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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
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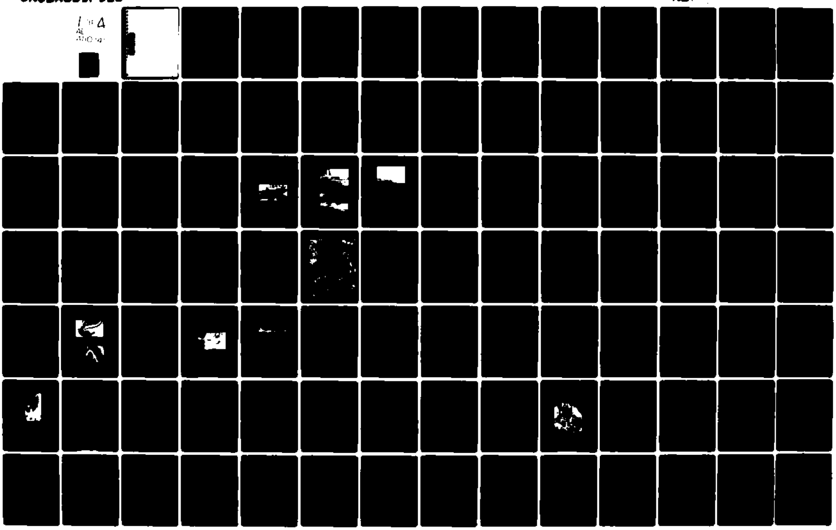

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The overall objects of this report are to assess the impacts of Corps of Engineers' activities on the Minnesota River from Shakopee, Minnesota downstream to its mouth. The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life, geology and water quality. This includes the habitats of rare and endangered species. Socioeconomic systems include industrial and recreational activities, and cultural considerations, such as archaeological and historic sites.

FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

MINNESOTA RIVER POOL

of the Northern Section of the UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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FOREWORD

Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement . . . on the environmental impact of the proposed action." The Act deals only with proposed actions. However, in keeping with the spirit of the Act, the U. S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U. S. Army Corps of Engineers contracted with the North Star Research Institute to prepare a report assessing the environmental impact of the Corps of Engineers' operations and maintenance activities on the Mississippi River from the head of navigation in Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from the heads of navigation at Shakopee and Stillwater, Minnesota, respectively, to the Mississippi River. This portion of the Mississippi River basin will be subsequently termed the "Northern Section" of the upper Mississippi River, the "study area", or "the St. Paul District".

The Corps of Engineers has been active in the Northern Section since the 1820's, when they first removed brush and snags from the river to permit navigation as far north as Fort Snelling. Later, in the 1870's, further improvements were made primarily through construction of wing dams, to deepen and maintain the channel. Presently, the river in the study area consists of a series of pools which were created by the construction of navigation locks and dams in the 1930's.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the construction and operation and maintenance of the Corps' nine-foot channel project on the Northern Section. The operations and maintenance include operations of facilities (locks and dams) and navigation channel maintenance (dredging and "snagging"). Actually, the impacts on the environment of the Corps' pre-nine-foot-channel operations are also being sought, but most of the information will concern the impacts of the present navigation system.

The studies are designed to identify the impacts and to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it will be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps' activities. The study will provide a comprehensive basis for the St. Paul District to prepare an environmental impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U. S. Army Corps of Engineers.

Scope of Current Report

The present report covers the complete study program, from January 15, 1973 through November 1973. It was preceded by a Phase II interim Report, which was completed July 1, 1973. The new report contains both historical information, and information and data collected in the field from activities such as water quality investigations and sampling of riverbank vegetation.

Research Approach

Three aspects of the research approach used in the study deserve clarification: (1) the benchmark point in time, (2) data collection and analysis of the natural systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Time Period

In order to analyze the impact of the Corps' nine-foot channel project in the Northern Section of the Upper Mississippi River, it is necessary to select a point in time that can serve as a benchmark. This benchmark is the time activities related to the nine-foot channel that were initiated. Because the Lock and Dam 2 raised the water surface in the Minnesota River and was constructed in the 1930's, the preconstruction benchmark was taken as 1930. However, it was not until 1958 that the Corps took over maintenance of the private nine-foot channel which had been dredged in the Minnesota River to Savage in 1943. Wingdams were built and other Corps activities took place prior to 1930, however, and these are discussed as preproject activities. The preproject benchmark data were obtained from available reports and from a variety of other sources cited at the end of each section.

Analysis of the Natural Systems

The impacts of Corps activity on the natural environment for a given pool were determined by the individual investigator responsible for that particular pool. The Northern Section of the upper Mississippi River was subdivided into fourteen distinct segments for purposes of study of the natural environment: Pools 1 through 10, Pool 5A (lying between Pools 5 and 6), the Upper and Lower Saint Anthony Falls (SAF) Pools (a single report covers both pools), the Minnesota River and the St. Croix River. A segment was assigned to an investigator on the natural sciences team, as listed below:

Number of River Pools and Miles Involved		Navigation Pools	Chief Investigator	Organization
5	92.4	Upper and Lower SAF Pools, Pool 1, Pool 2, Minnesota River, and St. Croix River	Roscoe Colingsworth	North Star Research Institute, Minneapolis, Minnesota
1	18.3	Pool 3	Edward Miller	St. Mary's College Winona, Minnesota
4	82.6	Pools 4, 5, 5A & 6	Calvin Fremling	Winona State College Winona, Minnesota
2	35.1	Pools 7 & 8	Thomas Claflin	University of Wisconsin, LaCrosse, Wisconsin
1	31.3	Pool 9	James Eckblad	Luther College, Decorah, Iowa
1	32.8	Pool 10	Edward Cawley	Loras College, Dubuque, Iowa

Because different problems arise in different segments of the Mississippi River, each investigating team used its own judgment in conducting its studies. However, North Star -- in conjunction with the investigators cited above -- developed general guidelines for conducting the field studies, acquiring data, and presenting the data in a final report. This required that North Star develop a format that could be used for all pool reports so that the series of reports would have maximum utility and comparability.

Analysis of Socioeconomic Activities

The socioeconomic analysis for all pools in the study area was conducted by a team including Dr. C. W. Rudelius of the University of Minnesota and Mr. W. L. K. Schwarz of North Star. The socioeconomic impacts were analyzed by the same team for all fourteen segments of the Northern Section because substantial economies in data collection were possible with this approach. The initial data for each pool were collected and then were submitted for review and updating to the investigator analyzing the natural systems for that pool. The suggestions of these investigators were incorporated in the socioeconomic portions of each pool report.

Report Objectives

The Corps is required to submit an environmental impact statement for each pool and tributary in the Northern Section on which they carry out operation and maintenance activities; thus, as far as is practical this study was carried out by pools.

The present report deals only with the Minnesota River from Shakopee downstream to its mouth, which is described in detail in subsequent pages. Other reports in this series deal with the other pools and tributaries comprising the Northern Section of the upper Mississippi River. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested only in a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to the Minnesota River. Specifically, following this section, the report is in the format required for the environmental impact statement, and seeks:

1. To identify the environmental, social and economic impacts of the Corps activities related to the Minnesota River.
2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effects of Corps activities.
3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers,

other public agencies, and private groups to reduce detrimental aspects of the project.

4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water. This includes the habitats of rare and endangered species and tracts of special value for environmental education.

Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams; recreational activities, such as fishing, boating, or hunting that are related to Corps operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

INTRODUCTION

The present Corps of Engineers' project on the Minnesota consists of a navigation channel from Shakopee, Minnesota, to the mouth of the River (See Figure 1 and 2). The Corps maintains a nine-foot-deep channel, generally at a width of 100 feet, upstream to Mile 14.7 near Savage, Minnesota, and a four-foot-deep channel from Mile 14.7 to Mile 25.6 at Shakopee. However, the Peavey Company dredges the channel an additional five feet to a total depth of nine feet between Mile 14.7 and the Peavey terminal at Mile 21.8. The Corps must review their plans prior to issuance of a permit to dredge and to dispose of dredgings.

The nine-foot depth for the navigation channel in the Minnesota River is maintained by dredging only. The use of locks and dams on this river was not necessary, because a minimum water surface elevation of 687.2 is maintained upstream to Shakopee by Lock and Dam 2, River Mile 815.3. Thus, navigation on the Minnesota is continuous with Pool 2 but, because this project was authorized separately, this study treats the navigable Minnesota River as a separate "pool".

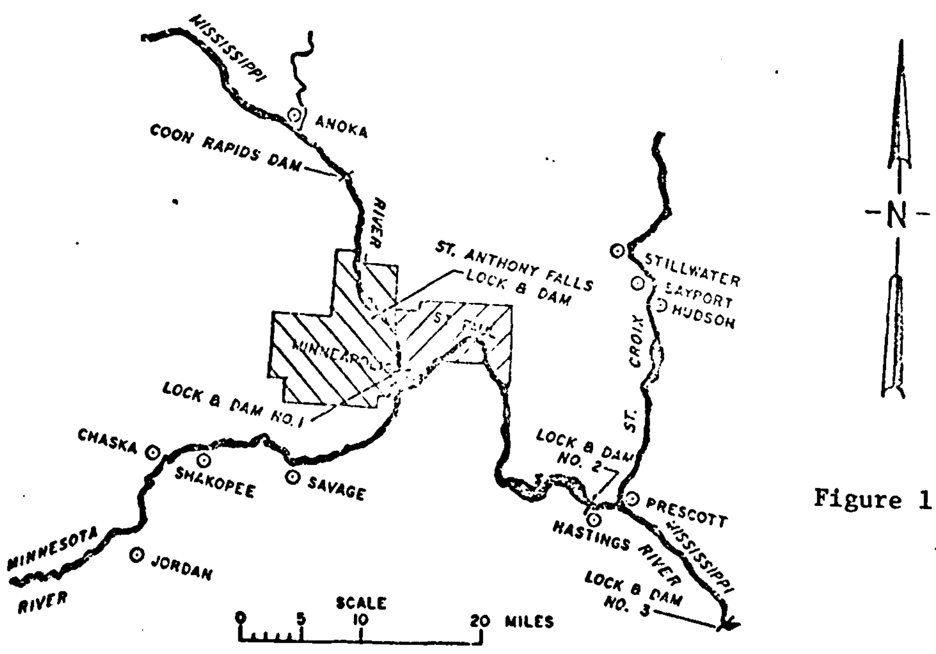
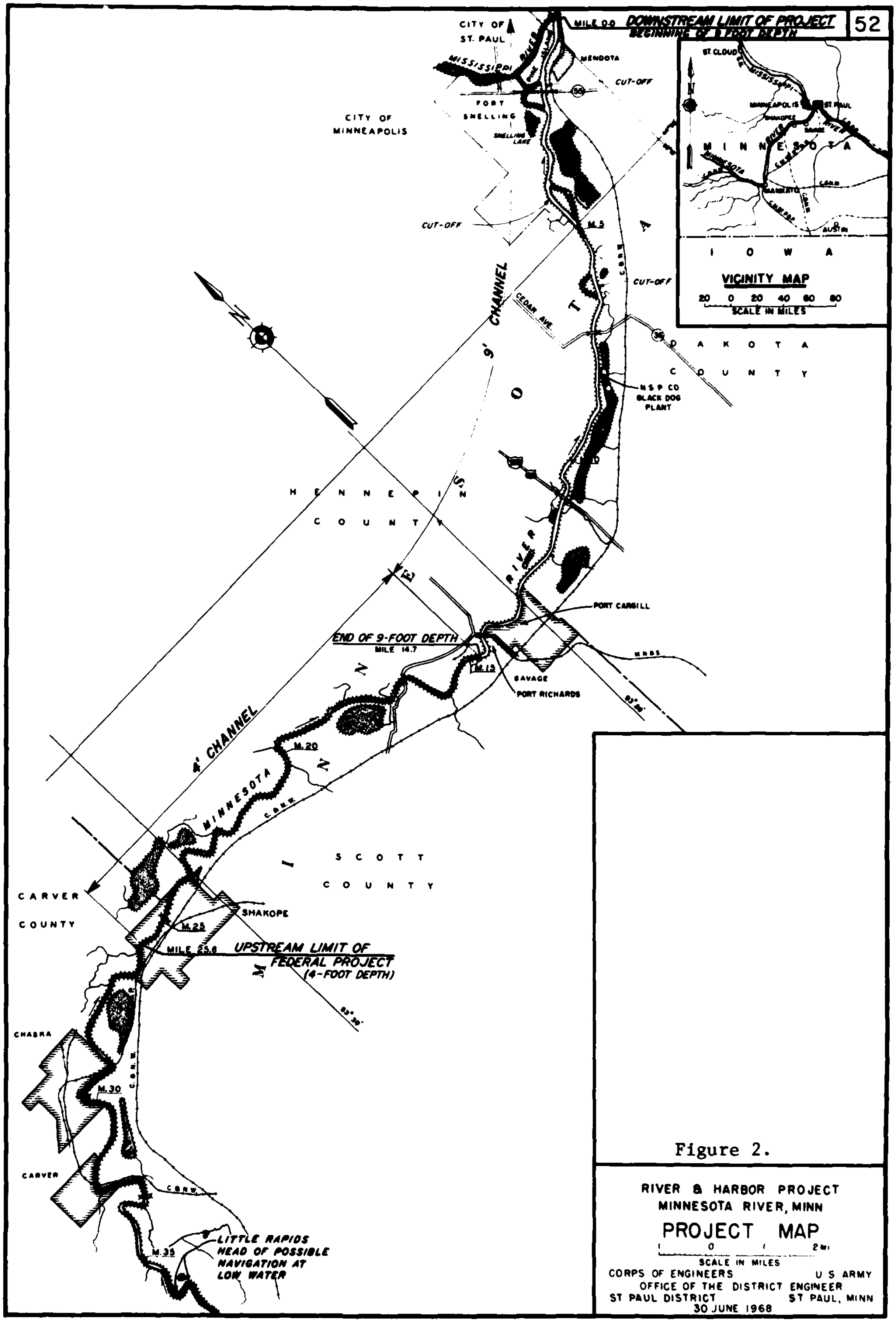


Figure 1. The Mississippi River and its Major Tributaries in the Twin Cities Area.


52
MILE 0.0 DOWNSTREAM LIMIT OF PROJECT
BEGINNING OF 9 FOOT DEPTH
CITY OF ST. PAUL
MISSISSIPPI RIVER
MENDOTA
CUT-OFF
FORT SNELLING
SNELLING LAKE
CITY OF MINNEAPOLIS
CUT-OFF
M.5
CUT-OFF
CEDAR AVE.
9' CHANNEL
DAKOTA COUNTY
N S P CO BLACK DOG PLANT
HENNEPIN COUNTY
MINNESOTA
RIVER
PORT CARGILL
END OF 9-FOOT DEPTH
MILE 14.7
M.15
SAVAGE
PORT RICHARDS
4' CHANNEL
M.20
MINNESOTA
SCOTT COUNTY
CARVER COUNTY
SHAKOPEE
M.25
MILE 25.6 UPSTREAM LIMIT OF FEDERAL PROJECT
(4-FOOT DEPTH)
CHASKA
M.30
CARVER
C&NW
M.35
LITTLE RAPIDS
HEAD OF POSSIBLE NAVIGATION AT LOW WATER
ST. CLOUD
MISSISSIPPI
MINNEAPOLIS
ST. PAUL
SHAKOPEE
MINNESOTA
MANKATO
AUSTIN
IOWA
VICINITY MAP
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SCALE IN MILES
RIVER & HARBOR PROJECT
MINNESOTA RIVER, MINN
PROJECT MAP
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SCALE IN MILES
CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN
30 JUNE 1968

Figure 2.

AUTHORIZATION

Congress authorized the nine-foot channel, between the mouth and Mile 14.7 of the Minnesota River, by the Rivers and Harbors Act of July 3, 1958 (See Table 1). The four-foot channel presently maintained by the Corps between Miles 14.7 and 25.6 was authorized by Congress with the Rivers and Harbors Act of July 13, 1892. Intervening acts authorized dredging, operation of snagboats, establishment of the nine-foot channel in the Mississippi River from the Illinois River to Minneapolis.

Table 1. Congressional Authorizations Pertinent to the Nine-Foot Channel in the Minnesota River (Sec. of Army, 1957; S.P.D.-NCS, 1970).

Rivers and Harbors Acts	Work Authorized	Authorizing Documents
1867*	Removal of snags and boulders from Yellow Medicine River to mouth.	House Document 58, 39th Congress, 2nd Sess
July 13, 1892	Four-foot channel from Shakopee to mouth.	House Document 150, 58th Congress, 1st Session
Sept. 22, 1922	Dredging to landing places.	None
July 3, 1930, Amended by H.R. No. 10, Feb. 24, 1932	Complete survey for 9-foot channel, modify permanent structures under construction to accommodate 9-foot channel; Chief of Engineers granted discretionary authority to modify plans as deemed advisable.	House Document 290, 71st Congress, 2nd Session
June 26, 1934	Operation of snagboats; care and operation of locks and dams.	None
Aug. 26, 1937	Adopt 9-foot channel project from Illinois River to Minneapolis.	House Document 137, 72nd Congress, 1st Session
	[Dredge 9-foot channel to Port Cargill (Mile 13.1), near Savage, Minn., in 1943]	[Authorized by the Secretary of the Army]

*Date of the letter by the Secretary of War transmitting the Corps of Engineers' Report to Congress, later printed as part of the House Document 58.

Table 1 (Cont.). Congressional Authorizations Pertinent to the Nine-Foot Channel in the Minnesota River (Sec. of Army, 1957; S.P.D.-NCS, 1970)

Rivers and Harbors Acts	Work Authorized	Authorizing Documents
Mar. 2, 1945	Changes or additions to payments, remedial works, or land acquisitions authorized by Rivers and Harbors Act of August 26, 1937 (House Doc. 137, 72nd Congr., 1st Session), as Chief of Engineers deems advisable.	None
Mar. 2, 1945	Survey of Minnesota River from a point 10 miles above New Ulm to the mouth.	None
July 3, 1958	Extend 9-foot channel to Savage, Minn.	House Document 144, 84th Congress, 2nd Session

HISTORY

Navigation of the Mississippi River began when the sternwheeler "Virginia" reached Fort Snelling in 1823. In the early 1820's infrequent trips were also made on the Minnesota River a short distance upstream from the Fort. In 1824 Congress authorized the Corps of Engineers to improve navigation on the Mississippi River.

Commercial navigation increased when southern Minnesota was opened for settlement by the signing of the Treaty of Traverse des Sioux in 1851. Regular traffic was established on the Minnesota River by 1865, when sternwheeled "packet" boats navigated on daily schedules upstream as far as Fort Ridgely. In 1867, one boat made as many as 90 round trips between Mankato and St. Paul (Ryder, 1972). In the same year Congress authorized the Corps to extend snag and boulder removal from the Mississippi River up the Minnesota River to the mouth of the Yellow Medicine River (Mile 236.7) (See Table 1). This project was essentially completed by 1879.

A decline in river transportation began in 1870 due to navigation hazards, a limited and uncertain navigation season, and competition among packet boat operators with the railroad and, later, the highways (Ryder, 1972). Improvement of the Minnesota River for commercial navigation was undertaken by means of a four-foot channel, which was authorized by Congress in 1892. The channel extended from Shakopee (Mile 25.6) to the mouth of the River, and was completed by 1931. The Corps is still authorized to maintain the four-foot channel in the River from Mile 25.6 to 14.7 as part of the present channel improvement on the Minnesota. (No records are available giving data on four-foot channel snagging and dredging.)

Nevertheless, commercial traffic on the Minnesota River continued to decline, reaching the point where no commerce was reported from 1910 to 1941, except for shipment of a couple thousand tons in 1920. At least part of the reason for this was decline in precipitation and persistence at the low water stages during the drought years of the 1930's. However, pleasure boats continued to use the channel.

On the Mississippi River the nine-foot channel was authorized by Congress with the Rivers and Harbors Acts of 1930 and 1937. Dam 2 at Hastings was completed as part of this project in 1930, raising pool elevation to 684.0 until May of 1935 when it was raised to the present 687.2 feet above mean sea level (1912 datum). This dam raised the water surface at the mouth of the Minnesota by about one foot, and as much as about 0.2 feet at Shakopee.

In 1943 the Corps of Engineers dredged the Minnesota River channel five additional feet to a total depth of nine feet, from the mouth upstream to Mile 13.1, mainly with funds supplied by Cargill, Inc. (Sec. of War, 1957). At the upstream terminus, a twenty-foot deep launching basin and thirteen-foot deep mooring basin were dredged as part of Port Cargill. The company also provided 10 acres of land (transferred by fee to the United States) at Mile 12.0 for construction of a cut-off (No. 4) in order to avoid a rock ledge (Petersen's Bar) in the natural channel (Sec. of War, 1935). The new nine-foot channel permitted Cargill to float downstream eighteen oceangoing tankers the company built for the Navy, and four towboats built for the Army, for use in World War II.

After the war, five more commercial terminals were established on the Minnesota River. The additional five-foot depth, below the Corps' authorized four-foot channel, was maintained by these private interests for thirteen years by permit from the Corps. No record is available of the quantities or sites of disposal.

In 1958, Congress authorized the Corps to maintain the nine-foot channel upstream to Mile 14.7. A cut-off (No. 1) was dredged from Mile 1.8 to 3.0 in order to eliminate two sharp bends which were difficult to navigate. An earth-filled closing dam was constructed across the upstream end of the by-passed natural channel to insure flow through the new cut-off. Two other cut-offs were also dredged, at Mile 4 (No. 2) and at Mile 6 (No. 3) (See Figure 2).

Numerous surveys of the river have been made for various purposes including geological, navigation, flood control, power and irrigation surveys. The present Corps project is based upon a 1952 survey to determine the feasibility of improving the River by means of a nine-foot channel for commercial navigation. Surveys made by the Corps date back to the topographic and geological surveys of General G. K. Warren made in 1866-67. Apparently the earliest account of the character of the Minnesota River was made by Jonathon Carver in 1776 (Sec. of War, 1875 and 1957; See also Sec. of War, 1935).

Several series of charts of the Minnesota River have been published by the Corps, including (1) a combined Corps and Minnesota Department of Waters (now Division of Waters, Soils and Minerals, MN DNR) in survey made from 1897 to 1910; (2) the 1932 Silting Investigations; (3) the 1967 Alignment and Profile; and (4) the latest "Navigation Charts" (1972).

CORPS FACILITIES

The nine-foot channel in the Minnesota River is maintained by dredging and snagging, and with the aid of water levels maintained by Lock and Dam 2. The only structures are the two earth-fill closing dams which exist on the cut-off (No. 1) in Ft. Snelling State Park (See Figure 2). At present, the culverts in these dams are not large enough to allow passage of any craft, even canoes.

Federal land included in the project includes 46.2 acres which was transferred by fee from the Departments of the Army and the Air Force. Local interests gave perpetual easement to another 123.1 acres.

Total cost of the project on the Minnesota River is $2,416,924, of which $130,272 was spent on previous projects and by earlier authorizations, and $349,202 was contributed by private interests and by the State. Thus, $1,927,450 was spent under the 1958 authorization (S.P.D.-NCS,197).

CORPS OPERATIONS AND MAINTENANCE

Presently, the Corps of Engineers' project on the Minnesota River consists of maintenance dredging and snagging from the mouth upstream to Mile 14.7, Savage, Minnesota. While there are no locks and dams on the lower 25 miles of the Minnesota, the water surface is regulated at an elevation of 687.2 feet (above mean sea level, 1912 datum) by the Hastings Dam (Lock and Dam 2, Mississippi River Mile 815.3). An explanation of the operation of the Hastings Dam will serve to describe the control of water surface elevations on the Minnesota River.

Lock and Dam Operations

Lock and Dam 2 was built to an elevation necessary only to maintain navigation of the channel during low flow in order to minimize flooding of adjacent lands. The low dam elevation and small pool capacity relative to flood volume precludes operation of the dam for power production or flood control.

Regulating Pool Levels

The initial elevation of Pool 2 was 684 feet (mean sea level, 1912 datum), which was increased to the present 687.2 feet in 1935. Presently, drawdown of pool elevation is less than one foot during normal operation (S.P.D.-NCS, 1969).

When there is no flow in a pool contained by a lower dam, the water surface of the pool is level throughout its entire length (See Figure 3). As the discharge entering the pool from upstream increases, the upstream water level rises, creating a slope in the pool elevation. Project pool elevation of 687.2 feet is maintained at the control point, near the middle of Pool 2 at Mile 833.9 in South St. Paul, and the water level at the lower dam is allowed to fall as the discharge from the upper dam increases. This continues until the maximum allowable drawdown elevation for the pool is reached at the lower dam. The drawdown at the lower dam of the pool must be limited, however, so that navigation and conservation interests in the area will not be damaged by extremely low water levels.

Thus, the water surface profile of the pool will tend to pivot about the control point as the flow in the pool varies. This pivot point, called the "primary control point", is at or near the intersection of the project pool elevation and the ordinary high water profile. Court decisions have defined the ordinary high water mark as that point up to which the presence and action is so continuous as to destroy the value of the land for agricultural purposes by preventing growth of vegetation. On navigable lakes and rivers the Federal Government holds easement to use the riparian lands up to the ordinary high water mark in the public interest.

When maximum drawdown is achieved, control of pool water level is shifted to the dam, and the pool is then said to be in "secondary control". While in secondary control, the maximum drawdown elevation is maintained at the dam by increasing the discharge as the inflow increases. The water level at the primary control point and at all other points in the pool is thus allowed to rise. When the difference in water level at the lower dam has been reduced to less than one foot (pool elevation minus tailwater elevation) during floods, the gates are raised completely out of the water, and open-river flow is in effect. This process is reversed as flood waters subside.

The principal reasons for using this method of controlling the pools is that only the area between the control point and the lower dam will be inundated by the operation of the dam by the Corps. This greatly reduces the cost to the government of acquiring flowage rights.

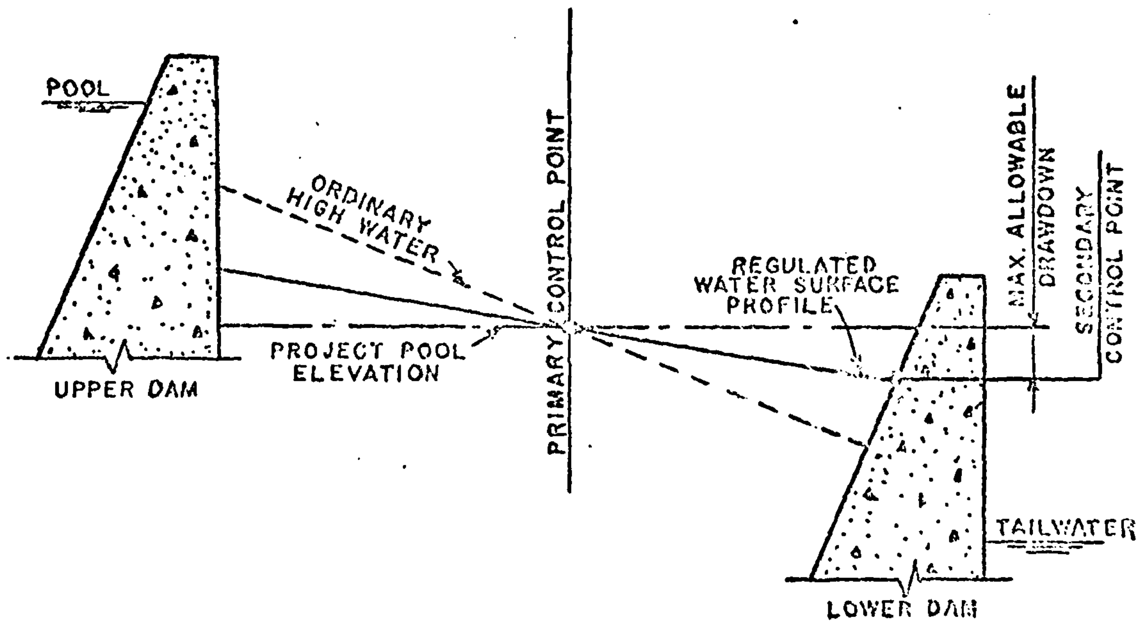

Figure 3. Basic Plan of Operation (S.P.D.-NCS, 1969).

Channel Maintenance

During the year, changes in hydraulic efficiency of the Minnesota River (i.e., its ability to maintain continually in suspension its load of sediment) along the length of the channel result in areas of sediment accumulation. These areas are dredged by the Corps to remove this hazard to commercial navigation using a clamshell dredge such as the Derrickbarge 767, or by private companies.

Maintenance dredging and spoil disposal began in the late 1930's, but has been much more frequent since 1959 (See Table 2). During the last fourteen years about 13,000 cubic yards have been dredged annually. This amounts to about 500 cubic yards per mile each year which is the lowest amount in the Twin Cities area. This volume is very low compared with the District average of nearly 9,000 cu.yd./yr./mile (Table 3). Most frequent Corps' dredging sites are between Mile 1-2 (Pike Island), 4-5 (Cut-off No. 2), and 12-13 (Petersen's Bar).

Table 2. Annual volume of sediment dredged, in cubic yards, from the Minnesota River (S.P.D. NCS, 1973).

Year		Amount Dredged, in Cubic Yards	
1939		12,714	
1940			
1941			
1942			
1943			
1944			
1945			
1946			
1947			
1948			
1949			
1950			
1951			
1952			
1953			
1954			
1955			
1956			
1957			
1958			
1959		2,605	
1960		2,276	
1961			
1962			
1963			
1964		8,918	
1965			
1966			
1967		53,615	
1968			
1969		70,323	Since 1939: Av. 5,757 cu. yds/yr.
1970			
1971		33,521	Since 1959: Av. 13,174 cu. yds/yr.
1972			
	TOTAL	171,258	Annual Av/Mile: 513 cu. yds/yr/mile

Table 3. Quantity of Sediment Dredged per Year from the Mississippi River and Navigable Tributaries in the St. Paul Engineers District (Calculated from data from S.P.D.--NCS, 1973)

Pool or Tributary	Average Annual Volume Per Year (in cubic yards)	Average Annual Volume Per Year Per River Mile (in cubic yards)
St. Anthony Falls	23,522	5,470
Pool 1	125,640	22,042
Minnesota River	12,253	834
Pool 2	175,126	5,422
St. Croix River	40,836	1,667
Pool 3	112,187	6,130
Pool 4	487,836	11,062
Pool 5	235,969	16,052
Pool 5A	152,302	15,865
Pool 6	95,371	6,716
Pool 7	150,303	12,738
Pool 8	282,549	12,127
Pool 9	155,000	4,984
Pool 10	94,313	2,875
Total 14 — Total Annual Volume, St. Paul District	2,143,207	

Average Annual Volume per Pool 153,086

Average Annual Volume per Mile 8,856

Dredging and spoiling are carried out by one of two procedures, depending on the proximity of the dredge site to shore. If the shore is within reach of the boom of the clamshell dredge, the dredged river bottom sediment is cast directly upon shore. If, however, a spoil site is not available or the dredge is beyond reach of shore the sediment is cast into barges and towed to the spoil site (See Figure 4). At this site the sediment is dropped back into the river by releasing the side gates on the barge (See Figure 5). The sediment is then redredged by another clamshell and cast upon the site, whereupon it is pushed away and levelled by bulldozers (See Figures 6 and 7).

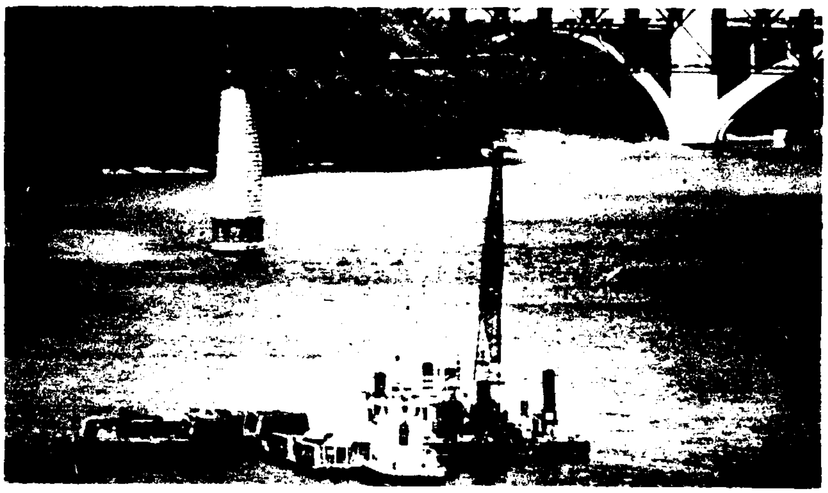

Figure 4. The Clamshell Dredge Derrickbarge 767 Deepening The Nine-Foot Navigation Channel on the Mississippi River. The Spoil is Dropped into Waiting Barges Which Transport it to the Spoil Site (Colingsworth)

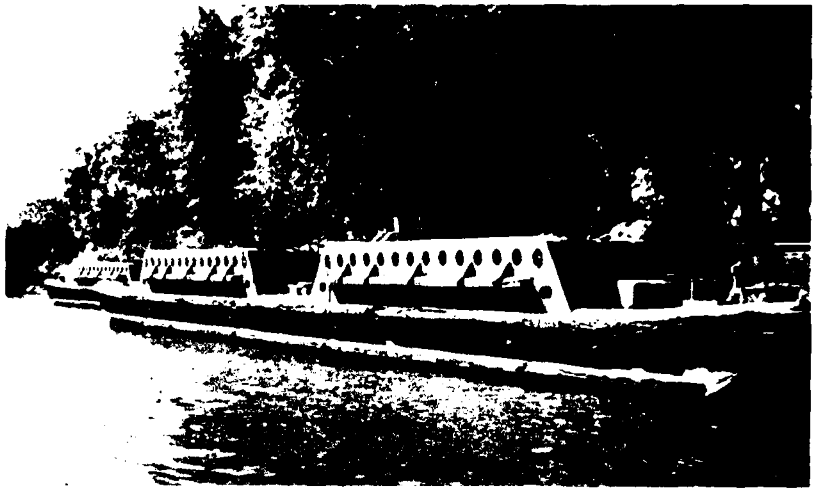

Figure 5. Spoil Barges Showing Side-Mounted Gates for Dropping the Spoil at the Spoil Site (Colingsworth)

Figure 6. The Clamshell Dredge Derrickbarge 771 Redredges the Spoil Dropped by the Barges and Casts it on to the Spoil Bank. Note the Figures in the Right Foreground (Colingsworth)

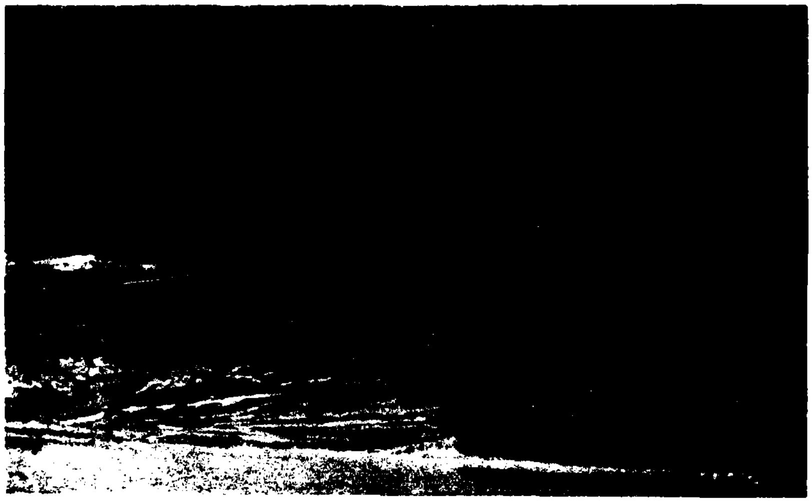

Figure 7. The Newly Deposited Spoil Piles are Levelled by Bulldozer (Colingsworth)

The river banks, particularly on the bends, are subject to considerable erosion, such as at Mile 16.8, which endangers Scott Co. Hiway 25, and are protected by riprap. Dead trees and other debris which are carried into the River due to eroded banks on the tributaries on the Minnesota, become lodged in the navigation channel. These "deadheads" or "snags" impede river traffic and are removed to the river bank, where they may be attached by a cable to a tree or placed in one of the former river channels.

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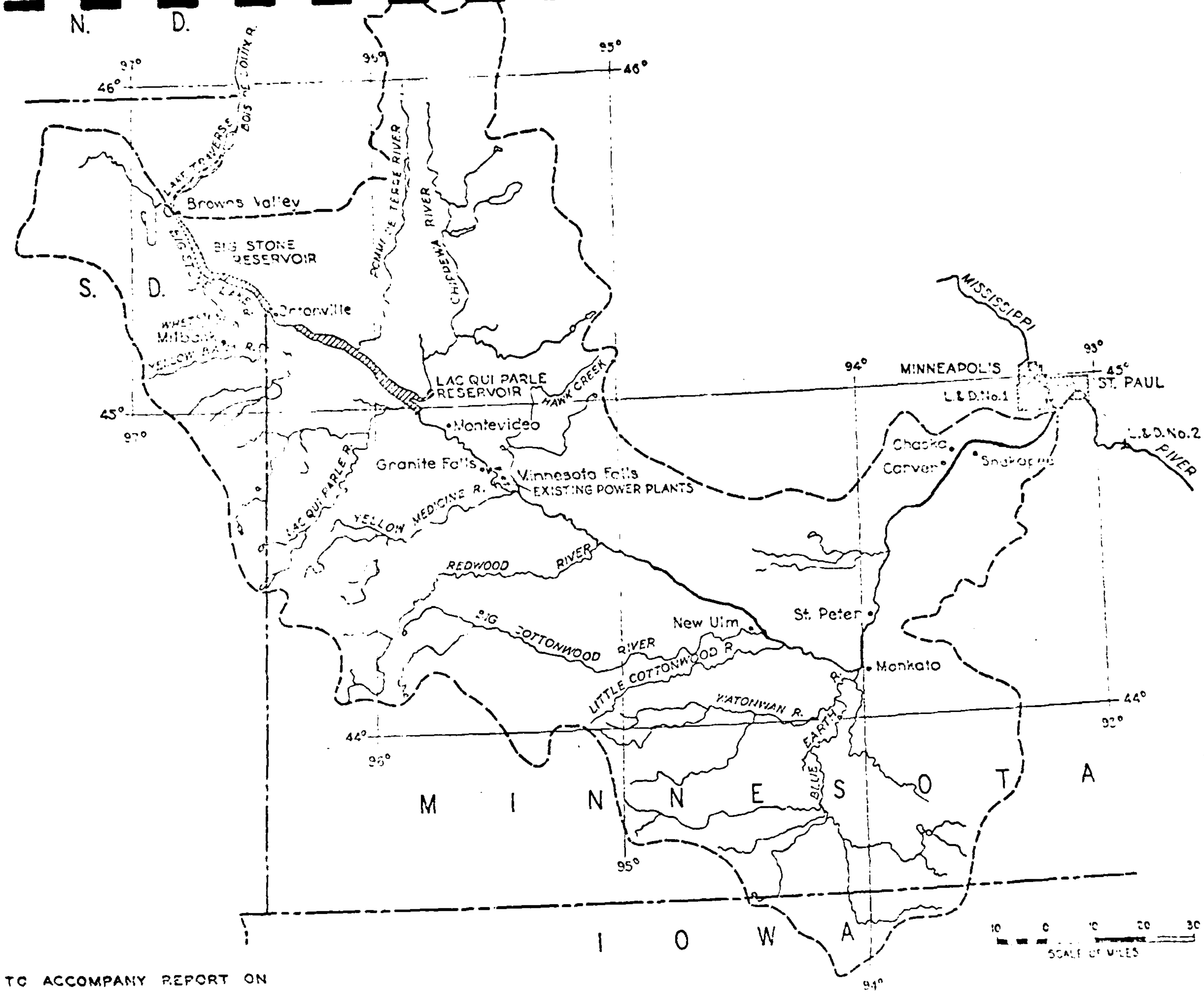
2. ENVIRONMENTAL SETTING

NATURAL SETTING

Because the nine-foot channel on the lower Minnesota River is an on-going project of the Corps of Engineers, the present environmental setting includes the project from 1930, when the Hastings Dam was completed (which raised the water level on the Minnesota River) to the present. The environmental setting without the project, in this case prior to construction of the Hastings Dam, must be reconstructed from published information.

The Minnesota River flows 224 miles in a southeasterly direction from Big Stone Lake to Mankato, where it turns abruptly northeasterly and flows 106 miles to Fort Snelling. There it joins the Mississippi River at Mile 844.0. The Minnesota River drains a watershed of 16,920 square miles, of which 1640 square miles are in South Dakota and 370 square miles in Iowa (See Figure 8). This large watershed consists principally of level to rolling terrain, although scenic bluffs 100 feet or more in height occur along some portions of the river and its tributaries. The present topography is derived mainly from the Pleistocene glaciers as subsequently modified by erosion and, more recently, by man. Presently the climate is moderately continental, grading eastward from dry subhumid to moist subhumid (USDA, 1970). The combined influence of climate, soils, and man's activities has led to a vegetational gradation from prairie eastwardly to mixed deciduous forest, bejeweled with lakes and marshes and laced with streams.

The ecosystems of the lower Minnesota River and its valley are divided into various components for more detailed description. The various components of the Minnesota River ecosystems may be divided into Physical and Biological Aspects sections, the first of which includes geologic, climatic, soils, groundwater, hydrologic, and land use elements. The Biological Aspects section includes floral and faunal elements as part of terrestrial and aquatic subdivisions.



TO ACCOMPANY REPORT ON
MINNESOTA RIVER MADE UNDER
SECTION 10 OF FLOOD CONTROL ACT
OF MAY 15, 1928

GENERAL MAP OF MINNESOTA RIVER BASIN

EXHIBIT B

Figure 8. General Map of Minnesota River Basin (Secretary of War, 1935).

However, it cannot be overstated that such divisions disguise the often numerous and complex interactions not only between elements within these river valley ecosystems, but also with those elements outside. Thus, wherever possible, the characteristics of elements in the Minnesota River will be discussed in related to the Twin Cities area, as well as the entire watershed. Interactions with areas outside of the basin may be dealt with in a very general manner.

Physical Aspects

Geology

The Minnesota River watershed is underlain by Cretaceous shales west of Mankato, except along the river valley which is underlain by Archaeozoic granite. East of Mankato the bedrock underlying the Minnesota River watershed is composed of Cambrian and Ordovician sandstones and dolomite (See Figures 9 and 10). The Shakopee dolomite outcrops along the river.

In the last million years at least four glaciers gouged their way across these rocks and through the Twin Cities, then receded and left hills and valleys formed from debris which they had transported long distances (See Figure 11). Deposits left by the last one, the Wisconsin Glacier, were first brought from the northeast by the Superior Lobe, and consist of red, sandy and (granitic) pebbly deposits (See Figure 12). Later the Grantsburg Sublobe of the Des Moines Lobe brought buff-colored calcareous sands, clays, and rock from the Cretaceous shales, more or less covering much of the previous deposits. Such deposits, if unstratified, are termed till; if transported and sorted according to size by glacial meltwaters, they are termed outwash. These tills and outwash, which have been subsequently modified by climate and vegetation, form our present soils and topography.

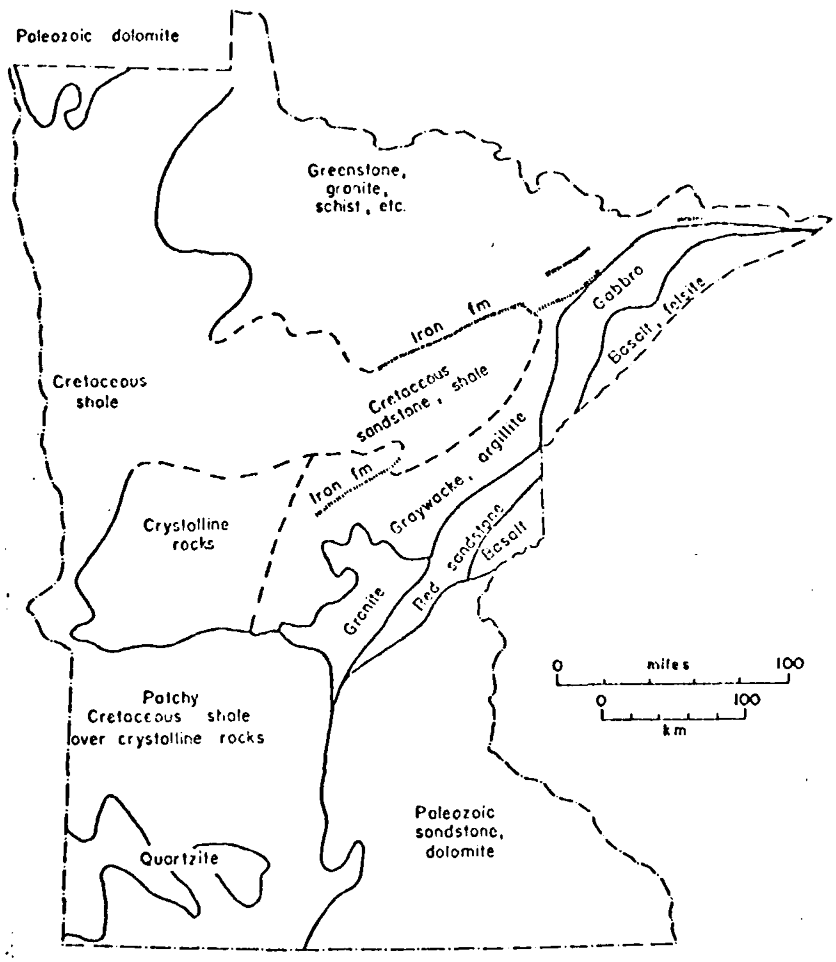


Figure 9. Bedrock Map of Minnesota (Minn. Geological Survey, 1969)

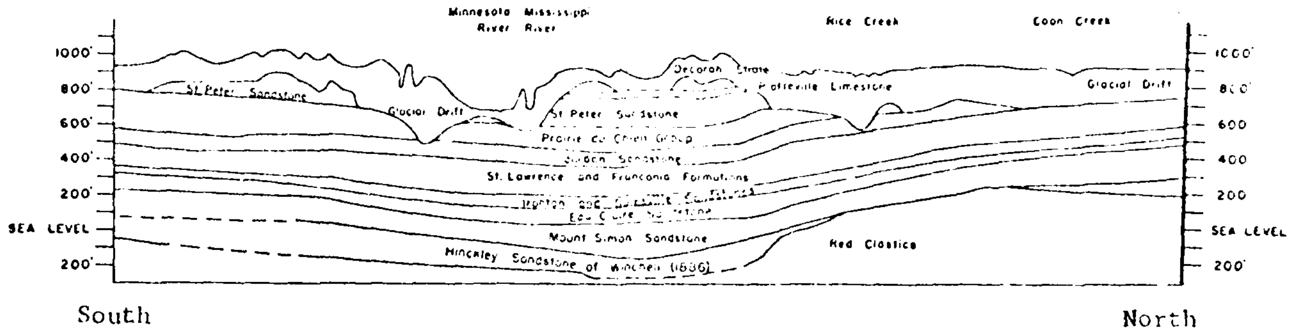


Figure 10. North-South Vertical Section thru the West End of Pike Island Showing the Twin Cities Artesian Basin (Winter and Norvitch, 1972).

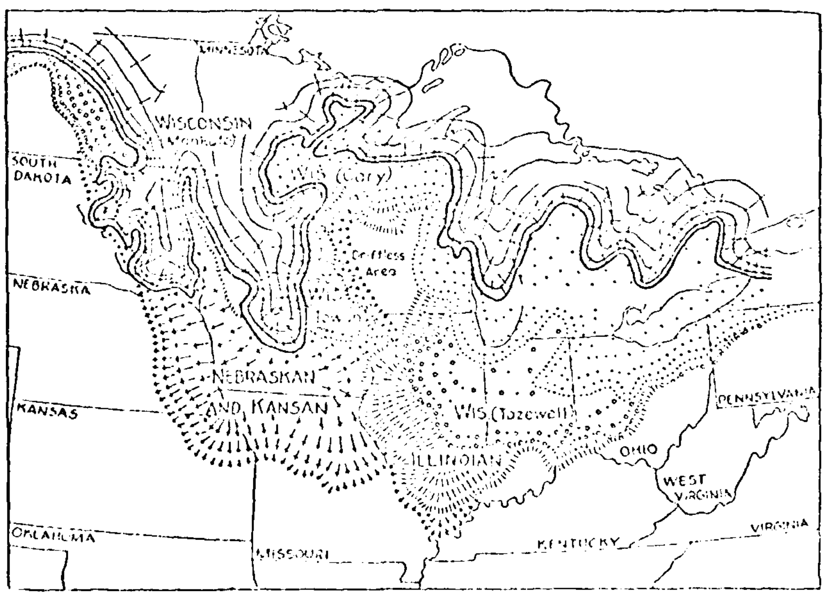
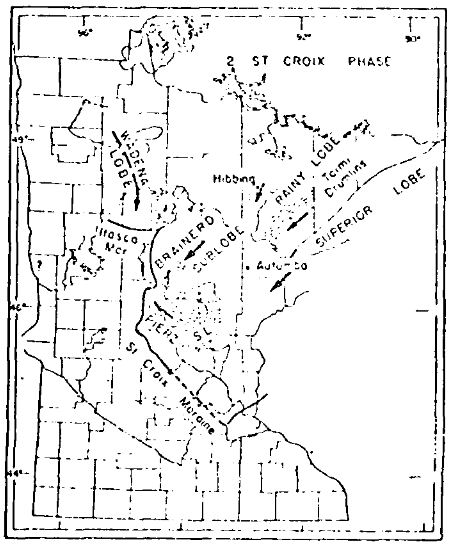


Figure 11. Map of the four ice sheets of the United States (Schwartz and Thiel, 1963).



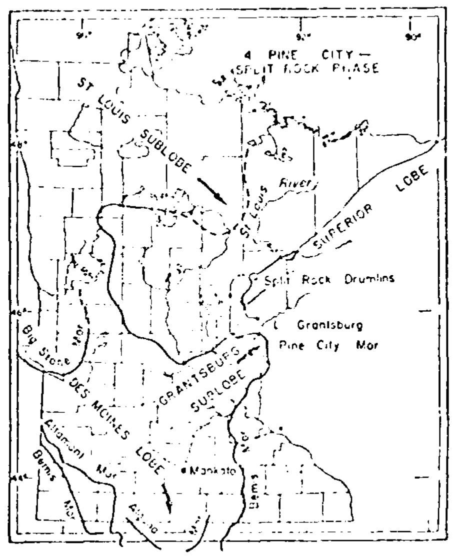


Figure 12. Maps of Minnesota Showing Extent of Ice Lobes During Various Phases of Wisconsin Glaciation. Short Dashes Indicate Drumlins (Winter and Norvitch, 1972).

During the recession of the Wisconsin Glacier, the present valley in which the Minnesota River is situated was created by rivers draining the front of the receding glacier, and later the vast Glacial Lake Agassiz (See Figure 13). This lake was formed by glacial meltwater trapped between moraines (hills of till mounded by a temporarily stationary ice fronts) to the south and the receding ice front to the north. The lake drained southeastward as the Glacial River Warren. This huge river scoured a broad, deep valley which is now partially filled with sediment, to 80 feet deep at Mendota and 180 feet at South St. Paul. The broad glacial valley is presently occupied by the much smaller Minnesota River from Big Stone Lake to Fort Snelling, and downstream by the present Mississippi River.

At St. Paul, near the present Holman Field, Glacial River Warren plunged over falls into a preglacial channel (See Figure 14). Other preglacial valleys were apparently filled with sediment. This falls receded upstream to the site of the present Fort Snelling, where it divided. The main falls soon became extinct when it encountered another preglacial valley about three miles up the present Minnesota River. The St. Anthony Falls were born as the River Warren falls eroded past a tributary: the present Mississippi River.

The falls were formed by the erosion of the soft St. Peter Sandstone from under the more resistant Platteville Limestone. These rock formations, as well as the Decorah Shale, are exposed in the river bluffs downstream to Newport. These and deeper formations dip about 20 feet/mile toward a low point on the Mississippi River just south of the University of Minnesota, forming the Twin City artesian basin (See Figure 10).

Several glacial advances stagnated at various times and places in Minnesota (and elsewhere), pushing large quantities of rock, stone, gravel, sand and clay into huge mounds. The mounds, formed at the margins of glaciers and generally conforming to their shape are low hills termed "end" or "terminal" moraines. These moraines and other tills and outwash, subsequently modified by climate, vegetation and man, are prominent features in the present Twin Cities landscape (See Figure 15).

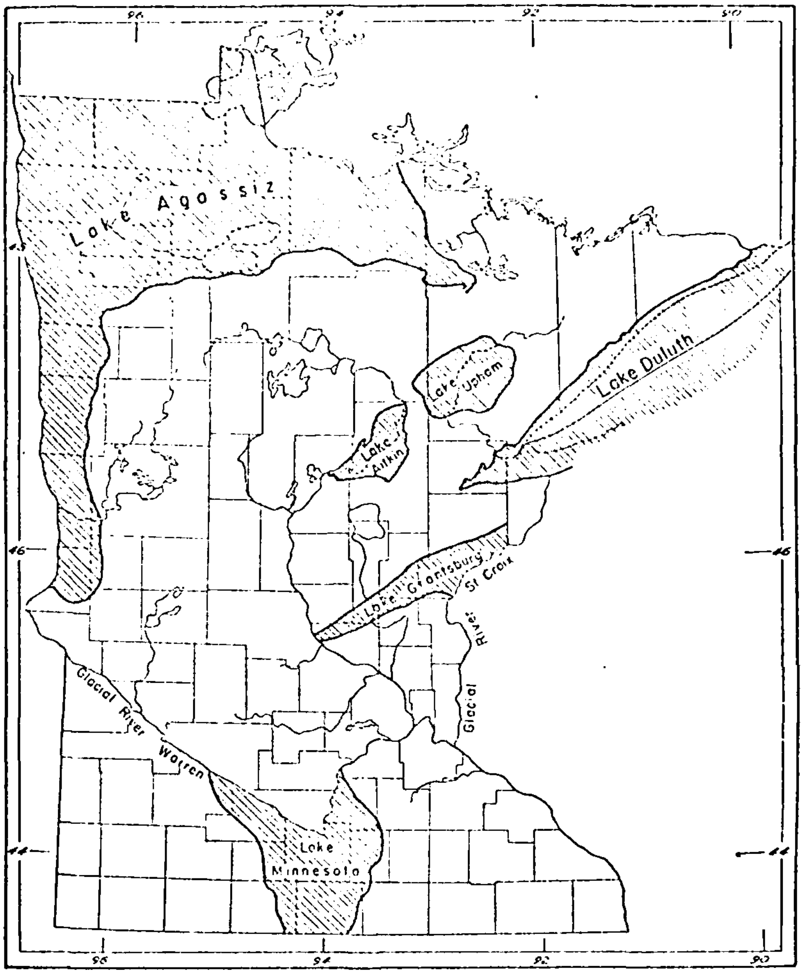


Figure 13. Map of Former Major Glacial Lakes and Rivers of Minnesota (Schwartz and Thiel, 1963)

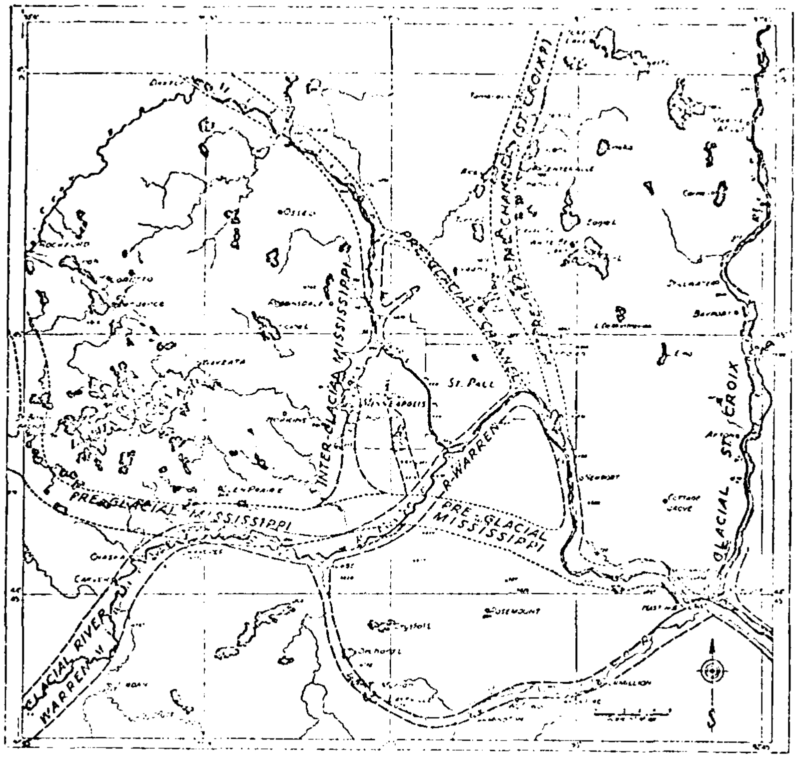


Figure 14. Map Showing Preglacial and Interglacial River Valleys of the Twin Cities Area (Schwartz and Thiel, 1963)

Climate

The climate in the upper Minnesota River watershed varies from dry subhumid in the west to moist subhumid near the Twin Cities. The average temperature is about 46^{o}F. and the average total precipitation is about 27 inches. Less than 10 percent of this precipitation falls between December and February. Average wind velocities range from 7 to 12 miles per hour with storm winds, especially tornados, greatly exceeding this. Generally the summer winds are southerly, bringing tropical air to the region, and northwesterly winter winds bring arctic air masses.

Figure 15. Map Showing Distribution of End (Terminal) Moraines of Minnesota (Schwartz and Thiel, 1963)

Soils

The composition and depth of soil results from climate, vegetation and animals modifying parent material. Topography and exposure are also important.

The soils in the upper Mississippi River watershed vary from the northeastern well-leached (pedalfer) soils, which are typical of moist forests and have a shallow organic layer, to poorly leached (pedocal) soils having a deep organic layer in the prairie southwest. The Twin Cities soils are primarily pedalfer and vary from sandy clay loams on till to loamy sands which were deposited in slow-water reaches, and a few small areas of clayey soils deposited in standing water (See Figure 16). Well-drained sites and northern exposures have lighter soils with less organic material.

The soils on the blufftops and terraces bordering the Minnesota River valley are coarse to moderately fine, with generally less than 12 percent slope and with rapid to slow drainage. The alluvial deposits are variable in texture, probably ranging from medium to silt, with less than 12 percent slope, except at the river bank. These alluvial deposits also have slow to very slow drainage (Hanson, et al., 1967).

The soils along the blufftop generally are coarse to medium on the left bank from Red Rock-Staring Lakes area downstream to Fort Snelling and on the right bank terrace at Shakopee, from Savage to the I-35W Bridge, and from the Black Dog plant to Mendota. These soils are characteristically well-drained, acid and low in nitrate and phosphate. The percolation rate is generally less than 10 minutes per inch. Medium to moderate fine soils are found on the blufftop and slope upstream from the Red Rock-Staring Lakes area and along the bluff slope downstream from these lakes to Fort Snelling. On the right bank these medium to moderately fine soils are found on the blufftop south of the terraces at Shakopee and along the bluff slopes from Scott County Highway 25 to Savage. These rich, clay soils have percolation rates 5 to 15 times slower than that of the sandy soils.

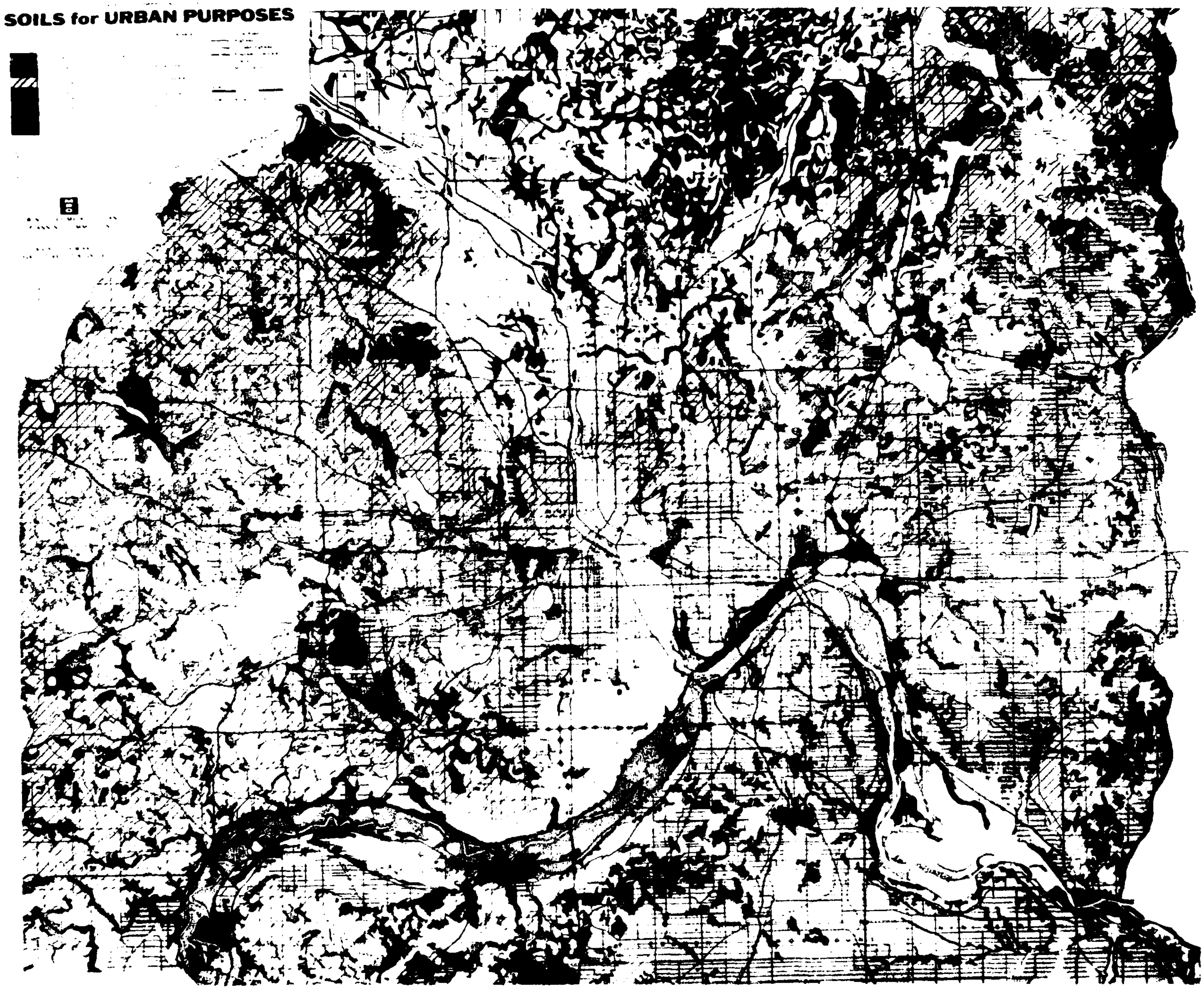


Figure 16. Soils Map of the Twin Cities Metropolitan Area (Hanson, et al., 1967)

In the river valley, dark, organic river-bottom soils are present which are seasonally inundated and poorly drained. These soils comprise the 17,600 acres of floodplain found in the lower 30 miles of the Minnesota River valley. Percolation is slow, ranging from virtually zero at saturation to as much as 5 inches per hour when the soils are dry or drained. The pH of these river-bottom soils is acid where peat has accumulated, and alkaline in the mineral soils.

Groundwater

Large quantities of groundwater are present in the highly permeable surficial sand deposits in the Upper Mississippi River Basin. Many lakes and streams are located in these deposits. Rapid removal of groundwater from these aquifers generally induces water to move from the lakes and streams. These aquifers supply 95 percent of the water outside of the large cities. They are similar in chemical composition from the Mississippi headwaters to the Twin Cities, except that in the Cities they have only 1 to 10 percent of the iron content.

In the Twin Cities and 13 surrounding communities, the Mississippi River is the source for municipal water supplies. However, due to the high organic and inorganic waste and silt content, groundwater is the major source of water for municipalities in the Minnesota River valley, from Shakopee downstream to the mouth. There are also a large number of wells in the Metropolitan area which are used mainly for industries and air conditioning. Total groundwater consumption was 200 mgd (million gallons per day) in 1970, which is estimated to be about 1/4 the total sustainable yield. The Jordan Sandstone supplies about 75 percent of this water, while the Mount Simon-Hinckley Sandstones supply another 15 percent. The former aquifer supplies a medium hard water (average 412 ppm as $CaCO_3$, 1961) from 350-to 450-foot depths. It also contains more dissolved solids, sulfates, and bicarbonates, but lower iron and chloride than the lower (1000 feet down) Mount Simon-Hinckley aquifer (USGS, 1970, Itasca Engineering, Inc., 1969).

Potentiometric studies (1970-71) of the water surface in the Prairie du Chien-Jordan aquifer in the Twin Cities area indicate two recharge areas (See Figure 17). Inflow is mainly southeastwardly from the Minnetonka area, and north and northeastwardly from the Farmington area. Similar directions of inflow were found in 1959 potentiometric studies of the water surface of the Mount Simon-Hinckley aquifer.

Several till sheets which were deposited by the glaciers on the Minnesota River watershed average about 200 feet deep with a maximum of more than 400 feet. The water table in these may be encountered commonly at depths from the surface down to less than 100 feet. Surface glacial and alluvial sediments in the watershed may yield up to five hundred gallons per minute, while the fine-grained alluvial sediments in the river valley probably yield relatively little water. Compared with the bedrock aquifers, however, the water from alluvial aquifers is very hard and very high in iron (USGS, 1970).

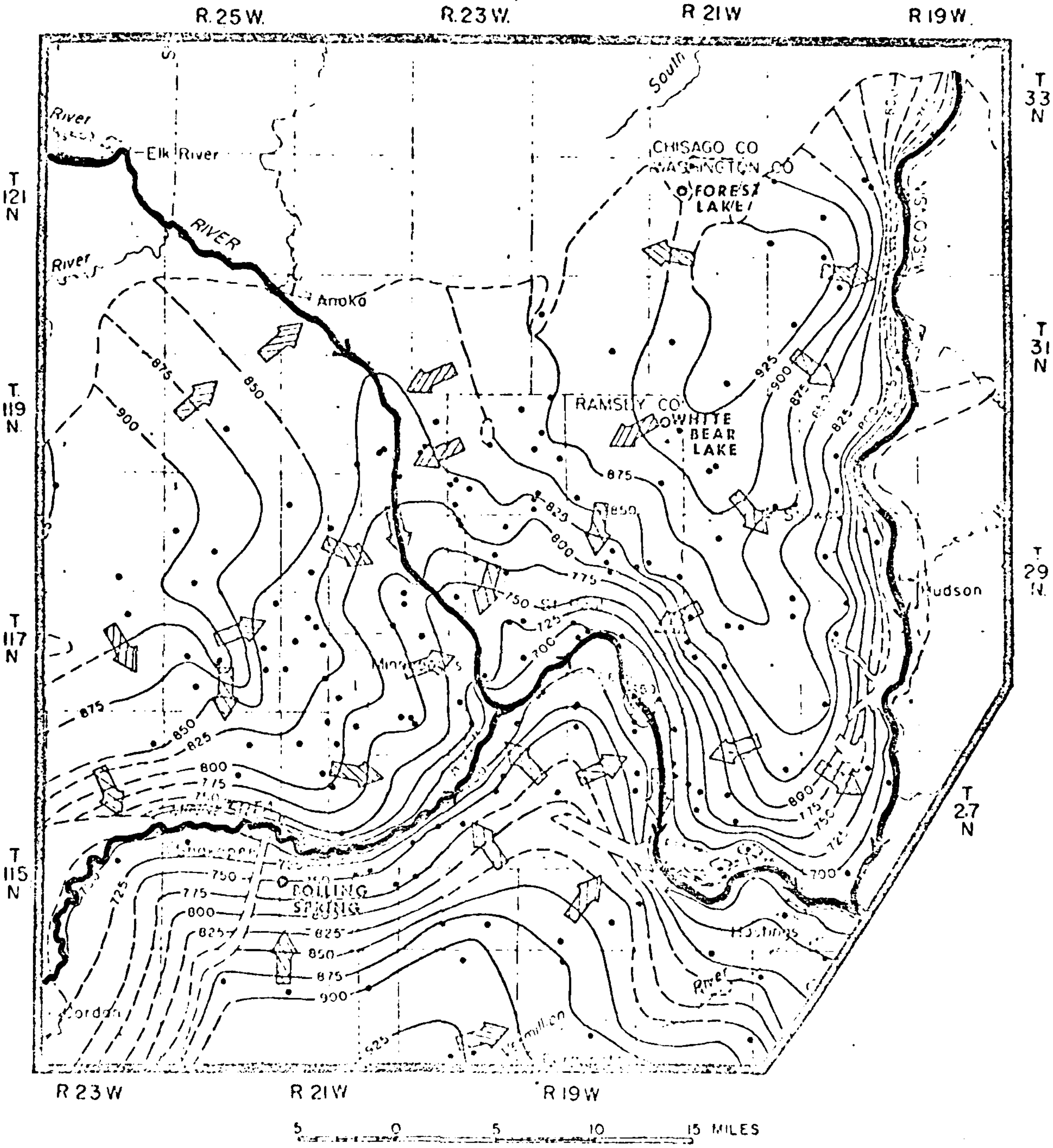


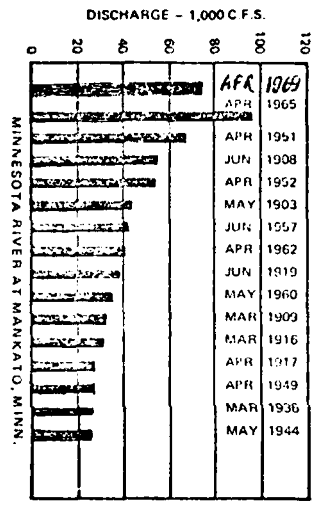
Figure 17. Potentiometric surface of water in the Prairie du Chien-Jordan Aquifer in Winter, 1970-71, in the Minneapolis-St. Paul Area (Winter and Norvitch, 1972).

Hydrology

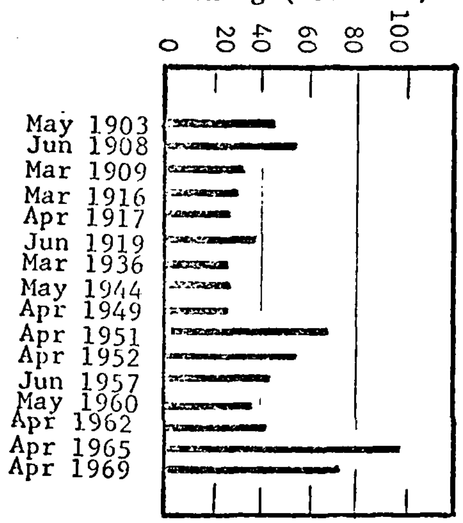
Annual runoff in the Minnesota River watershed varies from one inch in the western headwaters area to above five inches in the lower river valley near the Twin Cities. Some of the runoff is stored in Big Stone Lake and Lac Qui Parle reservoirs, as well as other lakes, marshes and the previously mentioned aquifers.

Maximum surface water evaporation is about 34 inches per year, occurring south along the headwaters of the Blue Earth River. Evaporation decreases northward to about 29 inches per year in the headwaters of the Pomme de Terre River, the northernmost extent of the Minnesota River watershed.

At the gage at Mankato, the Minnesota River drains a watershed of 14,900 square miles and discharges annually an average 2,650 cfs (50 years of record). The maximum discharges of 15 floods recorded at Mankato between 1903 and 1965 varied from over 20,000 to 94,000 cfs. (See Figure 18). The minimum discharge of 26 cfs was observed during the drought of the 1930's. These discharges may be indicative of those downstream from Mankato because no large tributaries enter the river.



In Order of Magnitude



In Chronological Order

Figure 18. Peak Discharge of Floods Recorded at Mankato Between 1903 and 1969 (USGS, 1970; Gudmundson, 1973)

It has been estimated that less than 200 cfs seeps into the lower 25 miles of the Minnesota River. Sources of this seepage water are the aquifers of the glacial sediments and bedrock. Groundwater seepage on the left bank (facing downstream) comes mostly from the glacial material deposited by the Wisconsin glaciation. On the right bank groundwater seepage and sprin s, such as Eagle Creek and Boiling Springs, have sand and sandstones of the St. Peter formation as their source. However, the major source of groundwater may be the Jordan Sandstone which underlies the deep alluvial sediments in the Minnesota River valley, as suggested by Figure 17. Eight flowing wells located on the floodplain may have this aquifer as their source (Itasca Engineering, Inc., 1969).

These creeks, springs and seepages are vital to uncommon assemblage of plants comprising the wet meadows, which are usually found only on the floodplain. These meadows are presently endangered by urban development near Savage both along the bluffs, which would seriously diminish or eliminate the flow of water, and by burial by development on the floodplain (Morley, 1973).

This floodplain development and associated leveesnear Savage are estimated to raise the stage of a 1965-type flood by 0.5 feet at Shakopee (Norvitch, 1973). The 1965 flood had a peak discharge of 117,000 cfs (cubic feet per second) , inundating areas approaching 720 ft. elevation (Itasca Engineering, 197).

Comparison of water surface areas in 1910 (preproject) with the present, based upon planimetry of maps (Corps of Engineers, U.S.G.S. and S.P.D.-NCS, 1973) indicate that there were 864 acres of mainriver channel between Mile 26.7 (the present MAA transect) and the mouth of the Minnesota River (Table 4). Along this reach in 1910 there were no backwater channels, but 1456 acres of open water in six floodplain lakes.(No measurement was made of the marshes).

Table 4. Comparison of Preproject with Present Water Surface Areas of Several Aquatic Habitats, in the Minnesota River Valley, Mile 26.7 to the Mouth.

Habitat	Acres		
	1910/1	1967/2	1973/3
Main Channel	864.1	850.2	1115.5
Backwater	0	-	145.4
Floodplain Lakes			
Snelling L.	58.1	106.2	117.1
Gun Club L.	323.1	269.8	404.8
Long Meadow L.	0	-	1081.7
Black Dog L.	348.5	-	650.2
Sheridan L.	159.7	0	0
Rice L. (Mi. 18)	0	156.4	-
Fisher L.	236.0*	262.6	-
Blue L.	0	163.6	-
Grass L.	0	305.7	-
Rice L. (Mi.23-25)	330.4	292.7	-
Pond 1 (Mi. 12.3)	-	-	51.5
Pond 2 (Mi. 12.8)	-	-	32.1
Pond 3 (Mi. 15.0)	-	-	58.3

* Present Fisher Lake was Rice Lake; present Rice and Blue Lakes were marshes with no open water in 1910.

/1 Planimetry data of maps of "Minnesota River from Big Stone Lake to Mouth", 1909-10.

/2 Planimetry data of U.S.G.S. topographic maps, 1967.

/3 Planimetry data of Environmental Study, Upper Mississippi River nine-foot channel project, S.P.D.-NCS, 1973.

By 1967 the main channel had decreased 14 acres, to 850 acres, although a 1973 aerial survey, made at high water, shows 1115.5 acres of main channel. In 1967 also there were 145 acres of backwater channels which had been created when the Corps dredged cut-offs, under its 1958 authorization, to by-pass three sharp bends in the river.

In 1910 there were six floodplain lakes with a total of 1456 acres of open water. Presently there are nine floodplain lakes with about 3289 acres of open water. Between 1910 and the present 160 acre Sheridan Lake, which was located on the right bank at about Mile 12.5 (about 1/2 mile downstream from the present Port Cargill) is now presently gravel pits. Four areas which were unnamed marshes in 1910 are now Grass Lake (306 acres), Blue Lake (164 acres), Rice Lake (156 acres) and Long Meadow Lake (1082 acres). (The present Fisher Lake was called Rice Lake in 1910).

Land Use

The annual increase in tons of goods shipped by river (See Socio-economic Section) attests to the continued economic growth at the Upper Mississippi River basin. This growth is particularly evident in the metropolitan areas as evidenced by housing developments, urban renewal, development of industrial parks, and highway construction.

About 100 square miles of the 3,000 square mile Twin Cities metropolitan area, or an area about 10 times downtown Minneapolis, is anticipated to go into urban development by 1980. Part of this area will be devoted to highway construction, such as I-494, I-35W, I-335 and I-94.

In light of this growth, the Metropolitan Council has adopted the Parks and Open Spaces Program to guide municipalities in preserving undeveloped areas for aesthetic, recreational, historical and productive uses. Examples of such sites include floodplains, wetlands, shorelines, steep slopes, aquifer recharge areas and wooded sites (Metropolitan Council, 1970).

Evidence of this need was indicated in a 1967 survey which showed only about 1/10 of the 310 miles of shoreline (above normal low water) along the major rivers in the metropolitan area to be in public ownership. Also only 42 of the 704 metropolitan lakes were fronted with parks of 15 or more acres, and only 40 lakes had public or commercial beaches.

The Council's program advocates completing acquisition of 12 major sites, consideration of 22 others, and the purchase and development of 107 waterside parks. Other types of areas suggested include a trail network, protection open space (such as flood and drainage ways), open space for industrial and agricultural production and scenic open space.

Extensive residential, institutional and commercial developments now crowd much of the blufftop upstream to Savage, and less extensively to Shakopee. By contrast, the floodplain upstream to Black Dog Lake is relatively undeveloped, while from Black Dog Lake to Shakopee barge terminals, industrial sites and croplands predominate in the floodplain (See Figures 19 and 20). For example, five of the seven barge terminals are located between Miles 13.9 and 21.8 (See Table 5). Significant erosion of these sites probably occurs mainly during spring runoff and high water, and later during heavy rain showers.

Figure 19. Aerial View of Land Use at Black Dog Lake, Minnesota River Mile 8 (Colingsworth)

Figure 20. Aerial View Downstream of Large River Terminal, Minnesota River Mile 12.5 (Colingsworth)

Table 5. Location of Minnesota River Barge Terminals, and Commodities Shipped, (S.P.D.-NCS).

Mile	Location	Company and Commodity
21.8	Shakopee, MN.	Peavey Company (grain)
14.7	Port Continental Elevator, Savage, MN.	Continental Grain Company
14.3	Port Richards, Savage, MN.	Richards Oil Company
14.1	Port Bunge, Savage, MN.	Bunge Corporation (grain)
13.9	Port Cargill, Savage, MN.	Cargill, Inc. (grain)
11.0	Port Marilyn	U.S. Salt Company
8.5	Black Dog Power Plant	Northern States Power Company (coal)

Some of the floodplain and bluff areas are reserved for public recreation and open space. These are principally Fort Snelling State Park (along the first five miles of the Minnesota River), the Rice Lake picnic grounds (near Savage), the nearby Blue-Fisher wildlife preserve, and Shakopee Memorial Park.

Major siltation sites are reported where tributaries enter the floodplain, such as Bluff Creek at Rice Lake (near Shakopee), Riley Creek at Grass Lake, Purgatory Creek at Old Shakopee Road, and Nine Mile Creek at Coleman Lake (Itasca Engineering, Inc., 1969). Upstream, sources of sediment probably enter mainly from agricultural lands, and locally from municipal and commercial areas. Tributaries, such as Carver, Spring and Chaska Creeks also are known to be sources of sediment. Where bridges and other structures cross the Minnesota River sedimentation may occur, such as at the Chicago Northwestern and Highway 41 Bridges.

Along much of the river, banks are covered with low, sometimes lush, vegetation and, at the present time, a screen of trees obscures many of commercial, residential and agricultural developments. In numerous reaches, however, the border of trees has become very thin by their removal due to wave (wake) erosion, their death by girdling by barge mooring cables, removal for barge terminals, and, perhaps in one case, also by killing due to spills of salt at a terminal (See Figures 21 and 22).

Figure 21. Exposed Tree Roots on an Eroding River Bank Along the Navigable Reach of the Minnesota River (Colingsworth)

Figure 22. Barge Terminal at I-35W Bridge
Minnesota River Mile 11.0
(Colingsworth)

Biological Aspects

Terrestrial Vegetation

The native vegetation in the Minnesota River basin consisted of a tall grass prairie mainly south and west from Mankato, and deciduous forest downstream from Mankato (See Figure 23). The deciduous forest extends upstream from Mankato along the floodplain of the Minnesota River and its tributaries. Elsewhere in the watershed the prairie-deciduous forest transition occurs as a series of mosaics, with peninsulas and small islands of one vegetation type in the other, rather than by distinct, separate zones. Nevertheless, the prairie-deciduous zones are more discrete than occur elsewhere in the eastern forests. Climate, topography and exposure, soils, animals, fire and human history are important determining factors in vegetational pattern.

West and south of Mankato, lies the tall-grass prairie region which included bluestems bunch grasses and a rich assortment of nitrogen-fixing legumes. This prairie had built up the soils of this area to a rich level of productivity. Urban and agricultural development has disrupted or removed much of this vegetation on the level uplands. Sizeable segments of Phragmites probably remain in the drier bottom lands and steep-sloped terrain.

A cross-section from the river, across the floodplain and up the bluff face, shows representative vegetational zones where prairie occurs on the bluff top in the Minnesota River valley (See Figure 24). The vegetation changes from rich, moist grassy meadows and bottomland woods to northern hardwood forest, then to dry upland forest and bur oak savannas near the top, to prairie grasses on drier bluff tops and south-facing bluffs, such as at Flying Cloud Airport.

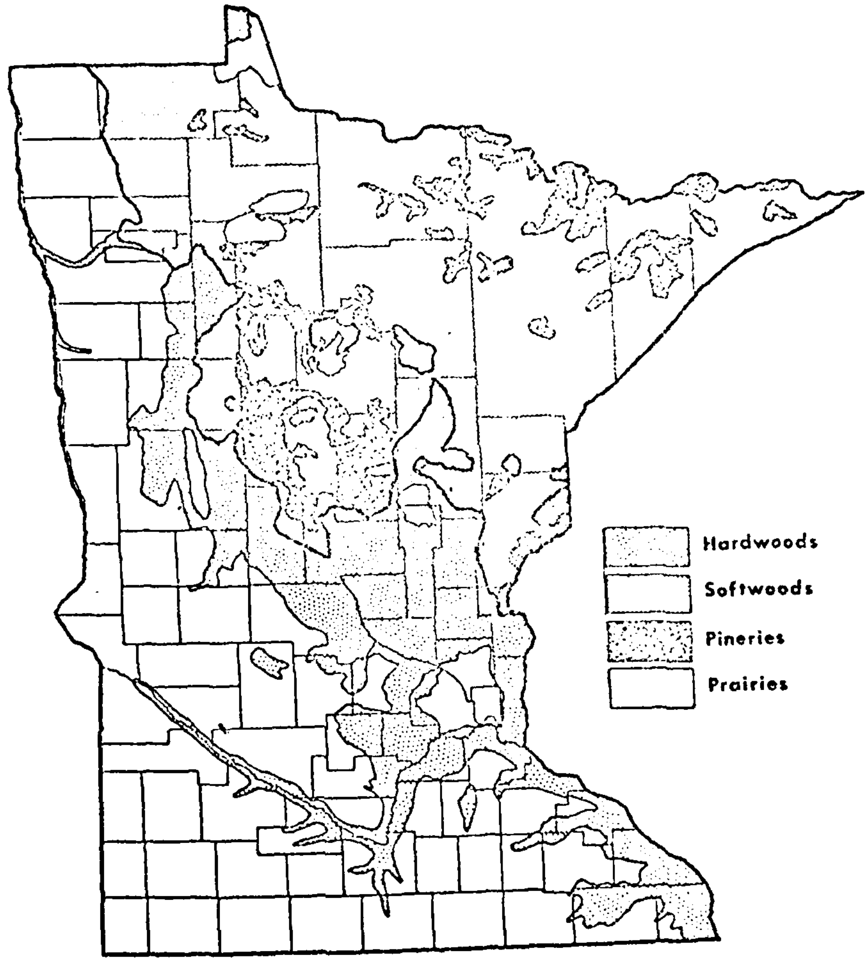


Figure 23. Present Day Forest Cover
(MN DNR, 1965)

River Border	Meadow	River Bottom and Islands	Lower Slope	Upper Slope	Hill Prairie
Love-grass	Bluegrass	Peach-leaved willow	Basswood	Red cedar	Big bluestem
Sand-grass	Golden glow	Hackberry	Bitter-nut hickory	White oak	Little bluestem
Reed-canary-grass	Sedges	Green ash	Hackberry	White pine	Nodding grama
Rice cutgrass	Milkweed	Cottonwood	Ironwood	Sugar maple	Northern dropseed
River sedge	Aster	Silver maple	Bur oak	Paper birch	Hairy grama
Jewelweed	Blue-joint grass	Slippery elm		Ironwood	Porcupine grass
Wild cucumber	Field horsetail	Amer. elm		Red oak	Leadplant
Cocklebur	Joe-pye-weed	Basswood		Bur oak	Ground plum
Beggar's ticks	Water-horehound	Bur oak		Hazelnut	
Canada wood nettle		Common nettle		Sumac	
Common nettle				Wolfberry	
White snake-root				Prickly ash	
Wild grape					
Va. creeper					
Sandbar willow					
Peach-leaved willow					
Amer. elm					
Green ash					
Cottonwood					
Silver maple					

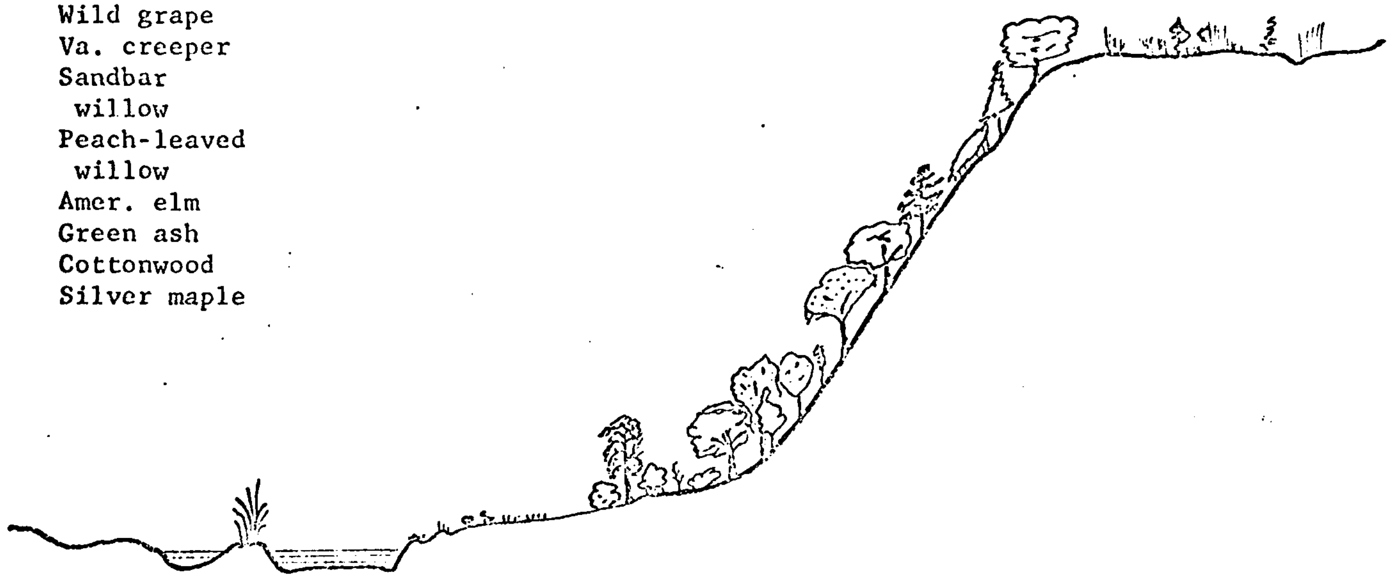


Figure 24. Typical Vegetation Zones Along a Transverse Section from the River to the Bluff Top

On the floodplain in the Twin Cities area, exposed sand and mud deposits become vegetated by herbs such as teal grass, millet, smartweed, cocklebures, and others (See Table 6), the major vegetative cover consists of seedling sandbar and peach-leaved willows, cottonwoods, elms and silver (river) maples. The herb layer, now composed of nettles, mint, sedges, anemone, jewelweeds, plaintain, white snakeroot and others, continues under the riverbottom forest. The forest consists mainly of elm, willow, cottonwood, ash, and the most effective of all our native tree species in resisting bank erosion: the silver maple. Under this forest, there is also a shrub layer consisting of seedlings of silver maple, American elm and green ash, and elder, riverbank grape and others.

Recent studies of vegetation patterns in Lower Pool 2 on the Mississippi River, an area not unlike lower Minnesota River habitats, provide further information on floodplain and bluff vegetation. At the eastern end of Spring Lake, Leisman (1959) divided the vegetation according to topography into ravine and bluff slope vegetation and river terraces and level upland vegetation, as part of an archaeological study. Elm, basswood, ash, box elder, and cottonwood were common on the slopes, with a shrub understory of mainly red-berried elder, gooseberry, raspberry, prickly ash and hazel (See Table 2 in Appendix A IV). Herbs consisted mainly of jewelweed, sweet cicely and nettles.

By comparison, the agriculturally-disturbed upland had a much-reduced vegetation, consisting mainly of oaks, elm, butternut and hackberry. The only understory vegetation was Kentucky bluegrass. Church's Woods, a site little if at all disturbed, demonstrates a much wider diversity of tree species and understory.

Vegetation on the river banks at the standard transects on the Minnesota River occurs in zones probably in response at least to soil moisture, inundation and erosion. Sampling stations were located in the middle of these zones where possible (See Figure 25). Transect MAA is

Table 6. Vegetation Common to the Habitats of the Upper Mississippi River Valley and Bluff Tops in the Twin Cities Area (from Wallace, McHarg, Roberts and Todd, 1969)

Habitat Type	Occurrence and Species
Mudflats, sandy shores	Rare in the metropolitan area. Often included in the river-bottom category.
	Varies greatly. Some areas contain smartweeds, wild millet, fall panicum, teal grass and cocklebur.
River-bottom forest	Forests that occur adjacent to the rivers and mainly on floodplains.
	Woody: elm, ash, cottonwood, box elder, oaks, basswood, maple, willow, aspen, hackberry, with occasional pines and arbor vitae in the pine region; many vines.
	Herbaceous: some smartweed, wild millet, fall panicum, teal grass, cocklebur, jewelweed, golden-glow, wild cucumber, common nettle, Canada woodnettle, sedges, Virginia rye-grass, and love-grass.
Upland hardwoods (Big Woods and aspen-birch)	Woody: "Big Woods"--oaks (bur, white, red, and black), elm, basswood and maple dominant; with ash, hornbeam, aspen, birch, wild cherry, hickory, butternut, black walnut.
	Aspen-birch--eventually become hardwood forests, includes ash, elm, maple, basswood and oaks.
Dry oak savanna and dry uplands (oak openings, barrens and aspen-oak), and transition zones	Bur and jack-oak openings and barrens: scattered trees--two species of aspens, and groves of oaks (mostly bur and jack-oaks) of scrubby form with some hazel, sumac, prickly ash, and New Jersey tea (a nitrogen-fixer) in brush and thickets, and occasionally with pines.
	Aspen-Oak Land: aspen, generally dense, but small in most places, with scattered oaks and few elms, ash, and basswood.
Brush prairie	Grass and brush of aspen, balm-of-Gilead and a little oak and hazel in the north; but mainly oak and hazel in the south, choke-cherry, dogwoods, prickly ash, wolfberry, sumacs.
Grassy meadows (prairie)	Willow prairie (prairie with clumps of willows), grass, wolfberry, verbena as an index of heavy overgrazing.

Profiles Drawn Looking Downstream

Bottom type: sa=sand, de=debris, gr=gravel, mu=mud, □=sample plot (quadrat) + = plotless tree sample (point quarter) ⊕ = both at same point, ☰ = top of bank

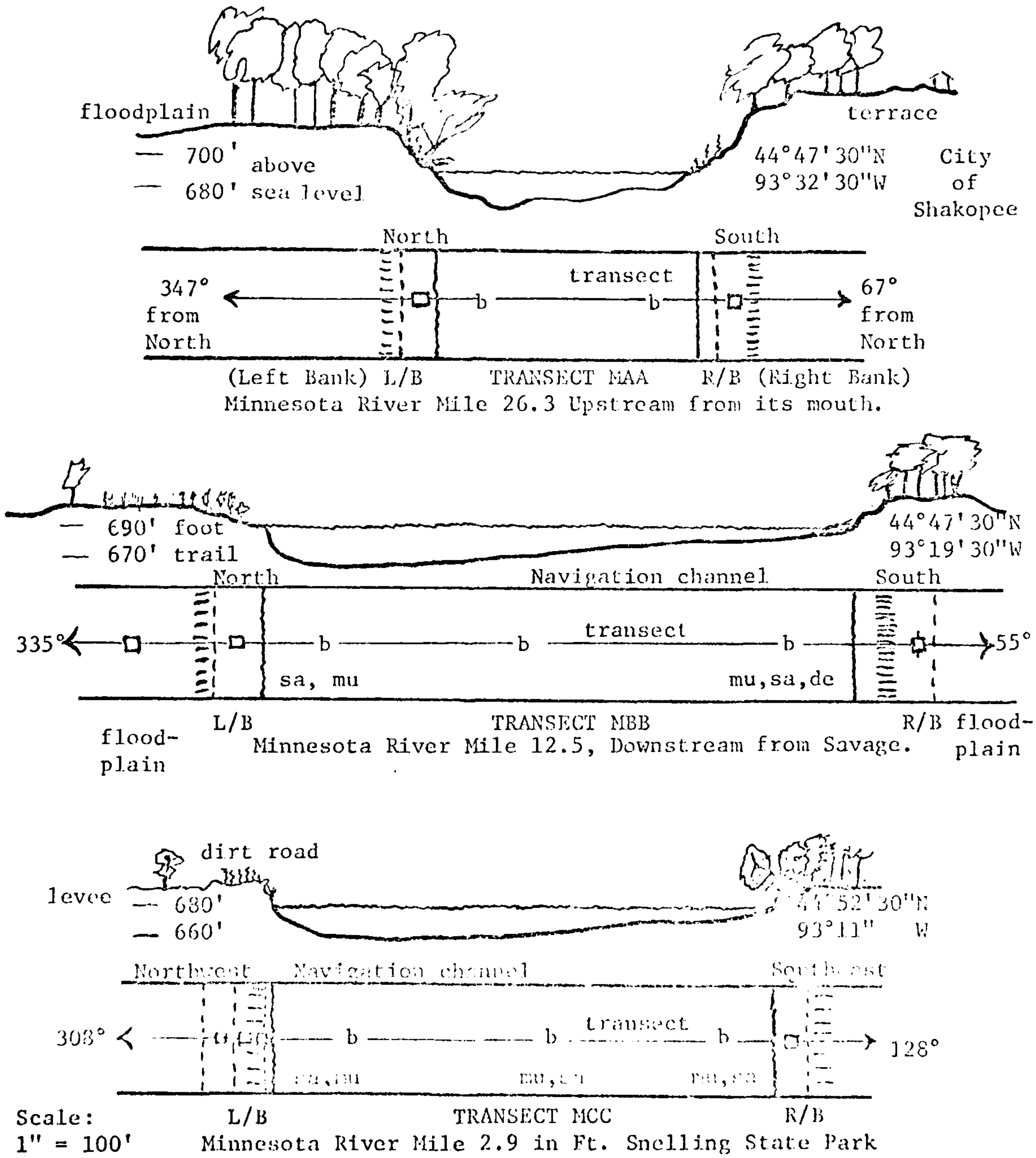


Figure 25. Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in the Minnesota River.

located about 1.3 miles (at Mile 26.4) upstream from State Highway 169 Bridge at Shakopee, and is about 0.8 mile upstream from the head of the Corps' four-foot channel. This transect thus will provide a reference point which is not affected by maintenance of the present navigation channels on the Minnesota River. Transect BB is located at Mile 12.5, just a couple hundred feet downstream from the barge slip at Port Cargill. Transect CC is located at Mile 2.9, in Fort Snelling State Park.

At Transect MAA the river banks are quite steep due to erosion. The south (right) bank, located on the outside of a sharp bend, consists mostly of rocky rubble, while the north (right) bank consists of finer material which also is eroded to a very steep bank about 5 feet high. The south bank has three plant zones, including a "beach" consisting of mostly bare rock with scattered vegetation; a "bank" zone with 80 percent exposed rock (in the quadrat), but more vegetation and 30 percent cover of leaf litter; and a tree and grasses zone about 34 above water level and maybe apparently rarely inundated (See Table 7).

The "beach" zone has scattered individuals of at least 17 different kinds of plants including grasses, sedges, composites, smartweed, and seedlings of sandbar willow and some cottonwood. The "bank" zone plants consisted mainly of the common horsetail and grasses, with some cottonwood seedlings. The trees--which are farther up the river bank and form a canopy over lower portions of the river--include box elder, ash, cottonwood and elm. The ground is completely covered with grasses, interrupted by patches of gooseberries.

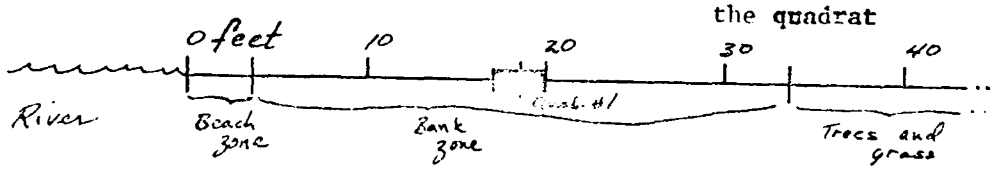
The bank, due to the steep, eroding rock, lacks a "beach" zone; the subdominant plants are a mixture of this zone and the drier "bank" zone. Pursh's love-grass covered the whole quadrat, which was overlain in 30 percent of the area by new cottonwood seedling were also abundant.

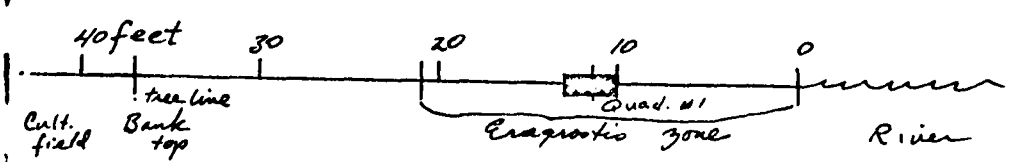
Table 7. Plant Presence or Abundance on the River Banks at the MAA Transect, Mile 26.7, Minnesota River, October 2, 1973. (P) = adjacent to, but not included in quadrat.

	R/B			L/B
	Above Trans.	Quad. #1	Beach Zone	Quad. #1
Acer negundo, box elder	P			
Fraxinus sp., ash	P			
Ulmus sp., elm	P			
Ribes spp., currant or gooseberry	P	<1%		
Gramineae, Grass* family	P	3%	P	15%
Populus deltoides, eastern cottonwood	P	1%	P	5%
Oxalis spp., sheep sorrel		<1%		
Taraxacum, sp., dandelion		<1%		
E. esula, leafy spurge and Artemisia biennis, biennial wormwood		1%		
Alchemilla, sp., lady's-mantle		<1%		
Equisetum arvense, field horsetail		10%	P	
Bidens spp., beggars ticks		(P)	P	(P)
Xanthium italicum, cocklebur		(P)	P	
Rumex spp., dock			P	(P)
Polygonum spp., smartweeds			P	(P)
Cruciferae, Mustard family			P	1%
Potentilla norvegica, Norwegian cinquefoil			P	2%
Eragrostis hypnoides, creeping love-grass			P	
E. pectinella, Pursh'. love grass				100%
Ranunculus scleratus, cursed crowfoot			P	
Leonurus cardiaca, common motherwort			P	
Lactuca spp., lettuce			P	
Salix interior, sandbar willow			P	
Solanum nigrum var. americana, black nightshade			P	
Cyperus inflexus, incurved galingale			P	
Chenopodium album, white pigweed			P	
Rocky rubble		80%		
Mimulus ringens, gaping monkey-flower				P
Leaf litter		30%		30%

* Panicum capillare, P. virgatum, Echinochloa sp.

P = present
(P)= present but outside the quadrat





The south (right) bank on Transect MBB is also a steep base, eroded slope (See Figure 26). On top of the river bank is a mature forest composed of equal abundance elm, box elder, silver (river)maple and green ash (See Table 8). The forest floor contains no herbs but is covered with leaf litter and sticks. The soil underneath is mostly sand and looks as though it may be a sand bank formed from dredge spoil.

By comparison the north (left) bank, which is located on the outside of the bend, consists of rock rubble overgrown with two zones of vegetation. Sandbar willow and silver (river) maple 10 and 8 feet tall, respectively, are the dominant plants from the shoreline to 8 feet up the bank. From the willow-maple zone to the bank top the dominant plants are field horsetail and white sweet clover. Bare, rocky ground is exposed in only 5 percent of the area.

An old field extends northward from the bank top, to the edge of a woods. The old field is dominated by grasses with a few thistles and members of the buckwheat family.

The south (right) bank of the MCC Transect has a low, flat area inches above the water surface; then the bank rises very steeply. The low, flat area is dominated by the creeping love grass, a member of the parsley family, and sand and dandelions (See Table 9). Bare ground was exposed in only 1 percent of the area and 25 percent of the area was covered with leaf litter. The north (left) bank vegetation is similar to the rocky rubble areas on the upstream transects, changing from a row of willows, to horsetail, to grasses, black-eyed susans and Virginia creeper.

Figure 26. View Downstream of the Right Bank (Foreground) and Left Bank (Background) of the MBB Transect, Minnesota River Mile 12.5 (Colingsworth)

Table 8. Plant Presence or Abundance on the River Banks at Transect MBB, Minnesota River, October 16, 1973

Plant Species	Beach Zone	Quad. #1	Quad. #2	Pt. Qtr.
Fraxinus pennsylvanica var. subintegerrima, green ash				25%
Acer negundo box elder				25%
Ulmus americana, American elm				25%
Acer saccharinum, silver maple	D			25%
Salix interior, sandbar willow	D			
Equisetum arvense, field horsetail		80%		
Melilotus alba, white sweet clover		35%		
Plantago spp., plantains		<1%		
Lactuca spp., wild lettuce		1%		
Aster spp., asters		<1%		
Labiatae, Mint family		<1%		
Panicum sp., panic-grass		<1%		
Gramineae, Grass family		5%	99%	
Cirsium spp., thistles		<1%	1%	
Polyg naceae, Buckwheat family			P	

D = dominant P = present but not dominant

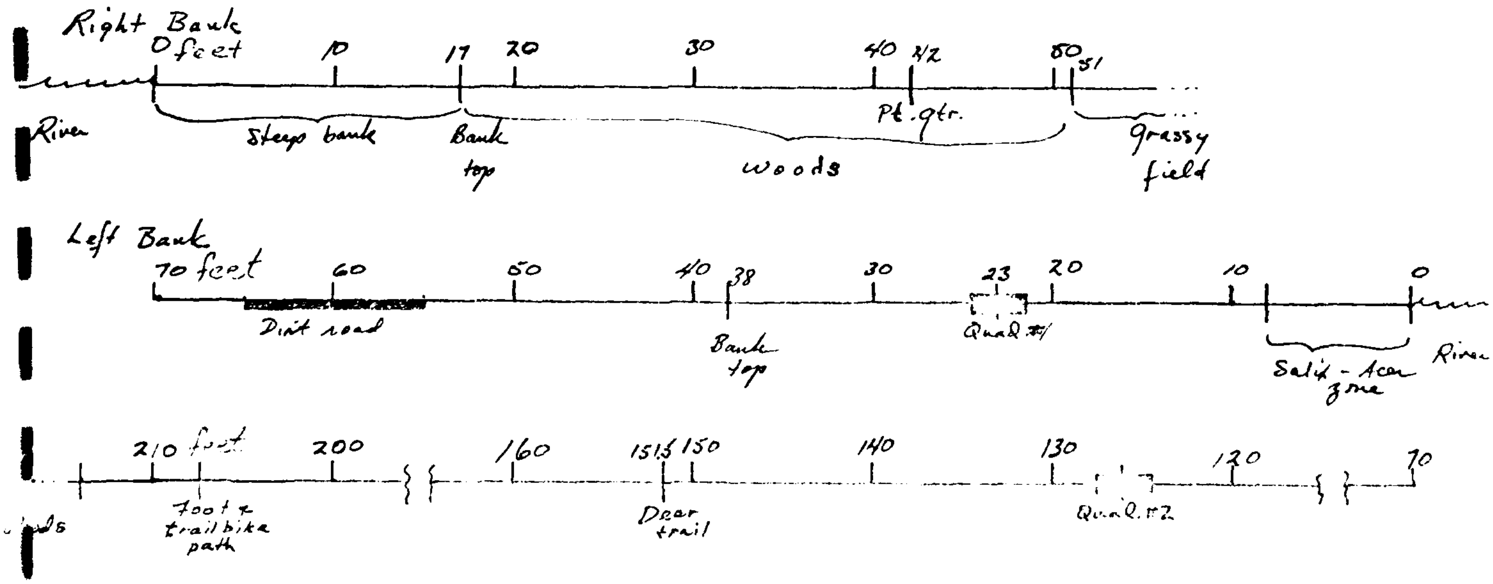
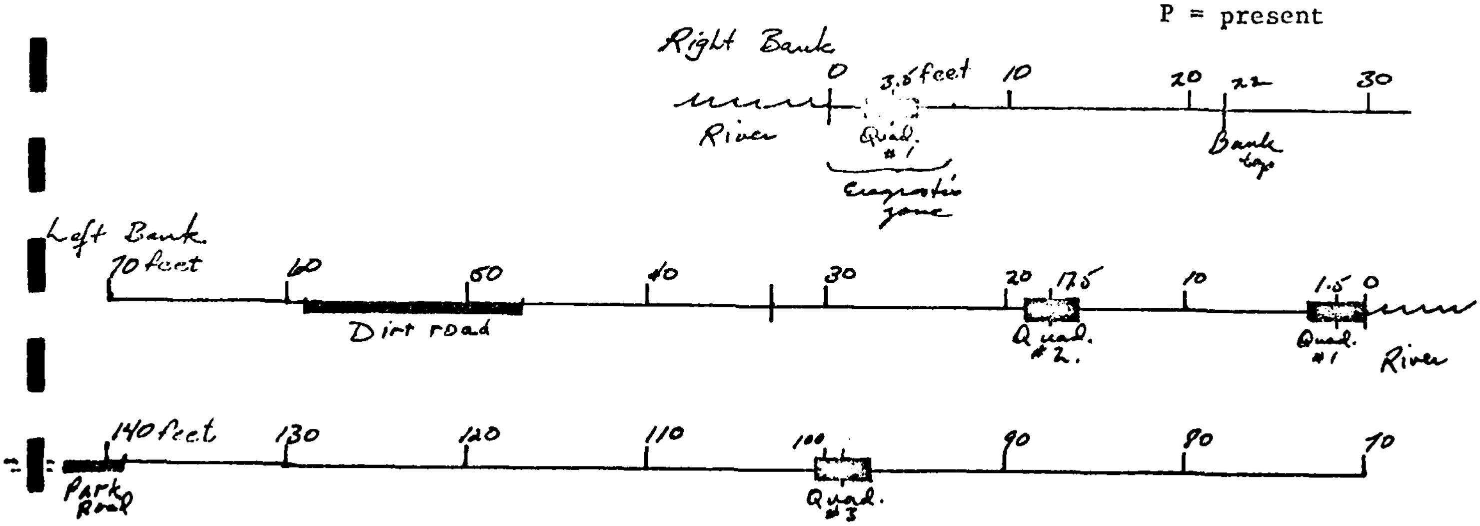


Table 9. Plant Presence or Abundance on the River Banks at the MCC Transect, Minnesota River, October 11, 1973

	L/B			R/B
	Quad. #1	Quad. #2	Quad. #3	Quad. #1
Bidens sp., beggar's ticks	<1%			
Acer saccharinum, silver maple	<1%			
Alchemilla sp., lady's-mantle	<1%			
Salix interior, sandbar willow	P			
Equisetum arvense, field horsetail	10%	40%		
Solidago sp., goldenrod	<1%	1%		
Potentilla sp., cinquefoil	<1%	<1%		5%
Gramineae, Grass family	<1%	P	11%	
Aster sp., asters		1%		
Urticiaceae, Nettle family		1%		
Triticum aestivum, wheat		1%		
Compositae, Composite family		<1%		
Cruciferae, Mustard family		P		
Populus deltoides, eastern cottonwood		P		P
Fraxinus sp., ashs		P		P
Taraxacum officinale, common dandelion		<1%		11%
Rudbeckia serotina, black-eyed susan			10%	
Parthenocissus inserta, woobine			10%	
Oenothera biennis, evening primrose			1%	
Rosa blanda, smooth wild rose			2%	
Sicyos angulatus, bur-cucumber			1%	
Aquilegia canadensis, columbine			<1%	
Eragrostis hypnoides, creeping love-grass				50%
Cyperaceae, sedges				3%
Vitis riparia, riverbank grape				P
Umbelliferae, Parsley family				25%
Plantago major, common plantain				1%
Polygonum, sp., smartweed				<1%
Gentiana or Lobelia, gentian or lobelia				1%
Labiatae, Mint family				1%
Rumex, sp., dock				10%

P = present



Vegetation on Spoil

Zonation and succession of vegetation on sandy spoil in the Twin Cities area has been studied by George (1924) and Cooper (1947). Cooper found that the moisture gradient from the shore to the top of the spoil, as indicated by the depth of dry sand, apparently results in a zonation of the developing vegetation on a spoil site in Pool 1 (See Table 10; also Table 3 in Appendix A IV). Bare, saturated sand recently exposed by a lowered water level (Zone 1) had a few patches of soft-stem bulrush (See Figure 27). As the depth of dry sand increased away from the shore the dominant herb was stick-tights (Zone 2), love-grass (Zone 3) and cocklebürs (Zone 4). In Zone 5 the depth was similar to that of Zone 3 and correspondingly, love-grass was dominant. In Zones 6 and 7 the dry sand was successively deeper, with first bristly foxtail dominant, then a few scattered pioneers of mainly the common saltwort at the highest elevation. Bark fragments present in Zones 2 and 3 reduced moisture loss, encouraging the establishment of herbs. A few cottonwood seedlings were found scattered in Zone 5, with the dry ridge top in Zone 4 and drier Zones 6 and 7 lacking tree seedlings. Sites in the Twin Cities area studied by Cooper indicated that tree succession from the very moist (hydric) and very dry (xeric) spoil soils culminated in the moderately moist (mesic) basswood and sugar maple bottomland forest (See Figure 28).

George's study dealt mainly with plant succession on floodplain areas, which produced 3 stages or communities:

1. the Populus-Salix community, consisting of pioneer cottonwood willows and several non-woody plants growing on open gravel flats which are flooded every spring but are very dry the rest of the year;
2. the Populus-Acer community, a forest made up of cottonwoods surviving from the above pioneer community and the silver (river) maple, located on river terraces or old floodplains in moderately moist habitats; and

Table 10. Vegetation Zones on Sandy Dredge Spoil (Cooper, 1947)

Vegetation: Common Name	Scientific Name	Zones*: 1	2	3	4	5	6	7
Trees								
Cottonwood	<u>Populus deltoides</u>		P		P	P		
Peach-leaved willow	<u>Salix amygdaloides</u>		P					
Herbs								
Soft-stem bulrush	<u>Scirpus validus</u>	P						
Stick-tights	<u>Bidens</u> sp.		D	P				
Barnyard grass	<u>Echinochloa crusgalli</u>		P					
Love-grass	<u>Eragrostis</u> sp.			D		D		
Cocklebur	<u>Xanthium</u> sp.			P	D		P	
Bristly foxtail	<u>Setaria</u> sp.						D	
Strong-smelling clammyweeds	<u>Polanisia graveolens</u>						P	
Common saltwort	<u>Salsola kali</u>						P	D
Smartweed	<u>Polygonum</u> sp.						P	

* Abundance: D = dominant
P = present

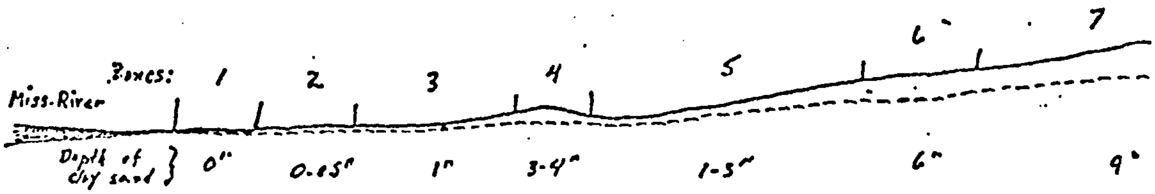


Figure 27. Vegetation Zones Along a Transect from the Mississippi River (in Pool 1) to the Top of Sandy Dredge Spoil (Cooper, 1947)

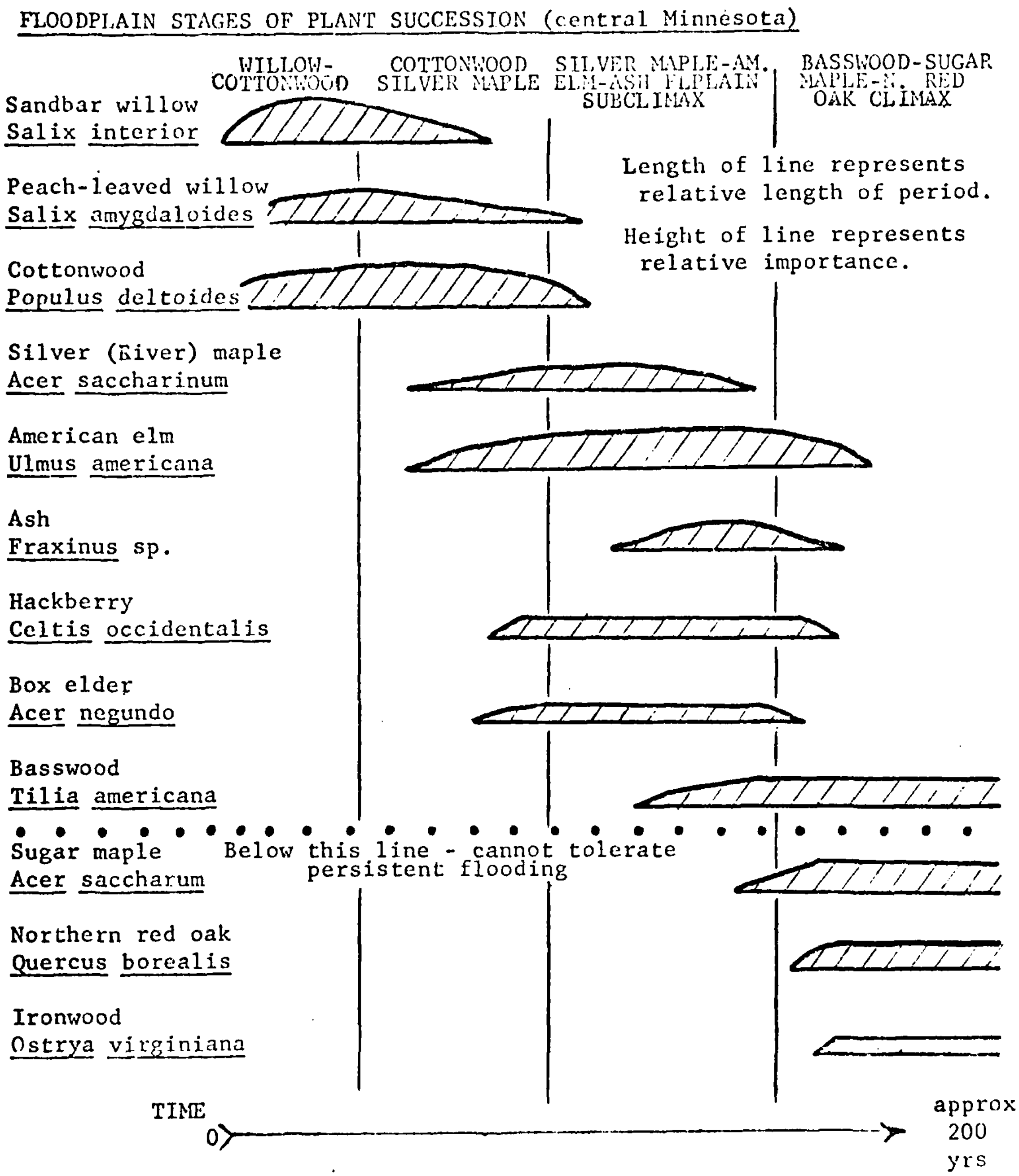


Figure 28. Stages in Floodplain Succession from Willow-Cottonwood to Basswood-Sugar Maple-Northern Red Oak Climax Forest (Adapted from Cooper, 1947).

3. the mature floodplain forest of the terraces, dominated by silver maple survivors from the Populus-Acer forest, American elm, and white ash.

During the earliest pioneer years, cottonwoods and willows grow together on the wet lower levels. Farther up and away from the water, the willow can grow only in fine soil which can retain much water or in moist sand, whereas the cottonwoods, with their larger root systems can reach down to the water underneath the dry higher coarse gravel areas.

Successful covering of floodplain areas by cottonwood seed germination is drastically affected by the time of flooding. For instance, a large crop of cottonwoods in 1922 was due to an extremely high flood that year, which receded and left a bare, moist soil just when the seeds were viable. The young seedlings of 1923, however, were completely destroyed by a rise of the water after germination. Because sandbar willows reproduce by sprouts, they are not subject to fluctuations in numbers to this extent.

More new information on floodplain succession would be useful: of the season of seed dispersal of the major floodplain species, the rate of decline of the spring floods, and time of deposition of spoil.

The species which will colonize dredge spoil during the season it is deposited depends largely on the date of deposition. If this occurs before about July 15 in the Twin Cities area, and a thin layer of silt forms the uppermost layer about 6 to 8 inches above the water table, prompt establishment of tree seedlings can be expected, especially of cottonwoods, peach-leaved willow, American elm, box elder, silver maple and the very important shrub: sandbar willow. This vegetation would provide enough cover immediately to improve the spoil area appearance early as the second year, and would reduce blowing of spoil sand into the backwaters or back into the channel.

Wildlife

Wildlife is possibly not as diverse in the Minnesota River watershed as it apparently is in the upper Mississippi River watershed at the present time. There are, in the latter, wildlife such as mink and river otter (See Table 11). Also numerous geese, diving and dabbling ducks and other birds migrate through the Mississippi and probably the Minnesota watersheds in spring and fall. In the Twin Cities area the shallow lakes and marshes are probably important especially during migration as well as for summer resident waterfowl.

Table 11. Game Animals, Game Birds, and Furbearers of the Upper Mississippi River Basin, 1960 (FWS, 1970)

Moose	*Alces alces*	Rock Dove	*Columba livia*
Whitetail Deer	*Odocoileus virginianus*	Woodcock	*Philohela minor*
Antelope	*Antilocapra americana*	Common Snipe	*Capella gallinago*
Black Bear	*Ursus americanus*	King Rail	*Rallus elegans*
Snowshoe Hare	*Lepus americanus*	Virginia Rail	*Rallus limicola*
Whitetail Jackrabbit	*Lepus townsendi*	Sora Rail	*Porzana carolina*
Swamp Rabbit[a]	*Sylvilagus aquaticus*	Canada Goose	*Branta canadensis*
E. Cottontail Rabbit	*Sylvilagus floridanus*	Snow Goose	*Chen hyperborea*
E. Fox Squirrel	*Sciurus niger*	Blue Goose	*Chen caerulescens*
E. Gray Squirrel	*Sciurus carolinensis*	Mallard	*Anas platyrhynchos*
Red Fox	*Vulpes fulva*	Black Duck	*Anas rubripes*
Gray Fox	*Urocyon cinereoargenteus*	Gadwall	*Anas strepera*
Raccoon	*Procyon lotor*	Pintail	*Anas acuta*
Opossum	*Didelphis marsupialis*	Green-winged Teal	*Anas carolinensis*
Mink	*Mustela vison*	Blue-winged Teal	*Anas discors*
River Otter	*Lutra canadensis*	American Widgeon	*Mareca americana*
Least Weasel	*Mustela rixosa*	Shoveler	*Spatula clypeata*
Shorttail Weasel	*Mustela erminea*	Wood Duck	*Aix sponsa*
Longtail Weasel	*Mustela frenata*	Redhead	*Aythya americana*
Striped Skunk	*Mephitis mephitis*	Canvasback	*Aythya valisineria*
Spotted Skunk	*Spilogale putorius*	Lesser Scaup	*Aythya affinis*
Beaver	*Castor canadensis*	Ring-necked Duck	*Aythya collaris*
Muskrat	*Ondatra zibethica*	Bufflehead	*Bucephala albeola*
Ruffed Grouse	*Bonasa umbellus*	Ruddy Duck	*Oxyura jamaicensis*
Sharp-tailed Grouse	*Pedioecetes phasianellus*	Common Merganser	*Mergus merganser*
Bobwhite Quail	*Colinus virginianus*	Red-breasted Merganser	*Mergus serrator*
Hungarian Partridge	*Perdix perdix*	Hooded Merganser	*Lophodytes cucullatus*
Ring-necked Pheasant	*Phasianus colchicus*	Coot	*Fulica americana*
Wild Turkey	*Meleagris gallopavo*	Common Gallinule	*Gallinula chloropus*
Mourning Dove	*Zenaidura macroura*		

Birds. Birds which have been reported in the Twin Cities area and their migration schedule is given in Table 5 (Appendix A IV). About 280 species of birds have been sighted, of which 97 are common summer residents and nest in the metropolitan area. Another 98 species are present in small numbers, often as spring and fall migrants. Irregularly seen bird species, i.e. single sightings, account for another 85 species. Considerable numbers of these birds frequent the varied and relatively continuous and undisturbed bluff and floodplain habitats in the lower Minnesota River valley.

An extremely unusual phenomenon for a large metropolitan area exists in the location of two large shorebird rookeries at the downstream tip of Pig's Eye Island on the Mississippi River, opposite the St. Paul stockyards. The largest one is a 170-nest black-crowned night heron and American egret rookery, sandwiched between a large barge fleeting basin on the west and a large barge terminal on the east (See Figure 29). This rookery is the largest in the state and is doubly important because elsewhere the night herons have been disappearing from their rookeries in recent years (Warner, 1973).

About 1000 feet upstream is a 60 to 70-nest great blue heron rookery. One evening, 24 of these huge shore birds were observed feeding along the remaining marshes in Pig's Eye Lake. Since 9 were sighted flying up the Minnesota on a single 2-hour trip one morning, and about half a dozen others were seen feeding in Rice Lake near Highway 169, it is probable that these herons use the valley of the Minnesota River frequently. Records of many sightings were taken during 1973 (See Table 12). A total of 417 birds were seen in the Minnesota River valley, nearly double the abundance observed in Pool 2 in the Mississippi River. The great blue herons and American egrets, probably from the Pig's Eye rookeries occur frequently in the floodplain lakes. More studies need to be made of the importance of these floodplain lakes and the river backwaters in the maintenance of bird populations.

Figure 29. A Large Egret and Heron Rookery Adjacent to a Barge Fleeting Basin (North Star--Colingsworth, 1973)

Table 12. Bird Abundance in the River Valleys in the Twin Cities Area Based Upon Casual Observations, 1973.

Bird Species	Flood Plain Lakes		SAF Pools	Pool 1	Pool 2	Minn. R	St. Croix R.	Total No. Individ.
	Minn. R.	Pool 2						
Great blue heron	75	29			13	84		201
Common egret	19	86			8	4		117
American bittern	3							3
Mallard	25	25	90	1	5	20		166
Coot	48	6						54
Wood duck	9	15	18		2	17		61
Pheasant			1					1
Woodpecker			2			1		3
Yellow-shafted flicker			3					3
Grackle			2			1		3
Sparrow			1					1
White-throated sparrow			1					1
Spotted sandpiper			1			19		20
Bank swallow						3		3
Belted kingfisher		1			8	22		31
Black tern						3		3
Teal						2		2
Black duck						1		1
Hooded merganser						1		1
Pied-billed grebe			1					1
Barn swallow			1					1
Osprey		1				2		3
Red-tailed hawk	1							1
Green heron		1			2	38		41
Crow						12		12
Black-crowned night heron					8			8
Common tern		12						12
Canada goose			10			7		17
Total No. individ./pool	180	176	130	1	47	237	0	771

Present terminal and waste disposal activity on Pig's Eye, as well as possible construction to enlarge these facilities, most likely present serious dangers to continued existence of these rookeries. Another danger is the possible loss of feeding sites in the Minnesota floodplain due to landfills, commercial activity and polluted drainage.

Herons, mallards, teal, terns, red-winged blackbirds and others are common inhabitants of the shallow floodplain lakes and marshes in the Twin Cities area.

Other Wildlife. Other animals occurring in the broad floodplain areas in the metropolitan area are muskrat and mink, turtles, snakes and other mammals and reptiles, and some amphibians (See Table 13). In the floodplain forest raccoons, deer, rabbits, wood ducks, foxes, and upland song and game birds and other animals may be found. The Minnesota River valley and that of its tributaries may serve as the last large, continuous natural band of wildlife habitat in the Twin Cities area. This refuge stands in greater jeopardy with increasingly intensive land use in the River valley, such as for landfills, industrial plants residential and cropland areas, and motorcycles and snowmobiles.

Table 13. Animals Common to the Diverse Zones of Vegetation from the River to the Blufftop (after Wallace, McHarg, Todd and Roberts, 1969)

Habitat Type	Species
Deep marshes	Frogs; water snakes, turtles; coot, grebes, rails, blackbirds, marsh birds, blue-winged teal, mallard, herons, black tern; muskrat, mink.
Shallow marshes	Frogs, toads, snakes and other amphibians and reptiles; coot, grebes, blue-winged teal, mallard (nesting), migrating ducks, pheasant; muskrat, mink, and white-tailed deer.
Wet meadows	Leopard frogs, salamanders, snakes, other amphibians and reptiles; herons, pheasant, nesting waterfowl, marsh song-birds; red fox, white-tailed deer.
Mud flats, sandy shores and bogs	Nesting ducks, other marsh and shore birds, songbirds; small mammals, deer.
Wooded and shrub swamps	Spring peeper, swamp tree frogs; woodcock, marsh and song birds, herons, wood duck (nesting); small rodents and shrews, beaver, mink, racoon, and deer.
River bottom forests	Green frog, salamanders; snakes, turtles; wood ducks, forest songbirds, upland gamebirds; cottontail rabbit, raccoon, gray fox, white-tailed deer.
Upland hardwoods	Wood frog, salamanders; snakes, including pilot black snake, red-bellied snake and Brocon snake; ruffed grouse; flying squirrel, raccoon, gray fox, red fox, white-tailed deer.
Dry oak savanna and dry uplands	Snakes; ruffed grouse, pheasant; spotted and striped skunks, red fox, woodchuck, white-tailed deer.
Brush prairie	Prairie songbirds including horned lark, bobolink, vesper sparrow, lark sparrow; killdeer.
Prairie grassland	Hog-nosed snake; upland plover, Hungarian partridge; whitetail jackrabbit, 13-lined and Franklin ground squirrels, badger.

Water Quality

The lower 25-35 miles of the Minnesota River receives the largest quantity of wastes and the floodplain perhaps is the most developed, (thus, having the lowest water quality) of any reach of the River. This water quality can be expected to fluctuate widely during the year due to variations in volume of discharge, ice cover and commercial activities.

A study of the major rivers in the Twin Cities area by the Federal Water Pollution Control Agency (now EPA) showed that, in general, water quality decreased downstream from Chaska to the mouth of the Minnesota River (See Table 14 and FWPCA, 1966). Water quality in the lower Minnesota River was similar to that in the Mississippi (See Table 15), except that turbidity and phytoplankton concentration was greater in the Minnesota. At the confluence of these two rivers the Minnesota also has greater numbers of coliform bacteria. Thus, although the water of the Minnesota River is generally of lower quality than the Mississippi at Mile 844, the Minnesota has only a moderate effect except for turbidity because its flow is about 30 percent that of the Mississippi River. Its turbidity and total coliform organisms are about two-fold, however.

At Mile 27.5 during the summer months, the DO (dissolved oxygen) averaged 9.1 ppm, decreasing abruptly below Shakopee (Mile 25.0) and continuing to decrease to 6.6 ppm (parts per million) at Mile 1.9 (FWPCA, 1966). The oxygen sag or minimum point of 2.7 ppm appeared to be located at Mile 10.8, just downstream from Port Marilyn (See Table 14).

Also, turbidity increased downstream, averaging 70 JTU (Jackson Turbidity Units) at the lower end. Although turbidity less than 25 JTU was found, as much as 240 units were observed, during and after rainfall.

Table 14. Water quality in the Minnesota River from Chaska to the mouth, in 1964 (FWPCA, 1966)

Dissolved Oxygen (DO)	9.1 ppm, av. (2.7 ppm, min.)	5.9 ppm, av. (upstream) to 1.8 ppm, av. (downstream)
Ammonia-nitrogen	0.3 ppm, av. (.6 ppm max.)	1.4 ppm, av. (upstream)to 1.1 ppm, av. (downstream)
Total inorganic nitrogen	1.72-2.01 ppm	
Orthophosphate	0.46 ppm (av.)	
Turbidity	70 JTU av. (upstream) to 110 JTU av. (downstream)	
Temperature	82-90°F.	32-11°F.
Bacteria	67,000 MPN/liter, av. (2.4 million, max.)	5 million MPN/1 (upstream) to 96,000 MPN/1 (downstream)
Phytoplankton (open-water algae)	38.8 million units/1 av.	
Bottom organisms (benthos)		1 individual/ft.^{2} to 487/ft.^{2}

ppm - parts per million
JTU - Jackson Turbidity Units
MPN/1 - Most probable number (of bacteria) per liter

River stations (river mile), upstream to downstream: 871 — U.S. 52-169, Elm Creek Area; Minneapolis Waterworks Intake; Head of 9-ft. Navigation; Upper St. Anthony Pool; Upper and Lower St. Anthony Falls Locks and Dams; Pool 1; 847.6 — Lock and Dam 1; Minnesota River; Lambert Landing, St. Paul; WWT Plant; Pool 2; Rock Is. RR Bridge; Shiely Co. Terminal, Up. Grey Cloud Island; 815.3 — Lock and Dam 2; U.S. 61 Bridge, Hastings; Pool 3; 796.9 — Lock and Dam 3, Red Wing

	Lock and Dam 1 (847.6)	Minnesota River	Lambert Landing, St. Paul	WWT Plant		Rock Is. RR Bridge	Shiely Co. Terminal, Up. Grey Cloud Island			Pool 3
DO, ppm (av.)	8.0	7.7	7.8	5.5		4.3		2.9	5.2	
DO, % sat.	86	105								
NH_3-N, ppm	0.30									
Turbidity, JTU (av.)	<25	60		——	——	55	——	——	——	
Temperature, °F. (max.)	93.3	84	85			85				
Phenols			40		620	210	200			
Bottom sediments (Sand and/or rock above Lock and Dam 1)		Sand and organic sludge, mixed				Organic Sludge				Sand and organic sludge, mixed
Bacteria: Total Col., MPN/10^6	170		344	32.7	65.0	50.0	15.0		1.0	
Bacteria: Fecal Col., MPN/10^6	020		.012			15.71				
Phytoplankton, no./10^6	12.45					15.71				
Benthos, no. spp.	13	7	6	2	1					
Tubificids/ft.^{2}, artificial substrate				259	396	127000	1,600			
Game fish, %	50					—— 6 ——	——		—— 9 ——	

Table 15. Water Quality in the Mississippi River in the Twin Cities area (FWPCA, 1966; Hokanson, 1968)

Coliform bacterial concentration is markedly increased above that entering this reach of the river, by effluents from Rahr Malting Company and the Chaska and Shakopee sewage treatment plants, so that the density at Mile 23.0 ranges from 240,000 to 2,400,000 MPN/1 (Most Probable Number per liter). Although Cargill (Mile 13.4) causes an increase by 10,000 MPN/1, coliform bacteria decreases downstream progressively to an average of 137,000 MPN/1 at Mile 1.9 due to die-off and dilution.

During the winter months water quality may decrease due to changes in commercial activity and the weather. When ice covers this segment of the river gaseous exchange with the air is prevented. Also light is blocked so that photosynthesis, which produces oxygen, does not occur. Thus, there is a build-up of CO_2, H_2S, etc. Thus, the DO averaged 5.0 ppm (35 percent saturation) at Mile 29.6, under the ice, and dropped progressively downstream from the now operating American Crystal Sugar Company to 1.4 ppm at Mile 14.3. For several miles below the Black Dog power plant the River is ice free, apparently increasing the DO to an average 3.0 ppm. The DO dropped again to an average 1.8 ppm under the ice by Mile 1.9.

A profound effect also on winter coliform bacterial concentration appeared to be due to the winter operation of the sugar company in 1964. Above their outfall (liquid waste outlet) the total coliform density was 2200 MPN/1, increasing to 5,000,000 MPN/1 nearly 5 miles downstream from the outfall. By Mile 1.9 the bacterial density had decreased to 96,000 MPN/1.

The use of water from the lower 25-35 Miles of the Minnesota River thus is suitable only for cooling water, for navigation, esthetic enjoyment and pollution-tolerant aquatic life. However, just below the Black Dog power plant in 1964 even the latter may be excluded. The low DO apparently caused a fish kill in the winter of 1964.

The lower reach of the Minnesota River is unsuited for irrigation, stock and wildlife watering and limited body contact due to the high bacteria concentrations. High turbidity interferes with swimming and potable use of the water (See Tables 6 and 7, Appendix A IV)

According to the FWPCA "most of the turbidity is a result of erosion of the river banks and inadequate land practices in the drainage area. Stock watering, sport fishing, and pleasure boating were practiced although the water quality was considered unsuitable" (FWPCA, 1966).

The flow and some water quality parameters of the lower Minnesota River are continously recorded by the USGS (U. S. Geological Survey) and EPA (Environmental Protection Agency), respectively. The daily mean flows, recorded at the USGS gaging station at Carver, Minnesota, shows that high water may occur in summer and fall as well as spring (See Figure 2 in Appendix A IV).

The water quality parameters include dissolved oxygen (DO), pH, temperature and specific conductance (an estimate of dissolved solids) and are monitored automatically at Mile 3.5 (where the airport approach lite cross the river). DO and specific conductance reach a maximum winter, and DO peaks again in spring (See Figure 3 in Appendix A IV). Temperature, however, is at a minimum during winter and highest in summer (See Table 4 in Appendix A IV). Variations in these data are attributable to variations in flow and temperature, while pH also shows considerable fluctuations but a seasonal pattern is not discernible (See Figure 6 in Appendix A IV).

Turbidity is low in the four-foot channel reach of the Minnesota River (Mile 14.7 to 21.7), compared with the nine-foot channel reach (Mile 0 to 14.7) (See Tables 8 and 9 in Appendix A IV). This seems to be due in part at least to navigation and maintenance dredging in this reach, and has its greatest effect near the river bottom. Turbidity in the Minnesota is nearly 10 times that of the Mississippi River.

Aquatic Vegetation

Some of the aquatic "macrophytes" (plants visible without a microscope) in the Twin Cities havebeen identified (See Table 16). These may be found in the backwaters and floodplain lakes, but no vegetation occurs in the main channel. The macroscopic aquatic vegetation has been grouped into habitat types, including deep and shallow marshes (greater or less than three feet deep), and wood and shrub swamps (Wallace, et al., 1969). This vegetation includes emergent species such as cattails, bulrush and others; floating species such as duckweed and white water lily; and submerged plants, including pondweed, coontail and others.

Rather high phytoplankton densities were recorded in 1964, although they apparently did not cause any problems. Abundance decreased slightly downstream from over 38 million units/1 at Mile 25.1 (Shakopee) to the previous concentration at Mile 1.9. No record was made of changes in abundance of species.

Table 16. Aquatic Vegetation in the Mississippi River in the Vicinity of the Twin Cities (Wallace, et al., 1969).

Habitat	
Deep Marshes	Cattail, bulrush, reed grass, round-stemmed bulrush, and wild rice. In open areas: pondweed, coontail, water milfoil, waterweeds, duckweed, white water-lily, spatterdock and other aquatics.
Shallow Marshes	Grasses, bulrushes, spikerush, cattail, arrowhead, pickerelweed, smartweed, reed grass, whitetop, rice cutgrass, sedge and giant bur reed, and wet willow growths.
Wood and Shrub Swamps	Undergrowth: moss, duckweed, smartweed, and others.

Aquatic Animals

More than 120 species of fish were found in the Upper Mississippi River basin, 48 of which have been found in Pool 2 in 1964 (See Table 17). The data may be indicative of the fish population near the mouth of the Minnesota River since the two rivers are continuous (no dams or other obstructions) and the water chemistry of the two rivers is similar.

Trap-netting data above the Minnesota River in 1964 showed that 50 percent of the fish caught were game species and the other half were rough fish (See Table 18). Most of the fish were black crappies, white bass and carp (Skrypek, 1969). Apparently a greater percentage of rough fish occur upstream from the mouth due to the lower water quality. In 1964 only 7 percent were game fish, mainly catfish (FWPCA, 1966).

In 1964 bottom sediments in the lower 35 miles of the Minnesota River were found to be a mixture of sand and sludge (See Figure 30). The sludge apparently is derived from commercial activities on the River since organiz material, even parts of whole beets, were found just downstream from the American Crystal Sugar Company effluent (this plant is now closed). The slower current in winter forms deposits of the organic material, which is probably carried out with the spring flood. However, benthic samples in 1973 indicates that the river bottom is composed of fine sand, silts, and clays.

The density of bottom organisms increased downstream in the lower reach of the Minnesota River in 1964, although there was much variation. Apparently the increase was due to sludge worms (tubificids). In the sandy bottom, 62 midges (flies) per square foot were found above the American Crystal Sugar Company effluent. Downstream for about 1000 feet organic sludge and parts of whole beets were found as a result of the operation of this facility in winter of 1964. "At [Mile] 27.7 (point of discharge) there were only 3 sludge worms per square foot and 4.7 miles below this point, only one per square foot was found. At [Mile] 16.8 the animal numbers, primarily represented by sludgeworms, were 33 per square foot

Table 17. Checklist of Fishes Found in the Upper Mississippi River Basin (FWS, 1970)

Petromyzontidae – lampreys
- Chestnut lamprey *Ichthyomyzon castaneus* Girard
- Silver lamprey *Ichthyomyzon unicuspis* Hubbs and Trautman

Acipenseridae – sturgeons
- Lake sturgeon *Acipenser fulvescens* Rafinesque
- Pallid sturgeon *Scaphirhynchus albus* (Forbes and Richardson)
- ✓Shovelnose sturgeon *Scaphirhynchus platorynchus* (Rafinesque)

Polyodontidae – paddlefishes
- ∤ Paddlefish *Polyodon spathula* (Walbaum)

Lepisosteidae – gars
- Spotted gar *Lepisosteus oculatus* (Winchell)
- X Longnose gar *Lepisosteus osseus* (Linnaeus)
- ✓Shortnose gar *Lepisosteus platostomus* Rafinesque

Amiidae – bowfins
- ✓Bowfin *Amia calva* Linnaeus

Clupeidae – herrings
- O Skipjack herring *Alosa chrysochloris* (Rafinesque)
- O Ohio shad *Alosa ohiensis* Evermann
- X ✓Gizzard shad *Dorosoma cepedianum* (LeSueur)
- Threadfin shad *Dorosoma petenense* (Gunther)

Salmonidae – trouts, whitefishes, and graylings
- Cisco or lake herring *Coregonus artedii* LeSueur
- Rainbow trout *Salmo gairdneri* Richardson

Hiodontidae – mooneyes
- Goldeye *Hiodon alosoides* (Rafinesque)
- ✓Mooneye *Hiodon tergisus* LeSueur

Umbridae – mudminnows
- Central mudminnow *Umbra limi* (Kirtland)

Esocidae – pikes
- Grass pickerel *Esox americanus vermiculatus* LeSueur
- XX ✓Northern pike *Esox lucius* Linnaeus
- Muskellunge *Esox masquinongy* Mitchill

Cyprinidae – minnows and carps
- Stoneroller *Campostoma anomalum* (Rafinesque)
- Southern redbelly dace *Chrosomus erythrogaster* (Rafinesque)
- XX ✓Carp *Cyprinus carpio* Linnaeus
- X Ozark minnow *Dionda nubila* (Forbes)
- Silverjaw minnow *Ericymba buccata* Cope
- Brassy minnow *Hybognathus hankinsoni* Hubbs
- Cypress minnow *Hybognathus hayi* Jordan
- Silvery minnow *Hybognathus nuchalis* Agassiz
- Northern plains minnow *Hybognathus placitas* Girard
- Speckled chub *Hybopsis aestivalis* (Girard)
- Flathead chub *Hybopsis gracilis* (Richardson)
- Sheepshead
- Sicklefin chub *Hybopsis meeki* Jordan and Evermann
- X Silver chub *Hybopsis storeriana* (Kirtland)
- Gravel chub *Hybopsis x-punctata* Hubbs and Crowe
- –X Golden shiner *Notemigonus crysoleucas* (Mitchill)
- Pallid shiner *Notropis amnis* Hubbs and Greene
- Pugnose shiner *Notropis anogenus* Forbes
- X Emerald shiner *Notropis atherinoides* Rafinesque
- X– River shiner *Notropis blennius* (Girard)
- Ghost shiner *Notropis buchanani* Meek
- Central common shiner *Notropis cornutus chrysocephalus* (Rafinesque)
- XX Common shiner *Notropis cornutus* (Mitchill)
- X– Bigmouth shiner *Notropis dorsalis* (Agassiz)
- XX Spottail shiner *Notropis hudsonius* (Clinton)
- Red shiner *Notropis lutrensis* (Baird and Girard)
- Rosyface shiner *Notropis rubellus* (Agassiz)
- Silverband shiner *Notropis shumardi*
- XX Spotfin shiner *Notropis spilopterus* (Cope)
- X Sand shiner *Notropis stramineus* (Cope)
- Weed shiner *Notropis texanus* (Girard)
- Blacktail shiner *Notropis venustus* (Girard)
- Mimic shiner *Notropis volucellus* (Cope)
- Channel mimic shiner *Notropis volucellus wickliffi* Trautman
- Pugnose minnow *Opsopoeodus emiliae* Hay
- Suckermouth minnow *Phenacobius mirabilis* (Girard)
- XX Bluntnose minnow *Pimephales notatus* (Rafinesque)
- XX Fathead minnow *Pimephales promelas* Rafinesque
- X – Bullhead minnow *Pimpephales vigilax* (Baird and Girard)
- Longnose dace *Rhinichthys cataractae* (Valenciennes)
- Creek chub *Semotilus atromaculatus* (Mitchill)

Catostomidae – suckers
- River carpsucker *Carpiodes carpio* (Rafinesque)
- Quillback *Carpiodes cyprinus* (LeSueur)
- Highfin carpsucker *Carpiodes velifer* (Rafinesque)
- XX White sucker *Catostomus commersoni* (Lacepede)
- O Blue sucker *Cycleptus elongatus* (LeSueur)
- Northern hog sucker *Hypentelium nigricans* (LeSueur)
- X Smallmouth buffalo *Ictiobus bubalus* (Rafinesque)
- X ✓Bigmouth buffalo *Ictiobus cyprinellus* (Valenciennes)
- Black buffalo *Ictiobus niger* (Rafinesque)
- Spotted sucker *Minytrema melanops* (Rafinesque)
- XX Silver redhorse *Moxostoma anisurum* (Rafinesque)
- Golden redhorse *Moxostoma erythrurum* (Rafinesque)
- XX ✓Northern redhorse *Moxostoma macrolepidotum* (LeSueur)
- Greater redhorse *Moxostoma valenciennesi* Jordan
- Common Sucker (sic)

X Hokanson, 1964
XX Hokanson (1968) - Coon Rapids
✓Dept. Conservation, 1969

O How rare in basin (BSFW - App. A)
∤ No longer commercially fished (BSFW - App.A)

Table 17. **Checklist of Fishes Found in the Upper Mississippi River Basin (Continued) (FWS, 1970)**

Ictaluridae – freshwater catfishes	Pumpkinseed *Lepomis gibbosus* Rafinesque
Blue catfish *Ictalurus furcatus* (LeSueur)	Orangespotted sunfish *Lepomis humilis* (Girard)
Black [illegible] *Ictalurus melas* (Rafinesque)	Bluegill *Lepomis macrochirus* Rafinesque
Yellow [illegible] *Ictalurus natalis* (LeSueur)	Longear sunfish *Lepomis megalotis* (Rafinesque)
Brown [illegible] *Ictalurus nebulosus* (LeSueur)	Redear sunfish *Lepomis microlophus* (Gunther)
Chann[illegible] *Ictalurus punctatus* (Rafinesque)	Smallmouth bass *Micropterus dolomieui* Lacepede
Stone[illegible] Rafinesque	Largemouth bass *Micropterus salmoides* (Lacepede)
Tadp[illegible] *gyrinus* (Mitchill)	White crappie *Pomoxis annularis* Rafinesque
Flath[illegible] *olivaris* (Rafinesque)	Black crappie *Pomoxis nigromaculatus* (LeSueur)
Anguillidae [illegible]	**Percidae** – perches
Ame[illegible] *rostrata* (LeSueur)	Crystal darter *Ammocrypta asprella* (Jordan)
Cyprinodont[illegible]	Western sand darter *Ammocrypta clara* Jordan and Meek
Black[illegible] *Fundulus notatus* (Rafinesque)	Mud darter *Etheostoma asprigene* (Forbes)
Poeciliidae [illegible]	Rainbow darter *Etheostoma caeruleum* Storer
Mos[illegible] *affinis* (Baird and Girard)	Bluntnose darter *Etheostoma chlorosomum* (Hay)
Gadidae – [illegible]	Iowa darter *Etheostoma exile* (Girard)
Burb[illegible] (Linnaeus)	Fantail darter *Etheostoma flabellare* Rafinesque
Gasterost[illegible]	Johnny darter *Etheostoma nigrum* Rafinesque
Broo[illegible] *inconstans* (Kirtland)	Banded darter *Etheostoma zonale* (Cope)
Percopsidae [illegible]	Yellow perch *Perca flavescens* (Mitchill)
Trou[illegible] *omiscomaycus* (Walbaum)	Logperch *Percina caprodes* (Rafinesque)
Aphredoder[illegible]	Blackside darter *Percina maculata* (Girard)
Pirate[illegible] *sayanus* (Gilliams)	Slenderhead darter *Percina phoxocephala* (Nelson)
Serranidae [illegible]	River darter *Percina shumardi* (Girard)
Whit[illegible] (Rafinesque)	Sauger *Stizostedion canadense* (Smith)
Yello[illegible] *mississippiensis* (Jordan and Eigenmann)	Walleye *Stizostedion vitreum vitreum* (Mitchill)
Centrarch[illegible]	**Sciaenidae** – drums
Rock[illegible] *rupestris* (Rafinesque)	Freshwater drum *Aplodinotus grunniens* Rafinesque
Warm[illegible] *gulosus* (Cuvier)	**Atherinidae** – silversides
Green[illegible] *cyanellus* Rafinesque	Brook silverside *Labidesthes sicculus* (Cope)

Table 18. Summary of trapnet catches of fish upstream from the Minnesota River in Pool 2 in 1964 (Skrypek, 1969)

Game Fish	Number (8 sets)	No./set
Northern pike	6	.75
Walleye		
Sauger		
Black crappie	91	11.38
White crappie	2	.25
Bluegill	3	.38
Green sunfish		
Rock bass		
White bass	31	3.88
Largemouth bass		
Smallmouth bass	1	.13
Game Fish Total	134	16.77
Percent Game Fish	50.0	
Rough Fish		
Carp	122	15.25
Northern redhorse	2	.25
Silver redhorse	2	.25
Common sucker		
River carpsucker		
Largemouth buffalo		
Smallmouth buffalo	2	.25
Sheepshead	3	.38
Black bullhead		
Yellow bullhead		
Brown bullhead		
Channel catfish		
Flathead catfish	1	.13
Gizzard shad	1	.13
Shortnose gar	1	.13
Rough Fish Total	134	16.77
Percent Rough Fish	50.0	

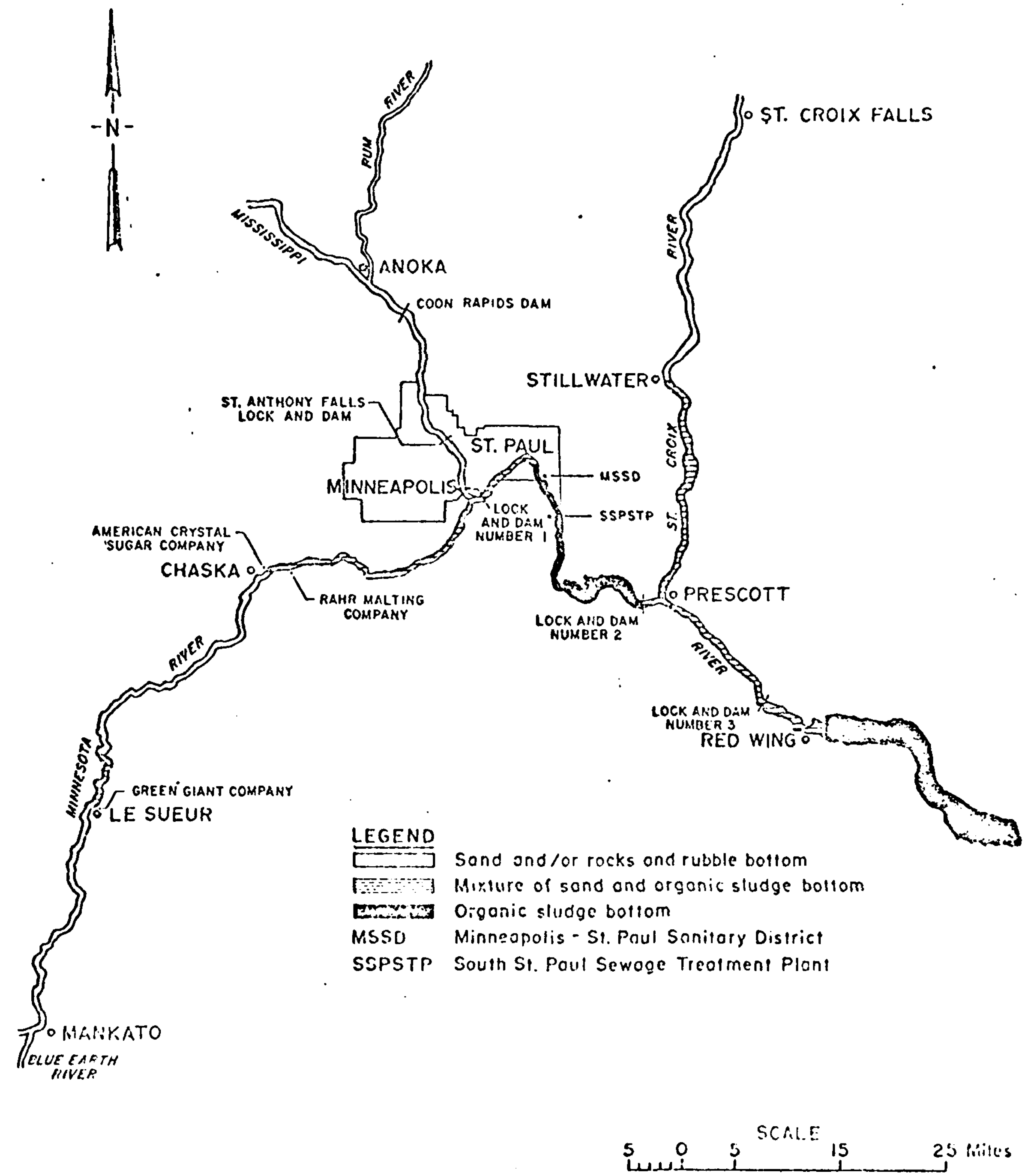


Figure 30. Distribution of Bottom Sediments (FWPCA, 1966)

and increased progressively to a maximum of 487 per square foot at [Mile] 7.4. The total numbers then dropped to 150 per square foot at [Mile] 1.9." (FWPCA, 1966). Thus, as for benthic macroinvertebrates, organic wastes seem to be a dominating influence on abundance in 1964.

In 1973 bottom (invertebrate) animals increased downstream in abundance while diversity decreased (See Table 19). Compared with 1964, the present abundance appears unchanged near Savage, while abundance increased near Shakopee at (Mile 26.4) and decreased near the mouth of the Minnesota River at (Mile 2.9). No organic material was found in the bottom sediments where organic material--even whole beets--were found nine years ago.

Apparently the abundant and diverse clam population in this reach of the Minnesota River has decreased since the 1930's to the extent that only one living specimen was obtained (at Mile 7.4) in 1964. This decline in numbers and kinds of clams "can be attributed to such factors as heavy organic pollution and dredging the barge canal" (FWPCA, 1966).

Field studies in 1943 and examination of previous collections indicate that the clam population was of greater variety than about twenty years later (See Table 20). The greatest variety occurred at Fort Snelling, while elsewhere in the Minnesota River drainage basin the number of species was less than half that near the mouth (Dawley 1947). The same report indicates that at the time of the study the variety of clams in the Minnesota River was similar to that of the Mississippi River below Minneapolis, and to the St. Croix River (See Table 21).

Table 19. Bottom (invertebrate) Animals Abundance at the Standard Transects in the Minnesota River, 1973.

Benthic Animals (Invertebrates)	Number of Individuals/ft²								
	MAA(Mile 26.4)			MBB(Mile 12.5)			MCC(Mile 2.9)		
	L/B	Mid.	R/B	L/B	Mid.	R/B	L/B	Mid.	R/B
Hydropsychidae (Trichoptera)	2								
Elmidae (Coleoptera)	1								
Chironomidae (Diptera)	11			1	7	1		2	
Nematacera (Diptera)	2								
Oligochaeta					11	1		28	5
Total Number Individuals/ft²		16			21			35	

Total Number of Bottom Organisms per Square Foot in the Lower Minnesota River

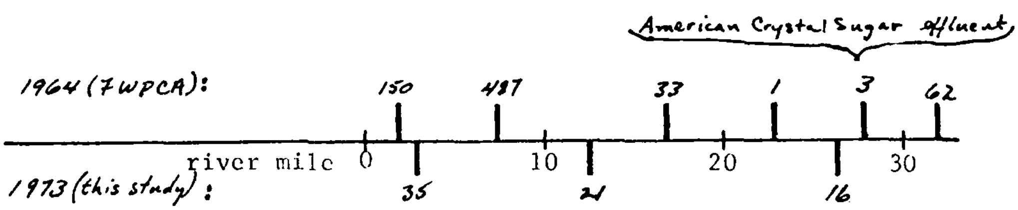


Table 20. Clams found in the Minnesota River and three of its major tributaries (Dawley, 1947).

Species	Minn. R. drainage					
	Minn. R.**	Ft. Snelling	above New Ulm	Blue Earth R.	Cottonwood R.	Chippewa R.
1. *Fusconaia undata*		x	x			
2. *Fusconaia flava*						
3. *Megalonaias gigantea*		x				
4. *Amblema peruviana*		x				
5. *Amblema rariplicata*		x	x			
6. *Amblema costata*						
7. *Quadrula quadrula*		x				
8. *Quadrula pustulosa*		x	x			
9. *Tritogonia verrucosa*		x				
10. *Plethobasus cyphyus*			x			
11. *Pleurobema cordatum coccineum*	x					
12. *Elliptio dilatatus*		x		x		
13. *Elliptio crassidens*	x					
14. *Elliptio complanatus*						
15. *Lasmigona compressa*						
16. *Lasmigona costata*	x					
17. *Lasmigona complanata*		x	x			
18. *Anodonta grandis*		x				
19. *Anodonta gigantea*		x				
20. *Anodonta corpulenta*		x				
21. *Utterbackia imbecillis*		x				
22. *Anodontoides ferussacianus*			x		x	
23. *Alasmidonta marginata truncata*	x					
24. *Arcidens confragosus*		x				
25. *Strophitus rugosus*						
26. *Obliquaria reflexa*		x				
27. *Obovaria olivaria*		x				
28. *Actinonaias carinata*			x			
29. *Truncilla truncata*		x	x			
30. *Truncilla donaciformis*		x				
31. *Leptodea fragilis*		x	x			
32. *Proptera alata megaptera*		x				
33. *Proptera laevissima*		x				
34. *Carunculina parva*		x				
35. *Ligumia recta latissima*			x	x		
36. *Lampsilis fallaciosa*		x				
37. *Lampsilis siliquoidea*		x				
38. *Lampsilis ventricosa*	x	x	x			
39. *Lampsilis higginsi*			x			
40. *Plagiola lineolata*		x				
Total Species	5	26	12	1.	1	

** No location designated

Table 21. Clams found in the major rivers which flow through the Twin Cities Area (Dawley, 1947).

Species	Mississippi R. below Minneapolis	Mississippi R. above Minneapolis	St. Croix R.	Minnesota R.
1. *Fusconaia undata*	x		x	x
2. *Fusconaia ebenus*	x			
3. *Fusconaia flava*			x	
4. *Megalonaias gigantea*	x		x	x
5. *Amblema peruviana*	x		x	x
6. *Amblema rariplicata*	x		x	x
7. *Amblema costata*	x		x	
8. *Quadrula quadrula*	x			x
9. *Quadrula pustulosa*	x		x	x
10. *Quadrula metanevra*	x			
11. *Tritogonia verrucosa*	x		x	x
12. *Cyclonaias tuberculata*	x		x	
13. *Plethobasus cyphyus*	x		x	x
14. *Pleurobema cordatum coccineum*	x		x	x
15. *Elliptio dilatatus*	x		x	x
16. *Elliptio complanatus*				
17. *Elliptio crassidens*	x			x
18. *Lasmigona compressa*		x	x	
19. *Lasmigona costata*	x		x	x
20. *Lasmigona complanata*	x		x	x
21. *Anodonta grandis*	x	x	x	x
22. *Anodonta marginata*		x		
23. *Anodonta gigantea*	x			x
24. *Anodonta corpulenta*	x		x	x
25. *Utterbackia imbecillis*	x	x	x	x
26. *Anodontoides ferussacianus*		x	x	x
27. *Alasmidonta marginata truncata*	x		x	x
28. *Arcidens confragosus*	x			x
29. *Strophitus rugosus*	x		x	
30. *Obliquaria reflexa*	x		x	x
31. *Obovaria olivaria*	x		x	x
32. *Actinonaias carinata*	x	x	x	x
33. *Truncilla truncata*	x		x	x
34. *Truncilla donaciformis*	x			x
35. *Plagiola lineolata*	x			x
36. *Leptodea fragilis*	x		x	x
37. *Proptera alata megaptera*	x		x	x
38. *Proptera laevissima*	x		x	x
39. *Carunculina parva*	x		x	x
40. *Ligumia recta latissima*	x	x	x	x
41. *Lampsilis fallaciosa*	x			x
42. *Lampsilis siliquoidea*	x	x	x	x
43. *Lampsilis ventricosa*	x	x	x	x
44. *Lampsilis higginsi*	x		x	x
Total Species	39	9	33	35

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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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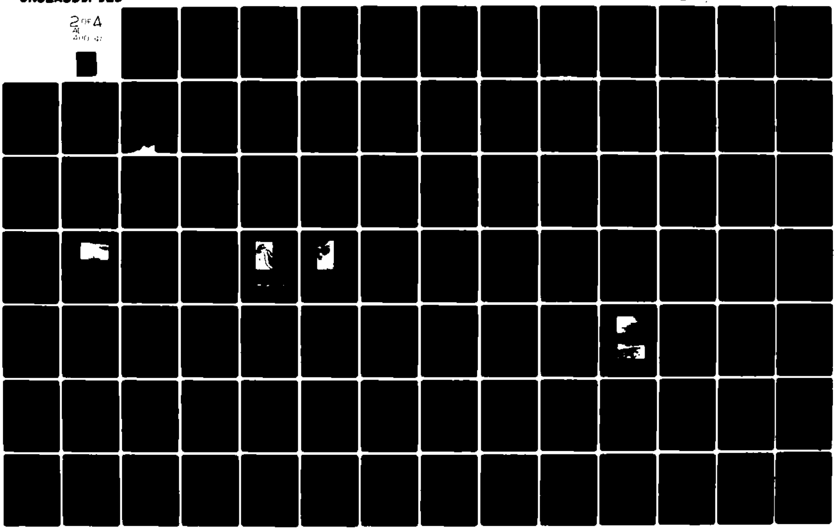

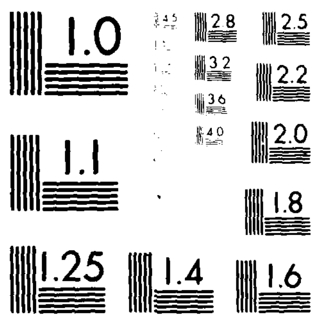

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Numerous clam shells were seen between Mile 16.8 and the mouth in 1964, however, and personal observations in 1973 of clam deposits in this reach and farther upstream suggest that possibly there is a population of greater dimensions than indicated in 1964. Shells of several species were collected in 1973 along the shoreline and lack of abrasion suggest that water-borne transport, if it occurred, probably was of a short distance (Table 22).

Table 22. Minnesota River Mollusks.

Shells Found in the Study Area	
Mile 5.5 2/14/73	4 *Amblema plicata* Say (some quite old shells)
	1 *Obliquaria reflexa* Rafinesque (paired valves)
	1 *Proptera laevissima* Lea (paired valves)
	3 *Campeloma* sp. (snail)
	1 *Stagnicola* sp. (snail)
Shells Found Upstream from the Study Area	
Above New Ulm, Minn. near the St. George Bridge 9/73	3 *Actinonaias ligamentina* Lamarck

Collected by Barbara Gudmundson

Identifications by Dale Chelberg, Curator of Biology, Science Museum of Minnesota

Floodplain Lakes

There are about nine relatively large floodplain lakes along the lower 25 miles of the Minnesota River (See Table 23 and Figure 1 in Appendix A II). They are shallow lakes with much emergent vegetation and surrounded by marsh. These lakes are important feeding and resting habitat for waterfowl. However, no detailed information could be found on these lakes.

Table 23. Location of Minnesota River Floodplain Lakes.

Lake	Bank	River Mile	Landmark
Rice	L	25.0 to 23.3	Just downstream from the Highway 169 Bridge.
Grass	L	22.5 to 20.5	
Blue	R	20.0 to 19.0	
Fisher	R	18.5 to 17.5	Just upstream from Scott Co. Highway 25.
Rice	R	17.3 to 16.3	Just downstream from Scott Co. Highway 25.
Black Dog	R	10.6 to 7.5	Black Dog power plant.
Long Meadow	L	9.8 to 5.3	Crossed by Cedar Ave. Bridge.
Gun Club	R	4.8 to 3.3	
Snelling	L	3.0 to 2.0	Just upstream from the Mendota Bridge.

Endangered Species

Animals. There are seven animal species considered rare or endangered in the Upper Mississippi River Basin (See Table 24). Of these the sprey is the only one observed in 1973 on the Minnesota River. Others such as the pine marten and fisher, which are threatened with extinction, are making a comeback in Wisconsin and Michigan (BSFW, 1973). No studies have been made on their status in the Minnesota River Valley. Given the degree of urbanization previously outlined, their presence is doubtful in the lower 25 miles of the River.

Table 24. Rare and Endangered Plants and Animals

PLANTS

Rare and Endangered Plants by habitat, MN DNR, 1971.

	Moist Prairie Habitat
Moist meadows	Wild orange-red lily, wood lily, Lilium philadelphicum
	Shooting star, Dodecatheon meadia
	Small white lady's-slipper, Cypripedium candidum (orchid)
	Prairie phlox, Phlox pilosa
	Blue-eyed grass, Sisyrinchium angustifolium
	In Hardwoods in the Southeast
Fairly open hardwoods	Bluebell, Virginia cowslip or Lungwort, Mertensia virginica
	*Minnesota trout-lily, Erythronium propullans
	*Adam-and-Eve root, Aplectrum hyemale (orchid)
	Northern Forest
Fairly open coniferous forests	Yew, Taxus canadensis
	Ram's-head lady's-slipper, Cypripedium arietinum (orchid)

*has always been fairly rare

Table 24 (cont.) Rare and Endangered Plants and Animals

PLANTS

Plants rare in Minnesota and in all of North America

Cruciferae; Mustard Family
Draba norvegica, Whitlow-grass: Cook.

Leguminosae; Pea Family
Lespedeza leptostachya, Prairie Bush-clover: Cottonwood, Crow Wing, Goodhue.

Liliaceae; Lily Family
Erythronium propullans, Dwarf or Minnesota Trout-lily or Adder's Tongue: Goodhue, Rice. Found nowhere else in the world.

Orchidaceae; Orchid Family
Malazis paludosa, Bog Adder's Mouth: Clearwater, Ottertail.

Plants legally protected in Minnesota (the protection is weak, and needs strengthening).

Ericaceae; Heath Family
Epigaea repens, Trailing Arbutus.

Gentianaceae; Gentian Family
Gentiana, Gentian, all species.

Liliaceae; Lily Family
Lilium, Lily, all species
Trillium, trillium, all species.

Nymphaeaceae; Water Lily Family
Nelumbo lutea, Lotus Lily.

Orchidaceae; Orchid Family
All Species.

Table 24 (cont.) Rare and Endangered Plants and Animals
ANIMALS

Animal	Present Distribution
Indiana Bat Myotis sodalis Status endangered with estimated population 500,000.	Midwest and eastern United States from the western edge of Ozark Region in Oklahoma to central Vermont to southern Wisconsin, and as far south as northern Florida.
Timber Wolf Canis lupus lycaon Status endangered with estimated population 300-500.	Lake Superior Region of Michigan, Wisconsin, and Minnesota.
Southern Bald Eagle Haliaeetus leucocephalus Status endangered with about 230 active nests in 1963.	Nests primarily in Atlantic and Gulf coasts but ranges northward in summer to northern United States and Canada.
American Peregrine Falcon Falco peregrinus anatum Status rare with estimated population 5,000-10,000.	Breeds from northern Alaska to southern Greenland south to Baja California; winters in northern United States.
N. Greater Prairie Chicken Tympanuchus cupido pinnatus Status rare within Basin.	Resident locally in prairie habitat from central southern Canada south to northeastern Colorado, northwestern Kansas and northeastern Oklahoma east to northern Michigan, Indiana, Wisconsin, Illinois and Missouri.
Greater Sandhill Crane Grus canadensis fabida Status rare with an estimated population of 2,000 east of Rocky Mountains.	Breeds locally from southern British Columbia, east to southern Manitoba including Minnesota, Wisconsin and Michigan.
Lake Sturgeon Acipenser fulvescens Status rare with estimated size of population unknown.	Distributed throughout Great Lakes Drainage with records from Mississippi and St. Croix Rivers.

Table 24 (cont.) Rare and Endangered Plants and Animals

ANIMALS

Reptiles

Blue tailed Skink

Wood Turtle

Blanding's Turtle

Cricket Frog

Red-backed Salamander

Common Newt

Mammals

Star-nosed Mole

Plants

Lotus

Mammilaria

Opuntia raffinesquii cactus

Birds

Sprague's Pipit

Baird's Sparrow

Yellow Rail

White Pelican

Egrets: 1. common (American)
2. cattle
3. snowy

Birds continued

Trumpeter Swan

Bald Eagle

Osprey

Peregrine Falcon

Marsh Hawk

Sandhill Crane

Piping Plover

Wilson's Phalarope

Avocet

Western Willet

Caspian Tern

Great Gray Owl

Hawk Owl

Boreal Chickadee

Chestnut-collared Longspur

Lark Sparrow

Sharp-tailed Sparrow

Le Conte's Sparrow

Grasshopper Sparrow

Henslow's Sparrow

Yellow-breasted Chat

Prothonotary Warbler

<u>Plants</u>. General preliminary lists of rare and endangered plants include more than nineteen kinds of plants (See Table 24). Moist meadows are common in the Minnesota River valley; however, these sites apparently have not been studied recently. Orchids have been found on the floodplain (Morley, 1973) and possibly could be adversely affected by spoil deposition in woodlands along the river bank. The American lotus (*Nelumbo lutea*) is found in Snelling Lake and possibly occurs in the other floodplain lakes. Further study is needed to determine its distribution.

Pre-Project Communities

Two early records indicate the nature of preproject natural ecosystems. These consist of the report of surveys of the Minnesota River by General G. K. Warren (Secretary of War, 1875) and the report of Leisman (1959) which includes early settlement (1855) vegetation and an account of the Spring Lake area (Pool 2, Mississippi River) in the 1920's and early 1930's.

General Warren's report is concerned with early prospects of navigation on the Minnesota and dealt primarily with water depth, obstructions and rock and timber resources for structures to aid navigation. The following quote records the nature of the river from Shakopee downstream to the mouth, made by Mr. C. E. Davis (a civil engineer) in 1866-68 for General Warren:

> " . . . the right bank bluffs are very regular, the first bluff being limestone from 40 to 60 feet high, and from one to one and a half miles wide, the second terrace being gravel and from 60 to 100 feet above the first bench, about one mile wide, extending back to the main bluff, which is wooded with oak, maple, and elm, and about 225 feet above bottom. On the lower terrace and about five miles below Chaska, in the right valley, is located the town of Shakopee, one of the oldest towns in the State.
>
> At Shakopee, the valley is one and a half miles wide, widening below this, the left bluff continuing the general course of the river, (northeast) the right bluff bearing off to the right until it joins the bluffs of Credit River, ten miles below where the valley is three miles wide. The bottom is about one mile

wide and in the left valley, the river from 300 to 350 feet wide with a muddy bottom, and the depth of water from 6 to 15 feet. On the right the first terrace is from 30 to 50 feet above bottom, with outcroppings of limestone on the face of the bluff. This terrace is from one to one and a half miles wide and is sand loam. The second bluff is of sand and gravel and from 60 to 100 feet above the first terrace; the terrace sand loam and one mile broad to the main bluff, which is from 200 to 225 feet above bottom, and wooded on slope and crest with oak, maple, and elm.

This formation extends down about eight miles below Shakopee, where the first terrace is lost in the second at a small creek which comes in through a ravine on the right. Below this creek the bottom is about one and a half miles wide, the terrace on the right heavily wooded and about 140 feet high and about one mile wide, the main bluff 50 to 75 feet above terrace and wooded on slope and crest.

Ten miles below Shakopee, Credit River comes in from the right through a wide ravine. This stream is about 30 feet wide, with gravel bed and banks, and during freshets rises 12 or 15 feet and contributes a considerable volume of water to the Minnesota.

Two miles below Credit River is a gravel-bar known as 'Swede's Bar' on which are some loose boulder rocks, the depth of water in the channel being from 4 to 6 feet, and below this is a good stage of water for navigation in all seasons.

The Minnesota bottom is now one low flat marsh on both sides, interspersed with clumps of willows, with a few scattering willow and cotton-wood trees on both banks of the river.

In the left bottom is a lake, separated from the river by a narrow strip of marsh, and extending about 5 miles down the river, and in seasons of high water these bottomlands are entirely overflowed from 10 to 15 feet, and in seasons of low water one impenetrable marsh, with large mud lakes in the bottom.

Near the mouth of the Minnesota the main bluff on the left bears off to the left and joins the bluff of the Mississippi River, while a bluff of sandstone about 100 feet high extends down to the junction of the two streams, and on this terrace is located Fort Snelling. On the right the main bluff bears off until it joins the bluff of a wide and deep ravine which opens into the Mississippi bottom, below the confluence of the Mississippi and Minnesota Rivers, but a sandstone bluff from 80 to 100 feet high follows down the general course of the river and becomes the right bluff of the Mississippi River.

> A line of levels from the Little Rapids to the mouth of the Minnesota, distance by river 35 miles, gives the fall to be 3-1/2 feet, an average slope of 1/10 foot per mile. A measurement made at Carver gives the volume of water to be 1,924 cubic feet per second.
>
> As the sand-bar at the mouth of the Minnesota had been examined by the party of the Mississippi survey, I made no examination further than the railroad bridge which crosses the Minnesota River a few rods above its confluence with the Mississippi."

Additional information on the early vegetation and wildlife is reported by Leisman (1959) for Spring Lake (Pool 2, Mississippi River), which may be similar in some respects to the lower reach of the Minnesota River.

The early-settlement (1855) vegetation of the eastern Spring Lake area has been mapped by Leisman (1959) based on the General Land Office Survey Map (See Figure 31). An elm-maple forest occupied the bottomlands and surrounded the marsh now covered by Spring Lake. Oaks fringed the blufftops, while open prairie with aspen groves lay beyond. At this time also,

> "a mill was constructed by D. W. Truax and John Blakeley at the mouth of the drainage creek at the northeastern end of the marsh. This mill raised the water level of the marsh so that the eastern half was transformed into a shallow open lake, while the western half remained as marsh. In the ensuing years the abundance of fish and wildlife in the lake and marsh attracted scores of fishermen and hunters to the area. Among them was the late Dietrich Lange, former St. Paul school superintendent and an ardent naturalist, who frequented the Spring Lake area many times in the 1920's and early 1930's. From his many notes and photographs, an accurate picture of the lake and marsh can be gleaned. The dominant plant of the marsh was the bulrush, *Scirpus* sp., with many cottonwoods and willows along the margins. (According to a long time resident of the area, wild rice, *Zizania aquatica* L., was also abundantly present in the marsh. However, his talent for stretching the truth and misconstruing natural phenomena is well known, and hence the occurence of wild rice in the marsh is open to considerable doubt. Wild rice does not occur there now, and there is no mention of it in any of Lange's notes.)

Game fish abounded in the lake, muskrats built their houses throughout the marsh, and countless ducks used the marsh and lake as a stopping point on their annual spring and fall migrations."

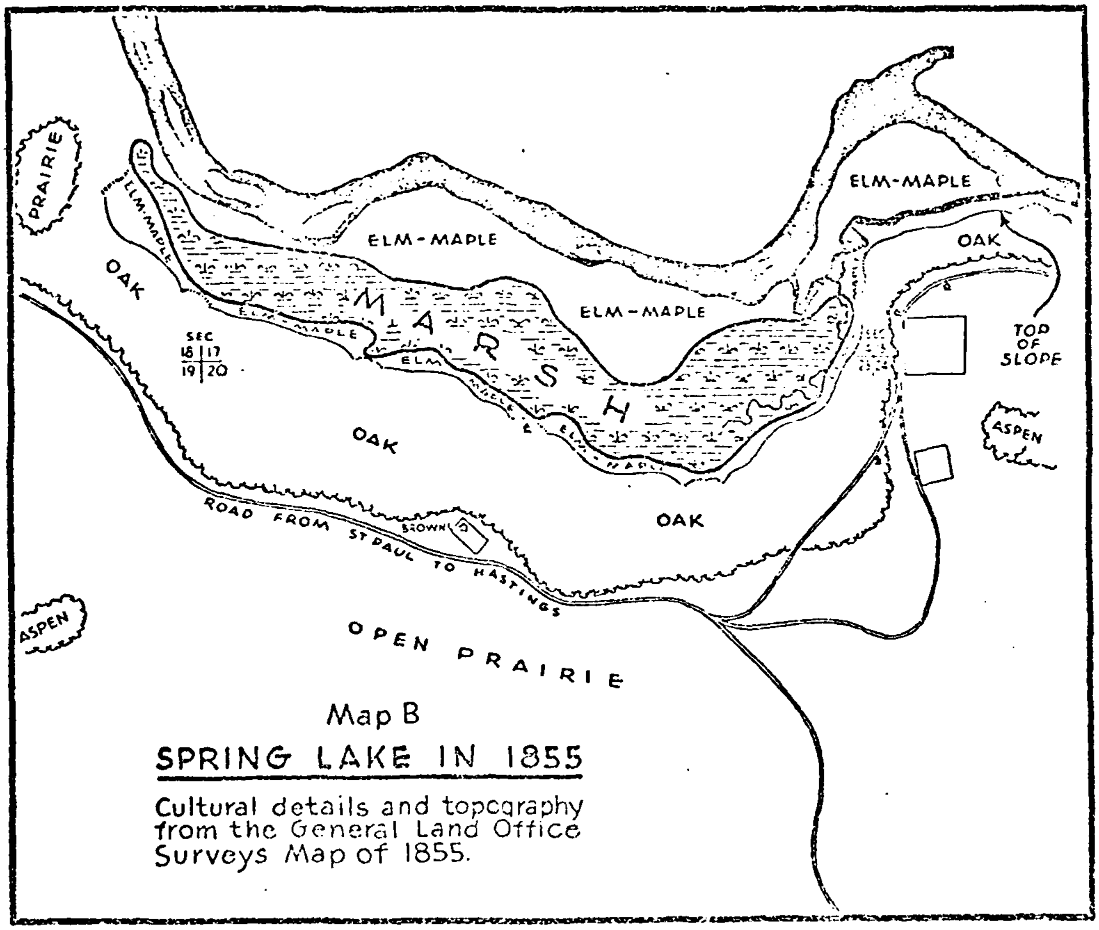

Figure 31. Map of Spring Lake. Civil Land Office Survey (Leisman, 1959)

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting are discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report and (2) by presenting an overview of these activities on the Mississippi River as they also relate to the Northern Section of the Upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful to divide a discussion of the socioeconomic setting of the study area of the Upper Mississippi River into (1) industrial activity, (2) recreational activity, and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial dock facilities, and commercial fishing. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of available data makes this impossible in the present study. As a result indices of this industrial activity -- such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught -- are generally used.

Recreational Activity

Recreational activity has two effects of interest. One is the psychological value to the users themselves of being near or on the Minnesota River for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the River for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently use units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor-days. It is often very difficult to find such measures for a particular segment of a river. Where such data are available they are used. Where they are not available -- such as fishermen using a specific pool -- proxy measurements are used; for example, number of sport fishermen observed annually, even though this is not as precise a measure as desired. Problems involved with placing dollar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural considerations are the third component of the socioeconomic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and contemporary sites. These sites can include such diverse physical assets as burial mounds, historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites, they are simply inventoried in the present study.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of the Minnesota River are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and South.

Historical Development of the Waterway. The development of the Northern Section of the Upper Mississippi and its tributaries as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and highway trucking utilize the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively utilized to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi and Minnesota Rivers were transportation corridors for the Indians. They were used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Minnesota and Mississippi Rivers were characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the rivers could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats could pass along the Minnesota and between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823 and steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U. S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's large grain shipments from Minneapolis began.

Although four and 1/2-foot and six-foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U. S.,and technological developments in barges and tugs led to the authorization of a nine-foot channel to Minneapolis in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

In order to understand the role of the Minnesota River in the industrial history of the entire Mississippi River system, it is necessary to understand the growth of freight shipped or the system as a whole as well as on the Minnesota.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to

Corps' activities. For example, the following factors [illegible] the [illegible] in [illegible] prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with [illegible] of statistical collection.

2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's due to the construction of [illegible] in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to profitable economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal period of transportation in the Upper Mississippi River Basin.

<u>Barge Shipments</u>. Table 25 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

Table 25. River Shipment from 1920 through 1945 (OCE, 1900 to 1971)

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,855	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

* Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

In more recent years, data are available for the St. Paul District. Table 26 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

Table 26. River Shipment from 1962 through 1971.

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,205,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,647,428
1970	15,423,713
1971	15,070,082
1972**	16,361,174

Sources: * S.P.D.-NCS, 1900 to 1971.
** Estimated

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the Mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

In 1928 data were collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,600 tons were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the nine-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

Table 27 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River, and on the Minnesota River in 1971.

Table 27. River Trips in 1971.

	Upbound		Downbound	
Transportation Mode	Miss R.	Minn. R.	Miss R.	Minn. R.
Self Propelled				
Passenger & dry cargo	1,900	2	1,875	1
Tanker	3		2	
Towboat or Tugboat	8,433	833	8,419	883
Non-Self Propelled (barge)				
Dry cargo	25,250	1,882	25,237	1,878
Tanker	7,312	251	7,311	246
TOTALS	42,898	3,018	42,844	3,008

Source: OCE, 1971

In recent years, traffic on the Minnesota River has grown substantially, keeping pace with growth in the St. Paul District as a whole. Table 28 below shows this growth since 1962.

Table 28. Comparative Statement of Traffic, Minnesota River

Section included: Mouth to Shakopee, Minnesota, Mile 25.6 Controlling Depth: 9 feet, Mouth to Savage, Minnesota, Mile 14.7; local interests maintain 9-foot channel for restricted widths from Mile 14.7 to Mile 21.8 near Shakopee, Minnesota, project depth: 9 feet, mouth to Savage; 4 feet, Savage to Shakopee. Navigation season: from about 23 March to 16 December 1971.

Year	Tons	Year	Tons
1962	1,923,190	1967	2,584,873
1963	2,231,671	1968	1,721,555
1964	2,339,271	1969	2,585,728
1965	2,207,908	1970	3,601,743
1966	2,816,376	1971	3,626,132

Source: OCE, 1971

Unlike all other pools and tributaries of the Mississippi River in the St. Paul District, exports exceed imports. In 1971 exports were 2,728,473 tons (mainly grains) and imports were 897,659 tons (mainly coal and minerals).

It should also be noted that the Minnesota River is not a thoroughfare to other pools or tributaries. Traffic entering or leaving the Minnesota River has its destination or origin at the commercial docks in that river.

The shipping season for most of the Mississippi River system within the St. Paul District is usually eight months, from mid-April to mid-December. The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System ranged from 700 to 800 miles. This indicates that the great bulk of shipments and receipts have origins or destinations outside the St. Paul District. Each pool then in addition to its own shipments and receipts contributes to the economic benefits enjoyed by the system as a whole. Thus, any measure of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary link in the Upper Mississippi system.

Commercial Dock Facilities. To accommodate the barge traffic on the Upper Mississippi River system, many firms maintain commercial docks. Some of these have elaborate facilities for loading or unloading specialized cargoes with which they deal -- coal, oil, grain, and gravel anc crushed rock. The facilities vary appreciably with individual pools and tributaries. Those serving the firms in the area covered by this report will be discussed later in Section 3 under "Socioeconomic Systems".

Commercial Fishing. As population along the Northern Section of the Mississippi River increased, industrial specialization also took place. The result was the development and growth of commercial fishing along the Upper Mississippi in the last half of the nineteenth century and during the twentieth century.

Limited data are available on the extent of commercial fishing prior to 1930. However, the rise in the water level behind the newly-constructed locks and dams in the Upper Mississippi River after 1930 increased the fish habitat over that existing prior to the construction.

No commercial fishing occurs in the Saint Anthony Falls Pool, Pool 1 and Minnesota River; and very little occurs in Pool 2. No comparable data are available on commercial fishing in the Minnesota and Saint Croix Rivers. In 1969 the Northern Section of the Upper Mississippi River produced about 5.5 million pounds of fish that were sold commercially; this was an increase of about 9 percent from the 1960 total. The commercial value of the fish caught in 1969 was about $400,000.

Recreational Activity

In addition to the industrial activity described above, the Northern Section of the Upper Mississippi River system has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4-1/2-foot channel in 1878 -- the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul -- settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the upper River were few. Thus, boating then was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

As the twentieth century dawned, leisure time accompanying the settler's higher standard of living led to recreational uses of the Upper Mississippi River system. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930, prior to the nine-foot channel, presents problems. These arise because of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living, and increased leisure from those caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi River system is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river -- and virtually all of it for the deeper-craft pleasure boats -- is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 32 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972. Although the Minnesota River has no locks and dams, the existence of Lock and Dam 2 on the Mississippi and dredging in the Minnesota River contributes to the boating and other recreational opportunities of the Minnesota.

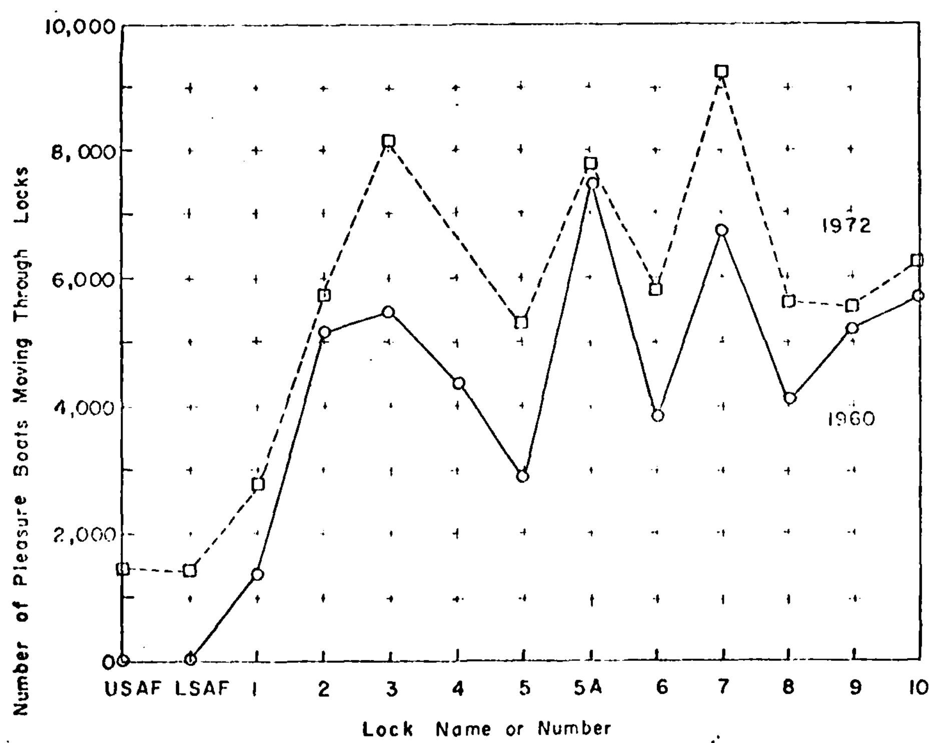

Figure 32. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972 (S.P.D.-NCS, 1960 and 1972)

Only one facility has been developed on the Minnesota River mainly to serve the pleasure boaters. This is a small boat marina at the Cedar Avenue Bridge. The facilities at Fort Snelling are not available to the boater on the Minnesota River.

Sport Fishing and Hunting. Precise measures of the number of sport fishermen using a specific pool or tributary are not available. Although creel census data are available for several of the pools in the study area, comparable data do not exist for the majority of the pools or the tributaries. Because water quality, particularly in the navigable portions of the Minnesota is low, particularly in DO, little sport fishing takes place.

Sport hunting for waterfowl along the Minnesota River study area is thought to be large. However, no statistics are available that measure this activity.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. A variety of parks exist along the river that are available for sightseeing and other recreational activities.

Cultural Considerations

A number of archaeological, historical, and contemporary sites exist in the study area. Although the bulk have been unaffected by Corps' operations, these sites in several pools have been hurt by the rising water level due to dam construction (See Appendix B for detailed archaeological information).

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3. THE ENVIRONMENTAL IMPACT OF THE NINE-FOOT NAVIGATION CHANNEL

INTRODUCTION

Impacts are understood here to be environmental responses to human activities. This study deals mainly with those impacts likely to be the result of the Corps of Engineers' navigation channel project in the lower 25 miles of the Minnesota River.

Because little detailed information appears to exist which describes such impacts on the Minnesota River the impacts listed below were derived from:

1. information from studies of the Minnesota River made for other purposes,
2. assumptions made from studies made on the Mississippi,
3. knowledge of basic ecological and socioeconomic principles and processes,
4. personal experience of the investigators.

Field studies during this phase of the study will extend the data base to provide further information on at least the major impacts.

The Corps' project which produces these impacts includes (a) the presence of Lock and Dam 2, Mississippi River Mile 815.3 and (b) the operation of these structures and the maintenance dredging of the nine-foot channel; additional impacts arise from (c) navigation by commercial and private vessels of the river and from their attendant facilities, which is provided by the channel. The environmental impacts of this project are the changes brought about in the physical and biological components of natural systems, and in changes in the cultural, economic, recreational, archaeological and aesthetic components of socioeconomic systems.

NATURAL SYSTEMS

Identification of Impacts

The primary impacts of impoundment and dredging by the Corps of Engineers in the Minnesota River are:

1. increase depth of the River;
2. dispose of dredge spoil
3. increased turbidity due to dredging and navigation;
4. creation of backwaters;
5. straightening the channel;
6. increased incentive for developing the floodplain and river banks, resulting in further loss of floodplain, increased flood steeps, more bare soil areas, and adverse effluents;
7. increased turbulence due to navigation;
8. moderation of water level changes.

The primary impacts listed above are related to Corps operations and maintenance activities, navigation, and to pre-project activities (such as snagging and cleaning activities) in Tables 29, 30 and 31. From the primary impacts, stem the "secondary" and "additional" environmental impacts which are then traced further, if possible, in the discussion section.

It should be noted that the impacts in the Minnesota River are not always completely isolated and ascribable to the Corps because they are part of a complex, multi-dimensional web of physical-chemical, biological and socioeconomic action and reaction; impacts also derive partially from other economic and cultural activities and from natural environmental processes acting in the local area as well as in the larger basin.

Table 29. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Upon the Components of Natural Systems.

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Dam #2	1. Impoundment of river (raised water levels)	1. Moderated water levels changes.	1. Increased plant and animal populations and variety in marshes and lakes.
			2. Increased rate of filling of floodplain lakes and marshes.
			3. Decreased bank erosion.
		2. Increased depth, slowed current.	1. Increased siltation; reduction in benthic animals.
			2. Reduced riffles; decreased flowing-river fish, clams, etc.
			3. Provided for better navigation at low water; increased commercial development of floodplain and bluffs.
Lock No. 2 (Mississippi River Mile 815.3)	1. Passage of vessels	1. Increased navigation of Minnesota River	1. Increased turbulence; increased bottom and bank erosion; increased turbidity; increased sedimentation; decreased benthos.
		2. Increased development of floodplain and bluffs.	1. Increased erosion of floodplain and bluff; increased sedimentation in floodplain and river; decreased wetland and benthic habitat.

Table 29. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Upon the Components of Natural Systems (Continued).

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
		3. Increased (or decreased) aesthetics.	
	2. Migration of aquatic organisms (fish, clams and other benthos)	1. Decreased biotic diversity and productivity.	
Lock No. 1 (Mississippi River Mile 847.6).	1. Passage of large, deep draft vessels.	1. Increased number of vessels on Minnesota River	1. Increased turbulence; increased bottom and bank erosion; increased turbidity; increased sedimentation; decreased benthos.
		2. Increased commercial development of floodplain and bluffs.	1. Increased erosion or deposition of floodplain, and erosion of bluff; increased sedimentation in floodplain and river; decreased wetland and benthic habitat.
		3. Increased (or decreased) aesthetics.	
	2. Migration of aquatic organisms (fish, clams and other benthos) impeded.	1. Maintain or bring on deterioration of biotic diversity.	
	3. Changes in water levels near mouth of Minnesota River.	1. Increased bank erosion	1. Increased sedimentation; decreased benthos.

Table 29. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems (Continued).

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Wing Dams	1. Channelize river.	1. Isolate riffles	1. Increase sedimentation; decrease benthos.
Bank protection structures.	1. Decrease bank erosion.	1. Reduce turbidity	1. Increase benthos, fish.
	2. Increase benthic habitat.		
Maintenance Dredging	1. Increase turbidity.	1. Cover benthos, plants.	1. Reduce biota.
		2. Suffocate fish, spawn.	
		3. Reduce water quality.	
	2. Exposes new sterile substrate.	1. Loss of benthos	1. Decrease fish, waterfowl, vegetation, decrease wildlife.
Spoil deposition	1. Decrease in marsh or terrestrial vegetation.	1. Spreads to cover more terrestrial habitat; redeposited in channel decreased aesthetics.	1. Decrease vegetation; decrease wildlife. 2. Confines channel. 3. Fills floodplain.
	2. Provide recreational sites.	1. Increased aesthetic enjoyment.	
		2. Increased disturbance of fish and wildlife.	
Snagging and debris clearance	1. Decrease benthos, turtles.	1. Decrease fish.	1. Decrease waterfowl, recreation (fishing, bird watching).

Table 29. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems (Continued).

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
	2. Increase turbidity.	1. Decrease fish, benthos.	1. Decrease waterfowl, recreation (fishing, bird watching). 2. Reduce aesthetic appeal.
	3. Reduce aesthetic appeal of disposal area.		

Table 30. Impacts of Commercial Navigation and Barge Terminals and Maintenance Facilities in Natural Systems.

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Navigation	1. Increased turbidity.	1. Decreased aquatic biota.	1. Decrease in wildlife and waterfowl.
	2. Increased bank(shore) erosion	1. Increased turbidity.	1. See second and additional impacts above.
	3. Increased fumes and effluents adverse to existing biota.	1. Decreased aquatic biota.	1. Decreased waterfowl and wildlife
	4. Possibility of spills of oil and hazardous materials.		
	5. Increased aesthetic interest.		
Barge terminal, fleeting area	1. Adverse effluents	1. Decreased aquatic biota.	1. Decreased waterfowl, furbearers.
	2. Loss of terrestrial habitat.	1. Decreased wildlife.	
	3. Increased noise level.	1. Decreased wildlife.	
	4. Adverse aesthetics.		

Table 31. Probable Impacts of Corps Activity and Structures Prior to 1930 Upon Natural Settings.

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Removal of snags, wrecks, shoals and sandbars, beginning about 1867.	1. Increased turbidity.	1. Decreased benthic organisms, fish.	1. Decreased waterfowl, furbearers.
	2. Decreased benthic substrate.		
Construction of wing dams and bank protection structures, beginning about 1878.	1. Increased quarrying, cutting of brush.	1. Loss of terrestrial habitat.	1. Decreased wildlife. 2. Increased runoff, erosion, sedimentation.
		2. Increased erosion.	1. Decrease in aquatic biota.
	2. Increased turbidity.	1. Decreases in aquatic biota (fish, benthos).	1. Decreased waterfowl, furbearers.
	3. Increased habitat for benthic organisms.	1. Increased aquatic biota (fish, benthos).	1. Increased waterfowl, furbearers.
	4. Channelized river.	1. Reduced water surface habitat as sediment collected behind wing dams.	2. Decreased aquatic biota; decreased waterfowl and furbearers.
	5. Reduced bank erosion.	1. Decreased formation of new backwaters.	1. Decrease of backwater biota.
		2. Reduced turbidity.	1. Increased aquatic biota (fish, benthos)

Table 31. Probable Impacts of Corps Activity and Structures Prior to 1930 Upon Natural Settings. (Continued).

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Pre-project Dredging	1. Increase turbidity.	1. Cover benthos, plants.	1. Reduce biota.
		2. Suffocate fish, spawn.	
		3. Reduce water quality.	
	2. Exposes new sterile substrate.	1. Loss of benthos.	1. Decrease fish, waterfowl, vegetation, decrease wildlife.
Spoil from preproject dredging	1. Increase turbidity.	1. Cover benthos, plants.	1 Reduce biota.
		2. Suffocate fish, spawn.	
		3. Reduce water quality.	
	2. Exposes new sterile substrate.	1. Loss of benthos.	1. Decrease fish, waterfowl, vegetation, decrease wildlife.

Discussion of Impacts

Environmental impacts of the navigation channel project in the lower Mississippi River apparently have not been studied previously. However, there appear to be several impacts which may be identified and probably are due mainly to a) increased water depth, b) dredging, and c) navigation and attendant facilities. These impacts are part of, and may interact with, other impacts coming from human activities along the river valley.

Human impact on river valley ecosystems developed as the river grew in importance as a trade route. In the nineteenth century, river transportation, which was important earlier in the fur trade, intensified as the land was plowed, the forests lumbered, and cities flourished. These alterations of the watershed probably yielded greater runoff carrying more sediment and nutrients to the river. Water levels may have changed more drastically, possibly leaving large areas of exposed river bottom. Compared with waterlevels which now remain full from bank to bank. These changes probably led to greater bank erosion, increased size and number of sandbars and snags, and cutting off and filling in of the small backwater areas.

Modification, by man of the river, floodplain, bluffs and watershed probably had a deleterious effect on extant ecosystems along the Mississippi River. The Mississippi River mainstem is the largest continuous freshwater and wetland corridor in the United States. It has long been recognized for its unique scenic, fish, shellfish, wildlife, recreation and transportation qualities.

The Minnesota River, which is a major tributary to the Mississippi, is a continuation of the freshwater and wetland corridor. Its qualities have not received as much attention in the past as has the Mississippi River. But more attention seems to be focusing upon the lower Minnesota River valley for its open space and a reserve of natural communities, due in part at least to the development of the uplands and generally increased public awareness of the need to preserve natural habitat.

The increasing importance of the Mississippi River and also the Minnesota River transportation to the economy of the Midwest led Congress early to direct the Corps of Engineers to develop the river for commercial navigation. Initially, impacts were limited to loss of substrate through the removal of snags and boulders. Later activities, probably mainly dredging, brought larger-scale impacts.

Impoundment Effects

Since impoundment of Pool 2 behind Lock and Dam 2 in 1930 increased water depth (at least at low water) of the Minnesota River apparently by as much as 1.4 feet, at Mendota, probably little impact resulted. Raising of the water surface by such a small amount probably submerged only a portion of the river bank and may have decreased some riffle area at Peterson's Bar, probably mainly at low water. While reduced riffle area may have deleterious effects on some aquatic organisms, moderated water levels may have been beneficial. To this end, the amount of water draw-down of Pool 2 water level has been decreased so as to protect fish and wildlife habitat as per the "Anti-Drawdown Law" of 1934 (S.P.D.-NCS, 1969).

Impoundment probably decreased the current in the lower reach of the Minnesota and thereby decrease flowing-river fish, clams and other species. Siltation may have increased also as a result of increased water levels.

Effects of Structures

While the dams apparently impede the migration of fish, clams and some other organisms (Ortman, 1909), the navigation locks may allow passage of these organisms. Thus, little effect upon biotic communities is expected, although apparently no studies have been made.

The rapids at Petersen's Bar may have decreased biotic productivity or perhaps altered benthic communities due to raised water levels, burial with spoil, and by diverting the current to the main channel.

The steep river banks are protected from erosion at some curves by riprap, which probably decreases turbidity and sedimentation and benefits the benthic organisms and fish. However, the benefits perhaps have not materialized due to the low quality of the water.

Effects of Maintenance Dredging

The effects of maintenance dredging and resulting spoiling of the Minnesota River apparently have not been studied previously. In part, the lack of interest may be due to the low annual volume, 13,000 cubic yards or about 500 cubic yards/mile/year, compared with other pools (See Table 32). However, most of the dredging has occurred at three sites in the lower 25 miles of the River, namely at Pike Island and at cut-off numbers two (Mile 5.0) and four (Mile 12.0) (See Table 1 in Appendix A IV). Thus, the impacts of dredging and spoiling are concentrated in a small area.

The effects of dredging, however, spread beyond the site and last longer than only the dredging period. Dredging creates a sterile area of the river bottom and increases turbidity in the river. Dredging triples the turbidity 100 feet downstream from the clamshell (See Figure 33). At 0.8 mile downstream it is still nearly double the turbidity measured upstream from the dredge.

Turbidity may be harmful to fish and other aquatic animals, as well as possibly reducing the productivity of aquatic plants on which the aquatic animals ultimately depend. Also, the unstable, unconfined spoil banks usually begin eroding as soon as they are deposited, with the resuspended sediments causing increased turbidity and redeposition downstream, possibly smothering bottom organisms and removing fish habitat (and often requiring redredging downstream in the navigation channel).

Table 32. Quantity of Sediment Dredged per Year from the Mississippi River and Navigable Tributaries in the St. Paul Engineers District (Calculated from data from S.P.D.--NCS, 1973)

Pool or Tributary	Average Annual Volume Per Year (in cubic yards)	Average Annual Volume Per Year Per River Mile (in cubic yards)
St. Anthony Falls	23,522	5,470
Pool 1	125,640	22,042
Minnesota River	12,253	834
Pool 2	175,126	5,422
St. Croix River	40,836	1,667
Pool 3	112,187	6,130
Pool 4	487,836	11,062
Pool 5	235,969	16,052
Pool 5A	152,302	15,865
Pool 6	95,371	6,716
Pool 7	150,303	12,738
Pool 8	282,549	12,127
Pool 9	155,000	4,984
Pool 10	94,313	2,875
Total 14 — Total Annual Volume, St. Paul District	2,143,207	

Average Annual Volume per Pool	153,086	Average Annual Volume per Mile	8,856

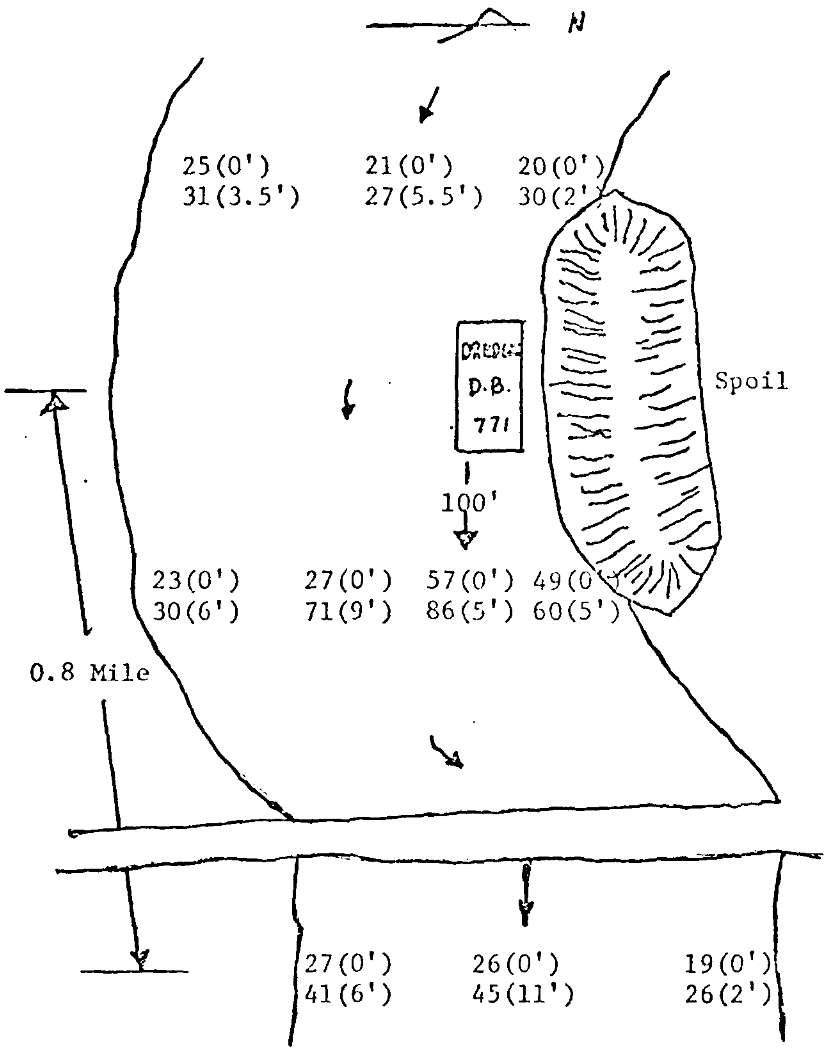

Figure 33. Effect of Clamshell Dredging Upon Turbidity in the Minnesota River, September 25, 1973 Depth in feet in ( ).

While the greatest turbidity may persist only as long as dredging proceeds, the recolonization of the bare river bottom may take years to accomplish. Mollusks have been reported to take ten or more years to recolonize a dredged area (Stansbery, 1970).

It seems, therefore, that the effects of dredging adversely affect the natural environment not only on the actual site, but further downstream, and through a longer period of time than at the actual dredging site and time.

Dredged spoil is cast by the clamshell along the river bank. It also covers existing riverbank and bottom habitats. In 1973 spoil was deposited both on the upstream and downstream edge of Peterson's Bar (Mile 12.0), removing productive benthic animal, fish and waterfowl habitat (See Figure 34). When high water comes next spring the spoil on the upstream edge will be transported downstream and deposited on the remaining shallow water in between the two spoil piles. Thus, more habitat will be made at least less productive if not sterile. This could have been easily avoided had the upstream spoil was deposited on the downstream pile.

Apparently some of the riverbank spoil is becoming revegetated, however, spoil still may be eroded and deposited in the river. This then must be redredged.

The clam population, which seems to have been rather diverse and abundant before the nine-foot channel was dredged, now apparently is much reduced (Dawley, 1947; FWPCA, 1966). The creation of the deep navigation channel possibly was involved in this reduction, but certainly the low water quality was also important.

Removal of snags also decreases aquatic organisms since substrate is removed and turbidity probably is increased. When the snags are fastened to trees along the river bank further deleterious impacts arise. The restraining cables kill the trees by girdling them.

Figure 34. Spoil on Peterson's Bar, Minnesota River Mile 12.0 (Colingsworth)

Navigation and Terminal Effects

Commercial navigation and barge terminals which are dependent upon the nine-foot channel, as well as pleasure boats and marinas, may have adverse environmental effects on the lower 25 miles of the Minnesota River. Due to the fine size of the sediment, commercial and private vessels have a deleterious effect on present Minnesota River ecosystems. The floodplain development which probably is stimulated, at least in part by river transportation, may be the most detrimental activity to terrestrial floodplain communities. Effluents from navigation and terminals are also important adverse effects. The nature and magnitude of these effects apparently have not been studied.

Turbidity may be increased by resuspension of bottom sediments due to propeller turbulence, and by bank erosion due to the dredging of the wake. A tow (boat with four loaded barges heading downstream) increased turbidity the width of the river by as much as twice the undisturbed level (See Figure 35). After thirty minutes turbidity at the water surface had returned to pre-disturbance levels. However, the turbidity near the river bottom remained high after thirty minutes and is estimated to remain so until about an hour after the passage of the tow.

The wake of a small outboard against a steep bank on the lower Minnesota River resulted in a 24 percent increase in turbidity along the shoreline (See Table 7 in Appendix A IV). Greater impacts may be expected from the larger wakes caused by such vessels as houseboats and tows.

Spills and discharges coming from the vessels, barge terminals and marinas may be adverse to the environment. Commercial traffic may provide aesthetic appeal, but may also disrupt fish and waterfowl behavior.

Several other impacts arise as a result of commercial navigation of the nine-foot channel in the Minnesota River.

Barge terminals and commodity storage areas occupy large areas of the river bank and floodplain (See Figure 36). Natural ecosystems are noticeably altered or completely eliminated, and aesthetics are diminished (See Figure 37). Barge fleeting areas such as at Mile 12.5 occupy additional large stretches of the river bank, and with the commercial tours, make navigation hazardous. Further deleterious impacts accrue when trees are sometimes used for mooring anchors even though a steel post is available nearby (See Figure 38). Mooring ropes and cables girdle the trees, which die and fall into the river. These trees, which help hold the river bank from erosion, must be snagged from the river at some later date. Sometimes these snagged trees are placed in the backwaters where they become roosts for birds and, below the water surface, substrate for

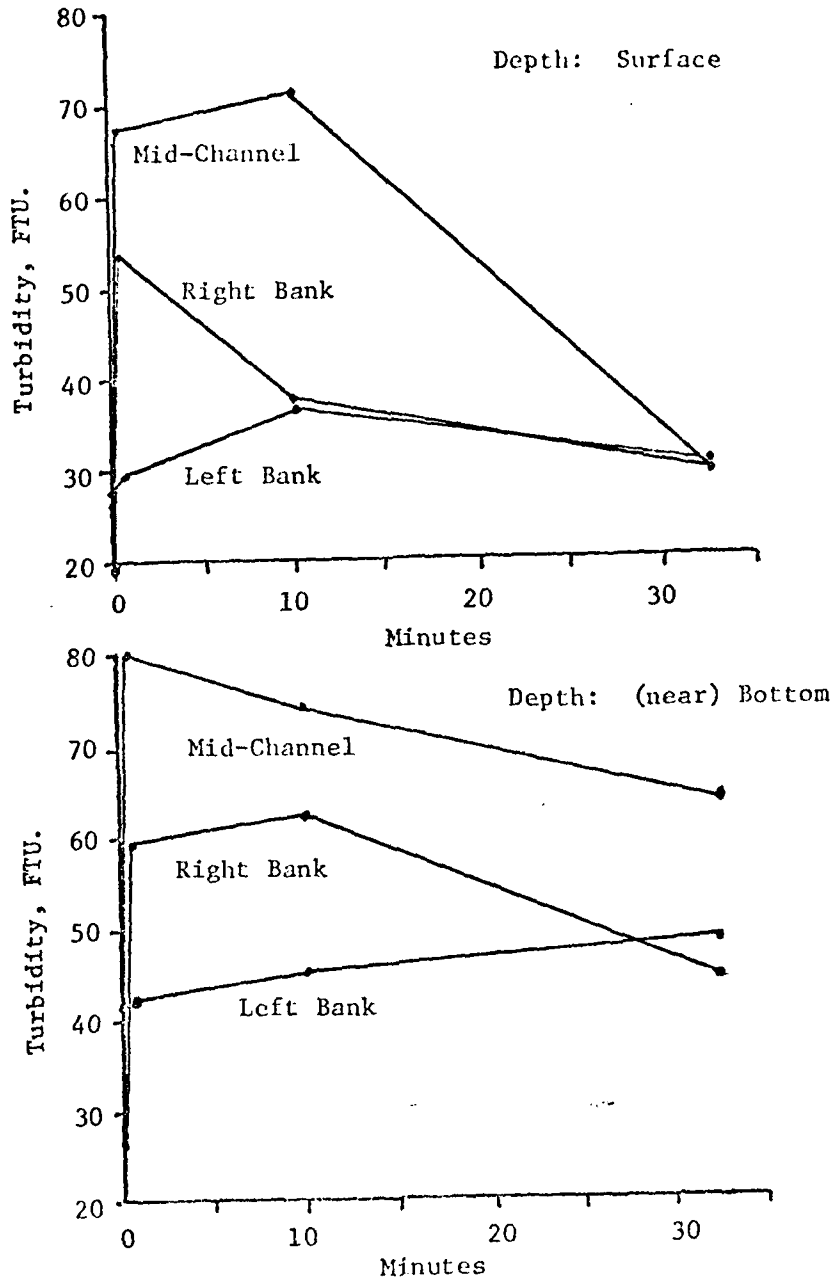

Figure 35. Duration (in minutes) of Increases in Turbidity Due to a Tow Boat on the Minnesota River at Mile 13.3, from the Right Bank to the Left Bank on September 25, 1973.

Figure 36. Aerial View of a Barge Terminal Showing Reduction of River Bank and Floodplain Habitat (Colingsworth)

Figure 37. Loss of River Bank Habitat Near a Barge Terminal (Colingsworth)

Figure 38. Mooring Practices, Minnesota River Mile 12.5 (Colingsworth)

attached algae and invertebrate animals. However, these snagged trees are sometimes cabled to other line trees along the river bank.

Pre-Project Activities

Preproject impacts apparently were due to dredging and snagging operations, and to construction of a weir.

Channel maintenance, as discussed above, increases turbidity and removes natural habitat, which requires considerable time before it is reinhabited.

Construction of the weir probably caused adverse effects due to brush cutting, quarrying and laying the weir, and isolating a riffle. Possibly the new, shallow substrate may have provided good habitat for benthic organisms and fish.

Dredging the cut-offs removed some floodplain while creating new backwaters. Thus, some decrease in terrestrial and wetland organisms may have occurred. However, formation of backwater channels may result in increased productivity as they shallow and a benthic community becomes established. These backwater channels, which were a product of realigning the channel for 9-ft navigation, are the only backwater areas along the lower 25 miles of the Minnesota River.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivisions of socioeconomic systems for the Minnesota River are identified below and then discussed in detail.

Identification of Impacts

The impacts on the socioeconomic systems related to the study area of the Upper Mississippi River divide into the industrial, recreational, and cultural effects.

Industrial Impacts

The principal industrial impacts are:

1. Barge transportation on the Minnesota and Upper Mississippi leads to:
   a. An increase in commercial docks on the River and attendant employment,
   b. Location of industrial plants along the River whose raw materials or products lend themselves to shipment by barge; this contributes direct employment in these plants and indirect employment in firms --
      (1) providing goods or services as inputs to the barge-oriented plants, or
      (2) using the outputs of these plants or raw materials for their own operations
   c. A decline in the quality and increased turbidity of water in some portions of the Upper Mississippi River due to --
      (1) effluents produced by barge-oriented plants, and
      (2) turbidity caused mainly by barge movement
2. Additional employment due to the maintenance of the channel.
3. Potential increase in commercial fishing due to:
   a. Increase in dissolved oxygen in channels due to faster current in deeper channels leading to increased water turbulence, and

b. More fish habitat due to increased acreage of fish spawning areas from rising water level. This potential has not always been realized for reasons developed below.

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel by the Corps of Engineers are an increase in the number of industrial plants and commercial docks along the Minnesota River with their associated employment, and an increase in the potential for fishing. The detrimental effects are a decline in water quality due to river barges and the related industrial plants along the River.

Recreational Impacts

The principal recreational impacts are:

1. An increase in recreational boating due to stable, navigable water levels, offset by a decrease due to the hazard of sharing the relatively narrow river with heavy traffic of wide barge tows.
2. A potential increase in sport hunting and fishing due to an increase in:
   a. Waterfowl habitat, and
   b. Fish spawning areas resulting from raised water levels.

The effects cited above are positive except for those due to increased industrial activity (barge traffic and industrial plants) that may hurt hunting and fishing, and may be hazardous to boating.

Cultural Impacts

At this stage of research no archaeological, cultural, or contemporary sites of cultural significance on the Minnesota River are known to have been affected by Corps' operations.

Discussion of Impacts

The actual industrial and recreational impacts identified above are examined in detail in the following three sections.

Industrial Activities

The economic effect of the activities of the Corps of Engineers on the Minnesota River in the St. Paul District can be measured mainly in terms of three major elements. They are:

1. The channel itself with its associated navigational aids;
2. The installations at riverside for the transfer of cargo, storage facilities, and access;
3. The vessels using the waterway.

In these terms, the impact of the Corps' activities on the Minnesota River is not as great as in some of the pools in the Northern Section of the Upper Mississippi River.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g., commercial docks and terminals, etc.) on the shores and the barge tows moving along the river. Each of these represents an economic alternative to rail or road transport increasing the competitive options open to industry.

In order to place the Minnesota River within the context of the Mississippi River transportation system as a whole, it is desirable to examine freight traffic activity with the other systems.

Tables 33 and 34 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970.

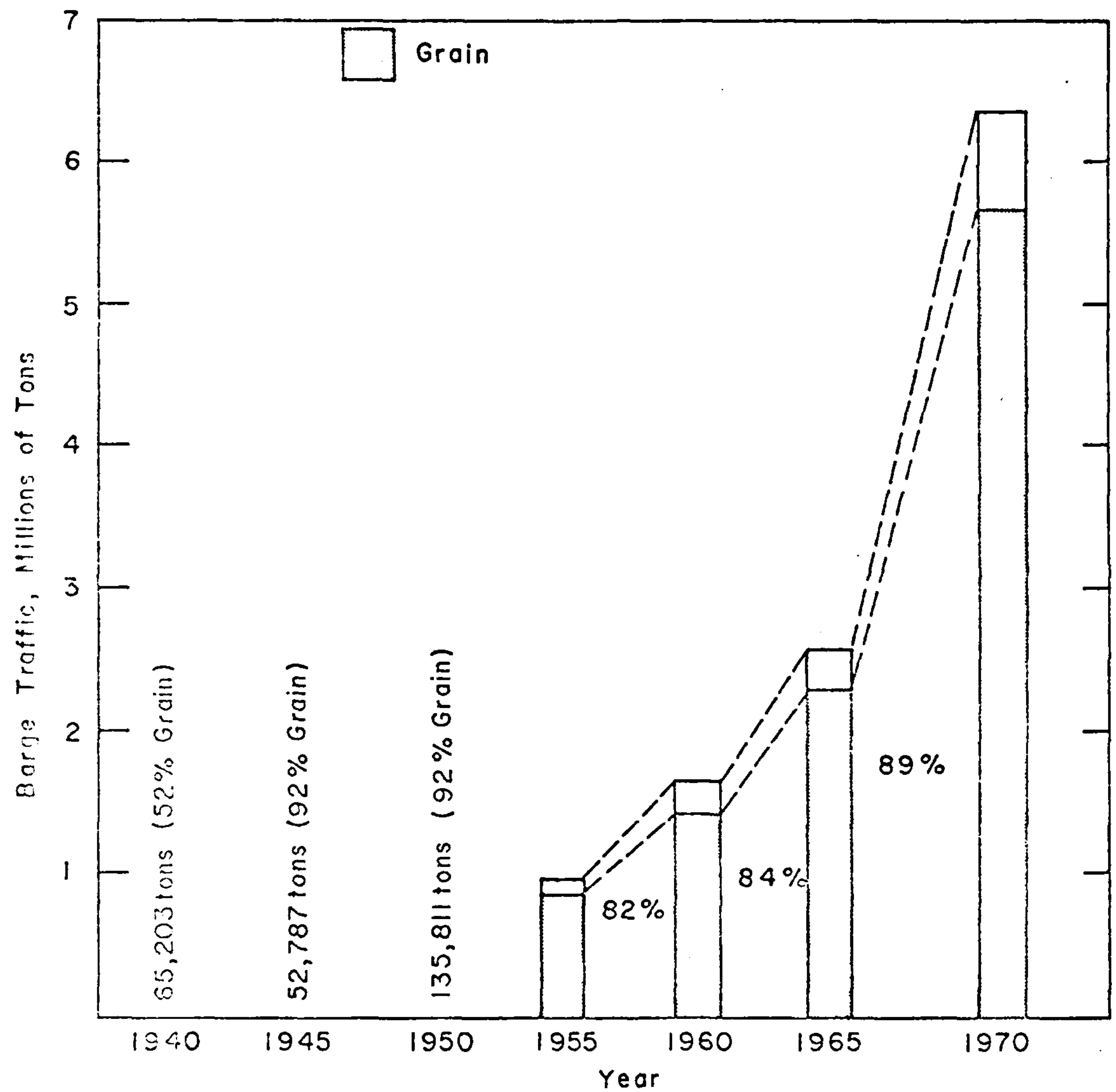

Table 33. Shipments Out of the St. Paul District
(S.P.D.-NCS, Selected years)

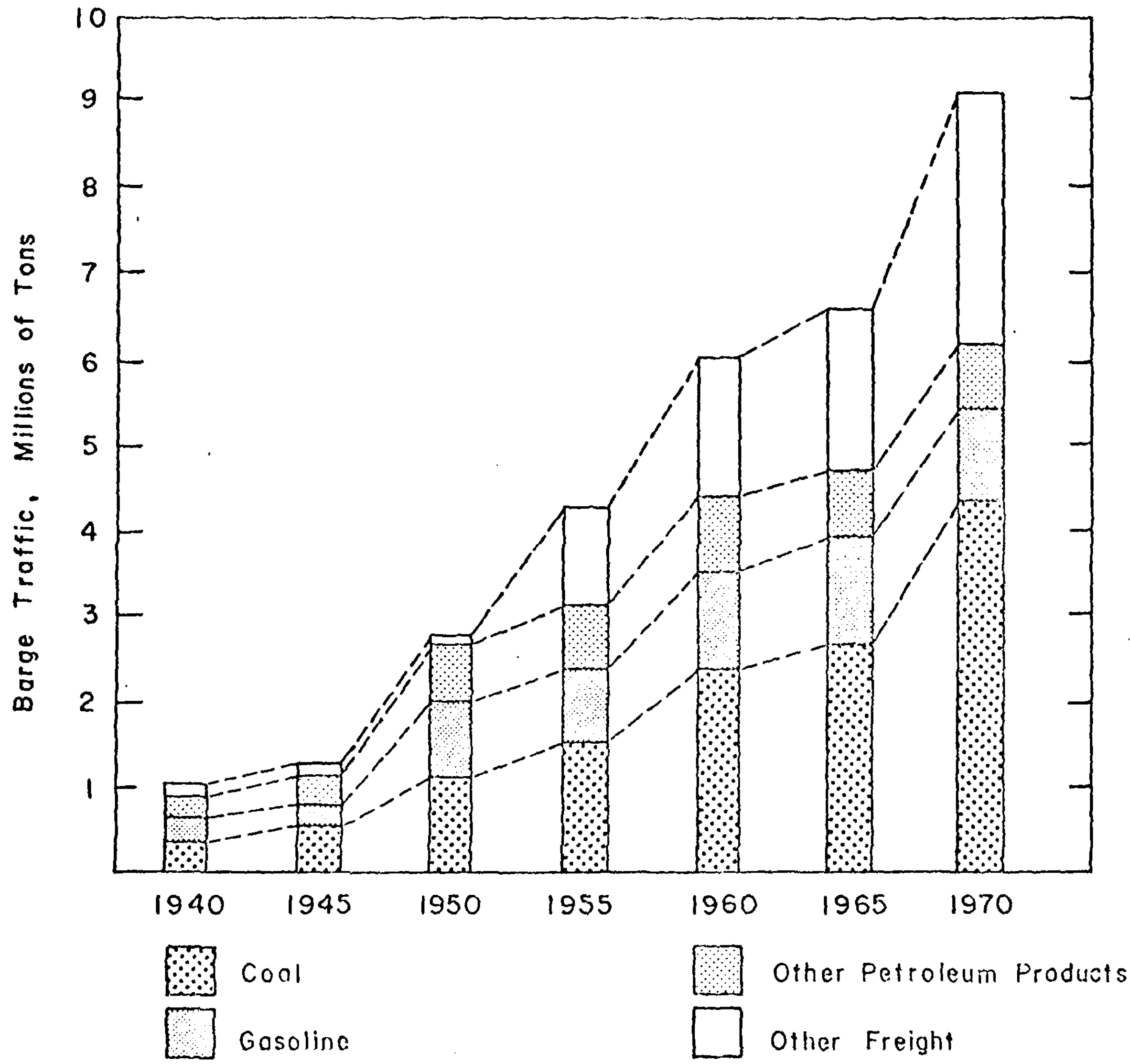

Table 34. Receipts of Major Commodities -- All Ports, St. Paul District (Based on data from U.S. Army Corps of Engineers, St. Paul District)

It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 3,052,144 tons, shipments = 334,233 tons). Recently, however, the ratio has been around 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the numbers of vessels originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMRCBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.

Table 28 gives the total tonnages shipped and received in the Minnesota River from 1962 through 1971. As was noted, shipments far exceeded receipts which reaches the Minnesota River pool in the St. Paul District. The following table (Table 35) gives a detailed account of the commodities shipped and received in 1971 illustrating the usage and value of commodities moving along the Minnesota River.

Table 35. Minnesota River Freight Traffic, 1971 (Waterborne Commerce Statistics Center, Corps of Engineers, 1971)

(SHORT TONS)

COMMODITY	TOTAL	INTERNAL INBOUND	INTERNAL OUTBOUND
TOTAL	3,626,132	897,659	2,728,473
0102 BARLEY AND RYE	14,639	----------	14,639
0103 CORN	[illegible]	----------	1,358,351
0104 OATS	[illegible]	----------	[illegible]
0107 WHEAT	465,993	----------	465,993
0111 SOYBEANS	542,967	----------	542,967
1121 COAL AND LIGNITE	543,155	543,155	----------
1499 NONMETALLIC MINERALS, NEC	118,768	118,768	----------
2049 GRAIN MILL PRODUCTS, NEC	21,981	----------	21,981
2062 MOLASSES	22,756	22,756	----------
2091 VEGETABLE OILS, MARG, SHORT	32,695	----------	32,695
2871 NITROGENOUS CHEM FERTILIZERS	19,265	19,265	----------
2873 PHOSPHATIC CHEM FERTILIZERS	35,693	35,693	----------
2879 FERTILIZER AND MATERIALS, NEC	92,423	91,022	1,401
2915 RESIDUAL FUEL OIL	11,012	11,012	----------
2918 ASPHALT, TAR, AND PITCHES	29,660	29,660	----------
3316 IRON AND STEEL PLATES, SHEETS	16,251	16,251	----------
3317 IRON AND STEEL PIPE AND TUBE	6,301	6,301	----------
3324 ALUMINUM AND ALLOYS, UNWORKED	1,119	1,119	----------
3411 FABRICATED METAL PRODUCTS	657	657	----------
TOTAL TON-MILES, 50,369,079.			

The overwhelming predominance of grains and grain products is apparent in this table. A substantial benefit results from barge shipping of grain and its products down the Minnesota: the decentralization of a great deal of truck traffic through the metropolitan area. Most grain is grown to the northwest, west, and southwest of the Twin Cities, and trucks can haul it directly to the grain terminals on the south side of the Minnesota River, avoiding the bridges and other traffic congestion of the urban area and, even more important, not adding to it. The load of grain then passes through the urban area by a less congested route: the rivers.

Certain industries, dependent upon barge traffic for their economic viability have located on industrial sites along the river. The investment which they represent and the employment they generate are also attributable to the activities of the Corps of Engineers. Connected with this physical evidence of the Corps impact is the human impact perhaps best expressed in the employment which these facilities and vessels provide.

Commercial Dock Facilities. Firms that depend heavily on the river often maintain riverside facilities. The Minnesota River contains seven commercial docks and terminals, including four that serve grain companies, one for Northern States Power, one for Richards Oil Company and Port Marilyn (salt, see Figure 37).

Behind many of these docks are factories and storage facilities that are dependent upon them. Thus, the ramifications of river navigation reach deeply into the entire economy of the region and indeed throughout the whole upper Mississippi region. Employment directly and indirectly connected to these industries forms a small though significant percentage of the regional work force.

From an economic point of view, most of the effect of the activities of the Corps of Engineers are beneficial. Ultimately the benefits of economic activity have to be measured in terms of providing livelihood to human beings. Employment generated by the availability of waterborne transport to the Minnesota River includes both workers directly connected with the river itself, and a far larger number of whose whole livelihood is less directly dependent on water shipping. In the first category is included employment by the Corps of Engineers itself, workers on docks and shoreside facilities, and those working on the vessels themselves. The second category consists of those whose livelihood is gained by either utilizing the products brought into the Minnesota River by waterborne carriers, or who process goods shipped by by water. Included in this category are those who supply goods and services to those directly involved with water shipping on the Upper Mississippi.

The total employment involved either directly or indirectly with all commercial operations on the river is not known. The Corps of Engineers itself has some 150 persons who are concerned with lock and dam operations. In addition to this, the dredge "Thompson" has approximately 65 crew members. U. S. Department of Commerce data on employment on the Minnesota are deficient as well. These data are collected for mid-March, a period when water traffic in the St. Paul District is almost completely inactive and seasonal lay-offs are in effect. Further, these data are aggregated in a way designed to prevent isolation and identification of particular firms. This also has the effect of preventing identification of employment or other economic activity in particular pools or even of particular waterways. However, some estimates of employment can be made. In mid-March of 1971, 8,632 persons in the U. S. were employed in River and Canal transport. This figure does not include warehousing or persons employed by firms where the SIC classification lies outside of transportation, even though they themselves may be working exclusively on the river. The same data show 556 persons in Minnesota as a whole who work in the field of water transport. This, however, includes the Great Lakes as well as the Upper Mississippi. Some of these people are employed by private dredging firms whose existence is dependent upon the work of the Corps.

A further benefit which can be attributed to the maintenace of navigation on the Minnesota River is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile*. It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, and move along the Minnesota River.

The socioeconomic impact of the physical effects of navigation cannot be measured precisely because of the inability to isolate single

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* Source: Upper Mississippi River Comprehensive Basin Study Appendix "J", p. 90.

factors from a wide-range of potential ones. Dredging and the movement of tugs and barges does increase water turbidity to which must be added pollution from barge spillage, washing and loss while loading or unloading. Yet this pollution is small relative to the load placed in the river from other sources. These impacts may have economic effects on recreational uses such as fishing and boating.

Commercial Fishing. No data are available on commercial fishing on the Minnesota River. If any fishing exists it has no economic consequence.

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and sightseeing and picnicking.

Boating Activities and Related Facilities. Unfortunately there is no information on the number of boats using the lower reaches of the Minnesota River, although observation indicates there is extensive usage.

One facility exists on the Minnesota River mainly to serve boaters using the pool. This is a small boat marina with a ramp, located at the Cedar Avenue Bridge.

Except possibly for the recreational sites without ramps, which do not cater primarily to boaters, these facilities are improved as a result of the Corps' operations on the River that contributed the channel and more stable water levels.

Sport Fishing and Hunting. Sport fishing and hunting on the Minnesota River are known to be small but noticeable. Indicative data are not presently available concerning its extent.

The rising water level of the Minnesota River has increased the spawning areas for fish. In theory this offers the potential for more sport fishing. The potential for increased fishing in the Minnesota River is probably partially offset by river pollution and turbidity from increased industrial activity along the perimeter of the river and barge activity in it.

As the water levels on the Minnesota River have been raised in Corps operations, habitat for residential and migratory waterbirds has also increased. This suggests the potential for greater bird hunting and probably a lessening of hunting opportunities for small animals. Increased industrialization has operated to reduce this hunting potential. Unfortunately, no data were found that measures hunting activity in and adjacent to the River.

Sightseeing and Picnicking. Recreational sites along the shores of the Minnesota River facilitate sightseeing, picnicking, and hiking. While non-boating visitors to these sites might be there whether Corps' operations existed on the River or not, virtually all of the activities at these sites by boaters are attributable to Corps' activities.

Cultural Impacts

Sites of cultural interest are known to exist along the Minnesota River, particularly at its junction with the Mississippi. Except for changes in the physical and topographical relationships of the sites, particularly such sites as Fort Snelling, the Oliver Faribault cabin, and the Mendota Historic District, to the River itself, the impact of the actions of the Corps of Engineers has been small. The impacts on archaeological sites are discussed in more detail in Appendix B.

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4. ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH COULD NOT BE AVOIDED AS THE PROJECT WAS IMPLEMENTED

The navigation project in the Minnesota River has unavoidably produced some adverse effects on the environment. The adverse effects are due mainly to maintenance dredging, commercial navigation and the development of the river bank by barge terminals and businesses, and increased water depth.

Dredging disturbs the river bottom and increases turbidity. The resuspended sediments causing the turbidity are deposited downstream where they may smother benthic organisms. Fish and other free-swimming organisms may also be smothered, although data on the specific effects on the organisms is lacking. However, the pre-nine-foot project diversity of clams has apparently decreased, possibly due to dredging as well as lowered water quality.

When dredge spoil is placed upon terrestrial and aquatic sites, plant and animal diversity is decreased or lost. Both aquatic and terrestrial dredge spoil sites seem to take a decade or more before abundance is restored.

Commercial development of the river bank probably has been stimulated by the navigation channel, removing the natural communities. Continued development, barge terminals and navigation produce the most adverse effects of the nine-foot channel in the Minnesota River, as does dredging, except the latter is of irregular occurrence. Construction sites, barge terminals, and dredge spoil sites are centers of soil erosion, adversely affecting still more habitats, and contribute to the sedimentation rate in the lower Minnesota River. At the same time these areas may detract from the aesthetic quality of the area. Home sites, recreation sites, apartment towers and other developments also contribute to the sediment problem as well as decrease the aesthetics of the Minnesota River. Studies need to be conducted to identify the sources of sediment and effects of sedimentation and turbidity on the aquatic organisms and water quality.

Commercial navigation increases the turbidity of the river and contributes to bank erosion. At the same time it also may detract from the aesthetic quality. Discharges and spills from vessels and barge terminals also have a detrimental effect, particularly on the aquatic environment. However, studies are needed to determine the nature and extent of adverse effects of these effluents.

Impoundment which raised the water surface as much as 1.4 feet may have reduced some riffle areas, such at Peterson's Bar. This, as well as a slowing of the current might cause a reduction in flowing river species of fish, clams, etc. A weir constructed across the upstream edge of the bar may have further reduced the productivity of this area of the River.

Lock and Dam 1 and 2 interrupted the free movement of fish, clams, and some other species, although locks may provide a by-pass around the dam. However, the effectiveness of this possible shunt apparently is unknown.

5. ALTERNATIVES TO THE PRESENT OPERATIONS AND MAINTENANCE ACTIVITIES AND FACILITIES

There are several possible alternative methods of operating and maintaining the navigation channel project in the lower Minnesota River. Since present adverse effects may derive mainly from navigation, terminals, dredging and spoiling, attention is directed particularly to alternatives of these features.

CHANNEL MAINTENANCE

In order to reduce adverse effects of dredging and spoiling in the Minnesota River, several alternatives could be considered. The best long-term remedy to reduce the impact of dredging and spoiling would be to barge the spoil to a central terminal for commercial use or inland disposal. A small hydraulic dredge should be used and the turbidity reduced before the water returns to the river. This would also present spoil areas to revegetate and become natural areas or recreation sites.

Until the time when the spoil will be barged to a terminal, spoil and other bare spoil sites should be planted and other measures taken to reduce wind and rain erosion. Fertilizing and covering with bark chips or other material would reduce erosion due to the river current. Riprapping with derrickstone where the bank is eroding would also provide good habitat for fish and benthic organisms.

Where deposition of spoil is unavoidable, greater care should be taken in selecting sites and in methods of dredging and spoil disposal.

The impact of a spoil site could be lessened if the spoil were deposited on dry land rather than in shallow water; erosion, sedimentation and turbidity would be reduced by revegetation. The spoil site should be placed in areas remote from the floodplain lakes and downstream and on the opposite bank from backwaters and tributaries. Thus, spring high water will be less likely to carry and deposit spoil in these important wildlife areas. Spoil should not be placed along the riverbank immediately upstream from the tributaries and backwater channels, such as was done at Peterson's Bar in 1973.

Where spoiling is necessary deposition in thin layers on sites with cottonwoods or willow trees would enhance natural revegetation of the site (compare Figures 39 and 40). The tree canopy would reduce the temperature and help retain moisture in the spoil. The falling leaves would increase the rate of soil formation and the abundance of plants.

Large deep sites without tree cover should be reseeded and watered using the techniques developed for revegetating new highway and railroad banks. Detailed study should be undertaken to determine the size, depth and location of sites as well as to determine the most rapid and economical techniques for revegetation.

The present spoil sites could be developed into picnic and campgrounds or could be left as natural habitat. These sites should be connected by a system of trails and paths for hiking, bicycling, horseback riding, cross-country skiing or snowshoeing. Such recreational activities and preservation of natural habitat has been advocated by Hennepin and Dakota counties, Metropolitan Council and private groups (IEI, 1969; DCPAC, 1970; Rebuffoni, 1973). However, further commercial or industrial development of the floodplain is still a likelihood, such as indicated by Dakota County's plans to develop industrial sites between Cedar Avenue and Normandale Bridges.

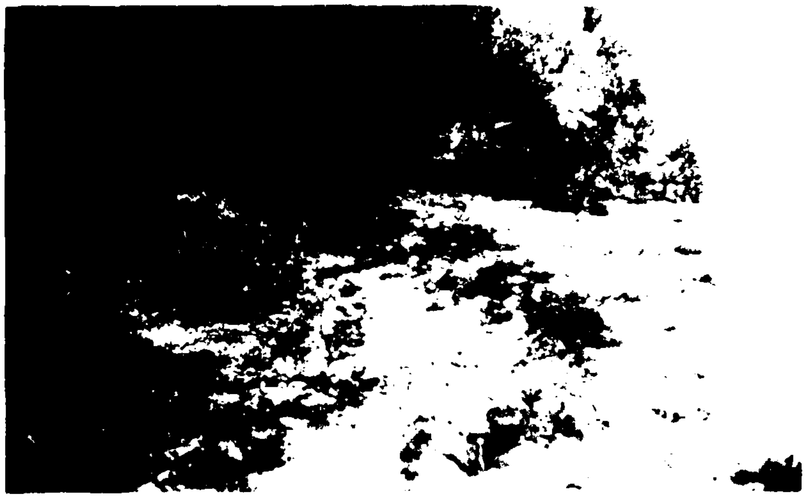

Figure 39. Plant Succession Upon a Spoil Site Adjacent to a Moist Woods (Colingsworth)

Figure 40. Plant Succession on a Dry, Exposed Spoil Site. Willows and Cottonwoods Indicate Low, Moist Area at Edge of Spoil (Colingsworth)

Development and occupation for industry, and cultivation of the floodplain should be limtied or eliminated to reduce erosion and protect wildlife habitat. Only those companies receiving or shipping cargoes by barge should have access to the floodplain. This access should be limited to only the minimum necessary equipment and area need for barge docking, loading and transfer of the cargo to or from an upland storage area. Main buildings and storage areas, such as grain elevators or petroleum storage tanks should not be located on the floodplain. Wildlife habitat and aesthetics could be enhanced if the terminals were well screened by trees and shunks common to the floodplain vegetation.

Areas of the floodplain could be restricted to enhance wildlife productivity such as is the practice with Hennepin County's Blue-Fisher preserve. Here the public is restricted from the area for part of the year in order that waterfowl may nest successfully. The large marshes are probably important feeding grounds for waterfowl and may be a key factor in the continued occupation of the egret-heron rookeries on Pigs Eye Island in Pool 2.

The natural environment could be enhanced around existing barge terminals by allowing natural vegetation to return and by planting trees in bare areas and along the river bank, except at the unloading facility itself. Further development and enlargement of these facilities and other commercial sites should be restricted in order to reduce erosion and sedimentation, preserve wildlife habitat, and improve aesthetics for recreational purposes. Eventually commercial sites should be transplanted to areas more remote to the floodplain.

Concomitantly, agricultural practices should be modified to reduce erosion and perhaps eventually phased out. Construction of highways across the river should be severely restricted so that free drainage and maintenance of natural habitats may be continued.

As the impacts of bluff-top and floodplain development are reduced and dredging at least partly phased out, the Minnesota River Valley may be returned to its greater biotic productivity. Thus, the River Valley may serve as a refuge for wildlife, waterflow, plants and aquatic life in the middle of a huge metropolitan area. At the same time, it could provide some relief to the high recreational demand such a population requires. If, in addition, the appearance of commodity storage areas and businesses could be improved by landscaping or eventually removal, the aesthetic value could be considerably improved. Further improvement of aesthetics and recreation would result if the water quality of the municipal treatment plants were improved. Reduction of soil erosion and of spills and discharges from vessels and terminals and other sources would help.

Improved water quality and river bank habitat probably would increase waterfowl, fish, clams, amphibians, and turtles as well.

LOCK AND DAM OPERATION

Present lock and dam operation probably has little impact on the Minnesota River outside of providing a channel for commercial navigation. The effects on fish and clam migration require further study.

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6. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Establishment of the navigation channel in the lower 25 miles of the Minnesota River brought economic and some recreational benefits to man. It directly or indirectly contributed to the loss or alteration of natural communities and perhaps biotic communities.

SHORT-TERM USES

Growth of river transportation has benefitted segments of the economy. River-related jobs and businesses have developed and expanded. This may have helped to forge a broader based economy upon which further economic growth may develop.

Pleasure boating and attendant facilities have developed because of the navigation channel, although boating may not be a highly popular activity on the Minnesota.

Enhancement and Maintenance of Long-Term Productivity

Development of commercial navigation of the Minnesota River may have benefitted man's long-term economic growth, but also may have altered or reduced natural productivity although specific information is lacking. The navigation channel resulted in increased water depth, dredging of the river bottom and spoiling on the banks, and construction of navigation facilities and development of commercial, industrial and residential areas. Natural habitats have been altered by the changes brought about by navigation, such as reduced riffle-communities, increased side-channel communities, and decrease in pollution sensitive organisms due to organic effluents.

Terrestrial habitat has been lost as a result of construction of locks and dams, barge terminals and river towns. These developments probably encouraged construction of other facilities not directly connected with navigation. The increased run-off from developed areas and bare-soil increases erosion and further decreases biotic productivity.

Creation and maintenance of the channel probably has disturbed the natural river habitats on and near the channel sufficiently to reduce biotic productivity. A single dredging or spoiling of a site requires ten or more years to be repopulated. Continued disturbance possibly may alter the physical environment to sufficiently extend this time. Dredging as well as industrial effluents seems to have led to a decrease in clams in the Minnesota River, seemingly from 27 species to one, while perhaps increasing other less desirable organisms. Dredged spoil also reduced biotic productivity as it buried existing terrestrial and aquatic communities.

Alternative land-use and maintenance practices could conceivably shorten the time necessary for repopulation of a site and may begin a return of the biotic productivity. Set-back of the businesses and terminals, except for the actual loading-unloading facilities, and a central spoil disposal site could result in a green along both banks. These and other erosion and sedimentation control measures probably could significantly reduce the adverse effects of the nine-foot navigation project and related activities on the enhancement and maintenance of the long-term productivity in the Minnesota River.

Resource Implications for Socioeconomic Activities

Table 36 summarizes the major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District. Resource implications for these four groups are discussed in sequence below.

Corps' Operations

Table 36 identifies the major first order direct benefits associated with lock and dam operation and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus, about 225 people derive jobs and income directly from Crops' operations. The annual direct cost to taxpayers for lock and dam operations is $2,601,000 (FY 1970) and for dredging operations is $1,200,000. Specific environmental costs of the stable water levels in the pools and the nine-foot channel in the St. Paul District are an increase in sedimentation behind dams and wing dams and a reduction in fish and waterfowl habitat due to improper dredge spoil placement.

Table 36. **First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel**

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps' Operations	Lock and dam (L/D) operation	1. L/D employment. 2. Stable water levels.	1. Cost of L/D operation. 2. Seddmentation behind dams and wing dams.
	Dredging Operations	1. Dredging employment. 2. 9-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat due to improper dredge spoil placement.
Industrial	Barge Operation	1. Barge Employment. 2. Low-cost water transportation. 3. Energy saving compared to alternate transportation modes.	1. Increased river turbidity. 2. River pollution from oil and gasoline from barges.
	Commercial Dock Operation	1. Dock employment. 2. Attraction of barge-transportation-oriented firms that provide local employment.	1. Increased river pollution from industrial activities along shore.
	Commercial Fishing and Trapping	1. Increased employment of fishermen and trappers. 2. Increased number of fish and pelts available for consumers.	
Recrea-tional	Boating Activity	1. Increased recreational opportunities for boaters.	
	Operation of Recreational Facilities	1. Increased employment and business opportunities for facilities serving recreational users of the river (boaters, sport fishermen and hunters, etc.)	

Table 36. **First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel** (Continued)

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recreational (Cont.)	Sport Fishing	1. Initially increased habitat for fish.	1. Increased sedimentation in fish habitat. 2. Decreased fish habitat from improper dredge spoil placement.
	Sport Hunting	1. Initially increase habitat for waterfowl.	1. Decreased waterfowl habitat from improper dredge spoil placement.
	Sightseeing, camping, picnicking, swimming, water skiing	1. Improved opportunities for miscellaneous recreational activities.	
Cultural	Archaeological Sites		1. Loss of selected sites due to L/D construction and rising water.
	Historical Sites		1. Loss of selected sites due to L/D construction and rising water.
	Contemporary Sites		1. Loss of selected sites due to L/D construction and rising water.

Industrial Activities

As summarized in Table 36, the major direct impacts of Corps' operations on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 36 shows that there are employment implications for each of these three activities but these benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How effective is barge transportation relative to other modes of transportation with respect to:

1. Energy usage?
2. Air pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition, savings in transportation costs due to barge movements are discussed.

Barge Transportation and Energy Usage. Effective energy utilization is particularly important due to the present (and probably continuing) energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation utilizes about 25 percent of the total U. S. energy budget for motive power alone. This usage has been increasing at an average annual rate of about 4 percent per year.

In comparing the efficiency of energy utilization between various transportation modes the term "energy intensiveness" is commonly used.

Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensiveness of various modes of freight transportation (Mooz, 1973):

Freight Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126

It is apparent from this table that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum energy availability the use of barging wherever feasible should be encouraged. Indeed, an increased use of the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments of other parts of the U.S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the costs energy rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and tied up in inventory and in storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3,272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both tugboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine due to its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gasoline engines. Among users of diesel engines, barging is more efficient than either rail or truck, as we have seen. Consequently, a smaller amount of fuel is required to move freight. With less fuel used, air pollution is reduced.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following table illustrates these pollution effects (U.S.P.H.S., 1968):

	Emission Factor	
Type of Emission	Pounds/1,000 gallons diesel fuel	Pounds/1,000 gallons gasoline
Aldehydes (R-CHO)	10	4
Carbon monoxide	60	2300
Hydrocarbons (O)	136	200
Oxides of Nitrogen	222	113
Oxides of Sulfur	40	9
Organic Acids(acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per-ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges.

Recreational Activities

Table 36 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and camping -- that may be helped or hindered by Corps' operations. Ideally it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 36 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist to perform a benefit-cost analysis of a recreation or tourism activity. One example is a study prepared for the U. S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Applying even this theoretical framework to the nine-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the nine-foot channel may hurt sport fishing because of the reduction in fish habitat. This means that the total value of sport fishing in the river should not be considered in the analysis. Rather, only the incremental increase or decrease in sport fishing attributable to present Corps' operations (not due to the initial lock and dam construction) should be weighed against those operations; no estimates are presently available to assess the effect of current Corps' operations on fish and wildlife. Also, reduced fishing and waterfowl habitat may eventially increase

This raises a second difficulty: How does one measure the total value of sport fishing on the river in order to start to measure the incremental portion attributable to Corps' operations? For sport fishing various measures have been identified, each having its own drawbacks (Clawson and Knetsch, 1966): gross expenditures by the fishermen, market value of fish caught, cost of providing the fishing opportunity, the market value as determined by comparable privately owned recreation areas, and the direct interview method -- asking fishermen what hypothetical price they would be willing to pay if they were to be charged a fee to fish.

If some average price per fisherman or trip were available, it still would be possible to assess the total value of sport fishing in the study area only if estimates of the number of sport fishermen or number of sport fishing trips were available. In the St. Paul District these estimates are available through sport fishery surveys for only three pools: Pool 4, Pool 5, and Pool 7. The most recent data available for these pools are for the 1967-68 year (Wright, 1970); comparable data for 1972-73 have been collected but are not expected to be published in report form until about December, 1973.

Value Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; Pennington, et al. , 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks virtually all river users are not away from home overnight and are omitted from such studies.

Information is then generally restricted to that available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fishing Trips	Value at $5.00 Per Trip[a]	Value at $1.50 Per Trip[b]
4	169,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	316,190	94,857

[a]Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.98 per day.

[b]Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus, the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area.

Cultural Sites

No attempt has been made in the present study to place dollar values on archaeological, historical, or cultural sites damaged or enhanced by Corps' operations. Rather, such sites have merely been identified, where existing data permit.

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7. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH HAVE BEEN INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

The construction of navigation facilities and continuing channel maintenance, as well as the barge traffic and terminal facilities which followed in the Minnesota River required the irretrievable commitment of human and natural resources.

Cement, steel, lumber and fuel (and thus the natural resources from which these are derived), plus labor and financial resources were consumed in the construction of the Lock and Dam 1 and 2 and appertenant structures. Some of the steel possibly could be retrieved as scrap.

There also is a continuing commitment of labor, fuel and financial resources in the operation and maintenance of these facilities.

The annual maintenance dredging of the nine-foot channel in the Minnesota River consumes fuel, labor and financial resources. Some steel and other structural materials are committed via the dredging equipment, some of which eventually may be salvageable.

Some of the natural habitats in and along the river are irreversibly committed to the navigation channel project and attendant activities. Dredging and siting of the Locks and Dam removed or altered river bottom and river bank communities. A diverse clam community has diminished and perhaps the fish and waterfowl have decreased as well. Riverbank communities also were altered or removed due to barge terminals, which are dependent upon the navigation. It is not known to what extent this removal or alteration amounted to, nor if any endangered species were lost.

The decrease in natural habitats and concomitant increased urbanization along the lower Minnesota River has possibly irretrievably diminished some portions of this section of the river as a natural, aesthetic and recreational resource to the Metropolitan Area. Perhaps loss or alteration of natural systems due to floodplain development is most extensive in area and effect on the floodplain, while navigation, dredging and spoiling are perhaps next most important. The increase in water level may have resulted in a relatively minor irreversible commitment of natural habitat.

8. RECOMMENDATIONS

Several studies should be conducted to better define the beneficial and adverse effects, and methods to reduce the latter, of the maintenance of the nine-foot channel project in the Minnesota River.

Most important is a long-range plan of land use of the floodplain. Important also are studies of the erosional sources of sediment and effects of dredging and spoiling operations. Efforts should be directed to restricting future floodplain development, screening existing sites with natural vegetation, locating and at least reducing the influx of sediment into the Minnesota River, at least that due to present land use practices and navigation in the lower Minnesota River floodplain. Industry should be removed to higher ground except for barge docks and cargo transfer equipment. A reduction in sediment inflow would, of course, reduce the need for dredging and spoiling, thus reducing related adverse environmental effects.

At the same time alternative methods of dredging should be investiated. A noticeable reduction in adverse environmental effect probably could be obtained if spoil disposal was centralized in a terminal and accessible from the bluffs. From this point on-land disposal would be more efficient. A further study of the potential market for dredge spoil, indicated by a preliminary study conducted by the BSFW, might reveal an economic return from a central disposal. Reclamation of badly eroded areas and sanitary landfills are also possible uses of spoil.

Since not much is unknown about the natural communities of the bluffs and floodplain lakes, particularly in the lower Minnesota River, studies should be made with an assessment of the degree of sensitivity to dredging and spoiling operations and other human distrubances. Correlative studies should be made on methods of enhancing present spoil sites for aquatic and terrestrial plants and animals. Enhancement measures would also provide protection from erosion of the spoil bank into the river.

Further, recreational and aesthetic benefits would accrue from spoil bank revegetation and enhancement. The Corps, acting in cooperation with other agencies, probably could make significant contributions to the improvement and maintenance of man's environment.

9. APPENDIX A: NATURAL SYSTEMS

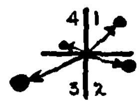
I. METHODS OF DATA COLLECTION

Methods for Collecting Samples

Biological Measurements

Benthic organisms were sampled using Petersen or Ekman dredges along standard and special transects. Vegetative cover, in acres was determined by planimetry from aerial photos in a study currently conducted by the Department of Forestry, University of Minnesota. Abundance of plant species was determined in one meter square quadrats (for herbs and vines) and by point-quarter techniques (for trees, vines and shrubs) (Cox, 1967).

QUADRAT
percent cover
of each species
reported



POINT QUARTER
percent frequency
of tree species
reported

Measurement of Physico-chemical Parameters

Temperature was measured using a thermister and a Precision Scientific Instruments meter, standardized to a precision mercury thermometer (APHA et al., 1971).

Dissolved oxygen was measured using a galvanic cell-type probe and a Precision Scientific Instruments meter, standardized to the Winkler titration, azide modification (APHA et al., 1971).

Turbidity was measured by nephelometry using a Horizon Ecology, Inc. Model 104 nephelometer (APHA et al., 1971).

Water depth was measured with sonar using a Heathkit Electronics Company Model M1-101-2.

II. MAP OF MINNESOTA RIVER AND TRANSECT LOCATION

The map of Minnesota River (Figure 1) shows the location of sampling

Figure 1. Map of the Lower Minnesota River (U.S.G.S.) Part A.

Figure 1. Map of the Lower Minnesota River (U.S.G.S.) Part B

stations along "standard" and "special" transects. Standard transects are surveyed lines which cross the river at a right angle in each pool and are chosen to sample its broad environmental diversity. They extend from bluff to bluff and include bluff slope, river banks, marsh, open river and river bottom (Figure 2). However, on long transects most of the sampling effort was concentrated on the smaller area between the railroad tracks on each side of the river. Standard Transect MAA is located about 1/4 mile upstream from Mile M25.6, the area most river-like and completely unmodified by impoundment; Transect MBB is located near mid-pool close to the primary control point, often the marsh zone; and transect CC is located 1/4 mile upstream from the lower dam in the deeper, lake-like region.

Special transects (XX,YY) could have been used to study features of particular interest such as the mouths of major tributaries, but were not considered necessary here. The azimuth (compass direction, using north as 0 and east as 90 degrees) and other pertinent data is given in Table 1.

Sampling stations were located along these transects, and clustered mainly in areas of transition between types of habitat such as forest to bare sandy soil.

Sampling Frequency

Field data to corroborate and expand the aerial survey of the terrestrial vegetation was completed in October.

Benthic samples were collected in April and May and again in August and September. Water quality data was collected in September and early November.

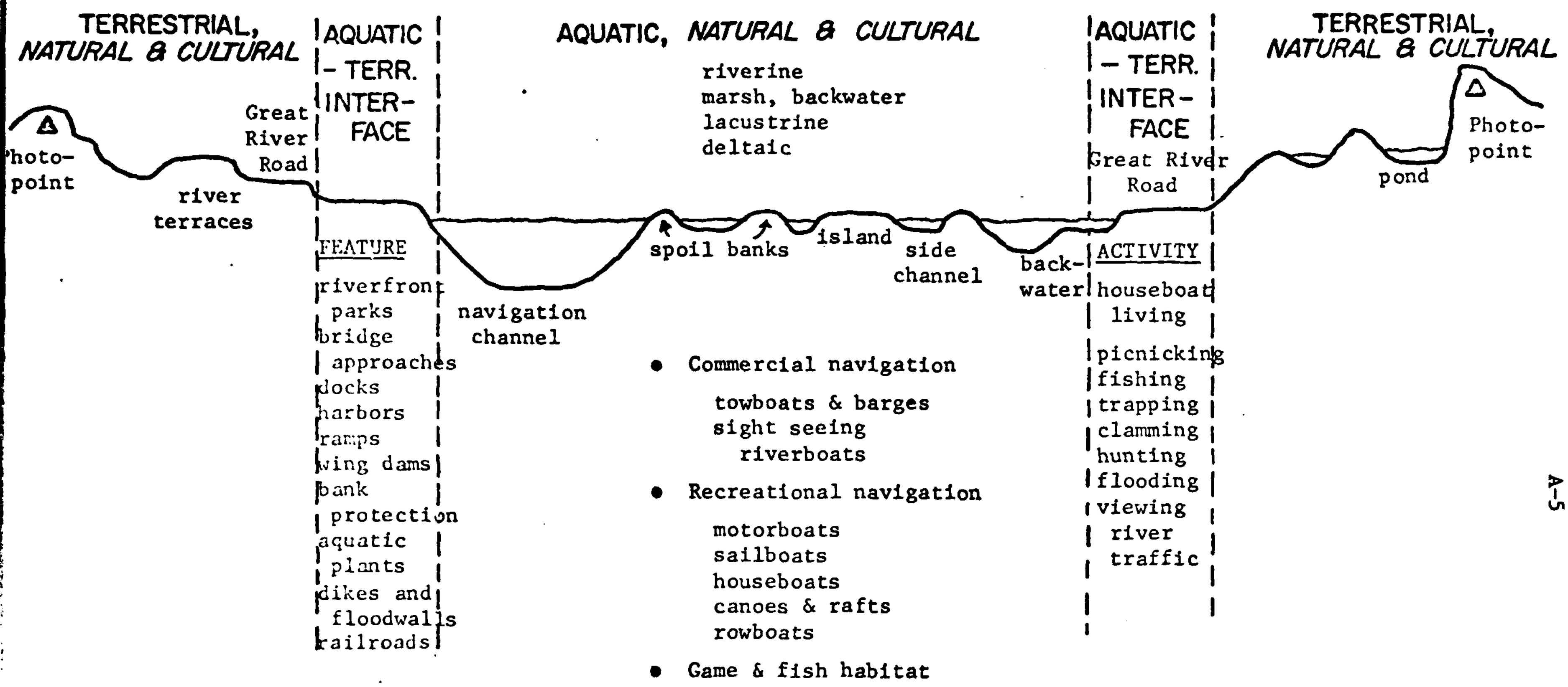


Figure 2. Profile of a Typical Transect of the Marsh Portion of a Typical Pool.

Note that the figure also lists the various environmental features that may be found at various places along the transect.

Source: ESD - North Star--Gudmundson, 1972

Table 1. Description of Transects

Pool; Pool Length	Transect Designation	River Mile Above Cairo, IL	Azimuth	Transect Length in Miles	Azimuth target, Location
USAF 3.6	Standard Transect UAA	858.9	86°	.15	SW corner of Minneapolis Water Works Bldg.
	Standard Transect UBB	855.7	278°	.13	Line up downstream legs of tower for high voltage line.
	Standard Transect UCC	854.4	52°	.31	Line up with D/S face of old limestone apt. bldg.
LSAF 0.6	Standard Transect LBB	853.4	175°	.15	Mooring cell ladder on R/B nearest lower L/D.
Pool 1 5.7	Standard Transect 1AA	853.1	28°	.15	Center of high-rise apt. bldg. on R/B.
	Special Transect 1XX	851.1	39°	.21	Gov't. daymark Mile 851.1; on spoil on L/B
	Standard Transect 1BB	850.6	46°	.15	Vertical seam on Platteville L.S. on left bluff
	Special Transect 1YY	849.4	99°		Oval pipe opposite; on R/B spoil downstream from Lake St. Bridge. Mid-stream azimuth 35° to WMIN radio tower, L/B.
	Standard Transect 1CC	848.0	86°	.20	Line up downstream face of high-rise apt. tower on L/B (720 River Terrace).
Pool 2 32.4	Standard Transect 2AA	847.4	263°	.15	Chimney on north wing (with white, round porch of MN Soldiers' Home Bldg.
	Standard Transect 2BB	831.7	264°	1.10	Gov't. (USCG) daymark Mile 831.7 R/B
	Special Transect 2YY	821.3,R	54°	1.10	Tall smokestack right of L/B water tower; transect runs from mid-channel to R/B, sampled by Hokanson in 1964.
	Standard Transect 2CC	815.5	52°	1.00	Tip of peninsula which extends 0.35 mi. upstream 4D #2.
	Special Study Area	833.2,R	54°	--	Mi. 833.1 Gov't daymark, 22?-yr-old R/B spoil site
	Special Study Area	832.0,L	256°	--	Tower for high voltage line on R/B, 8?-yr-old spoil site 4B.
	Special Study Area	827.7,R	85°	--	Gov't daymark Mi. 827.7, 2?-yr-old spoil site
Minn. R. 26.4	Standard Transect MAA	M24.8	347°	1.00	Second bend above Shakopee (US 169) Bridge
	Standard Transect MBB	M13.0	335°	1.05	Gov't. daymark, Mile 12.5
	Standard Transect MCC	M3.0	128°	.90	Gov't. daymark, Mile 2.9
St. Croix River 25.0	Standard Transect SAA	SC24.8	305°	.50	White bldg., right bank.
	Special Transect SXX	SC16.6	85°	.50	Upstream edge of bldg. at Lakefront Park.
	Standard Transect SBB	SC12.3	111°	1.05	Road coming down bluff to beach.
	Special Transect SYY	SC 6.4	291°	.38	Shallow dip in tree line on right bank
	Standard Transect SCC	SC 0.7	85°	.90	Fence marking upstream boundary of public beach on left bank.

III. SUMMARY OF DATA COLLECTION POINTS AND TIMES

Benthic (bottom) grab samples were taken on standard and special transects during the months of April and May and in August. Sediments were washed out using a 707 micron standard mesh screen, and organisms preserved. Identifications were made by Mr. Daniel Maschwitz, graduate student in the Department of Entomology, Fisheries and Wildlife, University of Minnesota.

The width of vegetation zones intersected by the transects was measured and one meter square quadrats and/or point quarter stations were used to determine the abundance of plant species. Plant species identifications were made in the field, and checked by Dr. Gerald Ownby, Curator of the Herbarium, Department of Botany, University of Minnesota.

Field data and pertinent data from the literature are presented on data sheets in Appendix A,IV.

IV. DATA SHEETS

Table 1. Abundance of plants found in the river valleys.

Table 2. Vegetation of floodplain and bluff habitats (Cooper, 1947).

Table 3. Vegetation of Spring Lake area (Leisman, 1959).

Table 4. Birds of the Minneapolis-St. Paul area (Dodge, et al., 1971)

Table 5. Benthic animal abundance.

Table 6. Present water uses along the Minnesota River.

Table 7. Water uses affected along Minnesota River June 2 - November 3, 1964.

Table 8. Downstream profile of turbidity and the effect of dredging and navigation, 1973.

Table 9. Turbidity, temperature and dissolved oxygen in the Mississippi and Minnesota Rivers, 1973

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area

(P - present; M - moderate; D - dominant)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees and Shrubs																	
ACERACEAE																	
Acer negundo Box elder	P	P	P	P	P		P		P	P	P	P					
Acer nigrum Black maple																	
Acer rubrum Red maple					P												
Acer saccharinum Silver or soft maple							P					P		P		P	
Acer saccharum Sugar or hard maple						P	P							P			
Acer spicatum Mountain maple																	
Acer sp. Maple													P				
ANACARDIACEAE																	
Rhus glabra Smooth sumac				P	P												
Rhus radicans Poison ivy																	
Rhus typhina Staghorn sumac						P									P		P

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (cont'd.)</u>																	
BETULACEAE																	
Alnus incana Speckled alder																	
Betula papyrifera Paper birch							P			P				P	P	P	P
Carpinus caroliniana Blue beech or hornbeam																	
Ostrya virginiana Ironwood or hop hornbeam				P						P						P	
CAPRIFOLIACEAE																	
Diervilla lonicera Bush honeysuckle																	
Lonicera prolifera Grape honeysuckle																	
Lonicera tatarica Tartarian honeysuckle										P							
Sambucus canadensis Common elder														P			
Sambucus pubens Red-berried elder				P		P											
Symphoricarpos occidentalis Wolfberry																	
Symphoricarpos orbiculatus Coralberry																	
Viburnum cassinoides Wild raisin																	
CELASTRACEAE																	
Celastrus scandens Climbing bittersweet																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
CORNACEAE																	
Cornus alternifolia Alternate-leaved dogwood																	
Cornus racemosa Panicled dogwood																	
Cornus stolonifera Red-osier dogwood																	
CUPRESSACEAE																	
Juniperus virginiana Red cedar										P						P	P
Thuja occidentalis White cedar																	
FABACEAE (LEGUMINOSAE)																	
Amorpha fruiticosa False indigo							P										
Robinia pseudo-acacia Black locust							P			P							
FAGACEAE																	
Quercus alba White oak																	
Quercus macrocarpa Bur oak or mossycup oak															P		
Quercus borealis Northern red oak							P			P						P	P
Quercus velutina Black oak															P		
Quercus sp. Oak																P	

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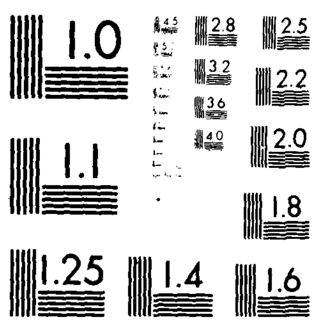

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Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
JUGLANDACEAE																	
Carya cordiformis Bitternut hickory			P				P										
LEGUMINOSAE: see FABACEAE																	
MORACEAE																	
Morus rubra Red mulberry						P											
OLEACEAE																	
Fraxinus nigra Black ash												P	P				
Fraxinus pennsylvanica var. *subintegerrima* Green ash			P			P	P										
Fraxinus sp. Ash	P			P	P					P				P	P	P	P
PINACEAE																	
Larix laricina Tamarack																	
Picea canadensis White spruce																	
Pinus resinosa Red pine															P		
Pinus strobus White pine																P	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees & Shrubs (Cont'd.)																	
ROSACEAE																	
Amelanchier huronensis Service-berry, Shadbush)																	
Amelanchier spp. Juneberry																	
Crataegus spp. Thorn-apple																	
Physocarpus opulifolius Ninebark																	
Prunus americana Wild plum																	
Prunus pensylvanica Pincherry																	
Prunus serotina Black cherry										P							
Prunus virginiana Choke-cherry							P										
SALICACEAE																	
Populus deltoides Cottonwood	M	D	P	P	P		P	P		P	P		P		P	P	P
Populus grandidentata Bigtooth aspen							P			P							
Populus balsamifera Balsam poplar																	P
Populus tremuloides Quaking aspen	P																P
Populus sp. Aspen	P																

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
SALICACEAE (Cont'd.)																	
Salix alba White willow						P											
Salix amygdaloides Peach-leaved willow		P				P								P			
Salix humilis Small pussy-willow																	
Salix interior Sandbar willow					P	P	P	P		P	P	P	P		P	M	
Salix nigra Black willow																	
Salix spp. Willows																	
TAXACEAE																	
Taxus canadensis Yew														P			
TILIACEAE																	
Tilia americana American basswood						P	P							P			P
ULMACEAE																	
Celtis occidentalis Hackberry			D														
Ulmus americana American elm	P		P	P	P	P	P		P			P		P			
Ulmus pumila Dwarf elm	P		P	P		P											

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Trees & Shrubs (Cont'd.)</u>																	
ULMACEAE																	
Ulmus rubra Slippery elm			P	D		P											
Ulmus sp. Elm	P				P					P					P	P	P
<u>Vines (lianas)</u>																	
VITACEAE																	
Parthenocissus quinquefolia Virginia creeper	P	P		P	P	P	P						P				
Vitis riparia Riverbank grape	P	D			P		P		P			P			P	P	
<u>Herbs</u>																	
AIZOACEAE																	
Mollugo verticillata Carpetweed																	
ALISMACEAE																	
Sagittaria sp. Arrowhead																	
AMARANTHACEAE																	
Amaranthus tamarincus (or tuberculata) Amaranth	P				P			P				P					
APOCYNACEAE																	
Apocynum androsaemifolium Dogbane							D										

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
ARACEAE																	
Arisaema triphyllum Jack-in-the-pulpit																	
Spathyema foetida Skunk cabbage																	
ARALIACEAE																	
Aralia nudicaulis Wild sarsaparilla																	
Panax quinquefolius Ginseng																	
Panax trifolius Dwarf ginseng																	
Hedera helix English ivy				P													
ARISTOLOCHIACEAE																	
Asarum canadense Canadian wild ginger														P			
ASCLEPIADACEAE																	
Asclepias exaltata Tall milkweed																	
Asclepias ovalifolia Oval-leafed milkweed																	
Asclepias syriaca Common milkweed					P	P	P										
Asclepias tuberosa Butterflyweed																	
Asclepias verticillata Whorl-leaved milkweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix RIver			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
BALSAMINACEAE																	
Impatiens sp.																	
Jewelweed										P				P	P		P
BORAGINACEAE																	
Hackelia virginiana																	
Beggar's lice																	
Lappula redowskii																	
Stickseed																	
Lithospermum canescens																	
Puccoon, Indian-paint																	
Lithospermum carolinense																	
Puccoon																	
Lithospermum incisum																	
Puccoon																	
Onosmodium molle																	
Marble-seed, False gromwell																	
Myosotis sp.																	
Forget-me-not														P			
CAMPANULACEAE																	
Campanula rotundifolia																	
Harebell																	
Lobelia sp.																	
Lobelia														P			
CAPPARIDACEAE																	
Polanisia trachysperma																	
Rough-seeded clamyweed								P									

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
CAPRIFOLIACEAE																	
Triosteum perfoliatum Horse-gentian																	
CARYOPHYLLACEAE																	
Cerastium arvense Field chickweed																	
Cerastium nutans Nodding chickweed																	
Cerastium vulgatum Common mouse-ear chickweed														P			
Saponaria officinalis Soapwort, Bouncing bet																	
Stellaria aquatica Water chickweed																	
CERATOPHYLLACEAE																	
Ceratophyllum demersum Coontail																	
CHENOPODIACEAE																	
Chenopodium album White pigweed	P										P						
Chenopodium gigantospermum Pigweed			P														
Corispermum hyssopifolium Hyssop-leaved pigweed		P															
Cycloloma atriplicifolium Winged pigweed						P											

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CISTACEAE																	
Helianthemum bicknellii																	
Frostweed																	
COMMELINACEAE																	
Tradescantia bracteata																	
Bracted spiderwort																	
Tradescantia occidentalis																	
Western Spiderwort																	
COMPOSITAE																	
Achillea millefolium																	
Yarrow																	
Ambrosia artemisiifolia																	
Common ragweed	P			P										P			
Ambrosia sp.																	
Ragweed		P						P									
Antennaria plantaginifolia																	
Pussytoes																	
Anthemis cotula																	
Mayweed																	
Arctium minus																	
Burdock																	
Artemisia biennis																	
Biennial wormwood	P										P		P				
Aster novae-angilae																	
New England aster																	P
Aster spp.																	
Aster									D	P		P	P	P			P

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
COMPOSITAE (Continued)																	
Bidens beckii Water marigold																	
Bidens connata Beggar's ticks																	
Bidens sp. Bur marigold	P			P							P		P				
Carduus nutans Musk thistle																	
Cirsium arvense Canada thistle		P			P							P					
Crepis tectorum Hawk's beard																	
Erigeron annuus Daisy fleabane		P		P			P										
Erigeron canadensis Horseweed		P															
Erigeron philadelphicus Fleabane											P						
Erigon pulchellus Robin's plantain																	
Erigeron strigosus White-top																	
Eupatorium maculatum Joe-Pye weed																	
Eupatorium perfoliatum Thoroughwort																	
Eupatorium rugosum White snakeroot	D	P	P	P	P	P	P										

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
COMPOSITAE (Continued)																	
Grindelia squarrosa Curlycup-gumweed																	
Helianthus occidentalis Western sunflower																	
Helianthus petiolarus Petioled sunflower					P												
Heliopsis helianthoides Ox-eye		P															
Krigia biflora Dwarf dandelion																	
Lactuca sp, Lettuce		P			P					P	P	P					
Prenanthes alba Rattlesnake root																	
Ratibida pinnata Coneflower																	
Rudbeckia hirta Black-eyed Susan																	
Senecio pauperculus Ragwort																	
Senecio plattensis Ragwort																	
Silphium perfoliatum Cup-plant, Rosinweed																	
Solidago altissima Tall goldenrod					P												
Solidago flexicaulis Zig-zag goldenrod																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF										Minn.			St. Croix			
Pool:	Upper			Lower	1			2			River			River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
COMPOSITAE (Continued)																	
Solidago gigantea Giant goldenrod		P															
Solidago graminifolia Grass-leaved goldenrod																	
Solidago nemoralis Gray goldenrod																	
Solidago so. Goldenrod	P			P	P			P	P	P			P	P	P	P	P
Taraxacum officinale Dandelion		P		P		P					P		P			P	P
Vernenia fasciculata Western ironweed								P									
Xanthium italicum Common cocklebur	P	P		P		P	P	P			P						
CRUCIFERAE																	
Berteroa incana Hoary alyssum																	
Brassica nigra Black mustard																	
Cardamine pensylvanica Bitter cress																	
Hesperis matronalis Dames violet																	
Lepilium virginicum Poor-man's pepper	P																
Nasturtium officinale Watercress														P			

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CRUCIFERAE (Continued)																	
Rorippa islandica Icelandic yellow cress																	
Rorippa obtusa Obtuse yellow cress																	
Unidentified sp.	P																
CUCURBITACEAE																	
Sicyos angulatus Bur-cucumber					P												
CYPERACEAE																	
Carex aenea Sedge																	
Carex annectens Sedge																	
Carex cephalophora Oval-headed sedge																	
Carex communis Sedge																	
Carex stenophylla Involute-leaved sedge																	
Carex laxiflora Sedge																	
Carex lurida Sedge																	
Carex meadii Sedge																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
CYPERACEAE																	
Carex normalis Sedge																	
Carex sartwellii Sartwell's sedge																	
Carex stipata Awl-fruited sedge																	
Carex umbellata Sedge																	
Carex vulpinoidea Fox sedge																	
Cyperus filiculmis Galingale																	
Cyperus inflexus (or aristotus) Awned cyperus								P			P						
Cyperus orbiculari Galingale								P									
Cyperus schweinitzii Galingale																	
Cyperus sp. Galingale											P						
Eleocharis palustris Spike-rush																	
Hemicarpha micrantha Least hemicarpha								P									
Scirpus americanus Sword grass																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
CYPERACEAE																	
Scirpus atrovirens Georgian bulrush																	
Scirpus cyperinus Woolgrass																	
Scirpus rubrotinctus Bulrush																	
Scirpus validus Giant bulrush																	
Unidentified sp.													P	P		P	
DIOSCOREACEAE																	
Dioscorea villosa Wild yam																	
EQUISETACEAE																	
Equisetum arvense Field horsetail							P			D	P	P	P	P			
Equisetum hyemale Scouring rush																	
Equisetum pratense Meadow horsetail																	
EUPHORBIACEAE																	
Euphorbia corollata Flowering spurge																	
Euphorbia cyparissias Cypress spurge																	

Table 1 . Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
EUPHORBIACEAE (Continued)																	
Euphorbia esula Leafy spurge		P		P							P						
Euphorbia sp. Spurge			P					P									
Euphorbia glyptosperma Engraved-seed spurge																	
Euphorbia nutans Eyebane																	
FABACEAE (LEGUMINOSAE)																	
Amorpha canescens Prairie lead-plant																	
Astragalus crassicarpus Ground plum																	
Medicago lupulina Black medick			P		P												
Melilotus alba White sweet clover	P	M			P	D	P					P				P	
Petalostemum candidum White prairie clover																	
Vicia cracca Tufted vetch																	
Vicia villosa Hairy vetch																	
GERANIACEAE																	
Geranium spp. Wild geranium				P													

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
GUTTIFERAE																	
Hypericum sp. St. John's-wort																	P
GRAMINEAE																	
Agrostis palustris Creeping bentgrass										P							
Bouteloua curtipendula Side-oats grama																	
Calamagrostis canadensis Reed bentgrass	P																
Echinochloa sp.	D				P	P		p			p						
Elymus canadensis Canadian wild rye						P				P							
Elymus virginicus Virginian wild rye	P																
Eragrostis hirsuta Hairy love-grass	P										P		D				
Eragrostis hypnoides Creeping love-grass	D																
Eragrostis pectinacea Pursh's love-grass	D							P			M	P					
Glyceria grandis Reed meadow-grass																	
Glyceria striata Fowl meadow-grass																	
Panicum capillare Witch grass	M							P			P	P			P		
Panicum depauperatum Panic grass																	

Table. 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
__Herbs (Continued)__																	
GRAMINEAE (Continued)																	
Panicum dichotomiflorum Spreading witch grass	P																
Panicum virgatum Switch grass											P						
Phalaris arundinacea Canary grass																	
Poa palustris Fowl meadow-grass		P															
Poa pratensis Blue grass																	
Setaria viridis Green foxtail		P				P		P				P				D	
Setaria sp. Bristly foxtail													P				
Spartina pectinata Prairie cord grass								P									
Unidentified sp.	D				P		P										
HYDROCHARITACEAE																	
Vallisneria spiralis Wild celery																	
HYDROPHYLLACEAE																	
Ellisia nyctelea (No common name)																	
Hydrophyllum appendiculatum Virginia waterleaf																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
HYPERICACEAE																	
Hypericum perforatum St. John's-wort																	
Hypericum punctatum Spotted St. John's-wort																	
IRIDACEAE																	
Sisyrinchium campestre Blue-eyed grass																	
JUNCACEAE																	
Juncus balticus Spikerush																	
Juncus compressus Spikerush																	
Juncus effusus Spikerush																	
Juncus longistylis Spikerush																	
Juncus secundus Spikerush																	
LABIATAE																	
Galeopsus tetrahit Hemp-nettle																	
Glecoma hederacea Creeping Charlie																	
Hedeoma hispida Mock pennyroyal																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
LABIATAE (Continued)																	
Leonurus cardiaca Motherwort						P					P						
Lycopus officinalis Water horehound																	
Lycopus virginicus Bugleweed																	
Monarda fistulosa Wild bergamot, horsemint																	
Mentha arvensis American wild mint			P					P									
Nepeta cataria Catnip					P												
Physostegia virginiana Obedient plant																	
Prunella vulgaris Mad-dog skullcap																	
Scutellaria lateriflora Leonard's skullcap																	
Stachys palustris Hedge-nettle			P														
Teucrium canadense American germander																	
Unidentified sp.			P					P	P							P	
LEMNACEAE																	
Lemna spp. Duckweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	Pool 1 AA	Pool 1 BB	Pool 1 CC	Pool 2 AA	Pool 2 BB	Pool 2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
<u>Herbs (Continued)</u>																	
LILIACEAE																	
Allium cernuum Wild onion																	
Lilium superbum Turk's-cap lily																	
Maianthemum canadense Wild lily-of-the-valley																	
Smilacina spp. False Solomon's seal																P	
Smilax sp. Greenbrier																P	
Trillium spp. Trillium																	
LOBELIACEAE																	
Lobelia spicata Highbelia, pale-spike lobelia																	
MENISPERMACEAE																	
Menispermum canadense Yellow parilla						P											
NAJADACEAE																	
Najas sp. Naiad																	
Zannichellia palustris Horned pondweed																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	1 AA	1 BB	1 CC	2 AA	2 BB	2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
<u>Herbs (Continued)</u>																	
NYCTAGINACEAE																	
Mirabilis hirsuta Hairy umbrellawort		P															
ONAGRACEAE																	
Circaea quadrisulcata Tall enchanter's nightshade																	
Epilobium ciliatum Willow herb																	
Epilobium paniculatum Willow herb																	
Oenothera biennis Evening primrose		P															
OPHIOGLOSSACEAE																	
Botrychium virginianum Rattlesnake fern																	
OSMUNDACEAE																	
Osmunda claytoniana Cinammon fern															P		
OXALIDACEAE																	
Oxalis dillenii Wood sorrel											P						
Oxalis stricta Upright wood sorrel																	
Oxalis violacea Violet wood sorrel																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Pool: Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
PAPAVERACEAE																	
Sanguinaria canadensis Bloodroot																	
PHYRMACEAE																	
Phyrma leptostachya Lopseed																	
PLANTAGINACEAE																	
Plantago major Common plantain	M									P		P	P				
Plantago rugelii Wood plantain																	
POLEMONIACEAE																	
Phlox divaricata Blue phlox																	
Phlox pilosa Phlox																	
Polemonium reptans Jacob's ladder																	
POLYGONACEAE																	
Polygonum ariculare Common knotweed																	
Polygonum coccineum Scarlet smartweed																	
Polygonum pensylvanicum Pennsylvania smartweed					P			P									
Polygonum sp. Smartweed	P										P	P	P				

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
POLYGONACEAE (Cont'd.)																	
Rumex acetosella Sheep sorrel																	
Rumex crispus Curled dock		P											P				
Rumex mexicanus Mexican dock	P																
Rumex sp. Dock		P			P						P			P		P	
POLYPODIACEAE																	
Adiantum pedatum Maidenhair fern																	
Cystoperis fragilis Fragile bladder-fern														P	P	P	
PRIMULACEAE																	
Lysimachia nummularia Moneywort																	
Lysimachia ciliata Loosestrife																	
RANUNCULACEAE																	
Anemone canadensis Canadian amenome																	
Anemone caroliniana Carolina anemone																	
Anemone cylindrica Thimbleweed																	
Anemone quinquefolia Wood anemone																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
RANUNCULACEAE																	
Anemone virginiana Thimbleweed																	
Anemone sp. Anemone														P	P	P	P
Anemonella thalictroides Rue anemone																	
Aquilegia canadensis Columbine													P	P			
Delphinium virescens Larkspur																	
Hepatica acutiloba Liverleaf, hepatica										P							
Hepatica americana Liverleaf, hepatica																	
Ranunculus acris Tall buttercup																	
Ranunculus abortivus Kidneyleaf buttercup																	
Ranunculus aquatilis White water-crowfoot																	
Ranunculus pensylvanicus Bristly crowfoot																	
Ranunculus rhomboideus Prairie buttercup																	
Ranunculus sceleratus Cursed crowfoot											P						
Ranunculus septentrionalis Swamp buttercup																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
ROSACEAE																	
Potentilla recta Upright cinquefoil																	
Potentilla simplex Old-field cinquefoil																	
Potentilla sp. Cinquefoil											P		P				
Rosa blanda Smooth wild rose										P							
Rosa suffulta Hairy prairie rose																	
Rosa sp. Rose													P		P		
Rubus occidentalis Black raspberry																	
RUBIACEAE																	
Galium boreale Northern bedstraw																	
Galium trifidum Small bedstraw																	
Houstonia longifolia Bluet																	
SANTALACEAE																	
Comandra umbellata Bastard toadflax																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																	
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
RANUNCULACEAE (Cont'd.)																	
Ranunculus sp. Buttercup											P						
Thalictrum dasycarpum Purple meadow-rue																	
Thalictrum sp. Meadow-rue										P				P			
RHAMNACEAE																	
Ceanothus americanus New Jersey tea																	
ROSACEAE																	
Agrimonia pubescens Cocklebur																	
Alchemilla sp. Lady's mantle													P				
Fragaria vesca Wild strawberry																	
Geum canadense White avens																	
Geum laciniatum Avens																	
Geum triflorum Three-flowered avens																	
Potentilla argentea Silvery cinquefoil																	
Potentilla arguta Tall cinquefoil																	
Potentilla norvegica Rough cinquefoil											A						

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
SAXIFRAGACEAE																	
Heuchera americana Alumroot																	
Heuchera richardsonii Richardson's alumroot																	
Ribes sp. Currant											P					P	
SCROPHULARIACEAE																	
Besseya bullii (No common name)																	
Linaria vulgaris Butter-and-eggs					P												
Mimulus glabratus Monkey-flower																	
Mimulus ringens Square-stemmed monkey-flower											P						
Penstemon gracilis Slender-leaved beard-tongue																	
Penstemon grandiflorus Large-flowered beard-tongue																	
Scrophularia lanceolata Figwort																	
Verbascum thapsus Mullein																	
Veronica americana Speedwell																	
Veronicastrum virginicum Culver's root																	
Unidentified sp.	P																

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	1 AA	1 BB	1 CC	2 AA	2 BB	2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
<u>Herbs (Continued)</u>																	
SOLANACEAE																	
Physalis heterophylla Clammy ground-cherry																	
Physalis longifolia Ground-cherry																	
Solanum nigrum var. *americana* Black nightshade			P	P					P		P						
SPARGANIACEAE																	
Sparganium Bur-reed																	
TYPHACEAE																	
Typha latifolia Cattail														P			
UMBELLIFERAE																	
Angelica atropurpurea Alexander																	
Cryptotaenia canadensis Wild chervil																	
Heracleum lanatum Cow parsnip																	
Osmorhiza longistylis Sweet cicely																	
Pastinaca sativa Wild parsnip																	
Sanicula marilandica Black snakeroot																	
Zizea aurea Golden alexander																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Herbs (Continued)																	
URTICACEAE																	
Boehmeria cylindrica False nettle																	
Parietaria pensylvanica Pennsylvania pellitory	P	D															
Urtica dioica Stinging nettle											P						
Laportia canadensis Canadian wood-nettle										P							
Unidentified sp.		P							P				P	P			
VERBENACEAE																	
Verbena bracterata Large-bracted vervian	P																
Verbena hastata Blue vervain																	
Verbena simplex Vervain																	
Verbena stricta Hoary vervain																	
Verbena urticifolia White vervain																	
VIOLACEAE																	
Viola pedata Bird's-foot violet																	
VITACEAE																	
Parthenocissus inserta Thicket creeper, woodbine																	

Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

	SAF																
Pool:	Upper			Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<u>Herbs (Continued)</u>																	
HEPATICAE (Liverworts)														P			
MUSCI (mosses)														P	P	P	P

Table 2. Vegetation of Floodplain (old dredge spoil) and Bluff Habitats on the Minnesota River (Cooper, 1947).

Trees	
Acer negundo	Box elder
Acer saccharinum	Soft (Silver) Maple
Fraxinus nigra	Black ash
Fraxinus pennsylvanica	White ash
Fraxinus sp.	Ash
Populus deltoides	Cottonwood
Salix amygdaloides	Beech-leaved willow
Ulmus americana	American elm
Ulmus rubra	Slippery elm
Shrubs	
Cornus stolonifera	Red-osier dogwood
Cornus racemosa	Racemose dogwood
Salix longifolia	Willow
Sambucus canadensis	Common elder
Vitis riparia	River-bank grape
Herbs	
Acalypha rhombodia	Three-seeded mercury
Anemone virginiana	Tall anemone
Aster lateriflorus	Calico aster
Aster sp.	
Bidens sp.	Stick-tights
Boehmeria cylindrica	False nettle
Boltonia latisquama	Small headed boltonia
Carex gracilima	Sedges
Cuscuta sp.	Dodder
Elymus virginicus	Virginia wild rye
Eupatorium perfoliatum	Common boneset
Geum sp.	
Helenium autumnale	Sneezeweed
Heuchera richardsonii	Alum root
Laportia canadensis	Wood nettle
Lathyrus sp.	Wild pea
Leersia oryzoides	Rice cut-grass
Lycopus virginicus	Bugle weed
Menispermum canadense	Moonseed
Mentha sp.	Mint
Physostegia speciosa	False dragon-head
Plantago major	Common plantain
Oryzopsis sp.	
Stachys aspera	Rough hedge nettle
Urtica gracilis	Slender wild nettle

Table 3. Vegetation of the Spring Lake area (Data from Leisman, 1959).

HABITAT: Ravines and Bluffs

Trees - common
- American elm *Ulmus americana*
- Slippery elm *Ulmus rubra*
- Basswood *Tilia americana*
- Green ash *Fraxinus pennsylvanica* var. *subintegerrima*
- Box elder *Acer negundo*
- Cottonwood *Populus deltoides*
- Red cedar *Juniperus virginiana*

  - present
- Ironwood *Ostrya virginiana*
- Butternut *Juglans cinerea*
- Oaks (several) *Quercus* spp.
- Paper birch *Betula papyrifera*

Shrubs - common
- Red-berried elder *Sambucus pubens*
- Missouri gooseberry *Ribes missouriense*
- Prickly gooseberry *Ribes cynosbati*
- Black raspberry *Rubus occidentalis*
- Prickly ash *Xanthoxylum americanum*
- Hazel *Corylus americana*

  - present
- Wolfberry *Symphoricarpos occidentalis*

Herbs
- Yellow jewelweed *Impatiens pallida*
- Nettle *Urtica procera*
- Sweet cicely *Osmorhiza* sp.

HABITAT: River Terraces and Uplands

Trees
- Northern red oak *Quercus borealis*
- Pin oak *Q. palustris*
- Bur oak *Q. macrocarpa*
- American elm *Ulmus americana*
- Bitternut hickory *Carya cordiformis*
- Butternut *Juglans cinerea*
- Hackberry *Celtis occidentalis*

Shrubs
- None

Herbs
- Kentucky bluegrass *Poa pratensis*

Table 3. Vegetation of Spring Lake area (cont.)

S.W. of Ranelius site	Butternut <u>Juglans cinerea</u>
Sorg site	Black walnut <u>Juglans nigra</u>
Church's Woods (upland) Southern and Central	Trees - common Pin oak <u>Quercus palustris</u> Northern red oak <u>Q. borealis</u> Basswood <u>Tilia americana</u> - present Slippery elm <u>Ulmus rubra</u> Hackberry <u>Celtis occidentalis</u> Butternut <u>Juglans cinerea</u> Shrubs Panicled dogwood <u>Cornus racemosa</u> Virginia creeper <u>Parthenocissus quinquefolia</u> Hazel <u>Corylus americana</u> Herbs Yellow jewelweed <u>Impatiens pallida</u> Sweet cicely <u>Osmorhiza</u> sp. Tick trefoil <u>Desmodium</u> sp. Solomon's seal <u>Polygonatum canaliculatum</u> False Solomon's seal <u>Smilacina stellata</u> Bellwort <u>Uvularia perfoliata</u> Wild geranium <u>Geranium maculatum</u> Blue cohosh <u>Caulophyllum thalictroides</u> Bloodroot <u>Sanguinaria canadensis</u>
Southern edge	Trees Green ash <u>Fraxinus pennsylvanica</u> var. <u>subintegerrima</u> Box elder <u>Acer negundo</u>
Eastern edge	Trees White oak <u>Quercus alba</u>
Northern edge	Trees Sugar maple <u>Acer saccharum</u>

Table 3. Vegetation of Spring Lake area (cont.)

Northern edge (cont.)	Shrubs Yew *Taxus canadensis* Choke-cherry *Prunus virginiana* Herbs Maidenhair fern *Adiantum pedatum* Bedstraw *Galium* sp.

Table 4.

The Birds of the Minneapolis-St. Paul Region

This combined field list and migration chart of birds for the Twin Cities and the surrounding area (see unlined area on map) is designed to fit inside A FIELD GUIDE TO THE BIRDS by R. T. Peterson and to be taken into the field as an aid to those who enjoy birding in this region. The list comprises all of the species authoritatively recorded for this area, plus a few based on sight records only. It is hoped that this list may encourage the accumulation of further accurate data and so broaden our knowledge of birds of this area.

The list includes a total of 285 species. The calendar graph on the left hand page is divided into the twelve months of the year; each month is divided into three sections indicating ten days each. In this way approximate dates are indicated. The graph itself is easy to read and should answer the question, "When is the bird found here?"

A solid line indicates a bird present, common to abundant. During summer months this indicates nesting.

Short, closely spaced dashes indicate the bird is here in limited numbers.

Long, widely spaced, dashes indicate the bird is here irregularly, or rarely. Dashed lines during summer months may or may not indicate nesting.

A separate dot indicates a specific record for the bird.

The habitat key following the name of each species should answer the question, "Where is the bird found?"

A. Aquatic

1. Open lakes and rivers
2. Marshes
3. Cattails and marsh borders

Asterisk (*) indicates additional species. See page 28.

B. Shrubs

1. Wet willow growth
2. Brushy hillsides
3. Woods borders
4. Forest undergrowth
5. Brushy creek banks

C. Forests

1. Bottomland
2. Maple-basswood
3. Oak-elm upland
4. Dry oak savannah
5. Conifer

D. Grassland

1. Wet sedge meadows
2. Grassy meadows
3. Dry uplands

E. Urban

F. Åerial

G. Cliffs and banks

H. Sandy beaches

I. Mud flats

The right hand page has been left for the observer to use in recording field trip observations.

The records on which the migration charts are based have been compiled from the files of the Museum of Natural History at the University of Minnesota, THE FLICKER, and THE BIRDS OF MINNESOTA, by Dr. T. S. Roberts. Special thanks are due to Mr. and Mrs. E. D. Swedenborg for the use of their personal records. The compilers want to thank Mrs. Helen Chapman of the Museum staff and Mrs. Margaret Ring of the Continental Machines Company of Savage for help in the mechanics of assembling this pamphlet.

Anne Winton Dodge
Helen Ford Fullerton
Walter J. Breckenridge
Dwain W. Warner

Table 4. (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Loon	A1												
Red-throated Loon	A1												
Holboell's Grebe	A												
Horned Grebe	A1-2												
Eared Grebe	A1-2												
Pied-billed Grebe	A2-3												
White Pelican	A1												
Double-cr. Cormorant	A1												
Great Blue Heron	A2-3												
American Egret	A2-3												
Green Heron	A3, B-5												
Bl.-cr. Night Heron	A2-3, C-1												
American Bittern	A2-3												
Least Bittern	A3												
Whistling Swan	A1												
Canada Goose	A1-2												
White-fronted Goose	A1-2												
Snow-Blue Goose	A1-2												
Mallard	A												
Black Duck	A												
Gadwall	A												
Baldpate	A												
American Pintail	A												
Green-winged Teal	A												
Blue-winged Teal	A2-3												
Cinnamon Teal	A2-3												
Shoveler	A2-3												
Wood Duck													
Red head	A												
Ring-necked Duck	A												
Canvas-back	A												
Lesser Scaup Duck	A												
Greater Scaup Duck	A												
Golden-eye	A1												
Barrow's Golden eye	A1												
Buffle-head	A1												
Old Squaw	A1												
White-winged Scoter	A1												
Surf Scoter	A1												
American Scoter	A1												
Ruddy Duck	A2-3												
Hooded Merganser	A												
American Merganser	A												
Red-breasted Merganser	A												
Turkey Vulture	F												
Swallow-tailed Kite	F												
Goshawk	C												
Sharp-shinned Hawk	C												

Table 4. (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cooper's Hawk	C												
Red-tailed Hawk	F, C												
Red-shouldered Hawk	F, C												
Broad-winged Hawk	F, C												
Rough-legged Hawk	F, D												
Ferruginous Rough-leg	F, D												
Golden Eagle	F												
Bald Eagle	F												
Marsh Hawk	F, D												
Osprey	F, C												
Gyrfalcon	F, D												
Duck Hawk	F, G												
Pigeon Hawk	F, C												
Sparrow Hawk	F, D												
Ruffed Grouse	C												
Prairie Chicken	D												
Sharp-tailed Grouse	B, D												
European Partridge	D												
Bob-white	B2-3												
Ring-necked Pheasant	D												
Sandhill Crane	A2-D												
King Rail	A2-3												
Virginia Rail	A2-3												
Sora	A2-3												
Yellow Rail	D1-2												
Florida Gallinule	A2-3												
Coot	A												
Piping Plover	H												
Semipalmated Plover	I, H												
Killdeer	A, I, D												
Golden Plover	I, D, H												
Black-bellied Plover	I, D, H												
Ruddy Turnstone	H												
Woodcock	B1												
Wilson's Snipe	I, D-1												
Upland Plover	D2-3												
Spotted Sandpiper	I-H												
Solitary Sandpiper	I												
Western Willet	H-I												
Greater Yellow-legs	H-I												
Lesser Yellow-legs	H-I												
Knot	H												
Pectoral Sandpiper	H-I												
White-rumped Sandpiper	H-I												
Baird's Sandpiper	H-I												
Least Sandpiper	H-I												
Red-backed Sandpiper	H-I												
Dowitcher	H-I												

Table 4. (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Stilt Sandpiper	H, I												
Semipalmated Sandpiper	H, I												
Buff-breasted Sandpiper	D, H, I												
Marbled Godwit	D, H, I												
Hudsonian Godwit	H, I												
Sanderling	H												
Avocet	H, I												
Wilson's Phalarope	DI- A												
Northern Phalarope	A, I												
Herring Gull	A, F												
Ring-billed Gull	A, F												
Franklin's Gull	A, D, F												
Bonaparte's Gull	A, F												
Forster's Tern	A												
Common Tern	A												
Least Tern	H, F												
Caspian Tern	F, A												
Black Tern	A												
Mourning Dove	D												
Rock Dove	E												
Yellow-billed Cuckoo	C												
Black-billed Cuckoo	C												
Screech Owl	C												
Great Horned Owl	C												
Snowy Owl	D												
Hawk Owl	C												
Barred Owl	C												
Great Gray Owl	C												
Long-eared Owl	C												
Short-eared Owl	D												
Saw-Whet Owl	C												
Whip-poor-will	C												
Night hawk													
Chimney Swift	F												
Ruby-th'd Hummingbird	CE												
Belted Kingfisher	C-1, G												
Flicker	C												
Pileated Woodpecker	C												
Red-bellied Woodpecker	C												
Red-headed Woodpecker	C												
Yellow-bellied Sapsucker	C												
Hairy Woodpecker	C												
Downy Woodpecker	C												
Artic 3-toed Woodpecker	C												
King bird	B-3, C-4, D												
Western Kingbird	C-4, D												
Crested Flycatcher	C												
Phoebe	C-1, B-3												

Table 4. (Continued).

Species	Hab.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Yellow-bellied Flycatcher	C												
Alder Flycatcher	BC												
Least Flycatcher	C												
Wood Pewee	C												
Olive-sided Flycatcher	C												
Horned Lark	D												
Tree Swallow	FB												
Bank Swallow	FG												
Rough-winged Swallow	FG												
Barn Swallow	EF												
Cliff Swallow	GE												
Purple Martin	EF												
Canada Jay	C												
Blue Jay	C												
Magpie	CB												
Raven	CF												
Crow	CF												
Black-capped Chickadee	C												
Hudsonian Chickadee	CS												
Tufted Titmouse	C												
White-breasted Nuthatch	C												
Red-breasted Nuthatch	C												
Brown Creeper	C												
House Wren	EC												
Winter Wren	B-4, C												
Bewick's Wren	C												
Carolina Wren	C												
Long-billed Marsh Wren	A3												
Short-billed Marsh Wren	DI												
Mockingbird	C												
Cat bird	CE												
Brown Thrasher	CE												
Robin	CE												
Wood Thrush	C												
Hermit Thrush	C												
Olive-backed Thrush	C												
Gray-cheeked Thrush	C												
Veery	C												
Bluebird													
Townsend's Solitaire	C												
Blue-gray Gnatcatcher	C												
Golden-crowned Kinglet	C												
Ruby-crowned Kinglet	C												
American Pipit													
Bohemian Waxwing	C												
Cedar Waxwing	C												
Northern Shrike	B-3, C-4, D												
Migrant Shrike	C-4, D												

Table 4. (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Starling	E												
Bell's Vireo	CB												
Yellow-throated Vireo	C												
Blue-headed Vireo	C												
Red-eyed Vireo	C												
Philadelphia Vireo	C												
Warbling Vireo	C												
Black & White Warbler	C												
Prothonotary Warbler	CI												
Worm-eating Warbler	B4												
Golden-winged Warbler	B3												
Blue-winged Warbler	B2-3												
Tennessee Warbler	C												
Orange-crowned Warbler	C												
Nashville Warbler	C												
Parula Warbler	C												
Yellow Warbler	B2-3, E												
Magnolia Warbler	C												
Cape May Warbler	C												
Black-th'd Blue Warbler	C												
Myrtle Warbler	C												
Audubon's Warbler	C												
Black-th'd Green Warbler	C												
Cerulean Warbler	C2												
Blackburnian Warbler	C												
Hooded Warbler	B4												
Chestnut-sided Warbler	B3												
Bay-breasted Warbler	C												
Black-poll Warbler	C												
Pine Warbler	C												
Palm Warbler	CB												
Oven-bird	B4												
Northern Water-Thrush	B5												
Louisiana Water-Thrush	B5												
Connecticut Warbler	B4												
Mourning Warbler	B4												
Yellow-throat	A-3, B1												
Yellow-breasted Chat	B2												
Wilson's Warbler	B3-4, C												
Canada Warbler	C												
Redstart	C												
English Sparrow	E												
Bobolink	D1												
Eastern Meadowlark	D												
Western Meadowlark	D												
Yellow-headed Blackbird	A3												
Red-winged Blackbird	A3												
Orchard Oriole	C3-4												

Table 4. (Continued).

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Baltimore Oriole	C												
Rusty Blackbird	C-1												
Brewer's Blackbird	D												
Bronzed Grackle	CDE												
Cowbird	BCDE												
Scarlet Tanager	C												
Cardinal	C												
Rose-breasted Grosbeak	C												
Indigo Bunting	B-2, 3												
Dickcissel	D-2												
Evening Grosbeak	C												
Purple Finch	C												
Pine Grosbeak	C-5												
Hoary Redpoll	D, B-2												
Redpoll	D, B-2												
Pine Siskin	C												
Goldfinch	CB												
Red Crossbill	C-5												
White-winged Crossbill	C-5												
Towhee	C												
Savannah Sparrow	D-2												
Grasshopper Sparrow	D-3												
Leconte's Sparrow	A3, D-1												
Henslow's Sparrow	A3, D-1												
Nelson's Sparrow	A3, D-1												
Vesper Sparrow	D-3												
Lark Sparrow	C-4, D-3												
Slate-colored Junco	C												
Oregon Junco	C												
Tree Sparrow	B, C-1												
Chipping Sparrow	B, C-5, E												
Clay-colored Sparrow	B-2, C-4												
Field Sparrow	B-2, C-4												
Harris's Sparrow	B-3, C												
White-crowned Sparrow	B-3, C												
White-throated Sparrow	C												
Fox Sparrow	C												
Lincoln's Sparrow	B-5, C												
Swamp Sparrow	A-3, B-1												
Song Sparrow	A3, B-1, 5												
Lapland Longspur	D												
Snow Bunting	D												
ADDITIONAL SPECIES													
Western Grebe	A												
Yellow Night Heron	A2-3, C1												
Western Tanager	C												

Table 5. Benthic Animal Abundance.

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (arranged by pool and transect from upstream down)

MISSISSIPPI RIVER

Upper St. Anthony Falls Pool

Transect UAA, Mile 857.3

UAA Rock Scrapings; Left bank; Spring 1973; 4" - 1" depth; Small amount of medium coarse sand and rocks

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Plecoptera	Chloroperlidae	*Hastaperla*	4	2.
	Perlidae	*Paragnetina*	2	
Trichoptera	Hydropsychidae	*Hydropsyche*	3	
		Cheumatopsyche	3	
	Hydropsychidae	Damaged or very immature	6	
Diptera	Chironomidae	*Polypedilum*	1	
	Simuliidae	(Very small larvae)	6	

UAA; Left bank; Summer 1973; 5.5' depth; Rocks, some gravel and sand

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	10	20.
		Cheumatopsyche	66	
		Macronemum	1	
		(Unident. pupae)	11	
Trichoptera	(Unident. very small larva)		1	
Plecoptera	Perlidae	*Phasganophora*	1	
Ephemeroptera	Gaenidae	*Caenis*	11	
Coleoptera	Elmidae		29	
	Elmidae	(Adult)	1	
Diptera	Chironomidae	*Polypedilum*	14	
		Chironomus	1	
		Rheotanytarsus	14	
	Chironomidae	(Unident. pupae)	3	
	Empididae	*Hemerodromia ?*	1	
		Hemerodromia ? (pupa)	1	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UAA, Mile 857.3 (Continued)

UAA: Mid-stream; Spring 1973; Coarse sand; 10 to 11', 12.3 maximum depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	67.

UAA: Mid-channel; Summer 1973; Rocks, sand and gravel, 7' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	22	64.
		Cheumatopsyche	6	
Ephemeroptera	Potamanthidae	*Potamanthus*	2	
	Heptageniidae	*Stenonema?* (damaged)	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	2	
		Rheotanytarsus	12	
	Pentaneurini		9	
		Polypedilum (pupa)	1	
	Tantytarsini (pupa)		2	
	Chironominae (unident. pupa)		1	
	Empididae	*Hemerodromia?*	4	
		Hemerodromia? (pupa)	2	
	Tipulidae	(unident. larva)	1	
	Simuliidae	*Simulium*	2	
		Simulium (pupa)	2	
	Chironomidae	*Rheotanytarsus ?*	1	

(in case, attached just behind head to cervical membrane of a Hydropsyche larva)

Table 5. Benthic Animal Abundance (cont.).

A Comparison of Spring and Summper Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croxi Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UBB, Mile 855.7

UBB : Left bank; Spring 1973; no organisms in sample

UBB : Burlington Northern RR bridge; 3rd pier from L/B; Summer 1973; Sand,rocks; 14' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	49.
Diptera	Chironomidae	*Cryptochironomus*	2	

UBB : Mid-channel; Summer 1973; Medium coarse sand

Diptera	Chironomidae	*Polypedilum*	1	65.

UBB : Mid-channel; Summer 1973; Sand and fine gravel with some plant debris; 13.75' depth

Diptera	Chironomidae	*Paratendipes*	1	54.

UBB : Right bank; Spring 1973; 4" d. chunk of cemet, very little fine sand, medium coarse sand; 2.7' deep, 12 yards from right bank

Trichoptera	Hydropsychidae	*Cheumatopsyche*	22	5.
		Hydropsyche	5	
		Macronemum	2	
Diptera	Chironomidae		2	
	Empididae		1	
Coleoptera	Elmidae		1	
	Elmidae	(Adults)	3	

UBB : Right bank; Summer 1973; no organisms

Table 5. Benthic Animal Abundance (cont.)
A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Concluded)

Transect UCC, Mile 854.4

UCC: E, Left bank only; Spring 1973; Fine sand (on shelf), hardly any sediments; 16' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			1	73.

UCC: Ekman, Left Bank; Summer 1973; no sample

UCC: Ekman, Mid-channel; Spring 1973; no sample

UCC: Ekman, Mid-channel; Summer 1973; Sand and gravel; 10' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	2	53.
Coleoptera	Elmidae		5	
Diptera	Chironomidae	*Stictochironomus*	1	
		Polypedilum	1	
		Eukiefferiella	1	

UCC: Mid- main channel; Summer 1973; Coarse sand with numerous small clam-shells; 18.5 - 19' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	
		Polypedilum	4	
		Paratendipes	1	

Table 5. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Lower St. Anthony Falls Pool

Transect LBB, Mile 853.4

LBB: Left bank; Spring 1973; 10 yards from left bank, and 325 yards from right bank; medium coarse sand with silt, plant and shell fragments; 3' depth

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	3	69.
		Rheotanytarsus	1	

LBB: Left bank; Summer 1973; Sand, silt and pebbles; 3' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Psychomyiidae	*Nyctiophylax*	3	
Ephemeroptera	Caenidae	*Caenis*		
	Heptageniidae	*Stenonema*	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Dicrotendipes*	8	
		Glyptotendipes	6	
		Polypedilum	2	
		Cryptochironomus	5	
		Psectrotanypus	1	
Oligochaeta			5	

Table 5. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota dn Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Lower St. Anthony Falls Pool (Concluded)

Transect LBB, Mile 853.4 (Continued)

LBB: Mid-channel; Spring 1973; A few pieces of bark, with Trichoptera larvae; 165 yards from Left bank and 155 yards from right bank, L guide wh

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	18	11.
		Hydropsyche (pupae)	2	
		Cheumatopsyche	9	
		Cheumatopsyche (pupae)	2	
	Philopotamidae	*Chimarra*	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Endochironomus*	1	
		Microtendipes	1	
		Polypedilum	1	
	Chironominae	(unident., very small larva)	1	

LBB: Mid-channel; Summer 1973; Sand and pebbles; 14' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	
Oligochaeta			1	

LBB: Right bank; Spring 1973; Medium sand and silt (little current); 100 yards from right bank, 240 yards from left bank; 10' deep

Class or order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	17	
		Chironomus	1	
Oligochaeta			11	

LBB: Right bank; Summer 1973; no sample

Table 5. Benthic Animal Abundance (cont)
Comparison of Spring and Summer Samples of Benthic
A Macroinvertebrates Collected in 1973 in the
Minnesota and Lower St. Croix Rivers and Mile
815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1

Transect 1AA, Mile 853.2

1AA: Left bank; Spring 1973; 62 yards from left bank and 127 yards from right bank; rocks with Trichoptera and 1 mayfly; 17.0' deep

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	3	9.
		Cheumatopsyche	8	
Ephemeroptera	Potamanthidae	*Potamanthus*	1	
Diptera	Chironomidae	*Polypedilum*	2	

1AA: Left bank; Summer 1973; no sample

1AA: Mid-channel; Spring 1973; no sample

1AA: Mid-channel; Summer 1973; Coarse sand and gravel, rocks, fine sand; 11.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	
	Potamanthidae	*Potamanthus*	1	
Ephemeroptera	(Unident. damaged nymph)		1	
Trichoptera	Hydropsychidae	*Cheumatopsyche*	3	
	Psycomyiidae	(Unident. damaged larva)	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Polypedilum*	3	
		Cryptochironomus	2	
	Tanytarsini		2	
	Pentaneurini		4	

Table 5. Benthic Animal Abundance (cont.)
Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

A

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

1AA: Right bank; Spring 1973; 20 yards to right bank and 145 yards to left bank; Rocks with 1 mayfly nymph; 13.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Hydropsyche*	4	7.
Plecoptera	Perlodidae	*Isoperla*	1	
Ephemeroptera	Heptageniidae	*Stenonema*	1	
Diptera	Chironomidae	*Polypedilum*	1	
	Orthocladiinae	(Unident. pupa)	1	

1AA: Right-bank; Summer 1973; no sample

Transect 1BB, Mile 850.6

1BB: Left-bank; Spring 1973; 8 yards to spoil on left bank, 225 yards to right bank tree; Rock, gravel, sand and silt; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	6.
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta	Tubificidae		12	

1BB : Left bank; Summer 1973; Fine sand, silt, rocks; 8.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatcpsyche*	1	
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta			3	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

Transect 1BB; Mile 850.6 (Continued)

1BB : Mid-channel; Spring 1973; 135 yards to left bank, 76 yards to right bank spoil and 54 more yards to base of bluff and tree; No record of substrate type; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	17.
Diptera	Chironomidae	*Polypedilum*	3	
		Paratendipes	3	
	Ceratopogonidae ?	(Unident. larva)	1	
Pelecypoda (clams)	Sphaeriidae	*Sphaerium*	1	

1BB : Mid-channel; Summer 1973; No organisms

1BB: Right bank; Spring 1973; No sample

1BB : Right bank; Summer 1973; No sample

Transect 1XX, Mile 851.1

1XX : Left bank; Spring 1973; No sample

1XX : Left bank; Summer 1973; 150' from left bank; Sand and a couple bark fragments; 12.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae	(damaged larva)	1	40.

1XX: Mid-channel; Spring 1973; no sample

1XX: Mid-channel; Summer 1973; Sand and bark fragments (pine), shell fragments; 14' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Paratendipes*	5	24.
Pelecypoda (clams)		*Sphaerium*	1	
Gastropoda (snails)		*Planorbula* (not alive)	1	
Oligochaeta			1	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Continued)

Transect 1XX, Mile 851.1 (Continued)

1XX: Right bank; Spring 1973; No sample

1XX: Right bank; Summer 1973; 35' to right bank; Shell fragments and bark, gravel and coarse sand; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	19.
Diptera	Chironomidae	*Cryptochironomus*	5	
		Polypedilum	2	
	Pentaneurini		1	
Pelecypoda (clams)	Unionidae	*Actinonaias*	1	

Transect 1CC, Mile 848.0

1CC: Left-bank; Spring 1973; 20 yards to left-bank; Fine sand, few 1" stones, sticks; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	23	16.
		Paratendipes	6	
		Phaenopsectra	6	
		Cryptochironomus	1	
		Chironomus	2	
	Psychodidae	*Psychoda*	1	
Oligochaeta			15	

1CC: Left bank; Summer 1973; 100' from left bank; Fine sand and silt, sewer smell in sediments; 4.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	1	46.
		Chironomus	2	
		Polypedilum	1	
Oligochaeta			1	

Table 5. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1 (Concluded)

Transect 1CC, Mile 848.0 (Continued)

1CC: Mid-channel; Spring 1973; No sample

1CC: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Chironomus*	3	23.
Oligochaeta			2	

1CC: Right bank; Spring 1973; No sample

1CC: Right bank; Summer 1973; No sample

Pool 2

Transect 2AA, Mile 847.4

2AA: East channel, Left bank; Spring 1973; 59 yards from left bank, 300 yards from right bank; Rocks; 9.1' depth

Trichoptera	Hydropsychidae	*Hydropsyche*	3	10.
		Cheumatopsyche	5	
	Hydropsychidae	(Unident. pupae)	9	
		(Damaged larvae)	2	
	Psychomyiidae	*Polycentropus*	1	
Ephemeroptera	Potamanthidae	*Potamanthus*	2	
Diptera	Chironomidae	*Phaenopsectra*	1	
	Tanytarsini		3	
Hirudinea (leeches)			1	

2AA: East channel; Summer 1973; 15 feet from island; Rocks and coarse gravel; 3.5-5.0' depth

Coleoptera	Elmidae		1	
Hirudinea (leeches)			3	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2AA, Mile 847.4 (Continued)

2AA :Rock Scrapings; Left channel, 15 feet from island; Rocks and coarse gravel 3.5-5.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Potamanthidae	*Potamanthus*	1	34.
Trichoptera	Psychomyiidae	*Polycentropus*	1	
Diptera	Chironomidae	*Dicrotendipes ?*	1	
	Chironomidae ? (unident. egg mass)		1	
Hirudinea (leech)			1	

2AA: Mid-channel; Spring 1973; No sample

2AA :Mid-channel by lock; Rock scrapings; Summer 1973; Rocks encrusted with algae, etc.

Diptera	Chironomidae	*Polypedilum*	1	59.

2AA: Right bank; Spring 1973; No organisms

2AA: Right bank; Summer 1973; no organisms

Transect 2BB, Mile 831.7

2BB: Left bank; Spring 1973; 30 yards from left bank; Gelatinous, with sand; 4.5' depth

Diptera	Chironomidae	*Polypedilum*	6	71.
		Phaenopsectra	6	
		Chironomus	1	
		Stitochironomus	1	
	Empididae	(Unident. larva)	1	

2BB: Left bank; Summer 1973; Mostly sludge, silt and organic clay; 11.1' depth

Diptera	Chironomidae	*Procladius*	6	35.
Oligochaeta			32	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2BB, Mile 831.7 (Concluded)

2BB : Mid-channel; Spring 1973; 10 yards from right bank and 250 yards to left bank; 23' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Plecoptera	Perlodidae	*Isoperla*	1	8.
Ephemeroptera	Ephemeridae	*Pentagenia*	1	
	Potamanthidae	*Potamanthus*	1	
Coleoptera	Elmidae		2	
Diptera	Chironomidae	*Xenochironomus*	18	
	Pentaneurini		3	

2BB : Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Chironomus*	4	29.
		Procladius	1	
	Chaoboridae	*Chaoborus*	6	
Oligochaeta			37	

2BB : Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	60.

2BB : Right bank; Spring, 1973; No sample

2BB : Right bank; Summer 1973; No sample

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Miscellaneous Pool 2 Sites

Pool 2: Right bank of back channel, Newport Island; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	47.
Oligochaeta				

Chute behind Island 2CC; Right-bank; Downstream from 827.7; Summer 1973; Clay, silt and some sand; 4' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta	(Many fragements)		47	28.
Nemertea (proboscis worm)			1	

Mile 827.7 : Left bank backwater; Upstream from spoil; Summer 1973; Sand with 1/8" silt on top; 6.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	63.

Grey Cloud Slough at twin fill; Summer 1973; Organic mud; 18' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Tanypus*	2	31.
		Chironomus?	1	
	Chaoboridae	*Chaoborus*	7	

Baldwin Lake; Downstream from spoil; Summer 1973; About 1" of silt on 2' deep sand and mud

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	48.
Oligochaeta			4	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi Rivers (Continued)

MISSISSIPPI RIVER (Continued)

Pool 2 (Continued)

Transect 2YY, Mile 821.4

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
2YY :"3A"; Spring 1973; 135 yards to right bank; Organic mud, much silt, some fine grit; 3.2' depth				
Diptera	Chironomidae	*Psectrotanypus*	1	1.
		Procladius	9	
		Cryptochironomus	1	
Oligochaeta	Tubificidae		54	
Oligochaeta		(Immatures and/or small)	23	
2YY :"3A"; Right-bank; Summer 1973; Soft mud; 3.5' depth				
Diptera	Chironomidae	*Procladius*	1	36.
Oligochaeta			5	
2YY :"3B"; Spring 1973; no sample				
2YY :"3B"; Summer 1973; Soft mud; 3' depth				
Diptera	Chironomidae	*Procladius*	3	41.
Oligochaeta			8	
2YY: "3C"; Spring 1973		Note: "3C" is mid-channel		
Diptera	Chironomidae	*Procladius*	19	15.
		Tanypus	2	
Oligochaeta			14	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix River and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Concluded)

Pool 2 (Concluded)

Transect 2YY, Mile 821.4 (Continued)

2YY:"3C"; Summer 1973; Medium coarse sand with 1/8" silt layer on top; 12.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	50.

Transect 2CC, Mile 815.5

2CC: Left bank; Spring 1973; 7 yards from left bank, 1 mile to right bank, 750 yards to upstream tip of Buck Island;Black clay mud (kept shape), sl anaerobic; 15.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			94.	14.

2CC: Left bank; Summer 1973; No sample

2CC: Mid-channel; Spring 1973; 155 yards from left bank; 3 tries and Petersen dredge wouldn't trip, anchor came up with partly decayed leaves, sticks, large branch and sludge attached; 28' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	8	68.

2CC: Mid-channel; Summer 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	8	27.
Oligochaeta			11	

2CC: Right bank; Spring 1973; No sample

2CC: Right bank; Summer 1973; No sample

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER

Transect MAA, Mile M24.8

MAA : Left Bank; Spring 1973; No organisms

MAA: Left bank; Rock Scrapings; Summer 1973; 40' from left bank; 1-2" silt over gelatinous mud, smelled slightly of decay; 5.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	21.
	Hydropsychidae	(Unident. damaged pupa)	1	
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Glyptotendipes*	9	
		Glyptotendipes (pupae)	2	
	Nematocera	(Unident. damaged pupae)	2	

MAA: Mid-channel; Spring 1973; No sample

MAA: Mid-channel; Summer 1973; No sample

MAA: Right bank; Spring 1973; No sample

MAA: Right bank; Summer 1973; No organisms

Transect MBB, Mile M13.0

MBB : Left bank; Spring 1973; No organisms

MBB: Left bank; Summer 1973; 6' depth

Diptera	Chironomidae	*Polypedilum*	1	57.

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER (Continued)

Transect MBB, Mile M13.0 (Continued)

MBB : Mid-channel; Spring 1973; No sample

MBB : Mid-channel; Summer 1973; No record of substrate; 8' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Tanypus*	2	25.
		Procladius	5	
Oligochaeta			11	

MBB : Right bank; Spring 1973; 12 yards from right bank; 120 yards from left bank; Coarse sand and clay pellets; 7.5' depth

Diptera	Chironomidae	*Cryptochironomus*	1	18.

MBB : Right bank; Summer 1973; Fine sand with clay lumps, silt layer on top; 3' depth

Diptera	Chironomidae	*Cryptochironomus*	1	18.

MBB: Right bank; Summer 1973; Fine sand with clay lumps, silt layer on top; 3' depth

Oligochaeta			1	51.

Transect MCC, Mile M3.0

MCC: Left-bank; Spring 1973; No organisms

MCC: Left-bank; Summer 1973; No sample

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St.Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

MINNESOTA RIVER (Concluded)

Transect MCC, Mile M3.0 (Continued)

MCC: Mid-channel; Spring 1973; No sample

MCC: Mid-channel; Summer 1973; Fine sand with shallow layer of silt; 12' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	30.
Oligochaeta			28	

MCC: Right bank; Spring 1973; Ekman dredge (small amount of sand, much water) 5 yards to right bank; 5' depth

Oligochaeta			1	72.

MCC: Right bank; Summer 1973; Clay silt and some sand; 4' depth

Oligochaeta			9	38.

ST. CROIX RIVER

Transect SAA, Mile SC24.8

SAA: Left bank; Spring 1973; 10 yards to left bank; Substrate not recorded; 9.5' depth

Oligochaeta			1	78.

SAA: Left bank; Summer 1973; No sample

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SAA, Mile SC24.8 (Continued)

SAA: Mid-channel; Spring 1973; Substrate not recorded; 5.2' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Micropsectra*	1	70.
	Ceratopogonidae ?	(Unident. larva)	1	
Oligochaeta			1	

SAA: Mid-channel; Summer 1973; Clay and mud (organic?); 1 chironomid; 22' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Tipulidae		1	22.
	Chironomidae	*Xenochironomus*	4	

SAA; Right bank; Spring 1973; No sample

SAA: Right bank; Mid backwater; Summer 1973; Fine sand overlain with silt; Middle of bay; 3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Procladius*	2	33.

Transect SXX, Mile SC16.0

SXX: Left bank; Spring 1973; 560 yards from left bank; Shallows; 10.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Ephemeroptera	Caenidae	*Caenis*	1	74.
Diptera	Chironomidae	*Cryptochironomus*	2	
		Potthastia	1	
Oligochaeta			1	

SXX: Left bank; Summer 1973; Medium to fine sand, wood fragments and clam-shell; Middle of the bay; 7.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	1	43.
	Chaoboridae	*Chaoborus*	1	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 in the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SXX, Mile SC 16.0 (Continued)

SXX: Mid-channel; Spring 1973; 1000 yards from left bank, 180 yards from right bank; Coarse red sand; 16.3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	75.
		Stictochironomus	1	
		Paracladopelma	1	
		Paracladopelma? (very small)	2	
Pelecypoda (clams)		*Pisidium*	10	
Gastropoda (snails)		*Stagnicola ?* (very small)	1	

SXX: Mid-channel; Summer 1973; No record of substrate; 15.7' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Oligochaeta			2	39.

SXX: Right bank; Spring 1973; No sample

SXX: Right bank; Summer 1973; No sample

Transect SBB, Mile SC 12.3

SBB: Left bank; Spring 1973; No organisms

SBB: Left bank; Summer 1973; No organisms

SBB: Mid-channel; Spring 1973; No sample

SBB: Mid-channel; Summer 1973; No organisms

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 in the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SBB, Mile (Continued)

SBB: Right Bank; Spring 1973; 1400 yards from left bank, 40 yards from right bank; Clams, snails, gravel to 5", coarse sand; 11.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Eggs (?) of unknown organism on pebble				
Diptera	Chironomidae	*Tanytarsini*	2	4.
Oligochaeta	Lumbriculidae		1	
Nematoda (roundworms)			1	

SBB: Right bank; Summer 1973; No sample

Transect SYY, Mile SC 6.4

SYY: Left bank; Spring 1973; Fine sand, sticks and plant debris; Backwater; 2.2 yards from right-bank; 3.0' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	5	3.
		Chironomus	8	
		Paratenaipes	7	
		Psectrotanypus	1	
		Procladius	8	
		Micropsectra	3	
		Harnischia	1	
		Polypedilum	4	
		Cladotanytarsus (most very small)	46	
	Ceratopogonidae	*Palpomyia ?*	3	
Oligochaeta	Tubificidae		2	

SYY: Left bank; Shallow; Summer 1973; Just downstream from Mo. and Kinnikinnick; Sand with a little silt; 3' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Cryptochironomus*	2	52.
		Polypedilum	2	
	Tanytarsini		1	
Oligochaeta			2	

Table 5. Benthic Animal Abundance (cont.)

A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

ST. CROIX RIVER (Continued)

Transect SYY, Mile SC6.4 (Continued)

SYY: Mid-channel; Spring 1973

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Odonata	Gomphidae	(Unident. small nymph)	1	12.
Coleoptera	Elmidae		1	
Diptera	Chironomidae	*Polypedilum*	2	
		Cryptochironomus	2	
	Ceratopogonidae	*Palpomyia*	1	
Oligochaeta			123	

SYY: Kinny mid-channel; Summer 1973; Medium to fine sand; 15.3' depth

Oligochaeta			1	44.

SYY: Right bank; Spring 1973; 12 yards from right bank; 1-2" stones, very little coarse sand; Depth not recorded

Diptera	Chironomidae		1	76.
Egg? (of a fish?)			1	

SYY: Right bank; Summer 1973; About 30' from right bank; Rocks, pebbles, sand and plant debris; 14.5-15' depth

Diptera	Chironomidae	*Glyptotendipes*	1	55.
		Glyptotendipes (pupa)	1	

Transect SCC, Mile ________

SCC: Left bank; Spring 1973; 30 yards from left bank, 700 yards from right bank; 12' depth

Coleoptera	Elmidae		1	77.

SCC: Left bank; Summer 1973; No sample

Table 5. Benthic Animal Abundance (cont.)

A

Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Concluded)

ST. CROIX RIVER (Concluded)

Transect SCC, Mile (Continued)

SCC: Mid-channel; Spring 1973; No sample

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera		(Unident. fragments)	1	62.
Oligochaeta			1	
Nemertea (proboscis worm)			1	

SCC: Right bank; Spring 1973; 5 yards from right bank; 1 rock 3" x 6" with worm-like encrustations; 3.5' depth

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	66.

SCC: Righ.. bank; Summer 1973; No sample

Table 5. Benthic Animal Abundance (cont.)

B — Benthic Macroinvertebrates*of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973. (Arranged alphabetically within phyla).

List of Abbreviations

AA,BB,CC	Standard transects, in downstream order
XX,YY	Special Transects, in downstream order
U,L,1,2	Upper and lower St. Anthony Falls Pools, and Pools 1 and 2, respectively
M, S	Minnesota and St. Croix Rivers, respectively
Spr	Spring: April and May
Su	Summer: August and September
D/S, U/S	Downstream, upstream
ch	Channel
19.	Serial number of sample

PHYLUM NEMERTEA Proboscis worms

2CC Su 28. SCC Su 62.

PHYLUM NEMATODA Roundworms

SBB Spr 4.

PHYLUM ANNELIDA Segmented worms

Class Hirudinea Leeches

2AA Spr 10. 2AA L Ch 34. 2AA L ch Su 45.

Class Oligochaeta Aquatic earthworms

Family Lumbriculidae

SBB Spr 4.

Family Tubificidae

2YY Spr 1. 3YY Spr 3. 1BB Su 6.

Unidentifiable oligochaetes

SYY	Spr	12.	LBB	Spr	13.	2CC	Spr	14.	2YY	Spr	15.
1CC	Spr	16.	1XX	Su	24.	1CC	Su	23.	MBB	Su	25.
1BB	Su	26.	2CC	Su	27.	2CC	Su	28.	2BB	Su	29.
MCC	Su	30.	2BB	Su	35.	2YY	Su	36.	LBB	Su	37.
MCC	Su	38.	SXX	Su	39.	SYY	Su	44.	1CC	Su	46.

*Benthic macroinvertebrates: bottom-dwelling nonmicroscopic animals without backbones.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973. (Continued).

PHYLUM ANNELIDA Segmented worms (Continued)

Class Oligochaeta (Continued)

Unidentifiable oligochaetes (Continued)

2	Su	47.	2	Su	48.	2YY	Su	50.	MBB	Su	51.
SYY	Su	52.	LBB	Su	58.	2BB	Su	60.	SCC	Su	62.
2		63.	SAA	Spr	70.	MCC	Spr	72.	UCC	Spr	73.
SXX	Spr	74.	SAA	Spr	78.	2YY	Su	41.			

Immatures and/or small Oligochaeta

2YY Spr 1.

PHYLUM ARTHROPODA Crustaceans, Insects and Spiders

Class Insecta Insects

Order Coleoptera Beetles

Family Elmidae

UBB	Spr	5.	2BB	Spr	8.	LBB	Spr	11.	SYY	Spr	12.
LBB	Spr	13.	1BB	Spr	17.	UAA	Su	20.	MAA	Su	21.
1AA	Su	32.	LBB	Su	37.	1XX	Su	40.	2AA	Su	45.
UCC	Su	53.	UAA	Su	64.	SCC	Spr	66.	SCC	Spr	77.

Order Diptera Flies, Mosquitoes and Midges

Family Ceratopogonidae (?) Unident. larva
1BB Spr 17.

Family Ceratopogonidae

Genus *Palpomyia (?)*
SYY Spr 3.

Genus *Palpomyia*
LBB Spr 13.

Family Chaoboridae

Genus *Chaoborus*
2BB Su 29. 2* Su 31. SXX Su 43.

*Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (?) Unident. larva

SAA	Spr	70.									

Family Chironomidae (?) Unident. egg mass

2AA		34.									

Family Chironomidae Unident. pupae

UAA	Su	20.	UAA	Su	64.						

Family Chironomidae

Subfamily Chironominae

LBB	Spr	11.									

Genus *Chironomus*

SYY	Spr	3.	LBB	Su	13.	1CC	Spr	16.	UAA	Su	20.
1CC	Su	23.	2BB	Su	29.	2*	Su	31.	1CC	Su	46.
2BB	Spr	71.									

Genus *Cladotanytarsus*

SYY	Spr	3.									

Genus *Cryptochironomus*

2YY	Spr	1.	SYY	Spr	3.	1BB	Su	6.	SYY	Spr	12.
1CC	Spr	16.	MBB	Spr	18.	1XX	Su	19.	1BB	Su	26.
1BB	Su	32.	LBB	Su	37.	UCC	Su	42.	SXX	Su	43.
1CC	Su	46.	UBB	Su	49.	SYY	Su	52.	LBB	Su	58.
SXX	Spr	74.									

Genus *Diamesa*

SYY	Spr	76.									

Genus *Dicrotendipes (?)*

2AA		34.									

Genus *Dicrotendipes*

LBB	Su	37.									

*Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Endochironomus*											
LBB	Su	11.									
Genus *Eukiefferiella*											
UCC	Su	53.									
Genus *Glyptotendipes*											
MAA	Su	21.	LBB	Su	37.	SYY	Su	55.			
Genus *Harnischia*											
SYY	Spr	3.									
Genus *Micropeectra*											
SYY	Spr	3.	SAA	Spr	70.						
Genus *Microtendipes*											
LBB	Su	11.									
Subfamily Orthocladiinae											
1AA	Su	7.									
Genus *Paracladopelma*											
SXX	Spr	75.									
Genus *Paratendipes*											
SYY	Spr	3.	1CC	Spr	16.	1BB	Spr	17.	1XX	Su	24.
UCC	Su	42.	UBB	Su	54.						
Genus *Pentaneurini*											
UBB	Spr	5.	2BB	Spr	8.	1XX	Su	19.	UAA	Su	64.
1AA	Su	32.									
Genus *Phaenopsectra*											
2AA	Spr	10.	1CC	Spr	16.	2BB	Spr	71.			

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Polypedilum*

UAA	Spr	2.	SYY	Spr	3.	1AA	Spr	7.	1AA	Spr	9.
LBB	Spr	11.	SYY	Spr	12.	LBB	Spr	13.	1CC	Spr	16.
1BB	Spr	17.	1XX	Su	19.	UAA	Su	20.	1AA	Su	32.
LBB	Su	37.	UCC	Su	42.	1CC	Su	46.	SYY	Su	52.
UCC	Su	53.	MBB	Su	57.	2AA	Su	59.	UAA	Su	64.
UBB	Spr	65.	UAA	Spr	67.	LBB	Spr	69.	2BB	Spr	71.
SXX	Spr	75.									

Genus *Polypedilum* (pupa)

UAA	Spr	64.

Genus *Potthastia*

SXX	Spr	74.

Genus *Procladius*

2YY	Spr	1.	SYY	Spr	3.	2YY	Spr	15.	MBB	Su	25.
2CC	Su	27.	2BB	Su	29.	MCC	Su	30.	SAA	Su	32.
2BB	Su	35.	2YY	Su	36.	2YY	Su	41.	2*	Su	47.
2**	Su	48.	2CC	Spr	68.						

Genus *Psectrotanypus*

2YY	Spr	1.	LBB	Su	37.	SYY	Spr	3.

Genus *Rheotanytarsus (?)*

UAA	Spr	64.

Genus *Rheotanytarsus*

UAA	Spr	20.	LBB	Su	69.	UAA	Su	64.

Genus *Stictochironomus*

UCC	Su	53.	2BB	Spr	71.	SXX	Spr	75.

Genus *Tanypus*

2YY	Spr	15.	MBB	Su	25.	2†	Su	31.

*Right bank in West channel, Newport Island, mile 831.0.
**Baldwin Lake.
†Special transect: in Grey Cloud channel at discharge from Mooers Lake.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Diptera (Continued)

Family Chironomidae (Continued)

Genus *Tanytarsini*
SBB Spr 4. 2AA Su 10. 1AA Su 32. SYY Su 52.
UAA Su 64.

Genus *Xenochironomus*
2BB Spr 8. SAA Su 22.

Family Empididae (Unident. larva)
UAA Su 64. 2BB Spr 71.

Family Empididae
UBB Spr 5.

Genus *Hemerodromia (?)*
UAA Su 20. UAA Su 64. Both samples also contain a pupa

Family Nematocera (Unident. damaged pupa)
MAA Su 21.

Family Psychodidae

Genus *Psychoda*
1CC Spr 16.

Family Simuliidae (very small larvae)
UAA Spr 2.

Family Simuliidae

Genus *Simulium*
UAA Su 64.

Genus *Similum* (pupa)
UAA Su 64.

Family Tipulidae
SAA Su 22.

Diptera (unident. fragment)
SCC Su 62.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Ephemeroptera Mayflies

Family Caenidae

Genus *Caenis*

UAA	Su	20.	1AA	Su	32.	LBB	Su	37.	SXX	Spr	74.
UBB	Su	49.									

Family Ephemeridae

Genus *Pentagenia*

2BB	Spr	8.

Family Heptageniidae
Genus *Stenonema*

1AA	Spr	7.	UAA	Su	64.	LBB	Su	37.

Family Potamanthidae

Genus *Potamanthus*

2BB	Spr	8.	1AA	Spr	9.	2AA	Spr	10.	1AA	Su	32.
2AA		34.	UAA	Su	64.						

Order Odonata Dragonflies and Damselflies

Family Gomphidae (Unident. small nymph)

SYY	Spr	12.

Order Plecoptera Stoneflies

Family Chloroperlidae

Genus *Hastaperla*

UAA	Spr	2.

Family Perlodidae

Genus *Isoperla*

1AA	Spr	7.	2BB	Spr	8.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Plecoptera (Continued)

Family Perlidae

Genus *Paragentina*

UAA	Spr	2.

Genus *Phasganophora*

UAA	Spr	20.

Order Trichoptera Caddis Flies

Family Hydropsychidae

Genus *Cheumatopsyche*

UAA	Spr	2.	UBB	Spr	5.	1BB	Spr	6.	1AA	Spr	9.
2AA	Spr	10.	LBB	Spr	11.	1XX	Su	19.	UAA	Su	20.
MAA	Su	21.	UCC	Su	53.	1BB	Su	26.	1AA	Su	32.
UAA	Su	64.									

Genus *Hydropsyche*

UAA	Spr	2.	UBB	Spr	5.	1AA	Spr	7.	1AA	Spr	9.
2AA	Spr	10.	LBB	Spr	11.	UAA	Su	20.	UAA	Su	64.

Genus *Macronemum*

UBB	Spr	5.	UAA	Spr	20.

Family Hydropsychidae (Unidentified pupae; some damaged)

2AA	Spr	10.	UAA	Su	20.	MAA	Su	21.

Family Hydropsychidae (Damaged or very immature)

UAA	Spr	2.

Family Philopotamidae

Genus *Chimarra*

LBB	Spr	11.

Table 5. Benthic Animal Abundance (cont.)

B Benthic Macroinvertebrates of the Navigable Twin Cities Rivers, Collected on Standard and Special Transects in 1973 (Continued)

PHYLUM ARTHROPODA (Continued)

Class Insecta (Continued)

Order Trichoptera (Continued)

Family Psychomyiidae

Genus *Nyctiophylax*
LBB Su 37.

Genus *Polycentropus*
2AA Spr 10. 2AA 34.

Order Trichoptera (Unidentified very small larva)
UAA Spr 20.

PHYLUM MOLLUSCA Snails and Clams

Order *Gastropoda*

Family *Lymnaeidae*

Genus *Stagnicola (?)* (Very small)
SXX Spr 75.

Order Pelecypoda

Family Unionidae

Genus *Actinonaias*
1XX Su 79.

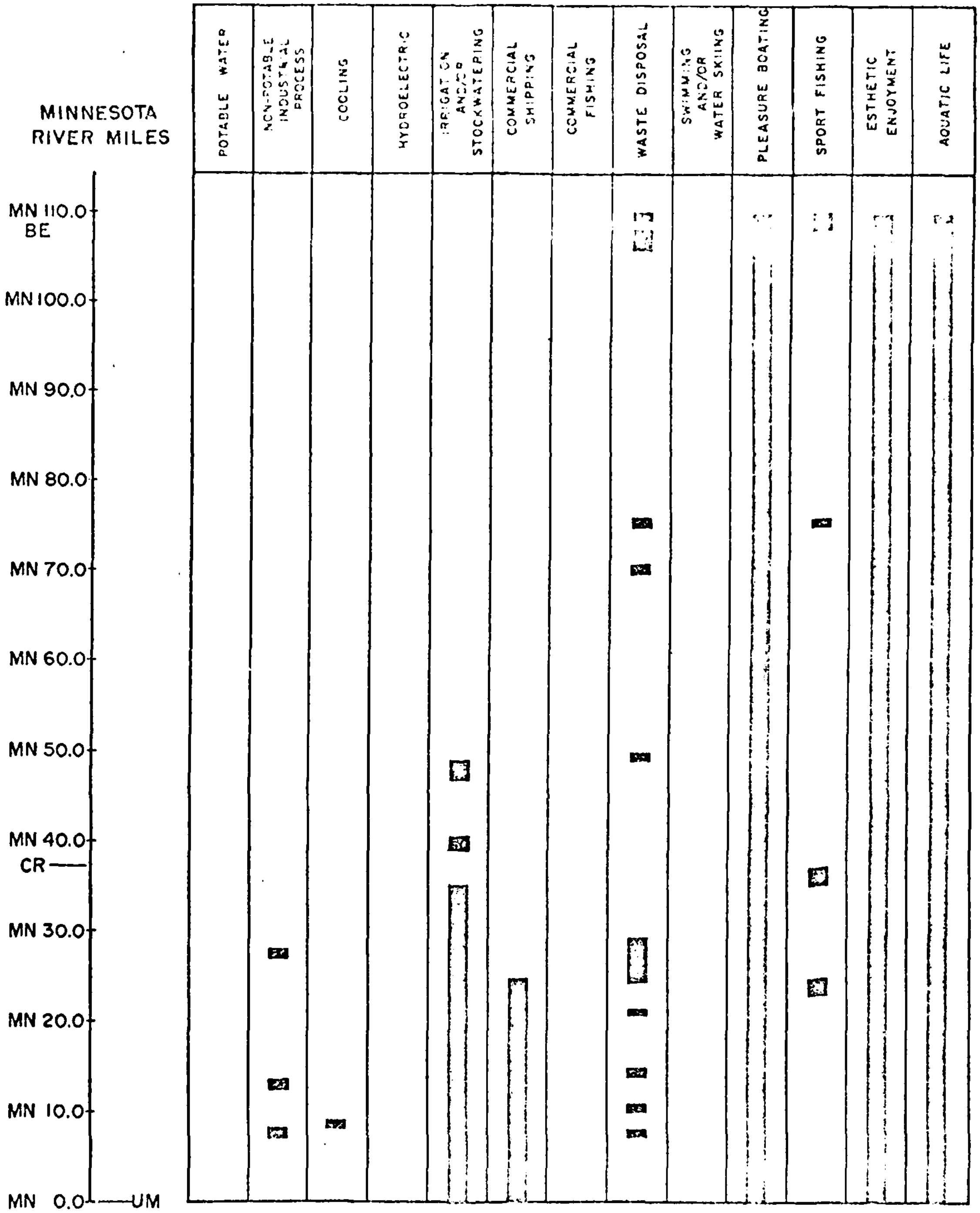
Family Sphaeriidae

Genus *Pisidium*
SXX Spr 75.

Genus *Sphaerium*
1BB Spr 17. 1XX Su 24.

EGGS (?) of unknown organism on pebble
SBB Spr 4.

EGG(?) of a fish
SYY Spr 76.



LEGEND

BE Blue Earth River
CR Carver Rapids
UM Mississippi River

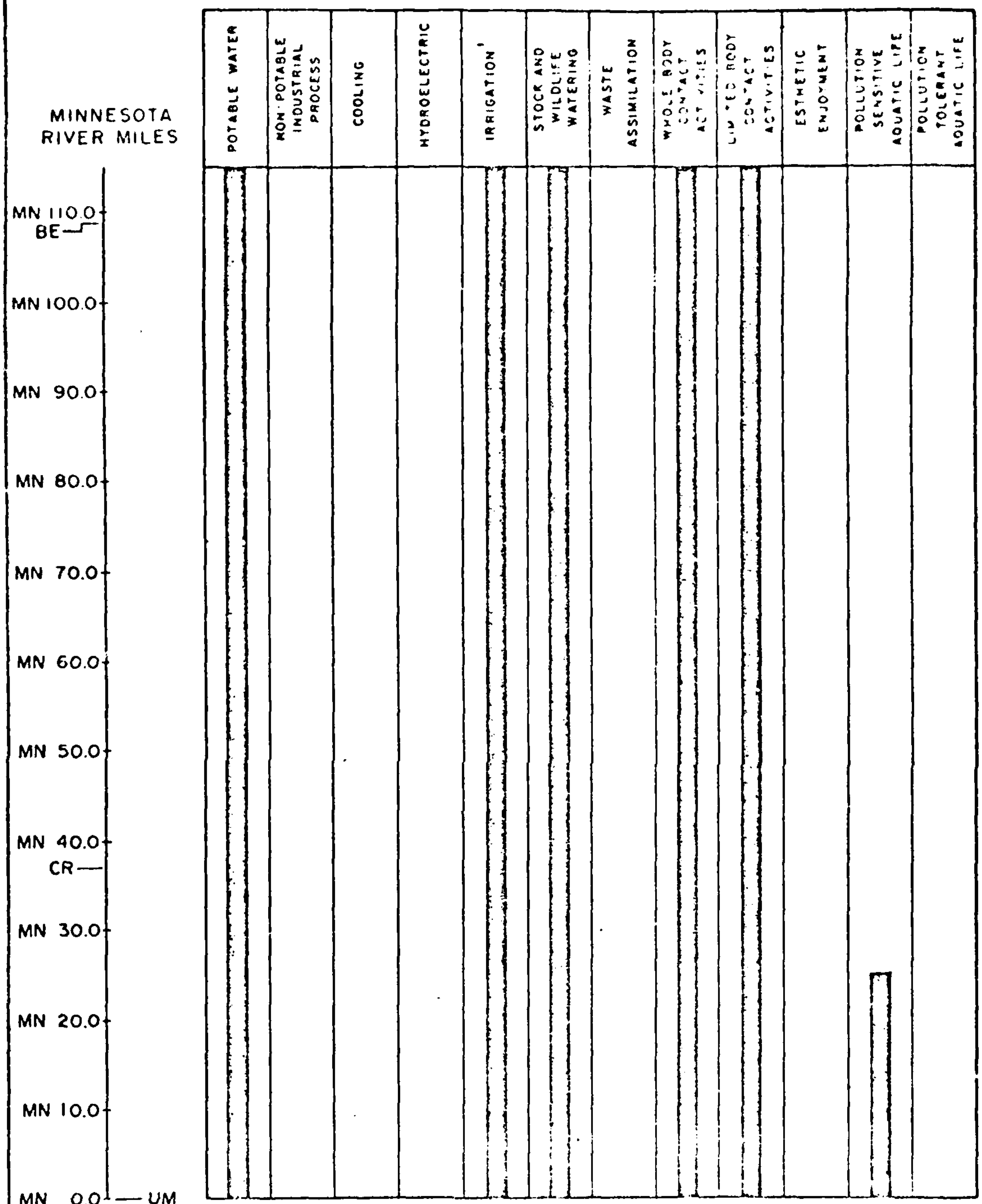
TWIN CITIES UPPER MISSISSIPPI RIVER PROJECT

PRESENT WATER USES ALONG THE MINNESOTA RIVER

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

GPO 828-545-D-4

Table 6.



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

Table 7.

Table 8. Downstream profile of turbidity, in FTU, and the effect of dredging and barge traffic on turbidity in the Minnesota River, September 25, 1973

(D') = water depth sampled, in feet.

MN.R. Mile	Location	Left Bank FTU	Left Bank (D')	Mid-chan. FTU	Mid-chan. (D')	Right Bank FTU	Right Bank (D')	Notes
21.8	150 yds upstream from Peavey terminal	33 37	(0') (2') (bottom 3')	36 42	(0') (4') (bottom 6')	35 39	(0') (5') (bottom 7')	Head of privately maintained nine-foot navigation channel.
21.7	130 yds downstream from Peavey terminal					31	(0')	ditto.
21.4	Sharp right bend	28	(0')			32	(0')	Left bank is on outside of bend, eroding.
19.5	Sharp right bend	21	(0')			23	(0')	Left bank is on outside of bend.
18.5	Sharp right bend	21	(0')			23	(0')	Left bank is on outside of bend.
16.8	Upstream from Co Hwy. 25 Brdg.	22	(0')			21	(0')	Right bank riprapped.
15.1	Upstream from Bunge terminal	21 25	(0') (5') (bottom 7')	18 23	(0') (9') (bottom 12')	22 27	(0') (3') (bottom 5')	Upstream from heavy barge traffic.

Table 9. Turbidity, temperature and dissolved oxygen in the SAF Pools, Pools 1 and 2 of the Mississippi River and the Lower Minnesota River, November 1 and 2, 1973

Date	Pool	Transect	Depth in ft.	Turbidity** FTU	Temp., OC	DO, ppm	Remarks
1 Nov 73	USAF	Hd. Nicollet Is.	0'	4	8.5	8.67	
			12'(b)*	4			
		AA* (Mid-ch)†	0'	4	8.0	8.04	
			12'(b)	4	8.0	7.70	
		BB (Mid-ch)	0'	5.5	8.2	7.70	
			15'(b)	4	8.3	6.67	
		CC (E. ch)	0'	18	8.2	6.65	
			10'(b)	2	7.7	7.00	
		CC (Mid-main ch)	0'	2	5.8	9.17	
			25'(b)	3	5.2	9.53	
	LSAF	BB (R/B)††	0'	2	9.3	6.88	@Shiely
			14'(b)	4	8.6	7.50	
		BB	0'	2.5	8.7	7.17	1.5 Min after
			14'(b)	4	8.0	7.00	Joaljim pushec
		BB (Mid-ch)	0'	3	7.5	8.06	2 loaded barge
			10'	3.5	7.0	7.28	u/s to 'C' yd.
		BB	0'	3	8.2	6.83	Underneath
			(b)	4	8.3	7.00	Stone Arch Br.
	1		0'	4	8.3	8.00	center
			13'(b)	4	7.5	9.54	
		AA (Mid ch)	0'	4	8.6	6.00	∿ 300' D/S
			22'(b)	5	8.5	6.67	from LSAF Dam,
		BB (Mid ch)	0'	4.5	8.4	6.13	Mid ch.
			18'(b)	5	8.3	6.20	
		CC (Mid)	0'	6	8.6	6.20	
			12'(b)	5	8.5	6.13	
	2	AA (Mid-main ch)	0'	4	8.6	7.50	
			18'(b)	5	8.6	9.33	
		AA (L ch mid)	0'	5	8.6	6.34	
			10'(b)	6	8.5	8.34	
	Minn.	CC (Mid-ch)	0'	42.5	9.3	6.18	
			15'(b)	56	7.0	8.82	
	2	St.P. ycht club	0'	11	8.6	5.67	
			12'(b)	12	9.0	3.78	
		Mile 831.1	0'	9	9.0	6.17	
			15"(b)	9	8.9	6.17	
		BB	0'	12	9.1	6.19	
			21'(b)	11	9.0	6.17	
2 Nov 73	Minn.	BB	0'	17.5	7.1	12.84	
			11'(b)	19.5	7.8	14.00	
		CC - R/B	0'	37			@R/B-no boat
			0'	46			wake
		- Mid ch	0'	33	8.6	7.67	@R/B-40 sec.
			15'(b)	36.5	8.5	7.83	after own boat wake (1/2 throttle ∿20' from R/B

*(b) = river bottom depth † ch = channel †† R/B = right bank

**FTU = Formazine Turbidity Units; measured with a nephelometer.

Table 10. Common Species of Game Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966)

Species	Mississippi River				Minnesota River		St. Croix River
	Rum River To St. Anth. Falls	Pool No. 1	Pool No. 2	Pool No. 3	River Mile 70 to 25	River Mile 25 to 0	
Walleyed Pike	X		X	X	X		X
Sauger			X	X	X		X
Northern Pike	X		X	X	X		X
Black Crappie	X		X	X	X	X	X
White Crappie				X	X	X	
Largemouth Bass			X		X		
Smallmouth Bass	X	(list is incomplete) X			X		X
Rock Bass	X		X				X
White Bass				X	X		X
Bluegill	X		X	X			X
Channel Catfish			X	X	X	X	X
Sturgeon							X
Flathead Catfish				X	X	X	X
Green Sunfish			X				
Pumpkinseed	X						X
Brown Trout							X
Number of Species	7	-	9	9	10	4	13

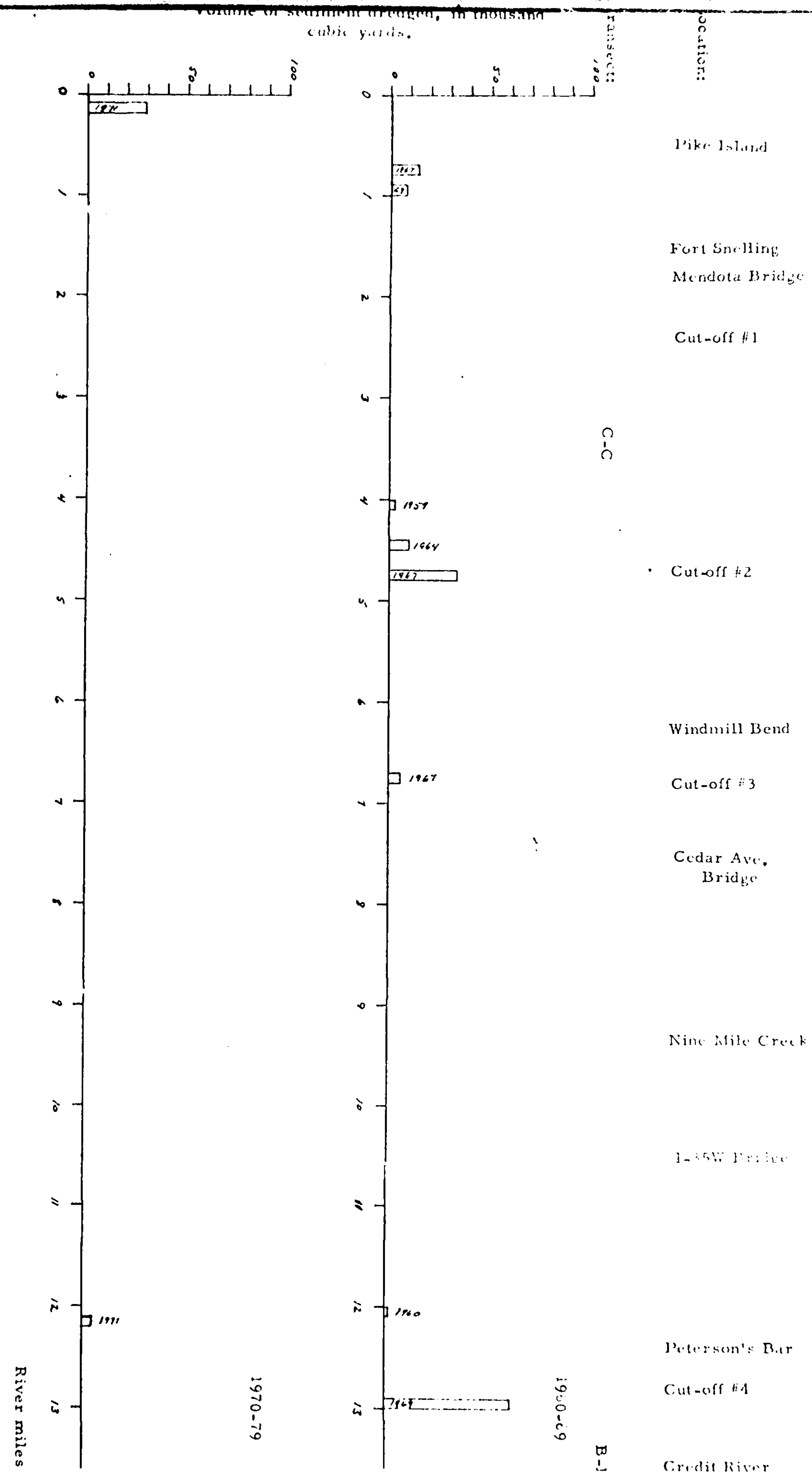
Note: This is not necessarily a complete list.

Table 11. Common Species of Rough Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966)

	Mississippi River				Minnesota River		
	Rum River to St. Anthony Falls	Pool No. 1	Pool No. 2	Pool No. 3	River Mile 70 to 25	River Mile 25 to 0	St. Croix River
Carp	X	X	X	X	X	X	X
Quillback					X		X
Sheepshead		X	X	X		X	X
Brown Bullhead							X
Bigmouth Buffalofish	X		X	X	X	X	X
Northern Carpsucker				X	X	X	
Northern Redhorse	X	X	X	X	X		X
Longnose Gar				X			X
Shortnose Gar			X	X	X	X	X
Bowfin		(list is incomplete)	X				
Mooneye			X	X			X
Gizzard Shad			X	X	X	X	
Common Sucker	X		X	X	X	X	X
Spotted Sucker							
Yellow Bullhead	X						
Black Bullhead	X						
Golden Shiner				X			
Perch			X				X
River Sucker			X				
Number of Species	6	--	11	11	8	7	11

Note: This is not necessarily a complete list.

A -92a-


Volume of sediment dredged, in thousand cubic yards.
Transect:
Location:
Pike Island
Fort Snelling
Mendota Bridge
Cut-off #1
C-C
Cut-off #2
Windmill Bend
Cut-off #3
Cedar Ave. Bridge
Nine Mile Creek
I-35W Bridge
Peterson's Bar
Cut-off #4
Credit River
B-B
River miles
1970-79
1960-69
0
50
100
1974
1971
1962
1959
1964
1967
1960

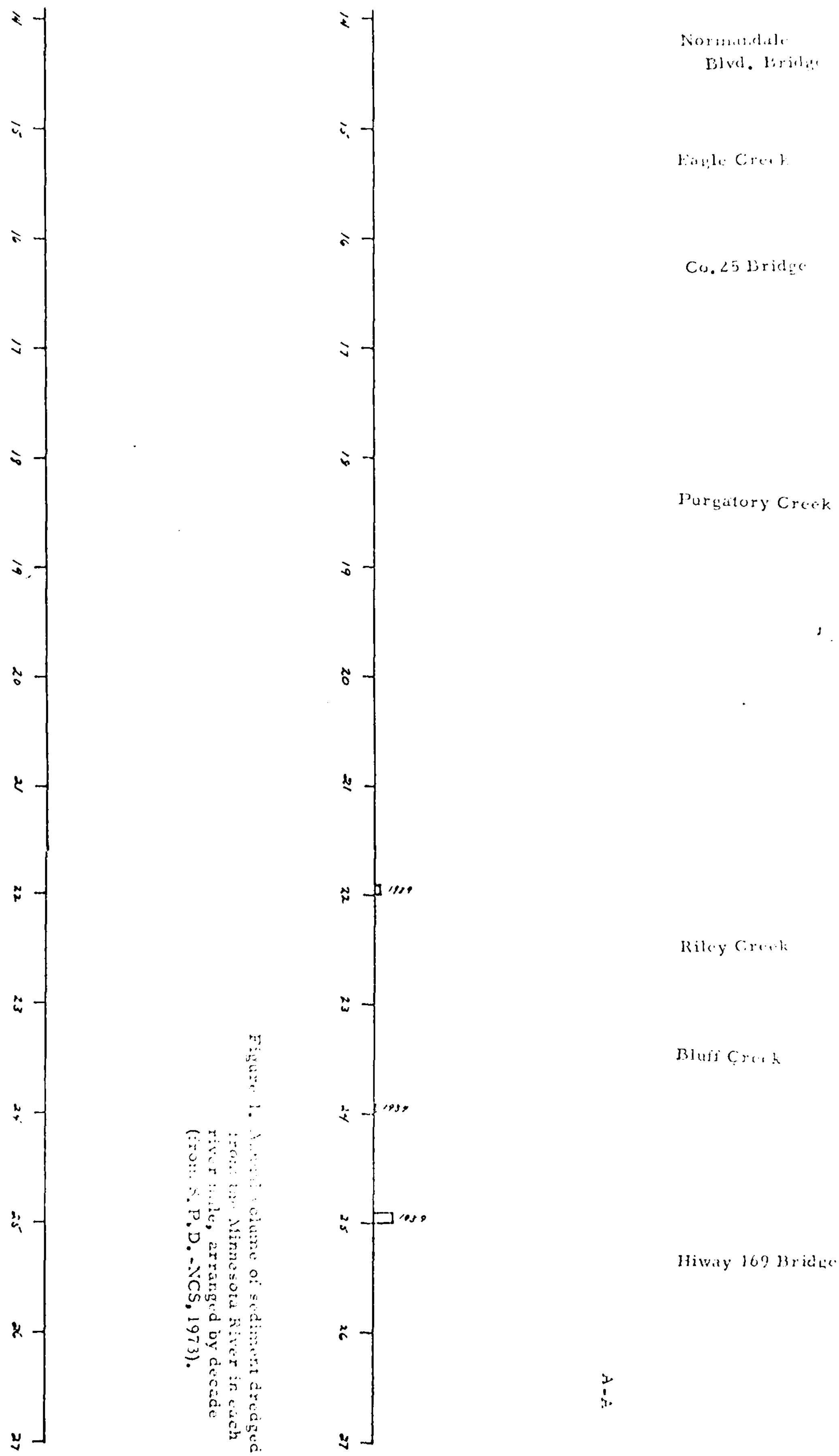


Figure 1. Annual volume of sediment dredged from the Minnesota River in each river mile, arranged by decade (from S.P.D.-NCS, 1973).

A-?

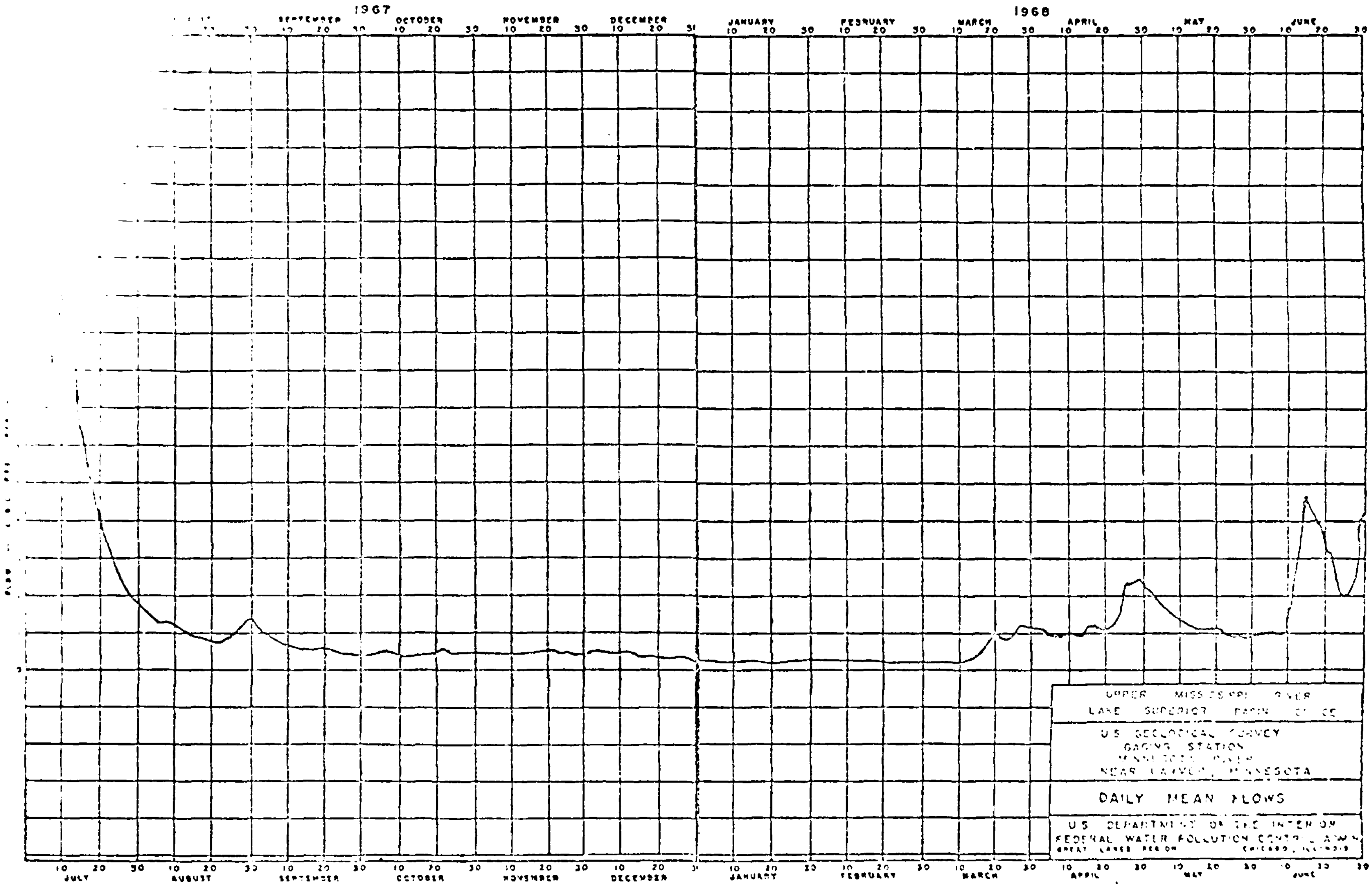

1967
1968
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
DAILY MEAN FLOWS

Figure 2.

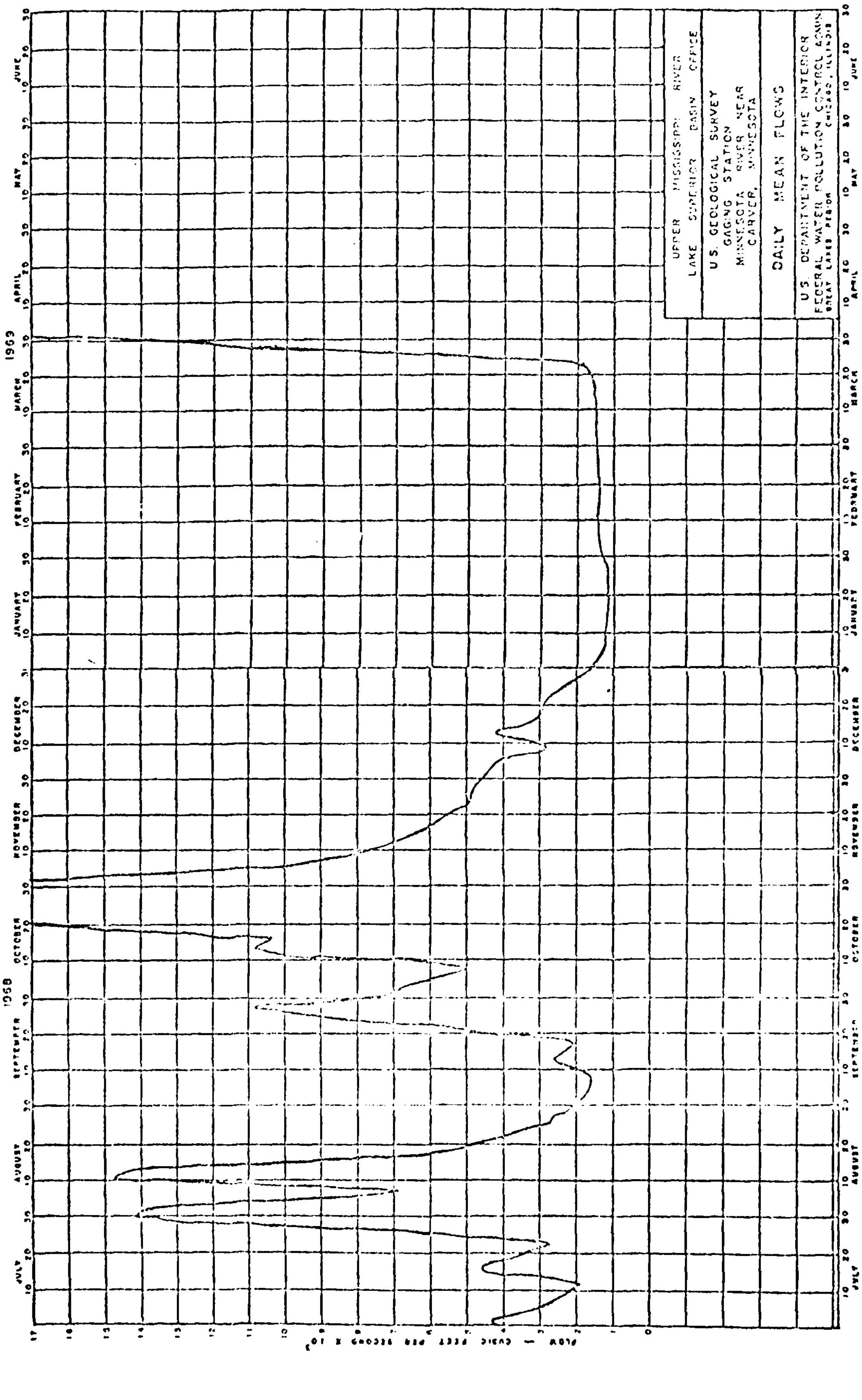


Figure 2 (Continued).

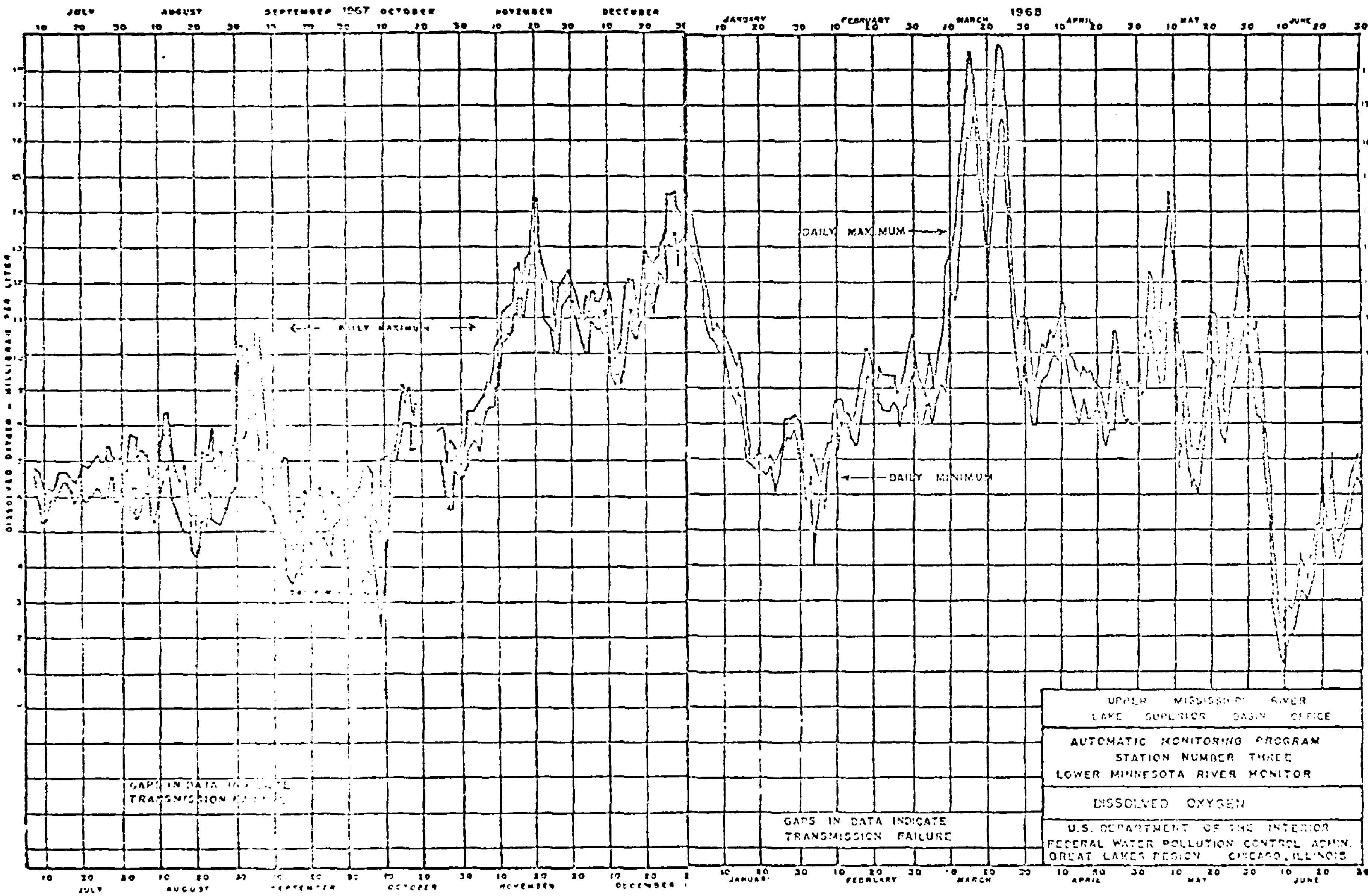

1967
1968
DAILY MAXIMUM
DAILY MINIMUM
DISSOLVED OXYGEN - MILLIGRAMS PER LITER
GAPS IN DATA INDICATE TRANSMISSION FAILURE
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER THREE
LOWER MINNESOTA RIVER MONITOR
DISSOLVED OXYGEN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

Figure 3.

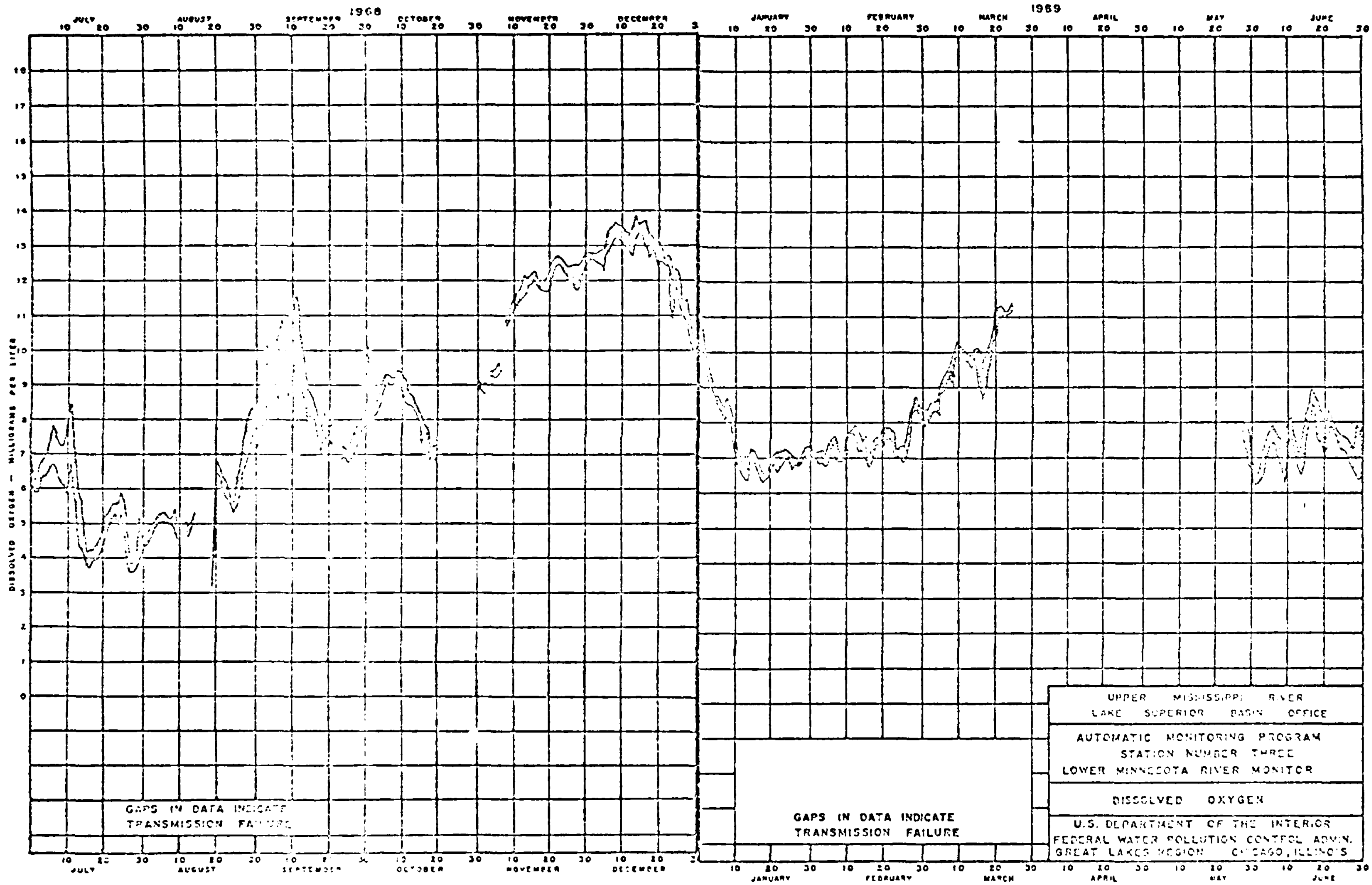


Figure 3 (Continued).

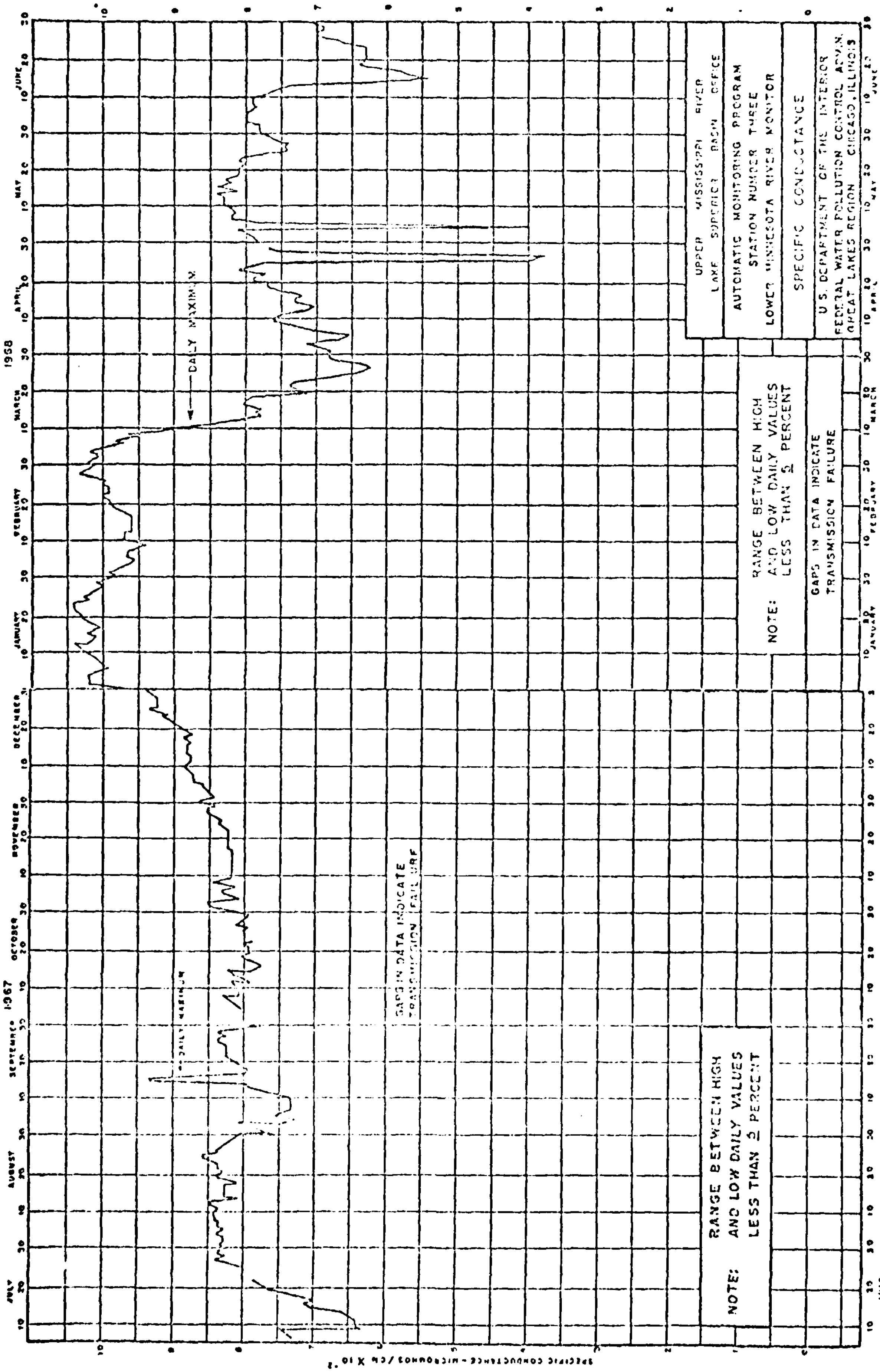

UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER THREE
LOWER MINNESOTA RIVER MONITOR
SPECIFIC CONDUCTANCE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADM'N.
GREAT LAKES REGION CHICAGO, ILLINOIS
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
GAPS IN DATA INDICATE TRANSMISSION FAILURE
DAILY MAXIMUM
1967
1968
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
SPECIFIC CONDUCTANCE - MICROMHOS / CM X 10

Figure 4.

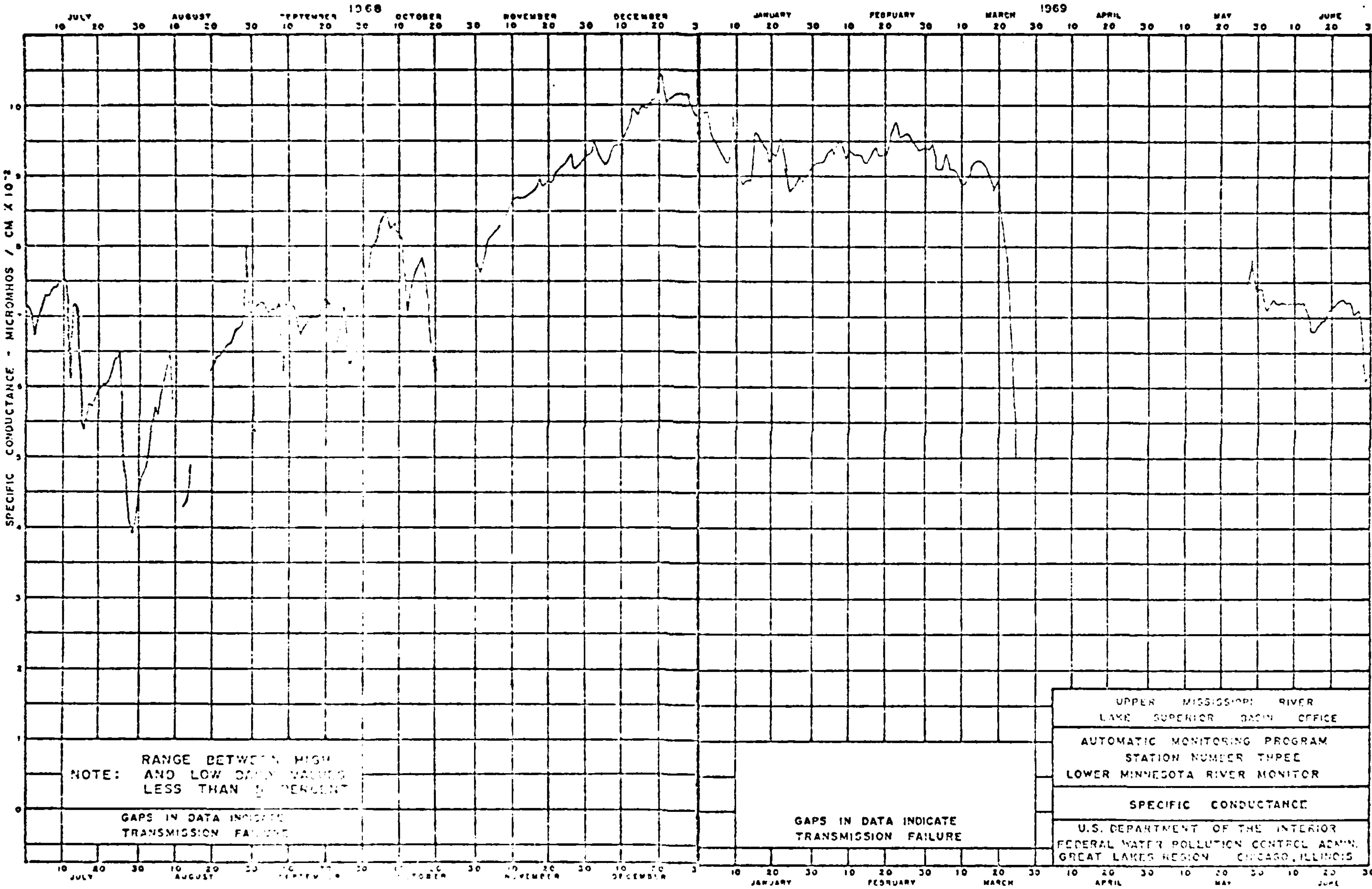


Figure 4 (Continued).

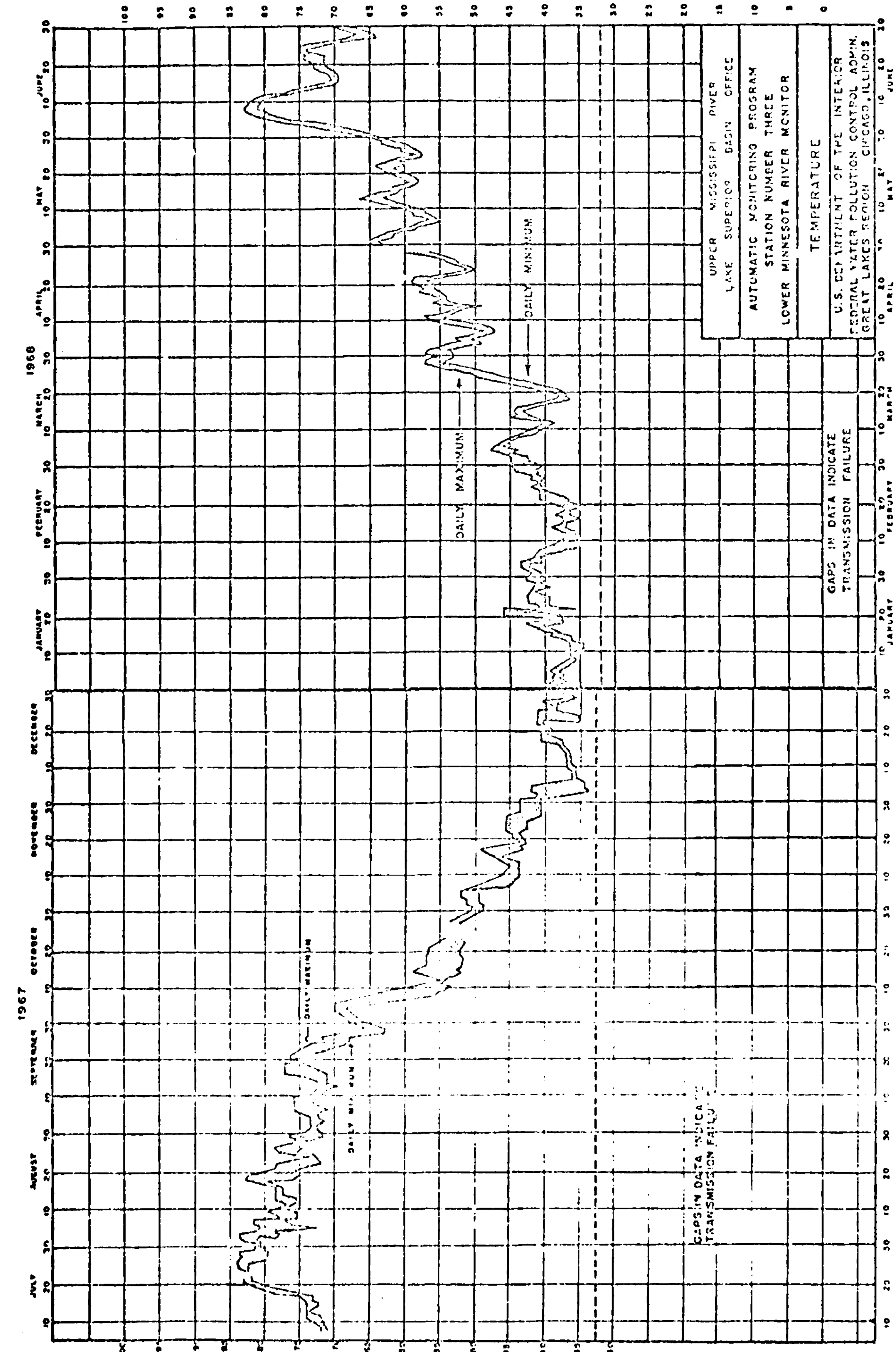

UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER THREE
LOWER MINNESOTA RIVER MONITOR
TEMPERATURE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS
GAPS IN DATA INDICATE TRANSMISSION FAILURE
DAILY MAXIMUM
DAILY MINIMUM
1967
1968
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE

Figure 5.

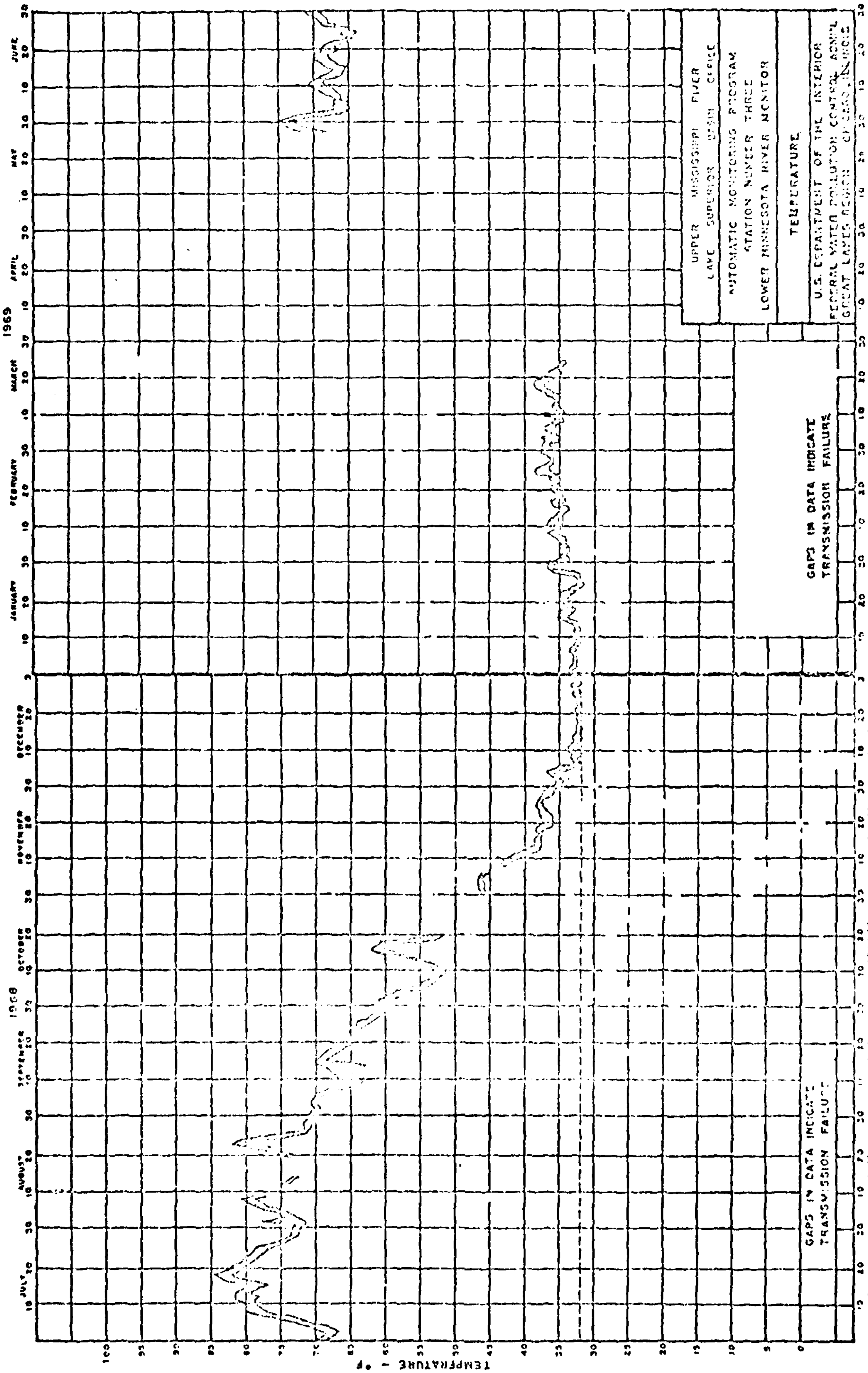


Figure 5 (Continued).

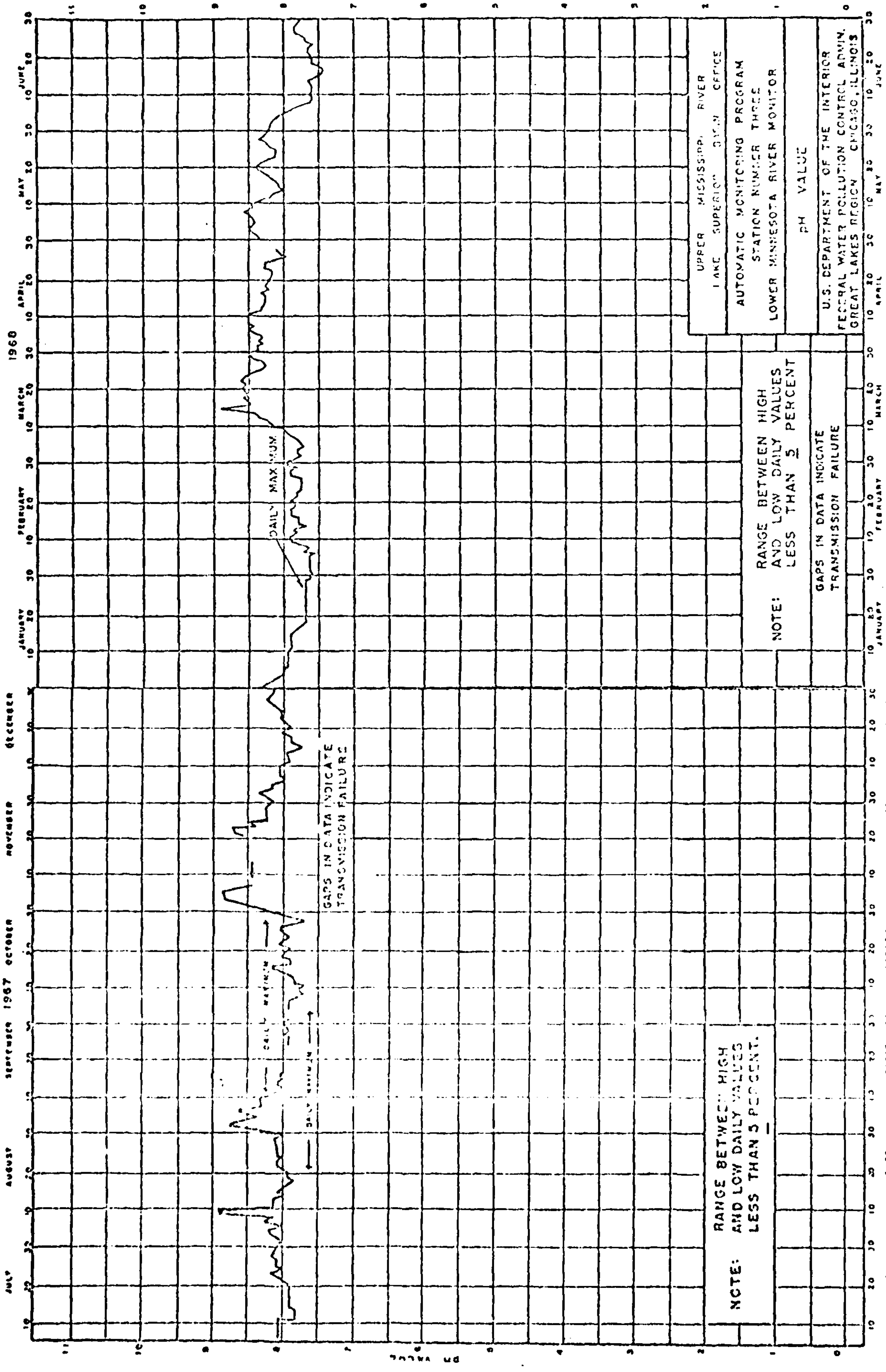

UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER THREE
LOWER MINNESOTA RIVER MONITOR
pH VALUE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
GAPS IN DATA INDICATE TRANSMISSION FAILURE
DAILY MAXIMUM
1967
1968
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
pH VALUE

Figure 6.

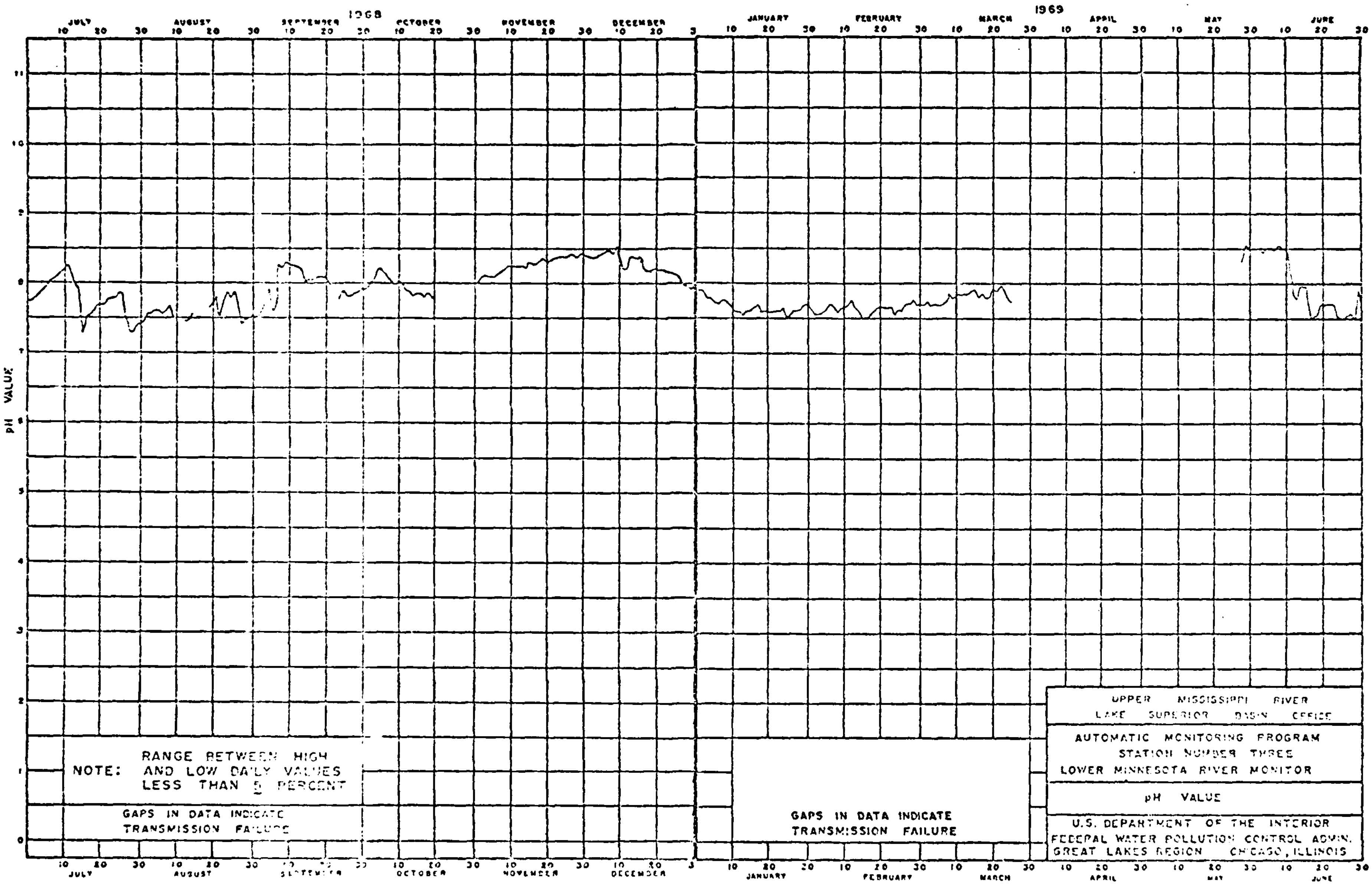


Figure 6 (Continued).

Glossary

acre-foot - the quantity of water required to cover an acre to a depth of 1 foot. It is equivalent to 43,560 cubic feet.

alluvial material - sediment, usually sand or silt, deposited on land by flowing water.

aerobic - an environment in which free oxygen is present.

anaerobic - an environment in which free oxygen is lacking.

aquifer - a water-bearing layer of porous rock, sand, or gravel.

backwaters - a term often divided now into sloughs and lakes and ponds adjoining a river.

benthic - pertaining to the bottom of a body of water.

benthic invertebrates - animals lacking a spinal column living in the benthic zone.

BSFW - Bureau of Sport Fisheries and Wildlife (U. S. Department of the Interior).

channel - a natural or artificial watercourse with definite bed and banks which confine and conduct flowing water.

cfs - cubic feet per second, used as a measure of rate of water flow in a river.

chute - sloping channel or passage through which water may pass.

closing dam - low dam extending across a side channel. These were constructed to divert water from side channels to the main channel during low water periods to maintain water sufficient for navigation.

coulee - steep-sided tributary valleys, commonly used in Wisconsin.

deciduous forest - forest dominated by broad-leaved trees which lose their leaves each Autumn.

discharge (rate of flow) - the quantity of water passing a point in a stream channel per unit of time, normally measured in cubic feet per second (cfs).

drainage area - the land area drained by a stream above a specified location on the stream. Measured in a horizontal plane, it is so enclosed by higher land (a divide) that direct surface runoff from precipitation normally drains by gravity into the stream above that point.

drawdown - a process of lowering the water level of an impoundment.

Driftless Area - the portion of southwestern Wisconsin, southeastern Minnesota, northeastern Iowa and northwestern Illinois which was virtually untouched by the last advance of the Pleistocene glaciers (i.e., Wisconsin Glacier).

flood - a temporary rise in streamflow and water level (stage that results in significant adverse effects in the vicinity under study.

flood peak - the highest value of water level or streamflow attained by a flood.

floodplain - the relatively flat lowland adjoining a watercourse or other body of water subject to overflow therefrom.

FTU - Formazine Turbidity Units - arbitrarily defined units used as standard for measuring water turbidity, currently recommended by APHA, et al., 1971.

gaging station - a site on a stream, canal, lake or reservoir where systematic observations of water-surface elevation or streamflow (discharge) are obtained.

humus - the surface layer of soil combining partially decomposed organic matter and mineral particles.

JTU - Jackson Turbidity Unit - arbitrarily defined units used as a standard for measuring water turbidity.

lake and pond - open areas with little or no current. They are formed behind dams, or on mature floodplains as a result of first scour, then abandonment, by the lowered river.

littoral - the shore zone of a body of water.

macroinvertebrates - collectively, all invertebrate organisms visible with the unaided eye.

main channel - the portion of the river used for navigation by large commercial craft. A minimum depth of 9 feet and a minimum width of 200 - 400 feet were established by the lock and dam system and are maintained by periodic dredging.

main channel border - the water zone between the main channel boundary and the main river bank, islands, or now submerged channel boundaries. Wing dams are located in this zone.

mesic - a type of vegetation which develops under moderate moisture conditions.

moraine - an accumulation of earth and stones carried and finally deposited by a glacier.

MPN/1 - most probable number per liter - an estimate of bacterial abundance (See Methods, Appendix AI).

MRRC - Mississippi River Research Consortium

MRRPC - Mississippi River Regional Planning Commission

mussels - clams, bivalves of the Phylum Mollusca.

outwash - glacial till reworked and sorted into sand and gravel, etc., by meltwater.

pedalfer soils - well-leached soils; soils that lack a more or less hardened layer of accumulated carbonates.

pedocal soils - soils that develop under approximately equal precipitation and evaporation conditions; soils that contain a definite more or less hardened layer of accumulated carbonates.

physiography - a branch of science that deals with the physical features of the earth.

phytoplankton - collectively, all those plants suspended in and on the surface of the water, usually microscopic.

piezometric surface - surface to which water of a given water-bearing rock unit will rise under its own pressure balance; an artesian water table.

plankton - free-floating plants and animals drifting in the water, usually microscopic.

podzolic - light-colored acid soil developing under coniferous forests, in cool, humid regions; result of leaching and removal of soluble minerals from the top layer into the deep layers.

riprap - rock fortifications on banks or shores which protect them from erosion by dissipating the energy of waves and wakes.

River Mile - miles above the entrance of the Ohio River at Cairo, Illinois measured on the river.

river stage - the elevation of a particular river surface.

roller gates - movable gates of dam; horizontal cylinders on inclined tracks which can be adjusted to affect water flow and its level.

rookery - the nests and breeding place of a colony of birds; the colony of birds.

runoff in inches (in.) - the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

savanna - grassland with trees spaced so far apart that their crowns are separate and the grass receives direct sunlight.

side channel - departures from the main channel or main channel border. At normal river stage, a current occurs in these channels.

slough - body of water through which there is no current at normal river stage. Muck bottoms and an abundance of submergent and emergent vegetation are characteristic. The slough category lies somewhere between the side channel and lake and pond categories.

spoil - waste material removed in making an excavation.

streamflow, discharge - the volume of water passing a point, per unit time, measured in cfs or in cubic meters per second.

tailwaters - water areas immediately below the dams. They are affected by the movement of water through the gates and locks, and they change in size in response to changing water levels.

tainter gate - movable gate of a dam which is a horizontal cylinder segment mounted on a steel framework attached to a horizontal downstream rod so it may be adjusted up and down to affect water flow and its level.

thermocline - a layer in an incompletely-mixed body of water where the temperature during the summer drops rapidly (more than 1°C. per meter) as the thermometer is lowered.

till - unsorted rock, sand and gravel deposited by the melting of glacier ice.

UMRCBS - Upper Mississippi River Comprehensive Basin Study.

UMRCC - Upper Mississippi River Conservation Committee.

watershed - drainage basin or drainage area.

weathering - the geologic process of decomposing rocks by the action of the forces of weather.

wing dams - low structures extending radially from shore into the river for varying distances to constrict low water flows. They were constructed of rocks and brush mattresses to establish a deeper main channel.

zooplanktonic - pertaining to the animal life of plankton.

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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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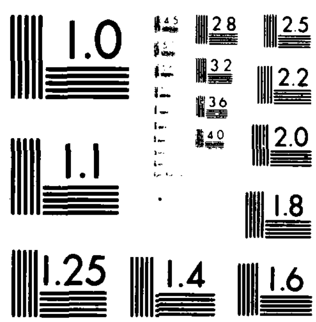

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

V. REFERENCES

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10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archaeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-size petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scapbooks of clippings on archaeological matters made by Lewis; numerous account books, vouchers, and other miscellany...
>
> "A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry the mounds alone

that were actually surveyed reach a grand total of over thirteen thousand -- to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Nebraska, Iowa, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures. ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." [Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indiana, and Michigan -- in all, eighteen states.]

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts...he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill and incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archaeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reproduced here:

[IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN]

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part of the river bottom on the sloping ground half-way between the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former.

It was in a cultivated field, and had itself been plowed over for years; yet it still had a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N 1/2 of SE 1/4 of Sec. 23, T. 28, R 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.

7. MOUNDS AT PRESCOTT, WISCONSIN.

At the angle formed by the confluence of the St. Croix and Mississippi Rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakan-teebe", became a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction by the 1880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists have resurveyed some of the sites, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

MINNESOTA

This section contains information on significant archaeological and historic sites in Minnesota.

Background

This format evolved from problems encountered in developing an inventory of sites. The listing of reasons for not doing so which follows is included because it may shed some light on future problems also.

Original plans were made to provide an inventory of Minnesota archaeological sites which lie in the study area. This idea was abandoned, however, due to the following considerations:

1. The number of sites in close proximity to the river is large and the amount of work required to review existing records (beginning in the early 1800's) exceeds the value of such an inventory in this report;

2. The records are known to be incomplete in many cases, scanty for certain areas or incorrect so that reliability of the inventory is questionable;

3. Many sites once recorded have been destroyed by the action of others (not the Corps of Engineers) but the records have never been updated. Nor has there ever been a complete systematic inventory of archaeological sites in Minnesota.

4. In many cases the location of sites given is not sufficiently accurate to determine if the site is close enough to the river bank to be threatened. In some cases, where the bluffs are close to the river bed, a vertical elevation of many feet may effectively remove a site from any threats by water, dredge spoil, or construction. The records may not show this.

5. The Minnesota State Archaeologist is understandably reluctant to publish for public consumption a list or inventory of archaeological sites because of risk of robbery, despoliation, vandalism, or unauthorized unscientific excavation. Such cases have been known in the past. However, the State Archaeologist and his staff have expressed the willingness and desire to assist individuals or government bodies in locating and identifying sites for preservation or excavation before destruction.

Impact on Prehistoric Archaeological Sites

Because the files of the State Archaeologist are located in the Twin Cities, it was possible to engage a professional archaeologist to investigate the current status of those archaeological sites in the Mississippi, Minnesota and St. Croix River areas in Minnesota. The report by consultant Jan Streiff is reproduced here in its entirety.

A Report of the Impact of the U. S. Army Corps of Engineers on Prehistoric Archaeological Sites on the Lower Mississippi, Lower St. Croix, and Lower Minnesota Rivers in Minnesota

By Jan E. Streiff, Archaeologist, Department of Anthropology, University of Minnesota, Minneapolis.

Introduction. There are approximately eighty-five (85) designated sites in the Corps of Engineers area under consideration (i.e., the Mississippi River from St. Anthony Falls to the Minnesota-Iowa border, the Minnesota River from Shakopee to Pike Island, and the St. Croix from above Stillwater to Prescott). The information on these sites has been collected since the late 1800's and all the data are filed in the Archaeology Laboratory at the University.

Although some of these sites have been revisited since being recorded, and a few have even been excavated, most have not been rechecked. Consequently there are many unknown things about most of the sites listed in this report. Ideally, a crew should have been sent out to resurvey the river valleys in question, to determine if sites formerly recorded are still there and, if not, how they were destroyed -- particularly if by the Corps of Engineers.

Since such an on-site survey was impossible at this time, the written records will have to suffice. I have organized the known sites into the three categories shown below.

Classification of Sites.

Group I. These are sites definitely known to have been destroyed by Corps of Engineers' activities. There are nine (9) of these sites.

Group II. These are sites in the area under consideration which should not be affected by the Corps because they appear too high above the river channels. Although they may never be flooded by raised water levels, they should be kept in mind as possibly being destroyed by borrow activity, dredging, etc. There are six (6) of these sites.

Group III. This is the largest group of sites (73) within the Corps of Engineers' area. This is the group for which no definite classification can be given. There are many reasons:

a. our site location description is too vague to determine if the site is or was in danger.

b. sites which were destroyed, such as the mound groups at Dresback, but where we cannot determine if the destruction was carried out by the Corps of Engineers dam construction or by some unrelated project.

c. sites, such as those on Pig's Eye Island, which have not been reexamined since recorded but are so located as to be assured destruction by a fluctuation in the river level or at least damaged by erosion by the river. Any dredging of the river and subsequent depositing of the debris on the nearby shore would undoubtedly cover the site.*

*For a detailed description of the sites destroyed by the Corps of Engineers' projects, see Appendix 1. A description of the Group III sites is included in Appendix 2.

The Effect of Corps of Engineers' Activities on Archaeological Sites by Pool. The following chart is a breakdown by pool of archaeological sites affected by the Corps of Engineers. The sites are listed using the groupings defined above.

Pool #	Group #1* (destroyed)	Group #2 (not affected)	Group #3* (uncertain)
2	2	1	7
3	4	2	11
4	0	1	7
5	1	0	1
5 or 5A	2	0	3
6	0	0	1
7	0	0	7
8	0	0	6
St. Croix River	0	0	5
Minnesota River	0	2	25
	9	6	73

*For a detailed description of the sites destroyed by the Corps of Engineers projects, see Appendix 1. A description of the Group III sites is included in Appendix 2.

Conclusions. Although this report is rather inadequate to determine the real impact of the Corps of Engineers on archaeological sites (there are still those 73 sites for which we have no information on Corps of Engineers' impact), it does point up the great need for future surveys along Minnesota's three greatest rivers to determine what effect the Corps of Engineers will have on prehistoric sites.

The importance of these rivers to life was no less important to the original Americans than it is to us today. And it is vital to the history of the American Indian that an attempt be made, if not to preserve, then at least to record the habitation and burial areas that are so numerous along these waterways.

The Corps of Engineers can expect that the professional archaeologists in Minnesota will do everything possible to cooperate with them to see that these ends are achieved.

February 1973

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Appendix 1 (Streiff)

Description of Sites Destroyed by Corps of Engineers' Activity.

1. 21 WA 1 Schilling Site located SE 1/4 Sec 32 T 27N R 21W
   A mound and village site located on Grey Cloud Island, Washington County, Pool #2. Site has been destroyed by raised water level.
2. 21 DK 1 Sorg Site located NE 1/4 NE 1/4 Sec 23 T 115N R 18W
   A habitation site located on Spring Lake, Dakota County, Pool #2. The site is under water now.
3. 21 GD 75 SW 1/4 SE 1/4 Sec 32 T 114N R 15W
   A group of 45 mounds located on Prairie Island, Goodhue County, Pool #3. Thirty-eight mounds are under water, 7 are still above water but are being eroded away by the river.
4. 21 GD 1 Nauer Site located NW 1/4 Sec 9 T 113N R 15W
   A mound and village group located on the southern tip of Prairie Island, Goodhue County, Pool #3. The mounds were destroyed with the construction of Lock and Dam #3.
5. 21GD 57 Nauer Site located NW 1/4 sec 9 T 113N R 15W
   Part of Site 1, above, Pool #3. Part of the village and several mounds were destroyed with the construction of the recreational area known as "Commissary Point", a picnic ground.
6. Unnumbered LeSueur and Perrot French Trading Post
   This site is listed as destroyed through "negative evidence". The site is recorded as being on Prairie Island, Goodhue County, Pool #3, and all attempts to locate the site have failed. It is thus assumed that because the post was on the water's edge that it is now under water.
7. Unnumbered, Unnamed Sec 34 T 109N R 9W
   This was a mound and habitation site at the mouth of the Whitewater River, Wabasha County, Pool #5. The landowner pointed the site out to the State Archaeologist after it had been covered with water.

8. Unnumbered Location T 108N 7W

   The site is a group of mounds on Prairie Island, Winona County. The site was covered by a Corps of Engineers' levee. Pool 5 or 5A.

9. Unnumbered same location as above

   This site, although spared in the first levee construction was buried with the addition of a later levee.

Appendix 2 (Streiff)

Location of Sites Potentially Vulnerable to Damage by Future Construction, Operations and Maintenance Activities.

Group I

Sites destroyed	None listed for the lower Minnesota River.

Group II

Sites probably not affected (except by borrow)	Mn R SC T115 R22	SC = Scott County
		T = Township
	Mn R SC T115 R22	R = Range

Group III

Sites potentially destroyable	HE 22 T116 R22	HE 8 T 27 R24
	HE 23 T116 R22	HE 7 T 27 R23
Minnesota Valley	SC 22 T115 R22	DK 26 T 27 R23
	SC 23 T115 R22	DK 25 T 27 R23
	HE 4 T115 R21	DK 8 T 27 R23
	HE 5 T115 R21	DK 17 T 28 R23
	HE 5 T115 R21	DK 18 T 28 R23
	HE 15 T 27 R24	DK 20 T 28 R23
	HE 95 T 27 R24	HE 99 T 28 R23
	HE 16 T 27 R24	
	HE 14 T 27 R24	HE = Hennepin County
	HE 1 T 27 R24	DK = Dakota County
	HE 13 T 27 R24	SC = Scott County
	HE 12 T 27 R24	T = Township
	HE 11 T 27 R24	R = Range

Note: For the exact locations (sections, quarter sections, etc) of the above sites, contact: Jan E. Streiff
Office of the State Archaeologist
S-48 Ford Hall
University of Minnesota
Minneapolis, Minnesota 55455
(612) 373-5560

National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers which are now Listed in the National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. Listed in the latest (1972) edition of the National Register of Historic Places are the following sites adjacent to the Minnesota River and adjacent to the Mississippi River in Minnesota. These sites have not been destroyed or damaged extensively by previous Corps of Engineer's activity, but must be considered as possibly vulnerable in the future:

Fort Snelling - located near the confluence of the Minnesota and Mississippi Rivers in Hennepin and Dakota Counties. This was the State's first military post and, until 1849, the northwesternmost outpost in the nation. Restoration of the fort is continuing and live interpretation of the past is scheduled daily for visitors. Cantonment New Hope, the site of the makeshift encampment occupied by the soldiers who built Fort Snelling, and located on low ground near the east end of the present day Mendota Bridge has been located by archaeological excavation, but has not been opened to the public.

Mendota Historic District - located in Dakota County, across the Minnesota and Mississippi Rivers from Fort Snelling. Mendota is the oldest permanent white settlement in Minnesota. The historic buildings are located on the bluffs.

Site Designated as Historic and Worthy of Preservation, Not Yet Included in the National Register which is Adjacent to the Minnesota River

Shakopee Historic District - (Scott County) along the lower bluffs of the Minnesota River near Shakopee. The location of Chief Shakopee's village from the 1820's to 1852 as well as a concentration of prehistoric Indian mounds and a grist mill. Additional buildings of historical significance are being brought to the site.

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