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NOV 73 R F COLINGSWORTH, B J GUDMUNDSON DACW37-73-C-0059

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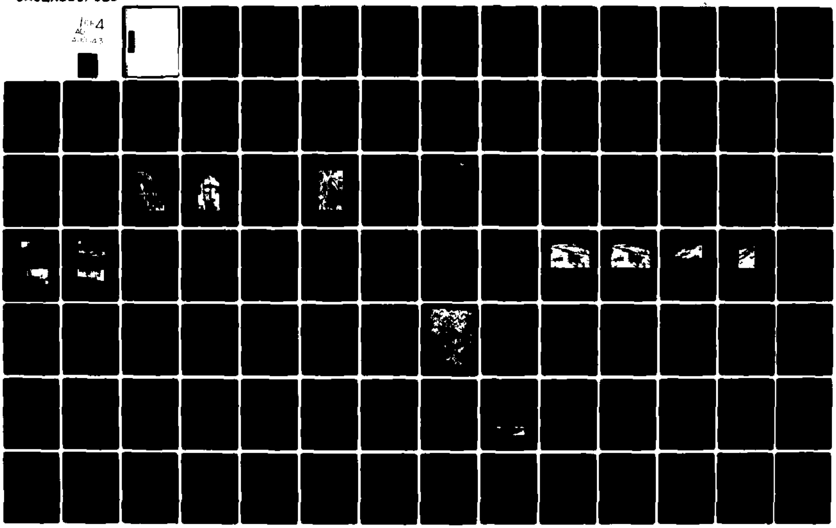

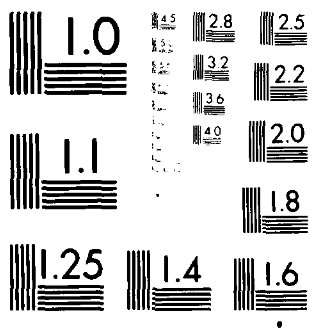

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

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The overall objectives of this report are to assess the impacts of Corps of Engineers' activities on the St. Anthony Falls Upper and Lower pools (Minneapolis, Minnesota) on the Mississippi River. The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life, geology and water quality. Socioeconomic systems include industrial activities, recreation, and cultural considerations, such as archaeological and historic sites.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

ST. ANTHONY FALLS UPPER AND LOWER POOLS

of the Northern Section of the
UPPER MISSISSIPPI RIVER

for the

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

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FOREWORD

Purpose of the Environmental Studies

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

In keeping with this policy, on January 15, 1973, the St. Paul District of the U. S. Army Corps of Engineers contracted with North Star Research and Development Institute to prepare reports assessing the environmental impact of all the Corps of Engineers' facilities and operations on the Mississippi River from the head of navigation in Minneapolis, Minnesota, to Guttenberg, Iowa. Also included in the study are the Minnesota and St. Croix Rivers from the heads of navigation at Shakopee and Stillwater, Minnesota, respectively, to the Mississippi River. This portion of the Mississippi River basin shall be termed the "Northern Section" of the upper Mississippi River or the "study area".

The Corps of Engineers has been active in the Northern Section since the 1820's, when it first was called upon to remove brush and snags from the river to permit safe navigation as far north as Fort Snelling. Later, in the 1870's, further improvements to deepen and maintain the channel were made primarily through construction of wing dams (long structures of brush and rock built at right angles to the river-bank). Presently, the river in the study area consists of a series of pools which were created by the construction of navigation locks and dams, the last of which (Upper St. Anthony Lock) was completed in 1963.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the construction and operation and maintenance of the Corps' nine-foot channel project on the Northern Section. The operations and maintenance activities include mainly operation of facilities (locks and dams) and maintenance of the navigation channel (dredging). Some recreation facilities also are maintained. Actually, the impacts on the environment of the Corps' operations prior to the nine-foot channel are also being sought, but the emphasis will be on those impacts of the present navigation system.

The studies are designed to identify the impacts and to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on natural ecosystems and on recreation, and many others. As a result of identification and assessment of the impacts, it will be possible to determine 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 in compliance with the National Environmental Policy Act of 1969 and the policy of the U. S. Army Corps of Engineers.

Scope of Current Report

The current report covers the complete study program, from January 15 through November 30, 1973, which was preceded by a planning phase (Phase I). The early phase of the study program concentrated on gathering historical information, field data collected by local scientists and information available through federal and state agencies. The early phase culminated in a Preliminary (Phase II) Report on July 1. The current report (Phase III) has expanded that report mainly to include field data collected during 1973.

Research Approach

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

Benchmark Time-Period

In order to analyze the impact of the Corps' nine-foot channel project in the Northern Section of the upper Mississippi, it is necessary to select a point of time that can serve as a benchmark. This benchmark is the year activities related to the nine-foot channel were initiated. Since the nine-foot channel project at St. Anthony Falls was begun in 1948, this year is taken as the benchmark. The preconstruction condition of the Mississippi at and upstream from St. Anthony Falls is taken as prior to 1948. Other Corps activities took place prior to 1948, however, and earlier data were also used where they were readily available. The preconstruction data were obtained from available reports and from a variety of other sources cited at the end of each major section.

Analysis of the Natural Systems

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

Number of River Pools Involved	River Pools	Principal Investigator	Organization
5	SAF Upper and Lower Pools, Pool 1, Pool 2, Minnesota River, and St. Croix River	Roscoe Colingsworth	North Star Research Institute, Minneapolis, Minnesota
1	Pool 3	Edward Miller	St Mary's College Winona, Minnesota
4	Pools 4, 5, 5A, & 6	Calvin Fremling	Winona State College
2	Pools 7 & 8	Thomas Claflin	University of Wisconsin, La Crosse
1	Pool 9	James Eckblad	Luther College, Decorah, Iowa
1	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.

Analysis of Socio-Economic Activities

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

Report Objectives

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

The present report deals only with the St. Anthony Falls Upper and Lower pools on the upper Mississippi River, which are described in detail in subsequent pages. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested only in a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to the St. Anthony pools. Specifically, following this section, the report is in the format required for Environmental Impact Statements, 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 effects of the Corps' activities.
3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers, other public agencies, and private groups, to reduce detrimental aspects of the project.
4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water. Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams; commercial fishing; recreational activities, such as fishing, boating, or hunting that are related to Corps operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

The present Corps of Engineers' project in the St. Anthony Falls Pools [Mississippi River Mile 857.6 to 853.3 (See Figure 1)] consists of structures and their operation and maintenance, and maintenance dredging of a navigation channel of nine feet minimum depth. The structures include (1) a lock and movable-crest dam at the Lower facility, (2) a lock at the Upper facility, (3) control stations, (4) an observation deck near the Upper Lock, and access roads and other structures.

"Operations" includes regulating the reservoir level in the Lower St. Anthony Falls pool, and the operation of the Lower and Upper locks in order to provide safe passage to commercial and pleasure craft.

Maintenance of the project includes dredging the channel to maintain the minimum nine foot depth to the head of navigation at the Soo Line Railroad Bridge (Mile 857.6), as well as clearing of debris and repairing the locks and dam.

AUTHORIZATION

The present nine-foot channel project in the Upper Mississippi River was authorized by Congress by the Rivers and Harbors Act of July 30, 1930, (H.D. 290-71-2)*, as amended by Public Resolution No. 10, February 24, 1932, and by the Act of August 26, 1937 (H.D. 137-72-1) (See Table 1). The extension of this project 4.6 miles above St. Anthony Falls was authorized by the Acts of 1937 (H.D. 290-72-1), 1945 (H.D. 135-84-1), and 1958 (H.D. 33-85-1).

Other Acts have provided for dredging, care and operation of the locks and dams, determination of extent and payment for damage due to seepage from

*H.D. 290-71-2 is an abbreviation for House Document No. 290, 71st Congress, 2nd Session.

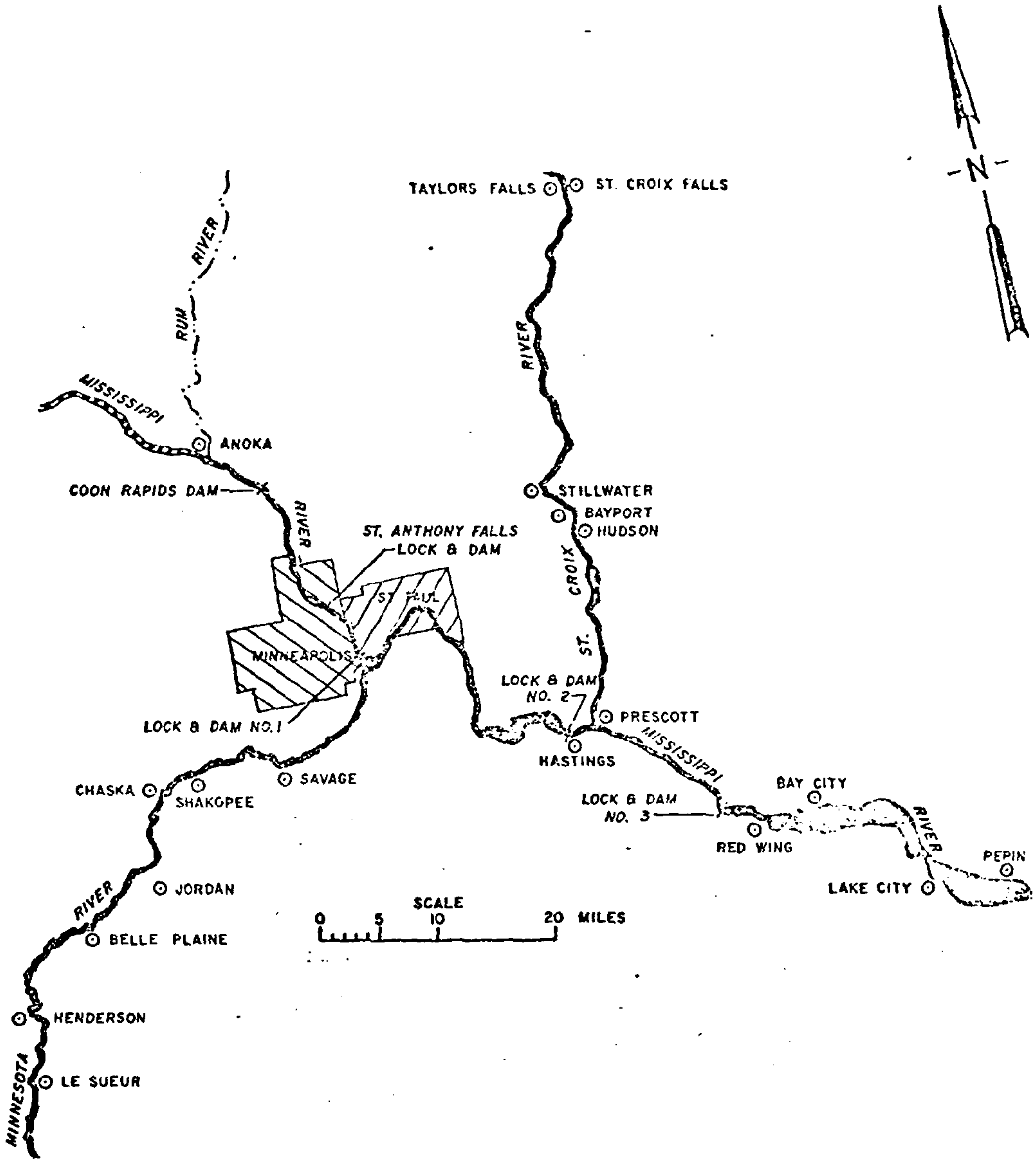


Figure 1. The Mississippi River and its Major Tributaries in the Twin Cities Area (FWPCA, 1966)

Table 1. Congressional authorizations pertaining to the 9-foot channel in the Upper and Lower St. Anthony Falls Pools (S.P.D-NCS, 1955; OCE, 1970)

Rivers and Harbors Acts	Work Authorized	Documents
September 22, 1922	Dredging to landings.	None
June 26, 1934	Operation of snag boats; care and operation of locks and dams.	None
July 3, 1930 Amended by P.R.* No. 10, Feb. 24, 1932	Survey for a 9-foot channel; modify permanent structures under construction to accommodate 9-foot channel; Chief of Engineers granted discretionary authority to modify plans as deemed advisable	House Doc. 290, 71st Congress, 2nd Session.
August 26, 1937	Extend 9-foot channel project above St. Anthony Falls to Northern Pacific Railroad Bridge by means of 2 locks and a dam, with supplementary dredging.	House Doc. 137, 72nd Congress, 1st Session.
August 26, 1937	Determine damages to drainage and levee districts caused by seepage and backwaters, and cost of rectifying.	Rivers and Harbors Committee Doc. 34, 75th Congr. 1st Session.
December 22, 1944	Park and recreation facilities.	None
March 2, 1945	Changes or additions to payments, remedial works, or land acquisitions authorized by the Rivers and Harbors Act of August 26, 1937 (River and Harbor Committee Doc. 34, 75th Congress, 1st Session), as Chief of Engineers deems advisable.	None
March 2, 1945	Limits vertical clearances of bridges to 26 feet at 40,000 cfs; provides for cash contributions by local interests in lieu of their altering privately owned bridges and utilities for St. Anthony Falls project.	House Doc. 449, 78th Congress, 2nd Session.

* P.R. = Public Resolution

Table 1 (cont.). Congressional authorizations pertaining to the 9-foot channel in the Upper and Lower St. Anthony Falls Pools (S.P.D-NCS, 1955; OCE, 1970)

Rivers and Harbors Acts	Work Authorized	Documents
July 3, 1958	Payment in lump sum for damages to drainage and levee districts caused by operation of navigation pools.	House Doc. 135, 84th Congress, 1st Session.
July 3, 1958	Modify vertical bridge clearances and completion of St. Anthony Falls project.	House Doc. 33, 85th Congress, 1st Session.
November 7, 1966	Repair Stone Arch Bridge, Minneapolis.	None

backwaters, and repair of the Great Northern (now Burlington Northern) Railway's famous Stone Arch Bridge.

HISTORY

In 1824, a year after the sternwheeler "Virginia" initiated navigation by working its way up to Fort Snelling, Congress authorized the Corps of Engineers to improve navigation by removing snags, wrecks, shoals, and sandbars (Ryder, 1972).

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. In 1890 the 4.5-foot channel was extended to Minneapolis, requiring the removal of boulders and dredging of bars. The Corps published from 1894 to 1907, 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.

The 6-foot Channel

The six-foot channel, authorized in 1907, was obtained by constructing more wing and closing dams and by dredging. This project was surveyed by air in 1927 and published in 1930 as the "Brown Survey", and reissued in 1933-34 as the "Flowage Charts". The latter included land use and helped determine the feasibility of the nine-foot channel.

The 9-foot Channel

In 1933 the Corps published charts of this nine-foot channel completed in 1938 (except for the St. Anthony Falls facilities) as 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 form than previously, although the arrangement is extremely inconvenient.

Early Structures at the Falls

Dam construction and protection from erosion at St. Anthony Falls began in the mid-1800's. Five electric power plants were built in the late 1800's and early 1900's; two of the four which remain are still producing power today. The St. Anthony Falls Water Power Co. built a rock and timber dam halfway across the river, forming the east half of a horseshoe-shaped dam above the Falls, while the Minneapolis Mill Co. constructed the west half of this dam to utilize the waterpower as provided for in a charter from the Territorial Legislature in 1857. This stimulated an active and rapidly increasing manufacturing business, principally flour and lumber milling. However, the operations of these companies severely constricted the river to about 450 feet, causing accelerated recession of the Falls. Also, at low water the greater part of the water was drawn through the sluices, often leaving bare the limestone ledge between the dam and the crest of the Falls. In winter, frost action caused rapid disintegration of the limestone. An attempt was made by the companies to protect the crest of the Falls by a timber apron in 1866, but this was destroyed by ensuing high water, and a second attempt in 1869 was likewise unsuccessful.

In the autumn of 1868, the Eastman Tunnel was begun in order to convey water to the Falls at the foot of Hennepin Island after supplying power to mills on Nicollet Island. On the 4th of October, 1869, construction in the tunnel had reached the foot of Nicollet Island, some 2000 feet from the Falls. Here, water passing under the limestone from its upstream edge nearby entered in such quantity that it drove the workmen from the tunnel. Soon it became a roaring sluiceway, enlarging rapidly to a diameter of 80 feet. Finally a portion of the limestone roof caved in, causing the collapse of several mills on Hennepin Island (Kane, 1966).

A temporary dam (cofferdam) was then built by the Corps of Engineers to stop the flow and repair the damage. However, four years passed before the tunnel was finally filled and cavities plugged, during which many mishaps delayed the work. From 1874 to 1876 the Corps built a concrete seepage wall 4 to 6.5 feet thick, extending across the entire river about 300 feet upstream from the crest of the falls. The top of the wall is directly under the limestone ledge and extends 38 feet down into the sandstone. The combination of all these works finally arrested the disintegration of the Falls. However, subterranean streams, the source of which is unknown, still persist and cause a great deal of trouble in foundation work.

In order to prevent further recession upstream of the Falls, a timber and rock apron 450 feet long was built across the face of the Falls by the Corps from 1870 to 1878, and rebuilt by William de la Barre of the Twin Cities Rapid Transit Company (See Figure 2). This apron was largely destroyed by the 1952 flood (See Figure 3) and was replaced with one of concrete by Northern States Power Company. A V-shaped dam was built by de la Barre in 1895 of large blocks of granite and limestone about a half mile downstream from the Falls, to provide water to run a hydroelectric plant which powered the Twin City Rapid Transit Company's streetcars (Kane, 1966). This dam was replaced by the Corps in 1959 when the Lower Lock was built.

The first hydroelectric plan in the western hemisphere was built in 1882 by the Minnesota Brush Electric Company on Upton Island, the present site of the Upper Lock. Also, at one time as many as eight sawmills shared space on the Island. The hydroelectric plant supplied power for light along Washington Avenue in the 1880's. The Hennepin Island hydroelectric plant was constructed under the direction of de la Barre for the Transit Company in 1908. This structure is now part of the University of Minnesota's St. Anthony Falls Hydraulics Laboratory, constructed in 1936.

The Main Street Station which now serves as a substation, was constructed in 1895 by the Minneapolis General Electric Company at the east end of the

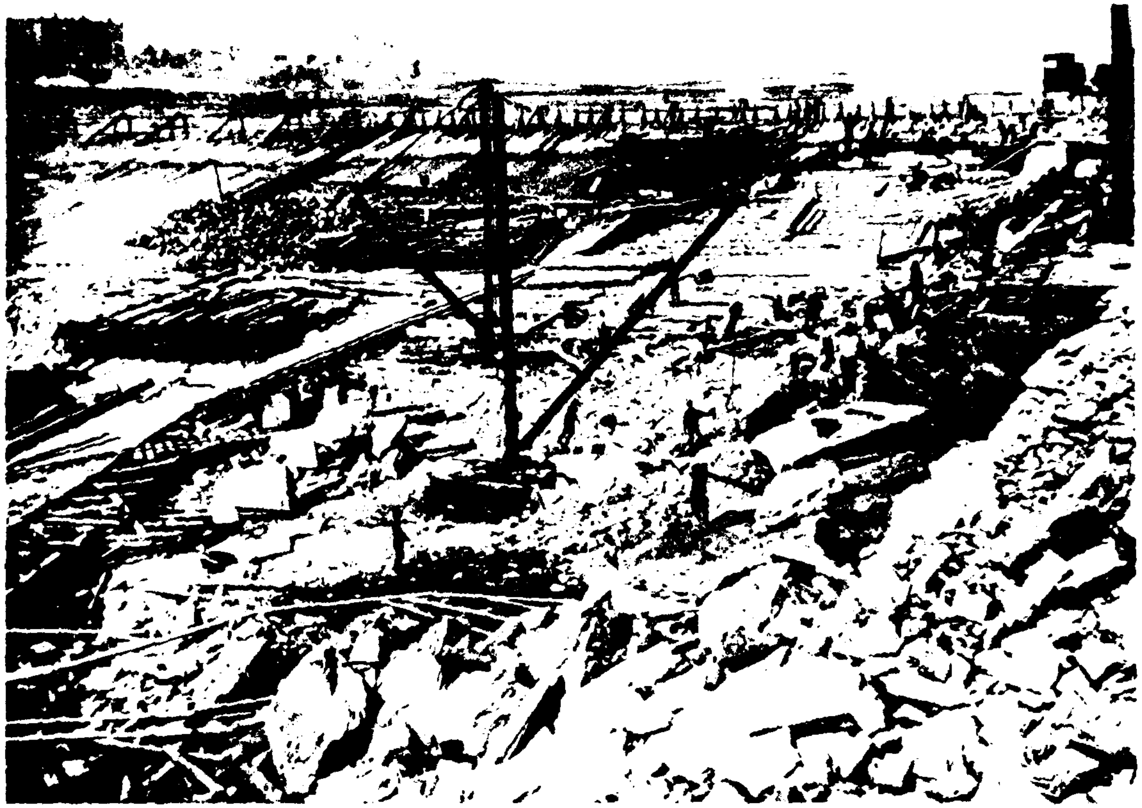


Figure 2. Reconstruction of the Timber and Rock Apron Dam at St. Anthony Falls in the 1890's (NSP)

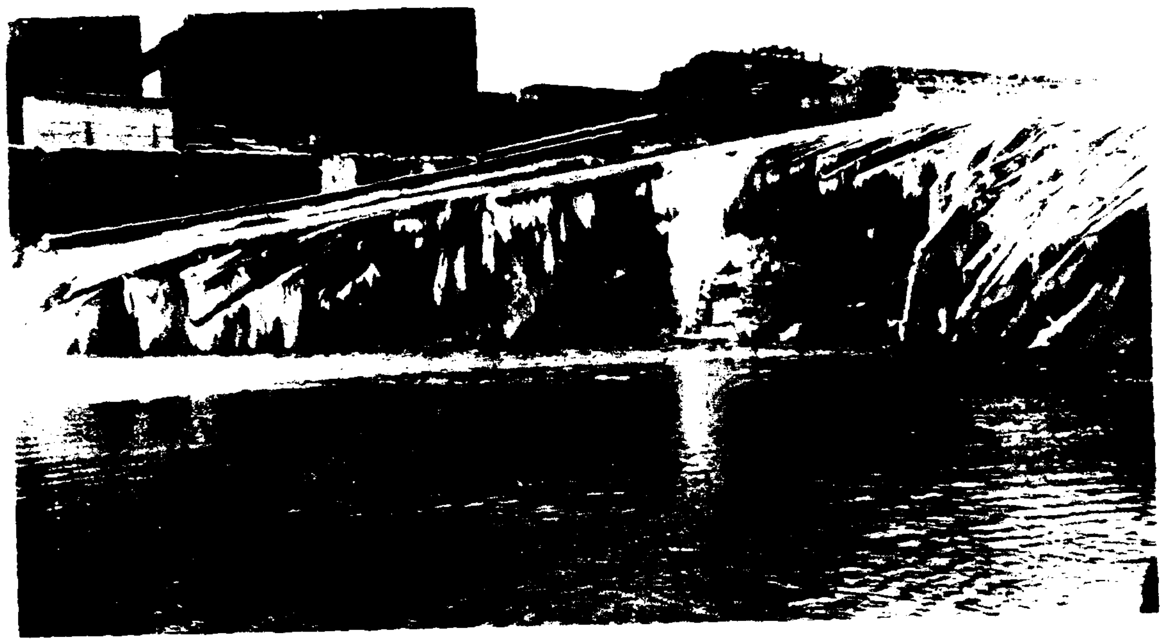


Figure 3. Damage Caused by the 1952 Flood to the Old Timer and Rock Apron at the Upper Dam (Corps of Engineers)

Upper Dam to replace the earlier plant. Another power plant, the Southeast steam plant, was built by the Transit Company in 1903 and is located on Hennepin Island. The other power plants as well as the Upper Dam, are presently owned and operated by Northern States Power Company, which produces a total of 20 megawatts of electric power.

CORPS FACILITIES

Presently, the Corps of Engineers project in the St. Anthony Falls Pools consists of operating and maintaining the Upper and Lower Locks and the Lower Dam (See Figure 4), as well as maintaining the 9-foot channel by dredging. These structures are the newest of 29 such locks and dams on the Mississippi River which have converted the free-flowing river into a "stairstep" series of navigable pools (See Figure 5). The St. Anthony Falls locks and dams provide for commercial navigation of a minimum 9-foot deep by 200-foot-wide channel from the Lower Lock and Dam upstream 4.3 miles to the head of navigation at the Soo Line Bridge (Mile. 857.6) in northern Minneapolis (See Figure 6).

The Upper Lock and the Lower Lock and Dam are located on over 15 acres of government property. Fee title was obtained for 12.46 acres and perpetual easement was obtained for another 2.96 acres from the city of Minneapolis. Total cost of these facilities was $31,748,535 of which about $1,000,000 was contributed locally (S.P.D.-NCS, 1967).

Locks and Dam

The Lower facility presently consists of a navigation lock, the upstream portion of an auxiliary lock, a 195-foot movable-crest dam, control station, observation platform and other structures (See Figure 6). This facility was open to navigation in 1959. The Upper facility consists solely of a navigation lock. The Upper dam, which is privately owned, was increased in height by one foot. Both locks have sufficient water depth to accomodate vessels of 12-foot draft (S.P.D.-NCS, 1967; USEO, 1945).

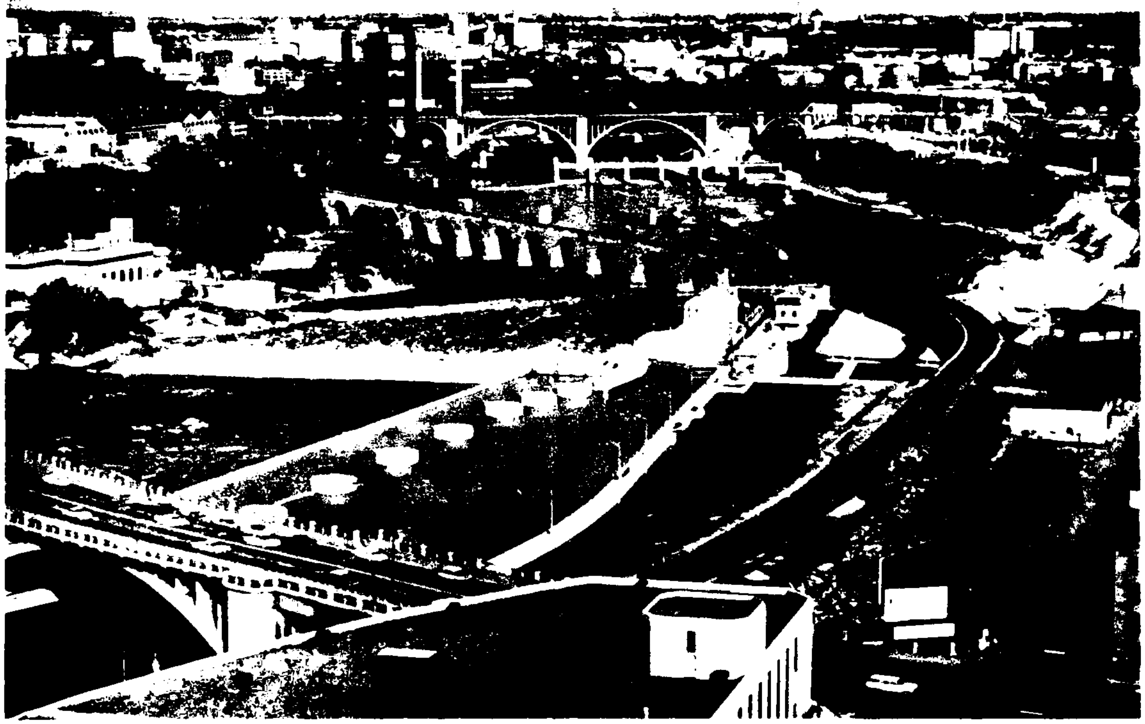


Figure 4. View Downstream in 1969 of the St. Anthony Falls Upper (Foreground) and Lower Locks and Lower Dam (Corps of Engineers)

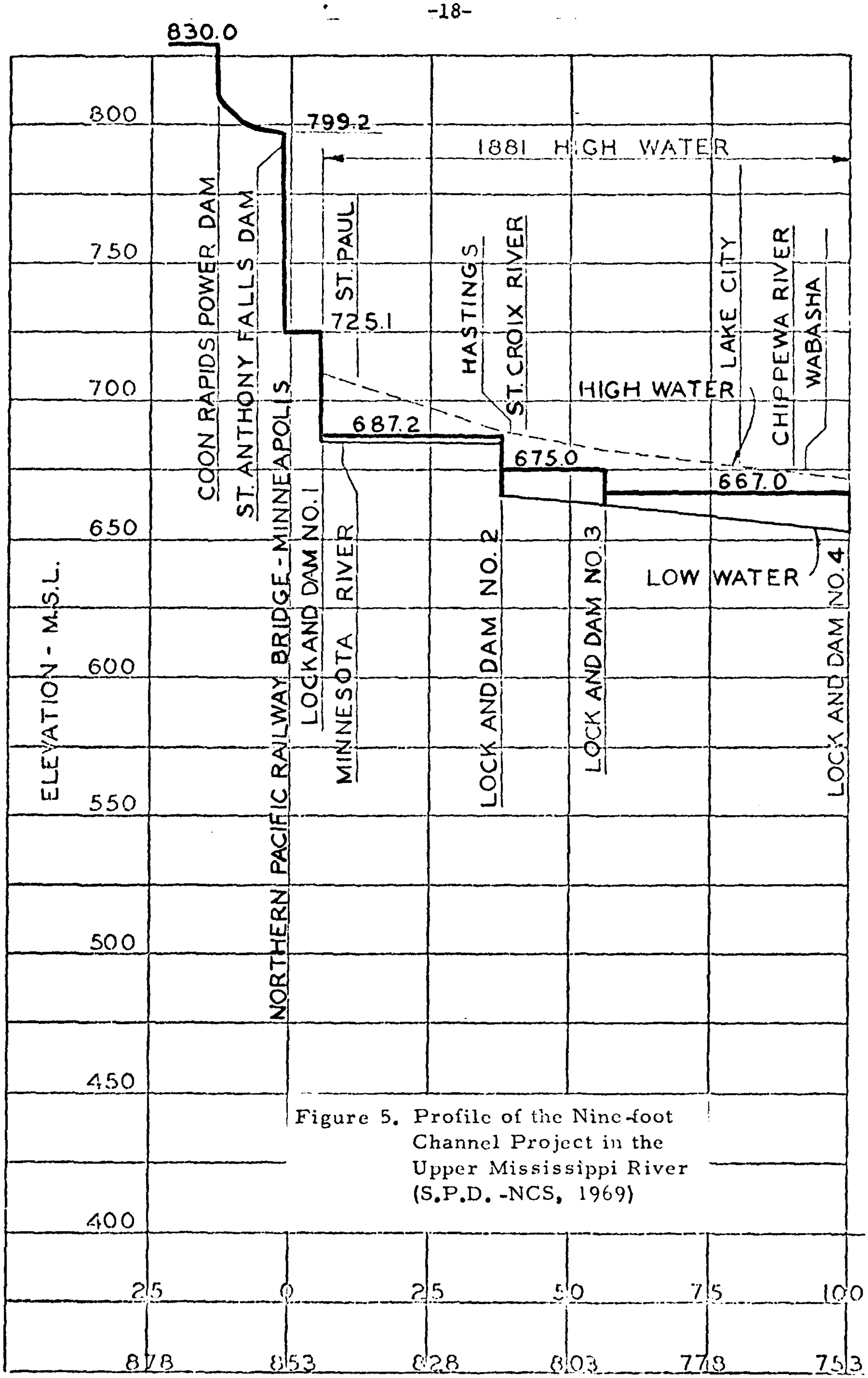


Figure 5. Profile of the Nine-foot Channel Project in the Upper Mississippi River (S.P.D. -NCS, 1969)

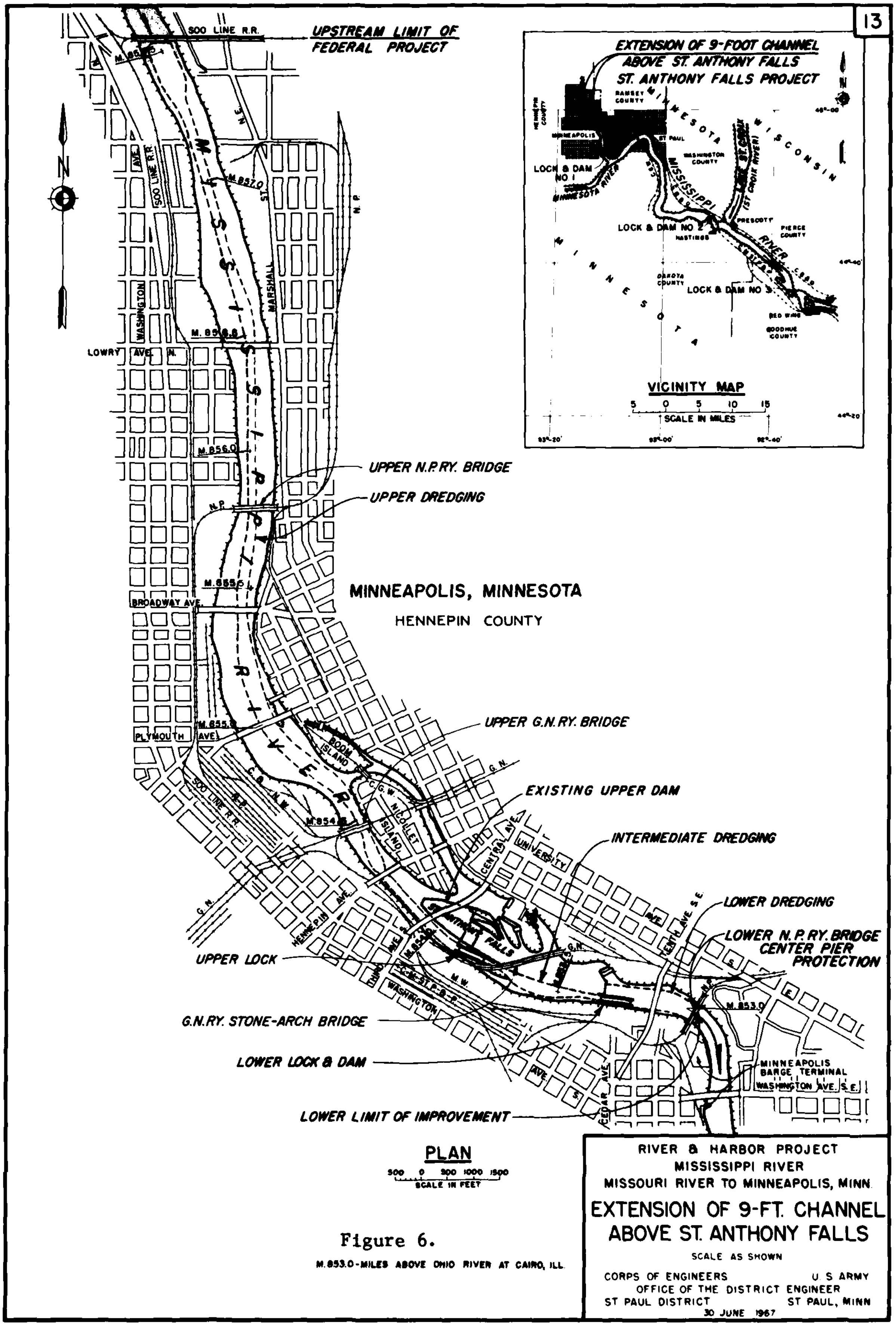


Figure 6.

M.853.0-MILES ABOVE OHIO RIVER AT CAIRO, ILL.

Lower Lock

The Lower Lock chamber is 56 by 400 feet. It is closed by a tainter gate (See Figure 7, B-B) at the head and by a pair of miter gates at the foot (See Figure 6 plan between D-D and C). A portion of the riverward wall of an auxiliary lock and its gate lie between the completed lock and the dam. The water level in the Lower Lock is changed 25.2 feet by gravity flow through a single culvert and filling and emptying ports in the lock (See Figure 7, Sect. C-C) by a system of valves.

Lower Dam

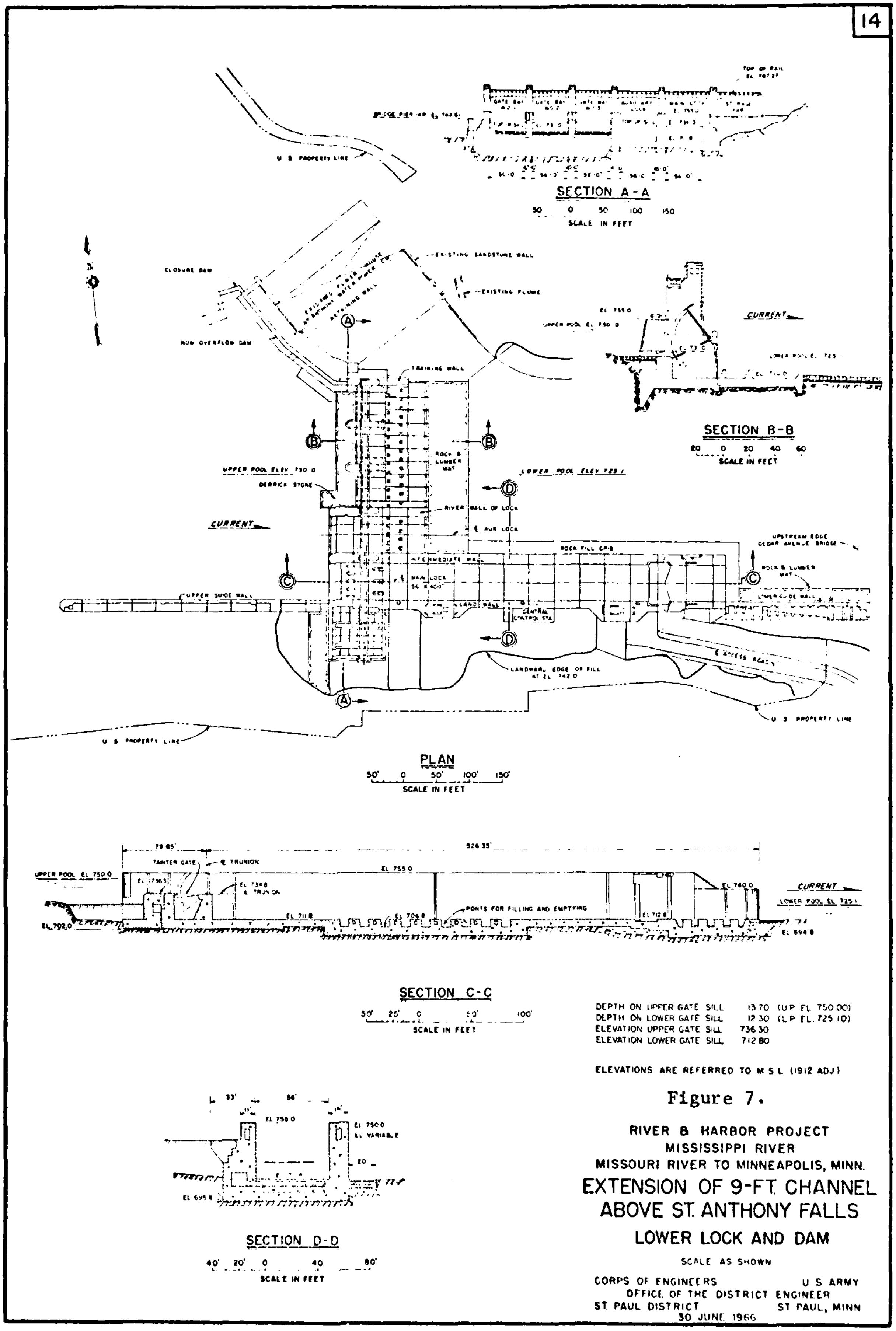
This structure is 195 feet long and is located between the auxiliary lock on the right and Northern States Power Company hydroelectric plant on the left bank. Water level is controlled by the dam's four tainter gates, which are moved to maintenance pool elevation at 750.0 feet above mean sea level*. Operation of the valves, gates and lights for these facilities requires electrical power. Other structures include control stations (one with an observation platform), an access road, guide walls and mooring cells.

Upper Lock

The Upper facility consists of a lock, guide walls, mooring cells, a control station with observation deck, access roads and parking area (See Figure 8, plan view). This facility, the most recent in the upper Mississippi River navigation system, was open to navigation in 1963. The Upper Lock was constructed on Upton Island at a non-overflow section of the Upper Dam. The latter structure was increased about one foot in height in order to gain the minimum nine-foot depth (U.S.E.O., 1945).

The Upper Lock chamber, which measures 56 by 400 feet, is closed by two sets of miter gates. There is also a tainter gate at the head of the Upper Lock which is used only during the season the lock is not in use for navigation.

* 1912 adjustment



DEPTH ON UPPER GATE SILL 13.70 (UP. EL. 750.00)
DEPTH ON LOWER GATE SILL 12.30 (L.P. EL. 725.10)
ELEVATION UPPER GATE SILL 736.30
ELEVATION LOWER GATE SILL 712.80

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

Figure 7.

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

EXTENSION OF 9-FT. CHANNEL ABOVE ST. ANTHONY FALLS

LOWER LOCK AND DAM

SCALE AS SHOWN

CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.
30 JUNE 1966

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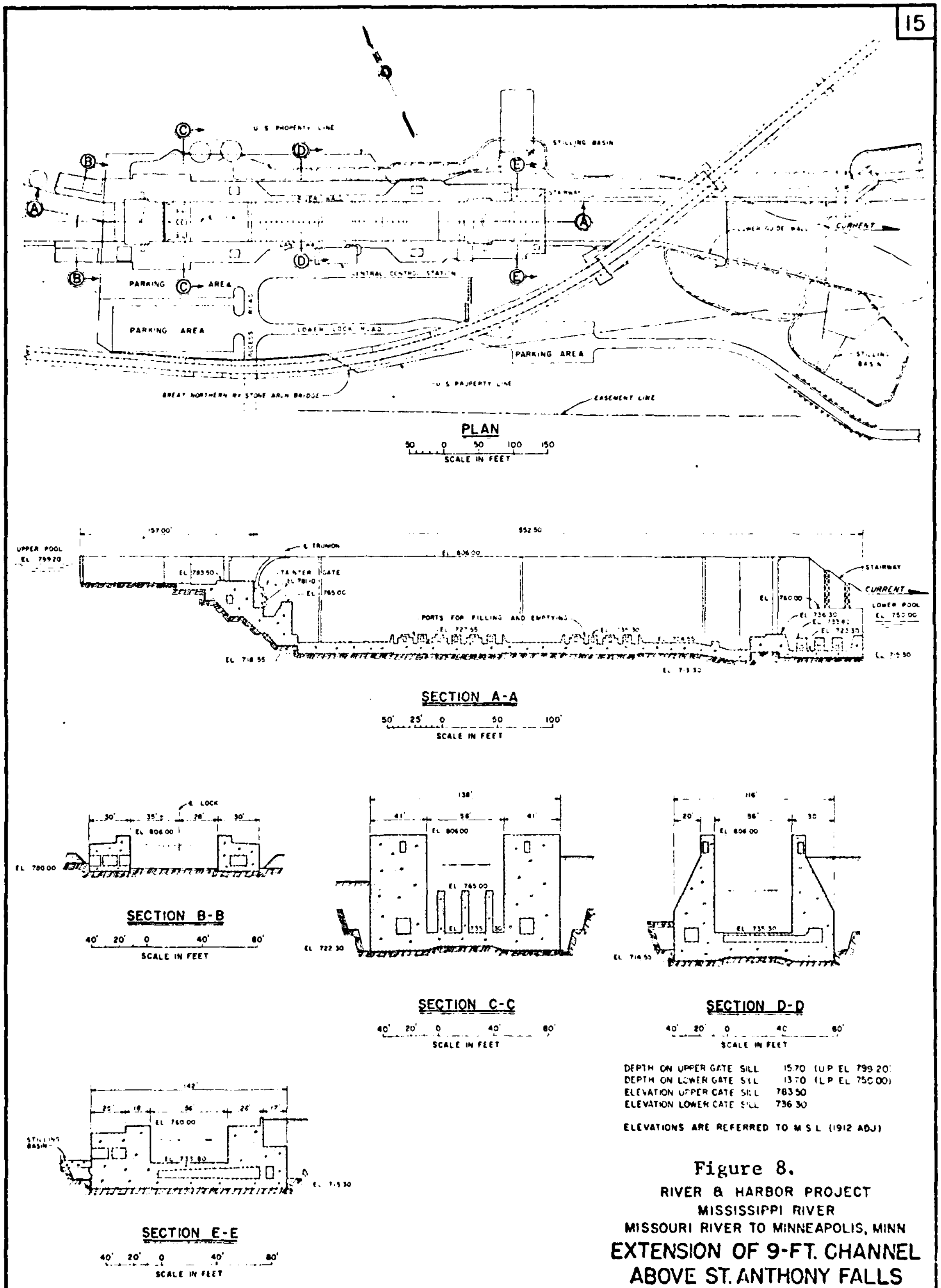

DEPTH ON UPPER GATE SILL 15.70 (U.P. EL 799.20)
DEPTH ON LOWER GATE SILL 13.70 (L.P. EL 750.00)
ELEVATION UPPER GATE SILL 783.50
ELEVATION LOWER GATE SILL 736.30

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

Figure 8.

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

EXTENSION OF 9-FT. CHANNEL ABOVE ST. ANTHONY FALLS

UPPER LOCK

SCALE AS SHOWN

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL DISTRICT ST PAUL, MINN
30 JUNE 1966

During floods, water is passed over the tainter gate, thus increasing the discharge areas of the Upper Dam. It serves to maintain the pool level and regulate flow through the lock. The water level is changed 49.2 feet by gravity flow through two culverts and filling and emptying ports in the Lock (See Figure 7, Sect. A-A) by a system of valves. A pool elevation of 799.2 is maintained by the private dam. Electrical power is required to operate the valves, gates and lights at the lock.

OPERATIONS AND MAINTENANCE

The Corps'project in the St. Anthony Falls Upper and Lower Pools now consists mainly of operating and maintaining the locks and Lower Dam, and dredging in order to maintain the navigation channel's minimum authorized depth.

Lock Operation

The locks at St. Anthony Falls are operated from the opening of the navigation season (usually mid-April), until its close (usually mid-December), on a 24-hour basis. The small size of the locks--compared with the standard 100 x 600-foot locks from Lock 2 downstream--limits tows to one or two barges plus a small shuttle towboat. Although the Upper Lock contains twice the volume of water of the Lower Lock, both locks require only about 8 minutes to fill. This is accomplished at the Upper Lock by means of two culverts, which doubles the intake and outlet rate of flow.

Free use of the locks is available to all craft. However, the Secretary of the Army has established the following priority system for vessels locking through (S.P.D.-NCS, 1969):

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

More detailed information on lock operations is available from the Lockmaster at each facility.

Dam Operation

The Lower Dam is operated by the Corps to maintain pool elevation at 750.0 feet. This provides sufficient depth for safe navigation of the pool to the Upper Lock, and for the 4800 cfs (cubic feet per second) needed for hydroelectric power production. The Upper Dam is a fixed-crest structure which maintains the water surface at an elevation of 799.2 feet (above mean sea level, 1912 data). Inflow increases the elevation upstream from the dam (See Table 2). It is owned and operated by Northern States Power Company. The Upper Dam has 2-foot flashboards which automatically release when the discharge of the Mississippi River becomes greater than 40,000 cfs. The Upper Dam provides sufficient depth to the head of navigation (Soo Line R.R. Bridge, Mile 857.6) and the 3830 cfs needed for hydroelectric power production. Neither dam can be operated to control floods due to low pool

Table 2. Ordinary High Water Elevations

Upper Mississippi River - Mile 853.3 To Mile 857.6 (S.P.D.-NCS, 1969)

Miles Above Ohio River	Pool No.	Project Pool Elev.	Ordinary High Water Elev. (1)			
854.0	Upper St. Anthony	799.2	801.9	Upper St. Anthony Falls Lock		
855.2	"	"	802.0	Minneapolis,	Minn.	-10th Avenue N.E.
855.8	"	"	802.1	"	"	Upper N.P. R.R. Br.
857.6	"	"	802.4	"	"	Soo Line R.R. Br.
859.0	"	"	802.5	"	"	51st Avenue North

(1) Preliminary Survey of O.H.W. - 1 September 1964.

capacity and constriction of the flood plain by extensive urban development upstream on the river banks.

Both Upper and Lower Locks have tainter gates at their upstream ends, which assist in pool elevation regulation. Passage of water through the locks can occur at discharges of over 40,000 cfs, because faster currents due to greater discharges are hazardous to navigation.

Channel Maintenance

The river bottom must be dredged in some reaches because increasing water depth by damming alone could not provide sufficient depth everywhere in the St. Anthony Falls Pools. During the year, changes in hydraulic efficiency of the river (i.e., its ability to keep its sediment load in suspension along the length of its channel) results in areas of sediment accumulation. These areas are dredged by the Corps of Engineers to remove this hazard to commercial navigation, using clamshell dredged such as the Derrickbarge 767.

Dredging and spoiling are carried out by one of two procedures, depending on the proximity of the dredge site to shore. If the shore is within reach of the boom of the clamshell dredge, the dredged river sediment is cast directly upon shore. If, however, a spoil site is not available within reach, the sediment is cast into barges and towed to the spoil site (See Figure 9). At this site the sediment is dropped back into the river by releasing the side gates on the barge (See Figure 10). The sediment is then redredged by another clamshell and cast upon the side, whereupon it is pushed away and levelled by bulldozers (See Figures 11 and 12).

Maintenance dredging in the St. Anthony Falls pools has yielded an average of over 23,500 cubic yards annually (5470 cubic yards per river mile per year) since the Lower Lock opened for navigation in 1959 (S.P.D.-NCS, 1973) (See Figure 13 and Table 3). The 5470 cubic yards dredged annually per river mile is intermediate compared with the other pools in the St. Paul

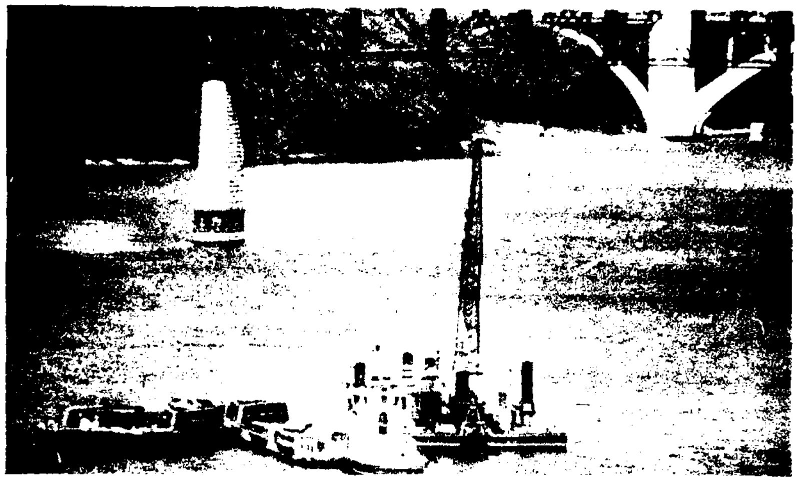

Figure 9. The Clamshell Dredge Derrickbarge 767 Deepening the Nine-Foot Navigation Channel on the Mississippi River. The Spoil is Dropped into Waiting Barges *which Transport it to the Spoil Site* (Colingsworth)

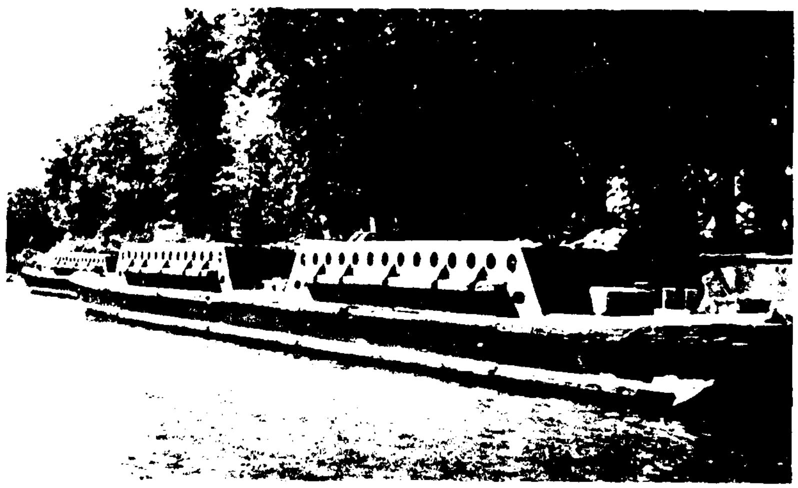

Figure 10. *Spoil Barges Showing Side-Mounted Gates for* Dropping the Spoil at the Spoil Site (Colingsworth)

Figure 11. The Clamshell Dredge Derrickbarge 771 Redredges the Spoil Dropped by the Barges and Casts it on to the Spoil Bank. Note the Figures in the Right Foreground (Colingsworth)

Figure 12. The Newly Deposited Spoil Piles are Levelled by Bulldozer (Colingsworth)

Table 3. Annual Volume of Sediment Dredged, in Cubic Yards, from Upper and Lower St. Anthony Falls Pools from 1959 to the Present (S.P.D.-NCS, 1973)

Year	Volume Dredged, in Cubic Yards
1959	1,405
1960	405
1961	443
1962	2,051
1963	5,338
1964	66,607
1965	9,629
1966	35,224
1967	39,221
1968	0
1969	14,356
1970	135,038
1971	0
1972	19,591
14 years	329,308

ANNUAL AVERAGE: 23,522 cubic yards per year

ANNUAL AVERAGE: 5,470 cubic yards per year per mile

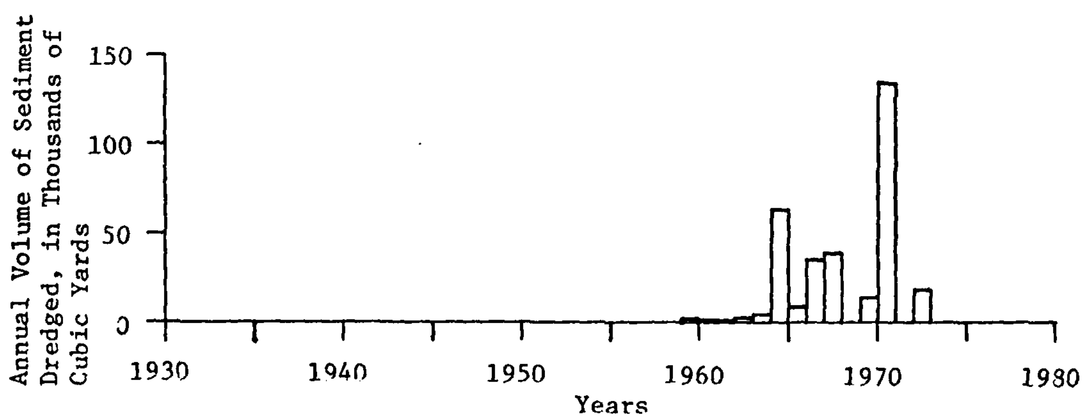

Figure 13. Annual Volume of Sediment Dredged, in Cubic Yards, from the St. Anthony Falls Pools from 1959 to the Present (S.P.D., NCS, 1973)

District (See Table 4). However, there are very few spoil sites, and those are small, due to the extensive development of the river banks in the St. Anthony Falls pools. The dredging data indicate that the upper reach of the Upper Pool requires more dredging than elsewhere in the pool (See Figure 1 in Appendix A, IV).

One million cubic yards of river bottom was dredged from the Falls pools during construction, which began in 1948. A portion of the dredged spoil was deposited along the river banks in the Upper and Lower Pools, and the remainder below the Washington Ave. Bridge. Also several islands were eliminated in order to create the navigation channel (S.P.D.-NCS, 1960).

Available data indicate that this construction dredging and alterations to the dams resulted in changes in the area of main channel, backwaters and islands. In the Lower Pool the acreage of main channel increased about 144%, to 52.2 acres, between 1935 and 1973 (See Table 5). During the same period the acreage of backwaters decreased about 18% and that of islands about 27% to 7.9 and 11.3 acres, respectively. In the Upper Pool the acreage of main channel increased about 14% to 280.2 acres from 1935 to 1960 (data for 1973 as yet unavailable), while backwater and island acreage decreased 40% and 9.2%, to 23.3 and 42.2 acres, respectively. From 1960 to 1963, which was during construction of the Upper Lock, acreage of main channel, backwater and islands decreased by 15%, 34% and 10%, to 237.8, 15.3 and 38.0 acres, respectively.

Bridges

Nine railroad and automobile bridges span the Mississippi River in the St. Anthony Falls pools (See Table 6), most of which required modification in order to accommodate barge traffic. Vertical clearance (height above water surface) of some of these bridges are less than those found downstream both because the fast current at discharges greater than 40,000 cfs are not navigable, and to minimize the cost of alterations to the bridges to allow navigation.

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

Table 5. Changes in Area of Water Surface and Islands in St. Anthony Falls Pools, 1895 to 1973.

Pool	Water Surface Area				Area of Islands	
	Main Channel		Backwater			
	Acres	% Change	Acres	% Change	Acres	% Change
Lower	32.6 (1895)[1]		8.6 (1895)		20.2 (1895)	
	21.4 (1935)[2]	(-)34.4	9.6 (1935)	(+)11.6	15.5 (1935)	(-)23.3
	52.2 (1973)[3]	(+)143.9	7.9 (1973)	(-)17.7	11.3 (1973)	(-)27.1
Upper	294.2 (1895)		38.4 (1895)		67.7 (1895)	
	246.5 (1935)	(-)16.2	39.0 (1935)	(+) 2.1	46.5 (1935)	(-)31.3
	280.2 (1960)[4]	(+)13.7	23.3 (1960)	(-)40.3	42.2 (1960)	(-) 9.2
	237.8 (1963)	(-)15.1	15.3 (1963)	(-)34.3	38.0 (1963)	(-)10.0

1. Area based on planimetry of Mississippi River Commission Chart No. 189, 1895.
2. Area based on planimetry of aerial photos, 1935, Holmberg Air Mapping Co.
3. Area based on planimetry of aerial photos: 1973 Environmental Study, Nine-foot Channel Project (S.P.D.-NCS, 1973).
4. Area based on planimetry of plates 4-6, Design Memo No. 8 (S.P.D.-NCS, 1960); St. Anthony Falls Upper Pool not included in May, 1973 "Environmental Study" Aerial Photos, and August, 1973 series of same were not yet available.

Table 6. Upper Mississippi River Bridges, St. Anthony Falls
Upper and Lower Pools
Mile 853.3 to 857.6 (S.P.D.-NCS, 1969).

Miles Above Ohio River	Bridge Location	Type of Structure	Use (2)	Year Comp. (3)	Height (feet) Above Project Pool Elevation	Owner
		Upper Pool Normal Elevation 799.1 (1)				
857.6	Mpls.-41st Ave. N.	Truss	R	1905	18.8	Soo Line R.R.
856.45	Mpls.-Lowry Ave.	Truss	H-P	1905 1958(N)	32.95	City of Mpls.
855.80	Mpls.-24th Ave. N.	Girder	R	1884-1927 1963(R)	27.3	N.P. Railway
855.45	Mpls.-Broadway Ave.	Truss	H-P	1888 1952(R)	26.27	City of Mpls.
855.0	Mpls.-Plymouth Ave.	Truss	H-P	1882-1919 1953(R)	30.4	City of Mpls.
854.40	Mpls.-5th Ave. N.	Girder	R	1891-1926 1962(R)	24.1	G.N. Railway
854.20	Mpls.-Hennepin Ave.	Steel Arch	H-P	1890	30.8	City of Mpls.
853.95	Mpls.-Third Ave.	Conc. Arch	H-P	1918	42.1	City of Mpls.
		Lower Pool Normal Elevation 750.0 (1)				
853.65	Mpls.-G.N Stone Arch	Stone(4)	R	1885-1907 1910-1963(R)	25.1	B.N. Railway

(1) All elevations are mean sea level (1912 adj.).
(2) H - Highway, P - Pedestrian walks, R - Railroad.
(3) N - New bridge, R - remodeled.
(4) Horizontal opening determined by lock approach - steel truss replaces a stone arch.

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2. ENVIRONMENTAL SETTING

NATURAL SETTING

Because the operation and maintenance of the nine-foot channel is an ongoing project, the present natural environmental setting includes the project from its beginning in 1948 to the present. The environmental setting without the project, in this case prior to project construction, must be reconstructed from published information.

The ecosystems of the upper Mississippi River and its valley to the head of navigation may be divided into several reaches and into various components or subdivisions for more detailed description. The uppermost reach of the navigable river is divided into two pools: (1) the Upper Pool, from the head of navigation at the Soo Line Bridge (Mile 857.6) to the Upper Lock and Dam (Mile 853.7) at St. Anthony Falls; and (2) the Lower Pool from the Upper Lock and Dam to the Lower Lock and Dam (Mile 853.3). Both areas are characterized by heavy concentration of industry. (Figures 14 to 19 and Figure 1 in Appendix A, IV).

The various ecosystem components of the St. Anthony Falls pools have been divided also into Physical Aspects and Biological Aspects sections in this report. The first aspect includes geologic, climatic, and hydrologic components. The Biological Aspects section includes floral and faunal components as part of terrestrial and aquatic ecosystems. It cannot be overstated, however, that such subdivisions disguise the often numerous and complex interactions between components within these river valley ecosystems, as well as with components throughout the watershed. Thus, wherever possible, the characteristics of elements in the St. Anthony Falls pools will be discussed in relation to the Twin Cities area, as well as the watershed. Interactions with areas outside the basin may be dealt with in a very general manner.

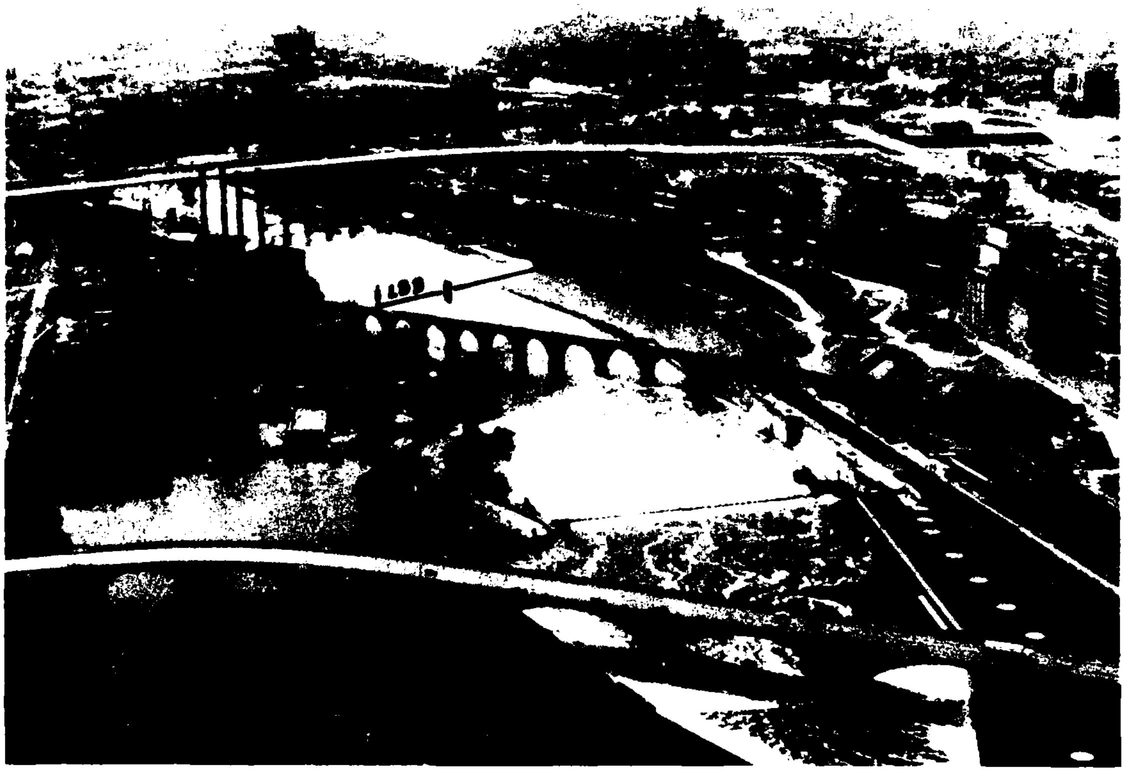


Figure 14. Aerial View Downstream of the Natural and Socioeconomic Setting of St. Anthony Falls Lower Pool, and the Location of the LBB Transect (Colingsworth)

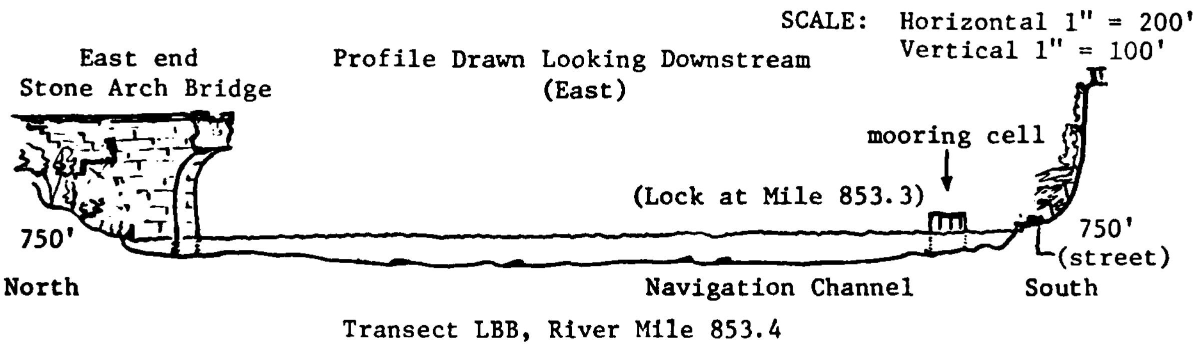
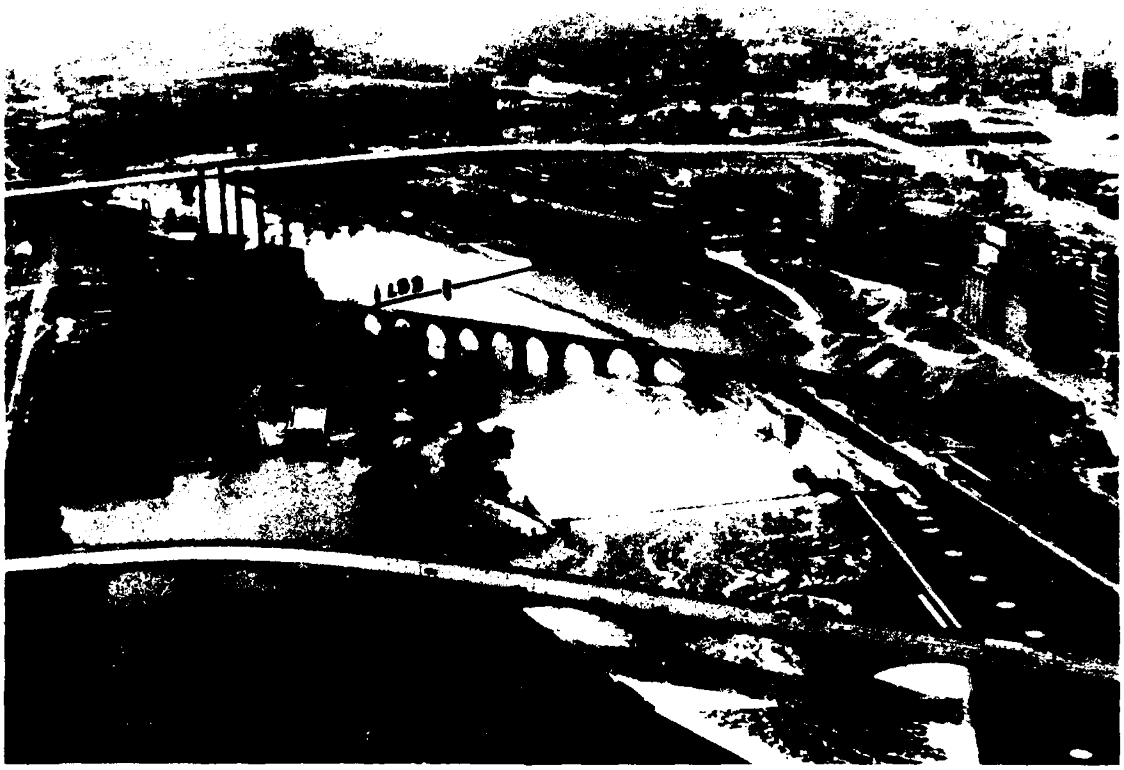


Figure 15. Profile of the Mississippi River at the LBB Transect, St. Anthony Falls Lower Pool (Gudmundson, 1973)



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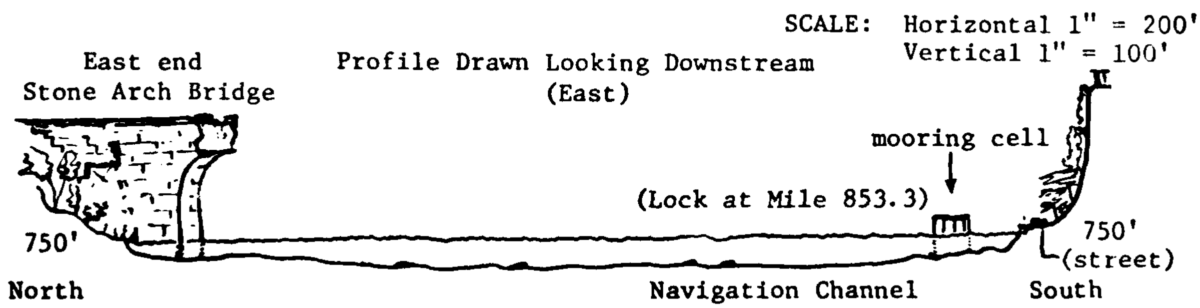


Transect LBB, River Mile 853.4

Figure 15. Profile of the Mississippi River at the LBB Transect, St. Anthony Falls Lower Pool (Gudmundson, 1973)

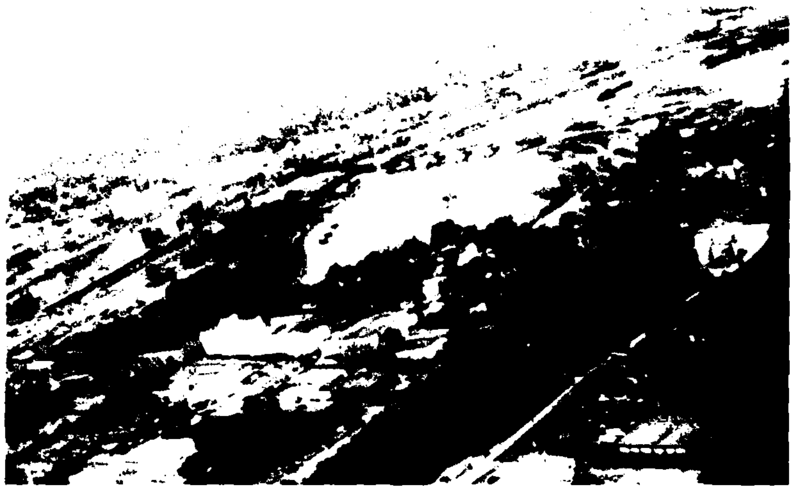


Figure 16. Aerial View Upstream of the Natural and Socioeconomic Setting at the UCC Transect, Nicollet Island, Boom Island and Broadway Avenue Bridge (Colingsworth)

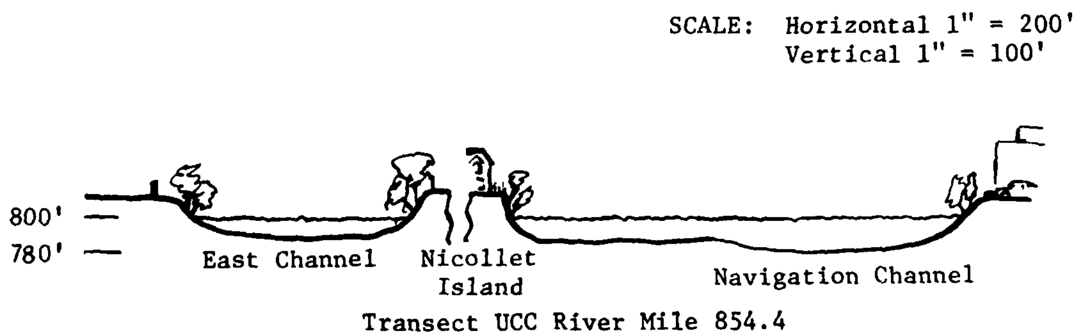


Figure 17. Profile of the Mississippi River at the UCC Transect, St. Anthony Falls Upper Pool (Gudmundson).

Figure 18. Aerial View Upstream of the Natural and Socioeconomic Setting At the Head of Navigation (Soo Line RR Bridge--arrow), St. Anthony Falls Upper Pool (Colingsworth)

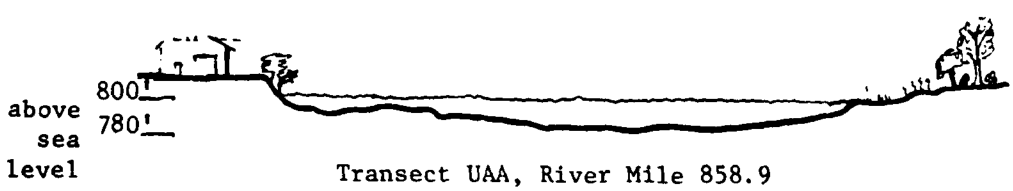


Figure 19. Profile of the Mississippi River at the UAA Transect, St. Anthony Falls Upper Pool (Gudmundson)

Physical Aspects

Topography

From its source in Lake Itasca downstream to St. Anthony Falls Lower Lock and Dam, the upper Mississippi River drains a watershed of about 19,680 square miles (Figure 20). 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. Present topography plus the climate (which grades eastward from dry subhumid to humid) soils and man's activities has led to a vegetational gradation from the extensive mixed pine-hardwood forests bejeweled with numerous lakes and streams in the northeast, to the productive open farmland in the southwest, dotted with marshes and lakes and laced with ditches and streams, much of which formerly was prairie.

Above St. Anthony Falls the Mississippi River meanders between banks 15 to 25 feet high through a broad, shallow glacial outwash valley. At St. Anthony Falls it descends 75 feet and then flows eight miles to Fort Snelling through a gorge 100 feet deep scoured by these falls. During this passage the Mississippi drops another 38 feet, at Lock and Dam 1, Minnehaha Creek joints it, and it flows past historic Fort Snelling. Downstream from the Fort, where it is joined by the Minnesota River, the Mississippi is contained by another deep but much braoder valley once carved by a huge glacial meltwater river.

Geology

The upper Mississippi River watershed is underlain by a series of Pre-cambrian igneous and metamorphic rocks north of Big Lake, Sherburne County, Minnesota. Downstream this basin is underlain by Cambrian, Ordovician and

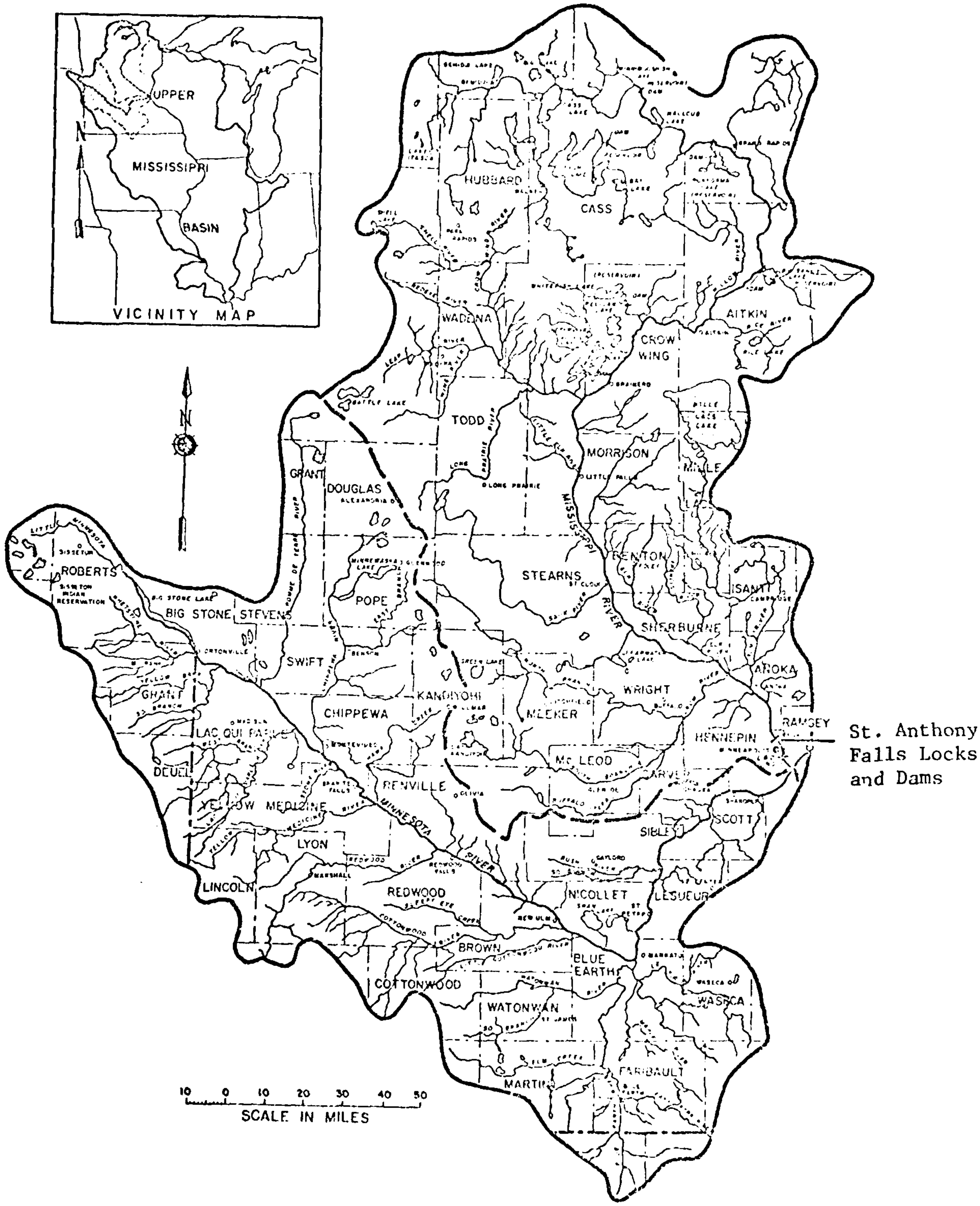


Figure 20. Upper Mississippi River Basin Above St. Paul, Minnesota (MN. DNR, 1972)

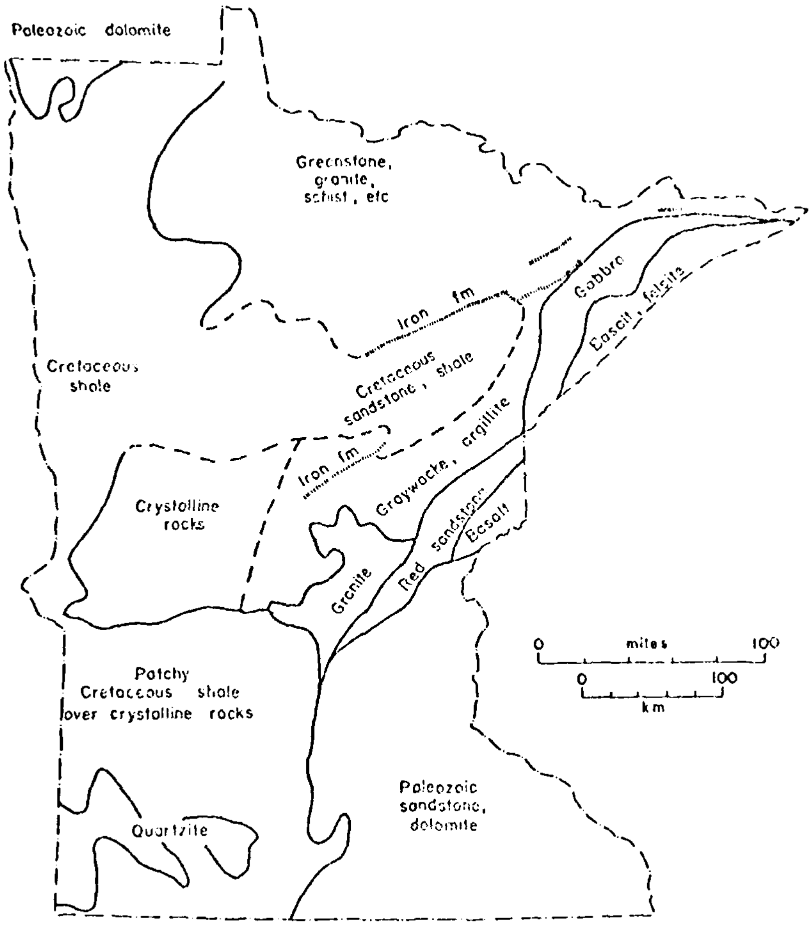


Figure 21. Bedrock Map of Minnesota (Minn. Geological Survey, 1969)

and Devonian sandstones and limestones to the east and south and by Cretaceous shales to the southwest and beyond the basin (See Figure 21 and Figure 22).

In the last million years at least four glaciers scoured their way across these rocks and through the present Twin Cities area (See Figure 23) then receded and left hills and valleys formed from debris or "drift", which they had transported long distances. Deposits left by the last one, the Wisconsin Glacier, were brought first from the northeast by the Superior Lobe, and consist of red-colored sandy and pebbly deposits (See Figure 24). Later

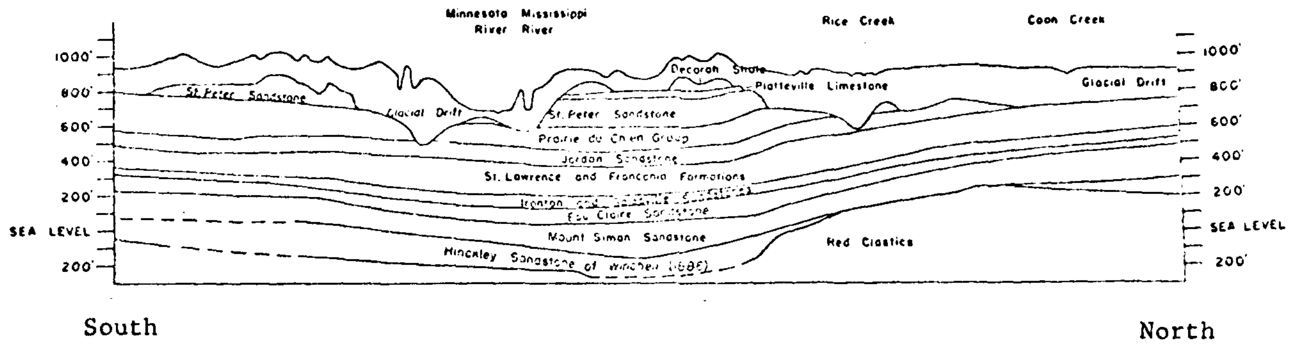


Figure 22. North-South Vertical Section Through the West End of Pike Island Showing the Twin Cities Artesian Basin (Winter and Norvitch, 1972)

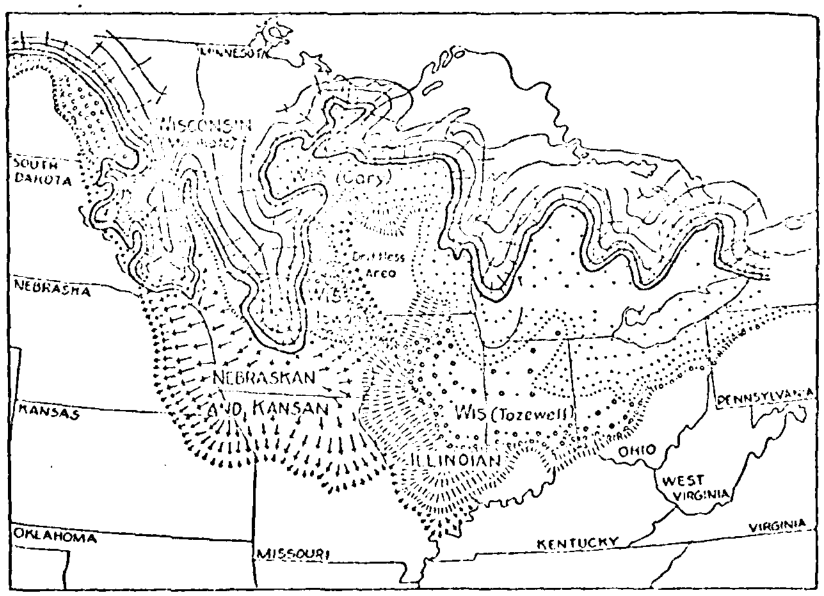


Figure 23. Map of Ice Sheets of the United States (Schwartz and Thiel, 1963

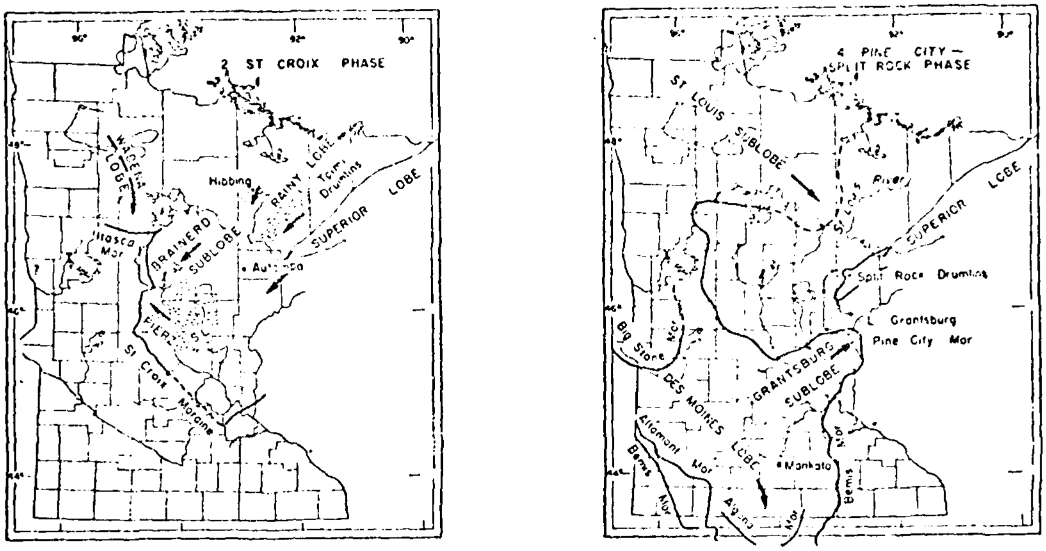


Figure 24. Maps of Minnesota Showing Extent of Ice Lobes During Various Phases of Wisconsin Glaciation (Winter and Norvitch, 1972)

the Grantsburg Sublobe of the Des Moines Lobe brought buff colored sands, clays, and rock from the Cretaceous shales, more or less covering much of the previous deposits. Such deposits, if unstratified, are termed till; if transported and sorted according to size by glacial meltwaters, they are termed outwash.

These glacial advances stagnated at various times and places in Minnesota (and elsewhere), dumping huge mounds of large quantities of rock, stone, gravel, sand and clay. Such mounds, formed at the terminus of the glaciers, generally conformed to their shape; thus, they are termed "end" or "terminal" moraines. These moraines and other till and outwash, which have been subsequently modified by climate, vegetation and man, form our present soils and topography.

One large outwash deposit, the Anoka Sandplain, was formed by the Grantsburg Sublobe (See Figure 25). The present Mississippi River above St. Anthony Falls glides through a broader valley which probably was carved during the last phase of formation of the Sandplain.

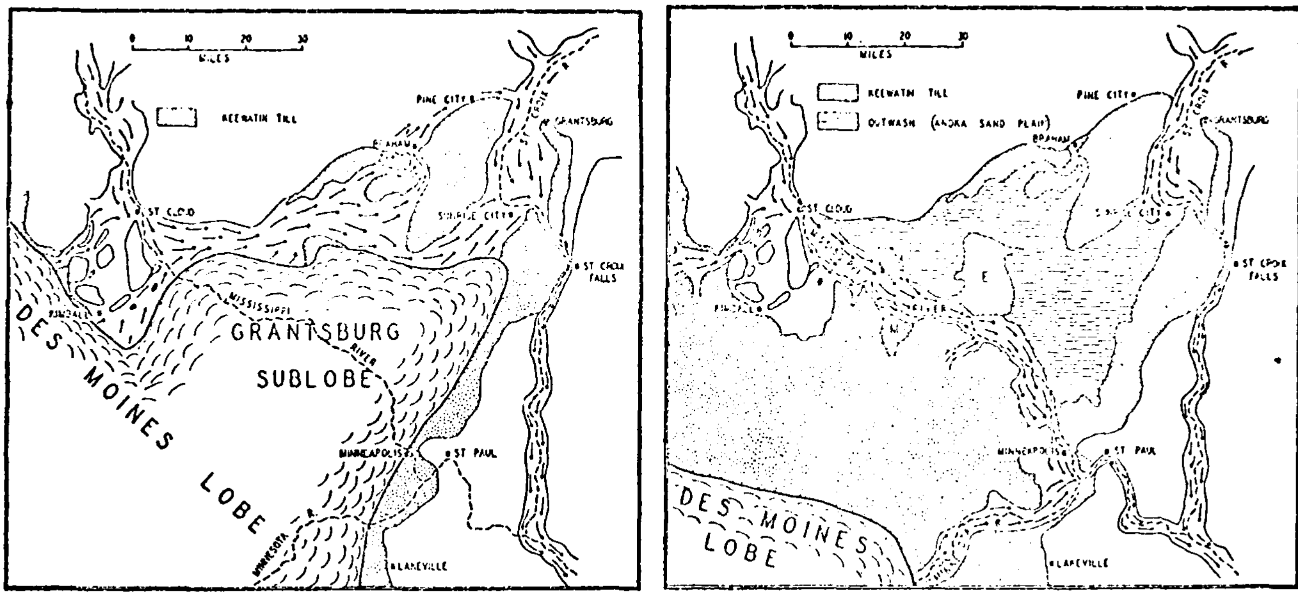


Figure 25. Maps Showing Formation of the Anoka Sandplain at Two Stages (Winter and Norvitch, 1972)

Later at St. Paul, near the present Holman Field, Glacial River Warren plunged over a rock ledge into a preglacial channel (See Figure 26); other preglacial valleys were apparently filled with sediment. The "River Warren Falls" thus formed receded upstream to the site of the present Fort Snelling, where it divided. The "River Warren Falls" soon became extinct when it receded to another preglacial valley about three miles up the present Minnesota River. The St. Anthony Falls was born as the falls eroded past a tributary, the forerunner of the present Mississippi River. Similarly, as St. Anthony Falls receded upstream past Minnehaha Creek, Minnehaha Falls began. As St. Anthony Falls continued to erode the soft, crumbly St. Peter Sandstone from under the more resistant Platteville Limestone, the deep gorge was formed in which lies the present St. Anthony Falls Lower Pool.

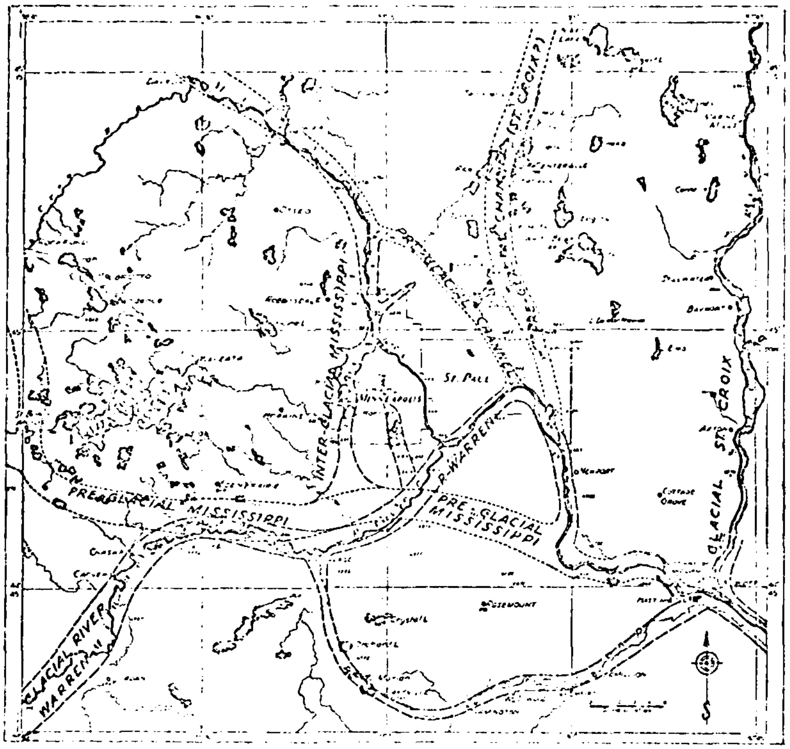


Figure 26. Map Showing Preglacial and Interglacial River Valleys of the Twin Cities Area Schwartz and Thiel, 1963)

These rock formations, are exposed along the river bluffs, such as Father Hennepin Bluffs Park located on the left bank of the Lower Pool. These and deeper rock formations dip about 20 feet/mile toward a low point on the Mississippi River just south of the University of Minnesota, forming Twin City artesian basin (See Figure 22).

Climate

The climate in the upper Mississippi River basin varies from dry sub-humid 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 degrees F. to less than 40 degrees 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 precipitation falls between November and March. This is a generally windy region, with seldom a windless day. Average wind velocities range from 6 to 12 miles per hour with storm winds, especially tornadoes, 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.

The soils in the upper Mississippi River basin 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 are deposited in slow-water reaches, and a few small areas of clayey soils deposited in standing water (See Figure 27). Well-drained sites and northern exposures have lighter soils with less organic material.

The soils along the river bank and on top of the bluffs in the St. Anthony Falls Pools are generally coarse sandy soils of less than 12% slope, ranging from shallow to over 15 feet deep. These soils are characteristically well drained on hills but with a high water table in lower areas. The percolation rate is generally less than 10 minutes per inch. These soils tend to be acid and low in nitrate and potassium.

Figure 27. Soils Map of the Twin Cities Metropolitan Area (Hanson et al., 1967)

Land Use

The land adjacent to the Upper and Lower St. Anthony Pools is one of the earliest areas of settlement in the Twin Cities area. In the early settlement period the Falls represented both a substantial barrier to navigation and a ready source of power for saw and grain mills, and for manufacturing. Hence this land has shown continuous and intensive urban settlement for over 150 years. The consequences of this are reflected in a number of ways. Almost complete obliteration of natural ecosystems, disruption of geologic and topographical features and obliteration of archeological features are among the effects of this long settlement and constant change. This has been and will be a continuing process.

Land in this area is almost completely zoned for industrial and commercial use (Figure 28) with only a few small areas set aside for recreational use (Figures 29 and 30).

Due to its early settlement the St. Anthony Falls district has many historical and cultural associations, but even the existing sites of interest have been integrated into continuing economic use. This is characteristic of land which has been of high monetary value over a long period and where current economic needs and cultural needs must be integrated.

The annual increase in tons of goods shipped by river (see Socioeconomic Section) attests to the continued economic growth in the Upper Mississippi River basin. This growth is concentrated in metropolitan areas as evidenced by housing developments, urban renewal, development of industrial parks, and highway construction (See Figure 28).

About 100 square miles of the 3000 square mile Twin Cities metropolitan area--an area about 10 times downtown Minneapolis is projected to be converted to urban development by 1980. Part of this area may be devoted to highway construction, including freeways such as I-35W, 1-94, I-494 and 1-335.

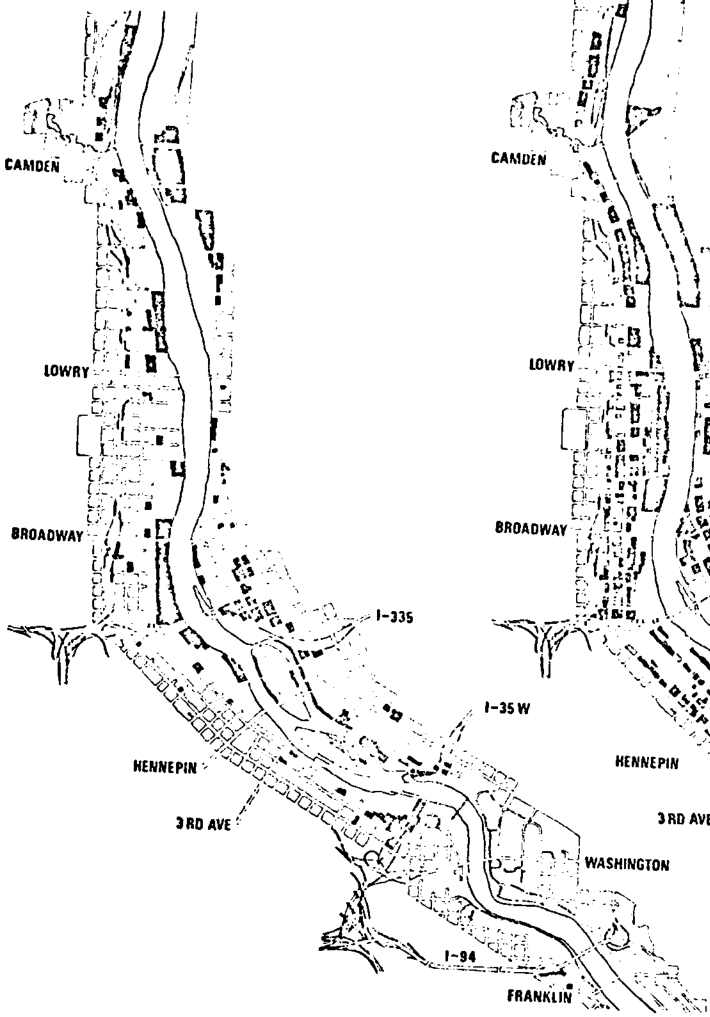


Figure 28. Existing Vacant Land (Minneapolis Planning and Development, 1972)

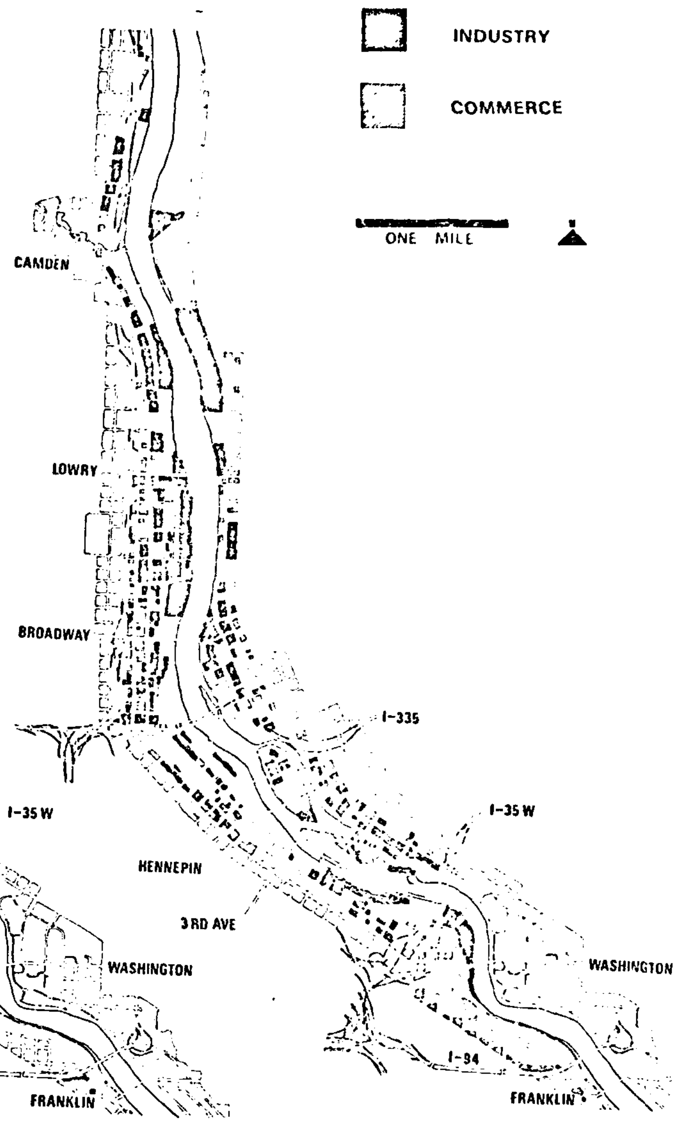


Figure 29. Existing Industrial and Commercial Land Use (Minneapolis Planning and Development, 1972)

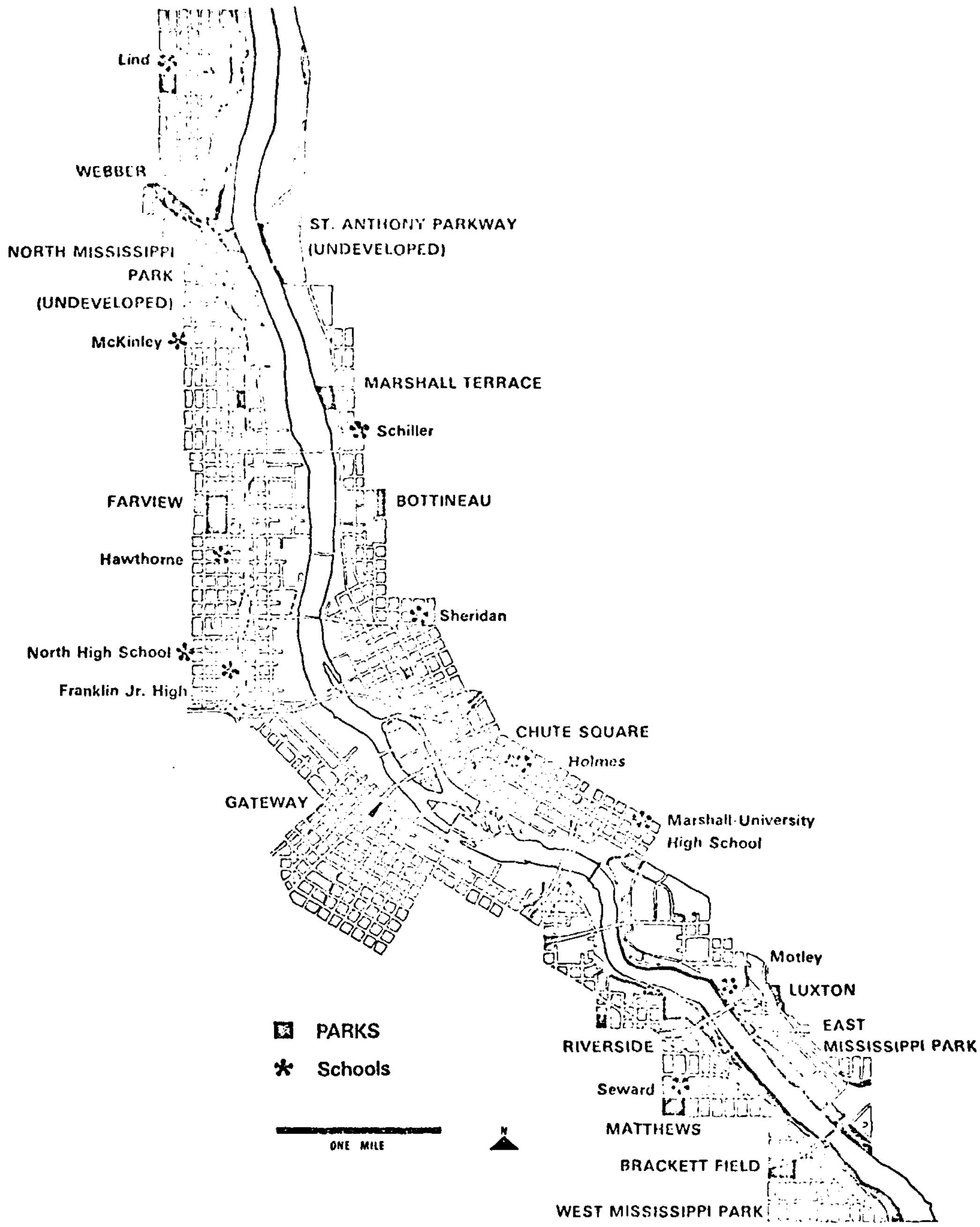


Figure 30. Parks and Schools
(Minneapolis Planning and Development, 1973)

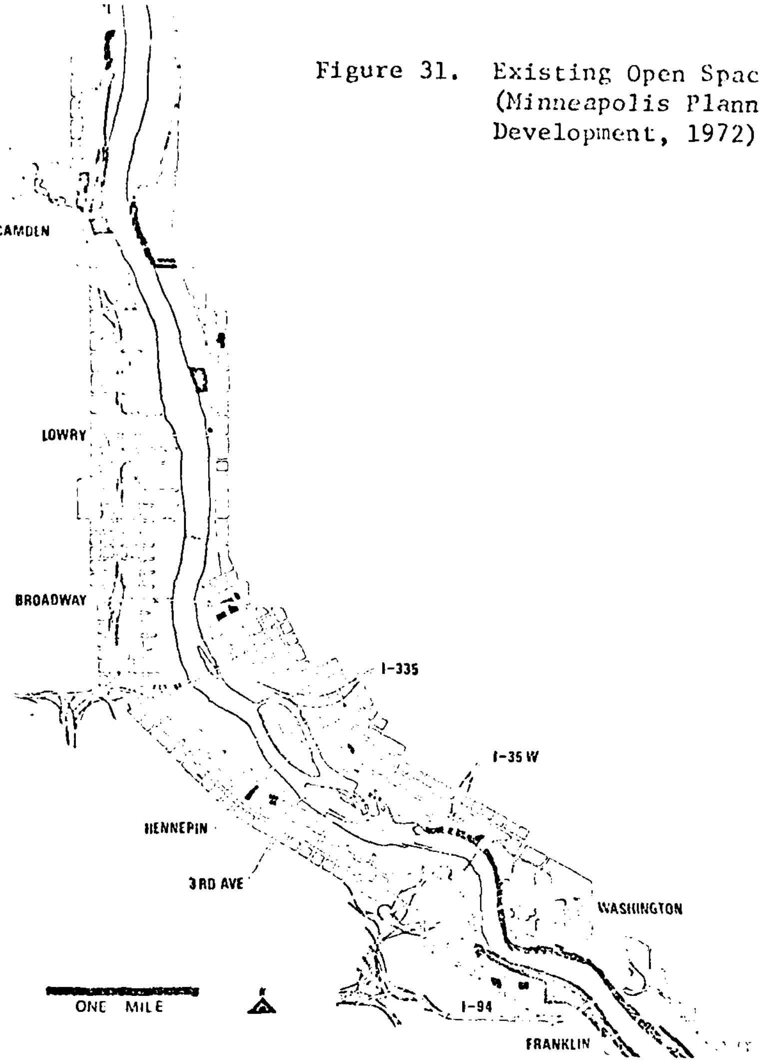


Figure 31. Existing Open Space Land Use (Minneapolis Planning and Development, 1972)

In light of this growth, the Metropolitan Council has adopted a Parks and Open Spaces Program to guide municipalities in preserving undeveloped areas (Figures 29 and 31) for aesthetic, recreational, historical and productive uses. Examples of such sites include floodplains, wetlands, shorelines, steep slopes, aquifer recharge areas and wooded sites.

Evidence of this need was indicated in 1967 when it was found that only about 1/10 of the 310 miles of shoreline along the major rivers in the metropolitan area were in public ownership. Also only 42 of the 704 metropolitan lakes were fronted with parks of 15 or more acres, and only 40 lakes had public or commercial beaches.

The Council's program urges completing acquisition of 12 sites for major metropolitan parks and consideration of 22 other sites, as well as the purchase and development of 107 waterside parks for public access to rivers and lakes. 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.

Development of riverbank top and slope is so extensive in the St. Anthony Falls Pools, that little vegetation remains (See Figure 16). A slight fringe does remain in the Nicollet Island area and in the six-acre Father Hennepin Bluffs Park which includes the former Lucy Wilder Morris Park. Thus bare soil is evident nearly the entire length of these pools, and may bring to the Mississippi significant amounts of sediment, nutrients and other pollutants.

Further development of barge terminals is occurring in this pool, partly due to the transfer of the Minneapolis Municipal Terminal from Pool 1. Thus materials entering the St. Anthony Falls Pools will increase with simultaneous decrease in vegetation, wild life and probably recreation.

Future planned development may further crowd out or diminish the natural environment (Minneapolis Planning and Development, 1972). This extensive redevelopment of the bluff tops and river bank includes apartments, towers, shops, marinas and other recreational facilities, as well as new bicycle trails and foot paths.

Groundwater

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

In the Twin Cities and 13 surrounding communities, the Mississippi River supplies the water. There are also a large number of wells in this area which are used mainly for industries and air conditioning. Total groundwater consumption was 200 mgd (million gallons per day) in 1970, estimated to be about 1/4 the total sustainable yield. The Prairie du Chien formation of Jordon Sandstone supplies about 75 percent of this water, while The Mount Simon-Hinckley Sandstones supply another 15 percent. The former aquifer supplies a medium hard water (average 412 ppm, 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 foot) Mt. Simon-Hinckley aquifer.

Potentiometric studies (1970-71) of the water surface in the Prairie du Chien-Jordan aquifer in the Twin Cities indicate two groundwater recharge areas which flow to the St. Anthony Falls Pools (See Figure 32). These include mainly southwestwardly inflow from White Bear Lake and eastward inflow through Lake Minnetonka area.

Hydrology

Runoff in the upper Mississippi River watershed varies from one inch in the westernmost extent to eight inches in the northeast, with four to

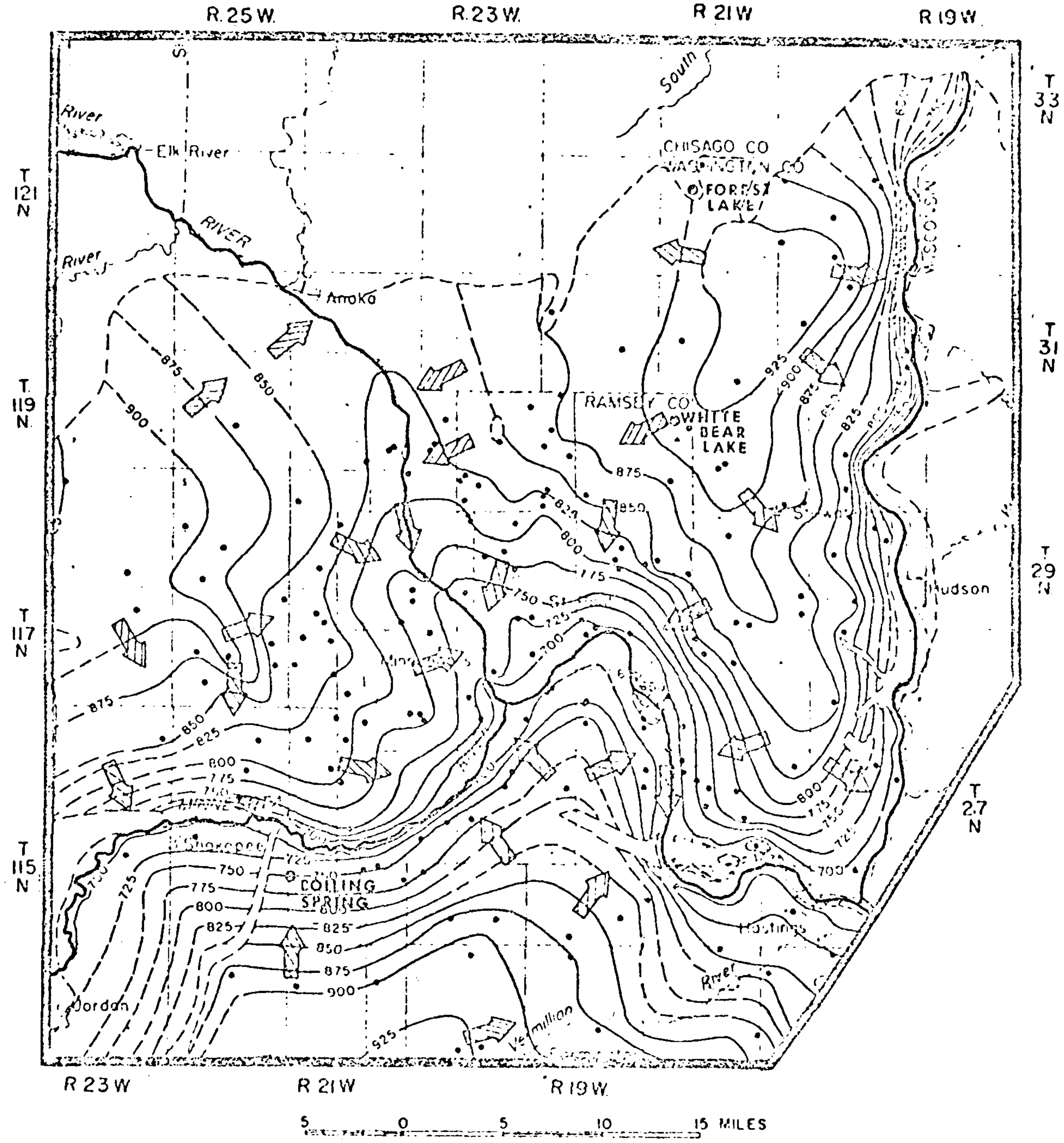


Figure 32. Potentiometric Surface of Water in the Prairie du Chien-Jordan Aquifer in Winter 1970-71, in the Minneapolis-St. Paul Area (Winter and Norvitch, 1972)

five inches in the Metropolitan area. 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.

Average (1907 to 1945) daily discharge of the Mississippi River at St. Anthony Falls is 5,510 cfs. Maximum discharge was 91,000 cfs in 1965 and the minimum was 462 cfs in 1934. The average water velocity in the St. Anthony Falls Pools is about one-half to two mph at normal stage (S.P.D.-NCS, 1969).

Since navigation is not feasible at discharges greater than 40,000 cfs, bridge clearances are based on the river elevation at this stage. The minimum horizontal clearance at this discharge is 121 feet and 21.4 feet vertically at the upper Burlington Northern Railroad Bridge at Mile 854.4 in the Upper Pool, and 56 feet horizontally and 24.4 feet vertically at Burlington Northern Railway's Stone Arch Bridge (Mile 853.7) in the Lower Pool.

Biological Aspects

Terrestrial Vegetation

The native vegetation in the upper Mississippi River watershed 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 33). This transition occurs as a series of mosaics rather than discrete belts, with small islands and peninsulas of vegetation of one type isolated by another. Topography, exposure, soils and man are important factors in this mosaic.

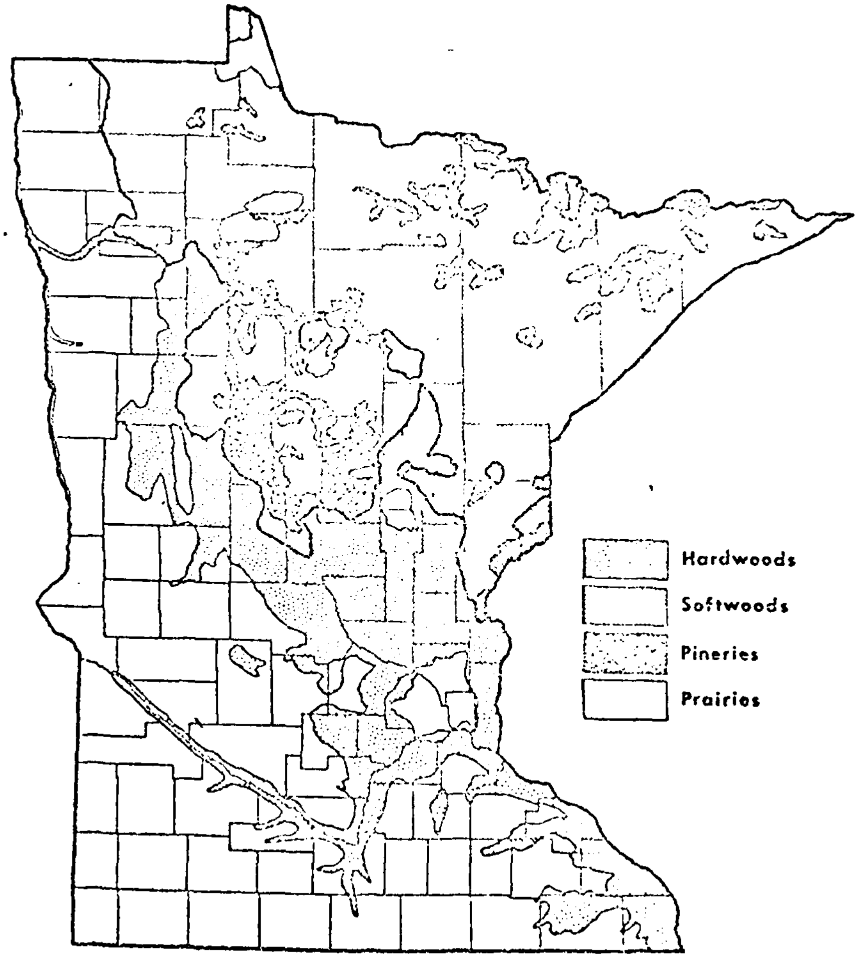


Figure 33. Present Day Forest Cover
(Minnesota Outdoor Recreation Preliminary
Plan, 1965. Minn. Dept. of Conservation)

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, Sherburn, southwest Benton and segments of adjacent counties--there is an island of a drier, less dense deciduous forest. This forest consists of well-spaced small to medium-sized oaks with an abundance of grasses, and is termed a savanna.

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 have 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 flood plain and up the bluff face, shows typical vegetation zones (See Figure 34) The vegetation 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 7). An herb layer of different composition continues under the river bottom forest, which consists of elm, maple, willow, cottonwood, and other trees.

A thin strip of trees, shrubs and herbs line the bluff-slope (See Figure 18). Along much of St. Anthony Falls Upper Pool upstream a three-quarter-mile newly sodded and seeded grass slope occurs along the right bank from the Plymouth Avenue Bridge upstream nearly to the Burlington Northern Railroad Bridge next to the new West River Road. Farther upstream on the right (west) bank and along most of the left (east) bank, little if any vegetation can be found. Vegetation is lacking beyond the top of the riverbank in most places due to their exclusion by industrial sites. The vegetation along the bluff slope begins again in the parks on either bank above the Soo Line Bridge, and continues on upstream.

Nicollet Island has a thicker ring of trees and shrubs around it, for the most part large enough to shield many residential and commercial buildings from recreational and other boaters.

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	Bitternut hickory	White oak	Little bluestem
Reed-canary-grass	Sedges	Green ash	Hackberry	White pine	Nodding grama
Rice cutgrass	Milkweed	Cottonwood	Ironwood	Sugar maple	Northern dropseed
River sedge	Aster	Silver maple	Bur oak	Paper birch	Hairy grama
Jewelweed	Blue-joint grass	Slippery elm	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					

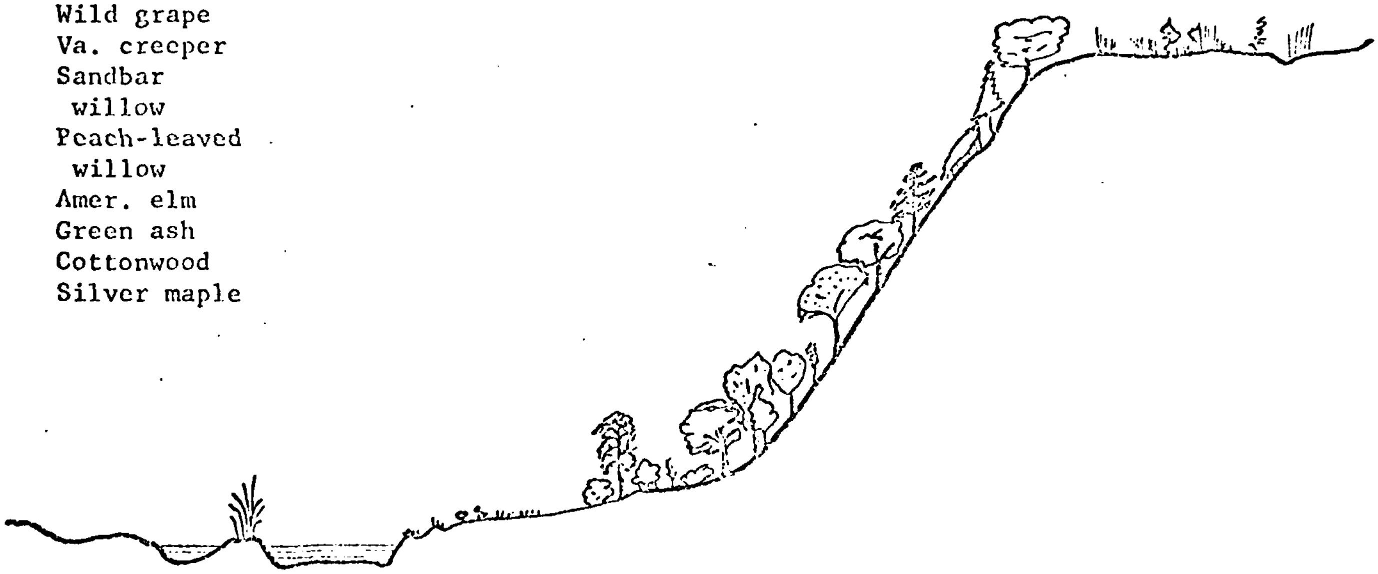


Figure 34. Typical Vegetation Zones Along a Transverse Section from the River to the Blufftop in the Twin Cities Area

Table 7. Vegetation Common to the Habitats of the Upper Mississippi River Valley and Bluff Tops in the Twin Cities Area (from Wallace, McHarg, Roberts and Todd, 1969)

Habitat Type	Occurrence and Species
Mudflats, sandy shores	Rare in the metropolitan area. Often included in the river-bottom category. Varies greatly. Some areas contain smartweeds, wild millet, fall panicum, teal grass and cocklebur.
River-bottom forest	Forests that occur adjacent to the rivers and mainly on floodplains. Woody: elm, ash, cottonwood, box elder, oaks, basswood, maple, willow, aspen, hackberry, with occasional pines and arbor vitae in the pine region; many vines. Herbaceous: some smartweed, wild millet, fall panicum, teal grass, 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.

From Hennepin Avenue downstream along the left bank to the Main Street Power Station a narrow bank-top park with picnic benches is protected by a canopy of cottonwoods, elm and box elder.

Just downstream from the Main Street Power Station is Father Hennepin Bluffs Park, a relatively large (six acres) area of box elder, cottonwood, willow, locust and staghorn sumac. Honeysuckle, wild grape and jewelweed are found as well as other shrubs, vines and herbs.

For this environmental impact study, imaginary sampling lines called 'transects" were selected and surveyed across the river above the head of navigation (UAA at Mile 858.9), halfway down (UBB at Mile 855.7 Figure 36) and 1/4 mile above (UCC at Mile 854.4 Figure 16 and Figures 35A and 35B). Because the Lower Pool is short, only one transect was set up, at the center of the Pool (LBB, Mile 853.4. See Figure 14).

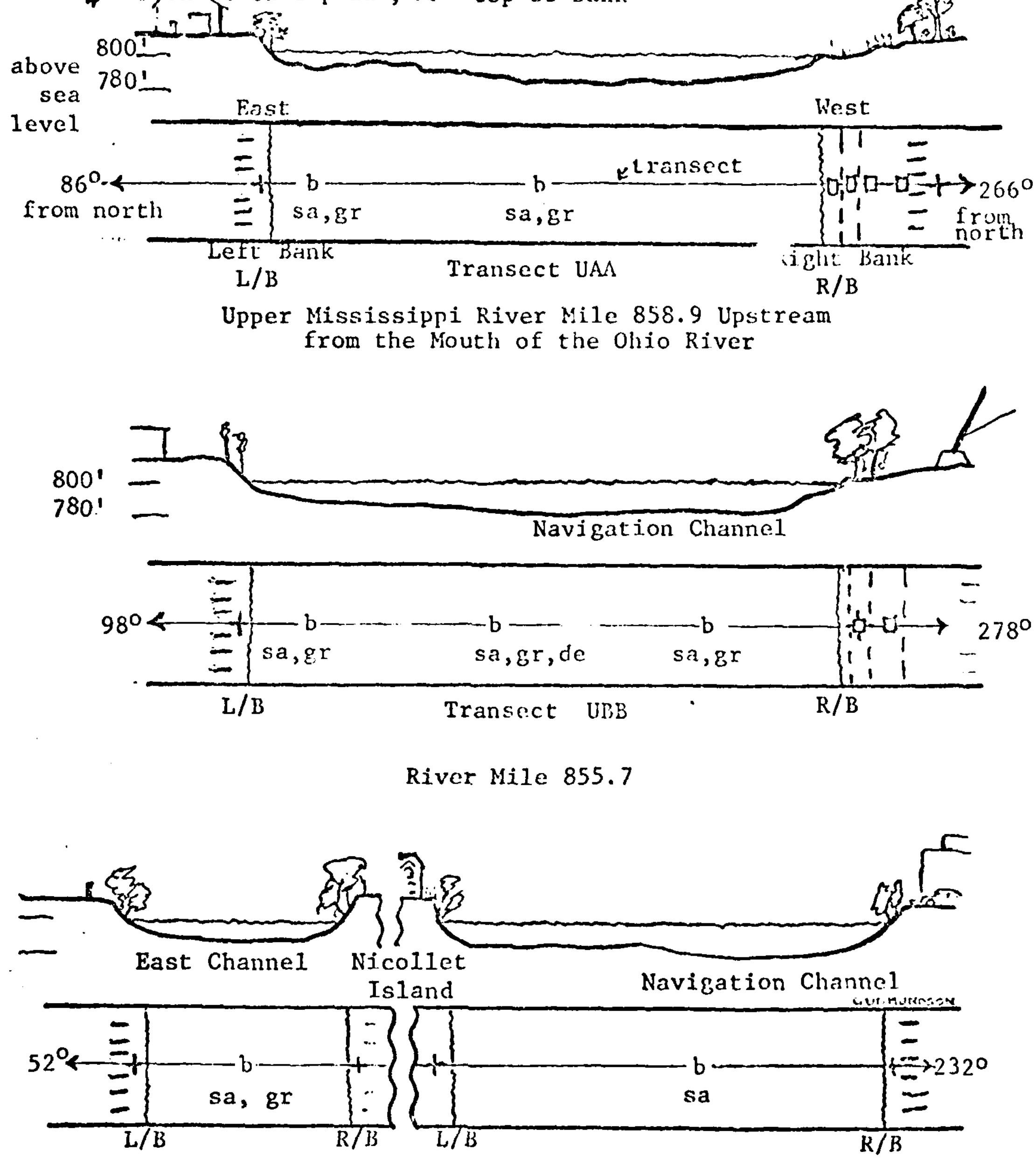
Vegetation along the standard transects in the St. Anthony Falls pools occurs in zones, probably in response to the amount of soil moisture and disturbance. Vegetation sampling stations were usually located in the middle of these zones in order to show these apparent patterns. The steep east (left) bank of the UAA transect is characterized by honeysuckle, slippery elm, pellitory and other herbs. The quadrat had a vegetation cover of only 40%. The broader west (right) bank consists mainly of grasses, smartweed, sweet clover, ragweed, wormwood, and hedgenettle on the lower portions. Above the hill were a line of cottonwoods with numerous seedlings of American elm and box elder, and the herb thoroughwort. Vegetation cover, except for the beach zone, ranged from 70 - 90% (See Tables 8 and 9).

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 10). Also numerous geese, diving and

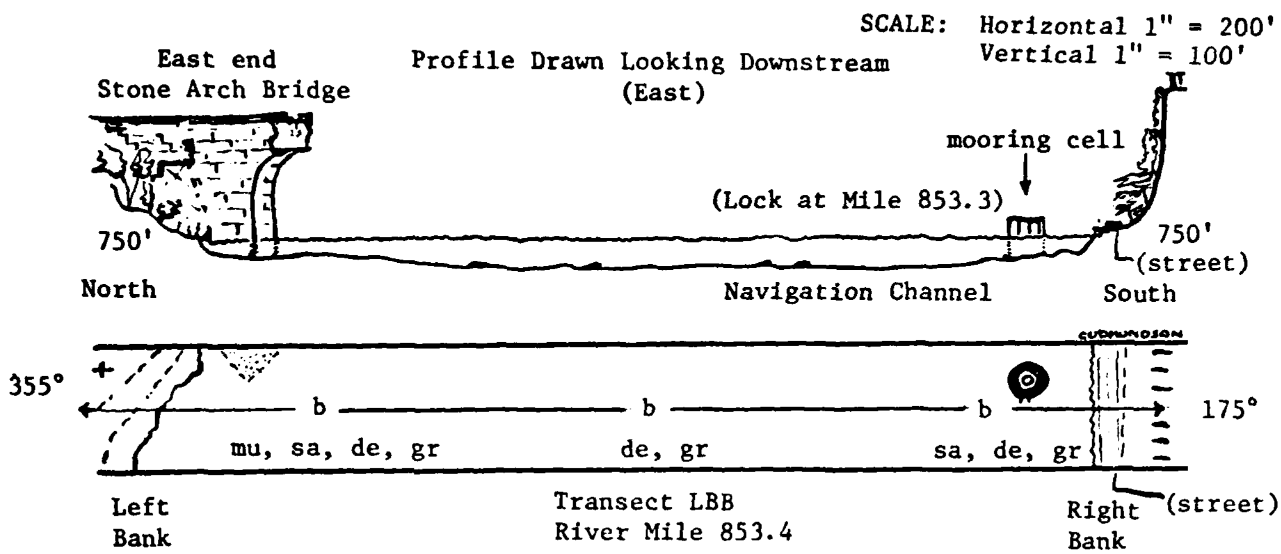
Profiles Drawn Looking Downstream (South)

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



SCALE: Horizontal 1" = 200'
Vertical 1" = 100'

Figure 35A Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in the Upper St. Anthony Falls Pool



Bottom type: mu = mud, sa = sand, de = debris, gr = gravel, rock.
+ = plotless tree sample (point quarter).

Figure 35B Schematic Diagrams of Riverscape Profile, Plant and Animal Sampling Locations, and Bottom Types at the Standard Transect LBB in the Lower St. Anthony Falls Pool

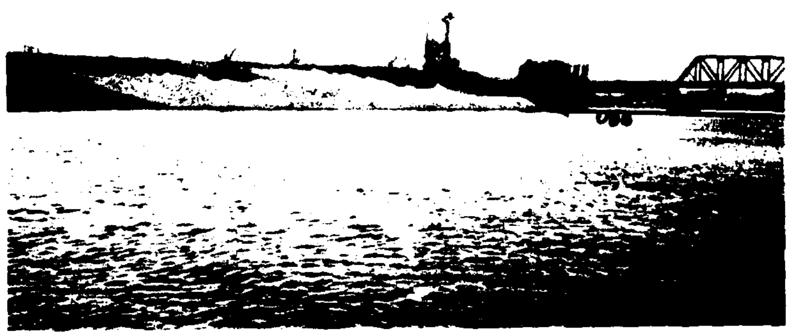


Figure 36. View Upstream of the UBB Transect: West (Right) Bank, St. Anthony Falls Upper Pool (Gudmundson)

Table 8. Plant Abundance on the UAA Transect (at the Minneapolis Water Works, Fridley), St. Anthony Falls Upper Pool, October 1973

Plant Species	L/B 1q	L/B Pt. Qtr.	R/B 1q	R/B 2q	R/B 3q	R/B 4q	R/B Pt. Qtr.
Bare Rock	60%		30%		10%	15%	
Parietaria pensylvanica, Pennsylvania pellitory	30%						
Lonicera tatarica, Tartarian honeysuckle		75%					
Populus, sp.* (seedling), poplar	<1%						
Cruciferae (unidentified), mustard family	<1%						
Labiatae (unidentified), Mint family	<1%						
Scrophulariaceae (unidentified), Figwort family	<1%						
Grasses--Panicum capillare, Eragrostis, and others	<1%		60%	80%	<1%		
Calamagrostis and others					<1%		
Polygonum, sp., smartweed	<1%		1%	15%	<1%		
Plantago major, common plantain	<1%		~1%	1%	20%		
Populus deltoides, cottonwood	1%		1%				100%
Ulmus pumila, dwarf elm	<1%	25%	1%				
Solidago sp., goldenrod	<1%			5%		1%	
Xanthium italicum, Italian cocklebur			1%				
Amaranthaceae (unidentified), Amaranth family			1%				
Salix interior, sandbar willow			1%				
Melilotus alba, white sweet clover				5%			
Lepidium sp., peppergrass				1%			
Antemisia biennis, biennial wormwood				1%	10%		
Eupatorium rugosum, white snakeroot				1%		40%	
Ambrosia artemisiifolia, common ragweed					10%		
Stachys palustris, woundwort, hedge-nettle					10%		
Parthenocissus inserta, woodbine					1%		
Verbenaceae (unidentified), Vervain family					<1%		
Mentha arvensis, peppermint					<1%		
Mentha sp., mint					<1%		
Chenopodium album, lamb's-quarters, pigweed					<1%		
Scutellaria laterifolia, mad-dog skullcap					<1%		
Taraxacum officinale, common dandelion					<1%		
Oxalis dellanii, wood-sorrel					<1%		
Erigeron annuus, daisy fleabane					<1%		
Phleum pratense, timothy grass					<1%		
Setaria viridis, green foxtail					<1%		
Ulmus americana, American elm						25%	
Acer negundo, box elder						20%	

* sp. in place of the species name indicates that it is "some species or other", i.e., that it was not possible to identify the specimen completely.

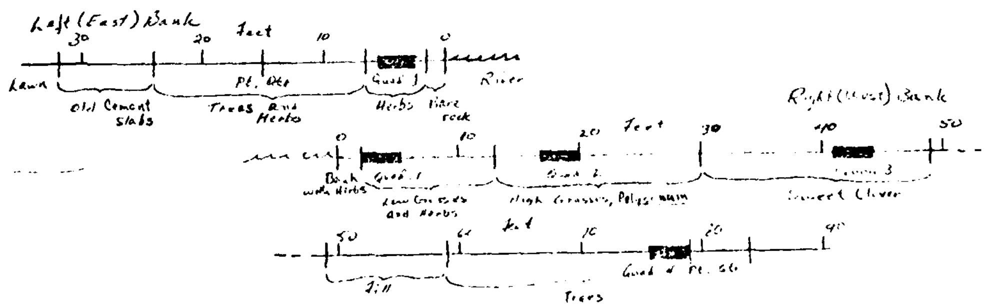


Table 9. Plants present along the LBB transect in St. Anthony Falls Lower Pool, October, 1973.

Taxa		R/B	L/B
Acer negundo	box elder	P	
Fraxinus sp.	ash	P	
Rhus vernix	staghorn sumac	P	
Ulmus sp.	elm	P	
Sambucus sp.	elder	P	
Vitis riparia	river bank grape	P	
Eupatorium rugosum	white snakeroot	P	
Echinochloa sp.	wild millet	P	
Bidens sp.	sticktights	P	
Taraxacum officinale	dandelion	P	
Brassica napus	turnip	P	
Geranium sp.	wild geranium	P	
Xanthium italica	cocklebur	P	P
Solanum sp.	nightshade	P	
Solidago sp.	goldenrod	P	P
Populus deltoides	cottonwood		P
Ulmus rubra	slippery elm		P
Ambrosia artemisiifolia	sagweed		P
Melilotus sp.	sweet clover		P
Euphorbia esula	leafy spurge		P
Parthenocissus inserta	woodbine		P
Nepeta cataria	catnip		P
Ostrya virginiana	hop hornbean		P

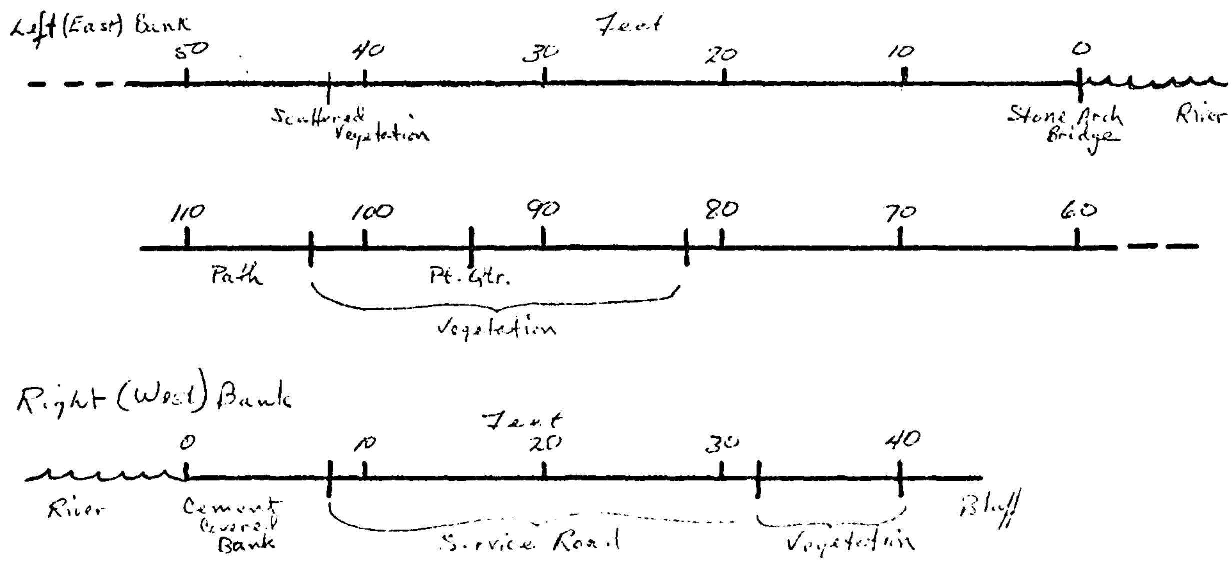


Table 10. Game Animals, Game Birds and Furbearers of the Upper Mississippi River Basin, 1960 (FWS, 1970)

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

[a] Species distribution on range maps.

dabbling ducks and other birds migrate through the watershed, including the Twin Cities area, in Spring and Fall.

More recent data (Wallace et al., 1969) suggests a wider diversity of animals in the Twin Cities area (See Table 11).

Birds which have been reported in the Twin Cities area and their migration schedule is given in Table 6 (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

Table 11. 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.

and fall migrants. Irregularly seen bird species, i.e. single sightings, account for another 85 species.

Bird counts, mainly casual except for herons, egrets and the hawks, showed a preponderance of mallards and wood ducks in the St. Anthony Falls pools compared with the other pools in the Twin Cities area (See Table 12).

These species comprised 90 of the 130 individual bird sightings recorded and include 25 ducklings. Most of these birds were sighted not on the river's main channel but in the east channel around Nicollet Island and in the backwaters downstream from Hennepin Island.

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

Water Quality

Water quality is considered generally good in the Mississippi River downstream nearly to St. Anthony Falls (See Figure 37) especially when compared with the next three downstream pools (FWPCA, 1966). Water use is varied in the Upper Pool, including use by industry, navigation, recreational boating and fishing, and aesthetic enjoyment; the only activity advised against is swimming (whole body contact).

Quality decreases just upstream from the Falls, affecting water usage for consumptive use by humans and the lower animals, and limited body contact (FWPCA, 1966) (Figure 38). Although the dissolved oxygen is high (average of 8 milligrams per liter) bacteria and phytoplankton reach relatively large numbers, some species of the latter sometimes causing taste and odor problems (See Table 13).

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

Bird Species	Flood Plain Lakes		SAF Pools	Pool 1	Pool 2	Minn. R	St. 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
[illegible]			10			7		17
[illegible]	180	176	130	1	47	237	0	771

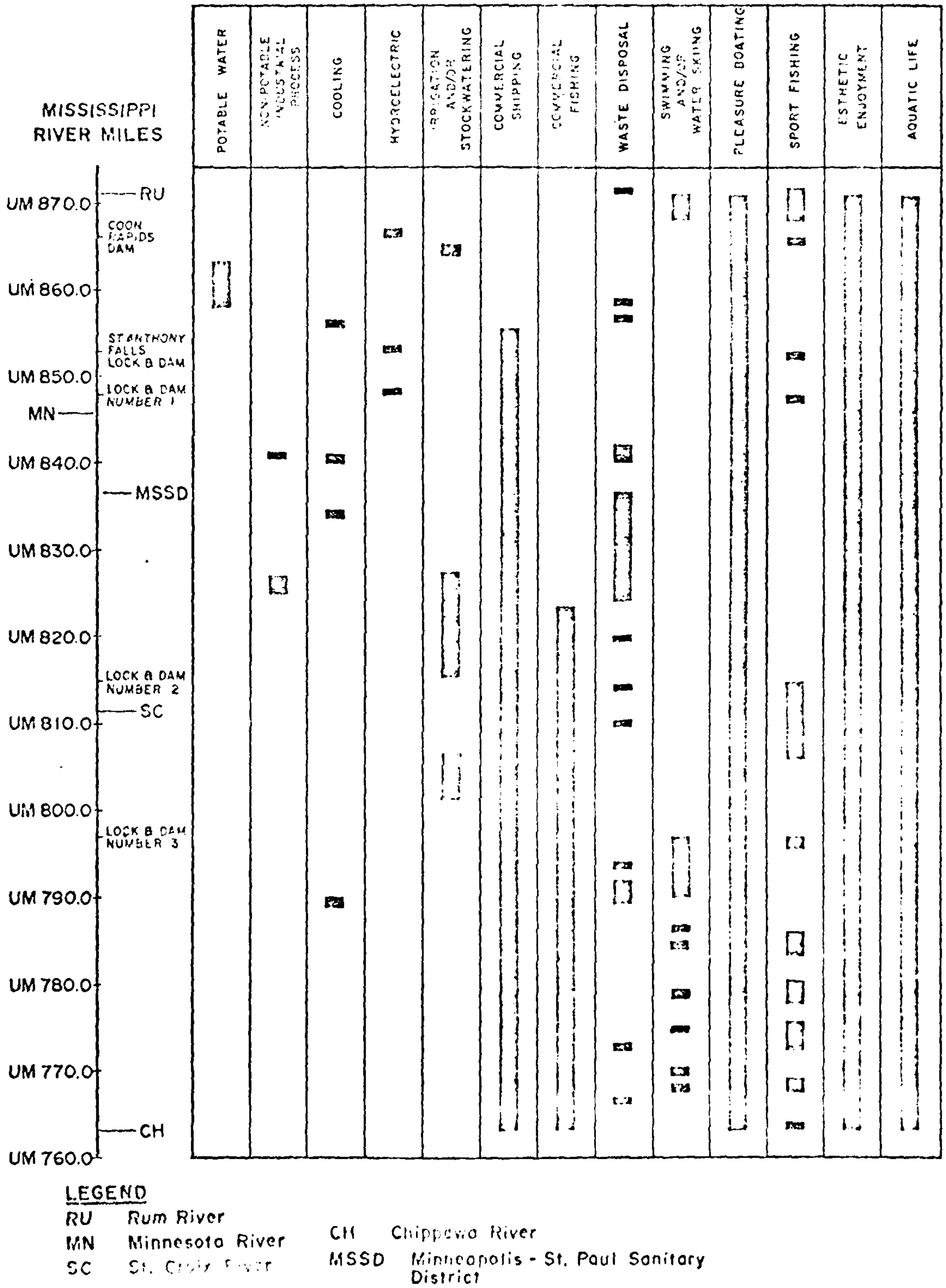


Figure 37. Present Water Uses of the Mississippi River in the Twin Cities Metropolitan Area (FWPCA, 1966)

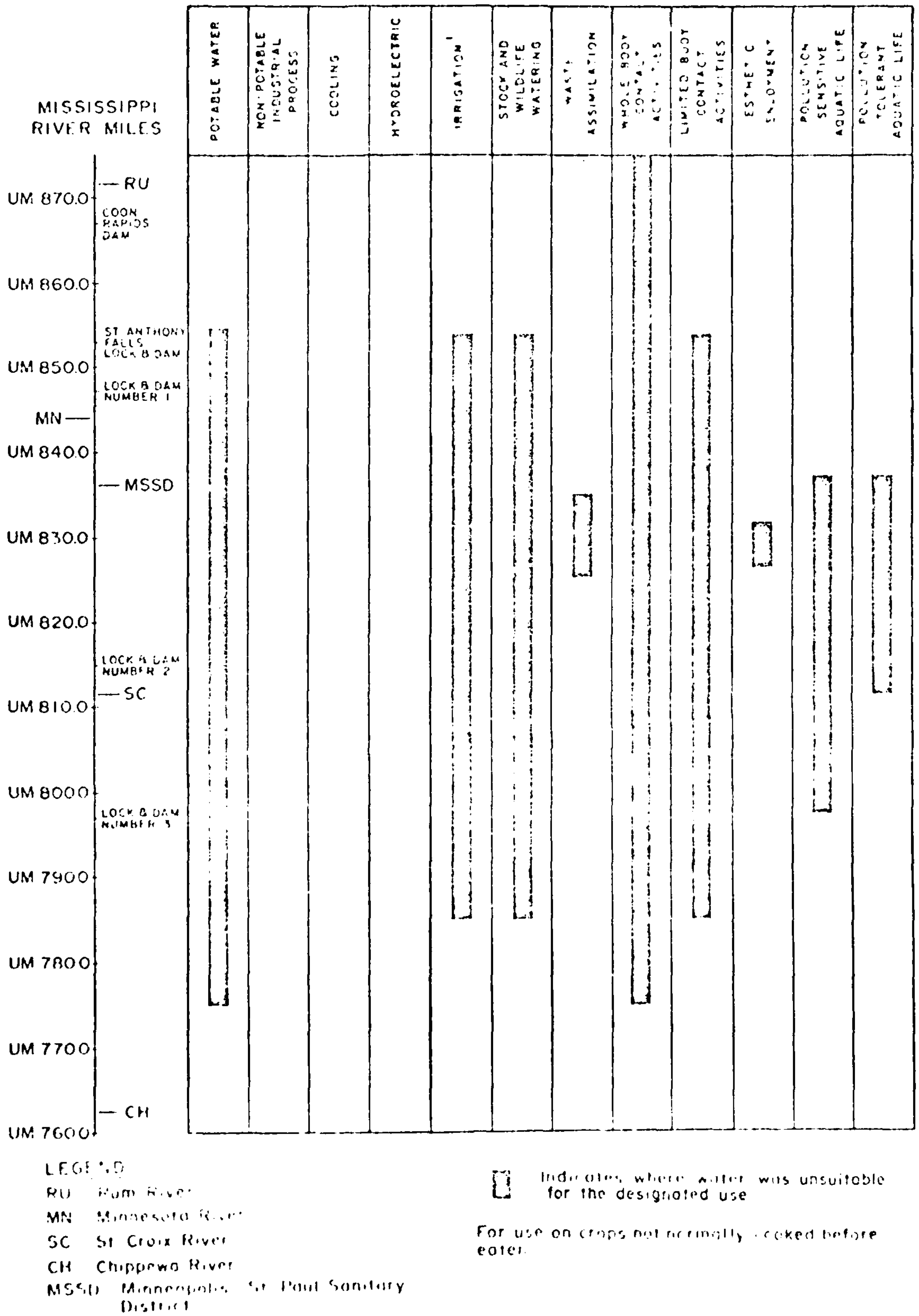


Figure 38. Water Uses Affected by Water Quality in the Mississippi River in the Twin Cities Metropolitan Area (FWPCA, 1966)

	U.S. 52-169 Bridge, Anoka (871.0)	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	PWI 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.					85	1[illegible]5											
NH_3-N, ppm					0.3[illegible]												
Turbidity, JTU (av.)					<25	6[illegible]		———	———	55	———	———	———	———			
Temperature, °F. (max.)					83.3	8[illegible]	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			
Bacteria 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	127000		1,600					
Game fish, %					50					——— 6	———	———		——— 9 ———			

Table 13. Water Quality in the Mississippi River in the Twin Cities Metropolitan Area (FWPCA, 1966; Hokanson, 1968)

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 this October (1973) also occurred in 1968 but not 1967.

There are also sometimes considerable differences both in magnitude and time of occurrence between the Riverside and Shiely stations due to 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 2 - 4 fold (Table 3,Appendix A, IV).

These data,plus continuing efforts to improve water quality, illustrate the weakness 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 non-continuous measurements.

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 due to the turbulance 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.

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.

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 14). No vegetation is known to occur in the main channel.

Such habitats are absent in these pools due to extensive development in the Upper Pool and inundation of the former floodplain.

Table 14. 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.

Aquatic Animals

More than 120 species of fish are found in the Upper Mississippi River Basin, 48 of which have been found in Pool 2, but only 16 species recorded from Coon Rapids (See Table 15). Since water quality is lower in the downstream pools, this apparent trend in fish diversity probably reflects both increased sampling effort as well as the greater number of backwaters with higher quality water and habitats compared with the Coon Rapids reach.

The St. Anthony Falls Pools have a diversity similar probably to that of Coon Rapids on the basis of similarity in water quality and lack of backwaters. The fish population at St. Anthony Falls contains 28% game fish (FWPCA, 1966), and sport fishing has been reported, (Cunningham, 1973 and Moen, 1973), with success for nothern pike at Nicollet Island and bass at the foot of Hennepin Island (see Tables 7 and 8, Appendix AIV).

Turtles have been seen sunning themselves on half-submerged logs ("deadheads") in the old mill races at the foot of Hennepin Island. However, aquatic reptiles and amphibians may have a very low population density upstream to the head of navigation because there seems to be little habitat along the straight sterile river margin.

Bottom sediments consist of sand and/or rocks upstream from the St. Anthony Falls; no change has been observed since 1964 (See Figures 39A, 39B and 40).

A dramatic difference in diversity of clam populations was found in the 1940's by Dawley (1947). Although she found an abundance of species below St. Anthony Falls, above the Falls there were very few (See Table 16). Changes probably have occurred in this distribution pattern since then with the presences of the Lower and Upper Locks, since they now allow occasional fish bearing attached clam larvae (glochidia larvae) to pass up above the Falls.

Table 15. 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
- ƒ 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
- Skipjack herring *Alosa chrysochloris* (Rafinesque)
- 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
- x xx ✓ Northern pike *Esox lucius* Linnaeus
- Muskellunge *Esox masquinongy* Mitchill

Cyprinidae – minnows and carps
- Stoneroller *Campostoma anomalum* (Rafinesque)
- Southern redbelly dace *Chrosomus erythrogaster* (Rafinesque)
- x xx ✓ Carp *Cyprinus carpio* Linnaeus
- ƒ 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
- xx Golden shiner *Notemigonus crysoleucas* (Mitchill)
- Pallid shiner *Notropis amnis* Hubbs and Greene
- Pugnose shiner *Notropis anogenus* Forbes
- x Emerald shiner *Notropis atherinoides* Rafinesque
- xx River shiner *Notropis blennius* (Girard)
- Ghost shiner *Notropis buchanani* Meek
- Central common shiner *Notropis cornutus chrysocephalus* (Rafinesque)
- x xx Common shiner *Notropis cornutus* (Mitchill)
- xx Bigmouth shiner *Notropis dorsalis* (Agassiz)
- x xx Spottail shiner *Notropis hudsonius* (Clinton)
- Red shiner *Notropis lutrensis* (Baird and Girard)
- Rosyface shiner *Notropis rubellus* (Agassiz)
- Silverband shiner *Notropis shumardi*
- x xx Spotfin shiner *Notropis spilopterus* (Cope)
- xx 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)
- x xx Bluntnose minnow *Pimephales notatus* (Rafinesque)
- x xx Fathead minnow *Pimephales promelas* Rafinesque
- x – Bullhead minnow *Pimephales 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)
- x xx White sucker *Catostomus commersoni* (Lacepede)
- ◌ 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)
- x xx Silver redhorse *Moxostoma anisurum* (Rafinesque)
- Golden redhorse *Moxostoma erythrurum* (Rafinesque)
- x 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
◌ How rare in basin (BSFW - App. A)
ƒ No longer commercially fished (BSFW - App.A)

Table 15. 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)

Anguillidae – 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)

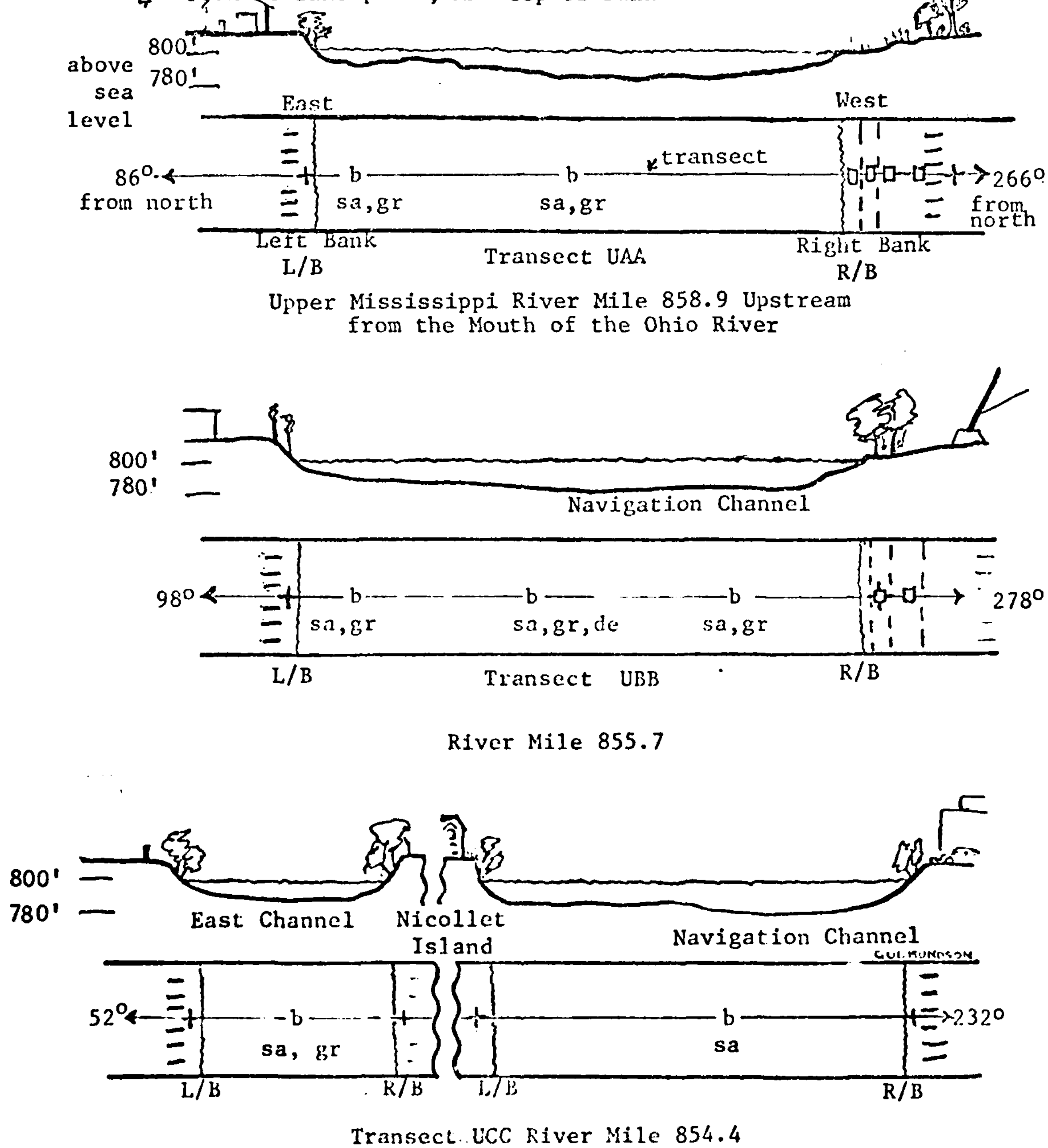
Percidae – perches
- Crystal darter *Ammocrypta asprella* (Jordan)
- Western sand darter *Ammocrypta clara* Jordan and Meek
- Mud darter *Etheostoma asprigene* (Forbes)
- Rainbow darter *Etheostoma caeruleum* Storer
- Bluntnose darter *Etheostoma chlorosomum* (Hay)
- Iowa darter *Etheostoma exile* (Girard)
- 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)

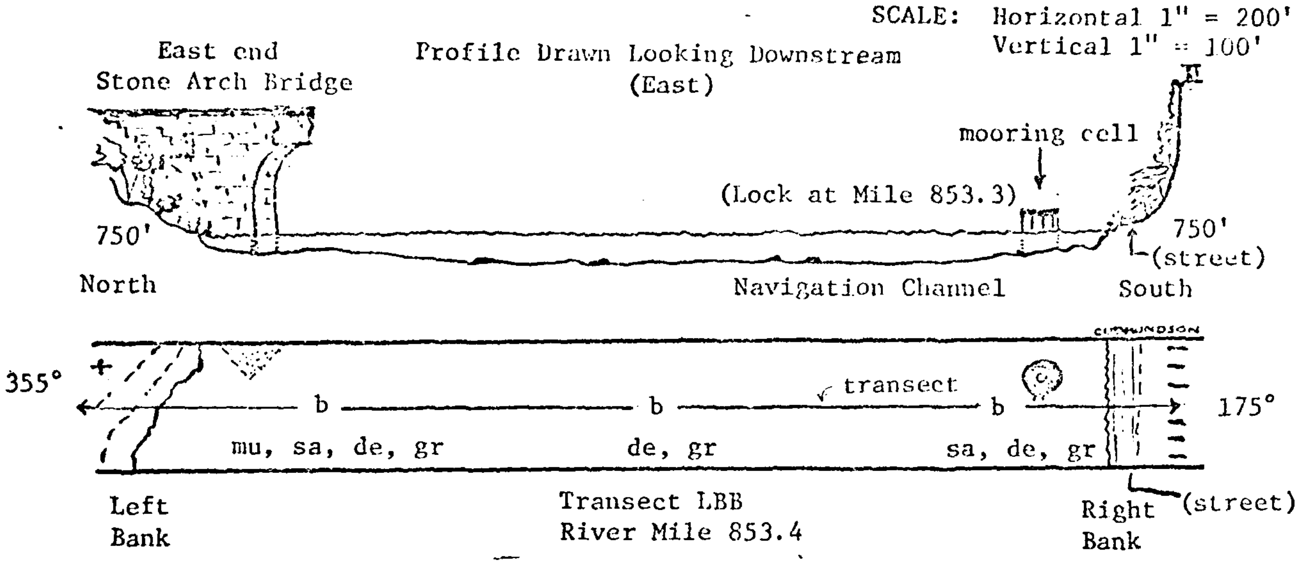
Profiles Drawn Looking Downstream (South)

Bottom type: sa = sand, de = debris, gr = gravel or rocks.
◻ = sample plot (quadrat), + = plotless tree sample (point quarter),
⌖ = both at same point, ☰ = top of bank



SCALE: Horizontal 1" = 200'
Vertical 1" = 100'

Figure 39A. Schematic Diagrams of Riverscape Profiles, Plant and Animal Sampling Locations, and Bottom Types at Each Standard Transect in the Upper St. Anthony Falls Pool



Bottom type: mu = mud, sa = sand, de = debris, gr = gravel, rock.
+ = plotless tree sample (point quarter).

Figure 39B. Schematic Diagrams of Riverscape Profile, Plant and Animal Sampling Locations, and Bottom Types at the Standard Transect LBB in the Lower St. Anthony Falls Pool

Other bottom organisms apparently have been studied only at Coon Rapids and in Spring Lake (Pool 2, Mile 821). Because of their greater similarity to Coon Rapids in their substrate and water quality the St. Anthony Pools' biota is more similar to the Coon Rapids biota than that in Spring Lake (See Table 17). Diversity was greater at Coon Rapids and is probably greater also in the St. Anthony Falls Pools than in Lower Pool 12 (Table 2 Appendix A, IV). However, the dominant family at Coon Rapids was Chironomidae whereas in St. Anthony Falls Pools they are Hydropsychidae and Chironomidae.

Endangered Species

There are seven animal species considered rare or endangered in the Upper Mississippi River Basin (See Table 18). Others such as the pine marten and

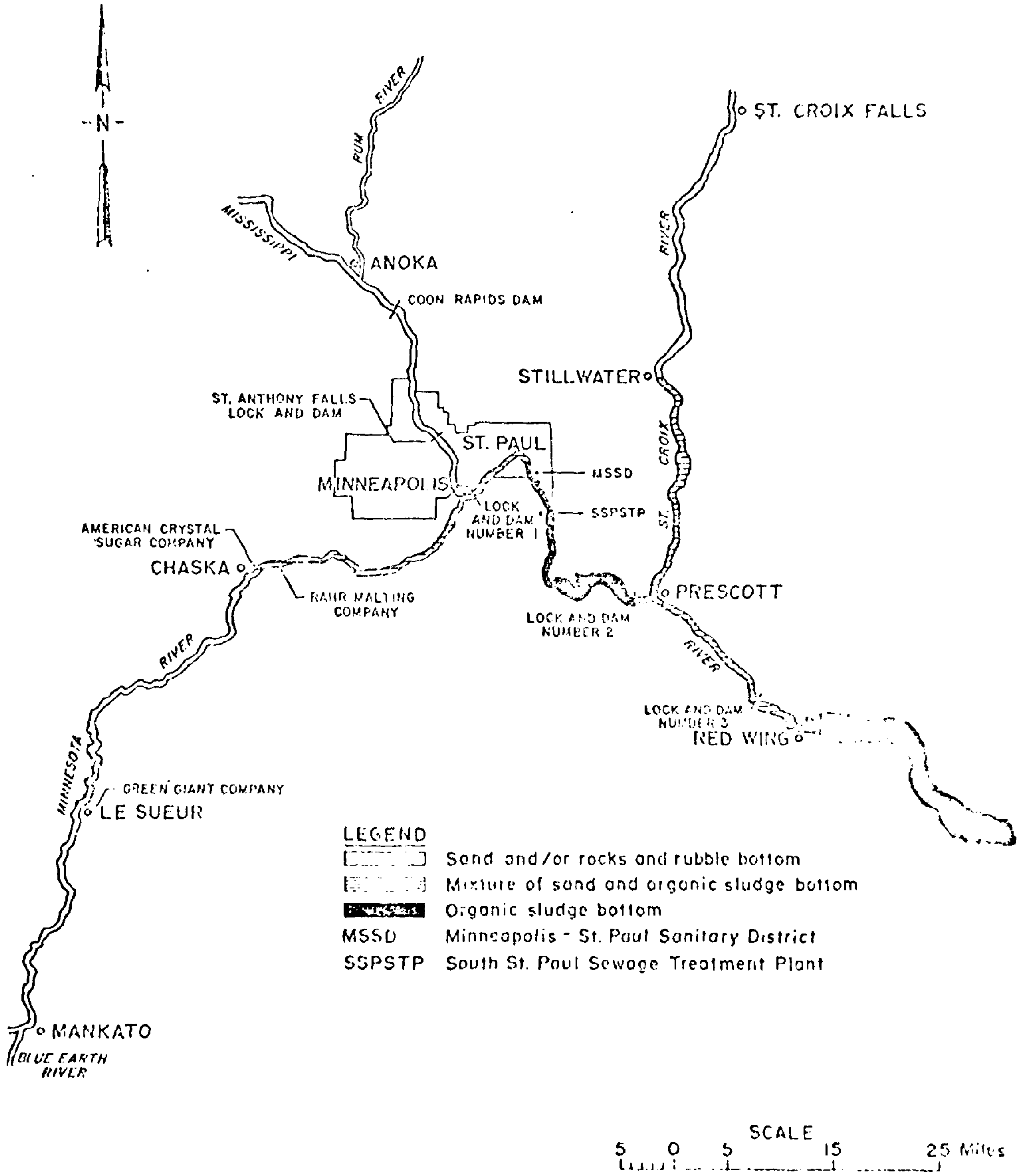


Figure 40. Distribution of Bottom Sediments
(FWPCA, 1966)

Table 16. 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. *Fusconaia flava*			x			
4. *Megalonaias gigantea*	x		x	x		
5. *Amblema peruviana*	x		x	x		
6. *Amblema rariplicata*	x		x	x		
7. *Amblema costata*	x		x			
8. *Quadrula quadrula*	x			x		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		
20. *Lasmigona complanata*	x		x	x	x	x
21. *Anodonta grandis*	x	x	x		x	x
22. *Anodonta marginata*		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		
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					
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		
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
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	
14. *Elliptio crassidens*												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				
19. *Anodonta gigantea*												x				
20. *Anodonta corpulenta*												x	x		x	
21. *Utterbackia imbecillis*										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
29. *Truncilla truncata*											x	x	x		x	
30. *Truncilla donaciformis*												x				
31. *Plagiola 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
40. *Lampsilis higginsi*												x				x

* below Minneapolis
** on Lake Pepin

Table 17. 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

	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
[illegible]ODA						
[illegible]idae	4					2
[illegible]IA	4					

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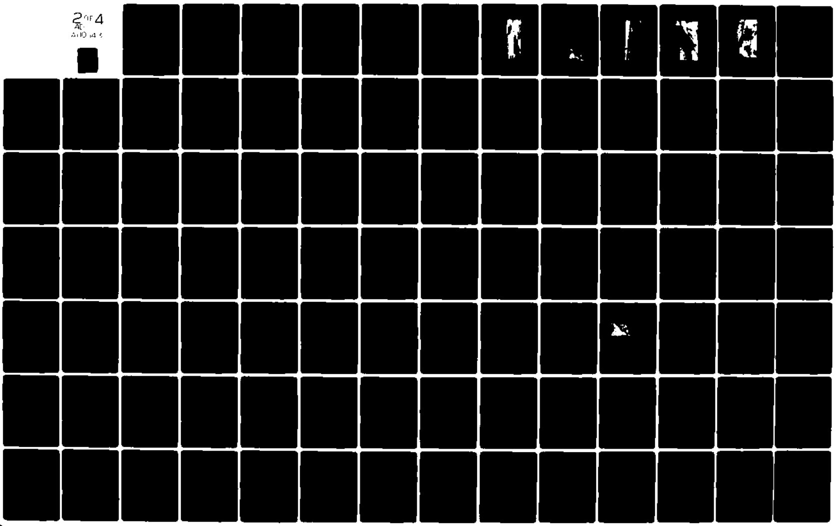

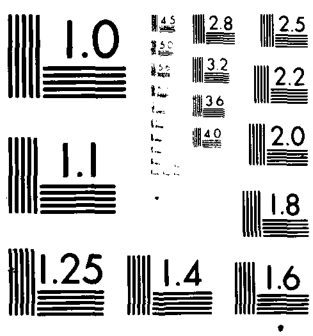

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Table 18. Rare and Endangered Animals of the Upper Mississippi River Basin (FWS, 1970)

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.

fisher, which are threatened with extinction, are making a comeback in Wisconsin and Michigan (BSFW, 1973). No studies exist on their status in these pools; given the degree of urbanization previously outlined it is very doubtful that they may be found in this area.

There are at least several lists of rare and endangered plants in Minnesota. The Minnesota Department of Natural Resources recognizes 10 such species and these are arranged by habitats in Table 19. A somewhat more extensive list distinguished between those species which are rare and endangered in Minnesota and all of North America and those which are legally protected in Minnesota (See Table 20). The latter list is part of a larger one compiled by Dr. T. Morley (Professor of Botany, University of Minnesota), the remaining portions of which include those species in Minnesota which are endangered because they are near the limits of their range, or because they have not been collected frequently.

None of these rare and endangered plant species was observed during this summer's vegetation survey nor are they reported to occur in the St. Anthony Falls Pools.

Another list of rare and endangered species in Minnesota includes reptiles, mammals and birds as well as plants (Table 21). The species are not necessarily threatened on the national level. While both the osprey and the common egret, which are included on the list, have been observed in 1973 in Pool 2 and on the Minnesota River, they have been seen visiting the St. Anthony Falls Pools.

Pre-project Environment

A few old photographs, a map, and several studies suggest the nature of the habitat at St. Anthony Falls Lower Pool prior to the 9-foot channel project.

A view of the Mississippi River downstream from the Upper St. Anthony Falls Dam taken in the 1890's shows a narrow rapid Mississippi River littered with

Table 19. Rare and Endangered Plants of Minnesota (Department of Natural Resources, 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

Table 20. 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.

Table 21. Rare and endangered reptiles, mammals plants, and birds in Minnesota (R. E. Barthelemy, 1971)

Reptiles

Blue tailed Skink

Wood Turtle

Blanding's Turtle

Cricket Frog

Red-backed Salamander

Common Newt

Mammals

Star-nosed Mole

Plants

Lotus americana birdsfoot-trefoil

Mammilaria

Opuntia raffinesquii cactus

Birds

Sprague's Pipit

Baird's Sparrow

Yellow Rail

White Pelican

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

Birds continued

Trumpeter Swan

Bald Eagle

Osprey

Peregrine Falcon

Marsh Hawk

Sandhill Crane

Piping Plover

Wilson's Phalarope

Avocet

Western Willet

Caspian Tern

Great Gray Owl

Hawk Owl

Boreal Chickadee

Chestnut-Collared Longspur

Lark Sparrow

Sharp-tailed Sparrow

Le Conte's Sparrow

Grasshopper Sparrow

Henslow's Sparrow

Yellow-breasted Chat

Prothonotary Warbler

logs of the lumbering industry (Figure 41). The exposed floodplain on the right bank is particularly littered with lumber, shacks and construction. In the foreground is the Stone Arch Bridge and farther downstream the (now absent) 10th Ave. Bridge. Buildings beyond on the right bank indicate approximately the head of the present Pool 1. Note the bare bluff under these buildings and a patch downstream on the left bank, near the present site of the University power plant. In 1895, lumber stacks lined the river bank, and booms and logs clogged the waterway (Figure 42). Also at this time Hall's Island (immediately upstream from Boom Island) consisted of 3 smaller islands, while another island occupied the opposite shore. Boom Island had a slough 2 to 4 feet deep, separating it from shore.

The water surface increased above the Lower St. Anthony Falls Lower Dam by 1926, the litter was gone, but the bluffs on the right bank near the steam were bare of cover (Figure 43). Residential development occured on the floodplain as well as industry, such as the University's power plant (Figure 44). The cement abutment on the left bluff is the Cedar Ave. Bridge under construction.

In contrast the bluffs presently (1973) are better vegetated and the river is of sufficient depth to cover the entire bottom of the valley (Figure 45). Development is extensive along the floodplain and bluff top and bare soil is seen at the Shiely yard on the right bank immediately downstream from the St. Anthony Falls Upper Lock.

An example of the plants and animals in the Twin Cities area prior to the project is available in a study by Leisman (1959). He mapped the vegetation of east Spring Lake from the General Office Survey Map of 1885 (See Figure 46). He also summarized the notes by late Dietrich Lange of the vegetation and animals in Spring Lake in the 1920's and early 1930's.

The early settlement (1855) vegetation in Spring Lake consisted of an elm-maple forest on the bottomlands, surrounding the marsh now covered by

Figure 41. View Downstream in 1890's Just Below Upper St. Anthony Falls Showing the Debris of the Lumbering Era of the Preproject Natural and Socioeconomic Settings. The Stone Arch Bridge is in the Foreground and the (now absent) 10th Avenue Bridge Farther Downstream. Buildings Beyond on Right Bank Indicate the Approximate Head of the Present Pool 1 (Corps of Engineers)

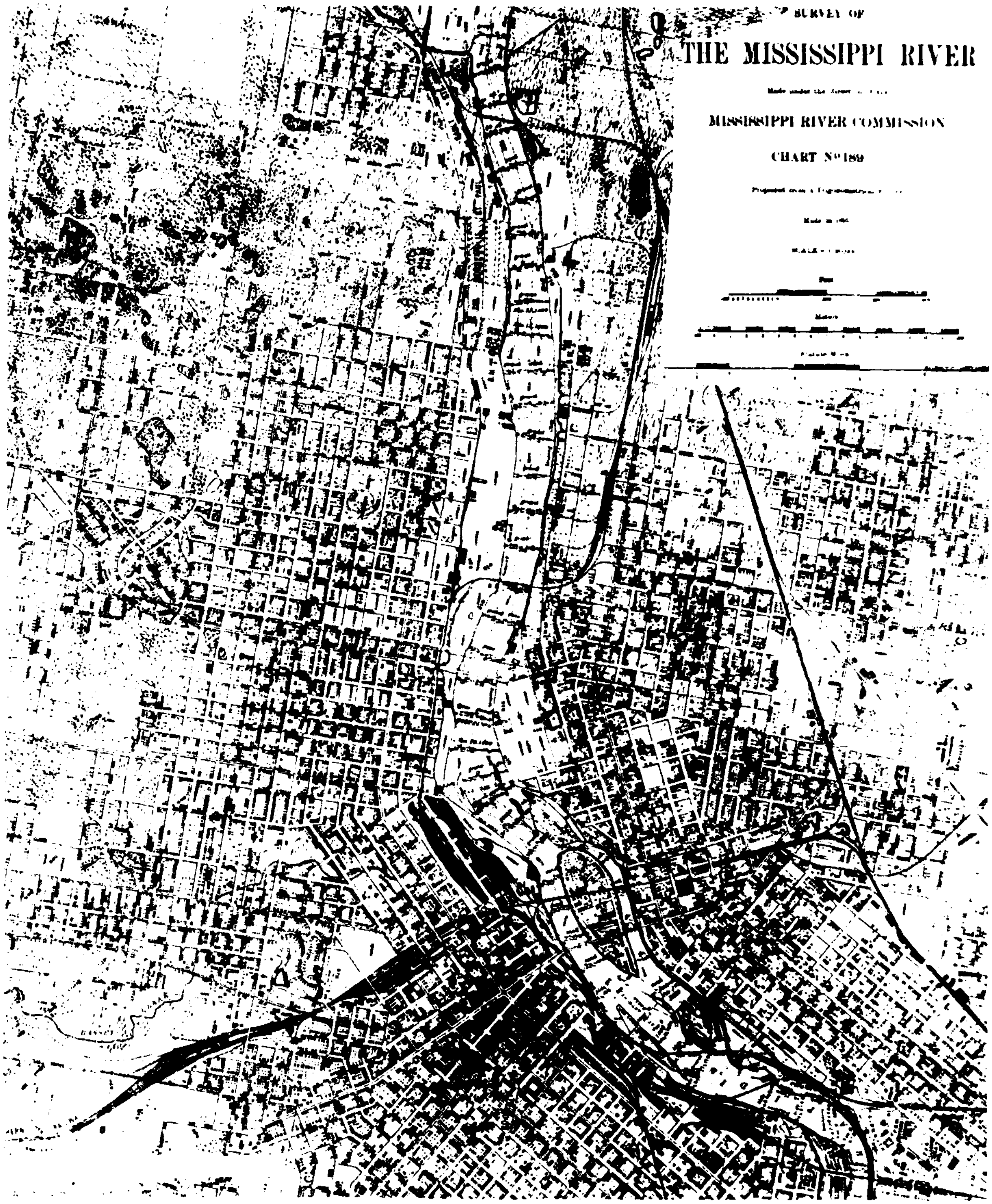

Figure 42. Map of the 1895 Survey of the Mississippi River, Mississippi River Commission, No. 189 (Corps of Engineers)

Figure 43. View Downstream in 1926 from the 10th Avenue Bridge, Showing the Preproject Natural and Socioeconomic Settings at the St. Anthony Falls Lower Dam. Note the Lack of Water at the Railroad Bridge and Naked Bluff, Especially where Steam is Rising. (Courtesy Corps of Engineers)

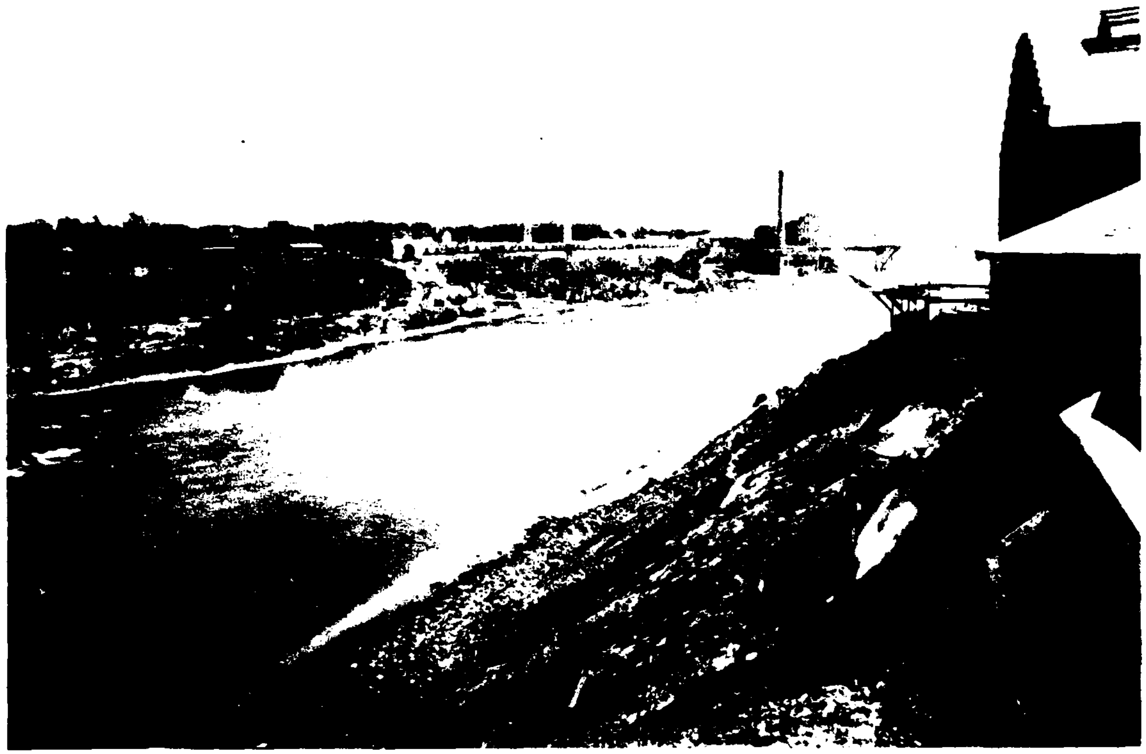

Figure 44. View Downstream in 1926 from Right Bank, where Steam is Rising in Previous Figure, Showing the Preproject Natural and Socioeconomic Setting. Cement Abutment on the Left Bank is the Cedar Avenue Bridge which is Under Construction. Downstream is the University of Minnesota's Power Plant and the (Presently) Burlington Northern Railroad Bridge (Courtesy, Corps of Engineers)

Figure 45. View Downstream in 1973 of St. Anthony Falls. Note Tree-Lined Bluffs Except at Shiely Terminal. Father Hennepin Bluff is on the Left Bank Upstream from the Stone Arch Bridge (Colingsworth)

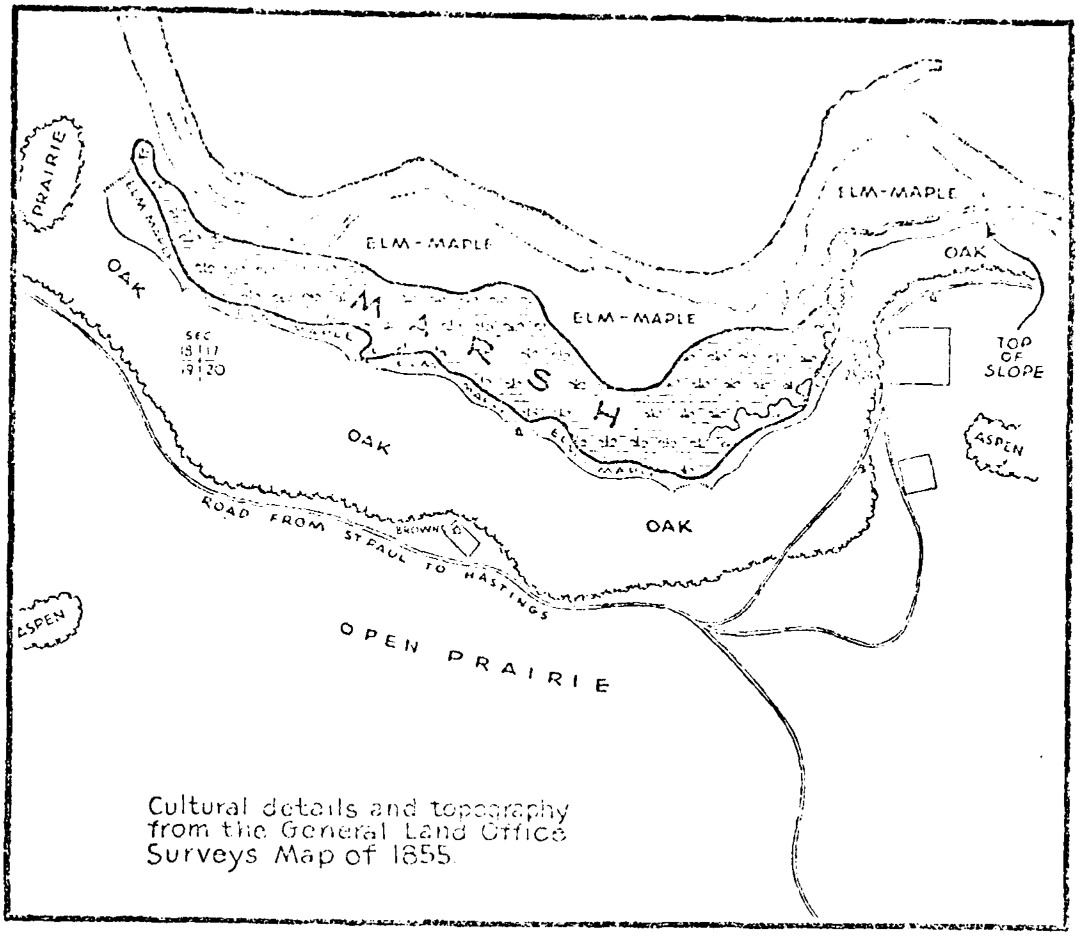

Figure 46. Spring Lake in 1855
(Leisman, 1959)

Spring Lake. Oaks fringed the bluff tops, while open prairie with aspen groves lay beyond. At his 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. The dominant plant of the marsh was the bulrush, Scirpus sp., with many cottonwoods and willows along the margins.
>
> Game fish abounded in the lake, muskrats built their houses throughout the marsh, and countless ducks used the marsh and lake as a stopping point on their annual spring and fall migrations (Leisman, 1959).

Studies made by George (1924) suggest successional stage from willow to cottonwood on a floodplain downstream from Dam 1 (Ford Dam) (See Table 22). This was accompanied by an overall increase in individuals which occured as the flood level increased elevation. A decrease in flood level elevation during the next year may have caused the reduction in individuals.

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 considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial

Table 22. Miss. River floodplain at Ford Plant at Mile 847. (H. George 1924).

Numbers based on 1,000 sq. m. area	Germinations surviving to 1923				Total No. indiv. 1,000 sq. meter 1923
	1920	1921	1922	1923	
Salix longifolia (now *S. interior*)	166	1278	2333	722	4500
S. amygdaloides		55	222		278
Populus deltoides		399	38444	1567	40500
Acer saccharinum			556		556
Ulmus americana		289	944		1853
Total no. trees	166	2612	42499	2289	47667
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 from dredging, 15 ft.

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 nine-foot channel in Section 3 of this report.

Industrial Activity

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

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

Long before the coming of the first white settlers, the Mississippi 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 U. S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

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

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

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps' activities. For example, the following factors 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 due to the construction of locks and dams in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized 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 23 shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

Table 23. River Shipment from 1920 through 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.

Source: Annual Report of the Chief of Engineers, U. S. Army, Part 2 "Commercial Statistics", Table 7, by selected year.

In more recent years, data are available for the St. Paul District. Table 24 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between

Table 24. River Shipment from 1962 through 1971.

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

Minneapolis and the mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

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

Table 25. River Trips in 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

Source: Waterborne Commerce of the United States Calendar Year 1971, Part 2, page 165. Department of the Army, U. S. Corps of Engineers.

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 25 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

The commercial lockages through the locks in the study area are shown in Figure 47 and provide another indication of the recent increase in barge traffic. From 1960 to 1972 the number of lockages in the portion of the River between Lock and Dam 2 and Lock and Dam 10 increased by about 600. The most dramatic increases occurred, however, in the St. Anthony Falls and Pool 1 area:

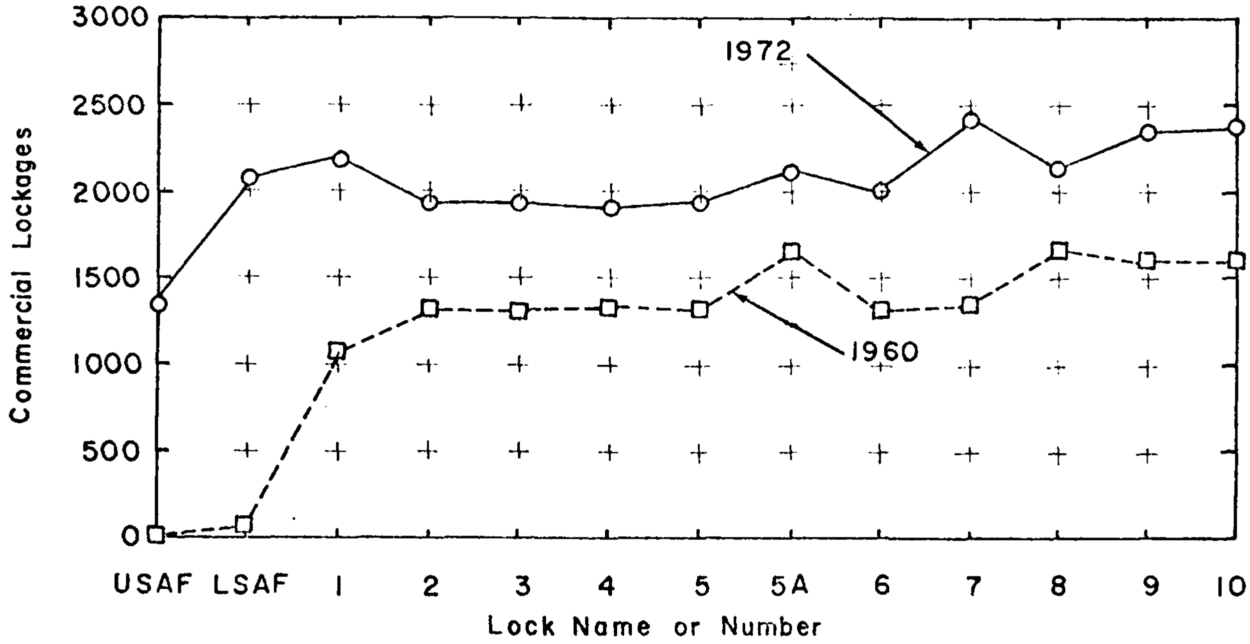

Figure 47. Commercial Lockages in Upper Mississippi River in 1960 and 1972 (S.P.D.-NCS, 1960 and 1972)

Figure 47 shows that commercial lockages through the three locks in this area increased by more than 1000 lockages each during the period, which includes the opening of the Upper St. Anthony Falls Lock and Dam.

The shipping season for most of the Mississippi River within the St. Paul District is usually eight months, from mid-April to mid-December. The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System ranged from 700 to 800 miles. This indicated 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 entire 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. Commercial fishing along the Upper Mississippi developed in the last half of the nineteenth century and during the twentieth century.

Limited data are available on the extent of commercial fishing on the Upper Mississippi prior to 1930. However, data on commercial fishing in the 1960's show that there was no commercial fishing in the St. Anthony Falls Pools (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 1/2-foot channel in 1878--the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul--settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the Upper River were few. Thus, boating was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly, hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

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

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

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river--and virtually all of it for the deeper draft pleasure boats--is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 48 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 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 twelve-year period. The St. Anthony Falls Locks which began operating in 1959 (Lower Lock) and 1963 (Upper Lock) show about the same growth in numbers as most other locks.

A few facilities have developed on the river in the St. Anthony Falls pools mainly to serve the pleasure boaters. Table 26 shows the major existing

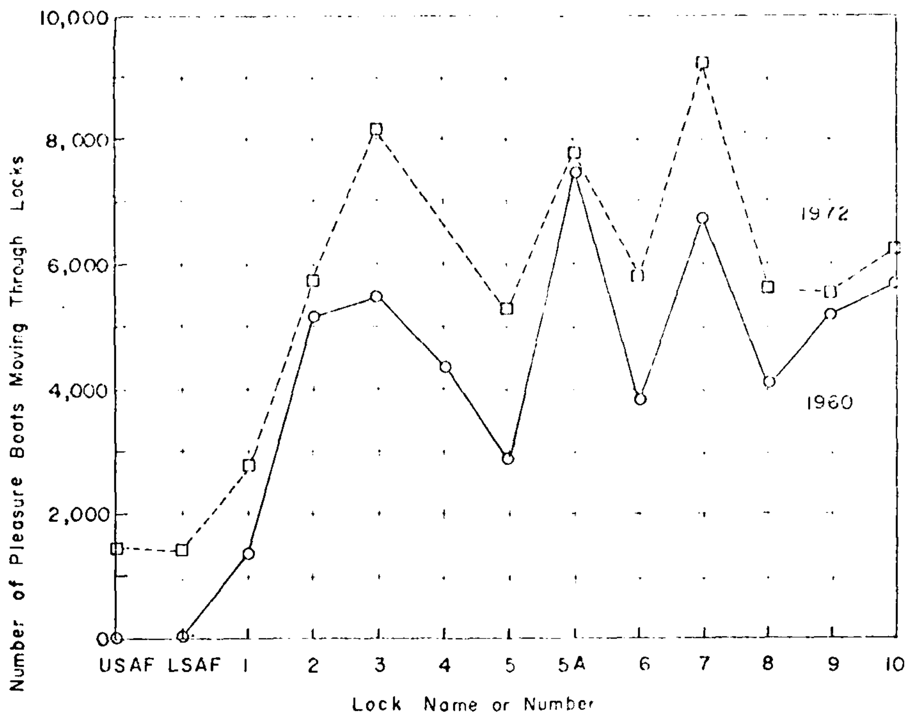

Figure 48. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972 (S.P.D.-NCS, 1960 and 1972)

public use facilities in the St. Anthony Falls pools (S.P.D., September 1972). The lack of access points to the water is apparent. Of the three public use sites shown, only 2 have water access for boaters. The Corps of Engineers neither owns nor operates any recreational facilities in these pools (with the exception of observation platforms at the locks and dams). Two are owned and operated by the Minneapolis Park Board. The St. Anthony Falls Pools are not oriented toward recreational uses. These pools are essentially commercial and industrial with residential, cultural and recreational facilities and use incidental to their major function.

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.

Table 26. Major Existing Public-Use Facilities -- St. Anthony Falls Pools

Site	River		Facilities developed by	Land managed by	Landowner	Boat launching ramp		Parking at ramp		Number of acres	Other facilities or remarks
	Mile	Bank				Number of lanes	Surface	Number of spaces	Surface		
10th Avenue	855.1	L	Minneapolis Park Board	Minneapolis Park Board	City of Minneapolis	5	Black-top	Very limited	Black-top	-	No facilities. Ramp is an extension of 10th Avenue N.E.
Edgewater Inn	856.4	L	Edgewater Inn	Edgewater Inn	Edgewater Inn	-	-	-	-	-	Docking facilities available for approximately four to seven boats. Open to public.
North Mississippi Park	857.8	R	Minneapolis Park Board	Minneapolis Park Board	Minneapolis Park Board	4	Black-top	20	Black-top	20	Picnic facilities available.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 49 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 proportion of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in Figure 49 are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figure shows that in 1970 a small number of sport fishermen were observed in the St. Anthony Pools area. However, this number was small due to the limited access to the pool, the urban-industrial character of the area and the degree of water pollution.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for citizens for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area including one at the Upper St. Anthony Falls Lock and Dam. In addition, a few parks exist along the river that are available for sightseeing and other recreational activities. These parks include Father Hennepin Bluffs Park, North Mississippi Riverfront Park, Marshall Terrace Park, and part of St. Anthony Parkway (undeveloped).

Cultural Considerations

A number of historical and contemporary sites exist in the St. Anthony Falls area. These have been unaffected by Corps' operations, except to the extent that the locks and dams occupy sites that date from the earliest years of Twin Cities settlement. Far greater change in historic, archaeological and cultural sites has occurred through the evolution of urban industrial activity in this area.

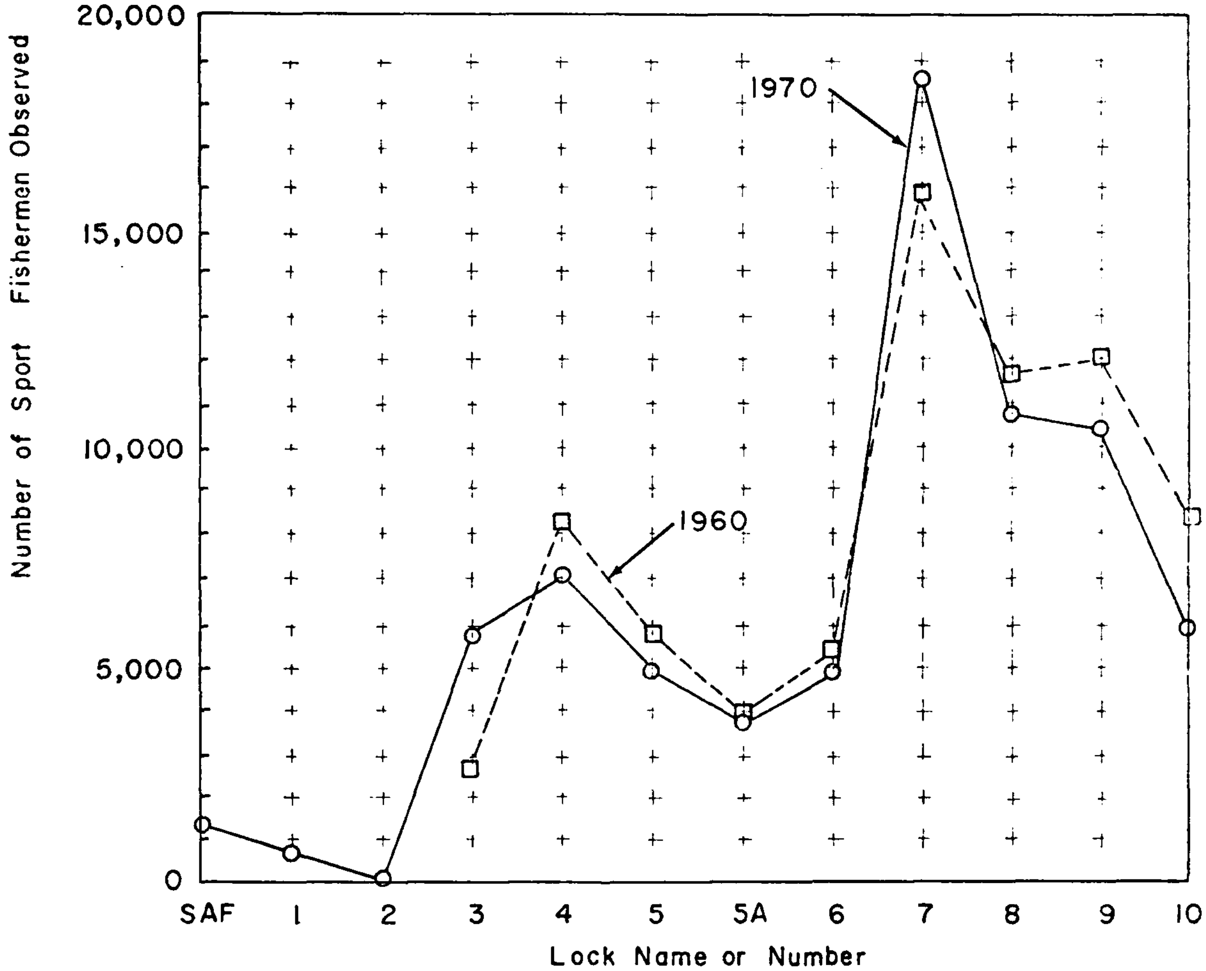

Figure 49. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites on the Upper Mississippi River in 1960 and 1970 (UMRCC, 1962-1971)

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3. THE ENVIRONMENTAL IMPACT OF THE PROJECT

INTRODUCTION

Impacts are understood here to be environmental responses to human activities. This study deals only with those impacts likely to be the result of the Corps of Engineers'nine-foot channel project in St. Anthony Falls Upper and Lower Pools (Mile 857.6 to 853.3) of the Mississippi River.

Because no information appears to exist which describes such impacts in the Upper and Lower Pools, the impacts listed below were derived from:

1. assumptions made from studies made elsewhere on the Mississippi.
2. knowledge of basic ecological and socioeconomic principles and processes, and
3. personal experience of the investigators.

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

The Corps' project which produces these impacts includes (a) the presence of the Lower Lock and Dam at Mile 853.3 and the Upper Lock at 853.7, and (b) the operation of these structures and the maintenance dredging of the nine-foot channel; additional impacts arise from (c) navigation by commercial and private vessels of the river and from their attendant facilities, which is provided for by the locks and the channel. The environmental impacts of this project are the changes in the physical and biological components of natural systems, and the changes in the cultural, economic, archeological and aesthetic components of socioeconomic systems.

NATURAL SYSTEMS

Identification of Impacts

The extension of the nine-foot channel upstream from St. Anthony Falls required the building of the Upper and Lower Lock, the Lower Dam, and dredging to deepen the channel. The primary impacts arising from the project are:

1. Deepening the original channel and annual maintenance dredging and disposal of dredgings.
2. Increased development of the river bank, probably principally from navigation stimulated by the channel.
3. Enlargement of Lower Pool.
4. Turbulence from the Lower Dam.
5. Operation of the locks and access by navigation to harbors along 4.3 miles of the river.

It should be noted that the impacts in the St. Anthony Falls Pools are not completely isolated and ascribable to the Corps' influence because they are part of a complex, multi-dimensional web of physical-chemical, biological and socioeconomic action and reaction characteristic of an urban, densely populated, industrial area. Also some effects derive partially from other economic and cultural activities and from natural environmental processes acting in the local area as well as in the watershed.

The probable relationships of the primary impacts listed above to Corps' operations and maintenance activities, navigation, and to pre-project activities are identified in Tables 27, 28 and 29. From the primary impacts stem the "secondary" and "additional" environmental impacts, which are then traced further, if possible, in the discussion section.

Discussion of Impacts

Taking all Corps' activities in the St. Anthony Pools heretofore into account, and judging from the amount of sediment removed and deposited on the banks (See Figure 13 and Table 3), the dredging activities employed to construct and maintain the nine-foot channel probably have had the greatest effect on the environment. This effect is accentuated greatly by the relative narrowness of the river in this reach.

Table 27. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems in the St. Anthony Falls Upper and Lower Pools.

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
St. Anthony Falls Lower Dam	1. Impoundment of river (Increased flooded area).	1. Flooded exposed riverbed.	1. Increased benthos, fish, recreation, aesthetics (according to preference for rocky or rough water riverscape).
			2. Loss of small amount of floodplain.
		2. Flooded dry land.	1. Decreased floodway area.
			2. Decreased terrestrial habitat; decreased terrestrial upland biota
			3. Increased shallow-water area; increased water-fowl, benthos, fish habitat.
St. Anthony Falls Lower Lock	1. Surges in channel, upstream end of Pool 1.	1. Increase in bank erosion and bottom scouring in Pool 1.	1. Increased sedimentation downstream, subsequent loss of benthos in Pool 1.
	2. Increased velocity of water flowing through dam by lock's restricting flow.	1. Increased aeration.	1. Increased benthos and fish.
	3. Permit passage of fish.	1. Allows passage of other aquatic life, such as clams and aquatic insect larvae.	1. Increase diversity in Lower Upper Pool and downstream.

Table 27. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems in the St. Anthony Falls Upper and Lower Pools (Continued).

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
St. Anthony Falls Upper Lock	1. Surges in channel, upstream end of Lower Pool.	1. Increase in bank erosion and bottom scouring in Lower Pool.	1. Increased sedimentation downstream, subsequent loss of benthos in Lower Pool.
	2. Increased velocity of water flowing through dam by lock's restricting flow.	1. Increased aeration.	
	3. Decrease of aesthetics during daytime hours.		
	4. Increase in aesthetics of river at night (points of light).		
Initial and Maintenance Dredging	1. Increase turbidity.	1. Cover benthos, plants.	1. Reduce biota and its diversity.
		2. Suffocate fish, spawn.	
		3. Reduce water quality.	
	2. Exposes new sterile substrate.	1. Loss of benthos.	1. Decrease diversity; decrease fish, waterfowl, vegetation, decrease wildlife.

Table 27. Probable Impacts of Operating and Maintaining the Nine-Foot Channel Project Upon the Components of Natural Systems in the St. Anthony Falls Upper and Lower Pools (Continued).

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Spoil deposition	1. Loss of terrestrial vegetation; decrease wildlife.	1. Redeposited in channel.	1. Decrease benthos, fish.
	2. Confines channel.	1. Increases water velocity.	1. Decrease river benthos, fish and diversity.
		2. Decrease shallow water area.	1. Decrease river benthos, fish and diversity.
		3. Covers benthos.	1. Decrease fish habitat.
	3. Provide recreational sites.	1. Increased riverside recreation.	
		2. Increased disturbance of fish and wildlife.	1. Decrease aesthetics when deposition repeated often.
Snagging and debris clearance	1. Decrease benthos, turtles, swimming area.	1. Decrease fish.	1. Decrease waterfowl, recreation (fishing, bird watching).
	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 28. Impacts of Commercial Navigation, Barge Terminals and Maintenance Facilities Upon the Components of Natural Systems in the St. Anthony Falls Upper and Lower Pools.

Activity or Structure	Primary Impact	Secondary Impact	Additional Impacts
Navigation	1. Increased turbidity.	1. Decreased aquatic biota	1. Decrease in biotic diversity. 2. Decrease in wildlife and waterfowl.
	2. Increased bank (shore) erosion.	1. Increased turbidity.	1. (See secondary and additional turbidity 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 material.		
	5. Increased aesthetic interest.		
Barge terminal, fleeting area, dry dock	1. Adverse effluents	1. Decreased aquatic biota.	1. Decreased waterfowl.
	2. Loss of terrestrial habitat.	1. Decreased wildlife.	
	3. Increased noise level.	1. Decreased wildlife.	
	4. Adverse aesthetics.		

Table 29. Probable Impacts of Corps Activity and Structures Prior to 1930 Upon Components of the Natural Setting in St. Anthony Falls Upper and Lower Pools.

Project Feature	Primary Impact	Secondary Impact	Additional Impacts
Preservation of the original Falls 1870-78.	1. Preserved from certain disappearance a rare geomorphic feature in a well-populated area.	1. Maintenance of high topographic diversity.	1. Maintenance of biotic diversity.
	2. Increased turbidity.	1. Decreased aquatic biota.	
	3. Maintenance of water level.	1. Increased variety and numbers of aquatic biota.	
	4. Preserved commercial and economic benefits of falls		

Other environmental effects are the increase in area of the Lower Pool and increased elevation in the Upper Pool, the shortening of the effective spilling of the dam by the lock, the turbulence of the dam, navigation and attendant facilities, and operation of the locks.

The Mississippi River is closely contained by banks which are intensively developed along the Upper Pool to the head of navigation. Part of this confinement is due to dredge spoil deposits and it looks similar to the downtown reach in St. Paul. A similarly confined , but larger, river flows between St. Louis and the mouth of the Ohio River. In the future, the fish and wildlife habitat that remains along the Mississippi in the St. Anthony Falls Pools possibly could eventually have a similar stark appearance if channelization by spoil deposits continues. The Mississippi River 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. The concern for the future of wildlife and fish which led to the establishment of the Upper Mississippi River Refuge is still vital today.

Effects of Impoundment

The increase in Lower Pool area due to the new Lower Dam though small presented more wildlife habitat and is aesthetically more pleasing than before. The Lower Dam was built about 800 feet downstream from the old Lower Dam, which was constructed by power interests in 1895. It regulates the pool at the same water level as the old dam in order not to flood the power houses.

Since a relatively small area of dry barren floodway was submerged, the newer dam may have had only a minor effect on the remaining terrestrial environment, although there is little remaining floodplain in this narrow gorge. In return, new river-bottom habitat was formed which may benefit the bottom organisms, fish and waterfowl. Mallard ducks successfully nest in the Lower Pool and are found up to the head of navigation. Turtles are common and some fishing in the Lower Pool.

The spillway length was reduced by the new Lower Lock. The reduced spillway may permit turbulent discharge to continue longer through the year, since the old spillway was dry at times. While the more turbulent discharge may increase scour immediately below and sedimentation further downstream, it oxygenates the water more thoroughly, thus improving the aquatic habitat for bottom organisms, fish and waterfowl.

Construction of the Upper Lock covered Upton Island, joining it completely to the bank, removing terrestrial vegetation and covering a historical site. Further, increase in pool elevation 1.3 to 3.7 feet (using flashboards) submerged riffle areas such as those above the Lowry Avenue Bridge.

Channel Maintenance

The effects of dredging in the St. Anthony Falls Pools apparently has not been studied. Compared with other ongoing Corps' activities in the Upper and Lower Pools, dredging possibly may have the greatest impact upon the natural environment.

Annually an average of over 27,000 cubic yards, or about 6,000 cubic yards per mile, are dredged from the St. Anthony Falls pools. This amount is low to intermediate compared with other pools in the Twin Cities area and the remainder of the St. Paul District as well (See Table 30). However, there is no place to put it at present without further constricting the channel. Although this constricting processes increases hydraulic efficiency-- thus possibly reducing dredging --it also increases flood levels upstream. An additional one million yards was dredged and spoiled along the river banks to create the nine-foot channel in the St. Anthony Falls pools (See Figure 50).

The effects of dredging may spread beyond the site and last longer than only the dredging period. Dredging creates a sterile area of the river bottom and increases turbidity in the river. Turbidity may be harmful to fish and

Table 30. 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	24,442	6,832
Pool 1	125,640	22,042
Minnesota River	13,174	513
Pool 2	179,931	5,553
St. Croix River	40,938	1,671
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	2,149,955	

Average Annual Volume per Pool 153,568

Average Annual Volume per Mile 8,940

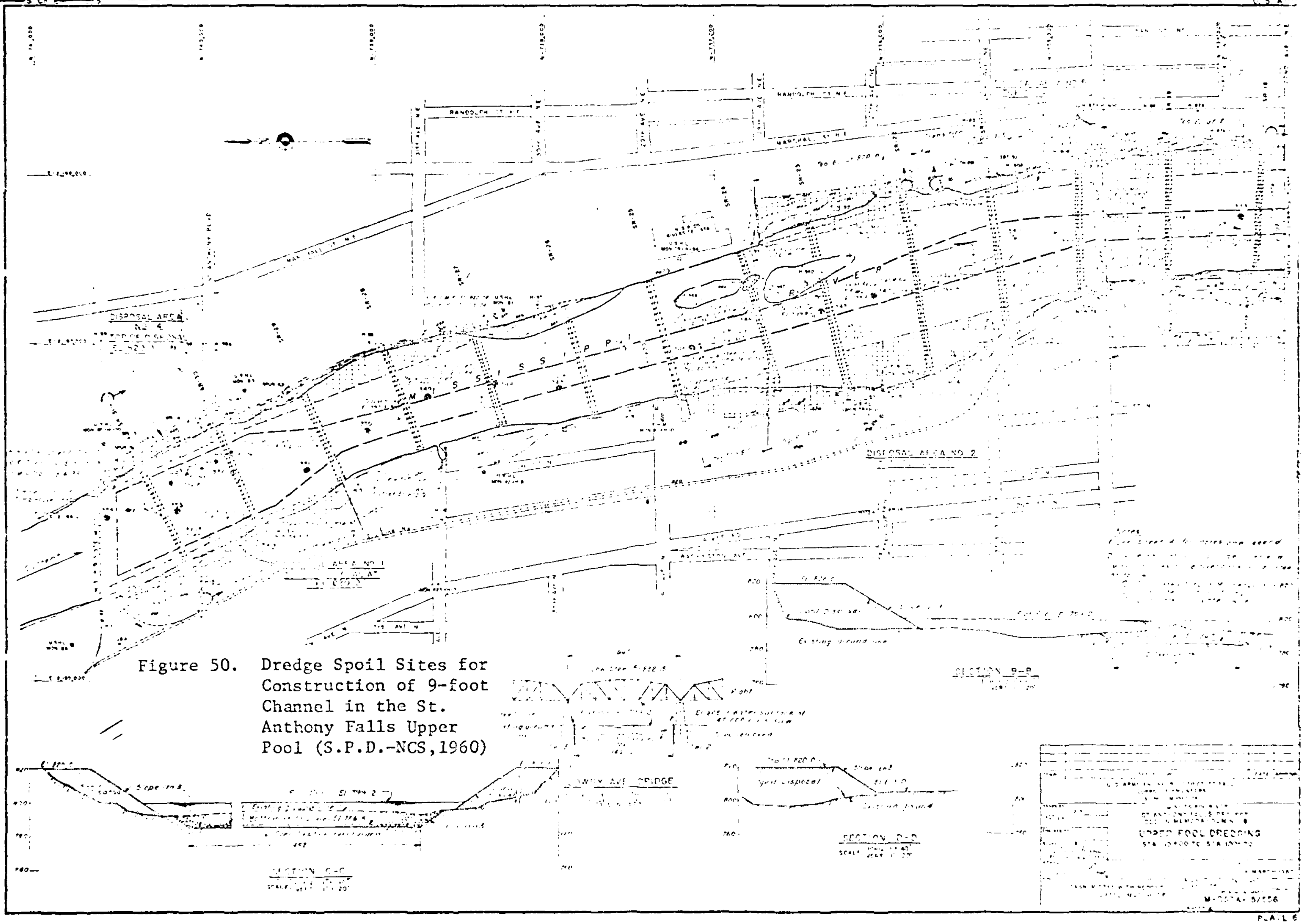

Figure 50. Dredge Spoil Sites for Construction of 9-foot Channel in the St. Anthony Falls Upper Pool (S.P.D.-NCS,1960)

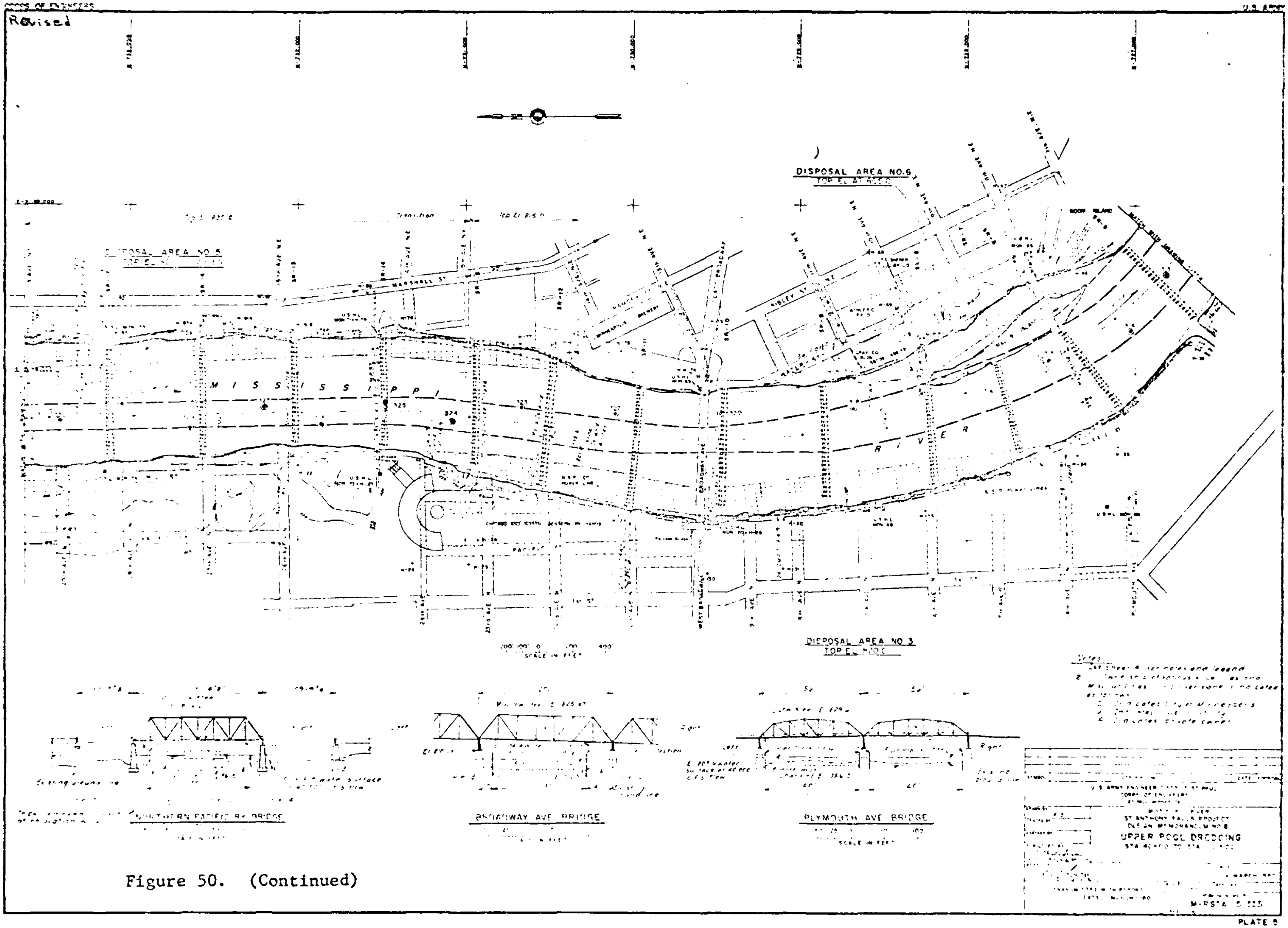

Figure 50. (Continued)

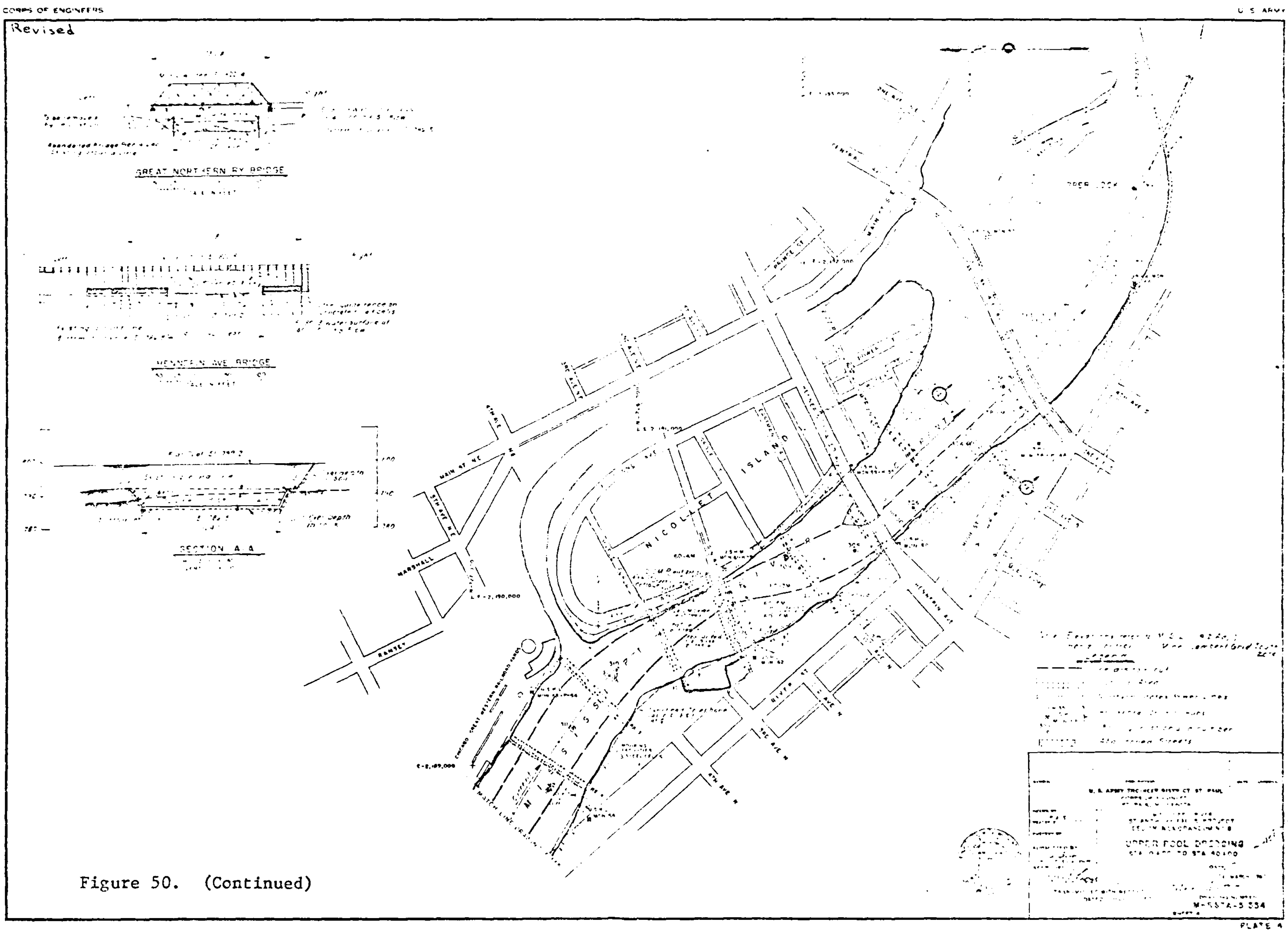

Figure 50. (Continued)

other aquatic animals, as well as possibly reducing the productivity of aquatic plants on which the aquatic animals ultimately depend. A study of the effects of dredging upon water turbidity revealed that a 3-fold increase in turbidity at the surface and at the bottom occurred 100 feet downstream from the clamshell dredge. While the surface turbidity returned to "normal", the turbidity on the bottom was still nearly double the "normal" nearly a mile downstream from the dredge (Figure 51). The amount of increased turbidity and area affected may be less in the St. Anthony Falls Pools, even though the same equipment is used, because sediments in these pools are generally coarser than at the study site in the Minnesota River.

The unstable unconfined spoil banks usually begin eroding as soon as they are deposited, with the resuspended sediments causing increased turbidity and redeposition downstream, possibly smothering bottom organisms and removing fish habitat (and often requiring redredging downstream in the navigation channel).

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

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

Dredged spoil, at least that produced when the channel was created, is deposited along the river bank. It covers existing riverbank and bottom habitat and, by filling a small channel, beside Hall's Island (Mile 854.9-855.1, Figure 50), eliminates this interesting intricacy of the river edge. It also removed Spirit Island in the Lower Pool.

Apparently some of the riverbank is being revegetated. However, most of the land along the top of the banks lacks natural vegetation because it is

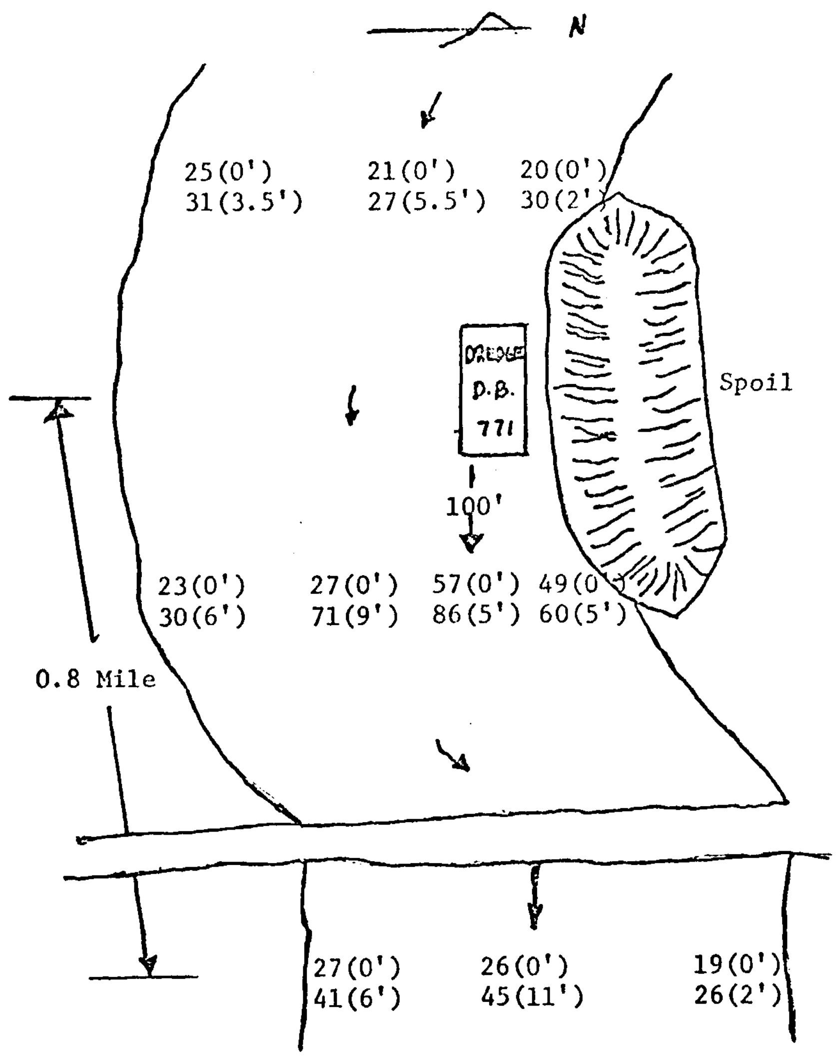

Figure 51. Effect of Clamshell Dredging Upon Turbidity in the Minnesota River, September 25, 1973 Depth in feet in ( ).

occupied by terminals and other businesses (See Figures 16 and 17). Aesthetic appeal of this reach of the river has also been impaired. These non-vegetated sites will erode and deposit more sediment in the river which must then be dredged out again.

Lock and Dam Operation

Lock operations provide a by-pass around the dam to fish and mussels. The 10,000 year old barrier may have resulted in time to the formation of new species, although man's introduction of new individuals such as during fishing may have already reduced this possibility. Attendant surges of water may produce some increase in turbidity and bank erosion.

Although they may retard the migration of fish and mussels, dams provide a good means for aerating the water and thus improving conditions for diverse aquatic life.

Navigation Effects

Commercial navigation, barge terminals and other facilities dependent upon the nine-foot channel, may have adverse environmental effects on the St. Anthony Falls Pools.

The turbidity increases by resuspension of bottom sediments due to propeller turbulence, and by bank erosion due to the energy of the wake by two to three times within 30 seconds after passing. Even 30 minutes after passing the turbidity may be 1 1/2 times that prior to passage of the tow (Figure 52). The amount may be less in magnitude and duration in the St. Anthony Falls Pools because the sediments generally are coarser than the study site in the Minnesota River. Spills and discharges coming from the vessels and barge terminals may be adverse to the environment. The activity of commercial traffic up and down the river provides aesthetic interest to many people, but may also disrupt fish and waterfowl behavior.

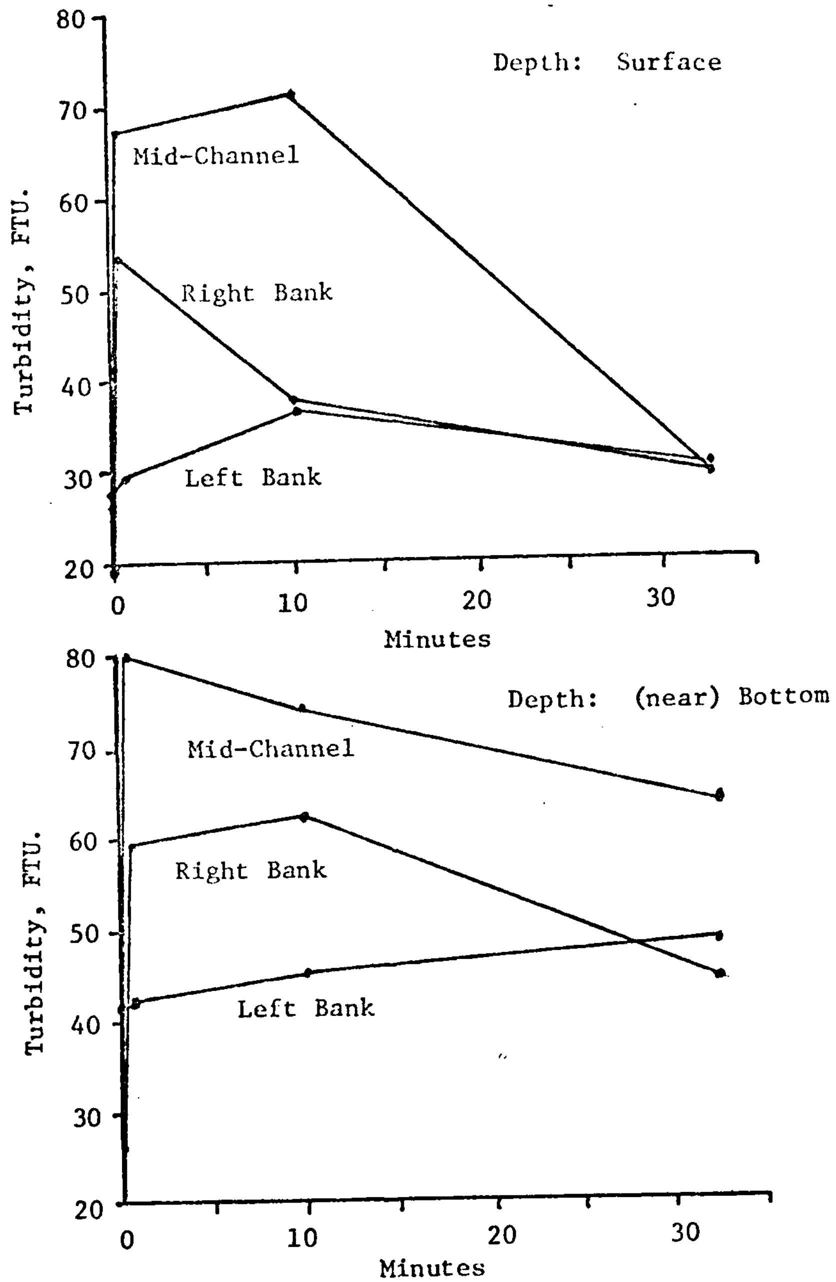

Figure 52. Duration (in minutes) of Increases in Turbidity Due to a Tow Boat on the Minnesota River at Mile 13.3, from the Right Bank to the Left Bank on September 25, 1973.

Pre-Project Effects

The natural gradual erosion upstream (recession) of St. Anthony Falls was accelerated by early construction and tunneling under the Falls. Concern in the 1860's over the continued breaking off of limestone slabs led the Corps of Engineers in the 1870's to strengthen and thus stabilize the position of the Falls at their present location.

If the Falls had been allowed to work its way upstream as little as 300 yards more, the upper end of the Platteville Limestone formation which forms the lip of the Falls would have been reached. Without the Corps-built seepage wall, built to reinforce the upstream end of the limestone, the Falls would quickly have lowered, forming rapids in its place and upstream, and so forming a smoother transition from upstream elevations to those at the foot of the Falls. Weathering and erosive processes would then have eventually extended the deep gorge from Pools 1 and Lower St. Anthony Falls upstream to the tail-waters of the next dam or firm bedrock upstream.

So the Corps' early action preserved not only the natural and distinctively aesthetic qualities of the Falls, but its steep energy gradient for power production and its natural impoundment for navigation. Some loss of flowing river and terrestrial habitat resulted, mainly by the presence of the dam, and by the stimulation of urban development.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivisions of socioeconomic systems for the Pools at St. Anthony Falls are identified below and then discussed in detail.

Identification of Impacts

The impacts on the socioeconomic systems related to the Upper Mississippi River as a whole divide into the industrial, recreational and cultural effects.

Industrial Impacts

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 these plants and indirect employment in firms --
      (1) providing goods or services as inputs to the barge-oriented plants, or
      (2) using the outputs of these plants or raw materials for their own operations
   c. A decline in the quality and increased turbidity of water in some portions of the Upper Mississippi River due to --
      (1) effluents produced by barge-oriented plants, and
      (2) turbidity caused mainly by towboat movement
2. Additional employment due to the operation of the Locks and Dams.
3. Decline in recreational opportunities on and alongside the River due to:
   a. Increase in barge activity in pools and locks
   b. Loss of potential ramp sites due to industrial development of riverbank property
   c. Loss of potential marina sites due to straightening and narrowing of the river, and joining islands to the banks
   d. Decline in aesthetic appeal of riverscape

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-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 due to river barges and the related industrial plants along the River, and a decline in opportunities for recreation on and beside the River.

Recreational Impacts

The principal recreational impacts are:

1. A potential increase in recreational boating due to stable, navigable water levels which should lead directly to more marinas -- and their accompanying employment,
2. A potential increase in bird watching and fishing due to an increase in --
   a. Waterfowl habitat, and
   b. Fish spawning areas resulting from rising water levels
3. An increase in sightseeing visitors to the St. Anthony Falls Locks and Dams.

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

Cultural Impacts

At this stage of research the historical site destroyed on Upton Island is the only archaeological, cultural, or contemporary site of cultural significance in the St. Anthony Falls Pools known to have been adversely affected by Corps' operations.

Discussion of Impacts

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

Industrial Activities

The economic effect of the activities of the Corps of Engineers on the 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 locks and dams and navigational aids;
2. The installations at riverside for the transfer of cargo, storage facilities, and access;
3. The vessels using the waterway.

In these terms the impact of the Corps' activities in the St. Anthony Falls Pools is greater than in most of the other pools in the Northern Section of the Upper Mississippi River.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g. locks and dams, commercial docks and terminals, etc.) on the shores and the barge tows moving along the river.

The St. Anthony Falls Pools are the origin or terminal point for a substantial amount of the commodities shipped in the St. Paul District. It is the end of the chain of navigable pools stretching to the Gulf of Mexico. Unlike the other pools, it is not a passive thoroughfare for shipping passing to other pools.

Figures 53 and 54 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).

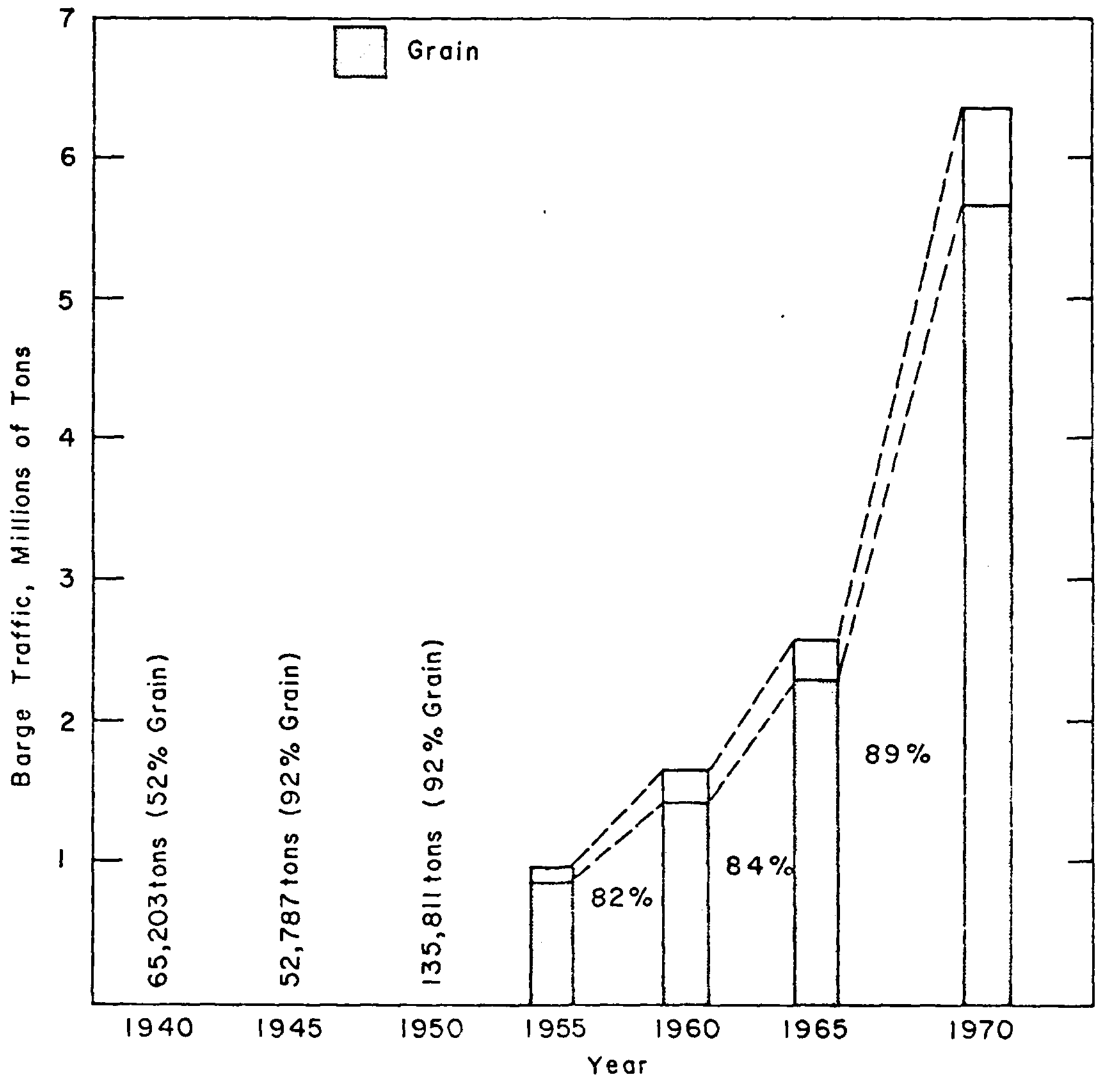

Figure 53. Shipments Out of the St. Paul District
(S.P.D.-NCS, Selected years)

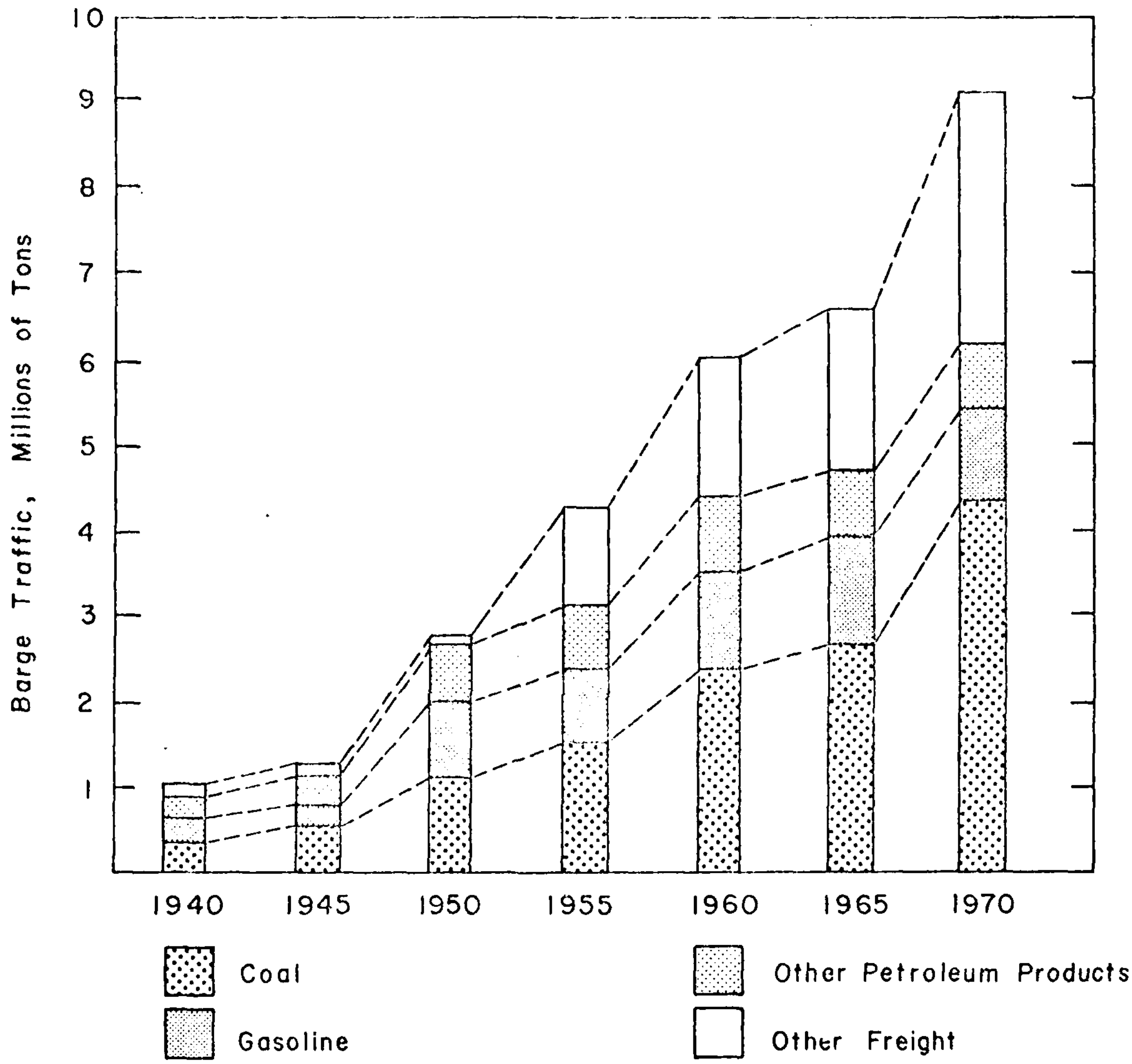

Figure 54. Receipts of Major Commodities -- All Ports, St. Paul District (Based on data from U.S. Army Corps of Engineers, St. Paul District)

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 these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

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

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

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.

Detailed data on the amounts of commodities originating in the St. Anthony Falls Pools or destined for it are not available. However, analysis of commercial and industrial facilities adjacent to the pool suggests that the major commodities originating or terminating in the pools are grain, cement and aggregate, and coal.

Statistics on the numbers of vessels originating, terminating, or passing through the St. Anthony Falls Pools are not available directly. However, some comparative idea of barge activity can be gained from studying the commercial lockages through the Upper St. Anthony Falls Lock and the Lower St. Anthony Falls Lock which are shown in Table 31. From 1963 to 1972 commercial lockages through both Locks showed steady and exceptional growth.

Commercial Dock Facilities. Firms that depend heavily on the river often maintain riverside facilities. The St. Anthony Falls Pools contain eight commercial docks and terminals, shipping and receiving a wide variety of products. Behind many of these docks are factories, storage facilities and refineries which are dependent upon them. These pools reach into the heart of the Minneapolis industrial and commercial district. Thus, the ramifications of river navigation extend deeply into the entire economy of the city and indeed throughout the whole upper Mississippi region. Employment directly and indirectly connected to these industries forms a small though significant percentage of the regional work force.

From an economic point of view most of the 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 in the St. Anthony Falls Pools 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

Table 31. Commercial Lockages in the St. Anthony Falls Pools 1960 - 1972.

Year	Commercial Lockages	
	Lock LSAF[a]	Lock USAF[b]
1960	71	0
1961	317	0
1962	69	0
1963	294	253
1964	523	519
1965	1,047	382
1966	1,199	427
1967	1,096	562
1968	1,419	725
1969	1,743	855
1970	1,694	996
1971	1,442	782
1972	2,072	1,335

Source: Annual lockage Data, (St. Paul, U. S. Corps of Engineers, St. Paul District, Unpublished Reports).

[a] Lower St. Anthony Falls

[b] Upper St. Anthony Falls

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

A further benefit which can be attributed to the 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*. It is generally recognized

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

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 and terminate in the St. Anthony Falls Pools.

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 may have economic effects on commercial and sport fishing, which are discussed below.

Commercial Fishing. There is no commercial fishing in either of the St. Anthony Falls Pools.

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 the St. Anthony Falls Pools the best available measures of pleasure boating activity are records of pleasure boats locking through the Upper St. Anthony Falls Lock and the Lower St. Anthony Falls Lock. These data -- along with the total pleasure-boat lockages through these two locks -- are shown in Table 32 for the years 1960 to 1972. The table shows sharp increases in pleasure craft locking through both St. Anthony Falls Locks (from 0 in 1960 to about 1,500 in 1972), during the period. The table also shows an accompanying increase in the number of pleasure boat lockages during the period, although the increases have not been as dramatic as for the number of pleasure boats moving through the two locks. The Upper St. Anthony Falls opens the way to 12 more miles of the Mississippi

Table 32. Measures of Boating Activity in the St. Anthony Falls Pools, 1960 - 1972.

Year	Pleasure Boats Through		Pleasure Boat Lockages Through	
	Lock LSAF[a]	Lock USAF[b]	Lock LSAF[a]	Lock USAF[b]
1960	0	0	0	0
1961	10	0	10	0
1962	1	0	1	0
1963	5	1[c]	5	3[c]
1964	887	879	679	668
1965	402	399	208	292
1966	809	794	581	582
1967	1,024	1,005	732	729
1968	1,218	1,211	881	885
1969	1,134	1,152	769	814
1970	1,482	1,555	1,010	1,014
1971	1,936	1,902	1,226	1,209
1972	1,455	1,458	926	943

Source: Annual lockage Data, (St. Paul, U. S. Corps of Engineers, St. Paul District, Unpublished Reports).

[a]Lower St. Anthony Falls

[b]Upper St. Anthony Falls

[c]Upper St. Anthony Falls Lock opened to navigation in 1963

River, above the head of navigation and up to the Coon Rapids Dam and is utilized by shallow draft pleasure boats to a considerable degree.

A few physical facilities have been developed in the St. Anthony Falls Pools to serve boaters using the pool. These include:

Facility	Number
Public recreational sites with ramps	2
Commercial recreational site with ramp	1

Except possibly for the recreational sites without ramps, which do not cater primarily to boaters, these facilities result from the Corps' operations on the River that guaranteed the deeper channel and contributed to greater water surface and more stable water levels.

Sport Fishing and Hunting. Although precise data on sport fishing 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 33. The table shows that a number of sport fishermen were observed from the Locks and Dams since 1965; although these data are only an index to sport fishing in the pool and the available data are scanty, it is apparent that the pools in spite of the urban nature of their shores are used for recreational fishing as well. However, the potential for increased fishing in the St. Anthony Falls Pools is probably offset by river pollution and turbidity from increased industrial activity along the perimeter of the pool and barge activity in it.

There is no hunting in the vicinity of the St. Anthony Falls Pools.

Sightseeing and Picnicking. Sites along the perimeter of the St. Anthony Falls Pools facilitate sightseeing. While non-boating visitors to these sites might be there whether Corps' operations existed on the Upper Mississippi or not, virtually all of the activities at these sites by boaters are attributable

Table 33. Number of Sport Fishermen Observed Annually by Attendants From Both St. Anthony Falls Dam Sites on the Upper Mississippi River, 1960 through 1970.

Year	St. Anthony Falls Lock and Dam
1960	Not Available
1961	Not Available
1962	Not Available
1963	Not Available
1964	2,117
1965	Not Available
1966	Not Available
1967	963
1968	1,162
1969	1,344
1970	1,281

Note: Counts are made once each day at 3:00 p.m.

Source: U. S. Corps of Engineers data published in the Proceedings of the Annual Meetings of the Upper Mississippi River Conservation Committee, 1960-1971.

to Corps' activities. In addition, visitors to overlooks at the locks and dams are a direct result of Corps' operations.

Cultural Impacts

Measures of cultural impacts by the Corps of Engineers in the St. Anthony Falls Pools are very complex. The perimeters of these pools are densely populated and have been built up and re-built over the past 150 years. Many sites of historic or cultural interest have been destroyed and built over; others are still being put to economically beneficial use (e.g. historic flour mills). Determining the effect, if any, of the Corps' activities is difficult indeed. Certainly the modification of the shoreline has had some impact on those early industrial sites which depended on the river for power, but in many cases other power sources were developed prior to modification made in the shoreline for navigational purposes.

One site of historical interest occupied a location now covered by the Upper St. Anthony Falls Lock and its attendant structures. This was the first hydroelectric power plant in the Western hemisphere built on Upton Island in 1882. *This site and its structures have completely disappeared, with the exception* of one turbine now on display with an accompanying bronze tablet which describes the power plant and its significance.

Archeological sites along the shores of these pools have long since disappeared as a result of contemporary building and occupation. With the exception of sites of historical interest actually covered by the locks and dams (plus auxiliary facilities) themselves, no sites are known to have been adversely affected by activities of the Corps of Engineers.

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

The nine-foot navigation project in the St. Anthony Falls pool may have unavoidably produced some adverse effects on the environment, although basic information is lacking. The adverse effects probably are due mainly to maintenance dredging, commercial navigation and the development of the river bank by barge terminals and businesses.

Dredging denudes the river bottom and increases turbidity. The resuspended sediments causing the turbidity are deposited downstream where they may smother benthic organisms. Fish and other free-swimming organisms may also be smothered, although data on the specific effects on these organisms in the St. Anthony Falls pools is lacking. Dredging and the disposal of dredgings have eliminated several islands in these pools by either dredging out the island, or by joining it to the mainland by filling in the back channel with dredged materials (See Figure 55). The largest of these was Spirit Island. Others included Boom Island and Upton Island. Both aquatic and terrestrial sites seem to take at least several years before they are recolonized.

The deposition of spoil has caused the elimination of at least one island: Hall's Island at Mile 855. The joining of an island to the mainland reduces the valuable aquatic-terrestrial interface habitat, and reduces sanctuaries for plants and birds and other animals.

Commercial development of the riverbank probably has been stimulated by the navigation channel and the additional land created by the spoil. Commercial and dredge spoil sites are probable centers of soil erosion, contributing to the sedimentation rate in the St. Anthony Falls pools and farther downstream. At the same time these areas detract from the aesthetic quality of the area. Studies should be conducted to identify the sources of sediment and effects of sedimentation and turbidity on the aquatic environment.

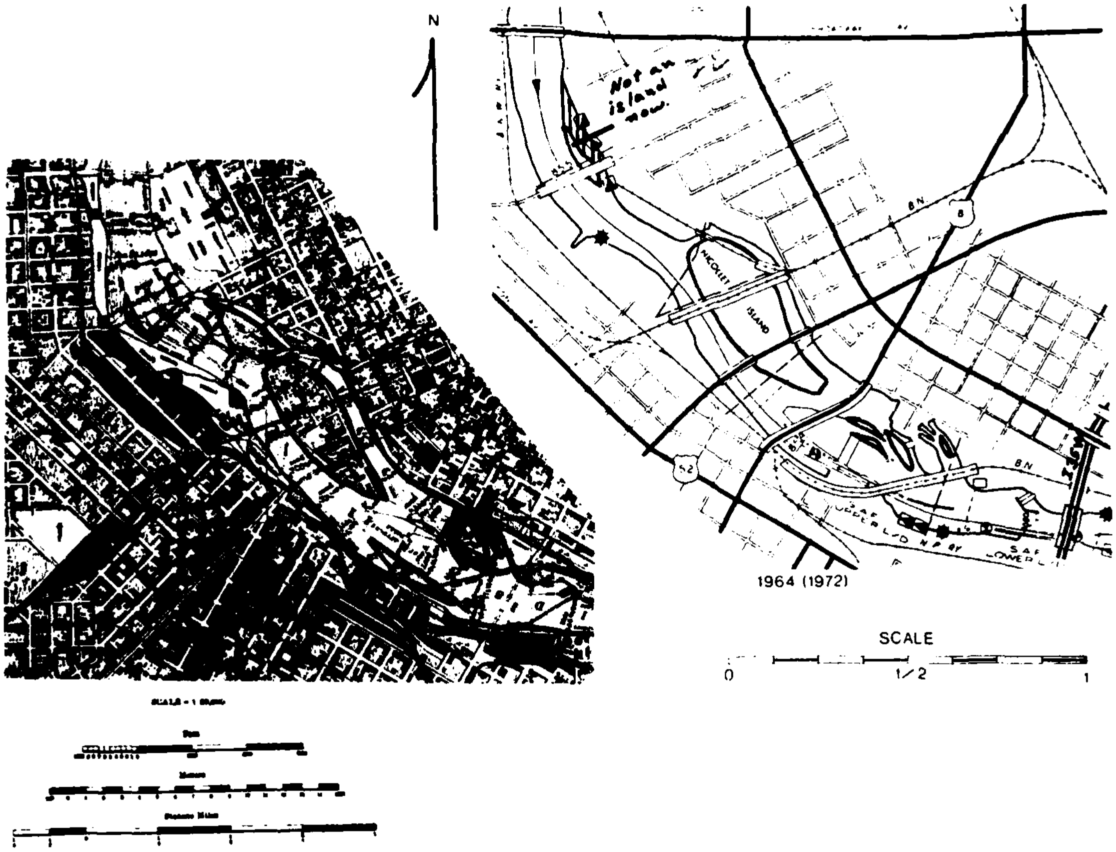

Figure 55. Maps of the St. Anthony Falls Area Showing Loss of Islands from 1895 to 1964. Hall's Island (855.0) was eliminated about 1964 (War Department, 1895; NCD (North Central Division), Corps of Engineers, 1972).

Commercial navigation increases the turbidity of the river and contributes to bank erosion. At the same time, it also may detract from the aesthetic quality. Discharges and spills from vessels and barge terminals would also have a detrimental effect, particularly on the aquatic environment. However, studies are needed to determine the nature and extent of adverse effects of these effluents. The building of the Upper Lock eliminated another island from the Upper Pool: Upton Island. This further reduced the interesting complexity of the riverscape above the Falls.

Other aspects of the nine-foot channel project possibly have relatively minor adverse effects upon the natural environment of St. Anthony Falls. Discharge from lock operations and turbulence from the dam spillway may cause some increased riverbed and bank scour, and thus downstream turbidity and sedimentation.

Enlargement of Lower Pool area submerged some terrestrial floodplain, but it is difficult to assess the significance of this impact.

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

There are several possible alternative methods of operating and maintaining the nine-foot channel project in the St. Anthony Falls Pools. Since adverse effects probably derive mainly from dredging and spoiling, attention is directed particularly to alternatives for channel maintenance.

Channel Maintenance

In order to reduce adverse effects of channel maintenance in the St. Anthony Falls Pools, several alternatives should be considered. First, only a hydraulic dredge should be used to remove the sandy sediments, thus reducing turbidity. Second, the spoil should be barged to a central terminal for commercial use or inland disposal. This would protect the remaining water surface area and allow vegetation to have a chance to grow on current spoil areas. They would then look better, become more suitable for recreation, and the whole riverscape would become more attractive.

Spoil and other bare-soil sites should be vegetated to reduce erosion due to rain, wind and current. Riprapping with stone would reduce erosion due to the river current and would also improve the fish and benthic habitat, but an effort to cover the riprap with attractive plants such as native vines should be made.

Some spoil banks and other areas along the riverbank should be developed for recreational use, such as picnic and rest areas, and scenic points. Bike trails and foot paths should connect with those upstream and downstream. If, in addition, the appearance of commodity storage areas and businesses could be improved, the aesthetics could be considerably enhanced. Commercial development should be restricted to those commodities which are most economically transported by barge. Unloading facilities should be kept to a minimum; all other equipment, buildings, storage piles, etc., should be removed from the riverbank and screened with vegetation. Further, no tall buildings (i.e.

apartment towers) should be built near the river. Another lift to the appearance could be plantings near the riprapped banks.

Further improvement in aesthetics and recreation would result if the water quality were improved. Reduction of soil erosion and in spills and discharges from vessels and terminals and other sources would probably help.

Improved water quality and riverbank habitat would probably increase waterfowl, fish and turtles. An increase in flow at the foot of Hall's "Island" or a decrease of effluents from the old mills would probably improve water quality, decreasing the carp and increasing bass populations.

Lock and Dam Operation

At present no alternatives are presented to lock and dam operation. Water quality improvement may warrant the construction of a fish ladder to facilitate fish and clam migration into the Upper Pool.

Realignment of the sign giving small boat operators directions for signalling their desire to lock down through the Upper Lock would promote boating safety, especially on the upper guidewall of the Upper Lock. The sign now can hardly be read from a small boat unless the boat is close to the danger zone above the Falls.

Aesthetics

The appearance of the Corps steel truss modification to the Stone Arch Bridge would be improved by painting it a color which would blend in with the color of the bridge stone.

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

Establishment of the nine-foot channel in the St. Anthony Falls Pools brought economic and some recreational benefits to Twin Citians. It also might have benefited some plant and animal populations while possibly contributing to a general reduction in biotic productivity. The facility also has removed several geomorphic features such as 3 islands and with them has removed productive natural habitat. Also the channel has stimulated urban development of the riverbank.

Short-term Uses

Extension of commercial navigation above St. Anthony Falls,by constructing 2 locks and dredging a deep channel, allowed the expansion of barge terminals and river-related jobs and businesses. The increased economic activity which results will help revitalize an old urban area and provides new recreational benefits. For instance,recreational boaters now have direct water access to the new North Mississippi River Park and a restaurant, as well as fishing areas above the head of navigation. Placement of the new terminals immediately adjacent to the river, and the spoiling of dredged sediment along the riverbanks, removes productive terrestrial and aquatic habitats from the potentially significant recreational river corridor. At the same time wasteland plant species such as smartweed, cocklebur and ragweed are encouraged. Bare soil areas associated with barge terminals and their development and the dredged spoil, unless carefully and rapidly revegetated, are easily eroded by wind and wakes, thus degrading the water quality of the Mississippi River. To this degredation may be added the effluents from barge terminals and related businesses, barge traffic and cleaning, and dredging and spoiling. Thus the carp population will increase possibly at the expense of the pike fishing at Nicollet Island.

Enhancement and Maintenance of Long-term Productivity

Development of commercial navigation in the St. Anthony Falls resulted in the dredging of a nine-foot-deep channel 4.3 miles upstream from the Lower Dam; and in construction of two locks and a dam. The locks and dam may have benefited as well as been detrimental to the natural environment. A relatively small area of the river is occupied by the facilities, while an avenue is provided for fish and clams and other benthos to by-pass the Upper Dam. Formerly bare river-bed was flooded, providing new aquatic habitat and probably increased productivity.

Creation and maintenance of the navigation channel probably has disturbed the natural river habitats in and near the channel sufficiently to reduce biotic productivity. Several islands were removed, shallow areas dredged or flooded, and a backwater at Hall's Island blocked and partially buried. A single dredging or spoiling of a site requires ten or more years to be repopulated by benthic organisms. Continued disturbance possibly may alter the physical environment to sufficiently extend this time.

Alternative land-use and maintenance practices could conceivably shorten the time necessary for repopulation of a site and may begin a return of the biotic productivity. Revegetation of construction sites such as is done along new road cuts could more quickly return the remaining land to a productive state and increase aesthetics. Setback of the businesses and terminals, except for the actual loading-unloading facilities, and a central spoil disposal site could result in a greenbelt along both banks of the St. Anthony Falls pools. Establishing access to this site so spoil may be removed for reuse could significantly reduce the adverse effects of the nine-foot navigation project and related activities on the enhancement and maintenance of the long-term productivity.

Thus recreation and its economic benefits which can come from the project have yet to be fully realized in the St. Anthony Falls Pools. The expertise of the Corps and other agencies cooperatively may realize the recreational and aesthetic potential in these pools, relieving in part the high recreational demand of the Metropolitan Area.

Resource Implications for Socioeconomic Activities

Table 34 summarizes the major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District. Resource implications for these four groups are discussed in sequence below.

Corps Operations

Table 34 identifies the major first order direct benefits associated with lock and dam operation and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus about 225 people derive jobs and income directly from 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 nine-foot channel in the St. Paul District are an increase in sedimentation behind dams, and a reduction in fish and waterfowl habitat and aesthetic appeal due to improper dredge spoil placement, and the presence of large piles of bare sand.

Industrial Activities

As summarized in Table 34, the major direct impacts of Corps' operations on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 34 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.

Table 34. 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
	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. Decreased fish habitat from improper dredge spoil placement and at lock sites

Table 34. 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

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

1. Energy usage?
2. Air pollution?

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

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

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

In comparing the efficiency of energy utilization between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensiveness of various modes of freight transportation (Mooz, 1973):

Freight Mode	Energy Intensiveness (BTU's/ ton-mile)	Ratios of E. I.
Waterways	500	1.0
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126.0

It is apparent from this table that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum energy availability the use of barging wherever feasible should be encouraged. Indeed, an increased use of the upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments of other parts of the U. S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the costs 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 towboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine due to its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gas. .ne engines. Among users of diesel engines, barging is more efficient than either rail or truck, as we have seen. Consequently a smaller amount of fuel is required to move freight. With less fuel used, air pollution is reduced.

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

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

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per ton mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will resul 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 34 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and picnicking -- 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 34 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

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

Applying even this theoretical framework to the nine-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the nine-foot channel may hurt sport fishing because of the reduction in fish habitat. The incremental increase or decrease in sport fishing, in relation to the total value of sport fishing in the river valley and attributable to present Corps' operations (not due to the initial lock and dam construction), should be weighed against those operations. However, no estimates are presently available to assess the effect of current Corps' operations on fish and wildlife. Further, an evaluation is needed where terrestrial species may benefit from spoiling which eliminates aquatic species.

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.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; Pennington, et al., 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the

St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks, virtually all river users are not away from home overnight and are omitted from such studies.

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

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

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

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

Thus the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benifit 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 damages or enhanced by Corps operations. Rather, such sites have merely been identified where existing data permit.

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7. IRREVERSIBLE COMMITMENTS OF RESOURCES INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

The construction of navigation facilities and continuing channel maintenance, as well as the barge traffic and terminal facilities which followed, in the St. Anthony Falls Pools required the irretrievable commitment of certain human and natural resources.

The cement, steel, lumber and fossil fuel (and thus the natural resources from which these are derived), plus labor and equipment resources were consumed in the construction of the Lower Lock and Dam, the Upper Lock, and related structures. Some of the steel possibly could be retrieved eventually as scrap.

There also is a continuing commitment of labor, electrical energy and equipment in the operation and maintenance of these facilities.

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

Some of the natural habitats in and along the river have been irreversibly committed to the nine-foot channel project and attendant activities. Dredging and siting of the Locks and Dam removed or altered river bottom, eliminated several islands, and reduced riverbank communities. Additional riverbank communities were altered or lost due to barge terminals, which are made possible by the project. It is not known to what extent this removal or alteration amounted to, nor if any endangered species were lost. Since this navigable portion of the river is continuous with and apparently similar to the upstream habitats, the loss of endangered species from the area seems remote.

The increased urbanization and concomitant decrease in natural habitat in the St. Anthony Falls Pools has diminished -- possibly irretrievably-- some portions of this section of the river as a recreational resource to the Metropolitan Area.

8. RECOMMENDATIONS

Several studies should be conducted to better define the beneficial and adverse effects, and methods to reduce the latter, of the nine-foot channel project in the St. Anthony Falls Pools.

Most important are studies of the sources of sediment and more detailed studies of impacts of dredging and spoiling operations. Efforts should be directed toward locating sediment sources and stopping (or at least reducing) the influx of sediment into the St. Anthony Falls pools. A reduction in sediment inflow would, of course, reduce the need for dredging and spoiling, and thus reduce the associated adverse environmental effects.

At the same time, alternative methods of spoiling and spoil dredging should be investigated.

The appearance of spoil in the St. Anthony Falls pools suggests that a study should be made of the possibility of using hydraulic dredging equipment. The use of a small hydraulic plant in place of clam-shell dredging probably would decrease the amount and duration of turbidity. The close proximity of the shoreline would facilitate centralized spoil sites and ready access to buyers.

A noticeable reduction in adverse environmental effect probably could be obtained if spoil disposal were centralized and the sand and gravel recycled. A study of the potential market for dredge spoil, indicated by a preliminary study conducted by the Bureau of Sport Fisheries and Wildlife, might reveal an economic return from a central recycling area. Reclamation of badly eroded areas and sanitary landfills also are possible uses of spoil. This is especially important in this relatively narrow part of the river where there is little room for any additional spoil deposition.

Furt er studies should be made with an assessment of the degree of sensitivity of terrestrial and aquatic communities to dredging and spoiling operations. Correlated studies should be made on methods of enhancing present spoil sites for aquatic and terrestrial plants and animals. Enhancement measures would also provide protection from erosion of the spoil bank into the river. Further, recreational and aesthetic benefits would accrue from spoil bank vegetation and enhancement. The Corps acting in cooperation with other agencies probably could make significant contributions to the improvement and maintenance of man's--that is, the total natural--environment.

In order to facilitate future impact analyses of the nine-foot channel, more precise records of dredging and spoiling information should be kept by the Corps. The maps of the area of the riverbed to be dredged which are used by the dredge operators should be kept in the Corps' archives. In addition the precise location of spoil sites, amount of spoil deposited and area covered by spoil should be recorded and kept along with the dredging maps. Periodically, every three years, aerial photos of the river valley should be made in order to be able to more quickly assess the rate of revegetation and filling of riverbank spoil disposal areas.

A land-use plan should be developed and strictly adhered to which would permit development of optimal recreational facilities along with the industrial developments in the St. Anthony Falls riverbanks. Such a plan should include an evaluation of a program for maintaining and enhancing fish and wildlife habitat in the area as well as plans for attractive spoil "recycling" areas, screened by an assortment of native trees, vines, herbs and shrubs.

A study should be made of the possible expansion of new clam populations to habitats above St. Anthony Falls. The number of species was low above the falls, compared with those below when collected by Dawley before 1947. A new study might show one more probable benefit to the upper river: a greater diversity of mollusks.

9. APPENDIX A: NATURAL SYSTEMS

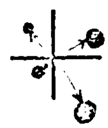
I. METHODS OF DATA COLLECTION

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 to identify species, and to determine abundance, age and growth rate. Both quadrat (per cent cover of herbs, etc. in one square meter) and point quarter methods (for trees) were employed.

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 thermistor 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 MI-101-2.

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

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

II. TRANSECT LOCATIONS ON THE UPPER AND LOWER ST. ANTHONY FALLS POOLS

The map of the St. Anthony Falls Pools (Figure 1) shows the location of sampling stations along the three "standard" transects. No "special" transects were needed. Standard transects are surveyed lines which here cross the river at a right angle in each pool, and are chosen to sample its environmental diversity. They extend from bluff to bluff and include bluff slope, riverbanks, open river and river bottom. Standard transect AA is located about 1/4 mile upstream from the head of navigation at Mile 858.9, the area least modified by impoundment; transect BB is located near mid-pool at Mile 855.7 (See Figure 2); and transect CC is located 1/4 mile upstream from the dam in the deeper, lake-like region. The azimuth (compass direction, using N as 0 and E as 90 degrees) and other pertinent data is given in Table 1.

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

III. SUMMARY OF DATA COLLECTIONS

Benthic (bottom) grab samples were taken on the standard transects and on several special transects during the months of April and May (Spring) and August (Summer). The sample was screened through 707 micron standard sieve and the organisms retained and preserved. 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 abundance determined per one meter square quadrant placed in the middle of a vegetation zone for herb composition, and by the point quarter technique, located similarly, for the composition of trees and shrubs. Plant identifications were made by Dr. Gerald Ownby, Curator of the Herbarium, Department of Botany, University of Minnesota, as well as by the investigators.

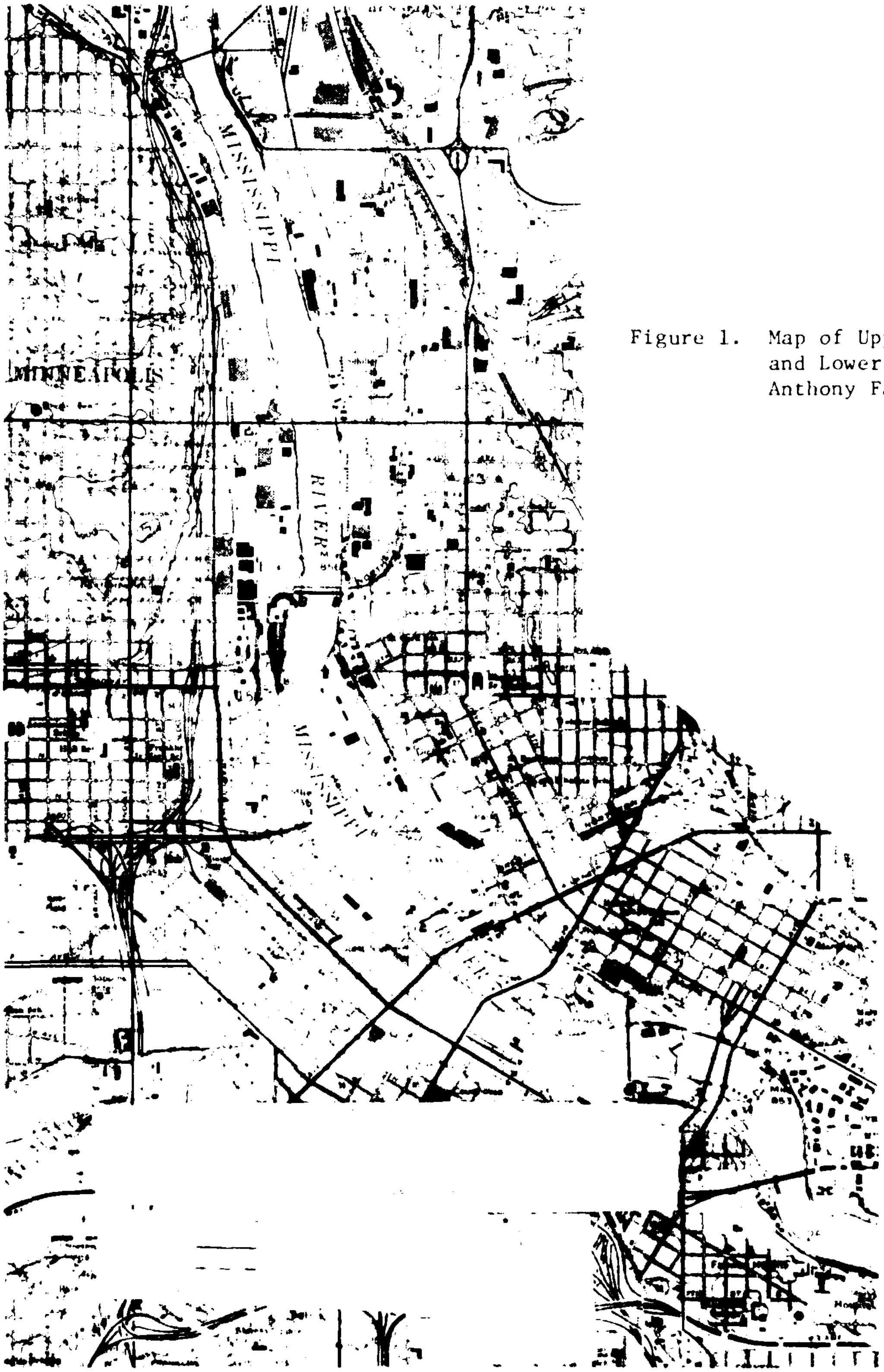


Figure 1. Map of Upper and Lower St. Anthony Falls

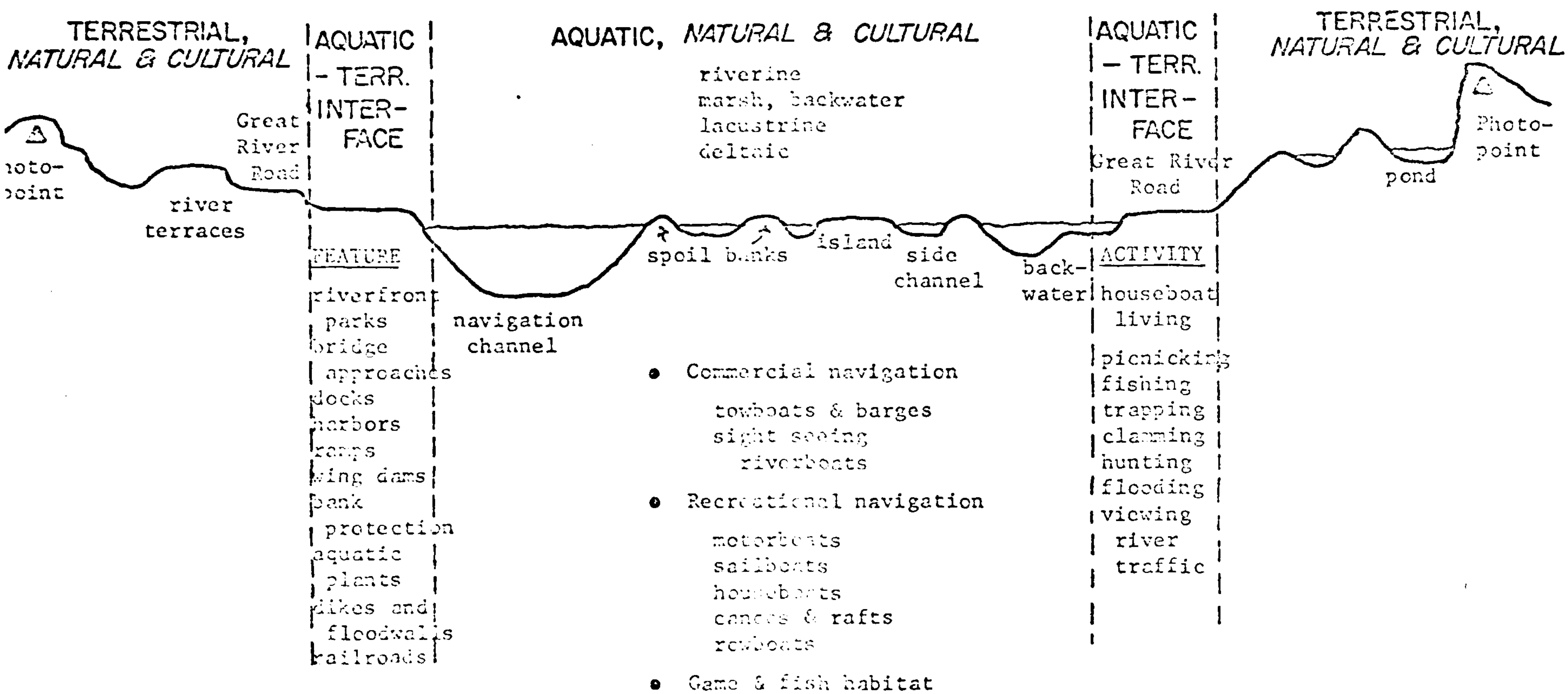


Figure 2. Profile of a Typical Transect of the Marsh Portion of a Typical Pool.

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 [illegible]
	Special Study Area	832.0,L	256°	--	Tower for high voltage line on R/B, [illegible] spoil site 4B.
	Special Study Area	827.7,R	85°	--	Gov't daymark Mi. 827.7, 22-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.

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 lack of time.

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 the 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. Benthic Animal Abundance.

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

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

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

Table 8. Common species of rough fish of the rivers of the Twin Cities Metropolitan Area (FWPCA, 1966).

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

Figure 2. Mean daily flow, Anoka Gaging Station. 1967 - 1969.

Figure 3. Mean daily flow, St. Paul Gaging Station. 1967 - 1969.

Figure 4. Temperature, Station 1. 1967 - 1969.

Figure 5. Temperature, Station 2. 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. Conductivity, Station 1. 1967 - 1969.

Figure 11. Conductivity, Station 2. 1967 - 1969.

V. REFERENCES

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

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

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

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

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

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

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
Trees & Shrubs (Cont'd.)																	
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
Trees & Shrubs (Cont'd.)																	
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)

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

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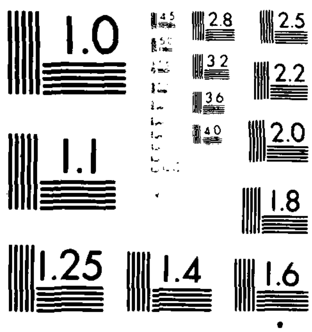

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Table 1. Abundance of Plants Found in the River Valleys in the Twin Cities Area (Continued)

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

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

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

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

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

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

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

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

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species / Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<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)

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)																	
COMPOSITAE (Continued)																	
Solidago gigantea Giant goldenrod		P															
Solidago graminifolia Grass-leaved goldenrod																	
Solidago nemoralis Gray goldenrod																	
Solidago so. Goldenrod	P			P	P			P	P	P			P	P	P	P	P
Taraxacum officinale Dandelion		P		P		P					P		P			P	P
Vernenia fasciculata Western ironweed								P									
Xanthium italicum Common cocklebur	P	P		P		P	P	P			P						
CRUCIFERAE																	
Berteroa incana Hoary alyssum																	
Brassica nigra Black mustard																	
Cardamine pensylvanica Bitter cress																	
Hesperis matronalis Dames violet																	
Lepilium virginicum Poor-man's pepper	P																
Nasturtium officinale Watercress														P			

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

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

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

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)																		
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)

	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																	
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)

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

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

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

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

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

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

Pool:	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Transect:	AA	BB	CC	BB	AA	BB	CC	AA	BB	CC	AA	BB	CC	AA	BB	YY	CC
<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
Herbs (Continued)																	
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)

	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>																	
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 Cinnamon fern															P		
OXALIDACEAE																	
Oxalis dillenii Wood sorrel											P						
Oxalis stricta Upright wood sorrel																	
Oxalis violacea Violet wood sorrel																	

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

Species	SAF 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)																	
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 aricularе 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 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)																	
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	SAF Pool: Upper			SAF Pool: 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)																	
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)

	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)																	
ROSACEAE																	
Potentilla recta Upright cinquefoil																	
Potentilla simplex Old-field cinquefoil																	
Potentilla sp. Cinquefoil											P		P				
Rosa blanda Smooth wild rose										P							
Rosa suffulta Hairy prairie rose																	
Rosa sp. Rose													P		P		
Rubus occidentalis Black raspberry																	
RUBIACEAE																	
Galium boreale Northern bedstraw																	
Galium trifidum Small bedstraw																	
Houstonia longifolia Bluet																	
SANTALACEAE																	
Comandra umbellata Bastard toadflax																	

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

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

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

	SAF Upper			SAF Lower	1			2			Minn. River			St. Croix River			
Species	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)

	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)																	
SOLANACEAE																	
Physalis heterophylla Clammy ground-cherry																	
Physalis longifolia Ground-cherry																	
Solanum nigrum var. *americana* Black nightshade			P	P					P		P						
SPARGANIACEAE																	
Sparganium Bur-reed																	
TYPHACEAE																	
Typha latifolia Cattail														P			
UMBELLIFERAE																	
Angelica atropurpurea Alexander																	
Cryptotaenia canadensis Wild chervil																	
Heracleum lanatum Cow parsnip																	
Osmorhiza longistylis Sweet cicely																	
Pastinaca sativa Wild parsnip																	
Sanicula marilandica Black snakeroot																	
Zizea aurea Golden alexander																	

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

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

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

Species	SAF Upper AA	SAF Upper BB	SAF Upper CC	SAF Lower BB	1 AA	1 BB	1 CC	2 AA	2 BB	2 CC	Minn. River AA	Minn. River BB	Minn. River CC	St. Croix River AA	St. Croix River BB	St. Croix River YY	St. Croix River CC
Herbs (Continued)																	
HEPATICAE (Liverworts)														P			
MUSCI (mosses)														P	P	P	P

Table 2. 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 2. 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 2. Benthic Animal Abundance (cont.).

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

MISSISSIPPI RIVER (Continued)

Upper St. Anthony Falls Pool (Continued)

Transect UBB, Mile 855.7

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

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

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

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

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Diptera	Chironomidae	*Polypedilum*	1	65.

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

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
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

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Trichoptera	Hydropsychidae	*Chewnatopsyche*	22	5.
		Hydropsyche	5	
		Macronemum	2	
Diptera	Chironomidae		2	
	Empididae		1	
Coleoptera	Elmidae		1	
	Elmidae	(Adults)	3	

UBB : Right bank; Summer 1973; no organisms

A Table 2. 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)

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 2. 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 2. 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 2. Benthic Animal Abundance (cont)
Comparison of Spring and Summer Samples of Benthic
A Macroinvertebrates Collected in 1973 in the
Minnesota and Lower St. Croix Rivers and Mile
815.3 to 857.3 of the Mississippi River (Continued)

MISSISSIPPI RIVER (Continued)

Pool 1

Transect 1AA, Mile 853.2

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

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

1AA: Left bank; Summer 1973; no sample

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

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

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

Table 2. 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

Trichoptera	Hydropsychidae	*Cheumatopsyche*	1	6.
Diptera	Chironomidae	*Cryptochironomus*	1	
Oligochaeta	Tubificidae		12	

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

Trichoptera	Hydropsychidae	*Cheumatcpsyche*	1
Diptera	Chironomidae	*Cryptochironomus*	1
Oligochaeta			3

Table 2. 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 2. 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	

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Table 2. 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)

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

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
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

Class or Order	Family	Genus	Organisms per sq ft	Sample Number
Coleoptera	Elmidae		1	
Hirudinea (leeches)			3	

Table 2. 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	
		Stictochironomus	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 2. 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 2. 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 2. 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 : Left bank; Spring 1973				
Diptera	Chironomidae	*Procladius*	19	15.
		Tanypus	2	
Oligochaeta			44	
2YY : Left bank; Summer 1973; No sample				
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	

Table 2. 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: Mid-channel; No organisms

2YY: "3C"; Spring 1973; No sample   Note: "3C" is mid-channel

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 2. 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 2. 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 2. 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 2. 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 clam-shell; Middle of the bay; 7.5' depth

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

Table 2. 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 2. 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 2. 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 2. 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 2. 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 2. 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 2. 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 2. 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 *Micropsectra*
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 2. 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 2. 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 2. 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 2. 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 2. 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.

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

arameter		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Bacteria in	Total	108690	114270	7850080	221300	117730	109400	67690	117270
aw water,	Aver.	3506	4081	253228	7343	3797	3647	2184	2783
ost Prob.	Max.	13000	17000	7160000	35000	13000	24000	7900	17000
No./100 ml	Min.	790	490	700	1300	170	450	330	170
urbidity,	Aver.	2.7	2.0	5.0	3.1	4.7	4.7	4.7	4.5
Jackson	Max.	3.1	2.4	14.0	4.0	20	9.0	24	10
Turbidity	Min.	1.9	1.5	1.9	2.5	2.9	3.3	3.3	2.2
nits									
Calcium	Aver.	119.4	125	96	106	107	107	104	94
ardness	Max.	126	135	124	113	135	116	116	102
in mg/l	Min.	112	119	69	95	94	101	100	85
as $CaCO_3$									
icarbo-	Aver.	168	175	128	132	130	136	133	120
nate, mg/l	Max.	178	180	175	144	139	146	140	139
	Min.	153	170	88	118	113	128	125	98
Alkalin-	Aver.	168.2	179	132.5	144	140	146	148	135
ty, mg/l	Max.	177	188	182	154	151	153	155	232
s $CaCO_3$	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
olor	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
uoride,	Aver.	0.15	0.12	0.14	0.15	0.17	0.19	0.18	0.17
mg/l	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 4. Turbidity, temperature and dissolved oxygen in the SAF Pools, Pools 1 and 2 of the Mississippi River and the Lower Minnesota River, November 1 and 2, 1973.

Date	Pool	Transect	Depth in ft.	Turbidity** FTU	Temp., OC	DO, ppm	Remarks
1 Nov 73	USAF	Hd. Nicollet Is.	0'	4	8.5	8.67	
			12'(b)*	4			
		AA* (Mid-ch)†	0'	4	8.0	8.04	
			12'(b)	4	8.0	7.70	
		BB (Mid-ch)	0'	5.5	8.2	7.70	
			15'(b)	4	8.3	6.67	
		CC (E. ch)	0'	18	8.2	6.65	
			10'(b)	2	7.7	7.00	
		CC (Mid-main ch)	0'	2	5.8	9.17	
			25'(b)	3	5.2	9.53	
	LSAF	BB (R/B)††	0'	2	9.3	6.88	@Shiely
			14'(b)	4	8.6	7.50	
		BB	0'	2.5	8.7	7.17	1.5 Min after
			14'(b)	4	8.0	7.00	Joaljim 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 Dam
		BB (Mid ch)	0'	4.5	8.4	6.13	Mid ch.
			18'(b)	5	8.3	6.20	
		CC (Mid)	0'	6	8.6	6.20	
			12'(b)	5	8.5	6.13	
	2	AA (Mid-main ch)	0'	4	8.6	7.50	
			18'(b)	5	8.6	9.33	
		AA (L ch mid)	0'	5	8.6	6.34	
			10'(b)	6	8.5	8.34	
	Minn.	CC (Mid-ch)	0'	42.5	9.3	6.18	
			15'(b)	56	7.0	8.82	
	2	St.P. ycht club	0'	11	8.6	5.67	
			12'(b)	12	9.0	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	
			15'(b)	36.5	8.5	7.83	@R/B-40 sec. after own boat wake ([illegible] throttle ~20' 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.

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

MN.R.		Left Bank		Mid-chan.		Right Bank		
Mile	Location	FTU	(D')	FTU	(D')	FTU	(D')	Notes
21.8	150 yds upstream from Peavey terminal	33 37	(0') (2') (bottom 3')	36 42	(0') (4') (bottom 6')	35 39	(0') (5') (bottom 7')	Head of privately maintained nine-foot navigation channel.
21.7	130 yds downstream from Peavey terminal					31	(0')	ditto.
21.4	Sharp right bend	28	(0')			32	(0')	Left bank is on outside of bend, eroding.
19.5	Sharp right bend	21	(0')			23	(0')	Left bank is on outside of bend.
18.5	Sharp right bend	21	(0')			23	(0')	Left bank is on outside of bend.
16.8	Upstream from Co Hwy. 25 Brdg.	22	(0')			21	(0')	Right bank riprapped.
15.1	Upstream from Bunge terminal	21 25	(0') (5') (bottom 7')	18 23	(0') (9') (bottom 12')	22 27	(0') (3') (bottom 5')	Upstream from heavy barge traffic.

Table 5 (continued).

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

MN.R. Mile	Location	Left Bank FTU (D')	Mid-chan. FTU (D')	Right Bank FTU (D')	Notes
14.5	Upstream from clamshell dredge D.B. 771	25 (0') 31 (4')	21 (0') 27 (7')	20 (0') 30 (2')	Effect of dredging upon turbidity: dredge at left bank.
	- - - - - - - - Dredge D.B. 771 - - - -				
	100' downstream from D.B. 771	23 (0') 31 (6')	27 (0') 57 (0') 71 (9') 86 (5')	49 (0') 60 (5')	
13.3	Upstream from Cargill terminal	27 (0') 41 (6') (bottom 8')	26 (0') 45 (11') (bottom 14')	19 (0') 26 (2') (bottom 4')	Area of heavy barge traffic.
13.3	Same spot: 0.5 min. after tow passed	29 (0') 42 (2') (bottom 3')	67 (0') 80 (11') (bottom 12')	53 (0') 59 (3') (bottom 6')	Effect of a tow (with four loaded barges headed downstream) upon turbidity.
13.3	Same spot: 10 min. after tow passed	36 (0') 45 (2') (bottom 3')	71 (0') 74 (10') (bottom 12')	37 (0') 62 (5') (bottom 6')	
13.3	Same spot 32.5 min. after tow passed	30 (0') 43 (2') (bottom 3')	29 (0') 64 (11') (bottom 12')	29 (0') 44 (3') (bottom 4')	
12.5	MBB transect	35 (0') 43 (3') (bottom 4')	38 (0') 55 (10') (bottom 11')	29 (0') 51 (2') (bottom 3')	Sampled about 20 min. after a tow passed upstream - two empty barges.
2.9	MCC transect	39 (0') 51 (3') (bottom 4')	44 (0') 76 (14') (bottom 15')	47 (0') 62 (3') (bottom 4')	Sampled about 35 min. after a tow passed upstream.
0.1	River mouth	46 (0') 56 (5') (bottom 6')	47 (0') 72 (12') (bottom 13')	32 (0') 54 (3') (bottom 4')	Sampled about 20 min. after a tow passed upstream.

Table 6.

The Birds of the Minneapolis-St. Paul Region

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

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

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

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

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

A separate dot indicates a specific record for the bird.

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

A. Aquatic

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

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

B. Shrubs

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

C. Forests

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

D. Grassland

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

E. Urban

F. Aerial

G. Cliffs and banks

H. Sandy beaches

I. Mud flats

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

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

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

Table 6 (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-crest. 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													
Redhead	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 6 (Continued)

Species	Habitat	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cooper's Hawk	C												
Red-tailed Hawk	I, 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	E2-3												
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 6 (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 6 (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 6 (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	C1												
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-breated 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 6 (Continued)

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

Table 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			X				
Moon-eye			X	X			X
Gizzard Shad			X	X	X	X	
Common Sucker	X		X	X	X	X	X
Spotted Sucker		(list is incomplete)					
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. Common Species of Game Fish in the Large Rivers of the Twin Cities Metropolitan Area (FWPCA, 1966)

Species	Mississippi River: Rum River To St. Anth. Falls	Mississippi River: Pool No. 1	Mississippi River: Pool No. 2	Mississippi River: Pool No. 3	Minnesota River: River Mile 70 to 25	Minnesota River: River Mile 25 to 0	St. Croix River
Walleyed Pike	X		X	X	X		X
Sauger			X	X	X		X
Northern Pike	X		X	X	X		X
Black Crappie	X		X	X	X	X	X
White Crappie				X	X	X	
Largemouth Bass			X		X		
Smallmouth Bass	X	(list is incomplete) X			X		X
Rock Bass	X		X				X
White Bass				X	X		X
Bluegill	X		X	X			X
Channel Catfish			X	X	X	X	X
Sturgeon							X
Flathead Catfish				X	X	X	X
Green Sunfish			X				
Pumpkinseed	X						X
Brown Trout							X
Number of Species	7	-	9	9	10	4	13

Note: This is not necessarily a complete list.

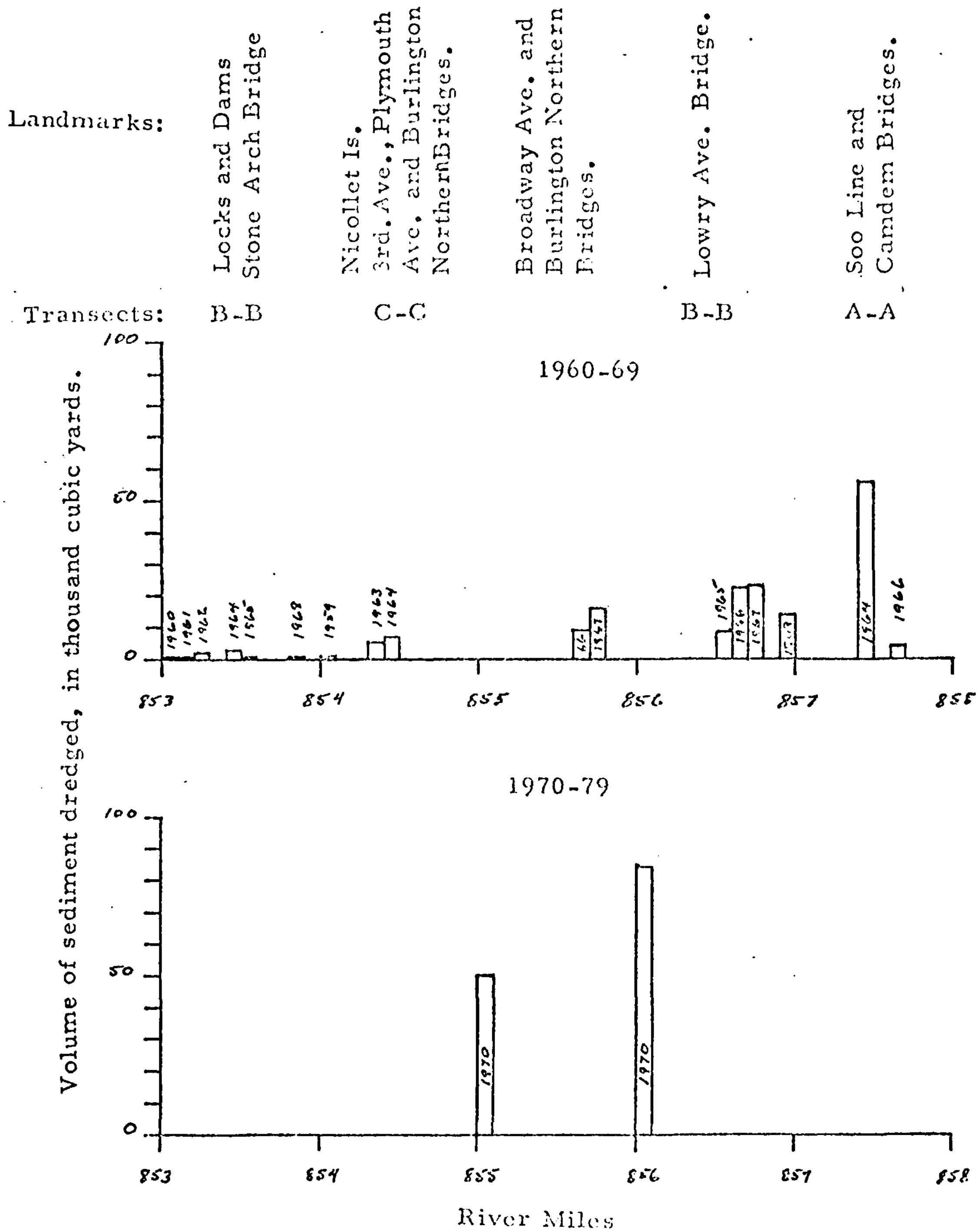


Figure 1. Annual Volume of Sediment Dredged From the St. Anthony Falls Pools Within Each River Mile, Arranged by Decade.

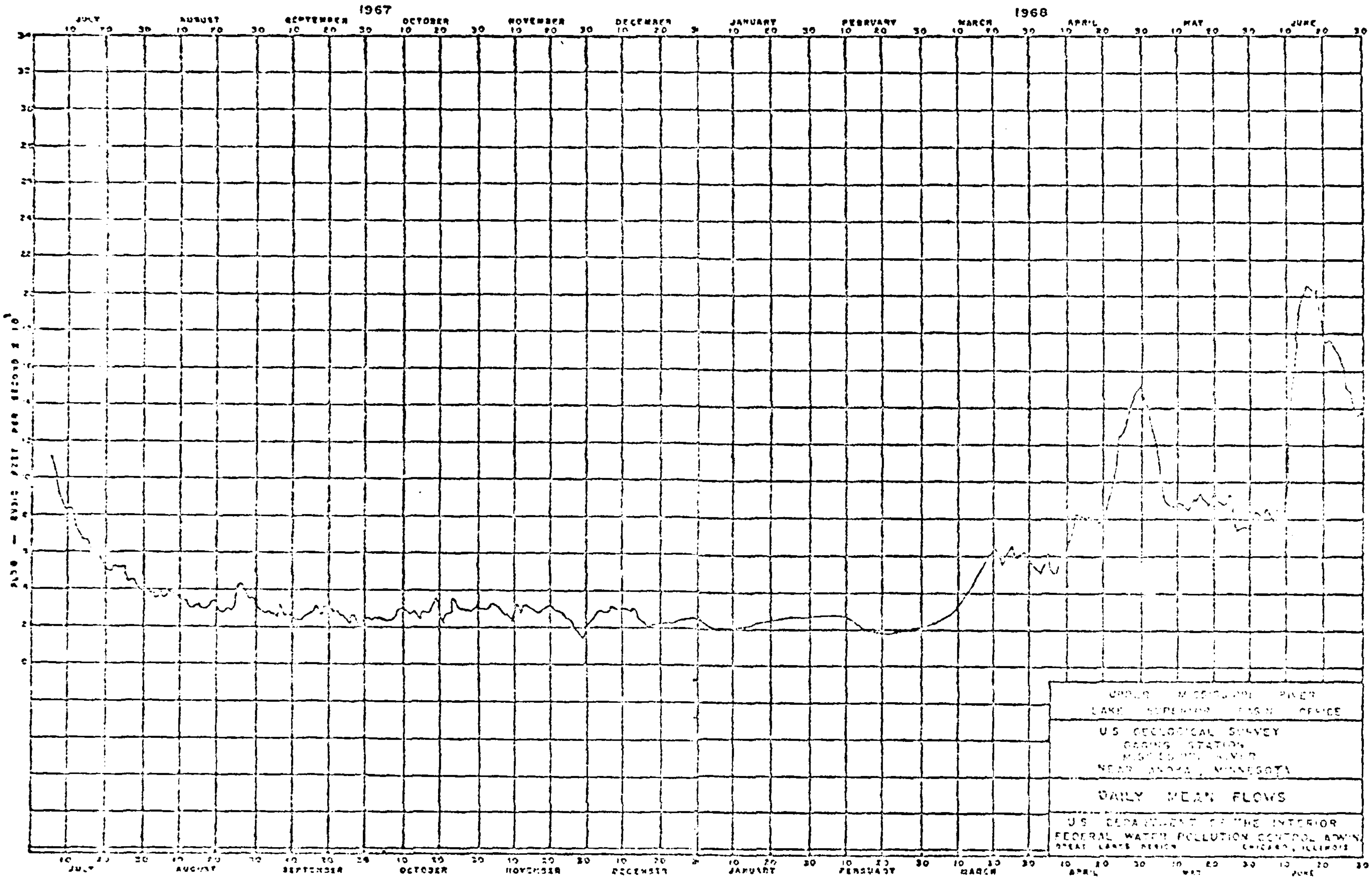


Figure 2. Mean Daily Flow, Anoka Gaging Station. 1967 - 1969.

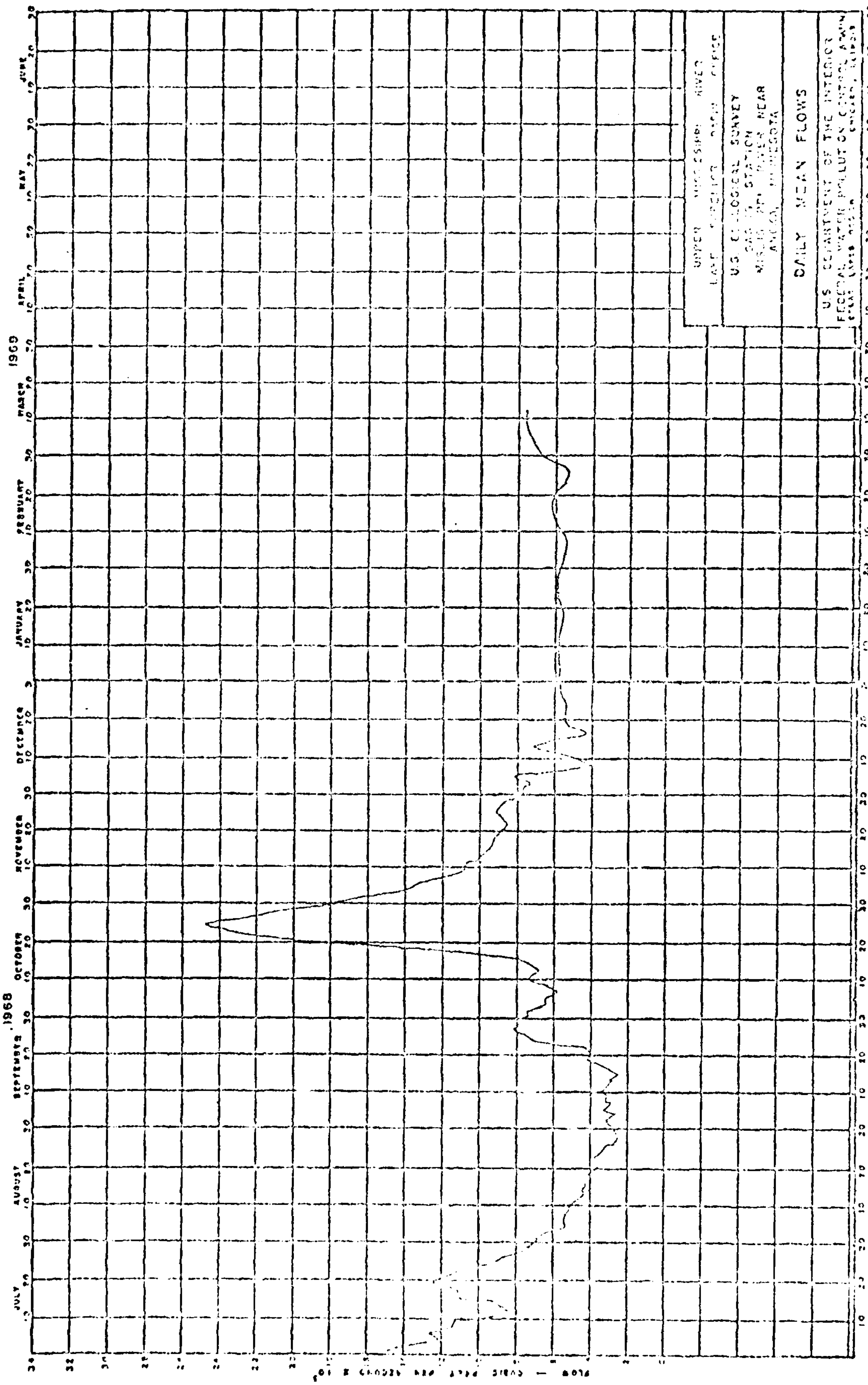


Figure 2. (Continued)

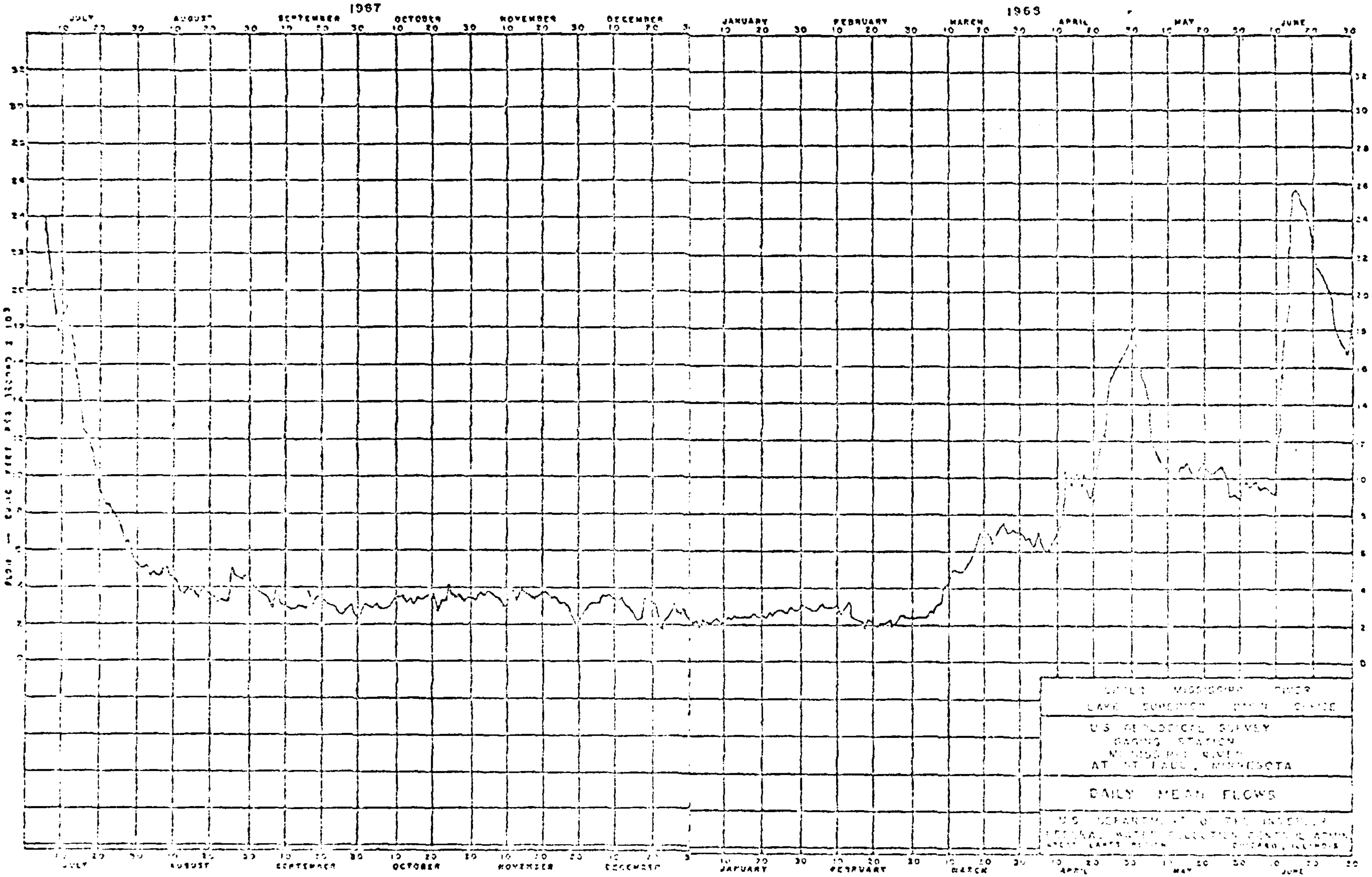
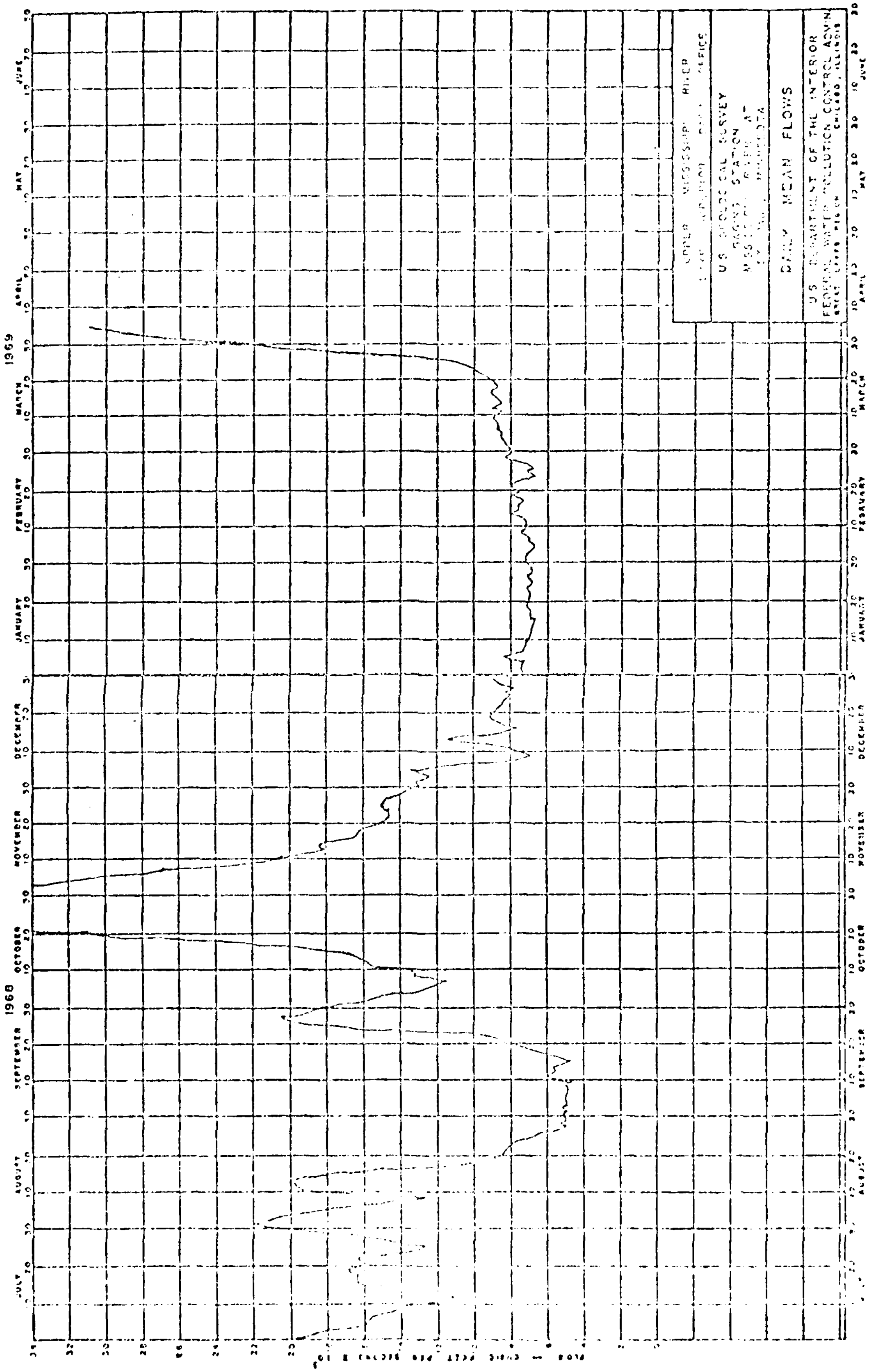


Figure 3. Mean Daily Flow, St. Paul Gaging Station. 1967 - 1969.



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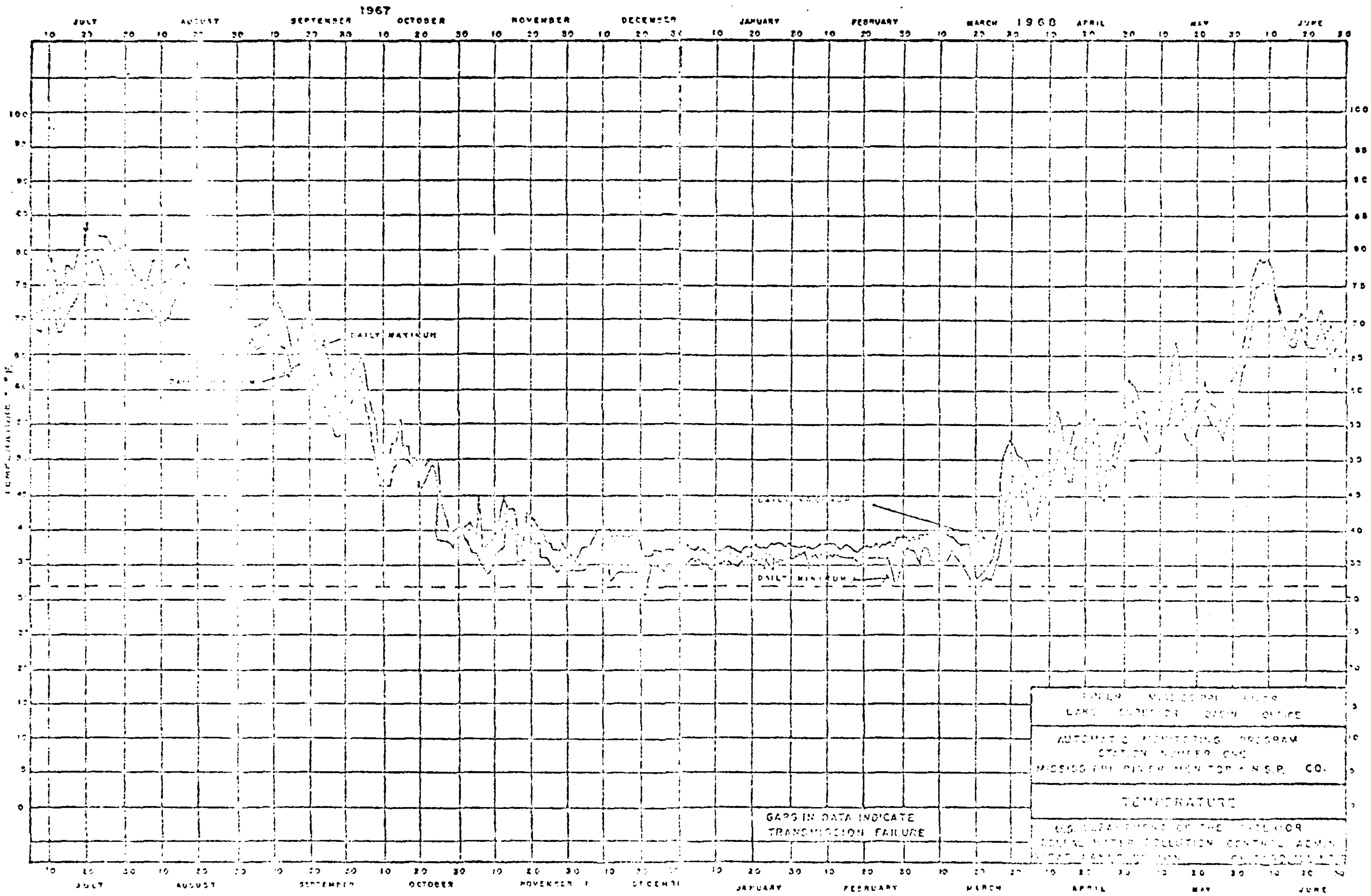
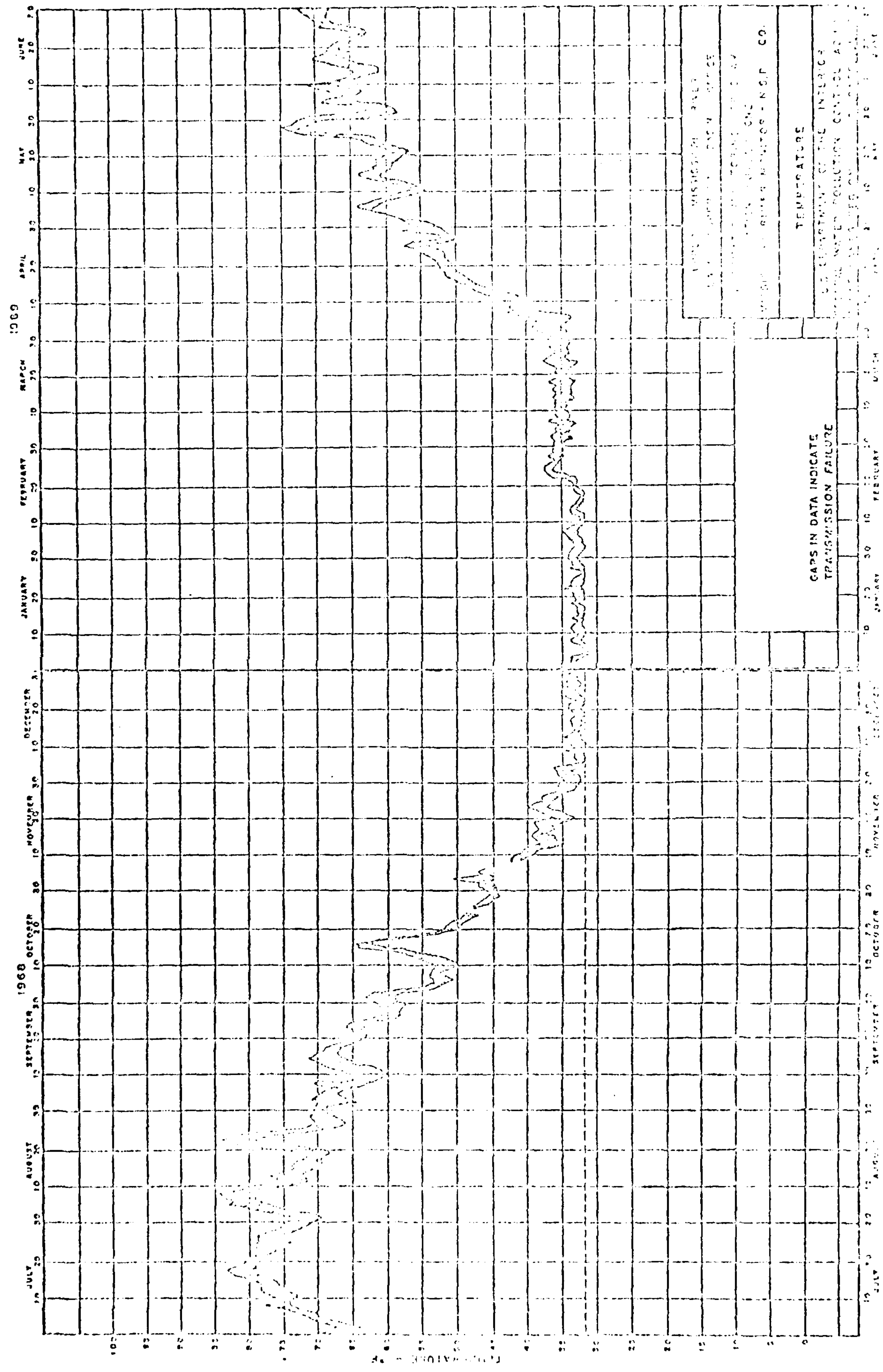


Figure 4. Temperature, Station 1. 1967 - 1969.



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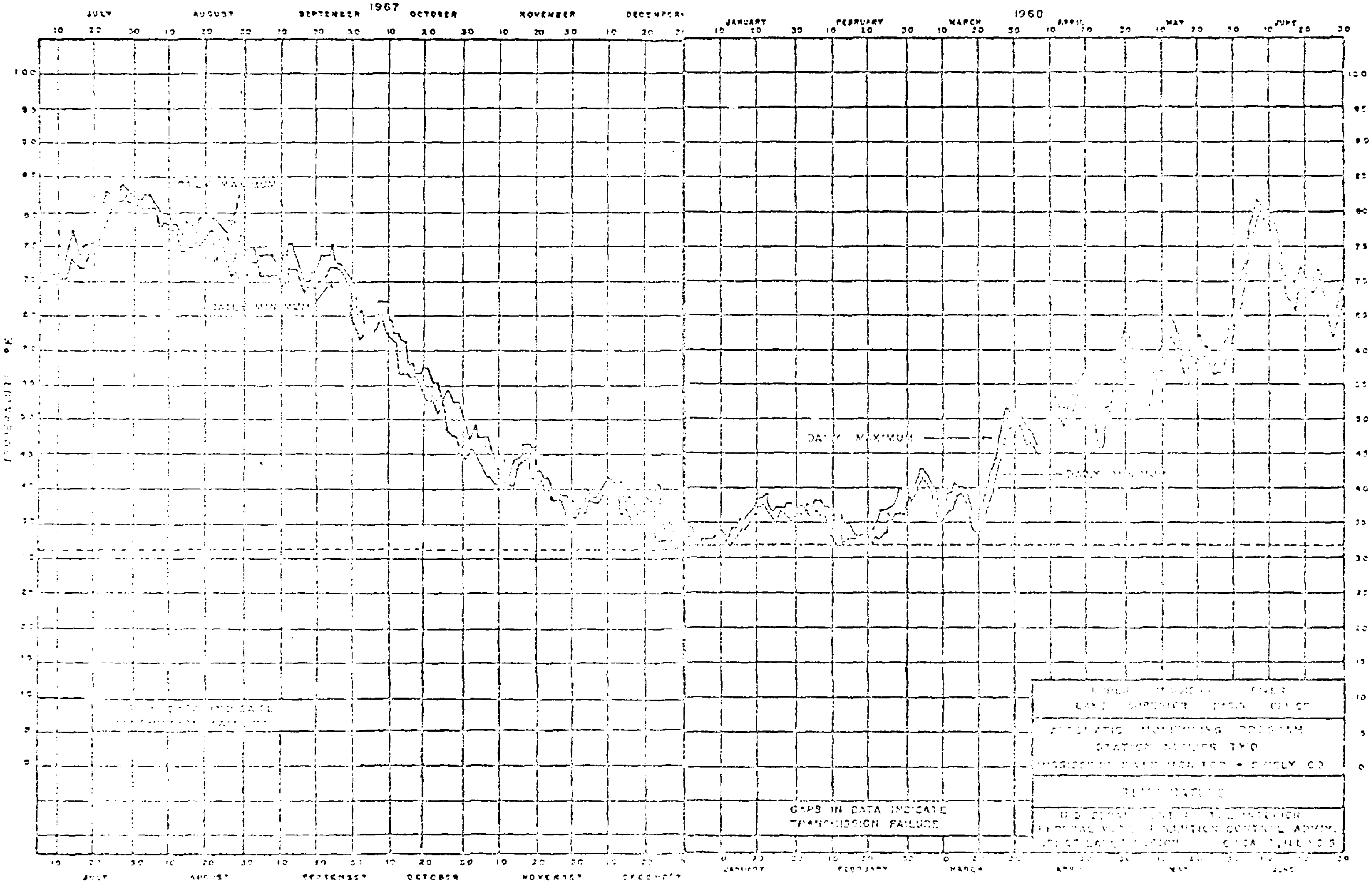
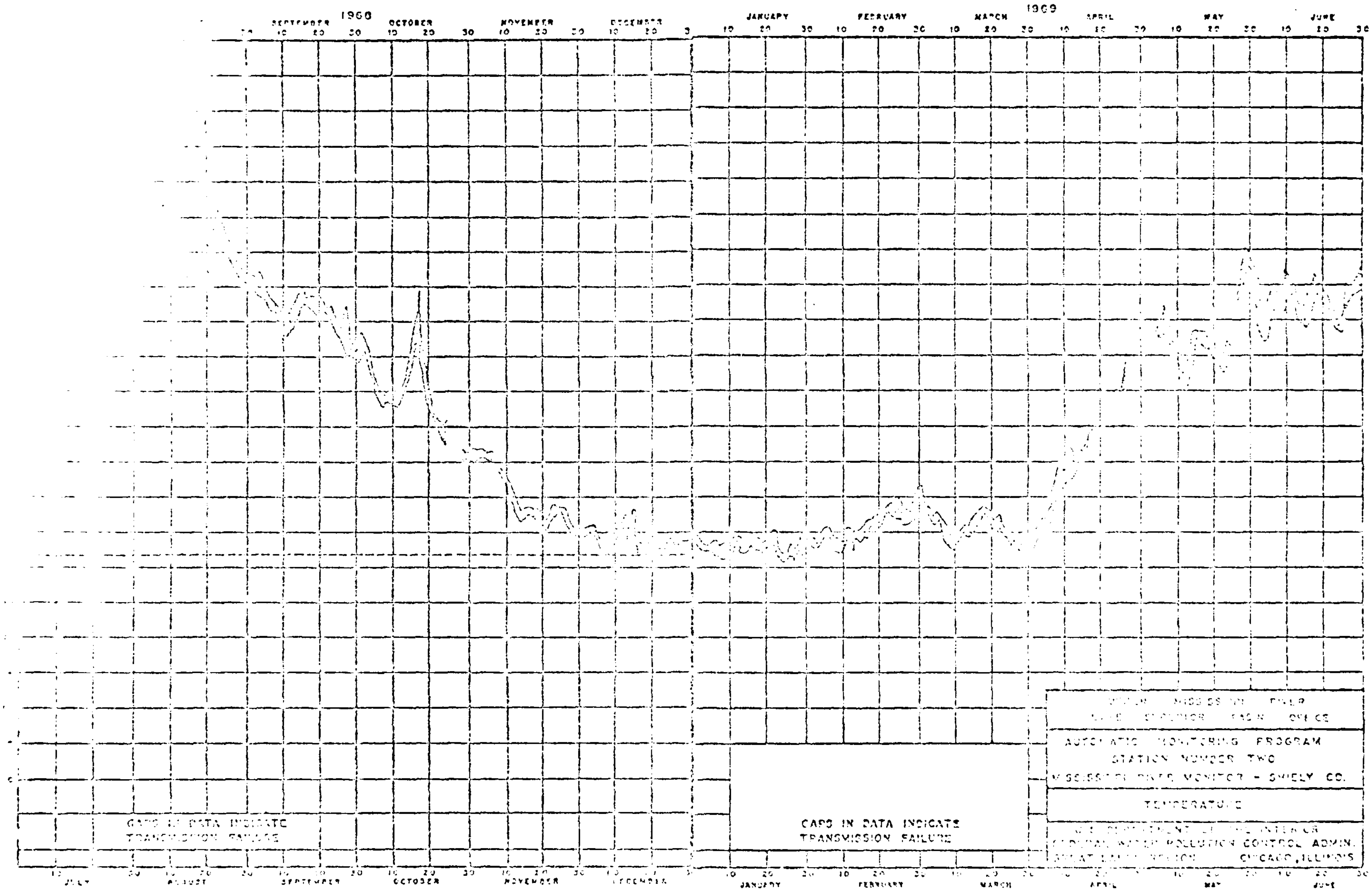


Figure 5. Temperature. Station 2. 1967 - 1969.



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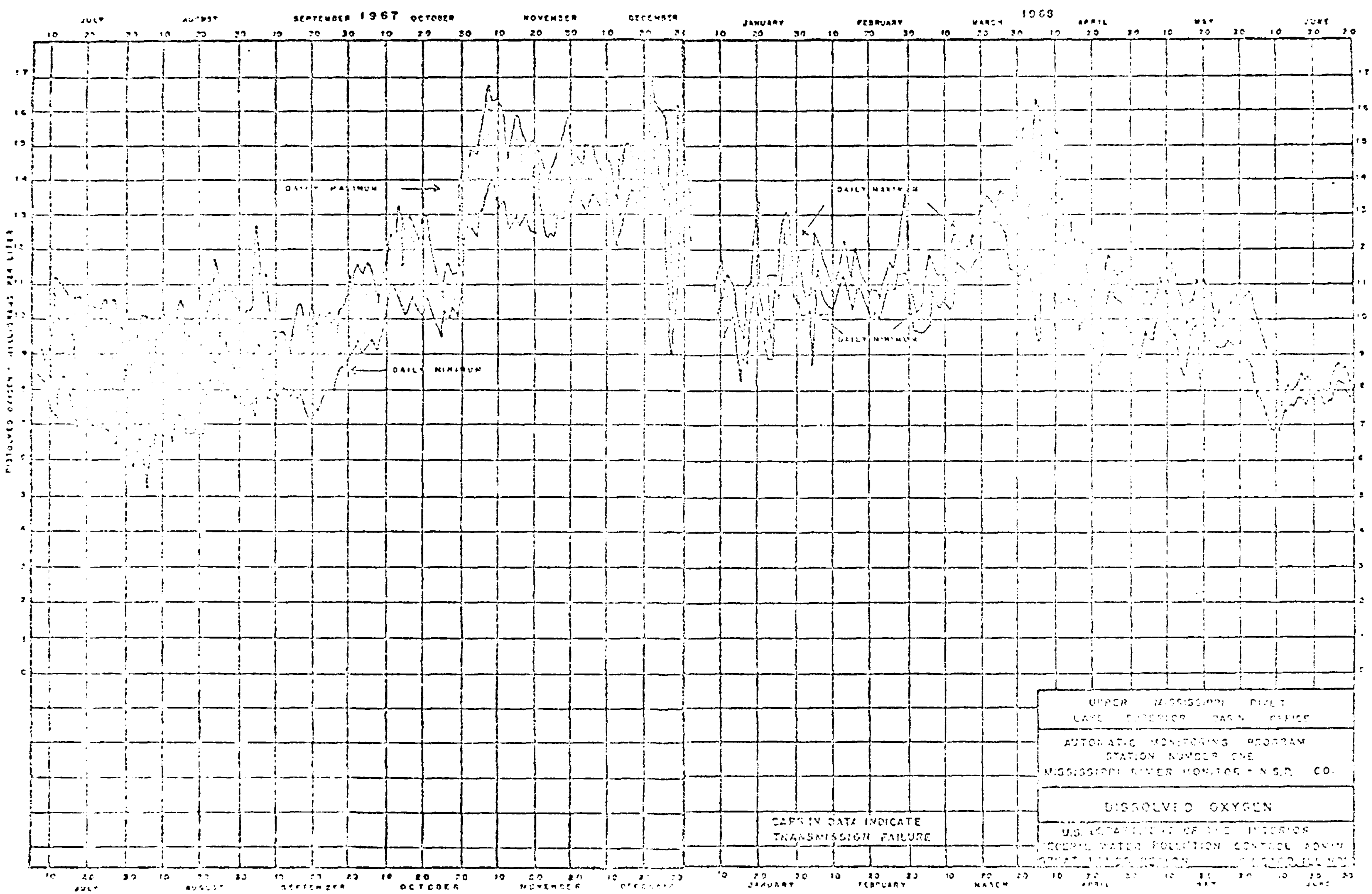
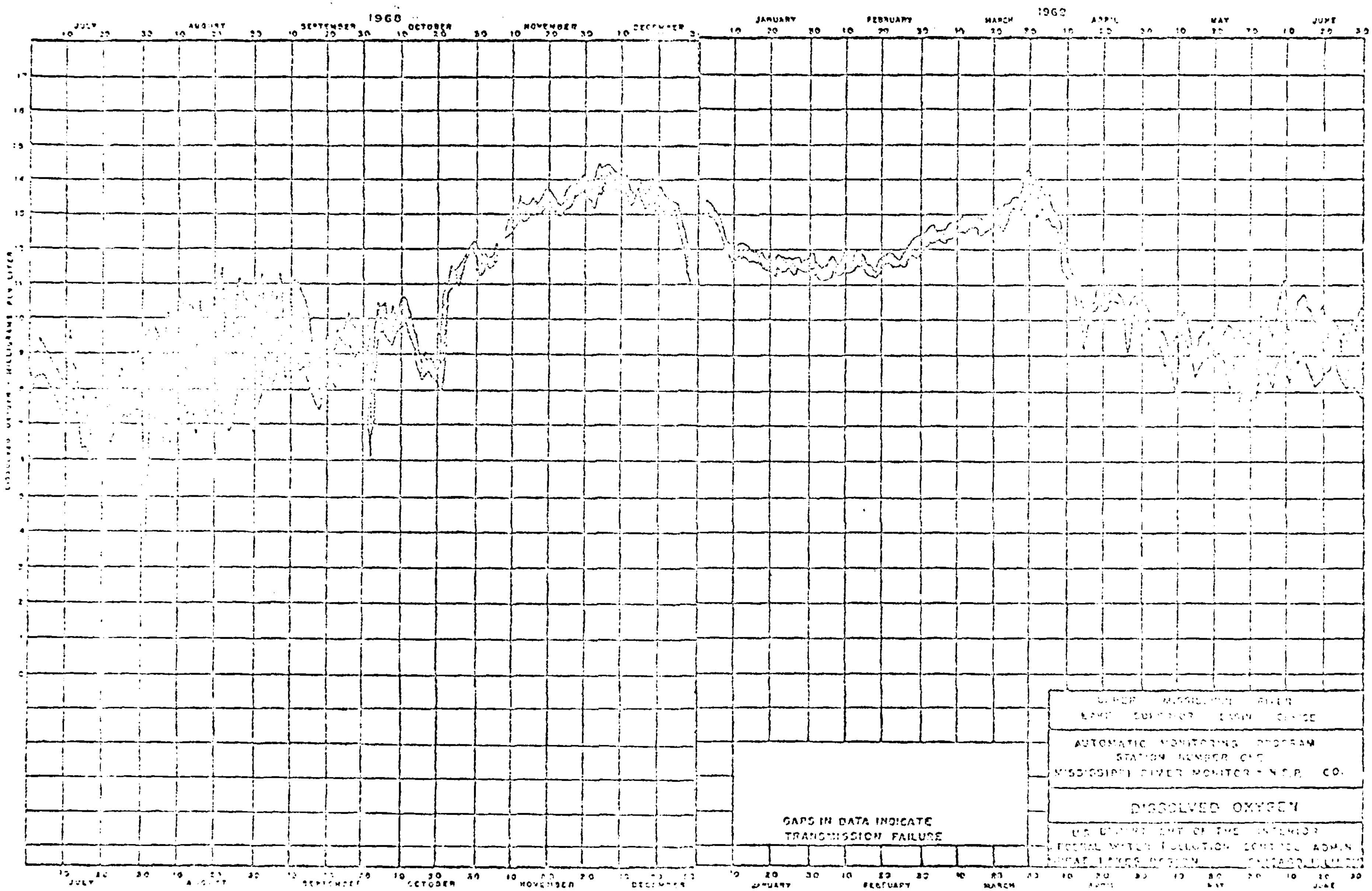


Figure 6. Dissolved Oxygen, Station 1. 1967 - 1969



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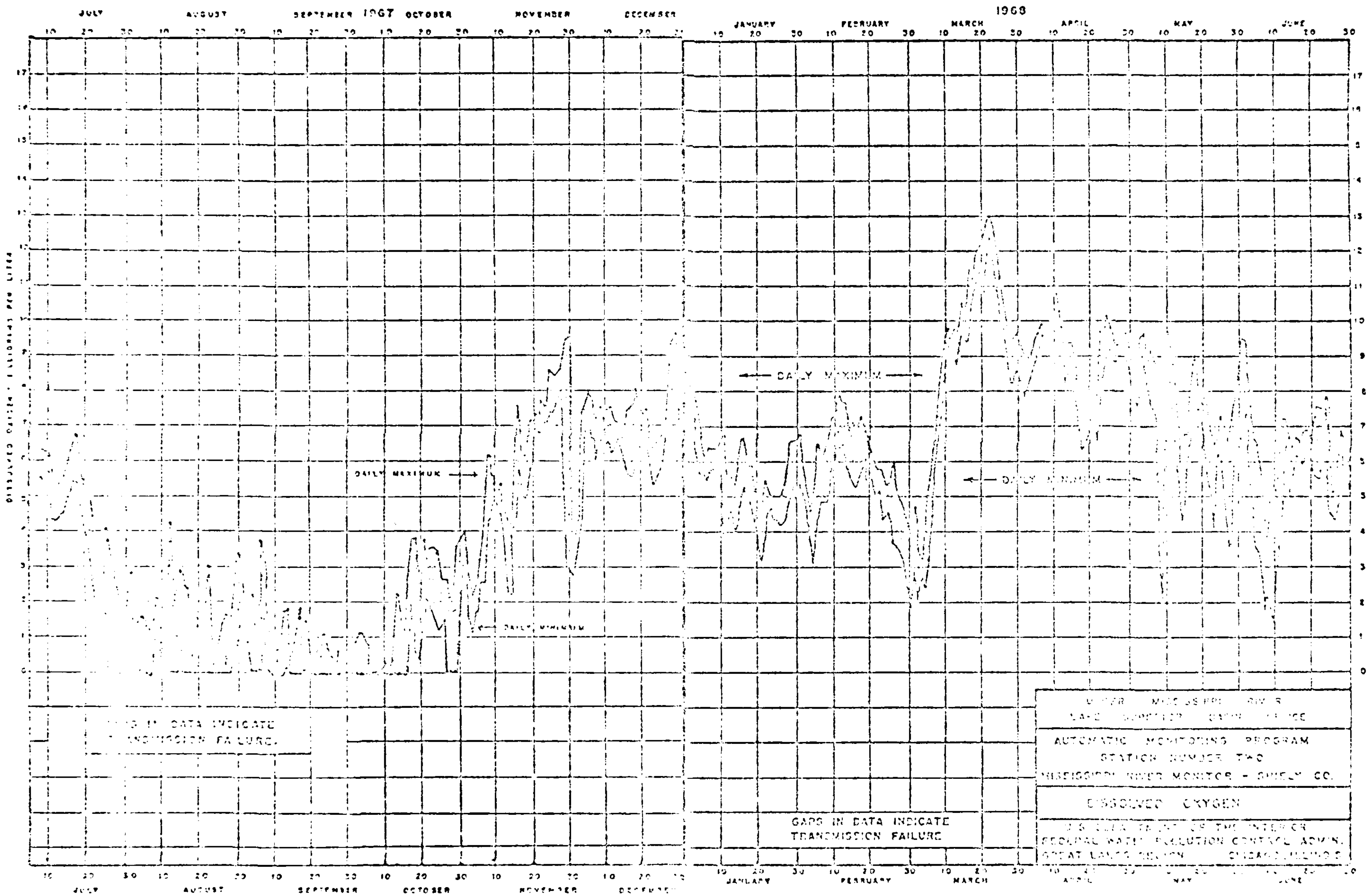
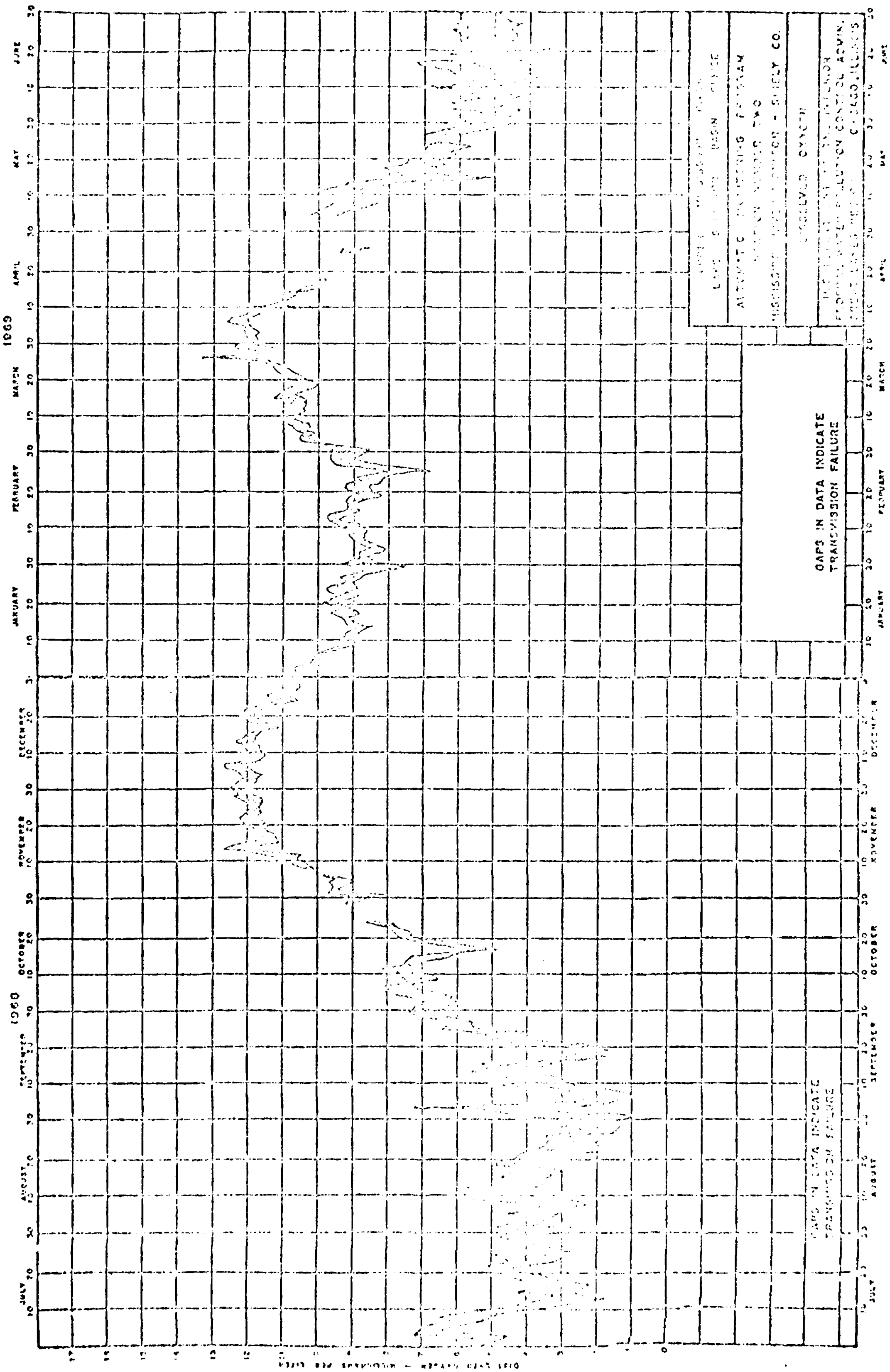


Figure 7. Dissolved Oxygen, Station 2. 1967 - 1969.



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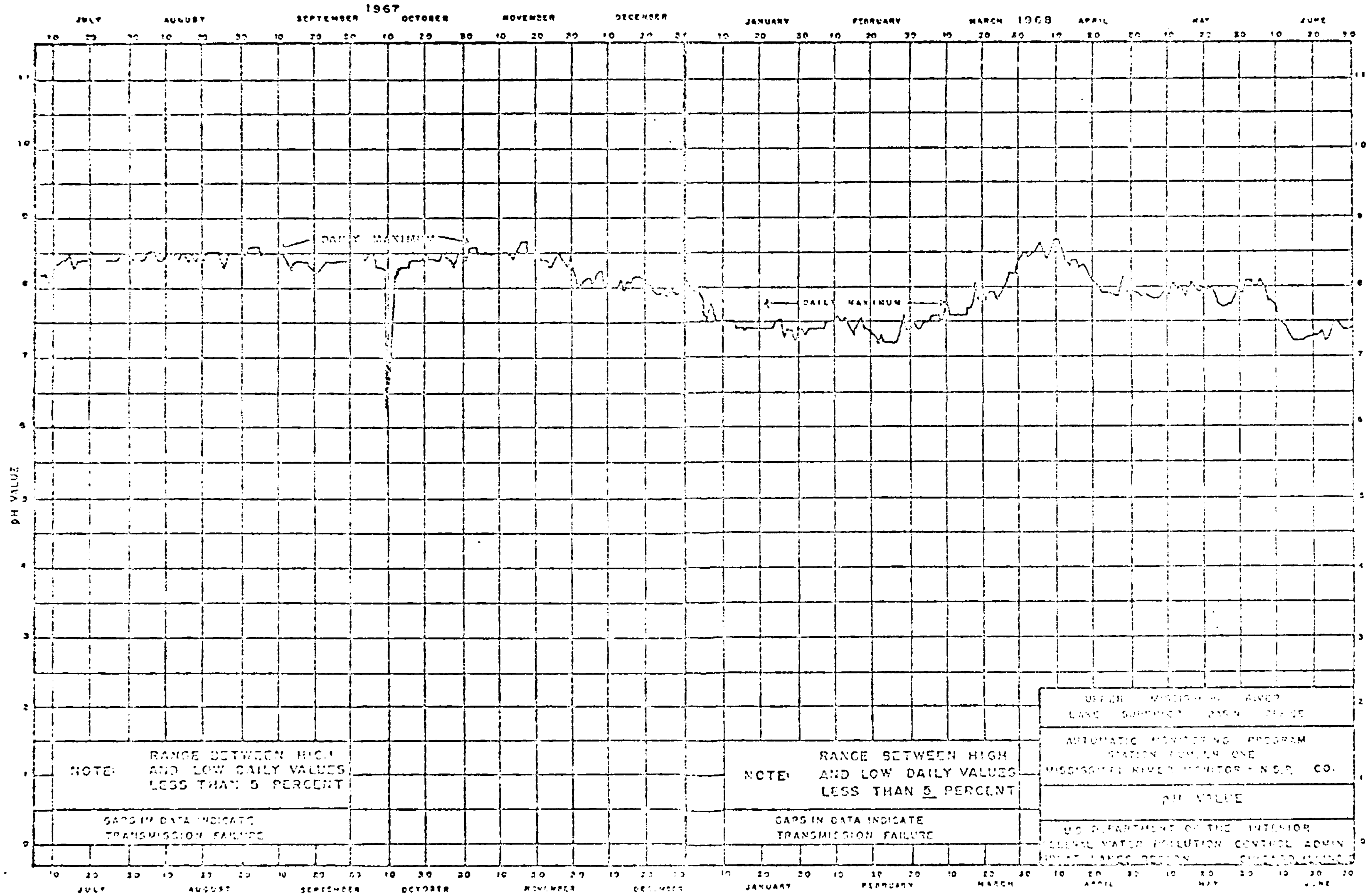


Figure 8. pH, Station 1. 1967 - 1969.

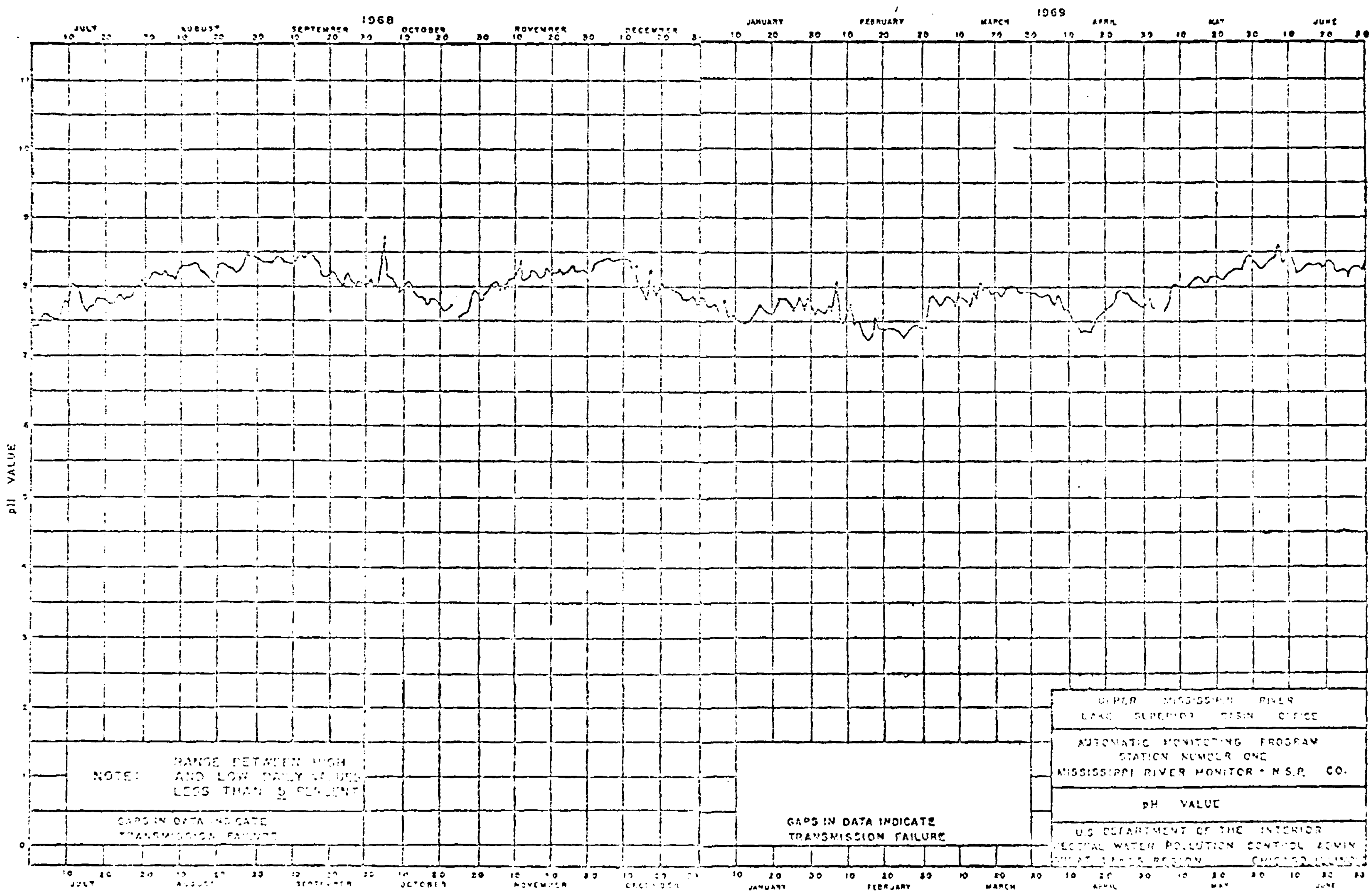


Figure 8 (Continued).

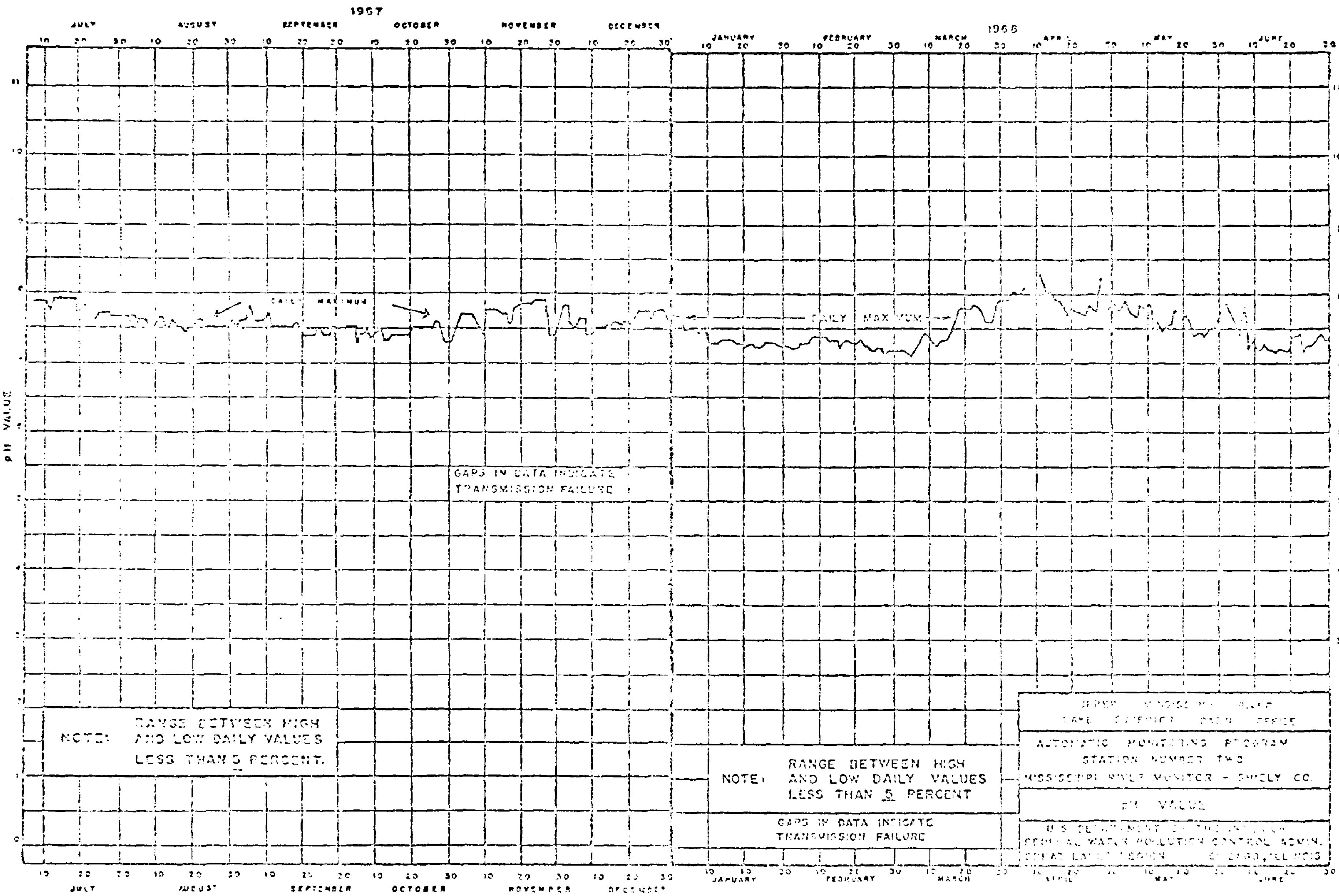


Figure 9. pH, Station 2. 1967 - 1969.

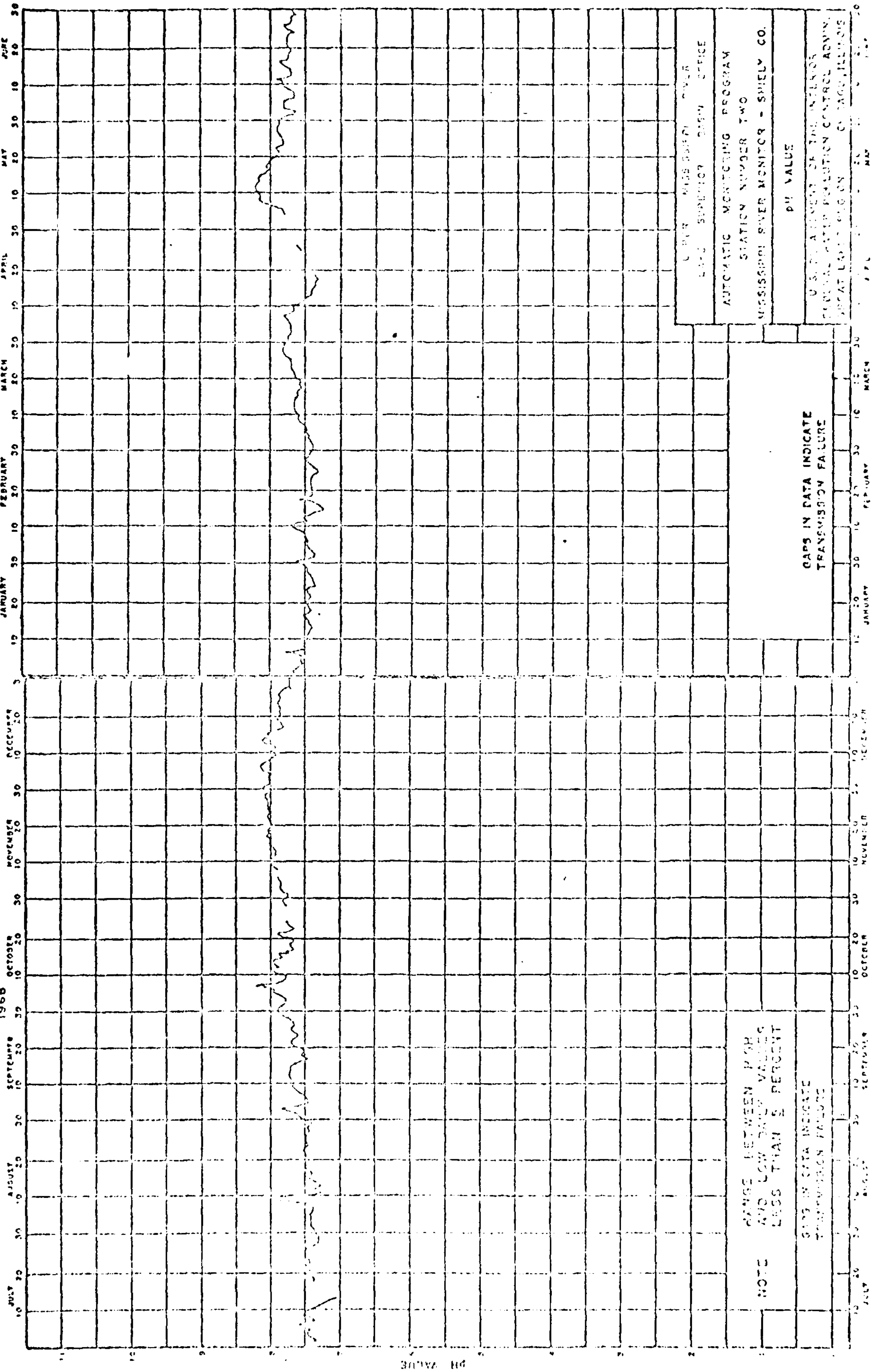


Figure 9 (Continued)

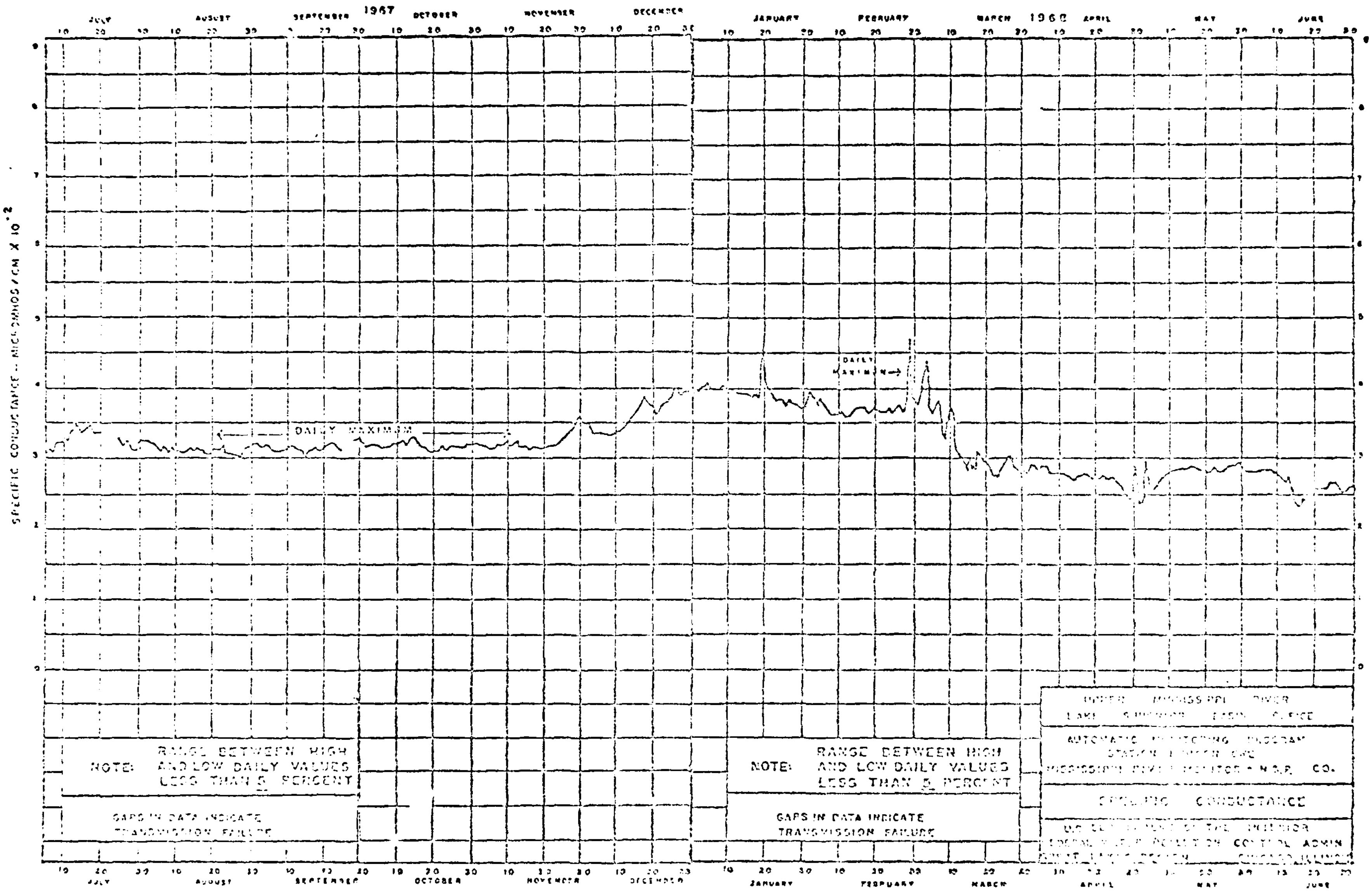
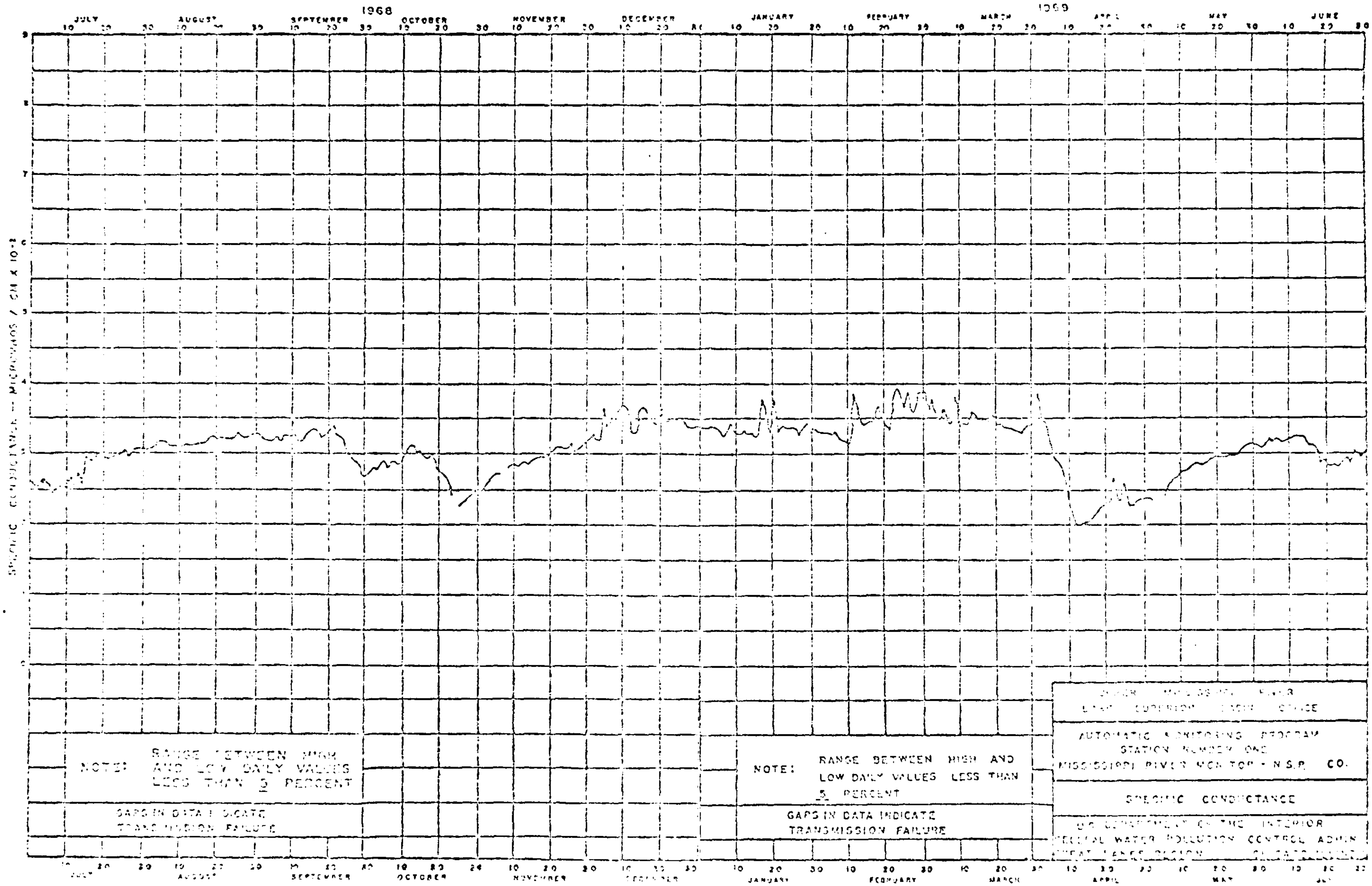


Figure 10. Conductivity, Station 1. 1967 - 1969.



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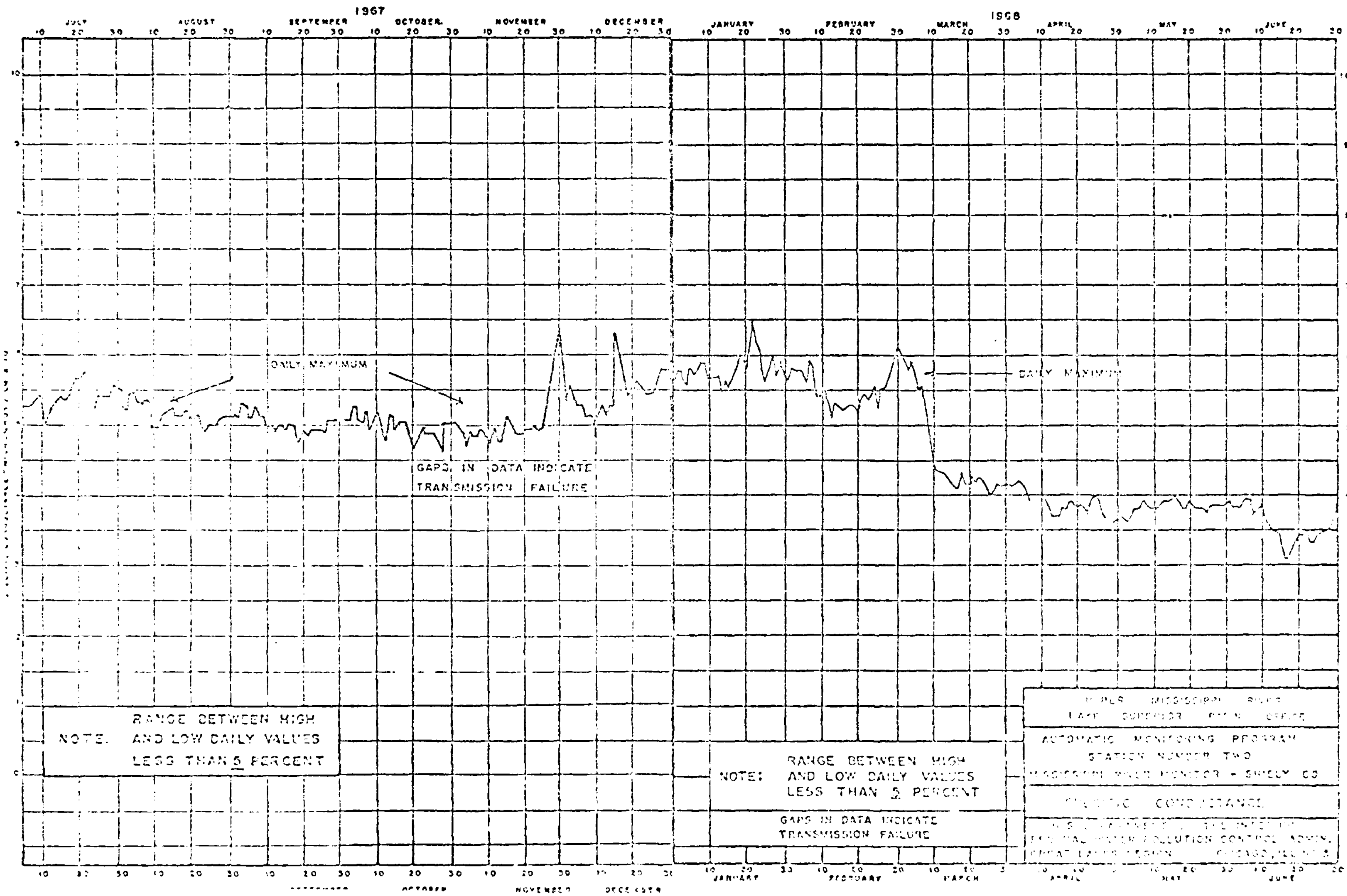

Figure 11. Conductivity, Station 2. 1967 - 1969.

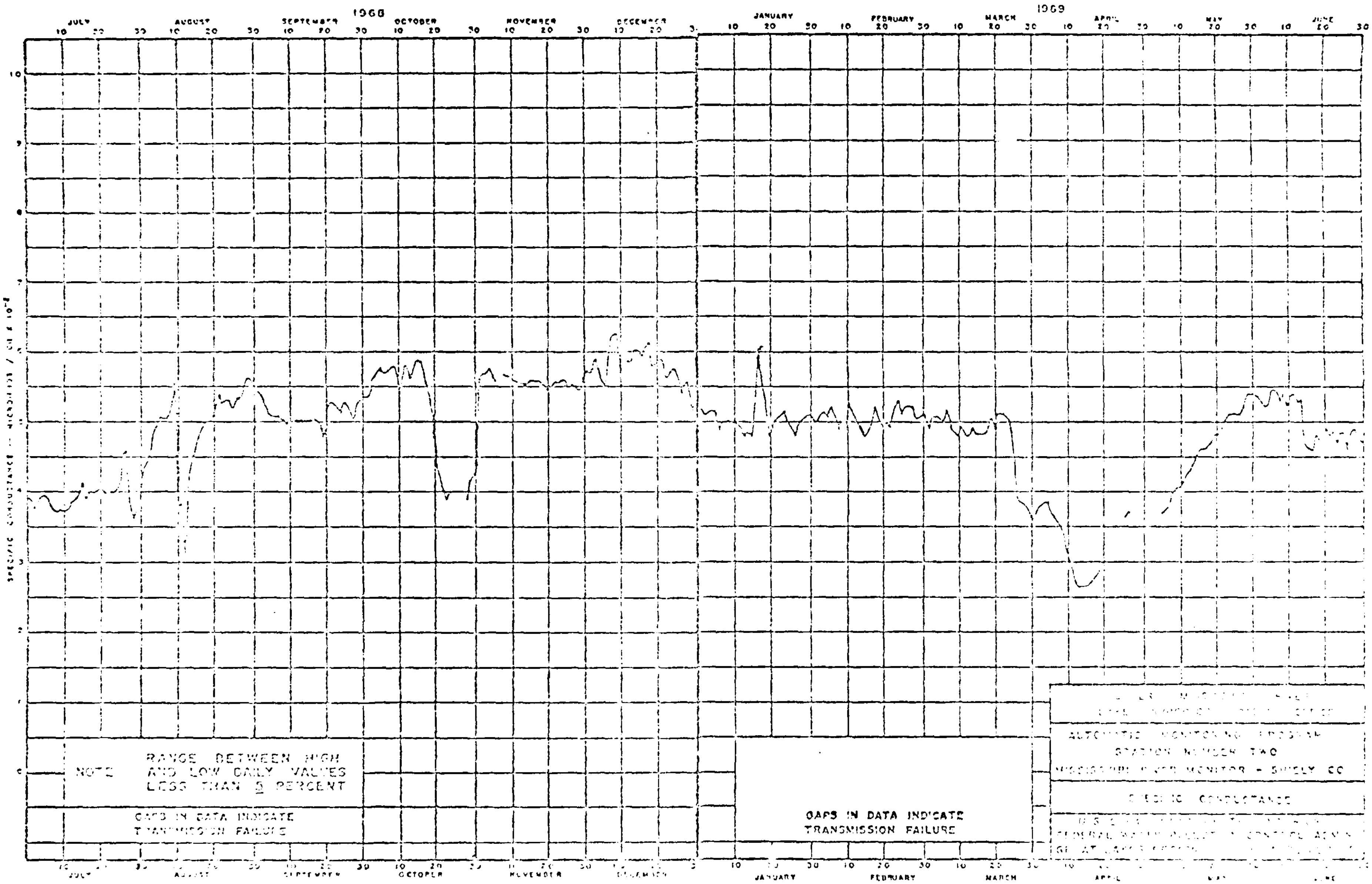

Figure 11 (Continued).

Glossary

acre-foot - the quantity of water required to cover an acre to a depth of 1 foot. It is equivalent to 43,560 cubic feet.

alluvial material - sediment, usually sand or silt, deposited on land by flowing water.

aerobic - an environment in which free oxygen is present.

anaerobic - an environment in which free oxygen is lacking.

aquifer - a water-bearing layer of porous rock, sand, or gravel.

backwaters - a term often divided now into sloughs and lakes and ponds adjoining a river.

benthic - pertaining to the bottom of a body of water.

benthic invertebrates - animals lacking a spinal column living in the benthic zone.

BSFW - Bureau of Sport Fisheries and Wildlife (U. S. Department of the Interior).

channel - a natural or artificial watercourse with definite bed and banks which confine and conduct flowing water.

cfs - cubic feet per second, used as a measure of rate of water flow in a river.

chute - sloping channel or passage through which water may pass.

closing dam - low dam extending across a side channel. These were constructed to divert water from side channels to the main channel during low water periods to maintain water sufficient for navigation.

coulee - steep-sided tributary valleys, commonly used in Wisconsin.

deciduous forest - forest dominated by broad-leaved trees which lose their leaves each Autumn.

discharge (rate of flow) - the quantity of water passing a point in a stream channel per unit of time, normally measured in cubic feet per second (cfs).

drainage area - the land area drained by a stream above a specified location on the stream. Measured in a horizontal plane, it is so enclosed by higher land (a divide) that direct surface runoff from precipitation normally drains by gravity into the stream above that point.

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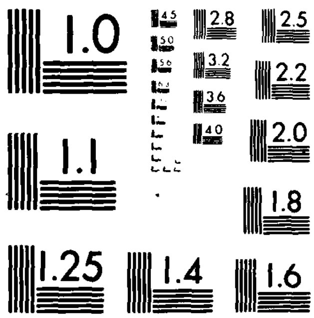

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drawdown - a process of lowering the water level of an impoundment.

Driftless Area - the portion of southwestern Wisconsin, southeastern Minnesota, northeastern Iowa and northwestern Illinois which was virtually untouched by the last advance of the Pleistocene glaciers (i.e., Wisconsin Glacier).

flood - a temporary rise in streamflow and water level (stage that results in significant adverse effects in the vicinity under study.

flood peak - the highest value of water level or streamflow attained by a flood.

floodplain - the relatively flat lowland adjoining a watercourse or other body of water subject to overflow therefrom.

FTU - Formazine Turbidity Units - arbitrarily defined units used as standard for measuring water turbidity, currently recommended by APHA, et al., 1971.

gaging station - a site on a stream, canal, lake or reservoir where systematic observations of water-surface elevation or streamflow (discharge) are obtained.

humus - the surface layer of soil combining partially decomposed organic matter and mineral particles.

JTU - Jackson Turbidity Unit - arbitrarily defined units used as a standard for measuring water turbidity.

lake and pond - open areas with little or no current. They are formed behind dams, or on mature floodplains as a result of first scour, then abandonment, by the lowered river.

littoral - the shore zone of a body of water.

macroinvertebrates - collectively, all invertebrate organisms visible with the unaided eye.

main channel - the portion of the river used for navigation by large commercial craft. A minimum depth of 9 feet and a minimum width of 200 - 400 feet were established by the lock and dam system and are maintained by periodic dredging.

main channel border - the water zone between the main channel boundary and the main river bank, islands, or now submerged channel boundaries. Wing dams are located in this zone.

mesic - a type of vegetation which develops under moderate moisture conditions.

moraine - an accumulation of earth and stones carried and finally deposited by a glacier.

MPN/1 - most probable number per liter - an estimate of bacterial abundance (See Methods, Appendix A1).

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.

10. APPENDIX B: ARCHAEOLOGICAL INFORMATION

A study conducted by University of Minnesota archaeologist Jan E. Streiff indicates that there are no records of archaeological sites within the St. Anthony Falls Pools. However, she reported that the Falls area is listed in the National Register of Historic Places. Her description follows:

> St. Anthony Falls Historic District and Pillsbury "A" Mill - an area on the east and west banks of the Mississippi River at St. Anthony Falls including Nicollet Island. The St. Anthony Falls district was the origin of the city of Minneapolis. The Falls area was rich in Indian folklore, before it was first seen and described in 1680 by Father Hennepin. The Falls, about 75 feet high and several hundred yards wide, were originally valued for their scenic beauty and the area became important as a tourist attraction. Later, the Falls provided power for lumbering and flour milling, and in 1882, became the location of the first hydroelectric plant in the Western Hemisphere. Construction of a concrete apron over the Falls to halt their once-rapid erosion generally diminished their scenic beauty. The Falls were bridged in the 1880's by a stone arch railroad bridge, still in constant use, which is said to resemble a Roman aqueduct. The lower lock and dam were completed in 1959 and the upper lock and dam in 1963 by the Corps of Engineers.
>
> Structures and sites considered worthy of preservation in the area include: Ard Codfrey Cottage, Lady of Lourdes Church, Nicollet Island, the Third Avenue Bridge, Stone Arch Bridge, and the Pillsbury "A" Mill, built in 1881, then the largest flour mill in the world, and still in operation today.

The Third Avenue Bridge was not altered to accommodate the navigation channel. A truss replaced two arches in the Stone Arch Railroad Bridge. This was necessary because the arches were narrow and aligned obliquely to the channel, providing insufficient clearance to commercial barge traffic. The truss has maintained the structural integrity of the Arch Bridge. The adverse impact of the truss upon the aesthetic appeal of the bridge could be ameliorated if the color of paint was changed from grey to a tan which would blend with the color of the stone.

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