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## REPORT TO LYALL HARBOUR BOOT COVE WATER LOCAL SERVICE COMMITTEE MEETING OF FRIDAY, NOVEMBER 7, 2014

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**SUBJECT**     **DAM SAFETY IMPROVEMENTS - MONEY LAKE DAM NO. 1**

### **ISSUE**

To provide background information regarding dam safety legislation and further details related to the proposed dam safety improvements for Money Lake Dam No. 1, Saturna Island.

### **BACKGROUND**

Money Lake Dam No. 1 is located adjacent to Harris Road and creates a reservoir of raw water used by the community of Lyall Harbour Boot Cove (LHBC). The dam was initially constructed in 1978 by the Money family and subsequently raised in 1981 by the Capital Regional District (CRD). Currently, there are six water licenses issued by the Province of BC related to this body of surface water. The CRD has five (5) of the water licenses. The holder of a water license has obligations and responsibilities associated with dam ownership.

In the Province of British Columbia dam structures are regulated under the British Columbia Dam Safety Regulation (Regulation) of the Water Act. The Regulation was passed into law as Regulation 44/2000 under the Water Act effective February 11, 2000, and there were two amendments to the Regulation in 2011.

A dam owner is expected to conduct site surveillance and formal inspections, monitor instrumentation, test the operation of outlet facilities, prepare and maintain an Emergency Preparedness Plan, maintain an Operation, Maintenance and Surveillance Plan, conduct dam safety reviews by qualified professional engineers and implement action items and report to the regulators, and annually review downstream conditions for changes in land use and risks related to dam-breach.

The Regulation rates dams according to the Dam Failure Consequence Classification system based on population, potential loss of life, environmental and cultural values and infrastructure and economics. The Dam Safety Officer has determined the dam failure consequence classification is "HIGH" for Money Lake Dam No. 1. The Province's "HIGH" classification notes that permanent population is located in the dam-breach inundation zone. More specifically for LHBC, a dam-breach may result in the loss of water supply for the community, damage roads and drainage systems, the community recreation centre, ambulance station, fire hall, water treatment plant, and commercial and residential property. It should be noted that drainage improvements were made relative to the community centre to guard against a dam-breach.

The purpose of the CRD's dam safety program is consistent with the legislation. The CRD's dam safety program was primarily established for the water supply dams within the Regional

Water Supply Commission's service area for Greater Victoria and more recently, included the local services and the dams operated and maintained by the CRD's Parks and Environmental Sustainability Department. In total, the CRD Integrated Water Services Department is responsible for the safe operation and maintenance of 27 dams and provides support for another eight dams throughout the region.

Money Lake Dam No. 1 is an earthen embankment structure approximately 50m in length and 7m in height originally constructed in 1978 by the private property owner and was raised in 1981 by the CRD. A concrete spillway was built on the east side of the dam in 1986 to replace a culvert spillway. In 2007, a trench was excavated at the west end of the dam crest in an effort to control seepage at the site by installing a core. Seepage continues at several locations at the downstream toe of the dam and west abutment.

Since 1978, there have been several specific reports completed related to the Money Lake Dam No. 1 and potential consequences of a dam breach. In accordance with the Regulation a dam safety review (Tetra Tech EBA, April 2012) was completed by professional engineers and is the most comprehensive study to date. The review contained eight recommendations and provided cost estimates to complete each improvement or assessment. These dam safety items were reviewed by the Committee and in November 2013, a decision was made to retain Tetra Tech to further refine the work and cost estimates and they delivered a report dated May 2, 2014 which is attached and their findings are summarized as follows:

Raise the Dam Crest – Tetra Tech's earlier report identified work to increase the dam freeboard. Upon further review and a more accurate survey of the dam crest, Tetra Tech concluded that the existing dam crest was of sufficient height and no further work was required.

Installation of Gravel Berm/Toe Drain – The earthen fill dam requires a functioning toe drain to ensure the performance of the dam to maintain slope stability. Tetra Tech recommended to collect soil samples through a drilling program, install piezometers to monitor the peizometric level (water table) and the drilling is proposed to be completed with the soils investigation described later.

Once the field data is collected and analysed, the toe drain detailed design can be completed and construction carried out. It is proposed to complete the soils investigation in 2016 and design the work in 2017 and construct in 2018. Until such time the toe drain is installed and commissioned it is prudent to monitor the dam status and take appropriate action in accordance with the Emergency Preparedness Plan should the dam's performance change. The estimated cost for the toe drain by Tetra Tech was \$63,530 excluding GST and additional effort by CRD staff and contingency amounts total \$90,000.

Replace the Log Boom – A log boom is intended to prevent floating debris from entering the spillway and obstructing flow. At the time of the dam safety review in 2012 it was noted that the existing log boom was partially submerged and the anchors were loose. It is proposed to remove the existing boom system and replace it with new logs, chains and anchoring system. The logistics of construction will be somewhat challenging to install the anchoring system especially on the east side of the spillway. Tetra Tech estimated the cost to be \$7,200 and additional effort by the CRD and contingency amount total \$10,000 and the work is proposed to be completed in 2015.

Soils Investigation and Seismic Assessment – Tetra Tech noted that there is little information regarding the embankment materials of the foundation and recommended that a drilling program be conducted to obtain soils information for a simple seismic analysis. Further, a drilling program would collect soils samples to assist with the design of the gravel berm/toe drain and leave in place piezometers to be used to monitor the groundwater level within the dam in the future. Tetra Tech estimated the cost to be \$34,849 excluding GST and additional effort by the CRD and contingency amount total \$40,000. It is proposed to complete this work in 2016.

In addition to the items of work by Tetra Tech, the following items were identified to be completed:

Re-Caulk Concrete Spillway Joints - The routine inspections conducted by the CRD staff noted that the joints within the concrete spillway could leak water into the dam structure and therefore, pose a hazard. It is proposed to prepare and re-caulk the joints by engaging the CRD staff to remove debris from the joints, procure and install caulking material at a cost of up to \$2,000 with the work to be completed in 2015.

Operation, Maintenance and Surveillance Manual and Emergency Preparedness Plan – The Regulation requires that a dam owner prepare an Operation, Maintenance and Surveillance Manual that describes the dam owner's procedures for the dam. The current version of the manual dates back to July 2000.

Further, because of the high consequence rating an Emergency Preparedness Plan is required to be prepared and submitted to the Dam Safety Officer and the plan would be utilized should there be a dam emergency.

It is proposed to engage the CRD staff who are familiar with the preparation and content that is expected by the Dam Safety Officer. It is estimated that both documents be prepared at a total cost of up to \$4,000, which is primarily CRD staff effort and it is proposed to be complete the documents in 2015.

### **RECOMMENDATION**

That the Lyall Harbour Boot Cove Water Local Service Committee receive this report for information.

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Fraser Hall, A.Sc.T.  
Senior Technologist

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Scott Mason, BSc., P. Eng.  
Concurrence, Manager, Water Engineering  
and Planning

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Peter Sparanese, P. Eng.  
Senior Manager, Infrastructure Engineering  
and Operations  
Concurrence

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Ted Robbins, B.Sc., C.Tech.  
General Manager, Integrated Water Services  
Concurrence

FH/SM:ls

Attachments: 1 (Tetra-Tech Report of May 2, 2014)

May 2, 2014

Capital Regional District  
Integrated Water Services  
479 Island Highway  
Victoria BC, V9B 1H7

ISSUED FOR USE  
FILE: V13103344-01  
SGudavicius@crd.bc.ca

**Attention:** Mr. Sigi Gudavicius, P.Eng  
Manager, Engineering Services

Dear Mr. Gudavicius,

**Subject:** Money Lake No. 1 Dam, Saturna Island, BC  
Refined Cost Estimates

## 1.0 INTRODUCTION

In 2011, Tetra Tech EBA Inc. (Tetra Tech EBA) completed a Dam Safety Review (DSR) of the Money Lake No. 1 Dam as presented in our April 2012 report. That report contained eight recommendations and provided approximate costs to complete each item.

Subsequently, the Capital Regional District (CRD) requested that Tetra Tech EBA refine these tasks and cost estimates such that the Lyall Harbour/Boot Cove Local Service Committee could assign the appropriate budget. A proposal was submitted February 4, 2014 to the CRD to refine the costs for six of these items. Discussions between CRD (Mr. Gudavicius) and Tetra Tech EBA (Bob Patrick) regarding the proposal led to the scope of services presented below.

## 2.0 RECOMMENDED ACTION ITEMS

### 2.1 Raise the Dam Crest

The CRD agreed to complete a topographic survey and provide this data to Tetra Tech EBA such that an assessment of the required work to raise the dam crest could be undertaken.

### 2.2 Installation of a Gravel Berm/Toe Drain

The information is not complete regarding embankment materials, filters, and drains. Therefore there exists the potential for migration of fine materials. Tetra Tech EBA is to prepare a conceptual design of the work required and a cost estimate to complete this work.

### 2.3 Increased Inspection Frequency

Until the gravel berm/toe drain is in place it is recommended the frequency of inspection of the dam/toe be increased. CRD agreed that the frequency would be increased to a minimum of twice a week. Mr. Gudavicius has confirmed that this has been implemented.

### 2.4 The Intake Valve was Inoperable

The CRD has confirmed that the Intake Valve is operating therefore no further action is required.

## 2.5 Replace the Log Boom

The log boom is partially submerged and the anchors are loose. Tetra Tech EBA will provide an updated cost estimate for this.

## 2.6 Site Investigation and Seismic Assessment

There is little information regarding the embankment materials or the foundation. A drilling program will be undertaken such that parameters can be developed to assess the seismic stability. A scope of work and cost estimate will be developed for this assessment.

## 2.7 Update the Operation, Maintenance, and Surveillance Plan

The CRD has confirmed they will undertake this.

## 2.8 Update the Emergency Response Plan

The CRD has confirmed they will undertake this.

This report has been prepared to present our refined scope of work and cost estimates for Items 2.1, 2.2, 2.5, and 2.6.

## 3.0 DAM CREST ELEVATION

Based on the topographic data available at the time of the DSR, it was estimated that the dam crest was 0.28 m too low to prevent 95% of the waves from overtopping it during the passage of the Inflow Design Flood (IDF).

The CRD recently completed a more accurate topographic survey of the dam crest and the top of the concrete spillway walls.

The new information shows:

Spillway weir crest:	Elevation 150.54 m
Top of spillway walls:	Elevation 151.54 m to 151.57 m
Dam Crest:	Elevation 151.9 m
Lake Level at IDF:	Elevation 151.32 m
Allowance for waves:	0.28 m
Required Crest:	Elevation 151.6 m

Therefore, the crest of the dam is of sufficient height to meet the freeboard requirements.

The IDF lake level is well below (0.22 m) the top of the spillway walls. However, some waves may overtop these walls by 60 mm. There is thick grass cover on the fill slope near the spillway walls, which should provide adequate resistance to erosion should this occur.

Tetra Tech EBA therefore concludes that the crest and spillway walls are suitable to pass the IDF and resist wave overtopping.

## 4.0 GRAVEL BERM/TOE DRAIN

There is some conflicting information regarding the drainage provisions at the downstream toe. The August 1979, CRD, "As Constructed" drawing (VI6553-1-18) indicates an "Approved gravel filter material" zone extending from the crest to near Elevation 146 where it ties in to a perforated 300 mm diameter, 12 m long, galvanized steel drain pipe that extends from the base of the filter to Manhole 1. The 300 mm diameter pipe is perforated and is bedded in drain rock.

An April 14, 2014 CRD drawing, which we understand is based on information provided by Mr. Richard Edwards who has been involved with this facility for many years, indicates a second manhole (No. 2) upstream of MH2. This manhole has two drain pipes extending across the valley. Manhole No.2 drains either to Manhole No.1 or through a pipe (which is believed to be crushed) to the spillway channel.

It is judged that a galvanized steel pipe in contact with moist soil for 30 plus years is likely at or nearing the end of its service life. This could result in perforations rusting over and/or collapse of sections of the pipe. Either of these would impact the current seepage regime and may result in an increased potential for the migration of fines.

In discussions with CRD (Mr. Gudavicius and Mr. Hall) it was decided that:

- All the existing drains/manholes should be removed and replaced;
- It will not be possible to lower the lake level during the construction of a toe drain/filter as the lake is most likely supplying at least part of the good quality water exiting the left bank downstream of the dam where it is collected for use; and
- The ability to discharge the water collected in the toe drain either to the spillway channel or to the ditch at the left abutment is required.

Therefore, the following is a recommended approach to this work:

- As part of the site investigation (refer to Section 6.0), collect samples of the embankment material and install piezometers to monitor the piezometric level;
- Drill up to four shallow holes in the area of the proposed toe drain to establish the target base elevation (Tetra Tech EBA do not recommend mobilizing a drill rig to do only this work, but when the drill is on site to complete the work described in Section 6.0, the incremental cost to do these holes will be modest and the information gained will help in lessening the unknowns inherent in the excavation/drain installation at the downstream toe);
- Complete a levelling survey to supplement the information collected by the recent CRD survey. Data to include approximate location and elevation of the testholes, the invert elevation of the Manhole 2, the ditch invert, and the dam crest elevation. It should be noted that this work will also be completed during the proposed site investigation;
- Using the available topographic and test hole information, determine where the two discharge pipes can be directed to; and
- Mobilize a contractor to install the new toe drain and discharge pipes, including:
  - Excavate a trench approximately 2.5 m in depth (to be confirmed) with a 0.5 m wide base width at the toe of the fill. The trench will be approximately 10 m in length;

- Remove or plug off any existing drainage pipes;
- Install a geotextile wrapped, drain rock zone in the bottom 1.5 m of the trench with a 100 mm diameter, perforated, rigid PVC pipe near its base. The drain rock should be 40mm minus, well graded, clean (<5% fines), sound gravel. The pipe should be graded to drain to the low point near the middle of the trench length;
- Install and operate suitable dewatering for the trench. This is likely to comprise a series of sumps with submersible pumps;
- Install a new manhole at the low point in the trench. Equip it with two 100 mm diameter outlet pipes, one to the spillway channel and one to the infiltration ditch. Install slide gates on the inlets to these pipes to allow the operator to discharge flow to either discharge point;
- Remove Manhole No 1 and install a reducer to connect the water line (to be confirmed on-site);and
- Install two 100 mm diameter, solid PVC pipes from the new manhole to the spillway channel (approximately 15 m) and to the infiltration ditch (approximately 25 m).

The estimated costs for completing the above works follow:

**Table 1: Gravel Berm/ Toe Drain – Cost Estimate**

Task	Cost	Disbursements	Subcontractors
Determine base level of drain	\$756		
Sketches of Toe Drain	\$2,952		
Mobilize contractor to site			\$15,000
Excavate Trench			\$2,000
Install Geotextile			\$2,000
Dewatering			\$5,000
Install new Manhole			\$4,500
Install piping			\$4,000
Construction Observations and Project Management	\$22,500 (Includes a \$10,000 contingency)	\$850	
<b>Totals</b>	<b>\$26,208</b>		<b>\$32,500</b>
Support, Supply and Communication (6%)	\$1,572		
Disbursement fee (10%)	\$3,250		
<b>TOTAL COST ESTIMATE: (excluding GST)</b>	<b>\$63,530</b>		

We note that there has been a substantial increase in the cost of this item. This is due to:

- The collection of additional test hole and survey data;
- The need to provide dewatering during the construction;



- The installation of two discharge pipes with plate valves; and
- The addition of a \$10,000 contingency.

## 5.0 REPLACE THE LOG BOOM

The log boom was found to be in poor condition and not adequately anchored during Tetra Tech EBA's November 2011 site visit. Replacement of the log boom will require mobilizing a suitable contractor to provide the following services:

- Supply approximately two - 6 m logs, and four - 12 m logs, as well as required length of galvanized chain;
- Drill holes at each end of the logs;
- Connect logs with chain;
- Clear sufficient vegetation to allow an excavator to access the two anchor points;
- At each anchor point excavate a 0.6 m deep hole in which a Lock Block can be buried; and
- Anchor the log boom to a Lock Block at each end.

The estimated cost for completing the above works is **\$7,200** not including applicable taxes.

## 6.0 SITE INVESTIGATION AND SEISMIC ASSESSMENT

The composition and condition of the dam fill, as well as the piezometric conditions within and under the embankment, are not known. For this reason a geotechnical site investigation followed by a slope stability analysis has been recommended.

### 6.1 Drilling Investigation

Tetra Tech EBA proposes completion of the soil investigation using a truck-mounted auger drill rig. The drilling investigation would be carried out over three 10 -12 hour days including travel, and consist of:

- Completion of up to 3 boreholes to approximate depths of 10 m, or until competent soil is encountered;
- Completion of up to four shallow boreholes at the proposed toe drain location, as part of the toe drain investigation (refer to section 4.0);
- Installation of two piezometers, one at the toe of the downstream slope and one on the dam crest. Once installed the piezometers will be secured with an above ground lockable steel box. (The piezometric data will be utilized in developing the seepage and stability models.) Supply one water level readout;
- Standard Penetration Testing (SPT) testing will be completed every 1.5 m in the 3 deeper boreholes;
- Disturbed soil samples will be recovered at regular intervals throughout the test drilling program and soil conditions recorded under the full time supervision of Tetra Tech EBA's site engineer;
- Approximate Borehole locations will be measured relative to existing structures, providing approximate Northings and Eastings of the locations; and

- A levelling survey will be carried out, determining ground elevations of boreholes relative to existing infrastructure.

The location and number of boreholes will be determined based on site conditions, in order to facilitate drilling and after consultation with the CRD.

Upon completion of drilling, each test hole will be sealed with bentonite. It should be noted that if loose saturated or other problematic soils are encountered, for proper analysis, further investigation may be required at an additional cost.

Setup for the drilling investigation will include the following:

- A limited background review, reviewing existing reports by other consultants and Tetra Tech EBA, surficial geology mapping, and bedrock geology mapping;
- Provision of a driller for drilling the selected boreholes;
- Selection of appropriate borehole locations;
- The required BC One Call; and
- Preparation of a Safe Work Plan and appropriate discussions with all parties as required both by WorkSafe BC and by Tetra Tech EBA's safety procedures.

## **6.2 Environmental Approvals**

It is understood that Money Lake contains fish. The Department of Fisheries and Oceans requires a letter of approval from a Qualified Environmental Professional (QEP), before work begins. Tetra Tech EBA's fisheries experts will prepare this document, on the behalf of the CRD.

## **6.3 Laboratory Testing**

The laboratory testing program will include classification testing, including Natural Water Content analyses in accordance with ASTM D2216, Sieve Analyses in accordance with CSA A23.2 2A, and if fine grained soils are encountered Soil Hydrometer testing in accordance with ASTM D422, and Atterberg limits in accordance with ASTM D4318.

## **6.4 Engineering and Reporting**

Upon completion of the laboratory test program, a piping potential assessment, liquefaction analysis and slope stability analysis will be undertaken based on field work, piezometric readings and test results.

Static and pseudo-static seismic global stability factors of safety for the existing embankment will be calculated using the two-dimensional Limit State Equilibrium analysis program SlopeW.

Initial pore water pressure conditions in the embankment will determined by importing the results of the two-dimensional steady state seepage analysis SeepW.

With respect to assessing the seismic stability of earthfill dams, the Canadian Dam Association (CDA) Technical Bulletin, Geotechnical Consideration for Dam Safety, recommends a staged approach, beginning with simplified methods using suitably conservative input assumptions to demonstrate that a dam is safe; progressing to more sophisticated analysis methods should the simplified approach lead to unfavourable results. The first

recommended stage of analysis undertaken is the pseudo-static method, in which the effects of an earthquake are applied as constant horizontal load via the use of dimensionless coefficients (kh) equal to the peak ground acceleration for the earthquake return period under consideration, which for the Money Lake Dam is 0.603 g for the 1/2,475 year event. Should the embankment have a factor of safety in excess of 1.0 for this loading, it is considered not to undergo any significant deformation during the design earthquake and therefore no further analysis is required. Should a factor of safety of less than 1.0 be obtained from the pseudo-static analysis, then it is likely that the embankment will undergo deformation during the design earthquake event and a simplified deformation analysis (e.g., as per Newmark (1965), Bray (2007)) approach is recommend as the second stage of analysis to confirm that the embankment has adequate freeboard post the design earthquake event deformation. Should the second stage of analysis yield unfavourable results, then a series of more sophisticated analysis approaches (e.g., Finite Element Analysis) will be recommended.

A geotechnical report will then be prepared, and will include the following:

- A site plan showing the test locations;
- Borehole logs and summary of test results;
- Piping potential for the dam based on the observed soil parameters;
- Liquefaction assessment;
- Seismic stability assessment; and
- Any additional issues of geotechnical concern uncovered during the investigation.

**Table 2: Geotechnical Investigation - Cost Estimate**

Task	Cost	EBA Laboratory	Disbursements	Subcontractors (Drillwell)
Project Coordination	\$1,145			
Environmental Approval	\$604			
EBA Mob/Demob/Lodging & Meals			\$850	
Site Geotechnical Investigation	\$4,710			\$8,600
Water level Readout Unit			\$600	
Logs/Lab Program	\$968	\$2,500		
Liquefaction Assessment	\$1,452			
Piping Analysis	\$1,228			
Slope Stability Analysis	\$1,712			
Reporting	\$5,598			
Project Management	\$2,530			
Subtotal	\$19,947	\$2,500	\$1,450	\$8,600
Support, Supply and Communication (6%)	\$1,347			
Disbursement fee (10%)	\$1,005			
<b>TOTAL COST ESTIMATE: (excluding GST)</b>	<b>\$34,849</b>			

## 7.0 SUMMARY

The estimate costs for the four items that Tetra Tech EBA was to revise are:

Item	Revised Cost Estimate	Previous Cost Estimate
Dam Crest	\$0	\$30,000
Toe Drain/Filter	\$63,530	\$40,000
Log Boom	\$7,200	\$14,000
Site Investigation/Seismic Assessment	\$34,849	\$40,000

The above revised costs are based on the preliminary design and typical unit rates. Actual costs (particularly for the toe drain/filter) may vary and we have included a contingency in the budget. Previous Costs are based on preliminary cost estimates in Tetra Tech EBA's April 2012 Dam Safety Report with a contingency added to each item by CRD.

## 8.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Capital Regional District (CRD) and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Capital Regional District (CRD), or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

## 9.0 CLOSURE

This proposal will be undertaken subject to the attached General Conditions, which will be incorporated into the report. We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,  
Tetra Tech EBA Inc.

Prepared by:



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Attachment: Appendix A - Tetra Tech EBA's General Conditions

# APPENDIX A

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## Appendix A - Tetra Tech EBA's General Conditions

# GENERAL CONDITIONS

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## GEOTECHNICAL REPORT

This report incorporates and is subject to these "General Conditions".

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### 1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA's Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA's Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

### 2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA's instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

### 3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

### 4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. Tetra Tech EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

### 5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

### 6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. Tetra Tech EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.



## **7.0 PROTECTION OF EXPOSED GROUND**

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

## **8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES**

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

## **9.0 INFLUENCE OF CONSTRUCTION ACTIVITY**

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

## **10.0 OBSERVATIONS DURING CONSTRUCTION**

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

## **11.0 DRAINAGE SYSTEMS**

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

## **12.0 BEARING CAPACITY**

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

## **13.0 SAMPLES**

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

## **14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY**

### **OTHERS**

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.