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224287

DAM SAFETY INSPECTION REPORT

TROWBRIDGE DAM
ID #00604
SW 1/4 SEC 12. T1N, R13W
KALAMAZOO RIVER
ALLEGAN COUNTY

OWNER: Michigan Department of Natural Resources

OPERATOR: Tyson Edwards
Allegan State Game Area
4590 118th Avenue
Allegan, Michigan

HAZARD POTENTIAL CLASSIFICATION: High

INSPECTED BY: Michael W. Oakland, P.E.
Stephen R. Amrein, P.E.
Todd W. King, P.E.
Camp Dresser & McKee
Detroit, Michigan

INSPECTION DATE: April 16, 2004

REPORT DATE: July 12, 2004

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INTRODUCTION

This report summarizes the results of a visual inspection of the Trowbridge Dam on the Kalamazoo River in Trowbridge Township, Michigan (Figure 1). The dam is being inspected as required by the Dam Safety regulations that stipulate high hazard potential dams be inspected every 3 years or 3 years following significant repairs. Repairs were made on the Trowbridge dam during the winter and spring of 2001 to temporarily stabilize the dam in the anticipation that PCB contaminated sediments would be removed within 5 years allowing the complete removal of the dam. No substantial progress has been made with respect to the removal of the sediments, and thus, for purposes of this report, it is assumed that the dam must meet the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 PA 451. This report is limited to a visual investigation and review of previous inspection reports, plans, and data which are available. This report should not be considered as an in depth engineering investigation.

The visual inspection was made by Michael Oakland, Stephen Amrein and Todd King of Camp Dresser & McKee. Paul Bucholtz (Michigan Department of Environmental Quality), James Hayes (Dam Safety Unit for the Michigan Department of Environmental Quality) and John Lerg, Scott Hanshue, Tyson Edwards and Sara Schaefer (Department of Natural Resources) were also present. Conditions during the time of the visit were sunny with temperatures around 60 degrees Fahrenheit. The water level at the dam was relatively low with about 6 inches of water flowing over the spillway. The flow of water obscured the spillway surface and downstream apron.

CONCLUSIONS AND RECOMMENDATIONS

The Trowbridge Dam is in very poor condition and has inadequate spillway capacity. The downstream apron of the dam and its training walls have largely broken away. A large sinkhole formed at the toe of the remaining spillway apron was filled with riprap as a temporary measure to dissipate energy, however continued erosion is possible and this should not be considered to be a permanent solution (see site sketches and photographs, Appendices A and B, respectively). While not observable on this visit, a hole broken into the spillway by a falling log or rock was previously observed. This suspected hole, while not penetrating the spillway, does create the potential for further accelerated deterioration. Also recently observed during higher pool levels is a sinkhole/seepage path on top of the dam. Dye poured into the sinkhole was seen exiting directly below the right training wall foundation indicating potential for undermining of the wall. The dam has inadequate slope protection on the upstream face which has resulted in recent sloughing on the upstream slope of the left embankment. While some patching was undertaken on the right training wall, the concrete continues to deteriorate in other areas where rough surfaces from the former partial demolition are exposed. Failure of the dam would have

potential severe environmental impacts as contamination currently isolated in impoundment sediments would be mobilized and transported downstream.

If the Trowbridge Dam is not to be removed in the very near future, the following recommended repairs should be completed as soon as possible. These repairs are listed by priority.

- Reconstruct the downstream portion of the spillway including the entire downstream apron which as broken off. Repair and underpin or entirely replace the spillway as required to provide adequate foundation support, patch deteriorated concrete and fix the hole recently created in the spillway ogee section. Replace missing sections of training wall upstream of spillway to avoid erosion of embankment.

- As part of the reconstruction, the new spillway should be enlarged (raised or widened) to meet the current capacity requirements for the design storm.

- Further investigate and grout or otherwise cut off seepage through the dam including the sinkhole/seepage path which exits below the right training wall foundation and seepage through the former penstocks and powerhouse.

- The entire left and right embankments should be re-graded, removing all trees and brush, and shaped with an even crest with upstream and downstream slopes no steeper than 3 horizontal to 1 vertical. The upstream slope of the re-graded spillway should be protected by riprap with grass planted over the remainder of the spillway. Additional slope protection should be provided on the downstream slopes in the range of potential backwater levels against the dam.

- Fill all erosion paths on the upstream and downstream areas of the embankment and abutments and vegetate with grasses.

- Fill around edges of grouted riprap and patch or seal cracks in riprap surface. Provide additional riprap at downstream edge of grouted riprap to avoid further loss of riprap.

- Provide gravel or other surface protection in parking area on top of left embankment.

PROJECT INFORMATION SECTION

The Trowbridge Dam and associated powerhouse were constructed in 1899 as part of a hydroelectric facility. In about 1965, the dam was decommissioned as a power generator and ownership of the dam was transferred from Consumers Power Company to the Michigan Department of Natural Resources (DNR) in 1967. The DNR raised and jammed the spillway control gates in the open position at that time to lower the upstream impoundment to the fixed weir level. In 1986, DNR removed the taintor gates and portions of the spillway above the fixed crest. Spillway abutment walls and the powerhouse were removed to an elevation approximately 10 feet above the crest of the spillway weir. At the same time, the embankment

slopes adjacent to the spillway and powerhouse were cut back to an approximate 4 horizontal to 1 vertical slope.

The dam is approximately 385 feet long. Looking downstream, the dam is comprised of an earthen embankment to the far left, the former taintor gates, the former concrete hydroelectric generation section, and the former transformer house at the right abutment. The section lengths are approximately 180, 80, 90, and 35 feet long respectively. The elevation datum used on the plans illustrating the partial demolition of the dam is not known, but it appears that a local datum of elevation (El.) 80 is approximately 680 feet using the National Geologic Vertical Datum (NGVD) (formerly the U.S.G.S. datum). Elevations mentioned in this report will be based on the datum shown on the demolition sheet.

No design drawings are available for the Trowbridge Dam. However, a limited amount of design information has been sketched onto the drawing used for the previous demolition work. Based on this drawing and descriptions in previous inspection reports and observations made during our site visit, the dam originally consisted of the following:

- A service spillway consisting of three 24 feet wide lift gates with 4 feet concrete buttresses between the gates. The sill of the taintor gates was set at El. 54.5. The original buttress between the lift gates had a top at El.71.25. Approximately 50 feet of concrete apron existed behind the sills. The top of the apron was at El. 48.25 with a bottom of the sill and apron at El. 45. The sill and apron are believed to be founded on the glacial deposits which underlie the area. An abutment wall was constructed on both sides of the spillway. The abutment wall on the left side was approximately 3 feet thick and bent to the left at the end of the buttress for the taintor gates, allowing the downstream apron to fan outward. The wall on the right side was part of the powerhouse and was about 6 feet thick. The wall originally extended as a straight wall 58 feet downstream from the end of the buttress which was approximately 35 feet beyond the end of the spillway apron. The top of the right abutment wall was at El. 58.0.

- A powerhouse to the immediate right of the spillway was approximately 90 feet by 35 feet in plan dimensions and had a top at El. 71.25 with a lowest level at El. 34.0. The powerhouse included three turbines with grates and raceways to each turbine. The powerhouse was founded in the glacial deposits which underlie the area. A near vertical concrete foundation wall formed the downstream side of the dam with the discharge below the water level.

- A generator building which measured approximately 35 feet by 50 feet in plan dimensions existed on the right abutment of the dam. No details of the building are available.

- A left embankment consisted of an earthen embankment up to about 35 feet in height with a crest at about El. 80. The embankment had a crest width of at least 50 feet with relatively flat upstream slopes and

approximately 2 horizontal to 1 vertical downstream slope. The embankment is currently grass covered with some saplings and brush.

PRIOR INSPECTIONS

As part of the 1986 demolition, a large portion of the powerhouse has been removed along with the spillway walls and buttresses to just above the level of the fixed spillway at about El. 60.5. A low area remains where the powerhouse existed with slopes of about 4 horizontal to 1 vertical extending upward from the removed powerhouse and left spillway abutment wall. During 1998 some cobbles and small boulders were placed over the downstream cut area on the left abutment as erosion protection.

Since the 1986 demolition, the dam has been inspected by the Dam Safety Unit in September 1993, August 1994 and September 1996. The 1996 inspection report by the DNR contained the following observations:

- The end of the left downstream abutment wall is cracked and separated by several inches. Water flowing through the crack is eroding the downstream embankment toe. The cobble and boulder riprap noted above was placed as a result of this erosion.
- Additional erosion of at the toe of the left embankment is occurring about midpoint between the spillway and abutment.
- Brush is growing within the embankment and along the crest of the remaining powerhouse foundation which is intended to act as an auxiliary spillway.
- Seepage is flowing from below the riprapped toe below the powerhouse foundation. However, the seepage is suspected to be through the turbine chamber rather than below the foundation.

The dam was inspected again in November 1998 by CDM for purposes of assessing interim repairs required to maintain the stability of the dam over the next 5 to 10 years during removal of PCB contaminated sediments upstream of the dam to allow for the dam removal. The inspection recommended that the large erosion hole downstream of the remaining apron be filled with large riprap to act as an energy dissipater to avoid further erosion, the heavily spalled concrete of the right training wall be patched, grouted riprap on the face of the downstream slope adjacent to the left training wall where severe erosion from overtopping had occurred be placed and some of the existing brush on the dam be removed. This work was completed in spring of 2001 and periodic inspections approximately every 6 months have been conducted since that time to assess the interim condition of the dams.

FIELD INSPECTION

Observations at the time of the site visit are summarized as follows:

- In general, the right embankment is uneven with a low area at the former powerhouse with demolition debris covering most of the embankment. The upstream edge is highly uneven with water forming pools in the debris as much as 15 feet into the embankment. A sinkhole/seepage path was seen on a former visit. Dye testing confirmed that it exited from below the right training wall foundation.

- Upstream portions of the right training wall are missing, causing water flow to move rapidly across the embankment on the right side.

- Upstream portions of the left training wall are missing, causing an area of the left upstream embankment to slough into the river.

- The missing training wall and low area of the embankment appears to allow overtopping behind the left training wall. Overtopping and/or surface water runoff are causing an erosion path in the upstream area and causing loss of topsoil from around the grouted riprap on the downstream side of the embankment.

- Brush and trees are present on the upstream and downstream areas of each embankment. No upstream erosion protection is present. In addition, areas of the left downstream embankment slope, where in contact with backwater pool, also require erosion protection.

- Cracks, 1/8-inch open, were observed in the grouted riprap on the left embankment. Cracks may be due to shrinkage or some movement, but appear to be stable over the last several visits.

- Parking area on top of left embankment is bare and required either grass or gravel protection.

- The area around the former powerhouse is low and continues to be an area overtopped during storm events.

- While not leaking at the time of this visit, recent visits during higher pool conditions have shown significant leakage through the embankment at the former powerhouse location. Continuing uncontrolled leakage could cause internal erosion of the embankment, ultimately leading to dam failure.

- Downstream areas of apron and training walls are broken off and missing. The large void which formed at toe of dam is filled with boulder fill as an energy dissipater. Boulder fill appears to be remaining in place.

- Erosion paths on upstream left embankment and downstream right embankment.

- Missing stones from toe of grouted riprap where grout penetration was inadequate.

It was not possible to confirm the condition of the downstream apron, stream bed below the apron or spillway buttresses. The large erosion hole that existed downstream of the dam (which was filled with boulder fill at the time of the previous repairs) likely contributed to the lateral movement and cracking of the downstream apron.

STRUCTURAL STABILITY

Given the condition of the downstream apron and presence of the large void, this area should not be considered to be stable. While the void was filled with large boulders to dissipate the energy and slow enlarging of the void, this should not be considered to be adequate for foundation support within the zone of influence of the void. In addition, in light of the seepage from below the left training wall, a void may also exist which compromises the support of the wall. This portion of the dam should also be considered as unstable until further investigations and adequate remediation are undertaken.

Continued erosion due to seepage/flow behind the training walls or through the powerhouse embankment will continue to result in sinkholes and the ground surface behind the walls should be considered unstable.

Continued deterioration of the concrete forming the piers and training walls, will also result in loss of stability of the spillway structure.

The dam embankments appear to be generally stable with no signs of displacement other than the sloughing where the training wall is missing as the left embankment. However, the area of the former powerhouse does overtop during storm events and while no significant erosion is currently visible, long term exposure to this event could cause instability of the embankment.

HYDROLOGY AND HYDRAULICS

The inspection report noted that the design discharge for the spillway is the 0.5 percent chance flood discharge of 14,300 cfs. This would result in a flood stage at about El. 65.7 at the dam which is about 5.2 feet above the top of the spillway abutments and the current embankment grade at the former powerhouse. The capacity of the spillway with a flood stage at the top of the spillway abutment walls is about 3900 cfs which is approximately equal to the estimated 10 percent flood.

Currently, each of the overflow areas has limited erosion protection consisting of vegetation cover, loose riprap and grouted riprap in the downstream area of the area behind the left training wall. This erosion protection is considered to be inadequate for the frequency of the overtoppings. The spillway capacity must be increased to the design storm condition.

OPERATION AND MAINTENANCE

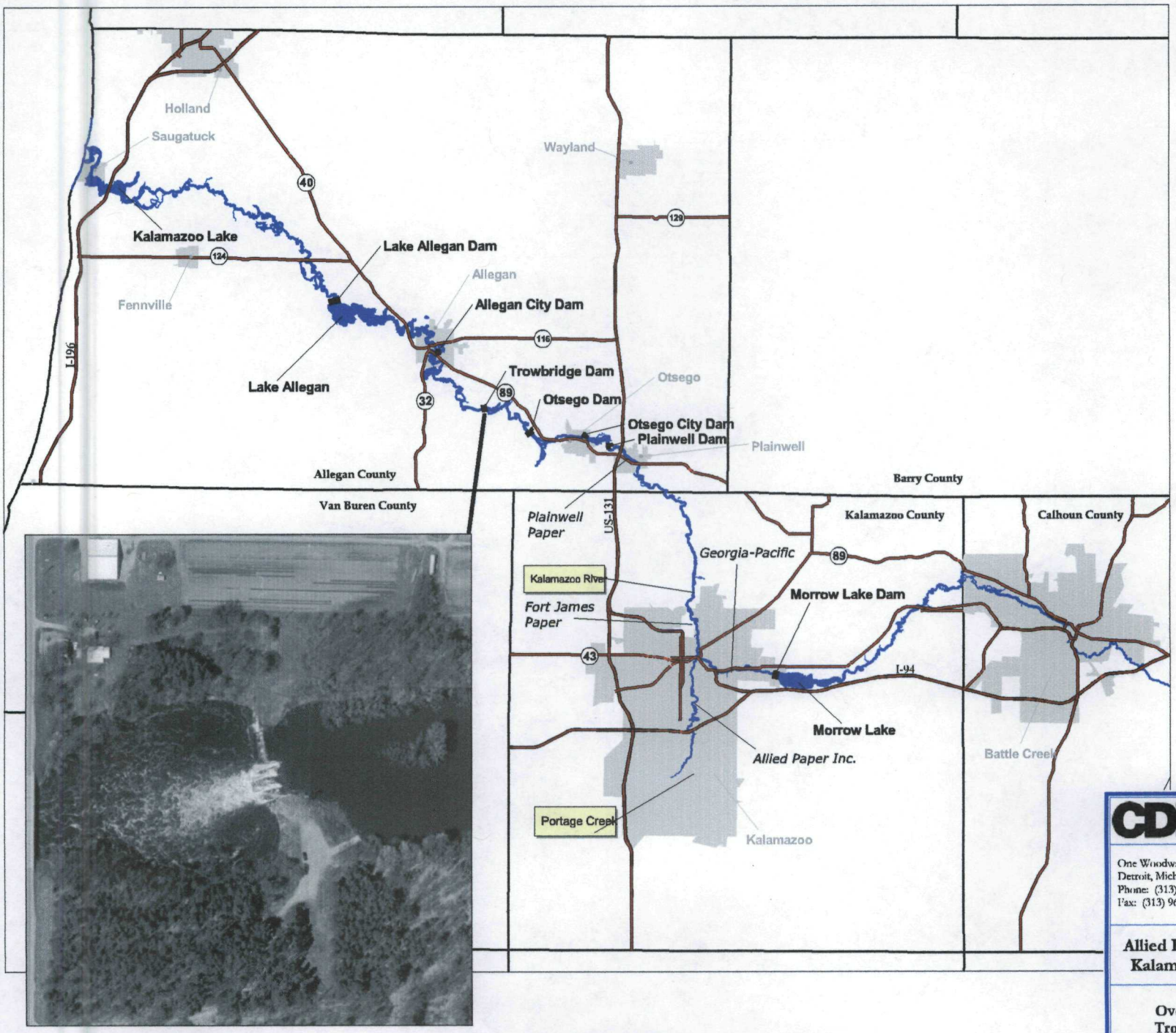
Operation of the dam is by Wildlife Division staff from the Allegan State Game Area. According to MDEQ and MDNR staff, a written operation and maintenance (O&M) plan has been developed for the dam and is on file with the Dam Safety Unit.

EMERGENCY ACTION PLAN

According to MDEQ and MDNR staff, an emergency action plan (EAP) has been prepared for this facility. A copy is on file with the Dam Safety Unit and with appropriate DNR offices. This EAP should be reviewed annually and updated as necessary.

APPENDIX

A sketch of the observations made at the time of the visit (Appendix A) and photographs from this inspection (Appendix B) are attached.



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6/11/04

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Overall Site Map Trowbridge Dam

Figure No. 1

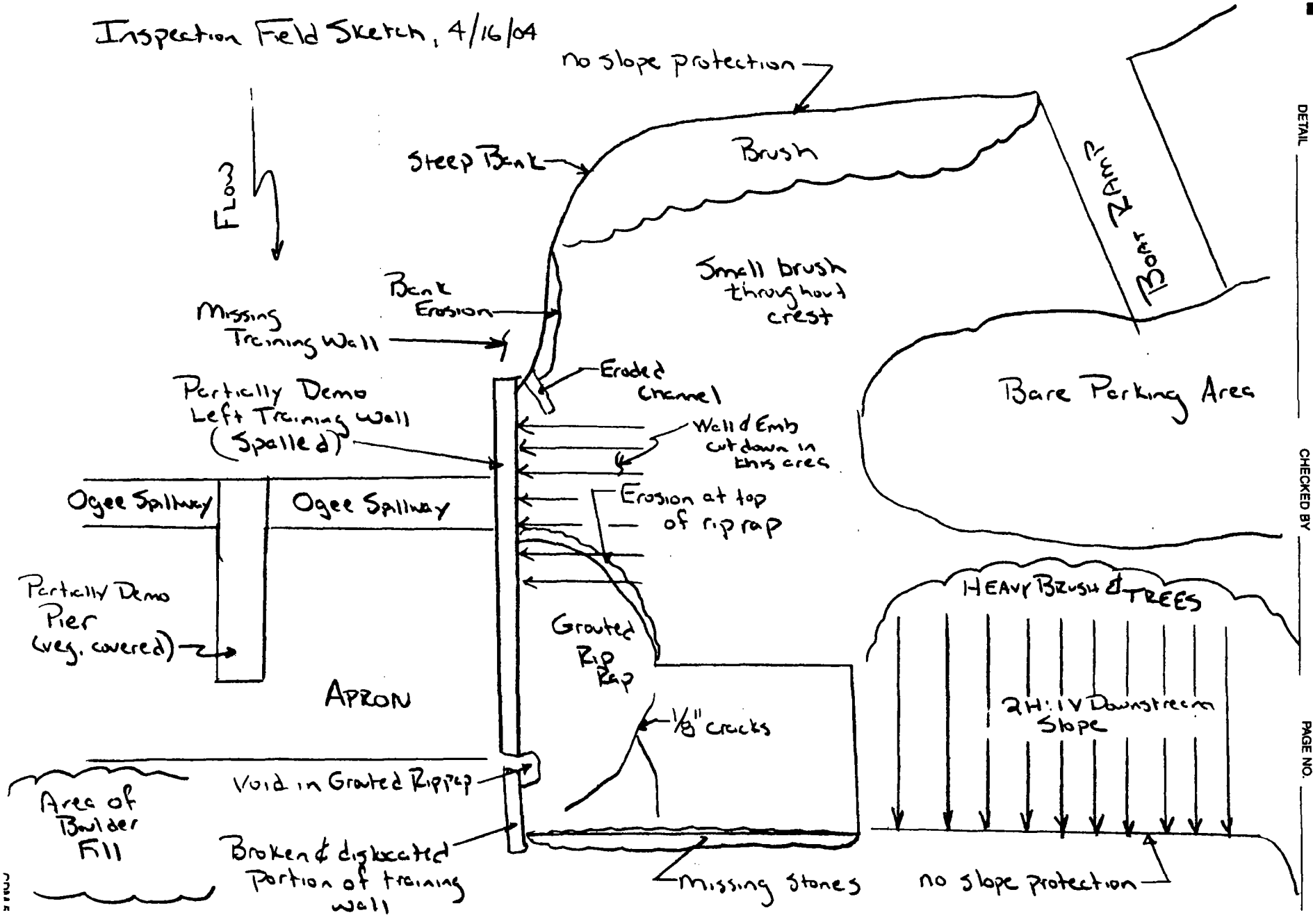
Site Sketches

April 16, 2004

Appendix A

TROWBRIDGE DAM, LEFT EMBANKMENT
NOT TO SCALE

Inspection Field Sketch, 4/16/04



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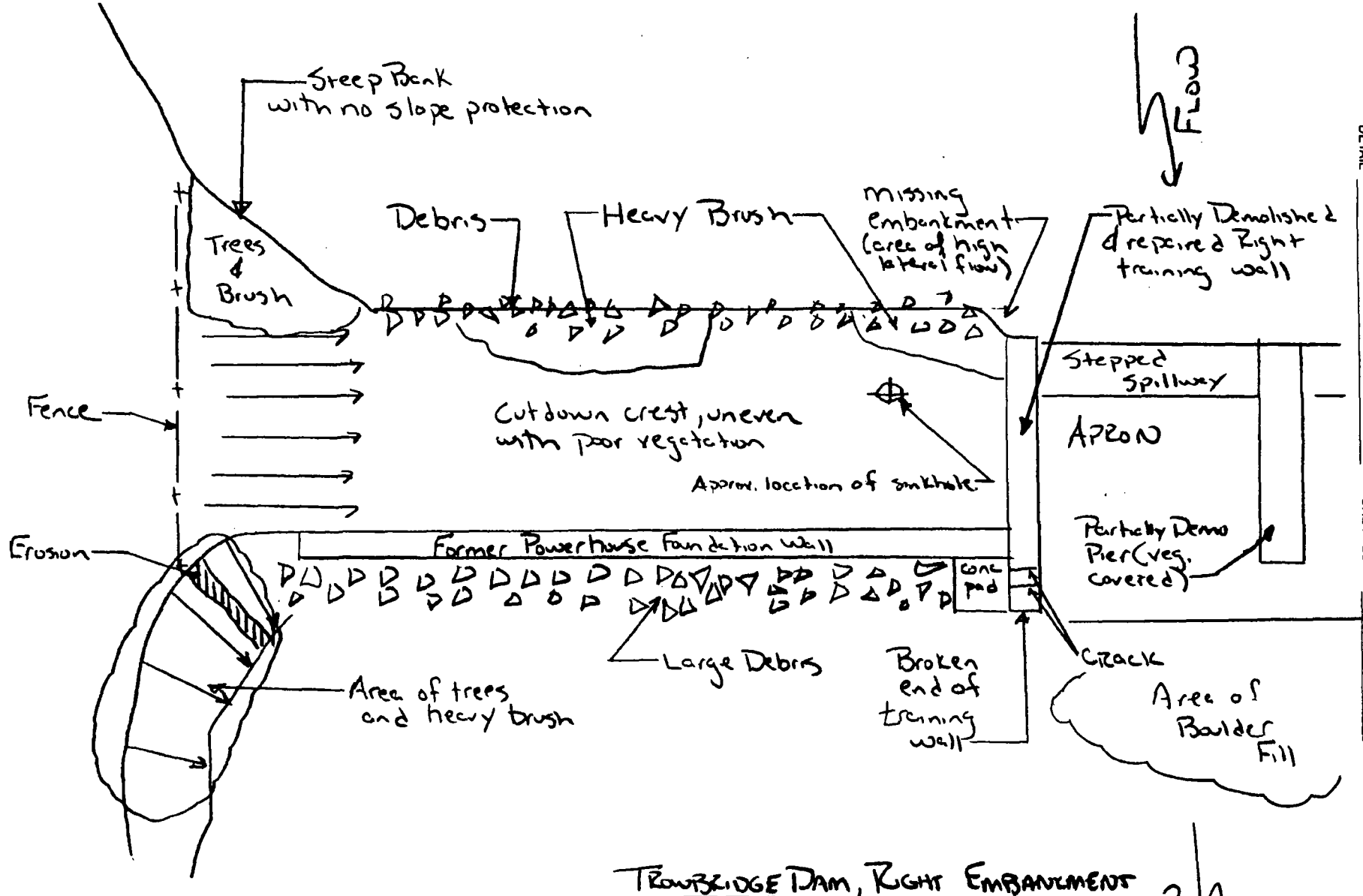

TROWBRIDGE DAM, RIGHT EMBANKMENT
NOT TO SCALE

Inspection Field Sketch, 4/16/04

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Site Photographs

April 16, 2004

Appendix B

Trowbridge Dam - Right Side

Crest of Right Embankment

Upstream Face of Right Embankment

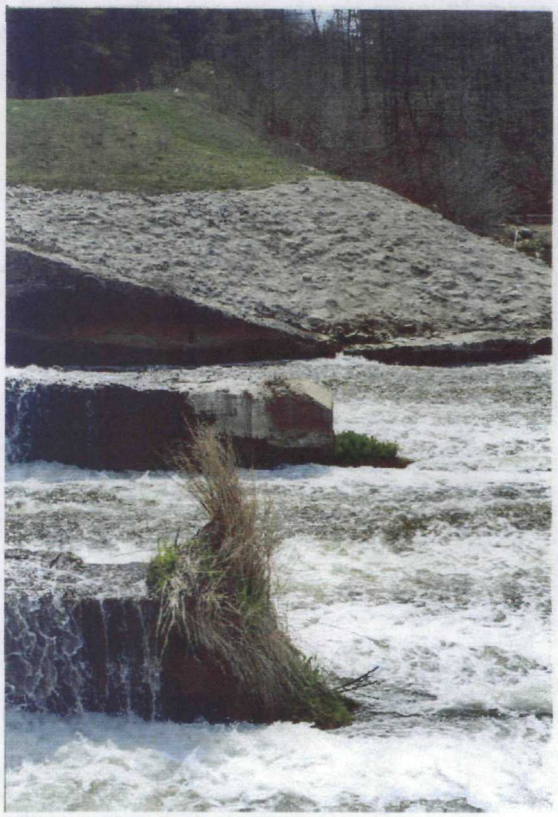
Trowbridge Dam - Right Side

Missing Wingwall and Lateral Flow at Upstream Face of Right Embankment

Cracks in Broken Downstream Right Training Wall

Trowbridge Dam - Right Side

View of Sloughing Soil and Erosion at Missing Left Upstream Training Wall



View of Grouted Riprap and Broken Downstream Left Training Wall

Trowbridge Dam - Left Side

Erosion on Upstream Left Bank

Animal Burrow on Downstream Face of Left Embankment

Trowbridge Dam - Left Side

Erosion along Edge of Grouted Riprap

Repaired Right Training Wall

Trowbridge Dam - Left Side

Brush on Downstream Slope of Left Embankment