1825	77.0	17.7	698.0	.025	.140	.030	1.340	1.500	.146	.310	9.0	35.000	110	
8/20/74	0010	77.0	14.4	570.0											
8/20/74	0410	75.5	11.2		.018	.170	.030	1.730	1.915	.067	.230	8.7	29.000	720	
8/20/74	1215	79.0	13.5	570.0											
8/20/74	1610	81.0	18.5	560.0	.016	.150	.030	1.700	1.862	.031	.240	9.1	33.000	510	
8/26/75	0015	75.0	8.1	576.0											
8/26/75	0415	73.0	6.9	576.0	.027	.600	.030	1.100	1.730	.118	.170	8.2	44.000	1,100	
8/26/75	1215	74.0	10.1	598.0											
8/26/75	1615	77.0	14.3	582.0	.022	.250	.030	1.380	1.610	.084	.140	8.6	43.000	300	
MI-07															
4/27/64		54.0	7.0	784.0								7.4	20.000		8800.000
5/27/64		68.0	9.7												15000.000
6/30/64		91.0	8.7												100.000
7/24/64		77.0													91000.000
8/21/64		68.0	5.6												120000.000
9/30/64		58.0	7.4	702.0		.701						7.6	20.000		50000.000
10/29/64		47.0	6.1												66000.000
11/27/64		33.0	11.6												50000.000
12/21/64		32.0	8.0												24000.000
1/25/65		32.0	10.2			.316									3000.000
2/17/65		32.0	6.5			.814									1500.000
10/19/66	1200	49.0	4.8	635.0	.003	.113				.220		7.5	20.000		41000.000
4/10/67	1135	42.0	9.1	705.0	.006	.723				.020		7.6	20.000		8600.000
4/22/68	0935	48.0	6.7	935.0	.038	3.975				.031		7.6	25.700	600	
8/15/68	1200	70.0	8.5	1,550.0	.033	.391				.267		8.4	324.170	900	29000.000
4/02/69	1315	40.0	12.0	860.0	.025	1.000				.073		7.8	35.000	120	13000.000
8/13/69	0915	78.0	5.7	695.0	.034	.400				.280		8.1	95.000	700	41000.000
8/12/70	1125	78.0	6.5	645.0	.043	.270				.237		8.4	38.000	90	
8/12/70	1450	82.5	8.6	650.0								8.5	40.000		
8/12/70	1545	84.5	8.4	610.0								8.5	38.000		
8/12/70	2030	78.0	6.6	645.0								8.4	38.000		
8/13/70	0210	75.0	3.5	695.0								8.1	40.000		
8/13/70	0525	73.5	4.2	630.0								8.2	38.000		
8/10/71	2235	72.0	4.7	610.0	.070	.410				.380		8.0	29.000	240	
8/11/71	0235	69.5	3.9	615.0								8.0	28.000		
8/11/71	0640	68.0	2.5	648.0								7.9	25.000		
8/11/71	1040	70.5	4.2	672.0								8.0	35.000		
8/11/71	1435	75.0	8.3	624.0								8.3	15.000		
8/11/71	1820	75.5	9.5	630.0								8.3	16.000		
8/16/72	0025	70.0	4.0	655.0											
8/16/72	0425	69.5	3.8	669.0	.094	1.590	.130	1.740	3.550			7.9	35.000	500	
8/16/72	1230	69.0	3.8	756.0											
8/16/72	1625	71.0	3.7	790.0	.062	1.340	.190	1.830	3.420	.235	.407	8.1	41.000	920	
8/16/73	0001	72.5	7.7	679.0											
8/16/73	0400	70.0	7.0	651.0	.120	1.210	.240	.930	2.500	.189	.320	7.8	26.000	3,700	
8/16/73	1201	73.0	5.2	680.0											
8/16/73	1600	77.0	7.2	724.0	.067	.900	.100	.740	1.810	.176	.240	8.3	26.000	3,700	
8/20/74	0030	74.0	5.5	620.0											
8/20/74	0430	71.0	4.3		.058	1.120	.260	1.240	2.676	.218	.360	8.0	27.000	27,000	
8/20/74	1240	75.5	5.7	630.0											
8/20/74	1640	76.5	6.8	640.0	.051	1.040	.160	1.130	2.381	.144	.200	8.1	25.000	5,400	
8/28/75	0035	70.0	4.1	576.0											
8/28/75	0435	68.0	4.1	574.0	.041	1.290	.140	1.550	3.030	.210	.220	7.7	32.000	2,700	
8/28/75	1240	68.5	4.2	591.0											
8/28/75	1630	72.5	5.0	592.0	.040	1.350	.130	1.300	2.830	.166	.180	7.9	33.000	1,700	
MI-08															
1/30/64		32.0	3.0	736.0	.200							8.3	20.000		200.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-08															
2/26/64		32.0	10.9	690.0								7.8	20.000		1100.000
3/26/64		33.0	13.1	720.0								8.3	20.000		1000.000
4/27/64		56.0	8.5	730.0								8.0	20.000		1200.000
5/27/64		67.0	9.2	1,150.0								7.4	130.000		11000.000
6/30/64		85.0	11.9	520.0								7.5	20.000		800.000
7/24/64		77.0		640.0								7.0	20.000		17000.000
8/21/64		68.0	6.4	554.0	.100							7.9	20.000		40000.000
9/30/64		56.0	9.7	708.0		.475						8.0	15.000		
10/29/64		50.0	9.8	690.0		.158						7.9	30.000		700.000
11/27/64		32.0	13.4	676.0		.362						7.9	20.000		800.000
12/21/64		33.0	6.6	888.0		.588						7.3	30.000		400.000
1/25/65		32.0	.4	652.0	.200	.203						7.3	20.000		100.000
2/17/65		32.0	4.0	574.0		.158						7.1	20.000		900.000
10/19/66	1220	49.0	9.5	630.0	.003	.068				.720		7.6	30.000		6800.000
4/10/67	1115	44.0	9.6	625.0	.009	.475				.060		8.0	15.000		4500.000
4/23/68	0850	52.0	7.5	770.0	.059	2.156				.082		7.8	22.300	800	
8/15/68	0920	69.0	6.8	830.0	.010	.196				.183		8.4	111.320	680	12000.000
4/02/69	1015	37.0	12.4	805.0	.018	1.400				.057		8.1	35.000	220	7400.000
8/12/69	1040		6.6	645.0	.012	.300				.143		8.3	78.000	360	6200.000
8/12/70	0730	71.5	4.4	640.0	.007	.120				.143		8.3	30.000	500	
8/12/70	1215	76.0	9.1	645.0								8.5	36.000		
8/12/70	1535	81.0	7.8	610.0								8.8	37.000		
8/12/70	2015	77.5	7.8	600.0								8.8	38.000		
8/13/70	0155	76.0	4.8	580.0								8.6	41.000		
8/13/70	0515	74.0	4.1	590.0								8.4	44.000		
8/10/71	2225	73.0	6.0	603.0	.009	.180				.227		8.6	29.000	150	
8/11/71	0225	69.0	4.4	629.0								8.3	30.000		
8/11/71	0625	68.0	4.4	636.0								8.2	24.000		
8/11/71	1025	68.0	5.9	643.0								8.3	28.000		
8/11/71	1420	71.5	9.1	611.0								8.4	13.000		
8/11/71	1810	74.0	9.8	609.0								8.6	13.000		
8/16/72	0010	72.0	5.3	540.0											
8/16/72	0410	70.5	5.4	550.0	.094	1.360	.070	.980	2.500	.384	.423	7.9	28.000	600	
8/16/72	1215	70.0	5.2	638.0											
8/16/72	1610	73.0	5.3	663.0	.071	1.410	.120	1.810	3.410	.232	.407	8.1	36.000	200	
8/16/73	0240	72.0	6.1	664.0											
8/16/73	0640	70.0	5.5	672.0	.022	1.060		.630	1.710	.164	.190	8.1	28.000	320	
8/16/73	1445	80.0	14.0	669.0											
8/16/73	1840	78.0	9.1	688.0	.028	.840		.940	1.810	.283	.370	9.0	39.000	140	
8/20/74	0015	75.0	6.0	620.0											
8/20/74	0415	74.0	5.1		.050	1.170	.070	1.190	2.477	.204	.230	8.0	25.000	820	
8/20/74	1225	76.0	7.1	650.0											
8/20/74	1620	77.5	8.2	660.0	.035	1.370	.190	1.100	2.703	.163	.210	8.4	27.000	1,600	
8/28/75	0025	72.0	4.9	543.0											
8/28/75	0425	69.0	5.2	551.0	.074	1.470	.090	1.640	3.280	.274	.370	7.8	30.000	5,300	
8/28/75	1220	69.5	4.9	549.0											
8/28/75	1625	72.0	5.1	570.0	.065	1.280	.110	1.430	2.880	.224	.280	8.0	31.000	1,500	
MI-09															
2/26/64		33.0	15.1	720.0								8.2	40.000		27000.000
4/27/64		54.0	9.8	594.0								8.4	15.000		3700.000
5/27/64		68.0	9.6												4000.000
6/29/64		85.0	16.5												2100.000
7/23/64		79.0	5.9												14000.000
8/20/64		68.0	8.0												10000.000
9/30/64		59.0	12.3	682.0		.520						8.3	30.000		11000.000
10/29/64		50.0	12.1												2000.000
11/27/64		33.0	14.3												3000.000
12/21/64		33.0	10.6												300.000
1/25/65		32.0	7.9			.407									100.000
2/17/65		32.0	12.8			.113									3000.000
10/19/66	1325	52.0	16.2	610.0	.009	.226				.570		7.8	30.000		5700.000
4/10/67	1205	46.0	12.4	560.0	.006	.294				.120		8.6	15.000		6000.000
4/23/68	0825	53.0	5.8	656.0	.054	1.108				.144		8.0	17.400	800	
8/15/68	0900	70.0	5.8	638.0	.013	.361				.617		8.2	47.060	900	2100.000
4/02/69	0945	37.0	15.0	700.0	.016	1.200				.193		8.3	25.000	1,200	26000.000
8/12/69	1010	72.0	9.0	640.0	.015	.200				.650		8.4	57.000	230	14000.000
8/12/70	0655	73.0	1.2	740.0	.072	.140				1.133		8.1	51.000	70	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-09															
8/12/70	1145	78.0	15.5	745.0								8.8	54.000		
8/12/70	1430	83.5	18.6	620.0								9.3	52.000		
8/12/70	2000	82.0	11.1	680.0								9.0	55.000		
8/13/70	0135	76.0	.5	710.0								8.3	61.000		
8/13/70	0500	75.0	.7	720.0								8.1	66.000		
8/10/71	2200	74.5	1.2	738.0	.043	.330				.513		8.1	49.000	10	
8/11/71	0200	71.0	1.2	728.0								7.9	50.000		
8/11/71	0600	67.0	.9	761.0								7.8	49.000		
8/11/71	1000	72.0	11.4	775.0								8.4	58.000		
8/11/71	1400	78.0	21.3	676.0								9.2	26.000		
8/11/71	1750	79.0	16.0	671.0								9.2	29.000		
8/16/72	0300	73.0	6.1	615.0											
8/16/72	0700	73.0	6.6	636.0	.036	.600	.100	1.350	2.090			8.3	31.000	50	
8/16/72	1440	74.0	10.1	572.0											
8/16/72	1900	76.0	6.7	596.0	.096	1.230	.150	1.510	2.990	.326	.380	8.3	33.000	280	
8/16/73	0255	71.0	4.3	722.0											
8/16/73	0655	70.5	4.5	698.0	.041	.960	.030	.830	1.830	.283	.410	8.0	38.000	280	
8/16/73	1505	76.0	9.0	669.0											
8/16/73	1855	78.0	10.1	662.0	.037	.800		.800	1.640	.189	.220	8.6	28.000	220	
8/20/74	0001	74.5	5.3	610.0											
8/20/74	0400	73.0	5.5		.022	.930	.030	1.530	2.491	.156	.280	8.3	32.000	710	
8/20/74	1200	79.5	12.2	640.0											
8/20/74	1600	80.5	12.7	650.0	.019	.880	.030	1.570	2.447	.170	.260	8.9	34.000	40	
8/26/75	0001	74.0	5.6	585.0											
8/26/75	0401	73.0	5.8	572.0	.031	.870	.030	1.170	2.110	.145	.160	8.1	41.000	860	
8/26/75	1200	74.0	7.8	585.0											
8/26/75	1600	75.0	7.9	562.0	.060	1.450	.050	1.520	3.080	.218	.140	8.2	36.000	760	
MI-10															
2/26/64		32.0	14.9	720.0								8.2	45.000		29000.000
4/27/64		56.0	10.1	652.0								8.1	30.000		23000.000
5/27/64		67.0	9.4												3500.000
6/29/64		87.0	11.6												11000.000
7/23/64		79.0	5.0												12000.000
8/20/64		68.0	7.5												16000.000
9/30/64		58.0	9.5	670.0		.520						7.9	20.000		150000.000
10/29/64		50.0	10.7												1000.000
11/27/64		33.0	14.9												1700.000
12/21/64		33.0	15.8												800.000
1/25/65		32.0	12.4			.429									3000.000
2/17/65		32.0	12.7			.610									13000.000
10/19/66	1345	52.0	11.9	625.0	.006	.181				.640		7.8	30.000		3300.000
4/10/67	1225	45.0	11.2	530.0	.006	.226				.120		8.2	15.000		5500.000
4/23/68	0810	53.0	8.7	640.0	.040	.912				.129		8.0	20.000	1,500	
8/12/68	1120	75.0	8.6	592.0	.036	.135				.510		8.6	19.530	30,000	389999.872
4/02/69	0930	36.0	13.7	700.0	.015	1.100				.143		8.2	28.000	1,900	53000.000
8/12/69	0940	74.0	7.9	660.0	.026	.200				1.177		8.6	57.000	400	18000.000
7/30/70	1000	80.0	8.7	670.0	.031	.290				.933		8.5	38.000	4,200	
7/30/70	1300	83.0	7.0	760.0								8.7			
7/30/70	1650	83.0	7.7	660.0								8.9	56.000		
7/30/70	2015	79.0	15.3	655.0								8.8	48.000		
7/31/70	0420	79.0	6.1	610.0								8.8	21.000		
7/31/70	1250	79.5	6.5	615.0								8.8	20.000		
8/10/71	0030	75.5	1.5	771.0	.107	.290				.700		8.3	60.000	5,200	
8/10/71	0430	76.0	1.6	774.0								8.3	52.000		
8/10/71	0845	77.0	4.1	763.0								8.4	56.000		
8/10/71	1215	83.5	7.6	788.0								8.6	57.000		
8/10/71	1715	75.0	2.3	739.0								8.2	63.000		
8/10/71	2040	75.0	2.3	768.0								8.2	58.000		
8/15/72	0200	74.5	7.1	600.0											
8/15/72	0600	74.0	7.2	603.0	.047	.830	.150	1.400	2.430	.102	.150	8.2	33.000	170	
8/15/72	1350	73.0	4.5	700.0											
8/15/72	1800	73.0	6.9	689.0	.058	.850	.200	1.330	2.440	.245	.387	8.2	41.000	300	
8/20/73	0240	75.0	6.7	701.0											
8/20/73	0635	75.5	7.1	699.0	.031	.450	.060	1.120	1.660	.228	.230	8.3	36.000	160	
8/20/73	1430	77.0	7.8	764.0											
8/20/73	1830	76.0	7.4	703.0	.065	.590	.250	1.060	1.970	.235	.320	8.6	49.000	930	
8/21/74	0150	76.0	8.0	575.0											

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-10															
8/21/74	0555	75.0	7.8	575.0	.024	.270	.240	1.580	2.115	.106	.250	8.6	34.000	400	
8/21/74	1345	77.5	10.7	650.0											
8/21/74	1800	78.0	9.4	600.0	.033	.250	.270	1.460	2.013	.111	.240	8.9	35.000	300	
8/27/75	0150	72.5	7.6	543.0											
8/27/75	0550	72.0	7.5	595.0	.031	1.020	.190	1.420	2.660	.176	.220	8.2	43.000	280	
8/27/75	1315	74.0	8.0	625.0											
8/27/75	1715	74.0	8.6	606.0	.025	.930	.180	1.430	2.560	.140	.200	8.5	47.000	150	
MI-11															
1/30/64		32.0	9.3	580.0	.300							7.8	80.000		45000.000
2/26/64		33.0	10.6	574.0								7.6	70.000		8000.000
3/26/64		33.0	13.9	584.0								7.8	45.000		4000.000
4/27/64		56.0	7.6	620.0								7.8	30.000		24000.000
5/27/64		73.0	7.1	648.0								7.4	20.000		1400.000
6/29/64		85.0	10.7	590.0								7.3	35.000		3000.000
7/23/64		79.0	4.6	388.0								7.4	20.000		170000.000
8/20/64		69.0	7.8	590.0	.100							8.6	30.000		19000.000
9/30/64		58.0	8.5	618.0	.100	.475						7.9	15.000		32000.000
10/29/64		50.0	5.8	560.0	.100	.746						7.4	45.000		60000.000
11/27/64		33.0	13.9	720.0		.452						8.5	30.000		160000.000
12/21/64		33.0	9.0	964.0		1.605						7.3	170.000		140000.000
1/25/65		32.0	10.9	840.0		.633						7.7	55.000		140000.000
2/17/65		32.0	11.7	540.0	.200	.136						7.3	55.000		50000.000
10/19/66	1410	51.0	7.7	585.0	.006	.181				.440		7.7	35.000		33000.000
4/10/67	1245	46.0	11.6	560.0	.006	.203				.190		8.4	20.000		469999.872
4/23/68	1135	54.0	8.8	662.0	.049	.957				.135		8.0	18.500	3,500	
8/12/68	1145	74.0	8.9	572.0	.012	.105				.450		8.6	18.530	13,000	220000.000
4/02/69	0915	38.0	11.0	710.0	.055	1.300				.217		7.9	55.000	15,000	160000.000
8/12/69	0910	73.0	7.3	600.0	.016	.100				2.380		8.6	53.000	40,000	440000.000
7/30/70	1025	80.0	11.0	600.0	.015	.200				.600		8.8	48.000	1,500	
7/30/70	1330	83.0	12.9	620.0								8.9			
7/30/70	1715	85.0	15.7	540.0								9.1	45.000		
7/30/70	2035	83.0	13.0	550.0								9.1	51.000		
7/31/70	0120	75.5	10.5	610.0								8.8	23.000		
7/31/70	0445	78.0	10.5	595.0								9.0	22.000		
8/10/71	0055	75.0	11.5	771.0	.088	.460				1.063		8.8	60.000	2,000	
8/10/71	0445	75.0	10.9	784.0								8.9	120.000		
8/10/71	0905	78.0	7.3	735.0								8.5	60.000		
8/10/71	1240	79.0	10.4	768.0								8.8	60.000		
8/10/71	1730	78.0	10.5	712.0								8.6	60.000		
8/10/71	2110	77.0	9.8	743.0								8.7	60.000		
8/15/72	0220	72.5	5.9	471.0											
8/15/72	0620	72.0	6.1	486.0	.073	.680	.330	1.200	2.280	.053	.070	8.0	33.000	4,300	
8/15/72	1410	75.0	5.5	530.0											
8/15/72	1815	74.0	6.5	572.0	.072	.830	.260	1.500	2.660	.155	.437	8.2	39.000	9,700	
8/20/73	0300	77.5	7.3	675.0											
8/20/73	0700	76.5	6.8	603.0	.016	.140	.030	1.280	1.440	.127	.290	8.6	39.000	590	
8/20/73	1450	78.0	10.7	617.0											
8/20/73	1850	77.0	12.0	637.0	.013	.190	.030	1.020	1.220	.136	.260	8.8	43.000	7,100	
8/21/74	0210	76.0	9.3	550.0											
8/21/74	0615	76.0	7.4	540.0	.017	.170	.080	1.460	1.723	.089	.220	8.8	35.000	220	
8/21/74	1410	78.0	9.7	560.0											
8/21/74	1820	78.5	11.0	560.0	.016	.210	.260	1.490	1.983	.088	.200	8.9	35.000	150	
8/27/75	0210	75.0	7.2	564.0											
8/27/75	0610	73.0	6.4	566.0	.027	.870	.140	1.270	2.310	.120	.260	8.4	42.000	620	
8/27/75	1340	75.0	10.5	585.0											
8/27/75	1740	75.0	12.4	564.0	.023	.770	.120	1.440	2.350	.089	.200	8.6	43.000	390	
MI-12															
4/27/64		57.0	5.8	696.0								8.4	45.000		110000.000
5/27/64		68.0	2.1												34000.000
6/29/64		79.0	2.0												9000.000
7/23/64		79.0	4.5												150000.000
8/20/64		69.0	2.9												14000.000
9/30/64		58.0	8.8	508.0	.100	.542						7.6	20.000		13000.000
10/29/64		51.0	6.9												3000.000
11/27/64		37.0	9.6												6000.000
2/17/65		33.0	12.0			.452									30000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MI-12															
10/19/66	1450	58.0	4.8	420.0	.012	.249				.360		7.5	35.000		26000.000
4/10/67	1320		9.3	605.0	.006	.226				.160		7.9	20.000		10100.000
4/23/68	1215	55.0	7.0	783.0	.081	.939				.179		7.8	39.600	29,000	
8/12/68	1210	72.0	.4	475.0	.028	.120				.350		7.4	15.550	15,000	240000.000
4/02/69	0845	39.0	10.7	880.0	.036	.600				.210		8.1	67.000	11,000	32000.000
8/12/69	0845	77.0	.6	525.0	.015	.100				.757		7.4	48.000	31,000	489999.872
8/11/70	1055	83.0	.4	465.0	.360	.090				.400		7.6	36.000	370	
8/11/70	1400	83.5	.7	480.0								7.8	32.000		
8/11/70	1720	86.0	2.0	485.0								7.6	34.000		
8/11/70	2105	84.0	.6	440.0								7.6	35.000		
8/12/70	0115	80.0	.4	470.0								7.6	32.000		
8/12/70	0500	79.5	.4	470.0								7.6	34.000		
8/09/71	0015	71.5	3.3	474.0	.075	.310				.193		7.5	29.000	80	
8/09/71	0415	62.0	3.8	468.0								7.4	29.000		
8/09/71	0830	69.5	3.6	515.0								7.5	33.000		
8/09/71	1210	75.0	3.6	485.0								7.5	30.000		
8/09/71	1615	75.0	4.0	478.0								7.5	29.000		
8/09/71	2010	75.0	3.7	456.0								7.5	27.000		
8/14/72	0245	75.0	3.1	608.0											
8/14/72	0645	75.0	3.1	577.0	.088	.420	.600	1.300	2.410	.337	.380	7.9	46.000	800	
8/14/72	1425	76.0	3.3	606.0											
8/14/72	1830	73.0	3.4	652.0	.080	.520	.440	1.540	2.580	.265	.423	7.8	45.000	6,600	
8/15/73	0215	74.0	.7	481.0											
8/15/73	0610	75.0	.4	507.0	.009	.070	.770	.610	1.460	.159	.270	7.5	30.000	300	
8/15/73	1410	72.0	.3	476.0											
8/15/73	1805	75.0	1.2	502.0	.008	.130	.210	.180	.530	.136	.320	7.4	29.000	26,000	
8/19/74	0215	67.5	3.7	800.0											
8/19/74	0610	68.0	3.7	420.0	.047	.150	.320	1.120	1.639	.078	.150	7.8	29.000	23,000	
8/19/74	1410	73.0	5.7	490.0											
8/19/74	1805	74.5	4.1	490.0	.019	.210	.250	1.220	1.704	.102	.180	7.9	32.000	22,000	
8/25/75	0205	76.0	2.5	401.0											
8/25/75	0610	75.0	2.6	409.0	.034	.590	.540	.960	2.120	.143	.190	7.6	42.000	2,300	
8/25/75	1320	77.0	3.2	412.0											
8/25/75	1715	78.0	3.0	467.0	.038	.670	.370	1.090	2.170	.125	.210	7.7	50.000	6,300	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-01															
1/29/64		34.0	3.1	1,350.0	.200							8.2	30.000		300.000
2/20/64		32.0	6.7	1,000.0								7.5	15.000		200.000
3/12/64		32.0	13.4	694.0											100.000
4/01/64		36.0	9.6	1,350.0								8.3	20.000		900.000
5/15/64		54.0	5.6	910.0								7.4	20.000		27000.000
6/18/64		67.0	1.0	638.0								8.3	15.000		100.000
7/22/64		70.0	.5	810.0								7.4	20.000		16000.000
8/19/64		61.0	2.8	656.0	.100							7.4	15.000		4000.000
9/28/64		46.0	5.1	676.0		.429						7.6	15.000		4000.000
10/14/64		47.0	5.8	678.0		.407						7.6	20.000		800.000
11/30/64		32.0	6.3	1,340.0		1.853						7.2	30.000		2500.000
12/17/64		32.0	8.0	1,170.0		.904						7.4	20.000		300.000
1/21/65		32.0	9.1	984.0		1.153						7.4	20.000		200.000
2/24/65		32.0	4.8	918.0	.100	1.333						7.3	20.000		100.000
4/12/66	1305	48.0	6.1	670.0		.500				.060		7.4	15.000		2500.000
4/05/67	0850	42.0	8.1	855.0	.010	7.100				.010		7.2	20.000		100.000
4/23/68	0740	46.0	5.6	1,182.0	.034	3.854				.019		7.2	27.000	100	
8/12/68	1100	59.0	6.0	718.0	.039	1.445				.100		7.8	21.770	1,200	9000.000
3/31/69	0955	32.0	10.1	1,100.0	.010	1.200				.013		7.4	34.000	10	200.000
8/13/69	0850	66.0	4.0	720.0	.029	1.200				.050		7.8	34.000	1,500	96000.000
7/31/70	0345	73.5	6.2	720.0								8.2	28.000		
7/31/70	0435	80.0	12.6	730.0								8.3	15.000		
7/31/70	0800	80.0	15.5	680.0								8.6	15.000		
7/31/70	0930	70.0	3.3	760.0	.044	.610				.096		7.3	28.000	800	
7/31/70	1225	77.0	10.8	690.0								8.4	28.000		
7/31/70	1240	75.0	5.5	800.0								7.8			
8/10/71	0015	75.0	4.0	725.0	.065	.550				.083		7.8	24.000	40	
8/10/71	0415	75.5	2.5	715.0								7.7	24.000		
8/10/71	0825	70.0	1.5	702.0								7.7	25.000		
8/10/71	1200	78.0	7.9	707.0								7.9	24.000		
8/10/71	1650	74.0	8.0	654.0								8.0	24.000		
8/10/71	2010	74.0	5.7	669.0								7.9	24.000		
8/15/72	0145	67.0	3.6	498.0											
8/15/72	0545	66.0	3.4	507.0	.110	1.890	.100	1.940	4.040	.338	.400	7.5	23.000	7,100	
8/15/72	1340	68.0	3.8	547.0											
8/15/72	1745	69.0	3.4	571.0	.098	1.920	.120	2.180	4.320	.110	.320	7.7	26.000	1,800	
8/20/73	0225	73.0	6.0	785.0											
8/20/73	0620	72.0	5.0	781.0	.061	2.290	.100	.690	3.140	.038	.070	7.9	27.000	140	
8/20/73	1405	75.0	7.7	785.0											
8/20/73	1805	77.0	9.6	779.0	.550	2.040	.030	.770	2.870	.027	.110	8.0	28.000	20	
8/21/74	0130	69.0	7.5	710.0											
8/21/74	0540	68.0	6.6	700.0	.041	2.540	.230	1.020	3.833	.059	.080	8.1	32.000	370	
8/21/74	1335	71.0	4.6	750.0											
8/21/74	1745	73.5	7.7	760.0	.051	2.470	.220	1.030	3.771	.068	.080	8.1	32.000	630	
8/21/75	0535	61.0	4.9	726.0	.023	1.740	.210	1.660	3.630	.119	.140	7.7	37.000	340	
8/27/75	1300	64.5	6.0	731.0											
8/27/75	1700	68.0	5.6	741.0	.015	1.700	.160	1.540	3.420	.076	.100	7.8	37.000	630	
MN-02															
4/01/64		41.0	6.3	1,100.0								8.2	30.000		40000.000
5/15/64		59.0	5.9	884.0								7.6			72000.000
6/18/64		65.0	1.7												26000.000
7/22/64		71.0	.7												110000.000
8/19/64		62.0	2.5												60000.000
9/28/64		51.0	4.0												14000.000
10/14/64		53.0	4.8	736.0		.249						7.6	45.000		10000.000
12/17/64		32.0	4.8												60000.000
1/21/65		33.0	2.7			.226									12000.000
2/24/65		32.0	6.9			.633									2100.000
4/12/66	1250	51.0	3.1	765.0	.030	.200				1.370		7.5	35.000		4000000.000
4/05/67	0905	44.0	6.8	860.0	.020	5.400				.160		7.4	30.000		10900.000
4/23/68	0750		6.3	1,032.0	.048	4.140				.157		7.4	30.000	12,000	
8/12/68	1045	64.0	2.3	732.0	.086	.425				.850		7.8	35.700	1,200	14000.000
3/31/69	0945	32.0	11.0	1,120.0	.018	1.900				.137		7.8	47.000	900	50000.000
8/13/69	0830	72.0	.1	900.0	.032	.100				.860		7.4	44.000	400,000	9999999.999
7/30/70	0425	81.0	4.5	825.0								7.7	58.000		
7/30/70	0755	79.0	2.9	655.0								7.7	40.000		
7/30/70	0940	71.0	2.3	745.0	.076	.750				.150		7.6	31.000	5,800	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-02															
7/30/70	1245	76.0	4.0	875.0								7.7			
7/31/70	0340	71.0	.8	765.0								7.2	17.000		
7/31/70	1230	73.0	1.2	740.0								7.4	15.000		
8/09/71	2400	77.0	1.7	884.0	.027	.890				1.610		7.6	55.000	3,000	
8/10/71	0400	74.0	2.1	877.0								7.6	52.000		
8/10/71	0820	70.5	3.2	876.0								7.7	55.000		
8/10/71	1145	77.0	5.2	889.0								7.8	51.000		
8/10/71	1700	73.0	2.7	764.0								7.6	57.000		
8/10/71	2025	72.0	3.6	723.0								7.8	45.000		
8/15/72	0135	68.0	3.7	501.0											
8/15/72	0535	67.5	4.3	518.0	.071	1.170	.110	1.780	3.130	.396	.520	7.6	31.000	10,000	
8/15/72	1330	68.5	7.2	622.0											
8/15/72	1735	70.5	4.1	633.0	.100	1.350	.190	1.810	3.450	.271	.390	7.9	37.000	2,700	
8/20/73	0215	74.5	12.2	910.0											
8/20/73	0615	73.0	10.6	902.0	.052	.390	.060	1.270	1.770	1.011	1.090	8.8	76.000	70	
8/20/73	1355	77.0	17.3	915.0											
8/20/73	1755	77.0	18.7	880.0	.020	.210		1.200	1.430	.975	1.320	9.1	79.000	70	
8/21/74	0125	74.5	10.8	660.0											
8/21/74	0535	73.5	9.7	650.0	.061	.340	.340	2.030	2.778	.253	.400	8.3	36.000	380	
8/21/74	1325	77.5	14.8	700.0											
8/21/74	1740	78.5	18.1	670.0	.056	.260	.110	2.240	2.664	.253	.460	9.0	40.000	510	
8/27/75	0125	69.5	6.0	668.0											
8/27/75	0525	68.0	5.7	673.0	.033	1.020	.310	1.960	3.310	.150	.070	7.8	48.000	630	
8/27/75	1250	73.0	8.1	668.0											
8/27/75	1650	73.5	11.6	694.0	.038	.900	.170	2.110	3.230	.043	.150	8.2	50.000	1,100	
MN-03															
2/20/64		32.0	6.8	836.0								7.5	30.000		1100.000
4/01/64		40.0	6.5	980.0								8.0	35.000		6000.000
5/15/64		59.0	8.5	884.0								7.8			10000.000
6/18/64		63.0	1.0												2000.000
7/22/64		73.0										7.2			150000.000
8/19/64		62.0	6.2												10000.000
9/28/64		48.0	11.3												6000.000
10/14/64		52.0	14.2	720.0		.203						8.0	35.000		200.000
12/17/64		32.0	5.6												13000.000
1/21/65		32.0	3.8			.113									2900.000
2/24/65		32.0	3.1			.610									2700.000
4/12/66	1240	49.0	9.6	710.0	.030	.200				.760		7.7	30.000		15000.000
4/05/67	0920	45.0	7.5	870.0	.020	4.400				.110		7.4	35.000		7500.000
4/23/68	0715	48.0	6.4	1,002.0	.048	3.035				.085		7.6	41.200	1,600	
8/12/68	1020	66.0	4.6	755.0	.023	.166				.770		7.8	43.160	40	900.000
3/31/69	0935	32.0	11.5	1,120.0	.018	1.500				.110		7.6	43.000	600	59000.000
8/13/69	1100	73.0	8.0	760.0	.114	.400				.650		7.9	56.000	390	20000.000
7/30/70	0415	86.0	4.6	700.0								7.9	38.000		
7/30/70	0740	81.0	3.2	650.0								7.8	33.000		
7/30/70	0915	74.0	2.5	675.0	.084	.260				.140		7.6	23.000	250	
7/30/70	1220	82.0	4.5	775.0								7.7			
7/31/70	0330	73.5	1.9	545.0								7.6	12.000		
7/31/70	1200	75.0	1.5	565.0								7.4	14.000		
8/09/71	2345	79.0	1.8	794.0	.043	.310				1.390		8.0	43.000	100	
8/10/71	0345	76.0	.7	898.0								7.7	62.000		
8/10/71	0805	74.0	1.9	898.0								7.8	60.000		
8/10/71	1130	79.5	7.8	893.0								8.0	60.000		
8/10/71	1635	77.0	5.0	788.0								8.0	53.000		
8/10/71	2000	75.0	3.2	756.0								7.9	41.000		
8/15/72	0125	69.5	2.4	558.0											
8/15/72	0525	68.0	2.6	581.0	.086	.950	.170	1.470	2.680	.365	.460	7.5	39.000	4,300	
8/15/72	1320	68.0	3.2	656.0											
8/15/72	1725	69.0	3.5	661.0	.081	.950	.130	1.530	2.640	.088	.410	7.8	44.000	2,800	
8/20/73	0205	74.5	6.3	842.0											
8/20/73	0555	72.0	5.1	859.0	.045	.410	.050	1.270	1.770	.604	.870	8.6	62.000	240	
8/20/73	1340	76.0	11.6	852.0											
8/20/73	1740	79.0	17.0	853.0	.024	.220		1.220	1.460	.567	.660	8.9	64.000	70	
8/21/74	0115	73.0	5.7	660.0											
8/21/74	0520	70.5	4.9	660.0	.063	.430	.210	1.850	2.553	.277	.380	8.2	40.000	860	
8/21/74	1315	77.0	15.3	700.0											
8/21/74	1730	80.0	20.1	680.0	.032	.180	.140	1.670	2.033	.191	.290	9.0	33.000	280	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-03															
8/27/75	0110	67.0	5.4	710.0											
8/27/75	0510	65.0	5.6	715.0	.026	.900	.250	1.440	2.620	.171	.210	7.8	47.000	470	
8/27/75	1240	67.5	6.5	731.0											
8/27/75	1640	73.0	7.5	731.0	.023	.810	.090	1.560	2.480	.106	.140	7.9	53.000	710	
MN-04															
4/01/64		40.0	11.5	1,100.0								7.8	70.000		180000.000
5/15/64		62.0	13.5	1,200.0								8.4			220000.000
6/18/64		66.0	6.0												16000.000
7/22/64		77.0	2.1												16000.000
8/19/64		64.0	2.3												80000.000
9/28/64		50.0	4.6												60000.000
10/14/64		53.0	6.1	996.0	.100	1.492						7.7	105.000		9000.000
11/30/64		32.0	12.8												90000.000
12/17/64		32.0	11.6												1100000.000
1/21/65		33.0	11.5			.226									290000.000
2/24/65		34.0	12.8			.678									250000.000
4/12/66	1220	52.0	3.5	1,190.0	.350	.600				.410		7.5	130.000		66000.000
4/05/67	0935	49.0	13.1	1,560.0	.050	3.800				.560		8.2	115.000		86000.000
4/23/68	0705	50.0	8.7	652.0	.086	1.915				.213		7.8	46.400	27,000	
8/12/68	1005	65.0	2.3	1,128.0	.163	.181				3.037		7.8	114.300	600	26000.000
3/31/69	0925	34.0	13.3	1,500.0	.081	1.200				.873		8.1	154.000	70,000	400000.000
8/11/69	1030	73.0	1.8	990.0	.423	.200				2.310		7.8	149.000	80	13000.000
7/30/70	0400	87.0	9.0	925.0								8.1	104.000		
7/30/70	0730	80.0	5.3	540.0								8.0	40.000		
7/30/70	0820	72.0	4.6	670.0	.340	1.200				1.930		7.8	27.000	900	
7/30/70	1210	72.0	8.5	1,030.0								8.0			
7/31/70	0315	75.0	3.8	730.0								7.6	26.000		
7/31/70	1145	75.0	3.4	720.0								7.6	26.000		
8/09/71	2330	77.0	3.3	1,282.0	.418	1.160				4.350		8.0	126.000	350	
8/10/71	0330	77.0	1.0	1,288.0								7.8	131.000		
8/10/71	0750	73.0	1.7	1,184.0								7.7	116.000		
8/10/71	1115	76.0	4.8	1,136.0								7.8	100.000		
8/10/71	1625	73.5	5.0	781.0								7.7	115.000		
8/10/71	1950	72.0	3.0	656.0								7.6	82.000		
8/15/72	0115	70.0	5.7	710.0											
8/15/72	0515	69.0	6.1	717.0	.111	.920	.370	1.840	3.240	.466	.570	7.7	57.000	2,200	
8/15/72	1310	70.0	7.4	693.0											
8/15/72	1715	71.0	7.0	681.0	.102	1.160	.290	2.300	3.850		.680	8.0	53.000	4,800	
8/20/73	0145	73.0	1.8	1,151.0											
8/20/73	0545	71.0	2.2	1,066.0	.170	2.090	1.180	1.230	4.670	2.480	2.820	8.0	105.000	350	
8/20/73	1320	76.0	6.0	1,566.0											
8/20/73	1720	80.0	9.8	1,524.0	.138	2.140	3.610	1.610	7.500	2.124	2.620	8.3	264.000	2,200	
8/21/74	0105	72.0	2.8	900.0											
8/21/74	0510	70.0	3.1	840.0	.245	2.440	1.050	1.670	5.398	1.738	2.370	8.1	57.000	1,000	
8/21/74	1305	77.5	5.7	1,100.0											
8/21/74	1720	81.5	7.4	1,150.0	.240	3.370	1.420	1.690	6.709	.941	1.040	8.5	119.000	320	
8/27/75	0055	68.0	6.7	731.0											
8/27/75	0455	65.0	7.2	741.0	.053	1.040	.550	1.320	2.970	.011	.060	8.0	52.000	3,400	
8/27/75	1230	68.5	7.8	814.0											
8/27/75	1630	71.0	7.6	793.0	.060	1.330	.670	1.570	3.620	.093	.040	8.2	62.000	2,100	
MN-05															
2/20/64			9.0	1,360.0	.100							7.3	185.000		30000.000
4/01/64		36.0	10.4	1,180.0								8.1	100.000		240000.000
5/15/64		59.0	9.1	1,020.0								7.9			260000.000
6/18/64		64.0	3.1												2000.000
7/22/64		77.0	.8												11000.000
8/19/64		64.0	2.5												5000.000
9/28/64		49.0	3.7												3000.000
10/14/64		53.0	8.3	1,350.0	.200	1.266						7.7	215.000		300.000
12/17/64		32.0	9.2												165000.000
1/21/65		33.0	8.0												350000.000
2/24/65		32.0	9.1			.701									70000.000
4/12/66	1200	49.0	3.5	1,540.0	.360	.700				.410		7.4	225.000		16000.000
4/05/67	0950	47.0	9.9	970.0	.060	3.700				.530		8.0	55.000		24000.000
4/23/68	0650	51.0	7.4	1,108.0	.105	2.662				.276		7.8	106.100	9,800	
8/12/68	0950	66.0	3.3	1,062.0	.143	1.144				1.697		7.8	114.300	300	18000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-05															
3/31/69	0910	32.0	11.6	1,240.0	.062	1.200				.393		8.0	73.000	4,500	82000.000
8/11/69	1015	74.0	1.4	1,100.0	.110	.200				1.870		7.8	138.000	120	10000.000
7/30/70	0335	83.0	7.1	930.0								8.1	100.000		
7/30/70	0720	81.0	5.5	965.0								8.0	90.000		
7/30/70	1000	75.0	1.5	875.0	.250	.640				2.060		7.6	65.000	510	
7/30/70	1155	79.0	5.3	1,030.0								7.9			
7/31/70	0305	76.5	.8	740.0								7.4	44.000		
7/31/70	1130	79.0	1.1	1,020.0								7.6	91.000		
8/09/71	2315	78.0	.8	1,513.0	.186	.240				3.640		7.8	229.000	60	
8/10/71	0315	81.0	1.0	1,437.0								7.8	192.000		
8/10/71	0715	75.5	.8	1,363.0								7.8	180.000		
8/10/71	1100	77.5	3.9	1,549.0								7.8	247.000		
8/10/71	1555	75.5	3.8	1,605.0								7.8	315.000		
8/10/71	1900	75.0	2.0	1,496.0								7.8	273.000		
8/15/72	0105	70.0	4.7	655.0											
8/15/72	0505	69.0	4.8	730.0	.144	.930	.390	1.930	3.390	.396	.573	7.7	76.000	3,700	
8/15/72	1300	70.5	5.3	743.0											
8/15/72	1705	72.0	5.7	729.0	.171	1.160	.400	2.200	3.930		.703	7.9	73.000	2,300	
8/20/73	0105	75.0	.7	1,151.0											
8/20/73	0505	73.5	.8	1,213.0	.270	.830	1.290	.990	3.380	2.572	2.270	7.8	149.000	160	
8/20/73	1305	76.0	7.2	1,459.0											
8/20/73	1705	78.0	9.9	1,240.0	.548	1.690	.630	1.270	4.140	2.235	2.470	8.2	166.000	310	
8/21/74	0100	75.0	3.4	1,200.0											
8/21/74	0505	73.0	2.4	1,180.0	.297	2.400	1.980	1.330	6.010	1.074	1.210	7.9	148.000	2,400	
8/21/74	1255	77.5	5.4	1,175.0											
8/21/74	1715	80.5	6.9	1,125.0	.306	1.920	1.710	1.390	5.327	1.605	1.730	8.1	100.000	840	
8/27/75	0050	69.0	5.4	773.0											
8/27/75	0450	67.0	5.5	775.0	.070	1.070	.640	1.400	3.190	.161	.340	8.0	62.000	3,600	
8/27/75	1220	69.0	6.5	835.0											
8/27/75	1620	72.0	6.7	877.0	.085	1.310	.680	1.390	3.480	.093	.320	8.2	86.000	5,200	
MN-06															
1/29/64		34.0	5.7	1,440.0	.100							7.4	155.000		50000.000
3/12/64		32.0	8.9	936.0								8.4	165.000		37000.000
4/01/64		37.0	10.2	1,240.0								8.4	120.000		50000.000
5/15/64		62.0	10.0	1,040.0								8.2	70.000		48000.000
6/18/64		65.0	9.5	1,240.0								8.4	155.000		2000.000
7/22/64		70.0	1.8	650.0								7.6	30.000		6000.000
8/19/64		64.0	10.0	1,080.0								8.1	115.000		3000.000
9/28/64		48.0	11.0	1,200.0	.100	1.605						7.4	140.000		5000.000
10/14/64		52.0	13.4	1,210.0	.400	1.514						8.0	140.000		2300.000
11/30/64		32.0	11.5	1,030.0		.701						7.8	90.000		42000.000
12/17/64		32.0	11.4	1,420.0		.452						7.9	170.000		60000.000
1/21/65		32.0	7.6	1,320.0		1.898						7.7	170.000		13000.000
2/24/65		32.0	7.3	944.0	.100	.475						7.3	80.000		110000.000
4/12/66	1140	48.0	6.6	1,450.0	.350	3.100				.930		7.5	200.000		2000.000
4/05/67	1000	46.0	9.9	980.0	.090	3.100				.680		8.0	55.000		86000.000
4/18/68	1250	49.0	10.8	1,402.0	.034	1.253				.032		8.0	116.900	450	
8/12/68	0935	66.0	9.7	1,062.0	.018	1.506				2.217		8.2	115.300	180	1900.000
3/31/69	0850	32.0	13.3	1,200.0	.055	1.600				.583		8.0	70.000	4,300	89000.000
8/11/69	1000	73.0	5.5	900.0	.117	2.300				2.480		7.9	116.000	460	22000.000
7/30/70	0320	83.0	7.8	875.0								8.4	88.000		
7/30/70	0750	73.0	3.7	900.0	.190	1.300				1.530		7.8	60.000	470	
7/30/70	1145	78.0	7.5	950.0								7.9			
7/31/70	0250	75.5	3.0	870.0								7.6	46.000		
7/31/70	0710	80.0	7.6	875.0								8.2	105.000		
7/31/70	1120	76.0	2.8	920.0								7.6	51.000		
8/09/71	2250	77.0	4.9	1,476.0	.048	1.520				3.520		8.3	215.000	160	
8/10/71	0250	75.0	1.7	1,435.0								8.0	197.000		
8/10/71	0700	75.0	1.7	1,363.0								7.8	178.000		
8/10/71	1050	78.0	6.5	1,399.0								8.1	185.000		
8/10/71	1530	76.0	8.0	1,414.0								8.4	266.000		
8/10/71	1850	75.0	6.6	1,441.0								8.3	274.000		
8/15/72	0055	71.5	4.5	618.0											
8/15/72	0455	70.0	4.5	655.0	.147	.940	.210	1.420	2.720	.555	.796	7.7	70.000	4,200	
8/15/72	1250	70.0	5.6	766.0											
8/15/72	1655	71.0	5.7	763.0	.140	1.200	.230	1.500	3.070		.960	8.0	75.000	1,200	
8/20/73	0055	74.5	2.6	1,485.0											

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-06															
8/20/73	0455	73.0	2.6	1,418.0	.165	2.200	.450	.940	3.750	2.412	2.770	7.8	200.000	370	
8/20/73	1255	75.0	8.8	1,213.0											
8/20/73	1655	79.0	10.2	1,171.0	.104	1.700	.100	.870	2.770	2.610	2.510	8.4	144.000	210	
8/21/74	0050	74.0	4.1	1,120.0											
8/21/74	0455	72.0	4.0	975.0	.156	2.500	.510	1.210	4.378	1.222	1.370	7.9	90.000	550	
8/21/74	1245	76.0	8.9	1,210.0											
8/21/74	1700	80.0	9.3	1,210.0	.171	3.340	.420	1.260	5.185	.986	1.200	8.4	119.000	910	
8/27/75	0040	69.5	5.5	783.0											
8/27/75	0440	67.0	5.7	791.0	.061	1.260	.380	1.540	3.240	.202	.230	8.0	66.000	1,300	
8/27/75	1210	67.0	6.1	793.0											
8/27/75	1610	72.0	6.2	783.0	.059	1.240	.310	1.360	2.970	.202	.240	8.1	76.000	3,000	
MN-07															
2/20/64			3.3	1,080.0								7.5	65.000		1100.000
4/01/64		37.0	13.2	1,160.0								8.6	100.000		400.000
5/15/64		61.0	10.9	1,040.0								8.2	55.000		13000.000
6/18/64		68.0	6.6												1500.000
7/22/64		78.0	2.9												2100.000
8/19/64		65.0	12.3												60000.000
9/28/64		51.0	10.5												38000.000
10/14/64		50.0	10.5	980.0		.068						8.0	30.000		220000.000
11/30/64		32.0	12.8												3800.000
12/17/64		32.0	6.9												16000.000
1/21/65		32.0	5.9			.203									30000.000
2/24/65		32.0	4.0			1.469									2100.000
4/12/66	1120	49.0	6.8	535.0		.700				1.470		7.6	35.000		700.000
4/05/67	1015	46.0	12.1	1,220.0	.040	3.200				.070		8.1	105.000		4700.000
4/18/68	1300	49.0	8.9	1,450.0	.039	1.241				.069		7.8	135.200	600	
8/12/68	0920	68.0	5.7	718.0	.011	.090				.843		7.8	22.010	270	18000.000
3/31/69	0900	32.0	13.1	1,340.0	.042	1.400				.243		8.0	90.000	2,800	33000.000
8/11/69	0945	72.0	6.2	800.0	.024	.200				.070		7.8	41.000	210	14000.000
7/30/70	0310	82.0	6.0	650.0								7.9	52.000		
7/30/70	0700	80.0	3.9	650.0								7.8	47.000		
7/30/70	0740	74.0	2.8	650.0	.100	.750				.153		7.5	145.000	550	
7/30/70	1130	77.0	4.8	620.0								7.7			
7/31/70	0235	76.5	.7	610.0								7.4	28.000		
7/31/70	1110	76.0	1.7	610.0								7.4	27.000		
8/09/71	2245	77.0	3.8	830.0		.130				.237		8.1	49.000	200	
8/10/71	0245	74.0	1.0	840.0								7.7	52.000		
8/10/71	0650	73.0	.6	837.0								7.6	58.000		
8/10/71	1045	75.0	7.0	847.0								8.0	51.000		
8/10/71	1500	78.0	8.7	753.0								8.3	48.000		
8/10/71	1845	74.0	5.0	743.0								7.9	41.000		
8/15/72	0045	70.0	3.5	389.0											
8/15/72	0445	69.0	3.4	448.0	.162	1.270	.080	1.410	2.920	.368	.450	7.6	41.000	2,700	
8/15/72	1240	69.5	4.2	641.0											
8/15/72	1640	71.5	4.1	640.0	.098	1.110	.110	1.210	2.530	.065	.246	7.9	54.000	1,700	
8/20/73	0045	74.5	3.2	722.0											
8/20/73	0440	73.5	1.7	716.0	.019	.260	.080	.660	1.020	.185	.290	7.7	64.000	40	
8/20/73	1245	80.0	10.3	743.0											
8/20/73	1645	82.0	12.9	748.0	.007	.230	.030	.650	.890	.160	.220	8.5	74.000	10	
8/21/74	0040	72.0	4.3	950.0											
8/21/74	0445	69.0	2.9	800.0	.040	.330	.120	.980	1.464	.118	.170	7.7	55.000	1,600	
8/21/74	1235	76.0	9.7	840.0											
8/21/74	1655	80.0	13.0	850.0	.035	.210	.160	.870	1.269	.085	.110	8.8	60.000	410	
8/27/75	0030	69.0	5.1	773.0											
8/27/75	0430	67.0	5.3	791.0	.060	1.190	.290	1.370	2.910	.099	.290	7.9	55.000	600	
8/27/75	1205	69.0	5.5	814.0											
8/27/75	1605	69.0	5.1	835.0	.048	1.160	.240	1.230	2.680	.094	.030	8.1	60.000	1,200	
MN-08															
2/20/64		33.0	12.0	1,640.0								7.6	305.000		2500.000
4/01/64		41.0	20.4	1,850.0								8.5	340.000		5000.000
5/15/64		59.0	14.1	1,240.0								8.3	105.000		20000.000
6/18/64		69.0	12.2												1000.000
7/22/64		78.0	4.2												83000.000
8/19/64		66.0	9.7												11000.000
9/28/64		53.0	11.1												4000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-08															
10/14/64		49.0	11.8	760.0		.226						8.1	80.000		1000.000
11/30/64		32.0	14.8												3600.000
12/17/64		32.0	14.0												1600.000
1/21/65		32.0	13.8			.203									100.000
4/12/66	1045	54.0	13.8	660.0		.300				.040		7.8	45.000		4000.000
4/05/67	1055	50.0	14.9	1,400.0	.020	1.200				.040		8.7	180.000		2200.000
4/18/68	1210	50.0	10.1	1,256.0	.067	.747				.176		7.8	145.500	300	
8/12/68	0850	66.0	11.7	856.0	.031	.271				.020		8.4	44.650	1,100	25000.000
3/31/69	0730	32.0	14.6	2,000.0	.018	.600				.060		8.0	216.000	40	11000.000
8/11/69	0820	69.0	11.2	1,120.0	.014	.100				.010		8.2	160.000	900	13000.000
7/30/70	0245	88.0	13.7	775.0								8.8	80.000		
7/30/70	0640	82.0	10.8	885.0								8.7	77.000		
7/30/70	0710	71.0	6.8	900.0	.024	.820				.080		7.8	40.000	14,000	
7/30/70	1110	84.0	12.1	925.0								8.7			
7/31/70	0210	72.0	7.3	1,090.0								8.0	52.000		
7/31/70	1035	74.5	7.1	1,030.0								8.0	46.000		
8/09/71	2225	74.0	5.7	999.0		.070				.030		7.9	98.000	240	
8/10/71	0225	72.0	6.1	1,014.0								7.8	100.000		
8/10/71	0630	69.5	7.0	945.0								7.9	101.000		
8/10/71	1025	81.5	10.7	940.0								8.7	96.000		
8/10/71	1440	77.0	5.3	835.0								7.3	137.000		
8/10/71	1820	73.5	6.9	824.0								8.2	97.000		
8/15/72	0020	69.5	7.9	881.0											
8/15/72	0420	68.0	8.2	969.0	.054	.410	.140	.840	1.440	.109	.096	8.0	128.000	680	
8/15/72	1220	80.0	10.8	1,056.0											
8/15/72	1625	80.0	10.2	1,080.0	.018	.150	.050	.850	1.070	.289	.140	8.7	140.000	1,500	
8/20/73	0020	72.0	7.4	1,234.0											
8/20/73	0420	68.5	8.0	1,207.0	.015	.210	.030	.450	.670	.034	.070	8.1	269.000	970	
8/20/73	1220	83.0	8.9	1,046.0											
8/20/73	1620	83.0	7.8	1,212.0	.082	.420	.030	.930	1.430	.177	.200	8.1	139.000	360	
8/21/74	0030	70.5	7.3	1,320.0											
8/21/74	0430	67.0	7.6	1,075.0	.012	.090	.110	.690	.900	.039	.040	8.1	95.000	870	
8/21/74	1220	80.5	10.6	1,175.0											
8/21/74	1635	86.0	10.5	1,025.0	.010	.070	.160	.730	.970	.030	.060	9.1	90.000	4,400	
8/27/75	0020	65.0	7.8	1,002.0											
8/27/75	0420	62.0	8.3	1,292.0	.018	.170	.030	.370	.490	.034	.070	7.9	123.000	620	
8/27/75	1145	71.0	11.7	960.0											
8/27/75	1545	82.0	11.2	911.0	.010	.070	.030	.410	.400	.037	.070	9.1	132.000	5,500	
MN-09															
2/20/64		32.0	12.1	2,960.0	.200							7.4	795.000		2300.000
3/12/64		36.0	12.7	848.0											2700.000
4/01/64		41.0	15.9	2,220.0								8.8	560.000		1600.000
5/15/64		58.0	11.1	854.0								8.2	100.000		20000.000
6/18/64		67.0	8.8	1,110.0								8.4	155.000		5000.000
9/28/64		50.0	8.3	580.0		1.153						7.0	50.000		200000.000
10/14/64		49.0	8.0	620.0		.181						7.5	65.000		6000.000
11/30/64		32.0	13.6	908.0		.316						7.7	135.000		430000.000
12/17/64		32.0	13.7	4,320.0	.100	.294						7.8	1270.000		5000.000
1/21/65		32.0	13.6	1,760.0	.200	.271						8.0	405.000		1000.000
2/24/65		32.0	13.3	1,140.0		.226						7.6	185.000		3500.000
4/12/66	1005	48.0	8.6	625.0	.030	.500				.140		8.2	50.000		4000.000
4/05/67	1140	50.0	10.8	1,490.0	.030	1.800				.310		8.4	225.000		56000.000
4/18/68	1155	50.0	10.4	1,208.0	.067	1.204				.107		8.8	172.200	2,400	
8/12/68	0800	68.0	9.3	582.0	.005	.015				.167		8.0	32.460	25,000	140000.000
3/31/69	0810	32.0	13.8	2,325.0	.034	1.100				.320		8.4	306.000	220	4200.000
8/11/69	0905	68.0	4.3	890.0	.015	.100				.170		7.8	141.000	1,100	100000.000
7/30/70	0220	81.0	7.8	660.0								8.5	93.000		
7/30/70	0550	81.0	6.5	565.0								8.5	48.000		
7/30/70	0655	70.0	6.0	775.0	.003	.160				.123		7.7	25.000	1,000	
7/30/70	1055	76.0	7.4	565.0								8.0			
7/31/70	0155	70.5	4.9	700.0								7.6	36.000		
7/31/70	1015	74.5	5.5	620.0								8.0	29.000		
8/09/71	2200	76.0	5.8	731.0		.120				.030		8.2	70.000	800	
8/10/71	0200	70.5	6.0	791.0								7.9	69.000		
8/10/71	0600	68.0	6.3	816.0								7.9	82.000		
8/10/71	1000	68.0	8.6	846.0								8.1	80.000		
8/10/71	1405	75.0	9.7	734.0								8.6	92.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-09															
8/10/71	1800	73.5	6.1	229.0								7.3	28.000		
8/15/72	0001	69.5	5.7	491.0											
8/15/72	0401	68.0	6.1	661.0	.077	.520	.500	1.060	2.160	.226	.296	7.8	99.000	5,900	
8/15/72	1200	70.0	7.4	1,332.0											
8/15/72	1600	75.0	6.9	783.0	.060	.350	.550	1.070	2.030	.161	.960	8.2	97.000	900	
8/20/73	0005	62.0	8.0	1,046.0											
8/20/73	0405	59.5	8.2	1,041.0	.009	.060		.260	.330	.023	.040	8.0	40.000	1,400	
8/20/73	1205	66.0	9.8	977.0											
8/20/73	1605	70.0	9.7	982.0	.004	.090	.030	.240	.330	.034	.060	8.2	31.000	330	
8/21/74	0005	73.0	5.9	1,250.0											
8/21/74	0405	70.0	5.5	800.0	.162	.550	.390	.620	1.722	.055	.100	7.9	88.000	620	
8/21/74	1205	73.5	8.7	825.0											
8/21/74	1615	80.0	7.1	800.0	.027	.200	.300	.920	1.443	.095	.140	8.7	99.000	690	
8/27/75	0005	69.0	3.9	898.0											
8/27/75	0405	66.0	5.4	843.0	.123	.420	.720	.480	1.740	.289	.250	8.0	118.000	1,000	
8/27/75	1120	67.5	8.6	793.0											
8/27/75	1520	72.0	8.7	749.0	.082	.500	.510	.720	1.820	.364	.390	8.6	118.000	2,600	
MN-10															
1/29/64		32.0	10.5	1,350.0	.300							7.7	205.000		15000.000
2/20/64		32.0	12.4	1,570.0								7.2	305.000		3700.000
3/12/64		33.0	12.8	1,280.0											13000.000
4/01/64		41.0	18.9	1,340.0								8.7	185.000		400.000
5/15/64		61.0	13.3	1,180.0								8.4	120.000		24000.000
6/18/64		68.0	11.5	1,050.0								8.1	140.000		4000.000
7/22/64		78.0	4.8	676.0								7.0	45.000		89000.000
8/19/64		68.0	10.8	1,220.0	.100							8.1	155.000		19000.000
9/28/64		53.0	10.8	868.0		.407						7.7	105.000		70000.000
10/14/64		50.0	11.4	1,020.0	.100	.588						8.0	115.000		2000.000
11/30/64		32.0	13.1	940.0		.407						7.6	100.000		185000.000
12/17/64		32.0	13.0	2,120.0		.316						7.8	425.000		14000.000
1/21/65		32.0	10.9	1,480.0	1.400	.362						7.7	220.000		31000.000
2/24/65		32.0	11.5	888.0	.100	.407						7.4	100.000		31000.000
4/12/66	1015	49.0	13.1	1,120.0	.010	.600				.980		7.8	165.000		3000.000
4/05/67	1130	48.0	14.2	1,210.0	.070	2.700				.420		8.7	90.000		60000.000
4/18/68	1145	50.0	9.5	1,240.0	.097	.831				.257		7.8	130.200	9,300	
8/12/68	0810	66.0	8.7	850.0	.013	.527				.773		8.2	52.610	1,700	41000.000
3/31/69	0800	33.0	14.3	1,475.0	.046	1.400				.357		8.2	158.000	950	57000.000
8/11/69	0855	71.0	7.8	1,130.0	.026	.500				.860		8.1	164.000	2,800	31000.000
7/30/70	0230	80.0	9.0	720.0								8.3	100.000		
7/30/70	0545	83.0	8.1	680.0								8.4	80.000		
7/30/70	0645	74.0	6.0	660.0	.086	.630				.163		7.8	20.000	600	
7/30/70	1050	76.0	8.4	710.0								8.1			
7/31/70	0150	76.0	5.2	780.0								7.8	46.000		
7/31/70	1000	79.0	5.7	700.0								8.0	36.000		
8/09/71	2205	76.0	5.5	1,099.0	.010	.270				.573		8.4	152.000	500	
8/10/71	0205	74.0	5.0	1,132.0								8.3	162.000		
8/10/71	0610	73.0	5.1	1,146.0								7.9	136.000		
8/10/71	1105	75.0	8.8	1,054.0								8.3	119.000		
8/10/71	1420	78.0	5.2	568.0								7.1	69.000		
8/10/71	1805	74.0	5.7	416.0								7.4	52.000		
8/15/72	0005	72.5	6.0	776.0											
8/15/72	0405	71.0	6.2	567.0	.177	1.360	.180	1.650	3.370	.612	.890	7.8	78.000	2,700	
8/15/72	1205	69.5	6.8	702.0											
8/15/72	1605	72.0	6.8	712.0	.090	.930	.130	1.260	2.410	1.046	.870	8.1	72.000	1,100	
8/20/73	0001	67.5	6.8	1,140.0											
8/20/73	0400	65.0	7.0	1,080.0	.013	.580	.030	.330	.920	.300	.350	8.0	81.000	910	
8/20/73	1201	70.0	12.4	1,098.0											
8/20/73	1601	74.0	11.3	1,091.0	.016	.390	.030	.450	.860	.412	.430	8.4	86.000	590	
8/21/74	0001	75.0	4.6	975.0											
8/21/74	0400	75.0	5.1	975.0	.062	.780	.270	.930	2.042	.262	.330	8.0	98.000	610	
8/21/74	1200	75.5	12.5	1,125.0											
8/21/74	1600	78.0	12.9	1,080.0	.024	.700	.160	1.060	1.942	.286	.350	8.8	113.000	180	
8/27/75	0001	69.0	7.0	762.0											
8/27/75	0401	68.0	7.2	980.0	.076	1.020	.030	.770	1.790	.262	.140	7.9	81.000	2,100	
8/27/75	1115	68.0	7.7	793.0											
8/27/75	1515	71.0	7.6	1,037.0	.071	1.020	.030	.870	1.960	.257	.200	8.2	86.000	1,700	
MN-[redacted] 7A															
4/12/66	1105	50.0	7.8	1,280.0	.070	1.800				2.600		7.5	170.000		4000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-7A															
4/05/67	1040	47.0	10.2	1,050.0	.100	3.000				.540		7.9	80.000		144000.000
4/18/68	1315	50.0	9.6	1,208.0	.079	1.421				.314		8.2	126.000	17,000	
8/12/68	0910	66.0	5.3	944.0	.042	1.144				1.383		8.0	32.460	210	9000.000
3/31/69	0840	32.0	13.0	1,320.0	.046	1.400				.720		8.0	88.000	3,300	26000.000
8/11/69	0930	71.0	5.0	900.0	.099	1.000				1.370		8.0	135.000	110	3200.000
7/30/70	0300	85.0	6.5	715.0								8.0	77.000		
7/30/70	0655	82.0	5.8	755.0								8.1	75.000		
7/30/70	0730	73.0	3.5	715.0	.110	1.000				1.030		7.6	25.000	400	
7/30/70	1125	80.0	5.2	775.0								7.8			
7/31/70	0230	71.0	2.7	860.0								7.6	40.000		
7/31/70	1055	78.0	3.7	790.0								7.8	34.000		
8/09/71	2235	79.5	9.0	1,213.0	.035	.890				1.150		8.8	143.000	1,000	
8/10/71	0235	75.0	4.7	1,201.0								8.7	152.000		
8/10/71	0640	75.5	3.1	1,220.0								8.5	163.000		
8/10/71	1035	75.0	4.6	1,232.0								8.2	135.000		
8/10/71	1450	76.0	9.8	1,026.0								8.1	144.000		
8/10/71	1830	76.5	8.1	1,196.0								8.5	195.000		
8/15/72	0035	72.0	4.5	529.0											
8/15/72	0435	70.0	4.5	566.0	.157	1.110	.160	1.860	3.290	.452	.526	7.7	64.000	3,700	
8/15/72	1230	70.0	5.7	722.0											
8/15/72	1635	72.0	5.6	729.0	.114	1.060	.170	1.470	2.810	.446	.670	7.9	75.000	1,200	
8/20/73	0035	75.0	6.3	1,255.0											
8/20/73	0435	73.5	4.7	1,213.0	.063	1.860	.220	1.010	3.150	1.493	1.940	8.0	166.000	190	
8/20/73	1235	75.0	6.7	1,151.0											
8/20/73	1635	76.0	8.5	1,116.0	.040	1.610	.040	.840	2.530	1.389	1.760	8.2	139.000	410	
8/21/74	0035	75.5	6.5	1,150.0											
8/21/74	0440	73.0	4.5	1,000.0	.056	1.940	.250	1.140	3.387	.489	.540	8.2	105.000	820	
8/21/74	1230	76.0	6.7	1,190.0											
8/21/74	1645	80.0	13.1	1,150.0	.069	2.220	.190	1.350	3.829	.565	.580	8.6	119.000	550	
8/27/75	0025	70.0	5.9	762.0											
8/27/75	0425	68.0	5.7	793.0	.061	1.400	.250	1.540	3.250	.191	.140	8.0	62.000	1,500	
8/27/75	1155	71.0	6.7	814.0											
8/27/75	1555	74.0	6.7	814.0	.061	1.400	.190	1.250	2.900	.218	.220	8.1	76.000	2,200	
MN-7B															
4/12/66	1135	50.0	8.0	1,330.0	.030	1.400				1.730		7.6	200.000		3000.000
4/05/67	1110	48.0	13.7	1,070.0	.110	3.100				.530		8.4			11500.000
4/18/68	1220	49.0	8.4	1,149.0	.097	1.241				.326		7.8	117.500	22,000	
8/12/68	0840	68.0	5.0	855.0	.054	1.265				1.290		8.0	47.140	200	11000.000
3/31/69	0825	32.0	13.8	1,320.0	.049	1.400				.743		8.1	112.000	2,000	23000.000
8/11/69	0840	73.0	4.8	1,000.0	.090	1.000				1.510		8.0	136.000	3,800	73000.000
7/30/70	0250	81.0	7.7	635.0								8.1	64.000		
7/30/70	0650	80.0	6.5	700.0								8.1	67.000		
7/30/70	0720	74.0	4.0	620.0	.094	.910				.966		7.7	13.000	1,900	
7/30/70	1115	77.0	6.2	695.0								7.9			
7/31/70	0215	77.0	2.6	775.0								7.6	41.000		
7/31/70	1040	78.5	3.3	730.0								7.6	19.000		
8/09/71	2220	76.0	6.5	1,114.0	.014	.440				1.010		8.7	136.000	110	
8/10/71	0220	75.0	4.2	1,133.0								8.6	141.000		
8/10/71	0625	74.0	2.1	1,156.0								8.3	144.000		
8/10/71	1015	75.5	7.3	1,167.0								8.4	341.000		
8/10/71	1430	77.0	10.3	1,125.0								8.6	164.000		
8/10/71	1815	73.5	5.5	959.0								7.9	130.000		
8/15/72	0015	72.0	5.3	734.0											
8/15/72	0415	70.0	5.2	866.0	.170	1.320	.180	1.760	3.430	.588	.640	7.7	62.000	3,900	
8/15/72	1215	69.5	5.7	658.0											
8/15/72	1615	70.5	5.8	715.0	.105	1.060	.130	1.460	2.750	.476	.540	8.0	72.000	970	
8/20/73	0025	75.0	5.4	1,177.0											
8/20/73	0425	73.0	4.5	1,200.0	.044	1.630	.100	.840	2.610	1.253	1.130	8.0	135.000	530	
8/20/73	1225	75.0	6.6	1,151.0											
8/20/73	1625	76.0	8.0	1,151.0	.038	1.640	.030	.850	2.530	1.206	1.150	8.2	147.000	460	
8/21/74	0020	75.0	6.5	1,320.0											
8/21/74	0420	73.0	4.3	1,000.0	.032	1.640	.160	1.240	3.073	.483	.620	8.1	100.000	670	
8/21/74	1215	75.0	8.3	1,000.0											
8/21/74	1625	78.0	11.5	1,075.0	.029	1.280	.180	1.260	2.752	.471	.530	8.7	105.000	160	
8/27/75	0015	69.0	6.6	793.0											
8/27/75	0415	68.0	6.5	804.0	.061	1.360	.220	1.140	2.780	.159	.330	8.1	81.000	690	
8/27/75	1135	67.5	6.0	814.0											

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
MN-78															
8/27/75	1535	69.0	7.0	802.0	.045	1.400	.24D	1.190	2.87D	.156	.240	8.2	76.000	1,300	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
OK-01															
4/09/64		40.0	13.3	1,020.0								8.5	135.000		6000.000
5/25/64		58.0	12.8												4700.000
6/05/64		54.0	11.6												1300.000
7/16/64		59.0	10.1												1100.000
8/06/64		61.0	13.4												3800.000
9/23/64		58.0	8.7	628.0		.181						7.4	30.000		22000.000
10/21/64		46.0	12.1												500.000
11/04/64		52.0	12.5												900.000
12/09/64		35.0	12.8												1600.000
1/07/65		39.0	10.9			.249									4000.000
2/04/65		32.0	13.7			.158									1300.000
10/10/66	1020														
4/04/67	0915	42.0	12.1	1,280.0	.010	.900				.140		8.0	105.000		1380.000
4/18/68	1000	48.0	8.7	1,503.0	.042	.819				.095		7.8	244.500	190	
8/14/68	1000	68.0	6.9	1,255.0	.013	.120				.090		8.0	128.390	1,000	13000.000
4/01/69	1145	36.0	13.5	1,520.0	.015	1.100				.063		8.0	191.000	70	8000.000
8/14/69	1105	77.0	6.9	1,130.0	.008	.200				.010		7.9	175.000	540	17000.000
8/11/70	0100	77.0	12.9	1,675.0								8.1	120.000		
8/11/70	0315	69.0	4.2	1,700.0								7.8	130.000		
8/11/70	0345	77.5	13.1	1,625.0								8.2	120.000		
8/11/70	0725	76.0	11.1	1,640.0								8.1	120.000		
8/11/70	0930	70.5	6.6	1,720.0	.031	.170				.043		7.9	190.000	550	
8/11/70	1145	71.0	8.1	1,645.0								7.8	140.000		
8/08/71	2215	73.0	6.2	1,448.0	.016	.160				.063		8.0	188.000	300	
8/09/71	0215	72.0	6.0	1,430.0								7.9	185.000		
8/09/71	0640	71.0	5.7	1,425.0								7.9	188.000		
8/09/71	1020	73.0	7.3	1,509.0								7.9	151.000		
8/09/71	1415	75.0	8.6	1,435.0								8.0	159.000		
8/09/71	1810	76.0	7.3	1,473.0								8.1	157.000		
8/14/72	0115	73.0	6.3	1,240.0											
8/14/72	0515	73.0	6.3	1,304.0	.050	.430	.150	.980	1.610	.176	.150	8.1	203.000	370	
8/14/72	1305	77.5	7.9	1,418.0											
8/14/72	1700	76.0	7.0	1,414.0	.030	.330	.100	.930	1.390	.086	.110	8.1	221.000	420	
8/15/73	0125	70.0	6.8	839.0											
8/15/73	0520	66.5	6.7	902.0	.007	.040	.280	.290	.620	.120	.140	8.0	27.000	1,200	
8/15/73	1320	71.0	10.2	852.0											
8/15/73	1720	81.0	8.5	829.0	.002	.110	.030	.180	.290	.095	.160	8.2	31.000	220	
8/19/74	0130	71.5	5.5	950.0											
8/19/74	0530	70.0	5.2	775.0	.024	.160	.210	.790	1.183	.095	.100	7.9	100.000	530	
8/19/74	1325	73.0	6.3	900.0											
8/19/74	1720	75.0	7.4	940.0	.016	.130	.420	.830	1.399	.061	.070	8.0	113.000	260	
8/25/75	0120	78.0	1.5	866.0											
8/25/75	0520	75.0	2.5	878.0	.043	.370	.360	.840	1.620	.064	.070	7.6	135.000	580	
8/25/75	1230	72.5	5.6	918.0											
8/25/75	1630	74.5	6.1	917.0	.047	.330	.440	.930	1.750	.043	.020	7.9	137.000	130	
OK-02															
1/29/64		34.0	10.7	924.0								7.7	105.000		1300.000
2/19/64		36.0	11.8	904.0								7.4	90.000		1800.000
3/26/64		33.0	13.2	1,000.0								8.2	135.000		20000.000
4/09/64		46.0	11.6	996.0								8.2	115.000		27000.000
5/25/64			6.4	870.0								7.8	65.000		3000.000
6/05/64		60.0	8.8	800.0								8.0	50.000		1400.000
7/16/64		73.0	10.0	726.0								8.3	65.000		6000.000
8/06/64		71.0	10.3	888.0								7.6	70.000		4000.000
9/23/64		64.0	7.3	544.0								7.3	35.000		33000.000
10/21/64		46.0	10.1	844.0		.294						7.7	65.000		11000.000
11/04/64		53.0	10.5	816.0	.100	.181						7.8	55.000		7000.000
12/09/64		33.0	12.3	860.0		.452						7.8	70.000		16000.000
1/07/65		39.0	10.9	888.0		.633						7.7	85.000		11000.000
2/04/65		32.0	10.9	916.0		.226						7.6	65.000		11000.000
10/10/66	1020	52.0	7.4	1,410.0	.020	.400				.050		7.3	70.000		5200.000
4/04/67	0915	43.0	10.6	1,350.0	.030	2.100				.210		7.9	170.000		14000.000
4/18/68	1000	49.0	7.6	1,467.0	.088	1.000				.377		7.6	218.300	13,000	
8/14/68	1000	67.0	7.3	1,160.0	.021	.331				.263		8.0	118.350	400	21000.000
4/01/69	1145	39.0	13.9	1,445.0	.023	1.500				.077		8.0	170.000	130	4000.000
8/14/69	1105	75.0	7.1	1,100.0	.013	.400				.010		8.1	211.000	350	14000.000
8/11/70	0115	74.0	8.8	940.0								8.2	69.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
OK-02															
8/11/70	0330	80.0	6.6	700.0								8.0	59.000		
8/11/70	0400	78.0	9.5	890.0								8.1	73.000		
8/11/70	0740	74.5	8.0	875.0								8.1	68.000		
8/11/70	0955	71.0	7.2	955.0	.008	.100				.047		8.0	100.000	150	
8/11/70	1200	74.0	6.8	815.0								8.0	72.000		
8/08/71	2200	72.5	7.0	984.0	.006	.140				.013		7.9	83.000	170	
8/09/71	0200	71.0	6.4	962.0								7.9	86.000		
8/09/71	0620	70.0	6.3	955.0								7.9	82.000		
8/09/71	1000	70.5	7.2	1,013.0								7.9	82.000		
8/09/71	1400	74.0	8.5	967.0								8.0	80.000		
8/09/71	1750	76.0	8.0	893.0								8.1	73.000		
8/14/72	0135	72.0	6.4	1,123.0											
8/14/72	0535	72.5	6.1	883.0	.100	1.770	.270	1.320	3.460	.312	.230	8.0	108.000	1,800	
8/14/72	1325	75.0	7.6	1,133.0											
8/14/72	1715	73.5	6.8	1,103.0	.082	.690	.110	1.120	2.000	.109	.110	8.0	134.000	230	
8/15/73	0145	71.5	6.1	947.0											
8/15/73	0540	68.0	6.2	962.0	.009	.330	.220	.300	.860	.068	.050	8.0	65.000	210	
8/15/73	1340	74.0	9.6	900.0											
8/15/73	1735	76.0	9.2	836.0	.004	.270	.030	.210	.510	.024	.080	8.2	48.000	1,100	
8/19/74	0150	72.0	5.9	850.0											
8/19/74	0545	68.0	6.1	830.0	.020	.310	.140	.790	1.262	.039	.070	7.8	89.000	540	
8/19/74	1340	73.0	7.9	875.0											
8/19/74	1735	77.0	7.9	815.0	.022	.270	.040	.790	1.132	.056	.070	8.2	79.000	390	
8/25/75	0125	77.0	5.6	619.0											
8/25/75	0535	75.0	4.1	609.0	.049	.490	.260	.960	1.750	.040	.060	7.8	67.000	340	
8/25/75	1250	72.5	7.1	662.0											
8/25/75	1650	74.5	7.9	628.0	.025	.410	.080	.650	1.170	.212	.150	8.1	69.000	200	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
PK-01															
2/19/64		33.0	2.3	800.0								6.9	85.000		100000.000
3/25/64		39.0	8.3												150000.000
4/08/64		40.0	11.5	996.0								7.6	55.000		65000.000
5/25/64		67.0	3.0												3000.000
6/10/64		69.0	.7												230000.000
7/20/64		73.0	4.1												140000.000
8/12/64		63.0	3.1												50000.000
9/23/64		64.0	1.9	618.0	.600	1.514						6.9	45.000		560000.000
10/22/64		43.0	2.9												380000.000
11/04/64		52.0	1.4												1400000.000
12/09/64		32.0	2.0												1800000.000
1/07/65		37.0	6.3			.904									500000.000
2/04/65		32.0	1.0			.158									450000.000
10/10/66	1055	54.0	1.7	595.0		.200				1.540		7.2	30.000		1300000.000
4/03/67	1300	47.0	10.5	840.0	.060	10.000				.140		7.6	35.000		78000.000
8/13/68	0930	61.0	4.7	896.0	.242	3.734				.243		7.6	35.700	600	18000.000
8/17/68	1155	48.0	4.4	960.0	.076	.759				1.242		7.6	43.400	6,100	
4/01/69	1000	37.0	11.0	1,070.0	.056	4.200				.163		7.8	48.000	700	30000.000
8/14/69	1015	72.0	2.2	800.0	.245	2.300				.247		7.5	45.000	1,500	57000.000
8/10/70	0500	80.0	10.8	455.0								8.8	20.000		
8/10/70	0905	68.0	4.3	545.0	.240	.600				.247		7.7	23.000	100	
8/10/70	0915	73.0	11.0	435.0								9.0	18.000		
8/10/70	1255	77.0	7.1	550.0								7.8	24.000		
8/11/70	0120	70.0	5.0	435.0								8.0	18.000		
8/11/70	0515	67.5	3.8	480.0								7.6	19.000		
8/03/71	2220	69.0	7.4	554.0	.097	1.350				.827		8.3	28.000	40	
8/04/71	0220	66.0	3.7	540.0								7.7	22.000		
8/04/71	0630	66.0	2.4	508.0								7.6	19.000		
8/04/71	1020	66.5	3.6	550.0								7.5	21.000		
8/04/71	1420	68.0	5.5	560.0								7.7	20.000		
8/04/71	1810	67.0	9.2	605.0								8.2	26.000		
8/09/72	0020	63.0	6.5	759.0	.036	3.810	.420	2.220	6.490	.433	.520	7.7	34.000	650	
8/09/72	0420	61.0	6.1												
8/09/72	1225	61.0	7.8	928.0											
8/09/72	1615	65.5	9.2	893.0	.239	3.510	.280	1.190	5.220	.387	.400	8.0	34.000	980	
8/08/73	0200	77.5	4.5	452.0											
8/08/73	0600	75.0	3.1	396.0	.326	1.200	.030	.270	1.800	.755	.800	7.5	16.000	270	
8/08/73	1350	77.0	7.8	445.0											
8/08/73	1750	80.0	10.2	368.0	.060	.620	.040	.520	1.240	.592	.510	8.8	16.000	190	
8/14/74	0200	69.5	5.0	400.0											
8/14/74	0550	66.0	3.6	390.0	.256	1.810	1.490	.780	4.330	.120	.140	7.5	22.000	680	
8/14/74	1345	67.5	5.5	400.0											
8/14/74	1745	73.5	10.3	400.0	.134	1.630	.330	.790	2.887	.138	.140	8.5	19.000	150	
8/20/75	0150	71.0	5.1	374.0											
8/20/75	0550	68.0	4.2	423.0	.249	1.180	.890	.300	2.620	.072	.100	7.7	24.000	210	
8/20/75	1410	71.0	4.6	374.0											
8/20/75	1730	73.0		313.0	.126	1.260	.270	.390	2.040	.166	.110	7.8	17.000	1,700	
PK-02															
3/25/64		38.0	10.1	1,020.0								7.9	90.000		20000.000
4/08/64		40.0	13.2	950.0								8.2	70.000		7000.000
5/25/64		63.0	8.0												4100.000
6/10/64		67.0	3.8												1200.000
7/20/64		70.0	5.9												24000.000
8/12/64		63.0	3.5												9000.000
9/23/64		63.0	5.0	984.0		.565						7.4	50.000		190000.000
10/22/64		43.0	5.4												23000.000
11/04/64		53.0	7.2												330000.000
12/09/64		32.0	7.0												10000.000
1/07/65		33.0	10.6			1.017									10000.000
2/04/65		32.0	3.1			.768									13000.000
10/10/66	1130	50.0	2.0	1,430.0		.400				.530		7.3	65.000		100000.000
4/03/67	1225	46.0	12.4	775.0	.020	10.300				.060		7.7	55.000		7500.000
8/13/68	0950	64.0	5.2	976.0	.057	3.312				.150		7.6	54.600	210	18000.000
8/17/68	1130	46.0	7.8	1,138.0	.065	2.230				.276		7.8	60.500	3,500	
4/01/69	0940	36.0	13.0	1,070.0	.025	4.300				.053		7.8	59.000	170	23000.000
8/14/69	0945	75.0	2.5	980.0	.059	2.100				.247		7.8	90.000	1,100	34000.000
8/10/70	0440	76.0	16.1	1,150.0								8.1	52.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
PK-02															
8/10/70	0845	71.0	3.1	1,455.0	.110	3.400				.183		7.6	53.000	100	
8/10/70	0855	75.0	5.4	1,220.0								7.7	48.000		
8/10/70	1230	71.5	11.6	1,375.0								8.1	52.000		
8/11/70	0450	73.0	2.3	1,310.0								7.8	46.000		
8/11/70	1220	75.0	2.0	1,390.0								7.8	49.000		
8/03/71	2245	66.0	6.0	1,153.0	.102	1.200				.460		7.8	61.000	90	
8/04/71	0240	61.0	1.5	1,208.0								7.6	60.000		
8/04/71	0645	60.5	1.7	1,288.0								7.6	57.000		
8/04/71	1040	66.0	10.2	1,222.0								8.0	25.000		
8/04/71	1445	70.5	14.5	1,172.0								8.3	50.000		
8/04/71	1835	70.0	14.1	1,163.0								8.3	51.000		
8/09/72	0035	62.0	6.9	888.0	.282	4.900	.210	1.890	7.280	.170	.200	7.6	56.000	470	
8/09/72	0435	60.0	6.5												
8/09/72	1240	60.0	8.4	1,056.0											
8/09/72	1635	63.5	9.5	1,019.0	.069	4.420	.190	1.180	5.860	.139	.136	7.9	58.000	260	
8/08/73	0140	74.0	2.4	1,099.0											
8/08/73	0540	72.5	1.6	997.0	.053	1.630	.030	.580	2.260	.183	.200	7.7	49.000	540	
8/08/73	1335	81.5	6.9	1,098.0											
8/08/73	1735	80.0	5.6	984.0	.067	1.310	.130	.990	2.500	.284	.280	7.9	51.000	1,200	
8/14/74	0145	67.0	2.5	875.0											
8/14/74	0540	65.0	2.3	840.0	.037	1.490	.200	.950	2.676	.137	.200	7.5	40.000	480	
8/14/74	1330	75.0	4.8	950.0											
8/14/74	1730	74.0	3.5	940.0	.034	1.600	.150	1.040	2.824	.143	.200	7.6	38.000	510	
8/20/75	0130	67.0	2.8	1,002.0											
8/20/75	0530	66.0	2.8	1,066.0	.062	.860	.120	.680	1.720	.231	.370	7.9	37.000	960	
8/20/75	1400	74.0	6.5	997.0											
8/20/75	1715	72.0	4.3	1,060.0	.061	.660	.070	.510	1.310	.156	.140	8.0	37.000	1,200	
PK-03															
2/19/64		33.0	1.9	1,330.0								7.0	70.000		50000.000
3/25/64		38.0	9.7												17000.000
4/08/64		40.0	12.3	950.0								8.2	70.000		9000.000
5/25/64		68.0	3.1	1,030.0								8.0	55.000		3000.000
6/10/64		65.0	.9	1,040.0								8.2	55.000		2200.000
7/20/64		71.0	1.9	810.0								7.9	50.000		27000.000
8/12/64		63.0	5.4	828.0	.100							8.0	35.000		4000.000
9/23/64		63.0	3.1	980.0		.475						7.2	55.000		14000.000
10/22/64		43.0	4.6	734.0		1.266						7.4	50.000		6000.000
11/04/64		53.0	.4	720.0		1.153						7.3	35.000		11000.000
12/09/64		32.0	7.6	1,110.0		.497						7.5	70.000		18000.000
1/07/65		32.0	11.0	934.0	.100	.949						7.6	80.000		43000.000
2/04/65		32.0	2.5	1,160.0		.294						7.3	65.000		10000.000
10/10/66	1110	56.0		565.0		.300				.290		7.2	30.000		240000.000
4/03/67	1245	45.0	11.4	745.0	.040					.070		7.8	50.000		8600.000
8/13/68	0940	64.0	7.7	952.0	.071	3.553				.300		8.0	54.100	2,100	510000.000
8/17/68	1145	48.0	6.8	1,069.0	.074	1.000				.313		7.8	59.400	3,400	
4/01/69	0955	37.0	10.0	1,290.0	.025	3.900				.457		8.0	61.000	2,000	38000.000
8/14/69	1000	73.0	5.4	930.0	.036	2.500				.440		8.0	82.000	700	15000.000
8/10/70	0550	73.0	11.7	530.0								8.7	24.000		
8/10/70	0855	71.5	8.8	520.0	.150	.930				.400		8.4	26.000	100	
8/10/70	0910	71.0	9.3	590.0								8.4	28.000		
8/10/70	1240	72.0	10.8	620.0								8.6	23.000		
8/11/70	0445	72.0	9.0	540.0								8.2	27.000		
8/11/70	1230	72.5	9.8	595.0								8.4	29.000		
8/03/71	2235	65.5	4.8	566.0	.056	.390				.613		7.7	30.000	120	
8/04/71	0230	63.5	4.7	681.0								7.9	30.000		
8/04/71	0640	65.0	3.9	731.0								7.9	30.000		
8/04/71	1025	66.0	5.4	775.0								8.1	32.000		
8/04/71	1430	75.0	6.0	736.0								8.0	30.000		
8/04/71	1820	68.0	7.1	638.0								8.0	25.000		
8/09/72	0025	60.5	8.6	861.0	.087	2.580	.150	.660	3.480	.173	.186	7.9	57.000	450	
8/09/72	0425	59.0	8.7												
8/09/72	1230	61.5	9.3	1,020.0											
8/09/72	1620	63.0	9.1	1,031.0	.052	2.670	.220	1.140	4.080	.193	.216	8.1	57.000	10	
8/08/73	0150	76.0	6.4	475.0											
8/08/73	0550	74.0	5.9	531.0	.122	.610	.030	.540	1.270	.506	.540	7.7	25.000	390	
8/08/73	1345	76.5	6.1	572.0											
8/08/73	1745	76.0	8.1	520.0	.077	.400	.160	.840	1.480	.472	.420	8.1	24.000	12,000	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
PK-03															
8/14/74	0155	70.0	7.1	460.0											
8/14/74	0545	68.0	6.9	440.0	.073	1.120	.310	.400	1.900	.206	.180	8.0	22.000	1,500	
8/14/74	1340	72.0	6.2	530.0											
8/14/74	1740	71.0	6.4	550.0	.116	1.260	.430	.680	2.484	.206	.170	8.0	24.000	240	
8/20/75	0140	69.0	7.7	387.0											
8/20/75	0545	67.0	6.8	391.0	.074	.760	.030	.200	.950	.119	.110	8.1	22.000	340	
8/20/75	1405	72.0	7.6	377.0											
8/20/75	1725	71.0	7.8	395.0	.150	1.360	.190	.760	2.460	.098	.150	8.0	23.000	540	
PK-04															
1/30/64		34.0	.1	1,280.0								7.2	90.000		1300000.000
2/19/64		33.0	.4	940.0								7.1	70.000		480000.000
3/25/64		39.0	11.3	960.0								8.2	85.000		210000.000
4/08/64		40.0	11.8	944.0								8.2	65.000		6000.000
5/25/64		71.0	6.4	976.0								7.4	65.000		2000.000
6/10/64		68.0	5.2	906.0								8.0	55.000		76000.000
7/20/64		75.0	6.0	756.0								8.2	45.000		8000.000
8/12/64		66.0	3.5	840.0								7.8	55.000		12000.000
9/23/64		64.0	2.8	522.0		.588						7.2	35.000		30000.000
10/22/64		46.0	9.9	840.0		.249						8.0	55.000		150000.000
11/04/64		53.0	10.7	810.0		.023						8.1	55.000		4000.000
12/09/64		32.0	6.8	1,080.0		1.153						7.4	80.000		5000.000
1/07/65		33.0	8.9	906.0	.100	.791						7.4	80.000		28000.000
2/04/65		32.0	1.5	1,220.0		.294						7.3	70.000		10000.000
10/10/66	1155	56.0	5.7	635.0						1.010		7.4	35.000		28000.000
4/03/67	1200	45.0	11.3	780.0	.070	8.900				.100		7.8	45.000		7300.000
8/13/68	1010	67.0	7.4	900.0	.131	3.854				.147		8.0	49.130	1,900	20000.000
8/17/68	1115	50.0	14.2	914.0	.045	1.084				.458		8.8	50.800	110	
4/01/69	0925	35.0	12.0	1,065.0	.073	2.700				.120		8.0	60.000	650	7500.000
8/14/69	0935	75.0	5.9	720.0	.076	3.000				.270		8.0	51.000	1,900	26000.000
8/10/70	0420	76.5	7.6	600.0								8.9	32.000		
8/10/70	0815	77.0	4.7	600.0	.086	.450				.327		8.2	34.000	100	
8/10/70	0840	75.5	7.4	610.0								8.9	32.000		
8/10/70	1200	81.5	6.9	605.0								8.6	31.000		
8/11/70	0415	74.5	7.3	590.0								8.8	33.000		
8/11/70	1205	75.0	7.2	590.0								8.8	32.000		
8/03/71	2300	68.0	7.0	637.0	.026	.370				.553		8.6	37.000	500	
8/04/71	0300	68.0	6.7	637.0								8.5	39.000		
8/04/71	0705	68.0	6.0	644.0								8.4	33.000		
8/04/71	1100	69.5	6.4	649.0								8.5	33.000		
8/04/71	1500	70.0	6.6	654.0								8.5	32.000		
8/04/71	1850	70.0	7.2	654.0								8.5	33.000		
8/09/72	0045	63.0	8.2	765.0	.057	2.710	.200	1.420	4.390	.230	.220	7.8	45.000	700	
8/09/72	0445	62.0	8.0												
8/09/72	1250	63.0	8.3	938.0											
8/09/72	1645	61.5	8.6	956.0	.108	2.830	.140	1.420	4.500	.288	.276	8.1	46.000	260	
8/08/73	0130	76.0	6.6	607.0											
8/08/73	0530	79.0	5.9	533.0	.020	.960	.340	.590	1.910	.258	.300	7.8	26.000	20	
8/08/73	1320	79.5	7.0	612.0											
8/08/73	1725	80.5	6.1	542.0	.027	.550	.160	1.070	1.800	.262	.340	8.1	27.000	50	
8/14/74	0130	72.0	4.7	480.0											
8/14/74	0525	72.0	3.7	490.0	.021	.910	.090	.900	1.918	.111	.130	7.5	24.000	2,100	
8/14/74	1320	75.0	3.2	500.0											
8/14/74	1715	78.0	4.5	520.0	.021	.500	.080	.900	1.496	.065	.090	7.7	24.000	150	
8/20/75	0115	71.0	8.5	455.0											
8/20/75	0515	71.0	7.2	477.0	.029	.710	.030	.480	1.150	.055	.120	7.9	26.000	310	
8/20/75	1345	74.0	8.1	445.0											
8/20/75	1700	73.0	8.4	448.0	.032	.660	.030	.740	1.330	.054	.050	8.0	25.000	650	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-01															
3/26/64		32.0		634.0								8.4	5.000		1300.000
4/02/64		41.0	11.7	680.0								8.3			1100.000
5/14/64		54.0	7.1	720.0								7.6	15.000		4500.000
6/03/64		59.0	7.1	586.0								8.4	5.000		900.000
7/15/64		71.0	7.2	476.0								7.8	5.000		700.000
8/13/64		62.0	8.1	590.0								7.9	15.000		1600.000
9/16/64		53.0	7.6	730.0		.226						7.6	15.000		2800.000
10/28/64		49.0	8.4	662.0		.090						7.6	30.000		800.000
11/18/64		37.0	12.8	720.0		.181						7.6	15.000		3000.000
12/14/64		33.0	12.5	670.0		.339						7.4	15.000		300.000
1/13/65		32.0	7.6	740.0		.362						7.2	20.000		21000.000
2/10/65		32.0	5.9	258.0	.100	.565						6.8	20.000		7000.000
10/18/66	1500	48.0	8.9	620.0	.010	.700					.120	7.3	20.000		7200.000
4/11/67	1135	41.0	12.7	695.0		.800					.050	8.1	15.000		430.000
4/22/68	0740	51.0	5.0	702.0	.008	1.445				.031		7.4	15.400	30	
8/15/68	1030	66.0	6.6	696.0	.036	.100				.110		8.0	17.950	390	3000.000
4/01/69	0935	35.0	10.9	840.0	.013	1.200				.057		7.8	18.000	320	1400.000
8/13/69	1110	78.0	3.9	630.0	.052	.400				.153		7.9	20.000	300	10000.000
8/13/70	0450	79.0	8.8	655.0								8.2	21.000		
8/13/70	0910	78.5	8.4	620.0								8.4	21.000		
8/13/70	0925	72.0	4.7	705.0	.042	.460				.143		8.0	20.000	310	
8/13/70	1240	75.0	6.4	660.0								8.1	21.000		
8/14/70	0135	76.0	5.1	645.0								8.2	20.000		
8/14/70	0455	72.0	5.1	675.0								8.1	20.000		
8/12/71	0025	69.0	6.0	628.0	.028	.380				.177		8.2	19.000	600	
8/12/71	0425	65.0	5.8	639.0								8.2	17.000		
8/12/71	0815	65.0	6.2	630.0								8.2	17.000		
8/12/71	1215	69.0	8.4	617.0								8.4	14.000		
8/12/71	1610	77.0	12.7	605.0								8.7	22.000		
8/12/71	2005	76.5	10.7	633.0								8.6	21.000		
8/17/72	0005	75.0	.6	453.0											
8/17/72	0405	75.0	.5	417.0	.046	.510	.190	1.630	2.380	.323	.390	8.0	21.000	20	
8/17/72	1210	77.0	.3	500.0											
8/17/72	1605	78.5	.5	515.0	.036	.450	.190	1.590	2.270	.348	.400	7.4	16.000	30	
8/21/73	0001	71.5		786.0											
8/21/73	0400	69.0	1.2	818.0	.026	.120	.130	1.230	1.510	.412	.360	7.6	25.000	280	
8/21/73	1200	70.0	3.0	790.0											
8/21/73	1600	74.0	5.1	759.0	.003	.220	.050	1.170	1.440	.327	.350	7.8	24.000	200	
8/22/74	0005	73.0	.8	660.0											
8/22/74	0405	72.0	.9	650.0	.019	.270	.120	1.660	2.057	.348	.360	7.5	25.000	110	
8/22/74	1210	71.5	.8	660.0											
8/22/74	1610	73.0	1.4	660.0	.017	.250	.280	1.750	2.302	.339	.360	7.6	25.000	140	
8/28/75	0005	71.0	3.5	773.0											
8/28/75	0405	70.0	3.4	760.0	.018	.310	.030	1.030	1.280	.261	.100	7.6	30.000	270	
8/28/75	1140	72.0	3.2	762.0											
8/28/75	1540	76.0	5.4	753.0	.021	.180	.030	.860	.970	.283	.240	7.7	30.000	100	
RK-02															
4/02/64		40.0	11.7	644.0								8.3	15.000		2300.000
5/14/64		52.0	8.8												1000.000
6/03/64		56.0	10.6												3300.000
7/15/64		70.0	10.0												1700.000
8/13/64		61.0	12.3												1300.000
9/16/64		50.0	10.0	660.0		.249						7.8	5.000		1400.000
10/28/64		49.0	8.3												1000.000
11/18/64		36.0	14.5												400.000
12/14/64		33.0	12.4												400.000
1/13/65		32.0	13.4			.610									300.000
2/10/65		32.0	6.0			.610									6000.000
10/18/66	1445	47.0	11.5	625.0	.010	1.300					.060	7.3	15.000		5300.000
4/11/67	1150	42.0	13.6	635.0	.010	1.000					.050	8.2	15.000		220.000
4/22/68	0750	48.0	5.4	701.0	.008	.632				.056		7.8	12.500	35	
8/15/68	1010	64.0	10.2	660.0	.019	.452				.037		8.2	15.940	580	5000.000
4/01/69	0945	36.0	11.7	720.0	.013	.800				.067		8.0	15.000	40	6000.000
8/13/69	1100	74.0	7.0	595.0	.030	.700				.113		8.0	17.000	600	11000.000
8/13/70	0440	79.0	11.4	580.0								8.6	12.000		
8/13/70	0900	75.0	6.0	590.0								8.4	11.000		
8/13/70	0915	72.0	6.5	635.0	.037	.430				.123		8.2	12.000	1,700	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-02															
8/13/70	1230	77.5	9.5	620.0								8.3	13.000		
8/14/70	0145	72.0	3.8	625.0								8.2	11.000		
8/14/70	0500	69.5	3.8	645.0								8.1	12.000		
8/12/71	0035	64.0	6.0	613.0	.034	1.070				.113		8.1	12.000	1,300	
8/12/71	0435	61.0	6.8	631.0								8.1	12.000		
8/12/71	0825	61.0	7.1	628.0								8.1	12.000		
8/12/71	1225	67.0	11.1	606.0								8.3	11.000		
8/12/71	1625	73.0	9.8	616.0								8.4	14.000		
8/12/71	2010	71.0	5.7	628.0								8.3	14.000		
8/17/72	0001	72.0	3.3	680.0											
8/17/72	0401	71.0	3.0	665.0	.008	.320	.130	1.690	2.150	.198	.240	8.2	25.000	80	
8/17/72	1200	72.5	3.9	722.0											
8/17/72	1600	75.0	4.0	721.0	.013	.400	.100	1.460	1.970	.192	.230	7.8	18.000	70	
8/21/73	0010	68.0	5.8	678.0											
8/21/73	0405	64.0	6.3	707.0	.043	1.320	.100	1.080	2.540	.089	.160	8.0	13.000	1,200	
8/21/73	1210	65.0	10.0	659.0											
8/21/73	1610	70.0	12.4	690.0	.009	1.300	.030	.920	2.230	.101	.080	8.3	13.000	460	
8/22/74	0001	73.5	5.1	640.0											
8/22/74	0400	70.0	5.2	600.0	.031	1.320	.080	1.240	2.669	.079	.100	8.0	16.000	2,300	
8/22/74	1200	69.5	6.4	610.0											
8/22/74	1605	70.5	7.7	610.0	.025	1.200	.060	1.060	2.354	.074	.090	8.2	15.000	790	
8/28/75	0001	70.0	5.8	626.0											
8/28/75	0401	67.0	5.7	644.0	.024	1.110	.030	.610	1.650	.079	.130	7.9	18.000	700	
8/28/75	1130	67.0	7.0	637.0											
8/28/75	1530	73.0	9.7	590.0	.013	1.120	.030	.360	1.450	.064	.060	8.3	18.000	340	
RK-03															
2/27/64		33.0	17.1	570.0								8.2	20.000		100.000
3/12/64		41.0	14.0												500.000
4/02/64		42.0	13.5	600.0								8.4	20.000		300.000
5/14/64		59.0	13.5												200.000
6/03/64		62.0	12.8												700.000
7/15/64		77.0	10.9												2000.000
8/13/64		64.0	12.2												900.000
9/16/64		53.0	13.1	674.0	.100	.136						8.0	15.000		600.000
10/28/64		49.0	9.3												1000.000
11/18/64		36.0	16.1												200.000
12/16/64		35.0	9.5												100.000
1/14/65		32.0	15.2			.158									100.000
2/11/65		32.0	7.8			.520									2000.000
10/18/66	1410	50.0	11.3	770.0	.020	1.200					.210	7.4	30.000		5900.000
4/11/67	1220	44.0	13.9	705.0	.010	1.900					.060	8.3	20.000		250.000
4/22/68	1010	54.0	9.1	676.0	.017	1.265				.038		7.8	14.400	50	
8/15/68	0935	67.0	8.6	800.0	.010	.301				.347		8.2	25.980	390	16000.000
4/02/69	0855	34.0	10.4	840.0	.020	1.100				.027		7.6	17.000	10	100.000
8/13/69	1150	83.0	8.4	670.0	.005	.200				.520		8.2	32.000	1,100	3100.000
8/13/70	0415	81.0	14.2	635.0								8.9	40.000		
8/13/70	0835	76.5	3.6	675.0								8.4	40.000		
8/13/70	0855	70.0	7.4	735.0	.014	.160				.367		8.1	39.000	40	
8/13/70	1210	76.5	14.3	665.0								8.6	38.000		
8/14/70	0100	72.0	.7	810.0								8.0	28.000		
8/14/70	0430	69.0	1.0	810.0								8.0	28.000		
8/11/71	2330	64.0	2.0	695.0	.022	.400				.123		7.8	23.000	600	
8/12/71	0330	61.5	2.3	707.0								7.8	25.000		
8/12/71	0720	62.0	5.2	680.0								7.8	85.000		
8/12/71	1125	68.0	7.8	687.0								8.1	45.000		
8/12/71	1530	77.5	8.5	704.0								8.3	48.000		
8/12/71	1925	73.0	5.7	719.0								8.2	49.000		
8/17/72	0035	73.0	3.0	572.0											
8/17/72	0435	72.0	2.3	572.0	.005	.170	.130	1.860	2.160	.449	.590	8.1	31.000	210	
8/17/72	1235	75.5	2.8	602.0											
8/17/72	1635	79.0	2.8	592.0	.006	.200	.160	1.940	2.310	4.147	.460	7.7	21.000	320	
8/21/73	0035	69.5	1.4	839.0											
8/21/73	0435	65.0	1.5	862.0	.041	.480	.070	1.470	2.060	.474	.450	7.9	29.000	90	
8/21/73	1225	69.0	6.3	722.0											
8/21/73	1625	73.0	7.6	723.0	.018	.520	.030	1.220	1.760	.179	.140	8.0	35.000	150	
8/22/74	0040	71.0	2.7	680.0											
8/22/74	0430	69.5	2.4	675.0	.019	.270	.120	1.660	2.057	.348	.360	7.8	27.000	750	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-03															
8/22/74	1240	71.5	5.9	690.0											
8/22/74	1640	72.5	7.5	700.0	.017	.250	.280	1.750	2.302	.339	.360	8.1	26.000	4,300	
8/28/75	0040	72.0	5.2	480.0											
8/28/75	0440	71.0	5.3	486.0	.009	.210	.030	.480	.610	.049	.040	7.8	35.000	100	
8/28/75	1200	71.5	5.7	522.0											
8/28/75	1600	76.0	5.7	486.0	.002	.090	.030	.670	.710	.040	.060	7.8	32.000	60	
RK-04															
1/29/64		32.0	7.2	2,080.0								7.3	445.000		170000.000
2/27/64		33.0	14.6	2,540.0								8.0	590.000		57000.000
3/12/64		42.0	15.1	1,080.0											6000.000
4/02/64		44.0	14.3	924.0								8.4	105.000		200.000
5/14/64		64.0	11.4	1,320.0								8.5	190.000		9000.000
6/03/64		62.0	12.3	2,320.0								7.6	510.000		8000.000
7/15/64		77.0	10.5	1,060.0								7.9	235.000		4000.000
8/13/64		64.0	13.9	2,310.0	.200							8.4	520.000		2000.000
9/16/64		57.0	10.3	2,030.0	.300	.927						8.0	455.000		39000.000
10/28/64		50.0	5.4	2,130.0	.200	.565						7.4	440.000		12000.000
11/18/64		41.0	10.9	2,430.0	.400	1.017						7.6	525.000		50000.000
12/16/64		35.0	8.3	2,700.0	.200	1.153						7.4	610.000		40000.000
1/14/65		32.0	4.2	3,390.0	.800	.723						7.4	850.000		270000.000
2/11/65		32.0	9.0	434.0		.678						7.1	55.000		30000.000
10/18/66	1340	48.0	9.7	1,750.0	.210	13.600					2.050	7.4	305.000		7100.000
4/11/67	1245	50.0	14.3	865.0	.040	2.200					.280	8.5	55.000		17400.000
4/22/68	1030	57.0	6.9	737.0	.048	.964				.151		7.8	22.600	100	
8/15/68	0900	68.0	4.2	2,310.0	.306	.226				1.957		7.8	400.470	1,900	1500000.000
4/02/69	0910	36.0	11.6	750.0	.086	1.100				.350		8.0	35.000	10	1200.000
8/13/69	1210	84.0	8.9	1,620.0	.701	1.500				2.253		8.2	460.000	1,000	30000.000
8/13/70	0350	84.0	6.9	2,275.0								8.1	370.000		
8/13/70	0820	79.0	1.8	3,000.0								7.9	600.000		
8/13/70	0845	72.0	2.6	2,120.0	.300	.510				1.130		8.0	390.000	50	
8/13/70	1200	80.0	7.1	2,070.0								8.1	350.000		
8/14/70	0415	72.0	.8	2,700.0								7.9	470.000		
8/14/70	1245	75.5	.6	2,930.0								7.9	560.000		
8/11/71	2350	69.0	.8	1,379.0	.095	.290				1.997		7.6	186.000	170	
8/12/71	0350	65.0	.9	1,340.0								7.6	158.000		
8/12/71	0740	65.0	1.6	1,392.0								7.7	897.000		
8/12/71	1140	71.5	6.0	1,778.0								7.8	275.000		
8/12/71	1545	78.5	5.8	2,081.0								7.9	332.000		
8/12/71	1935	74.0	1.4	2,129.0								7.8	362.000		
8/17/72	0050	73.0	3.0	700.0											
8/17/72	0450	73.0	3.2	657.0	.179	.490	.240	1.600	2.510	.477	.980	8.1	55.000	230	
8/17/72	1245	75.5	2.9	694.0											
8/17/72	1645	78.0	2.8	733.0	.185	.580	.560	2.400	3.720	.379	1.110	7.8	49.000	800	
8/21/73	0045	71.0	2.5	1,375.0											
8/21/73	0445	67.0	2.6	1,818.0	.265	.860	4.250	1.810	7.190	1.769	2.170	7.7	302.000	21,000	
8/21/73	1235	73.0	5.2	1,548.0											
8/21/73	1635	75.0	5.2	1,454.0	.355	1.050	2.840	1.820	6.060	2.711	2.450	7.8	241.000	5,100	
8/22/74	0050	74.0	5.7	900.0											
8/22/74	0445	72.5	5.7	725.0	.106	1.990	.220	1.970	4.289	.632	.650	7.8	62.000	210	
8/22/74	1250	72.5	6.3	700.0											
8/22/74	1655	74.0	6.8	760.0	.142	2.630	.280	1.840	4.890	.750	.640	8.1	86.000	1,700	
8/28/75	0055	69.0	5.8	647.0											
8/28/75	0455	68.0	6.1	655.0	.028	.830	.030	.670	1.460	.132	.280	7.7	57.000	260	
8/28/75	1220	73.0	7.2	668.0											
8/28/75	1630	75.5	7.4	644.0	.037	1.570	.030	.570	2.110	.185	.250	7.9	67.000	90	
RK-05															
2/27/64		33.0	13.1	696.0								7.9	20.000		700.000
4/02/64		39.0	13.3	512.0								8.2	5.000		100.000
5/14/64		64.0	5.1									8.4			700.000
6/03/64		66.0	9.9												1100.000
7/17/64		76.0	5.0												6000.000
8/07/64		77.0	9.2												10000.000
9/14/64		56.0	10.8	568.0		.181						8.0	5.000		2000.000
10/28/64		49.0	10.8												1700.000
11/18/64		41.0	15.9												500.000
12/07/64		32.0	9.6												1600.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-05															
1/14/65		32.0	10.1			.362									400.000
2/11/65		32.0	10.9			1.040									5000.000
10/18/66	1305	49.0	11.0	585.0	.010	.300					.080	7.6	15.000		5300.000
4/11/67	1320	51.0	13.6	630.0	.010	1.300					.060	8.5	15.000		610.000
4/22/68	1100	58.0	9.2	729.0	.040	1.656				.047		8.0	9.600	90	
8/14/68	1300	72.0	8.0	594.0	.010	.090				.040		8.2	15.940	1,500	23000.000
3/31/69	1100	36.0	14.9	680.0	.010	.500				.040		8.1	11.000	10	200.000
8/14/69	0800	72.0	1.5	630.0	.021	.300				.080		8.1	14.000	730	21000.000
8/13/70	0310	82.5	9.9	570.0								8.6	10.000		
8/13/70	0740	82.0	6.9	550.0								8.8	11.000		
8/13/70	0805	68.5	6.0	640.0	.016	.210				.143		8.2	13.000	2,000	
8/13/70	1120	76.0	8.0	590.0								8.3	10.000		
8/13/70	1200	77.0	4.7	550.0								8.5	10.000		
8/14/70	0335	72.0	4.7	595.0								8.2	11.000		
8/11/71	2245	71.5	5.9	610.0	.028	.550				.073		8.2	12.000	120	
8/12/71	0245	66.0	5.9	616.0								8.0	13.000		
8/12/71	0645	67.0	4.2	606.0								7.9	3.000		
8/12/71	1045	73.0	8.8	608.0								8.2	12.000		
8/12/71	1450	78.0	8.4	658.0								8.4	8.000		
8/12/71	1845	74.5	7.8	622.0								8.5	14.000		
8/17/72	0130	73.5	5.3	588.0											
8/17/72	0530	73.0	5.3	594.0	.017	.270	.130	1.370	1.790	.151	.210	8.2	19.000	90	
8/17/72	1330	81.0	6.3	602.0											
8/17/72	1730	83.0	6.3	628.0	.018	.300	.120	1.160	1.600	.155	.150	8.4	15.000	240	
8/21/73	0130	67.0	6.2	680.0											
8/21/73	0530	64.5	6.4	687.0	.019	.350	.130	1.370	1.870	.199	.240	7.9	17.000	700	
8/21/73	1250	72.0	8.0	680.0											
8/21/73	1650	77.0	8.2	651.0	.006	.330	.080	1.110	1.530	.219	.200	8.2	17.000	400	
8/22/74	0115	71.0	5.3	590.0											
8/22/74	0510	70.0	5.1	590.0	.013	.280	.100	1.130	1.518	.217	.220	7.8	15.000	850	
8/22/74	1315	72.5	5.8	660.0											
8/22/74	1715	73.0	6.5	560.0	.015	.290	.080	1.340	1.728	.151	.210	7.9	18.000	5,700	
8/28/75	0155	70.0	4.4	459.0											
8/28/75	0555	69.0	4.9	459.0	.015	.230	.030	.650	.830	.177	.150	7.6	12.000	180	
8/28/75	1300	74.5	5.0	480.0											
8/28/75	1700	73.5	4.9	480.0	.017	.320	.030	.690	.960	.193	.230	7.8	12.000	140	
RK-06															
3/12/64		36.0	13.6												200.000
4/02/64		39.0	14.0	480.0								8.4	5.000		600.000
5/14/64		61.0	11.7												1600.000
6/03/64		63.0	8.9												1300.000
7/17/64		76.0	6.6												1500.000
8/07/64		77.0	7.3												700.000
9/14/64		59.0	10.5	490.0								8.0			2500.000
10/28/64		51.0	10.5												300.000
11/18/64		38.0	14.1												200.000
12/07/64		32.0	13.0												300.000
1/14/65		32.0	13.1			.475									100.000
2/11/65		32.0	11.0			.452									1300.000
10/18/66	1235	49.0	10.2	550.0	.010	.600					.070	7.6	15.000		4800.000
4/12/67	0840	41.0	11.9	560.0	.020	1.200					.040	8.3	5.000		780.000
4/22/68	1115	57.0	9.0	612.0	.022	.813				.050		8.0	7.400	30	
8/14/68	1320	73.0	8.1	530.0	.020	.331				.037		8.2	11.420	2,000	6000.000
3/31/69	1030	33.0	13.2	710.0	.018	.900				.030		8.0	10.000	10	100.000
8/13/69	1305	83.0	6.5	560.0	.018	.200				.017		8.2	13.000	2,000	6000.000
8/13/70	0325	81.0	7.8	525.0								8.3	9.000		
8/13/70	0755	81.0	5.7	520.0								8.2	8.000		
8/13/70	0825	72.0	6.3	450.0	.024	.410				.080		8.1	9.000	350	
8/13/70	1135	78.0	7.3	470.0								8.3	10.000		
8/14/70	0355	76.0	5.4	505.0								8.2	8.000		
8/14/70	1225	78.0	5.2	520.0								8.2	9.000		
8/11/71	2305	71.0	6.5	576.0	.021	.630				.040		8.2	10.000	430	
8/12/71	0305	66.5	7.0	567.0								8.1	10.000		
8/12/71	0700	65.0	7.3	577.0								8.0	11.000		
8/12/71	1100	67.0	8.2	574.0								8.2	10.000		
8/12/71	1510	75.0	7.5	588.0								8.3	11.000		
8/12/71	1900	77.5	6.5	584.0								8.4	11.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-06															
8/17/72	0110	75.5	5.6	541.0											
8/17/72	0510	74.0	6.0	546.0	.023	.380	.150	1.220	1.770	.062	.110	8.2	17.000	140	
8/17/72	1310	78.5	6.0	564.0											
8/17/72	1715	84.5	5.8	566.0	.025	.270	.110	1.210	1.610	.067	.100	8.2	11.000	230	
8/21/73	0115	70.5	6.7	615.0											
8/21/73	0515	67.0	7.1	629.0	.010	.730	.030	1.140	1.880	.043	.090	7.8	11.000	230	
8/21/73	1305	70.0	6.2	607.0											
8/21/73	1705	75.0	7.4	601.0	.006	.580	.030	1.340	1.930	.094	.080	8.1	11.000	200	
8/22/74	0130	75.0	6.3	575.0											
8/22/74	0525	73.0	6.1	560.0	.016	.470	.070	1.060	1.609	.034	.060	8.0	14.000	340	
8/22/74	1330	72.0	6.8	525.0											
8/22/74	1735	72.5	6.8	550.0	.012	.440	.280	1.190	1.924	.026	.080	8.0	14.000	4,300	
8/28/75	0120	70.0	6.2	501.0											
8/28/75	0520	69.0	6.2	475.0	.007	.350	.030	.580	.850	.030	.070	7.8	16.000	450	
8/28/75	1245	73.0	6.3	491.0											
8/28/75	1645	78.0	6.2	486.0	.009	.310	.030	.590	.810	.036	.090	7.9	14.000	90	
RK-07															
2/20/64		37.0	13.8	436.0								8.4	15.000		100.000
3/12/64		41.0	13.7												200.000
4/02/64		40.0	13.5	392.0								8.2	5.000		100.000
5/14/64		63.0	9.7												100.000
6/03/64		68.0	10.1												100.000
7/17/64		78.0	8.8												200.000
8/07/64		80.0	10.5												100.000
9/14/64		64.0	10.7	376.0		.045						8.7	15.000		100.000
10/28/64		53.0	8.9												100.000
11/19/64		46.0	11.6												100.000
12/07/64		35.0	13.6												100.000
1/14/65		35.0	13.9			.023									100.000
2/11/65		37.0	12.5			.113									100.000
10/18/66	1210	51.0	8.9	425.0		.400					.070	7.5	15.000		1900.000
4/12/67	0855	42.0	12.2	455.0							.060	8.5	5.000		120.000
4/22/68	1215	55.0	11.1	544.0	.003	.015				.060		8.2	8.100	5	
8/14/68	1230	76.0	8.6	455.0	.003					.047		8.4	11.920	30	100.000
3/31/69	1045	37.0	12.9	535.0	.003	.100				.033		8.3	8.000	10	100.000
8/14/69	0820	76.0	7.0	450.0	.002	.100				.010		8.3	12.000	5	900.000
8/13/70	0250	81.0	10.6	415.0								8.8	9.000		
8/13/70	0715	75.0	9.1	445.0	.001	.050				.267		8.7	9.000	60	
8/13/70	0720	81.0	10.9	405.0								8.8	9.000		
8/13/70	1100	79.0	9.6	425.0								8.7	10.000		
8/13/70	1150	79.5	9.2	410.0								8.7	10.000		
8/14/70	0320	78.0	9.0	435.0								8.7	10.000		
8/11/71	2230	72.5	9.9	435.0		.090				.006		8.6	10.000	90	
8/12/71	0230	71.0	9.9	431.0								8.6	10.000		
8/12/71	0630	71.0	8.8	410.0								8.5	10.000		
8/12/71	1030	71.5	8.9	448.0								8.5	11.000		
8/12/71	1435	74.5	10.5	457.0								8.7	10.000		
8/12/71	1830	75.5	10.3	453.0								8.7	11.000		
8/17/72	0145	76.0	8.5	434.0											
8/17/72	0545	75.0	7.5	438.0		.040	.080	.770	.890	.016	.030	8.5	16.000	10	
8/17/72	1340	78.0	10.1	446.0											
8/17/72	1745	78.5	10.6	441.0		.040	.110	.780	.930	.008	.030	8.6	14.000	10	
8/21/73	0150	75.0	7.3	481.0											
8/21/73	0550	73.0	6.7	508.0	.002	.150	.030	.980	1.130	.130	.030	8.0	13.000	20	
8/21/73	1315	70.0	9.1	494.0											
8/21/73	1715	76.0	9.9	479.0		.130	.030	1.050	1.180	.033	.020	8.2	13.000	50	
8/22/74	0145	75.5	8.2	470.0											
8/22/74	0540	75.0	7.1	470.0	.008	.090	.050	.790	.936	.025	.020	8.3	14.000	10	
8/22/74	1350	75.5	8.0	460.0											
8/22/74	1750	75.0	8.3	460.0	.009	.080	.030	.740	.843	.025	.020	8.3	15.000	570	
8/28/75	0140	74.0	8.0	407.0											
8/28/75	0540	73.5	7.3	405.0	.002	.090	.030	.280	.290	.005	.020	8.4	16.000	10	
8/28/75	1320	76.0	9.5	397.0											
8/28/75	1720	76.5	9.8	395.0	.002	.100	.030	.350	.370	.015	.010	8.4	16.000	10	
RK-08															
1/29/64		35.0	10.2	544.0	.300							7.8	20.000		66000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-08															
2/20/64		37.0	7.9	644.0								7.2	45.000		88000.000
3/12/64		44.0	9.0	724.0											120000.000
4/02/64		41.0	10.4	470.0								8.0	15.000		100.000
5/14/64		64.0	9.6	488.0								8.2	15.000		37000.000
6/03/64		68.0	8.4	640.0								8.0	35.000		2300000.000
7/17/64		78.0	7.3	594.0								8.2	45.000		110000.000
8/07/64		79.0	10.5	604.0								7.7	35.000		440000.000
9/14/64		59.0	5.7	782.0	.100	.655						7.6	70.000		1100000.000
10/28/64		55.0	4.6	724.0	.400	.768						7.2	50.000		1500000.000
11/19/64		43.0	8.6	648.0	.400	.814						7.6	45.000		250000.000
12/07/64		32.0	13.3	502.0		.429						8.0	20.000		40000.000
1/14/65		32.0	11.7	586.0	.100	.045						8.2	30.000		170000.000
2/11/65		36.0	13.7	464.0		.203						7.8	15.000		19000.000
10/18/66	1150	50.0	5.6	580.0	.060	.800					1.590	7.2	35.000		92000.000
4/12/67	0910	45.0	10.9	495.0	.010	.400					.180	8.3	15.000		34000.000
4/22/68	1240	60.0	8.8	566.0	.017	.693				.007		8.2	14.300	220	
8/14/68	1140	75.0	9.4	438.0	.013	.120				.297		8.4	18.450	1,600	34000.000
3/31/69	1130	38.0	13.2	555.0	.008	.200				.040		8.3	13.000	70	800.000
8/14/69	0845	74.0	5.1	600.0	.024	.100				.960		7.7	39.000	4,900	2500000.000
8/13/70	0235	83.0	22.4	595.0								8.9	37.000		
8/13/70	0705	72.0	2.6	685.0	.063	.880				1.530		7.6	38.000	3,400	
8/13/70	0710	83.5	25.1	550.0								9.2	36.000		
8/13/70	1050	76.0	8.4	675.0								7.9	42.000		
8/13/70	1135	80.0	9.0	670.0								8.2	55.000		
8/14/70	0305	76.0	4.3	820.0								7.8	66.000		
8/11/71	2215	74.5	9.9	655.0	.072	1.120				2.607		8.3	46.000	1,000	
8/12/71	0215	71.0	4.3	701.0								7.7	49.000		
8/12/71	0615	68.0	2.8	710.0								7.6	53.000		
8/12/71	1015	69.0	5.7	684.0								7.6	45.000		
8/12/71	1415	77.5	12.8	691.0								8.3	45.000		
8/12/71	1815	77.5	15.8	660.0								8.8	41.000		
8/17/72	0200	76.0	5.3	480.0											
8/17/72	0600	75.0	5.2	484.0	.007	.200	.140	1.030	1.380	.261	.410	8.2	30.000	210	
8/17/72	1400	80.0	7.4	499.0											
8/17/72	1800	81.5	7.7	505.0	.013	.310	.120	.970	1.410	.223	.370	8.3	26.000	100	
8/21/73	0200	73.0	4.1	638.0											
8/21/73	0600	69.5	4.0	620.0	.043	.680	.440	1.420	2.580	.722	.700	7.7	36.000	740	
8/21/73	1325	75.0	6.8	573.0											
8/21/73	1735	76.0	7.2	544.0	.018	.170	.090	1.320	1.600	.519	.470	7.8	24.000	2,100	
8/22/74	0155	76.0	4.8	500.0											
8/22/74	0550	75.0	4.3	500.0	.067	.470	.170	1.300	2.013	.265	.340	7.9	28.000	280	
8/22/74	1405	74.5	5.5	475.0											
8/22/74	1800	74.5	5.6	430.0	.102	.670	.350	1.390	2.510	.238	.360	7.8	24.000	29,000	
8/28/75	0210	73.0	5.6	438.0											
8/28/75	0610	72.0	5.5	431.0	.011	.110	.030	.490	.530	.102	.220	7.9	22.000	1,400	
8/28/75	1340	76.0	6.6	438.0											
8/28/75	1740	76.5	6.4	420.0	.011	.210	.030	.480	.630	.075	.160	7.8	21.000	100	
RK-09															
3/12/64		40.0	12.3												600.000
4/02/64		42.0	10.9	448.0								8.0	5.000		23000.000
5/14/64		59.0	10.3									8.2			300.000
6/03/64		67.0	11.8												800.000
7/17/64		76.0	9.2												1000.000
8/07/64		74.0	9.4												2300.000
9/14/64		60.0	10.8	488.0		.294						7.9	5.000		9000.000
10/28/64		52.0	9.2												500.000
11/19/64		40.0	12.6												13000.000
12/07/64		32.0	11.7												100000.000
1/14/65		32.0	12.6			.294									25000.000
2/11/65		33.0	13.5			.181									1000.000
10/18/66	1125	49.0	9.2	495.0	.010	1.200					.220	7.4	20.000		8900.000
4/12/67	0930	42.0	11.6	475.0		.300					.080	8.5	5.000		1300.000
4/22/68	1250	59.0	8.7	545.0	.008	.542				.056		8.0	12.500	80	
8/14/68	1325	73.0	11.2	425.0	.005	.123				.053		8.4	12.390	100	900.000
3/31/69	1225	37.0	13.2	585.0	.009	.300				.083		8.2	15.000	270	1400.000
8/12/69	1300	78.0	7.0	500.0	.010	.200				.080		7.9	20.000	140	6500.000
8/13/70	0225	77.0	8.4	510.0								8.2	17.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-09															
8/13/70	0650	71.5	4.8	510.0	.007	.280				.113		8.0	15.000	200	
8/13/70	0655	78.5	9.8	495.0								8.6	17.000		
8/13/70	1040	75.0	6.4	475.0								8.1	17.000		
8/13/70	1120	77.5	4.6	450.0								8.4	15.000		
8/14/70	0245	75.5	3.4	445.0								8.2	15.000		
8/11/71	2200	73.5	6.9	452.0		.180				.027		8.6	16.000	40	
8/12/71	0200	70.0	4.9	444.0								8.5	16.000		
8/12/71	0600	68.0	4.1	461.0								8.0	16.000		
8/12/71	1000	70.0	8.9	470.0								8.3	17.000		
8/12/71	1405	72.0	8.1	491.0								8.3	17.000		
8/12/71	1800	68.5	8.1	514.0								8.3	19.000		
8/17/72	0210	76.0	4.5	465.0											
8/17/72	0610	74.5	4.1	466.0	.002	.080	.090	.860	1.030	.053	.090	8.2	27.000	190	
8/17/72	1410	79.5	7.5	483.0											
8/17/72	1815	82.0	7.5	474.0	.009	.100	.190	1.030	1.330	.097	.100	8.2	22.000	40	
8/21/73	0215	71.0	4.7	565.0											
8/21/73	0615	68.0	4.4	564.0	.005	.110	.050	1.140	1.310	.071	.110	7.6	21.000	360	
8/21/73	1340	72.0	7.9	572.0											
8/21/73	1740	74.0	10.2	550.0	.015	.150	.050	1.120	1.330	.101	.080	6.0	22.000	100	
8/22/74	0210	74.5	5.9	500.0											
8/22/74	0605	72.5	4.8	500.0	.009	.190	.050	1.080	1.327	.027	.050	7.8	23.000	170	
8/22/74	1405	74.5	5.5	475.0											
8/22/74	1800	74.5	5.6	430.0	.063	.740	5.690	1.360	7.845	.305	.340	7.9	19.000	60,000	
8/28/75	0225	72.0	5.6	449.0											
8/28/75	0620	70.0	5.2	431.0	.003	.090	.030	.440	.470	.022	.060	7.6	26.000	500	
8/28/75	1350	75.0	8.2	454.0											
8/28/75	1750	77.0	8.4	431.0	.002	.090	.030	.390	.390	.043	.090	8.1	29.000	200	
RK-10															
4/09/64		48.0	11.4	756.0								8.4	20.000		42000.000
5/14/64		64.0	7.4									8.2			90000.000
6/10/64		73.0	5.6												29000.000
7/17/64		80.0	6.1												17000.000
8/14/64		72.0	11.3												60000.000
9/14/64		66.0	10.4	500.0	.100	.565						8.2	15.000		140000.000
10/28/64		57.0	6.8												1000000.000
11/19/64		42.0	9.1												380000.000
12/16/64		41.0	9.6												250000.000
1/20/65		37.0	9.7			.407									90000.000
2/15/65		35.0	8.8			.994									60000.000
10/17/66	1040	51.0	8.4	540.0	.250	1.100					1.200	7.3	20.000		14000.000
4/12/67	1015	48.0	11.2	825.0	.060	3.500					.380	8.4	45.000		200000.000
4/22/68	1330	63.0	8.2	763.0	.132	1.867				.097		8.2	17.900	50,000	
8/14/68	1220	76.0	6.8	636.0	.061	.783				.833		8.2	33.510	12,000	180000.000
4/01/69	0830	37.0	13.5	830.0	.035	3.200				.477		8.2	27.000	2,500	269999.872
8/14/69	0930	76.0	5.6	640.0	.043	1.200				1.023		8.1	41.000	1,400	80000.000
7/29/70	0300	83.0	7.3	550.0								8.4	22.000		
7/29/70	0705	80.0	5.7	695.0								8.3	62.000		
7/29/70	0710	78.0	3.8	475.0	.110	2.400				.533		7.8	8.000	37,000	
7/29/70	1040	79.0	3.7	545.0								8.2	31.000		
7/29/70	2240	79.0	3.7	545.0								8.2	31.000		
7/30/70	0230	74.5	6.7	210.0								8.1	38.000		
8/04/71	0030	67.0	4.9	642.0	.066	.940				.847		8.2	28.000	10	
8/05/71	0435	65.0	4.9	581.0								8.2	20.000		
8/05/71	0825	66.0	5.3	585.0								8.1	16.000		
8/05/71	1230	72.0	7.1	628.0								8.3	27.000		
8/05/71	1630	77.0	7.9	676.0								8.4	38.000		
8/05/71	2030	71.0	6.3	693.0								8.3	40.000		
8/10/72	0215	68.0	4.4	593.0											
8/10/72	0615	66.0	4.7	590.0	.029	.340	.620	1.610	2.600	.931	.940	8.1	28.000	250	
8/10/72	1410	73.0	8.6	636.0											
8/10/72	1815	72.0	7.8	648.0	.041	.400	1.940	1.740	4.120	1.002	1.060	8.2	36.000	70	
8/09/73	0210	79.0	2.2	649.0											
8/09/73	0610	78.0	3.2	582.0	.087	1.030	.300	.770	2.190	.905	.970	7.9	19.000	14,000	
8/09/73	1425	81.5	6.8	664.0											
8/09/73	1810	82.0	5.5	612.0	.062	1.330	.210	1.030	2.630	1.009	1.280	8.0	26.000	12,000	
8/15/74	0210	71.5	6.4	610.0											
8/15/74	0610	70.0	6.6	600.0	.051	2.260	.180	1.120	3.610	.772	.710	8.2	25.000	200	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-10															
8/15/74	1430	78.5	8.0	675.0											
8/15/74	1810	78.5	9.9	690.0	.060	2.710	.660	1.240	4.679	.884	.980	8.2	29.000	700	
8/21/75	0210	78.5	6.3	555.0											
8/21/75	0610	71.0	6.4	506.0	.028	.680	.030	.330	1.210	.666	.660	8.2	22.000	110	
8/21/75	1305	77.0	9.2	533.0											
8/21/75	1710	81.0	9.9	527.0	.032	1.070	.090	.610	1.810	1.026	1.070	8.3	30.000	390	
RK-11															
3/30/64		36.0	12.6												100000.000
4/09/64		45.0	13.5	696.0								8.8	45.000		8000.000
5/14/64		52.0	4.4												150000.000
6/10/64		68.0	1.8												9000.000
7/30/64		74.0	1.6												54000.000
8/14/64		67.0	5.1												300000.000
9/16/64		59.0	5.9	1,010.0	.200	1.559						7.6	150.000		4000.000
10/28/64		54.0	6.3												29000.000
11/19/64		40.0	5.6												5400.000
12/16/64		35.0	4.9												80000.000
1/20/65		33.0	3.4			.610									220000.000
2/15/65		32.0	6.4			.633									70000.000
10/17/66	1155	50.0	5.4	855.0	.520	5.600					3.740	7.2	85.000		16000.000
4/12/67	1125	42.0	10.7	775.0	.070	2.900					.380	7.8	30.000		35000.000
4/16/68	1200	50.0	9.0	1,034.0	.118	1.387				1.104		8.2	47.700	2,100	
8/14/68	1130	71.0	2.6	1,390.0	.306	3.372				1.743		7.8	173.060	3,800	75000.000
4/01/69	1020	36.0	11.1	905.0	.075	2.700				.927		7.9	47.000	5,500	82000.000
8/13/69	0850	72.0	5.0	1,150.0	.126	.500				2.710		7.5	212.000	3,800	100000.000
7/29/70	0400	83.0	22.2	1,025.0								9.1	180.000		
7/29/70	0755	80.0	16.1	985.0								8.9	160.000		
7/29/70	0830	76.0	2.6	1,110.0	.400	.740				4.000		7.7	140.000	41,000	
7/29/70	1145	77.0	7.0	1,020.0								8.2	69.000		
7/29/70	1200	77.0	10.5	1,125.0								7.8	160.000		
7/30/70	0325	73.0	2.2	1,590.0								7.8	315.000		
8/04/71	2335	65.0	4.1	1,640.0	.404	2.480				4.153		7.9	311.000	190	
8/05/71	0340	64.0	3.0	1,542.0								7.8	304.000		
8/05/71	0725	64.0	2.5	1,708.0								7.8	284.000		
8/05/71	1120	68.5	3.2	1,708.0								7.8	292.000		
8/05/71	1530	71.5	5.1	1,708.0								7.9	280.000		
8/05/71	1930	71.0	7.1	1,669.0								7.9	277.000		
8/10/72	0120	64.0	4.4	915.0											
8/10/72	0520	63.0	4.2	888.0	.008	2.410	.690	1.690	4.800	.853	1.070	7.7	72.000	600	
8/10/72	1310	65.0	5.3	990.0											
8/10/72	1715	70.0	5.3	999.0	.127	2.330	1.370	2.220	6.050	.899	.860	7.9	103.000	830	
8/09/73	0115	77.0	3.7	1,339.0											
8/09/73	0515	77.0	2.0	1,190.0	.215	2.460	1.700	2.020	6.390	1.719	2.180	7.8	177.000	480	
8/09/73	1335	78.5	2.0	720.0											
8/09/73	1715	80.5	3.7	715.0	.136	1.300	.740	1.670	3.850	1.088	1.480	7.7	99.000	22,000	
8/15/74	0120	72.0	2.1	1,250.0											
8/15/74	0520	70.0	1.5	1,290.0	.209	1.630	3.630	1.700	7.165	2.129	2.830	7.8	163.000	440	
8/15/74	1325	79.0	6.0	1,460.0											
8/15/74	1715	82.5	13.7	1,480.0	.157	1.240	2.210	3.200	6.802	1.781	2.140	8.3	192.000	100	
8/21/75	0115	77.0	1.8	1,066.0											
8/21/75	0515	70.0	2.0	987.0	.203	1.810	1.460	.960	4.440	1.679	2.110	7.8	221.000	16,000	
8/21/75	1150	78.0	4.7	993.0											
8/21/75	1550	81.0	13.3	1,044.0	.238	1.670	.920	1.790	4.610	1.325	1.750	8.1	177.000	2,900	
RK-12															
2/19/64		32.0	13.8	434.0								7.8	20.000		100.000
3/30/64		36.0	14.0												100.000
4/09/64		43.0	13.4	440.0								8.1	20.000		100.000
5/14/64		59.0	9.3												100.000
6/10/64		68.0	14.7												800.000
7/30/64		75.0	12.6												21000.000
8/14/64		63.0	7.2												1000.000
9/16/64		59.0	7.5	580.0	.100	.429						7.6	30.000		200.000
10/28/64		54.0	8.6												11000.000
11/19/64		40.0	13.2												1300.000
12/16/64		35.0	11.8												1000.000
1/20/65		33.0	14.2			.090									100.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-12															
2/15/65		32.0	10.2			.203									5000.000
10/17/66	1135	48.0	10.3	450.0	.030	.500					.130	7.5	30.000		10000.000
4/12/67	1100	45.0	11.6	440.0	.010	.600					.080	8.8	20.000		230.000
4/16/68	1220	56.0	17.1	557.0	.028	.194				.104		9.0	22.200	15	
8/14/68	0930	69.0	5.3	550.0	.184	.241				.127		7.8	29.490	390	7000.000
4/01/69	0945	39.0	12.9	570.0	.014	.200				.140		8.4	27.000	10	500.000
8/13/69	0915	71.0	4.3	450.0	.071	.200				.123		8.1	39.000	400	4000.000
7/29/70	0345	84.0	4.8	445.0								8.1	31.000		
7/29/70	0740	80.0	2.2	440.0								8.0	30.000		
7/29/70	0745	76.0	2.0	430.0	.059	.270				.223		7.8	22.000	790	
7/29/70	1125	78.0	1.5	445.0								7.8	36.000		
7/29/70	2325	78.0	1.5	445.0								7.8	36.000		
7/30/70	0310	74.5	3.1	420.0								7.7	34.000		
8/04/71	2350	64.0	3.5	506.0	.068	.570				.153		8.4	32.000	520	
8/05/71	0350	61.0	2.5	519.0								8.1	32.000		
8/05/71	0740	61.0	3.7	513.0								7.8	49.000		
8/05/71	1130	69.5	6.2	495.0								8.2	31.000		
8/05/71	1545	80.5	6.7	494.0								8.5	32.000		
8/05/71	1945	77.0	4.4	489.0								8.7	32.000		
8/10/72	0135	66.0	1.7	472.0											
8/10/72	0535	67.0	1.5	452.0	.004	.110	.100	1.430	1.640	.090	.140	7.9	40.000	10	
8/10/72	1335	68.5	1.8	486.0											
8/10/72	1730	69.0	1.9	504.0	.008	.140	.130	1.380	1.660	.145	.200	7.9	37.000	10	
8/09/73	0130	74.0	2.2	675.0											
8/09/73	0530	71.0	1.7	645.0	.117	2.150	.050	.590	2.910	.139	.100	7.7	23.000	180	
8/09/73	1350	79.0	11.5	638.0											
8/09/73	1730	83.0	9.8	583.0	.056	1.710	.030	.910	2.680	.136	.180	8.1	20.000	390	
8/15/74	0130	72.0	3.1	450.0											
8/15/74	0530	71.0	3.1	450.0	.017	.270	.250	1.470	2.013	.174	.270	7.8	29.000	110	
8/15/74	1350	75.5	3.0	490.0											
8/15/74	1730	76.5	2.4	500.0	.015	.220	.110	1.470	1.820	.246	.280	7.5	28.000	170	
8/21/75	0135	77.5	1.8	496.0											
8/21/75	0535	70.0	1.7	482.0	.226	.960	.780	2.250	4.220	.281	.230	7.7	41.000	11,000	
8/21/75	1210	78.0	5.6	448.0											
8/21/75	1610	84.0	5.5	430.0	.172	.630	.390	1.320	2.520	.210	.230	7.9	35.000	1,400	
RK-13															
1/30/64		33.0	12.3	496.0								8.2	15.000		25000.000
2/19/64		41.0	13.0	584.0								7.5	30.000		5400.000
3/30/64		34.0	10.9	552.0											31000.000
4/09/64		45.0	13.3	472.0								8.4	15.000		1900.000
5/14/64		58.0	12.6	536.0								8.2	20.000		5000.000
6/10/64		69.0	10.1	646.0								7.8	45.000		400.000
7/30/64		71.0	7.8	618.0								7.5	30.000		7000.000
8/14/64		68.0	11.4	594.0								7.6	20.000		5000.000
9/16/64		60.0	14.6	656.0	.200	.768						8.0	35.000		16000.000
10/28/64		57.0	14.6	664.0	.400	.678						7.4	35.000		15000.000
11/19/64		40.0	13.0	608.0		.633						7.8	20.000		41000.000
12/16/64		35.0	12.5	674.0		.452						7.7	30.000		30000.000
1/20/65		33.0	12.0	606.0		.542						7.7	35.000		70000.000
2/15/65		32.0	11.6	346.0		.113						7.2	20.000		11000.000
10/17/66	1115	48.0	10.3	565.0	.240	.240					.190	7.5	35.000		8000.000
4/12/67	1045	46.0	12.6	560.0	.030	1.800					.080	8.2	20.000		37000.000
4/16/68	1240	57.0	15.0	639.0	.046	1.694				.329		8.6	20.300	1,500	
8/14/68	0900	67.0	8.8	667.0	.168	.831				.540		7.8	33.510	9,300	47000.000
4/01/69	0930	38.0	12.8	570.0	.025	.800				.233		8.2	25.000	600	16000.000
8/13/69	0930	68.0	6.0	610.0	.088	1.000				.597		7.9	45.000	4,300	55000.000
7/29/70	0330	82.0	17.9	550.0								8.9	30.000		
7/29/70	0730	73.0	4.5	625.0	.120	.720				.767		7.7	24.000	840	
7/29/70	1110	76.5	4.8	570.0								8.2	32.000		
7/29/70	1115	76.0	11.6	610.0								8.2	29.000		
7/29/70	1930	73.0	4.5	625.0	.120	.720				.767		7.7	24.000	840	
7/30/70	0300	73.5	4.6	570.0								7.9	30.000		
8/05/71	0005	65.0	6.0	597.0	.160	1.120				.583		8.1	26.000	12,000	
8/05/71	0410	62.0	4.3	602.0								7.8	26.000		
8/05/71	0800	61.0	5.1	602.0								7.8	25.000		
8/05/71	1145	67.5	10.5	595.0								8.2	25.000		
8/05/71	1600	77.0	13.1	570.0								8.6	24.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	IN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RK-13															
8/05/71	2000	74.0	10.3	570.0								8.6	21.000		
8/10/72	0150	66.5	5.6	480.0											
8/10/72	0550	65.0	5.5	480.0	.004	.240	.150	1.910	2.300	.179	.230	7.9	37.000	600	
8/10/72	1345	70.0	8.0	511.0											
8/10/72	1745	71.5	8.5	515.0	.014	.340	.170	2.030	2.550	.241	.230	8.1	37.000	100	
8/09/73	0145	74.0	5.0	690.0											
8/09/73	0545	71.5	3.8	615.0	.102	2.640	.320	1.300	4.360	.274	.440	7.8	28.000	1,400	
8/09/73	1400	78.0	8.7	612.0											
8/09/73	1740	80.0	9.0	603.0	.059	2.210	.100	1.350	3.720	.268	.370	7.9	29.000	12,000	
8/15/74	0145	69.0	5.4	480.0											
8/15/74	0545	68.0	5.4	490.0	.033	1.210	.180	1.630	3.081	.159	.280	7.8	27.000	1,700	
8/15/74	1400	78.0	9.7	550.0											
8/15/74	1745	80.0	7.4	560.0	.028	1.440	.030	1.650	3.120	.084	.520	8.2	26.000	790	
8/21/75	0145	76.0	4.3	465.0											
8/21/75	0545	67.0	4.3	506.0	.150	1.820	.240	.570	2.790	.186	.220	7.8	27.000	7,300	
8/21/75	1220	77.0	11.0	576.0											
8/21/75	1620	84.0	14.2	576.0	.123	1.980	.150	.620	2.870	.226	.190	8.2	34.000	1,300	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RT-01															
3/25/64		41.0	12.7	1,320.0								8.5	240.000		10000.000
4/08/64		38.0	10.4	930.0								8.4	30.000		20000.000
5/25/64		64.0	4.9												12000.000
6/11/64		59.0	5.9												800.000
7/16/64		74.0	5.1	566.0								7.2	80.000		2000.000
8/06/64		74.0	6.2	1,240.0								7.8	100.000		2400.000
9/11/64		63.0	4.4	960.0		.294						7.6	85.000		3000.000
10/02/64		59.0	2.6												10000.000
11/05/64		50.0	3.1												86000.000
12/03/64		32.0	9.6												50000.000
1/06/65		32.0	9.0			.791									20000.000
2/03/65		32.0	3.9			.475									2000.000
10/11/66	1000	50.0	.6	1,000.0		.090					.140	7.4	90.000		1900.000
4/04/67	1135	46.0	16.1	1,540.0	.006	.181					.100	8.2	225.000		1340.000
4/18/68	0700	47.0	8.0	1,247.0	.015	.221				.213		7.6	163.900	2,300	
8/14/68	0830	63.0	6.4	875.0	.040	.211				.050		8.0	76.430	140	16000.000
4/01/69	1215	37.0	11.9	1,670.0	.018	.500				.140		8.0	264.000	700	22000.000
8/14/69	1150	70.0	3.7	1,150.0	.148	.300				.583		7.7	58.000	32,000	389999.872
8/11/70	0825	65.5	4.7	945.0	.280	.150				.083		8.0	81.000	530	
8/11/70	1240	66.0	5.9	1,035.0								8.0	75.000		
8/11/70	1630	76.0	7.6	810.0								8.2	65.000		
8/11/70	2010	73.0	8.7	885.0								8.3	77.000		
8/12/70	0400	66.0	6.4	960.0								8.0	100.000		
8/12/70	1225	68.0	8.0	925.0								8.0	97.000		
8/08/71	2330	69.0	3.7	1,733.0	.265	.650				.467		7.9	279.000	700	
8/09/71	0330	69.0	3.3	1,689.0								7.9	395.000		
8/09/71	0755	69.5	3.1	1,590.0								7.9	245.000		
8/09/71	1130	71.0	3.3	1,634.0								7.8	250.000		
8/09/71	1530	74.0	4.8	1,535.0								7.8	267.000		
8/09/71	1920	75.0	4.4	1,507.0								7.8	252.000		
8/14/72	0200	75.0	5.5	1,494.0											
8/14/72	0600	72.0	6.3	464.0	.182	1.080	.440	1.190	2.890	.538	.527	7.7	85.000	2,600	
8/14/72	1345	73.0	5.2	1,431.0											
8/14/72	1740	73.5	5.8	814.0	.121	.810	.280	1.080	2.290	.214	.306	7.8	130.000	900	
8/15/73	0015	63.0	8.1	983.0											
8/15/73	0415	62.0	7.9	1,064.0	.014	.150	.200	.170	.530	.123	.070	7.9	60.000	150	
8/15/73	1220	59.5	8.3	962.0											
8/15/73	1615	60.0	9.9	973.0		.120	.030	.100	.220	.048	.100	8.1	48.000	140	
8/19/74	0020	70.0	2.6	740.0											
8/19/74	0415	68.0	2.2	750.0	.061	.370	.180	.790	1.398	.106	.120	7.6	120.000	500	
8/19/74	1225	70.5	3.9	860.0											
8/19/74	1620	73.5	3.9	925.0	.055	.230	.140	1.100	1.524	.092	.140	7.7	139.000	320	
8/25/75	0020	77.0	3.4	1,003.0											
8/25/75	0420	76.0	3.3	1,059.0	.084	.650	.320	.880	1.940	.130	.090	7.7	158.000	440	
8/25/75	1120	73.0	2.8	1,174.0											
8/25/75	1520	75.0	3.9	1,118.0	.083	.580	.420	1.120	2.200	.133	.120	7.7	173.000	610	
RT-02															
2/19/64		32.0	1.6	1,600.0								7.2	240.000		1100000.000
3/25/64		39.0	8.0												10000.000
4/08/64		39.0	9.9	924.0								7.6	100.000		77000.000
5/25/64		68.0	5.7												230000.000
6/11/64		64.0	7.2												5000.000
7/16/64		78.0	6.4												5000.000
8/06/64		75.0	3.9												7000.000
9/11/64		66.0	3.2	1,040.0	.300	1.198						7.6	115.000		5000.000
10/02/64		59.0	2.6												18000.000
11/05/64		51.0	3.7												1700.000
12/03/64		32.0	6.5												600000.000
1/06/65		33.0	9.0			1.266									90000.000
2/03/65		32.0	.7			.045									340000.000
10/11/66	1025	51.0	5.2	960.0	.052	.407					2.960	7.5	90.000		11000.000
4/04/67	1115	46.0	11.6	1,080.0	.015	.249					.640	8.2	135.000		12300.000
4/18/68	0900	49.0	6.2	1,043.0	.025	.191				.760		7.6	110.500	24,000	
8/14/68	0850	68.0	5.4	752.0	.166	.813				.797		8.0	57.600	7,800	40000.000
4/01/69	1130	39.0	12.0	1,400.0	.043	.800				.820		8.0	148.000	18,000	400000.000
8/14/69	1130	67.0	4.9	875.0	.117	.700				.643		7.7	95.000	13,000	180000.000
8/11/70	0810	70.0	6.9	1,110.0	.014	.190				.213		8.2	72.000	350	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	OP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RT-02															
8/11/70	1225	74.5	8.9	1,110.0								8.2	64.000		
8/11/70	1250	78.5	10.5	1,100.0								8.3	65.000		
8/11/70	1915	78.0	9.5	1,090.0								8.4	70.000		
8/11/70	2335	76.0	8.0	1,040.0								8.2	78.000		
8/12/70	0305	72.5	7.7	1,070.0								8.2	78.000		
8/08/71	2315	72.5	8.0	888.0	.027	.200				.450		8.5	104.000	380	
8/09/71	0315	71.0	4.1	880.0								8.8	107.000		
8/09/71	0745	71.0	2.3	875.0								8.2	107.000		
8/09/71	1110	73.0	6.5	888.0								8.5	101.000		
8/09/71	1515	82.0	10.4	855.0								8.6	105.000		
8/09/71	1905	82.0	11.6	865.0								8.8	102.000		
8/14/72	0050	74.0	6.6	1,092.0											
8/14/72	0450	74.5	6.1	1,076.0	.071	.870	.190	1.570	2.700	.678	.547	7.9	145.000	180	
8/14/72	1250	78.0	6.5	1,188.0											
8/14/72	1635	75.0	6.5	1,159.0	.084	.770	.150	1.380	2.380	.406	.537	7.9	158.000	110	
8/15/73	0035	73.0	9.0	1,109.0											
8/15/73	0430	71.0	8.0	1,178.0	.011	.120	.230	.660	1.020	.221	.380	8.3	91.000	250	
8/15/73	1230	73.0	9.1	1,104.0											
8/15/73	1630	74.5	10.4	1,124.0	.020	.320	.030	.630	.970	.162	.290	8.3	81.000	80	
8/19/74	0040	74.5	6.1	760.0											
8/19/74	0435	71.5	5.5	750.0	.091	.790	.210	1.250	2.350	.403	.500	7.7	86.000	800	
8/19/74	1240	76.5	6.0	825.0											
8/19/74	1635	80.5	6.7	890.0	.072	.740	.100	1.200	2.106	.373	.350	8.2	86.000	530	
8/25/75	0035	77.0	2.3	746.0											
8/25/75	0435	75.5	5.0	758.0	.063	.760	.170	1.250	2.240	.295	.410	7.8	101.000	780	
8/25/75	1140	75.5	5.7	832.0											
8/25/75	1540	77.0	6.0	830.0	.055	.790	.180	1.010	2.040	.312	.400	8.0	103.000	570	
RT-03															
2/19/64		32.0		1,360.0								7.0	170.000		1700000.000
3/25/64		39.0	6.9												100000.000
4/08/64		39.0	9.2	1,040.0								7.6	45.000		32000.000
5/25/64		67.0	1.2												6000.000
6/11/64		63.0	1.9												300.000
7/16/64		68.0	.9												4000.000
8/06/64		72.0	1.2												300.000
9/11/64		66.0	1.7	1,050.0	.200	.994						7.6	65.000		100.000
10/02/64		58.0	3.7												7000.000
11/05/64		53.0	8.9												100.000
12/03/64		32.0	1.0												3000.000
1/06/65		34.0	7.0			1.944									80000.000
2/03/65		32.0	.6			.136									19000.000
10/11/66	1100	51.0	.2	1,250.0	.003	.158					.590	7.2	85.000		10000.000
4/04/67	1025	41.0	9.9	795.0	.015	2.102					.160	7.4	35.000		22500.000
4/18/68	0930	48.0	5.4	1,319.0	.033	.457				.628		7.6	108.500	6,200	
8/14/68	0930	68.0	4.9	912.0	.306	2.770				.330		7.8	40.030	25,000	110000.000
4/01/69	1100	36.0	11.7	1,000.0	.045	3.500				.140		7.8	46.000	2,300	68000.000
8/14/69	1050	70.0	2.3	885.0	.201	1.600				1.060		7.7	75.000	2,200	45000.000
8/11/70	0755	70.5	1.9	1,120.0	.220	1.500				1.833		7.8	70.000	40	
8/11/70	1210	72.0	2.2	1,190.0								8.0	66.000		
8/11/70	1520	75.0	2.3	1,135.0								7.8	64.000		
8/11/70	1845	72.5	2.0	1,125.0								7.8	63.000		
8/11/70	2310	71.0	2.1	1,180.0								8.4	66.000		
8/12/70	0245	71.0	1.9	1,155.0								7.8	69.000		
8/08/71	2300	67.0	.5	1,313.0	.042	.210				4.717		7.7	194.000	2,700	
8/09/71	0300	67.0	.5	1,284.0								7.7	144.000		
8/09/71	0730	68.0	.8	1,276.0								7.8	105.000		
8/09/71	1100	70.5	3.1	1,347.0								7.8	100.000		
8/09/71	1500	72.0	2.8	1,264.0								7.7	100.000		
8/09/71	1850	72.0	1.2	1,274.0								7.7	100.000		
8/14/72	0020	71.0	5.0	872.0											
8/14/72	0420	72.0	4.9	886.0	.342	2.690	1.730	2.680	7.440	.746	.610	7.6	50.000	400	
8/14/72	1225	72.0	4.8	945.0											
8/14/72	1615	71.0	5.1	872.0	.399	2.860	.750	2.730	6.740	.511	.950	7.6	48.000	1,000	
8/15/73	0055	74.0	5.0	1,161.0											
8/15/73	0450	72.5	3.0	1,178.0	.099	.960	.970	2.110	4.140	.545	.910	7.9	98.000	1,300	
8/15/73	1255	77.0	10.6	1,172.0											
8/15/73	1650	77.0	12.4	1,178.0	.090	.770	.150	1.990	3.000	.550	.920	8.3	106.000	250	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RT-03															
8/19/74	0100	74.0	4.5	780.0											
8/19/74	0500	72.0	3.6	775.0	.240	.940	1.370	1.730	4.272	1.138	1.030	7.7	62.000	590	
8/19/74	1255	83.0	5.7	900.0											
8/19/74	1655	83.5	7.4	910.0	.231	.860	.710	1.700	3.495	1.096	1.090	8.2	62.000	320	
8/25/75	0055	79.0	1.7	960.0											
8/25/75	0455	78.0	4.5	950.0	.399	1.500	3.400	1.820	7.120	2.206	2.020	7.7	110.000	650	
8/25/75	1205	77.0	2.5	875.0											
8/25/75	1605	79.0	3.7	873.0	.316	1.130	4.090	2.050	7.580	2.229	3.230	7.8	84.000	350	
RT-04															
3/25/64		39.0	9.0	1,290.0								8.3	205.000		10000.000
4/08/64		39.0	9.5	920.0								8.1	85.000		47000.000
5/25/64		70.0	9.4	1,180.0								7.4	100.000		1000.000
6/11/64		66.0	6.6	1,280.0								8.0	120.000		100.000
7/16/64		77.0	4.7	1,020.0								7.8	105.000		1000.000
8/06/64		72.0	4.9	1,050.0								7.4	65.000		1200.000
9/11/64		68.0	5.0	1,030.0	.100	.881						7.8	90.000		7000.000
10/02/64		59.0	6.9	1,090.0		1.220						7.6	130.000		23000.000
11/05/64		53.0	9.4	1,100.0	.200							7.8	120.000		3000.000
12/03/64		32.0	5.5	1,040.0		.949						7.4	100.000		280000.000
1/06/65		32.0	9.1	906.0		1.469						7.4	65.000		40000.000
2/03/65		32.0	.6	1,320.0		.203						7.2	120.000		60000.000
10/11/66	1045	52.0	5.3	1,010.0	.061	.520					2.630	7.5	80.000		3200.000
4/04/67	1050	45.0	9.9	845.0	.018	1.401					.290	7.8	65.000		8400.000
4/18/68	0915	49.0	7.5	1,141.0	.029	.248				.597		7.6	112.800	20,000	
8/14/68	0910	67.0	6.3	841.0	.179	2.288				.513		8.0	42.040	2,600	25000.000
4/01/69	1115	37.0	11.7	1,100.0	.038	2.200				.397		7.8	76.000	4,800	55000.000
8/14/69	1110	70.0	5.1	825.0	.121	1.100				.517		7.9	89.000	3,400	47000.000
8/11/70	0745	72.0	6.1	1,180.0	.059	.800				.500		8.3	70.000	300	
8/11/70	1155	76.5	8.4	1,075.0								8.4	64.000		
8/11/70	1505	82.5	11.4	1,025.0								8.4	62.000		
8/11/70	1840	81.0	11.5	1,015.0								8.5	64.000		
8/11/70	2320	76.5	9.5	1,010.0								8.4	77.000		
8/12/70	0255	74.5	8.2	1,030.0								8.4	68.000		
8/08/71	2245	71.0	10.2	1,065.0	.378	1.880				1.943		8.6	114.000	700	
8/09/71	0245	70.0	6.3	1,051.0								8.6	110.000		
8/09/71	0715	72.5	5.1	1,079.0								8.3	105.000		
8/09/71	1045	77.5	13.2	1,086.0								8.7	100.000		
8/09/71	1445	86.0	23.0	998.0								8.8	102.000		
8/09/71	1840	85.0	22.6	1,027.0								9.0	108.000		
8/14/72	0040	71.0	5.5	927.0											
8/14/72	0440	71.0	5.5	927.0	.290	3.290	.410	2.020	6.010	.706	.597	7.8	79.000	440	
8/14/72	1240	75.0	5.5	1,004.0											
8/14/72	1625	72.5	5.8	963.0	.242	3.430	.220	1.790	5.680	.367	.650	7.8	70.000	300	
8/15/73	0045	73.0	8.0	1,062.0											
8/15/73	0440	71.5	7.2	1,137.0	.017	.570	.030	.720	1.340	.186	.580	8.2	91.000	310	
8/15/73	1245	76.0	8.5	1,067.0											
8/15/73	1640	75.0	9.5	1,104.0	.011	.360	.030	.720	1.090	.232	.450	8.4	89.000	90	
8/19/74	0050	82.0	6.0	790.0											
8/19/74	0445	71.0	5.5	780.0	.143	1.030	.450	1.540	3.161	.696	.670	8.0	89.000	470	
8/19/74	1245	78.0	7.8	875.0											
8/19/74	1645	81.5	9.8	900.0	.111	.930	.270	1.930	3.240	.551	.510	8.5	86.000	430	
8/25/75	0045	77.0	4.1	683.0											
8/25/75	0445	76.0	5.7	699.0	.183	1.480	.660	1.270	3.600	.672	.620	7.7	81.000	640	
8/25/75	1155	76.0	4.6	726.0											
8/25/75	1555	78.0	5.5	728.0	.175	1.310	.480	1.550	3.520	.672	.650	7.9	86.000	430	
RT-05															
2/19/64		32.0		1,500.0								7.1	215.000		1000000.000
3/25/64		40.0	13.2												20000.000
4/08/64		41.0	9.8	850.0								7.8	80.000		42000.000
5/25/64		72.0	10.3												45000.000
6/11/64		66.0	9.9												2000.000
7/16/64		77.0	8.5												21000.000
8/06/64		77.0	14.1												47000.000
9/11/64		67.0	6.3	1,070.0	.100	.475						8.3	100.000		390000.000
10/02/64		59.0	5.0												280000.000
11/05/64		53.0	6.6												20000.000

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RT-05															
12/03/64		32.0	7.5												150000.000
1/06/65		32.0	8.3			1.559									600000.000
2/03/65		32.0	1.3			.768									140000.000
10/11/66	1135	52.0	8.3	1,050.0	.091	.723					1.820	7.5	85.000		9000.000
4/04/67	0930	44.0	10.2	835.0	.018	1.401					.220	7.9	65.000		6700.000
4/18/68	0950	50.0	7.4	1,208.0	.026	.218				.910		7.8	102.500	26,000	
8/14/68	0945	70.0	7.2	833.0	.097	2.288				.370		8.0	39.030	2,100	33000.000
4/01/69	1040	36.0	12.6	1,075.0	.035	3.500				.353		7.8	70.000	1,300	39000.000
8/14/69	1050	78.0	6.1	750.0	.062	1.000				.497		7.9	83.000	2,400	44000.000
8/11/70	0720	73.5	5.7	1,040.0	.057	.340				.500		8.5	72.000	900	
8/11/70	1130	78.0	10.0	1,065.0								8.7	69.000		
8/11/70	1445	84.5	13.8	990.0								8.6	68.000		
8/11/70	1830	84.0	17.6	955.0								8.7	70.000		
8/11/70	2245	79.0	9.3	1,040.0								8.6	74.000		
8/12/70	0230	75.0	6.5	1,000.0								8.6	77.000		
8/08/71	2230	76.0	12.4	972.0	.160	.740				.940		9.3	134.000	3,600	
8/09/71	0230	73.0	5.0	1,004.0								9.1	131.000		
8/09/71	0650	73.0	2.2	1,028.0								8.8	125.000		
8/09/71	1030	79.5	11.2	1,031.0								9.2	132.000		
8/09/71	1430	87.0	21.2	942.0								9.0	127.000		
8/09/71	1820	86.0	22.8	927.0								9.1	125.000		
8/14/72	0001	72.0	5.9	891.0											
8/14/72	0401	71.5	5.8	895.0	.200	2.590	.270	1.920	4.980	.694	.663	7.9	79.000	530	
8/14/72	1200	74.0	6.1	936.0											
8/14/72	1600	73.0	6.0	890.0	.186	2.860	.150	1.820	5.020	.614	.620	7.8	70.000	1,100	
8/15/73	0115	74.0	5.8	939.0											
8/15/73	0510	71.5	4.7	962.0	.030	.410	.030	.700	1.140	.303	.800	8.0	74.000	6,300	
8/15/73	1310	78.0	8.5	968.0											
8/15/73	1710	80.5	10.2	962.0	.018	.410		.810	1.240	.401	.600	8.4	74.000	4,900	
8/19/74	0120	73.0	6.4	840.0											
8/19/74	0520	72.0	5.5	800.0	.144	1.330	.240	1.670	3.386	.805	.750	8.0	96.000	5,100	
8/19/74	1310	80.5	8.9	900.0											
8/19/74	1710	83.5	11.4	890.0	.165	1.130	.160	1.720	3.172	.592	.610	8.7	89.000	7,800	
8/25/75	0110	77.0	3.8	591.0											
8/25/75	0510	75.5	3.9	598.0	.135	1.450	.430	1.440	3.460	.625	.590	7.7	72.000	3,000	
8/25/75	1220	77.0	4.0	612.0											
8/25/75	1620	79.0	4.4	630.0	.125	1.290	.370	1.540	3.330	.625	.590	7.7	81.000	36,000	
RT-06															
1/30/64		33.0	9.6	980.0								7.3	185.000		32000.000
2/19/64		32.0	11.5	1,520.0								7.2	220.000		400.000
3/25/64		40.0	14.6	1,120.0								8.5	120.000		700.000
4/08/64		41.0	12.3	856.0								7.1	70.000		21000.000
5/25/64		68.0	9.0	1,070.0								7.4	80.000		10000.000
6/11/64		69.0	7.9	1,070.0								8.2	115.000		1500.000
7/16/64		77.0	8.1	880.0								7.8	80.000		6000.000
8/06/64		76.0	7.5	930.0								7.7	55.000		3000.000
9/11/64		67.0	8.1	1,020.0		.429						8.3	85.000		26000.000
10/02/64		59.0	9.3	968.0	.100	.610						7.8	105.000		17000.000
11/05/64		52.0	10.5	1,040.0		.429						8.2	100.000		1000.000
12/03/64		32.0	12.0	904.0		.859						7.6	100.000		16000.000
1/06/65		34.0	12.3	728.0	.100	1.401						7.4	65.000		20000.000
2/03/65		32.0	7.3	1,250.0		.226						7.2	120.000		2000.000
10/11/66	1155	54.0	9.5	995.0		.068					.280	7.7	90.000		22000.000
4/04/67	0955	46.0	10.9	840.0	.021	1.333					.190	7.9	70.000		6800.000
4/17/68	1230	49.0	9.6	1,076.0	.012	.259				.509		8.4	76.800	150	
8/13/68	0910	68.0	7.6	741.0	.082	3.156				.257		8.0	37.810	1,700	43000.000
4/01/69	1020	37.0	13.4	1,050.0	.027	3.700				.213		8.0	74.000	250	13000.000
8/14/69	1030	78.0	7.0	650.0	.039	1.300				.420		8.0	87.000	850	39000.000
8/10/70	0925	74.0	7.6	1,040.0	.062	.170				.333		8.5	79.000	100	
8/10/70	1315	80.5	8.7	990.0								8.7	70.000		
8/10/70	1720	84.0	9.1	980.0								8.7	70.000		
8/10/70	2140	82.0	7.0	950.0								8.6	74.000		
8/11/70	0135	77.5	7.0	950.0								8.5	77.000		
8/11/70	0530	74.5	7.2	950.0								8.5	73.000		
8/03/71	2200	71.5	5.4	1,091.0	.101	.400				.397		8.6	140.000	30	
8/04/71	0200	68.0	5.6	1,081.0								8.5	142.000		
8/04/71	0615	66.0	6.1	1,077.0								8.5	150.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
RT-06															
8/04/71	1000	70.0	6.6	1,133.0								8.5	124.000		
8/04/71	1400	74.0	6.9	1,096.0								8.6	117.000		
8/04/71	1755	73.5	7.3	1,091.0								8.7	114.000		
8/09/72	0001	63.0	8.1	585.0	.120	3.210	.200	2.500	6.030	.671	.610	7.8	50.000	1,600	
8/09/72	0401	62.0	8.2												
8/09/72	1210	64.0	8.3	781.0											
8/09/72	1600	65.0	8.3	810.0	.147	2.930	.280	1.750	5.110	.507	.557	8.0	50.000	720	
8/08/73	0215	80.0	6.9	1,046.0											
8/08/73	0615	78.0	6.6	960.0	.046	.360	.060	.870	1.340	.311	.390	8.2	77.000	90	
8/08/73	1410	83.0	7.3	1,046.0											
8/08/73	1805	82.5	7.1	951.0	.051	.480	.030	.790	1.320	.259	.380	8.5	77.000	100	
8/14/74	0215	72.0	7.5	890.0											
8/14/74	0605	70.0	7.4	870.0	.049	.650	.150	1.800	2.648	.454	.360	8.2	89.000	100	
8/14/74	1400	79.0	8.9	1,000.0											
8/14/74	1800	79.5	9.1	980.0	.028	.490	2.230	1.530	4.275	.215	.300	8.7	71.000	300	
8/20/75	0205	70.0	8.7	858.0											
8/20/75	0605	69.0	8.0	887.0	.051	.360	.030	1.060	1.390	.212	.470	8.4	96.000	230	
8/20/75	1430	71.0	8.4	863.0											
8/20/75	1800	72.0	9.2	899.0	.052	.500	.030	1.020	1.480	.277	.390	8.6	103.000	520	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
SB-01															
4/16/64		49.0	7.6	756.0								8.3	30.000		3400.000
5/27/64		61.0	9.5												3000.000
6/30/64		87.0	16.5												2000.000
7/15/64		68.0	12.0												4000.000
8/13/64		61.0	10.5												10000.000
9/30/64		55.0	1.0												200000.000
10/15/64		55.0	10.5	800.0	.100	.429						7.5	20.000		7000.000
11/13/64		50.0	10.2												8000.000
12/14/64		33.0	10.1												5000.000
1/13/65		32.0	9.4			.475									4000.000
2/10/65		32.0	9.3			.316									19000.000
10/11/66	1405	48.0	11.8	660.0	.010	1.200				.420		7.6	15.000		600.000
4/11/67	1020	40.0	10.6	710.0	.020	7.300				.060		7.5	30.000		11200.000
4/23/68	1000	47.0	8.3	533.0	.014	4.062				.119		7.4	18.800	21,000	
8/15/68	1100	65.0	11.8	690.0	.031	.346				.440		8.2	16.940	2,100	8000.000
4/02/69	1135	40.0	10.7	760.0	.050	1.000				.230		7.6	32.000	2,200	43000.000
8/12/69	1140	68.0	11.1	625.0	.028	.300				.430		8.3	19.000	2,900	17000.000
8/12/70	0110	73.0	9.6	785.0								8.3	19.000		
8/12/70	0510	77.0	7.0	670.0								8.4	23.000		
8/12/70	0845	66.0	2.9	720.0	.013	.090				1.130		8.0	17.000	200	
8/12/70	1010	72.0	1.1	700.0								8.2	20.000		
8/13/70	0400	66.5	1.8	695.0								7.9	20.000		
8/13/70	0640	66.0	1.9	670.0								7.8	18.000		
8/11/71	0015	69.0	1.1	643.0								7.9	16.000		
8/11/71	0415	65.5	1.2	650.0								7.8	19.000		
8/11/71	0825	64.0	1.3	694.0	.008	.190				.583		7.8	23.000	180	
8/11/71	1215	68.0	4.5	710.0								7.9	24.000		
8/11/71	1600	70.0	10.4	661.0								8.3	17.000		
8/11/71	1945	72.0	9.6	625.0								8.6	17.000		
8/16/72	0155	65.5	3.4	1,041.0											
8/16/72	0555	65.5	3.6	1,012.0	.205	2.140	.200	1.630	4.180		1.180	8.0	54.000	480	
8/16/72	1345	70.5	6.7	1,001.0											
8/16/72	1740	73.0	6.9	1,007.0	.111	2.090	.140	1.760	4.100	.394	1.410	8.2	63.000	100	
8/16/73	0135	68.0	2.9	748.0											
8/16/73	0535	66.0	3.1	741.0	.030	1.570		.920	2.520	.454	.510	7.6	31.000	2,400	
8/16/73	1335	74.5	12.8	722.0											
8/16/73	1730	77.0	13.6	621.0	.023	1.020	.030	.620	1.660	.372	.380	8.9	25.000	410	
8/20/74	0200	67.5	4.7	900.0											
8/20/74	0605	65.0	4.2	725.0	.063	1.180	.070	.880	2.189	.386	.450	7.9	27.000	1,200	
8/20/74	1400	80.0	13.3	690.0											
8/20/74	1800	76.0	8.8	630.0	.030	.900	.070	.960	1.958	.351	.280	8.9	22.000	740	
8/26/75	0205	67.0	3.1	612.0											
8/26/75	0605	64.0	3.8	793.0	.322	3.750	1.120	3.550	8.740	.882	.920	7.8	61.000	14,000	
8/26/75	1425	66.5	7.5	689.0											
8/26/75	1805	65.0	7.7	569.0	.016	.330	.160	.650	1.150	.013	.060	8.3	9.000	350	

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
SK-01															
4/16/64		52.0	14.2	740.0								8.3	30.000		16000.000
5/27/64		61.0	9.5												16000.000
6/30/64		86.0	14.7												200.000
7/15/64		69.0	9.1												36000.000
8/13/64		60.0	8.1									7.9			5000.000
9/30/64		54.0	3.4												200000.000
10/15/64		58.0	.1	992.0		.723						7.4	55.000		7000.000
11/13/64		47.0	5.7												36000.000
12/14/64		33.0	7.1												13000.000
1/13/65		32.0	5.2			.520									15000.000
2/10/65		32.0	12.1			.610									14000.000
10/11/66	1425	52.0	8.9	840.0		.271					.220	7.8	55.000		15500.000
4/11/67	1000	38.0	11.6	610.0	.012	1.153					.100	7.6	20.000		63000.000
4/23/68	0945	48.0	7.9	701.0	.099	5.166				.207		7.4	31.500	5,000	
8/15/68	1040	67.0	6.8	928.0	.014	1.054				1.053		8.8	74.170	1,100	
4/02/69	1125	37.0	11.1	715.0	.540	1.400				.420		7.8	32.000	2,500	
8/12/69	1135	68.0	6.3	910.0	.059	.200				1.427		8.2	213.000	3,100	
8/12/70	0100	80.0	14.6	985.0								8.8	94.000		
8/12/70	0525	76.0	9.0	860.0								8.7	74.000		
8/12/70	0830	71.0	4.3	1,065.0	.016	.180				1.000		8.6	90.000	400	
8/12/70	1020	71.5	3.2	1,460.0								7.8	230.000		
8/13/70	0345	70.0	.3	1,080.0								7.9	130.000		
8/13/70	0645	67.5	1.9	900.0								7.8	83.000		
8/11/71	0030	66.0	3.7	887.0	.040	.230				.433		9.0	100.000	250	
8/11/71	0430	64.0	3.1	887.0								8.9	100.000		
8/11/71	0840	65.0	2.2	918.0								8.8	90.000		
8/11/71	1230	65.0	5.0	901.0								8.9	100.000		
8/11/71	1620	66.0	5.7	878.0								8.9	80.000		
8/11/71	2000	65.0	5.9	878.0								8.9	84.000		
8/16/72	0205	68.5	2.1	1,C17.0											
8/16/72	0605	68.0	2.2	1,026.0	.202	1.930	.110	1.450	3.690	.907	.750	8.0	67.000	70	
8/16/72	1350	73.0	5.3	1,049.0											
8/16/72	1750	76.0	7.8	1,030.0	.143	1.790	.120	1.630	3.680	.909	.736	8.3	75.000	580	
8/16/73	0150	71.0	4.0	743.0											
8/16/73	0550	69.0	3.2	804.0	.043	.180	.100	1.170	1.490	1.030	1.130	7.6	38.000	860	
8/16/73	1345	80.0	9.9	751.0											
8/16/73	1745	81.0	10.2	734.0	.008	.120	.030	1.340	1.470	1.100	1.250	8.6	40.000	880	
8/20/74	0215	73.0	3.9	940.0											
8/20/74	0615	61.0	3.4	760.0	.092	1.340	.090	1.240	2.758	.536	.550	7.9	40.000	8,200	
8/20/74	1410	78.0	5.0	700.0											
8/20/74	1810	76.0	4.9	760.0	.016	.680	.160	.990	1.846	.217	.210	8.4	46.000	2,300	
8/26/75	0155	70.0	1.7	773.0											
8/26/75	0555	69.0	2.6	615.0	.099	.690	.450	2.230	3.470	.973	.890	7.8	42.000	54,000	
8/26/75	1405	74.0	5.7	522.0											
8/26/75	1755	74.0	5.8	625.0	.115	.980	.160	1.650	2.910	.648	.620	8.0	41.000	13,000	
SK-02															
1/30/64			12.5	584.0	.100							7.9	20.000		1400.000
2/26/64		32.0	19.3	660.0								8.7	20.000		6300.000
3/26/64		33.0	14.0	700.0											4000.000
4/16/64		53.0	17.0	720.0								8.2	35.000		400.000
5/27/64		67.0	15.8	720.0								8.2	30.000		3600.000
6/30/64		74.0	11.0	636.0								8.0	30.000		4400.000
7/15/64		63.0	10.9	580.0								8.4	30.000		1700.000
8/13/64		59.0	12.1	514.0								7.8	30.000		1200.000
9/30/64		54.0	11.2	790.0		.475						8.3	20.000		2000.000
10/15/64		56.0	16.1	680.0		.090						8.6	30.000		2500.000
11/13/64		50.0	14.4	770.0								8.1	20.000		2000.000
12/14/64		32.0	15.5	840.0		.768						8.0	30.000		1300.000
1/13/65		32.0	13.0	822.0		.610						7.9	35.000		600.000
2/10/65		32.0	12.7	292.0	.100	.565						7.1	35.000		14000.000
10/11/66	1450	53.0	11.8	715.0		.090					1.210	7.6	21.000		12000.000
4/11/67	0925	38.0	13.2	620.0	.009	1.311					.100	8.2	20.000		900.000
4/23/68	0905	49.0	10.0	734.0	.113	3.768				.009		8.0	33.000	370	
8/15/68	1000	62.0	11.2	711.0	.005	.662				.273		8.2	35.010	210	
4/02/69	1040	37.0	15.0	805.0	.032	1.100				.227		8.3	38.000	500	
8/12/69	1110	65.0	11.6	750.0	.004	.300				.140		8.2	44.000	500	
8/12/70	0600	74.0	5.5	755.0								7.9	56.000		

STATION DATE	TIME	TEMP	DO	SC	NO2	NO3	NH3	ON	TN	DP	TP	PH	CL	FECAL COLIFORM	COLIFORM
SK-02															
8/12/70	0800	67.0	6.9	765.0	.003	.120				.153		8.0	34.000	60	
8/12/70	1045	70.0	4.0	705.0								7.9	38.000		
8/12/70	1240	70.0	13.2	775.0								8.5	42.000		
8/13/70	0425	67.0	4.7	730.0								8.0	37.000		
8/13/70	0715	66.5	5.3	750.0								8.0	38.000		
8/11/71	0055	65.5	5.7	692.0		.280				.153		7.9	35.000	2,300	
8/11/71	0455	62.5	5.1	715.0								7.8	36.000		
8/11/71	0905	63.0	7.3	728.0								8.0	33.000		
8/11/71	1255	68.5	8.4	747.0								8.2	48.000		
8/11/71	1645	71.5	7.0	723.0								8.3	50.000		
8/11/71	2030	69.0	5.8	774.0								8.0	59.000		
8/16/72	0230	68.5	7.0	961.0											
8/16/72	0630	68.0	7.0	958.0	.063	1.710	.120	1.230	3.120	.421	.490	8.3	64.000	10	
8/16/72	1415	70.5	7.1	963.0											
8/16/72	1815	73.0	7.8	954.0	.052	1.410	.100	1.300	2.860	.473	.636	8.5	80.000	40	
8/16/73	0210	67.0	6.7	711.0											
8/16/73	0610	65.5	7.2	765.0	.003	.370		.190	.560	.071	.050	7.8	33.000	300	
8/16/73	1410	72.0	10.7	748.0											
8/16/73	1805	79.5	7.5	724.0	.028	.180		.350	.560	.089	.060	8.0	52.000	1,200	
8/20/74	0245	68.0	6.8												
8/20/74	0640	67.0	7.0	680.0	.019	1.110	.030	.950	2.104	.191	.240	8.1	36.000	450	
8/20/74	1445	76.0	8.4	710.0											
8/20/74	1840	74.5	6.7	710.0	.080	1.200	.070	1.340	2.694	.507	.500	8.1	38.000	860	
8/26/75	0235	64.0	7.5	651.0											
8/26/75	0635	66.0	7.5	653.0	.060	1.590	.060	1.080	2.790	.212	.300	8.1	36.000	4,000	
8/26/75	1455	73.0	7.9	585.0											
8/26/75	1840	70.5	7.2	676.0	.046	1.820	.030	1.210	3.040	.182	.200	8.3	44.000	1,800	