DAM SAFETY INSPECTION REPORT

CITY OF IQALUIT

Lake Geraldine Dam Safety Inspection

Prepared for

CITY OF IQALUIT, NUNAVUT

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McMillen
DESIGN with Vision. BUILD with Integrity.

October 2014

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1.0 INTRODUCTION

The City of Iqaluit (the City) owns and operates the Lake Geraldine reservoir, dam, and drinking water treatment plant. As Owner of the dam, the City recognizes its responsibility to protect the public and environment from the potential effects of dam failure as well as from any unplanned release. The City endeavors to keep the risk of dam safety incidents as low as reasonably practicable[1]. The Canadian Dam Association (CDA) guidelines clearly state that the "Owner is responsible for the safe management of a dam." In addition, the guidelines state: "The absence of specific regulation does not negate the Owner's responsibility for safe management."

In August 2014, the City retained McMillen-LLC (Millen) to perform a Dam Safety Inspection (DSI) to fulfill this commitment to dam safety. This report, prepared on behalf of the City, exceeds the recommendations of the 2007 CDA guidelines and Technical Bulletin: Surveillance of Dam Facilities (2007).

1.1 Purpose

The specific tasks completed under this DSI are as follows:

1. Review and comment on information gaps in existing documentation.
2. Visually inspect the submerged upstream side of the concrete dam and spillway and provide a report that includes:
    a. the general condition;
    b. a general condition assessment;
    c. photographic records of observations;
    d. identification of any potential concerns; and
    e. a prioritized listing of recommended repairs or actions.
3. Visually inspect the water retaining structures and generate a report that includes:
    a. a general condition assessment;
    b. photographic records of observations;
    c. identification of any potential concerns; and
    d. a prioritized listing of recommended repairs or actions.

In addition to these specifically-requested tasks, McMillen has prepared a basic dam safety checklist for periodic use by the City.

All reports, drawings, and video used in preparation of this inspection report are included on the DSI – Digital Video Disk (DVD).

[1] Canadian Dam Association. 2007. Dam Safety Guidelines. Paraphrase from Principle 1a. p.1.

1.2 Project Description

Lake Geraldine is a 12-metre (m) deep, 136,100-m^3, 29-hectare (ha) impoundment with a 3.52-kilometer (km) perimeter used by the City of Iqaluit for water supply[2]. The main project structures are a concrete gravity dam and overflow spillway, and three earth-fill berm structures referred to as North Berm, Central Berm and South Berm. The concrete dam sections on either side of the spillway are referred to as the north dam or right abutment and south dam or left abutment. For quick reference copies of the 2006 construction drawings are presented in Figures 1-1 and 1-2. Digital copies of the drawings are on the report DVD. These pdf files on the DVD permit more detailed review.

The City has increased storage in Lake Geraldine since the impoundment's original construction in the 1950s by raising the water retaining structures from Elevation (El) 106.3 m to the current crest elevation of El 112.26 m. For the concrete dam, the cumulative raise from the 1958 level is approximately 4.6 m. The overflow spillway crest is at El 111.33 m. With this ungated spillway configuration, water freely overflows from the reservoir when it still 0.93 m below the dam crest.

A summary of the main dam and reservoir features from existing sources and references is provided in Table 1-1 below.

[2] Environment Canada. 2006. Lake Geraldine, Iqaluit, Nunavut, bathymetric mapping.

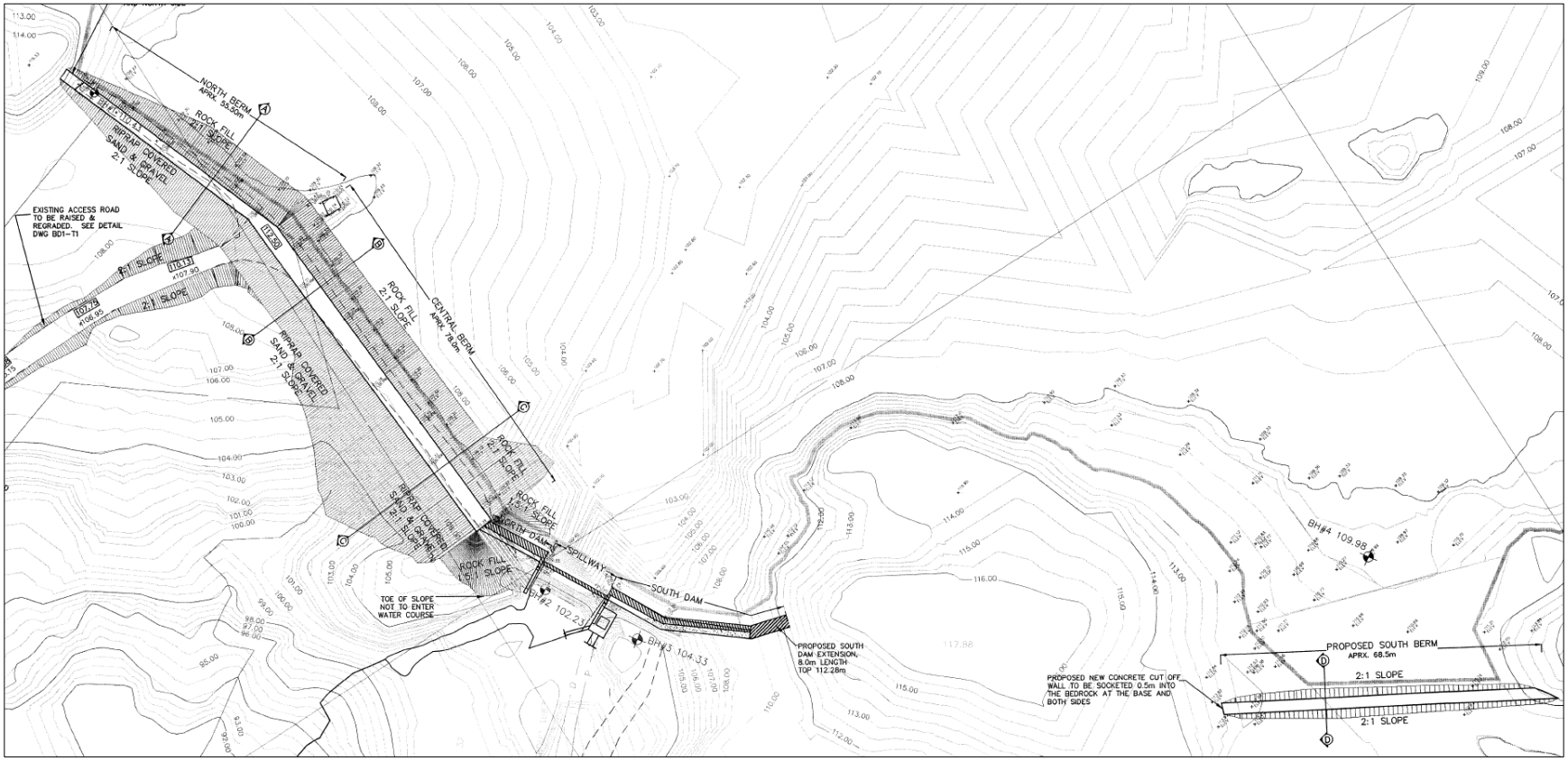


Figure 1-1: General plan of project from 2006 from construction drawings (Trow Assoc. 2005 dwg SP1)

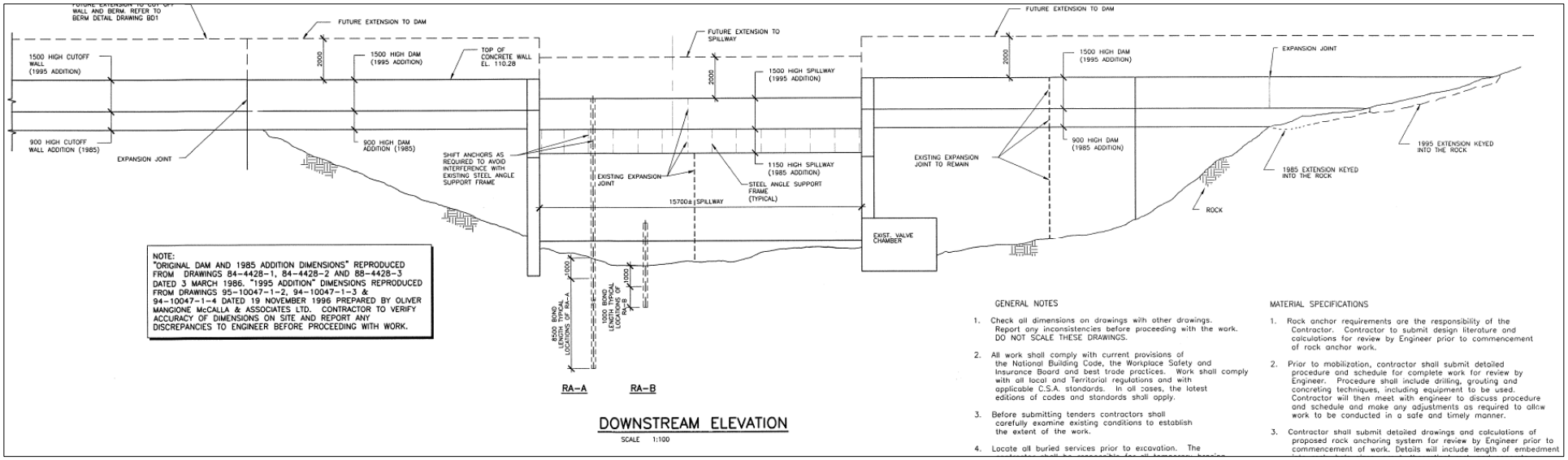


Figure 1-2: Downstream elevation of project from construction drawings (Trow Assoc. 2005 dwg RA1).

Table 1-1: City of Iqaluit – Lake Geraldine Dam and Reservoir Summary	
Location	**Magnitude**
Reservoir area	29 ha
Reservoir perimeter	3.52 km
Reservoir maximum depth (estimated from bathymetry)	12 m
Dam and berm crest elevation	112.26 m
Spillway crest elevation	111.33 m
Normal reservoir pool elevation	111.33 +/-
Spillway capacity at zero freeboard	30 m^3/s
Inflow design flood (IDF) 1/1,000-year event	14.1 m^3/s
Freeboard at IDF	0.37 m
Length of North Dam (right abutment)*	13.3 m
Length of Spillway*	15.3 m
Length of South Dam (left abutment)*	39.1 m
Length of North Berm*	55.5 m
Length of Central Berm*	78.0 m
Length of South Berm*	68.5 m

** From construction drawings; actual measure may differ slightly.*

The water treatment plant intake conduit through the dam is at the base of the left (looking downstream) concrete abutment (Figure 1-3). The elevation and the location of the upstream end of the intake pipe are unknown, but are likely near El 101 m due north of the dam near the lowest point of the reservoir. Photographs of the intake vault and face of the dam, as well as of the reservoir and dam from upstream, are shown in Figures 1-4 and 1-5 below.

Figure 1-3: Photograph of the left abutment downstream dam face.

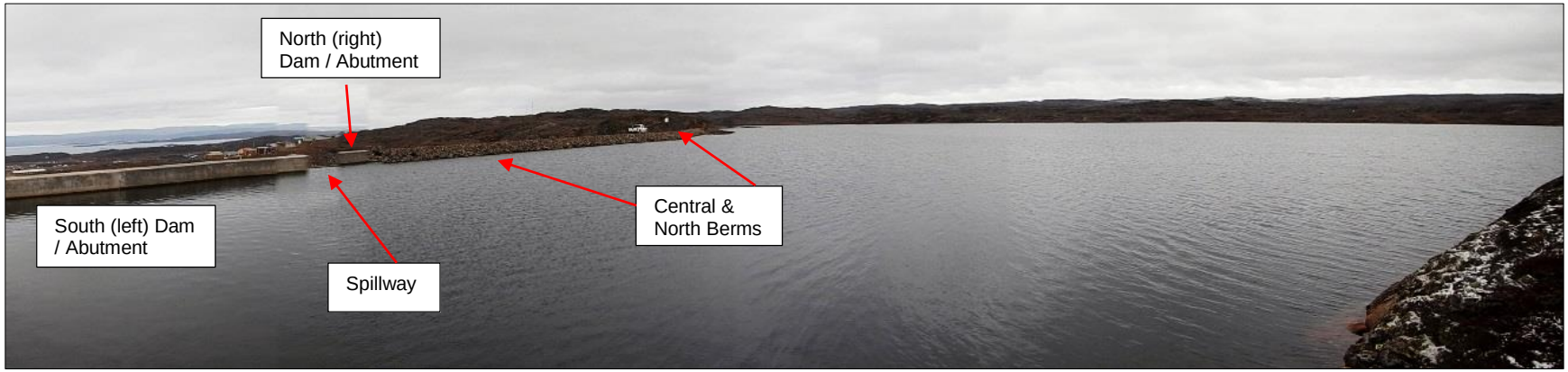


Figure 1-4: Panorama of reservoir and dam looking northwest upstream of left abutment.

Figure 1-5: Photo of dam face from downstream, spillway in center of photo.

2.0 REVIEW OF RECORDS, OPERATIONS, AND DOCUMENTATION

2.1 Records

Table 2-1 below summarizes historic project records, with a column noting which of these records was available for review in 2014. Few of the older records were available for review as part of this inspection effort. In particular, monitoring and instrumentation data, especially reservoir elevations, seepage monitoring, survey data, and records of visual inspections were not available for review before the inspection because they were unavailable. Electronic copies of the available records for this DSI are included on the report DVD.

Table 2-1: Lake Geraldine Technical Reports and Drawings – Reference List

Title	Author	Date	Available for Review October 2014
Water Storage at Lake Geraldine dwgs	DND	1957	no
Lake Geraldine Water Supply	OMM	1984	no
Water Supply Improvement Report	OMM	1985	no
Dam Inspection & Leakage Repair	Acres	1990	no
Dam Inspection for Blast Damage	Hardy BBT	1990	no
Dam Stability	Acres	1990	no
General Diving Report	Arctic Divers	1990	no
General Diving Report (September)	Arctic Divers	1990	no
Lake Geraldine Storage Design Drawings & Specification	OMM	1995	no
Lake Geraldine Storage Report	OMM	1995	no
Lake Geraldine DSI	Trow	1997	no
Dam Failure Study	EBA	1998	no
Lake Geraldine DSR	Trow	2001	yes
Lake Geraldine DSI	Trow	2002	no
Lake Geraldine DSI	Dillon	2003	no
Geotechnical Investigation	Trow	2005	no
Lake Geraldine Rock Anchors (spec's & dwgs)	Trow	2005	no
Lake Geraldine DSI	Concentric	2005	yes
Lake Geraldine Dam Raise (spec's & dwgs)	Trow	2006	yes
Lake Geraldine DSR	Concentric	2006	yes
Lake Geraldine OMS Manual & Log Book	Concentric	2007	yes
Lake Geraldine DSI	Concentric	2009	yes
Underwater Survey	Arctic Divers	2010	yes
Lake Geraldine DSI	Concentric	2010	yes

Table 2-1: Lake Geraldine Technical Reports and Drawings – Reference List			
Title	**Author**	**Date**	**Available for Review October 2014**
Lake Geraldine Dam Grout Repair (tender & dwgs)	Concentric	2011	yes
Lake Geraldine DSI	Concentric	2011	yes
Lake Geraldine DSI	Concentric	2012	yes
North Berm Repairs (spec's & dwgs)	Concentric	2012	no
Emergency Preparedness Plan	unknown	2012	no
Lake Geraldine DSR	Concentric	2014	yes

2.2 Drawings

There are no as-built drawings for the dam and structures from the 2006 dam raise. The most recent project drawings are construction drawings from the 2006 dam height increase, and grout repair drawings from 2012. There are as-built drawings for the grout repairs made in 2012.

2.3 Dam Safety Surveillance and Monitoring Program

Currently, there is no formal dam safety surveillance and monitoring program or checklist to guide inspections, analyses, or reporting. Informal visual inspection of the dam is performed periodically by the water treatment plant personnel. There is no dam safety training for operations personnel.

2.4 Analysis of Failure Modes

No failure modes analysis has been completed for the dam. Failure modes analysis provides a framework for linking surveillance and monitoring to potential modes of failure. For example, monitoring seepage provides an indication of dam or foundation conditions; changes in seepage magnitude and/or clarity can suggest potential future stability problems. Periodic crest surveys are also useful to monitor the dam condition and potentially guide any future dam safety actions.

2.5 Communication and Response

The adequacy and reliability of remote monitoring, communication, and control (e.g., Supervisory Control and Data Acquisition [SCADA]) could not be ascertained during the site visit due to the absence of knowledgeable staff. This in itself is an operational deficiency.

Based on observations and interviews during the site visit, the functionality of the reservoir elevation telemetry is unknown. Reservoir elevation is key to dam safety because it allows the City to know if the reservoir is spilling or dangerously

high or unusually low. All of these can be indications of a dam performance problem.

2.6 Electrical and Mechanical Systems

The spillway is a non-electrical/mechanical fixed concrete overflow structure. The water treatment plant intake valve was tested by actuating it from the plant during the inspection. It performed adequately.

2.7 Human Factors

City staff are not currently trained to inspect the dam for safety issues. Two people are trained to operate the water treatment plant. The plant has been operated by one individual for over 15 years (Robert Brouillet). There is no formal succession plan.

Turnover in staff is a challenge for the City. In the absence of the long-term operator from the water treatment plant, it was not possible to locate records or documentation, including the Emergency Preparedness Plan (EPP).

2.8 Flood Records

No reservoir elevation data or flow records were available for review. The date and magnitude of the flood of record are unknown. The highest level the reservoir reached in the past 5 years is unknown.

Wave action in 2010 damaged the North and Central Berm to the point of eroding and overtopping the berm during a storm (Figure 2-1 below). No detailed records of the pool elevation during the storm, estimates of wave run-up or damage or repair were available for review during the site visit. The crest was repaired and armored in 2012. The wave damage event occurred with the reservoir at full pool (reportedly) with approximately 1 m of freeboard.

Figure 2-1: Photograph of wave erosion on upstream side of Central Berm in 2010.

2.9 Regulatory Correspondence and Status of Dam Safety Review (DSR) Recommendations

2.9.1 Correspondence Record

There is no regulatory oversight of dam safety. The City is wholly responsible for dam safety as outlined in the 2007 CDA guidelines.

2.9.2 Dam Safety Review Recommendations

All of the late 2013/early 2014 DSR recommendations remain outstanding.

3.0 FIELD INSPECTIONS

The dam was inspected on the upstream and downstream sides on September 23 and 24, 2014, respectively.

On September 23, 2014, the upstream sides of the concrete structures were inspected using a Remotely Operated Vehicle (ROV) piloted by Chris Birt of All Sea Atlantic Ltd (All Sea).

The ROV inspection was attended by:

- Catrin Bryan, P.Eng., McMillen-LLC
- Chris Boyd, P.Eng., McMillen-LLC
- Richard Sparham, City of Iqaluit
- Jamie Van Tassel, All Sea, and
- Chris Birt, All Sea

Blue 1-m spaced markers showing the distance from the concrete contact with the Central Berm were made earlier by others. These blue markers were used during the ROV inspection to describe the location of spalling or other areas of concern (illustrated in Figure 3-1 below). The depth from the dam crest to areas of interest was simply the sum of the depth to water from the crest (approximately 1 m) and the depth to the anomaly as displayed on the ROV video.

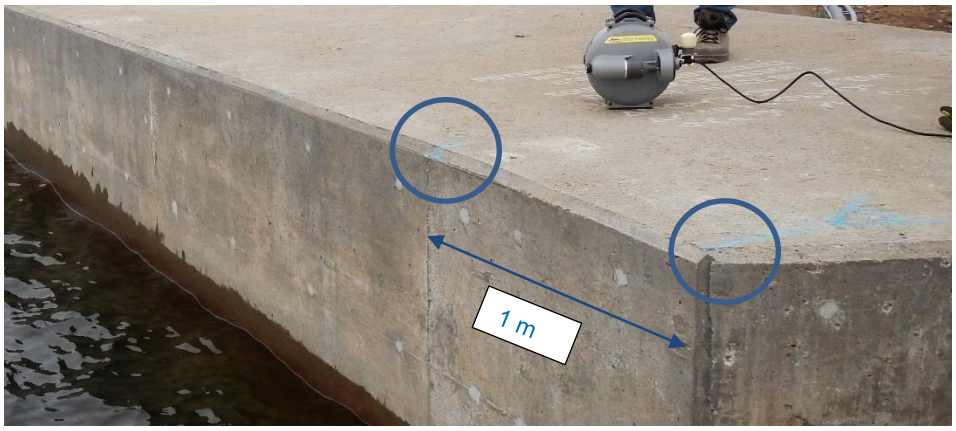


Figure 3-1: Photograph of blue 1-m markers on dam crest used to identify location of features identified using ROV. The blue letter A and ROV also in photograph.

To consistently identify the joints in the concrete structures, the joints were named J1 through J6, starting on the North Dam (abutment). This system is illustrated in Figures 3-2 and 3-3 below. In addition to the 1-m intervals, the

existing blue lettering (A, B, C, F, G, and H) along the dam were used. The purpose of the blue letters is unknown. Letters D and E were not observed, presumably on the spillway crest below the water line.

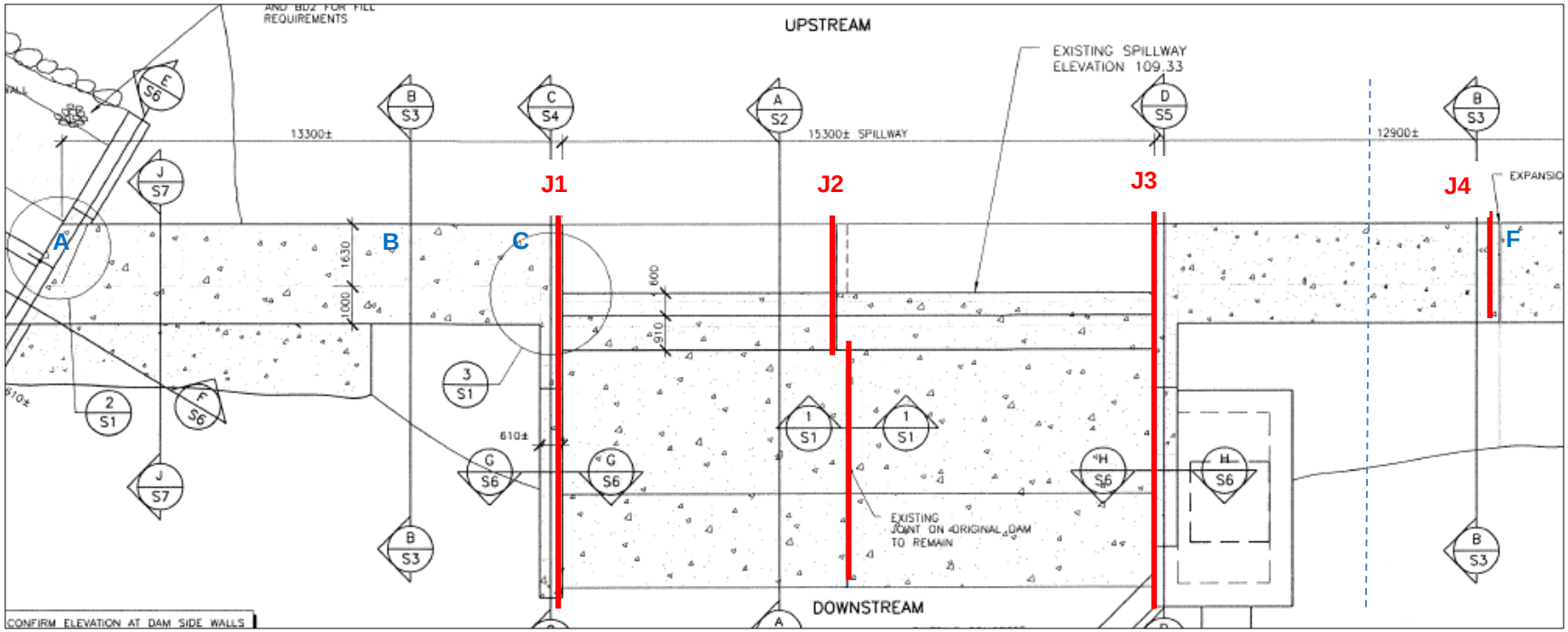


Figure 3-2: Plan of joint naming convention (adapted 2006 construction plans S1). Approximate locations of blue field lettering also shown.

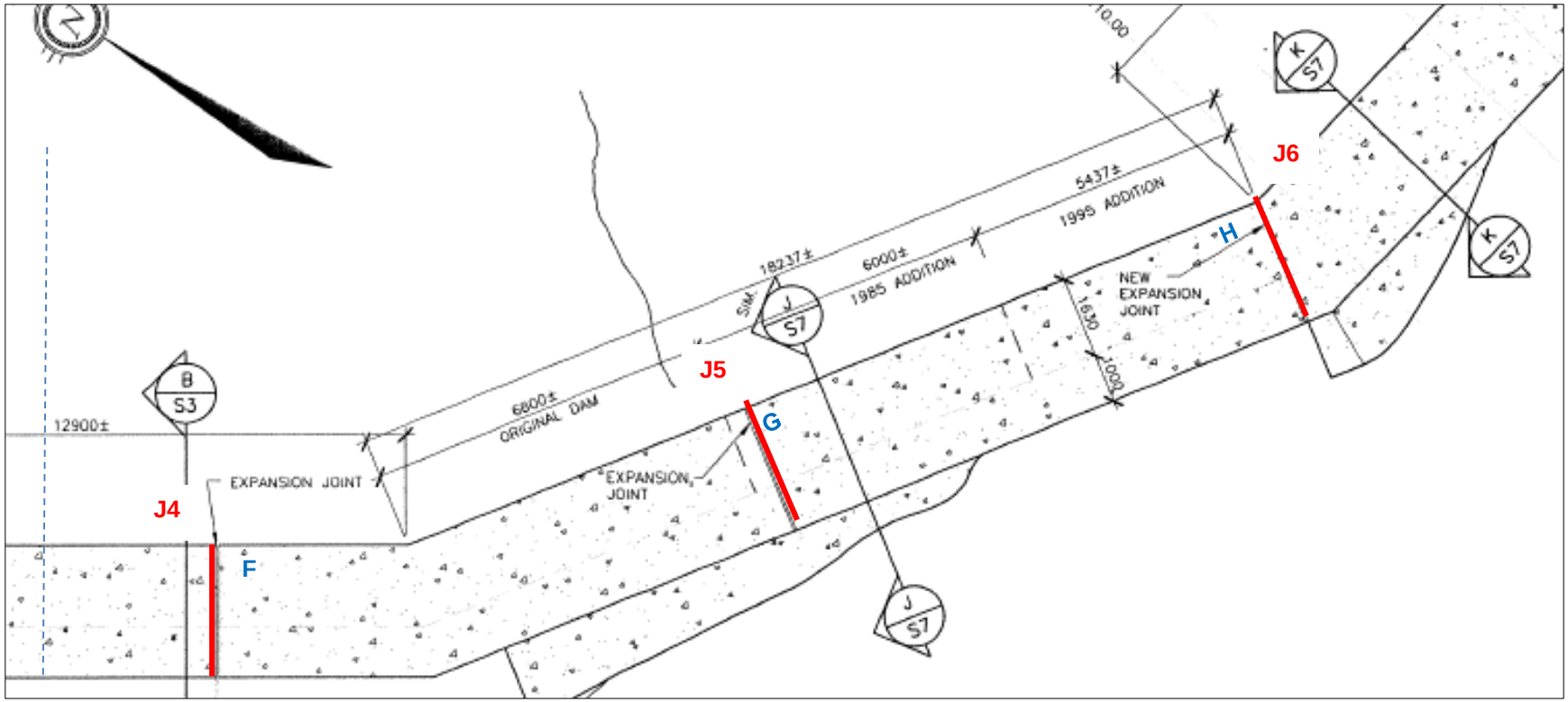


Figure 3-3: Continuation of plan of joint naming convention (adapted 2006 construction plans S1).

On September 24, 2014, the crest and downstream sides of the dam and berms were inspected by:

- Catrin Bryan, P.Eng., McMillen-LLC, and
- Chris Boyd, P.Eng., McMillen-LLC

To consistently identify berm locations in the field, McMillen marked 10-m stations on the North Berm and Central Berm starting at the bedrock exposure on the west extreme and terminating at the right gravity dam (abutment). Stations 0+00 and 1+35 are shown in Figure 3-4 below. This length is sufficiently consistent with construction drawings from 2006 that indicate the berm sections total approximately 131.5 m.

Figure 3-4: Photographs of Stations 0+00 and 1+35 on North Berm and Central Berm.

The findings from both the ROV and surface visual inspections are summarized in sections 3.1 and 3.2, respectively.

3.1 ROV Observations

The purpose of the underwater inspection was to identify any major changes in condition of the concrete since previous inspections. In preparation for the field visit, records and data provided by the City were reviewed by All Sea and McMillen. It was not possible to conclusively match earlier underwater survey photographs with this inspection because the observations from prior surveys were not adequately located. The All Sea ROV inspection report is presented in Appendix B and the video footage is included on the report DVD in Appendix D.

3.1.1 Settlement and Movement

There was no evidence of settlement or movement.

3.1.2 Concrete Deterioration and Joint Condition

Concrete spalling was noted along the contact between the 2006 lift and the earlier 1995 crest. The linear nature of the staining, coincident with the 2006 lift line and the geometry of the spalls or pop-outs, suggests the spalling is related to 2006 construction products, such as the water stop, or the execution of the work. Joint filler is missing in some of the lower section of the 2006 construction and is completely absent from the older concrete.

Spalling and joint observations are summarized in the photographs captured from the ROV video (Figures 3-5 through 3-14). Each screen shot from the video shows, from top left going clockwise, water temperature (degrees C), air temperature, pitch and yaw (degrees), bearing, depth below water. In Figure 3-5, the water was 4C, air temperature -1C, pitching downward 10 degree, no tilt (0), bearing 223 degrees and 1 m below the water surface.

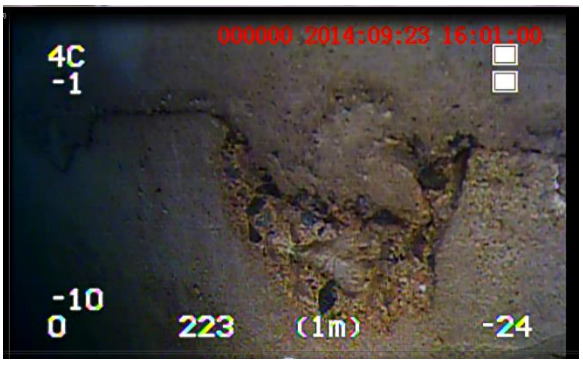


Figure 3-5: Spalling 2 m below crest, 7 m east of blue A.

Figure 3-6: Joint filler of J1 terminates at 2 m below the crest at the 1995 and 2006 construction contact. ROV camera directed upward.

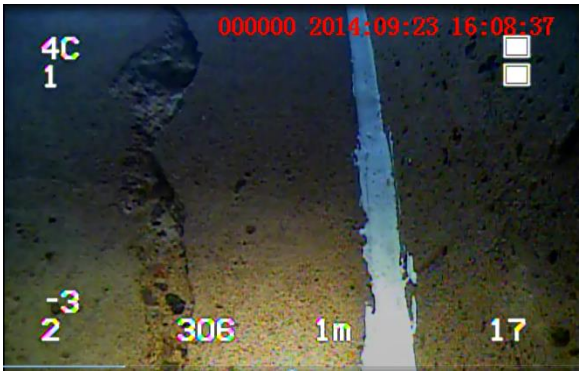


Figure 3-7: Spalling a metre or so below spillway crest to left of J1.

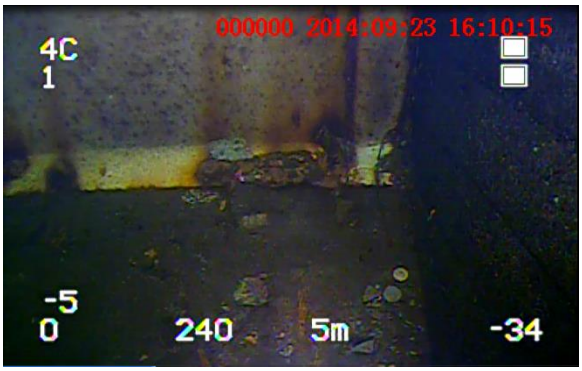


Figure 3-8: Corrosion of steel plate along spillway at El 106.7 m, corner junction at J1 (refer to Section A-A dwg S2, 2006).

Figure 3-9: Spalling in 1995 concrete joint J1.

Figure 3-10: Joint filler termination at 2 m below crest on J2.

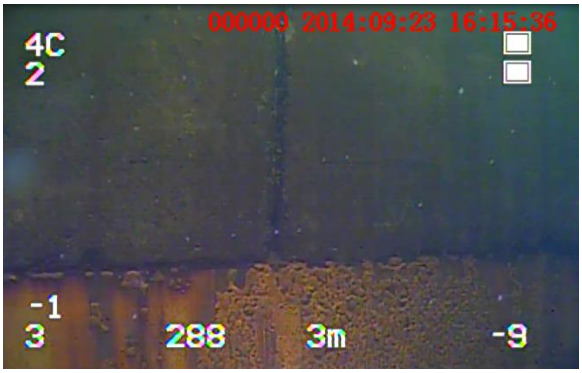


Figure 3-11: Joint filler missing from J2, photograph of contact with steel plate El 106.7 m.

Figure 3-12: Spalling at J3 on the eastern edge of the spillway, from 2-m depth to underlying contact with steel plate.

Figure 3-13: Spalling and absence of joint filler J4 on South Dam (left abutment).

Figure 3-14: Spalling ~2 m east of J4, 2 m below crest.

3.2 Visual Field Inspection Observations

The intent of the field inspection was to visually recognize major changes in condition or operations since previous inspections. In preparation for the field visit, records and data provided by the City were reviewed. A checklist summarizing the inspection is presented in Appendix C.

3.2.1 Settlement and Movement

There was no visually-notable evidence of settlement or movement. There are no records of survey for establishing the crest elevation or crest monitoring.

3.2.2 Erosion

Rock armor and cover have been lost due to wave action exposing smaller rip-rap and road fabric on the upstream side of the Central Berm Station 1+35 and 1+28 (Figure 3-15 below).

Figure 3-15: Evidence of wave action acting on Central Berm upstream armor.

3.2.3 Seepage STA 0+20 (approximate)

Seepage was not observed on the north side of the access road at the toe of the North Berm during the 2014 inspection, although it was noted in 2010. Photographs from 2010 and 2014 (Figure 3-16) compare conditions at the same location. The reservoir elevation and season are similar between the 2010 and 2014 inspections.

Figure 3-16: Photograph of seepage in 2010 on the downstream face of the North Berm. Seepage was not evident at this location in 2014 (right photograph).

3.2.4 Seepage STA 0+70

Partially frozen, clear, standing water from minor seepage was noted at the toe of the Central Berm. Figure 3-17 below shows the ponded water observed near Station 0+70. This seepage was observed in earlier inspections and is relatively unchanged.

Figure 3-17: Photograph of ponding due to seepage at Station 0+70.

3.2.5 Seepage STA 1+10

Clear seepage in the range of 10 litre/minute was observed at the Central Berm toe near the termination of the rock armor (photographs shown in Figures 3-18 and 3-19). Ponding from the seepage is directly below Station 1+10 and coincides with a natural draw in the bedrock topography (Figure 3-20), suggesting that the reservoir seepage may be traveling along the contact between the dam and the bedrock. Based on a review of earlier reports, there has been no change in seepage rate.

Figure 3-18: Photograph of seepage at Station 1+10.

Figure 3-19: Photograph of seepage measure location circled red below Station 1+10.

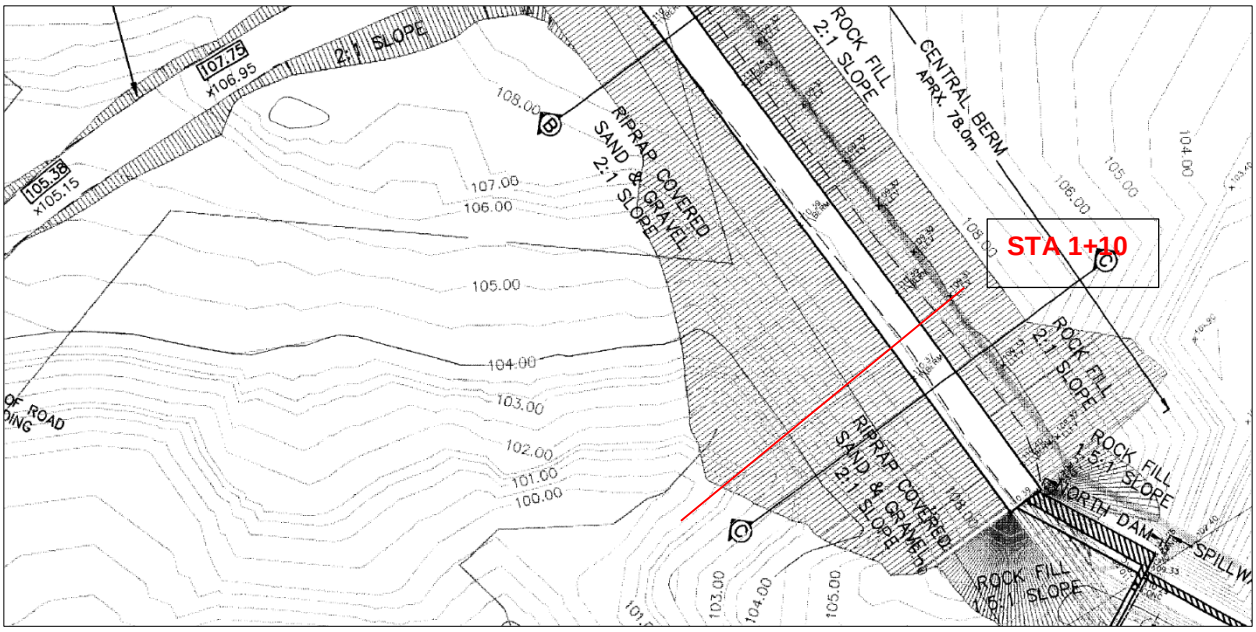


Figure 3-20: Topographic map showing natural depression in existing bedrock below Station 1+10.

3.2.6 Seepage and Staining at J1, J2, J3, J4, J6

Clear seepage too small to measure and staining were observed at J1, J2, and J3 on the downstream face of the dam (photographs from inspection in Figures 3-21 through 3-25 below). Based on the information available, this seepage and staining is relatively unchanged from earlier inspections.

Figure 3-21: Seepage and staining at J1 and along 2006 construction lift contact.

Figure 3-22: Close-up photograph of seepage and staining at J1.

Figure 3-23: Seepage and staining at J3 and along 2006 construction lift contact.

Figure 3-24: Downstream dam face showing efflorescence associated with seepage through spillway crack. Seepage and staining also noted at 2006 concrete lift contact.

Figure 3-25: Seepage and staining at J4 and along 2006 construction lift contact.

The seepage repair and efflorescence were observed at J6 (left abutment), Figure 3-26 below.

Figure 3-26: Efflorescence and staining at J6, left abutment. Injection ports from seepage repair shown.

3.2.7 Concrete Cracking or Deterioration

Concrete crack repairs on the downstream face of the dam and spillway are performing adequately. Seepage from cracks appears unchanged from earlier inspections. Minor surface shrinkage cracks were noted on the right abutment wingwall (Figure 3-27 below), Station 1+35.

Figure 3-27: Shrinkage cracks on wingwall right abutment Station 1+35.

3.2.8 Gate Operation

The valve to the water treatment plant was successfully exercised for the inspection. The actual intake to the water plant in the reservoir was not observed.

3.2.9 Foundation Drainage and Uplift Pressures

No measurement of uplift pressures is made. The design and the installation of the plastic tube drains at the 2006 left buttress are unavailable and no information is available regarding the discharge requirements to meet design uplift relief needs. The flow from the drains is less than a litre per minute (Figure 3-28 below).

Figure 3-28: Pressure relief tubing at left abutment buttress.

3.2.10 Piping

There was no evidence of piping through or beneath the berms.

3.3 Review of Documentation

The following dam safety information was unavailable for review during this safety inspection (refer also to Table 2-1):

1. Surveillance and monitoring plan or information, especially reservoir elevation data or record of periodic visual observations.
2. As-built drawings for the structures.
3. Survey data of concrete structures.
4. Emergency Preparedness Plan.
5. Construction records, testing, and commissioning.
6. Hydrologic modeling, especially dam break analysis and inundation mapping.
7. Stability analysis, including normal, flood, ice and seismic loading conditions for the current structure.
8. Correspondence with any regulatory agencies or partner agencies.

3.4 Adequacy of Public Alert Systems and Security

The Emergency Preparedness Plan was not available for review. The on-site public alert system consists of several warning signs. There are no locked gates or fences and the public has easy access to the dam and reservoir. There is unrestricted access to the dam and all appurtenant structures. There was no evidence at the dam of vandalism.

4.0 SUMMARY OF FINDINGS

4.1.1 Review of Documentation

The dam safety surveillance and monitoring documentation was incomplete or difficult for the new City staff to locate. Without continuity of records, the ability to evaluate dam performance based on earlier information, and transfer dam safety knowledge and operations to management, the chances of miss-operation or difficulties responding to an emergency may be significantly increased.

4.1.2 ROV Dam Inspection

- The upstream, submerged sections of the concrete dam and spillway structures were found to be performing adequately based on visual inspections.
- There is concrete spalling at the 2006 lift contact and missing joint filler compound on almost all the joints, especially the joints older than 2006.
- It was not possible to conclusively match locations from earlier underwater surveys due to the absence of a mapping system. The system created for this DSI will support future inspections and comparisons.

4.1.3 Dam Inspection

- The dam was found to be performing adequately based on visual observations and review of the available information. Changes noted since previous inspections were based solely on earlier annual or 5-year dam safety reports and inspections because there were no surveillance or monitoring records.
- Stationing on the North Berm and Central Berm and a construction joint numbering system were created to aid in locating areas of interest on the dam. This system will support future inspections and communications.
- Seepage was observed at the toe of the Central Berm at Station 1+10, from construction joints J1 through J3 on the spillway and south dam J4 and J5 (left abutment). Stationing and joint numbering were used to locate seepage.
- There is inadequate armoring of the North Berm and Central Berm to resist wave action and high reservoir levels.
- There is concrete shrinkage cracking on the right abutment.
- The function of the telemetry upstream from the left abutment is unknown.
- The public has unrestricted access to the dam and reservoir.

5.0 RECOMMENDATIONS AND PRIORITIES

The following recommendations are made based on our review of documentation and site inspection.

5.1.1 Review of Documentation

- Locate and update the missing dam safety documentation so the information is easy to locate, review, and revise.
- Maintain a current, complete record of this documentation in a readily available and known location.
- Complete this collection and inventory of information task before the next inspection in the **spring of 2015**.
- Develop plans to fill any critical information gaps before **autumn 2015**. Missing information includes but is not limited to the following:

1. Surveillance data histories and monitoring plan information, especially reservoir elevation data or record of periodic visual observations or structural surveys.
2. As-built drawings for the structures.
3. Emergency Preparedness Plan.
4. Records of construction, testing, and commissioning.
5. Hydrologic modeling, especially dam break analysis and inundation mapping.
6. Dam stability analyses, including normal, flood, ice, and seismic loading conditions for the current structure.
7. Correspondence with any regulatory agencies or partner government agencies.
8. Site security planning, for example consider restricting motorized access to the dam and reservoir.

5.1.2 ROV Dam Inspection

- Repair concrete spalling and fill joints on upstream faces of concrete structures by **autumn 2016**.
- Complete this work sooner if there are changes to site conditions such as seepage that are linked to concrete condition. If conditions deteriorate, repairs should be initiated as soon as practical.
- Record and document all repairs for inclusion in the project file.
- Inspect the upstream faces of the concrete structures during the **5-year DSRs** and time the inspection to gain as much visual inspection of the upstream face as possible. Document findings in the DSRs.
- Provide descriptions of observations that allow for repeatability.

5.1.3 Dam Inspection

Observations from periodic visual inspections and instrument monitoring need to be documented in a consistent, repeatable manner so that changes in conditions and trends can be recognized. Inspection checklists are often used in dam safety to guide inspections and serve as a record. As part of this DSI, a basic dam safety checklist has been prepared for the dam for periodic inspections by Iqaluit staff. This draft checklist is presented in Appendix A.

- Commence visual inspections and record observations using a checklist starting in **spring 2015**.
- Perform this inspection twice a year, after the snow melts and before the winter sets in, approximately early July and late September. Also, complete the checklist after any extreme event such as a flood, earthquake, or unusual storms. The checklist in Appendix A includes crack, joint, and seepage monitoring.
- Maintain the completed checklists in the project file and available for inspector review.

- Add stationing, such as driven steel rods on the North Berm and Central Berm. Add more permanent labeling of the joints. Complete this task before or as part of the **next DSI in 2015**.

- Visually inspect the dam monthly, and when the water is open, measure the reservoir elevation either manually or using existing telemetry.
- Begin this visual inspection **in 2015**.
- Record unusual findings in the plant log book. Consider completing this visual inspection along with other regularly scheduled plant activities.

Based condition of the armor on the upstream side of the North and Central Berms and the damage that was caused in 2010 when the reservoir was a normal pool, it is likely that without additional armor, future storms including the IDF will cause similar or worse damage. Under the IDF there is less than 50 cm of freeboard during the 2010 storm there was approximately 1 m of freeboard.

- Prepare and execute plans to armor the North Berm and Central Berm **in 2015**.
- Survey the main structural elements of the dam **in 2015**.

- Retain professional dam safety engineers to assist in dam safety planning, management and inspections until the program is adequately established for City staff to perform the inspections independently.
- Train city staff to complete routine inspections and documentation.
- Retain qualified professional engineers to complete DSRs every five years.

6.0 REFERENCES (DVD ONLY)

Digital copies of all prior reports used in preparation of this DSI are presented on the report DVD.

7.0 CERTIFICATION

I certify that I have completed this work to acceptable engineering standards.

Catrin Bryan (van Donkelaar), M.Sc., P.Eng.

Appendix A: Inspection Checklist

City of Iqaluit – Lake Geraldine Dam Safety Inspection Form

Staff:	Date:
Weather: °C km/hr	Reservoir Elevation (m):

Table 7-1: Lake Geraldine Dam Inspection Form	
Location	**Observations or No Change***
North, Central, and South Berms – upstream face including reservoir slopes (seepage, wave action damage, slumping).	
North, Central, and South Berms – downstream face and toe of the dam (seepage, vegetation growth, slumping, animal activity, and other ground disturbance).	
North, Central, and South Berms – embankment crest (cracking, displacement, settlement).	
Central Berm – specific note of any changes in downstream seepage at STA 0+70 or 1+10.	
North, South Dam Abutments and Spillway – upstream face (cracking, freeze/thaw damage spalling, exposed rebar); view at low reservoir level.	
North, South Dam Abutments and Spillway – downstream face (seepage, cracking, freeze/thaw damage spalling, efflorescence, exposed rebar).	
North, South Dam Abutments and Spillway crest – (cracking, displacement, settlement).	
South (left) Abutment – changes in seepage.	

Table 7-2: Periodic System Inspection, Maintenance, and Testing	
Flow control equipment (gates, hoists, valves).	
Instrumentation, monitoring equipment, and backup power sources (functional testing, periodic calibration).	
Public alert and protection systems (booms, warning signs, sirens, EPP test & review).	
Reservoir rim – review aerial photos, visual inspection.	

**Dated, annotated photographs and drawings, coupled with field notes serve as an inspection record. Field inspections need to be repeatable so that any changes are noticeable. Any abnormalities should be noted and investigated:*

- Seepage – the flow volume and clarity of water, changes in flow understood (seasonal) and any abnormalities reported. Look for evidence of piping (presence or accumulations of fine sediment) or excessive long-term seepage (vegetation types).
- Displacements, deformations, or settlement – look for cracking or other signs of displacement. Look for any evidence of excessive uplift pressures.
- Cracking – observe extent and any changes. Look for differential settlement at crack locations and measure relative vertical and horizontal displacement. Mark, date, and photograph cracks.
- Concrete Deterioration – observe any changes since last inspection, typically due to freeze/thaw weathering, especially look for exposed reinforcing steel.
- Erosion – look for overland flow from natural or facility drainage.
- Debris – note any unusual debris accumulations.
- Icing – observe and describe any unusual or destructive ice accumulations.

Appendix B: All Sea ROV Inspection Report (video on DVD)

ALL-SEA
UNDERWATER SOLUTIONS

ALL-SEA ATLANTIC LTD
9 Lower Cove Loop
Saint John, NB
Canada E2L 1W7
T: +1 (506)632-3483
F: +1 (506)657-2023

Friday Sept. 26th 2014

Attention: Catrin Van Donkelaar, McMillen LLC.

RE: Underwater Inspection of Dam, Iqaluit Nunavit
All-Sea Reference # 214-2895

All-Sea Atlantic was contracted to perform an inspection of the dam in Iqaluit Nu. A video and still pics are included with this report.

This report provides a brief summary of the work completed on Tuesday Sept. 23rd 2014.

Description of Work Completed and Overall Summary of Results

- Inspection of Dam was carried out by use of a ROV equipped with HD camera and recorder.

Procedures:

- Inspection followed along horizontal joint (area where addition was placed on top of existing structure) moving from north to south. Five positions were chosen (vertical joints in concrete) by clients and are labelled J1 to J5.

Observations:

- Vertical Joint J1 has white caulking from surface to 2m, showed signs of spalling between 3m and 4m deep. (Video 1 TS 16:07:33 to TS 16:12:55)

- Vertical joint J2 has missing material from 2m to 4m mark. (Video 1 TS 16:13:40 to TS 16:17:00)

- Vertical joint J3 has white caulking from surface to 2m mark. There is a crack in concrete at 2m mark descending to 4m mark. This crack appears to be in the surface only. (Video 1 TS 16:17:53 to TS 16:21:00)

- Following horizontal joint between J3 and J4 found more concrete spalling.

- Vertical Joint J4 has white caulking from surface to a depth of 1m only. There is a consistent gap in this joint down to the bottom at a depth of 8m. (Video 1 TS 16:24:16 to TS 16:29:17)

- Vertical Joint J5 has white caulking from surface to 2m mark. Joint extends to a depth of 4m and then stops on the horizontal joint between the old material and new material. (Video 2 TS 16:52:31 to TS 16:55:00)

These are links to the videos taken by the ROV Team. These videos are located on our secure server and are available to be seen at any time.

Video - Iqaluit Dam Inspection - 1

Video - Iqaluit Dam Inspection - 2

We trust this letter addresses your information requirements. If you have any questions or require further details, please call us at (506) 632-3483. Once again we appreciate your request for these services, and we look forward to working with you in the future.

Report prepared without prejudice and respectfully submitted by:

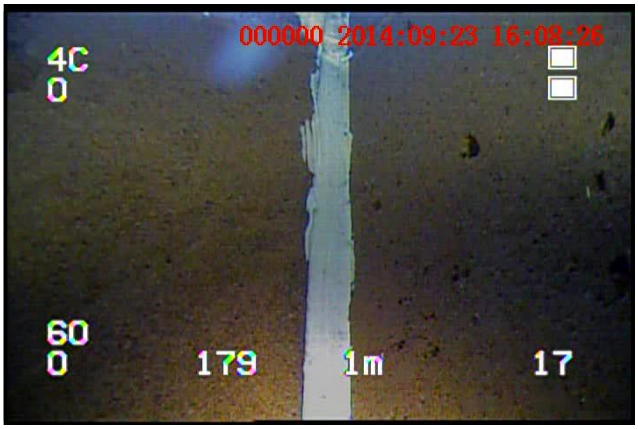
Christopher Kenney Bsc.

Operations Coordinator

All-Sea Atlantic Ltd.

Pics from Video

Spalling along horizontal joint prior to J1



Top of Vertical Joint J1

Joint J1 spalling in concrete

Joint J1 meeting lower

Joint J2 start of gap, and missing material

Bottom of J2

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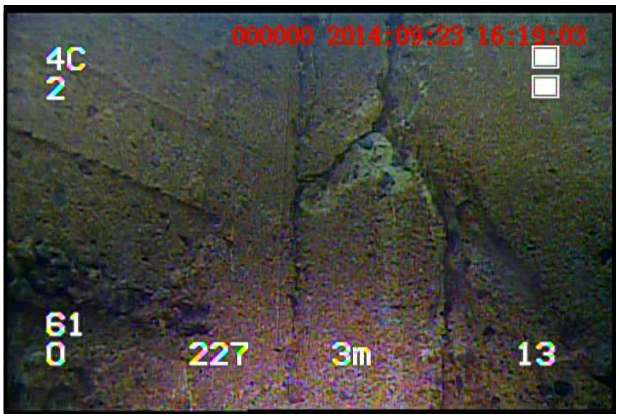
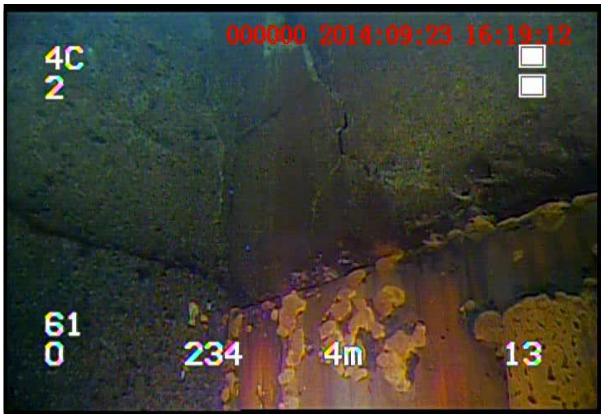
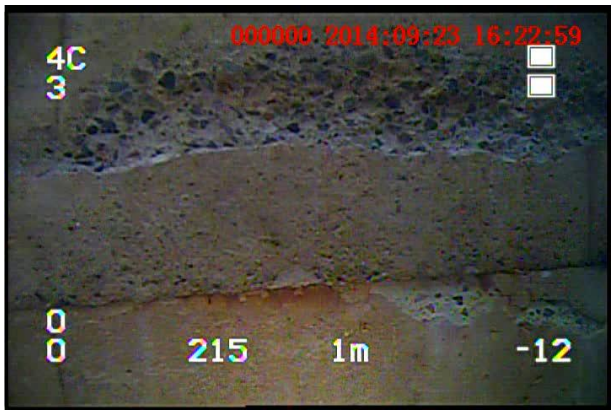


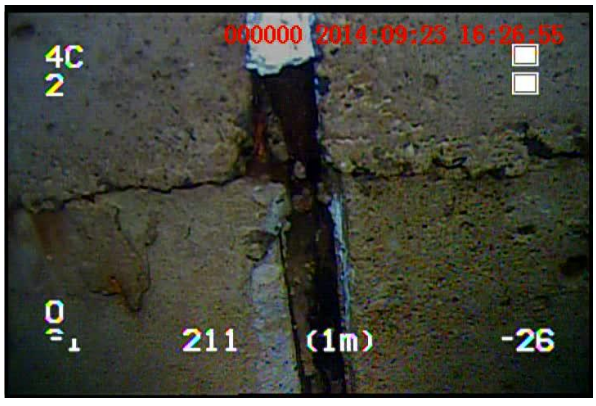
J3 just below caulking, crack in concrete extending down and out.



J3 continuing down showing crack until it reaches top of old structure.



Spalling in horizontal Joint between J3 & J4



J4 showing gap in joint starting just below white caulking

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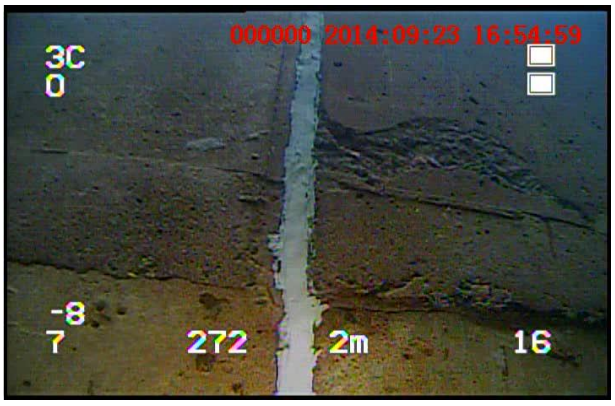
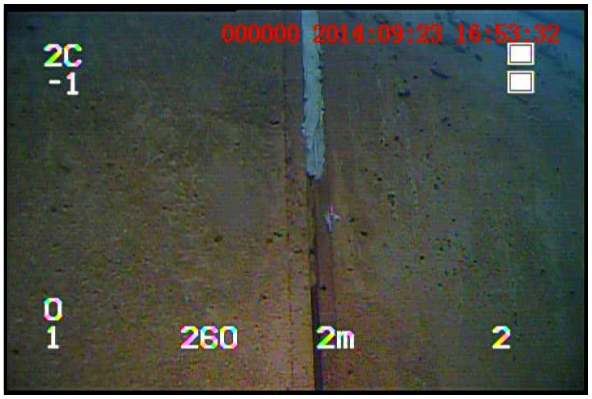
Spalling in concrete, horizontal joint between J4 & J5

J5 at the surface



Spalling in concrete along vertical joint J5



J5, white caulking ending at 2m mark

Bottom of J5, meeting Horizontal joint with old structure.

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Appendix C: Engineer's Dam Safety Inspection Checklist

NAME OF DAM: Lake Geraldine	OWNER: City of Iqaluit
PROVINCE/TERRITORY: Nunavut	DATE (D/M/Y): 24/09/14
HAZ. CATEGORY: High	WEATHER: high clouds, afternoon snow
TYPE OF DAM: Concrete gravity overflow structure with earthen berms.	TEMPERATURE (C) -1C
RESERVOIR EL.: full pool - crest El 111.3m	WIND (m/s): < 15 km/hr

ITEM	PREVIOUS CONCERN		REMARKS (Locations of observations)
	Yes	No	
1. DAM CREST		X	
a. Visual settlement		X	None observed.
b. Misalignment		X	None observed.
c. Cracking		X	Minor shrinkage cracking at contact with right abutment.
2. CONCRETE DAM UPSTREAM FACE (includes spillway section)	X		
a. Concrete deterioration	X		Spalling at contact with 2006 dam raise.
b. Longitudinal cracks		X	None observed.
c. Transverse cracks		X	None observed.
d. Construction joints	X		Loss of joint filler below 2006 contact. Some loss in 2006 section.
e. condition of previous repairs		X	Spalling at several previous patch locations and previous dam raise lifts.
f. evidence of subsidence?		X	None observed.
3. CONCRETE DAM & SPILLWAY DOWNSTREAM FACE	X		
a. Concrete surfaces:	X		Historic seepage from cracks and joints. Ongoing freeze/thaw damage.
(1) Spalling	X		Minor, non-structural spalling.
(2) Cracking	X		Repairs evident and performing adequately.
(3) Erosion		X	None observed.
(4) Exposed reinforcement		X	None observed.
b. Joints			
(1) Displacement/offset		X	None observed.

ITEM	PREVIOUS CONCERN		REMARKS (Locations of observations)
	Yes	No	
(2) Loss of joint material	X		Joint filler material missing from upstream side.
(3) Leakage	X		Seepage from left abutment expansion joint J5
c. Transverse cracks	X		Historic repairs remain sound.
d. Other seepage	X		Seepage from left abutment 2006 buttress block via plastic tubes
4. ABUTMENT CONTACTS			
a. Erosion		X	None observed.
b. Differential movement or subsidence		X	None observed.
c. Cracking		X	None observed.
d. Seepage		X	None observed.
5. SPILLWAY CHANNEL	X		-
a. Energy Dissipators or Channel:			-
(1) Deterioration		X	None observed.
(2) Debris		X	Remnants of historic structures.
b. Channel:		X	-
(1) Eroding or backcutting		X	None observed. Bedrock channel.
(2) Sloughing		X	None observed.
11. RESERVOIR CONTROL			Reservoir telemetry at the dam upstream of the left abutment.
a. Upstream development		X	None observed.
b. Slides in reservoir area		X	None observed, gently bedrock topography.
c. Change in reservoir ops. since last inspection		X	Unknown. Reservoir at full pool.
d. Impoundment changes		X	None reported.
12. INSTRUMENTATION			
a. Function of instrumentation			Unknown where/whom has access to the reservoir elevation data.
b. Condition			From surface, instrumentation is sound.
c. Reliability/Status			Unknown.
d. Data available			Unknown.

Appendix D: Project Drawings (DVD Only)

Appendix E: Inspection Photographs (DVD only)