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(a subsidiary of WPS Resources Corporation)
600 E. Lakeshore Drive
P.O. Box 130
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December 18, 2002

Ms. Peggy Harding
Regional Engineer
Federal Energy Regulating Commission
Chicago Regional Office
230 South Dearborn Street, Room 3130
Chicago, IL 60604

Dear Ms. Harding:

Au Train Project No. 10856 Documents Submitted

Per our letter dated October 24, 2002, we are submitting (3) copies of the final design, plans, specification and Q.C.I.P. Please respond back to us by March 7, 2003, so we can proceed with the project.

If you have any questions regarding this submittal please contact me, or Robert Edwards at (906) 483-4519 or Robert Meyers at (906) 485-2419.

Sincerely,

David W Harpole

David W. Harpole
Vice President – Energy Supply (for WPSC)
(920) 433-1264

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Au Train Basin Project

Au Train Hydroelectric Project
FERC Project No. 10856

Au Train Hydroelectric Project Dam Modifications

- Design Report
- Quality Control Inspection Plan
- Project Specification

DECEMBER 2002

MWH
MONTGOMERY WATSON HARZA

A WPS Resources Company

AU TRAIN BASIN PROJECT

Au Train Hydroelectric Project

FERC Project No. 10856

AU TRAIN HYDROELECTRIC PROJECT DAM MODIFICATIONS

DESIGN REPORT

DECEMBER 2002

Prepared by:

MWH
MONTGOMERY WATSON HARZA

Prepared for:

A WPS Resources Company

AU TRAIN HYDROELECTRIC PROJECT
DAM MODIFICATIONS

DESIGN REPORT

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 INTRODUCTION

This document summarizes design of the dam safety modifications for Upper Peninsula Power Company's (UPPCO) Au Train Hydroelectric Project in Alger County, Michigan. Dam safety modifications include lowering the crest of the South Levee is to protect the North Dam during a Probable Maximum Flood (PMF) event, installation of a toe drain at the North Dam, and the repair of deteriorated concrete in the outlet valve house.

2.0 SCOPE OF WORK

The scope of this task covers the following:

- Design for lowering the crest of the South Levee to elevation 784.3 and placing the excavated embankment material along the downstream slope of the levee;
- Design of a toe drain at the North Dam to maintain the phreatic surface below the ground surface and to protect against piping;
- Stability analysis to evaluate the spillway at the North Dam for normal, flood, and ice loads;
- Regrading the crest of the North Dam to elevation 790 to provide sufficient freeboard;
- Repair of concrete damage at the outlet valve house structure.
- Design of structural movement monuments on the crest of the spillway.

The following activities were conducted for preparation of the design, plans and specifications for the dam modifications:

- Hydraulic analyses to evaluate reservoir water level hydrographs, freeboard, and duration of outflows
- Hydraulic analyses to evaluate the geometry of the new South Levee overflow section
- Evaluation of the type and extent of concrete damage at the outlet structure

3.0 REFERENCES

The following references were used in the design of this project:

1. Boss Dambreak Computer Modeling Program.

2. Cedergren, H., Seepage, Drainage, and Flownets, 3rd Ed. 1989.

3. "Probable Maximum Floods and Flood Routing for Au Train Hydroelectric Project," prepared by Montgomery Watson Harza, Inc., for Federal Energy Regulatory Commission, February 2002.

4. National Resources Conservation Service (NRCS) Guidelines.

5. Mead and Hunt, Inc., "Second Consultant's Safety Inspection Report – Au Train Hydroelectric Project – FERC Project No. 10856", prepared for Upper Peninsula Power Company (UPPCO), February 2000.

6. Stone and Webster Michigan, Inc. "Initial Independent Consultant Safety Inspection – Au Train Hydroelectric Project – FERC Project No. 10856", prepared for Upper Peninsula Power Company, Final Report, Volume 1, November 1994.

7. United States Department of the Interior, Bureau of Reclamation, "Design Standards No. 13 – Embankment Dams,"August 1986.

8. United States Department of the Interior, Bureau of Reclamation, "Design of Small Dams," 1987.

4.0 BACKGROUND INFORMATION

4.1 General Description of the Project

The Au Train Hydroelectric Project is located on the Au Train River in Alger County, Michigan and is located upstream of Au Train Lake, a natural water body. The project began operation in 1910 and the embankment dams were constructed in 1930 and 1931 to enlarge the reservoir and increase the power generation capacity of the project.

The project structures consist of the main embankment dam (North Dam) located at the north end of the storage reservoir and with a central spillway and penstock; an embankment saddle dam located at the south end of the storage reservoir (South Levee); intake; a 2,516-foot long 5½ -foot diameter penstock; indoor powerhouse with two 800 horsepower generating units and two 560 kV generators; and a 2,500-foot long 2,300V transmission line.

The project impounds approximately 6.6 miles of the Au Train River and the impoundment has a surface area of approximately 1,557 acres at full pool.

The overall layout of the project is shown on Drawing 1 in Appendix A of this report.

4.2 Main Embankment – North Dam

The main embankment, also known as the North Dam, is located at the north end of the Au Train reservoir. The 1,500-foot long earth embankment dam is approximately 38 feet high at the maximum section with a crest width between 15 and 20 feet. A 20-foot high and 100-foot wide concrete spillway is located in the dam's center portion along with the penstock intake sections. A concrete core wall extends approximately 50 feet from both sides of the spillway into the embankment. The average crest elevation of the north dam is at El. 789.8 feet. The embankment is composed primarily of a loose sand fill, underlain by a granular alluvium composed of silty sand to sandy gravel with horizons of weathered sandstone bedrock. The upstream slopes were constructed at 3H:1V slopes while the downstream slopes were constructed at 4H:1V slopes with several parallel sets of toe drains along the downstream toe.

4.3 South Levee

The embankment saddle dam, or South Levee, is located on a saddle between the Lake Superior and Lake Michigan drainage basins and forms the south end of the impoundment of the Au Train Basin. The headwater for the Whitefish River is immediately south of the dam. The 4,500-foot long South Levee has a maximum height of about 15 feet with a crest width of 10 feet at an average crest elevation at 789.7 feet. The South Levee is a homogeneous loose sand embankment founded on granular alluvium composed of silty sand to sandy gravel.

Near the left abutment, there is an area of apparent spreading where the crest of the embankment is approximately 3 to 3.5 feet lower than along the rest of the embankment. The upstream and downstream slopes are at 2H:1V and have good ground cover. Old tree stumps are present on both slopes and nearly the entire downstream toe area is wet and swampy.

4.4 Spillway

The concrete gravity overflow spillway is 100 feet wide by 29 feet high and is located at the center of the North Dam embankment. The crest elevation of the spillway ogee is at El. 779.3 feet; manually operated stoplogs extend the crest to El. 781.3 feet. The spillway discharges into the Au Train River and under State Highway M-94 and the abandoned Lake Superior and Ishpeming (LS&I) Railway Bridges immediately downstream of the spillway.

4.5 Intake and Outlet Structure

Water passes through an intake structure and into a steel penstock that bifurcates and feeds the two turbines. Turbine discharge is regulated by adjustable wicket gates controlled by a gate shaft governor. Discharge is returned to the upper Au Train River via a 500-foot long, unlined tailrace channel. The intake structure is located in the main dam at the north end of the reservoir to the right of and abutting the overflow spillway. The intake contains stoplogs, a trashrack, and a butterfly shutoff valve. The invert elevation of the intake is at 755.5 feet. The 5.5-foot diameter steel penstock drops approximately

100 feet over its 2,516-foot length to the powerhouse. A 10-foot diameter, exposed steel surge tank connects the penstock above the powerhouse.

4.6 Powerhouse

The powerhouse is located on the east bank of the upper Au Train River, approximately 2,500 feet downstream of the Main Dam. The powerhouse has a reinforced concrete substructure and brick superstructure. The inside dimensions of the powerhouse are 37.5 feet long by 32 feet wide by 22 feet high. It houses two identical 800-horsepower, horizontal-axis, Francis type turbines with steel spiral casings. The units operate at a maximum gross head of 134 feet. Each synchronous-type generator is rated at 560 kilovolt-amperes, 600 rpm, 3-phase, 60 hertz, and is directly connected to the turbine shaft with a flywheel.

A 2,300-volt, 3-phase, 60-hertz transmission line, approximately 2,500 feet long, connects to UPPCO's transmission system.

4.7 Project Geology

The Au Train project is located on the northwestern flank of the Michigan structural basin, which formed during late Cambrian time. The bedrock consists of the Jacobsville sandstone, Munising Sandstone, and undifferentiated Cambrian-Ordovician rocks which are underlain by Precambrian-age basement rocks. Outcropping bedrock was found during the geologic mapping of the North Dam and consisted of flat-lying layers to east-west striking, very shallow dipping, dark grey, bioturbated glauconitic dolomitic sandstone that varied locally to quartzite.

The topography is dominated by large glacial outwash plains and low, rolling hills or ridges with numerous, scattered wet depressions. The topography and soils of the project area are the result of material deposited through continental glaciation. Sediments in the area include glacial tills, end moraines, outwash plains, and lake deposits.

4.8 Site Specific Geotechnical Investigations

Site-specific information on the rock foundation for the spillway is available from geologic mapping, borings, and construction photographs.

Stone & Webster mapped the outcrops downstream of the spillway in 1994. The rock was described as:

> Sandstone, fine- to medium-grained, hard to very hard, fresh to severely weathered. Bedding is thin to laminated, parallel to wavy, continuous to discontinuous, shallow dipping 2- to 5-degrees north. Two dominant joint sets were mapped. Both are near vertical, perpendicular to each other, and striking at an angle to the river.

A total of 33 borings were drilled during October 1988 to evaluate the concrete, embankment, and foundation materials. Thirteen borings were drilled at the North Dam, 13 were completed at the South Levee, and 7 were completed along the penstock alignment. The boring locations at the North Dam are shown on Drawing 5. Borings SW-4 and SW-9 were extended through the dam and alluvium into rock. Boring SW-15, drilled thorough the downstream lip of the spillway, penetrated 13.7 feet into rock. The bedrock in the borings was generally a gray to yellow-brown, fine- to medium-grained, well sorted, fresh, and well-indurated sandstone, with some siltstone interbeds.

The concrete-to-rock contact from boring SW-15 was separated. The rock immediately below the contact was described as:

> Siltstone, silt sized grains, top ½ inch moderately weathered, rest fresh to unweathered, very thinly bedded to laminated, wavy to parallel, discontinuous to continuous. The log suggested that water might be flowing along the contact. (Since the foundation was not grouted and the geologic mapping indicated intersecting vertical joint sets, the water is interpreted as primarily flowing along the joints.) RQD is 93 to 97 indicating good quality rock.

Seventeen photos of the construction were made between July 1930 and October 1931. The original glass photographic plates are stored in the offices of the Wisconsin Public Service Corporation in Ishpeming, Michigan. We have selected five of these that clearly show the condition of the foundation rock after it was excavated and cleaned for placement of concrete, one that clearly shows the bonding stones between concrete lifts, and one that shows the concrete section before placement of the embankment, and have included reproductions of these photographs in Appendix C.

Photo Plate Number	Date	Photo Title
8448	July 1930	View showing spillway footings looking northwest.
8449	July 1930	View of rock footings of east retaining wall of spillway looking north.
8450	July 1930	View of rock footings under east section of spillway looking west.
8451	July 1930	View showing methods of (tying) sections together, looking northeast.
8456	Oct. 1930	View of spillway, looking south.

In all photographs, it appears that the foundation was excavated to sound rock. The bedding plane surfaces are clearly visible and approximately horizontal, but the surfaces appear to be undulating and rough. The excavated rock surface is clearly shown as being stepped, which indicates that the bedding planes are not continuous planes of weakness. The irregular stepped rock surface will require intact concrete or rock to be sheared along any potential failure plane at the base of the dam.

The last photograph shows the core walls and wing walls are integral with the spillway section. It also shows the keys between the spillway blocks and the closure section.

After a review of the above site-specific information, it is our opinion that the friction angle of 33 degrees and cohesion of up to 40 psi are reasonable values for use in stability analyses. To be conservative, these were reduced to 30 degrees and <20 psi for the stability calculations.

4.9 Project Operation

UPPCO currently operates the project in a modified run-of-river mode based on the water level maintained at the reservoir. The powerhouse is operated in a semi-automated mode with remote start and stop capabilities. Normally, all releases from the dam are made through the penstock for use in power generation. Generally, the reservoir water level is maintained within two-foot of El. 779.3 feet between May and September. Reservoir levels near El. 781.3 occur during the spring runoff period in May while water levels near EL. 777.3 occur as a result of late summer drafting of the reservoir for downstream fisheries and recreation interests. During January, February, and March, the reservoir is lowered to average elevations of 776.8 feet, 774.0 feet, and 772.3 feet, respectively. The late winter drawdown provides a gradual and controlled rate of erosion of the ice in the river downstream from the dam and provides storage capacity in the reservoir. This provides some degree of protection for both the project structures and downstream developments from flooding during the spring runoff.

4.10 Project Instrumentation

Long-term monitoring of the phreatic surface through the embankment is accomplished through observation wells (open standpipe piezometers) installed in 24 locations. These piezometers also allow for monitoring of uplift on the concrete structures. Several sets of toe drains are located in the downstream slope area of the North Dam, upstream and downstream sides of the spillway, and various locations along the highway.

A crack gage monitors a minor crack in the horizontal lift joint in the downstream powerhouse substructure.

5.0 HYDRAULIC DESIGN AND ANALYSIS

5.1 Introduction

The results of hydraulic flood routing analyses performed for the February 2002 report to FERC indicated that the maximum flows during the warm season Probable Maximum Flood (PMF) would overtop the embankment crest at the North Dam and South Levee. To allow for the release of the PMF event without overtopping the North Dam and South Levee, the construction of a fuse plug spillway section at the South Levee was evaluated. After the meeting with FERC on September 26, 2002, a revised design was selected. The proposed scheme is to lower the crest of the entire 4,500 ft. long South Levee. This would allow the PMF passage without overtopping the North Dam and the discharge from the North Dam would also safely pass through the railroad bridge immediately downstream of the North Dam. Discharge over the South Levee would be routed to the Whitefish River just downstream of the South Levee.

5.2 Hydraulic Model Description

The PMF routing analyses were performed with the conservative assumption that the South Levee would be overtopped without failure at the South Levee. The analyses were based on the following configuration:

- Crest elevation of the top of the South Levee would be lowered to El. 784.3 ft.
- Overtopping would occur over the entire 4,500 ft. long South Levee

A detailed discussion of the PMF routing can be found in the October 24, 2002 letter to FERC.

5.3 Reservoir Water Level

The hydrograph for the reservoir water level was obtained as a result of reservoir flood routing analyses through a reservoir model and two river models describing the Au Train and Whitefish Rivers. The reservoir model simulates the reservoir reach, approximately

6.6 miles long, between the North Dam and the South Levee. The PMF event was developed for each of the nine sub-basins within the Au Train and Whitefish River Basins. In the reservoir model, the prescribed spillway rating curve for the North Dam consists of flow over the spillway section and flow over the embankment section when the water level is above El. 788.5 feet (minimum crest elevation of the embankment). The maximum water surface during the PMF flood routing was 788.5 so no flow over the embankment would occur. The top of the South Levee is assumed at a uniform elevation of 784.3 feet.

Freeboard studies in the February 2002 report show that minimum required freeboard is less than 1 foot during PMF. Adding 1 foot to the maximum water level during the PMF gives a minimum crest elevation of 789.5 ft. This is less than the average crest elevation of 789.8 feet. Therefore, the crest will be regraded to its average elevation of 789.8 feet to provide more than the minimum required freeboard.

5.4 Duration of Outflow

The duration and magnitude of outflow through the North Dam and South Levee were determined using the Boss DAMBREAK computer model. Based on the water levels and spillway rating curve at the North Dam, the discharges at the North Dam are estimated. The discharges from the South Levee are then estimated by subtracting the North Dam outflows from the predicted total outflows at the modeled dam. Figures 1 and 2 show the outflow hydrographs for the North Dam and the South Levee. Figures 3 and 4 show the stage hydrographs at the North Dam and South Levee. The maximum outflow at the South Levee is 63,920 cfs and occurs at approximately hour 21.0.

5.5 Inundation Mapping for South Levee

Inundation maps were prepared for the East Branch of the Whitefish River south of the project. The maps are included in Appendix D. Four separate maps are required to cover the area between the South Levee and Lake Michigan. The base maps are National Geographic CD version of the USGS 7.5 minute quadrangles, 1985 provisional edition.

The inundation areas were calculated using the BOSS DAMBRK computer program. The river geometry was modeled using the 39 cross sections from the *Initial Independent*

Consultant Safety Inspection (Stone & Webster, 1994). The southern most section is at the mouth of the river where it enters Lake Michigan where the boundary condition of constant water surface elevation was used due to the large volume of Lake Michigan relative to the Au Train Basin.

The maps show the area of inundation for hypothetical failure of the South Levee during Sunny Day and PMF conditions. Tables on each map show the peak flow, peak elevation, flood arrival time, peak arrival time, and stage increase for both cases.

5.6 Sunny Day Inundation

For the Sunny Day Inundation mapping, conservative breach parameters from the FERC guidelines were used due to the erodible nature of the materials in the South Levee. The average breach width was assumed to be 4 times the height of the South Levee (upper end of FERC breach parameter guidelines). The time to failure was assumed to be 10 minutes (near the lower limit of the FERC breach parameter guidelines) based on the empirical equation for lateral erosion rate from the *Hydraulic Model Studies of Fuse Plug Embankments* (USBR, 1985).

Based on the 1985 topographic data, it appears that there are several structures along the edges the Sunny Day inundation limits. The increase in stage varies from about 3 to 5 feet along this reach. The time for the flood arrival is about 10 hours and the time for the peak arrival is about 16 hours. The shallow depth of flooding and relatively slow rise of water indicates that the South Levee should be classified as having low hazard potential.

There is insufficient available information to identify whether or not the structures are inhabited or the specific rise in water level at them and other potential hazards such as the 38th Road, Route 2 bridge, and the Soo Line Railroad bridge. Therefore, the area should be surveyed to identify inhabited dwellings and other hazards and the elevations of them. The elevations should be compared to the elevation of flooding to evaluate the potential for loss of life or property.

5.7 Probable Maximum Flood Inundation

During the PMF, the entire South Levee is overtopped and the entire dike was conservatively assumed to fail. The time to failure was estimated to be 14.2 hours using the same lateral erosion rate as for the Sunny Day failure based on the empirical equation for lateral erosion rate from the *Hydraulic Model Studies of Fuse Plug Embankments* (USBR, 1985).

Although there are dwellings and bridges within the PMF inundation limits, the incremental rise due to dam failure is small. Table 1 presents the differences in peak elevations for the PMF case, with and without failure of the South Levee. The incremental rise in flooding due to dam failure is 1 foot or less, therefore the South Levee has a low hazard potential for the PMF case.

Where there are large lateral inflows such as at Section 25 where the West Branch of the Whitefish enters the East Branch, the flood arrival time (defined as a two-foot rise) from lateral inflow occurs before the flow from the failure of the South Levee. The peak time arrivals are not affected by the lateral inflow.

Table 1 Incremental Rise for Failure of South Levee during PMF

Mile	No Failure Peak Elevation, ft	With Failure Peak Elevation, ft	Difference, ft
.11	782.77	783.32	0.55
.27	782.24	782.84	0.60
.53	781.45	782.03	0.58
.64	781.19	781.76	0.57
.91	780.61	781.13	0.52
1.17	779.96	780.47	0.51
1.52	778.78	779.18	0.40
2.05	777.13	777.50	0.37
2.54	774.64	775.03	0.39
2.84	772.72	773.17	0.45
3.67	769.56	769.97	0.41
4.17	766.70	767.11	0.41
4.89	758.32	759.34	1.02
5.87	746.32	746.96	0.64

Mile	No Failure Peak Elevation, ft	With Failure Peak Elevation, ft	Difference, ft
6.89	742.03	742.63	0.60
7.31	739.64	740.23	0.59
7.95	731.84	732.45	0.61
8.48	724.01	724.56	0.55
8.86	716.28	717.07	0.79
9.13	714.86	715.58	0.72
10.23	711.01	711.51	0.50
10.87	706.42	706.92	0.50
12.16	690.67	690.94	0.27
13.52	660.14	660.61	0.47
14.81	651.57	652.09	0.52
16.33	640.53	641.07	0.54
17.05	637.72	638.23	0.51
18.14	626.45	626.67	0.22
18.64	619.61	620.40	0.79
19.43	613.86	614.37	0.51
20.27	607.93	608.40	0.47
21.78	603.62	604.05	0.43
22.65	601.90	602.31	0.41
23.22	599.72	600.10	0.38
23.60	596.64	596.69	0.05
24.43	589.02	589.07	0.05
25.23	583.90	583.93	0.03
25.45	581.70	581.71	0.01

5.8 Emergency Action Plan

The following information is provided for incorporating the inundation maps into the project Emergency Action Plan.

Because of the methods, procedures, and assumptions used to develop the flooded areas, the limits of flooding shown and flood wave travel times are approximate and should be used only as a guideline for establishing evacuation zones. Actual areas inundated will depend on actual failure conditions and may differ from areas shown on the maps.

<u>Use of Map</u>

The general procedures for use of the attached map are as follows:

1. Determine the portion of your area of concern, which would be affected by inundation or isolation.

2. Identify evacuation routes, which would be used for movement of people from each part of the area to be evacuated.

3. Identify the amount of time available for evacuation.

<u>Definition of Terms</u>

River mile	Assumed distance along the channel of the East Branch of Whitefish River from South Levee @ Mile 100.
Mile downstream	Distance from South Levee.
Peak elevation	Computed maximum water level elevation, which would be reached at a location due to the assumed dam failure.
Peak time	Time of occurrence for peak water level due to the assumed dam failure.
Peak flow	Computed maximum flow at a location due to the assumed dam failure.
Stage Increase	The difference in water level between peak elevation and an assumed base condition in the river. The base condition assumes a river flow of 100 cfs.
Flood arrival time	Elapsed time for the leading edge of flood with water level increases by 2 ft from the base condition.

NGVD	National Geodetic Vertical Datum (1929 Datum)
Inflow Design Flood	Elapsed time for the leading edge of flood with water level increases by 2 ft from the base condition.
Sunny Day Failure	Dam failure during non-flooding conditions. The reservoir water level would be at the normal maximum pool level of El. 781.3 ft.
Dam failure	Any condition resulting in the uncontrolled release of water other than over or through an uncontrolled spillway or outlet works. The dam failure cases include the IDF failure and sunny day failure.
Section number	Section numbers for the cross-sections used to define the shape of a stream channel or valley, usually in a directión perpendicular to the direction of flow.

5.9 Conclusions

The hydraulic analyses show that the PMF can be safely passed by lowering the crest of the South Levee.

Inundation mapping shows that the South Levee is probably a low hazard potential dam. Since the best available information if from 17 year-old topographic maps, the area should be surveyed to confirm the hazard classification.

6.0 SOUTH LEVEE EMBANKMENT MODIFICATION

6.1 Introduction

The crest of the South Levee will be lowered to pass the PMF without overtopping the North Dam. Details of the South Levee modification are discussed in the following paragraphs.

6.2 South Levee Modifications

The crest of the South Levee will be lowered to elevation 784.3 feet for its entire 4500-foot length. The approximately 5 feet of material removed from the top of the existing South Levee embankment will be placed immediately downstream against the downstream slope of the embankment. The crest width will increase to approximately 30 feet and downstream slope will be flattened to approximately 3:1 (horizontal:vertical).

The modified crest elevation and crest width will allow the PMF to pass over the dike (conservatively assuming that it doesn't fail) while maintaining adequate minimum freeboard at the North Dam. The normal freeboard at the South Levee will be 3-feet. This approach was accepted by the FERC in its October 24, 2002 letter to UPPCO.

The balanced cut and fill modification improves the stability of the existing South Levee by reducing its height and flattening the downstream slope. The increased width will also provide some increased protection against piping failure from seepage. Internal drainage was not included in the modified design because:

- The modified embankment section is an improvement, in an engineering sense, over the existing section which has performed adequately for about 70 years;
- The South Levee is a low hazard dam;
- Internal drainage would be expensive for such a long structure; and
- UPPCO accepts the risk that the South Levee may fail from overtopping or seepage.

The downstream slope and area downstream of the existing dam that will be beneath the new fill will be stripped of vegetation prior to placing the new fill. Large stumps on the downstream slope of, and immediately downstream of the existing embankment, will be left in place due to concerns that grubbing of them may cause seepage problems.

Embankment material will then be placed in lifts and be compacted by equipment traffic. The levee will be revegetated to prevent erosion from rain. In addition, a 10-ft. wide gravel surface will be constructed along the crest to serve as an access road.

7.0 TOE DRAIN DESIGN

7.1 Introduction

Based on the observations made in the November 1994 Independent Consultant's Safety Inspection Report, construction of a toe drain was recommended at the North Dam to control seepage through the embankment and the foundation of the dam, by lowering the phreatic surface and reducing the potential for piping.

7.2 Toe Drain

The toe drain will extend approximately 400 feet left of the spillway and 560 feet to the right of the outlet structure. Due to the topography, the toe drains will have a positive slope towards the spillway.

Based on preliminary profiles developed using topographic surveys and available borehole logs, the toe drain will have an average depth of six feet below the existing ground surface. Due to the sandy soil and high water table, excavation using well points, biodegradable slurry, or other suitable methods to control groundwater will be required. The trench will be backfilled with fill designed using filter criteria. Seepage will be collected by an 8-inch diameter corrugated high-density polyethylene pipe at the base of the trench. The pipe will discharge to manholes located near the spillway which will then discharge into the area just downstream of the spillway. Additional manholes will provide access to the toe drain for cleanout and maintenance purposes. The minimum slope of the 8-inch drainpipe for the east toe drain is 2.3% which will yield a capacity of 880 gpm. The minimum slope of the west toe drainpipe is 3.2% which yields a capacity of 1032 gpm. These capacities should be sufficient to handle anticipated flows.

Gradation testing results for the North Dam embankment presented in the November, 1994 Stone and Webster Report entitled "Initial Independent Consultant Safety Inspection, Au Train Hydroelectric Project, Volumes 1, 2 and 3" were used to design the toe train backfill. The foundation alluvium materials are nearly identical to the embankment material. Procedures outlined by the United States Department of Interior (August 1986) were used to develop the gradations of the toe drain backfill. The toe drain back fill is a free-draining material designed to prevent migration and piping, to provide sufficient permeability to pass anticipated flows, and to minimize segregation. The backfill was also sized to be compatible with the size of the perforations for the collection pipe. The recommended gradation for the toe drain backfill is provided below in Table 7-1.

Table 7-1
Recommended Gradations for Toe Drain Backfill

Description	**Gradation**	
	% passing	Size
Toe Drain Backfill	100	3"
	95-100	2 ½"
	88-95	2"
	80-90	1 ½"
	65-80	1"
	60-75	¾"
	45-65	½"
	30-50	¼"
	25-45	#4
	2-15	#16
	0-10	#20

8.0 STABILITY ANALYSIS

8.1 Introduction

The stability of the spillway structure at the North Dam was evaluated for normal, ice, and flood loadings. The analyses were performed in accordance with FERC criteria.

8.2 Method of Analysis

The stability and stresses for the concrete spillway were analyzed by the two-dimensional gravity method. Factors of safety along a failure plane at the base of the dam were calculated by the limit equilibrium method (shear-friction factor).

8.3 Design Criteria

The design criteria for the Au Train spillway stability analyses were determined based on a review of past studies including Stone and Webster's 1994 report.

8.3.1 Geometry

The geometry of the maximum section was based on field measurements and previous investigations done by Stone and Webster. An idealized section through the spillway was used as shown in Appendix B

8.3.2 Material Properties

Unit weights of the materials were based on laboratory measurements of concrete core samples and are as follows:

Table 8-1 Unit Weights	
Material	**Unit Weight (pcf)**
Water	62.4
Concrete	152

Shear strengths for the concrete to rock interface are given in Table 8-2. Stability was not evaluated along lift joints because the construction photographs clearly showed the use of bonding stones.

Table 8-2 Shear Strengths		
Interface	**Shear Strength c (psi)**	**Friction Angle φ°**
Concrete to Rock	<20	30

8.3.3 Loads

Water elevations were based on hydraulic calculations for the modified South Levee.

Table 8-3 Water Elevations	
Load Case	**Water Elevation (feet)**
Normal headwater elevation	781.3 (top of "flash boards")
Normal tailwater elevation	753.3 (top of rock)
PMF headwater elevation	788.5
PMF tailwater elevation	757.0

Measured silt depths of 3.3 feet upstream of the structure were judged to be insignificant.

The ice load was taken as 5 kips/foot since the reservoir rims are gently sloping and will only provide modest restraint to the ice sheet. This structure has withstood ice loading for many years and this should not be the controlling load case. Ice load was applied at the late winter target elevation of 772.3.

Uplift for the normal reservoir elevation was taken to vary linearly from headwater elevation to tailwater elevation over 100 percent of the base of the dam. Uplift for the PMF loading condition was taken to linearly vary from headwater elevation to tailwater elevation over 100 percent of the base. Uplift on portions of the base not in compression were full headwater pressure.

Hydrodynamic loads are accounted for by reducing the tailwater depth to 60 percent of the estimated depth.

8.3.4 Load Cases

The load cases analyzed for this report include:

- Normal Maximum Pool
- Normal Maximum Pool plus Ice
- Probable Maximum Flood (PMF)

The earthquake case was not considered for this analysis since the dam is located in seismic zone 1.

8.3.5 Acceptance Criteria

Minimum required factors of safety for sliding are based on factors of safety typically allowed when site-specific investigations have been performed. The Factors of Safety in table 8-4 are taken from Table 2A of Chapter III of the 2000 FERC Guidelines.

Table 8-4
FERC Recommended Minimum Factor of Safety for Sliding

Load Case	F.S.
Normal	2.0
Normal plus Ice	1.5
PMF	1.5

8.4 Results of Stability Analysis

The results of the stability analyses are summarized in the following table 8-7. The spillway meets the criteria for all load cases.

Table 8-5
Summary of Stability Analyses

Load Case	Factor of Safety		Percent Base in Compression	Cohesion Required (psi)
	Required	Calculated		
Normal	2.0	2.0	100	8
Normal plus Ice	1.5	1.6	100	0
PMF	1.5	1.5	57	20

The cohesion required to meet the required factors of safety are shown in the table. This cohesion is less than is judged to be available for the concrete-tock contact and therefore considered acceptable.

The results of the stability calculations are considered to be conservative because the spillway is narrow (100'), the blocks are keyed, and 3-dimensional effects from the large spillway training walls and core walls that extend into embankment were not included. These features are clearly shown in one of the construction photographs in Appendix C. By inspection, these features would greatly improve the stability. Therefor, the stability is considered acceptable.

9.0 ADDITIONAL SITE IMPROVEMENTS

Additional improvements have been incorporated into the design. These include the following items:

- Local repair of various areas of concrete damage at the spillway and outlet structure of the North Dam will be included.

- Control survey points will also be installed on the concrete structures of the North Dam.

These work items will be incorporated into the Contract Documents for the dam modifications.

FIGURES

Figure 1 - Outflow Hydrograph @ North Dam During PMF

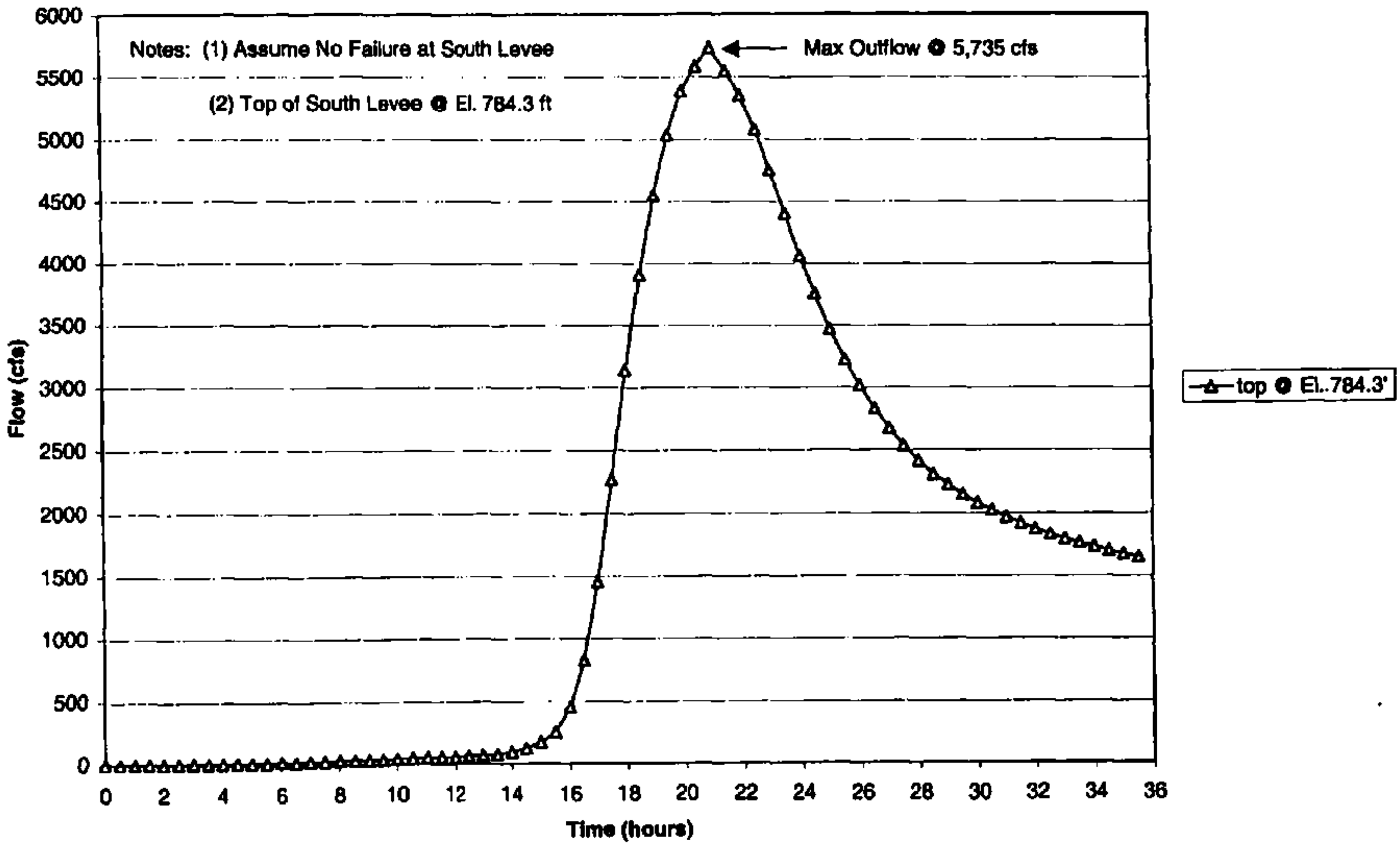


Figure 2 - Outflow Hydrograph @ South Levee During PMF

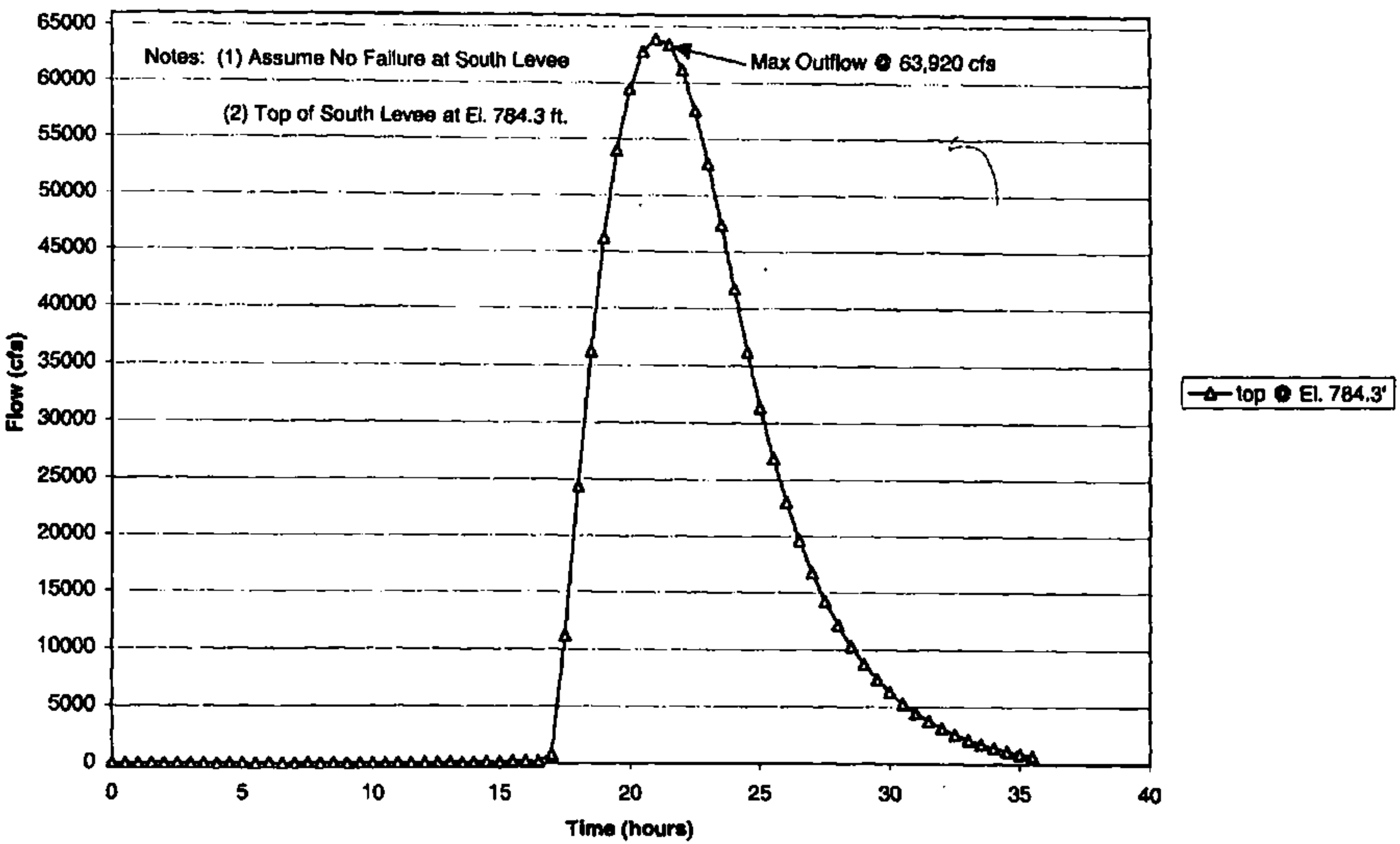


Figure 3 - Stage Hydrograph at North Dam During PMF

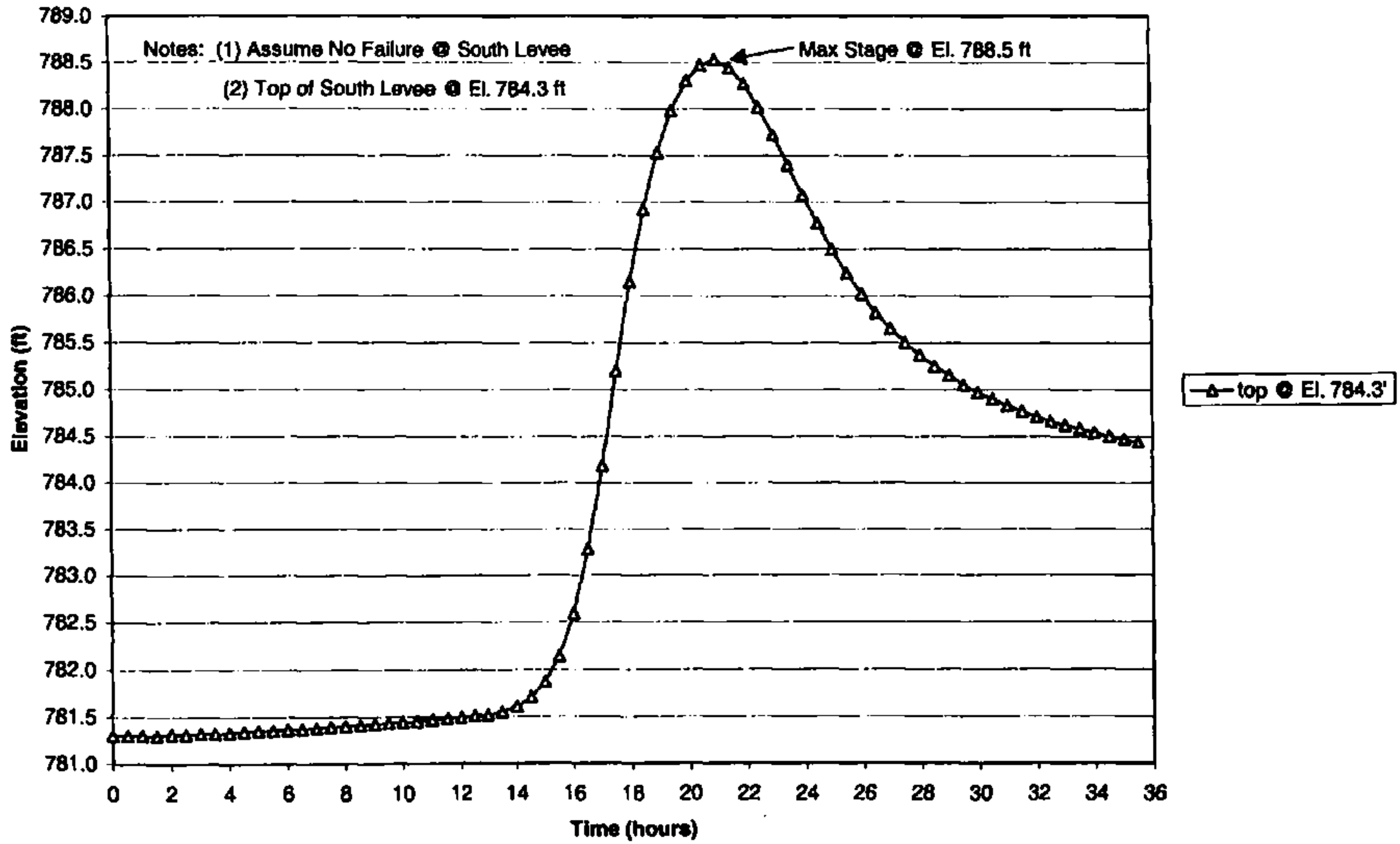
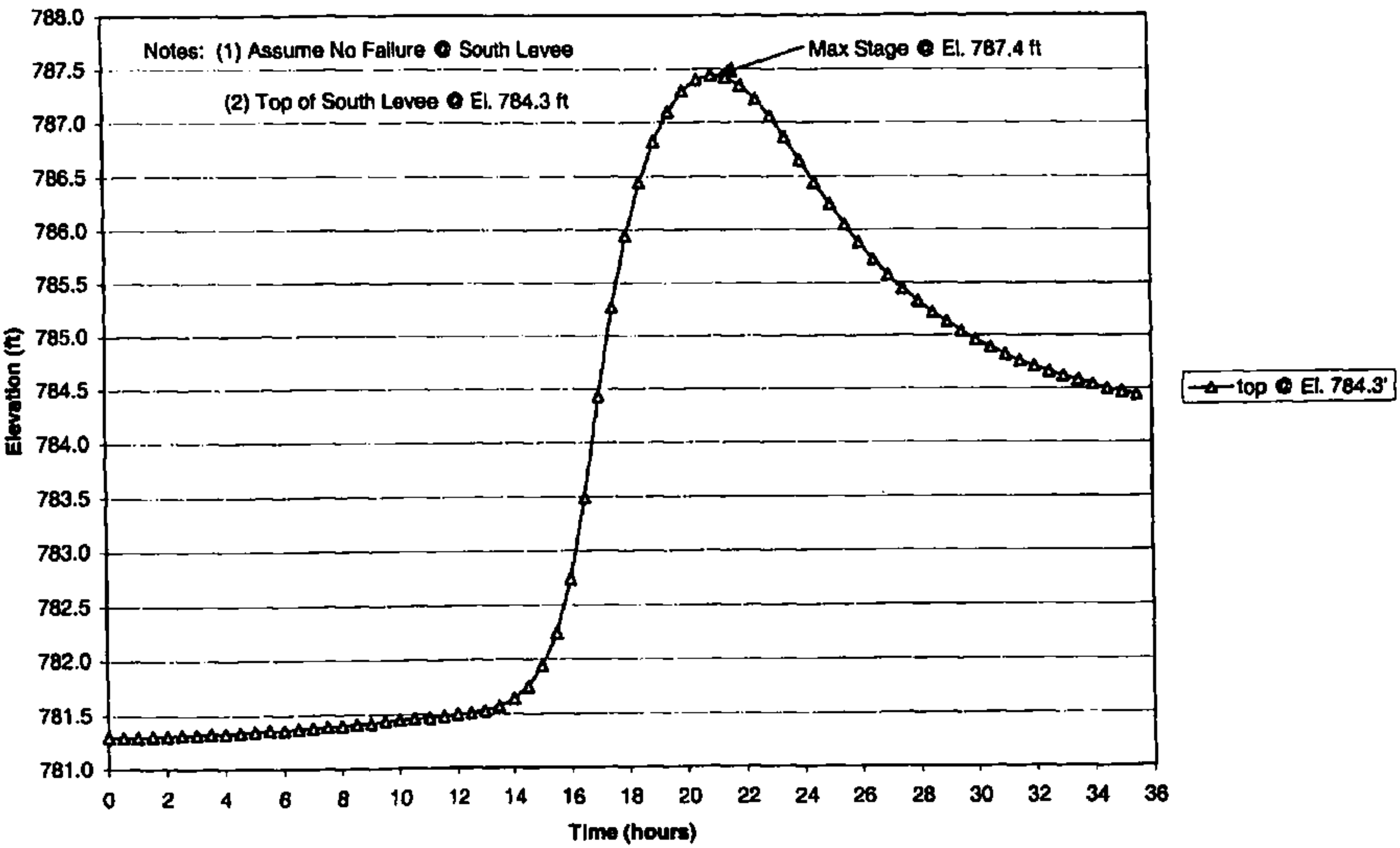


Figure 4 - Stage Hydrograph @ South Levee During PMF



APPENDIX A
DRAWINGS

Construction Drawings

LARGE-FORMAT IMAGES

One or more large-format images (over 8 ½" X 11") go here. These images are available in FERRIS at:

For Large-Format(s):
Accession No.: 20030601-0950

Security/Availability:

- ☐ PUBLIC
- ☐ NIP
- ☑ CEII
- ☐ NON-PUBLIC/PRIVILEGED

File Date: 12-20-02 Docket No.: P-10856

Parent Accession No.: 20030113-0049

Set No.: 1 of 1

Number of page(s) in set: 11

TRP-G REV.- 4/2003 (yellow)

APPENDIX B
CALCULATIONS

Stability Analysis for Spillway

MWH
MONTGOMERY WATSON HARZA

MWH ENERGY & INFRASTRUCTURE, INC.

COMPUTATION CHECKOUT SHEET

Project Name: Au Train Hydroelectric Project No. 10856

Project Number: 1001755

Project Feature: Spillway - North Dam

Purpose of Computation: Evalute Stability of Spillway

Craig Harris	Craig Harris	Manoshree Sundaram	Craig Harris
Supervisor (1)	Originator (1)	Checker (1)	Backchecker (1)

COMPUTATION CHECKOUT AND APPROVAL RECORD

Sequence Number	Responsible Individual	Procedure	Date Completed	Initials (2)
1	Supervisor	Check Originator's familiarity with DG-001. Discuss criteria, references, and planned procedures.	8/28/02	CWH
2	Originator	Review material and study scope of computation. Prepare computation outline; list criteria, references, and planned procedures.	8/28/02	CWH
3	Supervisor	Review and approve computation outline, criteria, and procedures.	8/28/02	CWH
4	Originator	Prepare computations, including sketches.	8/28/02	CWH
5	Checker	Check computations.	9/5/02	MS
6	Backchecker	Backcheck computations.	9/6/02	CWH
7	Supervisor	Review, approve, and release checked computations and sketches for preparation of drawings, reports, or other purposes.	9/6/02	CWH

(1) Full name.
(2) In own handwriting (not printed).

REVISION 1 Prepared 12/4/02 CWH
REVISION 1 Checked 12/5/02 ATB

HARZA

SUBJECT SPILLWAY STABILITY			PROJECT NAME AuTrain
COMPUTED CWH		DATE 8/28/02	PROJECT NUMBER
CHECKED MS		DATE 5Sept2002	
BACKCHECKED		DATE	

TABLE OF CONTENTS

1. GEOMETRY - SEE FIGURE ON PAGE 8, DEVELOPED FROM STONE & WEBSTER BORING, FIELDWORK AND DESIGN DRAWINGS. BASED ON THE CONSTRUCTION PHOTOS, THE FOUNDATION WAS IRREGULAR AND DID NOT FOLLOW BEDDING PLANES - A HORIZ BASE WAS USED FOR THE STABILITY CALCS

2. MATERIAL PROPERTIES - CONCRETE

STONE & WEBSTER REPORTED TWO DENSITY TESTS ON CONCRETE SAMPLES OF CORE FROM SW-15 (SEE P 40)

DEPTH	DRY DENSITY		WET DENSITY	
4.7'	137.2 pcf	AVG 142.2	148.7 pcf	AVG 151.8
5.6'	147.1		154.8	

MOST OF THE CONCRETE WILL BE WET - USE 150 pcf

3. MATERIAL PROPERTIES - ROCK

INFORMATION ON THE ROCK IS AVAILABLE FROM THREE SOURCES:

a. GEOLOGIC MAPPING STONE & WEBSTER 1994 MAPPED THE ROCK OUTCROPS DOWNSTREAM OF THE SPILLWAY. THE ROCK WAS DESCRIBED AS (SEE P36-37)

SANDSTONE, FINE-MED GRAINED, HARD TO V. HARD, FRESH TO SEVERELY WEATHERED.

BEDDING WAS THIN TO LAMINATED, PARALLEL TO WAVY, CONTINUOUS TO DISCONTINUOUS, SHALLOW DIPPING 2-5° NORTH (D/S)

JOINTS 2 DOMINATE JOINT SETS WERE MAPPED, BOTH NEAR VERTICAL, PERPENDICULAR TO EACH OTHER, STRIKING AT ABOUT 30° TO THE RIVER

b. BORINGS THE 1994 STONE & WEBSTER REPORT INCLUDED 3 BORINGS THAT ENCOUNTERED ROCK. (see pages 41-47)

SW-9 TO THE LEFT OF THE SPILLWAY

SW-15 ON THE TOE OF THE SPILLWAY

SW-4 TO THE RIGHT OF THE SPILLWAY

IN THESE BORINGS, THE ROCK IS PRIMARILY SANDSTONE WITH SOME SILTSTONE INTERBEDS

AT SW-15 - THE CONCRETE-ROCK CONTACT WAS SEPARATED. THE ROCK IMMEDIATELY BELOW THE CONTACT WAS DESCRIBED AS

SILTSTONE SILT SIZED GRAINS, TOP ½ INCH MODERATELY WEATHERED, REST FRESH, UNWEATHERED, THINLY BEDDED TO LAMINATED, WAVY TO PARALLEL, DISCONTINUOUS TO CONTINUOUS. WATER FLOWING ALONG CONTACT?

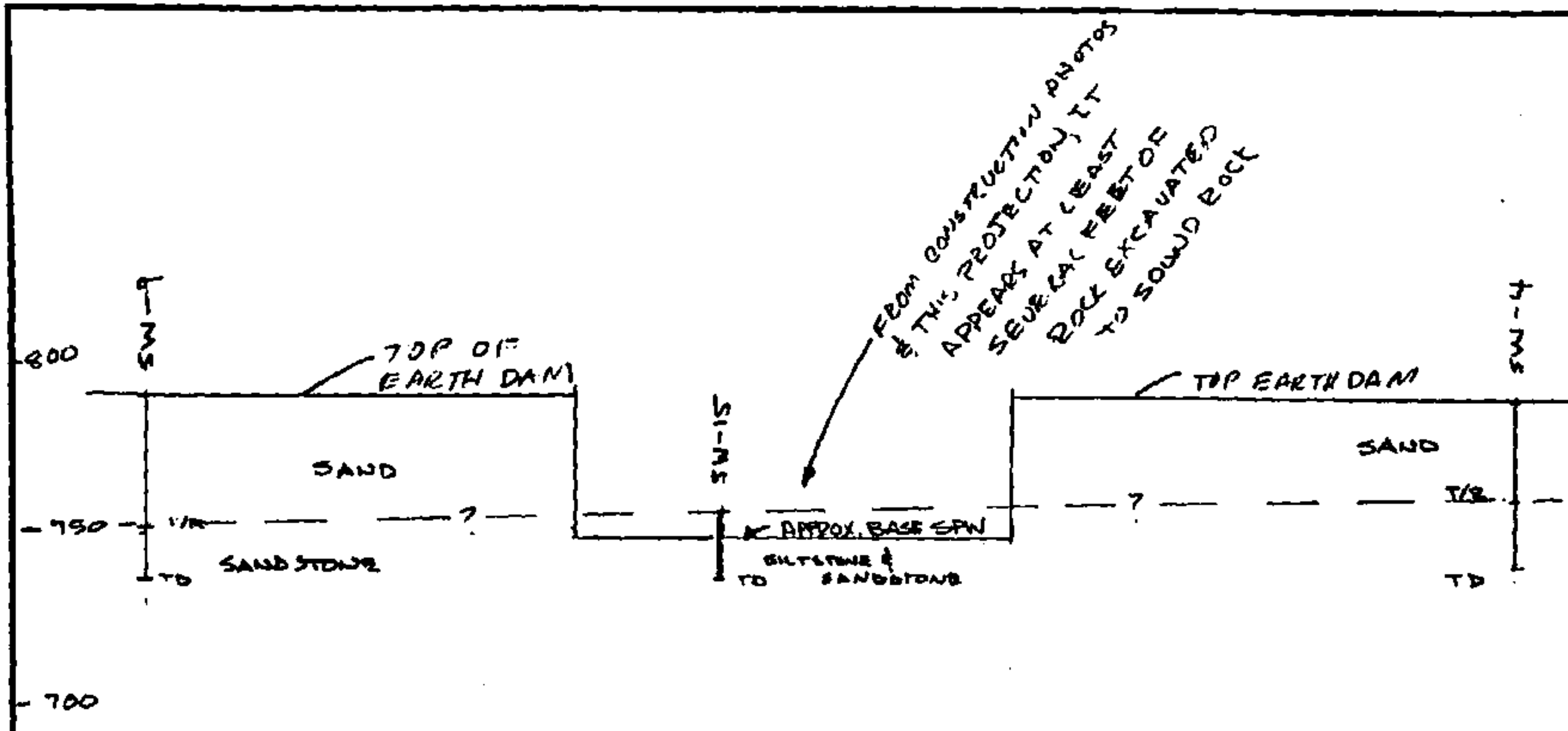
c. CONSTRUCTION PHOTOS (COPIES TO BE INCLUDED IN DESIGN REPORT)

PLATE 8448 July 1930 - SHOWS IRREGULAR ROCK SURFACE, STEPPED ON APPROX HORIZ. BEDS

HARZA — **DENVER**

SUBJECT Spillway Stability
COMPUTED CWJ DATE 8/28/02
CHECKED MS DATE 5 Sep 2002
BACKCHECKED DATE

PROJECT NAME AuTrain
PROJECT NUMBER 1001755



1"=50'

Section BB
Looking downstream
(SEE P 48 FOR LOCATION)

PLATE 8451, July 1930 SHOWS BONDING STONES BETWEEN LIFTS.

PLATE 8450, July 1930 SHOWS IRREGULAR, STEPPED ROCK FOUNDATION

PLATE 8454 July 1930 SHOWS IRREGULAR, STEPPED ROCK EXCAVATION

SUMARY OF ROCK PROPERTIES

IN ALL PHOTOGRAPHS, ROCK IS IRREGULAR & STEPPED. THE STEPS INDICATE BEDDING PLANES ARE NOT CONTINUOUS PLANES OF WEAKNESS

IT APPEARS THAT THE EXCAVATION WAS TAKEN TO SOUND ROCK.

BEDDING PLANES APPEAR ~ HORIZONTAL AND NOT SMOOTH OR PLANAR BUT WAVY AND ROUGH

ROCK IS HARD TO V. HARD AND AT CONTACT MOD WEATHERED TO FRESH.

WATER FLOWING AT CONTACT? IS PROBABLY DUE TO FLOW IN THE TWO SETS OF VERTICAL JOINTS IN ROCK (VISIBLE IN PHOTOS)

RQD IN SW 15 IS 93-97 INDICATING GOOD QUALITY ROCK

FOR THIS FOUNDATION $\Phi = 33°$ AND C UP TO 40 PSI ARE CONSIDERED REASONABLE.

IN LIEU OF TESTS | USE $\phi = 30°$ @ UPTO 20psc

4. FACTORS OF SAFETY

SINCE WE HAVE DONE A SITE SPECIFIC INVESTIGATION USE

COMBINATION	FS
FLOOD	1.5
ICE	1.5
NORMAL	2.0

EARTHQUAKE NOT REQ'D DUE TO LOW SEISMICITY

5. LOADS

	HW	TW	
NORMAL	781.3 TOP FLASH BOARDS	753.3 TOP ROCK	
PMF WITH FUSE PLUG 450'	786.6	757.0	(see page 7A FOR HW)

ICE 5 K/FT @ WINTER TARGET LEVEL 772.3

UPLIFT - ASSUME LINEAR HW - TW

SILT - APPROX 3.3 FEET - IGNORE

Au Train

	Report	SMODEL8A	SMODEL8B	
Top Fuse Plug	784.8	784.8	784.8	- PILOT CHANNEL
Base Ele, ft,	771.6	773.0	773.0	
Width, ft	400	400	450	
Max. WSL, ft	786.78	787.04	786.80	
Max Outflow, cfs	70,340	70,264	75,121	
Min. Freeboard*, ft.	2.92	2.66	2.90	OK.

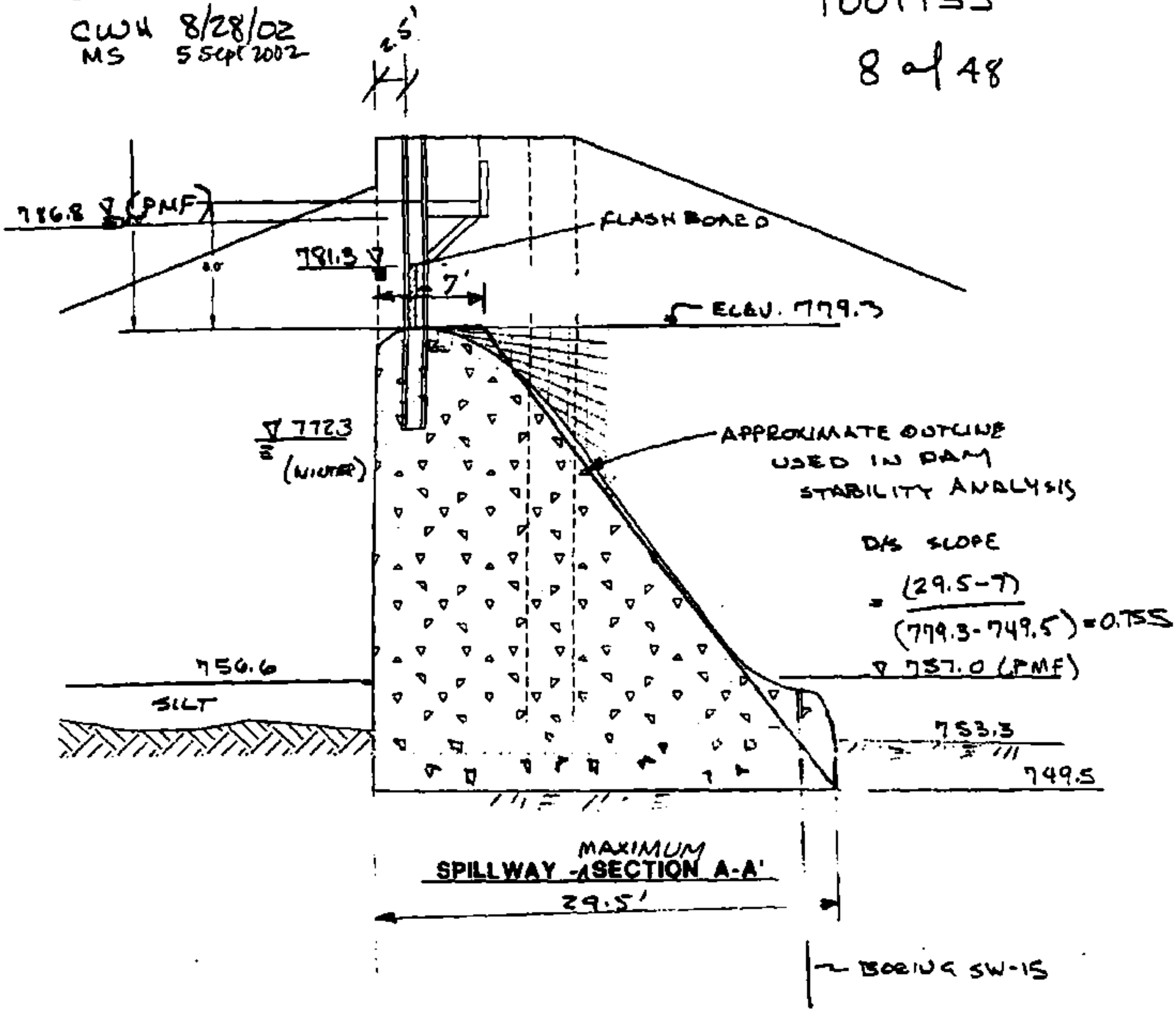
FLOOD ROUTING RESULTS FOR 450' LONG FUSE PLUG

* Top of South Levee @ El. 789.7'
Need 3.0'

Velocity thru fuse plug = 75121 cfs/(450 ft × 11.8) = 14.1 ft/sec

SPILLWAY

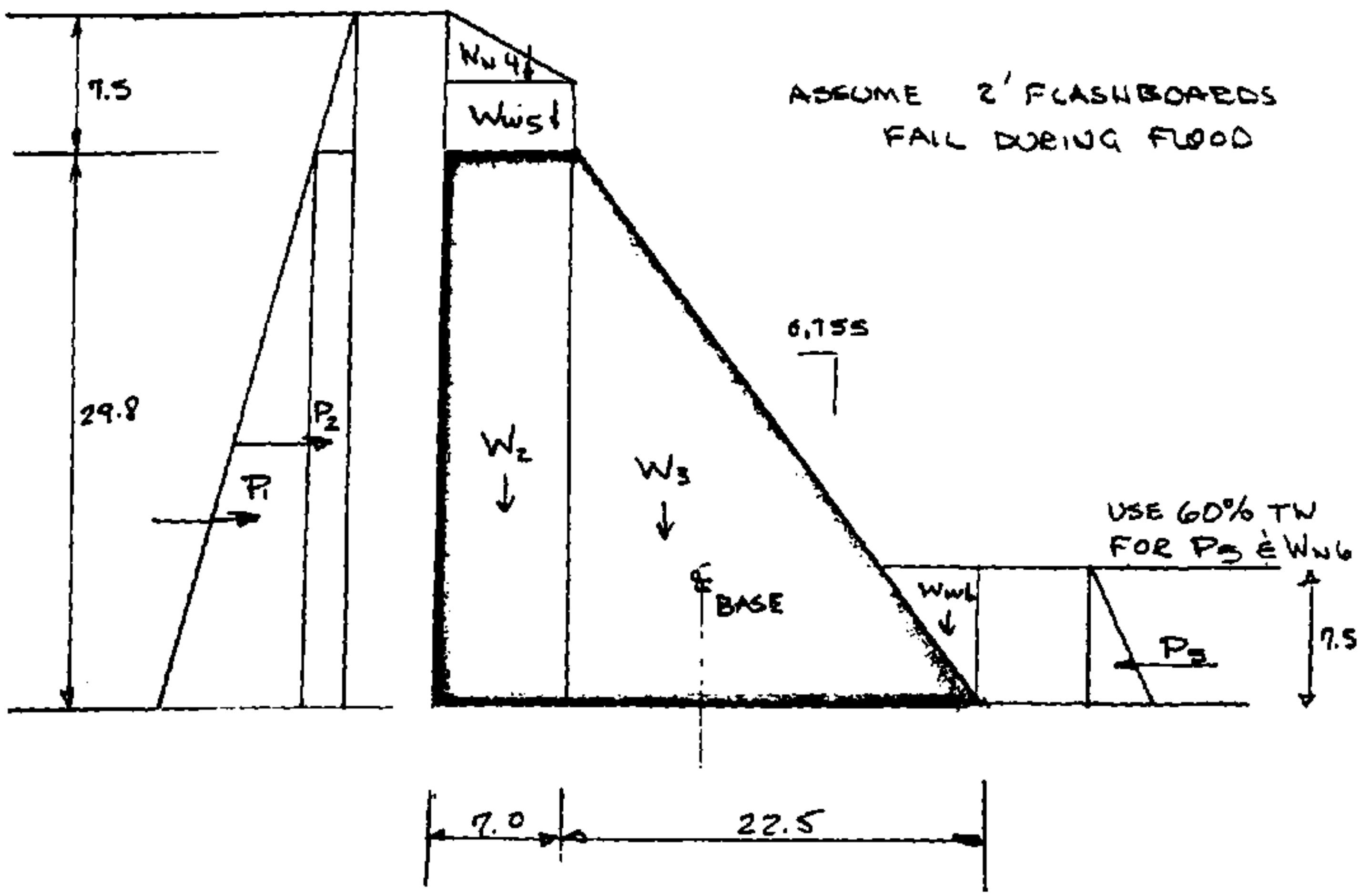
CWH 8/28/02
MS 5 Sept 2002



6. STABILITY CALC - PMF

IDEALIZED SECTION FOR STABILITY ANALYSIS

PMF FLOOD LOAD CASE



FORCE	HORIZ (KIP)	VERT (KIP)	ARM TO ℄ BASE FT	MOMENT FT KIP (+)
W_2		7 x 29.8 x 0.15 = 31.29 ↓	29.5/2 - 3.5 = 11.25	-352.0
W_3		29.8/2 x 22.5 x 0.15 = 50.29 ↓	29.5/2 - (2/3) 22.5 = 14.75 - 15.0 = 0.25 left	- 12.6
Ww4		3.75/2 x 7 x 0.0624 = 0.82 ↓	29.5/2 - 1/3 (7) = 12.4	-10.2
Ww5		3.75 x 7 x 0.0624 = 1.64 ↓	same as W_2 = 11.25	-18.4
Ww6		= ½ 0.755 (7.5 · 60%)² · 0.0624 = 0.48 ↓	= 29.5/2 - (0.755 · 7.5 · 0.60) · 1/3 = 13.6	+ 6.5
P_1	½ (29.8)² 0.0624 = 27.71 →		29.8/3 = 9.93	+ 275.2
P_2	7.5 (0.0624) 29.8 = 13.95 →		= 29.8/2 = 14.9	+ 207.9
P_5	½ (7.5 x 0.6)² 0.0624 = 0.63 ←		= (7.5 x 0.6) 1/3 = 1.5	- 0.9
Σ	Σ_H = 41.03 → ✓	Σ_V = 84.52		Σ_M = + 95.5

$$q = \frac{\Sigma V}{BL}\left(1 \pm \frac{6e}{L}\right)$$

B = 1

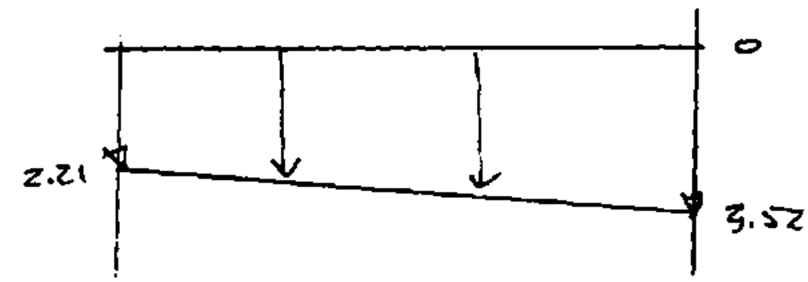
L = 29.5

$$e = \frac{\Sigma M}{\Sigma_V} = \frac{95.5}{84.52} = 1.13 \checkmark \text{ RIGHT OF ℄}$$

$$q_{heel} = \frac{84.52}{29.5}\left(1 - \frac{6(1.13)}{29.5}\right) = 2.865(1 - 0.23) = 2.21 \text{ ksf}$$

$q_{toe} = 2.865(1+0.23) = 3.52$ ksf

$U_{heel} = (29.8+7.5)\,0.0624 = 2.3275 > 2.21 \Rightarrow$ CRACKED BASE

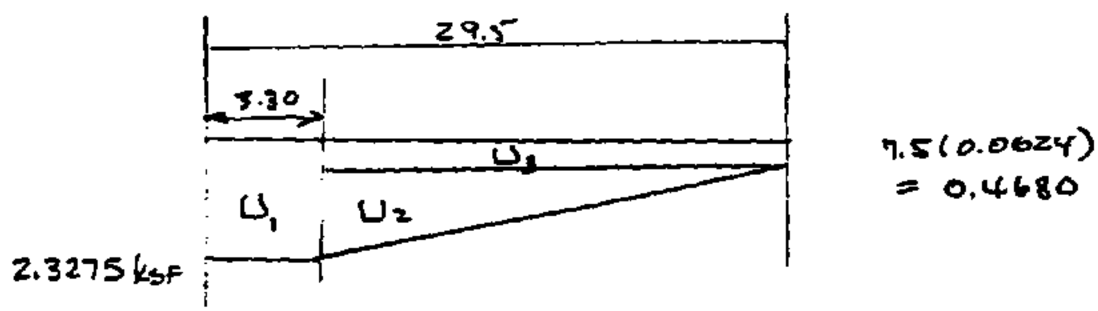


$$e' = \frac{\Sigma M}{\Sigma V - U_{heel}\,(L)}$$

$$= \frac{95.5}{84.52-(2.3275\;29.5)} = 6.02 \text{ FT}$$

UNCRACKED LENGTH $= 3\left(\frac{29.5}{2} - 6.02\right) = 26.2$

CRACK $= 29.5 - 26.2 = 3.30$



$U_1 = 3.30(2.3275)$	$= 7.68$
$U_2 = \frac{1}{2}(29.5-3.30)(2.3275-0.4680)$	$= 24.36$
$U_3 = (29.5-3.30)\,0.4680$	$= 12.26$
	44.30

$$FS = \frac{(\Sigma V - \Sigma U)\tan\phi}{\Sigma H} + \frac{L \times C}{\Sigma H}$$

$$= \frac{(84.52-44.30)\tan 30^\circ}{41.03} + \frac{(29.5-3.5)\,10.2\frac{lb}{IN^2}\cdot\frac{144\,IN^2}{1FT^2}\cdot\frac{1k}{1000lb}}{41.03}$$

$$= 0.566 + 0.938$$

$$= 1.504 > 1.5 \quad OK$$

ANALYSIS CONSERVATIVE BECAUSE IT DOES NOT INCLUDE RESISTANCE DUE TO:

1. PASSIVE ROCK WEDGE AT DOWNSTREAM TOE
2. 3-DIMENSIONAL EFFECT OF WING WALLS ONSIDE OF SPILLWAY. CONSTR PHOTOS SHOW BLOCK JOINTS KEYED

THE FOLLOWING SPREADSHEETS CALCULATE STABILITY FOR THE VARIOUS LOAD COMBINATION.

PAGE	LOAD COMBINATION	
13-17	PMF	REPEAT HAND CALC. ON PP 9-12
18-22	PMF	CALCULATE $\phi_{REQ'D}$ IF C=0
23-27	NORMAL+ICE	
28-32	NORMAL	

7. AUTRAIN SPILLWAY
Flood Loading

03:44 PM 29-Aug-02 CALC 1001755-1

Prep by: CWH Checked by: MS PAGE 13 OF 48

USBR Cracked Base Analysis Method with following limitations:
-No reduction of uplift within dam during flood, uplift reduction due to drains not considered,
tailwater level must be below downstream slope change, headwater overtopping flashboards not checked

A) Shape and Size of Dam/Pool Levels

Top of Concrete Dam	779.3 ✓	(Elev)
Bottom of Dam	749.5 ✓	(Elev)
T.O. Flshbrds,0 if none	0.0	(Elev)
U/S Slope Change	779.3 ✓	(Elev)
D/S Slope Change	779.3 ✓	(Elev)
Crest Width	7.0 ✓	(FT)
U/S Slope	0.000 ✓	(Decimal)
D/S Slope	0.755 ✓	(Decimal)
Headwater Elev.	786.8 ✓	(Elev)
Tailwater Elev.	757.0 ✓	(Elev)
F.B. Loc from U/S Crest	0.00 ✓	(FT)

ASSUME FLASHBOARDS FAIL DURING FLOOD

Input Summary

Dam Ht	29.8 ✓	(FT)
HW Level	37.3 ✓	(FT)
TW Level	7.5 ✓	(FT)
Overtop	7.50 ✓	(FT)
Eff TW	4.5 ✓	
Ice Load	No	
Silt Load	No	
Anchors	No	
Flshbrd Ht	0.00 ✓	(FT)

Load Summary

Elev. (ft)	Sum of Horiz. Forces (kips)	Sum of Vertical Forces w/o Uplift (kips)	Sum of Uplift (kips)	Sum of Moments w/o Uplift (kips)	e (ft)	e' (ft)
776.32	1.67	8.09	-3.02	-3	-0.54	-0.54
773.34	3.90	10.73	-4.63	-5	-0.42	-0.42
770.36	6.69	16.37	-7.06	-4	-0.25	-0.25
767.38	10.01	23.02	-9.69	-1	-0.06	-0.08
764.40	13.90	30.67	-12.75	4	0.13	0.13
761.42	18.34	39.33	-16.23	13	0.32	0.32
758.44	23.34	49.00	-20.13	25	0.51	0.51
755.46	28.89	59.67	-25.65	42	0.70	0.70
752.48	34.92	71.40	-33.02	64	0.89	0.89
749.50	41.02 ✓	84.51 ✓	-44.31	96 ✓	1.13	6.02

B) Material Properties

Unit Wt Water	0.0624 ✓	(KCF)
Unit Wt Concrete	0.1500 ✓	(KCF)
Friction Angle,Lift Jt	45.00 ✓	(DEG)
Friction Angle,Contact	30.00 ✓	(DEG)
Cohesion,Lift Jt	50.00 ✓	(psi)
Cohesion,Contact	10.20 ✓	(psi)

Stability Summary

Elevation (ft)	Section Width (ft)	Crack Length (ft)	Shear Friction Safety Factor
776.32	9.25	N/A	41.67
773.34	11.50	N/A	22.76
770.36	13.75	N/A	16.22
767.38	16.00	N/A	12.84
764.40	18.25	N/A	10.74
761.42	20.50	N/A	9.31
758.44	22.75	N/A	8.26
755.46	25.00	N/A	7.41
752.48	27.25	N/A	6.72
749.50	29.50	3.31	1.50

Stress Summary

Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)
0.89	-0.65	0.24	0.43	0.00	0.43
1.14	-0.84	0.30	0.73	0.00	0.73
1.32	-1.03	0.29	1.06	0.00	1.06
1.47	-1.21	0.26	1.41	0.00	1.41
1.61	-1.40	0.21	1.75	0.00	1.75
1.74	-1.58	0.15	2.10	0.00	2.10
1.86	-1.77	0.09	2.44	0.00	2.44
1.99	-1.96	0.03	2.79	-0.10	2.69
2.10	-2.14	-0.04	3.14	-0.28	2.85
2.33	-2.33	0.00	3.54	-0.47	3.07

C) Other Loads

Ice Point Load	0.00 ✓	(KIPS/FT)
Ice Load Elev	0.0 ✓	(Elev)
Sat Unit Wt Silt	0.1250 ✓	(KCF)
Silt Thickness	0.0 ✓	(FT)
Earth Pressure Coeff.	0.33 ✓	(Default = 75)
Anchor Load	0.0 ✓	(KIP/FT)
Anchor Distance from U/S Edge of Crest	4.0 ✓	(FT)
TW Retrogression Coeff. (.6 for Spwy. Section) (1 for Non-overflow)	0.60 ✓	
Horiz. Crest Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vert. Crest Pressure	0.00	(KIPS/FT)
Distance from U/S Edge of Crest	0.00	(FT)
Horiz. Bucket Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vertical Bucket Pressure	0.00	(KIPS/FT)
Distance from U/S Edge of Crest	0.00	(FT)

MWH

File: AuTrainSpwyPMF Load Case.xls

AUTRAIN SPILLWAY
Flood Loading

03:44 PM 28-Aug-02 CALC 1001756-1

Prep by: aWH Checked by: MS PAGE 14 OF 48

STATIC ANALYSIS

1. Concrete Weights and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	W1 (kips)	W2 (kips)	W3 (kips)	w1 (ft)	w2 (ft)	w3 (ft)	w (ft)	CLb (ft)	x1 (ft)	x2 (ft)	x3 (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.00	3.13	0.50	0.00	7.00	2.25	9.25	4.62	0.00	-1.12	3.13
2.00	0.80	773.34	23.84	0.00	6.26	2.01	0.00	7.00	4.50	11.50	5.75	0.00	-2.25	2.75
3.00	0.70	770.36	20.86	0.00	9.39	4.53	0.00	7.00	6.75	13.75	6.87	0.00	-3.37	2.38
4.00	0.60	767.38	17.88	0.00	12.52	8.05	0.00	7.00	9.00	16.00	8.00	0.00	-4.50	2.00
5.00	0.50	764.40	14.90	0.00	15.65	12.57	0.00	7.00	11.25	18.25	9.12	0.00	-5.62	1.63
6.00	0.40	761.42	11.92	0.00	18.77	18.10	0.00	7.00	13.50	20.50	10.25	0.00	-6.75	1.25
7.00	0.30	758.44	8.94	0.00	21.90	24.64	0.00	7.00	15.75	22.75	11.37	0.00	-7.87	0.88
8.00	0.20	755.46	5.96	0.00	25.03	32.18	0.00	7.00	18.00	25.00	12.50	0.00	-9.00	0.50
9.00	0.10	752.48	2.98	0.00	28.16	40.73	0.00	7.00	20.25	27.25	13.62	0.00	-10.12	0.13
10.00	0.00	749.50	0.00	0.00	31.29	50.29	0.00	7.00	22.50	29.50	14.75	0.00	-11.25	-0.25
					✓	✓							✓	✓

2. Vertical Weights + Moment Arms of Reservoir on Dam

Block	y/Hs	Elevation (ft)	y (ft)	Overtop Weight on U/S Fillet Ww1 (kips)	Normal HW Above U/S Fillet Ww2 (kips)	Normal HW On U/S Fillet Ww3 (kips)	Overtop Water Weight on Crest Ww4 (kips)	Overtop Water Weight on Crest Ww5 (kips)	Tailwater Weight Ww6 (kips)	Water U/S of Flashboards Ww7 (kips)	xw1 (ft)	xw2 (ft)	xw3 (ft)	xw4 (ft)	xw5 (ft)	xw6 (ft)	xw7 (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-2.29	-1.12	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-3.42	-2.25	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-4.54	-3.37	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-5.67	-4.50	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-6.79	-5.62	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-7.92	-6.75	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-9.04	-7.87	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-10.17	-9.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.82	1.64	0.06	0.00	0.00	0.00	0.00	-11.29	-10.12	13.24	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.82	1.64	0.48	0.00	0.00	0.00	0.00	-12.42	-11.25	13.62	0.00
							✓	✓	✓					✓	✓	✓	

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Prep by: CWH Checked by: MS PAGE 15 OF 48

AUTRAIN SPILLWAY
Flood Loading

03:44 PM 28-Aug-02 CALC 1001756-1

3. Horizontal Reservoir Forces, Silt Loads, Ice Loads, and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	HW P1 (kips)	HW P2 (kips)	Silt P3 (kips)	Ice P4 (kips)	TW P5 (kips)	yP1 (ft)	yP2 (ft)	yP3 (ft)	yP4 (ft)	yP5 (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.28	1.39	0.00	0.00	0.00	0.99	1.49	0.00	0.00	0.00
2.00	0.80	773.34	23.84	1.11	2.79	0.00	0.00	0.00	1.99	2.98	0.00	0.00	0.00
3.00	0.70	770.36	20.86	2.49	4.18	0.00	0.00	0.00	2.98	4.47	0.00	0.00	0.00
4.00	0.60	767.38	17.88	4.43	5.58	0.00	0.00	0.00	3.97	5.96	0.00	0.00	0.00
5.00	0.50	764.40	14.90	6.93	6.97	0.00	0.00	0.00	4.97	7.45	0.00	0.00	0.00
6.00	0.40	761.42	11.92	9.97	8.37	0.00	0.00	0.00	5.96	8.94	0.00	0.00	0.00
7.00	0.30	758.44	8.94	13.59	9.76	0.00	0.00	0.00	6.95	10.43	0.00	0.00	0.00
8.00	0.20	755.46	5.96	17.73	11.16	0.00	0.00	0.00	7.95	11.92	0.00	0.00	0.00
9.00	0.10	752.48	2.98	22.44	12.55	0.00	0.00	-0.07	8.94	13.41	0.00	0.00	0.51
10.00	0.00	749.50	0.00	27.71	13.95	0.00	0.00	-0.83	9.93	14.90	0.00	0.00	1.50
				✓	✓			✓	✓	✓			✓

4. Anchor Force, Silt Weight, Bucket and Crest Pressures, and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	Anchor Wa (kips)	Silt Ws (kips)	xs (ft)	ys (ft)	Crest Pressure Wc (kips)	Pc (kips)	xc (ft)	yc (ft)	Bucket Pressure Wb (kips)	Pb (kips)	xb (ft)	yb (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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5. Uplift Forces and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	Section Width (ft)	Crack Length (ft)	U1 (kips)	U2 (kips)	U3 (kips)	xu1 (ft)	xu2 (ft)	xu3 (ft)
=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	9.25	N/A	0.00	-3.02	0.00	0.00	-1.54	0.00
2.00	0.80	773.34	23.84	11.50	N/A	0.00	-4.83	0.00	0.00	-1.92	0.00
3.00	0.70	770.36	20.86	13.75	N/A	0.00	-7.06	0.00	0.00	-2.29	0.00
4.00	0.60	767.38	17.88	16.00	N/A	0.00	-9.69	0.00	0.00	-2.67	0.00
5.00	0.50	764.40	14.90	18.25	N/A	0.00	-12.75	0.00	0.00	-3.04	0.00
6.00	0.40	761.42	11.92	20.50	N/A	0.00	-16.23	0.00	0.00	-3.42	0.00
7.00	0.30	758.44	8.94	22.75	N/A	0.00	-20.13	0.00	0.00	-3.79	0.00
8.00	0.20	755.46	5.96	25.00	N/A	-2.40	-23.24	0.00	0.00	-4.17	0.00
9.00	0.10	752.48	2.98	27.25	N/A	-7.99	-25.34	0.00	0.00	-4.54	0.00
10.00	0.00	749.50	0.00	29.50	3.31	-13.61	-24.35	-6.16	0.00	-2.71	-13.08

6. Shear Friction Safety Factor

Block	y/Hs	Elevation (ft)	y (ft)	SigFH sum of horz. forces (kips)	SigM sum of moments w/o uplift (kip-ft)	SigFV sum of vertical forces w/o uplift (kips)	AS uplift at heel (ksf)	e (ft)	Sig1 heel stress w/o uplift (ksf)	Sig2 toe stress w/o uplift (ksf)	e' (ft)	T Crack Length (ft)	Section Width (ft)	Total Uplift (kips)	F.S. Shear Friction Factor
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	1.87	-3.31	8.09	-0.65	-0.54	0.89	0.43	-0.54	N/A	9.25	-3.02	41.87
2.00	0.80	773.34	23.84	3.90	-4.52	10.73	-0.84	-0.42	1.14	0.73	-0.42	N/A	11.50	-4.83	22.76
3.00	0.70	770.36	20.86	6.66	-4.05	16.37	-1.03	-0.25	1.32	1.06	-0.25	N/A	13.75	-7.06	16.22
4.00	0.60	767.38	17.88	10.01	-1.38	23.02	-1.21	-0.06	1.47	1.41	-0.06	N/A	16.00	-9.69	12.64
5.00	0.50	764.40	14.90	13.90	4.01	30.67	-1.40	0.13	1.61	1.75	0.13	N/A	18.25	-12.75	10.74
6.00	0.40	761.42	11.92	18.34	12.63	39.33	-1.58	0.32	1.74	2.10	0.32	N/A	20.50	-16.23	9.31
7.00	0.30	758.44	8.94	23.34	25.00	49.00	-1.77	0.51	1.86	2.44	0.51	N/A	22.75	-20.13	8.26
8.00	0.20	755.46	5.96	28.89	41.66	59.67	-1.96	0.70	1.99	2.79	0.70	N/A	25.00	-25.65	7.41
9.00	0.10	752.48	2.98	34.92	63.79	71.40	-2.14	0.89	2.10	3.14	0.89	N/A	27.25	-33.02	6.72
10.00	0.00	749.50	0.00	41.02	95.42	84.51	-2.33	1.13	2.21	3.52	6.02	3.31	29.50	-44.31	1.50

AUTRAIN SPILLWAY
Flood Loading

03.44 PM 28-Aug-02 CALC 1001755-1

Prep. by: CWW Checked by: MS PAGE 17 OF 49

7. Stresses at Heel and Toe

Block	y/Hs	Elevation (ft)	y (ft)	T Crack Length (ft)	Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)	Sum of Total Stress Diagram (kips)	Sum of Effect Stress Diagram (kips)	Sum of Uplift Diagram (kips)	Sum of Effect Diagrams (kips)	SigFV sum of vert forces w/o uplift (Part6,Col.6) (kips)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	N/A	0.89	-0.65	0.24	0.43	0.00	0.43	-6.1	-3.1	-3.0	-6.1	6.1
2.00	0.80	773.34	23.84	N/A	1.14	-0.84	0.30	0.73	0.00	0.73	-10.7	-6.8	-4.8	-10.7	10.7
3.00	0.70	770.36	20.86	N/A	1.32	-1.03	0.29	1.06	0.00	1.08	-16.4	-9.3	-7.1	-16.4	16.4
4.00	0.60	767.38	17.88	N/A	1.47	-1.21	0.26	1.41	0.00	1.41	-23.0	-13.3	-9.7	-23.0	23.0
5.00	0.50	764.40	14.90	N/A	1.61	-1.40	0.21	1.75	0.00	1.75	-30.7	-17.9	-12.8	-30.7	30.7
6.00	0.40	761.42	11.92	N/A	1.74	-1.58	0.15	2.10	0.00	2.10	-39.3	-23.1	-16.2	-39.3	39.3
7.00	0.30	758.44	8.94	N/A	1.88	-1.77	0.09	2.44	0.00	2.44	-49.0	-28.9	-20.1	-49.0	49.0
8.00	0.20	755.46	5.96	N/A	1.99	-1.95	0.03	2.79	-0.10	2.69	-59.7	-34.0	-25.6	-59.7	59.7
9.00	0.10	752.48	2.98	N/A	2.10	-2.14	-0.04	3.14	-0.28	2.85	-71.4	-38.4	-33.0	-71.4	71.4
10.00	0.00	749.50	0.00	3.31	2.33	-2.33	0.00	3.54	-0.47	3.07	-84.5	-40.2	-44.3 ✓	-84.5	84.5

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8. AUTRAIN SPILLWAY
Flood Loading

03:46 PM 28-Aug-02 CALC 1001756-1

Prep by: awH Checked by: MS PAGE 18 OF 48

USBR Cracked Base Analysis Method with following limitations:
-No reduction of uplift within dam during flood, uplift reduction due to drains not considered,
tailwater level must be below downstream slope change, headwater overtopping flashboards not checked

A) Shape and Size of Dam/Pool Levels

Top of Concrete Dam	779.3	(Elev)
Bottom of Dam	749.5	(Elev)
T.O. Flshbrds,0 if none	0.0	(Elev)
U/S Slope Change	779.3	(Elev)
D/S Slope Change	779.3	(Elev)
Crest Width	7.0	(FT)
U/S Slope	0.000	(Decimal)
D/S Slope	0.758	(Decimal)
Headwater Elev.	786.8	(Elev)
Tailwater Elev.	757.0	(Elev)
F.B. Loc from U/S Crest	0.00	(FT)

ASSUME FLASHBOARDS FAIL DURING FLOOD

Input Summary

Dam Ht	29.8	(FT)
HW Level	37.3	(FT)
TW Level	7.5	(FT)
Overtop	7.50	(FT)
Eff. TW	4.5	
Ice Load	No	
Silt Load	No	
Anchors	No	
Flshbrd Ht	0.00	(FT)

Load Summary

Elev. (ft)	Sum of Horiz. Forces (kips)	Sum of Vertical Forces w/o Uplift (kips)	Sum of Uplift (kips)	Sum of Moments w/o Uplift (kips)	e (ft)	e' (ft)
776.32	1.67	6.09	-3.02	-3	-0.54	-0.54
773.34	3.90	10.73	-4.63	-6	-0.42	-0.42
770.36	6.66	16.37	-7.06	-4	-0.25	-0.25
767.38	10.01	23.02	-9.69	-1	-0.06	-0.06
764.40	13.90	30.67	-12.76	4	0.13	0.13
761.42	18.34	39.33	-16.23	13	0.32	0.32
758.44	23.34	49.00	-20.13	25	0.51	0.51
755.46	28.89	59.67	-25.66	42	0.70	0.70
752.48	34.92	71.40	-33.02	64	0.89	0.89
749.50	41.02	84.51	-44.31	95	1.13	6.02

B) Material Properties

Unit Wt Water	0.0624	(KCF)
Unit Wt Concrete	0.1500	(KCF)
Friction Angle,Lift Jt	45.00	(DEG)
Friction Angle,Contact	57.00	(DEG)
Cohesion,Lift Jt	50.00	(psi)
Cohesion,Contact	0.00	(psi)

Stability Summary

Elevation (ft)	Section Width (ft)	Crack Length (ft)	Shear Friction Safety Factor
776.32	9.25	N/A	41.67
773.34	11.50	N/A	22.76
770.36	13.75	N/A	16.22
767.38	16.00	N/A	12.84
764.40	18.25	N/A	10.74
761.42	20.50	N/A	9.31
758.44	22.75	N/A	8.28
755.46	25.00	N/A	7.41
752.48	27.25	N/A	6.72
749.50	29.50	3.31	1.51

Stress Summary

Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)
0.89	-0.66	0.24	0.43	0.00	0.43
1.14	-0.84	0.30	0.73	0.00	0.73
1.32	-1.03	0.29	1.08	0.00	1.08
1.47	-1.21	0.26	1.41	0.00	1.41
1.61	-1.40	0.21	1.75	0.00	1.75
1.74	-1.58	0.15	2.10	0.00	2.10
1.86	-1.77	0.09	2.44	0.00	2.44
1.98	-1.96	0.03	2.79	-0.10	2.69
2.10	-2.14	-0.04	3.14	-0.28	2.86
2.33	-2.33	0.00	3.54	-0.47	3.07

C) Other Loads

Ice Point Load	0.00	(KIPS/FT)
Ice Load Elev	0.0	(Elev)
Sat Unit Wt Silt	0.12000	(KCF)
Silt Thickness	0.0	(FT)
Earth Pressure Coeff.	0.33	(Default = .75)
Anchor Load	0.0	(KIP/FT)
Anchor Distance from U/S Edge of Crest	4.0	(FT)
TW Retrogression Coeff. (.6 for Spwy. Section) (1 for Non-overflow)	0.60	
Horiz. Crest Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vert. Crest Pressure	0.00	(KIPS/FT)
Distance from U/S Edge of Crest	0.00	(FT)
Horiz. Bucket Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vertical Bucket Pressure	0.00	(KIPS/FT)
Distance from U/S Edge of Crest	0.00	(FT)

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AUTRAIN SPILLWAY
Flood Loading

03:46 PM 26-Aug-02 CALC 1001756-1 Prep by: CWH Checked by: MS PAGE 19 OF 48

STATIC ANALYSIS

1. Concrete Weights and Moment Arms

Block	y/He	Elevation (ft)	y (ft)	W1 (kips)	W2 (kips)	W3 (kips)	w1 (ft)	w2 (ft)	w3 (ft)	w (ft)	CLb (ft)	x1 (ft)	x2 (ft)	x3 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	3.13	0.50	0.00	7.00	2.25	9.25	4.62	0.00	-1.12	3.13
2.00	0.80	773.34	23.84	0.00	6.26	2.01	0.00	7.00	4.50	11.50	5.75	0.00	-2.25	2.75
3.00	0.70	770.36	20.86	0.00	9.39	4.53	0.00	7.00	6.75	13.75	6.87	0.00	-3.37	2.38
4.00	0.60	767.38	17.88	0.00	12.52	8.05	0.00	7.00	9.00	16.00	8.00	0.00	-4.50	2.00
5.00	0.50	764.40	14.90	0.00	15.65	12.57	0.00	7.00	11.25	18.25	9.12	0.00	-5.62	1.63
6.00	0.40	761.42	11.92	0.00	18.77	18.10	0.00	7.00	13.50	20.50	10.25	0.00	-6.75	1.25
7.00	0.30	758.44	8.94	0.00	21.90	24.64	0.00	7.00	15.75	22.75	11.37	0.00	-7.87	0.88
8.00	0.20	755.46	5.96	0.00	25.03	32.16	0.00	7.00	18.00	25.00	12.50	0.00	-9.00	0.50
9.00	0.10	752.48	2.98	0.00	28.16	40.73	0.00	7.00	20.25	27.25	13.62	0.00	-10.12	0.13
10.00	0.00	749.50	0.00	0.00	31.29	50.28	0.00	7.00	22.50	29.50	14.75	0.00	-11.25	-0.25

2. Vertical Weights + Moment Arms of Reservoir on Dam

Block	y/He	Elevation (ft)	y (ft)	Overtop Weight on U/S Fillet Ww1 (kips)	Normal HW Above U/S Fillet Ww2 (kips)	Normal HW On U/S Fillet Ww3 (kips)	Overtop Water Weight on Crest Ww4 (kips)	Overtop Water Weight on Crest Ww5 (kips)	Tailwater Weight Ww6 (kips)	Water U/S of Flashboards Ww7 (kips)	xw1 (ft)	xw2 (ft)	xw3 (ft)	xw4 (ft)	xw5 (ft)	xw6 (ft)	xw7 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-2.29	-1.12	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-3.42	-2.25	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-4.54	-3.37	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-5.67	-4.50	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-6.79	-5.62	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-7.92	-6.75	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-9.04	-7.87	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.82	1.64	0.00	0.00	0.00	0.00	0.00	-10.17	-9.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.82	1.64	0.05	0.00	0.00	0.00	0.00	-11.29	-10.12	13.24	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.82	1.64	0.48	0.00	0.00	0.00	0.00	-12.42	-11.25	13.62	0.00

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AUTRAIN SPILLWAY 03:49 PM 28-Aug-02 CALC 1001756-1 Prep by: CWH Checked by: MS PAGE 20 OF 48
Flood Loading

3. Horizontal Reservoir Forces, Silt Loads, Ice Loads, and Moment Arms

				HW	HW	Silt	Ice	TW					
Block	y/Hs	Elevation (ft)	y (ft)	P1 (kips)	P2 (kips)	P3 (kips)	P4 (kips)	P5 (kips)	yP1 (ft)	yP2 (ft)	yP3 (ft)	yP4 (ft)	yP5 (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.28	1.38	0.00	0.00	0.00	0.99	1.49	0.00	0.00	0.00
2.00	0.80	773.34	23.84	1.11	2.79	0.00	0.00	0.00	1.98	2.98	0.00	0.00	0.00
3.00	0.70	770.36	20.86	2.49	4.16	0.00	0.00	0.00	2.98	4.47	0.00	0.00	0.00
4.00	0.60	767.38	17.88	4.43	5.56	0.00	0.00	0.00	3.97	5.96	0.00	0.00	0.00
5.00	0.50	764.40	14.90	6.93	6.97	0.00	0.00	0.00	4.97	7.45	0.00	0.00	0.00
6.00	0.40	761.42	11.92	9.97	8.37	0.00	0.00	0.00	5.96	8.94	0.00	0.00	0.00
7.00	0.30	758.44	8.94	13.58	9.76	0.00	0.00	0.00	6.95	10.43	0.00	0.00	0.00
8.00	0.20	755.46	5.96	17.73	11.16	0.05	0.00	0.00	7.96	11.92	0.00	0.00	0.00
9.00	0.10	752.48	2.98	22.44	12.56	0.00	0.00	-0.07	8.94	13.41	0.00	0.00	0.51
10.00	0.00	749.50	0.00	27.71	13.95	0.00	0.00	-0.63	9.93	14.90	0.00	0.00	1.50

4. Anchor Force, Silt Weight, Bucket and Crest Pressures, and Moment Arms

				Anchor	Silt			Crest Pressure				Bucket Pressure			
Block	y/Hs	Elevation (ft)	y (ft)	Wa (kips)	Ws (kips)	xs (ft)	xa (ft)	Wc (kips)	Pc (kips)	xc (ft)	yc (ft)	Wb (kips)	Pb (kips)	xb (ft)	yb (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

AUTRAIN SPILLWAY
Flood Loading

03:48 PM 28-Aug-02

CALC 1001755-1

Prep. by: CWH Checked by: MS PAGE 21 OF 48

5. Uplift Forces and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	*Section Width (ft)	Crack Length (ft)	U1 (kips)	U2 (kips)	U3 (kips)	xu1 (ft)	xu2 (ft)	xu3 (ft)
1.00	0.90	776.32	26.82	9.25	N/A	0.00	-3.02	0.00	0.00	-1.84	0.00
2.00	0.80	773.34	23.84	11.50	N/A	0.00	-4.83	0.00	0.00	-1.92	0.00
3.00	0.70	770.36	20.86	13.75	N/A	0.00	-7.05	0.00	0.00	-2.29	0.00
4.00	0.60	767.38	17.88	16.00	N/A	0.00	-9.69	0.00	0.00	-2.67	0.00
5.00	0.50	764.40	14.90	18.25	N/A	0.00	-12.75	0.00	0.00	-3.04	0.00
6.00	0.40	761.42	11.92	20.50	N/A	0.00	-16.23	0.00	0.00	-3.42	0.00
7.00	0.30	758.44	8.94	22.75	N/A	0.00	-20.13	0.00	0.00	-3.79	0.00
8.00	0.20	755.46	5.96	25.00	N/A	-2.40	-23.24	0.00	0.00	-4.17	0.00
9.00	0.10	752.48	2.98	27.25	N/A	-7.89	-25.34	0.00	0.00	-4.84	0.00
10.00	0.00	749.50	0.00	29.50	3.31	-13.81	-24.36	-8.16	0.00	-2.71	-13.09

6. Shear Friction Safety Factor

Block	y/Hs	Elevation (ft)	y (ft)	SigFH sum of horz forces (kips)	SigM sum of moments w/o uplift (kip-ft)	SigFV sum of vertical forces w/o uplift (kips)	A3 uplift at heel (ksf)	e (ft)	Sig1 heel stress w/o uplift (ksf)	Sig2 toe stress w/o uplift (ksf)	e' (ft)	T Crack Length (ft)	Section Width (ft)	Total Uplift (kips)	F S Shear Friction Factor
1.00	0.90	776.32	26.82	1.67	-3.31	6.09	-0.66	-0.54	0.69	0.43	-0.54	N/A	9.25	-3.02	41.67
2.00	0.80	773.34	23.84	3.80	-4.52	10.73	-0.84	-0.42	1.14	0.73	-0.42	N/A	11.50	-4.83	22.78
3.00	0.70	770.36	20.86	6.89	-4.05	16.37	-1.03	-0.25	1.32	1.06	-0.25	N/A	13.75	-7.05	16.22
4.00	0.60	767.38	17.88	10.01	-1.38	23.02	-1.21	-0.06	1.47	1.41	-0.06	N/A	16.00	-9.69	12.84
5.00	0.50	764.40	14.90	13.90	4.01	30.67	-1.40	0.13	1.61	1.75	0.13	N/A	18.25	-12.75	10.74
6.00	0.40	761.42	11.92	18.34	12.83	39.33	-1.58	0.32	1.74	2.10	0.32	N/A	20.50	-16.23	9.31
7.00	0.30	758.44	8.94	23.34	25.00	49.00	-1.77	0.51	1.86	2.44	0.51	N/A	22.75	-20.13	8.28
8.00	0.20	755.46	5.96	28.86	41.86	59.67	-1.96	0.70	1.99	2.79	0.70	N/A	25.00	-25.65	7.41
9.00	0.10	752.48	2.98	34.92	63.79	71.40	-2.14	0.89	2.10	3.14	0.89	N/A	27.25	-33.02	6.72
10.00	0.00	749.50	0.00	41.02	95.42	84.51	-2.33	1.13	2.21	3.52	6.02	3.31	29.50	-44.31	1.51

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AUTRAIN SPILLWAY
Flood Loading

03:48 PM 28-Aug-02 CALC 1001755-1 Prep. by: CWH Checked by: MS PAGE 22 OF 48

7. Stresses at Heel and Toe

Block	y/He	Elevation (ft)	Y (ft)	T Crack Length (ft)	Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)	Sum of Total Stress Diagram (kips)	Sum of Effect Stress Diagram (kips)	Sum of Uplift Diagram (kips)	Sum of Effect Diagrams (kips)	SigFV sum of vert forces w/o uplift (Part6,Col 6) (kips)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	N/A	0.88	-0.65	0.24	0.43	0.00	0.43	-8.1	-3.1	-3.0	-8.1	8.1
2.00	0.80	773.34	23.84	N/A	1.14	-0.84	0.30	0.73	0.00	0.73	-10.7	-5.8	-4.8	-10.7	10.7
3.00	0.70	770.36	20.86	N/A	1.32	-1.03	0.29	1.08	0.00	1.08	-16.4	-9.3	-7.1	-16.4	16.4
4.00	0.60	767.38	17.88	N/A	1.47	-1.21	0.26	1.41	0.00	1.41	-23.0	-13.3	-9.7	-23.0	23.0
5.00	0.50	764.40	14.90	N/A	1.61	-1.40	0.21	1.75	0.00	1.75	-30.7	-17.8	-12.8	-30.7	30.7
6.00	0.40	761.42	11.92	N/A	1.74	-1.58	0.16	2.10	0.00	2.10	-39.3	-23.1	-16.2	-39.3	39.3
7.00	0.30	758.44	8.94	N/A	1.86	-1.77	0.09	2.44	0.00	2.44	-49.0	-28.9	-20.1	-49.0	49.0
8.00	0.20	755.46	5.96	N/A	1.98	-1.95	0.03	2.79	-0.10	2.69	-59.7	-34.0	-25.6	-59.7	59.7
9.00	0.10	752.48	2.98	N/A	2.10	-2.14	-0.04	3.14	-0.28	2.86	-71.4	-38.4	-33.0	-71.4	71.4
10.00	0.00	749.50	0.00	3.31	2.33	-2.33	0.00	3.54	-0.47	3.07	-84.5	-40.2	-44.3	-84.5	84.5

MWH

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9. AUTRAIN SPILLWAY
Normal + Ice

10:41 AM 29-Aug-02 CALC 1001755-1

Prep by: CWH Checked by: MS PAGE 23 OF 48

USBR Cracked Base Analysis Method with following limitations:
-No reduction of uplift within dam during flood, uplift reduction due to drains not considered,
tailwater level must be below downstream slope change, headwater overlapping flashboards not checked

A) Shape and Size of Dam/Pool Levels

Top of Concrete Dam	779.3	(Elev)
Bottom of Dam	749.5	(Elev)
T.O. Flshbrds,0 if none	781.3	(Elev)
U/S Slope Change	779.3	(Elev)
D/S Slope Change	779.3	(Elev)
Crest Width	7.0	(FT)
U/S Slope	0.000	(Decimal)
D/S Slope	0.755	(Decimal)
Headwater Elev.	772.3	(Elev)
Tailwater Elev.	753.3	(Elev)
F.B. Loc from U/S Crest	2.50	(FT)

Input Summary

Dam Ht	29.8	(FT)
HW Level	22.8	(FT)
TW Level	3.8	(FT)
Overtop	0.00	(FT)
Eff. TW	3.8	
Ice Load	Yes	
Silt Load	No	
Anchors	No	
Flshbrd Ht	2.00	(FT)

Load Summary

Elev. (ft)	Sum of Horiz. Forces (kips)	Sum of Vertical Forces w/o Uplift (kips)	Sum of Uplift (kips)	Sum of Moments w/o Uplift (kips)	e (ft)	e' (ft)
776.32	0.00	3.69	0.00	-2	-0.54	-0.54
773.34	0.00	8.27	0.00	-9	-1.03	-1.03
770.36	5.12	13.91	-0.83	-11	-0.80	-0.80
767.38	5.78	20.56	-2.48	-14	-0.70	-0.70
764.40	6.96	28.22	-4.50	-23	-0.81	-0.81
761.42	6.89	38.86	-6.96	-36	-0.98	-0.98
758.44	10.99	46.64	-9.84	-54	-1.16	-1.16
755.46	13.85	57.21	-13.13	-75	-1.32	-1.32
752.48	17.24	68.91	-17.56	-100	-1.45	-1.45
749.50	20.77	81.92	-24.49	-123	-1.50	0.00

B) Material Properties

Unit Wt Water	0.0624	(KCF)
Unit Wt Concrete	0.1500	(KCF)
Friction Angle,Lift Jt	45.00	(DEG)
Friction Angle,Contact	30.00	(DEG)
Cohesion,Lift Jt	50.00	(psi)
Cohesion,Contact	0.00	(psi)

Stability Summary

Elevation (ft)	Section Width (ft)	Crack Length (ft)	Shear Friction Safety Factor
776.32	9.25	N/A	#DIV/0!
773.34	11.50	N/A	#DIV/0!
770.36	13.75	N/A	21.90
767.38	16.00	N/A	23.16
764.40	18.25	N/A	22.33
761.42	20.50	N/A	20.42
758.44	22.75	N/A	18.24
755.46	25.00	N/A	16.18
752.48	27.25	N/A	14.36
749.50	29.50	0.00	1.80

Stress Summary

Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)
0.53	0.00	0.53	0.28	0.00	0.28
1.11	0.00	1.11	0.33	0.00	0.33
1.37	-0.12	1.24	0.66	0.00	0.66
1.62	-0.31	1.32	0.96	0.00	0.96
1.96	-0.49	1.47	1.13	0.00	1.13
2.32	-0.68	1.64	1.28	0.00	1.28
2.67	-0.86	1.81	1.42	0.00	1.42
3.01	-1.06	1.96	1.57	0.00	1.57
3.33	-1.24	2.10	1.72	-0.05	1.67
3.63	-1.42	2.20	1.93	-0.24	1.69

C) Other Loads

Ice Point Load	5.00	(KIPS/FT)
Ice Load Elev	772.3	(Elev)
Sat Unit Wt Silt	0.1250	(KCF)
Silt Thickness	0.0	(FT)
Earth Pressure Coeff.	0.33	(Default = .75)
Anchor Load	0.0	(KIP/FT)
Anchor Distance from U/S Edge of Crest	4.0	(FT)
TW Retrogression Coeff. (.6 for Spwy. Section) (1 for Non-overflow)	1.00	
Horiz. Crest Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vert. Crest Pressure	0.00	(KIPS/FT)
Distance from U/S Edge of Crest	0.00	(FT)
Horiz. Bucket Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vertical Bucket Pressure	0.00	(KIPS/FT)
Distance from U/S Edge of Crest	0.00	(FT)

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AUTRAIN SPILLWAY
Normal + Ice

10:41 AM 29-Aug-02 CALC 1001755-1

Prep. by CWH Checked by MS PAGE 24 OF 48

STATIC ANALYSIS

1. Concrete Weights and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	W1 (kips)	W2 (kips)	W3 (kips)	w1 (ft)	w2 (ft)	w3 (ft)	w (ft)	CLb (ft)	x1 (ft)	x2 (ft)	x3 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	3.13	0.50	0.00	7.00	2.25	9.25	4.62	0.00	-1.12	3.13
2.00	0.80	773.34	23.84	0.00	6.26	2.01	0.00	7.00	4.50	11.50	5.75	0.00	-2.25	2.75
3.00	0.70	770.36	20.86	0.00	9.39	4.53	0.00	7.00	6.75	13.75	6.87	0.00	-3.37	2.38
4.00	0.60	767.38	17.88	0.00	12.52	8.05	0.00	7.00	9.00	16.00	8.00	0.00	-4.50	2.00
5.00	0.50	764.40	14.90	0.00	15.65	12.57	0.00	7.00	11.25	18.25	9.12	0.00	-5.62	1.63
6.00	0.40	761.42	11.92	0.00	18.77	18.10	0.00	7.00	13.50	20.50	10.25	0.00	-6.75	1.25
7.00	0.30	758.44	8.94	0.00	21.90	24.64	0.00	7.00	15.75	22.75	11.37	0.00	-7.87	0.88
8.00	0.20	755.46	5.96	0.00	25.03	32.18	0.00	7.00	18.00	25.00	12.50	0.00	-9.00	0.50
9.00	0.10	752.48	2.98	0.00	28.16	40.73	0.00	7.00	20.25	27.25	13.62	0.00	-10.12	0.13
10.00	0.00	749.50	0.00	0.00	31.29	50.29	0.00	7.00	22.50	29.50	14.75	0.00	-11.25	-0.25

2. Vertical Weights + Moment Arms of Reservoir on Dam

Block	y/Hs	Elevation (ft)	y (ft)	Overtop Weight on U/S Fillet Ww1 (kips)	Normal HW Above U/S Fillet Ww2 (kips)	Normal HW On U/S Fillet Ww3 (kips)	Overtop Water Weight on Crest Ww4 (kips)	Overtop Water Weight on Crest Ww5 (kips)	Tailwater Weight Ww6 (kips)	Water U/S of Flashboards Ww7 (kips)	xw1 (ft)	xw2 (ft)	xw3 (ft)	xw4 (ft)	xw5 (ft)	xw6 (ft)	xw7 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	13.42	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	13.79	0.00

MWH

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AUTRAIN SPILLWAY
Normal + Ice

10:41 AM 29-Aug-02 CALC 1001758-1 Prep. by: CWH Checked by: MS PAGE 25 OF 48

3. Horizontal Reservoir Forces, Silt Loads, Ice Loads, and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	HW P1 (kips)	HW P2 (kips)	Silt P3 (kips)	Ice P4 (kips)	TW P5 (kips)	yP1 (ft)	yP2 (ft)	yP3 (ft)	yP4 (ft)	yP5 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	-1.34	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	-0.36	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.12	0.00	0.00	5.00	0.00	0.65	0.00	0.00	1.94	0.00
4.00	0.60	767.38	17.88	0.76	0.00	0.00	5.00	0.00	1.64	0.00	0.00	4.92	0.00
5.00	0.50	764.40	14.90	1.95	0.00	0.00	5.00	0.00	2.63	0.00	0.00	7.90	0.00
6.00	0.40	761.42	11.92	3.69	0.00	0.00	5.00	0.00	3.63	0.00	0.00	10.88	0.00
7.00	0.30	758.44	8.94	5.99	0.00	0.00	5.00	0.00	4.62	0.00	0.00	13.86	0.00
8.00	0.20	755.46	5.96	8.85	0.00	0.00	5.00	0.00	5.61	0.00	0.00	16.84	0.00
9.00	0.10	752.48	2.98	12.26	0.00	0.00	5.00	-0.02	6.61	0.00	0.00	19.82	0.27
10.00	0.00	749.50	0.00	16.22	0.00	0.00	5.00	-0.46	7.60	0.00	0.00	22.80	1.27

4. Anchor Force, Silt Weight, Bucket and Crest Pressures, and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	Anchor Ya (kips)	Silt Ws (kips)	xs (ft)	ys (ft)	Crest Pressure Wc (kips)	Pc (kips)	xc (ft)	yc (ft)	Bucket Pressure Wb (kips)	Pb (kips)	xb (ft)	yb (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MWH

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AUTRAIN SPILLWAY
Normal + Ice

10:41 AM 29-Aug-02 CALC 1001756-1 Prep by: CWH Checked by: MS PAGE 26 OF 48

5. Uplift Forces and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	Section Width (ft)	Crack Length (ft)	U1 (kips)	U2 (kips)	U3 (kips)	ru1 (ft)	ru2 (ft)	ru3 (ft)
=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	778.32	26.82	9.25	N/A	0.00	0.00	0.00	0.00	-1.54	0.00
2.00	0.80	773.34	23.84	11.50	N/A	0.00	0.00	0.00	0.00	-1.92	0.00
3.00	0.70	770.36	20.86	13.75	N/A	0.00	-0.83	0.00	0.00	-2.29	0.00
4.00	0.60	767.38	17.88	16.00	N/A	0.00	-2.46	0.00	0.00	-2.67	0.00
5.00	0.50	764.40	14.90	18.25	N/A	0.00	-4.50	0.00	0.00	-3.04	0.00
6.00	0.40	761.42	11.92	20.50	N/A	0.00	-6.95	0.00	0.00	-3.42	0.00
7.00	0.30	758.44	8.94	22.75	N/A	0.00	-9.84	0.00	0.00	-3.79	0.00
8.00	0.20	755.46	5.96	25.00	N/A	0.00	-13.13	0.00	0.00	-4.17	0.00
9.00	0.10	752.48	2.98	27.25	N/A	-1.39	-16.15	0.00	0.00	-4.54	0.00
10.00	0.00	749.50	0.00	29.50	0.00	-6.99	-17.49	0.00	0.00	-4.92	0.00

6. Shear Friction Safety Factor

Block	y/Hs	Elevation (ft)	y (ft)	SigFH sum of horz forces (kips)	SigM sum of moments w/o uplift (kip-ft)	SigFV sum of vertical forces w/o uplift (kips)	A3 uplift at heel (ksf)	e (ft)	Sig1 heel stress w/o uplift (ksf)	Sig2 toe stress w/o uplift (ksf)	e' (ft)	T Crack Length (ft)	Section Width (ft)	Total Uplift (kips)	F.S. Shear Friction Factor
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	778.32	28.82	0.00	-1.95	3.63	0.00	-0.54	0.53	0.28	-0.54	N/A	9.25	0.00	#DIV/0!
2.00	0.80	773.34	23.84	0.00	-6.56	8.27	0.00	-1.03	1.11	0.33	-1.03	N/A	11.50	0.00	#DIV/0!
3.00	0.70	770.36	20.86	5.12	-11.16	13.91	-0.12	-0.80	1.37	0.85	-0.80	N/A	13.75	-0.83	21.80
4.00	0.60	767.38	17.88	5.76	-14.39	20.98	-0.31	-0.70	1.62	0.95	-0.70	N/A	16.00	-2.46	23.16
5.00	0.50	764.40	14.90	6.95	-22.94	28.22	-0.49	-0.81	1.98	1.13	-0.81	N/A	18.25	-4.50	22.33
6.00	0.40	761.42	11.92	8.69	-38.29	36.86	-0.68	-0.98	2.32	1.28	-0.98	N/A	20.50	-6.95	20.42
7.00	0.30	758.44	8.94	10.89	-53.93	46.54	-0.88	-1.16	2.67	1.42	-1.16	N/A	22.75	-9.84	18.24
8.00	0.20	755.46	5.96	13.85	-73.32	57.21	-1.05	-1.32	3.01	1.57	-1.32	N/A	25.00	-13.13	16.16
9.00	0.10	752.48	2.98	17.24	-98.74	68.91	-1.24	-1.45	3.33	1.72	-1.45	N/A	27.25	-17.55	14.36
10.00	0.00	749.50	0.00	20.77	-123.17	81.92	-1.42	-1.60	3.63	1.93	0.00	0.00	29.50	-24.48	1.60

AUTRAIN SPILLWAY
Normal + Ice

10:41 AM 29-Aug-02

CALC 1001755-1

7. Stresses at Heel and Toe

Block	y/Ht	Elevation (ft)	y (ft)	T Crack Length (ft)	Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)	Sum of Total Stress Diagram (kips)	Sum of Effect Stress Diagram (kips)	Sum of Uplift Diagram (kips)	Sum of Effect Diagrams (kips)	SigFV sum of vert forces w/o uplift (Part6,Col 6) (kips)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	N/A	0.53	0.00	0.53	0.28	0.00	0.28	-3.6	-3.6	0.0	-3.6	3.6
2.00	0.80	773.34	23.84	N/A	1.11	0.00	1.11	0.33	0.00	0.33	-8.3	-8.3	0.0	-8.3	8.3
3.00	0.70	770.36	20.86	N/A	1.37	-0.12	1.24	0.66	0.00	0.66	-13.9	-13.1	-0.8	-13.9	13.9
4.00	0.60	767.38	17.88	N/A	1.62	-0.31	1.32	0.96	0.00	0.96	-20.6	-18.1	-2.5	-20.6	20.6
5.00	0.50	764.40	14.90	N/A	1.98	-0.49	1.47	1.13	0.00	1.13	-28.2	-23.7	-4.5	-28.2	28.2
6.00	0.40	761.42	11.92	N/A	2.32	-0.68	1.64	1.28	0.00	1.28	-38.9	-29.9	-7.0	-38.9	38.9
7.00	0.30	758.44	8.94	N/A	2.67	-0.86	1.81	1.42	0.00	1.42	-48.5	-36.7	-9.8	-48.5	48.5
8.00	0.20	755.46	5.96	N/A	3.01	-1.05	1.96	1.57	0.00	1.57	-57.2	-44.1	-13.1	-57.2	57.2
9.00	0.10	752.48	2.98	N/A	3.33	-1.24	2.10	1.72	-0.05	1.67	-68.9	-51.4	-17.6	-68.9	68.9
10.00	0.00	749.50	0.00	0.00	3.63	-1.42	2.20	1.93	-0.24	1.69	-81.9	-57.4	-24.5	-81.9	81.9

10. AUTRAIN SPILLWAY
Normal Operating Conditions   10:40 AM 29-Aug-02   CALC 1001755-1   Prep. by: CWH   Checked by: MS   PAGE 28 OF 48

USBR Cracked Base Analysis Method with following limitations:
-No reduction of uplift within dam during flood, uplift reduction due to drains not considered,
tailwater level must be below downstream slope change, headwater overtopping flashboards not checked

A) Shape and Size of Dam/Pool Levels

Top of Concrete Dam	779.3	(Elev)
Bottom of Dam	749.5	(Elev)
T.O. Flshbrds,0 if none	781.3	(Elev)
U/S Slope Change	779.3	(Elev)
D/S Slope Change	779.3	(Elev)
Crest Width	7.0	(FT)
U/S Slope	0.000	(Decimal)
D/S Slope	0.755	(Decimal)
Headwater Elev.	781.3	(Elev)
Tailwater Elev.	753.3	(Elev)
F.B. Loc from U/S Crest	2.50	(FT)

Input Summary

Dam Ht	29.8	(FT)
HW Level	31.8	(FT)
TW Level	3.8	(FT)
Overtop	0.00	(FT)
Eff. TW	3.8	
Ice Load	No	
Silt Load	No	
Anchors	No	
Flshbrd Ht	2.00	(FT)

Load Summary

Elev. (ft)	Sum of Horiz. Forces (kips)	Sum of Vertical Forces w/o Uplift (kips)	Sum of Uplift (kips)	Sum of Moments w/o Uplift (kips)	e (ft)	e' (ft)
776.32	0.77	3.94	-1.44	-2	-0.44	-0.44
773.34	1.98	8.68	-2.86	-5	-0.55	-0.55
770.36	3.73	14.22	-4.69	-9	-0.64	-0.64
767.38	6.05	20.67	-6.95	-14	-0.68	-0.68
764.40	8.91	28.53	-9.62	-20	-0.70	-0.70
761.42	12.33	37.19	-12.71	-25	-0.68	-0.68
758.44	16.30	46.85	-16.23	-30	-0.64	-0.64
755.46	20.83	57.53	-20.15	-33	-0.58	-0.58
752.48	25.89	69.22	-25.20	-35	-0.50	-0.50
749.50	31.10	82.23	-32.77	-30	-0.37	0.00

B) Material Properties

Unit Wt Water	0.0624	(KCF)
Unit Wt Concrete	0.1500	(KCF)
Friction Angle,Lift Jt	45.00	(DEG)
Friction Angle,Contact	30.00	(DEG)
Cohesion,Lift Jt	50.00	(psi)
Cohesion,Contact	0.00	(psi)

Stability Summary

Elevation (ft)	Section Width (ft)	Crack Length (ft)	Shear Friction Safety Factor
776.32	9.25	N/A	88.31
773.34	11.50	N/A	44.76
770.36	13.75	N/A	29.06
767.38	16.00	N/A	21.38
764.40	18.25	N/A	16.87
761.42	20.50	N/A	13.86
758.44	22.75	N/A	11.82
755.46	25.00	N/A	10.43
752.48	27.25	N/A	9.28
749.50	29.50	0.00	2.01

Stress Summary

Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)
0.55	-0.31	0.24	0.31	0.00	0.31
0.96	-0.50	0.46	0.53	0.00	0.53
1.32	-0.68	0.64	0.75	0.00	0.75
1.64	-0.87	0.77	0.97	0.00	0.97
1.92	-1.06	0.87	1.21	0.00	1.21
2.17	-1.24	0.93	1.46	0.00	1.46
2.41	-1.43	0.98	1.71	0.00	1.71
2.62	-1.61	1.01	1.98	0.00	1.98
2.82	-1.80	1.02	2.26	-0.05	2.21
3.00	-1.99	1.01	2.58	-0.24	2.34

C) Other Loads

Ice Point Load	0.00	(KIPS/FT)
Ice Load Elev	0.0	(Elev)
Sat Unit Wt Silt	0.1250	(KCF)
Silt Thickness	0.0	(FT)
Earth Pressure Coeff.	0.33	(Default = .75)
Anchor Load	0.0	(KIP/FT)
Anchor Distance from		
U/S Edge of Crest	4.0	(FT)
TW Retrogression Coeff.		
(0 for Spwy. Section)		
(1 for Non-overflow)	1.00	
Horiz. Crest Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vert. Crest Pressure	0.00	(KIPS/FT)
Distance from U/S		
Edge of Crest	0.00	(FT)
Horiz. Bucket Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vertical Bucket Pressure	0.00	(KIPS/FT)
Distance from U/S		
Edge of Crest	0.00	(FT)

MWH

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AUTRAIN SPILLWAY
Normal Operating Conditions

10:40 AM 29-Aug-02 CALC 1001755-1

Prep by CWH Checked by MS PAGE 29 OF 48

STATIC ANALYSIS

1. Concrete Weights and Moment Arms

Block	y/He	Elevation (ft)	y (ft)	W1 (kips)	W2 (kips)	W3 (kips)	w1 (ft)	w2 (ft)	w3 (ft)	w (ft)	CLb (ft)	x1 (ft)	x2 (ft)	x3 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	3.13	0.50	0.00	7.00	2.25	9.25	4.62	0.00	-1.12	3.13
2.00	0.80	773.34	23.84	0.00	6.26	2.01	0.00	7.00	4.50	11.50	5.75	0.00	-2.25	2.75
3.00	0.70	770.36	20.86	0.00	9.39	4.53	0.00	7.00	6.75	13.75	6.87	0.00	-3.37	2.38
4.00	0.60	767.38	17.88	0.00	12.52	8.05	0.00	7.00	9.00	16.00	8.00	0.00	-4.50	2.00
5.00	0.50	764.40	14.90	0.00	15.65	12.57	0.00	7.00	11.25	18.25	9.12	0.00	-5.62	1.63
6.00	0.40	761.42	11.92	0.00	18.77	18.10	0.00	7.00	13.50	20.50	10.25	0.00	-6.75	1.25
7.00	0.30	758.44	8.94	0.00	21.90	24.64	0.00	7.00	15.75	22.75	11.37	0.00	-7.87	0.88
8.00	0.20	755.46	5.96	0.00	25.03	32.18	0.00	7.00	18.00	25.00	12.50	0.00	-9.00	0.50
9.00	0.10	752.48	2.98	0.00	28.16	40.73	0.00	7.00	20.25	27.25	13.62	0.00	-10.12	0.13
10.00	0.00	749.50	0.00	0.00	31.29	50.29	0.00	7.00	22.50	29.50	14.75	0.00	-11.25	-0.25

2. Vertical Weights + Moment Arms of Reservoir on Dam

Block	y/He	Elevation (ft)	y (ft)	Overtop Weight on U/S Fillet Ww1 (kips)	Normal HW Above U/S Fillet Ww2 (kips)	Normal HW On U/S Fillet Ww3 (kips)	Overtop Water Weight on Crest Ww4 (kips)	Overtop Water Weight on Crest Ww5 (kips)	Tailwater Weight Ww6 (kips)	Water U/S of Flashboards Ww7 (kips)	xw1 (ft)	xw2 (ft)	xw3 (ft)	xw4 (ft)	xw5 (ft)	xw6 (ft)	xw7 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-3.37
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-4.50
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-5.62
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-6.75
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-7.87
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-9.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-10.12
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	-11.25
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.02	0.31	0.00	0.00	0.00	0.00	0.00	13.42	-12.37
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.31	0.00	0.00	0.00	0.00	0.00	13.79	-13.50

MWH

File: AuTrainSpwy Normal Load Case.xls

AUTRAIN SPILLWAY
Normal Operating Conditions

10:40 AM 29-Aug-02 CALC 1001756-1 Prep by CWH Checked by MS PAGE 30 OF 48

3. Horizontal Reservoir Forces, Silt Loads, Ice Loads, and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	HW P1 (kips)	HW P2 (kips)	Silt P3 (kips)	Ice P4 (kips)	TW P5 (kips)	yP1 (ft)	yP2 (ft)	yP3 (ft)	yP4 (ft)	yP5 (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.77	0.00	0.00	0.00	0.00	1.66	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	1.96	0.00	0.00	0.00	0.00	2.65	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	3.73	0.00	0.00	0.00	0.00	3.65	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	6.05	0.00	0.00	0.00	0.00	4.64	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	8.91	0.00	0.00	0.00	0.00	5.63	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	12.33	0.00	0.00	0.00	0.00	6.63	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	16.30	0.00	0.00	0.00	0.00	7.62	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	20.83	0.00	0.00	0.00	0.00	8.61	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	25.91	0.00	0.00	0.00	-0.02	9.61	0.00	0.00	0.00	0.27
10.00	0.00	749.50	0.00	31.55	0.00	0.00	0.00	-0.45	10.60	0.00	0.00	0.00	1.27

4. Anchor Force, Silt Weight, Bucket and Crest Pressures, and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	Anchor Wa (kips)	Silt Ws (kips)	xa (ft)	xs (ft)	Crest Pressure Wc (kips)	Crest Pressure Pc (kips)	xc (ft)	yc (ft)	Bucket Pressure Wb (kips)	Bucket Pressure Pb (kips)	xb (ft)	yb (ft)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Normal Operating Conditions

10:40 AM 29-Aug-02 CALC 1001755-1 Prep by CWU Checked by MS PAGE 31 OF 48

5. Uplift Forces and Moment Arms

Block	y/Hs	Elevation (ft)	y (ft)	Section Width (ft)	Crack Length (ft)	U1 (kips)	U2 (kips)	U3 (kips)	xu1 (ft)	xu2 (ft)	xu3 (ft)
=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	9.25	N/A	0.00	-1.44	0.00	0.00	-1.54	0.00
2.00	0.80	773.34	23.84	11.50	N/A	0.00	-2.88	0.00	0.00	-1.92	0.00
3.00	0.70	770.36	20.86	13.75	N/A	0.00	-4.69	0.00	0.00	-2.29	0.00
4.00	0.60	767.38	17.88	16.00	N/A	0.00	-6.95	0.00	0.00	-2.67	0.00
5.00	0.50	764.40	14.90	18.25	N/A	0.00	-9.62	0.00	0.00	-3.04	0.00
6.00	0.40	761.42	11.92	20.50	N/A	0.00	-12.71	0.00	0.00	-3.42	0.00
7.00	0.30	758.44	8.94	22.75	N/A	0.00	-16.23	0.00	0.00	-3.79	0.00
8.00	0.20	755.46	5.96	25.00	N/A	0.00	-20.15	0.00	0.00	-4.17	0.00
9.00	0.10	752.48	2.98	27.25	N/A	-1.39	-23.80	0.00	0.00	-4.54	0.00
10.00	0.00	749.50	0.00	29.50	0.00	-6.99	-25.77	0.00	0.00	-4.92	0.00

6. Shear Friction Safety Factor

Block	y/Hs	Elevation (ft)	y (ft)	SigFH sum of horz forces (kips)	SigM sum of moments w/o uplift (kip-ft)	SigFV sum of vertical forces w/o uplift (kips)	A3 uplift at heel (ksf)	e (ft)	Sig1 heel stress w/o uplift (ksf)	Sig2 toe stress w/o uplift (ksf)	e' (ft)	T Crack Length (ft)	Section Width (ft)	Total Uplift (kips)	F.S. Shear Friction Factor
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	0.77	-1.72	3.94	-0.31	-0.44	0.56	0.31	-0.44	N/A	9.25	-1.44	88.31
2.00	0.80	773.34	23.84	1.88	-4.71	8.58	-0.50	-0.56	0.96	0.53	-0.56	N/A	11.50	-2.88	44.78
3.00	0.70	770.36	20.86	3.73	-9.07	14.22	-0.66	-0.64	1.32	0.75	-0.64	N/A	13.75	-4.69	29.08
4.00	0.60	767.38	17.88	6.05	-14.28	20.87	-0.87	-0.68	1.64	0.97	-0.68	N/A	16.00	-6.95	21.36
5.00	0.50	764.40	14.90	8.91	-19.83	28.63	-1.06	-0.70	1.92	1.21	-0.70	N/A	18.25	-9.62	16.87
6.00	0.40	761.42	11.92	12.33	-25.19	37.19	-1.24	-0.68	2.17	1.45	-0.68	N/A	20.50	-12.71	13.86
7.00	0.30	758.44	8.94	16.30	-29.83	46.86	-1.43	-0.64	2.41	1.71	-0.64	N/A	22.75	-16.23	11.92
8.00	0.20	755.46	5.96	20.83	-33.26	57.53	-1.61	-0.59	2.62	1.98	-0.59	N/A	25.00	-20.15	10.43
9.00	0.10	752.48	2.98	25.89	-34.72	69.22	-1.80	-0.50	2.82	2.26	-0.50	N/A	27.25	-25.20	9.28
10.00	0.00	749.50	0.00	31.10	-30.21	82.23	-1.98	-0.37	3.00	2.56	0.00	0.00	29.50	-32.77	2.01

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AUTRAIN SPILLWAY
Normal Operating Conditions

10:40 AM 29-Aug-02 CALC 1001755-1

Prep. by: CWH Checked by: MS PAGE 32 OF 48

7. Stresses at Heel and Toe

Block	y/Ho	Elevation (ft)	Y (ft)	T Crack Length (ft)	Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)	Sum of Total Stress Diagram (kips)	Sum of Effect Stress Diagram (kips)	Sum of Uplift Diagram (kips)	Sum of Effect Diagrams (kips)	SigFV sum of vert forces w/o uplift (Part6,Col 6) (kips)
=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
1.00	0.90	776.32	26.82	N/A	0.66	-0.31	0.24	0.31	0.00	0.31	-3.9	-2.5	-1.4	-3.9	3.9
2.00	0.80	773.34	23.84	N/A	0.96	-0.50	0.46	0.53	0.00	0.53	-8.6	-5.7	-2.9	-8.6	8.6
3.00	0.70	770.36	20.86	N/A	1.32	-0.66	0.64	0.75	0.00	0.75	-14.2	-9.5	-4.7	-14.2	14.2
4.00	0.60	767.38	17.88	N/A	1.64	-0.87	0.77	0.97	0.00	0.97	-20.9	-13.9	-6.9	-20.9	20.9
5.00	0.50	764.40	14.90	N/A	1.92	-1.06	0.87	1.21	0.00	1.21	-28.5	-18.9	-9.6	-28.5	28.5
6.00	0.40	761.42	11.92	N/A	2.17	-1.24	0.93	1.45	0.00	1.45	-37.2	-24.6	-12.7	-37.2	37.2
7.00	0.30	758.44	8.94	N/A	2.41	-1.43	0.98	1.71	0.00	1.71	-46.9	-30.8	-16.2	-46.9	46.9
8.00	0.20	755.46	5.96	N/A	2.82	-1.61	1.01	1.98	0.00	1.98	-57.5	-37.4	-20.2	-57.5	57.5
9.00	0.10	752.48	2.98	N/A	2.82	-1.80	1.02	2.26	-0.06	2.21	-69.2	-44.0	-26.2	-69.2	69.2
10.00	0.00	749.50	0.00	0.00	3.00	-1.98	1.01	2.58	-0.24	2.34	-82.2	-49.5	-32.8	-82.2	82.2

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SUMMARY OF STABILITY PARAMETERS

LOAD CASE	HW	TW	ICE	$\phi_{CONTACT}$	$C_{CONTACT}$	
NORMAL	781.3 TOP OF FLASHBOARDS	753.3 D/S ROCK SURFACE	—	30°	CALCULATE REQ'D	
NORMAL + ICE	772.3 LATE WINTER TARGET	753.3	5 k/FT	30°	"	
PMF	786.8 w/ 450' LONG FUSE PLUG	757.0	—	30°	"	

SUMMARY OF STABILITY RESULTS

LOAD CASE	FACTOR OF SAFETY		THEORETICAL CRACK LENGTH		COHESION REQ'D	COMMENTS
	CALCULATED	REQUIRED	CALCULATED	REQUIRED		
NORMAL	2.0	≥ 2.0	0	< 29.5	8 psi	—
NORMAL + ICE	1.60	≥ 1.5	0	< 29.5	0	
PMF	1.50	≥ 1.5	3.3 ft	< 29.5	10.2	w/ c = 0 $\phi_{REQD} = 57^{\circ}$

10.2 COHESION REQ'D TO MEET STABILITY F.S. << AVAILABLE OF 20 psi
⇒ OK
NO REMEDIAL MEASURES REQ'D.

AU TRAIN
SPILLWAY STABILITY

1001755
35/48

INITIAL INDEPENDENT CONSULTANT SAFETY INSPECTION
AU TRAIN HYDROELECTRIC PROJECT
FERC PROJECT NO. 10856
FOR
UPPER PENINSULA POWER COMPANY

FINAL REPORT
VOLUME 1
November 1994

Stone & Webster Michigan, Inc.
Denver, Colorado
J.O. No. 18372

Spillway Stability 36

The valley containing the reservoir is underlain by an extension of the outwash plain found to the west. These sediments have been partially reworked and influenced by paleo Glacial Lake Duluth. Recent bog and peat deposits locally overlie the outwash plain.

Fill for the north dam came from a borrow pit located 1/4 mile north of the dam on the west side of the river. This pit exposes a good cross section of the glacial outwash plain. Exposed at the base of the cut is a lower fine-coarse sand, laminated to thinly bedded, with small scale crossbeds typical of braided streams on an outwash plain. Unconformably overlying this is a discontinuous, 2-ft-thick, red-brown sandy silt bed that was probably deposited during an inundation by Glacial Lake Duluth. Unconformably overlying this unit is a thickly bedded, coarse sand to gravel. The red brown sandy silt may have been the source for the "clay" blanket found on the upstream side of the north dam. The borrow area for the south levee is located at the east end of the levee. The borrow pit is developed in a massive, poorly stratified, fine to medium sand.

4.3 FOUNDATION CONDITIONS

A field exploration program, including geological mapping, borings, and test pits, was conducted in October, 1988. Descriptions of the field investigations are provided below.

4.3.1 Geological Mapping

Geologic mapping of the dams and reservoir area was conducted by a SWMICH geologist. The orientation of primary structural features and prevalent lithologies were mapped. The only outcropping bedrock found during mapping of the north dam area was located in the Au Train River bottom and along the river embankment. This outcrop was mapped from the spillway to the powerhouse. The outcrops consisted of flat-lying layers to east-west striking, very shallow dipping (2-5 degrees north), dark gray, bioturbated glauconitic dolomitic sandstone that varied locally to quartzite. The rock is fine-medium grained, poorly graded, thin bedded to laminated, locally cross bedded, with parallel to wavy continuous to discontinuous bedding. It is moderately hard to very hard, fresh to severely weathered. Locally, beds contain 1 to 5 percent sulfides and 0.5 to 1.5 cm quartz-lined vugs. No shale beds were observed.

The outcrops exhibit two dominant sets of joints, both of which are persistent. The primary set is vertical, wide (5 ft) to close spacing (6 inch) with a strike of N 15° - 45° E. The secondary set is high angle to vertical, very wide (20 ft) to moderately close spacing (2 ft) with a strike of N 40° - 80° W. Both sets are pervasive. No shear zones or faults were observed in outcrops.

Bedrock was encountered in the three core holes drilled in the north dam. These cores exhibited the same lithologic and bedding characteristics as those observed in the rock outcrops of the Au Train River.

4.3.2 Borings

A total of 33 borings were drilled during October 1988 to evaluate the concrete, embankment, and foundation materials. Thirteen borings were drilled at the north dam, 13 were completed at the south levee, and 7 borings were completed along the penstock alignment. Drilling was performed by STS Consultants, Ltd. of Marquette, Michigan. A list of test borings is given in Table 4-1. The boring locations at the dams are shown on Figures 5-1 and 5-5. Boring logs are included in Appendix E.

The soil borings were advanced in uncased holes using biodegradable drilling mud. Sampling was performed on 2.5-ft centers using the Standard Penetration Test (ASTM D 1586). A 2-inch outside diameter split barrel sampler with liners and sample retainer was used. Soil samples obtained using the split barrel sampler were logged, then placed in labeled sample jars. N-size concrete and rock core was logged and placed in core boxes. Test samples were wrapped in plastic and wax to preserve the natural moisture.

The north dam embankment is composed primarily of a loose sand fill. Standard Penetration Test (SPT) blow counts in the fill ranged from 1 to 37 blows per foot. The higher blow counts typically resulted from encountering a piece of gravel while driving the sampler. Typical blow count values range from 1 to 10 blows per foot and are considered characteristic of the loose sand fill.

Au Train
Spillway Stability

38

Beneath the embankment fill, granular alluvium was encountered. The alluvium was similar to the fill material. It was a silty sand to sandy gravel and often contained a horizon of weathered sandstone bedrock. Borings SW-4 and SW-9 were extended through the alluvium 15.5 ft into bedrock. The alluvium in these locations was 6 and 10 ft thick, respectively. Boring number SW-15, drilled through the downstream lip of the spillway, went 13.7 ft into rock. The bedrock is a gray to yellow-brown, fine- to medium-grained, well-sorted, fresh, and well-indurated sandstone.

Typical cross sections of the north dam embankment and foundation are shown on Figures 5-2 and 5-3. A typical cross section of the spillway and foundation is shown in Figure 5-4.

The south levee is a homogeneous loose sand embankment. Borings were completed to depths that ranged from 4.5 to 27.2 ft. Four of the borings were completed using a hand-held auger due to the difficult access. Standard Penetration Test values of the fill ranged from 1 to 12 blows per foot. A typical cross section of the embankment and foundation are shown on Figure 5-4.

The south levee embankment is founded on granular alluvium composed of silty sand to sandy gravel. The entire downstream area is boggy and soft. A construction picture shows a clamshell excavating unsuitable foundation soils from beneath the levee. Even so, a layer of peat was found beneath the fill in boring number SW-21.

4.3.3 Test Pits

Seven test pits were excavated in the north dam and south levee to evaluate the fill. Locations of the test pits are shown on the drawings in Appendices D and E. Test pit logs are in Appendix E. The test pits were excavated by O'Dovero Construction of Marquette, Michigan using a JD-690 backhoe with a 2-ft wide bucket. The test pits range from 4 ft to 8 ft in depth and generally 4 ft to 7 ft in width. Test Pit 1 in the north dam was excavated 15 ft by 15 ft in order to locate and examine the spillway concrete core wall. Bag samples of selected materials were taken for testing.

Ho Train
Spillway Stability 39

The test pits were backfilled in 4-inch to 6-inch loose lifts and each lift was compacted by 3 to 4 passes of a Makita R3988 vibrating plate compactor. The disturbed ground surface was sodded upon completion to minimize erosion.

4.4 FAULTING AND SEISMICITY

The Upper Peninsula of Michigan is located within the Canadian Shield structural province. Shield areas are the most stable portions within continental masses.

There are no known faults in the Upper Peninsula of Michigan, or within hundreds of miles of that region that exhibit evidence of movement within, at most, the last 15 million years (Howard 1979). This is considered as evidence that there are no capable faults of sufficient proximity to influence the structural integrity of the dam and associated structures.

The USGS Earthquake Data Base System was used to review the earthquake history within a 200-mile radius of the nearby Dead River Basin. This review, performed in February, 1992, showed that a total of 6 tectonically related earthquakes have occurred within the period from 1793 to 1991. Four of the earthquakes had epicentral intensities of ≤ 4.0 on the Richter scale and one each of intensities of ≤ 3.0 and ≤ 2.0.

The maximum credible earthquake was estimated to have a body wave magnitude of 5.3 and a return period of about 1000 years (Nuttli and Herrmann 1978). The maximum horizontal acceleration was estimated to be 0.03g with a return period of about 2400 years (Algermissen et. al. 1991).

4.5 SINKHOLE POTENTIAL

Sinkholes are formed by dissolution of rocks such as limestone and gypsum. No such soluble rocks are known to exist in the project area and no karst features were observed.

Au Train
Spillway Stability 40/48

granular materials shown in Naval Facilities Engineering Command (1982) and were adjusted to the in-situ densities using this relationship. Steady-state strengths were estimated from published test results on similar material (Committee on Earthquake Engineering 1985, Davis 1988, and Davis 1994).

Test pit samples from the south levee were tested for gradation, relative density, and shear strength. The material is a uniform medium to fine sand with less than 3 percent non-plastic fines. Maximum and minimum relative dry densities for this material were 107.2 pcf and 92.2 pcf. Six consolidated, undrained triaxial tests with pore pressure measurements were run on the material. A p-q plot is in Appendix F. The test results were in agreement with the relationship between angle of internal friction and dry unit weight for granular materials shown in Naval Facilities Engineering Command (1982) and were adjusted to the in-situ densities using this relationship. Steady-state strengths were estimated from published test results on similar material (Committee on Earthquake Engineering 1985, Davis 1988, and Davis 1994).

The boring logs show that the alluvium is similar to the material from the north dam. The laboratory test results on the north dam material were used to develop material properties for the alluvium.

Two concrete densities were performed on core samples from boring SW-15 in the spillway section. The samples were from depths of 4.7 and 5.6 ft; dry densities were 137.2 pcf and 147.1 pcf; saturated densities were 148.7 pcf and 154.8 pcf; effective porosities were 18.4 and 12.4 percent. The remaining concrete and rock properties were based on tests on the same geologic formation at the Victoria Dam and test results reported by EPRI (1992a).

7.4 UPLIFT PRESSURES

Uplift pressures were assumed to vary linearly between headwater and tailwater. Uplift pressures were applied over 100 percent of the base area. Uplift pressures for the failure surfaces in the foundation were estimated from the measured pressures and exceeded a linear variation between headwater and tailwater.

Hu Ilain Spillway Stability 1001155 p41

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-4 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/14/88 - 10/14/88
Coordinates: N 64,438 E 38,780
Ground Elevation: 790.4 ft
Groundwater Depth/Date:
Depth to Bedrock:
Total Depth Drilled: 49.0 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: ROTARY

Methods:
Casing Used: 10 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, TEVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: CORRED ROCK UTILIZING NX DOUBLE BARREL, SPLIT INNER TUBE CORE BARREL.

Comments: Piezometer SW-4 was installed in boring, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
790.4	0						
		SS	1	5-5-4 (12.0")	9	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded to sub angular, max. 1.2", <5% fines, dry, light brown, (fill).
785	5	SS	2	3-9-10 (18.0")	19	SP-SM	SAND, as above.
		SS	3	1-2-2 (10.0")	4	SP-SM	SAND, as above, trace black organics.
780	10	SS	4	2-1-2 (8.0")	3	SP-SM	SAND, as above.
		SS	5	14-12-8	20	SP-SM	SAND, as above, trace of gravel, moist.
775	15	SS	6	3-3-3 (8.0")	6	SP-SM	SAND, as above, wet.

Legend/Notes

- Datum is MSL.
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sampler
  NX = NX Rock Core

Approved	Date
	05/12/92

Av Train Spillway Stability 1001755 p42

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-4 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
		SS	7	2-3-3 (9.0")	6	SP-SM	SAND, as above, wet.
770	20	SS	8	3-3-2 (6.0")	5	SP-SM	SAND, as above, wet.
		SS	9	2-2-2 (12.0")	4	SP-SM	SAND, as above, wet.
765	25	SS	10	3-2-1 (5.0")	3	SP-SM	SAND, as above, wet.
		SS	11	7-14-18 (10.0")	32	SP	SAND, fine, poorly graded, non-plastic, 10-15% gravel, highly weathered bedrock, sub angular, moderatly indurated, <5% fines, trace to <5% organics, disseminated thoughout, wet, dark brown to red brown, with very thinly bedded, SAND, coarse to fine, well grade, non-plastic, sub rounded, wet, light brown, (soil development on top of weathered bedrock).
760	30	SS	12	5-1-12 (7.0")	13	SM	SILTY SANDSTONE, fine, poorly graded, non-plastic, sub rounded, 10-15% silt, highly weathered, soft, unconsolidated to moderately indurated, silica cement, wet, light brown, (weathered bedrock).
		SS	13	66-34 (11.0")	34/6		SILTY SANDSTONE, fine, poorly graded, sub rounded, 10-15% silt, highly weathered, moderately to well indurated, silica cemented, wet, light brown, (weathered bedrock).
755	35	NX	1	40 / 17			SANDSTONE TO SILTSTONE, (33.5-34.8'), fine sand to silt, poorly graded, sub rounded, thin to very thin bedded, bioturbated, moderately to severly weathered, unconsolidated to well indurated, with thinly laminated interbeds that are stained black to dark brown, sulfur smell on freshly borken surfaces, poor recovery-badly broken up. SANDSTONE, (39.5-37.8'), fine grained, poorly graded, sub rounded, laminated to thinly laminated, wavy continuous to discontinuous beding, fresh to moderatly weathered, well indurated, locally bioturbated, silica cement, (bedrock). Lost core .75 ft.
750	40	NX	2	50 / 20			SANDSTONE, (38.5-39.5'), fine grained, poorly graded, sub rounded, silica cement, laminated, locally bioturbated, parrallel to wavy continuous to discontinuous beds, sever to moderately weathered, moderately indurated, with spotty black to dark brown staining, poor recovery, badly broken up, tan to light brown. SANDSTONE, (39.5-41.0'), fine grained, poorly graded, subrounded, silica cement, very thinly laminated to laminated, locally bioturbated, wavy and perrall discontinuous to continuous beding, fresh-unweathered, moderately to well indurated, local thin black silt to clay partings, local .1" quartz lined vugs, light gray. Lost 2.5 ft of core.
745	45	NX	3	87 / 83			SANDSTONE, (43.5-44.5'), fine grained, poorly graded, sub rounded, silica cement, laminated, bioturbated, parrallel to wavy continuous to discontinuous beds, fresh unweathered, moderately indurated, locally thin silty discontinuous partings, light to dark gray. SANDSTONE, (44.5-47.8'), fine grained, poorly graded, sub rounded, silica cement, fresh unweathered, locally bioturbated, thin bedded to linly laminated, locally wispy laminations, local .1-.3", quartz lined vugs, local partially open vertical fracture, light to dark gray. Lost .6 ft of core.
		NX	4	0 / 0			NO CORE RECOVERY, bit sheared off in borehole.
							BOTTOM OF BORING AT 49.0 FT.

Note: See Sheet 1 for Boring Summary and Legend Information | Approved | Date 05/12/92

Autrain Spillway Stability 1001155 043

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-9 J.O. 18372 Sheet 1 of 3

Site: FOREST LAKE DAM — Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/11/88 - 10/11/88
Coordinates: N 64,411 E 38,388 — Ground Elevation: 789.2 ft
Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 53.0 ft
Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: — Casing Used: 36.6 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: CORED ROCK UTILIZING NX DOUBLE BARREL, SPLIT TUBE CORE BARREL.

Comments: Piezometer SW-9 was installed in borint, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
789.2	0						
		SS	1	6-12-7	19	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded, max. 1.2", 5% fines, dry, light brown, (fill).
785	5	SS	2	2-2-2	4	SP	SAND, as above, 10% gravel, <5% fines.
		SS	3	4-8-7 (6.0")	15	SP-SM	SAND, as above in sample #1, rock in tip of split spoon sampler.
780	10	SS	4	2-2-2 (7.0")	4	SP-SM	SAND, as above, moist.
		SS	5	2-6-7 (9.0")	13	SP-SM	SAND, as above, moist, rock in tip of split spoon sampler.
775	15	SS	6	3-3-6 (8.0")	9	SP-SM	SAND, as above, moist, rock in tip of split spoon sampler.

Legend/Notes
- Datum is MSL.
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  - SS = Split Spoon Sampler
  - NX = NX Rock Core

Approved	Date
	05/12/92

AuTrain Spillway Stability 10007 55,44

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-9 J.O. 18372 Sheet 2 of 3

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
		SS	7	6-3-4 (8.0")	7	SP-SM	SAND, as above, moist, rock in tip of split spoon sampler.
770							
	20	SS	8	4-5-6 (10.0")	11	SP-SM	SAND, as above.
		SS	9	6-5-4 (12.0")	9	SM	SILTY SAND, coarse to fine, well graded, slightly plastic, sub angular to sub rounded, 10-20% fines, wet, red brown, (alluvium), rock in tip of split spoon sampler.
765							
	25	SS	10	1-1-4 (4.0")	5	SM	SILTY SAND, coarse to fine, well graded, slightly plastic, sub angular to sub rounded, 10-20% fines, wet, red brown, (alluvium), rock in tip of split spoon sampler.
		SS	11	5-14-7 (9.0")	21	SM	SILTY SAND, fine, poorly graded, non-plastic, sub angular, 10-15% gravel, sub rounded, max. 1" severely to moderately weathered, soft to hard, weathered sandstone, 10-15% fines, wet red brown, (alluvium).
760							
	30	SS	12	7-9-6 (9.0")	15	SM	GRAVELY SILTY SAND, fine, poorly graded, non-plastic, sub angular, 10-15% gravel, sub rounded, max. 1", severely to moderately weathered, soft to hard, weathered sandstone, rounded granite and metamorphics, 10-15% fines, wet, mottled, red brown to brown, (alluvium and weathered bedrock).
		SS	13	22-15-18 (2.0")	33	SM	GRAVELY SILTY SAND, as above, 20-30% gravel, angular, max. 1", moderatly weatherd, soft to hard, weathered bedrock, 10-15% fines, wet mottled red brown, (alluvium and weathered bedrock).
755							
	35	SS	14	10-12-11 (14.0")	23	SM	GRAVELY SILTY SAND, as above.
		SS / NX	15 / 1	32 / 95/83	32/2		SANDSTONE, fine, well sorted, fresh, well indurated, with trace pyrite, gray, (bedrock), 1" rec. / SANDSTONE, fine grained, well sorted, sub angular, occasionally silty to very silty bedded, locally differential cementation, moderately weathered, moderately indurated, with very thin bedded interbeds of siltstone, wavy to parrall continuous to discontinuous bedding, top half of core yellow brown (oxidized), lower half light grey, (bedrock). Lost .35 ft of core.
750							
	40						
		NX	2	95/84			SANDSTONE, as above, fresh, moderatly to well indurated, light gray, (bedrock). Lost .26 ft of core.
745							
	45						
		NX	3	95/78			SANDSTONE, as above, moderate to fresh, moderatly to well indurated, local high angle to vertical fracture, local .1-.6" irregular quartz lined vugs, light gray to locally yellow brown, (bedrock). Lost .24 ft of core.
740							

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 05/12/92

Au Train Spillway Stability 1001755 pg 5

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-9 J.O. 18372 Sheet 3 of 3

Site: FOREST LAKE DAM | Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
	50						CONTINUED FROM PAGE TWO.
735							
	55						BOTTOM OF BORING AT 53.0 FT.
							DRILLING NOTES: Drove casing from 10' to 36.7', started to core. During coring operations no mud returns to the surface, while pulling core run #3 we were temporary stuck in hole. Based on no mud returns and material sluffing in it was decided to cancel core run #4.
730							
	60						
725							
	65						
720							
	70						
715							
	75						
710							
	80						

Note: See Sheet 1 for Boring Summary and Legend Information | Approved | Date 05/12/92

AuTrain Spillway Stability 1001755 p46

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-15 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM, SPILLWAY
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/20/88 - 10/20/88
Coordinates: N 64,431 E 38, 565
Ground Elevation: 756.2 ft
Groundwater Depth/Date:
Depth to Bedrock: 6.7 ft
Total Depth Drilled: 20.2 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: ROTARY

Methods:
Casing Used: NONE
Drilling Soil: NONE
Sampling Soil: NONE
Drilling Rock: 0-1.5'4 "TRI-CONE BIT, 1.5-4.5' NX CORE, 4.5-6.3' 5.75" BIT 4" CORE, 6.3-20.2' NX CORE

Comments: Piezometer SW-15 was installed in borehole, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
756.2	0						STARTER HOLE was drilled with a 4" tri-cone roller bit.
755		NX	1	100 / 95			CONCRETE, NEW DECK,(1.5-3.0), 10-12% aggregate, MSA 1.5", sub rounded to rounded, locally horizontal fracture (1.9') with white build up, calcium carbonate ?, dry, tan, (concrete) CONCRETE ORIGINAL CONCRETE (3.0-4.5'), 20-25% aggregate, sub angular to sub rounded, MSA 1', local iron staining around aggregate, dry, tan, (concrete).
	5	LD	2	100 / 97			CONCRETE, as above.
		LD	3	100 / 100			CONCRETE, as above.
750		NX	4	93 / 93			CONCRETE SANDSTONE CONTACT, concrete as above, contact at 6.7', contact was separated when core barrel was open. SILTSTONE (6.7-8.0'), silt, well sorted, sub rounded to sub angular, very thinly bedded to laminated, wavy continuous to discontinuous to parrall bedding, to .5" is moderately weathered (water flowing along contact ?), rest is fresh unweathered, local very thinly bedded interbeds of bioturbated fine grained sandstone, well sorted, moist, yellow brown along weathered zones to gray, fresh rock, (bedrock). SANDSTONE (8.0-11.3'), medium to fine grained, sub rounded, well sorted, bioturbated, trace to 10% .4-.1" well rounded glauconite pellets, thinly bedded, wavy bedding, locally moderately weathered, well indurated, light gray to yellow brown along moderately weatherd areas.
	10						
745		NX	5	93 / 93			SANDSTONE, as above in the lower portion of run #4.
	15						
740		NX	6	97 / 97			SANDSTONE, as above, good inter-granular porosity, well flowed water at a rate of 20-30 GPM. Lost .15 ft of core.

Legend/Notes
- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  NX = NX Rock Core
  LD = 5.75" ID, 4" Core

Approved	Date
	07/08/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-15 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM, SPILLWAY — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
		NX					CONTIUED FORM PAGE ONE
	20						
735							BOTTOM OF BORING AT 20.3 FT
	25						
730							DRILLING NOTES: Drilled starter hole (0.0-1.5') with a 4" tri-cone roller bit, drilled and recovered NX core from 1.5' to 4.5', entered hole with 5.75" ID core bit which cut a 4" core, reamed out hole to 4.5' and started coring to a depth of 6.3' at which depth the rods sheared off adjacent to core barrel-could not cxtract drill rod from core barrel, switched to NX core barrel.
	30						
725							
	35						
720							
	40						
715							
	45						
710							

Note: See Sheet 1 for Boring Summary and Legend Information — Approved — Date 07/08/92

STABILITY ANALYSIS OF CONCRETE GRAVITY DAM

REVISION 1

AUTRAIN SPILLWAY
Flood Loading

[illegible] PM 04-Dec-02 CALC 1001758-1

Prep by: CWH Checked by: AB PAGE 49 of 53

USBR Cracked Base Analysis Method with following limitations:
-No reduction of uplift within dam during flood, uplift reduction due to drains not considered
tailwater level must be below downstream slope change, headwater overtopping flashboards not checked

A) Shape and Size of Dam/Pool Levels

Top of Concrete Dam	779.3	(Elev)
Bottom of Dam	749.5	(Elev)
T.O. Flashbd, 0 if none	0.0	(Elev)
U/S Slope Change	779.3	(Elev)
D/S Slope Change	779.3	(Elev)
Crest Width	7.0	(FT)
U/S Slope	0.050	(Decimal)
D/S Slope	0.750	(Decimal)
Headwater Elev.	788.5	(Elev)
Tailwater Elev.	758.7	(Elev)
F.B. Loc from U/S Crest	0.00	(FT)

Input Summary

Dam Ht	29.8	(FT)
HW Level	39.0	(FT)
TW Level	9.2	(FT)
Overtop	9.20	(FT)
Br TW	9.5	
Ice Load	No	
Silt Load	No	
Anchors	No	
Flashbd Ht	0.00	(FT)

B) Material Properties

Unit Wt Water	0.0624	(KCF)
Unit Wt Concrete	0.1530	(KCF)
Friction Angle,Lift Jt	35.00	(DEG)
Friction Angle,Contact	30.00	(DEG)
Cohesion,Lift Jt	50.00	(psi)
Cohesion,Contact	30.00	(psi)

C) Other Loads

Ice Point Load	0.00	(KIPS/FT)
Ice Load Elev	0.0	(Elev)
Sat Unit Wt Silt	0.1250	(KCF)
Silt Thickness	0.0	(FT)
Earth Pressure Coeff.	0.33	(Default = .70)
Anchor Load	0.0	(KIPS/FT)
Anchor Distance from		
U/S Edge of Crest	4.0	(FT)
TW Reduction Coeff		
(.6 for Spwy. Section)		
(1 for Non-overflow)	0.60	
Horiz. Crest Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vert. Crest Pressure	0.00	(KIPS/FT)
Distance from U/S		
Edge of Crest	0.00	(FT)
Horiz. Bucket Pressure	0.00	(KIPS/FT)
Elev. of Application	0.0	(Elev)
Vertical Bucket Pressure	0.00	(KIPS/FT)
Distance from U/S		
Edge of Crest	0.00	(FT)

Load Summary

Elev. (ft)	Sum of Horiz. Forces (kips)	Sum of Vertical Forces w/o Uplift (kips)	Sum of Uplift (kips)	Sum of Moments w/o Uplift (ft-kips)	e (ft)	e' (ft)
776.32	1.90	8.60	-3.83	-4	-0.85	-0.86
773.34	4.57	11.39	-5.44	-4	-0.37	-0.37
770.36	7.83	17.11	-7.76	-2	-0.13	-0.13
767.38	11.38	23.88	-10.34	3	0.12	0.12
764.40	16.46	31.81	-13.72	12	0.38	0.38
761.42	20.34	40.36	-17.32	26	0.60	0.60
758.44	26.46	50.16	-21.92	41	0.83	0.83
755.46	31.42	60.88	-30.30	64	1.06	1.06
752.48	37.84	72.88	-35.81	80	1.29	1.29
749.50	43.86	88.30	-66.14	120	1.54	8.14

Stability Summary

Elevation (ft)	Section Width (ft)	Crack Length (ft)	Shear Friction Safety Factor
776.32	8.25	N/A	30.10
773.34	11.20	N/A	18.30
770.36	13.75	N/A	14.21
767.38	16.00	N/A	11.40
764.40	18.38	N/A	9.64
761.42	20.50	N/A	8.63
758.44	22.75	N/A	7.93
755.46	25.00	N/A	6.77
752.48	27.25	N/A	6.20
749.50	29.50	12.88	1.38

=1.5
OK

some cracking
OK

Stress Summary

Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)
0.98	-0.76	0.22	0.46	0.00	0.46
1.10	-0.86	0.24	0.80	0.00	0.80
1.31	-1.13	0.18	1.18	0.00	1.18
1.42	-1.32	0.10	1.56	0.00	1.56
1.53	-1.50	0.03	1.94	0.00	1.94
1.63	-1.68	-0.07	2.32	0.00	2.32
1.72	-1.88	-0.16	2.88	-0.02	2.87
1.83	-2.06	-0.23	3.05	-0.20	2.85
1.93	-2.25	-0.32	3.43	-0.39	3.03
2.43	-2.43	0.00	4.17	-0.87	3.30

PMF Headwater increased to 788.5 for modification of South Levee to pass PMF over it assuming no failure

PMF TW increased by equal amount (1.7 feet)

Concrete weight used was average of wet values.

AUTRAIN SPILLWAY
Flood Loading

02:02 PM 04-Dec-02 CALC 1001790-1 Prep by: CWH Checked by: AB PAGE 50 OF 53

STATIC ANALYSIS

1. Concrete Weights and Moment Arms

Block	y/H	Elevation (ft)	y (ft)	W1 (kips)	W2 (kips)	W3 (kips)	x1 (ft)	x2 (ft)	x3 (ft)	x (ft)	CLb (ft)	r1 (ft)	r2 (ft)	r3 (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.00	3.17	0.51	0.00	7.00	2.25	9.25	4.62	0.00	-1.12	3.13
2.00	0.80	773.34	23.84	0.00	6.34	2.04	0.00	7.00	4.50	11.50	5.75	0.00	-2.25	2.75
3.00	0.70	770.36	20.86	0.00	9.51	4.59	0.00	7.00	6.75	13.75	6.87	0.00	-3.37	2.38
4.00	0.60	767.38	17.88	0.00	12.68	8.15	0.00	7.00	9.00	16.00	8.00	0.00	-4.50	2.00
5.00	0.50	764.40	14.90	0.00	16.[illegible]	12.74	0.00	7.00	11.25	18.[illegible]	9.12	0.00	-5.62	1.63
6.00	0.40	761.42	11.92	0.00	19.02	18.34	0.00	7.00	13.50	20.50	10.25	0.00	-6.75	1.25
7.00	0.30	758.44	8.94	0.00	22.20	24.97	0.00	7.00	15.75	22.75	11.37	0.00	-7.87	0.88
8.00	0.20	755.46	5.96	0.00	25.37	32.61	0.00	7.00	18.00	25.00	12.50	0.00	-9.00	0.50
9.00	0.10	752.48	2.98	0.00	28.54	41.27	0.00	7.00	20.25	27.25	13.62	0.00	-10.12	0.13
10.00	0.00	749.50	0.00	0.00	31.71	50.95	0.00	7.00	22.50	29.50	14.75	0.00	-11.25	-0.25

2. Vertical Weights + Moment Arms of Reservoir on Dam

Block	y/H	Elevation (ft)	y (ft)	Overtop Weight on U/S Fillet Ww1 (kips)	Normal HW Above U/S Fillet Ww2 (kips)	Normal HW On U/S Fillet Ww3 (kips)	Overtop Water Weight on Crest Ww4 (kips)	Overtop Water Weight on Crest Ww5 (kips)	Tailwater Weight Ww6 (kips)	Water U/S of Flashboards Ww7 (kips)	xw1 (ft)	xw2 (ft)	xw3 (ft)	xw4 (ft)	xw5 (ft)	xw6 (ft)	xw7 (ft)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.90	776.32	26.82	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-2.30	-1.12	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-3.42	-2.25	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-4.54	-3.37	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-5.67	-4.50	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-6.79	-5.62	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-7.92	-6.75	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-9.04	-7.87	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	1.00	2.01	0.00	0.00	0.00	0.00	0.00	-10.17	-9.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	1.00	2.01	0.16	0.00	0.00	0.00	0.00	-11.29	-10.12	12.00	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	1.00	2.01	0.72	0.00	0.00	0.00	0.00	-12.42	-11.25	13.38	0.00

STABILITY ANALYSIS OF CONCRETE GRAVITY DAM

AUTRAIN SPILLWAY
Flood Loading

08:58 PM 04-Dec-02 CALC 1001765-1 Prep by: CWH Checked by: AB PAGE 51 OF 53

3. Horizontal Reservoir Forces, Silt Loads, Ice Loads, and Moment Arms

				HW	HW	Silt	Ice	TW					
Slice	y/Ho	Elevation (ft)	y (ft)	P1 (kips)	P2 (kips)	P3 (kips)	P4 (kips)	P5 (kips)	yP1 (ft)	yP2 (ft)	yP3 (ft)	yP4 (ft)	yP5 (ft)
#	#	#	#	#	#	#	#	#	#	#	#	#	#
1.00	0.90	776.32	26.82	0.28	1.71	0.00	0.00	0.00	[illegible]	1.49	0.00	0.00	0.00
2.00	0.80	773.34	23.84	1.11	3.42	0.00	0.00	0.00	1.99	2.98	0.00	0.00	0.00
3.00	0.70	770.36	20.86	2.49	5.13	0.00	0.00	0.00	2.98	4.47	0.00	0.00	0.00
4.00	0.60	767.38	17.88	4.43	6.84	0.00	0.00	0.00	3.97	5.96	0.00	0.00	0.00
5.00	0.50	764.40	14.90	6.93	8.55	0.00	0.00	0.00	4.97	7.45	0.00	0.00	0.00
6.00	0.40	761.42	11.92	9.97	10.26	0.00	0.00	0.00	5.96	8.94	0.00	0.00	0.00
7.00	0.30	758.44	8.94	13.58	11.97	0.00	0.00	0.00	6.95	10.43	0.00	0.00	0.00
8.00	0.20	755.46	5.96	17.73	13.68	0.00	0.00	0.00	7.95	11.92	0.00	0.00	0.00
9.00	0.10	752.48	2.98	22.44	15.40	0.00	0.00	-0.38	8.94	13.41	0.00	0.00	0.00
10.00	0.00	749.50	0.00	27.71	17.11	0.00	0.00	-0.88	9.93	14.90	0.00	0.00	1.84

4. Anchor Force, Silt Weight, Bucket and Crest Pressures, and Moment Arms

				Anchor	Silt			Crest Pressure				Bucket Pressure			
Slice	y/Ho	Elevation (ft)	y (ft)	Wa (kips)	Ws (kips)	xs (ft)	ys (ft)	Wc (kips)	Pc (kips)	xc (ft)	yc (ft)	Wb (kips)	Pb (kips)	xb (ft)	yb (ft)
#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
1.00	0.90	776.32	26.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	0.80	773.34	23.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	0.70	770.36	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	0.60	767.38	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.50	764.40	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	0.40	761.42	11.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	0.30	758.44	8.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	0.20	755.46	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	0.10	752.48	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	749.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STABILITY ANALYSIS OF CONCRETE GRAVITY DAM

AUTRAIN SPILLWAY
Flood Loading

[illegible] PM [illegible]

CALC 1001[illegible]-1

Prep. by: AWH

Checked by: ATB

PAGE 52 of 53

5. Uplift Forces and Moment Arms

Slice #	y/h -	Elevation (ft)	y (ft)	Section Width (ft)	Crack Length (ft)	U1 (kips)	U2 (kips)	U3 (kips)	m1 (ft)	m2 (ft)	m3 (ft)
1.00	[illegible]	776.22	[illegible]	9.20	N/A	0.00	-3.42	0.00	0.00	-1.54	0.00
2.00	[illegible]	773.34	[illegible]	11.[illegible]	N/A	0.00	-6.44	0.00	0.00	-1.92	0.00
3.00	0.70	770.30	[illegible]	13.75	N/A	0.00	-7.70	0.00	0.00	-2.20	0.00
4.00	[illegible]	767.30	17.[illegible]	16.00	N/A	0.00	-10.34	0.00	0.00	-2.67	0.00
5.00	[illegible]	764.40	14.90	18.2[illegible]	N/A	0.00	-13.72	0.00	0.00	-3.04	0.00
6.00	[illegible]	761.42	11.92	20.[illegible]	N/A	0.00	-17.32	0.00	0.00	-3.42	0.00
7.00	[illegible]	758.44	[illegible]	22.75	N/A	-0.37	-21.1[illegible]	0.00	0.00	-3.70	0.00
8.00	0.20	755.46	[illegible]	2[illegible]	N/A	-4.05	-2[illegible]	0.00	0.00	-4.17	0.00
9.00	0.10	752.46	2.[illegible]	27.2[illegible]	N/A	-10.[illegible]	-[illegible]	0.00	0.00	-4.24	0.00
10.00	0.00	749.[illegible]	0.00	[illegible]	12.[illegible]	-[illegible]	-1[illegible]	-23.[illegible]	0.00	3.83	-4.43

6. Shear Friction Safety Factor

Slice #	y/h -	Elevation (ft)	y (ft)	SigFH sum of horz forces (kips)	SigM sum of moments w/o uplift (kip-ft)	SigFV sum of vertical forces w/o uplift (kips)	A3 uplift at heel (ksf)	e (ft)	Sig1 heel stress w/o uplift (ksf)	Sig2 toe stress w/o uplift (ksf)	e' (ft)	T Crack Length (ft)	Section Width (ft)	Total Uplift (kips)	F.S. Shear Friction Factor -
1.00	[illegible]	776.22	[illegible]	1.[illegible]	-3.71	[illegible]	-0.7[illegible]	-0.[illegible]	0.[illegible]	0.44	-0.[illegible]	N/A	9.2[illegible]	-3.42	2[illegible].1[illegible]
2.00	[illegible]	773.34	[illegible]	4.[illegible]	-4.22	11.2[illegible]	-0.[illegible]	-0.37	1.1[illegible]	0.[illegible]	-0.27	N/A	11.50	-6.44	1[illegible]
3.00	0.70	770.30	[illegible]	7.[illegible]	-3.1[illegible]	17.11	-1.13	-0.13	1.31	1.16	-0.13	N/A	13.75	-7.70	14.21
4.00	0.60	767.30	17.[illegible]	11.3[illegible]	2.[illegible]	2[illegible]	-1.2[illegible]	0.12	1.42	1.[illegible]	0.12	N/A	16.00	-10.34	11.40
5.00	[illegible]	764.40	14.90	1[illegible]	11.[illegible]	31.81	-1.[illegible]	0.3[illegible]	1.52	1.84	0.3[illegible]	N/A	18.25	-13.72	9.84
6.00	0.40	761.43	11.[illegible]	2[illegible]	34.22	40.2[illegible]	-1.[illegible]	0.[illegible]	1.[illegible]	2.32	0.[illegible]	N/A	20.[illegible]	-17.32	8.43
7.00	0.30	758.44	[illegible]	2[illegible]	41.47	[illegible]	-1.[illegible]	0.[illegible]	1.72	2.[illegible]	0.[illegible]	N/A	22.75	-21.[illegible]	7.[illegible]
8.00	0.20	755.46	[illegible]	31.42	[illegible]	[illegible]	-2.[illegible]	1.[illegible]	1.[illegible]	3.05	1.[illegible]	N/A	2[illegible]	-2[illegible]	[illegible].77
9.00	0.10	752.46	2.[illegible]	37.[illegible]	[illegible].47	72.[illegible]	-2.2[illegible]	1.2[illegible]	1.92	3.43	1.2[illegible]	N/A	27.2[illegible]	-3[illegible]	[illegible].20
10.00	0.00	749.50	0.00	4[illegible]	133.47	[illegible]	-2.43	1.54	2.01	3.[illegible]	[illegible].14	12.[illegible]	[illegible]	-[illegible].14	1.[illegible]

STABILITY ANALYSIS OF CONCRETE GRAVITY DAM

AUTRAIN SPILLWAY
Flood Loading

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7. Stresses at Heel and Toe

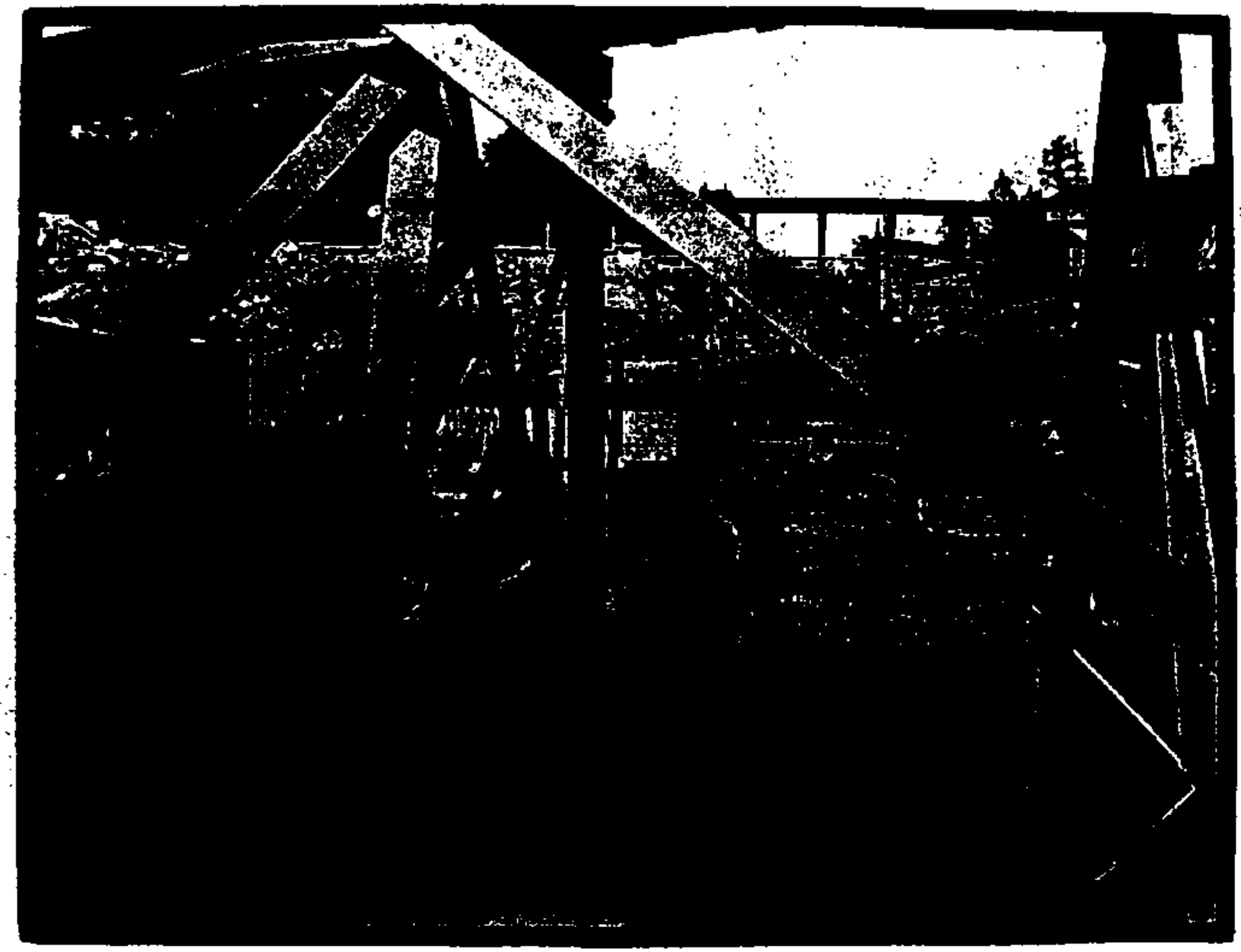
Block	p/Ho	Elevation (ft)	T (ft)	T Crack Length (ft)	Total Vertical Stress at Heel (ksf)	Uplift at Heel (ksf)	Effective Vertical Stress at Heel (ksf)	Total Vertical Stress at Toe (ksf)	Uplift at Toe (ksf)	Effective Vertical Stress at Toe (ksf)	Sum of Total Stress Diagram (kips)	Sum of Effect Stress Diagram (kips)	Sum of Uplift Diagram (kips)	Sum of Effect Diagrams (kips)	SigFV sum of vert forces w/o uplift (Part4,Col.8) (kips)
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00	0.00	776.32	26.82	N/A	0.95	-0.70	0.22	0.40	0.00	0.40	-6.7	-3.2	-3.0	-6.7	6.7
2.00	0.80	773.34	23.04	N/A	1.10	-0.95	0.24	0.80	0.00	0.80	-11.4	-6.0	-6.4	-11.4	11.4
3.00	0.70	770.36	20.46	N/A	1.31	-1.13	0.18	1.15	0.05	1.10	-17.1	-9.2	-7.8	-17.1	17.1
4.00	0.60	767.38	17.00	N/A	1.43	-1.22	0.18	1.56	0.00	1.56	-22.8	-13.3	-10.6	-23.0	23.0
5.00	0.50	764.40	14.00	N/A	1.52	-1.50	0.00	1.84	0.00	1.84	-31.6	-17.9	-12.7	-31.6	31.6
6.00	0.40	761.42	11.00	N/A	1.62	-1.60	-0.07	2.32	0.00	2.32	-40.4	-23.1	-17.3	-40.4	40.4
7.00	0.30	758.44	8.04	N/A	1.72	-1.85	-0.13	2.80	-0.02	2.87	-60.3	-30.7	-31.3	-60.2	60.2
8.00	0.20	755.46	5.00	N/A	1.83	-2.09	-0.23	3.06	-0.20	2.86	-61.0	-32.7	-28.3	-61.0	61.0
9.00	0.10	752.48	2.00	N/A	1.92	-2.26	-0.33	3.43	-0.38	3.05	-73.6	-37.1	-36.5	-73.8	73.8
10.00	0.00	749.50	0.00	12.65	2.43	-3.43	0.00	4.17	-0.57	3.50	-88.4	-50.3	-40.1	-88.4	88.4

APPENDIX C

CONSTRUCTION PHOTOGRAPHS

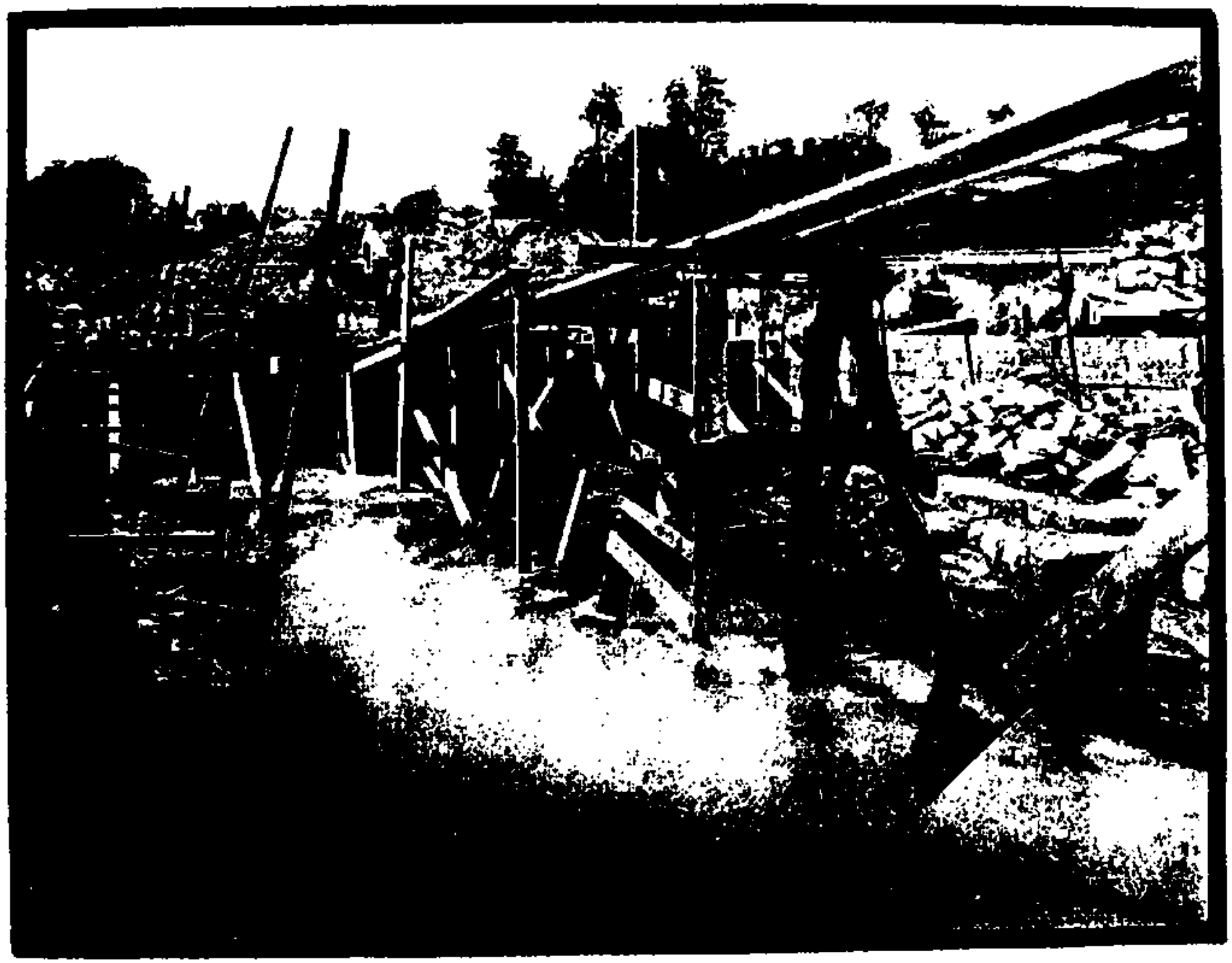
AU TRAIN RIVER WATER POWER [illegible]
VIEW SHOWING SPILLWAY FOOTINGS, LOOKING NORTHWEST

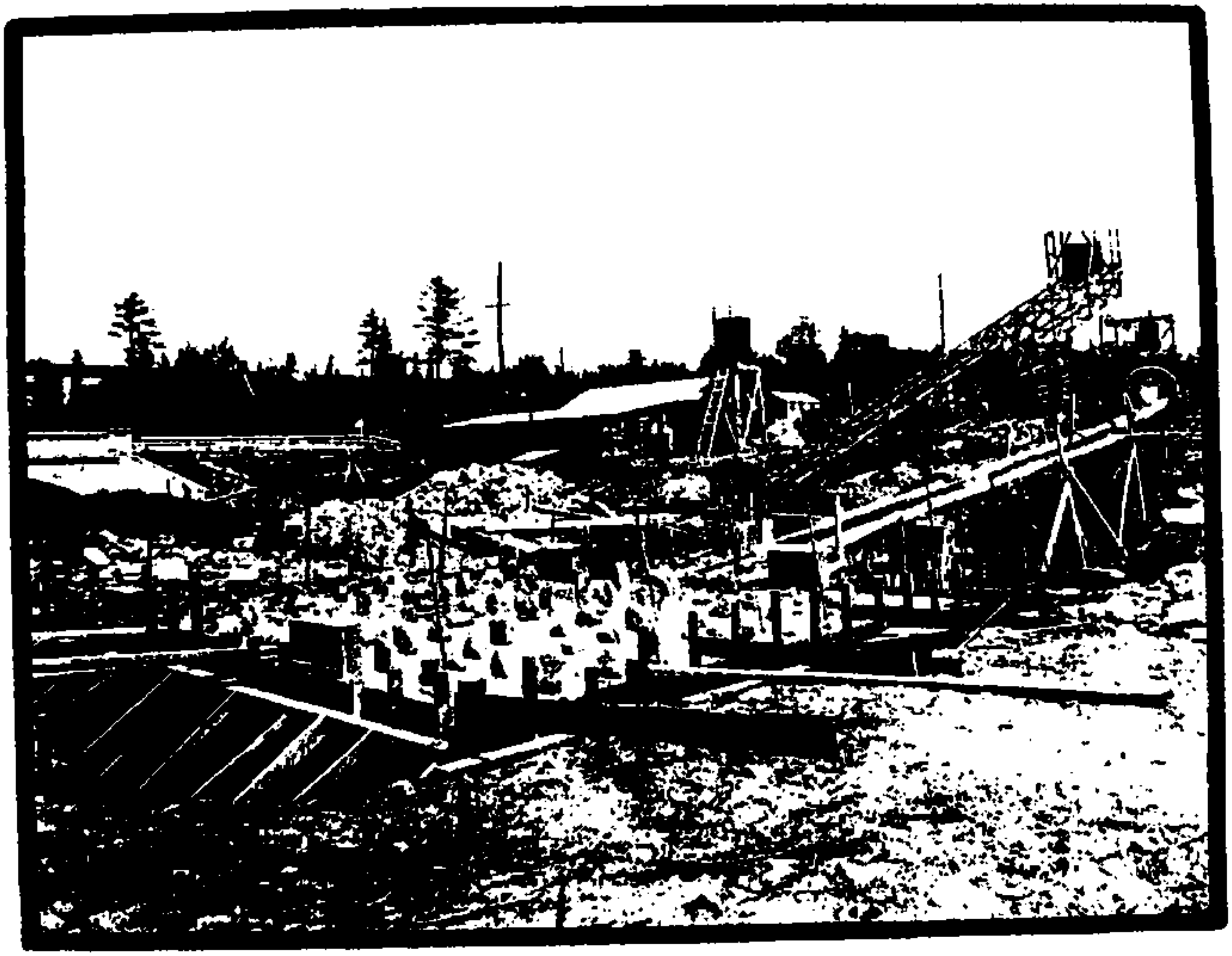
[illegible]

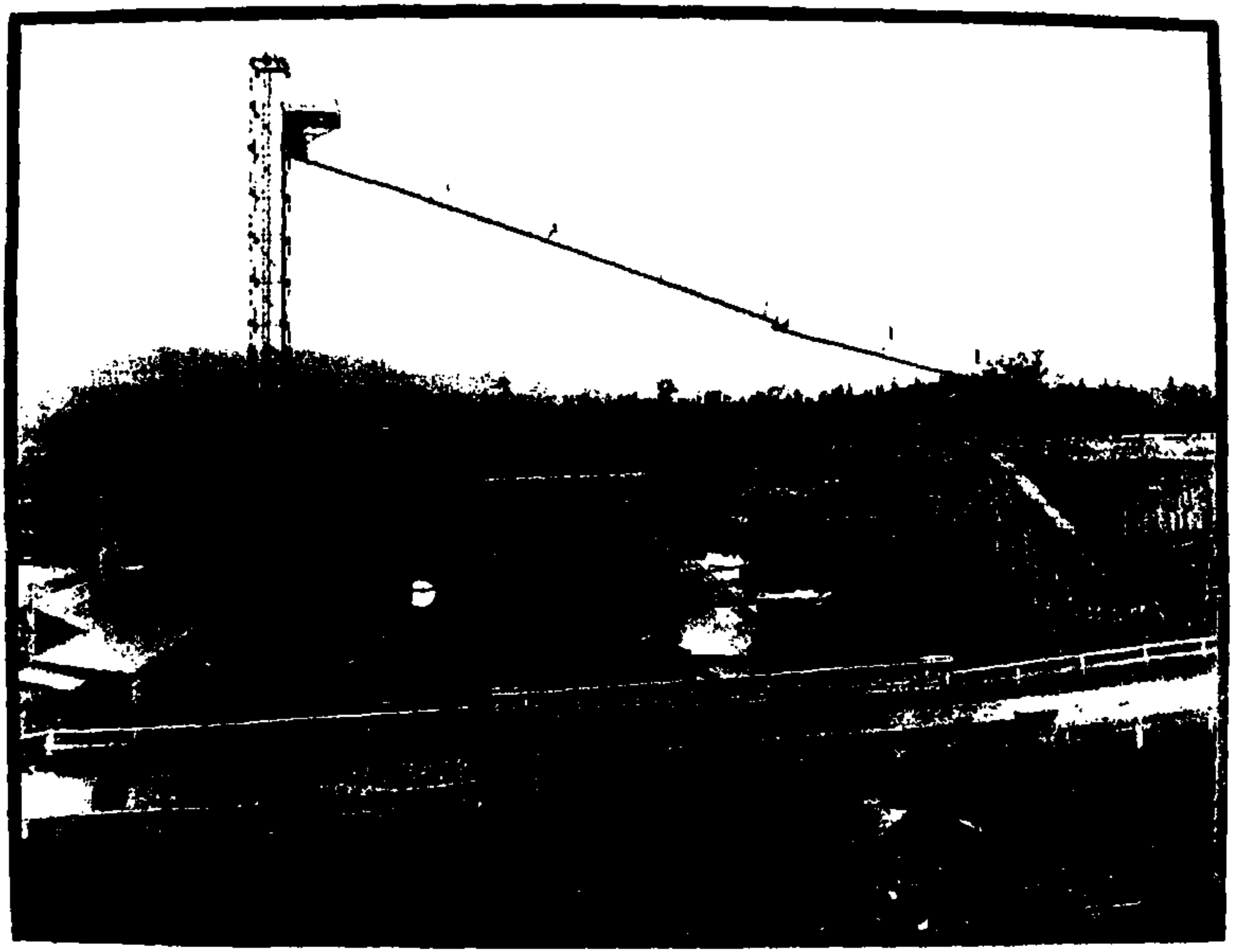


AU TRAIN RIVER WATER POWER--DAM SITE
VIEW OF ROCK FOOTINGS OF EAST RETAINING WALL OF SPILLWAY, LOOKING NORTH

JULY 19[illegible]
PLATE NO. [illegible]







AU TRAIN RIVER WATER POWER DAM SITE
VIEW OF SPILLWAY, LOOKING [illegible]

APPENDIX D

INUNDATION MAPS FOR EAST BRANK OF THE WHITEFISH RIVER

Au Train Hydroelectric Project
Dam Modifications
Quality Control and Inspection Plan
FERC Project No. 10856

Prepared for

Upper Peninsula
Power Company

A WPS Resources Company
WPS Resources

By

MWH
MONTGOMERY WATSON HARZA

December 2002

AU TRAIN HYDROELECTRIC PROJECT
DAM MODIFICATIONS
QUALITY CONTROL AND INSPECTION PROGRAM

TABLE OF CONTENTS

A. INTRODUCTION

General Description of the Project

The Au Train Hydroelectric Project is located on the Au Train River in Alger County, Michigan. The project began operation in 1910 and is located upstream of Au Train Lake, a natural lake. The main dam levee was constructed in 1930 and 1931 and the south levee was constructed in 1931. Both dams were constructed to enlarge the reservoir and increase the power generation capacity of the project. The project impounds approximately 6.6 miles of the Au Train River and the impoundment has a surface area of approximately 1,557 acres at full pool. The project is currently operated as modified run-of-river project based on the water level maintained at the reservoir.

The project features consist of an embankment saddle dam located at the south end of the storage reservoir (South Levee); the main embankment dam located at the north end of the storage reservoir (North Dam) and with a central spillway and penstock intake; a 2,516-foot long 5 ½ -foot diameter penstock; indoor powerhouse with two 800 horsepower generating units and two 560 kV generators; and a 2,500-foot long 2,300 V transmission line. The project layout is given in Appendix J-1.

Normally, all releases from the dam are made through the penstock for use in power generation. Under proposed operation, the normal reservoir water level will range between El. 777.3 feet and El. 781.3 feet, excluding late winter drawdown. The reservoir elevation near El. 781.3 feet will occur during the spring runoff period in May while water levels near El. 777.3 will occur as a result of late summer (August and September) drafting of the reservoir for downstream fisheries and recreation interests. The reservoir will be drawn down to a target level of El. 772.3 in late winter to reduce the frequency and magnitude of uncontrolled discharges during spring runoff. During late winter (March), the reservoir will be drawn down to a target elevation of 772.3 feet.

South Levee

The embankment saddle dam, or South Levee, is located between the Lake Superior and Lake Michigan drainage basins and impounds the south end of the Au Train Basin. The 4,500-foot long South Levee has a maximum height of 15 feet with a crest width of 10 feet at an average crest elevation at 789.7 feet. The embankment was constructed with 2H:1V upstream and downstream slopes which have good ground cover. In a small area near the left abutment, the crest of the embankment is approximately 3 to 3.5 feet lower than along the rest of the embankment. Old tree stumps are present on both the upstream and downstream slopes and the entire downstream toe area is wet and swampy due to poor drainage.

The South Levee is a homogeneous loose sand embankment. The South Levee embankment is founded on granular alluvium composed of silty sand to sandy gravel. The entire downstream area is boggy and soft.

Main Embankment – North Dam

The main embankment, also known as the North Dam, is located at the north end of the Au Train reservoir. The 1,500-foot long dam is approximately 38 feet high at the maximum section with a crest width between 15 and 20 feet at El. 790 feet. The concrete overflow spillway and penstock intake sections are located at the center of the dam. A concrete core wall extends approximately 50 feet from both sides of the spillway/intake into the embankment. The upstream slopes were constructed at 3H:1V slopes while the downstream slopes were constructed at 4H:1V slopes with several parallel sets of toe drains along the downstream toe.

The North Dam is a 1,500-foot long earth embankment with the average top crest elevation at 789.8 feet. A 20-foot high and 100-foot wide concrete spillway is located in the dam's center portion. The crest elevation of the spillway is at El. 779.3 feet with the stoplogs at extending the crest to El. 781.3 feet. Concrete core walls extend about 50 feet from both sides of the spillway into the embankment.

The North Dam embankment is composed primarily of a loose sand fill. Beneath the embankment fill, granular alluvium was encountered. The alluvium was similar to the fill material and was a silty sand to sandy gravel with horizons of weathered sandstone bedrock.

Fourteen drain outfalls are located in the downstream slope area of the North Dam. Half of the drains are metal pipes that extend through the base of the right spillway retaining wall. The remainder of the drain outfalls are the drains along the toe of the embankment and shoulders of the highway.

Spillway

The concrete gravity overflow spillway is 100 feet wide by 29 feet high and is located at the center of the North Dam. The crest elevation of the spillway ogee is at El. 779.3 feet; manually operated stoplogs extend the crest to El. 781.3 feet. The spillway discharges into the Au Train River and under the Highway M-94 and the abandoned Lake Superior and Ishpeming (LS&I) Railway Bridges immediately downstream of the spillway.

Powerhouse

The powerhouse is located on the east bank of the upper Au Train River, approximately 2,500 feet downstream of the main dam. The powerhouse has a reinforced concrete substructure and brick superstructure. The inside dimensions of the powerhouse are 37.5 feet long by 32 feet wide by 22 feet high. It houses two identical 800-horsepower, horizontal-axis, Francis type turbines with steel spiral casings. The units operate at a maximum gross head of 134 feet. Each synchronous-type generator is rated at 560 kilovolt-amperes, 600 rpm, 3-phase, 60 hertz, and is directly connected to the turbine shaft with a flywheel.

A 2,300 volt, 3-phase, 60-hertz transmission line, approximately 2,500 feet long, connects to UPPCO's transmission system.

1.1 Intake and Outlet Structure

Water passes through an intake structure and into a steel penstock that bifurcates and feeds the two turbines. Turbine discharge is regulated by adjustable wicket gates controlled by a gate shaft governor and is returned to the upper Au Train River via a 500-foot long, unlined tailrace channel. The intake structure is located in the main dam at the north end of the reservoir to the right of and abutting the overflow spillway. The intake contains stoplogs, a trashrack, and a butterfly shutoff valve. The invert elevation of the intake is at 755.5 feet. The 5.5-foot diameter steel penstock drops approximatley 100 feet over its 2,516-foot length to the powerhouse. There is a 10-foot diameter, exposed steel surge tank connected to the penstock above the powerhouse.

The following activities will be performed as part of the construction of the dam modifications at the Au Train Hydroelectric Project:

- Lower crest of the South Levee

- Construction of a toe drain at the North Dam
- Regrading of North Dam crest
- Repair of damaged concrete in the outlet valve house

B. ORGANIZATION AND STAFFING

The organization chart for the dam modification project is given in Appendix J-2. The Licensee and Owner of the project, Upper Peninsula Power Company, a subsidiary of Wisconsin Public Resources (WPS-UPPCO), will contract separately with the Contractor for the project.

The Contractor for the work will be selected through a competitive bidding process, with only qualified contractors invited to bid. The selected contractor will provide his respective contracted services, including civil works and quality control testing as described in Part C of this document.

Montgomery Watson Harza (MWH) completed the design of the work and will provide oversight of the contractor's work for conformance with the project technical specifications. MWH will also perform reviews during construction. The goal of the quality control and inspection program (QCIP) is to delineate responsibility with respect to quality control and quality assurance monitoring during construction for conformance with the requirements of the Contract Documents (see Appendix J-3). A description of the duties and responsibilities of the QCIP staff is provided below.

Construction Management

WPS-UPPCO, as Owner, assumes responsibility for coordinating construction activities enforcing all provisions of each respective contract, including those with regard to quality of the finished project. WPS-UPPCO has retained MWH to provide technical assistance, and to monitor compliance with quality objectives and compliance with Contract Documents and intent of the design.

Project Management

Responsibilities for management of the engineering and construction activities for this project have been assigned to Mr. Benedict Trotter of WPS-UPPCO (WPS-UPPCO Project Manager) and Mr. Craig Harris, P.E., of MWH (MWH Project Manager).

Mr. Benedict Trotter will have overall responsibility to WPS-UPPCO management for the project. He will interface with the Federal Energy Regulatory Commission, WPS-UPPCO's Environmental Compliance Officer, and MWH's Project Manager. He will review all field reports, correspondence and actions and will have final authority with respect to WPS-UPPCO's responsibilities under the Contract. He will have the authority to stop work.

Mr. Trotter will also serve as the Construction Manager. In this role, he will be responsible for oversight of construction activities and coordination with each of the contractors. He will be responsible for coordinating contractor activities as well for the execution of this QCIP. He will visit the site periodically during the work to observe performance of the work, review inspection and test reports, approve non-conformance reports (see Appendix J-4 for example), and prepare field directives and clarifications. He will discuss with MWH's Project Manager any situation where the plans and specifications need to be revised to reflect the field conditions encountered, document field changes, and maintain a record drawing file of changes or revisions made during construction.

As Construction Manager, Mr. Trotter has the responsibility and authority to approve or reject work performed by the contractor. Additionally, he may stop the work being performed, if in his opinion, the work is not in accordance with the Contract Documents. The Construction Manager will also review change order requests, scheduling of construction, and claims prepared by the Contractor. He will attend meetings at the site with the contractors during construction and prepare and issue minutes of these meetings. The Construction Manager will make a final inspection of the Work.

Mr. Craig Harris will interface with WPS-UPPCO's Project Manager/Construction Manager, MWH's Project Engineer, and other support personnel. He will be responsible for review and approval of contractor technical submittals, including manufacturers' catalogue information, for determining changes to the design necessary to accommodate field conditions, reviewing materials and construction methods for general conformance with the design intent, and responding to technical questions that arise during construction. He will have the authority to approve changes to the contract drawings and specifications, and to recommend stop work to UPPCO's Project Manager/Construction Manager.

Environmental Compliance

Mr. Rick J. Moser of WPS-UPPCO will serve as the Environmental Compliance Officer. Mr. Moser will have the responsibility for monitoring contractor compliance with pertinent environmental regulations as called for in the Project Specifications and as described in Part G of this document. He will coordinate with the Michigan Department of Natural Resources and Michigan Department of Environmental Quality and other interested parties during the course of the work, and interface with WPS-UPPCO's Project Manager/Construction Manager during construction.

Engineering and Technical Assistance

WPS-UPPCO has contracted MWH to provide engineering services for this project. Under the direction of MWH's Project Manager, Mr. Michael J. Miller, P.E., will be responsible for coordinating engineering and technical assistance activities during construction, and will interface with appropriate MWH engineering personnel to address geotechnical and civil engineering and technical questions that arise during course of construction.

Mr. Miller, will serve as MWH's Project Engineer and the Quality Assurance Engineer as described in the following paragraphs and will interface with the Project Manager/Construction Manager.

Quality Assurance

MWH's Quality Assurance Engineer will be responsible for reviewing all Quality Control testing and inspection reports submitted by the contractors for compliance with the Contract documents. The Quality Assurance Engineers will notify the Construction Manager of compliance or non-compliance, and will recommend approval or rejection of the contractors' submittals to the Construction Manager

Mr. Miller will also serve as Quality Assurance Engineer for the project. The Quality Assurance Engineer or the Construction Manager will be onsite to observe the following construction activities:

- Inspection of field conditions following clearing, grading and preparation of subgrade of the downstream area of the South Levee.

- Excavation of embankment material to lower the South Levee crest to elevation 784.3.
- Placement and compaction of embankment material downstream of the existing South Levee.
- Excavation and construction of toe drain at North Dam.
- Regrading the crest of the North Dam.
- Repair of the deteriorated concrete at the outlet structure building

They will document their observations for submittal to the Construction Manager, and provide technical assistance during activities, review quality control testing submittals, and provide written field directives and clarifications to the Construction Manager as necessary.

Quality Control

The Contractor will be responsible for Quality Control as part of his contract. The Contractor's responsibilities include performing all testing, inspections, and compliance monitoring stipulated in their respective contracts. The Contractor will be responsible for performing all material sampling, testing and reporting for embankment placement for the South Levee and toe drain backfill in accordance with the Contract documents. The Contractor will also be responsible for removal and disposal of the unsuitable fill material excavated from the South Levee, and for salvaging usable material for use in regrading the North Dam crest and leaving the subgrade of the South Levee in suitable condition for the placement of the new embankment fill material.

The contractor will be responsible for employing the services of an independent testing/inspection company to perform the necessary sampling, testing and inspection of materials and completed works. The contractor will be responsible for the supervision of each respective testing and inspection organization; however, when necessary, the Project Manager and Quality Assurance Engineer can order additional testing or inspection from these firms. The results of all required testing and inspection will be documented in testing and compliance reports submitted to the Quality Assurance Engineer. Appendix J-5 summarizes the testing and inspection activities for which the Contractor is responsible.

Resumes of the above key personnel are also included in Appendix J-2. If these personnel are unavailable to perform the above tasks, qualified individuals will be selected to replace them.

C. INSPECTION PLAN

MWH's Quality Assurance Engineer will monitor compliance with the Contract Documents and advise the Construction Manager of potential non-conformance. Compliance criteria will be as defined in the Contract Documents and any amendments or change orders executed during the Work. Adjustments may be made to account for changed field conditions. The Quality Assurance Engineer will also evaluate the appropriateness of the design to the actual field conditions. The Construction Manager will advise the Contractor of determinations of non-conformance. Potential changes to the design resulting from site conditions or for other reasons will be evaluated by MWH's Project Manager and Project Engineer, who will advise the WPS-UPPCO Project Manager/Construction Manger. Payment for changes to the design will be determined by WPS-UPPCO's Project Manager/Construction Manager. WPS-UPPCO and MWH will have access at all times to all parts of the Contractor's equipment for checking adequacy and appropriateness of the equipment.

The Contract drawings, specifications, codes, standards, and laws are the basis of the Contract enforcement and will be interpreted by the Construction Manager. The Construction Manager and Quality Assurance Engineer will verify that the Contractor meets the Contract obligations, but not direct or control the Contractor's operations.

<u>Cleaning and Stripping of the South Levee for Modifications to the Levee</u>

The Quality Assurance Engineer or Construction Manager will inspect the project site after cleaning and stripping of the South Levee to verify that the subgrade materials and finish grading are satisfactory to allow the placement of the embankment fill.

<u>Construction of South Levee Modifications</u>

The Quality Assurance Engineer will review the Contractor submittals for the following items for conformance with the Contract Documents:

- Subgrade preparations.

- Placement of embankment materials.
- Embankment lines and grades
- Embankment compaction.

Construction of Toe Drain

The Quality Assurance Engineer will review the Contractor submittals for the following items for conformance with the Contract Documents:

- Contractor's submittals relating to toe drain backfill, perforated and solid pipe, and concrete manholes
- Subrade preparations
- Control of water during construction
- Excavation of toe drain
- Placement of toe drain backfill materials
- Placement of perforated collection pipe
- Treatment of existing toe drain and discharge pipes

Regrading of North Dam

The Quality Assurance Engineer will review the Contractor submittals for the following items for conformance with the Contract Documents:

- Lines and grades of North Dam following regrading activities

Repair of Deteriorated Concrete in the Outlet Gate House at the North Dam

The Quality Assurance Engineer will review the Contractor submittals for the following items for conformance with the Contract Documents:

- Procedure related to urethane grouting to reduce seepage through the lift lines in the outlet gate house

- Repair procedures for the deteriorated concrete along the East and South walls of the outlet gate house

D. DOCUMENTATION

When on site, the Construction Project Manager will document in a daily report the contractor's operations. Note will be made of construction activities, when construction begins, when the construction is stopped, rationale and all important factors affecting job conditions, progress of work, and other items so that the daily report can be used as a history of the project. It will include weather conditions, description of activities performed, types of equipment used, testing incorporated into the work, description of any problems encountered in performing the work, corrections and corrective actions taken, detailed descriptions of directives given to each contractor, non-conformance, and any other information necessary to document each of the contractor's activities.

MWH's Project Manager will review non-conformance reports, and field directive and clarification reports. Appendix J-4 provides a sample of a Non-Conformance Report. Non-conformance reports may be resolved at the time they are issued by implementing corrective action immediately or they may require further study. Non-conformance reports may involve input from the MWH Project Manager, Quality Assurance Engineer, and other support staff. The Construction Manager will determine the need for involving other members of the QCIP Team. The non-conformance reports will be numbered consecutively in the order issued and include the following information:

- The date of issue.
- Originator.
- Description of deficient work.
- Disposition and technical basis for disposition.
- Date of closure, and pertinent references.

Because this is a time-critical project, no formal flow chart for tracking construction deficiency is provided. Construction deficiencies will be resolved immediately whenever possible. Issues not resolved immediately will be maintained in an unresolved issue file. After resolution, the non-conformance report will be placed in the file of resolved non-conformance reports.

Copies of all Quality Assurance reports will be provided weekly to WPS-UPPCO's Project Manager and MWH's Project Manager. A final construction report will be prepared by the Construction Manager to document the work. This report will include information on clearing and subgrade preparation at the South Levee and modifications to the South Levee including lowering of the crest and placement of embankment fill, regrading of the North Dam, excavation and construction of toe drain at the North Dam, installation of manholes, concrete repair work, difficulties encountered during construction, and photographs of the specific work items being performed by the Contractor. Appendix J-6 provides the record keeping procedures that will be followed by the Construction Manager.

The Contractor will provide submittals as described in the Contract for the review and approval by the Quality Assurance Engineer and Construction Manager. These will be logged, routed to the appropriate staff for review and acted upon. The resolution of these items will be recorded in daily reports.

E. TRAINING

No specific training is anticipated for this program, as the personnel selected for the specific assignments are trained professionals with expertise in the appropriate items being constructed or installed.

F. MATERIAL TESTING

All materials shall conform to the requirements established in the Contract Documents. Each contractor will provide material certifications or test results to demonstrate compliance. The tests and required frequencies are given in Appendix J-6 of this plan, Sampling and Material Testing Schedule, and in the Contract Documents. These tests and frequencies may be adjusted to account for the changes due to actual field conditions. The testing program may be modified on the basis of the results obtained.

G. EROSION CONTROL AND ENVIRONMENTAL COMPLIANCE

The potential exposure of the lake to soil erosion and sedimentation is minimal, as most work will be carried out away from the lake. No work in the lake is anticipated. An erosion and sedimentation control plan will be developed for the project by the Civil

Works Contractor. Features of this plan will include: haybales or silt fences where erosion and sedimentation problems due to construction activities develop during execution of the work.

Silt barriers will be installed downstream of the construction and stockpile areas to confine sediment that may be washed from the work areas and stockpiles. Ditches and silt barriers will be inspected frequently. Ditch erosion or silt barrier damage will be repaired immediately. Significant sediment accumulations will be removed and placed in a topsoil pile. Silt barriers will be maintained until construction is complete or ground cover materials have been placed.

The Contract Documents provide for the establishment of environmentally acceptable procedures by the Contractor to prevent spillage of oil, gasoline, chemicals, solvents, and other hazardous materials. They also provide that each Contractor properly dispose of any waste construction/demolition materials. Any violation of the Environmental Compliance requirements will result in a Non-Conformance Report issued by the Environmental Compliance Coordinator. The Contractor or other personnel will be notified of their responsibilities to correct any non-compliance. Appendix J-4 provides a copy of the Non-Conformance Report form. WPS-UPPCO's Environmental Compliance Coordinator will make the required notification to outside concerns to comply with special permit requirements.

H. CONSTRUCTION SCHEDULE

With the objective of completing the work during the summer and fall of 2003, construction milestones have been established as follows:

- Start of on-site mobilization and site construction activities 08/04/03
- Site restoration, cleanup and demobilization complete 10/10/03

Detailed schedule is in Appendix J-7.

I. PLANNED USE OF CONSULTANTS

The Licensee has retained MWH to provide Quality Assurance Engineering services for the emergency fuse plug spillway channel project. MWH prepared the plans and specifications for the work.

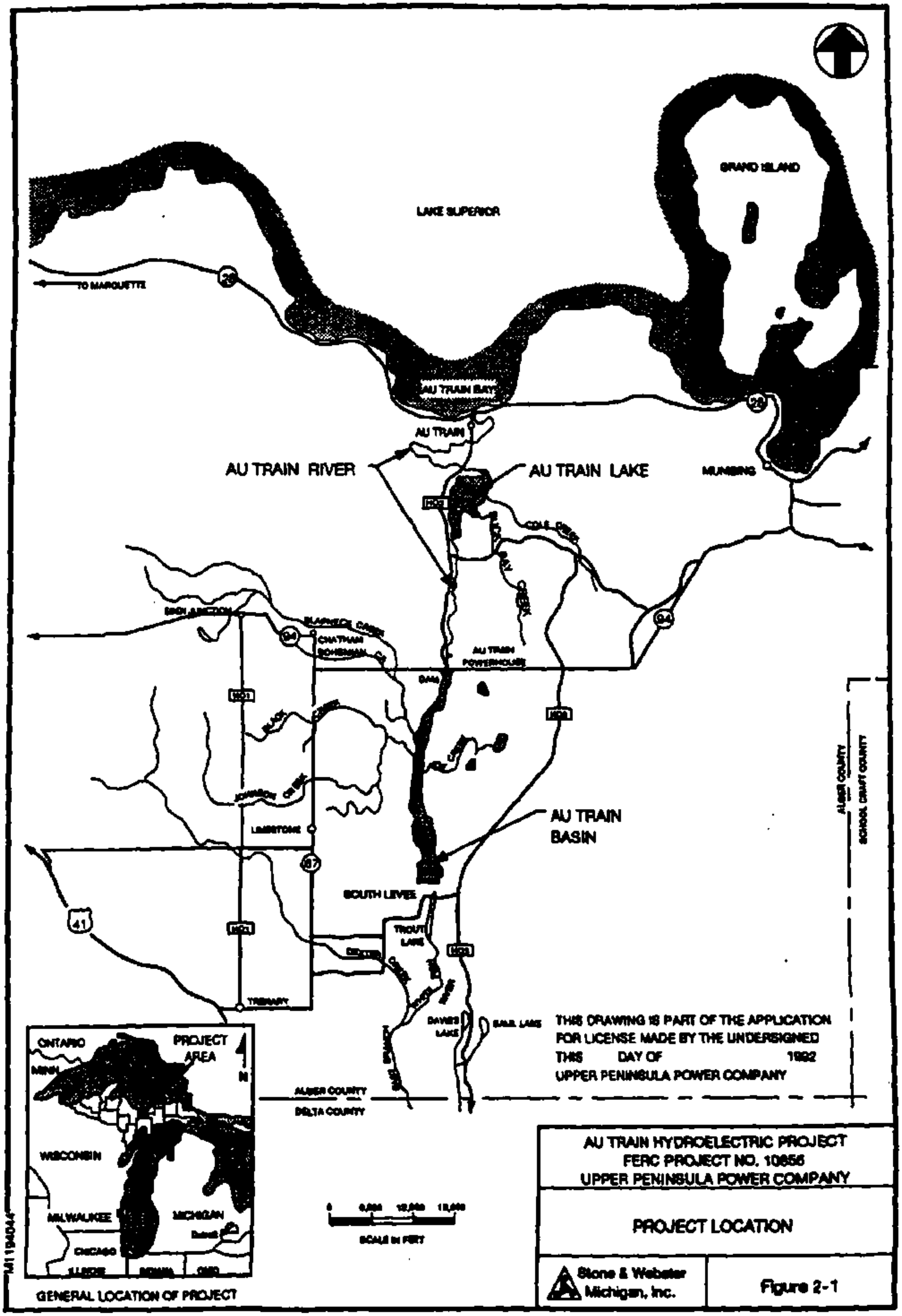
J. APPENDICES

Appendices J-1 to J-7 are provided to further assist the QCIP team in carrying out their respective responsibilities and to provide more detailed information for the various parts of the QCIP.

APPENDICES

APPENDIX J-1

PROJECT LAYOUT

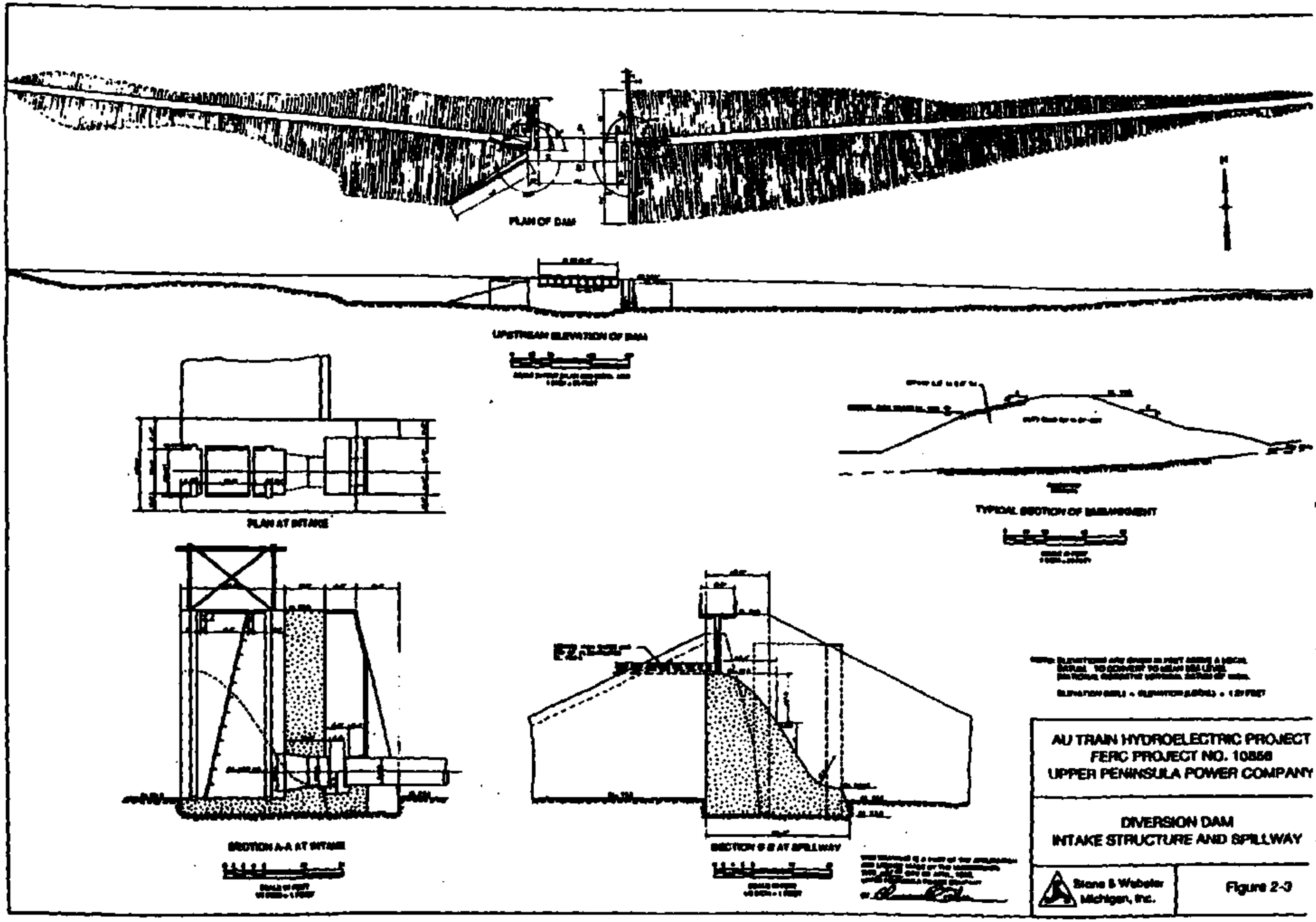


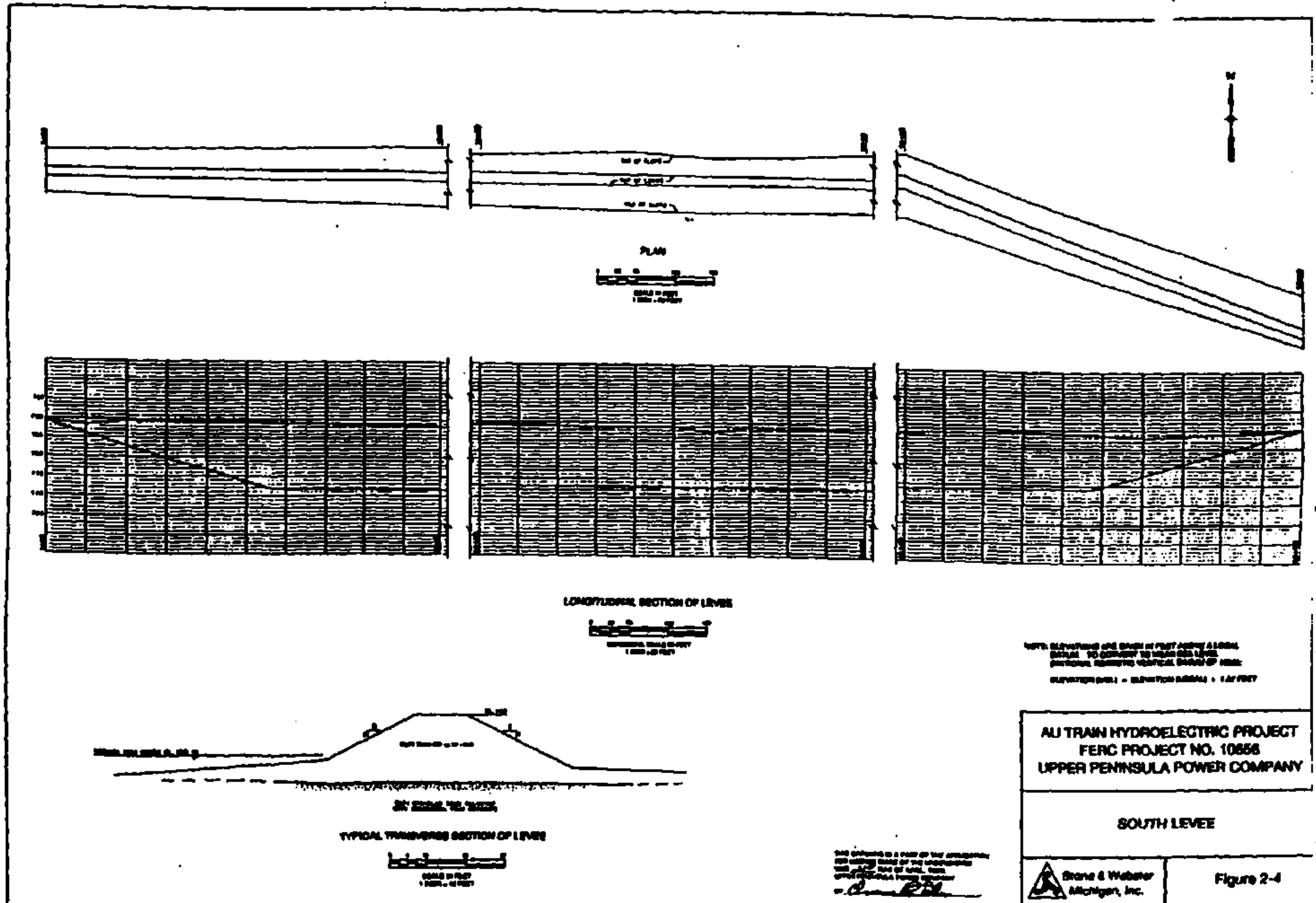
AU TRAIN HYDROELECTRIC PROJECT
FERC PROJECT NO. 10856
UPPER PENINSULA POWER COMPANY

PROJECT LOCATION

Stone & Webster Michigan, Inc.

Figure 2-1


PLAN OF DAM
UPSTREAM ELEVATION OF DAM
PLAN AT INTAKE
TYPICAL SECTION OF EMBANKMENT
SECTION A-A AT INTAKE
SECTION B-B AT SPILLWAY
AU TRAIN HYDROELECTRIC PROJECT
FERC PROJECT NO. 10856
UPPER PENINSULA POWER COMPANY
DIVERSION DAM
INTAKE STRUCTURE AND SPILLWAY
Stone & Webster Michigan, Inc.
Figure 2-3

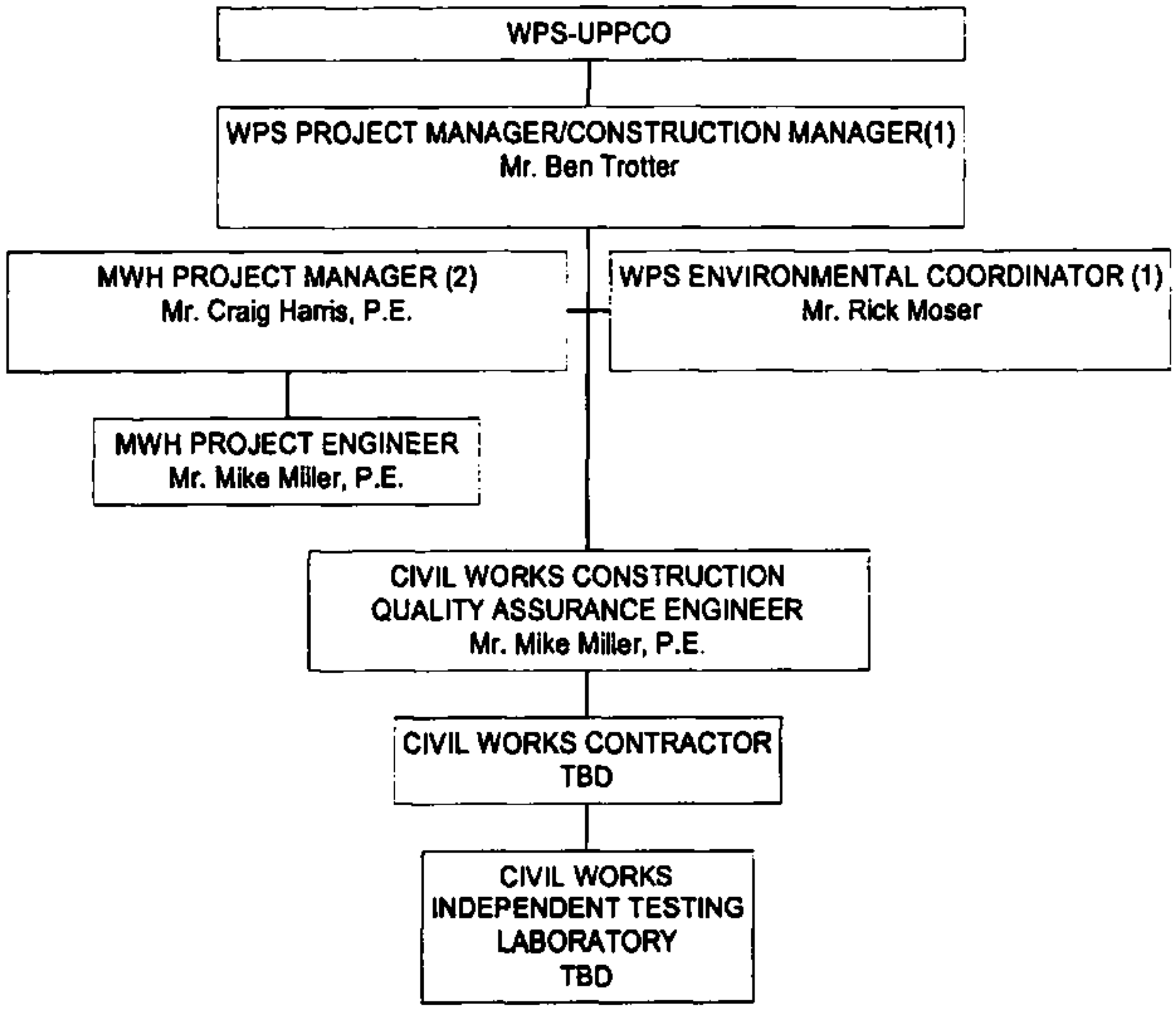

PLAN
LONGITUDINAL SECTION OF LEVEE
TYPICAL TRANSVERSE SECTION OF LEVEE
AU TRAIN HYDROELECTRIC PROJECT
FERC PROJECT NO. 10856
UPPER PENINSULA POWER COMPANY
SOUTH LEVEE
Stone & Webster Michigan, Inc.
Figure 2-4

APPENDIX J-2

ORGANIZATION CHART
and
RESUMES OF KEY PERSONNEL

AU TRAIN HYDROELECTRIC PROJECT
FUSE PLUG SPILLWAY AND DAM MODIFICATIONS PROJECT

QUALITY CONTROL AND INSPECTION ORGANIZATION CHART



(1) Authority to stop work due to adverse quality conditions.

(2) Authority to recommend stop work due to adverse quality conditions.

Ben P. Trotter

POSITION IN FIRM: Project Manager

YEARS WITH FIRM: 20

TOTAL YEARS OF EXPERIENCE: 20

PHONE #: (920) 433-5585
Fax #: (920) 433-1170
Cell #: (920) 680-6779

KEY QUALIFICATIONS:

Mr. Trotter has over 20 years experience in project management, construction management, and detailed design work related to electric power generation facilities while in the Project Services organization at Wisconsin Public Service Corporation.

EDUCATION:

Associate Degree - Mechanical Design / Pre-Engineering
Bay de Noc Community College, Escanaba, MI - 1982

Special Courses (Technical):

Basic Concrete Technology and Construction Practices - Portland Cement Association
Fossil Power Plant Boiler Plant Systems - Operation of plant systems WPSC training.
Nuclear Power System Overview - Operation of plant systems WPSC training.
American Concrete Institute - Repair concrete methods.
Effective Project Management - National Seminars Group
OSHA Training - Construction Practices and Procedures

SELECTED EXPERIENCE RECORD:

Employed by **Wisconsin Public Service Corporation** (WPSC), a regulated utility affiliate of WPS Resources Corporation (WPSR), from 1982 to present.

Project Manager, (2000 - present)

Responsible for engineering, design, technical support, contract administration, site construction and project management for numerous projects. These projects have been for the regulated affiliates of WPSR, located at hydro, fossil, natural gas, and nuclear-fired electrical generating facilities. Recent projects have included the following:

- Project Manager for the UPPCO hydro AuTrain Wingwall Repairs located in AuTrain, Michigan.
- Project Manager for the Spillway Repairs for UPPCO at the Escanaba Dam #3.
- Project Manager for the Spillway Repairs for UPPCO at the Escanaba Dam #1.
- Project Manager for the Silver Lake Basin Emergency Fuse Plug and Dam Modifications for UPPCO located 20 miles north of Marquette, Michigan.

Project Coordinator, (1997 - 2000)

Responsible for engineering, design, technical support, contract administration, site construction and project management for numerous projects. These projects have been for the regulated affiliates of WPSR, located at hydro, fossil, natural gas, and nuclear-fired electrical generating facilities. Recent projects have included the following:

- Project manager for the spillway and pier repairs for UPPC (Upper Peninsula Power Company), at the Escanaba River Dam #3, located in Escanaba, Michigan.
- Site Construction Manager for the installation of an 83-MW natural gas-fired combustion turbine located in Marinette, Wisconsin.
- Project Manager for the installation of a tainter gate hoist and automation for UPPCO Hydro Electric Plant, Dam #1, located in Escanaba, Michigan.
- Site Construction Manager for a new coal transport tunnel and conveyor along with dust collection and system upgrade. This was done at WPSC Pulliam Power Plant located in Green Bay, Wisconsin.
- Project Manager for the installation of a fly ash filter separator system for UPPCO at the Escanaba steam plant located in Escanaba, Michigan.
- Site Construction Manager for a new parking garage addition at WPSC Rhinelander Service Center located in Rhinelander, Wisconsin.
- Site Inspector for installation of new roads and foundations for 14 Vestes Wind Turbines for WPSC. These turbines are located in the Township of Rio Creek, Wisconsin.

Construction Technician (1983 - 1997)

Responsible for overall supervision of contractor labor for various projects assigned. This includes daily field logs, site inspection reports, and interface with existing facilities and systems, and start-up and testing with complete documentation of drawings and manuals.

- Site Inspector for the installation of a distributed control system on Units 3 through 8 at WPSC's Pulliam Plant, a coal-fired power plant located in Green Bay, Wisconsin.
- Site Inspector for steam and water soot blowers for the Pulliam Units 7 and 8 boilers. Pulliam is a WPSC coal-fired power plant located in Green Bay, Wisconsin.
- Site Inspector for a new centralized control room building inside the Pulliam Power Plant.

Lead Drafting Technician at the Kewaunee Nuclear Power Plant (1989 - 1993)

Responsible for overall supervision of on-site drafting staff. Provided documents and drawings for plant modification. Performed activities associated with the Nuclear Regulatory Commission mandated programs.

Drafter/Designer (1982 - 1988)

Responsible for performing detailed mechanical and civil design associated with power plant system modifications, and for WPSC Standards updates and Company Procedures manual.

CRAIG W. HARRIS

POSITION IN FIRM: Hydropower & Dams Denver Office Manager

YEARS WITH FIRM: 2

TOTAL YEARS OF EXPERIENCE: 24

KEY QUALIFICATIONS

Mr. Harris has more than 24 years experience with planning, design, construction, and management of dams, hydroelectric, and water resources mining projects. He has a Master's Degree in Civil Engineering and is a Registered Professional Engineer in five states.

Mr. Harris is currently a Senior Project Manager/Senior Geotechnical Engineer in the Denver Office with the responsibility to develop the office and manage dam, water resource and hydroelectric projects.

Prior to joining HARZA, he was an Associate Vice President with ECI, the Water Resources Division of DMJM+HARRIS, where he was a Project Manager for the evaluation and design of dams, hydroelectric, and other water resources projects. He was Senior Resident Engineer for the construction of a river diversion project in Peru that consisted a large dam, tunnel, and pipeline.

Previously with Steffen Robertson and Kirsten, he was responsible for engineering and design of a variety of mining projects including mine closure, infrastructure evaluation, and geotechnical design of new facilities. During his 13 years with Stone & Webster Engineering Corporation, he was a Principal Engineer in the Hydro Operations Group and responsible for the design of dams and hydroelectric projects. He inspected numerous dams and hydroelectric projects, designed modifications to existing dams, and designed new hydroelectric projects. He also authored guidelines for the Federal Energy Regulatory Commission, and conducted research of hydroelectric dams for the Electric Power Research Institute. Early in his career he was a Civil Engineer with the US Bureau of Reclamation where he performed engineering analyses of embankment dams.

EDUCATION

Master of Science in Civil Engineering, Cornell University, 1983
Post Graduate Study, University of Colorado, 1979-1980
Bachelor of Science in Civil Engineering, University of Akron, 1978

Professional Registrations

Professional Engineer - Colorado, 22140 - 1984,
Professional Engineer - Maine, 5560 - 1986,
Professional Engineer - Florida, 38210 - 1987,
Professional Engineer - Oklahoma, 16057 - 1990,
Professional Engineer - Michigan, 40803 - 1995,
Professional Engineer – Wisconsin, 35098-006, 1995

Professional Affiliations:

American Society of Civil Engineers, Member

International Society of Soil Mechanics and Foundation Engineers, Member
United States Society on Dams, Member of Materials for Embankment Dams Committee
Association of State Dam Safety Officials, Member

EXPERIENCE RECORD

MWH (Montgomery Watson Harza) Denver, Colorado, USA
Dams & Hydropower Office Manager responsible for developing Rocky Mountain office and managing dam and hydroelectric projects.

Security Risk Assessments
Client: U.S. Bureau of Reclamation
Project Manager Security Risk Assessments of 20 facilities including dams, hydropower plants, pumpgenerating plants, canals and control offices. (June 2002 to Present)

AuTrain Hydroelectric Project
Client: Upper Peninsula Power Company
Project Manager for dam safety modifications of this ___ foot combined concrete and embankment dam. Work to date has included hydrologic and hydraulic studies, stability analyses, and design of fuse plug spillway (October 2001 to Present)

Dillon Dam Spillway Modifications
Client: Denver Water
Part of team reviewing another consultant's design of modifications to the morning glory spillway as extension of State Engineer's staff. (June 2002)

McAllen Northwest Water Treatment Plant
Client: City of McAllen, Texas
Quality Assurance review of preliminary and final design of raw water storage reservoir for 40 MGD water treatment plant. (October 2001 to April 2002)

Wolford Mountain Hydroelectric Project
Client: Colorado Water Conservation District
Project Manager for small hydropower feasibility study at the Wolford Mountain Reservoir. Working includes energy generation and market studies, preliminary design, and cost estimates. (October 2001 to Present)

Dead River Hydroelectric Project
Client: Upper Peninsula Power Company
Project Manager for modifications to three dams to safely pass the PMF (Silver Lake Dam, Hoist Dam, and McClure Dam). Prepared final designs and construction bid documents for a 265-foot long fuse plug spillway and small saddle dam. Upcoming work includes design and support during construction of post-tensioned anchors in the concrete sections, flattening of slopes, small saddle dams, and raising crests of the dams. (June 2001 to Present)

Escanaba Dam No. 3
Client: Upper Peninsula Power Company
Prepared response to FERC letter-expressing concerns about rock strength parameters used in the stability analyses of the concrete sections of the dam. Work included site reconnaissance, reevaluation of strength parameters, and revision of stability analyses, and preparation of letter report. (October 2001 to November 2001)

Pisgah Dam
Client: Otter Tail Power Company
Evaluated high piezometric readings at this 40-foot high embankment dam. Work included reviewing instrumentation and monitoring program and site reconnaissance and preparation of letter report. (Sept 2001 to October 2001)

Prickett Hydroelectric Project
Client: Upper Peninsula Power Company
Project Manager for spillway modifications of the 55-foot high multiple arch buttress dam. Prepared conceptual designs and evaluation of alternatives for repair of scour hole downstream of spillway and constructing a stilling basin. (October 2001 to September 2001)

ECI, The Water Resources Division of DMJM+HARRIS, Greenwood Village, Colorado, USA
Associate Vice President, Director of Marketing, Geotechnical Department Manager, and Project Manager responsible for developing and implementing marketing plan, administrative and technical aspects of geotechnical department, and managing US and international water resources projects. Served as Senior Resident Engineer for large concrete-faced rockfill dam, tunnel, and pipeline during construction in Peru. (May 1998 to Jun 2001)

Lakewood Pipeline
Client: City of Boulder
Prepared demolition plan and bid documents for removal of existing raw water pipeline and supporting structures.

Green Lake No.2, Colorado
Client: City of Boulder
Prepared conceptual designs and evaluation of alternatives for repair of 40-foot steel faced rockfill dam that had been breached due to seepage concerns. (Apr 2001 to Jun 2001)

Rio Hato Grande Project, Nicaragua
Client: Ministry of Infrastructure and Transportation
In cooperation with EDICO Ingenieros Consultores of Managua, designed modifications to return the Rio Hato Grande to its original river channel. Following hurricane Mitch in October 1998, the river changed course and caused flooding of the adjacent highway. Performed site reconnaissance, supported hydrologic and hydraulic analyses to calculate the design storms, evaluated geotechnical conditions and prepared alternative designs for a dike to redirect the river into its previous channel. (Jan 2001 to Apr 2001)

Hoopes Dam, Delaware
Client: City of Wilmington
Project manager for a safety inspection of the 130-foot high concrete gravity dam. Performed site inspection, supervised stability analyses, and prepared a safety inspection report. (Nov 2000 to Jun 2001)

Garzas Dam, Puerto Rico
Client: Puerto Rico Electric Power Authority
Project Manager for comprehensive safety evaluation of the 202-foot high rockfill dam built in 1943. Performed safety inspection, supervised field investigations and stability evaluations, and made recommendations to bring dam into conformance with current dam safety regulations. (Jun 2000 to Jun 2001)

Lucchetti Dam, Puerto Rico

Client: Puerto Rico Electric Power Authority

Project Manager for comprehensive safety evaluation of the 178-foot high concrete gravity dam built in 1952. Performed safety inspection, supervised field investigations and stability evaluations, and made recommendations to bring dam into conformance with current dam safety regulations. (Jun 2000 to Jun 2001)

Gillespie Dam, Arizona

Client: Stantec Consulting, Inc.

Project Manager for stability evaluation of the 20-foot high concrete buttress dam built in 1921 that failed during a flood. The purpose of the project was to support legal defense of the dam owner the Flood Control District of Maricopa County. Reviewed project data, supervised field inspection and evaluation of stability, and summarized results in a verbal report. (Jun 2000 to Apr 2001)

Torata River Project, Peru

Client: Southern Peru Copper Corporation

Senior Resident Engineer during construction of river diversion project including first phase of 130m high concrete faced rockfill dam, underground valve chamber, inlet structure, 4km tunnel, 4km pipeline and over 10km of roads. As liaison between ECI, owner, and construction manager, prepared field designs, reviewed contractor submittals, provided recommendations to owner, interpreted specifications and drawings, responded to contractor's requests, and oversaw dam curtain grouting. Also evaluated an ancient landslide, designed the river diversion during construction, designed grouting, designed excavation slopes and support, redesigned dam and plinth to accommodate actual subsurface conditions, designed foundations and structure modifications to accommodate subsurface conditions, and made numerous field decisions and designs.

During design phase, prepared final construction specifications and drawings for dam and plinth. Developed innovative construction plan to use mine waste to construct a large portion of the embankment from concept to final design and save the Owner more than $30 million. (Aug 1998 to May 2000)

Carter Lake Pipeline, Colorado

Client: City of Longmont

Evaluated soil conditions and located borings along proposed raw pipeline route. (Nov 1998)

Apple River, Big Falls, and Wissota Projects, Wisconsin

Client: Northern States Power Company

Reviewed and evaluated dam safety instrumentation and monitoring for compliance with FERC instrumentation guidelines. (Aug 1998 to Nov 1998)

Goose Lake Dam, Colorado

Client: City of Boulder

Evaluated alternatives and prepared final design and bid documents for upstream rockfill berm with geosynthetic membrane to control seepage for this 30-foot high timber crib dam. (Jun 1998 to May 1999)

Oneida Dam, Utah

Client: PacifiCorp

Prepared engineering analysis and final design of foundation drains to reduce uplift pressures below 110-foot high concrete gravity dam and powerhouse in order to comply with a FERC requirement. (Aug 1998 to May 1999)

Big Thompson Siphon, Colorado
Client: Northern Colorado Water Conservancy District
Evaluated alternatives and prepared final design of selected alternative for maintaining soil cover to protect against freezing of steeply sloping section of a large raw water pipeline. (Aug 1998 to May 1999)

Wiwilli Dam, Nicaragua
Client: EDICO Ingenieros Consultores
Third party reviewed stability and proposed design of 15m high concrete gravity dam to provide water and power for a small village. (Jul 1998 to Aug 1998)

Logan First Dam, Utah
Client: Utah State University
Evaluated alternatives and prepared feasibility design for downstream rockfill buttress to support this 30-foot high concrete gravity and buttress dam to protect against overtopping from PMF, seismic loading from MCE, and up to 6 feet of displacement along fault in foundation. (Jul 1998 to Apr 1999)

Silver Lake Powerhouse, Colorado
Client: City of Boulder
Geotechnical engineer during construction of powerhouse. Inspected foundation excavation, prepared final design of post-tensioned anchored thrust blocks for high head penstock, and prepared final design of 10-foot high mechanically stabilized earth (MSE) wall to keep earth pressures from powerhouse wall. (Jun 1998 to Apr 1999)

Steffen Robertson and Kirsten, Inc., Lakewood, Colorado, USA
Acting Engineering Department Manager, Project Manager, and Senior Geotechnical Engineer responsible for administrative aspects of engineering department, management and engineering evaluations of mining infrastructure projects. (Oct 1996 to May 1998)

Cresson Mine, Colorado, and Jerritt Canyon Mine, Nevada
Confidential Client
Made third party evaluation of condition of existing infrastructure and need for additional infrastructure for remaining life of mine. Facilities reviewed included roads, power, water supply, wastewater treatment, buildings, communication facilities, ventilation, compressed air, solid waste handling, and engineering services. (Apr - May 1998)

San Andres Mine, Honduras
Client: Greenstone Mining Company
Prepared final design for 36m high mechanically stabilized earth (MSE) dump wall, cuts, fills, and conveyor foundations. (Apr - May 1998)

Grouse Creek Project, Idaho
Client: Hecla Mining Company
Design Manager for reclamation of the Waste Rock Disposal Facility consisting of a 50-acre soil cover, one-mile long diversion ditch, gabion lined groin ditch, and numerous bench ditches. Supervised the hydrologic and hydraulic analyses, prepared the preliminary design, cost estimates, optimization study, final design, and prepared construction bid documents. (Feb - Apr 1998)

Tonkin Springs Mine, Nevada
Client: Gold Capital Corporation
Supported final design of a demonstration heap leach pad and inspected and evaluated existing tailings dam. (Sep - Dec 1997)

Alumbrera Mine, Argentina
Client: Minera Alumbrera
Third party review of cause of excessive leakage from the Fresh Water Dam during first filling. Inspected 25m high embankment dam with upstream HDPE membrane, evaluated causes of the seepage and its effect on the dam stability, and recommended remedial measures. (Jul 1997)

Leigh Lake Dam, South Carolina
Client: Steffen Robertson and Kirsten
Peer reviewed seepage and stability modifications to a small embankment dam. The project consisted of flattening the slopes, adding a new outlet and drainage facilities. (Mar 1997)

Nixon Fork Mine, Alaska
Performed third party review of water supply and wastewater treatment facilities. (Mar 1997)

Mina Bella Vista, Costa Rica
Evaluated the geotechnical feasibility of an 8-million ton heap leach pad. (Jan 1997)

Pueblo Viejo Gold Mine, Dominican Republic
Client: MIM Holdings Limited
Task Manager for evaluation of existing infrastructure facilities and conceptual design and cost estimates for the additional infrastructure facilities required for a proposed expansion. Inspected and evaluated the port facilities, haulage road, water and sewage treatment, electrical power plants, communications facilities, accommodations, administration buildings, process plant layout, site roads, and solid waste facilities. (Jan 1997 to Jun 1997)

Ridgeway Gold Mine, South Carolina
Client: Ridgeway Gold Mine
Designed surface water management facilities for mine closure. Prepared preliminary designs, final designs, and construction cost estimates for a temporary siphon system, a concrete chute spillway, several miles of surface water ditches, and numerous drop structures. (May 1997 to May 1998)

Batu Hijau Gold Mining Project, Sumbawa, Indonesia
Client: Fluor Daniel
Project Manager of geotechnical subcontract to support final design. Peer reviewed drafts and prepared final Geotechnical Reports for the crusher, concentrator, mine maintenance area, coarse ore conveyor, tailings line, access road, and power transmission line. Subsequent tasks, undertaken during project construction, included geotechnical recommendations for the modified design of the sea water intake structure, recommendations for treatment of soft clays and potentially liquefiable soil beneath a proposed embankment, design of pipeline thrust blocks, and design of pile foundations. Other engineering tasks included evaluation of lateral loads from liquefied soil on proposed cargo berth piling, and feasibility design of the Santong Multi-purpose Dam. (Dec 1996 to May 1997)

Cannon Mine Project, Wenatchee, Washington
Prepared as-built report for Final Reclamation Plan, Emergency Action Plan, and Operation and Maintenance Plan for the tailings dam. (Oct to Nov 1996)

Kensington Mine, Juneau, Alaska
Prepared geotechnical instrumentation plan and peer reviewed dynamic deformation analysis for the proposed Dry Tailings Facility. (Nov 1997)

Stone & Webster Engineering Corporation, Denver, Colorado, USA
Project Manager and Principal Engineer in the Hydro Operations Division responsible for evaluation and design of hydropower and dam projects. (Aug 1987 to Sep 1996)

Wanapum Dam, Washington

Client: PUD No. 2 of Grant County

In response to a FERC concern, of rockfill embankment settlement continuing at a linear rate for several decades rather than decreasing as would be expected, evaluated potential causes of continued settlement of left embankment and made recommendations for additional investigation. (Apr to Jun 1996)

St. Croix Hydroelectric Project, Wisconsin

Client: Northern States Power Company

As Project Manager/Engineer, conducted a comprehensive evaluation of the St. Croix Hydroelectric Project and evaluation of alternative modifications to extend the plant life an additional 50 years. The project was built in 1905 and is an 83-foot-high, concrete gravity dam with an integral eight-unit powerhouse. Planned and coordinated the entire project, which included civil, mechanical, and electrical evaluations. Performed or supervised the civil evaluations, including a dam safety inspection equivalent to a FERC Part 12 inspection, an underwater inspection, core drilling, piezometer installation, geologic mapping, laboratory testing, development of design criteria, hydrologic and hydraulic reviews, energy optimization study, stability evaluations, conceptual designs and cost estimates of alternative modifications. Oversaw the mechanical and electrical evaluations including inspection of the turbines, generators, governors, gates and associated equipment, and the tainter gate spillway. Also supervised final design of a bulkhead type cofferdam to allow work on the tainter gate and design of modifications to a cracked pier that was found during the inspection. Documented the work in a report and presented the results to the client. (Aug 1991 to Sep 1996)

Prickett Dam, Michigan

Client: Upper Peninsula Power Company

As Independent Consultant, performed the 6th FERC Part 12 Dam Safety Inspection of this 55-foot high multiple arch buttress and embankment dam. Subsequently, supervised design of a reinforced concrete wall to replace a deteriorated wall in Bay 4 of the spillway. (Apr to Sep 1996)

Santeetlah Dam, North Carolina

Client: Tapoco, Inc.

As Lead Geotechnical Engineer, supervised field and laboratory investigations and developed geotechnical design criteria for this 212-foot high concrete arch dam with gravity abutments. The fieldwork included geologic mapping, overcoring to measure in-situ stresses in the arch, coring to retrieve samples for testing, water pressure testing, and installation of thermistors and vibrating wire piezometers. The laboratory testing included standard properties, direct shear, and triaxial tests. Evaluated the field and laboratory data and developed geotechnical design criteria for stability analyses. Documented the work in a supplement to the FERC Fifth 5-Year Inspection and Safety Report. (Jul 1994 to Sep 1996)

Calderwood Dam, North Carolina

Client: Tapoco, Inc.

As Lead Geotechnical Engineer, supervised instrumentation and field investigations for this 232-foot high concrete arch dam. The instrumentation work included design, specification and field engineering for an extensometer to measure movement across a fault and inclinometers to monitor arch deflections. The fieldwork consisted of geological mapping and documentation of geotechnical data for stability evaluations. Documented the work in a supplement to the FERC Fifth 5-Year Inspection and Safety Report. (Jul 1994 to Sep 1996)

Cheoah Dam, North Carolina

Client: Tapoco, Inc.

As Lead Geotechnical Engineer, supervised field investigations, instrumentation, geotechnical design criteria, and abutment stability analyses for this 225-foot high gravity arch dam. The fieldwork consisted of geological mapping and documentation of geotechnical data for stability evaluations. The instrumentation work includes design, specification and field engineering for inclinometers to monitor arch deflections. The abutment stability work consists of evaluating stability of rock wedges in the abutments. Documented the work in a supplement to the FERC Fifth 5-Year Inspection and Safety Report. (Jul 1994 to Sep 1996)

Osage Hydroelectric Project, Lake of the Ozarks, Missouri

Client: Union Electric Company

Performed the 6th and 7th FERC Safety Inspection of the 148-foot-high concrete gravity Bagnell Dam. Reviewed project documents, inspected the dam, evaluated instrumentation data, reviewed the stability analysis, reviewed the spillway adequacy, supervised concrete coring and laboratory testing, and made recommendations to correct deficiencies, and documented the work in a report. As Project Engineer, evaluated quarterly instrumentation data for indications of distress and for compliance with design assumptions. The instrumentation includes survey measurements of crest deflections, piezometers, flow measurement devices, and crack meters. Also designed new standpipe piezometers to replace the deteriorated pneumatic packer type piezometers. (Nov 1992 to Sep 1996)

Upper Baker Dam, Concrete, Washington

Client: Puget Sound Power and Light Company

Designed foundation drains and piezometers to reduce and monitor uplift pressures at this 285-foot-high concrete gravity dam. Developed the technical scope of work for the drilling, supervised the field inspector during the installation and documented the work in a report. Also evaluated monthly instrumentation data from piezometers, extensometers, and joint meters for indications of distress and for compliance with design assumptions. (Oct 1986 to Sep 1996)

Engineering Guidelines for Hydroelectric Projects, Washington, D.C.

Client: Federal Energy Regulatory Commission

Wrote Chapter 9 "Instrumentation and Monitoring" of FERC's Engineering Guidelines for Hydroelectric Projects. The chapter discusses the need for instrumentation, establishes minimum instrumentation requirements, and recommends monitoring procedures and schedules. Subsequently, presented a 3-day training course on Instrumentation and Monitoring to each of the five FERC regional offices. Also drafted the timber crib, buttress, and masonry dams portions of Chapter 10 "Other Dams" which discusses stability analyses methods, evaluation criteria, and acceptance criteria. (Oct 1993 to Apr 1996)

LPG Station, Columbia, SA

Client: Ecopetrol

Performed independent geotechnical assessment of LPG tank farm on peat foundation with nearly 1m estimated settlement. (Feb 1996)

Cataract Hydroelectric Project, Michigan

Client: Upper Peninsula Power Company

Supervised dam failure analysis of this small concrete gravity dam. (Dec 1995 - Jan 1996)

Dead River Hydroelectric Project, Marquette County, Michigan

Client: Upper Peninsula Power Company

As Project Engineer, prepared preliminary designs of modifications to safely pass the probable maximum flood at the Dead River Project, which includes the 37-foot-high McClure Dam, the 63-foot-high Hoist Dam, and the 36-foot-high Silver Lake Dam. The dams are a combination of dumped and hydraulic fill embankments, concrete gravity sections and concrete arch sections. The spillway modifications include a new labyrinth spillway at Silver Lake Dam, a grass lined emergency spillway for Hoist Dam and enlarging the spillway at McClure Dam. Embankment modifications consisted of riprap, toe drains, and regrading. The concrete dam modifications included post-tensioned anchors to improve stability and repair of deteriorated concrete. Supervised three-dimensional finite element analyses of the arch section of Hoist Dam and interpreted the results with respect to stability.

Subsequently, developed the Preliminary Supporting Design Report for the initial FERC License Application for the Dead River Project and performed the Initial FERC Safety Inspection of the Silver Lake, Hoist, and McClure Dams. Also supervised the PMF and IDF development, EAP flood inundation mapping, and responses to agency comments on the draft license application. (Feb 1992 to Dec 1995)

Casecnan Multi-Purpose Hydroelectric Project, Philippines
Client: Kiewitt Construction and Bank of America
Project Engineer for feasibility design of proposed hydroelectric project, including two dams, 23 km of tunnels, and 75 MW powerhouse.

As Lead Geotechnical Engineer, was part of a team that performed an independent technical review and assessment of the project for the Bank of America. Reviewed the geology, subsurface exploration program, and dam and tunnel plans. (Nov 1994 - Nov 1995)

Chillhowee Dam, Tallassee Project
Client: Tapoco, Inc.
As Lead Geotechnical Engineer, supervised geological mapping, developed geotechnical design criteria, and performed embankment stability analyses for this 91-foot high concrete gravity and rockfill dam. Evaluated the stability of the rockfill embankment in accordance with FERC criteria and developed conceptual designs for a fuse plug spillway to safely pass the PMF. Documented the work in a supplement to the FERC Fifth 5-Year Inspection and Safety Report. (Jul 1994 to May 1995)

Au Train Hydroelectric Project, Michigan
Client: Upper Peninsula Power Company
As Independent Consultant, performed the initial FERC Part 12 Safety Inspection of the Au Train Hydroelectric Project. The inspection consisted of review of the project documents, dam safety inspection, evaluation of instrumentation data, stability evaluation, spillway adequacy evaluation, recommendations to correct deficiencies, and documentation of the work in a report. Supervised the stability evaluation of the 29-foot-high, combined embankment and concrete dam using existing site and laboratory data.

Also supervised the PMF and IDF development, EAP flood inundation mapping, and responses to agency comments on the draft license application. (Feb 1992 to Nov. 1994)

SEED Inspections, USA
Client U.S. Fish and Wildlife Service
Performed Safety Evaluation of Existing Dams (SEED) inspections of 33 embankment and concrete gravity dams. The inspections consist of a review of the project documents, a site inspection, evaluation of the instrumentation data, recommendations to correct deficiencies and documentation of the work in a report. (Nov 1989 to Nov 1994)

Wichita Mountain Project, Oklahoma
Client: U.S. Fish and Wildlife Service
As Project Engineer, evaluated and prepared preliminary design of modifications for four concrete gravity dams to allow safe passage of the design flood. For both the 51-foot-high Lake Jed Johnson and 45-foot-high Lake Rush Dams, supervised field and laboratory investigations, engineering analyses, and developed conceptual designs and cost estimates for modifications to improve the stability of the structures. The modifications evaluated included breaching and removing, lowering, post-tension anchoring, and RCC buttresses. Deficiencies at the 34-foot-high Apache Dam were resolved through the analyses. Work on the 39-foot-high Comanche Dam was stopped due to funding restrictions. (Jan 1990 to Apr 1994)

Bond Falls, Victoria, and Prickett Projects, Michigan

Client: Upper Peninsula Power Company

Supervised PMF and IDF development, EAP flood inundation mapping, and responses to agency comments on the draft license applications. (Mar to Apr 1994)

Devil's Kitchen Dam, Illinois

Client: U.S. Fish and Wildlife Service

Inspected the dam, inspected the foundation drains with a borehole camera, reviewed the stability analyses, supervised the review of the hydrology and spillway adequacy, and made recommendations for resolving deficiencies at this 120-foot-high concrete gravity dam. Implemented a structural monitoring program including crack movements, uplift pressures, drain flows, and survey measurements of crest deflections and supervised evaluation of the monitoring data. (Oct 1992 to Sep 1993)

Chickamauga and Hiwassee Dams, Tennessee

Client: Tennessee Valley Authority

As Project Manger/Engineer, supervised a three-dimensional finite-element analysis of the Chickamauga Dam spillway. Concrete growth from alkali-aggregate reaction compressed the spillway causing binding of several of the spillway gates. The model was used to help evaluate where stress relief slots should be cut to relieve the compressive load. Also supervised the initial development of a three-dimensional finite-element analysis of Hiwassee Dam. The dam was experiencing high stresses and detrimental deflections due to concrete growth from alkali-aggregate reaction. The model was being developed to evaluate longitudinal slots for relieving some of the concrete growth effects. (Dec 1993 to Mar 1993)

Valerie Falls Hydroelectric Project, Atikokan, Ontario, Canada

Client: Credit Lyonnais

As Lead Geotechnical Engineer, was part of a team that performed an independent technical review and assessment of the 56-foot-high concrete gravity dam and 9 MW powerhouse. Reviewed the geology, subsurface exploration program, and stability analysis; inspected the powerhouse excavation and two upstream dams against which additional water would be impounded; and wrote the geotechnical assessment and stability assessment portions of the final report. (Oct 1993 to Nov 1993)

Penobscot Mills Project, Millinocket, Maine

Client: Great Northern Paper Company

As Lead Geotechnical Engineer, evaluated geotechnical conditions at the 35-foot-high North Twin Dam, the 24-foot-high Stone Dam, the 20-foot-high Millinocket Lake Dam and the 56-foot-high Dolby Dam in response to a FERC concern about the cohesion values that had been used for stability analyses. Performed a geologic reconnaissance, and estimated shear strength based on site geology, observed foundation conditions, shear tests on similar materials, and engineering judgment. The results showed that in all cases the estimated lower bound shear strength parameters exceeded those required to meet FERC safety criteria. (Jun 1993 to Jun 1993)

Ripogenus, Mattaceunk, and Great Northern Storage Projects, Maine

Client: Great Northern Paper Company

In anticipation of FERC questioning the cohesion values that had been used for stability analyses of the five concrete gravity dams at these projects, performed a geologic reconnaissance of the dams, and estimated the shear strength based on site geology, observed foundation conditions, shear tests on similar materials, and engineering judgment. The dams were the 80-foot-high Ripogenus Dam, the 50-foot-high Weldon Dam, the 50-foot-high Canada Falls Dam, the 60-foot-high Seboomook Dam, and the 30-foot-high Ragged Lake Dam. The results showed that in all cases the estimated lower bound shear strength parameters exceeded those required to meet FERC safety criteria. (Jun 1993 to Dec 1993)

Muskrat Dam, Walden, Colorado
Client: U.S. Fish and Wildlife Service
As Project Engineer, planned and conducted borings, test pits, site surveys, laboratory tests, and supervised stability evaluations for this 18-foot-high embankment dam. Designed and estimated the cost of seepage modifications. (Aug 1991 to Feb 1992)

Bear Rivers Narrows Hydroelectric Project, Idaho
Client: Federal Energy Regulatory Commission
Performed the initial civil and geologic review of the project and drafted relevant portions of the resource and issue profile and scoping document to be used in preparing the Environmental Impact Statement for the project. (Aug 1992)

Dorris Dam, Alturas, California
Client: U.S. Fish and Wildlife Service
Conducted an inspection and made recommendations for the 29-foot-high embankment dam to meet current dam safety criteria. (Mar 1990)

Concrete Gravity Dam Study, United States
Client: Electric Power Research Institute
As Project Engineer, planned, conducted, and supervised a comprehensive study of uplift pressures and strengths that are used for stability analyses of concrete gravity dams. Field, laboratory and office studies of 17 "host" dams showed that both concrete-lift-joints and concrete-to-rock contacts have substantial shear and tensile strength, often greater than would commonly be assumed. Uplift pressures beneath dams were found to be highly dependent on site geology and foundation drainage and common uplift pressure assumptions, such as straight-line variation between headwater and tailwater levels, were found to be generally, though not always, conservative. Several EPRI member utilities have credited the study with saving millions of dollars in repair costs. (Dec 1987 to Dec 1991)

Victoria Dam, Ontonagon, Michigan
Client: Upper Peninsula Power Company
Mapped clay seams in the foundation excavation, evaluated the stability, and designed a shear key to improve the stability of the new 120-foot-high roller compacted concrete (RCC) dam. (May 1991 to Jul 1991)

St. Anthony Falls Hydroelectric Project, Minneapolis, Minnesota
Client: Northern States Power Company
As Lead Geotechnical Engineer, developed the Preliminary Supporting Design Report for FERC for a completely new hydroelectric project to replace the previous hydroelectric plant that had failed by piping of the soft St. Peter sandstone foundation. Planned and developed the technical specifications for the subsurface investigation program, logged the core borings and piezometer installation, developed geotechnical design criteria, supervised the hydraulic analyses and stability evaluations, and participated in the layout, cost estimate, and design of the new 45-foot-high concrete dam and 16 MW powerhouse. (Apr 1989 to Jul 1991)

RMI T_i Cl_4 Project, Ashtabula, Ohio
Client: Minproc Engineers, Inc.
As Resident Geotechnical Engineer, evaluated and made recommendations for treatment of soft foundation soils that were not identified in the previous subsurface investigations. (Sep 1990 to Oct 1990)

Burton, Lloyd Shoals, Mathis, Bartletts Ferry, Tugalo, and Nacoochee Dams
Client: Georgia Power Company and Southern Company Services
Supervised direct shear testing of large-diameter cores from Burton, Lloyd Shoals, Mathis, Bartletts Ferry, Tugalo, and Nacoochee Dams and documented the work in test reports. (Oct 1989 to Sep 1990)

Inks, Wirtz, Starke and Tom Miller Dams, Texas
Client: Lower Colorado River Authority
Reviewed project history and stability analyses, developed recommendations for instrumentation, and documented the work and a safety inspection of the projects in reports. (Apr 1989 to Jun 1990)

Monticello Generating Plant, Minnesota
Client: Northern States Power Company
Inspected the excavation and developed geotechnical design criteria for a proposed diesel generator building foundation. (Apr 1989 to May 1989)

Rocky Reach Hydroelectric Project, Washington
Client: PUD No. 1 of Chelan County
As Lead Geotechnical Engineer for the Spillway Erosion Repair Project, designed relief wells to allow unwatering of the spillway apron, developed the technical scope of work for the drilling contractor and supervised the field inspector during the work. (Feb 1988 to Oct 1988)

Sandstone Dam, Baggs, Wyoming
Client: Wyoming Water Development Commission
As Geotechnical Engineer, logged soil and rock borings, performed water pressure testing and inspected piezometer installation at the site of a proposed 200-foot-high embankment dam, and supervised another engineer doing the same. Used the data from the field exploration program to develop a finite-element model of the dam, using the computer program FEDAR, to estimate seepage losses and documented the work in a report. (Jul 1987 to Dec 1987)

Glens Falls Hydro, Glens Falls, New York
Client: Finch, Pruyn & Company, Inc.
As Lead Geotechnical Engineer, performed a field inspection, supervised geological mapping of the site, developed geotechnical design criteria, designed post-tensioned anchors to stabilize a 35-foot-high concrete gravity dam and headwall, and prepared construction specifications. (Mar 1987 to Jul 1987)

Penobscott Mills Hydroelectric Project, Maine
Client: Great Northern Paper Company
As Lead Geotechnical Engineer, performed the geotechnical portions of the 4th FERC Safety Inspection of the North Twin, Millinocket Lake, Stone and Dolby Dams. At Dolby Dam, performed field investigations and evaluated the stability of the 45-foot-high embankment dam and the 56-foot-high concrete gravity dam and integral powerhouse, and updated the monitoring program. (Jun 1986 to Jun 1987)

Hydro-Kennebec Project (Winslow Dam), Maine
Client: Walsh Construction Company
As Geotechnical Engineer, designed rockbolts for excavation support, evaluated the stability of a large concrete retaining wall, and prepared civil works construction specifications for this 30-foot-high concrete dam and 15 MW powerhouse. (Dec 1986 to May 1987)

LIMB (Limestone Injection Multi-Stage Burner) Demonstration Project, Ohio
Client: Ohio Edison Company
Monitored proof rolling of foundation for the LIMB at the Edgewater Station. (Jun 1986)

Raystown Hydroelectric Project, Pennsylvania
Client: Allegheny Electric Cooperative, Inc.
As Geotechnical Engineer, developed the technical scope of work for the drilling subcontract, logged the soil and rock borings, performed water pressure tests, inspected piezometer installation and supervised the laboratory testing.

Participated in development of the geotechnical design criteria, tunnel layout, design of tunnel support, excavations support, and foundations at the new 20 MW hydroelectric power plant at an existing Corps of Engineers Dam. (Apr 1984 to Dec 1986)

Ripogenus Dam Penstock Inspection Program, Maine
Client: Great Northern Paper Company

Helped plan the inspection of the 4000-foot-long power tunnel during a two-day outage. (Nov 1986 to Nov 1986)

South Texas Project, Texas
Client: Houston Lighting and Power Company (HL&P)
On loan to HL&P, was responsible for all geotechnical aspects of the 2500 MW, 2-unit nuclear power plant under construction. The primary geotechnical issues included piping, sand boils and high piezometric pressures during initial filling of the 12.5 mile long, 48-foot-high Main Cooling Reservoir embankment, modifications to the cooling water pipe embankment penetrations to correct inadequate seepage design, remedial work to prevent leakage of the cooling water pipe joints, and settlement and backfill concerns with the main plant area. Reviewed and approved the Architect/Engineer recommendations, design documents, and budget changes for the geotechnical issues. These included relief wells for remedial treatment of the high piezometric pressures; dispersive clay and soil cement investigation and evaluations, and seepage, liquefaction, and stability analyses of the embankments. Also developed a monitoring and inspection program for the Main Cooling Reservoir embankment. (Jul 1985 to Apr 1986)

Decker Creek Power Station, Austin, Texas
Client: City of Austin Electric Utility
As Geotechnical Engineer, reviewed designs and made recommendations for proposed gas turbine foundations. (Mar 1986)

Regional Hydropower Development Project, Southeastern United States
Client: Independence Electric
Performed geotechnical evaluations of 62 potential hydroelectric sites in the southeastern United States. Performed a reconnaissance-level study of 11 sites that survived the initial screening. Developed geotechnical criteria and participated in conceptual designs and cost estimates for FERC Preliminary Permit Applications and License Applications for selected sites.

Prepared civil/geotechnical portions of FERC license applications for proposed hydropower projects at existing Corps of Engineers Dams on the Arkansas River, including developing proposed layouts, performing quantity take offs, and writing report sections.

Performed geotechnical evaluations and participated in conceptual designs and cost estimates for hydropower plants at seven existing Corps of Engineers dams on the Arkansas River. (Jun 1983 to Mar 1985)

Northside Generating Station, Florida
Client: Jacksonville Electric Authority
As Geotechnical Engineer for the Corrosion Protection Program, inspected surveying, hydrographic mapping and underwater inspection of a one-half-mile-long intake flume, a stilling basin, a screenwell, a discharge basin, and a discharge conduit. Designed and developed construction specifications for modifications to correct subsidence along the flume walls, undermining and erosion of the flume floor, and for other miscellaneous modifications. (Mar 1983 to Feb 1985)

Malakoff Electric Generation Station, Texas

Client: Houston Lighting and Power Company

As Geotechnical Engineer, designed foundations for the service water tower. Participated in design of foundations for other major structures, settlement analyses, and in design of the raw-water storage pond embankment. (May 1983 to Jan 1985)

Super Conducting Super Collider Independent Cost Estimate, Generic Site, United States

Client: U.S. Department of Energy

As Lead Geotechnical Engineer, developed estimated tunneling costs for 70 miles of hard rock, soft rock, and cut and cover tunnels, and for dozens of large excavations for the proposed super conducting super collider as part of an independent cost estimate. (May 1984 to Jun 1984)

Fairfax Falls Hydropower Project, Vermont

Client: Central Vermont Public Service Corp

As Geotechnical Engineer, logged borings at a proposed hydropower addition to an existing dam on the Lamoile River. . (Jan 1984 to Feb 1984)

Kennedy Generating Station, Florida

Client: Jacksonville Electric Authority

As Geotechnical Engineer for the Corrosion Protection Program, inspected hydrographic surveys, topographic surveys and underwater inspections of the existing cooling water intake structure. Participated in the design, reviewed contractor submittals and inspected construction of a new sheetpiling intake basin. (Mar 1983 to Feb 1984)

Seismic Hazard Analysis, Finland

Client: Industrial Power Company

As Geotechnical Engineer, researched the seismicity of Finland and supported the analysis of the annual seismic hazard for a proposed nuclear waste handling facility, using the computer program Seismic Risk Analysis (McGuire). (Nov 1983 to Jan 1984)

Pre-assembled Hydroelectric Plant, USA

Client: Stone & Webster

Developed the civil/geotechnical portions of an in-house reference design for a hydroelectric plant that could be floated into a prepared site at an existing dam. (Oct 1983 to Dec 1984)

Soil & Rock Identification Manual

Client: Stone & Webster

Revised the Geotechnical Division's soil and rock identification manual. (Jul - Sep 1984)

Clinch River Breeder Reactor Project, Tennessee

Client: U.S. Department of Energy

As Geotechnical Engineer, monitored blasting and inspected rockbolt installation for a 100-foot-deep rock excavation. Also evaluated remedial work for a waste embankment failure during construction and inspected structural fill placement. (Jul 1983 to Aug 1983)

Petersburg Unit 4, Indiana

Client: Indianapolis Power and Light Company

As Geotechnical Engineer, analyzed pipe piles and developed pile-driving criteria using the computer program WEAP. (Mar 1983)

Cornell University, New York
Client: New York Gas Group
As a Graduate Research Assistant, instrumented and tested cast iron bell and spigot joints from old gas mains and used the in a finite element program to evaluate the effect of trenching on adjacent gas mains. (Aug 1981 to Feb 1983)

U.S. Bureau of Reclamation, Denver, Colorado
As a Civil Engineer in the Embankment Dams Section, Dams Division, Engineering and Research Center, performed engineering analyses and prepared designs for embankment dams. (Jun 1978 to Aug 1981)

Twin Lakes Dam, Twin Lakes, Colorado
Performed a two-dimensional finite element analysis of the Twin Lakes Dam and evaluated proposed modifications. (Apr 1981 to Aug 1981)

Martinez Dam, Martinez, California
Performed liquefaction potential analyses of the 62-foot-high embankment dam. (Dec 1980 to May 1981)

Embankment Response Study
Evaluated various methods of computing embankment response to earthquake shaking, including simplified methods, and one-dimensional and two-dimensional finite element methods. (Mar 1981 to May 1981)

Sherburne Lake Dam, Milk River Project, Montana
Evaluated the stability of proposed modifications to raise the 87-foot-high embankment dam with Reinforced Earth. (Jan 1981 to Mar 1981)

Auburn Dam, Rockfill Alternative
Developed the computer program DYNDSP, which the U.S. Bureau of Reclamation uses to analyze deformation during earthquake shaking. Also planned and supervised a large-scale laboratory testing program to determine material properties of the rockfill for the proposed 690-foot-high dam. (Dec 1979 to Jan 1981)

Pueblo Dam, Pueblo, Colorado
Evaluated the stability of a proposed downstream berm to stabilize the embankment section of the 207- foot-high Pueblo Dam. (Dec 1979 to Jan 1980)

Soils Testing Section
As Rotation Engineer, participated in triaxial, dynamic triaxial, and resonant column testing of soils. (Oct 1979 to Nov 1979)

Soils Mechanics Section
As Rotation Engineer, participated in bridge footing design for the Granite Reef Aqueduct and evaluation of shale slaking properties for Rim Basin Dam. (Sep 1979 to Oct 1979)

Reach 8, Tehama-Colusa Canal, Woodland, California
As Rotation Engineer, inspected embankment placement, backfill placement and concrete canal lining placement, and supervised density testing. (May 1979 to Aug 1979)

Spillway and Outlets Section
As Rotation Engineer, developed the outlet works discharge curve for Palmetto Bend Dam and designed the spillway bridge reinforcement for Sugar Pine Dam. (Jan 1979 to Mar 1979)

Earth Dams Section
As Rotation Engineer, evaluated the stability of 195-foot-high Joe's Valley embankment dam. (Jul 1978 to Dec 1978)

University of Akron, Akron, Ohio
As a Research Assistant in the Engineering Department, modeled storm sewer flows, including developing input data from topographic sheets, entering data, and performing check calculations. (Sep 1977 to Jun 1978)

City of Barberton, Ohio
As an Engineering Aide in the Engineering Department, supported surveying, drafting, design, and construction inspection for several road and sewer improvement projects. (Jun 1975 to Sep 1977)

LANGUAGES:

- English
- Spanish - Fair

PAPERS AND PRESENTATIONS

Harris, C.W., "How Can Instrumentation and Monitoring be Improved?," presentation at FERC Independent Consultant Inspection Workshop, Portland, Oregon, March 6-7, 2001.

Harris, C.W., "Tainter Gate Testing and Evaluation," presentation at ASDSO Dam Safety '98, held in Las Vegas, Nevada, October 11-15, 1998.

Harris, C.W., "FERC's Instrumentation and Monitoring Guidelines," presentation at EPRI Dam Safety Workshop, Washington, D.C., June 9-10, 1998.

Harris, C.W. and Grenoble, B.A., presented 3-Day Instrumentation and Monitoring Workshop, to each of the 5 FERC Regional Offices, Spring 1996.

Harris, C.W. "Reinforced Rockfill and Reinforced Fill," Chapter 8, Materials for Embankment Dams, USCOLD Bulletin, Draft, David Kleiner, Editor, May 1995.

Harris, C.W. "Instrumentation and Monitoring," Chapter 9, Engineering Guidelines for the Evaluation of Hydropower Projects, Federal Energy Regulatory Commission, January 18, 1995.

Harris, C.W.; and Grenoble, B.A.; "Resolving the "Time Lag" Debate in Dam Stability Analysis." Paper published in Hydro Review, Vol. XII, No. 2, Kansas City, Missouri, 1993.

Harris, C.W.; Grenoble, B.A.; Meisenheimer, J.K.; and Ryan, K.K.; "Uplift Pressures, Shear Strengths, and Tensile Strengths for Stability Analysis of Concrete Gravity Dams, TR100345." Report published by the Electric Power Research Institute, Palo Alto, California, 1992.

Grenoble, B.A.; Harris, C.W.; Meisenheimer, J.K.; and Morris, D.I.; "Influence of Rock Joint Deformations on Uplift Pressure in Concrete Gravity Dam Foundations: Field Measurements and Interpretation." Paper presented at the Proceedings of the International Society for Rock Mechanics Conference, Fractured and Jointed Rock Masses, Lake Tahoe, California, 1992.

Grenoble, B.A. and Harris, C.W. "Measurements of Time Lag in Concrete Gravity Dam Foundations." Paper presented at Water Power '91, Denver, Colorado, 1991.

Meisenheimer, J.K. and Harris, C.W. "Evaluating Uplift Pressures for Concrete Gravity Dams." Paper presented at Water Power '89, Niagara Falls, New York, 1989.

Meisenheimer, J.K.; Harris, C.W. and Grenoble, B.A. "How Concrete Gravity Dams Were Built." Paper published in Hydro Review, Vol. VIII, No. 4, Kansas City, Missouri, 1989.

Meisenheimer, J.K. and Harris, C.W. "Guidelines for Core Drilling, Piezometer installation, and Core Sample Testing for the Analysis of Concrete Gravity Dams, GS-6365." Report published by the Electric Power Research Institute, Palo Alto, California, 1989.

Harris, C.W.; "Effects of Joints on Pipeline Response to Trench Construction." Master's Thesis, Cornell University, Ithaca, New York, 1983.

Von Thun, J.L. and Harris, C.W. "Estimation of Displacement of Rockfill Dams Due to Seismic Shaking." Paper presented at the International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, St. Louis, Missouri, April 26 - May 3, 1981.

MICHAEL J. MILLER, P.E.

POSITION IN FIRM: Principal Geotechnical Engineer

YEARS WITH FIRM: 1

TOTAL YEARS OF EXPERIENCE: 15

KEY QUALIFICATIONS:

Involved in geotechnical, civil, and construction engineering projects in the United States and has also worked on projects in Peru, Eritrea and South Korea. Experience on these projects includes proposal preparation, engineering analysis, design and report preparation, coordination of field investigations, laboratory testing, preparation of construction plans and specifications, cost estimating, consulting during construction, and project management.

Involved in more than 60 projects related to dam design and construction. The scope of these projects range from feasibility level siting studies to the preparation of construction documents for new and the rehabilitation of existing embankment, rockfill and concrete dams including concrete faced, roller-compacted concrete (RCC), concrete gravity and arch dams. Also served as resident engineer during the construction of 4 new RCC gravity dams and 4 RCC spillway rehabilitation projects. Involved with the construction of 10 RCC projects in which over 800,000 cy of RCC have been placed.

Geotechnical consulting has included investigations, analyses and designs of deep and shallow foundation systems, tunnels and shafts, structural slurry and secant pile walls, conventional and roller-compacted concrete (RCC) mix designs, earth and rock retaining systems, and the design of pavements. Also the design and construction management of cement and chemical injection grouting programs for dams and tunnels and compaction grouting programs for the rehabilitation of structures. Areas of expertise include: Dam Engineering, Geotechnical Engineering, Civil Engineering, Construction Engineering, and Grouting

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EDUCATION:

M.S., 1990, Civil Engineering (Geotechnical), Michigan State University, East Lansing, MI

B.S., 1987, Civil Engineering, Michigan State University, East Lansing, MI

Professional Affiliations: American Society of Civil Engineers, U.S. Society on Dams

Professional Registrations: PE/Ohio, 1993, #56968/Colorado, 1994, #29974/South Dakota, 1995, #5804

EXPERIENCE RECORDS:

AuTrain Hydroelectric Project, Alger County, MI. U.S.A.
Client: *Upper Peninsula Power Company / Wisconsin Public Service*
Project Engineer for the design and preparation of construction documents for the rehabilitation of AuTrain dam. Project entailed the rehabilitation of a 40-foot high embankment dam with a concrete gravity overflow spillway section. Project included the design of a 14-foot high emergency fuse plug spillway; concrete repairs to the valve house and a new toe drain system for the main dam. (2002-2003)

Hoist Hydroelectric Project, Marquette, MI. USA
Client: *Upper Peninsula Power Company / Wisconsin Public Service*

Project Engineer for the design and preparation of construction documents for the rehabilitation of Hoist dam. Project entailed the analysis and design of rehabilitation schemes to safely pass the PMF and to meet FERC requirements to stabilize the 60-foot high concrete gravity arch / gravity dam. The rehabilitation included the design of post-tensioned anchors with capacities up to 820 kips and the design of a new saddle dike to contain the PMF event. (2002-2003)

McClure Hydroelectric Project, Marquette, MI. USA
Client: *Upper Peninsula Power Company / Wisconsin Public Service*
Project Engineer for the design and preparation of construction documents for the rehabilitation of McClure dam. Project entailed the analysis and design of rehabilitation schemes to safely pass the PMF and to meet FERC requirements to stabilize the 55-foot high concrete gravity dam. The rehabilitation included the design of post-tensioned anchors with capacities up to 500 kips, the raising of the existing earthen wing dam and concrete repairs to the existing structure. Concrete repairs included overlaying the existing gravity outlet section; modifications to the gravity overflow spillway section including replacing the crest and stilling basin flip bucket; and epoxy and polyurethane grouting of cracks in the overflow and gravity sections of the structure. (2002-2003)

Tie Hack Dam, Buffalo, WY. U.S.A.
Client: *States West Water Resources Corporation / Wyoming Water Development Commission*
Project Design Engineer and Resident Engineer (Geotechnical and RCC) during the design and construction phases of Tie Hack Dam, a 160-foot high, 83,000 cy RCC dam near Buffalo, Wyoming. Responsibilities included preparation of the geotechnical design and borrow investigation reports, design and analyses of RCC mixes, the design of the consolidation and curtain grouting programs and design of the dam structure, submittal review, preparation of weekly progress reports and review and verification of contractors monthly pay estimate to the Owner. Also responsible for redesign of dam in the field due to differing site conditions; overseeing and verifying that all foundation excavation and preparation, grouting, RCC aggregate production, RCC and dental placement activities conformed to the project requirements. (1993 to 1998)

Toker Dam, Asmara, Eritrea
Client: *Natural Resources Consulting Engineers*
Resident Engineer during the construction phase of Toker Dam, a 78-meter high 184,000 cubic meter RCC gravity dam located outside of Asmara, Eritrea. Responsibilities included the training of the contractor's field personnel as to the proper techniques and procedures for RCC placement. Responsible for the training and supervision of a quality control/inspection staff consisting of three field engineers and seven inspectors. Also responsible for submittal review related to RCC construction; overseeing and verifying that all foundation excavation and preparation, RCC aggregate production, and all RCC, dental and facing concrete production and placement activities conformed to the project requirements. (1997-1998)

Penn Forest Dam, Eastern PA. U.S.A.
Client: *Conti Construction*
RCC Production and Placement Engineer for the contractor during bidding and construction phases of Penn Forest Dam. Project included the placement of 370,000 cy of RCC and 750,000 cy of earth and rock fill for the rehabilitation and reconstruction of a 180-foot high dam. Responsibilities included the training of the contractor's field personnel, the preparation of technical submittals, the supervision of the contractors RCC production and placement procedures and the design of RCC mixes. Also directed activities relating to the production and placement RCC and conventional concrete during construction. (1997 –1999)

Bullard Creek Dam, Lakeview, OR., U.S.A.
Client *USDA, Natural Resources Conservation Service*
Advisor to the United States Department of Agriculture, Natural Resource Conservation Service (NRCS) during the construction of Bullard Creek Dam near Lakeview, Oregon. Project entailed the placement of approximately 9,000 cy of RCC for the construction of a 51-foot high gravity flood control structure.

Duties included advising the NRCS and the contractor as to proper RCC construction techniques. Also advised the NRCS on foundation excavation, preparation and treatment, as well as the design of the final RCC mix. (1998-1999)

Box Creek Dam, near Leadville, CO, U.S.A.
Client *City of Aurora*
Project Manager for the performance of a site feasibility study and a geotechnical feasibility study to evaluate the suitability of the site for the construction of a 20,000 acre-foot reservoir. Project included the drilling of test holes and excavation of test pits to evaluate borrow material quantities and foundation conditions for the construction of a 180-foot high zoned embankment. A feasibility level embankment design and cost estimate was prepared to aid owner with his decision as to the purchase of the property for the project. (1999 to 2001)

Project Manager during planning and Senior Reviewer during the performance of an assessment of the stability of the south abutment of the dam. Project entailed the geologic mapping and drilling of vibra-core exploration test holes in the abutment and through an existing landslide adjacent to the abutment to aid in the characterization of the abutment stratigraphy and adjacent landslide. An analysis of the stability of the abutment was completed to aid in the assessment of the feasibility of the project.(2001-2002)

McKinney Dam, Rockingham, NC. U.S.A.
Client: *US Fish and Wildlife Service /AG&E Schnabel /North Carolina Wildlife Resources Commission*
Project Design Engineer for the rehabilitation of McKinney dam to eliminate identified dam safety deficiencies. Responsible for the preparation of construction plans and specifications for an RCC emergency spillway. Project included placement of 1500 cy of RCC for the emergency spillway construction, the repair of the existing concrete spillway structure and the relining of the existing outlet and hatchery pipes with cured-in-place pipe. (1999 – 2002)

Sourdough Creek Dam, Bozeman, MT. U.S.A.
Client: *City of Bozeman, Montana*
Project Engineer for a reservoir/dam siting study for the city of Bozeman, Montana. Ten potential sites were identified and evaluated. Preliminary designs and cost estimates at two of the sites were formulated. Both RCC and concrete faced rockfill dams were considered at both sites. The height of the dams considered were approximately 170 feet and their crest lengths were between 850 and 1,000 feet. (1997-1998)

Jed Johnson Dam, Lawton, OK. U.S.A.
Client: *US Fish and Wildlife Service*
Advisor to the U.S. Fish and Wildlife Service during the rehabilitation of Jed Johnson Dam. Project entailed the seismic stabilization of the dam by increasing the normal loading of the dam on the underlying bedrock by installing 43 post-tensioned anchors with capacities ranging from 80 to 1093 kips. Responsible for submittal reviews, the training of government inspectors and for the review of anchor installation procedures and test data. (2000-2001)

Long Lake Dam, near Steamboat Springs, CO. U.S.A.
Client: *City of Steamboat Springs / Mt. Werner Water*
Project Manager for the rehabilitation of Long Lake Dam to eliminate dam safety deficiencies. Project entailed the design of a new outlet works with a solar powered operator with the capability of being operated remotely from the Steamboat Springs filtration plant located approximately 10 miles from the dam. The outlet was designed to pass snowmelt floods that had previously caused the dam to overtop on three occasions. Also responsible for the preparation of filling and long term monitoring plans for the dam. (1997-2002)

Leyden Dam, Arvada, CO. U.S.A.
Client: *City of Arvada*

Construction Manager and Engineer of Record during the construction of an RCC spillway rehabilitation project to eliminate identified dam safety deficiencies for a 45-foot high homogeneous embankment dam. Project entailed the placement of approximately 10,000 cy of RCC, the construction of a new intake tower and a new outlet structure. (2000-2001)

Rocky Gulch Dam, Morenci, AZ. U.S.A.
Client: *Phelps Dodge Corporation*
Resident Engineer during the construction of a 65-foot high RCC gravity dam in eastern Arizona. Responsibilities included directing foundation preparation, grouting activities and RCC placement during construction. This work included the formation of grout curtains in the foundation rock and blanket grouting within the dam footprint, and the placement of more than 8,000 cy of RCC. (1993-1994)

Fawell Dam, Naperville, IL. U.S.A.
Client: DuPage County, Illinois
Resident Engineer during the rehabilitation of Fawell Dam. The project entailed placing approximately 13,000 cy of RCC to enable the dam to pass 1/3 of the PMF over its crest. Responsibilities included providing a technical review of the final design documents, the design of RCC mixes, review of submittals related to construction, preparation of pay estimates for the owner, and verifying that all construction activities conformed to the contract documents. (1997-2000)

Lost River Dam, Moorefield WV. U.S.A.
Client: *Conti Construction*
Design and Resident Engineer/RCC Placement Supervisor for the repair of the emergency spillway at Lost River Dam in northeast West Virginia. This project entailed the design of a control structure placed across the emergency spillway, formulating suitable RCC mix designs and placing approximately 20,000 cy of RCC for backfill of areas of the emergency spillway that were below grade. Supervised the contractors operations as to proper RCC placement techniques and procedures. (1995-1996)

Lake Vesuvius and Kenton Lake Dams, OH. U.S.A.
Client: *US Forest Service*
Project Engineer for the preparation of feasibility level designs to rehabilitate identified dam safety deficiencies for two dams in southern Ohio operated by the U.S. Forest Service. This work included the performance and coordination of field investigations, seepage and stability analyses, and supervision of hydrologic and hydraulic analyses to identify dam safety deficiencies. Rehabilitation designs were formulated to eliminate these deficiencies, including the modification of the existing spillways, the design of new spillways, and the design of an RCC overtopping protection systems to safely pass the design storms. (1993-1994)

Butt Valley Dam and Reservoir, CA. U.S.A.
Client *Pacific Gas and Electric*
Design Engineer for the development of feasibility level repair options to seismically strengthen an existing 95-foot high puddled core embankment dam. Repair options included constructing a double buttress along the upstream and downstream slopes of the dam, or replacing the existing structure with a new embankment or RCC dam. Feasibility level design drawings and cost estimates were developed for each option and a final repair scheme selected. (1996)

Fish Creek Dam, Steamboat Springs, CO. USA
Client: *City of Steamboat Springs / Mt. Werner Water*
Senior Review of the construction of a double row grout curtain utilizing microfine and portland cement grouts for the construction of a 75-foot high embankment dam. Also responsible for the design and inspection of the modifications to the existing low level outlet, which included the grouting of a new, 24-inch diameter steel pipe within the existing 36-inch diameter outlet pipe. (1994-1995)

Twin Lakes Dam, Sheridan, WY. U.S.A.

Client: *City of Sheridan*
Senior Review of the construction of a double row grout curtain utilizing microfine and portland cement grouts for the reconstruction of a 90-foot high embankment dam. (1997)

Greybull Valley Dam, Burlington, WY. U.S.A.
Client: *Greybull Valley Irrigation District*
Responsible for the review of the grouting program for a new 150-ft high embankment dam. Project included the construction of a double row grout curtain and a consolidation grouting program to improve foundation conditions, utilizing microfine and portland cement grouts. (1997-1998)

South Park Dam, Lake County, CO. USA
Client: Centennial Water and Sanitation District
Project Manager for the siting and feasibility study for the construction of a new 400 acre-foot storage reservoir. The project included the performance of cursory geologic hydraulic and geotechnical investigations at three sites to identify fatal flaws that would prevent the district from developing water storage facilities. In addition feasibility level designs and cost estimates were developed for two reservoir sites and one storage pond site that included 10,000 lineal feet of pipeline and a pump station. (1999-2000)

Stormwater Containment Facilities, Hanover, NM. USA
Client: Cobre Mining Company
Project Engineer for the performance of a siting study, geologic and geotechnical investigations, the design, the preparation of construction plans and specification and cost estimates for the construction of three concrete dams ranging from 32 feet to 45 feet in height. The purpose of the dams were to intercept runoff from the waste rock disposal areas of the mine before it entered the Mimbres River drainage. (2000-2001)

Lake Meredith Dam; Ordway, Colorado, U.S.A.
Client: Colorado Department of Transportation / Lake Meredith Reservoir Company
Engineer of Record for the rehabilitation of Lake Meredith Dam. Project included the design and construction of riprap energy dissipater for the dam outlet, the armoring of the downstream toe of the dam and outlet channel, an 18-foot high MSE retaining wall and reconfiguring the downstream slope of the dam where Colorado SH-71 crosses the dam. All construction documents and construction management activities were in accordance with CDOT standards. Project entailed extensive coordination with two State agencies and a local irrigation district. (1999-2000)

Lake Henry Dam; Ordway, Colorado, U.S.A.
Client: Lake Henry Reservoir Company
Engineer of Record for the design of the rehabilitation of Lake Henry Dam. Project included the design of a new toe drain system and the buttressing of the downstream slope to stabilize the west dam to stabilize the structure and to reduce seepage. (2000-2001)

Tucker Lake Dam, Jefferson County, Colorado, USA
Client: Denver View Reservoir and Irrigation Company
Project Design Engineer, Construction Manager and Engineer of Record during construction for the rehabilitation of a 26 feet high embankment dam in Jefferson County, Colorado. Project entailed the raising of the crest and the flattening the upstream slope of the north and south embankments, construction of a 8 foot high saddle dike and the reconstruction of the drop inlet spillway structure. Responsible for the preparation of the construction plans and specifications, assisting the irrigation district in the bidding phase and responsible for the management of contract during construction. (1998-1999)

Ketner Dam, Westminster Colorado, U.S.A.
Client: City of Westminster
Resident Engineer during the rehabilitation of the low level outlet works. Project consisted of relining the existing corrugated metal outlet works with a new cured in place liner (in-situform). (1998)

Pajarito Flood Retarding Structure, Los Alamos, New Mexico, U.S.A.
Client: Sundt Corporation
Designer - Responsibilities included assisting in the preparation of construction drawings for an RCC dam design. Project was a turnkey, fast track design-build project that required close coordination with the construction contractor and the Owner (Los Alamos National Laboratory) to provide a design that was compatible with the construction equipment and material that was available. Project design started on Thursday and construction began on the following Sunday. (2000)

Tenkiller Ferry Dam, Muskogee, Oklahoma, U.S.A.
Client: Wynn Construction
Design Engineer for the preparation of a remedial grouting program to repair voids caused by improper construction techniques for a mass concrete spillway. Responsible for the preparation of plans and specifications for both cement and urethane grouting programs. (2000 – 2001)

Yonggwang Unit 5 Fuel Handling Building, South Korea.
Client: *KOPEC*
Design Engineer for the development of a consolidation-grouting program to improve the strength properties of a rock foundation beneath the reactor unit of nuclear power plant in South Korea. This project included the preparation of construction plans and specifications. (1997)

West Leg Interceptor Project, Cuyahoga County, OH. U.S.A.
Client: *North East Ohio Regional Sewer District*
Assistant Resident Engineer for the West Leg Interceptor tunnel project. Project entailed approximately 15 miles of soft ground and hard rock tunneling. Duties included submittal review, addressing claims pertaining to differing site conditions, preparation of cost and credit estimates, preparation of weekly progress reports, and review of the contractors' monthly pay estimate to the owner. Also responsible for reading and analyzing instrumentation installed to monitor the performance of the earth and rock support systems, and mapping rock stratigraphy in the tunnel.

Supervised the construction of grout curtains and a concrete cap system where the West Leg Interceptor tunnel alignment intercepted the Rocky River. At this location, the crown of the tunnel passed within five feet of the river's bottom. This project involved the installation of rock anchors and the formation of grout curtains in both alluvium and bedrock. Also supervised chemical grouting activities in the West Leg Interceptor tunnel where the ground losses occurred in a flowing silt formation. (1991-1993)

Dearborn CSO Project, Dearborn, MI. U.S.A.
Client: City of Dearborn
Project Engineer for the evaluation of site conditions and review of construction procedures for the excavation of a 230-foot deep, 54-foot diameter drop shaft and several 15-foot diameter access shafts through glacial overburden and limestone in eastern Michigan. Formulated grouting procedures to control groundwater inflow into the shafts, which allowed for the contractor to complete the construction of these structures. (1997)

Gold Camp Road, Tunnels No. 3 and 6, El Paso County, Colorado, U.S.A.
Client: US Forrest Service
Project Design Engineer for the preparation of preliminary designs and cost estimates for the rehabilitation of two historical railroad tunnels, converted to highway tunnels. The tunnels are 154 feet and 245 feet in length respectively and the tunnel support consisted of with timber sets. The project required that the historical integrity of the tunnels be maintained in the rehabilitation scheme. (2001-2002)

Sawpit Gulch Tunnel, Lead, SD. U.S.A.
Client: *Homestake Mining Company*

Project Engineer for the forensic investigation and repairs to remediate the settlement of a pre-cast segmental tunnel structure in Lead, South Dakota. This project entailed the investigation of the causes of settlement of one of the wall footings of the segmental structure, the formulation of a compaction grouting scheme to remediate the settlement and the inspection of the contractor's work during the construction. (1993-1994)

Open Pit, High Wall Stabilization Project, Lead, SD. U.S.A.
Client: *Homestake Mining Company*
Served as Project Design Engineer and Construction Manager during the various phases of high wall stabilization at an active gold mine in western South Dakota. Activities performed included the design and installation of rock reinforcement systems consisting of active and passive cable bolts and soil reinforcement systems consisting of soil nails to increase the stability of the pit walls. Also designed and supervised the construction of underground pillars, walls, and plugs to stabilize underground openings near the pit face. In addition, methods to backfill underground stopes were designed to reduce the potential for collapse, causing pit wall instability. Also designed instrumentation systems to monitor displacement of various portions of the pit wall and reviewed data gathered from these systems. (1994-1996)

Grizzly Gulch Tailing Dam, Raise No. 3, Lead, SD. U.S.A.
Client: *Homestake Mining Company*
Project Engineer for the design and preparation of plans and specifications for the third raise to the Grizzly Gulch Tailings Dam in Lead, South Dakota. This project entailed the design of a 50-foot raise to the existing 400-foot high rock fill tailing dam. Included with this raise was the design of a new seepage collection system, the installation of horizontal drains to lower the phreatic water surface in the existing dam and the design of new monitoring systems.
(1996-1997)

Quebrada Honda Tailing Dam, Toquepalla, Peru
Client: *Southern Peru Copper*
Engineer during the field investigation for the design of a new tailing dam in southern Peru. Responsible for over site of drilling and test pit activities to evaluate the geologic conditions at the site. Also assisted in the performance of geologic mapping and seismic investigation activities. (1994)

Pipeline Stability Assessment, IN to AL. U.S.A.
Client: *Amoco Oil Company*
Conducted a slope stability assessment of 26 river crossings for a 500-mile petroleum product pipeline running from northern Indiana to northern Alabama. Developed a rating system for assessing the landslide potential of each site. (1991-1992)

Jacobs Field, Cleveland, OH, U.S.A.
Client: *Hellmuth, Obata & Kassabaum, Inc.*
Project Geotechnical Engineer during the design and construction of Jacobs Field, a new 45,000-seat baseball stadium in Cleveland, Ohio. Both shallow and deep foundation systems were designed for this project. (1990-1993)

Plain Dealer Printing Facility, Brook Park, OH. U.S.A.
Client *The Austin Company*
Project Geotechnical Engineer for a 600,000-square-foot newspaper printing facility in Cleveland, Ohio. Project included the closure of abandoned oil wells, site filling up to 12 feet, and the design of foundation mats for settlement-sensitive printing presses and spread and continuous footing systems for the building and out-structures. Also supervised a staff of 3 to 5 inspectors during project construction. (1992-1994)

Federal Reserve Bank, Cleveland, OH, U.S.A.
Client: *Hellmuth, Obata & Kassabaum, Inc.*

Geotechnical Manager for the preliminary design phase of a new building addition to the Federal Reserve Bank in downtown Cleveland, Ohio. This project included the design of a structural slurry wall to retain a 55-foot excavation immediately adjacent to a 22-story masonry structure founded on friction piles. Both shallow and deep foundation systems were evaluated for this project. (1993-1994)

Bus Maintenance Garage, Memphis TN., U.S.A.
Client: *Wiss, Jenny & Elstner*
Project Engineer for the design of a remedial compaction grouting program to halt the settlement of utilities and a loading dock at a facility constructed over a municipal landfill.

Puddingstone Dam, Southern CA., U.S.A.
Design Engineer responsible for the preparation of plans and specifications for the construction of a 60-foot deep cutoff wall at the end of a stilling structure where back cutting of the structure had occurred. Designs for both secant pile and structural slurry walls were included in the construction documents. (1994)

McCullough Water Tank, Colorado Springs, CO. U.S.A.
Client: *City of Colorado Springs*
Lead geotechnical engineer for the design and construction of a 5.6 M gallon water tank constructed on highly expansive claystone and shale. Responsible for the preparation of construction plans and specifications related to foundation excavation and preparation, earthwork and drainage. Also responsible for submittal review during construction. (1999-2000)

Crystal Valley Ranch Water Tank, Castle Rock CO., U.S.A
Client: *City of Castle Rock*
Lead geotechnical engineer for the design and construction of a 4 M-gallon post tensioned water tank constructed on interbedded layers of sandstone and claystone. Responsible for the preparation of construction plans and specifications related to foundation excavation and preparation, earthwork and drainage. Also responsible for the design of an 80-foot high rock cut immediately adjacent to the tank. During construction, consulted on site conditions and reviewed contractors submittals. (1999-2002)

Cracker Unit Design and Refinery Modifications, BP Oil, Toledo Refinery, Toledo, Ohio
Client: *BP Oil*
Project manager for the design of foundation systems to construct a new Cracker unit, new Storage Tanks and pipelines at the BP Toledo refinery. Project was in beach deposits overlying Glacial lacustrine deposits. Cracker unit was founded on a deep pile foundation and the tanks were founded on gravel mat foundations. (1993-1994)

Honda of America – East Liberty Assembly Plant, East Liberty, OH, USA
Client: *SSOE and Honda of America*
Project Geotechnical Engineer for the design of the new automobile assembly plant and out structures. Responsible for the design of shallow and deep foundation systems and retaining walls for the Assembly Plant, a new water tower and sub stations. Also responsible for the training of materials inspection technicians during construction (1988-1989)

Rail Car Unloading Facility, Honda of America, Marysville, OH, USA
Client: *SSOE and Honda of America*
Project Geotechnical Engineer for the design of concrete and geogrid reinforced pavements for the construction of a new rail car container unloading facility at an existing auto assembly plant. Concrete pavements were designed to support gantry cranes used to unload container which were then transported by truck to various facilities in region.

Kajima Glass Plant, Elizabeth Town, KY
Client: *SSOE*

Project Geotechnical Engineer for the design of a drilled pier foundation system constructed in karst conditions for the construction of a new Glass Factory in central Kentucky. (1988-1989)

McCullough Water Tank, Colorado Springs, CO. U.S.A.
Client: *City of Colorado Springs*
Lead geotechnical engineer for the design and construction of a 5.6 M gallon water tank constructed on highly expansive claystone and shale. Responsible for the preparation of construction plans and specifications related to foundation excavation and preparation, earthwork and drainage. Also responsible for submittal review during construction. (1999-2000)

Bradley Road Forensic Investigation, Cleveland, OH, USA
Client: *BP Oil Pipeline Company*
Project Manager for The forensic study and remedial design addressing the differential settlements (up to 3-feet) of three 120-foot diameter fuel oil tanks constructed on glacial lacustrine deposits in Northern Ohio. Tanks (1993-1994)

Highway Geotechnical Engineering, U.S.A.
Client: *Various*
Project Engineer for over 30 geotechnical bridge and highway soil survey investigations in various counties in Illinois, Ohio and New Mexico. Consulting for highways includes subgrade, embankment and pavement design, and construction recommendations for asphalt and concrete pavement systems. Consulting for bridges, culverts and retaining walls entailed providing geotechnical design and construction recommendations for foundation systems, including auger cast and driven piles, drilled piers and caissons, and spread footing foundations. (1987-2002)

TRAINING:

MSHA 24-hour Miner Training for Hard Rock/Coal Surface Mining

MSHA 8-hour Experienced Miner Refresher

OSHA 40-hour Health & Safety Training

OSHA 8-hour Site Supervisor Training

OSHA 8-hour Underground Construction Training

LANGUAGES:

English (native)
Spanish (conversational)

OVERSEAS ASSIGNMENTS

Eritrea, Peru

Employment History:

2002 to Present	MWH Energy and Infrastructure
1990 to 2002	Woodward-Clyde Consultants/ URS Consultants:
1987 to 1989	Professional Service Industries

Technical Papers

Roller Compacted Concrete Overtopping Protection Design Guide, Chapters 8 and 9 (Instrumentation and construction Considerations), prepared for the Portland Cement Association, April 2002.

Roller Compacted Concrete Quality Control Manual, Chapter 5 – Construction Placement Quality, prepared for the Portland Cement Association, June 2000.

Presentations: RCC Construction Means and Methods, RCC Dam and Dam Rehabilitation Seminar, Portland Cement Association, Naperville, Illinois August 2000.

Arnold, Terry and Mike Miller. How Dense is Your RCC, US Society on Dams, San Diego 2002.

Michael Miller, Dan Birch, Dan Johnson, Bob Stoddard. Rehabilitation of a High Mountain Dam Subjected to Frequent Overtopping Events, US Society on Dams, Denver 2001

Michael J. Miller, Thomas R. Scotese, Arthur O. Paeth. Groundwater inflow problems in tunneling at the west leg interceptor contract 3, Cleveland, Ohio. 35th U.S. Symposium on Rock Mechanics, Lake Tahoe, Nevada, 1995

APPENDIX J-3

LIST OF CONTRACT DOCUMENTS

The Contract Documents consist of the following:

Construction Specifications for Au Train Hydroelectric Project Dam Modifications.

Construction Drawings for Au Train Hydroelectric Project Dam Modifications

APPENDIX J-4

EXAMPLE OF REPORTS

NONCONFORMANCE REPORT

NCR NO:

Subject:

Contractor:

Description/Affected Area:

Reference Documents

Contract No./Section:

Construction Drawing:

Construction QA Manager — Date

WPS-UPPCO — Date

Disposition:

- Rework ☐
- Repair ☐
- Reject ☐
- Use as is ☐

Action taken to control non-conformance:

Construction QA Manager — Date

WPS-UPPCO — Date

Statement of completed action:

Construction QA Manager — Date

WPS-UPPCO — Date

APPENDIX J-5

MATERIAL TESTING SCHEDULE AND REFERENCE DOCUMENTS

MATERIAL TESTING SCHEDULE

MATERIAL	TEST	TEST METHOD/STANDARD	TEST FREQUENCY AND/OR CERTIFICATION
Toe Drain Materials	In-place Density	ASTM-D2993	One per material placed per day or at least one for every 200 cubic yards placed
Toe Drain Materials	Gradation/Sieve	ASTM-C136,	One per material or at least one for every 500 cubic yards at stockpile and in-place

REFERENCE DOCUMENTS

Standards and Codes:

ACI – American Concrete Institute
ANSI - American National Standards Institute
ASTM - American Society for Testing and Materials
MDOT – Michigan Department of Transportation Standard Specifications
AASHTO - American Association of State Highway and Transportation Officials

Project Specifications:

Au Train Hydroelectric Project Dam Modifications.

APPENDIX J-6

RECORD KEEPING PROCEDURES

RECORD KEEPING PROCEDURES

Records shall be kept by the Resident Project Representative and the Field Quality Control Engineer on-site. The Resident Project Representative and the Field Quality Control Engineer shall keep separate files of the following:

- Daily Reports
- Weekly Reports
- Non Conformance Reports Resolved
- Non Conformance Reports Pending Resolution
- Environmental Deficiency Reports
- Monthly Reports
- Field Directives and Clarifications
- Measurements for Payment
- Payment Requests and Evaluations
- Record Drawings of the As-Constructed Details

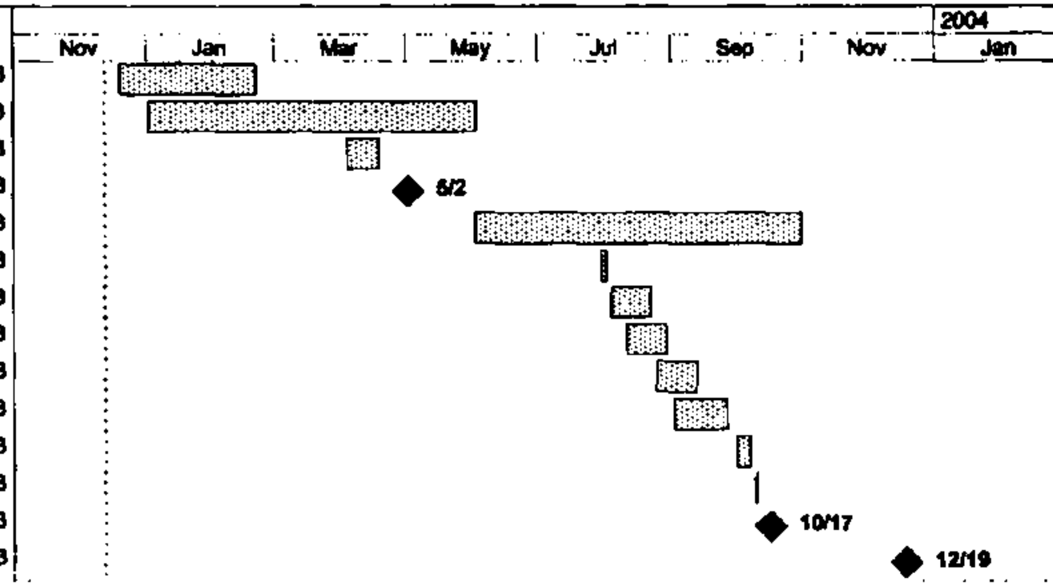
APPENDIX J-7

PROJECT SCHEDULE

UPPCO Autrain Hydro Electric Dam Modifications Project

Project:0100003002

ID	Task Name	Start	Finish
1	FERC Submittal / Approval	Fri 12/20/02	Thu 2/20/03
2	Environmental Permits	Thu 1/2/03	Mon 6/2/03
3	Out for Bids	Fri 4/4/03	Fri 4/18/03
4	*Award Contract*	Fri 5/2/03	Fri 5/2/03
5	Start Drawdown	Mon 6/2/03	Fri 10/31/03
6	Mobilization	Wed 7/30/03	Fri 8/1/03
7	Excavated South Levee Crest	Mon 8/4/03	Fri 8/22/03
8	Concrete Repair Work	Mon 8/11/03	Fri 8/29/03
9	*Placement & compaction South Levee*	Mon 8/25/03	Fri 9/12/03
10	Toe Drains and Manholes	Tue 9/2/03	Fri 9/26/03
11	Regrade crest of N. Dam	Wed 10/1/03	Tue 10/7/03
12	Demobilization	Fri 10/10/03	Fri 10/10/03
13	Construction Complete	Fri 10/17/03	Fri 10/17/03
14	*Final Construction Report Submittal*	Fri 12/19/03	Fri 12/19/03



Project Manager: Ben Trotter
Original Schedule: 12/13/02
File: 0100003002

Task		Milestone	◆	External Tasks	
Split		Summary		External Milestone	◆
Progress		Project Summary		Deadline	

CONSTRUCTION SPECIFICATIONS

DAM MODIFICATIONS

AU TRAIN HYDROELECTRIC PROJECT
FERC No. 10856
ALGER COUNTY, MICHIGAN

Prepared for
Upper Peninsula Power Company
(a subsidiary of WPS Resources)
Ishpeming, Michigan

December 2002

MWH
MONTGOMERY WATSON HARZA

1600 Stout Street, Suite 400
Denver, Colorado 80202

Project No. 1001755

UPPER PENINSULA POWER COMPANY

AuTrain Hydroelectric Project

DAM MODIFICATIONS

DIVISION 1 - GENERAL REQUIREMENTS

DIVISION 2 - SITE WORK

DIVISION 3 - CONCRETE

DIVISION 13 - SPECIAL CONSTRUCTION

APPENDIX A – SITE DATA

Section 01010
SUMMARY OF WORK

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Background

B. Scope of Work

C. Project Schedule

D. Michigan Sales and Use Tax

E. Retainage

1.2 Background

The Au Train Hydroelectric Project is located on the Au Train River in Alger County, Michigan. The project began operation in 1910 and is located on Au Train Lake, a natural lake. The present dams were constructed in 1930 to enlarge the reservoir and increase the power generation capacity of the project. The project impounds approximately 6.6 miles of the Au Train River and the impoundment has a surface area of approximately 1,557 acres at full pool. The project is currently operated as modified run-of-river project based on the water level maintained at the reservoir.

The project features consist of an embankment saddle dam with a central spillway and penstock intake located at the south end of the storage reservoir; the main embankment dam located at the north end of the storage reservoir; a 2,516-foot long 5 ½ -foot diameter penstock; indoor powerhouse with two 800 horsepower generating units and two 560 kV generators; and a 2,500-foot long 2,300 V transmission line.

Normally, all releases from the dam are made through the penstock for use in power generation. Under operation, the normal reservoir water level ranges between El. 777.3 (all elevations are mean sea level MSL) local datum = MSC –1.27) feet and El. 781.3 feet, excluding late winter drawdown. The reservoir elevation near El. 781.3 feet will occur during the spring runoff period in May while water levels near El. 777.3 will occur as a result of late summer (August and September) drafting of the reservoir for downstream fisheries and recreation interests. The reservoir will be drawn down to a target level of El. 772.3 in late winter (March) to reduce the frequency and magnitude of uncontrolled discharges during spring runoff.

South Levee - The embankment saddle dam, or South Levee, is located between the Lake Superior and Lake Michigan drainage basins and impounds the south end of the Au Train Basin. The 4,500-foot long South Levee has a maximum height of 15 feet with a crest width of 10 feet at an average crest elevation at 789.7 feet. The embankment was constructed with 2H:1V upstream and downstream slopes which have good ground cover. In a small area near the left abutment, the crest of the embankment is approximately 3 to 3.5 feet lower than along the rest of the embankment.

The South Levee is a homogeneous loose sand embankment. The South Levee embankment is founded on granular alluvium composed of silty sand to sandy gravel. Old tree stumps are present on both the upstream and downstream slopes. The entire downstream area is boggy and soft.

Main Embankment – North Dam - The main embankment, or the North Dam, is located at the north end of the Au Train reservoir. The 1,500-foot long dam is approximately 38 feet high at the maximum section with a crest width between 15 and 20 feet at El. 789.8 feet. The concrete overflow spillway and penstock intake sections are located at the center of the dam. A concrete core wall extends approximately 50 feet from both sides of the spillway/intake into the embankment. The upstream slopes were constructed at 3H:1V slopes while the downstream slopes were constructed at 4H:1V slopes with several parallel sets of toe drains along the downstream toe.

The North Dam embankment is composed primarily of a loose sand fill. Beneath the embankment fill, granular alluvium is encountered. The alluvium is similar to the fill material and is a silty sand to sandy gravel with horizons of weathered sandstone bedrock.

Fourteen drain outfalls are located in the downstream slope area of the North Dam. Half of the drains are metal pipes that extend through the base of the right spillway retaining wall. The remainder of the drain outfalls are the drains along the toe of the embankment and shoulders of the highway.

Spillway - The concrete gravity overflow spillway is 100 feet wide by 29 feet high and is located at the center of the North Dam. The crest elevation of the spillway ogee is at El. 779.3 feet; manually operated stoplogs extend the crest to El. 781.3 feet. The spillway discharges into the Au Train River and under Highway M-94 and the abandoned Lake Superior and Ishpeming (LS&I) Railway Bridges immediately downstream of the spillway.

Intake and Outlet Structure - Water passes through an intake structure and into a steel penstock that bifurcates and feeds the two turbines.

Turbine discharge is regulated by adjustable wicket gates controlled by a gate shaft governor and is returned to the upper Au Train River via a 500-foot long, unlined tailrace channel. The intake structure is located in the main dam at the north end of the reservoir to the right of and abutting the overflow spillway. The intake contains stop logs, a trash rack, and a butterfly shutoff valve. The invert elevation of the intake is at 755.5 feet. The 5.5-foot diameter steel penstock drops approximately 100 feet over its 2,516-foot length to the powerhouse. There is a 10-foot diameter, exposed steel surge tank connected to the penstock above the powerhouse.

Powerhouse - The powerhouse is located on the east bank of the upper Au Train River, approximately 2,500 feet downstream of the main dam. The powerhouse has a reinforced concrete substructure and brick superstructure. The inside dimensions of the powerhouse are 37.5 feet long by 32 feet wide by 22 feet high. It houses two identical 800-horsepower, horizontal-axis, Francis type turbines with steel spiral casings. The units operate at a maximum gross head of 134 feet. Each synchronous-type generator is rated at 560 kilovolt-amperes, 600 rpm, 3-phase, 60 hertz, and is directly connected to the turbine shaft with a flywheel.

A 2,300-volt, 3-phase, 60-hertz transmission line, approximately 2,500 feet long, connects to UPPCO's transmission system.

1.3 SCOPE OF WORK

A. The scope of work required under this contract is generally described as furnishing and installing all labor and materials necessary for the following work at the Au Train Hydroelectric Project:

1. Modifications to the South Levee Embankment;
2. Construction of a toe drain at the North Dam to maintain the phreatic surface below the ground surface and to protect against piping;
3. Regrading the crest of the North Dam to provide sufficient freeboard; and
4. And the repair of damage to the concrete walls of the outlet structure building

B. The Work includes furnishing all labor, tools, equipment, appliances, materials, transportation and services, and performing all necessary operations for, and properly incidental to, the construction and proper completion of the Project as shown and noted on the Drawings and as specified in these Specifications.

C. The Contractor shall prepare and submit with its proposal a plan for performing the Work. This Work Plan shall be approved by the Company prior to the start of the Work and shall describe in detail the means and methods of performing the work, including any dewatering, excavation, foundation preparation, furnishing, placement and compaction of fill materials, grading operations, construction procedures for the South Levee embankment modifications, the toe drain, and procedures for concrete repairs to the outlet valve house. It is likely that the groundwater level will be near the ground surface in the work area. Appropriate precautions to avoid damage might include avoiding unnecessary equipment traffic, careful excavation, dewatering to lower the groundwater table, placement of a mud mat, or other suitable methods proposed by the Contractor.

1. The construction procedures for the construction of the South Levee modification shall include a detailed discussion of how damage to the existing embankment and foundation due to construction operations will be avoided. It is essential that the foundation not be rutted, loosened or disturbed from its natural condition. The plan shall include a detailed description with sketches of construction procedures with details regarding how the Contractor will maintain the minimum widths shown on the Drawings.

2. Detailed procedures for construction of the toe drain shall include a detailed description with sketches for construction of the toe drain. Proposed methods shall include means to maintain stability of the toe drain throughout construction. Groundwater flow into the excavation will need to be controlled to prevent collapse of the sides of the drain. Methods to control groundwater may include utilizing bipolymer slurry construction techniques or well points. Procedures for placement of pipe, bedding material, and toe drain backfill material to the proper grade shall also be outlined.

3. The Work Plan shall include erosion and sediment control measures including silt barriers to be installed downstream of the construction area and stockpile areas to confine sediment that may be washed from the stockpiles. Ditches

and silt barriers will be inspected frequently. Ditch erosion or silt barrier damage shall be repaired immediately. Significant sediment accumulations shall be removed and placed in a topsoil pile. Silt barriers will be maintained until construction is complete or ground cover materials have been placed. The plan shall also include a discussion of measures that will be taken to avoid damage to the work from sudden rises in the reservoir level and/or heavy rains.

4. The plan shall include a discussion of methods and equipment for all other work including clearing and grubbing, foundation preparation, imported materials, borrow areas, disposal areas, compaction, grading, seeding and any other pertinent procedures.

5. The plan shall include a bar chart schedule showing individual tasks, duration of tasks, relationship and interdependency of tasks. Schedule shall support Company's overall construction schedule as indicated in the Contract Document.

   The Contractor shall submit with his proposal, a Contractor Quality Control Plan (CQC) in accordance with the requirements of Section 01400: The CQC plan shall include all QA/QC required by the specifications and shall outline all certifications, surveying, alignment checks, and inspections. The plan shall state frequency and acceptance criteria.

D. The Company will attempt to lower the water level in the Au Train Basin to elevation 770 feet during the construction period. However, the Company cannot guarantee this level because it cannot control the precipitation in the drainage basin above the reservoir. Rain, snowstorms, or high winds could cause the water level in the lake to rise without warning. The Contractor shall be prepared with necessary plan and provisions to complete the Work regardless of the water level in the Au Train Basin.

E. A minimum flow must be maintained through the outlet. Contractor shall not impede minimum flow and shall employ whatever means necessary so that flow is not affected by the work.

F. The location of the Work, together with details for construction, is as shown on the drawings incorporated herein. Where figures are shown on drawings, they shall take precedence over scaled distances and dimensions. All dimensions shall be verified in the field by the Contractor. The Contractor shall bring any discrepancies to the attention of the Company and proper corrections shall be made and approved by the Company. In the event of any discrepancy between the Drawings and these specifications, the interpretation of the Company shall be final. All notes on plans shall be carefully observed by the Contractor and are part of the Contract.

1.4 PROJECT SCHEDULE

A. The following design and construction schedule milestones are proposed:

Start of On-Site Mobilization	6/01/03
Start Work	6/01/03
Site restoration, cleanup and demobilization complete:	10/31/03
Complete Work	11/01/03

END OF SECTION 01010

Section 01018
CONSTRUCTION SURVEYING AND STAKING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Contractor shall provide all materials, items, operations or methods specified, listed or scheduled in specifications and drawings, including all materials, labor, equipment and incidentals necessary and required to conduct proper surveys to stake and layout the Work.

B. The Company will identify site reference points and baselines as shown on the drawings.

C. Contractor shall perform all surveys for the Work including establishing and reestablishing construction control, resetting of stakes and monuments, measurement for payment of completed work, and performing surveys needed for restoration of public and private improvements that have been damaged, destroyed, or relocated by Contractor.

D. All surveys and staking shall be performed under the direction of a land surveyor licensed in the State of Michigan.

E. The cost to the Contractor for all work and delays occasioned by giving lines and grades, or making other necessary measurements, will be considered as having been included in the unit and lump sum prices for items of Work.

1.2 RELATED SECTIONS

A. Not used.

1.3 SUBMITTALS

A. Surveyor: The surveyor performing the on site construction staking shall have a minimum of 5 years of construction staking experience. A resume detailing the experience level of the licensed land surveyor shall be submitted to Engineer for review 10 days prior to the start of any staking activities.

B. Survey Records:

1. Contractor shall use the control points established and shown on the drawings. As the work progresses, all subsequent changes to the control plan shall be submitted.

C. A certificate signed by the land surveyor, stating that the elevations and locations of the Work are in conformance with Contract Documents shall be submitted at Contract closeout.

1.4 PROJECT SURVEY CONTROL

A. Survey control points will be identified by the Company prior to the start of work.

1.5 PRIMARY CONTROL

A. Contractor shall be responsible for checking the position of the reference points comprising the primary control prior to starting site work and shall notify the Company of discrepancies found between actual and record measurements.

B. Permanent reference points shall not be located without prior written approval from the Company.

C. Protection of monuments and stakes shall be the responsibility of Contractor. Replacement of damaged control and reference points shall be at Contractor's expense.

1.6 SECONDARY CONTROL

A. From the primary reference control provided by the Company, Contractor shall establish secondary control points necessary for the construction of the Work. Secondary control shall consist of sufficient permanent points to establish the lines and grades for the various Work either directly or by offset. Layout lines for use in construction of the Work shall be taken directly from either the primary or secondary control.

B. Secondary control shall be tied to and closed upon the primary control. Secondary control networks shall be adjusted prior to use in developing subsequent control or in laying out the Work.

1.7 ACCURACY of SURVEYS

A. Points for cross sections shall be located to the nearest 0.05 foot horizontally and vertically.

B. Vertical elevation surveys shall close within 0.05 foot times the square root of the length of the circuit in miles.

C. All grade stakes shall be set to 0.02 foot.

D. Alignment of tangents and curves shall be within 0.01 foot.

E. Points for structures shall be set to the nearest 0.02 foot, except where operational function of special features require closer tolerances.

F. Survey movement monuments shall be surveyed within an accuracy of 0.01 foot vertical and 0.05 foot horizontal.

G. Tolerances for all other Work shall be as shown or specified in the Contract Documents.

H. Instruments shall be accurate and shall be subject to inspection by Engineer for proper operation.

1. Electronic distance measuring (EDM) instruments used by Contractor on the Site shall be checked for calibration a minimum of once per month on an established baseline approved by Engineer.

2. Defective instruments shall be promptly replaced, repaired, or adjusted to operate within the tolerances of the instrument manufacturer.

I. All work not performed with the methods and equipment as submitted by Contractor and accepted by Engineer shall be removed and replaced by Contractor at its own expense unless otherwise instructed by Engineer.

1.8 PROTECTION OF MONUMENTS, STAKES AND MARKS

A. Contractor shall preserve and protect all survey monuments and related marks. When removal is necessary, Contractor shall accurately reference the monuments or related marks, subject to the approval of the Company.

1. Except for boundary monuments, all other survey stakes, control points, monuments, benchmark, or reference stakes disturbed or destroyed during the Work shall be replaced and reset to the satisfaction of the Company at Contractor's expense.

2. Primary or secondary control monuments removed shall be reset by Contractor as soon as the Work requiring the removal is complete. Alternatively, other control points may be set so as to reestablish the control network.

3. The position of monuments, control points, or other marks that are subject to movement due to the passage of equipment or other forces shall be rechecked at regular intervals, but not less than monthly.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01018

Section 01040
COORDINATION AND MEETINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Coordination.

B. Field engineering.

C. Preconstruction meeting.

D. Progress meetings.

E. Examination.

F. Cutting and Patching.

1.2 COORDINATION

A. Coordinate scheduling, submittals, and Work of the various sections of the Construction Specifications to assure efficient and orderly sequence of installation of interdependent construction elements.

B. Coordinate completion and clean up of work of separate sections in preparation for Substantial Completion.

C. After Company accepts the Work, coordinate access to site for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of the Company's activities.

1.3 FIELD ENGINEERING

A. Contractor is required to locate and protect survey control, reference points, and all construction staking.

B. Verify setbacks and easements, confirm drawing dimensions and elevations.

C. Contractor shall preserve and protect established reference lines and points and shall make no changes without written approval of Engineer. Contractor shall bear any and all costs of surveying to re-establish

Company-furnished survey control and/or reference points and construction staking disturbed or destroyed due to Contractor's activities.

1.4 PRECONSTRUCTION MEETING

A. Prior to issuance of the Notice to Proceed, the Contractor shall meet with the Company and Engineer for a Preconstruction Meeting. The purpose of this meeting is to review the Company's ongoing operations onsite, submittal procedures, payrolls and labor relations, environmental protection, progress schedules, network analysis, scheduling, field clarification procedures and payment and procurement of materials. The principal features of work will also be reviewed and any questions regarding the Contract and work site will be addressed.

B. Attendance Required: Company, Engineer, and Contractor's Project Manager and Superintendent, the Contractor's Safety and Health Officer, and other key personnel.

C. Agenda:

1. Distribution of Contract Documents, including Contractors' executed bond, certificate of insurance and Contract.
2. Submission of list of Subcontractors, list of products, schedule of values, and construction schedule.
3. Designation of personnel representing the parties in Contract, and the Engineer.
4. Procedures and processing of requests for information; field decisions, submittals, substitutions, applications for payments, proposal request, change orders, and contract closeout procedures.
5. Scheduling.
6. Use of premises by the Company, Engineer and Contractor.
7. Company's requirements.
8. Construction facilities and controls provided by the Company.
9. Temporary utilities provided by the Company.
10. Survey and layout.

11. Security and housekeeping procedures.
12. Safety.
13. Permit Requirements.
14. Procedures for testing.
15. Record documents.

1.5 PROGRESS MEETINGS

A. The Contractor will schedule and administer meetings throughout progress of the Work at weekly or biweekly intervals.

B. Additional meetings may be called by the Company, Engineer, or the Contractor during any stage of the project when it is deemed necessary to raise any significant questions, establish new guidelines, introduce a new aspect to the project, or any other items that may affect the progress of work.

C. Meetings and conferences may take place at the project site or some other location that is satisfactory to the Company, Engineer and the Contractor.

D. Contractor will make arrangements for meetings, prepare agenda with copies for participants and preside at meetings.

E. Attendance Required: Contractor's Project Manager, Superintendent, Contractor's Quality Control Engineer, Contractor's Safety and Health Officer, major Subcontractors and suppliers, and Company's Representative, Engineer, as appropriate for agenda topics for each meeting.

F. All expenses associated with attending the meetings that are incurred by other than the Company and the Engineer shall be borne by the Contractor.

G. Agenda:

1. Review and approval of minutes of previous meetings.
2. Review of Work progress minutes of previous meeting.

3. Field observations, problems, conflicts, and decisions.

4. Identification of problems which may impede the schedule and proposed corrective actions.

5. Review of submittals schedule and status of submittals; expedite as required.

6. Revisions to project schedule.

7. Coordination of project schedules and projected progress.

8. Corrective measures and procedures to regain projected schedules.

9. Planned progress during succeeding Work period.

10. Maintenance of quality, and Safety and Work standards.

11. Pending changes and substitutions.

12. Effect of proposed changes on progress schedule and coordination, and effect on other contracts of the project.

13. Other business relating to Work.

H. Contractor will record minutes; include significant proceedings and decisions and distribute copies after meeting to participants and those affected by decisions made.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 EXAMINATION

A. Contractor will verify that existing site conditions and substrate conditions are acceptable for subsequent work. Beginning new work will be interpreted to mean that the Contractor has verified and accepted existing conditions.

B. Contractor will examine and verify specific conditions described in individual specification sections.

C. Contractor will verify that utility services are available, of the correct characteristics, and in the correct location.

D. Contractor shall locate all drains, underground piping, the rock walls, and other buried or partially buried features prior to construction.

3.2 COORDINATION

A. Contractor will employ skilled and experienced trades necessary to perform the Work.

B. Contractor will submit written request in advance of cutting or altering any existing elements which affects:

1. Structural integrity of element.

2. Efficiency, maintenance, or safety of element.

3. Visual qualities of sight exposed elements.

4. Work of Company or separate contractor.

C. Contractor will execute cutting, fitting, and patching, including excavation and fill, to complete work, and to:

1. Fit the several parts together, to integrate with other work.

2. Uncover work to install or correct ill-timed work.

3. Remove and replace defective and non-conforming work.

4. Remove samples of installed work for testing.

5. Provide openings in elements of work for penetrations of mechanical and electrical work.

D. Contractor will execute the Work by methods to avoid damage to other work, and which will provide proper surfaces to receive patching and finishing.

E. Contractor will restore the Work with new products in accordance with requirements of the Contract Documents.

F. Contractor will identify any hazardous substance or condition exposed during the Work to the Company for decision or remedy.

END OF SECTION 01040

Section 01060
REGULATORY REQUIREMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Contractor Obtained Permits

B. Company Obtained Permits

C. Responsibility and Coordination

1.2 GENERAL REQUIREMENTS

A. The Contractor shall familiarize himself with the conditions and requirements of all permits that are required by Federal, State, County, and local governing agencies. The Contractor shall comply with the conditions and the requirements of all permits in the performance of this Contract. If Contractor fails to comply with the conditions and requirements of any permit and such failure to comply results in fines, penalties, and/or suspension of work by a regulatory agency, all liability for such fines, penalties and delays shall be the sole responsibility of the Contractor.

1.3 CONTRACTOR OBTAINED PERMITS

A. The Contractor is responsible for researching permit requirements and obtaining the permits, plus such other permits as may be required by Federal, State, and local law. Duly executed copies of all permits obtained by the Contractor shall be submitted to the Owner and Engineer for information only.

1.4 COMPANY OBTAINED PERMITS

A. The Company has applied for permits from the Michigan Department of Environmental Quality (MDEQ) and Alger County (AC) for the work at the Au Train Basin. The Contractor shall follow all conditions of the MEDQ and AC permits. A copy of the permits will be issued to the successful contractor prior to construction. Any additional permits needed to perform work associated with the project shall be the responsibility of the Contractor.

B. **The Contractor shall comply with all conditions and requirements of these permits, and all conditions in accordance with the requirements of the Contract Documents.**

1.5 RESPONSIBILITY AND COORDINATION

A. The Contractor shall accept full responsibility for contacting all Federal, State, and local agencies to obtain permitting requirements for construction related activities on lands under jurisdiction by those agencies, and shall be fully responsible to research and become familiar with permitting requirements that must be met for the performance of the Contract work. The Contractor shall perform all coordination and documentation, as well as all engineering to obtain the required permits. Any engineering required to obtain permits shall be performed by a Michigan registered professional engineer.

B. The Contractor shall be fully responsible and solely accountable for meeting the requirements of all permits. The Contractor shall be the sole permittee for all permits.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01060

Section 01100
ENVIRONMENTAL QUALITY PROTECTION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Landscape Preservation

B. Preservation of Trees

C. Prevention of Water Pollution

1.2 RELATED SECTIONS

A. Section 01060 – Regulatory Requirements

B. Section 01515 – Diversion, Care of Drainage and Dewatering

C. Section 02290 – Earth Dams

D. Section 02935 – Reclamation

1.3 SUBMITTALS

A. The Contractor shall prepare a Stormwater Pollution and Prevention Plan (SWPPP) to cover all areas of the work in accordance with all government regulations and these Specifications. The Contractor shall also prepare a Spill Prevention Control and Countermeasure Plan (SPCC) covering all work activities in accordance with all government regulations and these Specifications.

B. Product Data

1. Submit product data for all material for environmental quality protection measures, such as silt fence, straw bales, mulch, erosion control blankets, and any other material planned for use in sediment and erosion control, or spill prevention and control for Engineer review.

C. Schedule

1. Provide a schedule for implementation of all environmental quality protection measure to the Company or his designated representative before any construction on the site begins.

1.4 LANDSCAPE PRESERVATION

A. General requirements:

1. Exercise care to preserve the natural landscape beyond the defined areas of work, and conduct construction operations so as to prevent any unnecessary destruction, scarring, or defacing of the natural surroundings in the vicinity of the work.

2. Except where clearing is required for permanent works, all trees, native shrubbery, and vegetation shall be preserved and shall be protected from damage which may be caused by the Contractor's construction operations and equipment.

3. Movement of crews and equipment within the project area and over routes provided for access to the work shall be performed in a manner to prevent damage to the land.

B. Temporary construction roads:

1. The location, alignment, road width, and grade of temporary construction roads shall be subject to approval of the Company.

2. When no longer required by the Contractor, construction roads shall be obliterated by removing all fill material and smoothing cutbanks to conform to natural contours, unless otherwise directed by the Company in writing.

3. Topsoil shall be placed over construction roads and other areas disturbed by the construction.

4. Construction roads will be revegetated in accordance with Section 02935: Reclamation within 30 days of topsoil placement.

C. Construction facilities:

1. The Contractor's shop, office, and yard area shall be located and arranged in a manner to preserve trees and vegetation to the maximum practicable extent.

2. On abandonment, all storage and construction facilities, including concrete footings and slabs, and all construction materials and debris shall be removed from the site. The area shall be left in a neat and natural appearing condition, unless otherwise directed by the Company in writing.

D. Borrow areas:

1. Contractor shall be responsible for meeting all landowner requirements and state and federal requirements for use and reclamation of land for borrow areas.

1.5 PRESERVATION OF TREES

A. Preservation:

1. All trees and shrubbery which are not specifically required to be cleared or removed for construction purposes shall be preserved and shall be protected from any damage that may be caused by the Contractor's construction operations and equipment.

B. Restoration of damage:

1. The Contractor shall be responsible for restoration of any injuries to trees and shrubs that occur beyond the defined work areas caused by his operations.

1.6 ABATEMENT OF WATER POLLUTION

A. General requirements:

1. The Contractor's construction activities shall be performed using means and methods that will prevent entrance, or accidental spillage of solid matter, contaminants, debris, and other objectionable pollutants (including soil) and wastes into flowing steams and rivers, dry watercourses, irrigation systems, impoundments (lakes, reservoirs, etc.), wetlands and underground water sources. Design, selection, and implementation of means and methods are the Contractor's responsibility.

2. Dewatering work for operations adjacent to, or encroaching on, streams, watercourses, or wetlands will be conducted using means and methods that prevent "muddy" or turbid water and eroded materials from entering the streams, watercourses or wetlands. Example means and methods include construction of intercepting ditches, bypass channels, barriers, settling ponds, or other approved means to protect water quality.

3. Excavated materials shall not be stockpiled or deposited near or on stream banks, lake shorelines, or other watercourse perimeters where they are susceptible to being washed away by high water or storm runoff or where they in any way encroach upon the actual watercourse itself.

4. Waste or disposal areas and construction roads shall be located and constructed in a manner that will keep sediment from entering streams, watercourses, or bodies of water.

5. Fording of live streams or rivers will not be permitted. Unless otherwise approved in writing by the Company, mechanized equipment shall not be operated in live bodies of water.

6. Turbidity in a stream or other bodies of water due to construction activities shall be in full compliance with ***401 Certification conditions***.

7. The Contractor shall be solely responsible for selection and implementation of all means and methods necessary to ensure that water quality standards are maintained with the limits permitted by State Water Quality Standards.

8. Wastewaters from construction operations shall not be allowed to enter streams, watercourses, or other surface waters without the use of such turbidity control methods that will prevent the water from exceeding State Water Quality Standards. Examples of means and methods include settling ponds, gravel-filter entrapment dikes, approved flocculating processes that are not harmful to fish, recirculation systems for washing of aggregates, oil water separators and others.

9. The Contractor is solely responsible for designing, constructing, operating, and maintaining all necessary pollution control measures in a safe and systematic manner, and for repairing any damage to, or failure of, the pollution control measures caused by floods or storm runoff.

B. Compliance with laws and regulations:

1. The Contractor shall comply with all applicable Federal, State and local laws, order, and regulations.

2. Contractor shall comply with Water Pollution Control Act (WPCA), Public Law 92-500, October 18, 1972.

1.7 ABATEMENT OF AIR POLLUTION

A. The Contractor shall comply with all applicable Federal, State, and local laws and regulations.

B. The Contractor shall provide and implement such smoke and dust control measures as are necessary to comply with the applicable rules, regulations and standards to prevent undue air pollution and hazardous traffic conditions.

C. In conduct of construction activities and operation of equipment, the Contractor will utilize methods and devices available to control, prevent, and otherwise minimize atmospheric emissions or discharges of air contaminants.

D. Burning of materials resulting from clearing of trees and brush, combustible construction materials, and rubbish will not be permitted on site.

E. Storage and handling of flammable and combustible materials, provisions for fire prevention, and control of dust resulting from construction operations shall be in accordance with the applicable State Regulations.

1.8 DUST ABATEMENT

A. During the performance of the work required by these Contract Documents or any operations, appurtenant thereto, the Contractor shall furnish all the labor, equipment, materials, and means required, and shall carry out proper and efficient measure wherever and as often as necessary to reduce the dust nuisance, and to prevent dust which has originated from his operation.

1.9 CLEANUP AND DISPOSAL OF WASTE MATERIALS

A. There shall be no disposal of waste materials on site unless approved by the Company in writing.

B. The Contractor shall maintain the site in an orderly workmanlike manner. Accumulated debris and trash shall be disposed of off site at a commercial location on a periodic basis or as specified by the Company. Waste oil shall be collected and disposed of off site and shall not be dumped or spilled on the ground. Oil-contaminated soil will be excavated and disposed of off site in accordance with Federal, State and local requirements.

C. After completion of construction, all remaining debris and other foreign materials shall be removed from the construction site and temporary construction areas and properly disposed of off site by the Contractor in a commercial site in compliance with appropriate laws and regulations.

D. Cleanup of temporary construction roads, regardless of location, shall include smoothing and grading of the ground surface to eliminate ruts for erosion prevention and the trimming and smoothing of eroded or caved slopes of cuts or embankments to stable conditions as determined by the Company.

1.10 TEMPORARY EROSION CONTROL MEASURES

A. Work that requires placement of erosion controls shall be planned and executed to minimize disturbance. Erosion control measures will be installed as described in the SWPPP using Best Management Practices (BMPs).

B. Requirements for placement of erosion control measures to minimize and control erosion and optimize protection of on-site and off-site areas during the construction will be completed using BMP's.

C. Erosion controls will be used to minimize erosion and to aid in the establishment of a seed cover will be completed using BMP's.

D. The Contractor shall maintain erosion and sediment control at all times during completion and occupation of construction. Additional erosion controls determined to be necessary by the Company will be implemented by the Contractor and shall comply with the intent of the SWPPP using BMP's.

1.11 MAINTENANCE

A. All erosion controls will be inspected by the Contractor at least weekly and after every storm event and repaired where damaged or eroded. Sediment deposits shall be removed before reaching one-half the height of the barrier and sediment deposits shall be disposed of in conformance with local, State, and Federal regulations.

B. The Contractor shall maintain the erosion control measures until all work on the contract has been completed and accepted.

C. Inspections and maintenance shall be in accordance with the SWPPP.

PART 2 PRODUCT

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION 01100

Section 01300
SUBMITTALS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Submittal Procedures

B. Product Data, Shop Drawings, and Samples

C. Miscellaneous Submittals

1. Construction Permits

2. Manufacturers' Instructions

3. Manufacturers' Certificates

4. Tests and Test Reports

5. Standards

1.2 RELATED SECTIONS

Not used.

1.3 DEFINITIONS

Work-related submittals of this Section are categorized for convenience as follows:

A. Product Data: Product Data includes standard printed information on materials, products and systems not specially prepared for the Work, other than designation of selections from among available choices printed therein.

B. Shop Drawings: Shop Drawings include specially prepared technical data for the Work, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information not in standard printed form for general application to other contracts.

C. Samples: Samples include both fabricated and unfabricated physical examples of materials, products and units of Work; both as complete units and as smaller portions of units of Work; either for limited visual inspection or (where indicated) for more detailed testing and analysis.

D. Miscellaneous Submittals: Miscellaneous Submittals related directly to the Work (non-administrative) include construction permits, Stormwater Pollution Prevention Plan (SWPPP) requirements, Spill Prevention Control and Countermeasures Plan (SPCC), warranties, maintenance agreements, workmanship bonds, project photographs, survey data and reports, physical Work records, quality testing and certifying reports, copies of industry standards, records, drawings, field measurement data, operation and maintenance materials, overrun stock; and similar information, devices and materials applicable to the Work and not processed as Product Data, Shop Drawings or Samples.

1.5 QUALITY ASSURANCE

A. The Engineer shall review submittals only for general conformance with the design concept. Such review by the Engineer shall not relieve the Contractor or any subcontractor of responsibility for full compliance with Contract requirements; for correctness of dimensions, clearances and material quantities; for proper designing of details; for proper fabrication and construction techniques; for proper coordination with other trades; and for providing all devices required for safe and satisfactory construction and operation.

B. Submittals reviewed by the Engineer and returned to the Contractor will be marked with one of the following designations:

1. Approved
2. Approved as Noted
3. Revise and Resubmit
4. Rejected

C. The Contractor shall not proceed with procurement, manufacture or fabrication of items for review until such submittals have been designated by the Engineer as "Approved" or "Approved As Noted," unless specifically authorized to do so by the Engineer in writing.

D. Processing of Accepted Submittals:

1. Each copy of the submittal so designated by the Engineer will be identified accordingly by being so stamped and dated.

2. One reproducible copy will be returned.

3. Construction shall be carried out in accordance therewith and no further changes made therein except upon written instructions from the Engineer. Final drawings (paper, mylar, or electronic) and/or microfilms shall be submitted to the Owner as specified in these Contract Documents.

E. Processing of Submittals not Approved:

1. If corrections to the submittals are required, minimum of one reproducible copy will be returned to the Contractor for correction.

2. Resubmissions will be handled in the same manner as first submissions. Direct specific attention, in writing or on the resubmittal, to revisions other than the corrections requested by the Engineer on previous submittals using the notation specified in Paragraph 3.1.A of this Section.

3. The Contractor shall promptly notify the Engineer, if any correction or notation indicated on submittals constitutes a change of the Contract requirements.

4. Work indicated on submittals marked "Approved as Noted" may be carried out in accordance with all notations, prior to resubmission and final review.

1.6 SUBMITTAL SEQUENCING AND SCHEDULING

A. Coordinate preparation and processing of submittals with performance of the Work so that Work will not be delayed by submittal review process.

B. Coordinate and sequence different categories of submittals for the same Work, and for interfacing units of Work, so that one will not be delayed for coordination with another.

C. The Contractor shall make all submittals far enough in advance of scheduled installation dates to provide all time required for reviews, for possible revisions and resubmittals, and for placing orders and securing delivery.

1.7 CONSTRUCTION PROGRESS SCHEDULES

A. Submit initial baseline construction schedule in triplicate within 10 days after award of contract for Engineer review as required by the Standard General Conditions and the Special Conditions.

B. Submit work progress schedule update with each Application for Payment, comparing actual progress to original baseline schedule.

C. Indicate estimated percentage of completion of each item of work at each submission.

1.8 SUBMITTALS

A. Submittal requirements are presented in each appropriate section.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 SUBMITTAL PROCEDURES

A. All submittals shall be transmitted with pre-printed letter of transmittal form of Contractor's choosing, dated and signed, with the job title and Section(s) of the Specification requiring the submittal clearly indicated. The forms shall be sequentially numbered. Resubmittals shall have the original number together with an alphabetic suffix (A, B, ...) indicating the number of resubmittals, where appropriate.

B. The Contractor shall certify by signing the submittal that review, verification of products required, field dimensions and coordination of information is in accordance with the Work as specific in the Contract Documents.

C. Submittals shall be processed in accordance with this section.

D. Identify specific variations from the Contract Documents and Product or system limitations which conflict or may be detrimental to successful performance of the completed Work.

E. Provide space for the Contractor and Engineer's review stamps. Submittals shall contain Contractor's executed review and approval marking. Submittals which are received from sources other than through Contractor's office or do not contain the Contractor's approval marking will be returned "without action."

F. Revise and submit resubmittal as required and identify all changes made since the previous submittal. Submission of resubmittals shall be performed in a similar manner as that of the submittals described in Paragraph 1.5 of this section.

G. Distribution:

1. A minimum of 6 copies of each submittal are required, and 2 copies (or one reproducible) will be returned to the Contractor.

2. Distribute copies of reviewed submittals to all subcontractors whose work will interface with the subject of the submittal.

3. Provide additional distribution of submittals (not included in other copy submittal requirements specified in this Section) to subcontractors, suppliers, fabricators, installers, governing authorities and others as necessary for performance of the Work.

4. Include such additional copies in transmittal to Engineer where required for status before final distribution, and show such distribution on transmittal form.

3.2 PRODUCT DATA, SHOP DRAWINGS, AND SAMPLES

A. Product Data:

1. Collect required data into one submittal for each unit of Work or system; and mark each copy to show which choices and options are applicable to the Work. Include manufacturer's standard printed recommendations for application of labels and seals, notation of field measurements which have been checked, and special coordination requirements.

2. Maintain one set of Product Data (for each submittal) at project site, available for reference by Engineer and others.

3. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide all information unique to this Project.

4. After review, distribute in accordance with paragraph 3.1 of this section.

B. Shop Drawings:

1. Submit the number of opaque reproductions which Contractor requires, plus two copies which will be retained by Engineer.

2. After review, reproduce and distribute in accordance with Paragraph 3.1 of this section and for Record documents described in Section 01700 - Contract Closeout.

C. Samples:

1. Provide units identical with final condition of proposed materials or products for the Work.

2. Include "range" samples (not less than three units) where unavoidable variations must be expected, and describe or identify variations that must be expected, and describe or identify variations between units of each set.

3. Provide full set of optional samples where the Company's selection is required. Prepare samples to match the Company's sample where so indicated.

4. Include information with each sample where so indicated. Include information with each sample to show generic description, source or product name and manufacturer, limitations, and compliance with standards. Samples are submitted for review and confirmation of color, pattern, texture, and "kind" by the Company.

5. Engineer will not "test" samples (except as otherwise indicated) for compliance with other requirements. Conformance with the Contract Documents is the exclusive responsibility of the Contractor.

3.4 MISCELLANEOUS SUBMITTALS

A. Construction Permits:

1. Acquire, maintain, and submit copies of all construction permits that are required to execute the Work.

B. Manufacturers' Instructions:

1. When specified in individual specification Sections, submit manufacturers' printed instructions for delivery, storage, assembly, installation, start-up, adjusting and finishing in quantities specified herein.

2. Identify any conflicts between manufacturers' instructions and Contract Documents.

C. Manufacturers' Certificates:

1. When specified in individual specification Sections, submit manufacturers' certificates to Engineer, in quantities specified herein.

2. Indicate that a material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

3. Certificates may be recent or previous test results on material or Product, but must be acceptable to Engineer. If these are outdated and/or not acceptable to Engineer, the Contractor shall submit to the Engineer the new certificates and test results on materials or product.

D. Tests and Test Reports:

1. Classify each as either "project related" or Product Data, depending upon whether report is uniquely prepared for project or a standard publication of workmanship control testing at point of production, and process accordingly.

2. All test equipment used shall be verified to be in calibration at the time of each test and test reports shall so indicate. No test shall be made without such verification.

E. Standards:

1. Where copy submittal is indicated, and except where specified integrally with Product Data submittal, submit a single copy for Engineer's use.

2. Where workmanship at project site and elsewhere is governed by standards, furnish additional copies to fabricators, installers and others involved in performance of the work.

END OF SECTION 01300

Section 01400
QUALITY CONTROL/QUALITY ASSURANCE

PART 1 GENERAL

This section shall apply to all Contractor's activities performed under this contract and includes:

A. Execution

B. Quality Control Plan

C. Quality Control Organization

D. Submittals

E. Control

F. Tests

G. Documentation

H. Cost of Testing

1.1 EXECUTION

A. The Contractor is responsible for quality control and shall establish and maintain an effective quality control system in accordance with these specifications. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product which complies with the Contract requirements. The system shall cover all construction operations, both on-site and off-site, and shall be coordinated with the proposed construction sequence.

1.2 QUALITY CONTROL PLAN

A. The Contractor shall furnish for review by the Company, not later than 15 days after receipt of Notice of Award, the Contractor Quality Control (CQC) Plan proposed to implement the requirements of the Specifications. The plan shall identify personnel, procedures, equipment, control, instructions, tests, records, and forms to be used in the Contractor's performance of the work.

B. The CQC plan shall include the following to cover all construction operations, both on-site and off-site, including work by subcontractors, suppliers and purchasing agents:

1. A description of the quality control organization with an organization chart and acknowledgment that the CQC staff shall implement the control system for all aspects of the work specified. The staff shall include a CQC system manager who shall report to the individual with responsibility for the overall management of the project including quality and production, or higher level.

2. The name, qualifications, duties, responsibilities, and authorities of each person assigned a CQC function.

3. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, fabricators, suppliers and agents.

4. Control, verification and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test.

5. Procedures for tracking construction deficiencies from identification through acceptable corrective action. These procedures will establish verification that identified deficiencies have been corrected.

6. Reporting procedures, including proposed reporting formats.

7. No fieldwork shall be conducted until the Company's acceptance of the Contractor's CQC plan. Acceptance is conditional on satisfactory performance during construction. The Company reserves the right to require the Contractor to make changes in the CQC plan and operations including removal of personnel, as necessary, to obtain the quality specified.

8. After acceptance of the CQC plan, the Contractor shall notify the Company in writing a minimum of seven (7) calendar days prior to any proposed change.

1.3 QUALITY CONTROL ORGANIZATION

A. The Contractor shall identify a CQC Manager who shall be responsible for overall management of CQC and have the authority to act in all CQC matters for the Contractor. The CQC manager shall be a professional in construction management, with a minimum of five (5) years construction experience on similar type construction projects, and will be employed by the Contractor. The CQC Manager shall be on the site at all times during construction, except as noted in the following. An alternate for the CQC Manager will be identified in the plan to serve in the event of the manager's absence. The requirements for the alternate will be the same as for the designated CQC manager.

B. The Contractor shall provide as part of the CQC organization, support personnel to assist and report to the CQC system manager. Each person will be responsible for assuring the construction complies with the contract requirements for their area of specialization. These individuals shall be present at the construction site during work on their areas of responsibility; and have the necessary education and/or experience to ensure contract compliance. These personnel may perform other duties, but must be fully qualified by experience and technical training to perform their assigned QC responsibilities and must be allowed sufficient time to carry out these responsibilities. The CQC plan will clearly state the duties and responsibilities of each staff member.

1.4 SUBMITTALS

The CQC organization shall be responsible for certifying that all submittals are in compliance with the contract requirements. The submittals shall be professional, concise, with correct spelling and grammar, and ready for submittal to the Federal Energy Regulatory Commission.

1.5 CONTROL

A. Contractor Quality Control is the means by which the Contractor ensures that the construction, including that of subcontractors and suppliers, complies with the Contract requirements. The controls shall cover all construction operations, including both on-site and off-site work, and will be keyed to the construction sequence. The controls shall include two phases to be conducted by the CQC manager for all definable features of work, as follows:

B. Preparatory Phase. This phase shall be performed prior to beginning work on each definable feature of work and shall include:

1 A review of each paragraph of applicable specifications.

2. A review of the contract plans.

3. A check to assure that all materials and/or equipment have been tested, submitted, and approved.

4. A check to assure that provisions have been made to provide required control inspection and testing.

5. Examination of the work area to assure that all required preliminary work has been completed and is in compliance with the contract.

6. A physical examination of required materials, equipment, and sample work to assure that they are on hand, conform to approved shop drawings or submitted data, and are properly stored.

7. Discussion of procedures for constructing the work. Document construction tolerances and workmanship standards for that phase of work.

8. Verification of required control inspection and testing.

9. Review of the activity with the site safety personnel.

C. Follow-up Phase. Daily checks shall be performed to assure continuing compliance with contract requirements, including control testing, until completion of the particular feature of work. The checks shall be made a matter of record in the CQC documentation. Final follow-up checks shall be conducted and all deficiencies corrected prior to the start of additional features of work, which may be affected by the deficient work. The Contractor shall not build upon or conceal non-conforming work.

1.6 TESTS

A. All testing shall be performed by an independent laboratory as a subconsultant to the Contractor. Tests shall be performed as specified or as required to verify that control measures are adequate to provide a product which conforms to contract requirements. A list of tests to be performed shall be furnished as a part of the CQC plan. The list shall give the test name, frequency, specification paragraph containing the test requirements, and an estimate of the number of tests required. The Contractor shall perform the following activities and record and provide the following data:

1. Verify that testing procedures comply with contract requirements.

2. Verify that facilities and testing equipment are available and comply with testing standards.

3. Check test instrument calibration data against certified standards.

4. Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.

5. Results of all tests taken, both passing and failing tests, will be recorded on the Quality Control report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test will be given. Actual test reports shall be submitted to the Engineer with a reference to the test number and date taken.

6. The Company reserves the right to check laboratory equipment for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques. Laboratories used for testing shall meet the criteria detailed in ASTM D 3740 and ASTM E 329.

1.7 DOCUMENTATION

A. The Contractor will prepare a written report every two weeks on his CQC program for submittal to the Company and Engineer that will include, as a minimum, the following:

1. Construction Progress Schedule: Report important critical events and dates, such as start and completion of construction activities. Show actual progress compared to scheduled progress.

2. Sources of Major Construction Materials: Provide information on the sources from which major construction materials and equipment are being obtained including all materials and equipment that may have an important bearing on the safety and efficiency of the project works.

3. Problem Areas: Discuss problems encountered and resolution thereof, and potential problem areas in upcoming scheduled work.

4. The reports shall be professional, concise, with correct spelling and grammar, ready for submittal to the Company, Engineer and Federal Energy Regulatory Commission.

B. The Contractor shall maintain current records of quality control operations, activities, and tests performed, including the work of subcontractors and suppliers. These records shall be on a form acceptable to the Company and the Site Representative and shall include factual evidence that required quality control activities and/or tests have been performed, including but not limited to the following:

1. Contractor/subcontractor and their area of responsibility.

2. Operating plant/equipment with hours worked, idle, or down for repair.

3. Work performed today, giving location, description, and by whom.

4. Test and/or control activities performed with results and references to specifications/plan requirements. The control phase should be identified (Preparatory, Initial, Follow-up). List deficiencies and corrective action.

5. Material received with statement as to its acceptability and storage.

6. Identify submittals reviewed, with contract reference, by whom, and action taken.

7. Off-site surveillance activities, including actions taken.

8. Job safety evaluations stating what was checked, results, and instructions or corrective actions.

9. List instructions given/received and conflicts in plans and/or specifications.

10. These records shall include a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The original and one copy of these records in report form shall be furnished to the Company daily, except that reports need not be submitted for days on which no work is performed. Reports shall be signed and dated by the CQC manager, and shall include copies of test reports ánd copies of reports prepared by all subordinate quality control personnel.

C. Except as specifically required under detailed material specifications, tests will be made by the Contractor in accordance with the commonly recognized standards of United States national organizations. The Contractor, when requested by the Company or Engineer, shall furnish samples of all materials as required by the Engineer for testing without charge. No material shall be used unless it has been approved by the Engineer. Where inspection and testing are to be conducted by an independent laboratory or agency, the sample or samples of materials to be tested shall be selected by such laboratory or agency or the Engineer and not by the Contractor.

D. When requested, the Contractor shall furnish access, facilities and labor assistance as necessary for the duties to be performed by the testing laboratory, inspector and Engineer or Company, including scaffolding, ladders, hoists, temporary lighting, safety equipment and procedures, temporary water supply and similar equipment and services. Testing by the Company and/or Engineer is for spot-checking of the Contractor's Quality Control and Quality Assurance measures, and does not relieve the Contractor of his responsibilities.

E. Contractor is responsible to provide material certifications for all material furnished by the Contractor and used in the work. If certifications cannot be produced, tests to confirm the characteristics of the materials are required. The Company may conduct its own independent tests. The Contractor shall cooperate fully with the Company by providing items for testing or retesting.

F. Test Reports: All tests specified shall be provided to the Company. Unless otherwise specified, three copies of each report shall be submitted to the Engineer for record. The results of any tests performed are for the information of the Company and Engineer. Regardless of any test results, the Contractor is solely responsible for the quality of workmanship and materials and for compliance with the requirements of the Drawings and Specifications.

G. At the conclusion of the Work, the Contractor shall compile three (3) copies of the complete Quality Control and Quality Assurance documentation. These copies will be submitted to the Company for submittal to the Federal Energy Regulatory Commission.

1.8 COSTS OF TESTING

A. The Contractor shall subcontract all testing to an independent laboratory and shall be responsible for and shall pay for all tests for quality control, except as specified otherwise. The Company and Engineer shall have the right to witness all tests.

B. When, in the opinion of the Engineer, additional tests or inspections are required because of the manner in which the Contractor executes his work, such additional costs thereof will be paid for by the Contractor. Examples of such additional tests and inspections are tests of materials substituted for previously accepted materials or substituted for specified materials or re-tests made necessary by failure of material to comply with the requirements of the Specifications.

C. Company shall pay the costs of any testing performed for spot-checking the Contractor's Quality Control/Quality Assurance procedures, provided results of such tests are satisfactory. If results of such tests are unsatisfactory, Contractor shall make necessary adjustments and bear the cost of the original testing and retesting until satisfactory results are achieved.

END OF SECTION 01400

Section 01500
CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Temporary Utilities: Potable water, and sanitary facilities.

B. Temporary Controls: Enclosures and fencing, and protection of the Work.

C. Construction Facilities: Stockpile and equipment storage areas, equipment maintenance facilities, field office facilities, temporary construction roads, parking, progress cleaning, and project signage.

1.2 RELATED SECTIONS

A. Section 01700 - Contract Closeout

1.3 TEMPORARY ELECTRICITY

A. Provide temporary power for Contractor's field office. Maintain and pay for all electricity required for the field offices.

B. The Contractor is responsible for all coordination with the power company, work and costs to complete and maintain temporary hookups.

1.4 TEMPORARY LIGHTING

A. Provide and maintain lighting as needed for construction operations.

1.5 TEMPORARY HEAT

A. Provide heat devices and heat as required to maintain specified conditions for construction operations.

1.6 TEMPORARY VENTILATION

A. Ventilate enclosed areas to assist cure of materials, to dissipate humidity, and to prevent accumulation of dust, fumes, vapors, or gases.

1.7 TELEPHONE SERVICE

A. Provide, maintain and pay for telephone service to Contractor's field office.

1.8 TEMPORARY WATER SERVICE

A. Provide fresh, sanitary drinking water.

1.9 TEMPORARY SANITARY FACILITIES

A. Provide and maintain sanitary facilities for all project field staff.

1.10 BARRIERS

A. Provide barriers around all excavations or obstructions to prevent accidents and protect Work, apparatus, equipment, and material from theft and accidental or other damages, and make good any damages thus occurring at no cost to the Company.

1.11 SECURITY

A. Provide security and facilities to protect Work and Company's operations from unauthorized entry, vandalism, or theft.

B. Coordinate with the Company and maintain locked gates as required.

C. Protect installed Work and provide special protection where specified in individual specification Sections.

1.12 ACCESS ROADS

A. Construct and maintain temporary roads accessing public thoroughfares to serve construction area, with the Company's approval and in accordance with all Federal, state, and local requirements.

B. Extend and relocate as Work progress requires.

C. Construct, maintain, and reclaim temporary construction roads for access to borrow areas, and for other purposes required for the Work, in accordance with the requirements of the specifications.

D. Indiscriminate construction of roads and travel will not be permitted.

1.13 PROGRESS CLEANING

A. Maintain areas free of waste materials, debris, and rubbish. Maintain site in a clean and orderly condition.

B. Remove waste materials, debris, and rubbish from site daily and dispose off-site.

C. Do not allow any condition to exist during construction which creates a nuisance; a fire hazard; an environment injurious to water quality, air quality, health or safety; or an attraction for children, animals, birds, rodents, etc.

D. Failure to comply with the above requirements after due and proper notice has been given by the Company will be sufficient grounds for the Company to proceed to clean up such material and debris, make repairs and charge same to the Contractor.

1.14 CONTRACTOR FIELD OFFICES AND SHEDS

A. Contractor's Field Office: Weather tight, with lighting. Mechanical equipment and furniture are at the Contractor's option. Field office shall be located in the staging area.

B. Provide space for Project meetings, with table and chairs to accommodate 8 persons.

C. Provide sheds for storage of tools and equipment as needed.

D. Temporary Buildings Erected by Contractor: Contractor may erect temporary buildings on the job site for such purposes as offices, warehousing, craft change rooms, and fabrication shops. The location and design of these buildings will be subject to approval by the Company and landowner as appropriate.

Trailers or semi trailers parked by Contractors on the job site shall be subject to Company's approval as to type and condition. Dilapidated trailers and semi trailers are prohibited. No utilities are permitted in semi trailers. Contractor's trailers and semi trailers shall be located in an area approved by the appropriate landowner.

Upon completion of the Contractor's work, any temporary buildings must be removed including any concrete slabs or any underground utilities installed by the Contractor, unless otherwise determined by the Company, in writing.

E. Land Use:

1. The Contractor will be permitted to use, without charge, for construction purposes, Contractor use areas as approved by the Company.

2. If additional land is needed, the Contractor shall make all necessary arrangements with the Company and individual landowners and shall pay all rentals or other Contractor associated costs.

3. Staging, storage and laydown areas for Contractor equipment and tool trailers can be established within the designated work area adjacent to the dam and the South Dike.

1.15 ENGINEER FIELD OFFICE

A. Provide a furnished 8' x 10' office within the Contractor's office for the exclusive use of the Company and Engineer. Furnishings shall include desk, two chairs, bookshelf and a four-drawer file cabinet.

1.16 REGULATORY REQUIREMENTS

A. All temporary facilities and controls shall conform to applicable provisions of all local, state and federal laws.

1.17 SUBMITTALS

A. A plan for staging, storage and laydown areas shall be developed for review and approval by the Company.

1.18 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

A. The Contractor shall not remove any existing or temporary facilities that affect others without approval by the Company.

B. Remove temporary above grade or buried utilities, equipment, facilities, materials, prior to Substantial Completion inspection.

C. Clean and repair damage caused by installation of or use of temporary work.

D. Restore existing and permanent facilities used during construction to original condition. Restore permanent facilities used during construction to specified condition.

1.19 OWNER FACILITIES AND OPERATIONS

A. Contractor shall provide the Company access to the site facilities at all times.

B. Any damage to the Company's facilities caused by the Contractor's activities shall be repaired by the Contractor. Any resulting financial loss to the Company will be reimbursed by the Contractor.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01500

Section 01505
MOBILIZATION AND PREPARATORY WORK

PART 1 GENERAL

1.1 SECTION INCLUDES

A. All facilities and equipment that are established at, or brought to, the work site shall be deemed to be subject to the provisions of this paragraph, unless the Company specifically provides otherwise in writing for a particular item or items. The Contractor shall be solely responsible for the adequacy, efficiency, use, protection, maintenance, repair, and preservation of all facilities and equipment. No facilities or equipment shall be dismantled or removed from the work site before completion of the work under the contract without written permission of the Company.

B. All facilities and equipment on the work site shall also be subject to the Company's right to take possession of and utilize the same for the purposes of completion of the work should the Contractor's right to proceed be terminated. In addition, any encumbrance, lien, or other security interest on any such facilities or equipment shall be subordinated to the Company's rights.

1.2 SUBMITTAL

A. Submit in accordance with Section 01300: Submittals.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01505

Section 01515
DIVERSION, CARE OF DRAINAGE AND DEWATERING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Diversion.

B. Dewatering of foundations and excavations.

C. Care for water entering and leaving the Au Train Drainage.

1.2 RELATED SECTIONS

A. Section 01060 - Regulatory Requirements.

B. Section 01100 - Environmental Quality Protection

C. Section 01300 - Submittals.

D. Section 02220 - Excavation, Fill Placement and Compaction.

1.3 SYSTEM DESCRIPTION

A. System Requirements

1. Design diversion and sediment control facilities to divert water around the construction area, or convey through the area in a controlled manner, and to control the quality of water leaving the construction area from diversion, dewatering and Contractor operations.

2. Furnish, install, maintain, and operate all diversion structures, pumps and other equipment for diversion and removal of water from the various parts of the work areas and to maintain water-free work areas.

B. Diversion and Erosion Control Requirements

1. Divert inflows from streams and seeps away from the Work.

2. Divert surface water away from excavated areas.

3. Intercept runoff from construction areas, soil stockpiles and other disturbed areas, and divert into sediment settling ponds and water quality control facilities to prevent runoff from contaminating the drainage.

4. Construct all diversion and erosion control facilities to protect facilities from erosion or damage.

5. Maintain the required flood handling capacity throughout construction.

6. Construct facilities as needed to maintain water quality from diversion, drainage, dewatering and all construction activities in compliance with the NPDES permit.

7. Do not begin construction until the Spill Prevention Control and Countermeasure Plan has been developed and implemented.

C. Dewatering Requirements

1. Dewater in a manner that will prevent loss of fines, will maintain stability of the excavated slopes and bottom of excavations, and will allow the Work to be performed in the dry.

2. Dewater by lowering and keeping groundwater level below the general bottom of excavations.

3. Methods of dewatering and controlling groundwater, including design and implementation, are the full responsibility of the Contractor.

4. Furnish, install, maintain, and operate all pumps and other equipment for diversion/removal of water from the various parts of the work areas and the maintenance of water-free work areas.

1.4 SUBMITTALS

A. Diversion Plan

1. Plan for diversion for protecting the Work from a storm with at least a 10-year recurrence interval and without violating water quality requirements.

B. Toe Drain Dewatering

1. Plan for controlling groundwater for toe drain excavation in accordance with Section 02220 Excavation, Fill, Placement and Compaction.

1.5 PROJECT/SITE CONDITIONS

A. Employ a designated on-site water pollution control specialist to monitor water quality conditions, including the following:

1. Ensure all water quality protection and erosion control facilities are designed, constructed and maintained to avoid water quality standards violations.

2. Ensure that any sediment problems including, but not limited to, those associated with borrow excavation, road construction, and stockpiling, are promptly corrected and their impacts mitigated.

3. Perform monitoring as required by any permits to construct, install or modify public water supplies, wastewater facilities and other facilities capable of causing or contributing to pollution.

4. Monitor and modify construction practices, as necessary, to protect water quality.

B. The Contractor shall be responsible for compliance with all permit conditions and shall be responsible for any water quality violations, penalties and fines resulting from construction activities.

1.6 MAINTENANCE

A. Maintain all diversion, water quality protection and erosion control facilities as needed to meet specification and permit requirements.

B. Repair any damage resulting from diversion operations at no cost to the Company.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Verify that Work and property upstream, downstream and adjacent to Work will not be damaged by water quality protection, erosion and sediment control diversion operations and facilities.

3.2 PREPARATION

A. Divert surface water without causing damage to Work or property upstream, downstream and adjacent to Work.

3.3 INSTALLATION

A. Provide diversion channels, dikes, breaches, cofferdams, embankment channel, and other facilities as needed for diversion.

B. Perform diversion operations so that Work is performed in dry conditions.

C. Provide silt fencing, check dams, sedimentation ponds and other sedimentation control and erosion control facilities as needed for sedimentation and erosion control and in conformance with all applicable permits and regulations.

3.4 FIELD QUALITY CONTROL

A. Provide testing and monitoring as required by the NPDES permit, and other permits required by these Specifications.

B. Repair at no expense to the Company any damage to the foundations, structures, adjacent property, or any part of the diversion or protective works.

3.5 CLEANING

A. After having served their purpose, remove all facilities and protective works or level as required by the Company so as not to interfere with the operation or usefulness of the reservoir, pipelines, channels and other facilities.

END OF SECTION 01515

Section 01610
SAFETY AND HEALTH

PART 1 GENERAL

1.1 REFERENCES

A. Williams – Steiger Occupation Safety and Health Act of 1970.

B. All other applicable Federal, State and Local Safety and Health requirements

1.2 CONTRACTOR'S RESPONSIBILITY

A. Contractor shall provide a safety program which conforms to all applicable regulations, safety orders, and health and safety plans. Contractor shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work.

B. Contractor must comply with all applicable federal, state, and local rules and regulations, health and safety plans, and building codes relating to safety.

C. Contractor shall designate a safety officer on the Site, whose duty shall be the prevention of accidents and enforcement of safety and health regulations. The name of such individual shall be posted in a conspicuous place. The safety officer's duties and responsibilities shall continue until the entire Work is completed and the Company has accepted the Work.

D. Contractor shall erect and properly maintain at all times, as required by the conditions and progress of the Work, all necessary safeguards for the protection of persons and shall post danger signs warning against any hazards at the Site.

E. Contractor shall at all times conduct its Work so as to insure the least possible obstruction to traffic and inconvenience to the general public and the residents in the vicinity of the Work.

F. No road or street, no any part thereof, shall be closed to the public except with the permission of the Company and the proper governmental authority.

G. Temporary provisions shall be made by Contractor to insure that private and public driveways remain available for use and that proper functioning of all gutters, sewer inlets, drainage ditches and culverts, irrigation ditches and natural watercourses are not affected.

H. Contractor shall exercise every precaution at all times for the protection of persons (including employees) and property which shall include, as needed, the use of shoring, bracing, barricades, guards, night watchmen, lighting and the elimination of hazardous conditions where possible.

I. Contractor shall defend, indemnify and hold harmless the Company and its officers and agents from all claims, damages, litigation, expenses, counsel fees and proceedings brought against the Company or its officers or agents from liability imposed on the Company or its officers or agents by reason of any violation or alleged violation of the Safety Standards Act in connection with or arising out of these operations and activities over which Contractor has management, supervision and control. The Company shall cooperate with Contractor in the event Contractor chooses to contest any citation, order, penalty or other enforcement action or liability in connection therewith, which Contractor is obligated to the Company under the terms of this paragraph.

J. Provide first-aid personnel and maintain a basic first aid kit for use of workmen:

1. Assure that at least one person on site for each shift has been trained in first aid and carries a card certifying such training.

2. Provide first aid supply commensurate with size of the project with items necessary for first aid treatment of all injuries.

3. Advise all workmen of the location of first aid supplies.

4. Post telephone numbers of nearest hospital or ambulance service and fire station in conspicuous location. Advise all workers of location of telephone numbers.

5. Advise all workers of the location and operation of the telephone on site.

6. Post "Hard Hat Area" sign at the project entrance.

1.3 COMPANY'S RESPONSIBILITY

A. Company or Engineer shall have no responsibility for enforcing the requirements referenced in Parts 1.1 and 1.2.

1.4 SUBMITTALS

A. The Contractor's Project Health and Safety Plan shall be submitted to the Engineer for information purposes only.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01610

Section 01700
CONTRACT CLOSEOUT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Closeout procedures

B. Final cleaning

C. Final approval

D. Project record documents

1.2 RELATED SECTIONS

A. Section 00700 - Standard General Conditions of the Construction Contract

B. Section 00800 - Special Conditions

C. Section 01300 - Submittals

D. Section 01500 - Construction Facilities and Temporary Controls

1.3 CLOSEOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for Engineer and Company's review.

B. Provide submittals to Engineer that are required by governing or other authorities.

C. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

D. Company will accept the Work as specified in Section 01010 - Summary of Work.

1.4 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

B. Clean debris from drainage systems.

C. Clean site; sweep paved areas, rake clean landscaped surfaces.

D. Disconnect all temporary utilities to the site.

E. Remove temporary site facilities and utilities.

F. Remove all Contractor constructed access roads and parking areas.

G. Clear, grade, and seed as required.

H. Remove waste and surplus construction materials, rubbish, wood, concrete, debris, other foreign material, and construction facilities from the site.

1.5 PROJECT RECORD DOCUMENTS

A. Maintain on site, one set of the following record documents; record actual revisions to the Work:

   1. Contract Drawings.

   2. Specifications.

   3. Addenda.

   4. Change Orders and other Modifications to the Contract.

   5. Reviewed shop drawings, product data, and samples.

B. Store Record Documents separate from documents used for construction.

C. Record information concurrent with construction progress.

D. Specifications: Legibly mark and record at each Product section description of actual Products installed, including the following:

   1. Manufacturer's name and product model and number.

   2. Product substitutions or alternates utilized.

3. Changes made by Addenda and Modifications.

E. Record Documents and Shop Drawings: Legibly mark each item to record actual construction including:

1. Measured depths of foundations in relation to the finish project datum.

2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements or benchmarks.

3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.

4. Field changes of dimension and detail.

5. Details not on original Contract Drawings.

F. Submit documents to Company with request for final Application for Payment.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION 01700

Section 02110
CLEARING, GRUBBING AND STRIPPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Removal of trees, bushes, shrubs, grass, weeds, topsoil and other vegetation, rocks, existing improvements or obstructions that exist within the construction areas for the South Levee embankment modifications, toe drain, other dam modifications, access roads, and borrow areas.

1.2 RELATED SECTIONS

A. Section 01110 – Environmental Quality Protection

B. Section 02220 – Excavation, Fill Placement and Compaction

1.3 PROTECTION

A. Protect trees, shrubs, and other features to remain.

1.4 DEFINITIONS

A. Topsoil – Topsoil stripped from the site shall be the selected portion of the top of the surface soil that is dark brown, black, fertile, and contains organic matter. The Contractor shall remove roots larger than 1 inch, rocks larger than three (3) inches, debris, and large weeds prior to stockpiling of the topsoil unless determined otherwise by the Engineer. Topsoil shall be free of subsoil, noxious weed seed or reproductive vegetation plants, heavy clay, hard clods, toxic substances or other material which would be detrimental to plant growth.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 CLEARING

A. Clearing operations shall be conducted in a manner which will prevent damage to vegetation outside the clearing limits.

1. Removal: Remove trees, bushes, shrubs, grass, weeds and other vegetation from an area extending 10 feet beyond the perimeter of the downstream toe of the South Levee embankment modifications and the toe drain.

3.2 GRUBBING

A. General: Includes removal of all rocks and boulders, stumps, roots and other vegetation below ground level, all debris, existing structures, and obstructions within the limits of the work area left from clearing, unless designated to remain.

B. Stumps: Includes removal of all old and new tree stumps. Remove all roots larger than 1/2 inch in diameter remaining from trees, tree stumps, bushes and shrubs.

C. Backfilling: Backfill holes created by removal of stumps and roots with native material.

3.3 DISPOSAL OF MATERIAL

A. Where removal and disposal of material is required, the Contractor shall remove and dispose of all materials in accordance with all applicable laws, permits, regulations, and ordinances, or orders made thereunder, and the lawful requirements of any public authority in any way affecting or applicable to this Work. The Company will provide a disposal area for stumps, roots and brush that are produced as part of this work. The Company will also provide a stockpile area for trees that are cleared as part of this work. Materials shall be disposed of as soon as practicable following clearing and grubbing activities. Burning will be permitted at a designated site approved by the Company. Contractor is responsible for any burning permit required.

3.4 PROTECTION AND RESTORATION

A. The Contractor shall protect all trees (beyond the areas to be cleared), structures, utilities and other features and shall not trespass beyond the construction limits.

B. All trees, shrubs and plants and other features damaged by construction operations shall be replaced in kind by the Contractor at no cost to the Company.

3.5 TOPSOIL STRIPPING

A. Remove and dispose of grass, weeds, roots, and rocks from all areas requiring stripping.

B. Excavate topsoil from areas within the limits of site disturbance at the North Dam and South Levee.

3.6 STOCKPILING TOPSOIL

A. Stockpile excavated topsoil separately from other materials in stockpile areas.

B. Stockpile topsoil at locations directed by the Company.

C. Stockpile topsoil to a height not exceeding 8 feet. Protect stockpiled topsoil from erosion.

D. Stockpiles of excavated topsoil which are in excess of that needed to complete the work shall be graded to no steeper than 4 horizontal to 1 vertical.

END OF SECTION 02110

Section 02220
EXCAVATION, FILL PLACEMENT AND COMPACTION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The work to be performed under this Section consists of the following:

1. Excavating, transporting, placement and compaction of embankment material for the construction of the modification of the South Levee embankment.

2. Furnishing, placement and compaction of fill material for regrading of the North Dam and the South Levee.

3. Excavation of the toe drain and furnishing, placement and compaction of fill materials and appurtenant materials for the toe drain.

1.2 RELATED SECTIONS

A. Section 01060: Regulatory Requirements

B. Section 01110: Environmental Quality Protection

C. Section 01515: Diversion, Care of Drainage and Dewatering

D. Section 02110: Clearing, Grubbing and Stripping

E. Section 02935: Reclamation

F. Section 03400: Precast Concrete Manholes

1.3 DEFINITIONS

A. Fines: Material passing the No. 200 sieve.

B. Suitable Material: Imported material or material excavated from cut areas which meets the specification requirements for use in constructing fills.

C. Borrow: Material excavated on the site or taken from designated borrow areas.

D. Well-Graded: A mixture of particle sizes that has no specific concentration, or lack thereof, of one or more sizes. A material type that, when compacted, produces a strong and relatively incompressible soil mass with a minimum of voids.

E. Coverage: One coverage is defined as the result of successive passes by a piece of compaction equipment, which by means of sufficient overlap, will ensure that all areas of the layer or lift being compacted have been subjected to one pass of the compaction equipment.

F. Optimum Moisture Content: The moisture content that will result in a maximum dry unit weight of soil when subjected to the ASTM D698 compaction test.

G. Percent Compaction: The percent compaction in place shall be calculated as the ratio (in percent) of the in-place dry density to the estimated maximum of dry density, in accordance with ASTM D698, of the representative fill material at the location of the in-place density test.

H. Proof Rolling: Rolling a soil or rock surface with a minimum of 4 passes with approved compaction equipment for the purpose of detecting soft or loose areas.

I. Unsuitable Materials: Materials that contain waste, debris, roots, organic matter, frozen matter, or any other materials determined by the Engineer to not meet the specifications for any embankment zone or required fill.

1.4 REFERENCES

A. ASTM C88: Test Method for Soundness of Aggregates by use of Sodium Sulphate or Magnesium Sulphate.

B. ASTM C127: Test Method for Specific Gravity and Absorption of Coarse Aggregate.

C. ASTM C136: Method for Sieve Analysis of Fine and Coarse Aggregates.

D. ASTM D75: Practice for Sampling Aggregates.

E. ASTM D422: Method for Particle-Size Analysis of Soils

F. ASTM D698: Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,500 ft-lb/ft^3).

G. ASTM D1140: Test Method for Amount of Material in Soils Finer than the No. 200 Sieve.

H. ASTM D1556: Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

I. ASTM D2216: Method for Laboratory Determination of Water Moisture Content of Soil, Rock, and Soil-Aggregate Mixtures.

J. ASTM D2487: Classification of Soils for Engineering Purposes.

K. ASTM D2922: Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

L. ASTM D3017: Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

M. ASTM D4253: Test Methods for Maximum Index Density of Soils Using Vibratory Table.

N. ASTM D4254: Test Methods for Minimum Index Density of Soil and Calculation of Relative Density.

O. ASTM D4318: Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

P. ASTM C131: Los Angeles Abrasion Test.

1.5 SUBMITTALS

A. The following items shall be submitted to the Engineer:

1. Gradations and certifications for materials used in the construction of the toe drain. Gradations for all fill materials obtained from offsite shall be submitted to the Engineer for review and approval prior to the transport and delivery of such materials to the site.

2. Records of inspections and quality control test performed, and corrective actions taken.

3. Toe Drain Construction Plan – Develop and submit a plan detailing the procedures that will be followed in the construction of the toe drain. Submittal to include:

   a. Method of excavation

   b. Trench support

   c. Dewatering plan

      The toe drain installation will be performed below groundwater level. The Contractor shall submit a detailed plan for controlling groundwater during toe drain excavation. Toe drain excavation shall not begin until the dewatering plan has been approved by the Engineer. Such approval shall not relieve the Contractor from complete responsibility for design and operation of the dewatering facilities.

   d. Method of drainpipe installation including a listing of pipe fittings and their locations on a piping diagram. Shop drawings, catalog cuts and product data shall be included for all materials used for this installation.

PART 2 PRODUCTS

2.1 MATERIALS

A. All fill materials shall be free from topsoil, clay balls, roots, trash, wood waste and other deleterious materials.

B. Embankment Materials

1. Embankment Material: Fill material for flattening of the downstream slope of the South Levee. Material shall be a uniform to fine sand with a USCS Classification of SP. Source of this material shall be from the excavation to lower the crest of the South Levee, the existing borrow immediately east of the South Levee or from some other approved source.

C. Toe Drain Materials

1. Toe Drain Material: Toe drain material shall have the physical characteristics of MDOT Class II material and shall meet the following gradations:

U.S. Standard Sieve Size	Total Percent Passing based on dry unit weight
3- inch	100
2 ½ -inch	95-100
2-inch	88-95
1 ½-inch	80-90
1-inch	65-80
¾-inch	60-75
½-inch	45-65
¼-inch	30-50
No. 4	25-45
No. 16	2-15
No 20	0-10

The percent passing the No. 200 Sieve shall be less than 5% and the material passing the No. 40 shall have a Plasticity Index of 0%.

2. Drain pipe shall be ADS Brand N-12 corrugated high-density polyethylene pipe or approved equivalent. Drainpipes shall have, at a minimum, three perforations uniformly spaced along the circumference of the drainpipe. The slot length of each perforation shall be, at a minimum, 1.25 inches. The slot width shall be 0.125 inches. Fittings shall be compatible and designed specifically for use with the drainpipe.

D. Regrading of North Dam

1. Fill: Fill material for regrading of the North Dam and South Levee shall be a poorly graded sand from the required excavations.

2.2 CONSTRUCTION EQUIPMENT

A. Excavation: The construction equipment for excavation and removal activities shall consist of excavation and transportation equipment adaptable to the work specified herein and approved by the Engineer.

B. Compaction: The compaction equipment required for the construction of the South Levee embankment modifications and for regrading activities shall be that capable of producing a compacted fill meeting the requirements of this specification, and shall be approved by the Engineer.

PART 3 EXECUTION

3.1 GENERAL

A. Lines and Grades

1. The South Levee embankment modifications, the regraded portions of the project, and the toe drain shall be constructed to the lines, grades, and cross sections described in these Specifications and as shown on the Drawings, unless otherwise directed by the Engineer. The lines and grades shown are intended to be the final surfaces after placement, compaction and settlement during construction.

B. Excavation and Removal

1. Excavation Limits: The Contractor shall excavate to specified lines, grades and dimensions as shown on the Drawings or to suitable foundations as directed by the Engineer. Such lines, grades and dimensions will be referred to hereafter as excavation limits. No excavation will be permitted outside the excavation limits as shown unless such excavation is approved by the Engineer. The Contractor shall be responsible for verifying the elevations and dimensions shown.

2. The Engineer may modify excavation depths to fit conditions encountered during construction. Rock or boulders encountered in the excavation shall be removed as required. Overburden slopes shall be dressed to present a neat and orderly appearance.

a. All necessary precautions shall be taken to preserve the materials beyond and below the lines and grades of excavation, as shown on the Drawings, or as directed by the Engineer, in a sound and undisturbed condition. Any unauthorized over-excavation shall be back filled as directed by the Engineer at no cost to the Company.

b. Work areas shall be protected against damage from erosion and traffic. Particular care shall be exercised so that the excavated grades and slopes are not rutted, squeezed, or otherwise damaged by repeated travel of construction equipment. Any such damage shall be repaired at no cost to the Company.

c. Suitable material salvaged from the removal activities shall be stockpiled for future use in regrading activities at a location provided by the Company or use in future regrading activities. Unsuitable material removed from the excavations shall be stockpiled at a separate location provided by the Company.

3. Excavation of the Toe Drain

a. Excavation of the toe drain shall be performed using approved methods. The Contractor shall submit evidence of past experience in performing similar excavations.

b. The excavation of the toe drain shall be maintained in an open condition and shall be conducted in a manner that provides for a continuous minimum width trench to the required depth along the centerline of excavation. The Contractor shall be responsible for maintaining stability of the excavated toe drain trench for its full length and depth. No more than 50 lineal feet of toe drain excavation shall be allowed to be open at one time during construction.

c. The Contractor shall control surcharges from excavation and backfilling equipment, waste, backfill stockpiles, and any other loading situations that may affect the trench excavation stability. Materials excavated from the toe drain shall be stockpiled a sufficient distance from the excavation to prevent slides or cave-in of slides.

d. In the event of failure of the toe drain excavation prior to completion of backfilling, the Contractor shall, at his expense, re-excavate the toe drain and remove all material displaced into the toe drain and take corrective action to prevent further deterioration as directed by the Company.

e. During excavation, the Contractor shall have at all times that toe drain excavation is open, a minimum of 20 cubic yards of gravel, acceptable to the Engineer, onsite in operable dump trucks that can be dumped into the trench in the event of failure of the dewatering system or other situation within 5 minutes.

f. If adjustments to the toe drain profile are required for site conditions, the drain shall be constructed to maintain a downward slope toward the outfalls.

C. Foundation Preparation

1. The Contractor shall clear the footprint of South Dam modifications removing all trees, brush and vegetation. Any stumps that are encountered shall be out at ground level and be left in place since the possibility exists that piping of the levee may occur due to the removal of stumps beneath the levee. Foundation preparation activities shall be approved by the Engineer prior to the start of embankment fill placement.

D. Placement and Compaction

1. Fill materials shall not be placed on any part of the South Levee embankment foundation until such areas have been inspected and approved by the Engineer. Embankment materials shall be placed and spread to be free from lenses, pockets, streaks or layers of material differing substantially in texture or gradation from the surrounding material. Areas shall be free from debris, snow, ice and water and ground surfaces shall not be in a frozen condition.

2. Embankment material shall not be placed over surfaces with running or standing water or existing subgrade surfaces which are yielding or softened unless directed by the Engineer. All material shall be carefully placed to grades, contours, levels and elevations shown to drain freely without ponding. Placement of these materials shall be suspended when the climatic conditions will not allow proper placement and compaction of fill. Successive layers of embankment materials shall be placed to produce the best practical distribution of material.

3. Any material not in compliance with the requirements of this Specification and considered unsuitable by the Engineer shall be excavated and removed from the fill and shall be disposed of in approved disposal areas. Excavated areas shall be properly refilled with suitable appropriate fill and be compacted to the proper density.

4. Placed materials shall be free from large open areas, objectionable pockets of gravel and cobbles and clusters of large cobbles and shall have a reasonably regular finish.

5. Placement operations including transport, handling, and stockpiling shall be accomplished in such a manner as to prevent segregation of material. Material in onsite and offsite stockpiles shall be protected from changes in gradation and contamination.

6. During the dumping and spreading of fill materials, roots, trash, and debris shall be removed from the fill and disposed of in disposal sites approved by the Company.

7. Care shall be exercised when operating construction equipment adjacent to existing structures to avoid causing damage. Disturbed material shall be repaired as directed by the Engineer.

8. The maximum lift thickness of all materials, before compaction shall be eight (8) inches. All materials shall be placed in horizontal lifts with no portion of the fill being more than one lift higher than the rest of the fill.

9. Embankment materials shall be compacted with 4 overlapping passes of D-6 dozer (or equivalent) as directed by the Engineer.

10. Traffic barriers shall be erected on each end of the South Levee. Traffic barrier shall consist of at least five (5) boulders that shall be placed on each end of the South Levee. Boulders shall be at a minimum 4-foot in diameter.

E. Toe Drain Construction

1. Backfilling of the toe drain shall commence as soon as practical and shall be continuous to minimize the area of unsupported toe drain. The areas for storage of the backfill material shall be approved by the Company or their designated representative and restored upon completion of the work.

2. The Contractor shall furnish, place, and compact material to construct the toe drain to the lines and grades as shown on the Drawings.

3. 8" diameter perforated high-density polyethylene corrugated drainpipe shall be furnished and placed at elevations as shown on drawings and/or as approved by the Engineer to provide sufficient gradient for drainage.

4. If a high water event occurs during the construction of the toe drain, the Contractor shall place backfill within the toe drain as directed by the Engineer or the Company, and re-excavate when the flood event is passed. The Company will be responsible for the extra excavation, if required.

5. Contractor shall furnish and install precast concrete manholes for installation at the locations as shown on the Drawings and in accordance with Section 03400: Precast Concrete Manholes.

6. If toe drain is constructed by means other than bio-polymer trench method, the drain material shall be placed in eight inch loose lifts and compacted to 70% relative density.

F. Regrading of North Dam

1. The Contractor shall place and compact material for regrading the crest of the North Dam prepared in accordance with Section 02110: Clearing, Grubbing and

Stripping. The crest of each structure shall be regraded to the minimum lines and grades given on the Drawings.

2. Fill materials used to regrade the North Dam shall be placed in horizontal lifts, not exceeding eight (8) inches thickness before compaction. All material shall be compacted with 4 overlapping passes of the spreading equipment.

G. Quality Control/Quality Assurance

1. Sampling and approval of materials

a. Prior to beginning fill placement activities, the Contractor shall perform sampling and testing of proposed sources of fill materials and obtain approval of fill materials by the Engineer.

2. Material testing

a. Sieve analyses and Atterberg Limits shall be performed in accordance with ASTM C136 and ASTM D2216 at a frequency of at least one test per each drain material source and not less than one test for every 200 cubic yards from each material source.

b. Sieve analyses shall be performed on samples taken from on-site stockpiles prior to placement of materials.

c. Results of Quality Control Testing as specified herein shall be submitted on a daily basis to the Engineer for evaluation and approval.

d. Additional testing of materials will be required as specified below. No additional testing of the other fill placement will be required unless the Company or their designated representative suspects the materials are not being placed in accordance with the Contract Documents.

3. Moisture control

a. The frequency of the testing of the density of fill placement for the toe drain shall be at a minimum, one density test for every 200 cubic yards of material placed. Testing shall be in accordance with ASTM D698 and ASTM D2992.

b. The moisture content of fill materials shall be maintained within optimum to + 3% of optimum moisture content in accordance with ASTM D2216.

c. The moisture content of the material shall be such that equipment can operate efficiently and is such that the fill does not exhibit rutting and waving when subjected to the action of the wheels and tracks of the compaction equipment.

4. Toe drain profile

a. The Contractor shall make measurements of the bottom elevation of the toe drain excavation the elevation of the perforated pipe at least every ten

(10) lineal feet. The Contractor shall generate and maintain on-site an as-built profile of the trench depth.

END OF SECTION 02220

Section 02935
RECLAMATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section covers the requirements of reclamation of areas disturbed by construction activities including preparation of subsoil, placing topsoil, seeding, mulching, fertilizing and maintaining reclaimed areas.

1.2 RELATED SECTIONS

A. Section 01060 – Regulatory Requirements

B. Section 01100 – Environmental Quality Protection

C. Section 01515 – Diversion, Care of Drainage, and Dewatering

D. Section 01700 – Contract Closeout

E. Section 02272 – Erosion and Sediment Control

1.3 AREAS TO BE RECLAIMED AND REVEGETATED

A. All areas disturbed by construction activities

1.4 SUBMITTALS

A. Seed Mixture Certification

B. Fertilizer Identification and Certification

C. Mulch Certification

D. Proposed Seeding Method

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver grass seed mixture in sealed bags. Seed in damaged packaging is not acceptable.

B. Deliver fertilizer in unopened, waterproof bags showing weight, chemical analysis, and name of manufacturer. It shall be uniform in composition, dry, and free flowing. Any fertilizer that becomes caked or otherwise damaged making it unsuitable for use, will not be accepted.

C. Stripped material to be used for topsoiling disturbed areas shall be transported to stockpile areas conducive to storage of topsoil and approved by the Company. Run-off shall be diverted around topsoil stockpiles to minimize erosion.

1.6 MAINTENANCE SERVICE

A. Maintenance operations will include, but are not limited to, watering, mowing, weeding, and repair of soil erosion. These operations will begin immediately after seeding and shall continue as required until final acceptance by the Company. Seeded areas are to be maintained for a minimum of one year from date of Substantial Completion. After installation, the Contractor will keep maintenance logs. These logs shall be supplied to the Engineer immediately upon request.

B. Watering will be done as needed to ensure uniform seed germination and plant survival. Water shall be provided from an approved off-site source and trucked to the site. Watering shall be done in a manner that provides uniform coverage, but will not cause erosion or damage to the finished surface.

C. Until final acceptance, seeded areas will be mowed to a height of 3 inches whenever the average height becomes 6 inches. Clippings will be removed from the site and properly disposed. Mowing will be done with sharp rotary equipment on dry grass and firm soil.

D. Weed control will be used as needed to eliminate undesirable weed species within the seeded turf. Target weed species will be removed by hand and properly disposed of, or sprayed when the new turf has become sufficiently established to withstand herbicide application. All herbicide applications will be made by a licensed commercial applicator licensed in the State of Michigan. The Contractor will be responsible for selecting the herbicide and rate at which it is to be used. Any damages arising from the use of herbicide will be repaired at no expense to the Company.

E. Any areas that are not producing at least 75 percent coverage of the intended plant species within one year of the seeding operations shall be reseeded at no expense to the Company.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Furnish grass seed meeting the requirements of MDOT Roadside Blend TDS (Turf Dry Sandy). This seed mixture, which is to be applied at 220 pounds/acre, consists of:

Common Name (Scientific Name)	Seeding Rate (lb/ac)
Kentucky Bluegrass (Poa pratensis)	11.0
Perennial Ryegrass (Lolium perenne)	55.0
Hard Fescue (Festuca longifolia)	55.0
Creeping Red Fescue (Festuca rubra)	99.0
TOTAL	220.0

B. The seed mixture will be packaged in durable bags. On each bag of seed, the supplier of the blended mix shall attach a tag, giving name, lot number, net weight of contents, purity, and germination. Seed testing shall be conducted according to the *Rules for Testing Seeds* specified in *The Proceedings of the Association of Official Seed Analysts.* The seed mixture will have minimum purity and germination percentages, by species, as follows:

Common Name (Scientific Name)	Purity (%)	Germ. (%)
Kentucky Bluegrass (Poa pratensis)	98.0	85.0
Perennial Ryegrass (Lolium perenne)	96.0	85.0
Hard Fescue (Festuca longifolia)	97.0	85.0
Creeping Red Fescue (Festuca rubra)	97.0	97.0

C. Deficiencies below the percentage specified for purity and germination will be evaluated for acceptability by the Company.

2.2 SOIL MATERIALS

A. Topsoil: Native organic materials removed and stockpiled during stripping of the dam foundation, borrow areas, roads, etc.

2.3 ACCESSORIES

A. Fertilizer. A time-release formulation in the following proportions by weight: Nitrogen 10 percent, phosphoric acid 10 percent, and soluble potash 10 percent.

B. Mulch to be used in conjunction with areas where seed is to be drilled or broadcast will consist of clean, weed-free straw.

C. Hydraulically applied mulch shall consist of wood fiber and be dyed green to facilitate visual monitoring of the application.

D. Mulch tack: Mulch tack for hydraulic-seeding shall be a commercial mulch tackifier approved by the Engineer. Handling and mixing shall be in accordance with the manufacturer's recommendations.

E. Water: Clean, fresh and free of substances that could inhibit vigorous growth of grass.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that the prepared soil base is ready to receive the work of this Section.

B. Reclaim areas disturbed by construction as determined by the Company.

3.2 PREPARATION OF SUBSOIL

A. Remove debris such as large stones, tree branches and large roots that will interfere with normal seeding operations.

B. In preparation for seeding, at least 3 inches of topsoil will be evenly spread over areas disturbed by construction operations,

3.3 TOPSOIL

A. The seedbed shall be weed free.

B. After weed elimination, the seedbed shall be scarified/tilled to a depth of at least 6-inches, fertilized and firmed. Areas not suitable for scarifying/tilling shall be left in a rough condition.

C. In areas where equipment cannot be operated, the seedbed shall be prepared by hand.

D. If the topsoil is compacted, a spring tooth harrow equipped with utility or seedbed teeth, or similar equipment, will be used to loosen and smooth the soil surface either after or in conjunction with fertilization.

E. If the topsoil is loose, it will be compacted with a cultipacker or similar implement to provide a firm seedbed.

3.4 HYDROSEEDING

A. Hydro-seeding shall be applied by experienced personnel and shall meet the following requirements:

1. Hydraulic equipment used for the application of the slurry mixture shall be of a type acceptable to the Engineer, having built-in agitators that will keep seed, fertilizer, mulch, mulch tack and water, or various combinations thereof, mixed homogeneously until pumped from the tank. Pump pressure shall be such as to maintain a continuous, non-fluctuating stream of the slurry.
2. The seed, fertilizer, mulch, mulch tack and water shall be combined and applied as specified herein. After the tank is at least one-third full, the mulch and remainder of the water shall be added as the slurry is continuously agitated to maintain the homogeneous mixture. When the tank is full of water, the seed and fertilizer shall be added and allowed to mix for at least 5 minutes prior to starting application. The seed and fertilizer shall not remain together in the tank for more than 45 minutes. If the 45 minutes is exceeded, the Contractor, at his own expense, shall add additional seed equal to the original amount specified.

3. Mulch tack shall be a commercial mulch tackifier approved by the Company. Handling and mixing shall be in accordance with manufacturer's recommendations. Mulch shall be divided in half and applied as indicated below.

4. Seed, fertilizer, water and approximately 2,000 pounds per acre of hydraulic mulch, shall be mixed and uniformly applied to the areas to be seeded. The seed shall then be covered with approximately ½ inch of soil using a clod buster or other means approved by the Company on all accessible

slopes. The remaining hydraulic mulch and mulch tack shall then be mixed with water and uniformly applied. This application shall be accomplished within 36 hours after the first application has been completed.

B. The selection of the appropriate measure will depend upon site-specific conditions and will be approved, prior to implementation, by the Company.

A. If mulching fails to prevent gullying or other seed and seedbed loss, restore the seedbed to the finished grade and reseed at no additional cost to the Company.

3.5 PROTECTION/MAINTENANCE

A. Immediately reseed areas which show bare spots.

B. Protect seeded areas subject to vehicular traffic with warning signs during maintenance period.

3.6 QUALITY CONTROL

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

END OF SECTION 02935

Section 03400
PRECAST CONCRETE MANHOLES

PART 1 GENERAL

1.1 WORK INCLUDES

A. Furnishing and installing precast concrete manholes for the new toe drain system for the dam as shown on the Drawings.

1.2 RELATED SECTIONS

A. Section 02220: Excavation, Fill Placement and Compaction

B. Section 03006: Concrete and Steel Reinforcement

1.3 QUALITY CONTROL

A. Tolerances shall be in accordance with ACI 117-90.

B. Precast concrete manholes shall be manufactured in accordance with ASTM C478-87.

1.4 SUBMITTALS

A. Submit the following for review and approval:

1. Shop Drawings – Submit shop drawings showing unit dimensions and section details, finishes, reinforcement and connection details, lifting and erection inserts, all other embedded items, and layout diagrams identifying installation locations and number identification marks.

2. Installation Schedule – Accompany delivered units with a schedule indicating sequence of installation, joints, support, and bracing and attachment systems.

1.5 PRODUCT DELIVERY, HANDLING, AND STORAGE

A. Lift and support units only at designated lifting and supporting points.

B. Transport units in a manner which will not result in overstressing or damage during delivery, handling, and storage of units.

C. Do not place units directly on earth.

D. Place stored units so that identification marks are discernible.

PART 2 PRODUCTS

2.1 PRECAST CONCRETE MANHOLE SECTIONS

A. Precast concrete manhole sections shall be in general conformance with ASTM C478-87: Standard Specification for Precast Reinforced Concrete Manhole Sections.

B. The riser sections shall be manufactured as shown on the drawings and approved shop drawings.

C. Holes shall be cast in the manholes at the elevation and sizes indicated on the drawings.

D. Joint sealers for the manhole sections shall be flexible material such as CONSEAL, RAMNEK, KOR-N-SEAL or equal.

2.2 FRAMES AND COVERS

A. Frames and covers for manholes shall be cast-iron, ASTM A48-83, R-1594 of Neenah Foundry Company, Neenah, Wisconsin, 54956, or approved equivalent. The manhole frame shall be flange mounted with bolts to the top of the precast concrete manhole. A water-tight seal and locking cover shall be required for the cover. Bolts for flange mounting the manhole frame shall be stainless steel lag bolts, type 303 or 304.

2.3 GROUT

A. Grout used to grout around PVC drain pipes at the manhole walls shall be non-shrink grout in accordance with Section 03006: Concrete and Steel Reinforcement.

2.4 CONCRETE

A. In accordance with Section 03006: Concrete and Steel Reinforcement

PART 3 EXECUTION

3.1 INSTALLING PRECAST CONCRETE MANHOLES

A. Precast concrete manholes shall be installed to the elevations and locations shown on the Drawings. Elevations and locations of each manhole shall be verified by the Contractor prior to delivering the manholes to the site.

B. Grout around drain pipes at the manhole walls to fill completely around the pipe. Place grout in accordance with Section 03006: Concrete and Steel Reinforcement.

C. Backfill adjacent to each manhole shall be as shown on the drawings and as specified in Section 02220: Excavation, Compaction and Backfilling.

END OF SECTION 03400

Section 03720
CONCRETE REPAIR AND RESTORATION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals for the repair and restoration of concrete work including curing and protection.

1.2 REFERENCES

A. Reference to standard specifications and practices stated herein shall be interpreted to mean the latest revisions.

B. Permission for deviation from any requirements stated herein or from the referenced standards shall be obtained from the Company in writing.

C. Comply with the provisions of the following specifications, standards, and guides except as specified otherwise herein:

1. *American Society for Testing and Materials (ASTM)*

ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 33	Specification for Concrete Aggregates
ASTM C 171	Specification for Sheet Materials for Curing Concrete
ASTM C 881	Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 920	Specification for Elastomeric Joint Sealants
ASTM C 1107	Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

ASTM C 1193	Standard Guide for Use of Joint Sealants
ASTM D 1752	Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

1.3 SUBMITTALS

A. Within 30 days after award of Contract and prior to their use, submit to the Engineer manufacturer's certification that nonshrink grout and polyurethane resins conform to the specified ASTM standards or other requirements. Submittal shall include manufacturer's technical data sheet. The Contractor shall provide samples of materials as requested by the Engineer or the Company.

B. The Contractor shall submit a detailed proposal for polyurethane resin injection repair to the Engineer for approval. The approval will be based on the degree of conformance to the basic steps of polyurethane resin injection and on Engineer's judgment of the technical feasibility of the Contractor's proposal.

C. Submit list of equipment to be used in the performance of the work for review.

D. Submit resumes of supervisory personnel showing experience in concrete repair work of similar nature as required herein.

E. Prior to the start of work, submit a quality control plan describing the procedures to be followed in inspection of each phase of the work to assure compliance of all work and installation of materials with these specifications. Submit daily inspection reports.

1.4 QUALITY CONTROL

A. The Contractor shall provide quality control including inspection and documentation that each item of work is performed in accordance with the requirements specified herein. An inspection report shall be submitted to the Engineer on a daily basis when work is performed. The report shall be submitted on the morning following the activity.

B. All work shall be performed with workmanship.

C. Quality assurance of the work and acceptance will be by the Company or his designated representative. Work that is found not to be in compliance with the specified requirements will be rejected by the Company and shall be removed and/or redone by the Contractor at no cost to the Company.

1.5 DELIVERY AND STORAGE

A. Materials for repair shall be delivered to the project in sealed containers or appropriate packaging bearing the manufacturer's name and material identification. Materials shall be stored in strict accordance with the manufacturer's printed directions, copies of which shall be furnished to the Engineer. All unsatisfactory materials shall be removed from the premises, and all damaged materials shall be replaced with new materials.

B. The storage of all materials and equipment shall be only in areas designated or approved by the Company.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Nonshrink mortar shall conform to the requirements of ASTM C 1107, Grade B or C.

B. Nonshrink concrete shall consist of a combination of nonshrink grout and pea gravel, ASTM C 33 Size Number 8. The amount of pea gravel used shall be in accordance with the recommendations of the manufacturer of the nonshrink grout.

C. Coarse aggregate used in nonshrink concrete shall conform to the quality requirements of ASTM C 33.

D. Reinforcing steel shall be ASTM A 615, Grade 60.

E. Epoxy bonding adhesive shall conform to the requirements of ASTM C 881, Type II, Grade 2 or 3, Class B or C.

F. Polyurethane resin – The polyurethane resin system for injection into cracked concrete shall be a two-part system composed of 100 percent hydrophilic polyurethane resin and water. The polyurethane resin, when mixed with water, shall be capable of forming either a flexible closed-cell foam or a cured gel dependent upon the water-to-resin mixing ration. The amount of water mixed with the polyurethane resin shall be such that the cured material meets the following physical properties:

1. Minimum tensile strength – 20 pounds per square inch.

2. Bond to concrete (wet) – greater than 20 pounds per square inch.

3. Minimum elongation – 400 percent.

The injection of pure polyurethane resin not mixed with water shall not be allowed.

G. Form materials shall be provided by the Contractor as required to confine the placement of nonshrink mortar or nonshrink concrete and shape it to the lines and grades of adjacent concrete. Forms may be metal or wood and shall be lightly oiled to prevent adhesion of the nonshrink mortar or nonshrink concrete.

H. Pre-molded joint grooves shall be made of plastic or wood in the groove shapes as shown on the Drawings. The pre-molded material shall be easily removable after the concrete has hardened without causing damage to the formed groove.

PART 3 – EXECUTION

3.1 GENERAL

A. No concrete replacement or joint or crack sealing shall be preformed until surface preparation has been inspected and approved by the Engineer. All deficiencies in surface preparation shall be immediately corrected. All repair work shall be performed by skilled workmen. Repair work shall only be performed when weather conditions are suitable for the work unless protection from warm or cold temperature is provided.

3.2 SURFACE PREPARATION

A. The perimeters of repairs to concrete that involve concrete removal and subsequent materials replacement shall be saw cut to a minimum depth of 1 inch. Where the replacement material is completely confined within the saw cuts, the saw cut shall be made at a slightly angle, 5 to 10 degrees, from perpendicular away from the removal area such that the replacement materials, when applied, will be physically locked into place. Where the replacement material is not confined, the saw cut shall be perpendicular to the surface. Featheredge repairs to concrete shall not be used.

B. All damaged, deteriorated, loosened, or unbonded portions of existing concrete and sound concrete within the saw cut perimeter shall be removed by small chipping hammer, bush hammer, or other approved method. Chipping hammers shall be less than 30 pounds. Concrete removal shall be to a reasonably uniform depth, where practical, and to sound concrete throughout. Care shall be taken to prevent damage to the saw cut faces. Where reinforcement is exposed either before or during concrete removal, completely remove the concrete from around the bar for the full length of the repair and to a depth of no less than ¾ inch below the bar.

C. Where the end of reinforcing bars, bolts or other similar steel objects are exposed on the surface of the concrete, the exposed end shall be over-cored to a minimum depth of 1-1/2 inches; the concrete within the core hole removed; and the bar or bolt cutoff by flame cutting at the base of the core hole. Minimum core diameter shall be 3 inches.

D. Immediately prior to filling areas of concrete removal, all surfaces within saw cut or core holes shall be cleaned with high pressure water blasting or wet sandblasting to remove any micro-fractured surfaces, coatings, contamination, loose or unsound fragments. Water blasting equipment shall operate at a minimum pressure of 6,000 psi. The use of acids for cleaning or preparing concrete surfaces for repair will not be permitted. Excess water shall be removed from the repair area and the bond surface of the repair area shall be allowed to air dry. Prepared surfaces shall be protected and maintained until repairs are completed

3.3 FORMWORK

A. Forms shall be installed where necessary to shape the nonshrink mortar or nonshrink concrete to existing lines and grades. Forms shall be temporary forms that can be quickly removed before the replacement material reaches final set so that surface imperfections can be filled and the final finish applied.

B. Form supports shall be located outside of the repair area. Drilled anchors will not be permitted. Form supports and bracing shall be sufficient to prevent form movement during placement of the nonshrink grout or nonshrink concrete.

C. Forms shall be tight to prevent loss of grout during placing operations.

3.4 PLACING NONSHRINK GROUT OR NONSHRINK CONCRETE

A. Immediately prior to placing nonshrink grout or nonshrink concrete, a bonding adhesive shall be applied to all surfaces of the repair area including existing reinforcing bars. The mixing and application of the bonding adhesive shall be in accordance with the manufacturer's instructions. While the bonding adhesive is still tacky, the repair area shall be filled with nonshrink grout or nonshrink concrete.

B. Nonshrink grout or nonshrink concrete shall be mixed with water in a mechanical mixer at the proportions recommended by the manufacturer of the nonshrink grout. The volume of mixed material shall be no more than can be placed within 30 minutes. The consistency of the mixture shall be suitable for the placing conditions.

C. In making repairs on vertical surfaces the mixture shall be reasonably dry. This dry mixture shall be tamped in layers and the repair area overfilled. The excess shall then be struck off and the finish applied by wood float and trowel to match the surrounding concrete texture.

D. Where forms are used they shall be removed after initial set and before final set of the repair material such that the formed surfaces can be finished to the texture of the surrounding concrete.

3.5 CURING AND PROTECTION

A. Immediately following final finishing of each concrete replacement, the area shall be covered with sheeting material and all newly placed grout, mortar, or concrete shall be moist cured for a minimum of 7 days. The sheeting material shall be cut to extend no less than 6 inches beyond the perimeter of the repair. The edges of the sheeting material shall be taped to existing concrete by duct tape or other suitable adhering tape. The sheeting material shall be protected from damage for the curing period. If damage should occur the replacement material shall be moistened with water, and the sheeting material replaced and re-taped.

B. The Contractor will be responsible for protection of the work while in progress until the repairs are completed and cured. Any damaged work such as prepared surfaces shall be corrected at the Contractor's expense.

3.6 POLYURETHANE RESINS

A. Concrete Preparation - The concrete surface to be repaired by resin injection shall be thoroughly cleaned of all deteriorated concrete, efflorescence, and all other loose material. The area to be injected shall then be thoroughly inspected and an injection port drilling and pumping pattern established.

Upon completion of resin injection, all excess material shall be removed from the exterior surfaces of the concrete. The final finished surfaces shall match the texture of the surfaces adjoining the repair areas.

B. Hydrophilic Polyurethane Resin Injection Repairs - The process used for polyurethane injection of cracks or joints to reduce water leakage shall consist of the following basic steps:

1. Intercept the water flow paths with valved drains installed into the concrete to control the leakage.

2. Install injection ports by drilling holes designed to intersect the cracks at depth below the concrete surface. The maximum spacing of injection ports shall not exceed 60 inches, and closer spacing of ports will be required.

3. All injection holes shall be flushed with clean water to remove drilling dust and loose debris and to clean the intersected crack line. Each drill hole shall be water tested at the resin injection pressure to determine if the crack intersection is open. Polyurethane resin shall not be pumped into a drill hole that refuses to take water at the resin injection pressure.

4. Inject polyurethane resin system into cracks or joints at the minimum pressure required to obtain the desired travel, fillings, and sealing. The mix water to resin ratio shall be 1:1 unless otherwise approved by the Engineer. The Contractor

should anticipate the necessity to provide a surface seal for the crack or joint to contain the injection resin. It may also be necessary to inject the crack or joint in an intermittent manner to achieve filling and sealing. Injection shall be by the method of split spacing unless otherwise approved by the Engineer. Primary holes shall be drilled and injected on centers not exceeding 5 feet. Secondary holes, half way between the primary holes, will then be drilled and injected. If resin take occurs in the secondary holes, a series of tertiary holes, half way between the secondary and primary holes, shall then be drilled and injected. All holes shall be injected to absolute refusal.

5. Remove drains, injection ports, and excess polyurethane upon completion of resin cure.

This process shall entirely stop the water leakage to a dust dry condition or as directed by the Company.

The pump used to inject the polyurethane resin system shall be a two-component positive-displacement-type pump with static mixing head and pressure regulation necessary to control injection pressures while pumping low volumes. The equipment will be subject to approval by the Engineer. The use of single component pumps and/or the injection of pure water followed by injection of pure resin will not be approved.

C. Safety - Polyurethane injection resin systems contain either toluene diisocyanate or methylene dephenyl diisocyanate. Both isocyanates can create risks if safe handling procedures are not followed. The principal hazards arise from isocyanate vapor, which will irritate the membranes of the nose, throat, lungs, and eyes. Adequate ventilation is required to prevent vapor concentrations from approaching the Threshold Limit Value (TLV). Protective clothing, including rubber or plastic gloves and protective glasses, shall be worn by all persons handling polyurethane resins. If necessary, respirators that filter isocyanate vapors and mists shall also be worn. Monomeric urethane resins react with water to produce polyurethane and carbon dioxide gas. If this reaction occurs inside a closed container, excessive pressures can develop that may rupture the container. Care must be taken to prevent contamination or monomeric urethane resin with water.

Polyurethane resin spillage shall be immediately and thoroughly cleaned up. Spilled polyurethane resin can be absorbed in sand and removed for burial.

D. Cleanup and Disposal of Injected Resin - All materials, tools, and containers contaminated with injection resin, surface sealers, or other contaminants shall be removed from the site for disposal in accordance with appropriate local or Federal regulations.

END OF SECTION 03720

Section 13505
STRUCTURAL SURVEY MONUMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section covers the installation of structural survey monuments on the concrete structure of the main dam. Structural survey monuments are installed to provide a measuring point for which to reference the potential movement of the concrete overflow structure.

1.2 SUBMITTALS

A. Conform with Section 01300 – Submittals

B. As-Built-Drawings – Following installation of the survey monuments, submit drawings showing the exact surveyed location of each monument.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Survey Monuments – Structural survey monuments as shown in the drawings. Horizontal measurements will be conducted with an Electronic Distance Measurement (EDM) instrument, and vertical measurements will be conducted using conventional level surveys. Specified hardware as manufactured by Berntsen International, Inc., Madison, Wisconsin.

PART 3 EXECUTION

3.1 INSTALLATION OF SURVEY CONTROL MONUMENTS

A. Install movement monuments on the dam and abutment using the following procedures.

1. Drill a 1-inch (±) diameter hole to the appropriate length to install the brass cap.

2. Clean the hole with appropriate cleaning methods.

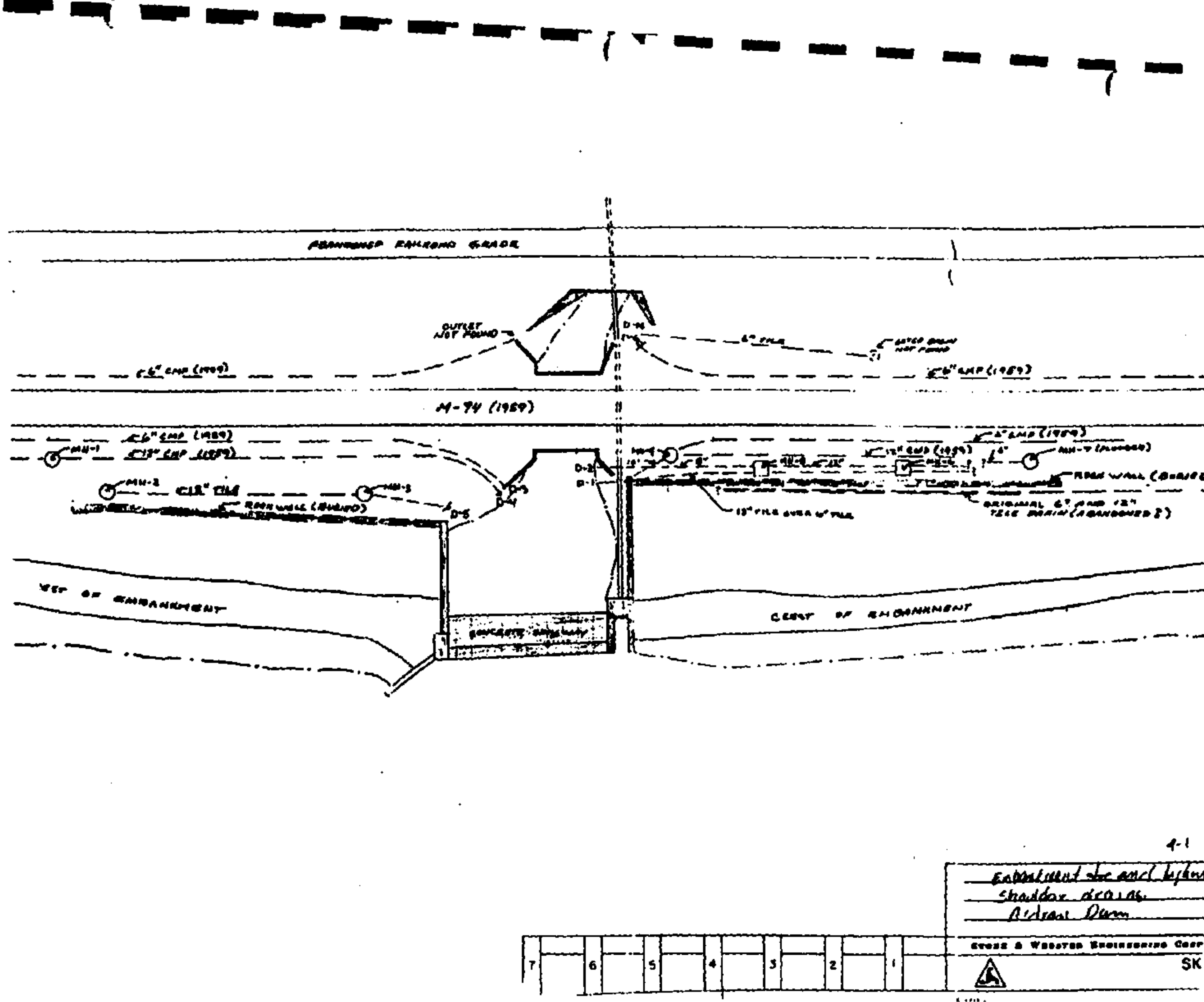
3. Place concrete grout or an approved epoxy resin in the drill hole.

4. Install brass cap as shown on the Drawings.

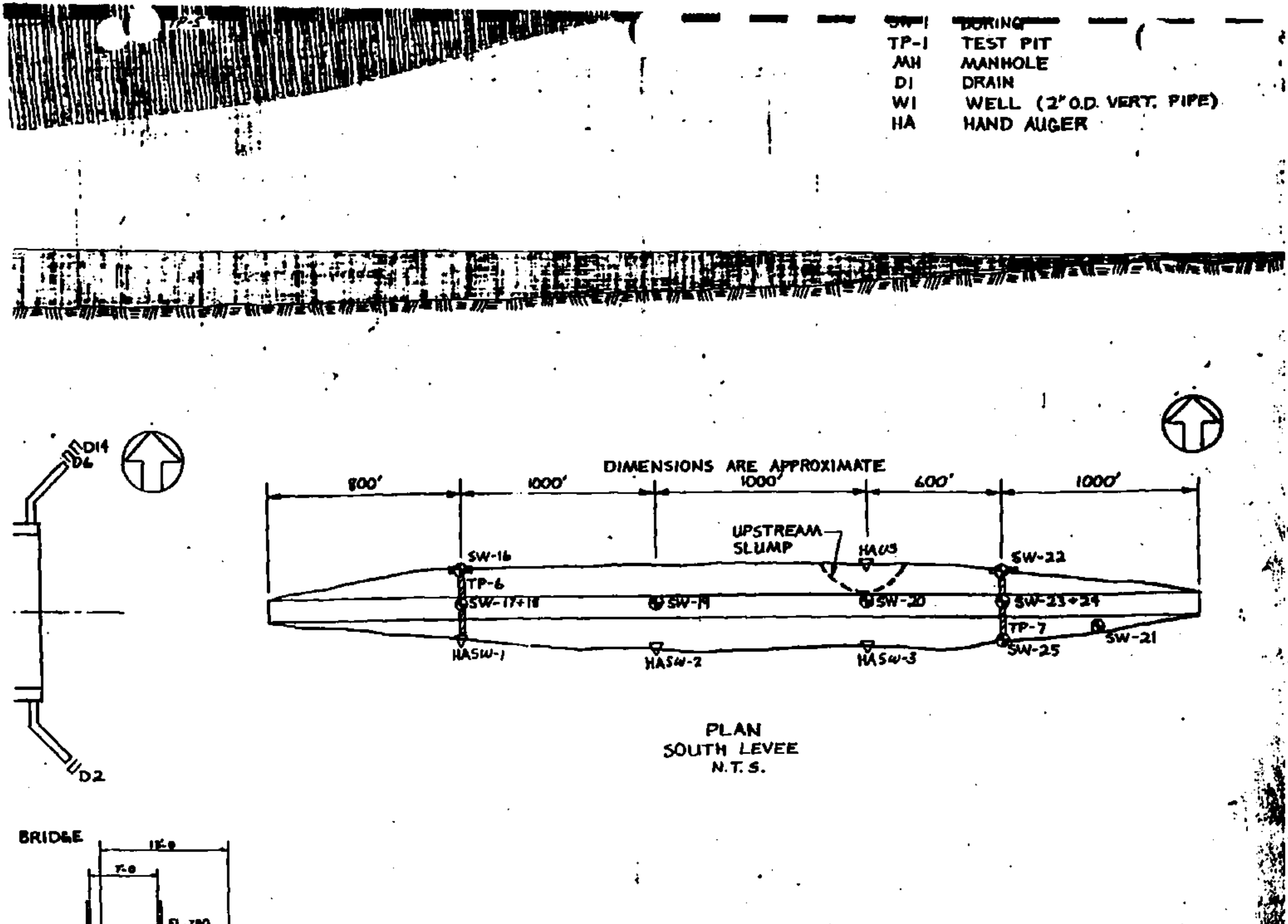
END OF SECTION 13505

APPENDIX A

SITE DATA



OUTLET NOT FOUND
M-94 (1959)
MH-1
MH-2
MH-3
D-5
4-1
SK



PLAN
SOUTH LEVEE
N.T.S.

REFERENCE: ESSOW NO. 18490-S101V

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-1 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/14/88 - 10/14/88

Coordinates: N 64,468 E 38,988 — Ground Elevation: 788.5 ft

Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 28.8 ft

Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: — Casing Used: 10 FT OF SURFACE CASING

Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD

Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER

Drilling Rock: NONE

Comments: Piezometer SW-1 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
788.5	0						
785		SS	1	2-2-3 (7.0")	5	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-15% gravel, sub rounded, max. 1.2", 3-10% fines, dry, light brown, (fill).
	5	SS	2	8-9-9 (17.0")	18	SP-SM	SAND, as above, trace of organics.
780		SS	3	2-2-2 (10.0")	4	SP-ML	SAND, as above, with a 1' thick interbed of CLAYEY SILT, fine sand to clay, well graded, slightly to moderately plastic, 60% fines, moist, red brown, (fill, appears to be same material reported to have been used on upstream side of the dam in 1930 for a "clay" liner).
	10	SS	4	2-1-2 (8.0")	3	SM	SAND, same as sample #1.
775		SS	5	15-10-4 (10.0")	14	SP-SM	SILTY SAND, fine to clay, well graded, slightly plastic, 20-25% fines, trace - 6% organics, organcis occur as very thinly bedded and disseminated, moist, dark brown to black, (alluvium, lake-bog deposit).
	15	SS	6	1-2-5 (13.0")	7	SM	SILTY SAND, fine to clay, slightly plastic, 12-20% fines, trace-6% organics, organics disseminated/wood fragments and peat, moist, red brown, (alluvium, lake-bog, deposit).

Legend/Notes

- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-1 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM | Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
770		SS	7	5-4-4 (14.0")	8	ML-SM	SILTY SAND, fine to clay, slightly plastic, 50-60% fines, moist, reb brown, (alluvium, lake bed or bog deposit).
	20	SS	8	1-1-1 (14.0")	2	ML	SILTY SAND, fine to clay, slightly plastic, 50-60% fines, moist, red brown, (alluvium, lake bed or bog deposit).
765		SS	9	11-10-6 (7.0")	16	SP	SAND, coarse to fine, well graded, non-plastic, sub rounded, locally sand grains coated with bauxite, <5% fines, trace of organics, saturated, red brown to brown, (alluvium, lake bed desposit).
	25	SS	10	11-8-9 (9.0")	17	SC	SAND, fine, poorly graded, slightly plastic, sub rounded, trace to 5% coarse sand, sub rounded, <5% fines, santurated, red brown, (alluvium, lake deposit-outwash).
760		SS	11	6-8-7 (12.0")	15	SM	SAND, fine to silt, poorly graded, slightly plastic, sub angular, 12-15% fines, saturated, red borwn with bottom 2" a SAND, gravel to fine, well graded, non-plastic, sub rounded, trace gravel, sub rounded, <5% fines, saturated, light brown, (alluvium).
	30						
							BOTTOM OF BORING AT 28.7 FT.
755							
	35						
750							
	40						
745							
	45						
740							

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-2 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER
Client: UPPER PENINSULA POWERE COMPANY — Date Start - Finish: 10/17/88 - 10/17/88
Coordinates: N 64,451 E 38,879 — Ground Elevation: 788.7 ft
Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 26.5 ft
Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: — Casing Used: 10 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: Piezometer SW-2 was installed in boring, see piezomenter installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Values	USC Symbol	Sample Description
788.7	0						
		SS	1	2-1-2 (10.0")	3	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded, max. 1.2", 3-13% fines, trace of organics, dry, light brown, (fill).
785							
	5	SS	2	3-9-8 (10.0")	17	SP-SM	SAND, as above, no organics
		SS	3	2-2-2 (8.0")	4	SP-SM	SAND, as above.
780							
	10	SS	4	2-1-2 (7.0")	3	SP-SM	SAND, as above.
		SS	5	5-13-11 (15.0")	24	SP-SM	SAND, as above.
775							
	15	SS	6	3-3-2 (10.0")	5	SP-SM	SAND, as above.

Legend/Notes
- Datum is MSL.
- ⊻ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-2 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM

Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
770		SS	7	3-4-3 (8.0")	7	SP-SM	SAND, as above.
	20	SS	8	2-2-2 (1.5")	4	SP-SM	SAND, as above, trace of organics, saturated.
765		SS	9	2-1-2 (5.0")	3	SP-SM	SAND, as above.
	25						BOTTOM OF BORING AT 26.5 FT.
760	30						
755	35						
750	40						
745	45						
740							

Note: See Sheet 1 for Boring Summary and Legend Information

Approved

Date 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-4 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/14/88 - 10/14/88

Coordinates: N 64,438 E 38,780 — Ground Elevation: 790.4 ft

Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 49.0 ft

Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: — Casing Used: 10 FT OF SURFACE CASING

Drilling Soil: 4" TRI-CONE ROLLER BIT, TEVERT DRILLING MUD

Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER

Drilling Rock: CORRED ROCK UTILIZING NX DOUBLE BARREL, SPLIT INNER TUBE CORE BARREL.

Comments: Piezometer SW-4 was installed in boring, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
790.4	0						
		SS	1	5-5-4 (12.0")	9	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded to sub angular, max. 1.2", <5% fines, dry, light brown, (fill).
785	5	SS	2	3-9-10 (18.0")	19	SP-SM	SAND, as above.
		SS	3	1-2-2 (10.0")	4	SP-SM	SAND, as above, trace black organics.
780	10	SS	4	2-1-2 (8.0")	3	SP-SM	SAND, as above.
		SS	5	14-12-8	20	SP-SM	SAND, as above, trace of gravel, moist.
775	15	SS	6	3-3-3 (8.0")	6	SP-SM	SAND, as above, wet.

Legend/Notes

- Datum is MSL.
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sampler
  NX = NX Rock Core

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-4 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N V a l u e	USC Symbol	Sample Description
		SS	7	2-3-3 (9.0")	6	SP-SM	SAND, as above, wet.
770	20	SS	8	3-3-2 (6.0")	5	SP-SM	SAND, as above, wet.
		SS	9	2-2-2 (12.0")	4	SP-SM	SAND, as above, wet.
765	25	SS	10	3-2-1 (5.0")	3	SP-SM	SAND, as above, wet.
		SS	11	7-14-18 (10.0")	32	SP	SAND, fine, poorly graded, non-plastic, 10-15% gravel, highly weathered bedrock, sub angular, moderatly indurated, <5% fines, trace to <5% organics, disseminated thoughout, wet, dark brown to red brown, with very thinly bedded, SAND, coarse to fine, well grande, non-plastic, sub rounded, wet, light brown, (soil development on top of weathered bedrock).
760	30	SS	12	5-1-12 (7.0")	13	SM	SILTY SANDSTONE, fine, poorly graded, non-plastic, sub rounded, 10-15% silt, highly weathered, soft, unconsolidated to moderately indurated, silica cement, wet, light brown, (weathered bedrock).
		SS	13	66-34 (11.0")	34/6		SILTY SANDSTONE, fine, poorly graded, sub rounded, 10-15% silt, highly weathered, moderately to well indurated, silica cemented, wet, light brown, (weathered bedrock).
755	35	NX	1	40 / 17			SANDSTONE TO SILTSTONE, (33.5-34.8'), fine sand to silt, poorly graded, sub rounded, thin to very thin bedded, bioturbated, moderately to severly weathered, unconsolidated to well indurated, with thinly laminated interbeds that are stained black to dark brown, sulfur smell on freshly borken surfaces, poor recovery-badly broken up. SANDSTONE, (39.5-37.8'), fine grained, poorly graded, sub rounded, laminated to thinly laminated, wavy continuous to discontinuous beding, fresh to moderatly weathered, well indurated, locally bioturbated, silica cement, (bedrock). Lost core .75 ft.
750	40	NX	2	30 / 20			SANDSTONE, (38.5-39.5'), fine grained, poorly graded, sub rounded, silica cement, laminated, locally bioturbated, parralled to wavy continuous to discontinuous beds, sever to moderately weathered, moderately indurated, with spotty black to dark brown staining, poor recovery, badly broken up, tan to light brown. SANDSTONE, (39.5-41.0'), fine grained, poorly graded, subrounded, silica cement, very thinly laminated to laminated, locally bioturbated, wavy and parrall discontinuous to continuous beding, fresh-unweathered, moderately to well indurated, local thin black silt to clay partings, local .1" quartz lined vugs, light gray. Lost 2.5 ft of core.
745	45	NX	3	87 / 83			SANDSTONE, (43.5-44.5'), fine grained, poorly graded, sub rounded, silica cement, laminated, bioturbated, parralled to wavy continuous to discontinuous beds, fresh unweathered, moderately indurated, locally thin silty discontinuous partings, light to dark gray. SANDSTONE, (44.5-47.8'), fine grained, poorly graded, sub rounded, silica cement, fresh unweathered, locally bioturbated, thin bedded to finly laminated, locally wispy laminations, local .1-.3", quartz lined vugs, local partially open vertical fracture, light to dark gray. Lost .6 ft of core.
		NX	4	0 / 0			NO CORE RECOVERY, bit sheared off in borehole.
							BOTTOM OF BORING AT 49.0 FT.

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-6 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/13/88 - 10/13/88
Coordinates: N 64,475 E 38,775 — Ground Elevation: 781.7 ft
Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 22.0 ft
Contractor: STS CONSULTANTS LTD — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: — Casing Used: 10 FT. OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: Piezometer SW-6 was installed in boring, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
781.7	0						
780		SS	1	3-2-1 (12.0")	3	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded to sub angular, max. 1.2", 5% fines, dry, light brown, (fill).
	5	SS	2	1-2-2 (14.5")	4	SP-SM	SAND, as above.
775		SS	3	2-2-3 (10.0")	5	SP-SM	SAND, as above.
	10	SS	4	3-3-2 (7.0")	5	SP-SM	SAND, as above.
770		SS	5	2-1-1 (10.0")	2	SP-SM	SAND, as above, saturated.
	15	SS	6	17-16-14 (10.0")	30	SM	SILTY SAND, fine, poorly graded, slightly plastic, sub rounded, trace gravel, sub angular, weathered sandstone, 15-30% fines, organics, dark brown, inter-beded SAND, coarse to fine, poorly graded, non-plastic, sub rounded, <5% fines, wet, dark brown, (soil horizon developed on top of alluvium). SAND,
765							

Legend/Notes

- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	05/12/9

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-6 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
		SS	7	11-11-6 (10.0")	17	GM-SM	GRAVELY SAND, coarse to fine, well graded, non-plastic, sub rounded, 20-40% gravel, sub rounded, max. 1.5", 12-15% fines, trace of organics, wet, brown, (alluvium or weathered bedrock).
	20	SS	8	63-37/3 (7.0")	37/3		SANDSTONE, fine to silt, poorly graded, silica cemented, severely weathered, soft to very soft, 10-15% silt, wet, tan, (weathered bedrock).
760							
							BOTTOM OF BORING AT 22.0 FT.
	25						
755							
	30						
750							
	35						
745							
	40						
740							
	45						
735							

Note: See Sheet 1 for Boring Summary and Legend Information — Approved — Date 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-7 J.O. 18372 Sheet 1 of 1

Site: FOREST LAKE DAM — Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/12/88 - 10/12/88
Coordinates: N 64,520 E 38,772 — Ground Elevation: 767.5 ft
Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 8.3 ft
Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: Casing Used: 00 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: *Piezometer SW-7 was installed in boring, see piezometer installation report for details*

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
767.5	0						
765		SS	1	1-1-4	5		NO RECOVERY, water table 1-1.5 ft below ground surface
	5	SS	2	12-25-12 (12.0")	37		SANDSTONE, fine, poorly graded, sub rounded, silica cement, severely to moderately weathered, soft to medium, 7-10% silt, saturated, mottled buff to red brown, (weathered bedrock)
760							
							BOTTOM OF BORING AT 8.3 FT
	10						
755							
	15						

Legend/Notes

- Datum is Sea Level
- ⊻ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	01/24/89

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-9 J.O. 18372 Sheet 1 of 3

Site: FOREST LAKE DAM
Client: UPPER PENINSULA POWER COMPANY
Coordinates: N 64,411 E 38,388
Groundwater Depth/Date:
Contractor: STS CONSULTANTS LTD.
Depth to Bedrock:
Driller: JOHN WRITE
Logged by: MIKE GASSER
Date Start - Finish: 10/11/88 - 10/11/88
Ground Elevation: 789.2 ft
Total Depth Drilled: 53.0 ft
Rig Type: ROTARY

Methods:
Casing Used: 36.6 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: CORED ROCK UTILIZING NX DOUBLE BARREL, SPLIT TUBE CORE BARREL.

Comments: Piezometer SW-9 was installed in borint, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Values	USC Symbol	Sample Description
789.2	0						
		SS	1	6-12-7	19	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded, max. 1.2", 5% fines, dry, light brown, (fill).
785	5	SS	2	2-2-2	4	SP	SAND, as above, 10% gravel, <5% fines.
		SS	3	4-8-7 (6.0")	15	SP-SM	SAND, as above in sample #1, rock in tip of split spoon sampler.
780	10	SS	4	2-2-2 (7.0")	4	SP-SM	SAND, as above, moist.
		SS	5	2-6-7 (9.0")	13	SP-SM	SAND, as above, moist, rock in tip of split spoon sampler.
775	15	SS	6	3-3-6 (8.0")	9	SP-SM	SAND, as above, moist, rock in tip of split spoon sampler.

Legend/Notes
- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sampler
  NX = NX Rock Core

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-9 J.O. 18372 Sheet 2 of 3

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
		SS	7	6-3-4 (8.0")	7	SP-SM	SAND, as above, moist, rock in tip of split spoon sampler.
770	20	SS	8	4-5-6 (10.0")	11	SP-SM	SAND, as above.
		SS	9	6-5-4 (12.0")	9	SM	SILTY SAND, coarse to fine, well graded, slightly plastic, sub angular to sub rounded, 10-20% fines, wet, red brown, (alluvium), rock in tip of split spoon sampler.
765	25	SS	10	1-1-4 (4.0")	5	SM	SILTY SAND, coarse to fine, well graded, slightly plastic, sub angular to sub rounded, 10-20% fines, wet, red brown, (alluvium), rock in tip of split spoon sampler.
		SS	11	5-14-7 (9.0")	21	SM	SILTY SAND, fine, poorly graded, non-plastic, sub angular, 10-15% gravel, sub rounded, max. 1" severely to moderately weathered, soft to hard, weathered sandstone, 10-15% fines, wet red brown, (alluvium).
760	30	SS	12	7-9-6 (9.0")	15	SM	GRAVELY SILTY SAND, fine, poorly graded, non-plastic, sub angular, 10-15% gravel, sub rounded, max. 1", severely to moderately weathered, soft to hard, weathered sandstone, rounded granite and metamorphics, 10-15% fines, wet, mottled, red brown to brown, (alluvium and weathered bedrock).
		SS	13	22-15-18 (2.0")	33	SM	GRAVELY SILTY SAND, as above, 20-30% gravel, angular, max. 1", moderatly weatherd, soft to hard, weathered bedrock, 10-15% fines, wet mottled red brown, (alluvium and weathered bedrock).
755	35	SS	14	10-12-11 (14.0")	23	SM	GRAVELY SILTY SAND, as above.
750	40	SS / NX	15 / 1	32 / 95 / 83	32/2		SANDSTONE, fine, well sorted, fresh, well indurated, with trace pyrite, gray, (bedrock). 1" rec. / SANDSTONE, fine grained, well sorted, sub angular, bioturbated, massive to very thinly bedded, locally differential cementation, moderately weathered, moderately indurated, with very thin bedded interbeds of siltstone, wavy to parrall continuous to discontinuous bedding, top half of core yellow brown (oxidized), lower half light grey, (bedrock). Lost .35 ft of core.
745	45	NX	2	95 / 84			SANDSTONE, as above, fresh, moderatly to well indurated, light gray, (bedrock). Lost .26 ft of core.
740		NX	3	95 / 78			SANDSTONE, as above, moderate to fresh, moderatly to well indurated, local high angle to vertical fracture, local .1-.6" irregular quartz lined vugs, light gray to locally yellow brown, (bedrock). Lost .24 ft of core.

Note: See Sheet 1 for Boring Summary and Legend Information — Approved: — Date: 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-9 J.O. 18372 Sheet 3 of 3

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Values	USC Symbol	Sample Description
	50						CONTINUED FROM PAGE TWO.
735	55						BOTTOM OF BORING AT 53.0 FT.
							DRILLING NOTES: Drove casing from 10' to 36.7', started to core. During coring operations no mud returns to the surface, while pulling core run #3 we were temporary stuck in hole. Based on no mud returns and material sluffing in it was decided to cancel core run #4.
730	60						
725	65						
720	70						
715	75						
710	80						

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-11 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/12/88 - 10/12/88
Coordinates: N 64,457 E 38,395 — Ground Elevation: 780.5 ft
Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 27.4 ft
Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRITE — Rig Type: ROTARY

Methods: — Casing Used: 10 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: Piezomenter SW-11 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
780.5	0						
780							
		SS	1	(10.0")		SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded, max. 1.2", 5% fines, dry, light brown, (fill).
775	5	SS	2	2-3-2 (3.0")	5	SP-SM	SAND, as above, rock in tip of split spoon sampler
		SS	3	1-2-3 (17.0")	5	SM-SP	SILTY SAND, fine, poorly graded, no-plastic, sub angular, 1-3% gravel, sub rounded to rounded, soft to very soft, severely weathered, clumps of brown clay silty fine sandstone, 12-15% fines, trace of organics, dry, light brown to red brown, (soil development on weathered bedrock or alluvium).
770	10	SS	4	1-3-2 (17.0")	5	SM	SILTY SAND, fine, poorly graded, no-plastic, sub angular, 1-3% gravel, sub rounded to rounded, soft to very soft, severly weathered, 10 % fines, dry, golden brown, (weathered bedrock or weathered alluvium derived from near by bedrock).
		SS	5	3-3-3 (12.0")	6	SM	SILTY SAND, as above, brown.
765	15	SS	6	27-11-10 (12.0")	21	SP	GRAVELLY SAND, fine, non-plastic, sub rounded, 10-15% gravel, sub rounded, decomposed bedrock, severely to moderately weathered, soft to moderatly indurated, max. 1.2", <5% fines, dry, light brown to red brown, (weathered bedrock).

Legend/Notes

- Datum is MSL
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-11 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM | Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
		SS	7	11-9-6 (13.0")	15	SM	SILTY SAND, fine, poorly graded, non-plastic, sub rounded, 10-15% gravel, sub rounded, decomposed bedrock, severely to moderately weathered, soft to moderately indurated, max. 1.2", 10% fines, dry, light brown to red brown, (weathered bedrock).
760	20	SS	8	13-11-10 (17.0")	21	SM-SP	GRAVELY SAND, fine, poorly graded, non-plastic, sub rounded, 10-15% gravel, sub rounded, decomposed bedrock, severely to moderately weathered, moderately indurated, max. 1.2", 10% fines, dry, light brown to red brown, (weathered bedrock).
		SS	9	13-14-14 (16.0")	28	GP	SANDY GRAVEL, 60% gravel, sub rounded, decomposed bedrock, severely to moderately weathered, moderatly indurated, hard, max. 1.2", 30% sand, fine, sub rounded, 10% fines, dry, red brown, (weathered bedrock).
755	25	SS	10	23-10-20 (14.0")	30		SILTY SAND, fine, poorly graded, no-plastic, sub angular, 1-3% gravel, sub rounded to rounded, soft to very soft, severly weathered, 10 % fines, dry, golden brown, (weathered bedrock or weathered alluvium derived from near by bedrock).
							BOTTOM OF BORING AT 27.4 FT.
750	30						
745	35						
740	40						
735	45						

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-12 J.O. 18372 Sheet 1 of 1

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Client: UPPER PENINSULA POWER COMPANY — Date Start - Finish: 10/12/88 - 10/12/88

Coordinates: N 64,499 E 38,391 — Ground Elevation: 771.6 ft

Groundwater Depth/Date: — Depth to Bedrock: — Total Depth Drilled: 12.5 ft

Contractor: STS CONSULTANTS LTD. — Driller: JOHN WRTIE — Rig Type: ROTARY

Methods: — Casing Used: 10 FT OF SURFACE CASING

Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD

Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER

Drilling Rock: NONE

Comments: Piezometer SW-11 was installed in boring, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Values	USC Symbol	Sample Description
771.6	0						
770							
		SS	1	1-7-5 (5.0")	12	SP-SM	SAND, fine, well graded, non-plastic, sub rounded, 5-20% gravel, moderatly weathered, max. .8", weathered sandstone, 5% fines, trace to 3% organics, pieces of wood & root hairs, dry, light brown, (fill).
	5	SS	2	2-4-4 (11.0")	8	SP-SM	SAND, fine, well graded, non-plastic, sub rounded, 20-30% gravel, moderatly weathered, max..8", weathered sandstone, 5% fines,trace to 3% organics, dry, light brown (fill).
765							
		SS	3	2-3-4 (12.0")	7	SP-SM	SAND, fine, well graded, non-plastic, sub rounded, 40-50% gravel, moderately weathered, max. .8", weathered bedrock, 5% fines, trace to 3% organics, pieces of wood & root hairs, dry, light brouwn, (soil horizons developed on top of weathered bedrock?).
	10	SS	4	10-10-9 (7.0")	19		SANDSTONE, fine grained, poorly graded, moderately weathered, soft, silica cemented, dry, brown, (weathered bedrock).
760							
							BOTTOM OF BORING AT 12.5 FT.
	15						
755							

Legend/Notes

- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.

* indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sampler

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-13 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/14/88 - 10/14/88
Coordinates: N 64,416 E 38,297
Ground Elevation: 788.1 ft
Groundwater Depth/Date:
Depth to Bedrock: 22.5 ft
Total Depth Drilled: 26.0 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: ROTARY

Methods:
Casing Used: 5 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: None

Comments: Piezometer SW-13 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
788.1	0						
785		SS	1	4-4-4 (13.0")	8	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded, max. 1.2, 5% fines, tace of organics, light brown, (fill)
	5	SS	2	2-2-1 (10.0")	3	SP-SM	SAND, as above
780		SS	3	1-5-9 (10.0")	14	SP-SM	SAND, as above
	10	SS	4	3-3-3 (8.0")	6	SP-SM	SAND, as above, base of sample recovered CLAYEY SILT, poorly graded, slightly plastic, dry, pink, (same material as "clay" blanket placed on the upstream side of the dam in the 1930's), rock in tip of split spoon sampler
775		SS	5	2-4-4 (8.0")	8	SP-SM	SAND, as above in sample 1
	15	SS	6	3-3-3 (8.0")	6	SP-SM	SAND, as above

Legend/Notes

- Datum is Sea Level
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  - SS = Split Spoon Sample
  - NX = NX Rock Core

Approved	Date
	01/24/89

Site: FOREST LAKE DAM   Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
770		SS	7	3-3-3 (8.0")	6	SP-SM	SAND, as above
	20	SS	8	6-5-5 (8.0")	10	SM	SAND, as above, bottom portion of sample SAND, fine, poorly graded, non-plastic, sub rounded, 20% gravel, sub rounded, soft, weathered bedrock, 10-15 fines, trace organics, yellow brown with lower 1" red brown, (contact with fill and weathered bedrock or alluvium)
765		SS	9	4-3-2 (4.0")	5	SM	SAND, as above, rock in tip of split spoon sampler
	25	SS	10	3-4-5 (11.0")	9	SM	SAND, fine, poorly graded, non-plastic, sub rounded, 10-20% gravel, sub rounded, soft, severely weathered, 15% fines, wet, yellow brown, (weathered bedrock)
760							BOTTOM OF BORING AT 26.5 FT
	30						
755							
	35						
750							
	40						
745							
	45						
740							

Note: See Sheet 1 for Boring Summary and Legend Information | Approved | Date 01/24/89

Stone & Webster Engineering Corporation

BORING LOG

Boring SW-14
J.O. 18372
Sheet 1 of 2

Site: FOREST LAKE DAM
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/18/88 - 10/18/88
Coordinates: N 64,415 E 38,172
Ground Elevation: 787.1 ft
Groundwater Depth/Date:
Depth to Bedrock:
Total Depth Drilled: 21.8 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: ROTARY

Methods:
Casing Used: 5 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: None

Comments: Piezometer SW-14 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
787.1	0						
785		SS	1	3-2-1 (11.0")	3	SP-SM	SAND, coarse to fine, well graded, non-plastic, sub rounded, 10-30% gravel, sub rounded, max. 1.2", 5% fines, trace of organics, dry, light brown, (fill)
	5	SS	2	2-9-8 (11.0")	17	SP-SM	SAND, as above, rock in tip of split spoon sampler
780		SS	3	3-2-4 (10.0")	6	SP-SM	SAND, as above, clumps of silty fine sand, dark brown
	10	SS	4	4-4-2	6	SP-SM	NO RECOVERY
775		SS	5	3-4-3 (8.0")	7	SM	SAND, as above, bottom 2" of sample is CLAYEY SILT, fine, poorly graded, slightly plastic, <5% gravel, 5-15% silt, moist, brown, (alluvium, soil horizon?)
	15	SS	6	4-3-4 (6.0")	7	SP-SM	SAND, fine, poorly graded, non-plastic, sub rounded, 15% gravel, sub rounded, 5% fines, wet, light brown, (alluvium)
770							

Legend/Notes

- Datum is Sea Level
- ⊻ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample
  NX = NX Rock Core

Approved	Date
	01/24/89

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-14 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
		SS	7	4-5-5 (7.0")	10	SP-SM	SAND, as above, 10% fines
	20	SS	8	5-6-6 (6.0")	12	SM	SILTLY SAND, fine, poorly graded, non-plastic, 10% gravel, sub rounded, 10-15% fines, wet, light brown, (alluvium)
765							
							BOTTOM OF BORING AT 21.8 FT
	25						
760							
	30						
755							
	35						
750							
	40						
745							
	45						
740							

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 01/24/89

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-15 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM, SPILLWAY
Client: UPPER PENINSULA POWER COMPANY
Coordinates: N 64,431 E 38, 565
Groundwater Depth/Date:
Contractor: STS CONSULTANTS LTD.

Depth to Bedrock: 6.7 ft
Driller: JOHN WRITE

Logged by: MIKE GASSER
Date Start - Finish: 10/20/88 - 10/20/88
Ground Elevation: 756.2 ft
Total Depth Drilled: 20.2 ft
Rig Type: ROTARY

Methods:
Casing Used: NONE
Drilling Soil: NONE
Sampling Soil: NONE
Drilling Rock: 0-1.5'4 "TRI-CONE BIT, 1.5-4.5' NX CORE, 4.5-6.3' 5.75" BIT 4" CORE, 6.3-20.2' NX CORE

Comments: Piezometer SW-15 was installed in borehole, see piezometer installation report for details.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N	USC Symbol	Sample Description
756.2	0						STARTER HOLE was drilled with a 4" tri-cone roller bit.
755		NX	1	100 / 95			CONCRETE, NEW DECK,(1.5-3.0), 10-12% aggregate, MSA 1.5", sub rounded to rounded, locally horizontal fracture (1.9') with white build up, calcium carbonate ?, dry, tan, (concrete) CONCRETE ORIGINAL CONCRETE (3.0-4.5'), 20-25% aggregate, sub angular to sub rounded, MSA 1", local iron staining around aggregate, dry, tan, (concrete).
	5	LD	2	100 / 92			CONCRETE, as above.
		LD	3	100 / 100			CONCRETE, as above.
750		NX	4	99 / 93			CONCRETE SANDSTONE CONTACT, concrete as above, contact at 6.7', contact was seperated when core barrel was open. SILTSTONE (6.7-8.0'), silt, well sorted, sub rounded to sub angular, very thinly bedded to laminated, wavy continuous to discontinuous to parrall bedding, to .5" is moderately weathered (water flowing along contact ?), rest is fresh unweathered, local very thinly bedded interbeds of bioturbated fine grained sandstone, well sorted, moist, yellow brown along weathered zones to grey, fresh rock, (bedrock). SANDSTONE (8.0-11.3'), medium to fine grained, sub rounded, well sorted, bioturbated, trace to 10% .4-.1" well rounded glauconite pellets, thinly bedded, wavy bedding, locally moderately weathered, well indurated, light gray to yellow brown along moderately weatherd areas.
	10						
745		NX	5	93 / 93			SANDSTONE, as above in the lower portion of run #4.
	15						
740		NX	6	97 / 97			SANDSTONE, as above, good inter-granular porosity, well flowed water at a rate of 20-30 GPM. Lost .15 ft of core.

Legend/Notes
- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  NX = NX Rock Core
  LD = 5.75" ID, 4" Core

Approved	Date
	07/08/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-15 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM, SPILLWAY — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
		NX					CONTIUED FORM PAGE ONE
	20						
735							BOTTOM OF BORING AT 20.3 FT
	25						DRILLING NOTES: Drilled starter hole (0.0-1.5') with a 4" tri-cone roller bit, drilled and recovered NX core from 1.5' to 4.5', entered hole with 5.75" ID core bit which cut a 4" core, reamed out hole to 4.5" and started coring to a depth of 6.3' at which depth the rods sheared off adjacent to core barrel-could not extract drill rod from core barrel, switched to NX core barrel.
730							
	30						
725							
	35						
720							
	40						
715							
	45						
710							

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 07/08/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-21 J.O. 18372 Sheet 1 of 1

Site: FOREST LAKE DAM, SOUTH LEVEE
Client: UPPER PENINSULA POWER COMPANY
Coordinates: N 33,246 E 37,500
Groundwater Depth/Date:
Contractor: STS CONSULTANTS LTD.

Depth to Bedrock:
Driller: JOHN WRITE

Logged by: MIKE GASSER
Date Start - Finish: 10/18/88 - 10/18/88
Ground Elevation: 781.5 ft
Total Depth Drilled: 15.5 ft
Rig Type: ROTARY

Methods:
Casing Used: 10 FT OF SURFACE CASING
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: Piezometer SW-21 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N / V_a / l_u	USC Symbol	Sample Description
781.5	0						
780							
		SS	1	1-1-2 (13.0")	3	SP	SAND, fine to medium grain, poorly graded, non-plastic, trace to 3% gravel, sub-rounded, max. 2.5 cm., < 5% fines, trace of organics/roots and root hairs, dry, light brown, fill
	5	SS	2	2-2-1 (9.0")	3	SP	SAND, as above, no organics, moist
775							
		SS	3	1 FOR 18" (3.0")	1	SP	SAND, as above, wet
	10	SS	4	2-1-2 (3.0")	3	SP	SAND, as above, 5% silt, fill
770							
		SS	5	2-3-8 (9.0")	11	PT	PEAT, organics and clay, slightly plastic, trace to 5% fine to medium sand, organics present as wood chips, roots, decomposed organics, wet, black, (bog deposit) SILT, poorly graded, non-plastic, bottom 2" of core, wet, light gray, alluvium
	15	SS	6	17-27-16 (14.0")	43	GP-GM	SANDY GRAVEL, silt to gravel grain size, well graded, non-plastic, 30-40% gravel, sub-rounded to angular, max. 1", 50-65% sand, coarse to fine, sub-rounded, 5-10% silt, wet, light gray, (alluvium)
765							
							BOTTOM OF BORING AT 15.5 FT

Legend/Notes

- Datum is Sea Level
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sampler

Approved	Date
	01/24/89

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-22 J.O. 18372 Sheet 1 of 1

Site: FOREST LAKE DAM
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/24/88 - 10/24/88
Coordinates: N 33,290.40 E 37,101.37
Ground Elevation: 781.13 ft
Groundwater Depth/Date:
Depth to Bedrock:
Total Depth Drilled: 8.7 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: POWER HAND AUGER

Methods:
Casing Used: NONE
Drilling Soil: 4" BORING WITH A LITTLE BEAVER POWER AUGER
Sampling Soil: GRAB SAMPLES OFF OF THE AUGER FLIGHTS
Drilling Rock: NONE

Comments: Auger borings where drilled to refusal point, a second auger boring was drilled to confirm the refusal point. If the two refusal depths varied more than .3" a third boring was drilled.

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery RQD	SPT N Value	USC Symbol	Sample Description
781.1	0	AG	1				SAND, medium to fine, poorly graded, sub rounded, <5% silt, light brown.
780							
	5						
775							
	10						BOTTOM OF BORING AT 8.7 FT.
770							
	15						
765							

Legend/Notes
- Datum is MSL
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  AG = Auger Flight Grab Sample

Approved	Date
	05/12/92

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-23 J.O. 18372 Sheet 1 of 2

Site: FOREST LAKE DAM, SOUTH LEVEE
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/18/88 - 10/18/88
Coordinates: N 33,266 E 37,119
Ground Elevation: 789.5 ft
Groundwater Depth/Date:
Depth to Bedrock:
Total Depth Drilled: 26.8 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: ROTARY

Methods:
Casing Used: DROVE CASING TO 25 FT.
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: Piezometer SW-23 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
789.5	0						
		SS	1	1-2-2 (9.0")	4	SP	SAND, medium to fine, poorly graded, non-plastic, sub rounded, <5% gravel, sub angular to sub rounded, max 1.2", <5% fines, dry, light brown (fill)
785	5	SS	2	1-1-2 (18.0")	3	SP	SAND, as above
		SS	3	1-2-1 (8.0")	3	SP	SAND, as above
780	10	SS	4	2-2-2 (8.0")	4	SP	SAND, as above, moist
		SS	5	2-1-6 (8.0")	7	SP	SAND, as above, moist, rock in tip of spoon
775	15	SS	6	2-1-1 (7.0")	2	SP	SAND, as above, saturated

Legend/Notes
- Datum is Sea Level
- ∇ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	01/24/89

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-23 J.O. 18372 Sheet 2 of 2

Site: FOREST LAKE DAM, SOUTH LEVEE — Logged by: MIKE GASSER

Elev (ft)	depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
		SS	7	1 for 18" (2.0")	1	SP	SAND, medium to fine, poorly graded, sub rounded, trace coarse sand, sub rounded, 5% fines, trace of organics, saturated, dark gray, (alluvium, bog deposit)
770	20	SS	8	18-24-19	43		No recovery, rock in tip of spoon
		SS	9	11-6-4 (12.0")	10	SW	GRAVELLY SAND, fine to medium, well graded, non-plastic, sub rounded to sub angular, 10-15% gravel, sub angular to sub rounded, 5% fines, trace of organics, saturated, gray dark brown, (alluvium)
765	25	SS	10	22-30-70 (9.0")	100		SANDSTONE, fine grained, poorly graded, sub rounded, severe weathered, mottled yellow brown to maroon, light gray inside less severely weathered rock fragments, saturated, (weathered bedrock)
							BOTTOM OF BORING AT 26.5 FT
760	30						
							DRILLING COMMENTS: Lost all of the mud in the mud pit at a depth of 23-25', drove casing from 10' to 25' to stop mud loss.
755	35						
750	40						
745	45						
740							

Note: See Sheet 1 for Boring Summary and Legend Information	Approved	Date 01/24/89

Stone & Webster Engineering Corporation	BORING LOG	Boring SW-25 J.O. 18372 Sheet 1 of 1

Site: FOREST LAKE DAM, SOUTH LEVEE
Logged by: MIKE GASSER
Client: UPPER PENINSULA POWER COMPANY
Date Start - Finish: 10/19/88 - 10/19/88
Coordinates: N 33,226 E 37,114
Ground Elevation: 776.6 ft
Groundwater Depth/Date:
Depth to Bedrock:
Total Depth Drilled: 9.0 ft
Contractor: STS CONSULTANTS LTD.
Driller: JOHN WRITE
Rig Type: ROTARY

Methods:
Casing Used: NONE
Drilling Soil: 4" TRI-CONE ROLLER BIT, REVERT DRILLING MUD
Sampling Soil: 2" O.D. SPLIT SPOON SAMPLER
Drilling Rock: NONE

Comments: Piezometer SW-25 was installed in boring, see piezometer installation report for details

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
776.6	0						
775							
		SS	1	1-0-1 (18.0")	1	SP	SAND, medium to fine, poorly graded, non-plastic, sub rounded, <5% gravel, sub rounded to sub angular, max. 1.5", <5% fines, dry, light brown, (fill)
	5	SS	2	1-5-7 (6.0")	12	SW	GRAVELLY SAND, coarse to fine, well graded, slightly plastic, sub angular, 5-10% gravel, sub angular, max. .75", <10% fines, trace to 2% black organic rick clay, wet, gray yellow brown, (alluvium)
770							
		SS	3	10-7-8 (9.0")	15	SW	GRAVELLY SAND, coarse to fine, well graded, slightly plastic, sub angular, 10-15% gravel, sub angular, max. .75", 50% of gravel is black chert, <10% fines, 1-3% black organic rich clay, wet, gray yellow brown, (alluvium, with soil profile development)
	10						
							BOTTOM OF BORING AT 9.0 FT
765							
	15						
760							

Legend/Notes

- Datum is Sea Level
- ∇ indicates groundwater level.
- ▮ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  SS = Split Spoon Sample

Approved	Date
	01/24/89