US Army Corps
of Engineers®
St. Paul District

WATER CONTROL MANUAL

FLOOD CONTROL
EAU GALLE RIVER, WISCONSIN

EAU GALLE RESERVOIR AND CHANNEL IMPROVEMENTS

UPDATED MAY 2003

WATER CONTROL MANNUAL

EAU GALLE RESERVOIR
SPRING VALLEY, WISCONSIN

EAU GALLE RIVER
FLOOD CONTROL RESERVOIR
AND CHANNEL IMPROVEMENT PROJECT

US ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

MAY 2003

Updated from
Water Control Manual, December 1984
Reservoir Regulation Manual, September 1969

EAU GALLE RESERVOIR

SPRING VALLEY, WISCONSIN

Aerial View Looking Upstream
Town of Spring Valley in the Foreground

NOTICE TO ALL 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. A “Reservoir Regulation Manual” went into effect upon completion of the project in September 1969. This document was updated by a “Water Control Manual” in December 1984. This manual is an update to that document. 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 during normal business hours, Water Control should be contacted by telephone (651-290-5617 or 5623), fax (651-290-5841), or VHF-FM radio, call sign WUG-613. During non-duty hours, assistance can be obtained by contacting one of the following persons in the order listed below.

Water Control Regulation Assistance			
James Noren	Hydrologist james.b.noren@usace.army.mil	Duty: Non-Duty:	651-290-5626 [redacted]
Ferris Chamberlin	Hydraulic Engineer ferris.w.chamberlin@usace.army.mil	Duty: Non-Duty:	651-290-5619 [redacted]
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Eau Galle Reservoir
And Channel Improvement
Spring Valley, Wisconsin

US Army Corps of Engineers
St. Paul District – May 2003

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Location: Eau Galle Reservoir is located on the Eau Galle River, at river mile 30.3, immediately upstream of the village of Spring Valley, Wisconsin. It straddles the Pierce and St. Croix County line at approximately latitude 44°51'10" and longitude 92°14'17". The Eau Galle River is located in west-central Wisconsin midway between St. Paul, Minnesota and Eau Claire, Wisconsin. The Eau Galle River is a tributary to the Chippewa River, which is a tributary to the Upper Mississippi River.

Drainage Areas:	Eau Galle River at Eau Galle Reservoir:	63.9 square miles
	Eau Galle River at the mouth:	230.0 square miles

Datum: 1929 NGVD

Real Estate Taking Line and Easements:

For Fee Title:	Elevation 949.0 ft:	230 acres
	Recreation:	332 acres
	Total Fee Title:	562 acres
For Flowage Easement:	Elevation 1020.0 ft:	519 acres
Outgrant:	Easement for power line servicing facilities at site.	

Dam:

Type:	Zone Embankment-Clay Core	Maximum Height:	122 feet
Length:	1800 feet	Top Width:	20 feet
Design Crest Elevation:	1038.5 feet	Side Slopes:	
Crest Over-Burden Elevation:	1040.25 feet	To Elev 1033.5 ft	1V:2.5H
Crest Over-Burden Low Point:	1040.15 feet	Above 1033.5 ft	1V:2H

Freeboard above Spillway Design Flood (PMF):	3.95 feet
Freeboard above Conservation Pool Elevation:	100.15 feet

Control Structures:

Type:	Morning Glory	Type:	Emergency Spillway
Diameter:	25 feet	Length:	1930 feet
Crest Elevation:	940.0 feet	Width:	100 feet
Outlet:	Horseshoe Conduit	Crest Elevation	
	9-feet 3-inch	Design:	1020.0 feet
Conduit Area:	67.2 sq ft	As-Built:	1019.53 feet
Conduit Length:	700 feet	Side Slopes:	Vertical
Discharge at 1020.0 ft:	3,800 cfs	Max Discharge:	25,000 cfs

Type:	Low Flow
Diameter:	48-inch
Inlet Gate:	4-foot Slide
Inlet Invert Elevation:	916.5 feet
Outlet Invert Elevation:	915.0 feet

Outlet Structure:

Type:	Flared Stilling Basin	Length: 150 feet - 1 inch
Width at Inlet:	10 feet	
Width at End Sill:	53 feet – 4 inches	

Reservoir:

Conservation Pool Elevation:	940.0 feet	Pool Area: 150 acres
Minimum Outflow		
Normal Conditions:	13 cfs	
Drought Conditions:	2 cfs	
Name of Lake:		
Project Pool Name:		Eau Galle Lake or Reservoir
As Shown on State Highway Maps:		Lake George

I – INTRODUCTION

1-01. Authorization for Preparation of this Manual. Authority to prepare "Reservoir Regulation Manuals", for flood control structures regulated by the Corps of Engineers, was granted by Engineering Regulation (ER) 1110-2-240, *Reservoir Regulation*, 1958. While the ER 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 is an update to the *Eau Galle Dam and Reservoir, Water Control Manual*, dated December 1984. It 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 1110-2-204, *Preparation of Water Control Plans and Manuals*, 1 January 1992.
d. Engineering Manual, EM 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 as a reference source for others who may be involved with the regulation of the project. The manual is for daily use in Water Control activities for most foreseeable conditions and occurrences. This 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 following is a chronological list of reports pertinent to this manual:

a. *Review Survey of Chippewa River Basin, Wisconsin, for Flood Control, Interim Report on Eau Galle, Wisconsin*, Corps of Engineers, St. Paul District, 28 December 1948.
b. *Eau Galle River Reservoir and Channel Improvement for Flood Control at Spring Valley, Wisconsin, Design Memorandum No. 1, Hydrology and Hydraulic Analysis,* Corps of Engineers, St. Paul District, November 1960.

c. *Eau Galle River Reservoir and Channel Improvement for Flood Control at Spring Valley, Wisconsin, Design Memorandum No.2, Site Selection*, Corps of Engineers, St. Paul District, February 1961.
d. *Eau Galle River Reservoir and Channel Improvement for Flood Control at Spring Valley, Wisconsin, Design Memorandum No. 3, General*, Corps of Engineers, St. Paul District, April 1961.
e. *Eau Galle River Reservoir and Channel improvement for Flood control at spring valley, Wisconsin, Design Memorandum No. 4, Mines Creek Improvements*, Corps of Engineers, St. Paul District, 1961.
f. *Eau Galle Reservoir and Channel Improvement for Flood Control at Spring Valley, Wisconsin*, *Design Memorandum No. 5*, *Dam and Spillway, Volumes 1 and 2*, Corps of Engineers, St. Paul District, May 1964.
g. *Eau Galle Reservoir and channel Improvement for Flood Control at spring Valley, Wisconsin, Design Memorandum No. 6, Master Plan for Reservoir Development*, Corps of Engineers, St. Paul District, October 1964.
h. *Eau Galle River Reservoir and Channel Improvement Project at Spring Valley, Wisconsin, Operation and Maintenance Manual No. 1, Mines Creek Improvements*, Corps of Engineers, St. Paul District, December 1964.
i. *Outlet Structure for Eau Galle Reservoir, Eau Galle River, Wisconsin*, Hydrologic Model Investigation, Technical Report No. 2-774, Corps of Engineers, Waterways Experiment Station, April 1967.
j. *Eau Galle River Reservoir and Channel Improvement for Flood Control at Spring Valley, Wisconsin, Reservoir Regulation Manual*, Corps of Engineers, St. Paul District, September 1969.
k. *Dam Safety Assurance, Spring Valley Dam, Eau Galle River, Wisconsin, Reconnaissance Report*, Corps of Engineers, St. Paul District, July 1980.
l. *Eau Galle Lake Pool Elevation Study*, prepared by Barton-Aschman Associates, Inc., for the Corps of Engineers, St. Paul District, April 1981.
m. *Seasonal Growth and Community Composition of Phytoplankton in a Eutrophic Wisconsin Impoundment*, Corps of Engineers, Waterways Experiment Station, for the Journal of Freshwater Ecology, Volume 2, Number 6, December 1984.
n. *Limnology Studies at Eau Galle Lake, Wisconsin*, Report 1, Introduction and Water Quality Monitoring Studies, Technical Repot E-85-2, Corps of Engineers, Waterways Experiment Station, March 1985 and Report 2, Special Studies and Summary, Technical Report E-85-2, March 1987.
o. *Effects of Alum Treatment on Phosphorus and Phytoplankton Dynamics in Eau Galle Reservoir: A Synopsis*, Corps of Engineers, Waterways Experiment Station, for the North American Lake Management Society, Lake and Reservoir Management, 1990.
p. *Effects of Alum Treatment on Phosphorus Dynamics in a North-Temperate Reservoir*, Corps of Engineers, Waterways Experiment Station, for Hydrobiologia 215, pp 231-241, 1991.
q. *Dam Safety Program, Flood Control Project, Eau Galle Dam and Reservoir Emergency Plan*, Corps of Engineers, St. Paul District, April 1992.

r. *Drought Contingency Plan, Eau Galle River Reservoir, Wisconsin*, Corps of Engineers, St. Paul District, September 1992.
s. *The Effects of a Change in Withdrawal Operations on Phytoplankton and Nutrient Dynamics in Eau Galle Reservoir, Wisconsin*, Corps of Engineers, Waterways Experiment Station, for Hydrobiologia 82, pp 531-543, 1997.
t. *Evaluation Report, Dam Safety Assurance Program, Eau Galle Dam, Eau Galle River, Spring Valley, Wisconsin*, Corps of Engineers, St. Paul District, December 1998, with 4 May 1999 revisions.
u. *Effects of Increased Hypolimnetic Discharge on the Water Quality of Eau Galle Reservoir during June through September 2000*, Corps of Engineers, St. Paul District, In-house paper, October 2000.
v. *Year Two: An Evaluation of Adjusting Sub-Surface Release to Improve Thermal Conditions Downstream of Eau Galle Dam*, Corps of Engineers, St. Paul District, In-house paper, October 2001.

1-04. Project Owner. The United States Government is the owner of Eau Galle Dam and Reservoir. The US Army Corps of Engineers, St. Paul District, St. Paul Minnesota, is responsible for regulation of the dam.

1-05. Operating Agency. Eau Galle Dam is regulated, operated, and maintained by the US Army Corps of Engineers, St. Paul District. Regulation is the responsibility of Engineering Division, while operation and maintenance is the responsibility of Construction and Operations (Con-Ops) Division.

1-06. Regulating Agency. Regulation of Eau Galle Dam and Reservoir is under the supervision of the Water Control Section, St. Paul District, US Army Corps of Engineers.

II – DESCRIPTION OF PROJECT

2-01. Location. The Eau Galle reservoir is located in west-central Wisconsin on the Eau Galle River at river mile 30.3. The Eau Galle River is tributary to the Chippewa River, which flows into the Upper Mississippi River upstream of Lock and Dam No. 4. The reservoir is located on the northern edge of the village of Spring Valley, Wisconsin, and straddles St. Croix County to the north and Pierce County to the south. It is approximately 50 miles east of the Minneapolis-St. Paul, Minnesota, metropolitan area and about 40 miles west of Eau Claire, Wisconsin. The approximate latitude and longitude is 44°51'10" and 92°14'17" respectively. See **Plate 2-1** for project location map.

2-02. Purpose. The authorized project purposes are flood control, recreation, and enhancement of fish and wildlife. The latter through recognition of incidental benefits. The following tables list the authorized project purposes and the public laws establishing each purpose.

Table 2-1
Authorized Purposes Assigned by Congress

Authorized Purpose	Public Law	Name
Flood Control	PL 85-500	Flood Control Act of 1958
Recreation	PL 78-534	Flood Control Act of 1944
Fish and Wildlife	PL 85-624	Fish and Wildlife Coordination Act of 1958

Table 2-2
Other Pertinent Legislation Affecting the Project

Authorized Purpose	Public Law	Name
Fish and Wildlife	PL 79-732	Fish and Wildlife Coordination Act of 1946
Fish and Wildlife	PL 93-205	Conservation, Protection, and Propagation of Endangered Species Law of 1973
Water Quality	PL 87-88	Federal Water Pollution Control Act Amendments of 1961
Water Quality	PL 92-500	Federal Water Pollution Control Act Amendments of 1972

2-03. Physical Components. The project consists of the Eau Galle River Reservoir and Channel Improvement. The reservoir portion of the project includes the dam embankment, emergency spillway, morning glory outlet, low flow intake, stilling basin, and downstream channel work. The channel improvement portion consists of work done on Mines Creek, which includes straightening and enlarging a portion of the creek, a drop structure, and a levee upstream of the drop structure. **Plate 2-1** shows the general layout and **Plate 2-2** shows typical sections of project features. The following is a description of each component.

a. Reservoir. The reservoir is roughly circular in shape. At conservation pool level of 940.0 feet (1929 adjustment) the reservoir is about 3,300 feet long and 2,000 feet wide. It covers an area of 150 acres and has a capacity of 1,550 acre-feet. Maximum depth is approximately 30 feet and the mean depth is 10.5 feet. The shoreline length is 2.5 miles. When the pool is at elevation 1020.0 feet (i.e. near the crest of the emergency spillway), the pool area is about 880 acres with a capacity of 44,000 acre-feet. **Plate 2-3** shows the area/capacity curve for the reservoir.

b. Embankment. The earth fill embankment has a crest length of about 1,800 feet, a crest width of 20 feet, and a maximum height of 122 feet above the streambed. The design crest elevation is 1038.5 feet (1929 NGVD) with overburden in the valley section to account for settlement. The actual crest elevation is 1040.25 feet with a low point at 1040.15 feet. A 20-foot wide gravel road, used only for maintenance, crosses the top of the dam with a turnaround at the east abutment. The zoned embankment has a central clay core that extends to bedrock the full length of the embankment. The outer shell consists of random fill in the downstream portion and of sand and gravel on the upstream side of the clay core. Embankment slopes are 1V:2.5H below elevation 1033.5 feet, both upstream and downstream. Above this elevation side slopes are 1V:2H. A horizontal drainage blanket of select material underlies the embankment downstream from the clay core. A toe drain and service road was constructed at the downstream toe of the embankment in

1970. The toe drain consists of a 15-inch CMP installed to collect seepage from the horizontal sand drain and to provide a means of monitoring such flow. The service road is bituminous and has a minimum elevation of 928.0 feet. The upstream slope is protected with a rock fill section varying from 27 inches thick at the top to nearly 60 inches thick at the bottom. The downstream slope is protected with a 12-inch gravel blanket to the natural ground line. See **Plate 2-2** for a typical dam embankment section.

c. Emergency Spillway. The unlined, uncontrolled spillway was excavated in a natural saddle about 650 feet west of the right (west) abutment. It outlets to a natural drainage course leading to Mines Creek, a small tributary to the Eau Galle River. Excavation of the spillway throughout most of its length was in dolomite bedrock. The channel cross section is rectangular where excavated in dolomite and is benched in the deeper cuts at elevation 1053.0 feet (1929 NGVD) with a 12-foot bench. Side slopes are 1V:3H in the overburden excavation. The channel bottom is 100 feet wide. The spillway cut is about 1,900 in length.

Figure 2-1. Emergency Spillway

A concrete sill 5 feet wide, 5 feet deep, and 100 feet long, is set flush with the channel bottom near the head of the channel excavation. The design elevation of the sill was 1020.0 feet; however, as constructed it is 1019.53 feet. The channel has a bottom slope of 0.3 percent. A paved road on the channel bottom provides access to the beach and recreational area by the conservation pool. See **Plate 2-2** for a typical spillway section.

d. Morning Glory Outlet Structure. The outlet structure consists of an uncontrolled morning glory intake, a horseshoe-shaped conduit, and a stilling basin at the outlet of the conduit. The morning glory intake is a reinforced concrete gravity structure with an ogee crest and has a cage-like trash rack surmounting the crest (see **Plate 2-4**).

Figure 2-2. Morning Glory Inlet and Trash Rack

The weir crest has a 25-foot diameter at elevation 940.0 feet (1929 NGVD). The throat of the morning glory intake has a diameter of 18 feet – 3.5 inches. The invert is at elevation is 916.5 feet. There is 10-foot long transition from the throat of the morning glory to a 10-foot by 10-foot square conduit with a length of 28 feet – 6.25 inches. Downstream of the 10-foot by 10-foot reach, the square section transitions to the horseshoe conduit over a distance of 20 feet. The invert remains constant at elevation 916.5 feet. The horseshoe conduit consists of thirty-two 20-foot long sections of reinforced concrete, giving it a length of 640 feet. The outlet invert is at elevation 915.0 feet. Because of cracking, the horseshoe shape conduit was lined with a 6-inch thick grout and steel liner during the winter season of 1981 and 1982. The liner was placed along the arch and walls of the conduit (i.e. not along the floor). The height was reduced to 9 feet – 3 inches. The steel lining reduced the cross sectional area of the conduit by 11.66 square feet giving a total flow area of 67.2 square feet (see **Plate 2-5**).

Figure 2-3. Steel-Lined Horseshoe Conduit

e. Low Flow Conduit. Within the horizontal 10-foot by 10-foot reach near the morning glory intake, a low flow conduit intersects at a 45-degree angle. The conduit is circular steel with a 4-foot diameter approximately 20 feet in length. It has an invert elevation of 916.5 feet. Flow through the conduit is controlled by a 4-foot wide slide gate. In 1971, a steel bulkhead with a 4-foot wide slide gate was installed into the stop log recess, upstream of the slide gate, to facilitate inspection of the original slide gate.

Figure 2-4. 48-inch Steel Conduit Looking at Slide Gate

Figure 2-5. Low Flow Inlet to the Horseshoe Conduit

Adjustments to the slide gate are made from the top control tower, which is at elevation 943.0 feet (**Figure 2-6**). The top of the railing is elevation 946.75 feet.

Figure 2-6. Control Tower for Low Flow Inlet

f. Stilling Basin. A stilling basin 150 feet in length is located at the end of the horseshoe conduit. At the conduit exit, the channel has vertical sidewalls and a 10–foot bottom width. The invert transitions from the rounded conduit invert to a flat surface forming a rectangular section over a distance of 10 feet. The invert elevation at the horseshoe exit is 915.0 feet and transitions to elevation 914.95 feet. From the rectangular transition, the stilling basin channel bottom begins to drop while the retaining walls begin to flare outward. The channel bottom follows a parabolic drop over the next 63.0 feet to the floor of the stilling basin while the channel bottom width expands from 10 feet to 30 feet – 8 inches. The stilling basin floor is 66 feet long and has an elevation of 901.0 feet. There are two rows of baffle blocks, 4 feet high and 4 feet wide, spaced on 4-foot centers. The end sill is 2 feet thick with a top elevation of 903.7 feet. At this point the channel bottom has expanded to 53 feet – 4 inches. From this point the channel bottom is lined with riprap and slopes upward to elevation 911.5 feet at a rate of 1V:3H. Wing walls curve outward from the end sill on a 70.7-foot radius for a horizontal distance of 46 feet where the channel bottom width is 70 feet. The top of the retaining walls transitions from elevation 934.0 feet at the horseshoe conduit outlet to elevation 926.5 feet at a distance 30 feet downstream. From there, the elevation remains constant to the end sill, where it then transitions down to elevation 921.7 feet at the end of the curved wing walls. See **Plate 2-2** for stilling basin sections.

Figure 2-7. Stilling Basin During Periodic Inspection

g. Downstream Channel. The outlet channel downstream of the stilling basin is trapezoidal in shape with a bottom width of 70 feet and slide slopes of 1V:2H. The channel is 2,460 feet long with an outlet elevation of 910.5 feet. The channel is followed by a 50-foot transition to existing ground. The channel bottom and side slopes are protected by riprap to elevation 921.7 feet. Where the channel passes beneath the North Fourth Street Bridge, the channel is transitioned to a bottom width of 66 feet and side slopes of 1V:1.5H.

A three-foot high v-notched weir is located approximately 1,000 feet downstream of the stilling basin. Its purpose is to create a pool for discharge measurements during low flows.

h. Mines Creek Improvements. The principal feature of the project consists of about 2,420 feet of channel straightening and enlargement with riprap protection along two reaches of Mines Creek and a levee approximately 1,500 feet in length along the right bank of the creek between the improved channel reaches. Related improvements include a concrete drop structure and a new highway bridge, which spans the improved channel at McKay Avenue.

Starting at the confluence with the Eau Galle River, about 1,470 feet of the Mines Creek channel was straighten and enlarged to a 40-foot bottom width with side slopes of 1V:2H (see **Plate 2-2** for typical section). The side slopes are protected by riprap from the confluence to the drop structure, which is located 1,292 feet upstream of the confluence. The structure consists of an ogee weir, a stilling basin with baffle blocks, and an end sill. A sheet-pile cutoff wall projecting 10 feet below the structure and 15 feet from each side controls seepage around and beneath the structure. A levee extends from the drop structure upstream a distance of 1,500 feet. The levee is about 7 feet high and has a crest width of 10 feet and side slopes of 1V:3H. Compacted impervious fill forms the embankment, which is protected against erosion by 4 inches of seeded topsoil. About 1,300 feet upstream of the drop structure, channel improvement begins again. This reach is 950 feet in length. Except for the channel transitions at each end, the channel bottom is 15 feet wide with side slopes of 1V:2H. The side slopes are protected with riprap.

2-04. Related Control Facilities. There are no related projects within the Eau Galle River basin.

2-05. Real Estate Acquisition. Land acquisition policy, at the time of design, set forth in Engineering Manual EM 405-2-150 required the purchase of reservoir land in fee up to the design flood pool level. However, Office of Chief Engineers approved acquisition of necessary lands by local interests in accordance with prior real estate acquisition policy. Under this policy, the Corps of Engineers acquired the land within the reservoir up to 5-year frequency flood pool elevation. The minimum guide taking line was established at elevation 949.0 feet (1929 NGVD) and encompassed a total area of 230 acres. An additional 332 acres in fee was acquired for recreation purposes, construction sites, and access roads. In the early 1970's an additional 78 acres of land was purchased for recreation purposes, bringing the total land area purchased in fee to 640 acres. Between elevation 949.0 feet and the design crest of he emergency spillway, 1020.0 feet, flowage easements were obtained for a total area of 519 acres. There is an easement granted for power line servicing facilities at the site. Williams Pipeline passes through the park for a distance of 2.6 miles; however, they do not have an easement.

2-06. Public Facilities. Recreational opportunities include camping at the Highland Ridge Campground, which offers 45 campsites from April through October. Facilities in the campground include toilets, drinking water, firewood, a playground, and a sanitary dump station. Picnicking accommodations range from shelters for large groups to isolated individual tables located in scenic natural areas. A swimming area features parking, toilets, change house, playground, volleyball courts, and a fishing dock. Canoeing is a popular activity on the 150 acre lake. Boats with electric motor are also permitted. Nearly five miles of hiking and self-guided interpretive trails wind through deep woods and lowlands, exhibiting a rich variety of flora and fauna. For public facility locations see **Plate 2-1**.

III – HISTORY OF PROJECT

3-01. Authorization. The Eau Galle Reservoir and Channel Improvement Project was developed for flood control at Spring Valley, Wisconsin. It was authorized by the Flood Control Act of 1958 (Public Law 85-500), approved 3 July 1958. The project was to be constructed substantially in accordance with the plans, and subject to the conditions recommended by the Chief of Engineers, in Senate Document 52, 84th Congress, 1st session.

3-02. Planning and Design. The impetus for construction of the Eau Galle Project was two severe floods, which took place in 1942. These floods resulted in approximately $1,500,000 in damages to the village of Spring Valley, Wisconsin. A preliminary analysis of the flood problems within the Chippewa River basin was completed in May 1944. The project document presented a plan that included a dam immediately upstream of Spring Valley with a morning glory outlet and an emergency spillway. The plan also included work downstream of the dam including enlargement of the Eau Galle River channel and improvements on Mines and Burghardt Creeks. Improvements to Mines Creek included channel straightening, channel enlargement, a levee, and a drop structure. The improvement provides protection for business and residential areas within the village of Spring Valley from all floods having an average frequency of occurrence of once in about 110 years. Within the improved reach, the design flow is 3,000 cfs. Improvements to Burghardt Creek were found to be economically infeasible therefore it was dropped from the plan. The following discusses other changes made to the original plans.

a. **Conservation Pool.** The original proposed conservation pool elevation was 935.0 feet (1929 NGVD); however, the US National Park Service and the US Fish and Wildlife Service recommended that the pool be raised to elevation 940.0 feet to improve silt retention and enhance fish habitat and recreational value. The reservoir was cleared below elevation 943.0 feet. The area at this elevation was 175 acres of which about 30 acres was wooded.

b. Emergency Spillway. The original design included a fixed-crest concrete chute spillway with a crest elevation of 997.0 feet. To reduce costs, this was replaced with a high-level unlined spillway constructed in erosion resistant dolomite bedrock that leads to Mines Creek. The high-level design elevation was elevation 1020.0 feet; however, as constructed, the sill ended up being at elevation 1019.53 feet. The rating curve for the emergency spillway was updated as part of the Dam Safety Assurance Program (Evaluation Report, 1998). Both curves are shown on **Plate 3-1**.

c. Outlet Conduit. The Project Document Plan showed the outlet conduit to be located near the center of the embankment. In Design Memorandum No. 3 the conduit was relocated to the left abutment of the dam thereby moving it from the clay and silty-clay backfill and placing it on a firm sandstone foundation. The low flow outlet culvert was designed to be a 10-foot circular culvert. It was computed that the conduit would convey 4,220 cfs with the pool at elevation 1020.0 feet (approximate elevation of the emergency spillway crest). To reduce construction costs, the circular culvert was replaced by 9 foot – 9 inch horseshoe shaped conduit equivalent. At a pool elevation 1020.0 feet, a model study by the Waterways Experiment Station (WES) in 1965 indicated the conduit would convey 4,800 cfs. Longitudinal cracking in the conduit was first reported in Periodic Inspection No. 4 in November 1971. Further inspections indicated the cracking was progressing. Following the inspection of 1978, a plan was developed to address the problem. During the winter season of 1981 and 1982, a 6-inch thick grout and steel liner was placed along the arch and walls of the conduit (i.e. not along the floor). The steel lining reduced the cross sectional area of the conduit by 11.66 square feet, giving a total flow area of 67.2 square feet (see **Plate 2-5**). New rating curves were developed in March 1979 for the lined and unlined conduit. As part of the manual update, these curves were reanalyzed. The unlined channel curve was confirmed and only a slight change in the lined conduit curve was noted. For a pool elevation of 1020.0 feet, the curves show a discharge of 4,270 cfs for the unlined conduit and 3,800 cfs for the lined conduit. While the analysis did not support the discharges indicated by the WES model study, it did support the concept that outflow was crest controlled to a pool elevation of around 944.5 feet and then switched to outlet control. Sample calculations used to produce these curves are shown in **Appendix B.** The two rating curves are shown on **Plate 3-2**.

d. **Morning Glory Intake and Stilling Basin.** During the period March 1965 to October 1965, the Waterways Experiment Station (WES) conducted a model study of the outlet structure for the reservoir. This resulted in changes to the morning glory outlet structure and the stilling basin. The 90-degree elbow transitioning flow from the morning glory intake to the horizontal conduit in the original design, produced unsatisfactory pressure and flow control conditions. WES proposed changing the elbow to a straight drop, which then transitioned to the horseshoe shaped conduit. Based on the model study, improvements were also made to the stilling basin design. The baffle blocks were repositioned and their heights were increased.

e. **Low Flow Outlet.** As part of the original design, a four-foot diameter vertical slide gate was installed in the low flow outlet works to permit drawdown of the conservation pool to about elevation 917 feet if needed for eradication of rough fish. In 1971, a steel bulkhead with a 4-foot wide slide gate was installed into the stop log recess, upstream of the slide gate, to facilitate inspection of the original slide gate.

f. **Downstream Channel.** The Project Document Plan called for an 8,000-foot long downstream channel improvement with a channel capacity of 5,000 cfs above Mines Creek. The optimum design, based on outlet conduit capacity, resulted in decreasing the channel improvement length to 2,060 feet for a channel capacity of 4,800 cfs, which is approximately equal to the existing river channel through Spring Valley. The channel has a 70-foot bottom width except where it passes beneath the Fourth Street Bridge. Because the restriction did not substantially reduce channel capacity, replacement of the bridge was not required.

g. **Probable Maximum Flood and Freeboard.** The Probable Maximum Flood (PMF) was used to design the spillway. Rainfall for the PMF was based on US Weather Bureau Hydrometerorological Report No. 33, *Seasonal Variation of the Probable Maximum Precipitation*. After applying a 10 percent basin shape reduction, the peak inflow was determined to be 153,700 cfs. This was routed through the reservoir starting at conservation pool elevation 940.0 feet and assuming the outlet conduit was operating at 50 percent capacity. The result was a maximum spillway discharge of 14,500 cfs and a maximum pool elevation of 1033.5 feet. A minimum freeboard of 5.0 feet above the maximum pool established the top of dam at elevation 1038.5 feet. An overburden of material was placed atop the valley portion of the dam to elevation 1040.25 feet to account for settlement. In 1980, a reexamination of the PMF inflow hydrograph was performed as part of the *Dam Safety Assurance Reconnaissance Report*. The reexamination was done in light of the current guidance at the time. Using NOAA Hydrometeorological Report No. 51, it was determined that the peak inflow would be 122,100 cfs. Reservoir routing, using modified-puls method, resulted in a peak outflow of 21,200 cfs and a maximum pool elevation of 1036.8 feet. This indicated freeboard had been reduced to 3.45 feet (1040.25-1036.8). In 1997, an Evaluation Report was performed as part of the Dam Safety Assurance Program. The previous study derived the spillway rating by backwater analysis that did not extend into the freeboard range, which is necessary for reservoir routings during dam safety investigations. Therefore a new backwater analysis was performed using HEC-2. The revised spillway rating curve was used to determine the maximum pool elevation during the PMF reservoir routing. The starting pool elevation was 943.0 feet, which corresponds to the level prevailing about five days after one half of the PMF is routed through the reservoir. This routing indicated a maximum PMF reservoir elevation of 1036.2 feet with a maximum outflow of 26,600 cfs. A plot of the flow routing and its impact on pool elevations is shown on **Plate 3-3**. A 1995 survey of the crest showed the lowest dam crest elevation to be 1040.15 feet, thus providing 3.95 feet of freeboard. Freeboard is necessary to prevent waves from overtopping the embankment at high reservoir levels and to account for uncertainty in the hydrologic analysis. Because the PMF hydrograph is based on conservative hydrologic analysis, with the hydrograph representing almost 20-inches of runoff in a 24-hour period, the level of uncertainty is low. The wave analysis presented in the report indicated maximum wave runup, combined with wind setup, to be 3.0 feet. An independent additional analysis of wave runup was performed as part of the manual update. The analysis is presented in **Appendix B**.

h. Emergency Warning. An emergency warning system for high water potential at the dam has been in the planning stage for years. Finding a suitable spot upstream proved to be difficult. The first site considered was the USGS gage site at the Low-Water Bridge just upstream of the lake. Because this site becomes inundated under a rising pool, it was abandoned and a site further up in the basin was selected. The new location was the USGS gage site on the Eau Galle River at the County Trunk Highway N Bridge. A cooperative agreement was entered into with USGS in July 2001 to install a gage house and make discharge measurements at the Low-Water Bridge during low flows and at the CT Highway N Bridge during high flows. The gage recorder at the site was to be programmed to alert dam personnel when a significant rainfall event occurred or a given stage had been exceeded. Upon further study in the spring of 2003, it was discovered that this site would provide only three hours advance warning over the Eau Galle Lake pool gage. Therefore, it was decided that funding for this gage should be eliminated and allow the pool gage to serve as the emergency warning site. The trigger alert is an elevation of 998.0 feet or 13-inches of rainfall within 30-hours.

3-03. Construction. The contract for Mines Creek improvements was awarded on 20 December 1960. The contract was considered complete on 8 October 1964. The completed project was transferred to local interests for operation and maintenance on 10 December 1964. The dam, spillway, and outlet structure were constructed under one contract. Construction began on 9 July 1965 and was essentially complete in October 1968. The reservoir first reached the conservation pool elevation of 940.0 feet on 24 March 1969. Final inspection of the project was in September 1969.

3-04. Related Projects. There are no related projects other than channel improvements to Mines Creek.

3-05. Modification to Regulations. No changes have been made to the Eau Galle Reservoir regulation plan other than minor modifications in low flow releases for improved trout habitat. See **Section 7-08. Fish and Wildlife** for an in depth discussion.

3-06. Principal Regulation Problems.

a. Cracking of the Outflow Conduit. Longitudinal cracking in the horseshoe conduit was first noted during the periodic inspection of November 1971. This was the result of improper installation by the contractor. The sandstone was to be excavated providing a protective channel for the conduit. As constructed, the sandstone was excavated such that lateral protection was removed, thereby increasing the load on the conduit. Additional cracking was discovered during subsequent periodic inspections. Following the inspection of 1978, a plan of repair was developed. In the winter of 1981 - 1982, the conduit was repaired with a grout and steel liner plate.

b. Downstream Seepage. Some residences in Spring Valley immediately downstream of dam have experienced wet and damp basements. They have alluded that the conservation pool, which they claim has raised ground water levels, caused this. In 1978, two piezometers and eight observation wells were installed in the general area of the downstream right abutment. The objective was to see if ground water levels correlated to pool level fluctuation. Because of the short time of rise experienced in pool levels, no correlation was noted. The study although not complete was terminated.

c. Floating Boom. As part of a safety feature, a floating boom was installed in front of the morning glory intake structure to keep boat traffic away from any drawdown effects at the morning glory spillway. While this is effective during normal pool periods, a sharp rise in pool elevation can cause the boom to break loose and become entangled around the trash rack (see **Figure 3-1.**) When the pool returns to conservation level, reservoir personnel are to remove the debris from the trash rack and reinstall the floating boom as soon as possible.

Figure 3-1. Morning Glory Intake – Spring 2001

IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Eau Galle River basin has a drainage area of about 230 square miles and is a tributary to the Chippewa River, which enters the Mississippi River just below Lake Pepin in Pool No. 4. The basin is oriented in a northwest-southeast direction varying in width from about 5 miles to a maximum width of 11 miles, and an overall length of about 50 miles (see **Plate 4-1**). Eau Galle Dam is located at river mile 30.3 and has a drainage area of 63.9 square miles. The major tributaries to the Eau Galle River lie downstream of the dam site; Cody Creek at river mile 19.3, Knights Creek at river mile 13.6, Missouri Creek at river mile at river mile 6.4, and Arkansas Creek at river mile 1.3. Just below the dam are two small tributaries; Mines Creek at river mile 29.9 and Burghardt Creek at river mile 29.4. These two small creeks join the Eau Galle River in Spring Valley and although their drainage areas are only 3.1 and 2.7 square miles respectively, they frequently contribute to flood conditions in the village. Upstream of the dam, three deeply incised tributary streams enter the reservoir; French Creek, Lousy Creek, and Lohn Creek. The valley in the headwaters region of the basin is poorly defined and appears as a bowl-shaped depression surrounded by gently rolling hills. Southward and progressing downstream, the valley is well defined, varying in width from a few hundred feet to about one half mile and bounded on either side by high bluffs which rise as much as 200 feet above the valley floor in the vicinity of Spring Valley.

The slope of the Eau Galle River averages about 11 feet per mile, varying from about 17 feet per mile near the headwaters to approximately 4 feet per mile near the mouth. In the vicinity of Spring Valley, the stream slope is about 11 feet per mile. The tributaries at Spring Valley are very steep. Mines Creek and Burghardt Creek drop at a rate of about 75 feet per mile from the bluffs west of Spring Valley.

4-02. Topography. The main valley and the deeply cut tributaries of the Eau Galle River are characteristic of the topography found in a maturely dissected plateau region. Glacial deposits have given the upland areas a gently rolling topography; whereas, the lower reaches of the basin show less modification by glaciers. There is evidence that the earliest Nebraskan stage of glaciation covered the area but that glaciers of the last Wisconsin stage did not reach the area. The elevation of the Eau Galle River at the headwaters is 1267 feet. The river falls 572 feet to elevation 695 feet at its junction with the Chippewa River.

4-03. Geology and Soils. Eau Galle Dam and reservoir lie in a deeply incised bedrock valley immediately upstream of the village of Spring Valley, Wisconsin. The Eau Galle River valley is about 1,800 feet wide and 200 feet deep at the dam site. North of the dam the valley widens to a width of approximately 4,000 feet. A scattering of trees, brush, and grasses covers the steep bedrock valley walls. The pre-glacial river valley was carved by the erosional process of river meanders working back and forth laterally. Further widening of the valley was accomplished by the scouring action of glacial ice. Glacial meltwaters cut the valley approximately 50 feet deeper than its present level. Since glacial times the valley has been filled principally with a mixture of alluvial and colluvial deposits. The valley fill consists of a thin cap of clays, silty clays, and clayey silts which overlay granular soils. Irregular pieces of dolomite are scattered throughout the granular material. A major portion the random fill used for the embankment construction came from the valley fill material.

Uplands surrounding the valley are mantled by stony glacial till and loess typical of the area. Maximum thickness of these glacial and wind-blown deposits is approximately 165 feet with an average thickness of 53 feet. The relatively impervious nature of the till-loess blanket allows for rapid runoff of surface waters. Immediately below the till and loess lie the Ordovician and Cambrian age bedrock formations that the dam is constructed on. The uppermost bedrock unit is the Oneota Dolomite Member of the Prairie du Chien Formation. At the project location, the Oneota Dolomite is a hard, well-cemented, jointed rock approximately 75 feet thick. The emergency spillway is cut into the dolomite.

Underlying the dolomite is a quartz-rich, alternatively hard to soft, jointed rock known as Jordan Sandstone. Total sandstone thickness at the project location is approximately 137 feet. The uppermost 30 feet of Jordan Sandstone is better cemented than the underling 100 feet. Minor water loss by seepage will occur through the sandstone. The dam abutments and the outlet conduit are founded on the Jordan Formation.

The base of the earthen embankment is keyed into the Lodi Siltstone Member of the St. Lawrence Formation. At the project location, the Lodi Siltstone is a thin-bedded, sandy, hard rock, approximately 14 feet thick. Occasional thin, shaley, green laminae are found in the unit. The Lodi Siltstone is relatively impermeable so that only minor water seepage can be expected. The bedrock at the site dips at a gradient of about 15 feet per mile. There is no folding or faulting of the rocks in the area.

4-04. Sediment. The original capacity curve was determined in 1960 from studies by A.M. Kinney Inc. Consulting Engineers of Cincinnati, Ohio. The data set started at elevation 935.0 feet with a capacity of 850 acre-feet and ended at elevation 1043.0 feet with a capacity of 66,500 acre-feet. Elevation data was again collected in 1970 but only to elevation 940.0 feet. Because the capacity at elevation 940.0 feet agreed with the original survey, the surveys were merged such that quantities below elevation 940.0 feet were from the 1970 survey and quantities above elevation 940.0 feet were from the original survey. The silting ranges for the 1970 and subsequent surveys are shown on **Plate 4-2**. In 1978 and again in 1987, new surveys were taken. These two surveys also only went to elevation 940.0 feet; however, there was no longer any agreement in the capacity at elevation 940.0 feet. Therefore, the new curves were adjusted above this elevation by the difference at the 940.0-foot elevation. **Table 4-1** shows the relationship. An elevation/capacity table is provided in **Appendix C**. An area/capacity curve is shown on **Plate 2-3**.

Table 4-1 **Comparison of Surveys at Elevation 940.0 feet**		
Year of Survey	Capacity at Elevation 940.0 ft	Difference from Original Survey
1960	1,550 ac-ft	
1970	1,552 ac-ft	+ 2 ac-ft
1978	1,576 ac-ft	+ 26 ac-ft
1987	1,506 ac-ft	- 44 ac-ft

A comparison of the surveys of 1970 and 1987 shows 46 acre-feet of storage has been lost to sedimentation. This averages out to 2.7 acre-feet per year lost to sedimentation. Based on a drainage area of 63.9 square-miles, the sedimentation rate is 0.04 acre-feet/square-mile per year.

4-05. Climate. The climate at Spring Valley is temperate with hot summers and cold winters. The closest long term National Weather Service station with temperature data is at Ellsworth, Wisconsin, located 15 miles southwest of the Eau Galle Dam. The average daily maximum temperature varies from 83 ^{o}F in July to 21 ^{o}F in January. The average daily minimum temperature varies from 60 ^{o}F in July to 2 ^{o}F in January. Temperature extremes of 102 ^{o}F and -40 ^{o}F have been recorded. Temperatures of 90 ^{o}F are not unusual and occur on the average of about 9 days per year. Temperatures below 0 ^{o}F occur on the average of about 30 days a year.

Table 4-2
30-Year Normal Monthly Temperature in ^{o}F for Ellsworth, WI

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
11.8	17.9	30.6	45.9	58.2	67.1	71.9	69.0	59.9	48.8	32.9	17.3	44.3

The annual average precipitation for Spring Valley, Wisconsin is about 31 inches. It has varied from a yearly high of 37.58 inches in 1953 to a low of 23.52 inches in 1963. Sixty percent of the precipitation occurs from May through September.

Table 4-3
30-Year Normal Monthly Precipitation in Inches for Spring Valley, WI

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.92	0.78	1.82	2.84	3.34	4.48	3.88	3.98	3.81	2.47	1.56	1.08	30.96

More than 38 inches of snow typically falls annually over the basin, as recorded at Baldwin, Wisconsin, located 11 miles northwest of the project. Snowfall has varied from a yearly high of 88.3 inches in 1983 to a low of 9.0 inches in 1958. The following table shows the mean monthly snowfall for Ellsworth (15miles SW of Eau Galle Dam), River Falls (19 miles W), Menomonie (16 miles E), and River Falls, Wisconsin (19 miles W).

Table 4-4
Mean Monthly Snow Fall in Inches

	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec	Annual
Ellsworth	11.0	7.3	9.8	2.1	0.0	0.4	6.3	10.4	44.7
River Falls	9.8	6.9	9.8	2.5	0.1	0.5	6.5	8.8	44.5
Menomonie	10.6	7.1	7.9	1.6	0.0	0.2	4.7	8.8	38.7
Baldwin	9.3	6.1	7.9	2.4	0.0	0.2	28.8	33.5	38.6

Monthly pan evaporation measurements are taken at Marshfield, Wisconsin and at the University of Minnesota in St. Paul. Marshfield is located 100 miles to the east; whereas, St. Paul is located 45 miles to the west. Evaporation from the pool will be less due to cooler water temperatures. Assuming a pan coefficient of 0.7 provides a convenient means of estimating reservoir evaporation.

Table 4-5
Average Monthly Pan and Reservoir Evaporation in Inches

	May	June	July	Aug	Sep	Oct	Period of Record
Marshfield, WI		6.93	7.24	6.10	4.68		1983 – 199
St. Paul, MN	6.71	6.49	7.20	6.01	4.56	2.93	1994 - 1999
Reservoir	4.70	4.70	5.05	4.24	3.23	2.05	

Wind speed and direction is recorded every normal duty day at the reservoir. 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 essentially cause water to “pile up” on the downwind side resulting in water level rise. The change in water level is called “wind setup”. The rise in water can be estimated by the following equation taken from EM 1110-2-1414.

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

Where,
S = Wind Setup (ft)
U = Wind Speed (mph)
F = Fetch Length (0.625 miles)
d = Average Depth (10.5 ft)

The equation can reasonably estimate wind setup for basins of simple shape and long compared to their width, assuming motion in the long axis only. In addition, the coefficient (1400) is an average based value based on previous investigations. The coefficient may vary for different basins. For Eau Galle Reservoir, the wind setup calculated by this equation is typically only a few hundredths of a foot. For this lake it is suggested that a coefficient of 200 be used. This would produce more reasonable results as shown in the following table.

Table 4-6
Wind Setup (ft) for Various Wind Speeds (mph) with C = 200

Wind speed	10	15	20	25	30	35	40
Wind setup	0.03	0.07	0.12	0.19	0.27	0.36	0.48

The National Weather Service meteorological station at Minneapolis, Minnesota, located 45 miles west of Eau Galle Dam, has a prevailing wind direction from the northwest and a mean wind speed of 11 mph. **Table 4-7** shows the prevailing mean wind speed and direction by month.

Table 4-7
Prevailing Wind Speed and Direction in MPH for Minneapolis, MN

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
W	NW	NW	NW	SE	S	SW	S	SW	SW	W	W
10	10	11	12	11	10	9	9	10	11	11	10

The *Climatic Atlas of the United States* (June 1968) contains monthly Fastest Mile information for various cities throughout the United States. The project site is best represented by La Crosse, Wisconsin, which is located about 90 miles to the southeast. Fastest Mile wind speeds are defined as the fastest speed at which wind travels one mile. Fastest Mile wind speeds are typically obtained from a short period of time, usually less than two minutes duration. **Table 4-8** shows the

Fastest Mile wind speeds modified to time-dependant (1-hour) average wind speeds using procedures presented in the US Army Corps of Engineers' *Shore Protection Manual* (1984).

Table 4-8
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

4-06. Storms and Floods. Rapid snowmelt or high intensity rainstorms have resulted in flash floods in Spring Valley, Wisconsin. These flash floods have occurred from early March to late October. By 1944 when the US Geological Survey (USGS) gage was established in Spring Valley, 10 major floods had occurred there. The sources of data for these floods include the USGS stations in or near the Chippewa River basin, approximate high water marks, and accounts published in local newspapers. The largest flood prior to establishment of the Spring Valley USGS gage occurred in the fall of 1942, when a peak flow of 33,000 cfs through Spring Valley was estimated from the USGS gage at Elmwood, Wisconsin, located 7 miles downstream of Spring Valley. From 1943 until the Eau Galle Dam was completed in the fall of 1969, the peak flow recorded at Spring Valley was 7,000 cfs on 15 April 1954. Since completion of the dam, the peak flow recorded at Spring Valley was 3,030 cfs on 7 June 1980. **Table 4-9** gives a summary of the major flood events. Note how badly the stage-discharge points for 1980 (pre-conduit liner) and 1989 (post-conduit liner) plot on the Conduit Rating Curve shown on **Plate 3-2**. This likely due to the change in flow conditions due to the collection of debris on the trash rack at the inlet. When more data points become available, the rating curve may be modified. Also, it should be noted that USGS revised discharges for water years 1975 through 1979. The revisions are note in the *USGS Water Resources Data Report* for Water Year 1992.

Table 4-9
Summary of Peak Elevations (ft) and Discharges (cfs)

Date	Pool Elevation		Tailwater	Peak Discharge
	0800-hrs	Peak		
30 May 1942				14,600[1]
18 Sep 1942			929.43[2]	33,000[3]
15 Apr 1954			924.95[2]	7,000
07 Aug 1959			921.28[2]	6,200
23 Aug 1975	945.87		918.95[4]	2,370[5]
31 Aug 1977	948.25	948.39	919.24[4]	2,570[6]
01 Jul 1978	947.19	948.50	918.92[4]	2,350[7]
07 Jun 1980	954.20	954.20	919.90[4]	3,030
27 Mar 1989	950.92	954.55	919.05[4]	2,570
12 Apr 2001	946.77	948.37	918.56[4]	2,260

1. Estimated by USGS based on high water marks.
2. Gage located 850 ft downstream of present location.
3. Estimate based on USGS flow of 39,000 cfs at Elmwood.
4. Gage located 770 ft downstream of dam.
5. Originally reported as 3,180 cfs by USGS. Revised in 1992.
6. Originally reported as 3,470 cfs by USGS. Revised in 1992.
7. Originally reported as 3,150 cfs by USGS. Revised in 1992.

a. May 1942. The May 1942 flood followed a period of unusually heavy precipitation. An unofficial record of 8 inches of rain was reported for a 30-hour period preceding the flood. According to reports, the flood lasted from about 1000-hours on 29 May to around 1300-hours on the 30th. High flows exceeding channel capacity on both Mines and Burghardt Creeks at Spring Valley were described as occurring in advance of the main flood on the Eau Galle River. The peak discharge estimated from high water marks was 14,600 cfs. Damages to homes, businesses, and public buildings in Spring Valley were reported. Downstream from the village, railroad embankments and highways were washed out, bridges were damaged, and cultivated fields were inundated.

b. September 1942. Residents of the Eau Galle River Valley had hardly recovered from the flood in May when the most disastrous flood of record occurred. Antecedent rains had brought the river up to about flood stage on

16 September when a period of intense rainfall caused the river to rise rapidly to a record stage, about 5.5 feet above the crest elevation of the May flood. Reports indicated that the flood had a duration of about 16 hours, rising rapidly after 2000-hours on 18 September to crest at an elevation of 926.0 feet about 2300-hours at Spring Valley, and returning to normal the next day. Maximum discharge at Spring Valley was about 33,000 cfs. The flood volume represented a runoff of about 3.8 inches over the drainage area above Spring Valley. Unusually high flows, which exceeded channel capacities on both Mines and Burghardt Creeks, were reported. Few buildings in Spring Valley escaped damage as the flood wave moved through the community at a height about 9 feet above the elevation of the main business street. The flood caused $1.5 million of damages in Spring Valley.

c. **August 1977.** Eau Galle Dam prevented an estimated $1.8 million in flood damages in the Spring Valley area on 31 August 1977. On this day, the reservoir rose 8.5 feet above project pool due to 3.93 inches of rainfall as recorded at the dam. Discharge from the dam was originally determined by the USGS to be 3,470 cfs; however, in 1992, it was revised to 2,570 cfs. An estimated flow of 8,150 cfs would have past through Spring Valley had the dam not been in place. This would have been larger than the flow of 7,000 cfs that occurred during the 1954 flood event, before completion of the dam.

d. **June 1980.** On 7 June 1980, Eau Galle Reservoir rose to elevation 954.20 feet due to a three-day total rainfall of 7.05 inches as recorded at the dam. Discharge from the dam peaked at 3,030 cfs. An estimated flow of 20,800 cfs would have past through Spring Valley had the dam not been in place. Eau Galle Dam prevented an estimated $6.8 million in flood damages.

e. **March 1989.** Unlike the 1977 and 1980 floods, the flood of 1989 was from snowmelt without additional precipitation. The runoff began on 26 March when reservoir levels started to rise slowly. The reservoir level peaked at

2200-hours on 27 March at 14.55 feet above project pool with a peak discharge of 2,570 cfs. It is interesting to note that the discharge for the flood event of 1980 was higher than 1989; however, the pool elevation for 1980 was slightly lower. While debris around the morning glory intake can have a significant impact on pool elevation, another reason for the higher stage in 1989 is the conduit liner, which was installed in 1981.

f. April 2001. The minor flood of 2001 was the result of a rapid snowmelt. The snow-water equivalent on 12 March was 4.38 inches with almost 20 inches of snow on the ground. On the first of April, the snow-water equivalent was 3.55 inches. A few days later all the snow had melted. Runoff began to slowly enter the pool on the 31st of March. At noon on the 11th of April inflow rapidly spiked upward sending the pool from elevation 940.7 feet to a crest of 948.37 feet at 0300-hours on the 12th of April. Peak outflow was 2,260 cfs.

4-07. Runoff Characteristics. Floods on the Eau Galle River are flashy in character and are associated with periods of rapid snowmelt and/or rainstorms of high intensity. River stages, which normally fluctuate within a range of about 5 feet, can rise 10 to 15 feet in a few hours and recede almost as quickly. Because of the steep topography along the valley, the smaller tributary streams carry flood flows at high velocities and frequently exceed channel capacities.

The unit hydrograph representing 1-inch of runoff from the watershed illustrates much about the runoff characteristics. Time of concentration is defined as the time from the end of the rainfall period to the inflection point of the recession limb of the runoff hydrograph. For reservoir inflows, this varies from 15 minutes for the local area to almost 7 hours for the largest headwater sub-area of the basin.

The period of record for reservoir operation is from 1969 to present, whereas, the period of record at Spring Valley goes back to 1944. In 1995, inflow duration and outflow duration tables were prepared using the period of record from 1945 to 1994. The stream flow records for the Spring Valley gage (1944-1968) were used as inflow to the reservoir and routed through the reservoir to extend the period of record. The inflow and outflow durations are shown in **Tables 4-10 and 4-11**. Because flood events are of such short duration, with outflows rather quickly returning to normal, the two duration tables are almost identical.

Table 4-10
Reservoir Inflow Duration (1945-1994)
Percent of Time At or Above Indicated Discharge

Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2400													
2200						0.1							
2000			0.1	0.1		0.1							
1800			0.2	0.2		0.1							
1600			0.2	0.3		0.1							
1400			0.4	0.3		0.1							
1200			0.7	0.4	0.1	0.3		0.2	0.1				0.2
1000			1.4	0.7	0.3	0.3		0.2	0.2				0.2
800			1.4	1.0	0.3	0.5		0.2	0.2			0.1	0.3
600		0.2	2.7	1.9	0.3	0.8	0.3	0.3	0.3	0.3	0.2	0.1	0.6
500		0.2	3.2	2.8	0.5	0.9	0.3	0.3	0.4	0.3	0.3	0.1	0.8
400		0.2	4.5	3.2	0.7	1.3	0.5	0.3	0.6	0.3	0.3	0.1	1.0
300		0.5	5.8	4.9	1.2	1.8	0.8	0.7	1.0	0.4	0.3	0.3	1.5
200		0.7	8.3	7.7	2.0	2.7	1.2	1.2	1.1	0.8	0.6	0.5	2.2
100	0.1	1.6	14.1	14.2	4.8	3.9	2.3	1.9	2.8	2.2	2.0	0.8	4.2

Table 4-11
Reservoir Outflow Duration (1945-1994)
Percent of Time At or Above Indicated Discharge

Discharge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2200													
2000			0.2										
1800			0.2	0.2									
1600			0.3	0.3		0.1							
1400			0.4	0.3		0.2							
1200			0.5	0.3	0.1	0.2		0.2	0.1				0.1
1000			0.6	0.7	0.1	0.3		0.2	0.2				0.2
800		0.1	1.4	1.0	0.2	0.5		0.2	0.2				0.3
600		0.2	2.5	2.0	0.3	0.8		0.2	0.3	0.2	0.1	0.2	0.6
500		0.3	3.3	2.3	0.4	1.0	0.2	0.3	0.3	0.3	0.1	0.2	0.7
400		0.3	4.4	3.1	0.8	1.5	0.4	0.3	0.4	0.3	0.2	0.3	1.0
300		0.5	5.7	4.9	1.1	1.6	0.7	0.6	07	0.5	0.4	0.3	1.4
200		0.8	8.1	7.3	2.1	2.7	1.2	0.8	1.1	0.7	0.5	0.5	2.2
100		1.6	14.5	14.6	4.7	4.6	2.3	1.6	2.7	1.9	1.5	0.7	4.2

The following table shows the average monthly and average annual reservoir inflow for the years the reservoir has been in operation. The "average monthly" values are based on the daily 0800-hour inflow calculations. That is, the 0800-hour discharge and the 24-hour change in pool elevation are used to determine reservoir inflow. The same is true for the "daily maximum" inflows shown at the bottom of the table.

Table 4-12
Average Monthly/Annual Reservoir Inflow (cfs)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	10	10	27	121	15	11	11	9	10	10	10	10	21
1970	9	9	10	73	53	36	13	11	12	82	84	19	34
1971	14	12	56	95	24	18	20	13	13	38	27	14	29
1972	11	12	68	38	16	13	23	15	30	19	28	14	24
1973	15	14	140	37	98	29	21	22	16	17	18	15	37
1974	15	14	41	115	24	21	13	14	12	13	13	13	26
1975	14	13	14	114	42	110	20	88	22	15	54	26	44
1976	16	50	83	55	18	16	14	13	12	13	13	12	26
1977	12	12	27	25	12	19	35	86	95	39	20	41	35
1978	16	14	44	59	49	65	114	21	22	17	16	15	38
1979	15	13	92	66	44	37	58	24	17	18	18	16	35
1980	16	15	94	64	18	152	32	83	152	26	19	17	57
1981	18	75	42	41	41	21	16	18	16	18	16	14	28
1982	14	13	120	74	45	18	15	16	17	29	62	34	38
1983	18	21	130	115	49	23	20	19	23	17	23	24	40
1984	17	52	37	86	61	23	22	19	16	20	23	29	34
1985	19	34	115	46	21	20	15	16	21	49	19	17	32
1986	15	15	119	70	39	27	33	31	141	67	33	23	51
1987	19	22	33	21	18	16	26	35	21	18	21	26	23
1988	16	15	62	23	26	14	13	13	24	23	26	15	23
1989	14	15	123	42	30	18	33	18	22	15	17	14	30
1990	13	12	155	38	78	173	38	20	17	17	15	15	49
1991	14	17	110	38	86	61	22	18	35	22	80	31	45
1992	20	19	110	113	26	23	49	19	37	25	40	24	42
1993	21	19	65	100	47	88	37	55	33	28	32	31	46
1994	23	60	40	82	33	27	25	31	53	33	21	20	37
1995	19	18	123	51	31	19	17	159	22	40	31	20	46
1996	20	20	60	91	37	39	27	20	17	22	73	25	38
1997	24	20	118	54	22	22	72	38	62	23	21	19	41
1998	19	61	140	81	35	78	27	22	21	20	20	18	45
1999	18	19	45	44	54	22	22	19	18	16	17	16	26
2000	15	18	22	19	20	57	33	15	15	14	33	15	23
2001	14	14	19	265	91	88	26	41	21	20	22	30	54
Daily Max/ Year	38 1997	696 1994	3370 1989	1352 2001	915 1970	2910 1980	1900 1978	2260 1977	2110 1980	734 1970	675 1970	370 1977	

Note: Daily Max Inflow was computed at 0800 hrs based on the 0800-hr outflow and the 24-hr change in storage.

The following table shows the average monthly and average annual reservoir outflow for the years the reservoir has been in operation. The "average monthly" values are based on the instantaneous discharge at 0800-hours. The "daily maximum" outflows at the bottom of the table reflect an instantaneous peak discharge as determined by the USGS for all months except September, November, and December. For these months, the peak discharge was not available; therefore, the daily average is shown.

Table 4-13
Average Monthly/Annual Reservoir Outflow (cfs)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	5	6	21	121	15	11	11	8	10	10	10	10	20
1970	9	9	10	73	53	36	13	11	12	81	84	19	34
1971	14	12	52	95	24	18	20	13	13	37	27	14	28
1972	11	12	68	38	16	13	23	15	30	19	28	14	24
1973	15	13	139	37	94	29	21	22	14	17	18	15	36
1974	15	14	41	113	24	21	13	14	12	13	13	13	26
1975	14	13	14	111	40	103	20	88	22	15	54	26	43
1976	16	49	81	55	18	16	14	13	12	13	12	12	26
1977	12	12	27	25	12	19	31	86	89	37	20	40	34
1978	16	14	42	59	48	64	110	21	22	17	16	15	38
1979	14	13	91	65	41	37	54	24	17	18	18	16	34
1980	16	15	94	64	18	152	32	83	148	26	19	17	57
1981	17	72	39	40	41	21	16	18	16	18	16	12	27
1982	14	13	115	68	45	18	15	15	17	29	59	33	37
1983	18	21	126	113	49	23	20	19	23	17	23	19	39
1984	17	52	37	86	60	23	22	19	16	20	23	24	33
1985	18	30	111	46	21	20	15	16	21	46	19	17	32
1986	15	15	112	67	39	27	33	31	133	67	31	23	49
1987	19	22	33	21	18	16	26	34	21	18	18	26	23
1988	16	15	60	23	26	14	13	13	24	23	25	15	22
1989	14	15	119	41	29	18	33	18	22	15	16	13	29
1990	13	12	152	37	73	165	38	20	17	17	15	15	48
1991	14	17	107	36	85	60	22	18	35	22	80	31	44
1992	20	19	107	112	25	23	48	19	37	25	40	24	42
1993	21	19	65	98	46	88	37	48	31	27	32	31	45
1994	23	58	40	80	33	27	25	31	51	33	21	20	37
1995	19	18	119	51	31	19	17	154	22	40	31	20	45
1996	20	20	60	91	37	39	27	20	17	22	73	25	38
1997	24	20	117	49	22	22	72	38	62	23	21	19	41
1998	19	61	139	79	35	77	27	22	21	20	20	18	45
1999	18	19	44	44	52	22	22	19	18	16	17	16	26
2000	15	18	22	19	20	55	33	15	15	14	33	15	23
2001	14	14	19	261	90	87	26	41	21	20	22	30	54
Daily Max/ Year	32 1997	866 1994	2570 1989	2260 2001	1750 1970	3030 1980	3150 1978	2570 1977	1760 1980	1330 1970	616 1970	465 1977	
Note: Daily Max Discharge is a daily average value for Sep, Nov, and Dec. All others are peak discharge.													

Note that instantaneous peak outflows may be higher than reservoir inflow values because inflows are a daily average value.

4-08. Water Quality. Eau Galle Lake is a shallow flood control reservoir that has four tributaries: (1) Eau Galle River, (2) Lousy Creek, (3) Lohn Creek, and (4) French Creek. These tributaries deliver abundant nutrients from the mainly agricultural watershed. The reservoir exhibits all the classical signs of eutrophication; i.e. abundant aquatic macrophyte growth, excessive algal production, periods of hypolimnetic anoxia, and reduced water clarity. Routine limnological studies conducted at Eau Galle Lake under Task VIIA of the Environmental and Water Quality Operational Studies Program (EWQOS) by the US Army Corps' Waterways Experiment Station (WES) spanned two complete annual cycles; November 1980 through October 1981 and November 1981 through October 1982. Weekly on site measurements were made for dissolved oxygen, specific conductance, pH, and temperature. Water samples for chemical analysis were collected every two weeks. The following conclusions were determined from these routine studies (Kennedy 1985).

(1) Changes in morphometry resulting from operation of the outlet control structure strongly influence in-lake flow patterns.

(2) Geology and land use patterns in each tributary basin plus spring snowmelt events influence material loadings. In general, highest constituent concentrations were found to occur during high-flow events.

(3) During high-flow events such as spring snowmelt, the resultant increase in material loadings contributed to increasing the in-lake nutrient, metal, and solids concentrations. Higher concentrations were also observed in the discharge.

(4) Eau Galle Lake undergoes weak thermal stratification, which allows the establishment of an anoxic hypolimnion. This results in the release of metals and nutrients from the lake sediments to the water column contributing to increased algal and macrophyte growth.

In 1986, an attempt was made to diminish the excessive phytoplankton production associated with high phosphorus loading from anoxic profundal sediments by treating the reservoir with a hypolimnetic dose of aluminum sulfate (alum). The alum effectively complexes the phosphorus into forms that are unaffected by the change in redox when the hypolimnion becomes anoxic. On the 29th of May, alum was administered to the reservoir. The treatment area was confined to depths of 3 meters and greater since sediments at these depths experience anoxia during summer stratification. Alum application has been used successfully to reduce phytoplankton abundance in many eutrophic natural lakes by retarding phosphorus recycling from anoxic profundal sediments. This application however was the first time a recreational reservoir was treated with alum to specifically control phytoplankton production. Numerous water samples were taken throughout the summer months of 1986, 1987, and 1988. One year following the alum treatment, tests indicated that concentrations of soluble reactive phosphorus were substantially reduced. However, during the summers of 1987 and 1988, tests indicated that effects of alum treatment on internal total phosphorus loading were essentially negated, and the epilimnetic total phosphorus and chlorophyll *a* remained unchanged from pretreatment years. Multiple potential sources of phosphorus input to the reservoir make it difficult to reduce epilimnetic phosphorus and phytoplankton growth.

4-09. Channel and Floodway Characteristics.

a. Eau Galle River Channel. The Eau Galle River was improved from the outlet conduit stilling basin to a point about 2,500 feet downstream (**Chapter II**). The channel, which has a capacity approximately equivalent to that of the existing river channel through Spring Valley, can carry a maximum discharge of 4,800 cfs. The river channel is slightly restricted where it passes beneath the North Fourth Street Bridge about 2,100 feet downstream of the stilling basin. Since the restriction does not substantially reduce the channel capacity, replacement of the bridge was not required.

b. Mines Creek. Mines Creek joins the Eau Galle River in Spring Valley. It has a drainage area of 3.1 square miles and falls about 75 feet per mile. A description of the channel improvements and levee work are given in **Chapter II**. In 1964, it was determined that the improvements provide protection for business and residential areas within the village of Spring Valley for floods on Mines Creek up an average frequency of occurrence of once in about 110 years. The project provides for a design flow of 3,000 cfs within the improved reach.

c. Burghardt Creek. Burghardt Creek joins the Eau Galle River in Spring Valley. It has a drainage area of 2.7 square miles and falls about 75 feet per mile. While channel improvements were initially proposed for the creek, it was determined that it was economically infeasible and the plans for improvements were dropped.

4-10. Upstream Structures. There are no reservoir structures upstream of the Eau Galle Dam at Spring Valley, Wisconsin.

4-11. Downstream Structures. Another dam is located on the Eau Galle River about 21 miles downstream of the Eau Galle Dam and Reservoir. It is located in the town of Eau Galle, Wisconsin, about 9 miles upstream of the Eau Galle River confluence. It is also named the Eau Galle Dam. It is operated by the Wisconsin Department of Natural Resources and has a height of 30 feet and a length of 190 feet. It has a maximum storage capacity of 2,300 acre-feet and a maximum discharge of 4,400 cfs.

4-12. Economic Data.

a. Agriculture. Agriculture is one of the major industries in the Eau Galle River watershed. The following table gives a brief summary of the agricultural activities with a comparison of 1992 and 1997. The data were obtained from the Census Bureau's Industry Report. With the exception of sheep and poultry, the table indicates there has been a reduction in farm activity over the years.

Table 4-14 Summary of Agricultural Activities by County				
	Pierce County		St. Croix County	
	1992	1997	1992	1997
Cattle and Calves				
No. of Farms	846	731	949	829
Number Sold	27,569	25,714	34,344	25,469
Sold - $1,000	15,292	13,374	17,817	11,385
Hogs and Pigs				
No. of Farms	142	78	86	65
Number Sold	28,376	15,196	22,446	11,120
Sold - $1,000	2,516	1,556	2,158	1,337
Sheep and Lambs				
No. of Farms	45	51	49	53
Number of Sheep	3,078	2,567	1,144	1,538
Poultry (any)				
No of Farms	25	32	35	47
Sold - $1,000	11	177	3,100	2,183
Dairy Products				
No. of Farms	472	354	541	372
Sold - $1,000	41,284	37,674	55,507	49,650
Harvested Crop Land				
No of Farms	1,066	943	1,186	1,071
No. of Acres	158,852	146,786	180,389	178,096

b. Population. The following table shows the changes in population over the past four decades for the area affected by the Eau Galle River Flood Control Project. The "percent change" shown is from 1990 to 2000.

Table 4-15 Population by County and Village in the Project Area					
	1970	1980	1990	2000	Percent Change
Pierce County	6,162	31,149	32,765	36,804	11.0
St. Croix County	34,354	43,262	50,251	63,155	20.4
Spring Valley	995	982	1,051	1,189	11.6
Elmwood	737	885	775	841	7.9

c. Flood Damages. Average annual urban damages and benefits were computed for the villages of Spring Valley and Elmwood, and for the agricultural property between the two villages, in 1990. **Table 4-16** shows the results. Note that dollar amounts are at October 1990 levels.

Table 4-16
Average Annual Damages/Benefits – 1990

	Without Project	With Project	Benefit
Spring Valley	$748,600	$5,000	$743,600
Elmwood	36,700	$4,400	32,300
Agriculture	30,800	$9,600	21,200

Project benefits are computed annually as part of the *Annual Flood Damages Prevented* report to congress. The accumulation through the year 2001 was $11.4 million. This translates to an average annual benefit of $356,500, whereas in 1990 (above table) it was about $800,000. This is explained by the fact that flood damages prevented for the period 1990 through 2001 were zero, thus lowering the average annual benefits.

V – DATA COLLECTION AND COMMUNICATION NETWORK

5-01. Hydrometeorological Stations.

a. Facilities. The only outlet control for the Eau Galle Project is located on the low flow conduit. All data necessary for its regulation are collected at the pool and tailwater gage house locations. Because there are operational concerns for large rainfall events (e.g. alerting campers and the village of Spring Valley) additional capabilities were incorporated into the pool gage. There are two stream gages located upstream of the pool. The gage site locations are shown on **Plate 5-1**. The following gives a description of each gage site followed by **Table 5-1** summarizing gage information.

(1) Pool Gage House. The pool gage house is located on a hill at the west end of the dam. Starting on 28 January 1969, pool elevations were obtained from a mercury monometer. A Stevens Type A35 continuous recorder maintained a constant record of pool elevations. A staff gage was present as a secondary gage and was also used to ground truth the readings from the mercury manometer. The US Geological Survey (USGS) maintained the equipment until 27 June 1990, when the Corps of Engineers installed a Synergetics DCP (Data Collection Platform). This enabled transmission of hourly pool elevations to the Water Control office. In March 1999, the mercury manometer, Synergetics DCP, and Stevens Recorder were removed. A Design Analysis H350 Smart Gas System replaced the mercury manometer, a Sutron 8210 with voice modem replaced the Synergetics DCP, and a Sutron 8200 data logger replaced the Stevens recorder. In April 1999, a tipping bucket (rain gage) was installed on top of the gage house. In July 1999, an anemometer and wind vane were installed on the roof of the gage house and wired to the DCP. In November of 2000 an hourly air temperature gage became operational. In May 2001, two water temperature gages (^{o}F) were installed in the pool. Both are located near the morning glory spillway with one near the water surface and the other at a depth of about 10 feet. The temperature signals are radioed back to the DCP in the pool gage house. All data is transmitted hourly and is available on the Water Control web site; www.mvp-wc.usace.army.mil.

In 2003, software was installed giving the gage the capability to notify dam personnel of a flood emergency situation. The object is to notify dam personnel when the pool reaches a trigger elevation or when the rainfall intensity exceeds a critical limit. The trigger elevation was set at 998.0 feet and the rainfall trigger was set at 13-inches within 30-hours. When a trigger event occurs, the program makes telephone calls in sequential order up to three telephone calls, until it gets an answer. It is scheduled to become fully operational in FY 2003.

↑ Figure 5-1. Pool Gage House

← Figure 5-2. Tailwater Gage House

(2) Tailwater Gage House. Before the dam was completed in October of 1968, the US Geological Survey (USGS) maintained a chain gage mounted on the North Fourth Street Bridge (formerly Sixth Street), which is located about 650 feet upstream of the Mines Creek confluence. It was installed on 30 March 1944. The gage was moved upstream 850 feet on 31 July 1957 to its present location. The chain gage was replaced by a Canfield wire-weight gage. The earthen dam was completed in October 1968. A gage house was constructed on 1 October 1968 and officially became the Eau Galle Reservoir tailwater gage. It is located on the right bank 770 feet downstream of the dam and 1,500 feet upstream of Mines Creek confluence. Equipment at that time consisted of a mercury manometer, a Stevens A-35 recorder, and a staff gage. In 1969, the USGS installed a v-notch sharp-crested weir for monitoring low flow discharge. A rating table is shown in **Appendix D**. In 1971, a Fisher and Porter digital display was attached to the manometer and recorder. On 1 June 1990, the Corps of Engineers installed a Synergetics DCP thus enabling hourly transmission of data. In September of 1996, the Synergetics DCP, the mercury manometer, and the Stevens recorder were removed. They were replaced with a Campbell CR-10 Micro Logger with voice modem, a Campbell GOES unit, and a PS-2 pressure sensor. The Corps of Engineers supplied the Campbell equipment and the USGS provided the pressure sensor. In May 2001, a water temperature gage (^{o}C) was installed just upstream of the v-notch weir. The temperature gage was wired to the DCP in the tailwater gage house.

A temporary tailwater gage was installed just downstream of the outlet in the spring of 2002. The gage consisted of a Sutron 8200 data logger with a temperature sensor. The purpose of the gage was to monitor outflow water temperatures for comparison with temperatures upstream of the v-notch weir. It was determined that the pooling of water upstream of the v-notch resulted in high instream temperature flows, which in turn was bad for the trout habitat. Therefore, it was proposed that the v-notch weir be removed and be replaced with a rock weir such that a much smaller pool would be created. The work was approved under Section 1135 and is scheduled to be constructed in the fall of 2003.

(3) Upstream Gages. There are two US Geological Survey (USGS) gage sites located upstream of the dam. They are *Eau Galle River at Low-Water Bridge at Spring Valley* and *Eau Galle River near Woodville*. The location of both sites is shown on **Plate 5-1**. The Low-Water Bridge site is a discontinued USGS gage. It had a drainage area of 47.9 square miles. The gage consisted of a water-stage recorder and a crest-stage gage. Its period of record was from November 1981 to September 1983 and from May 1986 to March 1996. It was not possible to develop a rating table for high discharges at this site because of backwater effects from a high pool elevation. The Woodville gage is outside the area of backwater impact. The gage site has a drainage area of 39.4 square miles and is located 20 feet downstream of the County Trunk Highway N Bridge. It has a period of record of July 1978 to September 1983. The site was selected in the spring of 2001 to be the future flood emergency warning site; therefore, the site was started up again in July 2001 as part of a cooperative agreement between the St. Paul District and the USGS. A Campbell Data Recorder records hourly stage data and the USGS periodically measures discharge. The St. Paul District owns all of the equipment. Under the cooperative agreement, the USGS maintains a rating at the site by measuring low flows at the Low-Water Bridge site and high flows at the CT Hwy N site. The data recorder was to be programmed to call dam personnel to notify them when a significant rainfall event had occurred or a trigger stage had been exceeded. In the spring of 2003, it was discovered that the CT Hwy N site only provided three hours advance warning ahead of the Eau Galle Lake pool gage. Therefore, in the summer of 2003, the emergency warning site was moved to the pool gage location, thus eliminating the need for the Woodville gage. It is proposed to eliminate Corps of Engineer funding at this site.

(4) Maintenance Shop. Outside the maintenance shop area is a standard eight-inch precipitation gage. Measurements are made daily. In addition, the shop is equipped with a frost tube, an ice auger, a measuring rod, a snow tube, and a scale for determining frost depth, ice thickness, snow depth and snow-water equivalent. These measurements are taken once a week during the winter months.

Table 5-1 Hydrometeorological Stations			
Location	**Data Type**	**Equipment**	**Notes**
Eau Galle River Tailwater Gage House 770 ft D/S of Dam	Water Surface Elev. Precipitation Water Temperature ^{o}C	Campbell CR-10 PS-2 Pressure Sensor Voice Modem Tipping Bucket Thermometer	Gage Zero: 0.0 ft Datum: NGVD 1929 USGS: 05370000 NWSID: SPRW3 Co-op Gage
Lake George Pool Gage House West end of Dam	Water Surface Elev. Precipitation Water Temp-10 ft deep Water Temp-Surface ^{o}F Wind Speed Wind Direction Air Temperature ^{o}F	Sutron 8210 Sutron 8200 H350 Smart Gas Tipping Bucket Voice Modem Thermometer (3) Anemometer Wind Vane	Gage Zero: 900.0 ft Datum: NGVD 1929 NWSID: SVPW3 COE Gage Lat: 44-51-30 N Long: 92-14-20 W
Eau Galle River near Woodville 20 ft D/S CTH N	Stage Discharge Precipitation	Campbell CR-10 Tipping Bucket Telemeter	Gage Zero: 1,058.65 ft Datum: NGVD 1929 Drainage: 39.4 sq mi USGS: 07050005 Co-op Gage
Eau Galle Project Maintenance Shop	Precipitation Frost Depth Ice Depth Snow Depth Snow-Water Equivalent	8-Inch Rain Gage Frost Tube Ice Auger Measuring Rod Snow Tube Scale	Winter Equipment: Maintained by site personnel. Rain Gage: Maintained by WC Gage Crew.

b. Reporting. During normal working days at 0800-hours, staff at the site record the pool elevation, tailwater elevation, low-flow gate setting, discharge, wind speed and direction, 24-hour precipitation, and the 24-hour maximum and minimum air temperature. This data is entered on a monthly log sheet (**Appendix B**) as well as a remote computer terminal, which reports the information directly to Water Control. Pool elevations, tailwater elevations, cumulative rainfall, air temperature, water temperatures, and wind speed and direction are sent to the Water Control office via the Data Collection Platforms (DCP) located at the pool and tailwater gage houses. The data is collected at the DCP and then sent to the US Geostationary Operational Environment Satellite (GOES). The GOES system sends the data to a Direct Readout Ground Station (DRGS) at Wallops Island, Virginia. The data is reformatted and sent to the Domestic Communications Satellite (DOMSAT), which transmits the data to the DOMSAT Receive Station (DRS) located at the St. Paul District Office. The following shows the path of data transmission. This data is available on the Water Control web site; www.mvp-wc.usace.army.mil.

Transmission Path of DCP Data

```
                 GOES                DOMSAT
                ↑    ↓              ↑        ↓
              ↑        ↓          ↑            ↓
            ↑            ↓      ↑                ↓
Gage → DCP               DRGS                    DRS→ Water Control
```

c. **Maintenance.** The pool gage is owned and maintained by the Corps of Engineers. The tailwater gage is part of a cooperative agreement between the St. Paul District and the US Geological Survey (USGS). The gage is owned by the Corps of Engineers but is maintained by the USGS. In an emergency, Water Control's gage crew can also provide maintenance. The precipitation gage, wind instrumentation, temperature gages, and all the winter gaging equipment are owned and maintained by the Corps of Engineers.

5-02. **Water Quality Stations.** The US Geological Survey maintained water quality stations at *Eau Galle River near Woodville*, *Eau Galle River at Low Water Bridge at Spring Valley*, and *Eau Galle River at Spring Valley* (tailwater gage). The following table shows the period of record and data collected at each site.

Table 5-2
USGS Discontinued Water Quality Stations

Eau Galle River	Drainage Area	Type of Record	Period of record
near Woodville	39.4 sq-mi	Temperature: Specific Conductance:	1978-83[1] 1978-83[1]
at Low-Water Bridge	47.9 sq-mi	Temperature: Specific Conductance:	1982-83 and 1987-93 1983
at Tailwater Gage	64.1 sq-mi	Temperature: Specific Conductance:	1978-90 1978-90
1. Numerous periods of missing record.			

In addition, several water quality stations were established in the lake as part of the *Limnology Studies at Eau Galle Lake, Wisconsin*. The Waterways Experiment Station performed the study in 1980 to 1981, with the report, Technical Report E-85-2, being published in 1985. Information regarding this study can be found in **Section 4-08**. Two of the stations established for this study were also used for a study to measure impacts of low-level releases on trout populations (**Section 7-07**). One station was located at the morning glory spillway and one at about the middle of the lake (**Figure 7-1**).

5-03. Sediment Stations. Periodic surveys of the reservoir are taken for the purpose of monitoring sedimentation of the pool (**Section 4-04.**). There are no sedimentation stations for monitoring sediment inflow.

5-04. Recording Hydrologic Data. The Corps of Engineers has five forms of recording and storing hydrologic data; (1) monthly log sheets, (2) Stevens role charts, (3) DCP tracking charts, (4) microfilm, and (5) the Corps of Engineers Data Storage System (DSS).

a. Log Sheets. Log sheets are filled out on a monthly basis and mailed to Water Control where the data are verified. Data includes the 0800-hour readings for the pool and tailwater elevations, gate setting, discharge, 24-hour rainfall, 24-hour maximum and minimum air temperature, and wind speed and direction. A copy of the log sheet is filed at the site and the original is mailed to Water Control where the data are used to verify DSS records generated from input by site personnel. The original copies are kept on file in Water Control until they are microfilmed.

b. Stevens Recorder and DCP Tracking Charts. Stevens role charts maintained a record of the pool elevation from construction of the dam until the recorder was removed in March 1999. The role charts were stored in Water Control until they were put on microfilm. The microfilm is stored in

Water Control. Since removal of the Stevens recorder, DCP Tracking Charts have been used to assure an accurate record of the pool elevation. The DCP elevation and a staff gage reading are periodically taken and compared for accuracy. If the variation becomes too great, the DCP is reset and the corrective action is noted on the DCP Tracking Chart.

c. **DSS Data.** Presently the Eau Galle staff inputs the daily log sheet data, via a remote computer, in a DWINDO program called "sig-na-term". This data set is then stored in the Corps' Data Storage System (DSS). During the winter months, the weekly measurements of frost depth, ice thickness, snow depth, and snow-water equivalent are also entered. The DSS files for daily pool elevations, tailwater elevations, and discharges have been back-entered such that the data string begins on 28 January 1969. The 24-hour precipitation record begins on 1 January 1971. Wind speed and direction begins on 3 January 1984. Gate settings and maximum and minimum air temperatures begin in November 1998. Hourly input from the DCP are also stored in DSS files. The data available are tied to the date the equipment was installed. For example pool and tailwater elevations begin in mid-1990. Wind speeds and precipitation begin in 1999. All DSS data is available from the Water Control web site at www.mvp-wc.usace.army.mil.

5-05. Communication Network. Communication between the staff at Eau Galle Dam and Water Control can be made by telephone, facsimile, e-mail, or FM radio.

Table 5-3
Communication Network

	Telephone	Facsimile	FM-Radio
Eau Galle	715-778-5562	715-778-4678	WUG 643
Water Control	651-290-5626	651-290-5841	WUG 613

5-06. Communication with Project.

a. **Regulating Office with Project Office.** Normal and emergency communication between Water Control personnel and the Eau Galle Park

Manager is by telephone on an as needed basis. In the event that the telephone system does not work, a FM radio network is available for use.

b. Between Project Office and Others. The Park Manager will furnish routine regulatory information upon request to interested agencies and parties. In the event of flood conditions or other emergency, the Park Manager should notify anyone in the recreation area and campground of impending danger.

5-07. Project Reporting Instructions. The Park Manager reports the necessary hydrologic conditions to Water Control every morning of each working day. If warranted by either flood conditions or maintenance work, reports are made more frequently at the request of Water Control.

5-08. Warnings. A rapid rise in the pool elevation can isolate people in the recreation area. The lowest section of the access road to the recreation area is at elevation 960.0 feet, which is 20 feet above the conservation level and about 40 feet lower than the highest point in the recreation area. Therefore, users of the recreation area could be unaware of the danger and could become stranded on the “island” for short period. When the Park Manager becomes aware that pool may rise above elevation 960.0 feet, he/she should evacuate the recreation area and campground.

A rapid rise in the downstream channel can catch people in their homes unaware of the potential danger from rising river levels. The pool gage at Eau Galle Dam acts as a flood emergency warning site. Should the pool rise to elevation 998.0 feet or record a rainfall event of 13-inches in less than 30-hours, the gage site will make telephone calls alerting dam personnel of an emergency situation at the dam. The Park Manager should immediately notify the proper authority for the village of Spring Valley of the situation. Notifications of severe weather or impending unusual conditions downstream of the Eau Galle Dam would be handled through local law enforcement and civil defense authorities.

VI – HYDROLOGIC FORECASTS

6-01. General. The National Weather Service has no forecast points on the Eau Galle River. The nearest forecast site is at Durand on the Chippewa River just upstream of the confluence of the Eau Galle River. The Corps of Engineers provides advisory forecasts for its projects as needed. These Corps forecasts may arise from either dry or wet conditions and are used to guide Water Control regulators and the Park Manager in their tasks.

6-02. Flood Condition Forecasts. Flood forecasts for the Eau Galle River Project are typically not necessary since there are no downstream control points nor reservoir level decision points due to the uncontrolled outlet structure. However, should a large event be eminent, it would be of great value for alerting campers in the Eau Galle recreation area and the village of Spring Valley. Therefore, an emergency flood-warning system was installed at pool gage house in FY 2003. The gage will alert dam personnel when the rain gage records 13-inches of rainfall within 30-hours or the pool reaches an elevation of 998.0 feet.

6-03. Conservation Purpose Forecasts. No conservation purpose forecasts are prepared for Eau Galle Reservoir.

6-04. Long-Range Forecasts. No long-range forecasts are performed for Eau Galle reservoir.

6-05. Drought Forecasts. No drought forecasts are performed for Eau Galle Reservoir.

VII – WATER CONTROL PLAN

7-01. General Objectives. The primary purpose of the Eau Galle Reservoir is flood control for the village of Spring Valley, Wisconsin, which is located immediately downstream of the dam (see photo on cover). Recreation and enhancements for fish and wildlife are recognized as additional benefits.

7-02. Constraints.

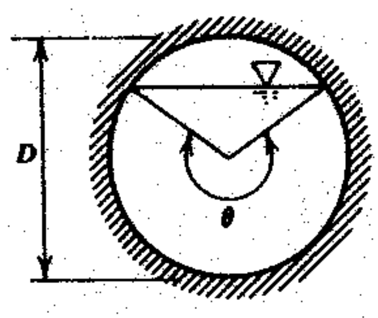
a. Dead Storage. The low flow outlet has an invert elevation of 916.5 feet (1929 adjustment); which would imply the pool could eventually be drawn down to this elevation if inflow was zero. For practical purposes, it is assumed drawdown of the pool is constrained to elevation 917.0 feet. Therefore, dead storage is 78 acre-feet, based on the 1987 sediment survey.

b. Conduit Capacity. The outlet for the reservoir was originally designed to be a 10-foot diameter circular culvert. To reduce construction costs, a 9-foot 9-inch horseshoe shaped conduit replaced the circular culvert. Computations performed in 1979 and as part of this manual update, indicate the conduit had a capacity of 4,270 cfs for a pool elevation of 1020.0 feet (approximate elevation of the emergency spillway crest). Due to cracking of the conduit, a grout and steel liner was installed over the winter of 1981–82. For a pool elevation of 1020.0 feet, the conduit capacity was reduced to 3,800 cfs. The rating curves are shown on **Plate 3-2**.

c. Emergency Spillway. The emergency spillway has a crest elevation of 1019.53 feet. Routing of the Probable Maximum Flood indicated a peak pool elevation of 1036.2 feet. At this elevation, the capacity of the emergency spillway is 25,000 cfs. The rating curve is shown on **Plate 3-1**.

7-03. Overall Plan for Water Control. The only outlet control is at the low flow culvert. The operating plan provides for maintaining a minimum discharge of 13 cfs whenever possible. During drought periods, if the pool falls below elevation

939.5 feet, minimum outflow may be reduced to 2 cfs (see *Drought Contingency Plan* 1992). During normal operations, the low flow outlet gate is typically set at 13 cfs and all additional inflow spills over the morning glory spillway, thus maintaining a conservation pool of elevation 940.0 feet (crest elevation of the morning glory spillway). The low flow conduit consists of a 48-inch circular steel pipe that taps into the transition portion of the main conduit, near the morning glory intake, at a 45-degree angle. A 4-foot vertical slide gate with a sill elevation of 916.5 feet controls flow. Therefore, the control is a rectangle superimposed on a circular outlet. Hence, area of flow is not linear with the gate opening. Area can be determined by,



$$\text{Area} = 0.125\,(\theta - \sin\theta)\,D^2$$

The angle θ can be determined from the known radius and the depth of flow. The following shows the areas developed.

Pipe Area (sq ft) for Various Water Levels

Opening (feet)	**Theta** (radians)	**Area** (sq ft)	**Opening** (feet)	**Theta** (radians)	**Area** (sq ft)
0.1	0.635	0.084	1.0	2.094	2.30
0.2	0.902	0.235	1.5	2.636	4.30
0.3	1.110	0.428	2.0	π	6.28
0.4	1.287	0.654	3.0	4.189	10.11
0.5	1.446	0.907	4.0	2π	12.57

Discharge can then be determined from the orifice equation,

$Q = CA\,[2gH]^{0.5}$ Where, C = Coefficient of Opening (0.5)
A = Area of Opening (sq ft)
H = Differential Head (ft)

Differential head was measured from the pool elevation to the midpoint of the gate opening. The following table shows the low flow gate rating.

Table 7-1 Low Flow Gate Rating in cfs										
	Gate Opening in Feet / Flow Area in Sq Ft									
Pool Elev.	0.1 0.084	0.2 0.235	0.3 0.428	0.4 0.654	0.5 0.91	1.0 2.30	1.5 4.30	2.0 6.28	3.0 10.11	4.0 12.57
917.0	0.2	0.6	1.0	1.4	1.8	2	2	2	2	2
918.0	0.4	1.1	2.0	3.0	4.1	10	15	15	15	15
919.0	0.5	1.5	2.6	4.0	5.5	14	23	31	37	37
920.0	0.6	1.7	3.1	4.8	6.6	17	29	40	57	62
921.0	0.7	2.0	3.6	5.4	7.5	20	33	47	70	80
922.0	0.8	2.2	4.0	6.0	8.4	22	37	53	81	94
923.0	0.9	2.4	4.3	6.5	9.1	24	41	59	90	107
924.0	0.9	2.6	4.7	7.1	9.9	25	44	64	99	118
925.0	1.0	2.7	5.0	7.5	10.5	27	48	69	107	128
926.0	1.0	2.9	5.3	8.0	11.1	29	51	73	114	138
927.0	1.1	3.0	5.5	8.4	11.7	30	54	78	121	147
928.0	1.1	3.2	5.8	8.8	12.2	32	56	82	128	155
929.0	1.2	3.3	6.0	9.2	12.7	33	59	85	134	163
930.0	1.2	3.5	6.3	9.6	13.2	35	61	89	140	171
931.0	1.3	3.6	6.5	9.9	13.8	36	64	93	146	178
932.0	1.3	3.7	6.8	10.3	14.3	37	66	96	152	185
933.0	1.4	3.9	7.0	10.6	14.7	39	68	99	157	192
934.0	1.4	4.0	7.2	10.9	15.2	40	71	102	162	198
935.0	1.4	4.1	7.4	11.2	15.6	41	73	105	167	205
936.0	1.5	4.2	7.6	11.5	16.0	42	75	108	172	211
937.0	1.5	4.3	7.8	11.8	16.4	43	77	111	177	217
938.0	1.6	4.4	8.0	12.1	16.8	44	79	114	181	223
939.0	1.6	4.5	8.2	12.4	17.2	45	81	117	186	228
940.0	1.6	4.6	8.3	12.7	17.6	46	82	120	190	234
941.0	1.7	4.7	8.5	13.0	18.0	47	84	122	194	239
942.0	1.7	4.8	8.6	13.2	18.4	49	86	125	199	244
943.0	1.7	4.8	8.8	13.5	18.7	50	88	127	203	249
944.0	1.8	4.9	9.0	13.7	19.1	51	89	130	207	254
945.0	1.8	5.0	9.1	14.0	19.4	52	91	132	211	259

7-04. Standing Instructions to Eau Galle Reservoir Staff. Each normal working day, Eau Galle Reservoir staff are to collect 0800-hour readings for the pool elevation, tailwater elevation, low flow gate setting, discharge through the low flow gate, discharge over the morning glory spillway, total discharge, wind speed and direction, maximum and minimum air temperature, and the 24-hour precipitation. During the winter months, data collection on Mondays will also include frost depth, pool-ice thickness, snow depth, and snow-water equivalent. If Monday is a holiday, data will be collected on Tuesday. By 0900-hours, the data are to be sent to Water Control via computer. Total discharge is to be obtained from the US

Geological Survey (USGS) web site for the tailwater gage. If the web site is not operational or the discharge is not posted, the USGS tailwater rating curve presented in **Appendix D**, or a later version, may be used. Discharge through the low flow outlet will be estimated using **Table 7-1**. Flow over the morning glory spillway will be the total discharge minus the low flow discharge. On the first workday following a weekend, missing data are filled in based on DCP recordings and the USGS web site. Log sheets with this data will be maintained at the site. Each month, a copy of the log sheet is to be mailed to Water Control. An example of a monthly log sheet is shown in **Appendix B**.

Water Control may contact the site for low-flow gate changes for the betterment of trout habitat. These gate changes will be made as soon as possible or as prescribed.

A rapid rise in pool elevation can isolate people in the recreation area. The lowest section of the access road to the recreation area is at elevation 960.0 feet. The Park Manager should notify anyone in the recreation area and campground when it appears the pool may rise above this elevation. If site personnel are notified by the emergency flood warning system at the project site, they are to immediately notify the proper village officials in Spring Valley and then confirm the warning.

Following a flood event, debris collected on the trash rack should be removed. If the event was sufficient for the safety boom to become detached, it should be replaced before recreational boating is allowed on the lake.

In the event of an emergency at site (e.g. seepage through the dam, low flow gate broken, etc.), Eau Galle staff should contact Water Control Section and Construction and Operations (Con-Ops) Division. Contact with Water Control should be made in the order listed on page iii.

7-05. Flood Control. Regulation of the Eau Galle Reservoir is automatically controlled by the morning glory spillway up to the crest of the emergency spillway. The downstream channel capacity is 4,800 cfs. With the pool at the crest of the emergency spillway, outflow is approximately 3,800 cfs. When the pool rises above the crest of the emergency spillway (elevation 1019.53 feet), regulation remains automatic; however, flow is also going down the emergency spillway. Peak pool elevation is 1036.2 feet, as indicated by the routing of the Probable Maximum Flood (**Section 3-02.g. PMF and Freeboard**).

7-06. Recreation. The pool is maintained at a conservation pool elevation of 940.0 feet. Canoeing is a popular activity on the 150-acre lake. Boats with electric motors are also permitted. More information regarding recreational facilities is presented in **Section 2-06. Public Facilities**.

7-07. Water Quality. During the stratified lake period from late April to September, the low level release of relatively cold water typically accounts for greater than 50 percent of the total outflow. This causes hypolimnetic heating and destabilization of the reservoir water column. This could make the reservoir susceptible to small scale mixing events induced by summer storms. These small-scale mixing events may help transport nutrients up to the epilimnion and lead to an increase in algal growth. In an effort to stabilize the water column, it was proposed that outflow be only surface level releases. This would allow a stronger thermal gradient to develop, thereby decreasing vertical entrainment of hypolimetic phosphorus, and it would also increase the epilimnetic flushing rate and discharge of algae. On a trial basis, surface only releases were made for the periods; 15 April to 23 July 1991, 25 April to 23 August 1992, and 3 May to 30 July 1993. The switch to surface withdrawal resulted in some anticipated changes in thermal structure and nutrient dynamics, but was ultimately unsuccessful in controlling phytoplankton biomass. Phosphorus loading was overwhelmingly dominated by external sources, and thus the depth of withdrawal had little effect on epilimnetic total-phosphorus concentrations.

7-08. Fish and Wildlife. The Eau Galle River upstream and downstream of the reservoir is designated a trout stream by the Wisconsin Department of Natural Resources (WDNR). Since construction of the dam, the trout fishery has declined dramatically. It was theorized that the decline in trout population downstream of the dam was due to the warm water being released from the dam. The Corps of Engineers in cooperation with WDNR completed a study of the influence of hypolimnetic releases on downstream thermal conditions in the Eau Galle River in 2000. Under normal operations, the low flow gate is set to pass about 13 cfs while the remainder of the outflow is through the morning glory spillway. A request to modify the operating plan was made to the Division Office (MVD) in the spring of 2000. The object of the plan was to provide cooler water downstream through an increase in the outflow through the low flow structure. If necessary, the pool was allowed to be drawn down below project pool by 0.5 feet during the test cycle. The test period was from June to September. The trout population measured after September 2000 showed increased numbers not seen in the last five years. A study of the effects of the increased hypolimnetic discharge on the water quality of the reservoir was also performed. Two sample sites were established; one at the morning glory spillway and one at "Site 20" of the 1980 to 1981 pool study. The locations are shown in **Figure 7-1**.

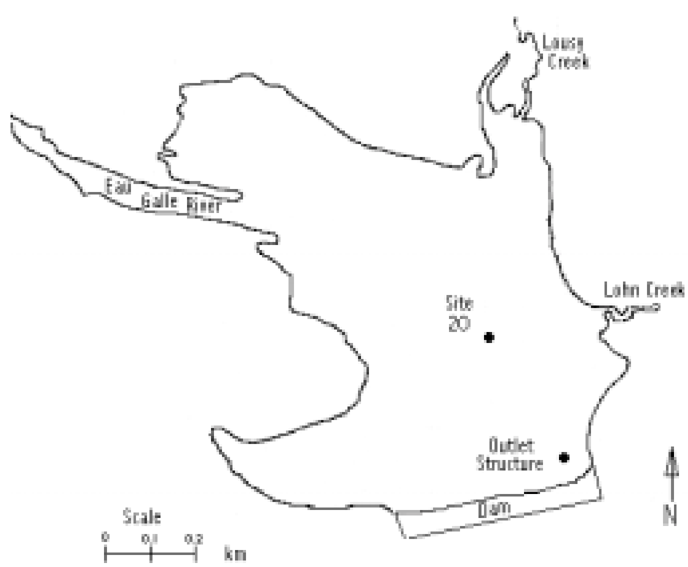


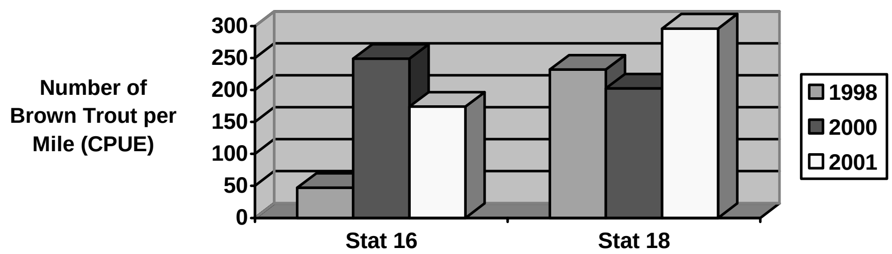
Figure 7-1. Water Quality Sample Sites

Every two weeks starting on 18 June, insitu limnological profiles were taken at Site 20 and the outlet structure. Site 20 is located at the deepest point in the reservoir and based on the previous pool study, it can be used as a good representative of a major potion of the reservoir (Kennedy 1985). Limnological variables included temperature, dissolved oxygen, specific conductance, pH, and Secchi depths. The routine water quality measurements showed no obvious effects of the experimental release regime on water quality.

Throughout the summer, the change of discharge rates and the decrease in discharge temperatures did not seem to disrupt the stratification of the lake and the water quality parameters measured continued to compare closely to previous years. However, the residence time increased for the epilimnion and this study was unable to characterize the lake in detail due to a lack of nutrient and biological data. Also, there was an increase in algal blooms in the pool in 2000 that were not seen in 2001; however, without any appropriate data, a conclusive result was not possible.

Results of the 2000 study supported continued releases of hypolimnetic waters from Eau Galle Reservoir. In 2001, a hypolimnetic release plan was formulated for improving downstream thermal conditions in the Eau Galle River. The release plan was to be implemented on a five-year trial basis. An Environmental Assessment of the operation was performed (**Appendix E**). Coordination with all necessary agencies was accomplished (e.g. US FWS, WI DNR, US EPA, etc.). Based on the assessment, a Finding of No Significant Impact was signed (**Appendix E**). Therefore, a request for deviation was sent to the Division Office (MVD). The request was to operate the low flow outlet to bring water temperatures down to 65 degrees Fahrenheit at the temperature probe located at the tailwater gage site. The gates were to be regulated to maintain a stream temperature between 65 and 68 degrees Fahrenheit. Drawdown of the pool below project pool was limited to 0.5 feet. The test period was from 1 July to 30 September. The trout count following the operation was similar to the previous year. The following figure shows the number of brown trout per mile for three separate years at two locations. Station 16 is located at Highway 29 upstream of Sixth Street. Station 18 is located upstream of 170th Avenue.

Figure 7-2. Number of Brown Trout per Mile



After examining the results, more consideration was given to the pool of water that is formed upstream of the v-notch weir near the tailwater gage house. The v-notch weir is three-feet high and is located about 1,000 feet downstream of the dam. Comparisons of the water temperature at the dam outlet and at the tailwater gage showed that the ponded water upstream of the weir was heated by the sun and thereby made it more difficult to maintain cooler instream temperatures. On 2 May 2003, the St. Paul District requested funding for *Eau Galle Restoration* under Section 1135. The recommended plan called for removing the v-notch weir and replacing it with a rock weir located 410 feet downstream of the stilling basin along with channel modification for a short distance downstream. The new weir would be two feet in height and would have a two-foot-wide notch extending down to the streambed elevation. The rock weir would impound less water over a shorter river reach. The Section 1135 plan was approved and construction is scheduled for the fall of 2003. Any necessary changes to the tailwater gage will be coordinated with USGS.

The monitoring of pool and tailwater temperatures continues today as does the release of additional subsurface waters at the dam to maintain better trout habitat. After completion of the five-year plan, an evaluation will be made and perhaps a permanent change in the operating plan will result.

7-09. Water Supply. The Eau Gale Reservoir is not used as a source of water supply. The village of Spring Valley gets its water from wells.

7-10. Hydroelectric Power. There is no hydroelectric power at the Eau Galle Dam.

7-11. Navigation. Eau Galle reservoir is not regulated for navigation.

7-12. Drought Contingency Plan. The drought contingency plan is a stand-alone document. It is entitled *Drought Contingency Pan* and was published as an appendix to the Eau Galle Reservoir Regulation Manual in September 1992. The plan calls for a minimum discharge of 13 cfs whenever possible (gate opening 0.33 feet). If drought periods should occur and inflow to Eau Galle Reservoir becomes so low that the reservoir falls below elevation 939.5 feet, discharge may be reduced to 2 cfs. The approximate gate opening for the low flow discharge conduit is 0.12 feet. Measurements of tailwater flow may be used to "fine tune" the gate opening.

7-13. Emergency Action Plan. An Emergency Action Plan was published in 1992 under the title *Dam Safety Program, Flood Control Project, Eau Galle Dam and Reservoir*. Copies of the plan are kept at the Dam site, Water Control Section, and Hydrology Section. The report is typically updated every 10 years. The plan provides a guide for actions to identify and mitigate or respond to various types of emergencies, which while rare, could occur in the operation of Eau Galle Dam. For example, the plan addresses emergencies related to above-normal pool failure (elevation 1020.0 feet) due to piping, and failure during the Probable Maximum Flood (pool elevation 1036.8 feet) with a breach formed by overtopping and erosion.

7-14. Other. The outlet conduit and stilling basin are inspected approximately every five years. The day before the "periodic inspection" the pool is drawn down below the crest of the morning glory spillway to about elevation 939.7 feet.

Outflow through the conduit is shut down to zero outflow for a period of one to two hours while the conduit is inspected. While the conduit is being inspected, sand bags are placed in the culvert just upstream of the stilling basin. After completion of the conduit inspection, the low flow is opened to pass approximately 4.5 cfs (approximate gate opening of 0.2 feet). A pool is formed behind the sandbags. Pumps then draw from this pool and bypass the stilling basin thereby maintaining an instream flow. Upon completion of the inspection, the pumps and sandbags are removed and normal operation is resumed.

7-15. Deviation From Normal Regulation. There are three forms of deviation; (1) a deviation because of an emergency situation, (2) an unplanned minor deviation due to an unplanned event, and (3) a planned deviation, typically to accomplish some task. To deviate from the operating plan requires permission from the Division Office (MVD), except for an emergency.

a. **Emergency.** Under an emergency deviation, the District Engineer may authorize a deviation in an attempt to abate the problem. The Division Office is to be notified as soon as practical. Written confirmation of the deviation is to be sent to the Division Water Control Manager.

b. **Unplanned Minor Deviation.** Should an unplanned instance create the need for a temporary minor deviation, permission to do so is to be obtained from the Division Office. Consideration must be given to upstream and downstream watershed conditions, potential flood threat, and alternative measures that can be taken. An e-mail explaining the deviation and its cause must be furnished to Division Water Control Manager. Approval for an unplanned minor deviation is typically obtained by e-mail.

c. **Planned Deviations.** Requests for planned minor deviations may be submitted to the Division Water Control Manager by e-mail. Major deviations must be presented formally to the Division Water Control Manager by a memorandum from the Chief, Engineering Division. The request should include sufficient data on flood potential, lake and watershed conditions, and benefits to be expected. Approval for minor deviations are typically by e-mail, while approval of major deviations are by memorandum.

7-16. Rate of Release Change. Normal operating procedures do not require any major changes in release. The largest possible change in controlled releases would be from zero cfs with the low flow gate completely closed, to 234 cfs with slide gate wide open at project pool. While the necessity for rapid changes in low flow discharge is highly unlikely, they are limited to a maximum rate of change of 50 cfs every four hours as guideline.

VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. The principal benefit of this project is flood control for the village of Spring Valley, Wisconsin. Benefits are also realized for recreation.

8-02. Flood Control. The reservoir is designed for automatic flood control operation. Under normal conditions, the morning glory spillway maintains a permanent conservation pool elevation of approximately 940.0 feet. During flood events, the limited capacity of the uncontrolled intake and outlet conduit will not permit discharges greater than the downstream channel capacity during floods that are stored below the emergency spillway crest at elevation 1019.53 feet. At a pool elevation of 1019.53 feet, an unplugged conduit will pass about 3,800 cfs. The downstream channel capacity is around 4,800 cfs.

The emergency Spillway Design Flood was the Probable Maximum Flood (PMF). The PMF presented in the 1969 Reservoir Regulation Manual was superceded in 1998 as part of the Dam Safety Assurance Program. This analysis was based on the then current OCE guidance and NOAA Hydrometeorological Report No. 51. The probable maximum precipitation above Eau Galle Dam was calculated from a depth-area-duration analysis. The rainfall amounts were distributed incrementally in accordance with Civil Works Engineer Bulletin 52-8.

Table 8-1
Maximum 24-hr Rainfall Amounts in Inches

Duration Hours	Cumulative Rainfall	Incremental Rainfall	Distributed Rainfall
0	0.0		
6	20.75	20.75	1.30
12	24.5	3.75	3.75
18	25.8	1.30	20.75
24	26.6	0.80	0.80

The distributed incremental rainfall amounts were broken down into 15-minute increments and a 15 percent Hop Brook adjustment was applied to account for the decreased likelihood of a major storm being centered over a drainage basin less than 1,000 square miles in area. The adjusted 15-minute values were applied to the basin unit hydrograph using the computer program HEC-1. Initial loss was 0.4 inches with a constant loss rate 0.11 inches/hour. The starting pool elevation was 943.0 feet. This was in accordance with Section 8-f of Engineering Regulation 1110-8-2 (FR) which states that the Inflow Design Flood (IDF) shall be full pool **or** an elevation prevailing five days after the last significant rainfall of a storm which produces one half of the IDF, whichever is most appropriate. In this case, the antecedent flood pool level of 943.0 feet selected for the PMF reservoir routing was the level prevailing about five days after one half of the PMF was routed through the reservoir. It was assumed for the PMF reservoir routing that the conduit and morning glory spillway was partially plugged by debris such that it had only 50 percent of the maximum capacity at high reservoir levels. The rock lined emergency spillway with an inlet crest elevation 1019.53 feet was assumed to have no blockage. The resulting peak inflow was 122,100 cfs with a volume of 20.1 inches of rainfall excess over the 63.9 square miles of drainage above the dam. The time to peak after the start of rainfall was 17 hours. Peak outflow was 26,600 cfs. The peak pool elevation was 1036.2 feet.

The lowest point along the dam crest is approximately elevation 1040.1 feet (i.e. 3.9 feet of freeboard). Engineering Regulation 1110-8-2 (FR) states that if the reservoir elevation is within 3 feet of the maximum pool elevation for the Inflow Design Flood routing, for more than 36 hours, the minimum freeboard should be 5 feet. Routing of the PMF indicated that the reservoir is within 3 feet of the maximum PMF pool level of 1036.2 feet for less than 10 hours. In addition, the analysis showed that pool level is above elevation 1035.0 feet for less than 3 hours. Therefore, the pool level falls back to within the 5-foot freeboard range in less than 3 hours. The wave analysis presented in the Evaluation Report, and supported by independent calculations presented in **Appendx B**, shows wave runup to be 3.0 feet, which is within the 3.9 feet of freeboard provided at peak pool level.

8-03. Recreation. The water control plan for the Eau Galle Reservoir provides a dependable and stable pool level which benefits swimming, fishing, and boating.

8-04. Water Quality. During normal operating conditions the pool is maintained at elevation 940.0 feet and inflow basically equals outflow. Because minimum release is 13 cfs, the low flow gate is typically set to pass this amount with any additional inflow going over the morning glory intake. Releasing water from only the surface was investigated with no appreciable change in pool conditions (**Section 7-07. Water Quality**).

8-05. Fish and Wildlife. The original plan for Eau Galle Reservoir was to maintain a pool elevation of 935.0 feet; however, as recommended by the US National Park Service and the US Fish and Wildlife Service, the conservation pool level was raised to elevation 940.0 feet. This change in the water control plan greatly impacted the fish and wildlife habitat.

Releasing low flows such that downstream water temperatures would be maintained between 65 and 68 degrees Fahrenheit for the months of July through September was investigated in 2001 (**Section 7-08. Fish and Wildlife**). This minor altercation in the operating plan was a benefit to the brown trout downstream of the dam. Because of this, downstream temperatures continue to be monitored and adjustments are made to the low flow gate as needed.

8-06. Water Supply. Eau Galle Reservoir does not provide any water supply.

8-07. Hydroelectric Power. There is no hydroelectric power at Eau Galle Reservoir.

8-08. Navigation. Other than recreational boating, there is no navigation at Eau Galle reservoir.

8-09. Drought Contingency Plans. A minimum outflow of 13 cfs is maintained at Eau Galle Reservoir whenever practical. During a drought period when the pool elevation is at the conservation level of 940.0 feet and the inflow drops below 13 cfs, an outflow of 13 cfs is maintained until the pool falls to elevation 939.5 feet. Assuming a pool elevation of 940.0 feet and an inflow of zero, an outflow of 13 cfs can be maintained for a little over two and one half days before the pool falls to elevation 939.5 feet. At a pool elevation of 939.5 feet, the *Drought Contingency Plan* allows for outflow to be as low as 2 cfs. Therefore, during periods of drought, the Water Control Plan provides continuous instream flow.

8-10. Emergency Action Plans. The flood emergency action plan is a stand-alone document entitled *Dam Safety Program, Flood Control Project, Eau Galle Dam and Reservoir, Emergency Plan*, dated April 1992. The plan provides a guide for actions to identify and mitigate or respond to various types of emergencies, which, while rare, could occur in the operation of Eau Galle Dam. A copy of the plan is kept in Water Control and at the reservoir site.

8-11. Frequencies.

a. Peak Inflow Probability. Inflow to the reservoir since completion of the dam is based on the 24-hour change in pool elevation and the assumed 24-hour outflow. Therefore, there are no good records of instantaneous peak inflow since construction of the dam; however, there are records prior to construction of the dam. The data shown in **Table 8-2** was used to develop the Inflow-Probability Curve presented in **Plate 8-1**.

b. Peak Outflow Probability. The dam was completed in 1969. **Table 8-3** shows the instantaneous peak outflow for with project conditions. Note that for the years 1975, 1977, 1978, and 1980, outflows were modified to reflect what the outflow would have been with the conduit liner in place. **Plate 8-2** shows the outflow-probability curve.

Table 8-2

Pre-Project Discharges Measured at USGS 6th Street Gage

Date	Discharge	Date	Discharge	Date	Discharge
1894	8,150 cfs	1946	2,680 cfs	1958	1,460 cfs
1901	8,150 cfs	1947	2,310 cfs	1959	6,200 cfs
1903	10,600 cfs	1948	2,140 cfs	1960	3,210 cfs
1907	13,200 cfs	1949	2,980 cfs	1961	2,540 cfs
1911	14,000 cfs	1950	3,390 cfs	1962	1,490 cfs
1923	8,150 cfs	1951	2,730 cfs	1963	3,390 cfs
1934	13,200 cfs	1952	3,120 cfs	1964	1,420 cfs
1938	19,100 cfs	1953	3,480 cfs	1965	6,820 cfs
1942	33,000 cfs	1954	7,000 cfs	1966	3,060 cfs
1943	3,540 cfs	1955	1,280 cfs	1967	2,660 cfs
1944	2,880 cfs	1956	5,130 cfs	1968	975 cfs
1945	3,900 cfs	1957	2,490 cfs	1969	1,430 cfs

Table 8-3

Instantaneous Peak Outflows - With Project Conditions

Date	Discharge	Date	Discharge	Date	Discharge
1970	1,750 cfs	1981	512 cfs	1992	993 cfs
1971	1,330 cfs	1982	2,050 cfs	1993	2,170 cfs
1972	1,050 cfs	1983	1,020 cfs	1994	866 cfs
1973	1,790 cfs	1984	640 cfs	1995	2,140 cfs
1974	1,440 cfs	1985	504 cfs	1996	444 cfs
1975	2,070 cfs	1986	2,340 cfs	1997	1,470 cfs
1976	890 cfs	1987	1,150 cfs	1998	1,750 cfs
1977	2,220 cfs	1988	252 cfs	1999	464 cfs
1978	2,050 cfs	1989	2,570 cfs	2000	1,180 cfs
1979	925 cfs	1990	2,190 cfs		
1980	2,560 cfs	1991	2,580 cfs		

c. Pool Elevation and Frequency. The following plot of the history of pool elevation is based on the 0800-hour pool readings. Because of the flashy inflows, the peak pool elevations for most flood events were missed. Therefore, it is not possible to plot a meaningful stage-duration curve.

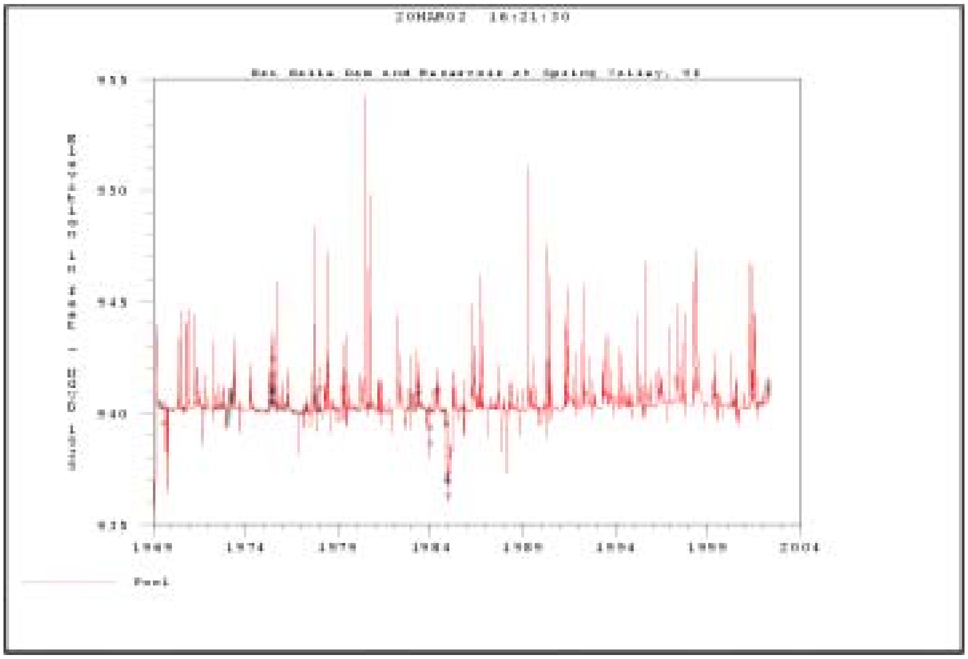


Figure 8-1. Historic Pool Elevations (0800-hr)

IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. **Corps of Engineers.** The Corps of Engineers is the owner, operator, and regulator of the Eau Galle Dam and Reservoir. The Water Control Section of the Hydraulics and Hydrology Branch, Engineering Division, has direct day-to-day responsibility for the regulation, whereas Construction and Operations (Con-Ops) Division has responsibility for the operation and maintenance of the project. Water Control has responsibility for the daily regulation. In the past, the low flow gate was set to pass 13 cfs with the remainder of any inflow passing over the morning glory spillway. Starting in the spring of 2000, the low flow gate was regulated, from July through September, for the benefit of trout downstream of the dam. The goal was to maintain a water temperature between 65 and 68 degrees Fahrenheit at the tailwater gage site. This is now part of the operating plan (**Sections 7-04 and 7-08**).

b. **Other Federal Agencies.** The National Weather Service is responsible for publishing the Quantitative Precipitation Forecast (QPF) daily. The QPF is used to note any significant rainfall events forecasted for the basin. The US Geological Survey (USGS) is responsible for maintaining a record of discharges from the reservoir. The tailwater gage is owned by the Corps of Engineers but the USGS is responsible for its maintenance.

9-02. Interagency Coordination.

a. **Local Press and Corps Bulletins.** The St. Paul District's Public Affairs Office (PAO) provides news releases to the local media of an advisory nature regarding important aspects of project regulation.

b. **National Weather Service.** There is little direct contact with the National Weather Service regarding regulation of Eau Galle Reservoir. The Corps of Engineers provides the pool elevation and the US Geological Survey provides the discharge.

c. **US Geological Survey.** The St. Paul District coordinates with the USGS regarding maintenance of the tailwater gage. Because of the infrastructure the USGS has in existence, it is beneficial for the St. Paul District to enter into a cooperative agreement regarding stream gages throughout the District. The Eau Galle tailwater gage is one of these.

d. **Other Federal, State or Local Agencies.** The Wisconsin Department of Natural Resources is notified when discharges are reduced for maintenance work or periodic inspections.

APENDIX A
SUPPLEMENTAL PERTINENT DATA

General Information

Project Name:	Eau Galle Reservoir and Channel Improvement Eau Galle Lake or Lake George
Location:	Upstream of Spring Valley, Wisconsin Eau Galle River, River Mile 30.3 Latitude 44° 51' 10" Longitude 92° 14' 17"
Type of Project:	Dam and Reservoir
Regulation Objectives:	Primary: Flood Control Secondary: Recreation
Project Owner:	Corps of Engineers
Operating/Regulating Agency:	Corps of Engineers
Cost of Construction:	$9,039,250 as of 1992
Closure Date:	Dam and Reservoir: October 1968 Mines Creek Improvements: October 1964

Hydrology

Drainage Areas:	At Eaul Galle Reservoir:	63.9 square miles
	At Eau Galle River Mouth**:**	230.0 square miles
Probable Maximum Flood:	Peak Inflow:	122,100 cfs
	Peak Outflow:	26,600 cfs
	Peak Pool Elevation:	1036.2 feet (1929)
	Freeboard:	3.95 feet
1-inch Runoff Equals:	3,400 acre-feet	

Discharge from Dam (1969-2001)

Min Daily Flow:	0 cfs	12-16 August 1971
Min Monthly Flow:	8 cfs	August 1969
Min Annual Flow:	22 cfs	1969
Max Monthly Flow:	261 cfs	April 2001
Max Annual Flow:	57 cfs	1980
Average Annual Flow:	36 cfs	
Max Instantaneous Flow:	3,030 cfs	7 June 1980

Data Recorded at Site:	Pool and Tailwater Elevations Low Flow Gate Setting Discharge Through Low Flow Discharge Over Morning Glory Total Discharge Wind Speed and Direction Max and Min Air Temperature 24-hour Precipitation Frost Depth Pool Ice Thickness Snow Depth and Snow-Water Equivalent
Snow Survey Sites:	At Dam Only
Sediment Ranges:	12 (in the pool)
Minimum Outflow:	
Normal Conditions:	13 cfs
Drought:	2 cfs

Reservoir Pool

Real Estate Taking Lines	
For Fee Title:	Elevation 949.0 ft (1929), 230 acres Recreation: Additional 332 acres Total Fee Title: 562 acres
For Flowage Easement:	Elevation 1020.0 ft (1929), 519 acres
Outgrant:	Easement for power line servicing facilities at site.
Range of Clearing:	Below Elevation 943.0 feet Total Area: 175 acres Wooded Area: 30 acres
Pool at Conservation Level	
Elevation:	940.0 feet (1929 NGVD)
Area:	150 acres
Length:	3,300 feet
Width:	2,000 feet
Length of Shoreline:	2.5 miles
Maximum Depth:	30 feet
Average Depth:	10.5 feet
Emergency Drawdown:	Low Flow Invert Elevation: 916.5 feet (1929)
Max Non-Damage Flow Rate:	Downstream Channel Capacity: 4,800 cfs Outflow with Pool about elev. 1020 ft: 3,800 cfs

Embankment

Crest Elevation	
Design Crest Elevation:	1038.5 feet (1929)
With Overburden:	1040.25 feet (low point 1040.15 feet)
Maximum Height:	122 feet above Stream Bed
Length:	1,800 feet
Top Width:	20 feet (with gravel road)
Design Flood:	Probable Maximum Flood (PMF)
Freeboard:	3.95 feet
Purpose/Type:	Impoundment/ Rolled Earth, Non-Overflow
Type of Fill:	Zoned Embankment; Central Clay Core Outer Shell Upstream: Sand and Gravel Outer Shell Downstream: Random Fill
Side Slopes:	Above Elevation 1033.5 ft: 1V:2H Below Elevation 1033.5 ft: 1V:2.5H Upstream Protection: 27 to 60-inch thick Rock Fill Downstream Protection: 12-inch Rip Rap
Toe Drain:	15-inch CMP

Emergency Spillway

Location:	Cut through rock 650 ft west of embankment.
Type:	Uncontrolled; Concrete Sill at Crest Unlined Chute in Rock
Crest Elevation:	1019.53 feet (1929)
Width:	100 feet
Side Slopes:	Vertical to Elevation 1053.0 feet
Length:	1,900 feet
Maximum Discharge:	25,000 cfs for PMF; Pool at 1036.2 feet
Channel Bottom Slope:	0.3 Percent

Morning Glory Spillway

Description:	Circular Concrete with Ogee Crest and Steel Trash Rack
Diameter	
Crest:	25 feet
Throat:	18 feet 3.5 inches
Crest Elevation:	940.0 feet (1929)
Invert Elevations	
At Inlet:	916.5 feet (1929)
At Outlet:	915.0 feet (1929)
Conduit Shape and Size:	Horseshoe Shape – 9 feet 3 inch Steel Lined Concrete
Conduit Length	
Length of Transition:	60 feet
Length of Horseshoe:	640 feet
Low Flow Conduit	
Enters Transition At:	45 Degree Angle
Approximate Length:	20 feet
Type and Diameter:	Circular Steel; 48-inch
Invert Elevation:	916.5 feet
Primary Control:	4-foot Slide Gate
Secondary Control:	Stop Logs
Top of Control Tower:	Elevation 943.0 feet (1929)
Stilling Basin	
Overall Length:	150 feet
Inlet Invert:	915.0 feet (1929)
Floor Invert:	901.0 feet (1929)
D/S Channel Invert:	911.5 feet (1929)
Floor Length:	66 feet
Baffle Blocks:	2 – Rows; 4-feet high and 4-feet wide
End Sill Elevation:	903.7 feet (1929)
Training Wall Elevations	
At Inlet:	934.0 feet (1929)
At Floor:	926.5 feet (1929)
Downstream:	921.7 feet (1929)

APPENDIX B

Design Wave Height and Wave Runup Analysis

From the Climatic Atlas of the United States (US Department of Commerce, June 1968), the fastest mile wind speed at LaCrosse, Wisconsin, out of the north north-west, is 60 mph. The fetch length along this route is approximately 4,000 feet. For this fetch length and wind speed, the wind speed duration necessary for seas to be fetch limited is around 15-minutes. Using the method outlined in the Shore Protection Manual (Corps of Engineers, Coastal Engineering Research Center, 1984), the fastest mile wind speed converts to a 15-minute duration wind speed of 50.7 mph. Based on wind speed (U), the wind stress factor (U_A) for determining wave heights is computed from: U_A=0.589 $U^{1.23}$. The resulting wind stress factor is 73.6 mph. The following equation for determining deep-water wave heights was developed from the JONSWAP experiment (Hasselmann et al. 1973): $H = [0.0016\ F^{0.5}\ U_A] / [g^{0.5}]$, where H is wave height (ft), F is fetch length (ft), and U_A is the wind stress factor (ft/sec). The resulting wave height is 1.9 feet. The following empirical equation for wave runup was developed by the Corps of Engineers as part of a Section 22 Study (USACE 1989) on the Lake Superior shoreline:

$$R = [H_O\ 0.967 \tan \alpha] / [(H_O / L_O)^{0.5}]$$

R = wave runup (ft)
H_O = wave height (ft)
L_O = wavelength (ft)
α = shoreline slope (degrees)

The shoreline slope at this pool elevation is 1V:2H (Chapter II, paragraph 2-03.a). Wavelength for deep-water can be determined from: $L_O = gT^2/2\pi$, where T is the wave period which can be determined from the equation developed from the JONSWAP experiment: $T = [F^{0.33}\ U_A^{0.33}] / [3.5\ g^{0.67}]$. The resulting wave period and wavelength is 2.0 seconds and 20.9 feet respectively. Therefore, wave runup is 3.0 feet. Neglecting wind setup, the required freeboard for wave action is 3.0 feet. Freeboard available is 3.9 feet (1040.1 – 1036.2).

APPENDIX B

Morning Glory and Outlet Conduit Rating

Crest Control $Q/D_{rc}^{5/2} = 4.14\ (L/D_{rc})\ [H/D_{rc} - 0.038]^{3/2}$

Where, D_{rc} = effective diameter of crest (22.3 ft)
L = crest length (70.0 ft – 10.0 ft = 60.0 ft)
H = head on crest

H = 0.5 ft	Q = 11 cfs*	H = 3.0 ft	Q = 784 cfs
H = 1.5 ft	Q = 131 cfs	H = 4.0 ft	Q = 1390 cfs
H = 2.0 ft	Q = 307 cfs	H = 4.5 ft	Q = 1734 cfs

* Based on USGS measurement minus the computed low flow.

Outlet Control $Q = A\ [2gH/K]^{1/2}$

Where, A = Cross-Sectional Area of Conduit
H = Differential Head
K = Total Loss Coefficient

$K_{\text{Friction Loss}} = K_f = (29.1\ n^2\ L) / R^{4/3}$
$K_{\text{Unlined}} = [29.1\ (0.0125)^2\ 688] / (2.475)^{4/3} = 0.93$
$K_{\text{Lined}} = [29.1\ (0.0107)^2\ 688] / (2.31)^{4/3} = 0.75$

$K_{\text{Total}} = K_{\text{Trash Struure}} + K_{\text{Intake Loss}} + K_{\text{Bend Loss}} + K_{\text{Transtion Loss}} + K_{\text{Friction Loss}} + K_{\text{Exit Loss}}$
$K_{\text{Unlined}} = 0.02 + 0.10 + 0.10 + 0.05 + 0.93 + 1.0 = 2.20$
$K_{\text{Lined}} = 0.02 + 0.10 + 0.10 + 0.05 + 0.75 + 1.0 = 2.02$

Head (feet)	Pool Elev. (feet)	Diff Head (feet)	Lined Discharge (cfs)	Unlined Discharge (cfs)
H = 5	Pool = 945	DH = 25	Q = 1900	Q = 2130
H = 10	Pool = 950	DH = 30	Q = 2080	Q = 2340
H = 15	Pool = 955	DH = 35	Q = 2245	Q = 2525
H = 20	Pool = 960	DH = 40	Q = 2400	Q = 2700
H = 30	Pool = 970	DH = 50	Q = 2680	Q = 3020
H = 40	Pool = 980	DH = 60	Q = 2940	Q = 3305
H = 50	Pool = 990	DH = 70	Q = 3175	Q = 3570
H = 60	Pool = 1000	DH = 80	Q = 3400	Q = 3820
H = 70	Pool = 1010	DH = 90	Q = 3600	Q = 4050
H = 80	Pool = 1020	DH = 100	Q = 3800	Q = 4270

Table C-1 Eau Galle Reservoir Stage/Storage Table									
Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
911.0	1	915.0	41	919.0	121	923.0	224	927.0	369
911.1	1	915.1	43	919.1	124	923.1	227	927.1	374
911.2	2	915.2	44	919.2	126	923.2	230	927.2	378
911.3	2	915.3	46	919.3	128	923.3	233	927.3	383
911.4	3	915.4	48	919.4	130	923.4	236	927.4	388
911.5	3	915.5	49	919.5	133	923.5	238	927.5	392
911.6	3	915.6	51	919.6	135	923.6	241	927.6	397
911.7	4	915.7	53	919.7	137	923.7	244	927.7	402
911.8	4	915.8	55	919.8	139	923.8	247	927.8	407
911.9	5	915.9	56	919.9	142	923.9	250	927.9	411
912.0	5	916.0	58	920.0	144	924.0	253	928.0	416
912.1	6	916.1	60	920.1	147	924.1	256	928.1	422
912.2	7	916.2	62	920.2	149	924.2	260	928.2	429
912.3	7	916.3	64	920.3	152	924.3	263	928.3	435
912.4	8	916.4	66	920.4	154	924.4	267	928.4	442
912.5	9	916.5	68	920.5	157	924.5	270	928.5	448
912.6	10	916.6	70	920.6	159	924.6	274	928.6	454
912.7	11	916.7	72	920.7	162	924.7	277	928.7	461
912.8	11	916.8	74	920.8	164	924.8	281	928.8	467
912.9	12	916.9	76	920.9	167	924.9	284	928.9	474
913.0	13	917.0	78	921.0	169	925.0	287	929.0	480
913.1	14	917.1	81	921.1	172	925.1	291	929.1	486
913.2	15	917.2	83	921.2	175	925.2	294	929.2	493
913.3	17	917.3	85	921.3	177	925.3	298	929.3	499
913.4	18	917.4	87	921.4	180	925.4	301	929.4	506
913.5	19	917.5	89	921.5	182	925.5	305	929.5	512
913.6	20	917.6	91	921.6	185	925.6	308	929.6	518
913.7	21	917.7	93	921.7	187	925.7	312	929.7	525
913.8	23	917.8	95	921.8	190	925.8	315	929.8	531
913.9	24	917.9	97	921.9	192	925.9	319	929.9	538
914.0	25	918.0	99	922.0	195	926.0	322	930.0	544
914.1	27	918.1	101	922.1	198	926.1	327	930.1	552
914.2	28	918.2	103	922.2	201	926.2	331	930.2	559
914.3	30	918.3	106	922.3	204	926.3	336	930.3	567
914.4	31	918.4	108	922.4	207	926.4	341	930.4	575
914.5	33	918.5	110	922.5	209	926.5	345	930.5	582
914.6	35	918.6	112	922.6	212	926.6	350	930.6	590
914.7	36	918.7	115	922.7	215	926.7	355	930.7	598
914.8	38	918.8	117	922.8	218	926.8	360	930.8	606
914.9	39	918.9	119	922.9	221	926.9	364	930.9	613

Table C-2 Eau Galle Reservoir Stage/Storage Table									
Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
931.0	621	935.0	961	939.0	1,386	943.0	2,150	947.0	3,150
931.1	629	935.1	971	939.1	1,398	943.1	2,170	947.1	3,180
931.2	636	935.2	980	939.2	1,410	943.2	2,190	947.2	3,210
931.3	644	935.3	990	939.3	1,422	943.3	2,210	947.3	3,240
931.4	652	935.4	999	939.4	1,434	943.4	2,230	947.4	3,270
931.5	659	935.5	1,008	939.5	1,480	943.5	2,250	947.5	3,300
931.6	667	935.6	1,018	939.6	1,494	943.6	2,270	947.6	3,330
931.7	675	935.7	1,027	939.7	1,508	943.7	2,290	947.7	3,360
931.8	683	935.8	1,036	939.8	1,522	943.8	2,310	947.8	3,390
931.9	690	935.9	1,046	939.9	1,494	943.9	2,330	947.9	3,420
932.0	698	936.0	1,055	940.0	1,536	944.0	2,350	948.0	3,450
932.1	706	936.1	1,066	940.1	1,550	944.1	2,370	948.1	3,480
932.2	715	936.2	1,076	940.2	1,570	944.2	2,390	948.2	3,510
932.3	723	936.3	1,087	940.3	1,590	944.3	2,410	948.3	3,540
932.4	732	936.4	1,097	940.4	1,610	944.4	2,430	948.4	3,570
932.5	740	936.5	1,108	940.5	1,630	944.5	2,450	948.5	3,600
932.6	749	936.6	1,119	940.6	1,650	944.6	2,470	948.6	3,630
932.7	757	936.7	1,129	940.7	1,670	944.7	2,490	948.7	3,660
932.8	766	936.8	1,140	940.8	1,710	944.8	2,510	948.8	3,690
932.9	774	936.9	1,150	940.9	1,730	944.9	2,530	948.9	3,720
933.0	783	937.0	1,161	941.0	1,750	945.0	2,550	949.0	3,750
933.1	791	937.1	1,172	941.1	1,770	945.1	2,580	949.1	3,780
933.2	800	937.2	1,182	941.2	1,790	945.2	2,610	949.2	3,810
933.3	808	937.3	1,193	941.3	1,810	945.3	2,640	949.3	3,840
933.4	817	937.4	1,203	941.4	1,830	945.4	2,670	949.4	3,870
933.5	825	937.5	1,214	941.5	1,850	945.5	2,700	949.5	3,900
933.6	834	937.6	1,225	941.6	1,870	945.6	2,730	949.6	3,930
933.7	842	937.7	1,235	941.7	1,890	945.7	2,760	949.7	3,960
933.8	851	937.8	1,246	941.8	1,910	945.8	2,790	949.8	3,990
933.9	859	937.9	1,256	941.9	1,930	945.9	2,820	949.9	4,020
934.0	868	938.0	1,267	942.0	1,950	946.0	2,850	950.0	4,050
934.1	877	938.1	1,279	942.1	1,970	946.1	2,880	950.1	4,080
934.2	887	938.2	1,291	942.2	1,990	946.2	2,910	950.2	4,110
934.3	896	938.3	1,303	942.3	2,010	946.3	2,940	950.3	4,140
934.4	905	938.4	1,315	942.4	2,030	946.4	2,970	950.4	4,170
934.5	915	938.5	1,327	942.5	2,050	946.5	3,000	950.5	4,200
934.6	924	938.6	1,339	942.6	2,070	946.6	3,030	950.6	4,230
934.7	933	938.7	1,351	942.7	2,090	946.7	3,060	950.7	4,260
934.8	943	938.8	1,363	942.8	2,110	946.8	3,090	950.8	4,290
934.9	952	938.9	1375	942.9	2,130	946.9	3,120	950.9	4,320

Table C-3 Eau Galle Reservoir Stage/Storage Table									
Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
951.0	4,350	955.0	5,550	959.0	6,750	963.0	8,250	967.0	9,850
951.1	4,380	955.1	5,580	959.1	6,780	963.1	8,290	967.1	9,890
951.2	4,410	955.2	5,610	959.2	6,810	963.2	8,330	967.2	9,930
951.3	4,440	955.3	5,640	959.3	6,840	963.3	8,370	967.3	9,970
951.4	4,470	955.4	5,670	959.4	6,870	963.4	8,410	967.4	10,010
951.5	4,500	955.5	5,700	959.5	6,900	963.5	8,450	967.5	10,050
951.6	4,530	955.6	5,730	959.6	6,930	963.6	8,490	967.6	10,090
951.7	4,560	955.7	5,760	959.7	6,960	963.7	8,530	967.7	10,130
951.8	4,590	955.8	5,790	959.8	6,990	963.8	8,570	967.8	10,170
951.9	4,620	955.9	5,820	959.9	7,020	963.9	8,610	967.9	10,210
952.0	4,650	956.0	5,850	960.0	7,050	964.0	8,650	968.0	10,250
952.1	4,680	956.1	5,880	960.1	7,090	964.1	8,690	968.1	10,290
952.2	4,710	956.2	5,910	960.2	7,130	964.2	8,730	968.2	10,330
952.3	4,740	956.3	5,940	960.3	7,170	964.3	8,770	968.3	10,370
952.4	4,770	956.4	5,970	960.4	7,210	964.4	8,810	968.4	10,410
952.5	4,800	956.5	6,000	960.5	7,250	964.5	8,850	968.5	10,450
952.6	4,830	956.6	6,030	960.6	7,290	964.6	8,890	968.6	10,490
952.7	4,860	956.7	6,060	960.7	7,330	964.7	8,930	968.7	10,530
952.8	4,890	956.8	6,090	960.8	7,370	964.8	8,970	968.8	10,570
952.9	4,920	956.9	6,120	960.9	7,410	964.9	9,010	968.9	10,610
953.0	4,950	957.0	6,150	961.0	7,450	965.0	9,050	969.0	10,650
953.1	4,980	957.1	6,180	961.1	7,490	965.1	9,090	969.1	10,690
953.2	5,010	957.2	6,210	961.2	7,530	965.2	9,130	969.2	10,730
953.3	5,040	957.3	6,240	961.3	7,570	965.3	9,170	969.3	10,770
953.4	5,070	957.4	6,270	961.4	7,610	965.4	9,210	969.4	10,810
953.5	5,100	957.5	6,300	961.5	7,650	965.5	9,250	969.5	10,850
953.6	5,130	957.6	6,330	961.6	7,690	965.6	9,290	969.6	10,890
953.7	5,160	957.7	6,360	961.7	7,730	965.7	9,330	969.7	10,930
953.8	5,190	957.8	6,390	961.8	7,770	965.8	9,370	969.8	10,970
953.9	5,220	957.9	6,420	961.9	7,810	965.9	9,410	969.9	11,010
954.0	5,250	958.0	6,450	962.0	7,850	966.0	9,450	970.0	11,050
954.1	5,280	958.1	6,480	962.1	7,890	966.1	9,490	970.1	11,100
954.2	5,310	958.2	6,510	962.2	7,930	966.2	9,530	970.2	11,150
954.3	5,340	958.3	6,540	962.3	7,970	966.3	9,570	970.3	11,200
954.4	5,370	958.4	6,570	962.4	8,010	966.4	9,610	970.4	11,250
954.5	5,400	958.5	6,600	962.5	8,050	966.5	9,650	970.5	11,300
954.6	5,430	958.6	6,630	962.6	8,090	966.6	9,690	970.6	11,350
954.7	5,460	958.7	6,660	962.7	8,130	966.7	9,730	970.7	11,400
954.8	5,490	958.8	6,690	962.8	8,170	966.8	9,770	970.8	11,450
954.9	5,520	958.9	6,720	962.9	8,210	966.9	9,810	970.9	11,500

Table C-4 Eau Galle Reservoir Stage/Storage Table									
Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
971.0	11,550	975.0	13,550	979.0	15,550	983.0	17,550	987.0	19,819
971.1	11,600	975.1	13,600	979.1	15,600	983.1	17,600	987.1	19,882
971.2	11,650	975.2	13,650	979.2	15,650	983.2	17,650	987.2	19,946
971.3	11,700	975.3	13,700	979.3	15,700	983.3	17,700	987.3	20,009
971.4	11,750	975.4	13,750	979.4	15,750	983.4	17,750	987.4	20,073
971.5	11,800	975.5	13,800	979.5	15,800	983.5	17,800	987.5	20,136
971.6	11,850	975.6	13,850	979.6	15,850	983.6	17,850	987.6	20,199
971.7	11,900	975.7	13,900	979.7	15,900	983.7	17,900	987.7	20,263
971.8	11,950	975.8	13,950	979.8	15,950	983.8	17,950	987.8	20,327
971.9	12,000	975.9	14,000	979.9	16,000	983.9	18,000	987.9	20,390
972.0	12,050	976.0	14,050	980.0	16,050	984.0	18,050	988.0	20,453
972.1	12,100	976.1	14,100	980.1	16,100	984.1	18,100	988.1	20,517
972.2	12,150	976.2	14,150	980.2	16,150	984.2	18,150	988.2	20,580
972.3	12,200	976.3	14,200	980.3	16,200	984.3	18,200	988.3	20,643
972.4	12,250	976.4	14,250	980.4	16,250	984.4	18,250	988.4	20,707
972.5	12,300	976.5	14,300	980.5	16,300	984.5	18,300	988.5	20,770
972.6	12,350	976.6	14,350	980.6	16,350	984.6	18,350	988.6	20,834
972.7	12,400	976.7	14,400	980.7	16,400	984.7	18,400	988.7	20,897
972.8	12,450	976.8	14,450	980.8	16,450	984.8	18,450	988.8	20,961
972.9	12,500	976.9	14,500	980.9	16,500	984.9	18,500	988.9	21,024
973.0	12,550	977.0	14,550	981.0	16,550	985.0	18,550	989.0	21,088
973.1	12,600	977.1	14,600	981.1	16,600	985.1	18,613	989.1	21,151
973.2	12,650	977.2	14,650	981.2	16,650	985.2	18,677	989.2	21,214
973.3	12,700	977.3	14,700	981.3	16,700	985.3	18,740	989.3	21,278
973.4	12,750	977.4	14,750	981.4	16,750	985.4	18,803	989.4	21,341
973.5	12,800	977.5	14,800	981.5	16,800	985.5	18,867	989.5	21,405
973.6	12,850	977.6	14,850	981.6	16,850	985.6	18,930	989.6	21,468
973.7	12,900	977.7	14,900	981.7	16,900	985.7	18,994	989.7	21,532
973.8	12,950	977.8	14,950	981.8	16,950	985.8	19,057	989.8	21,595
973.9	13,000	977.9	15,000	981.9	17,000	985.9	19,120	989.9	21,659
974.0	13,050	978.0	15,050	982.0	17,050	986.0	19,184	990.0	21,722
974.1	13,100	978.1	15,100	982.1	17,100	986.1	19,248	990.1	21,785
974.2	13,150	978.2	15,150	982.2	17,150	986.2	19,311	990.2	21,849
974.3	13,200	978.3	15,200	982.3	17,200	986.3	19,375	990.3	21,912
974.4	13,250	978.4	15,250	982.4	17,250	986.4	19,438	990.4	21,976
974.5	13,300	978.5	15,300	982.5	17,300	986.5	19,502	990.5	22,039
974.6	13,350	978.6	15,350	982.6	17,350	986.6	19,565	990.6	22,103
974.7	13,400	978.7	15,400	982.7	17,400	986.7	19,628	990.7	22,166
974.8	13,450	978.8	15,450	982.8	17,450	986.8	19,692	990.8	22,229
974.9	13,500	978.9	15,500	982.9	17500	986.9	19,755	990.9	22,293

Table C-5 Eau Galle Reservoir Stage/Storage Table									
Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
991.0	22,356	995.0	24,894	999.0	27,431	1003.0	30,100	1007.0	33,100
991.1	22,420	995.1	24,957	999.1	27,495	1003.1	30,170	1007.1	33,180
991.2	22,483	995.2	25,021	999.2	27,558	1003.2	30,240	1007.2	33,260
991.3	22,547	995.3	25,084	999.3	27,622	1003.3	30,310	1007.3	33,340
991.4	22,610	995.4	25,148	999.4	27,685	1003.4	30,380	1007.4	33,420
991.5	22,674	995.5	25,211	999.5	27,749	1003.5	30,450	1007.5	33,500
991.6	22,737	995.6	25,275	999.6	27,812	1003.6	30,520	1007.6	33,580
991.7	22,800	995.7	25,338	999.7	27,876	1003.7	30,590	1007.7	33,660
991.8	22,864	995.8	25,401	999.8	27,939	1003.8	30,660	1007.8	33,740
991.9	22,927	995.9	25,465	999.9	28,002	1003.9	30,730	1007.9	33,820
992.0	22,991	996.0	25,528	1000.0	28,066	1004.0	30,800	1008.0	33,900
992.1	23,054	996.1	25,592	1000.1	28,129	1004.1	30,870	1008.1	33,980
992.2	23,118	996.2	25,655	1000.2	28,193	1004.2	30,940	1008.2	34,060
992.3	23,181	996.3	25,719	1000.3	28,256	1004.3	31,010	1008.3	34,140
992.4	23,244	996.4	25,782	1000.4	28,320	1004.4	31,080	1008.4	34,220
992.5	23,308	996.5	25,845	1000.5	28,383	1004.5	31,150	1008.5	34,300
992.6	23,371	996.6	25,909	1000.6	28,446	1004.6	31,220	1008.6	34,380
992.7	23,435	996.7	25,972	1000.7	28,510	1004.7	31,290	1008.7	34,460
992.8	23,498	996.8	26,036	1000.8	28,573	1004.8	31,360	1008.8	34,540
992.9	23,562	996.9	26,099	1000.9	28,637	1004.9	31,430	1008.9	34,620
993.0	23,625	997.0	26,163	1001.0	28,700	1005.0	31,500	1009.0	34,700
993.1	23,689	997.1	26,226	1001.1	28,770	1005.1	31,580	1009.1	34,780
993.2	23,752	997.2	26,290	1001.2	28,840	1005.2	31,660	1009.2	34,860
993.3	23,815	997.3	26,353	1001.3	28,910	1005.3	31,740	1009.3	34,940
993.4	23,879	997.4	26,416	1001.4	28,980	1005.4	31,820	1009.4	35,020
993.5	23,942	997.5	26,480	1001.5	29,050	1005.5	31,900	1009.5	35,100
993.6	24,006	997.6	26,543	1001.6	29,120	1005.6	31,980	1009.6	35,180
993.7	24,069	997.7	26,607	1001.7	29,190	1005.7	32,060	1009.7	35,260
993.8	24,133	997.8	26,670	1001.8	29,260	1005.8	32,140	1009.8	35,340
993.9	24,196	997.9	26,734	1001.9	29,330	1005.9	32,220	1009.9	35,420
994.0	24,260	998.0	26,797	1002.0	29,400	1006.0	32,300	1010.0	35,500
994.1	24,323	998.1	26,861	1002.1	29,470	1006.1	32,380	1010.1	35,580
994.2	24,386	998.2	26,924	1002.2	29,540	1006.2	32,460	1010.2	35,660
994.3	24,450	998.3	26,987	1002.3	29,610	1006.3	32,540	1010.3	35,740
994.4	24,513	998.4	27,051	1002.4	29,680	1006.4	32,620	1010.4	35,820
994.5	24,577	998.5	27,114	1002.5	29,750	1006.5	32,700	1010.5	35,900
994.6	24,640	998.6	27,178	1002.6	29,820	1006.6	32,780	1010.6	35,980
994.7	24,704	998.7	27,235	1002.7	29,890	1006.7	32,860	1010.7	36,060
994.8	24,767	998.8	27,305	1002.8	29,960	1006.8	32,940	1010.8	36,140
994.9	24,830	998.9	27,368	1002.9	30,030	1006.9	33,020	1010.9	36,220

Table C-6
Eau Galle Reservoir
Stage/Storage Table

Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
1011.0	36,300	1015.0	39,500	1019.0	43,100	1023.0	47,000	1027.0	50,800
1011.1	36,380	1015.1	39,590	1019.1	43,190	1023.1	47,100	1027.1	50,890
1011.2	36,460	1015.2	39,680	1019.2	43,280	1023.2	47,200	1027.2	50,980
1011.3	36,540	1015.3	39,770	1019.3	43,370	1023.3	47,300	1027.3	51,070
1011.4	36,620	1015.4	39,860	1019.4	43,460	1023.4	47,400	1027.4	51,160
1011.5	36,700	1015.5	39,950	1019.5	43,550	1023.5	47,500	1027.5	51,250
1011.6	36,780	1015.6	40,040	1019.6	43,640	1023.6	47,600	1027.6	51,340
1011.7	36,860	1015.7	40,130	1019.7	43,730	1023.7	47,700	1027.7	51,430
1011.8	36,940	1015.8	40,220	1019.8	43,820	1023.8	47,800	1027.8	51,520
1011.9	37,020	1015.9	40,310	1019.9	43,910	1023.9	47,900	1027.9	51,610
1012.0	37,100	1016.0	40,400	1020.0	44,000	1024.0	48,000	1028.0	51,700
1012.1	37,180	1016.1	40,490	1020.1	44,100	1024.1	48,100	1028.1	51,790
1012.2	37,260	1016.2	40,580	1020.2	44,200	1024.2	48,200	1028.2	51,880
1012.3	37,340	1016.3	40,670	1020.3	44,300	1024.3	48,300	1028.3	51,970
1012.4	37,420	1016.4	40,760	1020.4	44,400	1024.4	48,400	1028.4	52,060
1012.5	37,500	1016.5	40,850	1020.5	44,500	1024.5	48,500	1028.5	52,150
1012.6	37,580	1016.6	40,940	1020.6	44,600	1024.6	48,600	1028.6	52,240
1012.7	37,660	1016.7	41,030	1020.7	44,700	1024.7	48,700	1028.7	52,330
1012.8	37,740	1016.8	41,120	1020.8	44,800	1024.8	48,800	1028.8	52,420
1012.9	37,820	1016.9	41,210	1020.9	44,900	1024.9	48,900	1028.9	52,510
1013.0	37,900	1017.0	41,300	1021.0	45,000	1025.0	49,000	1029.0	52,600
1013.1	37,980	1017.1	41,390	1021.1	45,100	1025.1	49,090	1029.1	52,690
1013.2	38,060	1017.2	41,480	1021.2	45,200	1025.2	49,180	1029.2	52,780
1013.3	38,140	1017.3	41,570	1021.3	45,300	1025.3	49,270	1029.3	52,870
1013.4	38,220	1017.4	41,660	1021.4	45,400	1025.4	49,360	1029.4	52,960
1013.5	38,300	1017.5	41,750	1021.5	45,500	1025.5	49,450	1029.5	53,050
1013.6	38,380	1017.6	41,840	1021.6	45,600	1025.6	49,540	1029.6	53,140
1013.7	38,460	1017.7	41,930	1021.7	45,700	1025.7	49,630	1029.7	53,230
1013.8	38,540	1017.8	42,020	1021.8	45,800	1025.8	49,720	1029.8	53,320
1013.9	38,620	1017.9	42,110	1021.9	45,900	1025.9	49,810	1029.9	53,410
1014.0	38,700	1018.0	42,200	1022.0	46,000	1026.0	49,900	1030.0	53,500
1014.1	38,780	1018.1	42,290	1022.1	46,100	1026.1	49,990	1030.1	53,600
1014.2	38,860	1018.2	42,380	1022.2	46,200	1026.2	50,080	1030.2	53,700
1014.3	38,940	1018.3	42,470	1022.3	46,300	1026.3	50,170	1030.3	53,800
1014.4	39,020	1018.4	42,560	1022.4	46,400	1026.4	50,260	1030.4	53,900
1014.5	39,100	1018.5	42,650	1022.5	46,500	1026.5	50,350	1030.5	54,000
1014.6	39,180	1018.6	42,740	1022.6	46,600	1026.6	50,440	1030.6	54,100
1014.7	39,260	1018.7	42,830	1022.7	46,700	1026.7	50,530	1030.7	54,200
1014.8	39,340	1018.8	42,920	1022.8	46,800	1026.8	50,620	1030.8	54,300
1014.9	39,420	1018.9	43,010	1022.9	46,900	1026.9	50,710	1030.9	54,400

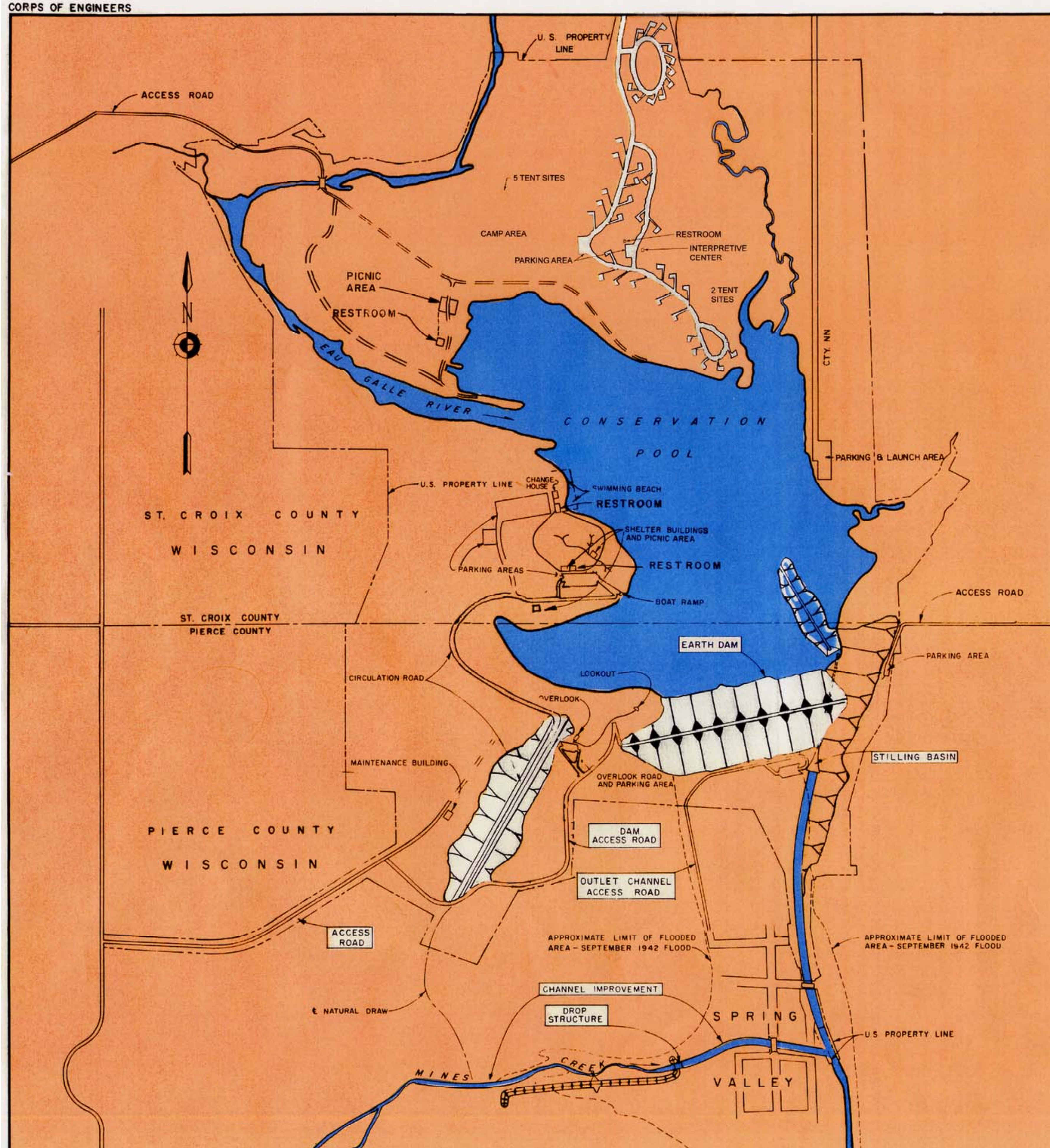
Table C-7 Eau Galle Reservoir Stage/Storage Table									
Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft	Pool	Ac-Ft
1031.0	54,500	1035.0	58,500	1039.0	62,500	1043.0	66,500		
1031.1	54,600	1035.1	58,600	1039.1	62,600				
1031.2	54,700	1035.2	58,700	1039.2	62,700				
1031.3	54,800	1035.3	58,800	1039.3	62,800				
1031.4	54,900	1035.4	58,900	1039.4	62,900				
1031.5	55,000	1035.5	59,000	1039.5	63,000				
1031.6	55,100	1035.6	59,100	1039.6	63,100				
1031.7	55,200	1035.7	59,200	1039.7	63,200				
1031.8	55,300	1035.8	59,300	1039.8	63,300				
1031.9	55,400	1035.9	59,400	1039.9	63,400				
1032.0	55,500	1036.0	59,500	1040.0	63,500				
1032.1	55,600	1036.1	59,600	1040.1	63,600				
1032.2	55,700	1036.2	59,700	1040.2	63,700				
1032.3	55,800	1036.3	59,800	1040.3	63,800				
1032.4	55,900	1036.4	59,900	1040.4	63,900				
1032.5	56,000	1036.5	60,000	1040.5	64,000				
1032.6	56,100	1036.6	60,100	1040.6	64,100				
1032.7	56,200	1036.7	60,200	1040.7	64,200				
1032.8	56,300	1036.8	60,300	1040.8	64,300				
1032.9	56,400	1036.9	60,400	1040.9	64,400				
1033.0	56,500	1037.0	60,500	1041.0	64,500				
1033.1	56,600	1037.1	60,600	1041.1	64,600				
1033.2	56,700	1037.2	60,700	1041.2	64,700				
1033.3	56,800	1037.3	60,800	1041.3	64,800				
1033.4	56,900	1037.4	60,900	1041.4	64,900				
1033.5	57,000	1037.5	61,000	1041.5	65,000				
1033.6	57,100	1037.6	61,100	1041.6	65,100				
1033.7	57,200	1037.7	61,200	1041.7	65,200				
1033.8	57,300	1037.8	61,300	1041.8	65,300				
1033.9	57,400	1037.9	61,400	1041.9	65,400				
1034.0	57,500	1038.0	61,500	1042.0	65,500				
1034.1	57,600	1038.1	61,600	1042.1	65,600				
1034.2	57,700	1038.2	61,700	1042.2	65,700				
1034.3	57,800	1038.3	61,800	1042.3	65,800				
1034.4	57,900	1038.4	61,900	1042.4	65,900				
1034.5	58,000	1038.5	62,000	1042.5	66,000				
1034.6	58,100	1038.6	62,100	1042.6	66,100				
1034.7	58,200	1038.7	62,200	1042.7	66,200				
1034.8	58,300	1038.8	62,300	1042.8	66,300				
1034.9	58,400	1038.9	62,400	1042.9	66,400				

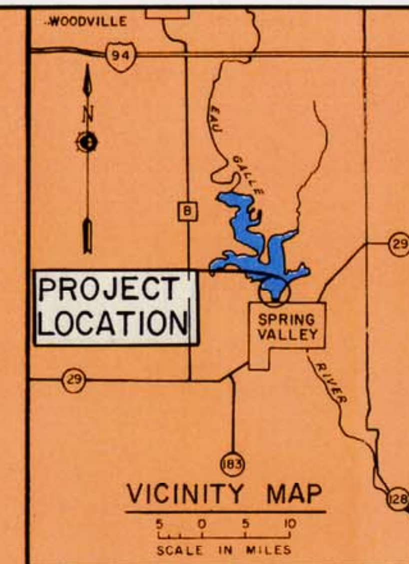
STATION NUMBER 05370000 EAU GALLE RIVER AT SPRING VALLEY, WI STREAM SOURCE AGENCY USGS
LATITUDE 445110 LONGITUDE 0921417 DRAINAGE AREA 64.10 DATUM 900.00 STATE 55 COUNTY 093
GAGE HEIGHT, IN (FEET)
RATING LIST
RATING ID: 22.0 STANDARD RATING TYPE: LOG
LAST UPDATED BY jschuler ON 05-10-2001 @ 09:42:32 REMARKS: Rating extended from 18.0 to 19.0 ft, 05 08 2001

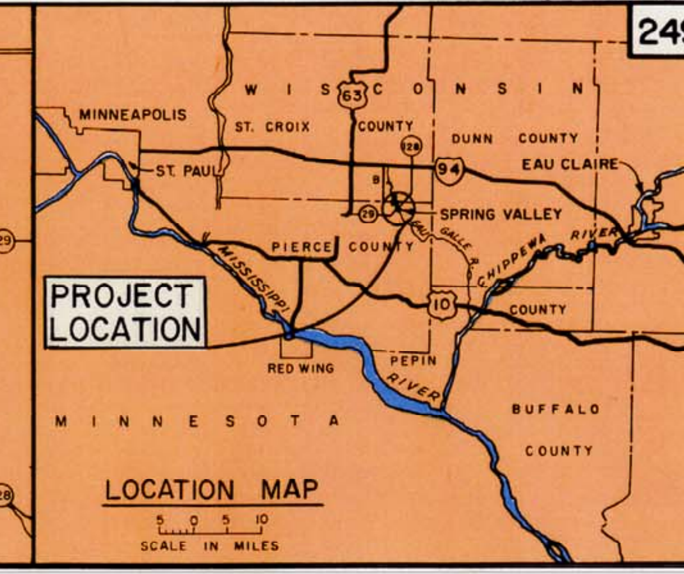
BASED ON _______ DISCHARGE MEASUREMENTS, NOS ________, AND ________, AND IS ______ WELL DEFINED BETWEEN ______ AND ______ CFS
COMP BY _____ DATE ________ CHK. BY _____ DATE ________

RATING VALUE IN	RATING VALUE OUT	RATING VALUE IN	RATING VALUE OUT	RATING VALUE IN	RATING VALUE OUT	RATING VALUE IN	RATING VALUE OUT	RATING VALUE IN	RATING VALUE OUT	RATING VALUE IN	RATING VALUE OUT
11.50	0.004	12.78	3.75	13.37	11.2	13.74	20.4	15.4	430	16.3	880
12.00	0.20	12.84	4.33	13.40	11.6	13.78	22.4	15.5	480	16.4	930
12.11	0.386	12.92	5.18	13.43	12.2	13.90	29.5	15.6	530	16.5	980
12.20	0.55	13.00	6.10	13.48	13.0	13.96	34.0	15.7	580	16.6	1030
12.30	0.86	13.11	7.52	13.50	13.3	14.10	47.0	15.8	630	16.7	1080
12.40	1.25	13.16	8.18	13.56	14.6	14.30	74.0	15.9	680	18.0	1860
12.50	1.73	13.22	9.00	13.60	15.4	14.55	124.0	16.0	730	19.0	2600
12.60	2.33	13.25	9.40	13.64	16.5	15.05	275.0	16.1	780		
12.68	2.90	13.30	10.10	13.68	18.0	15.30	380.0	16.2	830		

RATING START DATE	TIME		LOG OFFSETS			
10-03-2000	16:01	BREAKPOINTS:		13.400		---
		OFFSETS:	11.000		13.000	---







Conservation Pool Elevation	940.0	ft.
Conservation Pool Area	150	ac.
Maximum Pool Elevation (PMF)	1036.2	ft.
Emergency Spillway Crest Elevation	1019.53	ft.
Emergency Spillway Maximum Discharge	25,000	cfs
Conduit Discharge (Pool at 1020.0 ft.)	3,800	cfs

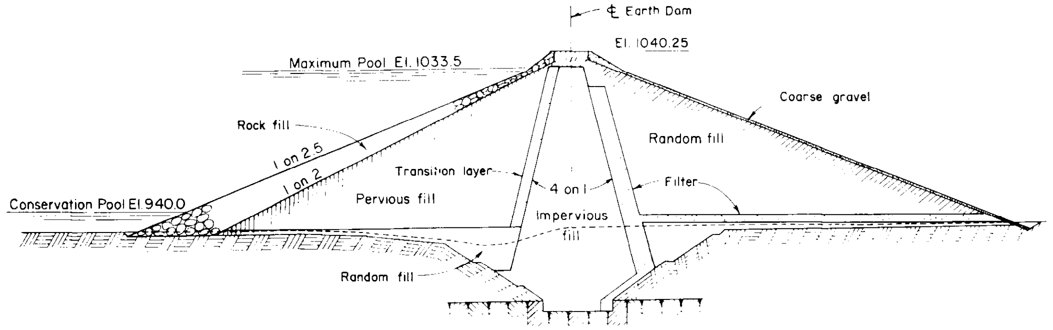
400 200 0 400 800
SCALE IN FEET

Eau Galle Reservoir and
Channel Improvement

Project Location and Plan

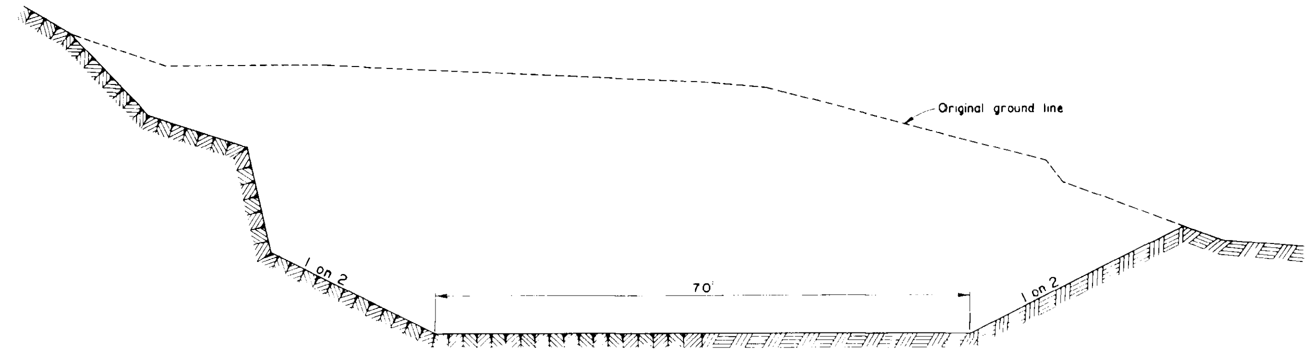
U.S. Army Corps of Engineers
St. Paul District - 30 September 1994

Plate 2-1

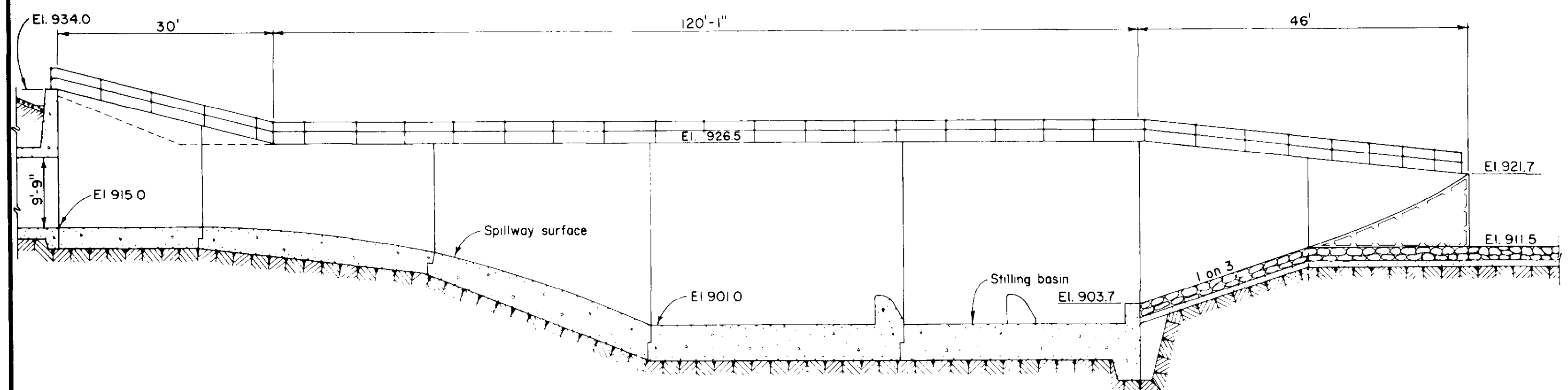


TYPICAL SECTION THROUGH EARTH DAM

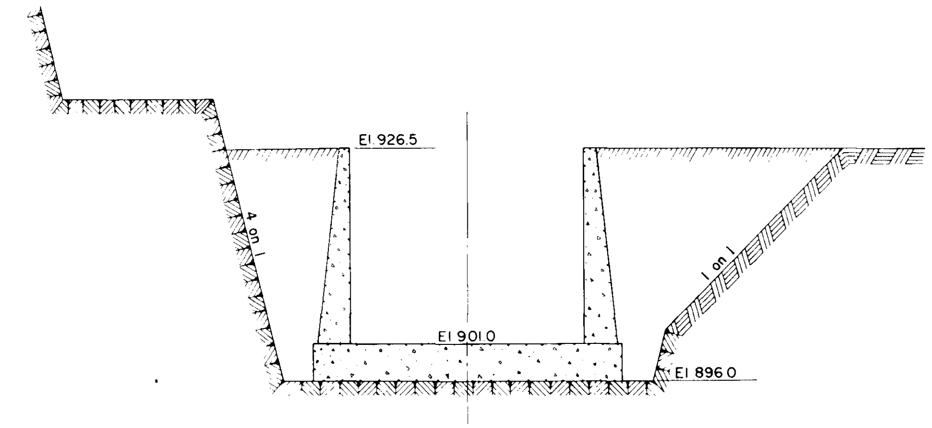
50 0 50 100
SCALE IN FEET



TYPICAL SECTION THROUGH DISCHARGE CHANNEL



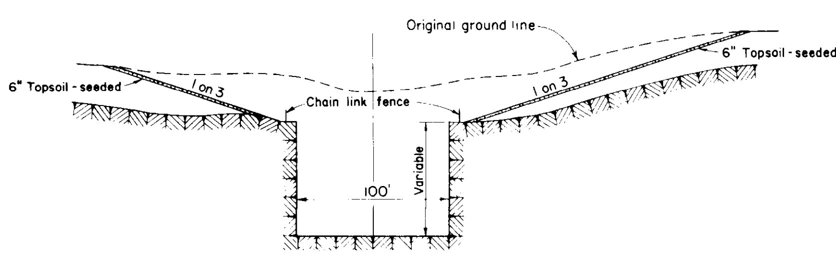
LONGITUDINAL SECTION THROUGH STILLING BASIN AT ℄



SECTION

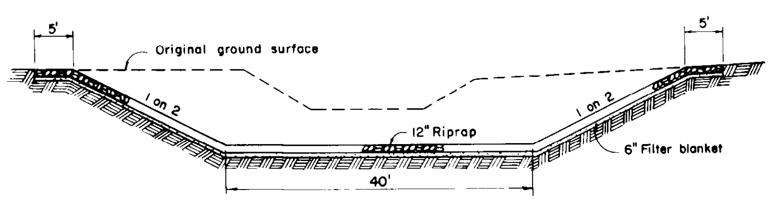
IMPROVEMENTS-EAU GALLE RIVER

10 0 10 20
SCALE IN FEET

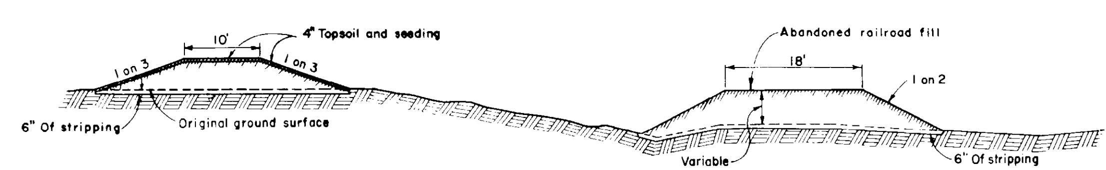


TYPICAL SPILLWAY SECTION

50 0 50 100
SCALE IN FEET



TYPICAL CHANNEL SECTION



TYPICAL SECTION THROUGH LEVEE AND RAILROAD FILL

IMPROVEMENTS-MINES CREEK

10' 5' 0 10' 20'
SCALE IN FEET

NOTE:
ELEVATIONS ARE REFERRED TO M.S.L. (1929 ADJ.)

Eau Galle Reservoir and
Channel Improvement

Typical Project Sections

U.S. Army Corps of Engineers
St. Paul District - 30 September 1977

Plate 2-2

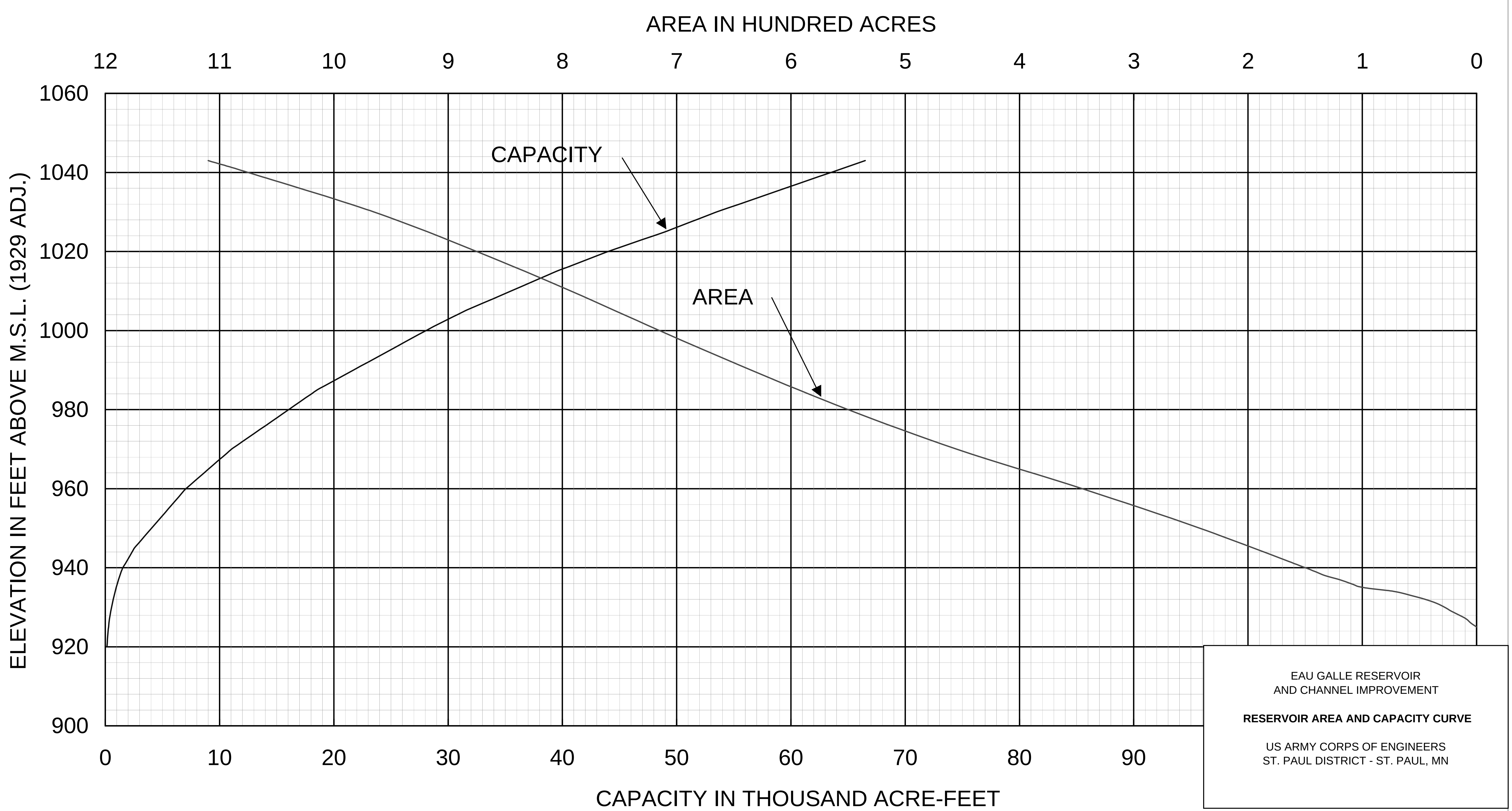
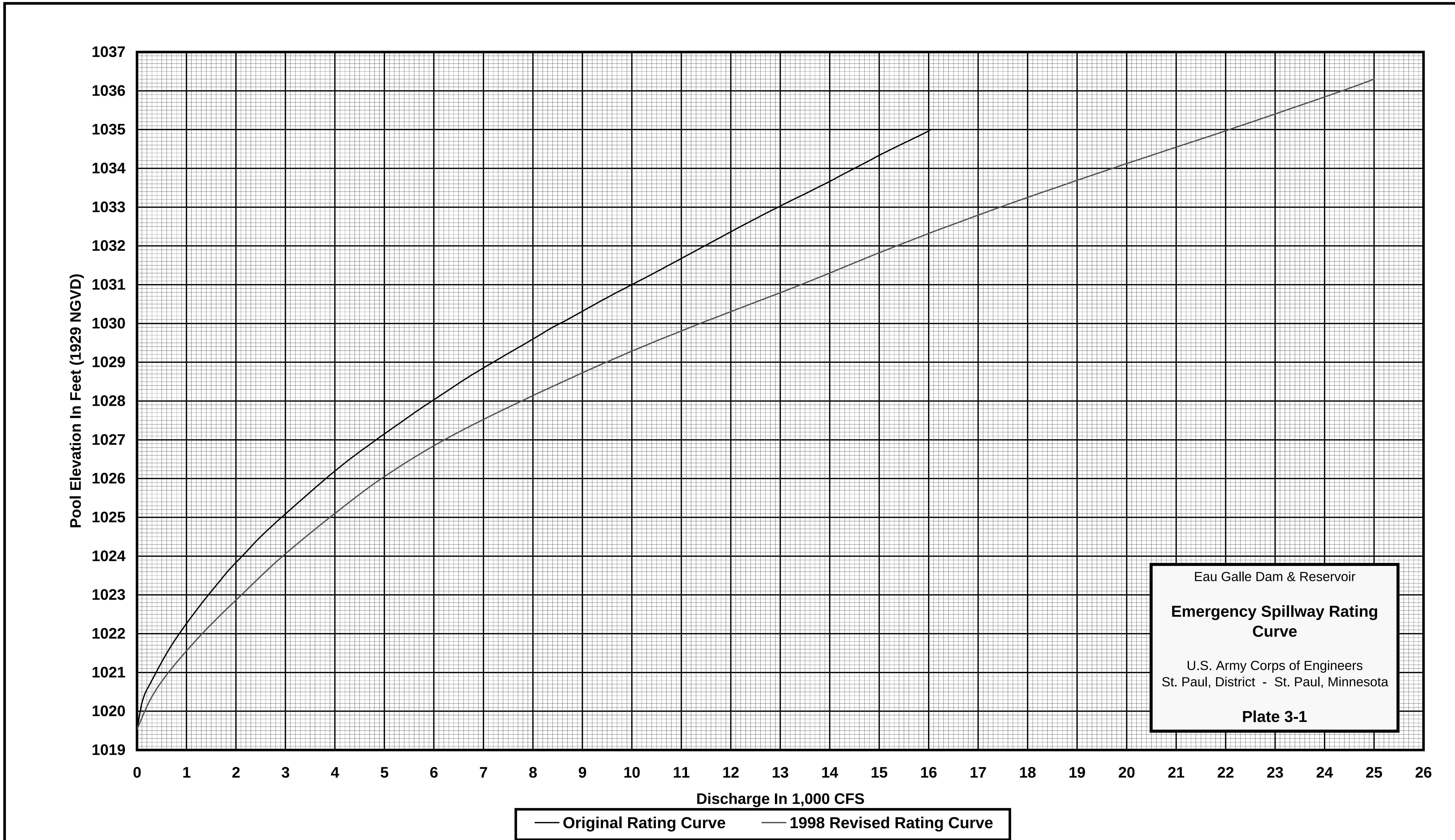
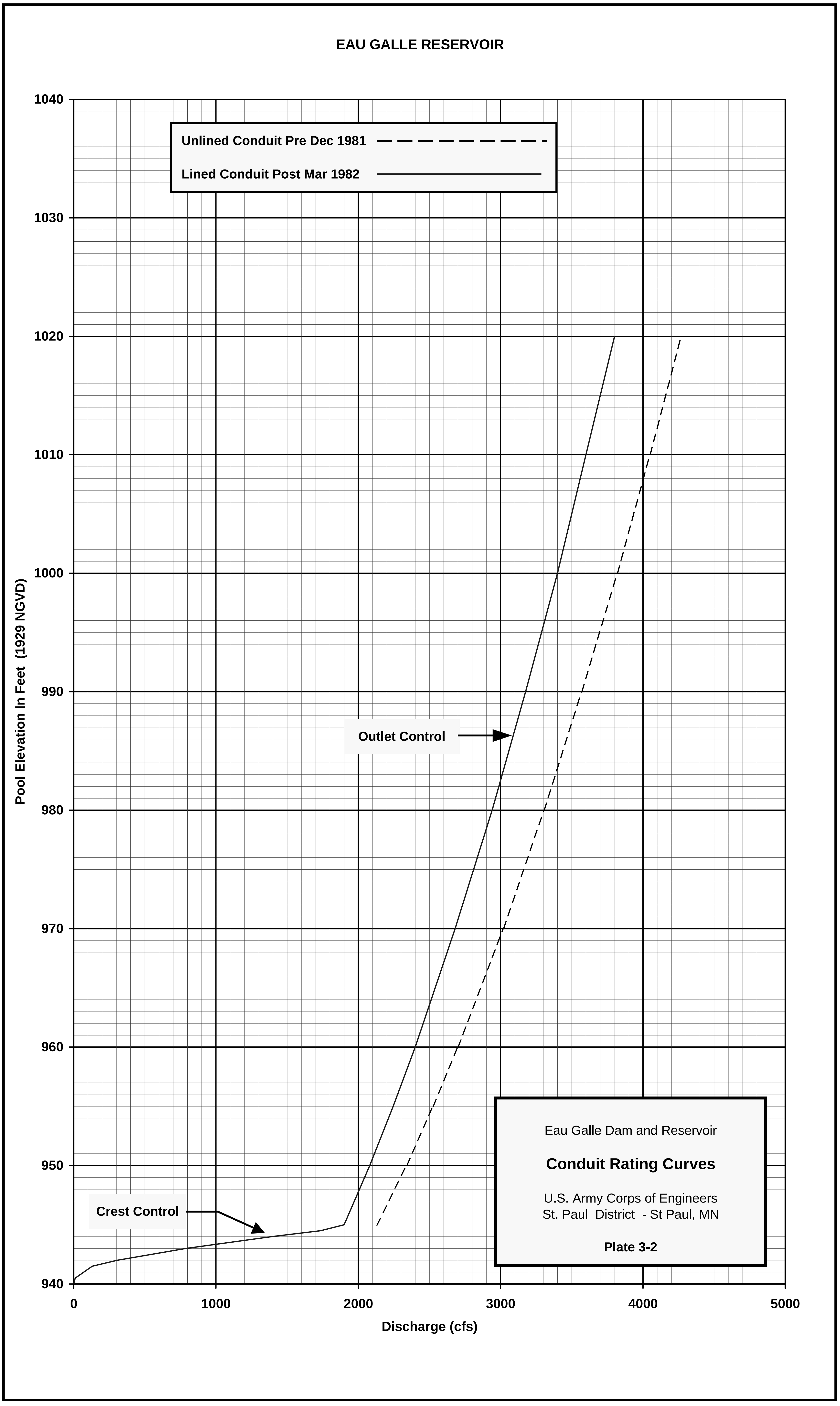
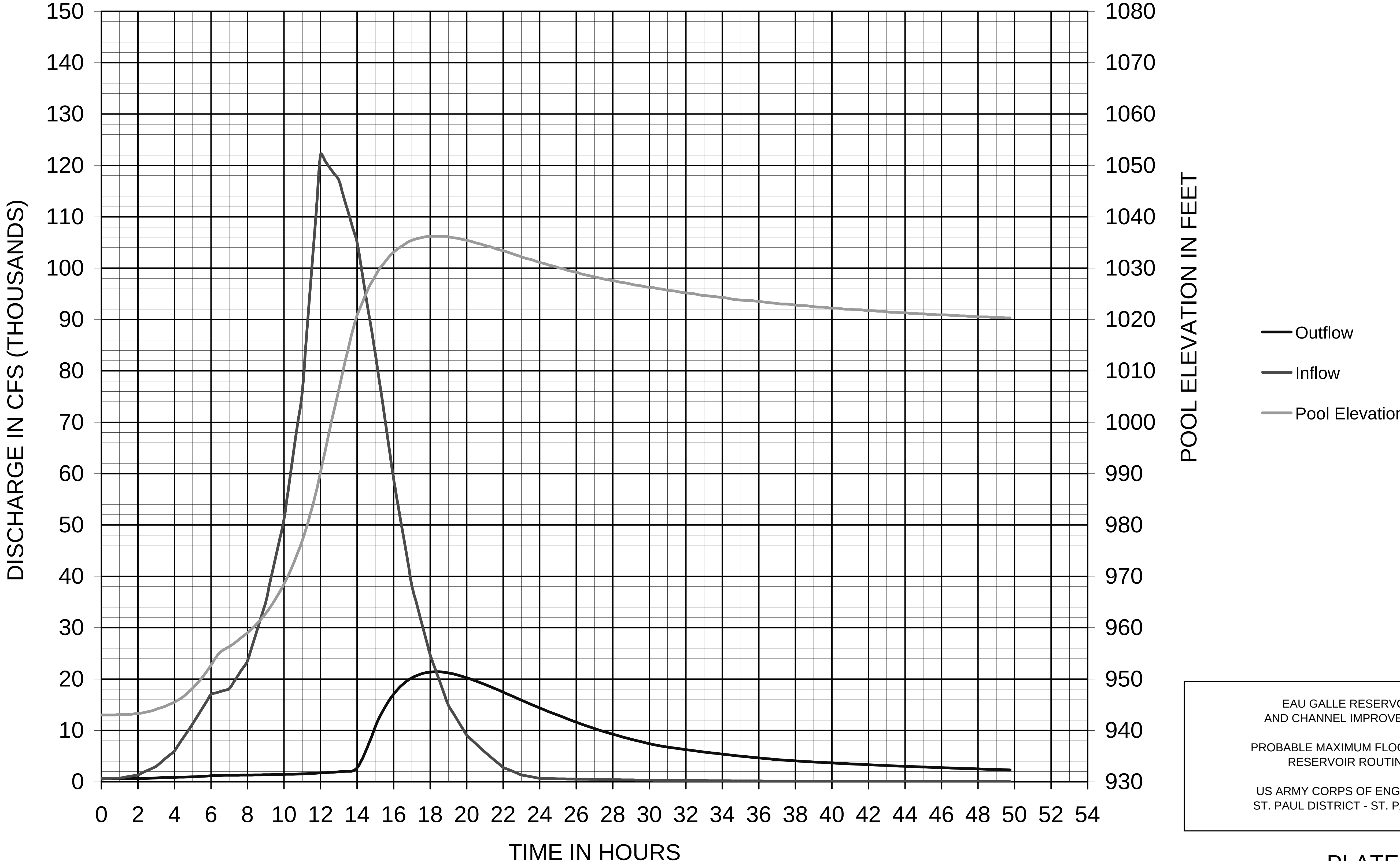

AREA IN HUNDRED ACRES
12 11 10 9 8 7 6 5 4 3 2 1 0
1060 1040 1020 1000 980 960 940 920 900
ELEVATION IN FEET ABOVE M.S.L. (1929 ADJ.)
CAPACITY
AREA
0 10 20 30 40 50 60 70 80 90
CAPACITY IN THOUSAND ACRE-FEET
EAU GALLE RESERVOIR
AND CHANNEL IMPROVEMENT
RESERVOIR AREA AND CAPACITY CURVE
US ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT - ST. PAUL, MN

PLATE 2-3



1037
1036
1035
1034
1033
1032
1031
1030
1029
1028
1027
1026
1025
1024
1023
1022
1021
1020
1019
Pool Elevation In Feet (1929 NGVD)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Discharge In 1,000 CFS
Original Rating Curve
1998 Revised Rating Curve
Eau Galle Dam & Reservoir
Emergency Spillway Rating Curve
U.S. Army Corps of Engineers
St. Paul, District - St. Paul, Minnesota
Plate 3-1


EAU GALLE RESERVOIR
Unlined Conduit Pre Dec 1981
Lined Conduit Post Mar 1982
Outlet Control
Crest Control
Pool Elevation In Feet (1929 NGVD)
Discharge (cfs)
1040
1030
1020
1010
1000
990
980
970
960
950
940
0
1000
2000
3000
4000
5000
Eau Galle Dam and Reservoir
Conduit Rating Curves
U.S. Army Corps of Engineers
St. Paul District - St Paul, MN
Plate 3-2

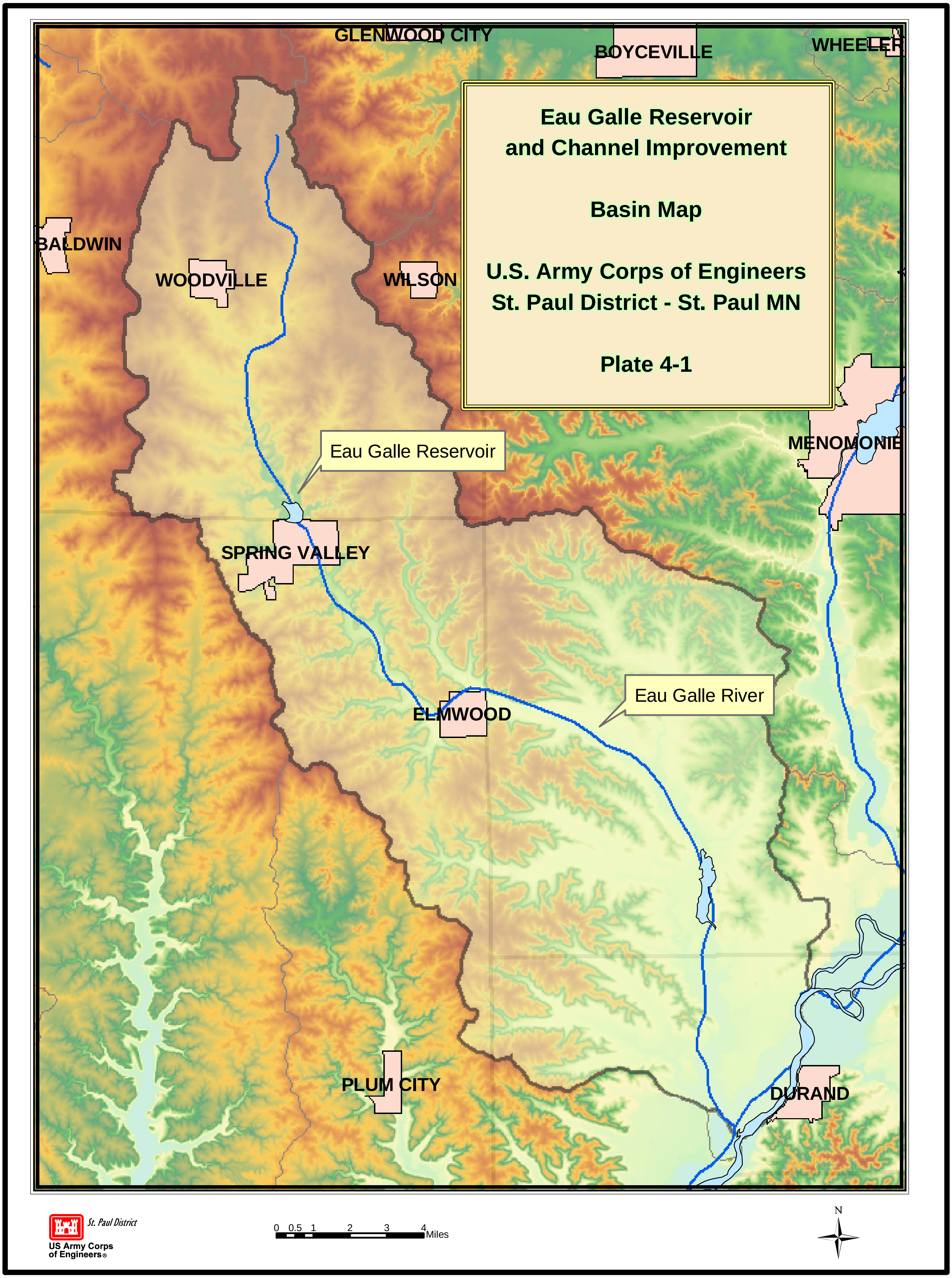


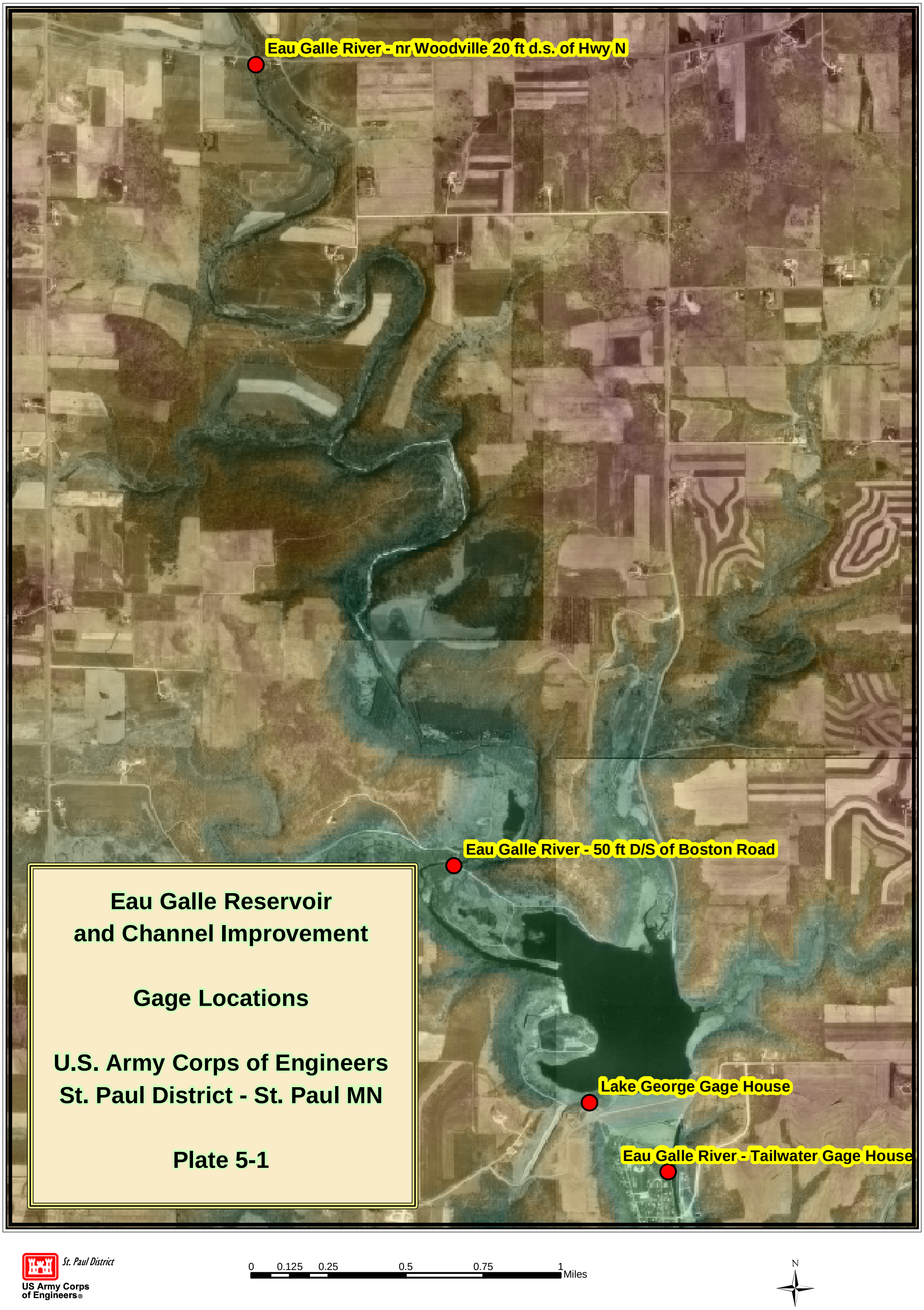
EAU GALLE RESERVOIR
AND CHANNEL IMPROVEMENT

PROBABLE MAXIMUM FLOOD (PMF)
RESERVOIR ROUTING

US ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT - ST. PAUL, MN

PLATE 3-3


Eau Galle Reservoir
and Channel Improvement
Basin Map
U.S. Army Corps of Engineers
St. Paul District - St. Paul MN
Plate 4-1
GLENWOOD CITY
BOYCEVILLE
WHEELER
BALDWIN
WOODVILLE
WILSON
MENOMONIE
Eau Galle Reservoir
SPRING VALLEY
ELMWOOD
Eau Galle River
PLUM CITY
DURAND
St. Paul District
US Army Corps
of Engineers
0 0.5 1 2 3 4
Miles
N



Eau Galle Reservoir and Channel Improvement

Gage Locations

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

Plate 5-1

St. Paul District
US Army Corps of Engineers