BOARDMAN RIVER FEASIBILITY STUDY
Boardman Dams Breach/Drawdown Study

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EXECUTIVE SUMMARY

Among the alternatives being considered in evaluating the fate of four Boardman River dams by the Boardman River Dams Committee is removal of one or more dams. The purpose of this report is to evaluate appropriate methods and estimate the costs to produce a controlled dam breach and/or completely draw down the reservoir levels at each of four dams on the Boardman River in Grand Traverse County, Michigan. The four dams are, starting downstream and working upstream, the Union Street Dam, Sabin Dam, Boardman Dam and Brown Bridge Dam.

This report evaluates ways to breach each dam, safely, such that pre-dam river flow can be restored through each dam site. Several methods of accomplishing a breach were considered, and either pumping the river around each site or constructing a stop-log drawdown control structure were the most favorable. While the potential for sediment movement or management was not a consideration in this report, each of these two methods of breaching the dam can be undertaken such that a responsible sediment management and river restoration plan can be accomplished.

I. INTRODUCTION

The Boardman River Dams Committee (BRDC) was formed to determine the fate of four aging dams on the Boardman River in and near Traverse City, Michigan. One of the many options under consideration is complete dam removal at one or more existing dam sites.

II. PURPOSE

The purpose of this report is to evaluate appropriate methods and estimate the costs to produce a controlled dam breach and/or completely draw down the reservoir levels at each of four dams on the Boardman River in Grand Traverse County, Michigan. The four dams are, starting downstream and working upstream, the Union Street Dam, Sabin Dam, Boardman Dam and Brown Bridge Dam.

The breach/drawdown would be in conjunction with a project to remove one or more of the dams. River restoration, sediment management, demolition and site restoration are outside the scope of this report and will be considered separately. Each dam will be analyzed as a separate project, independent of the other dams.

This report will identify the existing hydraulic control structures available at each dam; the dam sites; and seasonal flow probabilities for the Boardman River; and, develop a concept for a safe, complete, and controlled reservoir drawdown at each site.

The information contained in the following tables was obtained by reviewing existing construction plans in the possession of Traverse City Light and Power, the City of Traverse City, and on-site reconnaissance. The 10% exceedance flow was provided by MDEQ. It represents the Boardman River's flow rate which has a 10% chance of being exceeded during a particular month.

III. UNION STREET DAM

TABLE 1 Union Street Dam Data

MDEQ Dam Safety ID#	511
Hazard Potential Rating	High
Dammed Water Body	Boardman River
Pool Surface Area (normal elevation)	350 Ac.
Height (Top of Embankment to Downstream Toe)	21.5 ft.
Drawdown Height (Lowest Dam Control Structure to Downstream Invert)	8.5 ft.
Hydraulic Control Structures Available	
Embankment Elevation	595
Spillway #1 Sill Elevation	582
Spillway #2 Sill Elevation	584.80
Fish Ladder Upstream Invert Elevation	~582.80
Downstream Toe Elevation	~573.50
Hydraulic Information	
10% Exceedance Flow, Boardman River, June, July, August, Sept. (MDEQ)	410 cfs
Mean Flow, June, July, August, September (MDEQ)	290 cfs
Design (200-Year Flood) Flow at Dam (Q 200—routed) (MDEQ)	2,000 cfs
Drainage Area (MDEQ)	283 sq. mi.

IV. SABIN DAM

TABLE 2 Sabin Dam Data

MDEQ Dam Safety ID#	513
Hazard Potential Rating	High
Dammed Water Body	Boardman River
Pool Surface Area (normal elevation)	40 Ac.
Height (Top of Embankment to Downstream Toe)	30 ft.
Drawdown Height (Lowest Dam Control Structure to Downstream Invert)	12.3 ft.
Hydraulic Control Structures Available	
Embankment Elevation	617 - 618
Main Spillway Sill Elevation	608.90
Auxiliary Spillway Sill Elevation	611.90
Low-Flow "Chute" Elevation	600.30
Downstream Toe Elevation	588
Hydraulic Information	
10% Exceedance Flow, Boardman River, June, July, August (MDEQ)	390 cfs
Mean Flow, June, July, August, September (MDEQ)	270 cfs
Design (200-Year Flood) Flow at Dam (Q 200—routed) (MDEQ)	1,900 cfs
Drainage Area (MDEQ)	211 sq. mi.

V. BOARDMAN DAM

TABLE 3 Boardman Dam Data

MDEQ Dam Safety ID#	512
Hazard Potential Rating	High
Dammed Water Body	Boardman River
Pool Surface Area (normal elevation)	104 Ac.
Height (Top of Embankment to Downstream Toe)	61.1 ft.
Drawdown Height (Lowest Dam Control Structure to Downstream Invert)	38.3 ft.
Hydraulic Control Structures Available	
Embankment Crest Elevation	660
Auxiliary Spillway Sill Elevation	641.6
Penstock Intake Sill Elevation	637.20
Emergency Spillway Crest Elevation	657.2
Downstream Toe Elevation	598.9
Hydraulic Information	
10% Exceedance Flow, Boardman River, June, July, August, Sept. (MDEQ)	390 cfs
Mean Flow, June, July, August, September (MDEQ)	270 cfs
Design Flow at Dam (1/2 PMF—routed)	6,100 cfs
200-Year Flood Flow at Dam (Q 200—routed) (MDEQ)	1,900 cfs
Drainage Area (MDEQ)	209 sq. mi.

VI. BROWN BRIDGE DAM

TABLE 4 Brown Bridge Dam Data

MDEQ Dam Safety ID#	544
Hazard Potential Rating	High
Dammed Water Body	Boardman River
Pool Surface Area (normal elevation)	191 Ac.
Height (Top of Embankment to Downstream Toe)	46.5 ft.
Drawdown Height (Lowest Dam Control Structure to Downstream Invert)	36 ft.
Hydraulic Control Structures Available	
Embankment Crest Elevation	803
Turbine Spillway Crest Elevation	792.5
Log Chute Invert Elevation	797.50
Downstream Toe Elevation	756.50
Hydraulic Information	
10% Exceedance Flow, Boardman River, June, July, August (MDEQ)	220 cfs
Mean Flow, June, July, August, September (MDEQ)	150 cfs
Design (200-Year Flood) Flow at Dam (Q 200—routed) (MDEQ)	1,100 cfs
Drainage Area (MDEQ)	121 sq. mi.

VII. PROPOSED BREACH/DRAWDOWN CONCEPTS

This section will identify ways to design a controlled breach at each dam site in a manner that is safe, minimizes sediment mobilization, and allows for an orderly, gradual pool drawdown.

Each drawdown is recommended to begin by gradually lowering the impounded pool behind the dam as far as is possible using the existing hydraulic control structures at each dam site. Figures showing the hydraulic controls at each dam are presented later in this report. The Boardman Dam is currently at its maximum drawn-down level, as any further lowering must be accomplished by a controlled breach. The remaining three dams are at their normal pool elevations.

Once each pool is lowered using the dam's built-in control structures, further drawdowns are necessary to equalize upstream and downstream water surface and bottom elevations through the dam site and restore river flow. The required upstream water surface drawdown depths at each site are shown below:

Union Street:	8.5 ft.
Sabin:	12.3 ft.
Boardman:	38.3 ft.
Brown Bridge:	36 ft.

Several breaching/drawdown methods have been identified. They include:

1. Explosives.

2. Bypass pumping all river flow over or around the dam until the upstream and downstream water levels are equalized, while excavating a new river channel through the existing embankment.

3. Excavating a "knick-point" in the earthen embankment until the pool begins flowing over the embankment. The escaping water velocity and erosion of the embankment will quickly allow a breach to propagate until upstream and downstream flow levels reach equilibrium.

4. Construct a temporary drawdown structure that will allow for a controlled, gradual drawdown/breach. Using gates or stop logs, lower the pool slowly until upstream and downstream water levels equalize.

Using either Options #1 or #3 allows for very little control of water flow during the breach, and each is irreversible. As such, neither is a serious option. Accordingly, the remainder of the evaluation will focus on options #2 and #4.

Option 2: Bypass Pumping

The concept of by-pass pumping is to pump the river's entire flow over or around the dam's embankment to the downstream side of the dam until the water levels upstream and downstream of the dam are equal. (see Figure 1) Then, a channel for the river can be excavated through the embankment, before the pumps are turned off. It is estimated that between 300 and 400 cubic feet per second must be pumped to maintain existing flow and empty the impoundment, providing that the work is done in the summer months. This flow volume was selected based upon flow exceedance tables developed at each site by MDEQ. They are presented in the previous Tables 1 through 4.

Option 4: Drawdown Structure

The breach and drawdown sequence, conceptually, is as follows, and shown in Figure 2:

1. Drive steel sheet piling to form the drawdown structure. Each structure will have two "wings" that are driven into and parallel to the embankment core to provide anchorage against forces developed against the stop logs. Each structure will have two "walls" that extend perpendicular to the embankment, attaching to steel H-piles at the face of the drawdown structure.

2. Drive steel H-piles to anchor the drawdown structure and provide side rails for the stop logs.

3. Drive a cutoff "wall" to a nominal depth between the H-piles. This will prevent a "blowout" of water under the stop logs.

4. Place wooden or metal "stop logs" into drawdown structure, beginning at the top of the sheet pile cutoff wall extending to the top of the drawdown structure.

5. Place MDOT heavy rip-rap at the toe of the drawdown structure to prevent erosion during the drawdown.

6. Prepare for whatever sediment management plan that is proposed for the drawdown.

7. Begin the drawdown by carefully excavating through the embankment behind the drawdown structure until impounded water flows to the back side of the stop logs.

8. Begin slowly removing stop logs and continue until the upstream and downstream water levels at the embankment are equal.

9. Clean up the site and remove the temporary drawdown structure.

The breach site at the Union Street Dam could easily take advantage of the steel sheet piles at the upstream face of the embankment. The breach location could be between the fish ladder inlet and the southernmost 48-in.-diameter pipe through the embankment.

The breach site for the Sabin Dam can be either directly east of the “chute” spillway with the energy dissipating devices at its toe, essentially around this spillway. Alternatively, an existing but abandoned channel further east could also allow for a controlled breach via a drawdown structure.

At the Boardman Dam, a breach could be developed at the current boat launch, with flow directed into the existing “swamp” area downstream of the toe of the detached embankment. This flow path will likely require a new bridge to be built over the “new” Boardman River as it passes under Cass Road at the “dip” just west of the existing dam.

The Brown Bridge breach could utilize the embankment on either side of the current dam.

VIII. COST ESTIMATES

Once conceptual drawdown schemes were identified, experienced contractors were consulted to estimate construction costs. The King Company, a marine and heavy civil contractor from Holland assisted in developing cost estimates for the drawdown structure option, while Mersino Dewatering of Davison provided estimates to by-pass pump the Boardman River over each dam. Estimated costs are presented in the following tables.

TABLE 5

Preliminary Estimate of Probable Costs: Controlled Drawdown Structure

Boardman River Dams

Drawdown Structures Estimated Costs

Work Item	**Union**	**Sabin**	**Boardman**	**Brown Bridge**
Mobilization and Demobilization	$20,000	$20,000	$20,000	$20,000
Drawdown Depth (ft)	8.5	12.3	38.3	36
Sheet Piling Wing Length	20	25	75	75
Sheet Piling Side Length	25	40	90	90
Sheet Piling Embedment Depth	10	15	20	20
Sheet Pile "Toe" Depth	10	15	20	20
Sheet Pile "Toe" Width	30	30	30	18
Stop Log Bays	5	5	5	3
Stop Logs (ea)	85	123	383	216
H-Pile Depth	25	40	100	100
H-Piles (ea)	6	6	6	4
Drawdown Days	20	40	90	90
Site Preparation Cost	$20,000	$20,000	$20,000	$20,000
Rip Rap Depth (ft)	3	4	6	6
Rip Rap Width (ft)	40	40	40	30
Rip Rap Length (ft)	40	40	60	40
New Cass Road Bridge (100 ft span)	0	0	$600,000	0
Estimated Construction Cost	**$151,790**	**$240,030**	**$1,436,230**	**$ 735,640**
Allowances for Engineering, Contingencies (30%)	$ 45,537	$72,009	$430,000	$220,692
Total Estimated Drawdown Structure Cost	**$197,327**	**$312,039**	**$1,866,230**	**$956,332**

Cost Item	**Unit Cost**
Sheet Piling Installation, PZ 27(sft)	$30
H-Pile Installation (vft)	$30
3 x 6 Stop Logs (ea)	$180
MDOT Heavy Rip-Rap (tons)	$80
On-Site Drawdown Days (ea)	$500

TABLE 6

Preliminary Estimate of Probable Costs: By-Pass Pumping

Boardman River Dams

Drawdown Structures Estimated Costs

Work Item	**Union**	**Sabin**	**Boardman**	**Brown Bridge**
Mobilization and Demobilization	$145,000.00	$145,000.00	$145,000.00	$ 145,000.00
Drawdown Depth (ft)	8.5	12.3	38.3	36
Drawdown Days (0.5 ft/day)	30	50	100	100
Site Preparation Cost	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00
Embankment Excavation	$ 10,000.00	$ 15,000.00	$ 45,000.00	$ 45,000.00
Pump Set-Up Cost	$ 40,000.00	$ 40,000.00	$ 40,000.00	$ 40,000.00
Estimated Construction Cost	**$ 489,990**	**$ 671,650**	**$ 1,143,300**	**$ 1,143,300**
Allowances for Engineering, Contingencies (30%)	$ 146,997	$ 201,495	$ 342,990	$ 342,990
Total Estimated By-Pass Pumping Cost	**$ 636,987**	**$ 873,145**	**$ 1,486,290**	**$ 1,486,290**

Cost Item	**Unit Cost**
Pump Rental (day)	$7,733.00
Fuel (gals/day)	1,000.00
Fuel Cost (gals)	$5.00
O+M (day)	$100.00

IX. CONCLUSIONS

It is feasible to safely initiate a controlled breach of each of the four Boardman River Dams identified in this report. A breach can be created either by using a constructed, temporary drawdown structure or by-pass pumping the river over the embankment until each impoundment is empty, then excavating a new river channel through the dam's embankment.

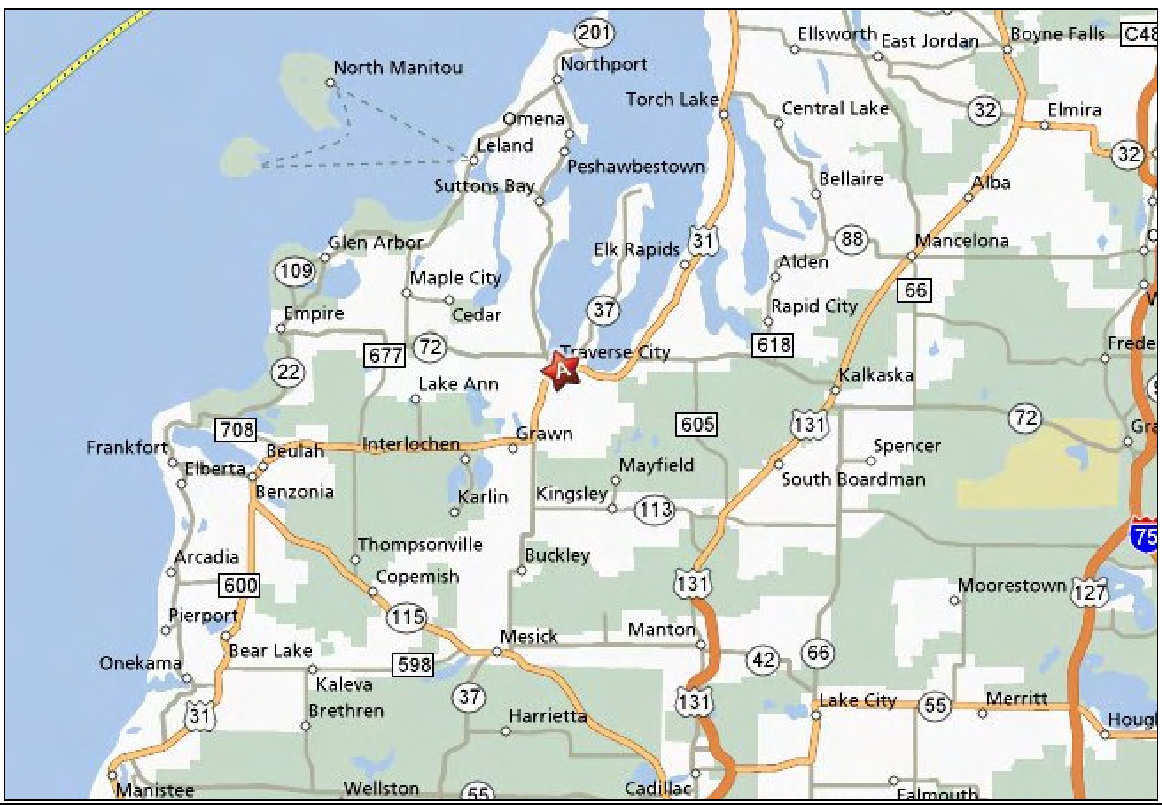
Drawdown structures can be built for between approximately $200,000 and $1,900,000, depending on which dam is breached. The Boardman Dam breach may require replacing the Cass Road culverts west of the dam with a bridge if the drawdown structure method is chosen. Similarly, by-pass pumping can be utilized at a cost of between approximately $650,000 and $1,500,000 for the same dams.

Appendix 1

MDEQ Flow Data

Maps


Greilickville
Traverse City
Union Street Dam
Acme
Bates
Sabin Dam
Boardman Dam
S Airport Rd W
N Us-31 S
Grawn
Interlochen
Brown Bridge Dam
Mayfield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Ellsworth
East Jordan
Boyne Falls
Central Lake
Elmira
Omena
Leland
Peshawbestown
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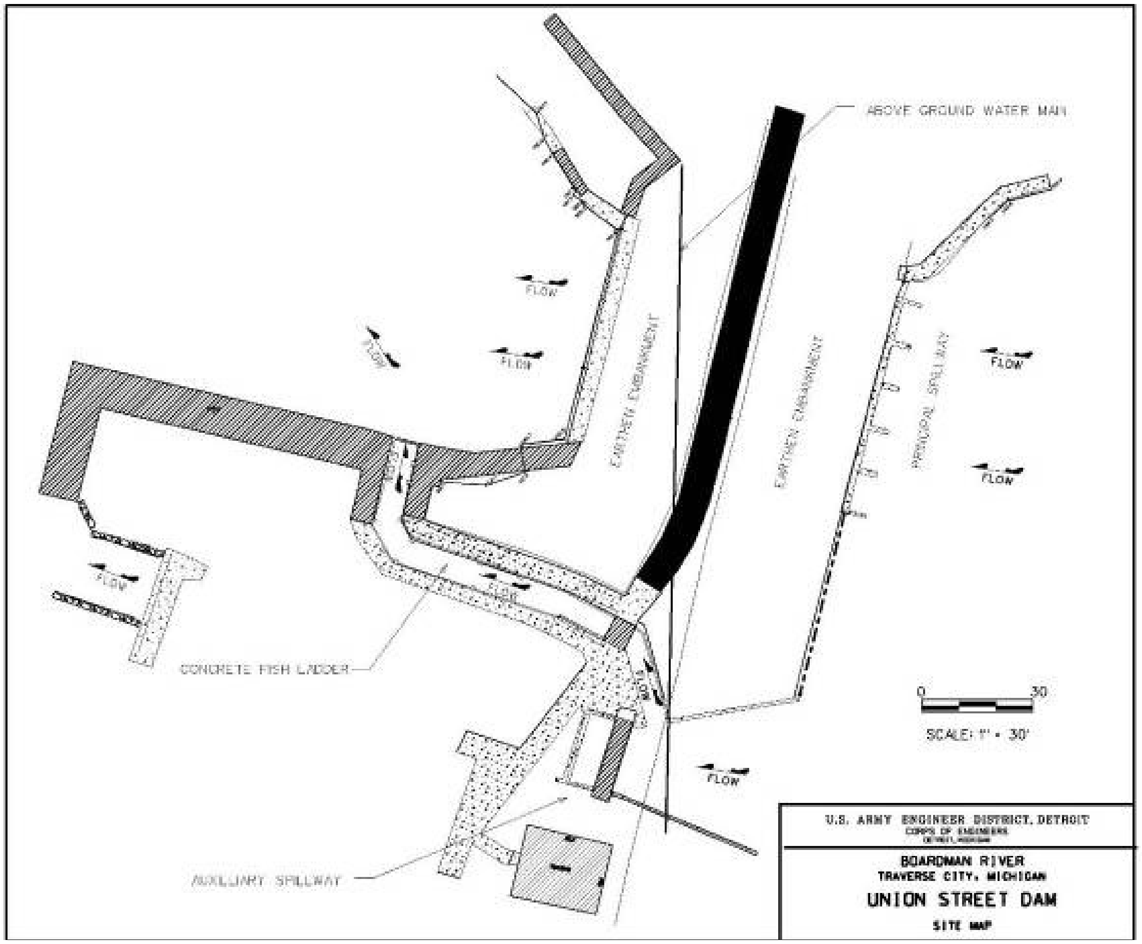
Bellaire
Alba
Glen Arbor
Elk Rapids
Mancelona
Alden
Maple City
Empire
Cedar
Rapid City
Traverse City
Kalkaska
Lake Ann
Grawn
Frankfort
Elberta
Beulah
Interlochen
Benzonia
Mayfield
Spencer
South Boardman
Karlin
Kingsley
Arcadia
Thompsonville
Copemish
Buckley
Moorestown
Pierport
Mesick
Manton
Onekama
Bear Lake
Kaleva
Brethren
Harrietta
Lake City
Merritt
Manistee
Wellston
Cadillac

Appendix 3

HEC-RAS Cross-Sections at Each Dam

Figures

FIGURE 3 Union Street Dam Site Plan



Source: US Army Corps of Engineers

FIGURE 4 Union Street Dam Hydraulic Control Structures

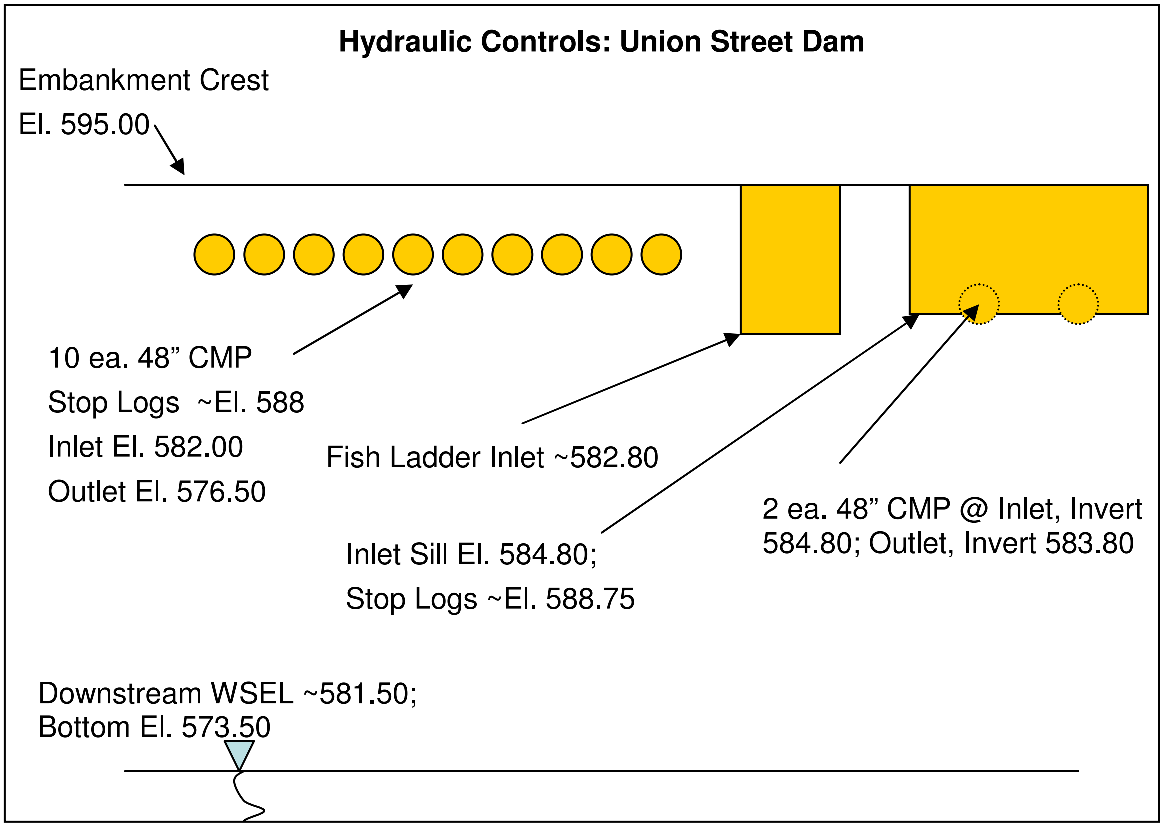
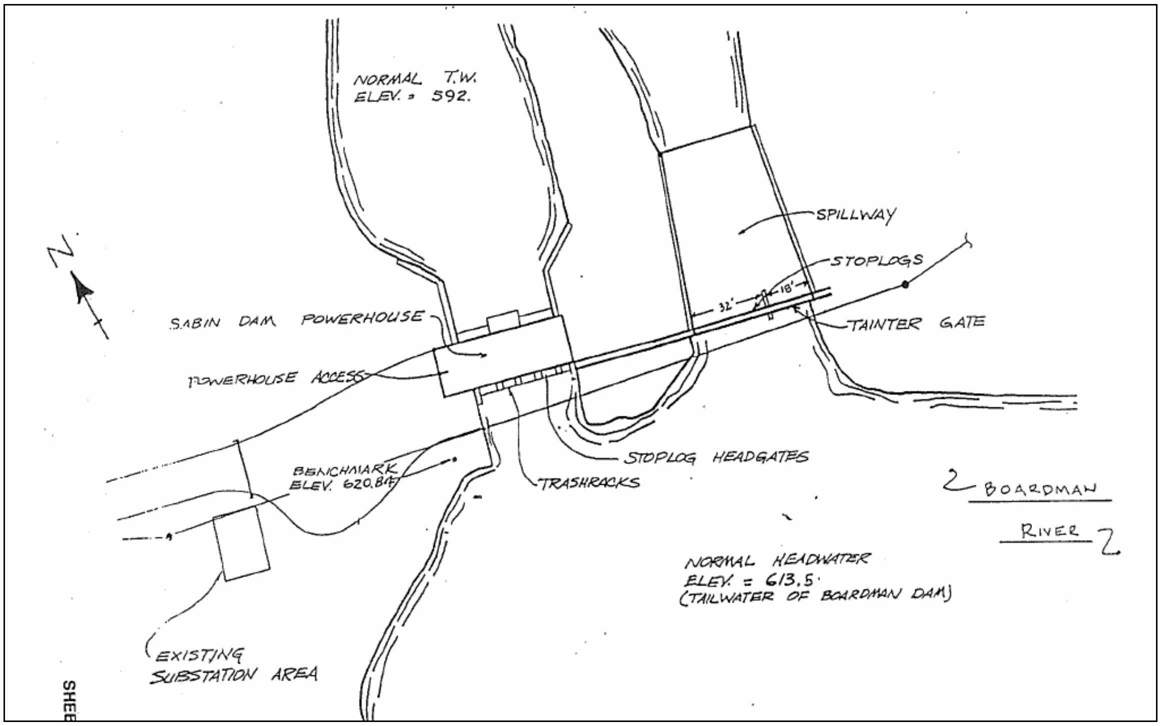


FIGURE 5 Sabin Dam Site Plan



Source: Mead & Hunt

FIGURE 6 Sabin Dam Hydraulic Control Structures

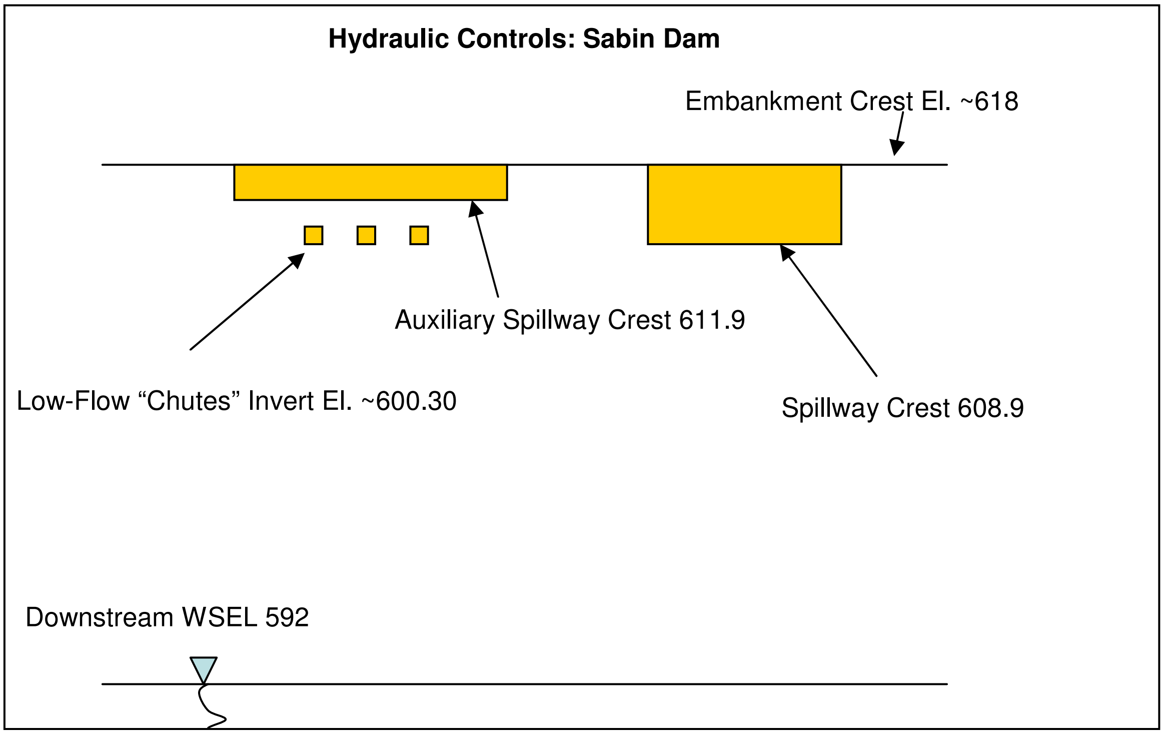
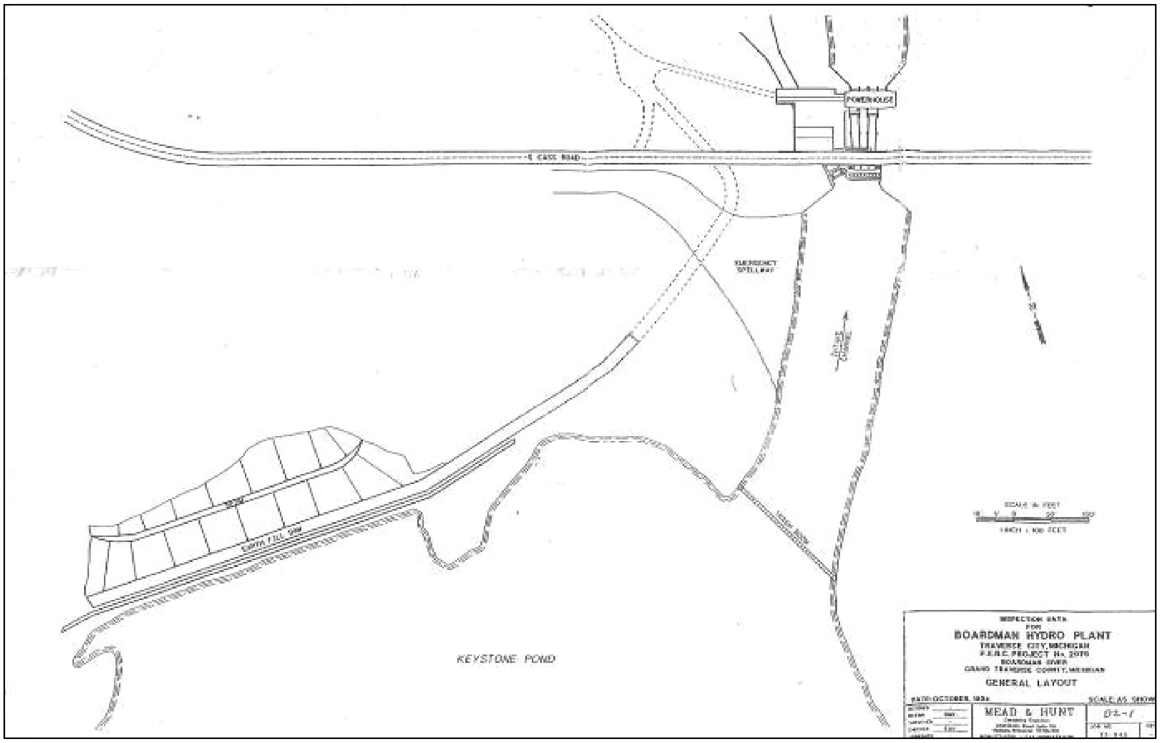


FIGURE 7 Boardman Dam Site Plan



Source: Mead & Hunt

FIGURE 8 Boardman Dam Hydraulic Control Structures

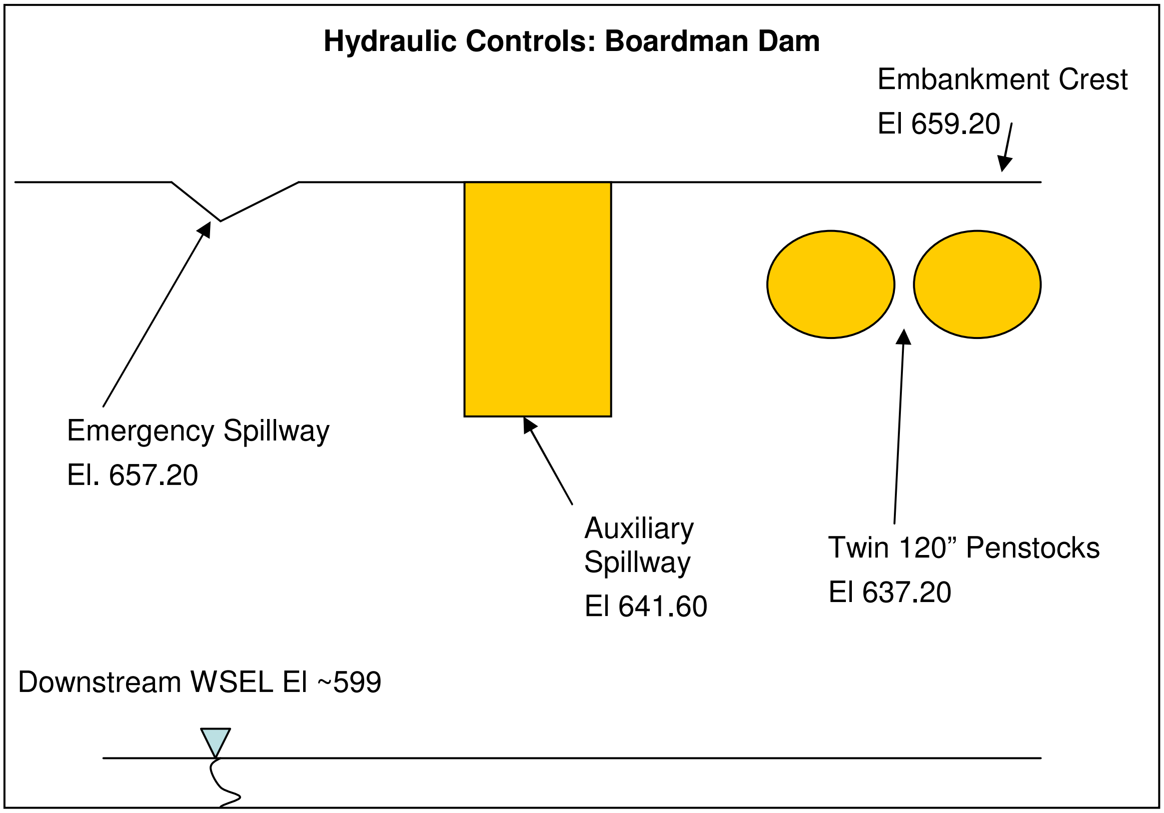
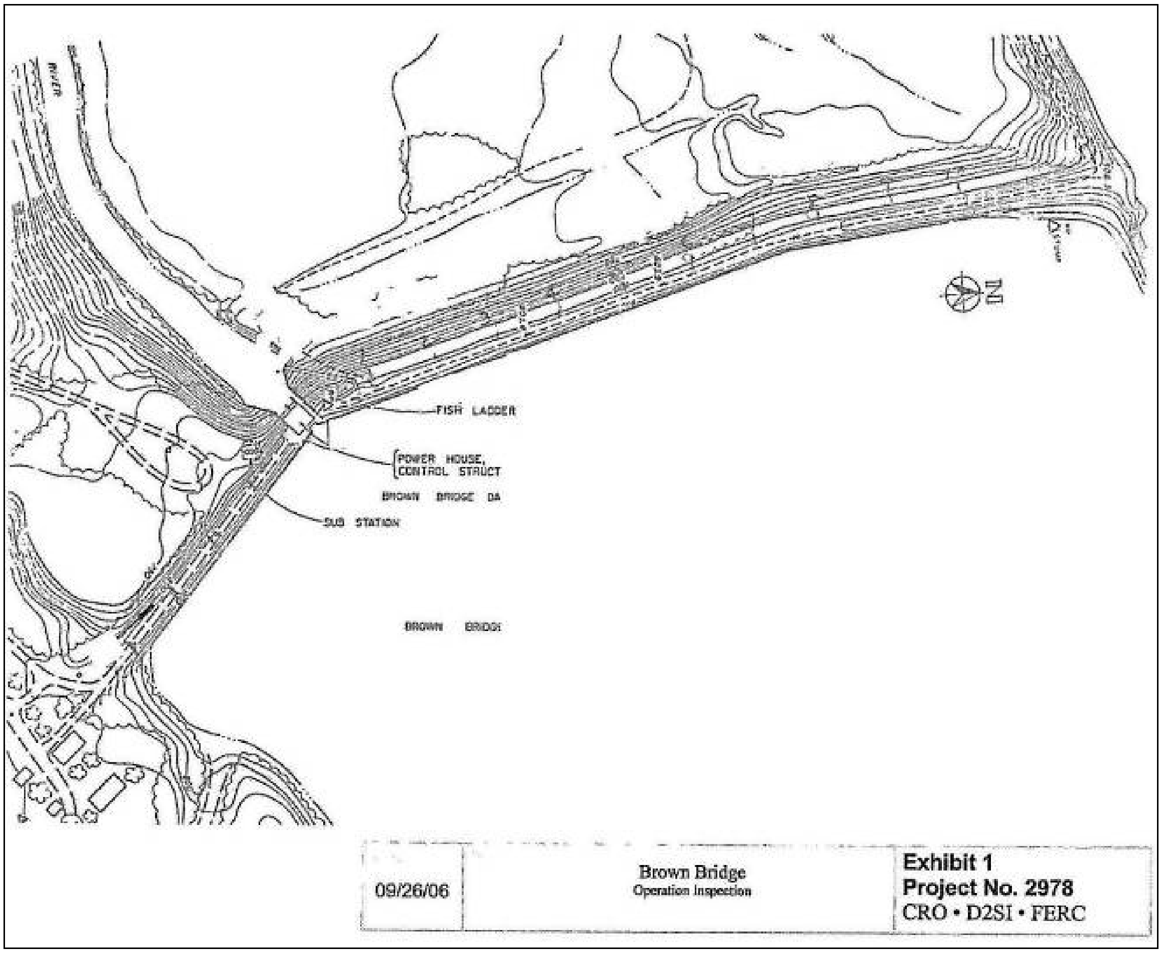


FIGURE 9 Brown Bridge Dam Site Plan



Source: Federal Energy Regulatory Commission

FIGURE 10 Brown Bridge Dam Hydraulic Control Structures