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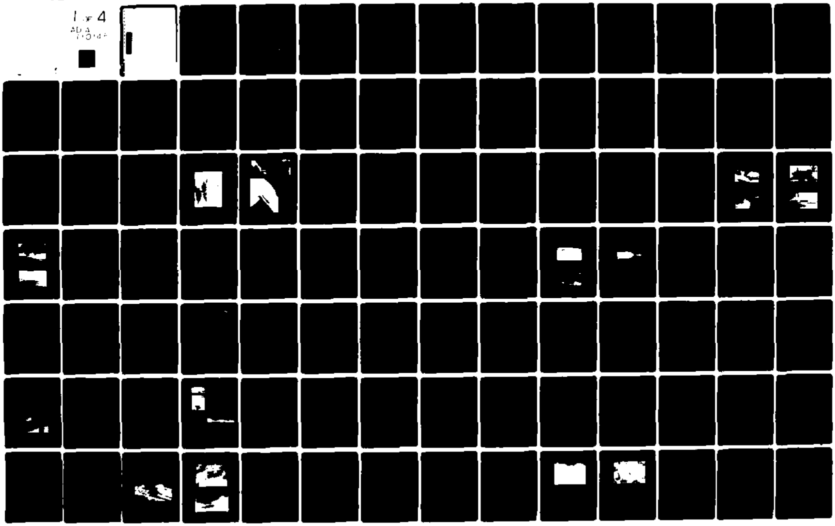

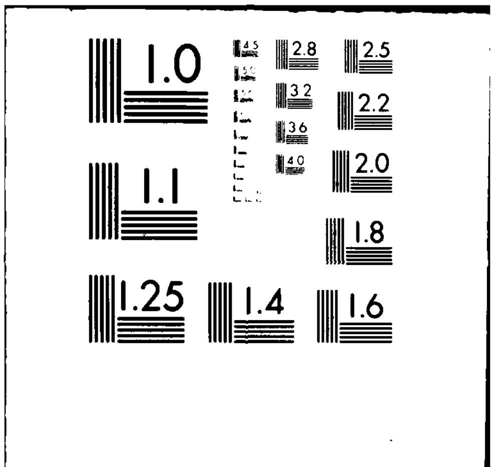

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The overall objective of this report is to assess the impacts, both positive and negative, of the Corps of Engineer's activities on Pool 2 (Hastings, Minnesota) of the Upper Mississippi River. An analysis of natural and socioeconomic systems is included. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and water quality. Socioeconomic systems include industrial and recreational activies, and cultural considerations.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 2

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 Stuides

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 Crops of Engineers contracted with North Star Research Institute to prepare a report assessing the environmental impact of the Corps of Engineers' operations and maintenance activities on the nine-foot navigation channel in the Mississippi River from the head of navigation in Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from their respective heads of navigation at Shakopee and Stillwater, Minnesota, to the Mississippi River. This portion of the upper Mississippi River basin will subsequently be 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. Between 1875 and 1930, 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. Several recreation areas along the river were also built by the Corps.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the Corps' construction, operations, and maintenance activities on the Northern Section. In addition, the study is to provide a broad background of information for periodic reassessment and more detailed analysis of impacts. The activities are defined as operations and maintenance activities and mainly include operations of facilities (locks and dams) and maintenance of the navigation channel (dredging). Actually, the impacts on the environment back to the earliest operations are also being sought, but the greatest emphasis will be on those of the present navigation system.

The environmental studies are designed not only to identify the impacts, but also 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 may 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 entire study program from January through November 1973. The report contains both historical 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 are: (1) the benchmark point in time; (2) data collection and analysis of the natural systems; and (3) data collection and analysis of the socioeconomic activities.

Benchmark Time Period

In order to analyze the impact of the activities of the Corps of Engineers on the Northern Section of the Upper Mississippi River, it was necessary to select a time period that can serve as a benchmark. This benchmark represents the state of the Mississippi River prior to the time activities related to the nine-foot channel were initiated. Since the nine-foot channel project was constructed in the 1930's, the preconstruction benchmark was taken as 1930. Wing dams were built and other Corps' activities took place prior to 1930, however, and earlier data were also used where they were readily available. The preconstruction 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 impact of Corps' activity on the natural environmenta 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 on the following page.

Number of River Segment Involved	Total Length in River Miles	River Segment	Principal Investigator	Organization
5	92.4	Upper and Lower 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 and 6	Calvin Fremling	Winona State College, Winona, Minnesota
2	35.1	Pools 7 and 8	Thomas Claflin	University of Wisconsin at 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 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 reporting 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 William 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

Since the Corps is required to submit an environmental impact statement for each pool and tributary in the Northern Section on which they arry out operation and maintenance activities, this study is being carried out and reported on by pool (and navigable tributary).

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to Pool 2. 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 Pool 2.

2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effect of Corps' activities.

3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers and 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. Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams and commercial fishing; recreational activities, such as fishing, boating, or hunting that are affected by Corps' operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

The present Corps of Engineers' project in Pool 2 (Mississippi River Mile 847.6 to 815.3) consists of structures, and operation and maintenance of these structures for navigation of a channel of nine-foot minimum depth (see Figure 1 and Figure 1, Appendix A II). These structures include: (1) 198 wing dams and shore protection, built between 1878 and 1910; (2) a low-head movable-crest dam and an earth dam; (3) two navigation locks; (4) several dwellings, control station, and other structures; and (5) an observation platform near the locks.

Operation of the dam and locks includes regulating the minimum depth of water in the reservoir and providing passage for commercial and pleasure craft.

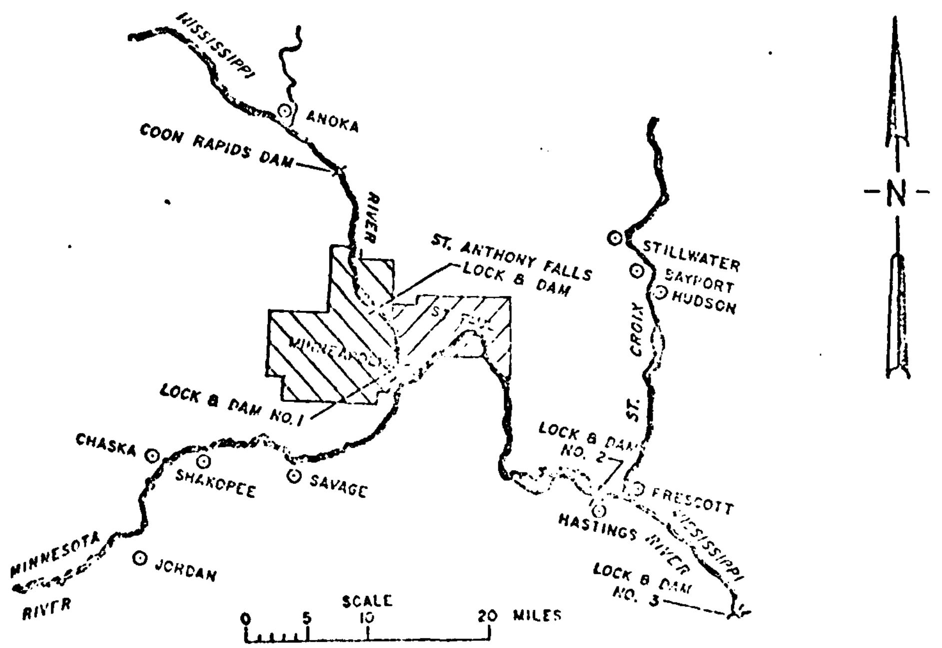


Figure 1. The Mississippi River and Its Major Tributaries in the Twin Cities Area (FWPCA, 1966)

Maintenance of the project includes dredging the channel to the minimum nine-foot depth, disposing of dredged material ("spoil"), clearing of debris, and repairing the locks and dam.

AUTHORIZATION

Congress authorized the present nine-foot project with the Rivers and Harbors Act of July 30, 1930, as amended by Public Resolution No. 10, February 24, 1932, and by the Act of August 26, 1937 (see Table 1). Earlier acts provided for bank protection, channel constriction by wing and closing dams, and dredging. More recently, additional acts have provided for lock and dam operation and care, harbor enlargement and channel dredging, an additional lock, modification of the dam for future power development and park and recreational facilities.

Table 1. Congressional Authorizations Pertaining to the Nine-foot Project in Pool 2

Rivers & Harbors Acts	Work Authorized	Documents
March 2, 1907	Adopted 6-foot channel project by constriction of river by wing, closing and trailing dams, bank protection, and dredging between Missouri River and Minneapolis.	House Document 341, 59th Congress, 2nd Session
September 22, 1922	Dredging to landings in main river and sloughs.	None.
January 21, 1927	Survey of Mississippi River between Missouri River and Minneapolis to determine feasibility of 9-foot channel.	House Document 378, 69th Congress, 1st Session
April 21, 1928	Alter dimensions of Hastings Lock.	House Document 8, 70th Congress, 1st Session

Table 1. Congressional Authorizations Pertaining to the Nine-foot Project in Pool 2 (Continued)

Rivers & Harbors Acts	Work Authorized	Documents
July 3, 1930 and amended by P.R. 10, February 24, 1932.	Modify permanent structures under construction to accommodate 9-foot channel; for completion of survey; Chief of Engineers granted discretionary authority to make such modifications in plans as deemed advisable.	House Document 290, 71st Congress, 2nd Session
June 26, 1934	Operation of snag boats; care and operation of locks and dams.	None
August 26, 1937	Adoption of 9-foot project from Ill. River to Minneapolis; dredging at head of pool	River and Harbors Committee Doc. 137, 72nd Congress, 1st Session
August 30, 1935	Enlarge St. Paul Harbor	House Document 44, 74th Congress, 1st Session
August 26, 1937	Determine damages to drainage and levee districts caused by seepage and backwater, cost of rectifying.	Rivers and Harbors Committee Doc. 32, 75th Congress, 1st Session
March 2, 1945	Changes or additions to payments, remedial works, or land acquisitions authorized by River and Harbors Act of August 26, 1937 (Rivers and Harbors Committee Doc. 34, 75th Congress, 1st Session), as Chief of Engineers deems advisable.	None
March 2, 1945	Channel enlargement, St. Paul	House Document 547, 76th Congress, 3rd Session
March 2, 1945	Modify Lock and Dam 2 for future power development	House Document 432, 77th Congress, 1st Session
July 3, 1958	Payment of lump sum for damages to drainage and levee districts caused by operation of navigation pools.	House Document 135, 84th Congress, 1st Session

HISTORY

In 1824, a year after the sternwheeler "Virginia" initiated navigation as far upstream as Fort Snelling, Congress authorized the Corps of Engineers to improve navigation by removing snags, wrecks, shoals, and sandbars.

The 4.5-Foot Channel

The first comprehensive improvement of the river for navigation was authorized by the Rivers and Harbors Act of June 18, 1878, to obtain a 4.5-foot channel from the mouth of the Missouri to St. Paul by means of wing dams, bank revetments (*i.e.*, walls for bank protection), closing dams and longitudinal dikes (see Table 2).

Table 2. Congressional Authorizations Pertaining to Pool 2 for Pre-9-foot-Channel Projects

Depth	Date	Work Authorized	Document
4.5'	Prior to 1867	Preliminary report of survey of Upper Mississippi River; recommended improvement of sect. St. Anthony Falls to Rock Island Rapids; experimental dams; dredging and snag boats; additional surveys.	House Document 58, 39th Congress, 2nd Session (January 21, 1867)
4.5'	April 6, 1968	Report on Survey of Upper Mississippi River (etc., as above)	House Document 247, 40th Congress, 2nd Session
4.5'	January 18, 1878	Adopt 4.5-foot channel from St. Anthony Falls to Alton, Illinois	House Document 75, Pt. 6, 43rd Congress, 2nd Session

Table 2. Congressional Authorizations Pertaining to Pool 2 for Pre-9-foot-Channel Projects (Continued)

Depth	Date	Work Authorized	Document
4.5'	January 8, 1881	Preliminary report of Mississippi River Committee on Mississippi River from St. Anthony Falls to mouth of Missouri River and recommend appropriations for continued improvement.	House Document 95, 46th Congress, 2nd Session
4.5'	January 15, 1884	Review of work from St. Paul to Illinois River and recommended appropriations for continuation.	Senate Report 36, 48th Congress, 1st Session
5'	August 18, 1894	Extended navigation to Minneapolis.	House Document 109, 53rd Congress, 2nd Session
6'	March 2, 1907	Adopted project from St. Paul to Missouri River by wing, closing and trailing dams, and dredging.	House Document 341, 59th Congress, 2nd Session
6'	November 3, 1910	Provided for channel improvement at St. Paul.	House Document 488, 64th Congress, 1st Session
6'	January 25, 1917	Certain St. Paul Harbor improvements and a survey for harbor line extension.	House Document 71, 66th Congress, 1st Session
6'	September 22, 1922	Dredging channels to landings on main river and sloughs.	None
6'	January 21, 1927	Construction of the Hastings lock and dam.	House Document 583

In the section of the Mississippi River presently known as Pool 2 (Mile 815.3 to 847.6), wing dams at approximately a right angle to the current and many miles of bank revetment were built from 1898 to 1910. Their function was to divert the current to the main channel and prevent bank erosion, respectively. These structures still exist, although most are presently submerged. Their present location may be found on the latest (1972) edition of the Upper Mississippi Navigation Charts (see Figure 1 in Appendix A II). Wing dams and bank revetments were built of alternate layers of brush bundles, usually willow, and rock (see Figure 2). No closing dams or longitudinal dikes were built in this section of the Mississippi River.

Numerous surveys of the Mississippi River have been made by the Corps since the mid-1860's. The Corps published a series of charts of the 4.5-foot channel project for the Mississippi River Commission (MRC Charts), showing river soundings, wing dams, bottom type and land use, from 1894 to 1907. In 1890 the 4.5-foot channel was extended to Minneapolis, requiring removal of boulders and dredging of bars.

The 6-Foot Channel

The six-foot channel was authorized in 1907 and was obtained by constructing more wing and closing dams and by dredging. The River and Harbor Acts of 1910 and 1917 provided for channel improvements at St. Paul and the Act of 1927 authorized construction of Lock and Dam 2 at Hastings, as part of this project. The Acts of 1928 and 1930 provided for changes in the dimensions of this lock, the latter to accommodate the anticipated 9-foot project. (A previous Lock and Dam 2 had been constructed at Mile 850. An increase in the elevation of Lock and Dam 1 at Mile 847.6 for hydroelectric power production for the Ford Motor Company assembly plant in St. Paul flooded this upstream facility, forcing the abandonment of the old Lock and Dam 2.)

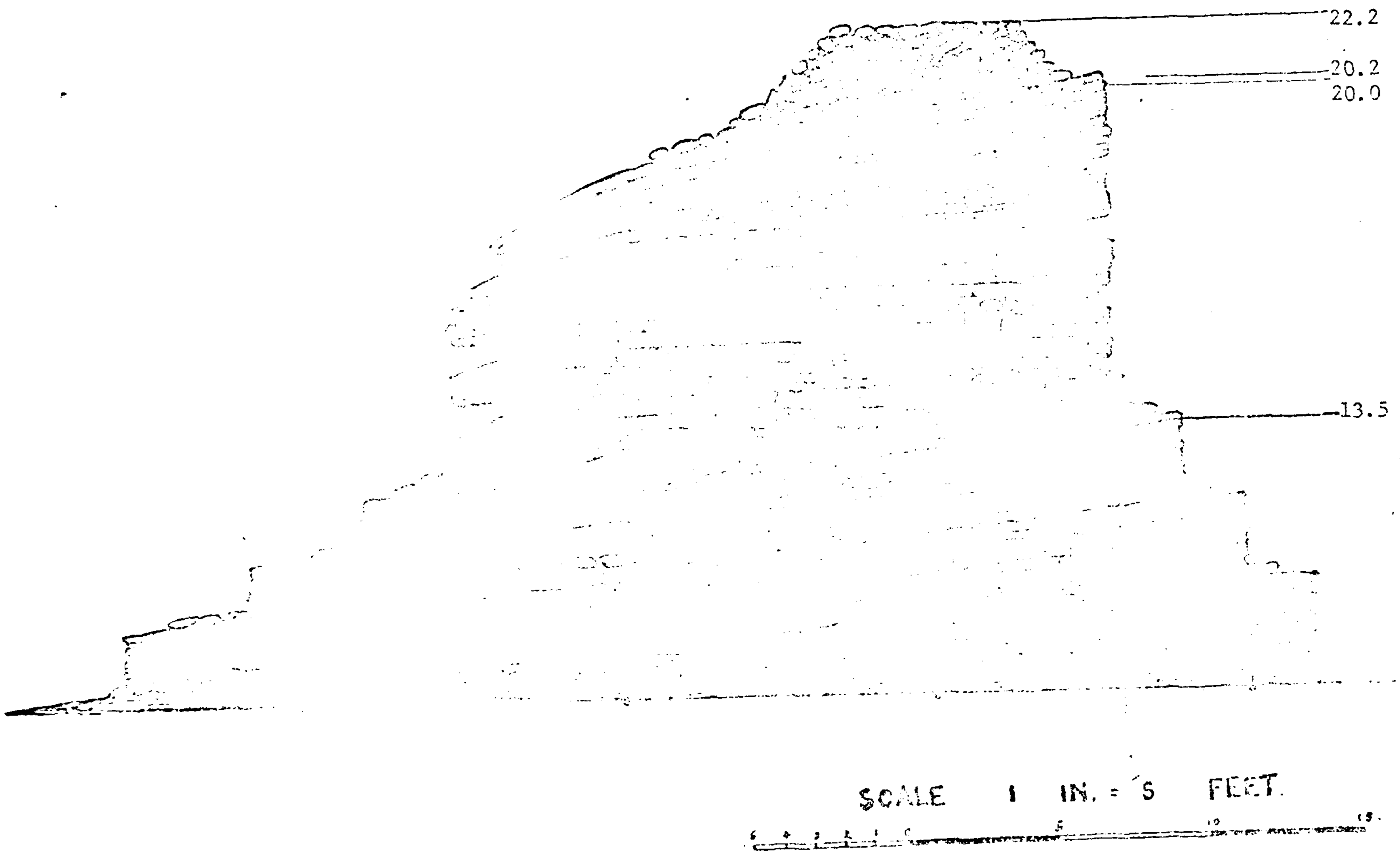


Figure 2. Cross Sections of Rock and Brush Wing Dams (SW, 1908)

The 6-foot project was surveyed by air in 1927. This survey, which was published in 1930 as the "Brown Survey" and reissued as the "Flowage Charts" in 1933-34 to include land use, provided the basis for determining the feasibility of the 9-foot channel.

The Nine-Foot Channel

In 1938 the Corps published charts of the new nine-foot channel, the "Continuous Survey", showing river soundings and sandbars. Several editions followed, as "Navigation Charts". The current (1972) edition is based on a 1964 aerial survey and presents updated information in a more compact format than the previous edition, although the arrangement of charts is extremely inconvenient.

CORPS FACILITIES

Presently, the Corps of Engineers' project in Pool 2 consists of the operation of Lock and Dam 2 and the maintenance of the nine-foot channel from the heart of the Twin Cities to Hastings, Minnesota. Lock and Dam 2 (Figure 3) located near Hastings, is the third oldest of 29 such facilities on the Mississippi River. Completed in 1930 as part of the six-foot project it was constructed to accommodate nine-foot-draft traffic. Originally it contained only one lock; the second, longer lock was added in 1948.

The facility presently consists of an 822-foot movable crest dam, including a 100-foot Boulé dam section, two navigation locks, and a 300-foot earth dam. The second lock was constructed on the landward side of the original lock and is the standard 110 by 600 feet. The original lock measures 100 by 500 feet and now serves as an auxiliary. Each lock is closed by a pair of miter gates and the level is changed 12.2 feet by gravity flow through ducts and filling and emptying ports (see Figures 4 and 5: Section X-X and Y-Y) by a system of valves. Pool elevation is maintained at 687.2

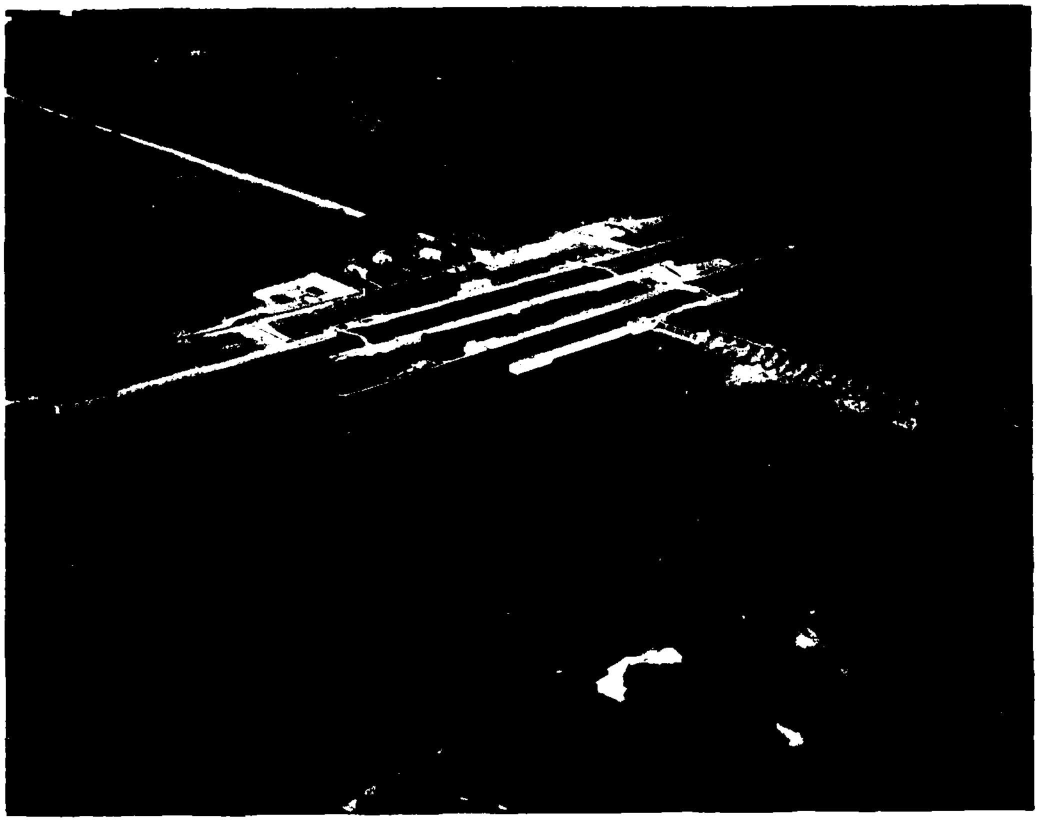
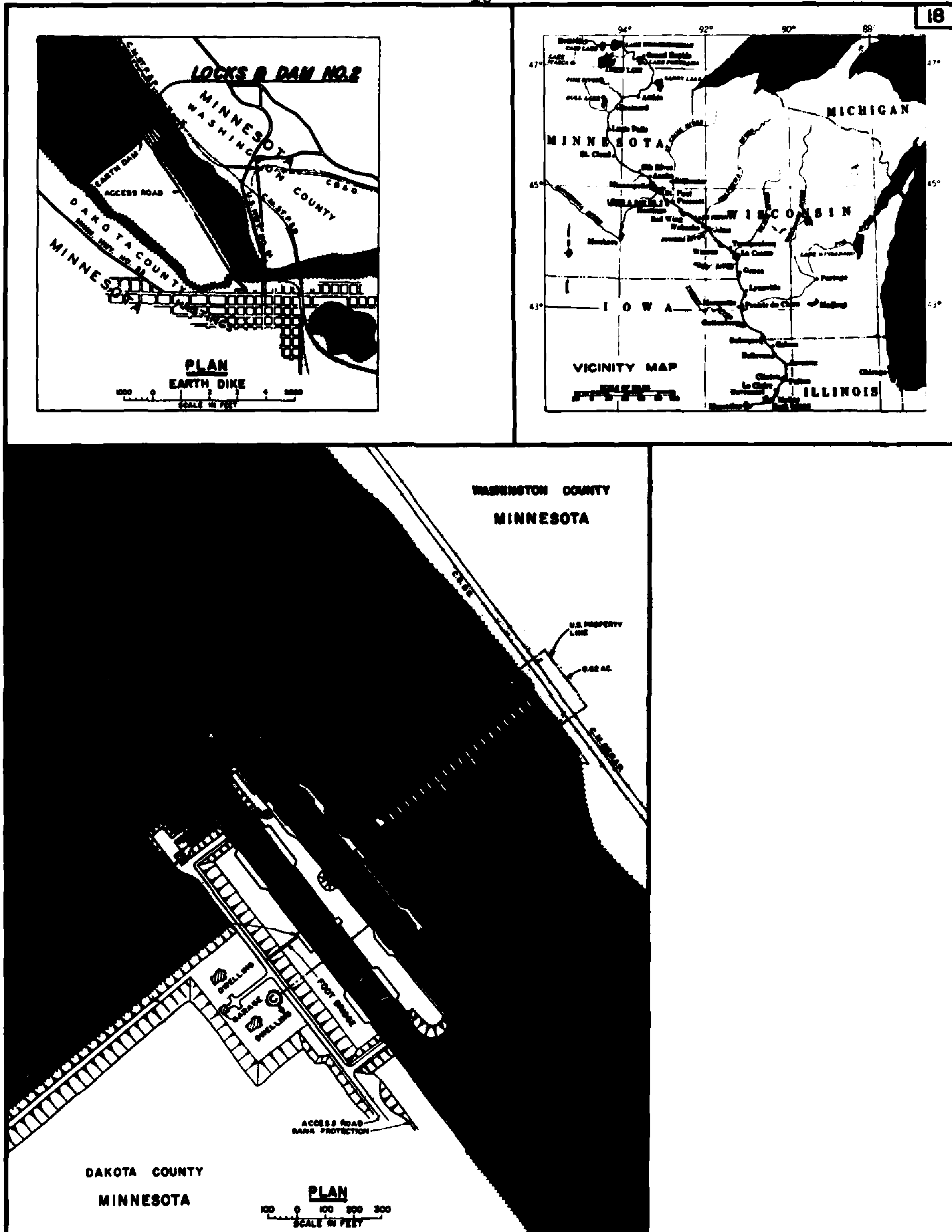


Figure 3. Aerial Photograph of the Facilities at Lock and Dam 2 at Hastings, Minnesota (Corps of Engineers)



	RIVERWARD LOCK	LANDWARD LOCK
DEPTH ON UPPER GATE SILL -	16.0 FT (U.P. EL 687.2)	22.2 FT (U.P. EL 687.2)
DEPTH ON LOWER GATE SILL -	15.0 FT (L.P. EL 675.0)	13.0 FT (L.P. EL 675.0)
ELEVATION UPPER GATE SILL -	671.2	665.0
ELEVATION LOWER GATE SILL -	660.0	662.0

Figure 4.

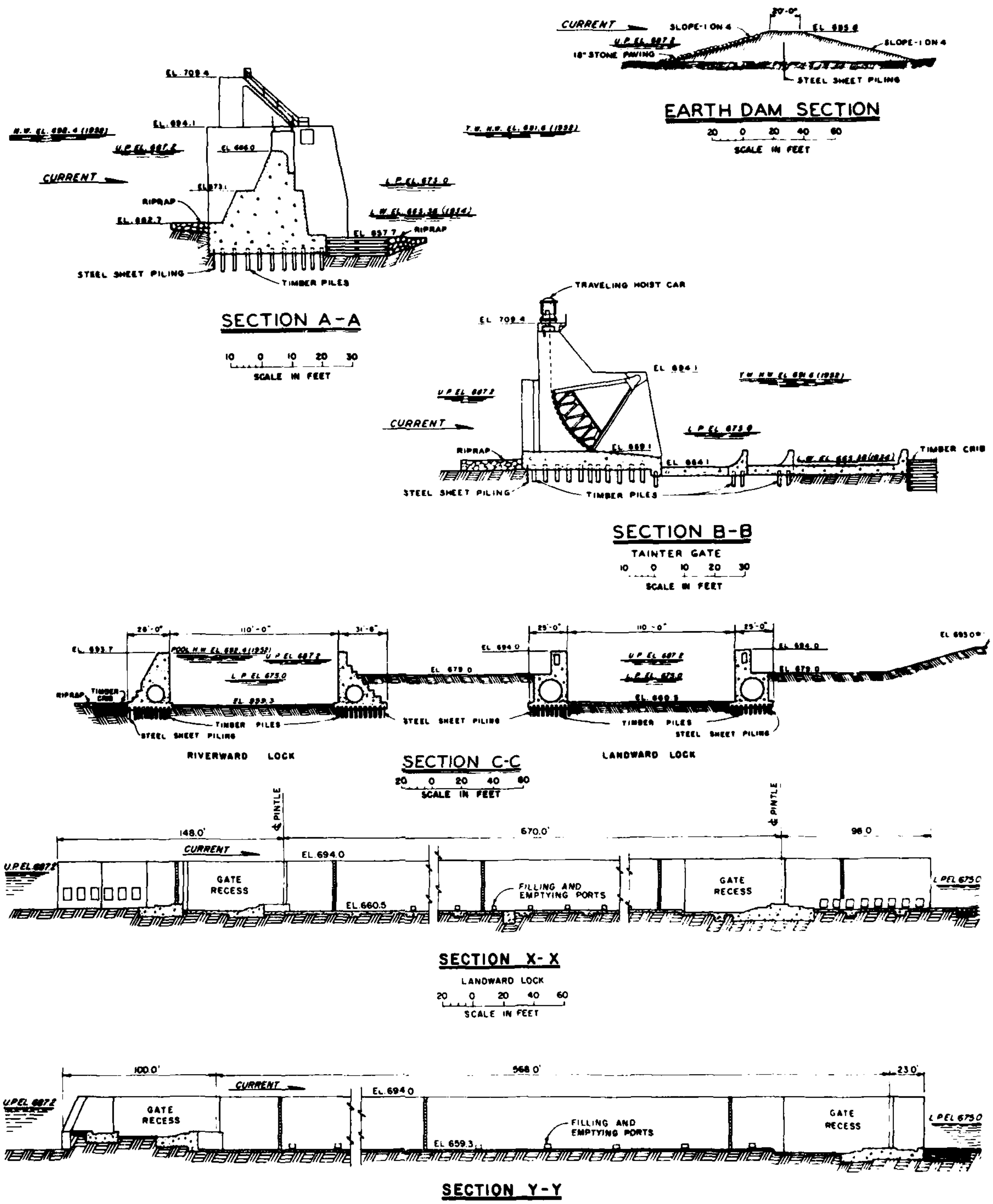
ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCKS & DAM NO. 2

IN 2 SHEETS SHEET NO. 1
SCALE AS SHOWN

CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.
JUNE 1961



ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

Figure 5.

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCKS & DAM NO. 2

IN 2 SHEETS — SCALE AS SHOWN — SHEET NO. 2

CORPS OF ENGINEERS — U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT — ST. PAUL, MINN.
JUNE 1961

feet above mean sea level* by a series of 20 tainter gates in the dam (see Figure 4: Section B-B). A relatively small amount of electric power therefore is required for the operation of the gates, valves and lights at Lock and Dam 2. The site also includes dwellings, equipment buildings,access road and observation deck.

CORPS OPERATIONS AND MAINTENANCE

The project now consists mainly of the operation of Lock and Dam 2 and maintenance of the navigation channel by dredging of accumulated sediment to maintain a minimum nine-foot channel, 200 feet wide. Occasionally the Corps also dredges small boat harbors, constructs flood levees, and directs emergency flood protection activities in cooperation with local interests, under different authorizations.

Lock and Dam Operations

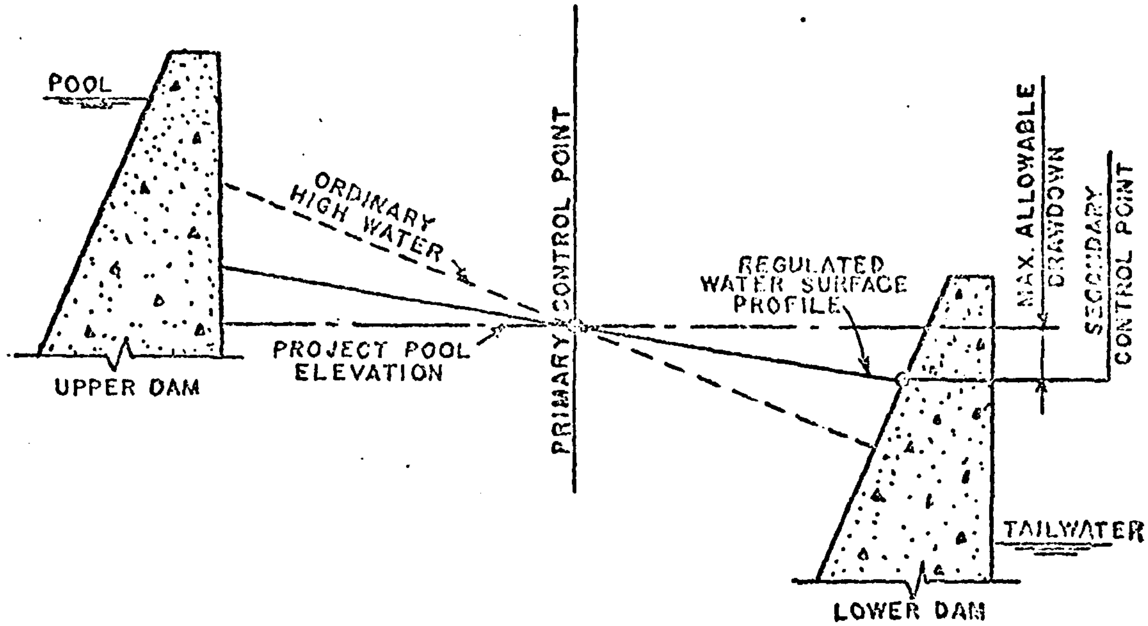
Lock and Dam 2 was built to an elevation necessary only to maintain navigation of the channel during low flow in order to minimize flooding of adjacent lands. The low dam elevation and small pool capacity relative to flood volume precludes operation of the dam for power production or flood control.

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 6).

*1912 adjustment.



(S.P.D. -- NCS, 1969)

Figure 6. Basic Plan of Dam Operation (Reservoir regulation)

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 by lowering the water level at the lower dam. The water level at the lower dam continues to be lowered as the discharge from the upper dam increases 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 elevation where the presence and action of the water 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 because of the operation of the dam by the Corps. This greatly reduces the cost to the government of acquiring flowage rights.

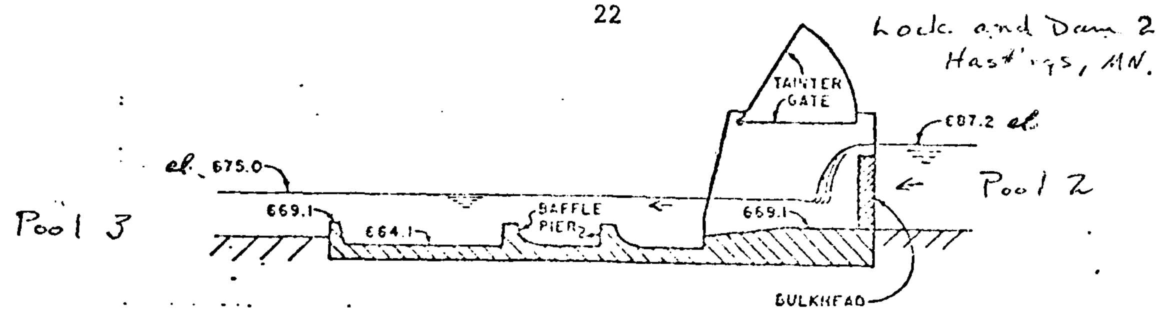
Aeration

Because Lock and Dam 2 is located downstream from considerable sewage effluent, the aeration occuring at Lock and Dam 2 has been continuously observed by the Corps since the project was completed in November 1930. The past operation of the dam and future improvements to supplement the dissolved oxygen (DO) content of the river, were part of a cooperative research program of the Sanitary Engineering Division of the University of Minnesota Civil Engineering Department and the Minneapolis-St. Paul Sanitary District (Susag, Robins and Schroepfer, 1967).

Pool 2 receives a considerable influx of wastewater from the Twin Cities metropolitan area. The microbial breakdown of organic wastewater components and natural organic solids discharged into the Mississippi River use up (*i.e.*, "exert a demand on") its dissolved oxygen resources, creating a "biochemical oxygen demand" (BOD). The DO content of the river is derived from a combination of factors including tributary streams, surface reaeration, photosynthesis, and aeration occuring at obstructions such as logs, rocks, and lock and dam operation. Prior to the start of operations at Lock and Dam 3 in July 1938, Lock and Dam 2 had provided a significant contribution to the assimilative capacity of the Mississippi River. However, when Pool 3 became part of the nine-foot channel, the tailwater elevation at Dam 2 was raised over six feet, submerging the discharge apron and baffles. Thus the effect the baffles may have had upon aeration was greatly reduced.

It was observed that more turbulence occurred below the dam at a given flow when the number of gates used was reduced. As a result, Dam 2 operation and the Mississippi River DO sampling records for a five-year period, January 1958 through March 1963, were analyzed to determine the effect on aeration of the number of gates employed in discharging through the dam. The analysis of this past operating data indicated that the increase in aeration would be 4 percent of DO saturation for each 100 cfs (cubic feet per second) increase in the discharge per gate.

As a result of a conference with the Minneapolis-St. Paul Sanitary District and the University of Minnesota Department of Civil Engineering, four of twenty tainter gates at Dam 2 were "bulkheaded" (see Figure 7) so that about 2.5 feet of water flowed over the crests of the weirs formed by the bulkheads. All inflow into Pool No. 2 of 3000 cfs or less is discharged over the bulkheaded gates. When the inflow exceeds 3000 cfs, the excess flow is discharged under the tainter gates in the normal manner as necessary to maintain the required pool stage.



(S.P.D. -- NCS, 1969)

Figure 7. Cross Section of Dam 2 Showing Discharge Over Bulkheads Built to Improve Aeration

Locking Priorities

A priority system for vessels locking through has been established by the Secretary of the Army, as follows:

1. U.S. military vessels
2. Vessels carrying U.S. mail
3. Commercial passenger ships
4. Commercial tows
5. Commercial fishing boats
6. Pleasure boats

(S.P.D. -- NCS, 1969)

Channel Maintenance

The river bottom is dredged in some reaches, since increasing water depth by damming alone does not always provide sufficient depth in every reach of Pool 2. During the year, changes in hydraulic efficiency of the river (*i.e.*, its ability to maintain its load of sediment continually in suspension) along the length of its channel result in areas of sediment accumulation. These areas are dredged by the Corps of Engineers to remove this hazard to commercial navigation. The equipment used is 1) the Corps' hydraulic dredge "Thompson" (see Figures 8 and 9), 2) the Corps' Derrickbarges 767 and 771 (see Figures 10 through 13), or by contracting with private companies.

Dredging to maintain the 9-foot channel in Pool 2 by the Corps began in 1934 and has since produced an average of almost 180,000 cubic yards annually (see Table 3). This is the highest volume in comparison with other pools in the Twin Cities area, but a moderate amount per river mile (Table 4). Apparently there is a trend to smaller volumes of sediment dredged in Pool 2 since 1955 (see Figure 14). However, in certain years large volumes were produced mainly at one site, mostly at the Municipal Barge Terminal in St. Paul (see Figure 1, Appendix A II).

Table 3. Annual Volume of Sediment Dredged from Pool 2 (1934 to 1972)

Year	Volume of Sediment Dredged, in cu yds	Year	Volume of Sediment Dredged, in cu yds
1934	8,189	1955	43,049
		1956	51,151
1935	0	1957	209,340
1936	0	1958	49,513
1937	9,750	1959	410,868
1938	477,386		
1939	96,077	1960	105,674
		1961	69,896
1940	447,783	1962	50,747
1941	150,749	1963	218,223
1942	105,733	1964	35,301
1943	183,938		
1944	177,692	1965	265,051
		1966	368,782
1945	440,367	1967	
1946	244,815	1968	206,740
1947	283,916	1969	109,258
1948	171,528		
1949	171,528	1970	28,864
		1971	288,198
1950	114,383	1972	342,292
1951	206,715		
1952	327,476	39 years	Annual Average 179,931
1953	164,304		
1954	232,154	Annual average per mile	5,553

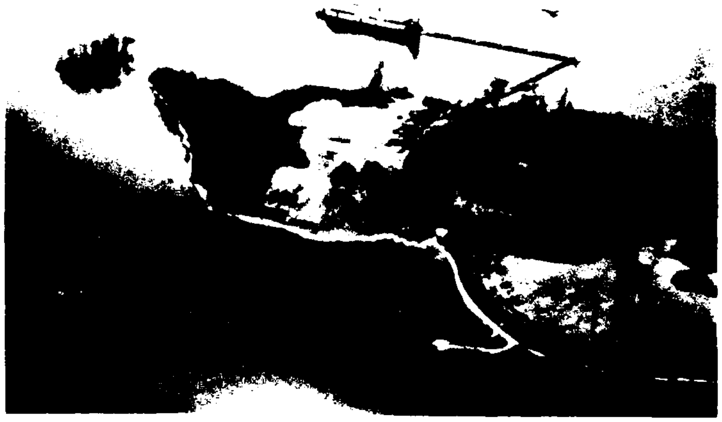


Figure 8. Aerial View of the Hydraulic Dredge, the *William* A. Thompson (S.P.D.-NCS)

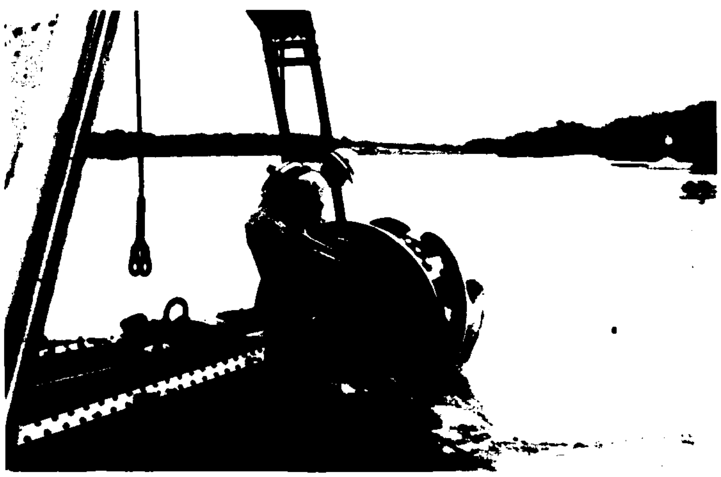


Figure 9. Cutter Head of Dredge Thompson (S.P.D.-NCS)

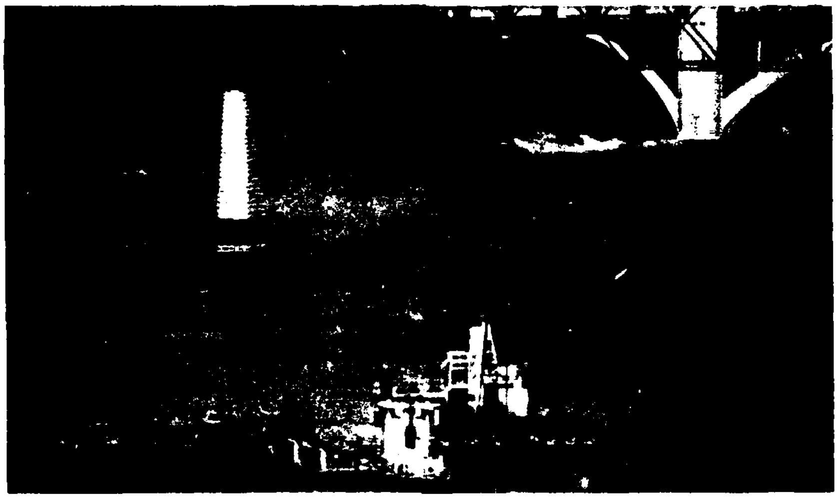


Figure 10. The Corps of Engineers' Clamshell Dredge Derrickbarge 767 Deepening the Nine-Foot Navigation Channel on the Mississippi River. The spoil is dropped into waiting barges which transport it to the spoil site. (Colingsworth)

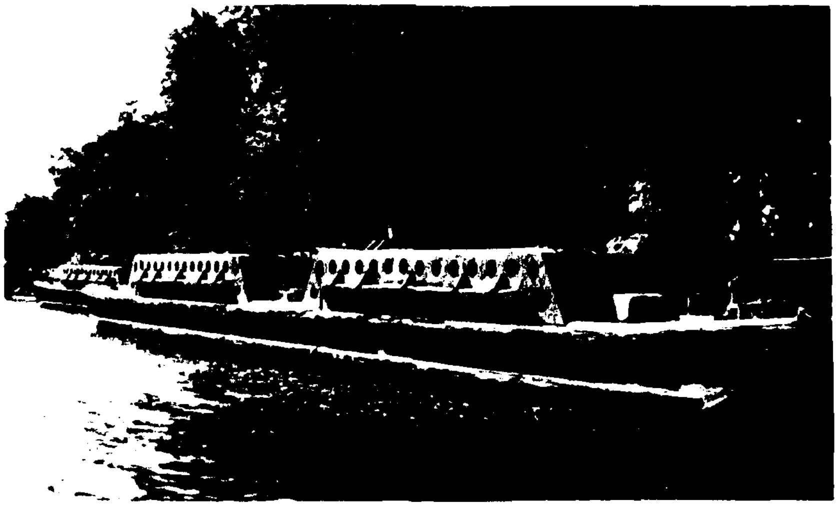


Figure 11. Spoil Barges Showing the Side-Mounted Gates for Dropping the Spoil into the River Near the Spoil Site (Colingsworth)

Figure 12. The Corps of Engineers' Dredge Derrickbarge 771 Redredges the Spoil Dropped by the Barges and Lifts It onto the Spoil Bank. Note the figures in the right foreground (Colingsworth)

Figure 13. The Newly Deposited Spoil Piles Are Levelled by Bulldozer (Colingsworth)

Dredging to maintain the 9-foot channel in Pool 2 by the Corps began in 1934 and has since produced an average of almost 180,000 cubic yards annually (see Table 3). This is the highest volume in comparison with other pools in the Twin Cities area, but a moderate amount per river mile (Table 4). Apparently there is a trend to smaller volumes of sediment dredged in Pool 2 since 1955 (see Figure 14). However, in certain years large volumes were produced mainly at one site, mostly at the Municipal Barge Terminal in St. Paul (see Figure 1, Appendix A II).

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1941	150,749
1942	105,733
1943	183,938
1944	177,692
1945	440,367
1946	244,815
1947	283,916
1948	171,528
1949	171,528
1950	114,383
1951	206,715
1952	327,476
1953	164,304
1954	232,154
1955	43,049
1956	51,151
1957	209,340
1958	49,513
1959	410,868
1960	105,674
1961	69,896
1962	50,747
1963	218,223
1964	35,301
1965	265,051
1966	368,782
1967	
1968	206,740
1969	109,258
1970	28,864
1971	288,198
1972	342,292
39 years Annual Average	179,931
Annual average per mile	5,553

Table 4. 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

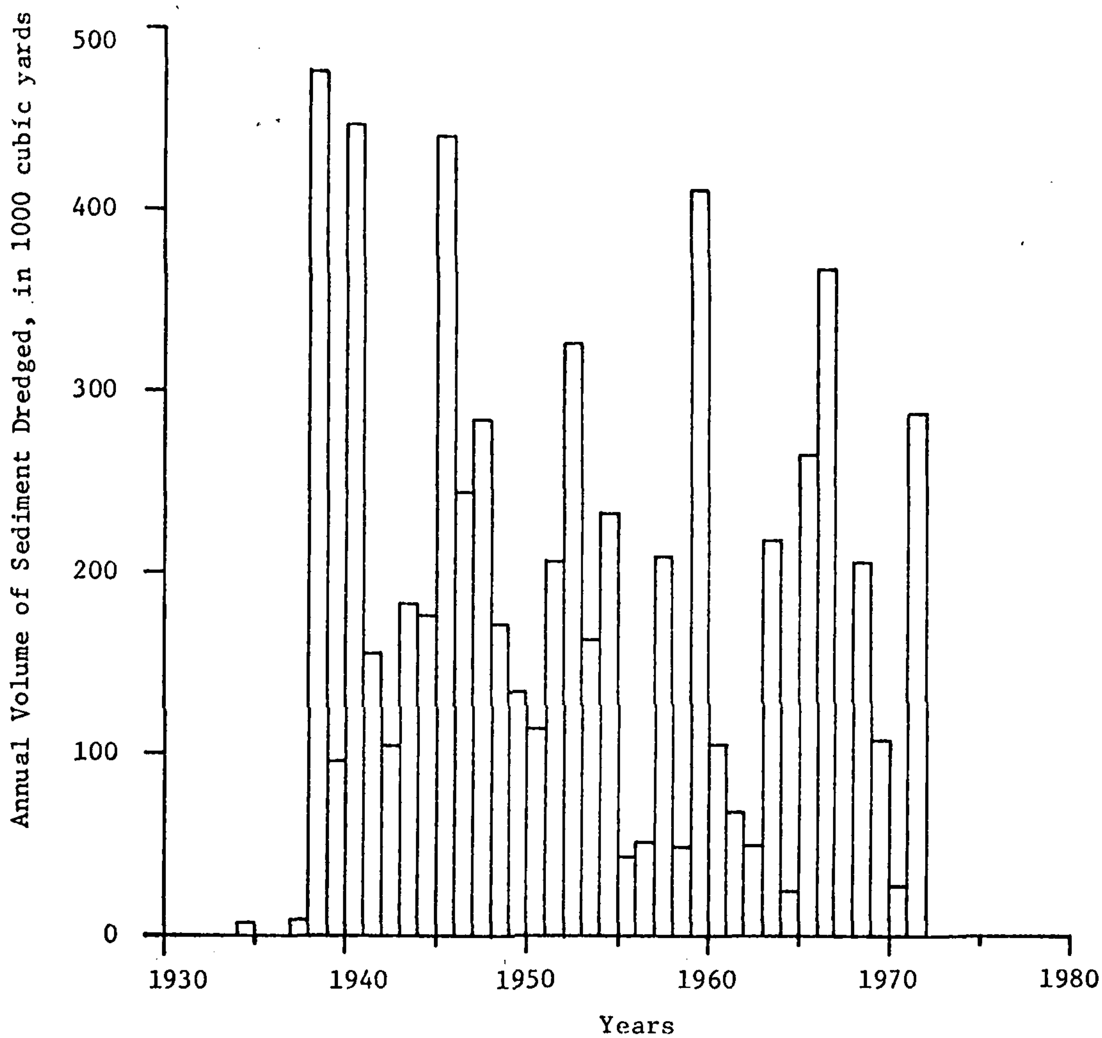

Figure 14. Annual Volume of Sediment Dredged from Pool 2 to Maintain the Nine-Foot Channel

Bridges

Eleven railroad and highway bridges span the Pool 2 reach of the Mississippi River (see Table 5), two of which required remodeling in order to accommodate barge traffic.

Table 5. Upper Mississippi River Bridges, Pool 2, Mile 815.2 to 853.3 (S.P.D. -- NCS, 1969)

Miles Above Ohio River	Bridge Location	Type of Struct.	Use**	Year Comp.†	Height (ft)* Above Project Pool El (687.2)††	Owner
845.5	St. Paul-Ft. Snelling to I-494	Girder	H-P	1961	88.31	Mn.Highway Dept.
843.2	St. Paul-Lexington Ave (I-35E)	Girder	H	1964	64.26	Mn. Highway Dept.
841.4	St. Paul-Lilydale	Swing Truss	R	1916	22.3(C)	C&NW Railway
840.4	St. Paul-Smith Ave.	Truss	H-P	1889	123.8	City of St. Paul
839.5	St. Paul-Wabasha St.	Truss	H-P	1890 1900 (R)	62.3	City of St. Paul
839.2	St. Paul-Robert St.	Vert. lift Truss	R	1913 1925 (R)	71.7(O) 25.4 (C)	C&GW Railway
839.2	St. Paul-Robert St.	Conc. Arch	H-P	1926	59.6	City of St. Paul
838.74	St. Paul-Lafayette St. (Hwy. 55)	Girder	H	Under const (N)	--	Mn. Highway Dept.
835.7	S. St. Paul-Pigs Eye Lake	Swing Truss	R	1910	20.6(C)	C&GW Railway
832.5	S. St. Paul-Newport-Hwy. 100	Tied Arch	H	1959	63.28	Mn. Highway Dept.
830.3	Newport-Inver Grove	Swing Truss	R-H	1895	19.4(C)	Rock Island Railway

Operation of movable bridges is governed by Code of Federal Regulations, Title 33, Chapter II, Sections 203.555 and 203.560 (g) (13).

*A - Crown of arch, C - closed position, L - at limits of navigation channel, O - open position
**H - Highway, P - Pedestrian walks, R - Railroad.
†N - New bridge, R - remodeled
††All elevations are mean sea level (1912 adjustment).

Changes in Extent of River Valley Features

With the filling of Pool 2, major shifts of natural features on land adjacent to the river were brought about. Table 6 shows a summary of some of these changes. They will be discussed in more detail in a later section.

Table 6. Changes in the Surface Area of Some River Valley Features in Pool 2 from 1895 to 1973 (in acres)

<table>
<tr><th rowspan="2">Year</th><th colspan="2">River</th><th rowspan="2">Floodplain Lakes</th><th rowspan="2">Islands</th><th rowspan="2">Spoil</th></tr>
<tr><th>Main Channel</th><th>Backwaters</th></tr>
<tr><td>1895</td><td colspan="2">3167</td><td>735</td><td>589</td><td>0</td></tr>
<tr><td>1932</td><td>3230</td><td>No data</td><td>1457</td><td>1932</td><td>0</td></tr>
<tr><td rowspan="2">1973</td><td>4059</td><td>3256</td><td rowspan="2">3757</td><td rowspan="2">546</td><td rowspan="2">52</td></tr>
<tr><td colspan="2">7315</td></tr>
</table>

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2. ENVIRONMENTAL SETTING

NATURAL SETTING

Since the operation and maintenance of the nine-foot channel is an on-going project, the present natural environmental setting includes the project from its construction in 1930 to the present. The environmental setting without the project, in this case prior to project construction, must be reconstructed from published information.

Physical Aspects

Topography

From its source in Lake Itasca downstream to Lock and Dam 2, the upper Mississippi River drains a watershed of 36,900 square miles, of which 16,550 square miles are in the Minnesota River basin (Figure 15). 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 humid. The combined influence of climate, soils, and man's activities has led to a gradation from the extensive mixed pine-hardwood forests bejeweled with numerous lakes and streams in the northeast, downstream to the productive open farmland in the southwest, dotted with marshes and lakes, and laced with ditches and streams. Most of the latter land was formerly tall-grass prairie and mixed-grass prairie.

The ecosystems of the upper Mississippi River and its valley in Pool 2 are located by sub-area, and divided into various components for more detailed description. Thus, Pool 2 is located in three reaches: (1) the Lower Gorge, (2) the Urban, and (3) the River Lakes reaches (see Figures 16, 17, and 18; Figure 1 in Appendix A II).

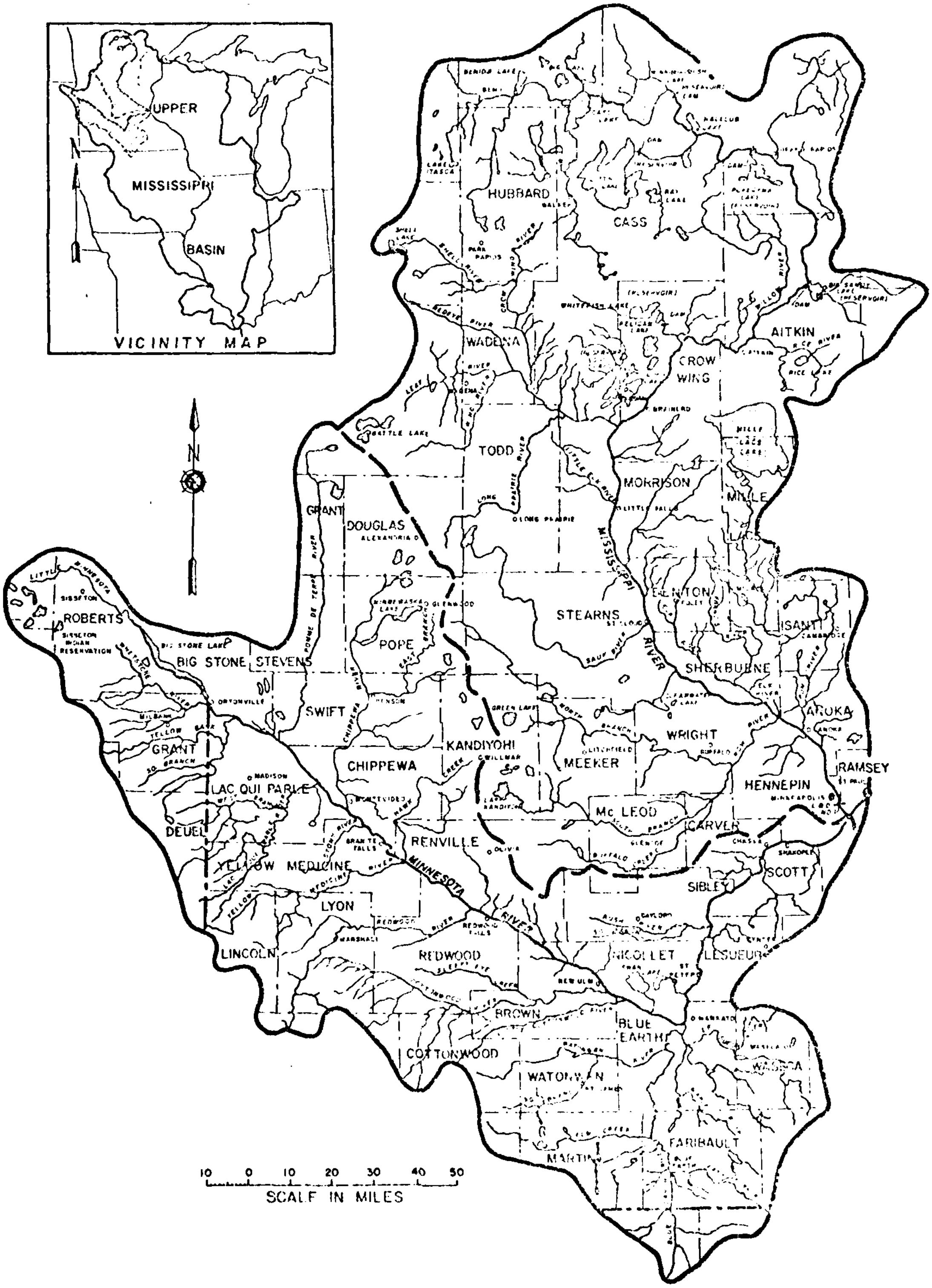


Figure 15. Upper Mississippi River Basin Above St. Paul, Minnesota (MNDNR, 1972)

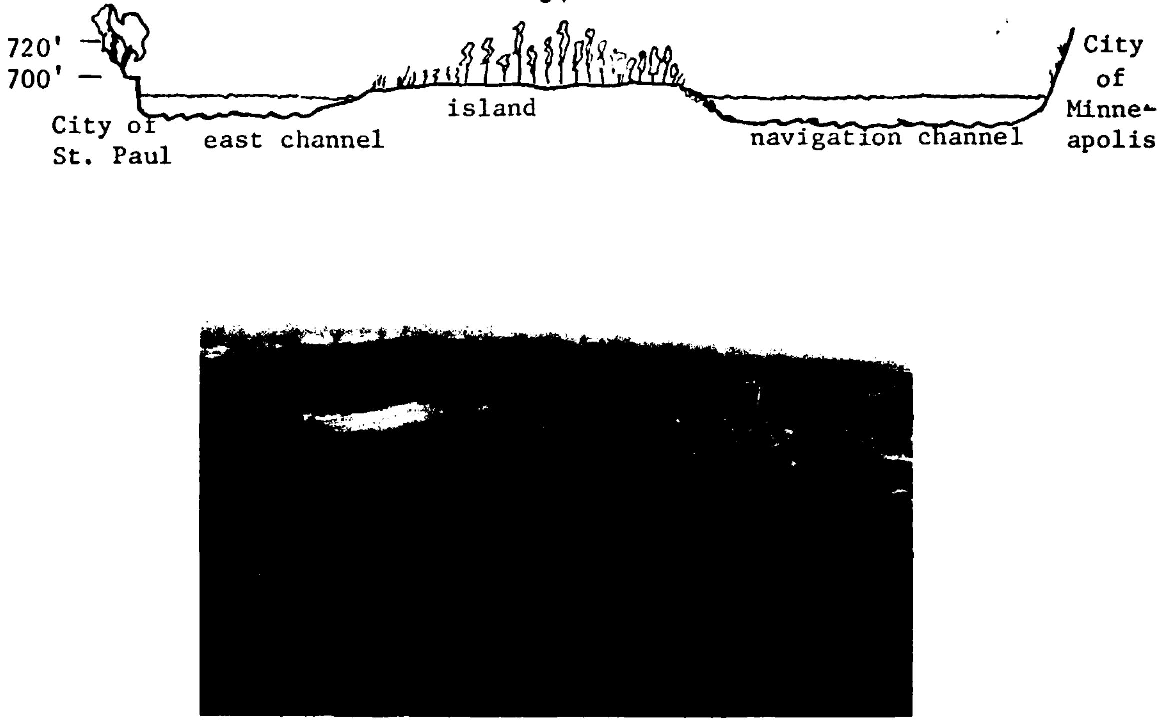


Figure 16. View and Profile of Lower Gorge Section of Pool 2 (Colingsworth and Gudmundson)

Figure 17. View and Profile of Part of the Urban Section of Pool 2 (Colingsworth and Gudmundson)

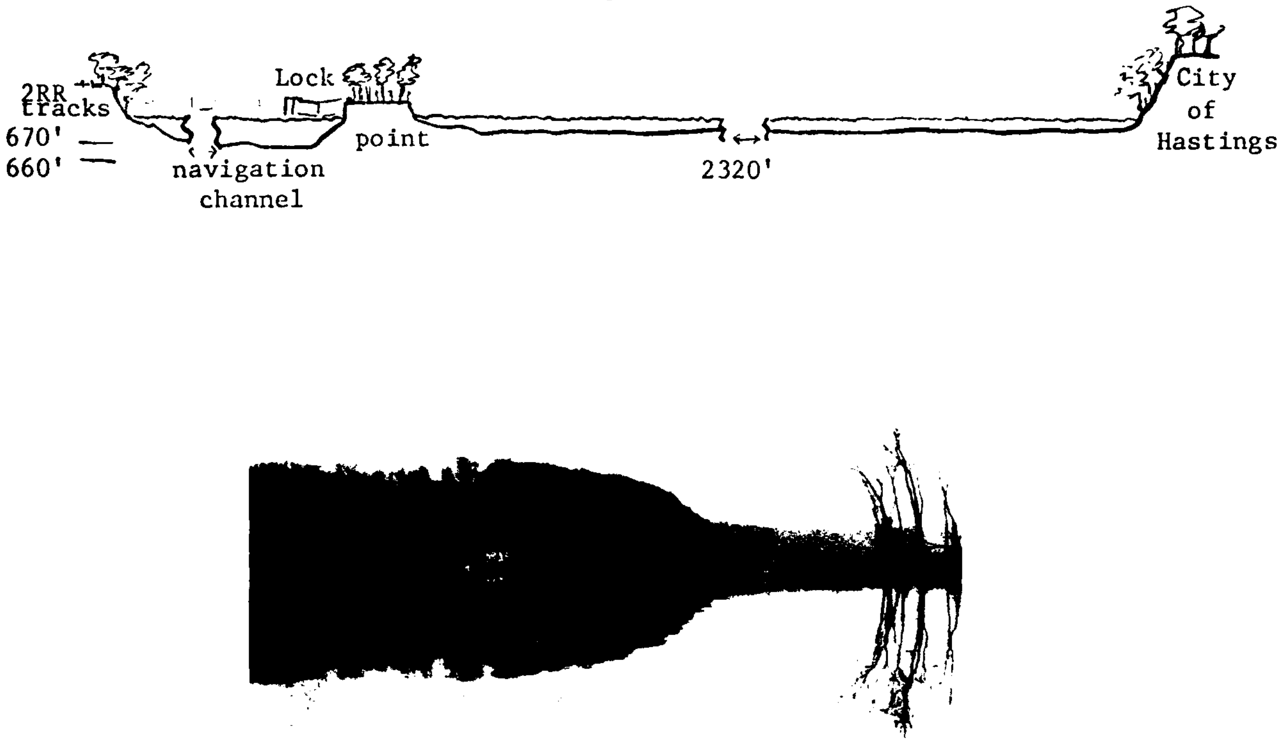


Figure 18. View and Profile of Spring Lake Section in the River Lakes Section of Pool 2 (Gudmundson and Colingsworth)

Also, the various components of Pool 2 ecosystems may be divided into Physical and Biological Aspects sections, the first of which includes geologic, climatic, soils, grondwater, hydrologic, and land use elements. The Biological Aspects section includes floral and faunal elements as part of terrestrial and aquatic subdivisions.

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, where-ever possible, the characteristics of elements in Pool 2 will be discussed in relation to the Twin Cities area, as well as the entire watershed. Inter-actions with areas outside of the basin may be dealt with in a very general manner.

Geology

The Upper Mississippi River watershed is underlain by a series of Precambrian igneous and metamorphic rocks north of Big Lake (Sherburne County). Downstream, this basin is underlain by Cambrian, Ordovician and Devonian sandstones and limestones to the east and south, and by Cretaceous shales to the southwest and beyond the watershed (see Figures 19 and 20).

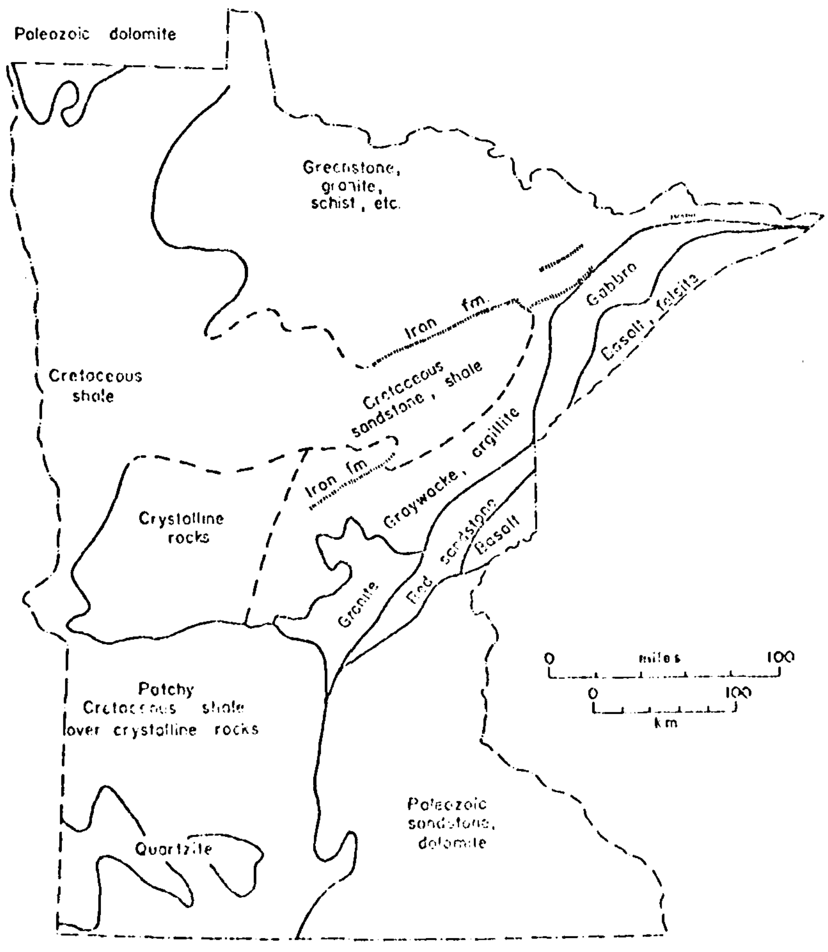
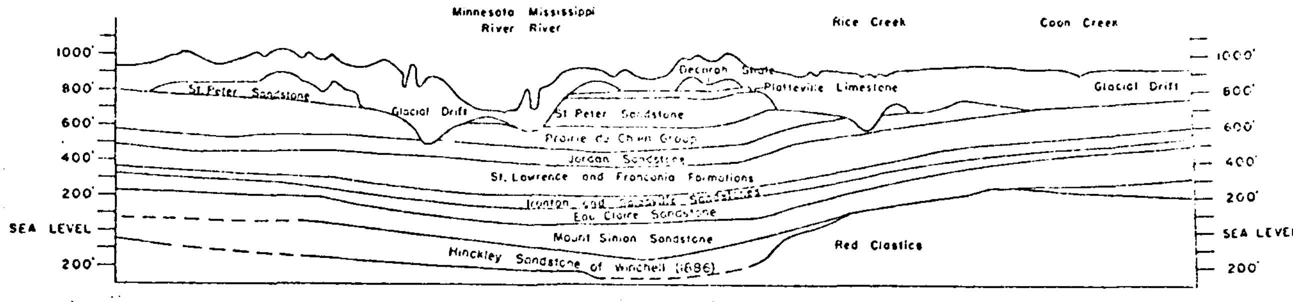


Figure 19. Bedrock Map of Minnesota
(Minnesota Geological Survey, undated)



South

North

Figure 20. North-South Vertical Section Through the West End of Pike Island Showing the Twin Cities Artesian Basin (From Winter and Norvitch, 1972)

In the last million years at least four glaciers scraped their way across these rocks and through what is now the Twin Cities area (Figure 21), then receded and left hills and valleys formed from debris which they had transported long distances. Deposits left by the last one, the Wisconsin Glacer, were first brought from the Northeast by the Superior Lobe, and consist of red, sandy

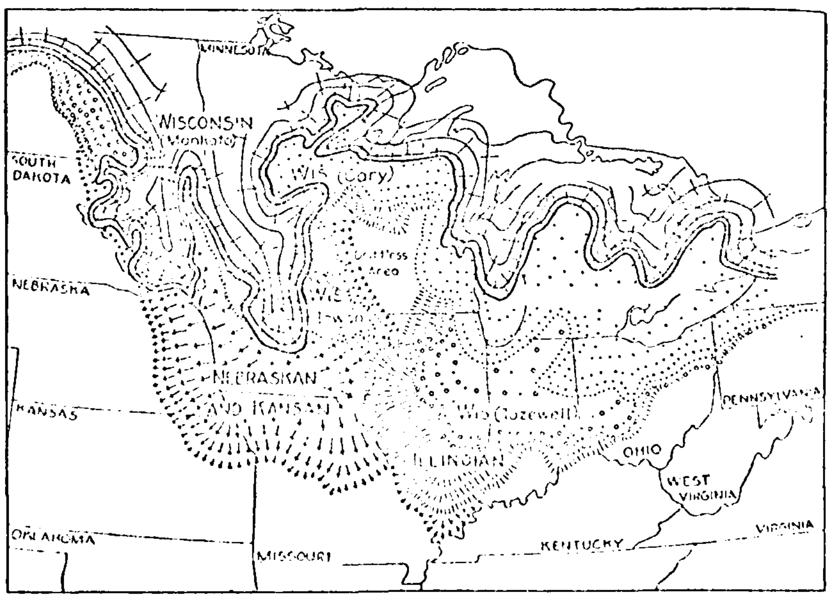


Figure 21. Map of Ice Sheets of the United States (Schwartz and Thiel, 1963)

and pebbly deposits (see Figure 22). Later, the Grantsburg Sublobe of the Des Moines Lobe brought buff-colored sands, clays, and rock from the Creataceous 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 subsequently modified by climate and vegetation, form our present soils and topography.

During the recession of the Wisconsin Glacier, the present valley in which Pool 2 is situated was created when the vast Glacial Lake Agassiz, formed by glacial meltwater trapped between moraines (hills of till mounded by a temporarily stationary ice front) to the south and the receding ice front to the north, drained southeastward as the Glacial River Warren. This huge river scoured a broad, deep valley which is not partially filled with sediment, to 80 feet deep at Mendota and 180 feet at South St. Paul. This valley is presently occupied by the much smaller Minnesota River from Big Stone Lake to Fort Snelling, and downstream by the present Mississippi River.

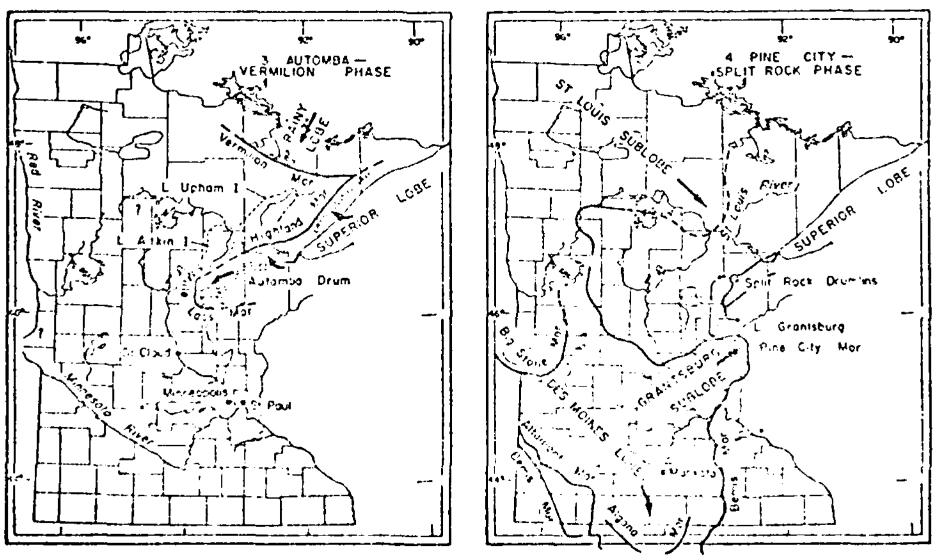


Figure 22. Maps of Minnesota Showing Extent of Ice Lobes During During Two Phases of Wisconsin Glaciation. Short dashes indicate drumlins. (Winter and Norvitch, 1972)

At St. Paul, near the present Holman Field, Glacial River Warren plunged over falls into a preglacial channel (see Figure 23). 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. In like fashion, as St. Anthony Falls receded upstream of Minnehaha Creek, Minnehaha Falls began. As the larger St. Anthony Falls eroded the soft St. Peter Sandstone from under the more resistant Platteville Limestone, the deep gorge was formed in which lies the upper portion of Pool 2. These rock formations, as well as the Decorah Shale, are exposed in the river bluffs downstream to Newport. From

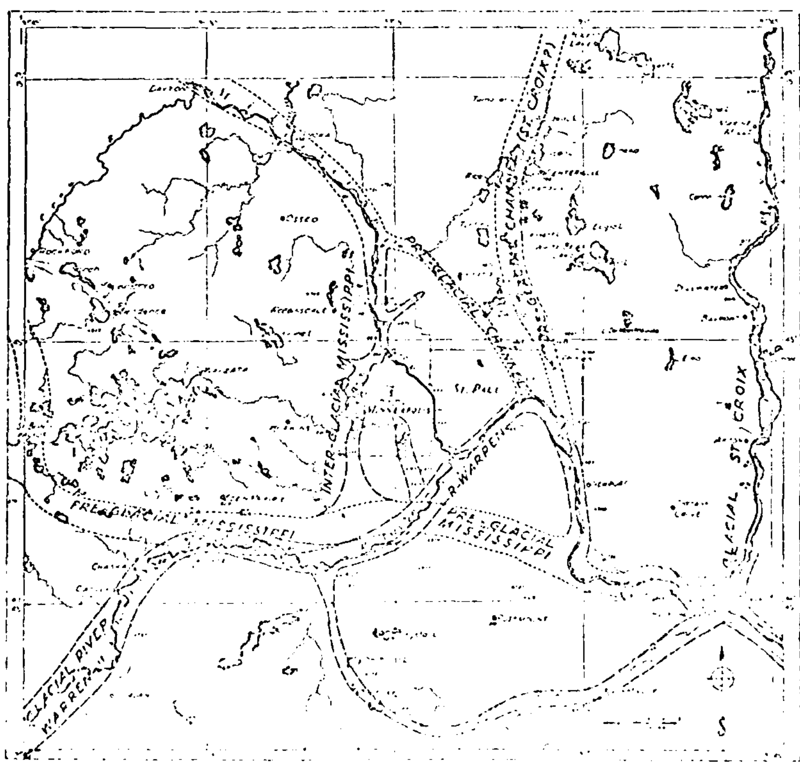


Figure 23. Map Showing Preglacial and Interglacial River Valleys of the Twin Cities Area (Schwartz and Thiel, 1963)

there downstream to Lock and Dam 2 the Jordan Sandstone is prevalent. These and deeper formations dip about 20 feet per mile toward a low point on the Mississippi River just south of the University of Minnesota, forming the Twin City artesian basin (see Figure 20).

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 terminus 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 24).

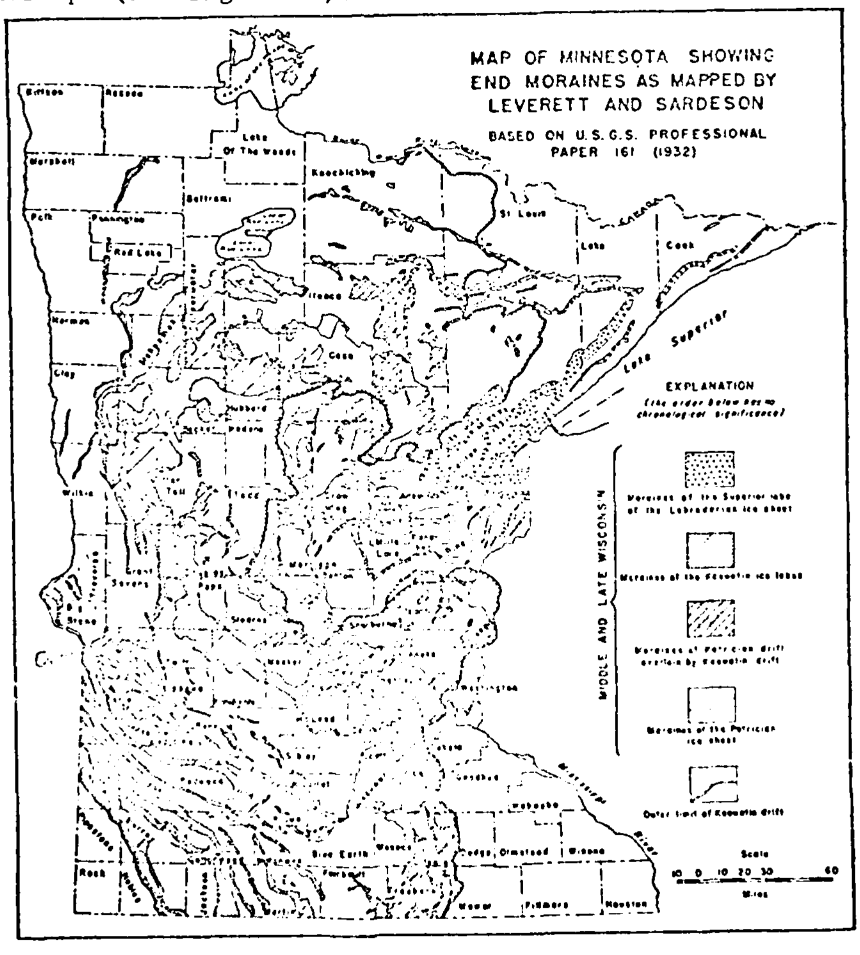


Figure 24. Map Showing Distribution of End (Terminal) Moraines of Minnesota (Schwartz and Thiel, 1963)

Climate

The climate in the Upper Mississippi River watershed varies from dry subhumid in the west to humid near Lake Superior with the Twin Cities in the larger, moist subhumid central region. The average temperature varies from about 45°F to less than 40°F from south to north, while the normal total precipitation varies from less than 20 inches per year in the prairie to more than 28 inches per year in the northeast. About 20 percent of this precipiation falls between November and March. 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 winter winds bring arctic air masses.

Soils

The composition and depth of soil is a product of climate, vegetation and animals modifying parent material. Topography and exposure are also important factors in soil development.

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 25). Well-drained sites and northern exposures have lighter soils with less organic material.

The soils along and on top of the bluffs in Pool 2 are generally medium to coarse sandy soils of variable thickness. From Mendota to Hastings in Dakota County (the right bank) they are overlain by 1 to 3 feet of river material. These soils are characteristically well drained, acid and low in

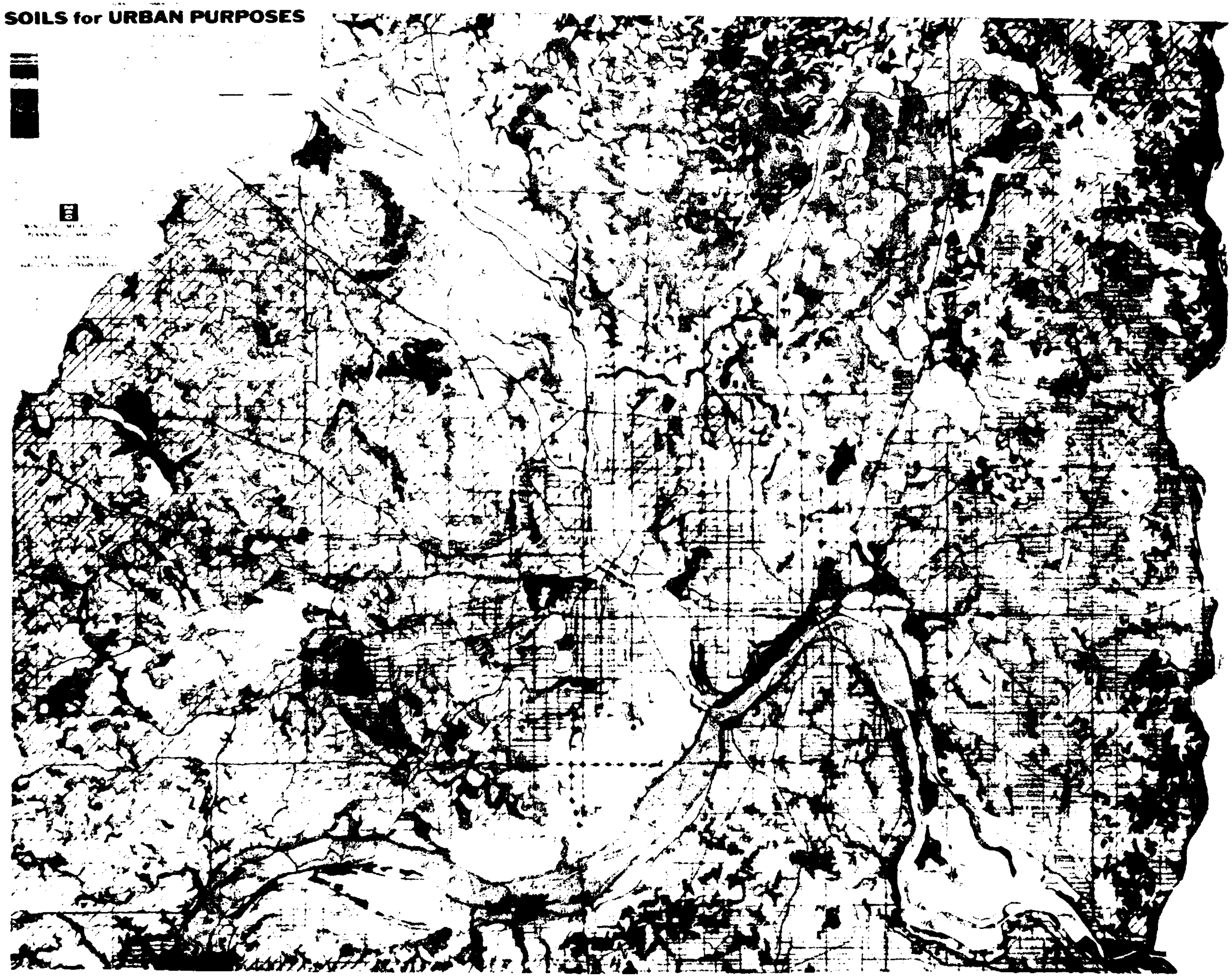


Figure 25. Soils Map of the Twin Cities Metropolitan Area (Hanson, *et al.*, 1967)

nitrate and phosphate. The percolation rate is generally less than 10 minutes per inch. A richer, clay soil occupies a small stretch, along Dayton's Bluff southeastward to Pig's Eye Lake, and has a percolation rate 5 to 16 times slower than the sandy soils.

In the river valley, dark, organic river-bottom soils are present, which are seasonally inundated and poorly drained. These soils comprise the 10,000 acres of floodplain, much of which is located between Ft. Snelling and St. Paul Park. In St. Paul much of this floodplain is being covered by fill for industrial and commercial development.

Groundwater

Large quantities of groundwater are present in the highly permeable, surficial sand deposits. Rapid removal of groundwater from these aquifers by the large local need for water generally induces water to move from 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 one-tenth to one-hundredth of the iron content.

In the Twin Cities and 13 surrounding communities, the Mississippi River supplies the water. However, there are also a large number of wells in this area which are used mainly for industries and air conditioners. Total groundwater consumption was 200 mgd (million gallons per day) in 1970, estimated to be about 1/4 of the total sustainable yield. The Prairie du Chien formation of 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 (averaging 412 ppm hardness as $CaCO_3$ in 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) Mt. Simon-Hinckley aquifer (U.S. Geological Survey, 1970).

Potentiometric studies (1970-71) of the water surface in the Prairie du Chien-Jordan aquifer in the Twin Cities indicate three recharge areas (see Figure 26. These include mainly inflow southwestwardly from an area bounded by White Bear Lake to just west of Afton, and north and northeastward inflow from the Farmington area. Southeastward inflow through Lake Minnetonka appears to contribute little groundwater directly to Pool 2.

Hydrology

Annual runoff in the upper Mississippi River watershed varies from one inch at its westernmost extent to eight inches in the northeast, with four to five inches in the metropolitan area (S.P.D.-NCS, 1970). Evaporation is greatest in the southwest, at 34 inches, and decreases to less than 24 inches in the northeast. The Twin Cities lose about 30 to 31 inches per year by evaporation. Some runoff is stored in six upstream reservoirs, built between 1881 and 1912 to augment low flow. After construction of the locks and dams, and establishment of the nine-foot channel, need for higher minimum flow centered on pollution abatement. With the filling of Pool 2, water area has increased and land area decreased (see Table 6).

Of the ten largest floods recorded at the USGS gaging station near the Robert Street Bridge, only four have occurred since 1900 (see Table 7). The discharges of these floods range from 80,800 to 171,000 cfs. These floods have been used for delineation of the regional flood and of the floodplain for regulation purposes by the Minnesota Flood Plain Management Act. (The regional flood is representative of reasonable characteristics of the river and locally large floods of recent record, and have a probable occurrence of one percent in any year. This flood level was exceeded only once--by the 1965 flood-- since records have been kept begining in the 1860's, although the 1969 flood approached it closely.)

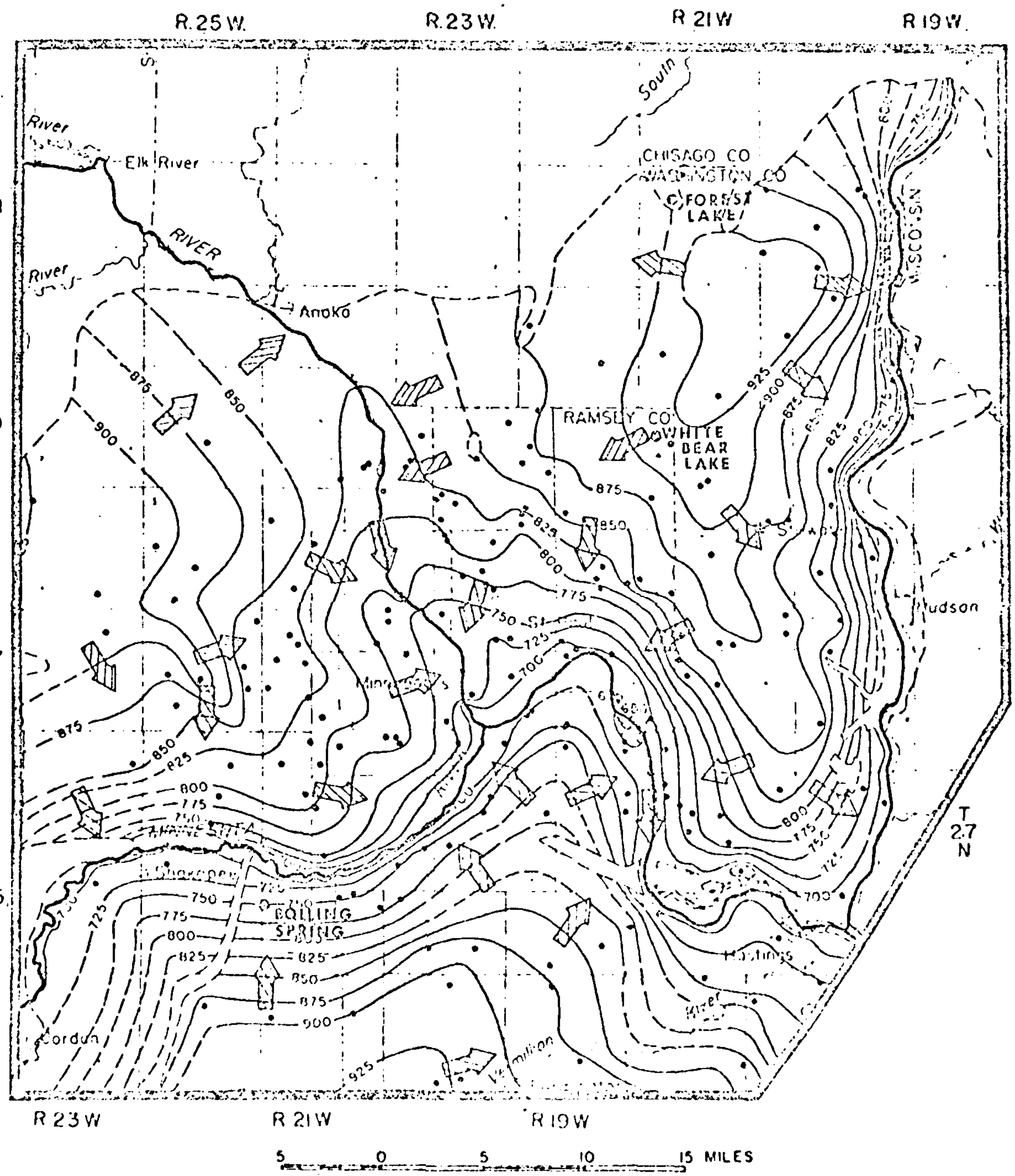


Figure 26. Potentiometric Surface of Water in the Prairie du Chien-Jordan Aquifer in Winter 1970-71, in the Minneapolis-St. Paul Area (Winter and Norvitch, 1972)

Table 7. Highest Ten Known Floods in Order of Magnitude -- Mississippi River at St. Paul

(U.S. Geological Survey gaging station, 300 feet upstream from Robert Street Bridge)*(MNDNR, 1972)

Order No.	Date of Crest	Gage Heights: Stage (feet)	Gage Heights: Elevation (feet)**	Peak Discharge (cubic feet per second)
1	April 16, 1965	26.01†	709.63	171,000
2	April 15, 1969	24.52†	708.14	156,000
3	April 16, 1952	22.02	705.64	125,000
4	April 29, 1881	19.7	703.4	107,000
5	April 11, 1870	19.4	703.1	100,000
6	April 16, 1951	18.79	702.41	92,800
7	July 23, 1867	18.6	702.3	92,000
8	April 6, 1897	18.0	701.7	86,200
9	April 16, 1875	18.0	701.7	86,200
10	April 22, 1867	17.4	701.7	80,800
Regional (100-yr) flood				160,000

*Prior to 1925 gage was at several sites within 300 feet of present site at same datum. Since September 1938 there has been an auxiliary waterstage recorder 5.4 miles downstream.

**From floodmark.

†Zero of gage = 683.62 feet above Mean Sea Level, datum of 1929. For conversion to 1912 datum add 0.54 feet to the values shown.

The average discharge of the Mississippi, which drains 36,880 square miles to the gage at the Robert Street Bridge is about 10,000 cfs. It ranges from the maximum during the 1965 flood to the minimum of 632 cfs which occurred during the drought of the 1930's. The average water velocity in Pool 2 is about 1 mph, but it may reach as much as 4 mph at the Robert Street Bridge. Downstream from St. Paul to Lock and Dam 2, minor additional volumes discharge to the River from groundwater, Pig's Eye and other sewage treatment plants, and Battle Creek and other small tributaries.

Biological Aspects

Terrestrial Vegetation

The native vegetation in the upper Mississippi River basin, comprising Minnesota and western Wisconsin, changes from tall-grass prairie in the west to deciduous forest to mixed deciduous-coniferous forest to the northeast (see Figure 27). This transition occurs as a series of mosaics rather than discrete belts, with small islands and peninsulas of vegetation of one type isolated by one another. Topography, exposure and soils are important factors in this mosaic.

The Twin Cities lie in the westward-extending deciduous forest peninsula consisting of maple and basswood on the heavier soils in the uplands, and poplar, willow and elm on the floodplains. On sandy soils to the northwest of the Twin Cities--in Anoka, Isanti, Sherburne, southwest Benton and segments of adjacent counties--there is an island of a drier, less dense deciduous forest. This forest, consisting of well-spaced small to medium-sized oaks with an abundance of grasses beneath them, is termed a savanna.

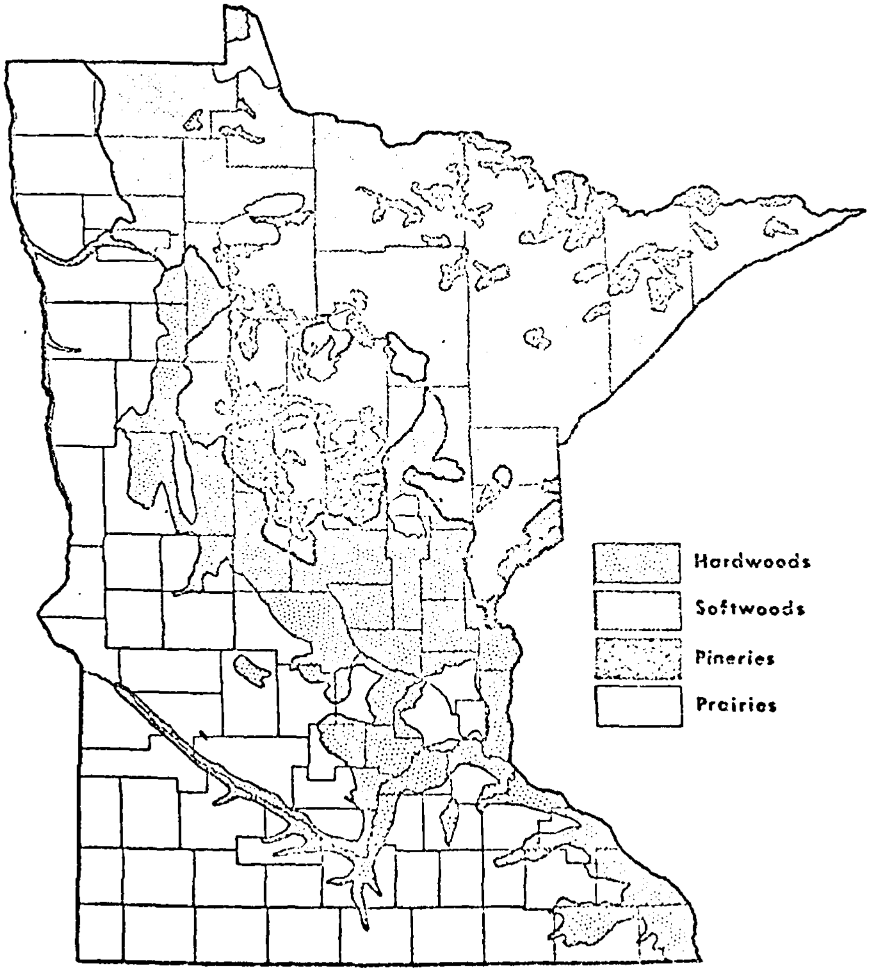


Figure 27. Present Day Forest Cover
(MN DNR, 1965)

West and south of Mankato and South St. Paul lies the tall-grass prairie region which includes bluestem and bunchgrasses. The prairie ecosystem has built up the soils of this area to their present rich level of productivity. Urban and agricultural development has disrupted or removed much of this vegetation on the level uplands, but sizeable segments remain on drier sites in the bottomlands and on steep-sloped terrain.

A cross-section from the river, across the floodplain and up the bluff face, shows typical vegetation zones (see Figure 28). The vegetaion changes from rich, moist grassy meadows and bottomland woods to northern hardwood forest, then to dry upland forest near the top, to prairie grasses on the drier blufftop.

On the floodplain in the Twin Cities area, exposed sand and mud deposits become vegetated by herbs such as teal grass, millet, smartweed, and others (see Table 8). An herb layer of different composition continues under the river bottom forest, which consists of elm, maple, willow, cottonwood, and other trees. Data collected this year can be seen in Table 1, Appendix A IV.

Spring Lake Study by Leisman. 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 archeological study (see Figure 29). 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 8). Herbs consisted mainly of jewelweed, sweet cicely and nettles.

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	[illegible]odding 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	Shagbark hickory	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		River birch		Wolfberry	
White snake-root		Swamp white oak		Prickly ash	
Wild grape		Red maple			
Va. creeper					
Sandbar willow					
Peach-leaved willow					
Amer. elm					
Green ash					
Cottonwood					
Silver maple					

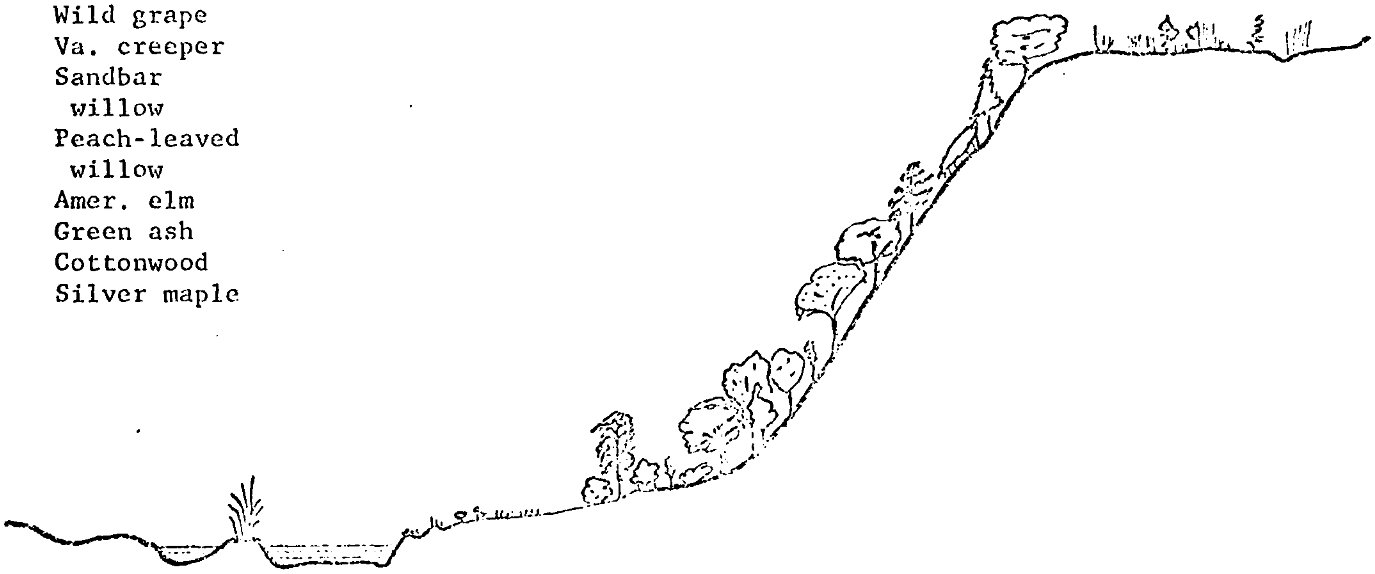


Figure 28. Typical Vegetation Zones Along a Transverse Section from the River to the Bluff Top (Lawrence and Gudmundson, 1973)

Table 8. Vegetation Common to the Habitats of the Upper Mississippi River Valley and Bluff Tops in the Twin Cities Area (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.
	Herbaceous: some smartweed, wild millet, fall panicum, teal grass, and cocklebur.
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	Woody: oak openings and barrens--scattered trees and groves of oaks (mostly bur oak) of scrubby form with some 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.
Grassy meadows (prairie)	Willow prairie (prairie with clumps of willows), grass.

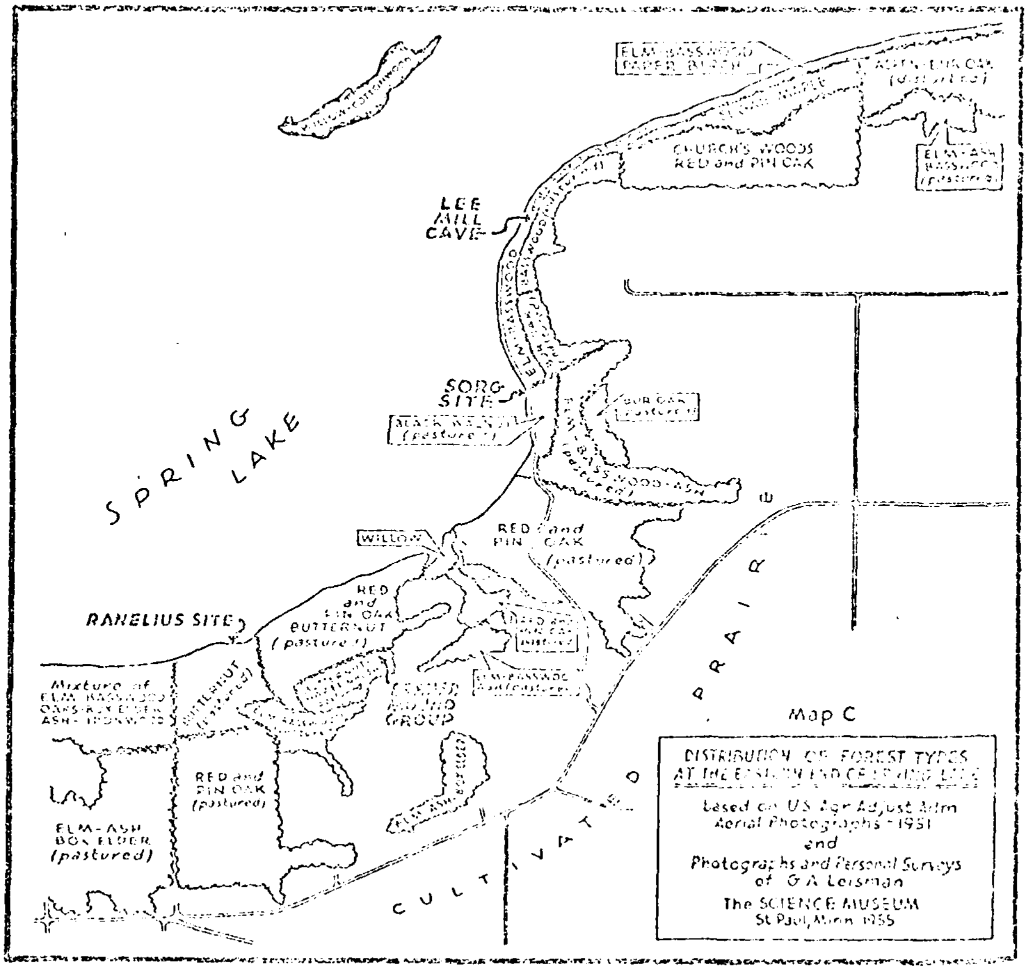
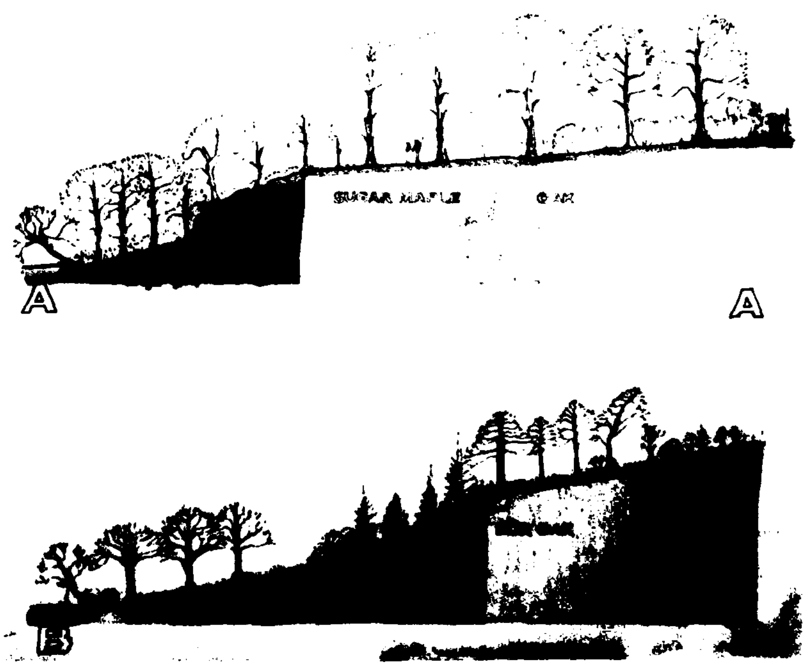


Figure 29. Vegetation of the Spring Lake Area
(Leisman, 1959)

By comparison, the agriculturally disturbed upland had a flora which was much less diverse, 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 species. One of the archeological sites contains the northern-most stand of black walnut in Minnesota.

Forsythe Studies of Spring Lake. Recent studies of the bluff slop and brim have been made by a landscape architect. These studies show the effect of disturbances upon vegetation, and provide data on present soils, hydrology, aesthetics, microclimate and cross-sections showing typical zone of vegetation (see Figure 30, Forsythe, 1973).



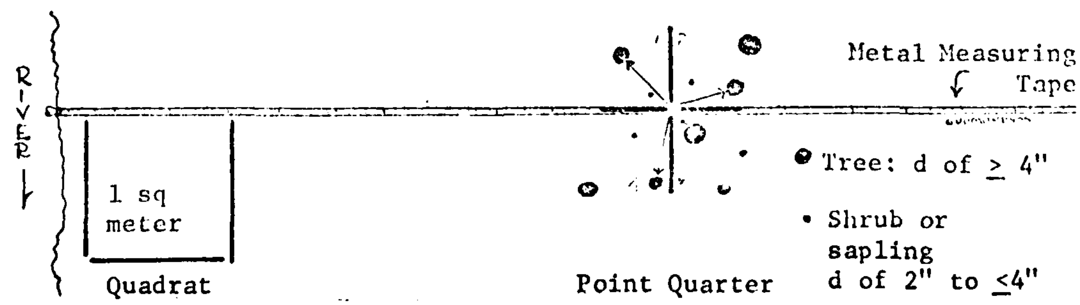
Scale: 1" = 500'

Figure 30. Vegetation Zones on the Bluff at Spring Lake (Forsythe, 1973)

Sampling: Transect, Quadrat and Point Quarter. For the present study, four imaginary lines called "transects" were selected and surveyed at right angles to the river (see Figure 31). They were set up in order to establish the location of most of the baseline data sampling, not only for this study but also for future studies to be conducted to assess changes occurring now and in the future.

From one end to the other, Pool 2 has three major ecological zone characters: at the upstream end, it resembles the river as it was before the navigation dams were built (Figure 32). In the middle reach, it forms marshes wherever the raised river level has flooded former meadows to shallow depths; and, at its downstream end, it resembles a lake (see Figure 33). In order to sample these diverse ecosystems, three "standard" transects--2AA,2BB, and 2CC--were located at the head, middle (near the primary control point for pool levels), and at the downstream end of the pool. The single "special" transect--2YY--was placed at the exact location at Mile 821.3 of the transect used in an earlier river study by Hokanson (1968).

In sampling the vegetation, two methods were used. Each "quadrat" (plot) was marked out as one square meter beside the transect line. On the transect line was the center of the crossed sticks for each "point quarter", from which the distance to the nearest tree was measured in each of the four quarters. Tables 9, 10, and 11 show the results of these field studies. Vegetation along the river tends to occur in bands (see Figure 31) and quadrats and point



Only the tree closest to the central point in each quarter is identified in a point quarter.

Profiles Drawn Looking Downstream (South)

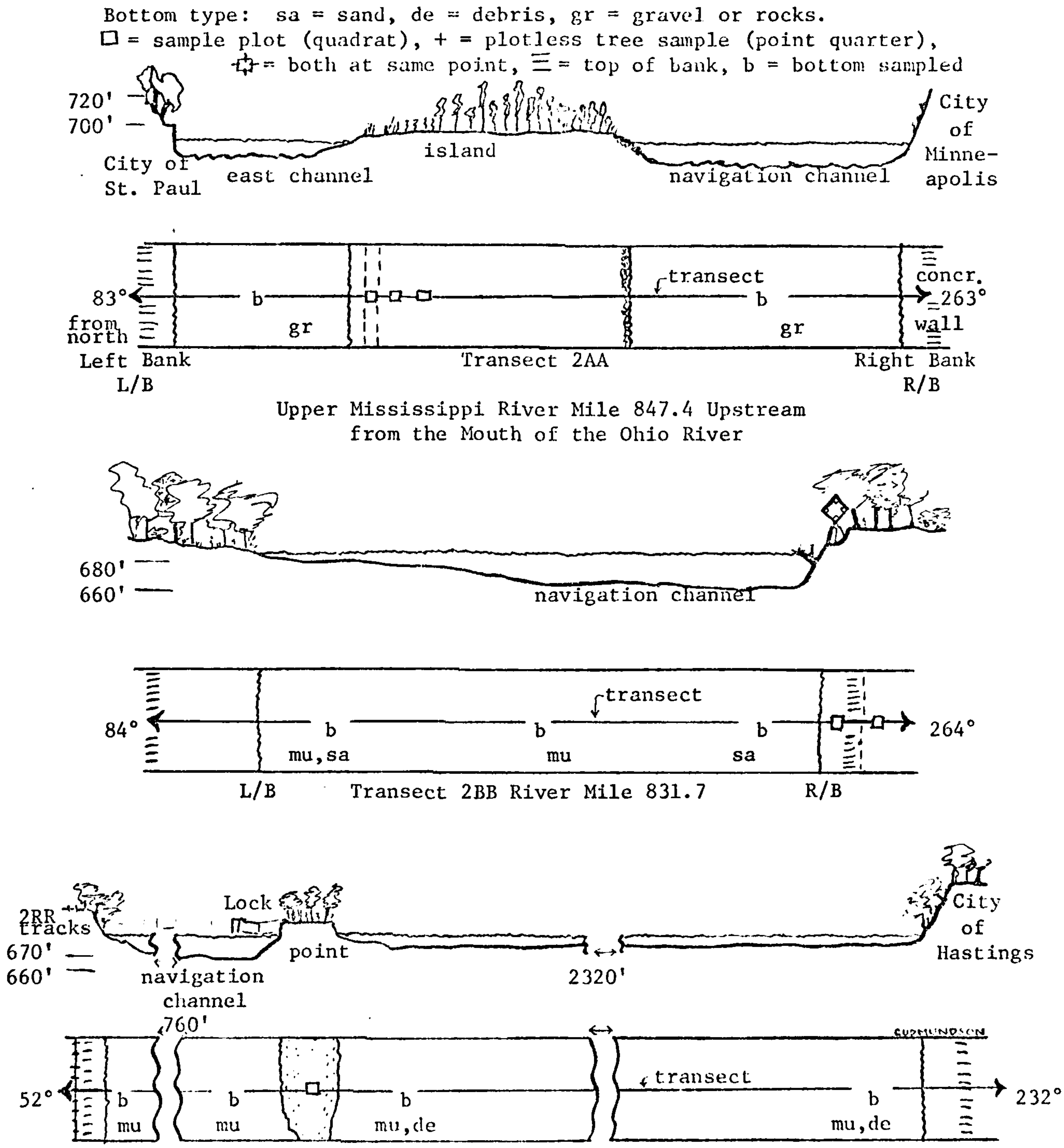


Figure 31. Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in Pool 2 (Gudmundson, 1973).

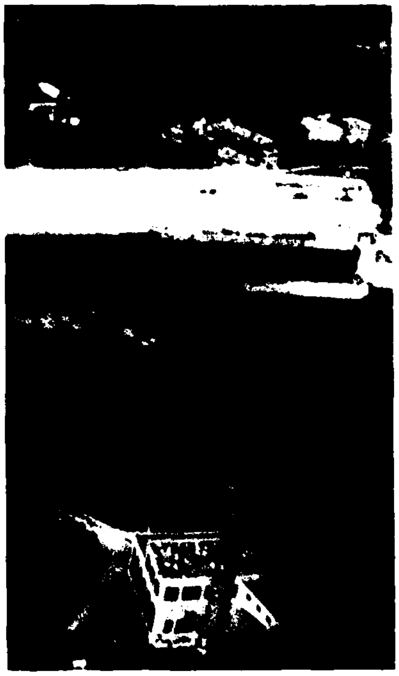


Figure 32. Aerial View of the Transect 2AA Area, Immediately Downstream from Lock and Dam 1 (Ford Dam). The lock (Minneapolis bank) is seen near the upper right corner. Ford Motor Company's heating plant (St. Paul bank) is seen at the lower edge. The east channel is in the foreground, island in the center (Colingsworth, 1973)

Figure 33. The Left (northeast) Bank of the Lake-like 2CC Transect Area Near Hastings. Taken in early spring, red cedars may be seen on the bluffs amid the deciduous trees. (Colingsworth, 1972)

Table 9. Plant Presence and Abundance on the 2AA Transect at Mile 847.4 in Pool 2

Species		West side of East Channel			
		Area	Quad. #1	Quad. #2	Quad. #3
Cladophora sp.*	Green alga	P**			
Cyanophyta	Blue-green algae	P			
Cyperaceae	Sedges		>1%		
Polygonum sp.	Smartweed		<1%		
Unknown	Unknown herb		<1%		
Euphorbiaceae	Spurges			10%	
Melilotus alba	White sweet clover			<1%	
	Small, opposite-leaved, saw-toothed plant			>1%	
Amaranthus sp.	Amaranth		>1%		P
Polygonaceae	(Other than smartweed)		<1%		P
Gramineae	Grasses		7%	30%	P
Populus deltoides	Eastern cottonwood		1%	2%	75%
Ambrosia artemisiifolia	Common ragweed				P
Compositae	Asters				P
Salix interior	Sandbar willow				P
Xanthium italicum	Cocklebur				P
	Unknown legume				P
Salix amygdaloides	Peach-leaved willow				P
Bare rock			90%	90%	95%

*sp. = of one unknown species
spp. = of more than one unknown species
**P = present

Table 10. Plant Presence and Abundance on the 2BB Transect at Mile 831.7 in Pool 2

Species		Right Bank (West)			
		Area	Quad. #1	Quad. #2	Qtr. #1
Compositae spp.*	Aster		75%		
Solanum nigrum var. *americana*	Black nightshade		7%		
Solidago spp.	Goldenrod		10%		
Acer saccharinum	Silver maple		P-C**		
Fraxinus pennsylvanica var. *subintegerrima*	Green ash		P-C		
Ulmus spp.	Elm	P†			50%
Acer negundo	Box elder		25%		50%
Urtica dioica	Stinging nettle		3%	P	
	Unknown herb		<1%		
	Leaf litter		100%		

*sp. = of one unknown species
spp. = of more than one unknown species
**P-C = present as canopy
†P = present

Table 11. Plant Presence and Abundance on the 2CC Transect at Mile 815.5 in Pool 2

Species		Left Bank (East) Area	Right Bank (West) Area	Right Bank (West) Quad #1 (Spit)
Gramineae spp.*	Grasses	P**		
Laportea canadensis	Wood nettle	P		
Lactuca sp.	Wild lettuce	P		
Nepeta cataria	Catnip	P		
Rosa blanda	Smooth wild rose	P		
Acer negundo	Box elder	P		
Juniperus virginiana	Red cedar	P		
Prunus serotina	Black cherry	P		
Compositae	Asters	P		1%
Impatiens capensis	Spotted jewelweed	P	P	
Plantago spp.	Plantain	P	P	
Solidago spp.	Goldenrod	P		5%
Vitis riparia	Riverbank grape	P	P	
Fraxinus pennsylvania var. *subintegerrima*	Green ash	P	P	
Ulmus spp.	Elm	P	P	
Agrostis palustris	Creeping bentgrass		P	
Cyperaceae	Sedges		P	
Equisetum arvense	Field horsetail			95%
Hepatica americana	Round-leaved hepatica		P	
Lonicera prolifera	Grape honeysuckle		P	
Musci	Mosses		P	
Setaria spp.	Foxtails		P	
Thalictrum dasycarpum	Purple meadow-rue		P	
Betula papyrifera	Paper birch		P	
Gleditsia triacanthos	Honey locust		P	
Ostrya virginiana	Hornbeam		P	
Populus balsamifera	Balsam poplar		P	
Populus deltiodes	Eastern cottonwood		P	
Quercus borealis	Northern red oak		P	
Salix interior	Sandbar willow		P	
	Bare soil		25%	
	Leaf litter		50%	

*sp. = of one unknown species
spp.= of more than one unknown species
** P = present

quarters were placed in the middle of those bands wherever possible in order to show the differences between these plant communities.

In the river-like reach of the pool (2AA transect) just below Lock and Dam 1, the regulation of the steep wooded left (east) bank is a sharp contrast to the often-flooded island across which the transect was run. Near the water the stones of the island were sparsely covered with mixed grasses. Further away, grass cover increased with spurges and a few cottonwood seedlings, and still further from the water grew mainly cottonwood (see Table 9).

The 2BB transect at Newport happens to be in a channel which is fairly narrow and where the backing up of the water in the pool did not create marshes, but were a fairly dense bottomland forest of elm and box elder, with some green ash and black nightshade and other herbs where the open space of the river allows more light to penetrate (see Table 10).

The steep banks of the lake-like downstream end of the pool (see Table 11 and Figure 3) had a varied flora dominated by green ash, box elder, red cedar and elms, and with a varied understory. The peninsula (spit) on which a 2cc quadrat was set up was covered with field horsetail, with a few goldenrods. Only five species were common to both right and left banks. Results of the observations and sampling of vegetation appear in Table 1, Appendix A IV.

Vegetation on Sandy Dredge Spoil

Cooper Study. Zonation and succession of vegetation on sandy spoil has been studied in the past by Cooper (1947). 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 (see Table 12 and Figure 34). Bare, saturated sand recently exposed by lowered water level (Zone 1) had a few patches of soft-stem bulrush (see Table 12). As the depth of dry sand increases away from the shore, the dominant herb was stick-tights (Zone 2), love-grass (Zone 3) and cockleburs (Zone 4). In Zone 5 the depth

Table 12. Vegetation Zones on Sandy Dredge Spoil (Cooper, 1947)

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

* Abundance: D = dominant
P = present

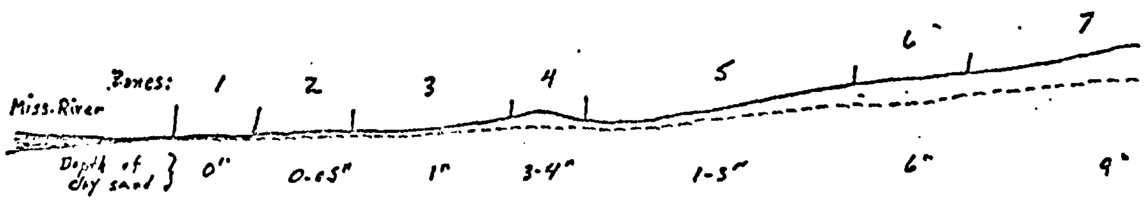


Figure 34. Vegetation Zones Along a Transect from the Mississippi River (in Pool 1) to the Top of Sandy Dredge Spoil (Cooper, 1947)

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 helped reduce moisture loss, thus encouraging the establishment of herbs. A few cottonwood seedlings occurred in Zones 2 and 4, and one to two year-old seedlings were found scattered in Zone 5, with the dry ridge top in Zone 4 and dryer Zones 6 and 7 lacking tree seedlings. Other sites studied by Cooper indicated that 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 35).

North Star Study. In the present Pool 2 study, five spoil sites of three different ages--2 years, 8 years and 27 years since disturbance by man-- were examined (see Table 13). The site without added spoil for 27 years was completely covered with box elder. No other species of plant was present. On the eight-year-old site were some box elder, but mostly silver maple and sandbar willow, elms, and riverbank grape.

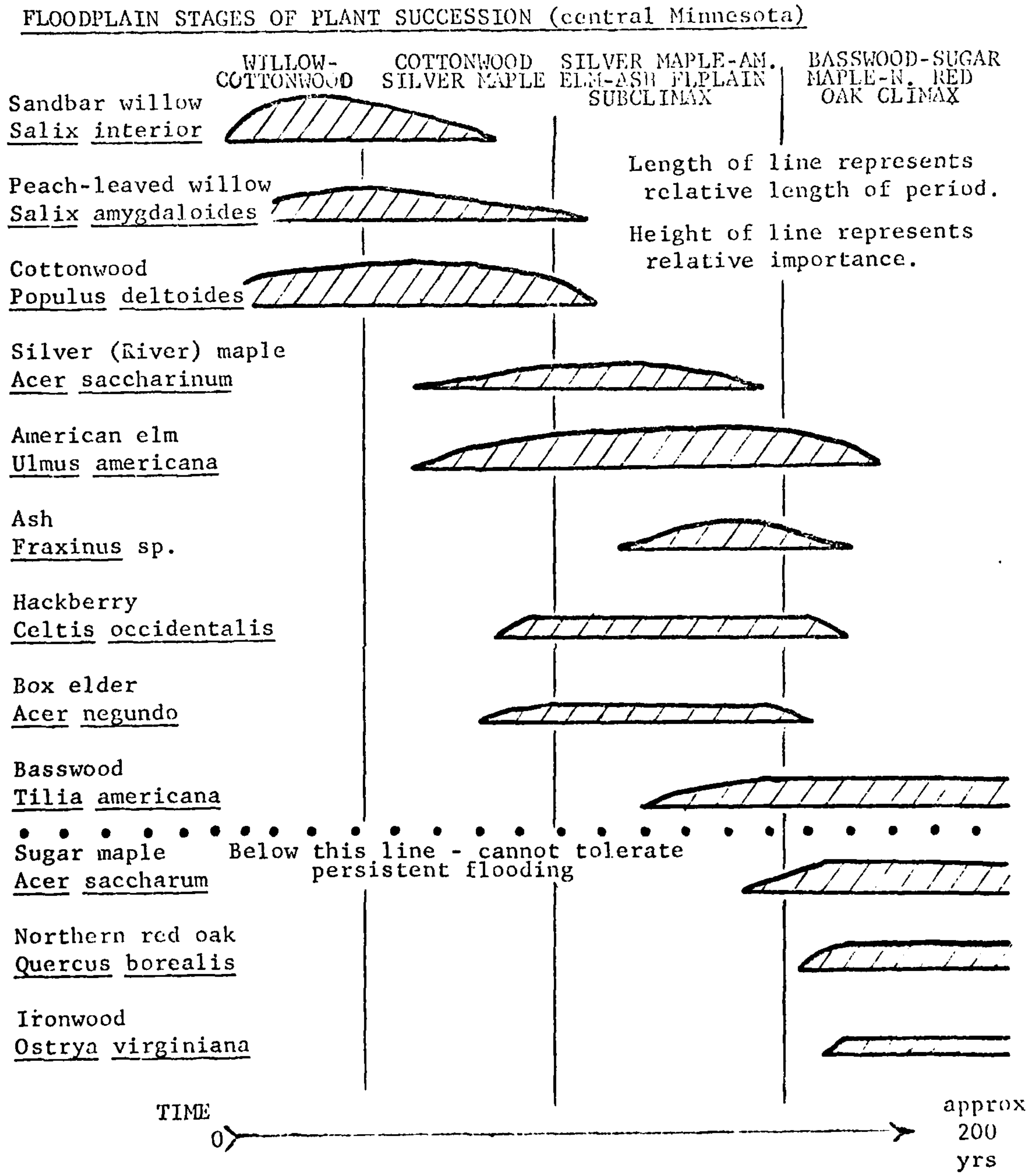


Figure 35. Stages in Floodplain Succession from Willow-Cottonwood to Basswood-Sugar Maple-Northern Red Oak Climax Forest (Adapted from Cooper, 1947)

Table 13. Plant Abundance at Four Pool 2 Spoil Sites of Various Ages Between Mile 823.3 and 833.2 (Colingsworth and Senecha, 1973)

Species		Herbs	Trees	Herbs	Trees	Trees
	Mile	823.3	827.7	832.2	832.2	833.2
	Age	2 yrs*	2 yrs	8 yrs	8 yrs	27 yrs
		R/B	R/B Pt.Qtr.	L/B Quad.	L/B Pt.Qtr.	R/B Pt.Qtr.
Compositae	Asters	P				
Cycloloma atriplicifolium	Winged pigweed	P				
Fabaceae	Legumes	P				
Cyperaceae	Sedges	P				
Melilotus sp.**	Sweet clover	P				
Panicum spp.	Panic grasses	P				
Polygonum sp.	Smartweed	P				
Trifolium pratense	Red clover	P				
	Unknown herb	P				
Fraximus pennsylvanica var. *subintegerrima*	Green ash		25%			
Populus deltoides	Eastern cottonwood		P			
Xanthoxylum americanum	Prickly ash		P			
Gramineae	Grasses	P		20%		
Solidago spp.	Goldenrods	P		P		
Vitis riparia	Riverbank grape	P		30%		
Acer saccharinum	Silver maple		38%		50%	
Salix amygdaloides	Peach-leaved willow		P		P	
Ulmus spp.	Elms		38%		25%	
Cirsium spp.	Thistles			20%		
Galium spp.	Bedstraws			<1%		
Salix interior	Sandbar willow				25%	
Solanum nigrum var *americana*	Black nightshade			P		
Taraxacum spp.	Dandelions			<1%		

*Age of spoil sites estimated from d edging record, Figure 1, Appendix A IV.
**sp. = of one unknown species
spp. = of more than one unknown species

Table 13. Plant Abundance at Four Pool 2 Spoil Sites of Various Ages Between Mile 823.3 and 833.2 (Continued)

Species		Herbs	Trees	Herbs	Trees	Trees
	Mile	823.3	827.7	832.2	832.2	833.2
	Age	2 yrs	2 yrs	8 yrs	8 yrs	27 yrs
		R/B	R/B Pt.Qtr.	L/B Quad.	L/B Pt.Qtr.	R/B Pt.Qtr.
Urtica dioica	Stinging nettles			<1%		
	Dead wood litter			100%		
	Unknown woody species			<1%		
Acer negundo	Box elder			18%		100%

Pre-Project Vegetation

The early settlement (1955) vegetation of the eastern Spring Lake area has been mapped by Leisman (1959) based on the General Land Office Survey Map (see Figure 36). 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, *Scripus* 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 occurrence 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 migration."
>
> (Leisman, 1959)

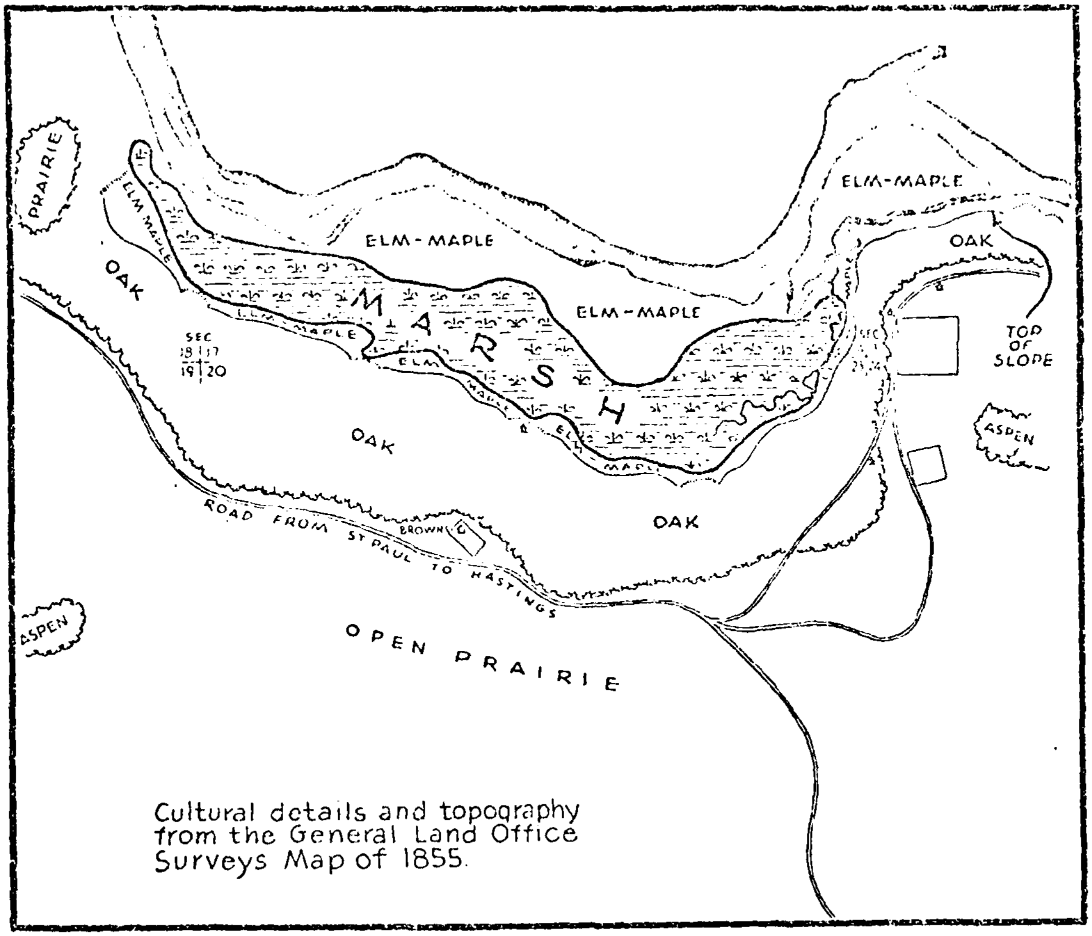


Figure 36. Map of Spring Lake,
Civil Land Office Survey
(Leisman, 1959)

A more complete picture of the Spring Lake area prior to the building of the dams may be gained from a segment of an "MRC" chart published later by the Mississippi River Commission in 1895 (see Figure 37). At normal river levels, Spring Lake was almost filled with emergent vegetation, as were the margins of [illegible] Lake (labeled, merely, "Lake") and Balden Lake. Much of the area now [illegible] water was then low meadows and winding watercourses.

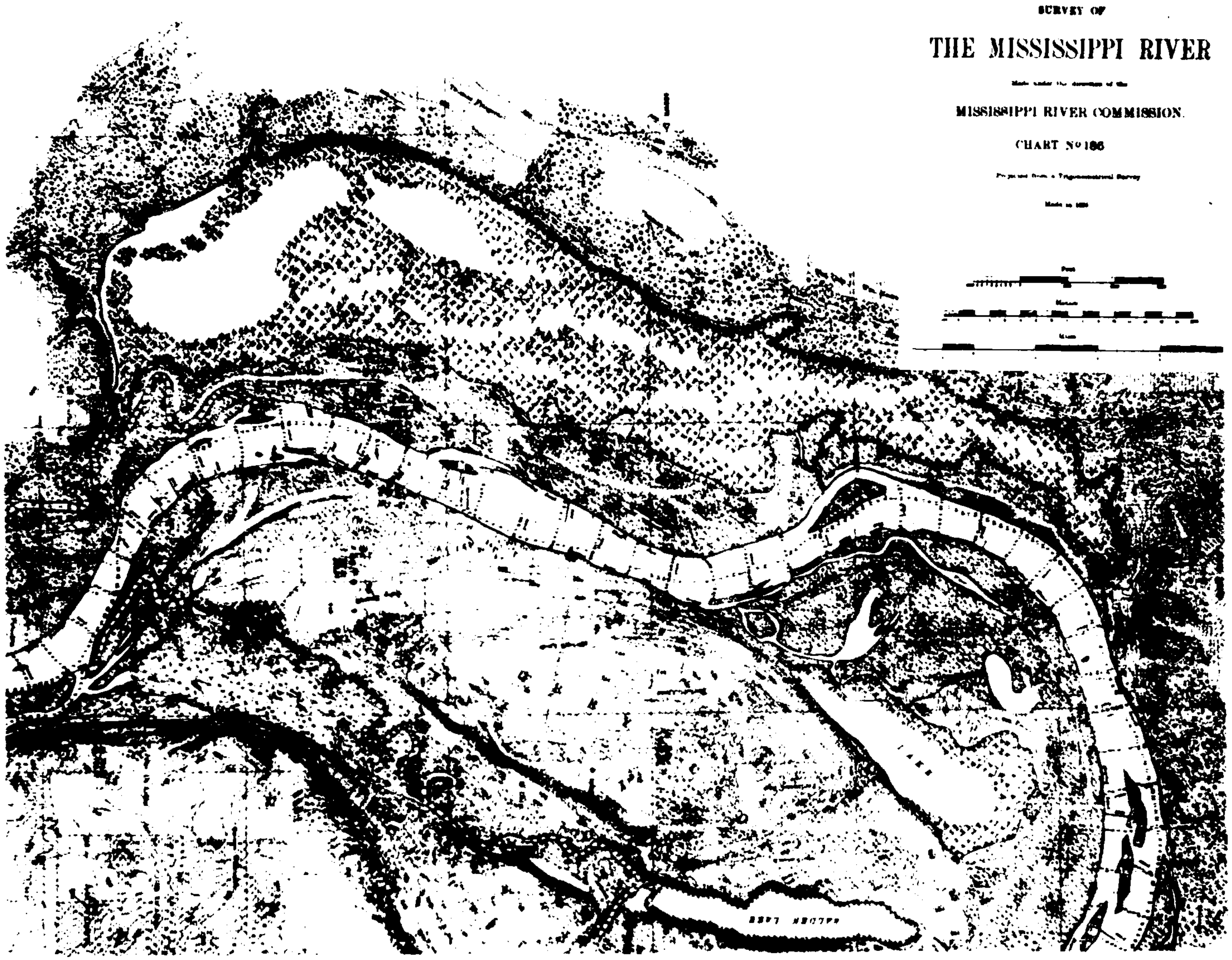


Figure 37. 1895 MRC Chart of the Spring Lake Area of the Mississippi River, Showing Pine Bend (upper margin), Grey Cloud Island (center right) and Numerous Islands in the River (MRC,1895)

Farther upstream, at the head of Pool 2 and immediately below Dam 1 (the Ford Dam), preproject vegetation patterns and plant communities can be fairly well seen in aerial and ground level photographs which illustrated a plant ecology thesis by George (1924, see Figures 38, 39, and 40). More island area was present then, and Figure 40 shows a preponderance of 3- or 4-year-old cottonwood seedlings on the left bank and the island.

Figure 38. Aerial View Upstream of the Preproject Environment at the Head of Pool 2 (below the Ford Dam), Mississippi River. marks the location of the ground-level photo (figure 40) Photo by Curtis Airplane Co. (*in* George, 1924)

Figure 39. Aerial Photo Mosaic of the Preproject Environment in November 1923, at the Head of Pool 2 (Lock and Dam 1 is at the right margin), Mississippi River Original photo by Curtis Airplane Co. (In George, 1924)

Figure 40. View Upstream Toward the Ford Dam (Ford hydroelectric plant is under construction) Showing the Preproject Environment *ca.* 1922 (George, 1924)

These studies suggest successional stage from willow to cottonwood on a floodplain downstream from Dam 1 (Ford Dam, see Table 14). This was accompanied by an overall increase in individuals which occurred as the flood level increased elevation. A decrease in flood level elevation during the next year may have caused the reduction in individuals.

Table 14. Mississippi River Floodplain at Ford Plant at Mile 847 (George, 1924)

Numbers, based on 1000 sq meter area	Germinations Surviving to 1923				Total No. Indiv. 1000 sq meter, 1923
	1920	1921	1922	1923	
Salix longifolia (now *S. interior*) sandbar willow	166	1,278	2,333	722	4,500
S. amygdaloides peach-leaved willow		55	222		278
Populus deltoides eastern cottonwood		399	38,444	1,567	40,500
Acer saccharinum silver maple			556		556
Ulmus americana American elm		289	944		1,853
Total no. trees	166	2,612	42,499	2,289	47,667
Flood level		716.6	723.3	714.9	

Man-made changes

1814 - 1920	Dredging, resulting in confining river entirely to channel except in flood.
1923	Burial of east channel by dredge spoil to a depth of 15 feet

Wildlife

Wildlife is diverse in the upper Mississippi River watershed, varying from large mammals such as moose, bear, and deer to small fur-bearers such as mink and river otter (see Table 15). Also, numerous geese, diving and dabbling ducks and other birds migrate through the watershed in spring and fall, or nest here.

Table 15. Game Animals, Game Birds and Furbearers of the Upper Mississippi River Basin, 1960 (FWS, 1970)

Moose[a]	*Alces alces*	Rock Dove	*Columba livia*
Whitetail Deer[a]	*Odocoileus virginianus*	Woodcock[a]	*Philohela minor*
Antelope[a]	*Antilocapra americana*	Common Snipe[a]	*Capella gallinago*
Black Bear[a]	*Ursus americanus*	King Rail[a]	*Rallus elegans*
Snowshoe Hare[a]	*Lepus americanus*	Virginia Rail[a]	*Rallus limicola*
Whitetail Jackrabbit[a]	*Lepus townsendi*	Sora Rail[a]	*Porzana carolina*
Swamp Rabbit[a]	*Sylvilagus aquaticus*	Canada Goose	*Branta canadensis*
E. Cottontail Rabbit[a]	*Sylvilagus floridanus*	Snow Goose	*Chen hyperborea*
E. Fox Squirrel[a]	*Sciurus niger*	Blue Goose	*Chen caerulescens*
E. Gray Squirrel[a]	*Sciurus carolinensis*	Mallard	*Anas platyrhynchos*
Red Fox[a]	*Vulpes fulva*	Black Duck	*Anas rubripes*
Gray Fox[a]	*Urocyon cinereoargenteus*	Gadwall	*Anas strepera*
Raccoon[a]	*Procyon lotor*	Pintail	*Anas acuta*
Opossum[a]	*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[a]	*Castor canadensis*	Ring-necked Duck	*Aythya collaris*
Muskrat[a]	*Ondatra zibethica*	Bufflehead	*Bucephala albeola*
Ruffed Grouse[a]	*Bonasa umbellus*	Ruddy Duck	*Oxyura jamaicensis*
Sharp-tailed Grouse[a]	*Pedioecetes phasianellus*	Common Merganser	*Mergus merganser*
Bobwhite Quail[a]	*Colinus virginianus*	Red-breasted Merganser	*Mergus serrator*
Hungarian Partridge[a]	*Perdix perdix*	Hooded Merganser	*Lophodytes cucullatus*
Ring-necked Pheasant[a]	*Phasianus colchicus*	Coot	*Fulica americana*
Wild Turkey[a]	*Meleagris gallopavo*	Common Gallinule	*Gallinula chloropus*
Mourning Dove[a]	*Zenaidura macroura*		

[a] Species distribution on range maps.

Generally, Pool 2 has a wide variety of mammals and birds present in its diverse vegetation zones in the valley (Table 16). There is evidence of beaver near the St. Paul Yacht Club and of deer on the floodplain in the lower reaches of Pool 2.

Birds which have been reported in the Twin Cities area and their migration schedule are given in Table 2, Appendix A IV. About 280 species of birds have been sighted, of which 97 are common summer residents and nest in the 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 Pool 2.

Casual bird counts in Pool 2 show a preponderance of herons: great blue, green, black-crowned night herons and American egrets (Table 17). Belted kingfishers were also commonly seen. These birds comprised 39 of the 47 birds sighted and recorded.

An extremely unusual phenomenon is the presence of two large shorebird rookeries at the downstream tip of Pig's Eye Island, opposite the St. Paul stockyards (see Figure 1, Appendix A II). The largest one is a 170-nest black-crowned night heron-American egret rookery, sandwiched between a large barge fleeting basin on the west and a large barge terminal on the east (see Figure 41). This rookery is the largest in the state and is doubly important since 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. In the evening as many as 24 of these huge shorebirds may be observed feeding along the remaining marshes in Pig's Eye Lake.

Table 16. 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.

Table 17. Bird Abundance in the River Valleys in the Twin Cities Area Based Upon Casual Observations, 1973(Colingsworth,1973)

Bird Species	Flood Plain Lakes		SAF Pools	Pool 1	Pool 2	Minn. R	St. Cx.R.	Total Indiv.
	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

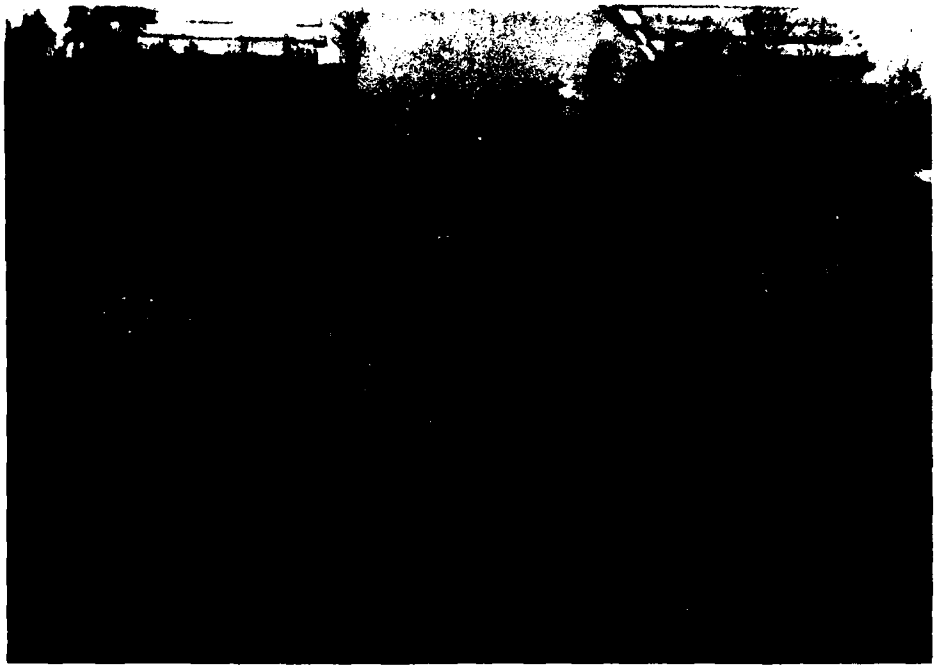


Figure 41. A Large Egret and Heron Rookery Adjacent to a Barge Fleeting Basin (Colingsworth, 1973)

Numerous trees have falled into the river at the head of the island on the side next to the fleeting basin where the rookery is located (Figure 42). Note also the dead trees at the point where the barges are moored.

Present terminal and waste disposal activity on Pig's Eye, as well as plans for enlarging these facilities, most likely present serious danger to continued use of these rookeries.

The trees along the bluff slopes and tops and especially the park areas such as surrounding Crosby and Pickerel Lakes attract spring and fall migrating birds, and provide nesting sites for some summer residents as well. These park areas may even serve as a reserve for these and other wildlife near the center of extensively urbanized downtown St. Paul.

Figure 42. Fallen Trees at the Head of the Rookery Island and Adjacent to the Fleeting Basin. Note the dead trees to which the barges are tied. (Colingsworth, 1973)

Water Quality

Water usage in Pool is varied since it includes industrial supply, navigation, irrigation and stock watering, waste disposal, and recreation and aesthetic enjoyment by a large metropolitan area. A comparison of several water quality parameters may be made from Tables 3A, 3B, and 3C in Appendix A IV. Table 3A shows water quality data of the water intake (from the river) for the City of Minneapolis, Table 3B gives data, also for 1973, on quality of water in Pool2, and Table 3C shows water quality data gathered before the navigation dam, both above and below the sewage treatment plant.

Generally speaking, water quality is good from Lock and Dam 1 to the outfall of the Metropolitan Wastewater Treatment Plant (MWTP) at Pig's Eye Island, except for the levels of bacteria. During and just after rainfall, some or all of numerous combined sewer discharges increase bacteria to levels which create a possible health hazard (FWPCA, 1966).

Although the water of the Minnesota River is generally of lower quality than that of the Mississippi at Mile 844, the Minnesota has only a moderate effect since its flow is only about 30 percent that of the Mississippi. Data collected in 1964 by the Federal Water Pollution Control Administration (FWPCA) indicated that the main effect of the Minnesota is to increase the turbidity and total coliform organisms about twofold (see Table 18). The High Bridge power plant temporarily increases the normal river temperature by about 1°F.

Effluents from the Metropolitan Wastewater Treatment Plant, the South St. Paul Sewage Plant, as well as 16 other sources enter Pool 2 from the MWTP site downstream to Lock and Dam 2. These decrease the dissolved oxygen (DO), benthic organisms, and percent of game fish in the total fish population. At the same,time, undesirable characteristics increase, such as coliform bacteria and other possible pathogens (FWPCA, 1966).

However, water quality throughout Pool 2 above the Metropolitan Wastewater Treatment Plant exceeds the maximum limits for such uses as potable water and swimming (see Figures 43 and 44). Below this plant, further use is restricted to such uses as waste assimilation, and aesthetic enjoyment.

Seasonal variation in several measures of water quality of the Mississippi River are available for mid-1967 to mid-1969 (figures 2 to 11 in Appendix A, IV). Daily mean flow is measured at gages in Anoka and St. Paul, while the other data are automatically recorded at the Northern States Power Company's Riverside plant (Mile 856.9) and the Shiely terminal on Upper Grey Cloud Island (Mile 826.6). While in general seasonal patterns are repeated, the magnitude and time of occurrence vary from one year to another. For instance, the high water experienced in October 1973 also occurred in 1968, but not 1967.

Parameter	U.S. 52-169 Bridge, Anoka (871.[illegible])	Minneapolis Waterworks Intake	Head of 9-ft. Navigation	Upper and Lower St. Anthony Falls Locks and Dams	Lock and Dam 1 (847.6)	Minnesota River	Lambert Landing, St. Paul	SWT Plant		Rock Is. RR Bridge	Shiely Co. Terminal, Up. Grey Cloud Island			Lock and Dam 2 (815.3)	U.S. 61 Bridge, Hastings	Lock and Dam 3, Red Wing (796.9)
Pool			Upper St. Anthony Pool	Pool 1				Pool 2							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.)					83.3	84	85			85						
Phenols							40		620	210	200					
Bottom sediments	Sand and/or rock					Sand and organic sludge, mixed				Organic Sludge					Sand and organic sludge, mixed	
Bacteria Total Col., MPN/10^6					.170		.344	37.7	65.0	50.0	15.0		1.0			
Fecal Col., MPN/10^6					.020		.017			15.71						
Phytoplankton, no./10^6					12.45					15.71						
Benthos, no. spp.					13	7	6	2	1							
Tubificids/ft.^{2}, artificial substrate								258	396	12,000	1,600					
Game fish, %					50					6			9			

Table 18. Water Quality in the Mississippi River in the Twin Cities Metropolitan Area (FWPCA, 1966; Hokanson, 1968)

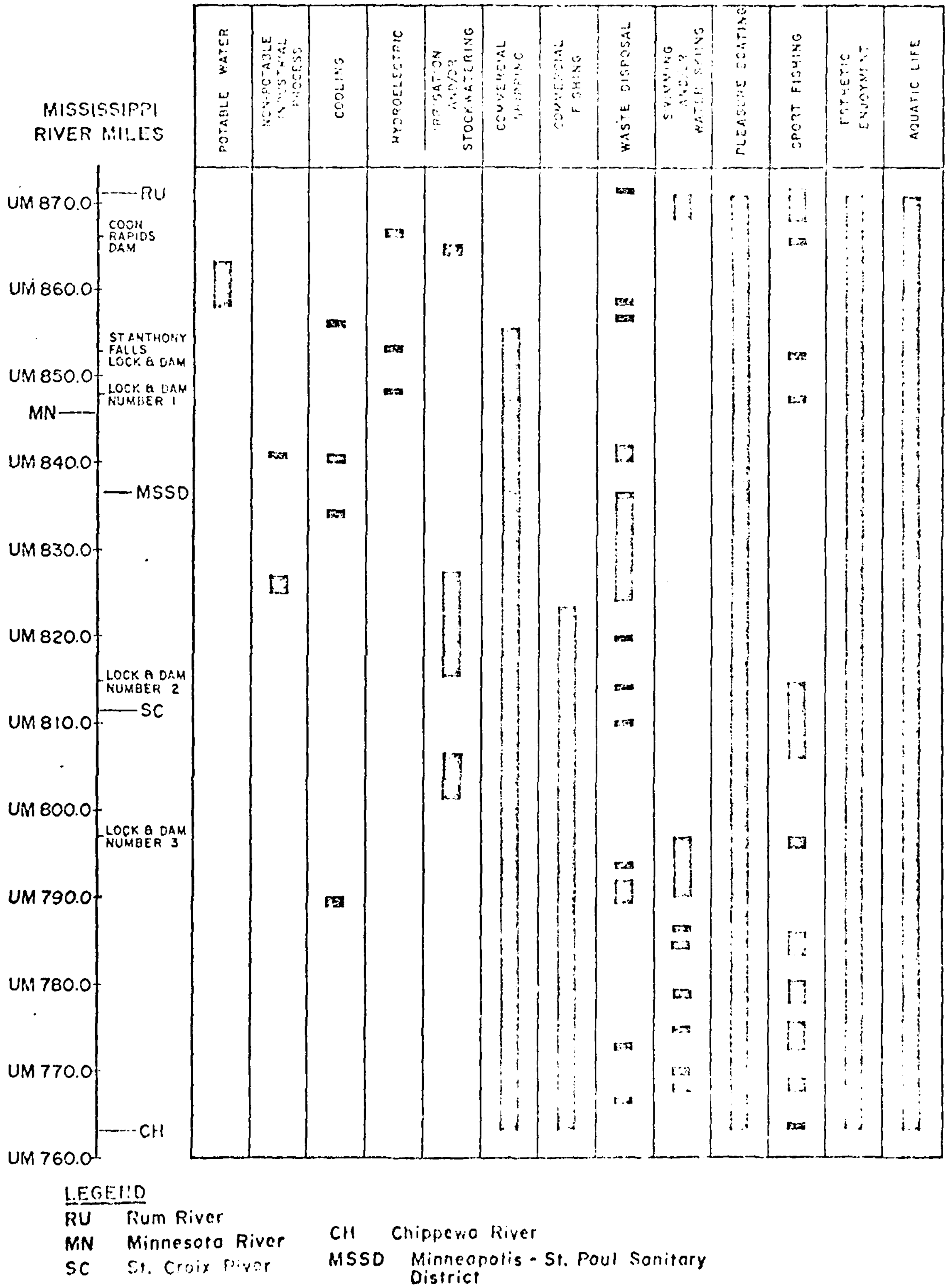


Figure 43. Present Water Uses of the Mississippi River in the Twin Cities Metropolitan Area (MWPCA, 1966)

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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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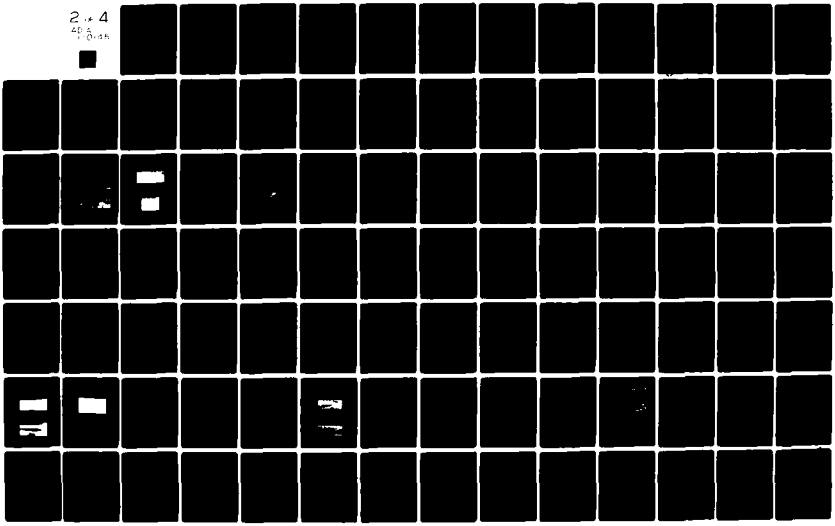
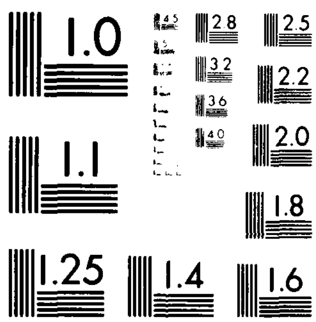




MICROCOPY RESOLUTION TEST CHART

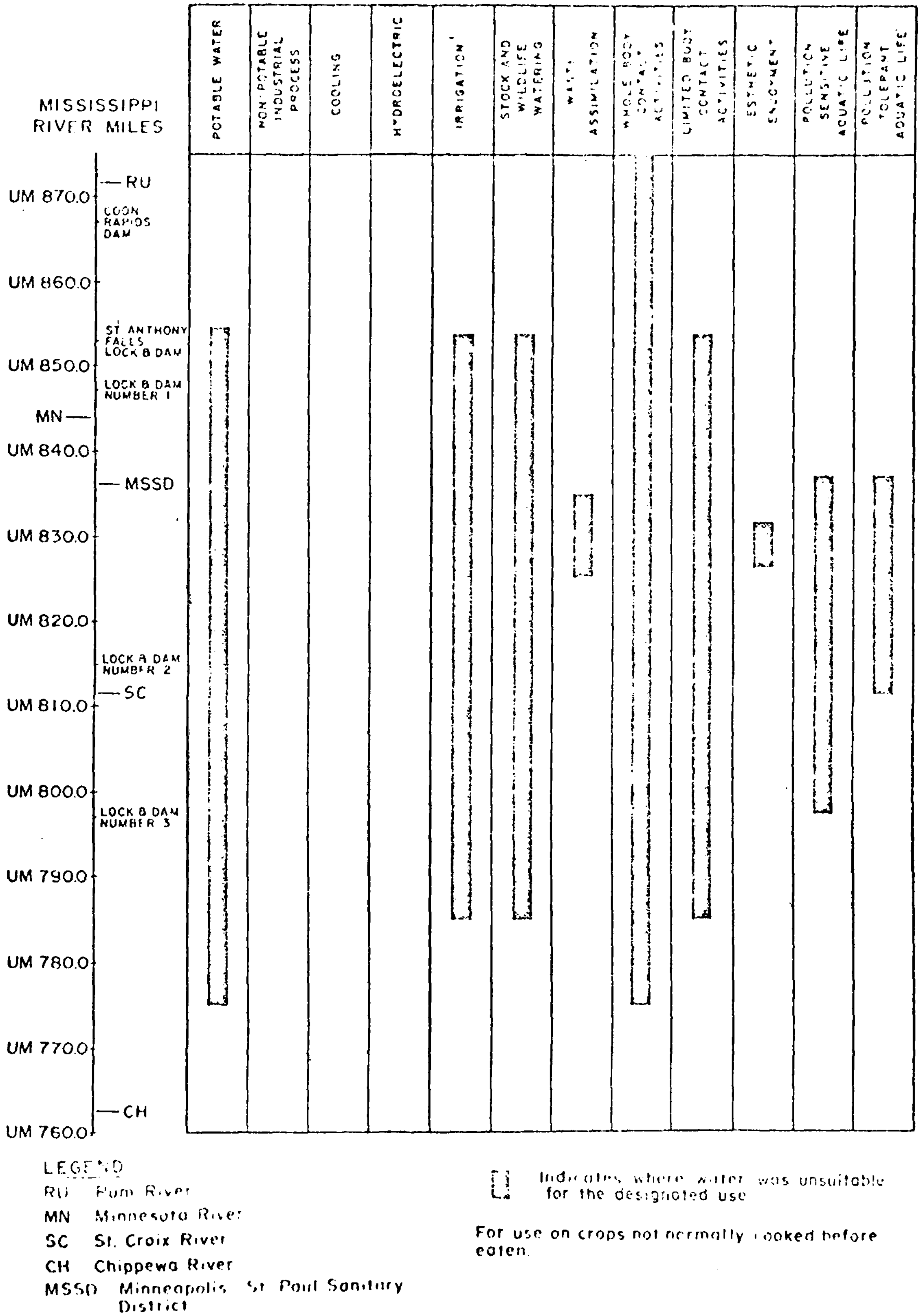


Figure 44. Water Uses Affected by Water Quality in the Mississippi River in the Twin Cities Metropolitan Area (FWPCA, 1966)

There are also sometimes considerable differences both in magnitude and time of occurrence between the upstream (Riverside) and Pool 2 (Shiely) stations caused by inflow of tributaries, storm sewers and industrial wastes.

These and other water quality parameters are available for January through August 1973 from the Minneapolis City Water Works in Fridley. Variations in these data range from two- to fourfold (Table 3A, Appendix A, IV).

These data, plus continuing efforts to improve water quality, illustrate the difficulty in attempting to characterize the Mississippi River water quality, except in general terms, based on a few sampling stations and one or a few years study. It also points to the obvious benefit of continuous data (automatically monitored) versus single noncontinuous measurements.

Turbidity of the Mississippi River does not vary from 3 to 6 FTU from Fridley to the mouth of the Minnesota River which has a turbidity of 42.5 to 56 FTU. This turbidity results in an increase to a turbidity of 11 to 12 FTU in the Mississippi River downstream from the confluence with the Minnesota.

Field Studies

Dissolved oxygen (DO), turbidity, and water temperature were collected in September and November 1973 along the length of the Mississippi and Minnesota Rivers in the Twin Cities area (Table 4, Appendix A, IV). DO in the Mississippi did not vary greatly from concentrations of 6 to 9 ppm from the Minneapolis Water Works to Newport, although there seemed to be a slight increase caused by the turbulence of the St. Anthony Falls Lower Dam and the Ford Dam. However, the river "metabolism" is not at its highest during November; thus, important differences along the length of the Mississippi may have been missed.

The effects of dredging and barge traffic were also investigated (see Table 5, Appendix A, IV). These effects will be treated in the following section on impacts.

Aquatic Vegetation

The potential aquatic vegetation in the Twin Cities area may be grouped into habitat types, such as deep and shallow marshes (greater or less than three-feet deep), and wood and shrub swamps (see Table 19). No vegetation is known to occur in the main channel.

Table 19. Aquatic Vegetation of Pool 2 Reach of the Mississippi River (from Wallace, McHarg, Roberts and Todd, 1969)

Habitats	Species
Deep marshes	Cattails, bulrushes, reeds, round-stemmed bulrush, and wild rice. In open areas: pondweed, naiad, coontail, water milfoil, waterweeds, duckweed, water lilies, spatterdock and other aquatics.
Shallow marshes	Grasses, bulrushes, spikerushes, cattails, arrowhead, pickerelweed, smartweed, reeds, whitetop, rice cut-grass, *Carex* and giant burreed, and wet willow growths.
Wood and shrub swamps	Undergrowth: moss, duckweed, smartweed, and others.

Such habitats are absent within sight of the navigation channel of Pool 2 because of the narrowness of the river, the extensive development in many reaches, and inundation of the former floodplain. However, in a few off-channel areas, aquatic plants may be found. Only *Potamogeton crispus* and (probably) *P. pectinatus* were seen during field studies in Pool 2.

Aquatic Animals

Fish. More than 120 species of fish are found in the Upper Mississippi River Basin, 48 of which have been found in Pool 2 (see Table 20 and Tables 6 and 7, Appendix A, IV). Trap netting data show that game fish comprised about 25 percent of the total fish population in Spring and Baldwin Lakes, while 50 percent are game species in the tailwaters of Lock and Dam 1 (see Figure 45 and Table 21). This group decreases dramatically to 6 percent above Spring Lake, increasing to 9 percent above Lock and Dam 2.

Benthic (bottom) Animals. Bottom sediments consist of sand and/or rock and rubble in the tailwaters of Lock and Dam 1 (see Figures 46 and 47). From these tailwaters to about the St. Paul Barge Terminal the bottom is a mixture of sand and organic sludge and from there to Lock and Dam 2 the bottom is organic sludge.

The clams of the Mississippi River above and below St. Anthony Falls have been studied and reported on by Dawley (1947). Though their diversity is small above the falls, 40 of the 45 Minnesota species are found "below Minneapolis" (see Table 22). The exact location from which these collections were made was not mentioned, so further investigation needs to be made on these locations. No clams or snails (mollusks) were found in Pool 2 benthic samples (Table 8B, Appendix A, IV).

Other bottom organisms apparently had been studied only at Coon Rapids and in Spring Lake (Mile 821) until the present field studies were conducted (see Table 23). Diversity was greater at Coon Rapids and Camden (Upper St. Anthony Pool) than in Lower Pool 2. The dominant family at Coon Rapids was Chironomidae, whereas in St. Anthony Falls Pools they are Hydropsychidae and Chironomidae; in Spring Lake chironomids (midges) and oligochaetes (probably sludge worms) are the predominant benthic organisms. In the benthic field studies, 64 collections were made from the 22 standard and special transects of the three major rivers in the metropolitan area. Pool 2 collections on 4 transects and 2 special study areas numbered 27. A complete listing of the benthic communities found in each sample arranged by transect may be seen in Table 8A, Appendix A, IV.

Table 20. 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 placitus* 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 rare in basin (BSFW - App. A)
∤ No longer commercially fished (BSFW - App.A)

Table 20. Checklist of Fishes Found in the Upper Mississippi River Basin (Continued) (FWS, 1970)

Ictaluridae – freshwater catfishes
- Blue catfish *Ictalurus furcatus* (LeSueur)
- Black bullhead *Ictalurus melas* (Rafinesque)
- Yellow bullhead *Ictalurus natalis* (LeSueur)
- Brown bullhead *Ictalurus nebulosus* (LeSueur)
- Channel catfish *Ictalurus punctatus* (Rafinesque)
- Stonecat *Noturus flavus* Rafinesque
- Tadpole madtom *Noturus gyrinus* (Mitchill)
- Flathead catfish *Pylodictis olivaris* (Rafinesque)

Anguilliade – freshwater eels
- American eel *Anguilla rostrata* (LeSueur)

Cyprinodontidae – killifishes
- Blackstripe topminnow *Fundulus notatus* (Rafinesque)

Poeciliidae – livebearers
- Mosquitofish *Gambusia affinis* (Baird and Girard)

Gadidae – codfishes and hakes
- Burbot *Lota lota* (Linnaeus)

Gasterosteidae – sticklebacks
- Brook stickleback *Eucalia inconstans* (Kirtland)

Percopsidae – trout-perches
- Trout-perch *Percopsis omiscomaycus* (Walbaum)

Aphredoderidae – pirate perches
- Pirate perch *Aphredoderus sayanus* (Gilliams)

Serranidae – sea basses
- White bass *Roccus chrysops* (Rafinesque)
- Yellow bass *Roccus mississippiensis* (Jordan and Eigenmann)

Centrarchidae – sunfishes
- Rock bass *Ambloplites rupestris* (Rafinesque)
- Warmouth *Chaenobryttus gulosus* (Cuvier)
- Green sunfish *Lepomis cyanellus* Rafinesque
- Pumpkinseed *Lepomis gibbosus* Rafinesque
- Orangespotted sunfish *Lepomis humilis* (Girard)
- Bluegill *Lepomis macrochirus* Rafinesque
- Longear sunfish *Lepomis megalotis* (Rafinesque)
- Redear sunfish *Lepomis microlophus* (Gunther)
- Smallmouth bass *Micropterus dolomieui* Lacepede
- Largemouth bass *Micropterus salmoides* (Lacepede)
- White crappie *Pomoxis annularis* Rafinesque
- Black crappie *Pomoxis nigromaculatus* (LeSueur)

Percidae – perches
- Crystal darter *Ammocrypta asprella* (Jordan)
- Western sand darter *Ammocrypta clara* Jordan and Meek
- Mud darter *Etheostoma asprigene* (Forbes)
- Rainbow darter *Etheostoma caeruleum* Storer
- Bluntnose darter *Etheostoma chlorosomum* (Hay)
- Iowa darter *Etheostoma exile* (Girard)
- Fantail darter *Etheostoma flabellare* Rafinesque
- Johnny darter *Etheostoma nigrum* Rafinesque
- Banded darter *Etheostoma zonale* (Cope)
- Yellow perch *Perca flavescens* (Mitchill)
- Logperch *Percina caprodes* (Rafinesque)
- Blackside darter *Percina maculata* (Girard)
- Slenderhead darter *Percina phoxocephala* (Nelson)
- River darter *Percina shumardi* (Girard)
- Sauger *Stizostedion canadense* (Smith)
- Walleye *Stizostedion vitreum vitreum* (Mitchill)

Sciaenidae – drums
- Freshwater drum *Aplodinotus grunniens* Rafinesque

Atherinidae – silversides
- Brook silverside *Labidesthes sicculus* (Cope)

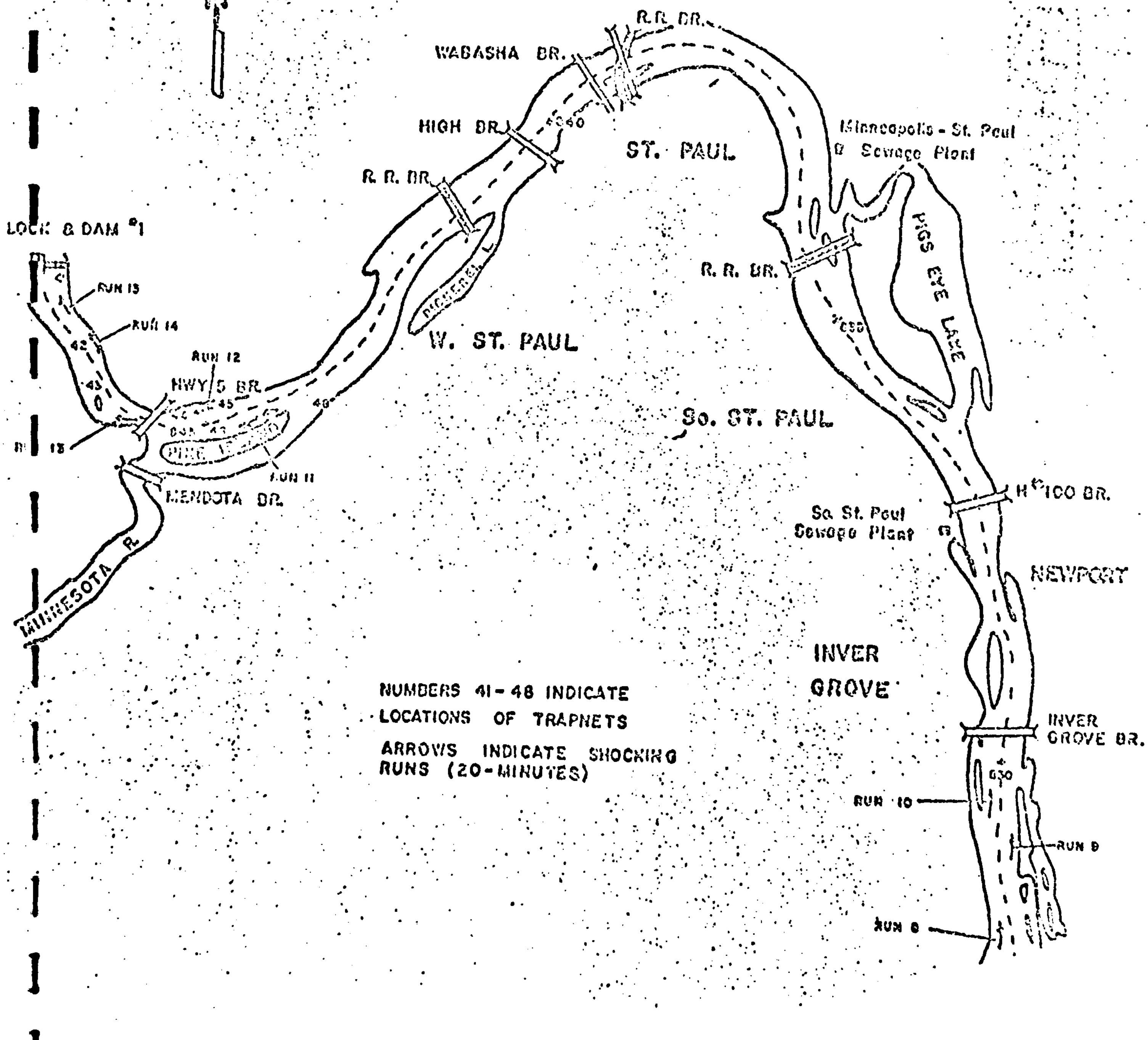


Figure 45. Location of Fish Trapping and Shocking Stations in the Department of Natural Resources' 1964 Fish Population Study of Pool 2 (Skrypek, 1969)

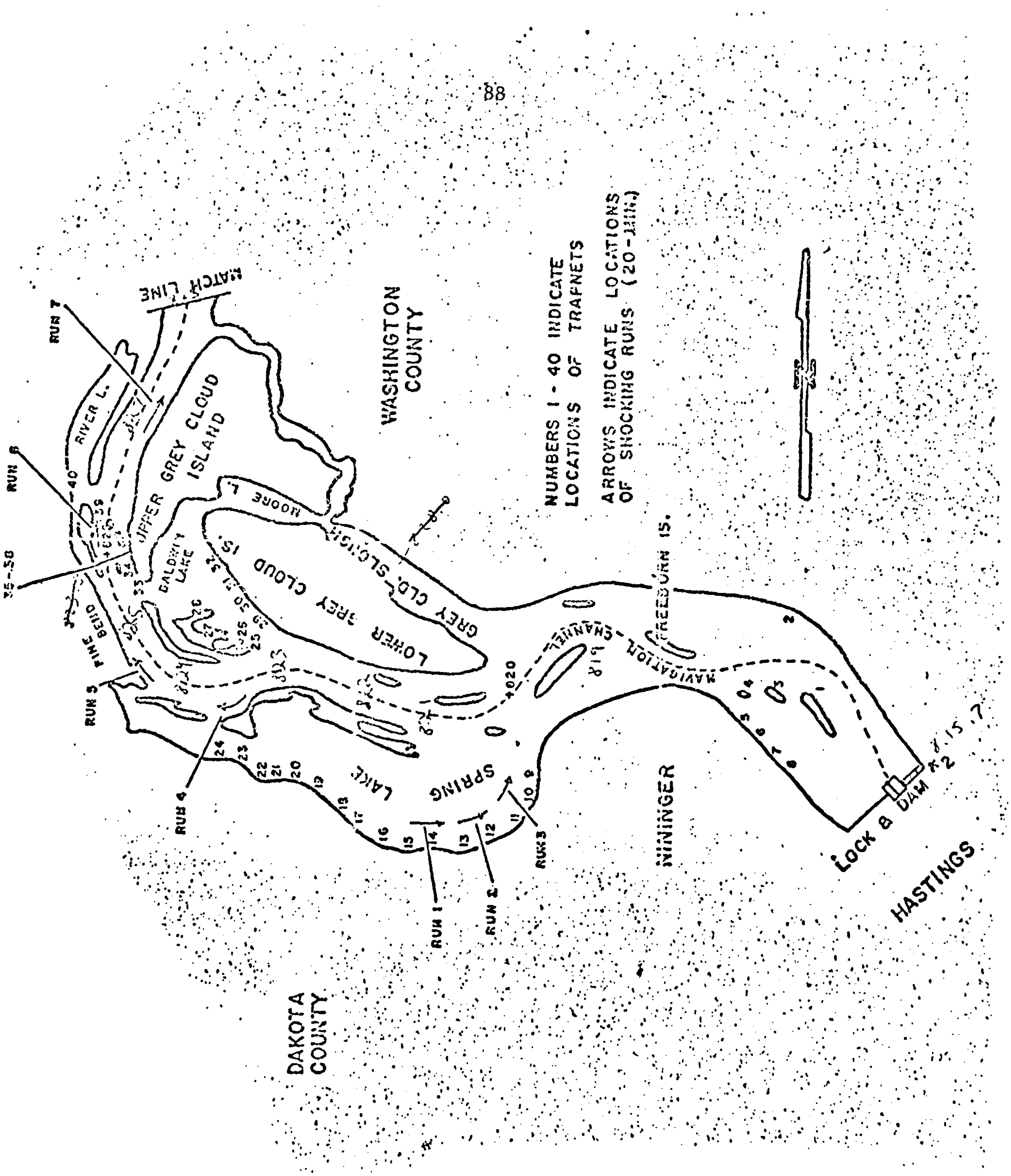


Figure 45. Location of Fish Trapping and Shocking Stations in the Department of Natural Resources' 1964 Fish Population Study of Pool 2 (Skrypek, 1969) (Continued)

Table 21. Summary of Trapnet Catches for Pool 2 (Skrypek, 1969).

Game Fish	Above L & D #2 (8 sets) Number	No./set	Spring L.* (15 sets)* Number	No./set	Baldwin & River L. (9 sets) Number	No./set
Northern pike	1	.13	12	.80	.2	.22
Walleye						
Sauger	1	.13	1	.07		
Black crappie	76	9.50	317	21.13	243	27.00
White crappie	6	.75	29	1.93	8	.89
Bluegill			2	.13	5	.56
Green sunfish	1	.13				
Rock bass			1	.07		
White bass	55	6.88	16	1.07	29	3.22
Largemouth bass						
Smallmouth bass						
Game Fish Total	140	17.52	378	25.2	287	31.89
Percent Game Fish	9.1		25.2		26.3	
Rough Fish						
Carp	1300	162.50	989	65.93	741	82.33
Northern redhorse	22	2.75	29	1.93	13	1.44
Silver redhorse	11	1.38	15	1.00		
Common sucker	7	.88	41	2.73	11	1.22
River carpsucker	1	.13	1	.07	5	.56
Largemouth buffalo			1	.07	2	.22
Smallmouth buffalo						
Sheepshead	17	2.13	28	1.87	7	.78
Black bullhead	22	2.75	15	1.00	20	2.23
Yellow bullhead	1	.13	1	.07		
Brown bullhead					1	.11
Channel catfish	3	.38	3	.20	1	.11
Flathead catfish						
Gizzard shad	11	1.38	2	.13	5	.56
Shortnose gar						
Rough Fish Total	1395	174.41	1125	75.00	806	89.56
Percent Rough Fish	90.9		74.8		73.7	

*Sixteen trapnet sets were made in Spring Lake but one net did not fish properly because of a large hole in the mesh. Data from this net is not included in the netting summary (Skrypek, 1969).

Table 21 (Continued).

	Above Spring L. (7 sets)		Above Minn. R. (8 sets)		Pool Totals (47 sets)	
Game Fish	Number	No./set	Number	No./set	Number	No./set
Northern pike			6	.75	21	.45
Walleye						
Sauger					2	.04
Black crappie	16	2.29	91	11.38	743	15.81
White crappie	4	.57	2	.25	49	1.04
Bluegill	1	.14	3	.38	11	.23
Green sunfish					1	.02
Rock bass					1	.02
White bass	8	1.14	31	3.88	139	2.96
Largemouth bass	1	.14			1	.02
Smallmouth bass			1	.13	1	.02
Game Fish Total	30	4.28	134	16.77	969	20.61
Percent Game Fish	6.0		50.0		19.8	
Rough Fish						
Carp	462	66.0	122	15.25	3614	76.89
Northern redhorse	2	.29	2	.25	68	1.45
Silver redhorse			2	.25	38	.81
Common sucker					59	1.26
River carpsucker					7	.15
Largemouth buffalo					3	.06
Smallmouth buffalo			2	.25	2	.04
Sheepshead	1	.14	3	.38	56	1.19
Black bullhead	8	1.14			65	1.38
Yellow bullhead					2	.04
Brown bullhead					1	.02
Channel catfish					7	.15
Flathead catfish			1	.13	1	.02
Gizzard shad	1	.14	1	.13	19	.40
Shortnose gar			1	.13	2	.04
Rough Fish Total	474	67.71	134	16.77	3934	83.70
Percent Rough Fish	94.0		50.0		80.2	

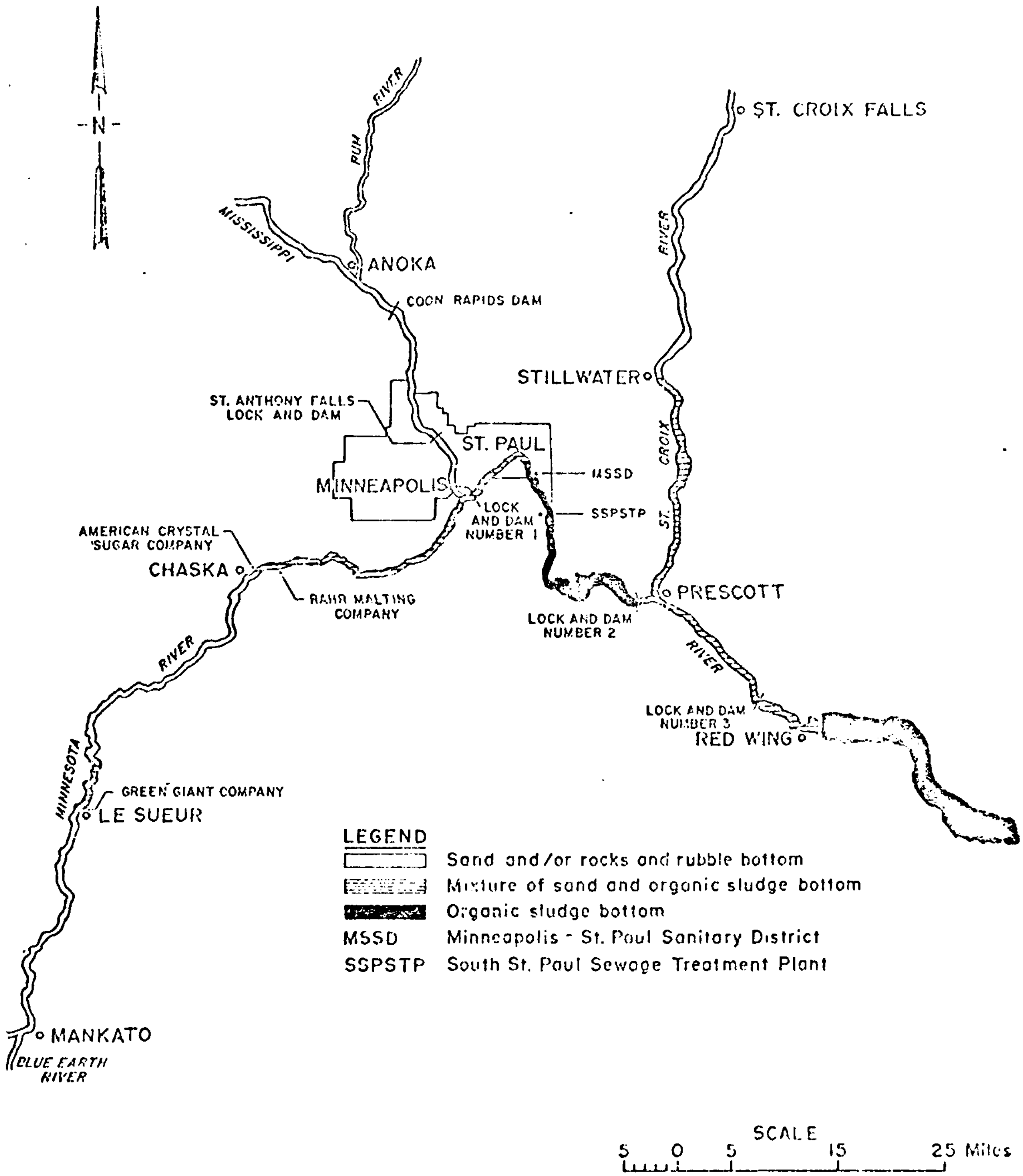


Figure 46. Distribution of Bottom Sediments (FWPCA, 1966)

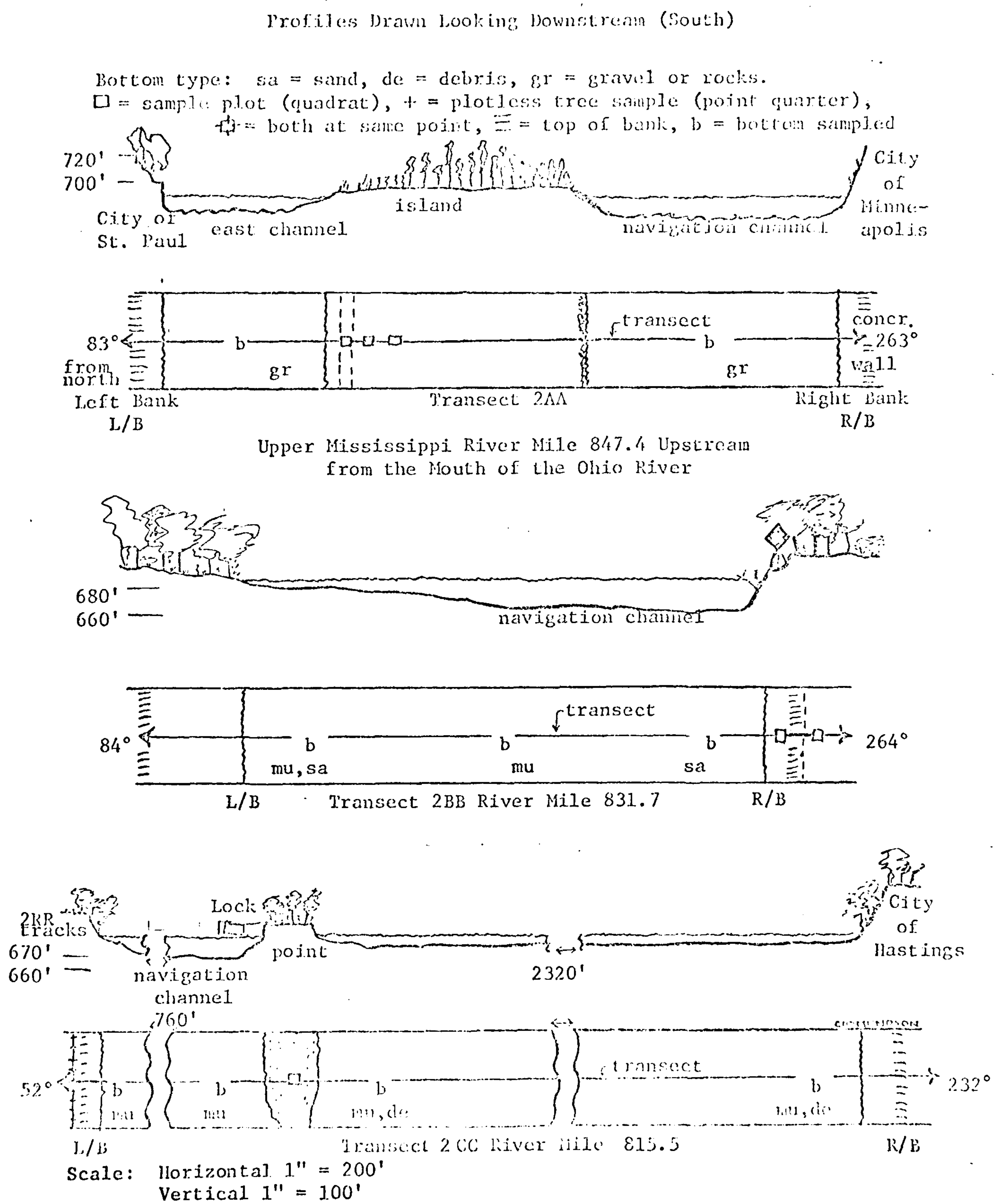


Figure 47. Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in Pool 2 (Gudmundson, 1973).

Table 22. Comparison of Clam Populations Above and Below St. Anthony Falls (Minneapolis) on the Mississippi River and Tributaries (Dawley, 1947)

	Mississippi R. below Minneapolis	Mississippi R. above Minneapolis	St. Croix R.	Minnesota R.	St. Lawrence	Hudson Bay
1. *Fusconaia undata*	x		x	x		
2. *Fusconaia ebenus*	x					
3. *Fusconia 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			x
8. *Quadrula quadrula*	x			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*					x	
17. *Elliptio crassidens*	x			x		
18. *Lasmigona compressa*		x	x		x	x
19. *Lasmigona costata*	x		x	x		x
20. *Lasmigona complanata*	x		x	x	x	x
21. *Anodonta grandis*	x	x	x	x	x	x
22. *Anodonta marginata*		x			x	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	x	x
27. *Alasmidonta marginata truncata*	x		x	x		
28. *Arcidens confragosus*	x			x		
29. *Strophitus rugosus*	x		x			x
30. *Obliquaria reflexa*	x		x	x		x
31. *Obovaria olivaria*	x		x	x		
32. *Actinonaias carinata*	x	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		x
38. *Proptera laevissima*	x		x	x		
39. *Carunculina parva*	x		x	x		
40. *Ligumia recta latissima*	x	x	x	x	x	x
41. *Lampsilis fallaciosa*	x			x		
42. *Lampsilis siliquoidea*	x	x	x	x	x	x
43. *Lampsilis ventricosa*	x	x	x	x	x	x
44. *Lampsilis higginsi*	x		x	x		

	Alida	above Cass Lake	Brainerd	Fort Ripley	Little Falls	Clearwater	Elk River	Dayton	Anoka	Fridley	Nininger*	Red Wing*	Lake City**	Minneiska*	Winona*	Dresbach*
1. *Fusconaia undata*												x	x	x	x	
2. *Fusconaia ebenus*												x	x	x	x	x
3. *Megalonaias gigantea*												x	x		x	
4. *Amblema peruviana*												x	x		x	x
5. *Amblema rariplicata*												x				
6. *Quadrula quadrula*											x	x	x			
7. *Quadrula pustulosa*											x	x		x	x	x
8. *Quadrula metanevra*											x	x	x		x	x
9. *Tritogonia verrucosa*											x	x	x	x	x	x
10. *Cyclonaias tuberculata*												x				
11. *Plethobasus cyphyus*												x		x		x
12. *Pleurobema cordatum coccineum*													x			
13. *Elliptio dilatatus*											x	x	x	x	x	
14. *Elliptio crassidens*												x	x		x	
15. *Lasmigona compressa*	x	x														
16. *Lasmigona costata*												x	x	x	x	
17. *Lasmigona complanata*												x	x	x	x	
18. *Anodonta grandis*		x					x	x	x			x	x			
19. *Anodonta gigantea*												x	x			
20. *Anodonta corpulenta*												x	x		x	
21. *Utterbackia imbecillis*										x			x			
22. *Anodontoides ferussacianus*	x	x														
23. *Alasmidonta marginata truncata*												x			x	
24. *Arcidens confragosus*												x		x		
25. *Strophitus rugosus*												x	x			
26. *Obliquaria reflexa*												x	x	x		x
27. *Obovaria olivaria*												x			x	x
28. *Actinonaias carinata*			x	x						x	x	x		x	x	x
29. *Truncilla truncata*											x	x	x		x	
30. *Truncilla donaciformis*												x				
31. *Plagiolata lineolata*											x	x	x	x		
32. *Leptodea fragilis*												x	x			
33. *Proptera alata megaptera*											x	x	x		x	x
34. *Proptera laevissima*												x	x			
35. *Carunculina parva*													x			
36. *Ligumia recta latissima*		x	x	x	x	x	x	x	x	x		x	x	x	x	x
37. *Lampsilis fallaciosa*												x	x			
38. *Lampsilis siliquoidea*		x	x	x	x	x	x	x	x	x		x	x	x	x	x
39. *Lampsilis ventricosa*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
40. *Lampsilis higginsi*												x				x

* below Minneapolis
** on Lake Pepin

Table 23. Comparison of Hokanson Summer 1964 Data with Summer 1973 Data of Average Number of Benthic Animals (Macroinvertebrates) Per Square Foot at Two Stations on the Mississippi River (Hokanson, 1968; Colingsworth and Gudmundson, 1973)

	Upstream from Twin Cities River Mile 866 and 857		Downstream from Twin Cities Spring Lake Mile 821 (Transect 2YY)			
CLASS Family	Coon Rapids 1964, Mile 866	UAA Camden 1973, Mile 857	Muddy "3A" 1973	Muddy 1964	Muddy "3B" 1973	Sandy "3C" 1964
INSECTA						
Diptera: Ceratopogonidae						6
Chironomidae	80	30	1	6	3	148
Empididae		3				
Simuliidae		3				
Tipulidae		1				
Trichoptera: Hydropsychidae		58				
Psychomyiidae	8					
Coleoptera: Elmidae	2	15				
Ephemeroptera: Baetidae	1					1
Caenidae	6	6				9
Ephemeridae	1	1				
Heptageniidae	12	1				
Leptophlebiidae	1					
Potamanthidae	6	2				
Plecoptera: Perlidae		1				
CRUSTACEA						
Asellidae						3
OLIGOCHAETA	11		5	10	8	55 2
HIRUDINEA						
Glossiphoniidae	1					3
GASTROPODA						
Ancylidae	4					2
TURBELLARIA	4					

Floodplain Lakes

There are eight lakes in the Pool 2 valley, including 1) Upper Lake, 2) Crosby Lake, 3) Pickerel Lake, 4) Pig's Eye Lake, 5) River Lake, 6) Moose Lake, 7) Baldwin Lake, and 8) Spring Lake. Of these, only the first two are isolated from the river proper, except at high water.

Pig's Eye Lake. Pig's Eye Lake is noteworthy because it has two large heron and egret rookeries, extensive pollution inflow, considerable barge traffic, and is St. Paul's Largest lake. Thus, it will be described in some detail (see Figure 48).

It occupies about 511 acres (MNDNR, 1972) depending on the water level of Pool 2, and is connected directly to the Mississippi River by a 12-foot deep barge canal. A barge terminal is located at the end of the lake, near the rookeries. At its upstream end the lake receives effluents from the Metropolitan Wastewater Treatment Plant and probably from seepage from the adjacent solid-waste landfill (see Table 24).

Pig's Eye Lake, which was a large marsh prior to creation of Pool 2, is now a shallow body of water 95 percent of which is less than 4 feet deep.

Submerged and floating flowering plants are generally lacking in Pig's Eye Lake, but emergent vegetation was found on all but the west and northeast shores. River bulrush *(Scirpus fluviatilis)* was judged relatively abundant on the east, west and north shores. The value of this species to waterfowl is light to fair. Cord-grass *(Spartina pectinata)*, of similar value to waterfowl, was common on the east, west and north shores. Arrowhead *(Sagittaria latifolia)* occurred occasionally on the north and south ends. It is of fair value to waterfowl, unlike smartweed *(Polygonum spp.)* which is of good to excellent value but which was only occasionally scattered around the shoreline. The narrowleaf cattail *(Typha angustifolia)*, a species indicative of disturbed

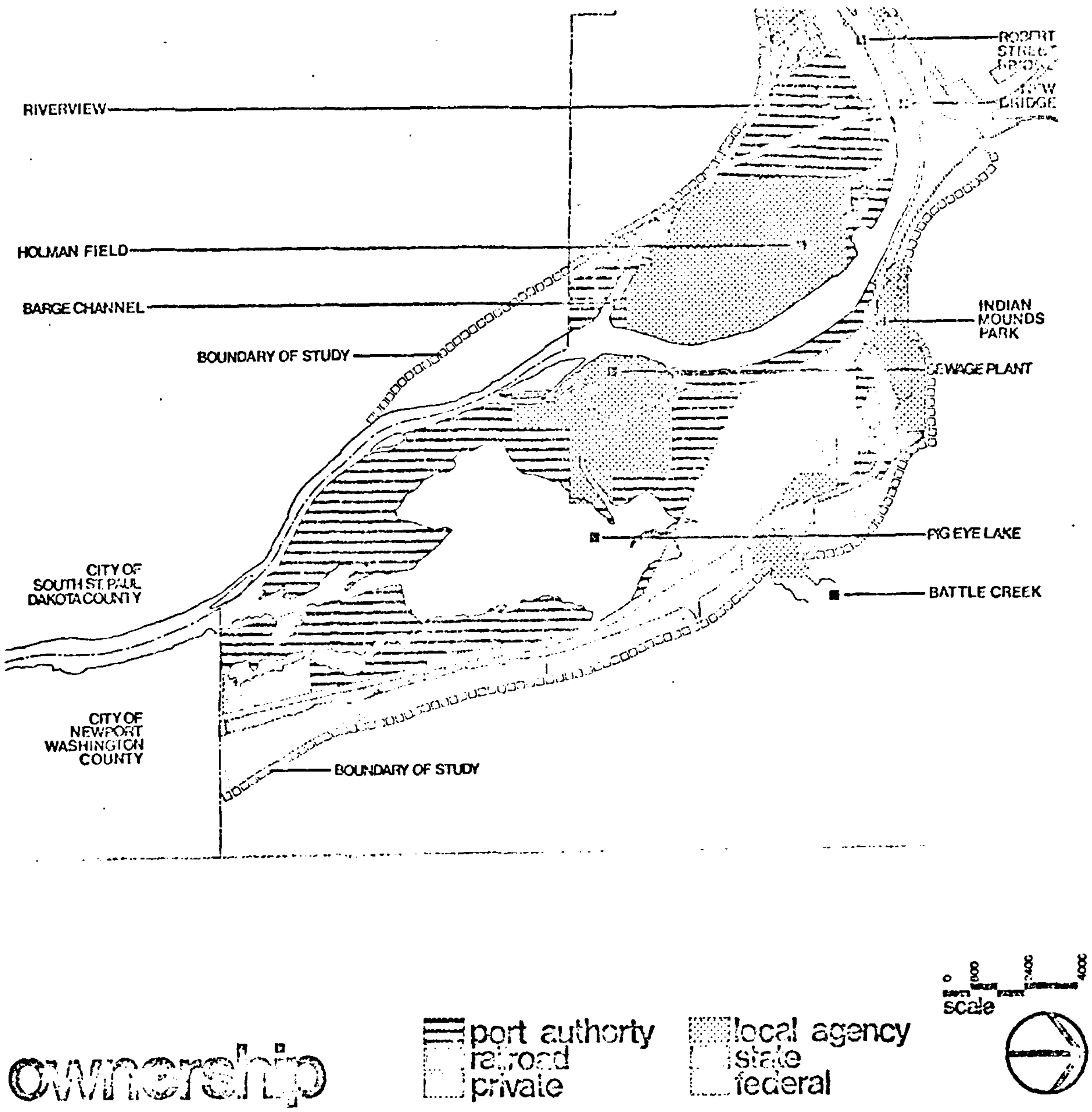


Figure 48. Map of Pig's Eye Lake Area, Showing Ownership of River-Related Land (Eckbo, et al., 1970)

Table 24. Water Quality Parameters of Pig's Eye Lake, 1972 (MNDNR, 1972)

Laboratory Tests		
Sulphate ion ($SO_4^=$)	120	ppm
Total phosphorus	0.486	ppm
Soluble phosphorus	0.24	ppm
pH	8.25	
Chloride ion (Cl^-)	54.5	ppm
Total alkalinity	116	ppm
Ammonia nitrogen (NH_3-N)	0.43	ppm
Nitrite nitrogen (NO_2-N)	---	
Nitrate nitrogen (NO_3-N)	0.057	ppm
Total nitrogen	2.85	ppm
Field Tests		
Secchi disk readings*	9	
Maximum	0.7	feet
Minimum	0.5	feet
Average	0.6	feet
Water color*	Green	

*Cause of turbidity and color was a bloom of blue-green algae.

conditions, occurred occasionally at the south end of the lake. Generally, emergent vegetation was found on all but the west and northeast shores. River bulrush was the major emergent species, but there were some sizable stands of smartweed and arrowhead.

The Department of Natural Resources (MNDNR, 1973) survey noted less than one percent occurence of submerged vegetation. The greatest depth to which rooted, submerged plants grew was 2.5 feet. Sago pondweed *(Potamogeton pectinatus)*, which is of excellent food value to waterfowl, was sparsely distributed along the west shore. The lesser duckweed *(Lemna minor)* was occasionally present at the north end. Also of fair to excellent value to waterfowl is the greater duckweed *(Spirodela polyrhiza)* which was scarce, present only at the north end of the lake.

The general sparseness of vegetation in Pig's Eye Lake seems unusual in view of the shallow water and the potential high fertility of the lake as indicated by the high concentrations of nutrients in the water. Two possible causes are (1) chemical concentrations (or toxicants) are so high as to be limiting or (2) the turbidity. For instance, high sulfate concentrations may have a significant effect on plankton plants and animals. (Moyle, 1956). The latter may be caused at least in part by algal blooms, barge and other water-borne traffic and wind.

The turbidity of the water is often very high because of blooms of blue-green algae. Experience in management of southeastern fish ponds indicates that large phytoplankton populations and heavy stands of aquatic vegetation are incompatible and that the heavy algal blooms are detrimental to rooted vegetation. Because blooms of blue-green algae are often caused by pollution, the general lack of aquatic vegetation is then probably caused by a combination of pollution damaging the plants in one, or all, of several ways, and competition by phytoplankton.

The Department of Natural Resources has made no fishery survey of Pig's Eye Lake, although there were investigations of fish kills in 1941 and 1947. The lake is connected to the river with no barrier to fish movement; thus, many kinds of fish common to this section of the river (perhaps up to 25) may be found in the lake. Carp were sighted throughout the lake during the 1972 survey.

The overall habitat for waterfowl was described as poor in the Department of Natural Resources report because of the lack of emergent vegetation and the existence of pollution. Although no official waterfowl population studies were made, the survey crew recorded waterfowl seen on 27 June and 3 July 1972.

They included:

Species	Number of Adults	Number of Broods*
Mallard	27	2 (?) (?)
Blue-winged teal	7	2 (6) (4)
Wood duck	1	1 (5)
Hooded merganser	1	1 (11)
Coot	12	

*Number of ducklings in brood in parentheses.

The sparse emergent vegetation in the lake in general limits waterfowl habitat for over-water brood cover. The emergent stands of vegetation along the shoreling, however, do provide good escape cover for broods of dabbling ducks; however, the numbers of waterfowl resting sites vary. For instance, at low water, numerous logs and exposed mud flats provide ample resting sites along the shore.

Muskrats were seen by the survey crew along the south and north shores. Generally, the crew considered conditions for muskrats to be poor because of the large annual fluctuations in water level and the limited amount of emergent vegetation. Nevertheless, trapping for furbearers is done near the lake. The trapping pressure on muskrat and mink is considered by the DNR to be heavy, and the success, fair. There is no hunting in the area because the lake is within the city limits of St. Paul and is closed to hunting.

The 1972 DNR survey notes that there are two Type IV deep marshes of about 100 acres within a mile of Pig's Eye Lake. These probably provide additional feeding sites for waterfowl and furbearers.

Prior to industrial development near the lake, a few people were reported to have fished the lake, but their success and the species of fish caught are unknown. The lake has apparently not been fished in recent years.

Threatened Species

Several lists of threatened (rare and endangered) plants and animals have been compiled. These lists of threatened species include species protected legally or other nonprotected species whose populations are known to be or are suspected of being dangerously low, either locally or nationally. Species rare locally but not in adjacent states, that is, species at the limit of their geographic range, are included in some lists. This inclusion serves to encourage maintenance of a broad genetic (breeding) pool to help ensure survival of the species. The inclusion of these species also serves to encourage the maintenance of a broad diversity of plants and animals for all persons to enjoy.

The variety of lists of threatened species is attributable to two difficulties which are encountered in compiling such lists. The first difficulty is the definition of a threatened species; *i.e.*, at what population size and survival rate (birth rate versus death reate) does a species population become in danger of extinction? Secondly, there is a lack of specific information on the current population size and breeding success of many species.

Plants. A list of rare and endangered plants in Minnesota was compiled by the Minnesota Department of Natural Resources (MNDNR, 1971). This list contains a total of ten plant species, including five plants found in moist prairies, three plants found in open hardwoods, and two plants found in the northern conifer forests (Table 25).

Morley (1972) compiled an extensive list of threatened plant species in several categories. His list of plants legally protected in Minnesota includes

Table 25. Rare and Endangered Plants of Minnesota (MNDNR, 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
	Grazing 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

all species of the orchid family; all species of lily, trillium and gentian; and trailing arbutus (see Table 26).

A second category in Morley's list included those plants rare in Minnesota and all of North America; a total of four plants. One of these species, the Minnesota trout-lily or adder's toungue, is found nowhere else but in Minnesota.

Table 26. Rare or Endangered Plants of Minnesota with the Counties in Which They Have Been Found (Nature Conservancy - Morley, 1972)

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.

Morley included a third category containing 252 plants which are rare in Minnesota but are more or less abundant in adjacent regions. A total of 36 of these species are found in one or more of the following Metropolitan Counites: Hennepin, Ramsey, Washington, Dakota and Scott (Table 27).

Moreley's fourth category includes those plants typical of our native grasslands. This list includes 122 plant species. The native grassland habitat is the "most poorly represented (in the University Herbarium) and in greatest danger of eradication in the state". A more detailed study is urgently needed to determine if the drier portions of the spoil banks do harbor these threatened plants, or if, not, then to determine the potential of the spoil sites to provide a refuge for native grassland plants.

Animals. Barthelemy's (1971) list (see Table 28) includes thirty-six rare and endangered animals, including three reptiles and amphibians, 29 birds, and one mammal. Of these, the sandhill crane, osprey and American (common) egret occur in the Twin Cities area. The osprey and American egret were sighted in the 1973 field studies.

The list of rare and endangered species compiled by the U.S. Fish and Wildlife Service (1970) includes two mammals, four birds and one fish (See Table 29). Although Pool 2 is within the geographic range or migration of these species, none are likely to occur in Pool 2 because of the lack of secluded habitat and a small population of the species.

Table 27. Plants Rare in Minnesota but More or Less Abundant in Adjacent Regions (Morley, 1972).

PLANTS	FOUND IN (COUNTY)
Angiosperms; Flowering Plants	
Alismataceae; Water Plantain family	
Sagittaria graminea, grass-leaved arrowhead	Ramsey, Washington, St. Louis
Araceae; Arum family	
Arisaema dracontium, Green dragon, dragon root	Dakota, Winona, Houston
Araliaceae; Ginseng family	
Panax quinquefolius, ginseng	Once widespread from Houston to Jackson to Mille Lacs to Washington Counties, now nearly exterminated by herb-hunters
Campanulaceae; Bluebell family	
Specularia leptocarpa, western Venus' looking-glass	Ramsey
Caryophyllaceae; Pink family	
Stellaria alsine, chickweed	Ramsey, Winona
Cistaceae; Rock-rose family	
Helianthemum canadense, frostweed	Fillmore, Houston, Winona, Washington
Compositae; Sunflower family	
Coreopsis tinctoria, golden coreopsis	Blue Earth, Hennepin, Ramsey
Convolvulaceae; Morning-glory family	
Cuscuta polygonorum, smartweed dodder	Freeborn, Hennepin
Cruciferae; Mustard family	
Arabis laevigata, smooth rock cress	Clearwater, Todd, Hennepin, Houston
Cyperaceae; Sedge family	
Carex formosa	Ramsey
Carex plantaginea	Hennepin, Winona
Scleria triglomerata, tall nut-rush	Anoka, Hennepin, Ramsey
Scleria verticillata, low nut-rush	Blue Earth, Dakota, Hennepin, Scott
Droseraceae; Sundew family	
Drosera linearis, slender-leaved sundew	Hennepin
Gramineae; Grass family	
Echinochloa walteri, cockspur grass	Wabasha, Washington
Juncaceae; Rush family	
Juncus articulatus, jointed rush	Ramsey

Table 27 (Continued).

PLANTS	FOUND IN (COUNTY)
Angiosperms; Flowering Plants	
Leguminosae; Pea family	
Astragalus ceramicus, rattle-pod	Ramsey
Lythraceae; Loosestrife family	
Decodon verticillatus, swamp loosestrife	Anoka, Chisago, Hennepin
Najadaceae; Naiad family	
Najas olivacea, bright-green naiad	Anoka, Ramsey
Onagraceae; Evening primrose family	
Gaura biennis, biennial gaura	Hennepin Houston
Potamogetonaceae; Pondweed family	
Potamogeton diversifolius, Rafinesque's pondweed	Anoka, Ramsey
Rosaceae; Rose family	
Rubus folioflorus, blackberry	Ramsey, Washington, St. Louis
Rubus latifoliolus, blackberry	Isanti, Ramsey
Rubus rosendahlii, Rosendahl's blackberry	Ramsey
Rubus semisetosus, blackberry	Anoka, Ramsey
Rubiaceae; Madder family	
Galium verum, yellow bedstraw	Hennepin, Lac Qui Parle, St. Louis
Scrophulariaceae; Figwort family	
Aureolaria pedicularia, false foxglove	Hennepin, Washington, Houston
Besseya bullii, besseya	Dakota, Goodhue, Hennepin, Ramsey, Scott, Washington
Gerardia auriculata, auricled gerardia	Blue Earth, Dakota, Nicollet
Gerardia gattingeri, Gattinger's gerardia	Nicollet, Wabasha, Winona, Washington
Gerardia purpurea, large purple gerardia	Hennepin
Solanaceae; Potato family	
Solanum triflorum, cut-leaved nightshade	Clay, Hennepin
Umbelliferae; Parsley family	
Hydrocotyle americana, American marsh pennywort	Chisago, Washington, Houston
Verbenaceae; Vervain family	
Verbena simplex, narrow-leaved vervain	Fillmore, Rock, Scott
Xyridaceae; Yellow-eyed grass family	
Xyris torta, slender yellow-eyed grass	Anoka, Hennepin

Table 28. Rare and Endangered Plants, Amphibians, Reptiles Birds and Mammals in Minnesota (Barthelemy, 1971)

Plants

Lotus americana, birdsfoot-trefoil
Mammilaria vivipara, cactus
Opuntia humifusa, prickly pear cactus

Amphibians

Cricket frog
Red-backed salamander
Common newt

Reptiles

Blue-tailed skink
Wood turtle
Blanding's turtle

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

Mammals

Star-nosed mole

Table 29. Rare and Endangered Animals of the Upper Mississippi River Basin (FWS, 1970)

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.

Land Use

Extensive residential, institutional and commercial developments now claim the bluff top and floodplain in Pool 2 upstream from St. Paul Park (Mile 829.0 to Lock and Dam 1, see Figure 49). Urban development along the 5.5-mile reach from Lock and Dam 1 to Lilydale is, however, partially screened by vegetation and high bluffs. Downstream from St. Paul Park (Mile 829.0 to Lock and Dam 2) the bluffs and floodplain only occasional residential or industrial sites interrupt the floodplain and bluff slope woodlands (see Figures 50 and 51).

Figure 49. Land Use Along the Mississippi River in Pool 2, Looking Upstream Toward the St. Paul Barge Terminal from the Metropolitan Sewage Treatment Plant (lower right) (Colingsworth, 1973)

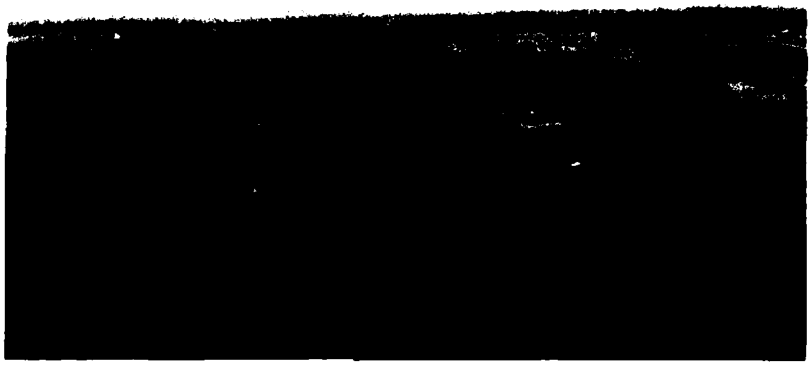


Figure 50. Aerial Southeast of Lower Grey Cloud Island Showing J.L. Sheily Nelson Plant and Barge Terminal (Colingsworth, 1973)

Figure 51. A Residential Area in the Town of Cottage Grove on the East (left) Bank of Pool 2 Near Lower Grey Cloud Island (Gudmundson)

The present land-use pattern of all major rivers in the Twin Cities has been inventoried and mapped by the Metropolitan Council (1970a), and for the St. Paul waterfront by Eckbo, *et al.*,(1970, see Figure 52). Thus, the view of Pool 2 from the river is urban from Lilydale downstream to South St. Paul; and generally rural from Lock and Dam 1 to Lilydale and from South St. Paul to Lock and Dam 2. This rural view from the river creates the illusion that the Mississippi is part of a scenic wilderness setting, rather than dominated by a large metropolitan area. This illusion, particularly between Lilydale and Lock and Dam 1, is a significant amenity and therefore an important consideration in the present and potential recreational use of the river valley in the Twin Cities area.

The importance of Pool 2 to the commercial navigation system, and the industries it serves in the Twin Cities, is reflected in part by the number of barge terminals. Of the 55 barge terminals in the metropolitan area, 34 (or 62 percent) are located in Pool 2 (Twin City Barge and Towing Co., Inc. undated). Half of these terminals are located between St. Paul Park and Lilydale, or an average density of one terminal per half mile.

The view of this urban reach of Pool 2 is not altogether displeasing. For instance, the reflection at night of lighted downtown St. Paul from the river at the south end of Holman Field can be spectacular. By daylight, however, the view is degraded by riverbanks crowded with buildings, barge terminals, and stockpiles of scrap metal and aggregate, unshielded by trees, vines or shrubs, and petroleum tank farms; by sterile levees and floodwalls; and by rusty dull brown hulks of barges at fleeting areas and barge-cleaning facilities.

While some of the buildings are freshly painted, much more could be done to improve the appearance of present land use practices merely by planting a screen of native vegetation along the riverbank, painting the barges and remaining buildings either in attractive colors or in green to blend with adjacent vegetaion.

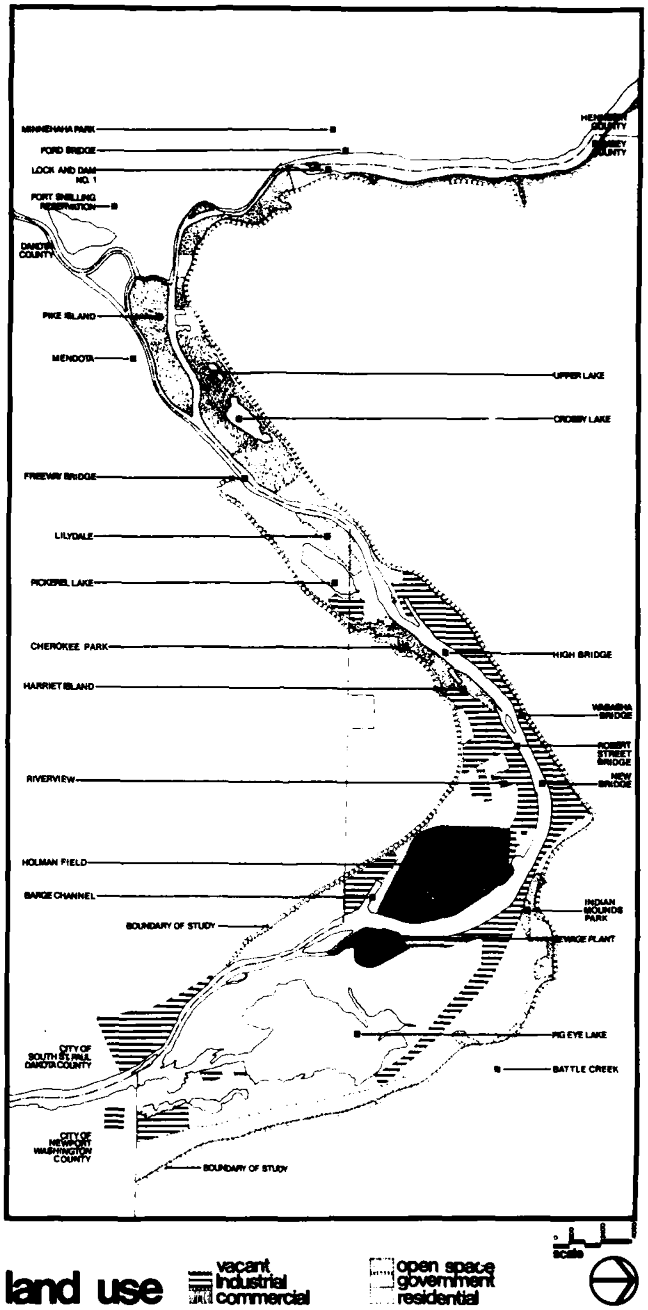


Figure 52. Land-Use Inventory of Pool 2 from Pig's Eye Lake to Lock and Dam 1 (Eckbo, et al., 1970)

Many of the urban developments fronting the river and on the nearby watershed, the spoil sites resulting from channel maintenance, as well as the urban and agricultural activities on the Minnesota River, are important sources of sediment, nutrients and other pollutants entering this reach of the Mississippi. Eighteen sites with bare soil have been identified along the river bank in Pool 2, apparently associated with these urban developments or 9-foot channel maintenance (see Table 30).

The annual increase in tons of goods shipped by river (see Socioeconomic 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 3000 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 probably will be devoted to highway construction, such as I-494, I-35W, I335, and I-94.

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

Evidence of this need was indicated in 1967 when a survey showed only about 1/10 to the 310 miles of shoreline 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.

Table 30. Bare Soil Sites Along the Riverbank in Pool 2 from April 1971 Aerial Photo for Flood Plain Information and Management Report (MNDNR, Corps of Engineers and USGC)

River Mile	Bank	Location
847.5	L	Fill downstream from Ford heating plant
845	L	At Watergate marina, between boat harbors
844.7	R	Head of Pike Island
843.4-5	R	Construction? Shiely
841.5	R	Construction, downstream end of Pickerel Lake next to river
841.0	L	Peninsula below NSP Peaking Plant
838.7-837.5	R	St. Paul flood levee
838.5-836.5	R	Airport area
	L	Barge terminal area
835.9	R	Downstream edge of scrap metal yard
833.5-.2	R	South St. Paul levee
829.6	L	St. Paul Park marina
827.1-.6	R	Islands & shore at upper end of River Lake
826.5	L	Shiely Quarry on Upper Grey Cloud Island
825.5	L	Upper end Baldwin Lake, on river side
824.9	L	3 spoil sites, in mid-Baldwin Lake (enlargement of existing island)
823.8	L & R	Area on Mississippi, also N E side Baldwin Lake. Also Shiely sand-gravel pits on lower Grey Cloud Island
823.2	R	South Shore, upper end Spring Lake Construction?

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.

Under present plans the St. Paul parks system will eventually include all floodplain and bluff slopes in Pool 2 downstream to Holman Field, except Watergate marina, Lilydale and the barge terminals. Further acquisitions are planned near Battle Creek and Holman Field.

Proposed development of the Pool 2 river valley in St. Paul will result in a small reduction in residential and government lands and a total elimination of vacant land (see Table 31). Concomitantly, open space will increase by 29 percent, to a total of 2961 acres, and industrial sites by 17 percent, to a total of 2558 acres out of a total of 6494 acres of river valley in St. Paul.

Table 31. Existing and Proposed Land Use (approximate acreages) in Pool 2 at St. Paul (Eckbo, *et al.*, 1970)

		Acres Existing		Change	Total Proposed	
Residential	Lilydale	90		- 90	0	
	Pt. Douglas Road	355			355	
	Total	455	7%	- 90	355	5.5%
Government	Holman Field	550		- 190	360	
	Sewage Treatment plt	100		+ 145	245	
	Total	650	11%	- 45	605	9.5%
Vacant	Ford Motor Co.	28		- 28	0	
	Holiday Marina Area	40		- 40	0	
	Lilydale	290		- 29	0	
	West Side	180		- 180	0	
	Riverview	255		- 255	0	
	Pt. Douglas Rd.	360		- 360	0	
	Southport	75		- 75	0	
	Pig's Eye Lake (including Newport)	1024		-1024	0	
	South St. Paul	320		- 320	0	
	Total	2572	43%	-2311	0	
Industrial	Twin City Brick	35		- 35	0	
	West Side	210		+ 35	245	
	Riverview	300		+ 240	540	
	Railroads & yards	350		- 50	300	
	Southport	25		+ 225	250	
	Barge Terminal #1	63		0	63	
	New Barge Channel	0		+ 280	280	
	Pig's Eye Lake Area (including Newport)	140		+ 350	490	
	South St. Paul	220		+ 170	390	
	Total	1343	22%	+1215	2558	39%
Open Space	Riverside Park	200		+ 68	268	
	Pike Island	232		0	232	
	Crosby Lake Park	344		+ 145	480	
	Cherokee Park & Lilydale	67		+ 380	447	
	Harriet Island	62		0	62	
	Shepard Rd.			+ 5	5	
	Indian Mounds Park	73		0	73	
	Battle Creek Park (Pt. Douglas Rd)	15		+ 360	375	
	Pig's Eye Lake Area (Including Newport)	0		+ 860	860	
	South St. Paul	0		+ 150	150	
	Total	993	17%	+1963	2961	46%
Commercial	Riverside Center			+ 15	15	
	Total	___		+ 15	___	100%
	GRAND TOTAL	6003*	100%	+ 491	6494*	

*Acreages are approximate and total acreages differ since no bodies of water are included in these figures and filling and dredging is a part of the plan.

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 in Pool 2 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 consideration.

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, lock and dam operations, 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 Mississippi 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 Mississippi 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 pool on the Mississippi River. Where such data are available--such as pleasure boat lockages--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 by lock and dam attendants are taken as a measure of fishing activity in the pools, 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 Pool 2 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 9-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 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 use the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the entire Mississippi River valley is intensively used to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It was 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 Upper Mississippi was 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 river could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats could pass 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, 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 United States 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 1906 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.

Both 4.5- and 6-foot channels had been authorized because of the increasing role of river transportation. Later, more powerful towboats were built which could push barges of larger cargo capacity. These barges were both longer and of deeper draft, so a 9-foot channel to Minneapolis was authorized in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to the Corps' activities. For example, the following factors complicate the problem of data analysis during the period 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 better methods of statistical collection.

2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's because of the construction of locks and dams in the St. Paul District.

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

Barge Shipments. Table 32 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

In more recent years, data are available for the St. Paul District. Table 33 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

When Table 33 is compared with Table 32, 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, a war year.

Table 32. River Shipment from 1920 Through 1945
(OCE, 1920 to 1945)

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.

Table 33. River Shipment from 1962 Through 1971
(S.P.D.-NCS)

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	15,423,713
1972**	16,361,174

* Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U. S. Army Engineer District, St. Paul, Minnesota

** Estimated

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 caused, to a large degree, by grain shipments from the District and by 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 9-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 34 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

Pool 2 contains 31 commercial docks which handle a wide range of products. This pool is both a point of origin and destination for barge traffic and a "thoroughfare" for shipments to and from Pool 1 and the St. Anthony Falls navigation area.

Figure 53 shows that the growth in commercial lockages between 1960 and 1972 increased by about 600. This is consistent with growth in most of the other pools except through Locks and Dams above Pool 2 which were just coming into use.

Table 34. River Trips in 1971
(WCSC, 1971)

Transportation Mode	Upbound	Downbound
Self-propelled		
Passenger and dry cargo	1,900	1,875
Tanker	3	2
Towboat or Tugboat	8,433	8,419
Non-self-propelled (barge)		
Dry cargo	25,250	25,237
Tanker	7,312	7,311
TOTAL	42,898	42,844

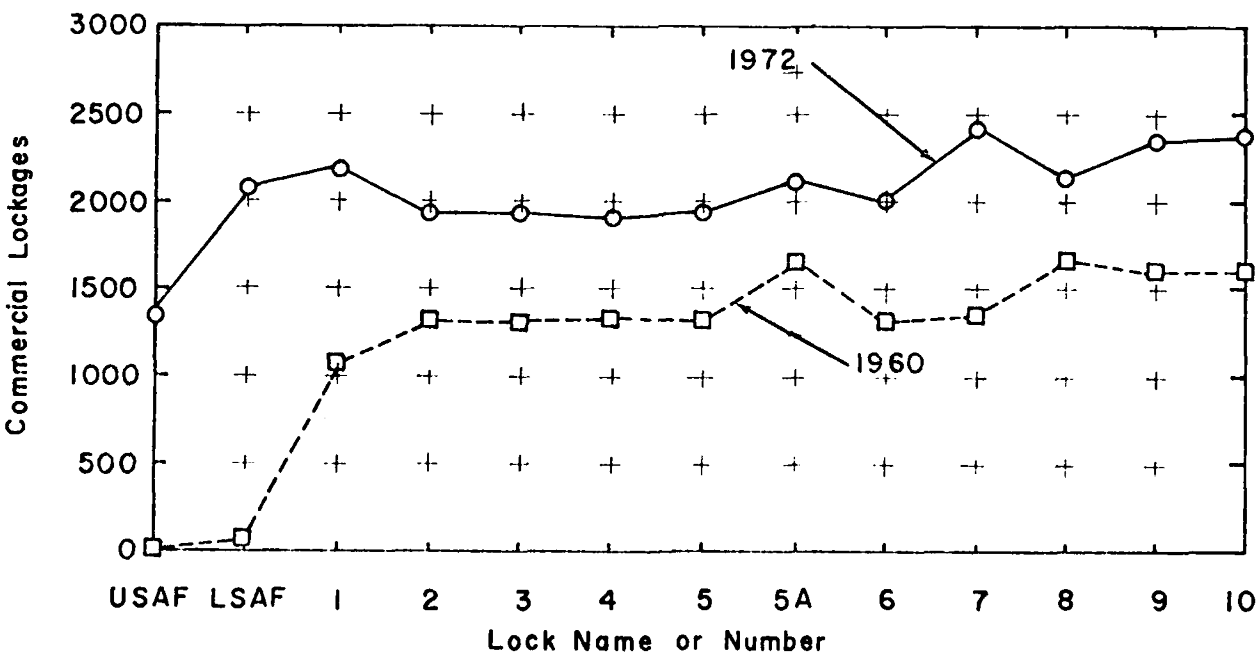


Figure 53. Commercial Lockages in Upper Mississippi River in 1960 and 1972 (S.P.D. - NCS, 1960 and 1972)

The shipping season for most of the Mississippi River within the St. Paul District is usually eight months, from mid-April to mid-December, although the release of heated water from St. Paul power plants allows intrapool shipping in the upper reaches of Pool 2 throughout most years. 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, 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 and crushed rock. The facilities vary appreciably with individual pools. 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. Presently, there is little, if any, commercial fishing in Pool 2.

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.

Data on commercial fishing in the 1960's in the pools in the study area are shown in Figure 54. No commercial fishing occurs in the St. Anthony Falls Pools and Pool 1; and almost none occurs in Pool 2.

There is a tendency not to fish the water of Pool 2 downstream from the Metropolitan sewage treatment plant. This is due, in large measure, to the pollution in this pool from the sewage treatment plant and other urban and industrial effluents which are thought to taint the flavor of the fish and may involve some risk to health from pathogenic organisms.

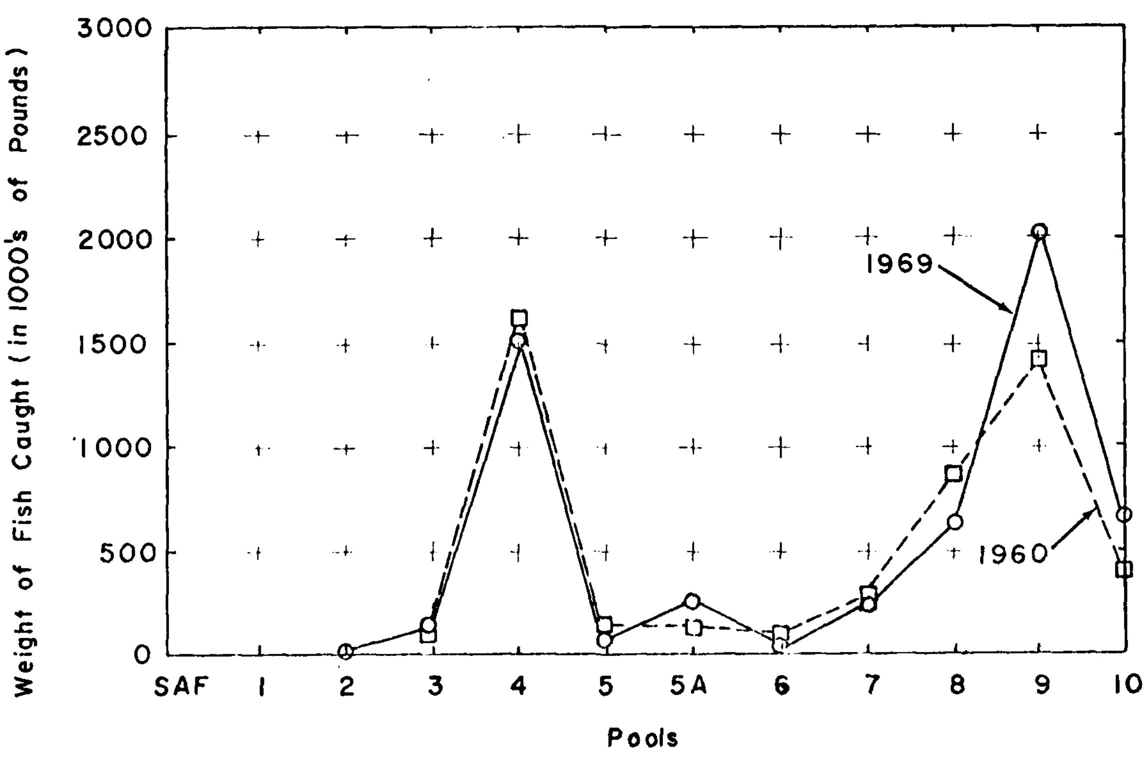


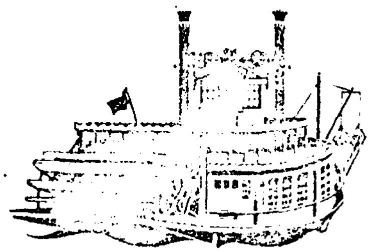
Figure 54. Thousands of Pounds of Fish Caught Annually by Commercial Fishermen in Upper Mississippi River Pools in 1960 and 1969 (UMRCC, 1962-1971)

Recreational Activity

In addition to the industrial activity described above, the Northern Section of the Upper Mississippi River has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4.5-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 enjoy visitors across and up and down the corridor. 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, the small amount of leisure time accompanying the settlers' higher standard of living led to recreational uses of the Upper Mississippi River. Problems are encountered in segregating present-day recreational uses originating from the Corps' operations from those existing prior to the 9-foot channel. These problems arise because of the difficulty of isolating the increased recreational uses of the river from the uses caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi is caused by (1) the improved navigation opportunities for large pleasure craft on the river, and (2) extended fish and muskrat habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not in Pool 2 because hunting is not allowed in the urban area, and because increased population and industrialization along the river has polluted the river and has reduced the available access areas.



One element of river recreation in Pool 2 which is almost unique is the sternwheeler "Jonathan Padelford", a shallow-draft steel-hull excursion boat, with a capacity of over 200 passengers. It plies up and down the river between Harriet Island, Fort Snelling, and the St. Paul Barge terminal at Mile 837.

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-draft pleasure boats--is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 55 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972.

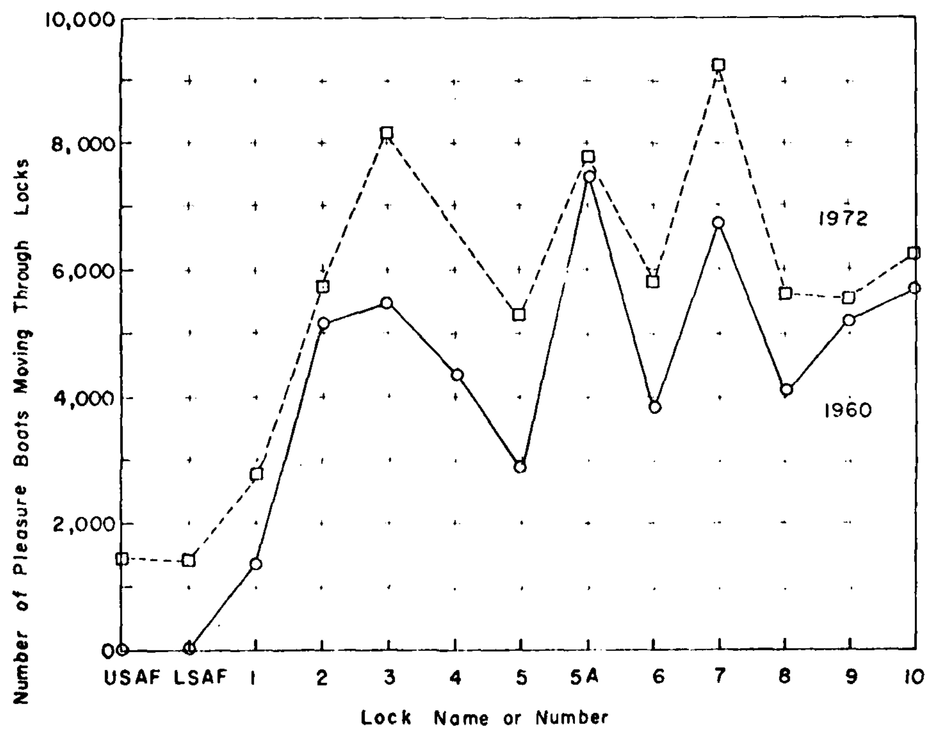


Figure 55. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972 (S.P.D.-NCS, 1960 and 1972)

The figure shows that number of pleasure boats moving through each lock in the study area increased by an average of about 1500 boats during the 12-year period. It can be seen that the number of pleasure boats moving through Locks 1 and 2, those at each end of Pool 2, increased by about the average for the District during this period.

Table 35 shows the eight public use facilities boardering Pool 2. Seven other sites include Indian Mounds Park (City of St. Paul), Cherokee Heights Park (City of St. Paul), Battle Creek Park (St. Paul), Hilary Path (MNDNR), Katherine Ordway Nature Center (Macalester College), and Watergate, Jolly Roger and Hidden Harbor marinas (all privately owned).

Thus, of these 15 sites, one is owned and managed by the Corps of Engineers, one by the State of Minnesota and eight by municipalities. Four sites are privately owned. The sites offer a wide range of facilities and appeal to a wide range of interests including sports, historical, and ecological. One site is accessible only by boat, and several have no direct access to the Mississippi.

Sport Fishing and Hunting. Precise measures of the number of sport fishermen using a specific pool 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. Probably the best data available are the number of sport fishermen observed annually by attendants at lock and dam sites. Attendants to each lock and dam observe the river pool areas above and below their site at 3:00 p.m. each day and record the number of sport fishermen seen; the annual data are simply a sum of these daily estimates.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 56 for the years 1960 and 1970. There has been little change during the ten-year period of the number of sport fishermen observed. Because fish tend to seek water with a high

Table 35. Major Existing Public-Use Facilities, Pool 2 (S.P.D.-NCS, 1973)

Site	River mile Bank	Facilities developed by	Land managed by	Landowner	Boat launching ramp: Number of lanes	Boat launching ramp: Surface	Parking at ramp: Number of spaces	Parking at ramp: Surface	Number of acres	Other facilities or remarks
Buck Islands	816.0 Middle	Primitive	Corps of Engineers	Corps of Engineers	0	-	-	-	55	The small islands are accessible by boat only. The area is in primitive condition.
St. Paul Yacht Club	839.7 R	City of St. Paul	St. Paul Yacht Club	City of St. Paul	1	Blacktop	150	Gravel	-	The public is permitted to use the facilities for a fee ($1). Parking is available in an adjacent city lot. Fuel, water, ice, slips, restrooms, electricity, hoist.
Harriet Island Park	840.1 R	City of St. Paul	City of St. Paul	City of St. Paul	2	Blacktop	50	Gravel	62	Park facilities are available adjacent to the Harriet Island ramp.
Lilydale Marine and Marina	842.5 R	Mr. Wayne Brown	Mr. Wayne Brown	Mr. Wayne Brown	3	Gravel	10	Gravel	67	Fuel, picnic supplies, picnic area, slips.
Crosby Lake Farm	843.0 L	Primitive	City of St. Paul	St. Paul Port Authority	0	-	-	-	410	City of St. Paul Department of Parks and Recreation is currently studying this area for inclusion in its park system. The area is available for use but is undeveloped as yet. Woods and low marshland make up the majority of the area.
Fort Snelling State Historical Park	845.5 R	State of Minnesota	State of Minnesota	State of Minnesota	1	Gravel	412	Gravel	2,500	Fort Snelling was the first military post in the area, founded in 1819, and includes Pike Island. There are picnic areas, trails, a spring-fed swimming beach, and restored portions of the original fort available for recreationists.
Riverside Park	845.7 L	City of St. Paul	City of St. Paul	City of St. Paul	1	Natural ground	5	Natural ground	129	Riverside Park includes Hidden Falls and Hiawatha Parks. There are picnicking facilities, trails, scenic falls, and a paved access road available.
Minnehaha Falls Park	847.1 R	City of Minneapolis	City of Minneapolis	City of Minneapolis	0	-	-	-	171	The falls in this park are the ones made famous by Longfellow's poem. Above the falls are statues of Hiawatha and Minnehaha. There are picnicking facilities, trails, scenic falls, and paved public access roads.

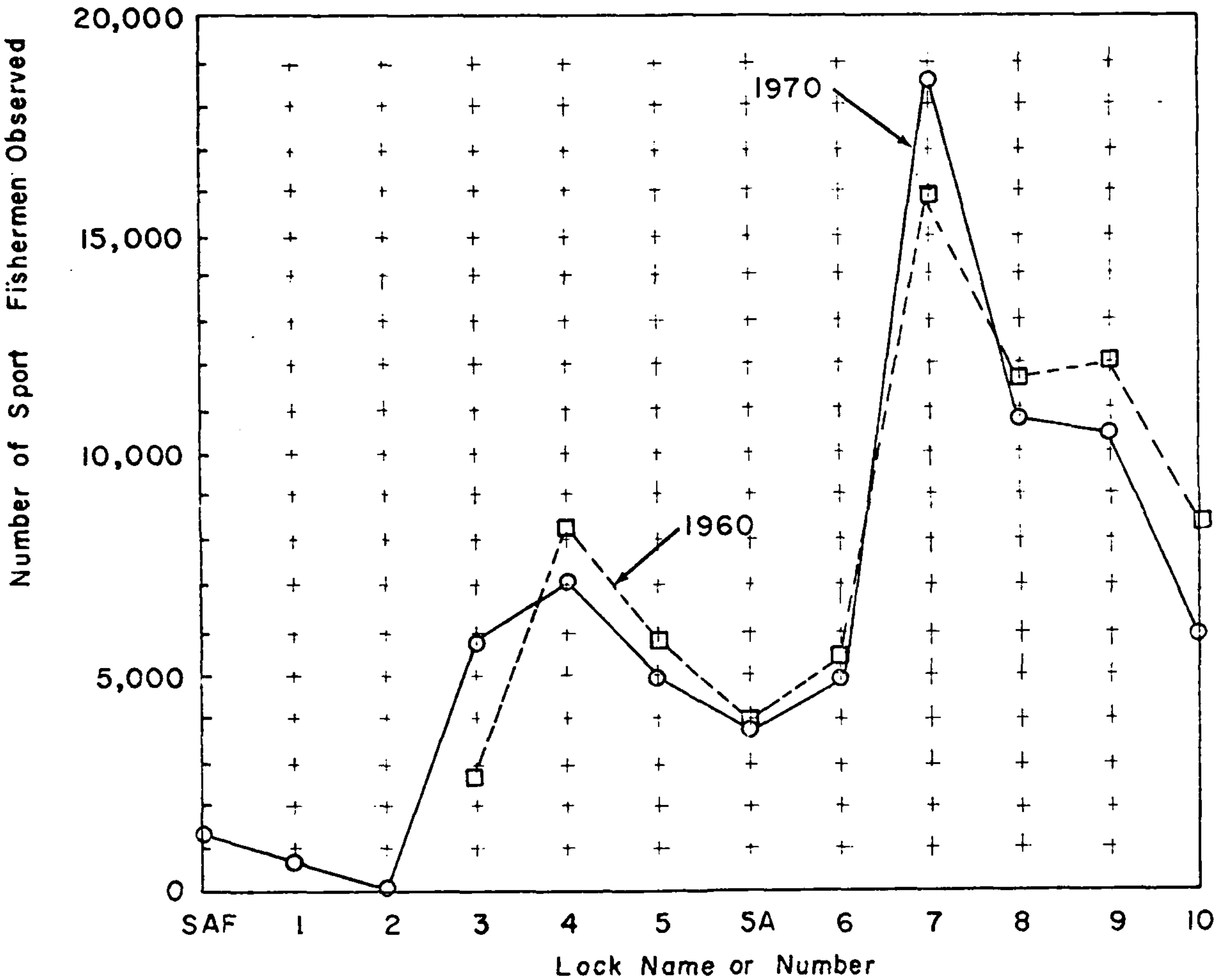


Figure 56. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites on the Upper Mississippi River in 1960 and 1970 (UMRCC, 1962-1971)

proportion of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in Figure 56 are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figures shows that in 1970 the largest of sport fishermen were observed from Lock and Dam 7, followed by Lock and Dam 8 and 9.

The small number of fishermen observed from the Lock and Dam at either end of Pool 2 (1,2) can be attributed to the actual pollution or fear of pollution in Pool 2. As mentioned above, fish from this pool are thought to taste tainted by many people.

Sport hunting of waterfowl along other parts of the Mississippi River study area is large. However, local ordinances limit use of urban areas of Pool 2 for hunting. Some trapping activity occurs around the Grey Cloud Island area.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreational 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 residents and visitors for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of the Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area. In addition, there are ten parks, preserves and nature areas along the river that are available for sightseeing and other recreational activities.

There has never been a systematic and continuous effort to determine the actual number of visitors throughout the river valley of the Pool 2 area. Table 36 presents the only visitor data avialable and is based upon spot-checks and sample counts made by 1963 by the Corps of Engineers (S.P.D.-NCS, 1973).

Table 36. Entire Pool 2 Visitation, 1963
(S.P.D.-NCS, 1973)

Activity	Annual 1963 Percent of total	Annual 1963 Number partic- ipating	Peak Month (July) Percent of total	Peak Month (July) Number partic- ipating
Camping	0	0	0	0
Picnicking	22.7	5,600	27.1	2,020
Boating	13.4	3,300	10.8	800
Fishing	62.7	15,500	61.0	4,600
Water-skiing	0.4	100	0.4	30
Swimming	0.8	200	0.7	50
TOTAL	100.0	24,700	100.0	7,500

Total annual visitation to Pool 2 in 1963 was the third lowest in the St. Paul District (which includes 11 pools on the Mississippi River). This low rate of visitation was probably affected by water pollution and the relatively small and poorly marked public access points, and the occupation of the riverbank by floodwalls and levees, industry and barge terminals. However, because the densely populated Twin Cities metropolitan area is located along the upper reach of the pool, this data seems conservative.

Observations made while conducting field studies, the apparent improvement in water quality and the establishment of Fort Snelling State Park suggest that the number of people now visiting Pool 2 may be substantially greater than in 1963.

The number of visitors could be improved further by improving locking procedures, by conspicuously marking public accesses and by increasing the number of such accesses, by improving water quality and by embarking on a long-range program to remove industrial and commercial facilities from the river valley, except those handling facilities necessary to load and unload the barges and to maintain the barges.

Cultural Considerations

A number of archaeological, historical, and contemporary sites exist in the larger study area. Although the bulk have been unaffected by Corps' operations, these sites in several pools have been hurt by the rising water level caused by dam construction.

The most prominent site in Pool 2 is the Fort Snelling Historic District which has been subject to considerable renovation and restoration in recent years. Other cultural areas of interest exist in this pool as well. Impact upon these sites is described in Section 3. Archaeological sites are discussed in Appendix B.

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3. ENVIRONMENTAL IMPACT OF THE PROJECT

INTRODUCTION

"Impacts" are interpreted here to be responses of the natural environment to human activities. This study deals only with those impacts likely to be the result of the Corps of Engineers' 9-foot channel project in Navigation Pool 2 of the Mississippi River. The present Corps project involves operating and maintaining the locks and dams, and the 9-foot channel by snagging and dredging.

The impacts of the construction of the locks and dams and creation of the slackwater pool, and the impacts of using dams which were constructed prior to authorization of the 9-foot channel, are included in this study because they continue to play an important role in the present project and continue to have an impact on the environment of Pool 2.

Because little information appears to exist which describes such impacts in Pool 2, the impacts listed below were derived from:

1. Field data collected for this study and information from previous studies in Pool 2 made for other purposes;

2. Assumptions made from studies made elsewhere on the Mississippi;

3. Knowledge of basic ecological and socioeconomic principles and processes; and

4. Personal experiences of the investigators.

Features of the Corps project which produce these impacts include (a) the maintenance, snagging and dredging of the nine-foot channel; (b) the presence of Lock and Dam 2 at Mile 815.3, and (c) the operation of these structures; additional impacts arise from (d) navigation by commercial and private vessels of the river and from their attendant facilities, which are provided by the channel. The environmental impacts of this project are the changes in the physical and biological components of natural systems, and in changes in the cultural, economic, recreational, aesthetic and archeological components of socioeconomic systems.

NATURAL SYSTEMS

Identification of Impacts

The most important impacts of impoundment and dredging by the Corps of Engineers in Pool 2 are:

1. Disturbance of the riverbottom biota because of dredging, and the resultant increased turbidity;
2. Burial of riverbank habitat and floodplain, terrestrial and aquatic habitats;
3. Increasing channelization and isolation of backwaters by spoil sediments transported by wind and floodwaters;
4. Creation of new beach areas for recreation;
5. Formation of a slackwater pool by the impoundment of a reach of the river;
6. Increase in commercial and recreational river traffic;
7. Decrease in floodplain area;
8. Pollution of the floodplain marshes and shallow lakes because of inundation by main channel water of a lower quality;
9. Increased incentive for developing the floodplain and river banks, resulting in further loss of floodplain, more baresoil areas, and adverse effluents.

It should be noted that the impacts in Pool 2 are not always completely isolated and ascribable to the Corps because the impacts are part of a complex, multidimensional web of physical-chemical, biological and socioeconomic interactions. The results of these impacts derive partially from other economic and cultural activities and from natural environmental processes acting in the Pool 2 area as well as in the larger river basin.

The impacts listed above are related to Corps operations and maintenance activities, structures, navigation, and to pre-project activities (such as construction). They most often first affect physico-chemical factors which in turn affect biological elements: "secondary" impacts. Subsequent environmental impacts are identified, then traced further, if possible, in the discussion section.

Discussion of Impacts

The Mississippi River "main stem" is the largest continuous freshwater corridor in the United States. It has long been recognized for its unique scenic, fish, shellfish, wildlife, recreation, and transportation resources. A great concern for the future of wildlife and fish--which led to the establishment of the Upper Mississippi River Wild Life and Fish Refuge--still lives and is even more vital today.

Environmental impacts of the 9-foot project have not been previously reported upon specifically for Pool 2. Some measure of these impacts, however, may be inferred from those described for the Refuge, the upstream border of which extends about a mile into Pool 2. The use of these impacts must be modified not only because the extensive development of marshes characteristic of the Refuge did *not* occur in the flooded lowlands of Pool 2, but also because substantial effects originate from the urbanization of the Twin Cities metropolitan area. Also, insofar as possible, the impacts described above should be considered in the framework of the entire Mississippi River system and in light of other human developments.

Channel Maintenance

The project feature causing some of the most important impacts is the maintenance of the navigation channel (see Table 37). This involves the dredging of mud, sand, debris or gravel up from the channel, depositing it on a nearby bank or island and removing dead branches and tree trunks ("snags") which constitute a hazard.

Table 37. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Maintenance dredging	1. Increases turbidity.	1. Cover benthos, plants. 2. Suffocate fish, spawn. 3. Reduce water quality.	1. Reduce biota.
	2. Exposes new sterile substrate.	1. Loss of benthos.	1. Decrease fish, waterfowl, vegetation, decrease wildlife.
	3. Equipment causes navigation hazard (minor)		
Spoil deposition	1. Loss of terrestrial vegetation.	1. Spreads to cover more terrestrial habitat; fill backwater; redeposited in channel.	1. Lose vegetation; decrease wildlife. 2. Confines channel. 3. Fills floodplain.
	2. Fills backwaters.	1. Decrease biota. 2. Decrease floodplain.	
	3. Confines channel.	1. Isolate backwaters.	1. Eutrophies and fills backwaters; decreases waterfowl and fish.
		2. Decrease shallow water area.	1. Decrease river benthos, fish
	4. Provide recreational sites.	1. Increased aesthetic enjoyment. 2. Increased disturbance of fish and wildlife.	
Snagging and debris clearance.	1. Decrease benthos, turtles and other air-breathers.	1. Decrease fish.	1. Decrease waterfowl, recreation (fishing, birdwatching).
	2. Increase turbidity.	1. Decrease fish, benthos.	1. Decrease waterfowl, recreation (fishing, bird watching). 2. Reduce aesthetic appeal of area.
	3. Reduce aesthetic appeal of disposal area.		

Table 37 (Continued).

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Pool 2	1. Impoundment of river (raised water levels).	1. Flooded backwaters.	1. Decreased marsh vegetation and wildlife, such as muskrat, otter. 2. Lost prairie, forested islands covered; thus wildlife habitat lost prairie chicken, badger; reduced deer, raccoon; loss of fish-spawning habitat. 3. Provided for influx of water of low quality; further decreasing plants and wildlife; filling of backwaters. 4. Loss of floodplain; increase in flood levels and damages.
		2. Flooded dry land.	1. Decreased floodplain. 2. Decreased terrestrial habitat; lost and decreased terrestrial upland biota. 3. Increased shallow-water area; could have increased waterflow, benthos, fish habitat, but didn't due to influx of water of low quality.
		3. Increased depth, slowed current.	1. Decreased flowing-river species of fish, clams. 2. Increased sedimentation, decreasing benthos.

Table 37 (Continued).

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Pool 2 (Continued)	1. Impoundment of river (raised water levels) continued.	3. Increased depth, slowed current (continued).	3. Increased eutrophication; nuisance species. 4. Submerged wing dams; decreasing benthos, fish. 5. Increased conversion of remaining floodplain to industry; increasing flood damage; decreasing water quality. 6. Increased rate of sewage degradation; decreased local water quality, increased water quality downstream. 7. Increased ice thickness; decreased aeration and sewage breakdown. 8. Reduced water level fluctuation; increased diversity; improved aesthetics for those who prefer lakes to rivers; improved for motorized craft; traffic and wakes make it poor for canoes, rowboats.
	2. Increases current downstream from Dam 2.	1. Eroded Burlington Northern Railroad bed on left bank.	
Pool 1	1. Increases dissolved oxygen in upper reach of Pool 2.	1. Increases benthos.	1. Increases percentage of sport fish, subsequently increasing recreation, also increases food for shorebirds.

Table 37 (Continued).

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Pool 1 (Continued)	1. Increases dissolved oxygen in upper reach of Pool 2 (continued).	2. Increases percentage of sport fish in upper Pool 2.	1. Increases recreation and shorebirds.
	2. Decreases sediment load.	1. Increases water quality in upper reach of Pool 2.	1. Increases quantity, diversity of biota in upper reach of Pool 2.
	3. Barrier to migration of fish and benthic animals	1. Decreases spawning, benthic animal diversity.	
Pool 3	1. Reduced effectiveness of aeration of water by raising water level of Pool 3 at Dam 2.	1. Reduced diversity of biota, esp. fish; increase nuisance species.	
		2. Changed Dam 2 operation; bulkheaded several gates to increase aeration.	1. Return of water quality; increased diversity, more desirable species.
Lock 1	1. Surges in current in upstream end of Pool 2.	1. Increases bank erosion and bottom scouring in Pool 2.	1. Increases sedimentation downstream, subsequent loss of benthos in Pool 2.
	2. Permit passage of fish.	1. Allows passage of other aquatic life, such as clams, larvae.	
Lock 2	1. Same, in Pool 3.	1. Same, in Pool 3.	1. Same, in Pool 3.
	2. Same, in Pool 3.	1. Same, in Pool 3.	
Wing dams	1. Channelize river.	1. Increases sedimentation along banks. 2. Decrease bank erosion.	1. Isolates backwaters.
	2. Increase benthic substrate.	1. Increases benthic populations.	1. Increases fish populations (and fishing above sewage treatment plant).

Table 37 (Continued).

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Bank protection structures	1. Reduce bank erosion.	1. Reduces loss of trees, etc.	1. Maintains terrestrial habitat and aesthetic appeal.
	2. Riprap or willow "mattresses" increase benthic habitat.	1. Increases benthic organisms.	1. Increases fish.
	3. Riprap decreases aesthetics if no vegetation present.		

Dredging

First, there is the dredging itself which removes living bottom (benthic) animals such as caddis fly larvae and clams, exposing a [illegible]le-river bottom and increasing turbidity and sedimintation downstream (see Figure 57). Recolonization of a dredged area by mollusks requires as much as ten years or more (Stansbery, 1970).

In Pool 2 nearly 180,000 cubic yards are dredged annually, the greatest amount per pool in the upstream urbanized area (see Table 38). Because of the length of the pool, this results in an average of nearly 5600 cubic yards annualy per mile, greater than that for the Minnesota River and less than that for Pool 1. Nevertheless, where this dredging occurs downstream from the Metropolitan Wastewater Treatment Plant, nutrients, toxicants, pathogens and other harmful substances may be reintroduced into the ecosystem. This must be a severe load on the survival capacity of the limited fish and wildlife population remaining in this highly urbanized area. It may reduce further waterfowl and other recreational attributes of Pool 2, which is in the center of an area of high recreation demand.

Disposal of Dredgings

Other impacts unfavorable to biological and human systems derive from disposal of the dredge spoil (see Table 38). This operation buries terrestrial vegetation (habitat) which serves as animal food and cover, and the spoil frequently finds its way into the backwaters where further habitat destruction occurs. Figure 58 shows several areas near Pine Bend where prime great blue heron and American egret habitat has been reduced by dredge spoil. The bare sand is also likely to be moved by wind and water to cover even more habitat acreages. Figure 59 shows the encroachment of spoil into a backwater. The margins of this spoil site, and the one in the background, are thickly covered by matted grasses. Further back from the shoreline are willows.

Table 38. 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

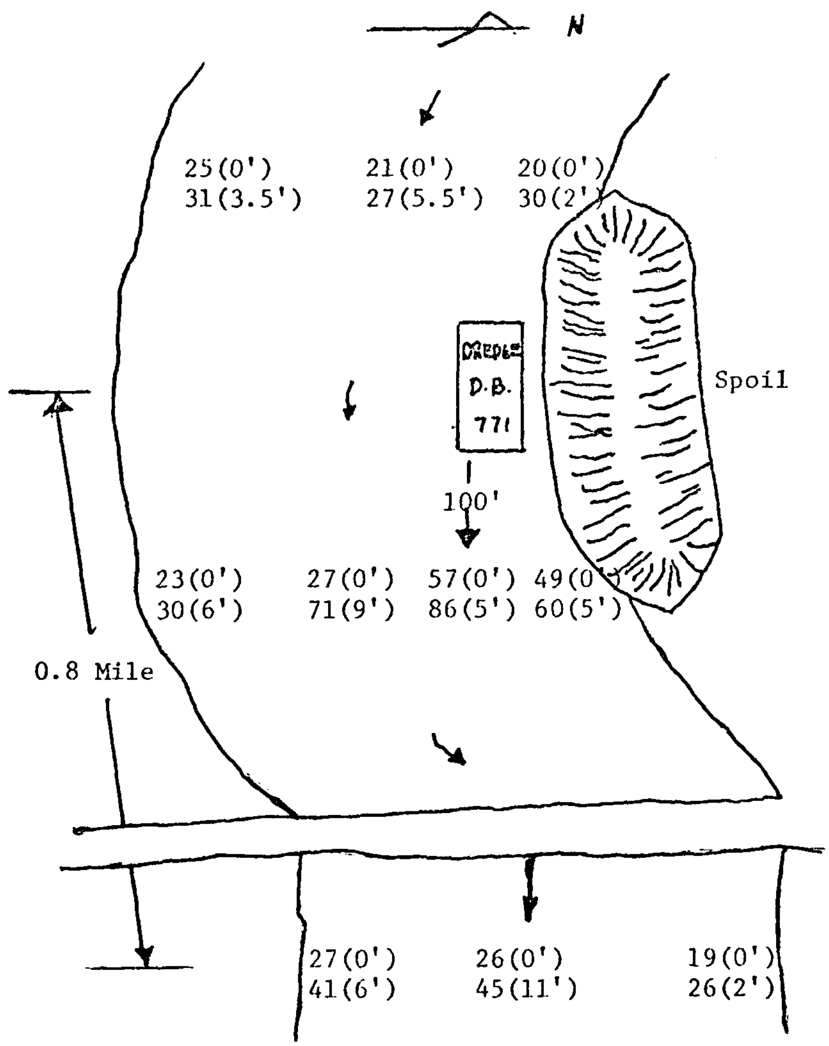

Figure 57. Effect of Clamshell Dredging Upon Turbidity in the Minnesota River, September 25, 1973 Depth in feet in ( ).

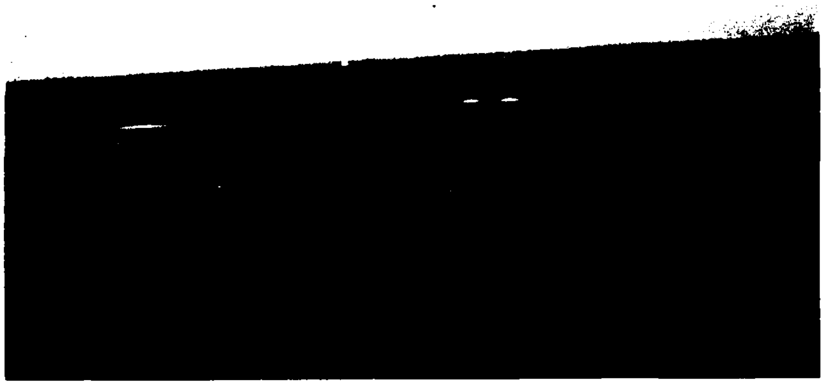

Figure 58. Aerial View Southwest of Baldwin Lake and the Mississippi River (Pine Bend is on the bluff in the background). Note the bare spoil sites. (Colingsworth, 1973)

Figure 59. Spoil Piles Enchroaching on Backwaters at Baldwin Lake. (The low elevations at the margin of the spoil are thickly covered with grasses and willows.) (Colingsworth, 1973)

This cover of vegetation holds the spoil, preventing further slipping into the backwater. By contrast the middle of the spoil pile, which is much drier, has a rather thin cover of vegetation (see Figure 60). Thus, this central area is more prone to erosion.

Figure 60. Open Spoil Site on Baldwin Lake Sparsely Covered by Grasses. Margin of spoil bank is closer to water level and thus supports willows and cottonwoods, partially screening the spoil site and reducing erosion (Colingsworth, 1973)

Natural revegetation of spoil may require more than ten years to provide cover sufficient to stabilize spoil banks (see "2. Environmental Setting - Vegetation on Sandy Dredge Spoil").

Although the amount of spoil dredged from Pool 2 averages around 180,000 cubic yards per year, construction projects have made use of large quantities of the sandy and rocky spoil. This has resulted in a double benefit by reducing both the negative impact of spoiling near the river and that of excavating from a sand or gravel pit. For instance, both Warner Road and

Shepard Road used dredge spoil, and some is presently being used for harbor improvements near downtown St. Paul.

At least two islands (at Mile 841 and Harriet Island) in the pool have been joined to the bank by filling the back channel in with spoil. This is considered a detrimental impact to natural communities, for which islands provide safe and very favorable habitats.

The dredgings piled on the river bank may erode back into the channel where transport and turbidity again take place. Then additional dredging costs are incurred when the material is deposited elsewhere in the pool and must again be dredged.

Snagging and Debris Clearance

Impacts associated with removing snags (trees and branches which create hazards to navigation) are detailed in Table 38. There are benefits to benthic communities of leaving the snags in the water. Merely pushing them to the side of the navigation channel benefits navigation in the channel proper, but creates a hazard in the non-channel part of the river (usually for small boats). Removing them from the water to the top of the bank may create an eyesore. Because of their extremely slow rate of decay, they remain for years in the place where they are deposited.

Effects of Impoundment

Some results of the impoundment of Pool 2 are described by Leisman (1959):

> "In 1932 the character of the Spring Lake area was radically changed by the erection of the Hastings dam. The water level behind the dam was raised to such an extent that Spring Lake actually became part of the Mississippi River, which probably was markedly affected then as now by effluents from the Twin Cities. The marsh vegetation disappeared entirely with the

> rising water level. Today Spring Lake is a broad expanse of open water confluent with the Mississippi River, with only the dead stumps of willows, cottonwoods, elms, and maples showing above the water to mark the former shore line. The game fish of the early 1900's have been largely replaced by rough fish, the muskrats no longer build their dome-shaped houses, and the ducks fly by overhead without pausing."

These same impacts may have occurred in Baldwin, Mooers and Pig's Eye Lakes also.

As a consequence of converting a free-flowing river to slackwater pools and the subsequent sedimentation, the impounding of the river is one of the most important human activities affecting the river system (see Table 39). The history of Pool 2 can be compared with what has happened 700 to 800 miles downstream (Vogtman, 1973):

> ". . . in the nonpooled section of the Mississippi River between Cairo, Illinois, and St. Louis, Missouri, a reach of nearly 200 river miles, there has been a loss of nearly 70 percent of the flowing side channels and approximately 30 percent of the channel surface since the 9-foot project began. These losses are directly due to the construction of emergent wing dams and closing structures, in combination with dredging. This section constitutes nearly one-fourth of the total Upper Mississippi River reach committed to a 9-foot navigation channel."

This serves to emphasize the uniqueness of the remaining diverse aquatic habitats this far upstream as well as to suggest what might eventually happen in this pool.

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, leaving broad areas of exposed bottom (see Figure 61), compared with the present pools which now remain full from bank to bank (see Figure 62). These changes probably led to greater bank erosion (some as a result of greater ice action), increased size and number of sandbars and snags and cutting off and filling in of backwaters.

The increasing importance of the Mississippi River transportation to the economy of the Midwest led Congress 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, channelization by wing and closing dams and by dredging brought larger scale impacts.

These impacts which arose from this early development in and along the river may have made necessary the extensive fish rescue work of the early 1900's described by Vogtman (1973). He states:

> ". . . Fish were often caught in off-channel backwaters and were subject to both summer and winter kills from oxygen depletion. Backwater chutes often dried up during the summer or froze out during the winter, or both. . . The fish kill problem was created primarily by the previous navigation project where side chutes were closed by wing dams or closing dikes, with resultant sedimentation of chutes and backwaters, as is now occurring in the Mississippi River below St. Louis. Thousands of fish have been trapped and lost in such areas. Pooling of the river and raising water levels only tended to correct a situation created by the previous navigation project."

Although fish seemed to suffer, scouring in spring may have served to prevent these chutes and marshes from filling in by sediment and vegetation. Through the years, meandering of the channel and tributaries at their mouths would also create new chutes and backwaters.

Some species of water fowl, wildlife and fish have benefited at the expense of other organisms. For instance, the skipjack, Ohio shad, and the blue sucker have nearly been eliminated from the river.

Figure 61. View Downstream in 1890's Just Below Upper St. Anthony Falls Showing the Debris of the Lumbering Era. The Stone Arch Bridge is in the foreground and the now absent 10th Avenue Bridge farther downstream. Building beyond on right bank indicates the approximate head of the present Pool 1 (Corps of Engineers)

Figure 62. View in 1926 from the 10th Avenue Bridge Showing the St. Anthony Falls Lower Dam and the (presently) Pacific Northern Bridge Now in Pool 1. Note lack of water at the railroad bridge and naked bluff, especially where steam is rising. (Corps of Engineers)

> "Near elimination of the skipjack has also greatly reduced the commercially important and valued niggerhead clam population in the river. The skipjack served as host for the larvae of these mussels. Also directly affected by pool creation have been the American eel, the blue catfish, and the paddlefish, among others. These latter fishes were once valuable commercial species, widely distributed before the river was blocked by dams. In general, the effects of pooling are to reduce to a monotype what was once a highly diversified and productive aquatic habitat. In the process, many spawning areas disappear, turbidity becomes a problem and populations of preferred sport fishes decline." (Vogtman, 1973)

Slowing of a rapid, free-flowing river into a slackwater pool plus a heavy pollutional load probably has resulted in near eradiation of the mollusk community.

Apparently most mollusks require a "lively" current, and a migrating fish community in order to disperse and maintain productivity. The migration of fish is prevent (or discouraged) by dams (Ortmann, 1909), although navigation locks may occasionally provide a means to by-pass this barrier. Grant found 27 species of mussels at Fort Snelling around 1890, where more recently only 13 species were located (Dawley, 1947). This reduction in diversity may be the result of the combination of urbanization and the 9-foot channel project.

Waterfowl and other wildlife in Pool 2 were significantly affected by the 9-foot channel project. Ducks and game fish are no longer common in the flooded marshes (Leisman, 1959). Information from the Refuge just downstream indicates that foxes, badgers, skunks and rabbits have decreased because of impoundment; prairie chickens have disappeared (Green, 1960). Muskrats and mink and waterfowl such as dabbling ducks, which are now more common in the Refuge, have not increased in Pool 2. This is probably because of the low quality of the water.

Thus, the excellent opportunities for hunting, fishing, birdwatching and trapping which developed in the Refuge, did not occur in Pool 2. However, the recreational potential at least in Lower Pool 2 probably is considerable and will be realized with the probable future improvement in water quality.

Lock and Dam Operation

Lock operations may provide a by-pass around the dam to fish and mussels, thus increasing chances for survival of the species. Attendant surges in current may produce some increase in turbidity and bank erosion (see Table 38).

Although they may retard the migration of fish and mussels, dams provide a good means for aerating the water and thus improve conditions for aquatic life. Four gates of Dam No. 2 were adapted ("bulkheaded") to increase aeration. Also, operation of the gate next to the left bank is modified to reduce the current which had been eroding the Burlington Northern Railroad embankment.

Further, the amount of annual winter drawdown of the water level in Pool 2 has been reduced to protect fish and wildlife habitat by the "Anti-Drawdown" Law of 1934 (S.P.D.-NCS, 1969).

The impoundment has also inundated the wing dams so they now constitute a hazard to small boaters.

Commercial Navigation

Some of the probable environmental impacts of commercial navigation and its facilities are listed in Table 39. Because of the great activity carried on in Pool 2, these impacts are estimated to be important. Increase i turbidity effects can be seen in Figure 63. The problem of oil spills is shown in a picture of oil sludge on the bank (see Figure 64) at Mile 828.7.

Table 39. Probable Impacts of Commercial Navigation, and Barge Terminals and Barge Maintenance Facilities on Natural Systems in Pool 2.

Activity or Structure	Initial Impact	Secondary Impact	Subsequent Impacts
Navigation	1. Increased turbidity.	1. Decreased aquatic biota.	1. Decrease in wildlife and waterfowl.
	2. Increased band (shore) erosion.	1. Increased turbidity.	1. See second and additional impacts above.
		2. Decreased terrestrial habitat.	1. Decreased wildlife.
	3. Increased fumes and effluents adverse to existing biota.	1. Decreased aquatic biota.	1. Decreased waterfowl and wildlife.
		2. Decreased aesthetics.	
	4. Possibility of spills of oil and hazardous materials.		
	5. Increased aesthetic interest.		
	6. Increased noise.		
Barge terminal, fleeting area, dry dock	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. Rusty or dark brown hulls.	1. Hazard at night when unmarked. 2. Adverse aesthetics.	
Barge cleaning facility	1. Possible adverse effluents.	1. Possible decreased aquatic biota.	1. Possible decreased waterfowl, furbearers.

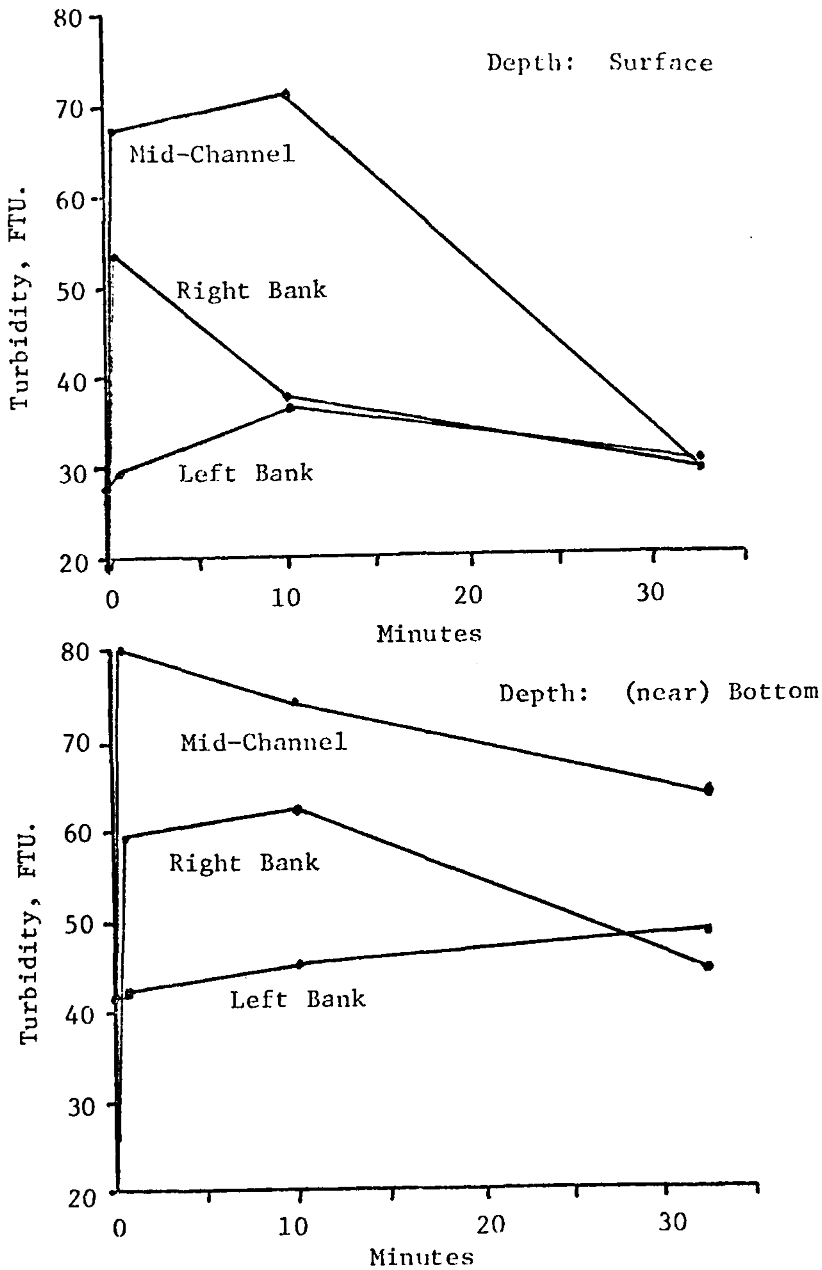

Figure 63. Duration (in minutes) of Increases in Turbidity Due to a Tow Boat on the Minnesota River at Mile 13.3, from the Right Bank to the Left Bank on September 25, 1973.

Figure 64. Patches of Oil Sludge Which Have Collected on the Sand Beach on the East (Left) Bank at Mississippi River Mile 828.7

Pre-Project Corps Activity

A list of probable impacts on natural ecosystems is seen in Table 40 on the following two pages.

Table 40. Probable Impacts of Pre-Project Corps Activity and Structures (Prior to 1930) Upon Natural Settings in Pool 2.

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Removal of snags, wrecks, shoals and sandbars, beginning about 1825.	1. Increased turbidity. (temporary).	1. Decreased benthic organisms, fish.	1. Decreased waterfowl, furbearers (minimal).
	2. Decreased benthic substrate.	1. Decrease fish and some waterfowl.	1. Decrease some waterfowl.
Construction of wing dams and bank protection structures, beg. 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.	1. 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).
Headwater reservoirs, beg. in 1880.	1. Moderated water level and current changes.	1. Increased abundance, diversity of aquatic biota.	1. Increased abundance of waterfowl, furbearers.
Extension of 4.5-foot channel to Minneapolis, in 1890.	1. Dredging sandbars, removal of boulders.	1. Decrease substrate.	1. Decrease benthos; decrease fish and wildlife.
		2. Increase turbidity.	1. Decrease benthos; decrease fish and wildlife.

Table 40 (Continued).

Project Feature	Initial Impact	Secondary Impact	Subsequent Impacts
Construction of original Lock and Dam 1, 1894-1907.	1. Increased turbidity.	1. Decreased aquatic biota.	
	2. Loss of substrate.	1. Decreased aquatic biota.	
	3. Increase water temperature.	1. Change in aquatic biota.	
6-foot channel, beg. in 1907.	1. Wing dam construction.	1. Decreased aquatic biota.	
	2. Dredging.	1. Increased turbidity.	1. Decreased benthos, fish.
		2. Increased bare area.	1. Decreased benthos, fish. 2. Decreased wildlife.
Construction of Lock and Dam 2.	1. Wing dam construction.	1. Decreased aquatic biota.	
	2. Dredging.	1. Increased turbidity.	1. Decreased benthos, fish.
		2. Increased bare areas.	1. Decreased benthos, fish. 2. Decreased wildlife.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdividisions of socio-economic systems for Pool 2 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

Pool 2 is the origin or destination of a major portion of the commodities moving on the Upper Mississippi. The principal industrial impacts are:

1. Barge transportation on the Upper Mississippi that 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 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 because of --
     - (1) Effluents produced by barge-oriented plants,
     - (2) Spills of oil or hazardous materials, and
     - (3) Turbidity caused mainly by barge movement.

2. Additional employment because of the operation of Lock and Dam 2.

3. Small potential increase in commercial fishing because of:

   a. Improvement of sewage treatment;

   b. Increase in dissolved oxygen in channel because of faster current in deeper channel leading to increased water turbulence, and

   c. More fish habitat because of increased average of fish-spawning areas from rising water level. This potential has not been realized for reasons developed below.

To summarize, beneficial industrial impacts that result from operating and maintaining the 9-foot channel and its associated locks and dams by the Corps of Engineers are an increase in the number of industrial plants and commercial docks along the river with their associated employment and the employment in lock and dam operation. The detrimental effects are a decline in water quality because of river barges and the related industrial plants along the river, decline in water quality because of the effect of sewage effluent entering a slackwater pool, damage through dredging and deposition of spoil, and damage to some ecological systems.

Recreational Impacts

The principal recreational impacts are:

1. An increase in recreational boating because of the widening of the river, and to stable, navigable water levels which have led directly to more marinas and their accompanying employment.
2. A decrease in sport hunting and fishing because of improper dredge spoil placement.
3. An increase in sightseeing visitors to the locks and dams, and to watch river traffic from the bank.

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

Cultural Impacts

The cultural impact in Pool 2 is mainly negative--the loss of two archaeological sites by raising the water level in Pool 2.

Discussion of Impacts

The industrial, recreational, and cultural 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 Mississippi 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 docks and dams and navigational aids;
2. The riverside installations that have been built to improve cargo transfer, storage, and access;
3. The vessels using the waterway.

In these terms the impact of the Corps' activities in Pool 2 is greater than in any of the other pools being studied. The water-related economic activity is intensified by a number of factors. The shores of Pool 2 show a wide variety of land uses, urban areas of St. Paul and Minneapolis with high population densities and much economic and social activity, extensive areas for heavy industry such as Pine Bend, and shoreline which is either agricultural or just in the process of commercial development. This variety is combined with variations in river width from the relatively narrow channel from Lock and Dam No. 1 to the wide Spring Lake. In addition, Pig's Eye Lake offers dock and mooring facilities.

<u>Barge Activity.</u> The greatest and most obvious impact of the activities of the Corps of Engineers has been the modification of the transportation system caused by the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (*e.g.*, locks and dams, 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.

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.

Figures 65 and 66 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Although receipts still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

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.

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

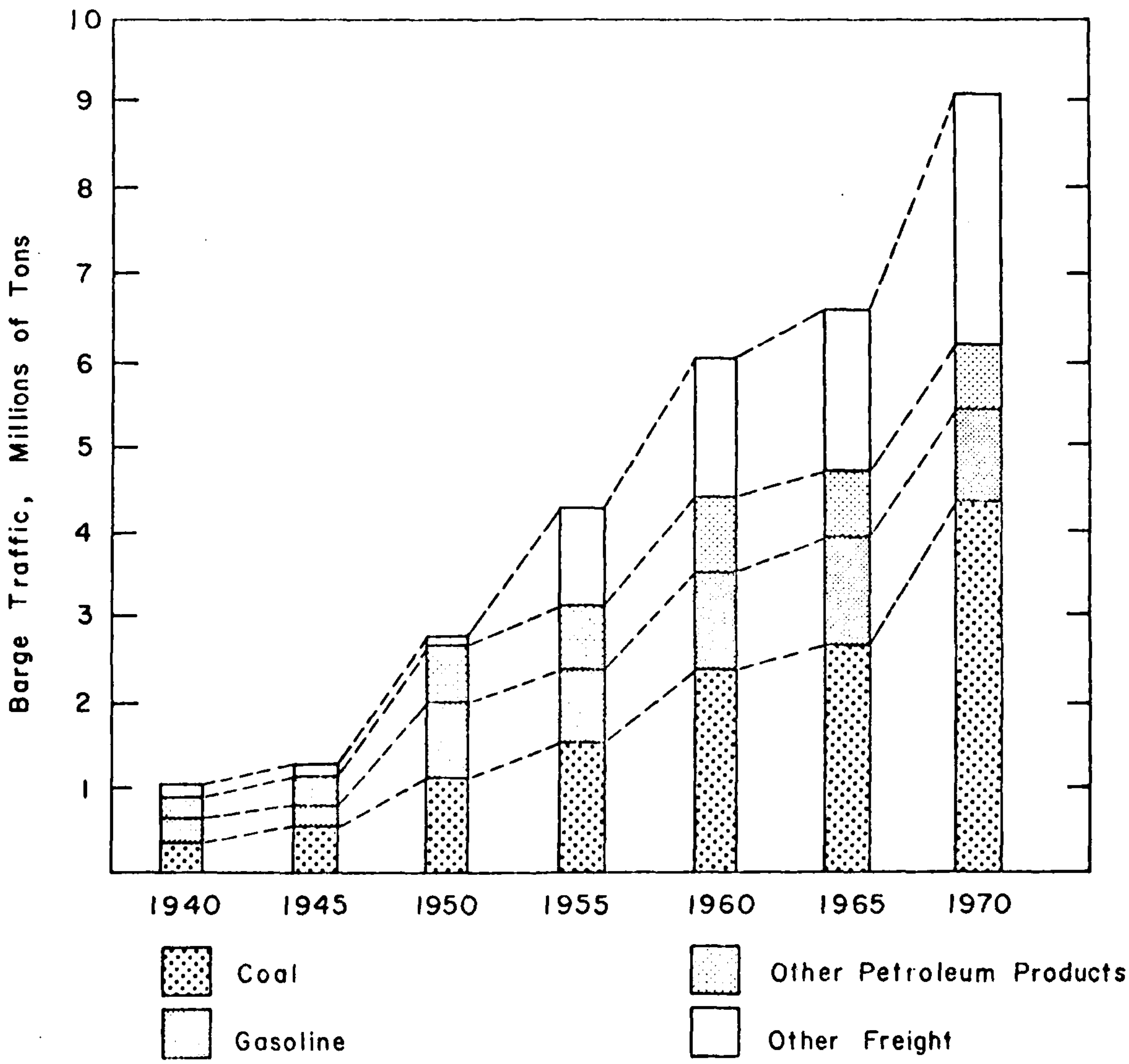

Figure 65. Receipts of Major Commodities -- All Ports, St. Paul District (Based on data from U.S. Army Corps of Engineers, St. Paul District)

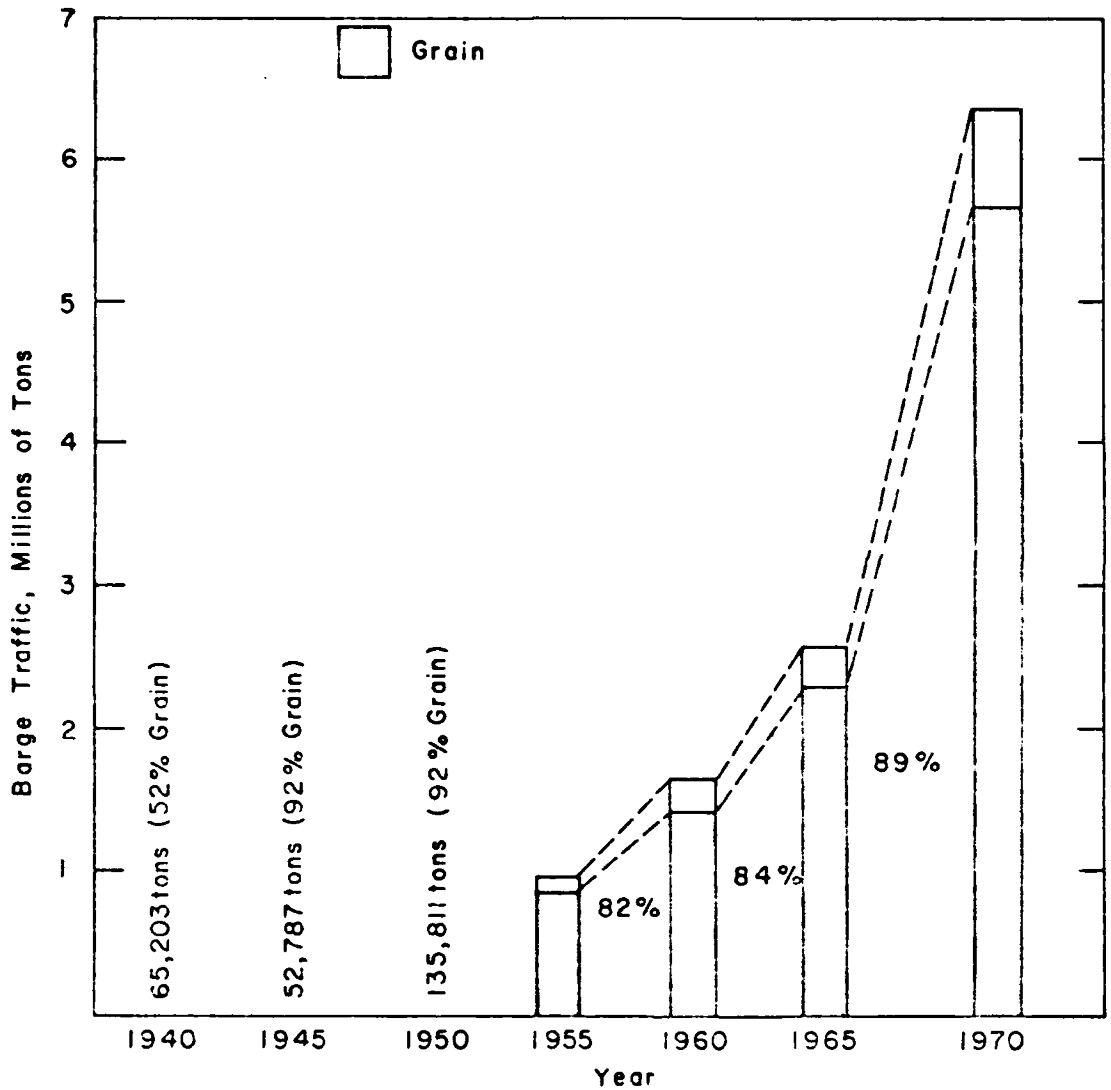

Figure 66. Shipments Out of the St. Paul District
(S.P.D.-NCS, Selected years)

these products can be profound because of 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 Ohio River is shown for selected years as follows:

Year	Total Vessel Traffic (tons)
1962	30,526,626
1964	34,108,482
1966	41,311,921
1968	46,174,929
1970	54,022,749
1971	52,773,097

The extensive nature of barge traffic and commercial docks in Pool 2 is evidenced in the statistical data on the pool. In 1971, for example, 30.5 percent of all barge traffic in the St. Paul District had its origin or destination at St. Paul (Pool 2 and possibly a small portion attributable to Pool 3), compared with 8.6 percent for Minneapolis (Pool 1 and above). In addition to the city of St. Paul itself, the industrial complex at Pine Bend is a substantial bulk commodity transit point.

Data for the year 1971 are illustrative of the kinds of commodities being shipped and received at the facilities in Pool 2. The largest major commodities received were:

Sand, gravel, crushed rock	1.2 million tons
Gasoline	0.9 million tons
Distilled fuel oil	0.2 million tons
Coal	0.5 million tons

Major shipments were:

Corn	0.4 million tons
Wheat	0.4 million tons
Soybeans	0.1 million tons
Coke	0.1 million tons

Total receipts for Pool 2 for 1971 were 3.5 million tons and total shipments were 1.3 million tons. The following tabulation is indicative of the origins and destinations of some major commodities to and from Pool 2.

Commodity	Origin	Destination
Selected grains	Minneapolis-St. Paul	New Orleans
Coal	Kaskaskia-St. Louis	Minneapolis-St. Paul
Petroleum and petroleum products	Intracoastal - New Orleans	Minneapolis-St. Paul
Sand and gravel	St. Paul	Minneapolis
Industrial chemicals and sulfur	New Orleans	Minneapolis-St. Paul
Agricultural chemicals	New Orleans	Minneapolis-St. Paul

Although the total tonnages originating and terminating in Pool 2 have shown a decline as a percentage of total tonnage in the entire St. Paul District, nonetheless substantial growth for the pool and the District as a whole is predicted.

Data on the number of vessels originating, terminating, or passing through Pool 2 are not available directly. However, some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 2 and Lock 1, which are shown in Table 41. From 1960 to 1972 commercial lockages through Lock 2 increased by about 48 percent and through Lock 1, increased by more than 100 percent.

Table 41. Commercial Lockages in Pool 2, 1960 - 1972 (S.P.D.-NCS, unpublished)

Year	Commercial Lockages through . . . Lock 2	Lock 1
1960	1,302	1,082
1961	1,191	1,323
1962	1,325	995
1963	1,561	1,367
1964	1,556	1,688
1965	1,426	1,571
1966	1,588	1,703
1967	1,727	1,560
1968	1,530	1,748
1969	1,539	1,949
1970	1,853	1,914
1971	1,825	1,765
1972	1,929	2,195

Commercial Dock Facilities. Many firms which depend heavily on the river maintain riverside facilities. Again, the significant barge activity in Pool 2 is apparent. Table 42 shows the terminals and dock facilities available in Pool 2.

The list of firms owning, operating, or using facilities in Pool 2 includes many of the major companies in the Twin Cities area. This list also includes names of firms having facilities above Lock and Dam 1 and on the Minnesota River whose traffic passes through Pool 2.

Other firms either using or maintaining facilities in Pool 2 include:

- Boise Cascade Company (dock)
- Land O'Lakes Company, Inc. (chemical terminal)
- Chevron Asphalt Company
- Industrial Molasses Corporation
- Dewey-Portland Cement Company
- Vel-Tex Chemical Company
- Northern Warehouse Company
- Morton Salt Company

Table 42. Commercial Docks in Pool 2

Mile	Bank	Terminal	Location	Commodity
814.5	R	G.N. Oil Company Storage	Hastings	Petro. Prod.
823.8	R	Central Farmers Fertilizer Company	Pine Bend	Phosphate
823.8	R	N.W. Coop Mills	Pine Bend	Fertilizer
824.2	R	CENEX (Central Farmers)	Pine Bend	Phosphate
824.2	R.	G.N. Oil Company Refinery	Pine Bend	Petro. Prod.
825.0	L	J.L. Shiely Company	Grey Cloud	Aggregates
830.0	L	Northwestern Refinery	St. Paul Pk.	Petro. Prod.
830.2	L	Erickson Petroleum Co.	Newport	Petro. Prod.
833.3	R	North Star Steel Company	St. Paul	Asphalt
836.8	L	Industrial Molasses Co.	St. Paul	Molasses
836.9	L	Continental Grain Co.	St. Paul	Grain
837.2	L	J.L. Shiely Company, Yard "A"	St. Paul	Aggregate
837.3	L	Northern Waterway Terminal	St. Paul	Misc. Freight
837.3	L	Municipal Dock	St. Paul	Coal & Misc.
837.4	L	Walsh Grain Elevator	St. Paul	Grain
838.0	R	Twin City Barge & Towing Company	St. Paul	Vessel yard
838.4	R	Gustavson Oil Company	St. Paul	Petro. Prod.
838.8	R	Minn. Farm Bureau Co.	St. Paul	Fertilizers
839.0	L	Lambert Landing	St. Paul	Passenger & Landing
839.4	R	AMSCO (Pure Oil Co.)	St. Paul	Chemicals
840.5	R	Barge Cleaning Facilities	St. Paul	Chemicals
840.5	L	NSP Company (High Bridge Plant)	St. Paul	Coal
840.8	L	Pure Oil Company	St. Paul	Petro. Prod.
841.6	L	Clark Oil Company	St. Paul	Petro. Prod.
841.7	L	Archer Daniels Midland Co.	St. Paul	Grain
842.2	L	Shell Oil Company	St. Paul	Petro. Prod.
842.3	L	Mobil Oil Company	St. Paul	Petro. Prod.
842.5	L	Texaco Company	St. Paul	Petro. Prod.
843.3	R	J.L. Shiely Company, Yard "B"	St. Paul	Aggregate
843.8	R	Marquette Cement Co.	St. Paul	Cement

The best indicator of the predominance of Pool 2 as the prime shipper and receiver of waterborne freight in the entire St. Paul District is the number of terminals and commercial docks within its confines. Of approximately 89 commercial docks in the St. Paul District, 34 (38 percent) are in Pool 2. This does not include docks on the Minnesota River, the traffic from which enters and leaves the Mississippi in Pool 2.

Based upon the tonnages received and shipped in Pool 2 and the numbers of commercial docks and terminals, it can be estimated that 35 to 40 percent of the commercial freight activity in the St. Paul District occurs in Pool 2. This excludes shipment through the pool to and from point on the Minnesota and pools above Pool 2.

These impacts are particularly evident in Pool 2 where (as noted earlier in this report) about 38 commercial docks and terminals have been installed. Behind many of these docks are factories, storage facilities and refineries which are dependent upon them. Thus, the ramifications of river navigation reach deeply into the entire economy of the region surrounding Pool 2 and indeed throughout the whole upper Mississippi region. Employment directly and indirectly connected to these industries forms a small but significant percentage of the regional work force.

From an economic point of view, most of the effects 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 Pool 2 includes both workers directly connected with the river itself and a far larger number of those whose 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 using the products brought into Pool 2 by waterborne carriers or who process goods shipped 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 about 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 Upper Mississippi are deficient as well. These data are collected for mid-March, a period when water traffic in the St. Paul District and particularly in Pool 2 is almost completely inactive and seasonal lay-offs are in effect. Further, these data are aggregated in a way designed to prevent isolalion and identificiation 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, 8632 persons in the United States 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. Based upon these scattered data and the number of terminals and firms included, it is estimated that, in Pool 2, some 2000 persons are directly involved in freight shipment. This employment is conservatively estimated to generate annual wages and salaries of about $16,000,000.

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, Appendix J). 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 Pool 2 on river barges.

The socioeconomic impact of the physical effects of navigation cannot be measured precisely because of the inability to isolate single 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 are felt economically in the area of commercial fishing (described below) where quality and quantity are affected negatively. But again, the major adverse effect on commercial fishing in Pool 2 comes from urban sewage and other industrial pollution.

Commercial Fishing. There is little commercial fishing in Pool 2; this is caused by conditions related to the presence of Dam 2 below the outfall of the Metropolitan sewage treatment plant. During the 1960's the only year for which commercial fishermen reported any catch in Pool 2 was in 1969, when a mere 2000 pounds was reported. What commercial fishing exists is done at the lower end of Pool 2 near Hastings, because pollution from the Twin Cities limits both the quantity and quality of fish caught. Fish kills have been reported often in Pool 2, associated with low levels of dissolved oxygen. Major problems have been reported with fish taken from Spring Lake. Frequently poor flavor has reduced the selling price of the fish and often holding tanks are required until the fish have lost this characteristic. In any event, the importance of commercial fishing in Pool 2 compared with either other economic activity in Pool 2 or with commercial fishing in other pools is small.

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. For Pool 2 the best available measures of pleasure-boating activity are records of pleasure boats locking through Locks 1 and 2--the locks at each end of the pool. These data--along with the total pleasure-boat lockages through these two locks--are shown in Table 43 for the years 1960 to 1972. The table shows a slight increase in pleasure craft locking through Lock 2 during the period (from about 5100 in 1960 to about 5700 in 1972) and more than a doubling of pleasure craft locking through Lock 1 during the same period (from about 700 to about 1600). Pleasure craft lockages as a percentage of total lockages have fallen from about 66 percent in 1960 to 55 percent in 1972 for Lock 2; they have remained comparatively stable at about 40 to 42 percent during the period for Lock 1.

Table 43. Measures of Pleasure Boating Activity in Pool 2, 1960-72 (S.P.D.-NCS, 1960 - 1972)

	Pleasure Boats Through...		Pleasure Boat Lockages Through...	
Year	Lock 2	Lock 1	Lock 2	Lock 1
1960	5137	1278	2484	708
1961	5536	1211	2519	838
1962	4270	959	2184	623
1963	5174	1427	2412	856
1964	5107	1890	2537	1155
1965	3308	1121	1827	743
1966	4423	1677	2213	1064
1967	3869	2088	1981	1221
1968	4702	2193	2181	1422
1969	4189	2415	1888	1405
1970	4555	2960	1953	1861
1971	5788	3455	2359	1783
1972	5723	2798	2345	1568

A variety of physical facilities have been developed in Pool 2 that exist mainly to serve boaters using the pool. These include:

Facility	Number
Small boat harbors, marinas, boat clubs	11
Public use facilities (see Table 35)	
Recreational sites with ramps	4
Recreational sites without ramps	1
State parks (Fort Snelling State Park)	1
Other parks (Harriet Island Park, Indian Mounds Park, Lake Rebecca Park)	3

Except for the parks and possibly the one recreational site without a ramp, which does not cater primarily to boaters, all of these facilities benefit from Corps' operations on the River that contributed the channel and stable water levels.

The parks are examples of other recreational sites adjacent to Pool 2 that are not directly affected by Corps operations. An example is Fort Snelling State Park, an important historical site. At first appearance, its location and importance have not been appreciably helped or hindered by the 9-foot channel project. However, a new navigation channel dredged in the mouth of the Minnesota River facilitated use of land on the floodplain as state park picnic and boating areas.

The 9-foot channel and associated locks have provided stable water levels that have contributed significantly to the increased boating activity in Pool 2, along with increased regional population, higher levels of family income, and more leisure time. The increased pleasure boating has led directly to the nine public use sites identified in Table 35 of Section 2.

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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
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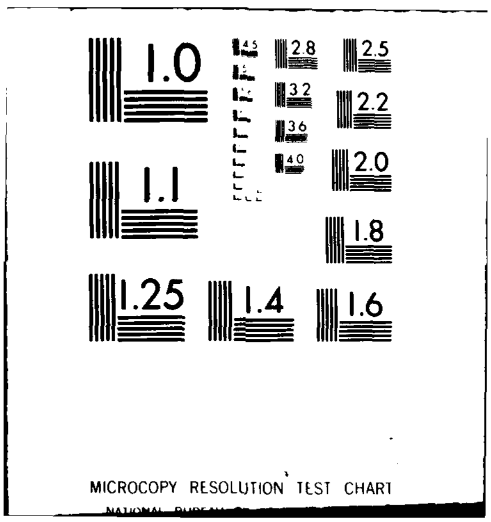
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4.5
MICROCOPY RESOLUTION TEST CHART

Sport Fishing and Hunting. For the reasons cited earlier in the discussion of commercial fishing, sport fishing in Pool 2 has declined appreciably in the dozen years prior to 1972. Although precise data are not available, attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the number of sport fishermen observed from their work location. Annual data for the most recent years for which these records are available appear in Table 44. The table shows a marked decline in sport fishermen observed from Lock and Dam 2 since 1963; because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 2 are in Pool 3. Fishermen in Pool 2--as seen from Lock and Dam 1--were stable at about 1100 to 1200 annually, in the mid-1960's; however, in 1969 this number jumped to over 1400 and then fell to about 600 in 1970; no explanation is available for this wide variation. In Pool 2, however, these data appear to be an especially good index to sport fishing activity in the pool because most of it occurs at the upstream end of the pool near Lock and Dam 1, or at the downstream end near Lock and Dam 2 to avoid the more polluted middle area of the pool below Pig's Eye Sewage Disposal Plant.

Table 44. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites at Both Ends of Pool 2 on the Upper Mississippi River, 1960 to 1970 (UMRCC, 1962-1971)

Year	Lock and Dam 1	Lock and Dam 2
1960	NA	NA
1961	NA	NA
1962	NA	NA
1963	NA	205
1964	1184	228
1965	NA	NA
1966	NA	268
1967	1108	369
1968	1194	401
1969	1428	103
1970	635	57
1971	NA	32

The rising water level in Pool 2 has increased the spawning areas for fish. In theory, this offers the potential for more sport fishing. However, the potential both for increased commercial and sport fishing in Pool 2 was realized only in the 1950's and early 1960's. Since then, effluents going into the pool have caused:

1. The amount of dissolved oxygen in the main river and channel to decline, and

2. The fish taken in Pool 2 to have an unpleasant taste.

Indeed, the sport fishing that still exists is probably largely attributable to the increase in spawning area and to improved local aeration of the water, both caused by the Corps' operation on the River.

As the water levels in Pool 2 have been raised in Corps' operations, habitat for residential and migratory waterbirds has also increased. This suggests the potential for greater bird hunting adjacent to Pool 2 and probably a lessening of hunting opoortunities for small animals. Increased industrialization has operated to reduce this hunting potential. Unfortunately, no data were found that measure hunting activity in and adjacent to Pool 2.

Sightseeing and Picnicking. Recreational sites along the perimeter of Pool 2 facilitate sightseeing, picnicking, and hiking. Again, however, non-boating visitors to these sites might be there whether Corps' operations existed on the Upper Mississippi or not. Significant improvements in one park, however, are a direct result of Corps' activities. This is Harriet Island Park. Harriet Island Park is somewhat of a misnomer; dredge spoil taken from the River to form the marina just upstream of Harriet Island was used to fill in the river between Harriet Island and the south bank so that Harriet "Island" is no longer an island.

Lock and dam attendants develop estimates and maintain records of recreational users of their pool areas. Dam tenders estimated the recreational users of Pool 2--including visitors to the Lock and Dam 2--numbered 63,000 in 1965 and 133,000 in 1970. The portion of this total visiting the overlook at Lock and Dam 2--about 20,000 annually in the 1970's--is directly attributable to Corps' operations; the remainder is caused by:

1. More people in the Twin Cities Metropolitan Area largely surrounding Pool 2,

2. More leisure time in the general population, and

3. More use of leisure time for participative types of recreational activities such as sightseeing, walking, and picnicking--activities that are possible on the banks of Pool 2.

Thus, while visitors to the overlook at Lock and Dam 2 are a direct result of Corps' operations, the remaining increase in recreational use of Pool 2 is not directly associated with Corps' activities.

Cultural Impacts. Records show that two archaeological sites were destroyed by the raising of the water level in Pool 2. These were the Schilling Site, a mound and village site on Grey Cloud Island, and the Sorg Site, a habitation site on Spring Lake. No other archaeological, historical, or contemporary sites of value are known to have been affected by Corps' operations on the Northern Section of the Upper Mississippi River.

Fort Snelling State Park, a combination historic site and recreation area, is enhanced somewhat by the project as noted previously. The historic part on the site is generally high above the river, however, and is unaffected by Corps' activities.

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

INTRODUCTION

Creation, operation and maintenance of the 9-foot channel in Pool 2 has had some unavoidable adverse effects on its natural and socioeconomic systems.

Natural systems have been and now are adversely affected by 1) the impoundment; 2) the dredging and "spoiling" (depositing of dredge spoil), 3) commercial navigation, and 4) barge terminals and associated facilities.

Socioeconomic systems have been and now are adversely affected by 1) the loss or modification of archaeological and historical sites, 2) the decrease in revenue to other forms of transportation, and 3) the decrease in recreational uses and aesthetics of the river.

NATURAL SYSTEMS

Unavoidable adverse effects upon the natural systems in Pool 2 which are caused by the 9-foot channel project come from 1) the impoundment of the Mississippi River, which raised water levels and slowed the river current; 2) the dredging and spoiling required to maintain the channel, which increases turbidity and creates bare, sterile areas; and 3) commercial navigation and barge terminals, which disturb and displace vegetation, fish and wildlife.

Impoundments Effects

The creation of a pool behind Lock and Dam 2 raised water levels to the extent that the adjacent floodplain areas were inundated, and slowed the current in the lower reach of the present pool. It also made riverbank trees subject to damage by ice expansion.

Shallow backwaters and low grassy meadows and wooded areas, such as Spring, Mooers, Baldwin and Pig's Eye Lakes, were covered by water which was of low . quality. Aquatic vegetation, game fish, waterfowl, and fur-bearers decreased and some animals, such as the prairie chicken and the badger vanished as they did elsewhere where this type of habitat was permanently inundated. The slower current resulted in the loss of flowing-river fish and some species of clams. It also increased sedimentation which smothered some benthic animals and aquatic vegetation. Residence time of nutrients and toxicants increased, and temperature increased. Natural aeration was lessened when flow, and thus turbulence, was reduced. These tended to increase eutrophication and undesirable fish and benthic organisms.

Submergence of wing dams may result in their becoming nearly covered by sediment, reducing benthic habitat and fish feeding areas. There are over 195 wing dams in Pool 2, all of which are now submerged.

Maintenance Dredging and Spoil Disposal

Sediments which pose an inconvenience or a hazard to navigation are dredged and spoiled, the latter accumulating nearby in large barren piles. Dredging increases the turbidity, nutrients, toxicants and pathogens in the water especially downstream from the metropolitan sewage treatment plant and 17 similar plants. Benthic organisms and fish in the area may be lost or weakened because of smothering, infestations of pathogens or poisoning.

Dredging also leaves bare, sterile river bottom areas and sandpiles. Spoil sites cover the low terrestrial vegetation and may slowly eliminate some tree species such as in the Baldwin Lake area. Recolonization of these bare areas is relatively slow, allowing erosion of the terrestiral spoil deposits by either wind or water. Spoil material which erodes into backwaters or the main channel smothers aquatic plants and benthic organisms. Resuspended spoil also blocks circulation of the water through the backwaters, which further reduces aquatic and wildlife populations.

Lock and Dam Operations

Unavoidable adverse effects caused by lock and dam operations seem limited to possible increases in turbidity and bank erosion when Lock No. 1 at the head of Pool 2 is emptied and in Pool 3 when Lock No. 2 is emptied. Left bank erosion by the Dam 2 gate closest to the Burlington Northern tracks (actually in Pool 3) is another adverse impact.

Snagging and Debris Clearance

Removal of substrate, clogging of shallow areas, increased turbidity and aesthetic degradation of areas used for disposal are unavoidable adverse effects of snagging and debris clearance.

Effects of Navigation

Passage of tows (towboats plus the barges they are pushing), operation of terminals, mooring barges along the river bank and clearing barges have unavoidable adverse effects upon the natural systems in Pool 2.

The turbulence created by passage of the tows erodes the riverbank and probably resuspends bottom sediments. Ice-breaking during early winter contributes to damage of riverbank trees. The increased turbidity which results tends to smother aquatic plants and animals.

Cleaning, filling and emptying the barges and operations of the towboats probably results in spills of fuels, lubricants, cargo and cleaning materials into the river, probably tending to reduce the vigor of the biota.

Fleeting basins, such as those located at the lower end of Pig's Eye Island, are a necessary adjunct of commercial navigation and may bring about several unavoidable adverse effects if not operated with great care.

Mooring of barges to trees on the riverbank girdles and eventually kills them. The trees fall into the river, becoming snags which soon must be removed, and the riverbank then is exposed to erosion. Such may already be happening at the small island at the foot of Pig's Eye Lake on which a large egret and heron rookery is located (see Figure 41). The noise and motion arising from barge fleeting activities and the Red Rock Terminal also may disturb and help ultimately to destroy this rookery.

Development of commercial navigation increased the development of the floodplain for barge terminals and industrial sites, necessitating levees and floodwalls which, by removing the floodplain's flood flow capacity, raise the height of floods in upstream floodprone areas.

Development of terminal sites usually causes complete removal of all vegetation, the most aesthetically pleasing feature of the riverscape. Terminal facilities, such as the St. Paul Barge Terminal usually require widening of the navigation channel, such as at the St. Paul Barge Terminal. Enlargement of the channel increases sedimentation and eventual dredging, with spoil disposal areas then claiming more natural floodplain habitat.

Further encroachment onto the floodplain occurs if the industies are attracted to locate near the terminals, commonly on low land filled by spoil and vulnerable to future flooding.

Pre-Project Effects

Previous Corps of Engineers projects having adverse effects on the Mississippi River include the removal of snags and debris, dredging and construction of wing and closing dams and bank protection structures. As in the present 9-foot channel project, removal of snags and debris and dredging decreased aquatic and terrestrial plants and animals because of increased turbidity and disturbance of habitat.

Constriction of the channel by wing and closing dams and bank protection structures required the disruption of the terrestrial and aquatic biota due to the quarrying of rocks, the cutting of brush, and the increase in turbidity and noise attending the building and placement of these structures. A long-term unavoidable adverse effect of channel constriction is prevention of the formation of new backwaters and probably the hastening of filling of existing marshes. Approximately 195 wing dams and probably several miles of bank protection are maintaining this adverse effect as part of the present project.

Probably the main unavoidable adverse environmental effects of the actual building of Lock and Dam 2 was the relatively minor loss of benthic river and marsh habitat at the site. Construction of Lock and Dam 1 also probably resulted in a small and temporary decrease in fish and benthic organisms in Pool 2 because of increased turbidity. However, in the long run, water quality may be improved in Pool 2 because of the increased retention time of the low quality water in Pool 1 and because of aeration at the dam.

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

NATURAL SYSTEMS

Project Feature

Channel Maintenance	Alternative
1. Dredging	1. Use only hydraulic dredge equipment for removal of dredgings; phase out derrick-boat.
	2. Modify cutterhead on Dredge Thompson and future dredging equipment to reduce turbidity.
	3. Constrict channel in spots where sediment accumulates by building additional wing dams. Concomitantly, enlarge another segment of the channel, near a "recycle" spoil site, where sediment can accumulate. For instance, this summer the Thompson dredged 325,000 cubic yards at the St. Paul Barge Terminal. This sediment was spoiled on a site adjacent to Holman Field, with an access road, and was hauled away by a building contractor.
	4. Prevent (or reduce) sediment from entering river, for instance, by improving conservation practices.
2. Spoil Reuse or Disposal	1. Vigorously pursue market potential for spoil, which may be good as indicated by the BSFW's 1973 preliminary survey. Future alterations of the present market potential should be considered; for instance, the possible curtailing of land-based sand and gravel operations because of adverse environmental impacts.

2. <u>Spoil Reuse or Disposal</u> (Continued)	2. Barge the spoil to a central terminal where it can be dewatered and removed for reuse, or at least disposal of with less adverse impact. These should be half screened by natural vegetation. Investigate the possibility of spoil disposal on existing dock of a building materials dealer.
	3. Protect spoil sites from erosion by wind and water by riprapping, sluicing and/or revegetating. Anchor floating log booms along the shoreline to protect riprap from ice-rafting of the stones. Moisture and nutrient may have to be added (carefully) to facilitate rapid growth. Strips of soil between spoil sites, perpendicular to the shoreline and at low elevation, thus close to water, would ensure rapid growth of willows. These willows would help to reduce wind and water erosion.
	4. Water draining a spoil site during deposition should be contained until the turbidity decreases to the level of the receiving waters.
	5. Maximize spoil site location, contours, erosion protection measures and other procedures to improve recreational use of spoil site and reduce loss of backwater and floodplain habitats.
	6. Have an *ecologist* to monitor and alter adverse dredging operations.
	7. Deposit spoil in an area remote from the river and wetlands, or even beyond the floodplain. No spoil should be placed on or upstream from the entrance of a slough or tributary or other backwater area. Spoil placed in a thin layer under a tree canopy seems to become more quickly and densely vegetated than when spoiled in deep piles in the open (see Figure 67; compare with Figure 60 Section 3).

Figure 67. Spoil Deposited Next to a Moist Woodland Appears to Become Vegetated More Rapidly Than a Spoil Site Not Protected by a Tree Canopy (Colingsworth, 1973)

2.	Spoil Reuse or Disposal (Continued)	8.	Investigate the possibility of improving fish and waterfowl habitat in Spring and Baldwin Lakes by blocking infiltration of lower quality river water.
3.	Dam Operation	1.	Investigate the need to build and operate fish ladder, or other device or procedure to permit migration of fish, clam larvae, etc.
		2.	Install and operate closing dikes with gates so that backwaters can be flushed out, especially during spring when water quality is high. Close gates when water is low and needed for navigation. However, some backwaters such as Pig's Eye Lake may need flushing year around.

4.	Lock Operation	1.	Revise locking priorities and adjust procedures and equipment to lock recreational boats through in the opposite direction between the two sections of double lockages of tows.
		2.	Realign signs containing directions for small boaters on lock guidewalls so they can be read from *small* boats approaching the locks.
		3.	Use the auxiliary lock on weekends and holidays when traffic is heavy. Future increases in pleasure boat lockages may be expected at Lock and Dam 2 as water quality continues to improve.
5.	Income	1.	An equitable system should operate, such as exists with highways, where users of locks and channels pay a toll, tax on fuel and/or license tax based upon gross tonnage, overall length (including barges), or draft of the vessel to help operate and maintain the system.
6.	Meetings on Spoil Disposal	1.	Include representatives from Minnesota PCA, Minnesota DNR, and Congressmen.
7.	Commercial Navigation	1.	Paint barges, using attractive colors that are more easily visible at night (when docked on-channel) and more aesthetically pleasing than rust or dark brown.
8.	Barge Docking Facilities	1.	Reduce gradually the occupants of the floodplain industrial areas to industries using barge transportation.
		2.	Reduce frontage of barge facilities to the minimum necessary for loading and unloading. These should be painted to blend with surrounding vegetation; screened from view by trees as much as possible; and should allow passage of people on paths along the river banks. Storage areas should be set back, and masked by natural trees, vines, and shrubs.

9.	<u>Floodplain Lakes Improvement</u>	1.	Increase flushing rate of Pig's Eye Lake by river water pumped by wind power into its north end.
10.	<u>Recreational Boating Safety</u>	1.	Mark ends of wing dams to warn small boat operators of these hazardous structures, since they must leave the navigational channel when two tows meet nearby.

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

Establishement of the 9-foot navigation channel in the Mississippi River brought economic, and some recreational, benefits to man and some plants and animals in Pool 2. However, it has affected large areas as a result of both its effective conversion of natural habitat to urban development and its reduction of productivity of some of the remaining natural, underdeveloped areas. The river corridor in St. Paul is termed a "unique natural resource" but, in the placc where most people see it--downtown St. Paul--little or nothing has been done to maintain its scenic qualities along with its development.

SHORT-TERM USES

During the life of the projett, economic growth of river transportation has and will continue to benefit segments of the commercial and industrial community. Increased business (and to a lesser degree, recreation) caused by the project has been important to the development of the Twin Cities and even more so to some smaller river towns downstream.

Recreational boating and other forms of recreation have been improved in some ways by the project, although the hunting, fishing and fur trapping (which developed in the marshes downstream) did not materialize in Pool 2. The danger of hitting submerged wing dams discourages many small boaters who would otherwise be using the river. Aesthetics have been improved for those who prefer lakes. The quality of the appearance has been reduced by the presence of unrelieved concrete and riprap in a few places, and by barge terminal facilities and drab, rusty barges.

MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The beneficial long-term effect of commercial navigation may be the development of a stronger, more broadly based economy upon which to secure future economic growth and direct human benefit in terms of cheaper goods and fuel. But, in the process, significant areas (*e.g.*, floodplain and blufftops) are converted from natural habitat to urban development, lowering biotic diversity and productivity, and the aesthetic quality of much of the pool.

Clearing of land and construction of terminals, locks and dams, residential areas, transportation links and spoil banks increase runoff and erosion, detrimental effects which are more pervasive and possibly longer-lasting than loss of specific sites of natural value.

Biotic productivity was decreased because the flooding of marshland, the grassy meadows of the floodplain and forests was by low quality water. These areas may recover in time if present pollution is significantly reduced. However, net productivity will be reduced even then with less sunlight reaching the plants and less plant life than before the project.

Aquatic plants and animals probably were increasingly affected by sedimentation, reduced current and pollution. Populations are generally reduced such as the paddlefish and the blue sucker. Some populations, such as badger, prairie chicken, skipjack herring and niggerhead clam possibly may never recover.

In general, diversity in the ecosystem has been reduced as can be expected when an area of alternating dry land, marsh and chute is converted to a flatwater lake with much less land-water interface. And the banks along the lake-like portion probably have more damage from ice than do those along the river-like portion.

In a sense, the formation of the pool and its current dedication as a natural aerobic and anaerobic waste reactor treating the water naturally before it goes downstream, improves the water quality of Pool 3. Thus, the environmental cost in Pool 2 becomes a benefit farther downstream.

The Mississippi River corridor could be a very great aesthetic asset. In a rush to develop it for industry, the scenic aspect has been all but forgotten. Many urban rivers have been successfully planned for multipurpose use. The Mississippi probably can also become a multipurpose project.

Resource Implications for Socioeconomic Activities

Table 45 summarizes the major resource implications of continuing to operate and maintain the 9-foot channel in the St. Paul District. The benefits and costs of the continuing operations of the Corps of Engineers (shown at the top of Table 45) must be compared with the benefits and costs to the three categories of socioeconomic activities used in this report; *e.g.*, industrial, recreational, and cultural. Resource implications for these four groups are discussed in sequence below.

Corps' Operations

Table 45 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 9-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 Corps' 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 9-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 because of improper dredge spoil placement.

Table 45. 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. Sedimentation behind dams and at head of flatwater pool
	Dredging Operations	1. Dredging employment 2. Nine-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat because of improper dredge spoil placement.
Industrial	Barge operation	1. Barge employment 2. Low-cost water transportation 3. Energy saving compared to alternate transportation modes 4. Decrease in air pollution compared to other modes.	1. Increased river turbidity 2. River pollution from oil and gasoline from barges 3. Hazard to small craft
	Commercial Dock	1. Dock employment 2. Attraction of barge-transportation-oriented firms that provide local employment	1. Increased river pollution from industrial activities along shore 2. Loss of riverfront property for recreational use
Recreational	Boating Activity	1. Increased safety of deeper channel for boaters	1. Decline in aesthetic appeal of riverscape
	Sport Fishing	1. Initially increased habitat for fish	1. Increased sedimentation in fish habitat 2. Hazard of wing dams and barges

Table 45. 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.)	Bird-watching	1. Initially increase habitat for waterfowl	1. Decreased waterfowl habitat from improper dredge spoil placement 2. Decrease in songbird habitat with removal of trees and brush, and joining of islands for industrial usage
	Sightseeing, picnicking, swimming		1. Decreased opportunities for miscellaneous recreational activities 2. River pollution from industrial and barge operation 3. Decrease in aesthetic appeal of river
Cultural	Historical Sites		1. Loss of single site due to Upper Lock construction

Industrial Activities

As summarized in Table 45, the major direct impacts of Corps' operations on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 45 notes 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 use?
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 caused by barge movements are discussed.

Barge Transportation and Energy Use. Effective energy use is particularly important because of the present, and probably continuing, energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

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

In comparing the efficiency of energy use 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 used more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum energy availability, the 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 United States 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 of 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 because of 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/1000 gallons diesel fuel	Pounds/1000 gallons gasoline
Aldehydes (R-CHO)	10	4
Carbon monoxide	60	2300
Hydrocarbons (O)	136	200
Oxides of Nitrogen (NO_x^-)	222	113
Oxides of Sulfur (SO_x^-)	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 air pollution per ton-mile as a barge tow. 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 45 identifies the variety of recreational activities--from boating and sport fishing to sighseeing 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 45 to weigh against the benefits of barge transportation made possible by maintaining the 9-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 9-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the 9-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 that can be attributed to present Corps' operations (not caused by 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 eventually increase wildlife habitat. What the fisherman loses, the hunter, or birdwatcher may gain.

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*	Value at $1.50 Per trip**
4	159,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	316,190	94,857

*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.

**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 value 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 COMMITMENTS OF RESOURCES WHICH HAVE BEEN INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

CAUSED BY CONSTRUCTION

The construction of navigation facilities and continuing channel maintenance in Pool 2 required an irretrievable commitment of certain human and natural resources. Planning, survey and design, labor and materials, fossil fuels, concrete, steel, lumber, dirt, sand, gravel, labor, wear on equipment, and a natural riverscape were committed to the construction of Locks and Dam 2 and appurtenant structures.

CAUSED BY OPERATIONS AND MAINTENANCE: AT LOCKS AND DAM 2, ON LAUNCHES AND DREDGES, THE MESSAGE CENTER AND THE DISTRICT OFFICE

There are continuing commitments of labor, fuel (mainly electric power), equipment and natural riverscape (aesthetic appeal) to the regular operation and maintenance of these structures. There is also a small commitment of land to the access road, lock and several buildings and their adjacent grounds.

The reconnaissance maintenance dredging of the 9-foot channel in Pool 2 consumes fuel (deisel fuel and electricity) and labor (of the survey crew taking soundings, on the dredge itself, and in the District Office), as well as the commitment of wear on the vessels themselves and equipment. Increasing commitments of land in Pool 2 have been and are being made in attempts to dispose of the sediments dredged from this channel.

LAND USE CHANGES

Some ecosystems have been disrupted permanently and thus have been irreversibly committed to the 9-foot channel project as well. The sites on which Locks and Dam 2 were constructred caused the removal of natural river bottom and banks, and floodplain habitat, eliminating those animals dependent on that cover and food. Further, floodplain as well as blufftop habitat was and is now being converted permanently to barge terminals, storage facilities and other navigation-related developments (such as the quarrying and sand and gravel operations on the Grey Cloud Islands), there by virtue of the 9-foot channel.

A commitment of 19 miles of free-flowing riverine ecosystem which is now flooded by the slackwater pool has been made, by the raising of the pool to design level. Also, the grassy meadows and woods and their diversity (both scenic, plant and animal) on the floodplain are irretrievable and irreversible because it is assumed that "no project" is not an alternative. Marsh and slough ecosystems, essential to the whole intricate living fabric of the area (such as Spring Lake and Nininger Slough), were irreversibly lost by inundation and sedimentation of the present shallow lakes and at the upstream end of the former sloughs.

Deposition of dredged materials has not only constituted a change in land use and repeated disruption of some ecosystems, but also has probably contributed to the elimination of some of the few backwaters in Pool 2, such as in a back channel and lagoon causing large-scale waterfowl botulism in 1969 at Newport (S.P.D.-NCS, 1971). Over a period of years, the current through this backwater has been almost eliminated by 1) wing and closing dams and attendant siltation, 2) spoil disposal on the islands forming the back channel, 3) sedimentation caused by lower velocities in the pool, and by making the velocity in the channel faster, 4) dredging upstream from the opening, 5) accumulation of tree trunks and branches in the inlet, and 6) a levee.

Removal of these habitats by creating the pool has reduced the extent and diversity of Pool 2 marsh and river ecosystems and eliminated others. Game fish, ducks, muskrats and other furbearers no longer frequent these areas, considerably reducing amenities which are highly desired near a large urban center: fishing, hunting and trapping. The low quality of the water present in Pool 2's shallow lakes is likely to prevent the return of many of these species for all time, unless (or until) the quality of the water improves.

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8. RECOMMENDATIONS

Certain studies should be conducted to determine specific adverse effects and alternative methods of operation and maintenance of the 9-foot channel.

FOR LONG-TERM BENEFITS TO NATURAL AND CULTURAL SYSTEMS

1. Investigate thoroughly the physical, chemical and biological (bacteriological) properties of spoil from each currently active dredging site in the pool in order to assess its value for reuse and more precisely analyze its limitations.
2. Pursue study of market potential and reuse of spoil as suggested by BSFW study (1973), using detailed analyses above.
3. Investigate in detail damage presently occurring to natural systems in the pool.
4. Study effects of turbidity, especially in polluted reach, on aquatic organisms and waterfowl.
5. Determine best method of barging spoil to central terminal and rapid method of unloading to eliminate impact on sensitive chutes, sloughs and other habitats of value.
6. Study the sources of sediment to Pool 2 to locate and eliminate primary sources.
7. Study to determine better method and/or equipment to dispose of spoil, such as a central redistribution terminal for sale or use elsewhere, or in floodplain area remote from river and important wetlands, or completely out of the floodplain.
8. Improve design of the Dredge Thompson cutterhead to reduce turbidity during dredging operations.
9. Survey Pool 2 to locate similar environmentally sensitive areas such as wildlife trails, fish spawning sites, clam beds, and to determine best means of protecting them.

10. Investigate population dynamics of egrets and herons of the Pig's Eye Lake area to determine effect of barge fleeting and terminal activity. Also determine rate of bank erosion on island.
11. Explore possibility of improving inflow into the north end of Pig's Eye lake.
12. Conduct a comparative study of recolonization of river bottom and spoil dredged from polluted and non-polluted reaches of the Mississippi.
13. Investigate effect of blocking Spring Lake from river water with spoil to improve water quality, fishing and wildlife in the lake. Check effect on downstream BOD of removal of acreage of natural waste reactor.
14. Improve arrangement of navigation charts. Rearrange them to begin with the head of navigation so they can be read in even sequence from one river mile to the next in either downstream or upstream direction.
15. On the lock guidewall, orient signs with directions for small boaters so they can be read as the boat approaches the guidewall within the navigation channel.
16. Look into ways to mark ends of wing dams, so small craft can leave the navigation channel safely.
17. Investigate ways to operate with a narrower channel such as legislation requiring river pilots to be properly trained and duly licensed, and embedding a sonar guidance device on difficult curves.
18. Formulate plan and implement to eventually remove all facilities and structures from floodplain, except those that can withstand flooding with no protection, so that natural systems may return to enhance the riverscape and all urban structures are out of danger. Move all stockpiles away from the bank and screen as well as possible with vegetation.
19. Study effects of opening the closing dikes during periods of greater flow in river and better water quality, but closing them for navigation needs during low flow.
20. Study of fish, clam, etc., migration and devise ways to enhance it at Lock and Dam 2.

21. Conduct a survey of future land use needs and potential of this reach of Mississippi Valley similar to that being done for the St. Croix valley.
22. Develop and implement plan to use natural vegetation to space terminals between natural areas and reduce to a minimum the terminal facilities. Encourage structures and stockpiles be located outside of floodplain or at least at highest levels of the floodplain.
23. Study measures to revegetate levees, which are biological deserts which block access to the river and are aesthetically displeasing.
24. Require small boat handlers to read and be quizzed on informational material on navigation on the river.
25. Install a pipe through the Hastings dam dike into Lake Rebecca, providing cascades for aeration of the Pool 2 water entering it.
26. Encourage some aesthetic improvement of barges and barge terminals: landscaped patches of riverbank, attractive paint on the barges and other measures to enhance what must be close to or on the river.

FOR SHORTER-TERM BENEFITS TO NATURAL AND CULTURAL SYSTEMS

1. Study present methods and devise new ones for effective, imaginative and attractive methods of confining dredge spoil. Develop a plan for diking, rip-rapping, etc., of spoil banks to reduce erosion into backwaters and main channel; try to adapt them to recreational use as well as sediment storage.
2. Work out methods of revegetating spoil banks more rapidly, including confining and mulching to reduce moisture loss, seeding and irrigation.
3. Study development of diked spoil disposal sites for wildlife, fish or recreational uses.
4. Investigate feasibility of constructing channel constriction structure where significant dredging occurs.
5. Investigate potential of dredging to rejuvenate backwaters.

REFERENCES

Bureau of Sport Fisheries and Wildlife (BSFW). Minneapolis Area Office, Division of Ecological Services. 1973. Upper Mississippi River Dredge Spoil Survey. U. S. Department of the Interior, BSFW. Twin Cities, MN. Unpublished mimeographed manuscript. 11 pp.

National Water Commission (NWC). 1972. Chapter 5, Section B: The inland waterway program. In Review Draft of the Proposed Report of the National Water Commission. National Water Commission, Washington D.C. National Technical Information Service, Springfield, VA. 1122 pp.

9. APPENDIX A: NATURAL SYSTEMS

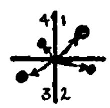
I. METHODS OF DATA COLLECTION

Methods for Collecting Samples

Biological Measurements

Benthic organisms were sampled using a Petersen (rarely, Ekman) dredge. Vegetation cover, in acres, was determined by planimetry from aerial photos, with subsidiary ground investigations along 3 standard transects and one special transect to identify species, and to determine abundance and in some cases, age and growth rate. Both quadrat (percent cover of herbs and vines in one square meter) and point quarter methods (for trees, vines and shrubs) were employed (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 by 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. nephelometer Model 104 (APHA et al., 1971)

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

Slope angle was measured using an instrument made at North Star Research.

Light penetration (water transparency) was determined by suspending a 20 cm Secchi disc with a marked cord (Golterman, 1970) in the water.

II. MAP OF POOL 2 AND TRANSECT LOCATION

The map of Pool 2 (See Figure 1) shows the location of the three standard transects and one special transect. Standard transects are surveyed lines which -- for this study -- cross the river at a right angle in each reach, an alignment designed to sample its maximum ecological diversity (See Figure 2). They extend (insofar as possible) from bluff to bluff and include bluff slope, riverbanks, marsh, open river and river bottom. Standard Transect 2AA is located about 1/4 mile downstream from the head of the pool (Lock and Dam 1), across the reach least modified by Dam 2. Standard Transect 2BB is located near both the midpoint of this pool and the primary control point at Mile 833.9 in South St. Paul. Special Transect 2YY was located and surveyed (run) in the same location as the transect on which Hokanson sampled Spring Lake bottom fauna in 1964. Standard Transect 2CC was run across the deep, lake-like Pool 2 approximately 1/4 mile upstream from Lock and Dam 2.

Azimuth (compass direction clockwise from north which is 0° with east as 90°) and other pertinent data is given in Table 1.

Sampling stations were located at chosen points along these transects, clustered mainly in areas of transition between types of habitat, such as forest to bare sandy soil. In addition, selected sites on three special study areas at Mile 833.2 (right bank), Mile 832.0 (left bank) and Mile 827.7 (right bank) were studied for a comparison of vegetation on dredge spoil which had been undisturbed for known and differing periods of time.

Sampling Frequency

Field studies to corroborate and expand the aerial survey of the terrestrial vegetation were performed in August, September and October.

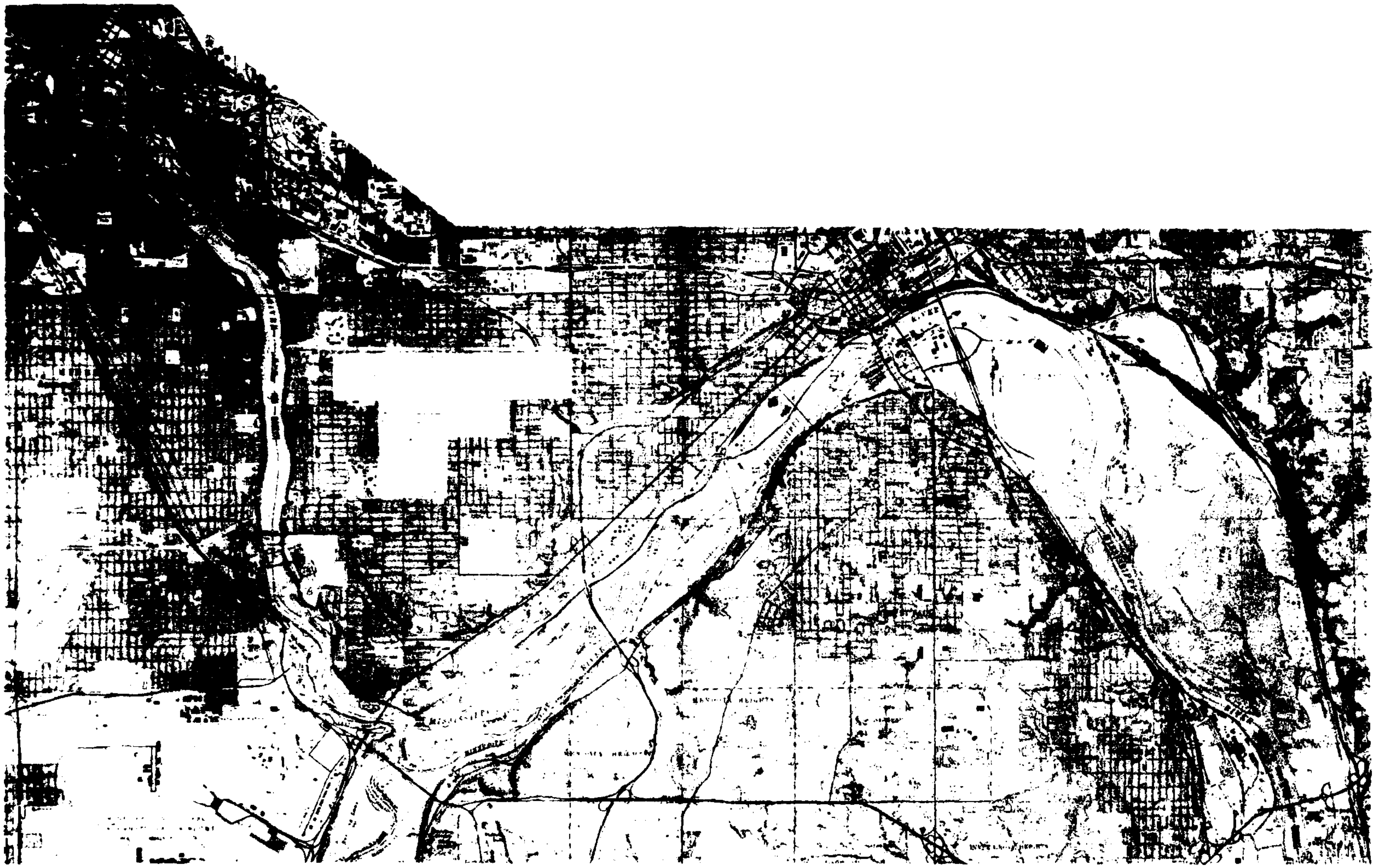
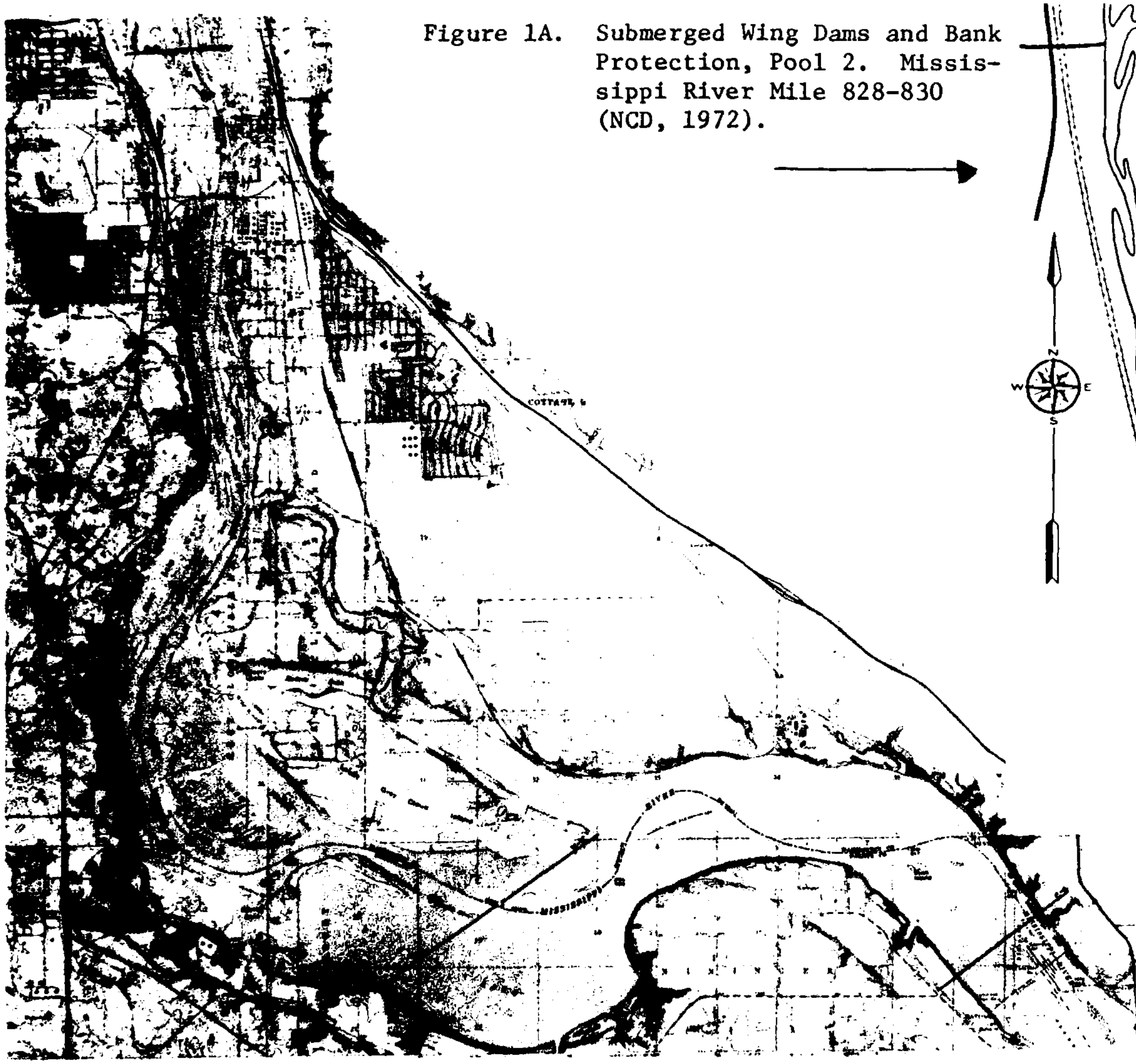


Figure 1. Map of Pool 2 (Part A).



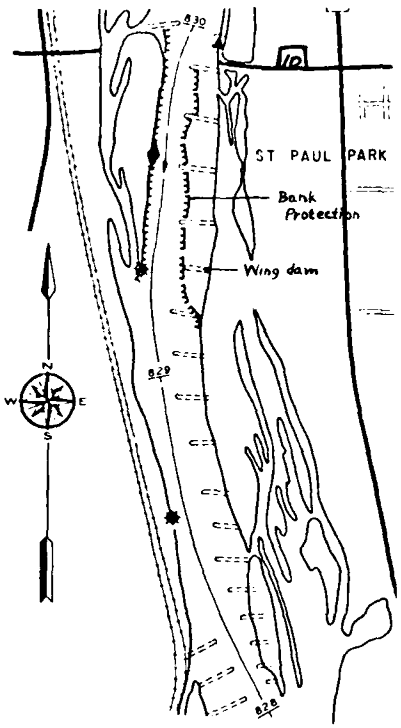


Figure 1A. Submerged Wing Dams and Bank Protection, Pool 2. Mississippi River Mile 828-830 (NCD, 1972).

Figure 1. Map of Pool 2 (Part B).

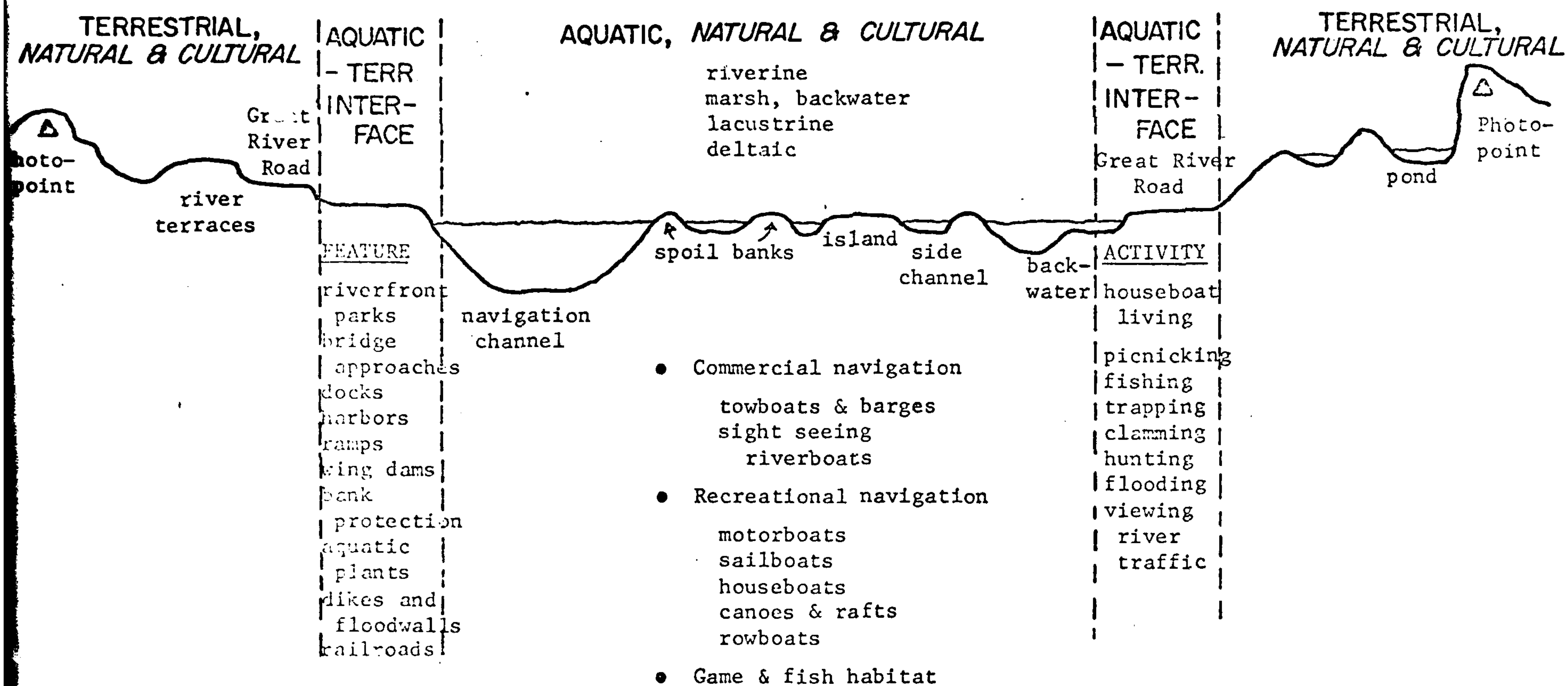


Figure 2. Profile of a Typical Transect of the Marsh Portion of a Typical Pool.

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.

Benthic samples were collected in April and May ("Spring") and again in July and September ("Summer"). Water quality data was collected at those times and in early November.

III. SUMMARY OF DATA COLLECTIONS

Benthic (bottom) grab samples were taken on three standard transects and on one special transect during the months of April and May (Spring), and August and September (Summer). Each sample was screened through a 707-micron standard sieve and the organisms retained and preserved in formation. Identifications of the benthic organisms were made by Mr. David Maschwitz, graduate student in the Department of Entomology, Fisheries and Wildlife, University of Minnesota.

Plant presence and abundance were determined by marking off a one-meter-square quadrat beside the tape used to measure distances from the riverbank. Each quadrat was placed in the middle of a vegetation zone for herb, vine and shrub composition. The composition of tree and shrub communities was determined by the point quarter method, with the central point located on the tape, and the first quarter (quadrant) to the left of the tape as the observer faced the ascending bank or the floodplain. After the crossed sticks were positioned, the tape was removed and used to measure from the "point" where the sticks crossed to the nearest tree (over 2" in diameter). The circumference (CBH = circumference breast high) was measured and recorded also. Plant identifications were made by Dr. Gerald Ownbey, Curator of the Herbarium, Department of Botany, University of Minnesota, as well as by the investigators.

Water quality, including turbidity, temperature and dissolved oxygen were determined at each transect and at several additional points in the Minnesota River and the Mississippi River from the head of navigation downstream to and including 2BB in Pool 2. The additional points include special transects, dredging or navigation studies. The portion of Pool 2 downstream from the 2BB transect to the Hastings Dam and the St. Croix River was not sampled due to an equipment breakdown near the end of the sampling season which required cancellation of the final field trip by boat.

Bird counts were made on a casual basis; i.e. a record was kept of most birds seen while involved in other studies. Some special attention was given to the herons and egrets; for instance a special trip was made to determine the abundance of these species both to some of the Minnesota River and to some of Pool 2 floodplain lakes.

IV. TABLES OF BASIC DATA

Table 1. Abundance of plants found in the river valleys in the Twin Cities area.

Table 2. The birds of the Minneapolis-St. Paul region (Dodge, et al., 1972).

Table 3A. Water quality of Mississippi River in 1973 measured at intake of the Minneapolis Water Works in Fridley.

3B. Water quality of Mississippi River, Pool 2, measured in a special study in 1973.

3C. Water quality of Mississippi River in 1928.

Table 4. Turbidity, temperature and dissolved oxygen in the SAF, Pool 1 and 2 in the Mississippi River, and in the lower Minnesota River, November, 1973.

Table 5. Downstream profile of turbidity and the effect of dredging and barge traffic on turbidity in the Minnesota River, September 25, 1973.

Table 6. Common species of game fish of the rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

Table 7. Common species of rough fish of the rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

Table 8. Benthic animal abundance.

Figure 1. Annual volume of sediment dredged within each river mile, arranged by decade.

Figure 2. Daily mean flows, Anoka Gaging Station. 1967 - 1969.

Figure 3. Daily mean flows, St. Paul Gaging Station. 1967 - 1969.

Figure 4. Temperature, Station 1. NSP Riverside Power Plant Mile 856.8. 1967 - 1969.

Figure 5. Temperature, Station 2. J. L. Shiely, Dock, Upper Grey Cloud Island Mile 826.5. 1967 - 1969.

Figure 6. Dissolved oxygen, Station 1. 1967 - 1969.

Figure 7. Dissolved oxygen, Station 2. 1967 - 1969.

Figure 8. pH, Station 1. 1967 - 1969.

Figure 9. pH, Station 2. 1967 - 1969.

Figure 10. Specific conductance, Station 1. 1967 - 1969.

Figure 11. Specific conductance, Station 2. 1967 - 1969.

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
Trees & Shrubs (cont'd.)																	
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	

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>																	
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
<u>Trees & Shrubs (Cont'd.)</u>																	
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)

	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>																	
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
<u>Herbs (Continued)</u>																	
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)

Species	Pool: 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>																	
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)

	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>																	
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
<u>Herbs (Continued)</u>																	
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																
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>																	
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			PP	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)

	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)																	
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
Herbs (Continued)																	
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
Herbs (Continued)																	
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)

Species	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)																		
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:	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)__																	
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)

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>																	
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
<u>Herbs (Continued)</u>																	
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)

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>																	
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	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
Herbs (Continued)																	
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)

	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)																	
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)

Species	SAF Upper			SAF Lower	Pool 1			Pool 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)																	
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)

Species / 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)																	
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)

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 (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										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
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)

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>																	
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
<u>Herbs (Continued)</u>																	
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
Herbs (Continued)																	
HEPATICAE (Liverworts)														P			
MUSCI (mosses)														P	P	P	P

Table 2.

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

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

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

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. Swedenberg 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 2. (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 2 . (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 2. (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 2 (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	C5												
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 2 (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												

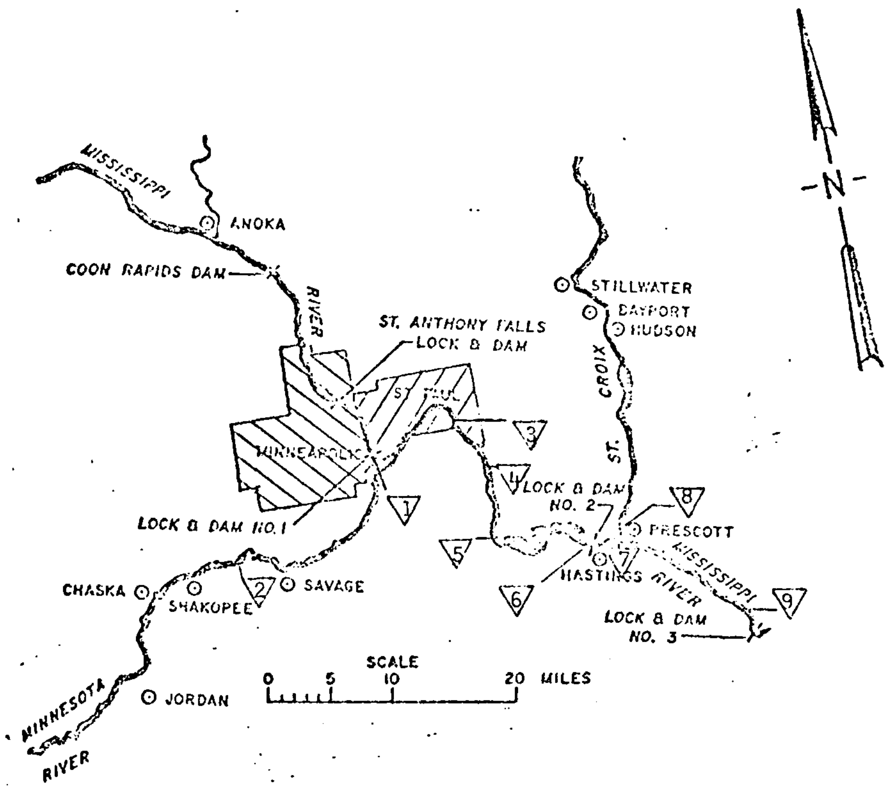
Table 2 (Continued).

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												
[illegible] Night Heron	A2-3, C1												
[illegible]	C												

Table 3A. Water Quality of Mississippi River Measured at the Intake of the Minneapolis Water Works in Fridley, 1973

Parameter		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Bacteria in raw water, Most Prob. No./100 ml	Total	108690	114270	7850080	221300	117730	109400	67690	117270
	Aver.	3506	4081	253228	7343	3797	3647	2184	2783
	Max.	13000	17000	7160000	35000	13000	24000	7900	17000
	Min.	790	490	700	1300	170	450	330	170
Turbidity, Jackson Turbidity Units	Aver.	2.7	2.0	5.0	3.1	4.7	4.7	4.7	4.5
	Max.	3.1	2.4	14.0	4.0	20	9.0	24	10
	Min.	1.9	1.5	1.9	2.5	2.9	3.3	3.3	2.2
Calcium Hardness in mg/l as $CaCO_3$	Aver.	119.4	125	96	106	107	107	104	94
	Max.	126	135	124	113	135	116	116	102
	Min.	112	119	69	95	94	101	100	85
Bicarbonate, mg/l	Aver.	168	175	128	132	130	136	133	120
	Max.	178	180	175	144	139	146	140	139
	Min.	153	170	88	118	113	128	125	98
Alkalinity, mg/l as $CaCO_3$	Aver.	168.2	179	132.5	144	140	146	148	135
	Max.	177	188	182	154	151	153	155	232
	Min.	155.5	172.5	91	126	125	134	137	120
pH	Aver.	7.90	8.1	8.02	8.4	8.2	8.21	8.5	8.4
	Max.	8.03	8.2	8.2	8.7	8.4	8.43	8.6	8.6
	Min.	7.75	7.95	7.75	8.05	8.0	8.0	8.3	8.1
Color	Aver.	28	24	48.7	44	51	59	47.7	56
	Max.	32	26	74	53	64	72	73	77
	Min.	25	20	20	38	45	47	40	37
Fluoride, mg/l	Aver.	0.15	0.12	0.14	0.15	0.17	0.19	0.18	0.17
	Max.	0.16	0.13	0.16	0.16	0.20	0.24	0.19	0.19
		0.15	0.5	0.13	0.13	0.13	0.15	0.16	0.15

Table 3B. Water Quality of Mississippi River, Pool 2, Measured in a Special Study in 1973.



Station 1 (Upper Mississippi River Mile 847.05)

Below L & D No. 1 (Ford Dam) and downstream from the mouth of Minnehaha Creek. This station will be at midstream about 200 feet downstream from the large storm sewer on the north bank.

Station 2 (Minnesota River Mile 0.20)

Upstream on the Minnesota River far enough to be sure that no mixing has occurred with the Mississippi River. This station will be located at midstream approximately 100 feet upstream from the large overhead power lines.

Station 3 (Upper Mississippi River Mile 835.35)

This station is to be located at midstream just off the first black navigation buoy below the railroad bridge at the Metro STP. The station is about 0.20 miles above the point of entrance of Metro's effluent with the Mississippi River.

Station 4 (Upper Mississippi River Mile 832.50)

This station will be at mid-channel under the Route 494 highway bridge.

Table 3B (Continued).

Station 5 (Upper Mississippi River Mile 826.50)

This station will be located at midstream opposite the existing automatic monitoring station.

Station 6 (Upper Mississippi River Mile 815.35)

This station will be at Lock and Dam No. 2. The sampling station is to be at the headwall upstream from the old, unused, small lock. The samples are to be taken just upstream from the permanent overflow section at the west end of the dam's spillway.

Station 7 (Upper Mississippi River Mile 811.80)

This station will be located at midstream off the black navigation buoy located at the upstream end of Prescott Island.

Station 8 (St. Croix River Mile 0.40)

This station is to be located far enough upstream on the St. Croix to insure that no mixing has occurred with the Mississippi. The station should be located 200 feet upstream from the center pier of the highway bridge, which is the most upstream of the two bridges.

Station 9 (Upper Mississippi River Mile 804.90)

This station is to be located at midstream off the existing navigation light. The light is placed on a tree which has been painted white.

Table 3B. Water Quality of Mississippi River, Pool 2, Measured in a Special Study in 1973 (Continued)

	Secchi	Wtr T	DO	pH	Alk as CO_3	SS	BOD_5	Turb JTU	Chl A	P as PO_4	Org C	Fecal Colif
DATA RECAP FOR STATION 1												
Number of observations	23	57	57	52	56	56	56	56	57	56	53	56
Maximum value	2.0	28.5	9.4	8.4	140.0	46.0	7.1	22.0	90.4	.2	21.0	12000.0
Minimum value	1.0	20.0	7.9	7.3	120.0	3.0	1.5	3.5	12.5	.0	10.0	.0
Range of observations	1.0	8.5	1.5	1.1	20.0	43.0	5.6	18.5	77.9	.2	11.0	12000.0
Mean value	1.5	24.1	8.6	8.1	126.6	25.2	3.0	8.8	39.8	.1	15.2	1799.0
Standard deviation	.2	1.6	.4	.3	5.8	6.1	.8	3.0	10.5	.1	2.0	2910.0
DATA RECAP FOR STATION 2												
Number of observations	25	56	56	50	57	57	57	57	57	57	52	56
Maximum value	1.0	28.2	6.3	8.9	240.0	218.0	14.0	53.0	60.4	.8	16.0	448.0
Minimum value	.5	23.0	4.1	7.2	120.0	19.0	3.2	5.3	19.9	.3	4.0	.0
Range of observations	.5	5.2	2.2	1.7	120.0	199.0	10.8	47.7	40.5	.5	12.0	448.0
Mean value	.9	25.8	4.9	7.9	223.5	55.2	5.6	19.5	43.7	.4	9.2	113.0
Standard deviation	.2	1.2	.5	.2	24.5	32.9	1.7	7.2	8.5	.1	2.1	90.0
DATA RECAP FOR STATION 3												
Number of observations	28	55	55	47	55	55	55	55	54	55	53	56
Maximum value	1.5	26.8	8.9	8.4	150.0	79.0	5.4	18.0	70.8	.2	16.0	16000.0
Minimum value	1.0	21.0	6.6	7.1	130.0	14.0	1.7	4.4	22.3	.0	9.0	100.0
Range of observations	.5	5.8	2.3	1.3	20.0	65.0	3.7	13.6	48.5	.2	7.0	15900.0
Mean value	1.4	24.7	7.7	8.0	137.8	29.2	3.2	9.8	40.9	.1	13.3	2640.0
Standard deviation	.2	1.4	.4	.3	6.3	9.4	.7	2.6	7.9	.0	1.5	3634.0
DATA RECAP FOR STATION 4												
Number of observations	27	55	55	46	55	55	55	55	54	55	51	55
Maximum value	1.8	26.3	8.2	8.2	150.0	43.0	7.0	17.0	54.0	16.1	28.0	40000.0
Minimum value	1.0	20.8	5.5	7.2	120.0	18.0	3.0	5.7	23.6	.1	9.0	300.0
Range of observations	.8	5.5	2.7	1.0	30.0	25.0	4.0	11.4	30.4	16.0	19.0	39700.0
Mean value	1.4	24.6	7.1	7.9	140.0	27.0	5.1	10.0	40.3	.8	14.9	4548.0
Standard deviation	.2	1.2	.5	.2	6.9	5.5	.7	2.4	7.6	2.7	2.4	8035.0
DATA RECAP FOR STATION 5												
Number of observations	27	55	55	47	55	55	55	55	53	55	51	55
Maximum value	1.8	26.2	7.3	8.1	150.0	72.0	6.5	18.0	63.8	.3	17.0	50000.0
Minimum value	1.0	21.0	4.6	7.2	130.0	2.0	3.2	1.4	25.3	.1	9.0	300.0
Range of observations	.8	5.2	2.7	.9	20.0	70.0	3.3	16.7	38.5	.2	8.0	49700.0
Mean value	1.4	24.7	6.3	7.8	41.6	32.1	4.8	10.7	40.7	.3	14.4	3945.0
Standard deviation	.2	1.1	.6	.2	6.3	11.3	.7	2.7	6.7	.0	1.8	8658.0

Table 3B. Water Quality of Mississippi River, Pool 2, Measured in a Special Study in 1973 (Continued)

	Secchi	Wtr T	DO	pH	Alk as CO_3	SS	BOD_5	Turb JTU	Chl A	P as PO_4	Org C	Fecal Colif
DATA RECAP FOR STATION 6												
Number of observations	38	55	54	41	55	55	55	55	55	55	50	54
Maximum value	2.0	29.0	9.6	8.4	160.0	68.0	14.0	24.0	72.8	.5	21.0	1100.0
Minimum value	1.0	21.0	4.9	7.4	140.0	.4	2.0	5.5	25.3	.2	10.0	4.0
Range of observations	1.0	8.0	4.7	1.0	20.0	67.6	12.0	18.5	47.5	.3	11.0	1096.0
Mean value	1.43	24.5	6.6	7.9	145.1	32.2	6.1	12.8	49.7	.3	14.5	92.0
Standard deviation	.2	1.6	1.0	.2	6.1	11.3	2.0	3.7	10.5	.1	2.0	152.0
DATA RECAP FOR STATION 7												
Number of observations	32	45	45	33	45	45	45	45	45	45	42	46
Maximum value	1.5	30.0	8.0	8.2	160.0	73.0	18.0	23.0	124.5	.5	17.0	248.0
Minimum value	1.0	22.0	6.0	7.5	140.0	6.0	2.7	4.6	20.8	.3	9.0	.0
Range of observations	.5	8.0	2.0	.7	20.0	67.0	15.3	18.4	103.7	.2	8.0	248.0
Mean value	1.4	25.2	6.8	7.8	146.2	36.7	5.6	13.00	52.2	.3	13.5	80.0
Standard deviation	.2	1.9	.4	.2	6.1	10.0	2.2	3.8	13.9	.0	1.7	56.0
DATA RECAP FOR STATION 8												
Number of observations	36	51	47	40	52	53	53	53	53	52	49	53
Maximum value	6.5	28.0	10.6	8.7	110.0	44.0	9.0	6.8	55.5	.2	11.0	236.0
Minimum value	4.0	23.0	6.4	7.7	90.0	2.0	1.2	1.5	11.3	.0	5.0	.0
Range of observations	2.5	5.0	4.2	1.0	20.0	42.0	7.8	5.3	44.2	.2	6.0	236.0
Mean value	5.1	24.4	8.3	8.3	99.0	8.3	3.3	3.7	20.4	.0	7.4	7.0
Standard deviation	.7	1.4	1.1	.3	3.8	10.4	1.6	1.0	7.2	.0	1.2	34.0
DATA RECAP FOR STATION 9												
Number of observations	17	29	29	19	29	29	29	29	29	29	29	29
Maximum value	2.0	29.0	8.4	8.7	140.0	43.0	7.2	45.0	66.4	1.6	14.0	300.0
Minimum value	11.0	23.0	6.0	7.5	120.0	6.0	3.3	5.0	25.2	.0	8.0	4.0
Range of observations	1.0	6.0	2.4	1.2	20.0	37.0	3.9	40.0	41.2	1.6	6.0	296.0
Mean value	1.9	25.5	7.0	8.0	132.0	28.0	4.7	12.0	47.4	.2	11.3	63.0
Standard deviation	.3	1.9	.5	.3	6.2	6.8	.8	6.7	8.1	.3	1.2	65.0
DATA RECAP FOR STATION 11												
Number of observations	0	0	0	0	58	57	0	58	0	56	55	57
Maximum value	.0	.0	.0	.0	280.0	41.0	.0	20.0	.0	5.4	66.0	8000.0
Minimum value	.0	.0	.0	.0	150.0	10.0	.0	8.2	.0	1.0	28.0	.0
Range of observations	.0	.0	.0	.0	130.0	31.0	.0	11.8	.0	4.5	38.0	8000.0
Mean value	.0	.0	.0	.0	234.8	25.5	.0	15.2	.0	2.8	49.0	288.0
Standard deviation	.0	.0	.0	.0	29.8	5.6	.0	2.5	.0	.9	7.4	1257.0

Station	Location	Color Max.	Color Min.	Color Av.	Turbidity Max.	Turbidity Min.	Turbidity Av.	Total Hardness Max.	Total Hardness Min.	Total Hardness Av.	Alkalinity Max.	Alkalinity Min.	Alkalinity Av.	Chlorides Max.	Chlorides Min.	Chlorides Av.
1	Camden Ave. Bridge	...	..	..	70	5	13	203	108	137	209	99	145	14	2.8	6.56
4	Lock and Dam, Mpls.	...	..	..	65	6	15	218	108	140	200	108	146	18.7	5.5	10.5
8	Inver Grove	...	..	..	120	10	39	218	124	172	210	114	155	34.2	7.6	15.5
9	Above Hastings	120	27	51	60	4	23	253	138	180	243	115	159	16.5	1.0	5.5
13	Above Red Wing	100	15	53	240	0	24	190	103	148	185	101	131	9.0	0.5	3.0
15	Outlet of Lake Pepin	75	20	45	10	0	5	198	120	151	193	105	135	9.0	0.0	3.3
17	Below Wabasha	90	13	53	200	2	17	172	80	123	179	60	110	7.0	0.0	1.9
19	Above Winona	110	36	64	135	0	26	156	40	111	139	45	100	4.5	0.0	1.3

Station	pH Value Max.	pH Value Min.	pH Value Av.	Dissolved Oxygen Max.	Dissolved Oxygen Min.	Dissolved Oxygen Av.	5-Day Demand Max.	5-Day Demand Min.	5-Day Demand Av.	Bacteria per c.c., 37° C., 48 hrs. Max.	Bacteria Min.	Bacteria Av.	*B. coli* per c.c. Max.	*B. coli* Min.	*B. coli* Av.
1	8.0	7.4	7.86	11.6	4.1	8.2	6.6	0.7	2.4	11,500	80	1,726	100	0.1	11
4	8.4	7.4	7.8	12.7	2.9	6.8	8.4	2.2	4.2	830,000	5,700	193,257	10,000	10	1,591
8	8.0	7.5	7.8	11.5	2.3	6.7	14.0	3.1	6.0	1,000,000	8,900	156,924	10,000	100	2,071
9	8.0	7.5	7.7	11.1	1.5	5.8	11.1	1.3	5.0	220,000	3,900	60,345	1,000	10	545
13	8.1	6.5	7.65	10.5	2.6	6.3	4.5	1.5	2.7	93,000	475	21,659	1,000	10	159
15	8.4	7.3	7.9	11.9	3.7	7.3	4.7	1.1	2.2	3,100	41	643	10	0.02	1
17	8.4	7.2	7.8	11.3	4.1	7.2	3.9	0.6	1.7	7,700	55	1,408	10	0.1	5
19	8.4	7.2	7.7	11.7	6.6	8.2	5.1	1.1	2.3	21,500	150	2,712	100	1	14

Table 3C. Water Quality of the Mississippi River in 1928 (Reinhard, 1931).

Table 4. Turbidity, temperature and dissolved oxygen in the SAF Pools, Pools 1 and 2 of the Mississippi River the the Lower Minnesota River, November 1 and 2, 1973 (Colingsworth, Gudmundson and Weir)

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 pushe
		BB (Mid-ch)	0'	3	7.5	8.06	2 loaded barg
			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 Da
		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	8.78	
		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 (... throttle ~... from R/B)

*(b) = river bottom depth † ch = channel †† R/B = right bank

**FTU = Formazine Turbidity Units; measured with a nephelometer.

Table 5. Downstream profile of turbidity (in FTU) and the effect of dredging and barge Traffic on Turbidity in the Minnesota River, September 25, 1973 (Colingsworth and Gudmundson)

(D') = water depth sampled, in feet.

MN.R. Mile	Location	Left Bank FTU (D')	Mid-chan. FTU (D')	Right Bank FTU (D')	Notes
21.8	150 yds upstream from Peavey terminal	33 (0') 37 (2') (bottom 3')	36 (0') 42 (4') (bottom 6')	35 (0') 39 (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 (0') 25 (5') (bottom 7')	18 (0') 23 (9') (bottom 12')	22 (0') 27 (3') (bottom 5')	Upstream from heavy barge traffic.

Table 6. Common Species of Game Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

Species	Mississippi River				Minnesota 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	St. Croix River
Walleyed Pike	X	(list is incomplete)	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	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 7. 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.

Table 8. 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	Caenidae	*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 8. 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 8. 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-chanrel; 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

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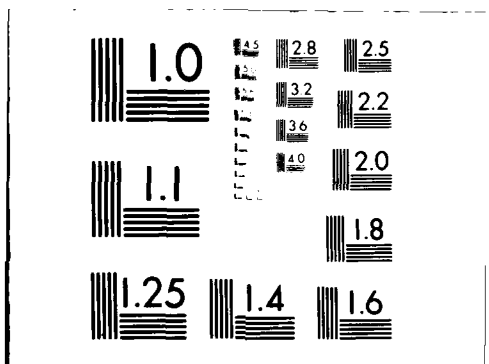

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Table 8. Benthic Animal Abundance (cont.)
A Comparison of Spring and Summer Samples of Benthic Macroinvertebrates Collected in 1973 in the Minnesota and Lower St. Croix Rivers and Mile 815.3 to 857.3 of the Mississippi River (Continued)

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 8. 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 8. 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 8. 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

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 8. 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	*Cheumatopsyche*	1	
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta			3	

Table 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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

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

Diptera	Chironomidae	*Procladius*	8	68.

2CC: Mid-channel; Summer 1973

Diptera	Chironomidae	*Procladius*	8	27.
Oligochaeta			11	

2CC: Right bank; Spring 1973; No sample

2CC: Right bank; Summer 1973; No sample

Table 8. 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

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	57.

Table 8. 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 8. 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 8. 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

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

Diptera	Chironomidae	*Procladius*	2	33.

Transect SXX, Mile SC16.0

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

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 clamshell; Middle of the bay; 7.5' depth

Diptera	Chironomidae	*Cryptochironomus*	1	43.
	Chaoboridae	*Chaoborus*	1	

Table 8. 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

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 8. 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 8. 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 8. 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: Right bank; Summer 1973; No sample

Table 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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 8. 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

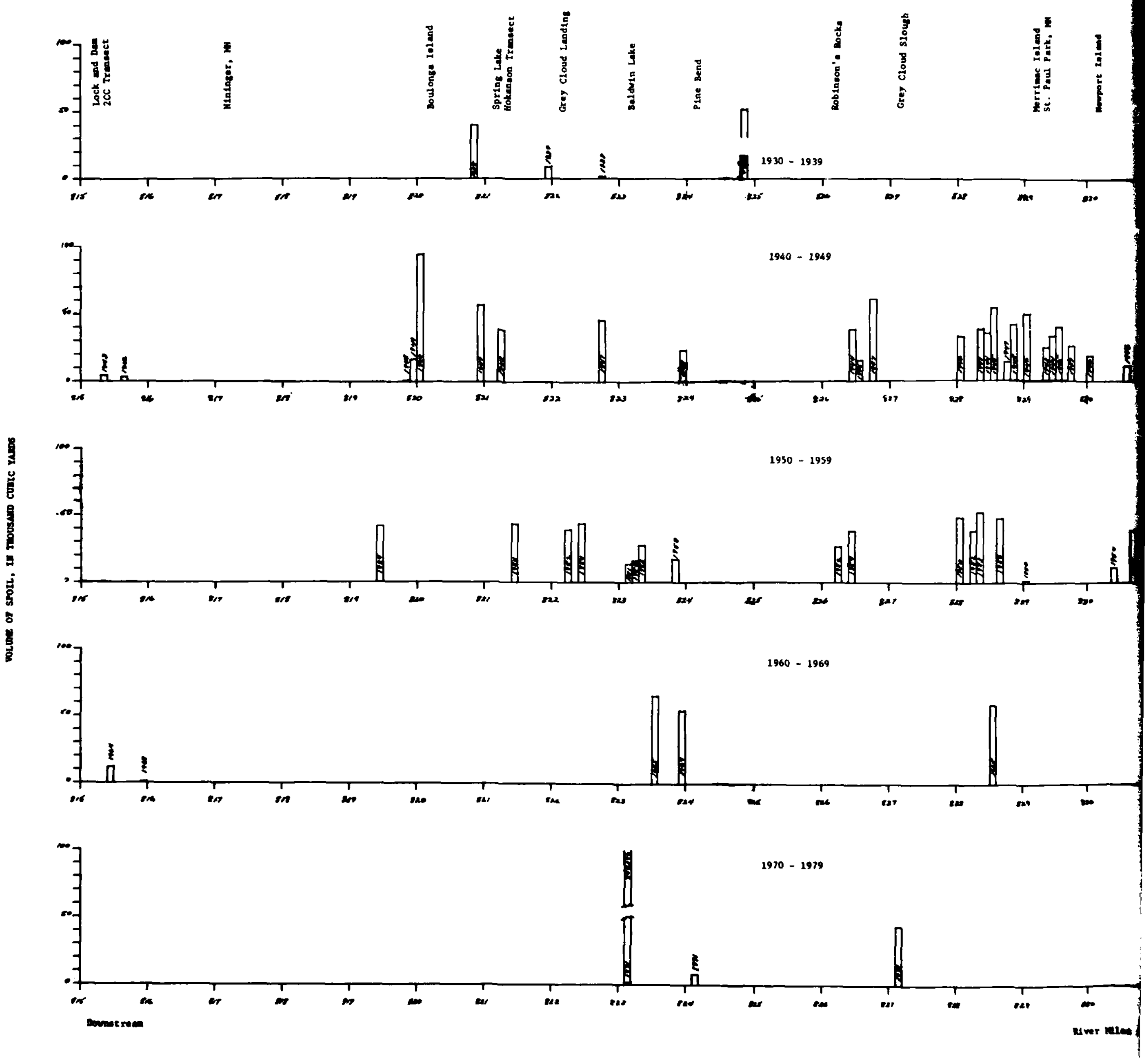
Genus *Pisidium*
SXX Spr 75.

Genus *Sphaerium*
1BB Spr 17. 1XX Su 24.

EGGS (?) of unknown organism on pebble
SBB Spr 4.

EGG(?) of a fish
SYY Spr 76.

POOL # 2



Lock and Dam
2CC Transect
Nininger, MN
Boulongs Island
Spring Lake
Hokanson Transect
Grey Cloud Landing
Baldwin Lake
Pine Bend
Robinson's Rocks
Grey Cloud Slough
Merrimac Island
St. Paul Park, MN
Newport Island
1930 - 1939
1940 - 1949
1950 - 1959
1960 - 1969
1970 - 1979
VOLUME OF SPOIL, IN THOUSAND CUBIC YARDS
Downstream
River Miles

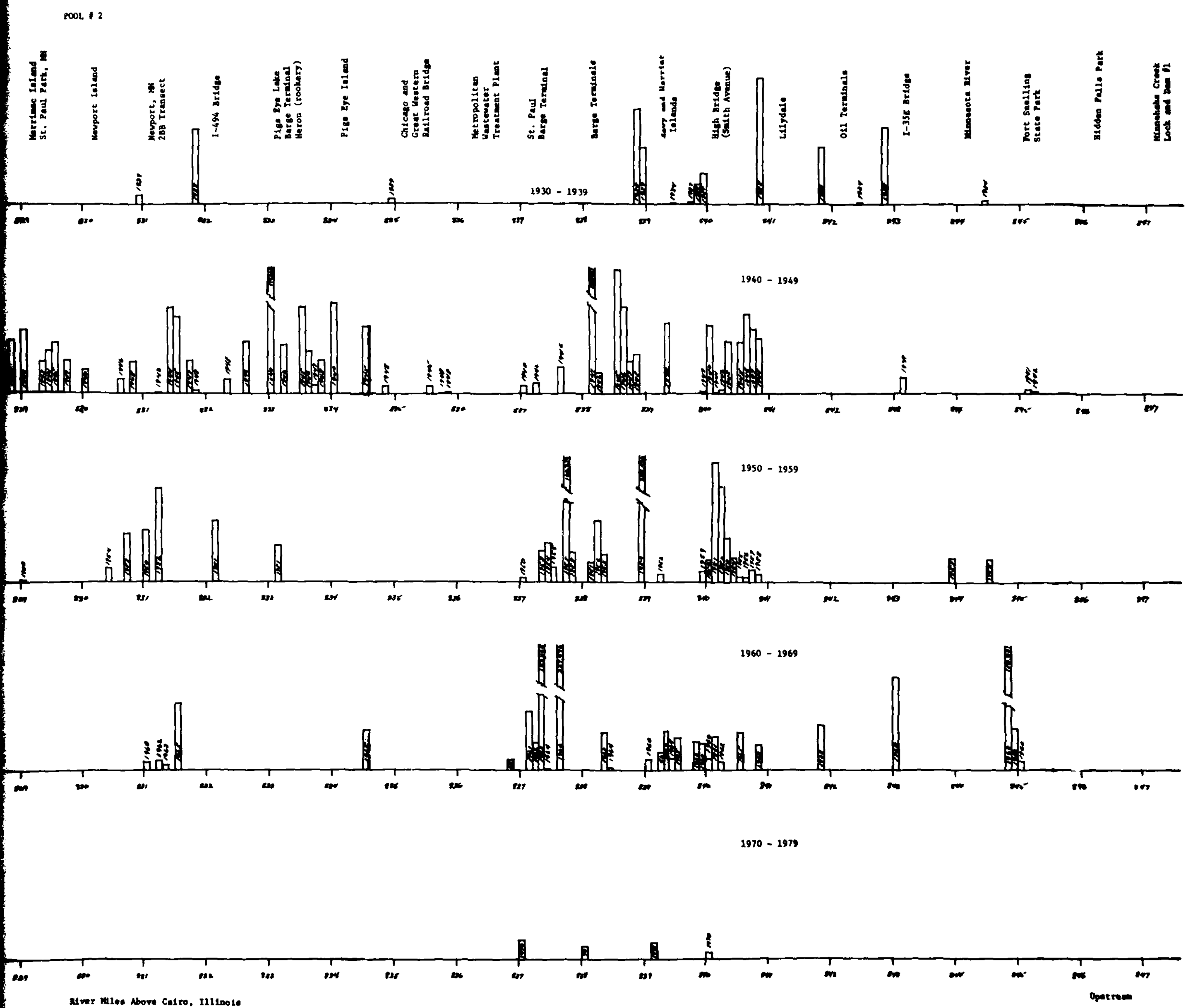
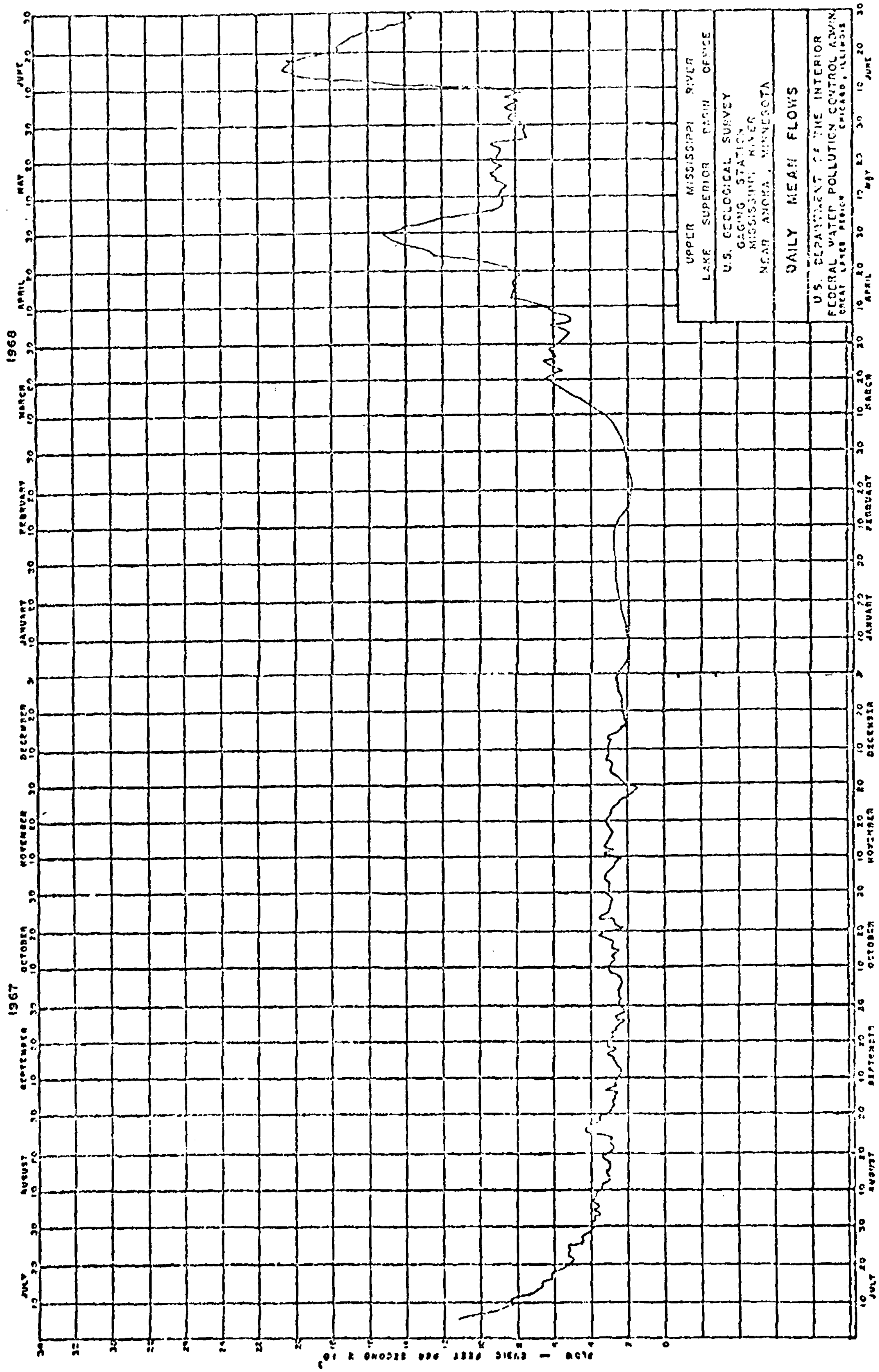


Figure 1. Annual Volume of Sediment Dredged Within Each River Mile, Arranged by Decade.


UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
U.S. GEOLOGICAL SURVEY
GAGING STATION
MISSISSIPPI RIVER
NEAR ANOKA, MINNESOTA
DAILY MEAN FLOWS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION
CHICAGO, ILLINOIS
1967
1968
JULY
AUGUST
SEPTEMBER
OCTOBER
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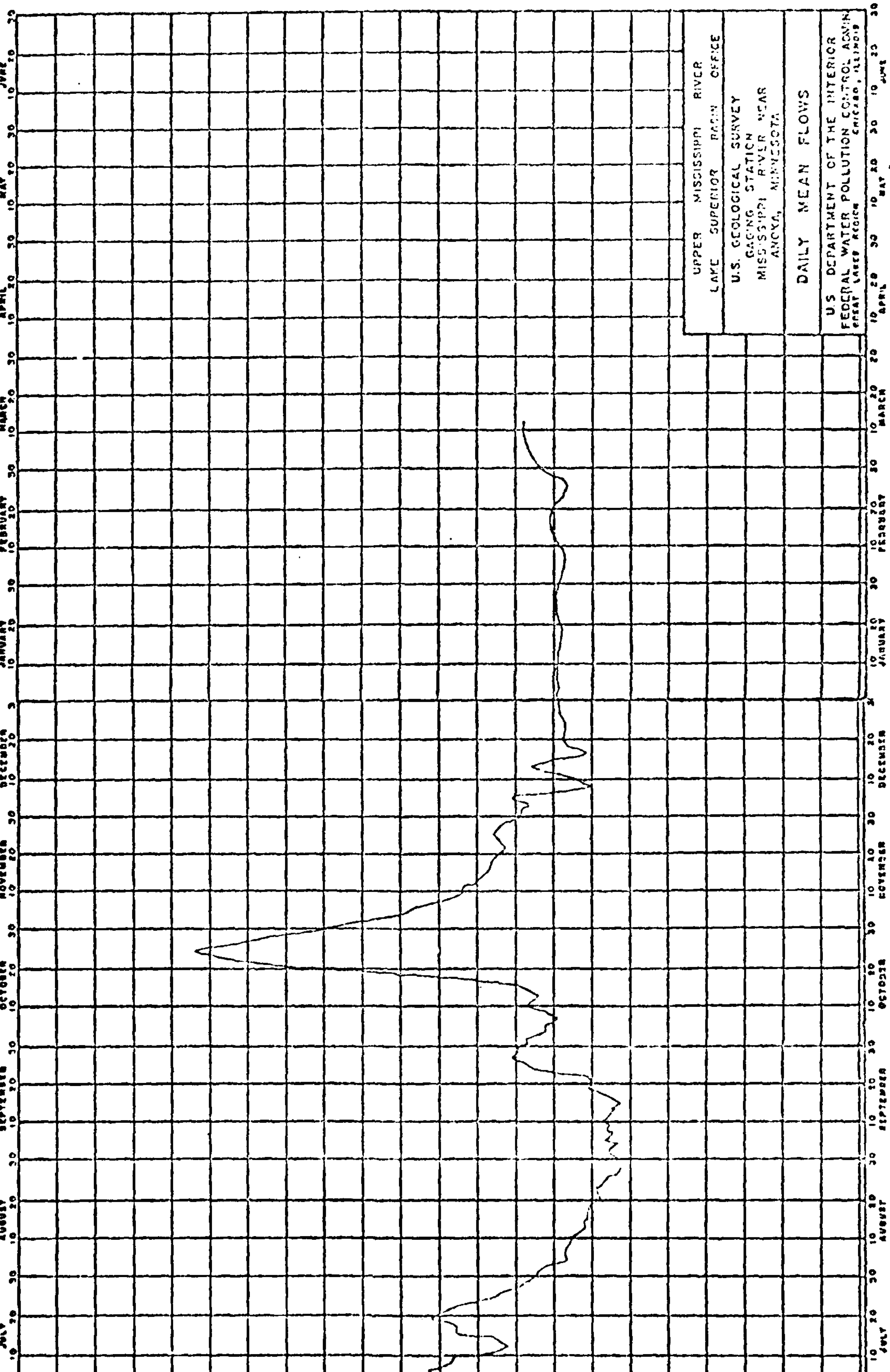
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE

Figure 2.



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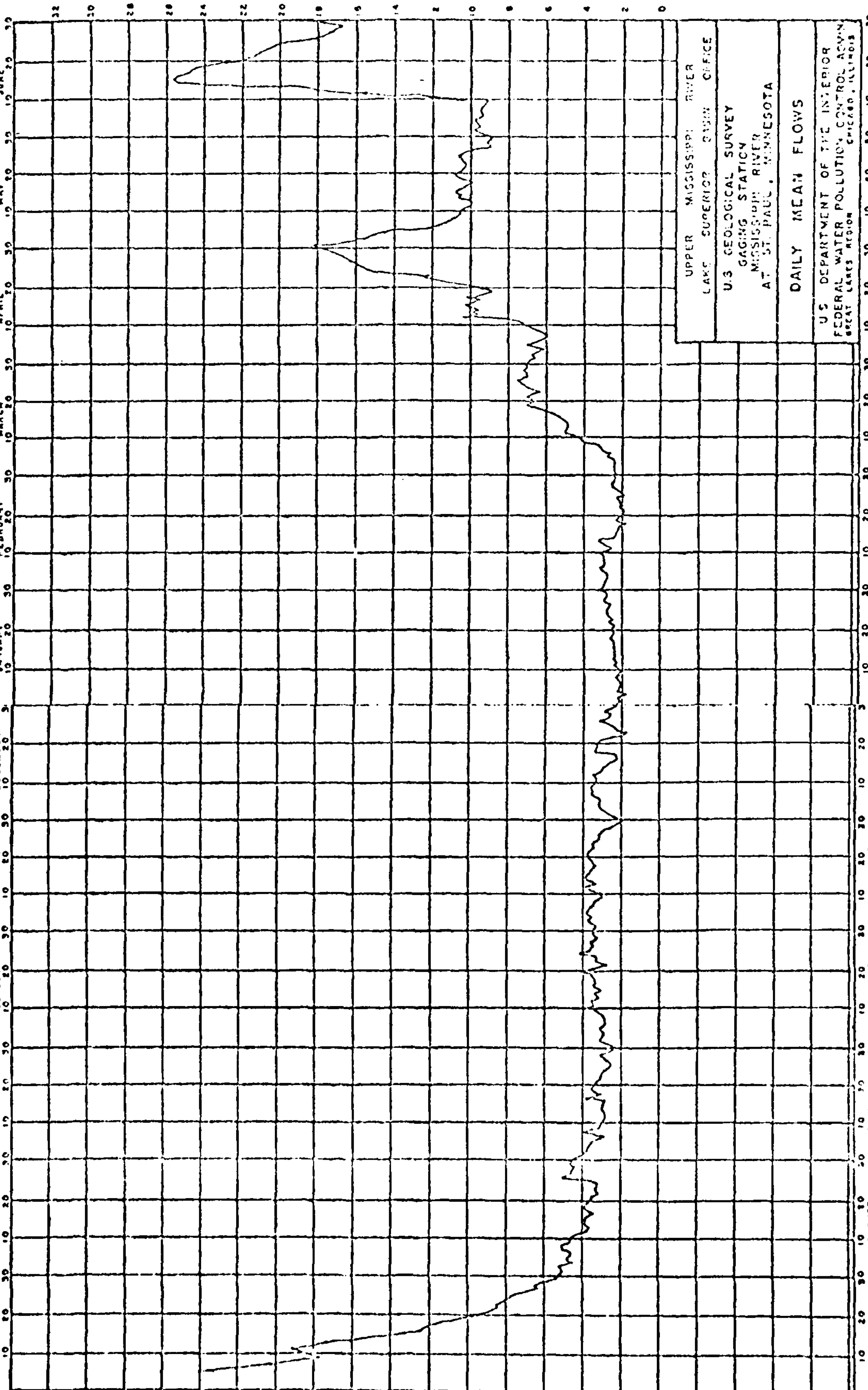
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
U.S. GEOLOGICAL SURVEY
GAGING STATION
MISSISSIPPI RIVER
AT ST. PAUL, MINNESOTA
DAILY MEAN FLOWS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS
FLOW — CUBIC FEET PER SECOND X 10³
1968
JULY
AUGUST
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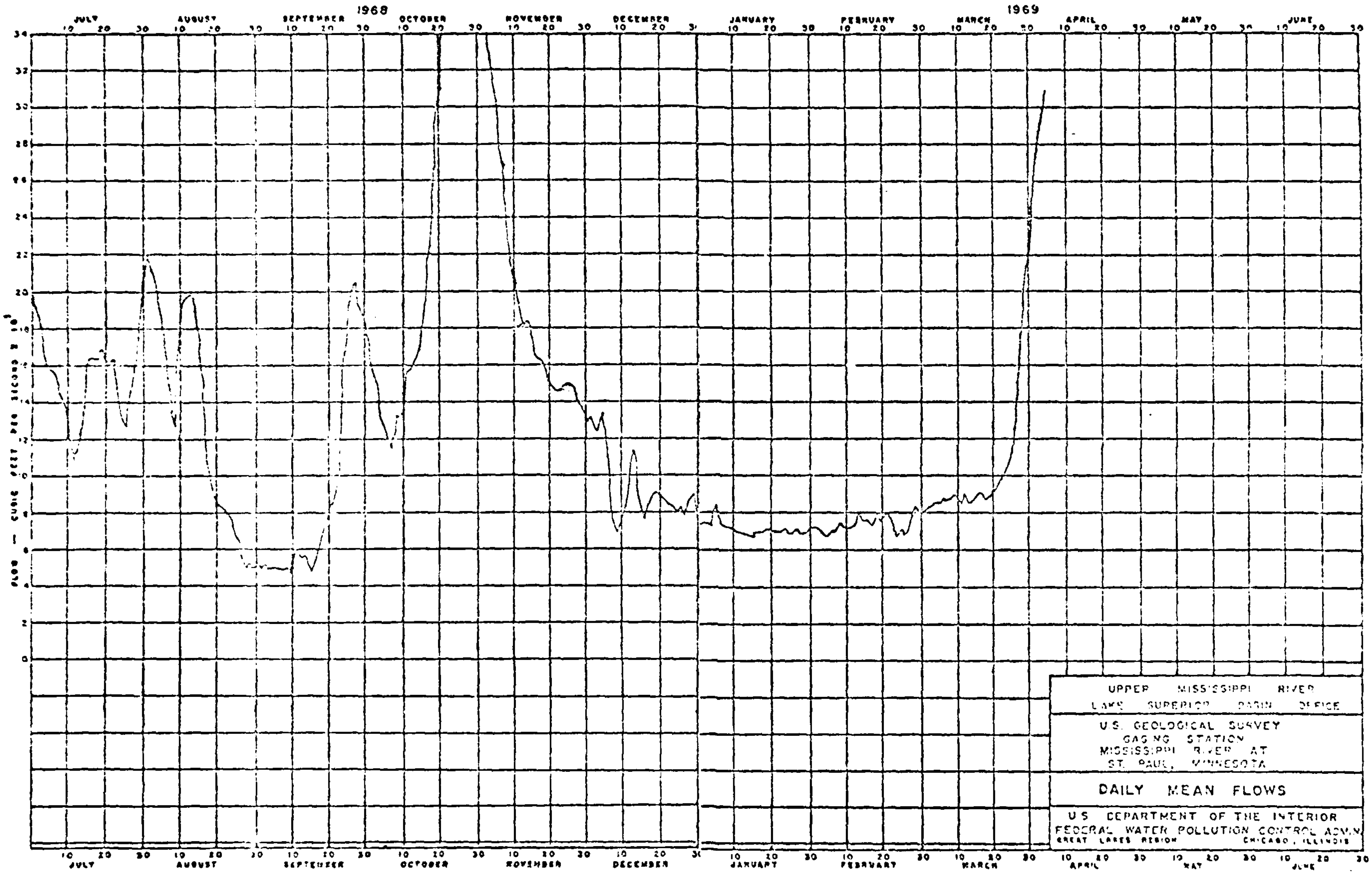
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE

Figure 3.



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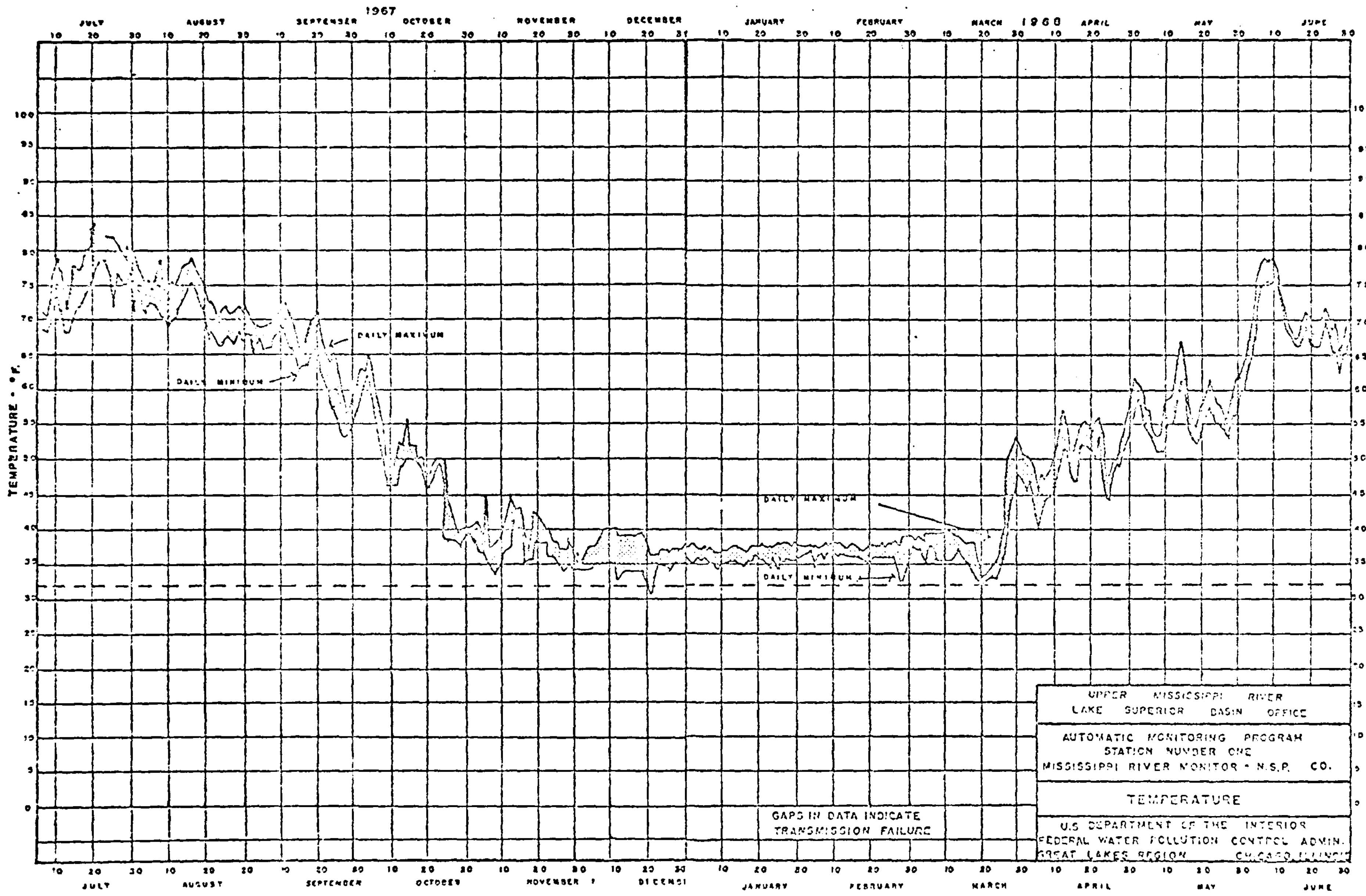
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FEBRUARY
MARCH
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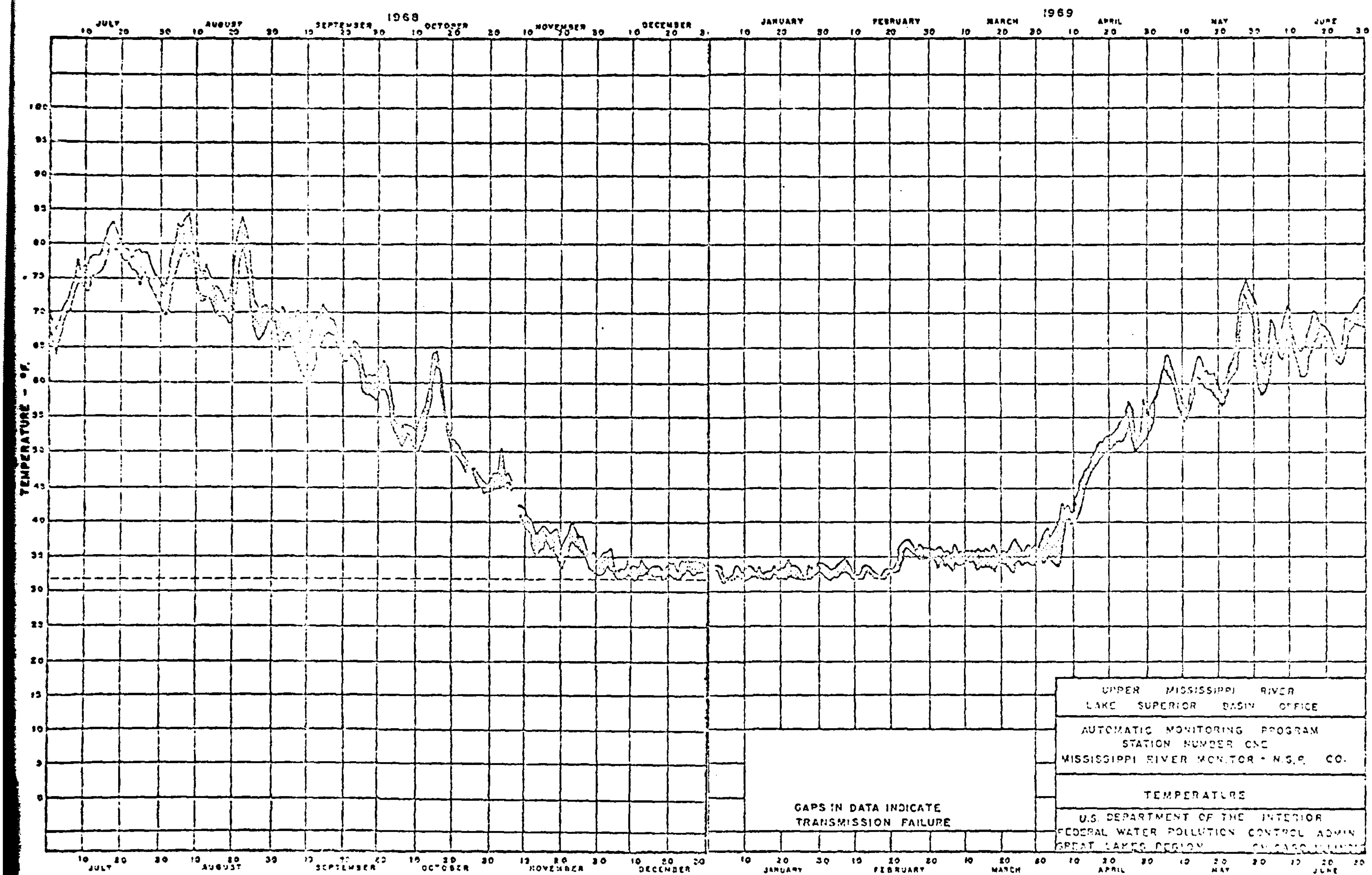
MAY
JUNE
TEMPERATURE - °F.
DAILY MAXIMUM
DAILY MINIMUM
GAPS IN DATA INDICATE TRANSMISSION FAILURE
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER ONE
MISSISSIPPI RIVER MONITOR - N.S.P. CO.
TEMPERATURE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION

Figure 4.



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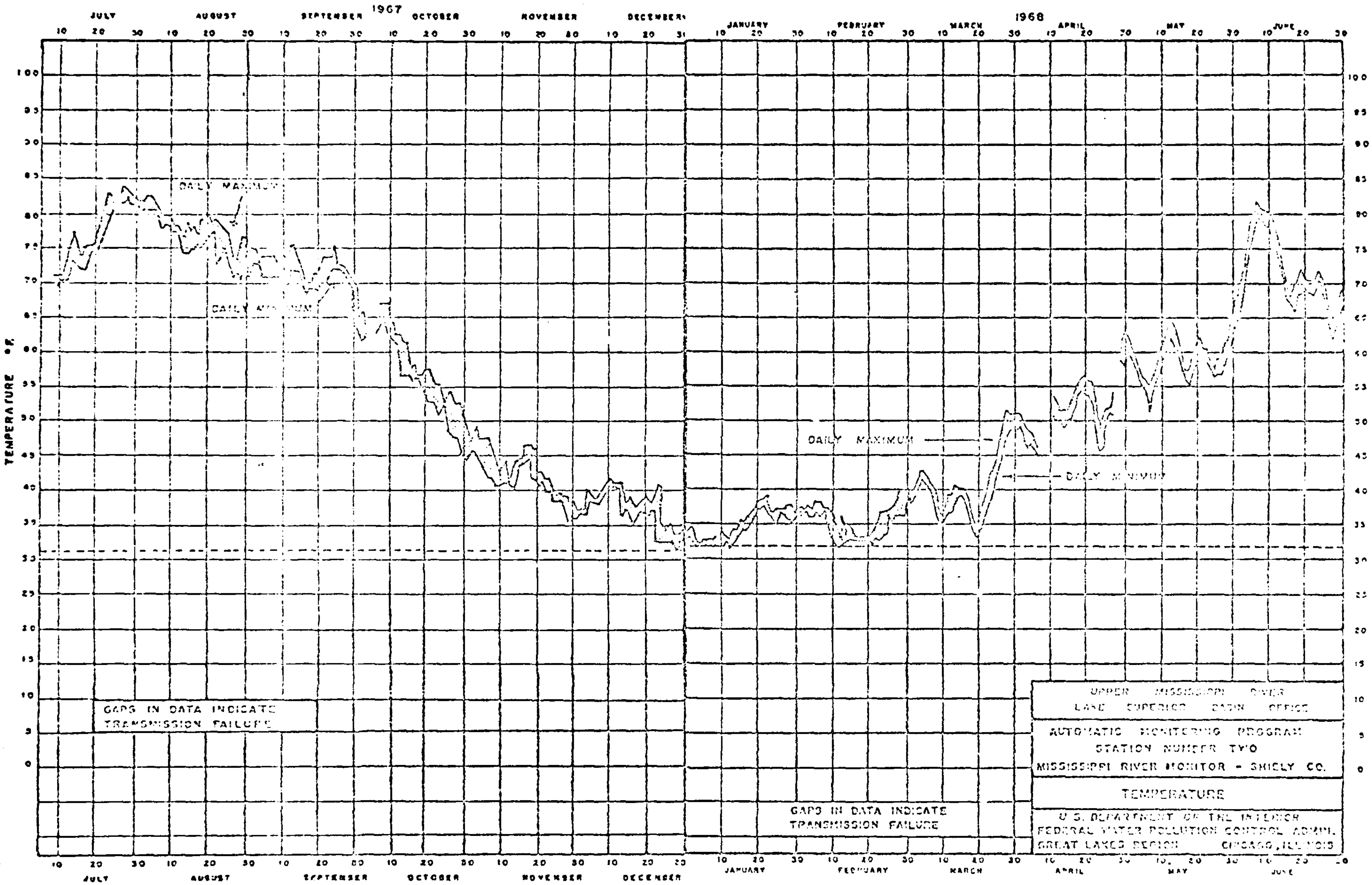
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FEBRUARY
MARCH
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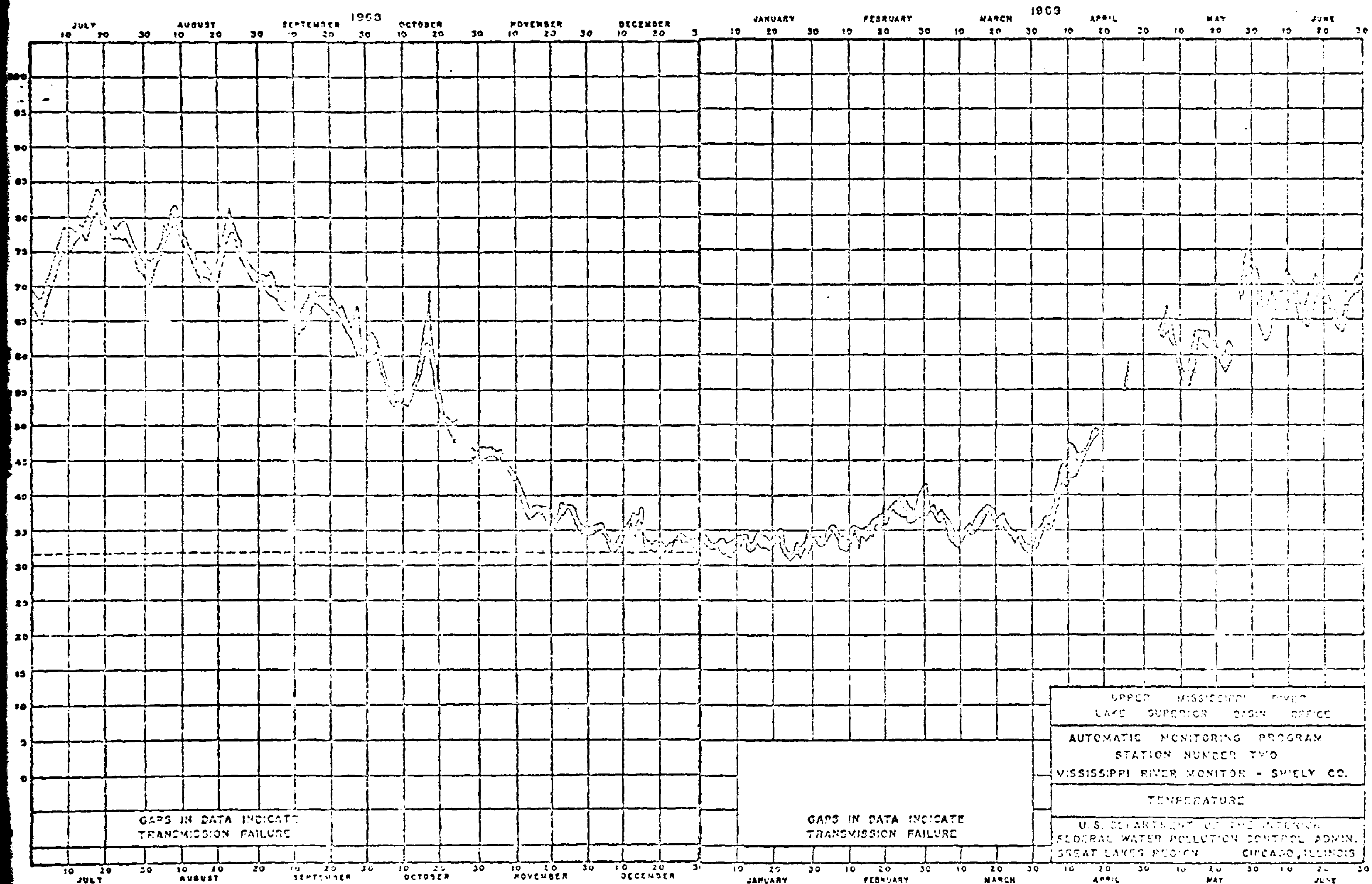
JUNE
TEMPERATURE °F.
DAILY MAXIMUM
DAILY MINIMUM
GAPS IN DATA INDICATE
TRANSMISSION FAILURE
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER TWO
MISSISSIPPI RIVER MONITOR - SHIELY CO.
TEMPERATURE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

Figure 5.



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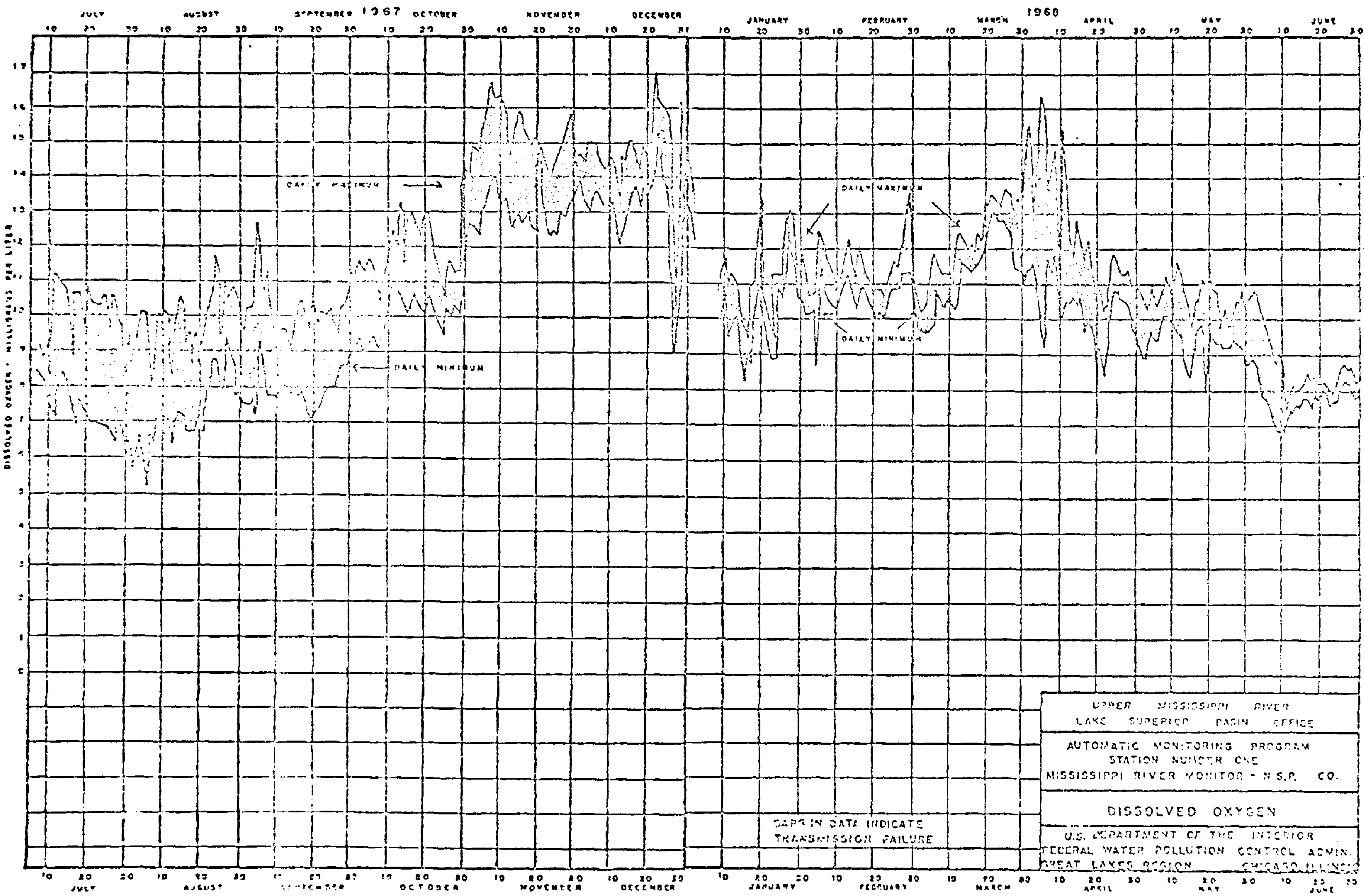

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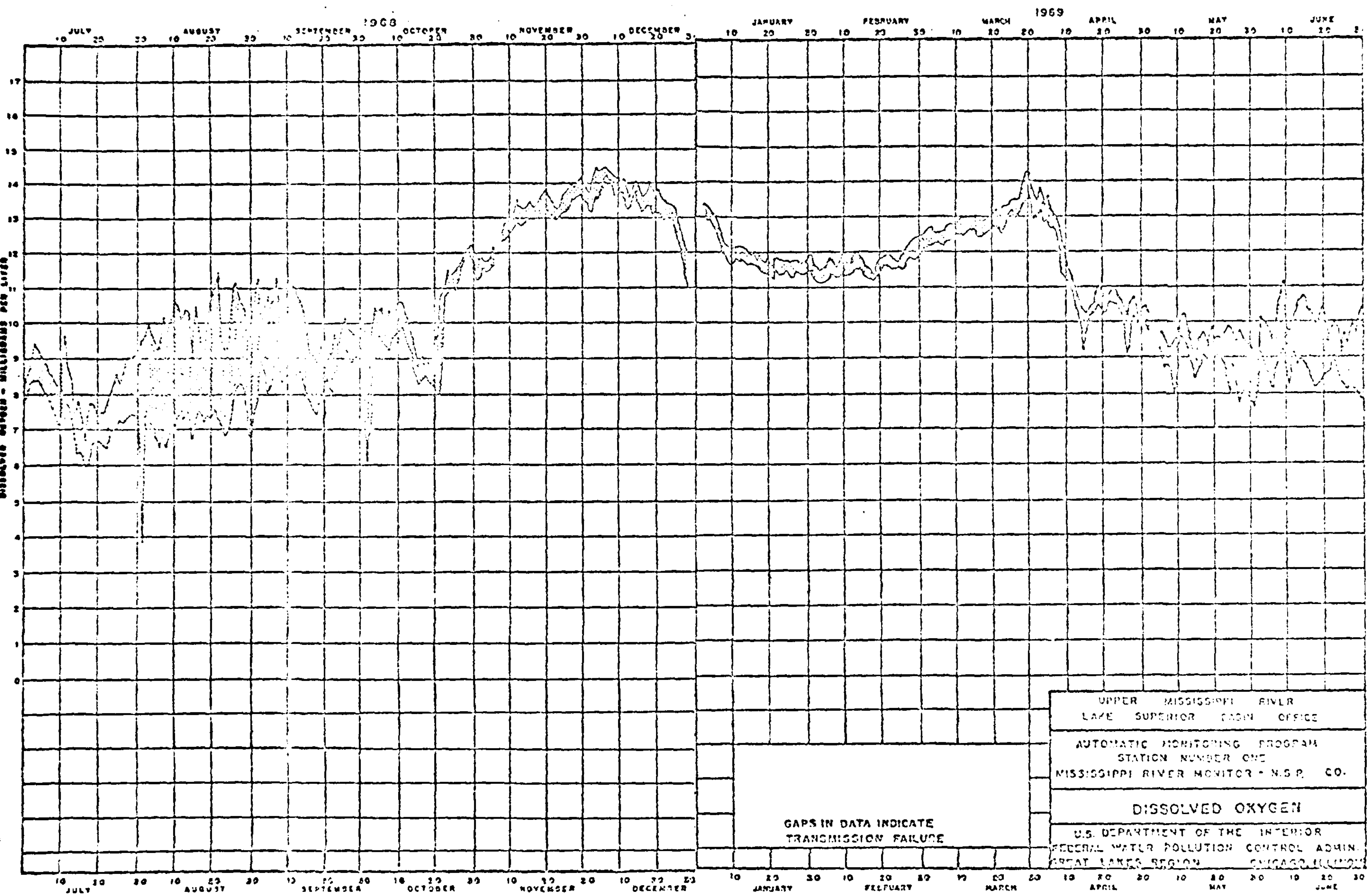
JUNE
DAILY MAXIMUM
DAILY MINIMUM
DISSOLVED OXYGEN - MILLIGRAMS PER LITER
GAPS IN DATA INDICATE
TRANSMISSION FAILURE
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER ONE
MISSISSIPPI RIVER MONITOR - N.S.P. CO.
DISSOLVED OXYGEN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

Figure 6.



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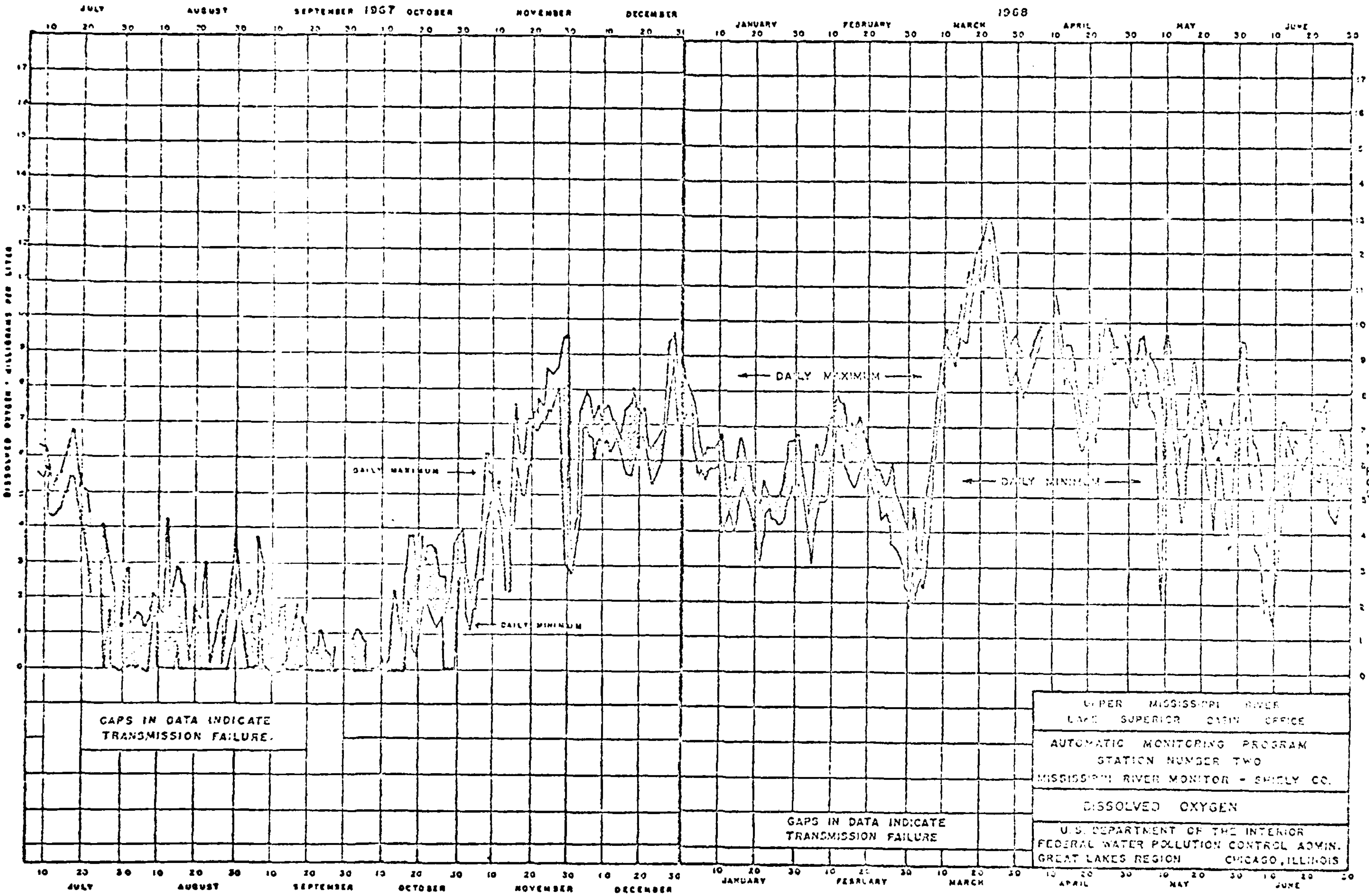
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NOVEMBER
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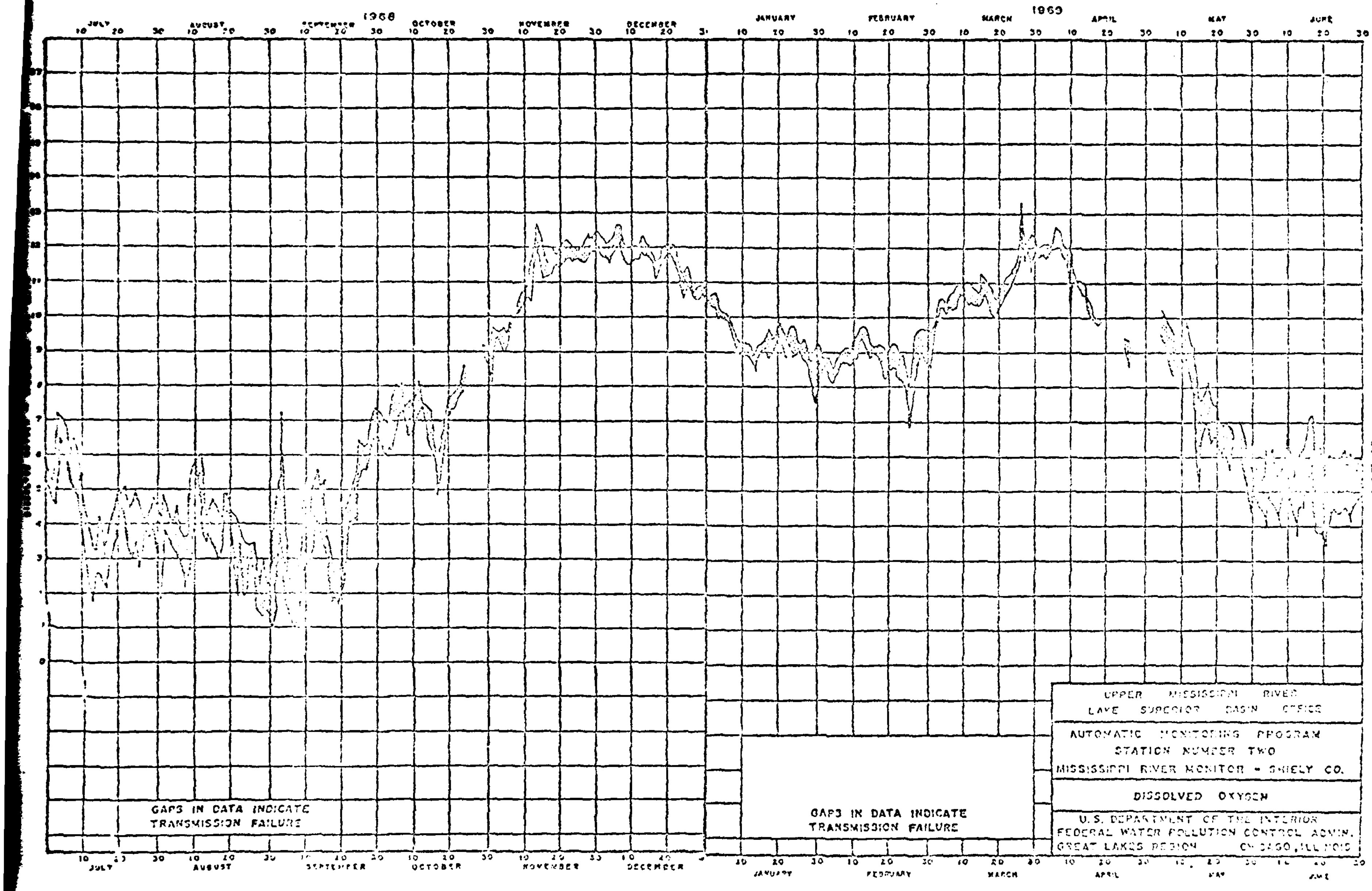
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
DISSOLVED OXYGEN - MILLIGRAMS PER LITER
DAILY MAXIMUM
DAILY MINIMUM
GAPS IN DATA INDICATE TRANSMISSION FAILURE.
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER TWO
MISSISSIPPI RIVER MONITOR - SHIRLY CO.
DISSOLVED OXYGEN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

Figure 7.



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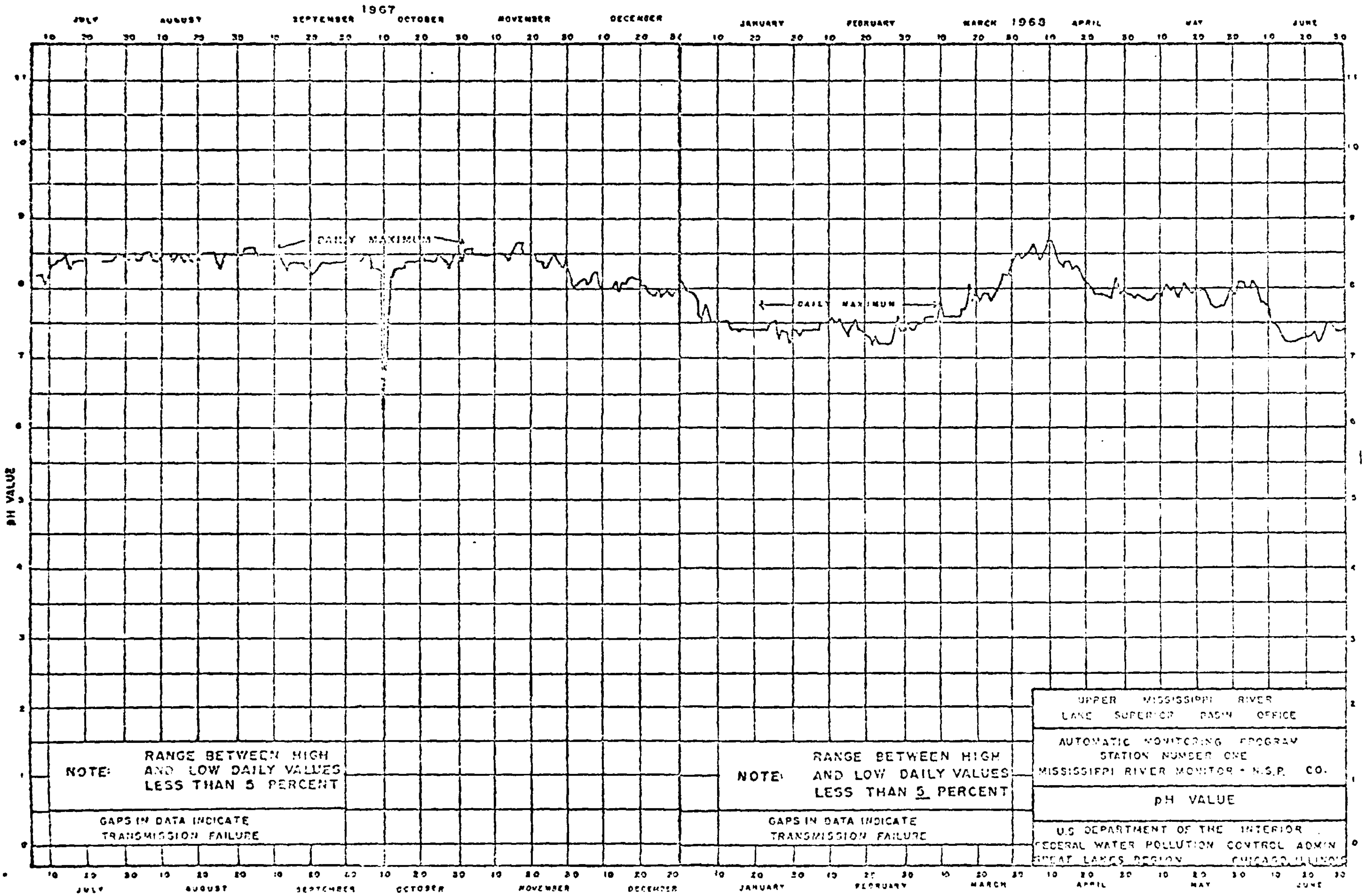
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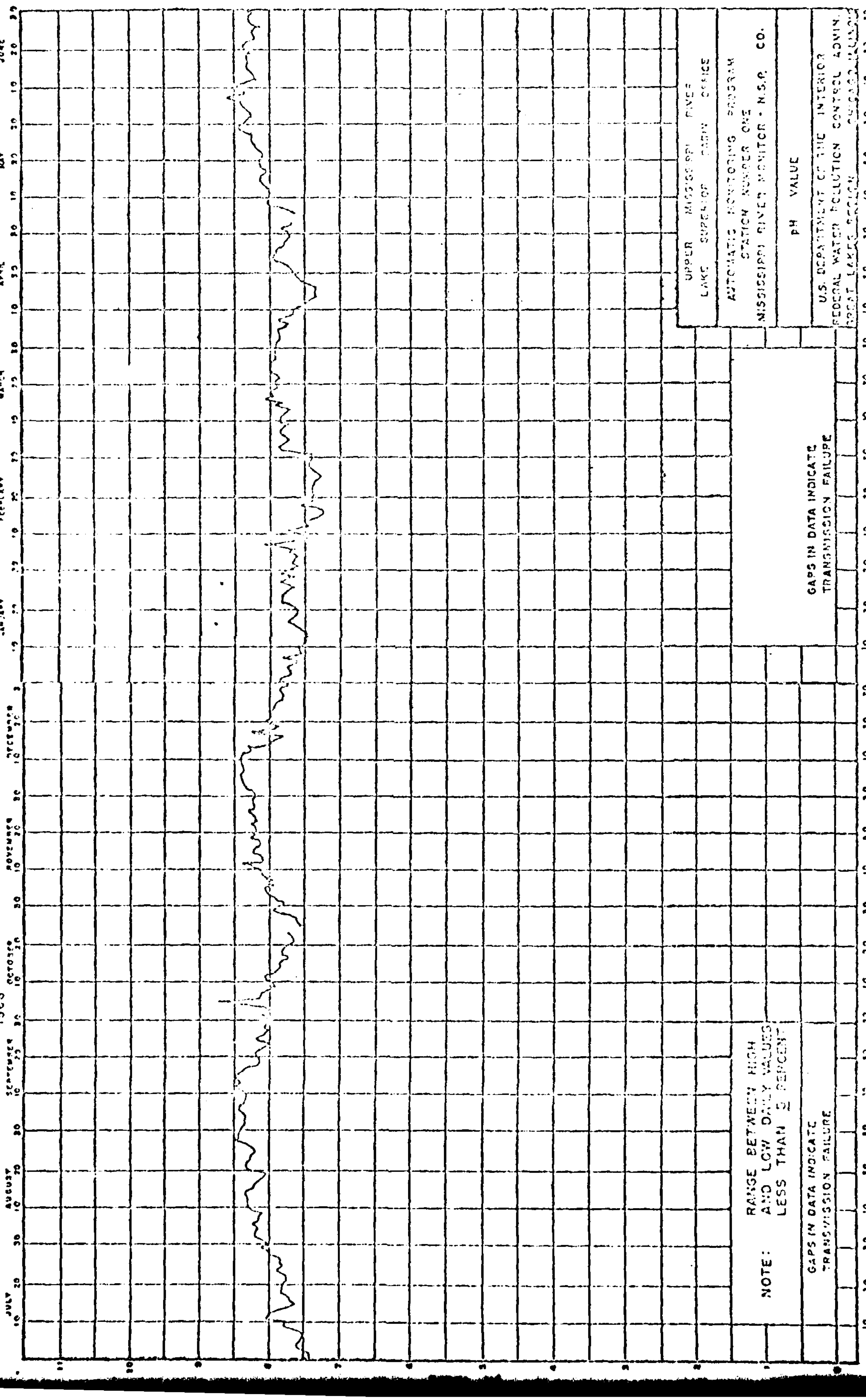
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
PH VALUE
DAILY MAXIMUM
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
GAPS IN DATA INDICATE TRANSMISSION FAILURE
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER ONE
MISSISSIPPI RIVER MONITOR - N.S.P. CO.
pH VALUE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
GREAT LAKES REGION CHICAGO, ILLINOIS

Figure 8.



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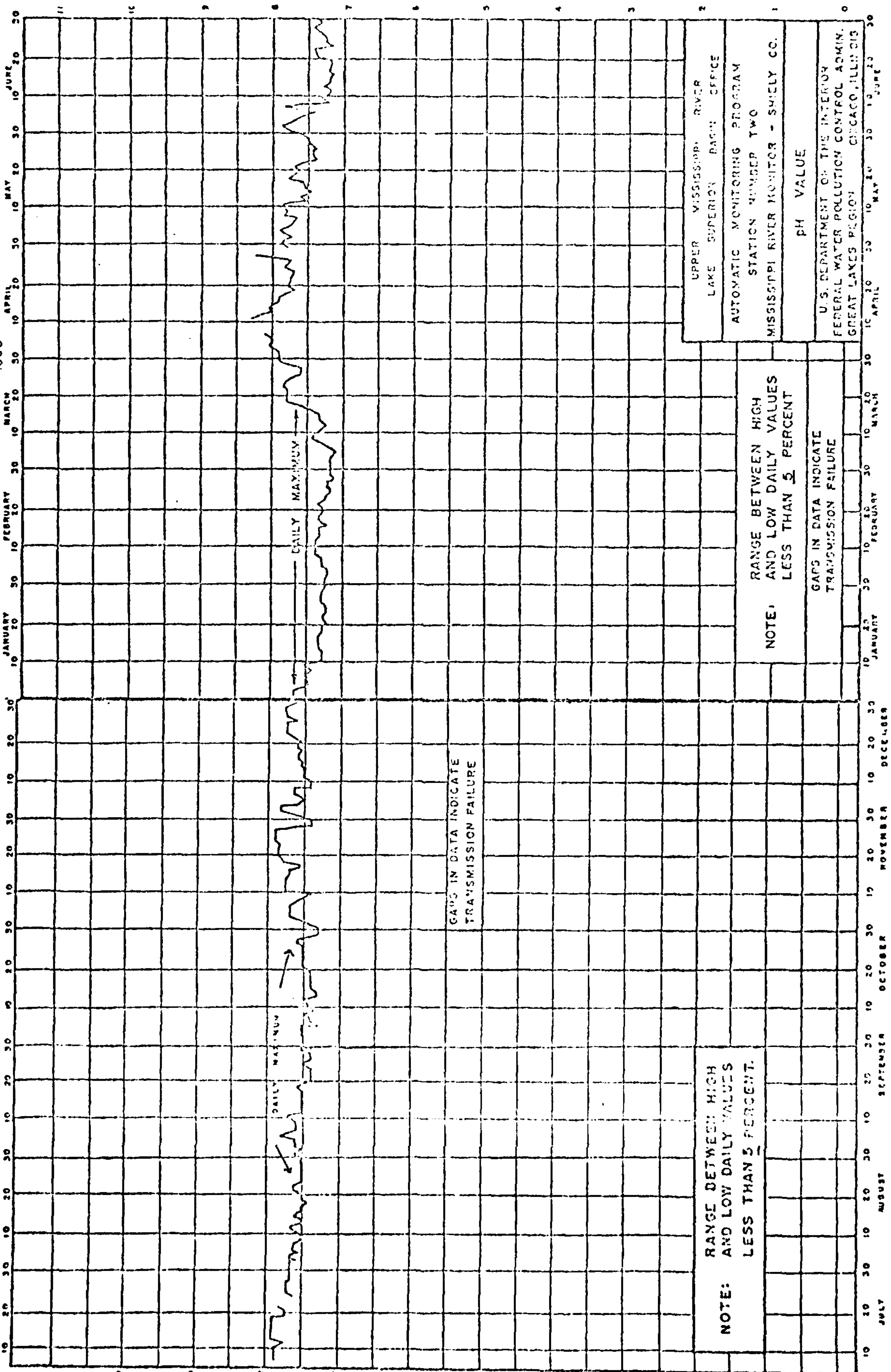
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER TWO
MISSISSIPPI RIVER MONITOR - SHIELY CO.
pH VALUE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
GAPS IN DATA INDICATE TRANSMISSION FAILURE
DAILY MAXIMUM
1967
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JULY
AUGUST
SEPTEMBER
OCTOBER
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DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
pH VALUE

Figure 9.

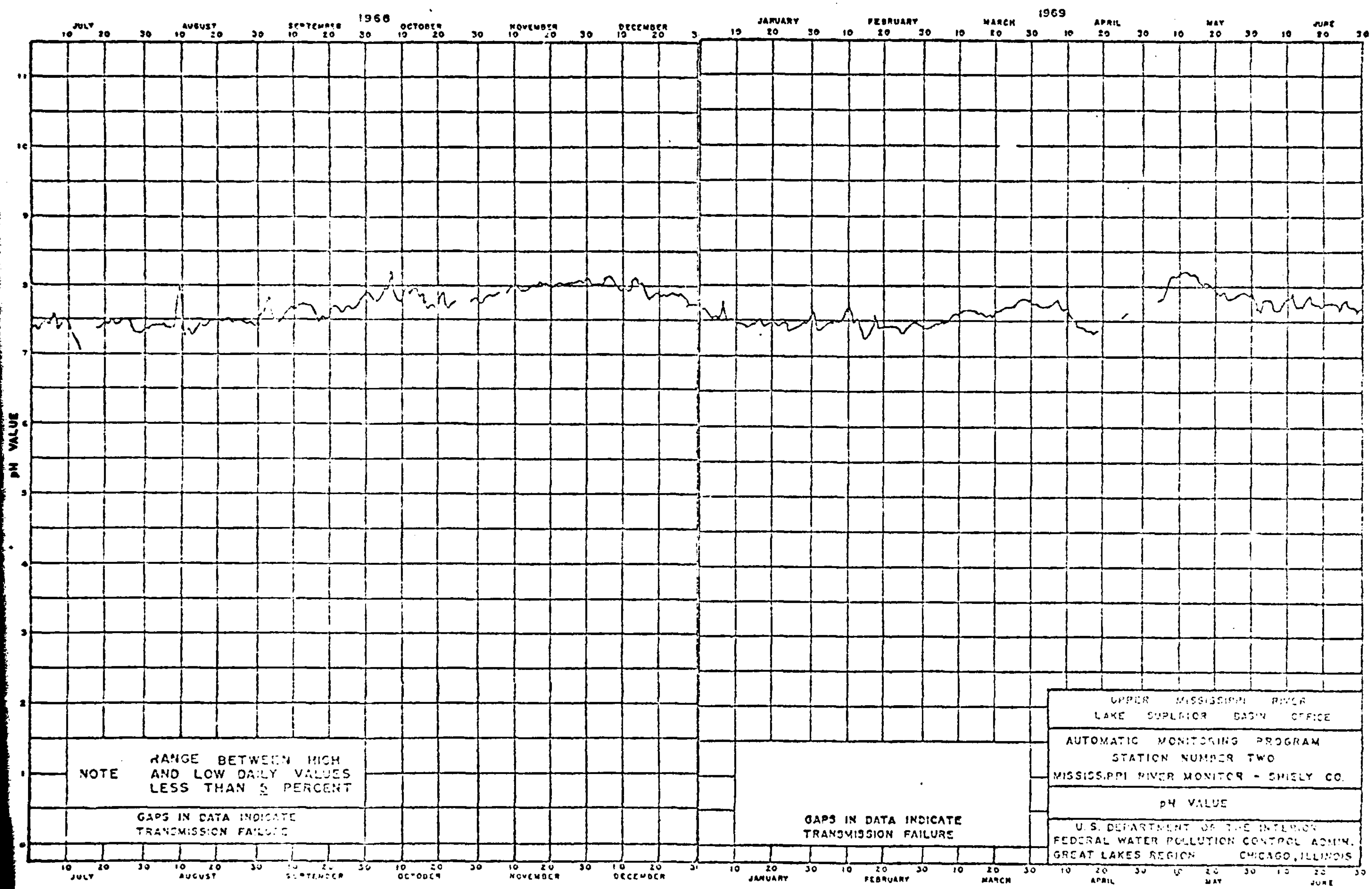
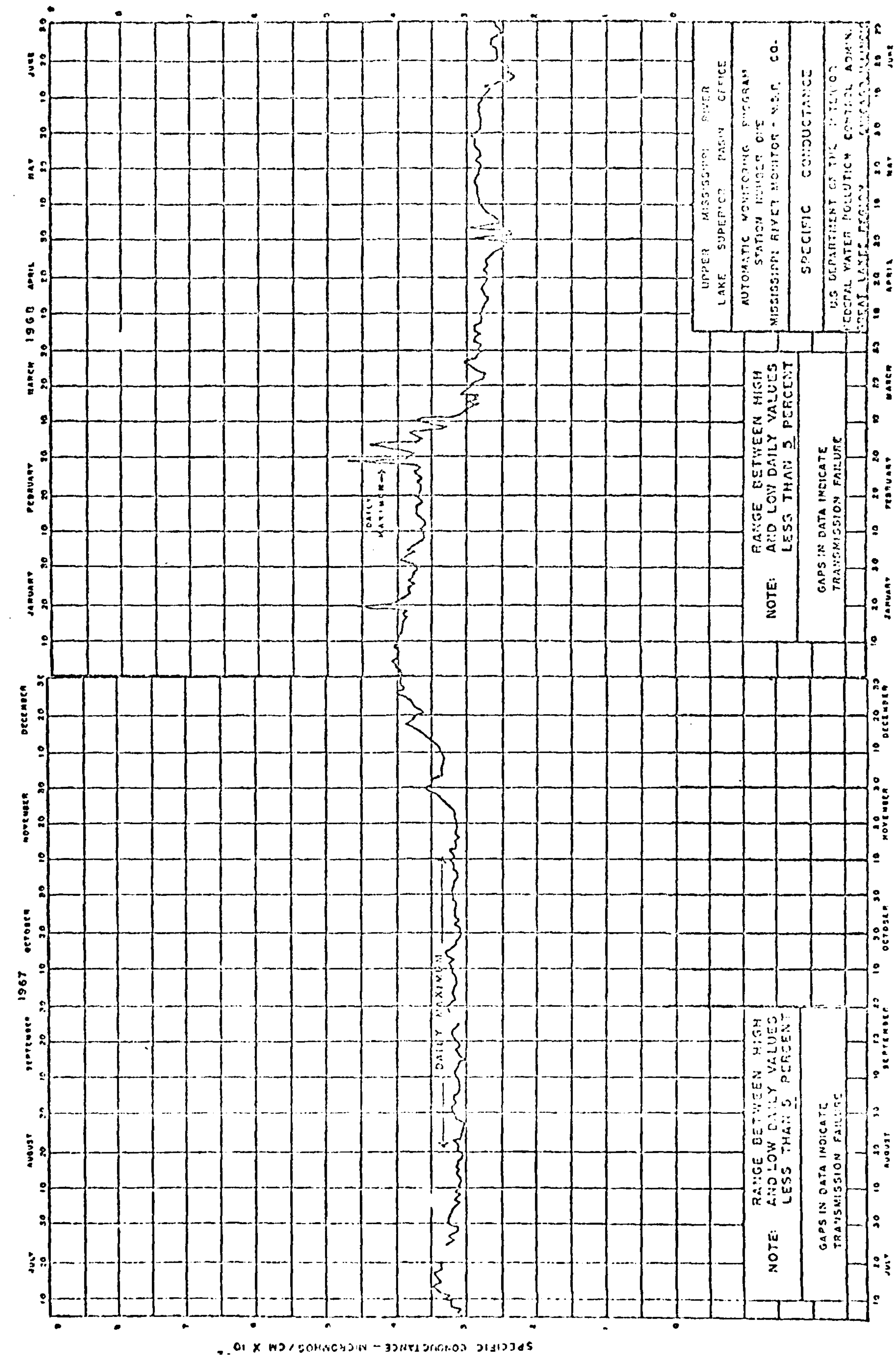


Figure 9 (Continued).


UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER ONE
MISSISSIPPI RIVER MONITOR - N.S.P. CO.
SPECIFIC CONDUCTANCE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
GAPS IN DATA INDICATE TRANSMISSION FAILURE
DAILY MAXIMUM
1967
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AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
SPECIFIC CONDUCTANCE - MICROMHOS/CM X 10

Figure 10.

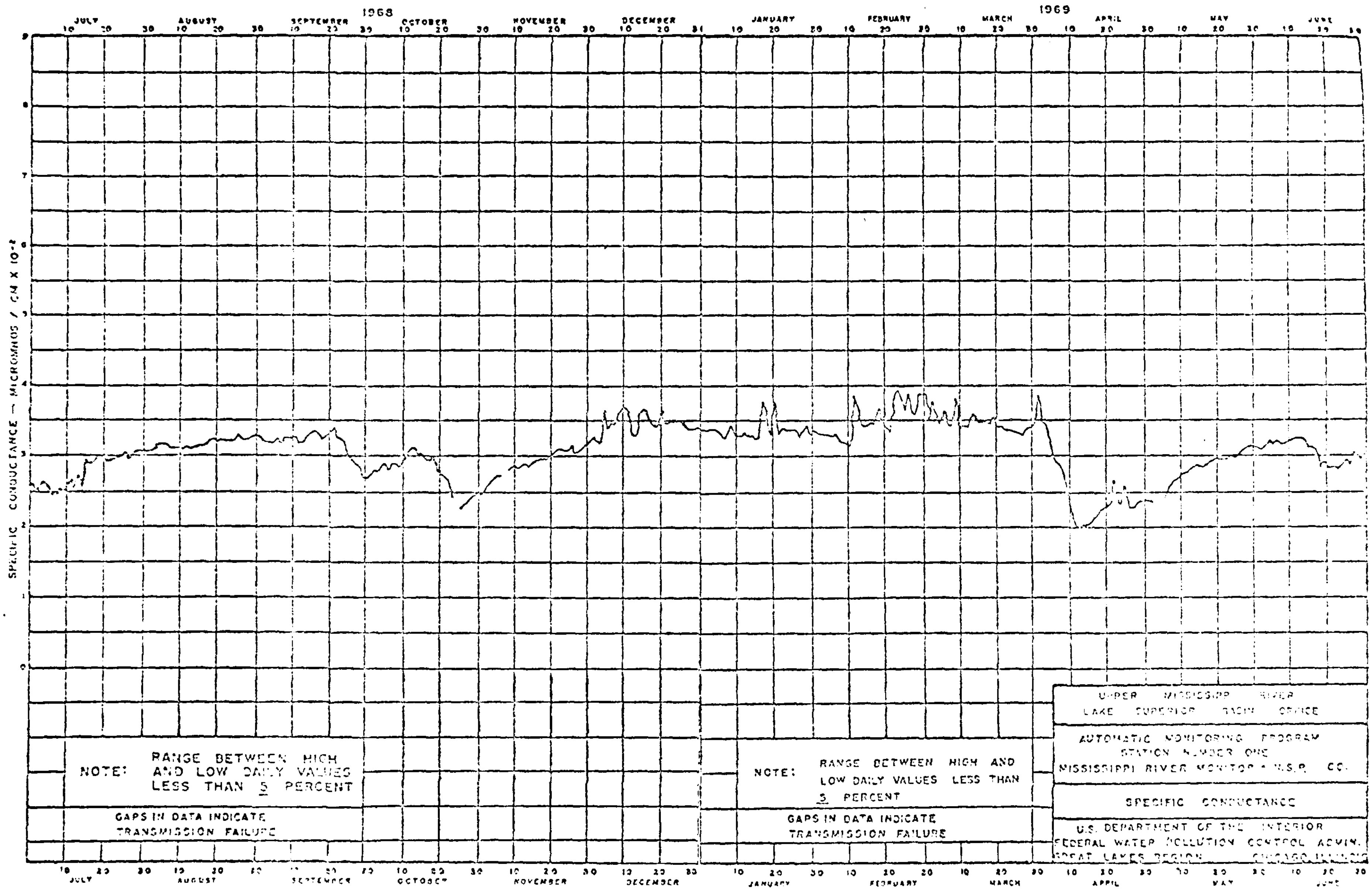
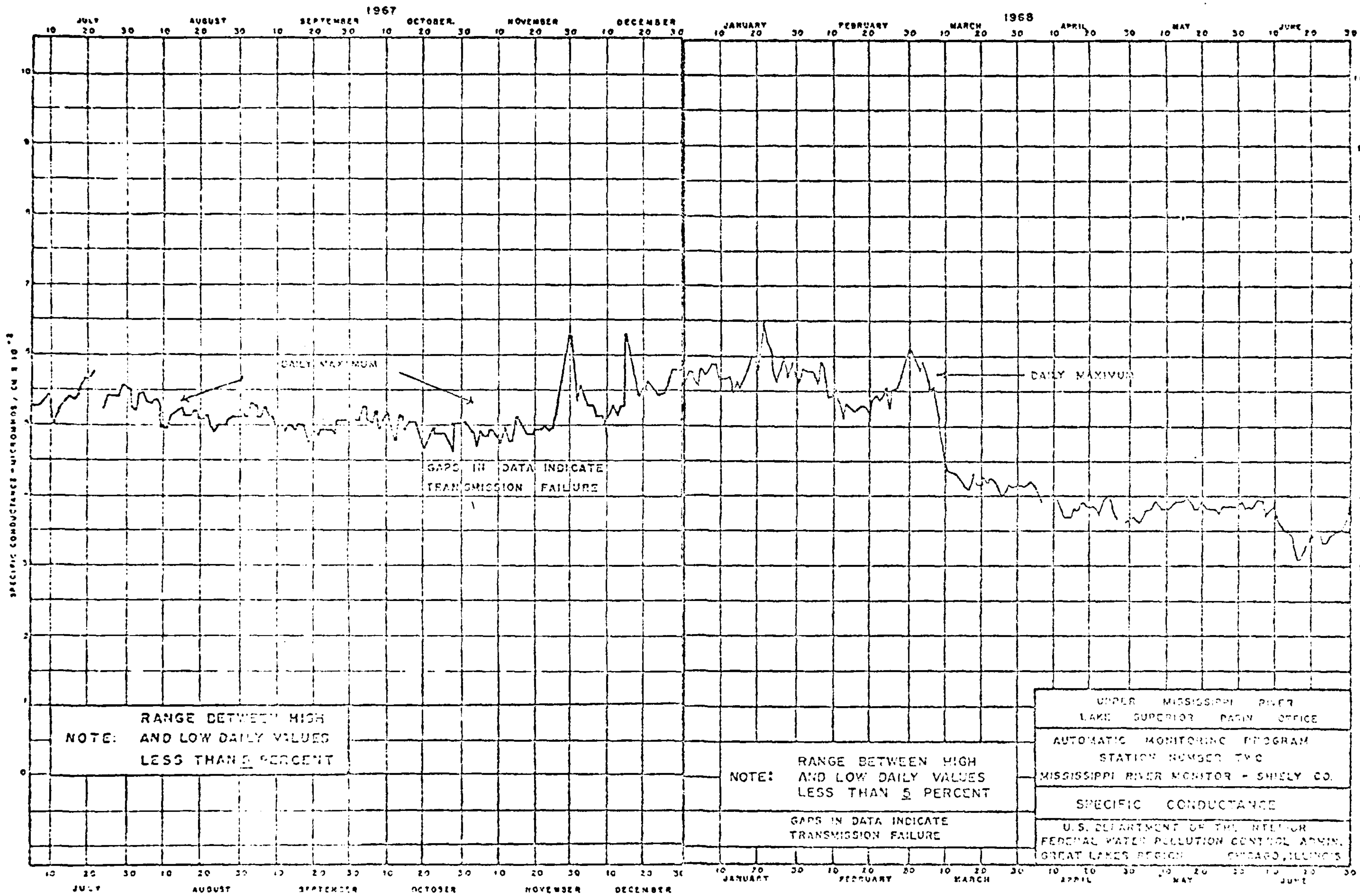


Figure 10 (Continued).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JUNE
SPECIFIC CONDUCTANCE - MICROMHOS / CM X 10^-2
DAILY MAXIMUM
GAPS IN DATA INDICATE TRANSMISSION FAILURE
DAILY MAXIMUM
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
NOTE: RANGE BETWEEN HIGH AND LOW DAILY VALUES LESS THAN 5 PERCENT
GAPS IN DATA INDICATE TRANSMISSION FAILURE
UPPER MISSISSIPPI RIVER
LAKE SUPERIOR BASIN OFFICE
AUTOMATIC MONITORING PROGRAM
STATION NUMBER TWO
MISSISSIPPI RIVER MONITOR - SHIELY CO.
SPECIFIC CONDUCTANCE
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

Figure 11.

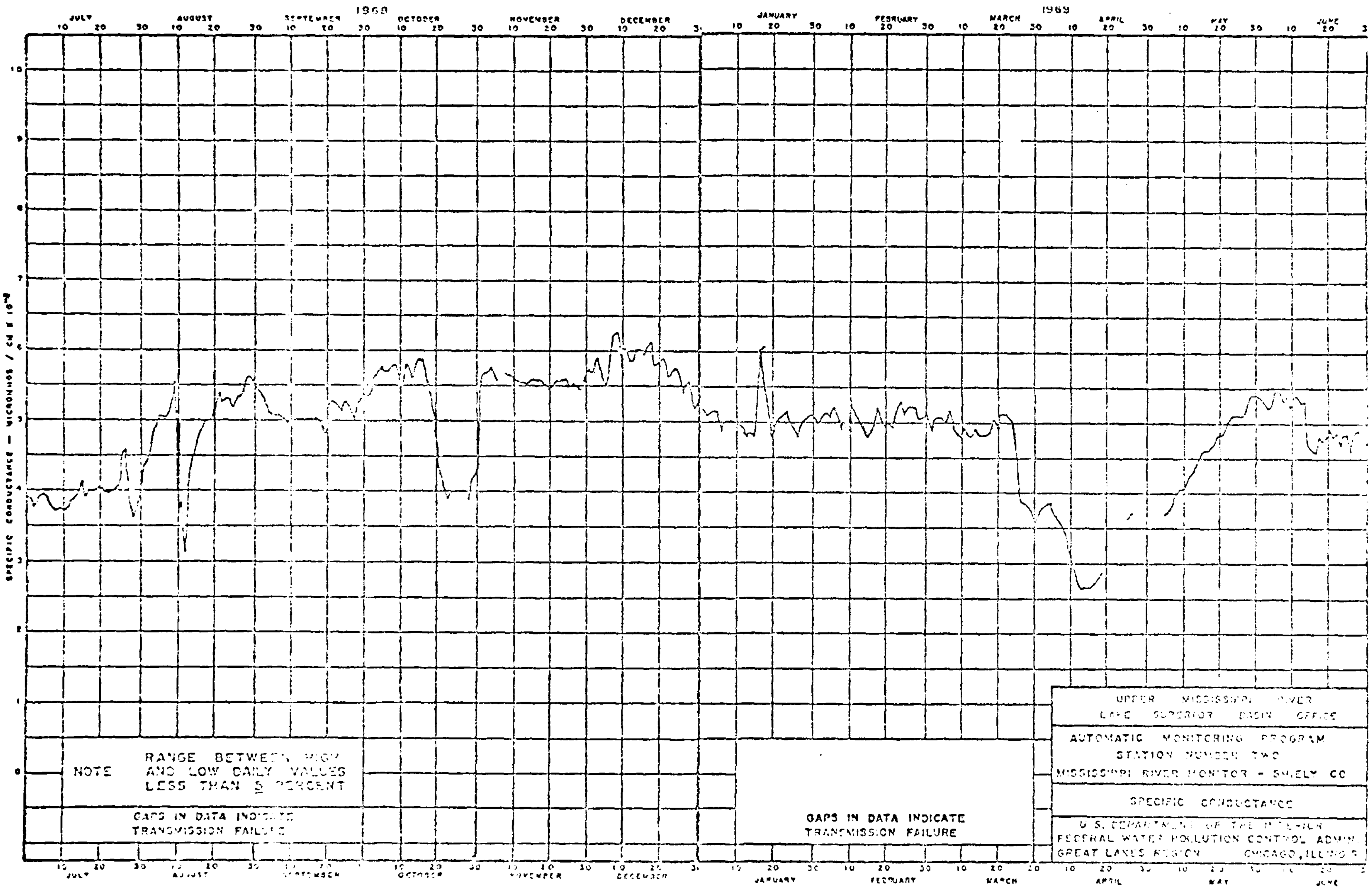

Figure 11 (Continued).

10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

PRESENT CONSIDERATIONS

MINNESOTA

Background

Impact on Prehistoric Archaeological Sites

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

Introduction

Classification of Sites

The Effect of Corps of Engineers' Activities on Archaeological Sites by Pool

Conclusions

Bibliography

Appendix 1

Appendix 2

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

Sites Designated as Historic and Worthy of Preservation, Not yet Included in the National Register, in Minnesota Which are Adjacent to the Minnesota, Mississippi, and St. Croix Rivers

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 Dresbach, 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. (See Figure 1)

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. (See Figure 1)

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	WA 1	SE 1/4		S32	T27N	R21W	(Schilling)*
	DK 1	NE 1/4	NE 1/4	S23	T115	R18	(Sorg)*
*See Figure 1	GD 75	SW 1/4	SE 1/4	S32	T114	R15	(P. I.)
	GD 1	NW 1/4		S9	T113	R15	(Nauer)
	GD 57	NW 1/4		S9	T113	R15	(Nauer)
	U.N.	LeSueur-Perrot Post					(P. I.)

Group II

Sites probably not affected (except by borrow)	RA 5	T29	R22
	WA 7	T26	R20
	GD 108	T113	R13
	SC 2	T115	R22
	SC 1	T115	R22

WA = Washington
DK = Dakota T = Township
GD = Goodhue R = Range
RA = Ramsey
SC = Scott

Group III

Sites potentially destroyable	DK 2	T115	R18*	GD 78	T114	R16
	DK 4	T115	R18*	GD 81	T114	R16
	DK 6	T115	R18*	GD 74	T114	R15
*See Figure 1	WA 6	T26	R20	GD 2	T113	R15
	DK 7	T115	R17			

Note: For the exact locations (sections, quarter sections, etc.) of the above sites, contact: Jan E. Streiff
Office of the State Archaeologist
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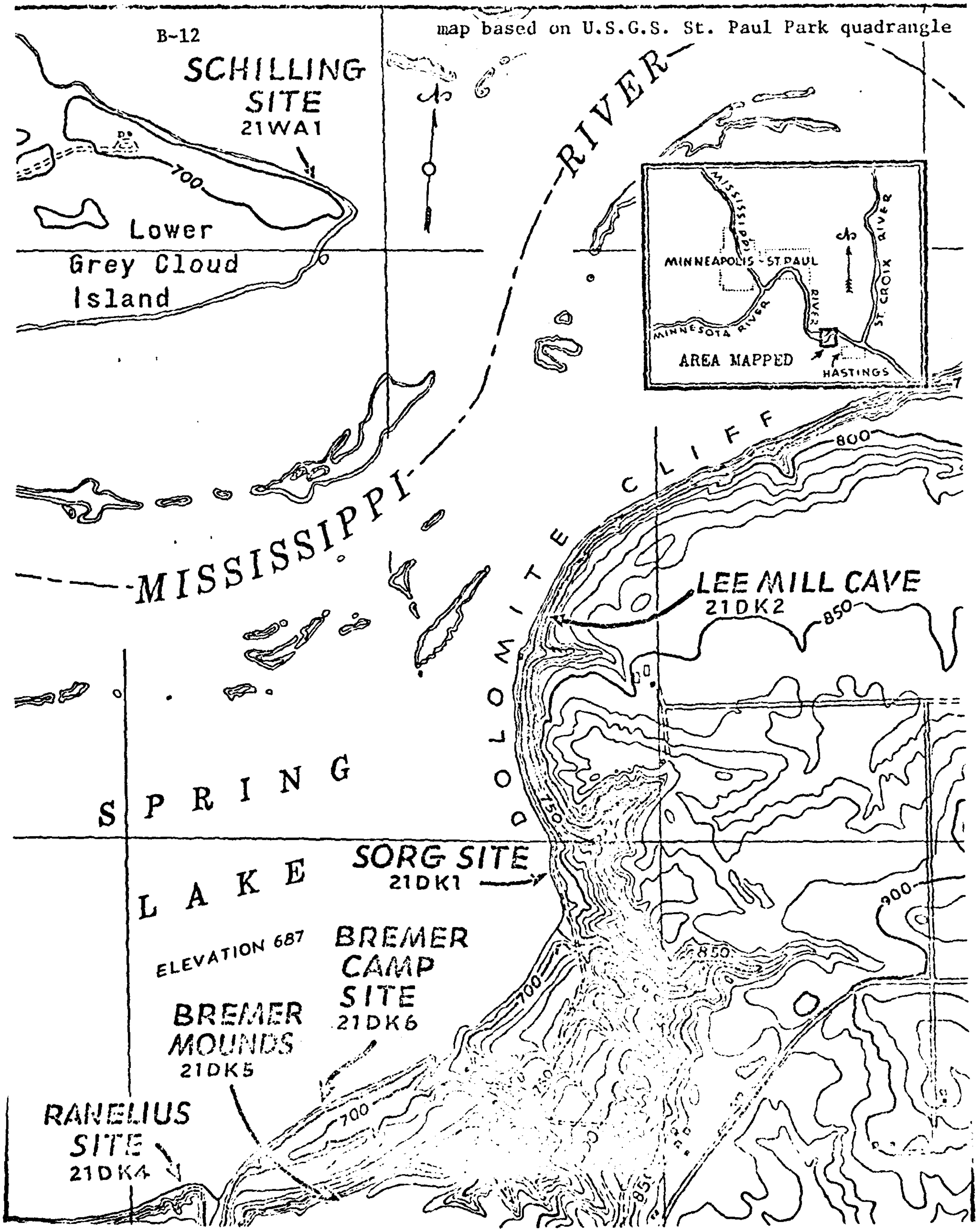
Minneapolis, MN 55455



Scale 0 ½ Mile 1 Mile

Figure 1. Eastern End of the Spring Lake Area (Johnson, 1959).

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.

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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). It is thought by many that it was never glaciated.

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/l - 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.