AECOM

Rehabilitation of Port Severn Area Dams, Fixed Bridge and Lock

Investigation Report

Public Works and Government Services Canada

Project Reference: EQ754-170947/001/PWL
Project Number: 60522156

November 21 2017

Quality Information

The persons signing below confirm that this document consists of all investigation reports as required by the Project Agreement. Report accuracy and completeness is confirmed by the report author with signoff included in each individual report.

Prepared by	Approved by	Reviewed by
2017-06-27		
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Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	June 14, 2017	Draft		James Wallace	Engineering Manager
1	Nov. 21, 2017	Final		James Wallace	Engineering Manager

Distribution List

# Hard Copies	PDF Required	Association / Company Name
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Our Reference 60522156

Dear Mr. Percival:

Regarding: Port Severn Area Dams/Bridge/Lock Investigation Report

AECOM is pleased to submit the following Investigation Report for the Port Severn Area Dams, Fixed Bridge, and Lock. The report includes findings for the following investigations conducted at each of the structures:

- Detailed visual inspection;
- Underwater inspection;
- Geotechnical investigation; and
- Material investigation.

Should you have any questions regarding the above, please contact the undersigned.

Yours sincerely,

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JW:nb

Table of Contents

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Port Severn Area Dams, Fixed Bridge, and Lock
Detailed Visual Inspection Letter Reports

AECOM Canada Ltd completed visual inspections of the Port Severn Area Dams, Fixed Bridge, and Lock. AECOM was on site November 14th, 2016 to conduct visual inspections of each of the following structures:

- Main Dam;
- Fixed Bridge;
- Lock 45 Common Wall;
- Dam D;
- Dam E;
- Dam A;
- Dam C;
- Dam G;
- Lock 45 Lower Approach Walls; and
- Lock 45 Upper Approach Walls.

The purpose of the inspection was to assess the existing condition of each structure, understand the scope of work, plan investigations and studies, verify information contained in the existing documentation, and obtain additional information required for design and construction. A licensed professional in each of the following specialties was on site:

- Dam design;
- Bridge design; and
- Electrical/Controls design.

The following report includes individual letter reports for each structure, which contain a summary of findings and photographs of each site.

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Our Reference 60522156

Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Main Dam

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

The Port Severn Main Dam is a gravity structure founded on bedrock. The deck consists of a service deck and stop log platform for nine (9) sluices, and an adjacent roadway deck. These two decks are separated by a concrete barrier wall and rest on the main piers of the dam. Concrete stairs along the side of the first pier link the Main Dam's deck to the downstream portion of Lock 45 on the right bank. On the left bank or the east end, the Main Dam is connected to an embankment dam (Dam D).

Issues with the dam identified in the PA include:

1. The dam is unstable under ice loading scenarios.
2. The reliability of operation of certain sluices poses a risk.
3. The log lifter is at the end of its useful operating life.
4. The dam is in fair condition; with cracks and damage to concrete requiring repair.

AECOM performed a visual inspection of the Main Dam from the deck and from each bank. The previous inspection report (refer to document 05-22157-2000-EX-0007 issued on March 8th, 2012) confirmed that dimensions and geometry are as specified on the original drawings.

Cracks and previous joint repairs are noticeable on the deck. Cracks are located on the corners of each sluice and at pier centerlines. The repair grout shows deterioration and cracks as well.

The upstream side of the Main Dam shows cracks, efflorescence, and eroded concrete in the drawdown zone of the piers. On the downstream side, AECOM has observed considerable loss of concrete on the downstream end of Pier 3 (starting from the right bank or west side).

Water infiltration was observed at the Pier 1 construction joints. AECOM has noticed leaks on the right side surfaces of Pier 1. More important infiltrations are found inside the staircase and on its outside wall. As such, there is a considerable gap between the stairs and the side of Pier 1.

The underside of the deck, the stop log sluice openings, and the underwater portions were not accessible for inspection during the visit. The previous inspection reported damaged concrete on the downstream wall of Sluice 1, visible stirrups at Sluice 2 and visible corrosion on rebars under the deck at Sluice 3. Regarding the underwater areas, zebra mussels, deteriorated concrete, and open construction joints were observed in the 2012 inspection report.

AECOM will consider two options in the Concept Design Report:

1. Replacement of existing downstream stop logs and gains in the sluiceways to accommodate new mechanized vertical steel lift gates. Concrete re-facing, crack injection and installation of post-tension anchors on all piers.
2. Full replacement of the dam.

Both options will have these works in common:

- Replace the service deck.
- Provide a secure and safe pedestrian corridor along the full length of the dam.
- Provide a control building to house the generator and electrical main control panel.
- New vertical lift gates with a low profile cable hoist and drum system with the following cable arrangement options on the gate:
  - Option 1: Six mechanized sluices; lifting points upstream of the gate, in the water.
  - Option 2: Four mechanized sluices; lifting points downstream of the gate, on the dry side.
- The sluiceways that will not be mechanized will retain the timber stop log and manual winch operating system with rails to allow for the winch to travel from one sluice to another.
- A cofferdam will be required to dewater the site.
- Adequate discharge capacity must be maintained throughout construction to meet operational requirements.

Yours sincerely,

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The Main Dam and Fixed Bridge (and Lock 45)

Cracks and previous joint repairs on deck

Cracks and efflorescence on upstream side of dam

Deteriorated concrete on downstream side of dam

Manual winch to be retained for all concept design options

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Fixed Bridge

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

The fixed bridge consists of a concrete deck with nine equal spans, composite with 4 concrete beams, and rigidly fixed on the dam piers. The total length of the bridge is 69.5 m. The roadway has an exposed concrete surface and a clear width of 4.67 m for a single lane of bi-directional traffic. No sidewalks are provided. The existing concrete barriers are 1.22 m tall.

It has already been determined that the fixed bridge is to be replaced and there is no need for a detailed condition assessment.

The PA identified the concrete beams to be simply supported between the dam piers but this is not the case. To be simply supported, the beams would need to be able to rotate and slide horizontally over the piers. The beams are actually fixed at the piers.

AECOM proposes to use a semi-integral configuration on the replacement bridge structure. A semi-integral configuration will allow the bridge to expand and contract independently of the piers due to temperature changes (the worst of which is a hot sunny summer day when the sun heats and expands the deck but the lake water cools the piers and keeps the dam from expanding with the deck). The bridge will be fixed to the 5th pier but will sit on elastomeric bearing pads at all other piers to allow for expansion and contraction of the bridge deck. A semi-integral configuration does not have intermediate joints and will not permit chloride contaminated surface water from the bridge to leak onto the abutments.

AECOM will consider two options in the Concept Design Report:

1. Replace the bridge with a new structure as per the Morrison Hershfield Report.
2. Replace the bridge with a new structure with a semi-integral configuration and heritage-style lighting and barriers.

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Yours sincerely,

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Fixed Bridge on piers

Fixed Bridge on pier bearing

Fixed Bridge on pier bearing

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Lock 45

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

The lock is a non-reinforced mass concrete gravity structure with an overall length of 25.6 m, a depth of 3.76 m, and a guaranteed draft of 1.64 m. The lock shares a common wall with the first pier of the dam. The PA identified a problem with leakage through the common wall. The leakage is causing problems related to ice, algae, and pooling water on the stair to the lower approach wall. Ice jacking from the leak is causing the stairs to separate from the wall. There is a large crack at the top of the staircase. The remainder of the walls are reported to be in good condition.

The lock was closed and full at the time of inspection and we were unable to observe the walls within the lock. We were able to identify three places were water is leaking through the common wall downstream of the lock walls, the most critical leak being the one at the stair to the lower approach wall. There were also numerous places on the wall where exudation and efflorescence were visible. This is a sign of either water within the concrete leaking through the wall, or frequent wetting of the wall from the operation of the lock.

AECOM will consider two options in the Concept Design Report:

1. Seal the cracks, remove and replace the concrete stair.
2. Seal the cracks, reface the wall, and remove and replace the concrete stair.

Yours sincerely,

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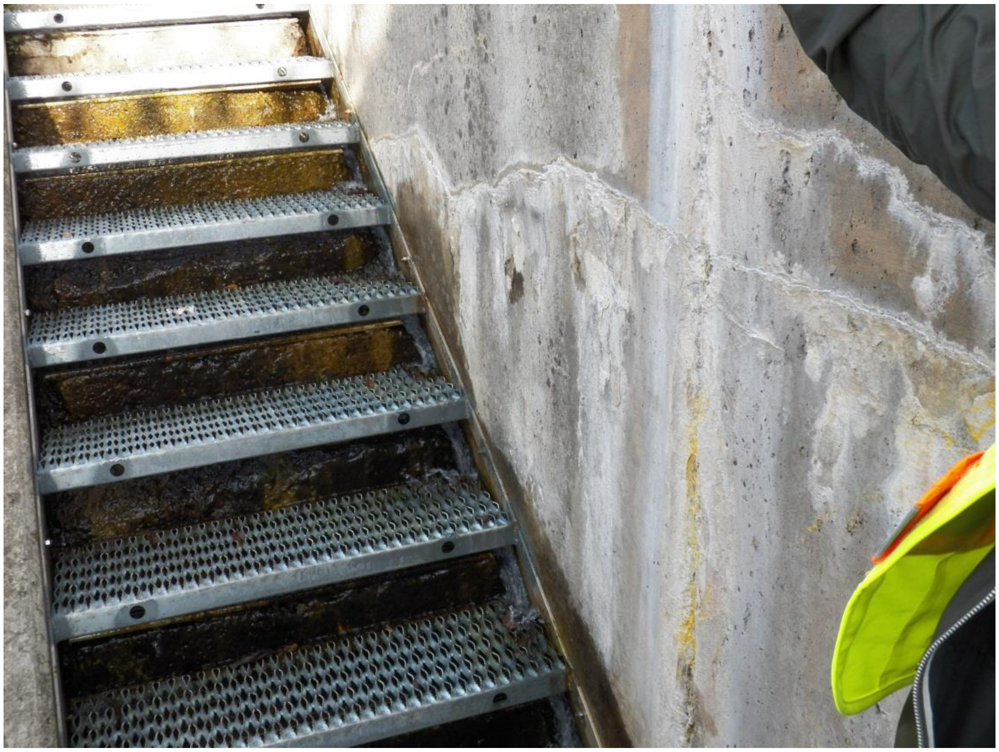
Lock 45 showing water leakage

Lock 45 showing displacement of the stairs



Water leakage under stairs

Crack at top of the stairs

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Dam D

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Dam D is a secondary structure located at the east end of the Main Dam. It protects the land adjacent to the Main Dam from flooding. The dam consists of a 70 m long concrete retaining wall founded on bedrock and backfilled with soil. The approximate height of the structure is 2.0 m. The dam fails to meet the minimum freeboard requirements for IDF by 0.5 m.

There is earth fill behind the structure. The public space behind the structure is at the same elevation as the top of the dam and would be flooded if the dam overtopped. There are some floating docks that extend from the structure and allow for mooring of watercraft during the navigation season.

AECOM reviewed the structure and found the concrete to range from generally poor to fair condition with large cracks and spalls observed. There are large spalls in the concrete just above the waterline. The sink holes identified in the PA could not be observed, as granular fill had been used to fill the holes.

The dam is in generally poor condition with multiple large cracks where it meets the Main Dam. This is likely due to large stresses induced by the relatively rigid concrete dam compared to the ductile behaviour of the soil along the rest of the length of the dam.

The first 5 m of the dam from where it meets the Main Dam appears to have shifted and to be leaning forward towards the water. The steel safety cable supporting the warning signs for the Main Dam is attached to this section of Dam D. The cable would be highly tensioned to keep it taut and clear of the water. This tension appears to be pulling this section of the dam forward and into the lake.

Yours sincerely,

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Dam D (spalled concrete)

Dam D (cracks in concrete)

Dam D (spalling concrete)

Dam D (anchor pulling on wall)

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Dam E

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Dam E is located 200 m west of the main dam on the west side of the island adjacent to Lock 45/the Main Dam. It is a 4.93 m tall concrete dam, 35 m long, with a 6.1 m wide sluice that can hold up to nine logs. The dam is manually operated using hand cranks to lift the logs into place. The dam has a concrete service deck for manipulating the stop logs and a bridge deck that supports a single lane of traffic.

Issues with the dam identified in the PA include:

1. The end section of the right bank wall is cut by a crack and has moved slightly upstream.
2. Three pieces of concrete have broken away in the drawdown zone of the right and left wall.
3. The concrete surface is deteriorated in the drawdown zone.
4. The concrete on the deck is deteriorated around the winch anchors.
5. A large vertical crack is noted on the right sluice side wall.
6. Cracks have been observed at the top of the wall, at the construction joints and in the drawdown zone.
7. There are no engineered anchors or tie off locations on the dam.
8. The handrails of the adjacent bridge do not meet the requirements of the Canadian Highway Bridge Design Code.
9. There is no lighting for nighttime stop log operation.
10. There are no capacity markings on the winches.
11. There are no rails or rolling strips to secure the removed logs.
12. The existing signage, safety boom, egress ladders, and other safety equipment are inadequate.

AECOM observed the dam and noted that the concrete deck beams under the bridge deck and the service deck are in poor condition with large spalls, exposed rebar, and rust staining. The deck beams that frame the joint between the bridge deck and the service deck are in especially poor condition due to years of exposure to chloride contamination. Note that there is no curb to keep surface runoff containing deicing salts from draining through this joint and exposing the deck beams to chloride contamination. In our opinion, the bridge deck cannot be salvaged and must be replaced in its entirety. While the service deck is salvageable, we recommend a full replacement as there is little merit in preserving an old service deck beside a new bridge deck.

The abutments are in fair condition with localized spalls and cracking. There is likely to be chloride contamination on the abutments under the joint between the bridge deck and service deck. The abutments can be salvaged. The merits of salvaging the existing abutments vs complete replacement of the abutments will be considered in the Concept Design Report.

A steady flow of water was observed from one of the subdrains behind the abutment. This suggests that water is leaking under the abutment on this side.

There are existing trees and overhead utility lines on the downstream right-of-way. The utilities would need to be moved to permit the bridge widening.

There is existing exposed bedrock on the downstream right-of-way that is higher than the road elevation. Some of the bedrock may need to be removed to accommodate the widened road. Further investigation is required to determine if the rock can be removed by blasting. The exposed bedrock also constitutes a traffic hazard and should be protected by steel beam guide rail.

Yours sincerely,

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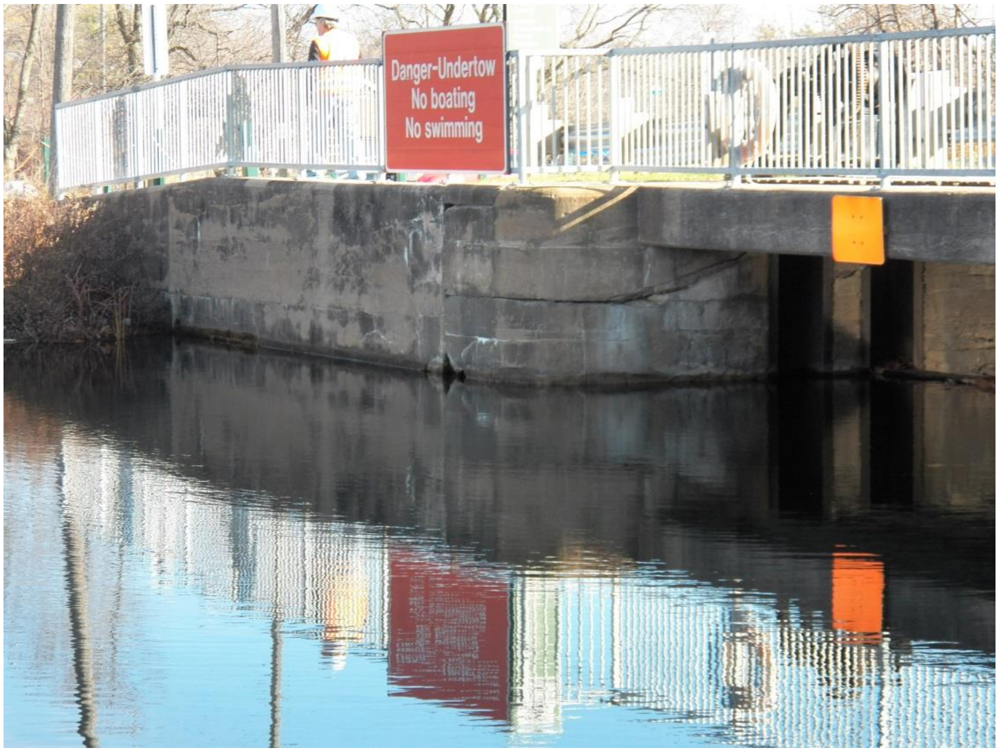
Dam E (outflow)

Dam E (deck girders failing due to chloride contamination)

Dam E (inflow)



Dam E (inflow)

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Dam A

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Dam A is located in a small bay 930 m northeast from the Main Dam and 100 m northwest of Baguley Road. Wetlands currently drain through a 1.2 m dia. CSP culvert under Baguley Road and into the bay behind the dam. The dam is a concrete faced structure founded on bedrock and originally intended to be backfilled by an earth berm, although the berm either was never built or has eroded and disappeared.

The dam is approximately 43 m long with an average height of approximately 1.4 m. The PA identifies a single manmade breach of 3 m in the dam; however, two manmade breaches were observed. The breaches appear to have been made to drain the wetlands.

The dam appeared to be in fair condition (aside from the breaches) with no obvious cracks or spalls. The scope of work given in the PA consists of preparing designs to repair the breaches in the dam, block the culvert under Baguley Road, fill the bay behind the dam, and address the drainage behind the dam.

AECOM observed the dam, the two manmade breaches, the bay, and the culvert under Baguley Road. The older breach has what appears to be smooth formed sill at the bottom of the north side of the north breach. It appeared as though a small sluice may have been present at this location, although no such sluice is shown on the original construction drawings. If there was a sluice, it has been enlarged by the breach. The second breach is larger and is located in the middle of the dam.

There is private property on the lots on both sides of the dam. The buildings on these lots are higher than the top of the dam, as is Baguley Road. In the event of a flood, the breached dam would allow flood water to flow through the culvert under Baguley Road and continue inland before draining downstream of the Main Dam. This is a breach in the reservoir perimeter that allows stored water to bypass the dams during flood conditions. As per the CCDC guidelines, this dam cannot be classified as safe as long as the breach to the reservoir perimeter is present.

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Yours sincerely,

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Dam A (Baguley Road to the left)

Breach at middle of dam (Baguley Road to the left)

Culvert under Baguley Road (owned by Severn Township)

Area under consideration to be filled (facing Baguley Road)

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Dam C

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Dam C is located 195 m northeast of the Main Dam. It protects the land adjacent to the Main Dam from flooding. The dam consists of a 119 m long concrete retaining wall founded on bedrock and backfilled with soil. The approximate height of the structure is 2.4 m. The dam fails to meet the minimum freeboard requirements for IDF by 0.3 m.

There is an earth berm behind the structure. The private properties behind the structure are at a lower elevation and would be flooded if the dam is overtopped. There are some floating docks that extend from the structure and allow for mooring of watercraft during the navigation season.

AECOM observed the structure and found it to be in generally fair condition with few cracks and spalls observed. There is a gouge in the concrete just above the waterline. The gouge runs in straight lines and may be manmade. Settlement is noticeable in one location in the earth berm.

Yours sincerely,

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Dam C

Dam C (gradient of berm visible)

Dam C (gouge in concrete)

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Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Dam G

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Dam G is a secondary structure located 700 m southwest of the Main Dam. It is a 4.26 m tall concrete dam, 137 m long, with a 2.44 m wide sluice that can hold up to seven logs. The dam is manually operated using hand cranks to lift the logs into place. The dam has a narrow concrete service deck with a cantilevered steel work platform for manipulating the stop logs and a bridge deck that supports two lanes of traffic. The bridge deck was originally only 4.9 m wide for a single lane of traffic but was widened in 2007.

Issues with the dam identified in the PA include:

1. The top 230 mm of the right bank wall starting at the sluice gate and extending for 9 m has broken away and shifted 200 mm downstream.
2. There is concrete degradation in the drawdown zone over the entire left wall and to a lesser extent along the right wall.
3. The vertical construction joint between the left wall and the left sluice pier is significantly deteriorated.
4. Most of the construction joints of the left wall are open.
5. Some of the construction joints have broken pieces of concrete at the drawdown zone.
6. The right wall is cracked horizontally at two locations: 300 mm below the crest and another smaller one approximately 600 mm below the crest.
7. The concrete in the gains located near the deck level is deteriorated.
8. The cantilevered deck section is pulling away from the concrete operation deck.
9. There are no engineered anchors or tie off locations on the dam.
10. The railings around the operating deck are insufficient and do not meet requirements.
11. There is no lighting for nighttime stop log operation.
12. There are no capacity markings on the winches.
13. There are tripping hazards around the dam operating area.
14. There are no rails or rolling strips to secure the removed logs.
15. The existing signage, safety boom, egress ladders, and other safety equipment are inadequate.

AECOM

AECOM observed the dam and found it to be in fair condition, although there are some localized areas that are in need of repair. The construction of the cantilevered steel frame work area appears to be light and should be replaced with a more robust platform. The concrete facing has localized areas of deterioration that are in need of patching.

In terms of safety, AECOM observed that there is no safety boom to warn watercraft of the dam, no life rings, and no gates or warning signs on the trail to the downstream side of the dam.

AECOM also observed that there is a large formation under the water that is ideally located to support a cofferdam to dewater the site for rehabilitation work. It is not clear if this is a natural formation or the remnants of the cofferdam used during the original construction.

Yours sincerely,

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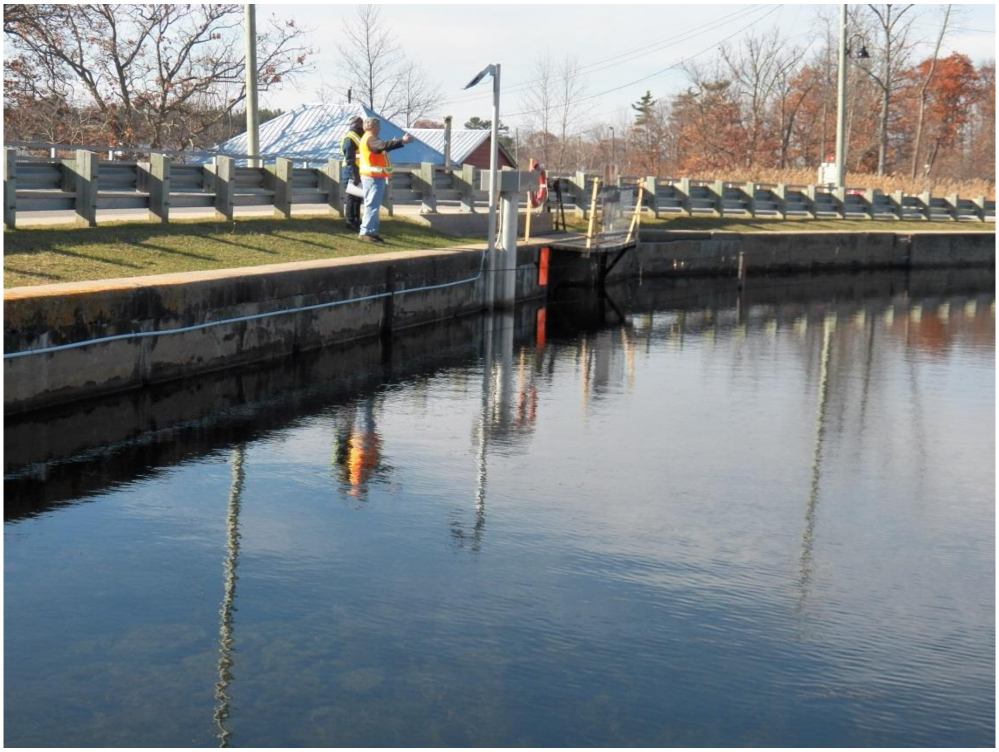

Dam G (inflow)

Dam G (concrete walls under service deck extension)

Dam G (concrete walls under service deck extension)

Dam G (flow through the dam)

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Our Reference 60522156

Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Lower Approach Walls

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Lock 45 is a non-reinforced mass concrete gravity structure with an overall length of 25.6 m, a depth of 3.76 m, and a guaranteed draft of 1.64 m. The lock shares a common wall with the first pier of the dam.

Issues with the lower approach walls identified in the PA include:

1. There are times when moderate to high discharge flows from the Main Dam and Dam E create currents in the navigation channel, which make it difficult for approaching boats to safely access the lower approach wall and lock.
2. The capacity for mooring of boats at the lower approach walls is inadequate, and it would be beneficial to lengthen one or both walls.

AECOM performed a visual inspection of the lower approach walls. Both eastern and western lower approach wall appeared to be in fair to good condition. A hydraulic study will be conducted to determine the most suitable method to reduce turbulent flow and provide safer access for boats within the lower approach to the lock.

AECOM will consider two options in the Concept Design Report:

1. Extension of lower approach walls, including underwater support such as timber cribbing, as well as the repair of concrete cracks, spalls, and delaminations in the existing walls.
2. Construction of an energy dissipating system or barriers necessary to mitigate turbulence at the entrance on the lock, as well as the repair of concrete cracks, spalls, and delaminations in the existing walls.

Yours sincerely,

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Lock 45 Eastern Lower Approach Wall

AECOM

Lock 45 Western Lower Approach Wall (right)

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Date
December 1 2016

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Our Reference 60522156

Dear Mr. Percival

Port Severn Area Dams/Bridge/Lock: Upper Approach Walls

AECOM was on site on November 14th, 2016 to review the structure. Weather conditions were favourable for the inspection; dry and sunny. Water levels are generally low across the province due to an unusually dry summer. This has exposed portions of some of the structures that are usually submerged.

Lock 45 is a non-reinforced mass concrete gravity structure with an overall length of 25.6 m, a depth of 3.76 m, and a guaranteed draft of 1.64 m. The lock shares a common wall with the first pier of the dam.

Issues with the upper approach walls identified in the PA include sinkholes that reoccur behind the north concrete wall section of the upper western approach wall. The PA described the upper west concrete wall as being in fair to good condition.

AECOM performed a visual inspection of the upper approach walls. Underwater spalls were observed on the western upper approach wall, and the sinkholes noted in the PA appeared to have been filled in.

AECOM will consider two options in the Concept Design Report:

1. Repair of concrete cracks, spalls, and delaminations on the western upper approach wall.
2. Partial re-facing of the western upper approach wall including any repair of remaining concrete cracks, spalls, and delaminations.

Yours sincerely,

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Lock 45 Western Upper Approach Wall

Lock 45 Eastern Upper Approach Wall

ASI Marine | REPORT

Submitted to:

AECOM Canada Ltd.
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Attention: James Wallace, P. Eng.,
Manager, Engineering, Alternative Delivery
Copy: Dave McDonald

Submittal Date:
January 25, 2017

Reference:
Underwater Inspections of Port Severn Area Dams, Fixed Bridge and Lock

AECOM Project:
60522156

Inspections Completed:
November 1 to 9, 2016

ASI Marine Project:
RH16-052

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Proprietary Notice

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REPORT

AECOM Canada Ltd.
Underwater Inspections of Port Severn Area Dams, Fixed Bridge and Lock

Inspections Completed: November 1 to 9, 2016

1.0 INTRODUCTION

ASI Marine, a division of ASI Group Ltd. (ASI), was contracted by AECOM Canada Ltd. (AECOM) to perform underwater inspections of the Port Severn area dams and structures located in Port Severn, Ontario. AECOM requested ASI to provide underwater survey and/or inspection services respectively for:

- Dam C
- Dam D
- Main Dam
- Dam E (Bayview)
- Dam G (Little Chute)
- Lock 45
- Lock 45 North Dam
- Lower Approach Wall of Lock 45
- Upper Approach Wall of Lock 45

The surveys and inspections were completed by ASI from November 1 to 9, 2016 inclusively to provide AECOM with the required data for their conditional assessment of the structures. The video inspections were completed simultaneously by ASI personnel from shore and the bathymetric and structure surveys from a survey vessel.

1.1 Site Location

The Port Severn area dams are located in Port Severn, Ontario on Port Severn Road (Figure 1). The dam structures are owned and operated by Parks Canada, who contracted AECOM for an assessment and rehabilitation of the structures. The assets surveyed and inspected are located throughout the area at separate locations. The scope of work for the separate structures varied. The inspections performed by ASI were conducted using a combination of remotely operated vehicle (ROV) and CCTV video pole-mounted camera from shore, and multi-beam echo sounder system (MBES) deployed from a survey vessel.

Figure 1: Aerial view of Port Severn area dams

1.1.1 Dam C

Dam C is a secondary structure located approximately 195 m northeast of the Main Dam. It was made to prevent flooding of the surrounding lands within the operating ranges of the Port Severn Dams. The dam is a 119 m long retaining wall (Figure 2).

Figure 2: Dam C retaining wall

1.1.2 Dam D

Dam D is located at the east end of the Main Dam and is a 70 m long concrete faced embankment dam (Figure 3).

Figure 3: Dam D concrete faced embankment dam

1.1.3 Main Dam

The Main Dam is a concrete gravity structure founded on bedrock built in 1916. The length of the dam is 71.32 m. There are nine sluiceways with timber stop logs that are operated with a hydraulic loglifter. Each sluice is 6.1 m wide and the piers of the dam are 1.83 m wide. The Sluice 1 stop logs are only operational with a mechanic winch. The downstream areas of Sluices 7, 8, and 9 are located over non-submerged ground, and operating these sluices would result in flooding and erosion of the land (Figure 4).

Figure 4: Main Dam with labelled sluice gates

1.1.4 Dam E

Dam E is located approximately 200 m west of the Main Dam. The dam is 35 m long. There is a single 6.1 m wide sluice in the dam. The dam is capable of operating with up to 9 stop logs, operated by a manual winch (Figure 5).

Figure 5: Dam E sluice

1.1.5 Dam G

Dam G is located on the westernmost channel of the outlet of Little Lake, 700 m southwest of the Main Dam. The dam is 137 m long. The dam utilizes a centralized sluice which is 2.44 m wide (Figure 6).

Figure 6: Dam G with roadway on top deck

1.1.6 Lock 45

Lock 45 is a non-reinforced, mass concrete gravity structure (Figure 7). The length of the structure is 25.6 m and shares the east wall of the structure with the Main Dam. The upper and lower approach walls of Lock 45 are also included in the scope of work (Figure 8).

Figure 7: Lock 45 displaying apparent water leakage on the east wall

Figure 8: Lower Approach Wall (left image) and Upper Approach Wall (right image) of Lock 45

2.0 SCOPE OF WORK

The following scope of work was identified by AECOM through email correspondence and a site visit[1]. It included underwater multi-beam echo sounder sonar (MBES) surveys and ROV/CCTV video inspections to assist AECOM in preparing to perform a conditional assessment of the Port Severn Area Dams. The project was divided into two phases of field data collection.

2.1 Phase 1

Phase 1 of the project included the collection of data for the following:

- CCTV pole mounted camera inspection of the shallower structures.
- ROV video for coverage of any area where a pole-mounted camera device would be unable to reach.
- Bathymetric survey of the upper and lower portions of the Main Dam.

2.1.1 CCTV Pole Mounted Camera

A visual inspection utilizing an underwater CCTV video and lighting system was used to acquire visual identification of any anomalies of the following structures:

- Dam C (upstream)
- Dam D (upstream)
- Main Dam Downstream
- Dam E (Bayview) (upstream)
- Dam G (Little Chute) (upstream)
- Lower Approach Wall of Lock 45 (east side)
- Upper Approach Wall of Lock 45

2.1.2 ROV Video Inspection

- Main Dam Upstream
- Main Dam Downstream of Gate 1
- Lock 45 (Upstream, Inner and Downstream)
- Lower Approach Wall of Lock 45 (west side)

2.1.3 Multi-beam Bathymetric Survey

- Upstream of the Upper Approach Wall of Lock 45 including the upper area of Lock 45 and 10 m upstream of the Upper Approach Wall
- Downstream of the Lower Approach Wall of Lock 45 including the canal downstream of the Main Dam. This bathymetric survey will extend to the island directly upstream of the Trans-Canada Highway. There were highly turbulent flows downstream of the Main Dam

[1] Email Subject: RE: Port Severn Dam Project – Investigation Work Plan October 26, 2016 9:28 AM; Site overview visit Tuesday November 1, 2016

with a low water depth. The inspection equipment and sensors do not operate well in these conditions, however, ASI attempted to safely survey the area on a best effort basis.

- The intake channel directly upstream of the Main Dam from the structure to an area in line with 10 m upstream of the Upper Approach Wall. The bathymetric survey will encompass the width of the intake channel.

2.2 Phase 2

Phase 2 of the project included the collection of data for the following:

- MBES structure survey of the vertical faces.
- Bathymetric survey spanning 5 m from the face of the structures listed below.

2.2.1 MBES Structure Survey

- Upstream of the Main Dam structure including the upstream face of the piers and inner edges of the sluice gates. There were highly turbulent flows downstream of the sluices with low water depths. For these reasons the downstream portion of the Main Dam was surveyed by ASI on a best effort basis.
- Lock 45 inner structure including the Upper Approach Wall and Lower Approach Wall. The east wall of the upstream portion of Lock 45 was surveyed in conjunction with the Main Dam. The eastern side of the Lower Approach Wall downstream of the Main Dam exhibited highly turbulent flows and low water depths. This portion of the structure was surveyed by ASI on a best effort basis.
- The upstream structure of Dam E including the upstream section of the sluice in all areas with the minimum depth of 1 m.
- The upstream structure of Dam G including the upstream section of the sluice in all areas with the minimum depth of 1 m.

2.2.2 MBES Bathymetric Survey

- Upstream of the Lock 45 North Dam Wall, Dam E and Dam G spanning 5 m from the structure for extraction of profiles of the canal bottom spaced in 5 m intervals along the face of the structures. ASI will also utilize the multi-beam bathymetric survey for detection of anomalies found on the canal bottom.

3.0 EQUIPMENT

3.1 Multi-Beam Bathymetric Echo Sounder

ASI used an R2Sonics 2024 MBES system for bathymetric surveys of the area upstream and downstream of the Main Dam to provide AECOM with the required xyz dataset for their hydraulic study. The MBES was also used for the bathymetric surveys upstream of the Lock 45 North Wall, Dam E and Dam G to extract cross-sectional profiles and structure surveys.

A MBES system allows large swaths to be surveyed with a single pass of the survey vessel (refer to Figure 9). Since there are multiple beams (256 beams from the ASI system) pointed downward in a swath across the survey vessel's track, bathymetric data is collected along the vessel's track as well as out to each side. Generally speaking, a minimum of 100% bottom coverage is achievable with multi-beam systems.

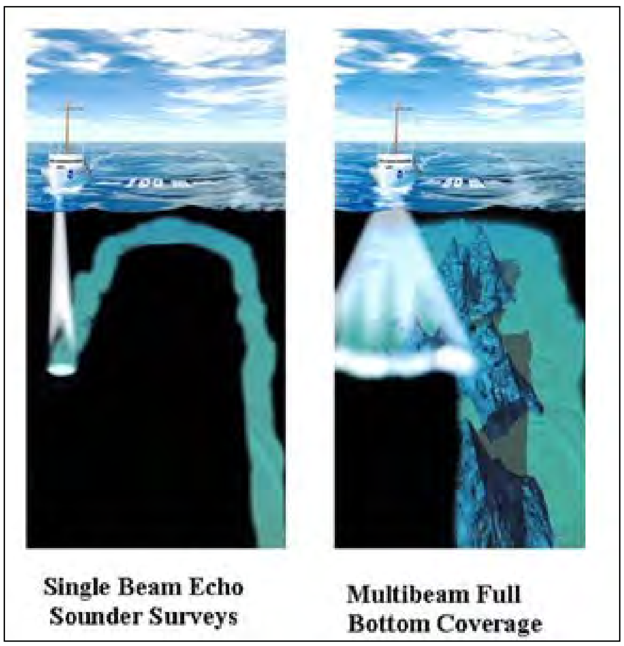

Figure 9: Single-beam versus multi-beam operation

With multi-beam bathymetry, a swath of data perpendicular to the survey line is collected; this swath is typically two to three times the water depth. Survey lines can be placed farther apart than with single-beam bathymetry, and line spacing is selected to ensure overlap in between lines, thereby ensuring 100% bottom coverage in the area surveyed. Bathymetric data is very dense, both along the survey line and in between adjacent survey lines. Features of interest (bathymetric high points and low points, obstacles, etc.) will not be missed in between survey lines. Small bottom features (i.e., rocks, timber, tires, anchors, etc.) can be located and possibly identified from the 3D data. The dimensional sizes and shapes of features can also be provided from the data, as required.

Some screen captures from a bathymetric data set are provided in Figure 10.

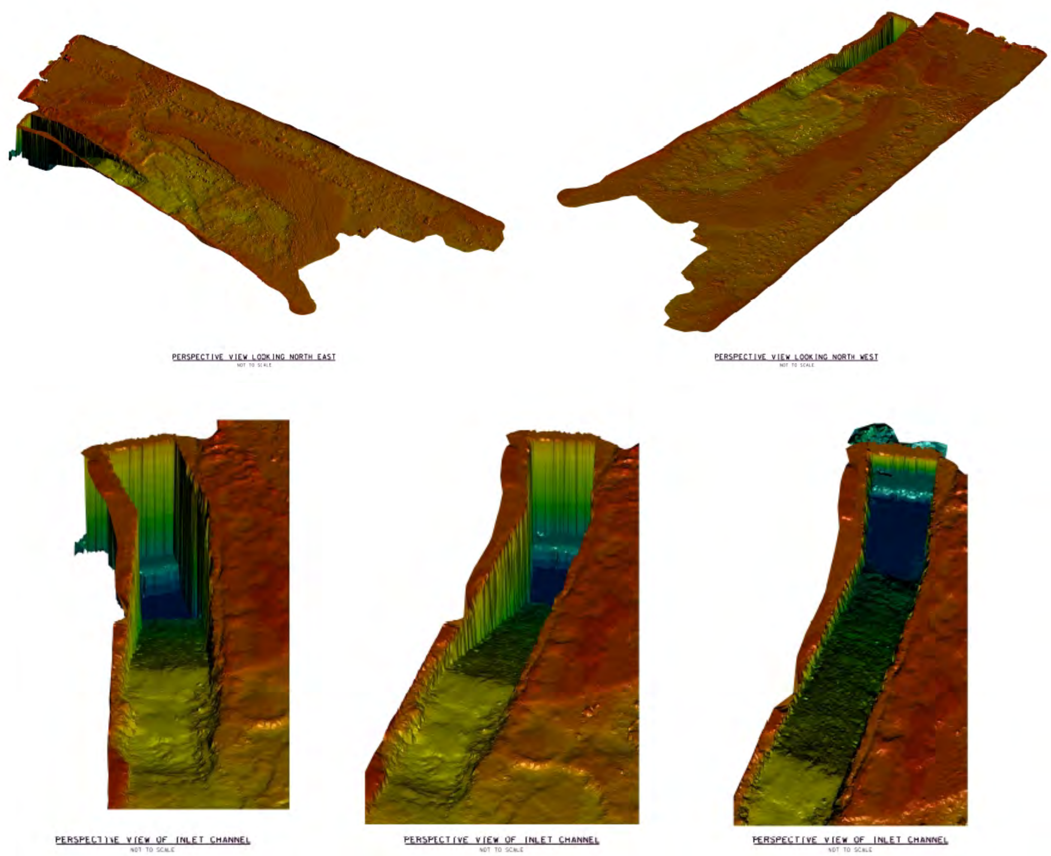

Figure 10: Examples of multi-beam bathymetric products; both plan view and perspective views

The proposed MBES system is comprised of the following components, descriptions of which are included in Appendix 1 – Equipment Descriptions.

3.1.1 Multi-Beam Echo Sounder System

The R2Sonic 2024 MBES shown in Figure 11 is an advanced multi-beam echo sounder with extremely high resolution and dynamically focused beams. The very high lateral resolution of a true 0.5 degrees, beam focusing, and optional snippets backscatter facilitates object recognition. The same unit can also be configured as a front looking imaging sonar. Main features of the MBES include the following:

- Bathymetry with side scan and snippets backscatter
- User-selectable wide band operation, tunable anywhere in the 200 kHz to 400 kHz frequency range (allows the operator to optimize the frequency to the environment, survey depths, and/or contract requirements)
- 1 to 500 m range from a single sonar receiver and transmitter
- Rotational swath sector
- 256 beams with beam compression
- Swath coverage variable from 10° to 160°

Figure 11: R2Sonic Multi-beam Transducer

A Valeport Model MiniSVS sound velocity sensor is mounted to the sonar head. It provides sound velocity profile data at the sonar head to aid in beam forming.

A YSI CastAway-CTD is used to accurately measure conductivity, temperature and depth profiles throughout the full water column. The instrument is lightweight, easy to use, and designed for this purpose. The CastAway makes use of both GPS and Bluetooth technologies. Plots of conductivity, temperature, salinity, and speed of sound versus depth can be displayed.

A Novatel ProPak6 GPS provides navigation, positioning, and heading data. The Novatel ProPak6 is a rugged GNSS/INS receiver delivering a 3D position, velocity, and attitude solution. The absolute accuracy of GNSS positioning and the stability of IMU gyro and accelerometer measurements are tightly coupled to provide an exceptional 3D navigation solution that is stable and continuously available, even during periods when satellite signals are blocked. Sub-meter DGPS positional accuracy can be accomplished using differential correction data from Space Based Augmentation Systems (SBAS) such as the U.S. Wide Area Augmentation System (WAAS), the European GPS Navigation Overlay System (EGNOS), and Japan's MTSAT Satellite Augmentation System (MSAS). Real-time Kinetic (RTK) centimeter DGPS positional accuracy is accomplished using a second ProPak6 (or equivalent) and a single antenna as a base station and transmitting DGPS corrections real-time via radio link.

The Pro-Pak6 features two GPS receivers inside one enclosure, and two multipath-resistant antennas in two separate enclosures (Figure 12). The enclosure is an extremely rugged and water-resistant IP67 housing for reliable use in harsh environments. Vessel heading is determined through the use of two GPS receivers and two antennae mounted on the vessel.

Figure 12: Novatel ProPak6 Receiver and Antennae (2)

Novatel's Inertial Explorer (IE) post-processing software can be used to post-process ProPak6 data and offer the highest level of accuracy with the system. IE maximizes the performance by ensuring the position, velocity, and altitude accuracy meet the application requirements. IE produces results suitable for demanding applications, such as aerial and hydrographic surveying.

ASI uses HYPACK and HYSWEEP software for project setup, navigation, data collection and data processing. The Windows-based software package performs all tasks necessary to complete the survey from beginning to end. HYSWEEP is an optional software module that provides for the calibration, data collection, and data processing of multi-beam sonar data inside the HYPACK package. Depending on client requirements, map/chart deliverables are generally prepared using MicroStation or AutoCAD software.

3.2 Remotely Operated Vehicle

ASI chose the SeaBotix LBV300-5 ROV due to its capabilities and size (see Appendix 1 – Equipment Description). The vehicle is ballasted to be neutrally buoyant in fresh water and uses five electric thrusters to propel itself through the water. Two horizontal thrusters are used for forward travel. The SeaBotix LBV300-5 has two vertical and one lateral thruster to enable the operator to move vertically and laterally through the water column. The vehicle is equipped with three variable intensity, high power LED lights to illuminate the area of inspection for the high resolution colour camera. The ROV is also equipped with a second low-light wide-angle colour camera.

Figure 13: SeaBotix LBV300-5 prior to deployment

The system utilized 350 m of neutrally buoyant high visibility umbilical cable for the inspection. This umbilical houses both signal and power conductors (fibre-optic and copper respectively), along with a Kevlar strength member and abrasion resistant protective jacket. The umbilical is neutrally buoyant in water to reduce the drag and allow for longer penetration distances. A ROV pilot controls the vehicle movement, lighting, and camera position from the surface with the use of a hand held control console.

The video signal is routed to the surface through a fibre-optic cable in the umbilical. The fibre-optic signal is converted in the reel junction box to an analogue video signal which is then fed into a high resolution video monitor for the pilot to view. The video signal is also recorded in real-time onto a data recording computer. Audio commentary is added to document any points of interest and anomalies as they are seen during the inspection.

3.2.1 Video Cameras

High quality video requires good visibility conditions (sufficient lighting, low turbidity). The video signals are recorded in real-time onto a recording PC in digital format. Audio commentary is added to document points of interest and anomalies as they are seen during the inspection.

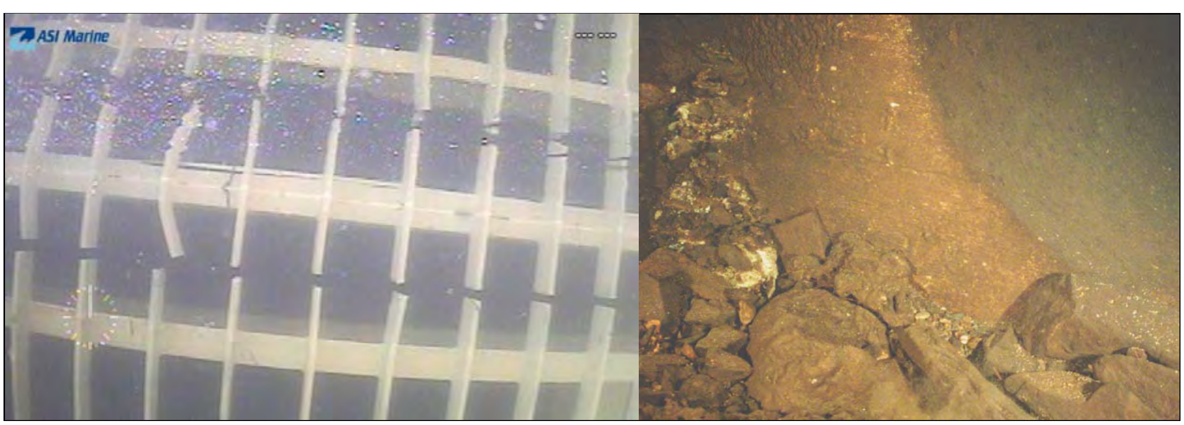

Figure 14: Sample still images captured from video streams for reporting.

3.2.2 ROV Navigation Sonar

A Tritech Micron DST scanning sonar operating at 700 kHz is mounted on the LBV for navigation purposes. The sonar, mounted upright, scans on a horizontal plane generating a plan view image of the surrounding area using an acoustic beam 35 degrees wide (Figure 15).

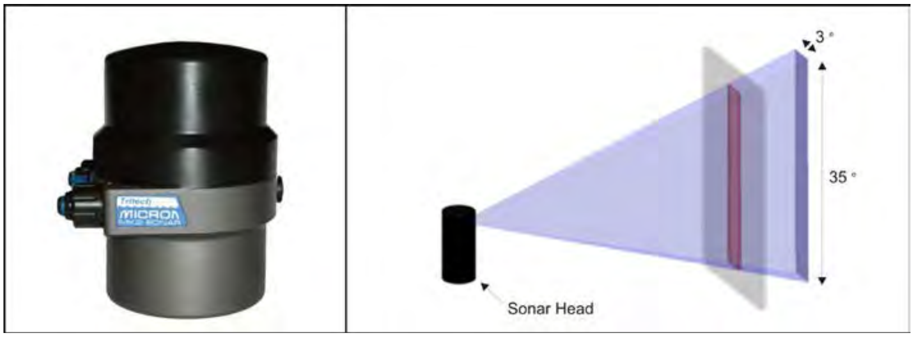

Figure 15: Tritech Micron DST sonar beam

The sonar is positioned to provide a full 360 degree view around the ROV. Targets are identified by strong returns (yellow) and shadows (black) (Figure 16).

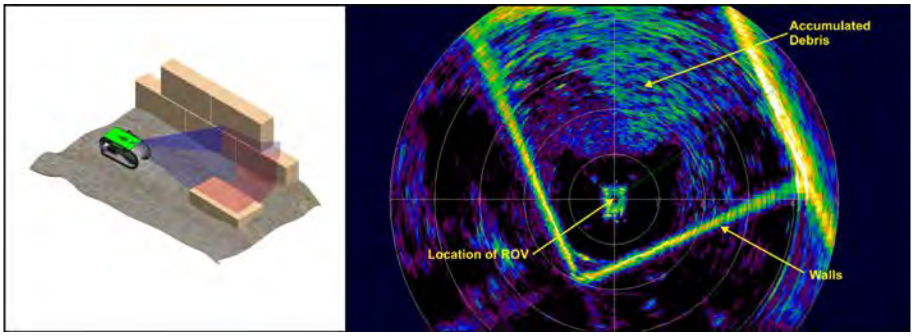

Figure 16: Navigation sonar (representation image only - not from this project)

3.3 CCTV Camera

An Outland camera and light system was mounted to a pole for visual inspection of the structures and features. The camera and light attach to a 100 m cable which is then routed to a control box with monitor. The video signal is split at the control console and a separate feed is recorded onto a computer.

The camera records a 4.1 Megapixel image and has a field of view of 70 degrees. The low light sensitivity of the camera is excellent in underwater conditions and can be supplemented with the separate system light. The light output is variably controlled in the control console.

4.0 INSPECTION PROCESS

4.1 Shop Preparation and Mobilization

4.1.1 ROV and CCTV Camera System

ASI personnel assembled the equipment packages and ancillary tools at ASI's shop prior to traveling to Port Severn. The pole-mounted CCTV camera and lighting system was fully function tested. All sonar and inspection equipment were integrated onto the ROV in a dry bench shop setting and function tested. After passing dry tests, the ROV was wet tested in ASI's test tank to ensure all components of the package functioned appropriately. Upon confirmation, the ROV was trimmed to be neutrally buoyant in fresh water. The equipment was packed into carry cases for transportation in ASI's cube van to the site location which was also utilized as a sheltered operations area.

4.1.2 Bathymetric Survey

ASI personnel involved with the bathymetric survey portion of the inspection assembled and function tested the utilized equipment at ASI's shop prior to mobilization to site. The equipment was confirmed operational during the week of the Port Severn scheduled work at a separate project. The equipment was packed into an ASI truck which also towed the survey vessel.

4.2 Site Operations

4.2.1 ROV and CCTV Camera System

ASI personnel travelled to Midland on October 31, 2016 to prepare for commencing operations on site the following day. On November 1, 2016 two (2) ASI personnel met with an AECOM representative to discuss site operations and a modified scope of work for the inspection of the structures. Upon completion of the site visit to each of the structures included in scope of work, ASI personnel completed a site safety meeting regarding any possible hazards associated with the separate structures to be inspected. The discussion also incorporated possibilities to reduce or mitigate hazards at each site, including weather, working near water, and traffic hazards.

During the morning of November 1, the equipment was set up at a staging area adjacent to the eastern end of the Main Dam (Figure 17) and function tested according to ASI's written pre-dive procedures. Three structures were inspected on November 1. At 12:00 p.m. a ROV inspection of the northern portion of the Main Dam was conducted. Upon completion of the ROV inspection of the Main Dam, post-dive tests were completed to confirm operation of the equipment. The ROV equipment was then loaded into the cube van.

Figure 17: Staging area for inspection operations at Main Dam

Setup of the CCTV pole-mounted camera system was completed. The CCTV system was tested for functionality prior to beginning the inspection of structures Dam C and Dam D. The CCTV camera inspection of Dam D began at 4:00 p.m. and concluded at 5:15 pm. The cube van was relocated adjacent to Dam C and the inspection commenced at 6:00 p.m. Upon completing the inspection of Dam C, the equipment was loaded into the cube van and ASI personnel left site at 6:40 p.m.

On November 2, 2016 ASI personnel arrived on site at 8:00 a.m. and met with the ASI personnel involved with the bathymetric survey, discussing the scope of work and hazard mitigation. The cube van was parked safely on the roadway shoulder adjacent to Dam G and the CCTV camera equipment was set up and tested. The inspection of Dam G started at 9:25 a.m. and concluded at 9:55 a.m. The equipment was then loaded into the cube van for transport to the next location.

ASI personnel relocated the cube van off the roadway adjacent to Dam E and began the setup for the inspection. The inspection of Dam E started at 12:20 p.m. and concluded at 12:55 p.m. The equipment was then unloaded from the cube van and carried to a bench adjacent to the Lock 45 North Wall. Between 3:20 p.m. and 4:30 p.m. the inspection of the Upper Approach Wall was conducted. At 5:00 p.m. ASI personnel began the inspection of Lock 45 North Wall. The inspection of Lock 45 North Wall concluded at 6:00 p.m. ASI personnel loaded the equipment into the cube van and left site by 6:20 p.m.

On November 3, 2016, ASI personnel arrived on site at 8:00 a.m. The cube van was located near the lower section of Lock 45 and the ROV equipment was set up (Figure 18). Pre-dive tests were conducted at 8:35 a.m. and the ROV inspection of the internal portion of Lock 45 was started at 8:50 a.m. The inspection concluded and the inspection of the lower portion of Lock 45 started at 10:00 a.m. This inspection also included the western side of the Lower Approach Wall.

Due to the high flows on the downstream section of the Main Dam, the ROV was not able to safely inspect the entire area. The CCTV camera system was set up and utilized for inspection of the Lower Approach Wall and the majority of the downstream section of the Main Dam. The inspection of the downstream portion of the Main Dam and eastern side of the Lower Approach Wall started at 12:00 p.m. and concluded at 4:00 p.m. ASI personnel loaded the equipment and were off site at 6:00 p.m.

Figure 18: Staging area for operations of inspections of Lock 45 and Lower Approach Wall

4.2.2 Multi-beam Bathymetric Survey

ASI personnel involved with the collection of bathymetric data travelled to Midland on November 1, 2016 to prepare for beginning the survey on November 2. On the morning of November 3, the two ASI personnel met with additional ASI personnel to discuss the modified scope of work for the survey and completed a safety meeting.

ASI personnel began the setup of a RTK DGPS base station on the Lock 45 Lower Approach Wall (Figure 19). The control point used for RTK/DGPS positioning was installed by an AECOM representative on October 31, 2016. The elevation was verified to a local benchmark and horizontal control set through GPS. A radio link transmitted differential corrections real-time to the DGPS unit on the survey vessel, where the position was corrected in real-time providing centimetre accuracy positioning.

AECOM provided ASI with the following values for this control point and elevation reference mark with horizontal coordinates in metres and presented as Universal Transverse Mercator (UTM-Zone 17) coordinates in the North American Datum of 1983 (NAD83) and vertical elevations in metres referenced to a local benchmark:

CONTROL POINT
Northing: 4961897.603 m, Easting: 601187.477 m
Elevation: 177.350 m

Figure 19: RTK-DGPS base station setup on Lock 45 Lower Approach Wall

Two ASI personnel began setup of the MBES and ancillary equipment onto the survey vessel. The survey vessel was launched on the upstream portion of the area to be surveyed at 11:55 a.m. ASI followed standard procedures for configuring and calibrating the MBES (see Appendix 2) which involved:

- Measurement and input of the static offsets of all of the sensors comprising the MBES
- Performance of a patch test which is designed to reveal and allow corrections for the pitch offset, roll offset, positioning time delay, and azimuth offset
- Measurement and compensation for latency (time delays) between all of the sensors comprising the MBES
- Measurement and input of the transducer draft
- Measurement and input of sound velocity cast data

On the days of multi-beam bathymetric data collection, the weather was sunny with cloudy periods. The air temperatures ranged between 4 °C and 17 °C. There was a very light breeze present with minimal waves. The multi-beam bathymetric equipment package included a motion sensor that corrects for most vessel and multi-beam sonar head movement (heave, pitch, roll, and yaw) that would be associated with windy weather and larger wave conditions if these conditions had been present.

After completing the required configuration and calibration of the MBES, ASI personnel began the survey of the upstream portion of the Main Dam. The bathymetric survey was completed throughout the area and reviewed at 4:30 p.m. The collected data was verified for complete coverage and the vessel was removed from the upper portion of the waterway.

ASI personnel relocated the vessel and equipment to the lower portion of the waterway downstream of the Main Dam where it would be left overnight with the MBES equipment in a secure location. The two ASI personnel then returned to recover the RTK-DGPS base station and loaded the components into the transport vehicle. All ASI personnel left site at 6:20 p.m. ASI personnel arrived at the site on November 3 at 8:00 a.m. Prior to launching the vessel into the water, the static offset measurements comprising the MBES were taken to verify that no movement had occurred during the short transport from the upper portion of the waterway. The RTK-DGPS base station was set up on the Lock 45 Lower Approach Wall utilizing the same control point for the upstream portion of the Main Dam. The vessel was launched into the lower waterway at 8:30 a.m. and ASI personnel commenced the configuration and calibration of the MBES in the same way as completed for the upper portion of the waterway.

After completing the required configuration and calibration of the MBES, ASI personnel began the survey of the downstream portion of the Main Dam. The bathymetric survey was completed throughout the area and reviewed at 4:35 p.m. The collected data was verified for complete coverage and the vessel was removed from the lower portion of the waterway. ASI personnel loaded the equipment into the transport vehicle and left site at 6:00 p.m.

4.2.3 Multi-beam Structures Survey

ASI personnel involved with the collection of the multi-beam structures data travelled to Midland on November 7, 2016 to prepare for beginning the survey on November 8. Three ASI personnel arrived on site at 7:00 a.m. on November 8 and completed a safety meeting regarding any possible hazards that could arise.

ASI personnel began the setup of a RTK DGPS base station again on the Lock 45 Lower Approach Wall. This control point used for RTK/DGPS positioning was installed by an AECOM representative on October 31, 2016. AECOM provided ASI with the following values for this control point and elevation reference mark with horizontal coordinates in metres and presented as Universal Transverse Mercator (UTM-Zone 17) coordinates in the North American Datum of 1983 (NAD83) and vertical elevations in metres referenced to a local benchmark:

CONTROL POINT
Northing: 4961897.603 m, Easting: 601187.477 m
Elevation: 177.350 m

ASI personnel began setup of the MBES and ancillary equipment onto the survey vessel. At 10:35 a.m. the survey vessel was launched on the upstream portion of the area to be surveyed.

After completing the required configuration and calibration of the MBES, ASI personnel began the survey of the Lock 45 North Wall and Upper Approach Wall. The bathymetric survey was completed throughout the area and reviewed at 4:45 p.m. ASI personnel removed the vessel from the waterway and left site at 5:40 p.m.

On November 9, 2016, ASI personnel arrived on site at 6:45 a.m. and began the setup of a RTK DGPS base station on Dam G. This control point used for RTK/DGPS positioning was installed by an AECOM representative on October 31, 2016. The elevation was verified to a local benchmark monument and horizontal control set through GPS. A radio link transmitted differential corrections real-time to the DGPS unit on the survey vessel where the position was corrected in real-time providing cm accuracy positioning.

AECOM provided ASI with the following values for this control point and elevation reference mark with horizontal coordinates in metres and presented as Universal Transverse Mercator (UTM-Zone 17) coordinates in the North American Datum of 1983 (NAD83) and vertical elevations in metres referenced to a local benchmark:

CONTROL POINT
Northing: 4961957.403 m, Easting: 600392.284 m
Elevation: 181.991 m

ASI personnel began the survey of Dam G after confirming the calibration of the MBES. The bathymetric survey was completed throughout the area and reviewed at 9:10 p.m. ASI personnel confirmed that the coverage of the structure was complete and relocated the RTK-DGPS base station at the Lower Approach Wall for collection of the structure survey data for the Main Dam, Lock 45 and Dam E.

ASI personnel began the multi-beam structures survey of the upstream portion of the Main Dam and Dam E at 10:00 a.m. Upon completion of the structure survey at 11:45 a.m., ASI personnel verified the coverage of the structures was complete. ASI personnel removed the survey vessel from the upper portion of the waterway and relaunched the vessel in the downstream portion. The remainder of the structure survey was completed at 1:30 p.m. and ASI personnel verified that complete coverage of the structures was accomplished. The survey vessel was removed from the waterway and the multi-beam equipment was loaded into the transport vehicle. ASI personnel left site at 3:30 p.m.

4.3 Reporting

During all operations all data was recorded real-time to a hard drive. All data was reviewed on site to ensure adequate data acquisition. At the completion of the day’s events, the data was backed up to an external portable hard drive.

Before starting the reporting phase, collected data was sorted and labelled by the structure and location of collected data.

A review of the inspection videos and data logs collected during the inspection was completed in the ASI office. The assembly of this report was then completed. The report includes methodology, site photos, equipment descriptions, select video images, video and above water images of the downstream gates of the Main Dam.

A review of the collected multi-beam data for the bathymetric and structure surveys was analysed and processed. During processing, the data was filtered for noise and sonar reflection artifacts caused by bio growth, air, and other targets in the water column (fish, debris, etc.). Cross-sectional profiles, 3D perspective views and bathymetric data from the MBES surveys are included in this report.

5.0 INSPECTION OBSERVATIONS

5.1 Dam C

The inspection of Dam C was conducted using a pole-mounted CCTV camera and light. The inspection was conducted in a north to south direction with the most southern tree at the northern end of the concrete retaining wall being the zero mark from which the distances were measured. All images of the inspection are included in Appendix 3A and the inspection video is provided in Appendix 7.

Joints in the dam face located at 10.3 m (Image 3A-02) and 31.5 m (Image 3A-04) were observed to have slight separation as well as minor spalling. The joint at 10.3 m had a separation of 5 cm and undercutting on the north side extending 50 cm from the joint and was 5 cm in depth. The joint observed at 31.5 m had a separation of 5 cm and a depth of 2 cm. A joint in the dam face observed at 25.5 m (Image 3A-03) was observed to exhibit minor spalling near the water surface approximately 5 cm in width and minimal depth, narrowing to no separation at 15 cm below the water surface. At a payout of 56 m there was an apparent piece of re-bar protruding from the dam face with spalling in the concrete surrounding the piece (Figure 20). This spalling was observed to be up to 10 cm deep and up to 20 cm wide.

Figure 20: Spalling with exposed rebar

There was minor cracking in the concrete face present at 7 m (Image 3A-01) and 41 m (Image 3A-05) but had no separation or depth apparent. Spalling was observed between 56.5 m (Image 3A-06) and 63 m (Image 3A-08) isolated to just below the water surface. The spalling was observed to be approximately 5 to 10 cm deep below the water surface and deeper above the water surface.

A light layer of biofouling was present throughout the inspection of the dam face but it was minimal and the concrete was visible.

The collected data of Dam C was limited to the pole-mounted CCTV camera and light due to the minimal water depth along the face of the structure. Because of the minimal water depth the collection of MBES data was unattainable.

5.2 Dam D

The inspection of Dam D was conducted using a pole-mounted CCTV camera and light. The inspection was conducted in a south to north direction with the zero point being the most southern point, where Dam D intersected the upstream structure of the Main Dam. All Images from this inspection are included in Appendix 3B and the inspection video is provided in Appendix 7.

A joint in the concrete face found at 19.6 m (Image 3B-10) was observed to have spalling extending from the joint with an overall width of 20 cm. The depth of the spalling was observed to be approximately 20 cm. The concrete at the joint had eroded away to reveal the wooden sub structure. A joint in the structure at 19.6 m (Image 3B-11) had the northern side of the concrete face severely eroded.

Significant undercutting was present in three locations. Undercutting observed from 0 m (Figure 21) to 15 m (Image 3B-09) was near the surface with a maximum depth of 30 cm and a height ranging from 15 cm to 30 cm below water surface. This undercutting was significant enough to reveal the wood sub structure at 0 m (Images 3B-01 and 3B-02) and at 8.5 m (Image 3B-06). At 8.5 m there was a possible piece of exposed PVC pipe protruding through the concrete into the water. There was undercutting observed from 29 m to 30.7 m approximately 10 cm in depth at the deepest point and varied from 5 cm to 10 cm in height from the bottom. There was slight undercutting observed from 46 m to 47.5 m which was 5 cm in height and 5 cm in depth.

Figure 21: Spalling starting at 0 m and continuing to 10 m. Left image taken at 0 m, right image taken at 4 m facing north.

Spalling was found in three locations. At 25.8 m (Image 3B-12) the spalling appears to be centred on a joint but is covered by significant biofouling. At 24.3 m (Image 3B-15) the spalling is mostly above the waterline and seems to be concentrated on the northern side of a joint. From 34.5 m (Figure 22) the spalling was significant enough to have created a cavity in the concrete approximately 80 cm wide and 15 cm deep.

Figure 22: Spalling in dam face observed at 34.5 m

There is a crack in the face of the dam at 42.7 m (Image 3B-17), which appears to run up the entire length of the face and along the top of the dam wall. Spalling can also be found on the southern side of this crack with a depth of 10 cm and maximum width of 10 cm.

The collected data of Dam D was limited to the pole-mounted CCTV camera and light due to the minimal water depth along the face of the structure. Because of the minimal water depth the collection of MBES data was unattainable.

5.3 Main Dam

For the purpose of the report and data collection, the inspection of the Main Dam was separated into two sections; the upstream section of the Main Dam, and the downstream section of the Main Dam.

5.3.1 Upstream

The inspection of Main Dam Upstream was conducted using a ROV. The inspection was carried out from east to west with Pier 1 being the starting point. All images of this inspection are included in Appendix 3C and the inspection video is provided in Appendix 7.

Heavy biofouling coverage on the surface of Pier 1 impeded the ability to assess conditions associated with possible cracking in the structure. Separation in the joints at the transition from Pier 1 to the Lock 45 east wall and the second most southern joint on the Lock 45 east wall were observed to exhibit water ingress into the downstream portion of Lock 45. These joints were not observed due to the heavy biofouling coverage. ASI previously inspected the structure in 2015 and had noted a separation in these joints with horizontal cracking observed on Pier 1. No scouring was observed on the Gate 1 slab and interface to the canal bottom.

Minor spalling was observed at the water surface on the northern and eastern face of Pier 2. This spalling was observed to be under 5 cm in depth and height. The sill of Gate 2 appeared to have no significant scouring or spalling. The elevation of the Gate 2 and Gate 3 sill directly upstream of the stop logs was observed to be 0.6 m to 0.7 m below the remaining gates as seen in Figure 23.

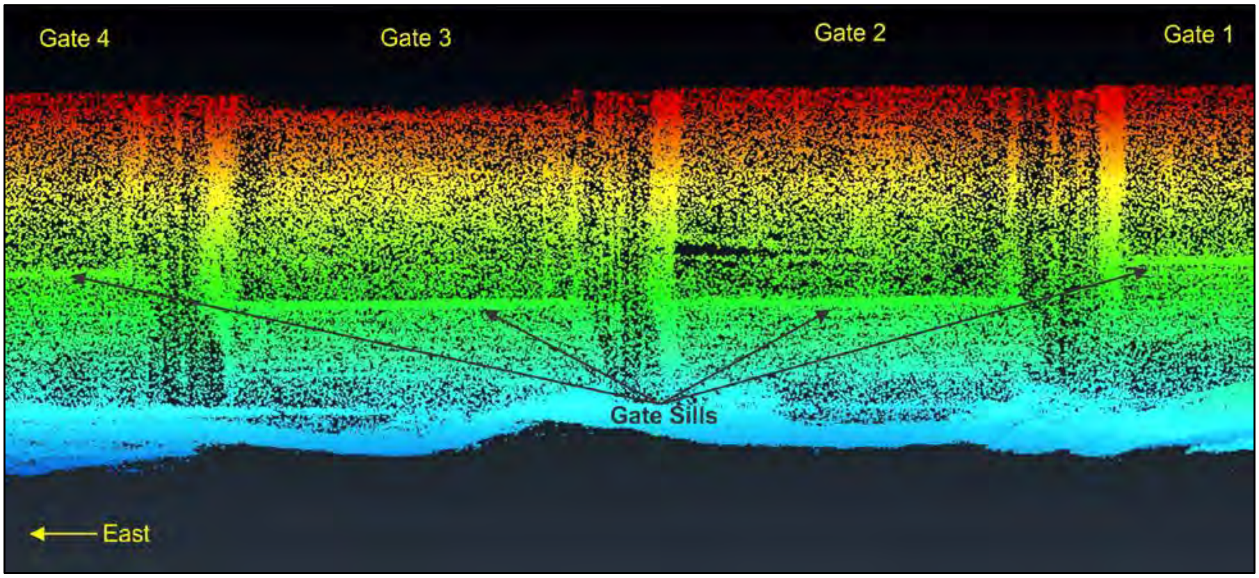

Figure 23: Gates 1 to 4 upstream sill elevations

The sill for Gate 3 had a cut out area adjacent to the Pier 3 bullnose (Figure 24). Minor scour marks were identified on Pier 3 and Pier 4 observed to be under 5 cm in depth and height.

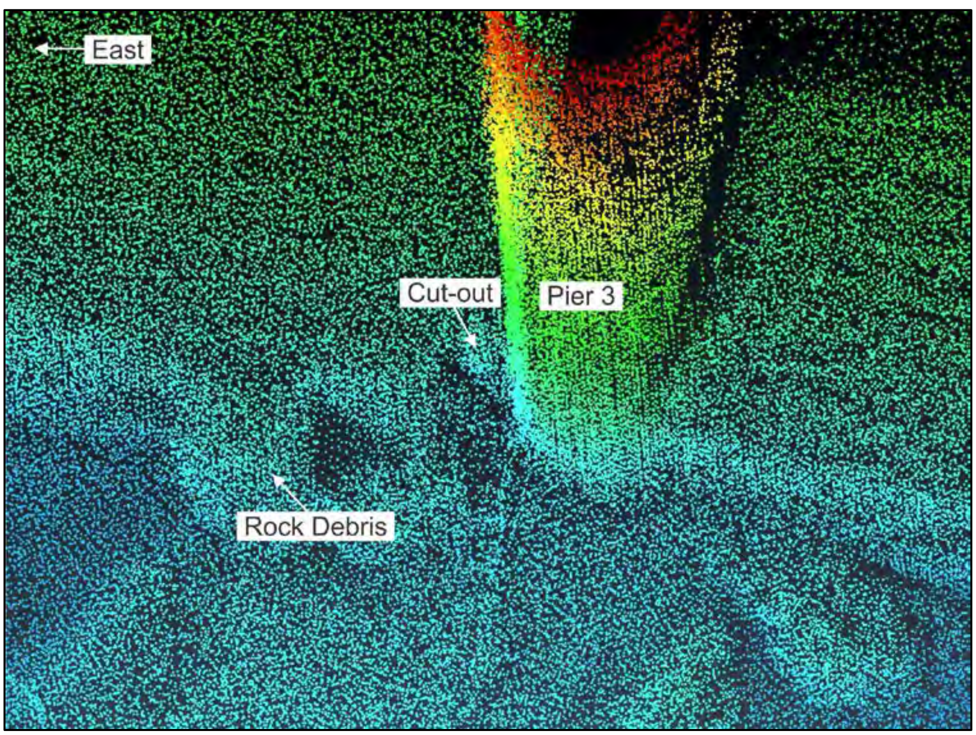

Figure 24: Gate 3 sill cut-out section

Directly upstream of Gate 4 the canal bottom was lower than the footing. At the eastern end of Gate 4 the bottom began an upslope to the east approximately 1.3 m upstream of the footing. Within the 1.2 m area the canal bottom was excavated 0.7 m below the upstream canal bottom. The Gate 4 footing had a cut out area adjacent to the Pier 4 Bullnose (Figure 25).

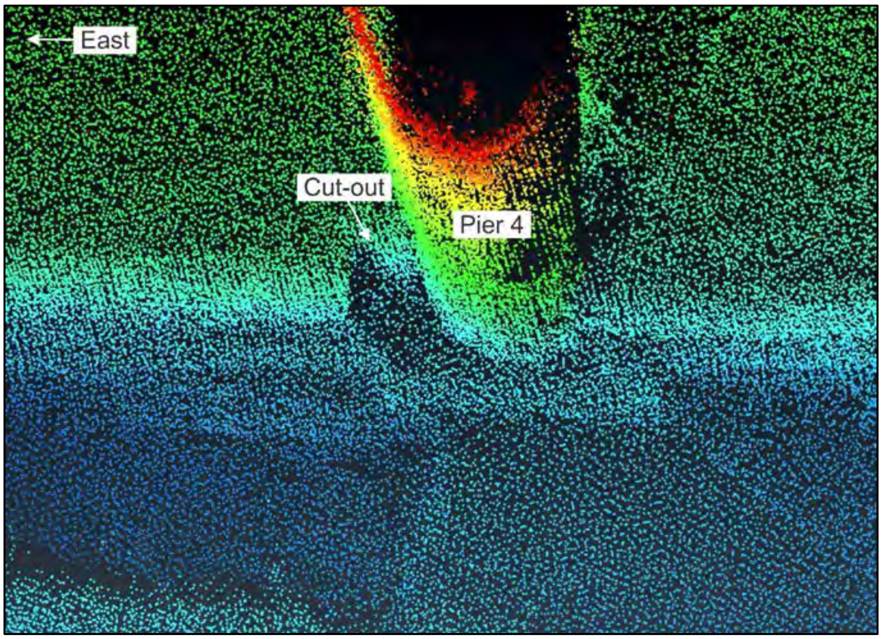

Figure 25: Gate 4 sill cut-out section

Minimal scouring was apparent on the Pier 4 bullnose directly below the water surface. During the 2015 inspection, scouring was observed upstream of the Pier 4 stop log slot, but was not noted in the 2016 inspection, possibly due to an increase in biofouling coverage on the concrete surfaces. Minimal scouring was observed on Pier 5.

The Gate 5 sill was observed to have no spalling or cracking observed. Directly upstream of the sill the canal bottom was excavated 1.5 m below the sill edge and extended 2.4 m to the north before transitioning to the unexcavated canal bottom. The Gate 5 sill was also noted to be 0.75 m from the bullnose face, which differed from the other gates which had the slab end at the pier bullnose (Figure 26).

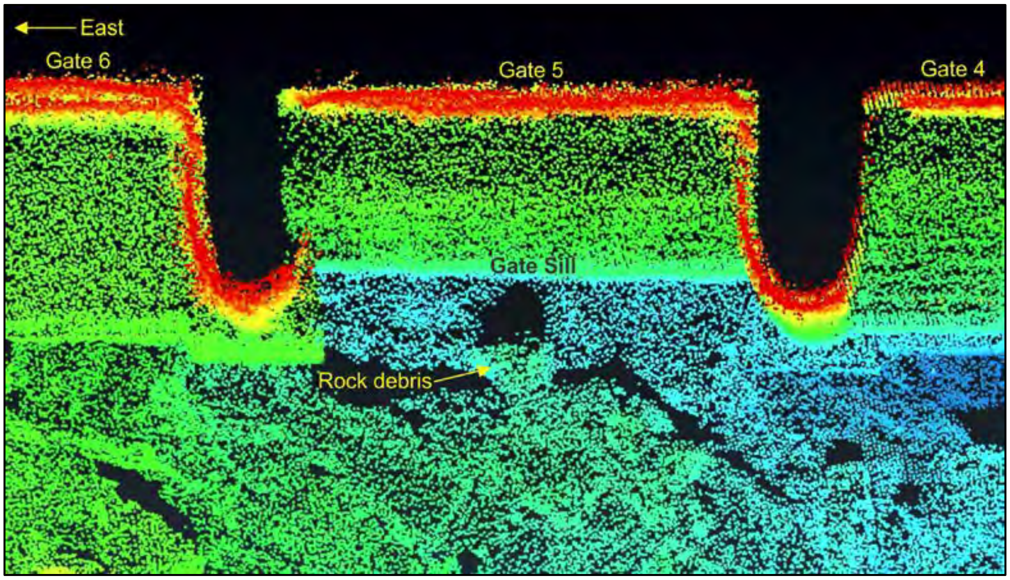

Figure 26: Gate 5 sill recessed from pier bullnose

Scouring was identified on Pier 5 near the water surface between the stop log slots in the 2015 inspection. Pier 6 had significant spalling observed on both the east (Images 3C-01 and 3C-03) and west (Image 3C-02) sides. The spalling continued around the upstream face of the pier and varied in height from 5 cm to 20 cm. The depth of the spalling was typically observed to be 5 cm to 10 cm. The Pier 6 bullnose was observed to be situated on a square footing 3.1 m below the water surface. This squared concrete footing protruded past the face of the pier 0.25 m to the north, east, and west (Figure 27).

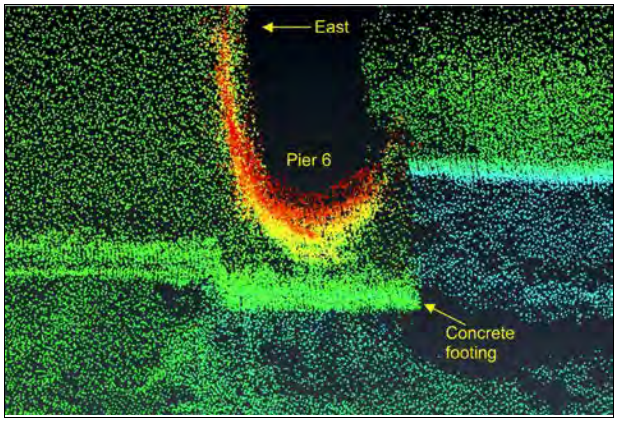

Figure 27: Protruding concrete footing beneath Pier 6

Gates 6 through 9 had a minimal change in elevation from the sill to the excavated canal bottom. The sills were horizontal from the stop logs to the canal bottom transition with no slope observed. There was no apparent spalling or scouring of the concrete sills, and some small debris was noted.

Pier 7 has spalling on both the east and west sides, continuing around the front bullnose (Images 3C-05 and 3C-06). The spalling was isolated to directly beneath the water surface and was observed to be typically 10 cm high and 15 cm deep. The footing at the base of Pier 7 was similar in structure to the footing observed under Pier 6.

Image 3C-07 shows the bottom transition of Pier 8 to the canal bottom which was similar in structure to the footing observed under Pier 6. Pier 8 was found to have some slight spalling on the north bullnose just below the surface (Image 3C-08). The spalling was observed to be 30 cm high and under 5 cm deep.

Pier 9 had significant spalling around the entire radius of the north bullnose (Image 3C-10) which was 30 cm high and 15 cm deep. The severity of the spalling decreased on the east and west sides of the pier to 10 cm high and 5 cm deep. The bottom of Pier 9 can be seen in Image 3C-10. The footing at the base of Pier 9 was similar in structure to the footing observed under Pier 6.

5.3.2 Downstream

The inspection of the Main Dam Gate 1 and Gate 2 of the downstream section was conducted using a ROV. The inspection was supplemented with the use of a CCTV camera stationed from a vessel for Gate 4 and partial inspection of Gate 5. Gates 6 to 9 had minimal water depth but the CCTV camera was used to partially inspect the transition from the concrete sill to the canal bottom. Select still images of this inspection are included in Appendix 3D and the inspection video is provided in Appendix 7. During the inspection, above-water images were taken and are included in Appendix 6.

The stop logs could not be manipulated to reduce the flow, resulting in limited inspections of Gates 2, 3 and 5. Gates 1 and 4 had leakage in the stop logs causing aeration to be produced on the lower concrete gate sills which impeded the visibility of the inspection. Heavy biofouling was apparent on the faces of the structure impeding the ability to distinguish light spalling and cracks. In the previously completed inspection in 2015, the stop logs were manipulated when on site and the biofouling coverage was less.

Image 3D-01 shows the condition of the downstream slab of Gate 5. Image 3D-02 shows erosion on the ledge below Gate 4 and Gate 5. Figure 28 shows undercutting below the concrete footing under Gate 1 and Pier 2. The undercutting was observed to be 10 cm in height and depth and was 0.7 m in length.

Figure 28: Slight undercutting observed beneath Pier 2 footing

Figure 29 shows undercutting on the downstream section of Gate 2 below the concrete footing. The undercutting was noted to be significant, spanning the length of Gate 2 with a height of 30 cm to 40 cm. The depth of the undercutting was unknown, but a minimum viewable area indicated a minimum depth of 30 cm.

Figure 29: Undercutting observed beneath Gate 2 footing

There was slight spalling observed on the downstream faces of the piers. All observed spalling was near the water surface and was under 5 cm in depth. There were linear markings associated with joints or form marks in the concrete structure observed, none which showed separation.

The concrete footings from Pier 5 to Pier 10 were observed to be at a higher elevation than the footings beneath Gate 1 to Gate 4. The condition of the footings throughout the inspection was observed to have minimal spalling. Possible areas of cracking of the slabs were observed but due to the heavy biofouling, it was unable to determine if the linear lines were from cracking in the concrete or biofouling.

5.4 Dam E

The inspection of Dam E was conducted using a pole-mounted CCTV camera. The inspection was carried out from east to west with the zero point being the survey control monument that was installed by AECOM on the east side of the dam with horizontal coordinates in metres and presented as Universal Transverse Mercator (UTM-Zone 17) coordinates in the North American Datum of 1983 (NAD83) and vertical elevations in metres referenced to a local benchmark:

CONTROL POINT
Northing: 4961921.814 m, Easting: 600405.157 m
Elevation: 181.396 m

All images from this inspection are included in Appendix 3E and the inspection video is provided in Appendix 7.

A small section of undercutting less than 1 m in length and 10 cm in depth and height was present at 6.7 m (Image 3E-02) at the transition to bedrock. The next section of undercutting began at 11 m (Image 3E-04) and traveled around the radius of the corner on the east side of Dam E sluice opening and was 10 cm in height and depth. At 11.8 m (Images 3E-05 and 3E-06) the undercutting was visible above the water surface where it led into a joint that was eroded away to reveal the wooden sub structure. The spalling observed was 30 cm in height from the water surface and approximately 40 cm in depth. Spalling was also observed at 21.5 m which was centred on a vertical crack and was 50 cm wide and 20 cm deep. The next section of undercutting began at 26.6 m (Image 3E-12) and continued to the end of the below water portion of the dam (Image 3E-13). This undercutting was observed to be 10 cm in height and depth.

A vertical crack was visible at 5.5 m (Image 3E-01) from above water and had inline spalling on the dam wall. At 21.5 m (Figure 30) there was severe cracking that ran vertically from the top of the dam and down the face. Above the water line the crack had widened to reveal two vertical timbers. The crack continued below the water line (Image 3E-11) to the bottom of the dam face.

Figure 30: Spalling associated with vertical crack on face of dam

Severe cracking was present at the west end of the dam wall at 27.5 m (Figure 31), where it appeared that the crack runs through the entire dam wall. It appeared that the west section of the dam, after the crack, may have shifted horizontally and was slightly offset.

Figure 31: Diagonal crack on dam face with spalling at water surface

5.5 Dam G

The inspection of Dam G was conducted using a pole-mounted CCTV camera. The inspection was carried out from west to east with the zero point being the survey monument that was installed by AECOM on the west end of the dam with horizontal coordinates in metres and presented as Universal Transverse Mercator (UTM-Zone 17) coordinates in the North American Datum of 1983 (NAD83) and vertical elevations in metres referenced to a local benchmark:

CONTROL POINT
Northing: 4961957.403 m, Easting: 600392.284 m
Elevation: 181.991 m

All images from this inspection are included in Appendix 3F and the inspection video is provided in Appendix 7.

There was a large concrete sill upstream of the gate, which was observed to be flat and protruded 3 m from the dam wall. There were no apparent separations or spalling observed on the slab and the edges appeared to be uniform (Figure 32). The line running diagonally across the image of the 3D point cloud is due to an increase in collected points as the survey vessel was slowed to turn across the face of the dam.

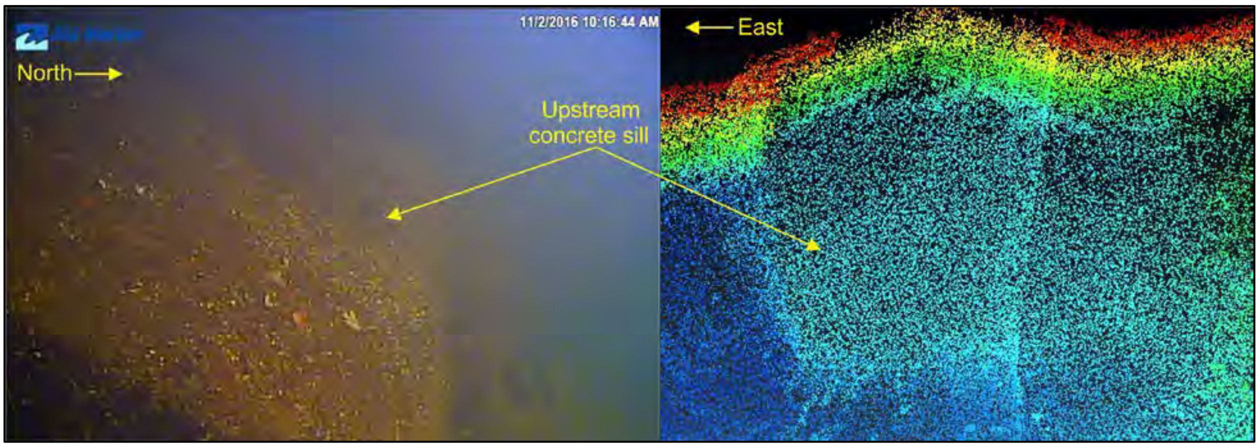

Figure 32: Concrete sill upstream of dam gate

The Joints at 21.8 m (Image 3F-01) and 65 m (Image 3F-15) showed signs of slight separation of under 5 cm. The depth of these cracks varied from 5 cm to 10 cm. The joint at 41.7 m (Images 3F-02 and 3F-03) had slight spalling visible with possible cavitation behind the joint at the water surface. The spalling was observed to be 10 cm in width at the widest point. The joints at 52 m (Image 3F-08) and 90 m (Image 3F-21) had shallow spalling below the water surface approximately 5 cm in depth. A joint observed at 111.5 m had shallow spalling under 5 cm in depth and under 10 cm in width under the water surface.

There was a section of undercutting at 60.2 m (Image 3F-12). A large section of undercutting began at a crack observed at 81 m (Figure 33) and continued to 89.2 m (Image 3F-20). The undercutting was observed to vary from 10 cm to 30 cm in height below the water surface and 5 cm to 10 cm in depth. The final section of undercutting begins at 106.3 m (Image 3F-26) and continues for 1.1 m to 107.4 m with a height of 20 cm and a depth under 10 cm (Image 3F-28).

Figure 33: Undercutting on dam face observed from 81 m to 89.2 m

Three small spalling marks under 5 cm in depth were observed at 47 m (Image 3F-05), 48 m (Image 3F-06) and 103.8 m (Image 3F-25). A grouping of spalling marks was observed at 101 m (Image 3F-23). The grouping situated at 101 m was observed to be under 5 cm in depth and ranged from 5 cm to 30 cm in width and 5 cm to 10 cm in height. At 108.3 m there was an observed grouping of spalling marks under 10 cm in height, 10 cm in length, and under 5 cm in depth (Image 3F-29).

Several cracks were observed along Dam G. One horizontal crack was found at 51 m (Image 3F-07) approximately 1 m in length and 2 cm in depth and height. Two small vertical cracks with erosion centered on them were found at 96.3 m (Image 3F-22) and 102.8 m (Image 3F-24). Both cracks were observed to be under 10 cm in depth and 20 cm in width at the widest points. At 45.5 m (Image 3F-04) a crack was found showing a significant amount of separation. The crack found at 53 m (Images 3F-09 and 3F-10) appeared to have significant depth with possible cavitation behind the crack. At 55.5 m (Image 3F-11) there was a large crack running vertically down the dam face with large amounts of erosion around it.

5.6 Lock 45

For the purpose of the report and data collection, the inspection of Lock 45 was broken up into four separate sections; the upstream section of Lock 45, Lock 45 internal, the downstream section of Lock 45 and the north dam wall.

5.6.1 Lock 45 Upstream

The inspection of Lock 45 Upstream was conducted using a ROV. All images from this inspection are included in Appendix 3G and the inspection video is included in Appendix 7.

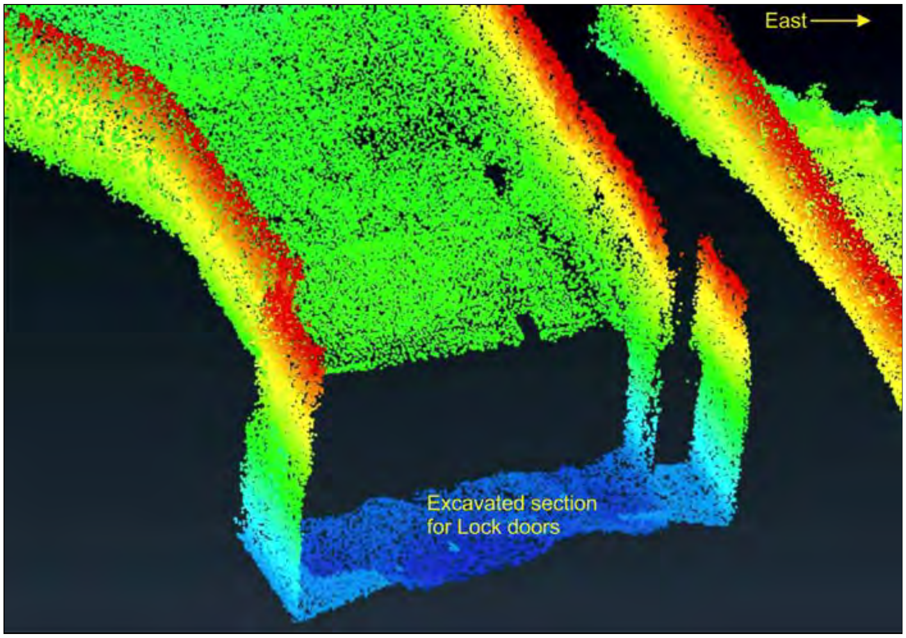

Figure 34: Upper Lock 45 entry

Minor undercutting was found on the northwest corner of Lock 45 Upstream (Image 3G-08). The undercutting runs for approximately 1 m and was under 5 cm in depth.

Minor scour marks were found on the northwest corner of Lock 45 Upstream (example is shown in Image 3G-09). The scouring observed was limited to under 5 cm in depth and height.

Several purpose-built features were documented. Images 3G-02 and 3G-03 show the first and second stop log slots on the east side of Lock 45 Upstream. The gate slots were observed to be in the open position (Figure 35). Images 3G-06 and 3G-07 show the southwest and northwest stop log slots.

Figure 35: Open gate slots of upper Lock 45

Heavy biofouling was present throughout the inspection of Lock 45 Upstream. An example of this is shown Image 3G-01.

5.6.2 Lock 45 Internal

The inspection of Lock 45 Internal was conducted using a ROV. All images from this inspection are included in Appendix 3H and the inspection video is provided in Appendix 7.

Examination of the video footage of the inspection of Lock 45 Internal did not reveal any apparent scour marks, cracking, undercutting or excessive biofouling. The following purpose-built features were documented. The gate slot in each of the four lock gates are shown in Images 3H-01, 3H-06, 3H-08 and 3H-10. The southern gate slots were in a closed position and the northern gate slots were in the open position.

Six openings in the concrete walls with metal pegs protruding from the bottom were found in the northeast corner (Image 3H-07), in the center of the east wall (Image 3H-04), in the southeast corner (Image 3H-11), in the southwest corner (Image 3H-02), in the center of the west wall (Image 3H-05) and in the northwest corner (Image 3H-09). A cut out with an installed ladder in the northwest corner was also observed (Image 3H-03).

5.6.3 Lock 45 Downstream

The inspection of Lock 45 Downstream was conducted using a ROV. All images from this inspection are included in Appendix 3I and the inspection video is provided in Appendix 7.

A joint with slight separation near the water surface which was under 5 cm was found on the lower west wall (Image 3I-13). A section of spalling running around the southwest corner of the west wall is shown in Images 3I-06, 3I-07, 3I-08 and 3I-09. There was a linear spall mark near the water surface and a separate linear mark near the bottom. Both of these spall marks were approximately 10 cm in width and 10 cm and height. Spalling marks were found at three locations on the lower west wall (Images 3I-15, 3I-16 and 3I-17). These areas of spalling had depths of 5 cm to 10 cm and were observed to be under 10 cm in height.

The northern gate slots can be seen in Image 3I-01 (east) and Image 3I-10 (west). The gate slots were in the closed position and showed no signs of apparent scouring or leakage. Two conduits were observed running along the bottom from cut out slots in the east and west walls (Images 3I-02, 3I-03, 3I-11 and 3I-12). The conduit was observed to turn to the south at the bottom of the water way for 1 m before crossing from east to west (Figure 36 and Figure 37).

Figure 36: Image of conduit on east (left) and west (right) intersection of lock wall and bottom

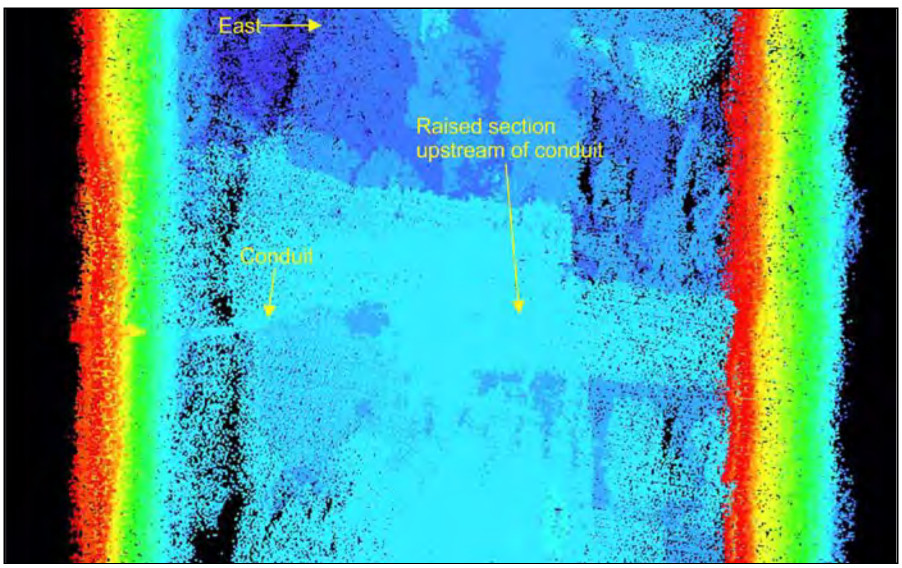

Figure 37: Raised section on bottom upstream of conduit

Image 3I-13 shows a horizontal form line with approximately a 10 cm lip. Figure 38 shows a step at the lock bottom of the concrete footing 10 cm in height and 10 cm in width.

Figure 38: Step in concrete at bottom of southwest wall of Lock 45 lower

5.6.4 Lock 45 North Dam Wall

The inspection of Lock 45 North Dam Wall was conducted using a pole-mounted CCTV camera. The inspection was carried out from east to west with the zero point being the eastern most point. All Images from this inspection are included in Appendix 3J and the inspection video is provided in Appendix 7.

The joint at 13.95 m (Image 3J-03) showed signs of separation and spalling which was 5 cm in width and 5 cm in depth. The joint at 57.7 m (Image 3J-14) was observed to have spalling to a depth of 15 cm, revealing the timber substructure. The width of the separation of the spalling at the joint was 10 cm to 15 cm and had has signs of spalling on either side of it (Figure 39).

Figure 39: Spalling in line with a vertical joint at 57.5 m

At 73 m (Image 3J-20) spalling was observed on the separated joint which was 10 cm in depth and 5 cm in width. There was slight horizontal scour marks perpendicular to this joint. At 88 m (Figure 40) there was a joint with visible spalling with a depth of 20 cm and width from 5 cm to 15 cm.

Figure 40: Spalling observed in line with a vertical joint at 88.2 m

Undercutting was found at 88 m (Image 3J-24) near the bottom of the wall and was 1.5 m in length and 5 cm in depth.

Light spalling was found at 44.4 m (Image 3J-08) which was observed to be 40 cm in width and under 5 cm in depth. At 46.2 m there was scour marks under 5 cm in depth (Image 3J-10). At

61.9 m slight scouring was observed on the face of the wall with a depth of under 5 cm (Image 3J-15). At 44.4 m (Image 3J-09) there was a section of spalling that continues for 0.4 m in length and was under 5 cm in depth. A 0.6 m long section of spalling was observed at 65.1 m which was up to 15 cm in depth and 30 cm in height (Image 3J-16). The section of spalling found at 68.6 m (Image 3J-18) continues to 70.5 m near the water surface and was 5 to 15 cm in depth except at 70.5 m where a depth of 40 cm was observed (Image 3J-19).

A horizontal crack was observed at 54 m and was approximately 4 m in length with a depth under 5 cm (Image 3J-12). A vertical crack was observed at 50.1 m with slight spalling to a width of 5 cm and depth of 5 cm (Image 3J-11). A vertical crack was also overserved at 67.7 m and had spalling up to 10 cm in width and 5 cm in depth (Image 3J-17). A vertical crack mostly observed above water surface was seen at 79.9 m and had minimal separation and depth (Images 3J-21 and 3J-22). Cracking was observed at 96.7 m (Figure 41) where the wall transitioned to bedrock and was 2 cm to 3 cm in width and 5 cm in depth. This area also showed signs of undercutting at the transition.

Figure 41: Transition from dam wall to bedrock with undercutting and cracking present

Images 3J-01 and 3J-02 show a pipe protruding from the wall at 3.2 m. At 28 m there were wooden concrete forms visible (Image 3J-05). Images 3J-06 and 3J-07 show the east and west side of the dock at 40 m. At 92 m there is a poured footing of concrete visible (Image 3J-26).

5.7 Upper Approach Wall

The inspection of the Upper Approach Wall was conducted using a pole-mounted CCTV camera. The inspection was carried out from south to north with the zero point being the southernmost point of the Upper Approach Wall where it intersected the Lock 45 North Wall. All images from this inspection are included in Appendix 3K and the inspection video is provided in Appendix 7.

The construction of the upper approach wall was observed to differ from a column-supported concrete slab on the south half of the structure to timber crib supported structure on the north end. The columns were centred on the joints in the concrete slabs at 6 m and 12 m from the transition to the Lock 45 North Wall. The change in structure to full cribbing occurred at the joint at 18 m from the transition to the Lock 45 Wall and continued to the end of the structure which was 30 m in length.

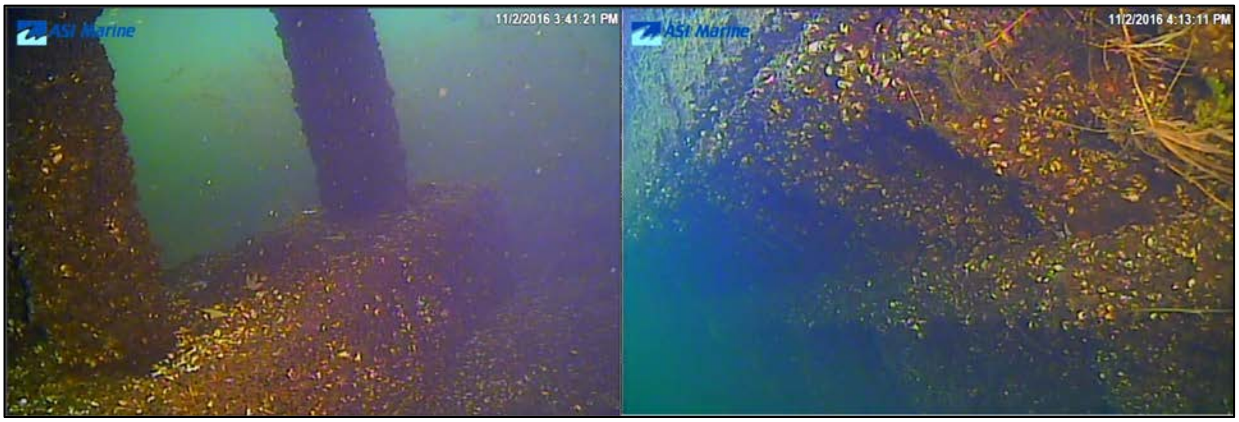

Figure 42: Differing construction from column supported (left) to full cribbing supported (right) structure

The transition between Lock 45 and the Upper Approach Wall is visible in Image 3K-01. An example of the joints on the east side and west side of the Upper Approach Wall is visible in Images 3K-03 and 3K-09.

Image 3K-02 shows the depth of the upper concrete deck with the aid of a metered rule (10 cm increments) which was observed to be 40 cm below the water surface. The upper cribbing on the east side of is visible in Image 3K-13 showing the timber structure with biofouling. In Image 3K-14, the transition between the cribbing and concrete slab is in view. Image 3K-10 shows the west side of the cribbing structure showing the submerged timber structures with heavy biofouling coverage.

The southernmost support columns are visible in Images 3K-04, 3K-05 and 3K-06. Images 3K-07 and 3K-08 show the two northern columns and support. The condition of the concrete footings under the supports can be seen in Images 3K-12 and 3K-15 and showed no signs of scouring of the concrete.

5.8 Lower Approach Wall

The inspection of the Upper Approach Wall was conducted using a ROV and pole-mounted CCTV camera. The inspection was carried out from north to south, with the ROV utilized for the west side and the CCTV camera for the east side. All images from this inspection are included in Appendix 3L and the inspection video is provided in Appendix 7.

Image 3L-05 shows the timber cribbing on the underside of the upper concrete deck covered in heavy biofouling. Images 3L-06 and 3L-07 show the condition of the upper concrete slab which was observed to have light biofouling coverage and no apparent spalling. Images 3L-01 and 3L-02 show uniform transition on the bottom of the upper concrete slab where the cribbing is attached to the underside of the concrete.

Figure 43: Transition from concrete (north) to timber (south) support structure situated on taper on west side

The concrete footing that supports the bottom of the structure had minimal biofouling coverage (Images 3L-03 and 3L-04). Image 3L-08 shows the condition of the southern end of the Lower Approach Wall cribbing with a pipe connected to an apparent water level gauge which was above the water surface. Images 3L-09 and 3L-10 show the wooden supports that attach to the concrete slab. The cribbing was observed to have heavy biofouling coverage but no apparent damage or missing sections.

The only observed undercutting was found where the Lower Approach Wall meets Pier 1 of the downstream side of the Main Dam and continued for approximately 1 m downstream. The undercutting had a height ranging from 5 cm to 30 cm and the typical depth was 5 cm to 10 cm. Image 3L-11 shows the northernmost section of undercutting, Image 3L-13 shows where the undercutting continued south and Image 3L-12 shows the end of the undercutting.

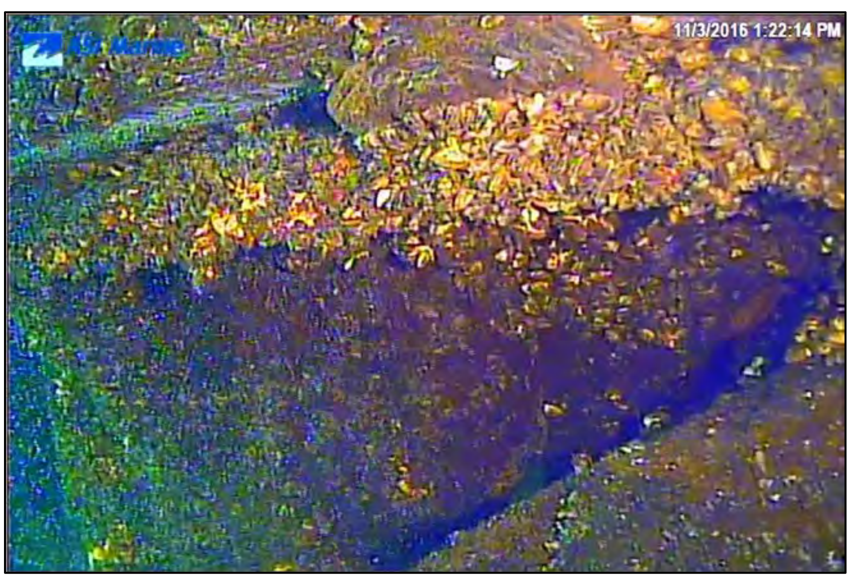

Figure 44: Section of undercutting observed at bottom downstream of Pier 1

5.9 MBES Bathymetric and Structure Surveys

5.9.1 Bathymetric Survey Upstream and Downstream of Main Dam

The bathymetric survey was completed during the Phase One portion of the inspection. The portion of the survey upstream of Lock 45 extended 25 metres north of the Upper Approach Wall to the Main Dam as seen in the yellow 3D dataset in Figure 45. Bottom elevations in the upstream surveyed area were observed to range from 172.38 m to 179.81 m.

A submerged channel was observed from the northern extent of the surveyed area to the Main Dam. A possible remnant of a coffer dam was distinguishable northeast of the Upper Approach Wall and was of a circular shape. At the most northern point of this circular feature, the apparent edge had an elevation difference of 1.77 metres. Throughout the surveyed area there were targets on the bottom consisting of large rocks and logs.

The portion of the survey downstream of Lock 45 extended from the Lower Lock and Main Dam to the island directly north of the highway, as seen in the purple 3D dataset in Figure 45. Bottom elevations in the downstream surveyed area were observed to range from 169.33 m to 175.89 m, the lowest portion observed in the center of the bay between Lock 45 and the island.

Areas of shallow depth, high aeration and heavy weed coverage pose difficulties in the collection and processing of the sonar data. These areas were completed on a best effort basis.

Appendix 8 contains the bathymetric survey data sets for the north and south portions of the Main Dam with points in 10 cm, 25 cm and 100 cm spacing.

Figure 45: Bathymetric survey coverage upstream (yellow) and downstream (purple) of Main Dam

5.9.2 Cross-Sectional Profiles

Bathymetric survey data was collected using the MBES and cross-sectional profiles were extracted at the Lock 45 North Wall, Dam E and Dam G. These cross-sectional profiles were required by AECOM spaced at 5 m intervals along the face of the separate structures and extended upstream 5 m. These profiles are provided in Appendix 4.

5.9.3 Structures Survey

The collection data pertaining to the vertical structures was completed with the MBES mounted in an angled orientation. Images of this data are found throughout the observations portion of the report and 3D perspective views are located in Appendix 5.

Appendix 1:

Equipment Specifications

<u>ASI GROUP – MULTI-BEAM BATHYMETRIC ECHOSOUNDER PACKAGE DESCRIPTION</u>

A multi-beam echosounder (MBES) collects a swath of highly detailed bathymetric data with the swath coverage usually being about 3 to 4 times the water depth. The advantage of multi-beam bathymetric data over single-beam bathymetric data is that it provides a 100% bottom coverage (subject to line spacing) meaning you do not have to interpolate between survey lines as you do with single-beam data. MBES also provides side scan sonar-like imagery called snippets data. An advantage of multi-beam over side scan sonar is that it provides highly accurate and geo-referenced 3D data whereas side scan sonar provides 2D data only with much less accurate geo-referencing.

ASI proposes to use our multi-beam echo sounding (MBES) system which is a professional tool for precision mapping of the seabed, complying with the performance standards defined by the International Hydrographic Organization's performance standards, S-44 edition 5. This system is characterized by high mapping productivity in combination with exceptionally high sounding accuracy, and a dense pattern of soundings to cover the seafloor in order to reveal all details on the bottom. In addition to the soundings, this mult-ibeam echo sounder can produce and record seabed image data (referred to as snippets data) similar to a side scan sonar image. This dataset is useful for characterizing the seabed material properties and sometimes for detecting small features not visible in the sounding data.

Multibeam Echo Sounder:

The R2Sonic 2024 MBES is an advanced multi-beam echo sounder with extremely high resolution and dynamically focused beams (See Figure 1). The very high lateral resolution of a true 0.5 degrees, beam focusing and optional snippets backscatter facilitates object recognition. The same unit can also be configured as a front looking imaging sonar.

- Bathymetry with side scan and snippets backscatter
- User selectable wide band operation, tuneable anywhere in the 200 kHz to 400 kHz frequency range (allows the operator to optimize the frequency to the environment, survey depths, and/or contract requirements).
- 1 to 500 m range from a single sonar receiver and transmitter
- Rotational swath sector
- 256 beams with beam compression
- swath coverage variable from 10° to 160°

Figure 1: R2Sonics 2024 Sonar Head

Positioning & Heading:

The Novatel ProPak6 is a rugged GNSS/INS Receiver delivering a 3D Position, Velocity, and Attitude Solution. The absolute accuracy of GNSS positioning and the stability of IMU gyro and accelerometer measurements are tightly coupled to provide an exceptional 3D navigation solution that is stable and continuously available, even through periods when satellite signals are blocked. Sub-metre DGPS positional accuracy can be accomplished using differential correction data from Space Based Augmentation Systems (SBAS) such as the U.S. Wide Area Augmentation System (WAAS), the European GPS Navigation Overlay System (EGNOS), and Japan's MTSAT Satellite Augmentation System (MSAS). Real-time Kinetic (RTK) centimeter DGPS positional accuracy is accomplished using a second ProPak6 (or equivalent) and a single antenna as a base station and transmitting DGPS corrections real-time via radio link.

The Pro-Pak6 features two GPS receivers inside one enclosure, and two multipath-resistant antennas in two separate enclosures (See Figure 2). The enclosure is an extremely rugged and water resistant IP67 housing for reliable use in harsh environments. Vessel heading is determined through the use of two GPS receivers and 2 antennae mounted on the vessel.

Figure 2: Novatel ProPak6 Receiver and Antennae (2)

Performance[1]	
Channel Configuration	
240 Channels[2]	
Signal Tracking	
GPS	L1, L2, L2C, L5
GLONASS	L1, L2, L2C
Galileo	E1, E5a, E5b, AltBOC
BeiDou[3]	
SBAS[4]	
QZSS	L1, L2C, L5
L-Band	
Horizontal Position Accuracy (RMS)	
Single Point L1	1.5 m
Single Point L1/L2	1.2 m
SBAS	0.6 m
DGPS	0.4 m
L-Band	
VBS	0.06 m
XP	0.15 m
HP	0.1 m
RT-2®	1 cm + 1 ppm
Initial time	<10 s
Initial reliability	>99.9%
Maximum Data Rate	
Measurements	up to 100 Hz
Position	up to 100 Hz
Time to First Fix[5]	
Cold start	50 s (typical)
Hot start	35 s (typical)
Signal Reacquisition	
L1	<0.5 s (typical)
L2/L5	<1.0 s (typical)
Velocity Accuracy[6]	< 0.03 m/s RMS
Time Accuracy[7]	20 ns RMS
ALIGN Heading Accuracy[10]	
0.5 m baseline	0.40°
1.0 m baseline	0.20°
2.0 m baseline	0.10°
Physical and Electrical	
Dimensions	
190 x 185 x 75 mm	
Weight[11]	1.79 kg
Power	
Input voltage	+9 to +36 VDC
Power consumption[11]	3.5 W
Antenna Port(s) Power Output	
Output voltage	5 VDC
Maximum current	150 mA
COM Port Power Output	
Output voltage[12]	+9 to +36 VDC
Maximum current	1.5 A
Connectors-Front Panel	
Power button	
Logging button	
Radio antenna[11]	TNC
USB host[11]	Type A
SIM[11]	Push-Push
Connectors-Rear Panel	
Power	4-pin LEMO
COM1, COM2, COM3/IMU	DB9M
I/O or Event	DB9F
USB device	Type micro B
Ethernet	RJ45
GPS1	TNC
GPS2 or EXT OSC[11, 13]	TNC/BNC
Expansion Port	9-pin LEMO

Novatel's Inertial Explorer (IE) post processing software can be used to post process ProPak6 data and offer the highest level of accuracy with the system. IE maximizes the performance by ensuring you get the position, velocity and altitude accuracy your application requires. IE produces results suitable for demanding applications such as aerial and hydrographic surveying.

Motion Sensor:

The Novatel IMU-CPT Motion Sensor provides high accuracy motion measurement data in a dynamic environment in all areas of hydrographic work in all weather conditions (See Figure 3). It is designed to be paired with Novatel's ProPak6 receivers. It is comprised of Fiber Optic Gyros (FOG) and Micro Electrical Mechanical Systems (MEMS) accelerometers. Paired with the ProPak6 the IMU-CPT offers a fully integrated, tightly coupled GNSS and IMU system delivering the most satellite observations and the most accurate, continuous position, velocity, and attitude solution possible.

IMU Performance[1]

IMU-CPT	
Gyro Technology	FOG
Gyro Output Range	±375°/s
Gyro Bias	20°/hr
Gyro Bias Stability	±1°/hr
Gyro Scale Factor	1500 ppm
Angular Random Walk	0.0667°/√hr (max)
Accelerometer Range	±10 g
Accelerometer Bias	50 mg
Accelerometer Bias Stability	±0.75 mg
Accelerometer Scale Factor	4000 ppm

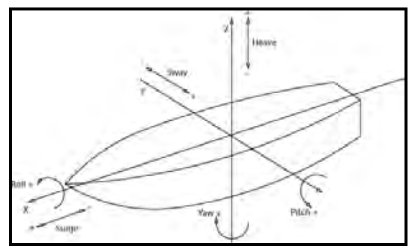

Figure 3: Novatel IMU-CPT Motion Sensor

Sound Velocity Sensor:

The Valeport *miniSVS* sound velocity sensor collects sound velocity profile data in the water column and is ideally suited for hydrographic applications (See Figure 4). The *miniSVP*S is fitted with Valeport's digital time of flight sound velocity sensor. This sensor is typically installed on the multibeam sonar head.

Sound Velocity	
Range:	1375-1900 m/s
Resolution:	0.001 m/s
Accuracy:	±0.02 m/s

Figure 4: Valeport miniSVS Sound Velocity Sensor

Conductivity/Temperature/Depth (CTD) Profiler:

The YSI CastAway-CTD is a lightweight, easy to use hydrographic instrument designed for quick and accurate conductivity, temperature, and depth profiles (See Figure 5). The *CastAway* makes use of both GPS and Bluetooth technologies. Plots of conductivity, temperature, salinity, and speed of sound versus depth can be displayed.

The CastAway-CTD Output Parameters

	Range	Resolution	Accuracy	Measured or Derived
Conductivity	0 to 100,000 µS/cm	1µS/cm	± 0.25% ± 5 µS/cm	Measured
Temperature	-5° - 45° C	0.01° C	± 0.05° C	Measured
Pressure	0 to 100 dBar	0.01 dBar	± 0.25% FS	Measured
Salinity	Up to 42 (PSS-78)	0.01 (PSS-78)	± 0.1 (PSS-78)	PSS-78[3]
Sound Speed	1400 - 1730 m/s	0.01 m/s	± 0.15 m/s	Chen-Millero[4]
Density[1]	990 to 1035 kg/m^3	0.004 kg/m^3	± 0.02 kg/m^3	EOS80[5]
Depth	0 to 100 m	0.01m	± 0.25% FS	EOS80[5]
Specific Conductivity[2]	0 to 250,000 µS/cm	1µS/cm	± 0.25% ±5 µS/cm	EOS80[5]
GPS			10 m	

Figure 5: YSI CastAway-CTD and Specifications

Navigation, Data Collection & Processing:

HYPACK® is a windows based software package used primarily for hydrographic surveying and data processing. Hypack performs all of the tasks necessary to complete your survey from beginning to end.

- Geodetic parameters
- Planned Line Design
- Equipment Configuration
- Data Collection supporting over 200 Sensors
- Data Processing
- Tides and Sound Velocity
- Sounding Reduction
- Export to DXF/DGN
- Plotting of Smooth Sheets
- Volumes by Section
- Volumes by Surface Model
- Contouring to DXF
- 3D Visualization
- Side Scan Collection and Processing
- ADCP Collection and Display

HYSWEEP is an optional module that provides for the calibration, data collection and data processing of multibeam sonar data inside the HYPACK® package (See Figure 6).

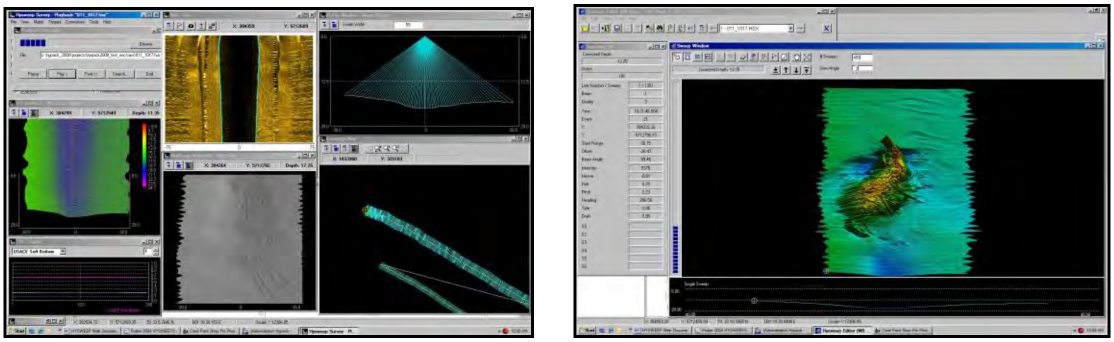

Figure 6: Sample Displays from HYPACK/HYSWEEP Software

High Resolution Multibeam Systems for:

Hydrography

Offshore

Dredging

Defense

Research

SONIC 2024

Multibeam Echo Sounder

Features:

- 60kHz Wideband Signal Processing
- Focused 0.5° Beam Width
- Selectable Frequencies 200-400kHz
- Selectable Swath Sector 10° to 160°
- System Range to 500m
- Embedded Processor/Controller
- Equiangular or Equidistant Beams
- Roll Stabilization
- Rotate Swath Sector

Applications:

- Hydrographic Survey
- Offshore Site Survey
- Pre & Post Dredge Survey
- Defense & Security
- Marine Research

System Description:

The Sonic 2024 is the world's first proven wideband high resolution shallow water multibeam echo sounder. With proven results and unmatched performance, the Sonic 2024 produces reliable and remarkably clean data with maximum user flexibility through all range settings to 500m.

The unprecedented 60 kHz signal bandwidth offers twice the resolution of any other commercial sonar in both data accuracy and image. With over 20 selectable operating frequencies to chose from 200 to 400 kHz, the user has unparalleled flexibility in trading off resolution and range and controlling interference from other active acoustic systems.

In addition to selectable operating frequencies, the Sonic 2024 provides variable swath coverage selections from 10° to 160° as well as ability to rotate the swath sector. Both the frequency and swath coverage may be selected 'on-the-fly', in real-time during survey operations.

The Sonar consists of the three major components: a compact and lightweight projector, a receiver and a small dry-side Sonar Interface Module (SIM). Third party auxiliary sensors are connected to the SIM. Sonar data is tagged with GPS time.

The sonar operation is controlled from a graphical user interface on a PC or laptop which is typically equipped with navigation, data collection and storage applications software.

The operator sets the sonar parameters in the sonar control window, while depth, imagery and other sensor data are captured and displayed by the applications software.

Commands are transmitted through an Ethernet interface to the Sonar Interface Module. The Sonar Interface Module supplies power to the sonar heads, synchronizes multiple heads, time tags sensor data, and relays data to the applications workstation and commands to the sonar head. The receiver head decodes the sonar commands, triggers the transmit pulse, receives, amplifies, beamforms, bottom detects, packages and transmits the data through the Sonar Interface Module via Ethernet to the control PC.

The compact size, low weight, low power consumption of 50W and elimination of separate topside processors make Sonic 2024 *very well suited* for small survey vessel or ROV/AUV operations.

R2Sonic LLC
1503-A Cook Pl.
Santa Barbara
California,
USA 93117

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F: 805 967 8611

www.r2sonic.com

Sonic 2024 Multi Beam Echo Sounder

Systems Specification:

Frequency	200kHz-400kHz
Beamwidth, across track	0.5°
Beamwidth, along track	1.0°
Number of beams	256
Swath sector	Up to 160°
Max Range	500m
Pulse Length	10µs-500µs
Pulse Type	Shaped CW
Ping Rate	Up to 60 Hz
Depth rating	100m
Operating Temperature	0°C to 50°C
Storage Temperature	-30°C to 55°C

Electrical Interface

Mains	90-260 VAC, 45-65Hz
Power consumption	<50W
Uplink/Downlink:	10/100/1000Base-T Ethernet
Data interface	10/100/1000Base-T Ethernet
Sync In, Sync out	TTL
GPS	1PPS, RS-232
Auxiliary Sensors	RS-232
Deck cable length	15m

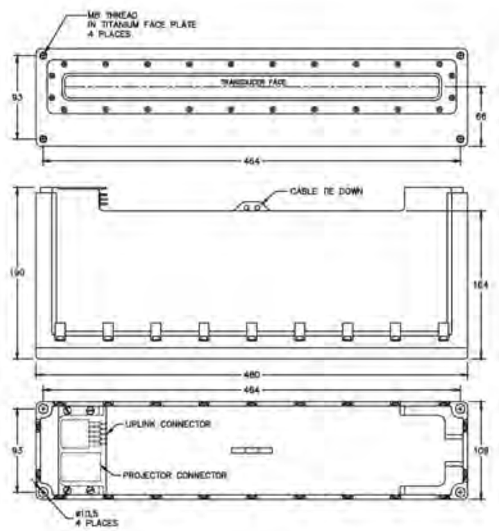
Mechanical:

Receiver Dim (LWD)	480 x 109 x 190 mm
Receiver Mass	12 kg
Projector Dim (LWD)	273 x 108 x 86 mm
Projector Mass	6 kg
Sonar Interface Module Dim (LWH)	280 x 170 x 60 mm
Sonar Interface Module Mass	2.4 kg

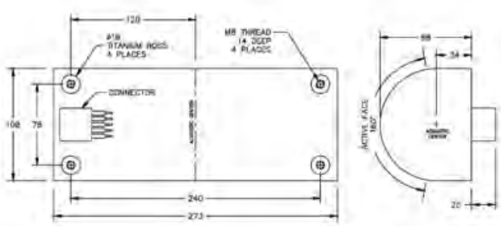
Sonar Options:

Snippets Imagery Output
Switchable Forward Looking Sonar Output
Mounting Frame & Hardware
Over-the-side Pole Mount
Sound Velocity Probe & Profiler
Extended Sonar Deck Cable, 25m or 50m
3000m Depth Immersion Depth

Sonar Interface Module



Sonic 2024 Receiver



Sonic 2022 Projector

High Resolution Multibeam Systems for:

Hydrography

Offshore

Dredging

Defense

Research

R2Sonic LLC
1503-A Cook Pl.
Santa Barbara
California,
USA 93117

T: 805 967 9192
F: 805 967 8611

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ProPak6™

Rugged Enclosure Delivers Scalable GNSS with Heading and Wireless Communication Options

Benefits

Efficient integration with standard hardware and software interfaces and experienced staff

Future proof for upcoming GNSS signal support

Reliable use in harsh environments with the IP67 housing

Multiple communication interfaces for easy integration and installation

SPAN® ready

Features

240 channels

Scalable positioning options from metre to centimetre-level

Standard connectors for simple interfacing

4 GB onboard memory for data logging

Standard Bluetooth® and Wi-Fi connectivity

Optional GPRS/HSPA cellular modem

Optional heading

If you require more information about our enclosures, visit novatel.com/products/gnss-receivers/enclosures

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China 0086-21-54452990-8011
Europe 44-1993-848-736
SE Asia and Australia 61-400-883-601

Precise Thinking Makes it Possible

NovAtel® designs, manufactures and sells high precision OEM Global Navigation Satellite System (GNSS) positioning technology. Developed for efficient and rapid integration, our GNSS products have set the standard in quality and performance for over 20 years. State-of-the-art, lean manufacturing facilities in our North American headquarters produce the industry's most extensive line of OEM receivers, antennas and subsystems. All of our products are backed by a team of highly skilled design and customer support engineers, ready to answer your integration questions. For unsurpassed quality, product selection and engineering know-how, choose NovAtel.

Flexible, Rugged and Reliable

ProPak6™ provides the latest and most sophisticated enclosure product manufactured by NovAtel. From standalone metre-level to AdVance® RTK centimetre-level positioning, the ProPak6 is flexible to meet your positioning needs. Reliability is safeguarded as a result of the extremely rugged and water resistant IP67 housing combined with its wide operating temperature range. NovAtel has also assured faster time to market by reducing integration time with standardized software and hardware connections. The ProPak6 offers optional GPRS/HSPA cellular modem and/or heading options to provide a solution for many applications.

Easy System Integration and Installation

The ProPak6 provides numerous interfaces including multiple RS-232/RS-422 serial ports, CAN Bus, USB host and device as well as Bluetooth®, Wi-Fi and optional cellular radio. Standard interfaces are provided through conventional connectors, eliminating the need for hard to find and expensive custom cables. The ProPak6 also features advanced Ethernet support for remote configuration and access of data logs. Installation and configuration time is reduced with multiple communication options: Wi-Fi, Bluetooth and optional GPRS/HSPA cellular modem.

ProPak6™

Performance[1]

Channel Configuration
240 Channels[2]

Signal Tracking

GPS	L1, L2, L2C, L5
GLONASS	L1, L2, L2C
Galileo	E1, E5a, E5b, AltBOC
BeiDou[3]	
SBAS[4]	
QZSS	L1, L2C, L5
L-Band	

Horizontal Position Accuracy (RMS)

Single Point L1	1.5 m
Single Point L1/L2	1.2 m
SBAS	0.6 m
DGPS	0.4 m
L-Band	
VBS	0.06 m
XP	0.15 m
HP	0.1 m
RT-2®	1 cm + 1 ppm
Initial time	<10 s
Initial reliability	>99.9%

Maximum Data Rate

Measurements	up to 100 Hz
Position	up to 100 Hz

Time to First Fix[5]

Cold start	50 s (typical)
Hot start	35 s (typical)

Signal Reacquisition

L1	<0.5 s (typical)
L2/L5	<1.0 s (typical)

Velocity Accuracy[6] < 0.03 m/s RMS

Time Accuracy[7] 20 ns RMS

Measurement Precision (RMS)
Fully independent code and carrier measurements:

	GPS	GLO
L1 C/A code	4 cm	8 cm
L1 carrier phase	0.5 mm	1.0 mm
L2 P(Y) code[8]	8 cm	8 cm
L2 carrier phase[8]	1.0 mm	1.0 mm
L2C code[9]	8 cm	8 cm
L2C carrier phase[9]	0.5 mm	0.5 mm
L5 code	3 cm	-
L5 carrier phase	0.5 mm	-

ALIGN Heading Accuracy[10]

0.5 m baseline	0.40°
1.0 m baseline	0.20°
2.0 m baseline	0.10°

Physical and Electrical

Dimensions
190 x 185 x 75 mm

Weight[11] 1.79 kg

Power

Input voltage	+9 to +36 VDC
Power consumption[11]	3.5 W

Antenna Port(s) Power Output

Output voltage	5 VDC
Maximum current	150 mA

COM Port Power Output

Output voltage[12]	+9 to +36 VDC
Maximum current	1.5 A

Connectors-Front Panel

Power button	
Logging button	
Radio antenna[11]	TNC
USB host[11]	Type A
SIM[11]	Push-Push

Connectors-Rear Panel

Power	4-pin LEMO
COM1, COM2, COM3/IMU	DB9M
I/O or Event	DB9F
USB device	Type micro B
Ethernet	RJ45
GPS1	TNC
GPS2 or EXT OSC[11, 13]	TNC/BNC
Expansion Port	9-pin LEMO

Status LEDS
Power
COM Port Activity
GPS1
GPS2
INS ALN
Radio status[11]
Datalogging
USB
Bluetooth®
Wi-Fi

Communication Ports

RS-232/RS-422	3
IMU1	
USB 2.0 host	1
USB 2.0 device (high speed only)	1
Ethernet	1
CANBus	2
Event input	4
Event output	4
Bluetooth	1
Wi-Fi	1
Radio[11]	GPRS/HSPA (optional)

Environmental

Temperature

Operating	-40° to +75°C
Operating (heading)	-40° to +65°C
Operating (radios)	-40° to +65°C
Storage	-40° to +95°C
Humidity	95% NC
Waterproof	IEC 60529 IPX7
Dust	IEC 60529 IP6X

Vibration (operating)

Random	MIL-STD-810 514.6 Category 24, 20-2000Hz/7.7 g 1hr/axis
Sinusoidal	IEC 60068-2-6 (5 g), 10-2000 Hz

Shock (non-operating)
MIL-STD-810G, 516.6 , procedure 1, 40 g 11 ms terminal sawtooth

Compliance
FCC, IC, CE, RoHS, WEEE, Bluetooth® SIG

Included Accessories

- 12 VDC power adapter (CLA) with slow blow fuse
- Mounting bracket and hardware
- Null modem cable
- Extension cable
- I/O Interface cable

Optional Accessories

- Advanced I/O Interface cable
- Straight serial cable
- USB cable
- Ethernet cable
- Cellular antenna
- GPS-700 series antennas
- ANT series antennas
- GrafNav/GravNet®

Firmware Options

- Auto-memory transfer to USB flash drive
- Field upgradeable firmware and field upgradeable software models
- Auxiliary strobe signals, including a configurable PPS output and two mark inputs
- RT-2
- L-Band
- ALIGN®
- GLIDE™
- RAIM
- API
- NTRIP v1.0 and v2.0
- 100 Hz output rate[14]

Version 3 - Specifications subject to change without notice.

Printed in Canada. D18297
ProPak6 September 2013
For the most recent details of this product:
http://www.novatel.com/products/gnss-receivers/enclosures/

[1] Typical value. Performance specifications subject to external factors including US DOD operational performance, atmospheric conditions, multipath, interference, etc.
[2] Tracks up to 76 L1/L2 satellites.
[3] Firmware update required.
[4] GPS only.
[5] Cold start with no almanac, ephemerides and no approximate time or position. Warm start with almanac and ephemerides saved, approximate time and position entered.
[6] Export licensing restrictions limit maximum velocity to 515 m/s.
[7] Time accuracy does not include biases due to antenna or RF delay.
[8] L2P for GLONASS.
[9] L2C/A for GLONASS.
[10] Dual receiver option required to support ALIGN heading.
[11] Model and/or configuration dependent. Refer to the Installation and Operation for this product for further details.
[12] COM port power output follows the input voltage.
[13] Single antenna version with BNC external oscillator input. Dual antenna (ALIGN heading) versions replace the external oscillator input with a TNC antenna input.
[14] 100 Hz when tracking up to 20 satellites.

XTend®-PKG RF Modems

1 Watt/900 MHz Stand-Alone Radio Modems

900 MHz radio modems offer long-range performance, advanced networking and simple out-of-the-box operation with multiple data interface options.

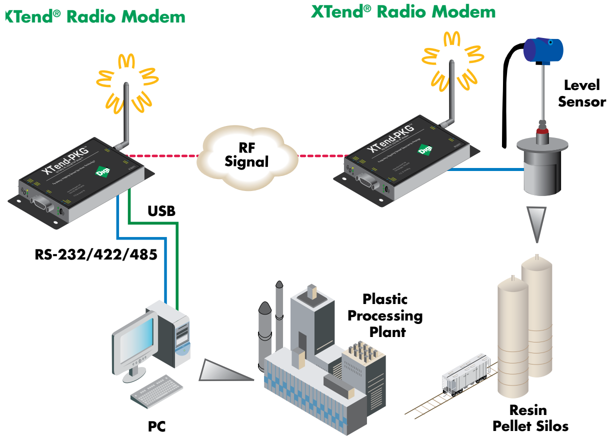
Overview

Digi's XTend-PKG RF modems provide everything you need for out-of-the-box serial cable replacement, enabling quick wireless connectivity of electronic devices across a broad range of applications. Simply feed data into one modem and the data is transported to the other end of a long range wireless link. Data security is provided by 256-bit AES encryption (128-bit AES is available outside of North America). If more advanced functionality is needed, the modems support an extensive set of AT and binary commands.

With superior receiver sensitivity, XTend modems hear what others can't, yielding two- to eight- times the range of competing RF modems. This allows OEMs and integrators to cover more ground with fewer transceivers, reducing the cost of deployment. And with no configuration required, complexity is minimized.

Available in multiple interface options, including RS-232/422/485 and USB, and with an optional NEMA 4-rated enclosure, XTend modems are ideally suited for remote monitoring, building automation/security, industrial automation/SCADA, fleet management/asset tracking and sensor data capture in embedded systems. For hazardous locations, a Class 1, Division 2 rated model is also available.

Application Highlight



Features/Benefits

- Indoor/urban range up to 3000 feet
- Outdoor line-of-sight range up to 40 miles (with high gain antenna)
- Outstanding receiver sensitivity (-110 dBm @ 9600 bps)
- Adjustable power output from 1 mW to 1 W; up to 4 W EIRP (with 6 dB antenna)
- Low power consumption for power-sensitive applications
  - Pin, serial port and cyclic sleep modes available
- Streaming, acknowledged and multi-transmit modes supported
- Easy out-of-the box operation — no configuration necessary
- Durable industrial grade enclosure

Features/Specifications

PERFORMANCE

- Indoor/Urban range (w/ 2.1 dB dipole antenna): Up to 3000 feet (900 m)
- Outdoor RF line-of-sight range (w/ high gain antenna): Up to 40 miles (64 km)
- Outdoor RF line-of-sight range (w/ 2.1 dB dipole antenna): Up to 14 miles (22 km)
- Transmit power output (software selectable): 1mW - 1W (0 - 30 dBm)
- Interface data rate: 10 - 230,400 bps (including non-standard baud rates)
- Receiver sensitivity: -110 dBm (@9,600 bps throughput data rate), -100 dBm (@115,200 bps)
- Throughput data rate (software selectable): 9,600 or 115,200 bps
- RF data rate:
  - 10,000 bps (@9,600 bps throughput data rate)
  - 125,000 bps (@115,200 bps)

CONNECTION OPTIONS

- RS-232/422/485, DB-9 (XTend-PKG-R)
- USB (XTend-PKG-U)
- RS-232/422/482, DB-9/screw terminal (XTend-PKG-NEMA)

DIMENSIONS

XTend-PKG-R, XTend-PKG-U,
- Length: 2.75 in (6.99 cm)
- Width: 5.50 in (13.97 cm)
- Depth: 1.13 in (2.86 cm)
- Weight: 7.10 oz (200 g)

XTend-NEMA
- Length: 5.13 in (13.02 cm)
- Width: 7.13 in (18.10 cm)
- Depth: 1.50 in (3.81 cm)
- Weight: 12.30 oz (348.70 g)

ENVIRONMENTAL

XTend-PKG-R, XTend-PKG-NEMA
- -40° C to 85° C (industrial)

XTend-PKG-U
- 0° C to 70° C (commercial)

POWER REQUIREMENTS

All models
- Power supply voltage: 7 - 28V

XTend-PKG-R
- Receive current: 110 mA
- Pin sleep power-down: 17 mA
- Serial port sleep power-down: 45 mA
- Idle current (various cyclic sleep intervals): 19 - 39 mA
- Transmit current (1 mW - 1W TX power output): 110 - 900 mA

XTend-PKG-U
- Receive current: 100 mA (Self Power)
- Pin sleep power-down: 17 mA
- Serial port sleep power-down: 45 mA
- Idle current (various cyclic sleep intervals): 21 - 35 mA (Self Power)
- Transmit current (1 mW - 1W TX power output): 88 - 480 mA

XTend-NEMA
- Receive current: 100 mA
- Pin sleep power-down: 17 mA
- Serial port sleep power-down: 45 mA
- Idle current (various cyclic sleep intervals): 19 - 39 mA
- Transmit current (1 mW - 1W TX power output): 110 - 900 mA

ANTENNA

XTend-PKG-R, XTend-PKG-U
- Connector: RPSMA (Reverse Polarity SMA)
- Impedance: 50 ohms unbalanced

XTend-NEMA (Weatherproof)
- External antenna version
  - Connector: RPTNC
  - Impedance: 50 ohms unbalanced
- Internal antenna version
  - Connector: MMCX
  - Impedance: 50 ohms unbalanced

CERTIFICATIONS

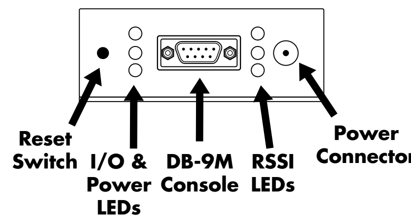
All models
- FCC Part 15.247: OUR-9XTEND
- Industry Canada (IC): 4214A-9XTEND

NEMA enclosure
- IP 66/67, IP 66
- IK 08
- NEMA 1, 4, 4X, 6 (12 and 13)
- UL 94-5V, UL 508

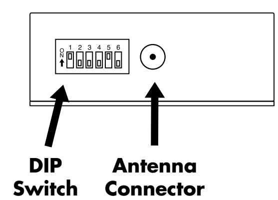
NETWORKING AND SECURITY

- Frequency: ISM 902 - 928 MHz
- Spread Spectrum: FHSS (Frequency Hopping Spread Spectrum)
- Modulation: FSK (Frequency Shift Keying)
- Supported Network Topologies: Peer-to-peer (no master/slave dependencies), point-to-point, point-to-multipoint and multidrop
- Channel Capacity: 10 hop sequences share 50 frequencies
- Encryption: 256-bit AES Encryption
  - AES algorithm meets Federal Information Processing Standard-197 (FIPS-197)

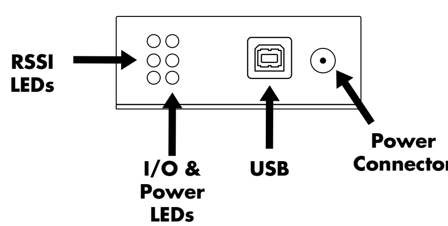
XTend-PKG-R - Front



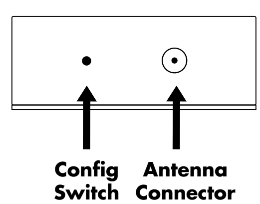
XTend-PKG-R - Back



XTend-PKG-U - Front



XTend-PKG-U - Back



MAKING Wireless M2M EASY™

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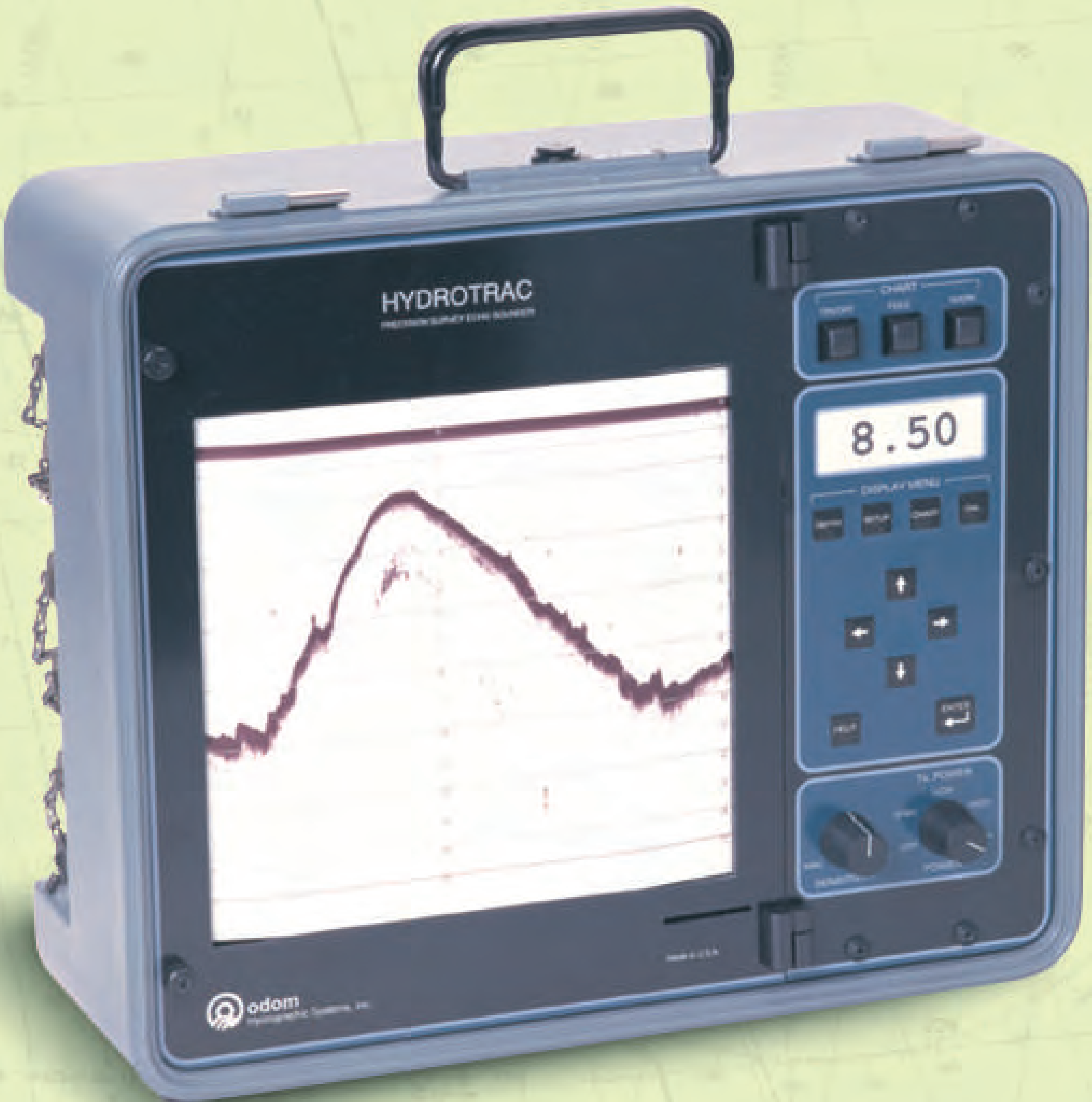
Hydrotrac™

PORTABLE SURVEY ECHO SOUNDER

AVAILABLE WITH BUILT–IN DGPS



Odom Hydrotrac
featuring full waterproof cover.

odom **Hydrotrac**™ was specifically designed to work on small survey boats and inflatable water craft in rugged conditions such as surf zones. while being compact and portable, it is fully waterproof during operation. hydrotrac incorporates the thermal printer and advanced features of odom's established echotrac line of echo sounders and is competitively priced.

SPECIFICATIONS

Frequency
- 200 kHz (standard)
- 210, 40 & 33 kHz (optional)

Output Power
- 600 Watts

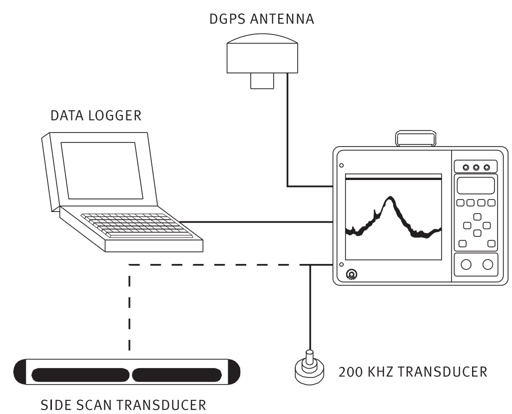
Power Requirement
- 11-28 VDC (standard)
- 110/220 VAC (optional)

Ports
- 2 (RS232 or RS422)

FEATURES
- 8.5"/216 mm Thermal Printer (fax paper)
- LCD Display (1" high)
- Sealed Keypad Controls
- Manual/Remote Mark Command
- Auto Scale Change (phasing)
- GPS Input
- Heave Input from Motion Sensor
- Annotation Printed on Chart
- Auto Pulse Length, AGC & TVG
- Output: NMEA, ECHOTRAC, DESO 25, etc.
- Waterproof
- Lightweight (24.8 lbs./ 11.25 kg.)
- Small Size (14.5 h x 16.5 w x 8.0 d inches) (36.83 h x 41.91 w x 20.32 d cm)
- Accuracy: 200 kHz-1cm±0.1% of depth value (corrected for sound velocity) 33 kHz-10cm±0.1% of depth value (corrected for sound velocity)
- Resolution: 0.1 ft./.01 meters
- Fix Mark Print Date, Time, Fix No., Depth (and GPS position if input)
- Optional 200 kHz Side Scan Transducer
- Optional Built-in DGPS Beacon Receiver Including Combined Antenna
- Optional Left-Right Indicator
- Flash Memory Upgrade
- Built-in Simulator

CONTROLS
- Sensitivity
- Chart On/Off & Advance
- Event Mark (internal selectable timer)
- Transmit Power (600/160/35 watts)

TOUCH PAD SETTINGS
- Draft, Velocity & Tide Inputs
- Time & Date
- Scale Width & Center
- Blanking
- Calibration Gate
- Alarm Filter
- Fix Interval
- Chart Speed
- HELP Function (prints on chart)
- Current Parameters (prints on chart)



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http://www.odomhydrographic.com

NEW

The CastAway™-CTD

with profiling and analysis software

The YSI CastAway-CTD is a lightweight, easy to use hydrographic instrument designed for quick and accurate conductivity, temperature, and depth profiles. Starting with a unique six-electrode array and a flow-through cell, the CastAway makes use of commercial Bluetooth and GPS technology to make an instrument that is as usable as it is accurate.

The CastAway is a multi-functional tool that incorporates the most modern technology available - yet is simple to use. It is designed for CTD profiling down to 100 m and is easy to deploy.

The palm-sized CastAway-CTD can easily be deployed by hand. Each cast is referenced with both time and location using its built-in GPS receiver. Latitude and longitude are acquired both before and after each profile. Plots of conductivity, temperature, salinity and sound speed versus depth can be viewed immediately on the CastAway's integrated color LCD screen in the field.

Raw data can be easily downloaded via Bluetooth to a Windows computer for detailed analysis and/or export at any time. Rugged, non-corrosive housing, AA battery power and tool-free operation reflect the technician-friendly pedigree of the CastAway-CTD. So do the simple, intuitive features – everything an operator needs to know about deploying the CastAway-CTD, viewing data and downloading the files fits in the lunchbox-sized carrying case.

Best used in:

- Coastal Oceanography
- Hydrology
- Aquaculture/Fisheries

When needed for:

- Saltwater Intrusion
- Surveying/Hydrography
- Sound Velocity Profiles
- Field Sensor Verification
- Estuarine Research

The CastAway-CTD Instant, reliable data in the palm of your hand!

- *GPS position, date and time*
- *Fast sampling and sensor response*
- *Waterproof interface works in and out of the water*
- *Bluetooth wireless communication*
- *No user calibration required*
- *No tools, computers or cables required!*

Pure Data for a Healthy Planet.®

www.ysi.com/castaway

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ISO 9001
ISO 14001
Yellow Springs, Ohio Facility

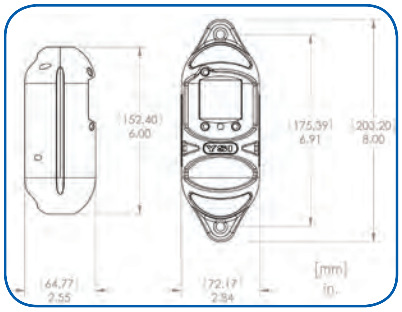
*Patent pending.

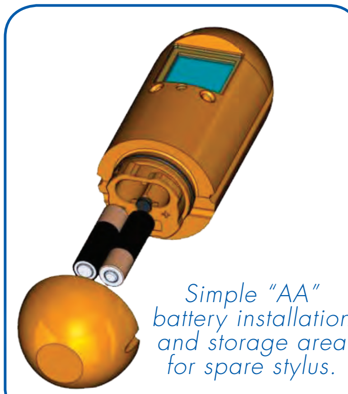
CE

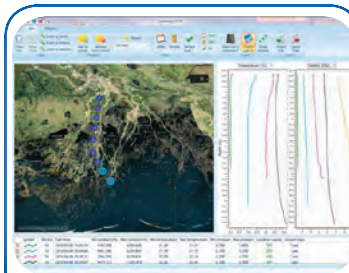
YSI incorporated
Who's Minding the Planet?®

Specifications

Memory	15 MB (750+ casts based on typical usage)
Communications	Bluetooth class II, up to 10 m range
Power	2 "AA" alkaline batteries, 40 hours continuous use
Data Output Format	- ASCII (CSV) -Hypack -Matlab
Environmental	- Depth range: 0-100 m - Use temperature: -5° to 45° C - Storage temperature: -10° to 50° C
Sampling Modes	- Casting (up/down) - Point sample (moving the unit back and forth)
Software	- Windows XP/Vista/7 - Geo-referenced - Multi-language - Data plots, filtering, import/export
Accessories	- Hard plastic storage/shipping case - Polyurethane jacket - 15m deployment line - Bluetooth dongle - Two locking carabiners - Three magnetic stylus pens - Cleaning brush
Thermistor Response	Less than 200 ms
Sampling Rate	5 Hz
Weight	In air: 1.0 lb (0.45 kg) In water: 0.06 lbs (0.03 kg)




Simple "AA" battery installation and storage area for spare stylus.


A screen capture of data from a river delta in Louisiana acquired using a CastAway-CTD. The technicians collected 21 casts in less than 3.5 hours.


Each CastAway ships in this hard plastic kit, complete with accessories and quick start guide.

The CastAway-CTD Output Parameters

	Range	Resolution	Accuracy	Measured or Derived
Conductivity	0 to 100,000 µS/cm	1µS/cm	± 0.25% ± 5 µS/cm	Measured
Temperature	-5° - 45° C	0.01° C	± 0.05° C	Measured
Pressure	0 to 100 dBar	0.01 dBar	± 0.25% FS	Measured
Salinity	Up to 42 (PSS-78)	0.01 (PSS-78)	± 0.1 (PSS-78)	PSS-78[3]
Sound Speed	1400 - 1730 m/s	0.01 m/s	± 0.15 m/s	Chen-Millero[4]
Density[1]	990 to 1035 kg/m³	0.004 kg/m³	± 0.02 kg/m³	EOS80[5]
Depth	0 to 100 m	0.01m	± 0.25% FS	EOS80[5]
Specific Conductivity[2]	0 to 250,000 µS/cm	1µS/cm	± 0.25% ±5 µS/cm	EOS80[5]
GPS			10 m	

[1]Based on temperature resolution and accuracy.
[2]Based on 100,000 µS/cm at -5° C.
[3]1978 Practical Salinity Scale.
[4]Chen-Millero, 1977. Speed-of-sound in sea water at high pressures.
[5]International Equation of State for sea water (EOS-80).

ASI Marine | ASI Relic

The ASI Relic is a custom-made aluminum survey vessel with dual consoles, and an open bow and aft deck area. This vessel supports diving operations, marine survey operations, and ROV operations. The ASI Relic is well-suited for small boat operations, especially where minimal clearance is required due to overhead structures.

GENERAL SPECIFICATIONS

Combined Boat and Trailer Weight	1506 kg	3320 lb
Est. Boat Weight	1279 kg	2820 lb
Hull Length	5.3 m	17.2 ft
Hull Beam	2.1 m	7.2 ft
Minimum Draft Requirement	0.4 m	1.2 ft
Maximum Speed	36 kn	

FUEL CAPACITY

- Sufficient for day operations

CONSTRUCTION

- Custom-made aluminum survey vessel with dual consoles

TRANSPORT CANADA COMMERCIAL VESSEL REGISTRATION

- C17922ON

DECK SPACE

- open aft deck and bow deck

DECK EQUIPMENT

- Small davit arm

PROPULSION

- Mercury 100 hp outboard

POWER SUPPLY

- 12 V supply

RADIO EQUIPMENT

- Cobra MRF45

NAVIGATION INSTRUMENTS

- DGPS/sounder combination

LICENSED TO CARRY

- 2 crew, 2 passengers

MOBILIZATION AND DEMOBILIZATION

The complete system can be trailered for road transportation to and from work sites. ASI Relic can be launched by trailer at suitable boat ramps or deployed by crane in areas with limited access.

ASI Marine | ASI LBV300-5

The ASI LBV300-5 is a highly versatile and portable inspection solution. This ROV is an ideal platform for open water, tanks, or reservoirs. It is configurable with a USBL positioning system for accurate tracking of the ROV in open water.

VEHICLE DIMENSIONS

Length	0.7 m	2 ft
Width	0.4 m	1.3 ft
Minimum Tunnel Diameter	0.6 m	2 ft
Depth Rating	300 m	1000 ft
Estimated Weight	15 kg	35 lb

POWER REQUIREMENTS

- Single phase 120-140 VAC at 2 kW 50/60 Hz

STANDARD EQUIPMENT

- 2 horizontal, 1 lateral, and 2 vertical brushless DC thrusters
- Cable payout counter
- Navigation scanning sonar
- 5 MP HD video and stills camera
- Video overlay

UMBILICAL LENGTH

350 m 1150 ft

OPTIONAL EQUIPMENT

Including but not limited to:

- Tritech Micron NAV USBL Positioning System
- Manipulator

SPECIALIZED TOOLING AVAILABLE ON A PROJECT-SPECIFIC BASIS

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Micron DST Sonar

Ultra Compact CHIRP Digital Sonar

Features

- Extremely compact - our smallest sonar yet
- Digital CHIRP system
- Full software functionality
- True acoustic zoom
- Instant scan reversal and sector scan options
- Inverted mode operation
- Hard boot protection for transducer
- Cost effective and reliable
- Target size measurement
- 750m depth rating
- Simple to operate

Applications

- Small ROV obstacle avoidance and target recognition
- AUV guidance

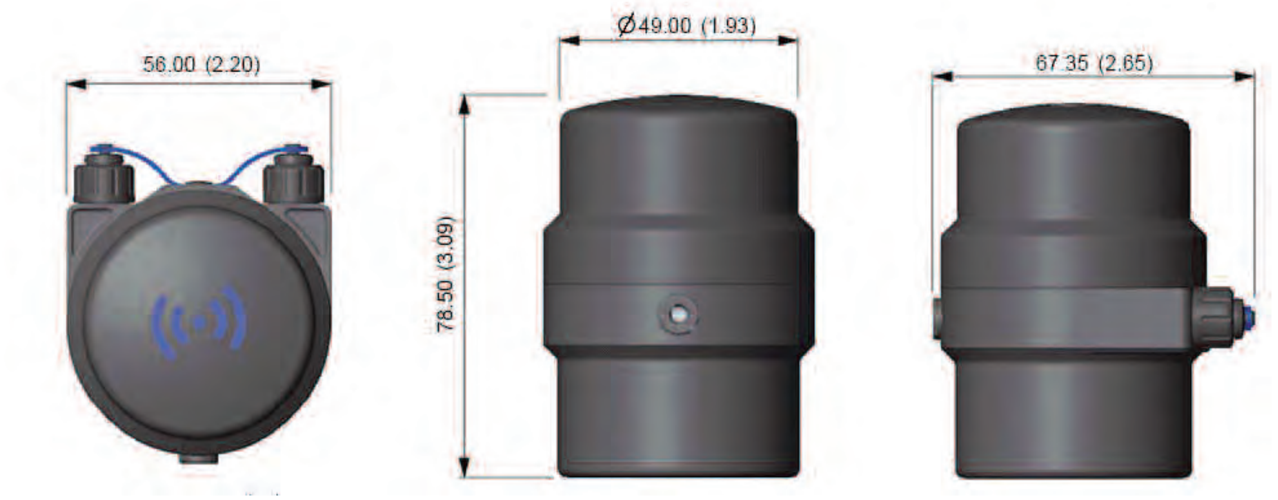
If the new generation of very small and low cost ROVs are to develop their full potential it is essential they are equipped with the vital tools and sensors expected on larger ROVs.

Along with the camera, the most important sensor for any vehicle is its obstacle avoidance sonar. The all new Tritech Micron DST (Digital Sonar Technology) sets new standards in compact sonar technology. It is the smallest digital CHIRP sonar in the world. CHIRP technology dramatically improves the range resolution compared with conventional sonars - it is a feature normally associated with much larger, more expensive systems.

Based on experience gained from Tritech's world class range of SeaKing and SeaPrince sonars, the Micron DST incorporates the most advanced acoustic features and software available today. The sonar can be controlled by a customer supplied PC or laptop and it can be configured for either RS232 or RS485 protocols. Micron DST has an auxiliary port to allow it to interface with other Tritech sensors.

This sonar incorporates the very latest surface mounted digital electronics and many software features normally found only on full sized commercial systems. Tritech believe that although the Micron DST is small in both size and cost it should offer the full range of functionality expected from a professional product.

Specifications



Operating frequency	Chirped 650kHz to 750kHz Other frequency bands available on request
Beamwidth, vertical	35°
Beamwidth, horizontal	3°
Range settings	From 2m (6ft) to 75m (250ft)
Scan sectors	User selectable up to 360° continuous
Step speed	Normal, Fast or Very Fast
True acoustic zoom	Yes
Instant reversal	Yes
Image measurement	Yes
Inverted head operation	Yes
Power requirements	12V - 50V @ 4 VA (Average)
Data communication	RS 485 (twisted pair), RS 232 (via modem up to 115kb/s)
Communication requirements	Maximum cable length 1000 metres (using RS 485)
Topside control	Customer supplied PC or Laptop using standard serial comms port. Windows 2000 or XP or Vista Operating System.
Software	Tritech SeaNet(OEM) display and control or low level direct command protocol
Maximum diameter	56mm (2.20 inches)
Maximum height	78.5mm (3.09 inches)
Weight in air	324g (10.25 ounces)
Weight in water	180g (5.15 ounces)
Maximum operational depth	750m (2,460ft) standard (3000m - 9,842ft version available)
Operating temperature	-10°C to +35°C
Storage temperature	-20°C to +50°C

**NB The Tritech Micron DST is only for use on vehicles with voltage spike protection on power supplies and communication lines.*

All specifications are subject to change in line with Tritech's policy of continual product development. Ref: EDS-SON-001.9

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Appendix 2:

Multi-beam System Configuration and Calibration

APPENDIX 2

Multi-Beam Echo Sounding Sonar (MBES) System Configuration and Calibration Procedures

ASI Marine Project RH16-052

Multi-beam sonar systems are the latest advancements in hydrographic surveying technology. With this improved resolution and coverage comes the need for much greater control and calibration to ensure that the sounding is recorded from the correct position on the sea floor (geo-positioning). These systems consist of a transducer, HPR (Heave, Pitch, Roll) motion sensor, heading sensor (dual DGPS antennae), and navigation system.

Field calibrations addressed physical biases which exist in multi-beam surveying. These biases are as follows:

- *Static offsets of the sensors* are the distances between the sensors and the reference point of the vessel or the positioning antenna.
- *Acceleration and translation measurements (dynamic offsets) of the HPR* are critical for corrections to the vessel's roll and pitch.
- *Time delay between the positioning system, sonar measurement, and HPR sensor* is the delay or latency that must be accurately known and compensated for in the processing of the hydrographic data.
- *Transducer draft* is the depth of the transducer head below the waterline of the vessel.
- *Sound velocity measurement* is the velocity of sound in the water column that must be accurately known so the correct depth can be measured.

These parameters must be measured and corrected in the multi-beam sonar system. The HYPACK/ HYSWEEP software used in collecting and processing the multi-beam bathymetric data accommodates these inputs.

Reliable data can only be acquired after proper calibration has been performed on the system as a whole. This calibration begins with the alignment and static offsets of the sensors referenced to the centerline of the vessel and the transducer. The alignment reduces the static corrections of each sensor. After the static offsets are determined, a "patch test" is performed. The patch test is performed in the field with the survey vessel in the water at the survey site. This test is designed to reveal the following residual biases: pitch offset, roll offset, positioning time delay (latency), and azimuthal offset. The test consists of a small survey of several lines that are evaluated for inconsistencies and then corrected using software designed for multi-beam surveys. This test is a series of parallel and cross lines with significant overlap to give redundant data.

ASI followed standard procedures for configuring and calibrating the MBES as per the manufacturer's recommendations, which involved determining both the static and dynamic offsets of the equipment configuration.

ASI utilized the ASI *Relic* survey vessel (refer to Figure 1 – ASI Survey Vessel, the *Relic*) for the purpose of performing the multi-beam bathymetric survey.

Figure 1: ASI Survey Vessel, the *Relic*

The various components of the MBES package have temporary mounting locations on the *Relic* and are mounted in such a way that no movement from the secured position is possible. The measurements or offsets between these fixed components of the MBES equipment package are referred to as the static offsets. These offsets, once determined for this particular survey vessel and MBES equipment setup, should remain unchanged throughout the survey. The static orientation (offsets) of the sonar head, motion reference unit, heading, and positioning antennas in relation to the boat reference point (BRP) must be known in order to convert the measured slant ranges to depths and to determine the position of each of the determined depths. ASI accurately measured these offsets prior to mobilizing to site and once again after the equipment was installed onto the vessel at site. These offsets were entered into the HYPACK/HYSWEEP software prior to surveying.

Dynamic offsets are offsets caused by survey vessel and MBES equipment motion once the vessel is in the water. These offsets or adjustments must be determined for pitch, roll, and yaw (refer to Figure 2 – Rotational Axes of a Survey Vessel). Latency must also be determined. Latency is the time delay between the positioning system, sonar measurements, and the HPR motion sensor. Dynamic offsets are determined by performing a patch test. A patch test reveals latency, pitch, roll, and yaw in the system. The patch test requires collecting sounding data over two distinct types of sea floor topography: a flat bottom is used for the roll computation, whereas a steep slope or feature is used for the latency, pitch, and yaw data collection.

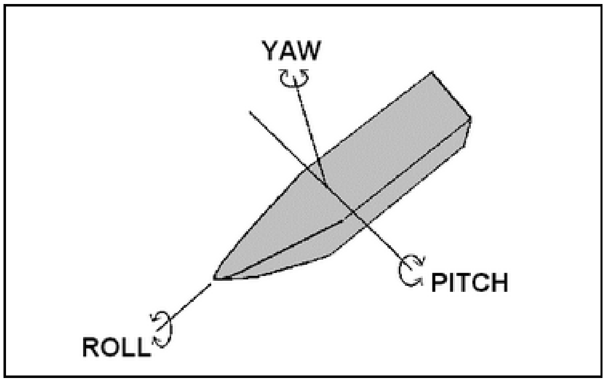

Figure 2: Rotational Axes of a Survey Vessel

For the latency test, data was collected on a pre-defined line on a sloped bottom. The line was surveyed at survey speed up the slope, and then surveyed again in the same direction, but at half of the original survey speed.

For the pitch test, data was collected over the same type of sea floor as the latency test (i.e. steep slope). One pre-defined line was surveyed twice in reciprocal directions at survey speed.

For the roll test, data was collected on a pre-defined line over a flat bottom. The line was surveyed twice in reciprocal directions and at the same survey speed in both directions.

For the yaw test, two pre-determined parallel lines over a sloped bottom were used, with the vessel surveying in the same direction on those lines at the same survey speed.

ASI performed the required patch test under close to ideal survey, and the required adjustments were entered into the HYPACK/HYSWEEP software prior to commencement of the multi-beam bathymetric data collection for this project.

Knowing the speed of sound through the water column is critical so the correct depth can be measured. ASI gathered speed of sound profiles prior to and following data collection on each survey day. The speed of sound profile data was applied to data during patch test processing and post-processing of project multi-beam bathymetric data.

A standard bar check was performed to confirm draft (vertical offset) between the phase center of the sonar head and the waterline. The standard bar check procedure involves lowering a flat bar below the nadir (center) beam of the sonar head at specific depths below waterline. Initially, the bar is set to 2m below the waterline to confirm draft and is then lowered to a depth close to the project's deepest depth. Then the bar was raised in 5m intervals back to the 2m below waterline. The nadir beam depth agreed with the bar depth, verifying that the correct speed of sound and draft had been used.

Prior to mobilizing to the project site, ASI investigated the forecasted GPS conditions for the proposed dates and project location of the survey. While a minimum of 4 visible satellites are needed for positioning in general, a DOP (Dilution of Precision) Position value of 5 or less is considered good for accuracy, with a value of 1 resulting in the highest possible precision. ASI found the GPS constellation, with a minimum of 12 visible satellites and DOP Position values below 5 for the proposed survey dates, to be sufficient for accurate DGPS positioning.

Appendix 3:

Video Images

Image 3A-1: 07 m - Minor horizontal crack observed on dam face

Image 3A-2: 10.3 m - Joint with spalling cracking

Image 3A-3: 25.5 m - Joint with minor erosion

Image 3A-4: 31.5 m - Joint with slight separation

AECOM	ASI Marine	ASI Project No: RH16-052 Project Date: November 2016 Drawn By: Randy Johnston	**Video Images** **Dam C** **Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock**	Appendix Number: 3A 2 of 91

Image 3A-5: 41 m - Slight cracking with slight erosion

Image 3A-6: 55.5 m - Spalling on crack with rebar protruding

Image 3A-7: 56.5 m - Spalling starting at crack 56 m to 71.5 m mostly above water

Image 3B-01: 0 m - Undercutting and wooden structure above waterline.

Image 3B-02: 0 m - Undercutting and wooden structure below waterline.

AECOM	ASI Marine	ASI Project No: RH16-052	**Video Images Dam D**	Appendix Number:
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		Drawn By: Randy Johnston		5 of 91

Image 3B-03: 0 m - Undercutting just below surface.

Image 3B-04: 4 m - Undercutting.

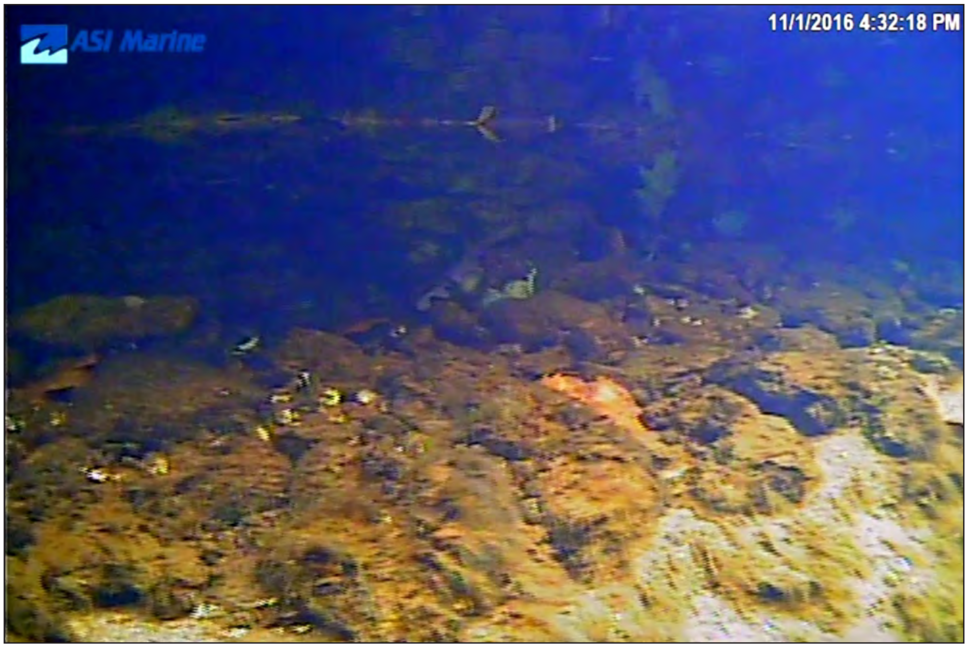

Image 3B-05: 5 m - Undercutting.

Image 3B-06: 8.5 m - Debris or conduit in deep undercut.

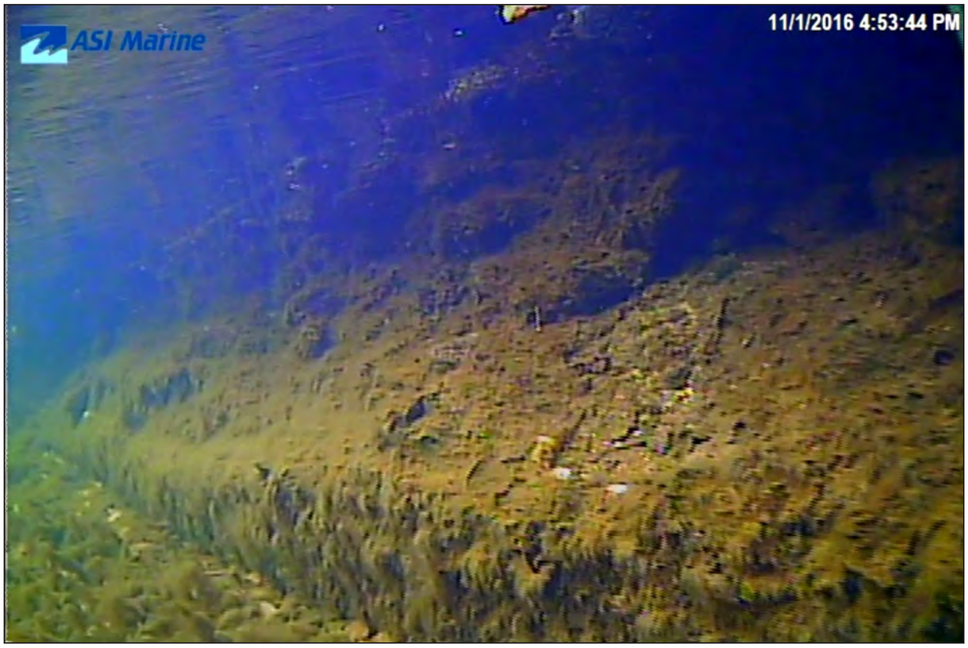

Image 3B-07: 10 m - Undercutting in shallow water depth.

Image 3B-08: 12.5 m - Undercutting deepens.

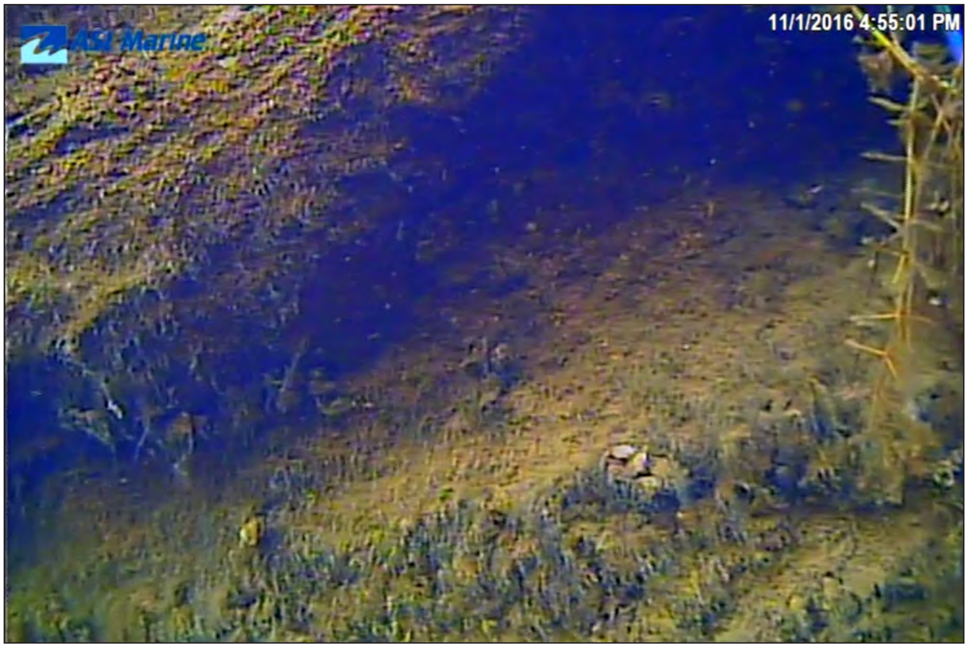

Image 3B-09: 15 m - Undercutting ends.

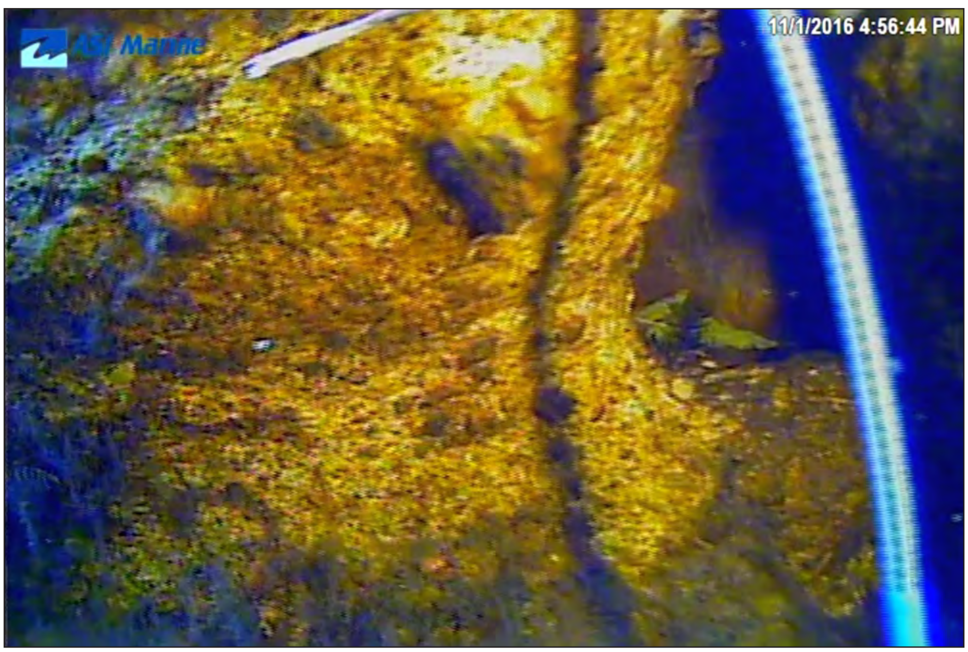

Image 3B-10: 19.6 m - Joint spalling and wooden structure.

Image 3B-11: 19.6 m - Joint spalling below waterline.

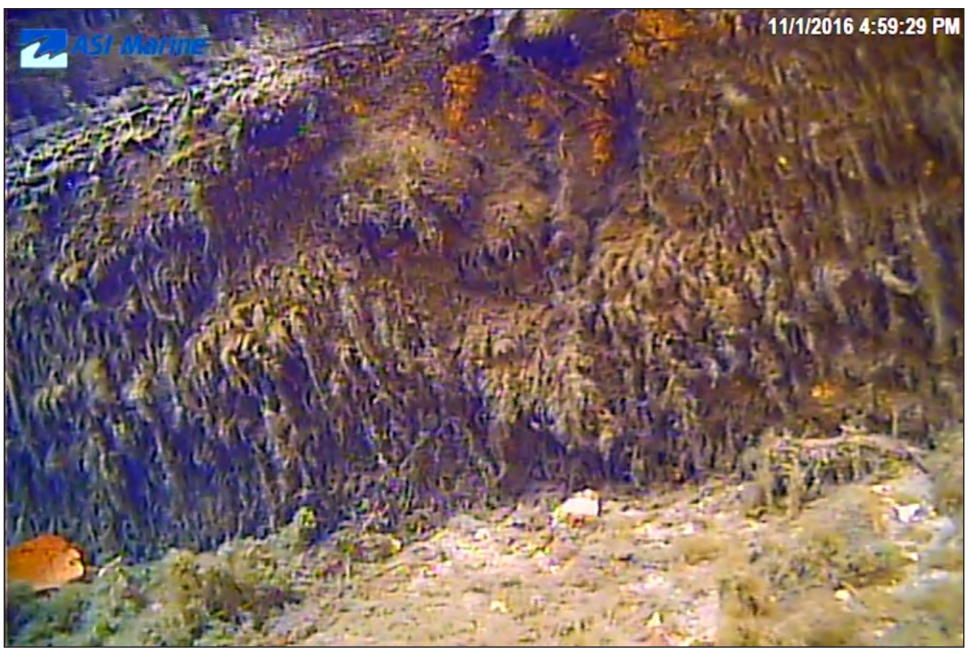

Image 3B-12: 25.8 m - Spalling below surface.

Image 3B-13: 25 m - Undercutting at bottom.

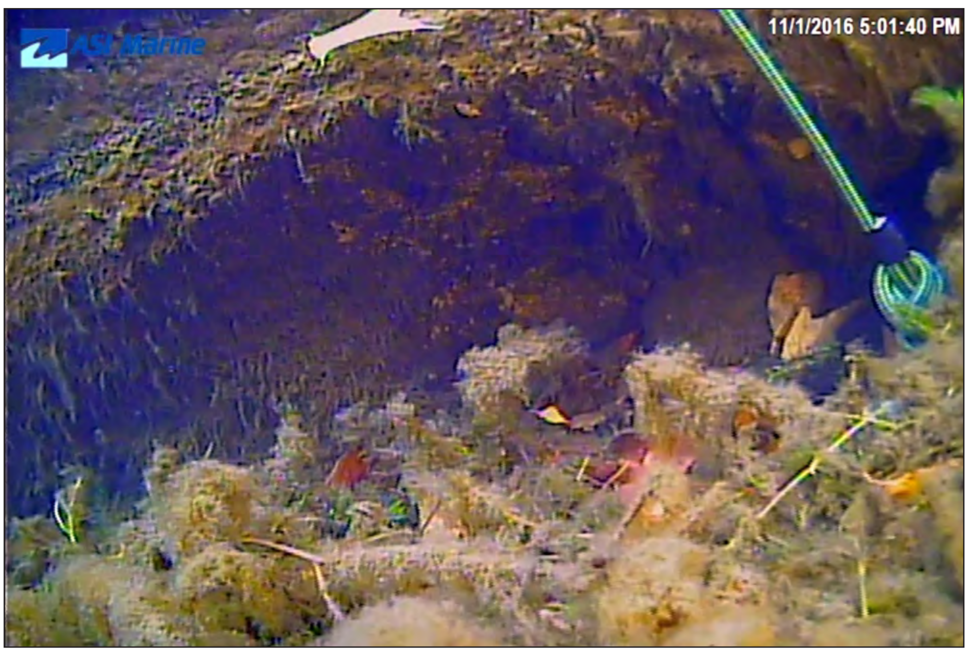

Image 3B-14: 29.5 m - Undercutting.

Image 3B-15: 34.3 m - Spalling above water surface.

Image 3B-16: 34.3 m - Spalling below water surface.

Image 3B-17: 42.7 m - Crack with spalling at waterline.

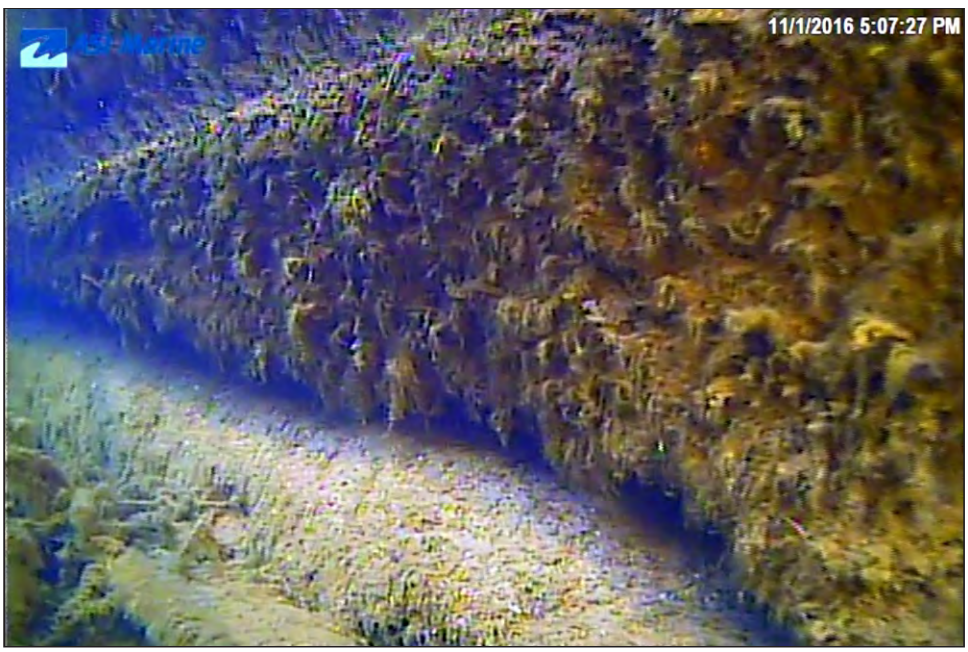

Image 3B-18: 46 m - Undercutting at bottom to 55.5 m, lost visibility.

Image 3B-19: 47.5 m - Undercutting at bottom - 30 cm deep.

Image 3C-01: Pier 6 - Spalling below surface and behind stop log gain.

Image 3C-02: Pier 6 - Spalling below surface west side.

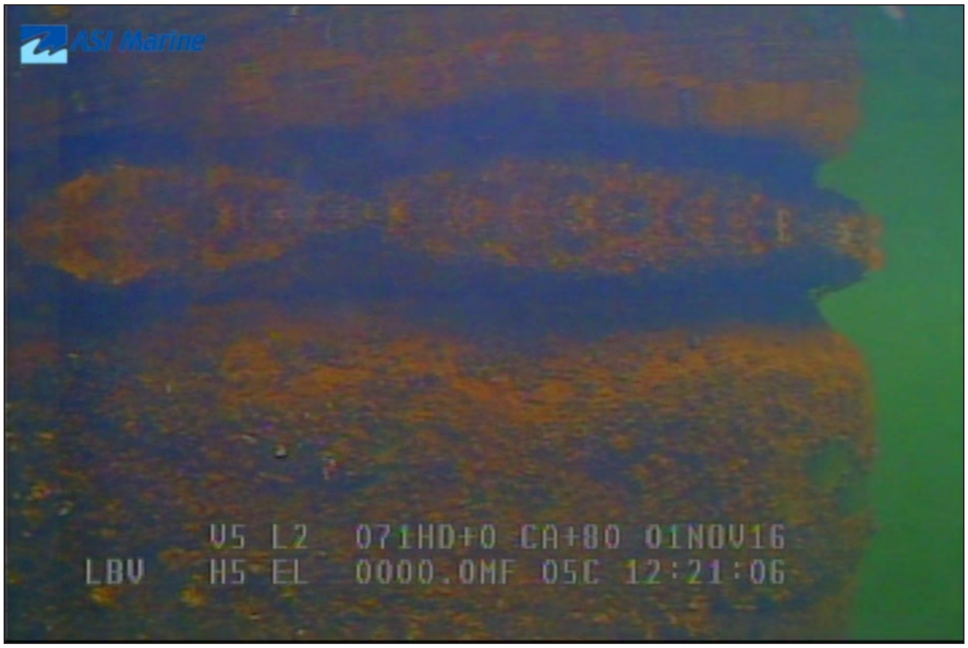

Image 3C-03: Pier 6 - Spalling below surface.

Image 3C-04: Pier 6 - Step down transition to next gate.

Image 3C-05: Pier 7 - Spalling below surface west side.

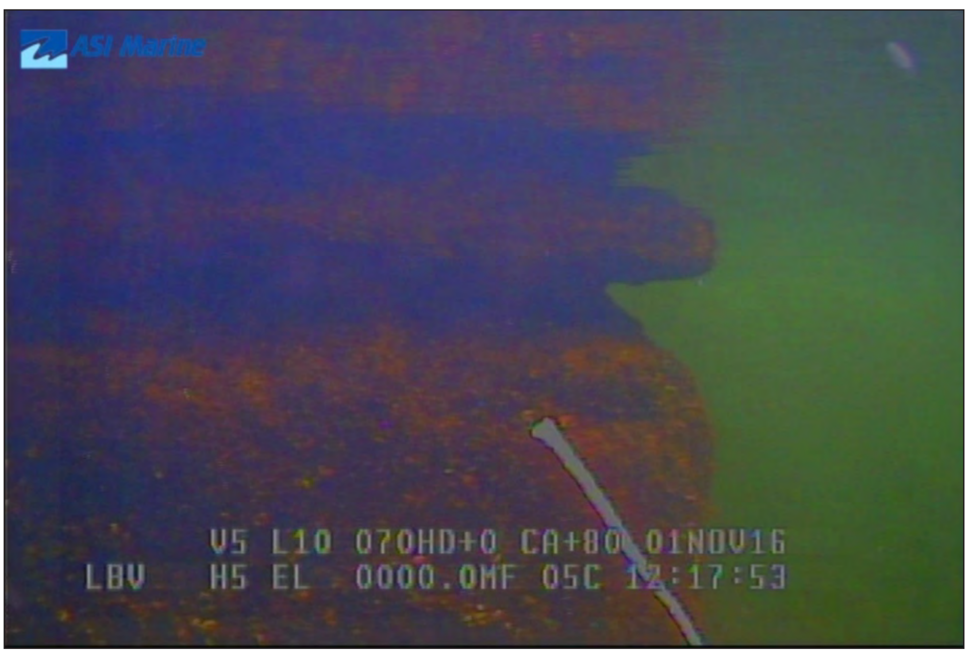

Image 3C-06: Pier 7 - Spalling below surface on east side.

Image 3C-07: Pier 8 - Bottom transition.

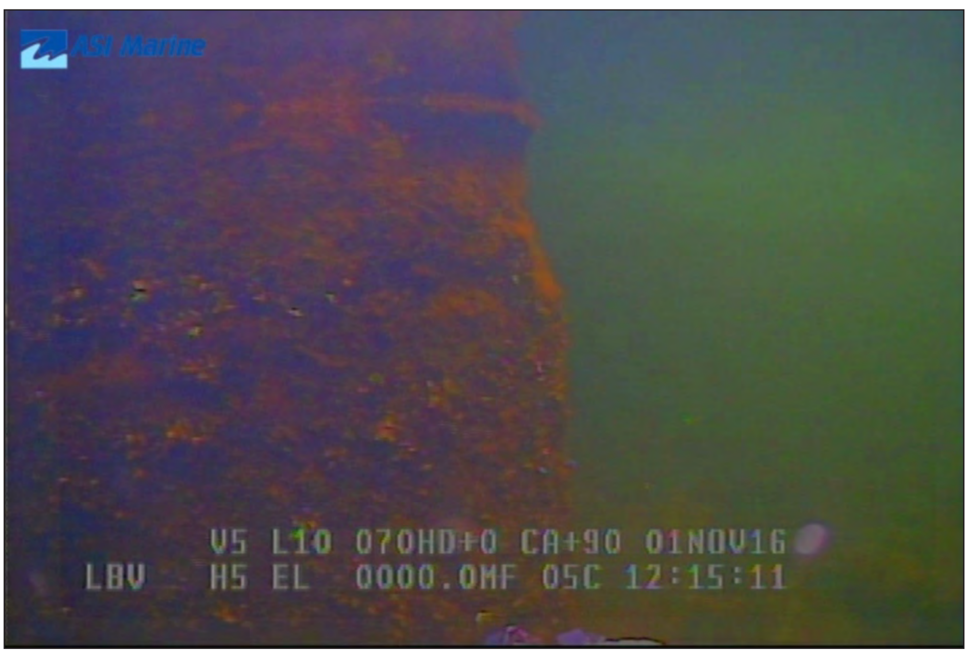

Image 3C-08: Pier 8 - Slight spalling below surface.

Image 3C-09: Pier 9 - Edge on bottom.

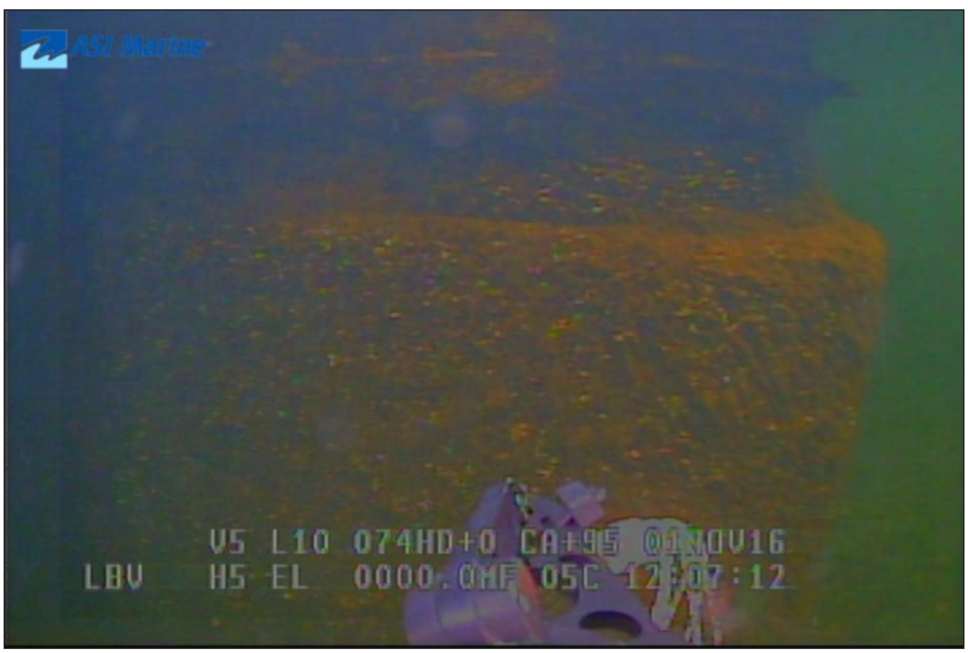

Image 3C-10: Pier 9 - Errosion at surface.

AECOM	ASI Marine	ASI Project No: RH16-052	**Video Images Upper Main Dam**	Appendix Number:
		Project Date: November 2016		3C
		Drawn By: Donavan Wilkens	**Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock**	19 of 91

Image 3D-01: Concrete slab downstream of Gate 5.

Image 3D-02: Step down ledge from Gate 5 to Gate 4.

Image 3D-03: Undercutting downstream of Gate 2.

Image 3D-04: Undercutting downstream from Pier 2 bottom

Image 3E-01: 5.5 m - Cracking present above waterline.

Image 3E-02: 6.7 m - Undercutting

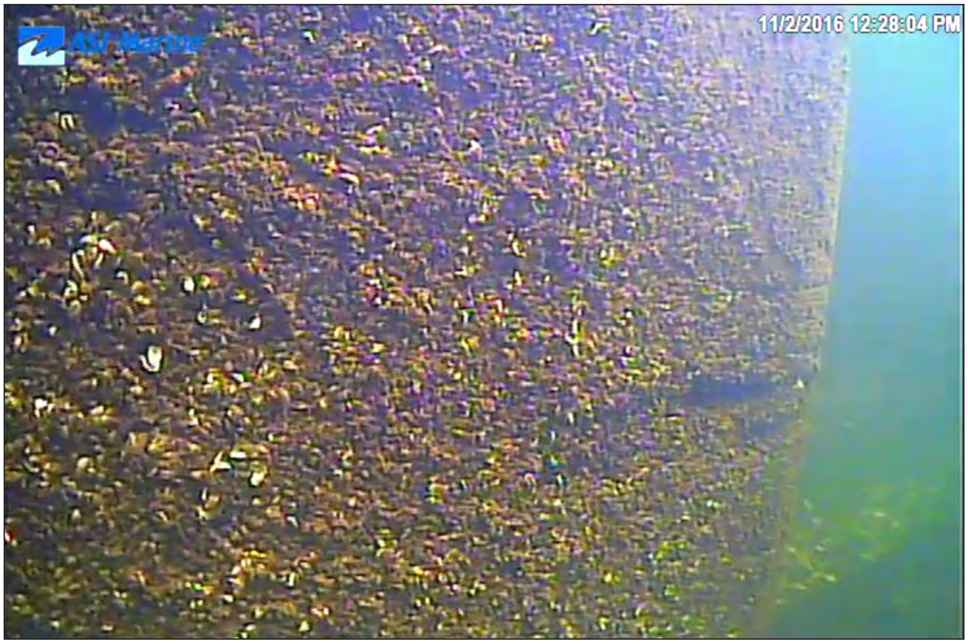

Image 3E-03: 11.8 m - Scour mark.

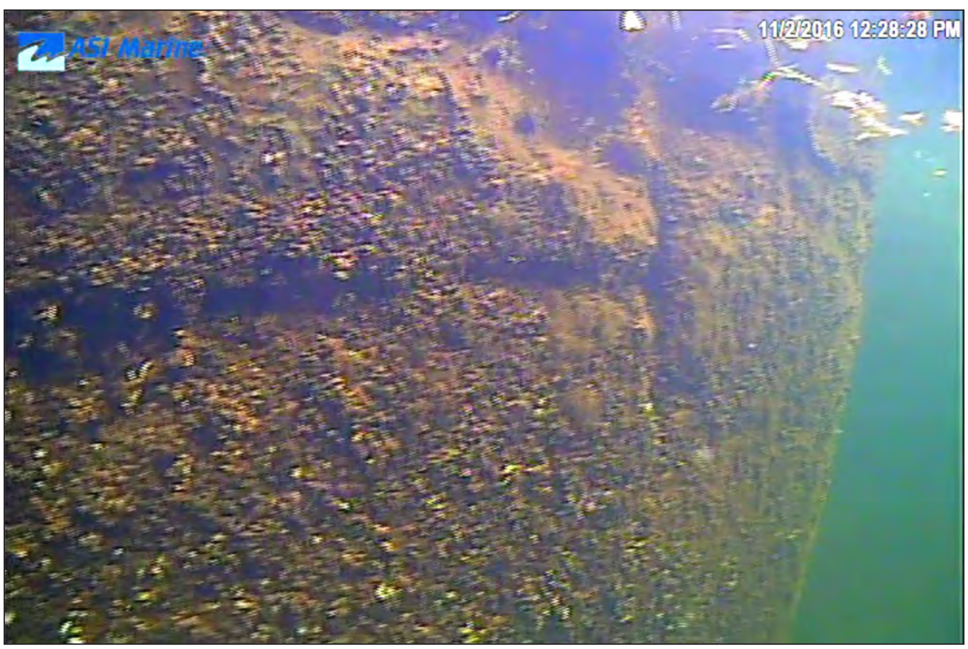

Image 3E-04: 11.8 m - Undercutting at surface.

Image 3E-05: 11.8 m - Undercutting continues above waterline.

Image 3E-06: 11.8 m - Exposed sub-structure.

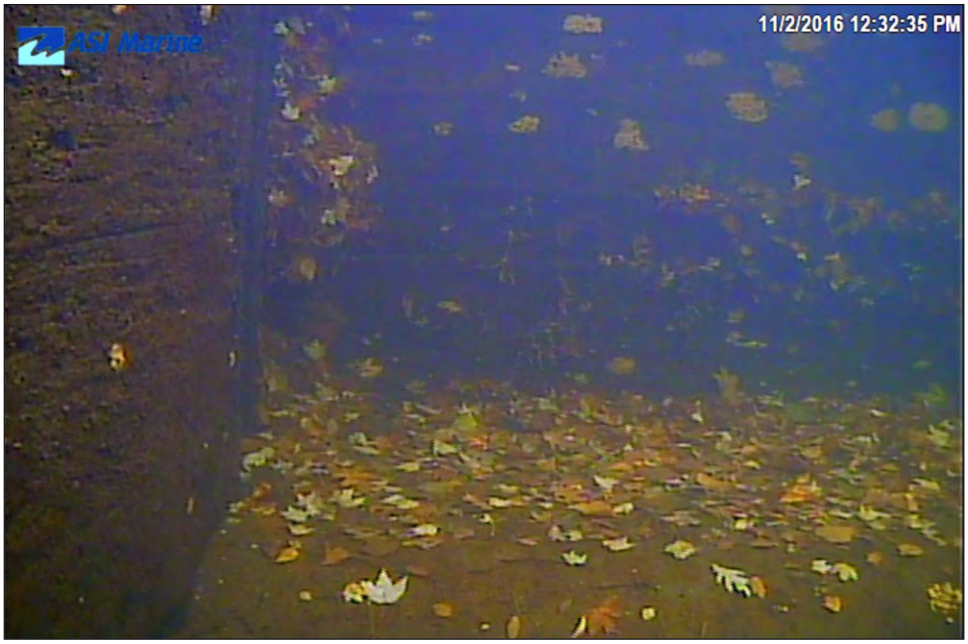

Image 3E-07: 12 m - Dam footing and stoplogs.

Image 3E-08: 19.9 m - Undercutting.

Image 3E-09: 19.9 m - Undercutting continues along radius of corner.

Image 3E-10: 21.5 m - Cracking with exposed sub-structure.

Image 3E-11: 21.5 m - Cracking continues below waterline.

Image 3E-12: 26.5 m - Undercutting below waterline.

Image 3E-13: 26.4 m - Undercutting continues to waterline.

Image 3E-14: 27.5 m - Cracking above water line.

Image 3F-01: 21.8 m - Joint showing slight separation.

Image 3F-02: 41.7 m - Joint showing signs of spalling.

Image 3F-03: 41.7 m - Joint showing signs of erosion.

Image 3F-04: 45.5 m - Cracking above waterline.

Image 3F-05: 47 m - Scour mark.

Image 3F-06: 48 m - Scour mark.

Image 3F-07: 51 m - Cracking

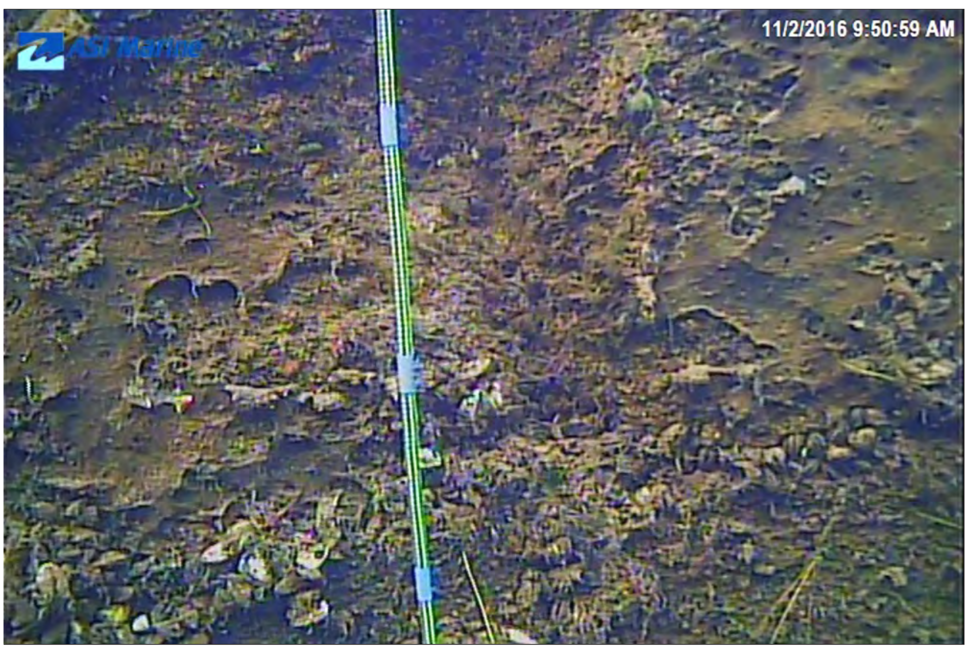

Image 3F-08: 52 m - Joint showing signs of shallow spalling.

Image 3F-09: 53 m - Cracking.

Image 3F-10: 53 m - Cavity behind crack.

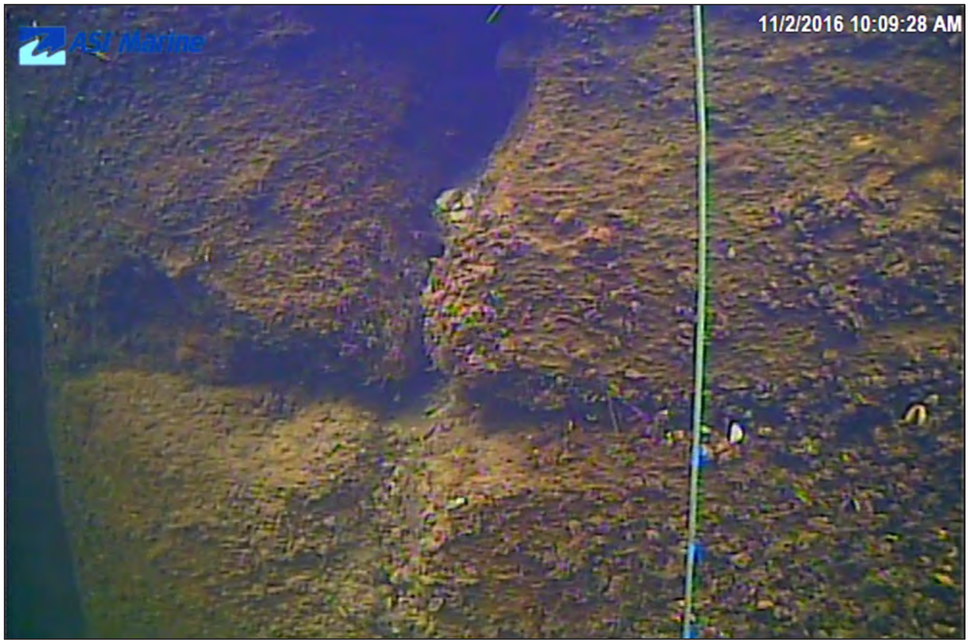

Image 3F-11: 55.5 m - Cracking.

Image 3F-12: 60.2 m - Undercutting.

Image 3F-13: 60.5 m - Dam G footing.

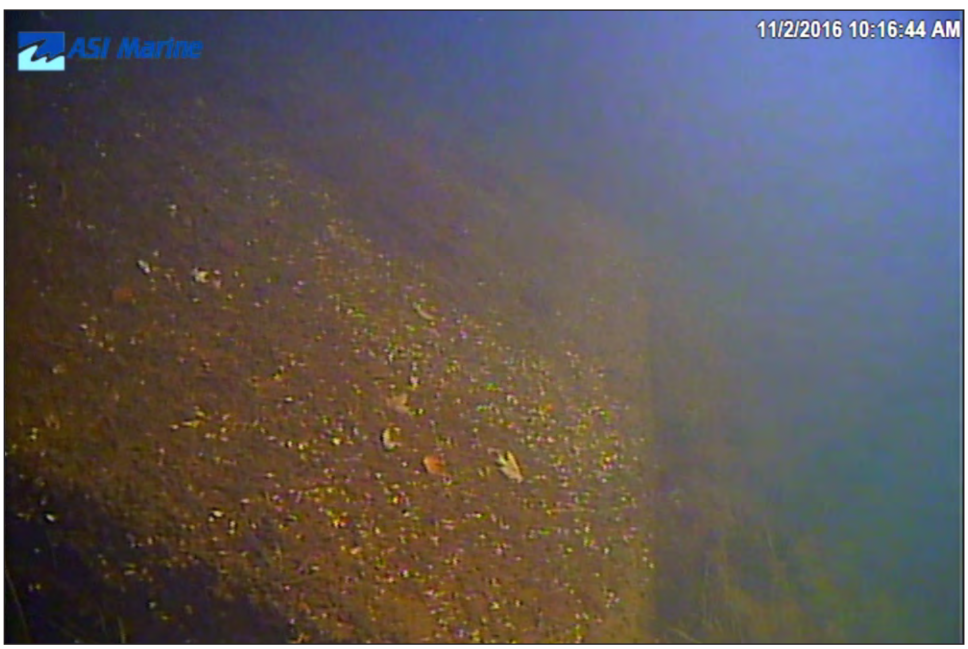

Image 3F-14: 60.5 m - Dam G footing.

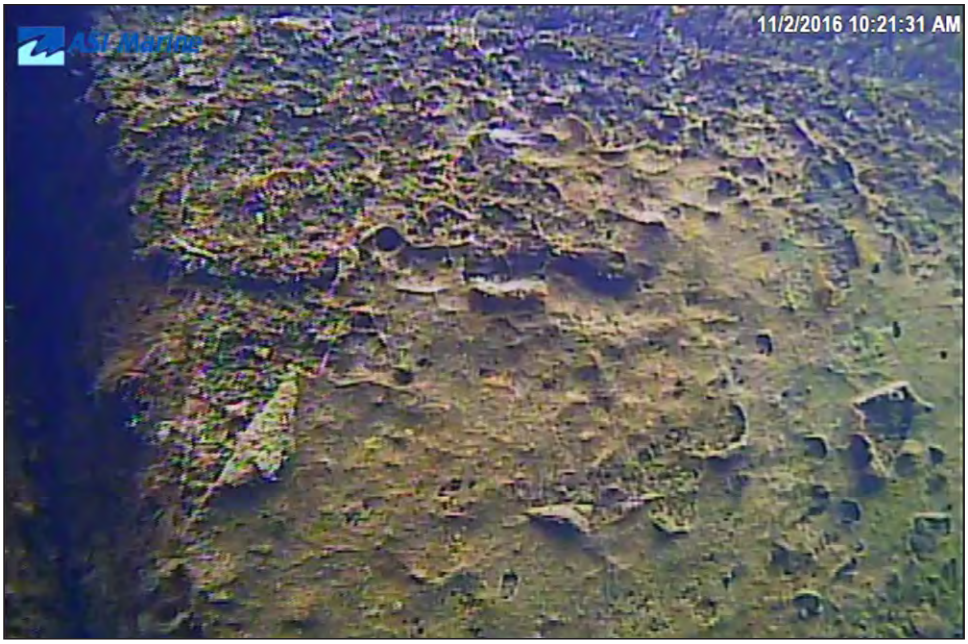

Image 3F-15: 65.8 m - Joint showing signs of separation.

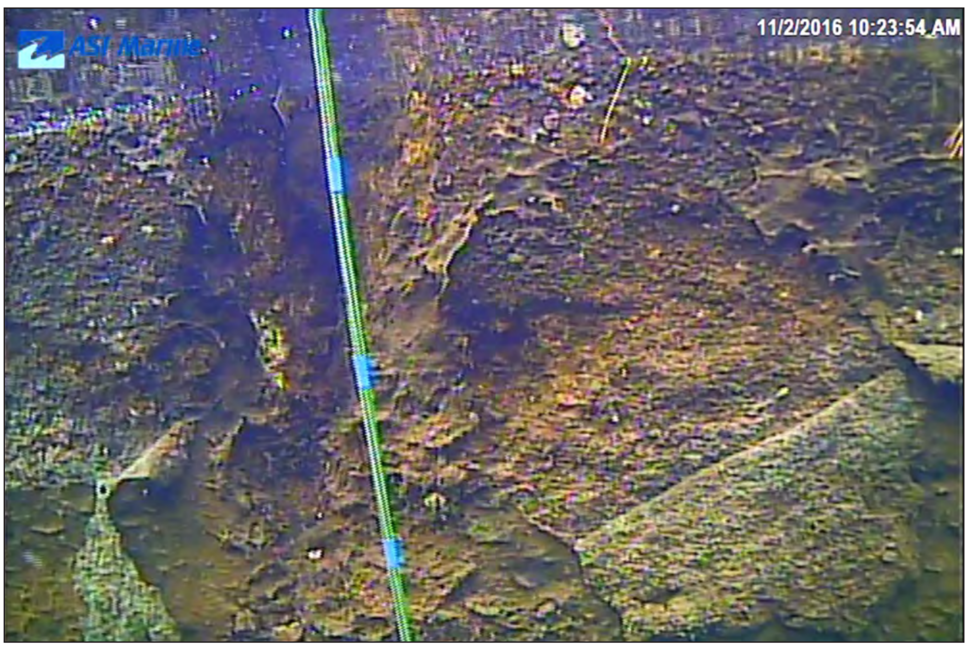

Image 3F-16: 69.6 m - Cracking.

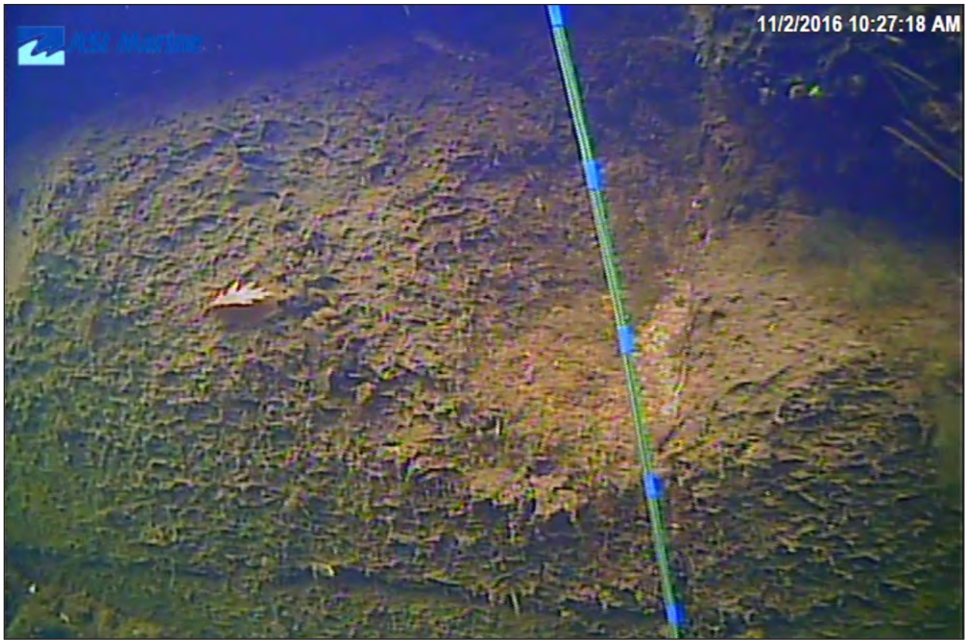

Image 3F-17: 81 m - Cracking leading into undercutting.

Image 3F-18: 81 m - Undercutting continues west.

Image 3F-19: 81 m - Undercutting.

Image 3F-20: 89.2 m - Undercutting from previous images ends here.

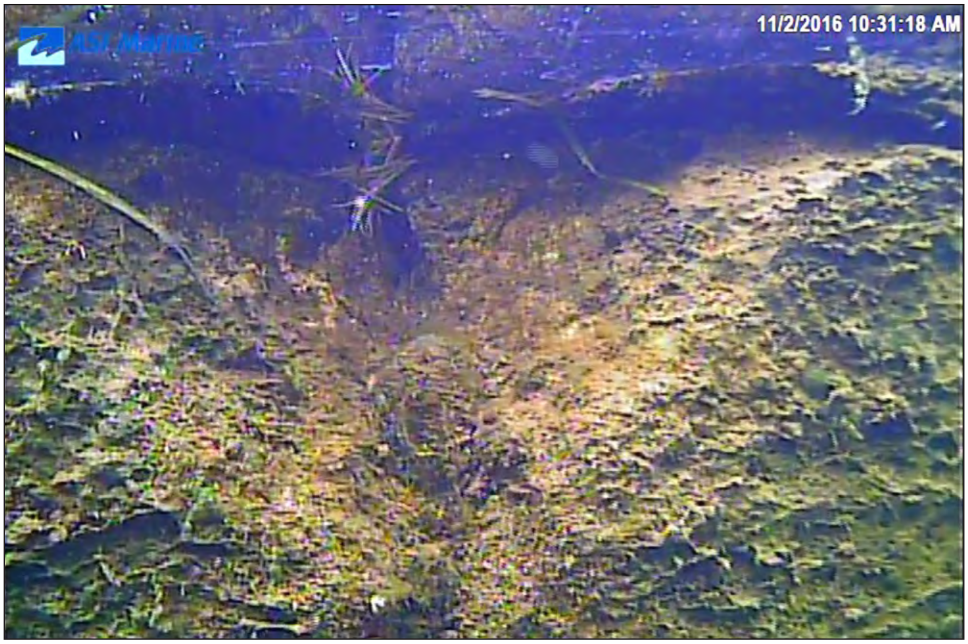

Image 3F-21: 90 m - Joint showing signs of erosion.

Image 3F-22: 96.3 m - Cracking.

Image 3F-23: 99.6 m to 101 m - Cluster of scour marks.

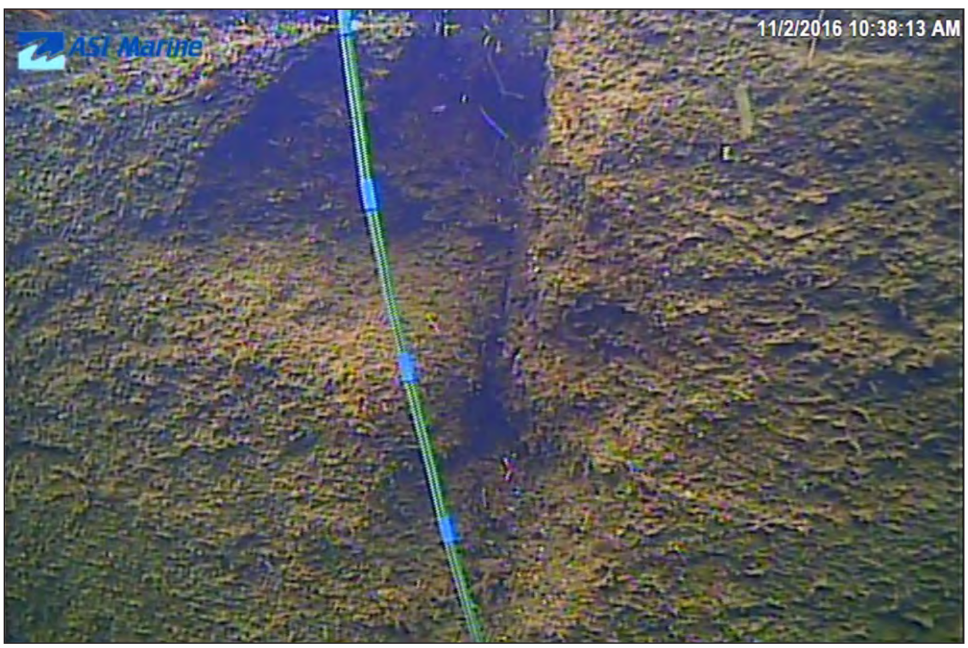

Image 3F-24: 102.8 m - Cracking.

Image 3F-25: 103.8 m - Scour mark.

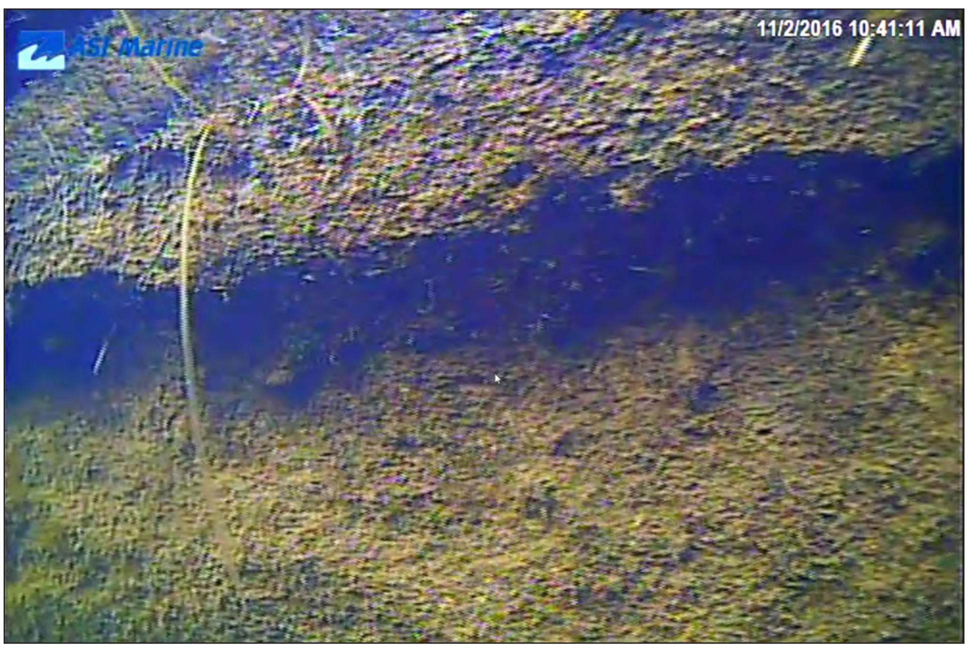

Image 3F-26: 106.3 m - Start of undercutting.

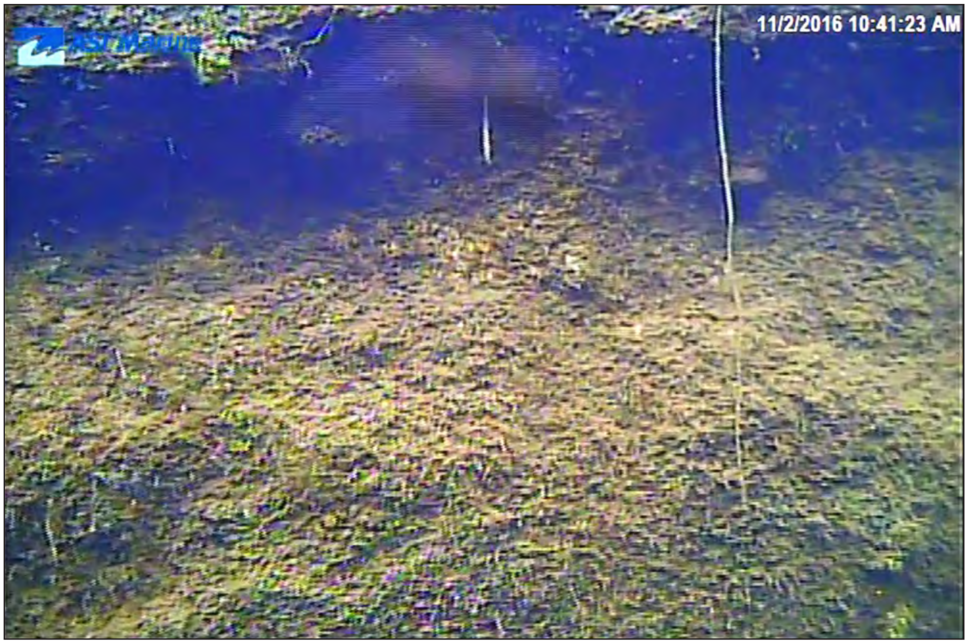

Image 3F-27: 106.8 m - Undercutting continues.

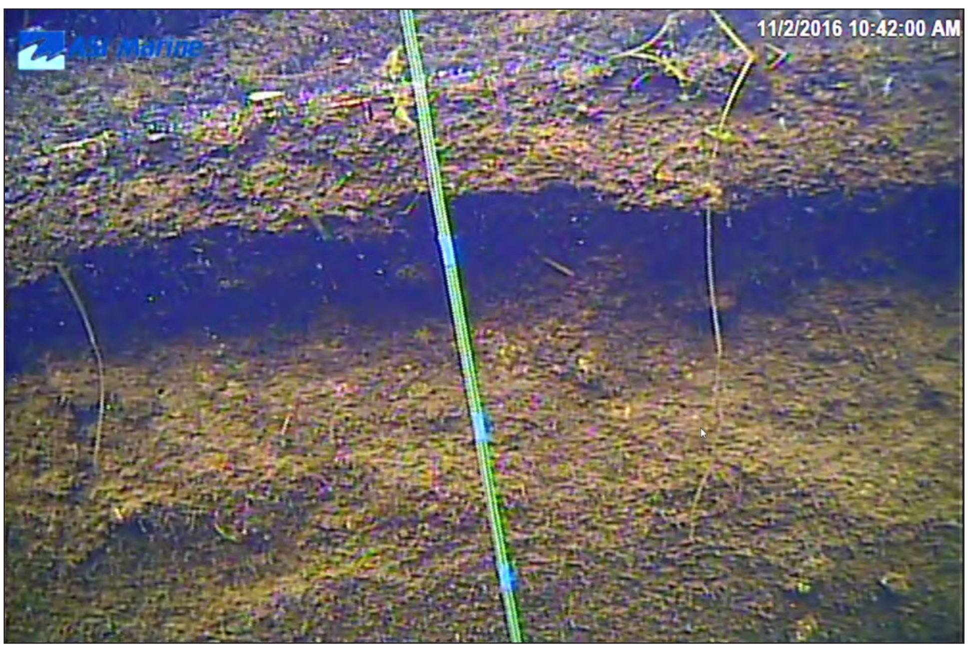

Image 3F-28: 107.4 m - Undercutting ends.

Image 3F-29: 108.3 m to 115.5 m - Cluster of scour marks.

Image 3G-01: Heavy biofouling 2 m from corner.

Image 3G-02: Inside first slot on east side.

Image 3G-03: Inside second stop log slot.

Image 3G-04: Northeast gate slot.

Image 3G-05: Northwest gate slot.

Image 3G-06: Southwest stop log slot.

AECOM	ASI Marine	ASI Project No: RH16-052	**Video Images Lock 45 Downstream**	Appendix Number:
		Project Date: November 2016		3G
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Image 3G-07: Northwest stop log slot.

Image 3G-08: Slight undercutting on corner.

Image 3G-09: Scour mark on the northwest corner.

Image 3H-01: Southwest gate slot.

Image 3H-02: Southwest opening in concrete wall.

Image 3H-03: Ladder in northwest corner.

Image 3H-04: Middle east opening in concrete wall.

Image 3H-05: Middle west opening in concrete wall.

Image 3H-06: Northeast gate slot.

Image 3H-07: Northeast opening in concrete wall.

Image 3H-08: Northwest open gate slot.

Image 3H-09: Northwest opening in concrete wall.

Image 3H-10: Southeast gate slot.

Image 3H-11: Southeast opening in concrete wall.

Image 3I-01: Lock 45 lower east gate opening.

Image 3I-02: Lock 45 lower east wall conduit channel.

Image 3I-03: Lock 45 lower east wall conduit on bottom.

Image 3I-04: Lock 45 lower east wall hole in wall internal.

Image 3I-05: Lock 45 lower east wall hole in wall.

Image 3I-06: Lock 45 lower southwest corner of wall near water surface.

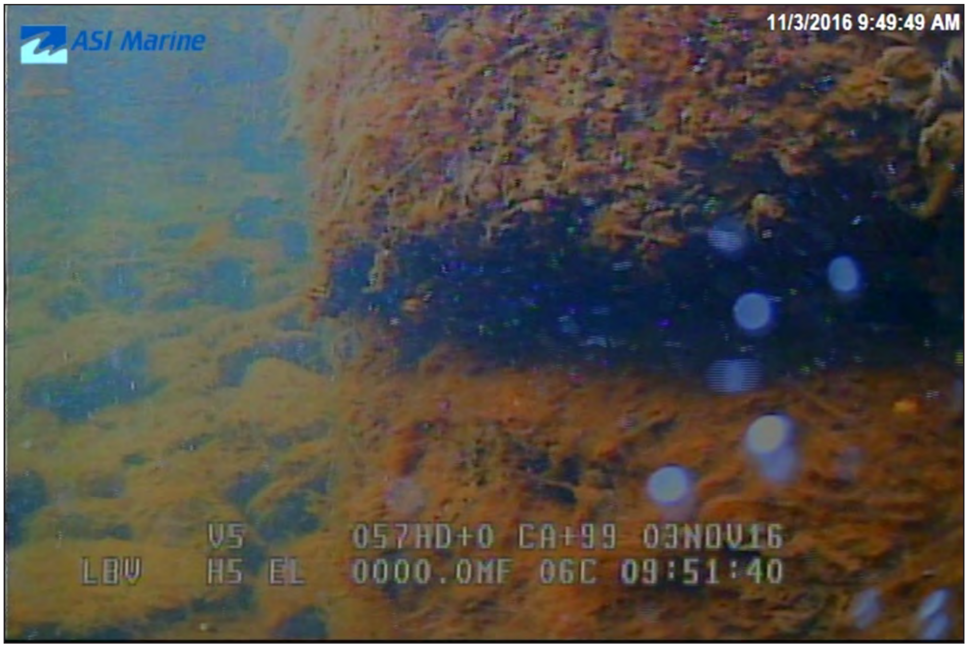

Image 3I-07: Lock 45 lower southwest corner of wall showing spalling near the bottom.

Image 3I-08: Lock 45 lower southwest corner spalling on inside of lock.

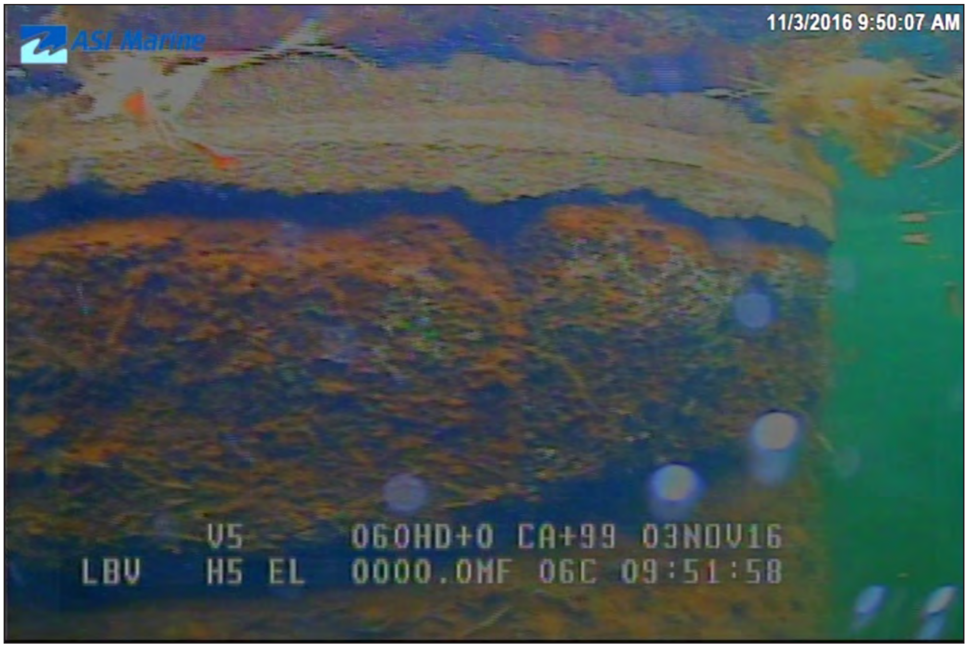

Image 3I-09: Lock 45 lower southwest corner spalling near water surface at end of west wall.

Image 3I-10: Lock 45 lower west gate opening.

Image 3I-11: Lock 45 lower west wall conduit channel.

Image 3I-12: Lock 45 lower west wall conduit on bottom.

Image 3I-13: Lock 45 lower west wall horizontal form line.

Image 3I-14: Lock 45 lower west wall joint.

Image 3I-15: Lock 45 lower west wall scour mark - 15 m from edge.

Image 3I-16: Lock 45 lower west wall slight scour on taper of wall.

Image 3I-17: Lock 45 lower west wall spalling at downstream gate slot.

Image 3I-18: Lock 45 lower west wall transition to bottom.

Image 3J-01: 3.2 m - Bottom of pipe.

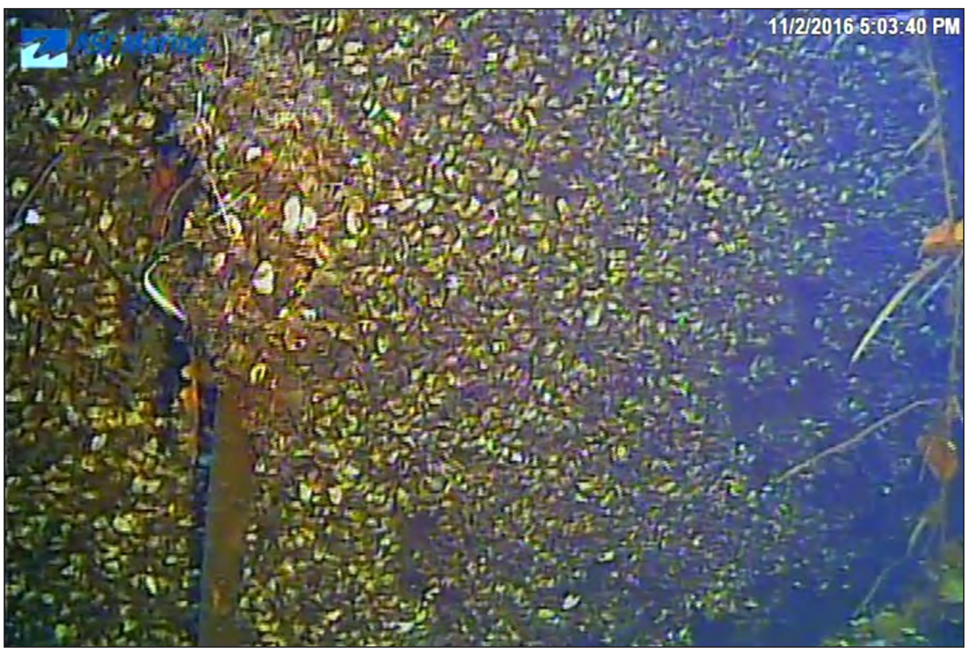

Image 3J-02: 3.2 m - Pipe protruding from wall.

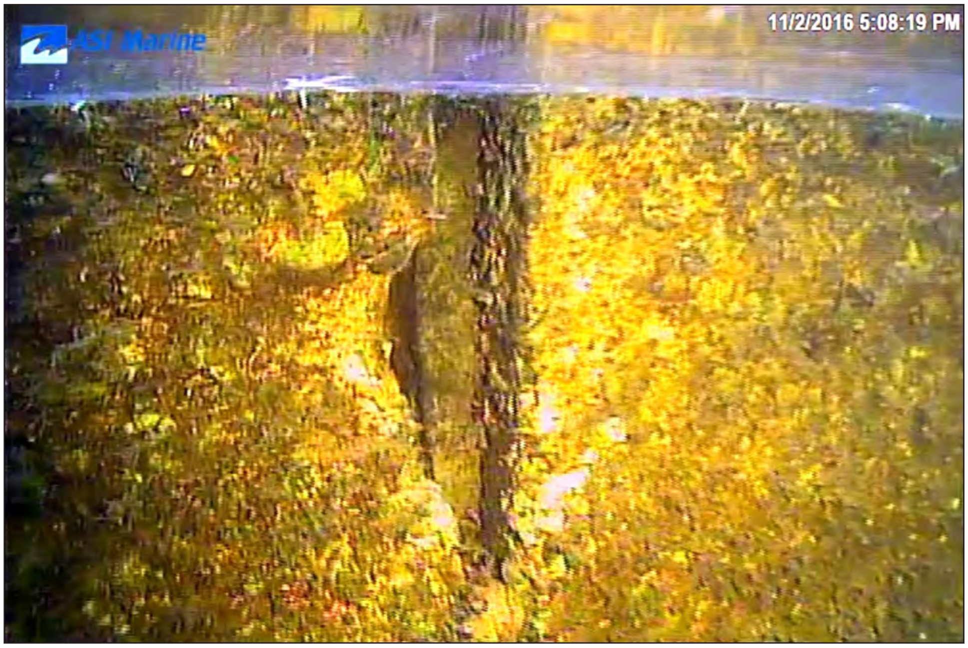

Image 3J-03: 13.95 m - Joint with some separation and spalling.

Image 3J-04: 17.6 m - Protrusion from wall continues to 19.2 m.

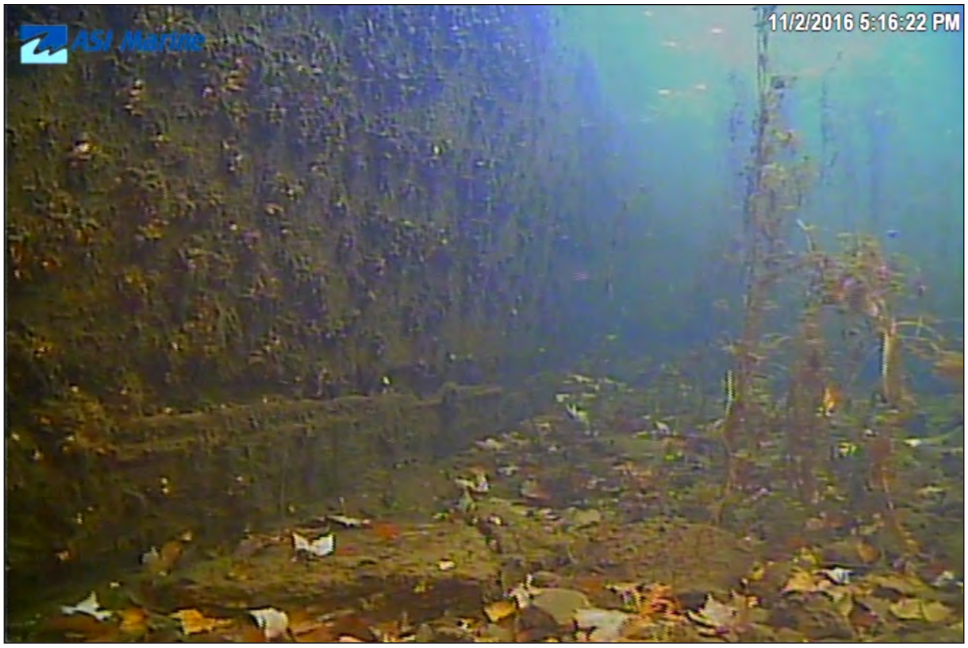

Image 3J-05: 28 m - Wood concrete forms on bottom.

Image 3J-06: 40 m - East side of dock.

Image 3J-07: 43.3 m - West side of dock.

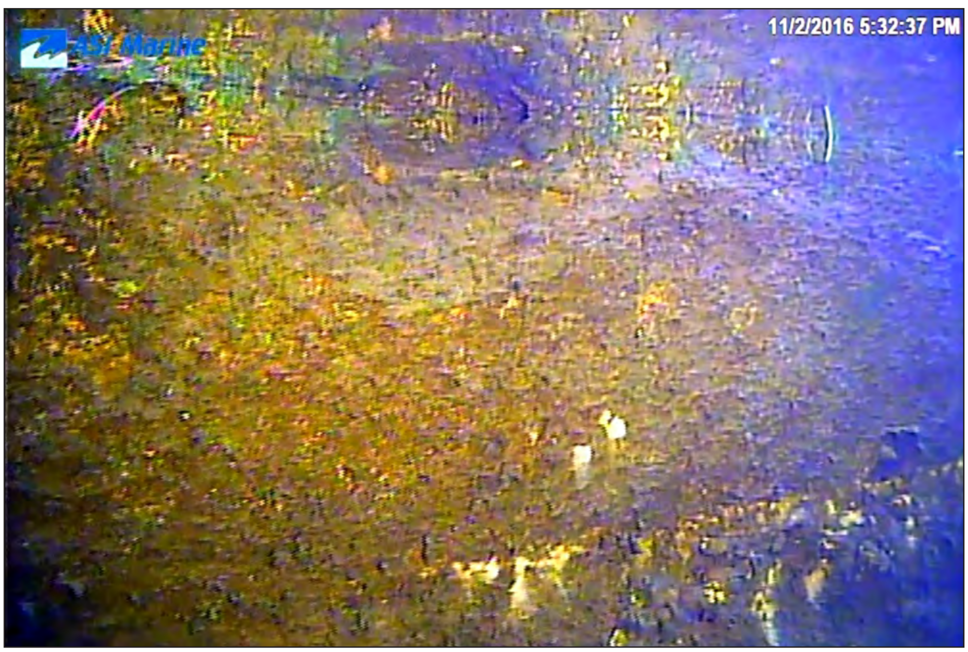

Image 3J-08: 44.4 m - 40 cm wide spall worsening above water surface.

Image 3J-09: 44.4 m - Spalling continues to 44.8 m.

Image 3J-10: 46.2 m - Minor horizontal spalling.

Image 3J-11: 50.1 m - Crack in wall with spalling.

Image 3J-12: 54 m - Horizontal cracking.

Image 3J-13: 57 m - Spalling on either end of open joint.

Image 3J-14: 57.7 m - Joint with spalling and wooden material.

Image 3J-15: 61.9 m - Slight spalling below surface.

Image 3J-16: 65.1 m - Spalling continues to 66.7 m.

Image 3J-17: 67.7 m - Crack with spalling.

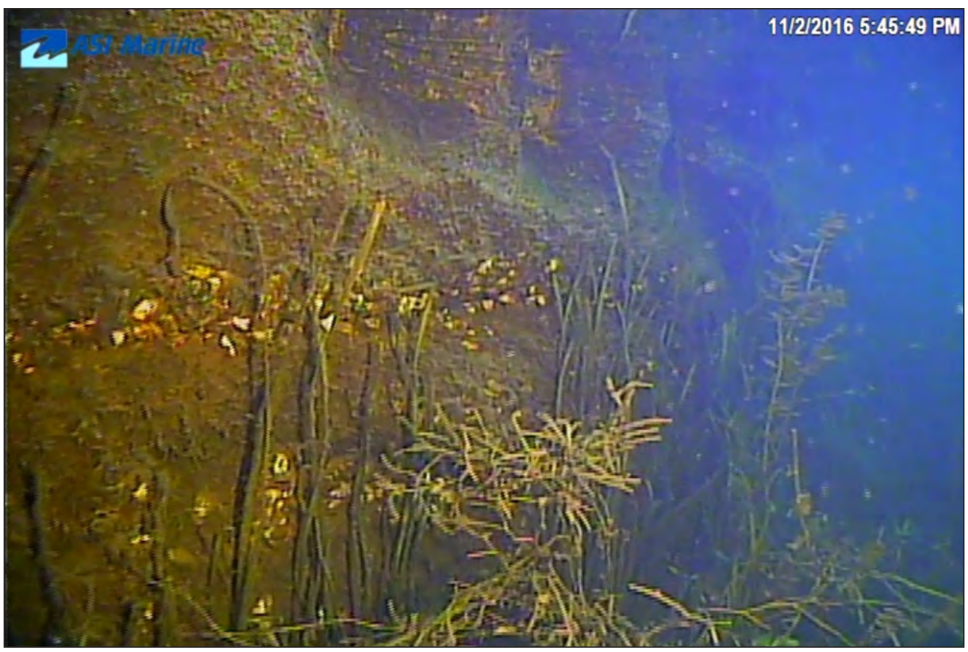

Image 3J-18: 68.6 m - Spalling that continues to 70.5 m.

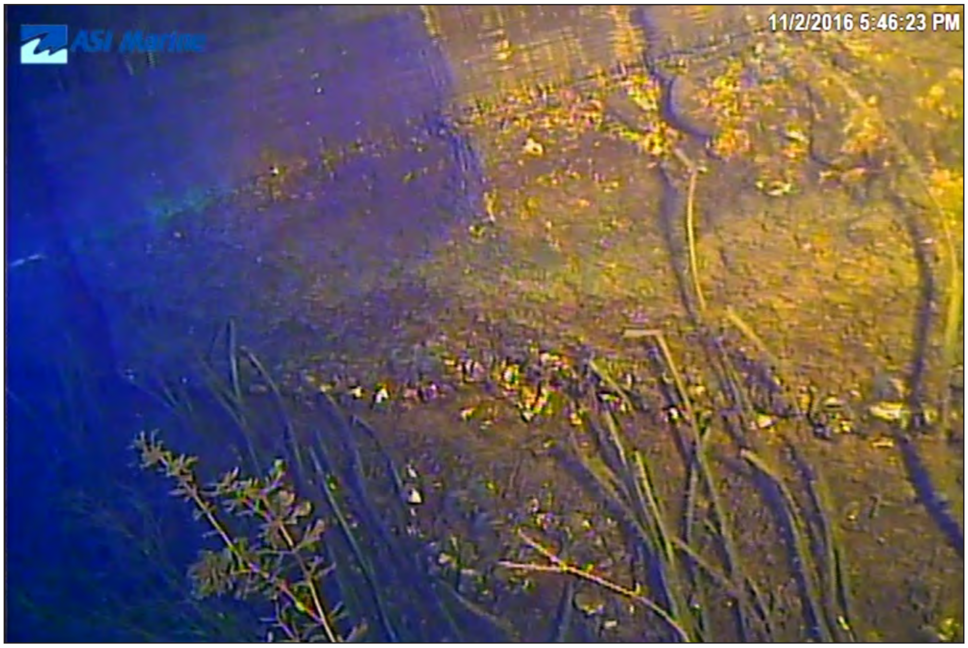

Image 3J-19: 70.5 m - Deep spalling 40 cm.

Image 3J-20: 73 m - Joint with spalling.

Image 3J-21: 79.9 m - Crack centred on spall that runs from 79.2 m to 80.4 m.

Image 3J-22: 79.9 m - Vertical crack ending at horizontal spalling.

Image 3J-23: 88.2 m - Joint with spalling.

Image 3J-24: 88 m - Undercutting near bottom.

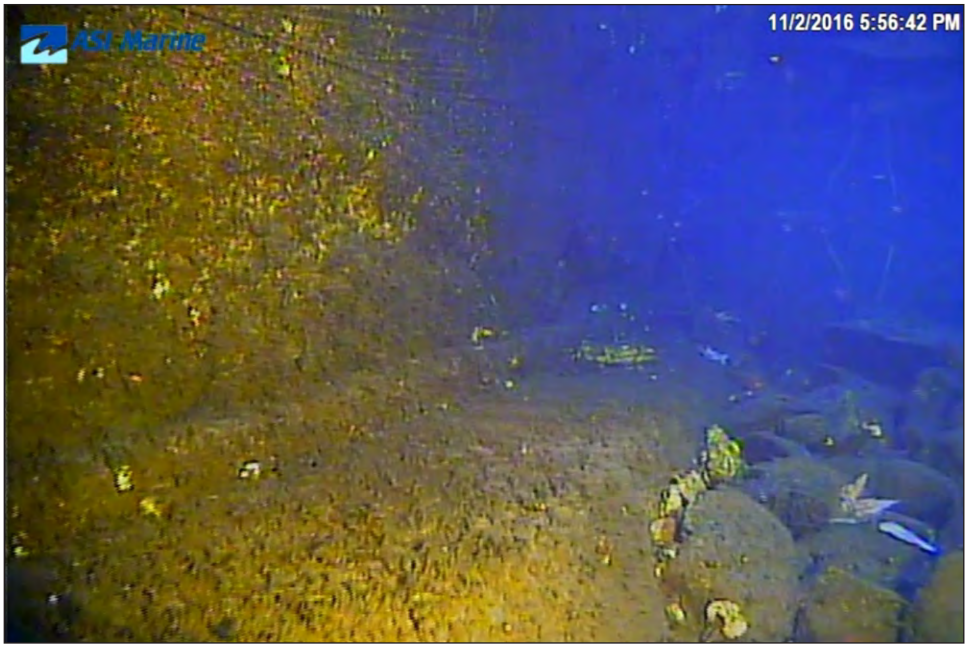

Image 3J-25: 92m - Poured edge near bottom.

Image 3J-26: 96.7m - Crack at bedrock transition with undercutting.

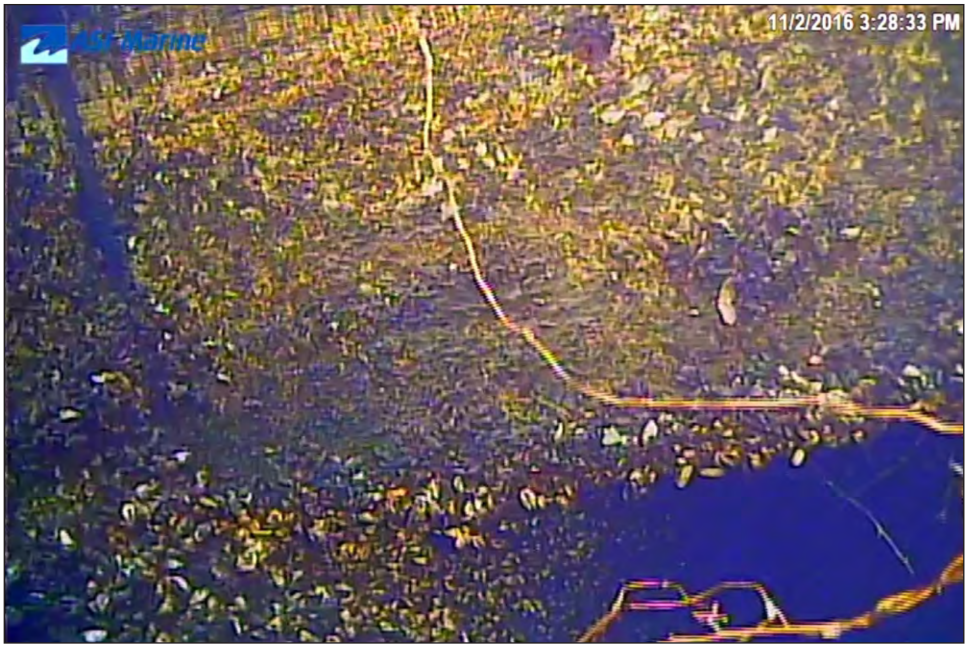

Image 3K-01: 0 m - East side transition to lock.

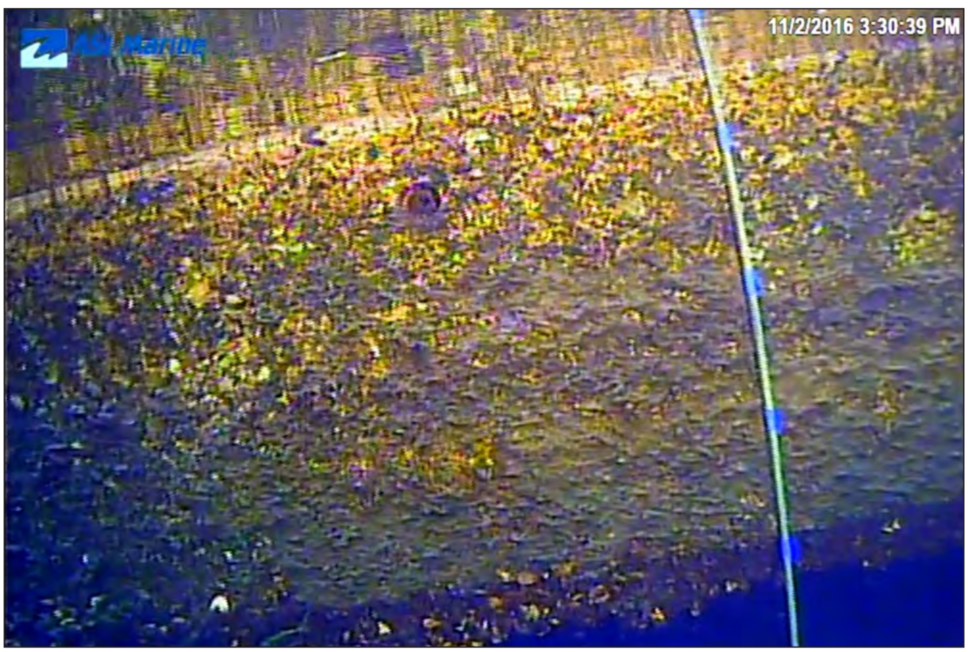

Image 3K-02: 4 m - East side deck depth.

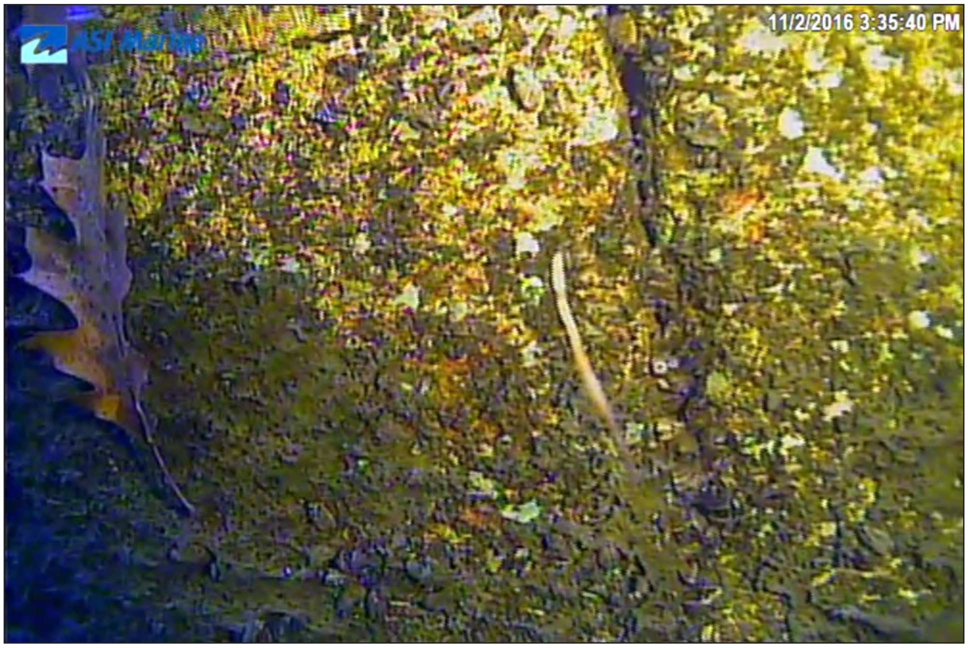

Image 3K-03: 6 m - East side joint.

Image 3K-04: 6 m - East side lower column support.

AECOM	ASI Marine	ASI Project No: RH16-052	Video Images Upper Approach Wall	Appendix Number:
		Project Date: November 2016		3K
		Drawn By: Randy Johnston	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	78 of 91

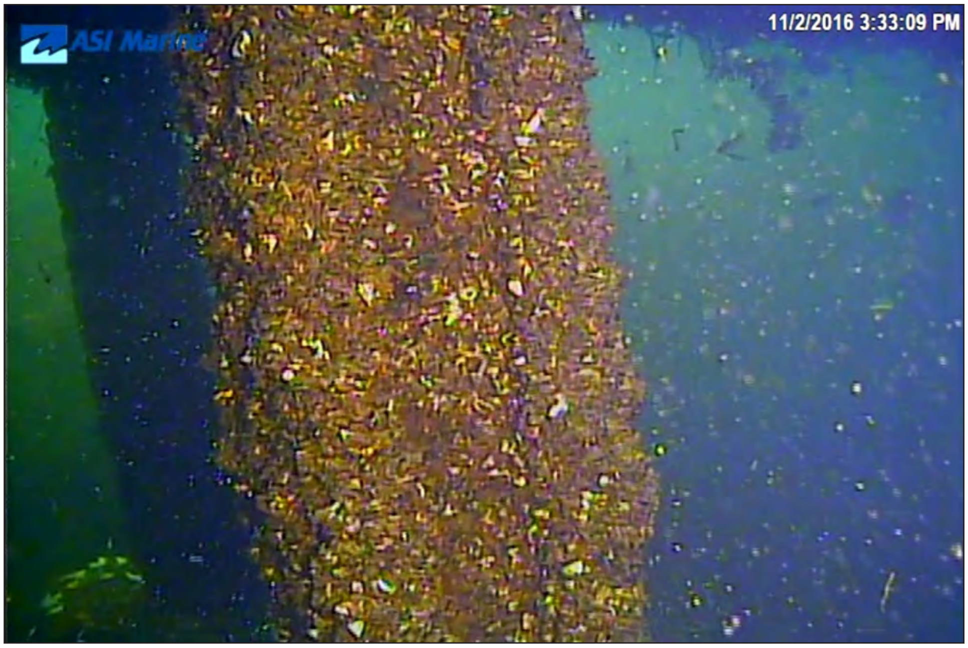

Image 3K-05: 6 m - East side support column.

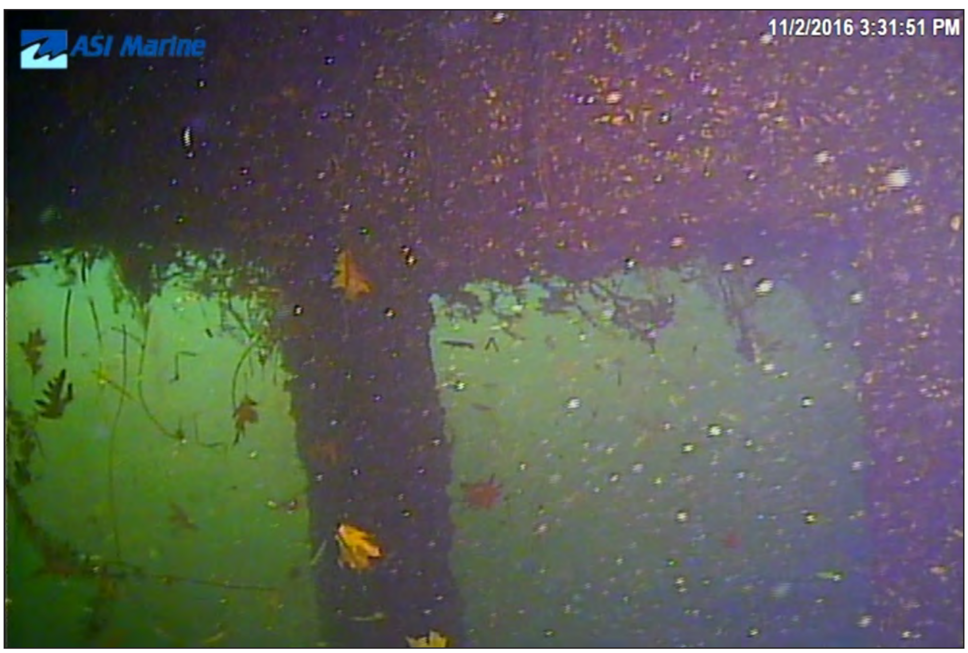

Image 3K-06: 6 m - East side upper column support.

Image 3K-07: 12 m - East side lower column support.

Image 3K-08: 12 m - East side upper column support.

Image 3K-09: 18 m - West side joint.

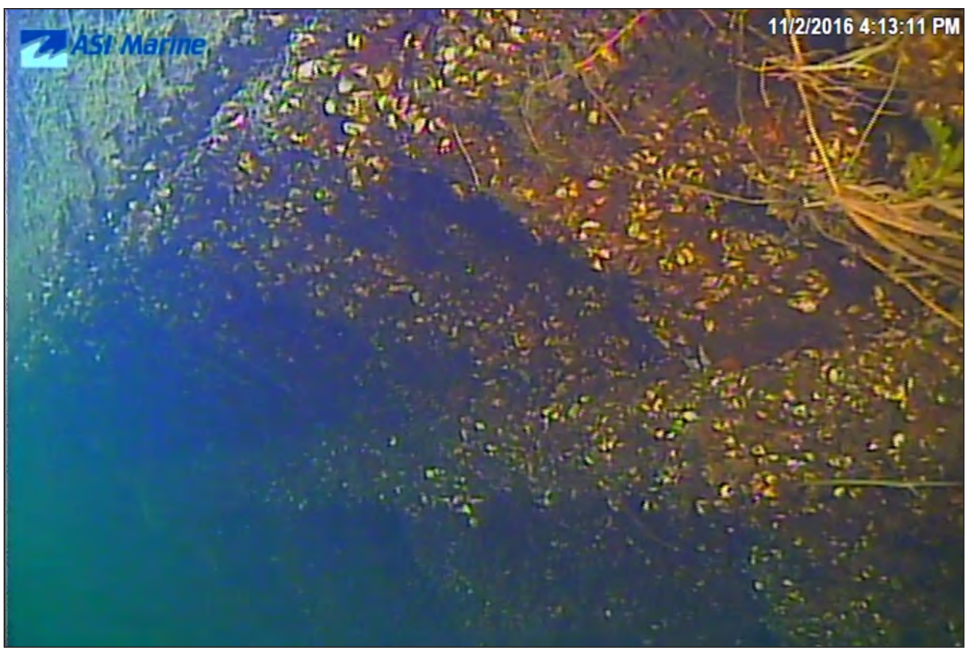

Image 3K-10: 18 m - West side upper cribbing.

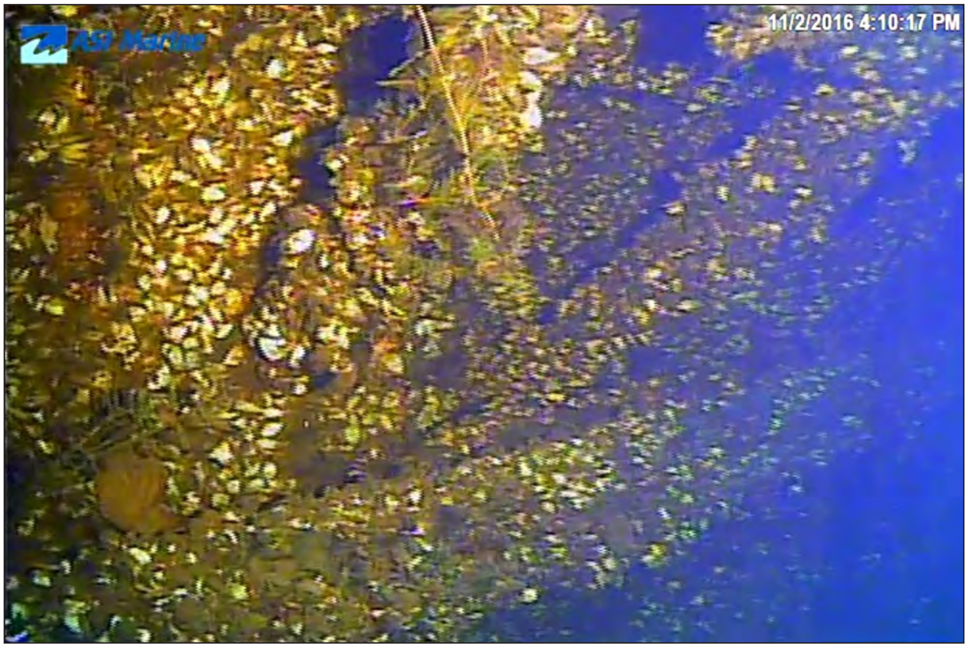

Image 3K-11: 19 m - West side crib structure.

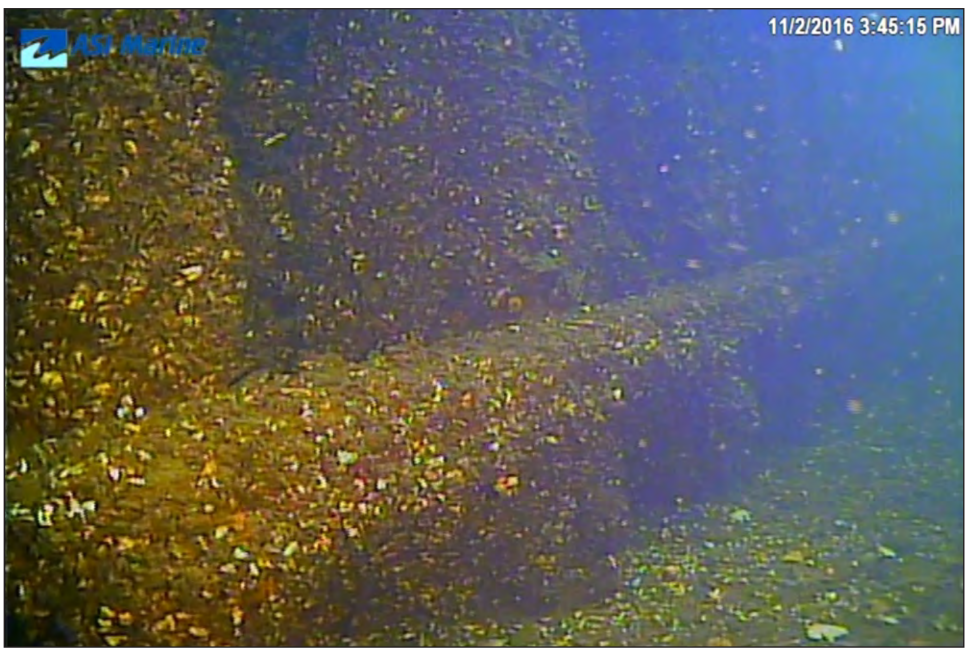

Image 3K-12: 20 m - East side lower crib section.

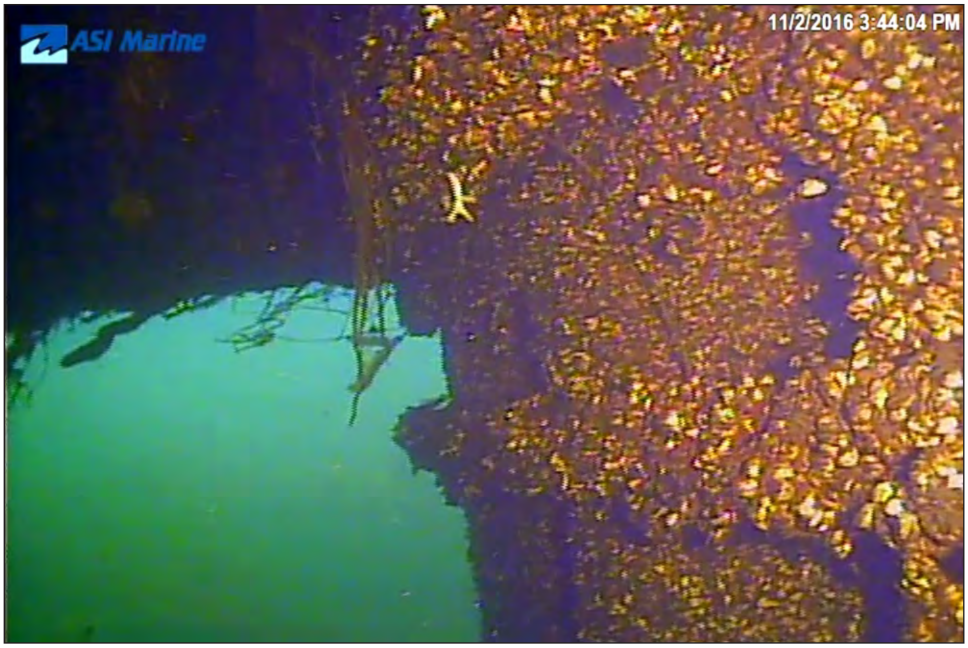

Image 3K-13: 20 m - East side upper crib section.

Image 3K-14: 29 m - East side upper crib transition to concrete slab.

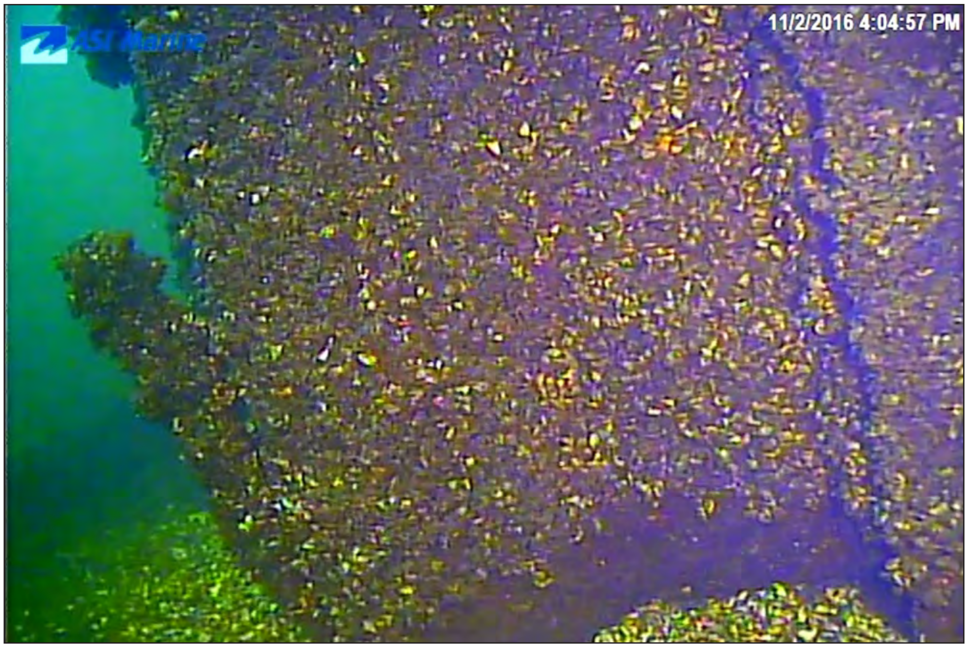

Image 3K-15: 30 m - Northwest corner bottom.

Image 3L-01: Lower approach east wall deck to structure.

Image 3L-02: Lower approach east wall downstream of bend.

Image 3L-03: Lower approach east wall formed base on taper of west side.

Image 3L-04: Lower approach east wall horizontal form line upstream of bend.

Image 3L-05: Lower approach east wall lower structure.

Image 3L-06: Lower approach east wall spall mark beside joint.

Image 3L-07: Lower approach south wall end cap transition.

Image 3L-08: Lower approach south wall lower end.

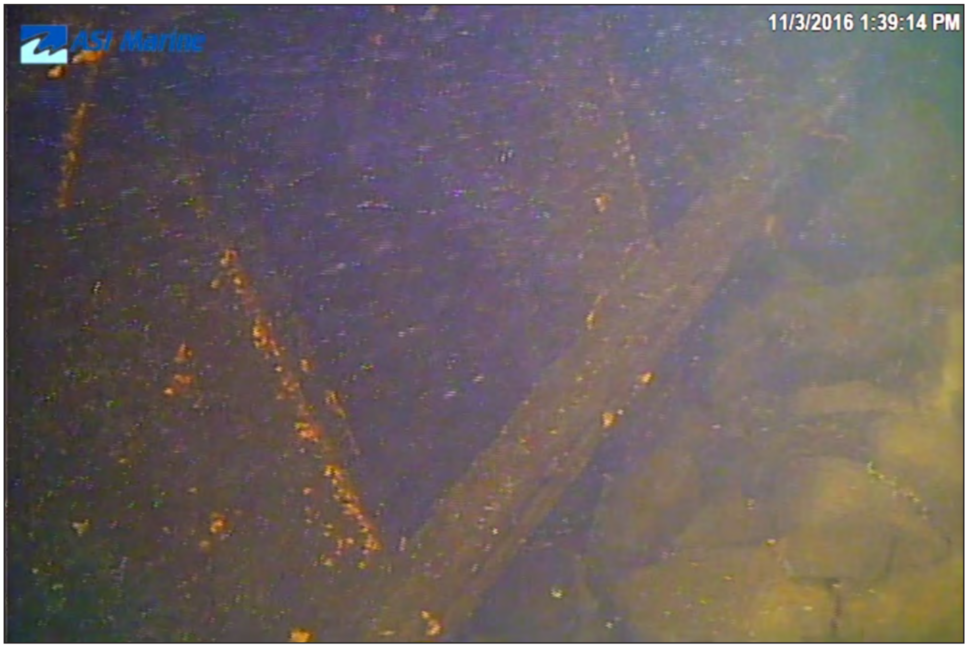

Image 3L-09: Lower approach west side wall south end lower structure.

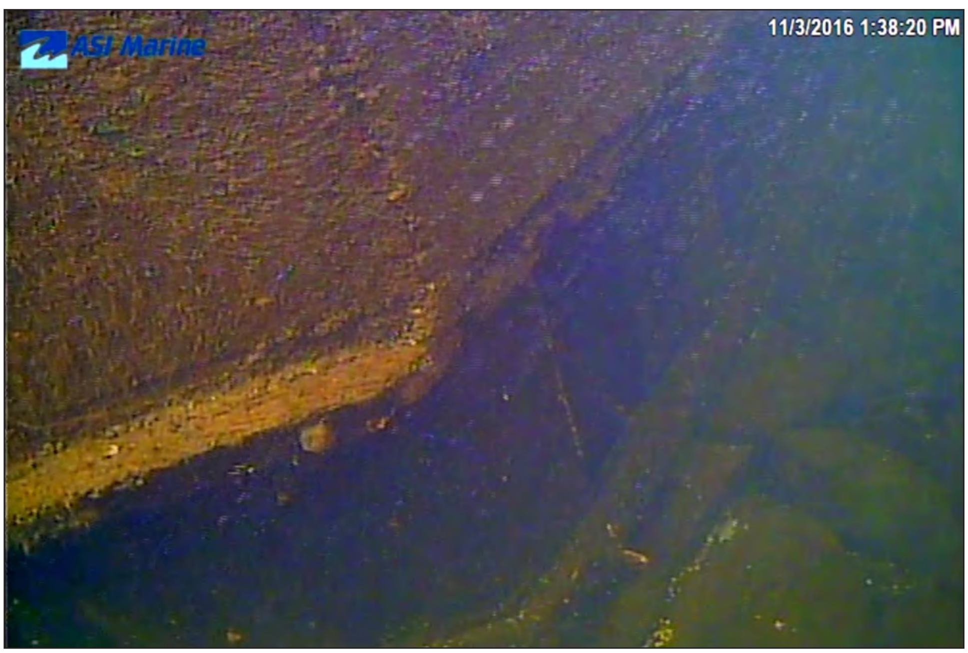

Image 3L-10: Lower approach west side wall south end.

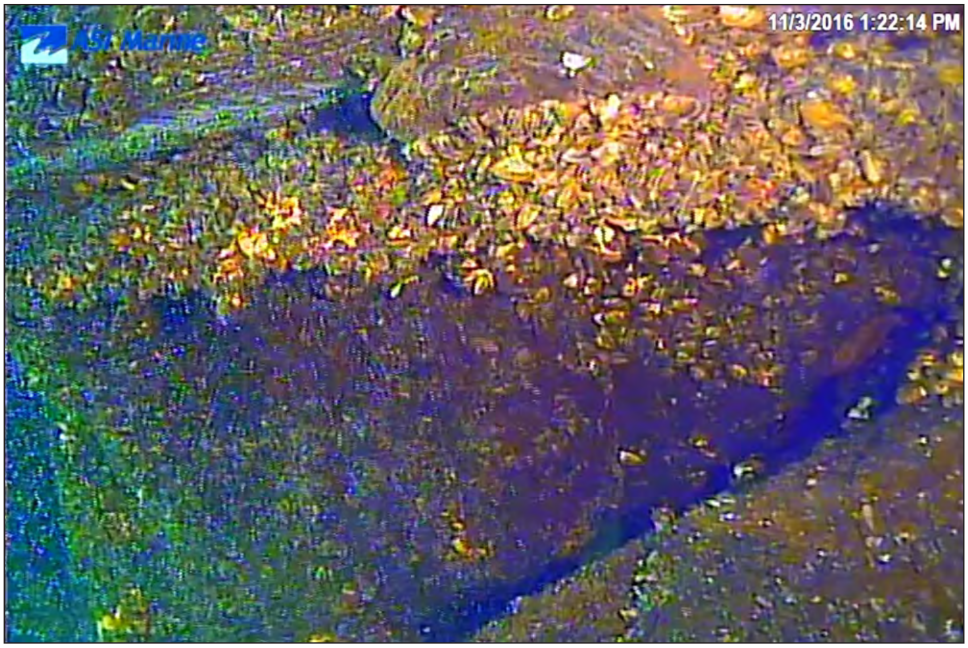

Image 3L-11: Lower approach west side wall undercut downstream of Pier 1.

Image 3L-12: Lower approach west side wall undercut downstream of Pier 1.

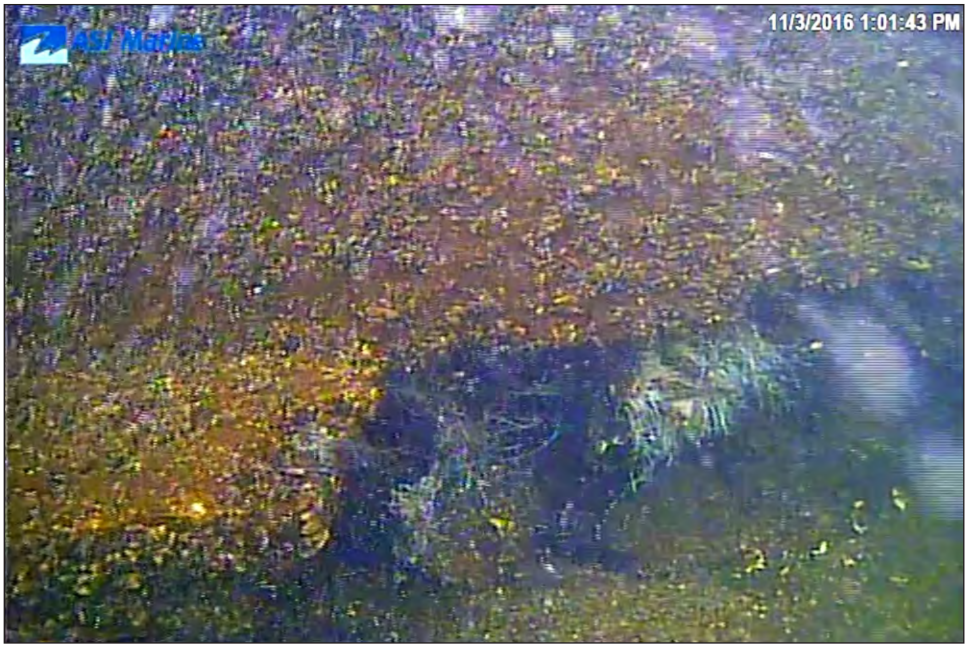

Image 3L-13: Lower approach wall undercutting of concrete on bottom on west side downstream of Pier 1.

Appendix 4:

Cross-Sectional Profiles

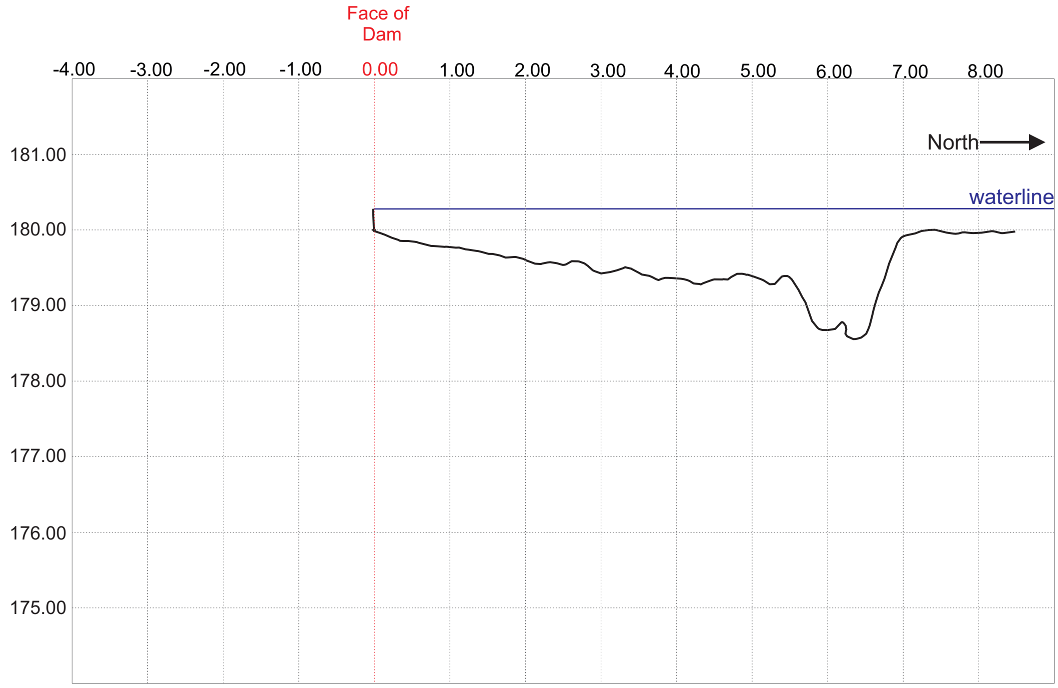

Image 4A-01: Profile 1 at 0 m

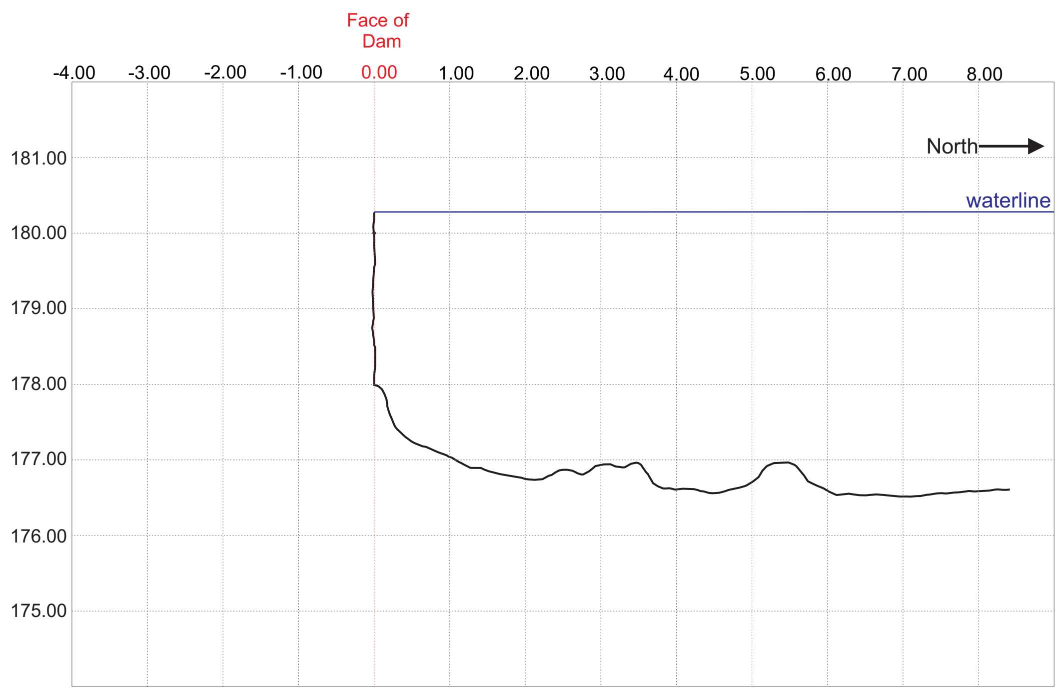

Image A4-02: Profile 2 at 2.5 m

NOTES:
1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
2. ELEVATIONS ARE EXPRESSED IN METRES AND REFERENCED TO THE NORTH AMERICAN DATUM OF 1983.
3. HORIZONTAL DISTANCES ARE EXPRESSED IN METRES.
4. ZERO POSITION ON DAM FACE AT UTM83 POSITION: NORTH: 4961919.470, EAST: 601043.970
5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

2 1 0 2

SCALE: 10 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam E

Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock

Appendix Number:

4A

1 of 20

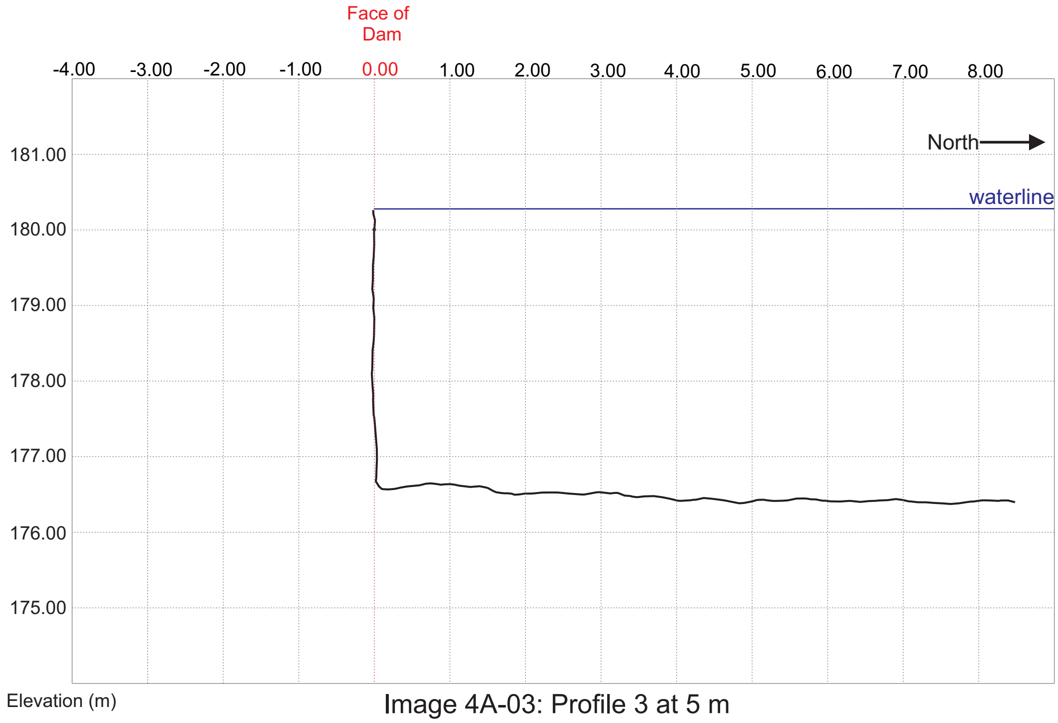

Image 4A-03: Profile 3 at 5 m

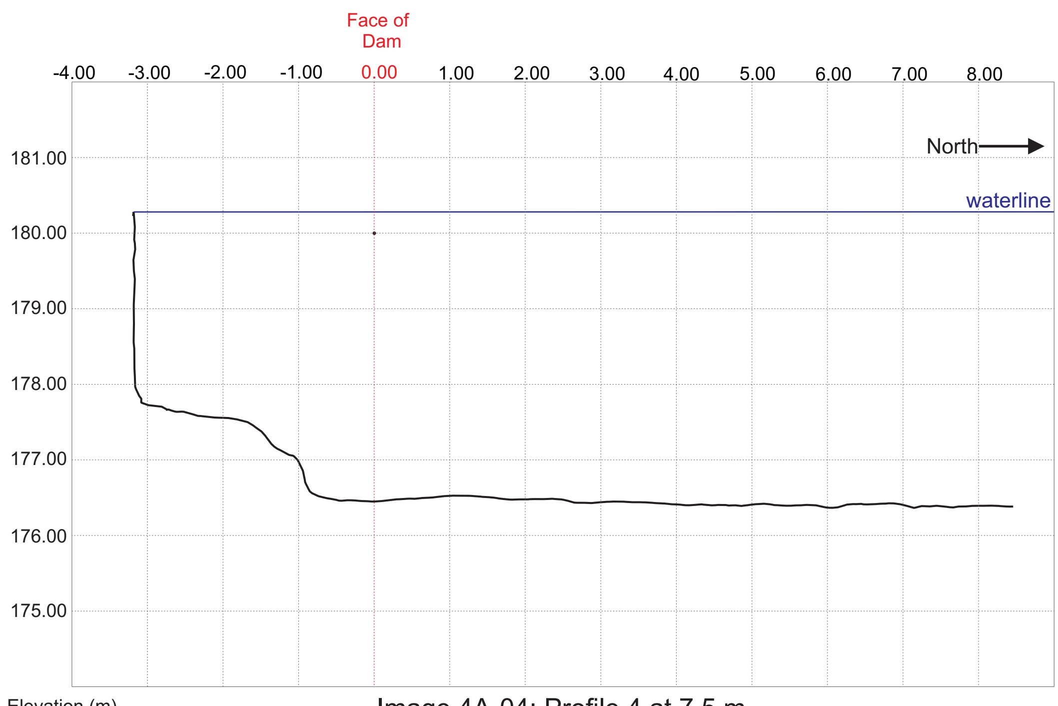

Image 4A-04: Profile 4 at 7.5 m

NOTES:
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2 1 0 2

SCALE: 10 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam E

Appendix Number: 4A

2 of 20

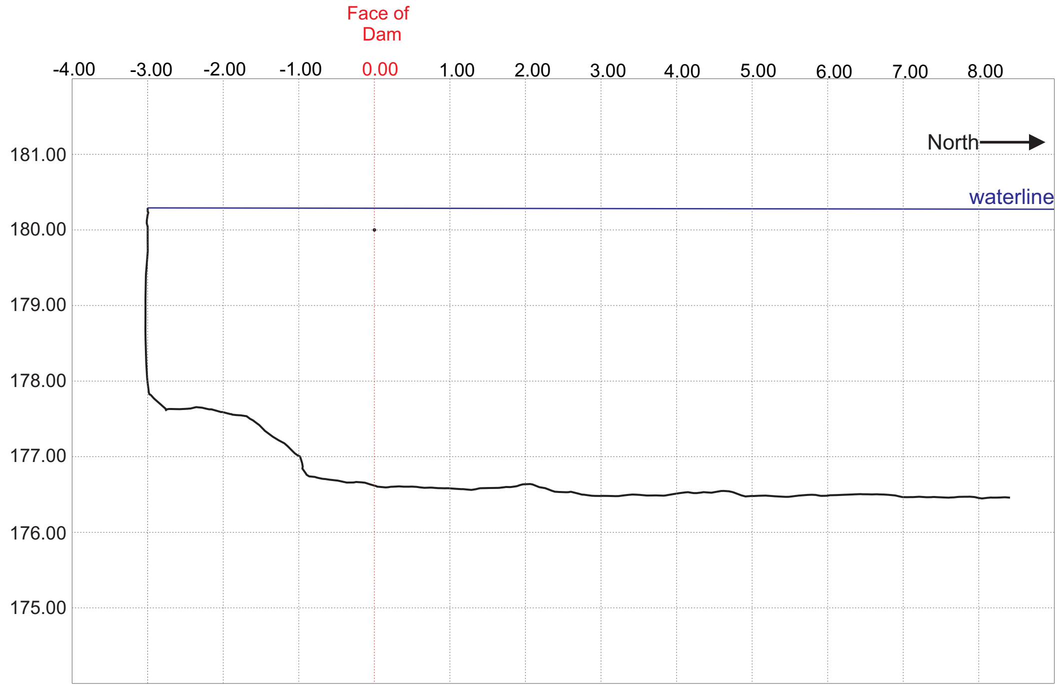

Image 4A-05: Profile 5 at 10 m

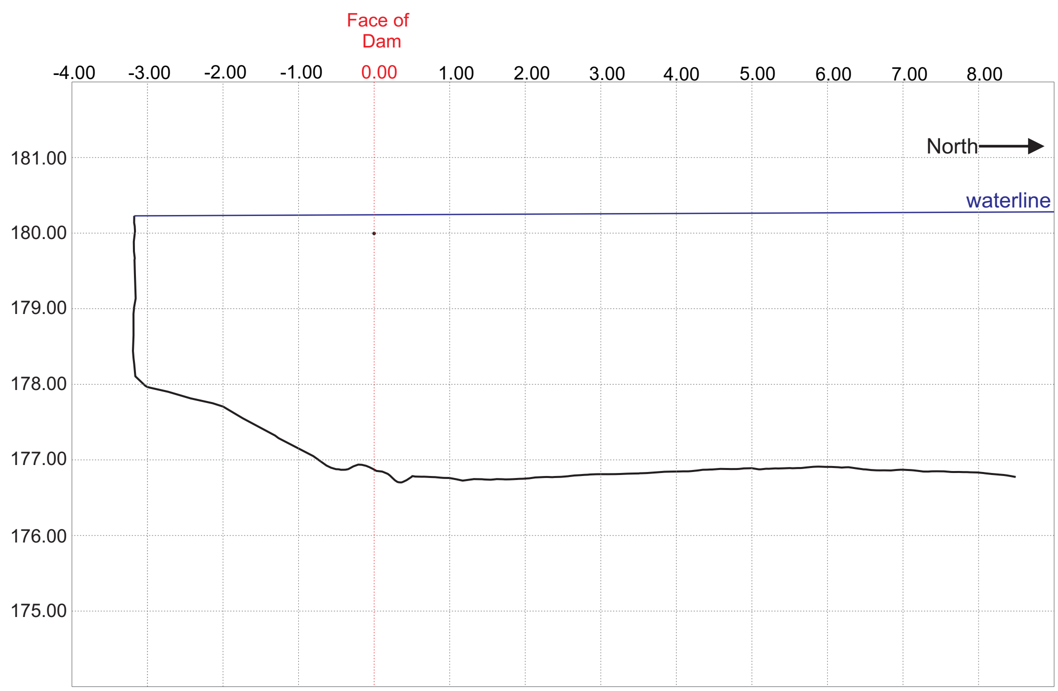

Image 4A-06: Profile 6 at 12.5 m

NOTES:
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2 1 0 2

SCALE: 10 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052	**Cross-Sectional Profiles Dam E**	Appendix Number:
		Project Date: November 2016		4A
		Drawn By: Robin Houlik		3 of 20

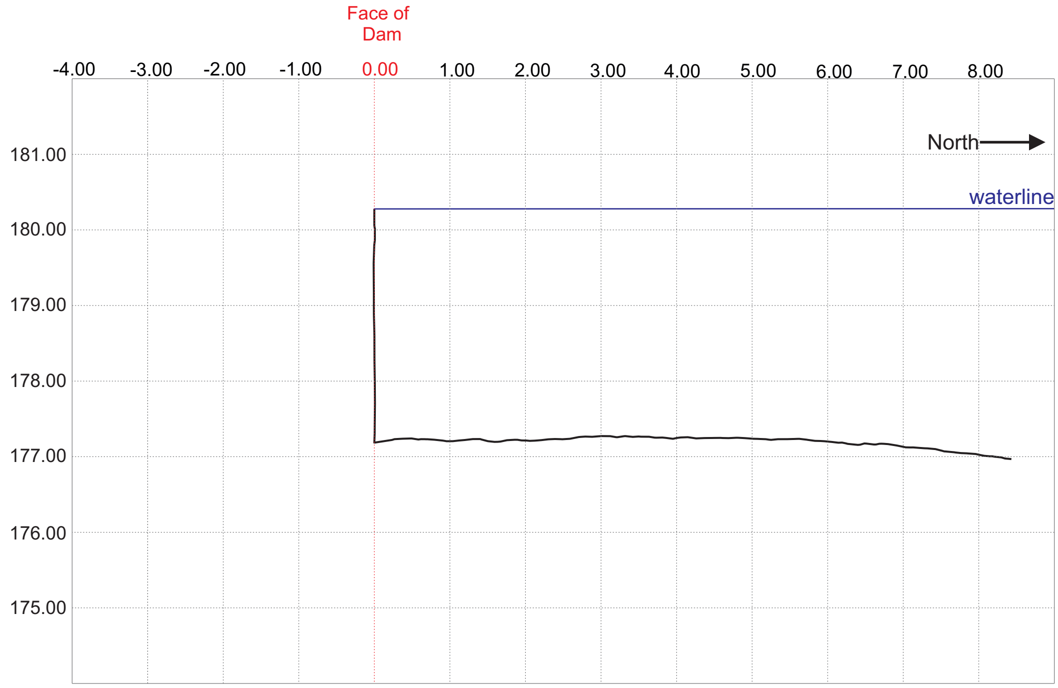

Image 4A-07: Profile 7 at 15 m

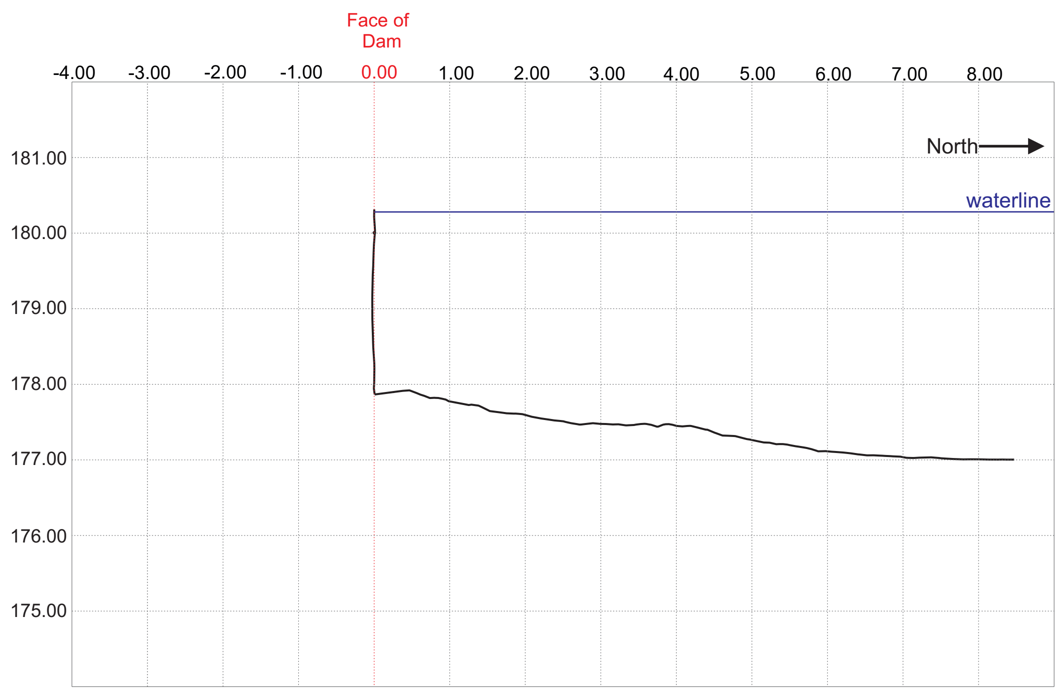

Image 4A-08: Profile 8 at 17.5 m

NOTES:
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2 1 0 2

SCALE: 10 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052	Cross-Sectional Profiles Dam E	Appendix Number:
		Project Date: November 2016		4A
		Drawn By: Robin Houlik		4 of 20

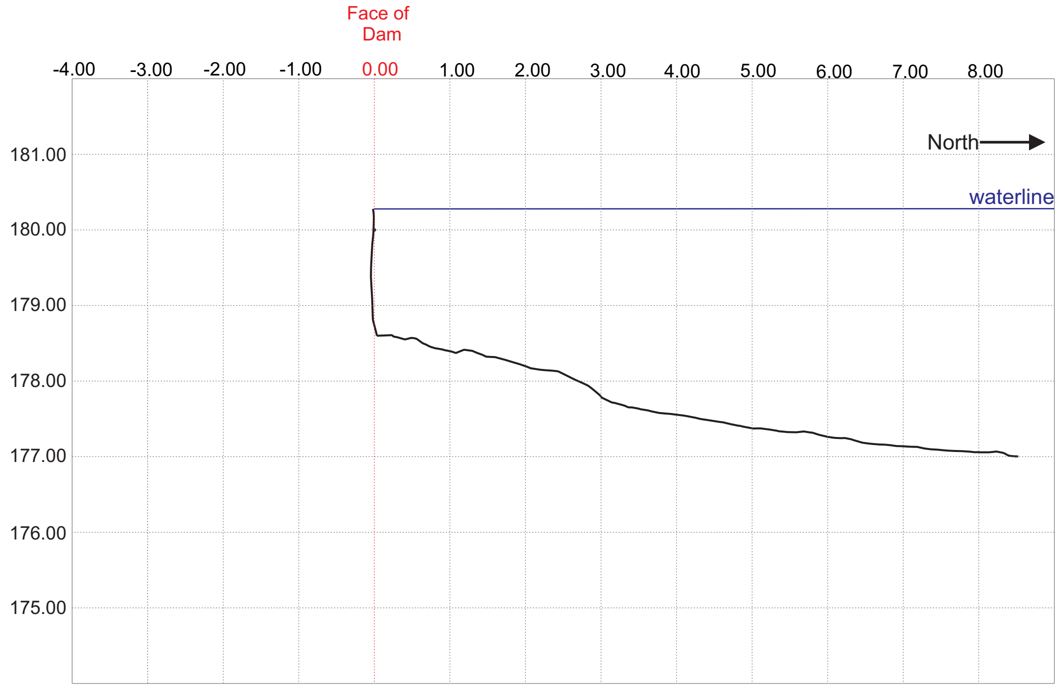

Image 4A-09: Profile 9 at 20 m

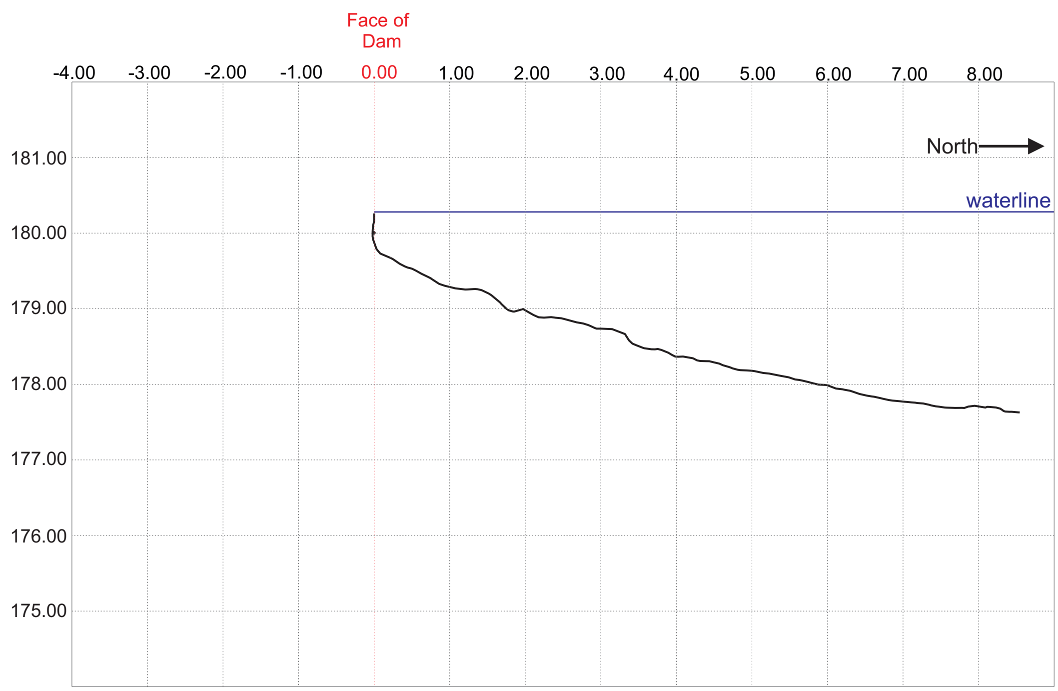

Image 4A-10: Profile 10 at 22.5 m

NOTES:
1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
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5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

2 1 0 2

SCALE: 10 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052 Project Date: November 2016 Drawn By: Robin Houlik	**Cross-Sectional Profiles Dam E**	Appendix Number: 4A 5 of 20

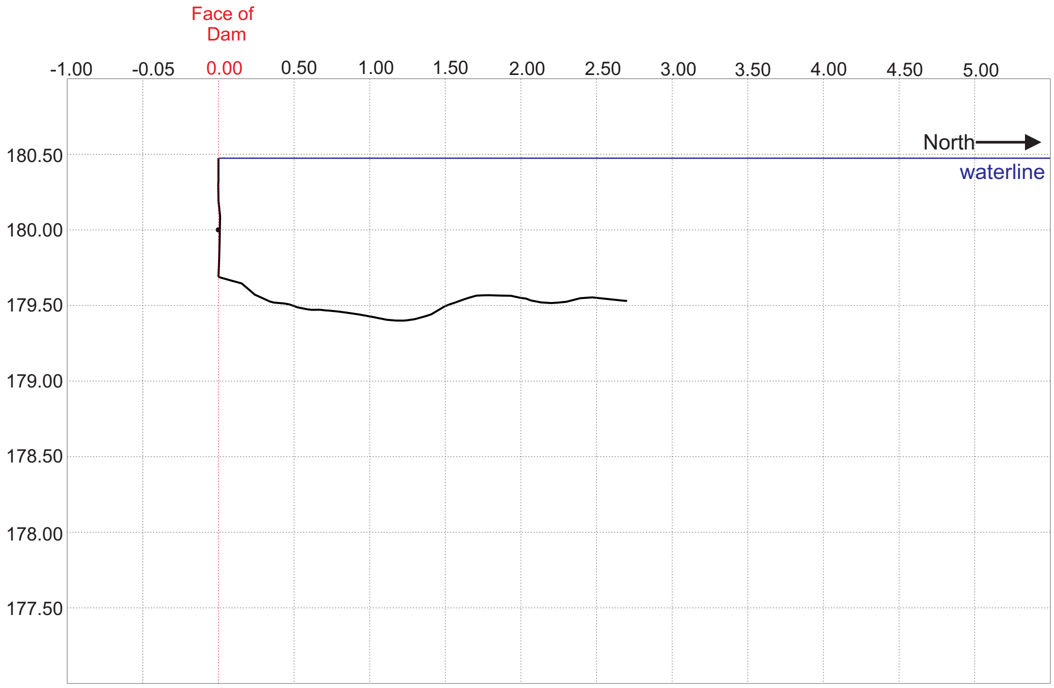

Image 4B-01: Profile 1 at 0 m

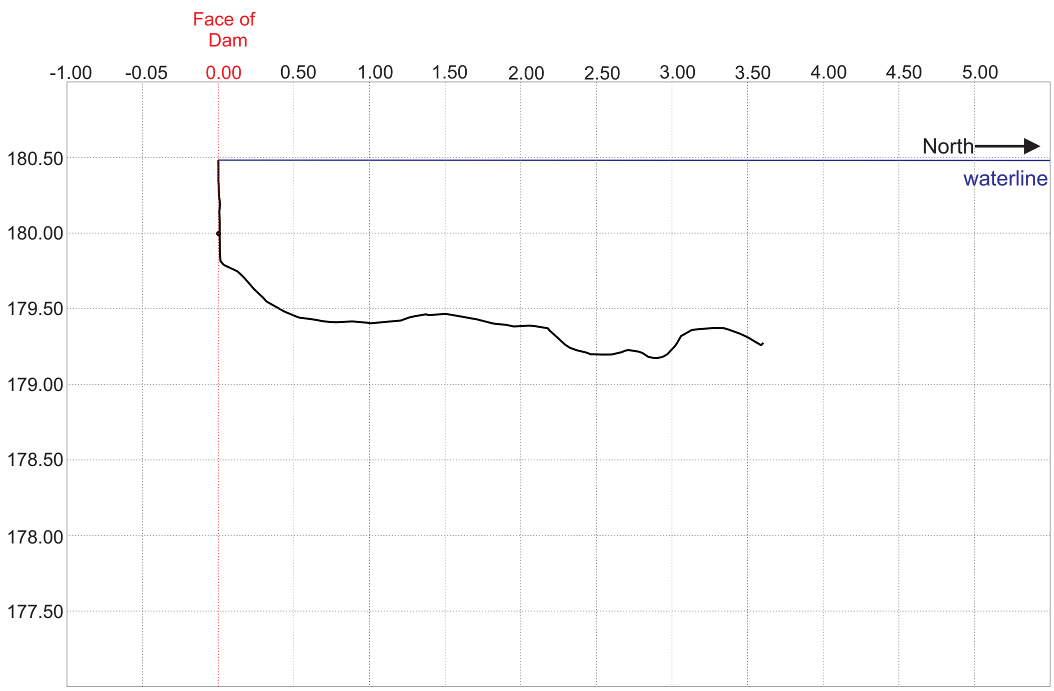

Image 4B-02: Profile 2 at 5 m

NOTES:
1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
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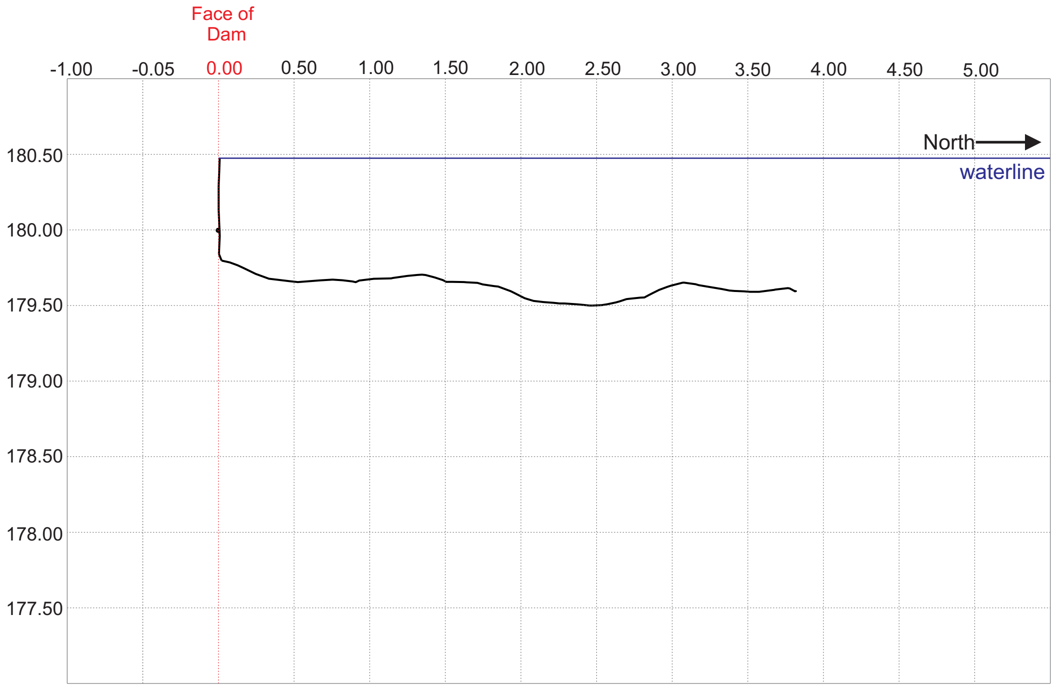
3. HORIZONTAL DISTANCES ARE EXPRESSED IN METRES.
4. ZERO POSITION ON DAM FACE AT UTM83 POSITION: NORTH: 4961878.980, EAST: 600497.660
5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

1 0 1

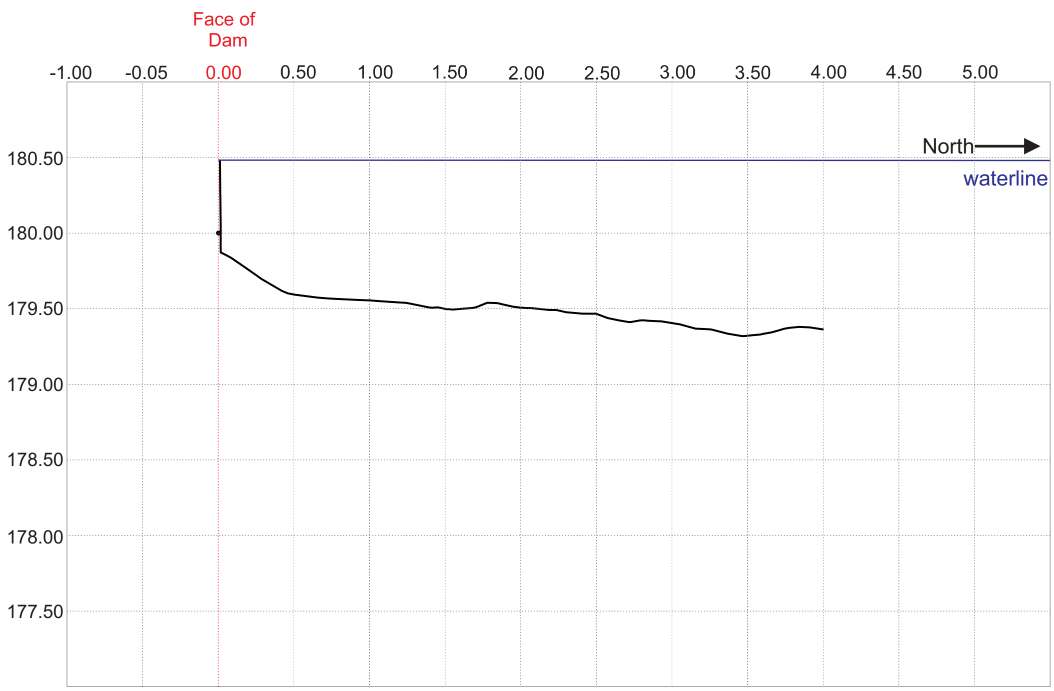
SCALE: 20 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052	Cross-Sectional Profiles Dam G	Appendix Number:
		Project Date: November 2016		4B
		Drawn By: Robin Houlik	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	6 of 20



Elevation (m)

Image 4B-03: Profile 3 at 10 m



Elevation (m)

Image 4B-04: Profile 4 at 15 m

NOTES:
1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
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1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam G

Appendix Number:

4B

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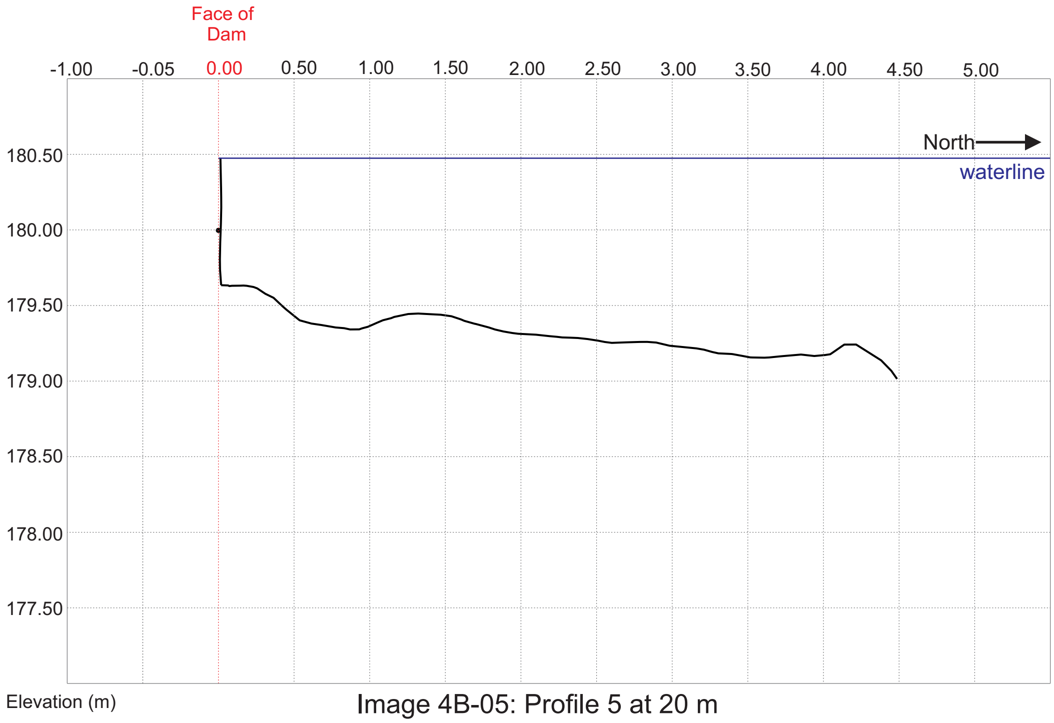

Image 4B-05: Profile 5 at 20 m

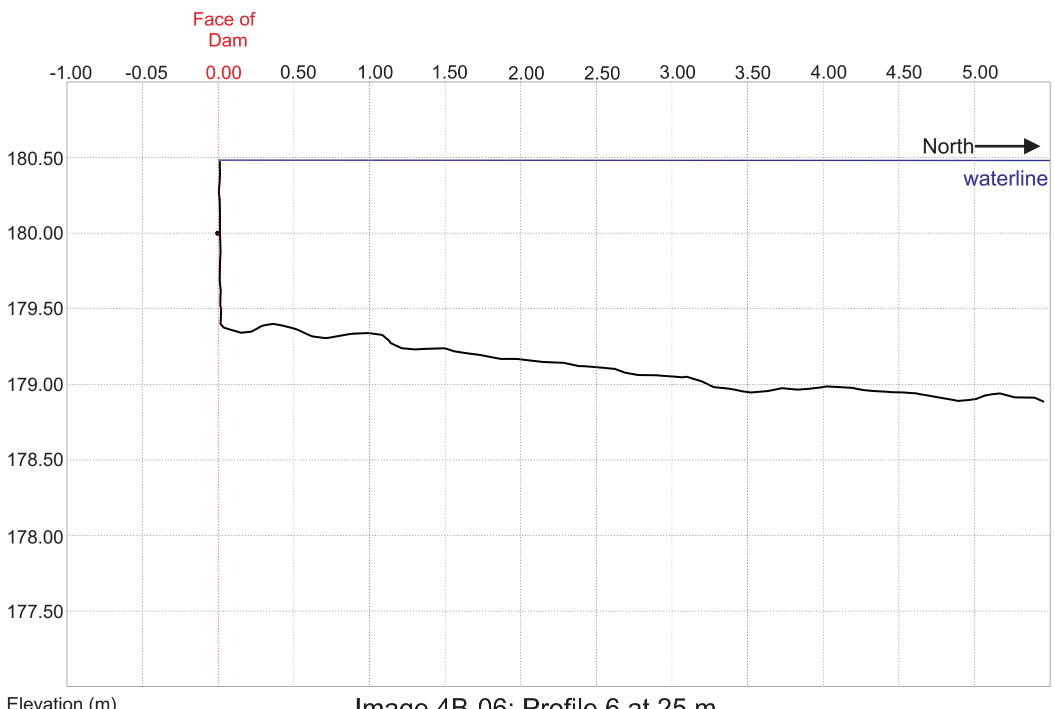

Image 4B-06: Profile 6 at 25 m

NOTES:
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5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam G

Appendix Number: 4B

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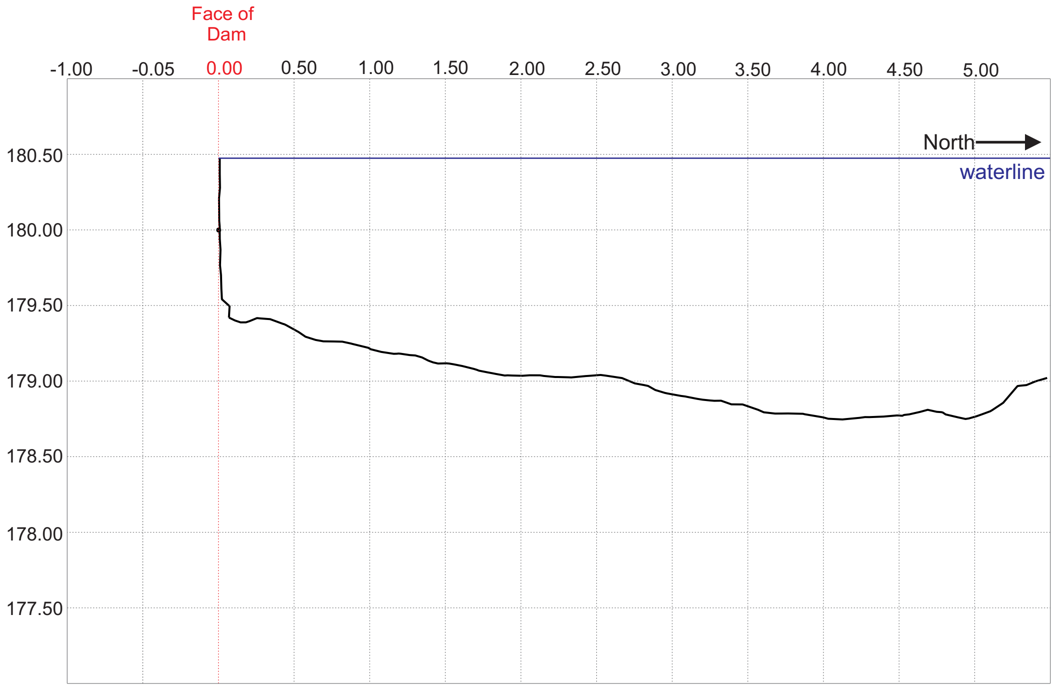

Image 4B-07: Profile 7 at 30 m

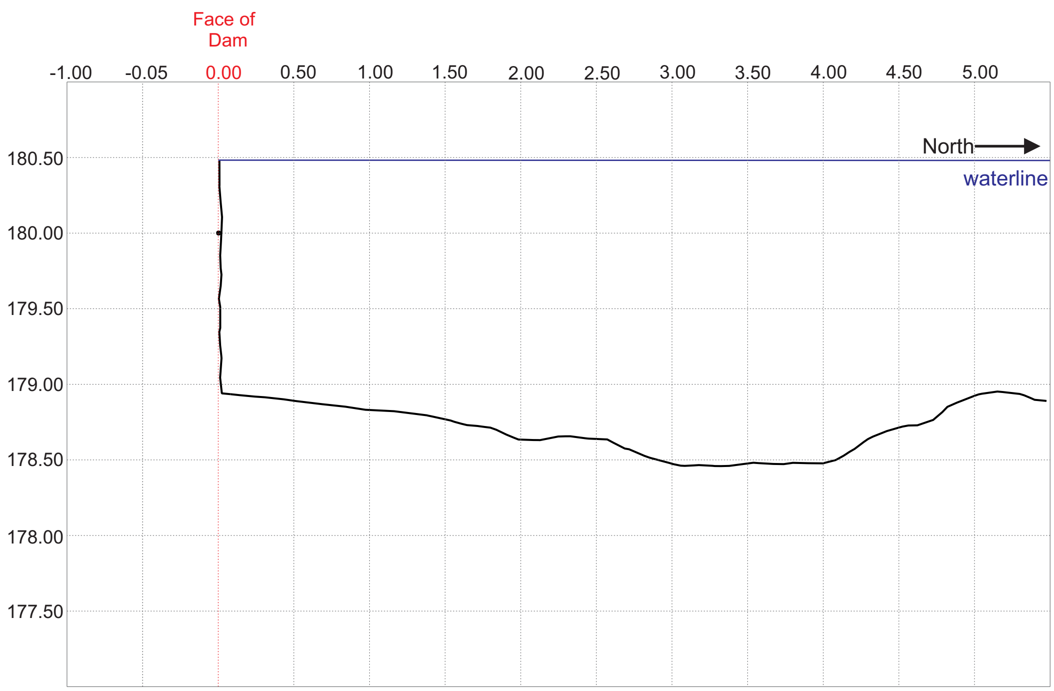

Image 4B-08: Profile 8 at 35 m

NOTES:
1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
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5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam G

Appendix Number:

4B

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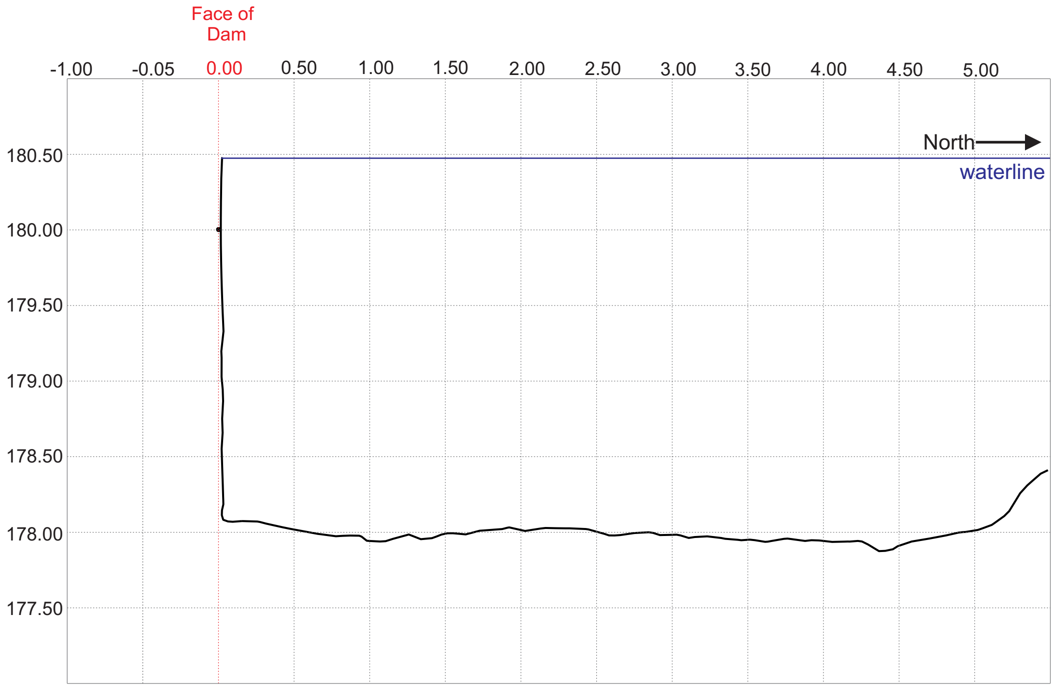


Image 4B-09: Profile 9 at 40 m

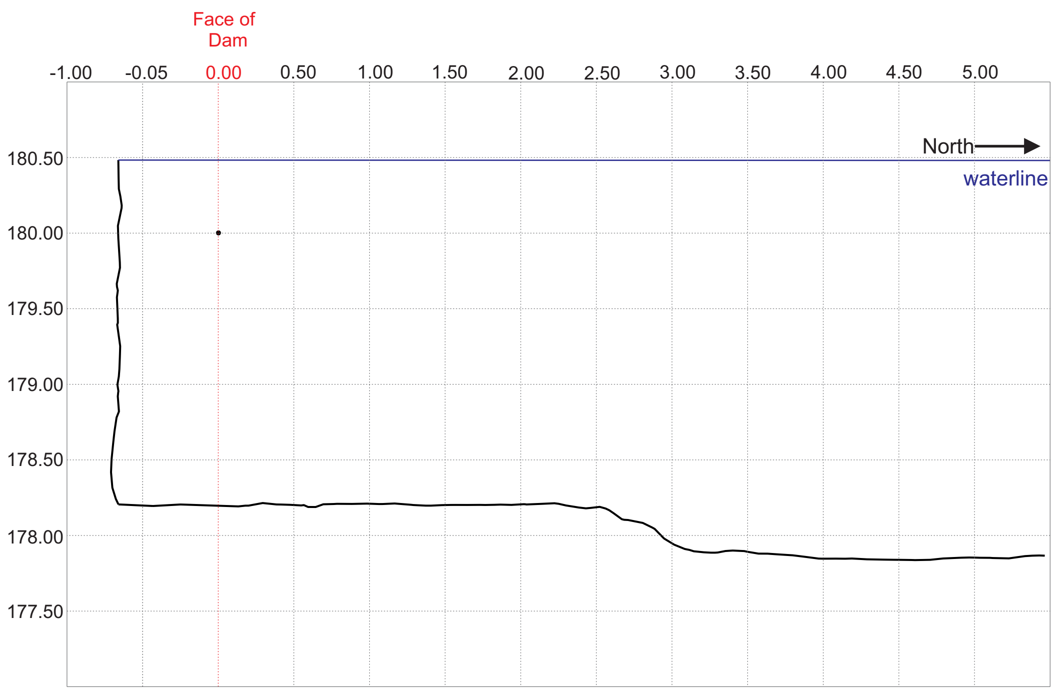
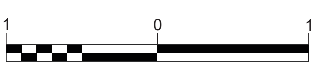


Image 4B-10: Profile 10 at 45 m



SCALE: 20 CM = 1 METRE

NOTES:
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AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam G

Appendix Number:

4B

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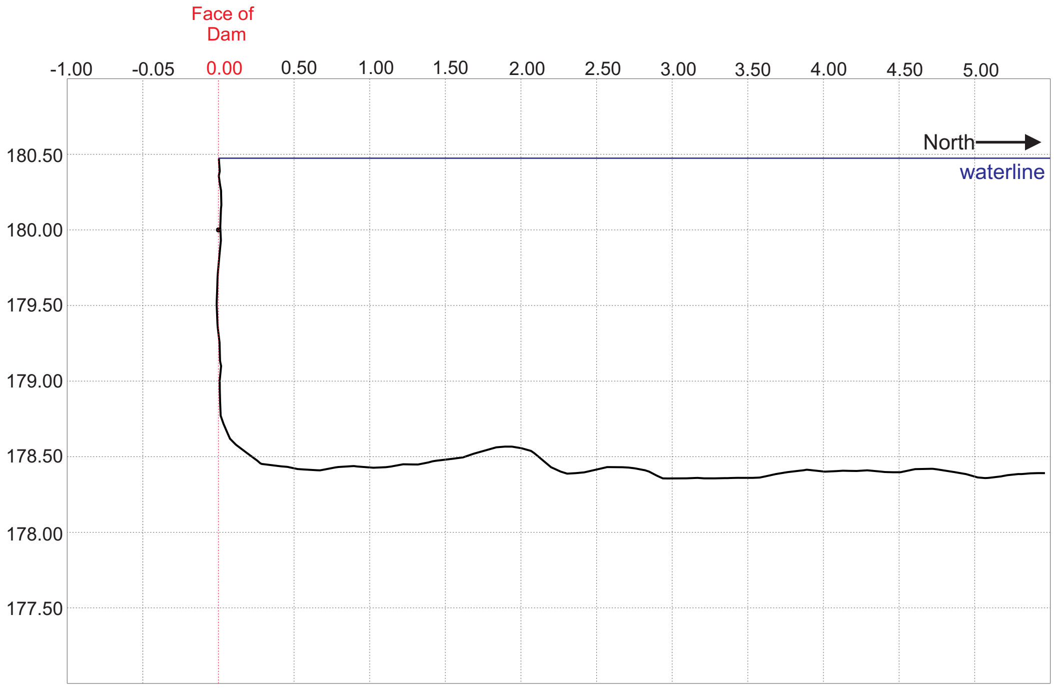

Image 4B-11: Profile 11 at 50 m

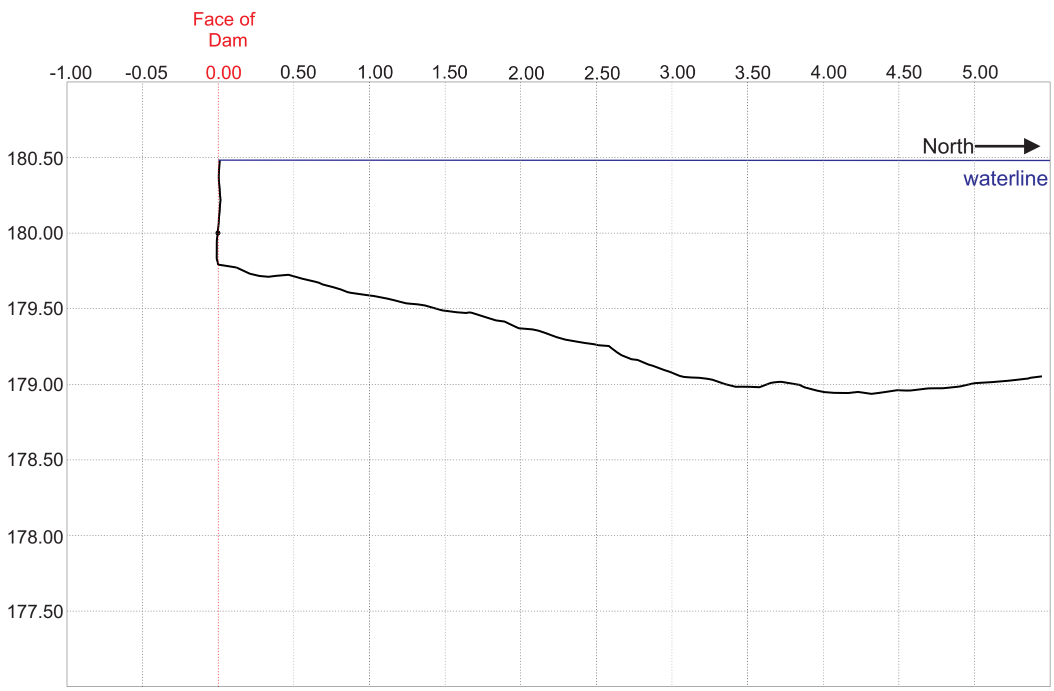

Image 4B-12: Profile 12 at 55 m

NOTES:
1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
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1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Dam G

Appendix Number:

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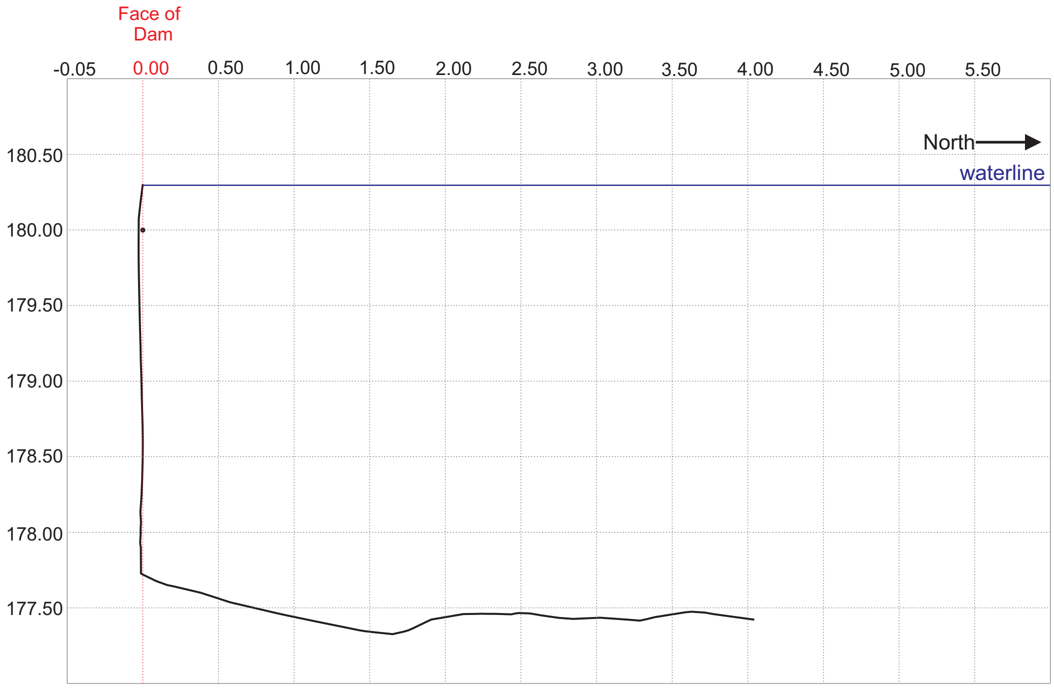

Image 4C-01: Profile 1 at 0 m

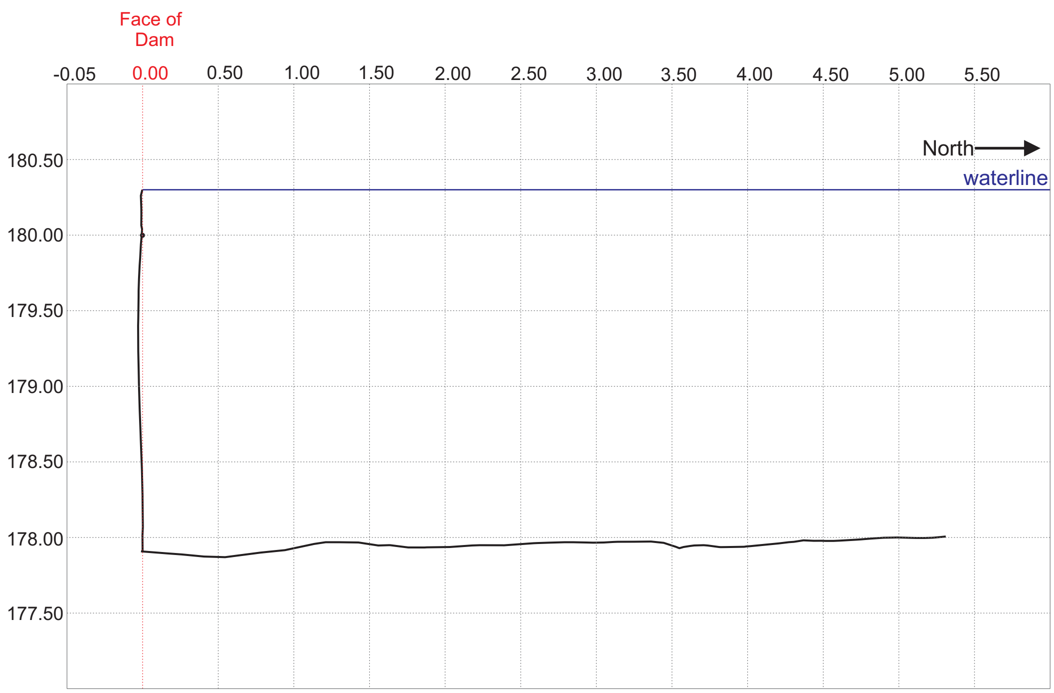

Image 4C-02: Profile 2 at 5 m

NOTES:
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3. HORIZONTAL DISTANCES ARE EXPRESSED IN METRES.
4. ZERO POSITION ON DAM FACE AT UTM83 POSITION: NORTH: 4962005.527, EAST: 601181.727
5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

1 0 1

SCALE: 20 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052 Project Date: November 2016 Drawn By: Robin Houlik	**Cross-Sectional Profiles Lock 45 North Wall** **Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock**	Appendix Number: 4C 12 of 20

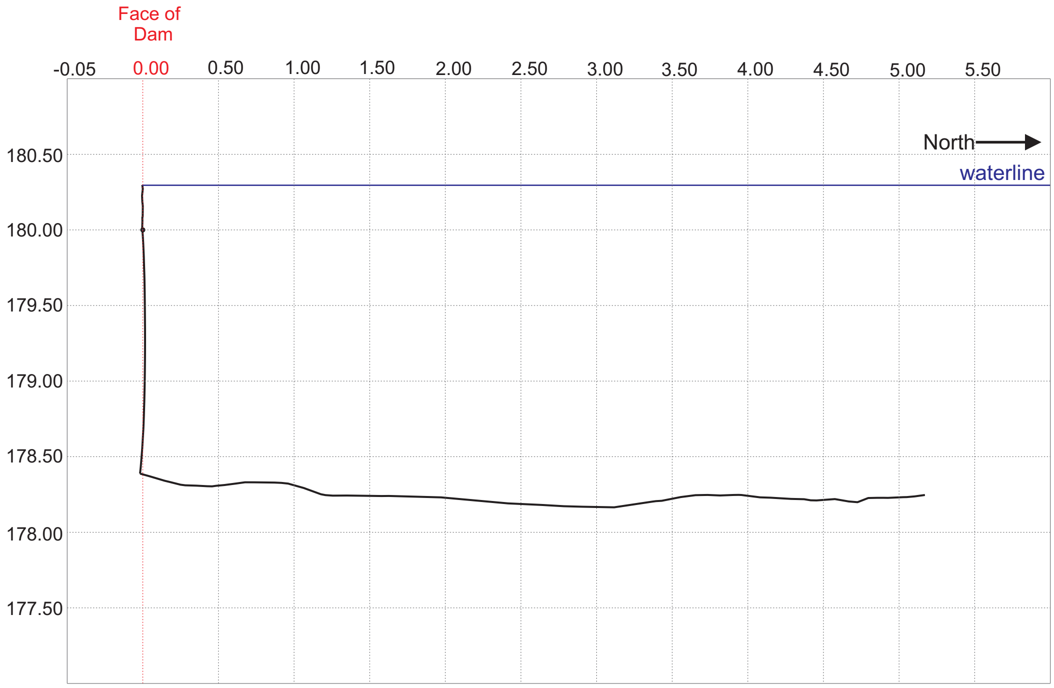

Image 4C-03: Profile 3 at 10 m

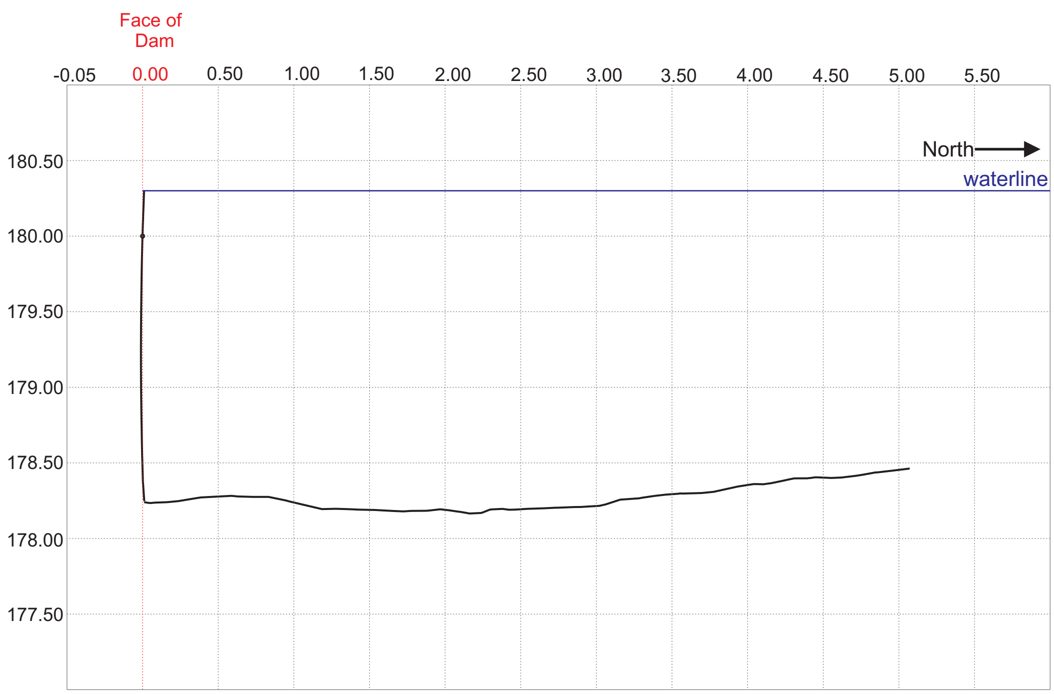

Image 4C-04: Profile 4 at 15 m

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1 0 1

SCALE: 20 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052 Project Date: November 2016 Drawn By: Robin Houlik	**Cross-Sectional Profiles Lock 45 North Wall**	Appendix Number: 4C 13 of 20

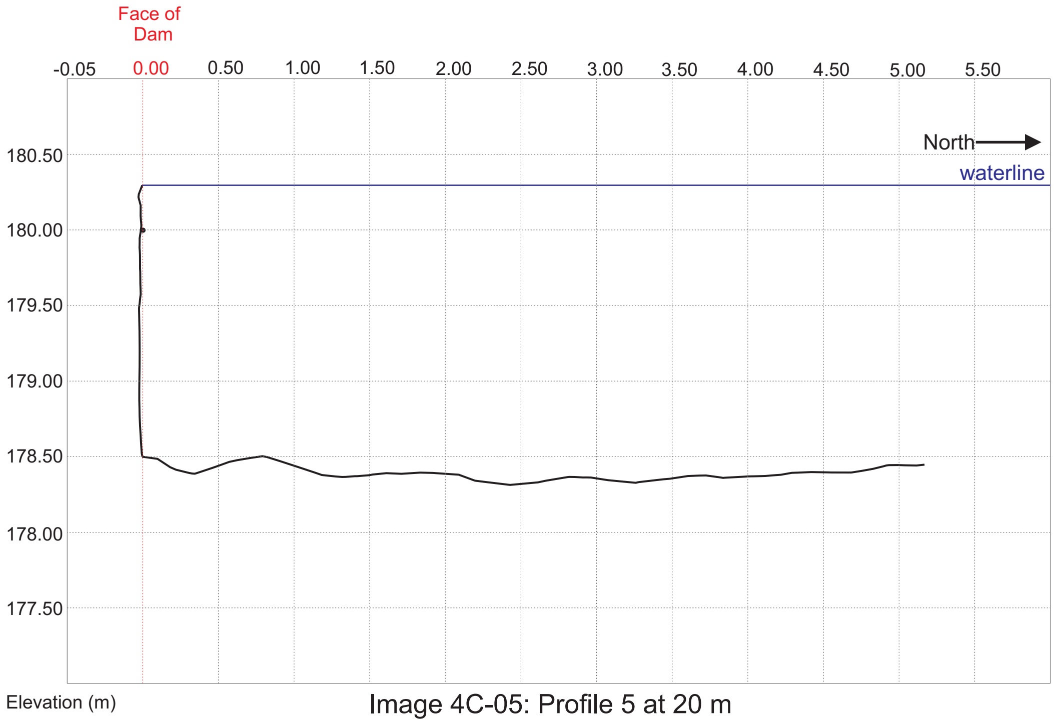

Image 4C-05: Profile 5 at 20 m

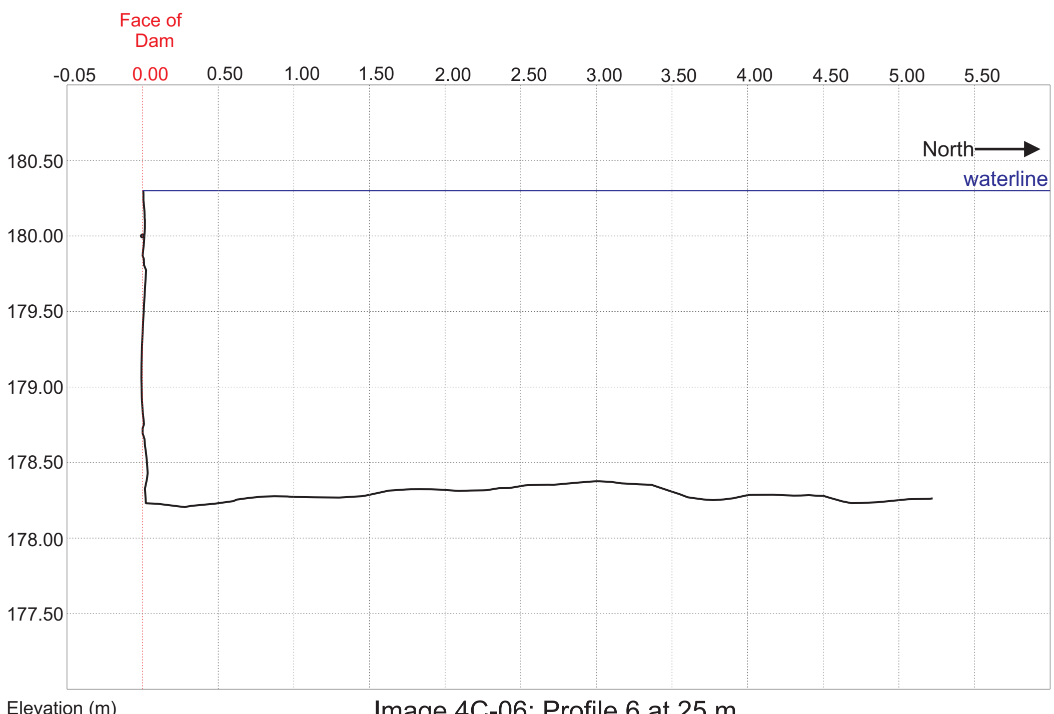

Image 4C-06: Profile 6 at 25 m

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1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052	**Cross-Sectional Profiles Lock 45 North Wall**
Project Date: November 2016	Appendix Number: 4C
Drawn By: Robin Houlik	14 of 20

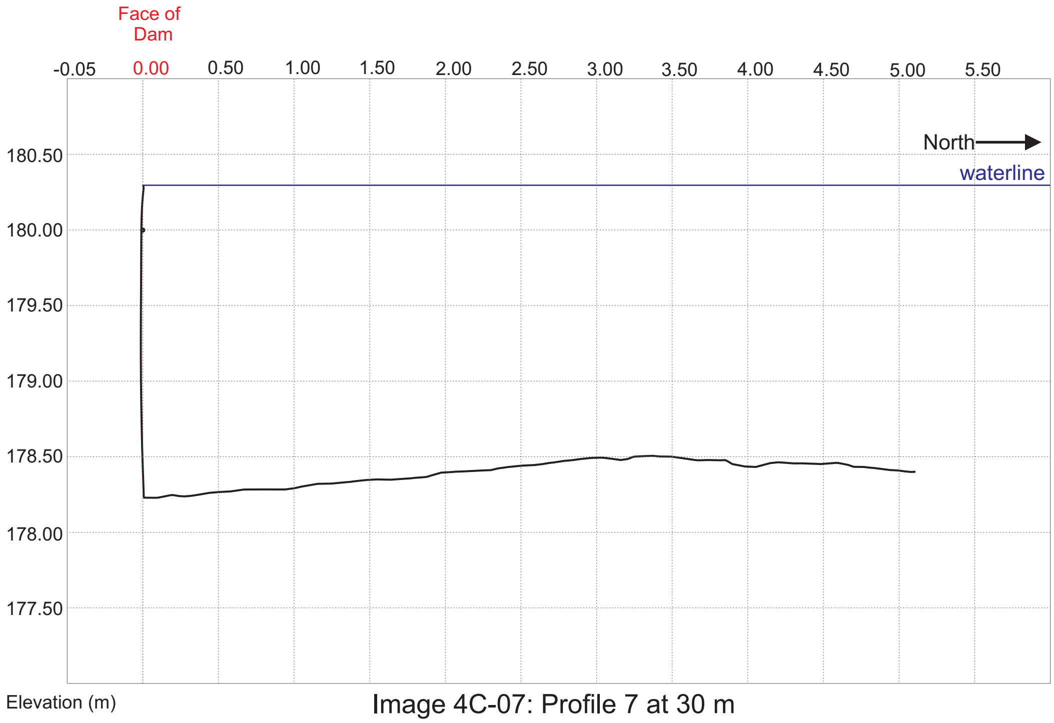

Image 4C-07: Profile 7 at 30 m

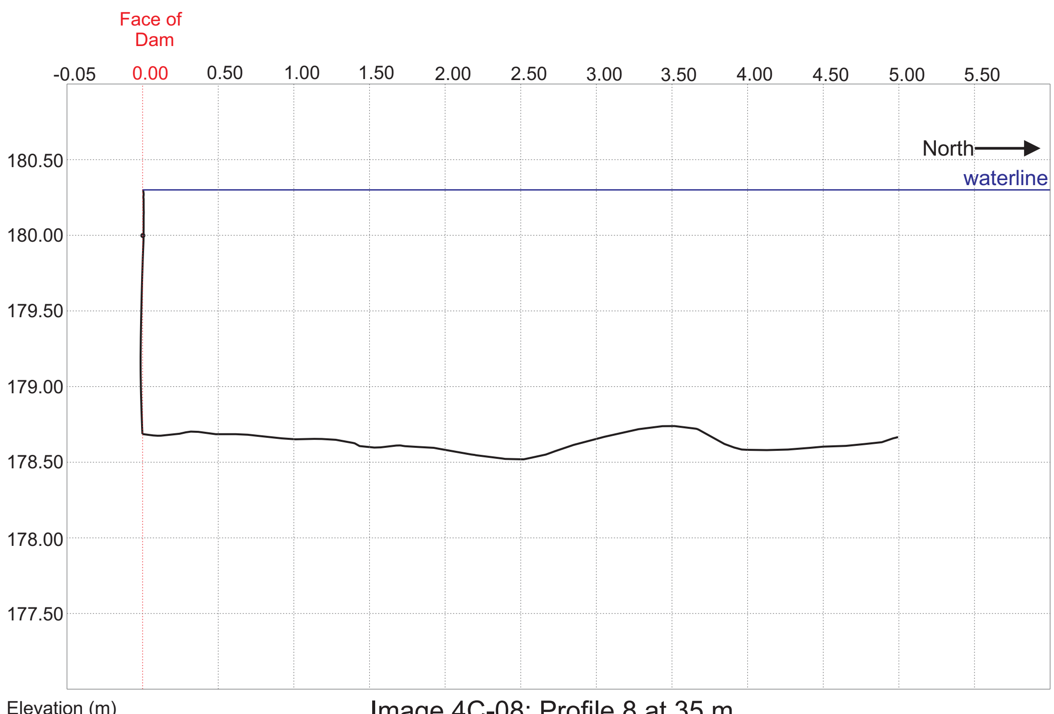

Image 4C-08: Profile 8 at 35 m

1 0 1

SCALE: 20 CM = 1 METRE

NOTES:
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AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Lock 45 North Wall

Appendix Number:

4C

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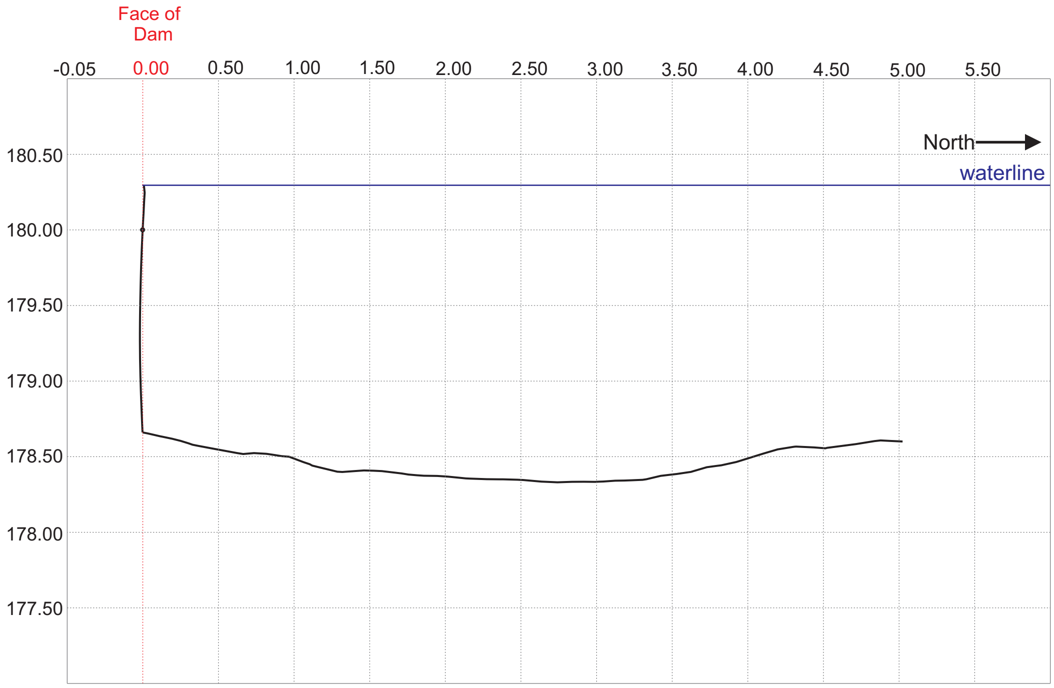

Image 4C-09: Profile 9 at 40 m

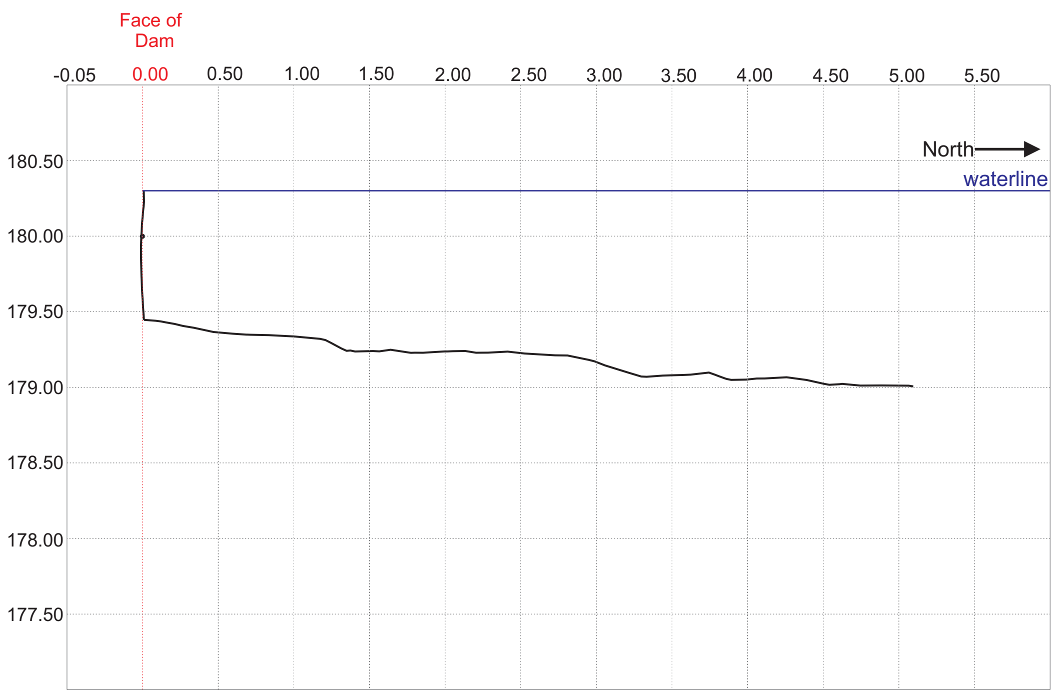

Image 4C-10: Profile 10 at 45 m

NOTES:

1. THE CROSS-SECTION INFORMATION DEPICTED REPRESENTS THE GENERAL CONDITION EXISTING ON THE DATES OF SURVEY.
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3. HORIZONTAL DISTANCES ARE EXPRESSED IN METRES.
4. ZERO POSITION ON DAM FACE AT UTM83 POSITION: NORTH: 4962005.527, EAST: 601181.727
5. DISTANCES REFERENCED FROM THIS POSITION IN WEST DIRECTION ALONG DAM FACE.

1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Lock 45 North Wall

Appendix Number:

4C

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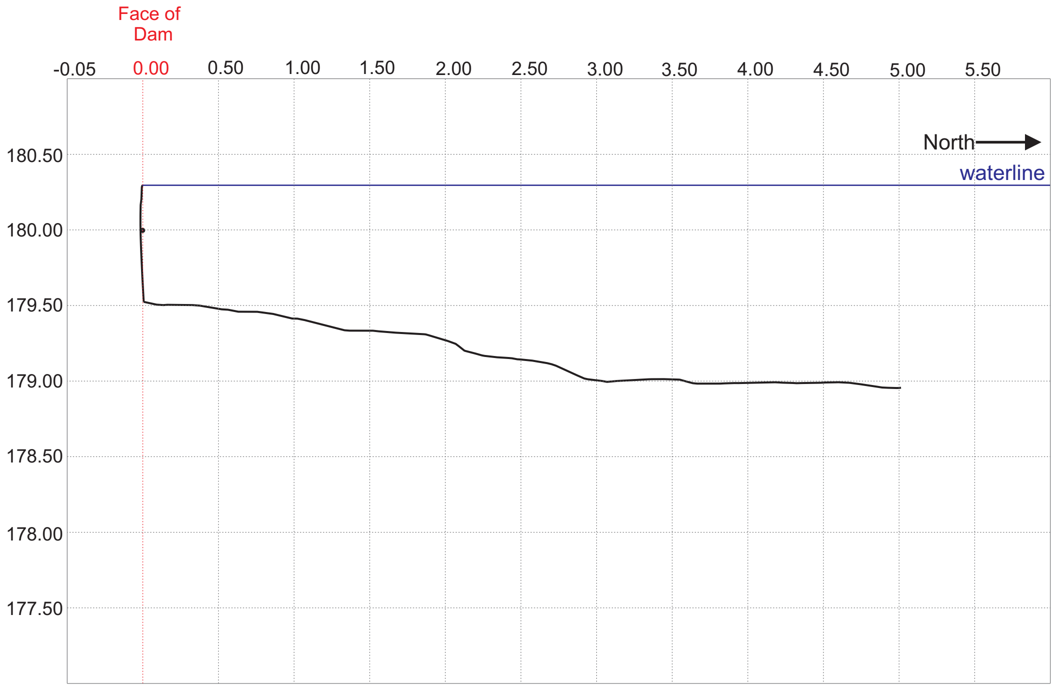

Image 4C-11: Profile 11 at 50 m

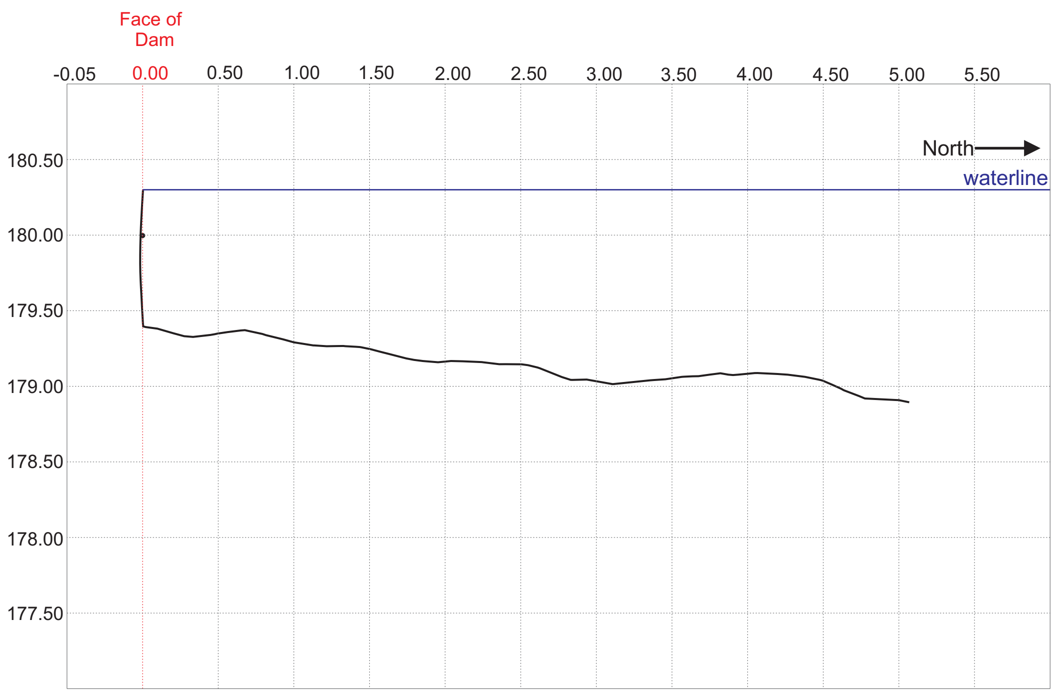

Image 4C-12: Profile 12 at 55 m

NOTES:
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1 0 1

SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Lock 45 North Wall

Appendix Number:

4C

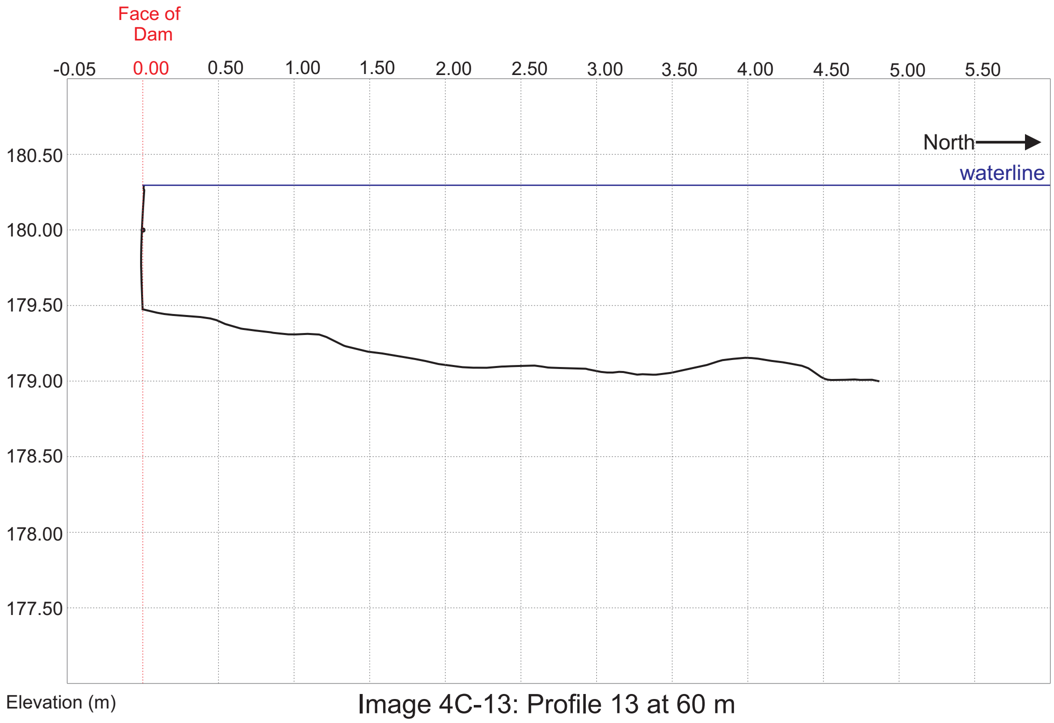


Image 4C-13: Profile 13 at 60 m

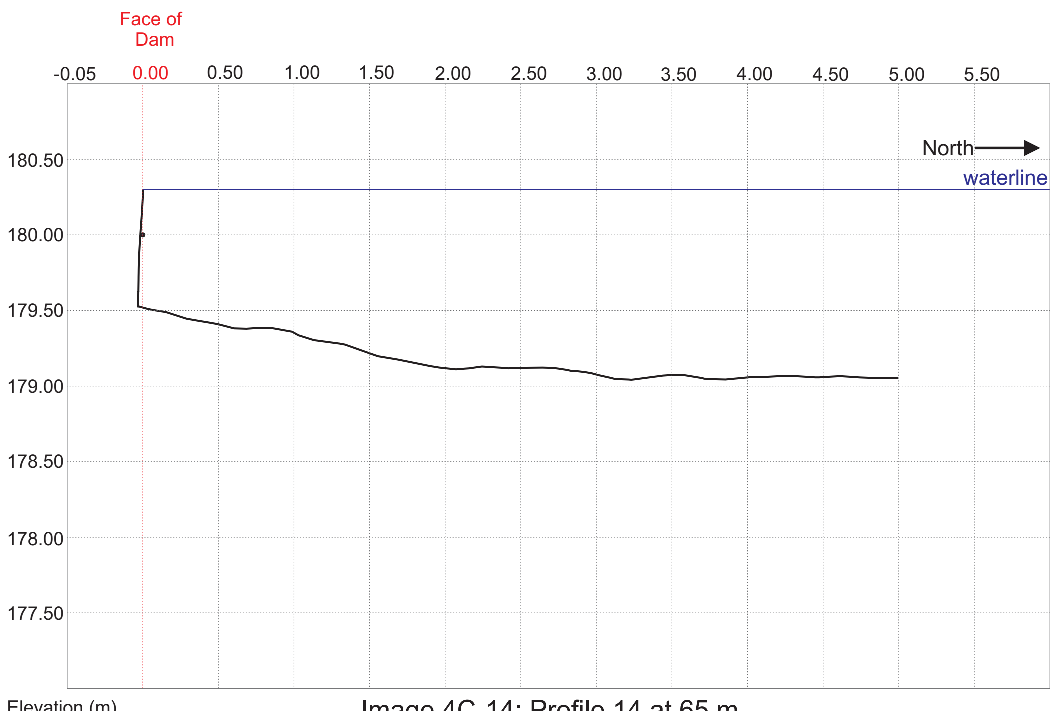
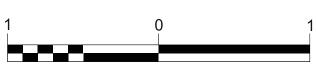


Image 4C-14: Profile 14 at 65 m



SCALE: 20 CM = 1 METRE

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		Project Date: November 2016		4C
		Drawn By: Robin Houlik		18 of 20

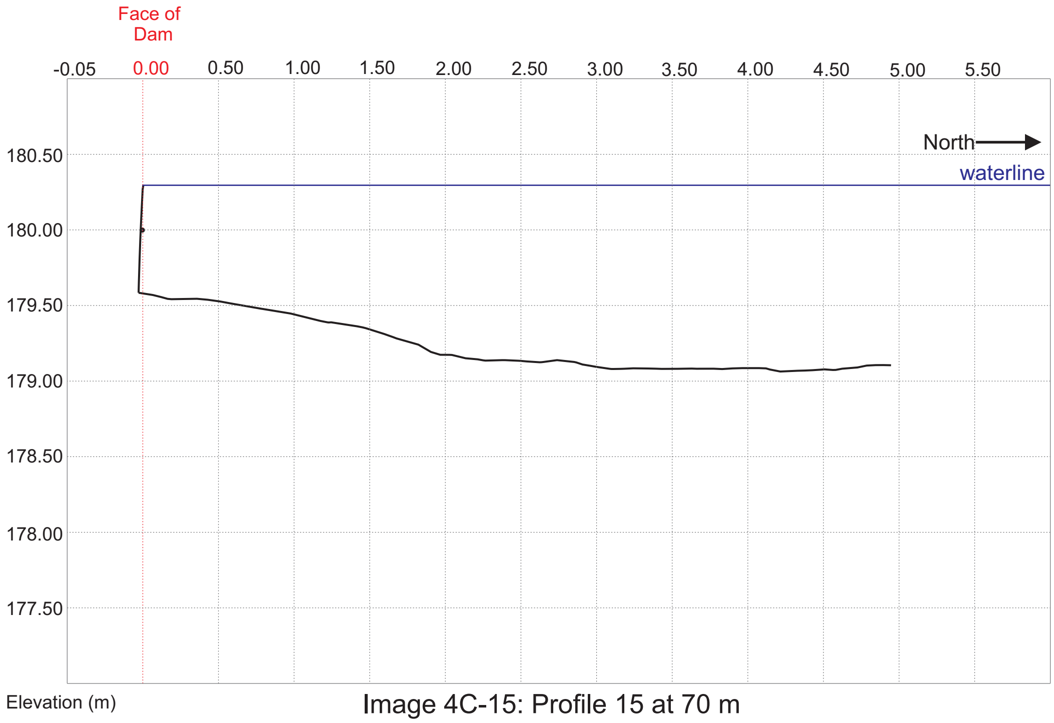

Image 4C-15: Profile 15 at 70 m

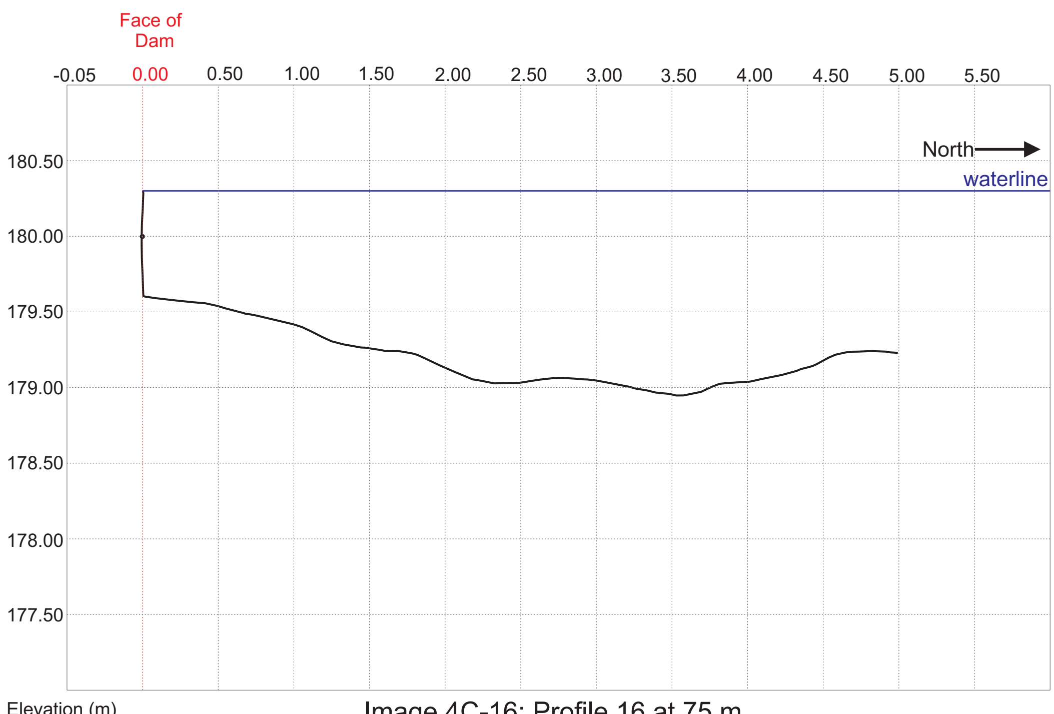

Image 4C-16: Profile 16 at 75 m

NOTES:
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SCALE: 20 CM = 1 METRE

AECOM	ASI Marine	ASI Project No: RH16-052	Cross-Sectional Profiles Lock 45 North Wall	Appendix Number:
		Project Date: November 2016		4C
		Drawn By: Robin Houlik		19 of 20

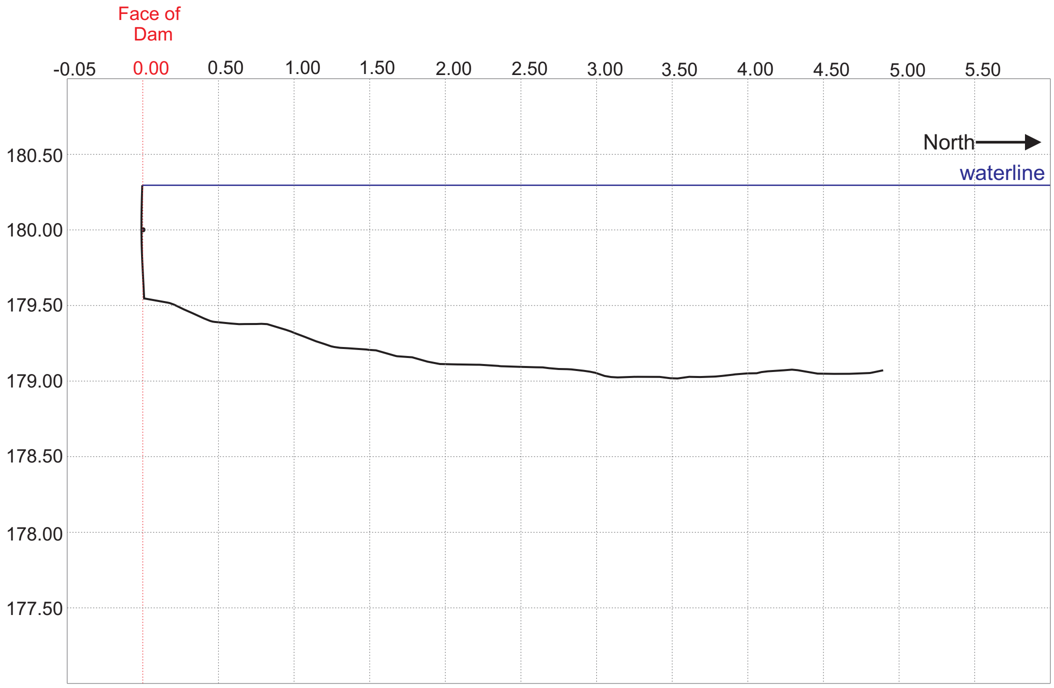

Image 4C-17: Profile 17 at 80 m

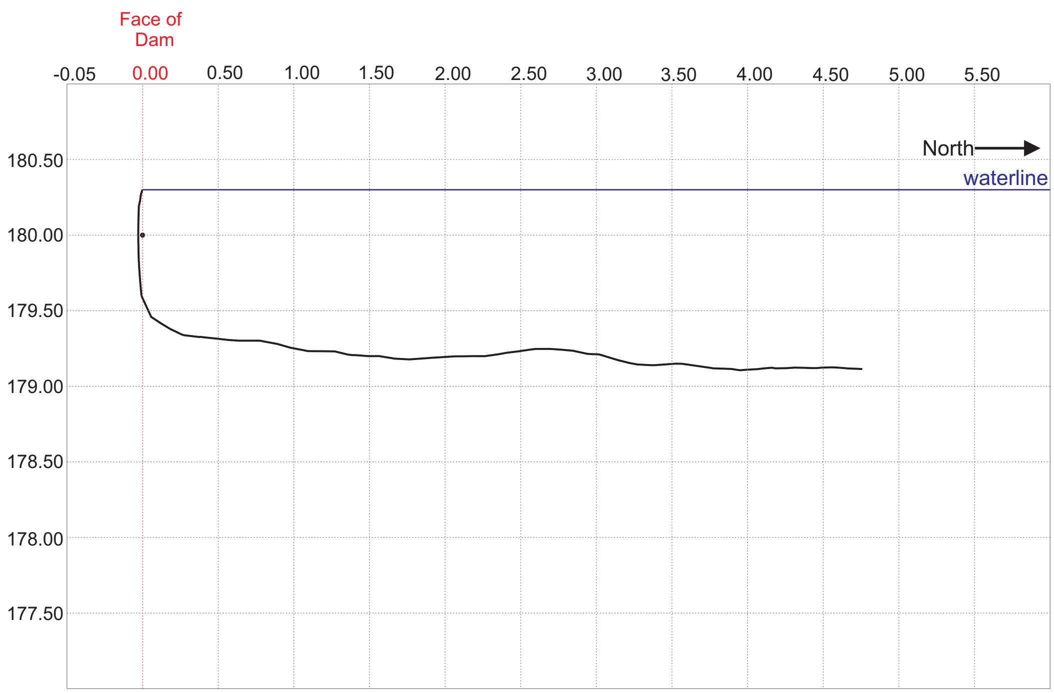

Image 4C-18: Profile 18 at 85 m

NOTES:
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SCALE: 20 CM = 1 METRE

AECOM

ASI Marine

ASI Project No: RH16-052

Project Date: November 2016

Drawn By: Robin Houlik

Cross-Sectional Profiles Lock 45 North Wall

Appendix Number:

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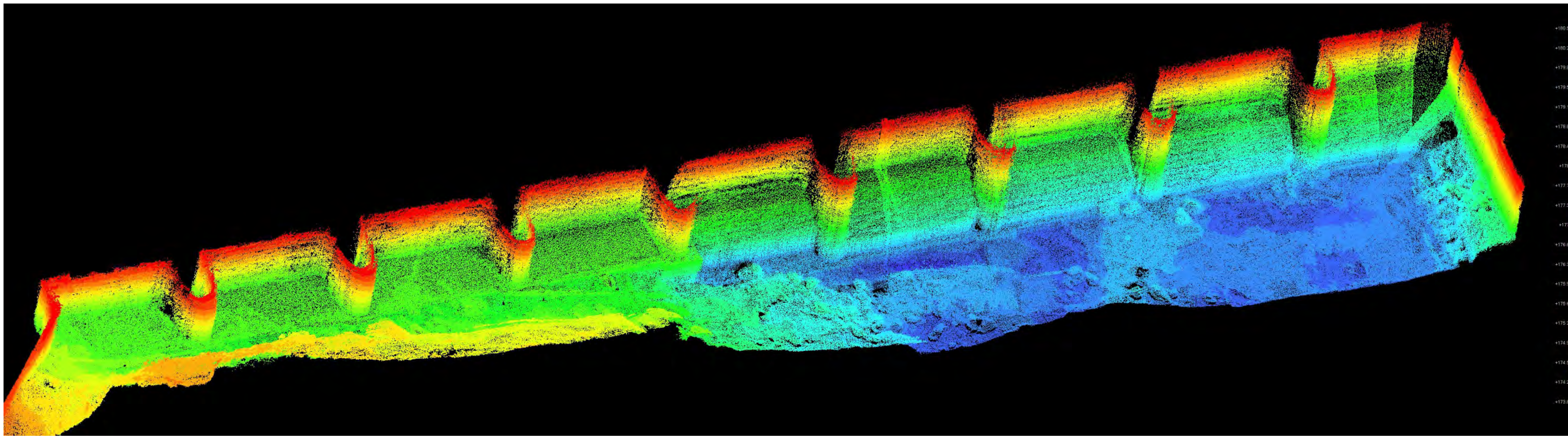
Appendix 5:

3D Perspective Views

MAIN DAM UPPER



PERSPECTIVE VIEW LOOKING SOUTH

NOTES:
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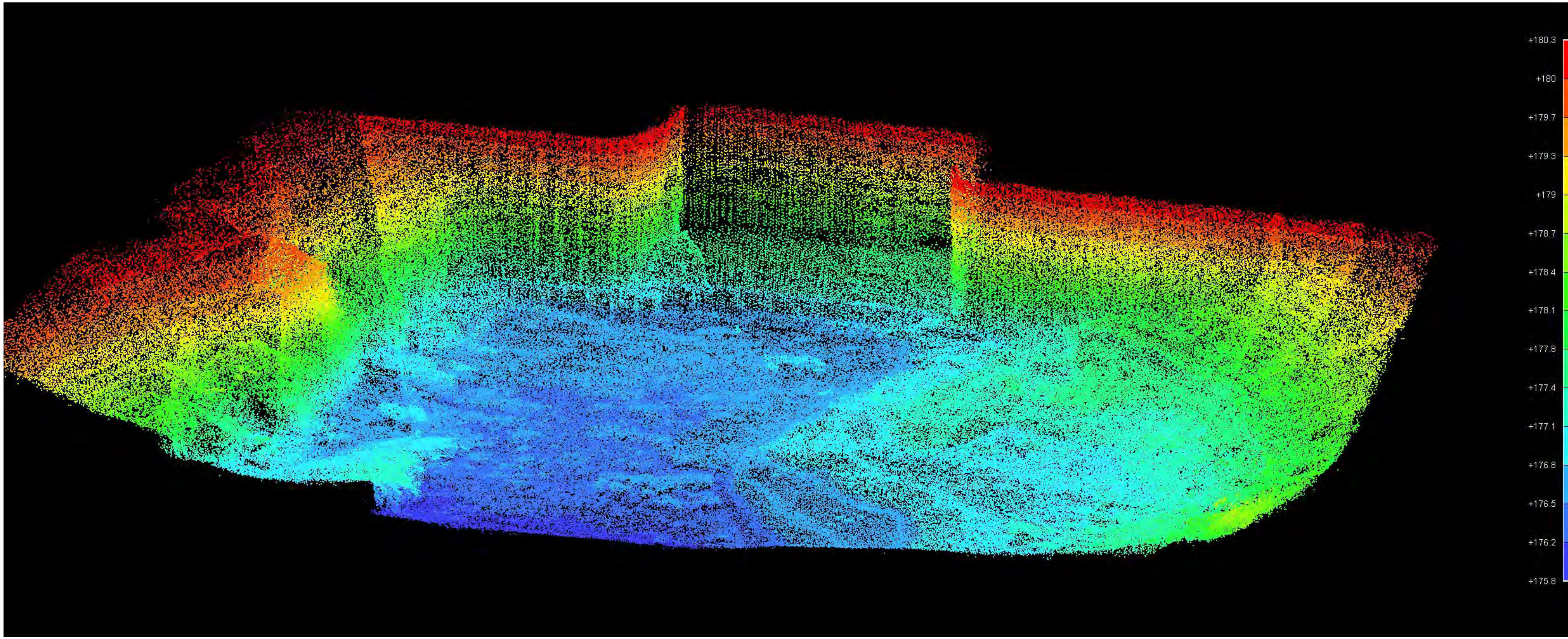
4. STANDARD MBES PROCEDURES WERE USED TO CALIBRATE THE SYSTEM.

AECOM	ASI Marine	ASI Project No: RH16-052	3D Perspective Views	Appendix Number:
		Project Date: November 2016		5
		Drawn By: R. Houlik	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	1 of 9

DAM E



PERSPECTIVE VIEW LOOKING SOUTHEAST

NOTES:
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		Project Date: November 2016	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	5
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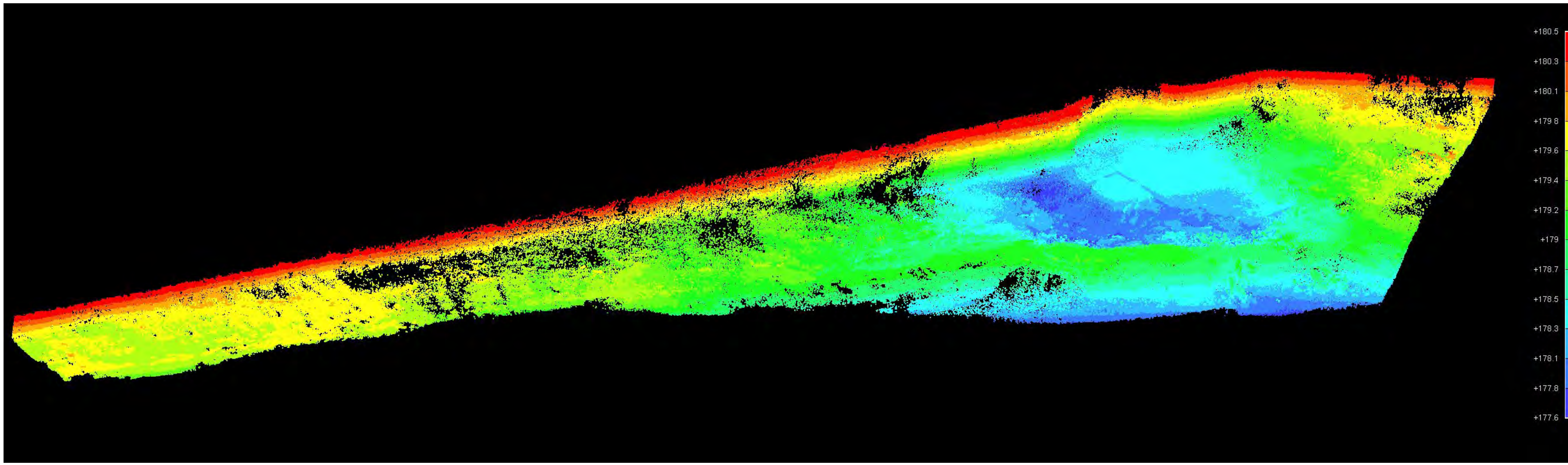
DAM G



PERSPECTIVE VIEW LOOKING SOUTHWEST

NOTES:
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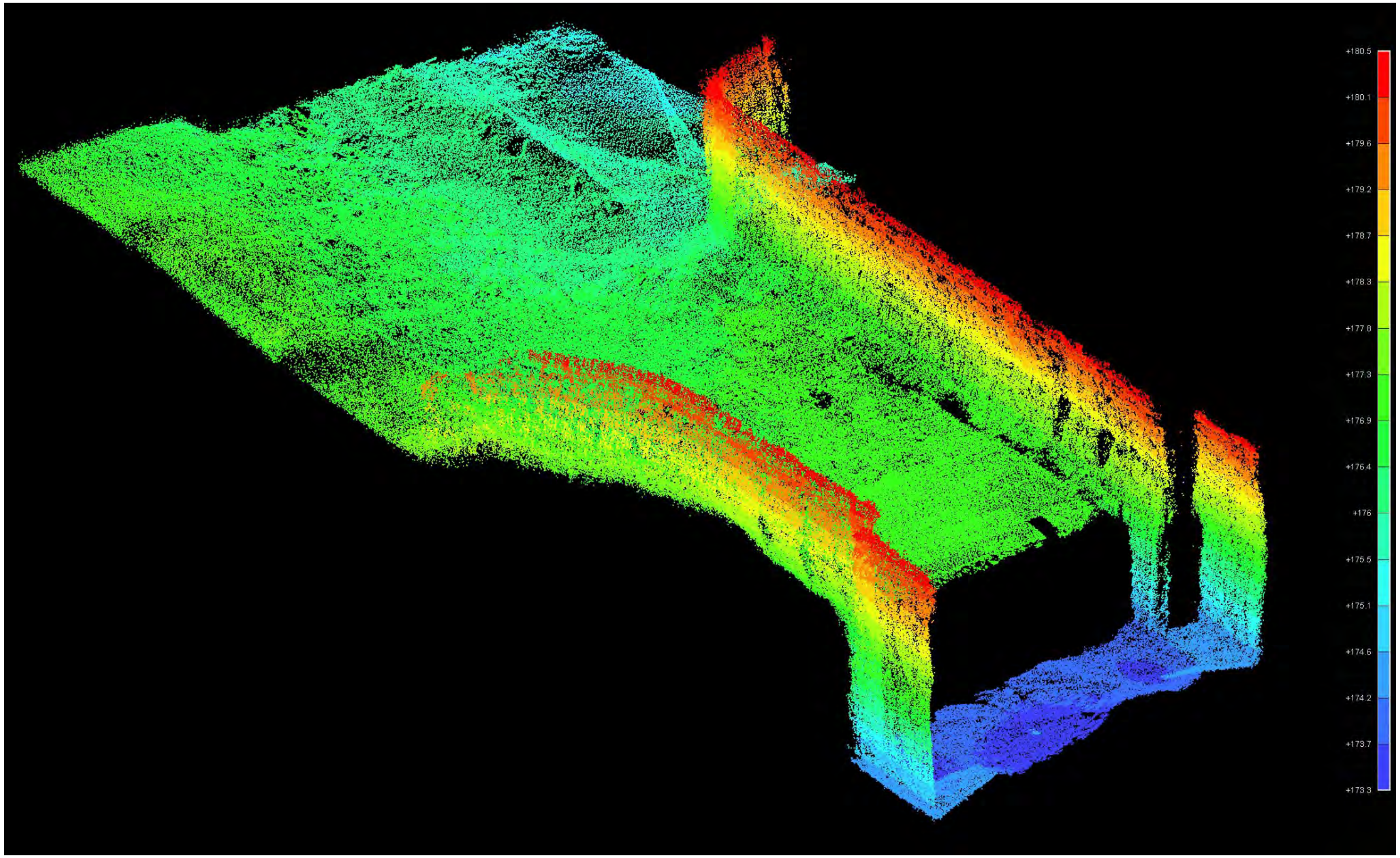
		Project Date: November 2016		5
		Drawn By: R. Houlik	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	3 of 9

LOCK 45 UPPER



PERSPECTIVE VIEW LOOKING NORTHEAST

NOTES:
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AECOM	ASI Marine	ASI Project No: RH16-052	**3D Perspective Views**	Appendix Number:
		Project Date: November 2016	**Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock**	5
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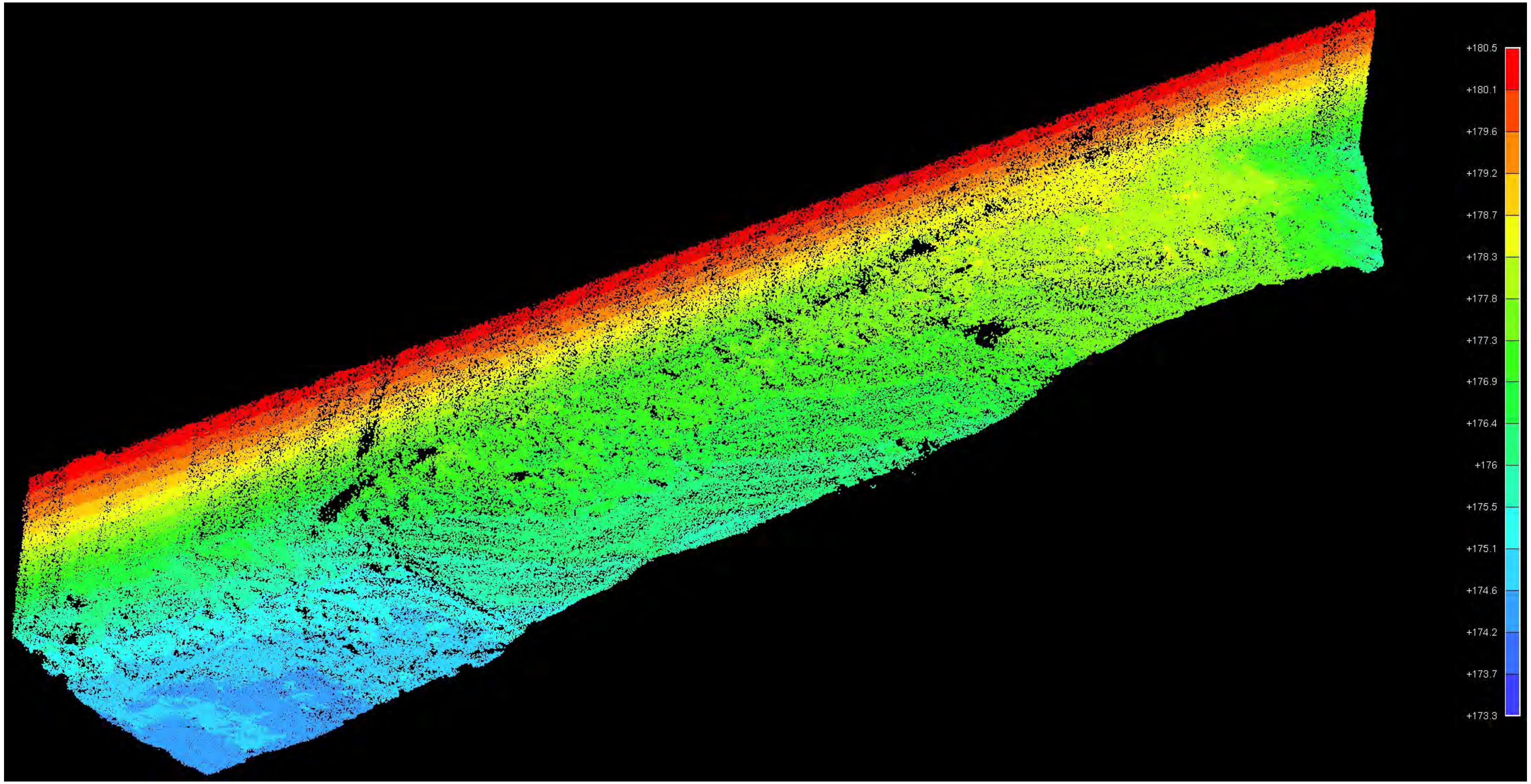
LOCK 45 EAST WALL



PERSPECTIVE VIEW LOOKING NORTHWEST

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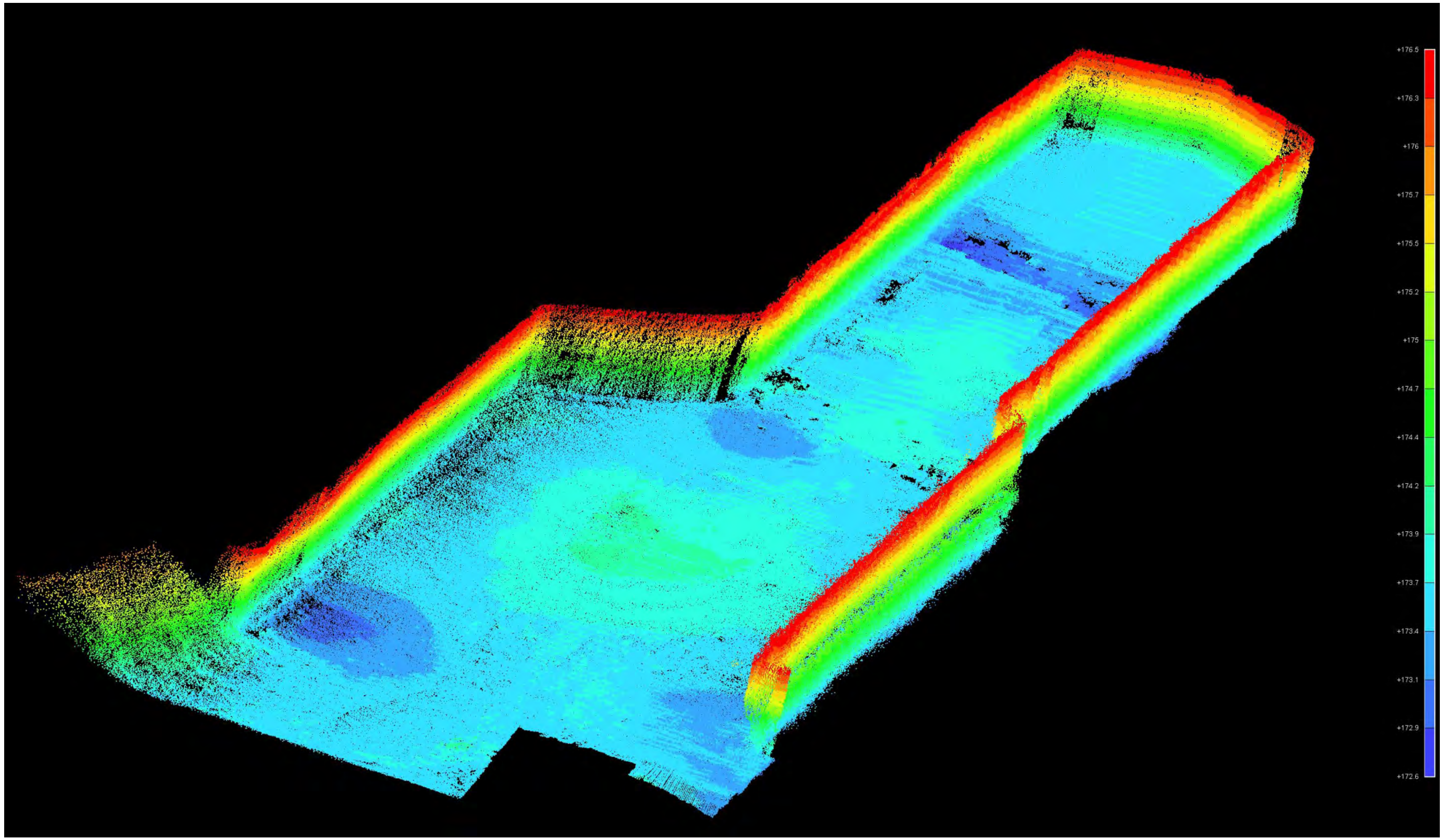
		Project Date: November 2016		5
		Drawn By: R. Houlik	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	5 of 9

LOCK 45 LOWER



PERSPECTIVE VIEW LOOKING NORTHWEST

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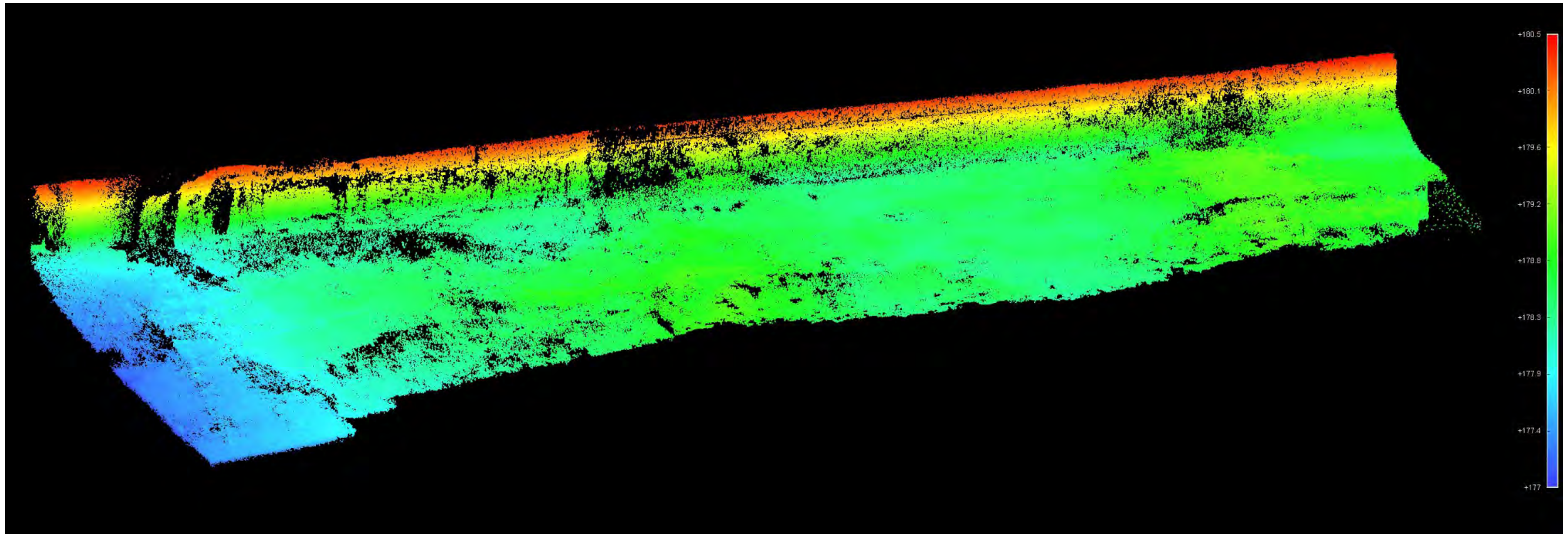
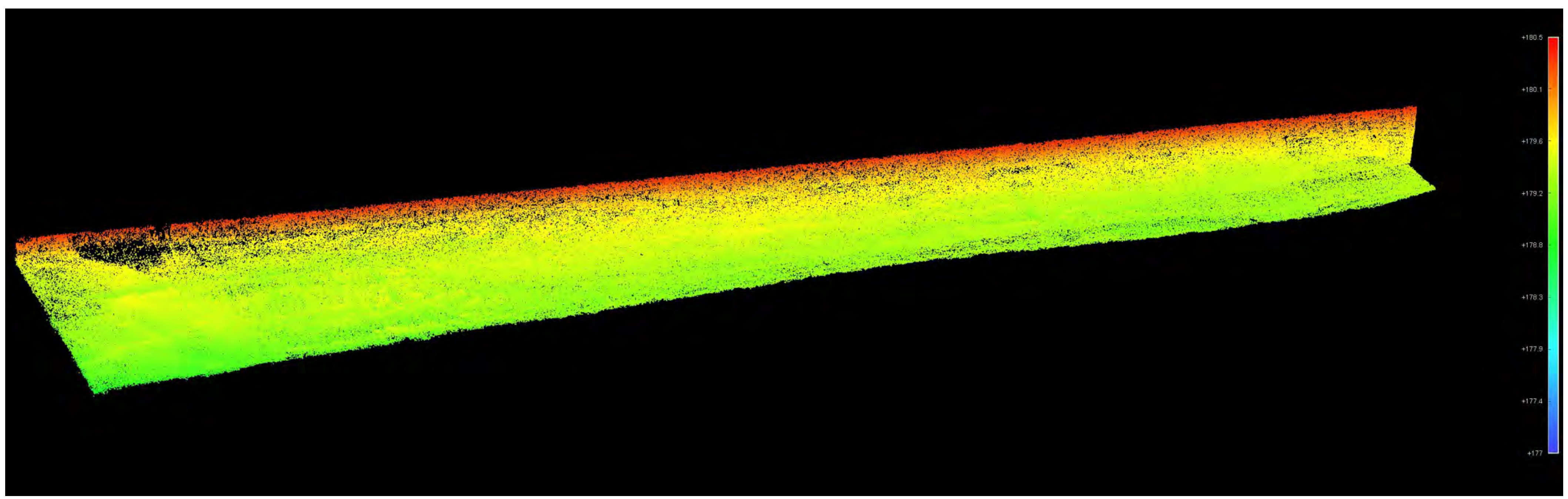
		Project Date: November 2016		5
		Drawn By: R. Houlik	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	6 of 9

LOCK 45 NORTH WALL



PERSPECTIVE VIEW LOOKING SOUTH



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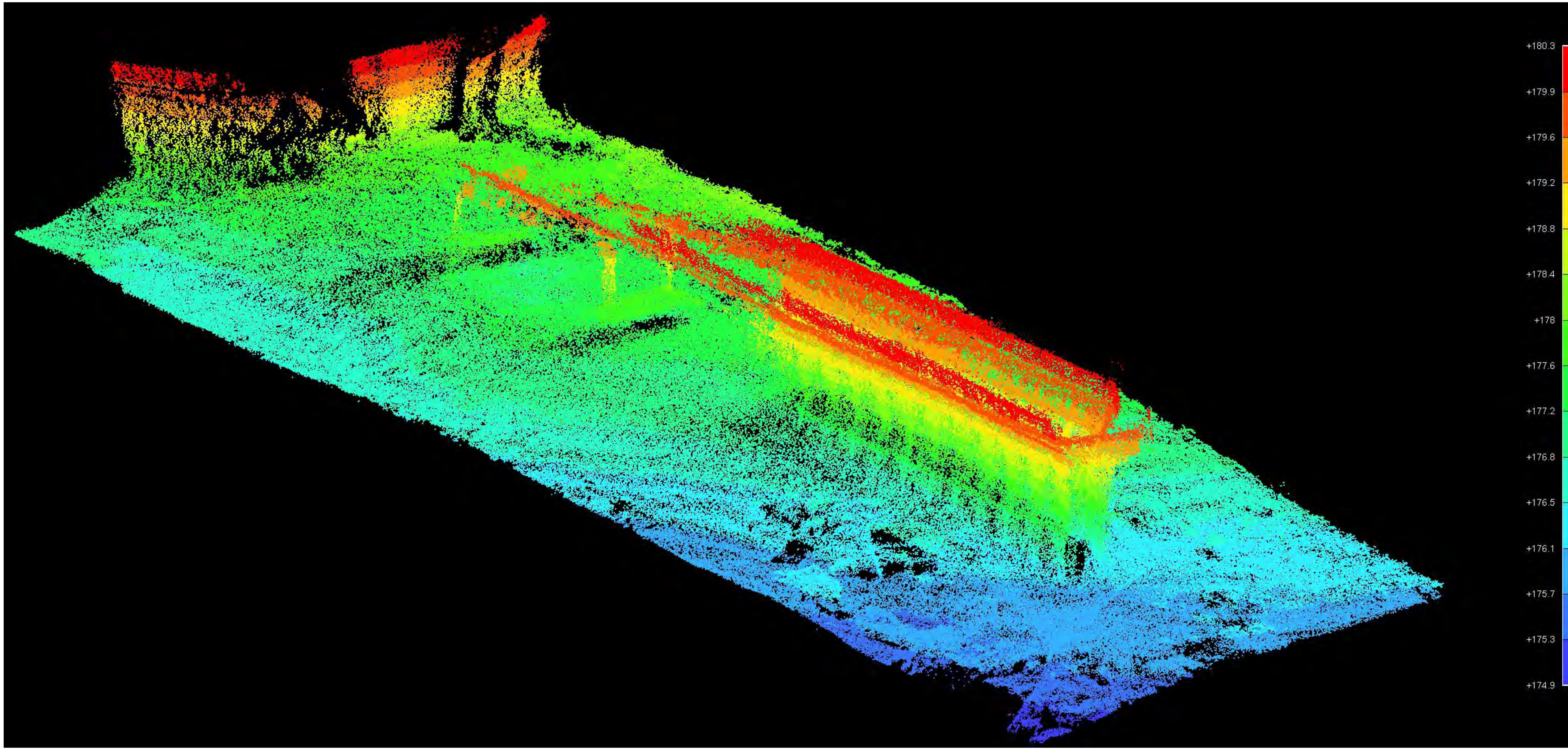
		Project Date: November 2016		5
		Drawn By: R. Houlik	Underwater Inspections of the Port Severn Area Dams, Fixed Bridge and Lock	7 of 9

UPPER APPROACH WALL



PERSPECTIVE VIEW LOOKING SOUTHWEST

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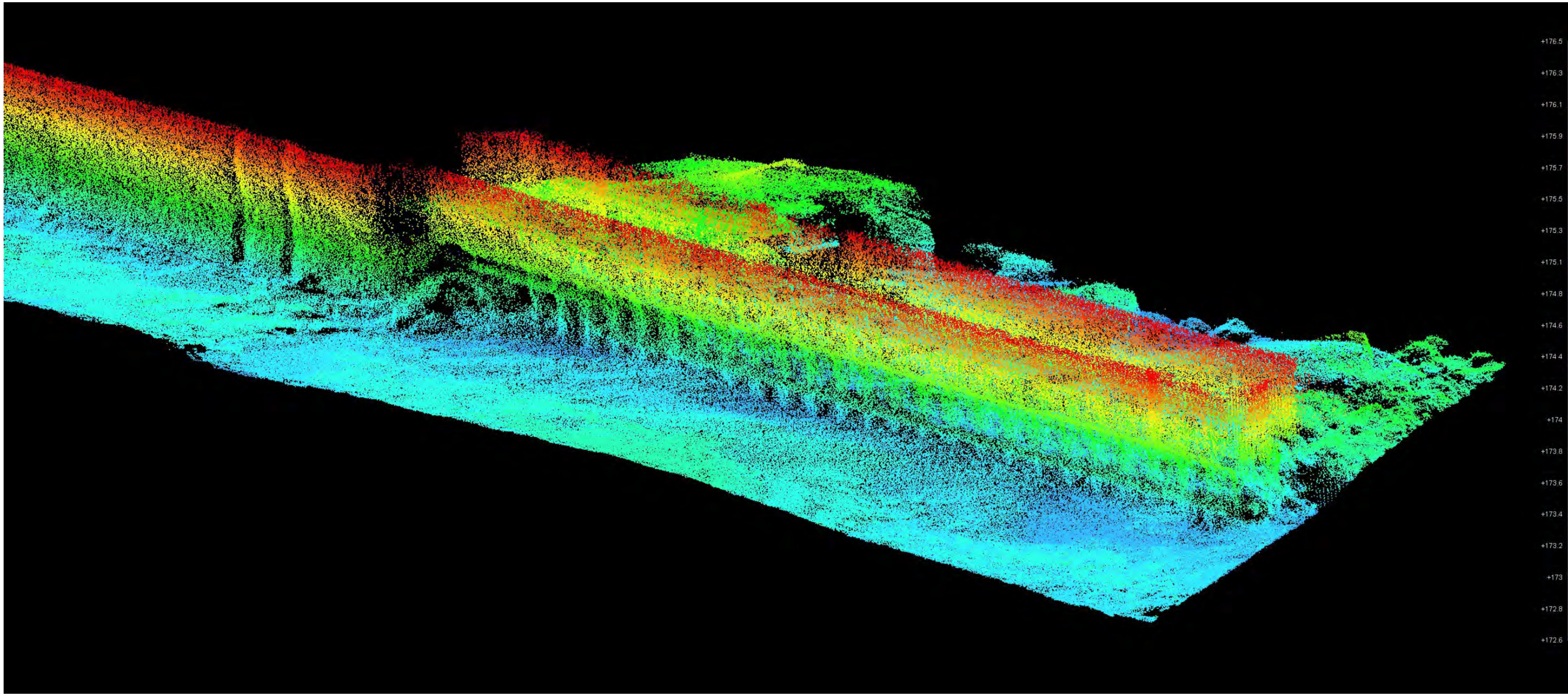
LOWER APPROACH WALL



PERSPECTIVE VIEW LOOKING NORTHEAST

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Appendix 6:

Main Dam Lower Above-Water Images

Image 6-01: Gate 1, Pier 1

Image 6-02: Gate 1, Pier 1 Spalling

Image 6-03: Gate 2, Pier 2

Image 6-04: Gate 2, Pier 3

Image 6-05: Gate 2, Pier 3 to far left of image.

Image 6-06: Gate 3, Pier 3

Image 6-09: Gate 4

Image 6-10: Gate 4, Pier 4

Image 6-07: Gate 5

Image 6-08: Gate 6

Image 6-11: Gate 7

Image 6-12: Gate 8

Image 6-13: Gate 9

Image 6-14: Gate 9, Pier 9

Appendix 7:

Inspection Video (USB)

Appendix 8:

Bathymetric Data (USB)

AECOM

Public Works and Government Services Canada

Final Report – Geotechnical Investigation for Port Severn Area Dams, Fixed Bridge and Lock Rehabilitation, Port Severn, Ontario

Prepared by:

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www.aecom.com

May, 2017 Project Number: 60522156

Distribution List

# Hard Copies	PDF Required	Association / Company Name

Revision History

Revision #	Date	Revised By:	Revision Description
0	March 22, 2017	A. Rauf	Draft Version
1	April 28, 2017	A. Rauf	Incorporating review comments
2	May 9, 2017	A. Rauf	Final Report

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations");
- represents AECOM's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

AECOM shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. AECOM accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

AECOM agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but AECOM makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

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Quality Information

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LICENSED PROFESSIONAL ENGINEER
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May 9, 2017
PROVINCE OF ONTARIO

Report Reviewed By:

Douglas McLachlin, M.Sc., P.Eng.
Geotechnical Practice Area Lead

LICENSED PROFESSIONAL ENGINEER
D. M. MCLACHLIN
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May 9, 2017
PROVINCE OF ONTARIO

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Appendices

1. Introduction

AECOM Canada Ltd. (AECOM) was retained by Public Works and Government Services Canada (PWGSC) to carry out a geotechnical investigation for the proposed rehabilitation program for dams, fixed bridges and Lock 45 adjacent walls and road widening at Port Severn area, Ontario.

The geotechnical investigation program was carried out in accordance with the proposal submitted by AECOM to PWGSC dated September 14, 2016. The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of advancing boreholes and a corehole, and to assess the engineering characteristics of the subsurface soils and bedrock by means of field and laboratory tests. This report provides factual information including subsurface conditions and laboratory test results.

1.1 Scope of Work

The scope of work included the following services to be provided by AECOM to PWGSC:

- Preparing a geotechnical investigation plan, layout of boreholes, clearing of underground utilities;
- Engaging a drilling sub-contractor, advancing boreholes and a corehole to collect soil samples, bedrock cores, concrete cores, and bedrock hydraulic conductivity measurements at proposed locations;
- Laboratory testing of selected soil samples, rock cores, and concrete cores;
- Measuring groundwater depths;
- Preparing borehole logs, completing a detailed visual analysis of soil samples, preparing borehole location plan; and,
- Preparing a factual data report presenting the findings of the geotechnical investigation.

2. Investigation Procedures

Borehole locations are provided in the Site Plan and Borehole Location Plans, Figures 1-1 to 1-5 in Appendix A.

The borehole locations were established in the field by AECOM engineering staff in relation to existing features. The underground utilities at the borehole locations were cleared by a private locate company and the respective public utility companies.

The fieldwork was performed from January 4 to January 24, 2017. It consisted of drilling and sampling nine (9) boreholes and one (1) corehole. The eight (8) boreholes (BHs 17-1, 17-2, 17-5A, 17-5B, 17-6, 17-7, 17-8A and 17-8B) were advanced at the proposed locations on land using a track-mounted drilling rig to a depth ranging from 2.1 to 7.1 m below ground surface (bgs). Boreholes 17-5B and BH 17-8B were advanced adjacent to boreholes BH 17-5A and BH 17-8A, respectively, for bedrock coring only. Borehole BH 17-3 was advanced close to Dam D on a platform over water using a track-mounted drilling rig to a depth of 8.1 m below the top of Dam D.

Corehole CH 17-4 was advanced at the second pier from the east on the Stoplog Platform of Main Dam (east of Lock 45) to core through the existing pier concrete using a track-mounted drilling machine. At approximately 3.2m below the top of the platform the core barrel and inner tube of coring equipment became stuck and had to be abandoned and corehole CH 17-4 was terminated at 3.2 m.

The boreholes were backfilled by using bentonite and non-shrinkable grout.

The boreholes were drilled using continuous flight hollow stem augers and HQ diamond rock coring equipment. The drilling machines were owned and operated by Walker Drilling Ltd., Ontario under the full-time supervision by AECOM engineering staff.

Standard Penetration Tests (SPTs) were carried out at selected intervals to assess the soil strength and to obtain samples for testing purposes. SPTs were carried out in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer over a vertical distance of 0.76 m to drive a 51 mm outside diameter (O.D.) split-barrel (split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground over a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil, which is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils). The bedrock and concrete coring was advanced by rotary drilling method using double tube HQ diamond rock coring equipment.

The groundwater levels were observed in the boreholes upon the completion of drilling, where encountered. The hydraulic conductivity of the bedrock was assessed at select boreholes using a single packer system provided by Walker Drilling Limited.

Table 1 below presents a summary of the borehole locations and the borehole termination depths in metres below ground surface (mbgs).

Table 1: Summary of Borehole Locations and Depths

Borehole Number	Borehole Location[1]	Borehole Depth (mbgs)
BH 17-1	Dam A	2.2
BH 17-2	Dam D – On Land	2.3
BH 17-3	Dam D – Over Water	8.1[2]
CH 17-4	Main Dam	3.2[3]
BH 17-5A	Lower Approach Walls at Lock 45	3.0
BH 17-5B		7.1
BH 17-6	Dam E – NE Corner	3.4
BH 17-7	Dam E – Rock Outcrop	2.1
BH 17-8A	Dam G	4.3
BH 17-8B		6.7

Notes: 1. The approximate borehole locations are presented in Figures 1-2 to 1-5 in Appendix A
2. Borehole depth of BH17-3 was measured from the top of Dam D
3. Corehole depth of CH17-4 was measured from the Stoplog Platform surface

Soil samples and rock cores were transported to an AECOM facility for visual and tactile examination and classification. Concrete cores were transported to Bridge Check Canada Ltd. for testing. Selected soil samples were tested at AECOM's Geotechnical Laboratory, and the laboratory testing program consisted of natural moisture content tests, Grain Size Distribution analyses and Atterberg Limits tests. The selected rock cores were submitted to Peto MacCallum Ltd. (PML) of Toronto, Ontario for compression strength tests. All the laboratory tests are in accordance with ASTM Standards. The results of the laboratory tests are presented on the borehole logs in Appendix B and in Appendix C.

3. Subsurface Conditions

3.1 Regional Geology

According to Ontario Geological Survey Open File Report 5882 – Quaternary Geology of the Huntsville-Penetanguishene Area, Central Ontario (Ministry of Northern Development and Mines, 1994), the site is located within the Physiographic Region known as the Georgian Bay Fringe, which is characterized as a low-relief, driftless plain with local accumulations of winnowed till, glaciolacustrine sediments and organic soils that do not generally exceed 2.0 to 3.0 m in thickness in most of this physiographic region.

The bedrock geology within the area is identified as being from the Precambrian age. The area east of Georgian Bay mostly lies within the Central Gneiss Belt of the Grenville Province. The belt consists mainly of quartzofeldspathic gneissic and migmatitic rocks which have been metamorphosed to upper amphibolite and locally, to granulite facies. Felsic igneous rocks also have been identified within the area (Ontario Geological Survey Open File Report 5882, Ministry of Northern Development and Mines, 1994).

3.2 Regional Geology

In general, the subsurface conditions at all borehole locations consist of fill materials overlying bedrock, and weathered bedrock was encountered at the interface of overburden and bedrock. In boreholes BH 17-1, topsoil/peat was encountered overlying fill material, which was in turn overlying a silty clay deposit. In borehole BH 17-3, lake sediments were encountered at the bottom of the lake overlying the bedrock. Concrete cores were collected from corehole CH 17-4 from the concrete pier of Main Dam. The records of Borehole and Corehole Logs are presented in Appendix B

3.2.1 Topsoil / Peat

A 100 mm thick layer of topsoil/peat with roots was encountered at the surface in borehole BH 17-1.

3.2.2 Concrete

A 200 mm thick concrete layer of was encountered at the surface in boreholes BHs 17-8A and 17-8B, when the boreholes were advanced at the sidewalk close to Dam G.

A 3.2 m long core was collected from corehole CH 17-4, and a 70 mm long layer of uncrushed rock was recovered from the bottom of the last core run. The concrete cores from the corehole were found to have a light grey cement paste with coarse aggregate in sizes ranging from about 20 to 100 mm. The larger aggregates were encountered below 0.9 m below the surface of the Stoplog Platform. A piece of reinforced bar with approximate 20 mm diameter was encountered at about 0.1 m depth. The horizontal joints were mostly observed at the contact with the larger aggregate pieces.

The concrete core testing results are referred to Concrete Coring & Laboratory Testing Report, prepared by Bridge Check Canada Ltd., dated February 6, 2017.

3.2.3 Fill

A 0.6 to 4.3 m thick layer of fill was encountered below topsoil/peat at 0.1 m in borehole BH 17-1, below the concrete sidewalk at 0.2 m in borehole 17-8A and at the surface in boreholes BH 17-2, BH 17-5A, BH 17-6, and BH 17-7, that extended to a depth of 0.6 to 4.3 mbgs. Various amounts of clay, silt, sand and gravel with inclusions of organics, red brick debris, wood debris and rootless were encountered in the fill materials. N-values generally ranged between 5 and 35 blows per 30 cm penetration. A low N-value of 0 locally recorded in borehole BH 17-1, possible due to high organic contents, and high N-values of 53 per 30 cm recorded in borehole BH 17-5A, which was due to the possible weathered bedrock.

The grain size distribution results of three (3) selected fill samples are presented in Figures GS-1 and GS-2 in Appendix C. The grain size distribution is as follows:

Grave Sized Particles:	6 - 20 %
Sand Sized Particles:	47 - 75 %
Silt Sized Particles:	9 - 30 %
Clay Sized Particles:	7 - 17 %

Atterberg Limits tests conducted on one (1) selected sample from borehole BH 17-8 are presented in Figure AL-1, Appendix C and are summarized below:

Liquid Limit:	21 %
Plastic Limit:	13 %
Plasticity Index:	8 %

The natural moisture contents measured within the fill materials ranged from 5% to 39%.

3.2.4 Lake Sediments

A 1.5 m thick lake sediments was encountered at 5.8 m below the top of Dam D (0.9 m below water surface) in borehole BH 17-3, which extended to 3.2 m below the top of Dam D. Lake sediments consisted of sand and gravel with inclusions of organics and wood debris. N-values recorded ranging between 4 and 62 per 23 to 30 cm penetration, indicating loose to very dense compactness. High N-value was due to the possible weathered bedrock. The natural moisture contents measured within the samples ranged from 15% to 39%.

3.2.5 Silty Clay

A 1.0 m thick silty clay deposit was encountered at 0.8 m below fill in borehole BH 17-1, which extended to 1.8 m bgs. In general, N-value was 10 blows per 30 cm penetration, indicating the deposit has a stiff consistency. High N-value of 50 to 53 blows per 1 to 29 cm penetration, due to possible weathered bedrock.

The grain size distribution results of one (1) selected silty clay sample are presented in Figure GS-3 in Appendix C. The grain size distribution is as follows:

Grave Sized Particles:	0 %
Sand Sized Particles:	16 %
Silt Sized Particles:	26 %
Clay Sized Particles:	58 %

The corresponding Atterberg limits results of the selected sample are given in Figure AL-2, Appendix C and are summarized below:

Liquid Limit:	38 %
Plastic Limit:	21 %
Plasticity Index:	17 %

The natural moisture contents measured within the silty clay samples were 26% and 27%.

3.2.6 Bedrock

The presence of possible bedrock was encountered by auger and / or spoon refusal in boreholes BH 17-1, BH 17-2, BH 17-5A, and BH 17-8A at the depth ranging between 2.2 and 4.3 m bgs. The bedrock was cored in boreholes BH 17-5B, BH 17-6, BH 17-7, and BH 17-8B to the depth ranging from 2.1 to 7.1 m bgs, and in borehole BH 17-3 to the depth of 8.1 m below the top of Dam D. In boreholes BH 17-3, BH 17-5B, BH 17-6, BH 17-7, the bedrock was identified as migmatite gneiss, which has black and white bands with some pink coloration, quartz, feldspar, biotite, and hornblende. The joints are rough planar to rough undulating with diagonal and vertical cross joints. In borehole BH 17-8B, the bedrock was identified as amphibolite, which contains black amphibole minerals and plagioclase feldspar.

The recorded Total Core Recovery (TCR) was ranging from 70% to 100%. The Solid Core Recovery (SCR) and the Rock Quality Designation (RQD) ranged from 17% to 100% and 0% to 100%, respectively. The 0% RQD was encountered locally in borehole BH 17-7. The general rock quality was identified as very poor to excellent. The results of Unconfined Compressive Strength (USC) testing of five (5) selected rock cores ranged from 103 to 165 MPa, indicating very strong strength, according to Canadian Foundation Engineering Manual (CFEM, 4th Edition). No test was conducted on the rock cores from borehole BH 17-7, because none of the rock core samples from borehole BH 17-7 were long enough to meet the dimension requirements for testing in accordance with ASTM Standards.

The results of the TCR, SCR, RQD and rock core laboratory testing were summarized in Table 2, and presented in the records of Borehole Logs in Appendix B and in Appendix C. The rock core photos were presented in Appendix D.

Table 2: Summary of TCR, SCR, RQD and Test Results of Rock Cores

Borehole Number	Borehole Location	Bedrock Information					
		TCR (%)	SCR (%)	RQD (%)	Rock Quality	UCS	Strength
BH 17-3	Dam D – Over Water	87 to 100	57 to 100	57 to 100	Fair to Excellent	138 MPa at Depth 4.1 m	Very Strong
						103 MPa at Depth 7.8 m	Very Strong
BH 17-5B	Lower Approach Walls at Lock 45	86 to 100	17 to 63	17 to 59	Very Poor to Fair	136 MPa at Depth 3.1 m	Very Strong
BH 17-6	Dam E – NE Corner	94 to 99	76 to 99	76 to 99	Good to Excellent	165 MPa at Depth 1.9 m	Very Strong
BH 17-7	Dam E – Rock Outcrop	70 to 100	17 to 61	0	Very Poor	–[1]	–[1]
BH 17-8B	Dam G	97 to 100	85 to 100	100	Excellent	140 MPa at Depth 5.2 m	Very Strong

Notes: 1. No UCS test was conducted on bedrock core from BH 17-7, due to poor rock quality

4. Hydrogeologic Conditions

Following a period of stabilization, the groundwater level in each borehole was measured upon the completion of drilling and is summarized in Table 3 below.

Table 3: Summary of Groundwater Levels after Drilling

Borehole Number	Borehole Location	Groundwater Depth, after Drilling (mbgs)
BH 17-1	Dam A	1.1
BH 17-2	Dam D – On Land	1.9
BH 17-3	Dam D – Over Water	2.1[1]
BH 17-5B	Lower Approach Walls at Lock 45	1.4
BH 17-6	Dam E – NE Corner	0.7
BH 17-7	Dam E – Rock Outcrop	1.3
BH 17-8A	Dam G	3.4

Notes: 1. Depth of groundwater after drilling BH 17-3 was measured from below the top of Dam D

It should be noted that groundwater levels are subject to variation due to the influence of rainfall, seasonal fluctuations, river stage, and other factors. There may also be a potential for the development of perched groundwater tables following periods of intense rainfall.

The hydraulic conductivity of the bedrock was measured at select borehole locations using a single packer system provided by Walker Drilling Limited. The results of this testing are included in Table 4 and the corresponding data sheets are included in Appendix E.

Table 4: Bedrock Hydraulic Conductivity Test Results

Borehole Number	Borehole Location	Calculated Hydraulic Conductivity (m/s)	Notes
BH 17-3	Dam D – Over Water	–	Bedrock impermeable to injected water
BH 17-5B	Lower Approach Walls at Lock 45	4.3×10^{-6}	
BH 17-6	Dam E – NE Corner	2.0×10^{-5}	
BH 17-8A	Dam G	–	Bedrock impermeable to injected water

Appendix A

Site Plan and Borehole Location Plans

NOTES:

1. This drawing should be read in conjunction with the report (project number as referenced) and Figures 1-2 to 1-5 .
2. Image from Google Earth dated June 21, 2016.

drawn	GZ	AECOM	client:	Public Services and Government Works Canada
approved			project:	Geotechnical Investigation for Port Severn Area Dams, Fixed Bridge and Lock Rehabilitation
date				
scale	N.T.S		title:	Site Plan
original size	Tabloid		project no:	60522156 Figure 1-1

Site plan and bh location plans.xls

NOTES:
1. This drawing should be read in conjunction with the report (project number as referenced) and Figure 1-1 .
2. Image from Google Earth dated June 21, 2016.
3. Borehole locations are approximate only.

drawn	GZ	AECOM	client:	Public Services and Government Works Canada
approved			project:	Geotechnical Investigation for Port Severn Area Dams, Fixed Bridge and Lock Rehabilitation
date				
scale	N.T.S		title:	Borehole Location Plan at Dam A
original size	Tabloid		project no: 60522156	Figure 1-2

Site plan and bh location plans.xls

NOTES:
1. This drawing should be read in conjunction with the report (project number as referenced) and Figure 1-1 .
2. Image from Google Earth dated June 21, 2016.
3. Borehole locations are approximate only.

drawn	GZ	AECOM	client:	Public Services and Government Works Canada
approved			project:	Geotechnical Investigation for Port Severn Area Dams, Fixed Bridge and Lock Rehabilitation
date				
scale	N.T.S		title:	Borehole Location Plan at Main Dam, Dam D, and Lock 45
original size	Tabloid		project no:	60522156 / Figure 1-3

NOTES:
1. This drawing should be read in conjunction with the report (project number as referenced) and Figure 1-1 .
2. Image from Google Earth dated June 21, 2016.
3. Borehole locations are approximate only.

drawn	GZ	AECOM	client:	Public Services and Government Works Canada
approved			project:	Geotechnical Investigation for Port Severn Area Dams, Fixed Bridge and Lock Rehabilitation
date				
scale	N.T.S		title:	Borehole Location Plan at Dam E
original size	Tabloid		project no:	60522156 Figure 1-4

Site plan and bh location plans.xls

NOTES:
1. This drawing should be read in conjunction with the report (project number as referenced) and Figure 1-1 .
2. Image from Google Earth dated June 21, 2016.
3. Borehole locations are approximate only.

drawn	GZ	AECOM	client:	Public Services and Government Works Canada
approved			project:	Geotechnical Investigation for Port Severn Area Dams, Fixed Bridge and Lock Rehabilitation
date				
scale	N.T.S		title:	Borehole Location Plan at Dam G
original size	Tabloid		project no:	60522156 Figure 1-5

Site plan and bh location plans.xls

Appendix B

Borehole and Corehole Logs

BOREHOLE LOG	PROJECT: 60522156	BOREHOLE: BH 17-1 1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation Port Severn, Ontario **Client:** PSGWS	**Northing:** N/A **Easting:** N/A **Methodology:** Hollow Augers **Contractor:** Walker Drilling	**DATE:** January 4, 2017 **LOGGED BY** AR **GROUND ELEV** N/A m ASL

DEPTH (m)	STRATIGRAPHY	SOIL/ROCK DESCRIPTION	MONITOR DETAILS	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% TCR	% RQD
0.1		**TOPSOIL/PEAT:** 100 mm thick Topsoil/Peat		1		SS	0	33		
0.8		**FILL:** silty clay, trace sand, trace gravel, organic inclusion, wood debris, very soft, brown, wet to moist		2		SS	10	26		
2.0		**SILTY CLAY:** trace to some sand, firm to hard brown, moist Grain Size: 0% Gr.,16% Sa.,26% Si.,58% Cl. -- weathered bedrock		3		SS	53 /292mm	27		
2.2				4		SS	50/10mm			
		WEATHERED BEDROCK: some sand, very dense, black, wet		5		SS	50/38mm			

Plot headers: N Value ■ (15 30 45 60 75); K (m/sec) (10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}); C_u(kPa) ⊕ ◆ ⊙ (50 100 150 200); W (%) W_P W W_L (10 20 30 40 50)

End of Borehole

1. Borehole was terminated due to auger refusal.
2. Groundwater measured upond completion of augering was 1.1 m below ground surface.

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BOREHOLE LOG

PROJECT: 60522156	**BOREHOLE:** BH 17-2	1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation	**Northing:** N/A	**DATE:** January 6, 2017
Port Severn, Ontario	**Easting:** N/A	**LOGGED BY** AR
Client: PSGWS	**Methodology:** Hollow Augers **Contractor:** Walker Drilling	**GROUND ELEV** N/A m ASL

DEPTH (m)	STRATIGRAPHY	SOIL/ROCK DESCRIPTION	MONITOR DETAILS	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% TCR	% RQD
		FILL: sand, and gravel to gravelley, trace silt, trace clay, rootless, loose to compact, wet to moist		1		SS	8	38		
1				2		SS	22	21		
		-- loose		3		SS	6	12		
2		Grain Size: 20% Gr.,62% Sa.,9% Si.,9% Cl.								
2.2										
2.3		**WEATHERED BEDROCK:** some sand, very dense, black, wet		4		SS	50/51mm			

Chart columns: N Value ■ (15 30 45 60 75); C_u(kPa) (50 100 150 200); K (m/sec) (10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}); W (%) W_P W W_L (10 20 30 40 50)

End of Borehole
1. Borehole was terminated due to auger refusal.
2. Groundwater measured upond completion of augering was 1.9 m below ground surface.

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BOREHOLE LOG

PROJECT: 60522156	BOREHOLE: BH 17-3	1 of 1

Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation
Port Severn, Ontario
Client: PSGWS

Northing: N/A
Easting: N/A
Methodology: HQ Coring
Contractor: Walker Drilling

DATE: January 24, 2017
LOGGED BY AR
GROUND ELEV N/A m ASL

DEPTH (m)	SOIL/ROCK DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	WATER %	TCR %	RQD %
	TOP OF DAM D						
1.5	**WATER SURFACE**						
1.8	**LAKE SEDIMENTS:** sand and gravel, organic inclusion, wood debris, loose to very dense, wet	1	SS	5	25		
		2	SS	4	39		
		3	SS	62 /229mm	15		
3.2	-- weathered bedrock						
	BEDROCK: migmatite gneiss, banded black and white, some pink quartz, feldspar, biotte, hornblede, unweathered, very strong strength, joints are at very close to moderately close spacing from 3.2 to 4.5 m, diagonal cross joints, joint surface are rough stepped to undulating.	4	HQ			87	57
		5	HQ			100	100
		6	HQ			99	99
		7	HQ			100	100
		8	HQ			97	97
8.1	**End of Borehole**						

1. Borehole was advanced over water near Dam D.
2. Groundwater measured upond completion of coring was 2.1 m below top of Dam D.

Chart columns: N Value ■ (15 30 45 60 75); K (m/sec) (10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}); C_u(kPa) (50 100 150 200); W (%) W_P W W_L (10 20 30 40 50)

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BOREHOLE LOG

PROJECT: 60522156	**BOREHOLE:** CH 17-4	1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation Port Severn, Ontario **Client:** PSGWS	**Northing:** N/A **Easting:** N/A **Methodology:** HQ Coring **Contractor:** Walker Drilling	**DATE:** January 23, 2017 **LOGGED BY** AR **GROUND ELEV** N/A m ASL

DEPTH (m)	STRATIGRAPHY	SOIL/ROCK DESCRIPTION	MONITOR DETAILS	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% TCR	% RQD	N Value ■ 15 30 45 60 75 / Cu(kPa) ⊕ ◆ ⊙ 50 100 150 200	K (m/sec) 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10} / W (%) W_P W W_L 10 20 30 40 50
1 2 3 3.2		**CONCRETE:** light grey cement paste with coarse aggregate in sizes ranging from about 20 to 100 mm, horizontal joints at the contact with the larger aggregate pieces. -- 20 mm diameter reinforced bar at depth 0.1 m -- larger aggregates below depth 0.9 m -- 70 mm uncrushed rock										
		End of Borehole 1. Corehole was advanced on the second pier from the east of the stoplog platform of Main Dam. 2. Corehole was terminated at 3.2 below the top of platform, because the corebarrel and inner tube of coring equipment was stuck at 3.2 m.										

BOREHOLE LOG

PROJECT: 60522156	**BOREHOLE:** BH 17-5A	1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation	**Northing:** N/A	**DATE:** January 8, 2017
Port Severn, Ontario	**Easting:** N/A	**LOGGED BY** AR
Client: PSGWS	**Methodology:** Hollow Augers	**GROUND ELEV** N/A m ASL
	Contractor: Walker Drilling	

DEPTH (m)	SOIL/ROCK DESCRIPTION	NUMBER	TYPE	N VALUE	WATER %
	FILL: sand, and gravel to gravelley, trace to some silt, trace clay, rootless, compact, moist	1	SS	18	5
		2	SS	15	13
1		3	SS	6	14
2		4	SS	29	13
		5	SS	53	11
2.8	Grain Size: 20% Gr.,55% Sa.,17% Si.,8% Cl.				
3.0	**WEATHERED BEDROCK:** some sand, very dense, black, wet				
	End of Borehole 1. Borehole was terminated due to auger refusal.				

Columns also shown: MONITOR DETAILS, STRATIGRAPHY, INTERVAL, TCR %, RQD %; N Value ■ (15 30 45 60 75); K (m/sec) (10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}); C_u(kPa) (50 100 150 200); W (%) W_P W W_L (10 20 30 40 50)

BOREHOLE LOG

Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation Port Severn, Ontario **Client:** PSGWS	**PROJECT:** 60522156 **Northing:** N/A **Easting:** N/A **Methodology:** HQ Coring **Contractor:** Walker Drilling	**BOREHOLE:** BH 17-5B 1 of 1 **DATE:** January 8, 2017 **LOGGED BY** AR **GROUND ELEV** N/A m ASL

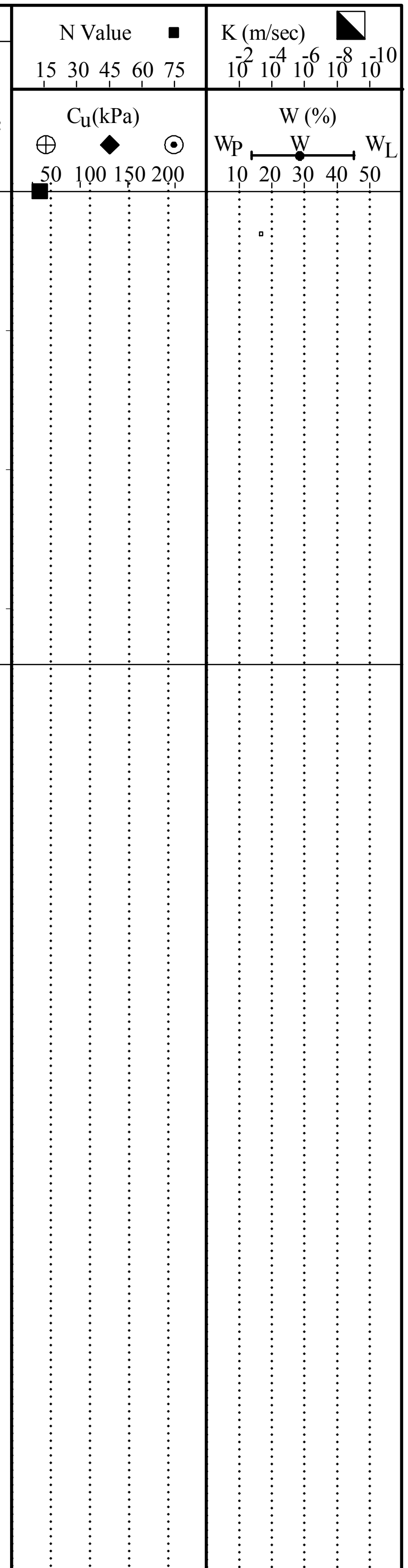
DEPTH (m)	STRATIGRAPHY	SOIL/ROCK DESCRIPTION	MONITOR DETAILS	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% TCR	% RQD
		Coring through overburden								
2.6		**BEDROCK:** migmatite gneiss, banded black and white, some pink quartz, feldspar, biotte, hornblede, highly weathered from 3.8 to 6.7 m, some grey clay, silt filling at 3.7 m, very strong strength, joints are at extremely close to close spacing, vertical and diagonal cross joints, joint surface are rough undulating, amphibolite was encountered from 7.0 to 7.1 m.		1		HQ			100	59
				2		HQ			86	18
				3		HQ			87	17
7.1		**End of Borehole** 1. BH 17-5B was advanced adjacent to BH 17-5A. 2. No samples were collected from overburden. 3. Groundwater measured upond completion of augering was 1.4 m below ground surface.								

N Value ■ 15 30 45 60 75; K (m/sec) 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}; C_u(kPa) 50 100 150 200; W (%) W_P W W_L 10 20 30 40 50

Northing:

BOREHOLE LOG	**PROJECT:** 60522156	**BOREHOLE:** BH 17-6 1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation Port Severn, Ontario **Client:** PSGWS	N/A **Easting:** N/A **Methodology:** Hollow Augers / HQ Coring **Contractor:** Walker Drilling	**DATE:** January 9, 2017 **LOGGED BY** AR **GROUND ELEV** N/A m ASL

DEPTH (m)	STRATIGRAPHY	SOIL/ROCK DESCRIPTION	MONITOR DETAILS	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% TCR	% RQD
0.2		**FILL:**		1		SS	13	17		
		sand, some silt, trace gravel, trace clay, compact, brown, moist Grain Size: 7% Gr.,75% Sa.,11% Si.,7% Cl.								
0.8										
1		silty clay, some sand, organic inclusion, red brick debris, stiff, moist -- weathered bedrock		2		HQ			99	99
		BEDROCK: migmatite gneiss, banded black and white, some pink quartz, feldspar, biotte, hornblede, unweathered, very strong strength, joints are at very close spacing with sand filling at 3.0 m, diagonal cross joints, joint surface are rough stepped to undulating.								
2				3		HQ			94	76
3										
3.4		**End of Borehole** 1. Groundwater measured upond completion of coring was 0.7 m below ground surface.								



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BOREHOLE LOG

PROJECT:	60522156	BOREHOLE:	BH 17-7	1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation	Northing: N/A	DATE:	January 6, 2017	
Port Severn, Ontario	Easting: N/A	LOGGED BY	AR	
Client: PSGWS	Methodology: Hollow Augers / HQ Coring; Contractor: Walker Drilling	GROUND ELEV	N/A	m ASL

DEPTH (m)	SOIL/ROCK DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	WATER %	TCR %	RQD %
	FILL: sand, some silt, trace gravel, trace clay, organic inclusion, compact, brown, wet	1	SS	8	39		
0.6	**BEDROCK:** migmatite gneiss, banded black and white, some pink quartz, feldspar, biotte, hornblede, highly weathered from 0.6 to 1.2 m, joints are at extremely close to close spacing, diagonal cross joints, joint surface are rough undulating.	2	HQ			100	0
1		3	HQ			76	0
		4	HQ			70	0
2.1	**End of Borehole** 1. Groundwater measured upond completion of coring was 1.3 m below ground surface.						

Chart columns: N Value ■ (15 30 45 60 75); Cu(kPa) (50 100 150 200); K (m/sec) (10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}); W (%) W_P W W_L (10 20 30 40 50); MONITOR DETAILS; STRATIGRAPHY; INTERVAL

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BOREHOLE LOG

PROJECT: 60522156

BOREHOLE: BH 17-8A

Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation

Port Severn, Ontario

Client: PSGWS

Northing: N/A
Easting: N/A
Methodology: Hollow Augers
Contractor: Walker Drilling

DATE: January 19, 2017
LOGGED BY AR
GROUND ELEV N/A m ASL

DEPTH (m)	SOIL/ROCK DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	WATER %
0.2	**CONCRETE:** 100 mm thick concrete	1	SS	23	5
	FILL: sand, and gravel to gravelley, trace to some silt, trace clay, rootless, compact to loose, moist	2	SS	8	26
1.0	clayey silt, sandy to and sand, trace gravel, firm to very stiff, wet to moist	3	SS	6	27
		4	SS	9	18
	Grain Size: 6% Gr.,47% Sa.,30% Si.,17% Cl.				
	-- wet to moist	5	SS	5	30
		6	SS	35	21
3.8	**WEATHERED BEDROCK:** some sand, very dense, black, wet	7	SS	62 /292mm	17
4.3	**End of Borehole**				

1. Borehole was terminated due to auger refusal.
2. Groundwater measured upond completion of augering was 3.4 m below ground surface.

Chart columns: N Value ■ (15 30 45 60 75); Cu(kPa) (50 100 150 200); K (m/sec) (10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}); W (%) Wp W WL (10 20 30 40 50)

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BOREHOLE LOG

PROJECT: 60522156	**BOREHOLE:** BH 17-8B	1 of 1
Port Severn Area Dams, Fixed Bridge, and Lock Rehabilitation Port Severn, Ontario **Client:** PSGWS	**Northing:** N/A **Easting:** N/A **Methodology:** HQ Coring **Contractor:** Walker Drilling	**DATE:** January 13, 2017 **LOGGED BY** AR **GROUND ELEV** N/A m ASL

DEPTH (m)	STRATIGRAPHY	SOIL/ROCK DESCRIPTION	MONITOR DETAILS	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% TCR	% RQD
		Coring through overburden								
3.7		**BEDROCK:** amphibolite, black amphibole minerals and plagioclase feldspar, unweathered, very strong strength, joints are at close to wide spacing, diagonal cross joints, joint surface are rough undulating, some clay, silt filling at 4.3 m				HQ			97	64
						HQ			100	100
6.7		**End of Borehole** 1. BH 17-8B was advanced adjacent to BH 17-8A. 2. No samples were collected from overburden.								

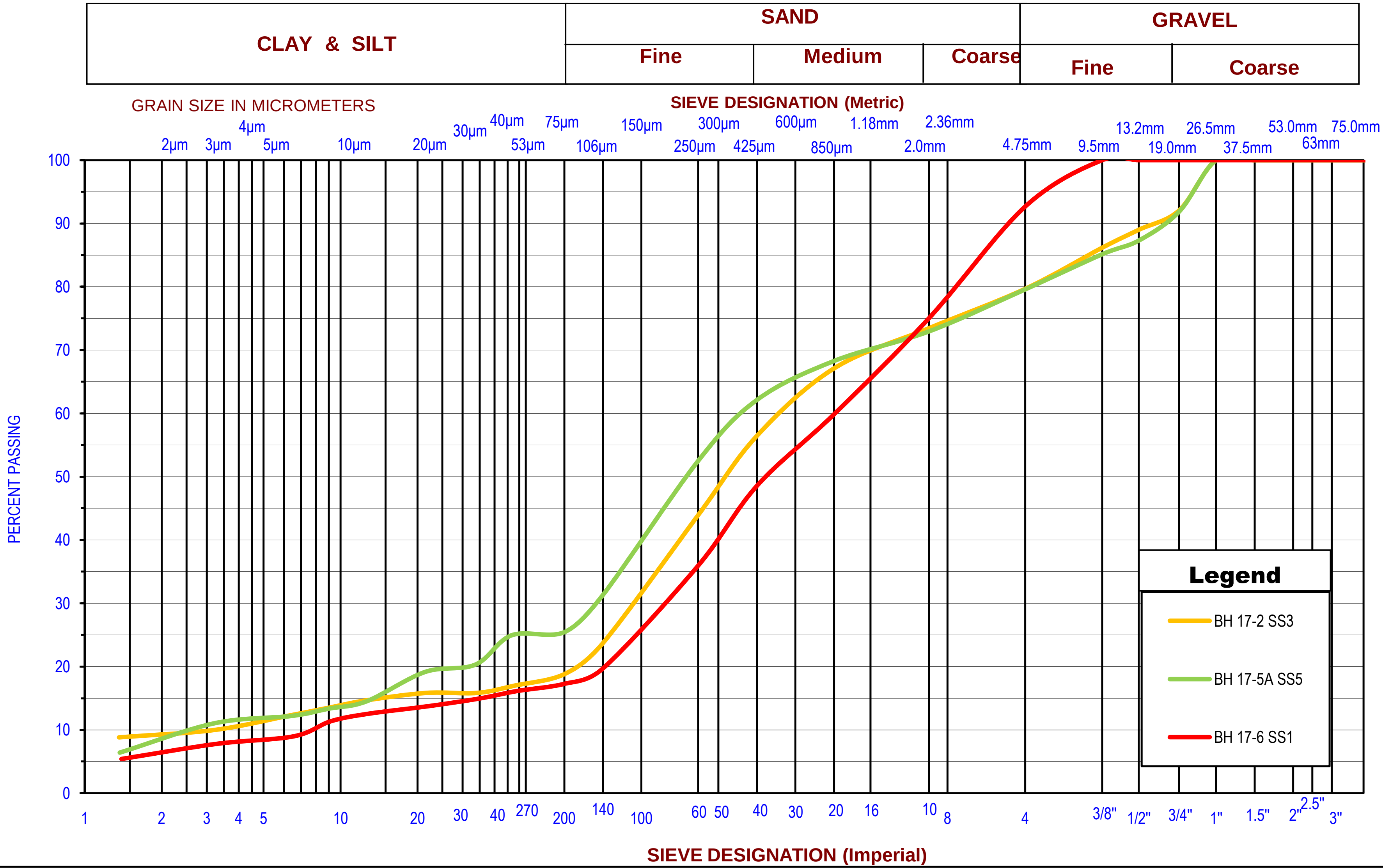
Chart axes: N Value ■ 15 30 45 60 75; C_u(kPa) ⊕ ◆ ⊙ 50 100 150 200; K (m/sec) 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10}; W (%) W_P W W_L 10 20 30 40 50

Appendix C

Laboratory Test Results

AECOM Canada Ltd.

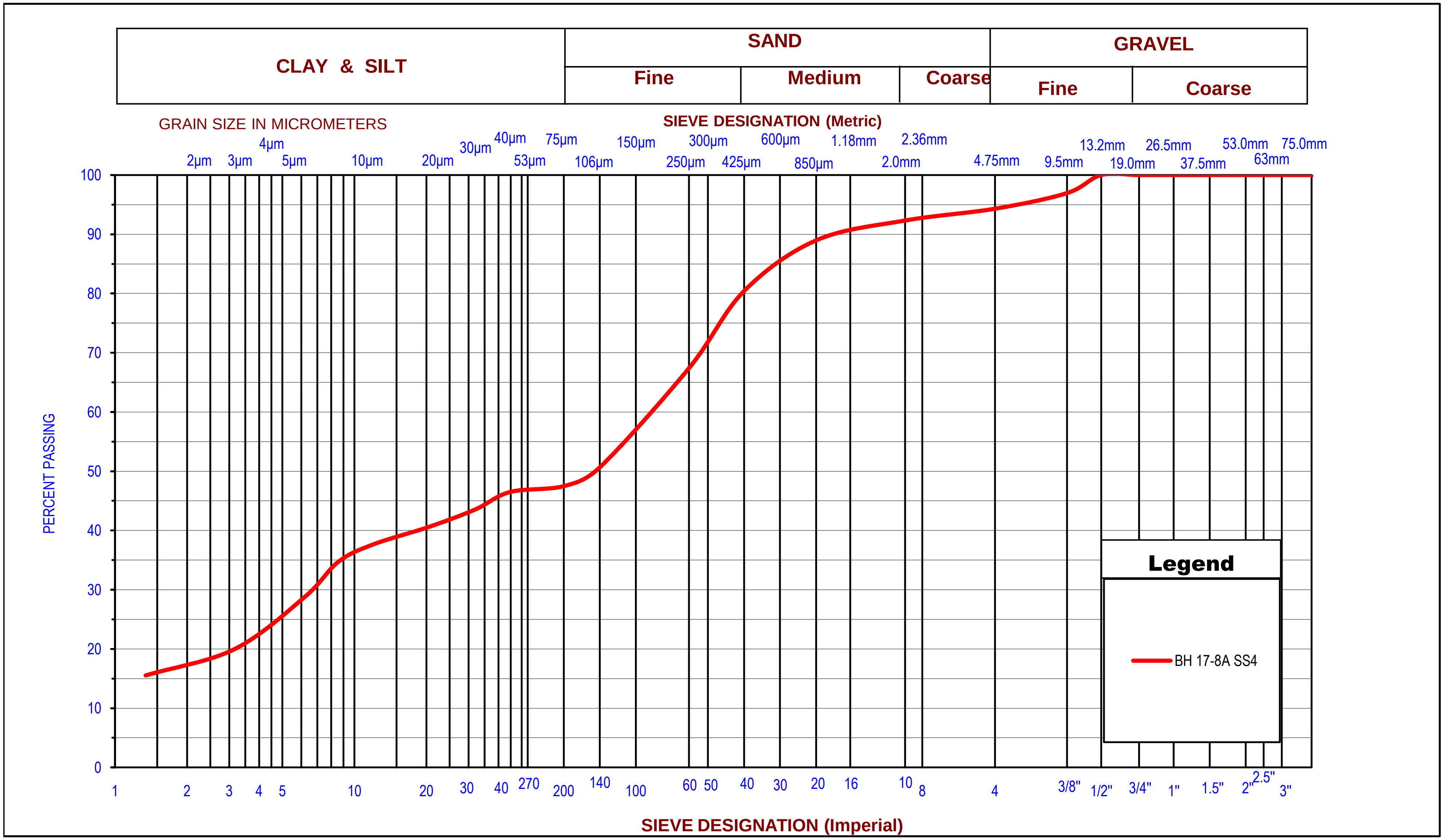
UNIFIED SOIL CLASSIFICATION SYSTEM



AECOM CANADA LTD. 83 Galaxy Blvd, Unit 6 Toronto, Ontario	**GRAIN SIZE DISTRIBUTION**	**Project No: 60522156**
		Project: Port Severn Dam Rehabilitation, Port Severn
	FILL - Sand, trace gravel to gravelley	**Sample Id: BH 17-2 SS3, BH 17-5A SS5, BH 17-6 SS1**
	AECOM Lab# 201701003S	**Date: Feb , 2017** — **FIGURE: GS-1**

AECOM Canada Ltd.

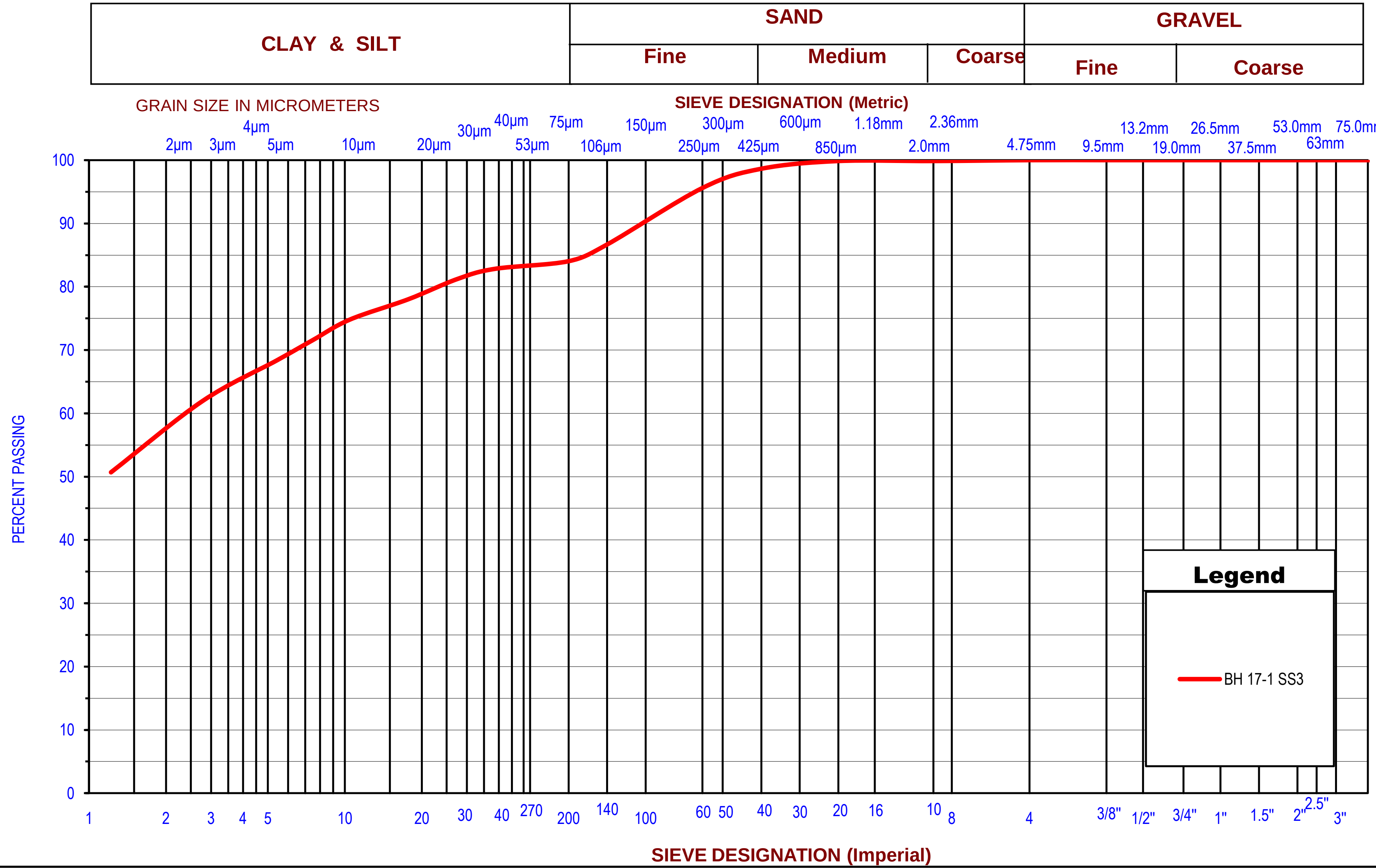
UNIFIED SOIL CLASSIFICATION SYSTEM



AECOM CANADA LTD. 83 Galaxy Blvd, Unit 6 Toronto, Ontario	**GRAIN SIZE DISTRIBUTION**	**Project No: 60522156** **Project: Port Severn Dam Rehabilitation, Port Severn**
	FILL - Clayey Silt **AECOM Lab# 201701003S**	**Sample Id: BH 17-8A SS4** **Date: Feb , 2017** — **FIGURE: GS-2**

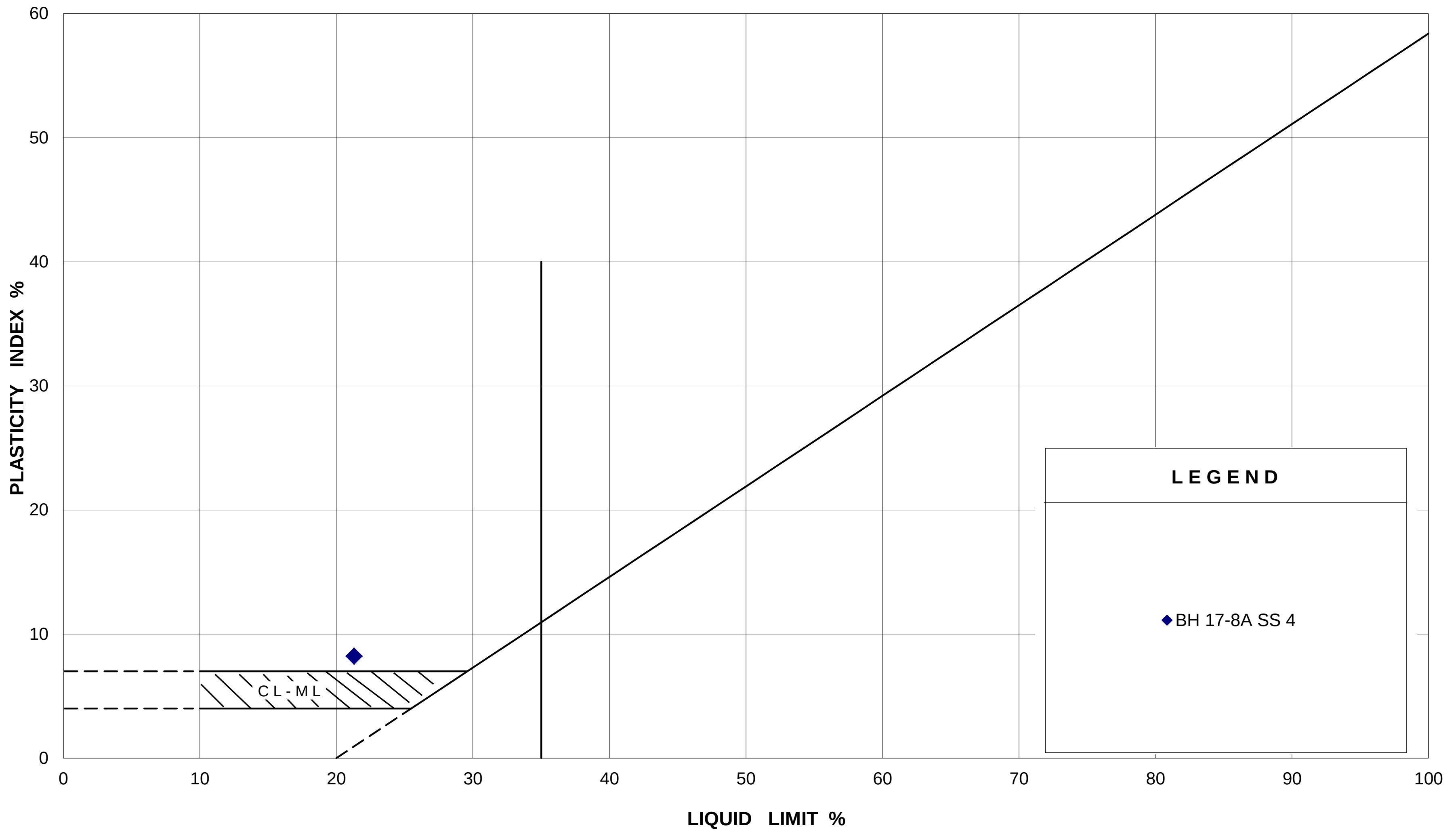
AECOM Canada Ltd.

UNIFIED SOIL CLASSIFICATION SYSTEM

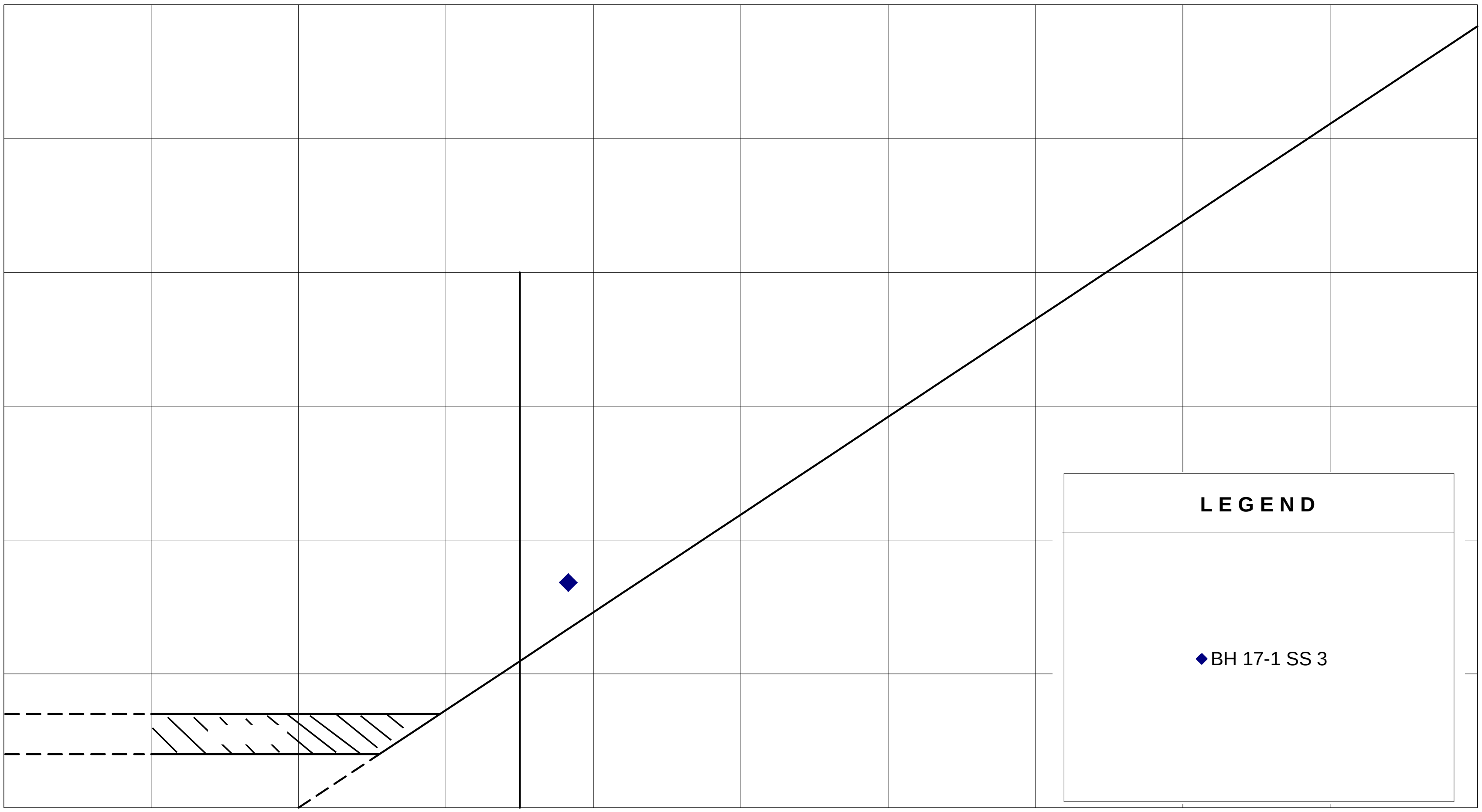


AECOM CANADA LTD. 83 Galaxy Blvd, Unit 6 Toronto, Ontario	**GRAIN SIZE DISTRIBUTION**	**Project No: 60522156**
		Project: Port Severn Dam Rehabilitation, Port Severn
	SILTY CLAY	**Sample Id: BH 17-1, SS3 Top**
	AECOM Lab# 201701003S	**Date: Feb , 2017** — **FIGURE: GS-3**

AECOM Canada Ltd.



AECOM CANADA LTD. 83 Galaxy Blvd, Unit 6 Toronto, Ontario	**PLASTICITY CHART**	**Project No: 60522156**	
		Project: Port Severn Dam Rehabilitation, Port Severn	
	FILL-Clayey Silt	**Sample Id: BH 17-8A SS4**	
	AECOM Lab#	**Date: Feb., 2017**	**FIGURE: AL-1**



AECOM Lab#

Date: Feb., 2017

FIGURE: AL-2

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CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT	AECOM	PML REF	16TM256
PROJECT	Port Severn Dam Rehabilitation	LAB NO.	1700253 A
SAMPLE IDENTIFICATION	BH-D-W (13.5' TO 14.4')	DATE SAMPLED	

BH 17-3 (Depth 4.1 m)

DATE TESTED	207-02-08
TESTED BY	AO/DK

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4807	TEST TIME (min) (spec. 2 to 15)	7:51
SPECIMEN LENGTH (in.)	5.296	MAXIMUM LOAD APPLIED (kN)	429.25
	5.305		
	5.311	COMPRESSIVE STRENGTH (MPa)	137.7
AVE.	5.304	TYPE OF FAILURE	3
SURFACE AREA (sq mm)	3118	LENGTH TO DIAMETER RATIO (spec 2-2.5)	2.14

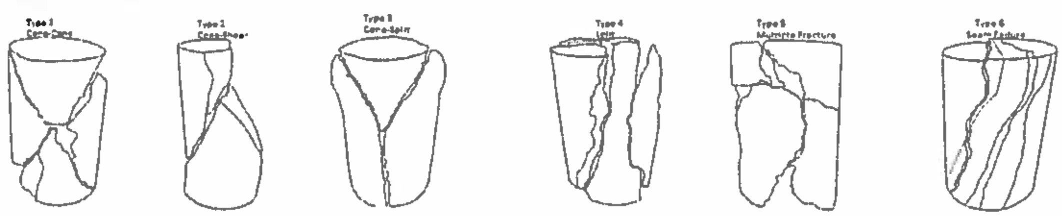
MOISTURE CONTENT

WEIGHT OF WET SAMPLE + TARE (g)	1113.78
WEIGHT OF DRY SAMPLE + TARE (g)	1111.76
WEIGHT OF WATER (g)	2.02
WEIGHT OF TARE (g)	100.47
WEIGHT OF DRY SAMPLE (g)	1011.29
MOISTURE CONTENT (%)	0.2

UNIT WEIGHT

WEIGHT OF DRY SAMPLE IN AIR (g)	1108.73
VOLUME OF SAMPLE (cu m)	0.000420
UNIT WEIGHT (kg/cu m)	2639

REMARKS



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ROCK CORE TESTING

CLIENT AECOM
PROJECT Port Severn Dam Rehabilitation
SAMPLE IDENTIFICATION BH-D-W (13.5' TO 14.4')

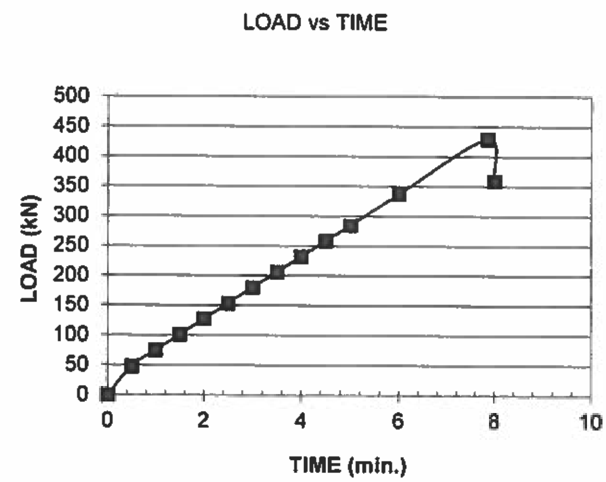
BH 17-3 (Depth 4.1 m)

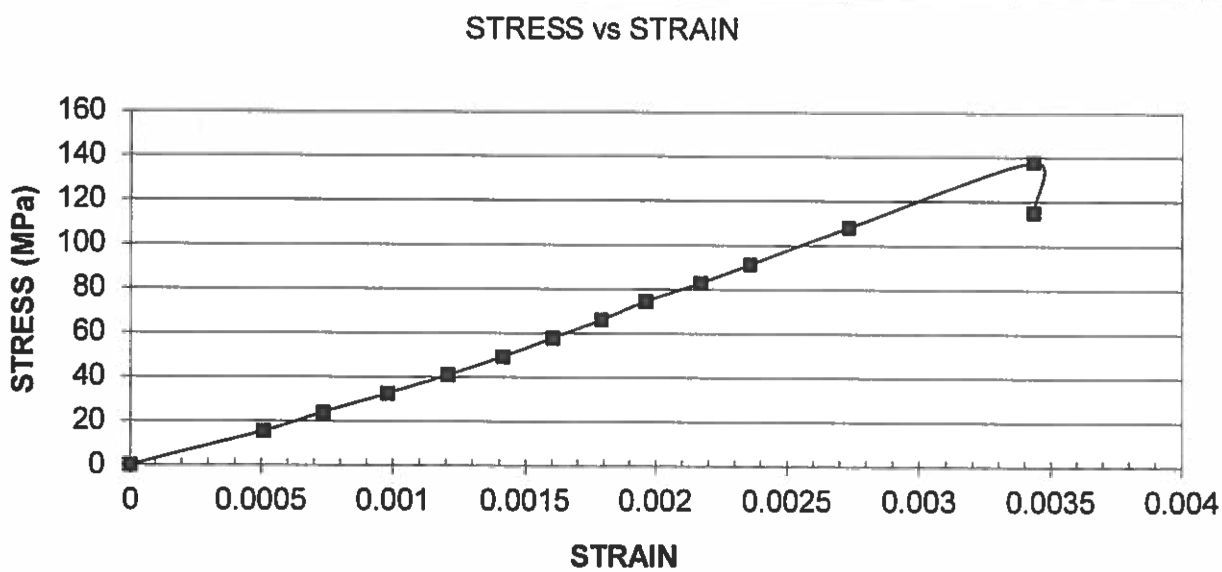
PML REF 16TM256
LAB NO. 1700253 A
DATE SAMPLED

DATE TESTED 08/02/2017
TESTED BY AO/DK

UNCONFINED COMPRESSIVE STRENGTH CURVE

TIME (min.)	STRAIN	LOAD (kN)	STRESS (MPa)
0	0	0	0
0.5	0.0005	48.13	15.4
1	0.0007	74.73	24.0
1.5	0.0010	101.01	32.4
2	0.0012	127.27	40.8
2.5	0.0014	153.46	49.2
3	0.0016	179.75	57.6
3.5	0.0018	205.90	66.0
4	0.0020	232.04	74.4
4.5	0.0022	258.18	82.8
5	0.0024	284.40	91.2
6	0.0027	336.61	108.0
7.85	0.0034	429.25	137.7
8	0.0034	358.72	115.0





Peto MacCallum Ltd.
CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT AECOM
PROJECT Port Severn Dam Rehabilitation
SAMPLE IDENTIFICATION UCS2, BH D-W, 25'8"-26'6"

BH 17-3 (Depth 7.8 m)

PML REF 16TM256
LAB NO. 1700253 B
DATE SAMPLED

DATE TESTED 01/02/2017
TESTED BY BM

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4793	TEST TIME (min) (spec. 2 to 15)	5:53
SPECIMEN LENGTH (in.)	5.122	MAXIMUM LOAD APPLIED (kN)	322.3
	5.171		
	5.175	COMPRESSIVE STRENGTH (MPa)	103.1
AVE.	5.156	TYPE OF FAILURE	
SURFACE AREA (sq mm)	3115	LENGTH TO DIAMETER RATIO (spec 2-2.5)	2.08

MOISTURE CONTENT

WEIGHT OF WET SAMPLE + TARE (g)	1182.11
WEIGHT OF DRY SAMPLE + TARE (g)	1181.60
WEIGHT OF WATER (g)	0.51
WEIGHT OF TARE (g)	0.00
WEIGHT OF DRY SAMPLE (g)	1181.60
MOISTURE CONTENT (%)	0.04

UNIT WEIGHT

WEIGHT OF DRY SAMPLE IN AIR (g)	1184.20
VOLUME OF SAMPLE (cu m)	0.000408
UNIT WEIGHT (kg/cu m)	2903

REMARKS

Peto MacCallum Ltd.
CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT AECOM
PROJECT Port Severn Dam Rehabilitation
SAMPLE IDENTIFICATION UCS2, BH D-W, 25'8"-26'6"

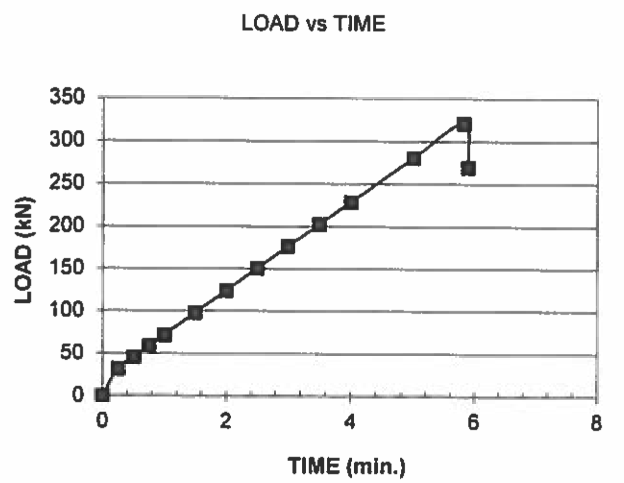
BH 17-3 (Depth 7.8 m)

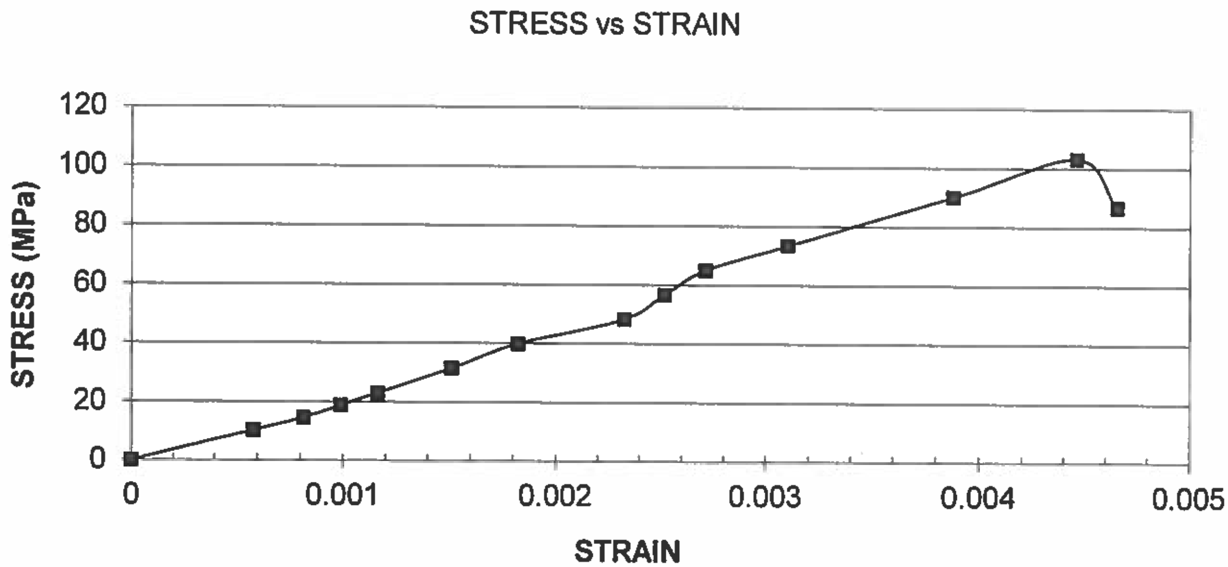
PML REF 16TM256
LAB NO. 1700253 B
DATE SAMPLED

DATE TESTED 01/02/2017
TESTED BY BM

UNCONFINED COMPRESSIVE STRENGTH CURVE

TIME (min.)	STRAIN (in.)	LOAD (kN)	STRESS (MPa)
0	0	0	0
0.25	0.0006	31.93	10.3
0.5	0.0008	45.33	14.6
0.75	0.0010	58.44	18.8
1	0.0012	71.57	23.0
1.5	0.0015	97.97	31.5
2	0.0018	124.11	39.8
2.5	0.0023	150.32	48.3
3	0.0025	176.34	56.6
3.5	0.0027	202.41	65.0
4	0.0031	228.57	73.4
5	0.0039	280.58	90.1
5.822	0.0045	321.22	103.1
5.891	0.0047	269.90	86.7





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ROCK CORE TESTING

CLIENT AECOM
PROJECT Port Severn Dam Rehabilitation
SAMPLE IDENTIFICATION UCS3, BH SL, 10'4"-11'2"

BH 17-5B (Depth 3.1 m)

PML REF 16TM256
LAB NO. 1700253 C
DATE SAMPLED

DATE TESTED 01/02/2017
TESTED BY BM

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4743	TEST TIME (min) (spec. 2 to 15)	7:42
SPECIMEN LENGTH (in.)	5.079	MAXIMUM LOAD APPLIED (kN)	420.7
	5.063		
	5.081	COMPRESSIVE STRENGTH (MPa)	135.6
AVE.	5.074	TYPE OF FAILURE	
SURFACE AREA (sq mm)	3102	LENGTH TO DIAMETER RATIO (spec 2-2.5)	2.05

MOISTURE CONTENT

WEIGHT OF WET SAMPLE + TARE (g)	1014.92
WEIGHT OF DRY SAMPLE + TARE (g)	1014.33
WEIGHT OF WATER (g)	0.59
WEIGHT OF TARE (g)	0.00
WEIGHT OF DRY SAMPLE (g)	1014.33
MOISTURE CONTENT (%)	0.1

UNIT WEIGHT

WEIGHT OF DRY SAMPLE IN AIR (g)	1017.40
VOLUME OF SAMPLE (cu m)	0.000400
UNIT WEIGHT (kg/cu m)	2545

REMARKS

Peto MacCallum Ltd.
CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT AECOM
PROJECT Port Severn Dam Rehabilitation
SAMPLE IDENTIFICATION UCS3, BH SL, 10'4"-11'2"

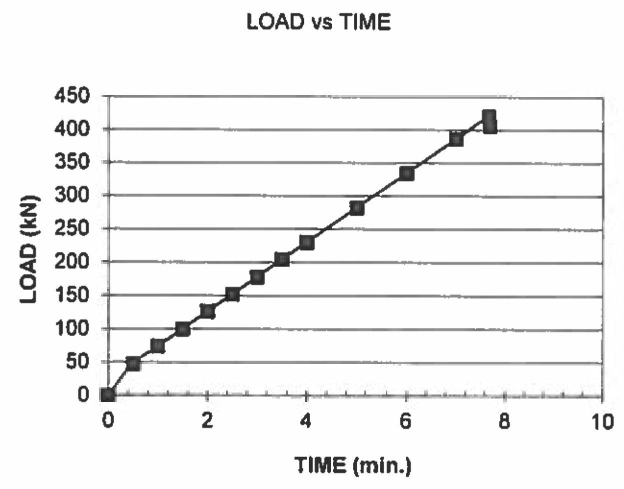
BH 17-5B (Depth 3.1 m)

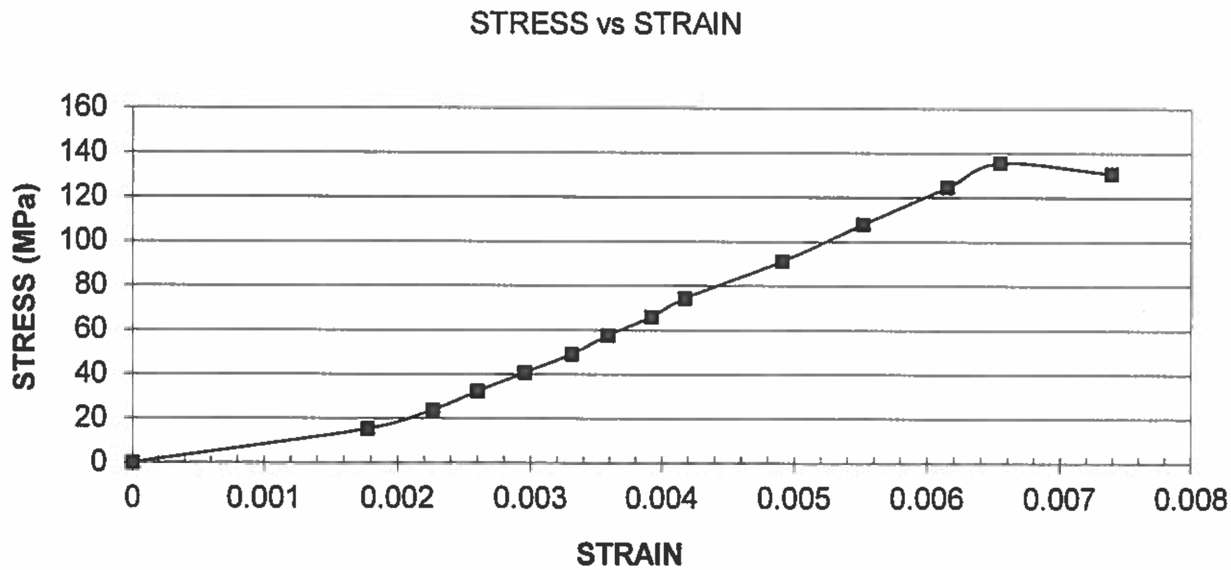
PML REF 16TM256
LAB NO. 1700253 C
DATE SAMPLED

DATE TESTED 01/02/2017
TESTED BY DK

UNCONFINED COMPRESSIVE STRENGTH CURVE

TIME (min.)	STRAIN	LOAD (kN)	STRESS (MPa)
0	0	0	0
0.5	0.0018	47.27	15.2
1	0.0023	73.69	23.8
1.5	0.0026	99.83	32.2
2	0.0030	126.10	40.6
2.5	0.0033	152.20	49.1
3	0.0036	178.16	57.4
3.5	0.0039	204.26	65.8
4	0.0042	230.22	74.2
5	0.0049	282.31	91.0
6	0.0055	334.43	107.8
7	0.0061	386.41	124.6
7.676	0.0065	420.74	135.6
7.7	0.0074	406.00	130.9





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ROCK CORE TESTING

CLIENT	AECOM	PML REF	16TM256
PROJECT	Port Severn Dam Rehabilitation	LAB NO.	1700253 D
SAMPLE IDENTIFICATION	BH-NE (DAM E - 6' 4")	DATE SAMPLED	
	BH 17-6 (Depth 1.9 m)		
		DATE TESTED	08/02/2017
		TESTED BY	AO/DK

UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4863	TEST TIME (min) (spec. 2 to 15)	9:52
SPECIMEN LENGTH (in.)	4.947	MAXIMUM LOAD APPLIED (kN)	517.95
	4.948		
	4.943	COMPRESSIVE STRENGTH (MPa)	165.4
AVE.	4.946	TYPE OF FAILURE	1
SURFACE AREA (sq mm)	3132	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.99

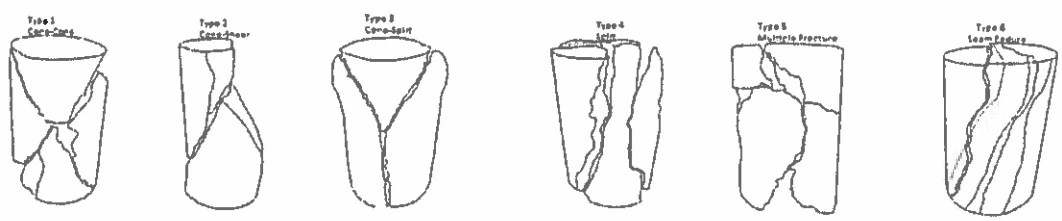
MOISTURE CONTENT

WEIGHT OF WET SAMPLE + TARE (g)	965.76
WEIGHT OF DRY SAMPLE + TARE (g)	965.36
WEIGHT OF WATER (g)	0.40
WEIGHT OF TARE (g)	117.87
WEIGHT OF DRY SAMPLE (g)	847.49
MOISTURE CONTENT (%)	0.05

UNIT WEIGHT

WEIGHT OF DRY SAMPLE IN AIR (g)	1068.30
VOLUME OF SAMPLE (cu m)	0.000394
UNIT WEIGHT (kg/cu m)	2715

REMARKS



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ROCK CORE TESTING

CLIENT AECOM
PROJECT Port Severn Dam Rehabilitation
SAMPLE IDENTIFICATION BH-NE (DAM E - 6' 4")

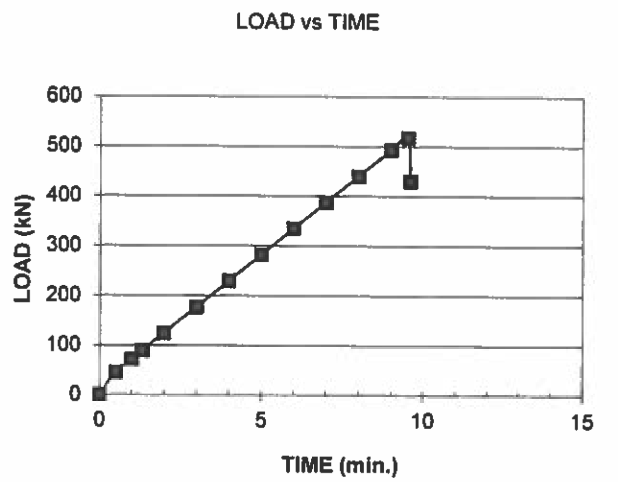
BH 17-6 (Depth 1.9 m)

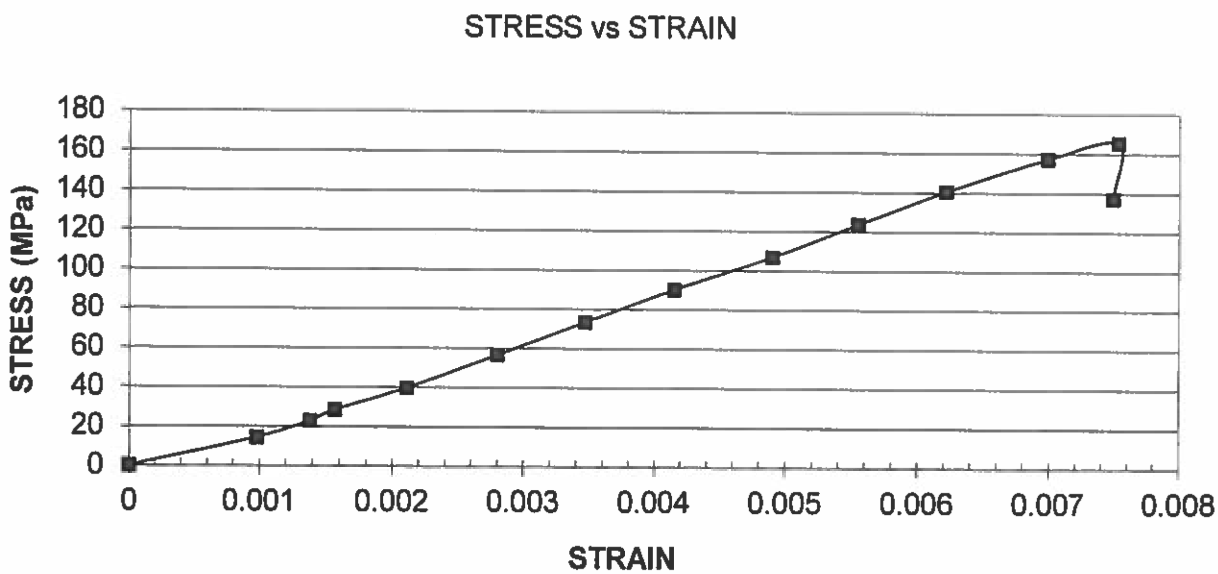
PML REF 16TM256
LAB NO. 1700253 D
DATE SAMPLED

DATE TESTED 08/02/2017
TESTED BY AO/DK

UNCONFINED COMPRESSIVE STRENGTH CURVE

TIME (min.)	STRAIN	LOAD (kN)	STRESS (MPa)
0	0	0	0
0.5	0.0010	45.37	14.5
1	0.0014	71.84	22.9
1.33	0.0016	89.22	28.5
2	0.0021	124.56	39.8
3	0.0028	177.07	56.5
4	0.0035	229.67	73.3
5	0.0042	282.24	90.1
6	0.0049	334.81	106.9
7	0.0055	387.38	123.7
8	0.0062	440.00	140.5
9	0.0070	492.52	157.2
9.52	0.0075	518.34	165.5
9.6	0.0075	429.76	137.2





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CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT	AECOM	PML REF	16TM256
PROJECT	Material Testing Services	LAB NO.	1700253 F
SAMPLE IDENTIFICATION	BH G, Sa 5, 17' 2" - 17" 9"	DATE SAMPLED	
	BH 17-8B (Depth 5.2 m)		
		DATE TESTED	2017-02-17
		TESTED BY	Ali/BM

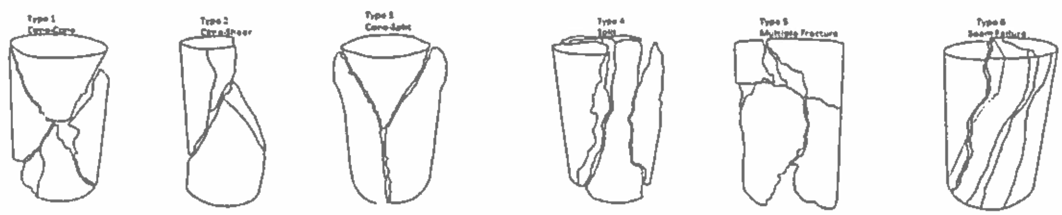
UNCONFINED COMPRESSIVE STRENGTH

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4800	TEST TIME (min) (spec. 2 to 15)	07:50
SPECIMEN LENGTH (in.)	5.586	MAXIMUM LOAD APPLIED (kN)	434.9
	5.597		
	5.590	COMPRESSIVE STRENGTH (MPa)	139.5
AVE.	5.591	TYPE OF FAILURE	1
SURFACE AREA (sq mm)	3116	LENGTH TO DIAMETER RATIO (spec 2-2.5)	2.25

MOISTURE CONTENT / UNIT WEIGHT

MOISTURE CONTENT		UNIT WEIGHT	
WEIGHT OF WET SAMPLE + TARE (g)	1323.50	WEIGHT OF DRY SAMPLE IN AIR (g)	1340.55
WEIGHT OF DRY SAMPLE + TARE (g)	1321.79	VOLUME OF SAMPLE (cu m)	0.000443
WEIGHT OF WATER (g)	1.71	UNIT WEIGHT (kg/cu m)	3029
WEIGHT OF TARE (g)	0.00		
WEIGHT OF DRY SAMPLE (g)	1321.79		
MOISTURE CONTENT (%)	0.1		

REMARKS



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CONSULTING ENGINEERS

ROCK CORE TESTING

CLIENT AECOM
PROJECT Material Testing Services
SAMPLE IDENTIFICATION BH G, Sa 5, 17' 2" - 17" 9"

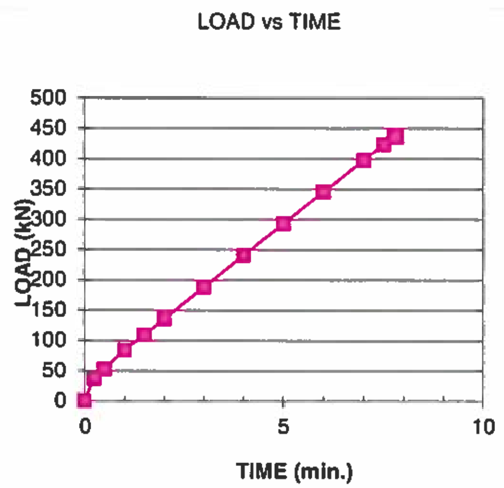
BH 17-8B (Depth 5.2 m)

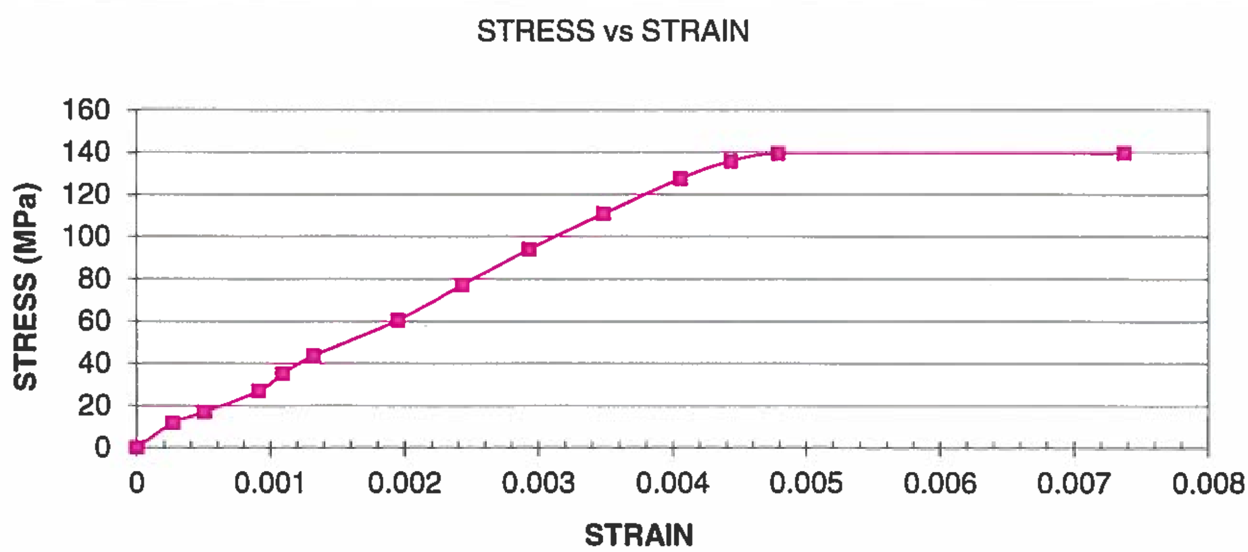
PML REF 16TM256
LAB NO. 1700253 F
DATE SAMPLED

DATE TESTED 2017-02-17
TESTED BY Ali/BM

UNCONFINED COMPRESSIVE STRENGTH CURVE

TIME (min.)	DEFLECTION (in)	LOAD (kN)	STRESS (MPa)	STRAIN (mm/mm)
0	0.074	0	0	0
0.25	0.0755	36.80	11.8	0.0003
0.50	0.0768	52.80	16.9	0.0005
1.00	0.0791	83.90	26.9	0.0009
1.50	0.0801	109.00	35.0	0.0011
2.00	0.0814	135.20	43.4	0.0013
3.00	0.0849	187.90	60.3	0.0019
4.00	0.0876	240.10	77.0	0.0024
5.00	0.0904	292.40	93.8	0.0029
6.00	0.0935	345.10	110.7	0.0035
7.00	0.0967	397.00	127.4	0.0041
7.50	0.0988	422.90	135.7	0.0044
7.75	0.1008	434.30	139.4	0.0048
7.83	0.1152	434.90	139.5	0.0074



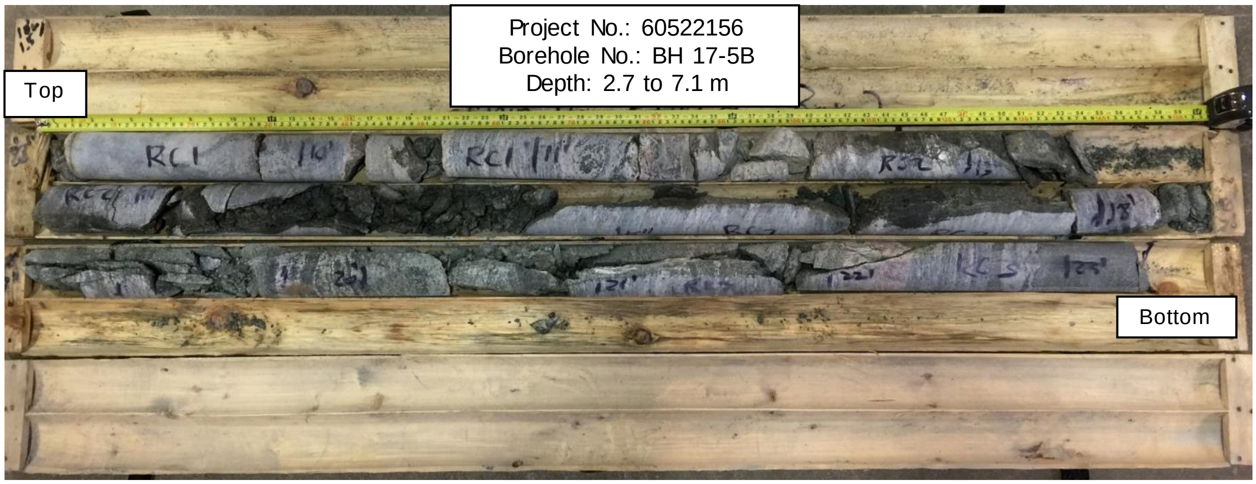


Appendix D

Bedrock Core and Concrete Core Photos

Core Photo 1: Concrete Cores from CH 17-4 from 0.0 to 3.2 m

Core Photo 2: Rock Cores from BH 17-3 from 3.2 to 8.1 m



Core Photo 3: Rock Cores from BH 17-5B from 2.7 to 7.1 m

Core Photo 4: Rock Cores from BH 17-6 from 0.8 to 3.4 m

Core Photo 5: Rock Cores from BH 17-7 from 0.6 to 2.1 m

Core Photo 6: Rock Cores from BH 17-8B from 3.7 to 6.7 m

AECOM

Appendix E

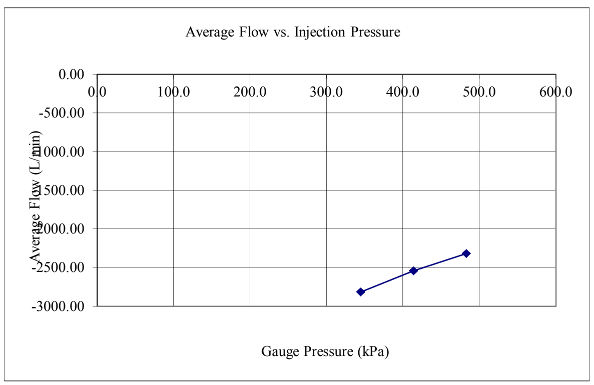
Packer Test Field Sheets

AECOM

Borehole Packer Testing Record

Project:	Port Severn	Project Number:	60522156	Borehole Name:	17-6
Area:	Dam E - NE Corner	Drill Type:	D-50 Turbo	Date:	9-Jan-17
Elevation (m ASL)		Borehole Size:	HQ	Test Number (m):	1
Dip (from horizontal):	90	Depth to Groundwater (m):	0.61 est.	Top of Test Interval (m down hole):	1.9
Coordinates (NAD83):	N	Gauge height above Ground (m):	1.00	Bottom of test Interval (m downhole):	3.4
	E				

Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8			Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	22.509	22.583	22.624	22.668	22.708	22.753						(L/min)	(m/s)
		Take	(L)		74.00	41.00	44.00	40.00	45.00	-22753.00	0.00	0.00				
344.8	35.16	Average Take	(L/min)		74.00	41.00	44.00	40.00	45.00	-22753.00	0.00	0.00			-2813.63	-6.51E-04
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9		Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	22.870	22.917	22.966	23.015	23.065	23.101						(L/min)	(m/s)
		Take	(L)		47.00	49.00	49.00	50.00	36.00	-23101.00	0.00	0.00	0.00			
413.8	42.20	Average Take	(L/min)		47.00	49.00	49.00	50.00	36.00	-23101.00	0.00	0.00	0.00		-2541.11	-4.94E-04
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	23.180	23.228	23.268	23.297	23.325							(L/min)	(m/s)
		Take	(L)		48.00	40.00	29.00	28.00	-23325.00	0.00	0.00	0.00	0.00	0.00		
482.7	49.23	Average Take	(L/min)		48.00	40.00	29.00	28.00	-23325.00	0.00	0.00	0.00	0.00	0.00	-2318.00	-3.88E-04
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)												(L/min)	(m/s)
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)												(L/min)	(m/s)
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00



Test Interval Bedrock Description:

migmatite gneiss

Assumed Parameters:

Friction Losses	0	m
Radius of Influence	5	m
Radius of Borehole	0.048	m

Hydraulic Conductivity:

	cm/s	m/s
Minimum	-6.51E-02	-6.51E-04
Maximum	0.00E+00	0.00E+00
Average	**-3.07E-02**	**-3.07E-04**

Testing Conducted By: A. Rauf

Measurement of Static Water Level:

Measured

Inferred If yes, define:

Drilling/Test Results and Comments:

Inj. Pressure gauge not sensitive, test stopped as pressure gauge became unresponsive

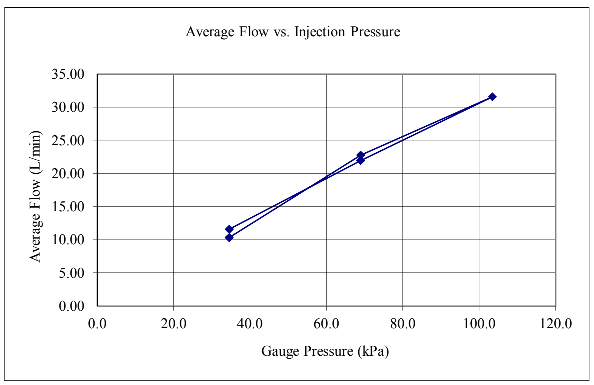
Packer pressure check 350/350

AECOM

Borehole Packer Testing Record

Project:	Port Severn	Project Number:	60522156	Borehole Name:	17-6
Area:	Dam E - NE Corner	Drill Type:	D-50 Turbo	Date:	13-Jan-17
Elevation (m ASL)		Borehole Size:	HQ	Test Number (m):	2
Dip (from horizontal):	90	Depth to Groundwater (m):	0.65 est.	Top of Test Interval (m down hole):	1.9
Coordinates (NAD83):	N	Gauge height above Ground (m):	1.00	Bottom of test Interval (m downhole):	3.4
	E				

Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8			Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	23.385	23.396	23.407	23.419	23.431	23.443						(L/min)	(m/s)
		Take	(L)		11.00	11.00	12.00	12.00	12.00							
34.5	3.52	Average Take	(L/min)		11.00	11.00	12.00	12.00	12.00						11.60	1.87E-05
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9		Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	23.470	23.498	23.513	23.534	23.557	23.580						(L/min)	(m/s)
		Take	(L)		28.00	15.00	21.00	23.00	23.00							
69.0	7.03	Average Take	(L/min)		28.00	15.00	21.00	23.00	23.00						22.00	2.11E-05
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	23.690	23.720	23.752	23.785	23.816	23.848						(L/min)	(m/s)
		Take	(L)		30.00	32.00	33.00	31.00	32.00							
103.4	10.55	Average Take	(L/min)		30.00	32.00	33.00	31.00	32.00						31.60	2.16E-05
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	23.8700	23.8950	23.9150	23.9370	23.9670	23.9840						(L/min)	(m/s)
		Take	(L)		25.00	20.00	22.00	30.00	17.00							
69.0	7.03	Average Take	(L/min)		25.00	20.00	22.00	30.00	17.00						22.80	2.19E-05
Gauge P	Gauge P	Time	(min)	0	1	2	2.7166667	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	23.9950	24.0050	24.0190	24.0240								(L/min)	(m/s)
		Take	(L)		10.00	14.00	5.00									
34.5	3.52	Average Take	(L/min)		10.00	14.00	6.98								10.33	1.67E-05



Test Interval Bedrock Description:

migmatite gneiss

Assumed Parameters:

Friction Losses	0	m
Radius of Influence	5	m
Radius of Borehole	0.048	m

Hydraulic Conductivity:	cm/s	m/s
Minimum	1.67E-03	1.67E-05
Maximum	2.19E-03	2.19E-05
Average	**2.00E-03**	**2.00E-05**

Testing Conducted By: A. Rauf

Measurement of Static Water Level:

Measured 0.65

Inferred [ ] If yes, define:

Drilling/Test Results and Comments:

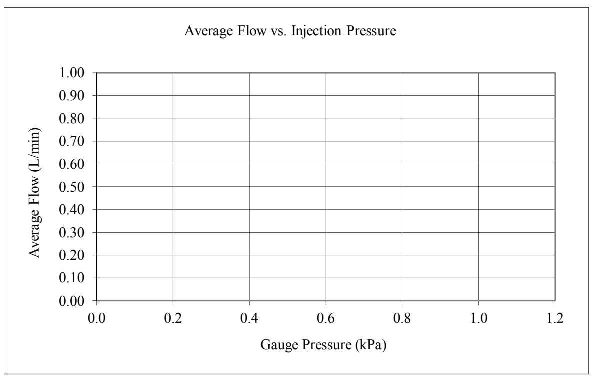
Inflated pressure at 340 psi

AECOM

Borehole Packer Testing Record

Project:	Port Severn	Project Number:	60522156	Borehole Name:	17-8A
Area:	Dam G - North Sidewalk	Drill Type:	D-50 Turbo	Date:	18-Jan-17
Elevation (m ASL)		Borehole Size:	HQ	Test Number (m):	1
Dip (from horizontal):	90	Depth to Groundwater (m):	3.40 est.	Top of Test Interval (m down hole):	5.0
Coordinates (NAD83):	N E	Gauge height above Ground (m):	0.79	Bottom of test Interval (m downhole):	6.7

Gauge P (kPa)	Gauge P (m H2O)														Avg. Flow (L/min)	K (m/s)
increasing		Time	(min)	0	1	2	3	4	5	6	7	8				
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9		Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00



Test Interval Bedrock Description:

amphibolite

Assumed Parameters:

Friction Losses	0	m
Radius of Influence	5	m
Radius of Borehole	0.048	m

Hydraulic Conductivity:	cm/s	m/s
Minimum	0.00E+00	0.00E+00
Maximum	0.00E+00	0.00E+00
Average	**0.00E+00**	**0.00E+00**

Testing Conducted By: A. Rauf

Measurement of Static Water Level:

Measured: 3.4

Inferred: If yes, define:

Drilling/Test Results and Comments:

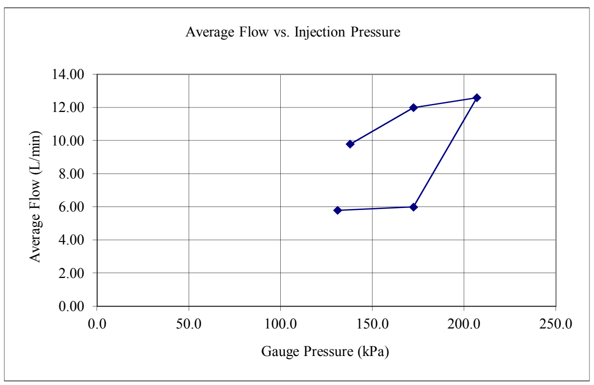
Drilled on Fri Jan. 13, 2017. Casing stickup = 2.6', bedrock at 12' bgs, top of packer ~14' bgs

Borehole Packer Testing Record

AECOM

Project:	Port Severn	Project Number:	60522156	Borehole Name:	17-5B
Area:	South Lock	Drill Type:	D-50 Turbo	Date:	20-Jan-17
Elevation (m ASL)		Borehole Size:	HQ	Test Number (m):	1
Dip (from horizontal):	90	Depth to Groundwater (m):	1.02 est.	Top of Test Interval (m down hole):	1.9
Coordinates (NAD83):	N E	Gauge height above Ground (m):	0.41	Bottom of test Interval (m downhole):	3.4

Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8			Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	24.196	24.201	24.205	24.214	24.220	24.225						(L/min)	(m/s)
		Take	(L)		5.00	4.00	9.00	6.00	5.00							
131.0	13.36	Average Take	(L/min)		5.00	4.00	9.00	6.00	5.00						5.80	3.34E-06
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9		Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	24.240	24.246	24.252	24.258	24.263	24.270						(L/min)	(m/s)
		Take	(L)		6.00	6.00	6.00	5.00	7.00							
172.4	17.58	Average Take	(L/min)		6.00	6.00	6.00	5.00	7.00						6.00	2.69E-06
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	24.281	24.291	24.303	24.316	24.330	24.344						(L/min)	(m/s)
		Take	(L)		10.00	12.00	13.00	14.00	14.00							
206.9	21.10	Average Take	(L/min)		10.00	12.00	13.00	14.00	14.00						12.60	4.76E-06
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	24.3600	24.3720	24.3800	24.3960	24.4080	24.4200						(L/min)	(m/s)
		Take	(L)		12.00	8.00	16.00	12.00	12.00							
172.4	17.58	Average Take	(L/min)		12.00	8.00	16.00	12.00	12.00						12.00	5.37E-06
Gauge P	Gauge P	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow	K
(kPa)	(m H2O)	Flow Meter	(m^3)	24.4300	24.4400	24.4500	24.4600	24.4700	24.4790						(L/min)	(m/s)
		Take	(L)		10.00	10.00	10.00	10.00	9.00							
137.9	14.07	Average Take	(L/min)		10.00	10.00	10.00	10.00	9.00						9.80	5.38E-06



Test Interval Bedrock Description:

migmatite gneiss

Assumed Parameters:

Friction Losses	0	m
Radius of Influence	5	m
Radius of Borehole	0.048	m

Hydraulic Conductivity:

	cm/s	m/s
Minimum	2.69E-04	2.69E-06
Maximum	5.38E-04	5.38E-06
Average	**4.31E-04**	**4.31E-06**

Measurement of Static Water Level:

Measured

Inferred If yes, define:

Testing Conducted By: A. Rauf

Drilling/Test Results and Comments:

nearby (open channel) was is 1.07mbgs

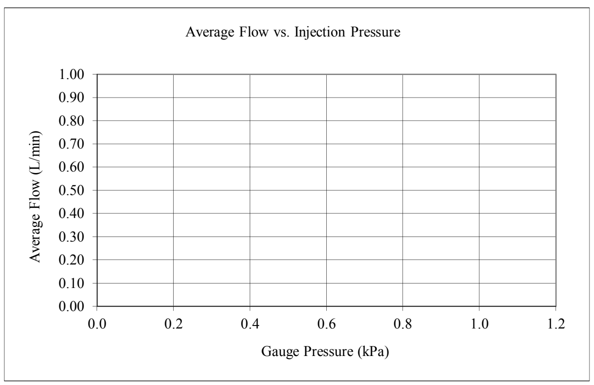
packer inflated to 350 psi

Borehole Packer Testing Record

AECOM

Project:	Port Severn	Project Number:	60522156	Borehole Name:	17-3
Area:	Dam D - Over Water	Drill Type:	D-50 Turbo	Date:	24-Jan-17
Elevation (m ASL)		Borehole Size:	HQ	Test Number (m):	1
Dip (from horizontal):	90	Depth to Groundwater (m):	2.11 est. below top of Dam	Top of Test Interval (m down hole):	6.6 below top of dam
Coordinates (NAD83):	N E	Gauge height above Ground (m):	0.79 above top of Dam	Bottom of test Interval (m downhole):	8.1 below top of dam

Gauge P (kPa)	Gauge P (m H2O)														Avg. Flow (L/min)	K (m/s)
increasing		Time	(min)	0	1	2	3	4	5	6	7	8				
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9		Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00
Gauge P (kPa)	Gauge P (m H2O)	Time	(min)	0	1	2	3	4	5	6	7	8	9	10	Avg. Flow (L/min)	K (m/s)
		Flow Meter	(m^3)													
		Take	(L)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	0.00	Average Take	(L/min)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00E+00



Test Interval Bedrock Description:

migmatite gneiss

Assumed Parameters:

Friction Losses	0	m
Radius of Influence	5	m
Radius of Borehole	0.048	m

Hydraulic Conductivity:	**cm/s**	**m/s**
Minimum	0.00E+00	0.00E+00
Maximum	0.00E+00	0.00E+00
Average	**0.00E+00**	**0.00E+00**

Testing Conducted By: A. Rauf

Measurement of Static Water Level:

Measured

Inferred   If yes, define:

Drilling/Test Results and Comments:

packer at 17'6" below top of casing, top of bladder = 17'6" + 7" below top of casing

Inflation pressure at 250 psi, 11:30am start packer test, no flow, pressure just built up

About AECOM

AECOM (NYSE: ACM) is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries.

As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges.

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CONCRETE CORING & LABORATORY TESTING REPORT

Public Works & Government Services Canada Solicitation No. EQ754-170947/A
Port Severn Area Dams – Concrete Coring and Laboratory Testing Services
Port Severn, ON

Prepared For:
AECOM

Prepared by:
Bridge Check Canada Ltd.

BCC Project No: BCC15118
Report Date: February 6, 2017

200 Viceroy Road, Unit 4, Vaughan, ON L4K 3N8 Tel: 905-660-6608 Fax: 905-660-6609
www.bridgecheckcanada.com info@bridgecheckcanada.com

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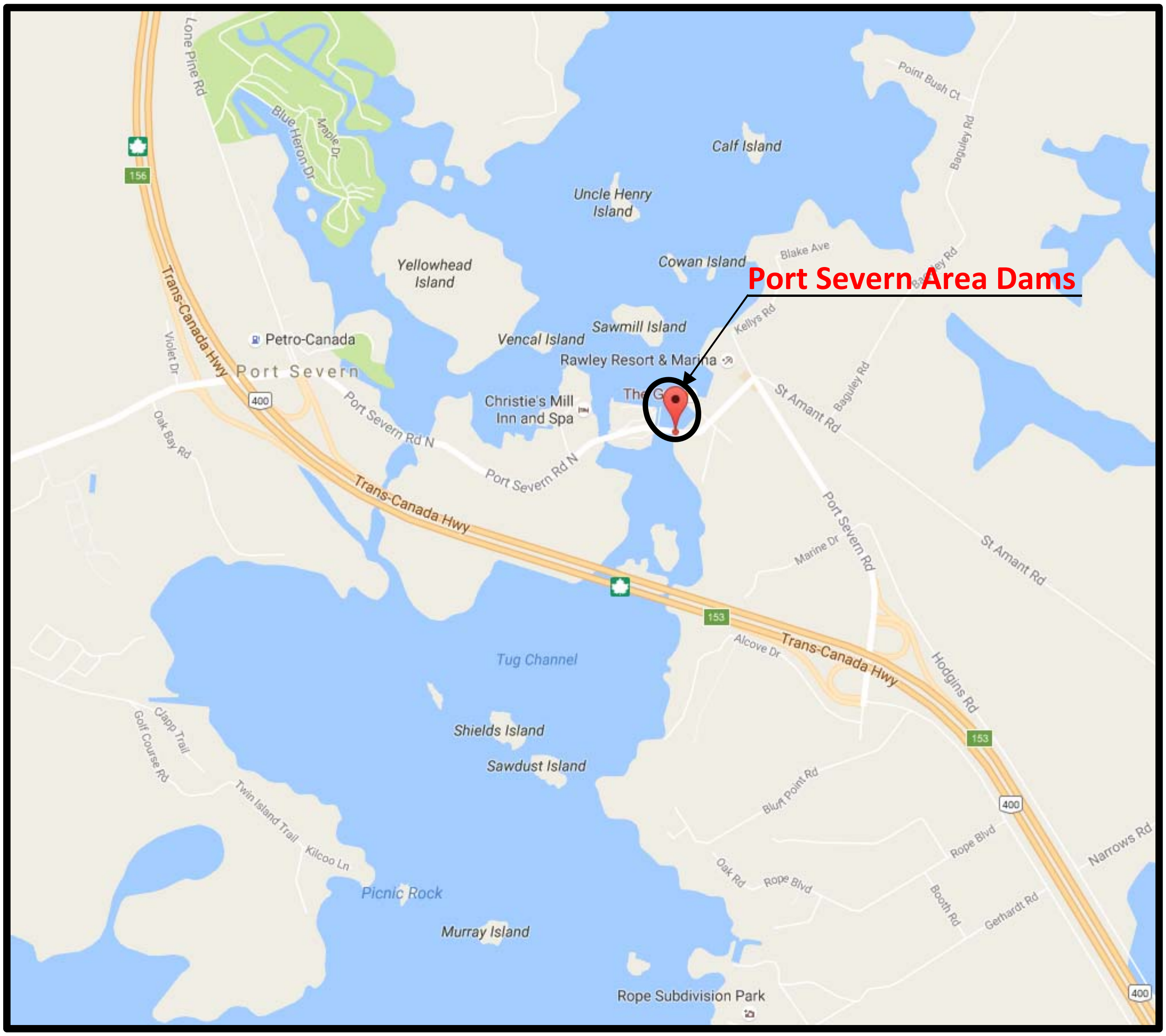
1/ Key Plan

KEY PLAN

Port Severn Area Dams

Port Severn, ON



2/ Summary of Significant Findings

SUMMARY OF SIGNIFICANT FINDINGS

Public Works & Government Services Canada Solicitation No. EQ754-170947/A
Port Severn Area Dams, Port Severn, ON

1.0 INTRODUCTION

Bridge Check Canada Ltd. was retained by AECOM to conduct concrete coring and laboratory testing services for the Port Severn Area Dams in Port Severn, ON. The purpose of this investigation was to determine the quality and condition of the existing concrete structures. This report summarizes the *Bridge Check Canada Ltd.*'s findings, through the field investigations and laboratory testing for the Port Severn Area Dams. The field investigation was carried out on November 22-23, 2016.

2.0 METHODOLOGY

Twenty-six (26) 70mm diameter cores were extracted from the following locations:

- Core C1, C2 - lower approach wall, west
- Core C3, C4 – Lock 45 / Main Dam, common wall
- Core C5, C6 – lower approach wall, east
- Core C7, C8 – upper approach wall, west
- Core C9, C10 – Dam E – Bayview, top of dam wall
- Core C11, C12, C13, C14 – Dam E – Bayview, deck
- Core C15, C16 – Dam E – Bayview, west abutment
- Core C17, C18 – Dam E – Bayview, east abutment
- Core C19, C20 – Dam D, top of wall
- Core C21, C22 – Dam C, top of wall
- Core C23, C24 – Dam G, top of wall
- Core C25, C26 – Dam A, top of wall

In addition, two (2) cores were delivered to our laboratory that were cored from the Main Dam, Pier 2 by AECOM on Jan. 17, 2017. These cores were labelled: RC1 and RC2.

The inside of the coreholes were examined carefully for cracks and the condition of the concrete. All the test holes were reinstated to their original condition using MTO-approved products.

Enclosed with this report are core photos, core logs and laboratory test results.

3.0 SUMMARY OF FINDINGS

A review of the concrete cores revealed the following defects (see Core Photos):

- Core C1 – light rust @ 100mm
- Core C2 – light rust @ 110mm, 120mm
- Core C7 – delamination plane @ 240mm, medium crack
- Core C8 – delamination plane @ 185mm
- Core C13 – medium crack
- Core C19 – medium crack
- Core C20 – delamination plane @ 180mm
- Core C26 – medium crack

Compressive strength testing of the hardened concrete was conducted in accordance with CSA A23.2-14-14C. Test results are summarized below (see Test Reports):

- Lower approach wall, west – 52.2 MPa (Core C1); 46.6 MPa (Core C2)
- Lock 45 / Main Dam, common wall – 47.4 MPa (Core C3); 49.3 MPa (Core C4)
- Lower approach wall, east – 58.9 MPa (Core C5); 44.0 MPa (Core C6)
- Upper approach wall, west – 36.9 MPa (Core C7); 42.4 MPa (Core C8)
- Dam E – Bayview, top of dam wall – 20.7 MPa (Core C9); 22.5 MPa (Core C10)
- Dam E – Bayview, deck – 27.5 MPa (Core C12); 25.4 MPa (Core C14)
- Dam E – Bayview, west abutment – 17.0 MPa (Core C15); 17.9 MPa (Core C16)
- Dam E – Bayview, east abutment – 15.9 MPa (Core C17); 17.1 MPa (Core C18)
- Dam D, top of wall – 14.9 MPa (Core C19); 14.9 MPa (Core C20)
- Dam C, top of wall – 36.7 MPa (Core C21); 23.3 MPa (Core C22)
- Dam G, top of wall – 36.2 MPa (Core C23); 45.0 MPa (Core C24)
- Dam A, top of wall – 33.9 MPa (Core C25); 45.1 MPa (Core C26)
- Main Dam, Pier 2 (170-285 mm) – 31.1 MPa (Core RC1)
- Main Dam, Pier 2 (2530-2645 mm) – 21.8 MPa (Core RC2)

The chloride ion content was determined for Cores C11 and C13 (from Dam E – Bayview, deck) using MTO LS-417 "Method of Test for Determination of Total Chloride Ion in Concrete – Acid Soluble". The chloride ion content values are summarized below.

Horizon from top of core	0-10mm	20-30mm	40-50mm	60-70mm	80-90mm	100-110mm
Core C11 - Corrected Chloride Content (%)*	0.053	0.026	0.010	0.000	0.001	0.000
Core C13 - Corrected Chloride Content (%)*	0.172	0.155	0.111	0.047	0.040	-

* Background chloride ion content was assumed to be 0.005% (lowest value from all horizons tested).

Air void system testing of hardened concrete was conducted on twelve (12) cores in accordance with ASTM C457 using the Modified Point Count Method. Test results and polished sample photos are attached. Concrete is normally considered to be properly air entrained if the air content exceeds 3.0%, the specific surface exceeds 24 mm^{-1}, and the average spacing factor is less than 0.200 mm.

4.0 CLOSURE

We trust that this Report is complete. Should you have any questions or comments, please do not hesitate to contact this office.

Yours very truly,
Bridge Check Canada Ltd.

Savio DeSouza, M.A.Sc., P.Eng.
CEO
Senior Principal Engineer

3/ Core Photographs

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CORE C1 (lower approach wall, west)

CORE C2 (lower approach wall, west)

CORE C3 (Lock 45/Main Dam common wall)

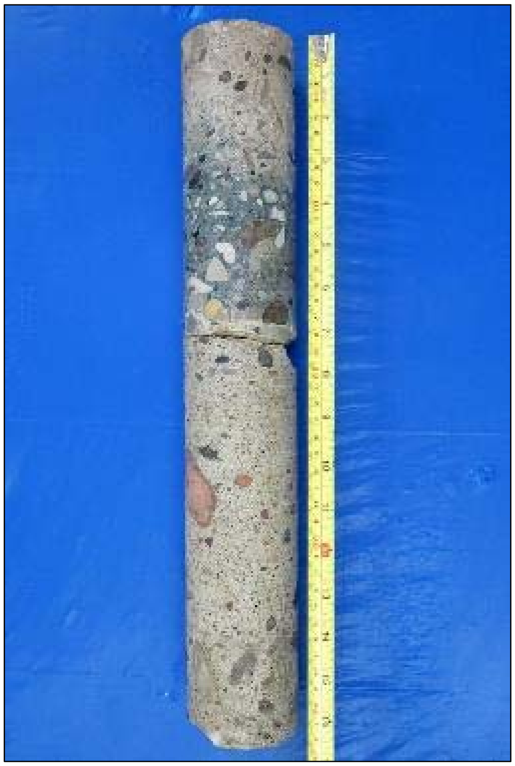
CORE C4 (Lock 45/Main Dam common wall)

CORE C5 (lower approach wall, east)

CORE C6 (lower approach wall, east)

CORE C7 (upper approach wall, west)

CORE C8 (upper approach wall, west)



CORE C9 (Dam E – Bayview, top of dam wall)

CORE C10 (Dam E – Bayview, top of dam wall)

CORE C11 (Dam E – Bayview, deck @ NE)

CORE C12 (Dam E – Bayview, deck @ NW)

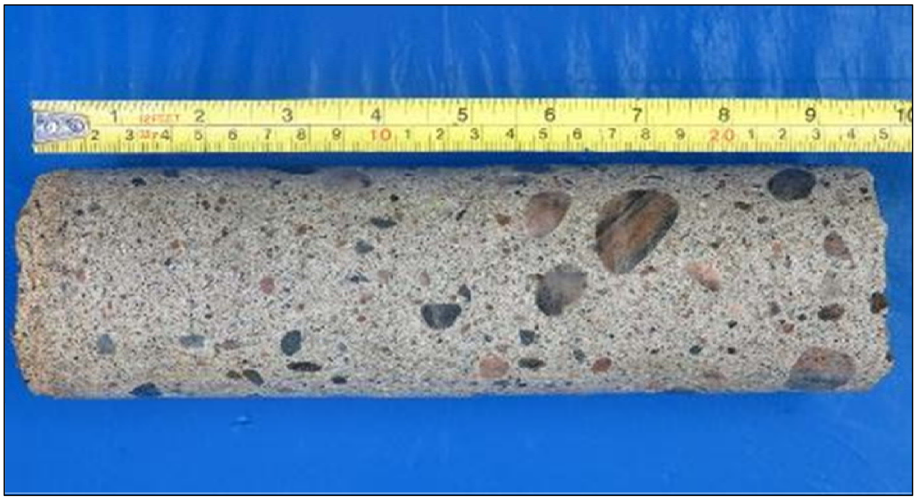
CORE C13 (Dam E – Bayview, deck @ SW)

CORE C14 (Dam E – Bayview, deck @ SE)

CORE C15 (Dam E – Bayview, west abutment)

CORE C16 (Dam E – Bayview, west abutment)

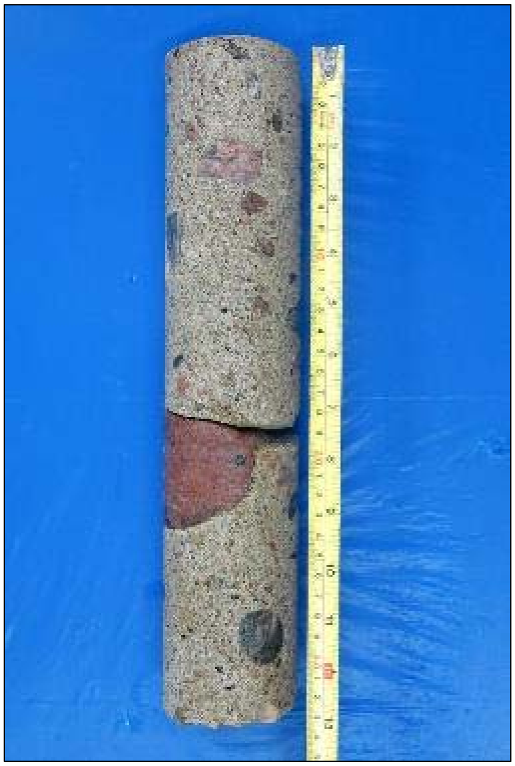
CORE C17 (Dam E – Bayview, east abutment)



CORE C18 (Dam E – Bayview, east abutment)

CORE C19 (Dam D, top of wall)

CORE C20 (Dam D, top of wall)



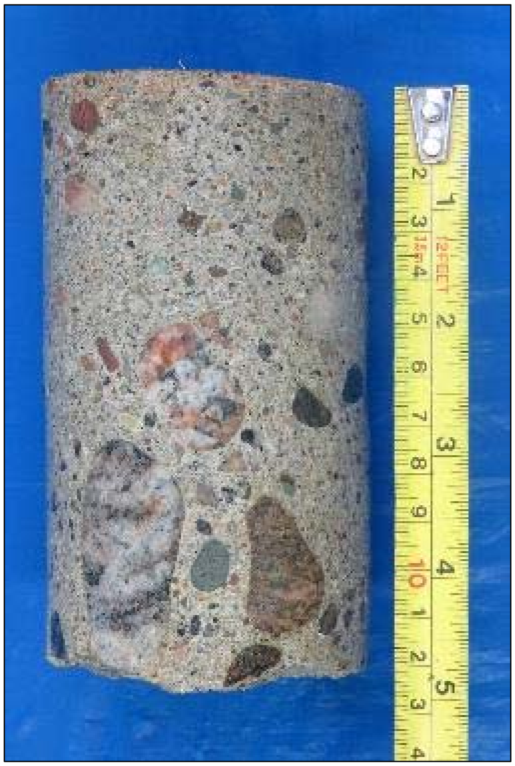
CORE C21 (Dam C, top of wall)

CORE C22 (Dam C, top of wall)

CORE C23 (Dam G – Little Chute, top of wall)

CORE C24 (Dam G – Little Chute, top of wall)

CORE C25 (Dam A, top of wall)



CORE C26 (Dam A, top of wall)

CORE RC1, RC2 (Main Dam, Pier 2)

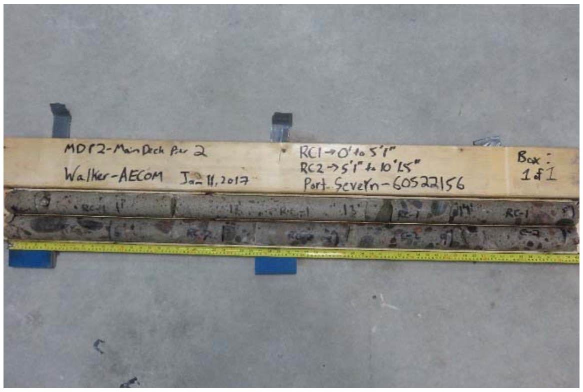


Photo P1 – Typical Condition of Inside of Core C1 (lower approach wall, west wall)

Photo P2 – Typical Condition of Inside Core C2 (lower approach wall, west wall)

Photo P3 – Typical Condition of Inside Core C3 (Lock 45/Main Dam common wall)

Photo P4 – Typical Condition of Inside Core C4 (Lock 45/Main Dam common wall)

Photo P5 – Typical Condition of Inside Core C5 (lower approach wall, west wall)

Photo P6 – Typical Condition of Inside Core C6 (lower approach wall, west wall)

Photo P7 – Typical Condition of Inside Core C7 (lower approach wall, west)

Photo P8 – Typical Condition of Inside Core C8 (lower approach wall, west)

Photo P9 – Typical Condition of Inside Core C9 (Dam E – Bayview, top of dam wall)

Photo P10 – Typical Condition of Inside Core C10 (Dam E – Bayview, top of dam wall)

Photo P11 – Typical Condition of Inside Core C11 (Dam E – Bayview, deck @ NE)

Photo P12 – Typical Condition of Inside Core C12 (Dam E – Bayview, deck @ NW)

Photo P13 – Typical Condition of Inside Core C13 (Dam E – Bayview, deck @ SW)

Photo P14 – Typical Condition of Inside Core C14 (Dam E – Bayview, deck @ SE)

Photo P15 – Typical Condition of Inside Core C15 (Dam E – Bayview, west abutment)

Photo P16 – Typical Condition of Inside Core C16 (Dam E – Bayview, west abutment)

Photo P17 – Typical Condition of Inside Core C17 (Dam E – Bayview, east abutment)

Photo P18 – Typical Condition of Inside Core C18 (Dam E – Bayview, east abutment)

Photo P19 – Typical Condition of Inside Core C19 (Dam D, top of wall)

Photo P20 – Typical Condition of Inside Core C20 (Dam D, top of wall)

Photo P21 – Typical Condition of Inside Core C21 (Dam C, top of wall)

Photo P22 – Typical Condition of Inside Core C22 (Dam C, top of wall)

Photo P23 – Typical Condition of Inside Core C23 (Dam G – Little Chute, top of wall)

Photo P24 – Typical Condition of Inside Core C24 (Dam G – Little Chute, top of wall)

Photo P25 – Typical Condition of Inside Core C25 (Dam A, top of wall)

Photo P26 – Typical Condition of Inside Core C26 (Dam A, top of wall)

4/ Core Logs

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		C1		C2		C3	
Location (between gridlines)		Lower Approach Wall, west		Lower Approach Wall, west		Lock 45/Main Dam, common wall	
Diameter, mm		70.0		70.0		70.0	
Length, mm		205.0		255.0		240.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete (1)		-		-		*	
Condition of Rebar (2)		LR		LR		G	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		52.2		46.6		47.4	
Chloride Content % Chloride by Weight of Concrete		Total	Corrected	Total	Corrected	Total	Corrected
	0-10 mm						
	20-30 mm						
	40-50 mm						
	60-70 mm						
	80-90 mm						
AIR VOIDS	Air Content,%			5.3		5.5	
	Spec. Surf.,mm2/mm3			27.93		38.67	
	Spacing Factor, mm			0.186		0.128	
TEST LABORATORY		BCC		BCC		BCC	
REMARKS - orientation of rebars and cover - presence of overlay, patch and thickness - other observed defects		10M rebar @100mm (transverse, LR)		10M rebar @110mm (transverse, LR): 20M-Rebar @120mm (longitudinal, LR)		Rebar imprint @85mm (transverse). *Core damaged upon removal.	

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		**C4**		**C5**		**C6**	
Location (between gridlines)		Lock 45/Main Dam, common wall		Lower Approach Wall, east		Lower Approach Wall, east	
Diameter, mm		70.0		70.0		70.0	
Length, mm		185.0		320.0		425.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete [(1)]		-		*		*	
Condition of Rebar [(2)]		N/A		N/A		G	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		49.3		58.9		44.0	
Chloride Content % Chloride by Weight of Concrete	**0-10 mm** **20-30 mm** **40-50 mm** **60-70 mm** **80-90 mm**	Total	Corrected	Total	Corrected	Total	Corrected
AIR VOIDS	**Air Content,%** **Spec. Surf.,mm2/mm3** **Spacing Factor, mm**					3.9 36.01 0.158	
TEST LABORATORY		BCC		BCC		BCC	
REMARKS **- orientation of rebars and cover** **- presence of overlay, patch and thickness** **- other observed defects**				*Core damaged upon removal.		20M rebar @ 250mm (transverse). *Core damaged upon removal.	

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		**C7**		**C8**		**C9**	
Location (between gridlines)		Upper Approach Wall, west		Upper Approach Wall, west		Dam E - Bayview, top of dam wall	
Diameter, mm		70.0		70.0		70.0	
Length, mm		405.0		425.0		235.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete (1)		D + C		D		-	
Condition of Rebar (2)		N/A		N/A		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		36.9		42.4		20.7	
Chloride Content % Chloride by Weight of Concrete	**0-10 mm 20-30 mm 40-50 mm 60-70 mm 80-90 mm**	Total	Corrected	Total	Corrected	Total	Corrected
AIR VOIDS	**Air Content,% Spec. Surf.,mm2/mm3 Spacing Factor, mm**	8.3 19.60 0.186					
TEST LABORATORY		BCC		BCC		BCC	
REMARKS - orientation of rebars and cover - presence of overlay, patch and thickness - other observed defects		Delamination plane @ 240mm. Medium crack.		Delamination plane @185mm.			

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed
Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		**C10**		**C11**		**C12**	
Location (between gridlines)		Dam E - Bayview, top of dam wall		Dam E - Bayview, deck @ NE		Dam E - Bayview, deck @ NW	
Diameter, mm		70.0		70.0		70.0	
Length, mm		275.0		275.0		260.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete [(1)]		-		-		-	
Condition of Rebar [(2)]		N/A		N/A		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		22.5				27.5	
Chloride Content % Chloride by Weight of Concrete		Total	Corrected	Total	Corrected	Total	Corrected
	0-10 mm			0.058	0.053		
	20-30 mm			0.031	0.026		
	40-50 mm			0.015	0.010		
	60-70 mm			0.005	0.000		
	80-90 mm			0.006	0.001		
	100-110 mm			0.005	0.000		
AIR VOIDS	**Air Content,%**	6.5		7.9			
	Spec. Surf.,mm2/mm3	25.60		20.06			
	Spacing Factor, mm	0.183		0.164			
TEST LABORATORY		BCC		BCC		BCC	
REMARKS **- orientation of rebars and cover** **- presence of overlay, patch and thickness** **- other observed defects**				95mm asphalt.		115mm asphalt.	

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		**C13**		**C14**		**C15**	
Location (between gridlines)		Dam E - Bayview, deck @ SW		Dam E - Bayview, deck @ SE		Dam E - Bayview, west abutment	
Diameter, mm		70.0		70.0		70.0	
Length, mm		135.0		180.0		200.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete [(1)]		C		-		-	
Condition of Rebar [(2)]		N/A		G		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa				25.4		17.0	
		Total	Corrected	Total	Corrected	Total	Corrected
Chloride Content % Chloride by Weight of Concrete	**0-10 mm**	0.177	0.172				
	20-30 mm	0.160	0.155				
	40-50 mm	0.116	0.111				
	60-70 mm	0.052	0.047				
	80-90 mm	0.045	0.040				
AIR VOIDS	**Air Content,%**						
	Spec. Surf.,mm2/mm3						
	Spacing Factor, mm						
TEST LABORATORY		BCC		BCC		BCC	
REMARKS **- orientation of rebars and cover** **- presence of overlay, patch and thickness** **- other observed defects**		120mm asphalt. Medium crack.		95mm asphalt. Rebar imprint @170mm (transverse).			

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed
Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		C16		C17		C18	
Location (between gridlines)		Dam E - Bayview, west abutment		Dam E - Bayview, east abutment		Dam E - Bayview, east abutment	
Diameter, mm		70.0		70.0		70.0	
Length, mm		220.0		255.0		270.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete [(1)]		-		-		-	
Condition of Rebar [(2)]		N/A		N/A		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		17.9		15.9		17.1	
Chloride Content % Chloride by Weight of Concrete		Total	Corrected	Total	Corrected	Total	Corrected
	0-10 mm						
	20-30 mm						
	40-50 mm						
	60-70 mm						
	80-90 mm						
AIR VOIDS	Air Content,%	11.3				7.9	
	Spec. Surf.,mm2/mm3	18.89				20.43	
	Spacing Factor, mm	0.129				0.181	
TEST LABORATORY		BCC		BCC		BCC	
REMARKS - orientation of rebars and cover - presence of overlay, patch and thickness - other observed defects							

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		**C19**		**C20**		**C21**	
Location (between gridlines)		Dam D, top of wall		Dam D, top of wall		Dam C, top of wall	
Diameter, mm		70.0		70.0		70.0	
Length, mm		225.0		335.0		190.0	
Full Depth (yes/no)		No		No		No	
Defects in Concrete (1)		C		D		-	
Condition of Rebar (2)		N/A		N/A		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		14.9		14.9		36.7	
Chloride Content % Chloride by Weight of Concrete	**0-10 mm** **20-30 mm** **40-50 mm** **60-70 mm** **80-90 mm**	Total	Corrected	Total	Corrected	Total	Corrected
AIR VOIDS	**Air Content,%** **Spec. Surf.,mm2/mm3** **Spacing Factor, mm**			13.3 19.74 0.103			
TEST LABORATORY		BCC		BCC		BCC	
REMARKS **- orientation of rebars and cover** **- presence of overlay, patch and thickness** **- other observed defects**		Medium crack		Delamination plane @180mm.			

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		C22		C23		C24	
Location (between gridlines)		Dam C, top of wall		Dam G -Little Chute, top of wall		Dam G -Little Chute, top of wall	
Diameter, mm		70.0		70.0		70.0	
Length, mm		195		220		230	
Full Depth (yes/no)		No		No		No	
Defects in Concrete (1)		-		-		-	
Condition of Rebar (2)		N/A		N/A		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		23.3		36.2		45.0	
Chloride Content % Chloride by Weight of Concrete		Total	Corrected	Total	Corrected	Total	Corrected
	0-10 mm						
	20-30 mm						
	40-50 mm						
	60-70 mm						
	80-90 mm						
AIR VOIDS	Air Content,%					7.8	
	Spec. Surf.,mm2/mm3					15.20	
	Spacing Factor, mm					0.287	
TEST LABORATORY		BCC		BCC		BCC	
REMARKS - orientation of rebars and cover - presence of overlay, patch and thickness - other observed defects							

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

CORE LOG FOR EXPOSED CONCRETE

Site: Port Severn Area Dams

Core No.		**C25**		**C26**		**RC1**	
Location (between gridlines)		Dam A, top of wall		Dam A, top of wall		Main Dam, Pier 2	
Diameter, mm		70.0		70.0		63.0	
Length, mm		125.0		205.0		10'1.5"	
Full Depth (yes/no)		No		No		No	
Defects in Concrete (1)		-		C		-	
Condition of Rebar (2)		N/A		N/A		N/A	
Corrosion Potential		-		-		-	
Compressive Strength, MPa		33.9		45.1		31.1 / 21.8	
Chloride Content % Chloride by Weight of Concrete		Total	Corrected	Total	Corrected	Total	Corrected
	0-10 mm						
	20-30 mm						
	40-50 mm						
	60-70 mm						
	80-90 mm						
AIR VOIDS	**Air Content,%**					8.3	8.4
	Spec. Surf.,mm2/mm3					21.56	19.54
	Spacing Factor, mm					0.209	0.161
TEST LABORATORY		BCC		BCC		BCC	
REMARKS **- orientation of rebars and cover** **- presence of overlay, patch and thickness** **- other observed defects**				Medium crack		31.1 MPa (170-285mm). 21.8 MPa (2530-2645 mm). AVS testing conducted at 520-680mm and 1790-1940mm.	

1. Defects-C= Cracked, D= Delamination, R= Rough, Sc= Scaling, S= Spalling
2. Condition Rebar-LR= Light Rust, SR= Severe Rust, N/A= No rebar exposed

Condition of Epoxy Coating – ECG=Good, ECF=Fair, ECP=Poor-rusted & debonded areas

5/ Laboratory Test Results

COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C1	C2	C3
Location	*Lower approach wall, west*	*Lower approach wall, west*	*Lock 45/Main Dam common wall*
Lab No.	L16-1360	L16-1361	L16-1362
Date Cast	-	-	-
Date Cored	Nov. 22, 2016	Nov. 22, 2016	Nov. 22, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	74.4	93.3	98.1
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2360	2306	2339
Corrected Compressive Strength (MPa)	52.2	46.6	47.4
*** Direction of Loading**	Same	Same	Perpendicular
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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Savio DeSouza, M.A.Sc., P.Eng.
Senior Principal Engineer

COMPRESSIVE STRENGTH OF CONCRETE CORES
(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C4	C5	C6
Location	*Lock 45/Main Dam common wall*	*Lower approach wall, east*	*Lower approach wall, east*
Lab No.	L16-1363	L16-1364	L16-1365
Date Cast	-	-	-
Date Cored	Nov. 22, 2016	Nov. 22, 2016	Nov. 22, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	111.5	131.5	108.0
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2332	2355	2360
Corrected Compressive Strength (MPa)	49.3	58.9	44.0
*** Direction of Loading**	Perpendicular	Same	Same
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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Senior Principal Engineer

COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C7	C8	C9
Location	*Upper approach wall, west*	*Upper approach wall, west*	*Dam E – Bayview, top of dam wall*
Lab No.	L16-1366	L16-1367	L16-1368
Date Cast	-	-	-
Date Cored	Nov. 22, 2016	Nov. 22, 2016	Nov. 23, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	143.2	102.6	128.7
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2272	2249	2061
Corrected Compressive Strength (MPa)	36.9	42.4	20.7
*** Direction of Loading**	Same	Same	Same
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

Savio DeSouza, M.A.Sc., P.Eng.
Senior Principal Engineer

COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C10	C12	C14
Location	*Dam E – Bayview, top of dam wall*	*Dam E – Bayview, deck @ NE*	*Dam E – Bayview, deck @ NW*
Lab No.	L16-1369	L16-1370	L16-1371
Date Cast	-	-	-
Date Cored	Nov. 23, 2016	Nov. 23, 2016	Nov. 23, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	112.5	84.2	134.1
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2092	2235	2171
Corrected Compressive Strength (MPa)	22.5	27.5	25.4
*** Direction of Loading**	Same	Same	Same
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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Senior Principal Engineer

COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C15	C16	C17
Location	*Dam E – Bayview, west abutment*	*Dam E – Bayview, west abutment*	*Dam E – Bayview, east abutment*
Lab No.	L16-1372	L16-1373	L16-1374
Date Cast	-	-	-
Date Cored	Nov. 23, 2016	Nov. 23, 2016	Nov. 23, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	145.8	94.1	142.9
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2265	2162	2145
Corrected Compressive Strength (MPa)	17.0	17.9	15.9
*** Direction of Loading**	Perpendicular	Perpendicular	Perpendicular
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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Senior Principal Engineer

COMPRESSIVE STRENGTH OF CONCRETE CORES
(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C18	C19	C20
Location	*Dam E – Bayview, east abutment*	*Dam D, top of wall*	*Dam D, top of wall*
Lab No.	L16-1375	L16-1376	L16-1377
Date Cast	-	-	-
Date Cored	Nov. 23, 2016	Nov. 22, 2016	Nov. 22, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	136.8	80.0	117.3
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2087	2310	1995
Corrected Compressive Strength (MPa)	17.1	14.9	14.9
*** Direction of Loading**	Perpendicular	Same	Same
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C21	C22	C23
Location	*Dam C, top of wall*	*Dam C, top of wall*	*Dam G, top of wall*
Lab No.	L16-1378	L16-1379	L16-1380
Date Cast	-	-	-
Date Cored	Nov. 22, 2016	Nov. 22, 2016	Nov. 22, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	106.6	132.0	140.0
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2287	2302	2203
Corrected Compressive Strength (MPa)	36.7	23.3	36.2
*** Direction of Loading**	Same	Same	Same
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C24	C25	C26
Location	*Dam G, top of wall*	*Dam A, top of wall*	*Dam A, top of wall*
Lab No.	L16-1381	L16-1382	L16-1383
Date Cast	-	-	-
Date Cored	Nov. 22, 2016	Nov. 23, 2016	Nov. 23, 2016
Date Tested	Nov. 28, 2016	Nov. 28, 2016	Nov. 28, 2016
Capped Height (mm)	78.2	96.1	91.0
Average Diameter (mm)	70.0	70.0	70.0
Density (kg/m^3)	2292	2135	2186
Corrected Compressive Strength (MPa)	45.0	33.9	45.1
*** Direction of Loading**	Same	Same	Same
Moisture Contact at Time of Test	As-received	As-received	As-received
Remarks			

*Relative to the direction of original placement.

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COMPRESSIVE STRENGTH OF CONCRETE CORES

(CSA A23.2-14C)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	RC1	RC2	-
Location	*Main Dam, Pier 2 170-285 mm*	*Main Dam, Pier 2 2530-2645 mm*	-
Lab No.	L17-0036	L17-0037	-
Date Cast	-	-	-
Date Cored	Jan. 11, 2017	Jan. 11, 2017	-
Date Tested	Feb. 1, 2017	Feb.y 1, 2017	-
Capped Height (mm)	115.0	117.2	-
Average Diameter (mm)	63.0	63.0	-
Density (kg/m^3)	2167	2344	-
Corrected Compressive Strength (MPa)	31.1	21.8	-
*** Direction of Loading**	-	-	-
Moisture Contact at Time of Test	As-received	As-received	-
Remarks			

*Relative to the direction of original placement.

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TOTAL CHLORIDE ION CONTENT

(Testing Method: MTO LS – 417)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	Lab No.	Horizon from the Top of the Core (mm)	Chloride Ion Content (%)	Chloride Ion Content Corrected for Background* (%)
C11 (Dam E – Bayview, deck @ NE)	L16-1384	0-10 20-30 40-50 60-70 80-90 100-110	0.058 0.031 0.015 0.005 0.006 0.005	0.053 0.026 0.010 0.000 0.001 0.000
C13 (Dam E – Bayview, deck @ SW)	L16-1385	0-10 20-30 40-50 60-70 80-90	0.177 0.160 0.116 0.052 0.047	0.172 0.155 0.111 0.047 0.040

**Background chloride content = 0.005%*
***The threshold of chloride ion generally regarded to be able to initiate reinforcing bar corrosion is 0.025%.*

Tested By: Sukhjinder Singh
Date Tested: Nov. 28, 2016

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BRIDGE CHECK CANADA Ltd.
Your Bridge and Concrete Inspection Specialists

AIR VOID TEST RESULTS
(Modified Point Count – ASTM C457, Procedure B)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	C2	C3	C6	C7	C10	C11	C16	C18	C20	C24
Lab No.	L16-1433	L16-1434	L16-1435	L16-1436	L16-1437	L16-1438	L16-1439	L16-1440	L16-1441	L16-1442
Air Content (%)	5.3	5.5	3.9	8.3	6.5	7.9	11.3	7.9	13.3	7.8
Specific Surface (mm^{-1})	27.93	38.67	36.01	19.60	25.60	20.06	18.89	20.43	19.74	15.20
Spacing Factor (mm)	0.186	0.128	0.158	0.186	0.183	0.164	0.129	0.181	0.103	0.287
Length of Traverse (mm)	3480	3146.4	3480	3480	3480	3128	3326	3240	3128	3009
Area Traversed (mm^2)	9048	7551	9048	9396	9396	7194	7983	8100	7507	6621
Number of Stops	1392	1368	1392	1392	1392	1360	1386	1350	1360	1368
No. of Voids per mm	0.371	0.537	0.355	0.408	0.418	0.398	0.538	0.404	0.660	0.300
Paste-Air Ratio	6.45	5.85	7.89	3.66	5.18	3.30	2.44	3.70	2.04	4.41
Paste Content (%)	34.33	32.52	31.17	30.53	33.90	26.25	27.84	29.33	27.42	34.86
Aggregate Content (%)	60.37	61.98	64.93	61.14	59.57	65.85	60.86	62.77	59.28	57.34

Tested By: B. Wiersma
Date Tested: Dec. 16, 2016

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AIR VOID TEST RESULTS

(Modified Point Count – ASTM C457, Procedure B)

Project No.:	**BCC15118**
Site No.:	**Port Severn Area Dams**
Location:	**Port Severn, ON**

Core ID	RC2 Main Dam, Pier 2 1790-1940mm	RC1 Main Dam, Pier 2 520-680mm
Lab No.	L17-0039	L17-0038
Air Content (%)	8.4	8.3
Specific Surface (mm^{-1})	19.54	21.56
Spacing Factor (mm)	0.161	0.209
Length of Traverse (mm)	2916	2760
Area Traversed (mm^2)	7290	7176
Number of Stops	1215	1200
No. of Voids per mm	0.414	0.449
Paste-Air Ratio	3.15	4.72
Paste Content (%)	26.74	39.33
Aggregate Content (%)	64.79	52.37

Tested By: Brad Wiersma
Date Tested: Feb. 2, 2017

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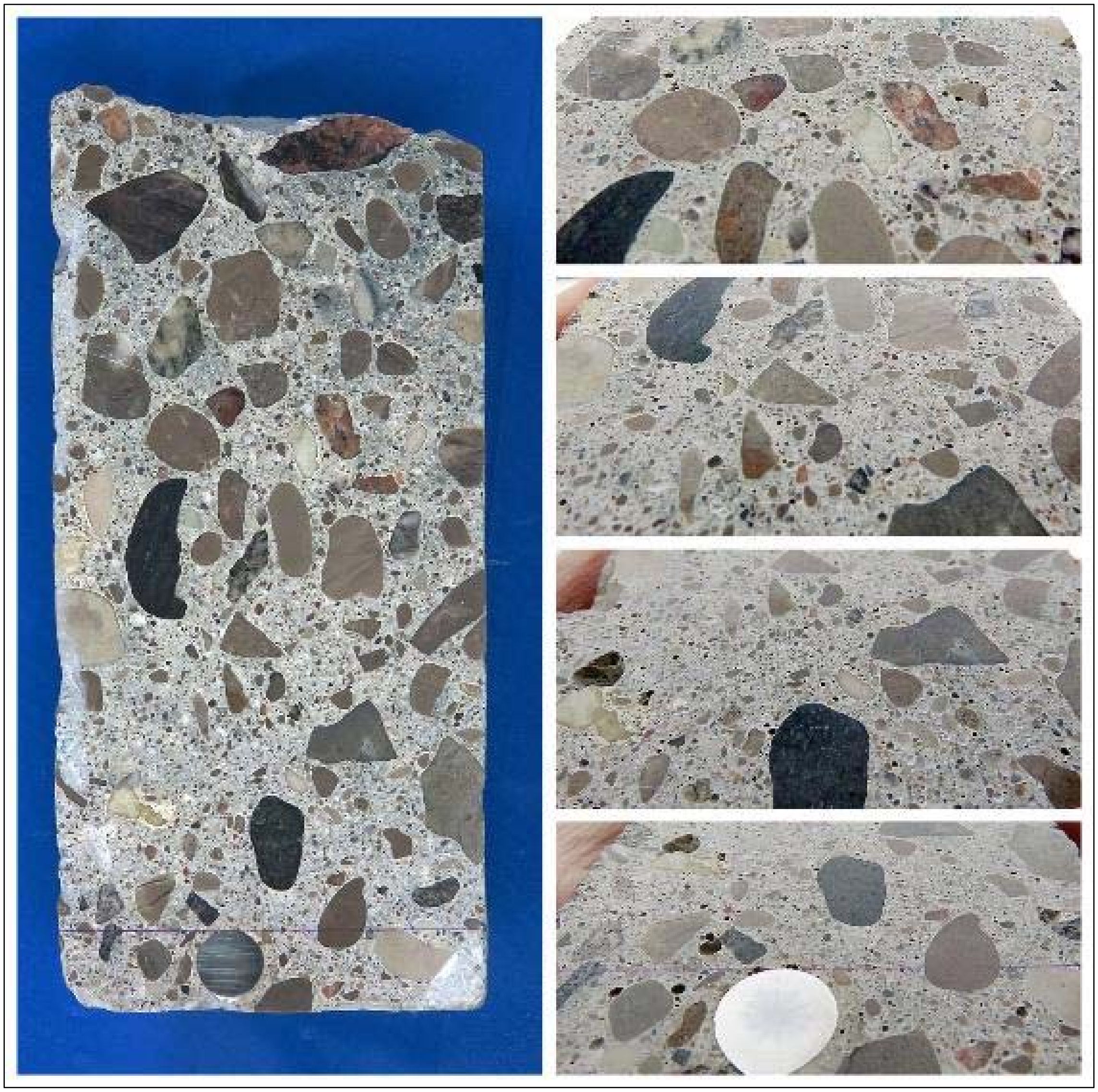
Senior Principal Engineer

CORE C2 (lower approach wall, west)

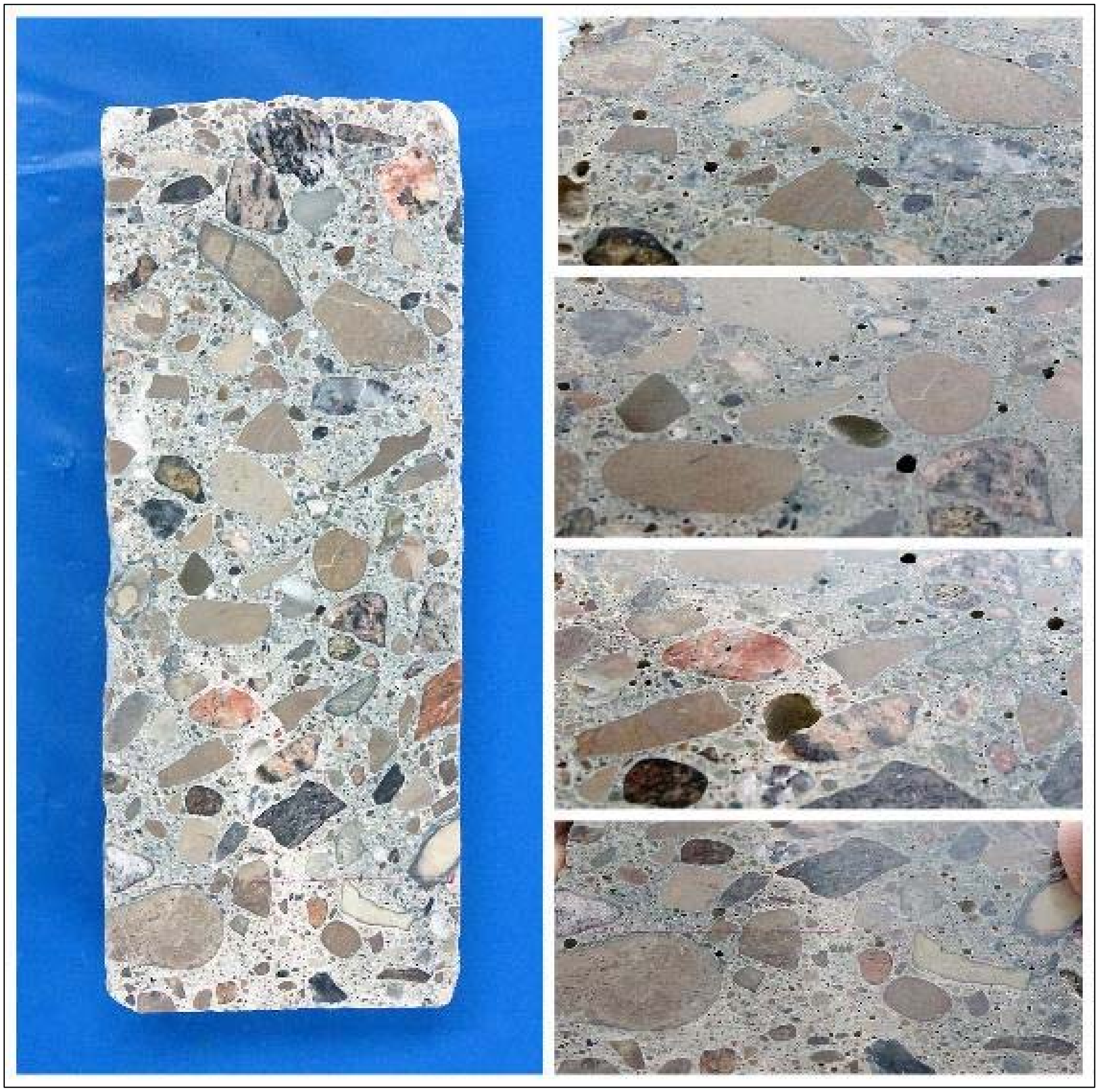


Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C2	**5.3**	**27.93**	**0.186**

CORE C3 (Lock 45 / Main Dam, common wall)

Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C3	**5.5**	**38.67**	**0.128**

CORE C6 (lower approach wall, east)

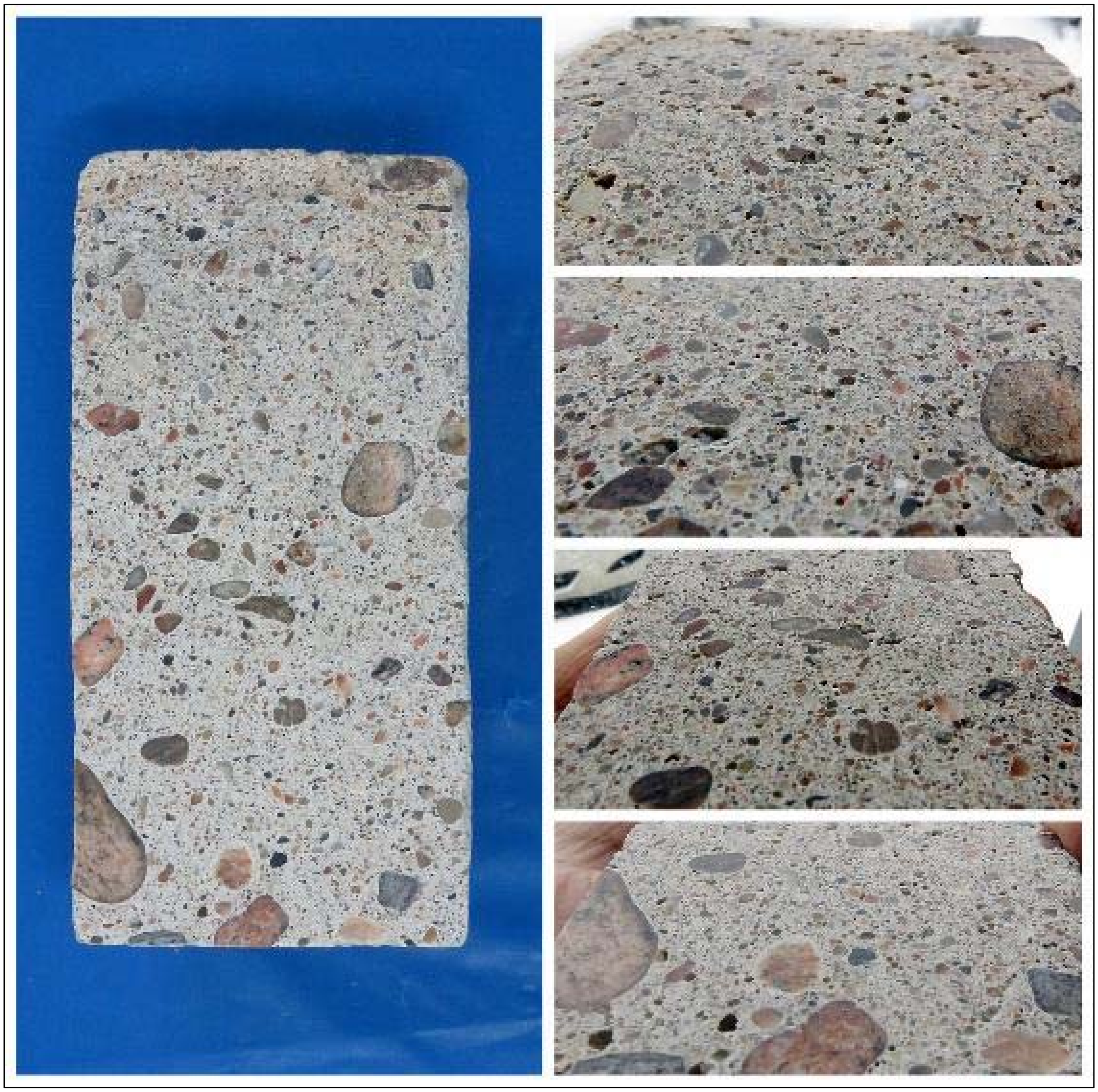


Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C6	**3.9**	**36.01**	**0.158**

CORE C7 (upper approach wall, west)

Air Void Test Result (Modified Point Count – ASTM C457, Procedure B)			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C7	**8.3**	**19.60**	**0.186**

CORE C10 (Dam E – Bayview, top of dam wall)

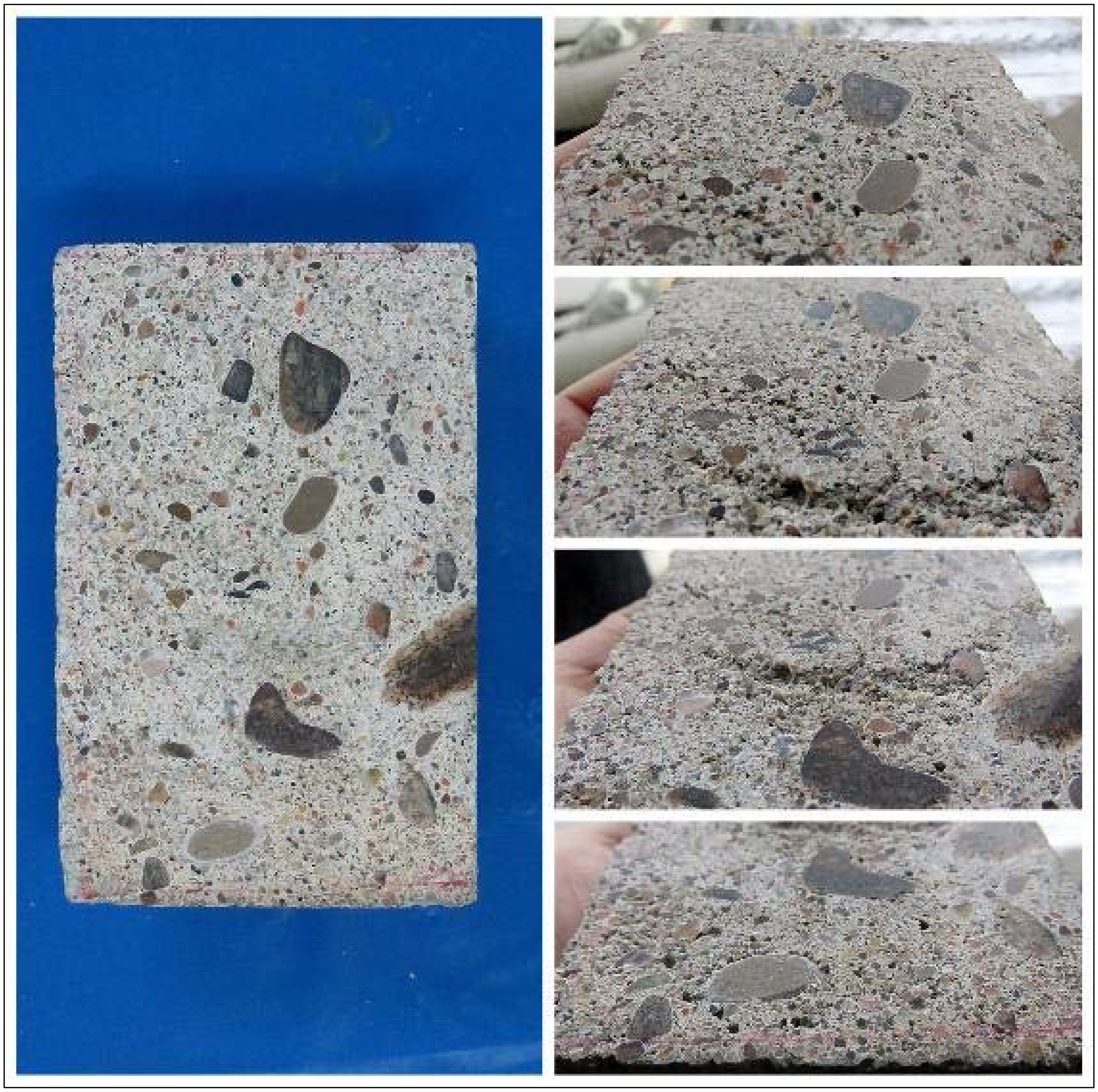


Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C10	**6.5**	**25.60**	**0.183**

CORE C11 (Dam E – Bayview, deck)

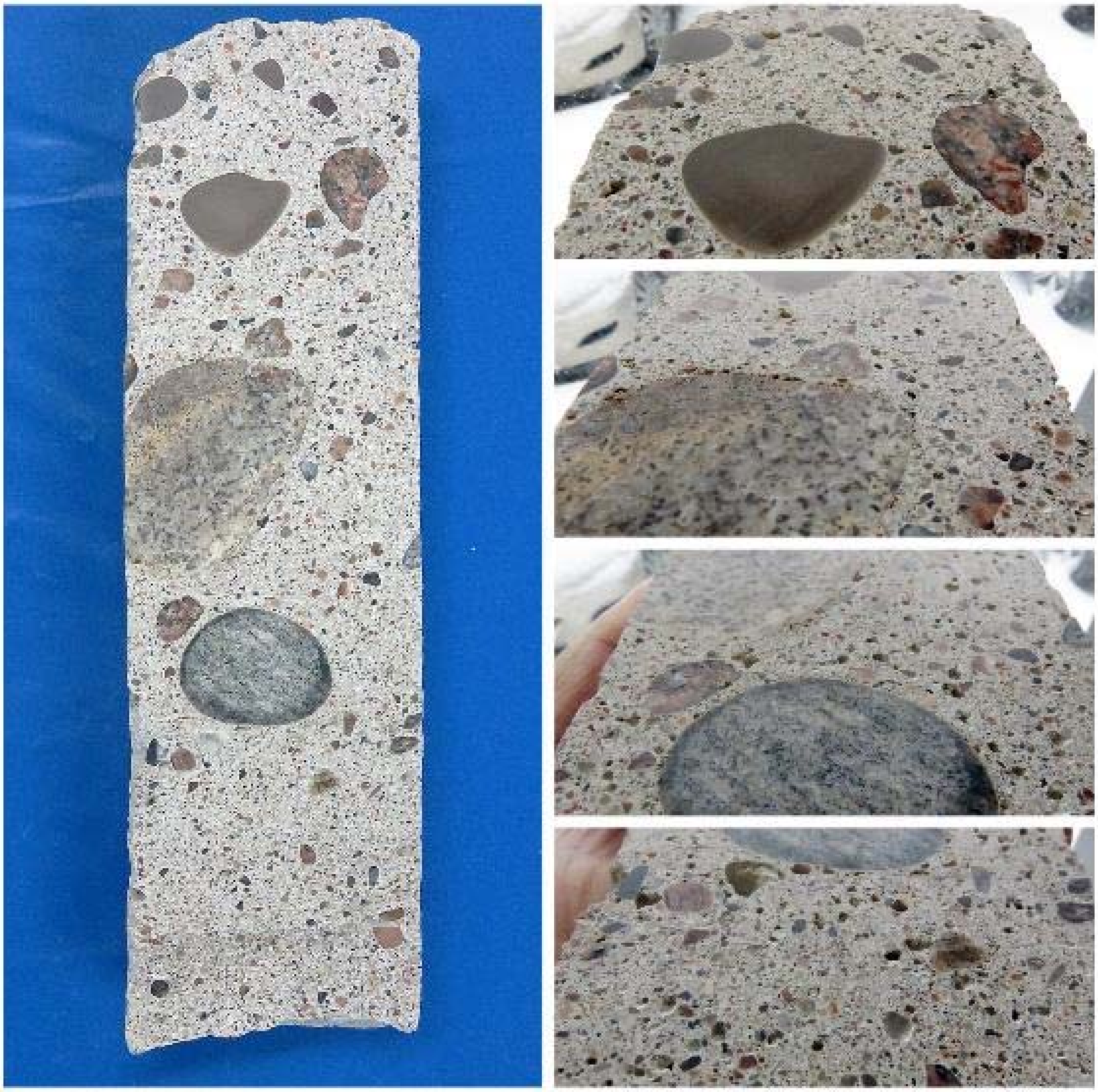
Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C11	**7.9**	**20.06**	**0.164**

CORE C16 (Dam E – Bayview, west abutment)



Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C16	**11.3**	**18.89**	**0.129**

CORE C18 (Dam E – Bayview, east abutment)

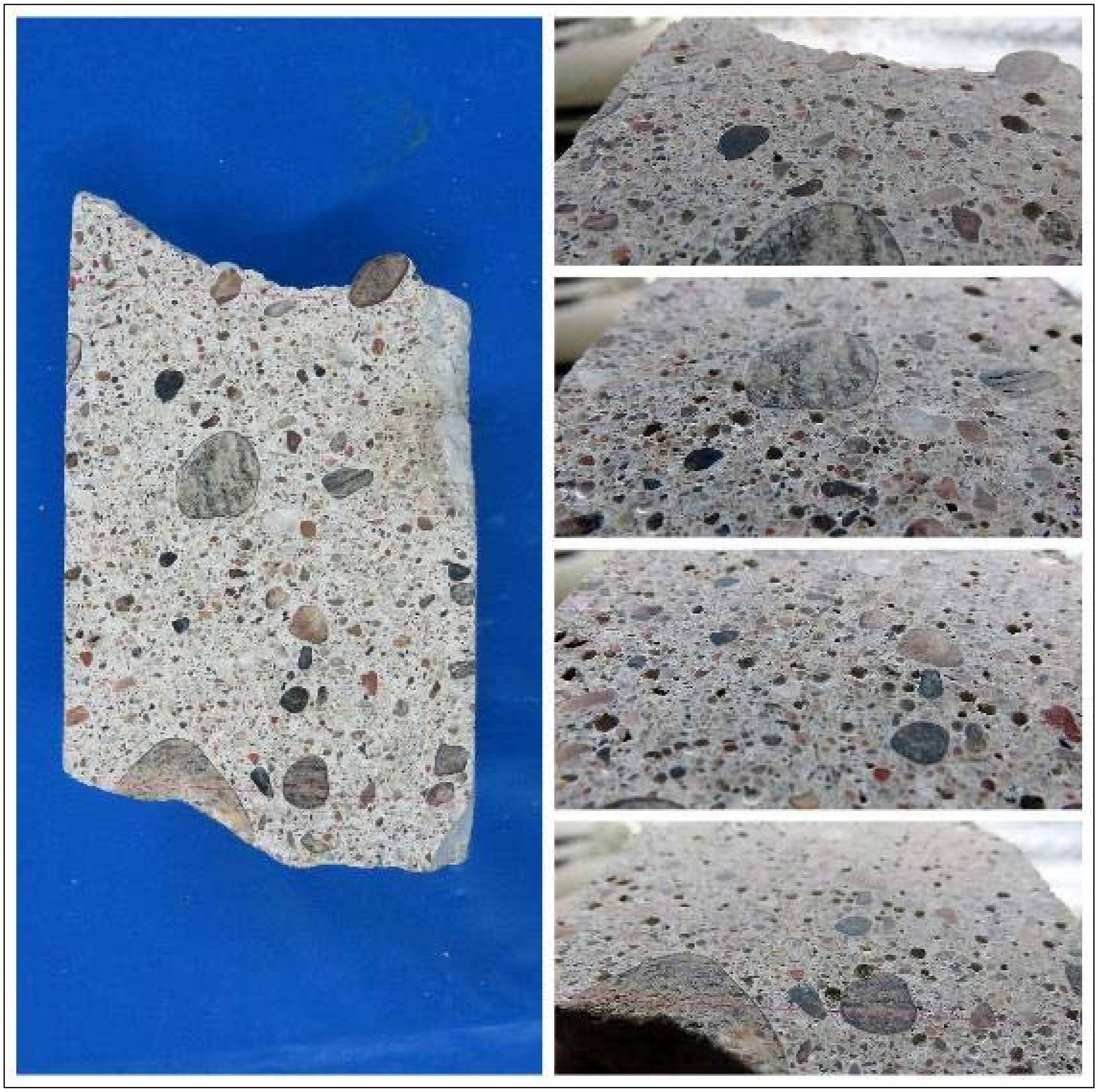


Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C18	**7.9**	**20.43**	**0.181**

CORE C20 (Dam D, top of wall)

Air Void Test Result **(Modified Point Count – ASTM C457, Procedure B)**			
Core No.	**Air Content (%)**	**Specific Surface (mm^{-1})**	**Spacing Factor (mm)**
C20	**13.3**	**19.74**	**0.103**

CORE C24 (Dam G, top of wall)



Air Void Test Result (Modified Point Count – ASTM C457, Procedure B)			
Core No.	Air Content (%)	Specific Surface (mm^{-1})	Spacing Factor (mm)
C24	7.8	15.2	0.287