Appendix A

Acres International Limited Dam Inspection Report

Form B2
November 12 and 20, 20002

Form B2

Dam Inspection Report

Date:	November 12 and 20, 2002
Structure:	Embro Dam
Municipality:	Zorra
Location:	County Road 16
GPS Coordinates:	UTM, NAD83: 17 506 888 E, 4 779 900 N Lat/Long: 43° 10' 19" N, 80° 54' 55" W
Inspected By:	B. Craig, T. Hartung, P. Last, M. Ragwen and B. Sinclair of Acres International Limited
Weather:	Overcast with occasional showers, air temperature approximately 6°C

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1. Earth Embankment

For details, see the photographs in Appendix A.

- Upstream bank overgrown with reeds and grass. No riprap slope protection visible. No erosion or benching apparent.
- Emergency spillway channel on right bank. Upstream end grassed and open but lower section overgrown with trees with piles of debris. Drilling mud visible in lower section.
- Downstream slope heavily overgrown with grass and shrubs. Erosion is occurring along the gully which follows the toe of the slope on the left side. Erosion occurring along the slopes of the downstream channel, possibly due to discharges from the pipe outlet.

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2. Concrete Structures (wingwalls, piers, deck, spillways, apron, etc)

For details, see the photographs in Appendix A.

- Concrete of the bottom draw inlet structure appeared in good condition.

- Concrete of the outlet conduit also appeared in good condition. Because of the flow in the pipe and the depth of the water at the outlet, a close examination along the length of the pipe was not performed to see if there was any misalignment along the length of the conduit.

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3. **Wooden and Metal Structures** (decks, gains, railings, conduits, etc)

For details, see the photographs in Appendix A.

- Bottom draw inlet structure trashrack is fabricated of galvanized steel, is in good condition, and is well-fastened to the concrete base.

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4. **Gates and/or Stop Logs** (identified looking downstream left to right)

For details, see the photographs in Appendix A.

Three stop logs are removed in the fall and replaced in the spring.

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5. **Water Level Gauge** (reading and condition)

For details, see the photographs in Appendix A.

No water level gauge was seen at this dam.

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6. **Winches** (type and number)

For details, see the photographs in Appendix A.

Stop logs are small enough that the top ones can be manipulated by hand. This occurs each fall and spring.

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7. **Valves** (type and number)

None at this site.

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8. **Boom** (driftwood, chains, anchors)

For details, see the photographs in Appendix A.

No boom present at this site.

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9. Erosion (upstream and downstream)

Erosion damage was seen on the downstream slope as indicated in Item 1 above.

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10. Seepage or Leaks

For details, see the photographs in Appendix A.

Close access to the pipe outlet was not possible for signs of leakage around the pipe. No other signs of leakage were visible.

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11. Access Route (location of gate keys, winch handles and keys)

Vehicular access is from the right, which is blocked by a locked gate. UTRCA and the Conservation Area staff have keys to unlock the gate. No keys or equipment are required to manipulate the stop logs. The parking lot and the path to the dam are not plowed in the winter season.

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12. Safety Issues (public and operator)

- No guard screen on the conduit outlet to prevent entry.
- Logs cannot be removed under overflowing conditions.

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13. Signage

For details, see the photographs in Appendix A.

- The only sign is one warning of unstable ice in winter.

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14. Divestment and/or Decommissioning Opportunities

Annual agreement with the Embro Pond Association for area management.

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15. General Remarks

There was a considerable buildup of weeds in front of the trashracks of the bottom draw inlet structure. Concrete is in good condition. Emergency spillway needs to be

excavated so that water flows down the alignment rather than down the toe of the left embankment. Slopes need to be cleared of vegetation.

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16. Recommendations

- Install riprap on slopes of outlet channel to prevent erosion.
- Excavate emergency spillway so water can flow along the alignment of this channel.
- Fill sinkhole and reshape downstream channel banks.
- Remove large vegetation with deep roots from slopes and from the emergency spillway alignment.
- Perform a topographic/bathymetric survey to define elevation of dam and emergency spillway and volume of the pond.
- Drill one hole in the dam to obtain information about the embankment and the foundation.

Appendix B

Acres International Limited Spillway Rehabilitation Letter

March 11, 2004

ACRES International

Acres International Limited
4342 Queen Street
P.O. Box 1001
Niagara Falls, Ontario, Canada • L2E 6W1
Tel: 905-374-5200 • Fax: 905-374-1157
www.acres.com

March 11, 2004
P14504.05.02
Seq. No. O-058

Upper Thames River Conservation Authority
1424 Clarke Road
London, Ontario
N5V 5B9

Attention: Mr. Chris Tasker, P.Eng.
Water Resources Manager

Dear Chris:

Dam Safety Program
Revisions - Embro Spillway Rehabilitation

I refer to my letter of February 2, 2004 (Seq No. O-054) and accompanying sketches of the recommended rehabilitation measures for Embro dam emergency spillway. Since that time, we have completed analysis of the 8-day rain and snowmelt event on the Embro dam drainage area and calculated the revised estimates of the inflow design flood (IDF) water level and corresponding outflow flood peak. The revised flood peak is larger than that previously estimated and would therefore require the previously designed emergency spillway to handle an approximately 31% higher flow. We have revised the designs of the emergency spillway crest and its outfall channel so that it would be able to handle the increased flow without freeboard encroachment. The design changes are modest but should be incorporated into your rehabilitation plans for the spillway to ensure it would have the necessary flood handling capacity.

Attached are three sketches showing the revisions to the proposed rehabilitation measures for the Embro dam based on observations made during the dam safety review, our previous discussions with you and our revised estimates of the outflow flood. These sketches supersede the ones previously sent to you.

The emergency spillway entrance should be excavated to a width of 11 m at an elevation of 99.26 m (based on local datum from the hazard identification drawing). The entrance invert and curve should be lined with cable-connected concrete blocks underlaid with a suitable geotextile to prevent the native material from becoming eroded as recommended previously. The emergency spillway channel should be excavated with a bed width of 6.50 m, 1.5H:1V side slopes and a bed slope of 0.0080 to prevent erosion. With respect to the connection between the spillway channel and creek, your proposal to flare out this channel horizontally and vertically over a sufficient distance as it enters the creek is feasible and should keep the exit down-slope velocity within the permissible limit.

If there are any questions on the details of the revisions, please do not hesitate to contact me.

Yours very truly,

Peter Last

PNL:mll

for M. E. McFarlane, P.Eng.
Project Manager

Encl (rehabilitation sketches)

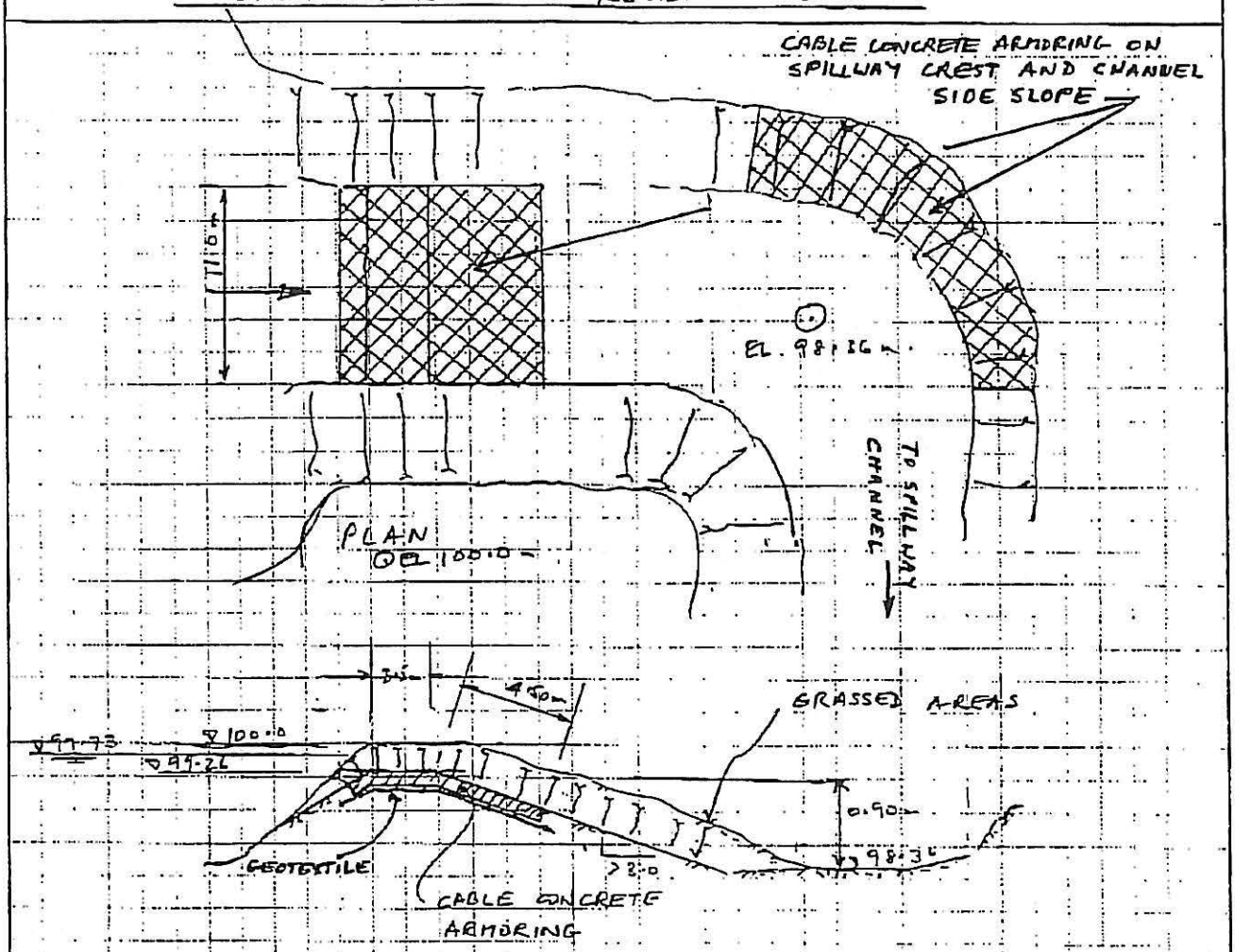
ACRES

Calculations

By RMM Date March 08/04 Project No. PIU504 08

Checked _____ Date _____ Calculation No. _____

Subject REVISION OF EMERGENCY SPILLWAY CREST DETAILS - REVISION #1 Page 2 of 3



CROSS SECTION @ EMERGENCY SPILLWAY ENTRANCE

Calculations

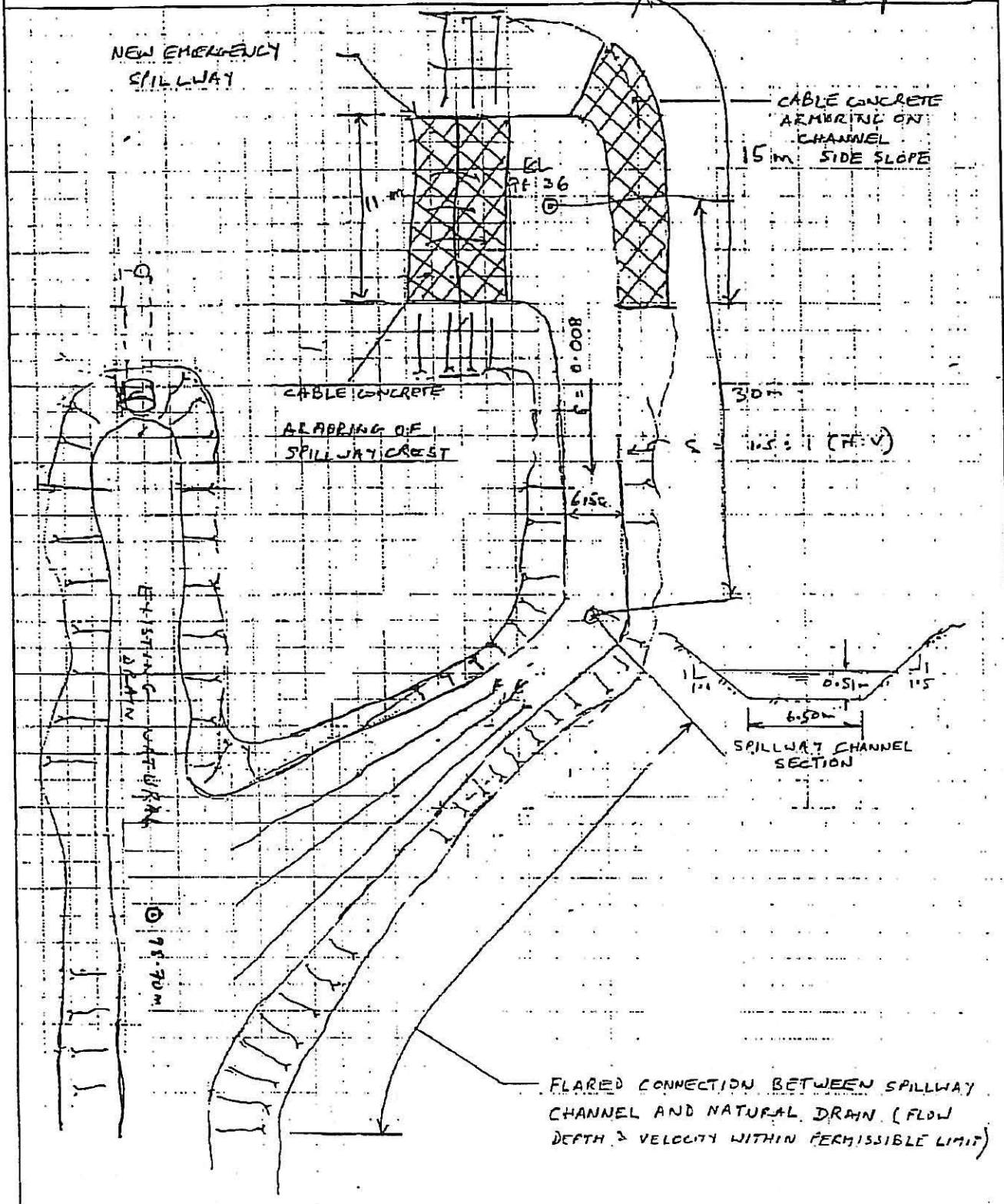
By KMM Date March 08/04 Project No. P1150 4.08

Checked _____ Date _____ Calculation No. _____

Subject EMBRO NEW SPILLWAY CHANNEL CONNECTION TO EXISTING DRAIN – REVISION # 1

Page 3 of 3

(2) of 3



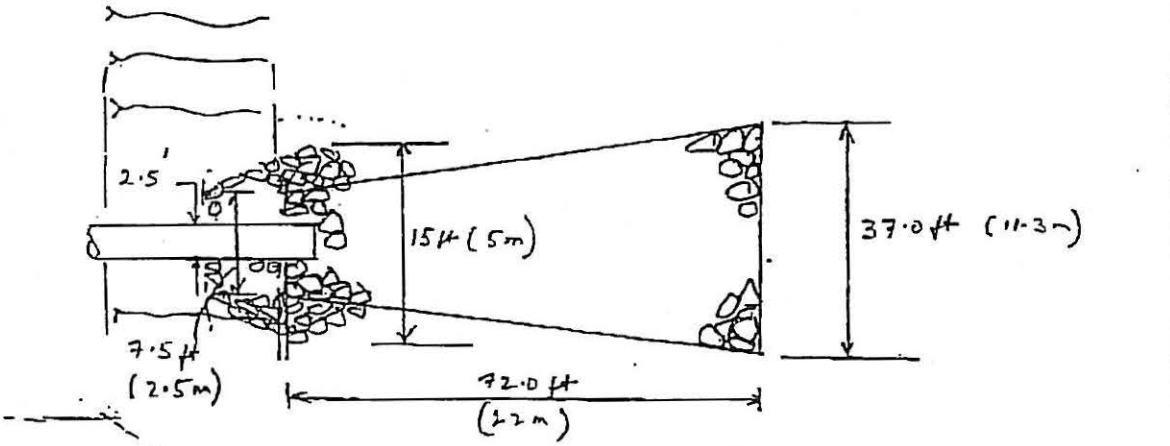
ACRES

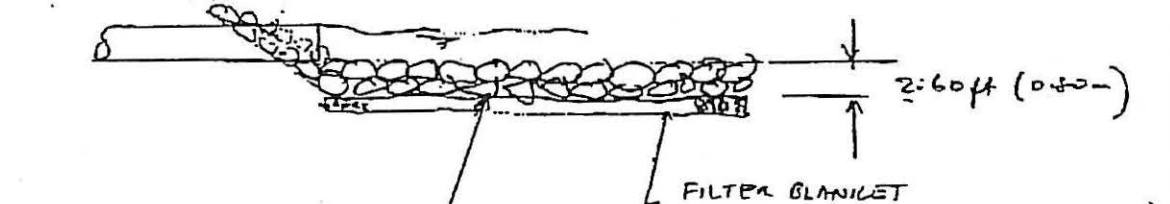
Calculations

By MMazzuca Date Jan 7/04 Project No. P145040r

Checked SH Date JAN 29/04 Calculation No.

Subject DIMENSIONS OF RIPRAP APRON PROTECTION AT PIPE OUTLET Page of





MEDIAN STONE SIZE (d_{50}) = 1.15ft (0.35m)
MAX. STONE DIAMETER = 1.73ft (0.53m)
IN WELL GRADED RIPRAP APRON

Appendix C

Acres International Limited Borehole Log, Laboratory Test Results and Civil/Structural and Geotechnical Assessment

Borehole 1 (Project No. P1450404)
Plasticity Chart (Project No. P1450404)
Grain Size Distribution (Project No. P1450404)
Civil/Structural Assessment (Project No. P1450404)
Geotechnical Assessment (Project No. P1450404)

BOREHOLE REPORT

CLIENT: Upper Thames River Conservation Authority
PROJECT: Dam Safety Assessment

HOLE: EM BH1
PAGE: 1 **OF:** 4

SITE: Embro Dam

COORDINATES: On dam centerline, 3.5m right of centreline culvert
DIP DIRECTION: 0
DIP: 90

ELEVATIONS
DATUM: Crest assumed elev 100m
PLATFORM:
GROUND: 92.64
END OF HOLE: 85.18

CONTRACTOR: Atcost Soil Drilling Inc.
DRILL TYPE: CME 75
METHOD SOIL: Hollow stem auger
ROCK:
CASING: Auger 200mm OD
CORE:

STARTED: 20 Nov 2003
FINISHED: 20 Nov 2003
INSPECTOR: D. Besaw
LOGGED BY: D. Besaw
REVIEWED: B. Sinclair
DATE: 10/13/04

See end of log for detailed groundwater measurements

ELEV. / DEPTH (m)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	TYPE/ NUMBER	REC'Y (mm)	RET'D (mm)	BLOW COUNTS	DEPTH (m)
92.64								
0.0		Embankment fill - dark brown clay (CL) with sandy fine gravel, soft consistency, medium plastic, moist, fine roots to 2 m, homogeneous, max size gravel is 20mm. The base of the fill consists of a brown firm clay (CL) with a 50mm layer of wet gravel in AQ 5.	0.76	AQ 1	480	480	2 1 3	1.0
			1.37					
			1.52	AQ 2	405	405	1 1 2	2.0
			2.13					
			2.28	AQ 3	585	585	0 1 2	
			2.69					3.0
			3.04	AQ 4	330	330	1 2 2	
			3.65					
			3.81					

SPT N-VALUES / DYNAMIC CONE PENETRATION: 20 40 60 80
SHEAR STRENGTH (kPa): UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.: 50 100 150 200
HYDRAULIC CONDUCTIVITY (m/s): 10^{-3} 10^{-4} 10^{-5}
WATER CONTENT & ATTERBERG LIMITS: 15 30 45 (%)
DRY DENSITY (kg/m3)

REMARKS AND GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Water level shown for 11/20/2003.

PIEZOMETER INSTALLATION

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
U - Wooden Box
Y - Core Box
Z - Discarded

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W_N — LIQUID LIMIT W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: Upper Thames River Conservation Authority **HOLE:** EM BH1

PROJECT: Dam Safety Assessment **PAGE:** 2 **OF:** 4

ELEV. / DEPTH (m)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	TYPE/ NUMBER	RECV (mm)	RETD (mm)	BLOW COUNTS	DEPTH (m)
			3.04	AQ 4	330	330	1 2 2	
			3.65					
			3.81	AQ 5	405	405	4 4 4	4.0
			4.42					
88.15 / 4.49		Glacial till (ML) - foundation material, tan colored sandy silt with subrounded fine gravel, maximum size of 10mm, dense to very dense, low plasticity, homogeneous, moist.	4.57	AQ 6	510	510	7 13 20	5.0
			5.18					
			5.33	AQ 7	630	630	11 17 20	
			5.94					6.0
			6.09	AQ 8	530	530	14 29 32	
			6.7					

SPT N-VALUES / DYNAMIC CONE PENETRATION: 20 40 60 80

SHEAR STRENGTH (kPa): ☐ UNCONFINED ■ QUICK TRIAXIAL ✖ FIELD VANE ✚ LAB VANE ◇ POCKET PEN. — 50 100 150 200

HYDRAULIC CONDUCTIVITY (m/s): 10^{-6} 10^{-5} 10^{-4}

WATER CONTENT & ATTERBERG LIMITS: 15 30 45 (%)

DRY DENSITY (kg/m3)

REMARKS AND GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

See gradation for AQ6.

PIEZOMETER INSTALLATION

SAMPLING METHOD

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Z - Discarded

PLASTIC LIMIT — NATURAL MOISTURE CONTENT — LIQUID LIMIT

W_P — W_N — W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: Upper Thames River Conservation Authority **HOLE:** EM BH1

PROJECT: Dam Safety Assessment **PAGE:** 3 **OF:** 4

ELEV. / DEPTH (m)	SYMBOL	DESCRIPTION	SAMPLE DEPTH	SAMPLE TYPE/ NUMBER	SAMPLE RECV (mm)	SAMPLE RETD (mm)	SAMPLE BLOW COUNTS	DEPTH (m)	SPT N-VALUES / DYNAMIC CONE PENETRATION (20 40 60 80) / SHEAR STRENGTH (kPa) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE, POCKET PEN.) (50 100 150 200)	HYDRAULIC CONDUCTIVITY (m/s) (10^{-6} 10^{-5} 10^{-4}) / WATER CONTENT & ATTERBERG LIMITS (15 30 45 (%))	DRY DENSITY (kg/m3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	PIEZOMETER INSTALLATION
85.18			6.85					7.0					
				AQ 9	530	530	15 29 40						
7.46			7.46										
		END OF BOREHOLE											

SAMPLING METHOD

A - Split Tube
B - Thin Wall Tube
C - Piston Sample
D - Core Barrel
E - Auger
F - Wash
G - Shovel Grab
K - Slotted

SHIPPING CONTAINER

N - Insert
O - Tube
P - Water Content Tin
Q - Jar
R - Cloth Bag
S - Plastic Bag
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Y - Core Box
Z - Discarded

PLASTIC LIMIT — NATURAL MOISTURE CONTENT — LIQUID LIMIT

W_P — W_N — W_L

Constant Head Test
Falling Head Test
Lab. Permeability

BOREHOLE REPORT

CLIENT: Upper Thames River Conservation Authority **HOLE:** EM BH1

PROJECT: Dam Safety Assessment

WATERLEVEL READINGS

11/20/2003 1:00:00 PM	2.71
12/22/2003 3:30:00 PM	2.75

NOTES/COMMENTS

1 **Water level Measurements**

Water level measurements are recorded from ground level.

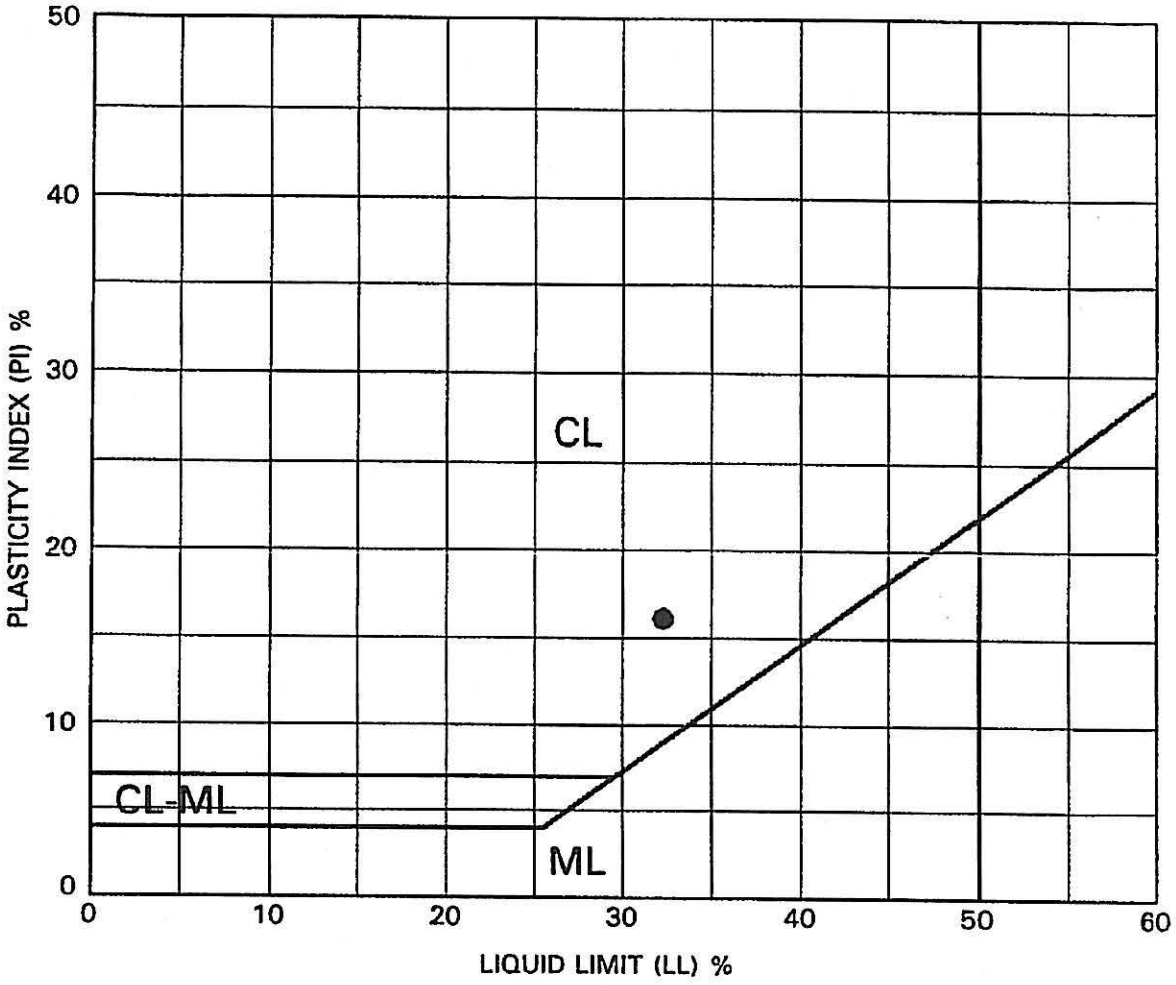
Reservoir level is +-1.3 m below crest for 2.71 reading and 1.49 m for the 2.75.

2 **Piezometer Installation**

Surface - Flush mount cap embedded in Sakcrete

0-0.76 Bentonite chips
0.76-3.20 Bentonite slurry
3.20-3.56 Coarse sand pack
3.56-4.48 Slottted screen in coarse sand pack
4.48-7.46 Coarse sand pack

Note: - riser and slotted screen consist of 50mm ID rigid, flush-coupled PVC



LEGEND	BH	DEPTH (m)	LL%	PL%	PI%
●	EMBH1	3.81	32	16	16

NP = Non-Plastic

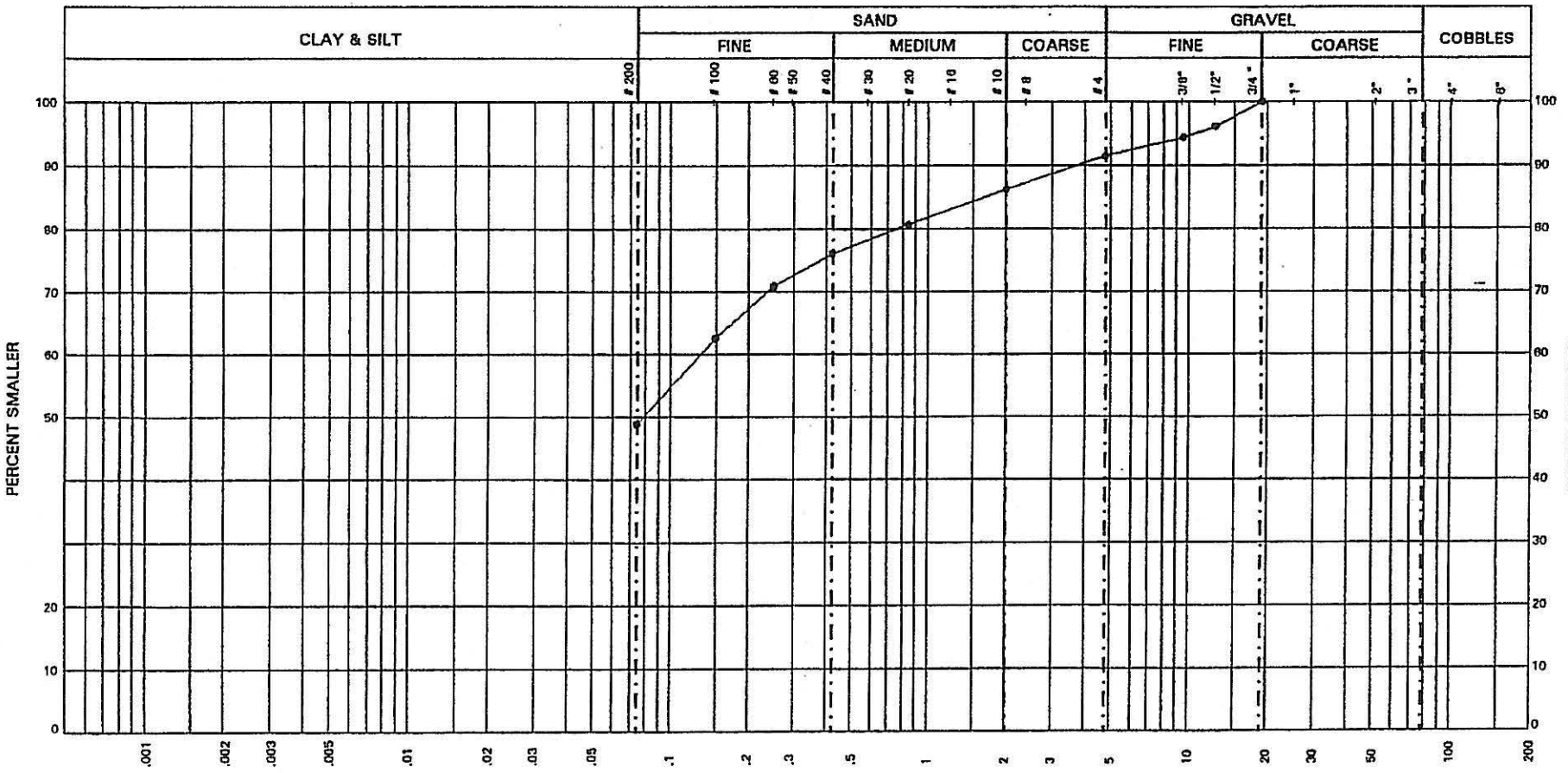
Geotechnical Investigations
Upper Thames Conservation Authority

PLASTICITY CHART
Embro Dam

PROJECT NO. P1450404
FIGURE NO.

ACRES

UNIFIED SOIL CLASSIFICATION SYSTEM



LAB SAMPLE NO.

LAB TEST NO.

DATE December 2003

TESTED BY RS

CHECKED BY AT

APPROVED BY

REMARKS: Embro Dam
UTRCA

GRAIN SIZE DISTRIBUTION

DEPTH	SAMPLE NO.	HOLE NO.	JOB NO.
4.57m	AQ8	BH1	P14504.04

ACRES

7 Civil/Structural Assessment

The Embro Dam is essentially an earth embankment with a bottom draw inlet structure located in the pond connected to a concrete pipe passing through the dam and an emergency spillway structure constructed on native material on the left bank. These structures do not lend themselves to stability analyses and thus none were performed.

Assessment of the earth structures is covered in Section 8.

8 Geotechnical Assessment

8.1 Geology

8.1.1 Regional Geology

The Embro Dam is on Spring Creek, a southward-flowing stream which is a tributary to the North Branch Creek. The North Branch Creek flows into the Middle Thames River just south of the dam. The latter and the Thames River to the southeast form the main drainage courses in the area.

The upland terrain is rolling and has a regional relief of about 30 m. The regional physiography has developed as a result of the latest glaciation.

According to government geological mapping (Min. Nor. Dev., 1991; Ont. Div. Mines, 1973), the area is characterized by thick deposits of glacial till which were deposited during the Wisconsin glaciation. Silty to sandy silt till with minor clay content, known as the Tavistock Till, predominates.

Deposits of sand and gravel glaciofluvial outwash and recent streambed alluvium exist along the Middle Thames River and the Thames River. These generally overlie the till. Local ice contact deposits such as drumlins also exist on the upland. Ancient beaches exist to the south.

Limestone bedrock underlies the area, but is only locally exposed.

8.1.2 Site Geology

The site is located in a relatively flat area of cultivated land. Overburden consisting of silt and sand, some limestone fragments and minor clay exists in the dam area and underlies the reservoir. The overburden overlies bedrock. Depth to top of bedrock is unknown.

8.2 Embankment Structure

8.2.1 Cross-Section Geometry

A typical cross section of the embankment is shown on the July 2001 Dam Hazard Identification drawing provided to Acres. This has been assumed to be typical. It is noted, however, that the upstream slope was not surveyed below the reservoir level. It is noted also that the survey showed erosion of the upstream face at the waterline. This erosion is wave-induced and was not previously noted during the site inspection due to the presence of thick reeds and grass along the waterline.

8.2.2 Foundation Preparation and Characteristics

There are no records of dam construction and of the foundation preparation. Based on the log of Borehole EM BH1, the absence of contaminating organics and topsoil suggests that all loose materials were removed prior to placement of the embankment fill.

8.3 Shear Strength Parameters

The embankment fill consists of clay with sandy gravel. Based on information presented in Section 5 and on an empirical correlation between effective angle of friction for clay-rich material and plasticity index (Holtz and Kovacs, 1981), an angle of friction of 31° was selected for the embankment fill. The material comprising the fill was assumed to be of a normally consolidated origin and, therefore, a cohesion of zero was assigned.

The foundation consists of glacial till comprising dense to very dense, sandy silt with gravel. Accordingly, an angle of friction of 38° and no cohesion were selected for the foundation, based on the in situ density and on Acres experience with the shear strength of tills in Ontario.

8.4 Bearing Capacity

The allowable bearing capacity of the glacial till foundation is estimated to be in the order of 600 kPa. The embankment exerts a maximum total pressure of approximately 80 kPa and, hence, the foundation has more than adequate bearing capacity.

8.5 Settlement

Embro Dam exhibited no signs of settlement, indicating no differential vertical movements since construction. Provided the vertical loads are not significantly increased and given the low seismicity potential of the site area, settlement of the embankment fill is not likely to occur in the future. The same applies to the foundation.

8.6 Liquefaction

The soils that comprise the embankment and the foundation are not considered to be liquefiable due to their clayey nature, grain-size, moisture content and liquid limit characteristics (Arumoli et al., 1999). The low seismicity potential in the site area also reduces the risk of liquefaction.

8.7 Seepage and Uplift

The water table in a homogeneous fill dam of this height is normally gently sloping from the reservoir to just above the tailwater. The inspection did not indicate any significant seepage. Very minor seepage may have existed, but may have been obscured by grass vegetation or may not have been evident due to evaporation.

8.8 Instrumentation

The only instrumentation in this dam is the piezometer referred to above. This monitors the phreatic surface. No other instrumentation is recommended.

8.9 Embankment Stability

8.9.1 Location of Sections

The stability of the earth embankment was examined. The section location taken for the stability analyses is through the highest portion of the dam at about its midpoint. At this section, the embankment is about 4.5 m high. Figure 8.1 shows the section used in the stability analysis.

8.9.2 Method of Analysis

Stability analyses were performed according to the limit equilibrium method of slope analysis utilizing the proprietary slope stability software SLOPE/W (GEO-SLOPE International Ltd.). All calculations were based on the effective strength method and analysis was performed according to the Morgenstern-Price method of slices with a half-sine function selected for the interslice force function. Several methods exist to perform slope stability calculations; however, the Morgenstern-Price method was selected since the appropriate factor of safety should be obtained from a slope stability method that satisfies both force and moment equilibrium.

8.9.3 Material Properties

Material properties were assigned based on typical values for these materials or as provided in the literature, since there were no laboratory tests performed to establish the shear strength of the embankment and foundation materials. Table 8.1 describes the properties for the various materials used in the stability analyses.

8.9.4 Phreatic Surface

A graphical method, as described by Craig (1997), was used to establish the phreatic surface and correspondingly the pore pressures within the embankment dam and foundation material. The graphical solution requires the plotting of a basic parabola. Figure 8.2 shows the details of generating the basic parabola for the dam. The phreatic surface is then obtained by applying the prescribed corrections to the basic parabola. Figure 8.2 shows the produced phreatic surface.

Table 8.1

Stability Analysis of Earth Embankments

Item	Acceptance Criteria	Calculated	Comments
General			
IHP			
Flood Conditions		Very Low	
IDF		50-yr flood	
Materials			
Embankment			
- embankment fill (CL)			
cohesion (kPa)		0	
ϕ (deg)		31	
moist unit weight (kN/m^3)		17.8	
saturated unit weight (kN/m^3)		19	
Foundation			
- glacial till			
cohesion (kPa)		0	
ϕ (deg)		38	
moist unit weight (kN/m^3)		18.5	
saturated unit weight (kN/m^3)		20.3	
Loads			
Normal water level (NWL)		98.82	
IDF water level		99.96	
Seismic, horizontal (S_h)		0.021*	* 2/3, i.e., 0.014g, was used in pseudostatic analyses
Load Combinations			
Upstream Slope			
NWL	1.5	1.24	Does not meet the criteria
Extreme (NWL, S_h)	1.1	1.18	
Extreme (IDF)	1.3	1.39	
Rapid drawdown	1.2	N/A	
Downstream Slope			
Normal (NWL)	1.5	1.16	Does not meet the criteria
Extreme (NWL, S_h)	1.1	1.12	
Extreme (IDF)	1.3	1.16	Does not meet the criteria
Rapid drawdown	N/A	N/A	

The piezometer installed in November 2003 indicates a water level slightly lower than what is determined from a parabolic analysis (Craig, 1997). This is possibly due to the relatively long length of equalization time required for the clay-rich embankment fill.

8.9.5 Seismic Parameters

The draft ODSG requires that dams withstand ground motions associated with a MDE. The MDE is selected based on the hazard potential classification and consequences of dam failure. In the case of the Embro Dam, an earthquake event with 1:100-yr return period was selected as the design load case for stability assessment. This selection was on the basis that the dam has a VERY LOW IHP classification.

Probabilistic earthquake parameters for the damsite, up to 1:1000-yr return period, were established based on data obtained from the Geological Society of Canada, and are shown in Table 8.2. The horizontal peak ground acceleration (PGA) is 0.021 for the 1:100-yr return period.

Table 8.2

Probabilistic Earthquake Parameters

Probability of Exceedance per Year	0.010	0.005	0.0021	0.001
Peak horizontal ground acceleration (g)	0.021	0.029	0.040	0.052

The pseudostatic method of analysis requires an equivalent sustained ground motion, and hence, two thirds of the PGA is considered appropriate. A ground acceleration of 0.014*g* was, therefore, applied in the stability analysis.

8.9.6 Load Cases

Load cases considered for the upstream and downstream slopes in the stability assessment are summarized in Table 8.1. The cases considered are normal, extreme (normal water level with earthquake or IDF) and rapid drawdown.

However, the rapid drawdown case was deemed as being not applicable to this site based on the discharge facilities available.

8.9.7 Results of Stability Analyses

The results of the stability analyses are provided in Table 8.1, together with the acceptance criteria and calculated factors of stability. Figures 8.3 to 8.8 graphically depict the cross sections analyzed and the minimum factors of safety established for both the upstream and downstream sections.

The upstream slope fails to meet acceptance criteria for the normal water level condition. The downstream slope fails to meet acceptance criteria for the normal water level condition and the extreme (IDF) condition.

A parametric study indicates that an unrealistically high angle of friction for the embankment fill would be required to bring the dam stability into compliance. It appears that the stability is being adversely influenced by the high water table which is characteristic of homogeneous dams.

It is noted that the stability analysis of the upstream slope was based on an assumed profile, and hence, the analysis should be confirmed using a surveyed profile.

8.10 Assessment

There is no evidence of settlement, cracking, displacement or sinkholes in the dam or in the abutments. Embro Dam is, however, poorly maintained; for example, there is no riprap protection on the upstream slope and wave-induced erosion has occurred (this conflicts with the site inspection report as explained in Section 8.1). A gully/sinkhole has been eroded on the left bank at the downstream toe. This appears to have been caused by emergency spillway overflow redirected towards the downstream toe of the dam instead of taking the planned route which was overgrown with grass. Some minor washing/erosion of the right bank downstream of the pipe outlet has also occurred as a result of this redirected overflow.

The dam does not meet all the required stability criteria. Stability of the upstream slope should be reviewed based on a surveyed profile.

Appendix D

Acres International Limited Recommendations and Costs

February 20, 2008

11 Recommendations and Costs

As a result of the 2002/2003 dam safety assessment, a number of recommended actions and maintenance activities were identified that are intended to ensure that the structure will satisfy current dam safety criteria within a 20-yr planning horizon. These ranged from routine monitoring to relatively major concrete rehabilitation works. In each case, an attempt was made to prioritize the remedial work requirements.

For each of the recommended issues, prefeasibility level cost estimates were developed based on an assessment of the general scope of work and typical unit price data from similar projects in Ontario. Note that the cost estimates that were developed were made on the basis of the actual estimated direct construction costs for the individual remedial action identified. As details of the contract packaging for a given dam are not known at this time, other costs (such as mobilization, control of water, increased access costs at remote damsites, contingency and engineering costs) were estimated on the basis of a percentage of the contract price according to the general guidelines summarized in Table 11.1.

Table 11.1

Summary of Additional Costs Associated With a Typical Remedial Repair Project

Item	Cost
Mobilization and demobilization	5% to 7% of capital cost
Control of water during construction	3% to 10% of capital cost (can vary significantly depending on complexity)
Barge access	10% to 15% of capital cost
Contingency	15% to 25% of capital cost
Engineering and supervision	8% to 15% of capital cost

In preparing cost estimates for repairing deteriorating concrete, it was generally anticipated that the scope of the repairs would include all of the deteriorated concrete and at least some of the concrete surrounding the repairs. It was usually assumed that, where necessary, the entire pier, upstream and downstream of the gains, would be repaired at one time. The actual timing of the repairs may, of

course, vary. For example, it may be cost-effective where the extent of upstream deterioration is relatively minor to undertake these repairs under a separate, smaller contract, at a later date. There was no attempt made to address the timing of repair issues in this report. It is also noted that costs for repairing areas of relatively minor deterioration, that are not considered to require attention at this time, were not developed.

An explanation of the priority numbers and concrete repair classifications are shown in Tables 11.2 and 11.3. Details of the recommended action and associated costs for the Embro Dam are summarized in Table 11.4. An overall cost summary of the remedial repairs, including allowances for engineering, permitting and environmental costs, is provided in Table 11.5.

Table 11.2

Explanation of Priority Numbers

Priority	Description
1	Immediate - Corrective action required immediately due to safety concerns.
2	High - Corrective action required within 2 years.
3	Medium - Corrective action required within 5 years.
4	Low - Corrective action required within 10 years.
5	Monitoring - Defect should be monitored with corrective action to be taken only when required.

Note: Each level reflects the relative importance or urgency associated with taking some form of action. In cases in which the defects were observed to be safety related (mostly Priority 1 items), action means actual construction. It is noted that some of the Priority 5 items may need to be reassigned a higher priority once the areas have been monitored and investigated and any defects have been identified.

Table 11.3

Concrete Repair Classification

	Description	Area (m^2)	Depth of Repair (mm)	Method
1	Sealing contraction joints (above water)	N/A	N/A	Remove existing cracked caulking by mechanical or other means. Clean joint of dirt and other residue. Apply backer rod if joint is deep. Apply primer. Apply polyurethane elastomeric sealant. Applicable to horizontal and vertical surfaces above waterline.
2	Sealing cracks and contraction joints below waterline	N/A	N/A	Requires diver. Remove existing sealant, if present. Clean joint of algae, etc, by wire brushing. Apply sealant such as Devclad 182 with ethafoam backing rod as required.
3	Bonding cracks (above waterline)	N/A	N/A	Required for structural bonding or to stop water leakage. Use epoxy injection for cracks less than 12 mm, cementitious injection for larger cracks. Where a crack is known to be damp or leaking water, use a water-reactive polyurethane resin.
4.1	Small vertical areas	0 – 2	1 – 50	Remove deteriorated concrete, saw cut, clean, trowel repair mortar
4.2	Horizontal areas	1 – 5	12 – 50	Remove deteriorated concrete, saw cut, pour free-flowing repair mortar
4.3	Large vertical areas	-	12 – 50	Remove deteriorated concrete, saw cut, shotcrete
4.4	Unlimited size vertical surfaces with deep deterioration	-	>75	Chip, saw cut, form and pour concrete. Dowels and rebar may be necessary.
4.5	Vertical areas with exposed rebar	-	12 – 50	Remove deteriorated concrete to 50 mm. Behind rebar, clean rebar of all rust, clean concrete and apply repair material.
4.6	Horizontal overlay with rebar	-	12 – 50	Remove deteriorated concrete to 50 mm. Behind rebar, clean rebar of rust, clean, apply overlay in accordance with manufacturer's directions.
4.7	Large areas of new reinforced facing concrete	-	>150	Roughen old concrete, dowel as required, place new rebar, form and pour concrete
5	Vertical grouting of masonry piers	-	-	Repoint masonry along wall faces. Drill vertically through pier from deck level. Grout using balanced, stable, cement-based suspension grouts to fill all voids and cracks in masonry.

Table 11.4

Estimated Remedial Repair Costs – Embro Dam

Item No.	Structure	Component	Defect Description	Repair Description	Repair Type	Estimated Quantity	Estimated Construction Cost (2004 $)	Priority	Remarks
1	Embankment	Upstream and downstream slopes	Stability of slopes do not meet criteria	Flatten slopes or add berms	-	1500 m^3	45,000	1	Survey first to verify inclination of slopes.
2	Emergency spillway	-	Flow does not stay within channel	Excavate clear path away from dam toe	-	420 m^3	8,000	2	During past floods, water has exited the channel and eroded the toe of the left bank.
3	Embankments	Upstream slope	Vegetation growing and some erosion occurring	Remove large vegetation and install riprap	-	22.5 m^3	2,250	2	Vegetation with a short root system such as grasses are beneficial in preventing erosion.
4	Embankments	Downstream slope	Vegetation growing	Remove large vegetation with deep roots	-	-	-	2	Vegetation with a short root system such as grasses are beneficial in preventing erosion. By UTRCA.
5	Downstream channel	Right bank	Erosion along bank	Repair erosion	-	-	Included in Item 2 above	2	From flow out of emergency spillway.
6	Drop inlet structure	Trashracks	Partially clogged with leaves, reeds and branches	Remove debris on a regular basis	-	-	-	5	By UTRCA staff.
7	Entire dam	-	Lack of signage	Install signs	-	4	1,500	2	Install "Use at Own Risk" signs at each end of dam and "Danger – Keep Away" signs on trashracks.

Table 11.4
Estimated Remedial Repair Costs – Embro Dam – 2

Item No.	Structure	Component	Defect Description	Repair Description	Repair Type	Estimated Quantity	Estimated Construction Cost (2004 $)	Priority	Remarks
8	Conduit outlet pipe	Pipe sections	Check alignment of pipe sections	First check visually	-	-	-	2	Perform during time of low flow. By UTRCA.
9	Entire dam	Crest	Overtopped during past floods	Redesign emergency spillway	-	-	Included in Item 2 above	2	Design already given to UTRCA.
10	Downstream channel	Banks and invert	Lack of erosion protection	Regrade and add riprap	-	160 m^3	5,600	2	As outlined in sketch by Mike Ragwen.
							62,350		

Table 11.5

Budget Estimate Summary of Construction Costs for Maintenance Repairs for the Embro Dam

Item No.	Description	Unit	Quantity	Unit Price ($)	Amount ($)
1	Mobilization and demobilization	LS	1	5,000	5,000
2	Repairs to dam and structures	LS	1	62,350	62,350
3	**Subtotal (Construction Costs)**				**67,350**
4	Contingency on Construction Costs (20%)				13,470
5	**TOTAL ESTIMATED CONSTRUCTION COSTS**				**80,820**

Appendix E

Naylor Engineering Associates Limited Report

February 20, 2008

INSPECTION REPORT

No. 2

Project: Dam Safety Assessment

Location: Embro Dam

Job No.: 7460G1

Inspection By: D. Kelly

Date: February 20, 2008

Time: 3:30 p.m.

Purpose/Type of Inspection: Visual inspection of Embro Dam
Weather: Partly cloudy, -9°C

Inspection Comments:

1. At the time of the site visit the Embro Dam was inspected. The ground was snow covered and the pond was ice covered except at the north end.

2. In general the Embro Dam appears as described in the Dam Inspection Report from November 2002 that is contained in the Acres International Report.

3. It was noted that there is strong flow at the outlet pipe and the erosion gully on the east side of the outlet pipe is quite deep. It is possible that water seepage is occurring into the erosion gully although none was visible at the time of the inspection.

4. It was also noted that the ground surface elevation on the downstream side of the earth embankment on the right (west) side of the outlet is close to the water level in the pond.

5. Based on our visual assessment the stability the earth embankments is satisfactory but there are problems at the outlet and overflow spillway.

6. It is recommended that three boreholes be drilled at the site to obtain information about the embankment foundation.

Inspection Comments:

7. The actions that will likely be required to ensure long term stability of the dam are as follows:

   a) Infill eroded gully with compacted Granular 'B',
   b) Extend outlet pipe to the south and construct a cutoff collar around the pipe;
   c) Partly fill the outlet channel with Granular 'B' after extending the outlet pipe;
   d) Install rip rap in outlet channel;
   e) Regrade emergency spillway and remove trees; and,
   f) Install subdrain in gully before filling.

8. The above recommendations are preliminary. Further geotechnical study and a detailed topographic survey are required.

Distribution:

1cc: Upper Thames River Conservation Authority
Attention: Mr. David Williams

Dennis Kelly, P.Eng.

TABLE 2

Embro Dam
Dam Safety Assessment
Thames River Watershed

ITEM	COMMENTS
Foundation Soil	Glacial till
Core Material	Clay with sand and gravel, loose
Construction Control	None
Design Parameters	None
Rip-Rap Erosion Protection	None
Spillway	None
Conduit Through Dam	Yes
Emergency Spillway	Right side, poor condition
External Erosion	Upstream slopes and outlet channel
Under Seepage	Unknown
Artesian Conditions	No
Dam Distortion	Unknown
Dam Settlement	Unknown
Uplift Pressure	No