US Army Corps
of Engineers®
St. Paul District

WATER CONTROL MANUAL

MISSISSIPPI RIVER NINE FOOT CHANNEL
NAVIGATION PROJECT

LOCK AND DAM NO. 1

MINNEAPOLIS, MINNESOTA

APPENDIX 1 OF THE MASTER WATER CONTROL MANUAL

UPDATED APRIL 2004

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LOCK AND DAM No. 1
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UPPER MISSISSIPPI RIVER BASIN
MISSISSIPPI RIVER – NINE FOOT CHANNEL
NAVIGATION PROJECT

APPENDIX No. 1
of the
MASTER WATER CONTROL MANUAL

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

APRIL 2004

Updated from
Reservoir Regulation Manual, September 1983
Operation of Navigation Pools, February 1943

LOCK AND DAM No. 1

MINNEAPOLIS, MINNESOTA

Aerial View Looking South – October 1995

Project Pool 723.1 feet (1912 Adjustment) with Rubber Bladder Deflated
Project Pool 725.1 feet (1912 Adjustment) with Rubber Bladder Inflated

LOCK AND DAM No. 1

MINNEAPOLIS, MINNESOTA

Lock and Dam No. 1 Control House

Riverward Lock Chamber and Miter Gates in Foreground

NOTICE TO USERS OF THIS MANUAL

This Water Control Manual complies with the latest US Army Corps of Engineers guidelines regarding management of water control systems and preparation of water control manuals. The St. Paul District prepared the *Preliminary Report on Operation of Navigation Pools* on 16 February 1943. This document provided the operational information for Lock and Dams 1 through 10. It was replaced by a Master Regulation Manual in September 1969. Appendices for most of the locks and dams were added during the years 1969 through 1972; however, Appendix No. 1 wasn't completed until September 1983. This manual is an update of Appendix No. 1. The manual is published in loose-leaf form to facilitate modifications. In the future, only those sections, or parts thereof, requiring changes will be revised and replaced.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise (e.g. gate failure, excessive rainfall), the Lockmaster, Area Lockmaster, and Water Control should be notified as to the extent of the event. During normal water control duty hours (i.e. 0630 to 1730 hrs weekdays and 0630 to 1030 hrs weekends and holidays), contact with water control can be made at 651-290-5624 or 651-290-5474. On weekends and holidays, the Mississippi River Duty Regulator Pager number can be used. If communication with Water Control cannot be established, the following list can be used as a guide for establishing contact.

Water Control Regulation Assistance		
Scott R. Bratten	Primary Mississippi River Regulator scott.r.bratten@usace.army.mil	Duty: 651-290-5624 [redacted]
Duty Regulator	Mississippi River Duty Regulator; Cellular Telephone and Fax	Cell: 651-260-9012 Fax: 651-290-5841
Dennis D. Holme	Physical Scientist dennis.d.holme@usace.army.mil	Duty: 651-290-5614 [redacted]
Theodore D. Petersen	Water Control Gage Crew theodore.d.pedersen@usace.army.mil	Duty: 651-290-5253 [redacted]
Ferris W. Chamberlin	Hydraulic Engineer ferris.w.chamberlin@usace.army.mil	Duty: 651-290-5619 [redacted]
Farley R. Haase	Hydrologic Technician farley.r.haase@usace.army.mil	Duty: 651-290-5633 [redacted]
Robert G. Engelstad	Chief, Water Control Section robert.g.engelstad@usace.army.mil	Duty: 651-290-5610 [redacted]
Michael R. Knoff	Chief, Hydraulics & Hydrology Br michael.r.knoff@usace.army.mil	Duty: 651-290-5600 [redacted]
John J. Bailen	Chief, Engineering Division john.j.bailen@usace.army.mil	Duty: 651-290-5303

Lock and Dam No. 1
Minneapolis, Minnesota

U.S. Army Corps of Engineers
St. Paul District – April 2004

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PERTINENT DATA

Location: Lock and Dam No. 1 is located on the Mississippi River, 847.6 river miles above the mouth of the Ohio River, 5.8 river miles below Lower St. Anthony Falls Lock and Dam, and 32.4 river miles above Lock and Dam No. 2. The lock is on the right bank of the river adjacent to the City of Minneapolis, MN at approximate latitude 44° 54' 54" N and longitude 93° 12' 6" W.

Drainage Area: 19,680 square miles

Datum: MSL - 1912 adjustment

Fixed Height Dam:

Type	Ambursen-type concrete structure
Length	574 feet
Crest Elevation	723.1 feet with bladder deflated 725.1 feet with bladder inflated
Stilling Basin Floor Elevation	693.6 feet
Height	29.5 feet
Sluiceways	8 @ 6 feet x 6 feet (plugged in 2003)
Inlet Invert Elevation	696.35 feet

Locks:

	Landward	Riverward
Chamber Dimensions	56 feet by 400 feet	56 feet by 400 feet
Top of Lock Walls	Elevation 732.7 feet	Elevation 732.7 feet
Top of Upper Gate Sill	Elevation 709.7 feet	Elevation 709.7 feet
Top of Lower Gate Sill	Elevation 677.2 feet	Elevation 679.7 feet
Lock Floor	Elevation 676.3 feet	Elevation 678.7 feet
Height of Upper Miter Gates	23.0 feet	23.0 feet
Height of Lower Miter Gates	55.5 feet	53.0 feet

Pool:

Normal (Project) Upper Pool	Elevation 723.1 feet (bladder deflated) Elevation 725.1 feet (bladder inflated)
Normal (Project) Lower Pool	Elevation 687.2 feet
Total Pool Area (at Project Pool)	525 acres

Power Plant:

Owner	Ford Motor Company
Total Horsepower Installed	23,200
Voltage	13,800
Average Daily Output (1994-2000)	266,600 KWH
MWH Generated to Date	~ 8 million
Hydraulic Capacity	7,000 cfs
Operation Hours	24 hours/day, 7 days/week

	Number	Type	Rating
Generators	4	Westinghouse	4,500 kVA
Turbines	4	Reaction	5,800 hp at 34 ft of head

I – INTRODUCTION

1-01. Authorization for Preparation of this Manual. Pursuant to the instructions from the Chief of Engineers dated 15 May 1942 and 29 August 1942, subject "Operation of Flood Control and Multiple-Purpose Reservoirs", the methods and technique used in operating the navigation pools on the Mississippi River in the St. Paul District was documented in February 1943. Authority to prepare regulation manuals for the locks and dams was granted by Engineering Regulation (ER) 1110-2-240, *Reservoir Regulation*, 1958. While ER 1110-2-240 has been updated and amended many times since the date of issuance, the document continues to give the Corps of Engineers authority to prepare what became known as "Water Control Manuals" by ER 1110-2-240, *Water Control Management*, 1982. This manual supercedes Lock and Dam 1 Regulation Manual dated December 1971 and was prepared in compliance with the guidelines presented in:

a. Engineering Regulation, ER 1110-2-240, *Water Control Management*, 8 October 1982, amended 30 April 1987 and 1 March 1994.
b. Engineering Manual, EM 1110-2-3600, *Management of Water Control Systems*, 30 November 1987.
c. Division Regulation, DIVR 1110-2-240, *Water Control Management, Preparation of Water Control Plans and Manuals*, 1 January 1992.
d. Engineering Regulation, ER 1110-2-8156, *Preparation of Water Control Manuals*, 31 August 1995.

1-02. Purpose and Scope. The purpose of this manual is to provide guidance and instruction for project personnel and to serve as a reference source for others who may be involved with the regulation of this project. The manual is for daily use in Water Control Section activities for most foreseeable conditions and occurrences. The manual covers all water control management activities as they relate to the hydraulic and hydrologic aspects of the project.

1-03. Related Manuals and Reports. The Upper Mississippi River Lock and Dam system was authorized when Congress approved the nine-foot channel on 3 July 1930. A general scheme of operation was developed on 28 March 1935. The following is a list of related Manuals and Reports in chronological order.

a. *Survey of Mississippi River Between Missouri River and Minneapolis,* Letter from The Secretary of War, 72 Congress, 1st Session, House Document No. 137, Part 1 – Report, 9 December 1931.
b. *Report on General Scheme of Operation for the Dams of the 9-Foot Channel Project*, by J. A. Grant, Senior Engineer, War Department, Office of the Chief of Engineers, 28 March 1935.
c. *Preliminary Report on Operation of Navigation Pools,* War Department, US Engineer Office, St. Paul District, St. Paul, Minnesota, 16 February 1943.
d. *Master Regulation Manual for Mississippi River Nine-Foot Channel Navigation Projects*, US Army Corps of Engineers, St. Paul District, September 1969.
e. *Mississippi River Nine-Foot Channel Navigation Project, Reservoir Regulation Manual, Appendix 1, Lock and Dam No. 1, Minneapolis, Minnesota,* US Army Corps of Engineers, St. Paul District, September 1983.
f. *Creativity, Conflict & Controversy: A History of the St. Paul District, US Army Corps of Engineers,* by Raymond H Merritt, 1979.
g. *Upper Mississippi River, Land Use Allocation Plan*, Master Plan for Public Use Development and Resource Management, Part I and Part II, US Army Corps of Engineers, St. Paul District, September 1983.
h. *Emergency Plan for Lock and Dam 1, Minneapolis, Minnesota*, US Army Corps of Engineers, St. Paul District, March 1987.
i. *Commerce and Conservation on the Upper Mississippi River*, by John O. Anfinson, District Historian, US Army Corps of Engineers, St. Paul District, St. Paul Minnesota, 1990.
j. *Gateways to Commerce*, The US Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River, National Park Service, Rocky Mountain Region, 1992.
k. *Authorized and Operating Purposes of Corps of Engineers Reservoirs,* US Army Corps of Engineers, Washington D. C., July 1992.
l. *Sluiceways Repair Report – Lock and Dam No. 1 Mississippi River,* Stanley Consultants, January 1993.
m. *Channel Maintenance Management Plan*, Upper Mississippi River Navigation System, US Army Corps of Engineers, St. Paul District, 1996.
n. *Channel Maintenance Management Plan, Final Environmental Impact Statement (FEIS),* Lead Agency US Army Corps of Engineers, St. Paul District, Volumes I and II, 6 June 1997.
o. *Record of Decision (ROD) for Final Environmental Impact Statement, Channel Maintenance Management Plan,* Major General Robert B. Flowers, Commander and Division Engineer, Mississippi Valley Division, US Army Corps of Engineers, June 1997.
p. *Zebra Mussel Response Plan*, Environmental Section, US Army Corps of Engineers, St. Paul District, November 1997.
q. *Locks and Dams Sounding Reports, Volume 2,* US Army Corps of Engineers, St. Paul District, 1999.

r. *Pool Lowering at Lock and Dam 1 Using the Lock Filling and Emptying System Mississippi River, Minnesota*, Engineering Research and Development Center, ERDC/CHL, TR-01-8, May 2001.
s. *2001 Annual Report – Water Quality Management Program*, US Army Corps of Engineers, St. Paul District, January 2002.
t. *Locks and Dams Sounding Reports*, US Army Corps of Engineers, St. Paul District, 2002.
u. *Ambursen Dam Sluiceways Feasibility Report*, Lock and Dam No. 1, Mississippi River, Minneapolis and St. Paul Minnesota, US Army Corps of Engineers, St. Paul District, July 2003.

1-04. Project Owner. The United States Government is the owner of Lock and Dam No. 1. Ford Motor Company is the owner of the powerhouse.

1-05. Operating Agency. Lock and Dam No. 1 is operated and maintained by the US Army Corps of Engineers, St. Paul District, Construction and Operations (Con-Ops) Division. The powerhouse is operated and maintained by Ford Motor Company.

1-06. Regulating Agency. Regulation of Lock and Dam No. 1 is conducted by the Ford Motor Company as stated in the FERC License No. 362 (**Exhibit B**) and is under the supervision of the Water Control Section as by the following command structure. Ford Motor Company is responsible for the regulation of flows through the powerhouse for flows less than the powerhouse capacity (approximately 7,000 cfs) and for raising and lowering of the inflatable rubber bladder flashboard system mounted atop the crest of the dam. Flows in excess of the powerhouse capacity are spilled over the dam and are essentially unregulated. The Ford powerhouse is attended 24 hours a day, every day of the year. A powerhouse operator can be contacted by telephone at 651-696-0502.

II – DESCRIPTION OF PROJECT

2-01. Location. Lock and Dam No. 1 is located on the Mississippi River, 847.6 river miles above the mouth of the Ohio River, 5.8 river miles below Lower Saint Anthony Fall Lock and Dam, and 32.4 river miles above Lock and Dam No. 2. The lock is on the right bank of the river adjacent to the city of Minneapolis, Minnesota at approximate latitude 44° 54' 54" N and longitude 93° 12' 6" W. The City of St. Paul is on the opposite side of the river. The project is bordered by Hennepin County on the Minneapolis side and Ramsey County on the St. Paul side. The project location is shown on **Plate 2-1** and **5-1**. The navigation channel is shown on **Plates 2-4** and **2-5**.

2-02. Purpose. Lock and Dam No. 1 is a unit of the Inland Waterway Navigation System of the Upper Mississippi River Basin. The system includes 29 locks and dams, which provide a "stairway of water" from Minneapolis, Minnesota to St. Louis, Missouri. The primary purpose of the dams is to maintain a depth of nine feet for navigation. The authorized purposes for Lock and Dam No. 1 are navigation under the River and Harbors Act of 1930 (PL 71-250) and recreation under the Flood Control Act of 1944 (PL 78-534). Facilities are provided for recreation but water is not controlled for that purpose.

A secondary purpose for Lock and Dam No. 1 is power generation. Under the River and Harbors Act of 1910, the original design lift of 13.3 feet was increased to about 30 feet for the purpose developing hydroelectric power. Ford Motor Company owns and operates the powerhouse located at the east end of the dam. Total potential power output is 16 MW.

2-03. Physical Components. Lock and Dam No. 1 consists of a landward and riverward lock, an Ambursen-type dam section, and a powerhouse (**Figure 2-1**). The riverward lock wall and a portion of the dam and apron are supported on timber piling driven into sand and gravel. The dam and portions of powerhouse and lock have sheet pile cutoff walls.

Figure 2-1. Lock and Dam No. 1 – 1996

a. Lock. Lock and Dam No. 1 has a landward and riverward lock (**Plate 2-1**). The upper and lower miter gates of the landward lock have a height of 23.0 feet and 55.5 feet, respectively. The respective sill elevations are 709.7 feet and 677.2 feet (1912 adjustment). The upper and lower miter gates on the riverward lock have a height of 23 feet and 53.0 feet, respectively. The respective sill elevations are 709.7 feet and 679.7 feet. Assuming a normal pool elevation of 687.2 feet in Pool No. 2, the water depth over the lower miter gate sill would be 10.0 feet for the landward lock and for the riverward lock it would be 7.5 feet. A walkway is located atop the miter gates and it meets the top of the lock walls at elevation 732.7 feet.

Both locks are 56 feet wide with a clear length of 400 feet. Filling and emptying of the landward lock chamber is controlled by reverse tainter valves; two at the upstream (upper) end of the lock and two at the downstream (lower) end. The riverward lock is similar except filling and emptying is controlled by Stoney gate valves. During the filling or emptying process, the miter gates are closed thus sealing the lock chamber. For a filling operation of the landward lock, the upper tainter valves are opened allowing flow to enter the culverts (**Plate 2-2**, Section B-B). Flow then enters the lock chamber through ports along the lock wall (Section X-X) and the water level in the lock chamber rises until it equals the pool elevation. The upper tainter valves are then closed and the lower tainter valves are opened thus emptying the lock chamber. Under normal conditions, filling and emptying times are about twelve minutes.

Recesses have been provided in the lock wall of the landward lock so that bulkheads may be inserted, and the lock chamber may be de-watered if repairs or inspections are required. Installation of the bulkheads can be accomplished by floating plant or by equipment from shore. As for the riverward lock, recesses were provided in the upper section of the lock chamber allowing the upper gate and culvert intakes to be de-watered. In the lower section of the lock chamber, recesses are also provided so the lower gate and the discharge laterals can be de-watered.

Guide walls are located upstream and downstream of the landward lock to provide a landing for down bound and up bound tows (**Plate 2-1**). The upper guide wall extends 620 feet upstream and the lower guide wall extends 340 feet downstream.

b. Dam. The dam is a hollow concrete Ambursen-type overflow structure that has an ogee-type crest at elevation 723.1 feet (1912 adjustment) and extends from the riverward lock to the power house (see **Plate 2-1**). A small ice sluice is located at the eastern end of the spillway next to the powerhouse. This structure permits ice and other floating material that is deflected around the powerhouse intake to pass over the dam. The dam is mostly supported by alluvial deposits, however a portion of the dam and apron are supported by timber piling. A steel sheet pile cutoff wall is located along the upstream face of the dam. A row of steel sheet piling is located along the toe of the apron as a preventative measure against scour. A baffle wall was constructed on the apron to induce a hydraulic jump to overcome potential scour below the dam. Sand was added within the dam to increase stability.

There were eight 6-foot by 6-foot concrete sluiceways designed to release water through the dam. At the upstream (intake) end of the sluiceways were rectangular steel sluice valves (gates) that were designed to slide up and down the inclined dam surface. **Figure 2-2** shows the original drive system within the dam used to operate the sluice gates. The sluiceways were plugged with concrete FY 2004.

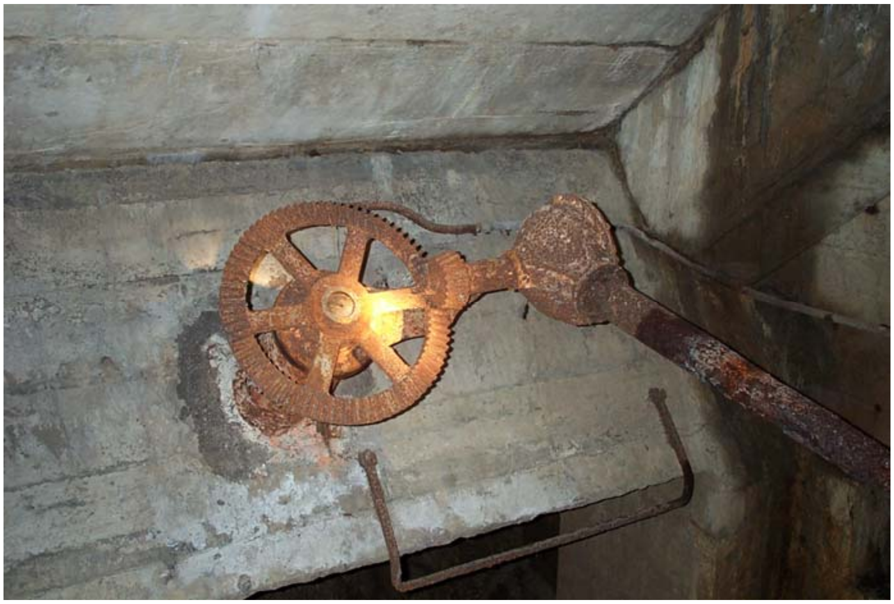

Figure 2-2. Original Sluice Gate Operating Equipment.

Across the top of the dam are two Kevlar coated inflatable rubber bladders separated by a central pier. This comprises the “flashboard system” for the powerhouse. Blowers and operating controls for the flashboard system are located near the spillway in the lower powerhouse level. When fully inflated the crest is at elevation 725.3 feet. **Figure 2-3** shows the both bladders in the inflated position.

Figure 2-3. Dam and Powerhouse. Bladders Inflated.

c. Powerhouse. The powerhouse is located at the east end of the dam as shown in **Plate 2-1**. It is owned and operated by Ford Motor Company under Federal Energy Regulatory Commission (FERC) License No. 362. The powerhouse is a concrete, steel and masonry structure. The powerhouse is 156-feet long by 112-feet wide with a total height of 116 feet. The powerhouse substructure consists of a steel frame building with masonry walls which shelter the intake area, generators, controls, electrical gear, and operating facilities. The concrete substructure includes the intake works, turbine pits, draft tubes, supporting walls and main generator floor. The landward portion of the powerhouse is founded in sandstone bedrock while the riverward portion is supported by timber piles driven through the alluvium to the underlying sandstone bedrock. A steel sheet pile cutoff wall prevents the portion of the powerhouse not bearing directly on bedrock from undermining.

Four identical turbine generator units are located in the powerhouse. The vertical axis Francis-type turbines were manufactured by Wellman-Seaver-Morgan. The badly worn original Francis runners were replaced in the 1990's with modern stainless steel runners manufactured by Voith Hydro. After the installation of the new runners, the turbines were up-rated from 4,500 hp to 5,800 hp at a flow of 1,750 cfs and a net head of 34 feet. The 13.8 kV, 60 Hz, three-phase generators were manufactured by Westinghouse and are rated at 4,500 kVA (**Figure 2-4**). Each unit has a hydraulic governor manufactured by Woodward Governor. Total maximum output is 14,400 kW. Total gross energy generated by the facility in the year 2000 was 101 million kWh. The hydraulic capacity of the powerhouse is 7,000 cfs, which the river exceeds approximately 40 percent of the time. There is no outside substation, switchyard or transmission line associated with the powerhouse. Power is routed through cable tunnels to the Ford Assembly Plant located on the bluff above the powerhouse. Another cable tunnel connects to a utility substation along Ford Parkway.

Figure 2-4. Westinghouse Generator Unit No. 1

The FERC license requires the Ford Motor Company to furnish free electricity to Lock and Dam No. 1. This was originally accomplished with electrical distribution cables running from the powerhouse, through the dam, to the lock area. When the increased power needs of the lock and dam exceeded the capacity of the distribution system, it was agreed that that the Corps would receive its power from Xcel Energy Corporation on the lock side of the river and Ford Motor Company would pay the bill.

d. Channel Protection. The majority of the structural components of Lock and Dam No. 1 are founded directly on bedrock. This reduced the need for large amounts of rock that are more typical of other District locks and dams on the Upper Mississippi River. Scour upstream of the dam is not a concern; in fact sedimentation appears to be occurring. **Plate 2-3** shows six transects upstream of the dam, all of which show approximately 10-15 feet of sediment deposition above the original upstream channel elevation. Scour downstream of the dam was a concern until 1953, when a large portion of the dam apron was replaced and a baffle wall was constructed to induce a hydraulic jump. The following gives a description of the riprap protection near the dam, locks and guide walls, and powerhouse.

(1) Dam. Downstream protection originally consisted of rockfill extending approximately 30 feet downstream of the concrete apron. This rockfill has a top elevation ranging from 692.6 feet at the apron to 687.2 feet at the downstream end. There was no original scour protection upstream of the dam.

(2) Lock and Guide Walls. The original design of both locks had minimal scour protection because most of the structural components are founded on rock. The landward lock and guide wall was constructed without any rock protection. The riverward lock was founded partially on rock and partially on piles driven into alluvial deposits. Original scour protection consisted of a 48-inch thick section of derrick stone placed on the downstream side at the outlet of the discharge culvert on the riverward wall and on the riverward side of the downstream riverward guide wall. The riverward guide wall failed in 1950 and was replaced with a rock paved earth dike.

Scour protection for the downstream guide wall of the landward lock was constructed in 1950 after the riverward downstream guide wall failed. It consisted of a 20-foot wide concrete slab adjacent to the rock filled cribs at the base of the guide wall. The slab was a minimum of 12-inches thick with a top elevation of 676.0 feet at the rock filled crib down to 674.4 feet in the channel. Riprap was placed downstream of the end of the lower guide wall at the base of the crib wall for a distance of 1200 feet in the 1950's. This protection consisted of an upper section with a 24-inch thick riprap section placed on 6-inches of gravel and a lower section of 24 inches of rock on a brush mat.

In the early 1980's, additional rock protection was placed downstream of the lower guide wall. This consisted of a rockfill wedge at the base of the crib wall with a 1V:2H slope toward the channel. The rockfill wedge extended for a distance of 90 feet downstream of the lower guide wall and had a top elevation of 696.0 feet.

Additional bank protection in the form of a sheetpile wall was constructed upstream of the upper guide wall in the late 1970's. This wall tied to the upstream end of the upper guide wall and extended 280 feet upstream. Excessive dredging adjacent to the sheetpile wall in the late 1970's caused undermining of the wall. Rock was placed at the base of the wall to remedy this. No details are available for this rock placement.

In the 1980's, the rehabilitation of Lock and Dam No. 1 resulted in a new intake manifold section at the upstream section of the landward lock and a new discharge laterals section at the downstream end of the landward lock. Additional scour protection was added during this rehabilitation. It consisted of a new sheetpile cutoff wall near the upstream end of the new intake manifolds section and a rock section with top elevation 706.7 feet placed upstream of the end of the concrete slab.

(3) Powerhouse. Channel and bank protection for the powerhouse is the responsibility of Ford Motor Company. Therefore, no specific information is available. However, it is known that in 1988 riprap was placed along the bank downstream of the east tailrace retaining wall to control erosion.

2-04. Related Control Facilities. There are no related control facilities in Pool No. 1.

2-05. Real Estate Acquisition. In Pool No. 1, approximately 33 acres are held in fee by the US Government. Of this total, 13.6 acres are utilized for project operations by the Corps and 2.4 acres are leased to the Ford Motor Company.

Table 2-1
Land Purchased in Fee and Easements (Acres)

County	Hennepin	Ramsey	Totals
Fee	23.73	9.05	32.78
Easement	194.24	69.42	263.66

2-06. Public Facilities. Major rehabilitation of the project was completed in 1984. This included a new Central Control Station and public facilities. As part of the public facilities a visitor center was constructed. The tour is self-guided and includes several pictorial descriptions of the operation of the lock and dam. From the second story, the lockage of a towboat or recreation craft can be witnessed. An elevated walkway provides access to the intermediate lock wall. **Figure 2-5** shows the visitor center.

Figure 2-5. Lock and Dam No. 1 Visitor Center.

In addition to the facilities at the Lock and Dam, additional recreational facilities located along the pool. **Table 2-2** shows a list of the facilities located in Pool No. 1 on the Mississippi River.

Table 2-2
Recreation Facilities on the Mississippi River

River Mile	Name	Manager	Parking	Camp Sites	Toilets	Picnic Tables
852.1 LR	River Flats Regional Parks	Minneapolis	40	No	No	No
849.9 LR	Minneapolis Rowing Club	Minneapolis	0	No	No	No

III – HISTORY OF PROJECT

3-01. Authorization. The Lock and Dam No. 1 project was originally authorized under the Rivers and Harbors Act of 18 August 1894. The design of Lock and Dam No. 1 was subsequently modified by the Rivers and Harbors Act of 25 June 1910, which changed the design lift from 13.3 feet to about 30 feet for the purpose of developing hydroelectric power at the site as well as providing for a nine-foot channel at the then head of navigation in Minneapolis, Minnesota. When the lower gate of the lock collapsed on 19 August 1929, navigation ceased on that portion of the river for just over a year. Due to the collapse, it was decided that twin locks would replace the single lock so that navigation would never be disrupted. A second lock was authorized on 3 July 1930 when the 71^{st} Congress, second session, passed an act that modified the existing six-foot channel project in accordance with the plan for a comprehensive project to procure a channel of nine-foot depth, submitted in House Document No. 290. The nine-foot channel was to be achieved by construction of a system of locks and dams, supplemented by dredging.

3-02. Planning and Design. Minneapolis and St. Paul had begun exploiting its river connection early and had become prosperous by the Civil War. St. Paul, a busy port, was the Mississippi's head of navigation. Minneapolis, first noted as the region's premier lumber-milling city, had become the nation's leading flour-milling center by 1880. Each city jealously guarded its tie to the river and tried to capture its neighbor's. In Minneapolis, civic and commercial boosters yearned to make their city the head of navigation. They raised funds in the 1850's to remove boulders and other obstacles to improve navigation. By 1852 they had begun discussing a lock and dam for the river above St. Paul. In 1855 the *St. Anthony Express* proposed building two locks and dams; one downstream of St. Anthony Falls and the other at Meeker Island about 3.5 miles downstream.

Bradley B. Meeker, a territorial judge, organized a group of Minneapolis businessmen to form the Mississippi River Improvement and Manufacturing

Company, which obtained permission from the territorial legislature in 1857 to construct a lock and dam below St. Anthony Falls. Congress, after ordering a survey of the river by the Corps of Engineers, granted the land to the state of Minnesota in 1868. When it appeared that the Mississippi River Improvement and Manufacturing Company would not be able to resolve its internal conflicts, Congress decided to turn the project over to the Corps of Engineers.

In 1873, Congress appropriated $25,000 to improve navigation on the Mississippi River and directed the Corps of Engineers to build a lock and dam. However, a dispute over returning the land grant delayed work for 20 more years. In 1893 the Corps was directed to prepare new and exact estimates for locks and dams. As before, two locks and dams were proposed. Lock and Dam No. 1 would be located above Minnehaha Creek (at its present location) with a vertical lift of 13.3 feet and Lock and Dam No. 2 would be located 2.9 miles upstream, below Meeker Island with a vertical lift of 13.8 feet. See **Figure 3-1**.

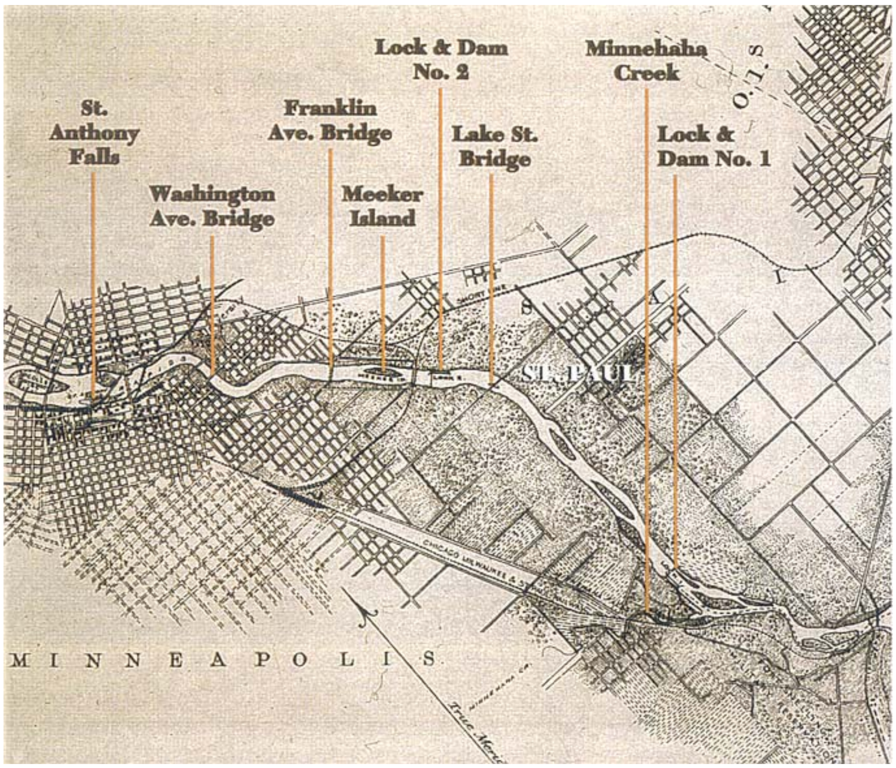

Figure 3-1. Location of Lock and Dam No. 1 and No. 2

The 1894 River and Harbor Act authorized the "Five-Foot Project Aid of Navigation". This directed the Corps to build Lock and Dam No. 2 at Meeker Island. Lock and Dam No. 2 was to be constructed before Dam No. 1 because navigation above Dam No. 2 was difficult and hazardous even under the most favorable conditions and was virtually impossible at low stages of the river. The project was transferred to the St. Paul District in 1897, though Rock Island District had maintained this portion of the river for 30 years. The 3 March 1899 Rivers and Harbors Act authorized the construction of Lock and Dam No. 1. By 1907, Lock and Dam No. 1 was about 20 percent complete and Lock and Dam No. 2 was finished. On 19 May 1907, the first vessel, the powerboat "Intura", was lifted 13.3 feet and went through the 80-foot by 334-foot lock. Minneapolis had captured the coveted status of the head of navigation. However, both cities were awakening to the importance of hydropower. Laying aside their long-standing feud, the cities began working together to convince the Corps and Congress to review and revamp the still-incomplete project. Congress established a commission to study the issue in the 1906 River and Harbor Act. It was determined that the low head at Locks and Dams No. 1 and 2 made developing hydroelectric power economically infeasible.

The 2 March 1907 Rivers and Harbors Act modified the existing five-foot channel to a six-foot channel. This would mean the already completed Lock and Dam No. 2 and the design of Lock and Dam No. 1 would have to be modified. Although authorized, no funding for the work was provided by congress. The expense of starting over in order to supply hydropower could now be compared to the cost of modifying the structures. The 3 March 1909 Rivers and Harbors Act provided for examination of the river as a potential source of hydroelectric power.

The design of Lock and Dam No. 1 was lead by Major Francis R. Shunk, an innovator and a long-range planner. He agreed with St. Paul interests that the power possibilities of the dam should not be neglected. Private companies were very interested in obtaining the power rights of the proposed high dam. Major

Shunk recommended that the federal government build the high dam for navigational purposes, install power plant facilities, and then lease the power generators to private companies. Shunk had the backing of Representative Frederick C. Stevens, who felt that Congress would approve the plan in order to supply Fort Snelling and other federal agencies with electricity. Shunk also appealed to the local business community, pointing out that one high lock and dam would cost less to operate than two low ones, would save boats time in passage, and could pay for itself in power generation.

Congress created a special commission to re-examine the twin lock and dam project. The commission's 26 September 1907 report did not settle the matter; however, it noted that the current designs did not allow for power generation and suggested that the project could be modified. A special board of engineers was called upon to make a second study of the project. Even though construction of Lock and Dam No. 1 had already begun, the board found that a single high dam would be more beneficial than the twin lock and dam system already in the works. It was estimated that a 30-foot dam would yield 15,000 horsepower. Also, if Congress would authorize a nine-foot-channel depth, there would be no need to modify the dam for any future navigation projects. Unfortunately, it would also submerge the already completed Lock and Dam No. 2. In the spring of 1909 the Corps suspended work on Lock and Dam No. 1. Lock construction was 75 percent complete.

Representatives of Minneapolis, St. Paul, and the state formed a commission to prepare a proposal for cost sharing the cost of building a high dam. On 31 January 1910, the board recommended that the Corps of Engineers work with both cities to build the new high dam. At that time it was agreed that the cities would pick up the additional costs. On 23 June 1910, President William H. Taft signed a new water-power act requiring the Corps to evaluate all plans for hydroelectric power development. The single lock and dam system was approved in the 25 June 1910 Rivers and Harbors Act and the St. Paul District began modifying Lock and Dam No. 1. The plan called for the Corps to build the base for a hydropower station but no station itself.

The planned destruction of Lock and Dam No. 2 did not go unnoticed. The Dean of the College of Engineering at the University of Minnesota, Francis C. Sharshon, thought the timber superstructure of Lock and Dam No. 2 should be converted to a dry dock or some other useful thing. Nevertheless, it remained in place and was cut down five feet in 1912, to give a ten-foot clearance for boats passing over it, only five years after it had opened.

By 1912, about fifty percent of the new lock design was complete. In that year the newly promoted Lieutenant Colonel Shunk was transferred out of the district and George W. Freeman, the civilian assistant on the job, took out Patent Number 1,043,761 on his modified design for a hollow concrete dam. Two years later a flood washed out the cofferdam and nearly destroyed the support for the unique structure. The damage was repaired and in 1917, seven years after initial construction began, the lock, dam, and powerhouse facilities were complete.

Figure 3-2. Lock and Dam No. 1 Under Construction - 1916

Lock and Dam No. 1 became operational on 30 June 1917. Included in the design of the Ambursen dam were eight 6-foot by 6-foot sluiceways that passed flow through the dam. Rectangular steel sluice valves that slid up and down the dam's inclined surface controlled flow. The sluice valves were operated within the dam (**Figure 2-2**). During construction of the dam, the sluiceways and powerhouse were used to divert the river's flow in order to allow completion of the final sections of the dam. The sluiceways were also used during the winter months between 1917 and 1924 to flush out the reservoir in order to deal with pollution dumped into the river above the dam.

Six years after Lock and Dam No. 1 was completed; the power capabilities of the dam were utilized much to the satisfaction of St. Paul. A lease was negotiated with the new Ford Motor Company assembly plant that was built in St. Paul on the east bank of the river. The Federal Power Commission (now Federal Energy Regulatory Commission - FERC) had turned down other lease applications from the City of St. Paul, the City of Minneapolis, Northern States Power Company, and the University of Minnesota. The Ford Power plant has been in operation since 7 June 1923, supplying power for the Ford Motor Company assembly plant and Lock and Dam No. 1 under FERC License No. 362. The hydraulic capacity of the original powerhouse turbines was 5,800 cfs, which was very close to the median flow of the river. At this flow rate, the overtopping depth is two-feet. Therefore, Ford Motor Company installed two-foot high flashboards on the dam crest to maintain a higher pool for power generation during low flows. In effect, the flashboard system was designed to keep the navigation pool at elevation 725.1 feet, exactly where it would be without hydropower development. Therefore, the flashboard system is not needed to maintain navigation. A nine-foot depth is maintained for a pool a pool elevation of 723.1 feet elevation of the dam crest). Under the FERC license, Ford Motor Company was responsible for operation and maintenance of the flashboard system. The flashboard system consisted of hinged steel plates anchored to the crest of the dam and braced up with steel rods inserted in special holes on the dam. The system was designed to limit upstream damage by collapsing under high water conditions (two-feet over flashboards) or severe ice conditions. The flashboards typically collapsed during the winter or early spring and had to be reset or repaired when lower water levels permitted. The sluiceways were used to lower the pool below the dam crest to allow for maintenance of the flashboard system.

On 19 August 1929, the lower lock gates of the 80-foot by 360-foot lock collapsed, closing navigation for over a year until repairs were completed on 30 September 1930. As a result of the gate failure, it was decided that the single lock should be replaced with twin locks so that navigation would never again be disrupted. A second lock was included in the nine-foot channel project and was given a high priority. The lock dimensions were increased to 56-feet by 400-feet. The intention was to provide a suitable draft over the lock end sills based on design lower pool elevation of 689.1 feet. The lower lock sill elevations were set at elevation 677.2 feet for the landward lock and elevation 679.7 feet for the riverward lock, thus providing respective clearances of 11.9 feet and 9.4 feet at project pool. However, due to probable seepage damages, interests in the South St. Paul stockyards area obtained a court order limiting the elevation to which Pool No. 2 could be raised to 685.7 feet. In 1934 the court approved the raising of the pool to elevation 687.2 feet or 1.9 feet less than its design height. This resulted in a riverward lock clearance of 7.5 feet at project pool or about 8.0 feet at normal tailwater elevation. Therefore, the riverward lock was used for pleasure boats, empty barges and shallow-draft towboats. The locks were completed in 1932, nearly 25 years after initial construction of the lock and dam began.

The original design elevation of Pool No. 2 was reduced by 1.9 feet in 1934, which reduced the depth over the lower lock sill of the riverward lock to 7.5 feet at flat pool. The operating machinery for this lock is in poor condition and the lack of guide walls make approaches to the lock difficult. While the lock was occasionally used for pleasure boats and shallow-draft towboats with empty barges, the expense of maintenance and repair of the operating machinery has justified its lack of use.

All eight of the sluiceway valves were operational until 1938 when gate number 1 failed. In 1950, a concrete slab was placed over the valve to close off leakage.

Major rehabilitation of the dam was conducted between 1949 and 1954. This work included: resurfacing of the crest and downstream face of the dam (1949-1953); replacement of a major portion of the apron and construction of a baffle wall on the apron to induce a hydraulic jump for the purpose of reducing the potential for scour below the dam (completed in 1953); the placement of sand fill in the interior of the dam to increase its weight to reduce the possibility of failure by sliding (1952); and the installation of hydraulic operating machinery on sluice gate numbers 2, 3, and 4 (1954). Gates 5, 6, 7, and 8 maintained the original equipment but were no longer operated.

Stoney gate valves were used to control flow into and out of, both of the lock chambers. The Stoney gate valves of the landward lock were replaced with reverse tainter valves in the early 1980's. At this same time, power transmission through the dam stopped. As part of the FERC agreement, Ford Motor Company is to supply power to the lock free of charge. This was originally accomplished with electrical distribution cables running from the powerhouse, through the dam, to the lock area. The increased power needs of the lock and dam had exceeded the capacity of the distribution system; therefore, it was agreed that that the Corps would receive its power from the local energy supplier (presently Xcel Energy Corporation) on the lock side of the river and Ford Motor Company would pay the bill directly. Ford provided the power equipment to make this possible. While the equipment lasted approximately 20 years, the Corps replaced it in the year 2000 due to frequent breakdowns.

In 1992, Stanley Consultants inspected the concrete sluiceways and downstream side of the sluice gates and frame, which had been dewatered during the downstream inspection. Concrete had deteriorated around the sluice gates, on the floors of the bays, and to a lesser extent on the walls and ceilings. Deterioration was found to be severe near the frames of several sluice gates. In several instances, the frame was missing up to four-inches of concrete. In addition, soundings of the pool immediately upstream of the dam indicated that the entire area was silted in above gates, except where gates were leaking. The three operating sluiceway valves (gates 2, 3, and 4) were all leaking. In fact, sluice gate number 3 was leaking so badly it had to be sealed off in 1993. In 1996, Ford Motor Company abandoned use of the sluiceways and installed an inflatable rubber flashboard system on the dam. It is comprised of two Kevlar coated inflatable rubber bladders separated by a central pier. Less than two-pounds of air pressure is required to maintain the flashboard in a fully raised position. Blowers and operating controls for the flashboard system are located near the spillway in the lower powerhouse level. When fully inflated the crest is at elevation 725.1 feet (1912 adjustment). The bladders are typically left in the raised (inflated) position throughout the winter. Ice will form up against the bladders during the winter and as the water rises due to high flows, the ice will break up and pass over the top of the bladders. The bladders are deflated one at a time as water depths increase. Overtopping begins when the river increases beyond 7,000 cfs, the present hydraulic capacity of the powerhouse turbines. At a discharge of 8,870 cfs, the flashboard overtopping depth is one-foot (i.e. elevation 726.1 feet). When the pool reaches this elevation, one of the bladders is deflated. The pool will fall to about elevation 724.7 feet. When the river discharge reaches 9,840 cfs, overtopping of the remaining inflated bladder commences. When the river discharge reaches 13,300 cfs, the overtopping depth on the second bladder is one-foot and it is deflated. This action will cause the pool to drop to elevation 725.3 feet. When the flood has passed, one bladder is re-inflated when the pool drops to elevation 725.3 feet. This will cause the pool to rise to elevation 726.1 feet. When the pool drops to elevation 724.7 feet, the second bladder is re-inflated.

The pool will then rise to elevation 726.1 feet. Uncontrolled overtopping ceases when the river discharge falls to 7,000 cfs.

In December 2000, Ayres Associates inspected the concrete sluiceways and downstream side of the sluice gates and frame, except gate number 4, which had significant leakage. The inspection confirmed significant concrete deterioration around the gates. Their report recommended concrete repair of the interior of the dam and sluiceways. Since the sluiceways are no longer needed, it was decided that the sluiceways be plugged with concrete. Plans and Specifications have been prepared for the repair work and the plugging of the sluiceways. The environmental documentation has been completed and the construction contract has been awarded. Construction was completed in March 2004.

As previously discussed, the lower sill elevations of the riverward lock is 2.5 feet higher than the landward lock. Because of the low clearance (7.5 feet), the riverward lock was only used for locking recreational craft. Over the years there were frequent breakdowns of the riverward lock such that its use began to significantly decline until its use was eliminated, however, it was cycled through periodically to ensure its operability. Continued breakdowns with the equipment resulted in complete abandonment in 2002.

The lock chamber is flushed of sediment by opening the downstream miter gates and then slowly opening the upstream tainter values until there is sufficient current to flush the chamber. Guarding any budget constraints, the District typically dewaters a lock every year. Therefore, Lock No. 1 would be dewatered approximately every 13 years. The last time the lock was dewatered was the winter of 1999-2000.

3-03. Construction. Construction of Lock and Dam No. 1 began in 1910 and was placed in operation seven years later in 1917. In 1929 the original lock failed, cutting off all barge traffic to Minneapolis. Two locks were constructed to replace the one. The riverward lock was completed in 1930 and the landward lock was completed in 1932. The total cost of Lock and Dam No. 1 in 1917 was approximately $1,949,000. Construction of the riverward and landward locks cost an additional $2,350,000. The Ford powerhouse was completed in the summer of 1924.

Due to extensive erosion of the sandstone bluff that is adjacent to the landward lock, it was necessary to protect the exposed sandstone with cribbing (**Plate 2-2**). Work on this feature was completed in 1956. Additional protection above the cribbing was completed in 1966. An extension of the upper guide wall was completed in August 1978. The stoney gate valves were replaced with tainter valves in the early 1980's. Major rehabilitation of the lock was completed in 1984.

3-04. Related Projects. Lock and Dam No. 1 is one part of the 29 locks and dams on the Mississippi River necessary to maintain the nine-foot navigation channel between Minneapolis, Minnesota and St. Louis, Missouri. Thirteen of the 29 locks and dams are located in the St. Paul District. These include Upper and Lower St. Anthony Falls, as well as Lock and Dam Numbers 1 through 10.

3-05. Modifications to Regulation.

a. 1929 Modification. On 19 August 1929, navigation through Lock and Dam No. 1 ceased. The lower lock gates collapsed and for over one year the lock was closed to navigation. It was decided that twin locks, 56-feet wide and 400-feet long, would replace the damaged lock. The new locks would be part of nine-foot channel project. The first lock (riverward lock) was completed in 1930. The second lock (landward lock) was placed into operation in 1932.

b. 1938 Modification. Sluiceway number 1 was removed from service due to leakage. It was capped off in 1950.

c. **1948 Modification.** The nine-foot channel depth was only important during the navigation season. Therefore, some of the pools were drawn down far below project pool over the winter months whenever it was considered necessary. On 19 June 1948, an amendment was made to the act of Congress dated 10 March 1934, entitled "An act to promote the conservation of wildlife, fish and game, and for other purposes". The amendment was Public Law 697 and it prevented drawdown of the pools on the Mississippi River between Rock Island, Illinois and Minneapolis, Minnesota during the non-navigation season. The law is known as the "Anti-Drawdown Law". The law states that the "…dam structures shall generally operate and maintain pool levels as though navigation was carried on throughout the year." This had little impact on Lock and Dam No. 1 since the pool level is already maintained at a high level for the purpose of power generation.

d. **1954 Modification.** Three of the eight sluice gates were rehabilitated and fitted with hydraulic operating machinery. The remaining five sluice gates were not functional. These three gates (numbers 2, 3, and 4), in conjunction with the powerhouse, were used to draw the pool down to facilitate the installation of the wooden flashboards.

e. **1993 Modification.** An underwater inspection conducted in 1992 found that sluiceway gate number 3 was severely deteriorated. As a result, the sluiceway was sand bagged shut. That left only gate numbers 2 and 4 functioning. They were last opened in October 1995. Each of the sluiceways were permanently sealed with concrete plugs in 2003.

f. **1996 Modification.** The existing flashboard system was replaced with an inflatable rubber bladder flashboard system. The system consists of twin 2-foot diameter inflatable Kevlar coated rubber bladders that are bolted to the crest of the dam. The bladders are separated by a small pier located in the approximate center of the spillway. Less than two-pounds of air pressure is required to maintain the bladder in the fully raised position (elevation 725.1 feet – 1912 adjustment). Low-pressure blowers, hydraulic operators and PLC-based controls for the system are located in the lower level of the powerhouse.

The badly worn original Francis turbine runners were replaced with modern stainless steel runners manufactured by Voith Hydro. This increased the rating for each turbine from 4,500 hp to 5,800 hp at 34 feet of head. Maximum discharge increased from 1,500 cfs to 1,750 cfs per turbine.

g. 2000 Modification. While use of the riverward lock was limited, its use was stopped in 2000 due to continual breakdowns. The lock was cycled once a month to try to keep it in operating condition. Unfortunately, each operating cycle typically ended with some kind of breakdown that resulted in costly repairs. In 2002 the lower miter gates were pinned back and the lock is considered to be inoperable. The Corps will likely seek de-authorization in the future.

3-06. Principal Regulation Problems.

a. Outdraft. An outdraft problem exists at Lock and Dam No. 1 for down-bound as well as up-bound tows. Signs are located at the end of the upper and lower guide walls to warn of outdraft when the pool elevation is greater than 0.2 feet above the crest of the dam whether the bladders are inflated or not. The signs are circular, about three feet in diameter, and are orange in color. They are permanently mounted on a hinge, thereby allowing them to be swung out into view when necessary.

b. Riverward Lock. The riverward lock is currently not used for navigation. There is a depth of 7.5 feet over the lower sill at flat pool or about 8 feet for a typical tailwater elevation. Also, the lack of guide walls makes the approach to the lock difficult. Hence the riverward lock has had little use except for occasional locking of pleasure boats, empty barges, or shallow draft towboats.

Because of the poor condition of the operating machinery, cycling of the lock ceased in 2000.

c. Zebra Mussels. Zebra Mussels are present at all St. Paul District locks and dams on the Upper Mississippi River. Quantities are far greater below Lock and Dam No. 4 than above, however several Zebra Mussels were discovered at Lock and Dam No. 1 when it was de-watered in the winter of 1999-2000. While Zebra Mussels are not having impacts on operations at Lock and Dam No. 1, it is possible that numbers could increase such that they may foul the gage wells, concrete surfaces, and untreated metal surfaces e.g. lock miter gates). In addition, masses of dead zebra mussels could accumulate in the gate recesses, hindering operation. The St. Paul District developed a "Zebra Mussel Response Plan" in November 1997. There were five methods for short-term control identified for locks and dams. The following tables show the possible problems and the recommended control techniques identified in the study.

Table 3-1
Zebra Mussel Control Techniques

Code	Method	Description
A	Physical Removal	Removed by scraping, brushing, or high-pressure water or steam spraying.
B	Mollusicides	Primarily oxidizing biocides (chlorine) with possibility of periodic use of nonoxidizing biocides.
C	Thermal Treatments	Hot water, steam, or air injection periodically to kill adult and larval zebra mussels.
D	Dewatering Dislocation	Isolation of susceptible components from the river. Components removed from river if possible.
E	Replacement Components	Replacement components which can be easily removed should infestation occur.

Table 3-2 Proposed Zebra Mussel Control Techniques for Locks and Dams		
Component	**Potential Problem**	**Method**
Lock Walls	Heavy encrustations can be expected. Structural damage limited to abrasion during cleaning.	A,D
Gages	Occlusion of the pipe leading from the well to the River. Encrustation of level markings.	A,B,C,D
Thermometers	Encrustations could reduce reliability of readings.	A
Miter Gates	Increased corrosion of metal surface, paint deterioration, and unbalanced loading.	A,D
Bulkhead Slots	Accumulation along the sealing surfaces.	A,D
Lock Culverts	Reduced flow area and increased roughness could cause increased emptying and filling times.	A,D
Roller Gates	Increased gate weight and corrosion.	A,D
Side Seals	Accelerated deterioration of seals.	A,D,C,E
Tracks, Chains, Cables	Accumulation could prevent movement of roller gates. Metal and paint deterioration.	A,D

IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. At project pool elevation of 723.1 feet (1912 adjustment), the pool has a total surface area of 525 acres. The drainage area of Pool No. 1 totals 19,680 square miles in Minnesota. Except for storm drainage and a few small creeks, there are no major tributaries to Pool No. 1.

4-02. Topography. The Master Water Control Manual for the Locks and Dams contains a description of the topography for the Upper Mississippi River basin.

4-03. Sediment. Part of the nine-foot navigation plan authorized by Congress included periodic dredging of sediment. There are eight sites within the Pool No. 1 navigation channel that require periodic dredging. Also requiring periodic dredging is the lower approach to Lock No. 1 (Pool No. 2). Quantities and frequency of these dredge sites are presented in **Paragraph 5-03**.

4-04. Climate. The National Weather Service does not maintain temperature and precipitation records for Lock and Dam No. 1; however, they do maintain these data for the nearby Minneapolis Airport. Pan evaporation data was collected at Lock and Dam No. 6, but stopped after 1997. Temperature and precipitation data shown in the following tables were taken from National Oceanic and Atmospheric Administration's *Climatological Data Annual Summaries* for Minneapolis Airport, Minnesota. The 30-year normal period used here was 1960 to 1990. Pool evaporation was estimated by assuming a pan coefficient of 0.7.

Table 4-1
30-Year Normal Monthly Temperature in Degrees Fahrenheit

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
11.8	17.9	31.0	46.4	58.5	68.2	73.6	70.5	60.5	48.8	33.2	17.9	44.8

Table 4-2 30-Year Normal Monthly Precipitation in Inches												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.95	0.88	1.94	2.42	3.39	4.05	3.53	3.62	2.72	2.19	1.55	1.08	28.32

Table 4-3 Pan and Pool Monthly Evaporation in Inches (Lock and Dam No. 6)								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Period of Record
Pan Evaporation	0.26	3.35	3.92	5.15	4.66	2.88	0.65	(1983 – 1997)
Pool Evaporation	0.18	2.35	2.74	3.61	3.26	2.02	0.46	(1983 – 1997)

Wind speed and direction are recorded each morning at Lock and Dam No. 1. While this information is valuable for the regulation of the dam, it is of little value for presenting monthly highest wind speeds and directions. The *Climatic Atlas of the United States* (June 1968) contains monthly Fastest Mile information for La Crosse, Wisconsin. Fastest Mile wind speeds are defined as the fastest speed at which wind travels one mile measured over one month. Fastest Mile wind speeds are typically obtained from a short period of time, usually less than two minutes duration. The Fastest Mile wind speeds presented in the Atlas were modified to time-dependant (1-hour) average wind speeds using procedures presented in the US Army Corps of Engineers' *Shore Protection Manual* (1984).

Table 4-4 Highest Monthly Wind Speed and Direction in MPH for La Crosse, WI												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direction	NNW	WNW	NNW	SSW	E	NNW	N	N	SSW	WNW	S	NNW
Fastest Mile	35	36	40	50	58	60	36	46	36	38	46	43
1-Hour	29.5	30.3	33.3	41.0	46.8	47.2	30.3	37.9	30.3	31.8	37.9	38.1

Because of the bluffs along the river, winds tend to be channeled either up river or down river. The wind blowing across the pool surface exerts a horizontal force on the water surface and induces a surface current in the general direction of the wind. The horizontal currents induced by the wind essentially cause water to "pile up" on the downwind side, resulting in a water level rise downwind and a water level drop upwind. The change in water level is due to "wind setup". The rise in water can be estimated by (EM 1110-2-1414):

$$S = (U^2 F)/(1400 D)$$

Where,
S = Wind Setup (ft)
U = Wind Speed (mph)
F = Fetch Length (miles)
D = Average Depth over Fetch (ft)

The above equation neglects the time required for the full wind setup to occur. The stronger the wind, the more time required. While it is recognized that the relationship is not linear, a rule of thumb has been developed that seems to work quite well for the lock and dam pools. For each ten miles per hour of wind speed, figure the change in the pool level to be 0.1 feet. Therefore, a northern wind at 20 mph would cause a 0.2 feet rise in the water surface at the dam, and conversely, a southern wind of 10 mph would result in a lowering of the water surface at the dam by 0.1 feet.

4-05. Storms and Floods. Minneapolis is fortunate in that there is little low lying area along the river's banks, and as a consequence has never suffered severe flood losses. There are no major tributaries to Pool No. 1; therefore, it is flooding of the main stem upstream and flooding of the nearby upper tributaries that produce flooding along Pool No. 1. After construction of the lock and dam in 1917, the first significant flood events didn't occur until the spring of 1951. On the 16th of April, the Mississippi River at Pool No. 1 crested at elevation 731.87 feet (1912 adjustment). This stage was exceeded the following year. On the 14th of April 1952, Pool No. 1 peaked with a peak pool gage elevation of 733.02 feet. This remained the flood of record until the flood of 1965, which still remains as the flood of record. **Table 4-5** gives a summary of peak elevations and discharges at the Pool No. 1 followed by a brief description of the larger events.

Table 4-5 Summary of Peak Stages/Elevations and Discharges			
Date	Pool Elevation ft – 1912 Adj.	Tailwater ft - 1912 Adj.	Discharge cfs
16-Apr-51	731.87	709.32	-
14-Apr-52	733.02	714.02	-
17-Apr-65	**734.50**	**719.02**	**91,000**
15-Apr-69	733.02	716.14	72,000
11-Apr-97	732.70	713.80	69,000
15-Apr-01	732.60	713.17	66,700

a. April - May 1965. Because of the magnitude of the snow-water content on the ground, forecasts and warnings of floods were issued by the Weather Bureau (now the National Weather Service). An advisory on the flood potential in the Upper Mississippi River basin was published on the 19th of March. The forecast cautioned that if rainfall of one inch should occur before or during the crest, the resulting peak stages would be near the 1952 level. Almost four inches of rain fell in the first two weeks of April. The rapid increase of inflow began on the 7th of April when the discharge rose from 5,000 cfs on this date to a peak of 91,000 cfs on the 17th of April. The motors that operate the lock miter gates were pulled on the 11th of April and the lock was out of operation for 22 days until the 3rd of May. The pool crested on the 17th of April at elevation 734.50 feet with a peak flow of 91,000 cfs. Although the peak flow was twenty-five percent greater than the design flood, there was no damage to the project.

b. April 1969. The flood of 1969 can be attributed primarily to an exceptionally heavy blanket of snow, which accumulated during December 1968 through February 1969. While the water surface profile in the pool was high, there were no significant flood damages in the Twin City vicinity. The peak pool elevation occurred on 15 April at elevation 733.02 feet and a discharge of 72,000 cfs. The lock was out of operation for 16 days, from the 9th of April to the 25th of April.

b. April 1997. The magnitude of the snow-water content on the ground indicated a high potential for flooding along the Upper Mississippi River. The pool at the dam crested on the 11th of April at elevation 732.70 feet. Peak discharge was 69,000 cfs. The high pool elevation necessitated removal of the lower tow haulage unit. The lock was out of operation for 14 days, from the 4th of April to the 18th of April.

c. April 2001. The National Weather Service's 2001 Spring Snowmelt Flood Outlook predicted minor to moderate flooding for Pool No. 1. This forecast was primarily due to the significant autumn precipitation the year before and the heavy winter snowfall. A less than ideal snowmelt followed by record breaking April precipitation resulted in producing high flood stages in Pool No. 1. On the 15th of April, the pool peaked at elevation 732.60 feet with a discharge of 66,700 cfs. Due to additional rainfall, a second, lower crest of 732.33 feet occurred on the 28th of April. As with the 1997 flood, the lower tow haulage unit was removed. The Coast Guard closed the river to navigation from the 9 April to 9 May.

4-06. Runoff Characteristics. The mean annual discharge at Lock and Dam No. 1 is 9,930 cfs based on a period of record from 1985 to 2002. The following table shows the monthly average discharges.

Table 4-6
Monthly Average Flow in cfs – (Years 1985 to 2002)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5,330	5,090	9,200	20,200	17,500	11,900	11,800	7,760	7,970	8,510	7,750	6,230

A maximum discharge of 91,000 cfs occurred at the dam on 17 April 1965 (**Table 4-5**). The lowest daily mean discharge occurred on 10 September 1934 with a flow of 602 cfs. A discharge-frequency curve for the Mississippi River at Anoka, Minnesota is shown on **Figure 8-1**. The following table shows the discharge-duration at the dam.

Table 4-7 Discharge-Duration at Lock and Dam No. 1 Percent Time At or Above Indicated Discharge (Years 1972-2000)													
Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
70,000				0.6									
68,000				1.0									
66,000				1.5									0.1
64,000				1.5									0.1
62,000				1.5									0.1
60,000				1.7									0.1
58,000				1.9									0.2
56,000				1.9									0.2
54,000				2.1									0.2
52,000				2.1									0.2
50,000				2.5									0.2
48,000				3.3	1.0								0.4
46,000				3.5	1.8								0.5
44,000				4.2	2.6								0.6
42,000				4.6	3.4				1.3				0.8
40,000				5.6	4.4				1.3	0.2			1.0
38,000				6.5	5.9				1.5	0.4			1.2
36,000				10.0	6.1				1.7	0.6			1.5
34,000			0.2	12.7	8.1		0.8		1.7	0.8			2.0
32,000			0.2	14.8	9.5		1.6		1.9	1.0			2.4
30,000			1.6	16.0	10.1		2.6		2.1	1.2			2.8
28,000			2.4	17.3	13.3	0.6	3.8		2.1	1.4			3.4
26,000			4.6	18.1	17.5	1.3	4.4		2.1	1.8			4.2
24,000			5.2	20.6	22.2	1.5	5.9		2.3	2.4			5.0
22,000			6.1	27.9	26.6	3.1	7.1		2.5	2.8			6.4
20,000			8.7	34.4	31.3	7.3	9.7		4.2	6.9			8.6
18,000			10.1	42.7	34.7	14.0	13.3	0.2	7.1	11.1	0.2		11.2
16,000			12.1	50.6	40.3	24.8	17.3	1.6	10.6	14.5	1.5		14.5
14,000		0.4	19.0	59.8	50.0	32.1	26.8	11.3	15.0	19.0	3.3		19.8
12,000		0.7	25.4	67.3	59.3	39.4	37.9	19.2	18.5	20.6	9.4	0.4	24.9
10,000		0.9	34.3	77.1	67.3	50.6	48.8	28.2	25.8	22.0	23.8	5.3	32.1
8,000	8.7	2.4	46.4	86.7	80.2	66.3	67.7	38.7	33.8	39.1	45.8	26.6	45.4
6,000	39.3	31.4	73.4	97.3	88.9	81.3	79.4	53.4	45.2	55.0	68.1	54.5	64.1
4,000	69.0	69.5	86.7	100.0	97.8	91.5	87.1	76.8	64.8	77.8	89.4	73.8	82.1
2,000	100.0	99.3	100.0	100.0	100.0	94.8	93.8	92.1	99.4	100.0	100.0	97.2	98.0

Construction of the lock and dam greatly influenced stage-duration curves throughout the pool. Based on a period of record from 1972 to 2000, the following two elevation-duration tables were developed: (1) Lock and Dam No. 1 tailwater and (2) Lock and Dam No. 1 pool. The tables indicate the percent of time the water surface ia at or above the indicated elevation (1912 – adjustment). Gage zero for the pool and tailwater is elevation 677.20 feet.

Table 4-8
Elevation-Duration, Lock and Dam No. 1 Tailwater
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
710.0				1.0									
709.5				1.2									
709.0				1.2									
708.5				1.4									0.1
708.0				1.4		0.3							0.1
707.5				1.5		0.5							0.2
707.0				1.6		0.7							0.2
706.5				1.7	0.3	0.7	0.1						0.2
706.0				1.7	0.7	0.8	0.6						0.3
705.5				2.0	0.8	0.8	0.8						0.4
705.0				2.5	1.2	0.8	1.2						0.5
704.5				3.5	1.6	0.8	1.7						0.6
704.0				4.4	2.6	0.8	1.8						0.8
703.5				5.2	3.0	0.9	1.9						0.9
703.0				5.6	3.3	1.3	2.2						1.0
702.5				6.2	3.5	2.0	2.2						1.2
702.0				7.2	3.7	2.5	2.2						1.3
701.5				8.6	4.1	2.6	2.5		0.3	0.2			1.5
701.0			0.3	8.9	4.9	2.8	2.8		0.6	0.3			1.7
700.5			1.1	9.9	5.9	2.9	3.2		0.7	0.4			2.0
700.0			1.9	10.5	7.6	2.9	3.7		0.7	0.6			2.3
699.5			3.0	12.9	8.8	3.1	3.7		0.8	0.7			2.8
699.0			3.7	16.3	10.5	3.2	4.1	0.1	0.9	0.7			3.3
698.5			4.2	19.2	12.8	3.2	4.6	0.4	0.9	0.7			3.9
698.0			4.8	23.8	14.7	3.3	4.7	0.7	0.9	0.8			4.5
697.5			5.9	26.1	17.1	3.3	5.3	1.1	1.2	0.9			5.1
697.0			7.7	30.1	20.7	3.9	5.8	1.7	1.2	1.2			6.0
696.5			8.1	34.1	23.7	5.4	7.2	2.0	1.2	1.8			7.0
696.0			9.3	38.1	26.3	7.5	8.7	2.8	1.2	2.2			8.0
695.5			10.6	42.3	31.5	10.2	10.5	3.9	1.3	2.8			9.5
695.0			11.9	46.4	36.4	12.9	13.4	4.7	1.6	3.5			10.9
694.5			13.5	50.1	39.5	17.0	15.9	5.5	2.0	6.0	0.2		12.5
694.0			14.4	54.6	43.2	23.5	17.8	5.9	2.6	8.3	0.9		14.3
693.5			15.7	58.1	47.6	27.8	19.1	6.0	3.7	9.6	1.5		15.8
693.0			18.7	59.3	50.5	32.6	22.8	6.5	5.5	11.4	1.7	0.1	17.5
692.5		0.5	20.7	61.4	53.7	36.7	26.4	7.8	7.9	13.6	2.3	0.1	19.3
692.0		0.9	23.5	64.7	56.1	42.4	32.0	10.5	9.1	15.8	4.3	0.6	21.7
691.5		1.0	26.0	68.4	60.2	46.9	38.3	14.0	11.7	17.0	6.9	0.9	24.4
691.0		1.3	29.7	75.4	64.5	53.8	44.5	18.4	14.9	18.8	12.0	1.8	28.0
690.5	0.1	2.0	34.3	81.4	67.9	61.5	50.1	21.9	18.9	20.1	17.2	4.6	31.8
690.0	0.7	2.6	39.4	83.5	73.5	66.8	54.7	27.0	23.3	22.3	27.8	11.4	36.2
689.5	7.4	7.9	47.9	86.9	77.5	71.4	60.0	33.5	28.3	27.8	39.8	21.9	42.6
689.0	20.5	14.9	55.0	90.6	83.7	76.6	67.7	41.3	33.6	40.4	53.6	36.6	51.3
688.5	44.8	31.0	65.2	93.5	88.1	81.7	73.8	53.5	40.5	49.2	63.5	51.2	61.5
688.0	71.8	62.6	78.9	98.4	91.1	88.3	78.8	70.0	60.9	66.6	78.5	68.1	76.2
687.5	81.2	82.1	89.5	100.0	97.7	93.7	88.3	83.4	82.4	89.3	90.6	80.1	88.2
687.0	100.0	99.8	99.9	100.0	100.0	100.0	99.4	99.3	99.9	100.0	100.0	100.0	100.0

Table 4-9
Elevation-Duration, Lock and Dam No. 1 Pool
Percent of Time at or Above Indicated Elevation (Years 1972 to 2000)

Elev.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
732.50				1.7									0.1
732.25				4.2									0.3
732.00				5.0									0.4
731.75				6.7	0.4								0.6
731.50				8.3	0.8								0.8
731.25				9.2	0.8								0.8
731.00				10.0	1.2								0.9
730.75				11.3	1.6								1.1
730.50				12.5	1.6								1.2
730.25				12.9	2.0								1.2
730.00				13.3	2.4								1.3
729.75				14.2	2.4								1.4
729.50				14.6	2.8								1.4
729.25				15.0	4.8								1.6
729.00				16.3	5.7	0.8							1.9
728.75				16.7	7.3	2.1							2.2
728.50				20.8	7.7	3.8	2.0						2.8
728.25				22.5	8.9	4.6	2.4						3.2
728.00				25.8	10.1	5.8	4.0						3.8
727.75				27.1	12.9	6.3	5.7						4.3
727.50				28.3	20.2	9.6	8.5						5.6
727.25				32.1	25.4	11.7	10.5						6.6
727.00				35.4	31.1	13.3	13.3	0.4					7.8
726.75				42.1	36.7	18.3	19.4	1.2		0.4			9.9
726.50		0.4	2.4	52.5	44.8	25.4	31.9	3.6	0.4	2.0	1.3	0.4	14.3
726.25		1.8	9.3	65.0	61.3	35.4	46.0	13.3	6.3	11.3	3.8	2.0	21.7
726.00	2.4	5.8	21.4	71.3	76.6	49.2	60.1	23.0	10.8	27.0	25.8	15.0	33.3
725.75	12.1	14.2	37.5	81.3	83.9	63.8	66.9	31.5	20.8	35.9	47.5	23.1	44.0
725.50	36.3	32.3	51.2	92.9	94.4	77.9	75.0	44.4	29.2	51.2	64.6	38.1	58.5
725.25	60.1	57.1	75.4	97.9	96.8	85.4	81.9	64.9	42.9	64.5	77.1	55.1	73.0
725.00	72.6	69.5	87.9	99.2	98.4	92.9	83.9	79.8	58.8	77.0	82.5	70.0	82.3
724.75	79.4	77.9	91.1	100.0	99.6	96.7	83.9	83.5	72.9	82.7	88.8	81.0	87.5
724.50	83.9	81.9	93.2	100.0	100.0	97.1	85.5	85.1	85.0	88.3	97.1	89.9	90.7
724.25	87.5	87.6	93.6	100.0	100.0	98.8	87.1	85.1	86.7	89.9	98.8	96.4	92.7
724.00	91.5	87.6	94.0	100.0	100.0	99.2	92.7	86.3	87.5	89.9	100.0	98.4	93.9
723.75	94.4	87.6	95.6	100.0	100.0	100.0	96.0	86.3	87.5	90.3	100.0	99.2	94.8
723.50	95.2	87.6	97.6	100.0	100.0	100.0	98.4	87.9	87.5	91.9	100.0	99.2	95.5
723.25	96.0	91.2	99.2	100.0	100.0	100.0	99.6	89.5	87.9	92.3	100.0	99.6	96.3
723.00	98.8	99.6	100.0	100.0	100.0	100.0	100.0	94.8	95.0	95.6	100.0	99.6	98.6
722.75	99.6	99.6	100.0	100.0	100.0	100.0	100.0	98.0	97.9	98.0	100.0	99.6	99.4
722.50	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The elevation-duration data presented in **Table 4-9** above reflects the current operating practices that began with the installation of the inflatable bladder in 1996. As shown in the table, pool elevations are rarely below the crest of the dam (elevation 723.1 feet).

At project pool elevation of 725.1 feet, the storage volume in Pool No. 1 is 7,750 acre-feet. A flow rate of approximately 3,900 cfs would result in a daily exchange in storage. **Table 4-10** can be used to determine the storage volume for various elevations at the dam.

Table 4-10
Flat Pool Storage Volume of Pool No. 1

Elevation 1912-Adj.	Storage Ac-Ft	Elevation 1912-Adj.	Storage Ac-Ft	Elevation 1912-Adj.	Storage Ac-Ft
701.0	50	710.0	650	719.0	3,900
702.0	70	711.0	850	720.0	4,450
703.0	100	712.0	1,050	721.0	5,100
704.0	150	713.0	1,300	722.0	5,700
705.0	200	714.0	1,600	723.0	6,350
706.0	250	715.0	2,000	**723.1**	**6,400**
707.0	300	716.0	2,400	724.0	7.000
708.0	400	717.0	2,900	725.0	7,700
709.0	500	718.0	3,350	**725.1**	**7,750**

4-07. Water Quality. Water quality is closely monitored by several federal, state, and local agencies such as the Minnesota Pollution Control Agency (MPCA), Metropolitan Council Environmental Services Division (MCES), and the USGS. Water quality in Pool No. 1 is generally considered to be pretty good; however, swimming is discouraged due to a problem with bacteria.

4-08. Channel and Floodway Characteristics. The top of the lower lock sill elevation at Lower St. Anthony Falls is elevation 712.8 feet and the top of the landward upper lock sill elevation at Lock and Dam No. 1 is elevation 709.7 feet. Therefore, there is a 3.1-foot drop in sill elevation along the pool, which has a length of 5.8 miles as measured along the navigation channel. The navigation channel is 200 feet in width in the straight stretches, and varies from 200 feet to 450 feet in the bends. The line of navigation is shown on **Plates 2-4** and **2-5**. The Minneapolis Harbor is located between the Washington Avenue Bridge and the lower Railroad Bridge. It was completed in 1932. The commercial harbor project provides a turning basin 1,600 feet long and from 420 to 530 feet wide.

4-09. Upstream Structures. Lower St. Anthony Falls is located 5.8 miles upstream of Lock and Dam No. 1. The drainage area above Lower St. Anthony Falls is 19,680 square miles. The lock and dam system continues upstream to the Upper St. Anthony Falls Lock and Dam located in Minneapolis, Minnesota.

4-10. Downstream Structures. Lock and Dam No. 2 is located 32.4 miles downstream of Lock and Dam No. 1. The drainage area above Lock 2 is 36,990 square miles. The lock and Dam system continues downstream to Lock and Dam No. 27 in St. Louis, Missouri; however, St. Paul District terminates with Lock No. 10.

4-11. Economic Data. Pool No. 1 lies entirely within the state of Minnesota. Hennepin County lies on the western side and Ramsey County lies on the eastern side. Based on the US Census Bureau, county populations have increased slightly.

Table 4-11
County and City Populations Near Pool No. 1

	1990	**2000**	**Difference**	**Change**
County				
Hennepin, MN	1,032,431	1,116,200	83,769	8.1 %
Ramsey, MN	485,765	511,035	25,270	5.2 %
City				
St. Paul, MN	272,235	287,151	14,916	5.5 %
Minneapolis, MN	368,383	382,618	14,235	3.9 %

The following table gives a break down of the employment by industry. The data were taken from the US Census Bureau's 1997 Industry Report.

Table 4-12 Employment by Industry – Counties on Pool No. 1 (1997)		
Industry	**Hennepin**	**Ramsey**
Manufacturing	106,772	41,550
Wholesale Trade	61,454	15,680
Retail Trade	78,226	32,615
Real Estate, Rental, Leasing	14,720	4,875
Professional, Scientific, Tech Services	58,051	12,225
Admin & Support, Waste Management	73,076	21,228
Education Services	2,905	426
Health Care & Social Services	32,525	15,342
Arts, Entertainment & Recreation	9,172	1,552
Accommodations & Food Services	54,567	20,952
Other Services	23,352	6,378
Totals	514,820	172,823

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The regulation and proper operation of the dam site requires the collection and evaluation of several hydraulic and hydrologic parameters. The Corps of Engineers (COE), US Geological Survey (USGS), National Weather Service (NWS), and Ford Motor Company (FMC) are involved in the data collection network. The FMC power plant monitors discharge through the turbines and over the dam. Discharge values are phoned into the lock twice a day at midnight and 0600-hours. The COE operates and maintains the pool and tailwater gages at the lock. The gage houses are located on the upper and lower riverward lock walls (**Figures 5-1** and **5-2**). The lower gage was elevated in 1999 after being inundated in the 1997 flood. Each gage house has a well with a float and tape system that reports elevation to the Stevens PAV-C Recorder located in the lock house (**Figure 5-3**). A reference mark is located near each gage house and is used to measure down to the water surface for verification of the tape in the well.

Figure 5-1. Pool Gage House

Figure 5-2. Tailwater Gage House

Figure 5-3. Stevens PAV-C Strip Chart Recorders

A water temperature sensor, reading in degrees Fahrenheit, is located in the upper ladder recess in the landward lock chamber. A standard eight-inch precipitation gage is located just outside of the control house for determining the 24-hour precipitation total (**Figure 5-4**). An anemometer is located atop the central control station (**Figure 5-5**). The site is equipped with a snow tube and scale for determining snow depth and snow water equivalent. Data types and equipment are listed in **Table 5-1**.

Figure 5-4. Rain Gage.

Figure 5-5. Anemometer.

Table 5-1 **Hydrometeorological Stations**			
Location	**Data Type**	**Equipment**	**Notes**
Upper Lock Wall	Pool Elevation	Stevens PAV-C Recorder, Stilling Well	Continuous Strip Chart record of pool elevations. Gage zero: 677.20 ft
Lower Lock Wall	Tailwater Elevation	Stevens PAV-C Recorder, Stilling Well	Continuous Strip Chart record of TW elevations. Gage zero: 677.20 ft
Central Control Station (CCS)	Snow Depth, Snow Water Equivalent	Snow Tube, Scale	Measured every Sunday during Winter Months.
Roof of CCS	Wind Speed and Direction	Anemometer	Recorded Daily.
Near CCS	Precipitation Snow Depth & Water Content	Standard 8-" Rain Gage	Recorded Daily.
Upper Ladder Recess	Water Temperature	Water Temperature Sensor	Electronically transmitted to Central Control Station.

b. Reporting. Site personnel report all collected data to Water Control via a remote computer using "sig-na-term". The day's data begins at 0400-hours. Data reported includes pool and tailwater elevations at the dam and at hydro power plant (every four-hours), discharge through the turbines and over the dam (midnight and 0600-hrs), pool and tailwater elevations at the power plant (daily, 0800-hrs), air temperature (every four-hours), water temperature (daily, 0800-hrs), and precipitation (daily, 0800-hrs). Water Control stores the data and makes it available from the Water Control web site at *www.mvp-wc.usace.army.mil*. The discharges are compiled with the Regulation Sheets to aid in the regulation of Lock and Dam No. 2. It should be noted that all 0800-hour data are actually taken at 0600-hours.

During the winter months, percent of ice coverage over the lower pool and upper tailwater, ice thickness (observed), snow depth, and snow-water content (all in inches) are reported to Water Control every Sunday. This information is available from the Water Control web site.

The Stevens PAV-C strip charts (**Figure 5-3**) are mailed to Water Control every year where they are then periodically micro-filmed.

c. Maintenance. Operation and maintenance of the pool and tailwater gages are the responsibility of the Water Control Gage Crew. Dam personnel maintain the Stevens PAV-C strip chart recorders with the Gage Crew used as a backup if necessary. The anemometer, water temperature sensor, and precipitation gage are maintained by site personnel; however, should the precipitation gage become damaged, a new one would be mailed to the site from Water Control.

5-02. Water Quality Stations. There are no Corps of Engineers' water quality stations in Pool No. 1; however, site personnel may be asked, on occasion, to assist district office personnel or contractors to collect water samples and/or water quality measurements in the project area.

5-03. Sediment Stations. No suspended sediment data is collected in Pool No. 1; however, sediment samples were collected from inside the discharge chamber of the sluiceways on 5 December 2003. The sluiceways are scheduled to be plugged in FY 2004, thereby requiring removal of the sediment. Removal of the sediment means disposal, therefore a test was required. The samples tested within the tolerance levels for heavy metals and PCB's.

Routine dredging of sediment is part of the nine-foot navigation plan. There are several sites in Pool No. 1 that require periodic dredging due to sedimentation. Dredging is the responsibility of the St. Paul District's Fountain City Boat Yard located at Fountain City, Wisconsin. As soon as the ice leaves the river, hydrographic surveys are made to get an early indication of channel conditions. After spring high water, surveys of the historic problem spots are performed. Equipment is lined up and a priority list is made. **Table 5-2** gives a summary of dredging in Pool No. 1 and in the lower lock approach since 1970.

Table 5-2 Summary of Dredging Activity – 1970 through 2000					
Cut Name	**River Mile**	**Avg. Vol. Per Year**	**Avg. Vol. Per Job**	**Freq. of Dredging**	**Last Year Dredged**
Lower Approach LSAF	853.4	155 yd	799 yd	19 %	2000
Washington Ave Bridge	852.5 to 853.0	1,641 yd	16,952 yd	10 %	1987
Above Franklin Ave	851.6 to 852.4	3,824 yd	16,933 yd	23 %	1991
Below Franklin Ave Bridge	850.7 to 851.4	8,453 yd	23,822 yd	35 %	2000
Above Lake St Bridge	849.9 to 850.5	12,958 yd	23,629 yd	55 %	1999
Below Lake St Bridge	848.9 to 849.9	7,034 yd	19,822 yd	35 %	1998
St. Paul Daymark	848.5 to 848.9	2,782 yd	14,372 yd	19 %	1988
Upper Approach L/D 1	847.7 to 848.4	4,639 yd	20,543 yd	23 %	2000
Lower Approach L/D 1	847.4 to 847.5	61 yd	1,880 yd	3 %	1994

5-04. Recording Hydrologic Data. A daily logbook is maintained at the site. It includes pool and tailwater elevations at the dam (every four-hours), discharge through the turbines and over the dam along with kWh (midnight and 0600-hours), pool and tailwater at the powerhouse (daily), air temperature (every four-hours), precipitation (daily), water temperature (daily), and wind speed and direction. All daily data reported to Water Control from the dam site (**5-01. b. Reporting**) is compiled and archived using Hydraulic Engineering Center's Data Storage System (HEC-DSS) and is accessible from the Water Control web site at *www.mvp-wc.usace.army.mil*. The following table shows the period of record for electronically stored data.

Type of Data	Frequency	Start of Record
Pool Elevations	Daily	31 Dec 1904
Tailwater Elevations	Daily	01 Nov 1904
Pool & TW Elevations	4-hours	01 Jan 1998
Discharge	Daily	01 Jan 1985
Discharge	4-hours	01 Jan 1998
Precipitation	Daily	06 Apr 1995
Air Temperature	Daily	07 Apr 1995
Water Temperature	Daily	14 Apr 1998
Pool & TW Percent Ice	Weekly	22 Nov 1998
Pool & TW Ice Thickness	Weekly	22 Nov 1998
Snow Depth	Weekly	22 Nov 1998
Snow Water Equivalent	Weekly	22 Nov 1998

In 2001, log sheets were made available on the Water Control web site. By using the lock and dam data stored in DSS files, log sheets were generated dating back to January 1993. Log sheets from 1 January through 6 April 1995 only included the daily power plant pool and tailwater elevations and the total discharge. The discharges were entered for the time periods 0600 and midnight. The program records the 0600 reading as 0800 and interpolates a discharge for 1200-hours. From 7 April 1995 to 31 December 1997, log sheets added daily precipitation and daily air temperature. Starting on 1 January 1998, log sheets included air temperature and the pool and tailwater elevations at the dam on four-hour intervals. In addition, total discharge was broken down to include water through the turbines and water over the dam. Water over the dam was interpolated to provide discharges at four-hour intervals. Daily water temperature was added to the table on 14 April 1998.

5-05. Communication Network. The communication network consists of computer terminal, T1 line, telephone, pager, facsimile, FM radio, voice modem, satellite, and the US Postal Service. Computer communication is done via e-mail, and "sig-na-term" which allows remote access to the Water Control network. When the computer is down, the transfer of data is by facsimile and telephone or FM radio. During non-duty hours on weekends and holidays, dam personnel can contact the river regulator by calling the pager number (612-660-8053). A T1 line ensures communication between Water Control and the Mississippi River Valley Division Office (MVD) in Vicksburg, Mississippi. Bulk items like Stevens PAV-C strip charts are delivered to Water Control through the postal service.

5-06. Communication with Project.

a. **Regulating Office with Project Office.** Dam site personnel input and transmit their data, via computer, to Water Control every day by 0630-hours. Communication is typically via e-mail; however, FM radio is available as backup, with the telephone serving as backup to the radio. Should the dam site have computer problems, such that the transfer of data is not possible, a facsimile is then sent to Water Control (651-290-5841). The Water Control river manager then enters the information into the Regulation Program and Information Management (IM) is notified of the computer problem.

b. Between Project Office and Ford Powerhouse. Ford powerhouse personnel contact the site at 0600-hours and at midnight. Should Corps staff need to contact the powerhouse, their telephone number is 651-696-0502. Short of walking through the dam or driving to the site, no backup communication device is available.

c. Between Project Office and Others. The general public has access to river level and discharge data by calling Water Control's "Corps of Engineers River Information Service" at 651-290-5861. This service provides a recording of daily stages and discharges along the Mississippi River. In addition, the Water Control web site at *www.mvp-wc.usace.army.mil* also provides river information to the general public. From this web site, the public can access current water surface elevations and discharges for the Mississippi River as well as the daily log sheets for the locks and dams. Notifications of severe weather or impending unusual conditions are handled through local law enforcement, civil defense authorities, and the National Weather Service.

5-07. Project Reporting Instructions. The project staff reports hydrologic and hydropower conditions to Water Control every morning. Also, any unusual condition should be reported to Water Control.

5-08. Warnings. In the event of a lock miter gate failure or failure of the inflatable flashboard system, communications must be established as quickly as possible with Water Control Section and Construction-Operations Division. Notification should also be given to the Ford Powerhouse, Lock and Dam No. 2, and Lower Saint Anthony Falls.

VI – HYDROLOGIC FORECASTS

6-01. General. During periods of low flow, all of the flow is passed through the powerhouse, while during high-flow events, discharge in excess of the power-house capacity is spilled over the dam. Other than the inflatable bladder on top of the dam, there are no operable gates. The lock goes out of operation when the pool reaches elevation 730.0 feet (1912 adjustment) or when the tailwater reaches 709.2 feet (1912 adjustment) at which time water is within half a foot of the top of the lower guide wall. The timing and elevation of the crest is important for planning flood emergency actions and forecasting when the lock would go out of operation. In addition, the timing on the receding limb of the hydrograph aids in determining when the lock would go back into service. In 1997, the St. Paul District developed an unsteady-flow model of the Mississippi River. The Mississippi Basin Model System utilizes the computer program UNET for forecasting purposes.

a. Role of the Corps. The St. Paul District previously relied solely on the National Weather Service (NWS) for Mississippi River forecasts. However, the NWS only forecasts for designated sites along the Mississippi River. The nearest forecast sites to Lock and Dam No. 1 are the Minneapolis gage located upstream of the Upper St. Anthony Falls Lock and Dam and the St. Paul gage which is located downstream in Pool No. 2. Also, the NWS forecast typically is only a five-day forecast with a projected crest height and date. The District saw a need for a model to forecast not only the time and elevation of the crest at the dam for planning flood emergency activities, but also the receding limb for forecasting when the lock may go back into operation. In 1997, the District developed such a model. It is called the Mississippi Basin Model System (MBMS) and utilizes the unsteady flow program UNET. The river regulator in the Water Control Section runs the MBMS model every morning. For the flood events of 1997 and 2001, the model provided excellent predictions of when the crest would occur and when the lock would be placed back into operation. This was of great use for planning flood emergency activities and keeping the towing industry abreast of the situation.

b. Roles of Other Agencies. The National Weather Service (NWS) electronically provides the District forecasted stage hydrographs of the major tributaries to the Mississippi River by 0830-hours daily. Water Control Section inputs these hydrographs into the Mississippi Basin River System model and makes a run. The stage hydrographs are internally converted into discharge hydrographs. The results are electronically transferred to the NWS River Forecast Center in Chanhassen, Minnesota by 0930-hours. The NWS uses the UNET results and the results from their Mississippi River forecast model to provide stage forecasts at various points along the Mississippi River (e.g. Minneapolis and St. Paul).

6-02. Flood Condition Forecasts. Since 1997, St. Paul District has been using the Mississippi Basin Modeling System (MBMS) to forecast flood conditions along the Mississippi River. The system utilizes UNET, which is an unsteady flow computer program. UNET was modified to simulate navigation dams according to operating rules. While the program allows the operating rules to vary according to the season, it does not account for gate operation. Therefore, model results are limited while the dam is in a regulated condition. Flow and stage data are required to provide the boundary conditions that drive the model. Observed stages are updated daily. The model is dependent upon forecasted tributary inflow. The National Weather Service (NWS) electronically mails the five-day forecasted stage hydrographs for the major tributaries to Water Control by 0830-hours daily. The hydrographs typically include the 24-hour quantitative precipitation forecast (QPF). The program coverts the stage hydrographs into discharge hydrographs. Water Control extrapolates the tributary discharge hydrographs to 30-days. Forecasts beyond 5-7 days are very approximate due to unknowns such as additional rainfall. Therefore, only the five-day forecast for the locks and dams is made available to the public via the Water Control web site; *www.mvp-wc.usace.army.mil*. A seven-day forecast is available to Corps personnel through the Intranet. The 30-day forecast is available to Water Control staff only.

Modeling efforts as part of the Corps of Engineers Water Management System (CWMS) began in 2001. CWMS will contain hydrologic and hydraulic models of the District's reservoirs and the locks and dams. When the Mississippi River portion of CWMS becomes deployed and operational, the functionality of the MBMS model will be replaced. Rather than using UNET, CWMS will use a HEC-RAS unsteady flow model. The sharing of data with the NWS will remain unchanged.

6-03. Long-Range Forecasts. The Mississippi Basin Modeling System (MBMS) is used for making long-range forecasts. It is run everyday at about 0930-hours. The model forecasts elevation and discharge for the locks and dams and control points 30-days out. However, as previously noted, the five-day tributary inflow provided by the National Weather Service only includes the 24-hour quantitative precipitation forecast (QPF). Therefore, judgment is required when looking at long-range forecasts.

6-04. Drought Forecast. The lock and dam system operates as "run of the river". That is, what ever flow enters the pool is passed on. During low flow, a project pool elevation of 723.5 feet (1912 adjustment) is maintained provided there is sufficient inflow to meet withdrawal needs and pool evaporation. There is no drought forecasting model other than the Mississippi Basin Modeling System previously discussed.

VII - WATER CONTROL PLAN

7-01. General Objectives. The general objective of the water control plan is to maintain a minimum depth of nine feet along the navigation channel of Pool No. 1. Project pool elevation with the flashboard system deflated is 723.1 feet (1912 adjustment). The dredge plan assumes this pool elevation. This is the crest of the dam. The pool is not to be lower than this elevation. Maintaining this pool elevation at the dam during periods of low flows ensures a minimum channel depth of nine feet; however, periodic dredging is required. Because the pool is typically maintained at the higher project pool elevation of 725.1 feet, emergency dredging is rarely needed.

7-02. Constraints.

a. Pool Levels. Project pool elevations are maintained at the dam. There are two project pool elevations for Lock and Dam No. 1. During navigation season, the lowest pool elevation allowed is the same as the crest of the dam, 723.1 feet. Attached to the crest of the dam are two air bladders. The bladders are operated by Ford Motor Company in conjunction with their power production. During low flow, both bladders are inflated and the pool is at elevation 725.1 feet. This is the second project pool elevation. In accordance with the FERC license, Ford Motor Company is bound by rules and regulations (**Exhibit B**). During the navigation season, the pool cannot drop below elevation 724.1 feet. During the non-navigation season the minimum allowable pool is elevation 722.8 feet (1912 adjustment).

b. Lock Operation. There are two locks at the site, a riverward and a landward lock. The riverward lock's lower sill elevation is 2.5 feet higher than the landward lock. At project pool elevation this provides only 7.5 feet of clearance. In addition there are no guide walls. Therefore, it was used for pleasure boats, empty barges, or shallow-draft towboats. Continual break down of the operating equipment lead to its abandonment in 2002. Therefore, all river traffic is constrained to the use of the landward lock.

c. Closure of the Lock to Navigation. When flows reach 30,000 cfs, the lock is closed to recreational craft due to high flow velocities. At a flow of about 41,000 cfs all navigation ceases. Prior to February 2000, the lock was closed when the pool elevation reaches 729.0 feet, which corresponds to the elevation of the hydraulic rams on the upper miter gate. After this date, elevation 729.0 feet was established as the lock closure elevation. It is at this elevation that sand bags are placed around the miter gate machinery pit hampering movement of the hydraulic ram. The lock will also be closed when the tailwater elevation reaches 709.2 feet, which is 0.5 feet below the top of the lower guide wall. It is not unusual for the Coast Guard to close the river to navigation before any of the closure elevations are reached.

The lock is also closed when ice is too thick to permit tow traffic. As winter approaches, the lock remains open as long as towboats and barges can travel. Water temperatures are monitored to predict lock closure. In late March, the ice often becomes thin enough for some tow traffic and the lock is opened. **Table 7-1** shows the history of opening and closing dates.

Table 7-1
Spring Opening and Fall Closing Dates

Year	Opening Date	Closing Date	Year	Opening Date	Closing Date
1978	25 Mar	30 Nov	**1991**	22 Mar	26 Nov
1979	30 Mar	30 Nov	**1992**	11 Mar	24 Nov
1980	27 Apr	23 Nov	**1993**	24 Mar	27 Nov
1981	02 May	08 Dec	**1994**	29 Mar	24 Nov
1982	04 Apr	02 Dec	**1995**	21 Mar	22 Nov
1983	11 Mar	30 Nov	**1996**	22 Mar	21 Nov
1984	24 Mar	30 Nov	**1997**	17 Mar	22 Nov
1985	18 Mar	25 Nov	**1998**	02 Mar	29 Nov
1986	24 Mar	02 Dec	**1999**	23 Mar	27 Nov
1987	27 Feb	23 Nov	**2000**	20 Mar	21 Nov
1988	24 Mar	23 Nov	**2001**	20 Mar	30 Nov
1989	29 Mar	27 Nov	**2002**	20 Mar	04 Dec
1990	08 Mar	26 Nov	**2003**	01 Apr	26 Nov

7-03. Overall Plan for Water Control.

a. General Plan. The navigation channel of Pool No. 1 is 200 feet wide along the straight reaches of the river and varies from 200 feet to 450 feet in the bends. The primary purpose of Lock and Dam No. 1, combined with periodic dredging, is to maintain a minimum depth of nine feet throughout the navigation channel. The secondary purpose is power generation. During flows of less than 10,000 cfs, the pool is fairly flat. To meet depth requirements in the upper pool requires the pool elevation at the dam to not be lower than elevation 723.1 feet (1912 adjustment). This is the dam crest elevation. There was originally a flashboard system atop the dam. When the flashboards were in place, the normal pool elevation was 725.1 feet. The flashboards were designed to fail at high flow but would sometimes fail when hit by debris. When the flashboards were down, Ford Motor Company would maintain a minimum elevation of 723.1 feet until the flashboards could be replaced. When the flashboards were put in place, Ford Motor Company would maintain a minimum pool elevation of 724.1 feet in accordance with the FERC license (**Exhibit B**). This elevation may seem odd since the top of the flashboards were at elevation 725.1 feet. This elevation allowed for some flashboards to be in the down position and also accounted for any discrepancy in gage readings, i.e. Corps' pool gage and Ford's pool gage. The operating curves are shown on **Plate 7-1**. They were updated for this manual based on historical data.

b. Computed Discharge. Discharges are computed by Ford Motor Company's powerhouse personnel and provided to Lock and Dam No. 1. Discharges are computed on four-hour intervals and are transferred to lock personnel at 0600-hours and midnight. Outflow from the powerhouse is determined by a relationship between effective head and percent of governor opening as shown in **Table 7-2**. Effective head is based on Ford's pool and tailwater gages, which are independent of the Corps' gages. When river discharge exceeds the capacity of the powerhouse, the additional flow spills over the dam. The discharge rating curve for the dam is based on the Corps' tailwater gage. The rating curve is shown on **Plate 7-2**.

Table 7-2
Ford Hydroelectric Plant Discharge (cfs) per Turbine-Generator Unit
Four Turbine-Generator Units

Head (feet)	Governor - Percent Opening									
	55	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
30.0	1040	1108	1184	1261	1337	1414	1486	1549	1613	1673
30.5	1048	1117	1194	1271	1348	1425	1498	1562	1626	1687
31.0	1057	1126	1204	1282	1359	1437	1510	1575	1639	1700
31.5	1065	1135	1213	1292	1370	1449	1523	1588	1653	1714
32.0	1074	1144	1223	1302	1381	1460	1535	1600	1666	1727
32.5	1082	1153	1233	1312	1392	1471	1547	1613	1679	1741
33.0	1090	1162	1242	1322	1402	1483	1558	1625	1691	1754
33.5	1099	1171	1251	1332	1413	1494	1570	1637	1704	1768
34.0	1107	1179	1261	1342	1424	1515	1582	1649	1717	1781
34.5	1115	1188	1270	1352	1434	1516	1593	1661	1730	1794
35.0	1123	1196	1279	1362	1444	1527	1605	1673	1742	1807
35.5	1131	1205	1288	1371	1455	1538	1616	1685	1754	1820
36.0	1139	1213	1297	1381	1465	1549	1628	1697	1767	1832
36.5	1147	1222	1306	1391	1475	1559	1639	1709	1779	1845
37.0	1155	1230	1315	1400	1485	1570	1650	1721	1791	1858

c. **Regulation Procedure.** Regulation of the pool is conducted by Ford Motor Company under FERC License No. 362 following specific rules and regulations as stated in **Exhibit B**. Project pool elevation is maintained at the dam. There are two project pool elevations for Lock and Dam No. 1. During navigation season, the lowest pool elevation allowed is the same as the crest of the dam, 723.1 feet. This is the first project pool elevation. Attached to the crest of the dam are two air bladders separated by a small concrete pier in the middle of the spillway. The bladders are operated by Ford Motor Company to maintain head for power production. The bladders are designed to have a useful life of over 20 years, but only if they are operated in the fully inflated or fully deflated position. Instabilities and oscillations occur at partial inflation as well as overtopping depths greater than one foot. Therefore the bladders are operated in steps. During low flow, the both bladders are inflated and the pool is at elevation 725.1 feet. This is the second project pool elevation. Overtopping of the inflated bladders begins when the river increases beyond 7,000 cfs, the present hydraulic capacity of the powerhouse turbines. At a discharge of 8,870 cfs, the overtopping depth is one-foot (i.e. elevation 726.1 feet). When the pool reaches this elevation, one of the bladders is deflated. As a result, the pool will fall to about elevation 724.7 feet. When the river discharge reaches 9,840 cfs, overtopping of the remaining inflated bladder commences. When the river discharge reaches 13,300 cfs, the overtopping depth on the second bladder is one-foot and it is deflated. This action will cause the pool to drop to elevation 725.3 feet. When the flood has passed, one bladder is re-inflated when the pool drops to elevation 725.3 feet. This will cause the pool to rise to elevation 726.1 feet. When the pool drops to elevation 724.7 feet, the second bladder is re-inflated. The pool will then rise to elevation 726.1 feet. Uncontrolled overtopping ceases when the river discharge falls to 7,000 cfs

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During the non-navigation season the minimum allowable pool is elevation 722.8 feet (1912 adjustment). During the navigation season, the pool is not to drop below elevation 724.1 feet. The variation in pool elevation is not to exceed 0.5 feet per day whenever the pool elevation is below 725.1 feet. The maximum rate of such variation may not exceed 0.1 feet per hour during non-navigation periods. However, increased hourly rates may be permitted during the navigation season to eliminate wasting of water during increases in river flow. When the pool is above elevation 726.1 feet due to high flows, the inflatable dam is to be placed in the lowered position.

d. Winter Regulation. Unlike most of the other Upper Mississippi River Locks and Dams, during the winter, the tainter valves in the lock walls are kept closed. Experience has shown that excessive sediment builds up in the lock chamber over the winter making it difficult to open the lower miter gates.

The original spillway flashboard system consisted of hinged steel plates anchored to the crest of the dam and braced up with steel rods inserted in special holes on the dam. The flashboards typically collapsed during the winter or early spring and had to be reset or repaired when lower water levels permitted. The current inflatable flashboard system is left in the raised (inflated) position throughout the winter. Ice will form up against the bladder during the winter and as the water rises due to high flows, the ice will break up and spill over the top of the bladder.

During the non-navigation season, on the weekends and holidays, shifts are limited to one person at the lock and dam site.

7-04. Standing Instructions to Lock and Dam No. 1 Staff. Lock and dam personnel record data received from the powerhouse at 0600-hours and midnight each day. All data recorded as 0800 hours is actually collected at 0600-hours. The data set includes:

Data Received from the Ford Dam
At 0600-hours and Midnight

Data Recorded	Time Interval	Start Time
Instantaneous Discharge	four-hour	0400-hours
Powerhouse Pool & TW	daily	0800-hours
Average Discharge	eight-hour	0800-hours
Average Discharge	daily	2400-hours
Kilowatt Hours	daily	2400-hours

Lock and dam personnel also enter data to be used by Water Control via a remote computer. Some of the data are taken directly from the "*Data Received from the Ford Dam*" while the remainder is collected at the site. The data intervals vary from once a day to every four hours; however, data are only entered at 0600 hours and 2400 hours. As with the above data table, all 0800-hour readings are collected at 0600-hours. The following table shows the intervals and start times for data collection.

Data Entered by Site Personnel
via Remote Computer

Data Recorded	Time Interval	Start Time
Corps Pool & TW	four-hour	0400 hours
Instantaneous Discharge	four-hour	0400 hours
Air Temperature	four-hour	0400 hours
Average Discharge	eight-hour	0800 hours
Powerhouse Pool & TW	daily	0800 hours
Average Discharge	daily	2400 hours
Precipitation	daily	0800 hours

During the winter months lock personnel also enter percent of ice coverage over the upper pool and lower tailwater, ice thickness, snow depth, and snow-water equivalent. These data are collected once a week on Sunday.

The Stevens PAV-C strip charts maintain the permanent record of the pool and tailwater elevations. The charts are to be mailed to Water Control a minimum of once a year.

Normal duty hours for Water Control are 0630 to 1500-hours during the week, and 0630 to 0930-hours on weekends and holidays. The weekend pager number is 612-660-8053. The following is a list of Water Control personnel with river responsibilities. Contact should be made in the order listed in **Table 7-3**. Lock personnel contacting Water Control personnel during non-duty hours should have pool and tailwater readings, wind speed and direction, and the amount of precipitation since last report.

Table 7-3
Water Control Personnel Telephone Numbers

Name	Non-Duty	Office
Scott Bratten	651-436-6135	651-290-5624
Ted Pedersen	715-639-2625	651-290-5253
Dennis Holme	651-483-4003	651-290-5614
Farley Haase	751-235-1928	651-290-5633
Ferris Chamberlin	651-653-7981	651-290-5619
Robert Engelstad	651-459-6343	651-290-5610

If lock personnel have any questions for Water Control, they are to contact the river regulator via telephone (651-290-5624) and the question will be resolved. During computer outages, information is to be faxed to Water Control Section (651-290-5841). Communication will be via telephone or FM radio.

7-05. Flood Control. Lock and Dam No. 1 has no flood control benefits. It is operated strictly for navigation and power generation.

7-06. Recreation. The major recreation features of Pool No. 1 are fishing and boating. There were over 2,000 recreational boat lockages in 2000. **Table 7-4** shows a comparison of recreational boating to commercial traffic.

Table 7-4
Commercial & Recreational Lockages at Lock No. 1

Year	Towboats & Barges	Recreation Boaters	Other Lockages	Total Lockages	Percent Recreation
1991	1,240	2,177	54	3,471	62.7 %
1992	1,408	2,212	37	3,657	58.0 %
1993	1,024	1,354	27	2,405	56.3 %
1994	1,177	2,403	37	3,617	66.4 %
1995	1,169	2,073	27	3,269	63.4 %
1996	1,211	2,138	51	3,400	62.9 %
1997	1,150	1,898	67	3,115	60.9 %
1998	1,213	2,420	86	3,719	65.1 %
1999	1,228	2,199	117	3,544	62.1 %
2000	1,300	2,376	162	3,838	61.9 %
2001	1,088	1,599	147	2,834	56.4 %
2002	1,233	1,471	168	2,872	51.2 %

7-07. Water Quality. The Minnesota Pollution Control Agency (MPCA) and the Metropolitan Council Environmental Services Division (MCES) monitor water quality in Pool No. 1. The MPCA periodically reports to Congress under Section 305(b) of the Clean Water Act. Their *Assessment of Stream Water Quality* was a part of the report. Based on this report, aquatic life was “full”, swimming was not recommended, and the presence of bacteria was above the standard.

7-08. Fish and Wildlife. Because the lock and dam was constructed for the primary purpose of navigation, the pool would sometimes be drawn down in non-navigation season through the use of the sluiceway gates. The completion of the powerhouse in 1923 prevented drawdown of the pool so as to maintain head for power generation. With the old flashboard system, winter pool elevations varied depending on the number of flashboards that were in place. The pool may have been at a high elevation of 725.1 feet when all the flashboards were in place, down to elevation 723.1 feet. Since installation of the inflatable bladders in 1996, the winter pool elevation has been maintained at elevation 725.1 feet. The higher winter pool elevation helps reduce the oxygen depletion in the pool.

7-09. Water Supply. Minneapolis and St. Paul draw their water from the Mississippi River upstream of St. Anthony Falls. Pool No. 1 does not provide water supply.

7-10. Hydroelectric Power. Ford Motor Company owns and operates the power plant, which is located at the east end of the dam as shown in **Plate 2-1**. It is operated under FERC license No. 362. The power plant houses four identical vertical axis Francis-type turbine-generating units manufactured by Wellman-Seaver-Morgan. Replacement of the badly worn original Francis runners with modern stainless steel runners manufactured by Voith Hydro was completed in 1996. After the installation of the new runners, the turbines were up-rated from 4,500 hp to 5,800 hp at a flow of 1,750 cfs and a net head of 34 feet. The 13.8 kV, 60 Hz, 3-phase generators were manufactured by Westinghouse and are rated at 4,500 kVA (**Figure 2-4**). Each unit has a hydraulic governor manufactured by Woodward Governor. Total gross energy generated by the facility in the year 2000 was 101 million kWh. The hydraulic capacity of the powerhouse is approximately 7,000 cfs, which the river exceeds about 40 percent of the time. **Table 7-2** lists the discharge capacity for each generator based on available head and governor opening.

7-11. Navigation. The primary purpose of Lock and Dam No. 1 is to provide navigation. Various products pass through the lock. **Table 8-**1 gives annual list of tonnage commodities over the past few years. The project has two locks; however, only the landward lock is operational. Each lock is 56 feet wide and 400 feet long. In a single lockage, this will accommodate a towboat and two barges (typically 35 ft by 195 ft). Although the site is equipped to allow for double lockages, it doesn't happen. Filling and emptying time for the lock under normal conditions is twelve minutes. Lockage time for a single lockage depends on the experience of the deck hands breaking and making couplings, number of loaded and empty barges, wind speed and direction, flow conditions, and whether it is an up bound or down bound tow. A down bound tow will take slightly longer due to outdraft conditions at the dam. On average, a single lockage takes about 45 minutes.

7-12. Emergency Action Plans. The Emergency Action Plan is a stand-alone document entitled *Emergency Plan for Lock and Dam 1, Minneapolis, Minnesota*, March 1987. The plan addresses emergencies related to above normal reservoir water levels and/or rapid release of large volumes of water past the dam. It covers identification of impending or existing emergencies and notification of other parties concerning impending or existing emergencies. Potential causes of an emergency affecting the operation or safety of Lock and Dam No. 1 include structural damage, sabotage, extreme storm, excessive seepage, and failure due to scouring.

There are several protective measures taken at Lock and Dam No. 1 when a flood occurs. When the pool level is forecasted to go above elevation 729.0 feet (1912 adjustment), the drain on the upper guide wall is sealed to prevent the entrance road from flooding and the four miter gate machinery pits are sandbagged. As the pool rises, other actions are required. The following gives a brief summary of the steps to be taken as water levels in the pool go higher:

Emergency Flood Action Plan - Pool Levels

Pool Elevation	Action Taken
729.0 feet	Seal drain on upper guide wall. Sandbag four miter gate machinery pits.
730.0 feet	Close lock to navigation.
731.0 feet	Protect upstream miter gate control box. Protect or remove fire equipment – upper intermediate wall. Protect upstream gage house.
731.5 feet	Remove or weight cable trench and machinery covers. Seal cable trenches on intermediate and river walls. Construct diversion dike across river wall.
732.0 feet	Secure lower miter gates to lock walls, land and river locks. Remove limit switch rods off upstream hydraulic gate rams. Implement visitor control and security. Implement esplanade lock wall protection measures. Protect bluff retaining wall to preclude flow behind it.
732.5 feet	Seal/sandbag drain holes on wall in turn around area.

There are also several protective measures taken at Lock and Dam No. 1 based on the tailwater level. When the tailwater level is forecasted to go above elevation 705.0 feet (1912 adjustment), the lifeboat and Handyflat are moved to the upper area. As the tailwater rises, other actions are required. The following gives a brief summary of the steps to be taken as tailwater levels go higher:

Emergency Flood Action Plan – Tailwater Levels

Tailwater Elevation	Action Taken
705.0 feet	Lifeboat and Handyflat are moved to the upper area.
709.0 feet	Disconnect power to lower guide wall. Protect or remove lower tow haulage unit. Pull hand railing by gage house/lower cell.
709.2 feet	Close lock to navigation.
709.5 feet	Remove equipment and materials from storage yard (life ring boxes, distance marker, signs). Protect lower tailwater gage and elevated walkway.

7-13. Deviation from Normal Regulation. Project pool elevation is mandated by Congress and the Federal Energy Regulatory Commission as stated in Article 41 of FERC License No. 362. The pool at the dam is not to be lower than elevation 722.8 feet during the non-navigation season and 724.1 feet during the navigation season. The pool is not to be intentionally lowered below these elevations; however, temporary deviations are permitted. Because these deviations are unplanned and are only temporary, while actions are being taken to correct the situation, these exceptions do not require notification of the division office. The division office (MVD) must be notified when deviation outside the limits is intentional and for a prolonged period of time. Planned deviations must be coordinated with MVD. A written request describing cause and effect will be sent to the Division Water Control Manager for approval. The District Commander or Chief of Engineering Division may deviate from the approved plan in an emergency situation. The District will inform MVD as soon as possible. This will include a written confirmation of the deviation and description of the cause.

7-14. Rate of Release Change. During the navigation season, when river flows are less than or equal to powerhouse capacity, the pool elevation should not vary by more than 0.5 feet per day whenever the pool is below elevation 725.1 feet (1912 adjustment), except that increases in pool elevation greater than 0.5 feet per day may be made to eliminate wasting of water during periods when the river is closed to navigation. The pool level should not vary at a rate greater than 0.1 feet per hour. Whenever the average daily flow is less than 1,000 cfs, the pool elevation should not vary more than 0.3 feet per day. When river flows are in excess of powerhouse capacity, rate of release change is nature driven.

VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. The effect of the water control plan for Lock and Dam No. 1 is to maintain a nine-foot depth in the navigation channel of Pool No. 1. Lock and Dam No. 1 is just one piece of the lock and dam system that provides navigation from St. Louis, Missouri to Minneapolis, Minnesota. Navigation on the Upper Mississippi River progressed from a four-foot deep channel in 1866, to a four and one-half foot channel in 1878, to a six-foot channel in 1907, and finally, to a nine-foot channel in the 1930's. A more complete description of this development is available in the Master Water Control Manual for the Locks and Dams.

8-02. Flood Control. The locks and dams provide no flood control benefits. They were constructed strictly for navigation purposes. The dam operates on a run-of-the-river principal. As discharge increases, more flow passes over the crest of the dam.

8-03. Recreation. The project provides recreational benefits although it is not regulated for this purpose. The two recreation qualities associated with Pool No. 1 are fishing and boating. While Lock and Dam No. 1 provides the necessary depths for the towing industry, it also is a benefit to recreational boating. The more stable water surface provides a more suitable environment for docks and marinas. There were over 2,000 recreation boat lockages in the year 2000.

8-04. Fish and Wildlife. Lock and Dam No. 1 is located near the midpoint of the 72-mile long Mississippi National River and Recreation Area, a unit of the National Park System. St. Paul Parks and the Minneapolis Park and Recreation Board own the shoreline and river bluffs for several miles upstream and downstream of the project. These riparian properties are part of the Mississippi Gorge Regional Park and are managed for recreation and resource preservation in cooperation with the National Park Service.

8-05. Hydroelectric Power. Ford Motor Company owns and operates a run-of-river hydroelectric project under FERC License No. 362. The powerhouse is operated 24 hours per day, seven days a week and is designed to generate the maximum amount of power for the available head and discharge. The power generated by the project is utilized as much as possible by the vehicle assembly plant located on the bluff above the powerhouse. Excess power is sold to Xcel Energy. Ford Motor Company also provides Lock and Dam No. 1 with free electricity via direct reimbursement. The average annual plant factor for the period 1996 to 2000 was 84 percent. Dependable capacity is estimated to be four megawatts. This is based on project generation at a flow of 2,080 cfs, the flow that is equaled or exceeded 90 percent of the time. Average annual gross energy production for the period 1994 to 2000 was 97,299 megawatt-hours.

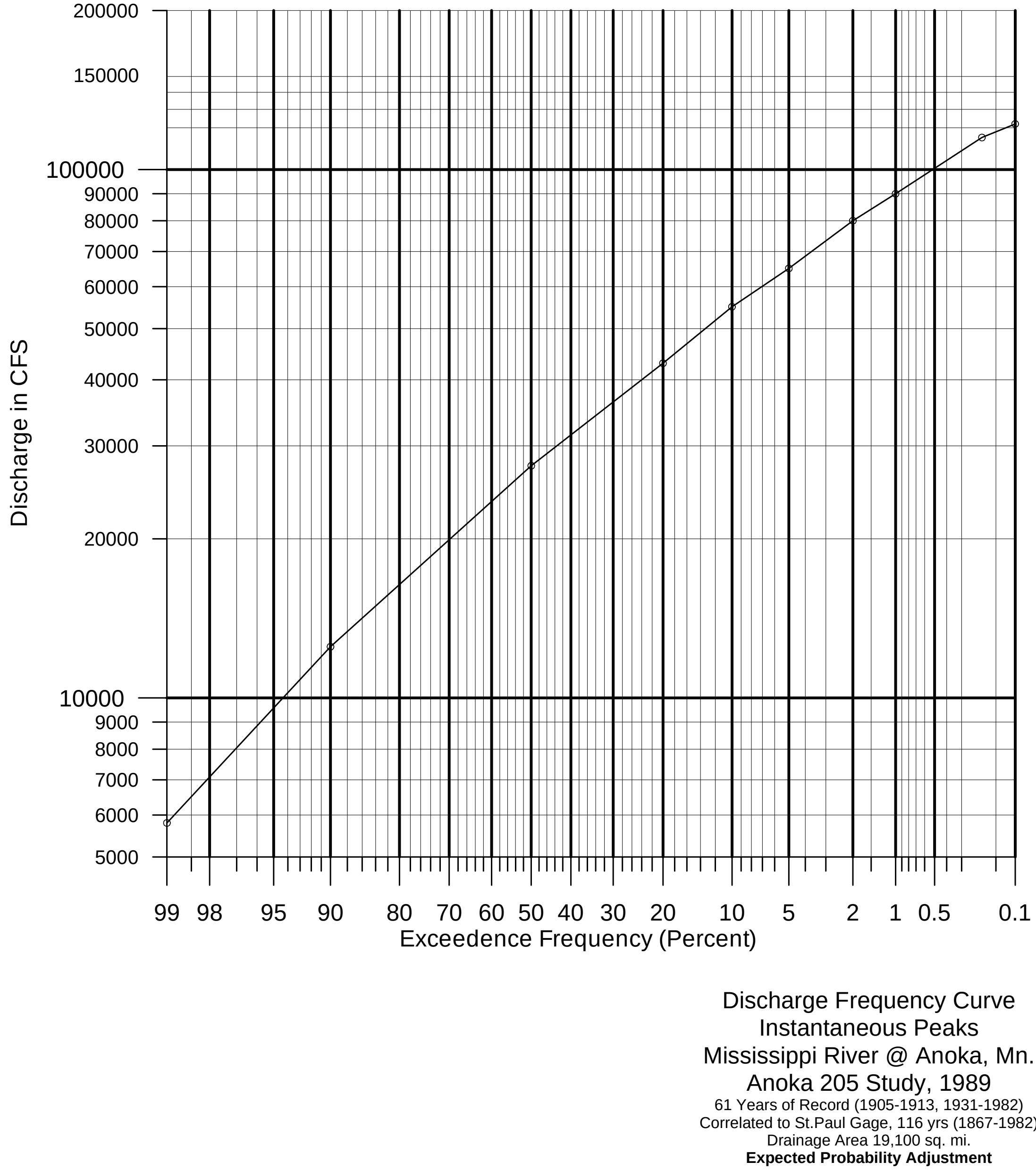
8-06. Navigation. Construction of Lock and Dam No. 1 was completed before authorization of the Upper Mississippi River Nine-Foot Channel Project. Because Lock and Dam No. 1 was authorized for power production, its high head requirement provided a nine-foot channel. For more historical information concerning the development of Lock and Dam No. 1 see **Paragraph 3-02**.

The minimum pool elevation of 723.1 feet at the dam provides a nine-foot channel to Lower St. Anthony Falls lock and dam. Periodic dredging is required to maintain the channel depth; however, because the inflatable bladder at the dam is in the raised position during low flows, there is rarely a need for emergency dredging. There are two locks at the site: a riverward and landward lock. The lower sill elevations are such that at project pool, clearance over the landward lock sill is 10.0 feet while it is only 7.5 feet over the riverward lock sill. Because of frequent breakdowns, use the riverward lock ceased in 2000. In 2002 the downstream miter gates were pinned back in an open position. Therefore, all river traffic is through the landward lock. **Table 8-1** shows the recent history of tonnage commodities at Lock and Dam No. 1.

Table 8-1 Lock and Dam No. 1 Tonnage – Commodities									
Year	Coal	Petrol Product	Chemical Products	Crude Material	Manu Goods	Farm Products	Equip Mach	Misc Product	Total Tonnage
1991	108,100	59,000	174,000	819,600	190,900	223,400	2,900	8,000	1,585,900
1992	99,000	1,500	214,500	841,200	198,800	578,000	6,500	3,100	1,942,600
1993	116,300	0	129,000	837,800	88,000	244,300	4,700	3,000	1,423,100
1994	124,200	0	39,600	998,900	125,100	357,800	5,700	3,000	1,654,300
1995	125,600	0	135,000	1,017,100	98,100	331,500	9,100	0	1,716,400
1996	136,100	1,500	143,400	1,065,900	95,300	321,000	11,200	0	1,774,400
1997	146,600	0	97,500	1,062,000	202,100	390,800	14,600	0	1,913,600
1998	115,600	0	120,000	1,088,400	291,000	347,900	10,000	1,900	1,974,800
1999	100,500	0	127,500	1,125,700	318,200	388,500	11,500	0	2,071,900
2000	124,502	0	150,000	1,128,380	362,400	480,000	11,900	0	2,257,182
2001	84,850	250	169,500	1,090,200	223,500	243,000	18,555	0	1,829,855
2002	109,725	0	195,000	1,117,150	289,060	261,000	5,305	8,655	2,045,895

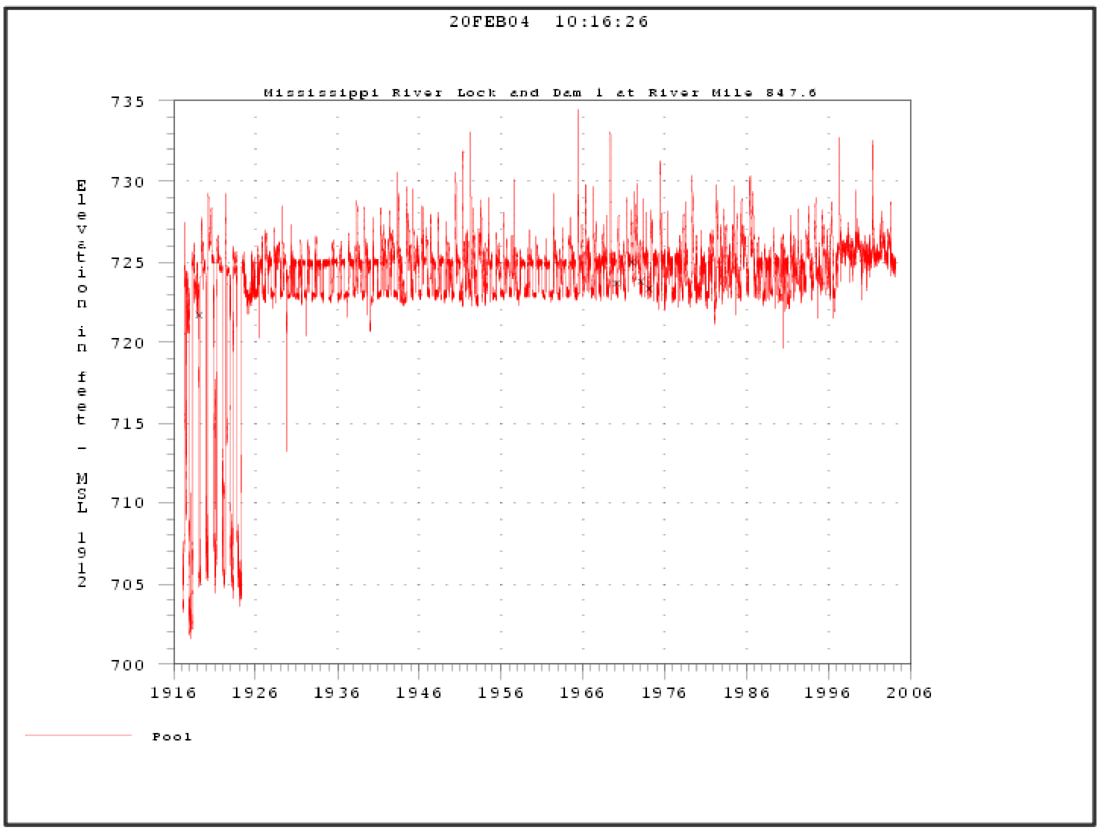
8-07. Frequencies. St. Paul District developed a discharge-frequency relationship in 2002 for the USGS gage located at Anoka, Minnesota (above Saint Anthony Falls). The gage is 17.2 miles upstream of Lock and Dam No. 1. The frequency curve displayed in **Figure 8-1** represents peak flow relationships for the Mississippi River at river mile 864.8. The frequency curve is derived from regionalized statistics for the mean and standard deviation, based on drainage area relationships at this location.

Figure 8-1.



Construction of the dam was completed in June 1917. By July, project pool elevation was achieved. **Figure 8-2** shows a history of the pool elevation. The high elevations represent flood events and the lows represent drawdown at the dam. Prior to hydropower, the pool was drawn down below project pool elevation (723.1 feet) to around elevation 705.0 feet during the winter months. This helped maintain the operability of the sluiceway system. Also, prior to completion of the powerhouse, the pool was drawn down to flush out pollution dumped into the river above the dam. With the exception of an emergency, after hydropower came on line in 1923, the only time the pool was drawdown was for installation of the flashboards. The greatest drawdown that occurred after completion of the powerhouse was in August 1929 when the pool was drawn down to elevation 713.17 feet. In the past 50 years there has been only three emergency conditions where lowering the pool aided in the recovery effort. They are: a barge incident in 1952, the Northern States Power Lower St. Anthony Falls hydro plant failure in 1987, and the Lake Street Bridge collapse on 24 April 1990. It should be noted that lowering of the pool only aided in the recovery efforts, it was not a requirement. Since the sluiceways are now defunct, the only method of lowering the pool is through passing flow through the power plant and the lock tainter gates.

Figure 8-2. History of Pool Elevation



IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. The Corps of Engineers is the owner and operator of Lock and Dam No. 1. Ford Motor Company owns and operates the powerhouse. Ford Motor Company has direct day-to-day responsibility for maintaining the pool at the dam when flows are less than powerhouse capacity. Construction and Operations Division is responsible for operation and maintenance of the lock and the dam. Water Control is responsible for monitoring the regulation of the pool and the storing and archiving of project data. Because there are no gates at the dam, daily contact by Water Control is not required; however, periodic contact is made to ensure communication lines are operating. The following shows the working relationship for the locks and dams within the St. Paul District.

St. Paul District Office
← ← ← District Engineer → → →

↓	↓
Chief Engineering Division	**Chief Con-Ops Division**
↓	↓
Chief H&H Branch	**Chief Lock & Dam Project Office**
↓	↓
Chief Water Control Section	**Area Lockmaster**
↓	↓
Water Control Manager → → → → →	**Lockmaster**

b. Other Federal Agencies. During high water, the National Weather Service (NWS) forecasts stage heights for Minneapolis (MSPM5), upstream of St. Anthony Falls, and St. Paul (STPM5), downstream of Lock and Dam No. 1. Water Control Section provides the NWS with the daily output from the Mississippi Basin Modeling System to aid them in making their forecast. The US Geological Survey (USGS) maintains the gage site at Anoka, Minnesota (gage # 05288500). Daily discharge values for the Anoka gage can be obtained from the USGS link on the Water Control web site at www.mvp-wc.usace.army.mil. Lock and Dam No. 1 is located at about the mid-point of the 72-mile long Mississippi National River and Recreation Area, a unit of the National Park System.

c. Local Agencies. St. Paul Parks and the Minneapolis Park and Recreation Board own the shoreline and river bluffs for several miles upstream and downstream of the project. These riparian properties are part of the Mississippi Gorge Regional Park and are managed for recreation and resource preservation in cooperation with the National Park Service

d. Private Agencies. Ford Motor Company operates and maintains the powerhouse at Lock and Dam No. 1. They are also responsible for operating and maintaining the inflatable rubber flashboard system that is mounted atop the dam. Powerhouse discharges are provided to Lock and Dam No. 1 by Ford Motor Company powerhouse personnel via telephone.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. Information concerning regulation of Lock and Dam No. 1 is provided by the St. Paul District's Public Affairs Office (PAO) to the local news media in response to their requests. In addition, Construction and Operations Division coordinates with PAO to provide News Releases regarding the opening or closing of the lock to navigation.

b. National Weather Service. The National Weather Service (NWS) provides the St. Paul District a "Work 10" file daily by 0830-hours. The file contains the five-day forecast for tributaries to the Mississippi River lock and dam system. The five-day forecast includes the 24-hour quantitative precipitation forecast (QPF). These stage hydrographs are input to Mississippi Basin Modeling System (MBMS) which converts them to discharge hydrographs internally. The MBMS is an unsteady flow model utilizing the computer program UNET. After the model is run, the output is sent to the NWS by

0930-hours. The NWS uses this information to forecast stages along the Mississippi River, which includes Minneapolis (MSPM5) upstream and St. Paul (STPM5) downstream of Lock and Dam No. 1.

c. US Geological Survey. To maintain the vast network of stream gages for operation of the locks and dams in the St. Paul District would be a costly undertaking. Because of the existing infrastructure of the US Geological Survey (USGS), the St. Paul District enters into a cooperative agreement each year with the USGS to maintain many of the gages on the Mississippi River and its tributaries. As for Pool No. 1, this includes the Mississippi River at Anoka, Minnesota. St. Paul District owns all the gage equipment. The USGS publishes the daily discharges for the Anoka gage annually as part of their *Water Resources Data – Minnesota*. Daily data can be obtained from the USGS link on the Water Control web site at www.mvp-wc.usace.army.mil.

d. River Resources Forum. The River Resources Forum and the subcommittee, Water Level Management Task Force, shares information and provides recommendations to the Corps of Engineers on river management. Participants include the US Fish and Wildlife Service, US Geological Survey, US Environmental Protection Agency, National Park Service, US Coast Guard, US Department of Transportation, Departments of Natural Resources of Minnesota and Wisconsin, Departments of Transportation of Minnesota and Wisconsin, and representatives of the commercial navigation industry.

9-03. Reports. "Operators Log" Form 2198 is the name for the daily log of river and dam conditions that is kept at the site. Also maintained at the site is a log sheet of data provided by the Ford Powerhouse (**Exhibit D**). The "Stevens Strip Charts" are sent to Water Control section at a minimum of once per year.

EXHIBIT A
SUPPLEMENTARY PERTINENT DATA

General Information

Location:	Mississippi River Mile 847.6 Minneapolis, Minnesota on the Right Bank St. Paul, Minnesota on the Left Bank Lat 44° 54’ 54” N Long 93° 12’ 06” W 5.8 miles below Lower St Anthony Falls Lock and Dam 32.4 miles above Lock and Dam No. 2
Type of Project:	Lock and Dam for Navigation Purposes
Project Owner:	Corps of Engineers
Operating Agency:	St. Paul District; Construction-Operations Division Ford Motor Company
Regulating Agency:	St. Paul District; Water Control Section
Completion Date:	June 1917
Datum:	MSL – 1912 adjustment

Hydrology

Drainage Area:	19,680 square miles
Design Flood:	Flood of 1881 Discharge: 73,500 cfs
Minimum Flow:	Of Record: July 1988 Discharge 49 cfs
Maximum Flow:	17 April 1965: Discharge 91,000 cfs
Average Daily Flow:	Years 1985-2002: Discharge 9,950 cfs
Median Daily Flow:	Years 1985-2002: Discharge 7,400 cfs
Maximum Monthly Flow:	April 1969: Discharge 42,970 cfs
Maximum Daily Flow:	17 April 1965: Discharge 91,000 cfs
Key Stream Flow Locations:	Mississippi River @ Anoka, Minnesota Mississippi River @ St. Paul, Minnesota Minnesota River near Jordan, Minnesota

Data Recorded at Dam Site:	Corps Pool & Tailwater Elevations (4-hr) Powerhouse Pool & Tailwater Elevations (24-hour) Total Discharge (4-hr) Average Discharge (8-hour and 24-hour) Power Generation – kWH (24-hr) Air Temperature (4-hr) Precipitation (daily) Water Temperature (daily) Snow Depth & Water Content (weekly) Percent Pool & Tailwater Ice Coverage (weekly)
Precipitation Gages:	Lock & Dam No. 1 and 2, and Lower SAF

Physical Features

Locks:		Landward	Riverward
	Dimensions:	56 ft by 400 ft	56 ft by 400 ft
	Top of Lock Walls:	Elevation 732.7 ft	Elevation 732.7 ft
	Top of Upper Gate Sill	Elevation 709.7 ft	Elevation 709.7 ft
	Top of Lower Gate Sill	Elevation 677.2 ft	Elevation 679.7 ft
	Lock Chamber Floor	Elevation 676.3 ft	Elevation 678.7 ft
	Height of Upper Miter Gates:	23.0 feet	23.0 feet
	Height of Lower Miter Gates	55.5 feet	53.0 feet
	Lift:	37.9 feet	37.9 feet
	Upper Guidewall Length:	620 feet	
	Lower Guidewall Length:	340 feet	
	Average Filling/Emptying Time:	12 minutes	
	Average Lockage Time:	45 minutes	
Pool:	Normal (Project) Upper Pool:	Elevation 723.1 ft (bladder deflated) Elevation 725.1 ft (bladder inflated)	
	Normal (Project) Lower Pool:	Elevation 687.2 ft	
	Total Pool Area (at Project Pool):	525 acres	
	Length in River Miles:	5.8 miles	
	Navigation Channel Width:		
	Straight Reaches:	200 feet	
	Curved Reaches:	200-450 feet	
	Most Frequent Dredge Site:	Above Lake Street Bridge	
Dam:	Type:	Ambursen concrete structure	
	Length:	574 feet	
	Crest Elevation:	723.1 feet with bladder deflated 725.3 feet with bladder inflated	
	Height:	29.5 feet	
	Sluiceways	8 @ 6 ft x 6 ft (no longer used) Inlet Invert Elevation 696.35 feet	

Power Plant:	Owner:	Ford Motor Company
	Generators:	
	Number:	4
	Type:	Westinghouse
	Rating	4,500 kVA
	Weight: (rotor and auxiliaries)	58 ton
	Cooling:	Oil bath
	Number of Poles:	72
	R.P.M.:	100
	Shaft:	16 inch diameter
	Turbines:	
	Number:	4
	Type:	Reaction (Wellman-Seaver-Morgan)
	Rating:	5,800 hp at 34 feet of head
	Controls:	Woodward Governors
	Flow Rate:	1,750 cfs at full load
	Total Horsepower Installed:	23,200
	Voltage:	13,800
	Average Daily Output (1994-2000):	266,600 KWH
	MWH Generated to Date:	~ 8 million
	Hydraulic Capacity:	7,000 cfs
	Operation Hours:	24 hours/day, 7 days/week

EXHIBIT B

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1135 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101

RULES AND REGULATIONS
GOVERNING THE
POOL LEVEL AT TWIN CITY LOCKS AND DAM, MISSISSIPPI RIVER
ST. PAUL, AND MINNEAPOLIS, MINN.

In accordance with the provisions of Articles 41, 42, and 43 of Federal Power Commission License of July 12, 1980 (Project No. 362-Minn., Ford Motor Co.), the following rules and regulations are prescribed for the control of the pool level created by the Twin City Locks and Dam, Minneapolis in the interest of navigation, and supersede rules and regulations prior to the above date:

Article 41. (a) During the navigation season, the Licensee shall not cause the pool above the dam (Lock and Dam No. 1) to drop below elevation 724.1 feet above mean sea level (1912 adjustment), except after loss or lowering of flashboards and before their replacement or raising. During the period when the river is closed to navigation, the licensee shall not allow the pool to fall below elevation 722.8 feet mean sea level (1912 adjustment). Also, when flashboards are down during the navigation season, the Licensee shall not allow the pool to fall below the crest of the dam elevation 723.1 feet mean sea level (1212 adjustment) as measured at the Lock and Dam No. 1 gage, except to facilitate replacement of the flashboards. The Licensee shall adhere to the non-navigation minimum stage during periods of actual flashboard replacement.

During the navigation season and except as provided for in paragraph (b) below, the Licensee shall not cause the pool level to vary in elevation by more than 0.5 foot per day whenever the pool is below elevation 725.1 feet mean sea level (1912 adjustment), except that increases in pool level greater than 0.5 foot per day may be made to eliminate wasting of water during periods when the river is closed to navigation, and except as provided for in paragraph (b) below, the pool level may vary at a maximum rate not to exceed 0.1 foot per hour:

(b) Whenever, due to low flows, the average daily flow at the dam is less than 1,000 cubic feet per second, the Licensee shall not cause the pool level to vary in elevation by more than 0.3 foot per day.

(c) The periods during which the river shall be open for navigation are those determined by the U. S. Army Corps of Engineers, District Engineer, St. Paul, Minnesota.

<u>Article 42</u>. To protect navigation in cases of emergency, such as the stranding of a boat or the loss of a pool below the Lock and Dam No. 1 (Twin Cities Lock and Dam), the Licensee shall temporarily depart from the limitations stated in Article 41 above and operate the project under the direction of the U. S. Army Corps of Engineers, St. Paul District Engineer.

<u>Article 43</u>. The Licensee shall operate and maintain the three sliding sluice valves, numbered 2, 3, and 4 from the hydro station, as originally constructed and now in the dam, in accordance with the rules prescribed by the U. S. Army Corps of Engineers, District Engineer, St. Paul, Minnesota.

EXHIBIT C
Mississippi River near Anoka Rating Table

1 UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION PAGE 1

EXPANDED RATING TABLE TYPE: LOG

05288500 DATE PROCESSED: 02-09-1999 @ 12:51 BY mcnellis

MISSISSIPPI RIVER NEAR ANOKA, MN DD: 9 TYPE: 001 RATING NO: 26.0

OFFSET: .00 BREAK,OFFSET: (2.40,.00) START DATE/TIME: 10-01-1987 (0015)

GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
.50	740.0*	751.2	762.4	773.5	784.6	795.6	806.6	817.5	828.4	839.2	110.0
.60	850.0*	861.2	872.3	883.4	894.4	905.4	916.4	927.4	938.3	949.2	110.0
.70	960.0*	972.1	984.2	996.2	1008	1020	1032	1044	1056	1068	120.0
.80	1080*	1093	1106	1119	1132	1145	1158	1171	1184	1197	130.0
.90	1210*	1224	1238	1252	1266	1280	1294	1308	1322	1336	140.0
1.00	1350*	1364	1378	1392	1406	1420	1434	1448	1462	1476	140.0
1.10	1490*	1506	1522	1538	1554	1570	1586	1602	1618	1634	160.0
1.20	1650*	1666	1682	1698	1714	1730	1746	1762	1778	1794	160.0
1.30	1810*	1826	1842	1858	1874	1890	1906	1922	1938	1954	160.0
1.40	1970*	1987	2004	2021	2038	2055	2072	2089	2106	2123	170.0
1.50	2140*	2158	2176	2194	2212	2230	2248	2266	2284	2302	180.0
1.60	2320*	2338	2356	2374	2392	2410	2428	2446	2464	2482	180.0
1.70	2500*	2520	2540	2560	2580	2600	2620	2640	2660	2680	200.0
1.80	2700*	2720	2740	2760	2780	2800	2820	2840	2860	2880	200.0
1.90	2900*	2920	2940	2960	2980	3000	3020	3040	3060	3080	200.0
2.00	3100*	3121	3142	3163	3184	3205	3226	3247	3268	3289	210.0
2.10	3310*	3332	3354	3376	3398	3420	3442	3464	3486	3508	220.0
2.20	3530*	3553	3576	3599	3621	3644	3667	3691	3714	3737	230.0
2.30	3760*	3783	3806	3829	3852	3875	3898	3921	3944	3967	230.0
2.40	3990*	4015	4040	4064	4089	4114	4139	4164	4189	4215	250.0
2.50	4240	4265	4290	4316	4341	4367	4392	4418	4443	4469	254.0
2.60	4494	4520	4546	4572	4598	4624	4650	4676	4702	4728	260.0
2.70	4754	4780	4806	4833	4859	4886	4912	4939	4965	4992	264.0
2.80	5018	5045	5072	5098	5125	5152	5179	5206	5233	5260	269.0
2.90	5287	5314	5341	5369	5396	5423	5451	5478	5506	5533	274.0
3.00	5561	5588	5616	5644	5671	5699	5727	5755	5783	5811	278.0
3.10	5839	5867	5895	5923	5951	5979	6007	6036	6064	6092	282.0
3.20	6121	6149	6178	6206	6235	6264	6292	6321	6350	6379	287.0
3.30	6408	6436	6465	6494	6523	6553	6582	6611	6640	6669	291.0
3.40	6699	6728	6757	6787	6816	6846	6875	6905	6934	6964	295.0
3.50	6994	7023	7053	7083	7113	7143	7173	7203	7233	7263	299.0
3.60	7293	7323	7353	7384	7414	7444	7474	7505	7535	7566	303.0
3.70	7596	7627	7657	7688	7719	7749	7780	7811	7842	7873	308.0
3.80	7904	7935	7966	7997	8028	8059	8090	8121	8152	8184	311.0
3.90	8215	8246	8278	8309	8341	8372	8404	8435	8467	8499	315.0

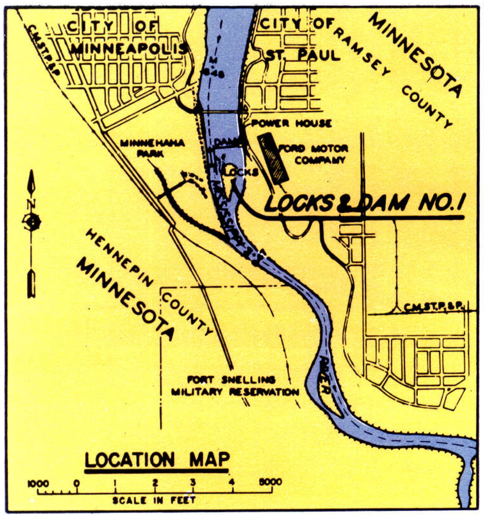
GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
			DISCHARGE IN CUBIC FEET PER SECOND				(EXPANDED PRECISION)				
4.00	8530	8562	8594	8626	8658	8689	8721	8753	8785	8817	319.0
4.10	8849	8882	8914	8946	8978	9010	9043	9075	9108	9140	323.0
4.20	9172	9205	9237	9270	9303	9335	9368	9401	9433	9466	327.0
4.30	9499	9532	9565	9598	9631	9664	9697	9730	9763	9796	331.0
4.40	9830	9863	9896	9929	9963	9996	10030	10060	10100	10130	330.0
4.50	10160	10200	10230	10260	10300	10330	10370	10400	10430	10470	340.0
4.60	10500	10540	10570	10600	10640	10670	10710	10740	10770	10810	340.0
4.70	10840	10880	10910	10950	10980	11010	11050	11080	11120	11150	350.0
4.80	11190	11220	11260	11290	11330	11360	11400	11430	11470	11500	350.0
4.90	11540	11570	11610	11640	11680	11710	11750	11780	11820	11850	350.0
5.00	11890	11920	11960	11990	12030	12070	12100	12140	12170	12210	350.0
5.10	12240	12280	12320	12350	12390	12420	12460	12490	12530	12570	360.0
5.20	12600	12640	12670	12710	12750	12780	12820	12860	12890	12930	360.0
5.30	12960	13000	13040	13070	13110	13150	13180	13220	13260	13290	370.0
5.40	13330	13370	13400	13440	13480	13510	13550	13590	13620	13660	370.0
5.50	13700	13740	13770	13810	13850	13880	13920	13960	14000	14030	370.0
5.60	14070	14110	14150	14180	14220	14260	14300	14330	14370	14410	380.0
5.70	14450	14480	14520	14560	14600	14640	14670	14710	14750	14790	370.0
5.80	14820	14860	14900	14940	14980	15020	15050	15090	15130	15170	390.0
5.90	15210	15250	15280	15320	15360	15400	15440	15480	15510	15550	380.0
6.00	15590	15630	15670	15710	15750	15790	15820	15860	15900	15940	390.0
6.10	15980	16020	16060	16100	16140	16180	16210	16250	16290	16330	390.0
6.20	16370	16410	16450	16490	16530	16570	16610	16650	16690	16730	400.0
6.30	16770	16800	16840	16880	16920	16960	17000	17040	17080	17120	390.0
6.40	17160	17200	17240	17280	17320	17360	17400	17440	17480	17520	400.0
6.50	17560	17600	17640	17680	17720	17760	17800	17850	17890	17930	410.0
6.60	17970	18010	18050	18090	18130	18170	18210	18250	18290	18330	400.0
6.70	18370	18410	18450	18500	18540	18580	18620	18660	18700	18740	410.0
6.80	18780	18820	18860	18910	18950	18990	19030	19070	19110	19150	410.0
6.90	19190	19240	19280	19320	19360	19400	19440	19490	19530	19570	420.0
7.00	19610	19650	19690	19740	19780	19820	19860	19900	19940	19990	420.0
7.10	20030	20070	20110	20150	20200	20240	20280	20320	20360	20410	420.0
7.20	20450	20490	20530	20580	20620	20660	20700	20750	20790	20830	420.0
7.30	20870	20920	20960	21000	21040	21090	21130	21170	21210	21260	430.0
7.40	21300	21340	21390	21430	21470	21510	21560	21600	21640	21690	430.0
7.50	21730	21770	21820	21860	21900	21950	21990	22030	22070	22120	430.0
7.60	22160	22210	22250	22290	22340	22380	22420	22470	22510	22550	440.0
7.70	22600	22640	22680	22730	22770	22820	22860	22900	22950	22990	430.0
7.80	23030	23080	23120	23170	23210	23250	23300	23340	23390	23430	450.0
7.90	23480	23520	23560	23610	23650	23700	23740	23790	23830	23870	440.0

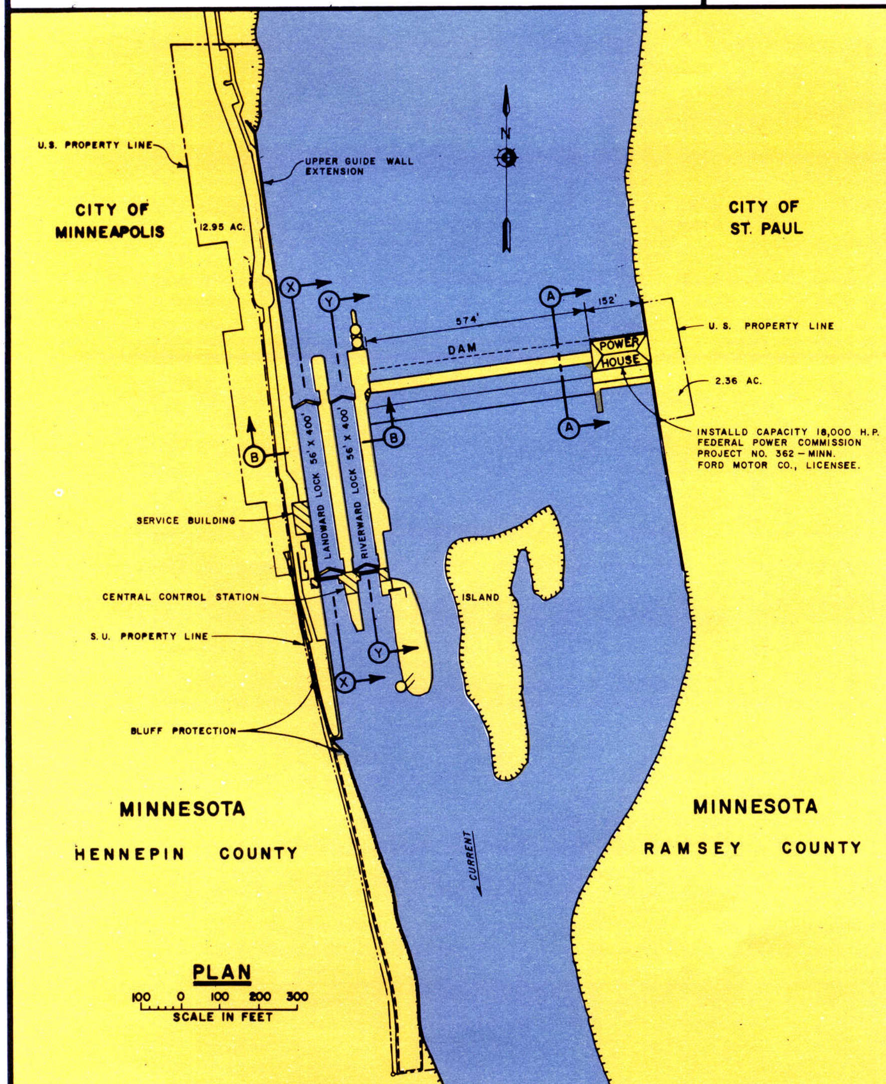
DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
8.00	23920	23960	24010	24050	24100	24140	24190	24230	24280	24320	440.0
8.10	24360	24410	24450	24500	24540	24590	24630	24680	24720	24770	450.0
8.20	24810	24860	24900	24950	24990	25040	25080	25130	25170	25220	450.0
8.30	25260	25310	25360	25400	25450	25490	25540	25580	25630	25670	460.0
8.40	25720	25760	25810	25860	25900	25950	25990	26040	26080	26130	460.0
8.50	26180	26220	26270	26310	26360	26410	26450	26500	26540	26590	460.0
8.60	26640	26680	26730	26770	26820	26870	26910	26960	27000	27050	460.0
8.70	27100	27140	27190	27240	27280	27330	27380	27420	27470	27520	460.0
8.80	27560	27610	27650	27700	27750	27800	27840	27890	27940	27980	470.0
8.90	28030	28080	28120	28170	28220	28260	28310	28360	28400	28450	470.0
9.00	28500	28550	28590	28640	28690	28730	28780	28830	28880	28920	470.0
9.10	28970	29020	29070	29110	29160	29210	29260	29300	29350	29400	480.0
9.20	29450	29490	29540	29590	29640	29680	29730	29780	29830	29880	470.0
9.30	29920	29970	30020	30070	30110	30160	30210	30260	30310	30350	480.0
9.40	30400	30450	30500	30550	30600	30640	30690	30740	30790	30840	490.0
9.50	30890	30930	30980	31030	31080	31130	31180	31220	31270	31320	480.0
9.60	31370	31420	31470	31520	31560	31610	31660	31710	31760	31810	490.0
9.70	31860	31910	31960	32000	32050	32100	32150	32200	32250	32300	490.0
9.80	32350	32400	32450	32490	32540	32590	32640	32690	32740	32790	490.0
9.90	32840	32890	32940	32990	33040	33090	33140	33190	33230	33280	490.0
10.00	33330	33380	33430	33480	33530	33580	33630	33680	33730	33780	500.0
10.10	33830	33880	33930	33980	34030	34080	34130	34180	34230	34280	500.0
10.20	34330	34380	34430	34480	34530	34580	34630	34680	34730	34780	500.0
10.30	34830	34880	34930	34980	35030	35080	35130	35180	35240	35290	510.0
10.40	35340	35390	35440	35490	35540	35590	35640	35690	35740	35790	500.0
10.50	35840	35890	35940	36000	36050	36100	36150	36200	36250	36300	510.0
10.60	36350	36400	36450	36510	36560	36610	36660	36710	36760	36810	510.0
10.70	36860	36910	36970	37020	37070	37120	37170	37220	37270	37330	520.0
10.80	37380	37430	37480	37530	37580	37630	37690	37740	37790	37840	510.0
10.90	37890	37940	38000	38050	38100	38150	38200	38260	38310	38360	520.0
11.00	38410	38460	38520	38570	38620	38670	38720	38780	38830	38880	520.0
11.10	38930	38980	39040	39090	39140	39190	39250	39300	39350	39400	520.0
11.20	39450	39510	39560	39610	39660	39720	39770	39820	39870	39930	530.0
11.30	39980	40030	40080	40140	40190	40240	40300	40350	40400	40450	530.0
11.40	40510	40560	40610	40670	40720	40770	40820	40880	40930	40980	530.0
11.50	41040	41090	41140	41200	41250	41300	41360	41410	41460	41520	530.0
11.60	41570	41620	41680	41730	41780	41840	41890	41940	42000	42050	530.0
11.70	42100	42160	42210	42260	42320	42370	42420	42480	42530	42590	540.0
11.80	42640	42690	42750	42800	42850	42910	42960	43020	43070	43120	540.0
11.90	43180	43230	43290	43340	43390	43450	43500	43560	43610	43660	540.0

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
			DISCHARGE IN CUBIC FEET PER SECOND				(EXPANDED PRECISION)				
12.00	43720	43770	43830	43880	43940	43990	44040	44100	44150	44210	540.0
12.10	44260	44320	44370	44420	44480	44530	44590	44640	44700	44750	550.0
12.20	44810	44860	44920	44970	45030	45080	45140	45190	45240	45300	540.0
12.30	45350	45410	45460	45520	45570	45630	45680	45740	45790	45850	550.0
12.40	45900	45960	46010	46070	46120	46180	46230	46290	46350	46400	560.0
12.50	46460	46510	46570	46620	46680	46730	46790	46840	46900	46950	550.0
12.60	47010	47060	47120	47180	47230	47290	47340	47400	47450	47510	560.0
12.70	47570	47620	47680	47730	47790	47840	47900	47960	48010	48070	550.0
12.80	48120	48180	48240	48290	48350	48400	48460	48520	48570	48630	560.0
12.90	48680	48740	48800	48850	48910	48960	49020	49080	49130	49190	570.0
13.00	49250	49300	49360	49420	49470	49530	49580	49640	49700	49750	560.0
13.10	49810	49870	49920	49980	50040	50090	50150	50210	50260	50320	570.0
13.20	50380	50430	50490	50550	50600	50660	50720	50780	50830	50890	570.0
13.30	50950	51000	51060	51120	51170	51230	51290	51350	51400	51460	570.0
13.40	51520	51570	51630	51690	51750	51800	51860	51920	51980	52030	570.0
13.50	52090	52150	52200	52260	52320	52380	52430	52490	52550	52610	570.0
13.60	52660	52720	52780	52840	52900	52950	53010	53070	53130	53180	580.0
13.70	53240	53300	53360	53420	53470	53530	53590	53650	53710	53760	580.0
13.80	53820	53880	53940	54000	54050	54110	54170	54230	54290	54340	580.0
13.90	54400	54460	54520	54580	54640	54690	54750	54810	54870	54930	590.0
14.00	54990	55040	55100	55160	55220	55280	55340	55390	55450	55510	580.0
14.10	55570	55630	55690	55750	55810	55860	55920	55980	56040	56100	590.0
14.20	56160	56220	56280	56330	56390	56450	56510	56570	56630	56690	590.0
14.30	56750	56810	56870	56920	56980	57040	57100	57160	57220	57280	590.0
14.40	57340	57400	57460	57520	57580	57630	57690	57750	57810	57870	590.0
14.50	57930	57990	58050	58110	58170	58230	58290	58350	58410	58470	600.0
14.60	58530	58590	58650	58710	58770	58830	58890	58940	59000	59060	590.0
14.70	59120	59180	59240	59300	59360	59420	59480	59540	59600	59660	600.0
14.80	59720	59780	59840	59900	59960	60020	60080	60140	60200	60260	600.0
14.90	60320	60380	60450	60510	60570	60630	60690	60750	60810	60870	610.0
15.00	60930	60990	61050	61110	61170	61230	61290	61350	61410	61470	600.0
15.10	61530	61590	61650	61720	61780	61840	61900	61960	62020	62080	610.0
15.20	62140	62200	62260	62320	62380	62440	62510	62570	62630	62690	610.0
15.30	62750	62810	62870	62930	62990	63050	63120	63180	63240	63300	610.0
15.40	63360	63420	63480	63540	63610	63670	63730	63790	63850	63910	610.0
15.50	63970	64030	64100	64160	64220	64280	64340	64400	64470	64530	620.0
15.60	64590	64650	64710	64770	64830	64900	64960	65020	65080	65140	610.0
15.70	65200	65270	65330	65390	65450	65510	65580	65640	65700	65760	620.0
15.80	65820	65890	65950	66010	66070	66130	66200	66260	66320	66380	620.0
15.90	66440	66510	66570	66630	66690	66760	66820	66880	66940	67000	630.0

GAGE HEIGHT (FEET)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER TENTH FT
			DISCHARGE IN CUBIC FEET PER SECOND				(EXPANDED PRECISION)				
16.00	67070	67130	67190	67250	67320	67380	67440	67500	67570	67630	620.0
16.10	67690	67750	67820	67880	67940	68000	68070	68130	68190	68260	630.0
16.20	68320	68380	68440	68510	68570	68630	68690	68760	68820	68880	630.0
16.30	68950	69010	69070	69130	69200	69260	69320	69390	69450	69510	630.0
16.40	69580	69640	69700	69770	69830	69890	69950	70020	70080	70140	630.0
16.50	70210	70270	70330	70400	70460	70520	70590	70650	70710	70780	630.0
16.60	70840	70910	70970	71030	71100	71160	71220	71290	71350	71410	640.0
16.70	71480	71540	71600	71670	71730	71800	71860	71920	71990	72050	640.0
16.80	72120	72180	72240	72310	72370	72430	72500	72560	72630	72690	630.0
16.90	72750	72820	72880	72950	73010	73070	73140	73200	73270	73330	650.0
17.00	73400	73460	73520	73590	73650	73720	73780	73850	73910	73970	640.0
17.10	74040	74100	74170	74230	74300	74360	74430	74490	74550	74620	640.0
17.20	74680	74750	74810	74880	74940	75010	75070	75140	75200	75270	650.0
17.30	75330	75400	75460	75530	75590	75650	75720	75780	75850	75910	650.0
17.40	75980	76040	76110	76170	76240	76300	76370	76430	76500	76560	650.0
17.50	76630	76690	76760	76830	76890	76960	77020	77090	77150	77220	650.0
17.60	77280	77350	77410	77480	77540	77610	77670	77740	77810	77870	660.0
17.70	77940	78000	78070	78130	78200	78260	78330	78400	78460	78530	650.0
17.80	78590	78660	78720	78790	78850	78920	78990	79050	79120	79180	660.0
17.90	79250	79320	79380	79450	79510	79580	79650	79710	79780	79840	660.0
18.00	79910	79980	80040	80110	80170	80240	80310	80370	80440	80500	660.0
18.10	80570	80640	80700	80770	80840	80900	80970	81030	81100	81170	660.0
18.20	81230	81300	81370	81430	81500	81570	81630	81700	81760	81830	670.0
18.30	81900	81960	82030	82100	82160	82230	82300	82360	82430	82500	660.0
18.40	82560	82630	82700	82760	82830	82900	82970	83030	83100	83170	670.0
18.50	83230	83300	83370	83430	83500	83570	83630	83700	83770	83840	670.0
18.60	83900	83970	84040	84100	84170	84240	84310	84370	84440	84510	670.0
18.70	84570	84640	84710	84780	84840	84910	84980	85050	85110	85180	680.0
18.80	85250	85320	85380	85450	85520	85590	85650	85720	85790	85860	670.0
18.90	85920	85990	86060	86130	86190	86260	86330	86400	86470	86530	680.0
19.00	86600	86670	86740	86800	86870	86940	87010	87080	87140	87210	680.0
19.10	87280	87350	87420	87480	87550	87620	87690	87760	87820	87890	680.0
19.20	87960	88030	88100	88170	88230	88300	88370	88440	88510	88570	680.0
19.30	88640	88710	88780	88850	88920	88980	89050	89120	89190	89260	690.0
19.40	89330	89400	89460	89530	89600	89670	89740	89810	89880	89940	680.0
19.50	90010	90080	90150	90220	90290	90360	90420	90490	90560	90630	690.0*
19.60	90700*										





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

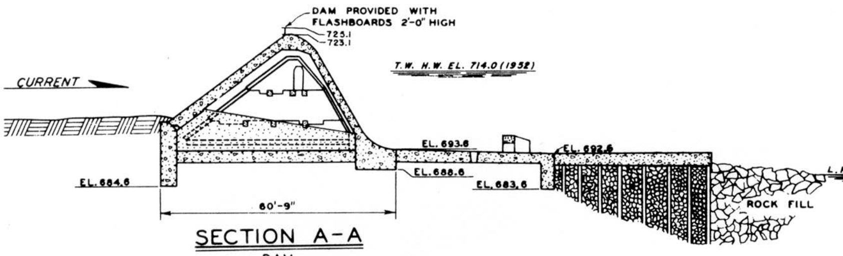
	RIVERWARD LOCK	LANDWARD LOCK
DEPTH ON UPPER GATE SILL	** 13.4 FT. (U.P. EL. 723.1) * 12.4	13.4 FT. (U.P. EL. 723.1)
DEPTH ON LOWER GATE SILL	7.5 FT. (L.P. EL. 687.2)	10.0 FT. (L.P. EL. 687.2)
ELEVATION UPPER GUARD SILL	* 710.7	NONE
ELEVATION UPPER GATE SILL	709.7	709.7
ELEVATION LOWER GATE SILL	679.7	677.2

**POOL ORDINARILY MAINTAINED AT EL. 725.1 BY FLASHBOARDS.
*OLD UPPER GUARD SILL IN RIVERWARD LOCK ONLY.

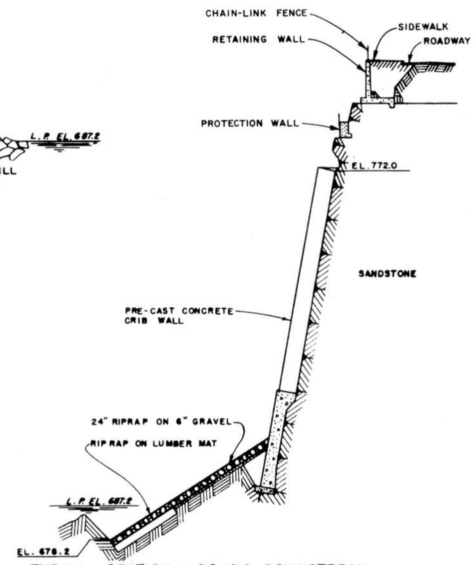
Upper Mississippi River
Nine-Foot Navigation Project

Lock and Dam No. 1
Project Location Map

US Army Corps of Engineers
St. Paul District - 30 Sept 1982

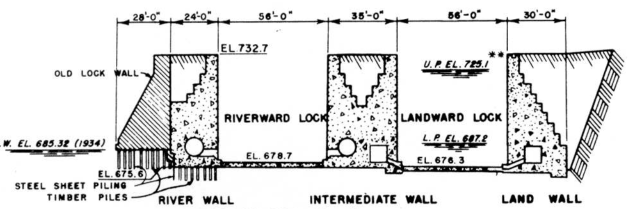


SECTION A-A
DAM
10 0 10 20 30
SCALE IN FEET

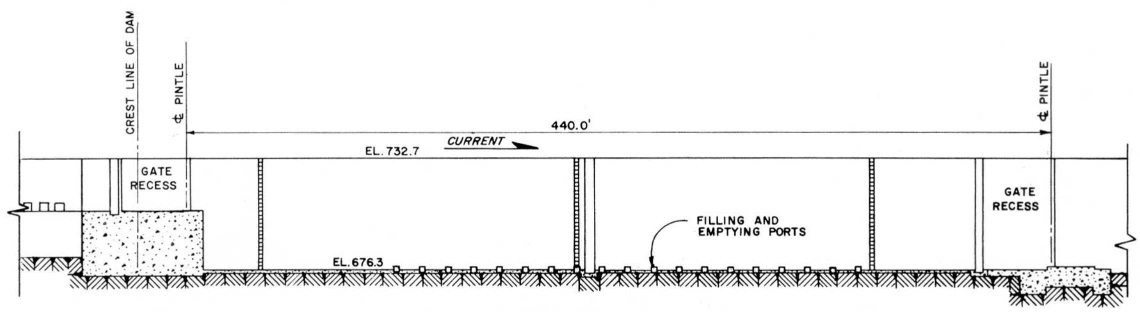


TYPICAL SECTION LOOKING DOWNSTREAM
BLUFF PROTECTION
10 0 10 20 30
SCALE IN FEET

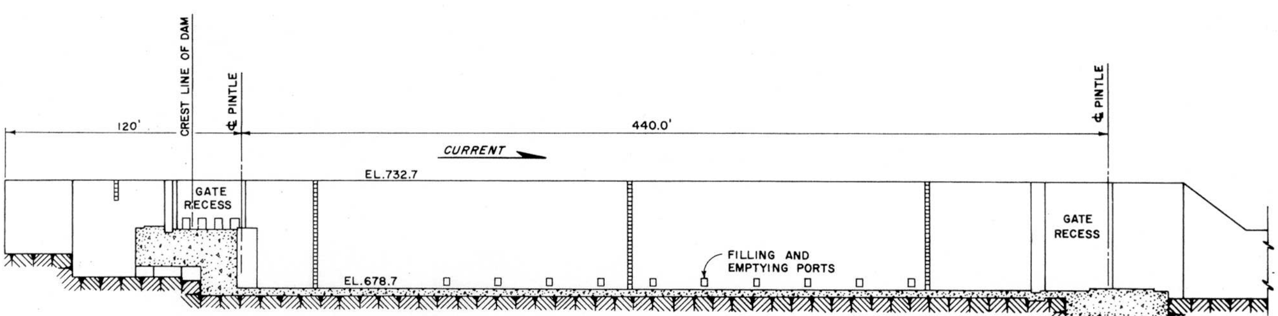
ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)



SECTION B-B
LOCKS
20 0 20 40 60
SCALE IN FEET



SECTION X-X
LANDWARD LOCK
20 0 20 40 60
SCALE IN FEET



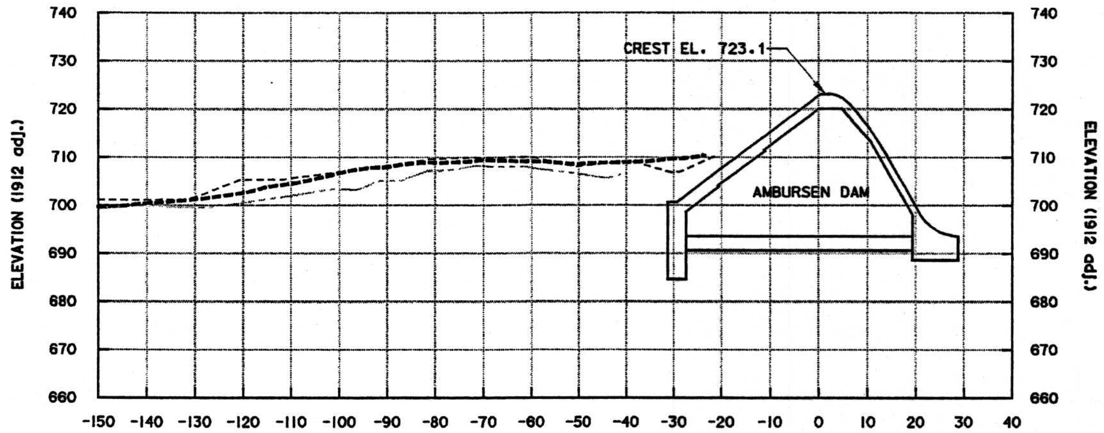
SECTION Y-Y
RIVERWARD LOCK
20 0 20 40 60
SCALE IN FEET

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

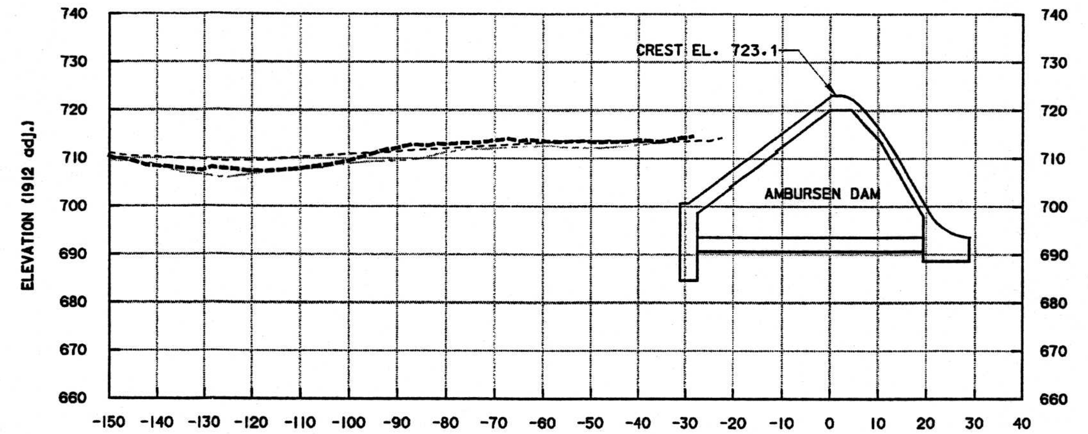
Upper Mississippi River
Nine-Foot Navigation Project

Lock and Dam No. 1
Cross Sections

US Army Corps of Engineers
St. Paul District - 30 Sept 1982



3+40



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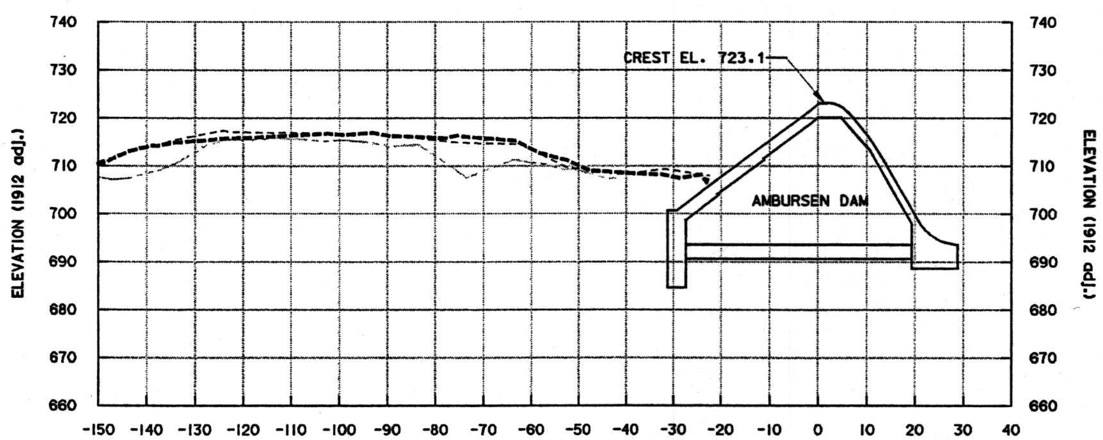

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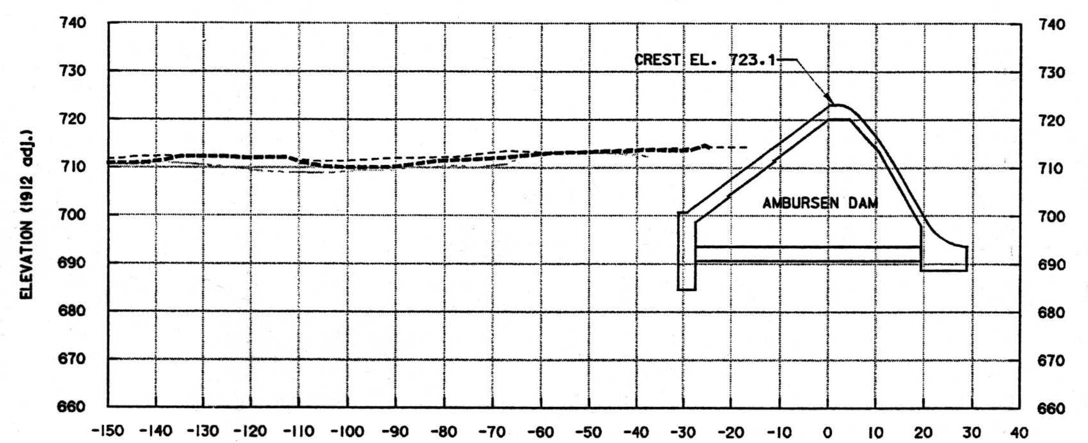

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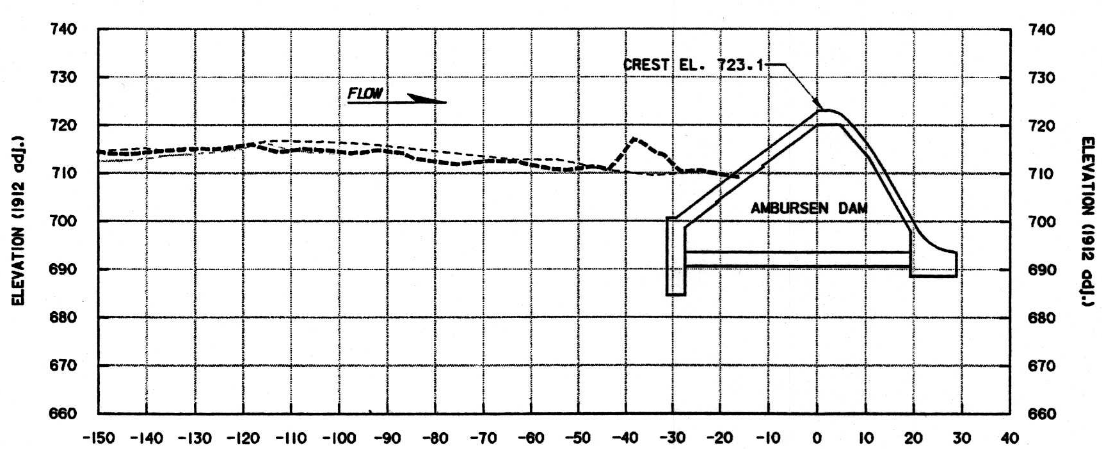
KEY

- - - - - (heavy dashed)	2001
- - - - - (light dashed)	2000
— - — (dash-dot)	1999



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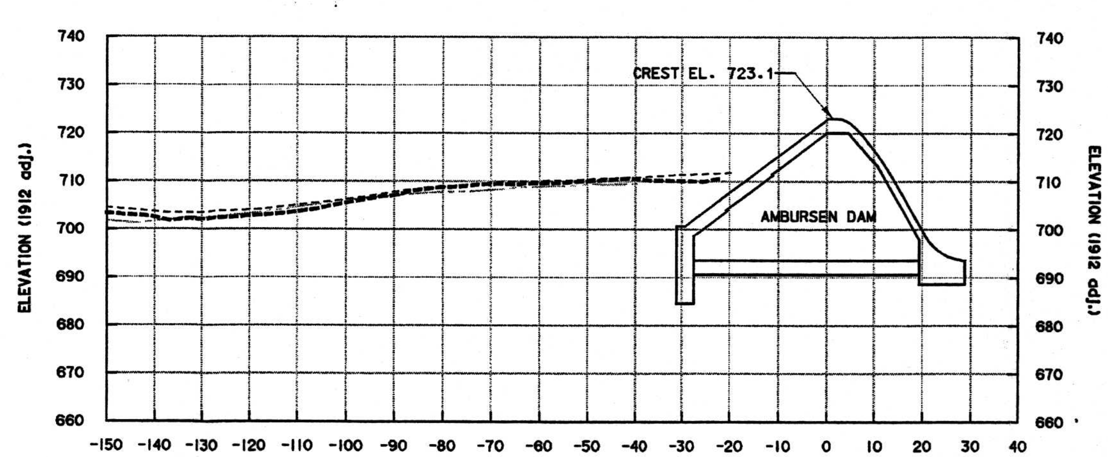


3+90

Upper Mississippi River
Nine-Foot Navigation Project

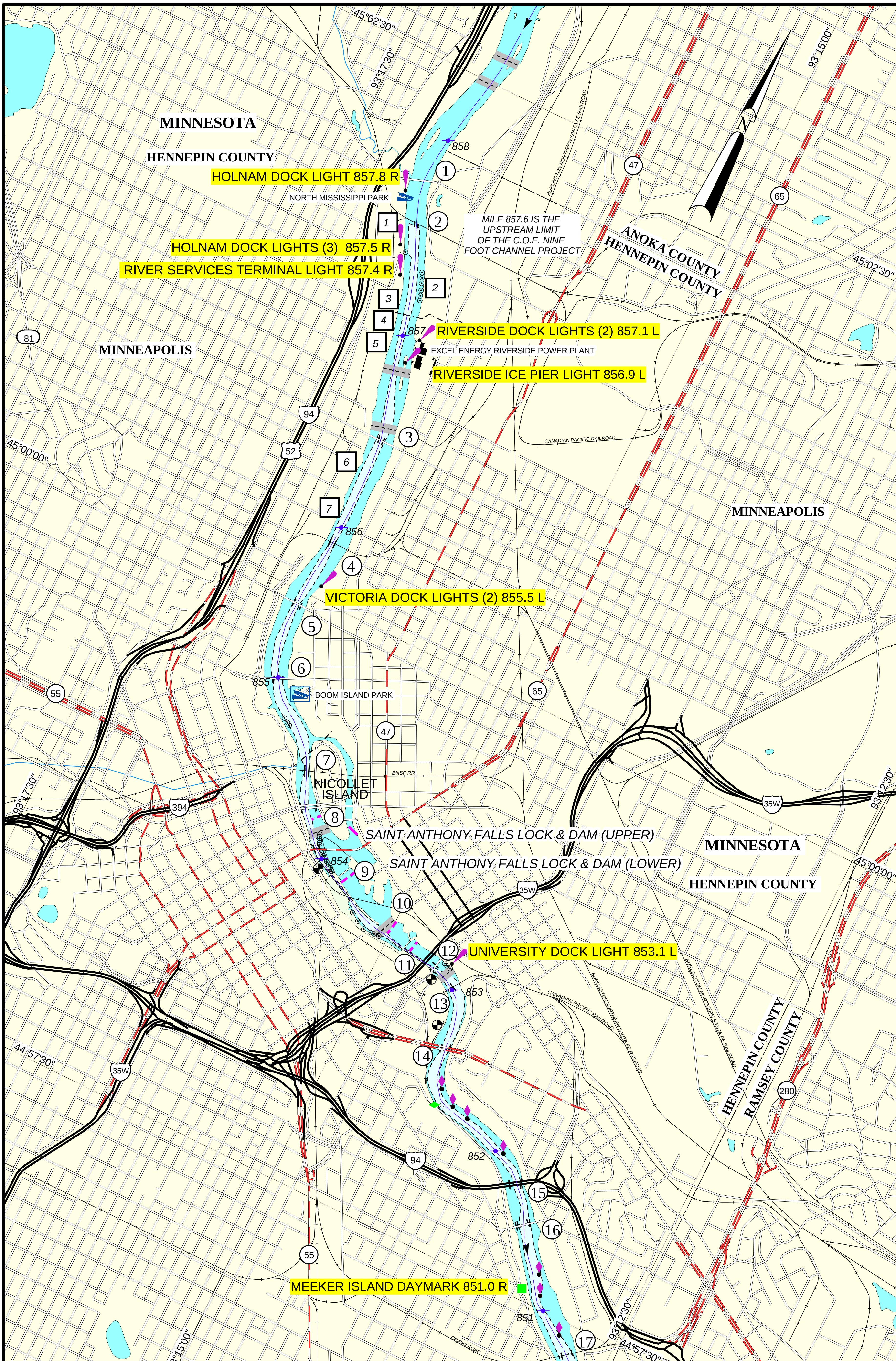
Lock and Dam Soundings
October 2001

U.S. Army Corps of Engineers
St. Paul District – St. Paul, MN

ST. PAUL DISTRICT — CORPS OF ENGINEERS
DRAWN BY: JGS — OCTOBER 2001

M-S3-13/__

MICROSTATION PREPARED DRAWING: a113x01a.dgn



2001

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE
1 0.5 0 1 MILES
1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project
Navigation Chart
River Mile 851 to 858
U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN

2001

BUOY POSITIONS ON CHARTS ARE APPROXIMATE, SEE NOTICE ON LEGEND NO. 1

SCALE 1:31,680
1 INCH = 1/2 MILE

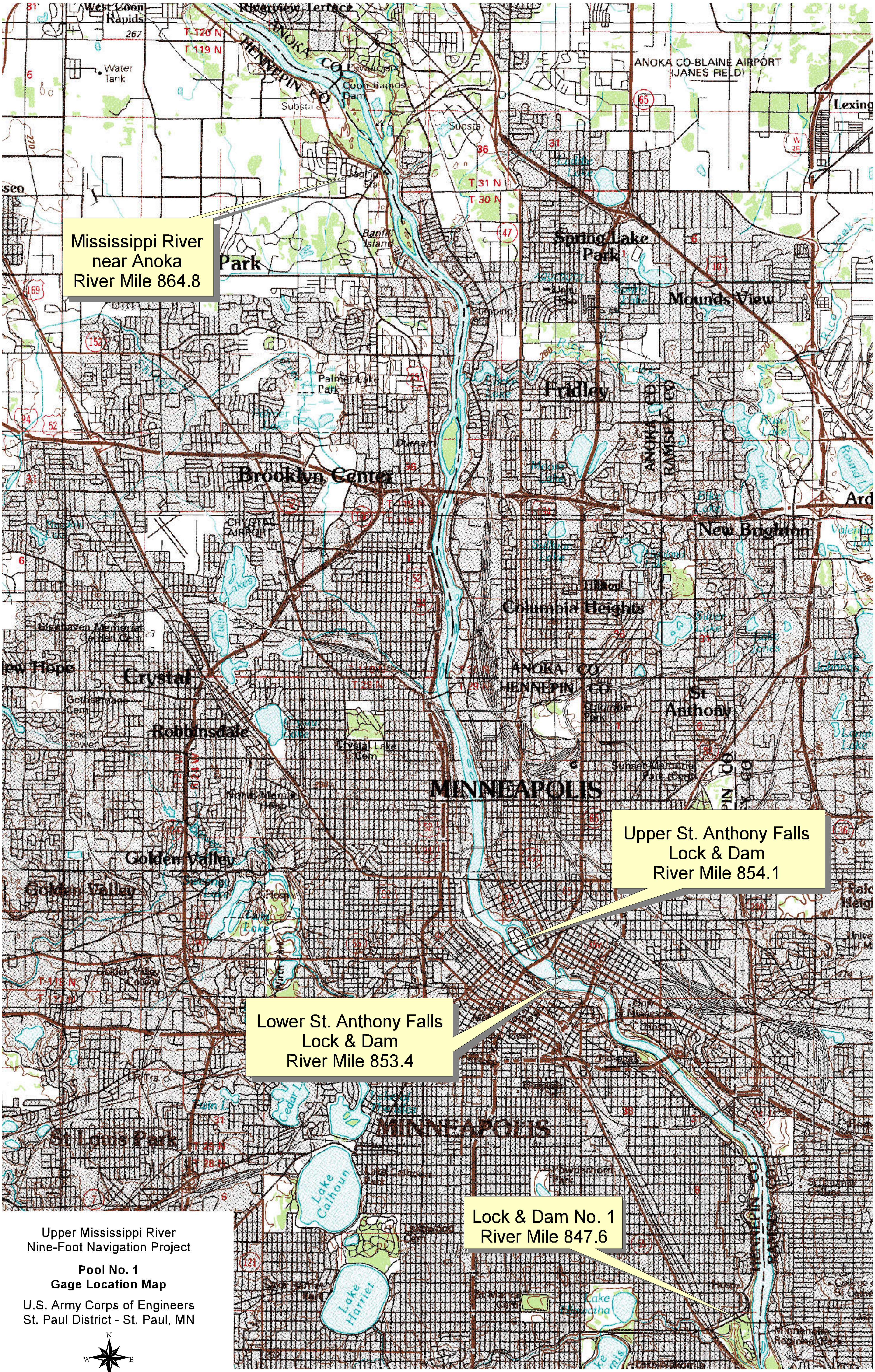
1 0.5 0 1 MILES

1 0.5 0 1 KILOMETERS

Upper Mississippi River
Nine-Foot Channel Navigation Project

Navigation Chart
River Mile 842 to 851

U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN



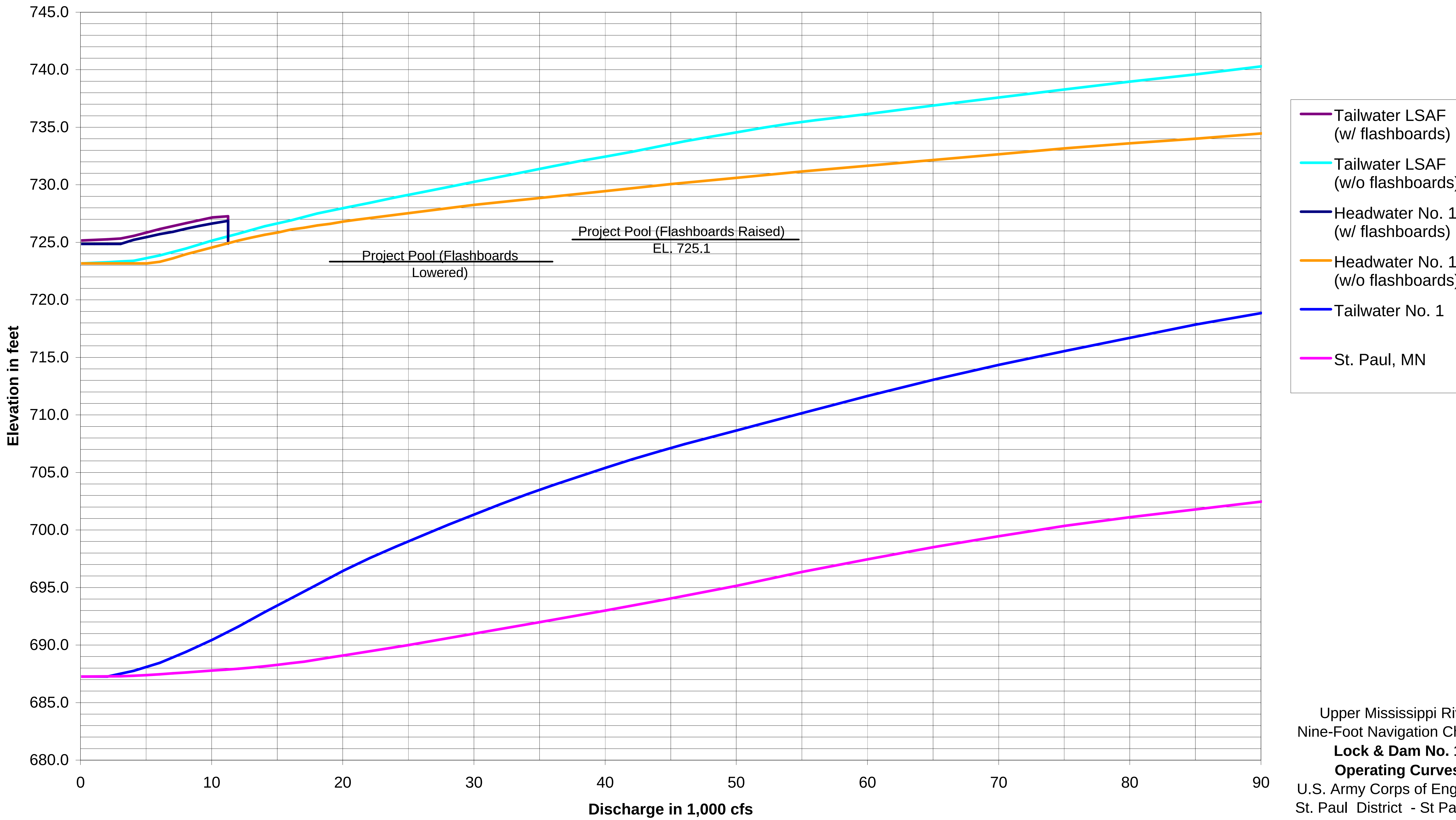
Upper Mississippi River
Nine-Foot Navigation Project

Pool No. 1
Gage Location Map

U.S. Army Corps of Engineers
St. Paul District - St. Paul, MN

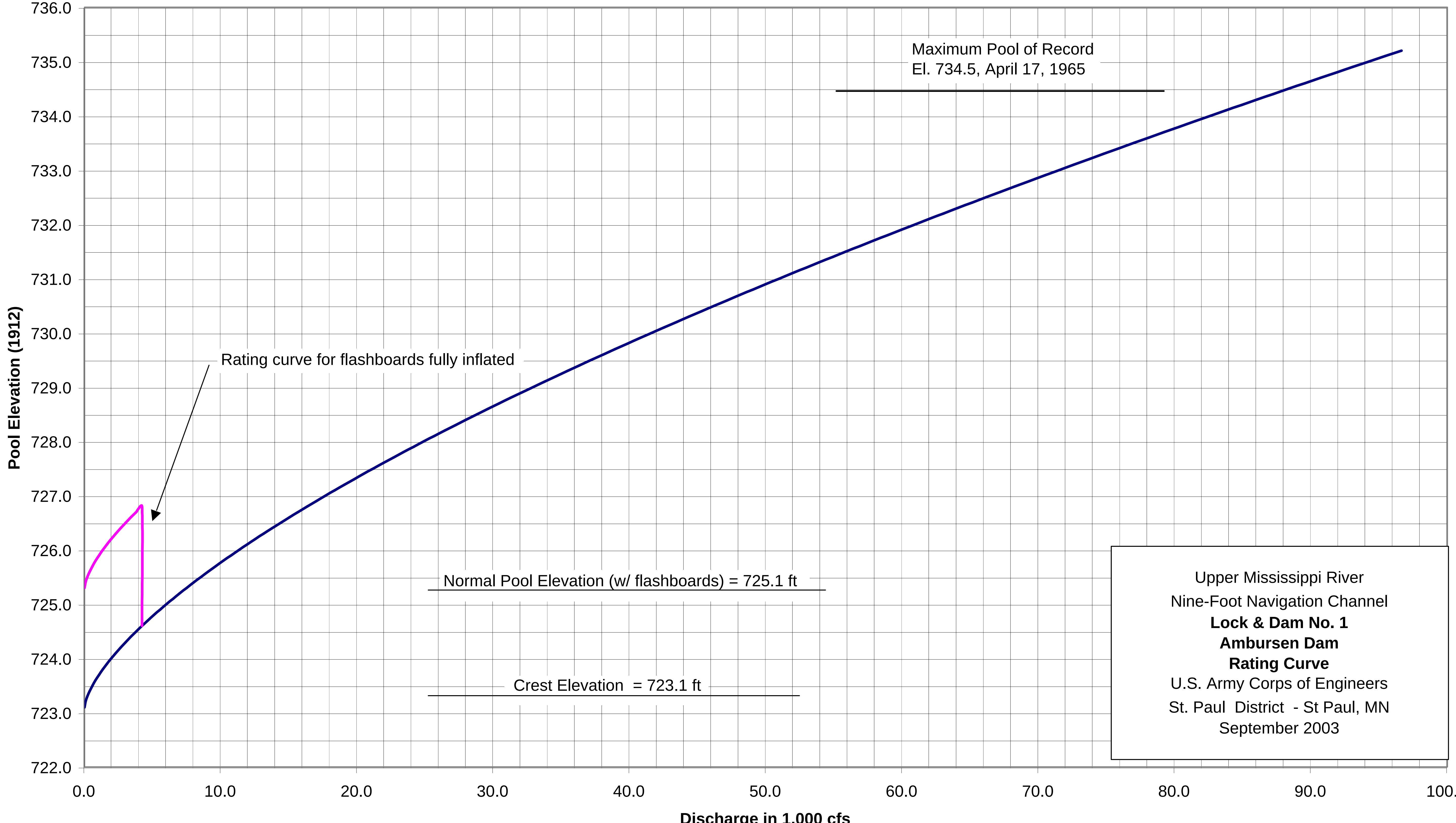
Plate 5-1

LOCK & DAM NO. 1 OPERATING CURVES



Upper Mississippi River
Nine-Foot Navigation Channel
Lock & Dam No. 1
Operating Curves
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN

Plate 7-1



Pool Elevation (1912)
736.0
735.0
734.0
733.0
732.0
731.0
730.0
729.0
728.0
727.0
726.0
725.0
724.0
723.0
722.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Discharge in 1,000 cfs
Maximum Pool of Record
El. 734.5, April 17, 1965
Rating curve for flashboards fully inflated
Normal Pool Elevation (w/ flashboards) = 725.1 ft
Crest Elevation = 723.1 ft
Upper Mississippi River
Nine-Foot Navigation Channel
Lock & Dam No. 1
Ambursen Dam
Rating Curve
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN
September 2003

Plate 7-2