A REPORT ON

POLLUTION OF THE UPPER MISSISSIPPI RIVER

AND

MAJOR TRIBUTARIES

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT

JULY 1966

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SECTION I

INTRODUCTION AND BACKGROUND

INTRODUCTION

Authority for Study

In letters from Governor Karl A. Rolvaag of Minnesota and Governor John W. Reynolds of Wisconsin to Secretary Anthony J. Celebrezze of the Department of Health, Education, and Welfare on September 9, 1963, a request was made for action to abate pollution in the area as provided in Section 8 of the Federal Water Pollution Control Act (33 U.S.C. 466 et seq.).

In response to the request of the Governors, on September 23, 1963, Secretary Celebrezze sent letters calling for a conference on the matter of pollution of the waters of the Mississippi River and its tributaries to official water pollution control agencies for the States of Minnesota and Wisconsin.

A formal public announcement of the conference and the initiation of a resident study was made by the late President, John F. Kennedy, in a speech at Ashland, Wisconsin, on September 24, 1963.

The concern of the public as well as the urgency of the situation was demonstrated at the conference held in St. Paul, Minnesota on February 7 and 8, 1964. Both Governor Rolvaag of Minnesota and Governor Reynolds of Wisconsin participated in the conference and gave strong positive support to the need for effective pollution control action utilizing Federal, State and local resources.

Conclusions of Enforcement Conference

In light of the conference discussions, the conferees unanimously agreed to the following conclusions and recommendations:

1. Pollution in these waters from industries, municipalities and storm overflow sources has created a health hazard to persons engaging in

water contact activities, causes visual nuisances, interferes with fish and fishing, causes sludge banks which give off noxious odors and floating sludge, interferes with bottom aquatic life, and with feeding and spawning grounds for fish propagation. This pollution must be abated.

2. The Wisconsin and Minnesota water pollution control agencies have active water pollution control programs. The delays, if any, are those which may be expected to occur in the execution of the pollution abatement program of a large metropolitan area.

3. The Department of Health, Education, and Welfare in conjunction with both State agencies and in keeping with State staff and fund limitations, is to conduct an intensive survey of the Mississippi River. Participation is to be on a cooperative basis by all agencies, both on the technical level and in advisory and policy direction capacities. This study project is to include but not be limited to investigation of municipal, industrial, and Federal installation wastes, thermal sources of pollution, agricultural sources of pollution, bulk storage areas, pipelines, barges, coliform bacteria, BOD, suspended solids, sludge deposits, oil, algae, tastes and odors, pesticides, and with the cooperation of the Corps of Engineers, low flow augmentation. The study can be modified or expanded at the request of the technical committee.*

4. At the suggestion of a Wisconsin member, the conferees agreed that the study area be extended to include St. Croix Falls, Wisconsin, and Taylors Falls, Minnesota.

5. The study and report is to be planned and carried out so that features relating to Twin City metropolitan area sewage disposal will be completed, if at all possible, in time to report the findings and recom-

* See section on Project organization for further information on technical committee.

mendations by January, 1965, the opening of the 1965 Minnesota State Legislature.

6. This study is not a substitute for, but a supplement to, already existing state programs for pollution control and abatement.

7. At the completion of the study and the report of its findings, the conference will be reconvened at the call of the chairman of the conference to determine necessary action.

Objectives of Project

Based upon these conclusions the Twin Cities-Upper Mississippi River Project was established to carry out the following objectives:

1. To determine the extent of pollution in the rivers of the study area. The study area extends on the Mississippi River for 107 miles between its confluences with the Rum and Chippewa Rivers, on the Minnesota River from its mouth upstream 110 miles to Mankato, Minnesota, and on the St. Croix River from its mouth 55 miles upstream to Taylors Falls, Minnesota. (See Figure I-1).

2. To investigate the principal sources of pollution and contributions from these sources.

3. To determine the effect of pollution on the numerous water uses.

4. To develop programs for the achievement of various water uses on rivers of the study area.

Project Organization

The Twin Cities-Upper Mississippi River Project was initiated as a special project of the Enforcement Branch of the Division of Water Supply and Pollution Control, Public Health Service. Immediate supervision was provided by the Project Director at Project Headquarters in Minneapolis, Minnesota. Administratively the Project was an activity of the Region V, Water Supply and Pollution Control Program.

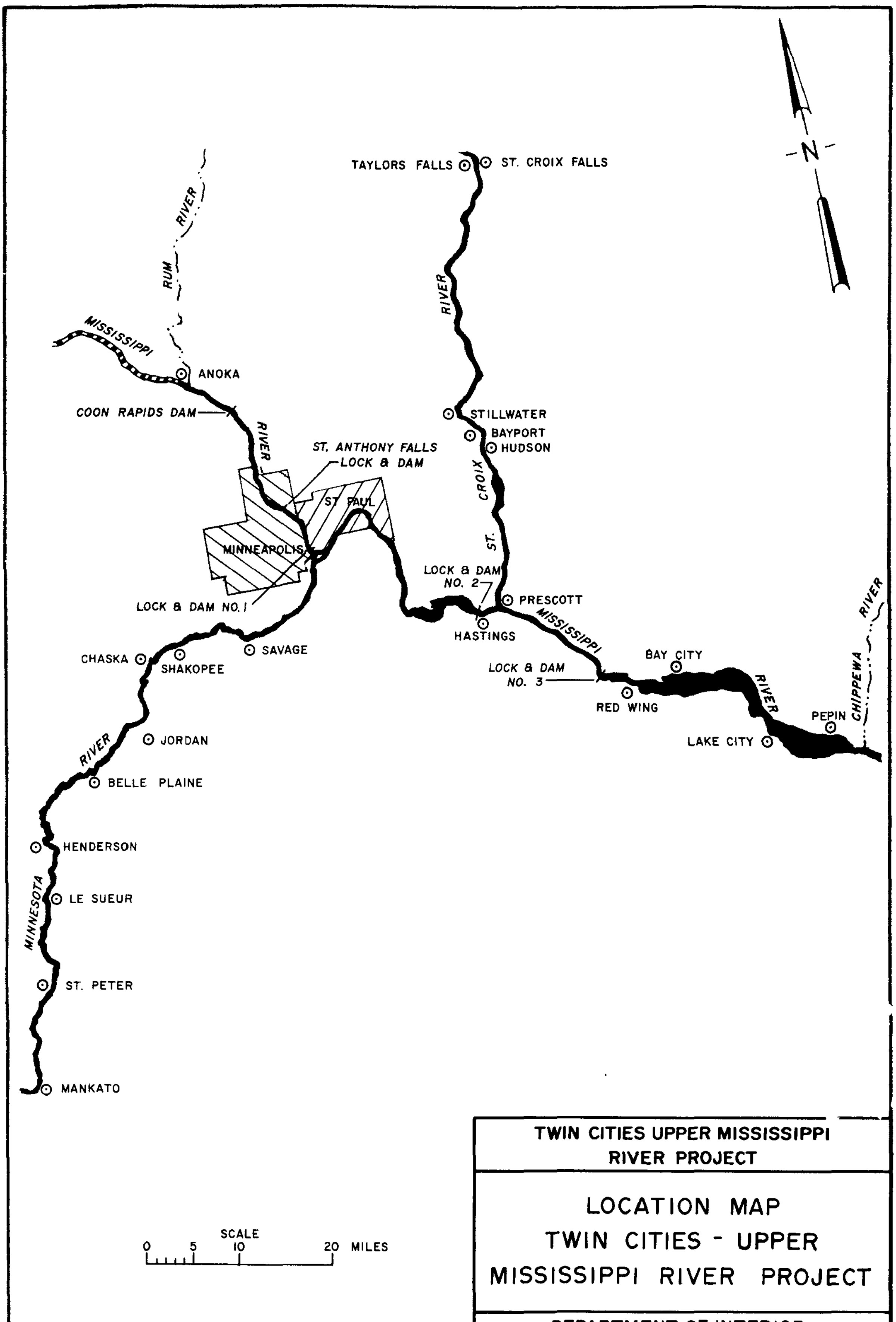

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FIGURE I-1

Organizationally the Project was divided into three principal sections. They, in turn, were subdivided into units. The organizational structure and personnel roster are shown on pages I-5, I-6, and I-7.

One of the recommendations of the conferees was the establishment of a Technical Committee. Experience in similar Projects demonstrated the need for a group of appropriate persons whom the Project could continually inform of its activities. In consideration of the length and character of the Project plus the administrative procedures required for the establishment of technical advisory boards, a decision was made to appoint members of Federal, State, municipal, civic, and industrial water oriented groups to a Project Committee. The principal purpose of this committee was to receive and disseminate information on Project activities and to suggest areas of additional concern. A list of the committee members and their affiliations is given on page I-8.

Technical consultation was obtained from Dr. Richard S. Engelbrecht, Professor of Sanitary Engineering, University of Illinois; Dr. Lawrence B. Polkowski, Professor of Civil Engineering, University of Wisconsin; and specialists in the Public Health Service.

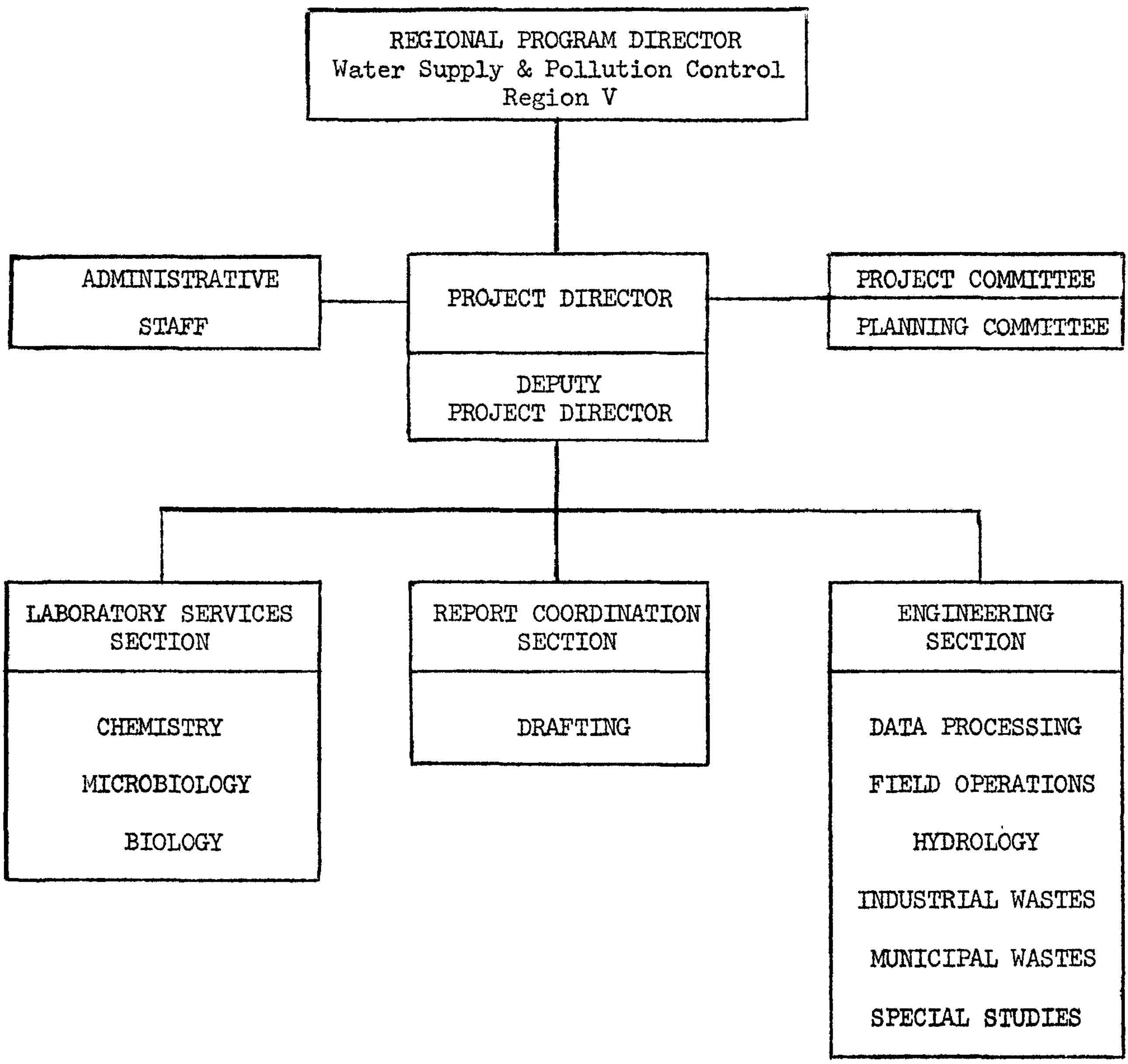
Operation of Project

Immediately following the assignment of a Director and part of the staff to the Project in late 1963, a conference report was prepared and procurement of adequate facilities, equipment, and personnel was initiated.

Space secured at the U.S. Naval Air Station in Minneapolis, Minnesota, required extensive modification and renovation of office and laboratory areas before occupancy. Office facilities were completed by mid-January, 1964. It was necessary to set up temporary laboratory facilities in a corridor for use from April until July, 1964, when the permanent laboratory became operational.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

ORGANIZATION CHART



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TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PROFESSIONAL STAFF

Albert C. Printz, Jr.
Resident Project Director
September 1963 - September 1964
Project Director
September 1964 - Present

John M. Rademacher
Project Director
September 1963 - September 1964

William T. Sayers
Chief, Engineering Section
November 1963 - August 1964
Deputy Project Director and
Chief, Report Coordination Section
August 1964 - Present

Dale S. Bryson
Chief, Engineering Section
August 1964 - Present

Thaddeus C. Kmieciak
Chief, Laboratory Services Section
March 1964 - November 1965

John W. Arthur
Biologist

Bobby Gene Benefield
Chemist

Ronald E. Gastineau
Chief, Field Operations Unit

Harry C. Grounds
Chief, Industrial Wastes Unit

Frank E. Hall
Chief, Hydrology Unit

Wm. Bliss Horning, II
Chief, Field Operations Unit & Biologist

William R. Norton
Chief, Data Processing Unit

William P. Schrader
Chemist

James L. Summers
Microbiologist

Wayne C. Tippets
Microbiologist

SUPPORTING STAFF

Marvin J. Schley
Administrative Officer

Michael A. Burg
Aquatic Sampler

June M. Clarke
Secretary

Ronald A. Erickson
Laboratory Helper

Ronald B. Faanes
Chemist

Delores Fitch
Clerk-Stenographer

Curtis A. Golden
Aquatic Sampler

Eugene P. Hines
Boat Operator

Darlene M. Hundley
Clerk-Typist

Thomas A. Lee
Draftsman

Willis J. Munson
Aquatic Sampler

R. Thomas Olson
Aquatic Sampler

Robert E. Pearson
Biological Technician

Sharon A. Sovde
Clerk-Stenographer

Robert V. Speer
General Mechanic

Bertha M. Thompson
Clerk-Stenographer

William E. White
Aquatic Sampler

NOTE: This list includes all permanent personnel participating in part or all of study.

PROJECT COMMITTEE

of

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

State of Minnesota

L. H. Smith	Executive Engineer	Water Pollution Control Commission
F. L. Woodward	Director	Div. of Environmental Sanitation, Department of Health
W. H. Olson	Commissioner	Department of Conservation
A. W. Winter	President	Great Northern Oil Co.
K. L. Mick	Supt. & Chief Engineer	Minneapolis-St. Paul Sanitary District
P. S. Duff, Jr.	Editor	Downstream Communities
R. A. Haik	Attorney	Member of President's Water Pollution Control Advisory Board

State of Wisconsin

T. F. Wisniewski	Director	Committee on Water Pollution
O. J. Muegge	Sanitary Engineer	State Health Department
L. F. Motl	Chief Engineer	Conservation Department
P. Pratt *	Director	Dept. of Resource Development
H. J. Krauss	Member	Advisory Committee to the Wisconsin Department of Resource Development
L. V. Spriggle	Citizen	Water Use Groups
Martin Hanson	President	Council of Resource Development and Conservation

Public Health Service

H. W. Poston (Chairman)	Regional Program Director, DWS&PC, Region V, Chicago
H. C. Clare	Regional Program Director, DWS&PC, Region VI, Kansas City
P. G. Kuh	Enforcement Branch, DWS&PC, Washington, D.C.

* Replaced F. P. Zeidler, former Director.

Detailed program plans based on Project objectives were prepared following review of available existing information. Planning began with the development of a final report outline in sufficient detail to indicate what information would be required. Then, individual studies needed to obtain this information were formulated. Planning was completed with the development of an operating schedule in the form of a program control chart in which the dates for completion of the various phases of each study were set.

As each study progressed and a greater familiarity with the problems was achieved, plans and schedules were revised as necessary to maintain a realistic program. The program control chart is shown in Figure I-2.

The studies were divided into two general categories: those for determination of waste sources and water quality and those for projecting water uses.

The following studies were conducted for the purpose of determining waste sources and water quality:

1. Municipal waste surveys
2. Industrial waste surveys
3. Routine and intensive stream surveys
4. Special studies
    a. Storm water overflow
    b. Accident potential
    c. Virus and pathogenic bacteria
    d. Fish flesh taste evaluation
    e. Ice cover effects
5. Terminal monitoring program

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PROGRAM CONTROL CHART

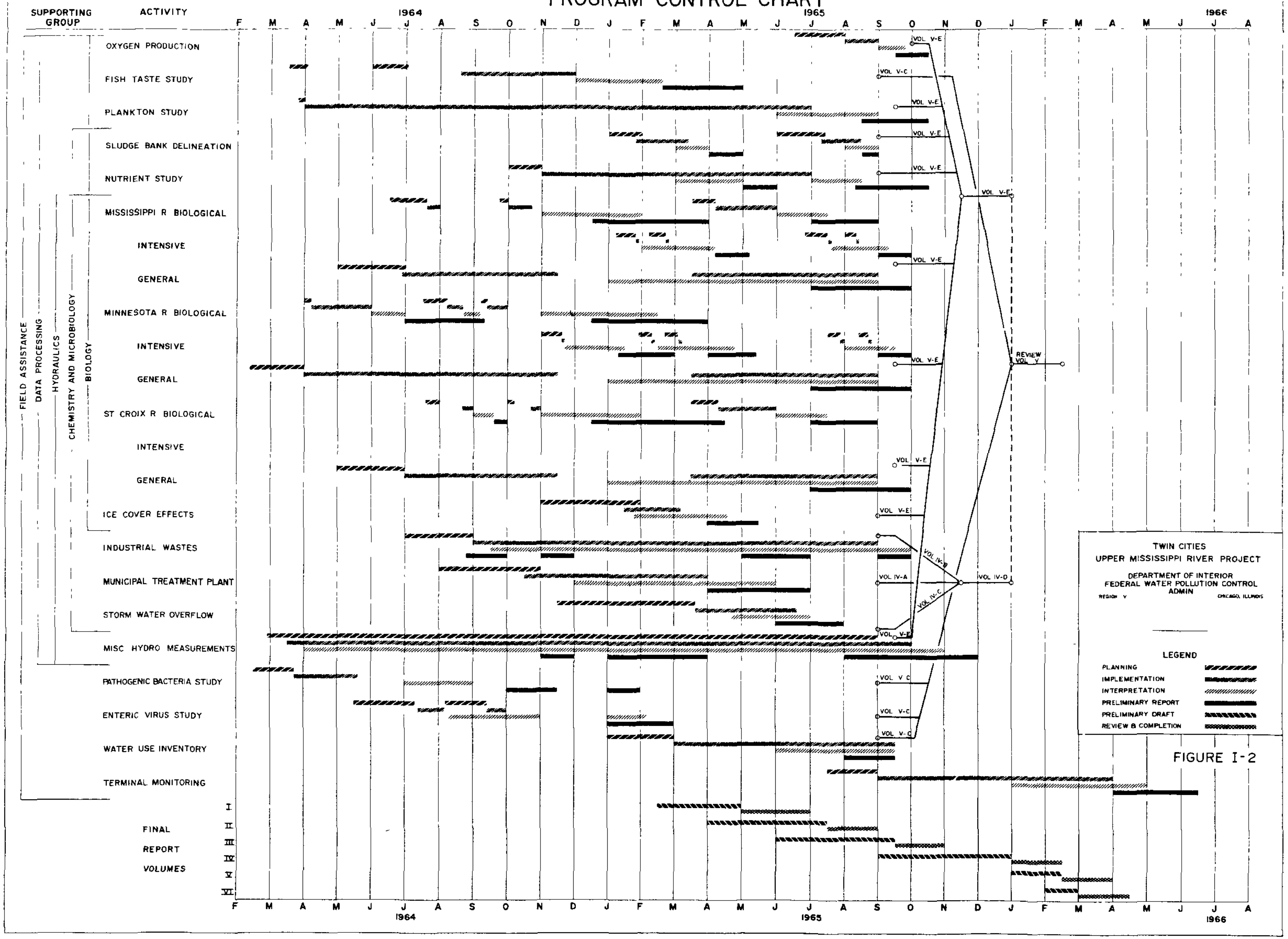

FIGURE I-2

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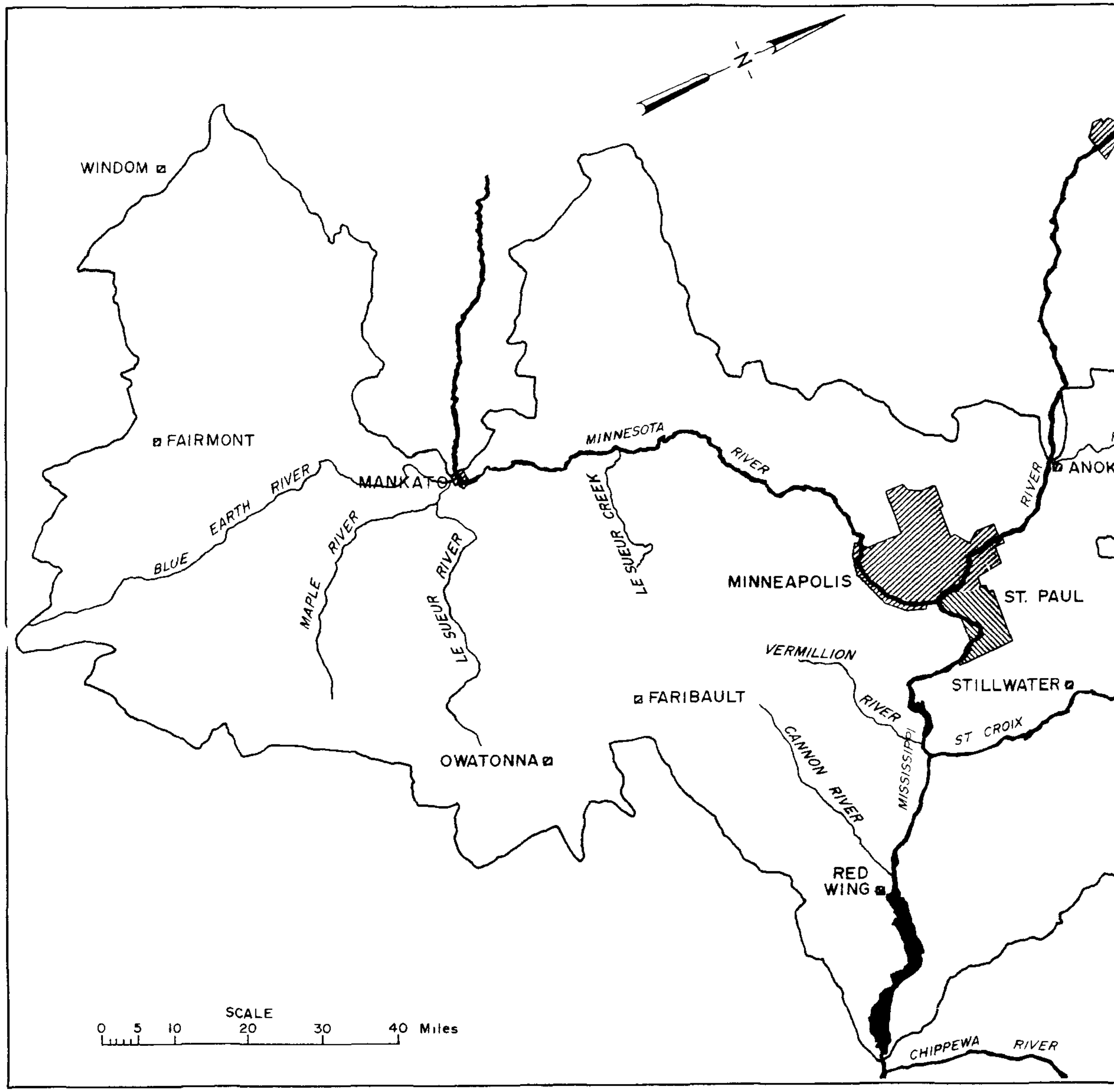

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PROJECT
STUDY AREA
WATERSHED

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE I-3

GPO 824-408-A-7

Activities required for water use projections were:

1. Water use inventory

2. Compilation of existing information on economic and demographic projections

3. Determination of flow regulation applicability

4. Development of mathematical expressions relating waste loadings to stream quality

All studies or activities are described in detail in subsequent sections.

Description of Report Contents

The Project's final report is divided into six major volumes. Summaries of technical data in the form of charts, graphs, and tables are given. Raw data and other similar material are available in the files of the Department of Health, Education, and Welfare.

Section I contains the introduction and background material and details the assistance obtained from other governmental agencies, private organizations, and individuals.

Section II discusses the legal and administrative aspects of current pollution control activities in the Project's study area. Local, State, and Federal aspects are presented.

Section III furnishes information on all present water uses in the study area and provides estimates of future water uses.

Section IV includes all studies concerned with the measurement of existing waste discharges and their effect on stream quality.

Section V discusses the impact of present and anticipated waste loadings on water uses. Projections of water quality under different abatement programs and future populations are covered.

Section VI contains a summary of the first five sections and presents the conclusions of the study along with recommendations for improvement of water quality. A bibliography is also included.

BACKGROUND

Geology and Glacial History (1)

The extensive mantle of glacial deposits covering the entire Upper Mississippi River watershed gives evidence of several invasions of the ice sheet from the north at widely separated times and from different directions.

The earlier invasions brought down from Manitoba the limestones which are found imbedded in the lower part of the drift. The older drift deposits, composed largely of blue till (a compressed mixture of sand, clay, and gravel), were eroded by the early drainage systems which became so extensive that very few lakes and undrained basins remained upon them. Today, the older drift deposits are visible on the Minnesota River Basin and areas south, where lakes and swampy areas are almost entirely lacking.

Later ice movements from the northeast, brought down the stony red drift from the Superior Basin as far as Mille Lacs Lake and St. Paul. The younger drift deposits of red till still retain their lakes and poorly drained areas, which the present river systems have not reached. This younger formation, in the upper part of the main river basin, accounts for the numerous lakes and swampy areas on this part of the watershed.

In the southwestern part of the basin, in Minnesota, the till is covered by a layer of loam, separated from it by a distinct line of demarcation. Along the valleys of the Mississippi and most of the larger tributaries flowing southerly there are deposits of a mixture of stratified sand and gravel covered with fine sand. The same formation is also found in isolated plains in some of the counties.

General Features of Upper Mississippi River Area (1)(2)

The source of the Mississippi River is Lake Itasca in southeastern Clearwater County, Minnesota, 2,550 miles from its mouth at the Gulf of Mexico. From its source the river flows northerly for a short distance, then easterly and southerly to the mouth of the Crow Wing River. Although covering a distance of 350 miles to this point, it is only about 75 miles from its source. From this point on to the Gulf of Mexico the course of the Mississippi River is almost consistently toward the south or southeast.

The topography of the area is gently rolling to hilly, with elevations reaching 1500 feet above sea level in some areas. The numerous lakes and swamps and the remaining forests in the northern area provide protection against rapid runoff and aid in the maintenance of a more uniform flow.

An outline of the watershed contributing to those portions of Mississippi River and its tributaries within the study area is shown in Figure I-3. The maximum length of the watershed from north to south is about 220 miles. The width from east to west varies from an average of about 20 miles at the northern portion to about 70 miles at the central and southern portions. The watershed area is estimated at 12,000 square miles. Of this amount, 340 square miles or 3 percent lie within the State of Iowa. About 1700 square miles or 14 percent of the total lie in the State of Wisconsin. The remaining 83 percent are within the State of Minnesota.

That portion of the Mississippi River within the study area has seven slack water pools formed by dams across the river constructed for navigation and/or power purposes. From the river's source through Anoka its slope is moderate, but after entering the study area the river drops rapidly with a 30 foot fall at Coon Rapids Dam, 75 feet more at the upper

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and lower St. Anthony Falls in downtown Minneapolis, and another 38 feet at the Twin Cities Lock and Dam No. 1 some six miles further downstream. Lock and Dams No. 2 and 3 located near Hastings and Red Wing, respectively, cause the river to drop another 20 feet in the remaining 85 miles to the outlet of Lake Pepin. A nine foot channel makes navigation possible upstream to within one mile of the northern city limits of Minneapolis.

The Minnesota River enters the Mississippi about 3.5 miles below Lock and Dam No. 1. The Mississippi widens somewhat at this point, averaging approximately 700 feet, with fertile flats between the river and the foot of the bluffs. The interstate St. Croix River combines with the Mississippi about 36 miles below the same dam and from that point the Mississippi River continues as the common boundary between Wisconsin and Minnesota.

Approximately 63 miles below Lock and Dam No. 1 the river widens into Lake Pepin. This Lake extends downstream for over 20 miles to the confluence of the Chippewa River which marks the lower end of the study area. The Lake was formed by a dam of sand which had been carried by the Chippewa River and deposited in the main stream of the Mississippi River. Lake Pepin has an average width of one and one-half miles and a maximum width of two and one-half miles. It has an average depth of 25 to 35 feet throughout its main portion. The upper end of the Lake is comparatively shallow, the depth increasing to a maximum of approximately 60 feet just above the outlet.

The climate of the area is continental with only slight variations between the northern and southern portions. The average annual precipitation is between 25 and 30 inches. Average air temperatures range from about 12°F in January to approximately 73°F in July, while temperature extremes range from -34°F to 108°F. The average annual snowfall for the area is approximately 40 inches.

Past Pollution Control

As early as 1885 the State Legislature passed an act to prevent pollution of rivers and other sources of water supply. At that time and for the next 60 years, responsibility for dealing with pollution problems was vested in the State Board of Health, except for pollution harmful to fish or aquatic life. In 1927 the Legislature charged the State Board of Health with the power and the duty of administering and enforcing all laws relating to pollution of any waters of the state and directed the formation of a Metropolitan Drainage Commission. The act, however, did not provide a substantial basis for dealing with the major problems of disposal of sewage and industrial wastes. The Board in 1917 adopted a regulation requiring the responsible municipalities or agencies to submit plans for the design and operation of sewers and sewage treatment plants before proceeding with construction. The staff also conducted pollution surveys and made recommendation for pollution abatement. As a result of these efforts, a number of such plant were built in different communities of the state beginning about 1914.

The earlier surveys and reports were invaluable to many communities concerned with constructing facilities during the depression of the 30's. This preplanning aided their projects and among the plants built with Federal aid were those in the Twin Cities and South St. Paul.

In 1945 the Legislature passed the "Water Pollution Control Act" which established the Water Pollution Control Commission. This Act was regarded at the time as one of the best pollution control acts in the country. It was amended in 1951, 1959 and 1963.

Economic Projections

Introduction. Economic and demographic projections for the Upper Midwest, the Minneapolis-St. Paul metropolitan area, and the State of Wisconsin have been made by various agencies including the Upper Midwest Research and Development Council, the Twin Cities Metropolitan Planning Commission, and the Wisconsin Department of Resource Development. The information in this section,is, essentially, a summary of data presented in reports by the above organizations.

Upper Midwest Economy. The area being considered in the Upper Midwest Economic Study by Borchert and Adams includes Montana, North Dakota, South Dakota, Minnesota, northwest Wisconsin, and upper Michigan.(3) In the past, agriculture has been the predominant activity in the Upper Midwest although industrial development has become more significant in latter years. This trend is expected to continue with manufacturing and mining making the biggest gains. Gains are also expected in other types of businesses oriented toward the Midwest and national market. The greatest increases in manufacturing employment are expected to be centered in and around the Twin Cities metropolitan area. This is due to the greater access that this area has to the national market. Figure I-4 indicates the location and degree of gains that are to be expected in and around the study area between 1960 and 1975. Heavy emphasis is expected to continue on meat, dairy, and vegetable production which has encouraged the development of processing industries, as well as many specialized farm service and equipment industries. Employment gains are also expected in the large wholesale-retail centers.

In comparison to industrial development, relatively slight gains in agriculture are expected. The increase in farm income per square mile expected between 1959 and 1975 in this area is shown in Figure I-5. At present agriculture is an important source of basic income for most of the Upper Midwest trade centers. The biggest gain in farm income is expected

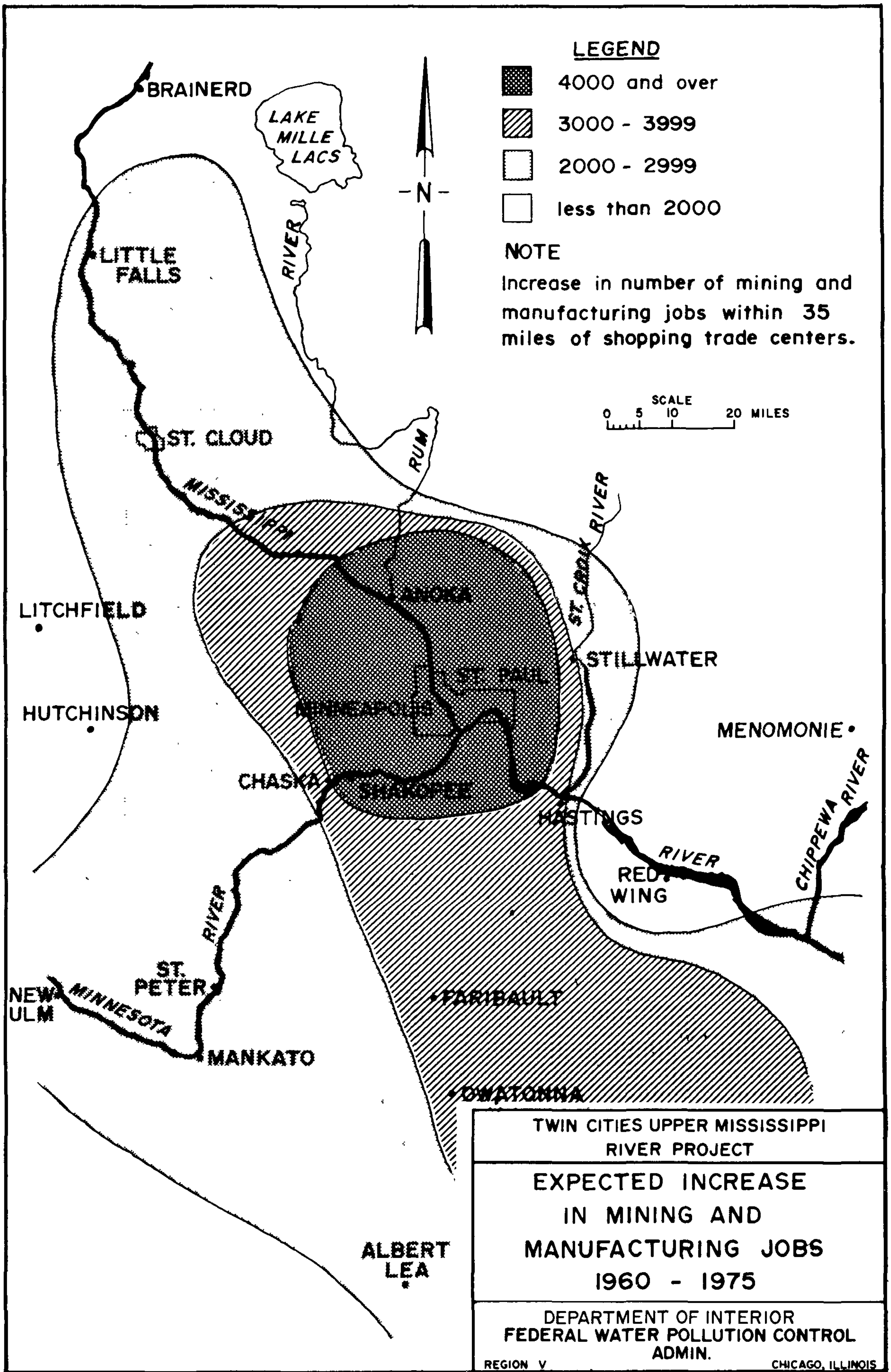
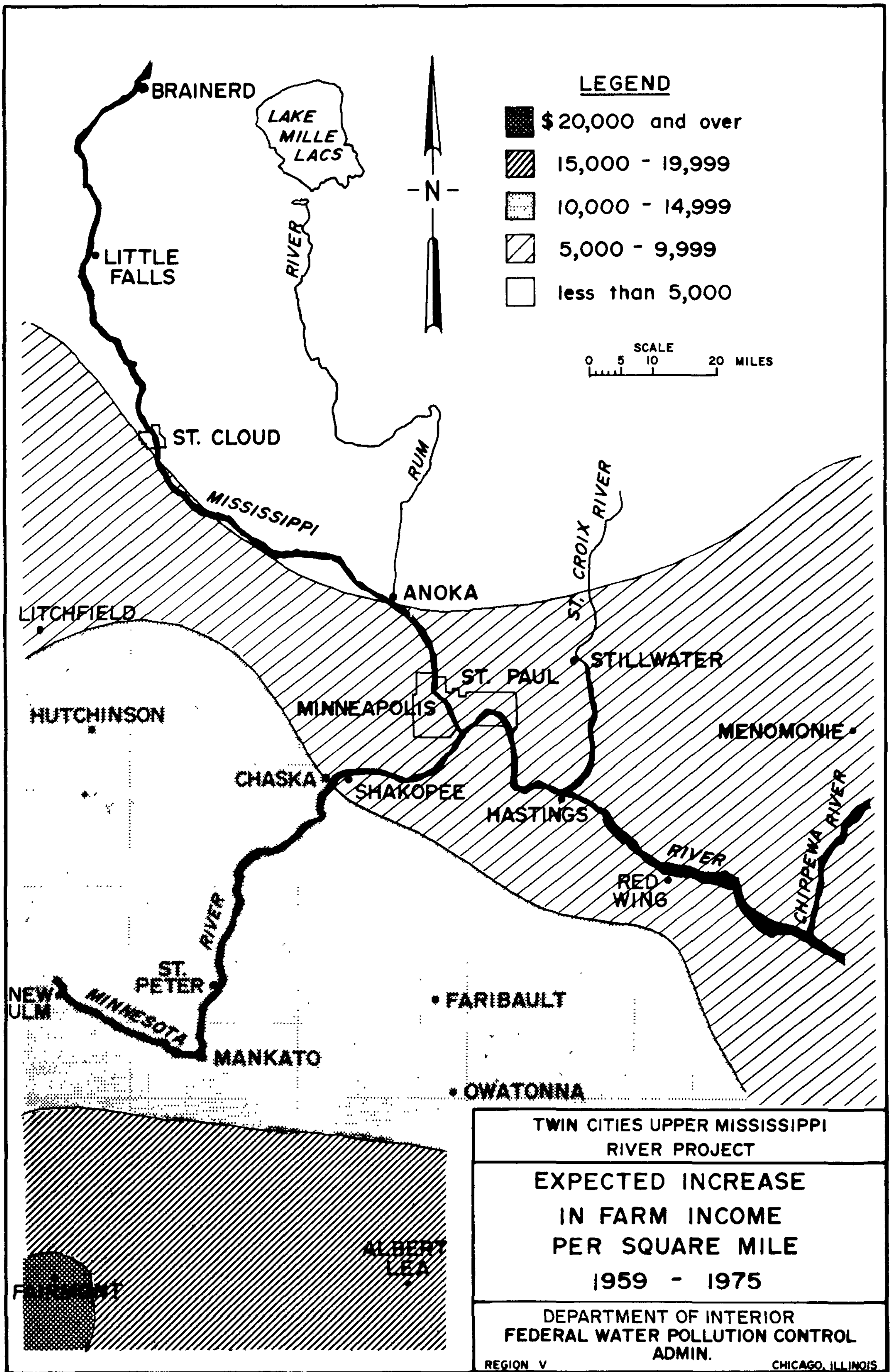

LEGEND
4000 and over
3000 - 3999
2000 - 2999
less than 2000
NOTE
Increase in number of mining and manufacturing jobs within 35 miles of shopping trade centers.
SCALE
0 5 10 20 MILES
N
BRAINERD
LAKE MILLE LACS
RIVER
RUM
LITTLE FALLS
ST. CLOUD
MISSISSIPPI
LITCHFIELD
HUTCHINSON
ANOKA
ST. CROIX RIVER
STILLWATER
ST. PAUL
MINNEAPOLIS
MENOMONIE
CHASKA
SHAKOPEE
HASTINGS
RIVER
RED WING
CHIPPEWA RIVER
RIVER
ST. PETER
NEW ULM
MINNESOTA
MANKATO
FARIBAULT
OWATONNA
ALBERT LEA
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT
EXPECTED INCREASE IN MINING AND MANUFACTURING JOBS 1960 - 1975
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V
CHICAGO, ILLINOIS

FIGURE I - 4


LEGEND
$ 20,000 and over
15,000 - 19,999
10,000 - 14,999
5,000 - 9,999
less than 5,000
SCALE
0 5 10 20 MILES
N
BRAINERD
LAKE MILLE LACS
RIVER
LITTLE FALLS
ST. CLOUD
RUM
MISSISSIPPI
ST. CROIX RIVER
ANOKA
LITCHFIELD
STILLWATER
ST. PAUL
MINNEAPOLIS
HUTCHINSON
MENOMONIE
CHASKA
SHAKOPEE
HASTINGS
RIVER
RED WING
CHIPPEWA RIVER
RIVER
ST. PETER
NEW ULM
MINNESOTA
FARIBAULT
MANKATO
OWATONNA
ALBERT LEA
TWIN CITIES UPPER MISSISSIPPI
RIVER PROJECT
EXPECTED INCREASE
IN FARM INCOME
PER SQUARE MILE
1959 - 1975
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL
ADMIN.
REGION V
CHICAGO, ILLINOIS
FIGURE I - 5

in south central Minnesota around Fairmont. This area enjoys an optimum combination of rainfall, growing season, soil, and level land resources. The expected income gains grow smaller as one moves toward the Twin Cities, principally because of poorer soils.

Both projected industrial employment and projected agricultural production favor urban growth within the Project's study area. Although these projections by Borchert and Adams (3) were made only up to 1975, the trend toward increased urbanization in this area is expected to continue indefinitely.

Twin Cities Economy. Economic development of the Twin Cities area has been considered by Toltz et al (4) and the Twin Cities Metropolitan Planning Commission (5)(6)(7). The following measures of economic activity were utilized to develop an estimate for the future: labor force and employment trends, population trends, land utilization for commercial and industrial purposes, and capital investment in industrial plants and equipment.

The labor force is considered to be widely diversified, adding to the stability of the local economy. In 1957, the metropolitan area provided employment to about 507,000 non-agricultural wage and salary workers and about 50,000 self employed, domestics and family help employees. Table I-1 gives a breakdown of the 1957 labor force employment.

As might be expected, the relative importance of the various types of manufacturing conducted over the past 60 years has shifted considerably. Early in the century lumber and wood products industries were of major importance. Today, however, they have conceded largely to the metals and machinery manufacturers, chemicals, scientific instruments and ordinance groups.

TABLE I-1

DISTRIBUTION OF EMPLOYMENT
IN TWIN CITIES METROPOLITAN AREA
IN 1957[1]

TYPE OF EMPLOYMENT	PERCENT OF TOTAL
Manufacturing	29
Retail Trade	17
Service	12
Government	12
Wholesale Trade	8
Transportation	7
Finance, Insurance and Real Estate	7
Construction	5
Public Utilities	3

1. Reference: Toltz et al in Report on the Expansion of Sewage Works in the Minneapolis-St. Paul Metropolitan Area, pp. 6-2, 1960, sponsored by the Minneapolis-St. Paul Sanitary District.

A comparison has been made of employment figures in the various employment fields between the years 1947 and 1957(4). There appeared to be a significant trend in the employment picture in that manufacturing employment increased more rapidly locally than nationally. Durable goods manufacturing employment increased by 21,000 while non-durable goods manufacturing employment decreased by 4,000.

Non-manufacturing employment, which accounts for some 70 percent of total non-farm employment, has increased at a slower rate than the national trend. Increases noted were primarily in the retail food store, service, public utility, and trucking industries.

In 1960 there were 616,700 persons in the seven county (Anoka, Washington, Hennepin, Ramsey, Dakota, Scott, and Carver) area labor force. This figure is expected to increase to 973,900 by 1980, and by 2000, the labor force is expected to be approximately 1,604,500(5).

In 1960, about 42 percent of the 246 square miles of urban land in the core area was used for residential purposes, 12.6 percent for industrial, 2.5 percent for commercial, 29 percent for streets and alleys, and 14 percent for other public and semi-public purposes(7). By 1980, estimates indicate that an additional 155 square miles of land will be needed for urban purposes. The area's abundance of usable land will more than satisfy this need.

Of the land used for industrial purposes in 1960, about 39 percent of it was within Minneapolis and St. Paul. An increasing percentage of industrial development is now taking place, however, in the suburbs and will continue to do so because of industrial land shortage within the Twin Cities.

Between 1946 and 1959, capital expenditures by the manufacturing, wholesaling, transportation, and warehousing industries totaled $192 million. The continued investments in new plants and equipment by local firms indicate their intentions to continue operations in this area for some time to come(4).

<u>West Central Wisconsin Economy</u> (8). The Wisconsin counties of Polk, St. Croix, and Pierce border that portion of the St. Croix River included in the Project study. The Wisconsin portion of the Project watershed area lays almost entirely within these three counties. In 1960 there were five industry groups representing approximately 55 percent of the 27,000 or more employed persons in the general area of these three counties. The predominent industrial activity was agriculture, which accounted for approximately 30 percent of the employment. Food and kindred industries made up approximately 6 percent of the employment. Other retail industries made up approximately 9 percent. Educational, medical, and professional employment made up another 10 percent.

Agriculture in the west central area was largely an outgrowth of lumbering operations which were concentrated to the north of it and not due to high quality soils. The soils in this area are generally low in fertility and the rugged topography adds to the problem of soil erosion.

Between 1930 and 1960, employment in the west central area expanded about one-fourth as much as the State average and actually declined slightly between 1950 and 1960. This slow rate of growth in employment was due largely to the 40 percent decline in agriculture between 1930 and 1960. There would not have been any increase in employment over this period had manufacturing not doubled in those years.

Total employment in the west central area is expected to advance by about 3.6 percent between 1960 and 1980 and about 7.2 percent between 1980 and 2000. This is a relatively slow advance when compared to the State's predicted increases of 27 and 26 percent, respectively, for the same two periods.

The Wisconsin Department of Resource Development[8] makes the following statement concerning the principal economic problem in this area, which includes eleven counties:

"The principal economic problem of the west central area is agriculture. Employment decline is precipitous and will continue its direction if not its rate of movement. This situation is aggravated by high soil erosion and low fertility, which carry serious meaning for the future of the area's important food processors. Foreign competition and technological change lend a disturbing note of uncertainty to the future of the area's most dynamic manufacturing groups of footwear, rubber goods, and paper".

It appears that agriculture will remain the principal employer in this area. It probably will continue to decline through 1980 but can be expected to make some slight gains by 2000.

Polk, St. Croix, and Pierce Counties cover an area of approximately 2,330 square miles. Approximately 47 percent of this area is used as cropland, 22 percent for forests, 19 percent for pasture and woodlot, and 4 percent for miscellaneous farmland. Water covers about 3 percent of the area and the remaining 5 percent is utilized by rights-of-way, rural communities, sub-marginal land, and urban land. Urban land makes up less than one-half percent of the total[9].

No great shift in land uses is anticipated for this three-county area in the next 30 years, except for some increased urbanization.

Demographic Projections

Upper Midwest. At least half the population growth of the upper midwest in the next 15 years is expected to be in the Twin Cities area(3). Outside of this area, rapid growth is expected to continue in the non-farm population around cities and in lake districts. Those communities with fewer than 2500 population are generally expected to experience a population drop. Smaller communities near the Twin Cities, however, will continue their development as residential areas for those employed in the metropolitan area.

The reasons for this shift in population, according to Borchert and Adams(3), can be attributed to "an underlying demand for urban living, withdrawal of surplus farm labor, growth of new industries and services, and development of new resources".

The results of 1975 population projections and interim growth rates for urban areas in the general vicinity of the Twin Cities are given in Table I-2. The estimating formula assumes that both the population and employment change in a city for any given decade approach the long-time average. The method of estimating is described in detail elsewhere(3).

From Table I-2, it appears that the larger cities will continue to grow at a high rate. In 1950, approximately 62 percent of the Minnesota population lived in urban areas. By 1975, this figure is expected to increase to 75 percent. As the population in urban areas increases, farm population will decrease. Small towns and non-farm settlements, in total, are expected to remain the same size or lose a portion of their share of the total population.

Twin Cities Metropolitan Area. The Twin Cities area will be discussed in terms of two metropolitan areas; the Standard Metropolitan Statistical

TABLE I-2

ANTICIPATED GROWTH IN SELECTED MINNESOTA URBAN AREAS[1]

Urban Area	1960 Population (Thousands)	Probable 1975 Population (Thousands)	Growth Rate (%) Anticipated 1960-1975	Past 1950-1960
Albert Lea	20.6	26.0	26	25
Anoka	12.1	15.8	31	51
Brainerd	15.7	18.2	17	10
Faribault	18.6	21.9	18	11
Hastings	11.7	15.5	33	48
Hutchinson	6.9	8.6	25	11
Le Sueur	4.4	5.3	20	17
Litchfield	5.3	6.1	16	11
Little Falls	9.2	11.1	20	31
Mankato	32.9	42.0	28	32
Mpls.-St. Paul-Urban Area	1401.5	1864.0	33	30
5-Co. SMSA[2]	(1482.0)	(1975.9)	(33)	(28)
7-Co. TCMA[3]	(1525.3)	(2055.0)	(35)	(27)
New Ulm	12.6	14.8	18	20
Owatonna	13.9	17.3	25	32
Red Wing	13.6	15.1	11	11
St. Cloud	48.0	60.2	25	24
St. Peter	9.6	11.9	24	8
Shakopee - Chaska	14.0	22.1	58	92
Stillwater	18.8	23.6	26	21

1. Reference: Borchert, J. R. and Adams, R. B, Projected Urban Growth in the Upper Midwest: 1960-1975, Upper Midwest Economic Study, Urban Report No. 8.

2. Standard Metropolitan Statistical Area.

3. Twin Cities Metropolitan Area.

Area (SMSA) which covers five counties, and the Twin Cities Metropolitan Area (TCMA) which covers the SMSA plus Carver and Scott Counties. The Twin Cities Metropolitan Planning Commission has under consideration the seven-county area(10)(11).

This seven-county area shown in Figure I-6 covers some 3,000 square miles, 500 square miles of which are urban or are urbanizing. The 1960 census showed 1,525,343 people living in this area. All except 43,267 of this number lived in the five-county standard metropolitan area. Of those in the standard metropolitan area, 796,283 or slightly more than one-half resided in Minneapolis and St. Paul, proper. The 1960 population of Minneapolis, St. Paul, and each of their suburbs is given in Table I-3. The distribution of population as it existed in 1964 is shown in Figure I-7.

The population distribution in the watershed is in some respects unusual. The five-county area contains more than a third of Minnesota's population, forming a standard metropolitan area that, in 1960, ranked 14th among such areas in the United States. The population is rather sparse throughout the remainder of the watershed with only four other cities having a population in excess of 10,000.

In the early 1940's, approximately 100 years after the first cabin was built in the Twin Cities seven-county area, the population reached its first million. The second million will be added in about 30 years, the third million in about 15 years, and the fourth million in about 12 years. This growth, both past and anticipated, is shown in Figure I-8. The expected distribution of this population is shown in Figure I-9.

The Cities of Minneapolis and St. Paul and the Minneapolis-St. Paul Sanitary District, in planning future sewage works requirements divided the metropolitan area likely to be served by the Sanitary District plant

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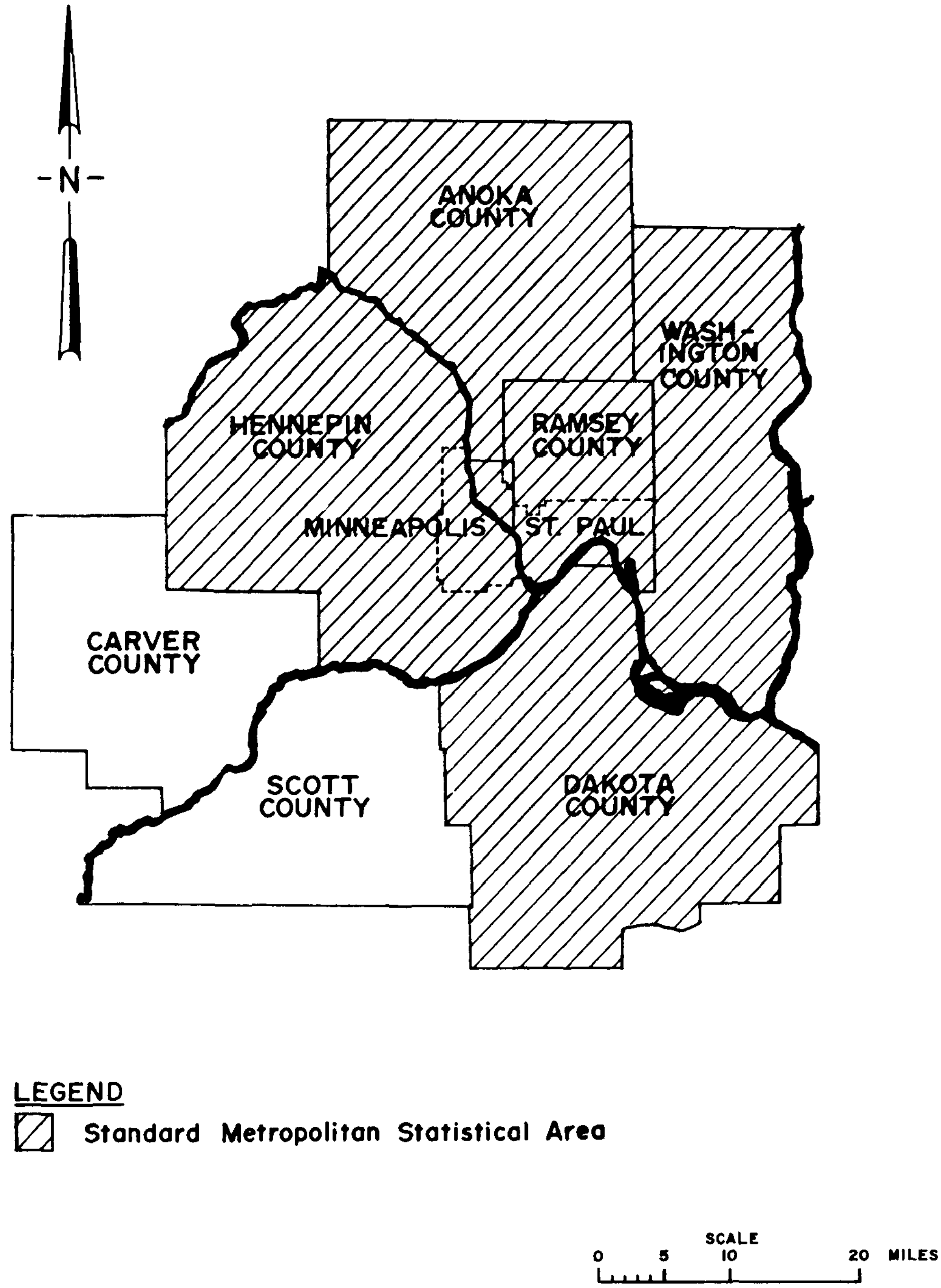


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

MINNEAPOLIS - ST. PAUL METROPOLITAN AREA

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

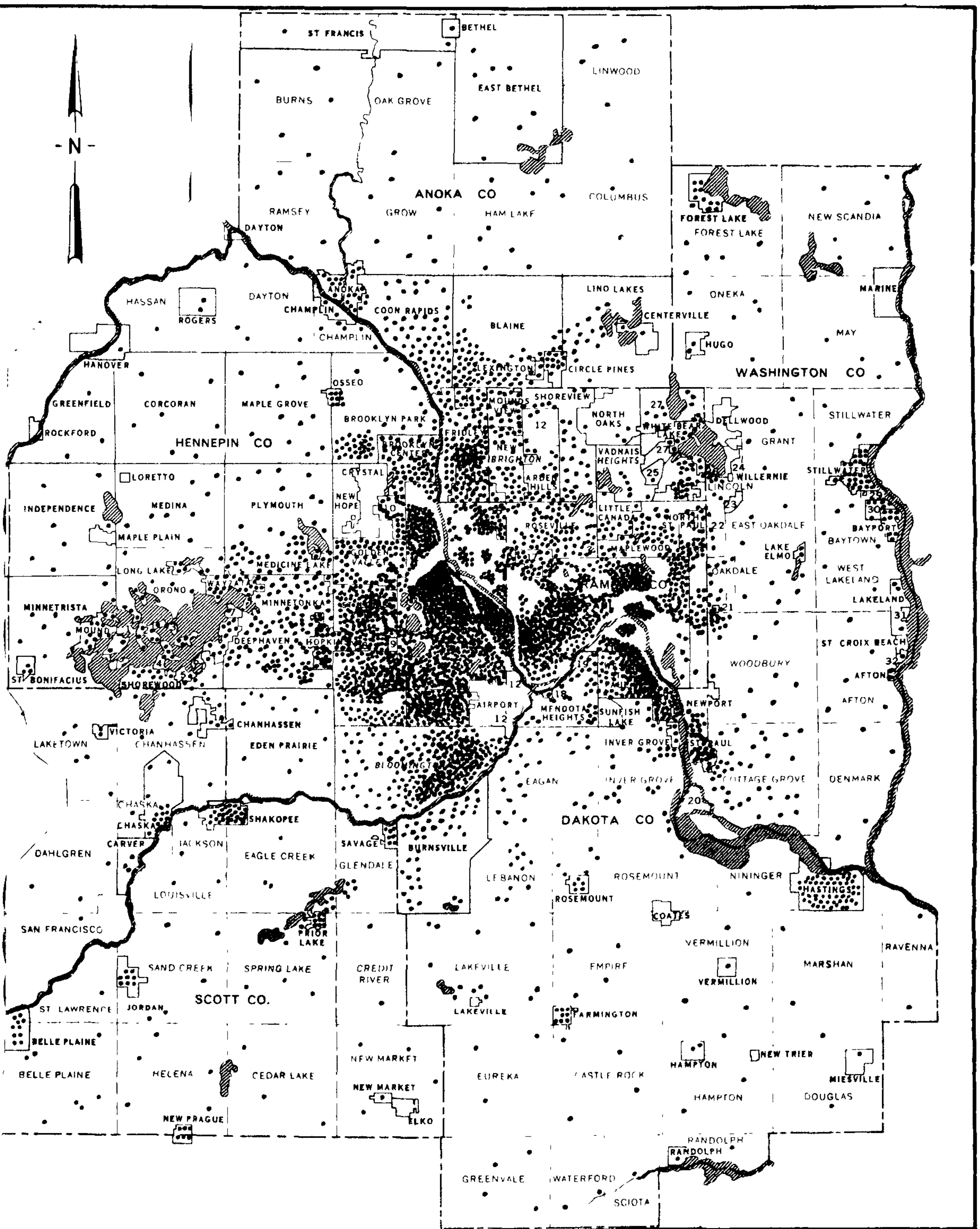
GPO 824-408-A-9

FIGURE I-6

TABLE I-3

CITIES IN MINNEAPOLIS-ST. PAUL STANDARD METROPOLITAN AREA

MINNEAPOLIS & SUBURBS	Population 1960 Census
Minneapolis	482,872
Anoka	10,562
Bloomington	50,498
Brooklyn Center	24,356
Brooklyn Park	10,197
Columbia Heights	17,533
Coon Rapids	14,931
Crystal	24,283
Edina	28,501
Fridley	15,173
Golden Valley	14,559
Hopkins	11,370
Morningside	1,981
New Hope	3,552
Plymouth	9,576
Richfield	42,523
Robbinsdale	16,381
St. Anthony	5,084
St. Louis Park	43,310
Lake Minnetonka Area:	
Deephaven	3,286
Excelsior	2,020
Minnetonka	25,037
Mound	5,440
Shorewood	3,197
Tonka Bay	1,204
Wayzata	3,219
ST. PAUL & SUBURBS	
St. Paul	313,411
Arden Hills	3,930
Blaine	7,570
Circle Pines	2,799
Falcon Heights	5,927
Little Canada	3,512
Lauderdale	1,676
Maplewood	18,519
Mendota Heights	5,028
Mounds View	6,416
New Brighton	6,448
Newport	2,349
North St. Paul	8,520
Roseville	23,997
South St. Paul	22,032
Vadnais Heights	2,459
West St. Paul	13,101
White Bear Lake	12,849



NOTE: One dot equals 200 people

SCALE
0 5 10 20 Miles

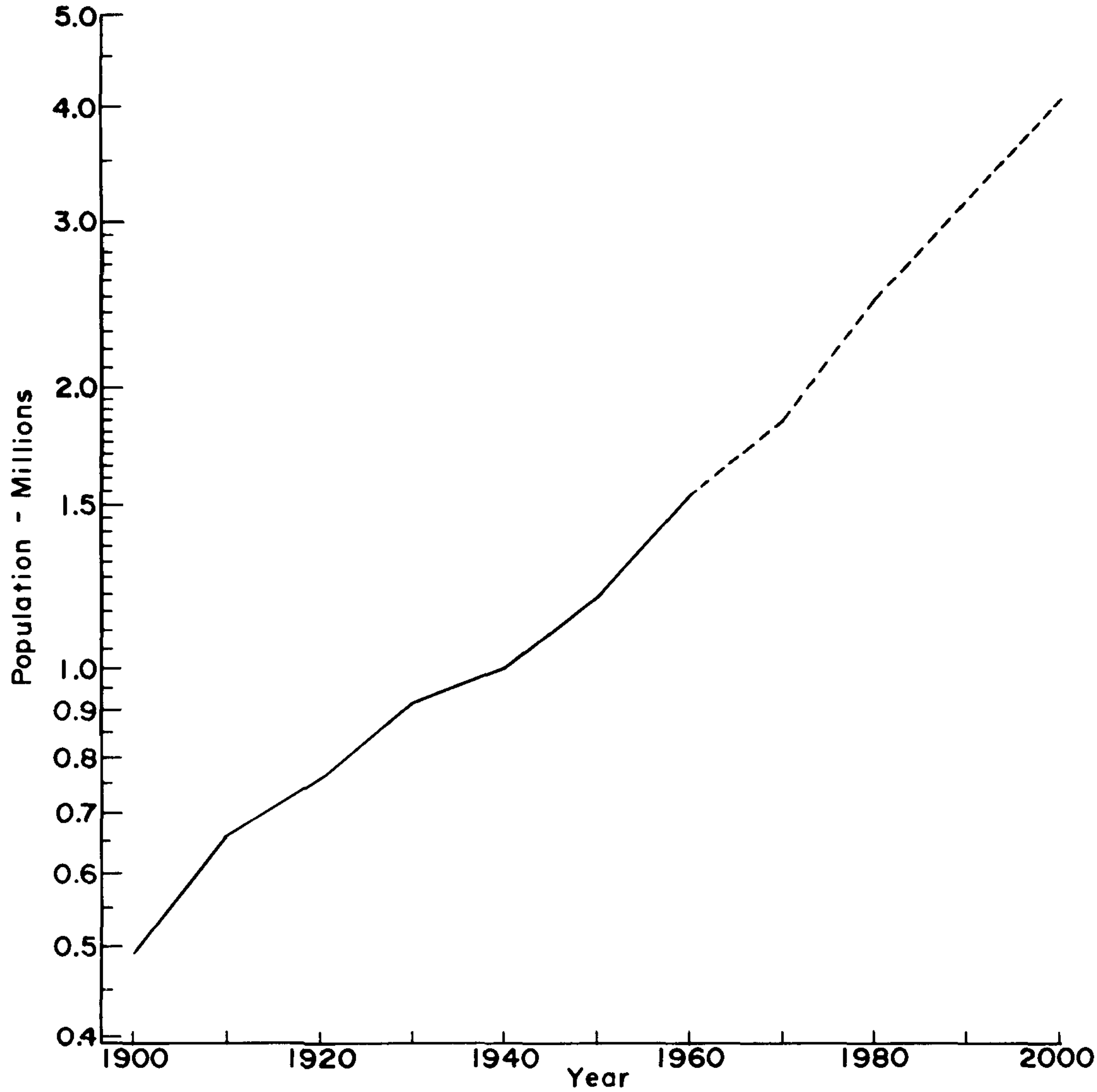
Courtesy of Twin Cities Metropolitan Planning Program

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

POPULATION DISTRIBUTION IN METROPOLITAN AREA 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE I-7



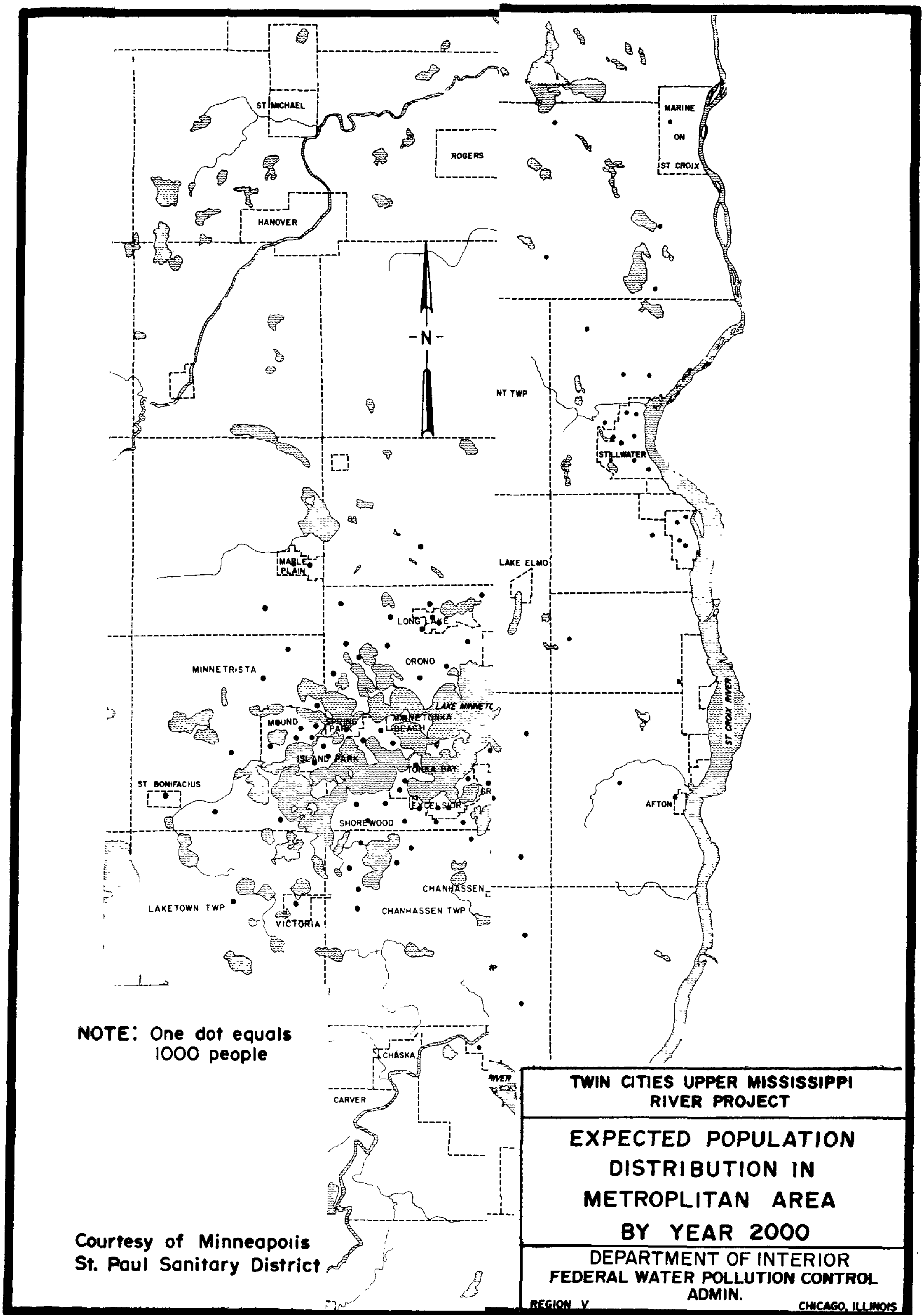
NOTE: Projections were made by the Twin Cities Metropolitan Planning Commission in 1963

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

POPULATION PROJECTIONS FOR SEVEN COUNTY METROPOLITAN AREA

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE I - 8



NOTE: One dot equals 1000 people

Courtesy of Minneapolis St. Paul Sanitary District

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

EXPECTED POPULATION DISTRIBUTION IN METROPLITAN AREA BY YEAR 2000

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V — CHICAGO, ILLINOIS

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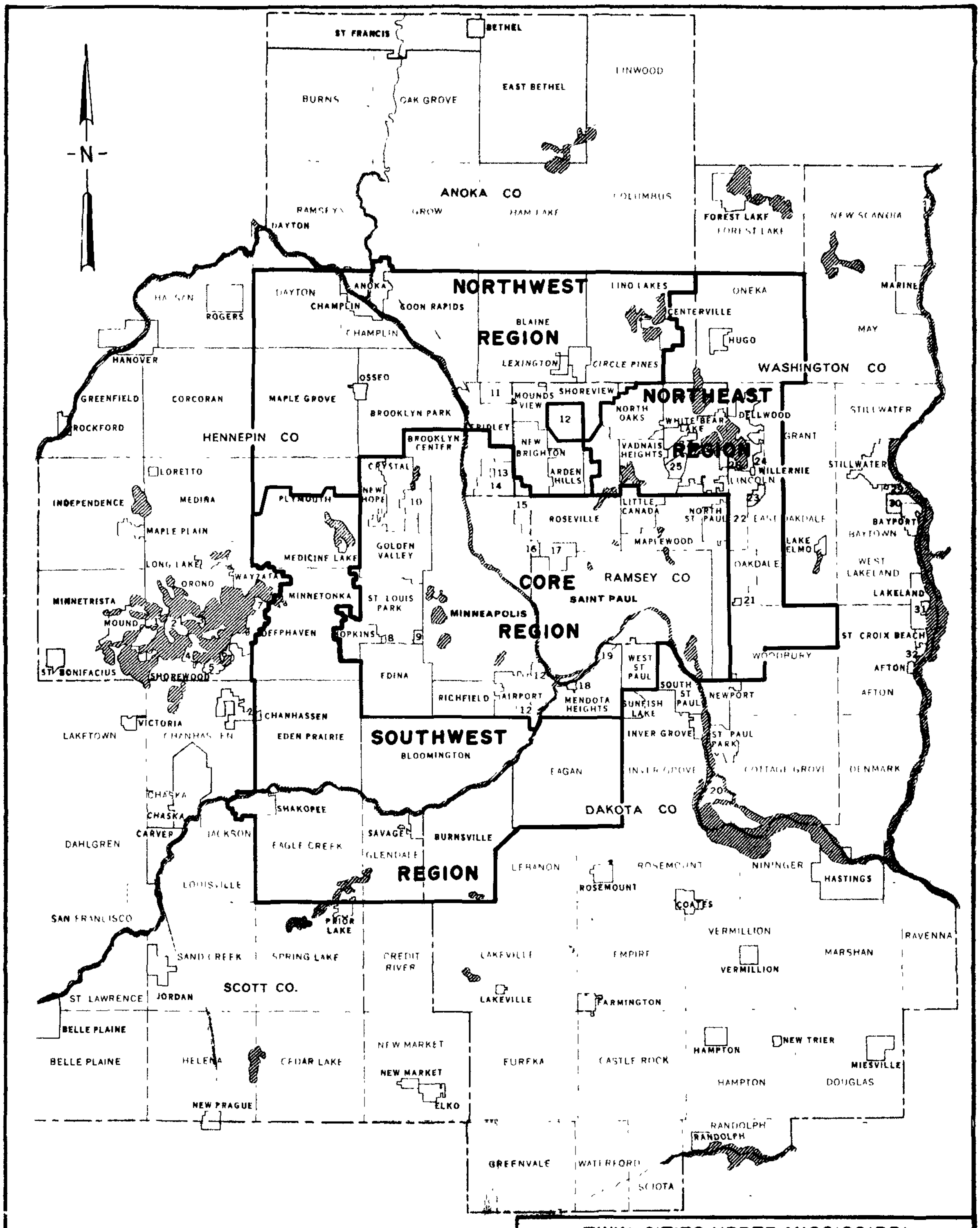
FIGURE I - 9

up into four major regions (see Figure I-10) and considered the population growth in each[12][13][14]. Boundaries were selected so that the entire population of a given region could be conveniently served by one collection system. Although the planning was done with a single treatment plant to serve all regions being considered, the regional population projections are equally valuable in considering any alternate plans which would utilize several treatment plants. These projections are given in Table I-4.

West Central Wisconsin Area. As Figure I-11 indicates, the population is less dense on the Wisconsin side of the lower St. Croix River than it is on the Minnesota side. In 1960 there was an average of between 35 and 45 persons per square mile in Pierce and St. Croix Counties as opposed to between 125 and 250 persons per square mile across the river in Washington County, Minnesota. Further upstream, in Polk County, Wisconsin, and Chisago County, Minnesota, the density was even lower, averaging between 25 and 35 persons per square mile[15].

The Wisconsin Report[15] gives population projections for the west central area as a whole. This area, shown in Figure I-12, covers 11 counties, including Polk, St. Croix, and Pierce. Table I-5 lists the 11 counties considered and their 1960 populations. Population projections made for this area anticipate there will be 316,000 persons by 1980 and 341,000 by 2000. The percent increase, then, based on the 1960 population will be 5.2 and 13.3 for 1980 and 2000, respectively.

Assuming this rate of population increase will occur in all counties of the west central area, population projections for Polk, St. Croix, and Pierce Counties would be as given in Table I-6. According to these projections, there will be an average increase of only four persons per square mile between 1960 and 2000 in this three-county area. The additional popu-



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

AREA CONSIDERED IN FUTURE SEWAGE WORK REQUIREMENTS BY MINNEAPOLIS, ST. PAUL AND SANITARY DISTRICT

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

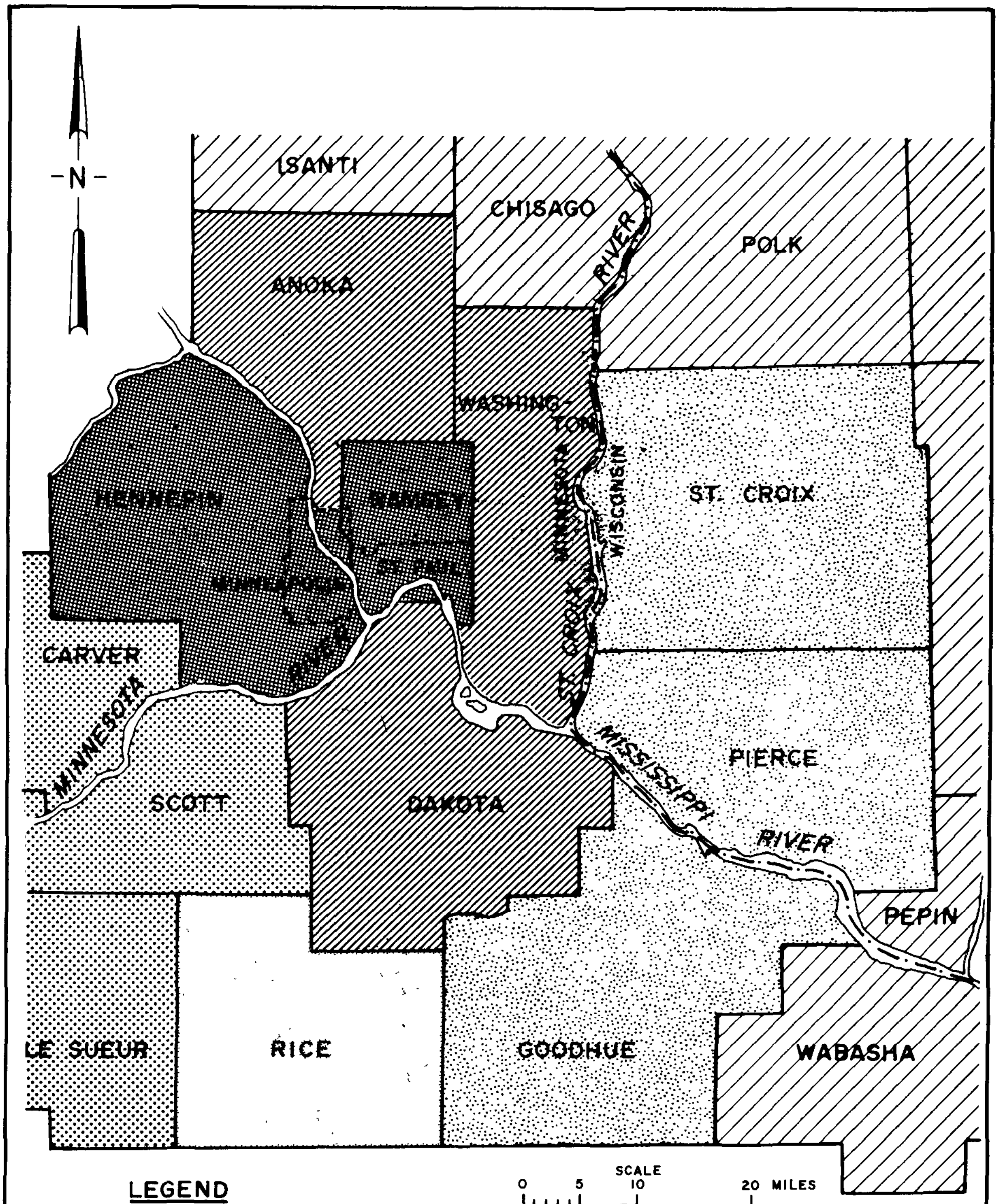
FIGURE I-10

TABLE I-4

REGIONAL POPULATION ESTIMATES*

Area	Estimated Total Population for Given Year				
	1960	1970	1980	1990	2000
Minneapolis	482,900	490,000	500,100	520,000	520,000
St. Paul	313,400	325,000	335,000	350,000	350,000
Core Area Suburbs	324,100	438,800	520,300	545,000	545,000
Sub-Total Core Area	1,120,400	1,253,800	1,355,400	1,415,000	1,415,000
Northwest Region	89,900	134,100	245,700	560,000	700,000
Northeast Region	39,600	58,300	93,200	120,000	330,000
Southwest Region	101,800	167,500	304,100	500,000	570,000
All Regions	1,351,700	1,613,700	1,998,400	2,595,000	3,015,000
Remainder of Metropolitan Area	173,600	230,700	321,900	545,000	1,020,000
Total Seven County Metropolitan Area	1,525,300	1,844,400	2,320,300	3,140,000	4,035,000

* As considered in future sewage works requirements by Minneapolis-St. Paul Sanitary District



LEGEND
(Persons/square mile)

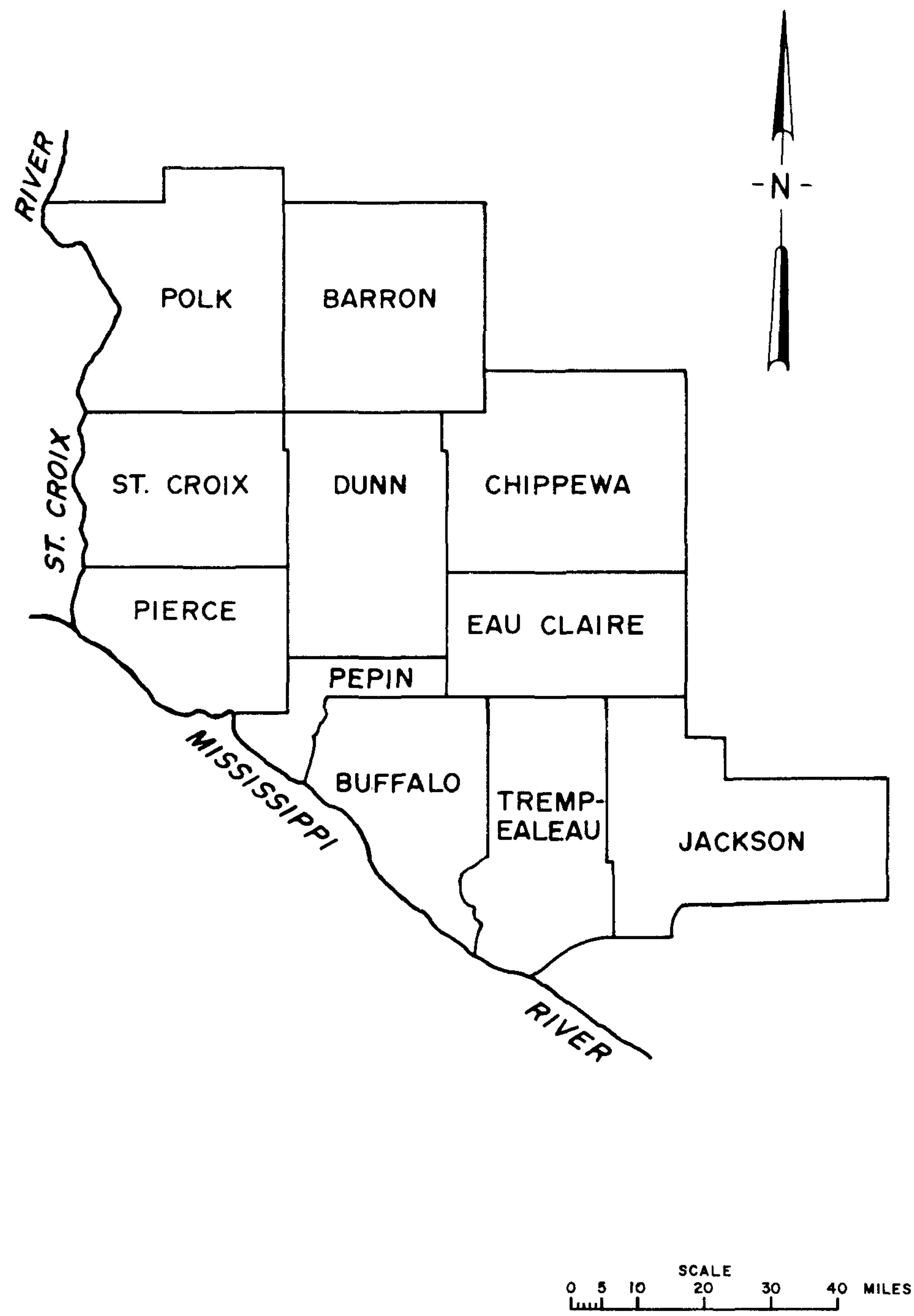
- 250 or greater
- 125 - 249.9
- 75 - 124.9
- 45 - 74.9
- 35 - 44.9
- 25 - 34.9

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

1960
POPULATION DENSITY
BY COUNTY

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE I-11



TWIN CITIES UPPER MISSISSIPPI
RIVER PROJECT

**COUNTIES IN
WEST CENTRAL AREA
OF
WISCONSIN**

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL
ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE I - 12

TABLE I-5

1960 POPULATION OF COUNTIES IN WEST CENTRAL AREA OF WISCONSIN

County	Population
Barron	34,270
Buffalo	14,202
Chippewa	45,096
Dunn	26,156
Eau Claire	58,300
Jackson	15,151
Pepin	7,332
Pierce	22,503
Polk	24,968
St. Croix	29,164
Trempealeau	23,377
Total	300,519

TABLE I-6

POPULATION PROJECTIONS FOR SELECTED WISCONSIN COUNTIES

County	1960		1980		2000	
	Population	Persons/mi^2	Population	Persons/mi^2	Population	Persons/mi^2
Polk	24,968	26	26,200	27	28,300	29
St. Croix	29,164	39	30,600	41	33,000	44
Pierce	22,503	37	23,600	39	25,500	42

lation, however, will not be spread evenly throughout the entire area. The biggest increase is expected to occur in rural non-farm areas with the next largest increase occurring in urban areas. There is a large decrease expected in the rural farm areas. Between 1960 and 1980 the rural farm population in the eleven county area is expected to decrease by over 20 percent.

Past Stream Investigations and Reports

There have been several noteworthy reports prepared in the past on water quality conditions within the area studied by the Project. The more significant ones are listed below in their chronological order of preparation:

A. A Study of the Pollution and Natural Purification of the Upper Mississippi River, H. R. Crohurst, Public Health Service, Public Health Bulletin No. 203, December 1932.

B. A Qualitative Inventory of the Upper Mississippi River (Prospectus), Public Health Service, Region V, 1958.

C. Pollution and Recovery Characteristics of the Mississippi River, Volume One (three parts), sponsored by the Minneapolis-St. Paul Sanitary District, conducted by the University of Minnesota under the direction of Professor G. J. Schroepfer.

D. Report on the Expansion of Sewage Works in the Minneapolis-St. Paul Metropolitan Area, Volume Three, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by Toltz, King, Duvall, Anderson and Associates, Inc. 1960.

E. Report on the Expansion of Sewage Treatment Works in the Minneapolis-St. Paul Metropolitan Area, Volume Four, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by Toltz, King, Duvall, Anderson and Associates, Inc. 1961.

F. Report on Investigation of the Mississippi River from the Mouth of the Rum River to the Mouth of the St. Croix River, July and August, 1960 and August and September, 1961, Minnesota Department of Health, 1962.

G. Report on Oil Spills Affecting the Minnesota and Mississippi Rivers, Winter of 1962-63, Public Health Service, 1963.

H. Summary Report on the Pollution Status of the Mississippi River and Major Tributaries from the Mouth of the Rum River to the Outlet of Lake Pepin, Minnesota Department of Health, January, 1964.

I. Report on Pollution of the Waters of the Upper Mississippi River and its Significant Tributaries Minneapolis-St. Paul Metropolitan Area, J. M. Rademacher, Public Health Service, Region V, February, 1964.

J. Lower Minnesota River Study, Minnesota Department of Health, October, 1964.

A brief description of each of these reports is given below. The order of presentation corresponds to the order in which they were listed above.

Public Health Service 1932 Report(1). A deficiency in rainfall on the Upper Mississippi River Basin, beginning in 1922, depleted reservoir and ground water storage to an extent that in the summer of 1925 the flow in the river through Minneapolis and St. Paul became insufficient to properly dilute the wastes discharged from the metropolitan area without creating objectionable conditions in the river.

The Minnesota and Wisconsin State Legislatures each appointed an interim committee to study conditions in the river through Minneapolis and St. Paul, and in the reaches of the St. Croix and Mississippi Rivers, which form the boundary between Minnesota and Wisconsin. They were to submit recommendations to the 1927 State Legislatures on methods of improving the condition of these waters. These two committees, in turn, combined to form a joint interim committee. This joint committee requested the Public Health Service to assist them in the study. Funds for the study were made available by the two States and the Cities of Minneapolis and St. Paul. The Public Health Service furnished the necessary laboratory equipment and supplies and detailed one man to have general supervision of the investigation.

The investigation was made during a 15-month period between June, 1926 and August, 1927, and covered approximately 137 miles of the Mississippi River from above Minneapolis downstream to above Winona, Minnesota. All the information collected is contained in this report and includes data relative to the physical features of the watershed and river channel; summaries of total and sewered population, with estimates of sewered population equivalent to the industrial waste pollution; estimates of discharge and times of flow; and a summary of the chemical and bacteriological findings at various points on the reach of river studied. These data are presented in a series of basic tabulations, condensed to the form of monthly averages, with a discussion of the salient features of each.

Public Health Service 1958 Inventory(16). Region V of the Public Health Service made a qualitative inventory of the Mississippi River from the Twin Cities to the confluence of the Ohio River. This inventory was a compilation of all available existing data from Federal, State, and local agencies on water use, river flows, water quality, and pollution contributors. It also provided a descriptive picture of the river with respect to its sanitary, chemical, and physical condition.

This report was developed in three sections. The first section considers the entire reach, dealing with all water uses, locations of sampling stations, types of analyses made at each station, and changing water quality as one progresses downstream. The second section considers each sampling station separately. Certain information for each station was evaluated to give a graphic picture of the river's condition and to predict the probability that certain magnitudes of observations will be reached.

The third section is a complete tabulation of the raw data as received from the Federal, State, and local contributors.

Minneapolis-St. Paul Sanitary District Reports(4)(17)(18)(19). This very extensive piece of work, in four volumes, was the result of a five-year study sponsored by the Minneapolis-St. Paul Sanitary District. The overall objective of the study, begun in 1956, was to determine future requirements of the Sanitary District sewage works and a means of financing them.

River water quality data collected periodically by the District over a 30-year period since 1926 provided much of the necessary information for Volume One of the report. Most of the data consisted of temperature, pH, turbidity, DO, BOD, total bacteria, and coliform test results which were run periodically on samples collected from 24 stations on the Mississippi River in and below the Twin Cities metropolitan area. This monitoring program, begun in 1926, is still in operation.

Volume One, Part One covers stream deoxygenation characteristics, DO frequency studies, diurnal variations in DO, and bacteriological quality studies.

Volume One, Part Two describes the activated sludge pilot plant study and summarizes the results of the test program.

Volume One, Part Three covers river capacity investigations and a preliminary algae study. An extension and reevaluation of parts of Part One is also included.

Volume Two, Parts One, Two, and Three cover an analysis of the apportionment, allocation, and distribution of sewage works costs in the metropolitan area.

Volume Three discusses a plan for the extension of the intercepting sewer system in order to service outside areas anticipating large population growths.

Volume Four gives a proposal for future plant expansion. It covers the degree of treatment believed to be required, the applicability and feasibility of various methods of sewage treatment and sludge disposal, and the development of a design basis, preliminary plans, and cost estimates for plant expansion.

Minnesota Department of Health 1962 Report. This report was prepared from data collected in July and August of 1960 and August and September of 1961 on the Mississippi River between the confluences of the Rum and St. Croix Rivers. This investigation was conducted to obtain information for the legislature and others concerned and to provide a basis for classification and adoption of standards on this reach by the Water Pollution Control Commission.

Topics covered in the report include the following:

1. Uses of the river.

2. Existing waste sources.

3. Field observations concerning sewer outfalls and the physical appearance of the river water.

4. Discussion of bacteriological, biological, and chemical data collected during the surveys.

Public Health Service 1963 Report. This report, prepared by the Water Supply and Pollution Control Technical Services Branch, Technical Advisory and Investigations Section, is concerned with the two oil spills that occurred during the winter of 1962-63. The report presents highlights of events and results of activities and studies conducted by the various

Federal, State, and local agencies during the period December 1962 to June 1963, with particular emphasis on Public Health Service activities.

Minnesota Department of Health 1964 Report[20]. This report was prepared for use at the Conference in the Matter of Pollution of the Interstate Waters of the Upper Mississippi River held by the U.S. Department of Health, Education, and Welfare at St. Paul, Minnesota, February 7 and 8, 1964. The following items are covered on the major streams within the Project study area:

1. Water uses within Minnesota.
2. Water quality and stream flow data.
3. Sewage works within Minnesota.
4. Industrial waste disposal within Minnesota.
5. Liquid storage depots within Minnesota.
6. State of Minnesota long range water pollution control plan and program from 1963 forward.

Public Health Service 1964 Report[21]. This report was also prepared for the conference held in St. Paul on February 7 and 8, 1964. The following general topics concerning the study area are covered in this report:

1. Water uses.
2. Sources of wastes.
3. Effects on water quality and water uses.
4. Control activities of State agencies.

Minnesota Department of Health Lower Minnesota River Study[22]. This report covers an investigation that was made between August, 1963, and February, 1964, on the waters of the lower Minnesota River and tributaries from Carver Rapids south of Carver, Minnesota to the mouth. The purpose of the study was to obtain information for planning purposes and to provide a basis for possible classification and adoption of water quality standards for these waters by the Minnesota Water Pollution Control Commission.

Topics covered in the report include the following:

1. Description of the river and geology of the area.

2. Existing waste discharges.

3. Uses of the river and bordering land.

4. Existing pollution conditions.

5. Bacteriological, biological, and chemical data obtained from stream sampling.

6. Recommendations for classifications and standards.

Summary. Much useful information was provided in these reports. However, more complete and more recent information was needed in several areas of concern along part or all of the stream reaches under study. Some of these areas are listed below:

1. Water uses.

2. Number, quantity, and quality of waste discharges.

3. General water quality in reaches not monitored by the Minneapolis-St. Paul Sanitary District.

4. Measurements of fecal coliform, fecal streptococcus, pathogenic bacteria, viruses, nutrients, and plankton organisms in the entire study area in addition to those measurements made routinely by the Sanitary District.

5. Time of travel measurements in reaches not covered by the Sanitary District Report.

6. Stream deoxygenation and reaeration rates in reaches not covered by the Sanitary District report and more recent information in the areas that were covered to ensure the reported values are still current.

7. Waste loads anticipated in the future.

8. Treatment requirements necessary to allow for various water uses.

9. Treatment requirements based on several plants as opposed to a single plant.

Studies carried out by the Project were designed to obtain the necessary data not included in previous reports. These studies were carried out to augment, not duplicate, previous work.

REFERENCES

1. Crohurst, H. R., A Study of Pollution and Natural Purification of the Upper Mississippi River, Public Health Bulletin No. 203, Public Health Service, December 1932.

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4. Report on the Expansion of Sewage Works in the Minneapolis-St. Paul Metropolitan Area, Volume Three, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by Toltz, King, Duvall, Anderson and Associates, Inc. 1960.

5. Metropolitan Economic Study, Report No. 5, Twin Cities Metropolitan Planning Commission, June 1960.

6. Interim Labor Force Projections, 1980 and 2000, Information Bulletin No. 3, September 27, 1963, Twin Cities Metropolitan Planning Commission.

7. Metropolitan Land Study, Report No. 4, Twin Cities Metropolitan Planning Commission, April 1960.

8. Wisconsin's Economy by State of Wisconsin Department of Resource Development, December 1962.

9. Land Use in Wisconsin by State of Wisconsin Department of Resource Development, June 1963.

10. Metropolitan Population Study, Report No. 2, Twin Cities Metropolitan Planning Commission, August 1959.

11. Metropolitan Population Study, Part III, Basic Characteristics, Report No. 11, Twin Cities Metropolitan Planning Commission, March 1962.

12. Report on Comprehensive Sewage Works Plan for the Minneapolis-St. Paul Metropolitan Area, prepared for City of Minneapolis by Toltz, King, Duvall, Anderson and Associates, Inc., May 1964.

13. Metropolitan St. Paul Sanitary Sewerage Report, City of St. Paul Department of Public Works, Bureau of Engineering, May 1964.

14. Report on Comprehensive Sewage Works Plan For The Minneapolis-St. Paul Metropolitan Area, prepared for Minneapolis-St. Paul Sanitary District by Toltz, King, Duvall, Anderson and Associates, Inc., May 1964.

15. Wisconsin's Population 1962 by State of Wisconsin Department of Resource Development.

16. A Qualitative Inventory of the Upper Mississippi River (Prospectus), Public Health Service, Region V, 1958.

17. Pollution and Recovery Characteristics of the Mississippi River, Volume One (Parts One, Two, and Three), sponsored by the Minneapolis-St. Paul Sanitary District, conducted by the University of Minnesota under the direction of Dr. G. J. Schroepfer, 1958 - 1961.

18. Present Practice in the Apportionment, Allocation, and Distribution of Sewage Works Costs in the Minneapolis-St. Paul Metropolitan Area, Volume Two (Parts One, Two, and Three), sponsored by the Minneapolis-St. Paul Sanitary District, conducted by Toltz, King, Duvall, Anderson and Associates Consulting Engineers, and prepared by Professor G. J. Schroepfer, 1958.

19. Report on the Expansion of Sewage Treatment Works in the Minneapolis-St. Paul Metropolitan Area, Volume Four, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by Toltz, King, Duvall, Anderson and Associates, Inc. 1961.

20. Summary Report on the Pollution Status of the Mississippi River and Major Tributaries from the Mouth of the Rum River to the Outlet of Lake Pepin, Minnesota Department of Health, January 1964.

21. Rademacher, J. M., Report on Pollution of the Waters of the Upper Mississippi River and It's Significant Tributaries Minneapolis-St. Paul Metropolitan Area, Public Health Service, Region V, February 1964.

22. Lower Minnesota River Study, Minnesota Department of Health, October 1964.

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Geological Survey

Public Health Service

Communicable Disease Center Field Station

U. S. Army Corps of Engineers

U. S. Navy

State of Minnesota Agencies

Water Pollution Control Commission

Department of Health

Department of Conservation

State of Wisconsin Agencies

Committee on Water Pollution

Board of Health

Department of Conservation

Department of Resource Development

Regional Agencies

Minneapolis-St. Paul Sanitary District

Twin Cities Metropolitan Planning Commission

Upper Midwest Research and Development Council

Universities

University of Minnesota

Municipal Agencies

City of Minneapolis Water Works

City of St. Paul Water Department

Consultants

Dr. Richard S. Engelbrecht, University of Illinois

Dr. Lawrence B. Polkowski, University of Wisconsin

Project Committee Members

(Membership list is given on Page 1-8)

Grateful acknowledgement is also made to sewage treatment plant personnel of all communities along the three major streams studied. Their assistance in the collection of samples and in providing necessary data added immeasurably to the success of the study.

GPO 828-545-1

SECTION II

CURRENT STATUS OF POLLUTION CONTROL

LEGAL AND ADMINISTRATIVE ASPECTS

INTRODUCTION

In the final analysis, water use (or abuse) is controlled by one thing - law. With this idea in mind, a water quality investigation conducted for the purpose of pollution abatement should include a review of the existing laws that apply to the waters under study. A summarization of State and Federal laws pertinent to the rivers within the study area is therefore included. Minnesota statutes are discussed first, with a similar discussion of the Wisconsin statutes immediately following. Interstate joint regulations between the two States are also discussed. Federal jurisdiction, exercised by the Corps of Engineers, Coast Guard, and the Department of Health, Education, and Welfare, is then reviewed.

MINNESOTA WATER POLLUTION CONTROL ACTIVITIES (1) (2)

General

The responsibility for controlling water pollution rests primarily with the Water Pollution Control Commission. Matters relating to sources of domestic water supplies and to public health are handled by the State Department of Health.

The Water Pollution Control Commission was established by the "Water Pollution Control Act" in 1945 (Minnesota Statutes 115.01 to 115.09). The Act has been amended by Chapter 517, Laws of 1951; Chapter 399, Laws of 1959; and Chapter 874, Laws of 1963.

Water Pollution Control Commission

Organization. The Commission has seven members and an executive engineer. It is comprised of the Secretary and Executive Officer of the State Department of Health, the Commissioner of Conservation, the Commissioner of Agriculture, Dairy, and Food, the Secretary and Executive Officer of the State Livestock Sanitary Board, and three members at large appointed by the Governor, with consent of the Senate, for six-year terms. In appointing the members at large, one is selected from each of the following three categories: general public, municipal government, and industry. The executive engineer is furnished to the Commission by the State Department of Health.

The Commission holds regular quarterly meetings each calendar year. At its first regular meeting in January of each year it elects a Chairman and a Vice-chairman to serve for the ensuing year. The Secretary and Executive Officer of the State Department of Health serves as Secretary of the Commission. Special meetings may be called by the Chairman or by any two members upon two day's written notice to each other member. A majority of the members constitutes a quorum.

Powers and Duties. The powers and duties of the Commission are summarized below. Unless indicated otherwise, they are found in Minnesota Statutes 115.03, Sub-division 1 (as amended in 1951 and 1959) and Chapter 874, Sec. 5, Laws of 1963.

1. Classification of waters and setting standards of water quality.

The Commission is authorized to classify the waters of the State as soon as practicable and to adopt classifications and standards of purity and quality therefor. In setting standards, consideration is given to present and future public uses of the waters.

Thus far, classifications and standards have been set for the Mississippi River from its confluence with the Rum River downstream to Lock and Dam No. 2 at Hastings, Minnesota (see Appendix, pp.1).

The Commission also adopted classifications and standards for the Minnesota River and tributaries from Carver Rapids to the mouth (see Appendix, pp. 15).

2. Issuance of permits and review of plans.

The Commission may require the submission of plans for disposal systems or any part thereof and the inspection of the construction thereof for compliance with the approved plans. It may also continue in effect, modify, revoke, or deny permits, for the discharge of sewage or other wastes, or for the installation or operation of disposal systems or parts thereof.

3. Enforcement.

The Commission is authorized to issue final orders after a hearing held before it or its authorized agent. Anyone affected by the order must be given ten days written notice of the hearing, and must be afforded an opportunity to submit evidence. A copy of the final order of the Commission must be likewise served on all persons who have entered an appearance at the hearing. When the Commission has determined that an emergency exists affecting the public health, it may make a final order without notice or hearing. Such final order must be served as indicated above.

An aggrieved party may appeal from a final order of the Commission, or the Attorney General may appeal in behalf of the State, to the District Court of Ramsey County. The Court on its own motion or on application of any party may take additional evidence on any issue of fact or may try all such issues de novo, but without a jury trial. If the Court determines that the action of the Commission appealed from is lawful and reasonable, and is warranted by the evidence, it affirms such action; otherwise, the Court may vacate or suspend the action appealed from in whole or in part, and thereupon the matter is remanded to the Commission for further action in conformity with the decision of the Court. The effectiveness of the Commission's order is not stayed by an appeal except by order of the Court for cause shown by the appellant (Sec. 144.375(8)).

It is unlawful for anyone to construct, install or operate a disposal system, or any part thereof, until plans therefor have been submitted to the Commission unless the Commission has waived such submission and granted a written permit.

It is unlawful for anyone to make any changes in any existing disposal system that would materially alter the method or the effect of treating the sewage, or other wastes, or to operate such system, as so changed, until plans therefor have been submitted to the Commission unless the Commission has waived such submission and granted a written permit.

It is unlawful for anyone operating a watercraft or other marine conveyance to permit the use of any marine toilet or similar device that is not acceptable to the Commission (Minnesota Statutes 1961, Sec. 361.29, as amended by Chapter No. 313, Laws of Minnesota, 1963).

"It is unlawful for anyone to store, keep, or allow any substance to remain in or upon any site without reasonable safeguards adequate to prevent the escape or movement of the substance or a solution thereof from the site under any conditions of failure of the storage facility whereby pollution of any waters of the State might result therefrom" (WPC 4 Regulation).

The pollution of any waters in violation of the Act or of any order or regulation adopted by the Commission constitutes a public nuisance and may be enjoined.

Violation of any provision of the Act or of any regulation adopted by the Commission thereunder is a misdemeanor.

4. Conduct of studies, investigations, and research.

The Commission is empowered to investigate the extent, character, and effect of the pollution of the waters of the State and to gather information necessary to the administration or enforcement of the pollution laws.

5. Cooperation with other public or private agencies.

The Commission may assist and cooperate with any agency of another State, of the United States or of the Dominion of Canada or any province thereof in any matter relating to water pollution control. It may also receive and accept money, property, or services from any other source for any water pollution control purpose within the scope of its functions.

6. Administrative powers.

The Commission is authorized to hold hearings, issue orders, permits, rules, and regulations. It may administer oaths, examine witnesses, and issue subpoenas. The Commission members or agents may enter upon any property for the purpose of obtaining information or conducting surveys. Anyone operating a disposal system, when requested by the Commission, must furnish it any information which he may have relevant to the Act. The Commission or an authorized agent may examine any books, papers, records, or memoranda pertaining to the operation of a disposal system.

In situations where cooperation between two or more municipalities is deemed necessary to abate pollution, the Commission may compel the municipalities to enter into a contract with each other for that purpose.

When deemed necessary the Commission may issue, modify, or revoke orders for the following purposes:

a. Prohibiting or directing the abatement of any waste discharge;

b. Prohibiting the storage of any liquid in a manner which may result in pollution of the waters of the State;

c. Requiring the construction (or alteration) and operation by any municipality of any disposal system.

7. Preservation of existing rights and remedies.

The Water Pollution Control Act, as amended, does not repeal any provisions of law relating to the pollution of any waters of the State, but is construed as supplementing the same and is in addition to the laws now in force, except as the same may be in direct conflict.

State Department of Health

The Department administers and enforces all laws relating to water pollution where such pollution affects the public health. The Department makes such investigations of water pollution and the plans for the construction of works affecting water pollution as may be required by the Water Pollution Control Commission. The Department is authorized to cooperate with other departments of the State, municipalities, the United States, the Dominion of Canada or any province thereof, industries, corporations and individuals, to protect and free the waters of the State from pollution (Section 144.38, Minnesota Statutes 1949).

In carrying out its water pollution functions, the Department is authorized to hold hearings and investigations, subpoena witnesses, administer oaths, and compel the production of books, papers, records, and other evidence (Sec. 144.39).

In furtherance of its water pollution functions, the Department is authorized to receive funds, property and services from any person, firm corporation, municipal corporation, the State, any of its departments or officers, any other State, or the United States (Sec. 144.40).

The Department is authorized to adopt and enforce reasonable regulations regarding the disposal of sewage, the pollution of streams and the distribution of water by private persons for domestic use. When such regulations are approved by the Attorney General and published, they have the force of law, except insofar as they conflict with statute or with the charter or ordinance of cities of the first class (Chapter 361, Laws of 1957).

Miscellaneous Statutory Provisions

It is unlawful to throw or allow to run into any of the waters of the State any refuse, lime, or other deleterious or poisonous substances in quantities injurious to fish life therein. Each day the violation continues is a separate offense. Recurrent violations are deemed a public nuisance and may be enjoined (Sec. 101.42, Subdiv. 3(15)).

It is unlawful for anyone to furnish impure water for public or private use (Sec. 616.09).

It is unlawful for anyone to willfully poison any spring, well, or reservoir of water (Sec. 616.21).

It is a gross misdemeanor to deposit or cast into any lake, creek, or river wholly or partly in the State, or to deposit upon the ice of any such lake, creek, or river, the offal from, or the dead body of, any animal (Sec. 616.16).

Miscellaneous Acts Relating to Water Pollution

An act, stated in Chapter 20, Laws of Minnesota, 1961, provides for the establishment of sanitary regions and for the creation and administration of a water pollution control advisory committee and sanitary districts. As set up, each congressional district of the State constitutes a sanitary region. The advisory committee consists of two members from each region. The members are appointed by the Governor, with the advice and consent of the Senate. The purpose of the committee is to assist the Water Pollution Control Commission in the performance of its duties and to maintain a liaison between the Commission and communities, industries, and persons concerned with water resources.

The Ashbach Bill (Chapter 882) enacted by the 1963 Legislature required the Board of Trustees of the Minneapolis-St. Paul Sanitary District to adopt a comprehensive plan for construction and financing of facilities required by the entire area to be served by the District.

Such a plan, prepared jointly by Minneapolis, St. Paul, and the Sanitary District (MSSD), was completed in 1964 and submitted to the Water Pollution Control Commission. Before acceptance, the Commission held numerous public hearings. After consideration to all testimony given, the Commission accepted the District report with some reservations and, on January 2, 1965, returned it to the District with the Commission's financing recommendations. At the same time, the Commission's report was given to the legislature. The Commission recommended acceptance of the engineering part of the MSSD's comprehensive plan and also recommended the establishment of a metropolitan sanitary district to be managed by a board with representation from the entire area. They recommended that there be only one permanent treatment plant for the District, however, and if any other plants should be built that they be strictly temporary, not to remain beyond 1980. Other modifications included the following: arrangements for financing be by an areawide general tax levy rather than on the use basis as proposed in the MSSD plan; purchase by the new District of all present sewerage facilities in the area including the MSSD and the North Suburban Sanitary Sewer District, at market value; a speedup in the timetable for construction of sewerage facilities in the metropolitan area; boundaries of the new district should be the same as that set out by the $145 million proposed plan, but with procedures included for expansion, notably in areas of South St. Paul and the semi-rural area west of Lake Minnetonka; and the authority for the new district to issue bonds and levy taxes.

The State legislature during the '65 session had the opportunity to establish effective long-range pollution controls in the Twin Cities metropolitan area. The plan submitted to the legislature by the Water Pollution Control Commission would have provided the area with a new and enlarged metropolitan sanitary district which could have effectively handled the metropolitan area sewage through the year 2000. These two proposals, the Commission's and the MSSD's, considered by the legislature were thought by many to be the most comprehensive and well researched pollution control measures ever to come to the Capitol.

The board of the Minneapolis-St. Paul Sanitary District elected in January, 1965, not to accept the recommendations of the Water Pollution Control Commission since they were, in their opinion, beyond the scope of the Ashbach Act of the 1963 Minnesota legislature. The District's attorney said the intent of the Ashbach Act was to have a plan developed, based on extension of the contract system, under which Minneapolis and St. Paul charged suburbs for handling sewage.

State Representative Robert O. Ashbach introduced a bill into the House of Representatives designed to set up a fifteen member board to run a metropolitan district, which would buy out the Minneapolis-St. Paul Sanitary District and could build regional sewage plants on the Minnesota River. The bill as originally proposed would have left the five northeast suburbs, who are members of the North Suburban Sanitary Sewer District, out of the metropolitan district. These suburbs were involved in court action with the Minnesota Water Pollution Control Commission for the right to build their own sewage treatment plant on the Mississippi River in Fridley, Minnesota. Hearings on this bill were held by the House Metropolitan and Urban Affairs Committee. A companion bill was introduced into the Minnesota Senate where the bill was attacked by the Senate Civil Affairs Committee after a series of amendments designed to enlarge and strengthen the proposed metropolitan district were offered. Among items questioned were: a provision which would make the bill effective with the ratification by two-thirds of the members of the Minneapolis-St. Paul Sanitary District board; the expansion of the membership of the district board and deletion from the House version of a provision allowing communities to detach themselves from the proposed metropolitan district; and the amendments which would increase the size of the district from about 55 communities to more than 70, placing in the district a number of communities which have been aligned with either proposed sewage districts or the North Suburban Sanitary Sewer District.

Although the House bill passed the House easily, the Senate sponsors of companion legislation could not get the issue to a vote at the Civil Administration Committee meeting. Thus, the metropolitan area sewage bill died in the Senate Committee.

The Senate Committee, however, did pass out two regional bills allowing construction of treatment plants on the Minnesota River. One regional bill permitted Bloomington, Burnsville, and Egan Township to join in a Southeast Suburban Sanitary Sewer District and construct a temporary plant on the Minnesota River. The other similar bill allowed Hopkins, Plymouth, Medicine Lake, Minnetonka, Deephaven, Woodlawn, and Eden Prairie to form the Southwest Suburban Sanitary Sewer District. This southeast regional plan was approved on a 112-5 vote by the House, but never reached the Senate floor for a vote.

Another regional sewage bill, which would have allowed the North Suburban Sanitary Sewer District to put treated sewage in the Mississippi River above Minneapolis, ran into opposition in the Minnesota House. This bill would have eliminated the need for the District to get permission from the Minneapolis-St. Paul Sanitary District, Minneapolis, St. Paul, and the Minnesota Water Pollution Control Commission before putting treated sewage in the river.

At the conclusion of the 1965 session there were no metropolitan sewage plans passed.

Recent Legislative Activities Relating to Water Pollution

The 1965 Minnesota legislature introduced and narrowly missed passage of legislation which would have replaced the present Water Pollution Control Commission. In presenting the legislation to the Senate, Senator Gordon Rosenmeier said that it was apparent in 1963 when a water pollution control law bearing his name was passed that the duties imposed upon the Commission with its present part-time ex-officio membership would be too great. The proposed Senate version, which had the backing of the administration of Governor Karl Rolvaag, suggested that the new Commission would take over the present Commission's duties of setting standards for the State's rivers and streams and also make studies with an eye toward establishing similar standards in the fields of air pollution and land use in areas affected by pollution. The new agency to be created would contain five members selected by the Governor with none from any State department and would have its own full-time director. This Senate version passed by a vote of 56 to 1. The version, if approved, would have required the agency to set water quality standards on rivers and bar the practice of prohibiting any treatment plant on specific sections of rivers. The law also would have exempted industries from having to get a permit from the Commission before dumping treated waste into waterways. Governmental units, however, would still have had to get a permit before constructing treatment facilities.

The companion House bill which was introduced received some modifications before receiving House approval by a vote of 105 to 16. Under the House version the new agency would have had the same powers as the present Commission to set pollution standards for the State's waterways and to grant permits for municipal sewage treatment plants. It differed from the Senate version in that the Governor would appoint the five members of the agency and the agency's director, for four-year terms. The Senate bill prohibited the appointment of any State, Federal, or local government official to the agency but the House version made the State Conservation Commissioner one of the members. The House version also provided that the present staff of the Water Pollution Control Commission and the Water Pollution Control Section of the State Board of Health be transferred to the new agency. The Senate bill made no provision for staff or financing.

The creation of the new agency died during the last hours of the legislature when the House refused a Senate request to appoint a conference committee to meet with a similar group from the Senate and iron out the differences in the two pieces of legislation. In the last hour of legislation the House agreed to appoint a conference committee but at that time it was too late for passage of any legislation. Thus, the legislature adjourned without creating any changes in the present Water Pollution Control Commission.

WISCONSIN WATER POLLUTION CONTROL ACTIVITIES(3)

General

Citations in this topic refer to Wisconsin Statutes, 1955, unless otherwise indicated.

In Wisconsin the Committee on Water Pollution, the State Board of Health, and the Conservation Department exercise functions relating to water pollution. The Committee exercises general supervision over the administration and enforcement of all laws relating to the pollution of the surface waters of the State (Sec. 144.53 (1)). The functions of the Board relate primarily to water supply, drainage, water systems, and sewage and refuse disposal (Secs. 144.01 -.12; 162.01 -.06). Under Sections 29.29 (3) and 29.65 the Conservation Department may take action following investigation by the Committee of intermittent discharges.

The State Laboratory of Hygiene is authorized to examine water supplies for domestic purposes, among other things. The examination of water supplies includes the establishment of a water survey of the State and comprehends not only examination from a public health standpoint but may also include the examination of water to ascertain its suitability for manufacturing and commercial purposes as determined by the rules and regulations provided for by the State Board of Health (Sec. 36.225(2)(3)).

An Act of the 1953 legislature provides an exemption from local taxation for 5 years for all real and personal property installed as the result of a recommendation or order of the Committee on Water Pollution, State Board of Health, City Council, Village Board or County Board, for the purpose of eliminating pollution of surface waters or the air, provided the operation of the facilities does not produce a net income during that period. The law also provides for accelerated amortization for tax purposes of industrial waste treatment facilities, allowing the cost to be written off in 60 months (Secs. 70.11 (21)(a), 71.04 (2b)).

Any person operating a plant which creates waste material which, if released without treatment would cause stream pollution, is permitted to condemn property for the location of treatment facilities. The law defines "person" as the State, a county, town, village, city, school district or other municipal corporation, a board, commission, corporation, or housing authority created under Sections 66.40 to 66.404. "Property" is defined as including estates in lands, fixture, and personal property directly connected with lands (Secs. 32.01(1)(2), 32.02(12)).

Committee on Water Pollution

Organization. The Committee consists of the State Chief Engineer, a member or representative of the Public Service Commission, a Conservation Commissioner or an employee of the Conservation Commission, the State Health Officer or a member of the Board of Health, and the State Sanitary Engineer or an engineer appointed by the State Board of Health. The State Board of Health, subject to the approval of the Committee, employs a full-time Director of the Committee. The administrative and executive powers and duties of the Committee are vested in the Director, subject to the direction of the Committee, its orders, rules, and regulations. The Committee holds regular meetings in January and July of each year, and such special meetings as are agreed upon, or upon call of the State Board of Health, the State Health Officer or of any three members of the Committee (Sec. 144.52).

The Committee has a full-time staff, organized as the Division of Water Pollution Control of the State Board of Health, which is also the administrative agency for the Committee.

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Powers and Duties. The powers and duties of the Committee summarized below, are divided into six categories.

1. General powers

The Committee exercises general supervision over the administration and enforcement of all laws relating to the pollution of the surface waters of the State (Sec. 144.53(1)).

2. Review of plans

The Committee may require the submission and approval of plans for the installation of systems and devices for treating industrial and other wastes (Sec. 144.53(6)).

3. Enforcement

The Committee issues general orders, and adopts rules and regulations for the installation of means for controlling water pollution from industrial and other wastes. Such general orders, rules and regulations are issued only after an opportunity to be heard thereon has been afforded interested parties (Sec. 144.53(4)).

The Committee is authorized to issue special orders directing particular owners to secure, within a specified time, such operating results toward the control of water pollution as the Committee may prescribe. Pending compliance with its order, the Committee may permit continuance of operations under prescribed conditions. If such results are not secured in the specified time, the Committee may direct the owner, within a specific time, to take particular steps, or to use designated devices, etc., for handling his wastes. The Committee may modify any of its orders (Sec. 144.53(5)).

Upon the verified complaint of six or more citizens filed with the Committee and alleging water pollution, the Committee is authorized to hold a public hearing. The Committee serves a copy of the complaint and a notice of hearing upon the alleged polluter at least 20 days prior to the time set for the hearing which must be held not later than 90 days from the filing of the complaint. The respondent must file his verified answer with the Committee and serve a copy on the person designated by the complainants as their representative by not later than 5 days prior to the date set for the hearing, unless the time for answering is extended by the Committee. Within 90 days after the closing of the hearing, the Committee must make its findings of fact, conclusions of law, and order. An aggrieved party may appeal such order by either asking for a rehearing or by appeal to the Courts. If a rehearing is had and the aggrieved party is still not satisfied he may then appeal to the Court (Secs. 144.537, 144.56).

In lieu of an appeal to the Court, any owner may agree in writing to submit the matter to the arbitration of three reputable and experienced sanitary engineers, one chosen by the owner, one by the Committee, and the third by the other two. The decision of such arbitrators must be rendered within 30 days after their selection, unless the time is extended by agreement. No decision is binding, however, unless agreed to by all the arbitrators. The expense of arbitration is borne by the owner (Secs. 144.537, 144.56).

All orders of the Committee are enforced by the Attorney General. Where the order of the Committee prohibits pollution, a violation thereof is deemed a public nuisance (Sec. 144.536).

Violations of the provisions of the Act or the failure to obey any order of the Committee or any joint order of the State Board of Health and the Committee is subject to a penalty of not less than $10 nor more than $100, and in case the violation is willful the penalty may be up to $250. Each day the violation continues is considered a separate offense. While the order of the Committee is suspended or stayed the penalty does not accrue (Sec. 144.57).

Where a problem of continued pollution is involved coming within the jurisdiction of the Committee or the State Board of Health, or both, and either or both such agencies have assumed jurisdiction, such jurisdiction is to be exclusive to these agencies notwithstanding the provisions of any statutes other than Sections 144.01 to 144.57 (Sec. 144.535).

The State Board of Health and the Committee may act jointly as to all matters relating to water pollution coming within the jurisdiction of either or both of said agencies. Any joint order may be subject to joint review (Sec. 144.565).

4. Conduct of studies, investigations and research

The Committee is authorized to study and investigate all problems connected with surface water pollution and its control and to make reports thereon (Sec. 144.53(2)). The Committee may conduct scientific experiments, investigations, and research to discover economical and practicable methods for the treatment of industrial wastes. For this purpose, the Committee is authorized to accept funds on behalf of the State from any public or private agency (Laws of Wisconsin, 1957, Ch. 289, Sec. 4, added to the *Statutes* as Sec. 144.53(3)). The Committee is further authorized to make investigations and inspections to insure compliance with any order, rule or regulations which it may issue (Sec. 144.53(6)).

5. Cooperation with other public and private agencies

The Committee is authorized to enter into agreements with other States, subject to the approval of the Governor, relative to means and measures to be employed to control pollution of any interstate streams and other waters and to carry out such agreement by appropriate orders. This power does not extend to the modification of any agreement with any other State concluded by direct legislative act, but, unless otherwise expressly provided, the Committee is the agency for the enforcement of any such legislative agreement (Sec. 144.53(7)).

6. Administrative powers

The Committee is authorized to hold hearings, issue orders and subpoenas, and adopt rules and regulations. It can administer oaths, compel the attendance of witnesses and the production of necessary data. It may enter any establishment for the purpose of collecting necessary information, and no owner is permitted to refuse such entry (Secs. 144.537, 144.53(4)(5), 144.55).

Exemption from Operation of Act. Nothing in the Act is to be construed to limit or modify in any manner the powers and duties of the State Board of Health relating to its functions regarding water supplies and sewage disposal, or to select, employ and direct the sanitary engineer and all other employees of its bureau of sanitary engineering (Sec. 144.54).

State Board of Health

The State Board of Health has general supervision and control over the waters of the State, drainage, water supply, water systems, sewage and refuse disposal, and the sanitary condition of streets, alleys, outhouses, and cesspools, insofar as their sanitary and physical condition affects health or comfort.

In carrying out its water pollution functions, the Board is authorized to conduct investigations, experiments, and research in the purification and conservation of water and the treatment of sewage or refuse, hold public hearings, and attend or be represented at such meetings inside or outside the State. For the conduct of said investigations, experiments, and research, the Board may on behalf of the State accept funds from any public or private agency.

The Board, upon request, and without charge for service or expense, shall consult with and advise owners having installed or about to install systems or plants, as to the most appropriate water supply and the best method of providing for its purity, or as to the best method of disposing of sewage or refuse, with reference to the existing and future needs of all communities or persons which may be affected thereby. The Board shall not be required to prepare plans.

Miscellaneous Statutory Provisions

It is unlawful for anyone to throw refuse into any waters of the State or leave the same upon the ice thereof. Violation carries a fine of up to $100.00 and/or imprisonment up to 30 days (Laws of Wisconsin, 1957, Ch. 353).

No one is permitted to take fish by the use of explosives, poison or other stupefying substances; or throw any fish offal into the waters of the State from any vessel; or deposit into any waters any lime, tanbark, ship ballast, sand, sawdust, acids or other refuse arising from manufacturing or any other substance deleterious to game or fish life other than authorized drainage from municipalities and industrial or other wastes discharged from mines or other industries through treatment facilities installed and operated in accordance with plans approved by the Committee on Water Pollution under Ch. 144, or in compliance with orders of that Committee. Any such orders are subject to modification by subsequent orders (Sec. 29.29).

It is unlawful for anyone to discharge untreated domestic sewage into any surface water; or to discharge the effluents or pumpage by any

Comparison of Authorizations and Delegated Functions
of State Agencies Concerned with Water Pollution Control

AGENCIES				
Minn.		Wisc.		
D of H	WPCC	D of H	Com. W.P.	FUNCTION
	X			Classify waters of state and adopt classifications and standards of purity and quality thereof.
	X			Issue, continue in effect, modify, revoke or deny permits for discharge of sewage or other waste or for installation and operation of disposal system.
	X			Issues final orders for pollution abatement after hearing or issue, modify or revoke orders for prohibiting or directing abatement of waste discharges, prohibiting storage of liquids which might result in pollution of waters.
X	X		X	Authorized to cooperate and enter into agreement with other states relative to means and measures to be employed to control pollution of interstate streams.
X	X	X	X	Investigate extent, character and effect of pollution on waters (surface water only in Wisconsin) of the state and issue reports thereof, conduct research and studies as necessary to administration.
X	X	X	X	Authorized to hold hearings, issue orders, subpoenas, examine witnesses, enter property for purposes of obtaining information or conducting surveys.
X	X	X	X	Receive and accept money, property or services on behalf of the state from any other source for any water pollution purpose within the scope of its function.
			X	Issue general orders, and adopt rules and regulations for installation of means for controlling water pollution from industrial and other sources.
			X	Issues special orders directing particular owners to secure results of pollution control as prescribed.

Comparison of Authorizations and
Delegated Functions of State
Agencies Concerned with Water
Pollution Control

AGENCIES				
Minn.		Wisc.		
D of H	WPCC	D of H	Com. W.P.	FUNCTION
X				Adopt and enforce reasonable regulations regarding the disposal of sewage and the pollution of streams.
X				Administers and enforces all laws relating to water pollution where such pollution affects public health.
		X		General supervision and control over waters, drainage, water supply, sewage and refuse disposal within the state, and sanitary conditions of streets etc., insofar as sanitary and physical conditions affects health or comfort.
		X		Shall consult with and advise owners of best methods of water and waste treatment with reference to future needs of communities or persons which may be affected.

Note:
D of H refers to Department of Health
WPCC refers to Water Pollution Control Commission
Com W. P. refers to Committee on Water Pollution

means from any septic tank, dry well, or cesspool into any surface water (Sec. 146.13(2)).

It is unlawful for anyone to deposit the carcass of any animal into any stream, lake, or swale (Sec. 95.50).

INTERSTATE JOINT RESOLUTIONS BETWEEN MINNESOTA AND WISCONSIN (4)

The water pollution control agencies of Minnesota and Wisconsin have adopted three joint resolutions pertaining to pollution of interstate streams and their tributaries.

The first resolution, adopted on February 14, 1952, concerns pollution abatement on the St. Louis River, St. Louis Bay, Superior Bay, and Lake Superior. Each agree to follow established programs for the improvement of the quality of these interstate waters and their tributary streams to the end that they may be maintained or rendered suitable for appropriate public uses.

The second resolution, adopted on August 11, 1953, concerns the interstate portion of the St. Croix River. Each agree that facilities for treatment of sewage for all sewered municipalities shall provide at least effective sedimentation, plus chlorination, with such design of treatment plants that secondary or other higher degrees of treatment may be added as conditions may require. They further agree that facilities for treatment of industrial waste shall provide the most effective treatment warranted by conditions in each case with the understanding that additional or special type treatment be required where water uses so dictate.

The third resolution, adopted on August 11, 1953, concerns pollution on the interstate portion of the Mississippi River and its tributaries.

The States of Iowa and Illinois are also included in the resolution. It was agreed that facilities for treatment of sewage and industrial wastes shall provide at least effective sedimentation or equivalent, substantially complete removal of floating solids or liquids, and reduction of toxic materials to less than lethal limits for aquatic life, with the understanding that additional or special type treatment be required in those areas where water uses so dictate.

The 1965 legislatures of both Minnesota and Wisconsin passed bills authorizing a joint compact for the purpose of reviewing proposed development of the boundary waters between the two States. The Minnesota - Wisconsin Boundary Area Commission to be formed as a result, would be financed by each of the two States as well as being provided with matching federal funds. Total appropriations for the first year of operation have been established at $200,000.

The legislation does not provide the two-State Commission with any real power to regulate development of the area. It must operate in an advisory capacity and leave zoning and land use regulations to others. In Minnesota this is generally the responsibility of the local political subdivisions.

U.S. ARMY CORPS OF ENGINEERS AND COAST GUARD WATER POLLUTION CONTROL ACTIVITIES (5)

In 1824, Congress assigned the responsibility for development of the nation's rivers and harbors to the Corps of Engineers. From that date until 1961, the Corps' responsibility in water pollution control was limited to cases involving interference to navigation.

Early congressional acts concerned with pollution were oriented toward protecting navigation from obstruction and injury. Section 13 of the River and Harbor Act of 1899, "...prohibits the discharge into navigable waters generally of refuse matter other than liquid sewage, including the discharge of those materials which are obstructive or injurious to navigation....". The Oil Pollution Act of 1924 prohibits the discharge of oil into coastal waters, but does not apply to inland waters. Oil discharged from vessels, however, has been held by the courts to be refuse matter and therefore a violation of Section 13 of the 1899 Act. Enforcement of these acts is carried out for the Corps by the Coast Guard.

The general policy of the Corps has been directed toward prevention of violations through public education. Where violations do occur, the Chief of Engineers considers the seriousness of the pollution, the degree of guilt on the part of the offender, his cooperation in corrective operations, and his past record in determining whether or not to recommend prosecution to the Department of Justice.

The 1899 Act also makes the Corps responsible for the issuance of permits for construction of structures such as wharfs, piers, and dolphins which may present an unreasonable obstruction to navigation. Industrial outfall sewers are also considered in this category and cannot be constructed without a permit. Comments are solicited from interested local and State authorities on permit applications.

The Water Pollution Control Act Amendments of 1961 spelled out additional responsibilities for the Corps in pollution abatement. The Act "...provides that in the survey or planning of any reservoir by the Corps of Engineers, Bureau of Reclamation, or other federal agency, consideration shall be given to inclusion of storage for regulation of stream flow for the purpose of water quality control..". The need and value of such storage is determined with the advice of the Secretary of Health, Education, and Welfare.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE WATER POLLUTION CONTROL ACTIVITIES (6)

General

The Federal Government's Water Pollution Enforcement Program is carried out by the Water Pollution Control Administration of the Department of Health, Education, and Welfare as prescribed by the Federal Water Pollution Control Act, as amended * (33 U.S.C. 466 et seq.). The declaration of policy as stated in this Act is divided into the following three parts: (a) The purpose of this Act is to enhance the quality and value of our water resources and to establish a national policy for the prevention, control, and abatement of water pollution. (b) In connection with the exercise of jurisdiction over the waterways of the nation and in consequence of the benefits resulting to the public health and welfare by the prevention and control of water pollution, it is hereby declared to be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution, to support and aid technical research relating to the prevention and control of water pollution, and to provide Federal technical services and financial aid to State and interstate agencies and to municipalities in connection with the prevention and control of water pollution. The Secretary of Health, Education, and Welfare shall administer this Act through the Administration created by Section 2 of this Act, and with the assistance of an Assistant Secretary of Health, Education, and Welfare designated by

* Basic Act (PL84-660), approved 7/9/56, amended by the Federal Water Pollution Control Act Amendments of 1961 (PL87-88), approved 7/20/61 and by the Water Quality Act of 1965 (PL89-234), approved 10/2/65.

him, shall supervise and direct (1) the head of such Administration in administering this Act and (2) the administration of all other functions of the Department of Health, Education, and Welfare related to water pollution. Such Assistant Secretary shall perform such additional functions as the Secretary may prescribe. (c) Nothing in this Act shall be construed as impairing or in any manner affecting any right or jurisdiction of the States with respect to the waters (including boundary waters) of such States.

The Act permits the Department to either assist or work with other Federal, State, and interstate agencies, municipalities and industries in carrying out its many endeavors. These include in part the following:

A. Development of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof.

B. Encouragement of the enactment of improved and so far as practicable, uniform State laws relating to the prevention and control of water pollution.

C. Research, investigations, experiments, demonstrations and studies relating to causes, control and prevention of water pollution.

D. Provide grants to assist in the development of new or improved methods of controlling the discharge of wastes into any waters.

E. Grants to assist States and interstate agencies in meeting the cost of establishing and maintaining pollution control measures.

F. Grants to assist in construction of necessary treatment works to prevent pollution of any waters.

G. The requiring from States, the development of water quality criteria applicable to interstate waters or portions thereof within such State and a plan for implementation and enforcement of the criteria.

H. Maintain jurisdiction over the pollution of interstate or navigable waters in or adjacent to any State or States, which endangers the health or welfare of any persons.

Enforcement

Enforcement procedures may be initiated in any of the following ways:

1. Upon request by the Governor of any State or a State water pollution control agency, or the governing body of any municipality (with the concurrence of the Governor and water pollution control agency), if the request refers to pollution originating in another State;

2. Upon request by the Governor of any State, if the request refers to intrastate pollution endangering the health or welfare of persons only in the requesting State;

3. At the discretion of the Secretary of Health, Education, and Welfare when, on the basis of reports, surveys, or studies, he has reason to believe that any interstate pollution exists.

Upon initiation of an enforcement action, the Secretary calls a conference of the State and interstate water pollution control agencies concerned with the problem. Discussions are held relative to the occurrence of pollution subject to abatement under the Act, the adequacy of measures taken toward abatement, and the nature of any delays being encountered in abating the pollution.

If, at the conclusion of a conference, the Secretary believes "...that effective progress toward abatement of such pollution is not being made and that the health or welfare of any persons is being endangered, he shall recommend to the appropriate State water pollution control agency that it take necessary remedial action". At least six months are allowed for the taking of such recommended action.

If the recommended action has not been taken by the end of the allotted time, "...the Secretary shall call a public hearing ... before a Hearing Board of five or more persons appointed by the Secretary". Each State participating is given an opportunity to select one member of the Board. "At least one member shall be a representative of the Department of Commerce and not less than a majority of the Board shall be persons other than officers or employees of the Department of Health, Education, and Welfare".

"...On the basis of the evidence presented at such hearing, the Board shall make findings as to whether pollution ... is occurring and whether effective progress toward abatement thereof is being made". If the Board finds there is pollution and ineffective progress toward abatement, "...it shall make recommendations to the Secretary concerning the measures, if any, which it finds to be reasonable and equitable to secure abatement of such pollution". The Secretary shall send these findings and recommendations to the persons causing the pollution, along with a notice specifying a reasonable time (not less than six months) to secure abatement.

If action to abate pollution has not been taken within the time specified in the notice, the Secretary:

1. In the case of interstate pollution, may request the Attorney General to bring suit on behalf of the United States to secure abatement;

2. In the case of intrastate pollution, may, with written consent of the Governor of such State, request the Attorney General to bring suit on behalf of the United States to secure abatement.

Pollution From Federal Installations

Any Federal department or agency having jurisdiction over any buildings, installation, or property shall cooperate with the Department of

Health, Education, and Welfare, and with any State or interstate agency or municipality in preventing or controlling pollution of waters into which any matter is discharged from such Federal property.

Executive Order 11258 issued November 17, 1965, prescribes the procedures and standards governing the treatment of wastes resulting from activities of Federal installations in the United States, outlines measures that are to be instituted to control or prevent water pollution in connection with those activities and establishes water quality criteria.

Administration

The Secretary is authorized to prescribe such regulations as are necessary to carry out his functions under the Act. To this end, he may utilize the officers and employees of any U.S. agency, with consent of its head. The Act further authorizes appropriation to the Department of Health, Education, and Welfare such funds as may be necessary to enable it to carry out its functions.

MISCELLANEOUS FEDERAL LEGISLATION

St. Croix Bill

A bill to provide for the establishment of the St. Croix National Scenic Waterway in the State of Minnesota and Wisconsin, and for other purposes, was introduced into the U.S. Senate as S. 897, 89th Congress, 1st Session. This legislation was still pending at the conclusion of the 1st Session.

This bill as it pertains to the area under study by the Project, is for the purpose of promoting broad recreational usage and more intensive types of recreational use of the portion of the St. Croix River downstream from the dam near Taylors Falls, Minnesota to its confluence with the Mississippi River.

The bill provides for the expenditure of $6.5 million over a five year period for development of a riverway over some 240 miles of river.

The bill will not permit new commercial or industrial uses not in accord with recreational and scenic environment.

The Secretary of the Interior, under whose jurisdiction the bill would be administered, shall also cooperate with the Secretary of Health, Education, and Welfare, and with the appropriate State water pollution control agencies, to prepare and develop agreements for eliminating or diminishing the pollution of waters within the St. Croix National Scenic Waterway.

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REFERENCES

1. *Digest of Water Pollution Control Legislation -- Minnesota*, U.S. Department of Health, Education, and Welfare, Public Health Service, September 1958.

2. *Proceedings of Conference in the Matter of Pollution of the Interstate Waters of the Upper Mississippi River, Volume II*, pp. 449-542 held in St. Paul, Minnesota on February 8, 1964, U.S. Department of Health, Education, and Welfare.

3. *Digest of Water Pollution Control Legislation -- Wisconsin*, U.S. Department of Health, Education, and Welfare, Public Health Service, September 1958.

4. *Wisconsin Administrative Code, Rules of Committee on Water Pollution*, Chapter WP3.

5. *Proceedings of Conference in the Matter of Pollution of the Interstate Waters of the Upper Mississippi River, Volume I*, pp. 251-257, and 295, held in St. Paul, Minnesota on February 8, 1964.

6. *Federal Water Pollution Control Act - Public Law 660* (as amended 1961 - PL 87-88 Federal Water Pollution Control Amendments).

APPENDIX

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION
CLASSIFICATION AND STANDARDS FOR THE MISSISSIPPI RIVER
AND TRIBUTARIES FROM THE RUM RIVER TO THE UPPER LOCK AND DAM
AT ST. ANTHONY FALLS

The classification for use and the pollution standards as hereinafter set forth are hereby adopted and established for that portion of the Mississippi River from but not including the mouth of the Rum River to the upper lock and dam at St. Anthony Falls, approximately at the northeastward extension of Fifth Avenue South in the City of Minneapolis, and streams tributary thereto.

Section 1. Classification for Use.

(a) The primary use of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed is as a source of public water supply for drinking, food processing, and related purposes.

(b) Other uses for which waters of such quality are suitable are industrial processing and cooling, navigation, pleasure boating, fishing, bathing, swimming, and other recreational uses, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health.

(c) Other beneficial uses for which water of lower quality may be suitable may be exercised in the waters, provided the effects do not actually or potentially conflict with the uses specified in paragraphs (a) and (b).

Section 2. Related Conditions

The waters should meet the recommended U. S. Public Health Service raw water requirements for Group IV, as defined in Public Health Bulletin No. 296, Manual of Recommended Water Sanitation Practice, 1964, so that after Class IV treatment as specified in said manual the water will meet the requirements for drinking water as specified in U. S. Public Health Service Drinking Water Standards, 1962. Waters having the quality aforesaid will be suitable for maintenance of game fish of species commonly inhabiting waters of the vicinity under natural conditions.

Section 3. Standards

(a) No raw sewage, and no industrial waste or other wastes, treated or untreated, containing viable pathogenic organisms or any substances which may cause disease, endanger the public health, or otherwise impair the quality of the receiving waters for public water supply shall be discharged into the waters.

(b) No treated sewage effluent shall be discharged into the waters from any source originating after the taking effect hereof, including, without limitation, discharges from watercraft.

(c) No treated sewage effluent, industrial waste, or other wastes shall be discharged into the waters so as to cause any nuisance conditions, including, without limitation, the presence of substantial amounts of floating solids, scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, substantial fungus growths, or other offensive effects.

(d) No treated sewage effluent, industrial waste, or other wastes shall be discharged into the waters so as to cause any material increase in taste, odor, color, or turbidity above natural levels, or otherwise to impair the quality of the water so as to render it objectionable or unsuitable as a source of water supply.

(e) The discharge of oxygen-demanding treated sewage effluent, industrial waste, or other wastes shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 5 milligrams per liter, based on the monthly average flow which is exceeded by 90 per cent of the monthly average flows of record for the month of August or February, whichever is lower, and so that a level of not less than 4 milligrams per liter will be maintained under any instantaneous low flow conditions.

(f) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperature of such waters above 93°F at any point, based on the critical month of August and the monthly average flow specified in paragraph (e).

(g) The discharge of treated sewage effluent, industrial waste, or other wastes shall be restricted so that at any water supply intake the maximum limits for chemicals in the waters shall be such that after Class IV treatment has been provided as specified in Section 2 (Public Health Bulletin No. 296), the concentrations recommended in the U. S. Public Health Service Drinking Water Standards, 1962, will not be exceeded in the treated water. Such discharges shall also be restricted so that after reasonable opportunity for mixing and dilution of the discharge with the receiving waters, on the basis of the monthly average flow specified in paragraph (e), the concentrations of the substances specified below will not be exceeded in the waters.

Ammonia	2.0 milligrams per liter (as Nitrogen)
Chromium	1.0 milligrams per liter (as Chromium)
Copper	0.2 milligrams per liter (as Copper)
Cyanide	0.02 milligrams per liter (as Cyanide ion)
Oil	Not to exceed a trace
pH range	6.5 - 9.0
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by tne appropriate Federal authority or by the State Board of Health.

Means for expediting mixing and dispersion of such treated sewage effluent, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(h) No treated sewage effluent, industrial waste, or other wastes shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law.

(i) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards.

Adopted March 28, 1963

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION
CLASSIFICATION AND STANDARDS FOR THE MISSISSIPPI RIVER AND TRIBUTARIES FROM THE UPPER LOCK AND DAM AT ST. ANTHONY FALLS TO THE OUTFALL OF THE MINNEAPOLIS-ST. PAUL SANITARY DISTRICT SEWAGE TREATMENT PLANT

The classification for use and the pollution standards as hereinafter set forth are hereby adopted and established for that portion of the Mississippi River from the upper lock and dam at St. Anthony Falls, approximately at the northeastward extension of Fifth Avenue South in the City of Minneapolis, to immediately above the outfall of the Minneapolis-St. Paul Sanitary District sewage treatment plant in the City of St. Paul, approximately at the eastward extension of Baker Street East in said city, and streams tributary thereto except the Minnesota River.

Section 1. Classification for Use.

(a) The uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed are pleasure boating, fishing, and other recreational uses, subject to such restriction on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health.

(b) The waters may be used for navigation, general industrial purposes, and other beneficial uses for which water of lower quality may be suitable, provided the effects do not actually or potentially conflict with the uses specified in paragraph (a).

Section 2. Related Conditions

The waters are suitable for the aforesaid uses and for maintenance of game fish of species commonly inhabiting waters of the vicinity under natural conditions, but not as a source of drinking water or special quality industrial process water, or for bathing or swimming, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health.

Section 3. Standards

(a) No major quantities of sewage, industrial waste, or other wastes, treated or untreated, shall be discharged into the waters. No treated sewage, industrial waste, or other wastes containing viable pathogenic organisms shall be discharged into the waters without effective disinfection during the summer months, except under emergency conditions. Effective disinfection of any discharges, including combined flows of sewage and storm water, may be required to protect the aforesaid uses of the waters.

(b) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any nuisance conditions, including, without limitation, the presence of substantial amounts of floating solids, scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, substantial fungus growths, or other offensive effects.

(c) The discharge of oxygen-demanding sewage, industrial waste, or other wastes shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 4 milligrams per liter, based on the monthly average flow which is exceeded by 90 per cent of the monthly flows of record for the month of August or February, whichever is lower, and so that a level of not less than 3 milligrams per liter will be maintained under the minimum daily flow which is exceeded by 98 per cent of the minimum daily flows of record for the month of August or February, whichever is lower.

(d) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperature of such waters above 93° F, based on the critical month of August and the monthly average flow specified in paragraph (c).

(e) The discharge of sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the monthly average flow specified in paragraph (c), the limits hereinafter specified will not be exceeded in the waters after reasonable opportunity for mixing and dilution:

Ammonia	2.0 milligrams per liter (as Nitrogen)
Chromium	1.0 milligrams per liter (as Chromium)
Copper	0.2 milligrams per liter (as Copper)
Cyanide	0.02 milligrams per liter (as Cyanide ion)
Oil	10 milligrams per liter
pH range	6.0 - 9.0
Phenolic materials	0.01 milligrams per liter (as Phenol)
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health

Means for expediting mixing and dispersion of such sewage, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the

Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(f) No sewage, industrial waste, or other wastes shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law.

(g) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards.

Adopted March 28, 1963

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION
CLASSIFICATION AND STANDARDS FOR THE MISSISSIPPI RIVER AND TRIBUTARIES FROM THE OUTFALL OF THE MINNEAPOLIS-ST. PAUL SANITARY DISTRICT SEWAGE TREATMENT PLANT TO LOCK AND DAM NO. 2 NEAR HASTINGS

The classification for use and the pollution standards as hereinafter set forth are hereby adopted and established for that portion of the Mississippi River from immediately above the outfall of the Minneapolis-St. Paul Sanitary District sewage treatment plant in the City of St. Paul, approximately at the eastward extension of Baker Street East in said city to the U. S. lock and dam No. 2 above Hastings.

Section 1. Classification for Use

The uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed are for industrial processes, general cooling water, stock and wild life watering, restricted irrigation, disposal of treated sewage and waste effluents, fish survival, esthetic enjoyment of river scenery, and passage of watercraft in connection with navigation and pleasure boating in such manner as to avoid close, frequent, or prolonged contact with the water.

Section 2. Related Conditions

The waters are suitable for the aforesaid uses and for survival or passage of game fish of species commonly inhabiting waters of the vicinity under natural conditions, and for disposal of treated sewage and industrial waste effluents for which no other means of disposal is available. Treatment of the waters may be necessary for some industrial uses.

Section 3. Standards

(a) No major quantities of untreated sewage, industrial waste, or other wastes shall be discharged into the waters. No treated sewage, industrial waste, or other wastes containing viable pathogenic organisms shall be discharged into the waters without effective disinfection during the summer months, except under emergency conditions. Effective disinfection of any discharges, including combined flows of sewage and storm water, may be required to protect the aforesaid uses of the waters.

(b) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any nuisance conditions, including without limitation, the presence of substantial amounts of floating solids, scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, substantial fungus growths, or other offensive effects.

(c) The discharge of oxygen-demanding sewage, industrial waste, or other wastes shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 2 milligrams per liter, based on the monthly average flow which is exceeded by 90 per cent of the monthly average flows of record for the month of August or February, whichever is lower, and so that a level of not less than 1 milligram per liter will be maintained under the minimum daily flow which is exceeded by

95 per cent of the minimum daily flows of record for the month of August or February whichever is lower. In addition to the aforesaid requirements, the highest levels of dissolved oxygen which are attainable by continuous operation of all the units of the treatment works discharging into this reach of the river at their maximum capability consistent with practical limitations of such works shall be maintained in the waters, except for emergencies, in order to improve conditions for fish and for other uses of the waters.

(d) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperature of such waters above 93° F based on the critical month of August and the monthly average flow specified in paragraph (c). Further reduction in heat discharges may be required if necessary to avoid substantial interference with or adverse effects upon other uses.

(e) The discharge of sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the monthly average flow specified in paragraph (c), the limits hereinafter specified will not be exceeded in the waters after reasonable opportunity for mixing and dilution:

Ammonia	2.0 milligrams per liter (as Nitrogen)
Chromium	1.0 milligrams per liter (as Chromium)
Copper	0.2 milligrams per liter (as Copper)

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Cyanide	0.02 milligrams per liter (as Cyanide ion)
Fluoride	2.0 milligrams per liter (as Fluoride ion)
Oil	10 milligrams per liter
pH range	6.0 - 9.5
Phenolic materials	0.1 milligrams per liter (as Phenol)
Radicactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health.

Means for expediting mixing and dispersion of such treated sewage effluent, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(f) No sewage, industrial waste, or other wastes shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law.

(g) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards.

Adopted March 28, 1963.

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION

CHAPTER FIVE: WPC 5

CLASSIFICATION AND STANDARDS FOR THE MINNESOTA RIVER AND TRIBUTARY WATERS FROM CARVER RAPIDS TO THE OUTLET OF REILLY CREEK AND GRASS LAKE BELOW SHAKOPEE ZONE 36 - 22.4

WPC 5 The classification for use and the standards of quality and purity as hereinafter set forth are hereby adopted and established for that portion of the Minnesota River from below the Carver Rapids, approximately at the eastward extension of the Carver Village south boundary lying between sections 30 and 31, Louisville Township, Scott County, to immediately below the outlet of Reilly (Terrell) Creek and Grass Lake below Shakopee, approximately at the northward extension of the boundary between sections 4 and 5, Eagle Creek Township, Scott County, and waters tributary thereto except Reilly (Terrell), Bluff, Chaska (East), Chaska (West), Spring, Carver, and Sand Creeks and waters tributary thereto.

(a) Classification for Use.

(1) The present or potential uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed include fishing, pleasure boating, esthetic enjoyment, irrigation, stock watering, wildlife, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health.

(2) The waters also may be used for navigation or general industrial purposes or any other beneficial uses for which the waters may be suitable.

(b) Related Conditions. The waters are suitable for the aforesaid uses and for maintenance of game fish of species commonly inhabiting waters of the vicinity under natural conditions, and for disposal of treated sewage and waste effluents for which no other means of disposal is available.

(c) Standards.

(1) No untreated sewage shall be discharged into the waters. No treated sewage, industrial waste, or other wastes containing viable pathogenic organisms, shall be discharged into the waters without effective disinfection. Effective disinfection of any discharges, including combined flows of sewage and storm water may be required to protect the aforesaid uses of the waters.

(2) Existing discharges of untreated sewage, and untreated industrial waste or other wastes, shall be abated or treated and controlled so as to comply with these standards.

(3) No treated sewage, and no industrial waste or other wastes shall be discharged into the waters so as to cause any nuisance conditions such as the presence of floating solids, scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, slimes or fungus growths, or other offensive effects.

(4) No treated sewage, and no industrial wastes or other wastes shall be discharged into the waters so as to cause any material increase in constituents or characteristics which may impair the quality of the water so as to render it

objectionable or unsuitable for fish or wildlife or as a source of water for general industrial use or agricultural purposes, including irrigation.

(5) The discharge of oxygen demanding sewage or waste effluents shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 4 milligrams per liter during April and May, based on the monthly average flow which is exceeded by 90 per cent of the monthly flows of record for the month of April or May, whichever is lower, and so that a level of not less than 3 milligrams per liter will be maintained during August and February, based on the minimum daily flow which is exceeded by 90 per cent of the minimum daily flows of record for the month of August or February, whichever is lower.

(6) In addition to the aforesaid requirements, the highest levels of dissolved oxygen which are attainable by continuous operation of all the units of the treatment works discharging into this reach of the river at their maximum capability consistent with practical limitations of such works shall be maintained in the waters, in order to improve conditions for fish and for other uses of the waters.

(7) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperature of such waters above 93°F, based on the average natural

water temperature in the month of August and the August monthly average flow which is exceeded by 90 per cent of the monthly average flows of record for August.

(8) The discharge of treated sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the monthly average flow specified in paragraph (5), the limits hereinafter specified will not be exceeded in the waters by reason of such discharges, after reasonable opportunity for mixing and dilution:

Ammonia	2 milligrams per liter (as Nitrogen)
Chlorides	100 milligrams per liter (as Chloride ion)
Chromium	1 milligram per liter (as Chromium)
Copper	0.2 milligram per liter (as Copper)
Cyanides	0.02 milligram per liter (as Cyanide ion)
Oil	10 milligrams per liter
pH range	6.0 - 9.5
Phenolic materials	0.01 milligram per liter (as Phenol)
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health.

(9) Means for expediting mixing and dispersion of sewage, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(10) Liquid substances which could constitute a pollution hazard shall be stored in accordance with Regulation WPC 4. Other wastes as defined by law or other substances which could constitute a pollution hazard shall not be deposited in any manner such that the same may be likely to gain entry into these waters in excess of or contrary to the standards herein adopted, or cause pollution as defined by law.

(11) No sewage, industrial waste or other wastes, shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law. In any case where the waters into which sewage, industrial wastes or other waste effluents discharge are assigned different standards than the waters into which, such receiving waters flow, the standards applicable to the waters which receive such sewage or waste effluents shall be supplemented by the following: The quality of any waters receiving sewage, industrial wastes or other waste discharges shall be such that no violation of the standards established for any other waters shall occur by reason of such sewage, industrial wastes or other waste discharges.

(12) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and

that no means for such disposal in strict conformity with the standards is reasonably available, the Commission in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards. Upon similar application, the Commission may permit a temporary variance from the provisions of these standards without a hearing to enable existing non-complying facilities to be brought into compliance within a reasonable time period and under other such conditions as it may prescribe.

Adopted: November 2, 1965

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION

CHAPTER SIX: WPC 6

CLASSIFICATION AND STANDARDS FOR THE MINNESOTA RIVER AND TRIBUTARY WATERS FROM THE OUTLET OF REILLY (TERRELL) CREEK AND GRASS LAKE BELOW SHAKOPEE TO THE JUNCTION WITH THE MISSISSIPPI RIVER AT FORT SNELLING ZONE 22.4 - 0

WPC 6 The classification for use and the standards of quality and purity as hereinafter set forth are hereby adopted and established for that portion of the Minnesota River from a point immediately below the outlet of Reilly Creek and Grass Lake below Shakopee, approximately at the northward extension of the boundary between sections 4 and 5, Eagle Creek Township, Scott County, to immediately above the junctions with the Mississippi River at Fort Snelling, approximately at the due southward extension of Edgecumbe Road from the intersection with West Seventh Street, and the due southward extension of Lexington Parkway from the intersection with West Seventh Street, in sections 21 and 22, St. Paul, and waters tributary thereto except Nine Mile Creek, the Credit River, Eagle Creek, Purgatory Creek and waters tributary thereto.

(a) Classification for Use.

(1) The present or potential uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed include pleasure boating, wildlife, fishing, esthetic enjoyment, and other recreational uses, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health.

(2) The waters also may be used for navigation, general industrial purposes, agriculture, and other beneficial uses for which the waters may be suitable and which do not conflict with the uses stated above.

(b) Related Conditions. The waters are suitable for the aforesaid uses and for maintenance of game fish of species commonly inhabiting waters of the vicinity under natural conditions, but not as a source of drinking water or special quality industrial process water.

(c) Standards.

(1) No untreated sewage, and no untreated industrial waste or other wastes containing viable pathogenic organisms or any substances which may cause disease, endanger the public health, or otherwise impair the quality of the receiving waters for the stated uses, shall be discharged into the waters.

(2) No major quantities of treated sewage from any source originating after the taking effect hereof shall be discharged into the waters. No treated sewage, and no treated industrial waste or other wastes containing viable pathogenic organisms, shall be discharged into the waters without effective disinfection. Effective disinfection of any discharges, including combined flows of sewage and storm water, may be required to protect the aforesaid uses of the waters.

(3) Existing discharges of major quantities of sewage, industrial wastes, or other wastes, treated or untreated, shall be abated, or diverted out of the watershed, or otherwise controlled so as to comply with these standards.

(4) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any nuisance conditions, such as the presence of floating solids, scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, slimes or fungus growths, or other offensive effects.

(5) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any material increase in any constituents or characteristics which may impair the quality of the water so as to render it objectionable or unsuitable for fish and wildlife or as a source of water for general industrial use or agricultural purposes, including irrigation.

(6) The discharge of oxygen demanding sewage or waste effluents shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 4 milligrams per liter during April and May, based on the monthly average flow which is exceeded by 90 per cent of the monthly flows of record for the month of April or May, whichever is lower, and so that a level of not less than 3 milligrams per liter will be maintained during August and February, based on the minimum daily flow which is exceeded by 90 per cent of the minimum daily flows of record for the month of August or February, whichever is lower.

(7) In addition to the aforesaid requirements, the highest levels of dissolved oxygen which are attainable by continuous opera-

tion of all the units of the treatment works discharging into this reach of the river at their maximum capability consistent with practical limitations of such works shall be maintained in the waters, in order to improve conditions for fish and for other uses of the waters.

(8) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperatures of such waters above 93°F, based on the average natural water temperature in the month of August and the August monthly average flow which is exceeded by 90 per cent of the monthly average flows of record for August.

(9) The discharge of sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the monthly average flow specified in paragraph (6), the limits hereinafter specified will not be exceeded in the waters by reason of such discharges, after reasonable opportunity fox mixing and dilution:

Ammonia	2 milligrams per liter (as Nitrogen)
Chlorides	100 milligrams per liter (as Chloride ion)
Chromium	1 milligram per liter (as Chromium)
Copper	0.2 milligram per liter (as Copper)
Cyanides	0.02 milligram per liter (as Cyanide ion)
Oil	10 milligrams per liter
pH range	6.0 - 9.5
Phenolic materials	0.01 milligram per liter (as Phenol)

Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health.

(10) Means for expediting mixing and dispersion of sewage, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(11) Liquid substances which could constitute a pollution hazard shall be stored in accordance with Regulation WPC 4. Other wastes as defined by law or other substances which could constitute a pollution hazard shall not be deposited in any manner such that the same may be likely to gain entry into these waters in excess of or contrary to the standards herein adopted, or cause pollution as defined by law.

(12) No sewage, industrial waste, or other wastes shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law. In any case where the waters into which sewage industrial wastes or other waste effluents discharge are assigned different standards than the waters into which such receiving waters flow, the standards applicable to the waters which receive such sewage or waste effluents shall be supplemented by the following:
The quality of any waters receiving sewage, industrial wastes or other waste discharges shall be such that no violation of

the standards established for any other waters shall occur by reason of such sewage, industrial wastes or other waste discharges.

(13) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards. Upon similar application, the Commission may permit a temporary variance from the provisions of these standards without a hearing to enable existing non-complying facilities to be brought into compliance within a reasonable time period and under other such conditions as it may prescribe.

Adopted: November 2, 1965

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION

CHAPTER SEVEN: WPC 7

CLASSIFICATION AND STANDARDS FOR REILLY (TERRELL) CREEK BLUFF CREEK, THE CHASKA CREEKS, SPRING CREEK CARVER CREEK AND SAND CREEK AND TRIBUTARY WATERS

WPC 7 The classification for use and the standards of quality and purity as hereinafter set forth are hereby adopted and established for the waters of Reilly (Terrell) Creek, Bluff Creek, Chaska Creek (East), Chaska Creek (West), Spring Creek, Carver Creek, and Sand Creek, and waters tributary thereto in Carver, Hennepin, Scott, LeSueur, and Rice Counties, from the source to the junction with the Minnesota River in sections 32 and 33, Eden Prairie, Hennepin County, and sections 31 and 32, Eden Prairie, Hennepin County, in section 4, Chaska, Carver County, in section 9, Chaska, Carver County, in section 20, Carver, Carver County, in section 20, Carver, Carver County, in section 20, Louisville Township, Scott County, respectively.

(a) Classification for Use.

(1) The present or potential uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed include fishing, swimming, esthetic enjoyment and other recreational uses, subject to such restrictions on any such uses which involve close, frequent or prolonged contact with the water as may be necessary for protection of public health.

(2) The waters also may be used for general industrial purposes, agriculture, and other beneficial uses for which the waters may be suitable and which do not conflict with the stated uses.

(b) Related Conditions. The waters are suitable for the aforesaid uses and for growth and propagation of game fish of species commonly inhabiting waters of the vicinity under natural conditions, but not as a source of drinking water or special quality industrial process water, and for disposal of treated sewage and industrial waste effluents for which no other means of disposal is available.

(c) Standards.

(1) No untreated sewage, and no untreated industrial waste or other wastes containing viable pathogenic organisms or any substances which may cause disease, endanger the public health, or otherwise impair the quality of the receiving waters for the stated uses, shall be discharged into the waters.

(2) No treated sewage, industrial waste or other wastes containing viable pathogenic organisms, shall be discharged into the waters without effective disinfection. Effective disinfection of any discharges, including combined flows of sewage and storm water, may be required to protect the aforesaid uses of the waters.

(3) Existing discharges of untreated sewage, and untreated industrial wastes or other wastes, shall be abated, or treated, or otherwise controlled so as to comply with these standards.

(4) No treated sewage, and no industrial waste or other wastes, shall be discharged into the waters so as to cause any nuisance conditions, such as the presence of floating solids,

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scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, slimes or fungus growths, or other offensive effects.

(5) No treated sewage, and no industrial waste or other wastes, shall be discharged into the waters so as to cause any material increase in any constituents or characteristics which may impair the quality of the water so as to render it objectionable or unsuitable for fish and wildlife or as a source of water for general industrial use or agricultural purposes, including irrigation.

(6) The discharge of oxygen demanding sewage or waste effluents shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 5 milligrams per liter during April and May, based on the monthly average flow which is exceeded by 90 per cent of the monthly flows of record for the month of April or May, whichever is lower, and so that a level of not less than 3 milligrams per liter will be maintained during August and February, based on the minimum daily flow which is exceeded by 90 per cent of the minimum daily flows of record for the month of February or August, whichever is lower. Where flow records are not available, the indicated flows may be estimated on the basis of available information on the watershed characteristics, precipitation, run-off and other pertinent data.

(7) In addition to the aforesaid requirements, the highest levels of dissolved oxygen which are attainable by continuous operation of all the units of the treatment works discharging into these creeks at their maximum capability consistent with practical limitations of such works shall be maintained in the waters, in order to improve conditions for fish and other uses of the waters.

(8) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperature of such waters above 93°F, based on the average natural water temperature in the month of August and the August minimum daily flow specified in paragraph (6), and during the months of December through May does not raise the temperature of such waters above 73°F, based on the applicable monthly average water temperature and the applicable monthly average flow which is exceeded by 90 per cent of such flows of record.

(9) The discharge of treated sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the minimum daily flow specified in paragraph (6), the limits hereinafter specified will not be exceeded in the waters by reason of such discharges, after reasonable opportunity for mixing and dilution:

Ammonia	2 milligrams per liter (as Nitrogen)
Chlorides	100 milligram per liter (as Chloride ion)
Chromium	1 milligram per liter (as Chromium)

Copper	0.2 milligram per liter (as Copper)
Cyanides	0.02 milligram per liter (as Cyanide ion)
Oil	Not to exceed a trace
pH range	6.5 - 9.0
Phenolic materials	0.01 milligram per liter (as Phenol)
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health.

(10) Means for expediting mixing and dispersion of sewage, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(11) Liquid substances which could constitute a pollution hazard shall be stored in accordance with Regulation WPC 4. Other wastes as defined by law or other substances which could constitute a pollution hazard shall not be deposited in any manner such that the same may be likely to gain entry into these waters in excess of or contrary to the standards herein adopted, or cause pollution as defined by law.

(12) In any instance where it is found that it may not be feasible to provide for effective mixing or dispersion of an effluent, or if at the applicable stream flows mentioned in the preceding sections on standards of water quality and purity, it is evident that the stream flow may be less than the effluent

flow at any time, the aforesaid standards may be interpreted as effluent standards for control purposes, where applicable. In addition, the following effluent standards may be applied in special situations where it is found necessary to protect the waters for the stated uses:

Turbidity value	25
Total Phosphorous	1 milligram per liter (as Phosphorus)
Biochemical oxygen demand	20 milligrams per liter (as 5-day Demand)
Total suspended solids	20 milligrams per liter

(13) No sewage, industrial waste or other wastes, shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law. In any case where the waters into which sewage, industrial wastes or other waste effluents discharge are assigned different standards than the waters into which such receiving waters flow, the standards applicable to the waters which receive such sewage or waste effluents shall be supplemented by the following:
The quality of any waters receiving sewage, industrial wastes or other waste discharges shall be such that no violation of the standards established for any other waters shall occur by reason of such sewage, industrial wastes or other waste discharges.

(14) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that

by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control or abatement of pollution and in harmony with the general purpose and intent of the standards. Upon similar application, the Commission may permit a temporary variance from the provisions of these standards without a hearing to enable existing non-complying facilities to be brought into compliance within a reasonable time period and under other such conditions as it may prescribe.

Adopted: November 2, 1965

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION

CHAPTER EIGHT: WPC 8

CLASSIFICATION AND STANDARDS FOR EAGLE CREEK AND PURGATORY CREEK AND TRIBUTARY WATERS

WPC 8 The classification for use and the standards of quality and purity as hereinafter set forth are hereby adopted and established for the waters of Eagle Creek and Purgatory Creek and waters tributary thereto in Scott, Dakota, Hennepin, and Carver Counties, from the source to the junction with the Minnesota River in section 7, Glendale Township, Scott County, and in section 36, Eden Prairie, Hennepin County, respectively.

(a) Classification for Use.

(1) The present and potential uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed include fishing, swimming, esthetic enjoyment, and other recreational use.

(2) The waters also may be used for general industrial purposes, agriculture, and other beneficial uses for which the waters may be suitable and which do not conflict with the stated uses.

(b) Related Conditions. The waters are suitable for the aforesaid uses and for growth and propagation of game fish, including trout, and other species commonly inhabiting waters of the vicinity under natural conditions, but not as a source of drinking water or special quality industrial process water.

(c) Standards.

(1) No untreated sewage, and no untreated industrial waste or other wastes containing viable pathogenic organisms or any

substances which may cause disease, endanger the public health, or otherwise impair the quality of the receiving waters for the stated uses, shall be discharged into the waters.

(2) No treated sewage effluent originating after the taking effect hereof, shall be discharged into the waters. No treated sewage, and no treated industrial waste or other wastes containing viable pathogenic organisms, shall be discharged into the waters without effective disinfection. Effective disinfection of any discharges, including mixtures of sewage with storm water, may be required to protect the aforesaid uses of the waters.

(3) Existing discharges of sewage, industrial wastes or other wastes, treated or untreated shall be abated, or diverted out of the watershed, or otherwise controlled so as to comply with these standards.

(4) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any nuisance conditions, such as the presence of visible floating solids, scum, foam, oil slicks, suspended solids, material discoloration, obnoxious odors, gas ebullition, sludge deposits, slimes or fungus growths, or any other offensive effects attributable to such discharges.

(5) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any material increase in any constituents or characteristics which may impair the quality of the water so as to render it objectionable or

unsuitable for the growth and propagation of fish and wildlife or as a source of water for general industrial use or agricultural purposes, including irrigation.

(6) The discharge of oxygen demanding sewage or waste effluents shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 7 milligrams per liter during April and May, based on the monthly average flow which is exceeded by 95 per cent of the monthly flows of record for the month of April or May, whichever is lower, and so that a level of not less than 5 milligrams per liter will be maintained during August and February, based on the minimum daily flow which is exceeded by 95 per cent of the minimum daily flows of record for the month of August or February, whichever is lower. Where flow records are not available the indicated flows may be estimated on the basis of available information on the watershed characteristics, precipitation, runoff and other pertinent data.

(7) In addition to the aforesaid requirements, the highest levels of dissolved oxygen which are attainable by continuous operation of all the units of the treatment works discharging into these creeks at their maximum capability consistent with practical limitations of such works shall be maintained in the waters, in order to maintain conditions suitable for fish and for other uses of the waters.

(8) The discharge of sewage, industrial waste or other wastes shall be controlled so that the heat content of such discharges does not materially raise the temperature of these waters above naturally prevailing levels at any time.

(9) The discharge of sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the minimum daily flow specified in paragraph (6), the limits hereinafter specified will not be exceeded in the waters by reason of such discharges, after reasonable opportunity for mixing and dilution:

Ammonia	Not to exceed a trace (as Nitrogen)
Chlorides	50 milligrams per liter (as Chloride ion)
Chromium	Not to exceed a trace (as Chromium)
Copper	Not to exceed a trace (as Copper)
Cyanides	Not to exceed a trace (as Cyanide ion)
Oil	Not to exceed a trace
pH range	6.5 - 8.5
Phenolic materials	Not to exceed a trace (as Phenol)
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health.

(10) Means for expediting mixing and dispersion of sewage, industrial waste, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary

by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(11) Liquid substances which could constitute a pollution hazard shall be stored in accordance with Regulation WPC 4. Other wastes as defined by law or other substances which could constitute a pollution hazard shall not be deposited in any manner such that the same may be likely to gain entry into these waters in excess of or contrary to the standards herein adopted, or cause pollution as defined by law.

(12) In any instance where it is found that it may not be feasible to provide for effective mixing or dispersion of an effluent, or it at the applicable stream flows mentioned in the preceding sections on standards of water quality and purity it is evident that the stream flow may be less than the effluent flow at any time, the aforesaid standards may be interpreted as effluent standards for control purposes where applicable. In addition, the following effluent standards may be applied in special situations where it is found necessary to protect the waters for the stated uses:

Turbidity value	10
Total phosphorous	1 milligram per liter (as Phosphorous)
Biochemical oxygen demand	10 milligrams per liter (as 5-day demand)
Total suspended solids	10 milligrams per liter

(13) No sewage, industrial waste, or other wastes shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause

pollution thereof as defined by law. In any case where the waters into which sewage, industrial wastes or other waste effluents discharge are assigned different standards than the waters into which such receiving waters flow, the standards applicable to the waters which receive such sewage or waste effluents shall be supplemented by the following: The quality of any waters receiving sewage, industrial wastes or other waste discharges shall be such that no violation of the standards established for any other waters shall occur by reason of such sewage, industrial wastes or other waste discharges.

(14) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards. Upon similar application, the Commission may permit a temporary variance from the provisions of these standards without a hearing to enable existing non-complying facilities to be brought into compliance within a reasonable time period and under other

such conditions as it may prescribe.

Adopted: November 2, 1965

STATE OF MINNESOTA
WATER POLLUTION CONTROL COMMISSION

CHAPTER NINE: WPC 9

CLASSIFICATION AND STANDARDS FOR NINE MILE CREEK AND THE CREDIT RIVER AND TRIBUTARY WATERS

WPC 9 The classification for use and the standards of quality and purity as hereinafter set forth are hereby adopted and established for the waters of the Nine Mile Creek and the Credit River and waters tributary thereto in Hennepin, Dakota, and Scott Counties, from the source to the junction with the Minnesota River in sections 28, and 29 in Bloomington, Hennepin County, and in section 31, Savage, Scott County, respectively.

(a) Classification for Use.

(1) The present or potential uses of the waters requiring maintenance of water quality in accordance with the standards hereinafter prescribed include fishing, swimming, esthetic enjoyment, and other recreational uses, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health.

(2) The waters also may be used for general industrial purposes, agriculture, and other beneficial uses for which the waters may be suitable and which do not conflict with the stated uses.

(b) Related Conditions. The waters are suitable for the aforesaid uses and for growth and propagation of game fish of species commonly inhabiting waters of the vicinity under natural conditions, but not as a source of drinking water or special quality industrial process water.

(c) Standards.

(1) No untreated sewage, and no untreated industrial waste or other wastes containing viable pathogenic organisms or any substances which may cause disease, endanger the public health, or otherwise impair the quality of the receiving waters for the stated uses, shall be discharged into the waters.

(2) No major quantities of treated sewage from any source originating after the taking effect hereof shall be discharged into the waters. No treated sewage, and no treated industrial waste or other wastes containing viable pathogenic organisms, shall be discharged into the waters without effective disinfection. Effective disinfection of any discharges, including combined flows of sewage and storm water, may be required to protect the aforesaid uses of the water.

(3) Existing discharges of major quantities of sewage, industrial wastes, or other wastes, treated or untreated, shall be abated, or diverted out of the watershed, or otherwise controlled so as to comply with these standards.

(4) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any nuisance conditions, such as the presence of floating solids, scum, oil slicks, suspended solids, material discoloration, obnoxious odors, visible gassing, sludge deposits, slimes or fungus growths, or other offensive effects.

(5) No sewage, industrial waste, or other wastes shall be discharged into the waters so as to cause any material increase

in any constituents or characteristics which may impair the quality of the water, so as to render it objectionable or unsuitable for fish and wildlife or as a source of water for general industrial use or agricultural purposes, including irrigation.

(6) The discharge of oxygen demanding sewage or waste effluents shall be restricted so that after reasonable opportunity for mixing and dilution thereof with the receiving waters the dissolved oxygen content of such waters will be maintained at not less than 5 milligrams per liter during April and May, based on the monthly average flow which is exceeded by 90 per cent of the monthly flows of record for the month of April or May, whichever is lower, and so that a level of not less than 3 milligrams per liter will be maintained during August and February, based on the minimum daily flow which is exceeded by 90 per cent of the minimum daily flows of record for the month of August or February, whichever is lower. Where flow records are not available, the indicated flows may be estimated on the basis of available information on the watershed characteristics, precipitation, run-off and other pertinent data.

(7) In addition to the aforesaid requirements, the highest levels of dissolved oxygen which are attainable by continuous operation of all the units of the treatment works discharging into these creeks or rivers at their maximum capability consistent with practical limitations of such works shall be maintained in the waters in order to maintain conditions suitable for fish and for other uses of the waters.

(8) The discharge of industrial waste or other wastes shall be controlled so that the heat content of such discharges, after reasonable opportunity for mixing and dilution thereof with the receiving waters, does not raise the temperature of such waters above 93°F, based on the average natural water temperature in the month of August and the August minimum daily flow specified in paragraph (6), and during the months of December through May does not raise the temperature of such waters above 73°F, based on the applicable monthly average water temperature and the applicable monthly average flow which is exceeded by 90 per cent of such flows of record.

(9) The discharge of sewage, industrial wastes, or other wastes shall be restricted so that, on the basis of the minimum daily flow specified in paragraph (6), the limits hereinafter specified will not be exceeded in the waters by reason of such discharges, after reasonable opportunity for mixing and dilution:

Ammonia	2 milligrams per liter (as Nitrogen)
Chlorides	100 milligrams per liter (as Chloride ion)
Chromium	1 milligram per liter (as Chromium)
Copper	0.2 milligram per liter (as Copper)
Cyanides	0.02 milligram per liter (as Cyanide ion)
Oil	Not to exceed a trace
pH range	6.5 - 9.0
Phenolic materials	0.01 milligram per liter (as Phenol)

GPO 824-408-B-5

Radioactive materials	Not to exceed the lowest concentration, permitted to be discharged to an uncontrolled environment as prescribed by the appropriate Federal authority or by the State Board of Health.

(10) Means for expediting mixing and dispersion of sewage, industrial wastes, or other wastes in the receiving waters shall be provided so far as practicable whenever deemed necessary by the Commission to maintain the quality of the receiving waters in accordance with applicable standards.

(11) Liquid substances which could constitute a pollution hazard shall be stored in accordance with Regulation WPC 4. Other wastes as defined by law or other substances which could constitute a pollution hazard shall not be deposited in any manner such that the same may be likely to gain entry into these waters in excess of or contrary to the standards herein adopted, or cause pollution as defined by law.

(12) In any instance where it is found that it may not be feasible to provide for effective mixing or disperson of an effluent, or if at the applicable stream flow mentioned in the preceding sections on standards of water quality and purity, it is evident that the stream flow may be less than the effluent flow at any time, the aforesaid standards may be interpreted as effluent standards for control purposes, where applicable. In addition, the following effluent standards may be applied in special situations where it is found necessary to protect the waters for the stated uses:

Turbidity value 25

Total phosphorus	1 milligram per liter (as Phosphorus)
Biochemical oxygen demand	20 milligrams per liter (as 5-day demand)
Total suspended solids	20 milligrams per liter

(13) No sewage, industrial waste, or other wastes shall be discharged into the waters in such quantity or in such manner alone or in combination with other substances as to cause pollution thereof as defined by law. In any case where the waters into which sewage, industrial wastes or other waste effluents discharge are assigned different standards than the waters into which such receiving waters flow, the standards applicable to the waters which receive such sewage or waste effluents shall be supplemented by the following:
The quality of any waters receiving sewage, industrial wastes or other waste discharges shall be such that no violation of the standards established for any other waters shall occur by reason of such sewage, industrial waste or other waste discharges.

(14) In any case where, upon application of the responsible person or persons, the Commission finds after a hearing thereon that by reason of exceptional circumstances the strict enforcement of a provision of these standards would cause undue hardship and would be unreasonable, that disposal of the sewage, industrial waste, or other wastes involved is necessary for public health, safety, and welfare, and that no means for such disposal in strict conformity with the standards is reasonably available, the Commission, in its discretion, may

permit a variance therefrom upon such conditions as it may prescribe for prevention, control, or abatement of pollution and in harmony with the general purpose and intent of the standards. Upon similar application, the Commission may permit a temporary variance from the provisions of these standards without a hearing to enable existing non-complying facilities to be brought into compliance within a reasonable time period and under other such conditions as it may prescribe.

Adopted: November 2, 1965

ADDENDUM TO WISCONSIN WATER POLLUTION CONTROL ACTIVITIES

On August 1, 1966, legislation became effective in Wisconsin which provided for the transfer of water quality functions from the Committee on Water Pollution and the State Board of Health and the water regulatory functions of the Public Service Commission to the reconstituted Department of Resource Development. There follows a digest of the new legislation.

I. GENERAL STATEMENT

The Department of Resource Development serves as the central unit of state government to protect, maintain and improve the quality and management of the waters of the State, ground and surface, public and private. (Sec. 144.025 (1)).

The State Laboratory of Hygiene is charged with operating in such manner so as to furnish complete laboratory services to the State Board of Health and The Department of Resource Development and to make available to the University of Wisconsin, the State Board of Health, and the Department of Resource Development such facilities for teaching in the fields of public health and water quality as may be required. (Sec. 36.225 (6)).

Any waste treatment plant and pollution abatement equipment purchased or constructed and installed pursuant to an order or recommendation of the Committee on Water Pollution, Department of Resource Development, State Board of Health, City Council, village board or county board may for the purpose of taxation be deducted in the year of cash disbursement for same (Sec. 71.05 (1) (b)5).

The Department may accept gifts and grants from any private or public source for any purpose under its jurisdiction and may expend or use such gifts and grants for the purposes for which received.

The Department is authorized to make studies, establish policies, make plans, and authorize municipal shoreland zoning regulations for the efficient use, conservation, development and protection of the State's water resources. The regulations shall relate to lands under, abutting or lying close to navigable waters. Annual grants-in-aid, up to $1,000, can be made for each county in which suitable regulations are properly administered and enforced (Secs. 144.26 (1)(4)).

The law defines "navigable water" or "navigable waters" as meaning Lake Superior, Lake Michigan, all natural inland lakes within Wisconsin and all streams, ponds, sloughs, flowages and other waters within the territorial limits of the state, including the Wisconsin portion of boundary waters, which are navigable under the laws of the State. "Water resources," where the term is used in reference to studies, plans, collection of publications on water and inquiries about water, means all water whether in the air, on the earth's surface or under the earth's surface (Sec. 144.26 (2)).

II. ADMINISTRATIVE ORGANIZATION

Department of Resource Development

1. Composition and organization

After January 1, 1967, the State will be divided into at least 12 regions based on criteria established by the Department. There will be a Regional Water Resources Advisory Board for each region composed of the Department of Resources Development regional director, an employee of the state board of health serving in the region, an employee of the conservation department serving in the region and five citizen members appointed by and serving at the pleasure of the governor. Each Regional

This power does not extend to the modification of any agreement with any other State concluded by direct legislative act, but, unless otherwise expressly provided, the Department is the agency for the enforcement of any such legislative agreement (Sec. 144.025 (2j)).

f) <u>Administrative Powers</u>

The Department is authorized to hold hearings, issue orders, subpoena, and adopt rules and regulations. It can administer oaths, compel the attendance of witnesses and the production of necessary data. It may enter any establishment for the purpose of collecting necessary information, and no owner is permitted to refuse such entry (Secs. 144.537, 144. 55).

g) <u>Intent of Legislature</u>

It is the intention of the legislature that the Department of Resource Development, as summarized, would become a part of the Department of Natural resources upon creation of that new department. The provisions relating to the reconstituting of the Department of Resource Development will be in effect only until the effective date of an act creating the Department of Natural Resources (Sec. 1)

GPO 828-545-2

SECTION III

WATER USE INVENTORY

INTRODUCTION

Water quality should be maintained at a level that will provide the greatest benefit to the water users. The quality of water needed varies with each water use. Therefore, pollution does not affect all water uses to the same degree. In fact, what may be considered pollution by one water user may not be considered as such at all by another one. Pollution then is a relative expression which can only be evaluated in terms of its effects on legitimate water uses. All uses must be considered before a decision can be made regarding what water pollution control measures are necessary. For this reason, information has been gathered and presented on all significant uses of the three major streams in the study area.

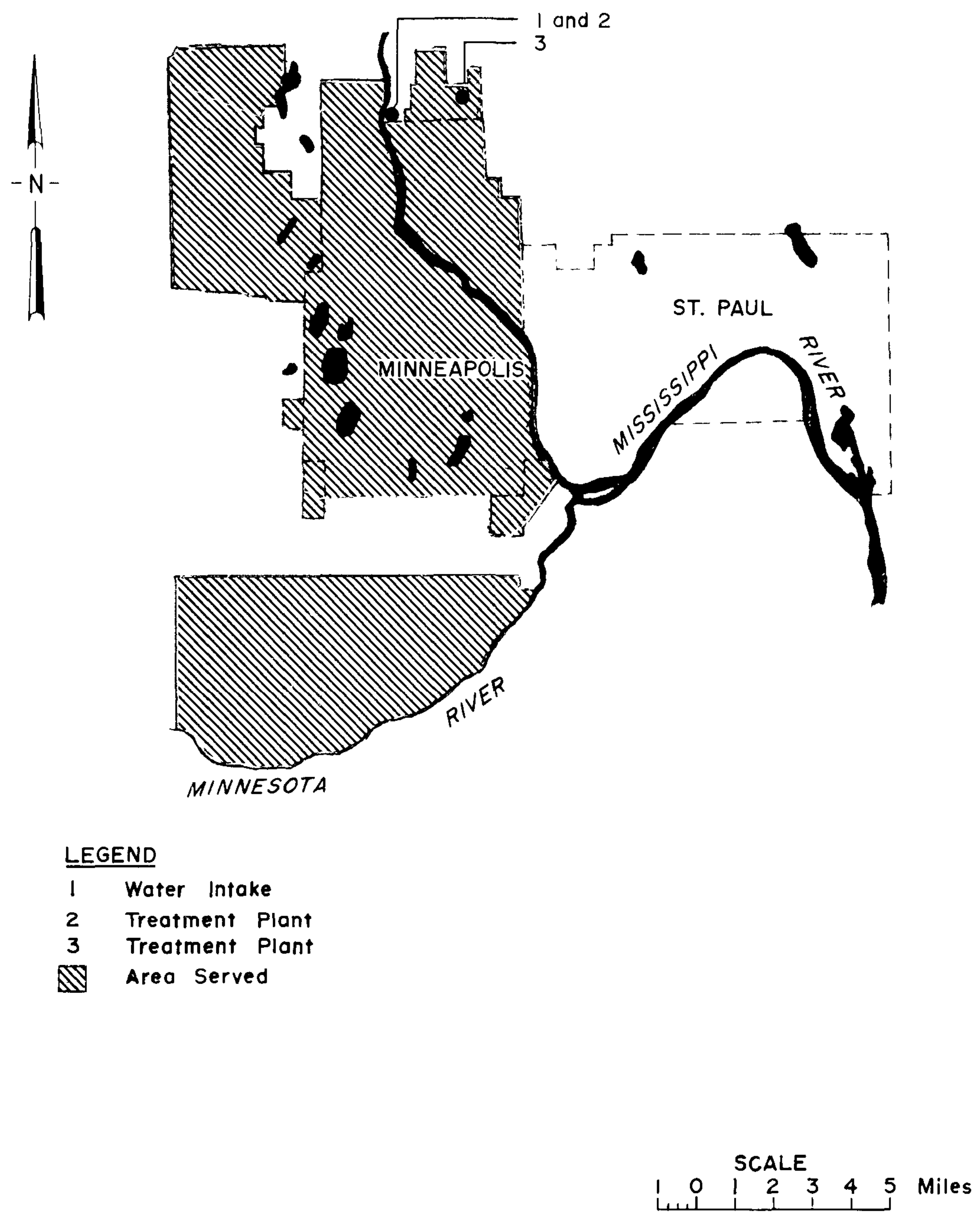
POTABLE WATER SUPPLIES

Public Supplies

Minneapolis and St. Paul use the Mississippi River system as a source of water supply. Other communities depend on ground water sources.

The City of Minneapolis obtains its entire supply from the Mississippi River at river mile 858.9. In addition to Minneapolis, this municipally owned system also serves Columbia Heights, New Hope, Crystal, Bloomington, Morningside, Golden Valley, Metropolitan Airport, and parts of Edina and Fort Snelling (see Figure III-1). Approximately 61.1 million gallons per day (mgd) are supplied to an estimated 530,000 people (1).

The Minneapolis water treatment plants, located in Fridley and Columbia Heights, employ prechlorination, softening with lime and soda ash, clarification with alum, carbon, and carbon dioxide (as required), rapid sand filtration, postchlorination, ammoniation, and fluoridation. Treatment



Source: Public Water Supplies of the 100 Largest Cities in the United States, 1962, Geological Survey Water Supply Paper 1812

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

AREA SUPPLIED BY MINNEAPOLIS WATER SYSTEM

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III - 1

facilities have a rated capacity of 160 mgd (2).

The City of St. Paul obtains approximately 90 percent of its supply from the Mississippi River at river mile 863.0. The remaining 10 percent is obtained from the Vadnais Lake system. Water from the Mississippi is pumped to the lake system, which provides about 150 days of storage, and on to the McCarron purification plant. In addition to St. Paul, the system serves Falcon Heights, Lauderdale, Maplewood, Mendota Heights, Roseville, and West St. Paul (see Figure III-2). This system supplies approximately 46.6 mgd to an estimated 343,000 people (3).

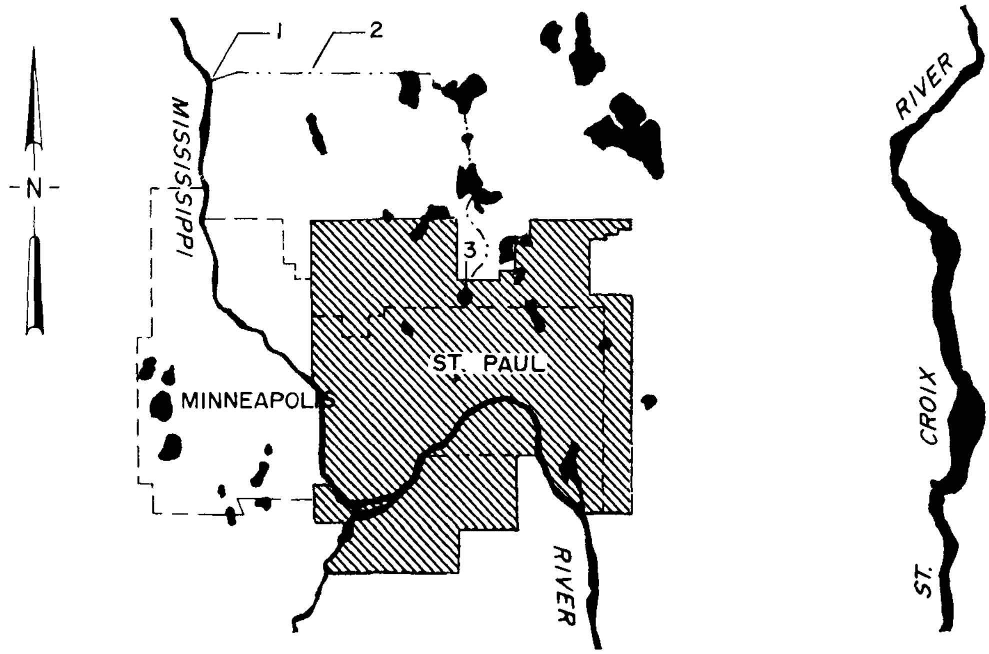
The McCarron purification plant employs aeration, softening with lime, recarbonation, coagulation with alum, sedimentation, rapid sand filtration, chlorination and fluoridation. It has a rated capacity of 84 mgd (2).

Industrial and Commercial Supplies

The metropolitan area is supported by a variety of water-using industries including meat packing, brewing, paper products, petroleum refining, milling, mineral and rubber products, as well as chemical and allied product industries. Almost 70 percent of the potable water used by industry is ground water. In 1960 approximately 31 mgd and 25 mgd were withdrawn from wells in Minneapolis and St. Paul, respectively, by commercial and industrial establishments. Of the potable water obtained from surface sources, over 99 percent is supplied by the Minneapolis and St. Paul municipal systems.

Future Requirements

The Twin Cities metropolitan area presently depends more upon ground water than upon surface water for its source of supply. In 1960 the ratio of ground water to surface water use was 1.4 to 1.



LEGEND
1 Water Intake
2 Raw Water Supply Conduit
3 Treatment Plant
Area Served

SCALE
5 0 5 Miles

Source: Public Water Supplies of the 100 Largest Cities in the United States, 1962, Geological Survey Water Supply Paper 1812

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

AREA SUPPLIED BY ST. PAUL WATER SYSTEM

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-2

The Minnesota Department of Conservation Division of Waters prepared estimates of water needs in the metropolitan area by 1980 (4). At this future date the total water demand is expected to be about 401 mgd, an increase of 73 percent over the 1960 use. Public supplies are expected to increase by 110 mgd (141 percent) in the 20-year period, while industrial and commercial use is expected to increase by 50 mgd (39 percent). This information is summarized in Table III-1.

At this time no estimates have been made regarding the apportionment of the future demand between surface and ground water sources. It is recognized, however, that ground water supplies alone will not be adequate to serve the future needs of the area. According to projections by the Minnesota Department of Conservation, the natural flow in the Mississippi River during periods of low flow must be greatly increased in the future if the river is to supply enough water for all uses (5). They estimate that by 1980 a flow of 1,000 cubic feet per second (cfs) in the Mississippi River would not be sufficient to meet the combined requirements of public water supply (est. 310 cfs average with a 620 cfs maximum), navigation (350 cfs required to operate the locks at St. Anthony Falls), the Riverside Power Plant (340 cfs required for cooling purposes), and hydro-electric power generation.

NONPOTABLE INDUSTRIAL WATER SUPPLIES

Process Water

Significant amounts of untreated water from the Mississippi River system are used by four industries in their processes at seven locations within the study area (see Figure III-3). The location of and use by each of these industries are described below.

TABLE III - 1

POTABLE WATER DEMANDS IN THE TWIN CITIES METROPOLITAN AREA[1]
(SEVEN COUNTIES)

WATER USE	1960 DEMAND (Million Gallons)		1980 DEMAND (Million Gallons)		PERCENT INCREASE
	Daily	Annual	Daily	Annual	
Public Supply	78.4	28,626	189	68,985	141
Industrial & Commercial Supply	126.0	45,985	175	63,753	39
Individual Wells (Private)	15.5	5,668	7	2,555	-55
Miscellaneous Uses	11.6	4,237	30	10,950	159
Total	231.5	84,516	401	146,243	73
Ground Water	134.1	48,967	-	-	-
Surface Water	97.4	35,549	-	-	-

(1) Information obtained from Metropolitan Water Study, Part II, Reports No. 6, Twin Cities Metropolitan Planning Commission, July 1960.

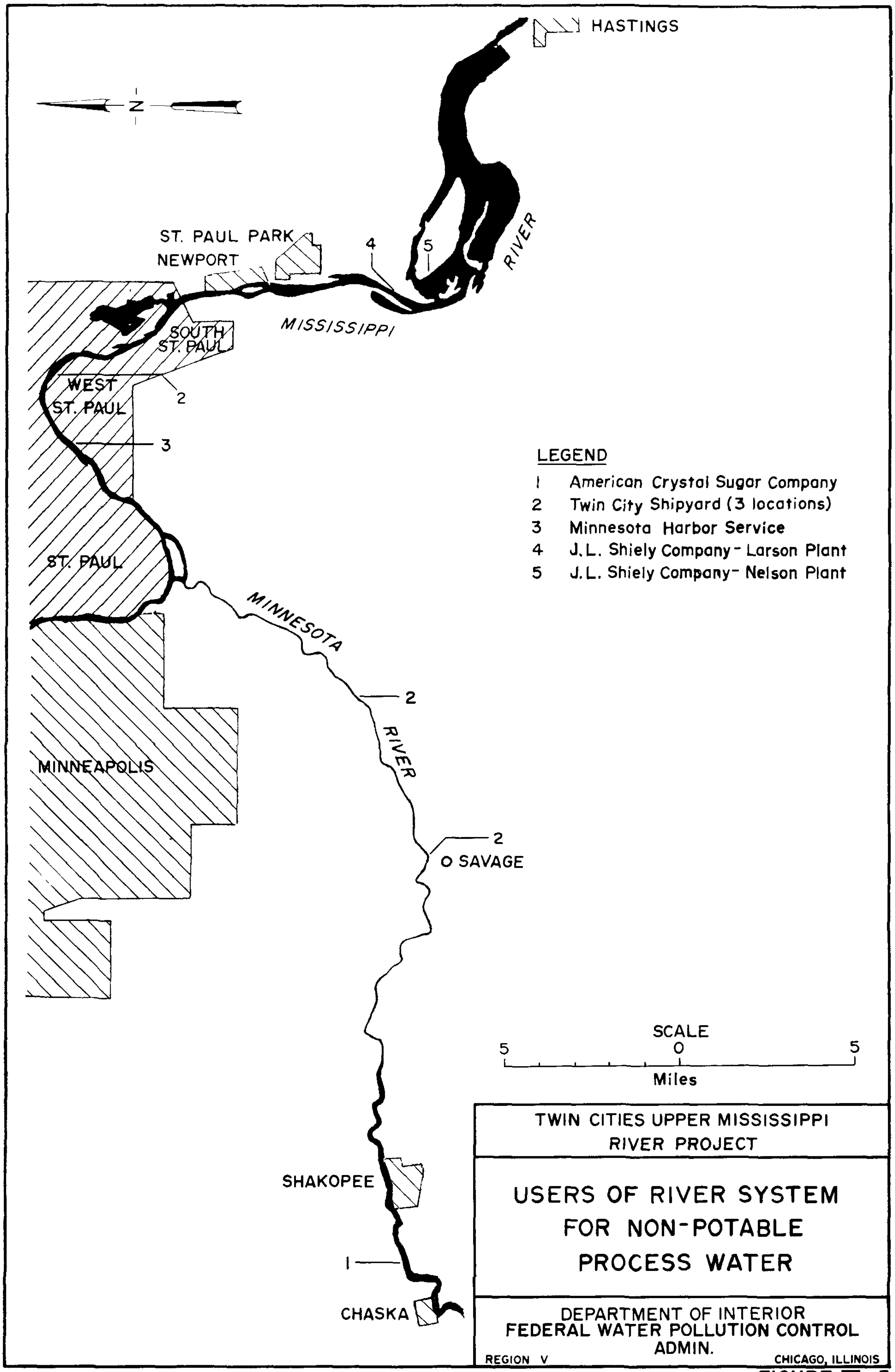

HASTINGS
N
RIVER
ST. PAUL PARK
NEWPORT
4
5
MISSISSIPPI
SOUTH ST. PAUL
WEST ST. PAUL
2
3
ST. PAUL
MINNESOTA
2
RIVER
MINNEAPOLIS
2
O SAVAGE
SHAKOPEE
1
CHASKA
LEGEND
1 American Crystal Sugar Company
2 Twin City Shipyard (3 locations)
3 Minnesota Harbor Service
4 J.L. Shiely Company - Larson Plant
5 J.L. Shiely Company - Nelson Plant
SCALE
5 0 5
Miles
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT
USERS OF RIVER SYSTEM FOR NON-POTABLE PROCESS WATER
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V
CHICAGO, ILLINOIS

FIGURE III - 3

American Crystal Sugar Company. The American Crystal Sugar Company, located near Chaska, Minnesota, uses Minnesota River water for fluming and washing of sugar beets. They operate 24-hours a day, seven days per week, from October through January of each year. While in operation they withdraw between 4.5 and 5.0 mgd of water at river mile 27.7 for this use.

Twin City Shipyard. This company, located on the Mississippi River at river mile 837.3 and the Minnesota River at river miles 13.2 and 8.0, has barge washing facilities at these locations which operate from April through October of each year. The water is taken from the rivers, about 2,000 gallons being required per barge. Approximately 800,000 gallons of water are used from each river over a seven-month period.

Minnesota Harbor Service. This company also operates barge washing facilities from April through October of each year. Located on the Mississippi River at mile 840.4, it utilizes river water at a rate of 1,000,000 gallons per season.

J. L. Shiely Company. The Shiely Company operates gravel washing facilities at their Larson and Nelson Plants on upper and lower Grey Cloud Islands, respectively. Both plants operate seven months per year from April through October. Water is withdrawn from the Mississippi River for use in the gravel washing operations.

The Larson Plant, located at river mile 826.5, conducts washing operations an average of four hours each day, sixty days per year. A 1,000 gpm pump supplies approximately 240,000 gallons of river water each day washing is conducted.

The Nelson Plant, located at river mile 825.0, operates washing facilities about 12 hours per day, 5 days per week, over the 7-month period. Two pumps, with a total capacity of 6,000 gpm, supply water (4.33 million gallons daily) from the river to the gravel washing facility.

Cooling Water

Waters of the Mississippi and Minnesota Rivers within the study area are used for cooling purposes by one industry and five steam-electric generating plants (see Figure III-4).

Swift and Company. This meat packing company, located on the Mississippi River at mile point 833.4, withdraws an estimated 5 mgd of water from the River for cooling purposes. The plant operates year-round, five to six days per week.

Steam-Electric Generating Plants. The Northern States Power Company operates five steam power plants within the study area. In warm weather they withdraw a maximum of 1,500 mgd from the Mississippi and Minnesota Rivers for cooling purposes. This is about 14 times the amount of river water withdrawn for potable use in the area.

The amount of water required by a given plant depends upon the generating load and incoming river temperature. Plant water use rates at full load for given stream temperatures are given in Table III-2.

Northern States Power Company anticipates the need for four additional steam-electric power plants by the year 2000. The first of these, the Allen S. King Plant, is scheduled to go into operation on the St. Croix River at mile point 21.2 early in 1968. Initially, this plant will have a generating capacity of 550,000 kilowatts (KW) and will use cooling water at a maximum rate of 426 mgd. At a later date the plant may be enlarged to a capacity of 1,000,000 KW. Cooling water use at this capacity would be a maximum of about 970 mgd.

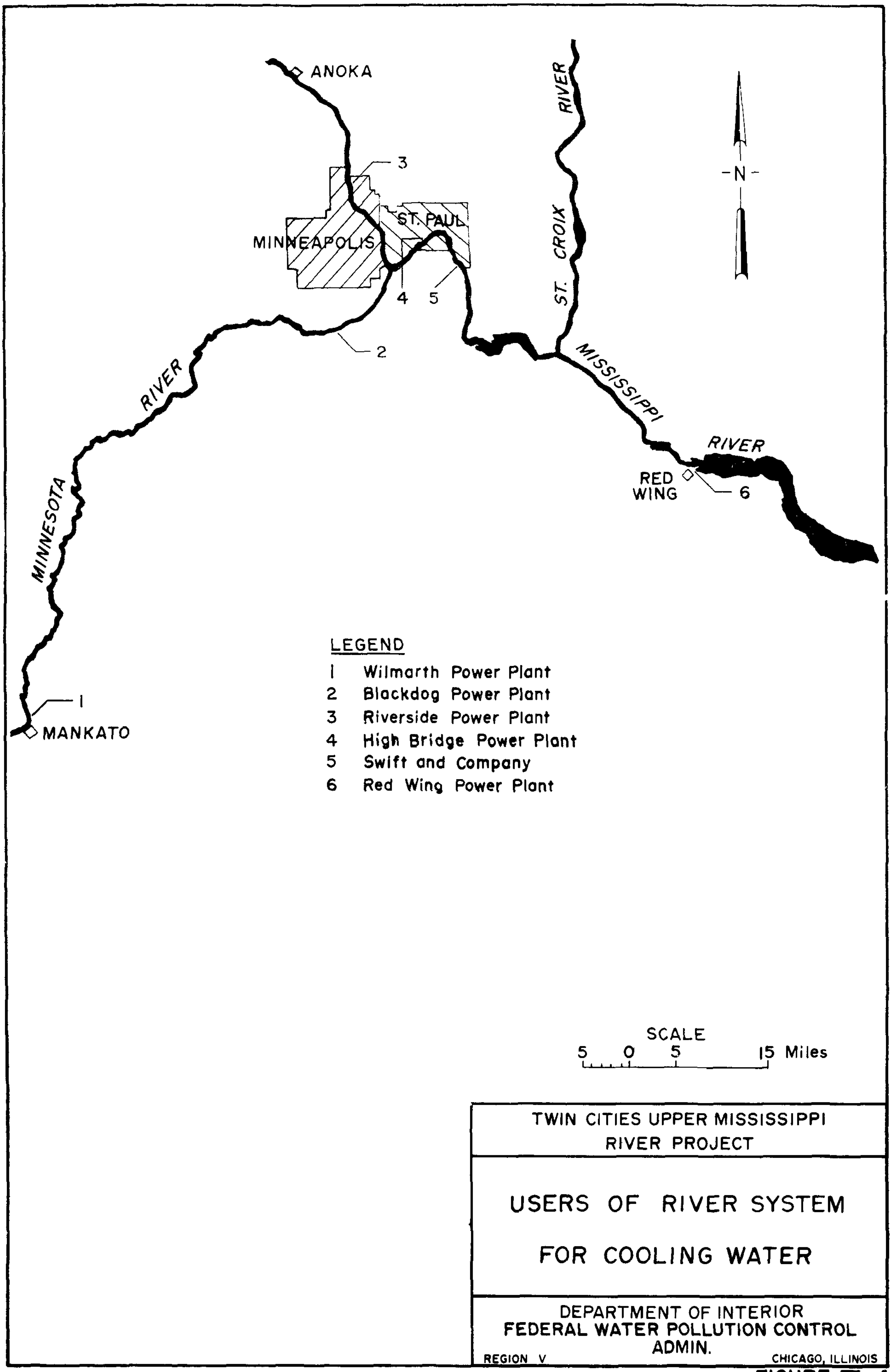

ANOKA
3
ST. PAUL
MINNEAPOLIS
4 5
2
RIVER
ST. CROIX
MISSISSIPPI
RIVER
RED WING
6
RIVER
MINNESOTA
1
MANKATO
N
LEGEND
1 Wilmarth Power Plant
2 Blackdog Power Plant
3 Riverside Power Plant
4 High Bridge Power Plant
5 Swift and Company
6 Red Wing Power Plant
SCALE
5 0 5 15 Miles
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT
USERS OF RIVER SYSTEM FOR COOLING WATER
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V
CHICAGO, ILLINOIS

FIGURE III-4

TABLE III-2

STEAM-ELECTRIC GENERATING PLANTS IN THE
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT STUDY AREA

PLANT	LOCATION (River Mile)(1)	RATED GENERATING CAPACITY (KW)	NET CAPABILITY (KW)	CAPACITY FACTOR(2) (%)	COOLING WATER INTAKE RATE AT FULL LOAD FOR GIVEN RIVER TEMPERATURES: INTAKE RATE (MGD)	RIVER TEMP. (°F)	INTAKE RATE (MGD)	RIVER TEMP. (°F)
Riverside	UM 856.9							
225 PSI Section			72,200	1.3	176.40	All Temp.	176.40	All Temp.
400 PSI Section			81,500	24.3	92.16	<61.5	142.56	>61.5
900 PSI Section			135,600	57.8	77.76	<56	120.96	>56
2400 PSI Section			223,000	95.1	76.32	<49.5	152.64	>49.5
TOTAL		478,000	512,300		422.64		592.56	
High Bridge	UM 840.5							
300 PSI Section			76,200	17.4	118.08	All Temp.	118.08	All Temp.
850 PSI Section			123,600	76.2	77.04	<65	113.76	>65
1450 PSI Section			116,400	104.9	72.58	<42	108.72	>42
1800 PSI Section			166,600	99.0	72.58	<65	108.72	>65
TOTAL		423,250	482,800		340.28		449.28	
Red Wing	UM 789.4	23,000	29,000	76.1	26.93	<38	53.86	>70
Wilmarth	MN 105.2	25,000	27,900	51.5	24.84	<60	33.12	>60
Blackdog	MN 8.4							
900 PSI Section			72,200	73.5(3)	41.76	<62	64.80	>62
1450 PSI Section			102,200	79.8	65.38	<59	97.92	>59
1450 PSI (reheat) Section			112,200	100.3	55.87	<40	86.40	>40
1800 PSI Section			174,300	106.4	87.84	<69	122.40	>69
TOTAL		416,250	460,900		250.85		371.52	

(1) UM refers to Upper Mississippi River
MN refers to Minnesota River

(2) Capacity Factor $= \frac{\text{Total KWH Generated}}{\text{Plant Rated Capacity x Hours}}$, for year ending 5/31/65 except as noted.

(3) For year ending 12/31/64

Northern States Power Company has indicated that another 1,000,000 KW plant will be needed in the 1970-80 decade. The tentative site for this plant is Prairie Island, near Mississippi River mile 800.

Based on the Power Company's estimates, Schroepfer, et al projected data for the years between 1980 and 2000 (7). They determined that two additional 1,000,000 KW power plants would be required in this period. They assume that one would be constructed in the 1980-90 decade and the other in the 1990-2000 decade. Since these plants would be approximately equal in capacity to the Allen S. King, it can be assumed that maximum cooling water demands would also be in the order of 970 mgd for each.

It is not known where these latter two plants would be located. The Power Company does, however, own property near Newport, Minnesota at Mississippi River mile 832.5 which could be used for a plant site. Original plans had called for a plant to be constructed there instead of on the St. Croix River site. Information on future plants is summarized in Table III-3.

Hydro-Electric Power

Most of the economical hydro-electric power sites in the Mississippi River system have been developed, and it is likely that increasing power demands will be met primarily by thermal plants.

The hydro-electric power generation capacity of the major streams in the study area is limited to the Mississippi River above its juncture with the Minnesota River and to the St. Croix River above Stillwater, Minnesota.

Within the study area watershed, there are five hydro-electric plants on the Mississippi River, one on the St. Croix River, twelve on tributaries to the St. Croix River, and one on the Blue Earth River, a tributary to the

TABLE III - 3

ESTIMATE OF FUTURE ADDITIONAL POWER REQUIREMENTS (1)

PERIOD OF ANTICIPATED CONSTRUCTION	PROBABLE LOCATION (2) (RIVER MILE)	ESTIMATED GENERATING CAPACITY (KW)	ESTIMATED COOLING WATER USE AT FULL LOAD (MGD)
1968-1975	SC 21.2	1,000,000	970
1970-1980	UM 800	1,000,000	970
1980-1990	UNKNOWN	1,000,000	970
1990-2000	UNKNOWN	1,000,000	970

(1) Estimates of power requirements are those given in Pollution and Recovery Characteristics of the Mississippi River, Vol. 1, Part 3, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by University of Minnesota under the direction of Professor G. J. Schroepfer, 1958-1961.

(2) SC refers to St. Croix River
MN refers to Upper Mississippi

Minnesota River (8) (9). Information on the plants located on the Mississippi and St. Croix Rivers is summarized in Table III-4. Plants on the above mentioned tributaries are not discussed since no serious pollution problems exist in their vicinity. Figure III-5 shows the locations of all hydro-electric plants in the watershed area.

The total capacity of the plants on the Mississippi River is 42,260 KW, only 3.2 percent of the total steam-electric power plant capacity in the Twin Cities area. With increased municipal and navigational demands for water above St. Anthony Falls, operation of those hydro-electric units will be limited during low stream flows.

Only one potential site exists in the study area where additional hydro-electric development is possible. This is on the St. Croix River at Stillwater and has a potential capacity of only 4,200 KW.

IRRIGATION AND STOCKWATERING

Very little use is made of the Mississippi River system for irrigation and stockwatering. Permits for withdrawal of irrigation water have been issued to persons along the Mississippi River near Fridley and North Lake in Pool No. 3; along the Minnesota River at Jordan; and along the St. Croix River just above Prescott. There may also be some use for irrigation by truck farmers along the north bank of the Mississippi River just above Lock and Dam No. 2 and along the lower 35 miles of the Minnesota River. Most irrigation water for the Twin Cities area is obtained from wells.

Some very limited use is made of the rivers for stockwatering. Small numbers of cattle have been seen drinking from the Minnesota River above Chaska and from the Mississippi River along the north bank above Lock and Dam No. 2. These are about the only two areas within the study area where steep banks are absent and the shoreline is easily accessible to livestock.

GPO 828-545-B-1

TABLE III-4

HYDRO-ELECTRIC GENERATING PLANTS
IN THE
TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT STUDY AREA(1)

NAME	OWNERSHIP	LOCATION	INSTALLED CAPACITY (KW)	MAXIMUM RIVER INTAKE (MGD)
Coon Rapids Dam	Northern States Power Company	UM 866.2	6,500	4,200
Upper St. Anthony Falls (Main St. Plant)	Northern States Power Company	UM 853.8	960 }	2,600
Upper St. Anthony Falls (Hennepin Island Plant)	Northern States Power Company	UM 853.7	12,400 }	
Lower St. Anthony Falls	Northern States Power Company	UM 853.4	8,000	3,600
Ford Unit (Lock & Dam No. 1)	Ford Motor Co.	UM 847.7	14,400	3,880
St. Croix Falls	Northern States Power Company	SC 52.5	23,200	

(1) Information obtained from the following Federal Power Commission, Bureau of Power Reports:

1. Mississippi Basin above Twin Cities, Minnesota - South Dakota Planning Status Report, 1964.

2. St. Croix River Basin above Twin Cities, Minnesota - South Dakota, Planning Status Report, 1964.

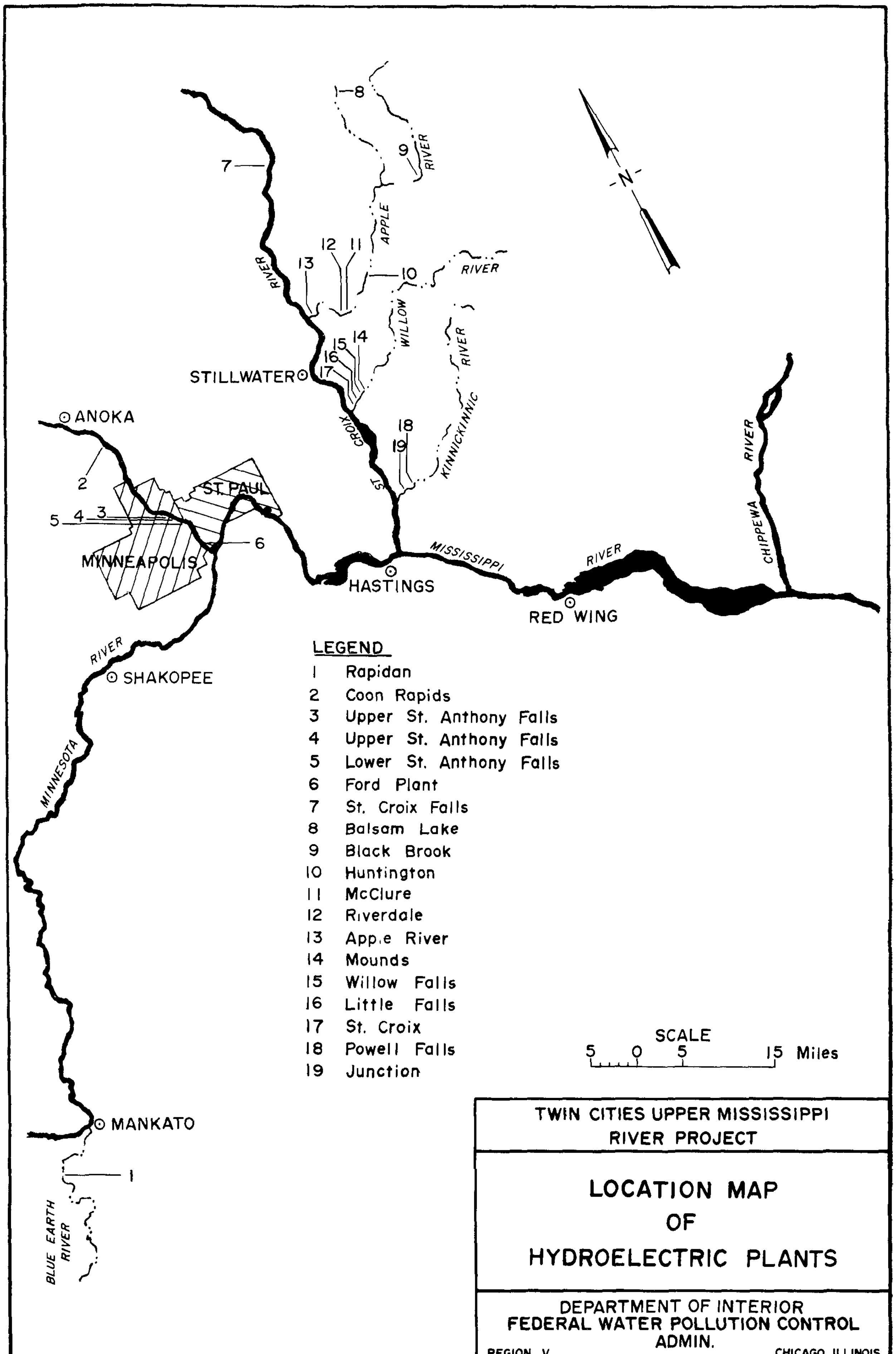

ANOKA
STILLWATER
ST. PAUL
MINNEAPOLIS
HASTINGS
RED WING
SHAKOPEE
MANKATO
N
RIVER
APPLE
WILLOW
RIVER
KINNICKINNIC
ST. CROIX
MISSISSIPPI
RIVER
CHIPPEWA
RIVER
MINNESOTA
RIVER
BLUE EARTH
RIVER
LEGEND
1 Rapidan
2 Coon Rapids
3 Upper St. Anthony Falls
4 Upper St. Anthony Falls
5 Lower St. Anthony Falls
6 Ford Plant
7 St. Croix Falls
8 Balsam Lake
9 Black Brook
10 Huntington
11 McClure
12 Riverdale
13 Apple River
14 Mounds
15 Willow Falls
16 Little Falls
17 St. Croix
18 Powell Falls
19 Junction
SCALE
5 0 5 15 Miles
TWIN CITIES UPPER MISSISSIPPI
RIVER PROJECT
LOCATION MAP
OF
HYDROELECTRIC PLANTS
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL
ADMIN.
REGION V
CHICAGO, ILLINOIS

FIGURE III-5

NAVIGATION

River System

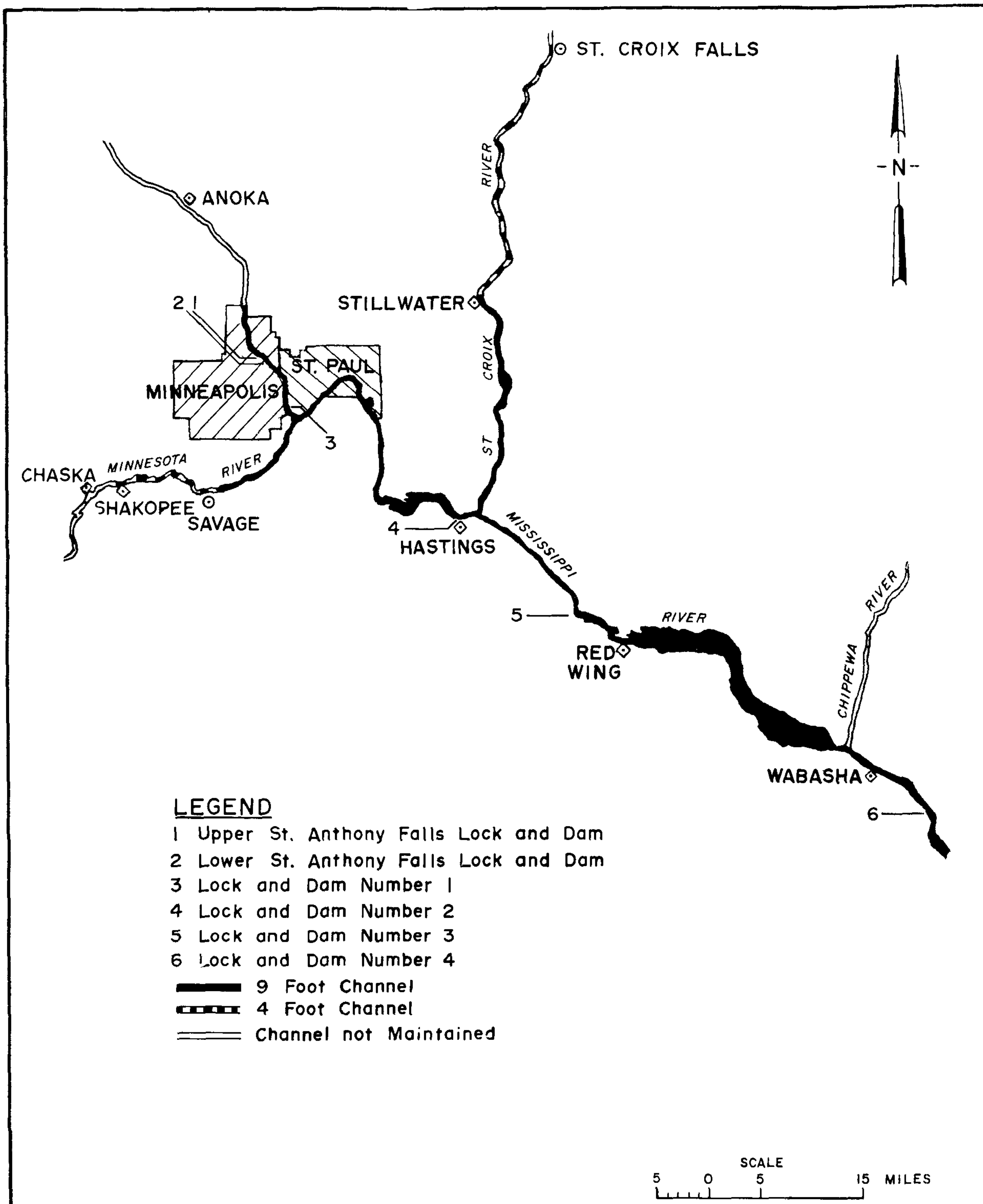
The present water transportation system serving the study area consists of the Mississippi River, with its locks and dams and a nine-foot channel extending upstream to mile point 857.6; the Minnesota River, with its nine-foot channel reaching from the mouth to mile point 21.8 above Savage and a four-foot channel to mile point 25.1 at Shakopee; and the St. Croix River with a nine-foot channel to mile point 23.3 at Stillwater and a four-foot channel to mile point 53.7 at Taylors Falls (see Figure III-6). The Corps of Engineers maintains the channel depths on the Mississippi and St. Croix Rivers. On the Minnesota River, however, the Corps maintains only a four-foot channel above mile 14.7; the remaining five feet are maintained by private interests up to mile 21.8.

The Corps has proposed plans for straightening the first 14.2 miles of the Minnesota River and deepening the channel to twelve feet. This project, however, has not yet been formally approved.

Between St. Louis, Missouri and St. Paul, Minnesota the locks are at least 110 feet wide, with a minimum length of 600 feet. At Lock and Dam No. 1, however, the twin locks are each 56 feet by 400 feet. This is of significance since the size of the barge tows are controlled by lock dimensions. The longest manageable tow is one that will pass through the locks in two sections by "double-locking."

Dredging Operations

Based on dredging operations conducted between 1954 and 1963, the volume of material removed yearly between Minneapolis and Lake Pepin averages 357,000 cubic yards. The breakdown for each pool is given in Table III-5.



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

NAVIGATION SYSTEM MAINTAINED BY CORPS OF ENGINEERS

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-6

TABLE III - 5

QUANTITY OF DREDGE MATERIAL REMOVED
FROM MISSISSIPPI RIVER SYSTEM BY U.S. ARMY CORPS OF ENGINEERS[1]

LOCATION	YEARLY AVERAGE VOLUME REMOVED[2] (CUBIC YARDS)
St. Anthony Pools (River mile 854.0 - 857.6)	30,000 (EST.)
Pool No. 1 (River mile 847.0 - 854.0)	73,287
Pool No. 2 (River mile 836.0 - 847.0)	114,391
Pool No. 2 (River mile 815.0 - 836.0)	29,607
Pool No. 3 (River mile 797.0 - 815.0)	59,235
Pool No. 4 (River mile 784.0 - 797.0)	50,695
TOTAL	357,215

1. This information was obtained from the U. S. Army Engineer District, St. Paul, St. Paul, Minnesota.

2. Based on quantities removed during the 10-year period 1954 - 1963.

Commercial Shipping

Although river traffic in the Twin Cities area is significant, it is less than on the remainder of the Mississippi River and quite small in comparison with the Illinois River and Great Lakes traffic (see Figure III-7) (10).

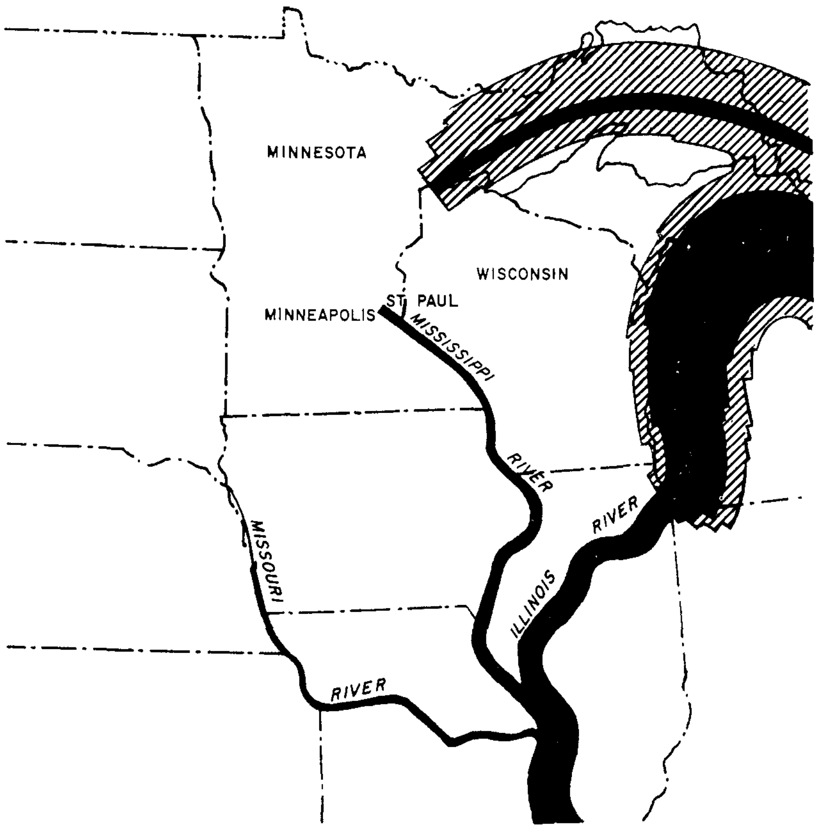
There is a total of 53 barge docking facilities on the three streams within the study area (see Figure III-8). All except five are within the seven-county metropolitan area.

In 1963 over 7.1 million tons of materials were received and shipped along the Mississippi, Minnesota, and St. Croix Rivers within the area under consideration. Table III-6 gives the tonnages received and shipped over a 10-year period at the Ports of Minneapolis and St. Paul and on the Minnesota and St. Croix Rivers. This information is summarized in Figure III-9.

Primary receipts at the ports of Minneapolis and St. Paul and on the Minnesota River include coal, gasoline, other petroleum products, sand, and gravel. Principal shipments are grain and soybeans.

In comparison to the Mississippi and Minnesota Rivers, barge traffic on the St. Croix River is very light. Receipts consist generally of only two products, coal and superphosphate. Of the 30,567 tons of material received in 1963, 17,939 tons were coal. The remainder was superphosphate. Coal receipts are expected to increase significantly after the Allen S. King power plant becomes operational. No materials are shipped out of the St. Croix area by barge.

To accomodate the Twin Cities metropolitan area barge traffic in 1964, there were 1556 commercial lockages made through Lock and Dam No. 2. Lockage data for the other locks and dams are given in Table III-7 (11).



YEAR 1958

LEGEND

5
15
30
60 All commodities except iron ore (millions of tons)

Iron ore

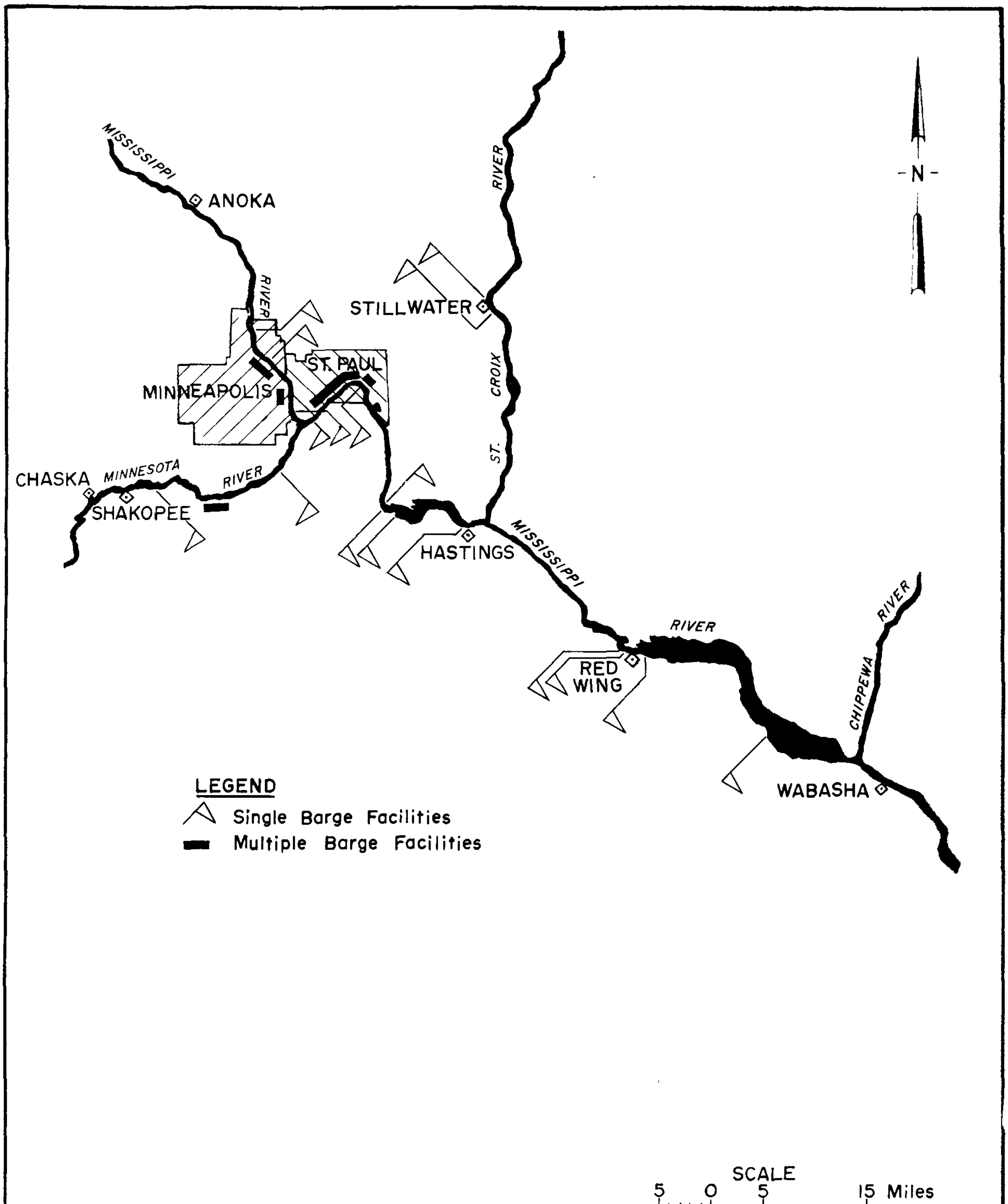
SOURCE: CORPS OF ENGINEERS
COURTESY OF: TWIN CITIES METROPOLITAN PLANNING COMMISSION

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

RELATIVE BARGE TRAFFIC ON MIDWEST INLAND WATERWAYS

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-7



TWIN CITIES UPPER MISSISSIPPI
RIVER PROJECT

BARGE

DOCKING FACILITIES

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL
ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III - 8

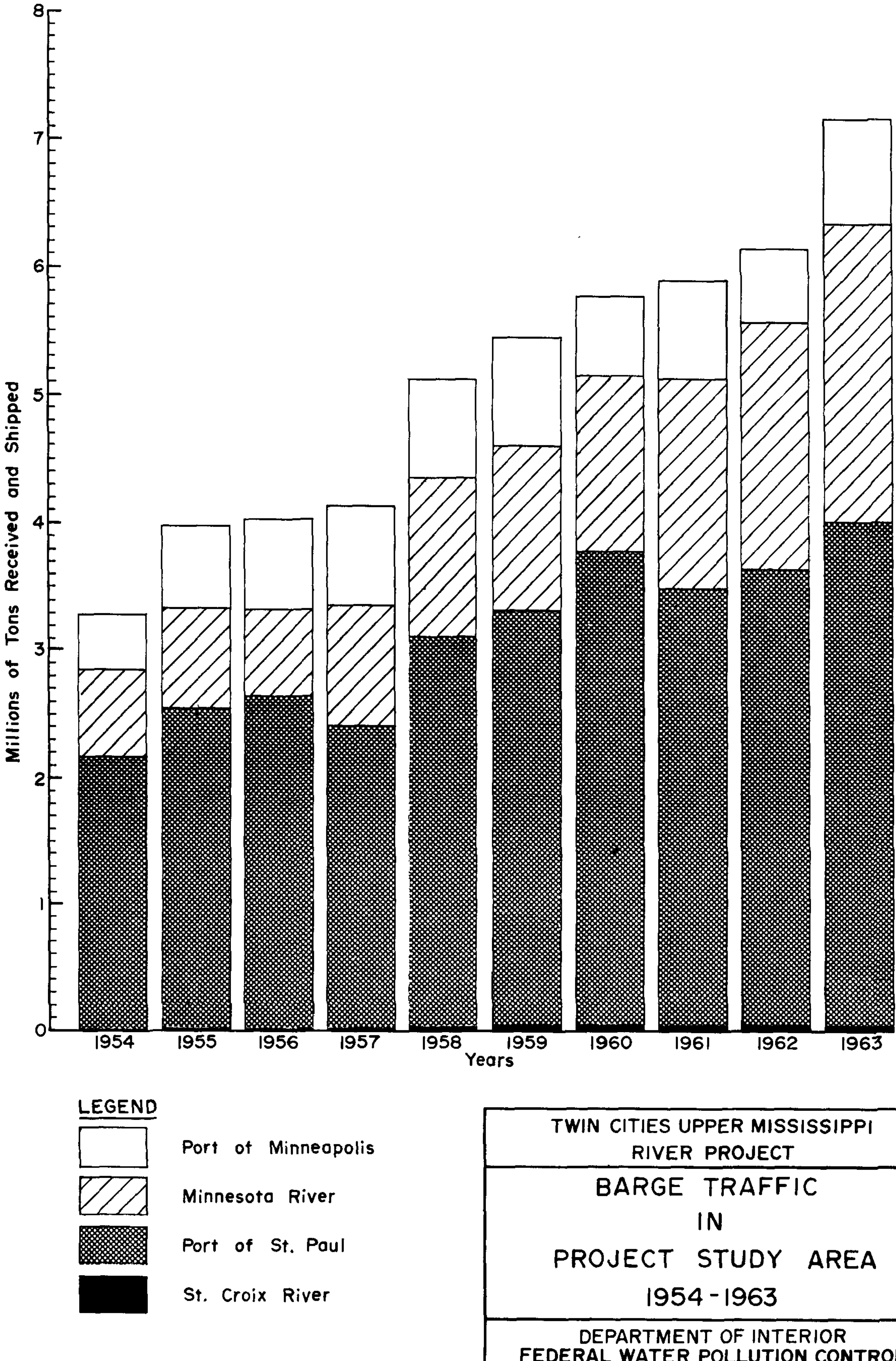
TABLE III - 6

BARGE TRAFFIC WITHIN PROJECT STUDY AREA[1]

YEAR	TOTAL RECEIPTS AND SHIPMENTS (IN TONS) PORT OF MINNEAPOLIS	PORT OF ST. PAUL	MINNESOTA RIVER	ST. CROIX RIVER
1954	446,090	2,168,922	666,980	5,304
1955	645,048	2,530,358	785,251	11,259
1956	692,291	2,622,877	682,602	16,566
1957	773,105	2,383,883	958,830	16,873
1958	762,136	3,084,943	1,236,367	26,891
1959	849,385	3,283,224	1,280,213	34,306
1960	606,073	3,740,391	1,367,502	43,145
1961	770,525	3,450,282	1,626,754	36,752
1962	569,605	3,608,091	1,923,190	33,357
1963	825,429	4,058,315	2,231,671	30,567
1964	1,203,404[2]	4,317,428[2]	-	-

1. This information was obtained from the U. S. Army Engineer District, St. Paul, St. Paul, Minnesota.

2. Approximate figures, based on Lockage Reports.



Source: Corps of Engineers

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

BARGE TRAFFIC IN PROJECT STUDY AREA 1954-1963

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-9

TABLE III - 7

COMMERCIAL LOCKAGES IN AND BELOW
TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT STUDY AREA[1]

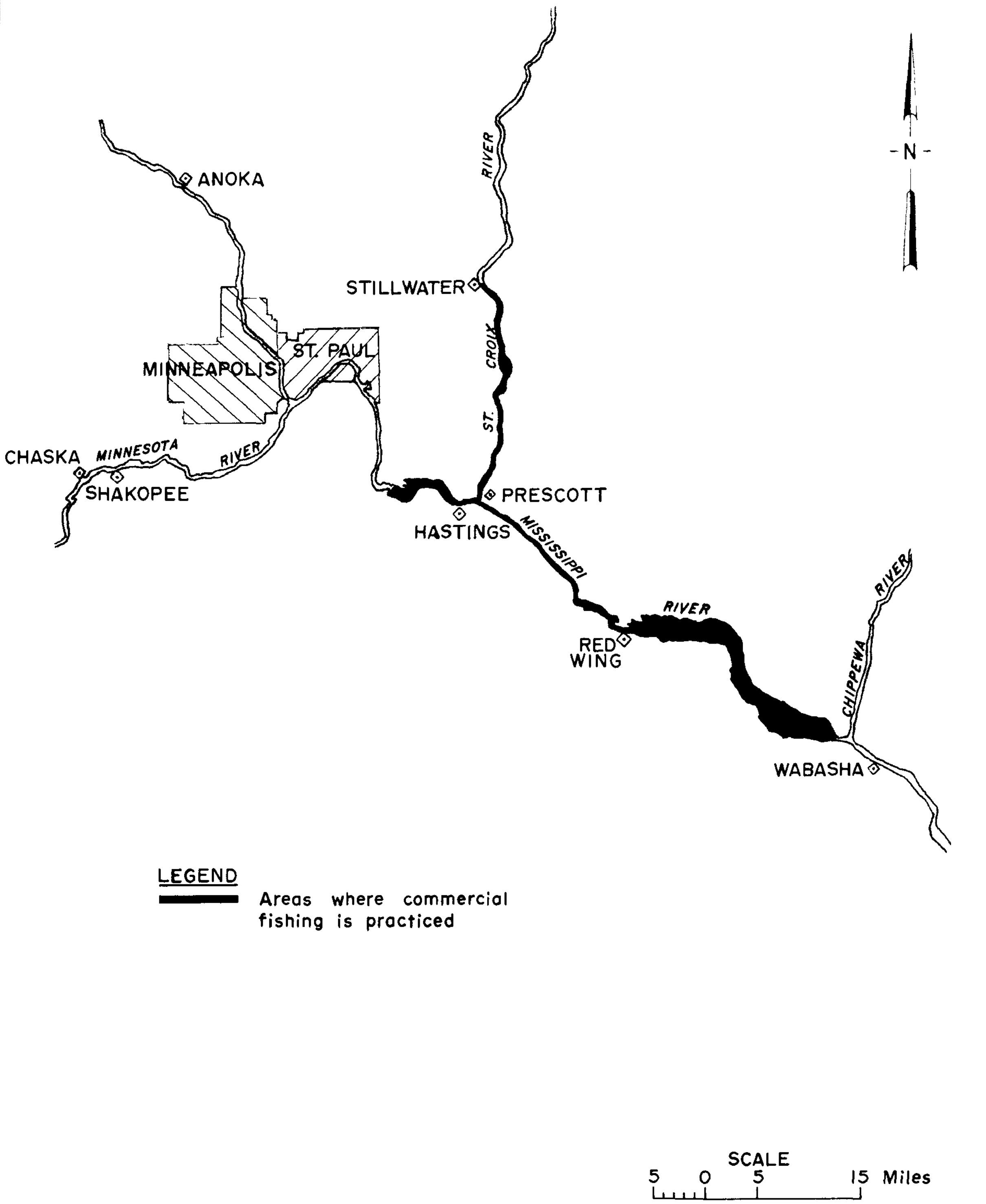
LOCK AND DAM	1960	1961	1962	1963	1964
Upper St. Anthony Falls	0	0	0	253	519
Lower St. Anthony Falls	71	317	69	295	523
No. 1	1082	1323	995	1367	1688
No. 2	1302	1191	1325	1561	1556
No. 3	1303	1318	1302	1468	1463
No. 4	1313	1294	1313	1373	1410

1. This information was obtained from the U.S. Army Engineer District, St. Paul, St. Paul, Minnesota.

COMMERCIAL FISHING

Commercial fishing is practiced on the Mississippi River in and below Pool No. 2 and on the lower 23 miles of the St. Croix River, known as Lake St. Croix (see Figure III-10). The major source of fish in this area, however, has always been Lake Pepin in Pool No. 4. In the five-year period between 1958 and 1962, the average annual catch in Lake Pepin was 58.2 pounds/acre as compared to 32.6 pounds/acre in the remainder of Pool No. 4. During this same period, the average annual catches in Pools 2 and 3 were 28.0 and 3.4 pounds/acre, respectively.

The principal species of fish caught are carp, buffalo fish, drum (sheepshead) and channel catfish. About two-thirds of the weight of the commercial catch, however, is carp. The total yearly catch in Lake St. Croix and Pools 2, 3, and 4 averages about 2,800,000 pounds and is worth approximately $110,000. A breakdown of catches and their values is given in Table III-8.



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

COMMERCIAL FISHING SITES

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

Source: Upper Mississippi River Conservation Committee Annual Proceedings 1961 - 1965

FIGURE III-10

TABLE III - 8

COMMERCIAL FISH CATCH(1)
IN
TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT STUDY AREA

YEAR	MISSISSIPPI RIVER						LAKE ST. CROIX	
	POOL NO. 2		POOL NO. 3		POOL NO. 4			
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1961	344,345	$16,131	104,180	$4,591	1,736,714	$76,418	519,608	$22,992
1962	330,924	20,382	46,035	2,198	1,870,079	69,009	390,594	17,640
1963	412,587	11,711	39,199	1,441	2,182,912	72,902	381,990	12,616
1964	0	0	88,921	2,979	2,592,750	88,341	511,586	15,752

(1) Information obtained from Proceedings of the 17th through the 21st Annual Meetings of the Upper Mississippi River Conservation Committee.

RECREATION

Introduction

Recreation in Minnesota and Wisconsin is big business. It is considered the fourth largest in Minnesota and the third largest in Wisconsin. In 1960 tourists spent $325 million and $581 million in Minnesota and Wisconsin, respectively.

Tourists come to Minnesota primarily to vacation at resorts on the many lakes and to rough it in the northern wilds.

Wisconsin appeals to many tourists because of its numerous recreational areas which include parks, forests, and scenic sites. Wisconsin also has much to offer the sportsmen. The State boasts of 10,000 miles of trout streams, 8,500 well-stocked lakes, and numerous game including deer, bear, partridge, geese, and ducks.

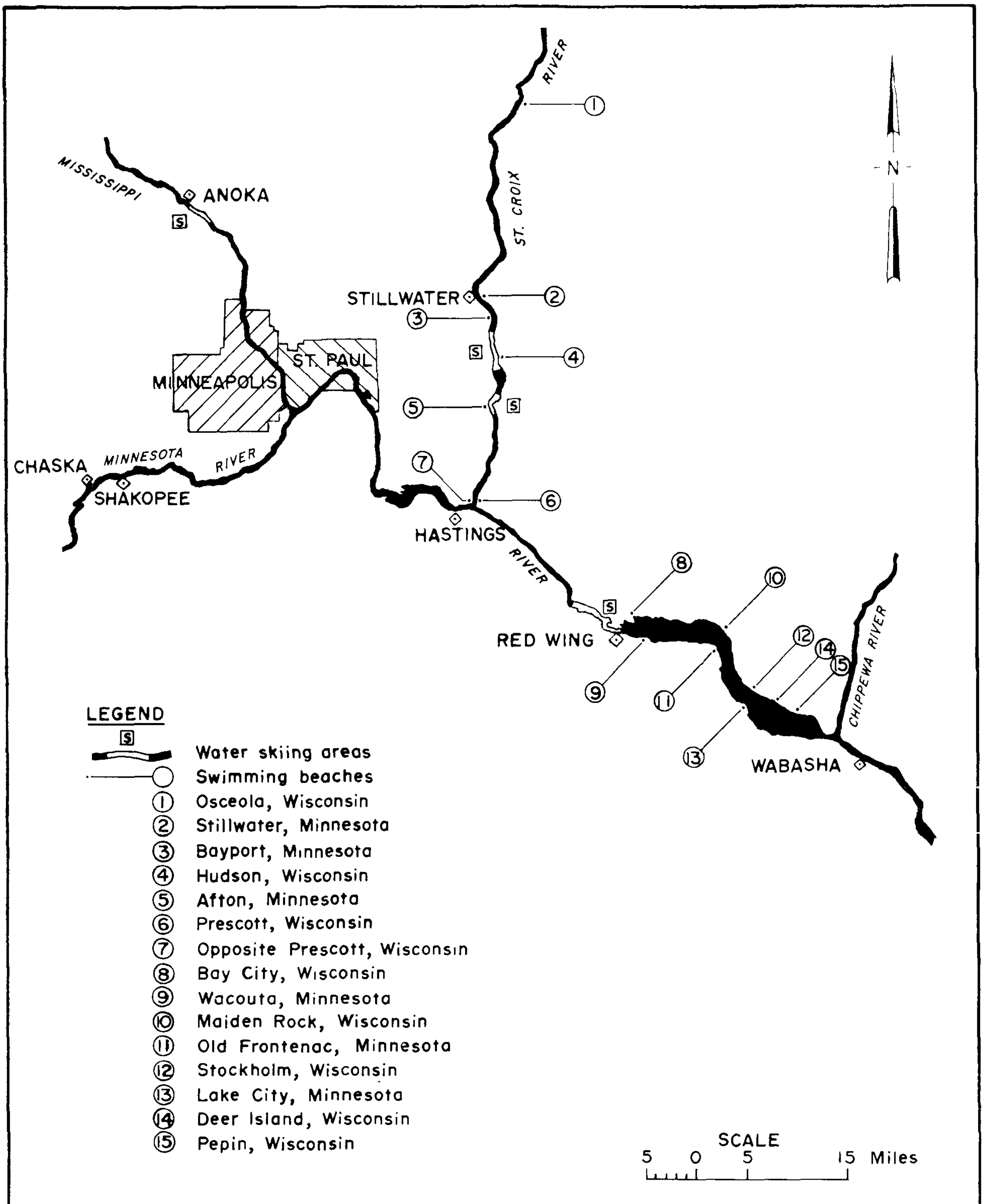
Rivers within the study area are used fairly extensively by local inhabitants, although they do not attract large numbers of out-of-state tourists. Two areas, Lake Pepin and Lake St. Croix, are rather attractive for water oriented vacationers and could possibly become resort centers.

Swimming

Swimming in the waters under consideration is generally confined to seven beaches on the St. Croix River and eight beaches on Lake Pepin (see Figure III-11). The approximate number of swimmers normally found at each beach on a typical warm, sunny weekend day is given in Table III-9.

Water Skiing

Water skiing is practiced in four general areas in the waters under consideration (see Figure III-11). The approximate number of skiers making use of each area is given in Table III-10.



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

SWIMMING AND WATER SKIING AREAS

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

GPO 828-545-B-2

FIGURE III-11

TABLE III - 9

SWIMMING BEACH USE ON WARM, SUNNY WEEKENDS[1]

SWIMMING BEACH	LOCATION	APPROXIMATE NO. OF PERSONS PER DAY
St. Croix River		
Osceola	SC 44.7	10
Stillwater	SC 23.3	50
Bayport	SC 19.5	150
Hudson	SC 17.0	100
Afton	SC 11.0	75
Prescott	SC 1.0	150
Opposite Prescott	SC 0.5	100
Lake Pepin		
Bay City	UM 786.0	50
Wacouta	UM 783.5	50
Maiden Rock	UM 779.5	50
Old Frontenac	UM 778.5	50
Lake City	UM 774-775	300
Stockholm	UM 774.5	50
Deer Island	UM 770.0	50
Pepin	UM 767.5	50

(1) Bather counts were made by Project staff during Summers of 1964 and 1965.

TABLE III - 10

USE OF RIVERS FOR WATER SKIING[1]
ON WARM, SUNNY WEEKENDS

LOCATION		APPROXIMATE NO. OF SKIERS PER DAY
DESCRIPTION	RIVER MILE	
Mississippi River		
Below Anoka, Minnesota	UM 869-871	25
Near Red Wing, Minnesota	UM 790-797	50
St. Croix River		
Near Hudson, Wisconsin	SC 15 - 19	100
Near Afton, Minnesota	SC 10 - 13	50

(1) Skier counts were made by Project staff during Summers of 1964 and 1965.

Pleasure Boating

General. Pleasure boating is practiced from April to September on all three of the major streams under consideration. Greatest use, however, is made of Lake St. Croix and the Mississippi River below Lock and Dam No. 2.

Mississippi River. In 1964 there were about 3,350 boats moored along the reach of the Mississippi River under consideration (14). Of this number over 85 percent were in Pools 3 and 4 (see Table III-11). Information on pleasure boat lockages, found in Tables III-11 and III-12, indicates that Pool No. 2 also receives considerable usage even though only 13 percent of the boats are moored there. Locks and Dams 2, 3, and 4 receive nearly the same usage, each handling about 5,000 pleasure craft per year. At these dams, pleasure boat lockages made up approximately 63 percent of the total number of lockages in 1964. Lock and Dam No. 1 had less than one-half as many pleasure boat lockages, making up about 40 percent of the total number in that year. St. Anthony Falls had still fewer lockages, about one-half as many as Lock and Dam No. 1.

To accomodate these boats, there are approximately 19 public launching ramps, 19 marinas with permanent slips, and 14 other privately owned facilities offering a variety of services. Their locations are shown in Figure III-12.

Minnesota River. At present, on the Minnesota River, there are 4 launching ramps and two marinas with facilities for a total of about 100 boats (see Figure III-12). The marinas are located along the lower 25 miles, where a channel is maintained. It is reported that in the near future the marina at river mile 10.8 plans to construct a restaurant, motel, and slips for an additional 200 to 300 boats (15).

TABLE III-11

RECREATIONAL BOATING ON THE MISSISSIPPI RIVER IN 1964[1]

LOCK & DAM	NUMBER OF BOATS MOORED IN POOL	TOTAL PLEASURE BOAT LOCKAGES	TOTAL NO. OF PLEASURE BOATS THROUGH LOCKS	PEAK DAY LOCKAGES	NUMBER OF PLEASURE BOATS LOCKED ON PEAK DAY
Upper St. Anthony Falls	52	668	879	16	31
Lower St. Anthony Falls	-	679	887	16	31
No. 1	-	1155	1890	22	58
No. 2	428	2537	5107	36	113
No. 3	1483	2488	4784	45	200
No. 4	1388	2633	4347	32	105

1. Information obtained from U.S. Army Engineer District, St. Paul, St. Paul, Minnesota and Proceedings of the Twenty-First Annual Meeting of the Upper Mississippi River Conservation Committee, pp. 161, 1965.

TABLE III-12

NUMBER OF PLEASURE BOATS THROUGH LOCKS[1]

LOCK AND DAM	1959	1960	1961	1962	1963	1964
Upper St. Anthony Falls	0	0	0	0	1	879
Lower St. Anthony Falls	0	0	10	1	5	887
No. 1	1080	1278	1211	959	1427	1890
No. 2	5297	5137	5536	4270	5174	5107
No. 3	4960	5486	5490	4501	5113	4784
No. 4	3568	4305	4361	3943	4225	4347

1. Information obtained from U.S. Army Engineer District, St. Paul, St. Paul, Minnesota.

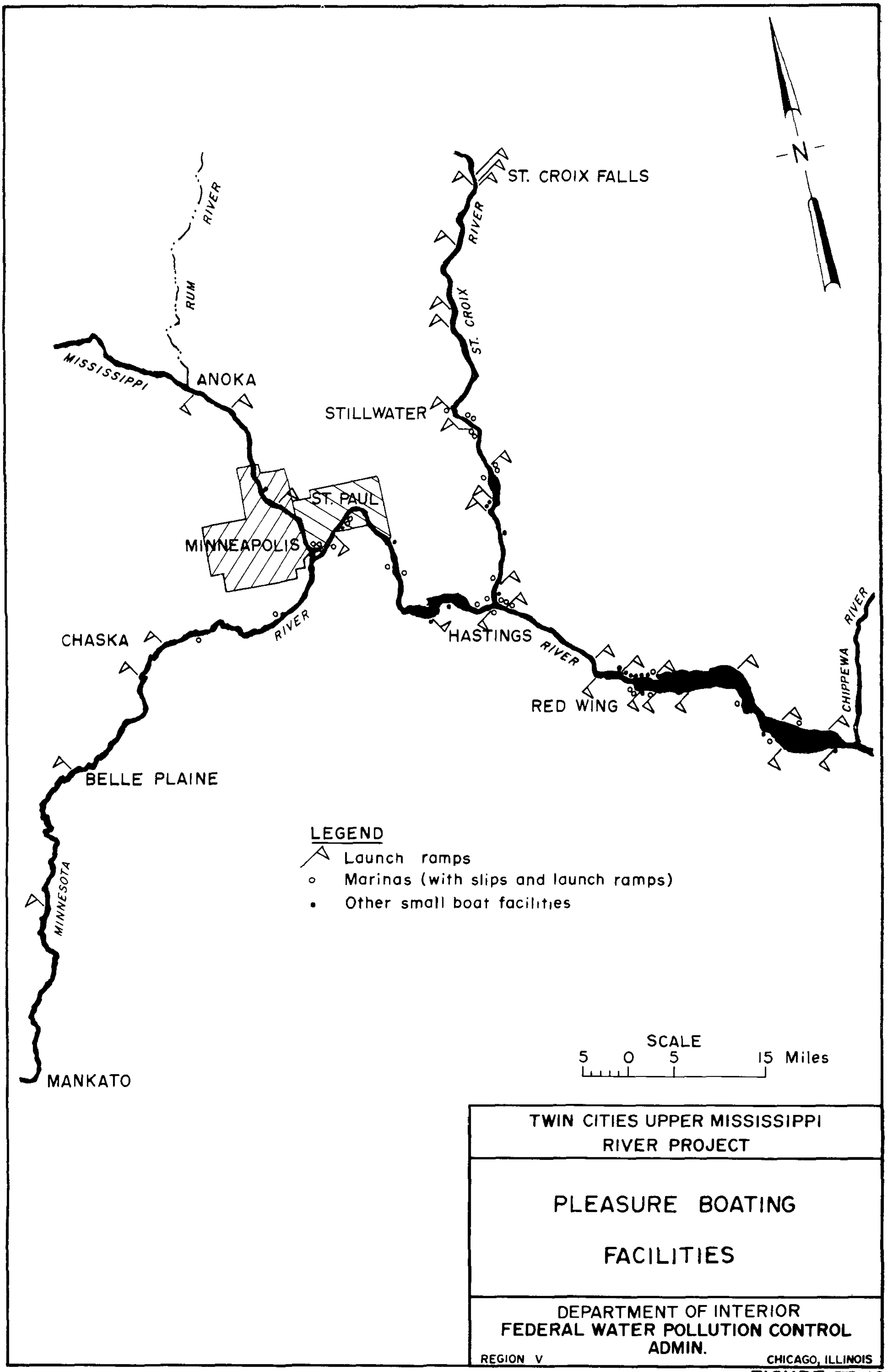


FIGURE III-12

Above Shakopee the river is used more for canoeing than for motor boating. This reach has no maintained channel and during periods of low flow, occasional sand bars present problems to the motor boats. Even so, a regatta is held annually during the summer months from New Ulm (river mile 142) to Bloomington (river mile 10) in which approximately 150 motor boats participate without undue difficulty.

To improve boating conditions the 1961 Minnesota legislature appropriated approximately $20,000 for channel clearing and removal of snags between Shakopee and New Ulm. In 1963, the appropriations for snag clearance were doubled (15).

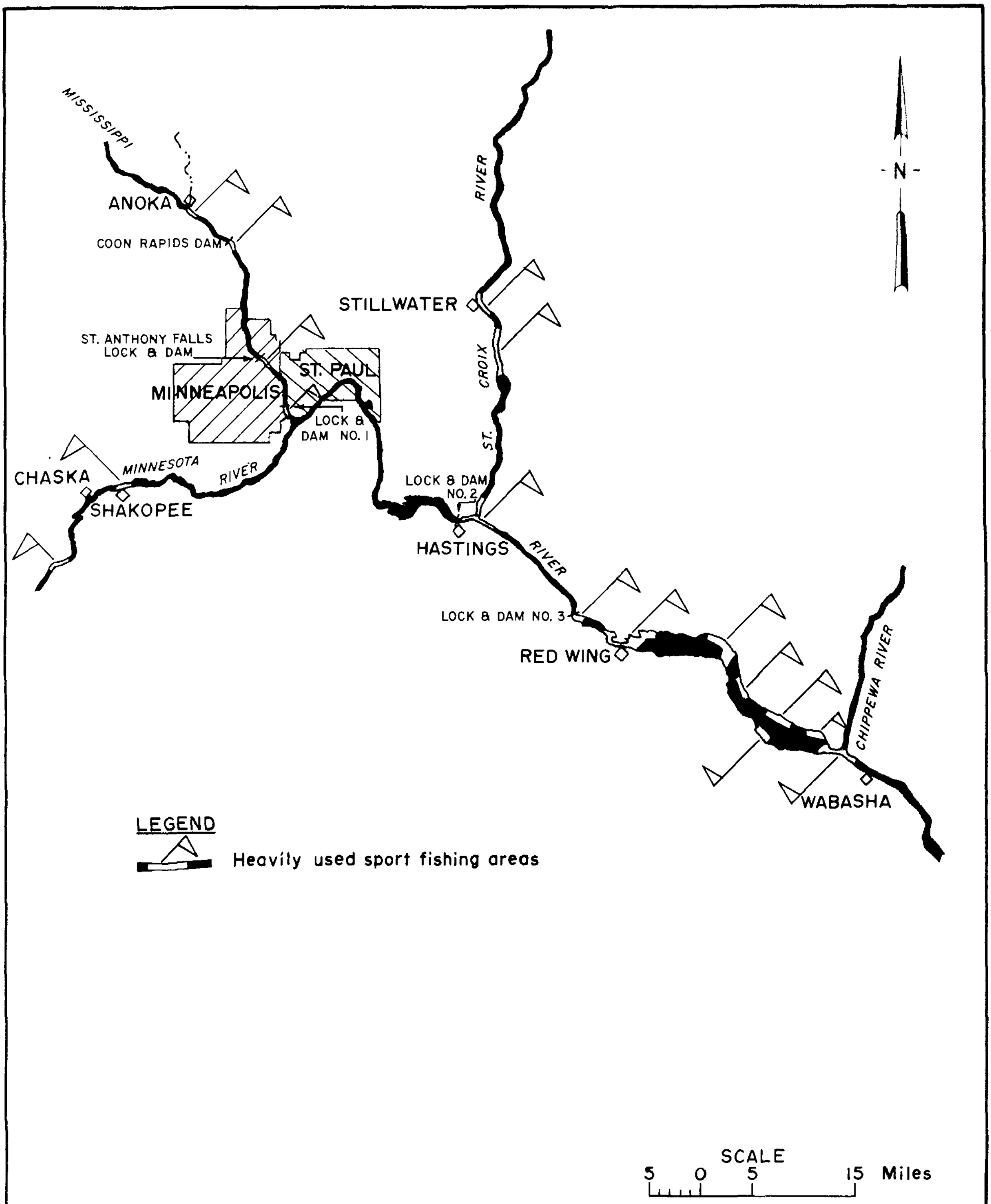
St. Croix River. Boating is very popular on the St. Croix River below Taylors Falls, Minnesota. In 1963 there were reportedly 4,378 boaters who launched their crafts in this reach. By 1975 this number is expected to increase by 55 percent to 6,800 (16). To accomodate the boaters there are 13 launching ramps, 10 marinas, and 4 other facilities in this reach (see Figure III-12).

Canoeing is also popular on the St. Croix River, especially between Taylors Falls and Stillwater. No figures are available, however, on the number of canoeists.

Sport Fishing

Fishing is an important summer as well as winter recreational activity in the area under consideration. The St. Croix River and the Mississippi River below its confluence with the St. Croix receive the greatest use although fishing is practiced to some extent over the entire area. Figure III-13 indicates where sport fishermen generally concentrate.

Mississippi River. The Minnesota Department of Conservation conducts



TWIN CITIES UPPER MISSISSIPPI
RIVER PROJECT

AREAS RECEIVING HEAVIEST
USE BY
SPORT FISHERMEN

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL
ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-13

aerial flights several times a year to make counts of fishermen. The average numbers found per flight in Pools 3 and 4 during the summer for the period 1956-1964 were 29 and 385, respectively. The average numbers found per flight during the winter for the same period were 26 and 142, respectively. In Pool No. 3, between 20 and 30 ice houses were found in use during the winter over this same period. Approximately 100 ice houses can be found on Lake Pepin on a typical winter day (14).

The Corps of Engineers, over the past several years, has been making once-daily counts of fishermen in boats and ashore visible from locks and dams. Highest counts are generally made between May and September as illustrated in Table III-13, which gives monthly totals for 1964 at each lock and dam. Yearly totals for the 1961-1964 period are given in Table III-14.

Although most sport fishing on the Mississippi River is done at and below the mouth of the St. Croix, the data indicate that significant numbers of fishermen do utilize the river above this point.

Surveys conducted by the Upper Mississippi River Conservation Committee and the Minnesota and Wisconsin Conservation Departments indicate that the sport fish harvest for Pools 1 and 2 is negligible. The reported average annual catches for Pools 3 and 4 are 8,000 and 73,000 pounds, respectively (14).

Minnesota River. Fishing in the Minnesota River is considered mediocre and is not extensive. However, game fish are present and some sport fishing, principally for catfish and walleye pike, is done. The reach in the vicinity of Carver Rapids is visited more often by fishermen interested in catfish. Some fishermen can be found almost anywhere along the entire reach, however.

TABLE III-13

NUMBER OF FISHERMEN VISIBLE FROM LOCKS AND DAMS[1]
DURING 1964

MONTH	LOCK AND DAM							
	St. Anthony Falls		No. 1		No. 2		No. 3	
	ASHORE	AFLOAT	ASHORE	AFLOAT	ASHORE	AFLOAT	ASHORE	AFLOAT
January	4	0	0	0	0	0	27	5
February	15	0	5	0	0	0	14	24
March	23	0	9	3	0	0	0	7
April	132	0	3	5	12	0	0	12
May	422	3	177	29	44	0	9	230
June	310	3	173	35	51	16	35	177
July	582	6	299	93	19	6	53	179
August	270	2	136	45	25	18	48	182
September	236	6	56	28	20	9	44	151
October	66	0	38	6	5	3	34	975
November	37	0	35	5	0	0	13	586
December	0	0	4	0	0	0	13	12
TOTAL	2097	20	935	249	176	52	290	2540

Note: Counts were made daily at 3:00 p.m.

1. Information obtained by Corps of Engineers and presented in the Proceedings of the Twenty-First Annual Meeting of the Upper Mississippi River Conservation Committee, 1965, pp. 83 & 84.

TABLE III - 14

ANNUAL NUMBER OF FISHERMEN VISIBLE FROM LOCKS AND DAMS[1]
1961 - 1964

YEAR	LOCK AND DAM							
	St. Anthony Falls		No. 1		No. 2		No. 3	
	ASHORE	AFLOAT	ASHORE	AFLOAT	ASHORE	AFLOAT	ASHORE	AFLOAT
1961	2606	47	1262	457	264	50	89	3195
1962	2762	5	1110	427	301	22	66	2667
1963	2534	20	1477	401	169	36	69	2527
1964	2097	20	935	249	176	52	29	2540

Note: Counts were made daily at 3 p.m.

(1) Information obtained from Corps of Engineers and presented in the Proceedings of the Eighteenth through the Twenty-First Annual Meetings of the Upper Mississippi River Conservation Committee.

According to the Minnesota Department of Conservation, the proportion of game fish to the total number of fish in the Minnesota River is rather low. Between the River's mouth and Shakopee game fish make up less than 10 percent of the population. Between Shakopee and Henderson, less than 20 percent are game fish (15).

St. Croix River. Fishing on the St. Croix River is good along the entire reach under consideration. The portion from Stillwater to the mouth, known as Lake St. Croix, however, receives the greatest use. This segment is more convenient to the center of population and also harbors larger numbers of fish because of its greater depth.

Lake St. Croix, like Lake Pepin, is very popular with winter fishermen. In February 1964 for instance, the Minnesota Department of Conservation counted 120 fish houses on the Lake (17).

Esthetic Enjoyment

The scenic beauty afforded by the streams in this area has resulted in the location of many parks along their banks (see Figure III-14). The two parks receiving greatest use are located on the St. Croix River. They are the Interstate and O'Brien State Parks. Attendance figures for 1961 were 246,720 and 61,340, respectively (16). By the year 2000 with a metropolitan area population of 4,000,000, the St. Croix River is expected to be a playground for at least 50 percent of Minnesota's population.

In addition to the existing scenic highways that border on the streams under consideration, there is a plan to construct the Great River Road as a national parkway generally following the course of the Mississippi River on both sides from Canada to the Gulf of Mexico. Plans for this scenic route are being developed by the States with assistance from the U.S. Bureau of

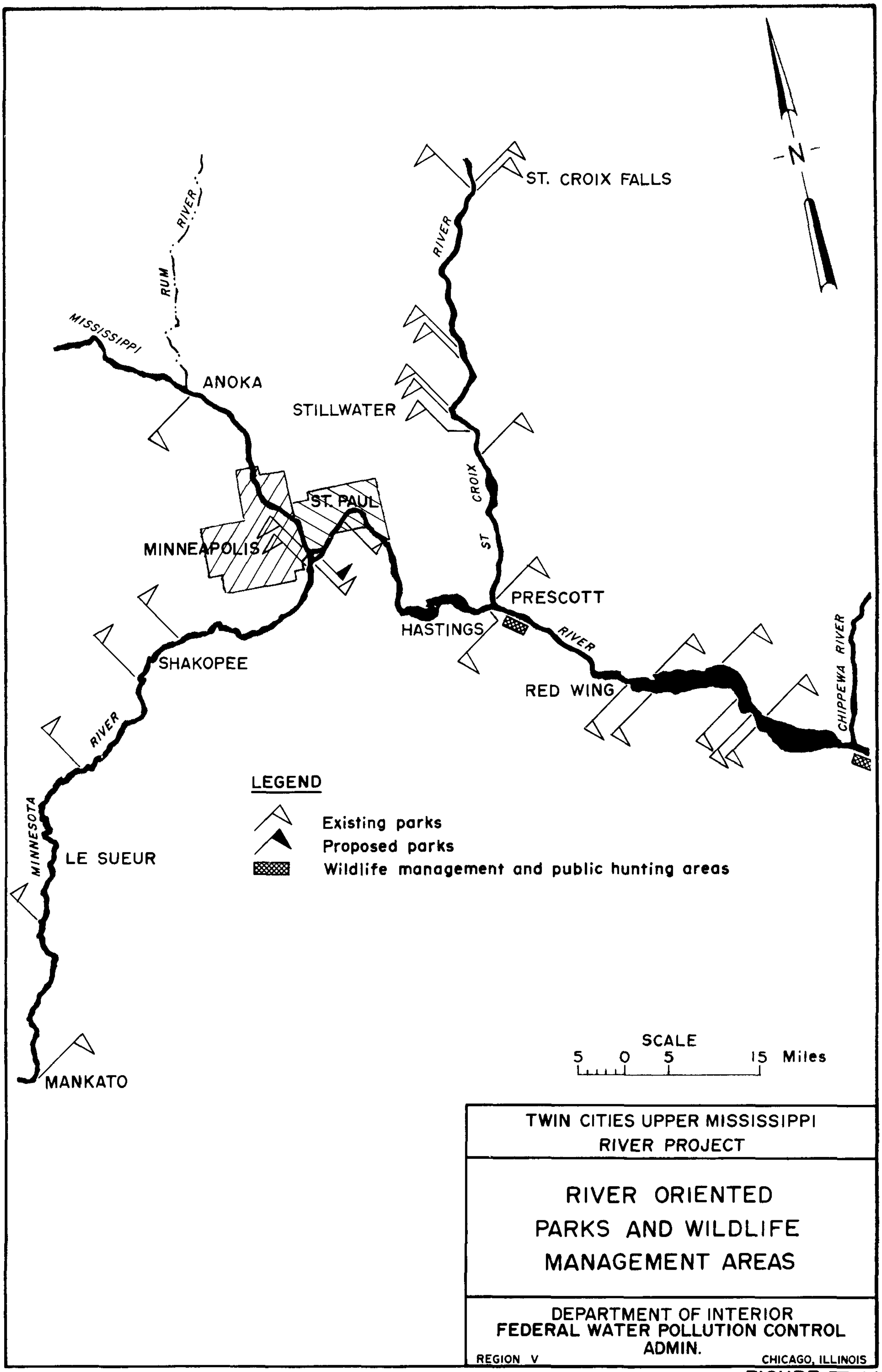


FIGURE III-14

Public Roads. Some of the existing highways, where suitable, have become a part of this system. Other portions are being constructed as plans are completed and funds become available.

Future Recreational Needs

The greatest population increase in this area over the next few decades is expected to center around the Twin Cities. The seven-county metropolitan area population is expected to more than double in the next 30 years. Along with this striking growth, a very marked increase in recreational demands can be expected. Greater demands for recreational usage will certainly be exerted on all three of the major streams as well as on the numerous lakes in the area.

Heaviest use will probably be centered around Lake St. Croix and Lake Pepin since they excel in natural scenic beauty and have shorelines more suitable for the development of bathing beaches. This is in addition to their already existing fine fishing and boating qualities. Canoeists will probably make greatest use of the St. Croix River above Stillwater and the Minnesota River above Shakopee. Pleasure boaters, fishermen, and park enthusiasts can be expected to make greater use of the entire length of all three major streams within the area under consideration.

AQUATIC LIFE

Fish

As indicated previously in sections on commercial and sport fishing, fish can be found in varying numbers and species over the entire length of each stream under consideration. Tables III-15 and III-16 list the species of game and rough fish, respectively, found in the three major streams being studied.

Game fish make up a relatively small percentage of the fish population in the Minnesota River and in a good portion of the Mississippi River (see Table III-17). In the Minnesota River, only 7 to 17 percent are game fish. In the Mississippi's Pool No. 2 only 20 percent of the fish are of the game species. By comparison, game species in Pools 4 and 5 make up 68 and 74 percent, respectively, of the total fish population.

Game and Wildfowl

There is one Wildlife Management and Public Hunting Area within the study area and another one immediately below it (see Figure III-14). The one within the study area is located on the bottom lands of Pool 3 and is influenced by the Mississippi. It is the Gores-Pool 3 Unit which contains 5,430 acres. It is estimated that several thousand hunting enthusiasts make use of this facility yearly.

The Upper Mississippi River Wildlife and Fish Refuge, covering approximately 195,000 acres, extends some 284 miles immediately below the outlet of Lake Pepin. Activities include fishing, hunting, boating, picnicking, camping, and swimming. Although not in the area specifically under review, this major wildlife resource is dependent on good water quality. Each year more than 3 million visitors are accommodated at the refuge.

TABLE III-15

COMMON SPECIES OF GAME FISH IN THE STREAMS UNDER CONSIDERATION[1]

SPECIES	MISSISSIPPI RIVER					MINNESOTA RIVER			St. Croix River
	Rum River to St. Anthony Falls	Pool No. 1	Pool No. 2	Pool No. 3	Pool No. 4	River Mile 110 to 70	River Mile 70 to 25	River Mile 25 to 0	
Walleyed Pike	X	(List is incomplete)	X	X	X	X	X		X
Sauger			X	X	X	X	X		X
Northern Pike	X		X	X	X	X	X		X
Black Crappie	X		X	X	X	X	X	X	X
White Crappie				X	X	X	X	X	
Largemouth Bass			X		X	X	X		
Smallmouth Bass	X	X			X	X	X		X
Rock Bass	X		X		X				X
White Bass				X	X	X	X		X
Bluegill	X		X	X	X				X
Channel Catfish			X	X	X	X	X	X	X
Sturgeon					X				X
Flathead Catfish				X	X	X	X	X	X
Green Sunfish			X						
Pumpkinseed Sunfish	X								X
Brown Trout									X

Note: This is not necessarily a complete list.

1. Composite list from:
   A. Minnesota Department of Conservation, Division of Game and Fish.
   B. Wisconsin Department of Conservation, Surface Water Resources of St. Croix County by L. M. Sather and C. W. Threinen (Madison, 1961).

TABLE III-16

COMMON SPECIES OF ROUGH FISH IN THE STREAMS UNDER CONSIDERATION[1]

SPECIES	MISSISSIPPI RIVER					MINNESOTA RIVER			St. Croix River
	Rum River to St. Anthony Falls	Pool No. 1	Pool No. 2	Pool No. 3	Pool No. 4	River Mile 110 to 70	River Mile 70 to 25	River Mile 25 to 0	
Carp	X	X	X	X	X	X	X	X	X
Quillback						X	X		X
Sheepshead		X	X	X	X			X	X
Brown Bullhead					X				X
Bigmouth Buffalo	X		X	X	X		X	X	X
Northern Carpsucker				X	X		X	X	
Northern Redhorse	X	X	X	X	X	X	X		X
Longnose Gar				X	X				X
Shortnose Gar		(List is incomplete)	X	X	X		X	X	X
Bowfin			X		X				
Mooneye			X	X	X				X
Gizzard Shad			X	X	X		X	X	
Common Sucker	X		X	X	X		X	X	X
Spotted Sucker					X				
Yellow Bullhead	X								
Black Bullhead	X				X				
Golden Shiner				X	X				
Perch			X		X				X
River Sucker			X						

Note: This is not necessarily a complete list.

1. Composite list from:
   A. Minnesota Department of Conservation, Division of Game and Fish.
   B. Wisconsin Department of Conservation, Surface Water Resources of St. Croix County by L. M. Sather and C. W. Threinen (Madison, 1961).

TABLE III-17

PERCENT GAME SPECIES IN TOTAL FISH POPULATION

RIVER	PERCENT GAME FISH
Mississippi	
Coon Rapids Dam Pool	12
St. Anthony Falls Pool	28
Pool 2	20
Pool 3	46
Pool 4	68
Minnesota	
River Mile 110-70	13
River Mile 70-25	17
River Mile 25-0	7

Data composited from following sources:

1. Game and Fish Values of the Mississippi River between Rum River at Anoka and the Chippewa River below Lake Pepin, State of Minnesota Department of Conservation, Division of Game and Fish, 1964.

2. A Fisheries Survey of the Minnesota River, Mankato to Mouth, State of Minnesota Department of Conservation, Division of Game and Fish, 1959.

3. Electro-Fishing Survey of the Upper Mississippi River Near Elk River, Minnesota, State of Minnesota Department of Conservation, Division of Fish and Game, 1961.

The Mississippi River Valley is a major artery in the continental system of flyways serving the wildfowl migrations. Each year thousands of ducks, geese, and other migratory birds make their annual trek to and from the north lands using the Mississippi River as a way station in their travels. Pools 2, 3, and 4 are spring and fall concentration areas for diving ducks, particularly scaup, ringnecked ducks, and goldeneyes. During periodic surveys, conducted by the Bureau of Interior and the respective State Conservation Departments, several thousand ducks have been seen in this reach. As many as 10,000 ducks at a time have been seen in the Spring Lake area. The entire river is a suitable wood duck breeding habitat and substantial numbers are produced. Other breeding waterfowl include mallard and blue-winged teal.

Fish, ducks, and other aquatic life will continue to inhabit these waters as long as the water quality permits it. In general, the better the water quality the greater will be the number of desirable species.

WASTE WATER DISPOSAL

General

There are 59 significant waste water contributors to the major streams within the study area (see Figure III-15). Their discharges total 1,768 mgd. The steam-electric generating plants contribute 85 percent of this amount. Municipalities and industries contribute 12 and 3 percent, respectively. In addition to the above contributors there are more than 100 combined and storm sewer outfalls which discharge during and immediately after rains. Approximately 80 of these are located in Minneapolis and St. Paul.

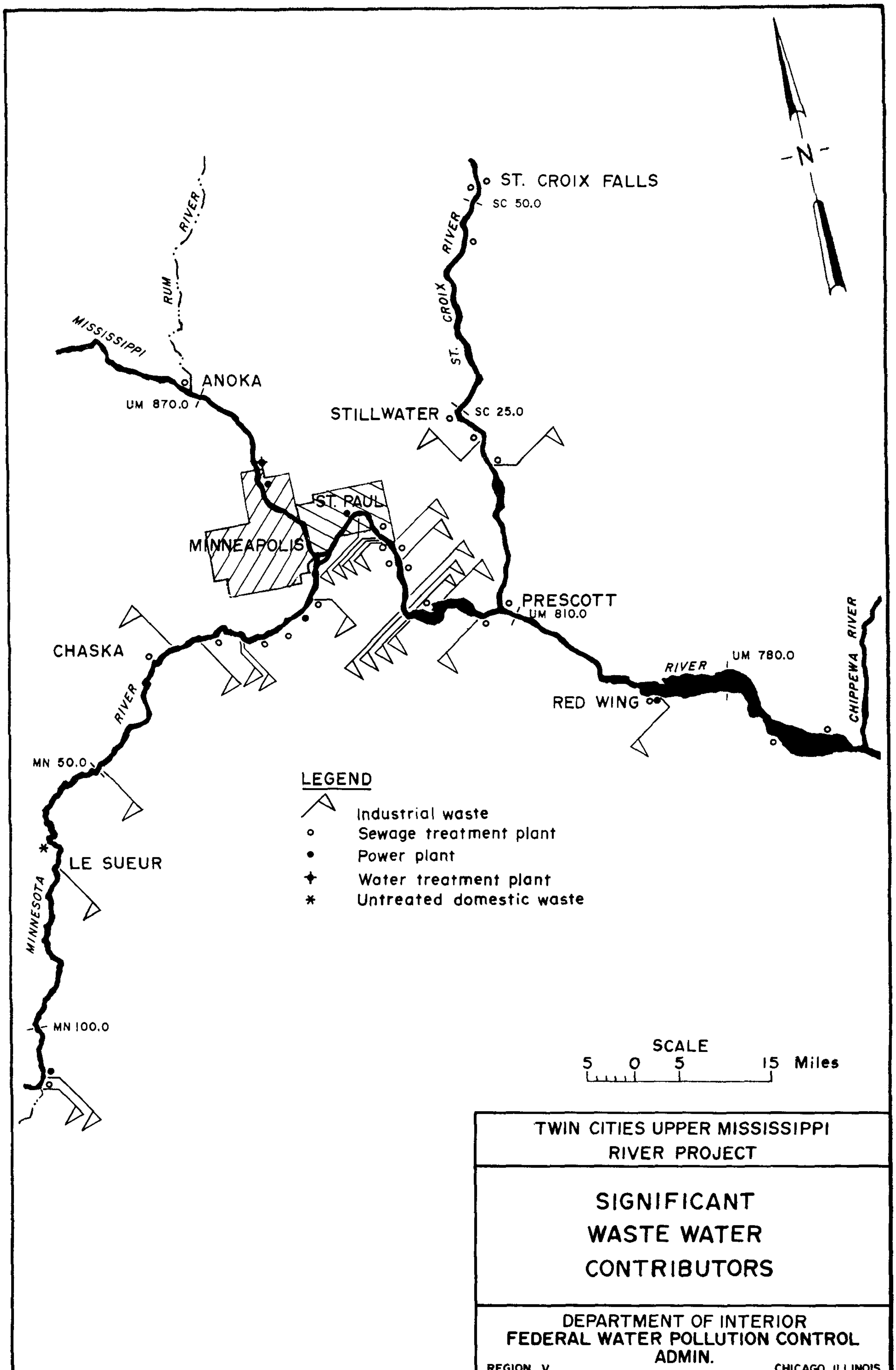


FIGURE III-15

Mississippi River

On the Mississippi River there are 32 significant contributors, 12 of which are sewage treatment plants (see Table III-18). Of the 1,336 mgd discharged to the Mississippi, 15.5 percent are emitted by sewage treatment plants. The three steam-electric generating plants discharge by far the largest amount, a maximum of 1,096 mgd or 82 percent. Industries contribute about 2 percent of the total.

Minnesota River

There are 19 significant contributors of waste water to the Minnesota River (see Table III-19). Their discharges total 429 mgd, 94 percent of which is cooling water from the two power plants. Municipalities contribute 6.1 mgd or about 1.5 percent of the total. Industries contribute 18.3 mgd or about 4.3 percent.

St. Croix River

In comparison to the other two streams, the St. Croix River receives a relatively small amount of wastes (see Table III-20). A total of 3.60 mgd of waste water is discharged into the 54 miles of river under consideration. Of this amount 3.09 mgd, or 86 percent, of it are contributed by municipalities. The remaining 14 percent is contributed by two industries.

Future Waste Discharges

As discussed in Section I, it is expected that the greatest economic and population growth along the Upper Mississippi River will be centered in and around the Twin Cities area. Toltz et al divided the metropolitan area into five regions (see Figure III-16) and estimated the average annual sewage flows expected from each at various future dates (18) (19). This information has been revised and is summarized in Table III-21. The sewage

TABLE III-18

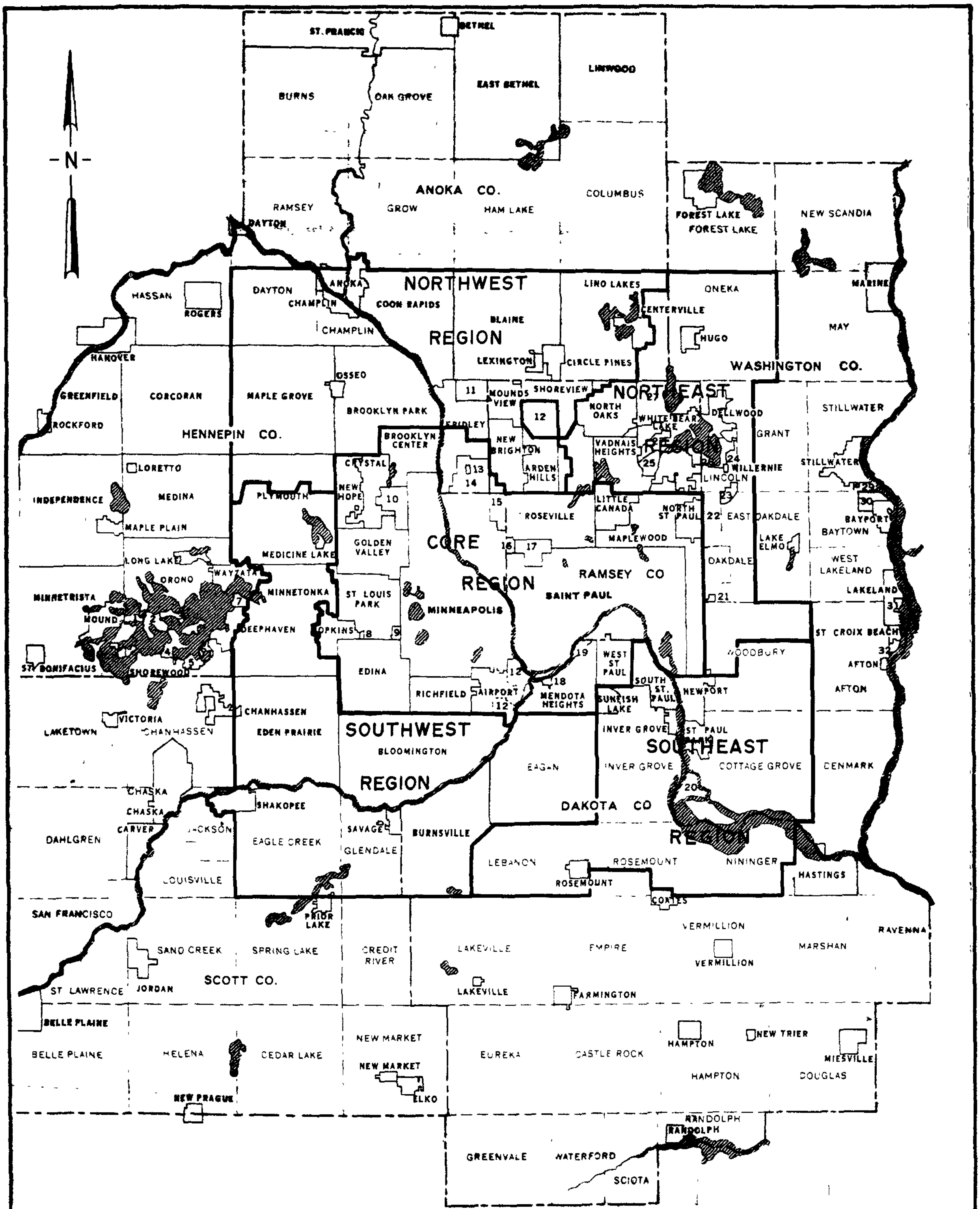
MAJOR WASTE WATER CONTRIBUTORS TO MISSISSIPPI RIVER

WASTE WATER CONTRIBUTOR	RIVER MILE	DISCHARGE RATE 1000 GAL/DAY
Anoka Sewage Treatment Plant	871.5	957
Cornelius Manufacturing Company (Rum R. 0.8)	871.4	125
Minneapolis Water Treatment Plant	858.7	2,300
NSP Riverside Steam-Electric Generating Plant	856.9	592,560 (Max.)
NSP High Bridge Steam-Electric Generating Plant	840.5	449,280 (Max.)
Minneapolis-St. Paul Sanitary District Sewage Treatment Plant	836.3	188,600
Swift and Company	833.4	5,000
Union Stockyards	833.2	2,000
Armour and Company	833.0	2,400
King Packing Company	832.5	1,730
So. St. Paul Sewage Treatment Plant	832.4	14,170
Newport Sewage Treatment Plant	831.0	58
Inver Grove Sewage Treatment Plant	830.3	20
Northwestern Refining Company	830.0	1,440
St. Paul Park Sewage Treatment Plant	829.0	350
J. L. Shiely Company-Larson Plant	826.5	1,440
J. L. Shiely Company-Nelson Plant	825.0	8,640
General Dynamics-Liquid Carbonic Division	824.2	698
St. Paul Ammonia Products Company	824.2	655
Great Northern Oil Company	824.0	3,230
Northwest Cooperative Mills	823.8	46
Cottage Grove Sewage Treatment Plant	819.6	425
Minnesota Mining and Manufacturing Company	817.2	5,760
Hudson Manufacturing Company	814.2	0.6
Hastings Sewage Treatment Plant	813.8	800
Prescott Sewage Treatment Plant	809.8	135
S. B. Foot Tanning Company	792.8	1,030
Pittsburgh Plate Glass Company	790.7	1,000
Red Wing Sewage Treatment Plant	790.2	2,200
NSP Red Wing Steam-Electric Generating Plant	789.4	53,860 (Max.)
Lake City Sewage Treatment Plant	772.6	260
Pepin Sewage Treatment Plant	767.2	54

TABLE III-19

MAJOR WASTE WATER CONTRIBUTORS TO MINNESOTA RIVER

WASTE WATER CONTRIBUTOR	RIVER MILE	DISCHARGE RATE 1000 GAL/DAY
Honeymead Products Company	109.2 (Blue Earth 0.6)	4,300
Mankato Sewage Treatment Plant	106.5	4,540
Archer Daniels Midland Company	106.0	42
Blue Cross Rendering Company	105.5	94
NSP Wilmarth Power Plant	105.2	33,120 (Max.)
Green Giant Company	75.4	230
City of Henderson	70.0	40
Minnesota Valley Milk Producers Cooperative Association	49.8	270
Chaska Sewage Treatment Plant (includes Gedney Company Wastes)	29.4	460
American Crystal Sugar Company	27.7	7,000
Rahr Malting Company	25.4	2,800
Shakopee Sewage Treatment Plant	23.9	311
Owens-Illinois Forest Products	20.9	20
American Wheaton Glass Company	20.7	200
Savage Sewage Treatment Plant	14.4	215
Cargill, Inc.	13.4	3,320
Burnsville Sewage Treatment Plant	10.5	510
NSP Blackdog Power Plant	8.4	371,520 (Max.)
Cedar Grove Sewage Treatment Plant	7.3	90



SCALE

0 5 10 20 Miles

Courtesy of Minneapolis St. Paul Sanitary District

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

GREATER MINNEAPOLIS - ST. PAUL AREA

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V — CHICAGO, ILLINOIS

FIGURE III-16

TABLE III - 20

MAJOR WASTE WATER CONTRIBUTORS TO ST. CROIX RIVER

WASTE WATER CONTRIBUTOR	RIVER MILE	DISCHARGE RATE 1000 GAL/DAY
St. Croix Falls Sewage Treatment Plant	51.9	180
Taylors Falls Sewage Treatment Plant	51.8	70
Osceola Sewage Treatment Plant	44.3	97
Stillwater Sewage Treatment Plant	21.2	1,786
Andersen Window Company	20.2	446
Bayport Sewage Treatment Plant	19.4	400
United Refrigerator Company	16.5	59
Hudson Sewage Treatment Plant	16.3	560

TABLE III - 21

ESTIMATED FUTURE SEWAGE FLOWS IN
GREATER MINNEAPOLIS-ST. PAUL AREA

REGION	AVERAGE ANNUAL SEWAGE CONTRIBUTION, MGD				
	1965	1970	1980	1990	2000
Northwest	5.7	10.6	20.9	48.0	70.0
Northeast	1.0	3.2	7.5	11.2	30.9
Core	187.6	191.0	206.0	220.0	234.0
Southwest	9.1	17.6	33.9	59.5	82.8
Southeast	29.1	32.2	39.0	43.9	48.8
TOTAL	232.5	254.6	307.3	382.6	486.5

Note: This information is a composite and reevaluation from the following sources:

1. Report on the Expansion of Sewage Works in the Minneapolis-St. Paul Metropolitan Area, Volume Three, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by Toltz, King, Duvall, Anderson and Associates, Inc. 1960.

2. Report on Comprehensive Sewage Works Plan for the Minneapolis-St. Paul Metropolitan Area, by Toltz et al Consulting Engineers, May 1964.

3. Tables III-18 and III-19 of this report.

flows listed include contributions from all residential, commercial, and industrial sources with the exception of cooling water discharges.

By the year 2000 the volume of sewage contributed by the five regions listed is expected to be more than double its present value. Present plans call for the transport of practically all sewage from all regions, except the southeast one, to the Minneapolis-St. Paul Sanitary District plant where it would be treated and discharged to the Mississippi River at that point. At present the District plant treats sewage from the core region and a small portion of the northeast region.

In addition to the above anticipated future waste sources, the location of a steel mill has been proposed for an area adjacent to the Minneapolis-St. Paul Sanitary District (MSSD) sewage treatment plant.

Future needs regarding steam-electric generating plants have already been discussed under "Cooling Water".

SUMMARY OF PRESENT WATER USES

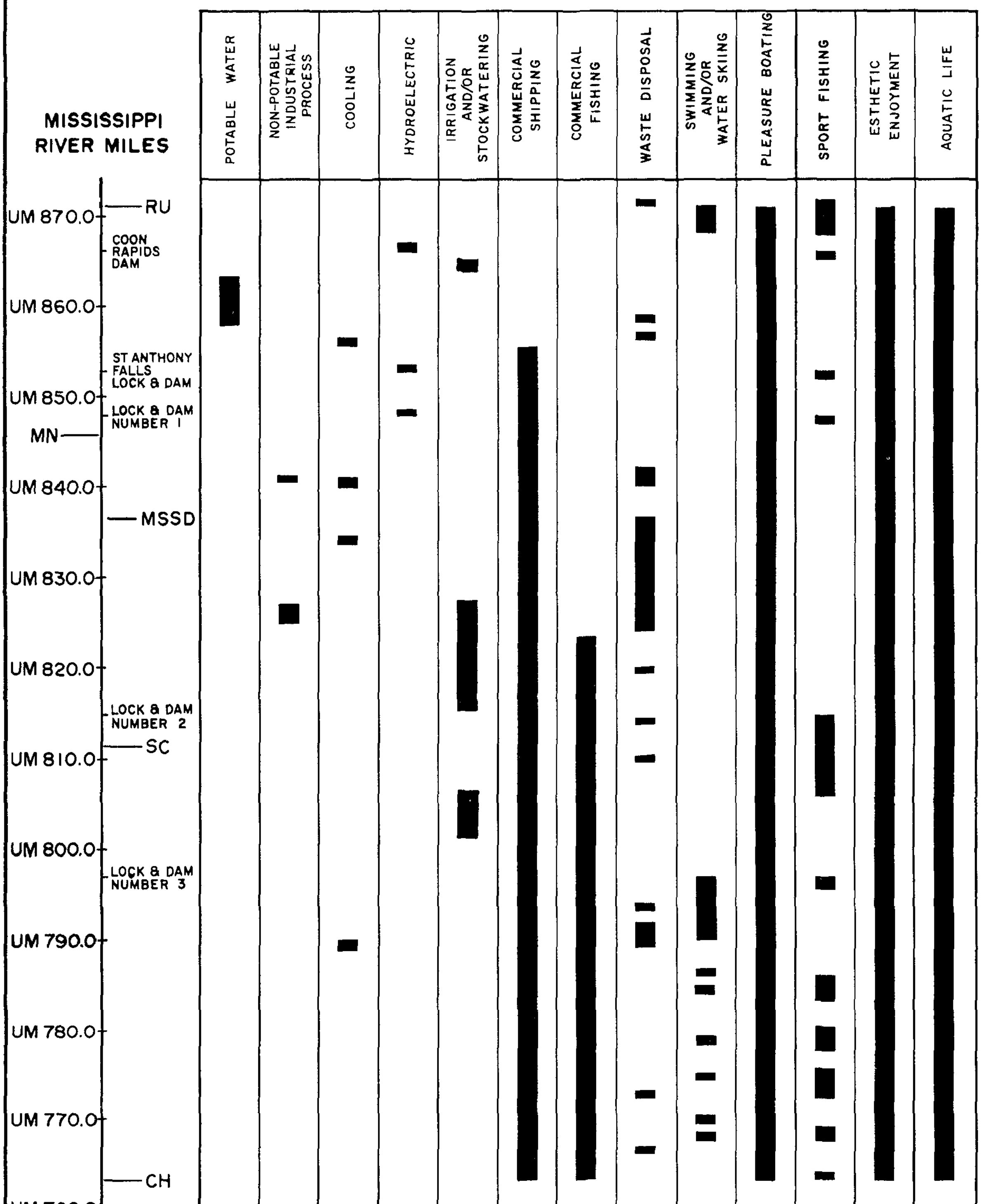
Mississippi River (See Figure III-17)

Rum River to St. Anthony Falls. The primary uses of the Mississippi River between the Rum River and St. Anthony Falls at this time are as a raw water supply for the cities of Minneapolis and St. Paul, a source and sink of cooling water, for esthetic enjoyment by neighboring property owners, and the maintenance of aquatic life. The Minnesota Water Pollution Control Commission (MWPCC) has classified this reach to be used primarily ..."as a source of public water supply for drinking, food processing, and related purposes" (20).

They consider the following as suitable secondary uses: "...industrial processing and cooling, navigation, pleasure boating, fishing, bathing, swimming, and other recreational uses, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health". The suitable secondary uses as listed by the MWPCC generally agree with actual water use practices in this reach (see Figure III-17).

St. Anthony Falls to MSSD. The primary uses of this reach at the present are as a source and sink of cooling water, for commercial shipping, pleasure boating, esthetic enjoyment, and the maintenance of aquatic life. The MWPCC has classified this reach to be used primarily for "...pleasure boating, fishing, and other recreational uses, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health" (21).

Present secondary uses include sport fishing, hydroelectric power generation, and barge washing. The MWPCC considers this reach as also being



LEGEND

RU Rum River
MN Minnesota River
SC St. Croix River
CH Chippewa River
MSSD Minneapolis - St. Paul Sanitary District

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PRESENT WATER USES ALONG THE MISSISSIPPI RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-17

suitable "... for navigation, general industrial purposes, and other beneficial uses for which water of lower quality may be suitable, provided the effects do not actually or potentially conflict with the ..." primary uses stated above.

MSSD to L&D No. 2. At present the primary uses of this reach are waste disposal, commercial shipping, pleasure boating, esthetic enjoyment, and maintenance of aquatic life. The MWPCC has classified it to be used primarily "... for industrial processes, general cooling water, stock and wild life watering, restricted irrigation, disposal of treated sewage and waste effluents, fish survival, esthetic enjoyment of river scenery, and passage of watercraft in connection with navigation and pleasure boating in such manner as to avoid close, frequent, or prolonged contact with the water" (22).

Present secondary uses include industrial use for cooling and gravel washing, irrigation and stockwatering, and some commercial fishing. Practically no sport fishing is carried out since carp is the predominant species in this reach. The Commission does not specify any secondary uses but states that the waters are suitable for the primary uses which they listed and for the "... survival or passage of game fish of species commonly inhabiting waters of the vicinity under natural conditions, and for disposal of treated sewage and industrial waste effluents for which no other means of disposal is available. Treatment of the waters may be necessary for some industrial uses" (22).

Pool No. 3. The primary water uses in Pool 3 are commercial shipping, pleasure boating, commercial and sport fishing, esthetic enjoyment, and maintenance of aquatic life.

Waste disposal can be considered a secondary use since only two communities discharge wastes (after treatment) to this reach.

All except the upper four miles of this pool are interstate waters between Minnesota and Wisconsin and neither State has classified water uses for the river below Lock and Dam No. 2.

L&D No. 3 to Chippewa River. Primary uses in this reach include swimming, water skiing, sport and commercial fishing, commercial shipping, esthetic enjoyment, and maintenance of aquatic life.

Secondary uses include a source and sink for cooling water and waste disposal. There are two industries, one steam-electric generating plant, and three municipalities discharging to this reach.

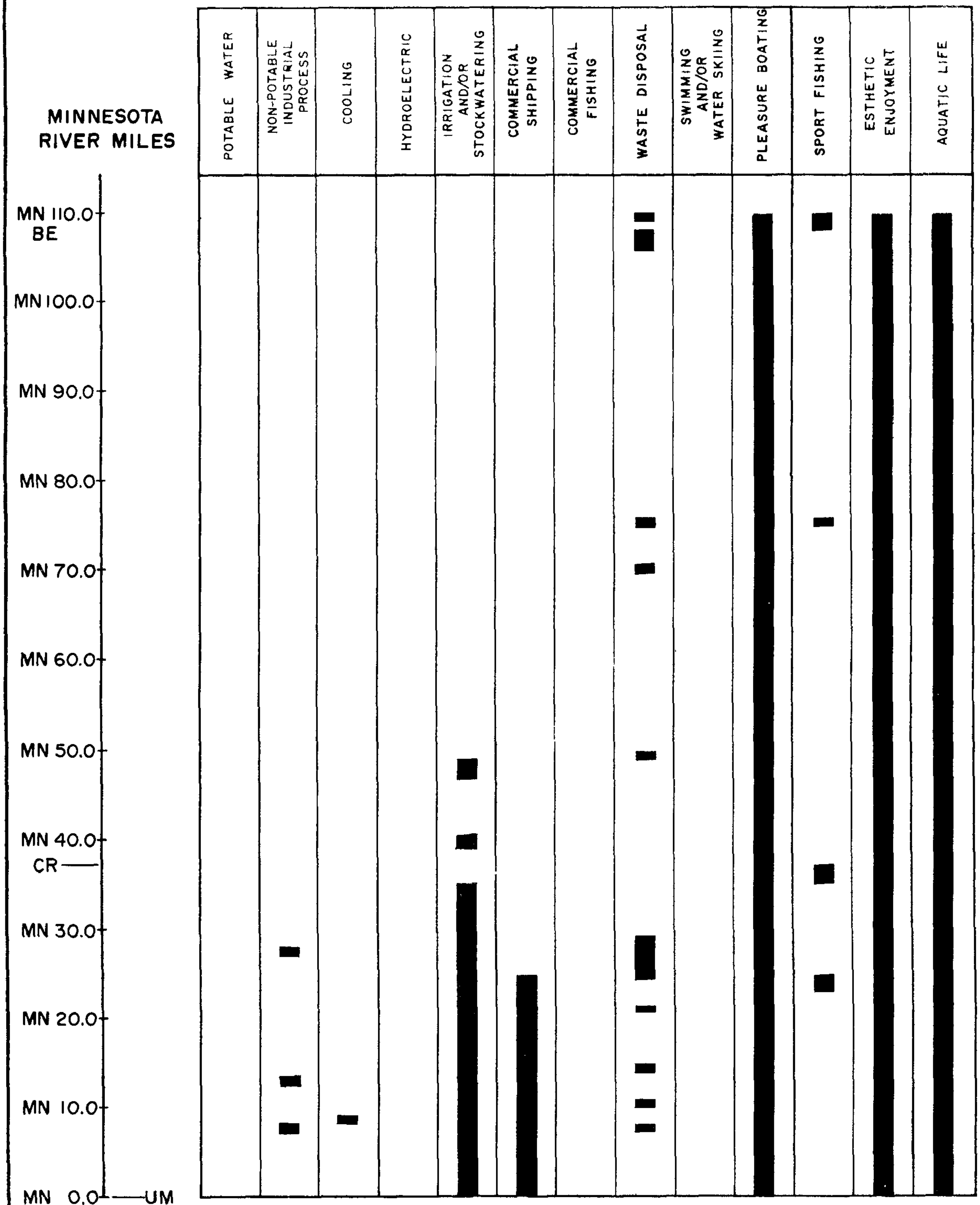
Minnesota River (See Figure III-18)

Blue Earth River to Carver Rapids. The primary uses of this sparsely developed reach of the Minnesota River are as a source and sink for cooling water, for waste disposal, esthetic enjoyment, and maintenance of aquatic life.

Secondary uses of this reach include stockwatering, sport fishing, canoeing, and some pleasure boating.

Carver Rapids to River Mile 22.3. The primary uses of this reach at the present are for waste disposal, esthetic enjoyment, and maintenance of aquatic life. The MWPCC has proposed that its present or potential primary uses be "... fishing, recreational boating, esthetic enjoyment, irrigation, stockwatering, wildlife, and disposal of treated sewage and waste effluents" (23).

Secondary uses at this time include sport fishing, canoeing, pleasure boating, some irrigation, a source of sugar beet wash water, and com-



LEGEND
BE Blue Earth River
CR Carver Rapids
UM Mississippi River

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PRESENT WATER USES ALONG THE MINNESOTA RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

GPO 828-545-B-4

FIGURE III-18

mercial shipping along the lower three miles. The Commission proposed that secondary uses include navigation or general industrial purposes or any other beneficial uses for which the waters may be suitable.

River Mile 22.3 to Mouth. The primary uses of this portion of the Minnesota River are commercial shipping, a source and sink for cooling water, waste disposal, esthetic enjoyment, and maintenance of aquatic life. The Commission has proposed that this reach be used primarily for "... pleasure boating, water skiing, fishing, swimming, and other recreational uses, subject to such restrictions on any such uses which involve close, frequent, or prolonged contact with the water as may be necessary for protection of public health". (24).

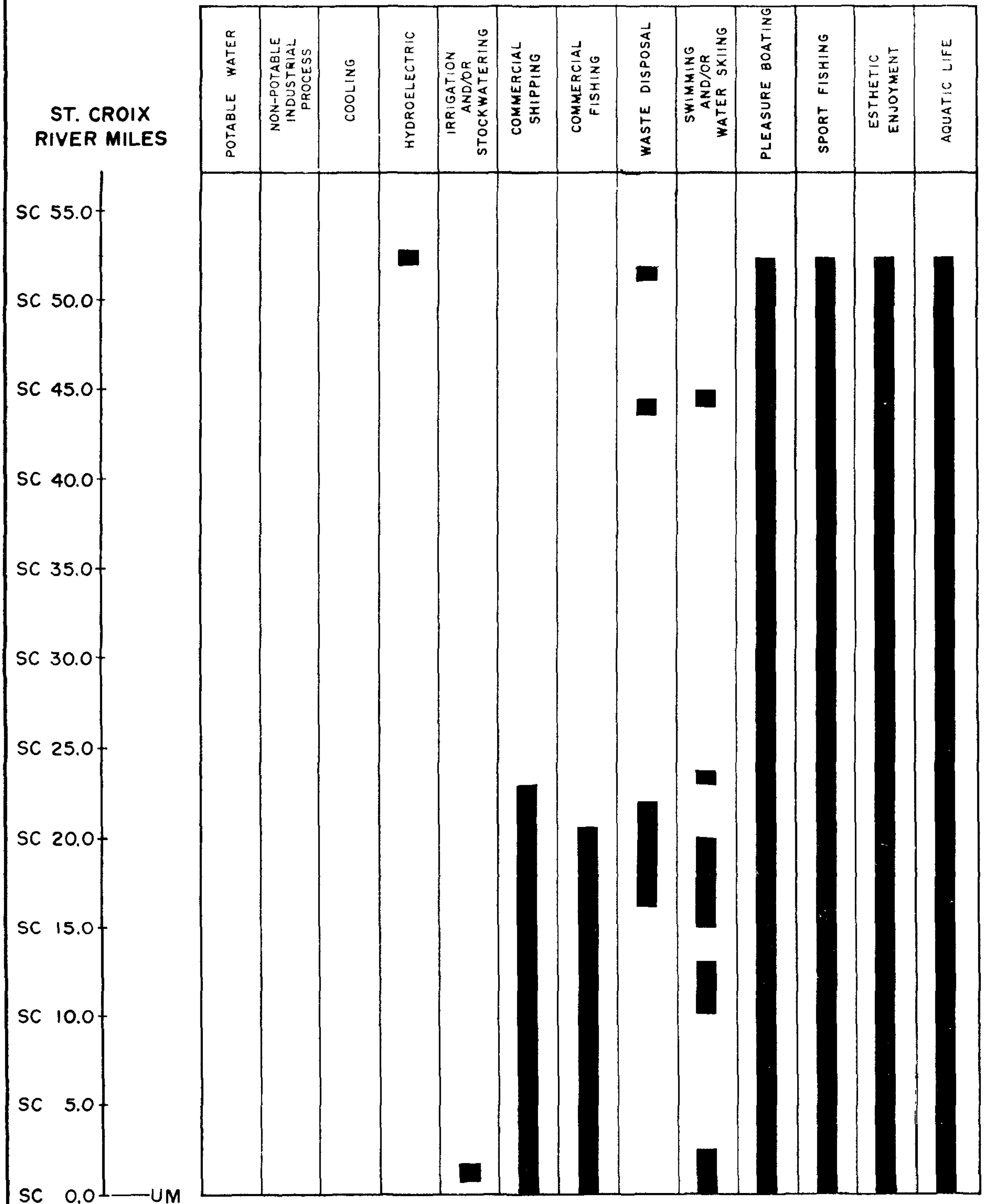
Present secondary uses include pleasure boating, irrigation, and a source of barge wash water. The Commission's proposal for secondary uses include navigation, general industrial purposes, agriculture, and other beneficial uses for which the waters may be suitable and which do not conflict with the above proposed primary uses.

St. Croix River (see Figure III-19)

Taylors Falls to Stillwater. This very sparsely developed reach is used primarily for sport fishing, canoeing, esthetic enjoyment of the natural scenic beauty, and maintenance of aquatic life.

Secondary uses include hydroelectric power generation, waste disposal by three communities, and swimming.

Stillwater to Mouth. The primary uses of this portion, known as Lake St. Croix are pleasure boating, swimming, water skiing, sport fishing, esthetic enjoyment of the natural scenic beauty, and maintenance of aquatic life.



LEGEND

TF Taylors Falls
UM Mississippi River

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PRESENT WATER USES ALONG THE ST. CROIX RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE III-19

Secondary uses of Lake St. Croix include commercial fishing, commercial shipping, waste disposal, and some ice harvesting.

RECOMMENDED WATER USE REQUIREMENTS

General

Each water use requires a different minimum water quality. For any given use there is no sharp or distinct level of quality above which the water is acceptable and below which it is unacceptable. But rather, as water quality decreases, the water becomes less and less acceptable for a given use until it finally becomes totally unacceptable. The point at which this occurs depends on the particular use itself and upon the availability of other sources of water of higher quality. The water quality guides used in this report for the various water uses are intended to indicate the minimum water quality that is reasonably acceptable for each particular use.

To completely characterize the quality of water suitable for a particular use, limits would have to be given for more than 50 parameters. Of these, there are only seven or so that are in a range that may be of concern within the study area. The remaining ones are at levels far below threshold values. For this reason consideration is given in this report to only those parameters whose values were found to approach significant levels.

Source of Potable Water Supply

Raw water used as a source of potable water supply should be of such quality that after treatment consisting of coagulation, sedimentation, filtration and chlorination, or the equivalent thereof, it will meet the mandatory and recommended requirements of the Public Health Service Drinking Water Standards, 1962.

The only limits which might be violated anywhere within the study area are temperature, turbidity, phenol, algae and coliform organisms. The remaining constituents are well below the limits expressed in the Drinking Water Standards for finished waters. Recommended limits for the parameters mentioned are given in Table III-22.

Non-Potable Industrial Process Water

Use of non-potable process water by industries within the study area is limited to barge and gravel washing, and the fluming of sugar beets. The waters are of sufficient quality to permit these uses. Some potato washing is also done occasionally.

Cooling Water

Water to be used for cooling purposes on a "once through" basis need not be of as high a quality as recycled cooling water. On the other hand, the treatment required for water to be used only once and then wasted should be minimal. The water should have an initial temperature low enough to permit a sufficient exchange of heat and should not deposit scale, be corrosive or encourage the growth of slimes (see Table III-22). Most waters of the study are already of sufficient quality to be able to meet this criteria after simple chlorination.

Hydroelectric Power Generation

Water quality within the study area is already sufficient to permit the use of streams for hydroelectric power generation.

Irrigation

Important characteristics to be considered of water used for irri-

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TABLE III-22

WATER USE REQUIREMENTS

(This Guide was developed by the investigators and does not indicate endorsement by the FWPCA)

WATER USE	WATER QUALITY PARAMETER: Temp. °F. (Max.)	Dissolved Oxygen, mg/1 (Min.)	Ammonia (As Nitrogen) mg/1 (Max.)	Turbidity Units (Max.)	Phenol mg/1 (Max.)	Coliform MPN (Avg.)	Floating Solids & Liquids & Excessive Algae
Source of Potable Supply	86	NLS	1.0	25	0.001	4,000	None
Cooling	90	-	NLS	250	NLS	NLS	None
Irrigation	90	-	-		NLS	5,000[1]	None
Stock & Wildlife Watering	100	-	NLS	250	NLS	5,000	None
Whole Body Contact Activities:							
Recreation	90	0	-	25	NLS	1,000[2]	None
Limited Body Cont. Activities:							
Recreation	93	0	-	250	NLS	5,000	None
Navigation	93	0	-	250	NLS	5,000	None
Sport Fishing	86	5.0	1.0	250	0.01	5,000	None
Commercial Fishing	93	3.0	2.0	250	0.01	5,000	None
Esthetic Enjoyment	100	0	-	NLS	NLS	-	None
Maintenance of Aquatic Life:							
Pollution Sensitive Species	86	5.0	1.0	250	0.01	NLS	None
Pollution Tolerant Species	93	3.0	2.0	250	0.01	NLS	Trace

Notes: NLS means no limit set.
Values of parameters not listed may be assumed to be below threshold levels in waters of the Study Area. Waters of the Study Area are of sufficient quality to permit use as a source of non-potable industrial process water and for hydroelectric power generation without additional treatment.

1. For irrigation water use on crops normally eaten raw.

2. In light of recent findings, the following criteria may be substituted:
   a) Satisfactory if MF Coliforms are less than 1,000/100 ml and MF Fecal Streptococci are less than 100/100 ml.
   b) Satisfactory if MF Coliforms are from 1,000 to 5,000/100 ml and MF Fecal Streptococci are less than 20/100 ml.
   c) The number of bacteria shall be the Arithmetic Average of the last five consecutive sample results.

gation are temperature, dissolved solids, sodium and boron. The bacteriological quality of irrigation water is also important when it is used on crops normally eaten uncooked. The only parameters of possible concern within the study area are temperature, algae, and coliforms. Recommended limits for these parameters are given in Table III-22. The remaining parameters are well below threshold values.

Stock and Wildlife Watering

Parameters of principal concern in the evaluation of water for this use are pH, temperature, dissolved solids and coliform organisms. Those of possible concern within the study area are temperature and coliform organisms. Recommended values for these parameters are given in Table III-22.

Navigation

It is desirable that the water used for navigation be reasonably free from the grosser forms of pollution. The most objectionable constituents are acid, alkali, excessive suspended solids, hydrogen sulfide, foul odors and pathogenic bacteria. Within the study area only dissolved oxygen and bacterial concentrations approach limits of concern. The presence of dissolved oxygen is necessary to prevent foul odors. Exposure of work crews handling lines and equipment in frequent contact with the water is similar in many respects to the exposure received by recreational users (boaters and fishermen) having limited body contact with the water. For this reason, temperature and coliform limits are the same for both navigational and limited body contact recreational uses. Recommended limits for the parameters of concern are given in Table III-22.

Recreational-Whole Body Contact

This category of water use includes swimming, wading, and waterskiing. Water for this use should be free from excessive color and turbidity, odor, floating solids and oil, pathogenic bacteria, sludge banks, or anything visible of an objectionable nature. In addition the water should be of a comfortable temperature and void of anything injurious to public health.

Parameters whose limits may be exceeded for this use within the study area are temperature, dissolved oxygen, turbidity, and coliform organisms. Recommended limits for these parameters are given in Table III-22.

Recreational-Limited Body Contact

This category of water use includes boating and other similar activities involving less contact with the water than those listed under whole body contact activities. Water for this use should be of the same general quality as that used for whole body contact recreational activities, except for temperature and bacterial content. The water may be of slightly higher temperature and bacterial content and still be suitable for limited body contact type of activities. Recommended limits for these and other parameters are given in Table III-22.

Sport Fishing

For waters to be suitable for sport fishing, they must be fit for the fisherman as well as the fish. The act of fishing is, itself, a limited body contact activity and hence waters adequate for their use would also be suitable for the fisherman. The fish sought by the fishermen fallin the category of pollution sensitive aquatic life. Therefore, the waters should also be suitable for the maintenance of pollution sensitive species of fish. The parameters considered in relation to use for sport fishing are discussed under limited body contact recreational activities and maintenance of aquatic life.

Commercial Fishing

As with sport fishing, the waters must be suitable for both the fishermen and the fish. In the study area commercial fishing is limited to the catching of rough fish (pollution tolerant species) only. Any aport fish caught by the commercial fishermen must be thrown back. Therefore, waters suitable for commercial fishing must also be suitable for limited body contact activities and the maintenance of pollution tolerant aquatic life. Parameters of concern are discussed under the latter two activities.

Esthetic Enjoyment

Conditions that effect the esthetic enjoyment of a body of water are visible floating, suspended or settled solids; floating grease and oil; discoloration or high turbidity; foam; sludge banks; slimes; excessive algal growths; evolution of dissolved gases; excessive acidity or alkalinity that leads to corrosion or delignification of boats and docks; and excessive temperatures that cause high rates of evaporation and cloudiness over the water.

Within the study area, visible signs of pollution found were occasional oil slicks and the evolution of dissolved gases in areas devoid of oxygen. Those parameters of concern and their limits are given in Table III-22.

Maintenance of Aquatic Life

The effect of a given pollutant on fish and other aquatic life varies with each species. In general, however, the most desirable species are the most sensitive to pollution; the least desirable ones usually being the least sensitive. In a pollution free environment, the percentage of desirable fish in the total fish population will be relatively high.

As the water quality is lowered beyond a certain point, the desirable fish population decreases and conditions become more favorable for survival of the less desirable species. As water quality deteriorates still further, conditions become unfavorable for even the less desirable species.

Pollution sensitive species of fish (e.g. game fish) require waters containing no materials at harmful levels and having a temperature of generally less than 86°F., a dissolved oxygen content of at least 5 mg/l, a turbidity of generally less than 250 units, and a sufficient food supply. Since a major fish food supply consists of the bottom organisms which normally inhabit the stream bed, it is important to keep solids deposition at a minimum. This includes silt and sand as well as organic sludge.

Pollution tolerant species of fish can withstand higher temperatures, lower dissolved oxygen levels, and are willing to feed on organic sludges and other materials not acceptable as a food by the more sensitive species. Thus, at greater pollution levels, the tolerant species are better able to compete in the struggle for existence and gradually win out over the more sensitive species.

Water quality guides recommended for aquatic life in Table III-22 are divided into two categories: pollution sensitive and pollution tolerant species. Water quality maintained at the "pollution sensitive" level should result in a good, mixed fish fauna. Water quality maintained at the "pollution tolerant" level should result in a fairly high percentage of rough fish. This is considered as the lowest water quality level which will support the propagation and maintenance of a rough fish population without difficulty.

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21. Classification and Standards for the Mississippi River and Tributaries from the Upper Lock and Dam at St. Anthony Falls to the Outfall of the Minneapolis-St. Paul Sanitary District Sewage Treatment Plant, adopted March 28, 1963 by State of Minnesota Water Pollution Control Commission.

22. Classification and Standards for the Mississippi River and Tributaries from the Outfall of the Minneapolis-St. Paul Sanitary District Sewage Treatment Plant to Lock and Dam No. 2 near Hastings, adopted March 28, 1963 by State of Minnesota Water Pollution Control Commission.

23. Proposal for Classification and Standards for the Minnesota River and Tributary Waters from Carver Rapids to the Outlet of Reilly Creek and Grass Lake below Shakopee by State of Minnesota Water Pollution Control Commission.

24. Proposal for Classification and Standards for the Minnesota River and Tributary Waters from the Outlet of Reilly (Terrell) Creek and Grass Lake below Shakopee to the Junction with the Mississippi River at Fort Snelling, by State of Minnesota Water Pollution Control Commission.

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SECTION IV

WASTE DISCHARGES

An evaluation of the plant's performance, made in April 1960, determined that the BOD and suspended solids removal efficiencies were 70 and 80 percent, respectively. During the recent visit the facilities appeared to be still operating satisfactorily.

934th Troop Carrier Group Officers Club. A visit to the Post Engineer on February 10, 1964, verified that sanitary sewage from this facility is treated at the rate of 2,000 gpd by a septic tank, constructed in 1934. The tank effluent discharges to a marsh area draining to the Minnesota River on the Southeast and Gun Club Lake on the Northeast. Plans and details of the size of this treatment device are not available.

During summer months the Air Force operates a 131,000 gallon swimming pool at the site of the officers club. Operating practices during the swimming season prior to 1966 were such that the pool was drained and filled at weekly intervals with adequate disinfection of the pool water. Pool wastewater was discharged to a sewer believed to be connected to the septic tank receiving sanitary wastes from the club.

A water filtration system was installed during the Spring of 1966 which will permit recirculation in lieu of weekly draining and filling operations. This device will be placed into operation at the beginning of the 1966 swimming season.

U.S. Army Corps of Engineers

Federal personnel, accompanied by a representative of the Minnesota Department of Health, obtained information on the waste treatment facilities at the five locks in the study area from the Chief of the Lock and Dam Section on January 30, 1964.

Upper St. Anthony Falls. Wastes generated at this Lock and Dam emanate from the control station and are discharged to the municipal sewage collection system.

Lower St. Anthony Falls. The only sanitary facilities located at this site are in the control house. Wastes from this source are discharged to a septic tank and in turn to a leaching pit.

Lock and Dam No. 1. Two sanitary facilities are provided at this installation; one within the control building and one within the maintenance shed located on the shore. The former discharges to a septic tank constructed within the sand core of the structure and thence to a leaching pit. On occasion, the rate of flow to the pit is greater than the rate of seepage from it and ponding occurs. When this happens it is pumped out and hauled away by a tank cleaning company.

The on-shore facility is not operational during the winter due to possible freezing of the sewer lines. Wastes are discharged to a septic tank and leaching pit when the facility is in use.

Lock and Dam No. 2. At this site, wastes emanate from two dwellings provided for employees and the control building. Each of the two dwellings discharge to its own septic tank and leaching pit. The sanitary facility within the control building discharges to a septic tank beneath the structure. The effluent is pumped to a leaching pit on the shore. Each of the three leaching pits is pumped out by a private firm as required and hauled away to approved disposal points.

Lock and Dam No. 3. The same situation exists here as at Lock and Dam No. 2, with the exception that the wastes going to the control building leaching pit from its septic tank are gravity-fed rather than pumped.

Dredge and Work Boat Facilities. According to a letter dated November 26, 1965 from the Chief of the Construction-Operations Division, the Corps of Engineers plans to have waste treatment devices installed on all of its vessels in the St. Paul District by July 1, 1966.

U.S. Army

Nike Sites. There are four Nike sites in the Twin Cities area. The individual site complex is comprised of an administrative (radar and control) area and a launch area each of which has separate waste treatment facilities.

The administrative area consists of some personnel living quarters, dining hall and kitchen, and office building serving approximately 100 personnel. All facilities are connected to a separate sanitary sewer terminating at a secondary treatment facility. The treatment plant at each of the sites is essentially the same and consists of a manually cleaned bar screen, covered circular Imhoff tank with dosing chamber, covered trickling filter, secondary sedimentation tank, sludge return pump, sludge drying beds, and chlorination facilities. Each plant receives an average of 4,000 - 5,000 gpd, which is well below the design capacity. The plants were built in late 1958. The final disposal of the effluent varies between the different sites and therefore will be discussed below on an individual basis.

The waste treatment at the launch area consists of a septic tank system and subsurface tile field to handle approximately 500 gpd of domestic sewage from approximately 25 personnel. A cesspool in the vicinity of the launch area receives waste from dog kennels. Both the septic tank and cesspool are periodically pumped out.

Variations from the general description above will be discussed for each of the Nike sites.

Nike Site No. 90, Bethel, Minnesota. An evaluation of the waste treatment facilities at this site was made by Federal and State personnel accompanied by the Battalion Medical Services Officer on August 10, 1965. Effluent from the secondary treatment plant is discharged to a tributary of the Rum River. While chlorination is generally practiced from May - October of each year, the chlorination facilities were not in use at the time of the visit. There was no discharge to the surface from the septic tank system nor the cesspool. No laboratory analyses were being performed at the plant.

Nike Site No. 70, St. Bonifacius, Minnesota. The most recent visit to this site was made by Federal and State engineers in late September 1965. Effluent from the secondary treatment plant is discharged to a lagoon having a surface area of approximately one acre and a liquid depth ranging up to five feet. The pond effluent is discharged to a small land locked slough. No laboratory tests are being performed on the plant influent or effluent. The chlorination facilities were not in use at the time of the visit.

The 500 gpd of waste generated at the launching site are treated by an extended aeration sewage treatment plant, manufactured by the Chicago Pump Company, and a final effluent pond. The pond has a surface area of approximately 1/2 acre and has never reached the overflow level during the life of the installation. No laboratory analyses are being performed on this waste, either. Flow from the cesspool does reach a roadside ditch located on the station. This flow is assimilated by the soil after traveling a short distance.

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Nike Site No. 40, Farmington, Minnesota. The most recent evaluation of waste treatment facilities serving Nike Site No. 40 was performed during the early part of August 1965. The inspection was conducted by a Federal engineer accompanied by an engineer from the Minnesota Department of Health, and the Battalion Medical Services Officer. At this installation the launch area and control area discharge to a secondary treatment plant. Final plant effluent is piped an estimated 3/4 mile through tilled farm land and discharged to a roadside ditch. The effluent then continues through the ditch approximately 1/4 mile to a small unnamed creek. No laboratory tests are being conducted on the waste. Chlorination was not being practiced.

The radar portion of the Nike Site is served by the septic tank and tile field. No discharge to the surface was visible from this installation nor from the cesspool serving the dog kennels.

Nike Site No. 20, Roberts, Wisconsin. Waste treatment facilities at Site No. 20, located approximately two miles north of Roberts, Wisconsin was evaluated by members of the Federal Water Pollution Control Administration, the Wisconsin Board of Health, and the Third Missile Battalion. The final effluent is discharged to a lagoon from which there is no discharge or overflow. The lagoon is approximately 1/2 acre in size and has a high water depth of about four feet. There were no laboratory analyses being performed on the wastes in order to evaluate treatment efficiency. Chlorination is practiced from May - October of each year.

The septic tank system at the launch area and the cesspool at the dog kennels were not experiencing drain field or other clogging problems as no surface discharge was visible.

Twin Cities Army Ammunition Plant. During January 1964 a representative of the Minnesota Department of Health accompanied a Federal engineer to the ammunition plant to observe and discuss waste disposal practices. At this time it was learned that all domestic and industrial wastes were discharged to the municipal sewerage system. This amounts to approximately one million gallons per day.

Cooling water in the amount of 750,000 gpd plus storm water are discharged to the plant-owned Round Lake. Backwash water containing calcium chloride, incident to the operation of the company's zeolite water softening process, is discharged to Rice Creek, a tributary to the Mississippi River.

Summary

Information on the type of treatment and place of final disposal of wastes from each of the Federal installations covered is summarized in Table IV-1.

TABLE IV-1

SUMMARY OF FEDERAL INSTALLATIONS

FACILITY	TYPE OF TREATMENT	FINAL DISPOSAL
U.S. Air Force		
Osceola Air Force Station	Secondary	Ground
934th Troop Carrier Group Officers Club	Primary	Marsh area near Minnesota River
U.S. Army Corps of Engineers		
Upper St. Anthony Falls	Primary	Ground
Lower St. Anthony Falls	Primary	Ground
Lock & Dam No. 1	Primary	Ground
Lock & Dam No. 2	Primary	Ground
Lock & Dam No. 3	Primary	Ground
U.S. Army		
Nike Site No. 90		
Administration Site	Secondary	Tributary to Rum River
Launch Site	Primary	Ground
Dog Kennels	Primary	Ground
Nike Site No. 70		
Administration Site	Secondary	Slough
Launch Site	Primary	Ground
Dog Kennels	Primary	Ground
Nike Site No. 40		
Administration-Launch Site	Secondary	Unnamed Creek
Radar Control Site	Primary	Ground
Dog Kennels	Primary	Ground
Nike Site No. 20		
Administration Site	Secondary	Pond
Launch Site	Primary	Ground
Dog Kennels	Primary	Ground
Twin Cities Army Ammunition Plant		
Cooling & Storm Water	None	Round Lake (Company Owned)
Zeolite Softener Packwash Water	None	Rice Creek (Tributary on Mississippi River)
Other Wastes	(to municipal system)	

DOMESTIC WASTES

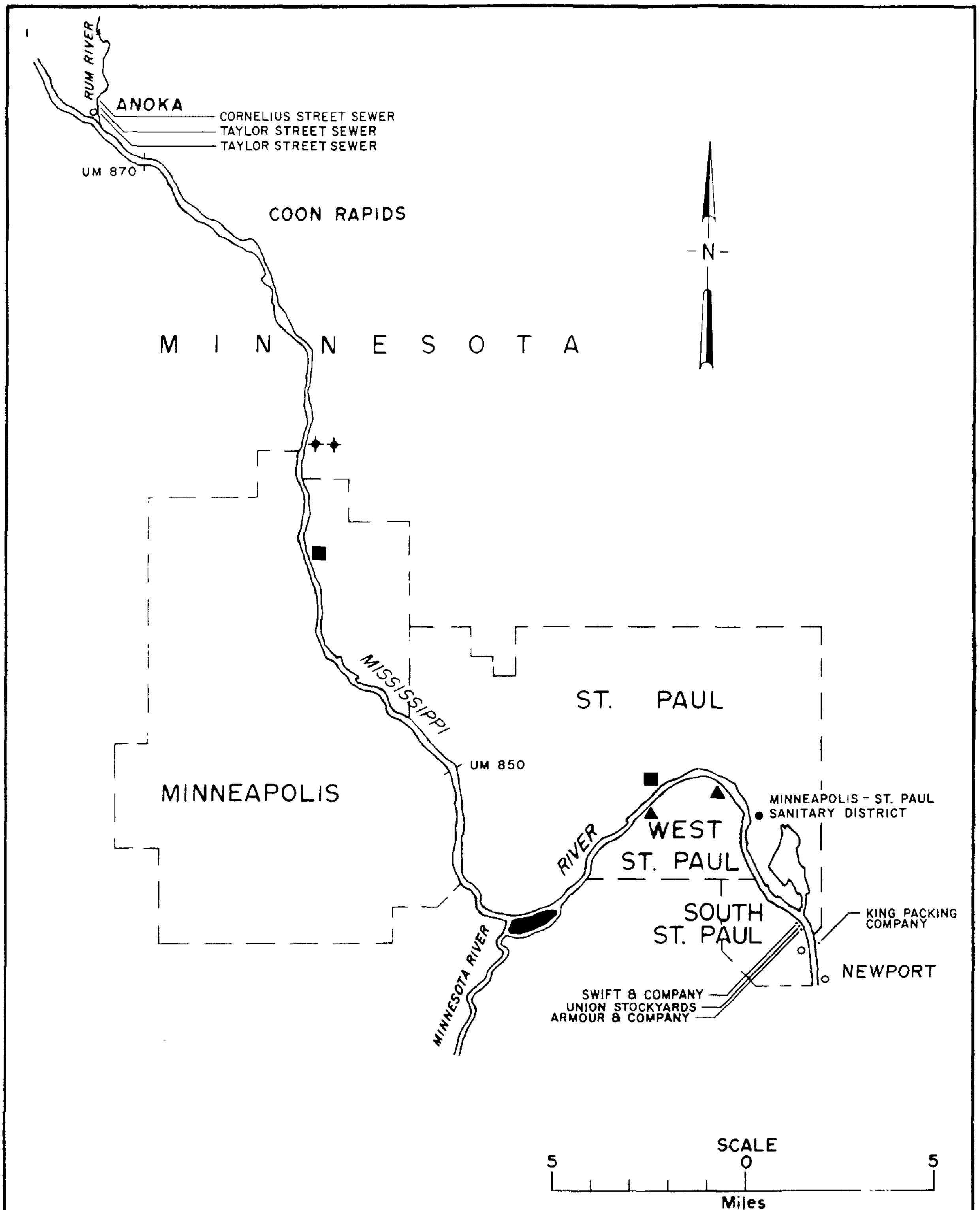
Introduction

There are 24 sewage treatment plants on the three major streams within the area studied (see Figures IV-2 through IV-7). They range in capacity from 0.02 to 189 mgd, and discharge a total of about 220 mgd. Fifteen (62 percent) have secondary treatment facilities presently in operation. The largest plant, operated by the Minneapolis-St. Paul Sanitary District (MSSD), has secondary facilities which are under construction and are expected to be in operation in 1966. With the exception of the two largest ones, the plants treat very little industrial wastes. All sewage treatment plants, together, discharge a total of 309,500 pounds of 5-day BOD and 188,800 pounds of suspended solids to the Mississippi, Minnesota, and St. Croix Rivers. Of these amounts, 97 and 96 percent of the 5-day BOD and suspended solids, respectively, are contributed by the two largest plants, MSSD and South St. Paul.

There is only one source of untreated domestic wastes known to be discharging to the streams in the area. This is the City of Henderson, Minnesota (population 750), which contributes about 0.04 mgd to the Minnesota River.

Survey Methods

After reviewing all available information on domestic waste discharges within the study area, preliminary visits were made, in cooperation with either the Minnesota or Wisconsin Departments of Health, to each sewage treatment plant on which additional information was required. During these visits, information was sought relating to average flows,



LEGEND

- ● Sewage Treatment Plant - Primary
- ○ Sewage Treatment Plant - Secondary
- ✦ Water Treatment Plant
- ■ Power Plant
- ▲ Barge Washing Facility
- ⁄ Manufacturing or Processing Industry

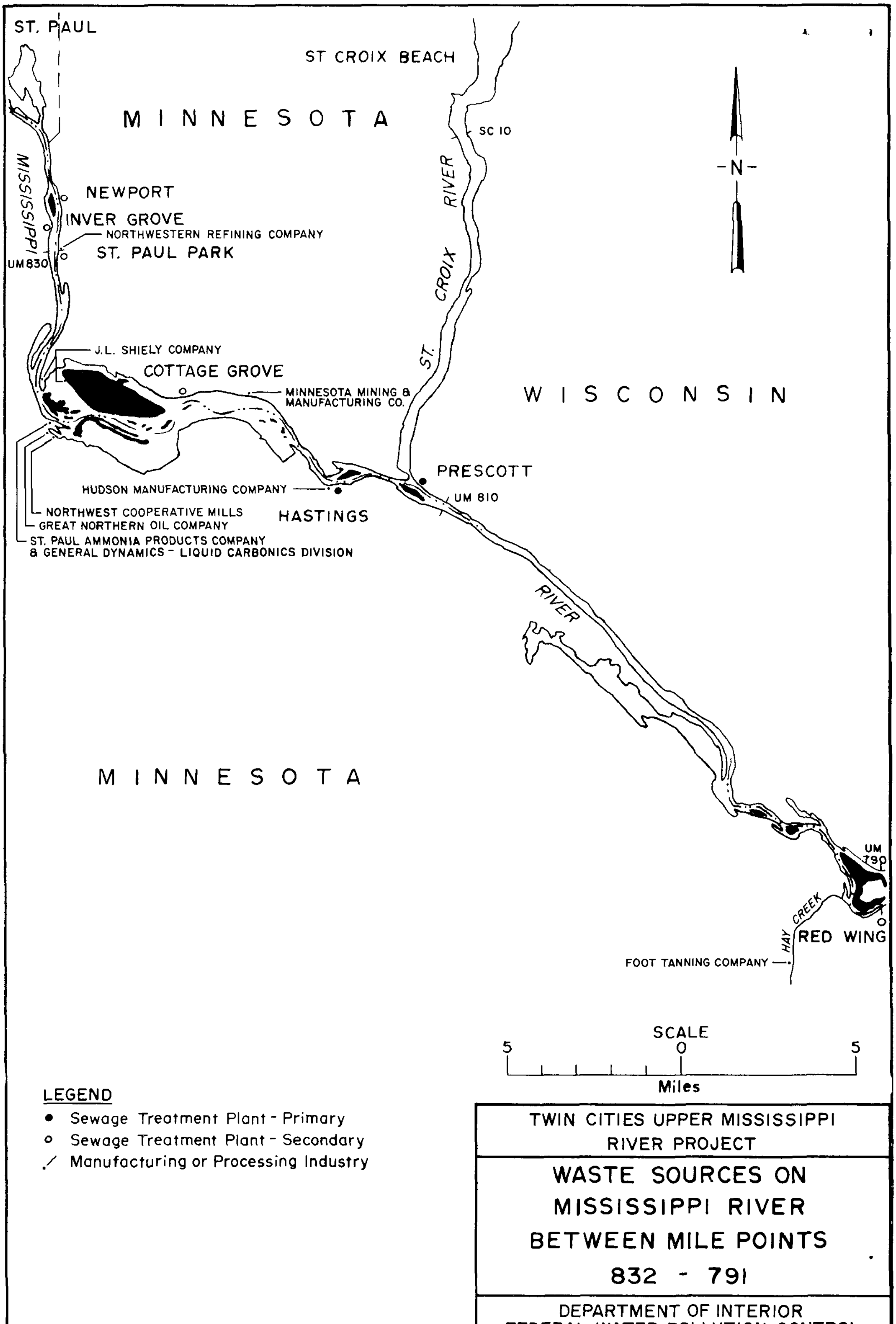
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WASTE SOURCES ON MISSISSIPPI RIVER BETWEEN MILE POINTS 872 - 832

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.

REGION V — CHICAGO, ILLINOIS

FIGURE IV-2

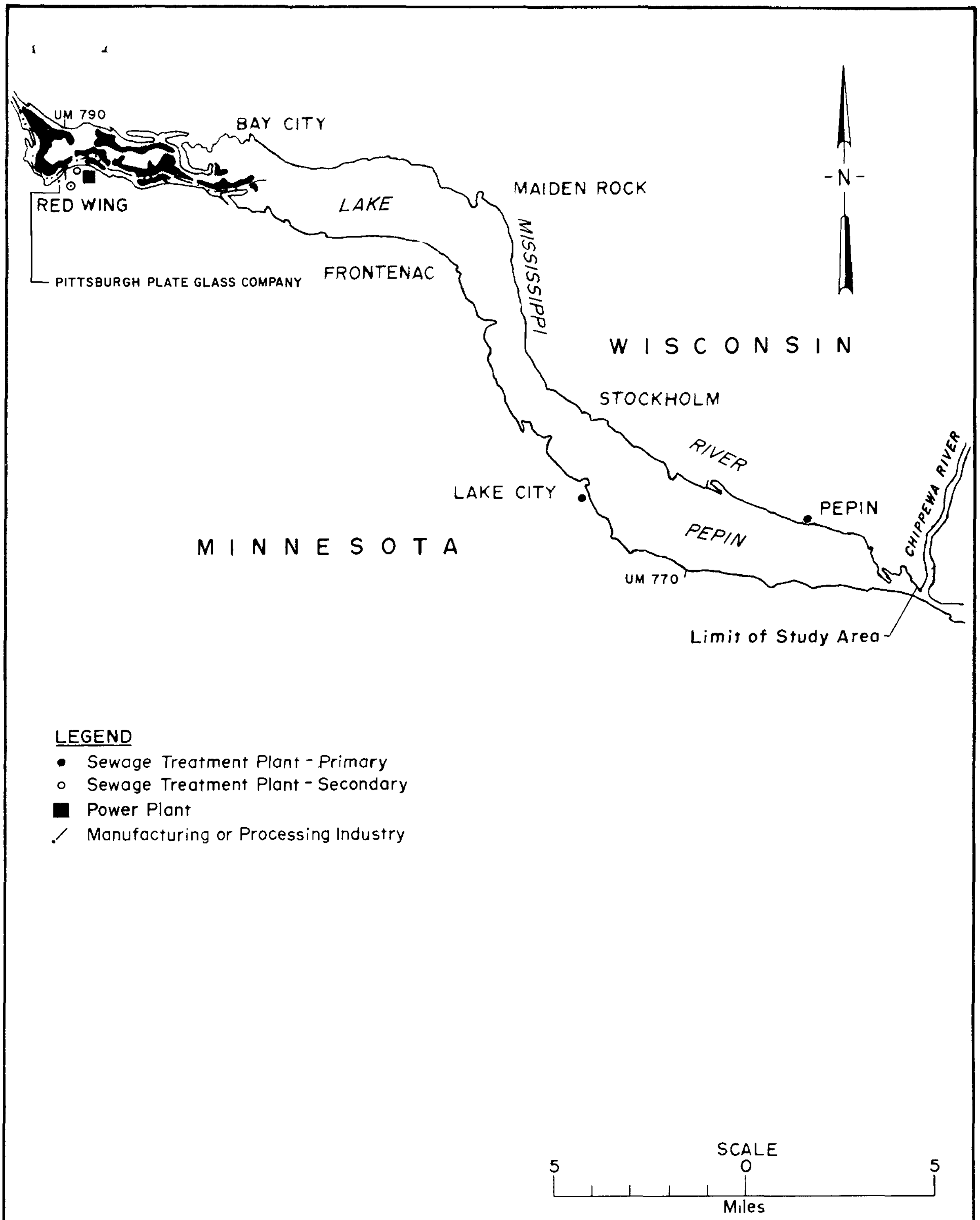


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WASTE SOURCES ON MISSISSIPPI RIVER BETWEEN MILE POINTS 832 - 791

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE IV-3



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WASTE SOURCES ON MISSISSIPPI RIVER BETWEEN MILE POINTS 791 - 763

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE IV-4

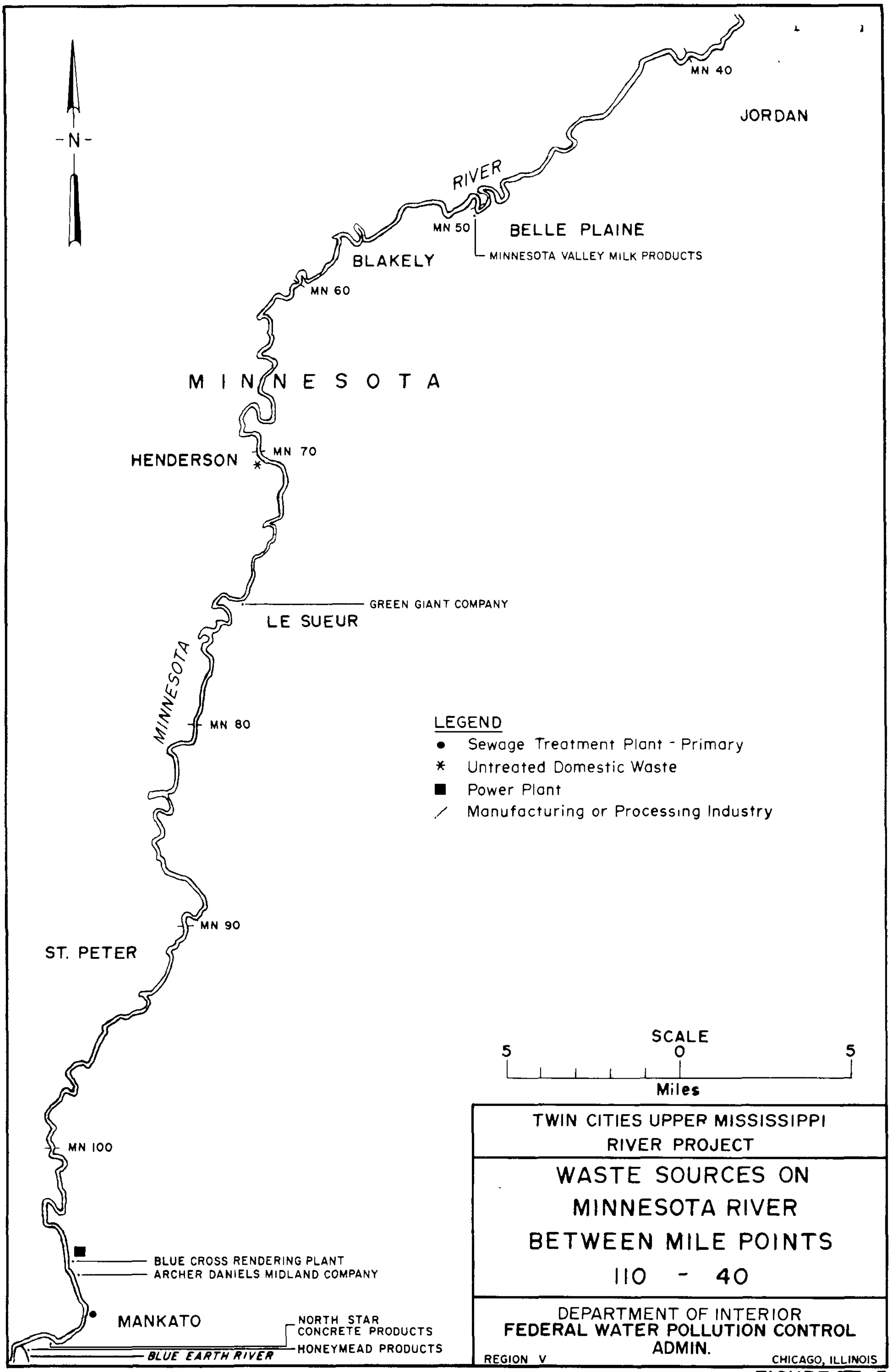


FIGURE IV-5

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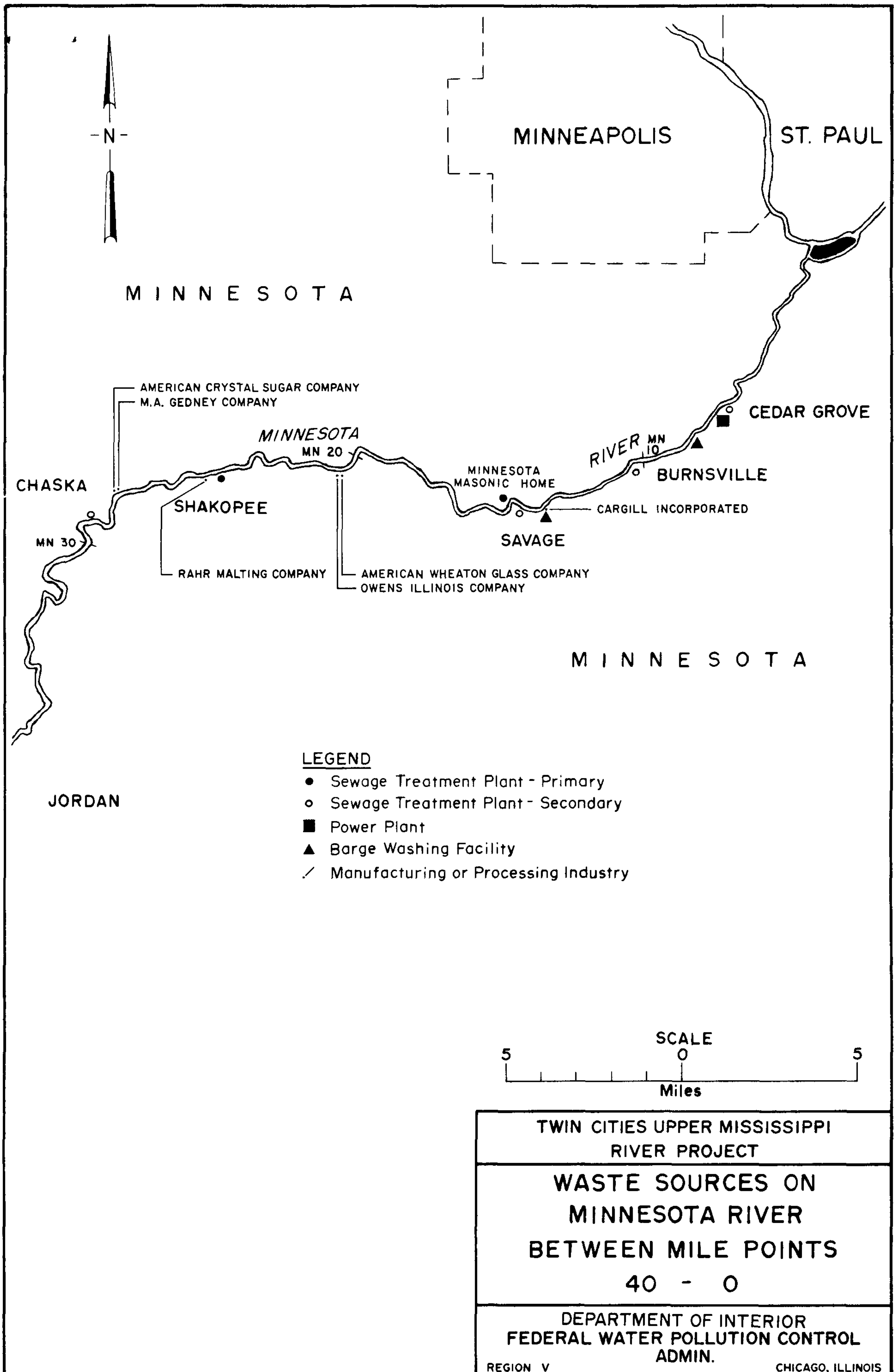
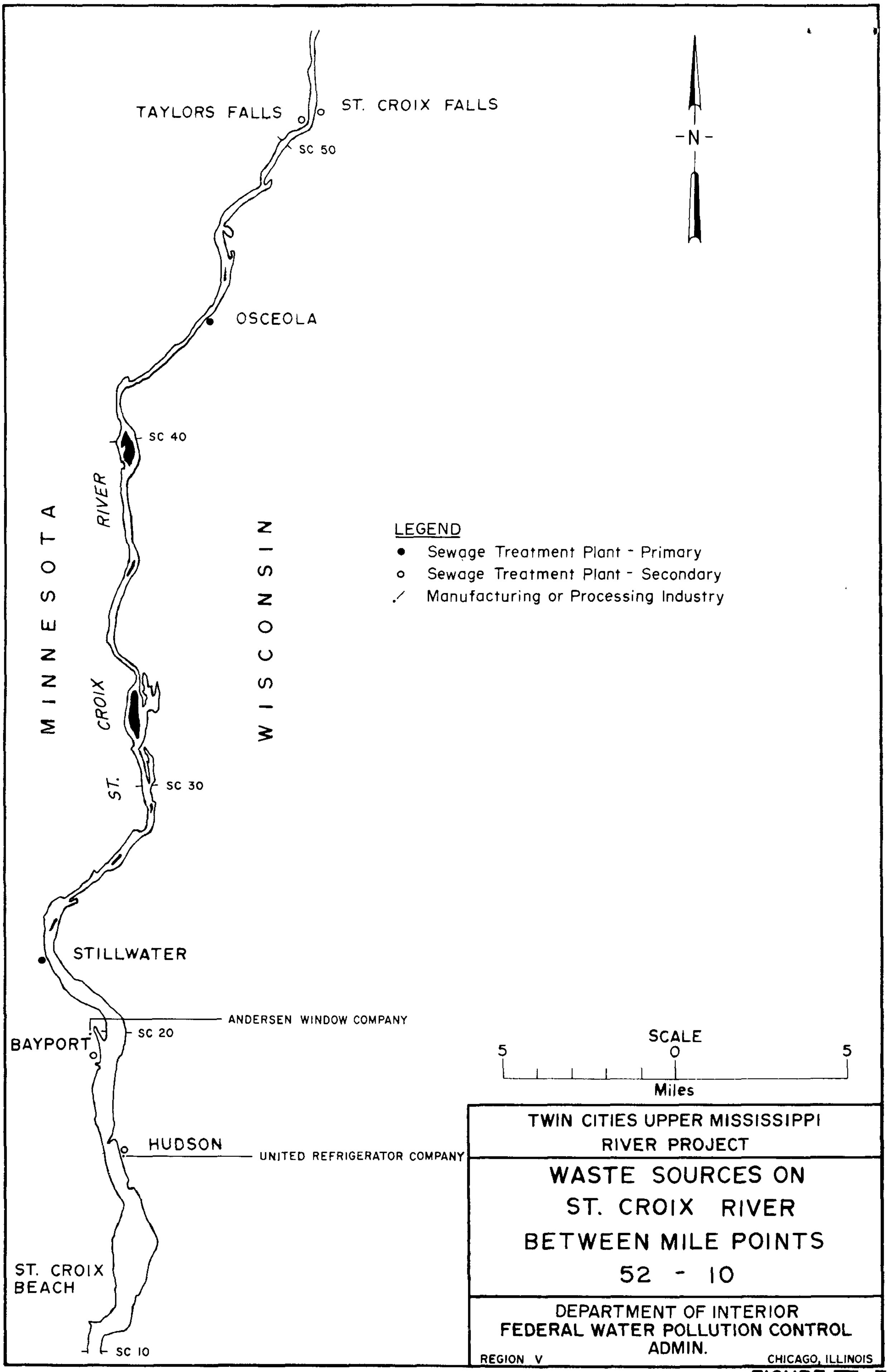

N
MINNEAPOLIS
ST. PAUL
MINNESOTA
AMERICAN CRYSTAL SUGAR COMPANY
M.A. GEDNEY COMPANY
MINNESOTA
MN 20
CHASKA
SHAKOPEE
MN 30
RAHR MALTING COMPANY
AMERICAN WHEATON GLASS COMPANY
OWENS ILLINOIS COMPANY
MINNESOTA MASONIC HOME
SAVAGE
CARGILL INCORPORATED
RIVER
MN 10
BURNSVILLE
CEDAR GROVE
MINNESOTA
JORDAN
LEGEND
Sewage Treatment Plant - Primary
Sewage Treatment Plant - Secondary
Power Plant
Barge Washing Facility
Manufacturing or Processing Industry
SCALE
5 0 5
Miles
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT
WASTE SOURCES ON MINNESOTA RIVER BETWEEN MILE POINTS 40 - 0
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V
CHICAGO, ILLINOIS

FIGURE IV-6


TAYLORS FALLS
ST. CROIX FALLS
SC 50
-N-
OSCEOLA
SC 40
MINNESOTA
ST. CROIX RIVER
WISCONSIN
LEGEND
• Sewage Treatment Plant - Primary
o Sewage Treatment Plant - Secondary
/ Manufacturing or Processing Industry
SC 30
STILLWATER
ANDERSEN WINDOW COMPANY
BAYPORT
SC 20
SCALE
5 0 5
Miles
HUDSON
UNITED REFRIGERATOR COMPANY
ST. CROIX BEACH
SC 10
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT
WASTE SOURCES ON ST. CROIX RIVER BETWEEN MILE POINTS 52 - 10
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V
CHICAGO, ILLINOIS
FIGURE IV-7

waste characteristics, treatment practices, maintenance of records, and laboratory control practices. After reviewing this additional information, a domestic wastes sampling program was planned and executed to obtain the remaining necessary data. The St. Croix Falls and Hudson, Wisconsin plants were investigated by the Wisconsin Department of Health and the analytical data were provided to the Project.

A cooperative study of the MSSD Plant, involving the District, the Minnesota Department of Health (MDH), and the Project, was conducted to obtain information on this facility (1). During two periods, composite samples were collected around-the-clock for seven days and analyzed by the three laboratories.

Information on the South St. Paul sewage treatment plant was obtained from field surveys, plant records, and a report prepared for the City of South St. Paul by two consulting engineering firms (2). The report describes the design and performance of existing facilities and recommends improvements that would provide the degree of treatment required to comply with the present stream standards established by the Minnesota Water Pollution Control Commission. Nominal analyses were performed to insure that results of the plant's laboratory were compatible with those of the Project's laboratory.

The remaining treatment plant studies began with the collection of random grab samples on each influent and effluent. This procedure was continued until either an adequate picture of the particular waste was obtained or it became apparent that other methods would be required. Where necessary, composite samples (weighted with flow) were taken to supplement the random grab samples. Results of analyses on all these samples, along with information provided by plant personnel, were used to calculate the waste loading rates.

Mississippi River Domestic Waste Sources

There are twelve municipal sewage treatment plants within the study area discharging about 208 mgd of effluent directly to the Mississippi River (see Figures IV-2 - IV-4). Seven of the plants have secondary treatment facilities. The two largest plants, Minneapolis-St. Paul Sanitary District and South St. Paul, contribute a total of 203 mgd of effluent containing 300,000 pounds of 5-day BOD and 180,700 pounds of suspended solids. The remaining 10 plants discharge a total of 5.2 mgd of effluent containing 3,770 pounds of 5-day BOD and 2,830 pounds of suspended solids. Three of the plants chlorinate their effluents the year-round; three chlorinate only between May and November; and six do not chlorinate at all.

Information obtained on each of the more significant plants is summarized below. The order of presentation follows the sequence in which they occur as one proceeds downstream. The terms "left bank" and "right bank" apply as one faces downstream.

Anoka Sewage Treatment Plant. This plant, located on the left bank of the Mississippi River at Mile 871.5 just above the mouth of the Rum River, treats 0.957 mgd of sewage contributed by about 9,500 people and over 100 commercial establishments in the area served. No known industrial wastes presently enter the plant.

The plant, served by separate sanitary sewers, employs a high-rate trickling filter system designed for a population equivalent of 21,600 and a flow of 1.44 mgd. Disinfection of the effluent is practiced year-round using 70 pounds of chlorine gas per day (8.7 mg/l). Sewage characteristics and stream loading rates are given in Tables IV-6 and IV-7 in the domestic wastes summary. The efficiency of BOD and suspended solids removal is typical of a well operated secondary plant.

Minneapolis-St. Paul Sanitary District Sewage Treatment Plant (MSSD). This plant, located on the left bank of the Mississippi River at mile 836.3, treats about 188.6 mgd of sewage and industrial wastes produced in the 150-square mile metropolitan area it serves. Within this area are some 1.2 million people, 1,500 manufacturers, and numerous commercial establishments. Approximately 39 percent of the organic waste load is contributed by industry.

The existing plant, served by a combined sewer system, began operation in 1938 and was designed to provide primary treatment for an average daily flow of 134 mgd, expected from an estimated 910,000 people in 1945. The treatment process consists essentially of screening, grit removal, and sedimentation. Sludge disposal consists of concentration, vacuum filtration, and incineration. Facilities for chemical treatment and effluent chlorination although available are not used.

Due to difficulties with clogging in one of the inverted siphons conveying sewage across the river to the plant, the entire plant flow is bypassed directly to the river for part of one day each month. This produces higher velocities through the siphon, flushing it of debris accumulated during the previous month. Bypassing of part of the plant flow is also necessary during and shortly after rainfall to prevent overloading the plant. In 1963, a total of 2,089 million gallons of the plant flow was bypassed directly to the river. Roughly an equal amount also reached the river through an estimated 80 or more combined sewer overflows which generally discharge during and shortly after periods of rainfall. More information on combined sewer overflows is given elsewhere in this section. Some wastes are also bypassed when the St. Paul water treatment plant discharges lime sludge to the city sewer. This occurs about one day per month.

The plant is presently undergoing an expansion which will provide secondary treatment with the high-rate activated sludge process. It is expected to be adequate for flows up to 1973. The general basis for design is given below (3):

Sewered Population	1,545,000 persons
Industrial Population Equivalent	1,065,000 persons
Total Population Equivalent	2,610,000 persons
Average Annual Flow through Plant	218 mgd
Removal of Suspended Solids	85 percent
Removal of BOD with Basic Treatment Process	75 percent
Control of Effect of BOD by Supplemental Methods	(as required to meet river water quality standards)
Destruction of Bacteria as measured by Coliform Indicator Organisms	99 percent

Construction is expected to be completed in 1966.

Results of the cooperative survey on this plant, mentioned under Survey Methods, are given in Tables IV-2 and IV-3. The plant efficiency is typical for primary treatment.

South St. Paul Sewage Treatment Plant. This plant, located on the right bank of the river at mile 832.4, treats wastes at the rate of about 14.2 mgd on weekdays and 8.1 mgd on weekends. The wastes are contributed by about 25,000 people, three meat packing industries, a stockyard, and many small commercial and industrial establishments. Approximately 1.7 mgd of the total is domestic sewage; 1.4 mgd is infiltrated ground water;

TABLE IV-2

WASTE CHARACTERISTICS OF THE
MINNEAPOLIS-ST. PAUL SANITARY DISTRICT
SEWAGE TREATMENT PLANT INFLUENT AND EFFLUENT

CONSTITUENT	(Results are in mg/l unless specified otherwise) INFLUENT CONCENTRATION[1] MAXIMUM	AVERAGE	MINIMUM	EFFLUENT CONCENTRATION MAXIMUM	AVERAGE	MINIMUM	AVERAGE REMOVAL EFFICIENCY %
pH (units)		7.5			7.5		-
Alkalinity	326	292	184	301	279	169	13
5-Day BOD	305	251	120	225	174	61	31
COD	756	585	393	667	378	196	35
Total Solids	1,850	1,010	615	1,535	770	445	24
Volatile Solids	527	444	310	363	296	205	33
Tot. Sus. Solids	430	316	205	140	107	84	66
Vol. Sus. Solids	311	226	150	105	81.0	62	64
Organic Nitrogen	26.1	13.2	2.9	26.3	3.3	11.0	17
Ammonia Nitrogen[2]	14.0	11.5	6.2	13.8	11.2	5.0	-
Total Phosphate	21.2	13.8	4.8	22.4	13.5	3.6	-
Fluoride[2]	1.00	0.60	0.31	0.85	0.67	0.23	-
ABS	7.4	3.9	1.1	7.3	3.8	1.1	-
Phenol	0.90	0.47	0.14	1.00	0.526	0.190	-
Iron[2]	6.1	3.1	1.8	1.7	1.4	1.0	5.5
Manganese[2]	0.17	0.13	0.08	0.17	0.13	0.10	-
Copper	0.93	0.49	0.19	0.78	0.33	0.17	33
Cadmium	1.80	0.19	$<$ 0.05	0.23	0.10	$<$ 0.05	47
Chromium[2]	0.43	0.22	$<$ 0.05	0.30	0.18	$<$ 0.05	12
Lead	0.27	0.16	0.05	0.17	0.09	0.03	44
Nickel	1.60	0.29	0.08	0.54	0.26	0.08	-
Zinc	2.40	0.89	0.22	1.40	0.58	0.20	35
Tot. Coli,MPN[3]	-	-	-	-	$> 1.6 \times 10^7$	-	-
Fecal Coli,MPN[3]	-	-	-	-	4.3×10^6	-	-

1. Influent samples were taken after screening and grit removal
2. This constituent was measured in first Survey, only
3. This constituent was measured in two 10-day Surveys, summer of 1965.

TABLE IV-3

MINNEAPOLIS ST. PAUL SANITARY DISTRICT
SEWAGE TREATMENT PLANT EFFLUENT LOADING RATES[1]

CONSTITUENT	AVERAGE LOADING RATE lb./day
5-Day BOD	268,000
COD	573,000
Total Solids	1,270,000
Total Volatile Solids	463,000
Total Suspended Solids	170,000
Volatile Suspended Solids	126,000
Total Nitrogen	35,600
Total Phosphate	20,800
Fluoride	1,220[2]
ABS	5,900
Phenol	850
Iron	2,540[2]
Manganese	235[2]
Copper	515
Cadmium	145
Chromium	325[2]
Lead	140
Nickel	400
Zinc	880
(Total Coliform)	($>1.1 \times 10^{17}$ No./day)
(Fecal Coliform)	(3.1×10^{16} No./day)

1. Values are based on two round-the-clock surveys conducted Sept. 14-23, 1964 and January 5-12, 1965. Average plant flows were 218 and 168 mgd, respectively. Annual average plant flow is 188.6 mgd.

2. This constituent was measured in the first survey, only.

and the remaining amount is contributed by the meat industry complex (including the stockyard) which processes 5 days per week. On weekdays, the meat industry complex contributes about 98 percent of the BOD and 96 percent of the suspended solids going to the sewage treatment plant.

The existing plant, served by a combined sewer system, is equipped with a bar screen, grit chamber, floculation and settling tanks, trickling filters, intermediate settling tanks, and an anaerobic stabilization pond. Chlorination facilities were included in the design but are not used. Hydraulically, all facilities except the stabilization pond are handling flows approximately 50 percent above those for which they were designed. Organic loading is about 250 percent of the designed loading. On weekdays, for example, the trickling filters handle about 22,800 pounds of 5-day BOD per acre-ft. per day, 7.6 times the rate recommended for high-rate filters. The pond, with a maximum volume of 72.6 million gallons, provides a theoretical detention time of five days at the 14.2 mgd rate.

Portions of the combined sewer system serving South St. Paul are overloaded and this results in frequent bypassing of part of the sewage flow directly to the river at four locations. Additional information on the combined sewer system is given elsewhere in this section (see Page IV-44).

Influent and effluent waste characteristics and loading rates to the river found during the Project's Survey are given in Tables IV-4 and IV-5. Removal efficiencies were generally typical of a secondary treatment plant.

Since the Project's survey, two of the meat packing industries con-

TABLE IV-4

WASTE CHARACTERISTICS ON WEEKDAYS
OF THE
SOUTH SAINT PAUL SEWAGE TREATMENT PLANT INFLUENT AND EFFLUENT

(Results are in mg/l except where noted otherwise)

CONSTITUENT	AVERAGE INFLUENT CONCENTRATION	AVERAGE EFFLUENT CONCENTRATION	AVERAGE REMOVAL EFFICIENCY
5-day BOD	1,298	272	79.1
Total Solids	2,723	1,662	39.0
Volatile Solids	1,200	280	76.8
Total Suspended Solids	855	92	89.3
Volatile Suspended Solids	750	70	90.7
Settleable Solids ml/l	15.2	1.0	93.3
Total Nitrogen	-	44.5	-
Total Phosphate	-	19.1	-
Total Coliform, MPN	-	3.9×10^6	-
Fecal Coliform, MPN	-	2.5×10^6	-

1. Removal efficiency is based on influent and effluent concentrations. Pond leakage and evaporation are not considered.

TABLE IV-5

SOUTH SAINT PAUL SEWAGE TREATMENT PLANT
EFFLUENT LOADING RATES ON WEEKDAYS

CONSTITUENT	AVERAGE LOADING RATE TO RIVER[1]
5-day BOD, lb/day	32,200
Total Solids, lb/day	196,000
Volatile Solids, lb/day	33,100
Total Suspended Solids, lb/day	10,900
Volatile Suspended Solids, lb/day	8,270
Total Nitrogen, lb/day	5,200
Total Phosphate, lb/day	2,300
Total Coliform, No./day	2.1×10^{15}
Fecal Coliform, No./day	1.3×10^{15}

1. Pond leakage and evaporation are not considered.

tributing wastes to the plant have reportedly instituted water saving procedures which have reduced their flows by 1.8 mgd (4). The BOD loading received by the sewage treatment plant is essentially the same, however.

Other Sewage Treatment Plants on Mississippi River. There are nine other sewage treatment plants discharging a total of 3.8 mgd to the Mississippi River within the study area. Of these, seven treat less than one-half million gallons per day each. The other two, belonging to the Cities of Hastings and Red Wing, Minnesota, treat 0.8 and 2.0 mgd, respectively. Chlorination is practiced either part or all of the time at five of the nine plants. Additional information on each of these plants is given in Tables IV-6 and IV-7 in the domestic wastes summary.

Of these nine plants, only the one at Hastings appears to be operating at an efficiency well below the expected range. BOD and suspended solids removal averaged approximately 5 and 42 percent, respectively. A primary plant such as this one would be expected to maintain a BOD removal of at least 25 percent. Also the efficiency of suspended solids removal is near the lower limit expected of primary plants. Part of the problem may be due to hydraulic overloading. It was designed for a 0.60 mgd flow and receives about 0.80 mgd. Part of the problem is also probably due to the manner of operation.

Minnesota River Domestic Waste Sources

Seven communities and a Masonic home were discharging a total of 6.2 mgd of sewage to the Minnesota River within the study area (see Figures IV-5 and IV-6). Six of the communities and the Masonic home provide treatment. The City of Henderson (population 750) is without treatment facilities and discharges approximately 0.04 mgd to the river through a combined collection system.

Three other communities on the Minnesota River have stabilization ponds (each providing over 250 days of storage) for the treatment of their wastes. None of these ponds as yet, however, is filled to the point of overflow.

The six municipal plants, ranging in size from 0.09 to 4.54 mgd, discharge a total of 4,200 pounds of 5-day BOD and 3,900 pounds of suspended solids to the river daily. The City of Henderson contributes an estimated 85 and 100 pounds per day of 5-day BOD and suspended solids, respectively, to the river. A very small amount of BOD and solids is contributed by the Masonic home septic tank and overflowing tile field. Four of the plants chlorinate their effluents the year-round; one chlorinates only during periods of low stream flow; and one does not chlorinate at all. Sewage from Henderson and the Masonic home are not chlorinated.

Information obtained on each of the plants is presented below. The method of presentation is similar to that used for the sources on the Mississippi River.

<u>Mankato Sewage Treatment Plant</u>. This municipal plant located on the right bank of the Minnesota River at mile 106.6, treats 4.54 mgd of wastes contributed by about 21,500 people in Mankato, 5,400 people in North Mankato, several industries, and a number of commercial establishments. It is the largest municipal plant on the Minnesota River within the study area.

The plant, served by a combined sewer system, employs primary treatment and is designed for a population equivalent of 72,700 and a flow of 5.82 mgd. Disinfection of the effluent is practiced on a continuous basis using chlorine gas (8 mg/l). Sewage characteristics and loading rates to the stream are given in Tables IV-6 and IV-7 in the domestic wastes summary. Removal efficiencies are typical of a primary treatment plant.

Henderson Domestic Waste Discharge.. This community of 750 people is located on the left bank of the Minnesota River near mile 70. The sewerage system, serving 500 persons, discharges an estimated 0.04 mgd of untreated domestic wastes to the river. Assuming the addition of 0.17 and 0.20 pound per capita per day of 5-day BOD and suspended solids, respectively, the community contributes about 85 pounds of 5-day BOD and 100 pounds of suspended solids to the stream each day.

Chaska Sewage Treatment Plant. This municipal plant, located on the left bank of the Minnesota River at mile 29.4, treats 0.06 mgd of sewage contributed by about 2,300 people, several commercial establishments, and the Sugar City Creamery. Until recently, the plant also received an additional 0.40 mgd of wastes from the M. A. Gedney Company, which now has separate treatment facilities.

The plant, served by separate sanitary sewers, employs an activated sludge system designed for a population equivalent of 7,200 and a flow of 0.75 mgd. Disinfection is not practiced. The actual flow received by the plant is far below the design flow now that it does not receive the Gedney Company wastes.

The survey of this plant was conducted while it was still receiving wastes from the Gedney Company. The waste characteristics and loading rates determined from this survey are given in Tables IV-6 and IV-7 in the domestic wastes summary. The BOD removal efficiency was excellent but the efficiency of suspended solids removal was less than expected for a secondary plant. This condition should be improved now that the plant no longer receives the Gedney Company wastes.

Shakopee Sewage Treatment Plant. This municipal plant, located on the right bank of the river at mile 23.9, treats 0.311 mgd of sewage contributed by about 4,700 people and several commercial establishments.

The plant, served by separate sanitary sewers, employs primary treatment designed for a population equivalent of 13,500 and a flow of 0.90 mgd. Disinfection of the effluent is practiced only during periods of low stream flow using chlorine gas at the rate of 25 pounds per day (9.6 mg/l). Sewage characteristics and waste loading rates are given in Tables IV-6 and IV-7 in the domestic wastes summary. BOD and solids data indicate the plant was being operated satisfactorily.

Savage Sewage Treatment Plant. This municipal plant, located on the right bank of the river at mile 14.4, treats about 0.22 mgd of sewage contributed by about 1,700 people, a few small industries, and some commercial establishments.

The plant, served by separate sanitary sewers, employs a trickling filter system designed for a population equivalent of 7,000 and a flow of 0.39 mgd. Disinfection is practiced the year-round using about 6 pounds of chlorine gas per day (3.3 mg/l). Sewage characteristics and loading rates are given in Tables IV-6 and IV-7 in the domestic wastes summary. BOD and suspended solids removals were in the range expected for a secondary plant.

Burnsville Sewage Treatment Plant. This plant, located on the right bank of the river at mile 10.5 treats about 0.51 mgd of sewage contributed by 4,400 people and several commercial establishments.

The plant, served by separate sanitary sewers, employs an activated sludge system designed for a population equivalent of 5,000 and a flow of 0.50 mgd. Disinfection is practiced the year-round using about 10 pounds of chlorine per day (2.4 mg/l). Effluent is discharged to Black Dog Lake which drains into the Minnesota River. Sewage characteristics and loading rates are given in Tables IV-6 and IV-7 in the domestic wastes summary. BOD and suspended solids removal efficiencies were satisfactory.

Cedar Grove Sewage Treatment Plant. This plant, located on the right bank of the river at mile 7.3, treats about 0.09 mgd of sewage contributed by about 2,200 people.

The plant, served by separate sanitary sewers, employs an extended aeration system designed for a flow of 0.160 mgd. Disinfection is practiced the year-round using 15 pounds of chlorine per day (20.0 mg/l). Effluent is discharged to Black Dog Creek which drains into the Minnesota River. The BOD and suspended solids removals were satisfactory. Tables IV-6 and IV-7 give additional information on the waste characteristics and loadings.

St. Croix River Domestic Waste Sources

There are six communities discharging about 3.1 mgd of treated sewage to the St. Croix River within the study area (see Figure IV-7). The sewage treatment plants range in size from 0.07 to 1.7 mgd. Four of them have secondary treatment facilities. Year-round chlorination is practiced at one plant; the remainder chlorinate only between May and

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November. Together they discharge a total of 1,600 pounds of 5-day BOD and 1,400 pounds of suspended solids. The BOD and suspended solids removal efficiencies were generally as expected. Additional information on each of these plants is given in Tables IV-6 and IV-7 in the domestic wastes summary.

Summary of Domestic Waste Sources

Pertinent information on each of the plants, along with plant influent and effluent characteristics is given in Table IV-6. Waste loadings contributed by each of the sources are given in Table IV-7.

Domestic waste effluents having 5-day BOD and suspended solids concentrations greater than 50 and 60 mg/l, respectively, are listed in Tables IV-8 and IV-9 in order of decreasing strength. Similar information on coliform densities is summarized in Table IV-10.

Domestic waste effluents having 5-day BOD and suspended solids loading rates greater than 500 pounds per day are listed in Tables IV-11 and IV-12, respectively, in order of decreasing load. Similar information on coliform loadings is given in Table IV-13.

Properly designed and operated primary sewage treatment plants exhibit BOD and suspended solids removal efficiencies of 25 to 40 percent and 40 to 75 percent, respectively. Of all the primary plants, only the one at Hastings, Minnesota did not meet this criteria. BOD removal was found to be only in the order of five percent. The Minneapolis-St. Paul Sanitary District plant, although receiving 140 percent of its designed flow, was able to maintain BOD and suspended solids removal efficiencies of 31 and 66 percent, respectively.

Properly designed and operated secondary sewage treatment plants normally exhibit BOD and suspended solids removal efficiencies of 65 to 95 percent. Of all the secondary plants, only the one at St. Croix Falls, Wisconsin did not meet this criterion during its evaluation. BOD and suspended solids removal efficiencies were found by the Wisconsin Department of Health to be approximately 46 and 48 percent, respectively. An operational problem which has been corrected was largely responsible for this low efficiency. The mercury seal on the distributor of the high-rate trickling filter had failed, allowing most of the filter influent to discharge onto the center of the filter instead of being spread over the entire surface.

Only one community, Henderson, Minnesota, does not have treatment facilities. Approximately 500 of its 750 population are served by the municipal sewerage system which discharges untreated sewage to the Minnesota River at mile point 70.0.

The Minneapolis-St. Paul Sanitary District (primary) plant receives considerable amounts of industrial wastes. Because of this, it is the largest contributor of metals and phenol to the rivers within the study area. It is also the largest contributor of BOD, suspended solids, nitrogen, phosphate, and coliforms within the study area. Secondary units are under construction and will be completed this year.

The South St. Paul (secondary) plant is the second largest sewage treatment plant within the study area. Its primary and secondary units are grossly overloaded. Part of the difficulty, however, is overcome by its anaerobic lagoon which follows the trickling filters and intermediate settling tanks. The City has engaged an engineering firm to plan necessary additional treatment facilities.

TABLE IV - 6

SUMMARY OF DOMESTIC WASTE CHARACTERISTICS

SOURCE	RIVER MILE	AVG. FLOW RATE MGD	POPULATION SERVED	TYPE OF TREATMENT: PRI-MARY	SEC-ONDARY	TER-TIARY	CONT. Cl_2	SUMMER Cl_2	INFLUENT	EFFLUENT	AVERAGE CONSTITUENT CONCENTRATIONS: 5-DAY BOD mg/1	COD mg/1	SUSPENDED SOLIDS: TOTAL, mg/1	SUSPENDED SOLIDS: VOLATILE, mg/1	NITROGEN: TOTAL, mg/1	NITROGEN: NO_3 mg/1	TOTAL PHOSPHATE mg/1	COLIFORM DENSITY (DURING SUMMER): TOTAL MPN	COLIFORM DENSITY (DURING SUMMER): FECAL MPN	REMOVAL EFFICIENCY PERCENT: BOD	REMOVAL EFFICIENCY PERCENT: TOTAL SUSPENDED SOLIDS
MISSISSIPPI RIVER																					
Anoka STP[1]	871.5	0.96	9,500		x		x		x	x	259 19	455 164	238 46	223 33	- 30.5	- 0.7	- 24.7	9.4×10^7 $>2.7 \times 10^5$	4.3×10^7 $>2.6 \times 10^5$	93	81
Mpls.-St. Paul San. Dist. STP[2]	836.3	188.6	1,200,000	x					x	x	251 174	585 378	316 107	226 81	24.7 22.2	- -	13.8 13.5	- $>1.6 \times 10^7$	- 4.3×10^6	31	66
So. St. Paul STP[2]	832.4	14.2	25,000		x				x	x	1,298 272	- -	855 92	750 70	- 44.5	- -	- 19.1	- 3.9×10^6	- 2.5×10^6	79	89
Newport STP[1]	831.0	0.058	800		x			x	x	x	157 14	161 78	117 34	95 25	- 4.6	- 16.4	- 22.6	1.12×10^7 5.5×10^4	3.03×10^6 9.5×10^3	91	71
Inver Grove STP	830.3	0.020	230		x		x				(Effluent seeps	into ground	before reaching	River)						-	-
St. Paul Park STP	829.0	0.35	5,100		x				x	x	217 61	368 216	190 61	168 46	- 38.2	- 0.5	- 40.2	8.1×10^7 8.7×10^6	1.4×10^7 2.8×10^6	72	67
Cottage Grove STP[1]	819.6	0.425	6,500		x		x		x	x	240 56	535 210	196 55	162 51	- 39.5	- <1	- 54.2	8.2×10^6 4.2×10^6	2.3×10^6 1.3×10^6	77	72
Hastings STP	813.8	0.80	8,070	x					x	x	>188 180	307 348	205 118	176 99	- 24.8	- 1.2	- 30.0	9.2×10^7 6.6×10^7	4.1×10^7 2.0×10^7	>5	42
Prescott STP[1]	809.8	0.135	1,350	x				x	x	x	366 246	672 354	316 133	248 86	- 47.0	- 1.8	- 38.8	1.6×10^8 2.1×10^7	2.5×10^7 5.0×10^6	33	58
Red Wing STP	790.2	2.2	11,000		x				x	x	232 78	409 144	256 48	209 12	- 7.9	- 3.6	- 23.0	3.3×10^7 2.0×10^6	1.3×10^7 4.4×10^5	66	81
Lake City STP[1]	772.6	0.26	3,150	x				x	x	x	223 94	499 250	203 81	172 67	- 35.8	- 0.5	- 25.8	6.3×10^7 2.3×10^7	4.9×10^7 1.6×10^7	53	60
Pepin STP	767.2	0.054	900	x					x	x	508 303	684 594	255 157	213 133	- 62.6	- 0.8	- 74.4	2.3×10^8 1.1×10^7	7.1×10^7 5.5×10^6	40	38

1 Coliform densities were measured while chlorination facilities were operating.
2 Also receives industrial wastes.
3 Coliform densities were measured while the plant was not chlorinating.

TABLE IV - 6 (Continued)

SUMMARY OF DOMESTIC WASTE CHARACTERISTICS

SOURCE	RIVER MILE	AVG. FLOW RATE MGD	POPULATION SERVED	PRI-MARY	SEC-ONDARY	TER-TIARY	CONT. Cl_2	SUMMER Cl_2	INFLUENT	EFFLUENT	AVERAGE CONSTITUENT CONCENTRATIONS: 5-DAY BOD mg/1	COD mg/1	SUSPENDED SOLIDS: TOTAL, mg/1	SUSPENDED SOLIDS: VOLATILE, mg/1	NITROGEN: TOTAL, mg/1	NITROGEN: NO_3 mg/1	TOTAL PHOSPHATE mg/1	COLIFORM DENSITY (DURING SUMMER): TOTAL MPN	COLIFORM DENSITY (DURING SUMMER): FECAL MPN	REMOVAL EFFICIENCY PERCENT: BOD	REMOVAL EFFICIENCY PERCENT: TOTAL SUSPENDED SOLIDS
MINNESOTA RIVER																					
Mankato STP[1,2]	106.5	4.54	21,480	x			x		x		139	258	130	105	-	-	-	0.82 x 10^7	7.4 x 10^6	<32	45
										x	96	227	71	55	15.1	1.3	7 1	3.9 x 10^6	9 0 x 10^5		
Henderson	70.0	0.04	500		NONE															0	0
Chaska STP[2]	29.4	0.46	2,300		x				x		686	-	286	241	-	-	-	>2.2 x 10^7	>5 9 x 10^6	94	49
										x	41	-	145	87	15.3	0.2	12 3	1.34 x 10^7	<4 0 x 10^6		
Shakopee STP[3]	23.9	0.31	4,700	x				x	x		204	380	224	184	-	-	-	3.60 x 10^7	1.82 x 10^7	42	60
										x	118	276	90	85	35.0	0.8	32.1	2.55 x 10^7	1.53 x 10^7		
Savage STP[1]	14 4	0.22	1,700		x		x		x		>127	263	89	72	-	-	-	1.7 x 10^7	4 2 x 10^6	91	73
										x	> 11	85	24	14	12.8	2.4	12 5	6.7 x 10^4	3.4 x 10^4		
Burnsville STP[1]	10.5	0 51	4,400		x		x		x		>122	260	288	135	-	-	-	1.0 x 10^7	3 3 x 10^6	>92	83
										x	10	71	48	35	17.7	0.6	19 3	4.8 x 10^5	1 4 x 10^5		
Cedar Grove STP[1]	7.3	0.09	2,200		x		x		x		303	521	311	253	-	-	-	2.7 x 10^7	8 7 x 10^6	93	81
										x	21	149	59	45	21.0	0.8	31 6	3.5 x 10^5	1.1 x 10^5		
ST. CROIX RIVER																					
St. Croix Falls STP	51.9	0.18	1,100		x			x	x		101		124	96	-	-	-	-	-	46	48
										x	55		64	52	18.6	0.1	-	-	-		
Taylors Falls STP[1]	51.8	0 070	500		x			x	x		122	198	115	98	-	-		1.4 x 10^7	5.7 x 10^6	83	67
										x	20	94	38	32	9 5	3 7	16.9	7.4 x 10^5	1 7 x 10^5		
Osceola STP[1]	44.3	0.097	930	x				x	x		240	460	252	202	-	-		1.8 x 10^6	1 0 x 10^6	40	62
										x	144	301	95	76	36.7	0.6	28.7	1.2 x 10^6	5.8 x 10^5		
Stillwater STP[1,2]	21.2	1.79	7,480	x				x	x		180	275	105	95				>3 9 x 10^7	3.54 x 10^7	53	32
										x	84	174	71	52	15.9	0 6	17.7	1 3 x 10^6	1.3 x 10^6		
Bayport STP[1]	19.4	0.40	3,000		x		x		x		247	320	178	103				[illegible] 3 x 10^6	3.1 x 10^6	96	96
										x	9	4[illegible]	8	6	9 4	4 3	15 9	1.0 x 10^6	5 5 x 10^5		
Hudson STP	16.3	0.56	5,000		x			x	x		130	-	212	184	-	-	-	-	-	82	87
										x	23.1	-	28	26	18.1	6.8	-	-	-		

1. Coliform densities were measured while chlorination facilities were operating.
2. Also receives industrial wastes
3. Coliform densities were measured while the plant was not chlorinating.

TABLE IV - 7

SUMMARY OF DOMESTIC WASTE LOADING RATES TO STREAMS

SOURCE	RIVER MILE	AVG. FLOW RATE MGD	AMOUNT OF GIVEN CONSTITUENT DISCHARGED: 5-DAY BOD lb./day	Suspended Solids: Total lb./day	Suspended Solids: Volatile lb./day	Nitrogen: Total lb./day	Nitrogen: NO_3 lb./day	Total Phosphate lb./day	Coliforms: Total No./day	Coliforms: Fecal No./day
MISSISSIPPI RIVER										
Anoka STP	871.5	0.96	150	365	265	245	6	105	>1.0 x 10^{13}	>9.5 x 10^{12}
Mpls-St. P.San. Dist.	836.3	138.6	268,000	170,000	126,000	35,600	-	20,300	>1.1 x 10^{17}	3.1 x 10^{16}
So. St. Paul STP	832.4	14.2	32,200	10,900	8,270	5,200	-	2,300	2.1 x 10^{15}	1.3 x 10^{15}
Newport STP	831.0	0.058	7	16	12	2	2	10	5.[illegible] x 10^{12}	1.2 x 10^{11}
Inver Grove STP	830.3	0.020	(Effluent seeps into ground before reaching River)							
St. Paul Park STP	829.0	0.35	175	180	135	110	2	155	1.1 x 10^{14}	3.7 x 10^{13}
Cottage Grove STP	819.5	0.42	105	105	1[illegible]0	140	-	100	6.3 x 10^{13}	2.1 x 10^{13}
Hastings STP	813.3	0.80	1,100	700	660	145	[illegible]	200	2.0 x 10^{15}	6.1 x 10^{14}
Prescott STP	800.8	0.135	280	150	95	50	2	45	1.1 x 10^{14}	2.6 x 10^{13}
Red Wing STP	790.2	2.20	1,430	[illegible]0	220	14[illegible]	65	420	1.7 x 10^{14}	3.7 x 10^{13}
Lake City STP	772.[illegible]	0.26	205	175	145	[illegible]	1	55	2.3 x 10^{14}	2.3 x 10^{14}
Pepin STP	767.2	0.054	135	70	60	90	<1	5	2.2 x 10^{13}	1.1 x 10^{13}
MINNESOTA RIVER										
Mankato STP	106.5	4.54	3,560	2,6[illegible]0	2,080	570	50	270	6.7 x 10^{14}	1.5 x 10^{14}
Henderson	70.0	0.04	85 (Est.)	100(Est.)	65(Est.)	15(Est.)		15(Est.)	2.0 x 10^{14}(Est.)	-
Chaska STP	29.4	0.46	160	560	470	60	1	15	2.3 x 10^{14}	6.0 x 10^{13}
Shakopee STP	23.9	0.31	305	235	220	70	2	75	3.0 x 10^{14}	1.8 x 10^{14}
Savage STP	14.4	0.22	>20	45	25	25	4	25	5.6 x 10^{11}	2.3 x 10^{11}
Burnsville STP	10.5	0.51	40	205	150	75	3	35	9.3 x 10^{12}	2.7 x 10^{12}
Cedar Grove STP	7.2	0.09	15	15	35	15	1	25	1.2 x 10^{12}	3.3 x 10^{11}
ST. CROIX RIVER										
St. Croix Falls STP	51.9	0.18	85	100	80	20	<1	40(Est.)	-	-
Taylors Falls STP	51.8	0.070	10	20	20	5	2	10	2.0 x 10^{12}	4.5 x 10^{11}
Osceola STP	44.3	0.097	115	75	60	30	<1	25	3.3 x 10^{13}	1.7 x 10^{13}
Stillwater STP	21.2	1.79	1,250	1,0[illegible]0	775	235	9	2[illegible]5	[illegible] x 10^{13}	8.3 x 10^{13}
Bayport STP	19.4	0.40	30	25	20	30	15	55	1.5 x 10^{13}	8.3 x 10^{12}
Hudson STP	16.3	0.56	110	130	120	[illegible]5	30	100(Est.)	-	-

TABLE IV-8

DOMESTIC WASTES WITH GREATEST 5-DAY BOD CONCENTRATIONS[1]

(Listed in order of decreasing strength)

SOURCE	5-DAY BOD CONCENTRATION mg/l
Pepin STP	303
South St. Paul STP	272
Prescott STP	246
Hastings STP	180
Minneapolis-St. Paul Sanitary District STP	174
Osceola STP	144
Shakopee STP	118
Mankato STP	> 94
Lake City STP	94
Stillwater STP	84
Red Wing STP	78
St. Paul Park STP	61
Cottage Grove STP	56

1. Waste Sources with a 5-day BOD less than 50 mg/l are not listed.

TABLE IV-9

DOMESTIC WASTES WITH GREATEST SUSPENDED SOLIDS CONCENTRATIONS[1]

(Listed in order of decreasing strength)

SOURCE	SUSPENDED SOLIDS CONCENTRATION mg/l
Pepin STP	157
Chaska STP (while receiving Gedney Co. wastes)	145
Prescott STP	133
Hastings STP	118
Minneapolis-St. Paul Sanitary District STP	107
Osceola STP	95
South St. Paul STP	92
Shakopee STP	90
Lake City STP	81
Mankato STP	71
Stillwater STP	71
St. Croix Falls STP	64
St. Paul Park STP	61

1. Waste sources with a suspended solids concentration less than 60 mg/l are not listed.

TABLE IV-10

DOMESTIC WASTES WITH GREATEST TOTAL COLIFORM DENSITIES[1]
(Summer Values)
(Listed in order of decreasing strength)

SOURCE	TOTAL COLIFORM DENSITY MPN /100M/
Hastings STP	66,000,000
Shakopee STP	25,500,000
Lake City STP	23,000,000
Prescott STP	21,000,000
Minneapolis-St. Paul Sanitary District STP	> 16,000,000
Chaska STP (while receiving Gedney Co. wastes)	13,400,000
Pepin STP	11,000,000
Osceola STP	9,000,000
St. Paul Park STP	8,700,000
Cottage Grove STP	4,200,000
South St. Paul STP	3,900,000
Mankato STP	3,900,000

1. Waste sources with a total coliform density less than 3,000,000 MPN/100M/ are not listed.

TABLE IV-11

LARGEST DOMESTIC SOURCES OF 5-DAY (20°C) BOD[1]

(Listed in order of decreasing rate)

SOURCE	LOADING RATE TO STREAM	
	POUNDS/DAY	POPULATION[2] EQUIVALENT
Minneapolis-St. Paul Sanitary District STP	267,800	1,570,000
So. St. Paul STP	32,200	189,000
Mankato STP	3,560	20,900
Red Wing STP	1,430	8,420
Stillwater STP	1,250	7,350
Hastings STP	1,190	7,000

1. Sources contributing less than 500 pounds/day are not listed

2. Population equivalent based on 0.17 lb/day contributed per capita.

TABLE IV-12

LARGEST DOMESTIC SOURCES OF SUSPENDED SOLIDS[1]
(Listed in order of decreasing rate)

SOURCE	LOADING RATE TO STREAM	
	POUNDS/DAY	POPULATION[2] EQUIVALENT
Minneapolis-St. Paul Sanitary District STP	169,800	848,000
South St. Paul STP	10,900	54,500
Mankato STP	2,680	13,400
Stillwater STP	1,060	5,300
Red Wing STP	880	4,400
Hastings STP	790	3,950
Chaska STP (while receiving Gedney Co. wastes)	560	2,800

1. Sources contributing less than 500 pounds/day are not listed.

2. Population equivalent based on 0.20 lb/day contributed per capita.

TABLE IV-13

LARGEST DOMESTIC SOURCES OF TOTAL COLIFORMS[1]
(Summer Values)
(Listed in order of decreasing rate)

SOURCE	LOADING RATE TO STREAM NO./DAY	POPULATION EQUIVALENT[2]
Minneapolis-St. Paul Sanitary District STP	$> 1.1 \times 10^{17}$	>1,100,000
South St. Paul STP	2.1×10^{15}	21,000
Hastings STP	2.0×10^{15}	20,000
Mankato STP	6.7×10^{14}	6,700
Shakopee STP	3.0×10^{14}	3,000
Chaska STP (while receiving Gedney Co. wastes)	2.3×10^{14}	2,300
Lake City STP	2.3×10^{14}	2,300
Henderson	2.0×10^{14} (Est.)	2,000 (Est.)
Red Wing STP	1.7×10^{14}	1,700
Prescott STP	1.1×10^{14}	1,100
St. Paul Park	1.1×10^{14}	1,100
Stillwater	8.8×10^{13}	880
Cottage Grove STP	6.8×10^{13}	680
Osceola STP	3.3×10^{13}	330
Pepin STP	2.2×10^{13}	220
Bayport STP	1.5×10^{13}	150
Anoka STP	$>1.0 \times 10^{13}$	>100

1. Sources contributing less than 1.0×10^{13} coliforms/day are not listed. St. Croix Falls and Hudson sewage treatment plants were not considered.

2. Population equivalent based on 1.0×10^{11} coliforms/day contributed per capita.

INDUSTRIAL WASTES

Introduction

There are approximately 300 industries within the Project watershed area that discharge wastes to various water courses. A review of available industrial wastes information and field reconnaissance indicated that studies of industrial facilities which are remote from the water course of primary interest (Mississippi, Minnesota, and St. Croix Rivers) were unwarranted. Studies, therefore, were confined to those industries discharging wastes either directly into the three rivers of concern or into tributaries thereof a short distance above their confluences. In all, thirty-four industries were investigated (see Figures IV-2 - IV-7). None of the industries which discharge all their wastes to municipal facilities was studied, except the Foot Tannery.

The industries investigated can be classified as food and kindred products, chemical and allied products, leather and leather products, and petroleum refining and related industries. They discharge a total of 53,000 pounds of 5-day BOD and 63,000 pounds of suspended solids to the Mississippi and Minnesota Rivers. Their combined BOD and suspended solids loadings are about 20 and 37 percent, respectively, of those contributed by the Minneapolis-St. Paul Sanitary District sewage treatment plant.

Survey Method

Preliminary visits were made in cooperation with State Departments of Health to each industry investigated. During these visits information was obtained relating to water usage, the industrial process, and waste disposal practices. This information was then utilized in planning the industrial wastes sampling program.

Field work began with the collection of random grab samples from the waste outfalls. This procedure was continued until each particular waste was adequately characterized or until it became apparent that grab samples alone were not adequate. Where necessary, composite samples, weighted according to waste flow, were taken to supplement the random grab samples.

Results of the analyses on these samples, along with information provided by the industries, were used to calculate the waste loading rates.

Mississippi River Industries

Fourteen industries, one water treatment plant, three steam-electric generating plants, and two barge washing facilities were investigated on the Mississippi River.

The industries' principal products are meats, petroleum products, chemicals, fertilizers, printing and copying materials, and leather products. They discharge a total waste volume of about 30 mgd, containing 6,000 pounds of 5-day BOD and 14,000 pounds of suspended solids. In addition, three electric generating plants (when operating at full load) discharge about 160 billion BTU/day of heat directly to the river.

Information obtained on each industry is presented below. The order of presentation follows the sequence in which the industries occur as one proceeds downstream. The terms "left bank" and "right bank" apply as one faces downstream.

Minneapolis Water Treatment Plants. The City of Minneapolis owns and operates the Fridley and Columbia Heights water treatment plants. Raw water is pumped at an annual average rate of 61.6 mgd from the Mississippi River at mile 858.9 to the Fridley plant, located on the left bank at that point. Here, the water is softened. After softening, the water is divided about equally between the two plants for filtering and chlorination. Together the plants produce potable water for an estimated 530,000 people.

Wastes from these plants consist of sand filter backwash water and a lime slurry from the softening process. The Fridley plant pumps the lime slurry waste to a settling basin from which supernatant overflows to the river near mile 858.3 at a rate of about 1.6 mgd.

Backwashing operations are similar at both plants. In 1964, 252 million gallons were used for 1600 backwashes at Fridley and 1300 backwashes at Columbia Heights. On an average annual basis, then, both plants together used 0.69 mgd of water for backwashing. This operation lasts about five minutes and is carried out 6 to 10 times a day at each plant. Both plants discharge this waste directly to the river without treatment. The Fridley and Columbia Heights plants' outlets are located at mile 859.0 and 857.8, respectively. Waste characteristics and loading rates for all waste generated are given in summary Tables IV-18 and IV-19.

Riverside Steam-Electric Generating Plant. This plant, owned and operated by the Northern States Power Company (NSP), is located on the left bank of the Mississippi River at mile 856.9 and uses river water for cooling purposes. According to information obtained from NSP, the plant has eight generating units with a total net capability of 512,300 KW(5). The units are divided into four sections, each served by a separate circulating water intake and discharge. The flow rate of the circulating water through each unit is determined by the number of pumps being operated. Pump operation, in turn, is dependent on the generating load and incoming water temperature. The higher the load or water temperature, the more pumps there are in operation (see Table IV-14). At full generating load, 80.7

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TABLE IV-14

SUMMARY OF OPERATING DATA
FOR
RIVERSIDE STEAM-ELECTRIC GENERATING PLANT[1]
(River Mile 856.9)

SECTION	UNITS	NET CAPABILITY KW	SECTION[2] CAPACITY FACTOR, %	COOLING WATER PUMP CAPACITY 1 Pump in use at each unit GPM	COOLING WATER PUMP CAPACITY 2 Pumps in use at each unit GPM	INTAKE TEMP. AT [illegible] AT FULL LOAD °F	TEMP. RISE OF COOLING WATER AT FULL LOAD, °F 1 Pump/unit	TEMP. RISE OF COOLING WATER AT FULL LOAD, °F 2 Pumps/unit	HEAT REJECTION RATE AT FULL LOAD BILLION BTU/Day
400 PSI	1,2	81,500	24.3	64,000	99,000	>61.5	20.4	13.2	15.7
225 PSI	3,4,5	72,200	1.3	122,500	122,500[3]	-	11.3	-	16.6
900 PSI	6,7	135,600	57.8	54,000	84,000	>56	36.8	23.6	23.9
2400 PSI	8	223,000	95.1	53,000	106,000	>49.5	38.3	19.2	24.5
TOTAL		512,300	-	293,500	411,500	-	-	-	80.7

1. Information was provided by the Northern States Power Company.

2. Section Capacity Factor = $\frac{\text{Total Kwh Generated}}{\text{Plant Rated Capacity} \times \text{Hours}}$

3. Units 3,4, and 5 have only one pump, each.

billion BTU/day of heat is transferred to the cooling water which is discharged directly to the river.

High Bridge Steam-Electric Generating Plant. This plant, also owned and operated by NSP, is located on the left bank of the Mississippi River at mile 840.5. River water, used for cooling purposes, is returned directly to the river after use. This plant has six generating units with a total net capability of 482,800 KW. The units are divided into four sections and operated in a manner similar to the Riverside plant. At full generating load, the heat rejection rate is 74.1 billion BTU/day. A summary of the operating information is provided in Table IV-15.

Minnesota Harbor Service. This company operates barge washing facilities on the right bank of the Mississippi River at mile 840.4. In one season (April through October), they clean approximately 500 coal barges, 25 salt barges, and 25 phosphate (fertilizer) barges. Water used for cleaning is pumped from the river at a rate of 2,000 gallons per barge. Waste water is pumped to a settling pit for removal of solids before discharge back into the river. Visual inspection of the operation indicated that the mass of wastes discharged was too small to warrant a detailed evaluation.

Twin City Shipyard. This company operates barge cleaning facilities from April through October on the left and right banks of the river near mile 837.3 (and also on the Minnesota River at two locations). In one season they clean approximately 315 coal barges, 30 phosphate barges, 5 grain barges, 12 molasses barges, and 1 or 2 gasoline barges at the Mississippi River location. Barges having contained dry cargos are vacuum cleaned by special equipment that allows air borne solids and wash water

TABLE IV-15

SUMMARY OF OPERATING DATA
FOR
HIGH BRIDGE STEAM-ELECTRIC GENERATING PLANT[1]

SECTION	UNITS	NET CAPABILITY KW	SECTION[2] CAPACITY FACTOR, %	COOLING WATER PUMP CAPACITY: 1 Pump in use at each unit GPM	COOLING WATER PUMP CAPACITY: 2 Pumps in use at each unit GPM	INTAKE TEMP. AT WHICH 2 PUMPS IN USE/UNIT AT FULL LOAD °F	TEMP. RISE OF COOLING WATER AT FULL LOAD °F: 1 Pump/unit	TEMP. RISE OF COOLING WATER AT FULL LOAD °F: 2 Pumps/unit	HEAT REJECTION RATE AT FULL LOAD BILLION BTU/Day
300 PSI	1,2	76,200	17.4	82,000	82,000[3]	-	15.4	-	15.1
850 PPSI	3,4	123,600	76.2	53,500	79,000	<65	30.8	20.7	19.7
1450 PSI	5	116,400	104.9	50,400	75,500	<42	32.0	20.7	19.0
1800 PSI	6	166,600	99.0	50,400	75,500	<65	33.5	22.4	20.3
TOTAL		482,800	-	236,300	312,000	-	-	-	74.1

1. Information was provided by the Northern States Power Company.

2. Section Capacity Factor = $\frac{\text{Total Kwh Generated}}{\text{Plant Rated Capacity x Hours}}$

3. Units 1 and 2 have only one pump, each.

(2000 gallons per barge) to be collected in two 14 cubic yard sediment tanks. Each tank outlet is equipped with a 12 mesh screen to prevent larger particles from escaping when the water is drained out and returned to the river. Visual inspection of the operation indicated that the mass of wastes discharged was too small to warrant a detailed evaluation.

South St. Paul Meat Industries. The meat industry complex in South St. Paul is comprised of Swift and Company, Union Stockyards, Morris Rifkin & Sons, Inc., and Armour and Company. They are situated on the right bank of the Mississippi River between mile points 833.4 and 833.0. In this complex livestock is housed, slaughtered, and processed. Most of the wastes are conveyed by an interceptor sewer to the South St. Paul sewage treatment plant. This interceptor sewer, which runs parallel to the river, also accepts flows from several combined trunk sewers serving the City of South St. Paul. At each trunk sewer connection, there is a diversion chamber designed to divert dry weather flow from the trunk sewer to the interceptor. During periods of peak industrial activity or storm water runoff, flows in excess of the interceptor sewer capacity are diverted to the river at each diversion chamber. A more complete description of this situation is given in the sections on domestic wastes and combined sewer overflows.

Some of the wastes generated by the stockyards, Swift, and Armour are not received by the sewerage system at all, but are discharged directly to the river. These wastes, however, are generally of much lower strength than the wastes discharged to the interceptor system. Those discharged directly by Swift and Company and Armour and Company are cooling water. Swift and Company utilizes about 5 mgd of Mississippi River water for cooling purposes, returning it directly to the river. Armour and Company utilizes approximately 2.4 mgd of well water for cooling purposes, discharging it directly to the river. The latter three, designated as sewers No. 3, 4B, and 5, are described in a report prepared for the City of South St. Paul by their consulting engineers (2).

According to that report, wastewater in sewer No. 3 normally consists of watering trough overflow and surface drainage having an average 5-day BOD of 48 mg/l. During summer months, it also receives wastewater resulting from the flushing or washing of hog pens for one and one-half to two hours each day in the late afternoon. During this period each day, however, all wastewater in Sewer No. 3 is supposedly pumped into the intercepting sewer. The maximum dry weather flow rate in Sewer No. 3 during the flushing operation is about 4.3 mgd.

Stockyards sewer No. 4B receives surface drainage and watering trough overflow which is pumped directly to the river. The 5-day BOD of this waste ranges from 12 to 51 mg/l. The maximum dry weather flow rate ever anticipated in this sewer is 1.7 mgd.

Stockyards sewer No. 5 receives surface drainage and watering trough overflow with an average 5-day BOD of about 8 mg/l. It is discharged directly to the river.

According to reference 2 the estimated average discharge rate to the river from sewers No. 3, 4B, and 5, combined, is 2 mgd. The 5-day BOD loading to the river from these three direct discharges is estimated to be less than 500 pounds/day.

King Packing Company. This plant, located on the left bank of the Mississippi River at mile 832.5, is engaged in the packaging of meats. About 100 persons are employed by the Company which operates 12 months a year, 5 days per week, 16 hours per day. The only waste discharged to the river is cooling water, which is obtained from wells. It is discharged continuously at an average rate of 1.73 mgd and has a BOD of only 2 mg/l.

Other wastes generated in the plant are discharged to a primary settling tank and thence to a pond with no outlet for final disposal.

Northwestern Refining Company. This company, located on the left bank of the Mississippi River at mile 830.0 employs 192 persons and processes approximately 25,000 barrels of crude oil per day. Products include gasoline, kerosene, No. 2 fuel oil, No. 3 fuel oil, industrial fuel, asphalt, and jet fuel. Operation is continuous throughout the year.

All wastes subject to oil contamination are passed through an API oil separator before being discharged, along with other wastes, to a primary lagoon. From there the wastes pass to a secondary lagoon which provides a residence time of about 10 days. The secondary lagoon discharges at a rate of 1.44 mgd to the river through either a pipe at the bottom of the lagoon or a hay filter at the surface. Waste characteristics and loading rates to the river are given in Tables IV-18 and IV-19 in the summary at the end of the discussion on industrial wastes.

J. L. Shiely Company. The Shiely Company operates gravel washing facilities at their Larson and Nelson Plants, located on the left bank of the river at mile points 826.5 and 825.0, respectively. Both plants operate seven months per year from April through October. Wash water is obtained from the river at each installation.

The Larson Plant conducts washing operations at an average of four hours per day, sixty days per year. A 1,000 gpm pump supplies about 240,000 gallons of water each of these days. Wastewater passes through a clarification basin before being returned to the river.

The Nelson Plant conducts washing operations about 12 hours per day, 5 days per week over the 7-month period. Two pumps, with a total capacity of 6,000 gpm, supply 4.33 million gallons of water daily to the facility. Wastewater passes through a clarification basin before being returned to the river. Visual inspection of the operation indicated that the mass of wastes discharged was too small to warrant a detailed evaluation.

General Dynamics Corporation-Liquid Carbonics Division. This plant, located one mile back from the right bank of the Mississippi River near mile 824.2, employs 20 persons and produces liquid carbon dioxide and dry ice. Approximately 75 tons of carbon dioxide are processed daily. Operation is 24 hours per day, 5-7 days per week, the year-round. Peak operation occurs from June through August. Process wastes, including cooling water, are pumped at a 0.7 mgd rate to a force main carrying the St. Paul Ammonia Products Company wastes to the river. Waste characteristics and loading rates to the river are given in Tables IV-18 and IV-19 of the industrial wastes summary.

All sanitary wastes are treated by means of a septic tank and seepage field.

St. Paul Ammonia Products, Inc. This plant is about one mile back from the right bank of the river near mile 824.2 and employs 150 people. It produces ammonia, ammonium, nitrate, nitric acid, and carbon dioxide from natural gas. Approximately 12 million cubic feet of natural gas is processed per day.

Plant sanitary wastes are disposed of by means of septic tanks and seepage fields.

Process wastes are passed through a basin equipped for oil removal and the collection of chemical sludge before being discharged to the river via a force main. The discharge rate averages 0.66 mgd. Waste characteristics and loading rates to the river are given in Tables IV-18 and IV-19 of the industrial wastes summary.

Great Northern Oil Company. This company, located about one mile back from the right bank of the river at mile 824.0, refines approximately 50,000 barrels of crude oil per day. Products include gasoline, heating oils, heavy fuel oils, propane, coke, and sulfur. Operation is continuous year-round with the exception of a two-week shutdown period.

Process wastes pass through a sour water stripper followed by a surge tank and trickling filter. Oily waters pass through an API oil separator into the same intermediate pond that receives the trickling filter effluent. From there the wastes pass into a second intermediate pond, then through a hay filter into the activated sludge unit and then into a final pond. Boiler blowdown water is also discharged to the final pond. The final pond effluent is pumped to the river at an average rate of 3.23 mgd. Waste characteristics and loading rates are given in summary Tables IV-18 and IV-19.

Northwest Cooperative Mills, Inc. This plant, located on the right bank at mile 823.8 and employing about 100 persons, produces 240 tons of ammonium phosphate fertilizer per day. About 100 tons per day of phosphoric acid are produced as an intermediate product. Water requirements of about 239 gpm (0.34 mgd) are satisfied by a single well. Ammonium phosphate and phosphoric acid process wastes, containing chiefly gypsum and fluorides, are discharged at rates of 34 and 16 gpm, respectively, to a 22-acre storage pond where the calcium sulfate slurry is collected. Supernatant from the pond is reused elsewhere in the plant. The only discharge ordinarily resulting from pond operation is due to leakage, estimated by the company to be four gpm. The plant also has what they refer to as a compositing pond, primarily to collect storm water runoff. Approximately 96 gpm of wastewater from miscellaneous plant sources are also discharged to this pond, which has an overflow to the Mississippi River. All sanitary wastes are treated separately with final disposal in the soil.

During the waste survey (June 28 - August 6, 1965) there was a leak in the storage pond dike resulting in average flow of 48 gpm (0.0697 mgd) in an adjacent ditch which discharges to the river. Eleven grab samples were collected from this ditch, designated as INC 371. The fluoride concentration was checked in one of these samples and found to be 262 mg/l. This leak has since been repaired.

Effluent from the compositing pond (INC 370) was also sampled eleven times during the same period. The discharge rate averaged 32 gpm (0.0458 mgd). The fluoride concentration was checked in one of the samples and found to be 19.5 mg/l. Further characteristics and loading rates of wastes from INC 370 and 371 are given in Tables IV-18 and IV-19 of the industrial wastes summary.

Minnesota Mining and Manufacturing Company. This company's Chemolite Plant, located on the left bank of the river near mile 817.2, employs 1,200 people and operates continuously in some departments. The plant produces a variety of products including dry copy paper, film developing paper, polymers, resins, miscellaneous chemicals, coating products, reflective signs, and printing products. Total water usage at the plant is approximately

4.5 mgd and is supplied by wells.

Plant cooling water (IMM 359) is discharged at an average rate of 4.08 mgd directly to a ravine a short distance above its confluence with the river. Other plant wastes pass through neutralization and settling tanks and then through three ponds. The final pond effluent (IMM 358) discharges at an average rate of 1.68 mgd to the same ravine and together with the cooling water enters the river. Further information on the wastes is given in summary Tables IV-18 and IV-19.

This company plans to begin construction of secondary biological treatment facilities this year.

H. D. Hudson Manufacturing Company. This company, located on the right bank of the river at mile 814.2 in Hastings, Minnesota manufactures hand operated sprayers and dusters for use in the application of pesticides. The plant operates year-round, 8 hours per day, 5 1/2 days per week, and employs a maximum of 275 people. All wastes, except those from metal cleaning operations, are discharged to the Hastings sewerage system. Wastes consisting of drippings from the brass cleaning process, which utilizes chromic acid, is collected in a sump and pumped to one of two holding tanks. When a tank becomes full it is treated chemically to precipitate the Chromium. Supernatant is then pumped to the river at a rate of about 600 gallons per day (gpd). The Chromate sludge is hauled away to a dumping area by truck. Analysis of a sample of holding tank waste before treatment showed it contained 100 mg/l of copper, 16 mg/l of zinc, and 0.75 mg/l of total chromium. No nickel, cadmium, or lead was found to be present. At the 600 gpd rate, only 0.5 pound of copper, 0.08 pound of zinc, and 0.004 pound of chromium reach the tank daily for treatment.

S. B. Foot Tanning Company. This company, located about two miles distant from the right bank of the river near mile 792.8, employs 340 people and operates year-round, 6 days per week, 18-24 hours per day. The company processes 118,800 pounds of hides per day by both chrome and vegetable tanning methods. Average daily water use is approximately 1.1 mgd and is supplied by two wells.

All plant wastes are pumped to six anaerobic lagoons owned and operated by the City of Red Wing for the sole use of the tannery. One lagoon is used at a time. When one fills with sludge to the point where it is no longer effective in removing solids, another one is placed into operation. Usually, all lagoons become filled with sludge in a year's time. When this occurs, all six lagoons are dredged and the same procedure is repeated. Effluent from the lagoons is discharged to Hay Creek about three miles above its confluence with the river.

Difficulties, observed by Project personnel, have been experienced with the present waste treatment system. Occasionally lagoon influent lines clog and wastes must be bypassed directly to Hay Creek. Waste characteristics and loading rates when treating and when bypassing are given in summary Tables IV-18 and IV-19.

Pittsburgh Plate Glass Company - Linseed Oil Division. This plant, located on the right bank of the river at mile 790.7 in Red Wing, Minnesota, discharges cooling water obtained from wells directly to the river at a rate of about 1.0 mgd. All process and sanitary wastes are discharged to the municipal sewage treatment plant.

Red Wing Steam-Electric Generating Plant. This plant, owned and operated by NSP, is located on the right bank of the river at mile 789.4. River water is used for cooling purposes, being returned directly to the river after use. According to NSP, this plant has one unit with a net capability of 29,000 KW(5). At full generating load, the heat rejection rate is 4.18 billion BTU/day. The cooling water flow rate is determined by the number of pumps in operation. This in turn, is dependent on the generating load and incoming water temperature. When running at full load with an up-river temperature in excess of 70°F, three pumps (capacities of 18,700, 11,200 and 7,500 gpm) are operated producing a flow of 37,400 gpm. This produces an increase in the cooling water temperature of 9.3°F. At up-river temperatures below 38°F, only the large pump or the two small pumps are operated. This causes an increase of 18.6°F in the cooling water temperature.

Blue Earth River Industry

Honeymead Products Company. This company, located on the right bank of the Blue Earth River 0.6 mile above its confluence with the Minnesota River, was the only industry on the Blue Earth River investigated. It was the site of one of the two oil spills that occurred in the winter of 1962-63. The company processes 40 to 50 thousand bushels of soybeans daily and produces a variety of products therefrom, including: soybean oil, meal, lecithinated meal, lamisoy, soy flour, toasted soy flour, brew flakes, crude oil, degummed oil, gums, lecithin, once refined oil (clearsoy), refined, bleached oil (lustersoy), fully refined, deodorized oil (savorsoy), shell drain oil, clabber oil, and acidulated soap stock. The company employs approximately 75 people and operates 12 months per year, 7 days per week, 24 hours per day.

All process wastes and cooling water are discharged through an oil separator unit to the Blue Earth River at a rate of 4.32 mgd. Waste characteristics and loading rates to the river are given in summary Tables IV-18 and IV-19.

Minnesota River Industries

Eleven industries, two steam-electric generating plants and two barge cleaning facilities were investigated on the Minnesota River.

The industries' principal outputs are sugar and other food products, dairy products, malt, and crude soybean oil. While in operation they discharge a total waste volume of 14 mgd, containing 45,000 pounds of 5-day BOD and 47,000 pounds of suspended solids (when existing waste treatment facilities are functioning). In addition, the two electric generating plants (when operating at full load) discharge about 61 billion BTU/day of heat.

Information obtained on each industry is summarized below. The presentation is similar to that used in the previous discussion of Mississippi River Industries.

North Star Concrete Products Company. This company's installation is located on the right bank of the Minnesota River at mile 108.2. In addition to the manufacture of concrete products, the company is also engaged in the washing of sand and gravel from April through October, 6 days per week, 8 hours per day. Wash water is obtained from an adjacent flooded quarry using a 1,000 gpm pump. Waste wash water is passed through a clarification basin before being discharged to the river. The basin was designed to provide a detention period of 7 days for a 600 gpm flow rate. Visual inspection of the operation indicated that the mass of wastes discharged was too small to warrant a detailed evaluation.

Archer Daniels Midland Company. This company, located in Mankato, Minnesota on the right bank of the river near mile 106.0, is engaged in the production of crude soybean oil and employs about 50 people. The plant, which operates year-round 24 hours per day, processes some 17,000 bushels of soybeans daily. Approximately 187,000 pounds of crude oil and 80,000 pounds of soybean meal are produced daily.

All process and sanitary wastes are discharged to the Mankato sewerage system. About 0.042 mgd of cooling water, obtained from wells, is discharged to a ditch leading to the Minnesota River. Waste characteristics are given in summary Table IV-18.

Blue Cross Rendering Company. This company, located in Mankato, Minnesota on the right bank of the river at mile 105.5, processes about 50,000 pounds per day of dead animals, meat scraps, and animal offal to produce nonedible fats and high-protein feed additives. It employs 14 people and operates year-round, 15 hours per day, 6 days per week. Peak operation occurs from March through May each year. Minimum production occurs in November and December. Average water flow through the plant is 65 gpm, 40 gpm (0.058 mgd) of which is used for cooling.

Plant wastes, averaging 25 gpm (0.036 mgd) are treated by a tilt trough trickling filter prior to discharge to the river. Cooling water is passed through a grease trap before it is discharged to the river. Waste characteristics and loading rates to the river are given in summary Tables IV-18 and IV-19.

Wilmarth Steam-Electric Generating Plant. This plant, owned and operated by NSP, is located on the right bank of the river at mile 105.2. River water is used for cooling purposes, being returned directly to the river after use. According to NSP, the plant has one unit with a net capability of 27,900 KW(4). At full generating load, the heat rejection rate is 4.12 billion BTU/day. The cooling water flow rate is determined by the number of pumps in operation. This, in turn, is dependent on the generating load and incoming water temperature. When running at full load with an up-stream temperature in excess of 60°F, three pumps (capacities of 11,500, 5,750, and 5,750 gpm) are operated producing a flow of 23,000 gpm. This produces an increase in the cooling water temperature of 14.9°F. At up-river temperatures below 60°F, only the large pump and one small pump are operated. This causes an increase of 19.9°F in the cooling water temperature.

Green Giant Company. The Green Giant Company plant, located in LeSueur, Minnesota, on the right bank of the river at mile 75.4, is engaged in the canning of corn and peas. Approximately one million cases of 12 oz. cans (24 cans per case) of corn and one-half million cases of 17 oz. cans (24 cans per case) of peas are produced each season. The canning season is normally from June through September with peak operation during August. Plant operation averages 15 hours per day, 7 days per week over the four-month period. Approximately 140 and 400 people are employed during the "pea pack" and "corn pack" operations, respectively. Process water is supplied by the City of LeSueur. Water use data for the plant during the 1964 season are given in Table IV-16.

Wastes from the operation include sanitary wastes, process wastes, cooling water, corn silage stack liquor, and clean-up water. The vast majority of the sanitary wastes are discharged to the City of LeSueur sewerage system. A small amount, however, is discharged directly to the

TABLE IV-16

SUMMARY OF PLANT WATER USE DATA
AT GREEN GIANT COMPANY DURING 1964 SEASON
(Minnesota River Mile 75.4)

TYPE OF WATER USE	WATER USE DURING PEA PACK JUNE 13-JULY 25 (562 Hours)		WATER USE DURING CORN PACK AUGUST 1-SEPTEMBER 20 (734 Hours)	
	Rate of Use gpm	Total Use Gallons	Rate of Use gpm	Total Use Gallons
Cooling	120	4,042,000	120	5,310,000
Boiler	75	2,527,000	75	3,317,000
Sanitary	20	674,000	20	885,000
Process	627	21,155,000	1,015	44,903,000
TOTAL	842	28,398,000	1,230	54,415,000

river along with other miscellaneous wastes (through the outlet designated as IGG 235). Process wastes and silage liquor are normally discharged to ridge and furrow irrigation fields. As a result of the spring floods in 1965, however, these fields were rendered inoperable during most of the "pea pack" operation that year. The process wastes were discharged directly to the river (through the outlet designated as IGG 236) until the fields could be placed back into operation. Bypassing of process wastes also occurs when the sump pump breaks down. Cooling water is discharged directly to the river (through outlet IGG 233) at all times. Grab samples were collected from all three discharge lines during the period between June 6 to July 23, 1965. A 24-hour survey was conducted on July 14 and 15, 1965, while all wastes were being discharged to the river. During the 24-hour survey, discharge rates from IGG 236, 235, and 233 were 865, 10, and 150 gpm, respectively. Waste characteristics and loading rates determined during the survey are given in summary Tables IV-18 and IV-19. Since all wastes discharged from outlet IGG 236 normally go to the ridge and furrow irrigation fields, waste loadings from outlets IGG 235 and 233 represent "usual" conditions.

Minnesota Valley Milk Processing Cooperative Association. The Belle Plaine plant of this association is located on the right bank of the river at mile 49.8. The plant, which employs 25 to 50 persons, processes 250 to 500 thousand pounds of skimmed milk daily, producing non-fat dry milk. Operation is year-round, 9 to 16 hours per day, 7 days per week with peak production from June through August. Average water use (estimated by the company) is 0.27 mgd for all purposes.

Waste treatment facilities, consisting of a lift station and mechanical ditch aeration, were completed in November, 1965 and placed into operation in the spring of 1966. These facilities receive all process and sanitary wastes. Cooling water is and will continue to be discharged directly to the river. Until these new facilities were placed into operation, sanitary wastes were discharged to a septic tank and drain field system and process and cooling waters were discharged directly to the river. Summary Tables IV-18 and IV-19 present waste characteristics and loading rates before operation of the treatment facilities.

American Crystal Sugar Company. This company's plant in Chaska, Minnesota at mile 27.7 on the left bank of the river produces refined granular sugar and molasses from sugar beets using the straight house process. Normally, the plant operates from early October through January employing about 240 people. Operation is generally uniform 24 hours per day, 7 days per week during this period. Process water is obtained from two sources, the river and a well. The company estimates their water usage rate to be between 5.5 and 5.7 mgd. Measurements of waste discharge made by the Minnesota Department of Health indicated it to be 6.2 mgd.

Sanitary wastes are discharged to the Chaska sewerage system. All process wastes are discharged directly to the Minnesota River without treatment. Condensate and screen and press water, however, are recirculated. Grab samples were collected over a period from October 11, 1964 to November 20, 1964. Composite samples were collected during a 48-hour survey on November 18, 19 and 20, 1964. During the 48-hour survey, the waste flow was relatively constant, averaging 7.0 mgd. The wastes were high in BOD, suspended solids, and coliforms. While in operation, this company is the greatest industrial contributor of these constituents. Waste characteristics and

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loading rates to the river are given in summary Tables IV-18 and IV-19.

M. A. Gedney Company. This company, located in Chaska, Minnesota on the left bank of the river near mile 27.5 produces pickles, salad dressing, vinegar, and mustard. Operation is continuous year-round, 7 days per week, 24 hours per day. Peak operation occurs from July through September.

The company is presently building treatment facilities to handle all process wastes. These facilities, when completed, will consist of a pumping station, force main, and two stabilization ponds (Ponds A and B). All except Pond B was completed by December, 1965. Pond B is planned for completion by August, 1966. Sanitary wastes will continue to be sent to the municipal sewerage system.

Until Pond A was put into operation early in 1966, all wastes were discharged to the municipal sewerage system. After this data all wastes were stored in Pond A until occurrence of 1966 spring high rivers flows. At that time the partially stabilized wastes from Pond A were drained to the river at a controlled rate under conditions specified by the Water Pollution Control Commission to avoid unsatisfactory conditions. Wastes were again allowed to accumulate and will continue to accumulate in Pond A until the completion of Pond B. At this time the two ponds will be operated as a series of cells in a waste stabilization pond system and no wastes will be discharged until completely treated.

Rahr Malting Company. The Rahr Malting Company plant at Shakopee, Minnesota is located on the right bank of the river at mile 25.4. The company employing about 80 people, produces malt from barley, processing an average of 18,000 bushels per day. Operation is uniform year-round, 24 hours per day, 7 days per week. Water use depends on such things as the type of malt and the ambient air temperature and can vary from 1 to 3 mgd.

Waste sources within the plant include steep tank drainage and overflow, germinating drum wash water, cooling water, and sanitary wastes. Sanitary wastes are discharged to the Shakopee sewerage system. All other wastes are discharged directly to the river without treatment except for screening. Waste characteristics and loading rates, based on a 48-hour survey during which the discharge averaged 2.03 mgd, are given in summary Tables IV-18 and IV-19.

Owens-Illinois Glass Company. This company's Paper Products Division, located on the right bank of the river near mile 20.9, is engaged in the fabrication of cardboard boxes.

All wastes (0.02 mgd) are treated in a "rated aeration" plant before being discharged into a ditch leading to the river. Due to the low volume of effluent, however, very little if any of it ever reaches the river. The waste characteristics are given in Table IV-18 in the summary.

American Wheaton Glass Company. This company's plant, located on the right bank of the river near mile 20.7, employs about 437 people and produces glass containers. Operation is continuous the year-round. Total water usage at the plant averages 0.2 mgd.

Sanitary wastes are treated in septic tanks. The process waste is discharged to a ditch leading to the river. Characteristics of the process waste are given in Table IV-18 in the summary.

Cargill, Inc. Cargill, Inc., located in Savage, Minnesota on the right bank of the river at mile 13.4, operates a soybean oil extraction plant and stores certain commodities, including fertilizers, salt, and coal at the site. The extraction plant, operating continuously, produces crude soybean oil from approximately 18,000 bushels of soybeans daily. Water required for this purpose is approximately 1.0 mgd.

Treatment of wastes consists of screening and oil separation. Following treatment, the wastes are discharged to a slough a short distance from its confluence with the Minnesota River. The slough also carries drainage from the plant property and could contain various amounts of the materials stored thereon.

Samples were collected over a 5 1/2 month period at the mouth of the slough and results, therefore, are indicative not only of plant processing wastes but also of the drainage from the Cargill property. Waste characteristics and loading rates are given in Tables IV-18 and IV-19 in the summary.

Twin City Shipyard. This company operates barge cleaning facilities from April through October on the right bank on the river at mile points 13.2 and 8.0. In one season they clean about 10 molasses barges at the upper location. At mile 8.0, they clean approximately 410 coal barges and 20 grain barges per season.

Barges having contained dry cargos are vacuum cleaned by special equipment that allows air borne solids and wash water (2,000 gallons per barge) to be collected in a 25 cubic yard sediment tank. The tank outlet is equipped with a 12 mesh screen to prevent larger particles from escaping when the water is drained out and returned to the river. Visual inspection of the operation indicated that the mass of wastes discharged was too small to warrant a detailed evaluation.

Blackdog Steam-Electric Generating Plant. This plant, owned and operated by NSP, is located on the right bank of the river near mile 8.4 and uses river water for cooling purposes. The plant has four generating units with a total net capability of 460,900 KW. Each unit is equipped with two cooling water pumps. Their operation, summarized in Table IV-17, is similar to those of the other NSP plants already discussed. At full generating load, the heat rejection rate is 56.6 billion BTU/day. The discharged cooling water can be returned directly to the river (at mile 8.4)or to Blackdog Lake, which is used as a cooling pond. Blackdog Lake has two controlled outlets to the river, one at mile 10.4 and the other at mile 7.5. The apportionment of the discharged cooling water flow among the three outlets is varied, depending on river flow, temperature, and plant load.

St. Croix River Industries

Only two industries were found on the St. Croix River within the study area that discharged wastes directly to the river. They are the Andersen Window Company in Bayport, Minnesota and the United Refrigerator Company in Hudson, Wisconsin. Together, they discharge 0.5 mgd of wastes containing 16 pounds of 5-day BOD and 57 pounds of suspended solids.

Andersen Window Company. This company, located on the right bank of the St. Croix River at Andersen Bay near mile 20.2, manufactures wooden windows at a rate of 80 boxcar loads per day. Operation is uniform throughout the year, 8 hours per day, 5 days per week. Plant employees number about 1,000. Water usage averages 15,000 gallons per week in winter and 1,000,000 gallons per week in summer.

Sanitary Wastes are discharged to the municipal sewerage system. Plant wastes, which include cooling water, boiler blowdown water, and paint wash

TABLE IV-17

SUMMARY OF OPERATING DATA
FOR
BLACKDOG STEAM-ELECTRIC GENERATING PLANT[1]
(Minnesota River Mile 8.4)

UNIT	NET CAPABILITY KW	SECTION[2] CAPACITY FACTOR,%	COOLING WATER PUMP CAPACITY: 1 Pump in use at each unit GPM	COOLING WATER PUMP CAPACITY: 2 Pumps in use at each unit GPM	INTAKE TEMP. AT WHICH 2 PUMPS IN USE/UNIT AT FULL LOAD °F	TEMP. RISE OF COOLING WATER AT FULL LOAD, °F: 1 Pump/unit	TEMP. RISE OF COOLING WATER AT FULL LOAD, °F: 2 Pumps/unit	HEAT REJECTION RATE AT FULL LOAD BILLION BTU/Day
1	72,200	73.5	29,000	45,000	>62	30.2	19.5	10.5
2	102,200	79.8	45,400	68,000	>59	24.3	16.2	13.2
3	112,200	100.3	38,800	60,000	>40	28.4	18.3	13.2
4	174,300	106.4	61,000	85,000	>69	26.8	19.1	19.6
TOTAL	460,900	-	174,200	258,000	-	-	-	56.5

1. Information was provided by the Northern States Power Company.

2. Section Capacity Factor $= \frac{\text{Total Kwh Generated}}{\text{Plant Rated Capacity x Hours}}$

water, are discharged directly to the river from four outlets. The total combined discharge rate averages 0.45 mgd. Waste characteristics and stream loading rates are given in summary Tables IV-18 and IV-19.

United Refrigerator Company. This company, located on the left bank of the river at mile 16.5, produces refrigerators and freezers at a rate of 120 units per day. Operation is continuous the year-round, 8 hours per day, 5-6 days per week. Total plant water usage averages 0.073 mgd.

Sanitary wastes are discharged to the municipal sewerage system. Metal cleaning and rinsing wastes and cooling water are discharged to the river at an average rate of 0.059 mgd. Waste characteristics and stream loading rates are given in summary Tables IV-18 and IV-19.

Summary of Industrial Wastes Information

Concentrations of the various constituents measured in each industrial waste are summarized in Table IV-18. Waste loadings contributed by each of the sources are summarized in Table IV-19.

Wastes having 5-day BOD and total suspended solids concentrations greater than 50 and 60 mg/l, respectively, are listed in Tables IV-20 and IV-21, in order of decreasing strength. Table IV-22 summarizes industrial waste coliform densities in a similar manner.

Wastes having 5-day BOD and total suspended solids loading rates equal to or greater than 500 pounds per day are listed in Tables IV-23 and IV-24, respectively, in order of decreasing load. Similar information on coliform loading rates is given in Table IV-25.

TABLE IV-18

SUMMARY OF INDUSTRIAL WASTES CHARACTERISTICS

INDUSTRIAL WASTE SOURCE	RIVER MILE	AVG. FLOW RATE MGD	TYPE OF TREATMENT	AVERAGE CONSTITUENT CONCENTRATIONS																						
								SOLIDS					NITROGENS			PHOSPHATES										
				pH mg/1	Alka-linity mg/1	5-Day BOD mg/1	COD mg/1	TOTAL mg/1	VOLA-TILE mg/1	TOTAL SUSP. mg/1	VOL. SUSP. mg/1	SETT. mg/1	ORGA-NIC mg/1	AMMO-NIA mg/1	NO_3 mg/1	TOTAL mg/1	ORTHO mg/1	CHLO-RIDE mg/1	FLUO-RIDE mg/1	SUL-FATE mg/1	OIL & GREASE mg/1	PHENOL	CHRO-MIUM	TOTAL MPN	FECAL MPN	FECAL STREPT. No/100 ml
MISSISSIPPI RIVER																										
Mpls. Water Trtmt Plants	859.0																									
Filt. Backwash Water	857.8	0.7	None	8.4		1.7				1,900	300													<2	<2	
Lime Sludge	858.3	1.6	Settling Ponds	10.2	42	-				37	-													-	-	
Riverside Power Plant	856.9	592.6[1]	None for Cooling Water																							
Highbridge Power Plant	840.5	449.3[1]	None for Cooling Water																							
Minnesota Harbor Service	840.4		Settling Pond																							
Twin City Shiphard	837.3		Screens																							
Swift & Company	833.4	5.0	None for Cooling Water																							
Union Stockyards	833.2	2.0	None for Direct Discharge																							
Armour & Company	833.0	2.4	None for Cooling Water																							
King Packing Company	832.5	1.73	None for Cooling Water	7.7	350	2.5 Est.	4.9	325	97	7	5	-	12.8	8.1	0.0	0.3	0.2	9	-	-	-	-	-	-	-	-
Northwestern Refining Company	830.0	1.44	Oil Separator, Lagoons	8.4	320	22	74	653	139	17	13	-	1.6	25.2	<0.2	2.7	1.2	100	1.5	-	7.6	1900	-	$<1.7 \times 10^{4}$	$<4.5 \times 10^{3}$	
J. L. Shiely Company																										
Larson Plant	826.5	1.44	Settling Pond																							
Nelson Plant	825.0	8.64	Settling Pond																							
General Dynamics Liq. Carb. Div.	824.2	0.70	None	7.2	540	-	6.5	574	210	35	28	-	0.2	0.6	5.9	0.5	0.6	-	-	-	-	-	-	-	-	-
St. Paul Ammonia Products Company	824.2	0.66	Oil Separator, Settling Pond	8.0	390	14	52	2602	474	21	<14	-	5.8	92.4	84.4	7.9	5.8	-	-	-	17.8	33	-	3.8×10^{2}	1.2×10^{2}	-
Great Northern Oil Company	824.0	3.23	Oil Separator, Sec. Sett. Ponds	7.6	240	16	110	1087	220	39	30	-	0.6	62.8	0.1	3.2	1.6	65	-	-	1.6	159	-	1.3×10^{4}	8.9×10^{3}	-
Northwest Coop. Mills	823.8																									
Pond Leakage (INC 371)		0.070	Storage Pond	4.9	1200	16	130	17920	5405	2249	463	1.4	113.1	471.6	4.4	9030	7400	-	260[2]	-	-	-	-	-	-	-
Comp. Pond Eff(INC 370)		0.046	Settling Pond	6.2	870	34	260	10850	4707	419	228	17.2	119.2	424.0	4.1	2790	1970	-	20[2]	-	-	-	-	7.9×10^{5}	1.7×10^{5}	-
Minn. Mining & Mfg. Co.	817.2																									
Cooling Water (IMM 359)		4.08	None for C. Wtr.	8.1	300	16	48	357	105	9	6	-	0.4	4.7	2.1	10.8	7.6	-	-	-	-	26	-	<64	<6	-
Treated Waste (IMM 358)		1.68	Neut. & Sett. Tanks, Ponds	7.5	370	220	490	1212	214	38	24	-	6.9	98.6	9.7	58.2	42.9	-	-	-	-	741	-	$>9.4 \times 10^{5}$	$<2.8 \times 10^{3}$	-
Cooling and Waste (IMM 357)		5.76	(See Above)	7.5	370	120	180	736	169	86	39	-	19.4	36.8	5.3	44.7	33.3	-	11.3	-	3.4	466	-	$>5.9 \times 10^{4}$	$<4.0 \times 10^{3}$	-
H.D. Hudson Manufacturing Company	814.2	-	Chem. Precip.																							
Foot Tanning Company	792.8																									
Raw Waste (IFT 381)		1.03	(Inf. to Lagoons)	7.6	670	330	1100	7110	1551	1233	578	54	<0.2	33.0	1.7	25.0	0.9	-	-	-	-	-	-	$>1.2 \times 10^{4}$	$>9.4 \times 10^{3}$	
Treated Waste (IFT 380)		1.03	Screens & Lagoons	9.1	480	170	490	5744	545	59	35	1.7	0.2	27.6	0.9	5.4	0.3	-	-	-	-	-	14	<17	<13	
Pittsburgh Plate Glass Company	790.7	1.0	None for Cooling Water																							
Red Wing Power Plant	789.4	53.9[1]	None for Cooling Water																							

1. Maximum rate of discharge.
2. Based on one sample.

TABLE IV-18 (Continued)

SUMMARY OF INDUSTRIAL WASTES CHARACTERISTICS

INDUSTRIAL WASTE SOURCE	RIVER MILE	AVG. FLOW RATE MGD	TYPE OF TREATMENT	pH mg/l	Alkalinity mg/l	5-Day BOD mg/l	COD mg/l	SOLIDS: TOTAL mg/l	SOLIDS: VOLATILE mg/l	SOLIDS: TOTAL SUSP. mg/l	SOLIDS: VOL. SUSP. mg/l	SOLIDS: SETT. mg/l	NITROGENS: ORGANIC mg/l	NITROGENS: AMMONIA mg/l	NITROGENS: NO_3 mg/l	PHOSPHATES: TOTAL mg/l	PHOSPHATES: ORTHO mg/l	CHLORIDE mg/l	FLUORIDE mg/l	SULFATE mg/l	OIL & GREASE mg/l	PHENOL	CHROMIUM	COLIFORMS: TOTAL MPN	COLIFORMS: FECAL MPN	FECAL STREPT. No/100 ml
RUM RIVER																										
Cornelius St. Sewer, Anoka	0.8	0.1±	None	7.6	480	4.2	13	382	141	18	7	-	1.2	2.5	2.8	14.3	10.6	30	-	16	0.3	-	0.02	4.5×10^3	2.0×10^3	-
Taylor St. Sewer, Anoka	0.7	Low	None	7.8	410	7.8	28	430	153	27	13	-	1.1	3.7	3.0	13.2	6.8	29	-	32	6.0	-	-	2.0×10^2	1.8×10^2	-
Taylor St. Sewer, Anoka	0.6	Low	None	7.6	480	16	33	474	129	46	9	-	<1.4	7.1	3.7	11.6	2.9	28	-	120	8.0	-	-	1.7×10^2	1.9×10^2	-
BLUE EARTH RIVER																										
Honeymead Products Company	0.6	4.3	Oil Separator, Acidulation	7.2	350	58	78	700	172	24	20	-	1.2	2.2	0.2	7.2	2.8	-	-	-	16.8	-	-	9.2×10^5	3.1×10^5	-
MINNESOTA RIVER																										
North Star Concrete Products Company	108.2	0.86	Settling Pond																							
Archer Daniels Midland Co.	106.0	0.042	None for Cooling Water	7.9	460	5.0	9.0	636	138	102	18	-	1.2	0.8	0.9	7.0	2.0	-	-	-	1.8	-	-	2.4×10^4	3.1×10^3	-
Blue Cross Rendering Company	105.5																									
Treated Waste		0.036	Trickling Filtr	7.1	990	1200	2700	4347	2086	1559	777	-	23.4	142.6	2.8	68.4	46.6	1800	-	-	387	-	-	$>2.7 \times 10^7$	$>2.4 \times 10^7$	-
Cooling Water		0.058	Grease Trap	7.7	530	700	1000	543	121	27	22	-	0.9	44.8	0.2	5.9	3.4	-	-	-	1.7	-	-	2.7×10^4	$<1.3 \times 10^4$	-
Wilmarth Power Plant	105.2	33.1[1]	None for Cooling Water																							
Green Giant Company	75.4																									
Wastes (IGG 236)		1.25	Irrigation Flds	7.7	630	1200	1900	5768	2881	371	221	1.0	30.2	4.2	1.3	20.9	15.8	-	-	-	-	-	-	3.0×10^7	5.6×10^5	-
San. + Misc. (IGG 235)		0.014	None	7.7	560	200	500	4282	959	135	109	0.5	11.6	2.3	0.6	5.1	2.9	-	-	-	-	-	-	5.7×10^6	2.1×10^6	-
Cooling Water (IGG 233)		0.216	None	8.0	520	54	180	861	226	26	18	0.1	2.9	0.5	0.1	3.1	1.0	-	-	-	-	-	-	1.1×10^6	1.1×10^6	-
Minnesota Valley Milk Processing Association	49.8	0.27	None--Aeration Ditch not in use	7.9	590	130	280	1390	425	120	49	-	9.7	1.6	0.2	22.0	14.6	-	-	-	-	-	-	$<8.2 \times 10^5$	$<2.4 \times 10^5$	-
American Crystal Sugar Co.	27.7	7.0	None	9.0	530	650	1000	10150	1365	766	<165	-	11.3	1.3	1.4	6.8	2.7	-	-	-	-	-	-	$>1.0 \times 10^7$	2.5×10^6	8.9×10^2
M. A. Gedney Company	27.5	0.40	Stab. Ponds																							
Rahr Malting Company	25.4	2.0	Screens	-	-	300	690	5087	720	38	>34	-	6.7	1.3	3.8	-	-	-	-	-	-	-	-	1.3×10^7	6.1×10^4	7.7×10^3
Owens-Illinois Glass Company	20.9	0.02	"Rated" Aeration	7.8	280	11	58	393	183	34	28	-	0.6	0.1	<0.1	1.9	1.4	-	-	-	7.9	-	-	73	45	-
American Wheaton Glass Co.	20.7	0.20	None for Process Wastes	8.0	230	8.3	23	290	136	33	9	<0.1	0.0	0.0	3.5	0.2	0.2	-	-	-	20.8	-	-	4.0×10^2	57	-
Cargill, Inc.	13.4	3.32	Screens & Oil Separation	7.9	360	25	68	620	122	33	22	-	2.0	3.0	<0.1	9.0	4.0	4	-	-	2.7	-	-	$>3.9 \times 10^5$	$<2.1 \times 10^4$	-
Twin City Shipyard																										
Cargill Location	13.2		Screens																							
Blackdog Location	8.0		Screens																							
Blackdog Power Plant	8.4	371.5[1]	Cooling Pond																							
ST. CROIX RIVER																										
Andersen Window Company	20.2																									
Upper Waste Disch. (IAW 157)		0.014	None	7.7	500	40	110	472	258	54	41	0.75	16.0	35.2	<0.6	2.3	0.4	-	-	-	-	-	-	1.1×10^5	$<2.5 \times 10^3$	-
Middle Waste Disch. (IAW 156)		0.216	None	7.7	490	4.9	12	286	90	18	12	<0.1	<0.5	<0.2	1.2	6.6	0.9	-	-	-	-	-	-	2.8×10^2	<86	-
Cooling Water (IAW 155)		0.216	None for Cooling Water	7.6	510	1.4	5.4	239	63	9	4	<0.1	0.6	0.5	0.4	0.9	0.2	-	-	-	-	-	-	$<3.6 \times 10^3$	$<2.0 \times 10^2$	-
United Refrigerator Company	16.5	0.059	None	7.8	-	4	-	268	106	256	6	-	-	-	-	0.8	-	-	-	-	-	-	3.4			

1. Maximum rate of discharge.
2. *Based on one sample.*

TABLE IV-19

SUMMARY OF MORE SIGNIFICANT INDUSTRIAL WASTE LOADING RATES TO STREAMS

(Results are in Pounds/Day, except where noted otherwise)

SOURCE	RIVER MILE	AVG. FLOW RATE MGD	OPERATION Hours per Day	OPERATION Days per Week	OPERATION Mos. per Year	5-Day BOD	COD	SOLIDS TOTAL	SOLIDS VOLATILE	SOLIDS TOTAL SUSP.	SOLIDS VOLATILE SUSP.	TOTAL KJELDAHL NITROGEN	PHOSPHATES TOTAL PO_4	PHOSPHATES ORTHO PO_4	FLUORIDE	OIL & GREASE	PHENOL	CHROMIUM	COLIFORMS TOTAL No./Day	COLIFORMS FECAL No./Day	HEAT Billion BTU/Day (At Full Capacity)
MISSISSIPPI RIVER																					
Mpls. Water Treatment Plant	858.9	2.3	24	7	12					11,000	1,800										
Riverside Power Plant	856.9	592.6[1]	24	7	12																80.6
Highbridge Power Plant	840.5	449.3[1]	24	7	12																74.2
Northwestern Refining Company	830.0	144	24	7	12	270	840	7,800	1,700	200	150	320	33			90	23		$<9.3 \times 10^{11}$	$<2.5 \times 10^{11}$	
General Dynamic Liq. Carb. Div.	824.2	0.70	24	5-7	12	17	38	3,300	1,200	200	150										
St. Paul Ammonia Products Company	824.2	0.66	24	7	12	80	290	14,000	2,600	110	<70	450	45			95	0.2				
Great Northern Oil Company	824.0	3.23	24	7	12	440	3,000	29,000	5,900	1,000	800	1,700	85			40	4.2		1.6×10^{12}	1.1×10^{12}	
NW Coop Mills (Pond Leakage) (Normal Eff.)	823.8		24	7	12	 10 13	 75 100	 10,400 4,100	 3,100 1,800	 1,300 160	 270 85	 340 200	 5,250 1,070	 4,300 750	 5± 150±				 1.4×10^{12}	 3.0×10^{11}	
Minnesota Mining & Mfg. Company	817.2	5.76	24	7	12	3,600	8,400	29,000	6,500	800	540	1,600	1,200	850	450		10		$>1.3 \times 10^{13}$	$<8.7 \times 10^{11}$	
Foot Tanning Co. (When Bypassing) (Normal Oper)	792.8	 1.03 1.03	18-24	6	12	 2,800 1,500	 9,100 4,200	 61,000 49,000	 13,300 4,700	 10,600 500	 5,000 300	 290 240	 212 46					 120			
Red Wing Power Plant	789.4	53.9[1]	24	7	12																4.18
BLUE EARTH RIVER																					
Honeymead Products Company	0.6	4.3	24	7	12	2,100	2,800	25,000	6,200	860	720	120	260	100		600			1.5×10^{14}	5.1×10^{13}	
MINNESOTA RIVER																					
Blue Cross Rendering Company	105.5	0.094	15	6	12	700	1,300	1,570	680	480	240	72	23			120			$>3.7 \times 10^{13}$	$>3.4 \times 10^{13}$	
Wilmarth Power Plant	105.2	33.12[1]	24	7	12																4.1
Green Giant Co. (When Bypassing) (Normal Oper.)	75.4	 1.48 0.23	15	7	4	 13,000 120	 20,000 380	 60,000 2,000	 30 000 400	 3,900 60	 2,300 45	 370 8	 220 6	 170 2					 1.4×10^{15} 1.2×10^{13}	 2.6×10^{14} 1.0×10^{13}	
Minnesota Valley Milk Processing (Before Trtmt.)	49.8	0.27	9-16	7	12	290	620	3,000	950	250	100	25	49						$<8.3 \times 10^{12}$	$<2.4 \times 10^{12}$	
American Crystal Sugar Company	27.7	7.0	24	7	4	38,000	59,000	590,000	80,000	44,800	9,600	740	400	160					2.8×10^{15}	6.6×10^{14}	
M. A. Gedney Co.	27.5	0.4	24	7	12		(Not	discharging	directly to	stream,	yet.)										
Rahr Malting Co.	25.4	2.0	24	7	12	5,000	11,730	80,000	10,000	600	<600	136							1.0×10^{15}	4.7×10^{12}	
Cargill, Inc.	13.4	3.32	24	7	12	700	1,900	17,000	3,400	900	600	140	250	110		70			$>4.8 \times 10^{13}$	$<2.6 \times 10^{12}$	
Blackdog Power Plant	7.5	371.5[1]	24	7	12																56.6[2]
ST. CROIX RIVER																					
Andersen Window Co	20.2	0.45	8	5	12	15	45	1,000	300	55	30	8	14	2					$<9 \times 10^{10}$	$<3 \times 10^{9}$	
United Refrig. Co.	16.5	0.059	8	5-6	12	2		132	52	6	3		0					1.7			

1. Maximum rate of discharge.
2. When bypassing cooling pond.

TABLE IV-20

INDUSTRIAL WASTES WITH GREATEST 5-DAY BOD CONCENTRATIONS[1]
(Listed in order of decreasing strength)

INDUSTRY	5-DAY BOD CONCENTRATION mg/l
Blue Cross Rendering Company (Treated process wastes)	1219
Green Giant Company (IGG 236, when bypassing treatment facilities)	1214
Blue Cross Rendering Company (Cooling Water)	705
American Crystal Sugar Company	648
S. B. Foot Tanning Company (When bypassing treatment facilities)	331
Rahr Malting Company	295
Minnesota Mining and Manufacturing Company (Process wastes only)	218
Green Giant Company (IGG 235, Sanitary and miscellaneous wastes)	202
S. B. Foot Tanning Company (Treated Effluent)	174
Minnesota Valley Milk Processing Cooperative Association (Untreated)	130
Minnesota Mining and Manufacturing Company (Process and cooling wastewaters combined)	120
Honeymead Products Company	58
Green Giant Company (Cooling Water)	54

1. Wastes with a 5-day BOD less than 50 mg/l are not listed.

TABLE IV-21

INDUSTRIAL WASTES WITH GREATEST SUSPENDED SOLIDS CONCENTRATIONS[1]
(Listed in order of decreasing strength)

INDUSTRY	SUSPENDED SOLIDS CONCENTRATION mg/l
Northwest Cooperative Mills (INC 371, flow resulting from dike leakages)	2249
Minneapolis Water Treatment Plants	1900
Blue Cross Rendering Plant (Treated waste)	1559
S. B. Foot Tanning Company (Untreated waste)	1233
American Crystal Sugar Company	766
Northwest Cooperative Mills (INC 370, compositing pond discharge)	419
Green Giant Company (IGG 236, when bypassing irrigation fields)	371
United Refrigerator Company	256
Green Giant Company (IGG 235, Sanitary and miscellaneous wastes)	135
Minnesota Valley Milk Processing Cooperative Association (Untreated)	120
Archer Daniels Midland Company	102
Minnesota Mining and Manufacturing Company (Combined waste load)	86

1. Wastes with a Total Suspended Solids concentration less than 60 mg/l are not listed.

TABLE IV-22

INDUSTRIAL WASTES WITH GREATEST TOTAL COLIFORM DENSITIES[1]
(Listed in order of decreasing strength)

INDUSTRY	TOTAL COLIFORM DENSITY, MPN/100M/
Green Giant Company (IGG 236, when bypassing treatment facilities)	>46,520,000
Blue Cross Rendering Company (Treated process wastes)	>27,000,000
Rahr Malting Company	13,400,000
American Crystal Sugar Company	10,700,000
Green Giant Company (IGG 235)	5,700,000
Green Giant Company (IGG 233)	1,100,000
Honeymead Products Company	920,000
Minnesota Valley Milk Processing Association (Untreated wastes)	824,000
Cargill, Inc.	>386,000

1. Wastes with a total coliform density less than 300,000 MPN/100M/ are not listed.

TABLE IV-23

INDUSTRIES HAVING THE GREATEST 5-DAY BOD LOADING RATES[1]
(Listed in order of decreasing rate)

INDUSTRY	LOADING RATE TO STREAM lb/day	OPERATION hr/day	POPULATION EQUIVALENT[2]
American Crystal Sugar Company	38,000	24	224,000
Green Giant Company (All wastes combined, irrigation fields not in use)	13,000	15±	47,800
Rahr Malting Company	5,000	24	29,400
Minnesota Mining and Manufacturing Company	3,600	24	21,200
S. B. Foot Tanning Company (Untreated wastes)	2,800	20±	13,800
Honeymead Products Company	2,100	24	12,400
S. B. Foot Tanning Company (Treated waste)	1,500	20±	7,350
Blue Cross Rendering Company (All wastes combined)	700	15	2,580
Cargill, Inc.	700	24	4,120

1. Waste loading rates less than 500 lb/day are not listed

2. Population Equivalent based on 0.17 lb/day contributed per capita.

TABLE IV-24

INDUSTRIES HAVING GREATEST TOTAL SUSPENDED SOLIDS LOADING RATES[1]
(Listed in order of decreasing rate)

INDUSTRY	LOADING RATE TO STREAM lb/day	OPERATION hr/day	POPULATION[2] EQUIVALENT
American Crystal Sugar Company	44,800	24	224,000
Minneapolis Water Treatment Plants	11,000	24	55,000
S. B. Foot Tanning Company (When bypassing)	10,600	20±	44,200
Green Giant Company (All wastes combined, irrigation fields not in use)	3,900	15±	12,200
Northwest Cooperative Mills (All wastes, including dike leakage)	1,500	24	7,500
Great Northern Oil Company	1,000	24	5,000
Cargill, Inc.	900	24	4,500
Honeymead Products Company	860	24	4,300
Minnesota Mining and Manufacturing Co.	800	24	4,000
Rahr Malting Company	600	24	3,000
S. B. Foot Tanning Company	500	20±	2,080

1. Waste loading rates less than 500 lb/day are not listed.

2. Population equivalent based on 0.20 lb/day contributed per capita.

TABLE IV-25

INDUSTRIES HAVING THE GREATEST TOTAL COLIFORM LOADING RATES[1]
(Listed in order of decreasing rate)

INDUSTRY	LOADING RATE TO STREAM No./day	OPERATION hr/day	POPULATION[2] EQUIVALENT
American Crystal Sugar Company	2.8×10^{15}	24	28,000
Green Giant Company (All wastes combined, irrigation fields not in use)	$> 2.2 \times 10^{15}$	15±	>22,000
Rahr Malting Company	1.0×10^{15}	24	10,000
Honeymead Products Company	1.5×10^{14}	24	1,500
Cargill, Inc.	$> 4.8 \times 10^{13}$	24	>480
Blue Cross Rendering Company (All wastes combined)	$> 3.7 \times 10^{13}$	15:	>370
Green Giant Company (With irrigation fields in use)	1.2×10^{13}	15±	120

1. Waste loading rates less than 1.0×10^{13}/day are not listed.

2. Population Equivalent based on 1.0×10^{11} coliforms/day contributed per capita.

COMBINED SEWER OVERFLOWS

Introduction

In the development of sewer systems in our larger cities, a general pattern has been followed. For a number of reasons early communities were located on or near a major stream or body of water. In this era before the adoption of public water supplies or indoor plumbing, the first wastewater problem to be faced by these developing communities was the disposal of runoff resulting from precipitation. The simplest solution at the time was to channel this water through open or closed conduits to the nearby stream or body of water.

With the development of water supplies, another problem was introduced: the disposal of wastewater which necessarily accompanies a water supply. Again, the simplest solution was followed and these wastes were also discharged to the existing drainage systems and ultimately to the nearby receiving waters.

At some later date, the effects of the wastes being discharged and the greater demands being placed on the receiving waters led to the conclusion that some type of waste treatment was required. The action usually taken was the construction of a system of sewers which parelleled the shoreline and intercepted the existing sewers just above the former discharge points. These new interceptor sewers were generally designed to convey the dry-weather flow to a single location for treatment. At the time of construction, bypasses were provided at the junction points so that flows in excess of the interceptor hydraulic capacity could spill over to the receiving waters.

Herein lies the problem of combined sewer overflow. The waters

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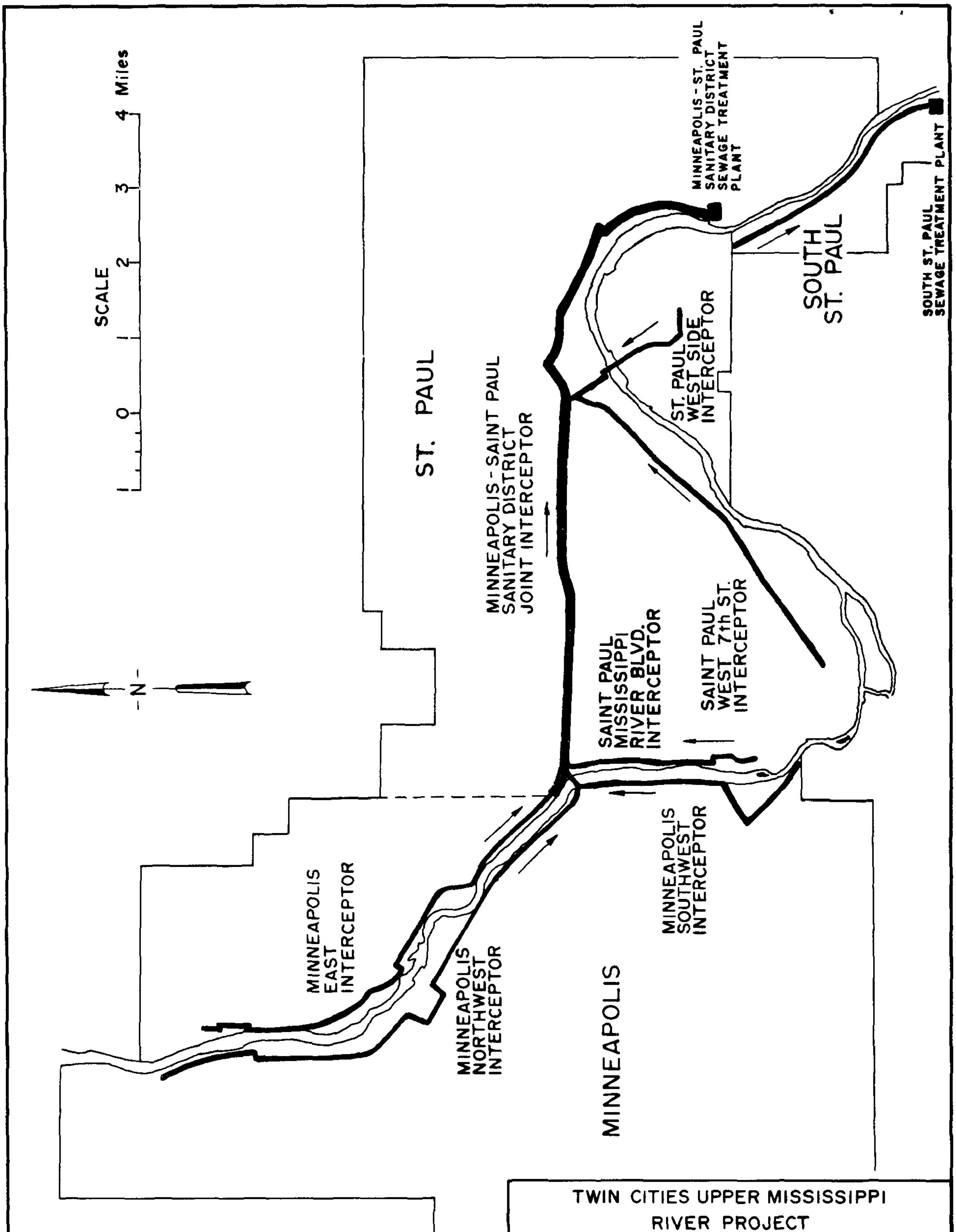
which are bypassed usually contain a fairly high percentage of the sanitary sewage which is present in the system immediately before and during the period of storm flow. Also, the greater velocities which accompany high flows often have the effect of "flushing" the sewer system and washing material from the system which has been deposited during periods of dry-weather flow.

Minneapolis-St. Paul Combined Sewer Overflow System

Interceptor System. The development of sewerage systems in the Twin Cities follows very closely the pattern described above. The earliest recorded sewer installations in Minneapolis and St. Paul date back to 1882 and 1873, respectively. By the year 1960, Minneapolis had almost 1,000 miles of sewers and St. Paul had nearly 800 miles. These figures include both separate and combined sewers.

In the period from 1934 to 1938 approximately 50 miles of intercepting sewers were built in the Twin Cities area (see Figure IV-8). At the time of construction, provisions were made to divert combined flows in excess of interceptor hydraulic capacity directly to the Mississippi River. Presently there are more than 80 of these points in the interceptor system where flow can be discharged directly to the river. The diversion points are scattered along the entire length of the intercepting system with no regularity in either placement or size.

Four types of diversion regulators are in general use in the system. These are float operated gates, tipping gates, orifice regulators and leaping weirs. One of these four types is used at each of 67 overflow points. The remainder of the overflows are simple diversion structures built within the sewers.



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

COMBINED SEWER INTERCEPTORS IN MINNEAPOLIS, ST. PAUL AND SOUTH ST. PAUL

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.

REGION V CHICAGO, ILLINOIS

FIGURE IV-8

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The original design of the intercepting works provided a hydraulic capacity to deliver approximately 620 mgd to the sewage treatment plant operated by the Minneapolis-St. Paul Sanitary District. It was expected that 55 percent of this capacity would be required to carry the maximum dry-weather flow in the year 1970 and the remaining capacity would be sufficient to handle surface runoff resulting from a rainfall of 0.04 inches per hour. The designers, of course, did not expect that this allotment for storm flows would be adequate in all situations. It was estimated that 1.1 percent of the 1970 sanitary flow would be lost directly to the river 1.7 percent of the time. Investigations made in 1959 showed that actual losses were already somewhat higher than design estimates (6). It was also found that access to the regulators is generally poor and that most of the structures need maintenance. Some diversion structures were found to be discharging raw sewage directly to the river even during dry-weather flows.

Separation Program. One means of reducing pollution from combined sewers is separation of sanitary and storm sewers. The cities of Minneapolis and St. Paul recognize this fact and have taken steps in this direction. They require separate sanitary sewers in all suburban communities which connect to their sewer systems. No connections are made to suburban combined or storm sewers.

Of the two cities, Minneapolis follows the more active sewer separation program. Prior to 1926 virtually all sewers built in Minneapolis were of the combined type, but by 1932 the policy of building only separate sewers had been established. At present the major portion of sewer construction in Minneapolis is for the purpose of separating existing combined sewers. Separation is also carried out when sewers must be altered because of other construction. In this respect free-way construction, which has been active in various parts of the area, has greatly aided separation, but the work is slow and costly. In 1960 approximately 40 percent of Minneapolis was still served by combined sewers.

St. Paul has never followed an active separation program. Generally, St. Paul will separate sewers in new construction if the cost is not too great or if an existing storm sewer is easily accessible. If separate sewer construction is not economical or if a long extension of a storm sewer is required, the general policy is to extend existing combined sewers. Exceptions to this policy, of course, are numerous especially in areas of new freeway construction. In 1960, however, over 90 percent of St. Paul's sewered area was still served by combined sewers.

Effects of Combined Sewer Overflows on River. The effects of combined sewer overflow are very difficult to evaluate due to the complex nature of the entire overflow mechanism. Immediate problems encountered are non-uniform rainfall distribution and non-uniform response to similar rainfalls. Meaningful discharge-frequency relationships can be established only after sampling the system over a period of time sufficiently long to provide the required statistical confidence. The period of time required for such a study was not available to the Twin Cities Project. However, information sufficient to evaluate the general seriousness of the problem had already been gathered in the investigation previously mentioned (6).

Although no accurate assessment of the overflow is purported in the above reference, it was estimated that over a period of one year, up to 3.5 percent of the sewage reaching the diversion points and up to 3.1

percent of sewage reaching the treatment plant may be lost without treatment. The total of these figures would represent about 7.5 million pounds of 5-day BOD and 9.5 million pounds of suspended solids on a yearly basis. Even though this overflow occurs during only 10 percent of the time in a given year, there is no appreciable effect on dissolved oxygen in the Mississippi River above the MSSD outfall as indicated by sampling. The suspended solids loading undoubtedly contributes to sludge deposits along the stream bed.

A potentially more serious problem and one that is more difficult to assess is the bacteriological pollution that is delivered to the river by combined sewer overflows. Little data is available on this aspect and estimates cannot be made as easily as for BOD. As an indication of the magnitude of the problem, however, the results of ten consecutive days of sampling at several locations within the reach affected can be used. These stations are located between a point just above the first bypass and a point just above the sewage treatment plant outfall which is downstream from all the bypasses in the intercepting system. Sampling took place on the first day just prior to the first rainfall recorded at the Minneapolis-St. Paul International Airport in 48 hours. Between 0.01 and 0.4 inches of rain per day fell during most of the 10-day survey. The median fecal coliform MPN at the uppermost station (mile 858.5) during the survey was 800. At the station below all bypass points (mile 836.4), the median fecal coliform MPN was 75,000. Other than combined sewer overflows, the most significant sources of fecal coliforms are Bassett Creek and the Minnesota River. During the survey, they contributed amounts of fecal coliforms sufficient to increase the median density in the Mississippi

River by 200 and 350 MPN, respectively. The combined sewer overflows, then, were responsible for a 73,600 MPN increase in the median fecal coliform density of the river as it passed through the Twin Cities. These figures are not intended to imply that the river always contains over ninety times as many fecal coliform organisms after a rainstorm. However, they are intended to point out that a health hazard may exist to downstream users for several days following a rainstorm and that the subject of combined sewer overflow must be considered in any pollution control program for the Twin Cities.

South St. Paul Combined Sewer Overflow System

Interceptor System. Of the 2,615 acres provided with sewerage within the corporate limits of South St. Paul, 2,034 acres (78 percent) are served by a combined system. This system is fairly similar to those of the Twin Cities not only in the basis of design but also in that the interceptor sewer is located adjacent and parallel to the Mississippi River and intercepts the trunk sewers that originally discharged to the river. The interceptor, which receives flows from four trunk sewers and the meat industry complex, discharges to the municipal sewage treatment plant (see Figure IV-8). At each point of connection of a trunk sewer to the interceptor, there is a bypass to allow flows in excess of the interceptor hydraulic capacity to spill over into the Mississippi River.

A recent investigation of this system made by City's consulting engineers determined that there was a surcharging problem along a considerable portion of the interceptor during periods of maximum dry-weather flow (2). They concluded that the existing interceptor does not provide any capacity for storm water at times of maximum dry-weather flow. In general, the interceptor has only about one-half the required capacity to handle the maximum dry-weather flow plus the runoff resulting from a rainfall intensity of 0.04 inches per hour.

The weekday dry-weather flow reaching the sewage treatment plant via the interceptor ranges from 9 to 23 mgd, averaging 14.2 mgd. Reference 2 estimates the interceptor capacity necessary to handle the present maximum dry-weather flow plus surface runoff resulting from a rainfall of 0.04 inches per hour to be about 46.5 mgd. To handle the ultimate maximum dry-weather flow plus the same amount of surface runoff, the capacity would have to be 53.7 mgd.

Separation Program. The City of South St. Paul at one time had a master plan for complete separation of storm and sanitary wastes, but it was never put into effect. The only storm sewer separation currently being considered is in those areas where basement flooding occurs as a result of surcharging during rainstorms.

Effects of Combined Sewer Overflows on River. As is the case with the Twin Cities, no precise figures are available on the amount of wastes diverted to the river through combined sewer overflows during periods of rainfall. The hydraulic capacity of this interceptor is about 4 percent of the capacity of the Twin Cities interceptor system; the average and maximum dry-weather flow is about 8 and 10 percent, respectively, of the Twin Cities'; and the week-day BOD concentration of the transported wastes is about 500 percent of that of the Twin Cities'. This information indicates that the BOD loading contributed by the South St. Paul combined sewer overflows is something less than 80 percent of that contributed by Twin Cities system and occurs over about 20 percent of the time in a given year. Here again the most significant problem caused by the overflow is the possible health hazard imposed on downstream users due to the presence of pathogens in the wastes.

AGRICULTURAL AND NATURAL POLLUTION

Pollutants of primary concern resulting from agricultural activities and the natural death and decay of plant and animal life are nutrients. Among the nutrients, nitrogen and phosphorus are considered the most important. Nutrients are of concern because along with the proper chemical and physical conditions in a body of water, they can raise algal and aquatic weed growths to nuisance proportions. Inorganic nitrogen and phosphorus concentrations in excess of 0.3 and 0.01 mg/l, respectively, are generally considered sufficient to support an algal bloom in lakes. (At low flows, pools behind dams essentially become lakes.)

In order to evaluate what fraction of the nutrients present in the Mississippi River within the study area was of natural and agricultural origin a materials balance was made among the nutrients found entering and leaving the study area and those being discharged to the waters within the study area between August 24 and September 2, 1965. During this 10-day period the Mississippi River's flow at St. Paul averaged 6,400 cfs. (This flow condition has a recurrance interval of 1.5 years.) Since nutrient concentrations in the waters entering the study area were found not to decrease with increasing stream flows, it was a strong indication that most of the nutrients present in the entering waters resulted from surface runoff and hence were of natural or agricultural origin.

In the total nitrogen balance, 21,600 pounds/day entered the study area via the Mississippi River from above Anoka. The Rum, Minnesota and

St. Croix Rivers contributed 1,400, 3,900 and 10,000 pounds/day, respectively. Municipal and industrial waste sources on the Mississippi River within the study area contributed 41,800 and 4,800 pounds/day, respectively. At the outlet of Lake Pepin 63,000 pounds/day left the study area. This meant that 20,500 more pounds/day were entering than leaving the waters of the study area and were probably accumulating in sludge deposits or escaping to the atmosphere. Municipal and industrial waste sources on the Minnesota River Contributed only 1,300 of the 3,900 pounds/day reaching its mouth. On the St. Croix River, municipal and industrial sources were responsible for only 400 of the 10,000 pounds/day contributed. Of the 83,500 pounds/day of nitrogen entering the waters of the Mississippi River within the study area 35,200 pounds/day (42 percent) came from sources outside the immediate study area. This amount, incidentally, is approximately equal to the Minneapolis-St. Paul Sanitary District's contribution of nitrogen.

In the phosphorus balance (values given as PO_4), 9,300 pounds/day entered the study area via the Mississippi River from above Anoka. The Rum, Minnesota, and St. Croix Rivers contributed 1,300, 2,800, and 1,700 pounds/day, respectively. Municipal and industrial waste sources on the Mississippi River within the study area contributed 24,400 and 7,700 pounds/day, respectively. At the outlet of Lake Pepin 47,000 pounds/day left the study area. Municipal and industrial waste sources on the Minnesota River contributed only 1,100 of the 2,800 pounds/day reaching its mouth. On the St. Croix River, municipal and industrial sources contributed only 500 of the 1,700 pounds/day reaching its mouth. Of the 47,000 pounds/day of phosphorus entering the waters of the Mississippi

River within the study area, 15,000 pounds/day (32 percent) came from sources outside the immediate study area. This is about 6,000 pounds/day less than the Minneapolis-St. Paul Sanitary District's contribution.

As stated previously, most of the nutrients found in the rivers as they entered the study area are believed to be of natural and agricultural origin. Then most of the 35,200 pounds/day of nitrogen and 15,000 pounds/day of phosphorus (as PO_4) found in the entering waters during the survey were of natural or agricultural origin.

Assuming that the amount of nutrients coming from outside the immediate study area is proportional to stream flow, approximately 52,000 and 22,000 pounds/day of total nitrogen and phosphorus (as PO_4), respectively, would be expected to enter the Mississippi River from these outside sources at the mean August flow (9,482 cfs at St. Paul). Even if all the municipal and industrial waste sources evaluated in the study area ceased to discharge nutrients, the waters of the study area would still contain concentrations sufficient to support algal populations in nuisance proportions in lakes or in pools behind dams at low stream flows.

LIQUID STORAGE FACILITIES

Two accidental oil spills on the Minnesota River in the winter of 1962-1963 created an awareness of the immense pollution potential of liquid storage facilities. These spills, involving approximately 2.5 million gallons of oils, resulted in the fouling of the Minnesota and Mississippi River for a distance of over 150 miles and in the killing of several thousand ducks and other birds during the spring migration. The Governor of Minnesota declared the situation an emergency, activated two units of the National Guard, alerted State agencies, and obtained aid from several Federal agencies in fighting the problem. As this experience demonstrated, not only are valuable commodities lost as a result of a spill but such spills can produce far-reaching damages to the receiving waters and the uses made of them.

According to information gathered by the Minnesota Department of Health there are or soon will be, respectively, thirty-eight, nine, and one liquid storage sites of significant size along the Mississippi, Minnesota and St. Croix Rivers within the study area (see Table IV-26). Together they contain well over 200 million gallons of liquids. Approximately 30 percent of these sites have adequate safeguards to protect river waters in the event of spillage. The adequacy of protective devices at the remaining 70 percent is questionable.

In accordance with State legislation enacted in 1963, the plans of all proposed new liquid storage facilities in Minnesota must be approved by the Water Pollution Control Commission and a permit issued before construction of them can begin.

Existing storage facilities are being evaluated by the Minnesota Department of Health for the Commission to determine the adequacy of protective devices for containing spills.

There is also a potential hazard involved in the shipment by barge of hundreds of tons of gasoline and other petroleum products annually. The Corps of Engineers estimates that possibly 5 percent of the barges in this traffic would develop as "leakers".

TABLE IV-26

PRELIMINARY LISTINGS OF MAJOR LIQUID STORAGE SITES IN TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT STUDY AREA

(Prepared by Minnesota Department of Health)

Minnesota River (Mankato Mouth)	Location	Type	Approx. Vol. Gals.
Honeymead Products Co.	Mankato	Veg. Oil	Many Million
Northern States Power Co. Wilmarth Plant	Mankato	Fuel Oil	3,300
St. Peter State Hospital	St. Peter	Fuel Oil	600,000
American Crystal Sugar Co.	Chaska	Molasses	
M. A. Gedney Co.	Chaska	Brine	
Commercial Chemical Co.	Scott Co.	Solvents	25,000
Richards Oil Co.	Scott Co.	Fuel Oil and asphalt	4,000,000
Cargill, Inc.	Savage	Veg. Oil Molasses	Many Million
Northern States Power Co. Black Dog Plant	Burnsville	Fuel Oil	12,000
Mississippi River (Anoka to Wabasha)			
Cornelius Co.	Anoka	Plating Chemicals	
Federal Cartridge Co., Anoka	Anoka	Plating Chemicals	
Designware Industries, Inc.	Fridley	Anodizing Chemicals	
Joyner's,.Inc.	Brooklyn Park	Platinc Chemicals	
Howe, Inc.	Brooklyn Center	Chemical fertilizers	
Northern States Power Co., Riverside Plant	Minneapolis	Fuel Oil	25,500

TABLE IV-26 (Continued)
PRELIMINARY LISTING OF MAJOR LIQUID STORAGE SITES IN
TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT STUDY AREA

Mississippi River (Anoka to Wabasha)	Location	Type	Approx. Vol. Gals.
Land-O-Lakes	St. Paul	Caustics	600,000
Industrial Molasses Corp.	St. Paul	Molasses Chemicals	6,264,000
Chevron Asphalt Company	St. Paul	Petroleum	79,700
Northwestern Refining Co.	St. Paul Park	Petroleum	Many Million
Farmer's Union Central Exchange Inc.	Inver Grove Heights*	Petroleum	420,000
Great Northern Oil Company	Dakota Co.	Petroleum	Many Million
Northwest Cooperative Mills, Inc.	Dakota Co.	Chemical fertilizers	
Central Farmer's Fertilizer Co.	Dakota Co.*	Ammonia	21,150,000
Great Northern Oil Company	Hastings	Petroleum	
Hudson Manufacturing Company	Hastings	Chemicals	
Northern States Power Company	Red Wing	Petroleum	500
Pittsburgh Plate Glass Co.	Red Wing	Veg. Oil, Solvents	
St. Croix River (Taylors Falls to Mouth)			
Northern States Power Co., A. S. King Plant	Oak Park Heights	Petroleum Chemicals	19,000

* Under Construction

TABLE IV-26 (Continued)
PRELIMINARY LISTING OF MAJOR LIQUID STORAGE SITES IN
TWIN CITIES-UPPER MISSISSIPPI RIVER PROJECT STUDY AREA

Mississippi River (Anoka to Wabasha)	Location	Type	Approx. Vol. Gals.
Western Oil and Fuel Oil	Minneapolis	Petroleum	7,000,000
Barber Oil Company	Minneapolis	Petroleum Solvents Chemicals	2,500,000
Minneapolis-St. Paul Sanitary District	St. Paul	Fuel Oil	Several Hundred
Economics Laboratory, Inc.	St. Paul	Chemicals	
Ford Motor Company	St. Paul	Chemicals	
Mobile Oil Company	St. Paul	Petroleum	49,000,000
Texaco Oil Company	St. Paul	Petroleum	38,000,000
Shell Oil Company	St. Paul	Petroleum	40,000,000
Clark Oil Company	St. Paul	Petroleum	12,000,000
Pure Oil Company	St. Paul	Petroleum	28,000,000
Northern States Power Co., High Bridge Plant	St. Paul	Petroleum	1,500
Industrial Steel Container Company	St. Paul	Petroleum Chemicals	11,000
Minnesota Harbor Service	St. Paul	Petroleum	10,000
American Mineral Spirits Co.	St. Paul	Solvents	3,800,000
W. H. Sweney Company	St. Paul	Veg. Oil Solvents	57,000
Minnesota Mining and Manufacturing Company	St. Paul	Solvents	272,000
Gustafson Oil Company	St. Paul	Petroleum	3,864,000
Minnesota Farm Bureau Service Company	St. Paul	Chemicals	10,000
Twin City Barge and Towing	St. Paul	Petroleum	55,000
Vel-Tex Chemical Company	St. Paul*	Caustics	420,000

SUMMARY OF WASTE DISCHARGES

In all, 25 sources of domestic wastes and 34 sources of industrial wastes were investigated. The total BOD loading rate of these wastes was 362,409 pounds per day. Industries contributed 14.5 percent of the total. The Minneapolis-St. Paul Sanitary District and South St. Paul sewage treatment plants, together, contributed about 83 percent of the total. The remaining sewage treatment plants contributed 2.6 percent. Suspended solids, nitrogen, and phosphate were contributed by the Twin Cities and South St. Paul plants in about the same proportions as BOD. These two plants were also responsible for about 92 percent of the coliform loading rate.

The five greatest contributors of 5-day BOD were:

1. Minneapolis-St. Paul Sanitary District STP (267,800 lb/day)
2. American Crystal Sugar Co., while in operation (38,000 lb/day)
3. South St. Paul STP (32,200 lb/day)
4. Rahr Malting Company (5,000 lb/day)
5. Minnesota Mining & Manufacturing Co. (3,600 lb/day)

The five greatest contributors of suspended solids were:

1. Minneapolis-St. Paul Sanitary District STP (169,800 lb/day)
2. American Crystal Sugar Co., while in operation (44,800 lb/day)
3. Minneapolis Water Treatment Plants (11,000 lb/day)
4. South St. Paul STP (10,900 lb/day)
5. Mankato STP (2,680 lb/day)

The five greatest contributors of total nitrogen were:

1. Minneapolis-St. Paul Sanitary District STP (35,600 lb/day)
2. South St. Paul STP (5,200 lb/day)

3. Great Northern Oil Company (1,700 lb/day)

4. Minnesota Mining & Manufacturing Co. (1,600 lb/day)

5. American Crystal Sugar Co., while in operation (740 lb/day)

The five greatest contributors of total phosphate were:

1. Minneapolis-St. Paul Sanitary District STP (20,800 lb/day)

2. South St. Paul STP (2,300 lb/day)

3. Minnesota Mining & Manufacturing Co. (1,200 lb/day)

4. Northwest Cooperative Mills (1,070 lb/day)

5. Red Wing STP (420 lb/day)

The five greatest contributors of total coliforms were:

1. Minneapolis-St. Paul Sanitary District STP ($>1.1 \times 10^{17}$/day)

2. American Crystal Sugar Co., while in operation (2.8×10^{15}/day)

3. South St. Paul STP (2.1×10^{15}/day)

4. Hastings STP (2.0×10^{15}/day)

5. Rahr Malting Company (1.0×10^{15}/day)

The three greatest contributors of fluoride were:

1. Minneapolis-St. Paul Sanitary District STP (1,220 lb/day)

2. Minnesota Mining & Manufacturing Co. (450 lb/day)

3. Northwest Cooperative Mills (150± lb/day)

The three greatest contributors of phenol were:

1. Minneapolis-St. Paul Sanitary District STP (850 lb/day)

2. Northwestern Refining Company (23 lb/day)

3. Minnesota Mining & Manufacturing Company (10 lb/day)

The five greatest contributors of thermal pollution were:

1. Riverside Power Plant (80.6 billion BTU/day, max.)

2. Highbridge Power Plant (74.2 billion BTU/day, max.)

3. Blackdog Power Plant (56.6 billion BTU/day, max.)

4. Red Wing Power Plant (4.2 billion BTU/day, max.)

5. Wilmarth Power Plant (4.1 billion BTU/day, max.)

The above lists were prepared on the assumption that all treatment devices in existence at the time of the studies were in use. Contributions from combined sewer overflows, boats, barges, agricultural sources, and natural sources were not considered in these lists.

The most serious problem caused by combined sewer overflow is the intermittent discharge of bacteria which results in a potential hazard to the health of downstream users. Another undesirable effect is the discharge of suspended solids, which can be expected eventually to settle out and affect bottom life.

None of the Federal installations investigated have any measurable effect on water quality in the portions of rivers under study. One however, the 934th Troop Group Officers Club, has unsatisfactory waste treatment facilities which discharge effluent to a marsh area adjacent to the Minnesota River. These wastes present more of a potential than actual health hazard to water users on the lower Minnesota River.

The numerous liquid storage facilities along the rivers do not ordinarily contribute pollution but many are potentially hazardous from the standpoint of possible accidental spillage of the stored liquid.

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2. South St. Paul, Minnesota, Report on Sewerage and Sewage Treatment, February, 1965, prepared by Greeley and Hansen Engineers and Bannister Engineering Co.

3. Summary Report on a Comprehensive Sewage Works Plan for the Minneapolis-St. Paul Metropolitan Area, prepared by the Cities of Minneapolis and St. Paul and the Minneapolis-St. Paul Sanitary District, October, 1964.

4. Report on Wastewater Treatment Plant Expansion for South St. Paul, Minnesota, prepared by Toltz, King, Duvall, Anderson & Associates, Inc.

5. Letter from Mr. D. E. Gilberts, Steam Plant Supervising Engineer, Northern States Power Company, dated June 28, 1965.

6. Report on the Expansion of Sewage Works in the Minneapolis-St. Paul Metropolitan Area, Volume Three, sponsored by the Minneapolis-St. Paul Sanitary District, prepared by Toltz, King, Duvall, Anderson and Assoc., Inc., September, 1960.

GPO 828-545-C-7

SECTION V

EFFECTS OF POLLUTION ON WATER QUALITY

INTRODUCTION

Sewage and other wastes contain many constituents, which affect water quality (and hence, water uses) in different manners. The effects may be rather subtle or very obvious and a complete discussion of them could easily fill several volumes. The brief description which follows regarding some of the more obvious effects, however, covers most of the problems of concern in the Project study area.

Water pollution takes many forms. Visible signs of pollution such as grease, oils, floating solids and offensive odors lower the esthetic quality of a body of water, making it less attractive for all uses. Decomposable organic matter can cause an excessive reduction of the dissolved oxygen resources which, in turn, will result in a reduction of desirable aquatic life, including both fish and fish food organisms. Complete depletion of the dissolved oxygen results in the generation of offensive odors. Nitrogen, phosphorous, and heat promote the growth of algae which, in turn, create nuisance conditions affecting water supplies, recreational uses, and esthetic quality. Some chemical pollutants such as metals and fluoride are irritating or toxic to man and aquatic life. Others, such as oils and phenol, impart undesirable tastes and odors to the water and the flesh of fish. Suspended solids, including silt from land erosion, create turbidity which not only makes the water less suitable for municipal, industrial, and recreational uses, but can also be damaging to fish and inhibit the growth of algae. The latter effect may or may not be favorable, depending upon the circumstances. The larger suspended solids eventually settle out, forming a sludge blanket along the stream bottom. This sludge is undesirable for several reasons: It may smother the sensitive bottom organisms which serve as food for fish;

the organic fraction exerts a demand on the oxygen resources; and on navigable streams, dredging must be performed more often to maintain a channel. Pathogenic bacteria and viruses make water less safe as a source of water supply or for any other use requiring (occasional or frequent) body contact. This includes such uses as swimming, boating, fishing and commercial shipping. Many other constituents, such as chlorides, boron, pesticides, and surface active agents, can affect water uses but none of these were found in sufficient concentrations in the Project study area to warrant concern at this time.

STREAM SURVEY METHODS

The stream sampling program for measuring physical, chemical, and bacteriological parameters was conducted in three distinct phases. The first phase, termed as routine sampling, was performed during the summer and fall of 1964. Approximately 90 stations were established covering all of the major streams and their significant tributaries within the study area. Most of these stations were sampled many times over the four-month period on different days of the week and at different times of the day. This program served to characterize the quality of all the waters of concern and to point out areas requiring further study.

The second phase of the sampling program consisted of several 72-hour, around-the-clock intensive surveys of those areas found to be of concern in the first phase. These surveys were conducted between November 1964 and February 1965. They provided much of the information necessary to characterize hourly fluctuations of water quality in the more polluted reaches and to establish "cause and effect" relationships between waste discharges and stream quality.

The third phase of the sampling program consisted of three 10-consecutive-day surveys, covering the entire study area. They were conducted during August and September, 1965. These surveys provided further information on daily fluctuations in water quality and on "cause and effect" relationships over the entire study area during a fairly stable flow regime.

No stream sampling of consequence was performed between February and August, 1965, because of the unusually high flow conditions.

The biological sampling program was conducted separately but generally over the same period of time. Bottom sampling was carried out at 64 stations on the Mississippi River, 30 stations on the Minnesota River, 14 stations on the St. Croix River, and one station each on the Rum and Blue Earth Rivers. Over the 18-month period of sampling, 1,110 bottom samples and 224 qualitative shoreline samples were examined.

During summer, fall, and winter of 1964 bottom surveys were performed on the Mississippi and St. Croix Rivers and spring, fall, and winter surveys were conducted on the Minnesota River. Because of high waters resulting from the 1965 spring flood, bottom sampling was discontinued until the summer of 1965 when surveys were again performed on all three rivers. Further bottom sampling in the fall of 1965 was limited to the critical reaches of the Mississippi and Minnesota Rivers.

Phytoplankton samples were collected at two-week intervals between April and December, 1964, from 20 stations located throughout the study area.

To evaluate the palatability of fish flesh, 11 species of fish were collected on a one-time basis in late August and early September, 1964, from fourteen stations on the Mississippi River, three on the Minnesota

River, and one on the St. Croix River.

Information on the physical characteristics of the streams, necessary to determine reaeration rates and times of flow between points, was obtained in separate surveys and from other agencies.

Each stream sampling station used in the surveys is designated by the river mile at its particular location preceded by a two-letter initial of the river's name. Initials used for the Mississippi, Rum, Minnesota, and St. Croix Rivers are UM, RU, MN and SC, respectively. River mile 0 is usually located at the mouth of the particular river. The only exception to this is the Upper Mississippi River where the mileage system begins at the confluence of the Mississippi and Ohio Rivers at Cairo, Illinois.

MISSISSIPPI RIVER WATER QUALITY DURING 1964 & 1965

General Flow and Water Quality Conditions

The Upper Mississippi River discharge rate is usually lowest between December and February. Following this period the flow increases, reaching a maximum in April and then decreases to a second low sometime between July and September. It generally increases again in the fall before dropping off to the winter low flow. This flow pattern is illustrated in Figures V-1, V-2, and V-3, which give the range of mean monthly discharges at three locations along the Mississippi River for the period 1940-1964. From the standpoint of flow then, the two most critical periods are December-February and July-September. The lowest flow occurs in the December-February period when ice cover prevents reaeration. The second lowest flow occurs in the July-September period when stream temperatures and, hence, deoxygenation rates are highest.

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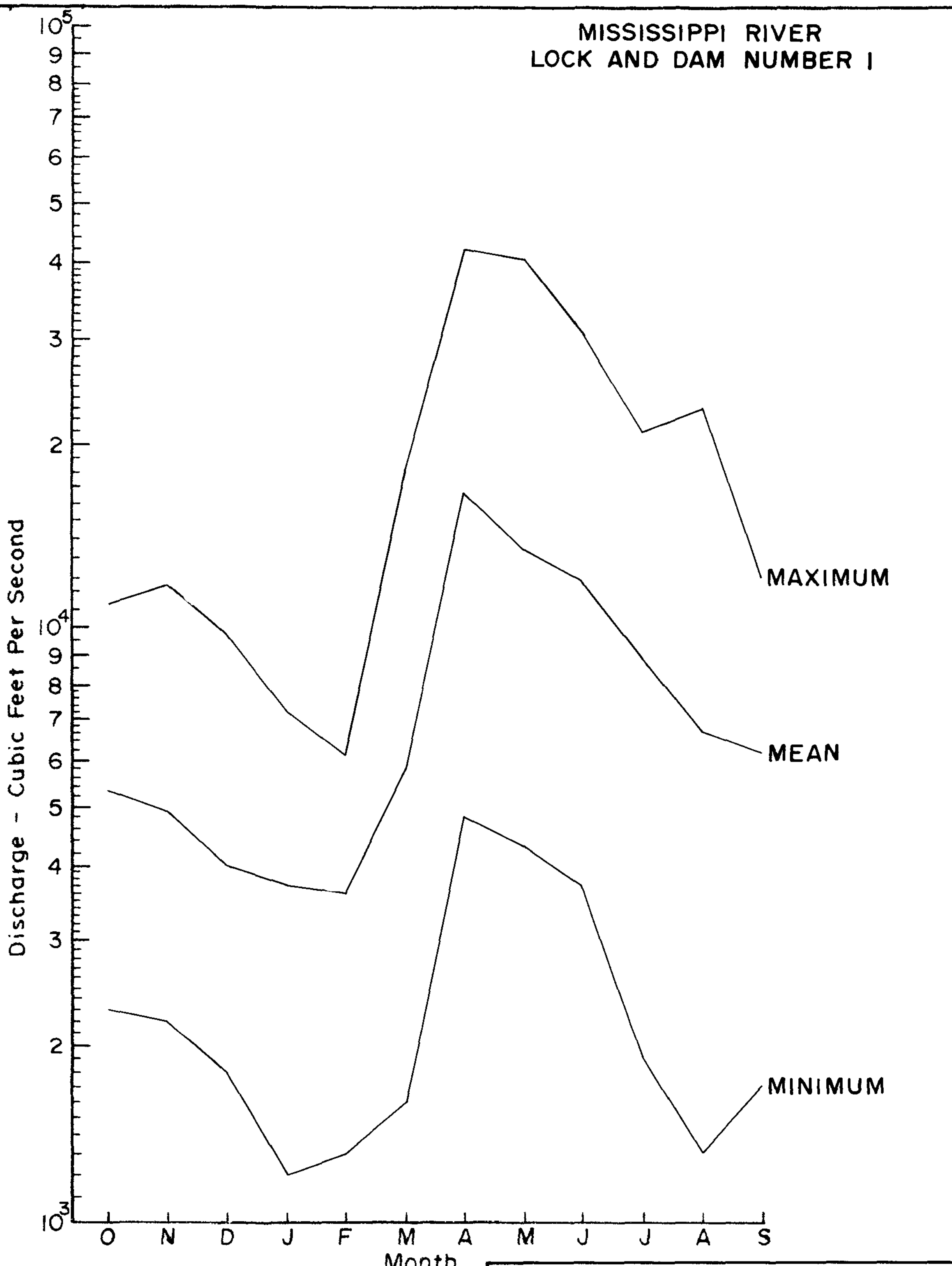


NOTE

MAXIMUM - MAXIMUM OF MEAN MONTHLY DISCHARGE

MEAN - MEAN OF MEAN MONTHLY DISCHARGE

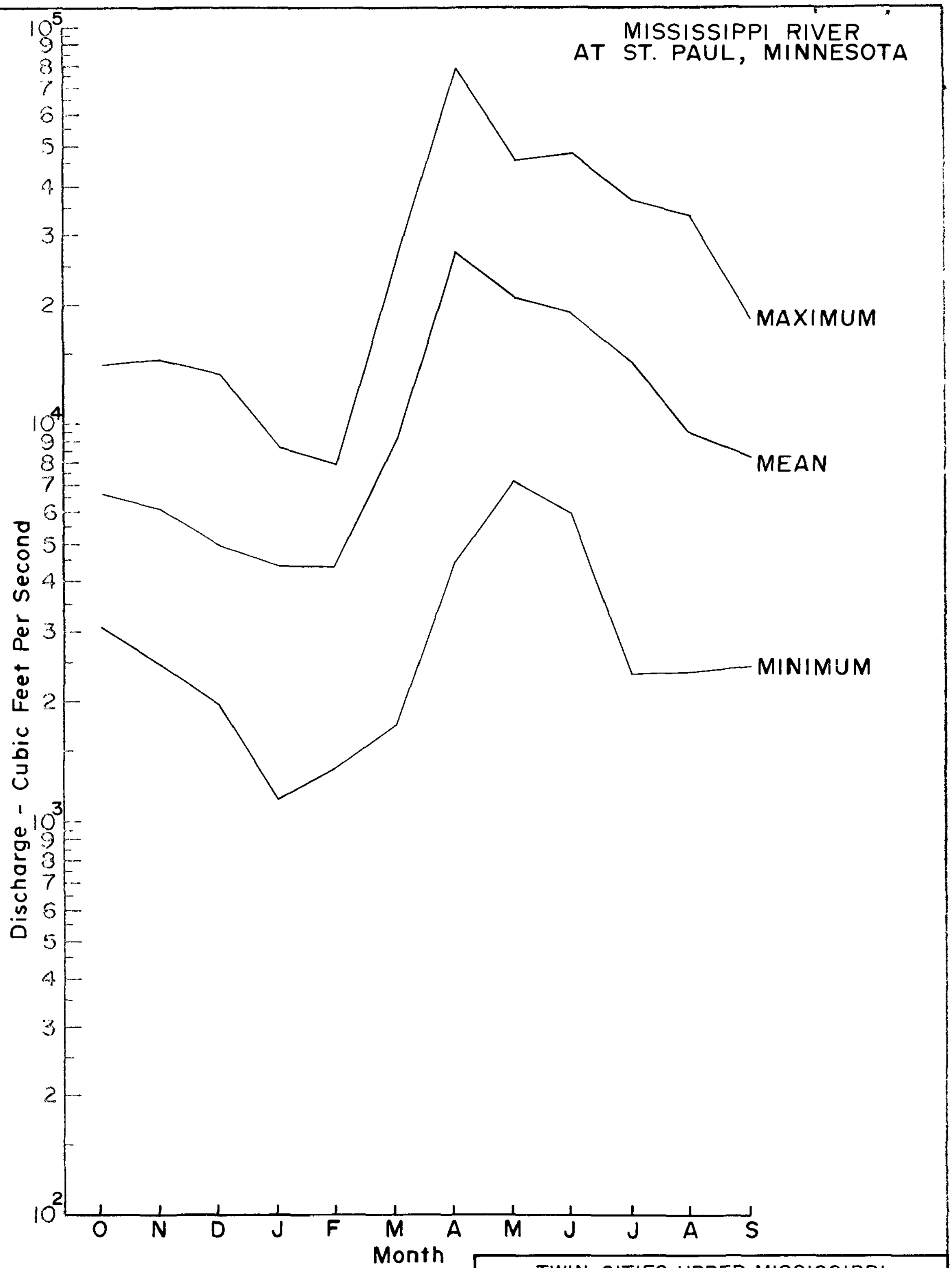
MINIMUM - MINIMUM OF MEAN MONTHLY DISCHARGE

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

RANGE OF MEAN MONTHLY DISCHARGES WATER YEARS 1940 - 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-1



NOTES

MAXIMUM - MAXIMUM OF MEAN MONTHLY DISCHARGE

MEAN — MEAN OF MEAN MONTHLY DISCHARGE

MINIMUM — MINIMUM OF MEAN MONTHLY DISCHARGE

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

RANGE OF MEAN MONTHLY DISCHARGES WATER YEARS 1940 - 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
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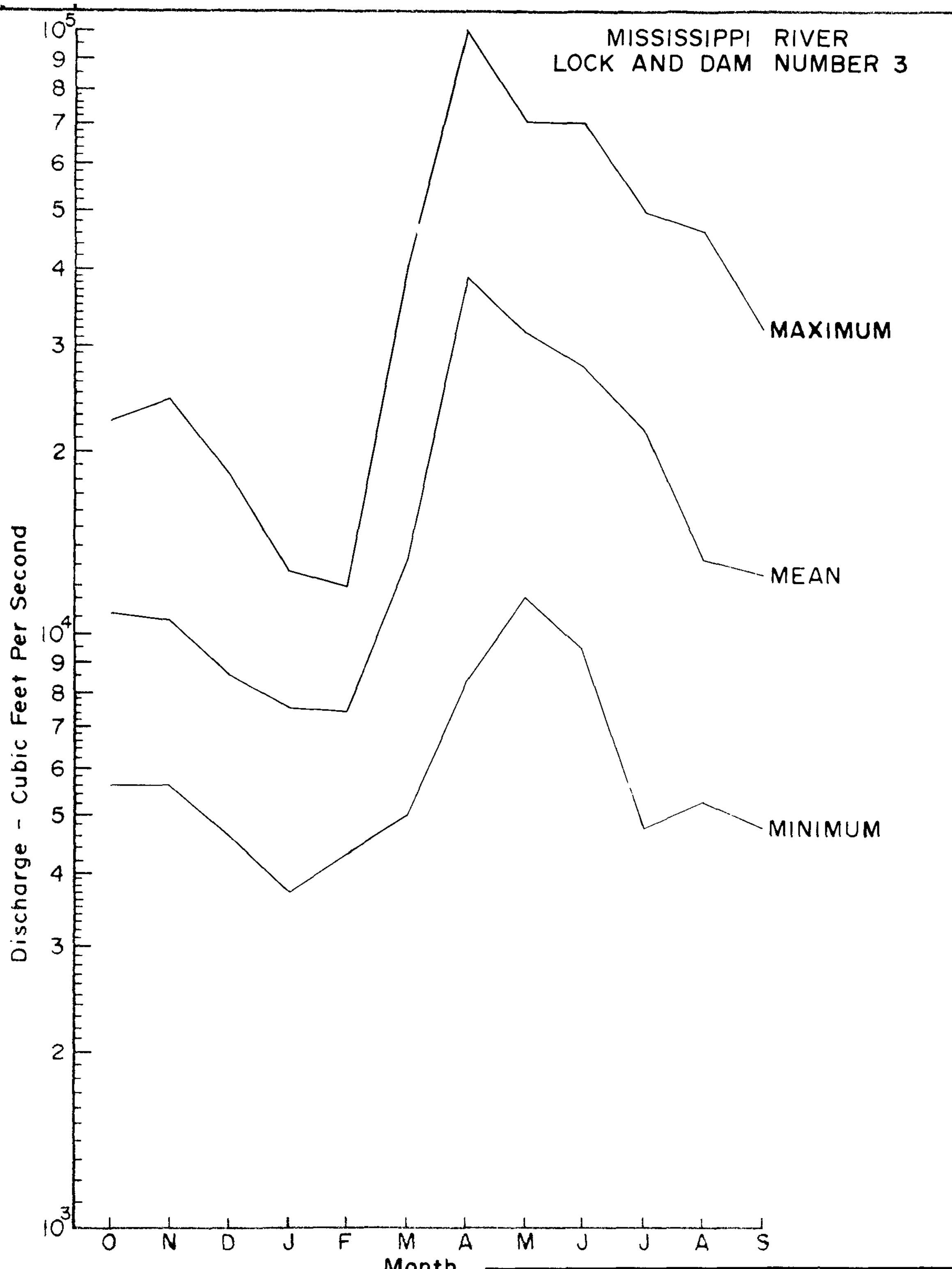
FIGURE V-2



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RANGE OF MEAN MONTHLY DISCHARGES WATER YEARS 1940 - 1964

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NOTE

MAXIMUM – MAXIMUM OF MEAN MONTHLY DISCHARGE

MEAN – MEAN OF MEAN MONTHLY DISCHARGE

MINIMUM – MINIMUM OF MEAN MONTHLY DISCHARGE

FIGURE V-3

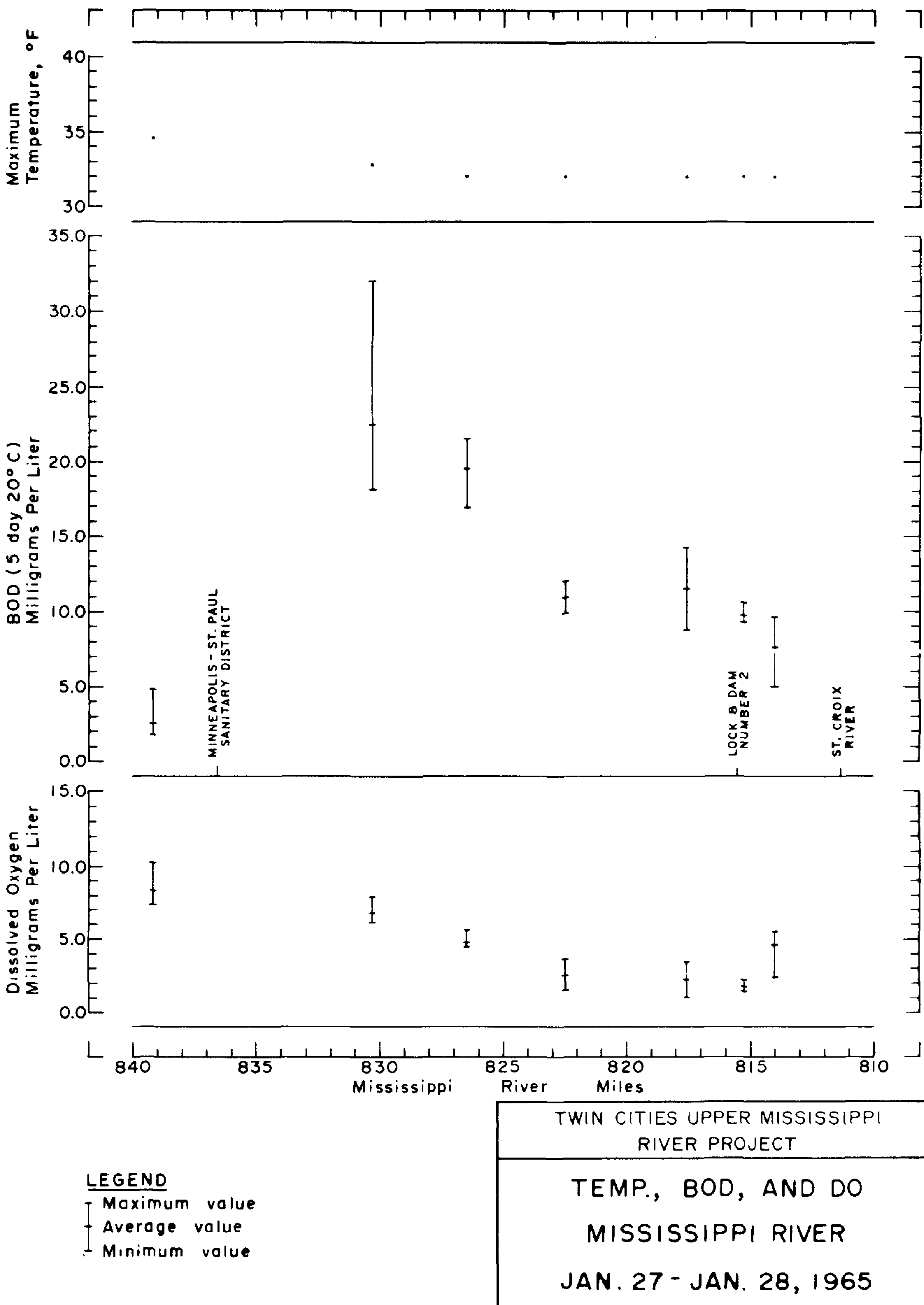
During the routine sampling surveys (first phase) the flow at St. Paul varied between 2,200 and 16,500 cfs, averaging 7,250 cfs. During the second and third phases, the flow at this location averaged approximately 4,100 and 8,400 cfs, respectively. Only samples collected in the low (<5,000 cfs) and intermediate (5,000-15,000 cfs) flow ranges (at St. Paul) were considered to be representative of usual conditions. Mississippi River water quality was not evaluated during flows (at St. Paul) greater than 15,000 cfs.

Results of the routine sampling survey which was conducted between June 24 and October 31 of 1964 are given in Figures V-4 through V-7. The more significant data collected in one of the 72-hour surveys (second phase) are summarized in Figure V-8. Results of one of the 10-day surveys (third phase) conducted in August and September of 1965 are given in Figures V-9 through V-12. Biological survey results are given in Figures V-13 through V-15. These data are discussed below according to river segments.

Mississippi River at Anoka

Water quality of the Mississippi River as it entered the study area at Anoka (UM 871.6) during 1964 was generally good, with the exception of bacterial content (see Table V-1). The water was high in dissolved oxygen (DO), low in biochemical oxygen demand (BOD) and turbidity, and there were no visible signs of pollution such as floating solids or liquids or excessive color. The minimum total coliform density measured was 2,100 MPN/100 ml, however, approximately twice the recommended limit for the whole body contact activities practiced in this area. The average fecal coliform density was 780 MPN/100 ml.

At low and intermediate flows the average concentration of any given



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., BOD, AND DO
MISSISSIPPI RIVER
JAN. 27 - JAN. 28, 1965

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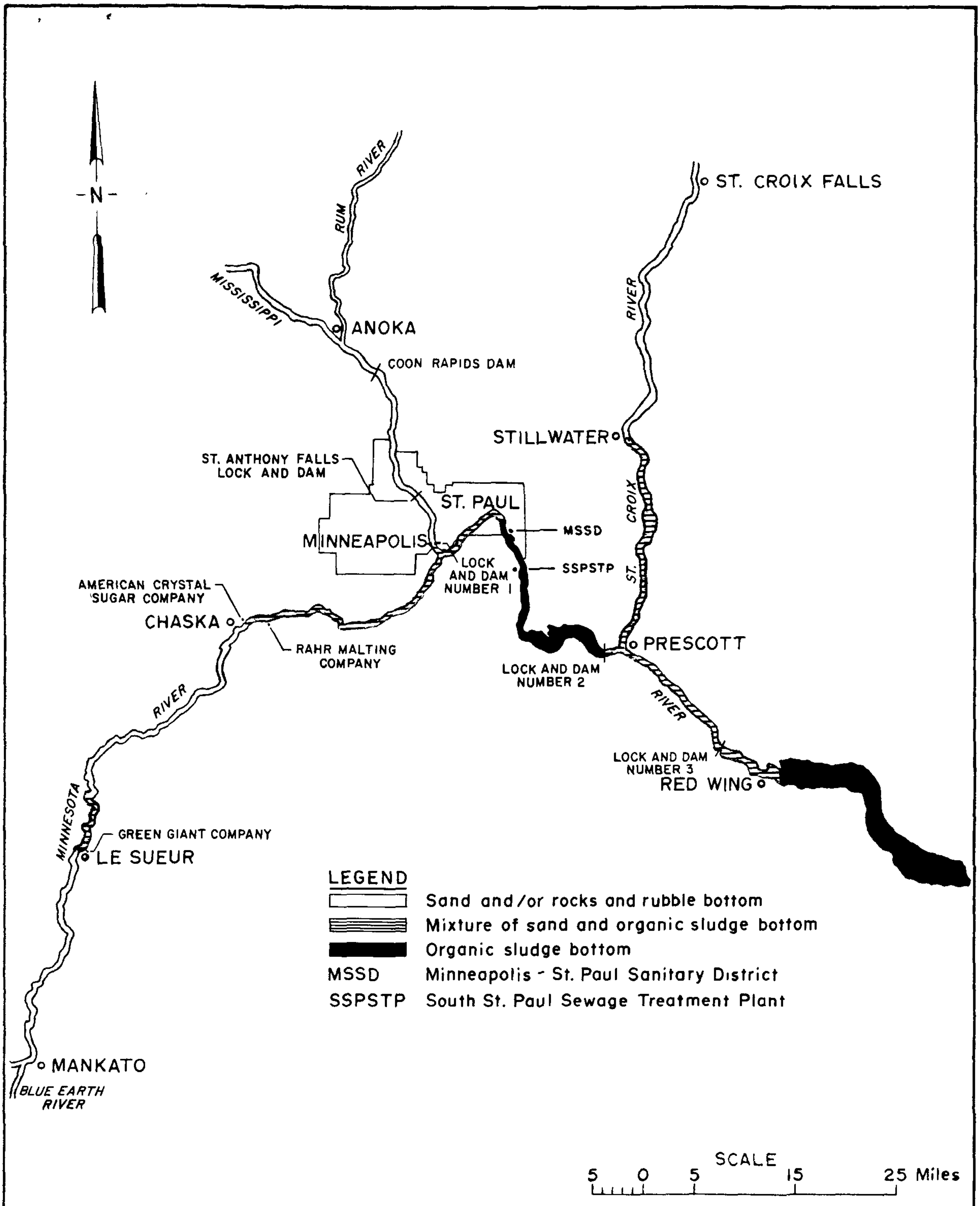
FIGURE V-8



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

DISTRIBUTION OF BOTTOM SEDIMENTS

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FIGURE V-15

TABLE V-1

MISSISSIPPI RIVER WATER QUALITY ON
ENTERING STUDY AREA IN 1964
(at Flows Less than 15,000 cfs)

PARAMETER	VALUES		
	MAXIMUM	AVERAGE	MINIMUM
pH	8.6	-	7.0
Temperature, °F	80	-	-
Dissolved Oxygen (DO) mg/l	10.1	7.9	6.8
% DO Saturation	98	86	78
5-Day (20°C) BOD	6.0	3.0	1.3
Total Suspended Solids, mg/l	30	17	3
Volatile Suspended Solids, mg/l	21	10	2
Turbidity, Jackson Units	<25	-	-
Organic Nitrogen, mg/l	1.79	1.17	0.03
Ammonia Nitrogen, mg/l	0.38	0.23	0.00
Nitrate Nitrogen, mg/l	0.16	0.07	0.00
Total Phosphate (as PO_4), mg/l	0.52	0.34	0.14
Total Coliform, MPN/100 ml	14,100	6,000	2,100
Fecal Coliform, MPN/100 ml	2,400	780	14

constituent was generally the same, regardless of the flow. Stated another way, the number of tons per day of a given constituent passing station UM 871.6 was roughly proportional to the stream flow rate for flows less than 15,000 cfs.

Mississippi River - Anoka to St. Anthony Falls

Chemical and Physical Quality. Immediately below station UM 871.6 the Anoka secondary sewage treatment plant and the Rum River discharge to the Mississippi River. The quality of the sewage treatment plant effluent is covered in the previous Section on waste discharges. Although viruses were found occasionally in the plant effluent none were detected in the river downstream from the plant.

The Rum River water quality was found to be approximately the same as that of the Mississippi River at station UM 871.6. During the surveys the Rum River flow was about 5 percent of that of the Mississippi River where they join.

Except for a temporary slight increase in the coliform density, the water quality below Anoka was found to be about the same as that of the incoming Mississippi River. In dry weather the water quality was essentially uniform throughout the segment between Anoka (UM 871.6) and Upper St. Anthony Falls (UM 853.7). The DO was never detected below 6.5 mg/l and averaged about 8.0 mg/l during the first sampling phase. Ammonia nitrogen never exceeded 0.5 mg/l and the maximum turbidity was less than 25 units. The maximum temperature found above the Riverside Steam-Electric Generating Plant (UM 856.9) was 82°F. at UM 867.2 (four miles below Anoka) on July 30, 1964. The Riverside Plant increased the average river temperature by 3 to 3.5°F. immediately downstream. Within one mile below the plant the temperature had dropped by almost 1°F.

The rate of decrease was much slower beyond this point.

Bacteriological Quality. The coliform density decreased steadily with distance downstream below UM 867, averaging 4,000 MPN/100 ml at UM 858.5 (4.8 miles above St. Anthony Falls) during the first sampling phase. Below UM 855 the density increased somewhat especially during wet weather as a result of storm runoff and combined sewer overflows. Bassett Creek, which enters at UM 854.7, had a high coliform density at all times. During the 1964 routine survey, the coliform density in Bassett Creek averaged 219,000 MPN/100 ml. During the 1965 surveys it averaged about 50,000 MPN/100 ml. The flow in Bassett Creek generally ranged from 10 to 50 cfs during the surveys. On one occasion during heavy rainfall the flow was as high as 190 cfs.

Biological Quality. Phytoplankton are of basic importance in aquatic environments since they provide the first steps in the food chain of fishes. Excessive numbers, however, can create nuisances including problems with water treatment, tastes and odors, and unsightly conditions.

Phytoplankton in the waters entering this reach during 1964 were of varied species. The density near Anoka measured at the one-foot depth was relatively high, averaging 7,400/ml between April and December of 1964. The density increased during passage through this reach, averaging 11,100/ml at UM 855.0 (1.3 miles above St. Anthony Falls) over the same period. (At this station total inorganic nitrogen and orthophosphate (as PO_4) levels averaged 0.43 and 0.17 mg/l respectively during the first sampling phase.) According to the Minneapolis Water Works Department (located at UM 858.9), the phytoplankton occasionally cause taste and odor problems in the drinking water.

Bottom organisms found in this reach during 1964 were indicative of a non-polluted environment. Based on qualitative and quantitative sampling, a wide variety of bottom organisms (16 to 24 kinds) were found in this reach with clean water associated animals generally comprising over 50 percent of the total. The mean total number of organisms was less than 50 per square foot at the eight stations sampled. Similar conditions were found on the Rum River at RU 0.5.

During the late summer and early fall of 1965 another check was made of bottom organisms in this reach of the Mississippi River through the use of artificial substrates. At stations UM 873.0, 871.7, and 859.0 between 88.2 and 99.0 percent of the organisms collected were sensitive or clean-water associated forms. This corroborated the 1964 data which indicated the river to be unpolluted in this reach.

The Minnesota Department of Conservation has determined that game fish make up 12 and 28 percent of the total fish population in the pools above Coon Rapids Dam (UM 866.2) and St. Anthony Falls (UM 853.7), respectively. Game species included walleyed and northern pike, smallmouth and rock bass, black crappie, and bluegill. Species of rough fish commonly found in this area include carp, bigmouth buffalo, northern redhorse, common sucker, and yellow and black bullheads.

A fish flesh evaluation study was conducted by the Project in cooperation with the Minnesota Department of Conservation. Fish tasting was handled by the University of Minnesota under contractual agreement. In this study it was determined that the flesh of fish caught in the vicinity of Anoka had high palatability levels in comparison to fish caught elsewhere within the study area (see Table V-2). In a scoring system of 0 to 10, smallmouth bass caught at Anoka were rated highest with a mean score of 6.2. Carp, also caught at Anoka, were given a mean palatability rating of 5.1. The highest rating given carp by the

TABLE V-2

RESULTS OF FISH FLESH PALATABILITY STUDY[1]

PALATABILITY LEVEL	CARP LOCATION OF CATCH	CARP MEAN TASTE SCORE	SMALLMOUTH BASS LOCATION OF CATCH	SMALLMOUTH BASS MEAN TASTE SCORE	WALLEYE PIKE LOCATION OF CATCH	WALLEYE PIKE MEAN TASTE SCORE
Lowest	MN 10.9 (Hwy 35 Bridge)	3.4				
	UM 821.2 (Spring Lake)	3.8				
	UM 811.5 (Just above confluence of St. Croix River)	4.0				
	UM 852.2 (University Landing)	4.2				
	UM 830.3 (Inver Grove)	4.3				
Intermediate	MN 49.4 (Belle Plaine)	4.5			UM 821.2 (Spring Lake)	4.4
	UM 790.0 (Red Wing)	4.6			UM 794.5 (Trenton Slough	4.6
	UM 794.5 (Trenton Slough)	4.7				
	MN 108.0 (Mankato)	4.8	UM 852.2 (University Landing)	4.9	UM 774.3 (Middle of Lake Pepin)	4.9
					UM 764.7 (Lower end of Lake Pepin)	5.0
	UM 785.4 (Upper end of Lake Pepin)	5.1				
	UM 871.7 (Anoka)	5.1				
	SC 20.0 (Bayport)	5.1			MN 108.0 (Mankato)	5.2
	UM 764.7 (Lower end of Lake Pepin)	5.4				
Highest	UM 774.3 (Middle of Lake Pepin)	5.7	SC 20.0 (Bayport)	6.0	SC 20.0 (Bayport)	6.2
			UM 871.7 (Anoka)	6.2		

Note: Scoring system range was 0-10. A score of 4 or below is considered as unacceptable.
1. Study was conducted in cooperation with the Minnesota Department of Conservation.

taste panel was 5.7. A score of 4 or below is considered unacceptable.

Effects on Water Uses. This segment of the Mississippi River was relatively clean. During low and intermediate flows in 1964 and 1965 it was suitable for all the water uses listed in Table III-22 except whole body contact activities. The total coliform density averaged nearly 5,000 MPN/100 ml, or about five times the maximum recommended density for this use.

Mississippi River - St. Anthony Falls to MSSD Outfall

Chemical and Physical Quality. During dry weather, the water quality in this segment was essentially the same as that in the preceding segment. During and immediately following rainfall, however, some or all of more than 80 combined sewer overflows discharge into this reach. These discharges impair the bacteriological quality creating a health hazard for downstream water users.

Occasional discharges have been reported to come from the Ford Motor Co. plant near UM 847.6. Project personnel, however, never witnessed any such discharges during stream sampling activities.

The Minnesota River enters the Mississippi River at UM 845.5 and UM 844.0, the latter point receiving the major portion of the flow. The Minnesota River water quality is usually lower than that of the Mississippi River just above the point of confluence. The flow of the Minnesota River is generally 10 to 20 percent of that of the Mississippi River at this point.

Although the Minnesota River was usually of lower quality, it had no serious effect on the chemical quality of the Mississippi River, due primarily to the greater flow in the latter. During the first sampling phase the DO concentration in the Mississippi above and below the confluence averaged 8.0 and 7.7 mg/l, respectively. The percent DO saturation ranged from 86 to 105 over the entire segment. The maximum ammonia nitrogen level measured was 0.85 mg/l and averaged about 0.3 mg/l. The turbidity was generally less than 25 units with a maximum of 40 units recorded above the Minnesota River confluence. Below the confluence, however, the turbidity ranged between 30 and 110 units, averaging about 60 units. The turbidity of the Minnesota River as it entered the Mississippi ranged between 60 and 160 units, averaging about 110 units.

The river water temperature on entering this segment at lower St. Anthony Falls (UM 853.4) is slightly above equilibrium because of the heat added by the Riverside plant. At UM 852.3 and 845.5, the maximum temperatures found in 1964 were 85.5 and 83.5°F., respectively. Additional heat is added to the river by the Minnesota River (UM 844.0) and the Highbridge Steam-Electric Generating Plant (UM 840.5). During 1964 the Minnesota River at its mouth was, on the average, 3.5°F. warmer than the Mississippi at the point of confluence. This produced an increase in the Mississippi River temperature of about 0.5°F. The Highbridge Plant added an amount of heat sufficient to increase the river temperature temporarily by another 1°F. The highest temperature measured at UM 836.4 (just above MSSD Outfall) was 85°F.

Bacteriological Quality. The total and fecal coliform densities in this segment of the Mississippi River were somewhat higher than those found in the segment above St. Anthony Falls. During the first phase of sampling the total coliform density at UM 852.3 averaged 26,000 MPN/100 ml. The fecal coliform density was approximately one-tenth of the total coliform density. Stream data collected by the Minneapolis-St. Paul Sanitary District (MSSD) personnel showed the 1964 yearly average total coliform density to be 23,000 MPN/100 ml at UM 852.6. Their data indicate that the average total coliform density at UM 852.6 between May and August, inclusive, was 12,000 MPN/100 ml.

At UM 845.5, just above the Minnesota River confluence, the total and fecal coliform densities during the first phase of sampling averaged 17,000 and 2,000 MPN/100 ml, respectively. Data collected at this station by MSSD personnel indicated an average total coliform density of 43,000 MPN/100 ml during this same period. This difference is not too great considering the great fluctuation in bacterial quality in this reach produced by intermittent overflows from combined sewers.

At UM 836.4, below the Minnesota River confluence and just above the MSSD plant outfall, the total coliform density ranged from 4,600 to 88,000 MPN/100 ml, averaging 34,400 during the first phase of sampling. The fecal coliform density was about 5 percent of the total coliform density. Over the same period MSSD results showed the average total coliform density to be 32,700 MPN/100 ml at UM 839.2. On one occasion six types of pathogens were isolated from samples collected at this station (see Table V-3).

Biological Quality. Slightly higher numbers of phytoplankton were found in this segment than in the segment above St. Anthony Falls. The density, measured at the one-foot depth between April and December of 1964 at UM 847.8 (3.8 miles above the Minnesota River) averaged 12,450/ml. Although these densities are considered to be rather high, they produced no reported problems. In comparison to levels of phytoplankton density found elsewhere within the study area, these values are relatively low. The phytoplankton density of the Minnesota River near its mouth, for instance, averaged over 30,000/ml.

TABLE V-3

ENTERIC PATHOGENS ISOLATED FROM WASTE AND RIVER SAMPLES[1]

SAMPLING LOCATION	ENTERIC PATHOGENS ISOLATED SALMONELLA	VIRUS
UM 836.4	Typhimurium	
(Above MSSD Outfall)	Montevideo	Polio
	Newport	
	Infantis	
	Java	
MSSD Effluent	Heidelberg	Polio
(Discharges at UM 836.3)	Virginia	Coxsackie, type B-5
	Montevideo	ECHO, type 12
	Newport	(unidentified enteric virus)
	Panama	
	Infantis	
	Tennessee	
	Litchfield	
	Muenchen	
	Oranienburg	
	Kentucky	
	San Diego	
	Derby	
	Paratyphi B	
UM 836.2		
(100 yards below MSSD Outfall)	Heidelberg	(unidentified enteric virus)
	Infantis	
	Bredney	
	Blockley	
	Worthington	
UM 835.0	St. Paul	None found
UM 834.0	Heidelberg	(unidentified enteric virus)
	Montevideo	ECHO, type 7
	Typhimurium	
	Newport	
	Chester	
	St. Paul	
	Oranienburg	
South St. Paul Effluent	Anatum	No tests made
(Discharges at UM 832.4)	Ohio	
	Binza	
	Typhimurium	
	Newington	

TABLE V-3 (Continued)

ENTERIC PATHOGENS ISOLATED FROM WASTE AND RIVER SAMPLES

SAMPLING LOCATION	ENTERIC PATHOGENS ISOLATED SALMONELLA	VIRUS
UM 830.3	Heidelberg Newport Typhimurium Oranienburg Anatum Muenchen Montevideo Cubana Kentucky Tennessee	(unidentified enteric virus)
UM 826.0	Heidelberg Newport Typhimurium Oranienburg Infantis Anatum Java	None found

1. Study was conducted in cooperation with the Minnesota Department of Health, Federal Water Pollution Control Administration Great Lakes-Illinois River Basins Project, and the Public Health Service Communicable Disease Center Field Station.

The diversity of bottom animals decreased in Pool No. 1 compared to areas sampled above St. Anthony Falls. In this pool there was a general lack of rocks and rubble to house a wide variety of organisms as compared to upstream conditions. A slight accumulation of organic sludge (mostly natural) was found throughout the pool. This also accounts for the decrease found in the ratio of clean-water associated animals to pollution tolerant animals.

Biologically, the river at UM 846.0 (2.0 miles above the Minnesota River) was still a relatively unpolluted water. A variety of bottom organisms was present, with a significant number of them being clean-water associated. A sparsity of rocks and rubble in this area prevented inhabitance by an even greater variety of animals.

The Minnesota River had an adverse effect on the aquatic biota in the Mississippi River. There was a decrease in the number of kinds of organisms from 13 at UM 846.0 (2.0 miles above the confluence) to 7 and 6 at stations UM 841.4 and UM 836.4, respectively. The density of organisms, however, remained essentially the same over the entire segment as far downstream as UM 836.4 (just above the MSSD outfall). Here the density of bottom organisms increased sharply with a maximum of 139 per square foot found during the fall of 1964. Sludge worms constituted the bulk of the animal population in this reach below the confluence. Clean-water associated forms averaged less than 50 percent of the total kinds. This adverse effect reflects the influence of organic materials carried into the Mississippi River by the Minnesota River.

Studies conducted by the Minnesota Department of Conservation determined that game fish make up 50 percent of the total fish population in the reach between Lock and Dam No. 1 (UM 847.6) and the Minnesota River

(UM 844.0). Game fish present in greatest numbers were black crappie and white bass. Northern pike, bluegill, white crappie, and smallmouth bass were also present, but in smaller numbers. Approximately 90 percent of the rough fish population were carp. Both game and rough fish are present in Pool No. 1. However, the relative proportions of each are not known. There is also no specific information on relative game and rough fish populations in the reach between the Minnesota River and MSSD plant outfall (UM 836.3).

Smallmouth bass and carp caught at UM 852.2 were evaluated in the fish flesh evaluation study mentioned previously. The smallmouth bass received a mean palatability rating of 4.9, which is considered to be in the intermediate range. The highest rating given smallmouth bass by the taste panel was 6.2. Carp were given a mean rating of 4.2 which is in the low palatability range. The highest rating given carp by the test panel was 5.7.

Effects on Water Quality. This segment of Mississippi River was generally more polluted than the segment above St. Anthony Falls mainly because of frequent overflows from combined sewers during the survey period. The recommended limit of 25 units of turbidity for sources of a potable water supply and for whole-body contact activities was exceeded in a few samples above the Minnesota River confluence and in all samples collected below it. The average total coliform density exceeded all limits for various water uses. Under the conditions found, the waters in this segment were unsuitable for body contact activities (e.g. swimming, boating, fishing, and navigation), irrigation of crops normally eaten raw and stock and wildlife watering. These waters are presently being used for boating, fishing, and navigation, and this use constitutes a health hazard.

Mississippi River - MSSD Outfall to Lock & Dam No. 2

Chemical and Physical Quality. This segment of the river receives wastes from approximately 18 sources, including the two greatest contributors in the study area. As a result this 21.1-mile reach of river has the lowest water quality of the entire study area.

Immediately above the MSSD plant outfall (UM 836.5), the DO averaged 7.8 mg/l during the first sampling phase. Wastes added principally by MSSD and South St. Paul (UM 832.4) caused the DO to decrease progressively with distance downstream as far as UM 821. DO levels in this reach were particularly low between July 29 and August 18, 1964, where the stream flow rate was 3,000 cfs and the river temperature averaged 79.5°F., reaching a maximum of 85°F. At UM 835.0 (1.4 miles below MSSD) the DO was much lower, ranging from 0.6 to 9.6 mg/l and averaging 5.5 mg/l during the first sampling phase. Between July 29 and August 18, it averaged only 0.8 mg/l at this station. At UM 830.3 (2.1 miles below the South St. Paul plant outfall) the average DO over the first sampling phase was 4.3 mg/l. The DO was generally lowest at UM 821.2 (six miles above Lock & Dam No. 2) during the first phase. It ranged from 0.5 to 7.1 mg/l, averaging 2.9 mg/l. Below this point the DO increased, reaching an average of 5.2 mg/l at UM 817.2.

Ammonia nitrogen levels were highest at station UM 830.3. The concentration at this point ranged from 0.57 to 2.01 mg/l, averaging 0.96 mg/l. Ammonia nitrogen levels exceeded 1.0 mg/l one or more times during the survey at all stations in the entire segment of river being considered.

The water quality during winter, under conditions of ice cover and low stream flow, was nearly as critical as during summer low flow conditions.

During two intensive surveys conducted January 27-28 and February 24-26, 1965, the DO level at UM 839.2 (above the major waste sources) averaged 8.3 and 7.7 mg/l, respectively. At UM 817.6, however, the average DO levels during these surveys were, respectively, 2.2 and 2.3 mg/l. The highest DO measured at the latter station during both surveys was 3.1 mg/l. The water temperature remained at 32°F. during both surveys.

Ammonia nitrogen levels were also generally higher during the winter. At UM 822.5, the average levels during the two winter surveys were 1.66 and 1.96 mg/l, respectively. The average stream flows at Lock & Dam No. 2 during these surveys were 4,100 and 3,900 cfs, respectively.

According to data collected by MSSD personnel, the turbidity at any given time was quite uniform over the entire segment during the first sampling phase. It ranged between 30 and 120 units, averaging about 55 units between June and October of 1964.

During August, 1964 when the stream flow was low, there were gas bubbles and some floating sludge rising from the bottom in the reach between UM 835 and UM 830. There were also dense growths of fungi along the shoreline in this reach. Small oil slicks were sighted occasionally in the segment between MSSD and Lock & Dam No. 2.

Approximately 890 pounds of phenol were being discharged to this segment of the river daily, 850 pounds of it by MSSD. At the minimum flow experienced within the reach during the first sampling phase (2,200 cfs), the contribution from MSSD increased the average phenol concentration in the river just below the plant by 0.07 mg/l. The MSSD, in its stream monitoring program, measures phenol concentrations above and below their plant outfall. Between June and October of 1964 their data indicate that an average of 40, 620, 210, and 200 pounds/day passed stations UM 839.2, 832.5, 830.3, and 822.5, respectively. For the first six miles below the MSSD plant outfall then, the phenol loading was reduced naturally at an average rate of approximately 110 pounds/mile. The maximum concentration of phenol measured at UM 832.5 (3.9 miles below MSSD) was 0.05 mg/l when the stream flow was 3,100 cfs.

The maximum temperature measured in this reach during the summer of 1964 was 85°F.

Bacteriological Quality. The bacteriological quality of the river decreased markedly below the MSSD outfall, which discharged an average of about 1.1 x 10^{17} coliform organisms per day. Of this number 28% were found to be fecal coliform. At UM 835.0 data collected by MSSD during the first sampling phase showed that the total coliform density averaged 3,760,000 MPN/100 ml. The density increased, due to multiplication in the stream and to discharges from South St. Paul's combined sewer overflows, reaching a maximum at UM 832.5 (about one-half day below the MSSD outfall). At this point the density ranged from 460,000 to 17,000,000 MPN/100 ml, averaging 6,500,000 MPN/100 ml. At UM 832.4 the South St. Paul sewage treatment plant discharged an average of 2.1 x 10^{15} coliform organisms per day to the river. This contribution, being only 2 percent of that added by MSSD, did not appreciably increase the coliform density in the stream. The coliform density in the river continued to decrease with distance downstream, averaging 5,000,000, 1,500,000, and 100,000 MPN/100 ml at UM 830.3, UM 822.5, and UM 815.2, respectively.

The river and the MSSD and South St. Paul effluents were also monitored for enteric pathogens. The results are given in Table V-3. Polio virus and five species of Salmonella were found in the river at UM 836.4, just upstream from the MSSD outfall. They were most likely

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discharged either from the Twin Cities' combined sewer overflows or from the Minnesota River. Polio, Coxsackie, and ECHO viruses and fourteen species of *Salmonella* bacteria were isolated from the MSSD effluent. Five species of *Salmonella* were isolated from the South St. Paul plant effluent. *Salmonella* were found in river samples taken at UM 836.2, UM 835.0, UM 834.0, UM 830.3, and UM 826.0. Viruses were also isolated at several of these stations. *Shigella flexneri 2* was also isolated from 826.0, the lowermost station sampled for enteric pathogens in this reach. Positive identification of these disease producers in the waters of the study area validates the use of the coliform group as indicators of pathogens.

Biological Quality. Still greater numbers of phytoplankton were found in this reach than in the previous ones. At UM 830.3 (six miles below MSSD) between April and December of 1964, the phytoplankton density averaged 15,710/ml. Nutrient levels were also higher in this reach. Total inorganic nitrogen and orthophosphate levels averaged 0.86 and 0.68 mg/l, respectively.

To evaluate the relative abundance of periphyton (attached algae) in various sectors of the river, the amount of chlorophyll-a in the plant cells attached to the artificial substrates was measured. Results indicated little change in the relative abundance of periphyton downstream to UM 829.7. However, from UM 824.5 (11.8 miles below MSSD) to the outlet of Lake Pepin (UM 764.7) there was a significant and progressive increase in periphyton as demonstrated by the increase of chlorophyll-a to as much as six times the upstream values.

This increase in phytoplankton and periphyton was largely a response to the nutrient and organic load received from upstream sources. An immediate response to the nutrients did not take place since they were in the less readily available state of organic nitrogen, ammonia, and insoluble phosphates. Once converted to nitrate and soluble phosphate through chemical and biochemical action in the stream, the nutrients were readily available and quickly utilized by the phytoplankton and periphyton.

Studies were also conducted in this reach to evaluate the significance of oxygen production by algae during the second sampling phase. Oxygen production and respiration rates were measured at stations UM 840.2 (3.9 miles above MSSD), UM 830.3 (six miles below MSSD), and UM 817.2 (19.1 miles below MSSD) using light and dark bottles. Results showed that the effects of algal photosynthesis and respiration on the oxygen balance were minimal in this critical reach and need not be further considered

The varieties of bottom organisms were reduced from six at UM 836.4 (just above MSSD) to two, and one at stations UM 835.0 (1.3 miles below MSSD), and UM 833.1 (3.2 miles below MSSD), respectively. All pollution sensitive animals were eliminated. The river bottom materials in this reach were composed mainly of organic sludge with a septic odor. Sewage fungus was commonly found growing on shoreline rocks. This reach between the MSSD outfall and UM 832.0 was clearly a zone of degradation.

The zone of active decomposition began at UM 829.7 and extended downstream to Lock & Dam No. 2 (UM 815.2). The sludge worm population markedly increased in this river reach (for example from 8 per square ft. at UM 829.7 to 162 per square ft. at UM 815.6 in the fall survey). The bottom materials in this reach were organic sludge. Soybean oil deposits were found at UM 815.6 in 1965.

Artificial substrates were placed at UM 835.0, UM 833.1, UM 829.7 and UM 824.5 in the summer of 1965. All became coated with slick, slimy brownish-colored organic materials and growths of sewage fungus were microscopically identified and confirmed by laboratory culture. The sludge worm populations found growing on the substrates at UM 835.0 and UM 833.1 were low (258 and 396 respectively) when compared to the much higher sludgeworm populations (12,000 and 1,600, respectively) at UM 829.7 and UM 824.5.

In the reach between UM 830 (six miles below MSSD) and UM 823 the Minnesota Department of Conservation found that only six percent of the total fish population were game fish. In Spring and Baldwin Lakes, the backwater areas near UM 823, game fish made up approximately 25 percent of the fish population. In the two-mile reach (UM 817.2-UM 815.2) just above Lock & Dam No. 2, game fish made up only nine percent of the population. Carp was the predominant species throughout Pool No. 2, making up about 74 percent of the total fish population.

Flesh palatability tests were made on fish caught at UM 830.3 and UM 821.2. Carp caught at these stations were given ratings of 4.3 and 3.8, respectively, which places them in the lowest level of palatability. Walleye pike, caught at UM 821.2, was given a rating of 4.4. Again, palatability ratings of 4 or below indicate the fish flesh to be unacceptable.

Effects on Water Uses. This segment of the Mississippi River was heavily polluted. The two greatest contributors of pollution were the MSSD and the South St. Paul sewage treatment plants. During part or all of the stream survey period, some of the requirements for every water use listed in Table III-22 except cooling water, were exceeded. The fishing, pleasure boating, and navigation currently practiced in this segment of river represent a health hazard.

Mississippi River - Lock & Dam No. 2 to Lock & Dam No. 3

Chemical and Physical Quality. This reach of the river, which receives three minor waste discharges, lies in the pollution recovery zone. Water quality in this reach is also enhanced by the St. Croix River which enters at UM 811.3.

The DO level was generally increased by 1 to 2 mg/l during passage of the water over Lock & Dam No. 2. At UM 814.0 (1.2 miles below the Dam) the DO ranged from 3.1 to 9.1 mg/l, averaging 6.3 mg/l between June and October of 1964. Below the confluence of the St. Croix River, the DO ranged from 4.4 to 9.0 mg/l, averaging about 6.5 mg/l.

During the two winter surveys of 1965, the DO levels at UM 814.0 were lower than the summer values. They ranged from 2.1 to 5.8 mg/l, averaging 4.4 mg/l for both surveys. Below the confluence of the St. Croix, winter and summer levels were more nearly the same. At UM 808.5 (2.8 miles below the St. Croix River) during the second winter survey, the DO ranged from 5.7 to 7.5 mg/l and averaged 6.1 mg/l.

Ammonia nitrogen levels, measured at UM 806.0 (5.3 miles below the St. Croix River) between June and October, 1964, ranged from 0.42 to 1.10 mg/l and averaged 0.75 mg/l. Higher values were obtained during winter months, however. At UM 814.0 (2.7 miles above the St. Croix River) during the two winter surveys, the levels ranged from 1.49 to 2.59 mg/l, averaging 2.12 mg/l. At UM 808.5 winter values ranged from 1.33 to 1.63 mg/l, averaging 1.53 mg/l.

Data collected by MSSD over the June-October period indicated that the turbidity of the river above the St. Croix averaged 65 units. Below the St. Croix River the turbidity averaged 50 units.

Bacteriological Quality. The bacteriological quality of this river segment was better than the previous segment, but still rather poor. At UM 814.0 (2.7 miles above the St. Croix River) the total coliform density (as indicated by MSSD data) averaged 74,500 MPN/100 ml during the first sampling phase. Less than 2 percent of the total were fecal coliforms. Below the confluence of the St. Croix River (at UM 810.2) the total coliforms averaged 67,500 MPN/100 ml. The improvement in bacteriological quality that would have been expected between UM 814.0 and 810.2 from dilution by the St. Croix River (which enters at UM 811.3) was offset by the addition of wastes from the Hastings sewage treatment plant, located at UM 813.9. The Prescott sewage treatment plant, which discharges at UM 809.8, also contributes to pollution in this reach.

The coliform density continued to decrease with distance downstream. At UM 796.9 (upstream side of Lock & Dam No. 3) the total coliform density averaged 31,000 MPN/100 ml.

Biological Quality. Phytoplankton were found in greater numbers at UM 813.9 (2.6 miles above the St. Croix River) than at any point upstream. At the one-foot depth the average density at this station between April and November of 1964 was 21,200/ml. Even at this level no problems were created by the phytoplankton. Their presence was apparent only by microscopic examination.

After reaching a peak density at UM 813.9, the phytoplankton population began to decrease progressively with distance downstream. The nutrient concentration in this segment was still relatively high, but had also begun to decrease. At UM 806.0 the inorganic nitrogen and orthophosphate concentrations averaged 0.89 and 0.54 mg/l, respectively.

Bottom organism data showed the recovery zone to extend from UM 814 (1.2 miles below Lock & Dam No. 2) on beyond Lock & Dam No. 3. There were three to four times as many different kinds of animals at UM 813.9 as compared to just above Lock & Dam No. 2, but all were pollution tolerant. The number of organisms per square foot below the dam during 1964 was, on the average, 50 percent greater than above it. The density of bottom organisms decreased somewhat immediately below the mouth of the St. Croix River and then increased progressively down to Lock & Dam No. 3 where, during the fall of 1964, it reached 261 per square foot. All bottom organisms in this reach were also of the pollution tolerant type. Bottom materials in the entire segment varied from sand to a mixture of sand and organic sludge having a moderately septic odor.

Greater numbers of game fish were found in this segment of the Mississippi River than in any of the previous segments discussed. The Minnesota Department of Conservation determined that in 1964 game fish made up 46 percent of the total fish population in this pool.

The flesh of carp caught at UM 811.5 (just above the St. Croix River) was evaluated by the taste panel and given a mean palatability rating of 4.0, indicating unacceptable quality. No fish in Pool No. 3 below the mouth of the St. Croix River were evaluated.

Effects on Water Uses. This segment of the river is a part of the pollution recovery zone. The water quality was unsuitable for use as a source of potable water, for irrigation of crops normally eaten raw, stock and wildlife watering, body contact activities, and pollution sensitive aquatic life. The reach above the St. Croix was also considered unsuitable for pollution tolerant species because the ammonia nitrogen level exceeded 2.0 mg/l and the DO fell below 3.0 mg/l. The fishing, pleasure boating, and navigation currently practiced in this segment of river represent a health hazard.

Mississippi River - Lock & Dam No. 3 to Chippewa River

Chemical and Physical Quality. This segment of the river, which also lies in the pollution recovery zone, receives wastes from three sewage treatment plants, two industries, and one steam-electric generating plant. These waste sources have little measurable effect on the water quality.

The DO level at UM 794.5 (2.4 miles below Lock & Dam No. 3) ranged from 4.8 to 8.3 mg/l, averaging 6.5 mg/l during the period between June and October, 1964. The average DO increased only slightly between this point and the outlet of Lake Pepin. At UM 764.7 (the outlet) the DO ranged from 4.6 to 13.0, averaging 7.5 mg/l. The greater fluctuation in DO levels in Lake Pepin (40-140% of saturation) was due more to algal activity rather than to varying BOD loadings.

The ammonia nitrogen level was lower in this segment and diminished with distance downstream. The average decreased from 0.53 mg/l at UM 794.5 to 0.38 mg/l at UM 764.7 (the outlet of Lake Pepin).

Turbidity, as measured by MSSD personnel, decreased from an average of 45 units at UM 792.0 (7 miles above head of Lake Pepin) to 10 units at UM 764.9 during the June-October, 1964 period.

The maximum temperature of the water measured in 1964 as it entered this segment was 85°F. The largest source of thermal pollution below this point is the steam-electric generating plant at Red Wing, Minnesota (UM 789.4), which produced no detectable increase in the river temperature. Water temperatures measured throughout Lake Pepin did not exceed 86°F.

Bacteriological Quality. There was a very marked improvement in the bacteriological quality of the water during passage through this segment.

Data collected by MSSD personnel during the June-October, 1964 period showed that the average coliform density decreased from 31,000 MPN/100 ml at UM 796.9 (Lock & Dam No. 3) to 20,000, 2,500, 230, and < 250 at 792.0, UM 779.0, UM 772.8, and UM 764.9, respectively. Fecal coliforms usually made up less than 2 percent of the total number.

The Red Wing sewage treatment effluent was monitored on ten occasions for Salmonella and enteric viruses. Positive results were obtained nine of the ten times. In all, seven species of Salmonella in addition to polio, Coxsackie, and ECHO viruses were isolated from the effluent which discharges to the river at UM 790.2. The river was also monitored on three occasions at a point 100 yards downstream from the outfall. Two of the samples were negative. The third one contained Salmonella infantis.

Biological Quality. Phytoplankton densities continued their decrease during passage through this segment after having reached a peak at UM 813.9 (1.3 miles below Lock & Dam No. 2). During the period from April to December, 1964 the Phytoplankton density at UM 790.6 (6.3 miles below Lock & Dam No. 3), averaged 18,590/ml. Just below the outlet of Lake Pepin (UM 760.2), the density averaged 12,490/ml during the same period.

Phytoplankton densities in many shallow areas along the shorelines of Lake Pepin, however, were very high. During the summer of 1965, a greenish algae bloom of pea soup consistency was observed in Lake Pepin at Stockholm, Wisconsin's bathing beach (UM 774.3). Rocks along the bathing beach were coated with a green slimy mass of algae cells. Decaying cells created a putrescible odor in the area and attracted hordes of flies. A water sample from this area revealed 12,511,000 blue-green algae/ml, with 12,487,000/ml being Aphanizomenon flos-aquae and 24,000/ml being Anabaena sp. During the summer of 1964, an algal bloom was observed at the Lake City Marina (UM 774.3). The water was colored pea-green and a thick green slime coated the boat hulls. These and other observations demonstrate that algae populations can and do become a problem in the lower part of the study area.

The chlorophyll-a content of the plant cells attached to artificial substrates showed that periphyton were about six times as abundant on those substrates in Lake Pepin as on those located elsewhere upstream. As mentioned previously, this increase was largely a response to the nutrient and organic load received from upstream sources.

Nutrient concentrations, although more than sufficient to support large numbers of algae, were somewhat lower in this segment. Inorganic nitrogen levels became progressively lower during passage downstream. The average concentration decreased from 0.70 mg/l at UM 794.5 (1.4 miles below Lock & Dam No. 3) to 0.54 mg/l at UM 764.7 (outlet of Lake Pepin). The orthophosphate level remained fairly constant throughout the entire segment, averaging 0.56 mg/l (as PO_4).

Bottom organisms found in the 10-mile reach between Lock & Dam No. 3 and the head of Lake Pepin were all pollution tolerant and ranged in density from 46 to 214 animals per square foot during the fall of 1964. Both the number of animals per square foot and the number of kinds of animals increased beyond this point. At UM 784.2 (the head of Lake Pepin) there was a maximum of 491 animals per square foot during this same period. Twenty kinds of animals were found at this station with clean-water-associated or pollution sensitive animals making up 20 percent of the total kinds. This marked the first reappearance of pollution sensitive organisms below the MSSD outfall.

Hay Creek, which enters the Mississippi River at UM 792.8, was grossly polluted, biologically, by wastes from Foot Tannery but had no significant effect on the river quality. Only 5 bottom-associated animals per square foot were found in Hay Creek 0.5 mile from its mouth and these were pollution tolerant sludgeworms and midges. Hay Creek bottom materials consisted of sand and organic sludge. Growths of sewage fungus were also commonly found along the creek edges.

Throughout Lake Pepin (between the UM 784.2 and UM 764.7) a gelatinous organic sludge bottom, sometimes mixed with natural organics and silt, supported a large mean total number of animals (318 to 903 per square foot during the fall of 1964) made up of from 16 to 20 kinds. Sludgeworm populations exceeded 100 per square foot at all stations in the lake. (Sludgeworm populations in excess of 100 per square foot are generally considered indicative of polluted conditions.) The highly tolerant Tendipes sp. midges (as many as 60 per square foot at UM 774.3), absent in upstream segments, were found in significant numbers throughout the lake. These populations of sludgeworms and midges indicate that Lake Pepin serves as a natural settling basin for silt and organic sludges carried in from upstream. Pollution sensitive animals, such as unionid clams, mayflies, caddis flies, and riffle beetles, represented less than 50 percent of the total kinds and were found only in the sandy shoreline areas. Even at the south end of Lake Pepin (UM 764.7), the total numbers and kinds of clean-water associated (pollution sensitive) animals were far fewer than in the reach between Anoka (UM 871.6) and the upper confluence of the Minnesota River (UM 845.5).

Game fish were present in far greater numbers in this segment than anywhere else in the study area. The Minnesota Department of Conservation reports that 68 percent of the fish population in Pool No. 4 are game fish. The average annual catches of all types of fish by sport and commercial fishermen in Pool No. 4 are approximately 73,000 and 2,500,000 pounds, respectively.

Flesh palatability tests were made on carp and walleyed pike caught at UM 794.5 (1.4 miles below Lock & Dam No. 3), UM 790.0, UM 785.4 (head of Lake Pepin), UM 774.3, and UM 764.7 (outlet of Lake Pepin). Carp were caught at all these stations while walleyed pike were caught only at UM 794.5, UM 774.3, and UM 764.7. Generally, the fish flesh palatability improved with distance downstream as far as UM 774.3. Below this point there was no significant further improvement. Carp caught at UM 774.3 received the highest rating (5.7) of all those tested from the entire study area. Those caught at UM 764.7 received the second highest rating (5.4). Walleyed pike caught at the three stations mentioned above were given ratings of 4.6, 4.9, and 5.0, respectively. Walleye caught on the St. Croix and Minnesota Rivers received still higher ratings (6.2 and 5.2, respectively).

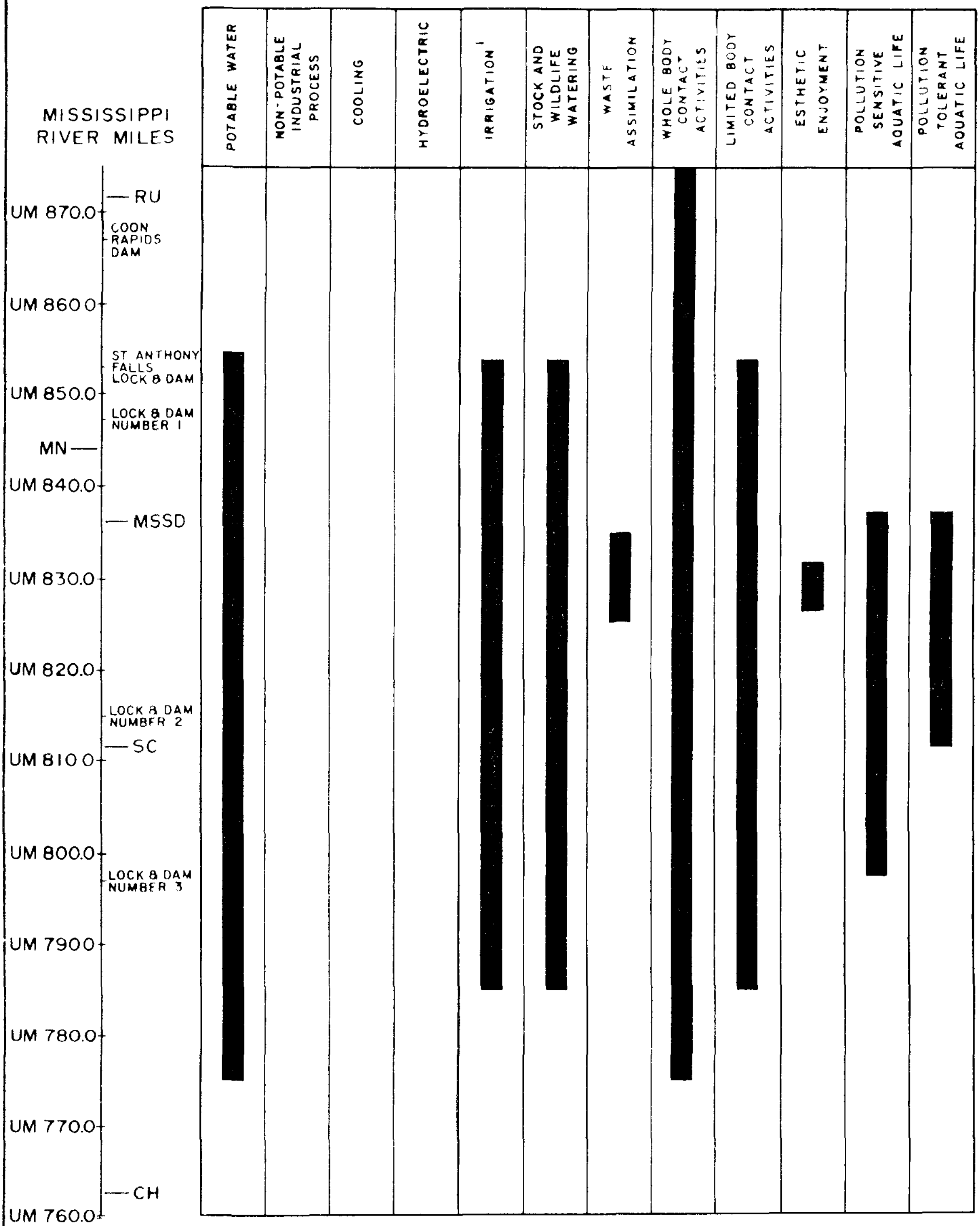
Effects on Water Uses. This segment of the Mississippi River is still within but near the end of a pollution recovery zone. The waters of the entire segment are suitable for the maintenance of pollution-sensitive as well as pollution-tolerant aquatic life, esthetic enjoyment, and as a source of cooling water. The reach below UM 785 (head of Lake Pepin) was suitable for limited body contact activities, stock and wildlife watering, and irrigation. The reach below UM 775 was also suitable for whole body contact recreational activities and as a source of potable water supply.

The practice of swimming and water skiing above UM 775 and sport and commercial fishing, pleasure boating, and navigation above UM 785 represents a health hazard.

Summary of Mississippi River Water Quality

Above the Minnesota River the Mississippi was unpolluted from a physical, chemical, and biological standpoint, but bacteriologically it was contaminated. The water quality in the 7.7-mile reach between the Minnesota River and the Minneapolis-St. Paul Sanitary District sewage treatment plant was degraded further at times by the Minnesota River. This usually occurred between November and February when the Minnesota River was most heavily polluted. The six-mile reach immediately below the Sanitary District plant was a zone of degradation and severely polluted in all respects. The zone of active decomposition encompassed the next 15 miles, down to Lock & Dam No. 2. The remainder of the river within the study area below Lock & Dam No. 2 (to the outlet of Lake Pepin) was in the pollution recovery zone.

Many water uses were affected to varying degrees over most of the length studied. The particular reaches unsuitable for each water use are illustrated in Figure V-16.



LEGEND

RU Rum River

MN Minnesota River

SC St. Croix River

CH Chippewa River

MSSD Minneapolis St Paul Sanitary District

■ Indicates where water was unsuitable for the designated use

[1] For use on crops not normally cooked before eaten.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WATER USES AFFECTED ALONG MISSISSIPPI RIVER JUNE 24 - OCTOBER 31, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-16

MINNESOTA RIVER QUALITY DURING 1964 AND 1965

General Flow and Water Quality Conditions

The pattern of variation of the Minnesota River's discharge rate is very similar to that of the Mississippi River. Flow is generally lowest in the December-February period and second lowest in the July-September period. Maximum flow usually occurs in April. This flow pattern is illustrated in Figure V-17 which gives the range of mean monthly discharges near Carver, Minnesota (MN 36.0) for the period 1940-1964.

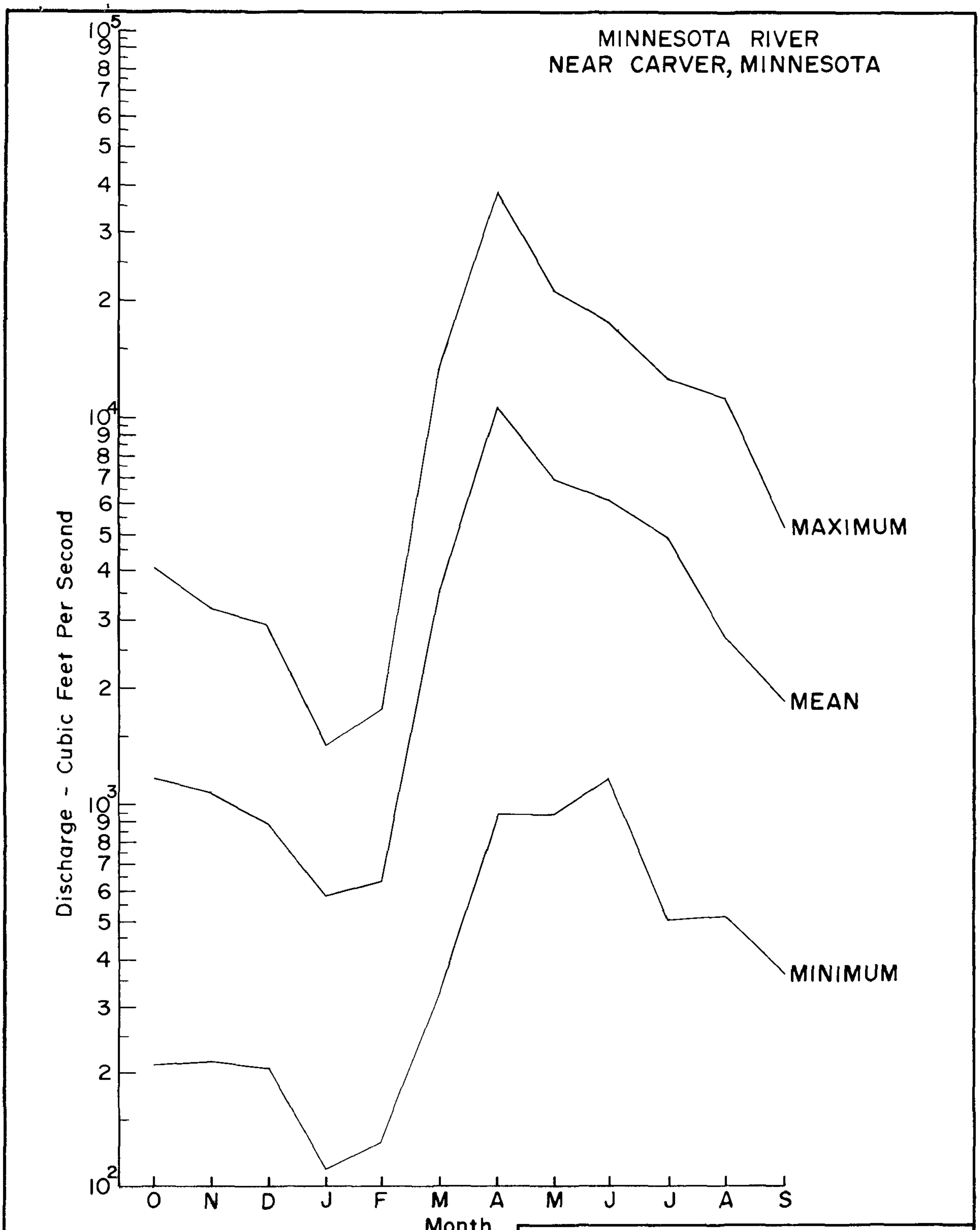
As with the Mississippi River, the two most critical periods with respect to pollution are December-February and July-September. Because of greater waste contributions by the American Crystal Sugar Company between November and February, the former period has been the more critical from a dissolved oxygen standpoint.

During the first phase of stream sampling, (June 2-November 3, 1964) the flow at Carver varied between 500 and 4,200 cfs, averaging 1,750 cfs. During the second and third phases, the flow at this location averaged approximately 399, and 960 cfs, respectively. Only samples collected at flows in the low (<1,000 cfs) and intermediate (1,000-5,000 cfs) ranges were considered to be representative of usual conditions. Minnesota River water quality was not evaluated during flows (at Carver) greater than 5,000 cfs.

Results of the routine sampling survey (first phase) are given in Figures V-18 through V-20. Figures V-21 through V-24 give results of the second and third phases. Biological survey results are given in Figures V-25 and V-26. These data are discussed below by river segments.

Minnesota River at Mankato

Water quality of the Minnesota River as it entered the study area



NOTES

MAXIMUM - MAXIMUM OF MEAN MONTHLY DISCHARGE

MEAN - MEAN OF MEAN MONTHLY DISCHARGE

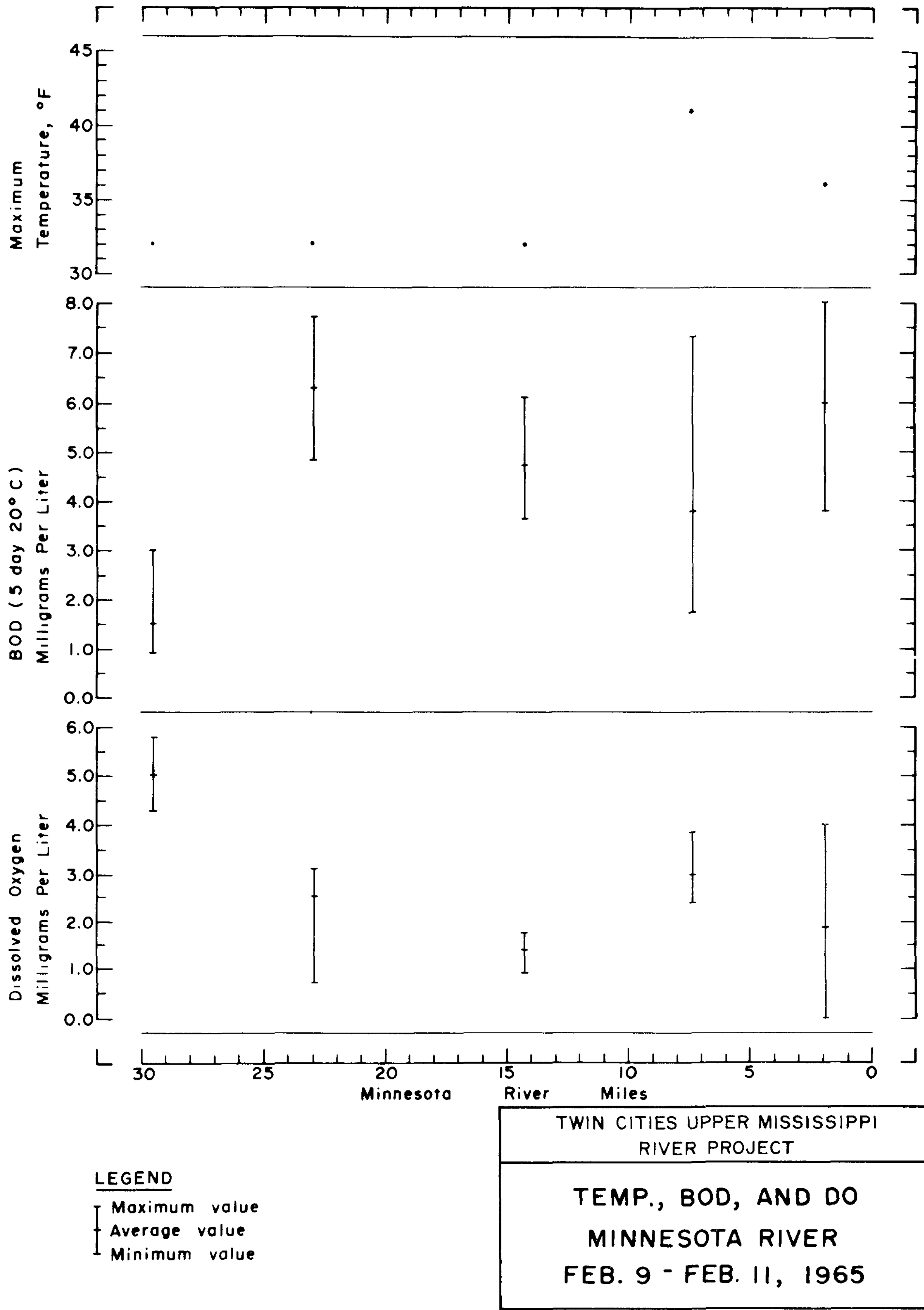
MINIMUM - MINIMUM OF MEAN MONTHLY DISCHARGE

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

RANGE OF MEAN MONTHLY DISCHARGES WATER YEARS 1940 - 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-17



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., BOD, AND DO
MINNESOTA RIVER
FEB. 9 - FEB. 11, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

GPO 828-545

FIGURE V-21

at MN 109.3 was generally good with the exception of bacterial content (see Table V-4). The water was high in DO, suspended solids, and phytoplankton, moderately high in BOD and coliforms, and relatively low in turbidity. There were no visible signs of pollution such as floating solids or liquids or excessive color. The rather high suspended solids content is probably a result of erosion and generally inadequate land management practices as opposed to the discharge of domestic or industrial wastes. With one exception, the total coliform density was always greater than 1,000 MPN/100 ml, indicating the water was not suitable for whole body contact activities. Coliform data collected by the Project in 1964 and 1965 and by the Minnesota Department of Health since 1957 indicate that the water entering the study area at this point is normally safe for limited body contact activities. Phytoplankton densities (31,690/ml) along with nutrient concentrations (inorganic nitrogen = 1.29 mg/l and orthophosphate = 0.23 mg/l as PO_4), were rather high as the river entered the study area.

Immediately below station MN 109.3, the Blue Earth River enters the Minnesota River with a flow of about one-half that of the Minnesota River. The water of the Blue Earth River just upstream from the Honeymead Products Company's point of discharge (BE 0.6) was of slightly higher quality than the Minnesota River at MN 109.3. The waste from Honeymead had little effect on the Blue Earth and Minnesota Rivers except for total coliform densities. In the Minnesota River it increased the density by an average of approximately 5,000 MPN/100 ml during the first phase of sampling. This resulted in an average total coliform density of approximately 10,000 MPN/100 ml in the reach between MN 109.2 and MN 106.5. The average DO and BOD in this 2.7 mile reach were 7.6 and 5.3 mg/l, respectively.

TABLE V-4

MINNESOTA RIVER WATER QUALITY ON ENTERING STUDY AREA IN 1964

(At Flows Less than 5,000 cfs)

PARAMETER	VALUES		
	MAXIMUM	AVERAGE	MINIMUM
pH	8.8	-	8.3
Temperature, °F.	82	-	-
Dissolved Oxygen (DO), mg/l	9.4	8.4	6.4
% DO Saturation	116	97	82
5-Day (20°C) BOD, mg/l	8.4	7.4	5.8
Total Suspended Solids, mg/l	205	110	62
Volatile Suspended Solids, mg/l	35	22	19
Turbidity, Jackson Units	80	-	<25
Organic Nitrogen, mg/l	1.89	1.72	1.57
Amonia Nitrogren, mg/l	0.55	0.45	0.33
Nitrate Nitrogen, mg/l	2.80	0.84	0.07
Orthophosphate (as PO_4), mg/l	0.43	0.23	0.00
Total Coliform, MPN/100 ml	14,100	5,000±	542
Fecal Coliform, MPN/100 ml	483	-	37
Phytoplankton (Monthly averages), No. /ml	63,240	31,690	6,120

Minnesota River - Mankato to Chaska

Chemical and Physical Quality. This segment of river receives three waste discharges within the first 1.3 miles. The Mankato sewage treatment plant and Blue Cross Rendering Company effluents and cooling water from the Wilmarth steam-electric generating plant are discharged at MN 106.5, MN 105.5, and MN 105.2, respectively. Except for an increase in the coliform density these discharges have very little effect on the water quality. The minimum DO measured during the first sampling phase at MN 103.6 was 6.4 mg/l, (79.5% of saturation). The maximum temperature recorded was 82.5°F. The total coliform density was highest at this station and ranged from 9,200 to 700,000 MPN/100 ml.

Only three other wastes were being discharged to the river above Chaska (MN 29.4) and they were less significant during 1964 than the four previously mentioned. During the summer of 1965, however, one of these three (the Green Giant Company) discharged all wastes directly to the river (at MN 75.4) for several months because of flood damages to their ridge and furrow irrigation fields which usually received a majority of the wastes. Abnormally high stream flows, coincident with the period of waste bypassing, prevented serious damage to water quality.

Except for a rather high turbidity and coliform density, the water in this 79.9-mile segment between Mankato and Chaska was of acceptable quality. The minimum DO measured anywhere in this reach during the first sampling phase was 5.7 mg/l. The DO and 5-day (20°C) BOD averaged 8.2 and 5.7 mg/l, respectively. The maximum temperature measured in 1964 was 84°F. Ammonia nitrogen levels ranged from <0.01 to 0.85 mg/l in this segment, averaging 0.36 mg/l. The turbidity generally ranged from 25 to 220 units in this segment. The higher values occurred during and immediately following periods of surface runoff. No one portion of this segment was consistently more turbid than another.

Bacteriological Quality. During the first sampling phase, the Mankato sewage treatment plant discharge increased the total coliform density in the river by approximately 89,000 MPN/100 ml (at point of maximum density). The Blue Cross Rendering Company produced an additional 1,000 MPN/100 ml increase. Dilution and bacterial die-off produced a steady reduction in the density with distance downstream. At MN 77.3, (Le Sueur), the coliform density averaged 8,000 MPN/100 ml. At MN 70.0 the City of Henderson discharge increased the density at this point by an estimated 5,000 MPN/100 ml. Further dilution and die-off accounted for the gradual decrease in density below this point to Chaska. At MN 49.4 (Belle Plaine), and MN 29.6 (Chaska), the total coliform density averaged approximately 6,000 MPN/100 ml.

Biological Quality. Phytoplankton densities at the one-foot depth were high throughout the entire segment, but were generally highest at MN 49.4 (Belle Plaine). Between April and December of 1964, the density at this station averaged 46,420/ml. Phytoplankton, during the same period, were least numerous at MN 74.7 (below Le Sueur), with the density averaging 27,580/ml. Even at these high densities, they produced no reported problems. Their presence in these numbers was generally obvious only upon microscopic examination, due partly to the natural turbidity of the water. At times, however, the water had a greenish color.

Nutrient concentrations were more than sufficient to support nuisance growths of algae (provided other conditions are suitable). Total inorganic nitrogen levels were highest just below Mankato (average of 1.33 mg/l) and decreased progressively downstream. At Chaska (MN 29.6) the inorganic nitrogen level averaged 0.69 mg/l. As expected, the organic nitrogen level increased progressively downstream along with the phytoplankton population. Orthophosphate levels were about the same over the entire reach, averaging about 0.29 mg/l (as PO_4).

Bottom organism populations were very sparse (generally less than 10 mean numbers per square foot) throughout the entire segment. This was due to the sand and gravel bottom which provided few areas for organisms to attach themselves. Spring floods also keep populations down through scouring of the sand and gravel bottom and thus creating an abrasive action which physically eliminates many of the organisms that would have otherwise survived. The only region of organic sludge deposition was below the Green Giant Company between MN 75.0 and MN 70.0.

Pollution sensitive animals were present at most of the stations in this 79.9 mile segment but generally accounted for less than 50 percent of the total kinds.

The Minnesota Department of Conservation reports that game fish make up less than 15 percent of the total fish population in this segment and were represented mainly by white bass and sauger. Channel and flathead catfish make up about 5 percent of the total. The rough fish were chiefly carp, quillback, northern redhorse, and sheepshead. Most of the fish inhabiting this segment are found in pools formed at the outside of the extremely sharp bends in the river. The shifting sand bottom, turbid waters, and extreme range of flows undoubtedly limit the development of a reasonable game fish population.

The palatability of fish caught at Mankato (MN 108.0) and Belle Plaine (MN 49.4) was also evaluated. Carp and walleye pike found in the vicinity of Mankato were given mean palatability ratings of 4.8 and 5.2, respectively, which placed them in the intermediate range of palatability.

Only carp were found at MN 49.4 and they were given a mean rating of 4.5. This placed them only slightly higher than carp caught at UM 830.3 below the MSSD and South St. Paul outfalls on the Mississippi River.

Effects on Water Uses. The water quality of the entire segment between June and October of 1964 was suitable for use as a source of cooling water, for esthetic enjoyment, and maintenance of pollution sensitive aquatic life. Although the water quality was satisfactory for both game and rough fish, the absence of bottom animals restricted the number that could be maintained in this segment.

The waters were unsuitable for irrigation, stock and wildlife watering, and limited body contact activities due to high coliform densities. The excessive turbidity of the water also interfered with its meeting the criteria for whole body contact activities or as a source of potable supply. As mentioned previously, most of the turbidity is a result of erosion of the river banks and inadequate land management practices in the drainage area. Stock watering, sport fishing, and pleasure boating were practiced although the water quality was considered unsuitable.

Minnesota River - Chaska to Mouth, Summer Conditions

Chemical and Physical Quality. This segment of the river, which receives far greater quantities of wastes than the previous one, is of lower quality. Its quality is lowest during late fall and winter while the American Crystal Sugar Company plant (located at MN 27.7) is in operation.

During the first sampling phase (when American Crystal Sugar Company plant was not operating) the DO at MN 27.5 averaged 9.1 mg/l. It decreased rather abruptly below MN 25.0 (at Shakopee), and continued to decrease with distance downstream reaching 6.6 mg/l at MN 1.9. At this point the range was from 3.1 to 10.7 mg/l. The minimum DO measured anywhere in the segment during this phase was 2.7 mg/l at MN 10.8.

Ammonia nitrogen levels ranged from <0.01 to 0.58 mg/l in this segment, both values occurring at MN 1.9. The average concentration over the whole reach was about 0.3 mg/l.

Turbidity levels in this reach were generally slightly higher than those found in the previous segment, especially near the lower end. The turbidity ranged from <25 to 240 units, averaging approximately 70 units near the upper end and 110 units at the lower end. The higher values occurred during and after periods of rainfall.

The maximum temperature recorded in this segment above the Blackdog steam-electric generating plant (MN 8.4) was 82°F. at MN 27.5. At MN 7.4, the first station located below the power plant, the maximum temperature measured at the four foot depth was 90°F. On this particular occasion the power plant was discharging cooling water directly to the river at MN 8.4 rather than to Blackdog Lake which serves as a cooling pond. The temperature immediately below the point of discharge was calculated to be approximately 100°F. By the time the flow reached MN 1.9 the temperature had dropped to 85.6°F.

Bacteriological Quality. The coliform density of the water entering this segment during the first sampling phase averaged about 6,700 MPN/100ml. Effluent from the Chaska sewage treatment plant, discharged at MN 29.4, increased the average density by about 15,000 MPN/100 ml. At MN 27.5 the density was found to range from 7,900 to 54,200 MPN/100 ml. Rahr Malting Company, located at MN 25.4, produced an increase of about 60,000 MPN/100 ml in the river coliform density. At MN 23.9 the Shakopee sewage treatment plant added enough coliforms to increase the density in the river by another 10,000 MPN/100 ml. At station MN 23.0, the coliform density ranged from 24,000 to 240,000 MPN/100 ml. These values were the highest found at any of the stations located in this 29.4 mile segment during the summer. Due to die-off and dilution, the coliform density decreased progressively with distance downstream. At MN 13.4, Cargill, Inc. added an amount sufficient to increase the density by 1,000 MPN/100 ml. By the time the flow reached MN 1.9 the coliform density ranged from 2,780 to 27,600 MPN/100 ml, averaging 13,700 MPN/100 ml.

Biological Quality. Phytoplankton densities were of the same magnitude as those found in the previous segment. The density decreased progressively from MN 25.1 (Shakopee) to MN 7.4 and then increased slightly beyond this point. At MN 25.1 and MN 7.4 the average densities for the period between April and December, 1964 were 38,640/ml and 21,850/ml, respectively. Densities at MN 1.9 were measured during July and September-November, only. The average density over these months was 38,870/ml, 125 percent of the average density at MN 7.4 over the same four-month period. Although the phytoplankton density was quite high over the entire segment, they created no nuisance conditions.

Nutrient levels were of the same magnitude in this segment as in the previous segment. Total inorganic nitrogen averaged from 1.72 to 2.01 mg/l over the reach and orthophosphate concentrations were about the same throughout, averaging 0.46 mg/l (as PO_4).

There was a general increase in the number of bottom organisms from MN 27.7 to the mouth. A wide range in total numbers per square foot was found over the 18-month period. Pollution tolerant sludgeworms comprised the largest portion of the benthic population with as many as 237 per square foot occurring at the mouth during the fall survey.

Pollution sensitive animals were even less abundant in this reach than in the upper one. The river bottom was composed of organic sludge and sand and the sludgeworm population increased markedly, as compared to the upper river reach. The deposition of solids is due to the lower stream velocities and larger solids loadings in this reach.

Until the 1930's the Minnesota River supported an abundant and diverse population of fresh water clams. During the bottom surveys, however, this rich and varied clam population was found to be markedly reduced. Only one living mussel was found (at MN 7.4) and clam shells were especially numerous between MN 16.8 and the mouth. Their demise can be attributed to such factors as heavy organic pollution and dredging of the barge channel. Only seven percent of the total fish population in this lower segment are game fish. They consist primarily of catfish and crappie.

Effects on Water Uses. The water during the summer of 1964 was suitable for use as cooling water, esthetic enjoyment, and pollution tolerant aquatic life. Above MN 25.0, it was also suitable for pollution sensitive aquatic life. In the 0.4-mile reach below the Blackdog power plant, however, the temperature sometimes exceeded 93°F., the maximum temperature adequate for pollution tolerant species.

High coliform densities made the waters unsuitable for irrigation, stock and wildlife watering, and any body contact activities, such as swimming or boating. These activities were practiced in this segment, however, and constitute a health hazard.

The minimum DO was too low below MN 25.0 and the maximum temperature too high between MN 8.4 and MN 3.0 for the waters to be suitable for pollution sensitive aquatic life. The game fish population was further limited by the small available food supply.

The waters are usually too turbid for use as a source of water supply or for whole body contact activities. It is doubtful that any measure short of lining the stream bed or constructing impoundments would be sufficient to maintain a turbidity of less than 25 units.

Minnesota River - Chaska to Mouth, Winter Conditions

Chemical and Physical Quality. An intensive survey (second sampling phase) of this lower segment of the river was conducted in February 1965 under conditions of ice cover while the American Crystal Sugar Company (located at MN 27.7) was in operation. The average stream flow during the survey was 399 cfs. The BOD loading rate contributed by this company was more than three times the loading rate contributed by all other sources on the Minnesota River below Mankato combined.

The DO level in the river was moderately low (35 percent of saturation) as it entered this segment because of ice cover which prevented reaeration. At MN 29.6 the DO averaged 5.0 mg/l. The 5-day (20°C) BOD at this station averaged 2.6 mg/l and the water temperature remained at 32°F. throughout the survey. The DO dropped progressively from the American Crystal Sugar Company's outfall to the vicinity of the Blackdog power plant where ice cover was absent. At MN 14.3 the DO ranged from 0.9 to 2.6 mg/l, averaging 1.4 mg/l. At MN 7.4, below the power plant, the DO ranged from 2.4 to 3.8 mg/l, averaging 3.0 mg/l. The water temperature at this point ranged from 36 to 41°F. Several miles below the power plant ice cover formed again, preventing further reaeration. At MN 1.9 the DO ranged from 0.0 to 4.0 mg/l, averaging 1.8 mg/l.

Ammonia nitrogen levels were about four times higher during the winter than in summer. Highest values were measured at MN 29.6 where the range was from 1.12 to 1.58 mg/l, averaging 1.37 mg/l. The average values found at MN 14.3 and MN 1.9 were 1.24 and 1.07 mg/l, respectively.

Bacteriological Quality. Coliform densities were also considerably higher during the winter survey below the American Crystal Sugar Company. Above their outfall, the total coliform density averaged 220 MPN/100 ml. The average density 4.7 miles below the outfall was 500,000 MPN/100 ml. At MN 1.9 (25.8 miles below the outfall) the average density was 9,600 MPN/100 ml. Fecal coliform made up 25 to 40 percent of the total numbers at these points.

Biological Quality. The reach of the river between MN 28.0 and the mouth was also sampled biologically during the winter of 1964-1965, several months after the American Crystal Sugar Company had been in operation that season. Above their waste discharge the sandy bottom supported 62 midges per square foot. Immediately downstream from the discharge and for almost 1,000 feet, organic sludge and parts of whole sugar beets were found. At MN 27.7 (point of discharge) there were only 3 sludgeworms per square foot and 4.7 miles below this point, only one per square foot was found. At MN 16.8 the animal numbers, primarily represented by sludgeworms, were 33 per square foot and increased progressively to a maximum of 487 per square foot at MN 7.4. The total numbers then dropped to 150 per square foot at MN 1.9. During this winter period the stream velocities were low enough to allow suspended solids to settle out in significant quantities anywhere below MN 49.4. The data indicate that organics from American Crystal Sugar Company wastes and other sources were, in fact, deposited in this lower reach.

Artificial substrates were placed in the river for about two months above and below the American Crystal Sugar Company and removed one week after the company began processing in the fall of 1965. A large number of clean-water associated (pollution sensitive) organisms were recovered from the substrates suspended at MN 29.1, MN 16.8, and MN 0.3. Five to twelve kinds of animals were found with over 50 percent of them being of the pollution sensitive type. These results contrasted sharply with the seasonal bottom survey results, suggesting that the factor limiting river biota in the lower reach is a lack of suitable natural habitats rather than the chemical quality.

There was a 90 percent reduction in the total numbers of organisms on the substrates suspended at MN 27.7 (immediately below the American Crystal Sugar Company outfall) as compared to the other three stations and only three kinds of animals were found. Growths of sewage fungus were found on the substrates at this station only.

Effects on Water Uses. During the winter survey this segment was suitable only for use as cooling water.

Low dissolved oxygen and high coliform levels made it unsuitable for other uses.

The low DO levels throughout this segment, due in part to ice cover, made the waters unsuitable for even the pollution tolerant species of fish. The MSSD personnel sited from 75 to 100 dead bass along the shore near MN 1.9 on January 30, 1964 when the DO level was zero. On February 20, 1964 they counted a dozen more dead fish (carp and bass) in this same area.

Summary of Minnesota River Water Quality

The lower 109 miles of the Minnesota River was rather turbid ($<$25 to 250 units) and during the summer had a coliform density in excess of 5,000 MPN/100 ml. The minimum DO level with no ice cover was in excess of 5 mg/l everywhere except in the lower 25 miles where it was greater than 3.0 mg/l. The ammonia nitrogen level was less than 0.8 mg/l during the summer over the entire length. The maximum temperature was less than 86°F everywhere except in the reach between MN 8.4 and MN 3.0.

During periods of ice cover, the DO level in the lower 25 miles became critically low. Ammonia nitrogen levels were also higher in this reach (<1.6 mg/l).

Phytoplankton densities in the Minnesota River, although more than double the densities found in the Mississippi River, created no reported problems.

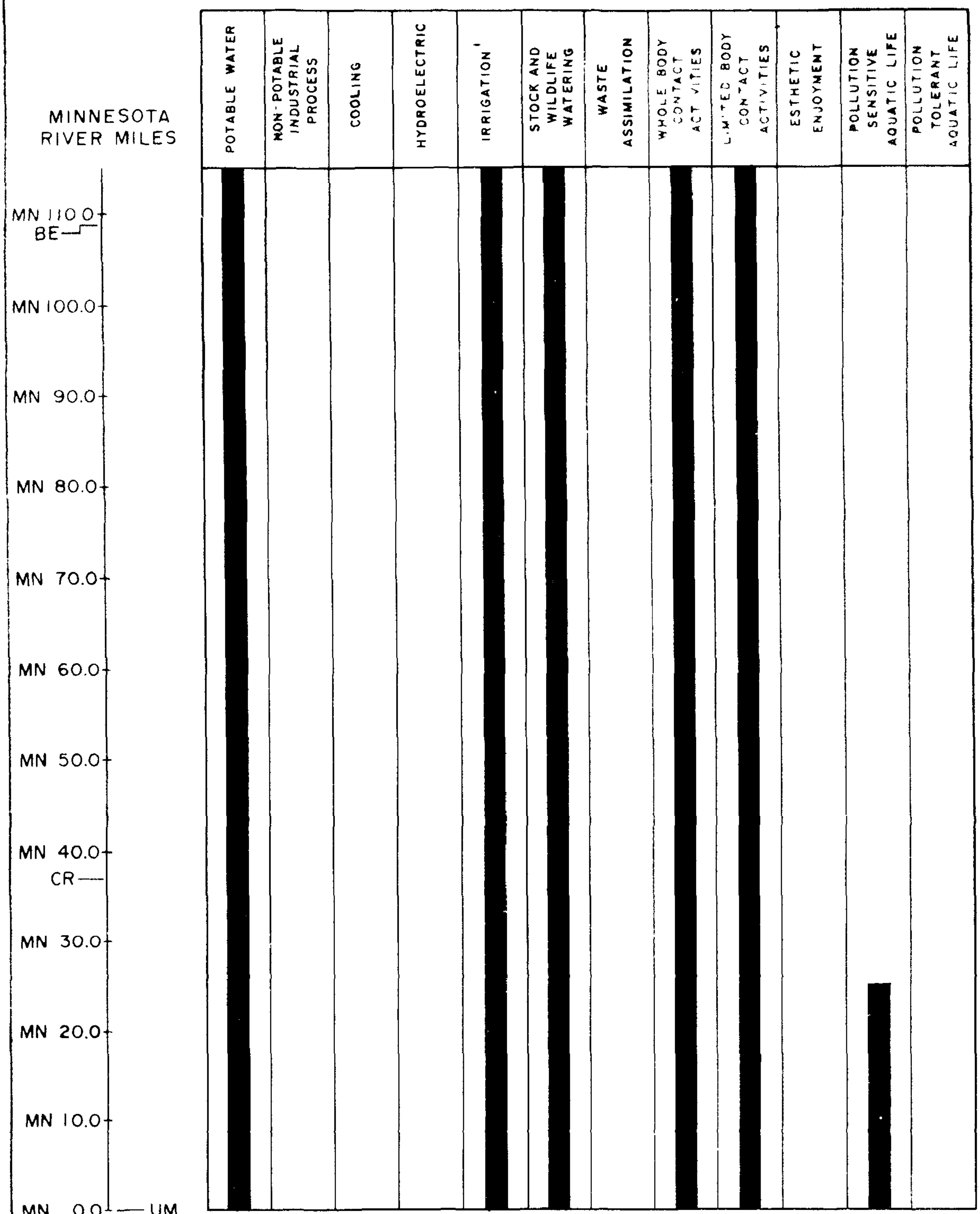
Bottom life was practically nonexistent in the segment between Mankato and Chaska because of the sand and gravel riverbed. Below Chaska (MN 27.7) the riverbed consisted of a mixture of sludge and sand which supported mainly sludgeworm populations with very few additional numbers and kinds of other animals.

The bacteriological quality of the entire segment under consideration made the water unsafe for irrigation of crops not ordinarily cooked, stock and wildlife watering, and body contact activities, such as swimming, boating, fishing, and commercial shipping (see Figure V-27). During periods of ice cover the lower 28 miles or so also became unsuitable for the maintenance of fish because of low dissolved oxygen levels. The values of other parameters were such as to pose no problem with present water uses.

ST. CROIX RIVER WATER QUALITY DURING 1964 AND 1965

General Flow and Water Quality Conditions

The pattern of variation of the St. Croix River's discharge rate is very similar to that of the Mississippi and Minnesota Rivers. Flow is generally lowest in the December-February period and second lowest in the



LEGEND

BE Blue Earth River

CR Carver Rapids

UM Mississippi River

■ Indicates where water was unsuitable for the designated use

1. For use on crops not normally cooked before eaten

NOTE: During winter, the lower 29 miles were suitable for use as cooling water and esthetic enjoyment, only.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WATER USES AFFECTED ALONG MINNESOTA RIVER

JUNE 2 - NOVEMBER 3, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-27

July-September period. Maximum flow usually occurs in April. This flow pattern is illustrated in Figure V-28 which gives the range of mean monthly discharges near Stillwater, Minnesota (SC 23.3) for the period 1940-1964.

The river is a free flowing stream between St. Croix Falls (SC 52.5) and Stillwater (SC 23.3) with three domestic waste discharges and one significant tributary, the Apple River. Below Stillwater the river is known as Lake St. Croix and is part of the pool formed by Lock and Dam No. 3 on the Mississippi River. Lake St. Croix receives wastes from three municipalities and two industries.

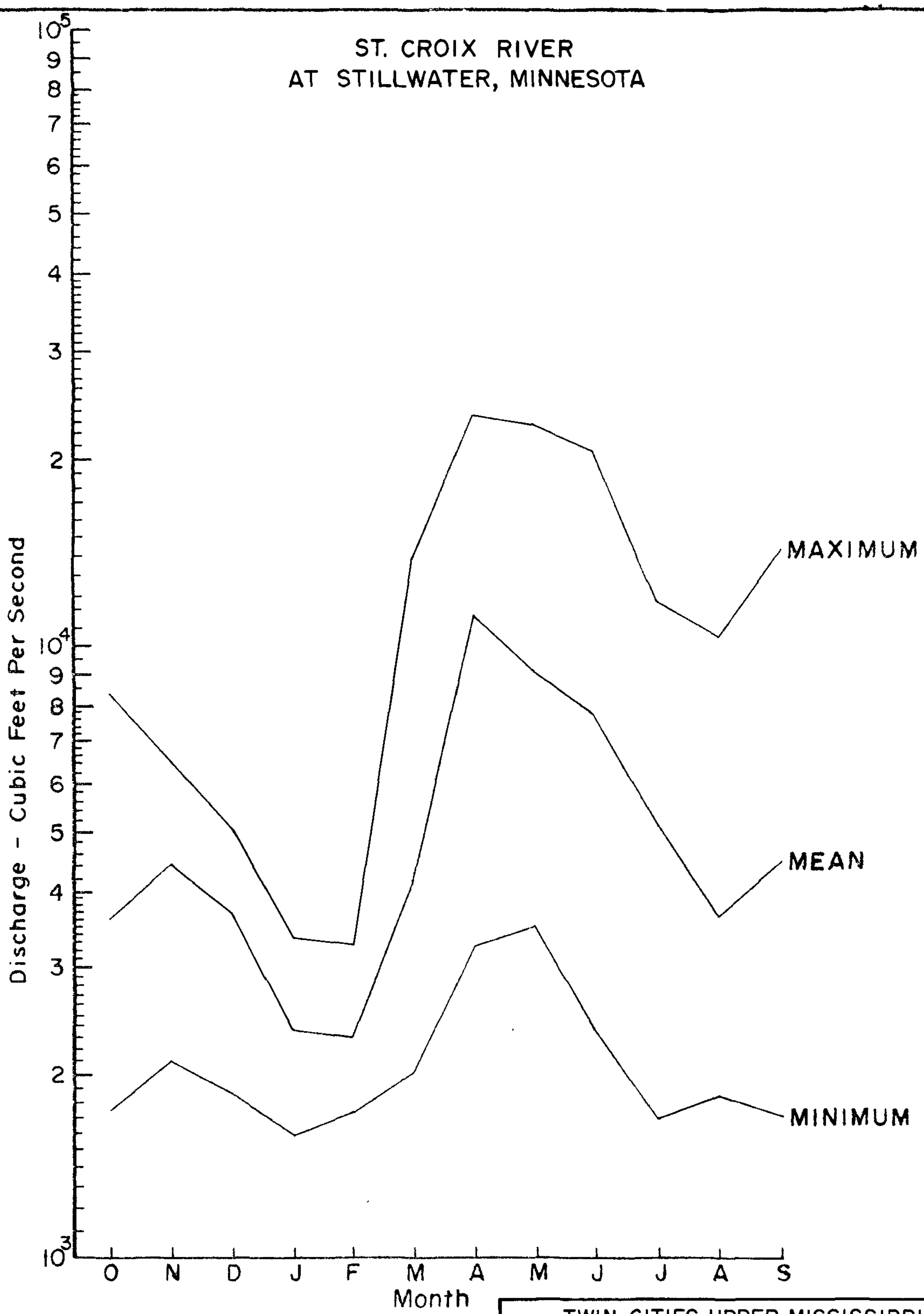
Stations along the 52-mile segment were sampled periodically between July 23 and September 21, 1964 and on a daily basis over the September 8-16, 1965 period. The station located nearest the mouth (SC 1.0) was sampled periodically from June 24, 1964 to October 28, 1964 and on a bi-hourly basis between February 24 and 26, 1965. This station was also monitored during the third sampling phase of the Mississippi River survey.

During the July 23-September 21, 1964 period the flow at Stillwater varied from 1520 to 6202 cfs, averaging 2600 cfs. The flow at this point averaged 2370 cfs during the nine-consecutive day survey in 1965. Water quality was not evaluated at flows in the high range (>6,000 cfs at St. Croix Falls). Only samples collected in the low (less than 1,000 cfs) and intermediate (1,000-6,000 cfs) ranges were considered to be representative of usual conditions.

Survey results are given in Figures V-29 through V-35. These data are discussed below by river segments.

St. Croix River at Taylors Falls

Water quality of the St. Croix River as it entered the study area



NOTE

MAXIMUM – MAXIMUM OF MEAN MONTHLY DISCHARGE

MEAN – MEAN OF MEAN MONTHLY DISCHARGE

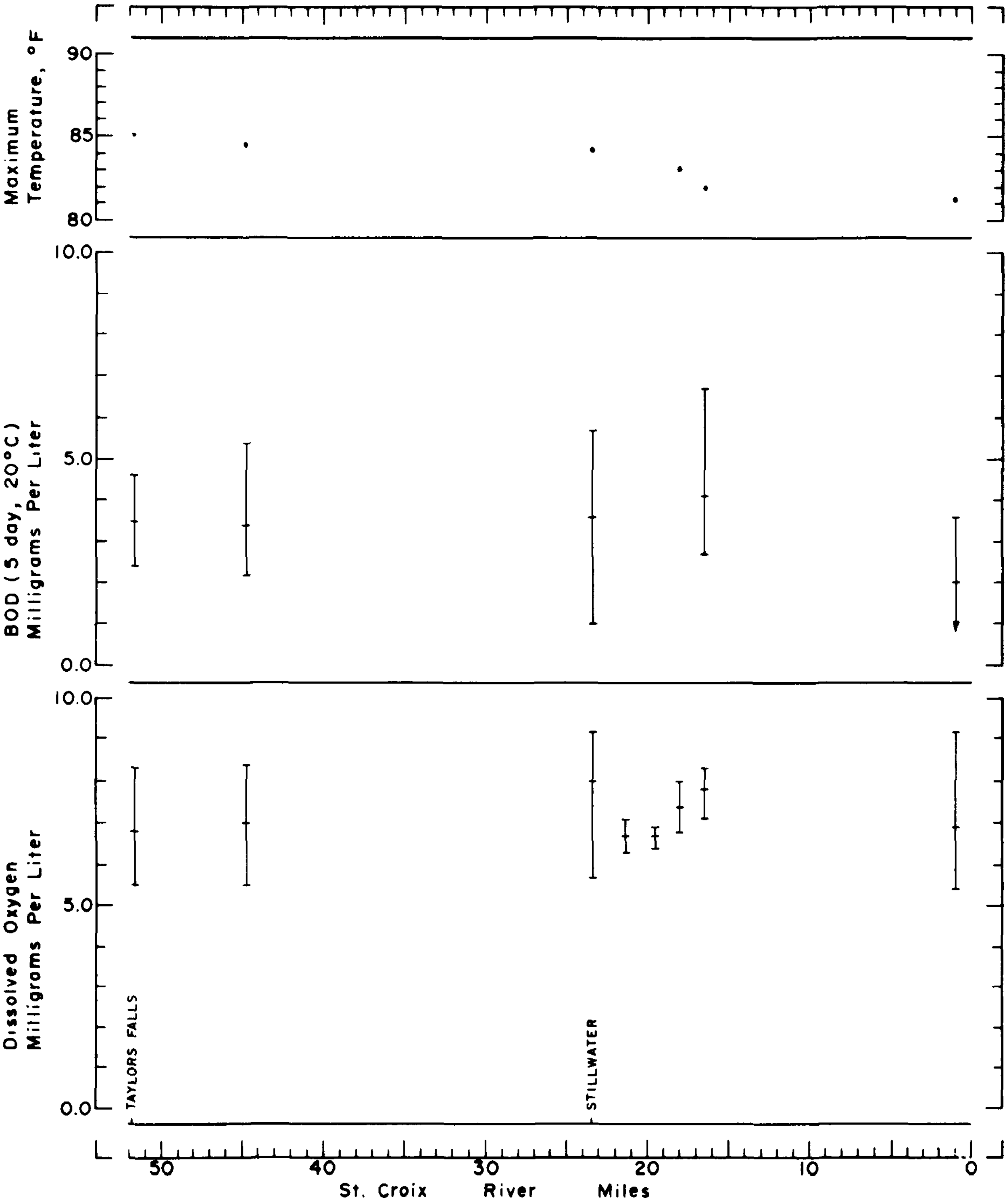
MINIMUM – MINIMUM OF MEAN MONTHLY DISCHARGE

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

RANGE OF MEAN MONTHLY DISCHARGES WATER YEARS 1940 - 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE **V-28**



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

LEGEND

- Maximum value
- Average value
- Minimum value
- Less than value

TEMP., BOD, AND DO
ST. CROIX RIVER
JUNE-OCTOBER, 1964

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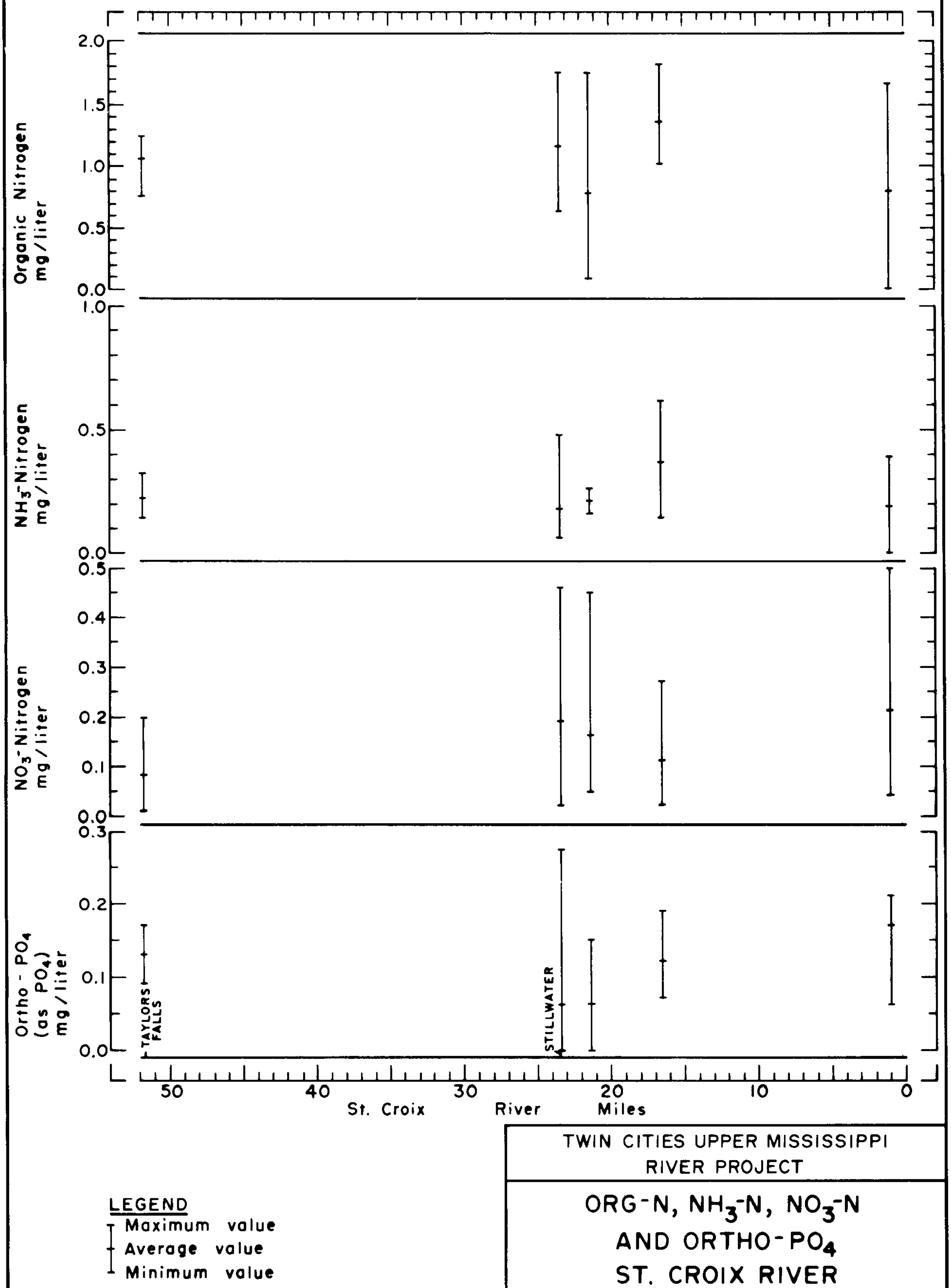
FIGURE V-29



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

ORG-N, NH_3-N, NO_3-N AND ORTHO-PO_4 ST. CROIX RIVER JUNE - OCTOBER, 1964

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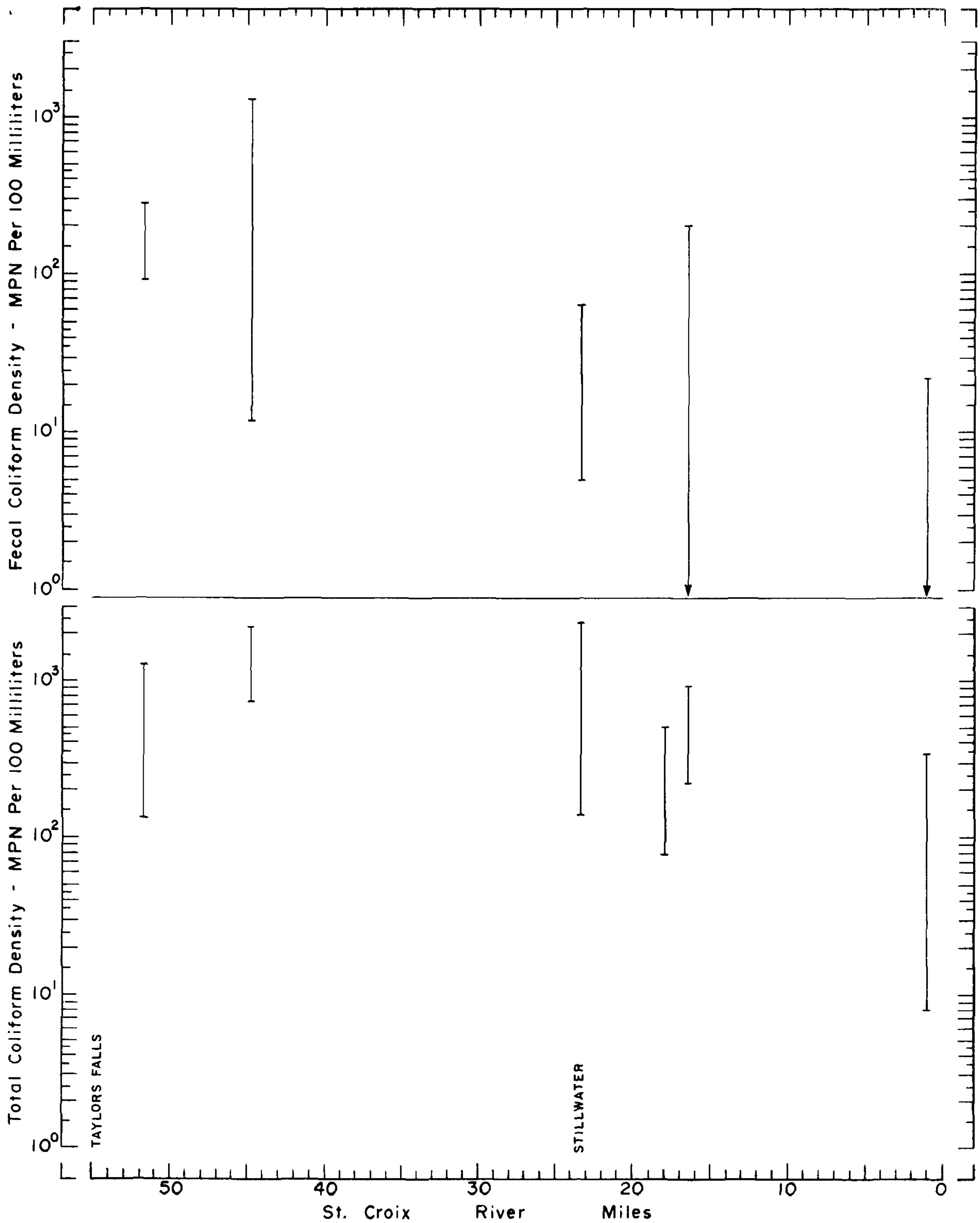
FIGURE V-30



LEGEND

- Maximum value
- Minimum value
- Less than value

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TOTAL AND FECAL COLIFORM DENSITY ST. CROIX RIVER JUNE-OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
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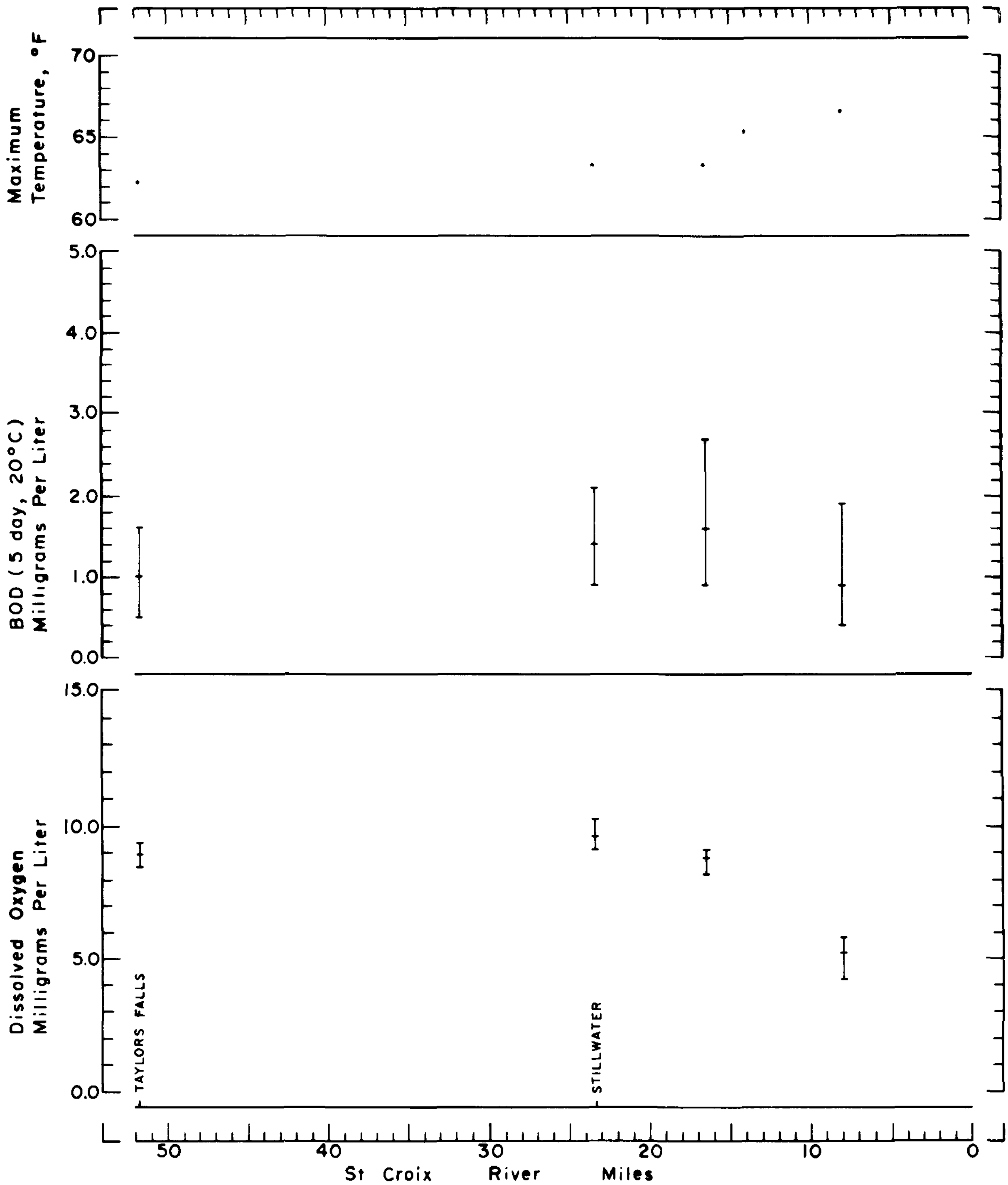
FIGURE V-31



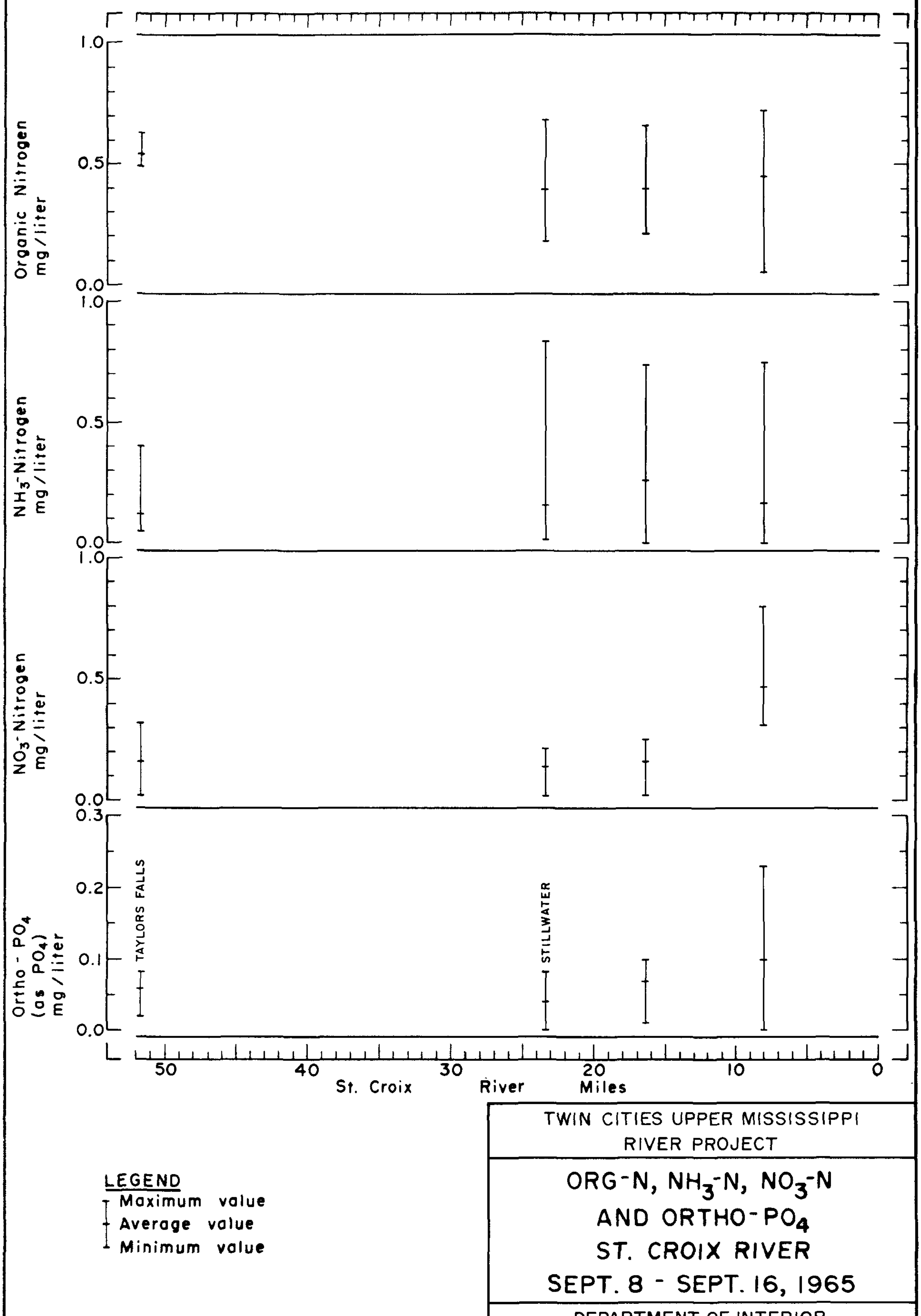
LEGEND
Maximum value
Average value
Minimum value

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., BOD, AND DO
ST. CROIX RIVER
SEPT. 8-SEPT. 16, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-32

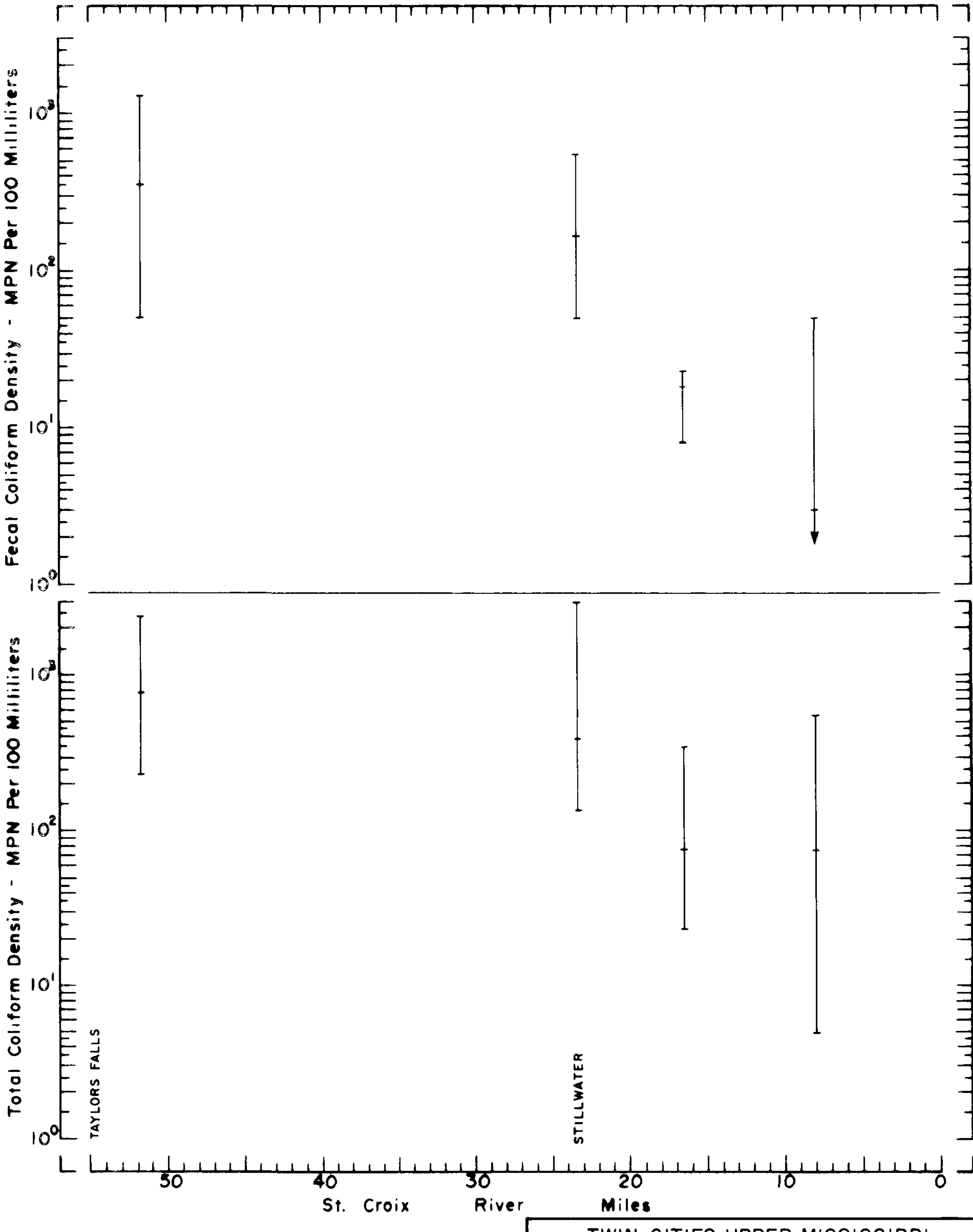


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

ORG-N, NH_3-N, NO_3-N AND ORTHO-PO_4
ST. CROIX RIVER
SEPT. 8 - SEPT. 16, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-33



LEGEND

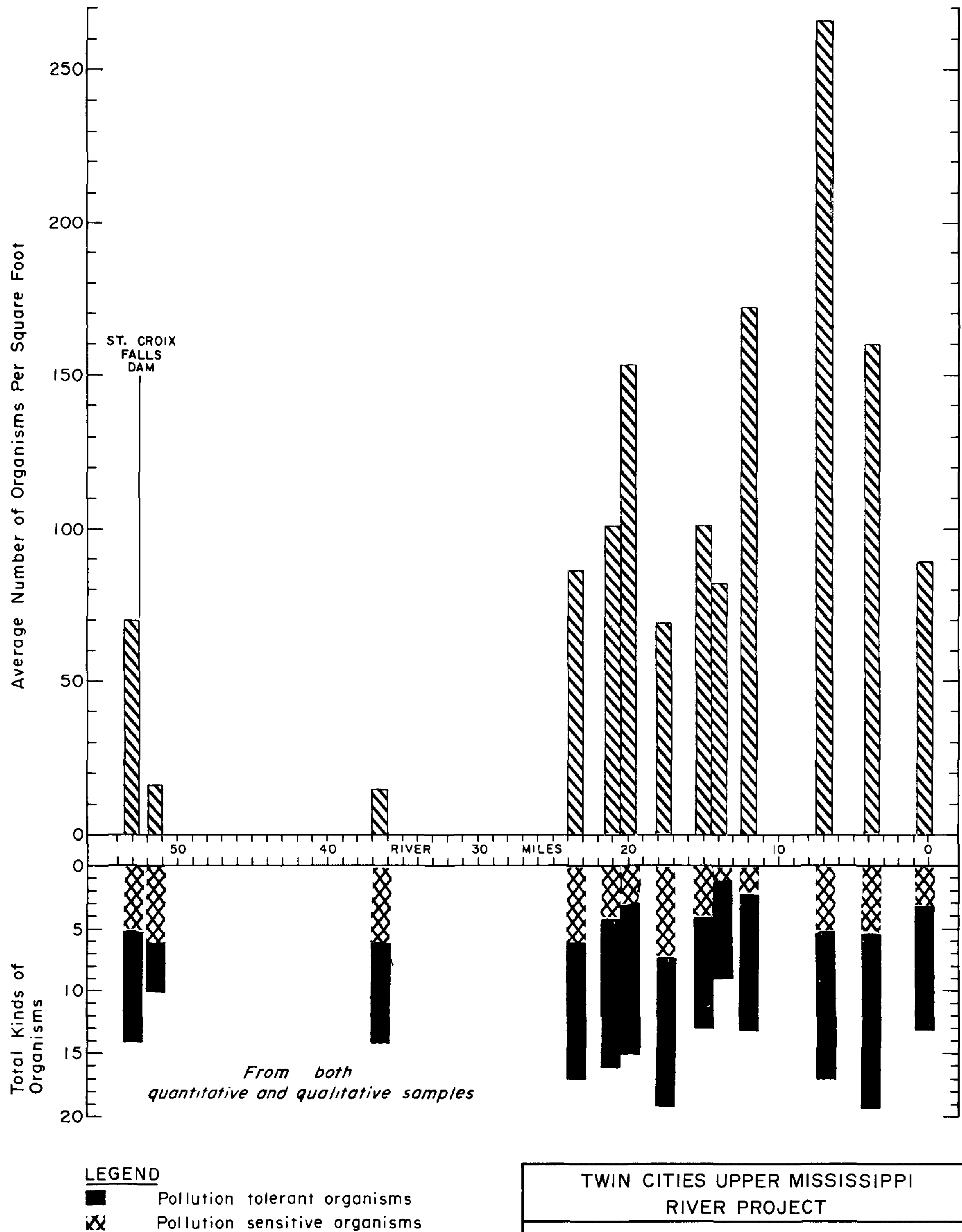
- Maximum value
- Average value
- Minimum value
- Less than value

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TOTAL AND FECAL COLIFORM DENSITY ST. CROIX RIVER SEPT 8 - SEPT. 16, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-34



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

BOTTOM ORGANISM DATA
ST. CROIX RIVER
1964

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REGION V CHICAGO, ILLINOIS

FIGURE V-35

at Taylors Falls during 1964 and 1965 was good. The water was high in DO, low in BOD, turbidity, and coliforms and there were no visible signs of pollution such as floating solids or liquids or excessive unnatural color. The water quality remained essentially unchanged between this point and Stillwater, 27 miles downstream.

St. Croix River - Taylors Falls to Stillwater

Chemical and Physical Quality. The waters of this segment were found to be of good quality. The minimum DO during the summer of 1964 was 5.5 mg/l; (62 percent of saturation) the average DO was 7.3 mg/l. The 5-day (20°C) BOD averaged 3.5 mg/l. The maximum temperature measured was 85°F. Ammonia nitrogen levels ranged from 0.06 to 0.48 mg/l, averaging 0.20 mg/l.

Although the turbidity was always low (<25 units) the water had a rusty color, apparently caused by the leaching of natural pigments from bog areas further upstream.

The organic and nutrient loadings received from the Taylors Falls, St. Croix Falls, and Osceola sewage treatment plants were too small to be detected in the river.

Bacteriological Quality. The coliform density at SC 51.8 during the summer was low, ranging from 130 to 1300 MPN/100 ml. It was slightly higher at SC 44.8, ranging from 400 to 2210 MPN/100 ml. At Stillwater (SC 23.3) the density ranged from 300 to 2,400 MPN/100 ml, averaging about 1,000 MPN/100 ml. Fecal coliform made up approximately 10-30 percent of the total at SC 51.3, 1-60 percent of the total at SC 44.8, and 1-17 percent of the total at SC 23.3. The density of fecal streptococci was also determined on several occasions at SC 23.3 and found to range between 5 and 92 per 100 ml. Total coliform densities during the nine-consecutive day survey in 1965 were lower, averaging 350 and 165 MPN/100 ml at SC 51.8 and SC 23.3, respectively.

Biological Quality. Algae populations did not approach nuisance levels in this segment even though nutrient concentrations were sufficient to allow it (provided other conditions were also suitable). Total inorganic nitrogen and orthophosphate concentrations averaged 0.32 and 0.09 mg/1, respectively, during the summer of 1964. Similar levels were also found during the nine-consecutive day survey conducted in 1965.

The stream bed of this segment is composed of sand, gravel, rocks, and boulders which supported a wide variety of animals including pollution sensitive stoneflies, mayflies, caddis flies, and unionid clams. Small numbers of pollution tolerant midges and sludgeworms were also present.

No quantitative information was available on relative proportions of game and rough fish in this segment. However, field observations by staff of the Project and the Minnesota Department of Conservation lend evidence of a substantial sports fishery in this segment.

Effects on Water Uses. The waters were suitable for all uses, although occasionally the bacteriological quality of the water in the vicinity of Osceola, Wisconsin (SC 44.8) became marginal for whole body contact activities.

St. Croix River - Stillwater to Mouth

Chemical and Physical Quality. This segment, known as Lake St. Croix, is more characteristic of a lake than a river. At flows under 6,000 cfs the mean velocity is less than 0.2 ft/sec and the mean depth is 31 feet. At low and intermediate flows the volume of water in this segment is constant, regardless of the flow rate because of Lock and Dam

No. 3. The wastes discharged into this large volume of water by the three communities and two industries along its banks produce no detectable change in the water quality.

During the summer of 1964 the DO ranged from 5.7 to 8.9 mg/l at the upper end (SC 23.3) and from 5.1 to 9.2 mg/l at the lower end (SC 1.0). The minimum DO measured in the winter at SC 1.0 was 8.8 mg/l. This wide fluctuation in DO during the summer was caused by algal activity rather than by a varying pollution loading. The average BOD ranged from 3.5 mg/l at the upper end to 2.0 mg/l at the lower end. The maximum temperature measured in this reach was 84°F. Ammonia nitrogen levels ranged from 0.04 to 0.64 mg/l, averaging 0.26 mg/l.

The turbidity of this segment, like the one above, was always less than 25 units. The water also possessed the same natural rusty color as in the upper segment.

Bacteriological Quality. The coliform density in the entire segment was low, ranging from 8 to 920 MPN/100 ml during the summer. During the nine-consecutive day survey in 1965, the density in this segment ranged from <2 to 49 MPN/100 ml.

Biological Quality. As in the upper segment the nutrient concentration was more than sufficient to produce nuisance blooms of algae. The total inorganic nitrogen and orthophosphate concentrations averaged 0.40 and 0.11 mg/l, respectively. During 1964 algal densities were high enough along the shoreline at several locations to produce a very greenish cast to the water. Dense growths of the alga *Cladopora* sp. covered the rocks along most of the shoreline. An algal bloom was observed on August 13, 1965 in the reach from SC 15.0 to SC 6.5. The predominant species were the blue-green algae, *Aphanizomenon flos aquae* and Anabaena sp. The total algae densities at SC 14.0 and SC 8.0 out in midstream were 4,188 and 1,194 per ml, respectively. Another algal bloom consisting primarily of Anacystis sp. (a blue-green algae), was observed during the same period along the western shoreline of Lake St. Croix near SC 0.3. The algal cells covered shoreline rocks with a green slime.

The bottom survey verified what was indicated by the extremely low velocity of flow; that Lake St. Croix is a settling basin for organics and other materials carried in from upstream. Bottom materials were composed of sand, natural organics such as decaying leaves and plant fragments, and organic sludges. Further indication of organic accumulations was the presence of significant sludgeworm populations. These populations were low during the summer of 1964, ranging from an average of 12 per square foot at SC 12.0 to 122 per square foot at SC 3.8. The latter station was the only one where the density exceeded 100 per square foot. These densities increased to a maximum at SC 7.0 of 296 and 289 per square foot during the fall and winter, respectively, with a general increase to greater than 100 per square foot at the other stations sampled. Where samples were collected at depths greater than 15 feet, invariably there was an association of Tendipes sp. midges, phantom midges, and sludgeworms which are typical of eutrophic ("food rich") lakes. In the shallows (<5 feet deep) where qualitative samples were collected, a typical association of animals was found which included both the clean-water associated mayflies, caddis flies, unionid clams, and pollution tolerant snails, dragon flies, damsel flies, scuds, sow bugs, leaches, midges and sludgeworms.

Based on the benthic and nutrient data, this lake reach of the river is unpolluted with a strong eutrophic tendency. Surface runoff from agricultural lands and natural sources contributes the majority of the nutrients and organic materials that maintain the fertility of the lake.

The fact that a large and varied fish population is maintained in this segment is evidenced by the considerable amount of commercial and sports fishing that is practiced each year in this reach. A yearly average of 369,225 pounds of rough fish (including catfish) was obtained by commercial fishermen during the years from 1958 through 1962. This amounted to about 45 pounds of fish per acre per year. During the same period the annual commercial catch in Lake Pepin averaged 58 pounds per acre.

The flesh of fish caught near Bayport, Minnesota (SC 20.0) was evaluated in the fish palatability test mentioned previously. Carp, smallmouth bass, and walleye pike received mean palatability ratings of 5.1, 6.0, and 6.2, respectively, which were among the highest ratings received by any of the fish evaluated from the entire study area.

Effects on Water Uses. The waters were suitable for all uses being practiced in this segment. In certain areas along the shoreline, however, excessive algal growths in the summers threatened the esthetic quality of the water. This condition can only be reduced or eliminated through more effective land management practices which would reduce the amount of nutrients reaching the stream.

Summary of St. Croix River Quality

The lower 52 miles of the St. Croix River was found to be unpolluted and suitable for all water uses practiced along it. The minimum DO measured was 5.1 mg/l; the maximum temperature was 85°F. Average coliform densities were less than 1,000 MPN/100 ml. Bottom organism data, nutrient data, and observed algal blooms indicate, however, that Lake St. Croix is eutrophic.

No water uses presently in practice along the length of the river studied were adversely affected by the water quality except, possibly, for the esthetic quality in those shoreline areas where algal blooms occurred.

EFFECTS OF PRESENT WASTE LOADINGS ON WATER QUALITY AT LOW STREAM FLOWS

General

The effect that a given waste loading has on stream quality depends upon the flow in the stream. At low flows there is less dilution and hence the effect is more severe. As a minimum requirement waste loadings should not exceed an amount that will affect water uses during the 7-consecutive day once in ten-year summer or winter low flow, whichever is the more critical.

The summer (July - September) and winter (December - February) 7-consecutive day low flows with a recurrence interval of 10 years were determined for several gaging stations using data collected by the U.S. Geological Survey between 1940 and 1964. These values, given in Table V-5, are used in the following evaluations which determine the water quality that can be expected at low flows with the waste loadings found during the Project's Survey.

Mississippi River

Dissolved Oxygen. At the 7-consecutive day, once in 10-year low summer flow the DO level will remain essentially the same over the reach between Anoka and the MSSD outfall. Below this point it will drop from

TABLE V-5

7-CONSECUTIVE DAY LOW FLOWS EXPECTED ONCE IN 10 YEARS*

STATION	STREAM FLOW, CFS	
	SUMMER	WINTER
UM 847.6 (Lock & Dam No. 1)	1,700	1,470
UM 839.4 (St. Paul)	1,950	1,900
UM 796.9 (Lock & Dam No. 3)	4,200	4,250
MN 36.0 (Carver)	320	180
SC 23.3 (Stillwater)	1,570	1,650

*Calculated from USGS data collected during water years 1940-1964, inclusive.

about 7.0 mg/l just above the outfall to 0.0 mg/l near UM 835.0 (1.3 miles below the MSSD outfall) and remain at this level on downstream to Lock and Dam No. 2. From this point on, the stream will recover, reaching 3.0 mg/l or more after passage over Lock and Dam No. 2 at UM 815.2 and reaching 5.0 mg/l at the confluence of the St. Croix River at U M 811.3 (provided the Taintor gates at Lock and Dam No. 2 are bulkheaded). Thus at the summer low flow the existing waste loadings will lower the DO level below 5 mg/l in a 25-mile segment and below 3 mg/l in a 21-mile segment (See Figure V-36).

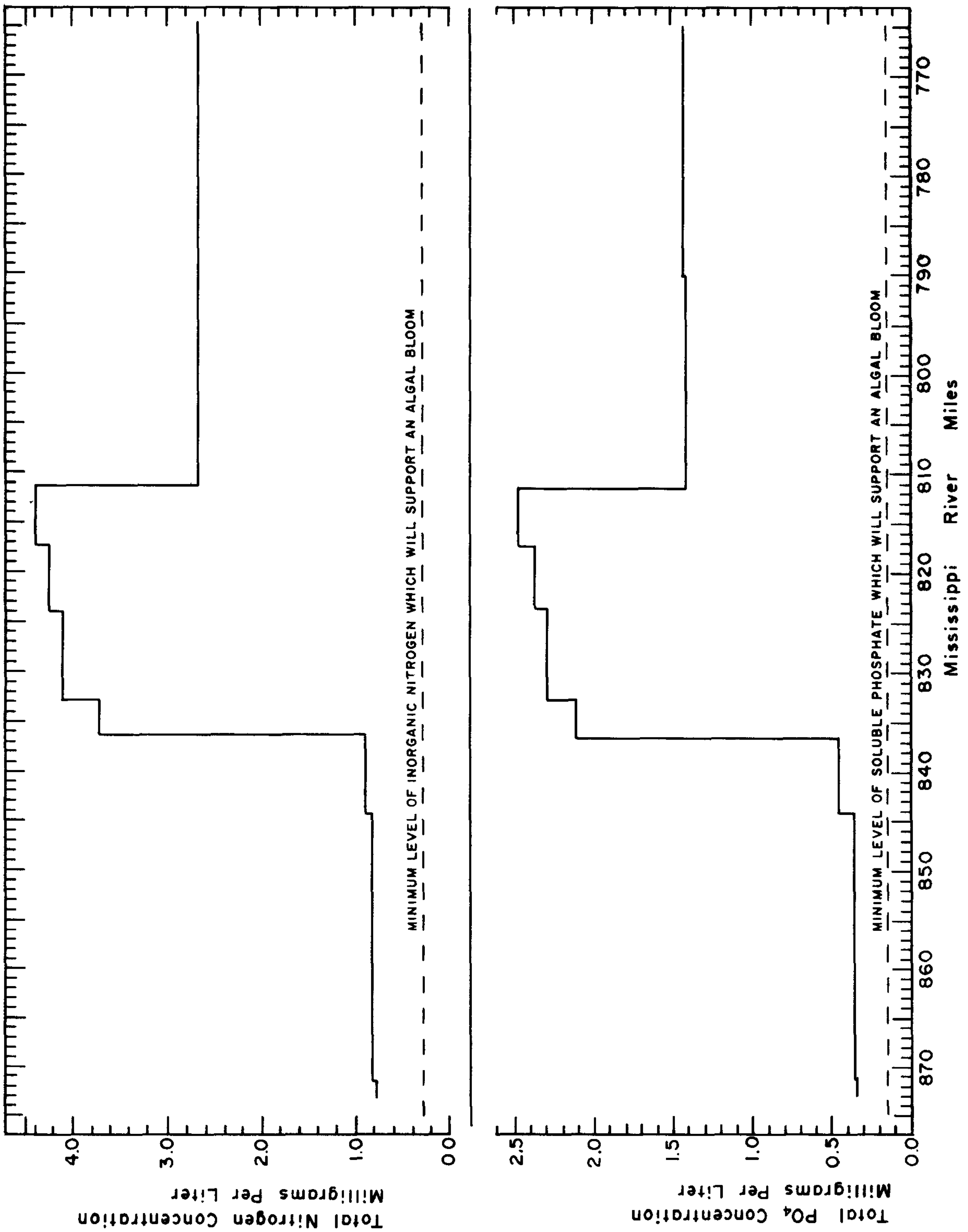
During the winter low flow of similar frequency, the DO level will remain essentially the same as far downstream as the Minnesota River. It will drop slightly at this point as a result of the comparatively low DO level of the water entering from the Minnesota River. Near the High Bridge power plant open water will permit reaeration with an accompanying increase in DO. A little father downstream the waste contributions by the MSSD and South St. Paul sewage treatment plants will cause the DO level to decrease steadily, reaching a low of zero about 3.5 miles above Lock and Dam No. 2. This decrease in DO with distance downstream occurs at a much lower rate in the winter than summer because the winter deoxygenation rate is less than 10 percent of the summer rate. Even though the deoxygenation rate is low it is very significant because of the restricted reaeration due to ice cover.

The DO level will increase to at least 3 mg/l as the water is reaerated during its passage over Lock & Dam No. 2 (provided the Taintor gates are bulkheaded). Four miles father downstream the St. Croix River, with its high quality water, will serve to increase the DO level still more, to greater than 5 mg/l. Thus at low stream flows approximately the same segment of river is affected in summer as in winter. The effect on DO, however, is more widespread in the summer.

Nutrients (Summer Conditions). The nutrients of primary concern are inorganic nitrogen and soluble phosphorus. Total nitrogen and phosphorus are considered here, however, since most if not all of the total nitrogen and phosphorus found entering the water of the study area will eventually be transformed to the inorganic and soluble forms, respectively.

During the Project survey, total nitrogen and phosphorus concentrations in the waters entering the study area were generally about the same, regardless of stream flow rates. This indicates that a predominant amount of the nitrogen and phosphorus loadings accompanied surface runoff. For this reason the total nitrogen and phosphorus concentrations in the waters entering the study area during the 7-consecutive-day, once in 10 year low flow were assumed to be equal to the values found during the Project survey, which was carried out at higher stream flows. The increase in concentrations resulting from present nitrogen and phosphorus loadings to the stream were calculated for the 7-consecutive-day, once in 10-year low summer flow and plotted in Figure V-37. No nutrient losses were assumed to take place.

During this low flow period the total nitrogen concentration in the water entering the study area at Anoka would be approximately 0.79 mg/1 . Contributions by the Anoka sewage treatment plant and the Minnesota River will increase it to 0.82 mg/1. The contribution of nitrogen from the Minnesota River will increase it to 0.90 mg/1. The Minneapolis-St. Paul Sanitary District, by far the largest single source will more than quadruple the concentration, bring it up to 3.72 mg/1. Contributions from South St. Paul and the industrial complex in the Spring Lake area will increase it to 4.41 mg/1. The St. Croix River, entering at UM 811.3, will have a diluting effect, producing a nitrogen concentration of 2.69 mg/1 below



NOTE: Summer low flow is considered as the 7 consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED NUTRIENT PROFILE AT SUMMER LOW FLOW MISSISSIPPI RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-37

its mouth and throughout the remainder of the river within the study area.

The variation in total phosphorus concentration along the Mississippi River will be similar to that of the nitrogen concentration just described. The phosphorus level (measured in PO_4) would be about 0.34 mg/l upon entering the study area, increase to a maximum of 2.49 mg/l before reaching the St. Croix River, and decrease to about 1.41 mg/l below the mouth of the St. Croix River.

During periods of low flow that portion of the Mississippi River within the study area will exhibit very low velocities because of the pooling effect of the dams. Each pool will, in many respects, resemble a lake. It is generally agreed that a 0.30 mg/l concentration of inorganic nitrogen and 0.03 mg/l concentration of soluble phosphorus (as PO_4) in a lake at the start of the active growing season could produce nuisance algal blooms(1). With the nitrogen and phosphorus concentrations anticipated during low flow periods, there is little doubt that there would be more than enough nutrients to support nuisance algal blooms throughout the entire length of the stream studied. For blooms to actually occur, of course, other chemical and physical characteristics (e. g., pH, temperature, and sunlight) must also be favorable.

Coliform Bacteria. The coliform density of the water upon entering the study area just below Anoka during low flow was assumed to be 5,000/100 ml, the average density found during the Project's survey. Die-off rates during the low flow periods were assumed to follow those given by Kittrell and Furfari. (2). Actual coliform die-off rates found during the Project's survey agreed very closely with those given in this reference.

Coliforms densities anticipated during the summer low flow (assuming no overflow from combined sewers) are given in Figure V-38. During this period the waters would be unsafe for even limited body contact activities between UM 836.3 and Um 785. Whole body contact activities would be safe only in the following reaches: UM 853 - UM 836.4, UM 780 - UM 772, and UM 771 - UM 763.5.

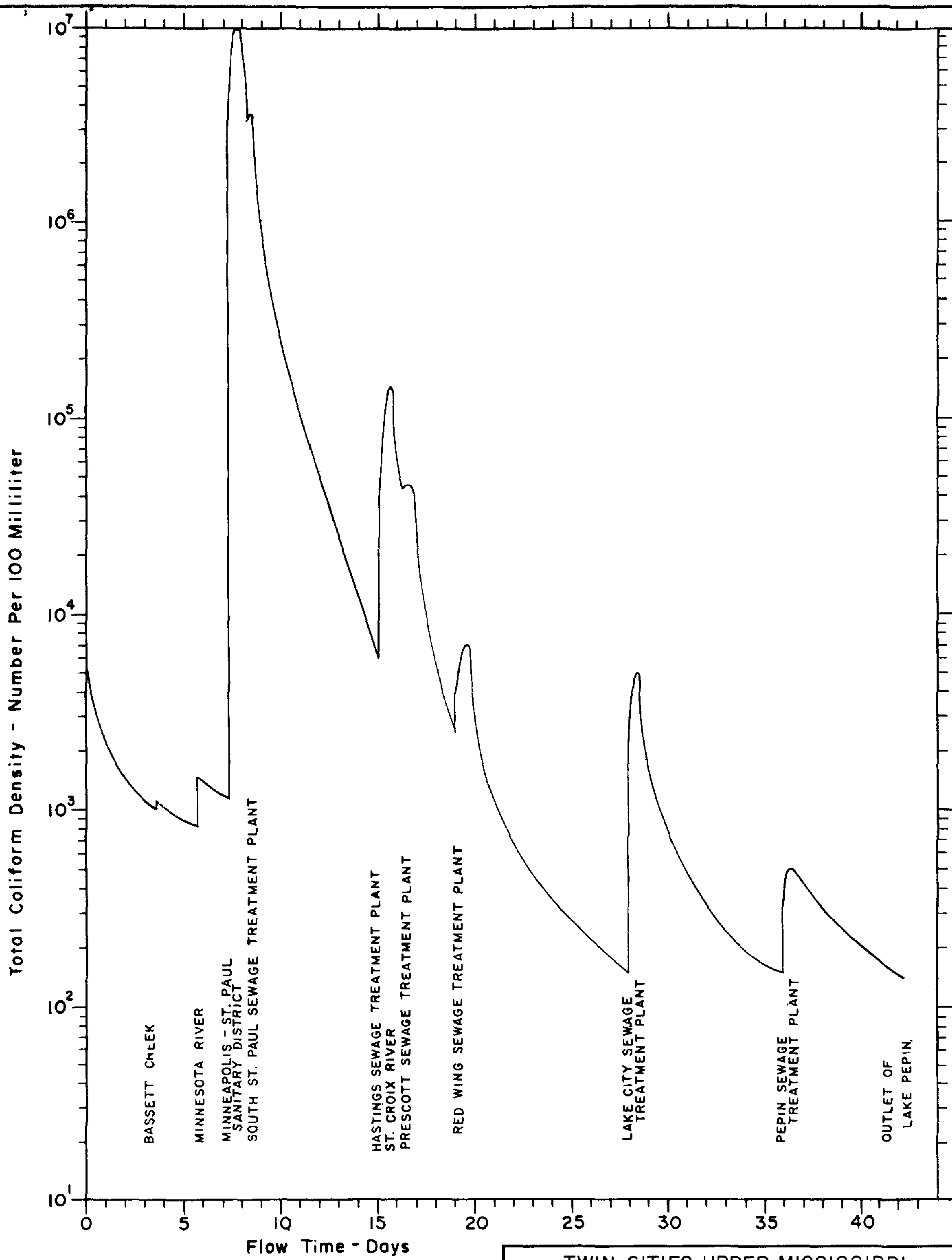
Coliform densities anticipated at the winter low flow are given in Figure V-39. Limited body contact activities would be safe everywhere except in the reach between UM 836.3 and UM 781. Whole body contact activities are not considered in winter.

Effects on Water Uses. The effects of existing pollution loadings on water uses at the summer low flow are summarized in Figure V-40. Conditions during the winter low flow would be very similar and therefore are not shown.

Minnesota River

Dissolved Oxygen. At the 7-consecutive-day, once in 10-year summer low flow the DO level will remain essentially the same over the reach between Mankato and Shakopee. Below this point it will drop, reaching a low of approximately 5 mg/l at MN 10 and then increase slowly, to approximately 5.5 mg/l near the mouth (see Figure V-41).

During the winter low flow of similar frequency the DO profile will show a slight but steady decrease from Mankato to the American Crystal Sugar Company outfall, reflecting the satisfaction of BOD under ice cover when reaeration is absent. Below the American Crystal Sugar outfall additional loadings will cause the DO profile to drop rather abruptly reaching 0 mg/l at MN 17. The DO level will remain at zero from this point on downstream.



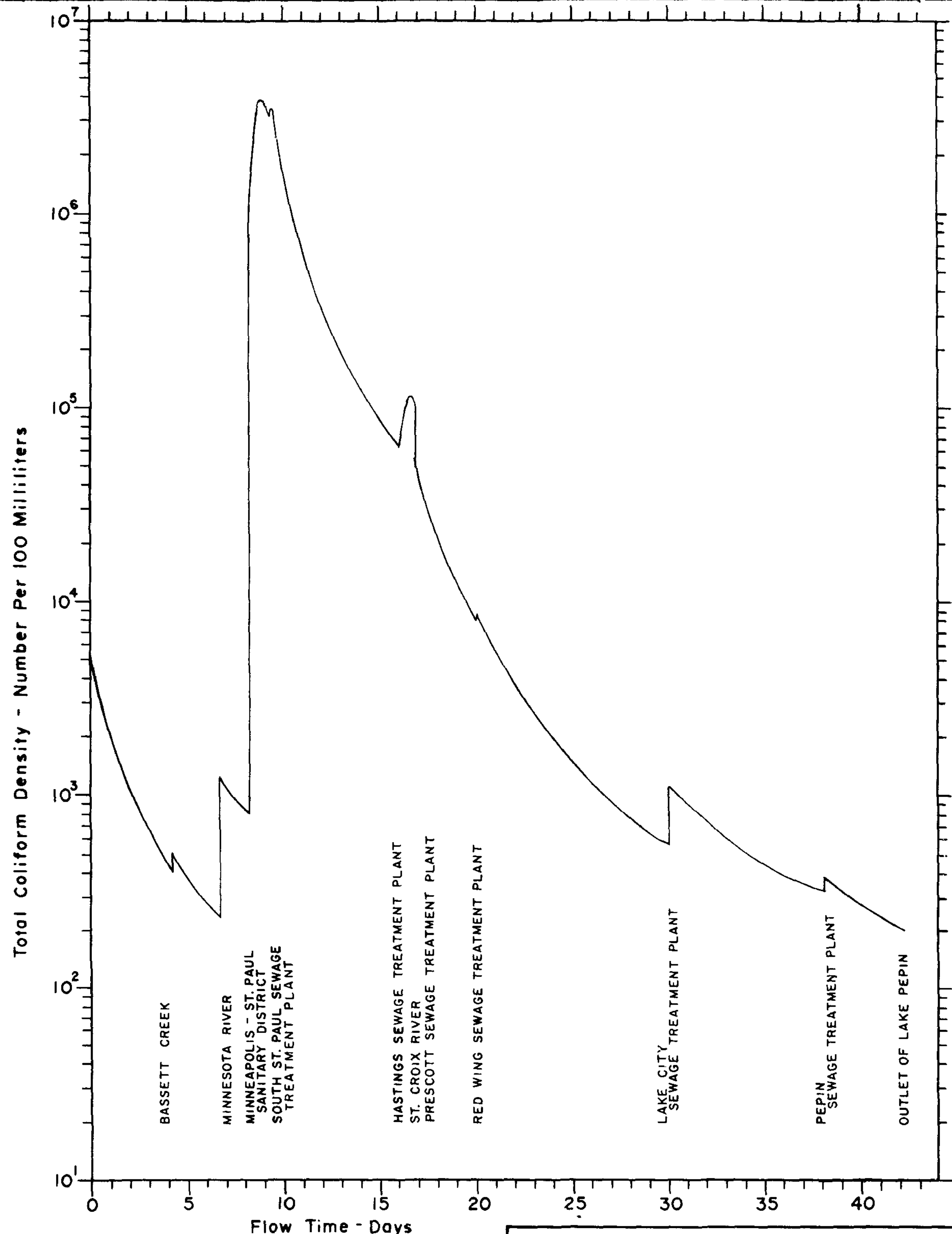
NOTE: Summer low flow is considered as the 7-consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED COLIFORM PROFILE AT SUMMER LOW FLOW MISSISSIPPI RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-38



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED COLIFORM PROFILE AT WINTER LOW FLOW MISSISSIPPI RIVER

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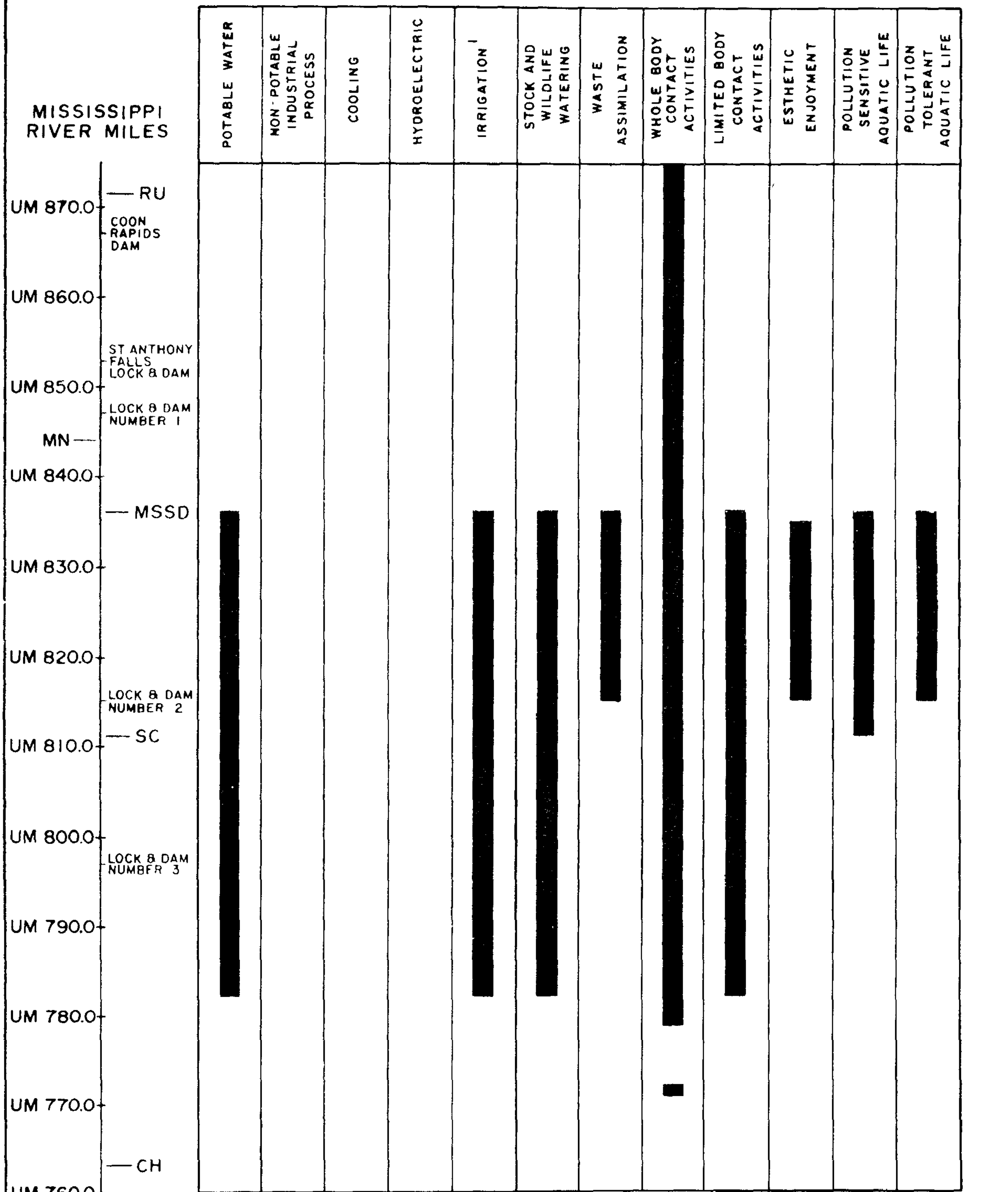
REGION V   CHICAGO, ILLINOIS

NOTE: Winter low flow is considered as the 7-consecutive day, once in 10 year low flow.

FIGURE V-39



LEGEND

RU RUM RIVER
MN MINNESOTA RIVER
SC ST CROIX RIVER
CH CHIPPEWA RIVER
MSSD MINNEAPOLIS - ST. PAUL SANITARY DISTRICT
■ INDICATES WHERE WATER WAS UNSUITABLE FOR THE DESIGNATED USE

1 FOR USE ON CROPS NOT NORMALLY COOKED BEFORE EATEN

NOTE A LOW FLOW IS CONSIDERED AS THE 7-CONSECUTIVE DAY, ONCE IN 10-YEAR LOW FLOW
B PROVIDED TAINTOR GATES AT LOCK & DAM NUMBER 2 ARE BULKHEADED IN ORDER TO PROVIDE OPTIMUM REAERATION.
C NO STORM RUNOFF IS ASSUMED TO OCCUR

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WATER USES AFFECTED ALONG MISSISSIPPI RIVER AT SUMMER LOW FLOW

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FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-40

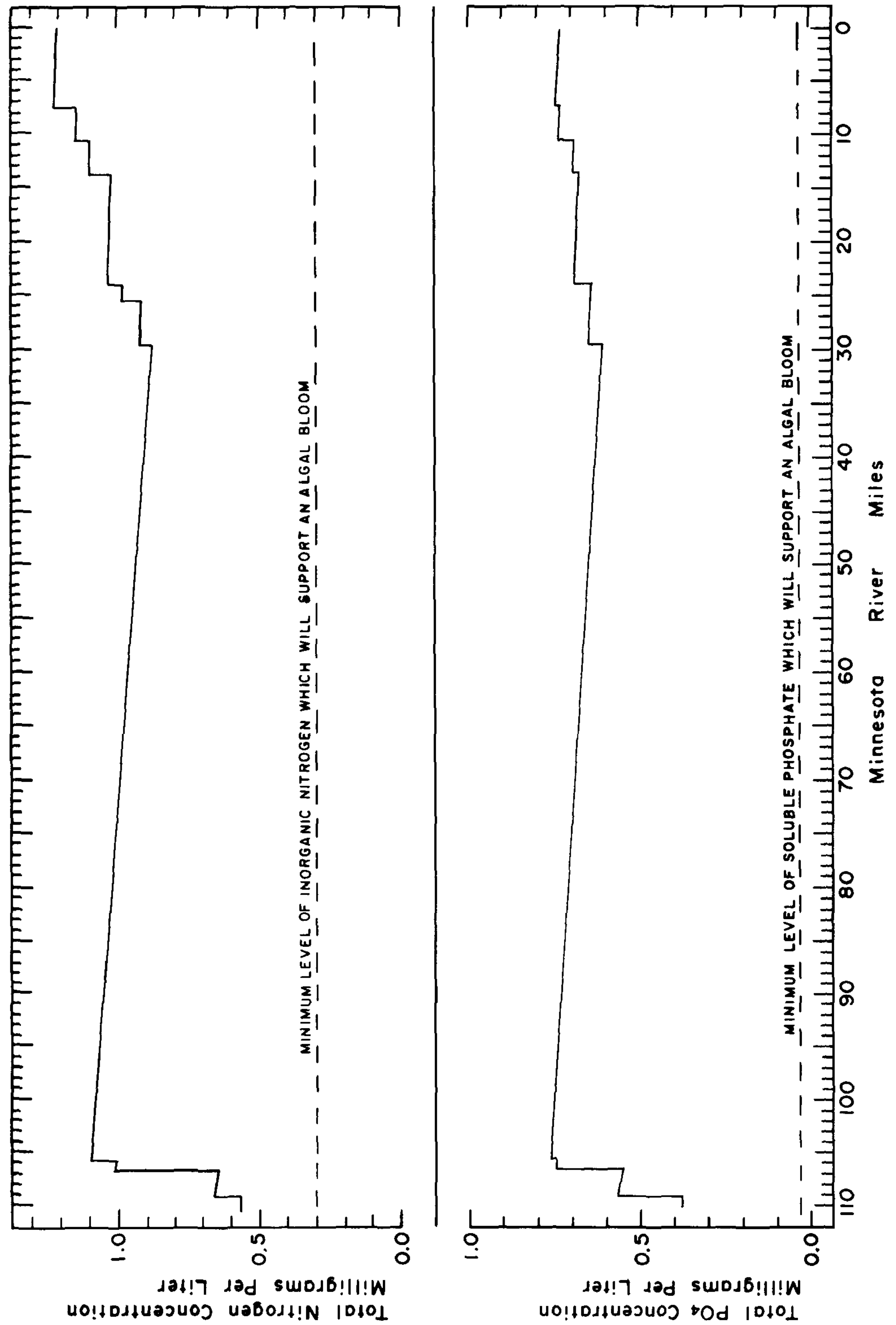
Thus conditions in the lower Minnesota River from a dissolved oxygen standpoint will be much more critical at low flow during winter rather than summer because of the greater organic loading and almost complete ice cover at this time of year.

Nutrients (Summer Conditions). The procedure for evaluating nutrients in the Minnesota River under low flow conditions follows closely that used for the Mississippi River. Ground water infiltration, which accounts for most of the increase in flow between Mankato and the mouth, was assumed to be void of any nitrogen or phosphorus. This produced a diluting effect on the nutrient concentrations in the stream.

The total nitrogen and phosphorus profiles expected in the Minnesota River at the summer low flow are given in Figure V-42. The anticipated nitrogen concentrations range from 0.57 to 1.15 mg/l while the phosphorus concentrations (as PO_4) range between 0.38 and 0.76 mg/l. Here also, there's little doubt there will be sufficient concentrations of nutrients to support nuisance algal blooms throughout the entire length of the stream studied. Again, it is emphasized that other conditions (e.g., pH, temperature, and sunlight) must also be suitable for blooms to actually occur.

Coliform Bacteria. The procedure for evaluating coliform densities on the Minnesota River was also similar to that used for the Mississippi River. The coliform density of the water entering the study area just above Mankato was assumed to be 5,000/100 ml, the average density found during the Project's survey.

The coliform profile anticipated at the summer low flow is given in Figure V-43. During this period the waters will be suitable for limited body contact activities between river miles MN 44 and MN 29.4, only.



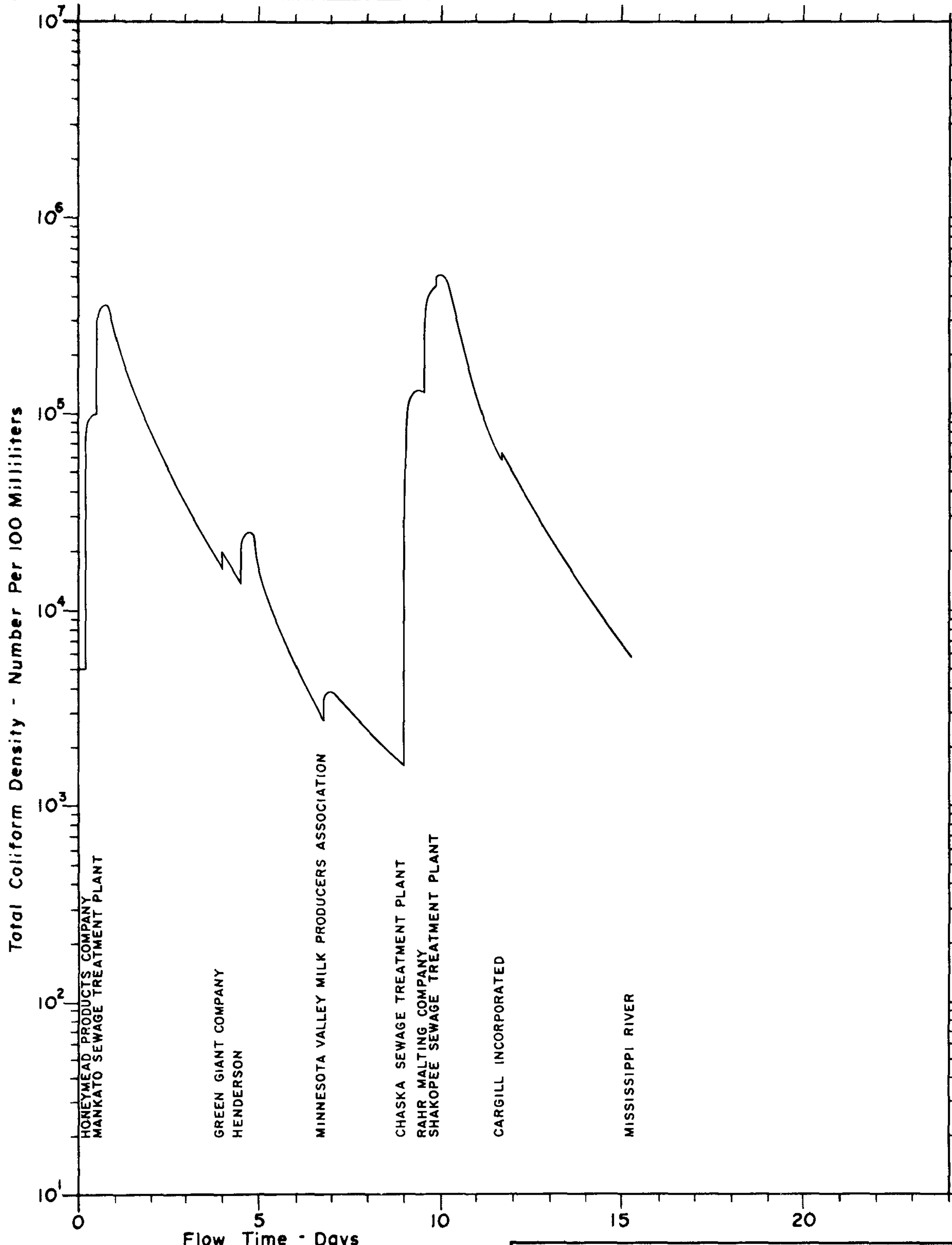
NOTE: Summer low flow is considered as the 7 consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED NUTRIENT PROFILE AT SUMMER LOW FLOW MINNESOTA RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-42



NOTE: Summer low flow is considered as the 7-consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED COLIFORM PROFILE AT SUMMER LOW FLOW MINNESOTA RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-43

The waters will not be suitable for whole body contact activities anywhere along the entire reach studied.

The coliform profile anticipated at the winter low flow is given in Figure V-44. During this period the waters will be suitable for limited body contact activities between river miles MN 52 and MN 29.4, only. Whole body contact activities are not considered in winter.

Effects on Water Uses. The water uses that will be affected by existing pollution loadings at the winter low flow are given in Figure V-45. The same water uses will be affected at the summer low flow, with the exception of maintenance of pollution tolerant aquatic life.

St. Croix River

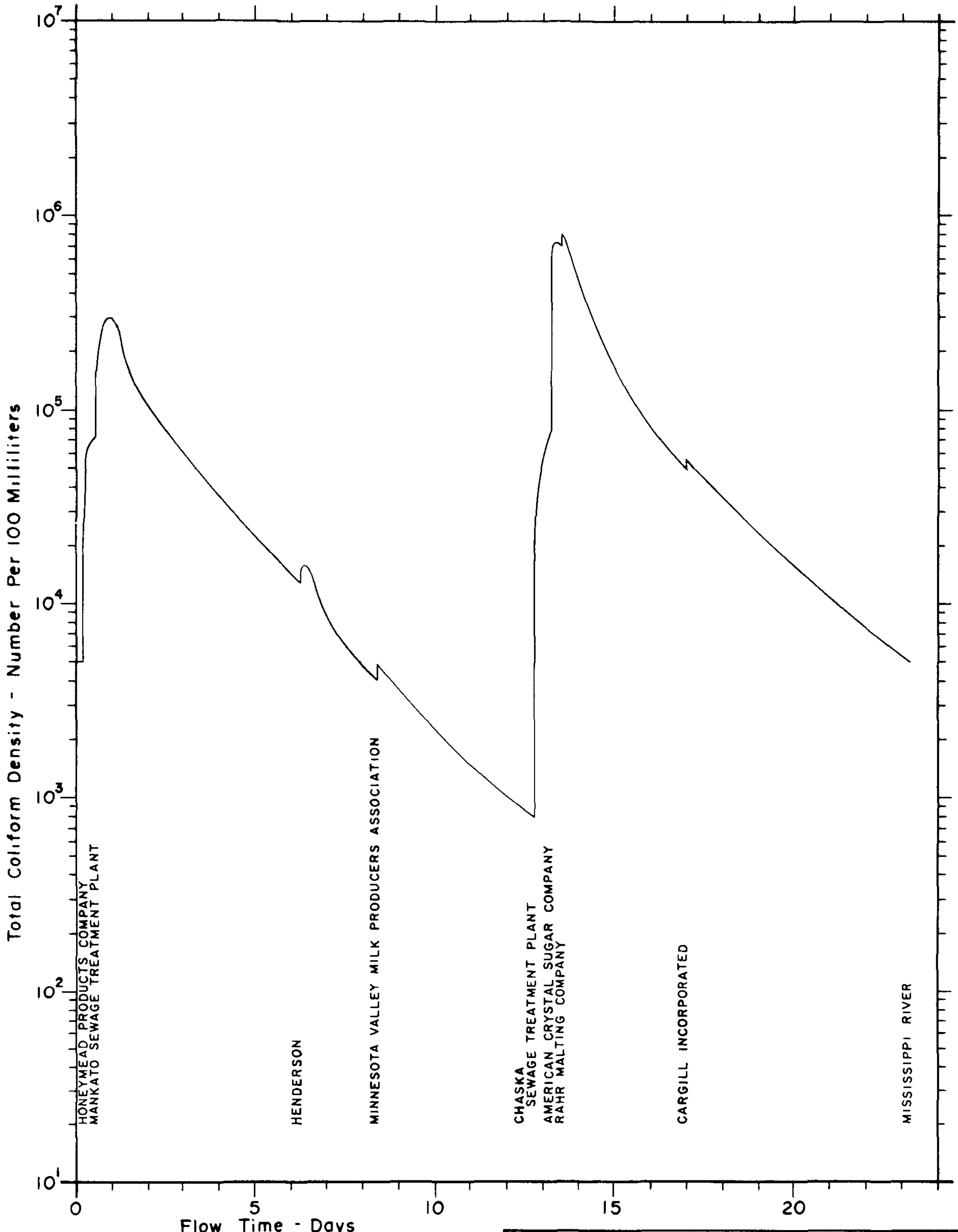
Waste sources along the St. Croix River within the study area would not produce any significant changes in water quality even at the low flow being considered here. Water quality at the low flow can be expected to be essentially the same as that found during the Project's survey.

Nutrient concentrations, which were found to be sufficient to support nuisance algal blooms, will continue to be high until natural and agricultural sources in the St. Croix drainage area are brought under greater control. Total nitrogen and phosphorus profiles expected in the St. Croix River at the summer low flow are given in Figure V-46.

WATER USE CATEGORIES APPLICABLE TO STREAMS OF STUDY AREA

General

As a minimum requirement, all waters of the study area should be of sufficient quality to support the following water uses: Maintenance of pollution tolerant fish and aquatic life, navigation and esthetic enjoyment. Waters of this quality will also generally support the following uses: Irrigation, stock and wildlife watering,



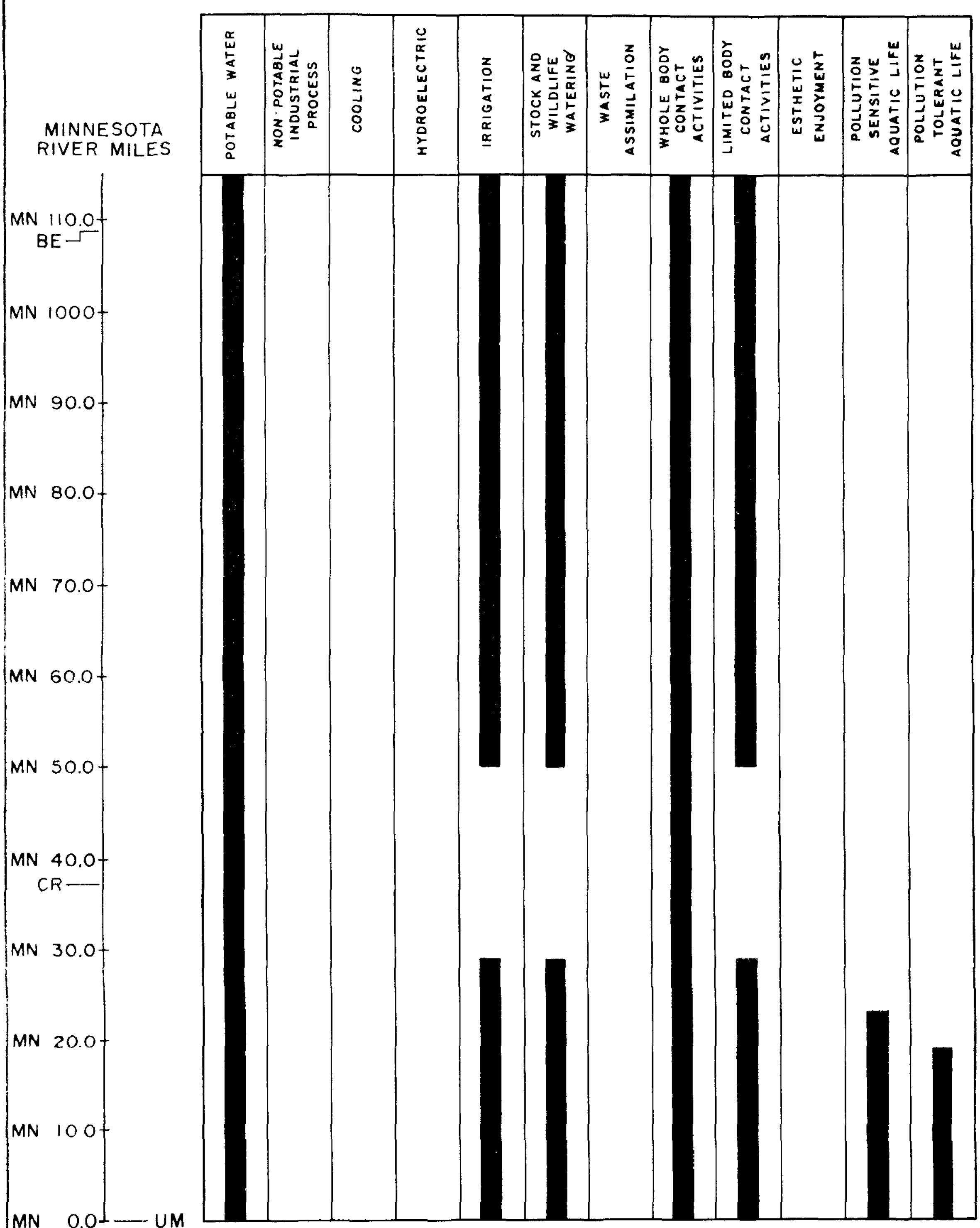
NOTE: Winter low flow is considered as the 7-consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED COLIFORM PROFILE AT WINTER LOW FLOW MINNESOTA RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-44



LEGEND

BE Blue Earth River

CR Carver Rapids

UM Mississippi River

█ Indicates where water was unsuitable for the designated use

NOTE. A. Low flow is considered as the 7-consecutive day, once in 10-year winter low flow.

B. No storm water runoff is assumed to occur.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

WATER USES AFFECTED ALONG MINNESOTA RIVER AT WINTER LOW FLOW

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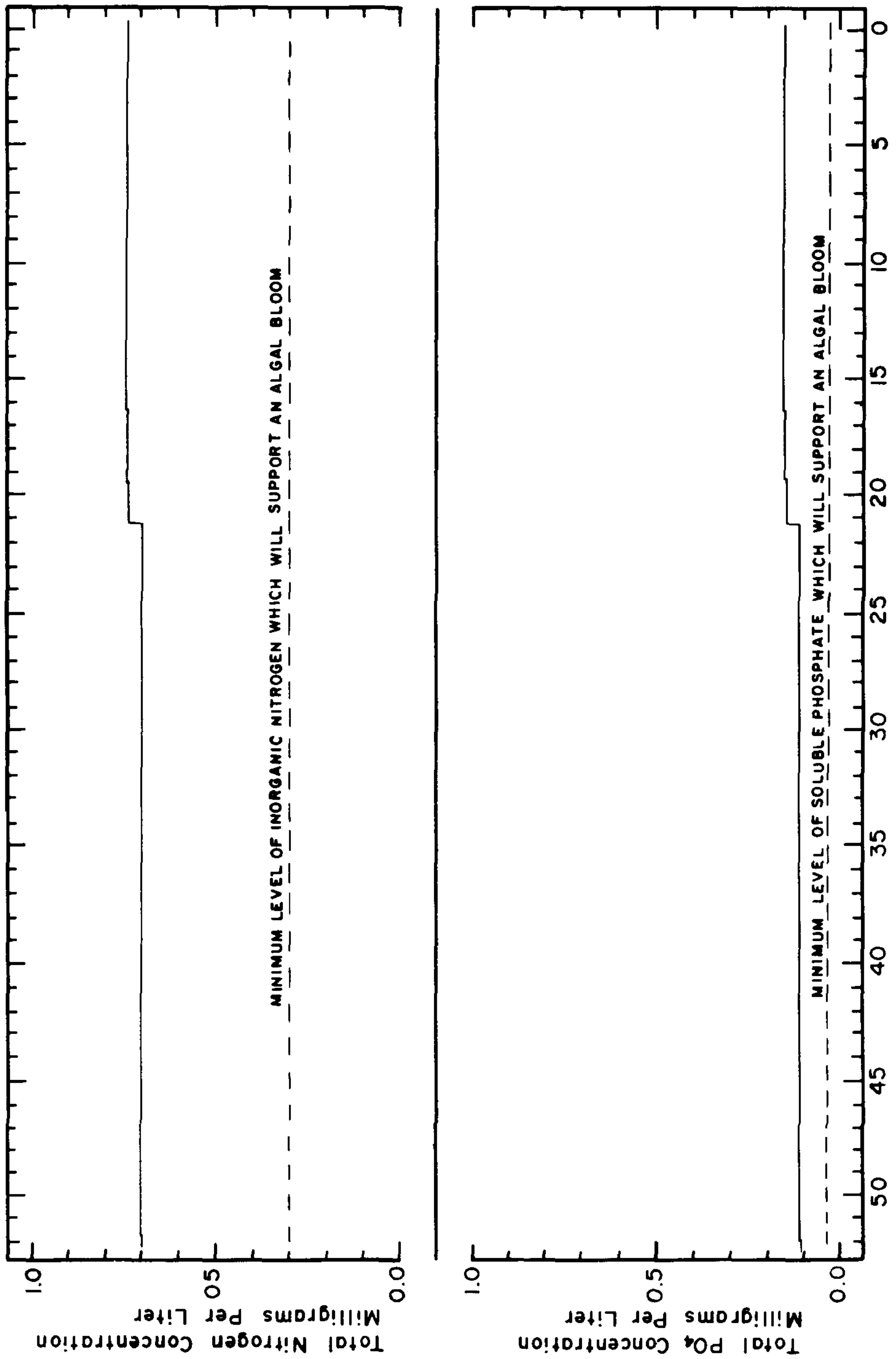
FIGURE V- 45



NOTE: Summer low flow is considered as the 7 consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED NUTRIENT PROFILE AT SUMMER LOW FLOW ST. CROIX RIVER

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FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-46

limited body contact recreational activities, commercial fishing, and a source of cooling and industrial non-potable process water. These uses would require maximum temperature, turbidity, ammonia, and phenol limits of 90°F, 250 units, 2.0, and 0.01 mg/l, respectively; a minimum DO of 3 mg/l; and an average coliform density of $<$ 5,000 /100 ml. Of course, floating liquids and solids should also be absent. (An additional decrease in the turbidity and coliform density to less than 25 units and 1,000/100 ml, respectively, would also permit whole body contact activities).

By increasing the minimum dissolved oxygen concentration to 5 mg/l, decreasing the maximum temperature and ammonia values to 86°F and 1.0 mg/l, respectively, waters suitable for the uses described in the preceding paragraph would also be suitable for the maintenance of a well-mixed population of fish. If the turbidity, phenol, and coliform limits were decreased still further, to 25 units, 0.001 mg/l and $<$4,000/100 ml, respectively, the water would also be suitable as a source of raw water for a potable supply.

For the major rivers within the study area, then, it is convenient to group water uses into four general categories: Groups A, B, C, and D.

Water Use Group D

Water uses in this group include the following:

1. Maintenance of pollution tolerant aquatic life
2. Irrigation
3. Stock and wildlife watering
4. Limited body contact recreational activities
5. Source of non-potable industrial process water
6. Source of cooling water

7. Commercial fishing

8. Navigation

9. Waste assimilation

10. Hydroelectric

11. Esthetic enjoyment

The minimum water quality necessary to maintain these water uses should be as follows:

Parameter	Limiting Value
Temperature (Maximum)	$90^{\circ}F$
Dissolved Oxygen (Minimum)	3.0 mg/l
Ammonia, as nitrogen (Maximum)	2.0 mg/l
Turbidity (Maximum)	250 Units
Phenol (Maximum)	0.01 mg/l
Coliform (Average)	<5,000 /100 ml.

In addition, there should be an absence of visible floating, suspended, or settled solids; floating grease and oil; discoloration; foam; slimes; excessive algal growths, acidity, alkalinity, and materials in concentrations sufficient to be harmful to aquatic life.

Water Use Group C

Water uses in this group include all uses in Group D plus whole body contact recreational activities.

The water quality parameter limits quoted for Group D apply for Group A, except as listed below:

Parameter	Limiting Value
Turbidity (Maximum)	25 Units
Coliform (Average)	< 1,000 /100 ml.

Water Use Group B

Water uses in this group include all uses in Group D plus the maintenance of pollution sensitive aquatic life and sport fishing.

The water quality parameter limits quoted for Group D uses apply for Group B uses, except as listed below:

Parameter	Limiting Value
Temperature (Maximum)	86°F
Dissolved Oxygen (Minimum)	5.0 mg/l
Ammonia, as nitrogen (Maximum)	1.0 mg/l

Water Use Group A

Water uses in this group include all those in Group B plus the use as a source of potable water supply.

The water quality parameter limits quoted for Group B apply for Group A, except as listed below:

Parameter	Limiting Value
Turbidity (Maximum)	25 Units
Phenol (Maximum)	0.001 mg/l
Coliform (Average)	$<$4,000 /100 ml

Water Use Groups A_b and B_b

These subscripted groups are used to define stream reaches that have or should have water of a quality designated by the corresponding non-subscripted group, but which have sandy beds and cannot support much, if any, bottom life regardless of the quality of the overlying water. This condition results in a fairly high percentage of rough fish in the total fish population, even in the absence of pollution. Many species of game fish will generally occupy these waters, but in relatively low numbers in comparison to rough fish.

PLAN FOR IMPROVEMENT OF MISSISSIPPI RIVER

General

The parameters of real concern are dissolved oxygen and coliforms since they will be the most difficult ones to bring to acceptable levels. In most cases the treatment required to obtain the desired DO levels will also be sufficient to obtain the desired ammonia, turbidity, and phenol levels. In the evaluation then, only the DO and coliform removals necessary to meet the limits given for each water use group will be discussed.

The criteria for each water use group in this discussion are reduced, then, to the following:

WATER USE GROUP	DO (Min) mg/l	TOTAL COLIFORMS (Avg.) No/100 ml
D	3	< 5,000
C	3	< 1,000
B	5	< 5,000
A	5	< 4,000

The location of waste sources and certain water use practices along the Mississippi River makes it convenient and logical to divide the river into five discrete segments for consideration of a water use program. These are the same segments into which the river was divided in the discussion on present Mississippi River water quality.

Recommended Water Use Program

The highest water use program felt to be practicable for each segment of the Mississippi River studied is shown in Table V-6. The waters should be fit for all the stated uses at stream flows equal to or greater than the 7-consecutive day once in 10-year low flow. Under this program, Segment I (Anoka to St. Anthony Falls) would be suitable for all uses considered in this report (Groups A and C). Segment II (St. Anthony Falls to MSSD) would be suitable for Groups B and C uses, which includes all those except for a source of potable water supply. At times the reach between the Minnesota River and MSSD may be too turbid for whole body contact activites because of the Minnesota River's inflow. Segment III (MSSD to Lock & Dam No. 2) would be suitable for Group D uses, which includes all those listed under Group B, except for the maintenance of pollution sensitive aquatic life and sport fishing. Actually, at stream flows greater than 5,000 cfs, this segment would be fairly suitable for these uses as well. The two remaining segments extending from (Lock and Dam No. 2 to the Chippewa River) would be suitable for Groups B and C which include all uses except for a source of potable water supply.

Abatement Requirements

Anoka to St. Anthony Falls. No improvements are needed in this segment to maintain a minimum DO of 5 mg/l. The most significant source of oxygen demanding wastes here during dry weather is the Anoka sewage treatment plant whose discharge of 150 lb/day of 5-day BOD produces no detectable effect on the consistently high DO level in the river even at the 7-consecutive-day, once in 10-year low flow.

The average coliform density of the incoming waters of the Mississippi and Rum Rivers is approximately 5,000 MPN/100 ml. The Anoka plant effluent, which contains about 300,000 MPN/100 ml, increases the coliform density along the east bank above 5,000 MPN/100 ml for a

TABLE V-6

RECOMMENDED WATER USE PROGRAM FOR MISSISSIPPI RIVER

SEGMENT	QUALITY TO BE SUITABLE FOR GIVEN WATER USE GROUP[1]	LIMITING VALUES OF WATER QUALITY PARAMETERS: MAX. TEMP (°F)	MIN. DO (mg/l)	MAX. AMMONIA-N (mg/l)	MAX. TURBIDITY (jackson units)	MAX. PHENOL (mg/l)	AVG. COLIFORM (No/100 ml)
Anoka (UM 871.6) (I)	A & C	86	5	1.0	25	0.001	<1,000 [2] <4,000 [3]
St. Anthony Falls (UM 853.7) (II)	B & C	86	5	1.0	250	0.01	<1,000 [2] <5,000 [3]
MSSD Outfall (UM 836.3) (III)	D	90	3	2.0	250	0.01	<5,000
L & D No. 2 (UM 815.2) (IV)	B & C	86	5	1.0	25	0.01	<1,000 [2] <5,000 [3]
L & D No. 3 (UM 796.[illegible]) (V)	B & C	86	5	1.0	25	0.01	<1,000 [2] <5,000 [3]
Chippewa River (UM 763.5)							

1 Water uses in each group are as follows: D - Maintenance of pollution tolerant aquatic life, irrigation, stock and wildlife watering, limited body contact recreational activities, non-potable industrial process water, cooling water, commercial fishing, navigation, hydroelectric power generation, and esthetic enjoyment.
C- All uses listed under "D" plus whole body contact activites (e.g. swimming and water skiing)
B -All uses listed under "D" plus maintenance of pollution sensitive aquative life and sport fishing.
A- All uses listed under "B" plus as a source of potable water supply.

2 During bathing season

3 Rest of time.

short distance downstream.

To maintain a coliform density not exceeding 1,000 MPN/100 ml in this segment during the summer, sources above the study area on the Mississippi and Rum Rivers would have to be brought under greater control.

The Anoka plant effluent coliform density would also have to be reduced to not greater than 1,000 MPN/100 ml during the summer to conform with these conditions. In winter, a stream coliform density not exceeding 5,000 MPN/100 ml would be accpetable.

St. Anthony Falls to MSSD Outfall. During low flow it is especially important to maintain the DO level in this segment higher than the 5 mg/l required for maintenance of pollution sensitive aquative life so that wastes from MSSD and South St. Paul can be assimilated with a minimum of detrimental effect. It would be desirable from this standpoint to maintain a DO level of about 7 mg/l or more in the river at UM 836.4, immediately above the MSSD outfall.

At UM 845.5 (above the Minnesota River) the August and January DO exceeded 7.5 and 11.0 mg/l, respectively, 50 percent of the time between 1942 and 1955 (3). Values were independent of stream flow.

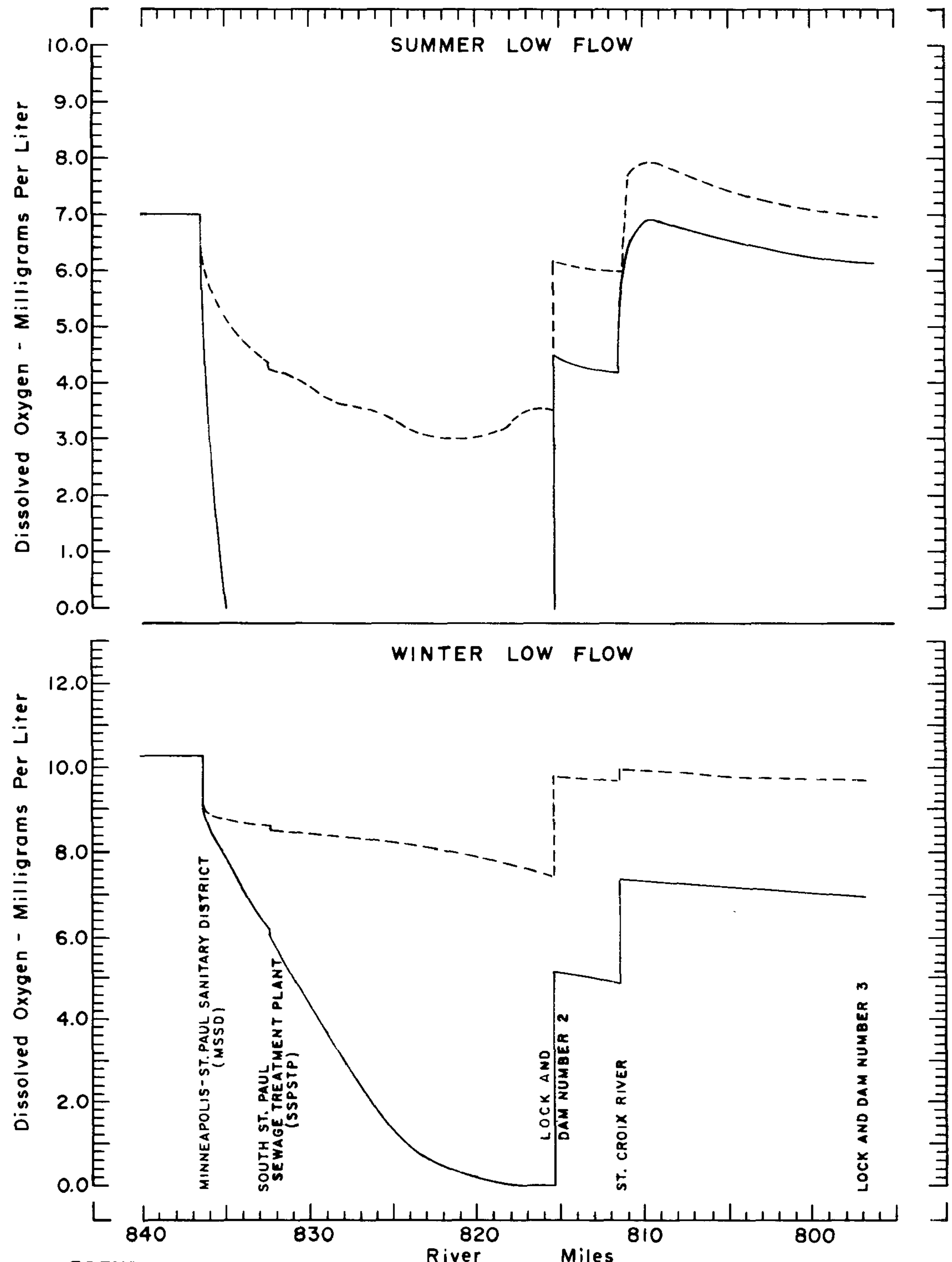
The most significant contribution of BOD and coliforms in this segment are combined sewer overflows and the Minnesota River. In dry weather, then, the only source of consequence is the Minnesota River. To maintain a DO of 7 mg/l or more 50 percent of the time in the Mississippi River during August at UM 836.4 then, the minimum DO level that can be tolerated during August in the Minnesota River at its mouth is 5.0 mg/l. (During January, the Minnesota River DO could drop to zero without lowering the DO in the Mississippi River below 8.8 mg/l 50 percent of the time). Since the minimum DO level (hourly average) anticipated in the Minnesota

River at its mouth during the summer low flow, even without any improvements, above 5 mg/l, there should be no problem in maintaining a DO level of 7 mg/l or more in the reach immediately above the MSSD outfall.

If the coliform density of wastes discharged to the Minnesota River do not exceed 5,000/100 ml, dilution and die-off in the stream should result in a coliform density of about 1,000/100 ml at the mouth during dry weather. The coliform density of the water entering this segment of the Mississippi River from above during dry weather (and with no combined sewers overflowing) is also expected to be about 1,000/100 ml. Hence, by making the minimum of improvements on Minnesota River coliform levels, a coliform level not exceeding 1,000/100 ml will be assured in this segment of the Mississippi River during dry weather. Practice of whole body contact activities should not be considered in this segment, however, until a solution is found to the combined sewer overflow problem. Once a solution is found, the average coliform density in this segment should not exceed 1,000/100 ml, the limit specified for whole body contact activities.

MSSD Outfall to Lock & Dam No. 2. This segment of the river has only two waste sources which produce a measurable effect on the stream's DO level. These are the MSSD and South St. Paul sewage treatment plants. At the 1965 loading rates these plants will cause the DO level in the Mississippi River to drop to zero at low summer and winter flows (see Figure V-47).

To ensure a minimum DO of 3 mg/l in the river at the 7-consecutive-day, once in 10-year low summer flow, (the more critical condition) the maximum discharge of 5-day (20^{o}) BOD permitted in the reach occupied by



LEGEND

CURVE TYPE	COMBINED MSSD & SSPSTP LOADING POUNDS PER DAY, 5-DAY, 20°C BOD
———	267,800 (1965 loading)
– – – –	68,500

NOTES: 1. It is assumed that taintor gates at Lock and Dam Number 2 are bulkheaded.

2. Summer and winter low flows are considered as the 7-consecutive day, once in 10 year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

EFFECTS OF TREATMENT PLANT LOADINGS ON MISSISSIPPI RIVER DISSOLVED OXYGEN PROFILE AT LOW FLOW

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
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FIGURE V-47

the two plants is 68,500 pounds/day. (At present MSSD and South St. Paul are the only sources that need be considered). If this loading were apportioned in a manner that would result in equal effluent concentrations, MSSD and South St. Paul could discharge 40 mg/1 of BOD, based on their 1965 flow rates. If, however, the loading were apportioned in a manner that would result in equal removal efficiencies, they would each have to provide 87.5 percent removal, based on 1965 loading rates.

The effect on the stream DO level of reducing the maximum BOD loading by the waste contributors to 68,500 pounds/day is illustrated in Figure V-47. Information on data used to calculate these curves is given in the appendix.

To ensure a maximum coliform density of 5,000/100 ml in this segment of the river during dry weather, none of the discharges to the river should contain more than 5,000 coliforms/100 ml. At this level, dilution provided by the stream would be sufficient to maintain the density in the stream at the point of maximum regrowth to less than 5,000/100 ml. To meet this requirement, the sources listed in Table V-7 would have to remove between 60.63 and 99.97 percent of coliforms presently in their effluents. The greatest removal, 99.97 percent, would have to be provided by the MSSD plant. Judging from the performance of other metropolitan plants, this degree of removal is not unreasonably difficult to attain. The Detroit, Michigan primary sewage treatment plant, for example, receives about 2.7 times as much sewage (with a geometric mean coliform density of 31,600,000 MPN/100 ml) a s the MSSD plant. It can consistently provide 99.999 percent removal, producing an effluent with a geometric mean coliform density of 245 MPN/100 ml.

TABLE V-7

TOTAL COLIFORM REMOVALS REQUIRED BY WASTE SOURCES BETWEEN MSSD AND LOCK & DAM NO. 2 TO ACHIEVE EFFLUENT DENSITIES OF 5,000 MPN/100 ml

SOURCE	PRESENT EFFLUENT DENSITY (MPN 100 ml)	PERCENT REDUCTION REQUIRED IN EFFLUENT DENSITY TO PRODUCE 5,000 MPN 100 ml
Minneapolis-St. Paul Sanitary District STP	16,000,000	99.97
South St. Paul STP	3,900,000	99.87
Newport STP	55,000	90.91
Northwestern Refining Company	17,000	70.59
St. Paul Park STP	8,700,000	99.94
Great Northern Oil Company	12,700	60.63
Northwest Cooperative Mills	790,000	99.37
Cottage Grove STP	4,200,000	99.88
Minnesota Mining & Manufacturing Company	59,000	91.53

To minimize the tainting of fish flesh, the concentration of phenolic compounds should not exceed 0.01 mg/l at the 7-consecutive day, once in 10-year low winter flow. The maximum allowable discharge of these compounds to this segment, then, is 110 pounds/day. During 1965, 887 pounds/day were being discharged to this segment, 850 pounds/day of it by MSSD. The loading rate of phenolic compounds will have to be reduced by 87 percent, then, in order to meet the recommended level.

Lock & Dam No. 2 to Lock & Dam No. 3. The DO level in this segment of the River is controlled primarily by the DO level and oxygen demanding materials associated with the water coming in from the above segment. None of the waste sources along the segment have a measurable effect on the DO. The St. Croix River, entering four miles below Lock & Dam No. 2, provides a favorable effect below the confluence because of its consistently high quality. Hence, the DO level in the reach between Lock & Dam No. 2 and the mouth of the St. Croix River, as in the above segment, is influenced principally by the MSSD and South St. Paul sewage treatment plant discharges.

If sufficient treatment is provided by the two plants to maintain a 3 mg/l DO level in the above segment at low flows, no additional treatment will be required to maintain 5 mg/l of DO in this segment (provided the Taintor gates at Lock & Dam No. 2 are bulkheaded).

If the coliform density of all wastes discharged to the previous segment do not exceed 5,000/100 ml, then the coliform density of the water entering this segment from above would be in the range of 1,000/100 ml because of dilution and die-off. The St. Croix River, also having a relatively low bacteriological density, would not produce any increase in the density.

There are only two waste sources that could affect the bacteriological quality here. These are the Hastings, Minnesota and Prescott, Wisconsin sewage treatment plants. To preserve the bacteriological quality that will result from upstream abatement efforts, then the coliform density of these plants' effluents should not exceed 1,000/100 ml. During winter when a density of up to 5,000 coliforms/100 ml would be acceptable, the coliform density of the two effluents may be as high as 5,000/100 ml.

Lock & Dam No. 3 to Chippewa River. If sufficient treatment is provided by the MSSD and South St. Paul plants to maintain a 3 mg/l DO level in the critical reach below them during low flows, no additional treatment will be required to ensure a DO level in this segment of at least 5 mg/l. None of the waste sources in this segment produce a measurable effect on the DO level.

If the coliform density of all upstream waste discharges is held to 5,000/100 ml or less, the coliform density of the waters entering this segment should be well below 1,000/100 ml. To preserve the high quality resulting from upstream abatement efforts, the wastes discharged to this segment should contain no more than 1,000/100 ml. During winter when a density of up to 5,000 coliforms/100 ml in the river is acceptable, the coliform density in the discharges may be as high as 5,000/100 ml.

Summary of Abatement Requirements. To attain the recommended water use program, the following abatement measures are imperative:

1. Reduce coliform levels in the Mississippi and Rum River waters entering study area to $<$ 1,000/100 ml during the bathing season and to $<$ 5,000/100 ml during the rest of the time.

2. Reduce coliform levels in all waste discharges to Segments I and II of the river to 1,000/100 ml during the bathing season and to 5,000/100 ml during the rest of the time.

3. Maintain a coliform density of 5,000/100 ml in the Minnesota River at its mouth.

4. Reduce waste loads from the MSSD and South St. Paul sewage treatment plants so that combined discharges of 5-day BOD do not exceed 68,500 pounds/day.

5. Reduce loading of phenolic compounds to $\leq$ 110 pounds/day in Segment III.

6. Reduce coliform densities to $<$5,000/100 ml in all wastes discharged to Segment III.

7. In Segments IV and V, reduce coliform densities to $<$1,000/100 ml during the bathing season and to 5,000/100 ml during the rest of the time.

It is emphasized that these are the minimum improvements necessary to obtain a water quality suitable for the recommended water use program. In addition to these measures, all waste contributors should provide the greatest amount of treatment practicable in order to make the river as clean as possible. More specific information concerning what is expected of all waste contributors is given in the Recommendations.

In order to maintain this recommended water use program in the future, successively higher BOD removal efficiencies will be required as greater waste quanities are generated, especially in the areas served by the MSSD and South St. Paul sewage treatments plants. If, for instance, the population served by MSSD increased as predicted and equal effluent concentrations are maintained by MSSD and South St. Paul, MSSD will have to provide BOD removals of 88, 90, and 94 percent by the years 1970, 1980, and 2000, respectively. The information on which these estimates are based is given in Table V-8.

Flow augmentation may be considered for the purpose of water quality control in lieu of additional treatment once adequate treatment has been provided. In this instance adequate treatment is felt to be 90 percent removal of biologically oxidizable materials. Thus, flow augmentation need not be considered for use before approximately 1980.

PLAN FOR IMPROVEMENT OF MINNESOTA RIVER

General

As with the Mississippi River the parameters of primary concern are DO and coliforms. In most cases the treatment required to obtain the desired DO levels will also be sufficient to obtain the desired ammonia levels.

Criteria for the possible water use groups in this discussion are reduced, then, to the following:

WATER USE GROUP	DO (Min) mg/l	TOTAL COLIFORM (Avg) No/100 ml
D	3	< 5,000
C	3	< 1,000
B_b	5	< 5,000
A_b	5	< 4,000

The location of waste sources and certain water use practices along the Minnesota River makes it convenient and logical to divide the river

TABLE V-8

ESTIMATED FUTURE TREATMENT REQUIREMENTS AT THE MINNEAPOLIS-ST. PAUL SANITARY DISTRICT SEWAGE TREATMENT PLANT TO MAINTAIN AT LEAST 3 mg/1 OF DO IN MISSISSIPPI RIVER[1]

YEAR	ESTIMATED POPULATION SERVED[2]	BOD RECEIVED AT PLANT 3 lb/DAY	MAX. ALLOWABLE DISCHARGE OF BOD lb/DAY	BOD REMOVAL REQUIRED PERCENT
1965	1,170,000	395,000	63,700	84
1970	1,585,000	535,000	63,700	88
1980	1,904,400	643,000	63,700	90
2000	3,007,000	1,017,000	63,700	94

1. Assuming that MSSD and South St. Paul have equal effluent concentrations of BOD and that the ratio of their flow rates remain constant. It is further assumed that the MSSD and So. St. Paul plants are the only significant waste contributors to this segment in the future.

2. Population estimates for 1970, 1980 and 2000 were obtained from Summary Report on a Comprehensive Sewage Works Plan for the Minneapolis-St. Paul Metropolitan Area, October 1964 by Cities of Minneapolis and St. Paul and the Minneapolis-Saint Paul Sanitary District.

3. BOD estimates for 1970, 1980, and 2000 were assumed to be proportional to the population served in the same ratio of BOD to population found for 1965 data. The BOD loading rate used for 1965 is equal to the daily average value exceeded two percent of the time during the summer.

Note: BOD refers to the 5-day (20°C) BOD.

into two discrete segments for consideration of a water use program.

Recommended Water Use Program

The highest water use program felt to be practicable for each segment of the Minnesota River studied is shown in Table V-9. The waters should be fit for all the stated uses at stream flows equal to or greater than the 7-consecutive-day, once in 10-year low flow. Under this program, the water quality in the segment of river between Mankato to Chaska would be suitable for all uses normally practiced in the study area except whole body contact activities (e. g. swimming and water skiing) and as a source of potable water supply. Excessive natural turbidity in the water makes it impracticable to consider these uses at this time. If the turbidity should be reduced sufficiently in the future through some means, such as by the construction of in-stream reservoirs, then only a greater coliform reduction in the waste effluents would be necessary to permit the practice of these uses as well.

The segment between Chaska and the river's mouth under this program would have water quality suitable for all uses except whole body contact activities, source of potable water supply, and the year-round maintenance of pollution sensitive aquatic life. The first two uses were not considered here for the same reason they were not considered in the previous segment. The additional expense required to raise the winter DO level from 3 to 5 mg/l in order to make the water suitable for pollution sensitive aquatic life is not felt to be justified since the lack of a suitable habitat on the river bottom would prevent any significant increase in the population of pollution sensitive species, regardless of the quality of the overlying water.

TABLE V-9

RECOMMENDED WATER USE PROGRAM FOR MINNESOTA RIVER

SEGMENT	Quality to be suitable for Given Water Use Groups[1]	LIMITING VALUES OF WATER QUALITY PARAMETERS				
		Max. Temp. (°F)	Min. DO (mg/1)	Max. Ammonia-N (mg/1)	Max. Turbidity (Jackson Units)	Average Coliform (No/100 ml)
Mankato (MN 109.3) (I) to Chaska	B_b	86	5	2.0	250	5,000
Chaska (MN 30.0) (II) to Mouth	D	90	3	1.0	250	5,000

1. Water uses in each group are as follows:

D	C	B_c
1. Maintenance of pollution tolerant aquatic life. 2. Irrigation 3. Stock & Wildlife watering 4. Limited body contact Recreation Activities (e.g. boating and sport fishing) 5. Non-potable industrial process water 6. Cooling Water 7. Commercial Fishing 8. Navigation 9. Hydroelectric power gen. 10. Esthetic Enjoyment	All uses listed under "D" plus whole body contact activities (e.g. swimming & water skiing)	All uses listed under "D" plus the maintenance of any pollution sensitive aquatic life that happen to be inhabiting the given segment. (Bottom conditions are not conducive to the maintenance of a high percentage of pollution sensitive aquatic life, regardless of water quality).

Abatement Requirements

Mankato to Chaska. In this segment of the river there are two waste sources which have a slight, but measurable effect on the stream's DO level. They are the Honeymead Products Company and Mankato sewage treatment plant. At present loadings, however, these sources do not depress the DO level below 5 mg/l during the 7-consecutive-day, once in 10-year summer or winter low flows.

The average of coliform density of the incoming waters of the Minnesota River above Mankato and the Blue Earth River above Honeymead Products Company is approximately 5,000/100 ml. To maintain the density below 5,000 organisms/100 ml over the length of this segment during dry weather, none of the discharges to the Blue Earth and Minnesota Rivers within the study area should contain more than 5,000 coliforms/100 ml.

Turbidity, occurring naturally, is considerably more than 25 jackson units except on occasions of low stream flows after long absences of surface runoff. The sand-silt-clay mantle, through which the river flows is largely responsible for this condition. It is doubtful that any measure short of lining the river channel or constructing in-stream reservoirs would be successful in producing a turbidity consistently below 25 units, the limit for use as a bathing water and as a source of potable water supply.

Except for during periods of heavy surface runoff, the turbidity is practically always less than 250 units. No remedial measures to keep the turbidity below 250 units are necessary since this condition occurs so infrequently.

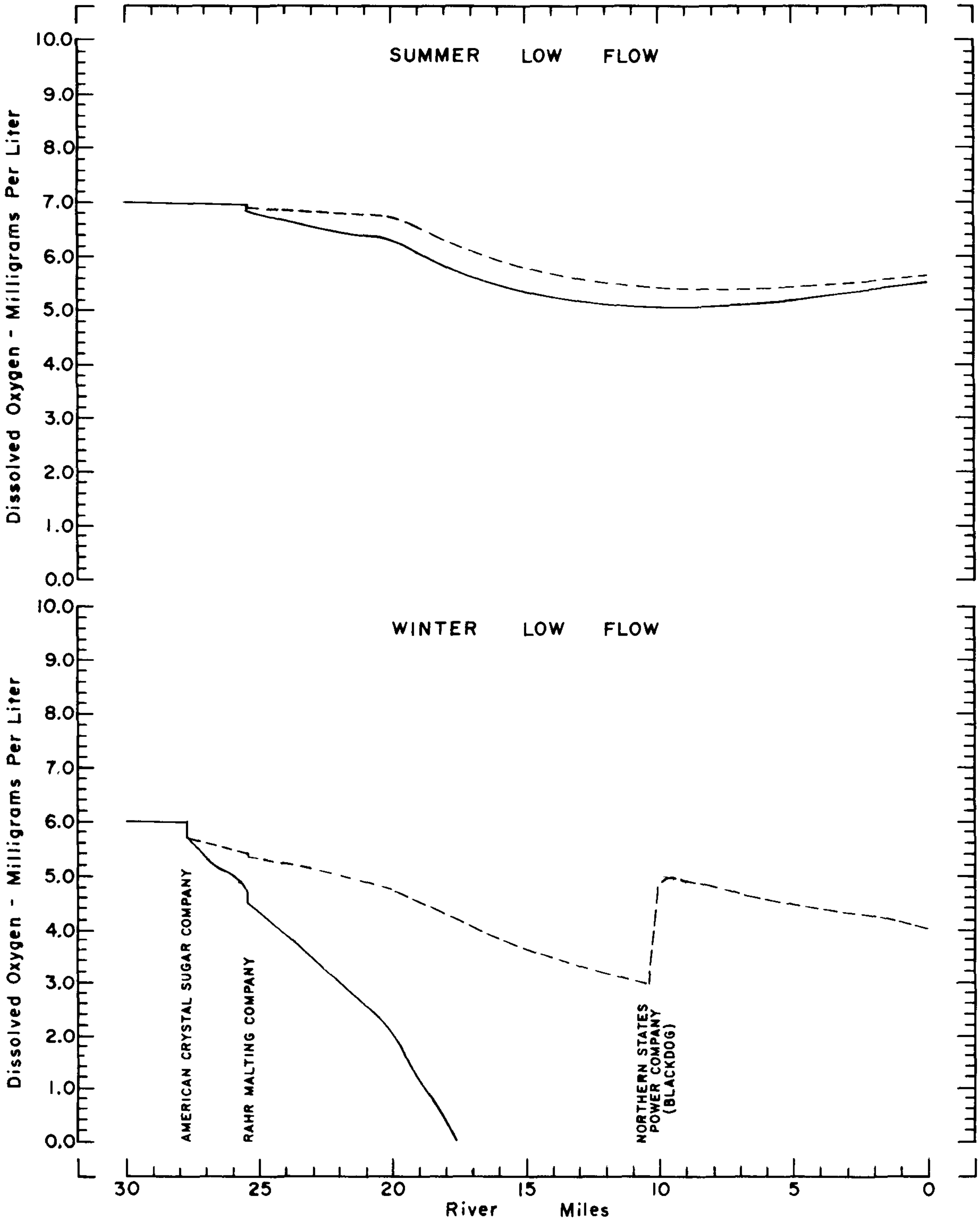
Chaska to Mouth. There are two waste sources along this segment which have a measurable effect on the stream's DO level. They are the

American Crystal Sugar Company (ACSC) and Rahr Malting Company (RMC). The former operates only from November through February discharging 38,000 pounds/day of 5-day BOD over that period. The latter operates the year-round and discharges approximately 5,000 pounds/day of 5-day BOD. The remaining sources in this segment contribute 1,240 pounds/day. Thus, conditions are far more serious in this segment during winter because of the greater waste loading and the restricted reaeration caused by ice cover. The 1965 loadings produce a DO level of zero between river mile 17 and the mouth during the 7-consecutive-day, once in 10-year winter low flow (see Figure V-48).

No improvements are needed to maintain a DO level in the river of greater than 3 mg/l during the summer low flow. To ensure a minimum DO of 3 mg/l in this segment at the winter low flow (with an incoming DO level of 6 mg/l) the maximum discharge of 5-day BOD that could be permitted by ACSC and RMC combined, is 12,000 pounds/day. If this loading were apportioned in a manner that would result in equal effluent concentrations, ACSC and RMC could discharge 160/ mg/l of BOD. Apportioning the allowable loadings on the basis of equal removal efficiencies, each would have to provide 72 percent removal, based on 1965 loading rates. No treatment less than 75 percent should be considered for these or any other waste sources. If additional waste contributors should locate within this reach, then the maximum allowable loading would have to be redistributed among all of them.

The effect on the stream DO level of reducing the maximum BOD loading to 12,000 pounds/day is illustrated in Figure V-48. Information on data used to calculate these curves is given in the appendix.

If the maximum coliform density of all upstream waste discharges



LEGEND

——— Result of loadings found during 1965

- - - - - All sources with effluent concentration of 160 milligrams per liter

NOTES: 1. American Crystal Sugar Company operates only during winter.

2. Summer and winter low flows are considered as the 7 - consecutive day, once in 10-year low flow

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

EFFECT OF WASTE TREATMENT LOADINGS ON DISSOLVED OXYGEN PROFILE MINNESOTA RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-48

is held to 5/000/100 ml, the coliform density of the waters entering this segment (at river mile 30.0) should be well below 1,000/100 ml. The coliform density in the discharges along this segment should not be greater than 5,000/100 ml.

Turbidity in this segment, occurring naturally, is generally above 25 units but less than 250 units. As with the previous segment, it is not considered practicable at this time to attempt to reduce the turbidity within a range that would make the waters consistently suitable for bathing purposes or as a source of potable water supply.

<u>Summary of Abatement Requirements.</u>

To attain the recommended water use program, the following abatement measures are necessary:

1. Reduce coliform levels in all discharges to the river to $<$5,000/100 ml.
2. Reduce waste loads from American Crystal Sugar Company and Rahr Malting Company so that combined discharges of 5-day BOD do not exceed 12,000 pounds/day during the winter.

Again, these are the minimum improvements necessary to obtain a water quality suitable for the recommended water use program. In addition to these measures, all waste contributors should provide the greatest amount of treatment practicable in order to make the river as clean as possible. More specific information concerning what is expected of all waste contributors is given in the Recommendations.

PLAN FOR IMPROVEMENT OF ST. CROIX RIVER

The water quality of the St. Croix River is already suitable (except in the immediate vicinity of waste discharges) and occasional shoreline algal blooms for all water uses without additional remedial measures.

To make the waters completely suitable from a bacteriological standpoint, the coliform density in all waste discharges should be maintained at a level no greater than 1,000/100 ml during the bathing season and no greater than 5,000/100 ml at any other time where they are in the vicinity of areas used for whole body contact activities. Other waste dischargers should maintain a coliform density of no greater than 5,000/100 ml in their effluents at all times. In addition to these measures all waste contributors should provide the greatest amount of overall treatment practicable in order to make the river as clean as possible. More specific information concerning what is expected of all waste contributors is given in the Recommendations.

REFERENCES

1. Sawyer, C. N., Some New Aspects of Phosphates in Relation to Lake Fertilization, Sewage and Industrial Wastes, Vol. 24, No. 6, pp. 768-776.

2. Kittrell, F. W. and Furfari, S. A., Observations of Coliform Bacteria in Streams, JWPCF, Vol. 35, No. 11, pp. 1361-1385.

3. Pollution and Recovery Characteristics of the Mississippi River, Volume One, Part Three, pp. 159, sponsored by the Minneapolis-St. Paul Sanitary District, conducted by the University of Minnesota under the direction of Prof. G. J. Schroepfer, 1958-1961.

APPENDIX

The primary purpose of waste treatment is the improvement of stream water quality. Despite the efforts to reduce the volume and strength of the waste, some waste still remains for disposal. In any specific case the amount of treatment and hence the desirable degree of stream improvement is directly related to planned water use.

The natural capacity of a stream to assimilate organic pollution without suffering serious oxygen depletion is a real asset - it has considerable dollar value in terms of reduced costs of waste treatment. This capacity of a stream to assimilate pollution is not a fixed capacity but rather a range in variability of capacity involving several interrelated factors including hydrology, natural purification, and stream biota. It is the purpose of this appendix to review briefly the principles of self-purification with reference to organic wastes and to present the significant variables that were considered in subsequent calculations.

The introduction of organic wastes into a stream brings about an oxygen demand with a resulting depletion of the dissolved oxygen of the flowing stream. The amount of oxygen depletion which takes place is known as the biochemical oxygen demand or BOD. The satisfaction of pollution loads, or BOD, in a stream is a time-temperature function that usually takes place in two stages and whose rate of satisfaction or decrease can be predicted or measured directly. The concentration of dissolved oxygen in the stream, however, depends not only on the rate of satisfaction (oxidation) of decaying organic matter but also on the rate of reaeration of the stream. When water is in contact with the atmosphere, the concentration of dissolved oxygen (DO) in the water tends toward a "saturation" level at which the partial pressures of oxygen in the two media are equal. When the DO in the water is lower than its possible saturation concentration, oxygen from the atmosphere is taken up by the water. This process is known as atmospheric reaeration.

The simultaneous action of deoxygenation and reaeration produces a pattern in the DO concentration along the stream known as the dissolved oxygen sag curve. This concentration pattern can be mathematically approximated by the differential equation

$$\frac{dD}{dt} = k_1 L - k_2 D$$

where: $\frac{dD}{dt}$ = change of dissolved oxygen deficient with time.

L = concentration of organic matter (BOD)

k_1 = rate of oxidation of organic matter.

D = dissolved oxygen deficit from a saturated value.

k_2 = rate of reaeration.

This equation states that the rate of change of dissolved oxygen in a stream is a function of two independent rates proceeding at the same time. The dissolved oxygen tends to be decreased by its use in the satisfaction of decaying organic matter and to be increased by reaeration from the atmosphere, which is a function of the hydraulic factors of the stream. Integration of equation (1) gives:

$$D_t = \frac{k_1 L_o}{k_2 - k_1} (10^{-k_1 t} - 10^{-k_2 t}) + D_o (10^{-k_2 t}) \quad (2)$$

where: D_t = dissolved oxygen deficit at time t.

k_1 = rate of oxidation of organic matter in the stream.

L_o = concentration of organic material (BOD) in the stream just below the waste discharge.

k_2 = rate of reaeration.

t = time of travel in the stream.

Other factors such as photosynthesis, second stage BOD and oxygen demand from the bottom deposits may be incorporated into the original differential equation. The resulting integration will yield an equation similar in form to equation (2), but with the effect of these additional variable included in the resulting dissolved oxygen deficit.

The biochemical oxygen demand of a waste exerted in any time interval is expressed by the equation:

$$Yt = L_o\ (L\text{-}10^{-k_1 t}) \tag{3}$$

where: Yt = BOD exerted at time t.

L_o = ultimate or total amount of organic material available for oxidation.

k_1 = rate of deoxygenation.

The most common measure of the BOD of a waste in the 5-day BOD value (Y_5). Since it is the total amount of material that is depleting the oxygen resources of the stream that is important, the 5-day BOD value is nothing more than an indicator. This 5-day value coupled with the laboratory deoxygenation rate (k_1) allows the calculation of the total amount of material available for oxidation. There are methods available for a determination of this k_1 rate and these have been used in evaluating the BOD data obtained during the survey. Consequently, the total quantity of BOD available in the stream at each point of interest has been calculated.

The rate of removal of BOD in the stream (k_r) is given by

$$k_r = \frac{LOG\ L_{o1} - LOG\ L_{o2}}{t}$$

where: L_{o1} = ultimate BOD at the upstream station in the reach.

L_{o2} = ultimate BOD at the downstream station in the reach.

t = time of travel through the reach.

The initial dissolved oxygen deficit (D_o) may be determined from observed data. The reaeration coefficient (k_2) has been defined by several researchers as a function of velocity and depth. These measurable physical factors were obtained by cross-sections at numerous stations and values of k_2 then claculated using O'Conners method. (1)

The temperature influence of the deoxygenation and reaeration coefficients may be expressed as follows:

$$k_{T_2} = k_{T_1} \; \theta^{(T_2 - T_1)} \qquad (5)$$

where: k_{T_2} = the rate at temperature T_2

k_{T_1} = the rate at temperature T_1

For the reaeration rate, θ has a value of 1.016, and for the summer and winter deoxygenation rates, θ had values of 1.047 and 1.11 respectively.

When a quantity of thermal pollution is discharged to a stream the water temperature rises at the outlet and then becomes progressively cooler downstream. A formulation for the determination of the temperature at any point downstream from an outlet has been reported by LeBosquet (2) as follows:

$$F = F_a \, 10^{-0.0102 \frac{KWD}{Q}} \qquad (6)$$

where: F = excess temperature in ^{o}F (of water over air) at distance D.

F_a = initial excess temperature in ^{o}F.

W = average width of stream in feet.

D = distance downstream in miles.

Q = flow in cubic feet per second.

K = heat exchange coefficient in BTU per square foot per ^{o}F excess temperature per hour.

The heat exchange coefficients for the affected reaches of river within the study area were determined by field measurements of existing temperature profiles. The above formula was then used in the stream analysis calculations.

Dissolved oxygen sag curves were calculated below each significant waste source or complex of waste sources for the two critical flow periods (see main report). The significant variables that were considered in these profile calculations were:

1) Income river discharge.

2) Incoming river dissolved oxygen concentration.

3) Incoming river biochemical oxygen demand concentration and deoxygenation rate.

4) River temperature.

5) Treatment plant waste loadings and deoxygenation rates.

The values for these variables for the various reaches of river are presented in the Tables A-1 and A-2.

Certain general factors and assumptions that were considered are as follows:

1) The dissolved oxygen concentration in the waste effluents was considered to be zero.

2) The streams were assumed to be completely covered with ice of zero thickness for winter conditions. The only open water was that below a source of thermal pollution for a distance as calculated by equation 6 such that the excess temperature was less than 0.5°F.

3) Aeration at Lock & Dam No. 2 was assumed to follow the pattern presented in Figure 1, reference 3.

4) It was assumed there was a uniform water temperature over the entire reach of river under study.

TABLE A-1

VALUES USED IN CALCULATION OF
DISSOLVED OXYGEN PROFILES

MISSISSIPPI RIVER

I Incoming River Discharge (St. Paul Gage)

7-Consecutive day once in 10-year low flow

Summer	Winter
1,950	1,900

II Incoming River DO Concentrations

	Concentrations, Mg/l Summer	Winter
UM 845.0	7.5	11.0
UM 836.5	7.0	10.2

III Incoming River BOD Concentration and Deoxygenation Rate

River Mile	Summer 5-Day BOD	k_1	Winter 5-Day Bod	k_1
UM 845.0	2.5	0.05	3.0	0.05
UM 836.5	2.5	0.05	3.0	0.05

IV River Temperature

Summer	Winter
30°C	0°C

V Treatment Plant Waste Loadings and Deoxygenation Rates

EFFLUENT CONCENTRATION 5-Day BOD	MSSD* 5-Day BOD lbs/day	MSSD* k_1	South St. Paul STP** 5-Day BOD lbs/day	South St. Paul STP** k_1
126	197,000	0.255	14,900	0.1
63	98,700	0.255	7,430	0.04
50	79,400	0.20	5,960	0.04
38	59,200	0.145	4,460	0.04
13	19,800	0.04	1,490	0.04

* Minneapolis - St. Paul Sanitary District, Flow = 188.6 MGD
** South St. Paul Sewage Treatment Plant, Flow = 14.2 MGD

TABLE A-2

VALUES USED IN CALCULATION
OF DISSOLVED OXYGEN PROFILES

MINNESOTA RIVER

I Incoming River Discharge (Carver Gage)

7-Consecutive day once in 10-year low flow

	Summer	Winter
MN 109.3	256	144
MN 30.0	320	180

II Incoming River DO Concentration

	Concentration, mg/l	
	Summer	Winter
MN 109.3	6.5	8.0
MN 30.0	7.0	6.0

III Incoming River BOD Concentration and Deoxygenation Rate

River Mile	Summer		Winter	
	5-Day BOD	k	5-Day BOD	k
MN 109.3	5.0	0.10	2.6	0.05
MN 30.0	2.0	0.05	2.0	0.05

IV River Temperature

Summer	Winter
26.7°C	0°C

V Treatment Plant Waste Loadings & Deoxygenation Rates

EFFLUENT CONCENTRATION	ACS*		RMC**	
5-Day BOD	5-Day BOD lbs/day	k_1	5-Day BOD lbs/day	k_1
200	11,700	0.26	4,670	0.20
150	8,750	0.26	3,500	0.20
100	5,840	0.15	2,340	0.20
75	4,380	0.13	1,750	0.20
50	2,920	0.10	1,170	0.15
25	1,460	0.05	584	0.13

* American Crystal Sugar Company, Flow = 7.0 MGD
**Rahr Malting Company, Flow = 2.8 MGD

5) The effect of photosynthesis was investigated and found not to be significant and therefore was not included in the calculations.

6) Under 1965 conditions benthal deposits in the Mississippi River were significant. It was assumed, however, that with the increased treatment at the various sources, benthal demands would cease being significant.

GPO 828-545

APPENDIX REFERENCES

1) O'Conner, Donald J., "The Effect of Stream Flow on Waste Assimilation Capacity" Proceedings Seventeenth Purdue Industrial Waste Conference, May 1962.

2) LeBosquet, M., Jr. "Cooling-Water Benefits from Increased River Flows" Journal N.E.W.W.A., June 1946.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Sewage and industrial wastes discharged to the Mississippi River from Minnesota cause pollution in the interstate waters of the Mississippi River which endangers the health and welfare of persons in Wisconsin and, therefore, is subject to abatement under the provisions of the Federal Water Pollution Control Act.

1. The following sources of waste water discharged to the Mississippi during the period of investigation:

   Anoka Sewage Treatment Plant

   Minneapolis Water Treatment Plants

   NSP Riverside Steam-Electric Generating Plant

   NSP High Bridge Steam-Electric Generating Plant

   Minnesota Harbor Service

   Twin City Shipyard

   Minneapolis-St. Paul Sanitary District Sewage Treatment Plant

   Swift and Company

   Union Stockyards

   Armour and Company

   King Packing Company

   So. St. Paul Sewage Treatment Plant

   Newport Sewage Treatment Plant

   Inver Grove Sewage Treatment Plant

   Northwestern Refining Company

   St. Paul Park Sewage Treatment Plant

   J. L. Shiely Company - Larson Plant

   J. L. Shiely Company - Nelson Plant

General Dynamics - Liquid Carbonic Division

St. Paul Ammonia Products Company

Great Northern Oil Company

Northwest Cooperative Mills

Cottage Grove Sewage Treatment Plant

Minnesota Mining and Manufacturing Company

Hudson Manufacturing Company

Hastings Sewage Treatment Plant

Prescott Sewage Treatment Plant

S. B. Foot Tanning Company

Pittsburgh Plate Glass Company

Red Wing Sewage Treatment Plant

NSP Red Wing Steam - Electric Generating Plant

Lake City Sewage Treatment Plant

Pepin Sewage Treatment Plant

2. The following sources of waste water discharged to the Minnesota River during the period of field investigation:

Honeymead Products Company

Mankato Sewage Treatment Plant

Archer Daniels Midland Company

Blue Cross Rendering Company

NSP Wilmarth Power Plant

Green Giant Company

City of Henderson

Minnesota Valley Milk Producers Cooperative Assoc.

Chaska Sewage Treatment Plant (includes Gedney Co. wastes)

American Crystal Sugar Company

Rahr Malting Company

Shakopee Sewage Treatment Plant

Owens-Illinois Forest Products

American Wheaton Glass Company

Savage Sewage Treatment Plant

Minnesota Masonic Home

Cargill, Inc.

Twin City Shipyard

Burnsville Sewage Treatment Plant

NSP Blackdog Power Plant

Cedar Grove Sewage Treatment Plant

3. The following sources of waste water discharged to the St. Croix River during the period of investigation:

St. Croix Falls Sewage Treatment Plant

Taylors Falls Sewage Treatment Plant

Osceola Sewage Treatment Plant

Stillwater Sewage Treatment Plant

Andersen Window Company

Bayport Sewage Treatment Plant

United Refrigerator Company

Hudson Sewage Treatment Plant

4. The discharge of excessive amounts of wastes produced oxygen concentrations below 5 mg/l in the following stream reaches:

a. Mississippi River between the Minneapolis-St. Paul Sanitary District sewage treatment plant and Lock and Dam No. 3 (39.4-mile reach) during summer of 1964.

b. Mississippi River between the Minneapolis-St. Paul

Sanitary District sewage treatment plant and St. Croix River (25.0-mile reach) during the winter of 1964-1965.

c. Minnesota River between Shakopee and its mouth (25.4-mile reach) during the summer of 1964.

d. Minnesota River between Chaska and its mouth (27.7-mile reach) during the winter of 1964-1965.

5. The discharge of excessive amounts of wastes produced oxygen concentrations below 3 mg/l in the following stream reaches:

a. Mississippi River between the Minneapolis-St. Paul Sanitary District sewage treatment plant and Lock & Dam No. 2 (21.1-mile reach) during the summer of 1964 and the winter of 1964-1965.

b. Minnesota River between Chaska and the mouth (27.7-mile reach) during the winter of 1964-1965.

6. Minnesota River Temperatures exceeded 90 and 93°F on occasion in a one-mile reach immediately below the Northern States Power Company's Blackdog steam-electric generating plant.

7. The average turbidity exceeded 25 jackson units in the following stream reaches during the summer of 1964:

a. Mississippi River between the Minnesota River and the head of Lake Pepin (59.0-mile reach).

b. Minnesota River from some point above Mankato (the limit of the study area) to the mouth.

8. Ammonia nitrogen levels exceeded 2.0 mg/l in the Mississippi River between Lock & Dam No. 2 and the St. Croix River (3.9-mile reach) during the winter of 1964-1965.

9. Ammonia nitrogen levels exceeded 1.0 mg/l in the following stream reaches:

a. Mississippi River between the Minneapolis-St. Paul Sanitary District sewage treatment plant and Lock & Dam No. 3 (39.4-mile reach) during the period of the survey.

b. Lower 15 miles of the Minnesota River during the winter of 1964-1965.

10. Phenol levels occasionally exceeded 0.01 mg/l in a 20-mile reach immediately below the Minneapolis-St. Paul Sanitary District sewage treatment plant.

11. The average concentration of the nutrients, inorganic nitrogen and phosphorus, exceeded 0.3 (as N) and 0.03 (as P) mg/l, respectively, throughout the three major streams studied.

12. Average coliform densities exceeded 1,000 MPN/100 ml in the following stream reaches during all surveys:

a. Mississippi River from some point above Anoka (limit of study area) to Lake City.

b. Minnesota River from some point above Mankato (limit of study area) to the mouth).

13. Average coliform densities exceeded 5,000 MPN/100 ml in the following stream reaches during all surveys:

a. Mississippi River between St. Anthony Falls and the head of Lake Pepin (70-mile reach).

b. Minnesota River between the Blue Earth River at Mankato and the mouth (109.2-mile reach).

14. Pathogenic bacteria and enteric viruses were present in the following stream reaches:

a. Mississippi River between St. Paul and Grey Cloud Island (10 miles below the Minneapolis-St. Paul Sanitary District Plant).

b. Mississippi River immediately below Red Wing sewage treatment plant.

15. Algae reached nuisance proportions in the following locations:

a. Mississippi River's Lake Pepin in shallow areas along the shorelines.

b. St. Croix River's Lake St. Croix in shallow areas along the shorelines.

16. Bottom sediment consisted of a mixture of organic sludge and sand in the following stream reaches during 1964:

a. Mississippi River between Lock & Dam No. 1 and the Minneapolis-St. Paul Sanitary District sewage treatment plant (11.3-mile reach).

b. Mississippi River between Lock & Dam No. 2 and the head of Lake Pepin (30-mile reach).

c. Minnesota River along a five-mile reach immediately below the Green Giant Company (at LeSueur).

d. Minnesota River between American Crystal Sugar Company (at Chaska) and the mouth (27.7-mile reach).

e. All of Lake St. Croix (lower 23 miles of the St. Croix River).

17. Bottom sediment consisted almost solely of organic sludge in the following stream reaches during 1964:

a. Mississippi River between the Minneapolis-St. Paul

Sanitary District sewage treatment plant and Lock & Dam No. 2 (21.1 mile reach).

b. All of Lake Pepin (lower 22 miles of Mississippi River under study).

18. Fish caught in the lower 10 miles of the Minnesota River and in the segment of Mississippi River between South St. Paul and the St. Croix River had lower levels of palatability than fish caught elsewhere in the study area.

RECOMMENDATIONS

GENERAL

River water quality shall be preserved or upgraded, as required, to permit maximum use and full recreational enjoyment of the waters. Remedial measures necessary to attain this goal are given in the recommendations. The recommendations are given in two groups: General and specific. General recommendations cover the broad objectives of pollution abatement in the Project area. Specific recommendations are given for the solution of particular problems and are offered in addition to, not in place of, the general recommendations.

These recommendations represent the initial phase of a long-range and more comprehensive water resource development program for the entire Upper Mississippi River Basin. They apply to problems needing immediate correction.

Although fertilization of the rivers and backwater areas is undesirable, no recommendations are made at this time concerning the installation of specialized treatment facilities designed to reduce nitrogen and phosphorus compounds in the waste effluents. Operation of treatment facilities so as to optimize nutrient removal will reduce the problem.

MUNICIPALITIES, INSTITUTIONS, AND INDUSTRIES

General Recommendations

It is recommended that:

Protection of Existing Water Quality

1. There be no further decrease in quality of any of the waters within the Study Area (Mississippi River between Anoka, Minnesota and the outlet of Lake Pepin; Minnesota River in and below Mankato, Minnesota; and St. Croix River in and below St. Croix Falls, Wisconsin.)

Enhancement of Water Quality

2. Water quality be enhanced as stipulated in the remaining recommendations to provide the following dissolved oxygen and coliform levels in the given segments of the Mississippi, Minnesota, and St. Croix Rivers during flows equal to or greater than the 7-consecutive-day, once in 10-year summer and winter low flows.

RIVER SEGMENT FROM (RIVER MILE)	TO (RIVER MILE)	(MAXIMUM OR MINIMUM CONCENTRATIONS FOR ANY ONE SAMPLE) DO (Min.) mg/l	COLIFORM GUIDE (Maximum)[1]
Mississippi River			
871.6 (Anoka)	836.3 (MSSD)	No deterioration in present level (>5 mg/l)	A&C[2]
836.3 (MSSD)	815.2 (L&D No.2)	3	B
815.2 (L&D No.2)	763.5 (Chippewa River)	5	A
Minnesota River			
109.2 (Mankato)	30.0 (Chaska)	No deterioration in present level (>5 mg/l)	B
30.0 (Chaska)	0.0 (Mouth)	3	B
St. Croix River			
52.0 (Taylors Falls)	0.0 (Mouth)	No deterioration in present level (>5 mg/l)	A&C

(1) See following pages for explanation of Coliform Guide.

(2) Coliform Guide C applies to the segment between Anoka and St. Anthony Falls, only.

(1) Coliform Guides

Coliform Guide A - Recreational whole body contact use. The water uses for which this guide is intended are those that entail total and intimate contact of the whole body with the water. Examples of such use are swimming, skin diving, and water skiing, in which the body is totally immersed and some ingestion of the water may be expected. The recommended guide value for coliforms is 1,000 per 100 milliliters (1,000/100 ml). For all waters in which coliform levels are below the guide value of 1,000/100 ml, the water is considered suitable provided there is proper isolation from direct fecal contamination as determined by a sanitary survey. Situations may arise wherein waters having coliform counts somewhat higher than the guide value can be used, provided supplemental techniques are used to determine safe bacterial quality. The analysis for fecal streptococci is more definitive for determining the presence of organisms of intestinal origin, and is suggested as the supplemental technique to be employed. A coliform level of 5,000/100 ml is considered satisfactory, provided the fecal streptococcus count is not more than 20/100 ml, and provided also that there is proper isolation from direct fecal contamination as determined by a sanitary survey.

The waters designated for whole body contact use should be maintained acceptable for this use at least between May and October, inclusive. During the remainder of the year when the weather is unsuitable for whole body contact activities, these waters should conform to Coliform Guide B.

Coliform Guide B - Recreational, limited body contact use and commercial shipping (barge traffic). The water uses for which this guide is intended are those that entail limited contact between the water user and the water. Examples of such uses are fishing, pleasure boating, and commercial shipping. Recommended guide value for coliforms is 5,000/100 ml. For all waters in which coliform levels are below this guide value, the water is considered suitable for use, provided there is proper isolation from direct fecal contamination as determined by a sanitary survey.

Coliform Guide C - Applies to municipal water source. Where municipal water treatment includes complete rapid-sand filtration or its equivalent, together with continuous post-chlorination, source water may be considered acceptable if the coliform concentration (at the intake) averages not more than 4,000/100 ml.

If the foregoing water quality is assured, then the water will be suitable for the following uses in each of the given river segments.

WATER USE	RIVER SEGMENT
a. Source of municipal water supply	Mississippi River: Anoka - St. Anthony Falls St. Croix River: Taylors Falls - Mouth
b. Maintenance of habitat for Group I[3] fish	Mississippi River: Anoka - MSSD L&D No. 2 - Chippewa River Minnesota River: Mankato - Chaska St. Croix River: Taylors Falls - Mouth
c. Whole body contact recreational activities	Mississippi River: Anoka - Minnesota River L&D No. 2 - Chippewa River St. Croix River: Taylors Falls - Mouth
d. Maintenance of habitat for Group II[4] fish	All portions of three major streams
e. Irrigation	"
f. Stock and wildlife watering	"
g. Limited body contact recreational activities	"
h. Source of non-potable industrial process water	"
i. Source of cooling water	"
j. Commercial fishing	"
k. Navigation	"
l. Hydroelectric power generation	"
m. Esthetic enjoyment	"

(3) & (4) See following page for explanation of Group I and Group II fish.

(3) Group I Fish - Are those generally sought after by sport fishermen and include but are not limited to the following species: Walleyed Pike, Sauger, Northern Pike, Black Crappie, White Crappie, Largemouth Bass, Smallmouth Bass, Rock Bass, White Bass, Bluegill, Channel Catfish, Sturgeon, Flathead Catfish, Green Sunfish, Pumpkinseed Sunfish, and Brown Trout.

(4) Group II Fish - Are those generally sought after by commercial fishermen in this area and include but are not limited to the following species: Carp, Quillback, Sheepshead, Brown Bullhead, Bigmouth Buffalo, Northern Carpsucker, Northern Redhorse, Longnose Gar, Shortnose Gar, Bowfin, Mooneye, Gizzard Shad, Common Sucker, Spotted Sucker, Yellow Bullhead, Black Bullhead, Golden Shiner, Perch, and River Sucker.

Treatment of Municipal Wastes

3. All municipalities and other institutions discharging sewage to the rivers under investigation provide at least secondary biological treatment plus continuous disinfection of the effluent. This treatment is to produce an effluent containing no more than:

a. 20 percent of the mass of 5-day (20°C) BOD originally contained in the influent.

b. 20 percent of the mass of suspended solids originally contained in the influent.

c. 5,000 coliforms/100 ml (except where "d" applies).

d. 1,000 coliforms/100 ml between May and October, inclusive, where receiving waters are used for whole body contact activities (see preceding list).

These limits are to be followed except where more stringent ones are given in the specific recommendations or are required by State Water Pollution Control agencies.

Reports by Municipal Treatment Plants

4. Municipal waste treatment plants maintain at least the minimum laboratory control and records as recommended by the Conference of State

Sanitary Engineers at their 38th Annual Meeting in 1963 (See Appendix). In addition, all plants should maintain a record of chlorine feed rates and those plants of 2 million gallons/day capacity, or greater, should provide analyses for total and fecal coliforms on a once per week basis. Results of laboratory tests and other pertinent records should be summarized monthly and submitted to the appropriate State agency for review and evaluation. These records are to be maintained in open files of the State agency for use by all persons with a legitimate interest.

Phosphate Removal

5. New waste treatment facilities be designed to provide adequate capacity of individual units and components as well as maximum flexibility in order to permit later modification in operating procedures so as to effect the greatest amount of phosphate removal. Existing plant facilities should be operated so as to optimize phosphate removal.

Monitoring of Water Quality

6. The States of Minnesota and Wisconsin establish a program of monitoring and surveillance in area waters for evaluating progress in improvement of stream quality resulting from implementation of actions recommended by the conferees. The FWPCA should establish monitoring stations where appropriate on portions of the Mississippi and Minnesota Rivers within the State of Minnesota to aid in the evaluation. Water quality surveillance activities should be coordinated and all information made available to the States, the FWPCA, and other parties with a legitimate interest.

Bypassing and Spilling of Wastes

7. All present and future sewerage and sewage treatment facilities be modified or designed and operated to eliminate bypassing of untreated

wastes during normal maintenance and renovation operations. The appropriate State agency (Minnesota Water Pollution Control Commission or Wisconsin Department of Resource Development) is to be contacted for approval prior to any expected bypassing of waste. All accidental or emergency bypassing or spillage should be reported immediately.

Pretreatment of Wastes

8. Wastes (such as sludge from the St. Paul water treatment plant) which discharge into a municipal sewerage system be pretreated to avoid any detrimental effect on waste treatment operation.

Protection Against Spillage

9. Programs be developed by those responsible for the facilities to prevent or minimize the adverse effect of accidental spills of oils, gases, fuels, and other material capable of causing pollution. The elements of such programs should include:

a. Engineering works such as catchment areas, relief vessels, and dikes to trap spillage.

b. Removal of all spilled materials in a manner acceptable to the regulatory agencies.

c. Immediate reporting (by those responsible for the facilities) of any spills to the appropriate State agency.

d. In-plant surveys and programs to prevent accidental spills.

Combination Storm and Sanitary Sewers

10. Combined storm and sanitary sewers be prohibited in all newly developed areas and be eliminated in existing areas wherever opportunity to do so is afforded by redevelopment. Present combined sewers should be

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continuously patrolled and operated so as to convey the maximum possible amount of combined flows to and through the waste treatment plant. In addition, studies to develop effective control of wastes from this source should be continued by the MSSD and should be initiated by the City of South St. Paul. Although the immediate problem is a bacterial one, both studies should also consider the discharge of BOD and solids. Methods to be used to control wastes from combined sewers and a time schedule for their accomplishment should be reported to the Conferees within two years after issuance of the Conference Summary.

Treatment of Industrial Wastes

11. All industries discharging wastes to the rivers under investigation, unless otherwise specified, provide treatment sufficient to produce an effluent containing no more than 20 percent of the mass of 5-day (20°C) BOD and suspended solids originally contained in the untreated process waste. Settleable solids and coliforms in the effluent are not to exceed the following:

a. Settleable solids - 5 ml/l

b. Coliforms - 5,000/100 ml (except where "c" applies)

c. Coliforms - 1,000/100 ml between May and October, inclusive, where receiving waters are used for whole body contact activities (see preceding list).

Reporting of Industrial Wastes

12. Industries discharging wastes to the waters maintain operating records containing information on waste discharge rates and concentrations of constituents found in significant quantities in their wastes.

This information should be summarized and submitted to the appropriate State agency at monthly intervals for review and evaluation.

These records are to be maintained in open files of the State agency for use by all persons with a legitimate interest.

Vessel Wastes

13. All watercraft provide adequate treatment on board or arrange for suitable on-shore disposal of all liquid and solid wastes.

Garbage and Refuse Dumps

14. Garbage or refuse not be dumped along the banks of the river and no open dumps be allowed on the flood plain. Material in present dump sites along the river banks should be removed and the appearance of the bank restored to an esthetically acceptable condition. Present open dumps on the flood plain should be converted to sanitary landfills operated acceptably to the appropriate State agencies.

Upstream Bacterial Control

15. Waste sources upstream from and outside of the study area on the Mississippi, Minnesota, and St. Croix Rivers and their tributaries be sufficiently controlled so that waters entering the study area conform to General Recommendation No. 2.

Specific Recommendations - Mississippi River

Specific recommendations are offered in addition to, and not in place of, the general recommendations.

Municipal Sources

It is recommended that:

MSSD to South St. Paul - Maximum BOD and Suspended Solids Loadings

1. Maximum waste loadings from all sources between and including the Minneapolis-St. Paul Sanitary District and the South St. Paul Sewage Treatment Plants be such that a minimum dissolved oxygen content of

3.0 mg/l can be maintained during the 7-consecutive-day, once in 10-year low summer flow in the reach of river between Mississippi River miles 836.4 and 815.2. To attain this, combined wastes loads from these sources should not exceed 68,500 pounds/day of 5-day (20°C) BOD, exclusive of combined sewer overflows. Suspended solids loadings discharged to this reach (exclusive of combined sewer overflows) should not exceed 85,500 pounds/day in order to minimize sludge deposits.

<u>Maximum Phenolic Loadings</u>

2. Maximum loadings of phenolic wastes from the Minneapolis-St. Paul Sanitary District sewage treatment plant, Northwestern Refining Co., Great Northern Oil Co., and Minnesota Mining and Manufacturing Co., all combined, not exceed 110 pounds/day in order to maintain the stream concentration of this material under 0.01 mg/l at stream flows equal to or greater than the 7-consecutive-day, once in 10-year low flow.

<u>Bypassing at MSSD</u>

3. An engineering study of the Minneapolis-St. Paul Sanitary District sewerage system be undertaken to determine what changes are required to make unnecessary the practice of bypassing wastes periodically for the purpose of cleaning the inverted siphon under the Mississippi River.

<u>Hastings Plant</u>

4. The BOD removal efficiency at the Hastings, Minnesota primary sewage treatment plant be increased from the 5 percent figure found during the survey to a minimum of 30 percent until secondary biological treatment facilities are in operation.

Industrial Sources

It is recommended that:

Water Treatment Plants of the City of Minneapolis

1. Treatment facilities be provided capable of producing an effluent with a suspended solids concentration not exceeding that found in other treated effluents being discharged to the same reach of river. At no time should the daily average suspended solids concentration exceed 50 mg/l.

The two water treatment plants of the City of Minneapolis discharge sand filter backwash water to the river without prior treatment. Together the two plants discharge approximately 0.69 mgd of backwash water having an average suspended solids concentration of 1,900 mg/l.

Swift & Co., Armour & Co., and So. St. Paul Union Stockyards

2. The industries in the South St. Paul area (Swift & Company, Armour & Company, and the St. Paul Union Stockyards) provide an effective method of control and correction of direct discharges to the Mississippi River. These include so-called clean waste waters, watering trough overflows, truck washing wastes, surface drainage, and hog pen flushings. The coliform densities of any of these discharges should not exceed 5,000/100 ml once the control devices are in operation.

Northwest Cooperative Mills

3. Additional treatment be provided to reduce the suspended solids concentrations of the compositing pond effluent to substantially the same levels found in other effluents being discharged to the same reach of river after satisfactory treatment. In no instance should the daily average suspended solids concentration exceed 50 mg/l.

The discharge from the compositing pond averages 46,000 gallons/day (gpd) and contains about 420 mg/l of suspended solids.

Foot Tanning Company

4. Any additional facilities constructed for the company's waste produce an effluent of a quality acceptable to the Minnesota Water Pollution Control Commission (MWPCC) and in conformity with recommendations in this report. The possibility of discharging the settled waste to the Red Wing sewerage system in lieu of additional treatment should be considered and a report on the conclusions of such questions submitted to the MWPCC.

On April 1, 1966 the company submitted to the MWPCC plans and specifications for a primary clarifier and a study plan for evaluating secondary treatment methods.

Specific Recommendations - Minnesota River

Municipal Sources

No specific recommendations.

Industrial Sources

It is recommended that:

Green Giant Company

1. An additional pump be provided for standby purposes at the waste water sump for use when the main pump fails. The sanitary and miscellaneous process wastes should be handled as specified by General Recommendations 3 and 11.

This company had pump failures at the waste water collection sump where process waste is collected and pumped to ridge and furrow fields. When pump failure occurs, the waste is discharged directly to the river. Some sanitary and miscellaneous process wastes are discharged directly to the river without treatment as a normal practice.

American Crystal Sugar Co. and Rahr Malting Co.
Maximum BOD and Suspended Solids Loadings

2. Maximum waste loadings from all sources between and including the American Crystal Sugar Co. and the Rahr Malting Co. be such that a minimum dissolved oxygen content of 3.0 mg/l can be maintained during the 7-consecutive-day, once in 10-year low winter flow in the reach of river between Minnesota River miles 29 and 0. To attain this, combined waste loads from these sources should not exceed 12,000 pounds/day of 5-day (20°C) BOD during winter when there is no ice cover in the vicinity of the Blackdog power plant. At times of complete ice cover, the maximum waste loading of 5-day (20°C) BOD from these sources should not exceed 6,500 pounds/day. In no case, however, should treatment efficiency be less than that specified in the General Recommendations.

Northern States Power Company Blackdog Plant

3. A water temperature of not greater than 90°F be maintained in the lower Minnesota River. To attain this, the existing cooling pond should be utilized to its fullest extent during the summer at stream flows less than 1500 cfs. During these periods the thermal addition to the Minnesota River should not exceed 13.5 billion BTU/day.

Specific Recommendations - St. Croix River

Municipal Sources

No specific recommendations.

Industrial Sources

No specific recommendations

FEDERAL INSTALLATIONS

Federal installations contribute less than 0.1 percent of the pollution entering the three major streams studied. Although their contributions are small, full consideration is still given to Federal installations, in compliance with Section 11 of the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.)

U.S. Army - Nike Missile Installations

General Recommendations

It is recommended that:

1. A minimum of one hour per day be devoted to proper treatment plant operation and maintenance.

2. The treatment facilities be operated such that removal efficiencies approach those for which the plants were designed.

3. Laboratory analyses and records maintenance consistent with recommendations of the Conference of State Sanitary Engineers for plants of 0.25 mgd capacity be carried out. A report of these functions, including results of analyses, are to be furnished to the Federal Water Pollution Control Administration upon request.

Specific Recommendations

Nike Site No. 20, Roberts, Wisconsin

No specific recommendations.

Nike Site No. 40, Farmington, Minnesota

It is recommended that:

1. Discharge of effluent to the roadside ditch be terminated as soon as possible. The present outfall sewer line should be extended so as to discharge the effluent into the unnamed creek which at present ultimately receives the waste.

2. Continuous chlorination facilities be activated immediately with disinfection sufficient to produce a free chlorine residual of 0.5 mg/l after a 15 minute contact at peak flow rates.

Nike Site No. 70, St. Bonifacius, Minnesota

No specific recommendations.

Nike Site No. 90, Bethel, Minnesota

It is recommended that continuous chlorination facilities be activated immediately with disinfection sufficient to produce a free chlorine residual of 0.5 mg/l after a 15 minute contact at peak flow rates.

U.S. Air Force - Air Defense Command

Osceola, Wisconsin Station

It is recommended that a schedule of maintenance practices be instituted consistent with accepted procedures for operation of oxidation ponds so as to insure satisfactory treatment.

U.S. Army Corps of Engineers

Locks and Dams

It is recommended that:

1. Present plans be continued concerning improvement or replacement of inadequately sized treatment facilities.

2. At stream flows of 7,000 cubic feet per second (cfs) or less (as measured at the St. Paul gage), as much water as possible be passed over bulkheads before the Taintor gates at Lock & Dam No. 2. At flows of 3,000 cfs or less, the equivalent of the inflow to Pool No. 2 should be passed over the bulkheads.

Floating Dredge Thompson

It is recommended that a planned schedule of analyses be continued on effluent from the waste treatment facilities so as to insure adequate removals prior to overboard discharge of effluent.

U.S. Air Force - 934th Troop Carrier Group

Officers Club

It is recommended that the present single compartment septic tank be changed to a two compartment tank. A subsurface tile field of adequate size should be installed to supplement the present field.

SCHEDULE FOR REMEDIAL PROGRAM

MUNICIPALITIES, INSTITUTIONS, AND INDUSTRIES

In light of the excellent progress the MWPCC has made in making various industrial firms and municipalities aware of the need for abatement facilities, the following time schedule for the foregoing remedial program is recommended. The time periods given commence with the issuance of the Conference Summary by the Secretary of the Interior.

a. Submission of preliminary plans for remedial facilities within 6 months.

b. Submission of final design for remedial facilities within 12 months.

c. Financing arrangements for municipalities completed and construction started within 18 months.

d. Construction completed and plants placed into operation within 36 months.

e. Existing schedules of the State agencies calling for earlier completion dates are to be met.

FEDERAL INSTALLATIONS

Schedules for Federal installations requiring only operational and maintenance changes shall be initiated immediately. Changes required at Nike Site No. 40 and the Ft. Snelling Officers Club should be completed and made operational within 6 months.

SCHEDULE MODIFICATIONS

It is recognized that modifications in this schedule may be necessary. These may include:

a. A lesser time where the control agency having jurisdiction considers that a practical method of control can be in operation prior to the time stated.

b. In a few industries and municipalities some variation from this schedule may be sought from the appropriate State and local pollution control agencies. In such cases after review the conferees may make appropriate recommendations to the Secretary of the Department of the Interior.

APPENDIX

EXCERPTS FROM

"RECOMMENDATIONS FOR MINIMUM PERSONNEL, LABORATORY CONTROL AND RECORDS FOR MUNICIPAL WASTE TREATMENT WORKS"

BY

The Conference of State Sanitary Engineers

in cooperation with

U. S. Department of Health, Education, and Welfare

Public Health Service

1963

PLANT CAPACITY 0.25 MGD

Laboratory Control

In a plant of this size, the operator should conduct the following tests:

(1) Settleable solids (Imhoff Cone) once or twice a week using grab samples. The grab samples should be taken at a time of representative flow and should reflect varying days of the week and hours of the day.

(2) Relative stability (methylene blue) daily, Monday through Friday.

(3) Chlorine residual of effluent daily, Monday through Friday; twice daily when stream conditions require.

(4) For activated sludge plants, in addition to the above tests, sludge index tests daily and a colorimetric dissolved oxygen test weekly.

RECORDS

Usually personnel and time limitations will permit the keeping of only minimal records. However, two types of records should be kept: (1) a diary-type log showing a necessarily wide variety of useful and important information such as unusual maintenance work, failure of a piece of equipment, accidents, unusual weather, flooding, bypassing, complaints, visitors, etc; and (2) a tabular record showing the observation or results of each laboratory test made and other available measured data such as plant flow, volume of sludge, or time sludge pumped. Emphasis is placed here on the need for the operator to record the data available to him with strict regularity and in a form best suited to his schedule.

PLANT CAPACITY 0.5 MGD

Laboratory Control

For a plant other than activated sludge the following tests should be conducted:

(1) Settleable solids (Imhoff Cone) daily, Monday through Friday. Tests should be made at varying hours during the day.

(2) Relative stability (methylene blue) daily, Monday through Friday. Tests should be made at varying hours during the day.

(3) Colorimetric pH of raw waste water occasionally.

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(4) Chlorine residual of effluent daily; twice daily when stream conditions require.

(5) Total solids of digested sludge occasionally and when the sludge is drawn to the drying beds.

(6) pH of digested sludge occasionally and when the sludge is drawn to the drying beds.

For an activated sludge plant the following tests should be conducted:

(1) Settleable solids (Imhoff Cone) daily.

(2) Relative stability (methylene blue) daily.

(3) Sludge index daily.

(4) Mixed liquor dissolved oxygen (colorimetrically) daily.

(5) Sludge depth measurements in primary and secondary settling tanks daily.

(6) pH of digested sludge when sludge is drawn.

(7) Total solids of digested sludge when sludge is drawn.

RECORDS

A diary should be kept similar to the 0.25 MGD plant, but with a full-time operator it should be more comprehensive. Regularity is emphasized.

The laboratory control record also is slightly more detailed because of the additional tests specified and with a full-time operator should be maintained withease. Consultation with State regulatory agency representatives, university personnel, and/or other experienced personnel, and attendance at short courses in his State will assist the operator to establish and maintain suitable records. These records should be accurate and complete for the items specified.

PLANT CAPACITY 1.0 MGD

Laboratory Control

For primary and trickling filter plants the following tests are specified:

(1) Settleable solids (Imhoff Cone) daily.

(2) Relative stability (methylene blue) daily.

(3) BOD's of raw waste, final effluent, and of such other components as possible once a week and preferably twice a week. Samples should be 3-hour composites taken at 11 a.m., 12 noon, and 1 p.m.

(4) Suspended solids of raw waste, final effluent and of such other components as possible once a week and preferably twice a week. Samples should be 3-hour composites taken at 11 a.m., 12 noon, and 1 p.m.

(5) pH of digested sludge when drawn or when operating difficulties are experienced or anticipated.

(6) Total solids of digested sludge when drawn or when operating difficulties are experienced or anticipated.

(7) DO of receiving stream at least twice a week above and below the plant discharge.

(8) Chlorine residuals of effluent daily; twice daily, when stream conditions require.

For activated sludge plants the following tests are specified:

(1) Settleable solids (Imhoff Cone) daily.

(2) Relative stability (methylene blue) daily.

(3) BOD's of raw waste, final effluent, and of such other components as possible twice a week. Samples should be 3-hour composites taken at 11 a.m., 12 noon, and 1 p.m.

(4) Suspended solids of raw waste, mixed liquor, and final effluent once a week. Samples should be 3-hour composites taken at 11 a.m., 12 noon, and 1 p.m.

(5) pH of digested sludge when drawn or when operating difficulties are experienced or anticipated.

(6) Total solids of digested sludge when drawn or when operating difficulties are experienced or anticipated.

(7) Depth of sludge in primary and final settling tanks daily.

(8) Sludge index daily.

(9) Dissolved oxygen (colorimetric) of mixed liquor daily.

(10) DO of receiving stream at least twice a week above and below the plant discharge.

(11) Chlorine residual of effluent daily; twice daily, when stream conditions require.

RECORDS

For a plant of this size considerable care and technical competence is required in assembling and recording the data. Included in the supervision should be the understanding and patience needed to interpret the control procedure carried on. To establish and maintain adequate records, some guidance will be needed from State regulatory agency representatives, university personnel, and/or other experienced individuals.

PLANT CAPACITY 5.0 MGD

Laboratory Control

Following are recommended test procedures for plants other than activated sludge:

(1) Settleable solids daily.

(2) Relative stability daily.

(3) Dissolved oxygen of raw waste, effluent and receiving stream above and below the plant discharge 5 days per week.

(4) pH of raw waste and effluent 5 days per week.

(5) BOD's of raw waste and effluents 3 times per week on 24-hour composite samples.

(6) Suspended solids of raw waste and effluents 3 times per week on 24-hour composite samples.

(7) pH of digested sludge when drawn or as necessary to control digester operation.

(8) Total and volatile solids of digested sludge when drawn or as necessary to control digester operation.

(9) Volatile acids of digested sludge when drawn or as necessary to control digester operation.

(10) Chlorine residual of effluent daily, twice daily when stream conditions require.

For activated sludge plants the recommended test procedures are as follows:

(1) Settleable solids daily.

(2) Relative stability or nitrates 5 days per week on 24-hour composite samples.

(3) Dissolved oxygen of raw waste, effluent and receiving stream above and below discharge 5 days per week.

(4) pH of raw waste and final effluent daily.

(5) BOD's of raw waste and effluents 5 days per week on 24-hour composites.

(6) Suspended solids of raw waste and effluents 5 days per week on composite samples.

(7) Sludge index daily on each shift.

(8) Mixed liquor DO (colorimetric) daily on each shift.

(9) Sludge depth in primary and final settling tanks daily on each shift.

(10) pH of digested sludge when drawn or as needed to control digester operation.

(11) Total and volatile solids of digested sludge when drawn or as needed to control digester operation.

(12) Volatile acids of digested sludge when drawn or as needed to control digester operation.

(13) Chlorine residual of effluent daily, twice daily when stream conditions require.

RECORDS

The size of this plant makes it desirable to keep daily records of all operations - many of them on a shift basis. With a full-time superintendent and a staff of trained men, including a chemist in an activated sludge plant, there should be no difficulty in maintaining the records in a highly competent manner. The specified personnel should assure the interpretation and use of the control information in such a way as to obtain the maximum treatment efficiency.

Since this falls in the large plant category there may be considerable flexibility in the form of records and various control procedures. In addition to the recorded laboratory control and diary-type log information, this plant may need to record a number of other determinations. Some of these might include alkalinity, ORP, heavy metals, or certain components indicative of particular industrial waste problems.

There are frequent needs to record other information which contributes markedly to the control procedure. Some of these data include the following:

(1) Weather and wind direction in the event of odor problems.

(2) In addition to the raw waste flow, a record of bypassing.

(3) Amount of course solids handled; i.e., grit screening, dried sludge hauled from beds, or sludge removal from digesters.

(4) Primary and secondary settling tank cleanup - hours of hosing or skimming and/or maintenance, etc.

(5) Trickling filter maintenance - nozzle cleaning, dosing or recirculating pump operation, humus sludge pumping to primary tanks,etc.

(6) Activated sludge operation - air volume and blower operation, volume of sludge return and waste, replacement or cleaning diffusers, etc.

(7) Sludge handling - in addition to volume of sludge pumped and time, such information as amount of recirculation or transfer of digested sludge, gas mixing, supernatant withdrawal, final sludge to drying beds or filters , disposal of sludge from beds, conditioning chemicals for filters, incineration, etc.

Records of the above operations may be kept in a form most convenient to the superintendent. Because of the wide variation in plants of this size and individual needs, the way these records are kept will vary considerably.

PLANT CAPACITY 10.0 MGD (or larger)*

Laboratory Control

Required test procedures for plants other than activated sludge are:

(1) Settleable solids daily.

(2) Relative stability daily.

(3) Dissolved oxygen of raw waste, effluent and receiving stream above and below discharge 5 days per week.

(4) pH of raw waste and effluent daily.

(5) BOD's of raw waste and effluents daily, Monday through Friday, based on 24-hour composite samples.

(6) Suspended solids of raw waste and effluents daily, Monday through Friday, based on 24-hour composite samples.

(7) pH of digested sludge when drawn or as needed to control digester operation.

(8) Total and volatile solids of digested sludge when drawn or as needed to control digester operation.

(9) Volatile acids of digested sludge when drawn or as needed to control digester operation.

(10) Chlorine residuals of effluent daily, twice daily when stream conditions require.

* Note enclosed in parentheses has been added by the Twin Cities-Upper Mississippi River Project.

For an activated sludge plant the required test procedures are:

(1) Settleable solids daily.

(2) Relative stability or nitrates daily on 24-hour composite samples.

(3) Dissolved oxygen of raw waste, final effluent and receiving stream above and below discharge 5 days per week.

(4) pH of raw waste and final effluent daily.

(5) BOD's of raw waste and effluents daily, Monday through Friday, on 24-hour composite samples.

(6) Suspended solids of raw waste and final effluents daily, Monday through Friday, on 24-hour composite samples.

(7) Sludge index daily on each shift. Solids should be determined in conjunction with the BOD and suspended solids determinations.

(8) Mixed liquor DO (colorimetric) daily on each shift.

(9) Sludge depth in primary and final settling tanks daily on each shift.

(10) pH of digested sludge when drawn or as needed to control digester operation.

(11) Total and volatile solids of digested sludge when drawn or as needed to control digester operation.

(12) Volatile acids of digested sludge when drawn or as needed to control digester operation.

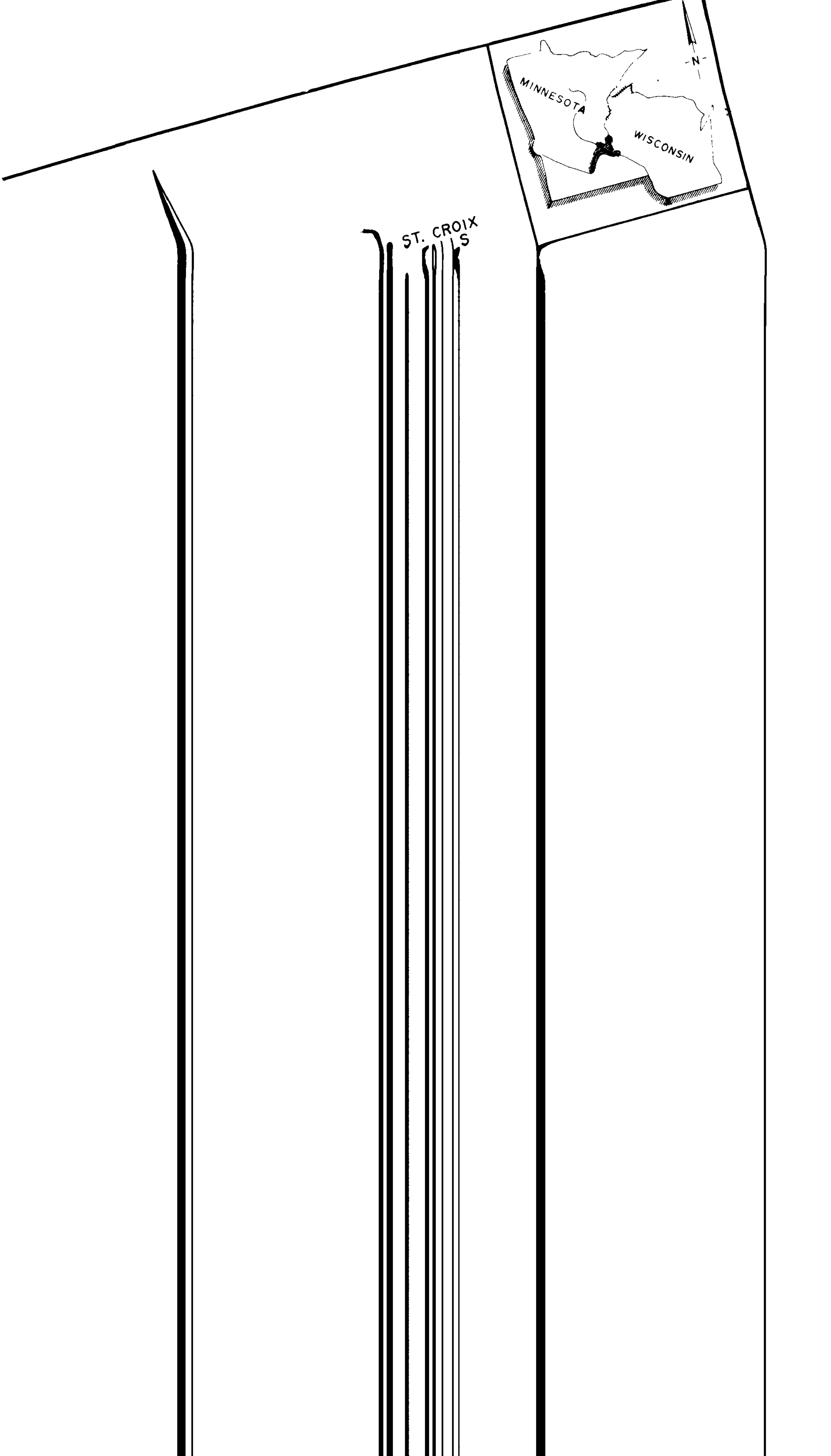
(13) Chlorine residual of effluent daily, twice daily when stream conditions require.

RECORDS

The comments on records for the 5.0 MGD plant also apply to the 10.0 MGD plant. The administrative personnel should select the record style best suited to their specific needs. Many more items of control data also may be desirable, based on the superintendent's judgment and on special conditions.

With a larger staff the 10.0 MGD plant may be able to carry on special projects beyond that possible in the smaller plants. Such projects may include special studies on industrial wastes or operational research projects. These projects may result in published information which can be valuable to many others with similar problems.

A plant of this size normally is expected to produce an annual operating report containing comprehensive records of the year's activities and performance. This procedure enables the superintendent to transform the daily records into summary and unusual information which is quite helpful to others.


MINNESOTA
WISCONSIN
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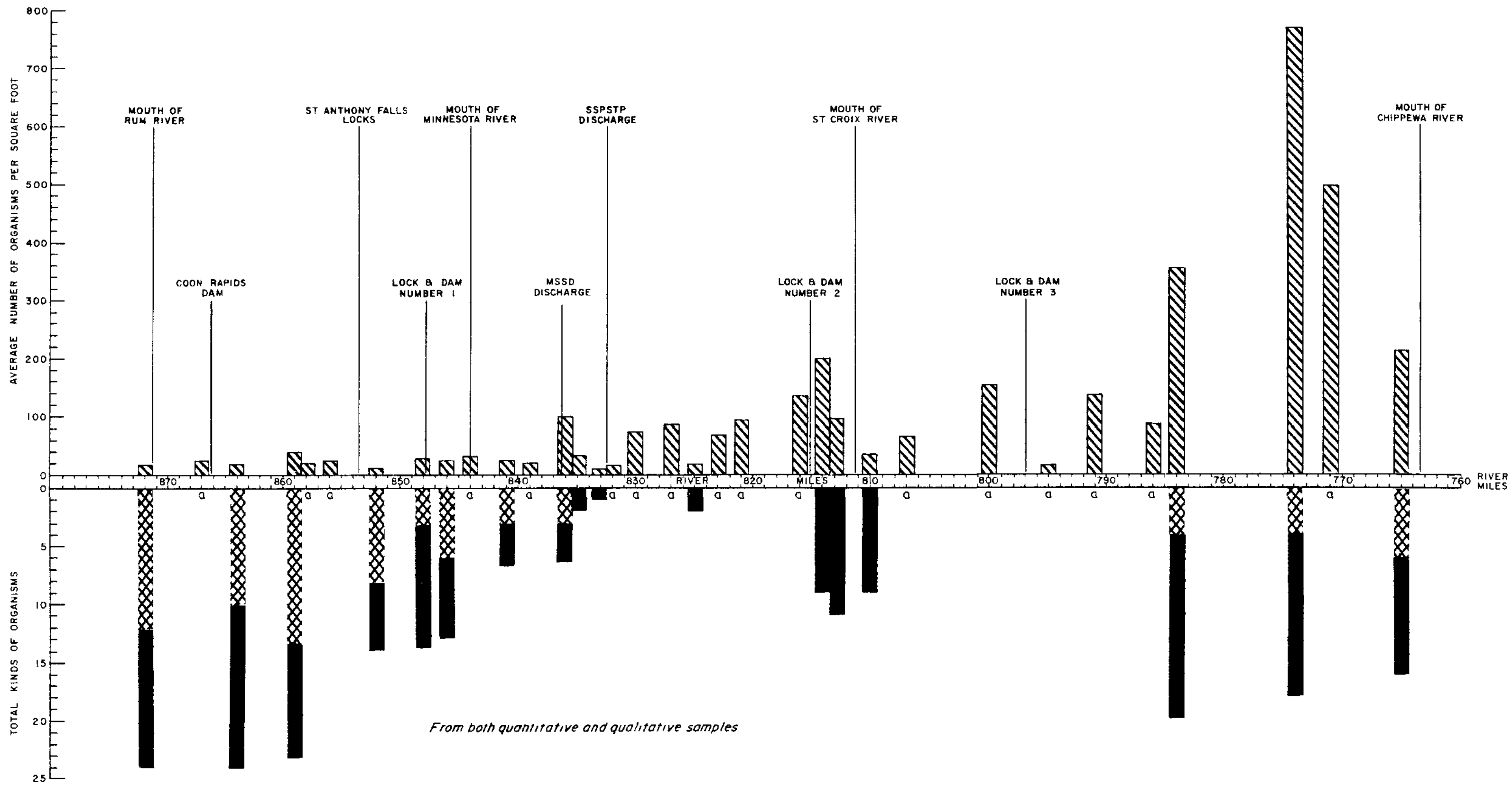
ST. CROIX



LEGEND

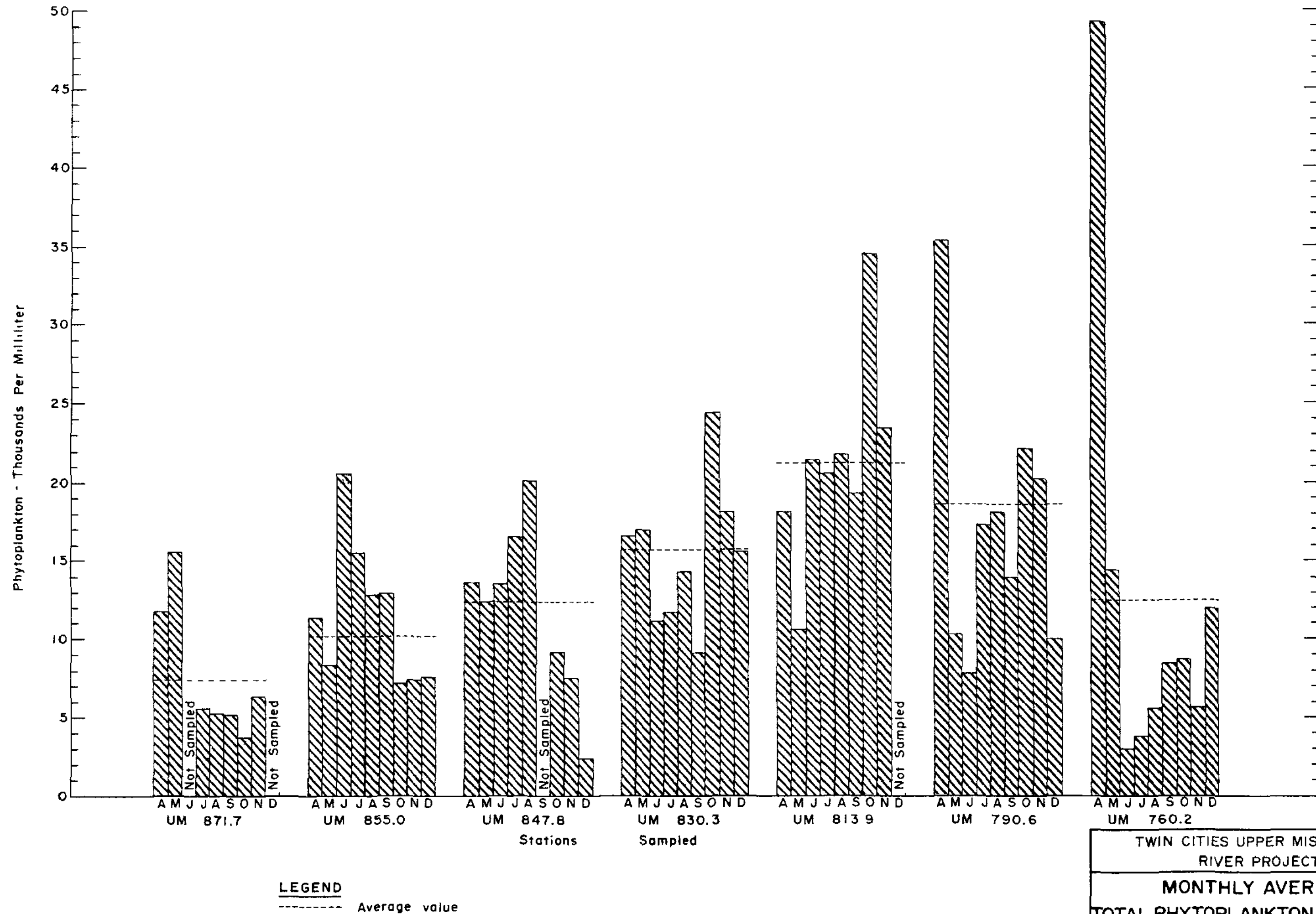
- ■ POLLUTION TOLERANT ORGANISMS
- ▩ POLLUTION SENSITIVE ORGANISMS
- MSSD MINNEAPOLIS ST PAUL SANITARY DISTRICT
- SSPSTP SOUTH ST PAUL SEWAGE TREATMENT PLANT
- a COMPARATATIVE QUALITATIVE SAMPLING AREAS NOT AVAILABLE

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

BOTTOM ORGANISM DATA
MISSISSIPPI RIVER
1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-14

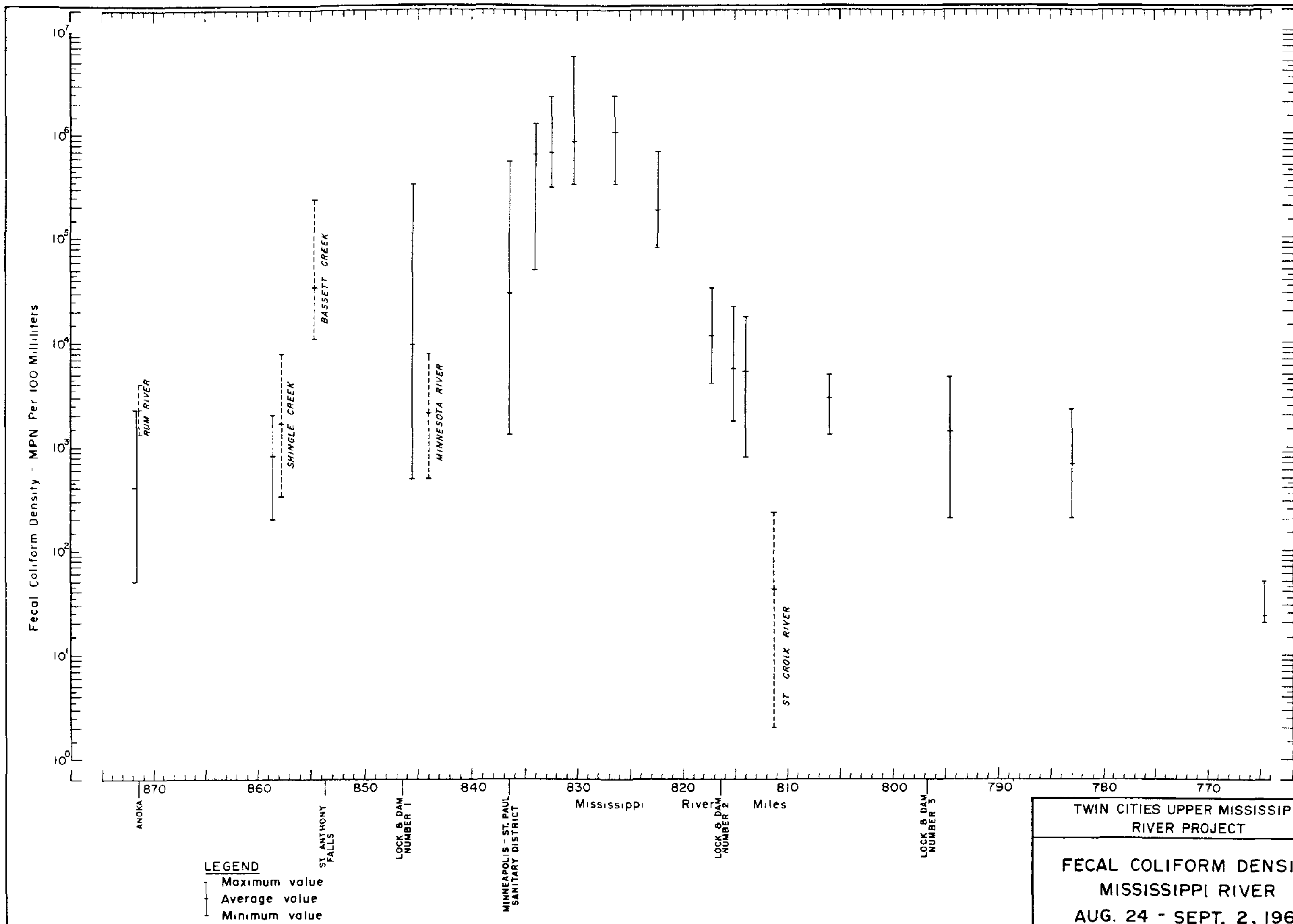


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

MONTHLY AVERAGE
TOTAL PHYTOPLANKTON DENSITIES
MISSISSIPPI RIVER
APRIL - DECEMBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-13

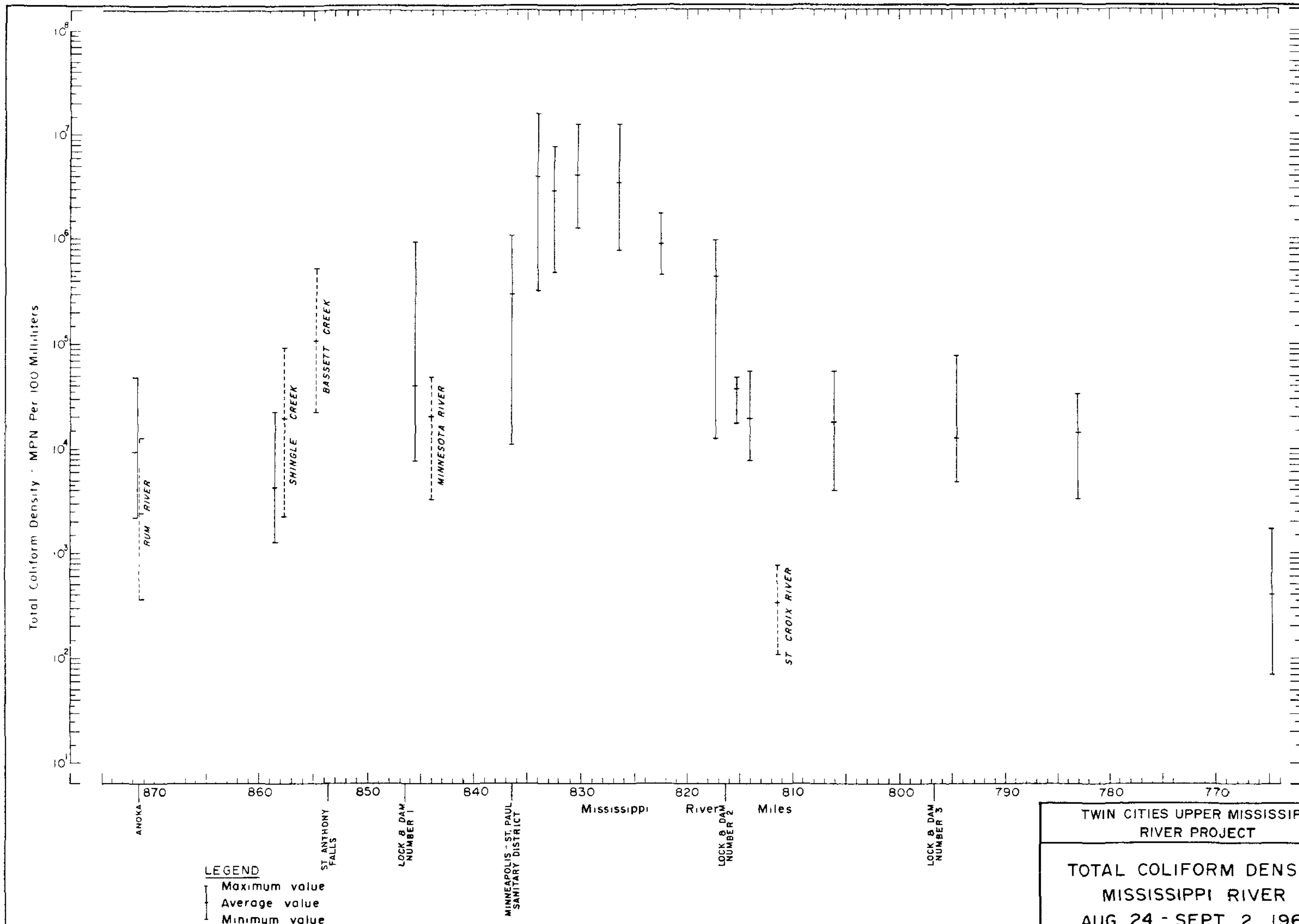


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

FECAL COLIFORM DENSITY
MISSISSIPPI RIVER
AUG. 24 - SEPT. 2, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-12

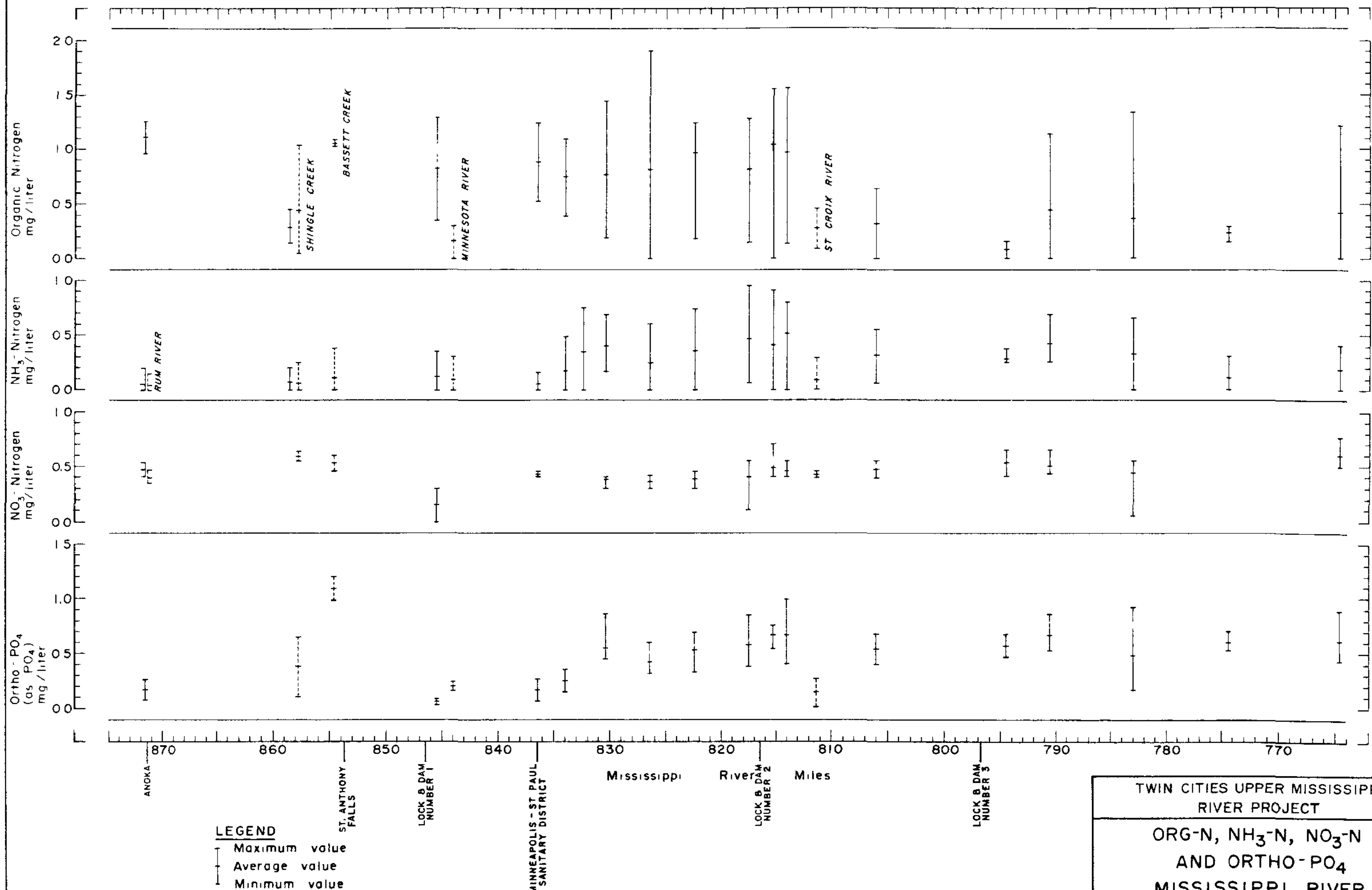


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TOTAL COLIFORM DENSITY
MISSISSIPPI RIVER
AUG. 24 - SEPT. 2, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-11

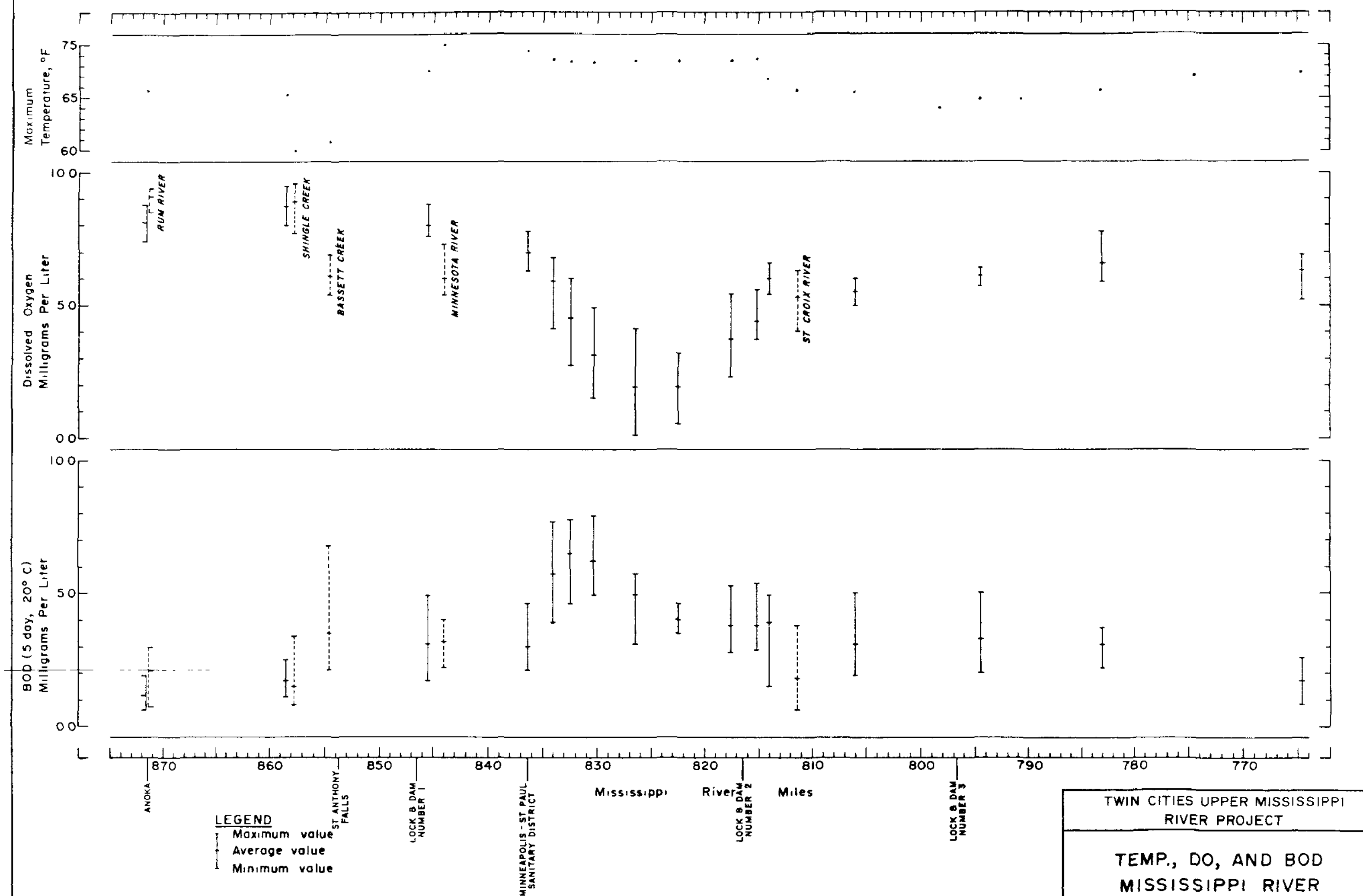


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

ORG-N, NH_3-N, NO_3-N AND ORTHO-PO_4
MISSISSIPPI RIVER
AUG. 24 - SEPT. 2, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-10

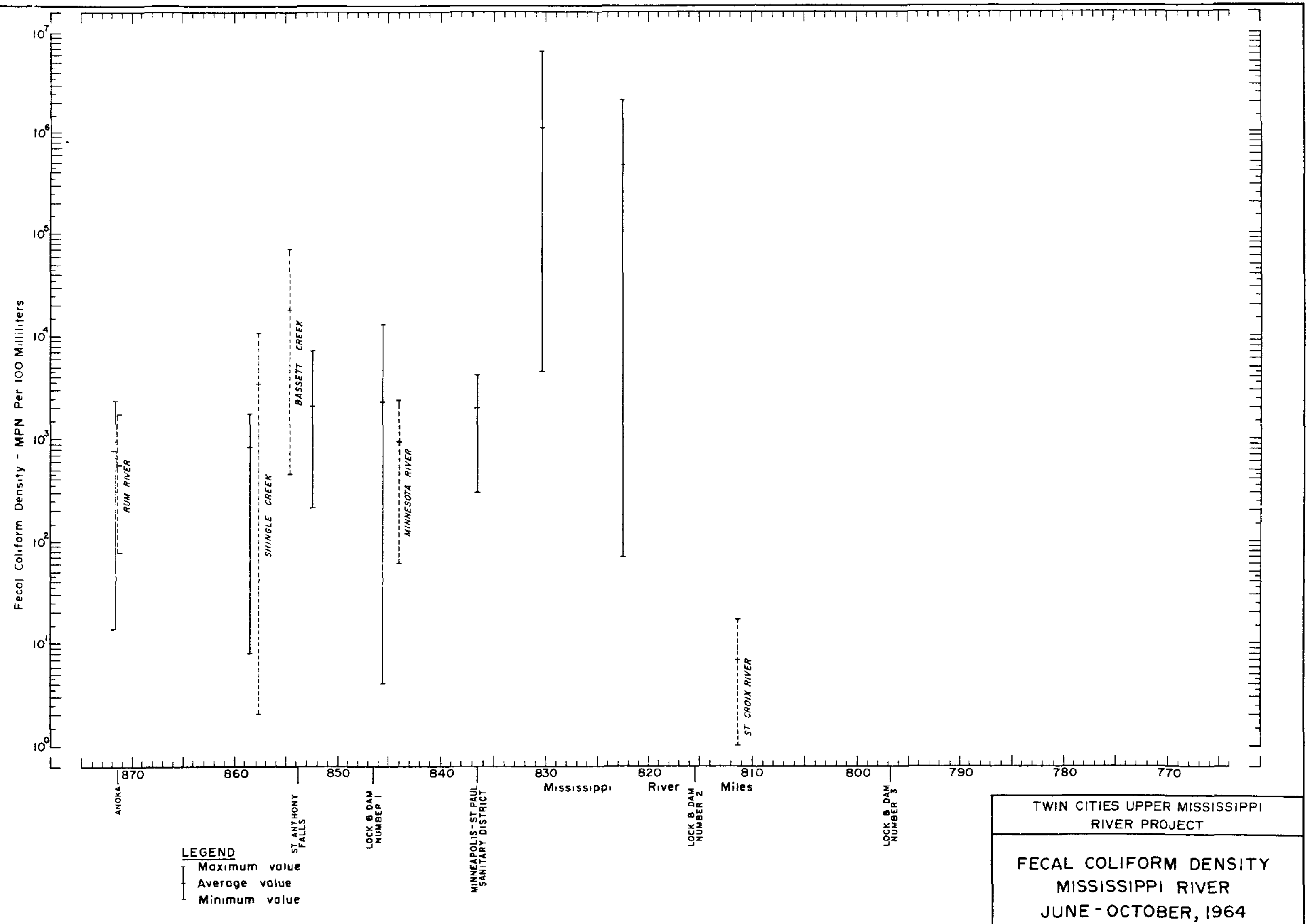


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., DO, AND BOD
MISSISSIPPI RIVER
AUG. 24 - SEPT. 2, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-9

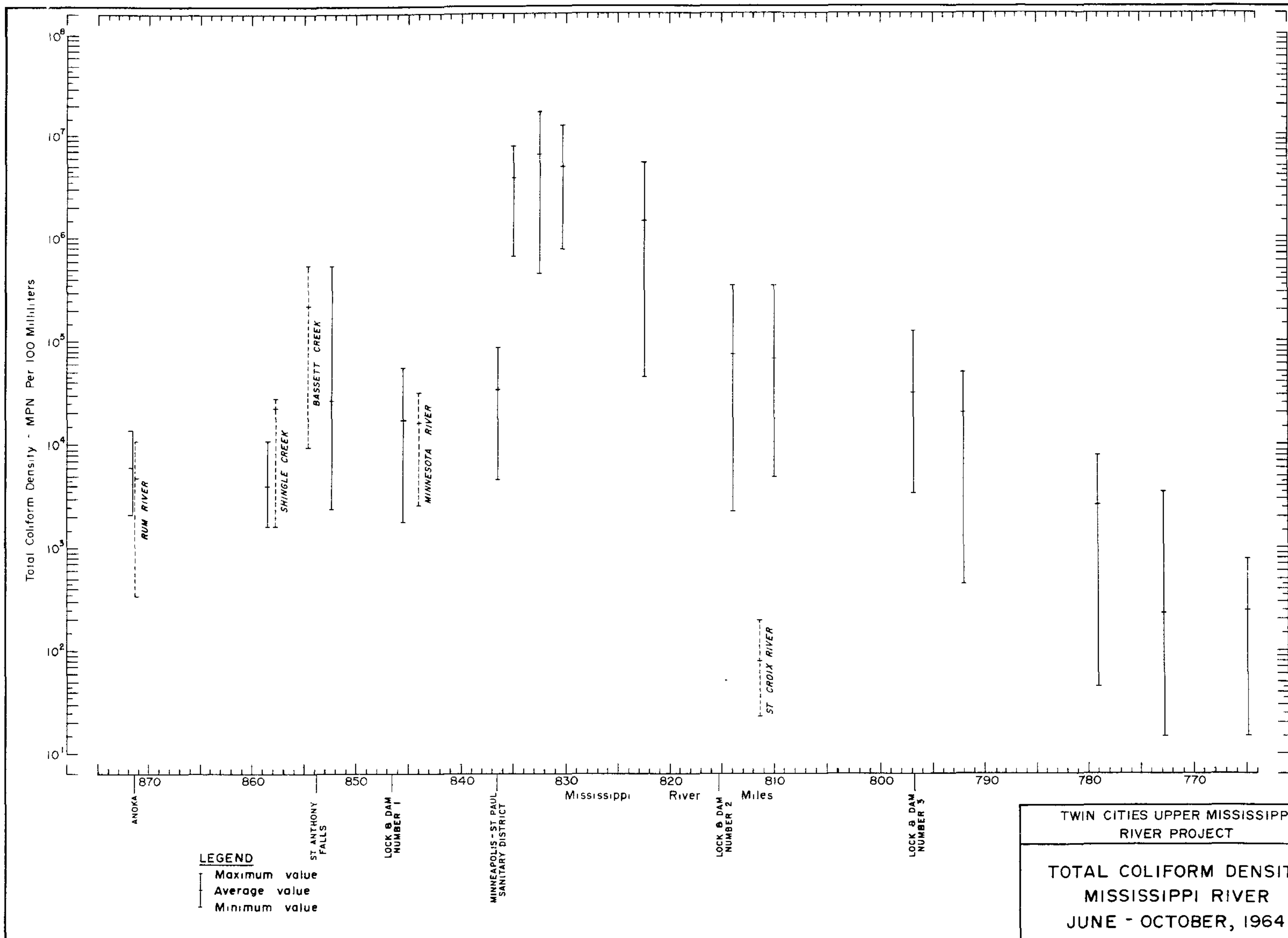


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

FECAL COLIFORM DENSITY
MISSISSIPPI RIVER
JUNE - OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-7

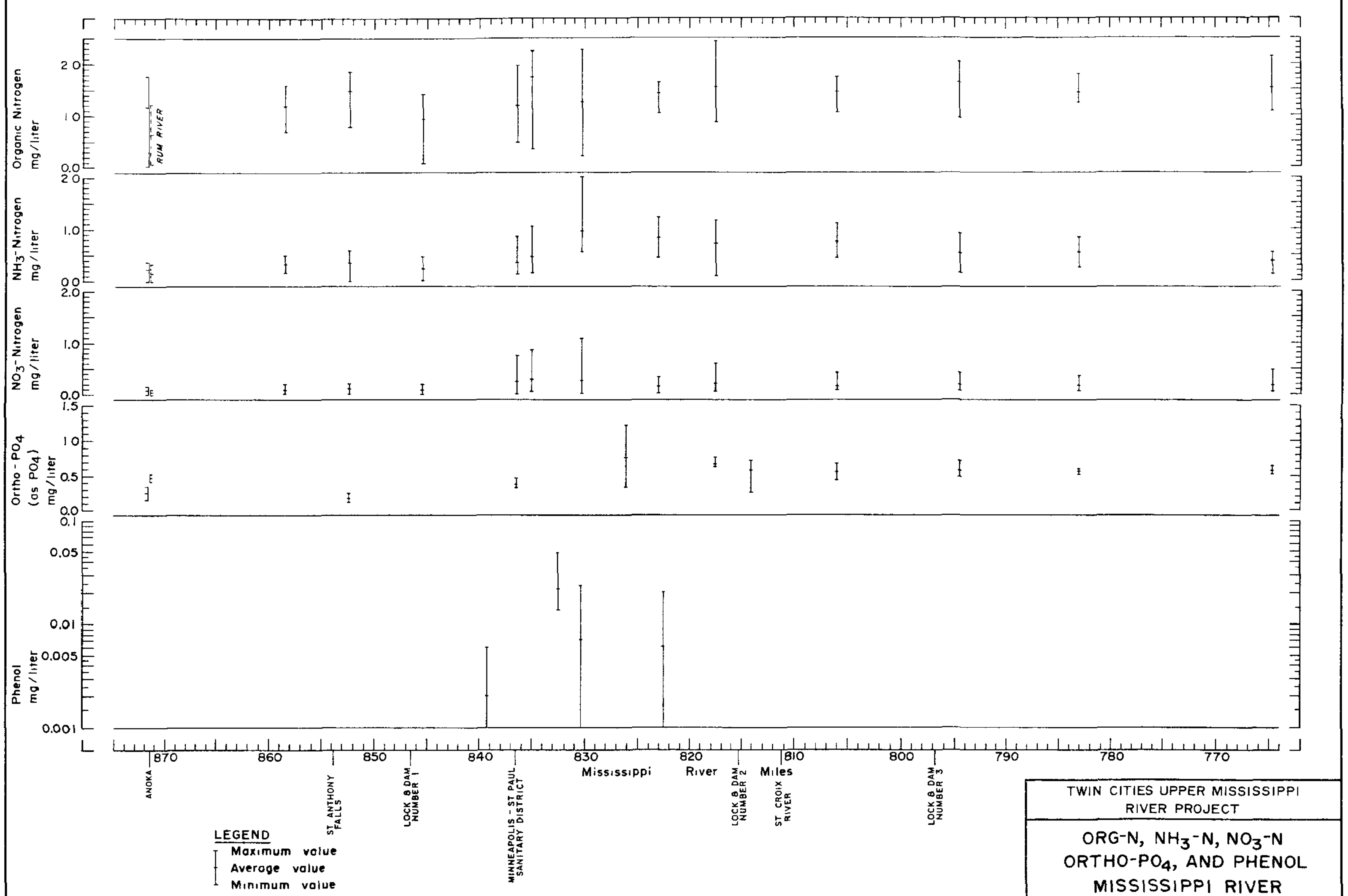


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TOTAL COLIFORM DENSITY
MISSISSIPPI RIVER
JUNE - OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-6

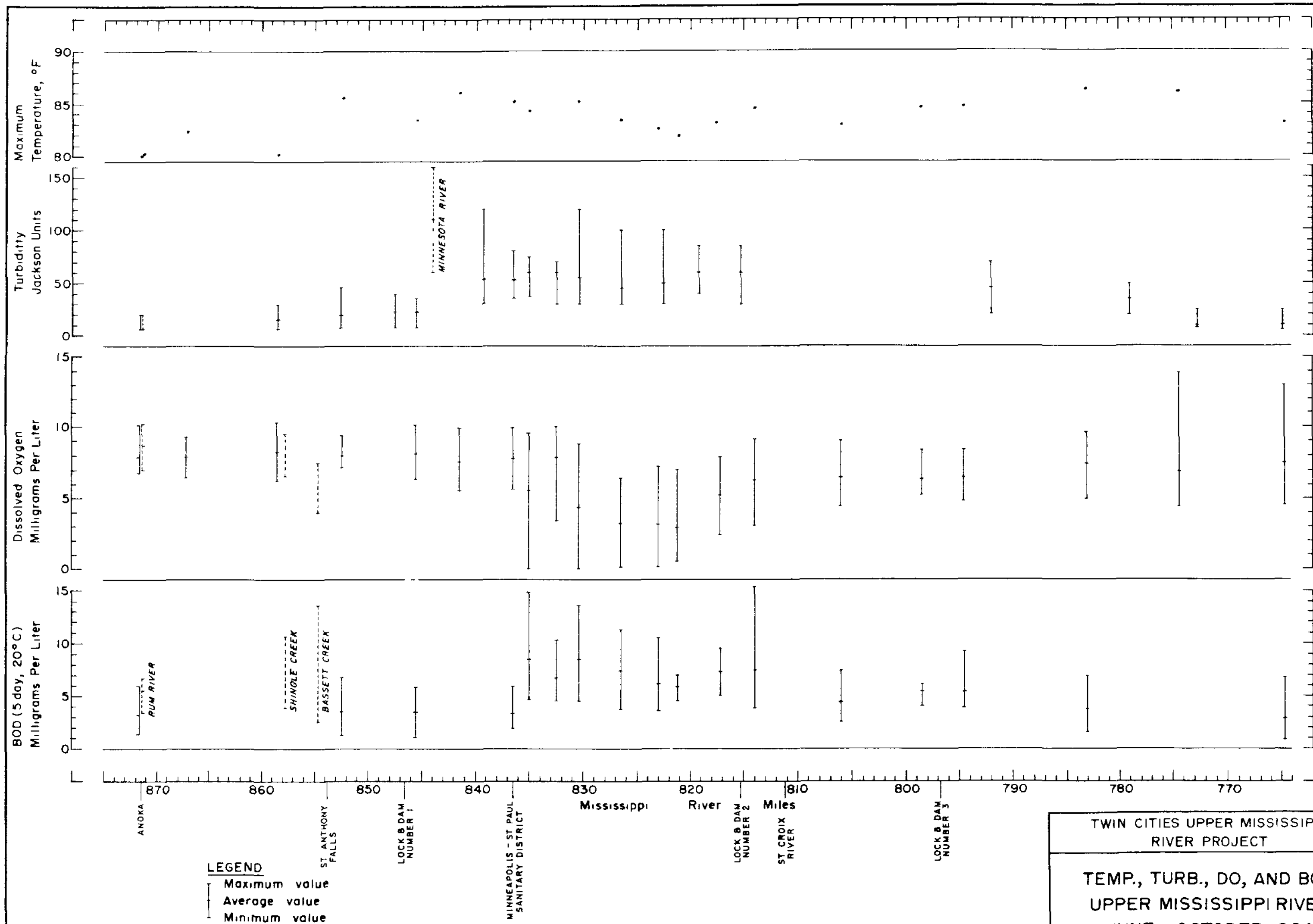


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

ORG-N, NH_3-N, NO_3-N
ORTHO-PO_4, AND PHENOL
MISSISSIPPI RIVER
JUNE - OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-5



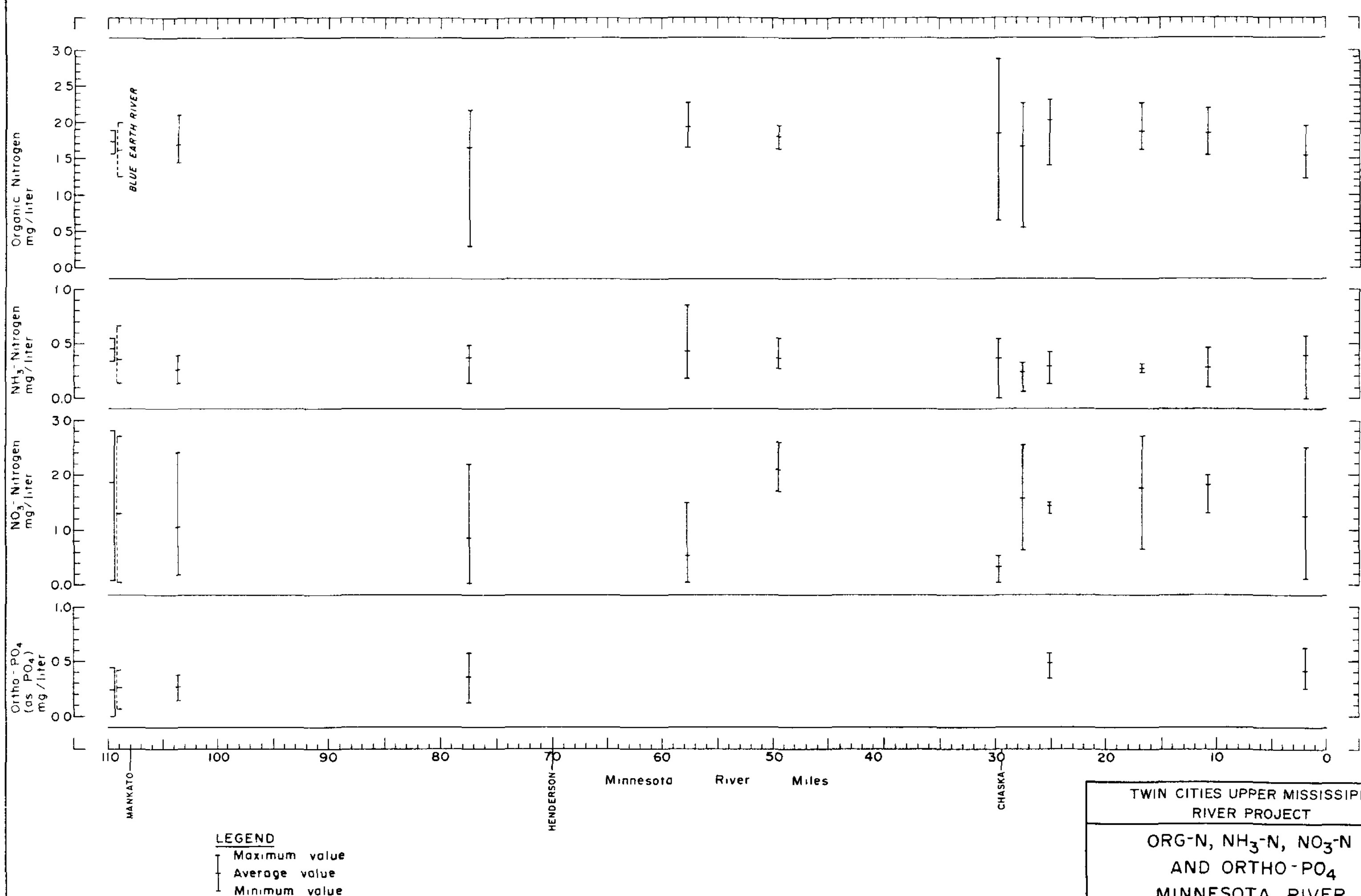
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., TURB., DO, AND BOD
UPPER MISSISSIPPI RIVER
JUNE - OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-4

GPO 828-545



TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

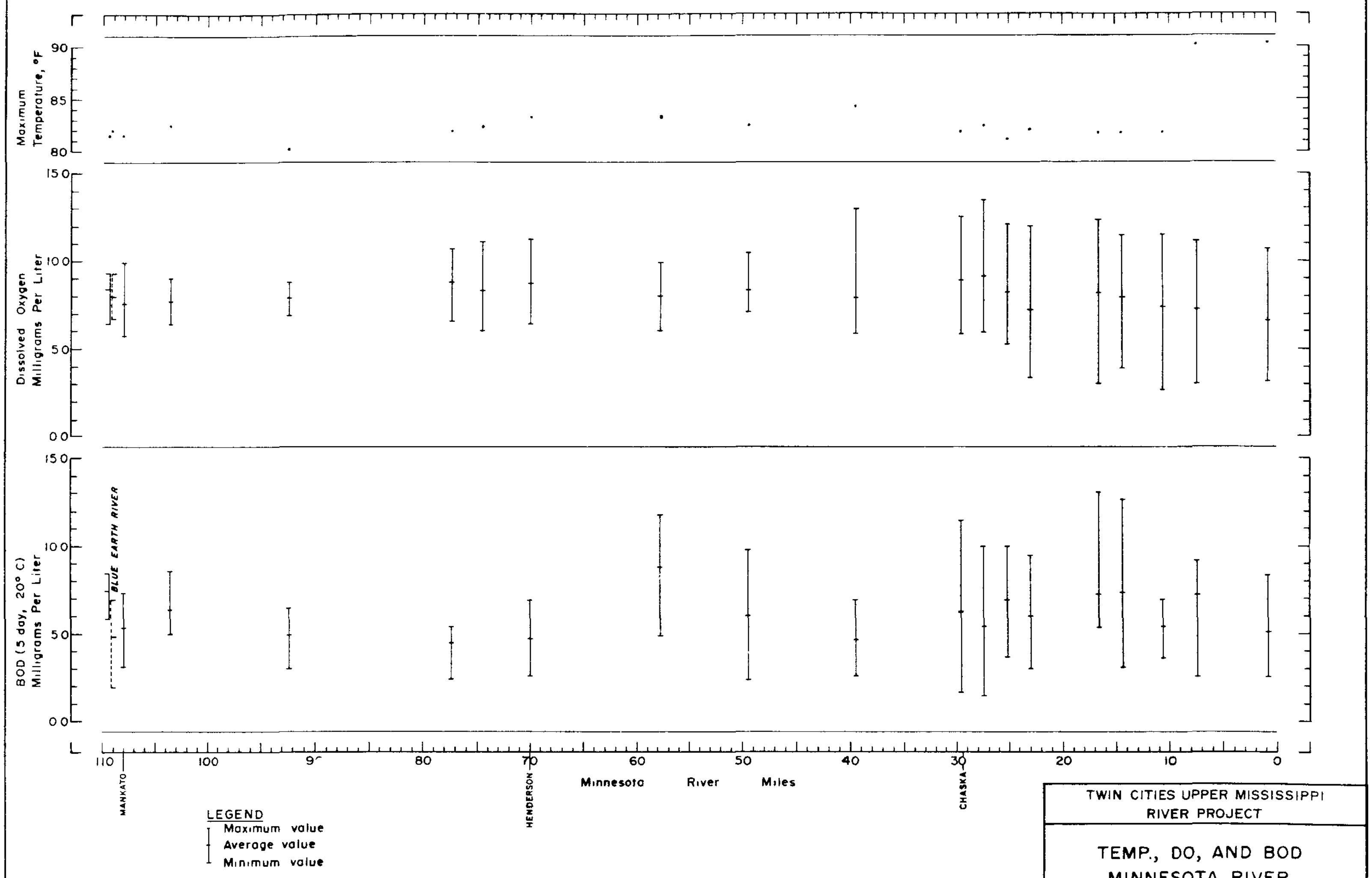
ORG-N, NH_3-N, NO_3-N AND ORTHO-PO_4

MINNESOTA RIVER

JUNE - OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-19

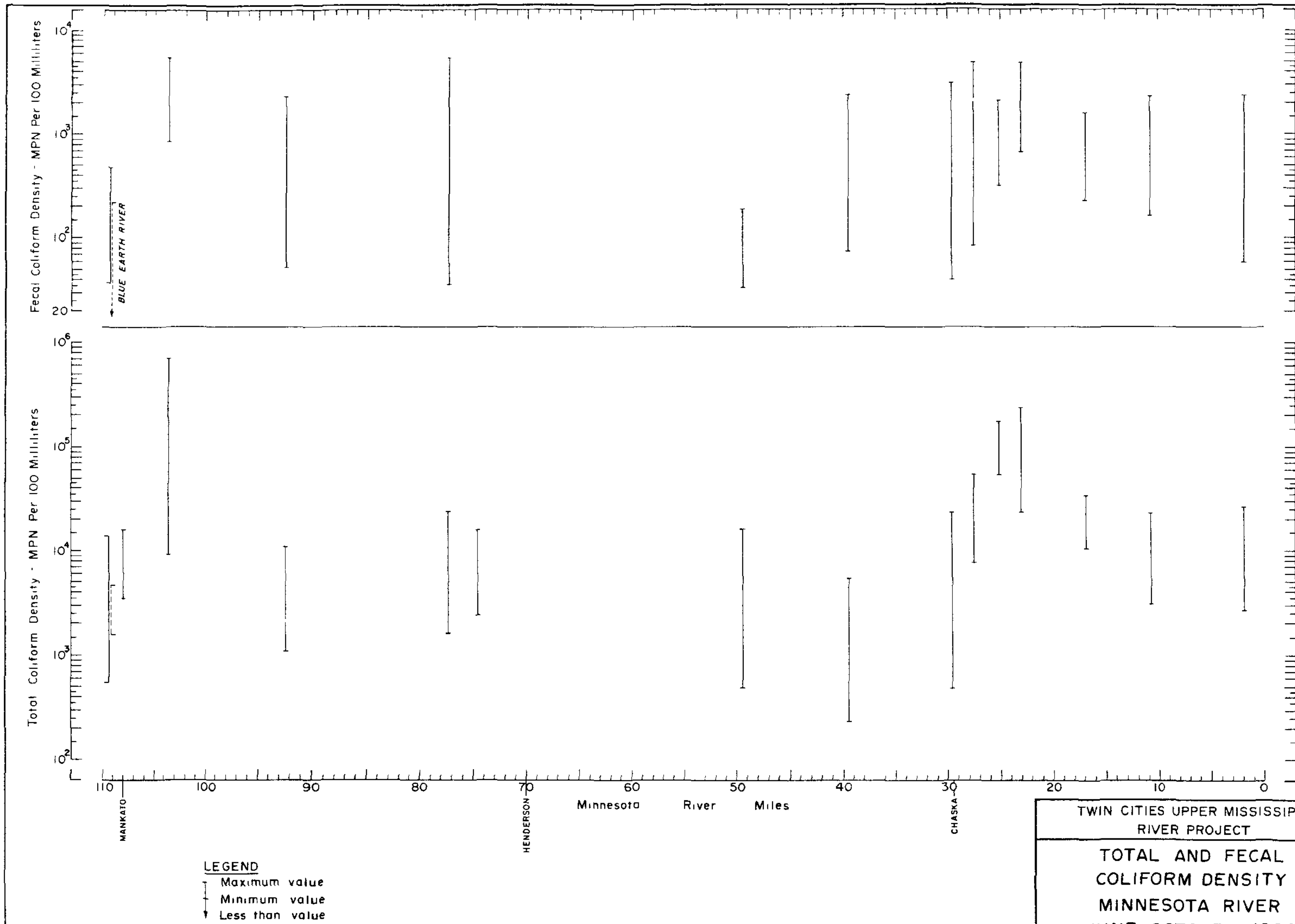


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., DO, AND BOD
MINNESOTA RIVER
JUNE - OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-18

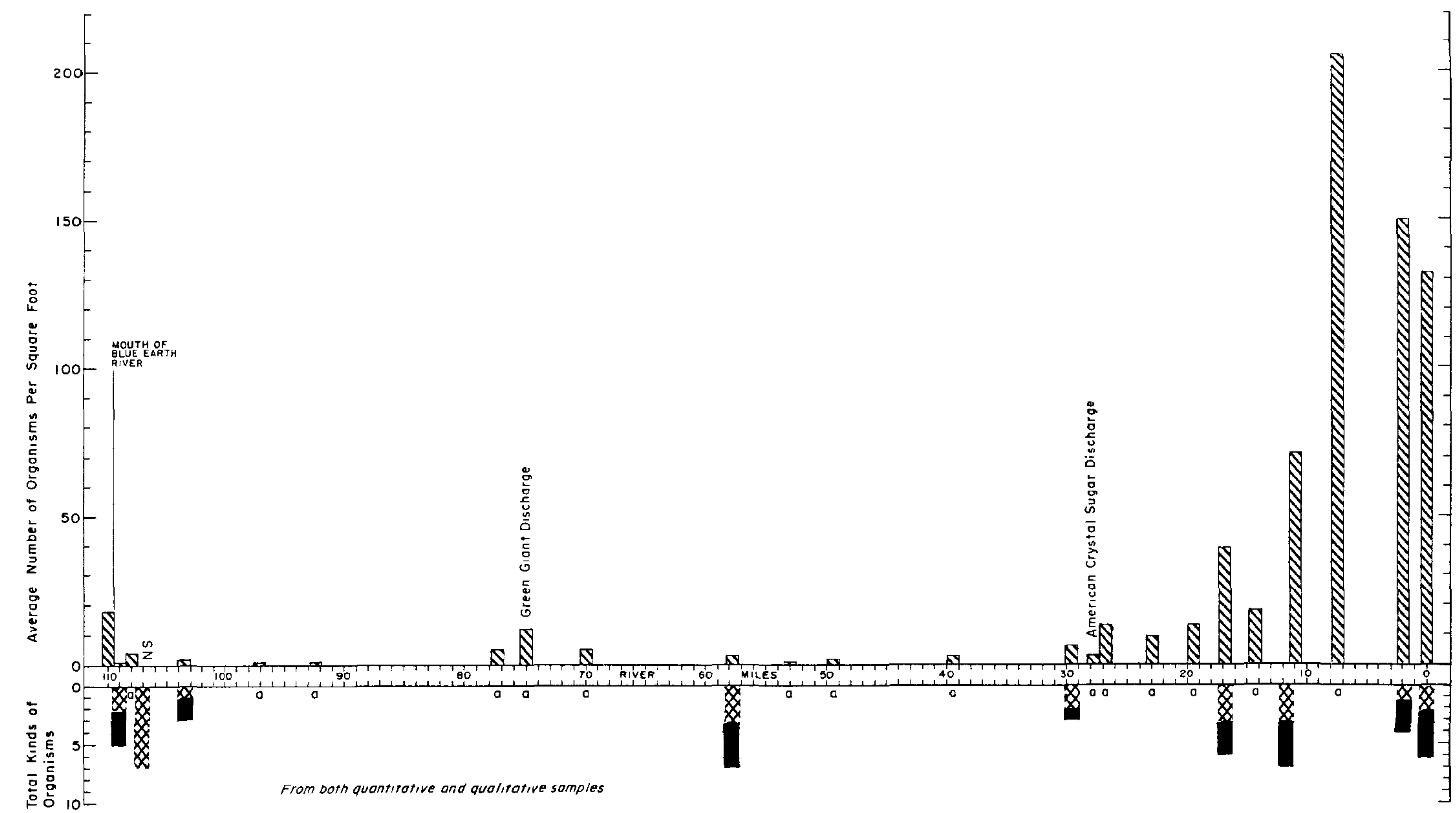


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TOTAL AND FECAL COLIFORM DENSITY MINNESOTA RIVER JUNE-OCTOBER, 1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-20



LEGEND

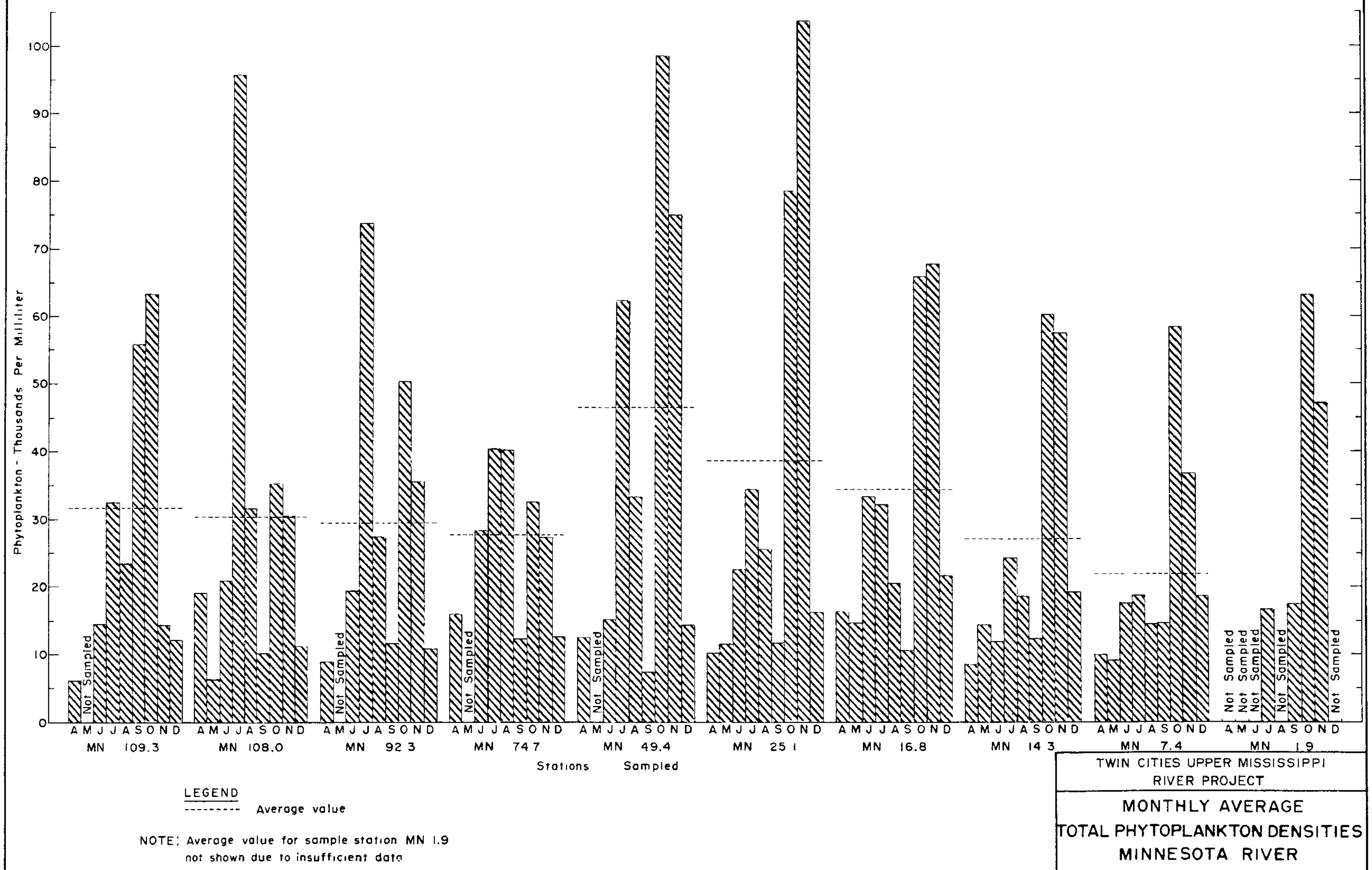
■ Pollution tolerant organisms
XX Pollution sensitive organisms
a Comparative qualitative sampling areas not available
NS Not sampled quantitatively

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

BOTTOM ORGANISM DATA
MINNESOTA RIVER
1964

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-26

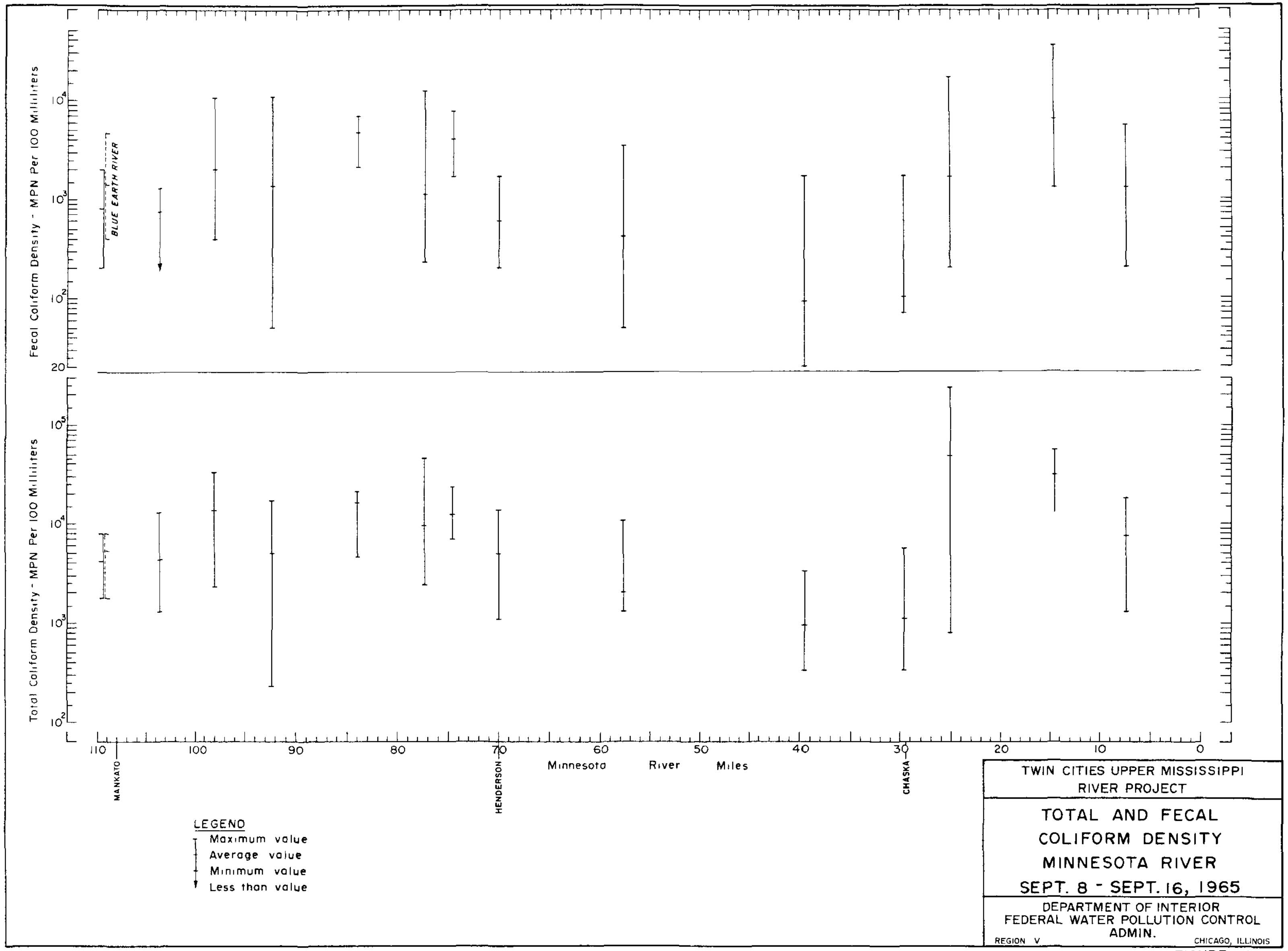


TWIN CITIES UPPER MISSISSIPPI
RIVER PROJECT

MONTHLY AVERAGE
TOTAL PHYTOPLANKTON DENSITIES
MINNESOTA RIVER
APRIL - DECEMBER, 1964

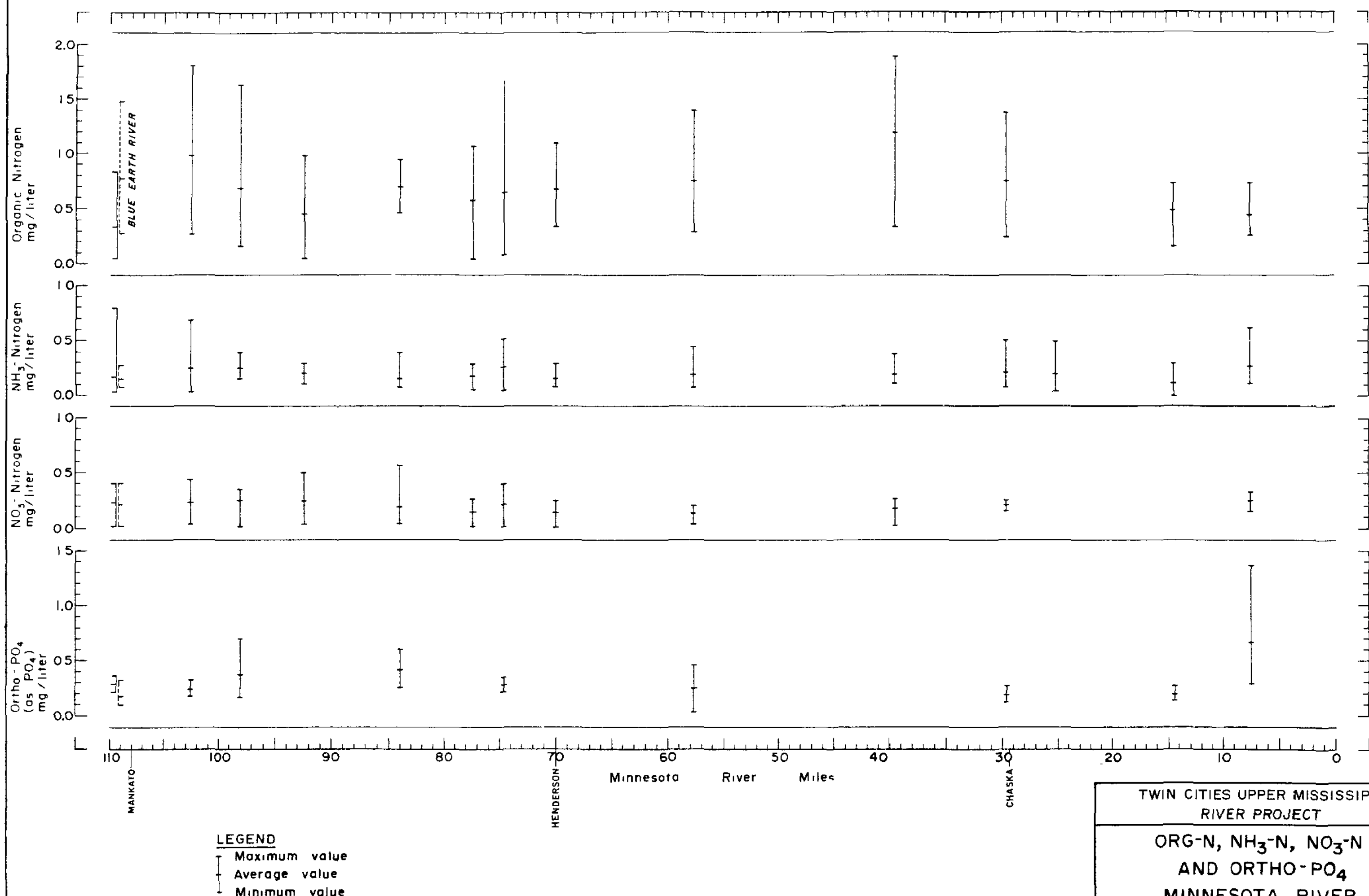
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL
ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-25



Fecal Coliform Density - MPN Per 100 Milliliters
Total Coliform Density - MPN Per 100 Milliliters
BLUE EARTH RIVER
MANKATO
HENDERSON
CHASKA
Minnesota River Miles
LEGEND
Maximum value
Average value
Minimum value
Less than value
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT
TOTAL AND FECAL COLIFORM DENSITY MINNESOTA RIVER
SEPT. 8 - SEPT. 16, 1965
DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V
CHICAGO, ILLINOIS

FIGURE V-24

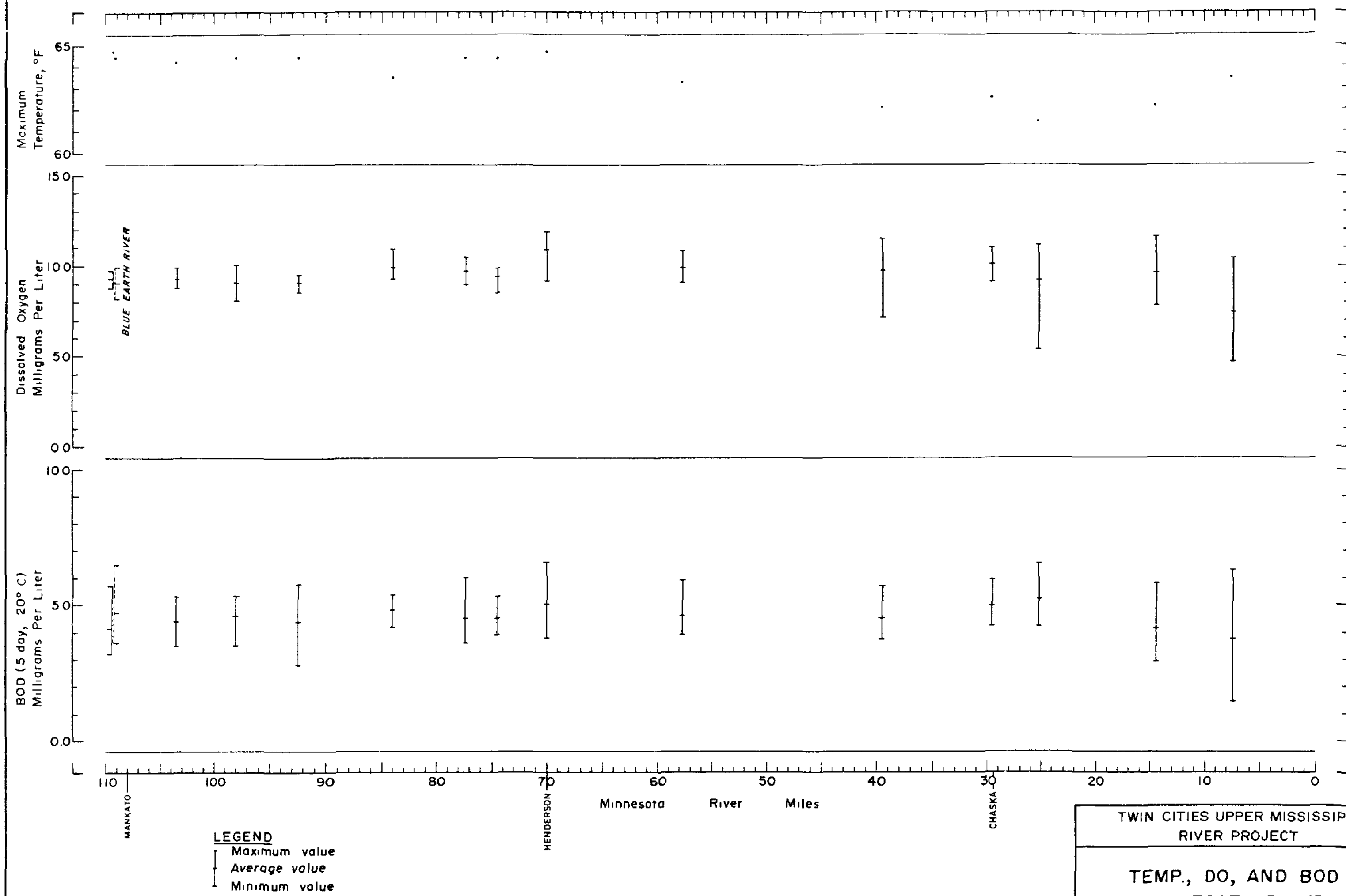


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

ORG-N, NH_3-N, NO_3-N AND ORTHO-PO_4
MINNESOTA RIVER
SEPT. 8 - SEPT. 16, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-23

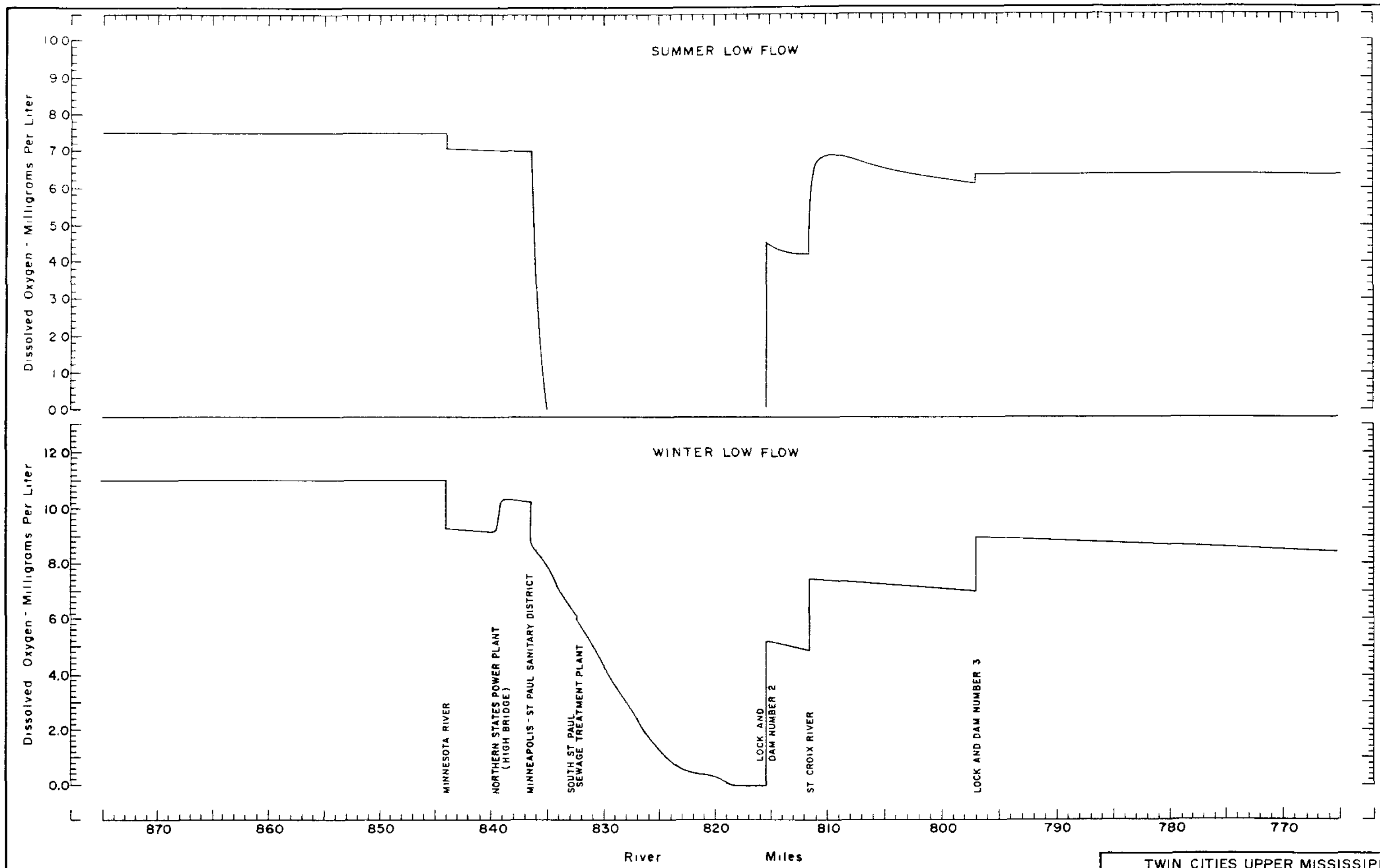


TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

TEMP., DO, AND BOD
MINNESOTA RIVER
SEPT. 8 - SEPT. 16, 1965

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
REGION V CHICAGO, ILLINOIS

FIGURE V-22



NOTES 1. Waste loadings found during 1964 and 1965 were used in calculating the above curves.
2. Summer and winter low flows are considered as the 7-consecutive day, once in 10-year low flow.

TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PREDICTED
DISSOLVED OXYGEN PROFILE
AT LOW FLOW
MISSISSIPPI RIVER

DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
REGION V CHICAGO, ILLINOIS

FIGURE V-36