Columbia River Project Water Use Plan

Arrow Lakes Reservoir Wildlife Management Plan

Arrow Lakes Reservoir: Implementation of Wildlife Physical Works – Revelstoke Reach

Detailed Design

Reference: CLBWORKS-30A

Cartier Bay Site 15A Erosion Repair – Detailed Design Report

Study Period: 2021 - 2022

Kerr Wood Leidal
Victoria, B.C.

May 13, 2022

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CLBWORKS 30A Cartier Bay Site 15a Engineering Services

Detailed Design Report

Final Report
May 13, 2022
KWL Project No. 0478.237

Prepared for:
BC Hydro

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1. Introduction and Background

The Cartier Bay Wetland is located in the drawdown zone of BC Hydro's Arrow Lakes reservoir, approximately 10 km south of Revelstoke and 20 km downstream of BC Hydro's Revelstoke Dam. It is impounded by an abandoned railway embankment and drains through an engineered outlet at its west end, known as Site 15a, during low reservoir operations. The engineered outlet section of the embankment is registered as a regulated dam and is currently classified as Low Consequence.

The outlet at the Site 15a Dam is accessed by an informal road along the wetland's north bank that crosses three topographic low areas: Areas A, B and C, which have been identified by BC Hydro as actively eroding or potentially prone to erosion, see Figure 1-1. Erosion of the north bank of the wetland has occurred along Area B and formed a channel which is directing wetland discharge, and early reservoir inundation away from the Site 15a outlet, since this channel is now at a lower elevation than Site 15a. Left unchecked, the erosion will likely reduce water levels in the wetland and therefore the amount of wetland area available for habitat and aquatic life. A temporary bulk bag berm was installed to prevent further erosion; however, a permanent solution is required at this location. This area is completely inundated by up to 6 m of water as the reservoir is filled every spring to full pool.

Kerr Wood Leidal Associates Ltd. (KWL) was retained to design measures to mitigate future erosion at the topographic low points along the Cartier Bay wetland's north bank, as well as lower the outlet at Site 15a such that it remains the preferential drainage path for water impounded in the wetland.

Further to Conceptual Design Report[1] (KWL, 2022), this report outlines the additional engineering assessment and design undertaken by KWL as part of the detailed design.

[1] KWL, 2022, CLBWORKS 30A Cartier Bay Site 15a Engineering Services – Conceptual Design Report, final report to BC Hydro dated January 27, 2022

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BC Hydro and Power Authority

artier Bay Wetland Site 15A Arrow Lakes

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Project No.	478-237
Date	May 2022
Scale	1:8,000

0 50 100 200 Metres

Cartier Bay Wetland Overview

Figure 1-1

2. Detailed Design

KWL developed three conceptual design options for Area A and Area B, as well as three sub-options for the Site15a outlet. These concepts were prepared in order to meet environmental and design objectives that aimed to secure long-term sustainment of the Cartier Bay wetland while limiting the reduction in habitat for diving ducks and other fauna. The conceptual design report is enclosed in Appendix A.

BC Hydro selected Option 3 from the range of options presented in KWL (2022) based on an evaluation of total footprint, minimizing ground disturbance and. environmental imparts, public safety, visual impacts, operations and maintenance, access and ease of constructability, regulatory considerations, and costs. Option 3 includes the following to advance to detailed design in addition to preparing detailed design drawings, technical specifications, and issue for tender drawings:

- **Site 15a:** Lower the outlet invert to a new target elevation and line the channel with articulated concrete block mattress (ACBM) to maintain a hard invert elevation resistant to flows and vehicular traffic.
- **Area A:** Raise the existing road to a target elevation at the two identified low points.
- **Area B:** Construct an armoured saddle dam to replace the current temporary bulk bag berm. Fill in the eroded channel and repair the eroded section of road.
- **Area C:** No works are proposed for Area C as it is sufficiently above the proposed Site 15a outlet elevation. This area should be visually monitored for potential future evidence of erosion.

The detailed design is described in the following sections and is presented on the detailed design drawings enclosed in Appendix B. The general site layout is shown in Drawings 201B-C09-00001 and 201B-C09-00002.

In general, the detailed design aims to salvage and reuse onsite excavated material wherever reasonably possible, and thereby limit imported material and avoid hauling surplus material offsite for disposal at a suitable landfill.

2.1 Site 15a Outlet

Site 15a is the primary Cartier Bay wetland outlet with an existing elevation of approximately 433.92 m. The existing outlet was constructed in 2016 and is a cut in the railway embankment armoured with Class 50 kg riprap at its downstream end. The outlet invert upstream of the riprap is not currently armoured and is composed of railway ballast.

BC Hydro has submitted an application to the Dam Safety Section of the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development (FLNRORD) to have the dam reclassified as a Minor Dam as part of the proposed improvements.

2.1.1 Outlet Geometry and Invert Elevation

The layout and geometry of the outlet did not significantly change from the conceptual design Sub-Option A (Articulated Concrete Block Mattress) and remained with a 4 m wide invert and 3:1 H:V side slopes.

Additional analysis of the available bathymetry and water depth data was undertaken to assess potential changes to the Cartier Bay wetland lower compartment area as a result of lowering the outlet elevation at Site 15a (See Figure 1). Digital Terrain Model (DTM) data from 2019 and 2020 was compared with their associated orthophotos to determine wetland water surface elevations at the time of the data collection. Generally, elevations collected below a water surface in a DTM are considered inaccurate and should not be used for bathymetry or topography. The wetland water level at the time of the 2019 and 2020 DTM collection was estimated to be approximately 434 m for both years, which is higher than the target outlet elevation of 433.7 m, and so could not be used to assess wetland area reduction.

Prior to the construction of the existing outlet in 2016 to an elevation of approximately 433.92 m, the outlet was a wooden box culvert with an invert elevation of approximately 433.8 m. BC Hydro has not observed significant changes in the area of the wetland's lower compartment since the 2016 outlet construction, which raised the outlet elevation by approximately 0.12 m. Significant changes in wetland area were also not observed following the 2020 Area B erosion as the wetland water level began to fall below the Site 15a outlet invert. These observations indicate that the area may not be sensitive to small changes in the Site 15a outlet invert elevation.

The Site 15a outlet invert elevation should also be set below the eroded level at Area B, which was surveyed at approximately 434.84 m in April 2021, to help provide long term stability of the wetland's north bank.

An outlet invert elevation of 433.7 m was selected for the final design as it would reduce the potential for erosion along the north bank and is expected have limited impact to the wetland's area, while preserving and protecting the desired wetland habitat.

2.1.2 Outlet Armouring (ACBM)

The existing Site 15a outlet will be excavated and armoured with an articulated concrete block mattress (ABCM) to the geometry and elevation noted in the previous section. Excavated fill material and riprap will be salvaged for reuse at the Area B saddle dam.

A Class 40 Open Cell ACBM as manufactured and supplied by Armorflex was selected for the Site 15a outlet in order to maintain a hard invert elevation that is resistant to vandalism, water flows, and vehicular traffic. These mattresses are 2.4 m wide, 6.1 m long, and 0.12 m thick, with a 20% open area. They are stable and resistant to flows of up to 3 m/s which exceeds the expected peak velocity at this outlet of less than 1.5 m/s. The selected mattress is suitable for the expected typical vehicle traffic loads (pick-up trucks, etc.)

The outlet is designed to have two ACBMs butted end to end to span the 4 m wide outlet invert and extend up the side slopes at a 3:1 angle as shown in Drawing 201B-C09-00003. Each mattress will be underlain with a non-woven geotextile and the open area of each block will be backfilled with Surfacing Aggregate Fill.

Installation of the ACBM will require a specialized spreader bar to attach to a small crane or excavator boom and bucket. Once installation is completed, the finished top surface will provide an obvious reference for future inspections to confirm that the outlet elevation is maintained.

The upstream and downstream transitions of the ACBM will be armoured with a 200 mm minus granular fill, which will provide a smooth transition to the existing riprap apron on the downstream side of the outlet structure.

2.2 Area A

Area A has two low points identified as being at risk for overflow and erosion. The design objective of the selected Option 3 (and sub-Option 1) was to eliminate these low points by raising the road to an elevation at least 0.6 m higher than the proposed Site 15a outlet to a target elevation of 434.4 m as shown in Drawings 201B-C09-00008 and 201B-C09-00009.

No significant changes were made to the layout of the Area A works from the conceptual design phase. Two low areas on the access road will be stripped of plant cover and organics and excavated to a depth of approximately 0.1 m (maximum 0.3 m) at the vegetated margins and then raised with new fill to an elevation of 434.4 m to match the adjacent road grade with a 4 m wide crest and 6:1 side slopes. The low points in the road will be filled with an imported 75 mm minus pit run fill placed to an elevation of 434.3 m, and an additional 100 mm of surfacing aggregate will form the driving surface at a completed elevation of 434.4 m.

2.3 Area B

Area B underwent significant erosion and headcutting when the wetland overflowed the north bank at this location in 2020 and 2021. This created a pronounced and well-defined eroded channel which cut through the access road, and necessitated the installation of a temporary bulk bag berm to stop additional flow across this area. Large rock was also placed at the road to create a temporary driving surface though the eroded channel.

The primary design objective is to address the overflow and erosion at the Area B low point by replacing the temporary bulk bag berm with a permanent saddle dam with a crest elevation at least 0.6 m higher than the proposed Site 15a outlet invert elevation. Additional design objectives include filling the eroded channel to recover its pre-eroded geometry and the repair of the eroded access road, which is consistent with the selection of Option 3.

2.3.1 Saddle Dam

The saddle dam location was moved from its initially proposed location in the conceptual design to the location of the existing temporary bulk bag berm to limit potential ponding and fish stranding as the wetland draws down in the summer. This location will also limit new construction related disturbance areas as it has already been partially disturbed. The temporary bulk bag berm will be removed as part of construction, and the bulk bag granular fill and riprap will be salvaged and reused on site.

The saddle dam will be keyed into the existing ground at least 0.5 m, underlain with a non-woven geotextile, and filled with compacted fill to a design elevation of 434.15 m. The saddle dam fill will be a mixture of imported 75 mm minus pit run fill and salvaged material from the Site 15a outlet excavation.

The crest of the saddle dam will be 4 m wide at an elevation of 434.4 m and will tie into the adjacent high ground. A 250 mm thick layer of 200 mm minus granular fill will provide erosion protection on the dam crest. To discourage public use and access to the top of the saddle dam, selected suitably sized and shaped boulders will be placed along the crest at random intervals.

Saddle dam side slopes will be armoured with a 0.7 m thick layer of riprap placed over a non-woven geotextile. The riprap will be a combination of Class 10 kg imported and salvaged rock from Site 15a excavation, the removal of Area B temporary rock fill at the access road, and riprap from the temporary bulk bag berm. The imported and salvaged riprap will be blended as far as practical to create a uniform installation. The riprap voids will be infilled with salvaged fill from the Saddle Dam foundation

excavation in order to promote future vegetative growth and provide a more naturalized aesthetic finished surface.

2.3.2 Eroded Channel

The existing eroded channel will be backfilled to approximately match existing adjacent grades and eliminate any potential preferential and undesirable flow paths. The fill for this channel will be primarily sourced onsite from stripping and excavating at other locations. If additional fill is required, imported 75 mm minus pit run fill may be used. Final grading of the finished surface will form a low gradient towards the road to promote drainage away from the saddle dam. The surface will also be roughened or hummocked to create a natural look and match the existing topography. Salvaged vegetation from the stripping may be replanted at BC Hydro's direction if desired.

2.3.3 Access Road Repairs (Area B)

The existing rock used as a temporary repair at the eroded section of the access road will be removed and reused as riprap on at the saddle dam (Section 2.3.1). The eroded section of road will be backfilled with an imported 75 mm minus pit run fill, suitably compacted, and finished to include a gentle swale to maintain the drainage from the eroded channel area. This road section will not be surfaced with the surfacing aggregate specified for the raising of the road at Area A.

3. Cost Estimate

A Class A capital construction cost estimates was prepared for the detailed design works, and is defined by the Association of Consulting Engineering Companies – BC (APEGBC/ACEC-BC)[2] as:

> *"A detailed estimate based on quantity take-off from final drawings and specifications. It is used to evaluate tenders or as a basis of cost control during day-labour construction."*

The 2009 APEGBC/ACEC-BC guideline referenced above also indicates that Class A cost estimates are approximately in the range of ±10-15% of what the actual project construction cost could be; however, this range is highly dependent on market conditions, variability, and risk.

A 10% base contingency has been included to account for possible but limited differences between the detailed design and construction quantities and assumed contractor methodology. An additional contingency should be considered given that there is significant construction market cost uncertainty associated with the COVID-19 pandemic, supply chain disruptions, and ongoing provincial response due to widespread flood damages in BC in late 2021, which is difficult to quantify. While it is not considered an accurate forecast of present market variability, an additional 20% contingency allowance has been included to accommodate at least some of the potential market uncertainty. As such a total contingency of 30% was included in the cost estimate.

The capital cost estimate totals $182,000 excluding contingency, and totals $237,000 including a 30% contingency. These estimates do not include applicable taxes.

It is understood that BC Hydro plans to procure the ACBMs in advance of contract award and supply them to the contractor. This supply cost has been included in the capital cost estimate.

The cost estimates are capital construction costs only and excludes the following:

- professional fees (engineering review, environmental monitoring, and completion documentation);
- regulatory permitting;
- archaeological monitoring;
- construction and contract management; and
- other project related overheads.

A detailed breakdown of the cost estimate costs has been included as Appendix C.

[2] 2009, APEGBC/ACEC-BC Budget Guidelines for Consulting Engineering Service.

4. Construction Implementation and Considerations

Construction is planned to occur in May of 2022 in order to take advantage of projected low water levels in the reservoir. BC Hydro provides regular forecasts of projected reservoir water levels, and it is currently anticipated that reservoir water levels are likely to be too high to work safely and in dry conditions by the beginning of June 2022.

The ease of site access and equipment maneuverability (trafficability) is somewhat dependent on the reservoir water level, rainfall, and soil water saturation conditions at the time of construction, and the largest concern for trafficability is soft saturated surficial soils in the work and access areas. The successful contractor may need to use swamp mats to create local temporary working surfaces, particularly in the vicinity of the new saddle dam in Area B.

Stockpile and laydown areas for temporary use by the contractor near the existing access routes are indicated on the drawings in Appendix B.

Control of water may be required in the form of isolation and pumping, especially at the Site15a outlet, in order to work in the dry. This is dependent upon construction timing, wetland water levels and inflows, and reservoir levels.

5. Operations, Maintenance, and Monitoring

The Site 15a structure is currently considered a Low Consequence dam by the Provincial Dam Safety Office (PDSO) under the Dam Safety Regulation (DSR); however, BC Hydro is currently seeking to redesignate it to a Minor Dam.

The DSR sets out owner requirements and frequency of inspections, monitoring, and maintenance requirements. If the dam is reclassified as a Minor Dam, the DSR may not apply.

The operation, maintenance and monitoring sections below assume that the dam will be redesignated as a Minor Dam. If it is not, there are additional requirements as set out by the DSR.

5.1 Operation and Maintenance

This section outlines operations and maintenance considerations and possible maintenance items. These items are provided as initial considerations and will be updated upon completion of the works.

BC Hydro has noted a preference for design components that require minimal inspections and maintenance and can operate passively during operations. The design was completed with this goal in mind, and as a result, the proposed physical works are expected to require little maintenance or safeguards to protect the works from normal reservoir operations and unauthorized activity.

Engineering operation and maintenance requirements for the design are expected to include the following:

- periodic inspection of physical works;
- potential sediment and or debris removal if required for wetland outlet function; and
- repair of damage to physical works that may be noted during inspections (see below).

Potential maintenance items are identified in Table 5-1 below. It is not an exhaustive list but provides examples of potential maintenance items to inspect and monitor.

Table 5-1: Possible Maintenance Items for Cartier Bay Wetland – Site 15a

Item	Comments
Site 15a Outlet	• If debris or sediment has accumulated in the outlet, it should be removed. • If the ACBM has been damaged by vandalism or vehicle use, repair or replacement may be required. • If the 200 mm minus armouring has been damaged by vandalism, vehicle use or erosion, repair may be required.
Area B Saddle Dam	• Minor settlement of the saddle dam is acceptable. • If debris has accumulated and is there is any erosion, damage, or degradation, debris should be removed, and any damage repaired. • If erosion or settlement is observed to exceed 0.15 m, repair may be required. • If the saddle dam has been damaged by vandalism, vehicle use or erosion, repair may be required.
Area B Road and Eroded Channel Fill	• Minor settlement of the channel infilling and road repair is acceptable. • If ponding is observed between the Area B saddle dam and the road, additional fill and grading may be required.
Area A Road Fill	• Minor settlement of the road fill is acceptable. • If settlement, erosion, or damage due to road use is observed to exceed 0.15 m, repair may be required.

5.2 Monitoring

This section outlines the recommended engineering monitoring plan for the works which includes:

- periodic inspection of the Site 15a and Area B saddle dam structures;
- monitoring of Areas A, B and C for any evidence of erosion or settlement at the road;
- potential sediment removal at the Site 15a outlet; and
- repair of damage to structures that may be noted during inspections (see below).

The following engineering monitoring plan in Table 5-2 has been developed to address regular reservoir operations, maintenance, and inspection frequency.

A repeat topographic survey of the completed works is recommended 5 years after construction. The monitoring inspections may also recommend a survey if settlement or damage is observed.

Table 5-2: Engineering Monitoring Plan

Item (Frequency)	General Details and Procedures	Resource Requirement	Scheduling, Access, and Safety
General Site Overview and Inspection (1st and 3rd years after construction, then every 5 years)	• Take notes and photographs of general site conditions such as reservoir water level, overall appearance and performance of works, and Cartier Bay wetland water level. • Document any changes in geometry, significant erosion or aggradation, new channels, or avulsion paths. • Assess and document any significant accumulation of debris and/or sediment around the structures. • Assess and document any accumulation of debris and/or sediment at the Site 15a outlet. • Assess riprap at Area B saddle dam and Site 15a dam for shifting, slumping, or losses. • Review Areas A, B and C for signs of potential erosion. • Assess and document any apparent signs of public use adjacent to and along the structures. • Assess and document any apparent signs of vandalism. • Note the condition of the roads. • Note any establishment of vegetation • GPS tagged photos at repeat locations and of key items. • Consider the need for a survey of the works. • Prepare an inspection report of the findings.	**Personnel:** Qualified Professional (P.Eng.) for 1st and 3rd year, then every 5 years or after major events. **Equipment:** measuring tape, GPS, camera, rangefinder. **Duration:** ½ day on site plus travel.	**Scheduling:** • Time inspection for minimal snow and ice cover and low reservoir levels. • Prior to site visit, monitor weather forecast, snow surveys, local observations, and reservoir predictions. • Timing roughly around April to May for spring inspection or September to October for fall inspection. **Access:** • Site is located approximately 10 km south of Revelstoke, accessed from Airport Way. **Site Safety:** • Bears are active in the area, so prepare for this and be bear aware. • Cell phone service is available at site. • Work in around water, so have PFDs and training, if necessary, based on expected site conditions.

6. Report Submission

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

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Reviewed by:

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Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of BC Hydro for the Detailed Design Report. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision	Author
0	May 13, 2022	Final		LM
A	March 29, 2022	Draft		LM

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Appendix A

Conceptual Design Report

KERR WOOD LEIDAL
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Technical Memorandum

DATE: January 27, 2022

TO: Mark Sherrington
BC Hydro

FROM: Liam Mackle, P.Eng.
Kalie Siemens, EIT

RE: **CLBWORKS 30A Cartier Bay Site 15a Engineering Services**
Conceptual Design Report
Our File 0478.237-300

1. Introduction

Kerr Wood Leidal Associated Ltd. (KWL) was retained by BC Hydro to develop a conceptual design to maintain the integrity of the function of the Cartier Bay Wetland on Arrow Reservoir near Revelstoke, BC.

The Cartier Bay Wetland is approximately 26 ha and is impounded by an abandoned railway embankment; it is located in the drawdown zone of BC Hydro's Arrow Lakes reservoir. A collapsed culvert in the abandoned railway embankment retained water in the wetland until it was replaced in 2016 by an engineered water retention structure with an aggregate spillway and riprap on the downstream side, referred to as Site 15a. It is understood that the province considers the Site 15a structure a 'Low Consequence' dam; however, BC Hydro is currently seeking to redesignate it to a Minor Dam. When the reservoir level rises each year, Cartier Bay is inundated. The wetland drains through Site 15a during early spring freshet, and also when the reservoir level recedes in the fall and becomes lower than the water level in the wetland.

Erosion of the north bank of the wetland has occurred along a topographic low point and formed a channel which is directing wetland discharge, and early reservoir inundation away from the Site 15a outlet, since this channel is now at a lower elevation than Site 15a. Left unchecked, the erosion will likely reduce water levels in the wetland and therefore the amount of wetland area available for habitat and aquatic life. Temporary mitigation works were installed in 2020 and remain at present, but without long-term mitigation works, further erosion and headcutting are expected to continue and direct wetland discharge away from the Site 15a outlet. BC Hydro intends to construct permanent works in spring 2022 prior to the reservoir filling in early summer, if possible, to eliminate the risk of further erosion from outflows on the north bank. This risk of erosion exists at three low points along the north bank.

This technical memorandum outlines the design criteria, an assessment of the Cartier Bay wetland, and provides conceptual design options with cost estimates and next steps.

2. Project Background

Cartier Bay is located on Arrow Lakes Reservoir, approximately 20 km downstream on the Columbia River from BC Hydro's Revelstoke Dam constructed in 1985. Arrow Reservoir is approximately 230 km long, extending from Revelstoke to Castlegar, and is impounded by the Hugh Keenleyside Dam constructed in 1968.

Arrow Lakes Reservoir has a normal operating range of approximately El. 419 m to El. 440 m (CGVD28 datum), which inundates Cartier Bay wetland by approximately 6 m when the reservoir is full.

Cartier Bay wetland has two compartments each impounded by former road and railway embankments with narrow outlets, as shown in Figure 1. During the spring of 2020, erosion of the fine-grained floodplain soils along the northern edge of the Cartier Bay wetland's lower compartment created a channel at a low point in the topography a distance away from the Site 15a outlet/spillway. Following emergency approval in October 2020, BC Hydro retained a contractor to install temporary mitigation works that remain in place at present. The works include gravel filled bulk bags and riprap placed in a temporary berm across the low point of the north bank and upstream of the eroded channel, which is referred to as Area B. Two other low points (Areas A and C) were also identified at the time that could have the potential to allow wetland discharge and erode.

On April 21, 2021, the outlet works at Site 15a were damaged/vandalized by unauthorized construction equipment. ATV traffic is also known to cause some damage to the outlet structure by eroding the side slopes and depositing material in the base of the outlet/spillway at Site 15a. BC Hydro retained a contractor to repair the outlet in May 2021 and restore it to its original design geometry.

Repairs were made to the existing temporary berm at the Area B in November 2021 following a KWL and BC Hydro site visit where water was seen to be flowing through the berm, resulting in renewed headcutting downstream in the channel that had previously formed.

An overview of the Cartier Bay wetland and features of interest is shown in Figure 1.

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BC Hydro and Power Authority

artier Bay Wetland Site 15A Arrow Lakes

KERR WOOD LEIDAL consulting engineers

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Image:
World Imagery: Maxar

Coordinate System: NAD 1983 CSRS UTM Zone 11N

Scale Disclaimer: The map scale of 1: is only valid on a 8.5"x11" print.

Project No.	478-237
Date	January 2022
Scale	1:8,000

0 50 100 200 Metres

Cartier Bay Wetland Overview

Figure 1

2.1 Cartier Bay Background Information

The following background information was provided by BC Hydro and was used for analysis and design:

1. Topographic survey of the Site 15a outlet and eroded areas to the north (denoted as A, B, and C) that was conducted on April 14, 2021 (Monashee, 2021).
2. As-built drawings of the existing Site 15a outlet and riprap on the downstream side of the dam (Watson, 2016).
3. Forecasted Arrow Reservoir levels at Cartier Bay and Cartier Bay water level data (various forecast dates).
4. Two Digital Terrain Models (DTM) of the wetland, one from 2019 and one from 2020.
5. A 2019 orthophoto and aerial imagery.
6. 2020 UAV imagery.
7. Areas of archaeological potential.
8. Reports from the Arrow Reservoir Wildlife Management Plan, which include information about Cartier Bay.
9. Wetland water depth data measured on six separate occasions between 2010 and 2014 (water depths only, not elevation) for the upper and lower wetland compartments.
10. Reports detailing the April 2021 vandalism and repairs.
11. Several photographs of the site, including photos of the vandalism and repairs, and the temporary bulk bag fix and emergency repairs at Area B.
12. Water level logger data recorded in Cartier Bay from May 8, 2021 to November 5, 2021.

Background information and files received from BC Hydro has been compiled and summarized in detail in Attachment E.

3. Site Assessment and Observations

On November 18, 2021, Liam Mackle and Kalie Siemens of KWL performed a site assessment with Harry van Oort, of BC Hydro, to document observations and existing conditions at Cartier Bay, including:

- the state of erosion at Area B, and along the northern boundary (north bank) of the lower compartment;
- existing conditions at Areas A and C;
- the Site 15a outlet channel and riprap on the downstream side of the dam;
- the temporary works installed at Area B;
- flow and water level conditions at Site 15a compared to other eroded areas;
- existing topography, vegetation, and soil conditions; and
- other features or infrastructure which could impact the design.

At the time of the site visit, the water level in Arrow Reservoir was 431.87 m GSC recorded at Water Survey of Canada station 08NE104 (Arrow Reservoir at Nakusp). Snow and ice partially covered the areas of interest at the time of the site visit.

Photos from the site assessment can be found in Attachment A. The primary findings of the site visit are summarized below:

1. The main source of water flowing into the lower compartment comes from the upper compartment where a former paved road embankment separating the upper and lower compartments is breached. This inflow location is shown in Photo 1 of Attachment A. Other inflows to the lower compartment include a small amount of runoff from the surface along the southern wetland margins.
2. The water level in the upper wetland compartment was less than 0.3 m higher than the lower compartment.
3. The roadways along the northern boundary (north bank) of the lower wetland compartment where identified low Areas A, B, and C are located are not paved and have some low spots where water had ponded (Photo 2). The roads have several ruts from vehicle tires and blends in with the surrounding topography (there is no formal elevated embankment).
4. The primary vegetation at the wetland is reed canary grass. The coverage and height of the grass is generally uniform except along the roads, former railway embankment, and eroded areas.

Site 15a Outlet

1. The depth of water in the outlet channel was measured at 13 cm near the center of the outlet, but the water level was below the riprap crest on the downstream slope of the outlet (Photo 12). This relates to an approximate lower wetland compartment water surface elevation of 434.05 m.
2. Water was flowing through the outlet, by seeping through the riprap and discharging out of the riprap fill on the downstream margin (Photos 13 and 14).
3. There is a 600 mm diameter CSP culvert through the former railway embankment approximately 10 m north of the Site 15a outlet (Photo 15). The crown of the culvert is close to the crest of the former railway embankment above the outlet. The culvert was above the water level at the time of the site visit and was clear and dry.
4. An anchored water level logger was found in the channel downstream of the Site 15a outlet (Photo 16).
5. The soil in the channel downstream of Site 15a is a similar erodible silty floodplain soil to what was observed at Area B. The channel had near vertical eroded side slopes and was flowing slowly towards the main reservoir.

Area A

1. There is a noticeable topographic low channel along Area A (Photos 3, 4, and 5).
2. The roads are lower at Area A and had ponded water during the site visit.
3. There was no flowing water along area A at the time of the site visit.
4. The area was generally vegetated with a few bare patches, potentially at low points where water could pool.

Area B

1. There is a narrow-eroded channel that partially connects the wetland's lower compartment north across the road to an adjacent historic (inactive) oxbow channel. The channel was actively flowing with an actively receding headcut at the time of the site visit (Photo 6).
2. The temporary bulk bag berm placed in the spring of 2020 had begun to fail. There was water flowing between bags near the center of the barrier, and one of the bags had ripped open resulting in the loss of some sand and gravel on the downstream side and an approx.100 mm deep scour hole had formed (Photo 7).
3. There was approximately 25 cm of head difference (water level) between the upstream and downstream sides of the temporary bulk bag berm (Photo 8).
4. Vehicles had driven south of the area of the road that had been washed out but infilled with rock riprap, forming a depression just north of the temporary bulk bag berm (Photo 9).
5. Water was flowing underneath the angular rock fill that was placed across the road to provide access after the road had been washed out (Photo 10).
6. The soils along the eroded channel are generally easily erodible, fine silts with a small amount of clay and fine sand content (typical of floodplain soils). This was seen in exposures at locations of previous headcuts in Photo 11.
7. There is a defined swale with reduced or minimal vegetative cover, likely due to active flow through the area.

Area C

1. The location of the Area C low point was not visibly detected on site due to the subtle differences in topography and a continuous cover of canary reed grass. There were no topographic indicators or changes in the road surface or vegetation marking the location of a low point in Area C. There was no evidence of erosion observed to be occurring at this location.

Following the site visit, a repair was conducted to the Area B temporary berm to reinstate the integrity of the bulk bags on November 26, 2021. A new bulk bag was added to block the flow and a second bulk bag was placed where the damaged bag had been removed. Sand from the damaged bulk bag was salvaged and transferred to the upstream bags to increase their size and height, and reduce voids between bags.

4. Design Criteria/User Requirements

The following are the objectives, requirements and related considerations that were used to guide the initial development of design concepts. These design criteria were initially circulated to BC Hydro in December 2021 and the feedback solicited at that time has been incorporated in the text below.

4.1 Environmental Objectives

1. Secure long-term sustainment of the lower compartment of Cartier Bay by lowering the outlet elevation, while minimizing a reduction in availability of suitability of the lower compartment for diving ducks. Alterations to the Site 15a outlet elevation or geometry will not result in a substantial reduction in wetland area, or a biologically non-significant change to pool depth for diving ducks. Proposed

changes to the Site 15a outlet and its effect on total area of the wetland is discussed in further detail in Section 5.

2. Suppression of reed canary grass is not a design objective.
3. Works will not be designed to create aquatic and wildlife habitat above or near to the reservoir full-pool level.
4. Trees and shrubs will not be planted as the elevation would be too low for survival during inundation; however, wetland vegetation species could be incorporated.
5. Habitat windows and wetland area/ water elevations will be generally considered, if desired, in the context of available construction periods.

4.2 Hydrologic Analysis

1. Historical water level data in both Cartier Bay wetland and Arrow Lakes Reservoir will be reviewed.
2. Additional hydrologic analysis beyond the water level review noted above will not be conducted.
3. Alterations to the Site 15a outlet elevation or geometry will yield a similar or greater discharge to what was originally designed/intended.
4. Any changes in discharge at the outlet will not be significant enough to result in a change in dam consequence classification.
5. Accordingly, an inflow-design flood (IDF) will not be developed as a part of the proposed works.

4.3 Design Options and Considerations

Initial design considerations and design criteria are outlined below. The conceptual design options are presented in detail in Section 6.

General Options, Alignment, and Geometry

1. The three general conceptual design options of the appurtenant structures at Areas A, B, and C to be considered all include lowering and widening the invert of the outlet channel at Site 15a. The three appurtenant structure options and Site 15a sub-options for consideration include:
   a. Option 1 – Raising the access road to address low points at Areas A and B and no proposed works at Area C, combined with lowering Site 15a.
   b. Option 2 – Erosion protection such as riprap armouring or rock channel stabilizers at Areas A and B and potentially Area C, combined with lowering Site 15a.
   c. Option 3 – Construction of a saddle dam at Area B, raising the road at Area A and no proposed works at Area C combined with lowering Site 15a.
   d. Three sub-options to Options 1, 2 and 3 for the Site 15a outlet channel lowering include:
      - Sub-Option A – Articulated Concrete Block Mattress (ACBM) to line the outlet channel and maintain a hard outlet elevation.
      - Sub-Option B – An aggregate lined channel similar to the existing and at the new elevation.
      - Sub-Option C – Embedded precast concrete blocks to define and maintain the new invert elevation.

e. The three sub-options for the Site 15a outlet lowering all would include a level outlet (i.e., no raised riprap crest above and downstream of the outlet).

2. Initial design criteria include:

   a. Appurtenant structures (saddle dams or roads) will be designed with an elevation difference of approximately 0.6 m above the Site 15a outlet invert elevation.

   b. The saddle dams or road are to have a minimum 4 m wide crest.

   c. The embankment side slopes will not require armouring if constructed at a shallow slope (assumed 6H:1V or shallower).

   d. Side slopes are to be no steeper than 3H:1V.

   e. The existing eroded channel at Area B is to be protected against further erosion.

   f. Some settlement of the crest of the raised road or saddle dam is expected and can be built into the design crest elevation.

   g. A limited amount of settlement (<50 mm) at the invert of the outlet at Site 15a is tolerable.

   h. Lowering of the existing Site 15a outlet/spillway elevation was initially considered to be in the range of 0.25 to 0.5 m. This is discussed further in Section 5.

   i. A trapezoidal outlet geometry was specified by BC Hydro with a 4 m invert width to improve discharge capacity and further reduce risk of blocking by floating debris.

   j. BC Hydro prefers simple construction materials and methods with limited machine and related construction footprint impacts, which will be considered in the design.

Public Safety and Recreational Use

1. Any signage or vehicle barricades, if included in the design, should not pose a navigational hazard.
2. Driving over the Site 15a outlet or potential saddle dams could be discouraged with barricades or other measures; however, the works will be designed with public and worker safety in mind.
3. The Site 15a outlet works should be designed to be difficult for members of the public to alter or damage.
4. Sedimentation and algae growth will be considered in geometry and material selection at Site 15a.

Materials

1. Use of readily available manufactured products (i.e., concrete and geotextile) or natural materials (i.e., aggregate, riprap, soil) will be considered in the design.
2. Materials used at the Site 15a outlet will be safe for driving or walking over.
3. The Site 15a embankment will remain as a semi-permeable outlet. Initial concepts involving sheet piles will not be advanced.
4. Some of the existing riprap will be excavated to lower the Site 15a outlet elevation, and this riprap could be replaced elsewhere in the existing apron or be used in design concepts at Areas A and B.
5. It is acceptable to consider incorporating the existing temporary bulk bag berm at Area B in the long-term solution providing it can meet long term design life and environmental requirements.

Erosion Protection

1. Erosion and scour protection of slopes and discharge locations will be assessed to reduce the potential for erosion from:
   - freshet discharge from the wetland (based on hydrologic assumptions);
   - raising and lowering of the reservoir level;
   - wave action; and
   - vehicle and foot traffic.
2. Saddle dam structures are not intended to be fully impermeable, therefore dam core materials will provide adequate filtering to reduce the potential for internal erosion and piping.
3. The flanks of the saddle dams may be protected from erosion if they are proud of the surrounding topography and where intermittent concentrated discharge is expected.

Operations and Maintenance

1. The outlet works design will seek to limit potential debris and sediment build-up.
2. Low maintenance designs are preferred.
3. Inspection and monitoring of proposed works will form part of BC Hydro's annual inspection program for the dam and reservoir.
4. The Site 15a outlet is preferred to be a concept that would be resistant to vandalism and wear and tear that could affect the elevation and geometry of the invert.

Construction Timing

Construction is planned to occur in April/May of 2022 in order to take advantage of projected low water levels in the reservoir. Figure 2 shows forecasted reservoir levels through to fall of 2022, mean water levels, and the historic water level range which indicates that the wetland would often be inundated following freshet through the winter and into early spring. A potential target maximum water level elevation for completing the works 'in the dry' is estimated to be approximately 423.5 m and is presented as a line on the figure to aid in the evaluation of potential construction windows. This target elevation will be refined during detailed design.

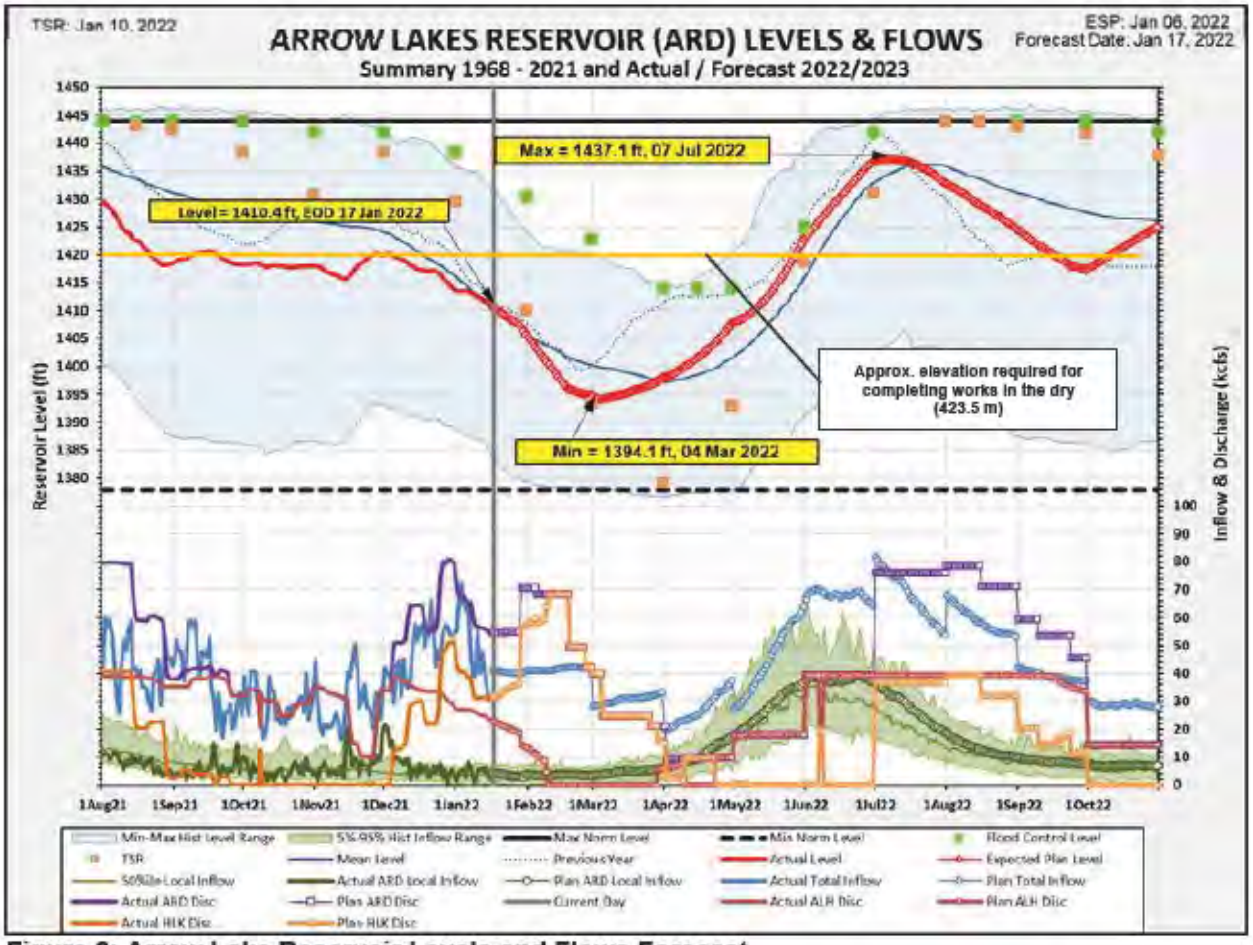

Figure 2: Arrow Lake Reservoir Levels and Flows Forecast

A potential phased approach may be explored in detailed design if BC Hydro considers the selected design option cannot be fully constructed within the available window. If required, construction could start with the Site 15a outlet lowering in Spring 2022, followed by construction of the works at Areas B and A in Spring of 2023.

4.4 Regulations and Guidelines

Dam Safety Regulations (DSR)

1. The Site 15a structure is considered a Low Consequence dam by the Provincial Dam Safety Office (PDSO) under the DSR; however, BC Hydro is currently seeking to redesignate it to a Minor Dam.
2. Alterations to the Site 15a outlet will not result in sufficient changes in discharge or hazard to warrant a change to the consequence classification.
3. Appurtenant structures, such as saddle dams or raised road embankments, will maintain the existing Low or potentially Minor Consequence classification.

4. Typical dam freeboard criteria do not have much relevance to the appurtenant structures being proposed for the conceptual designs as they will become completely inundated each time the reservoir rises. Accordingly, dam freeboard will not be a specific design criterion.

Navigable Waters Protection Act (NWPA)

1. When the proposed physical works are inundated, there is the potential for navigation impacts within the reservoir. The works will be designed with the lowest possible profiles and with smooth geometries to limit potential navigational impacts.
2. It is expected that BC Hydro will need to submit the selected design for review relative to the NWPA. This may result in a need to modify the design and/or include appropriate warning signage.

Others

1. No specific design criteria have been identified at this stage of design for the other relevant regulations and acts such as:
   - Water Sustainability Act (WSA);
   - Federal Fisheries Act; and
   - Species at Risk Act.

5. Water Level and Wetland Analysis

Water levels on Arrow Reservoir are recorded at Fauquier and Nakusp, which are approximately 130 km and 80 km downstream of Cartier Bay, respectively, at the following Water Survey of Canada (WSC) hydrometric stations:

- 08NE102 – Arrow Reservoir at Fauquier
- 08NE104 – Arrow Reservoir at Nakusp

The Nakusp station is the closest to Cartier Bay and is therefore used for comparison with water levels at the wetland. Reservoir levels near Cartier Bay are expected to be slightly higher than Nakusp as it is located 80 km upstream. A sensor was temporarily installed in the wetland just upstream of the Site 15a outlet to monitor water levels in Cartier Bay from May through November 2021.

BC Hydro generates forecast water levels for Arrow Lakes Reservoir for an 8-9 month look ahead as presented in Figure 2 for the period of January to October 2022. Historic reservoir water level data is also available.

Based on Arrow Reservoir levels at Nakusp and key wetland elevations, generally the water level in Cartier Bay is controlled by the reservoir level as it fills and rises above the wetland in late spring. In some years the reservoir will recede and lower below the Site 15a outlet in late summer/fall prior to winter as occurred in 2021. In early spring, upland drainage to Cartier Bay discharges through the Site 15a outlet.

A summary of relevant water levels with reference to key topographic features around the wetland that control inflow and outflow are presented in Table 1.

Table 1: Relevant Water Level and Key Cartier Bay Wetland Feature Elevations

Description	Elevation
Arrow Reservoir maximum normal operating level	440.13 m
Elevation of 15a outlet invert (Monashee, 2021) [a]	433.92 m
Elevation of Riprap crest at 15a Outlet [a & b]	Approx. 434.47 m
Elevation of crest of Area A swale [a & c]	Approx. 434.25 m
Elevation of crest of Area B swale [a & c]	Approx. 433.84 m
Elevation of crest of Area C swale [a, c & d]	Approx. 434.44 m
Arrow Reservoir minimum normal operating level	419.98m

Notes:
[a] Monashee survey conducted April 14, 2021 - Drawing 7559 Topo, R0.
[b] Could be different following the 2021 outlet vandalism and repair.
[c] Point above which Area A, B or C flows.
[d] Monashee survey drawing (7559 Topo, R0) Area 'C' profile of contains an error. The high point is higher than stated.

5.1 Wetland and Reservoir Level Review

A plot of Cartier Bay wetland and Arrow Lakes Reservoir water levels (based on Nakusp) is presented in Figure 3. Wetland water levels are available for the period of from May 8, 2021 to November 5, 2021[1]. This allowed for a review of the water levels and the function of the wetland during reservoir filling and drawdown and a comparison of the elevations of the key wetland features including the swales on the north bank (Areas A, B, and C).

Wetland water levels are expected to normally exceed the Site 15a invert and Area B elevations in early spring freshet and then seep through the permeable Site 15a structure once water levels lower below the Site 15a invert (and Area B) elevation until the reservoir levels become higher than the wetland levels and the reservoir starts to gently reverse the flow back into the wetland as it starts to inundate.

[1] The recorded water levels compared well to surveyed water levels (<3 cm difference), email correspondance from Mark Sherrington (November 15, 2021).

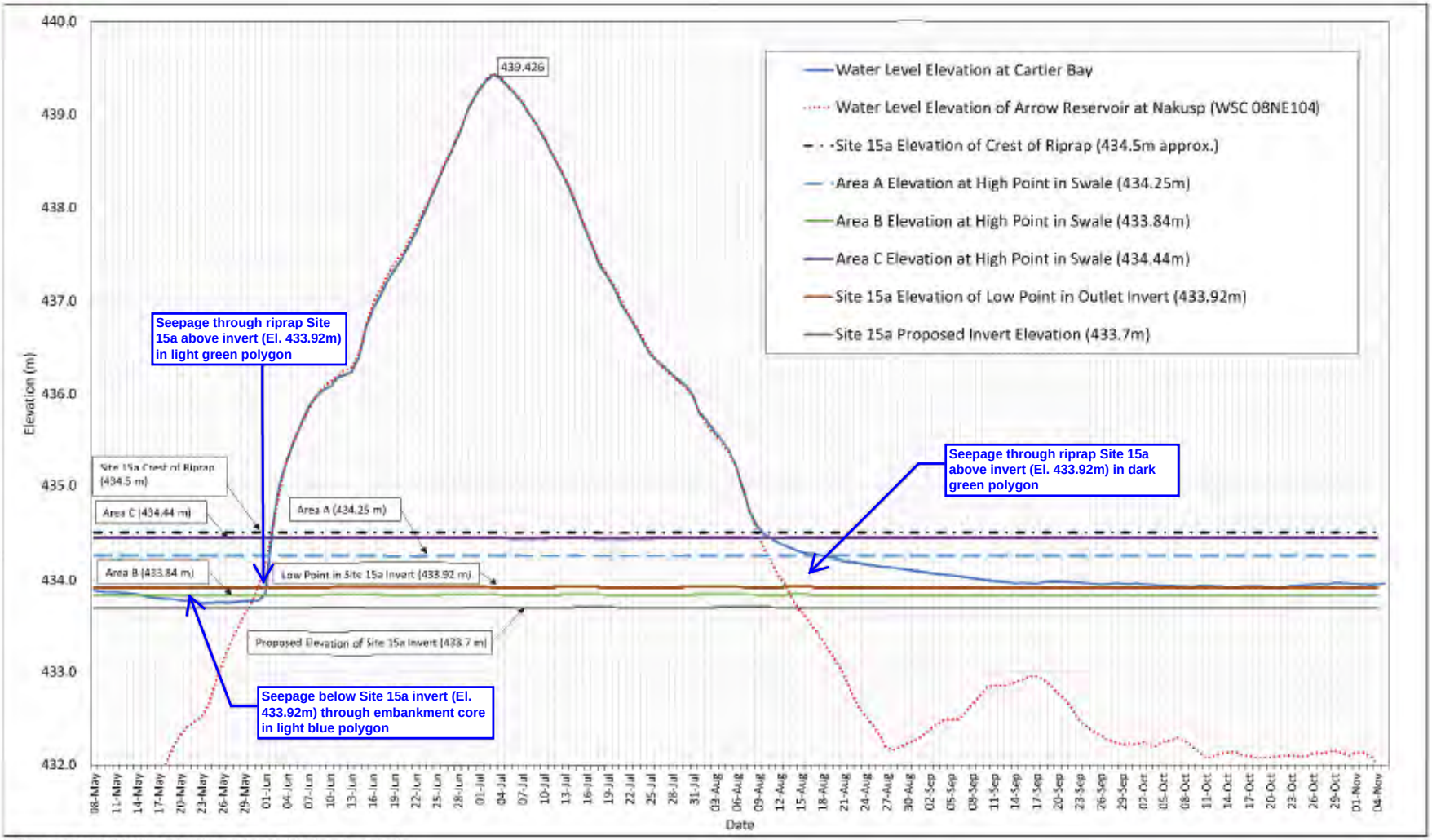

Figure 3: 2021 Cartier Bay Water Levels

Key observations and assessment from Figure 3 are as follows:

1. Wetland water levels were below the Site 15a outlet on May 8, 2021, when the data series started.
2. Water continued to gently fall below the invert elevation after May 8, 2021 (blue shaded area), which implies that there is no flow over the Site 15a outlet and that the discharge is through the permeable Site 15a dam since the temporary bulk bag berm at Area B was in place in 2021.
3. As the reservoir level rose, it exceeded the Site 15a invert level at 433.92 m, but the wetland levels lagged (light green shaded area) until a few days later in late May/early June when the reservoir level rose above the Site 15a riprap crest at 433.5 m.
4. Above 433.5 m elevation the wetland water levels followed the reservoir levels as the wetland inundated.
5. In the later stages of reservoir drawdown, and as the reservoir level receded below 433.5 m in August 2021, the water level in the wetland lagged behind the reservoir water level (dark green shaded area) and did not drop below the Site 15a invert elevation until several weeks later.
6. September through early November 2021 the water level in the wetland was slightly above the Site 15a invert level, but below the riprap crest elevation.
7. Based on the observations from KWL's November 18, 2021 site visit, water was ponded above the Site 15a invert behind the crest of the riprap (See Photo 12), but it had not exceeded the riprap elevation, which is similar to the November 5, 2021 data two weeks earlier as shown in Figure 3.

The existing riprap crest at the outlet at Site 15a is proud of the invert by 0.4 to 0.5 m, which likely explains the delay in the rising and falling limbs in the hydrograph of the wetland relative to the reservoir. Following the construction of Site 15a in 2016, the riprap voids may have partially filled in with sediment and debris and become less permeable. A transverse section through the Site 15a outlet is provided in Figure 4.

The elevated riprap crest may also be contributing to unwanted wetland discharge at Areas A and B, and erosion at Area B prior to inundation, as the riprap is above the elevations of the swales at Areas A and B and perhaps C.

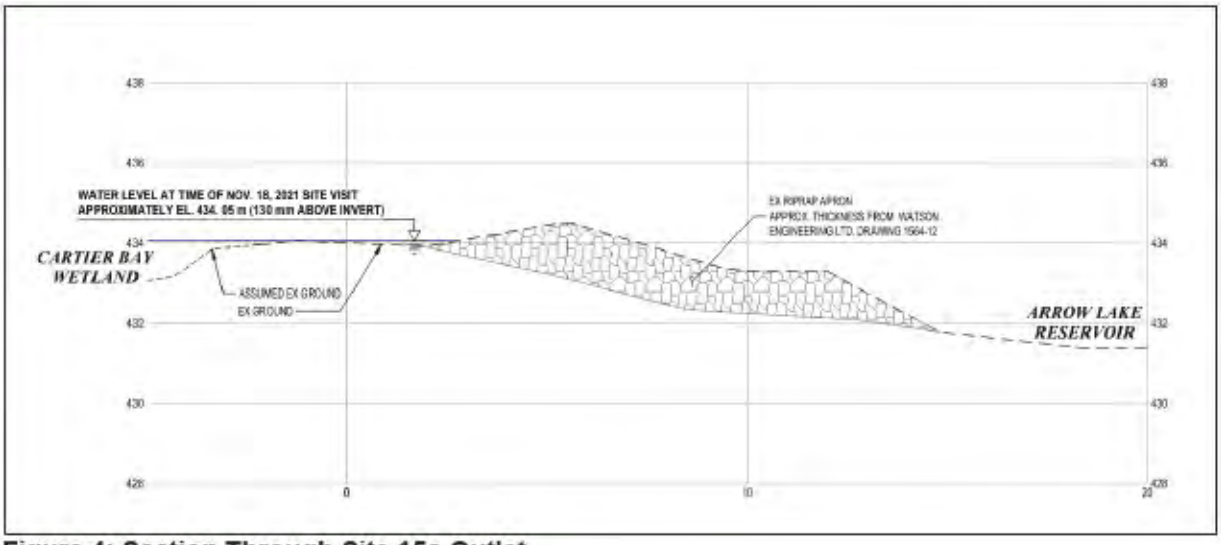

Figure 4: Section Through Site 15a Outlet

5.2 Wetland Inundation Spatial Review

A spatial visualisation exercise was undertaken using GIS to visualize the interaction of the wetland and the main pool of the reservoir during filling and drawdown operations. Figure 5 presents a view of the water levels reaching sufficient elevation to overtop both Area B and the Site 15a outlet. It also shows that there are no other obvious low points (such as the swales at Areas B and C) that the reservoir would inundate the wetland from at this elevation.

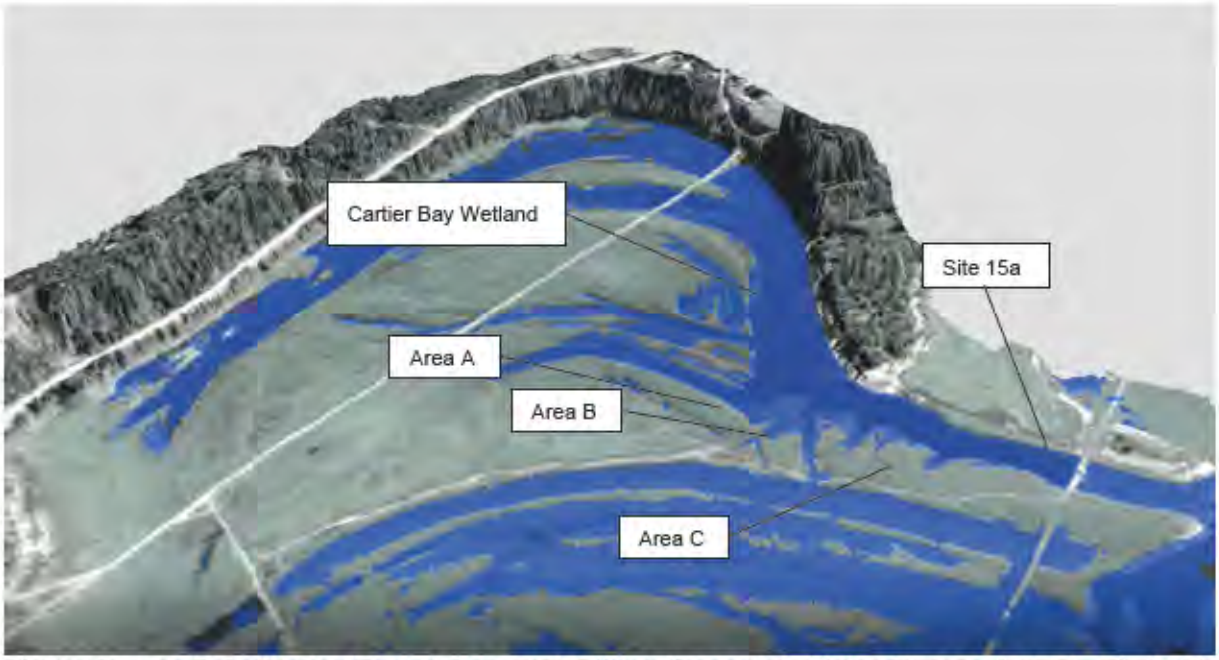

Figure 5: Area B Activation During Reservoir Filling (Reservoir Water Surface Approx. El. 434.1 m)

As the reservoir continues to fill, all identified swales at Areas A, B, and C provide flow connection as shown in Figure 6. As with the previous figure, it also shows that there are no other obvious low points that the reservoir would inundate the wetland from at this higher elevation.

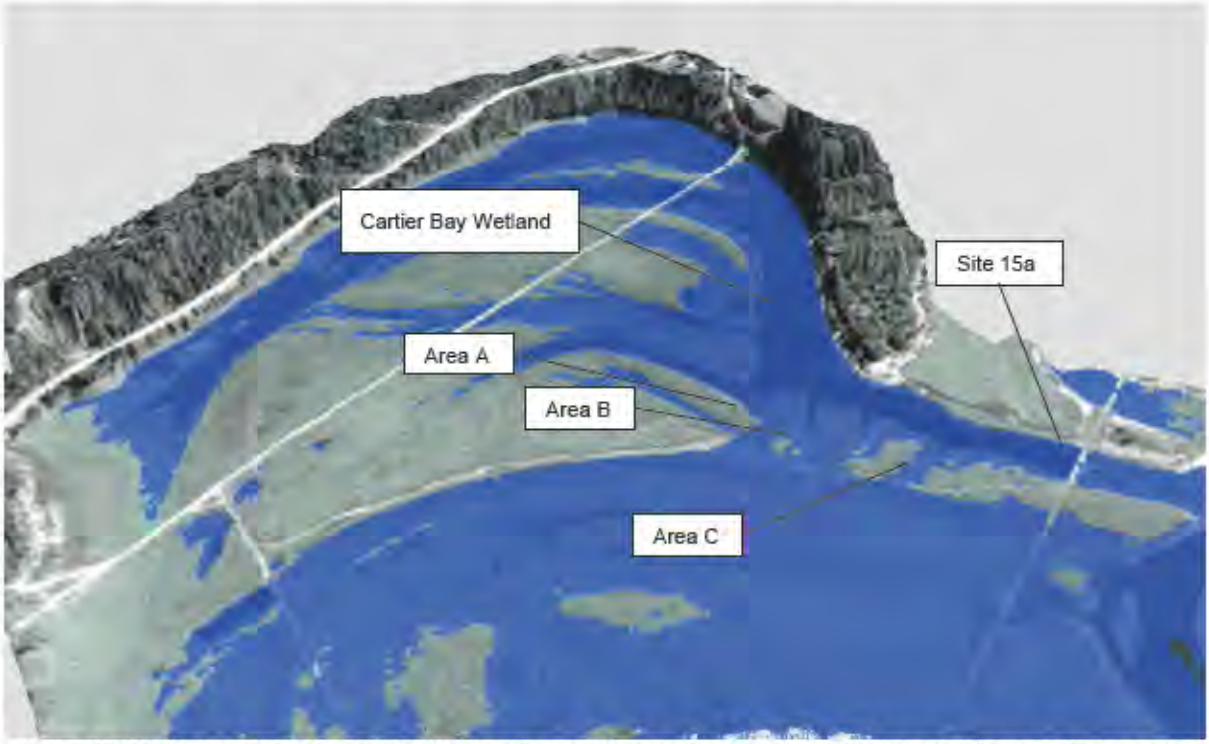

Figure 6: Wetland and Reservoir Connected at Areas A, B and C (Reservoir Water Surface El. Approx. 434.8 m)

The existing erosion and headcutting at Area B is thought to be a result of the existing outlet (invert and riprap) elevation at Site 15a allowing the low point at Area B to activate and become a preferential flow path while the wetland is draining and during the early stages of infilling. Lowering the Site 15a invert elevation and raising and/or armouring the swales (particularly at Area B) is expected to significantly reduce the risk of erosion through these alternate flowpaths.

5.3 Wetland Bathymetry and Areal Review

One of the objectives of the conceptual design for altering the Site 15a outlet elevation is to avoid a substantial reduction in wetland area. This requires a review of the available bathymetric data for the wetland area.

Upon review, KWL found that the bathymetic dataset was actually based on water depth data collected on six separate dates between 2010 and 2014 the upper and lower wetland compartments[2]. The water

[2] Refer to Figure 5-4 of the LGL 2015 report entitled '*CLBWORKS-30: Ecological Impact Assessment – Wildlife Physical Works Projects 14 & 15A*'

depths do not appear to have not been tied to a water surface elevation, which likely varied based on when the water depths were taken.

An assessment of the impacts of lowering the invert at the Site 15a outlet was carried out by BC Hydro in order to quantify potential wetland area and habitat loss. This exercise was also conducted by KWL with similar findings summarized in Table 2, however the pond area (and % reduction) data is highly uncertain, as discussed further below.

Table 2: Cartier Bay Wetland Depth Reduction vs. Area

Site 15A Outlet Invert Elevation Reduction		
Water Depth Reduction (m)	Pond Area (ha) *	Estimated Area Reduction (%) *
–	9.49	
0.1	9.49	0%
0.2	9.49	0%
0.3	9.48	<1%
0.4	9.47	<1%
0.5	9.42	<1%
0.6	9.20	3%
0.7	8.84	7%
0.8	8.19	14%
0.9	7.45	22%
1	6.48	32%
* Pond area and % Area reduction are highly uncertain, as discussed in the text below.		

The 'starting' elevation of the associated wetland water surface for the water depth data used for Table 2 is not known, so it is presently unknown at what elevation the area starts to become sensitive to the reduction in elevation. Also, it is unknown how the pond water surface area was derived, and how it relates to the various years of water depth data (if at all).

KWL compared the boundary of the 2010 to 2014 water depth dataset shape file with the DTM topography in an attempt to see if the results provide a potentially reasonable water surface elevation. The mean water surface elevation around the north boundary at the times of the surveys was 433.9 m (ranged between 432.9 m and 434.6 m). This elevation compares well with the Site 15a invert elevation of 433.92 m, but it does not confirm the starting water level of the bathymetric data, nor its accuracy.

Based on the data, it appears that the wetland could be lowered by up to 0.5 m without much change in the retained water (pond) area in the wetland area; however, there are significant concerns with the underlying data and assumptions used to prepare the results in Table 2:

1. There is no change in area between 0 m and 0.2 m of depth, which is highly unlikely and potentially reflects incomplete survey data, especially in shallow areas;
2. The accuracy of the bathymetric surface is unknown;
3. The water depth data has not been tied to an elevation; and
4. The basis of the water surface area associated with 0 m depth is unknown.

For the reasons above, the results in Table 2 are not considered to be reliable.

To be conservative, the conceptual design will limit lowering the invert at the Site 15a outlet to no more than 0.3 m. Additional analysis using other available DTMs will be evaluated during detailed design to develop more accurate assessments of wetland area and depth relationships, if possible, in the context of lowering the Site 15a outlet and finalizing the outlet elevation.

6. Conceptual Design Options & Costs

6.1 Conceptual Design Options and Considerations

Conceptual designs are outlined below and are detailed further relative to a variety of evaluation criteria in Attachment B.

Following discussions of initial conceptual options with BC Hydro, it was agreed that the swale at Area C, at this stage, would not require any works or appurtenant structures under the current proposed design heights and objectives. The existing swale elevations are above the design height of the appurtenant structure crests and is unlikely to require any design elements to prevent overtopping and/or erosion from wetland discharge. This area will be monitored for future signs of any erosion once the selected design has been implemented.

Plans and sectional views of the conceptual design options are included as figures in Attachment C.

Site 15a

1. Three options for the Site 15a outlet were considered and two were advanced for conceptual level cost estimating:
    a. Option A – Articulated Concrete Block Mattress (ACBM) to line the outlet channel and maintain a hard invert elevation.
    b. Option B – An aggregate lined channel similar to the existing and at the new elevation. (This option was removed from further consideration during the conceptual design process)
    c. Option C – Embedded precast concrete blocks to define and maintain the invert elevation.
2. All three sub-options include a level or shallowly sloped outlet with no raised riprap crest above the elevation of the invert.
3. Additional excavation will be undertaken as required to place an armoured riprap or cobble surface along the bottom of the invert around the concrete works.
4. A lowered Site 15a outlet invert elevation of 433.7 m (approximately 0.2 to 0.3 m lower than existing) was selected for conceptual design. This elevation helps establish Site 15a as the preferential inlet and outlet for the Cartier Bay wetland to and from the reservoir, and reduces the risk of discharge and potential erosion at the swales at Areas A, B, or C; however, it would only be marginally lower (by approximately 15 cm) than the lowest point of the swale at Area B. The elevation of the new invert elevation will be refined in detailed design.
5. The eroded channel in Area B should be infilled to reduce the potential for further erosion.
6. A v-notch or lower swale in the outlet invert could be considered in detailed design to maintain a more concentrated flow path at lower water levels. This could be achieved through the placement of concrete mattresses at an angle meeting in the middle. Precast concrete blocks can also be installed at a low angle to accomplish an approximate "V" shape, or with a gentle swale.

Areas A, B, and C

Design options for appurtenant structures only include Areas A and B since the swale at Area C naturally meets the initial design criteria of 0.6 m above the Site 15a outlet elevation. All of the design options would include annual monitoring of Area C for evidence of erosion.

Area A may only require monitoring rather than designing an engineered solution as it nearly meets the initial design criteria of 0.6 m above the Site 15a outlet invert elevation (approx. 0.05 m less) and there was no observed evidence of erosion along the swale at Area A. This will be evaluated further and discussed with BC Hydro as detailed design advances.

Option 1 – Raise Road at Areas A and B (Do Nothing at Area C)

1. Raising the road to address swales at Areas A and B and no proposed works at Area C, combined with lowering the invert at Site 15a.
    a. The raised road would have a 4 m wide granular driving surface and a crest elevation of 434.3 m, which is 0.6 m above the proposed Site 15a outlet invert elevation. Fill will likely be 75 mm minus pit run material (to be confirmed in detailed design). As noted above, Area A could be considered optional and only be monitored for future erosion, similar to Area C.
    b. Angular gravel erosion protection would be included on the crest of the road (above 434.3 m), if required.
    c. For the conceptual design, the raised road design crest elevation would be 434.4 m, which is 0.1 m above the design criteria of 434.3 m. This is additional 0.1 m would allow for an erosion resistant, but more permeable, material on the crest, and also would accommodate some settlement of the new fill.
    d. The side slopes of the raised road would not require armouring if constructed at a shallow slope (assumed to be at 6H:1V or shallower).
    e. The eroded channel at Area B would be filled (likely with pit run - 75 mm with fines) and compacted back to its estimated grade prior to being eroded.

Option 2 – Channel Stabilizers in Areas A and B (Do Nothing at Area C)

1. A series of rockfill channel stabilizers installed in the swales at Areas A and B and no proposed works at Area C, combined with lowering the invert at Site 15a.
    a. The eroded channel at Area B would be filled (likely with pit run - 75 mm with fines) and compacted back to its initial grade, including the eroded section of road that is currently filled with riprap.
    b. Channel stabilizers would consist of Class 10 kg or smaller riprap (potentially mixed with onsite excavation) and be installed at discrete locations along the swales at Areas A and B. As with Option 1, Area A could be considered optional and only be monitored for future erosion, similar to Area C.
    c. The top elevation of the channel stabilizers would be consistent with the adjacent existing grade.

Option 3 – Saddle Dam at Area B, Raise Road at Area A (Do Nothing at Area C)

1. This option includes construction of a saddle dam in the swale at Area B, raising the road at Area A and no proposed works at Area C combined with lowering the invert at Site 15a. Fill for the road and saddle dam will likely be 75 mm minus pit run material (to be confirmed in detailed design).

a. The crest elevation for saddle dam at Area B will connect to the existing adjacent topographic high points at 434.3 m to maintain a height of 0.6 m above the Site 15a outlet invert elevation.

b. The raised road in Area A would have a 4 m wide granular driving surface and a crest elevation of 434.3 m, which is 0.6 m above the proposed Site 15a invert elevation. As with Options 1 and 2, Area A could be considered optional and only be monitored for future erosion, similar to Area C.

c. Angular gravel erosion protection would be included on the crest of the road and saddle dam (above 434.3 m), if required.

d. For the conceptual design, the saddle dam and raised road design crest elevation would be 434.4 m, which is 0.1 m above the design criteria of 434.3 m. This is additional 0.1 m would allow for an erosion resistant, but more permeable, material on the crest, and also would accommodate some settlement of the new fill.

e. The saddle dam side slopes will be no steeper than 3H:1V and would be armoured with Class 10 kg or smaller riprap.

f. The raised roadside slopes would not require armouring if constructed at a shallow slope (assumed to be at 6H:1V or shallower).

g. The eroded channel at Area B would be filled (likely with pit run - 75 mm with fines) and compacted back to its initial grade.

6.2 Conceptual Level Cost Estimates

Class D capital construction cost estimates were prepared for selected conceptual design options based on the conceptual design criteria, lidar and topographic survey, extents estimated in the field, and unit costs based on similar projects. Class D cost estimates are defined by the Association of Consulting Engineering Companies – BC (APEGBC/ACEC-BC)[3] as:

> *"A preliminary estimate which, due to little or no site information, indicates the approximate magnitude of cost of the proposed project, based on the client's broad requirements. This overall cost estimate may be derived from lump sum or unit costs for a similar project. It may be used in developing long term capital plans and for preliminary discussion of proposed capital projects."*

The 2009 APEGBC/ACEC-BC guideline referenced above also indicates that Class D cost estimates are approximately in the range of ±50% of what the actual project construction cost could be; however, this range is highly dependent on market conditions, project uncertainty, and risk. We understand that BC Hydro typically uses -50%/+100% range for conceptual level design cost estimates.

Given that that there is further design refinement pending in the detailed design phase, there is considerable construction market cost uncertainty at this time, and to align with BC Hydro's typical assumed upper cost estimate accuracy range for conceptual design, a 100% contingency has been applied to the Class D cost estimates. Cost and contractor availability uncertainty could be reduced by engaging a pre-selected construction contractor during the detailed design.

The cost estimates are capital construction costs only and exclude professional fees (engineering and environmental).

[3] 2009, APEGBC/ACEC-BC Budget Guidelines for Consulting Engineering Service.

Modifications to Site 15a Outlet (Sub-Options A, B, and C)

A summary of the estimated Class D estimated costs for each outlet design option are outlined in Table 4 and detailed further in Attachment D. Each of the sub-options include an allowance for coffer dam isolation and pumping during construction, which may be required depending on water levels and final outlet design elevations. Equipment delivery and specialized equipment (if required, e.g., spreader bar for ACBM installation) are included in the lump sum for mobilization and demobilization.

Table 3: Class D Cost Estimate for Site 15a Design Options (Incl. 100% Contingency)

Design Option	Estimated Cost
Sub-Option A – Articulated Concrete Block Mattress	$182,000
Sub-Option B – Aggregate Lined Channel (not advanced)	N/A
Sub-Option C – Embedded Precast Concrete Blocks	$164,000

Options 1 - 3 – Appurtenant Structures at Areas A and B

Class D cost estimates for all three design options are summarized in Table 3. Additional detail can be found in Attachment D.

Allowances include equipment delivery and site access considerations are encompassed in mobilization and demobilization costs. Additional site access requirements such as swamp mats have not been included in the primary cost items but could be captured within the contingency allowance.

Table 4: Class D Cost Estimate for Appurtenant Structures at Areas A and B (Incl. 100% Contingency)

Design Option	Estimated Cost
Option 1 – Raise Road at Areas A and B	$80,000 ($76,000 excluding optional Area A)
Option 2 – Channel Stabilizers at Areas A and B	$132,000 ($96,000 excluding optional Area A)
Option 3 – Saddle Dam at Area B, Raise Road at Area A	$98,000 ($96,000 excluding optional Area A)

As discussed in Section 6.1, works at Area A could also be considered optional as there was no observed evidence of channelized erosion at Area A, and would be approximately 0.55 m above the proposed Site 15a invert elevation. Area A could also be monitored for erosion similar to Area C. Estimated costs excluding Option A are presented in brackets in Table 4 and are also included in more detail in Attachment D.

7. Selected Concept and Next Steps

Through internal consultation and assessment, BC Hydro selected the Articulated Concrete Block Mattress (Sub-Option A) for the Site 15a outlet, and Saddle Dam at Area B (Option 3) to advance to detailed design. These options will be developed further during detailed design, and the feasibility of monitoring Area A rather than designing an engineered solution will be evaluated.

The following next steps will be undertaken:

1. Perform additional analysis (wetland area reductions, saddle dam alignment, etc.) to confirm design assumptions and parameters.

2. Finalize design elevations of the Site 15a outlet and appurtenant structures.
3. Preparation of detailed design drawings (Issue for Tender (IFT)) and technical specifications.
4. Detailed cost estimation for the selected design.
5. Provide construction planning and procurement support to BC Hydro.
6. Preparation of Issue for Construction (IFC) drawings.
7. Conduct part-time engineering construction review.
8. Prepare a construction completion report and record drawings (Issued for Record (IFR)).

8. Closure

Please contact the undersigned for any additional information or clarification.

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Encl.: Attachment A: Photo Summary (November 18, 2021)
Attachment B: Conceptual Design Options
Attachment C: Design Figures
Attachment D: Class D Cost Estimate
Attachment E: Summary of Data Sources

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
0	January 27, 2022	Final		LM/KS
A	January 18, 2022	Draft		LM/KS

Proudly certified as a leader in quality management under Engineers and Geoscientists BC's QQM Program from 2013 to 2021.

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Attachment A

Photo Summary (November 18, 2021)

Attachment A – Photo Summary (November 18, 2021)

Photo 1: Looking south along alignment of decommissioned road separating upper and lower compartments of Cartier Bay. Water flow is from upper into lower compartment (left to right).

Photo 2: Looking west along alignment of unpaved access road north of swales at Areas A, B, and C.

Photo 3: Looking south along vegetated swale at Area A. A low spot in the road was visible.

Photo 4: Looking south along partly vegetated swale at Area A. Subdued swale and frozen/ponded water were observed.

Attachment A – Photo Summary (November 18, 2021)

Photo 5: Looking north along vegetated swale at Area A. Swale extends to the oxbow channel to the north.

Photo 6: Looking south along eroded channel at Area B. Headcut was receding towards the temporary bulk bag saddle dam.

Photo 7: Downstream side of temporary bulk bag saddle dam above eroded channel at Area B. Sand and gravel spilled out of a torn bag and water was flowing between bags.

Photo 8: Looking west. Approximately 25 cm difference in hydraulic head between upstream and downstream of the bulk bag saddle dam.

Attachment A – Photo Summary (November 18, 2021)

Photo 9: Looking south along swale in Area B. Vehicles have contributed to the depression where the swale has formed connecting the lower compartment to the oxbow channel to the north.

Photo 10: Looking north along area B. Riprap was placed in the eroded channel to partly re-establish the road.

Photo 11: Looking north along eroded channel at Area B. Evidence of previous head-cutting in erodible floodplain silts.

Photo 12: Looking south along former railway embankment at location of Site 15a outlet. Depth of water in outlet was 13 cm above invert. Note riprap proud of invert on left side of outlet.

Attachment A – Photo Summary (November 18, 2021)

Photo 13: Looking south. Riprap facing on downstream side of Site 15a Dam.

Photo 14: Looking east at Site 15a outlet from downstream side.

Photo 15: Looking east. 600 mm diameter CSP culvert approximately 10 m north of Site 15a outlet.

Photo 16: Anchored water level logger found downstream of Site 15a outlet.

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Attachment B

Conceptual Design Options

Attachment B: Cartier Bay Concepts Comparison Table

Criteria	Options for Site 15a Outlet			Options for Swales: Areas A/B/C		
	Sub-Option A Articulated Concrete Block Mattress	Sub-Option B Aggregate-lined Channel *(REMOVED FROM CONSIDERATION)*	Sub-Option C Embedded Precast Concrete Block in Channel	Option 1 Raise Road at Areas A and B	Option 2 Channel Stabilizers in Areas A and B	Option 3 Saddle Dam at Area B, Raise Road at Area A
Description	• Excavate material to lower invert to design elevation (433.7 m) • Regrade outlet geometry to trapezoidal configuration with 4 m base width • Dig shallow trenches along the side slopes to allow for embedding the ends of the ACBM's into the slopes • Compact subgrade • Place geotextile • Place open-cell Articulated Concrete Block Mattress (ACBM) laterally across outlet channel • Fill open cells with gravel • Backfill shallow trenches to cover ends of mats	• Excavate material to lower invert to design elevation (433.7 m) • Regrade outlet geometry to trapezoidal configuration • Compact subgrade • Likely a mix of imported granular fill and the existing rail ballast • Blend into existing side slopes.	• This option is very similar to Option B however with smooth-topped precast concrete blocks used to define the invert elevation. • Excavate down approx. 1m below desired invert elevation in a trench across the outlet entry. • Compact subgrade • Place precast concrete blocks across bottom of trench such that the top of the precast concrete block is at the desired outlet elevation of 433.7 m • Backfill up to 0.3m below top of precast concrete block • Grade side slopes to blend into existing or use angled precast concrete block • Place aggregate up to top of precast concrete block similar to Option B	• Raise the existing road surface at low points in Areas A and B to elevation 434.3 m to provide a consistent "saddle dam" along the north boundary of the lower wetland compartment • The road geometry would match the existing widths and side slopes, however if the side slopes are steeper than 6H:1V they may require armouring • The existing eroded channel in Area B would be filled with compacted granular material mixed and returned to its original grade • Area A could also be considered optional as there was no observed evidence of erosion at Area A, and it is approximately 0.55 m above the proposed Site 15a outlet elevation. Area A could also be monitored for erosion similar to Area C.	• A series of buried grade control structures (channel stabilizers) would be installed along the outlet swales at Areas A and B. These would serve as hard points to reduce the likelihood of headcutting if erosion were to occur through these low points during drawdown of the reservoir • The existing eroded channel in Area B would be filled with compacted granular material mixed with spoil material from adjacent excavation and returned to its original grade • The channel should be revegetated with native species or reed canary grass • As noted in Option 1, Area A could be considered optional and could be monitored for erosion similar to Area C.	• Tie together topographic high points with an earth dam embankment (saddle dam) to a crest elevation of 434.3 m • Saddle dam will likely have 3H:1V side slopes, a semi-permeable core that will prevent piping, and riprap armor with a granular filter on the crest, side slopes, and outer edges/flanks • The road geometry would match the existing widths and side slopes, however if the side slopes are steeper than 6H:1V they may require armouring • The existing eroded channel in Area B would be filled with compacted granular material mixed and returned to its original grade • As noted in Option 1, Area A could be considered optional and could be monitored for erosion similar to Area C.
Environmental Impacts/Benefits	• Uses a manufactured, precast, non-natural product • Concerns about spalling concrete and/or corrosion of cables if damaged through recreational use • Compatible permeability with the existing dam materials	• Uses natural and natural-looking materials • Compatible permeability with the existing dam materials	• Uses a manufactured, precast, non-natural product • Reduces permeability • Significant excavation • Will likely require a small cofferdam and/or pumping wetland discharge water around the work area (may require fish permits)	• Providing a raised, graded road could deter driving elsewhere • Works would be completed in the dry • Could use semi-permeable materials • Larger footprint than Option 3 • Works are in previously impacted area (low habitat value) vs in the wetland	• Could vegetate with wetland species • Maintains permeability • Requires working in or near the waters edge • Excavation would be required which could introduce fine sediment to the wetland or reservoir – appropriate ESC measures will be required • Smallest footprint of the options	• Could vegetate with wetland species • Dam may require a shallow key trench • Could make the saddle dam semi-permeable through the selection of core materials
Public Safety and Recreational Considerations	• Could fill the open cells in the ACBMs with gravel to make surface look more natural • Surface could be prone to fine sediment and algae growth • Safe for walking and driving, but surface can become slippery in winter or with sediment/algae accumulation • Difficult to vandalize the ACBM surface, but aggregate surface around it could still be vandalized.	• Surface can be driven on, but vehicle traffic can cause erosion and damage • Surface can be walked on • Susceptible to vandalism	• Surface can be driven on, but vehicle traffic can cause erosion and damage • Surface can be walked on • Road surface susceptible to vandalism	• Encourages vehicles driving into the wetland area • People could camp on it	• Could cause erosion in other areas (i.e., downstream of channel stabilizers)	• Would want to discourage driving on the saddle dam crest • Armoring would help to prevent vandalism
Visual or Aesthetic Impacts	• Uses a manufactured, non-natural product • Can maintain similar swale shape • Flexible components that can readily contour to excavated surface and can accommodate any post construction deformation or settlement	• No major change to existing outlet appearance, except for lower elevation and broader trapezoidal geometry	• Uses manufactured concrete blocks that would be mostly buried • Maintains a nearly natural-looking channel	• Little visual impact beyond a slight widening of the existing embankment	• Least change to surrounding topography. • Restore existing eroded area to original grade • Low visual footprint especially once vegetated	• Armored saddle dam could be made to look natural with planted wetland species
Operations and Maintenance	• Minimal maintenance beyond regular inspection • Should be inspected regularly for settlement, etc. • Can consistently and reliably maintain the design outlet elevation relative to desired water levels with reference to the ACBM • Less maintenance than Option B and C	• Should be inspected annually • Invert elevation would be at risk of change from traffic related erosion • May require annual survey to confirm outlet elevation • Greatest amount of maintenance of the options	• Should be inspected regularly for erosion from flows and vehicles and after every high-water event. • Can consistently and reliably maintain the design outlet elevation relative to desired water levels with reference to the concrete blocks • Similar maintenance to Option B	• Road surface may require maintenance due to use and submergence • Road surface and side slopes should be inspected annually • Little maintenance required • Requires annual inspections as part of a Dam Safety inspection program	• Erosion between channel stabilizers may occur if the wetland empties preferentially through these swales rather than the Site 15a outlet • Unarmoured areas may become vulnerable to erosion • Should be regularly inspected for erosion issues • Very little maintenance required	• Similar operation and maintenance to Option 1 • Riprap on surface may require maintenance over time due to debris, ice action, human caused erosion. Erosion could occur on the flanks if unarmoured. • Dam should be inspected regularly to check for seepage and erosion issues.
Access, Constructability, and Duration	• Access using road to the north and former railway bed • Likely need a large excavator with a spreader bar to handle ACBMs • Where to procure geotextile and ACBMs? • May require a small cofferdam and/or pumping wetland discharge water around the work area • Construction period estimated at 1-2 weeks	• Access using road to the north and former railway bed Simple construction equipment – medium sized excavator and dump truck • May require a small cofferdam and/or pumping wetland discharge water around the work area • Construction period estimated at 1-2 weeks	• Access using road to the north and former railway bed • Excavator may need longer reach (>3m) • Concrete blocks likely available from local sources • Greatest excavation of the options • May require a small cofferdam and/or pumping wetland discharge water around the work area • Construction period estimated at 1-2 weeks	• Access using existing roads • Soft soils in this area, Could consider taking advantage of constructing on frozen ground in winter • Requires importing granular materials and riprap (if required) • Requires compaction equipment and review during construction • Construction period estimated at 1-2 weeks	• Access using existing gravel road • Soft soils in this area. Could consider taking advantage of constructing on frozen ground in winter • Construction period estimated at 1-2 weeks • Simple design and materials, minimal equipment - likely just a small excavator and a dump truck needed	• Access using existing gravel road • Soft soils in this area. Could consider taking advantage of constructing on frozen ground in winter, however ground survey control and compaction would be more challenging • Requires importing riprap, granular filter, and dam core material • Requires compaction equipment and review during construction • Uses relatively simple equipment • Construction period estimated at 1-2 weeks
Regulatory Considerations	• Lowering invert elevation will require review by the Provincial dam safety officer (DSO) • Must maintain Low Consequence classification • There would likely be no CNWA considerations	• Same as Option A	• Same as Option A	• DSR requirements as it is an appurtenant structure to the Site 15a dam • Could trigger Canadian Navigable Waters Act if works are considered an impediment to navigation (unlikely)	• May be considered an appurtenant structure to the Site 15a dam. • Construct at low water so works can be completed in the dry • Potential for Fisheries implications but could be managed through ESC measures	• DSR requirements as it is an appurtenant structure to the Site 15a dam • Could trigger Canadian Navigable Waters Act if works are considered an impediment to navigation (unlikely)
Costs	• $182,000	• N/A	• $166,000	• $80,000 ($76,000 excluding optional Area A)	• $132,000 ($96,000 excluding optional Area A)	• $98,000 ($96,000 excluding optional Area A)

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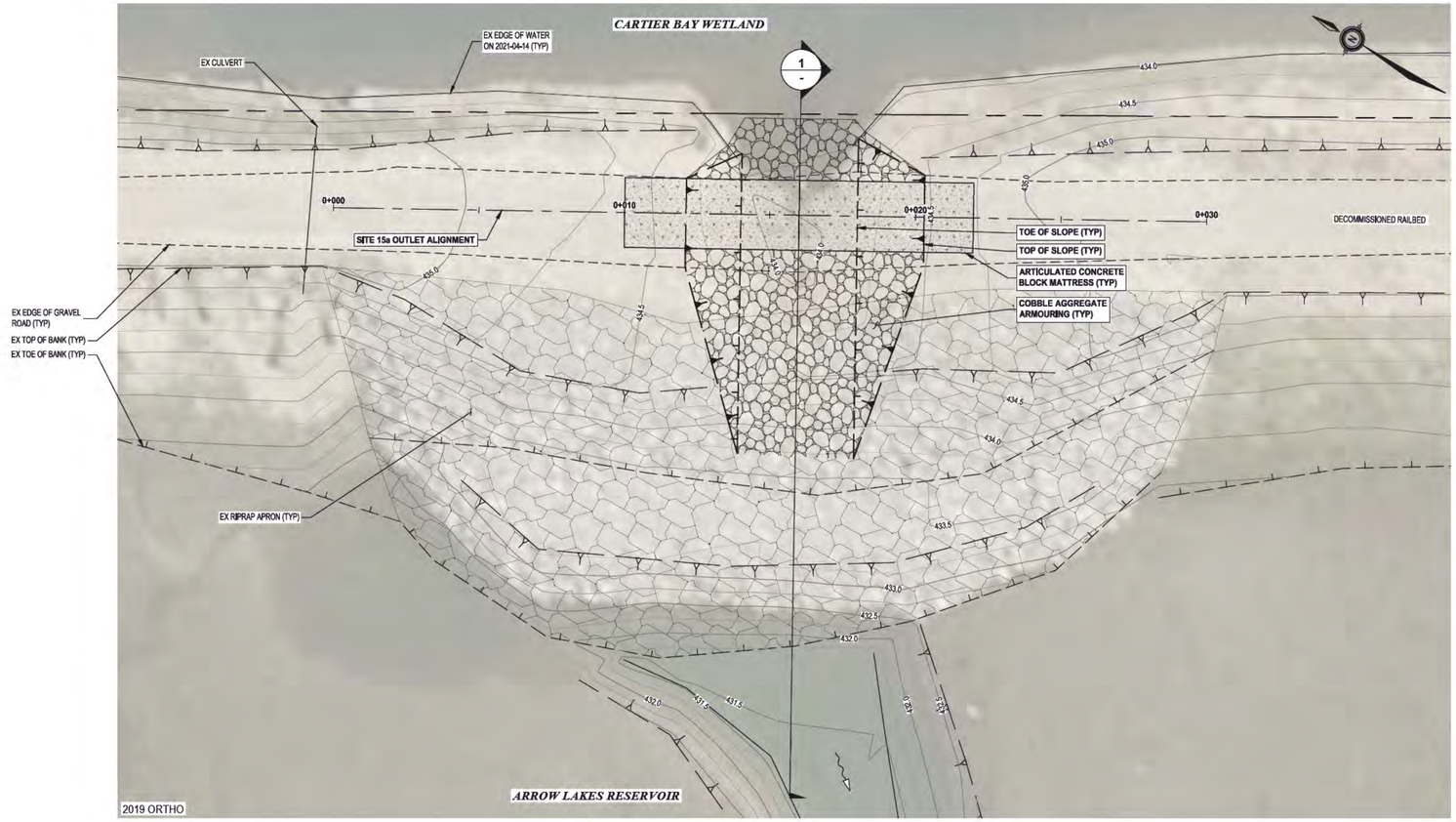
Attachment C

Design Figures



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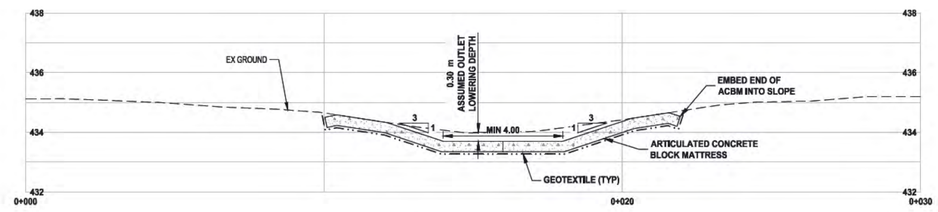

SITE 15a OUTLET PROFILE
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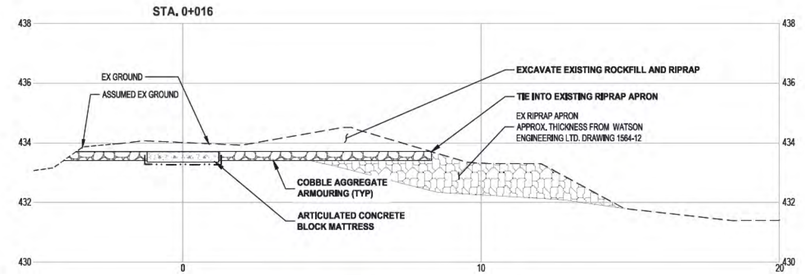

SITE 15a OUTLET SECTION 1/-
Scale 1:100

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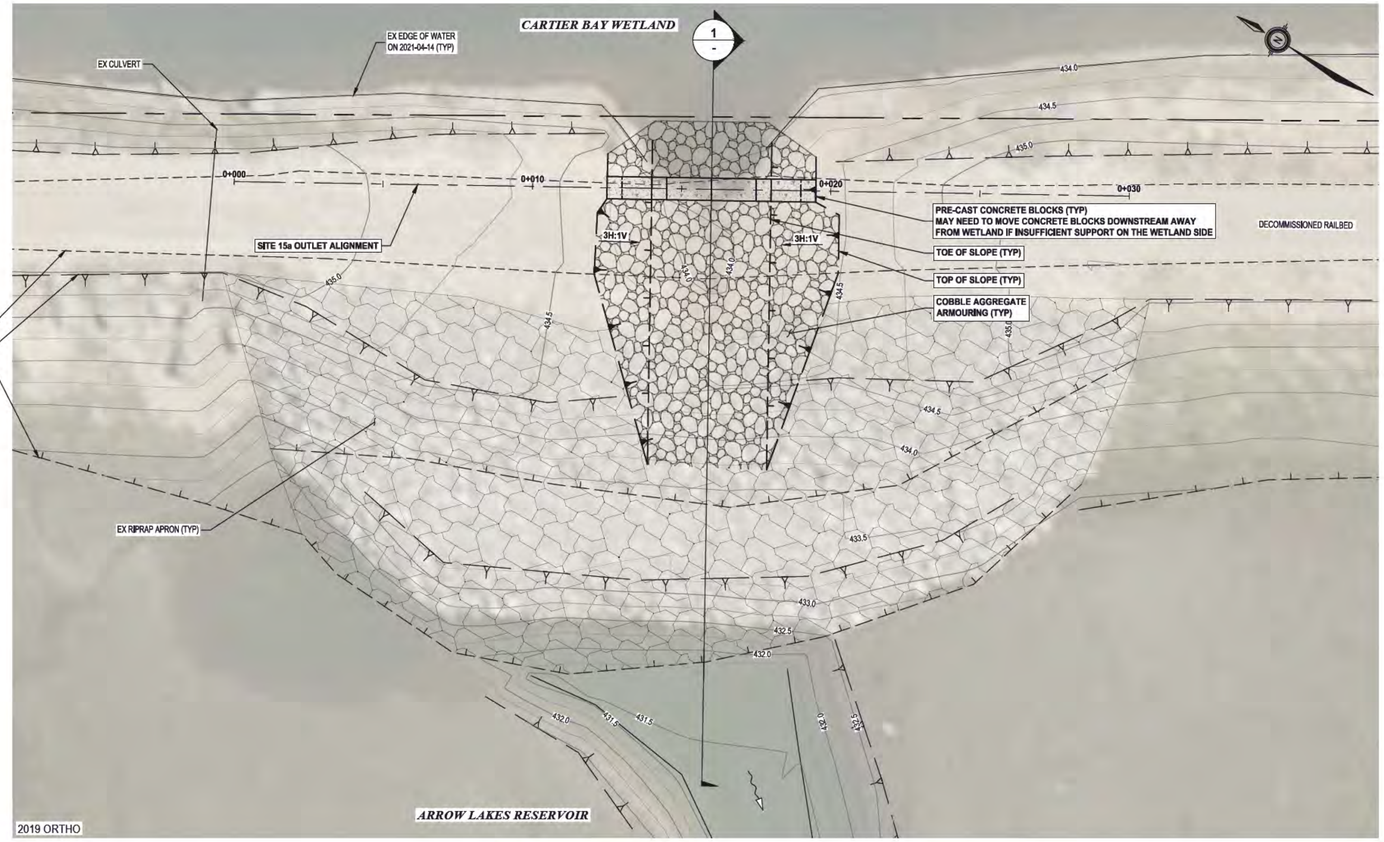
BC HYDRO
CLBWORKS 30A CARTIER BAY SITE 15a
FIGURE C1 - OUTLET SUB-OPTION A
ARTICULATED CONCRETE BLOCK MATTRESS (ACBM)



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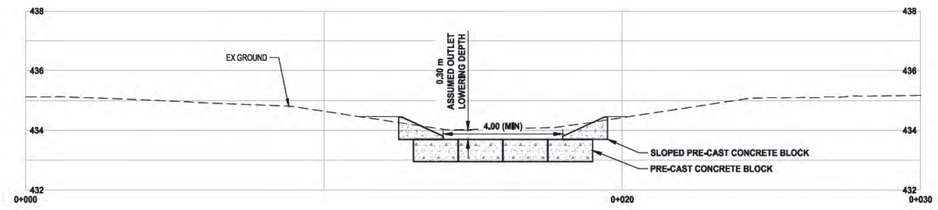

SITE 15a OUTLET PROFILE
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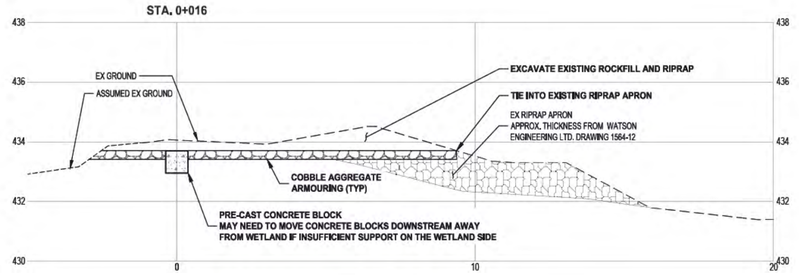

SITE 15a OUTLET SECTION 1/-
Scale 1:100

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CLBWORKS 30A CARTIER BAY SITE 15a
FIGURE C2 - OUTLET SUB-OPTION C
EMBEDDED PRE-CAST CONCRETE BLOCKS

SAVED 2022/01/26, 10:26 AM

Paper Size = ANSI D
A1 Full Size, this border measures 520 mm x 800 mm

0 10 50 100 millimetres

NORTH BANK

1
-

EX UNPAVED ROAD (TYP)

EX FLOW PATH (TYP)

RAISE EXISTING ROAD SURFACE TO EL. 434.3 m
SEE TYPICAL SECTION

FILL ERODED AREA TO MATCH PREVIOUS GRADE, ROUGHEN AS REQUIRED

AREA C

AREA A

AREA B

EX TEMPORARY BULK BAG BERM

REMOVE TEMPORARY WORKS

SEE FIGURES C1 & C2 FOR OUTLET 15A SUB-OPTIONS

EDGE OF WATER APRIL 14, 2021

EX DECOMMISSIONED RAILBED

EX PROPERTY LINE (TYP)

CARTIER BAY WETLAND

2019 ORTHO

PLAN
Scale 1:750

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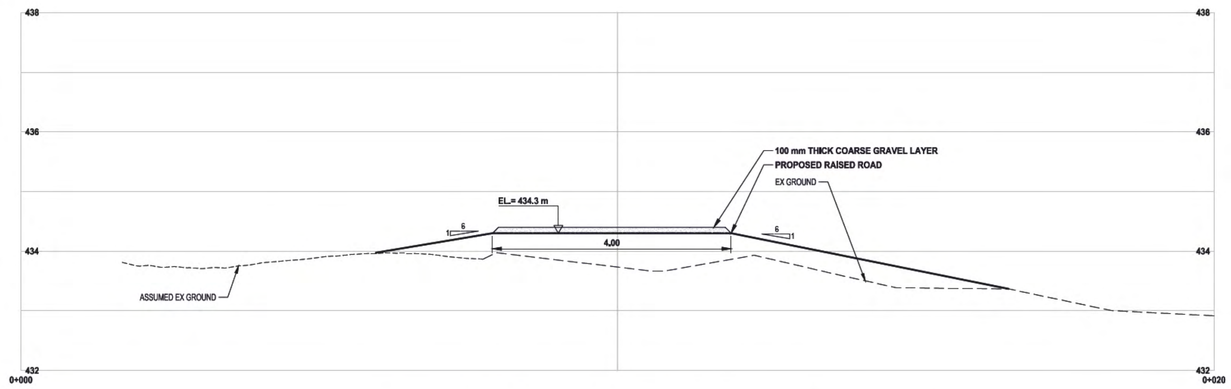

TYPICAL ROAD RAISING SECTION
Scale 1:50

1
-

0 0.5 (1:50) 2.5m

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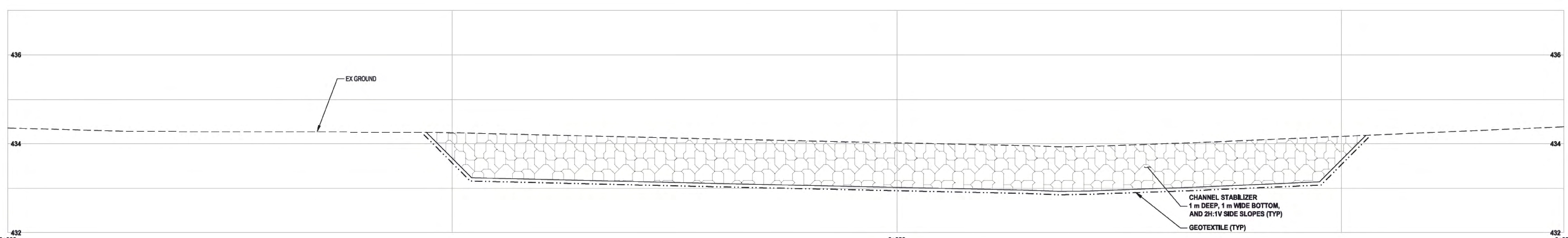
BC HYDRO
CLBWORKS 30A CARTIER BAY SITE 15a
FIGURE C3 - OPTION 1 RAISE ROAD AT AREAS A AND B

Z:\0000-0999\0409\0409.479-2375\01-Drawings\b_Figures\Fig3_Concept-Road.dwg

PLAN

Scale 1:750



TYPICAL CHANNEL STABILIZER SECTION 1 -

Scale 1:50

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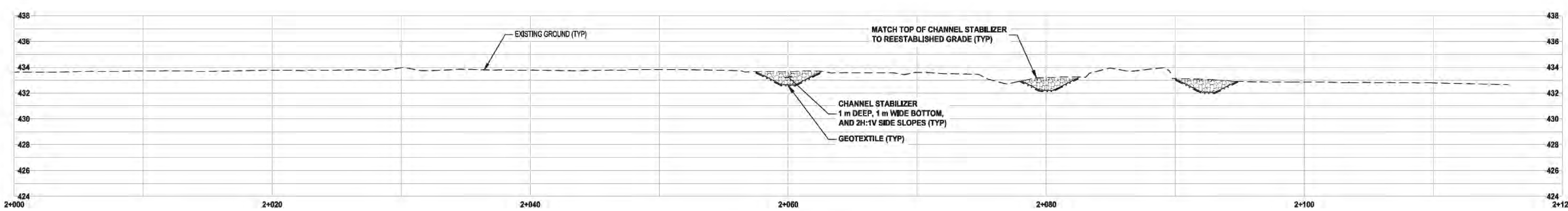
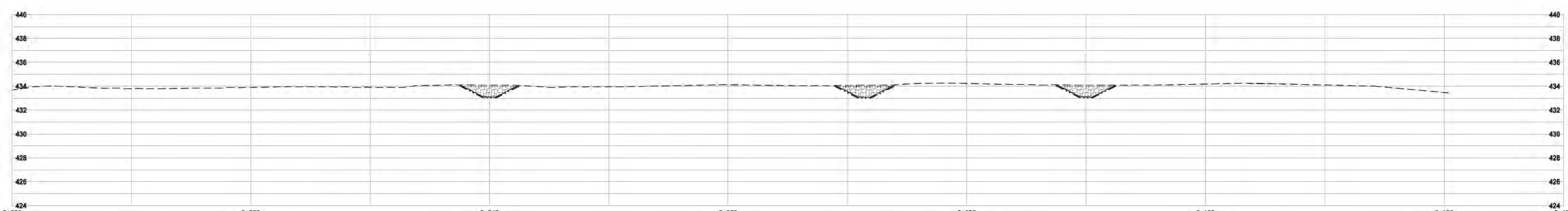
BC HYDRO
CLBWORKS 30A CARTIER BAY SITE 15a
FIGURE C4A - OPTION 2 CHANNEL STABILIZERS



AREA B THALWEG PROFILE

Scale 1:200



AREA A THALWEG PROFILE

Scale 1:200

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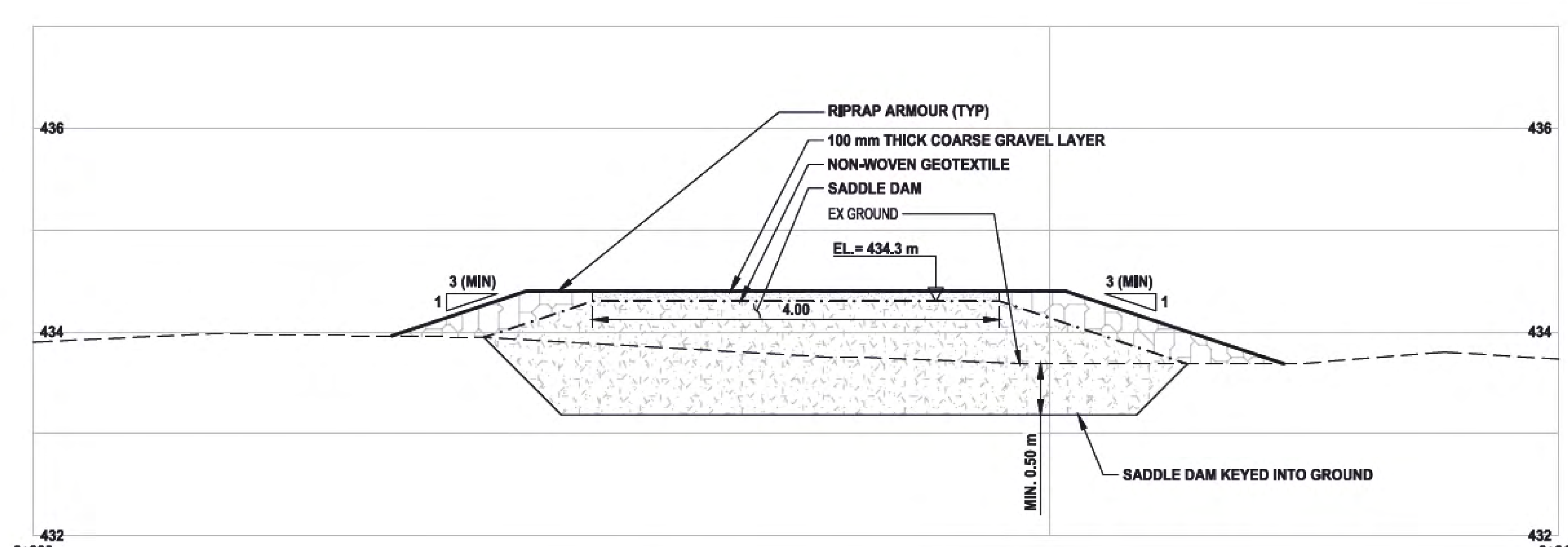
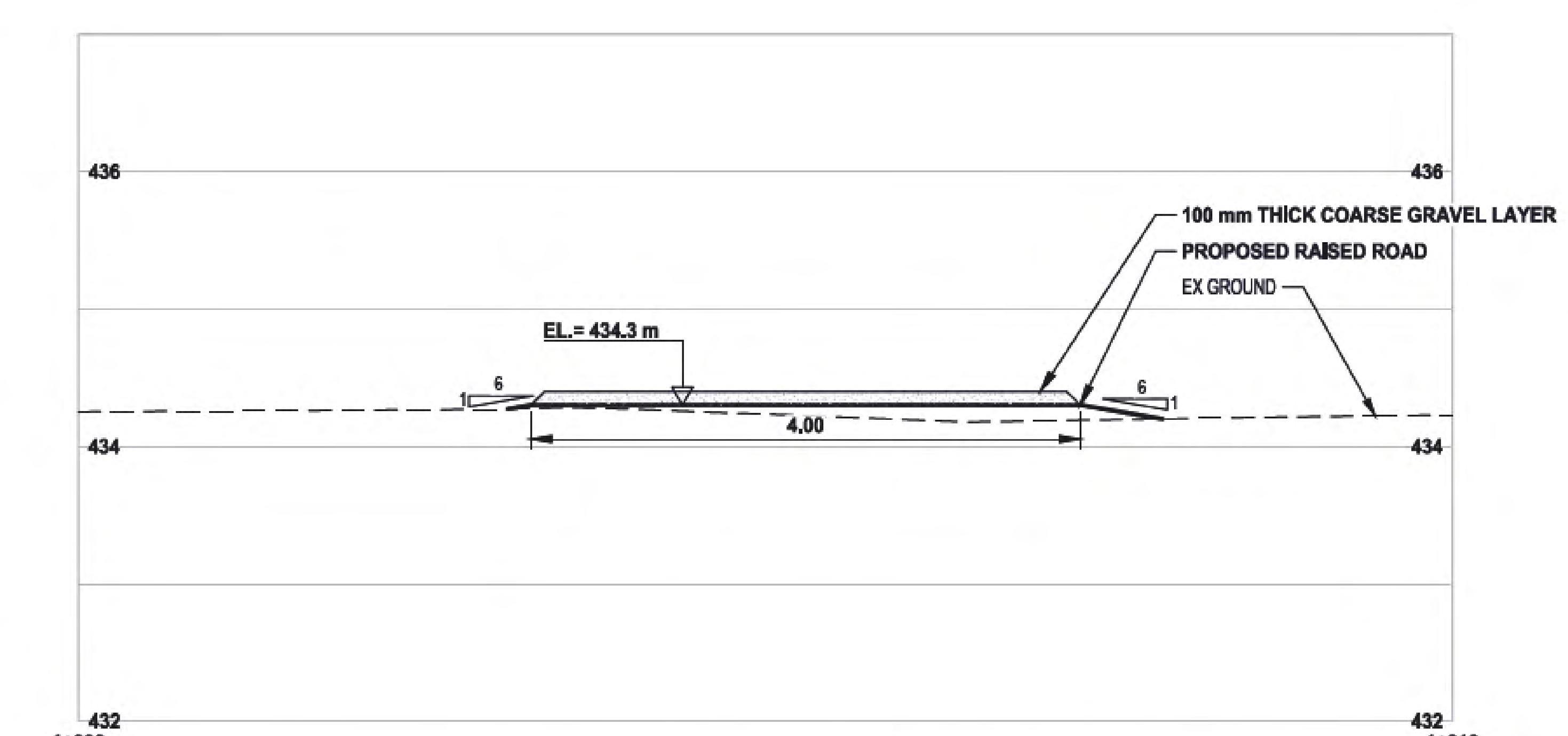
BC HYDRO
CLBWORKS 30A CARTIER BAY SITE 15a
FIGURE C4B - OPTION 2 CHANNEL STABILIZERS - PROFILES

PLAN
Scale 1:750



TYPICAL SADDLE DAM SECTION 1
Scale 1:50



TYPICAL ROAD RAISING SECTION 2
Scale 1:50

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BC HYDRO
CLBWORKS 30A CARTIER BAY SITE 15a
FIGURE C5 - OPTION 3 SADDLE DAM AT AREA B, RAISE ROAD AT AREA A

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Attachment D

Class D Cost Estimate

Class D Cost Estimate

Table D1: Sub-Option A - Articulated Concrete Block Mattress (ACBM)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 7,000	$ 7,000	Includes spreader bar rental (min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Isolate Outlet Area and Pumping	L.S.	1	$ 50,000	$ 50,000	If required (based on water levels)
1.05	Outlet Excavation	m^3	24	$ 55	$ 1,309	Includes hauling and disposal
1.06	ACBM Transport	L.S.	1	$ 6,000	$ 6,000	Based on discussion with supplier
1.07	ACBM	ea.	2	$ 2,000	$ 4,000	
1.08	ACBM Preparation and Installation	L.S.	1	$ 4,000	$ 4,000	Includes labour, equipment, and geotextile
1.09	Remove/Replace Existing Riprap	L.S.	1	$ 1,500	$ 1,500	~14 m^3 of riprap. Assumed to be utilized onsite as additional armouring
1.10	Invert Armouring at Outlet	m^3	17	$ 90	$ 1,539	Supply and place
1.11	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR SUB-OPTION A				**$ 91,348**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 91,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 91,000	
	TOTAL AMOUNT (excl. GST)				**$ 182,000**	

Class D Cost Estimate

Table D2: Sub-Option C - Embedded Precast Concrete Blocks

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Isolate Outlet Area and Pumping	L.S.	1	$ 50,000	$ 50,000	If required (based on water levels)
1.05	Outlet Excavation	m^3	24	$ 55	$ 1,309	Includes hauling and disposal
1.06	Concrete Block Transport	L.S.	1	$ 1,500	$ 1,500	Delivery from Kelowna
1.07	Concrete Blocks	ea.	6	$ 150	$ 900	
1.08	Concrete Block Installation	L.S.	1	$ 4,000	$ 4,000	Includes labour and equipment
1.09	Remove/Replace Existing Riprap	L.S.	1	$ 1,500	$ 1,500	~14 m3 of riprap. Assumed to be utilized onsite as additional armouring
1.10	Invert Armouring at Outlet	m^3	21	$ 90	$ 1,890	Supply and place
1.11	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR SUB-OPTION B				**$ 82,099**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 82,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 82,000	
	TOTAL AMOUNT (excl. GST)				**$ 164,000**	

Class D Cost Estimate

Table D3A: Option 1 - Raise Road at Areas A and B

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Raise Road Embankments	m^3	51	$ 75	$ 3,810	Supply and place 75 mm minus pit run
1.05	Road Surface/Armour (100 mm Gravel)	m^3	24	$ 90	$ 2,179	Supply and place
1.06	Fill Eroded Channel at Area B	m^3	136	$ 75	$ 10,230	Supply and place pit run
1.07	Remove Temporary Bulk Bag Berm	L.S.	1	$ 3,000	$ 3,000	Haul and dispose - fill materials possible for reuse
1.08	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR OPTION 1				**$ 40,219**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 40,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 40,000	
	TOTAL AMOUNT (excl. GST)				**$ 80,000**	

Class D Cost Estimate

Table D3B: Option 1 - Raise Road at Area B (Area A Excluded)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Raise Road Embankments	m^3	44	$ 75	$ 3,300	Supply and place 75 mm minus pit run
1.05	Road Surface/Armour (100 mm Gravel)	m^3	7	$ 90	$ 639	Supply and place
1.06	Fill Eroded Channel at Area B	m^3	136	$ 75	$ 10,230	Supply and place pit run
1.07	Remove Temporary Bulk Bag Berm	L.S.	1	$ 3,000	$ 3,000	Haul and dispose - fill materials possible for reuse
1.08	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR OPTION 1				**$ 38,169**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 38,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 38,000	
	TOTAL AMOUNT (excl. GST)				**$ 76,000**	

Class D Cost Estimate

Table D4A: Option 2 - Channel Stabilizers in Areas A and B

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	LS	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Stabilizer Excavation - Area B	m^3	128	$ 25	$ 3,200	
1.05	Excavation Disposal - Area B	m^3	64	$ 30	$ 1,920	Includes hauling and disposal fees
1.06	Stabilizer Excavation - Area A (optional)	m^3	120	$ 25	$ 3,000	
1.07	Excavation Disposal - Area A (optional)	m^3	60	$ 30	$ 1,800	Includes hauling and disposal fees
1.08	Rock Fill for Stabilizers - Area B	m^3	128	$ 90	$ 11,520	Supply and place Class 10 kg riprap
1.09	Rock Fill for Stabilizers - Area A (optional)	m^3	120	$ 90	$ 10,800	Supply and place Class 10 kg riprap
1.10	Geotextile - Area B	m^2	216	$ 10	$ 2,160	Supply and place
1.11	Geotextile - Area A (optional)	m^2	220	$ 10	$ 2,200	Supply and place
1.12	Fill Eroded Channel at Area B	m^3	105	$ 50	$ 5,265	Half imported pit run, half reused from excavation onsite
1.13	Remove Temporary Bulk Bag Berm	L.S.	1	$ 3,000	$ 3,000	Haul and dispose - fill materials possible for reuse
1.14	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR OPTION 2				**$ 65,865**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 66,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 66,000	
	TOTAL AMOUNT (excl. GST)				**$ 132,000**	

Class D Cost Estimate

Table 4B: Option 2 - Channel Stabilizers in Area B (Area A Excluded)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Stabilizer Excavation - Area B	m^3	128	$ 25	$ 3,200	
1.05	Excavation Disposal - Area B	m^3	64	$ 30	$ 1,920	Includes hauling and disposal fees
1.06	Rock Fill for Stabilizers - Area B	m^3	128	$ 90	$ 11,520	Supply and place Class 10 kg riprap
1.07	Geotextile - Area B	m^2	216	$ 10	$ 2,160	Supply and place
1.08	Fill Eroded Channel at Area B	m^3	105	$ 50	$ 5,265	Half imported pit run, half reused from excavation onsite
1.09	Remove Temporary Bulk Bag Berm	L.S.	1	$ 3,000	$ 3,000	Haul and dispose - fill materials possible for reuse
1.10	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR OPTION 2				**$ 48,065**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 48,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 48,000	
	TOTAL AMOUNT (excl. GST)				**$ 96,000**	

Class D Cost Estimate

Table D5A: Option 3 - Saddle Dam at Area B, Raise Road at Area A

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Raise Road Embankments (optional)	m^3	7	$ 75	$ 510	Supply and place 75 mm minus pit run
1.05	Road and Dam Surface/Armour (100 mm Gravel)	m^3	16	$ 90	$ 1,471	Supply and place
1.06	Saddle Dam Fill	m^3	81	$ 75	$ 6,075	Supply and place 75 mm minus pit run
1.07	Geotextile	m^2	157	$ 10	$ 1,572	Supply and place
1.08	Saddle Dam Riprap	m^3	44	$ 120	$ 5,256	Supply and place
1.09	Fill Eroded Channel at Area B	m^3	136	$ 75	$ 10,230	Supply and place pit run
1.10	Remove Temporary Bulk Bag Berm	L.S.	1	$ 3,000	$ 3,000	Haul and dispose - fill materials possible for reuse
1.11	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR OPTION 3				**$ 49,114**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 49,000**	Rounded to nearest $1,000
	ontingency Allowance	100%			$ 49,000	
	TOTAL AMOUNT (excl. GST)				**$ 98,000**	

Class D Cost Estimate

Table D5B: Option 3 - Saddle Dam at Area B (Area A Excluded)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	General					
1.01	Mob/Demob and Insurance	L.S.	1	$ 5,000	$ 5,000	(min 5% of construction subtotal or $5000)
1.02	Site Survey	L.S.	1	$ 10,000	$ 10,000	Layout and record
1.03	Erosion and Sediment Control	L.S.	1	$ 3,000	$ 3,000	Labour and materials (set up and take down)
1.04	Dam Surface/Armour (100 mm Gravel)	m^3	9	$ 90	$ 792	Supply and place
1.05	Saddle Dam Fill	m^3	81	$ 75	$ 6,075	Supply and place 75 mm minus pit run
1.06	Geotextile	m^2	157	$ 10	$ 1,572	Supply and place
1.07	Saddle Dam Riprap	m^3	44	$ 120	$ 5,256	Supply and place
1.08	Fill Eroded Channel at Area B	m^3	136	$ 75	$ 10,230	Supply and place pit run
1.09	Remove Temporary Bulk Bag Berm	L.S.	1	$ 3,000	$ 3,000	Haul and dispose - fill materials possible for reuse
1.10	Site Restoration	L.S.	1	$ 3,000	$ 3,000	
	SUBTOTAL FOR OPTION 3				**$ 47,925**	
	SUBTOTAL AMOUNT - CAPITAL COST (excl. GST)				**$ 48,000**	Rounded to nearest $1,000
	Contingency Allowance	100%			$ 48,000	
	TOTAL AMOUNT (excl. GST)				**$ 96,000**	

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Attachment E

Summary of Data Sources

Attachment E - Background Information References Provided by BC Hydro

Title	File Type	Source	Description
Monashee Survey			
7559 TOPO	pdf	BC Hydro/Monashee Surveying	Topographic survey, including contours, of areas A, B, and C and Site 15a
7559 TOPO	dwg	BC Hydro/Monashee Surveying	
7559 POINTS	csv, xlsx	BC Hydro/Monashee Surveying	points from topo survey
Watson Engineering			
as built sealed drawing 1564-11 as built sealed drawing 1564-12	jpg	BC Hydro/Watson Engineering	Original sealed drawings, including profile and cross sections
20132 Site 15A Cartier Bay Remediation Report	pdf	BC Hydro/Watson Engineering	Record of completion of remedial works following April 2021 vandalism
CLBWORKS30A 15A Completion Report 2016-11-16	pdf	BC Hydro/Watson Engineering	Describes 2015 15a buttressing construction
Project Report-clbworks-30a-yr3-yr4-2016-11-16	pdf	BC Hydro/Watson Engineering	Describes 2015 15a buttressing construction
1564-11-AB	dwg	BC Hydro/Watson Engineering	CAD files of as built drawings
20132 Combined	dwg	BC Hydro/Watson Engineering	Survey CAD file from Watson
BC Hydro - various			
ALR Hydrograph Site 15a Cartier Bay	pdf	BC Hydro	Forecasted water levels at Arrow Lakes Reservoir/Cartier Bay for 2021
Cartier levels_9 May to 5 Nov 2021-Dsedits	xlsx	BC Hydro	Comparison of water levels at Cartier Bay and Arrow Reservoir at Nakusp
Cartier options	pdf	BC Hydro	Graphic of concept ideas for the 4 sites
EMAIL - FW- [External] Re- Cartier Bay Data Loggers	pdf	BC Hydro	David S interpretation of water levels and description of water level spreadsheet
WPW15A.OutletAdjust.PondArea.Memo	docx	BC Hydro	Dec 2020 memo on ecological considerations with lowering the Site 15a invert.
Sept 28_2021 Field Visit Summary_Martin L and John Watson	pdf	BC Hydro	Bullet list of observations from Martin and responses from Mark
OMSS15A JUNE2015 FINAL	pdf	BC Hydro	Dam OMS manual
Cartier Bay Area B - 2021-11-26	pdf	BC Hydro	Report describing November 2021 emergency fix at Area B
LL.ds15A.20211215	csv	BC Hydro	Data from logger downstream of 15A (2017 falling limb)
Metadata on Baro-loggers 2017	docx	BC Hydro	Metadata for logger data
Bathymetry_CartierBay	.tif	BC Hydro	Water depth data used for plot of depth reduction vs wetland area in WPW15A memo, including R-script to interpolate surface.
Arrow_Reservoir_Forecast_2022	png	BC Hydro	Forecasted water levels at Arrow Lakes Reservoir for 2022
June 2020 DTM			
UAV (drone) CartierBay processing report	pdf	BC Hydro	output report from photogrammetry software
CLBMON11B4CartierBay_DTM_export_WedJan20235423398251	tif	BC Hydro	DTM from 2020 imagery
CLBMON11B4CartierBay_DTM_export_WedJan20235423398251	kml	BC Hydro	
CLBMON11B4CartierBay_DTM_export_WedJan20235410307926	tif	BC Hydro	DTM from 2020 imagery
CLBMON11B4CartierBay_DTM_export_WedJan20235410307926	kml	BC Hydro	
May 2019 DTM			
Photos	jpg	BC Hydro	Folder of photos of bulk bag fix installation
UAV Imagery	jpg	BC Hydro	Folder of aerial images.
May 2019 25 cm contours	pdf	BC Hydro	
Contours (folder)	shp	BC Hydro	major and minor contours, as lines and polygons, with labels
CartierBay.DTM.smoothed	.tif	BC Hydro	Digital terrain model
CartierBay.DTM	.tif	BC Hydro	Digital terrain model
Orthophotos (folder)	.tif	BC Hydro	May 2019 Orthophotos and reports from Peregrine Aerial Surveys
kmz's			
Cartier Bay area of interest	kmz	BC Hydro	Cartier Bay site extents
Addition to Area A	kmz	BC Hydro	Investigation area for archaeology
Addition to Location B	kmz	BC Hydro	Investigation area for archaeology
Location C polygon	kmz	BC Hydro	Investigation area for archaeology
Laydown Area	kmz	BC Hydro	Investigation area for archaeology
Arrow Reservoir Wildlife Management Plan			
Project Report-clbworks-30a-yr3-yr4-2016-11-16	pdf	BC Hydro/Watson Engineering	Original design report from Watson Engineering
Hawkes et al 2015 clbworks-30-cartier-bay-eia-2015-03-26	pdf	BC Hydro/LGL	Ecological impact assessment of physical works at Cartier bay
cartier-bay-protection-project-update-september-2016	pdf	BC Hydro	Description of works to take place at Site 15a in 2016.
clb-tor-2021-03-25-clbworks-30a-Add-3	pdf	BC Hydro	Physical works terms of reference
clbworks-30-as-built-2014-02-12	pdf	BC Hydro/Golder	As-built report of nearby Site 6A airport outflow
clbworks-30-cartier-bay-enhancements-review-2014-11-01	pdf	BC Hydro	15A wildlife enhancements review

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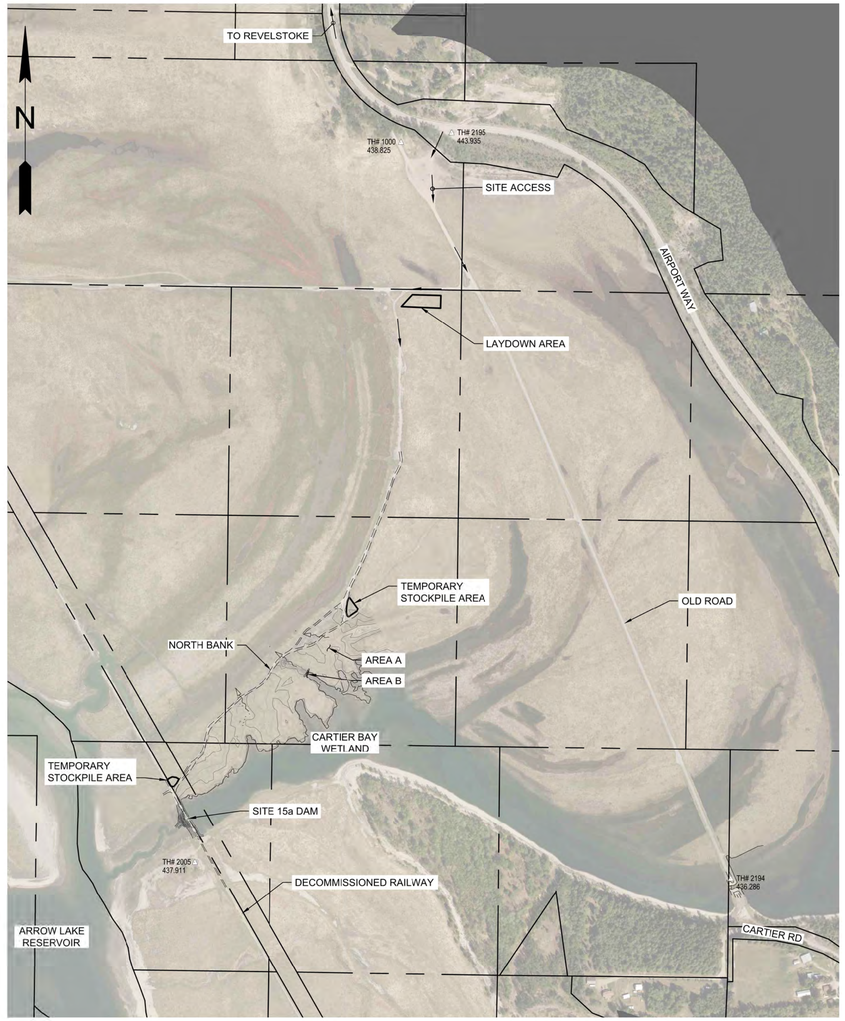
Appendix B

Detailed Design Drawings

LOCATION PLAN
NTS



KEY PLAN
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DRAWING LIST	
DRAWING NUMBER	DRAWING TITLE
201B-C09-00001	LOCATION PLAN, KEY PLAN, & DRAWING LIST
201B-C09-00002	OVERVIEW AND GENERAL ARRANGEMENT - PLAN
201B-C09-00003	SITE 15a DAM - PLAN AND PROFILE
201B-C09-00004	SITE 15a DAM - SECTIONS
201B-C09-00005	AREA B SADDLE DAM - PLAN AND PROFILE
201B-C09-00006	AREA B SADDLE DAM - SECTIONS
201B-C09-00007	AREA B ERODED CHANNEL FILL - PLAN, PROFILE, & DETAILS
201B-C09-00008	AREA A ROAD RAISING - PLAN AND PROFILE
201B-C09-00009	AREA A ROAD RAISING - SECTIONS

PROPOSAL DRAWINGS SHOW THE SCOPE AND GENERAL NATURE OF THE WORK, NOT ALL DIMENSIONS AND DETAILS ARE SHOWN.

ALL RELEVANT INFORMATION WILL BE SHOWN ON THE DRAWINGS ISSUED FOR CONSTRUCTION PURPOSES DURING THE COURSE OF THE WORK.

BC Hydro Contract No ..RFQ17501.....

ISSUED FOR PROPOSAL

By ..... Date ..11-03-2022.....
Hydro's Representative

BC Hydro Contract No RFQ17501

ACCEPTED

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By ..... Date 11-03-2022
Hydro's Representative

NOT FOR CONSTRUCTION

NOTES:
1. ORTHO PHOTO TAKEN BY PEREGRINE AERIAL SURVEYS INC. ON MAY 9 & 10, 2019 FOR BC HYDRO.
2. SURVEY NOTES:
   2.1. HORIZONTAL DATUM: NAD83(CSRS) 2002.0 - UTM ZONE 11N
   2.2. VERTICAL DATUM: CVD28BC
   2.3. FIXED VERTICAL BENCHMARK: MASCOT GCM #666461
   2.4. ELEVATION VERIFIED USING NRCAN PPP SERVICE.
   2.5. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021.

CONTROL POINTS				
POINT #	NORTHING	EASTING	ELEV.	DESCRIPTION
TH# 2005	5641906.516	418369.803	437.911	SPIKE IN GROUND
TH# 2194	5641877.631	419320.994	436.286	NAIL IN PAVEMENT
TH# 1000	5643184.609	418735.399	438.825	-
TH# 2195	5643201.246	418825.491	443.935	-

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ALL DIMENSIONS ARE IN METRES, UNLESS OTHERWISE SHOWN

KERR WOOD LEIDAL consulting engineers

NO	DRAWING NUMBER	DRAWING TITLE
REFERENCE DRAWINGS		

NO	REMARKS
0	ISSUED FOR PROPOSAL
REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY	NAD83 - 11UTM
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA
L. T. MACKLE # 54686
Permit to Practice: #1000696
2022-03-11

BC Hydro

ARROW LAKE RESERVOIR

CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
LOCATION PLAN, KEY PLAN, & DRAWING LIST

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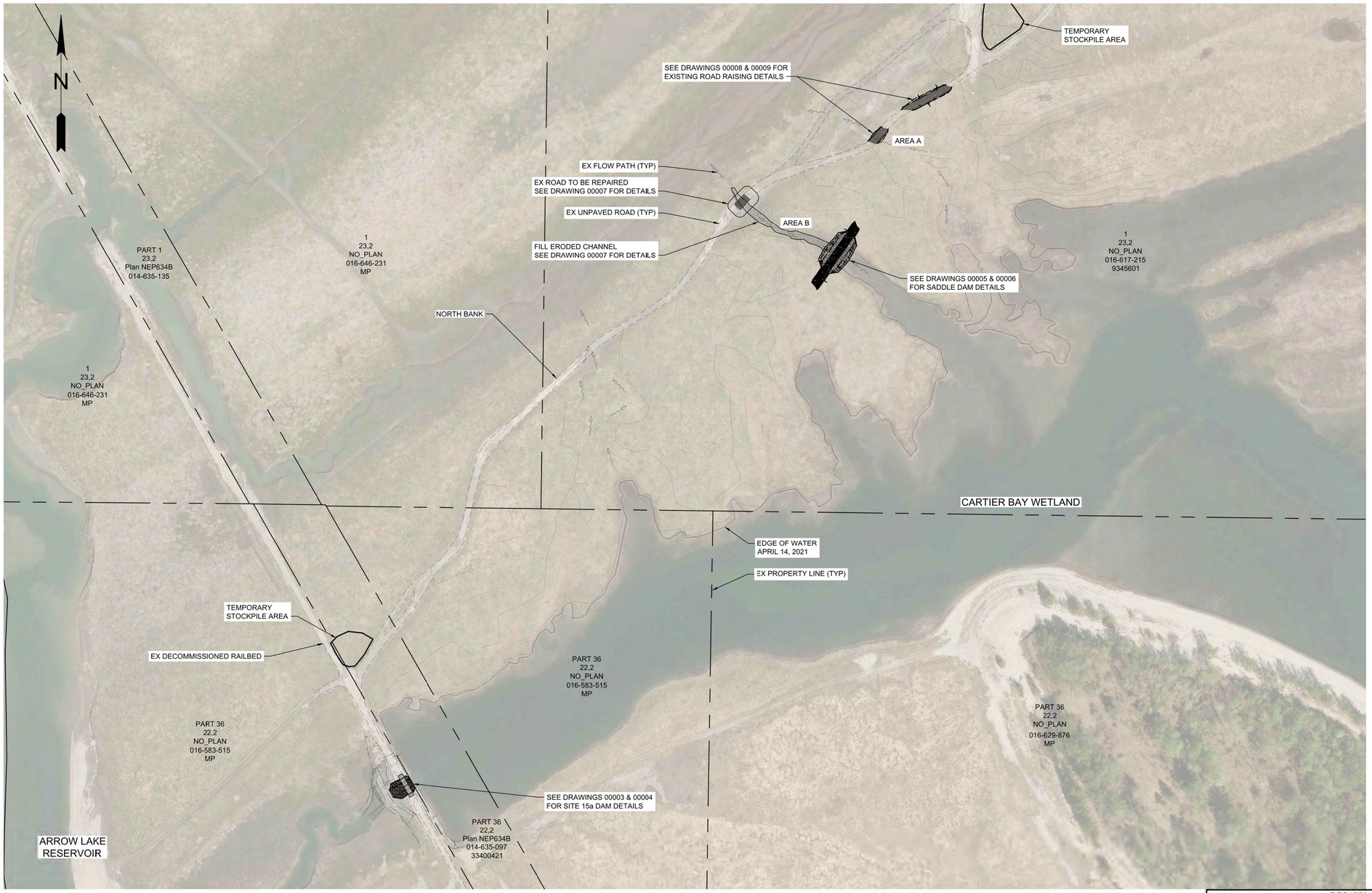

OVERVIEW AND GENERAL ARRANGEMENT

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PROPOSAL DRAWINGS SHOW THE SCOPE AND GENERAL NATURE OF THE WORK. NOT ALL DIMENSIONS AND DETAILS ARE SHOWN.

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BC Hydro Contract No RFQ17501

ISSUED FOR PROPOSAL

By _____ Hydro's Representative Date 11-03-2022

BC Hydro Contract No RFQ17501

ACCEPTED

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By _____ Hydro's Representative Date 11-03-2022

NOTES:
1. ORTHO PHOTO TAKEN BY PEREGRINE AERIAL SURVEYS INC. ON MAY 9 & 10, 2019 FOR BC HYDRO.
2. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

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NO	DRAWING NUMBER	DRAWING TITLE
REFERENCE DRAWINGS		

NO	REMARKS
0	ISSUED FOR PROPOSAL
REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY NAD83- 11UTM	
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

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CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
OVERVIEW AND GENERAL ARRANGEMENT PLAN

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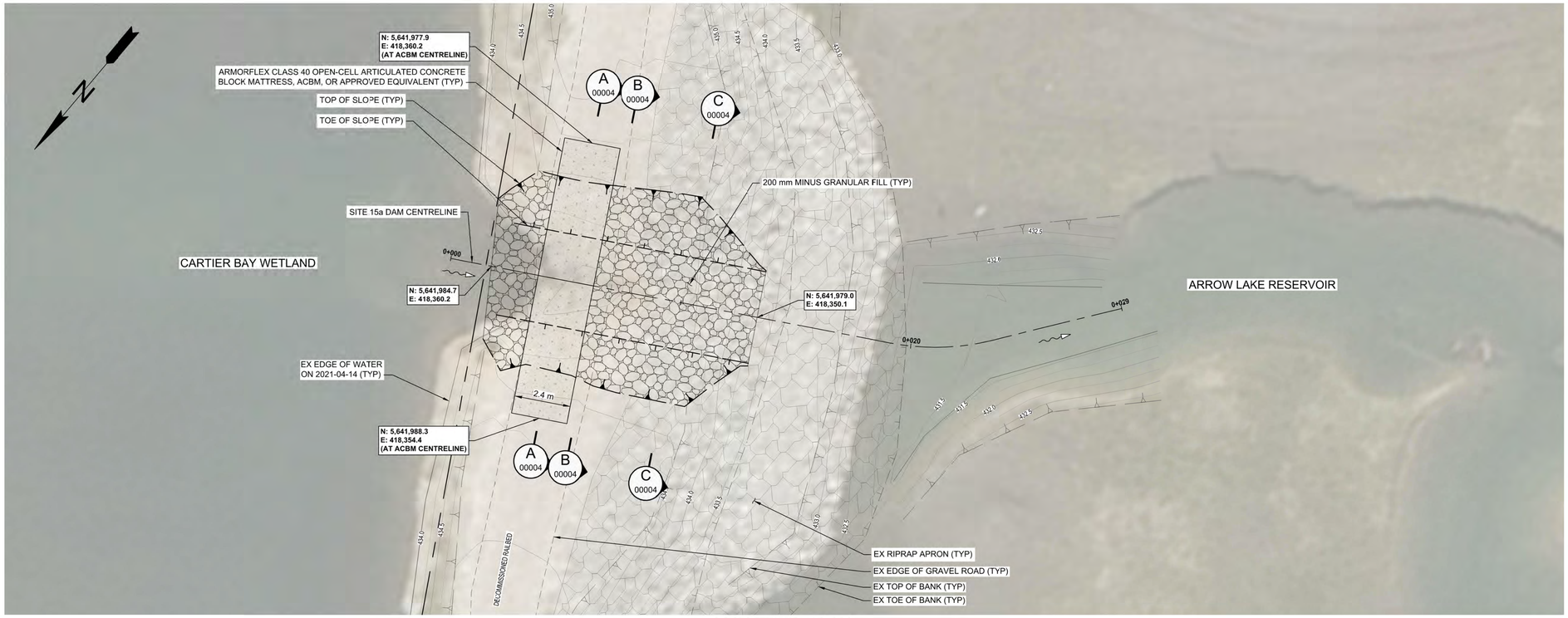

SITE 15a DAM - PLAN
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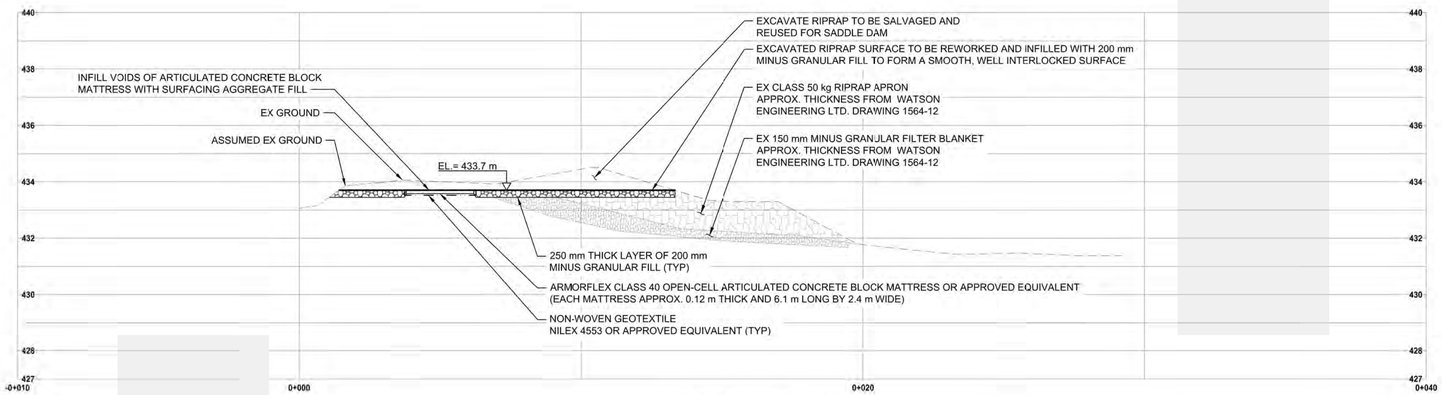

SITE 15a DAM - PROFILE
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ALL RELEVANT INFORMATION WILL BE SHOWN ON THE DRAWINGS ISSUED FOR CONSTRUCTION PURPOSES DURING THE COURSE OF THE WORK.

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By _____ Date 11-03-2022
Hydro's Representative

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Hydro's Representative

NOTES:
1. ORTHO PHOTO TAKEN BY PEREGRINE AERIAL SURVEYS INC. ON MAY 9 & 10, 2019 FOR BC HYDRO.
2. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

NOT FOR CONSTRUCTION

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ALL DIMENSIONS ARE IN METRES, UNLESS OTHERWISE SHOWN

KERR WOOD LEIDAL consulting engineers

NO	DRAWING NUMBER	DRAWING TITLE
REFERENCE DRAWINGS		

NO	REMARKS
0	ISSUED FOR PROPOSAL
REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY NAD83- 11UTM	
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

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BC Hydro

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CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
SITE 15a DAM
PLAN AND PROFILE

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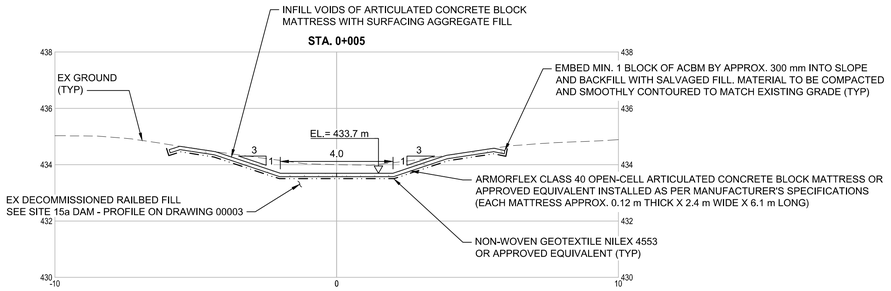

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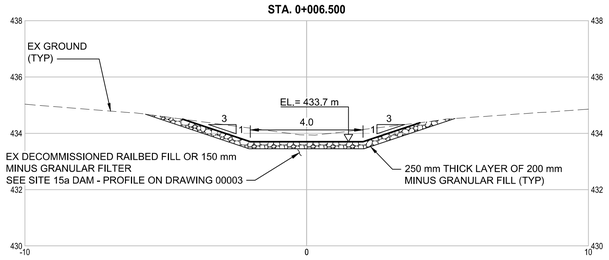

200 mm MINUS GRANULAR FILL

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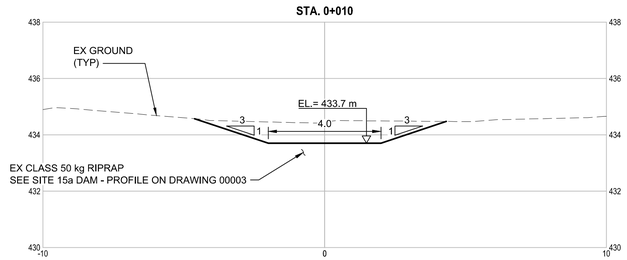

EXCAVATED RIPRAP

SECTION C
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By ..... Date ..11-03-2022.....
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BC Hydro Contract No RFQ17501

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By ..... Date 11-03-2022
Hydro's Representative

NOTES:
1. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

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SCALE: 1:100 0 5m

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NO	DRAWING NUMBER	DRAWING TITLE
REFERENCE DRAWINGS		

NO	REMARKS
0	ISSUED FOR PROPOSAL
REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY NAD 83 - 11UTM	
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER PROVINCE OF ALBERTA L. T. MACKLE # 54686 COLUMBIA
Permit to Practice #1000686
2022-03-11

BC Hydro

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CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
SITE 15a DAM
SECTIONS

DATE	DIST	DRAWING NUMBER	REPORT NUMBER	FIG NO	SIZE	REV
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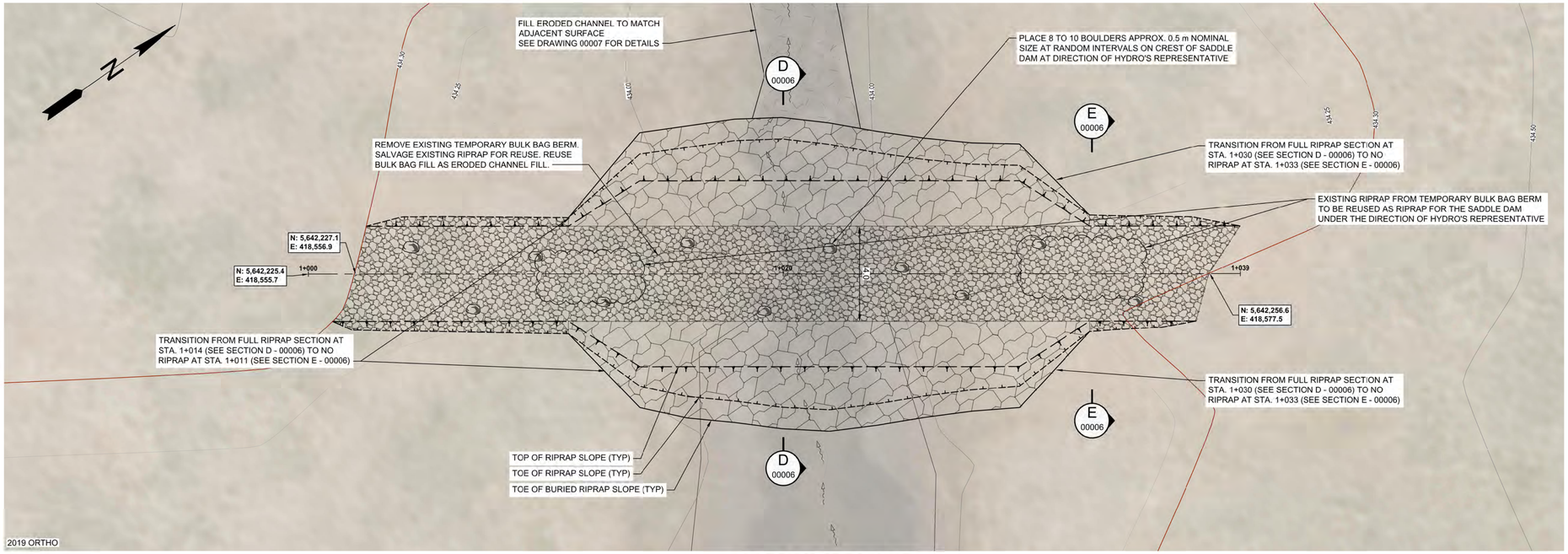

AREA B SADDLE DAM - PLAN
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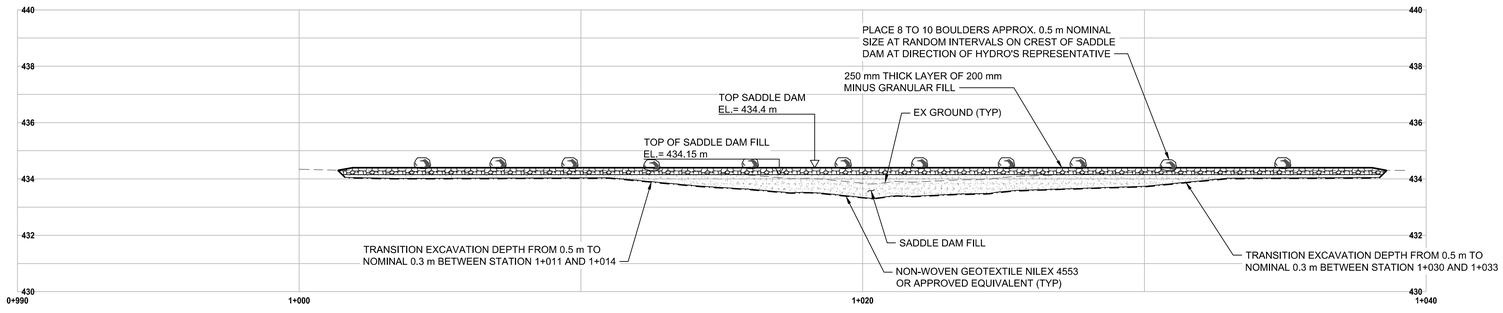

AREA B SADDLE DAM - PROFILE
1:100

NOTES:
1. ORTHO PHOTO TAKEN BY PEREGRINE AERIAL SURVEYS INC. ON MAY 9 & 10, 2019 FOR BC HYDRO.
2. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

NOT FOR CONSTRUCTION

SCALE: 1:100 0 5m

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KERR WOOD LEIDAL consulting engineers

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BC Hydro Contract No .RFQ17501.....
ISSUED FOR PROPOSAL
By ..... Date ..11-03-2022.....
Hydro's Representative

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Hydro's Representative

NO	DRAWING NUMBER	DRAWING TITLE
REFERENCE DRAWINGS		

NO	REMARKS
0	ISSUED FOR PROPOSAL
REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
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BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA L. T. MACKLE # 54686
Permit to Practice #1000696 2019-05-11

DATE 2022MAR11 DIST

BC Hydro

ARROW LAKE RESERVIOR

CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
AREA B SADDLE DAM
PLAN AND PROFILE

DRAWING NUMBER	REPORT NUMBER	FIG NO	SIZE	REV
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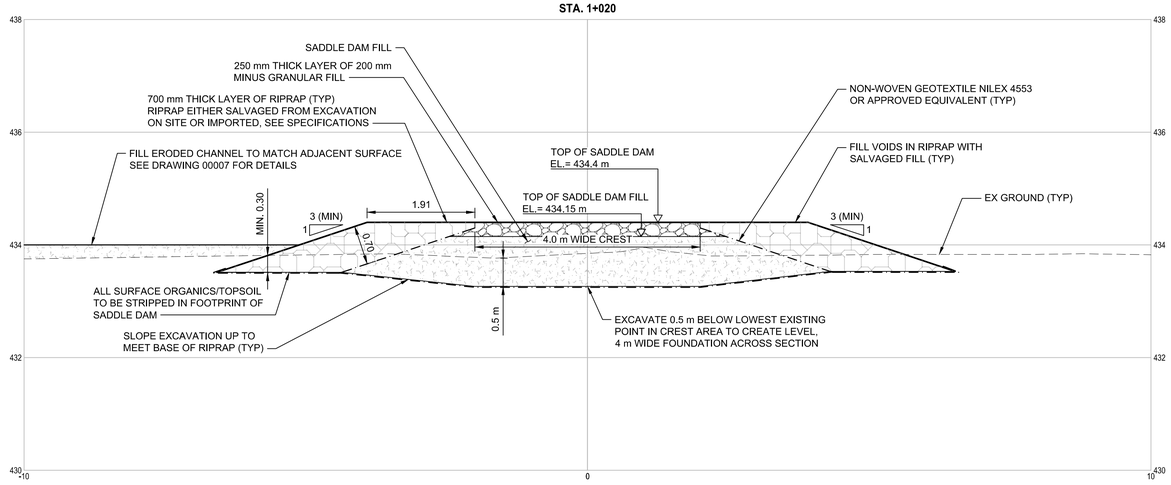

AREA B SADDLE DAM AT ERODED CHANNEL

SECTION D
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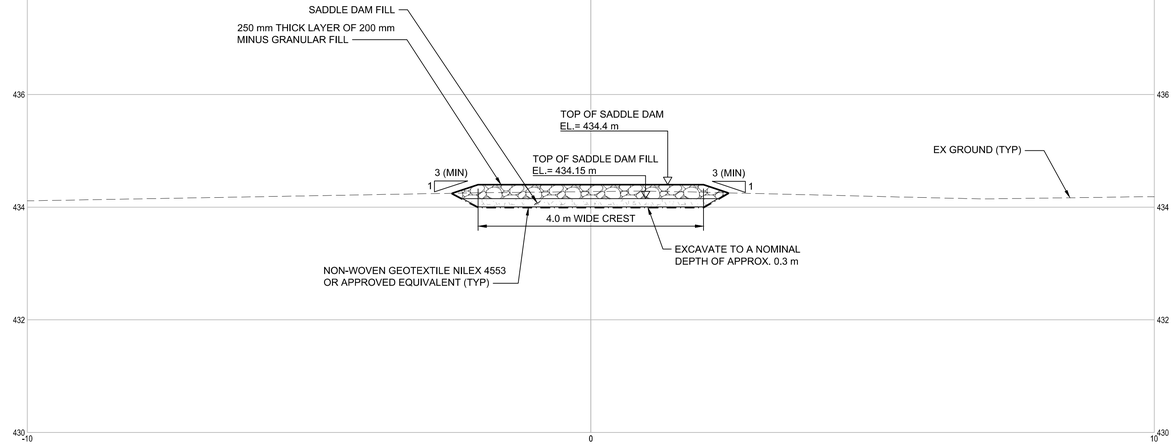
STA. 1+033



AREA B SADDLE DAM AT SIDE TRANSITION

SECTION E
SCALE:1:50 00005

NOTES:
1. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

NOT FOR CONSTRUCTION

SCALE: 1:50 — 0 2.5m

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REFERENCE DRAWINGS		

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REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY NAD 83 - 11UTM	
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — L. T. MACKLE # 54686 — Permit to Practice #1000696

BC Hydro

ARROW LAKE RESERVOIR

CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
AREA B SADDLE DAM
SECTIONS

DATE	DIST	DRAWING NUMBER	REPORT NUMBER	FIG NO	SIZE	REV
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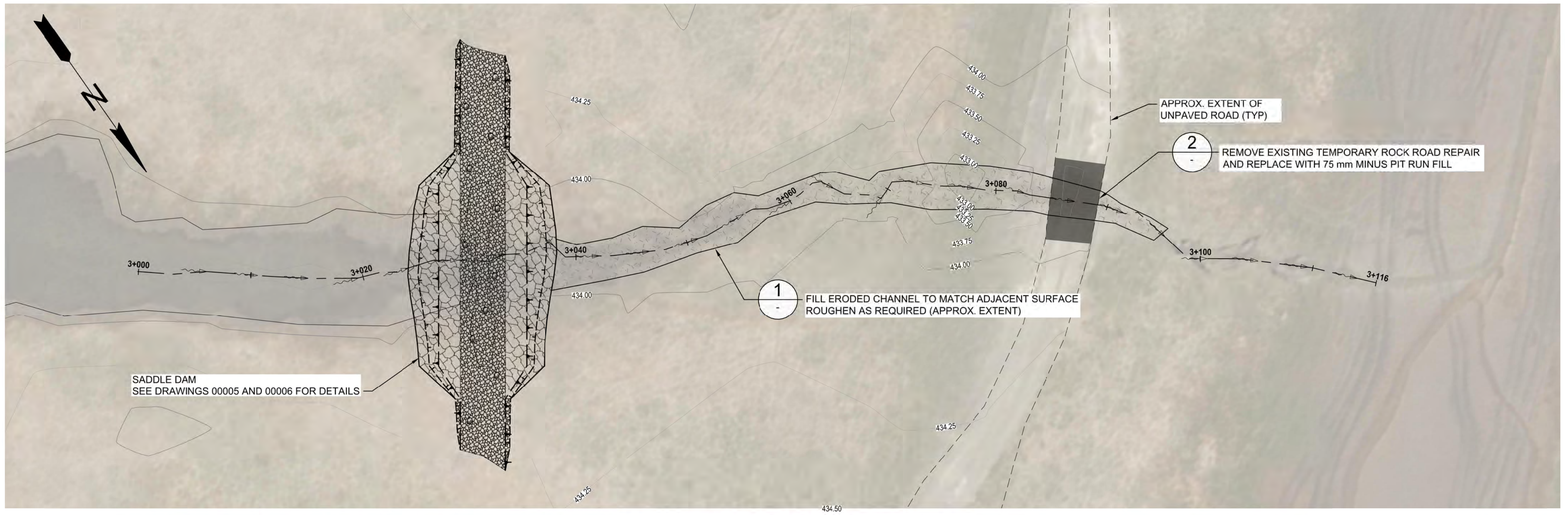

AREA B ERODED CHANNEL FILL - PLAN

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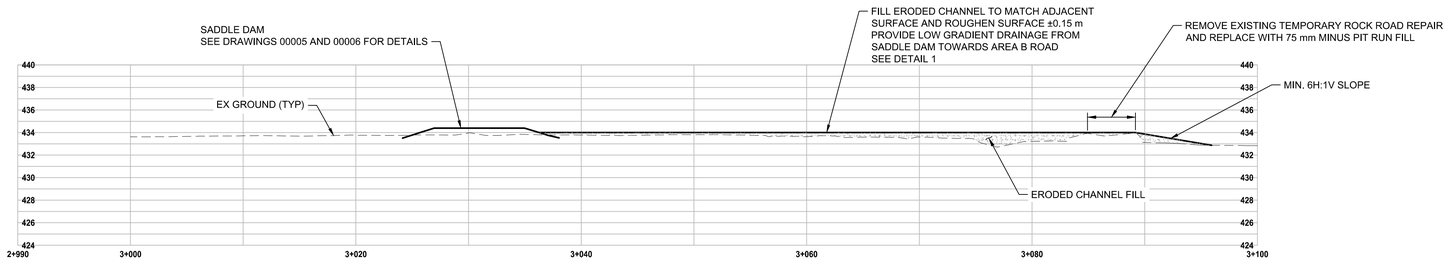
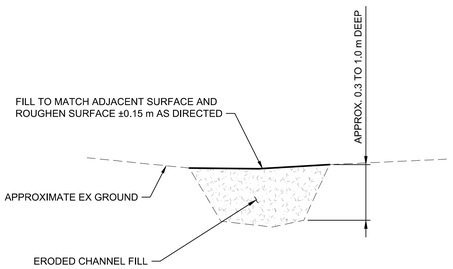


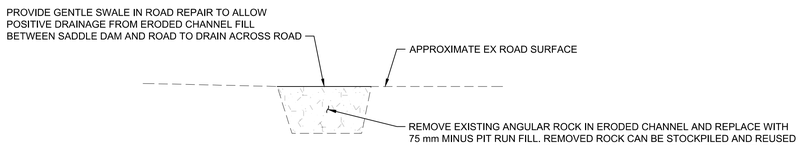
AREA B ERODED CHANNEL FILL - PROFILE

1:250



AREA B ERODED CHANNEL FILL SECTION

DETAIL 1 - NTS



PROFILE ALONG ROAD AT ERODED CHANNEL

DETAIL 2 - NTS

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NOT FOR CONSTRUCTION

SCALE: 1:250 — 0 10m

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NO	DRAWING NUMBER	DRAWING TITLE
REFERENCE DRAWINGS		

NO	REMARKS
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DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY NAD83 - 11UTM	
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — L. T. MACKLE # 54686 — Permit to Practice #1000666 — 2022-03-11

BC Hydro

ARROW LAKE RESERVOIR

CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
AREA B ERODED CHANNEL FILL
PLAN, PROFILE, & DETAILS

DATE	DIST	DRAWING NUMBER	REPORT NUMBER	FIG NO	SIZE	REV
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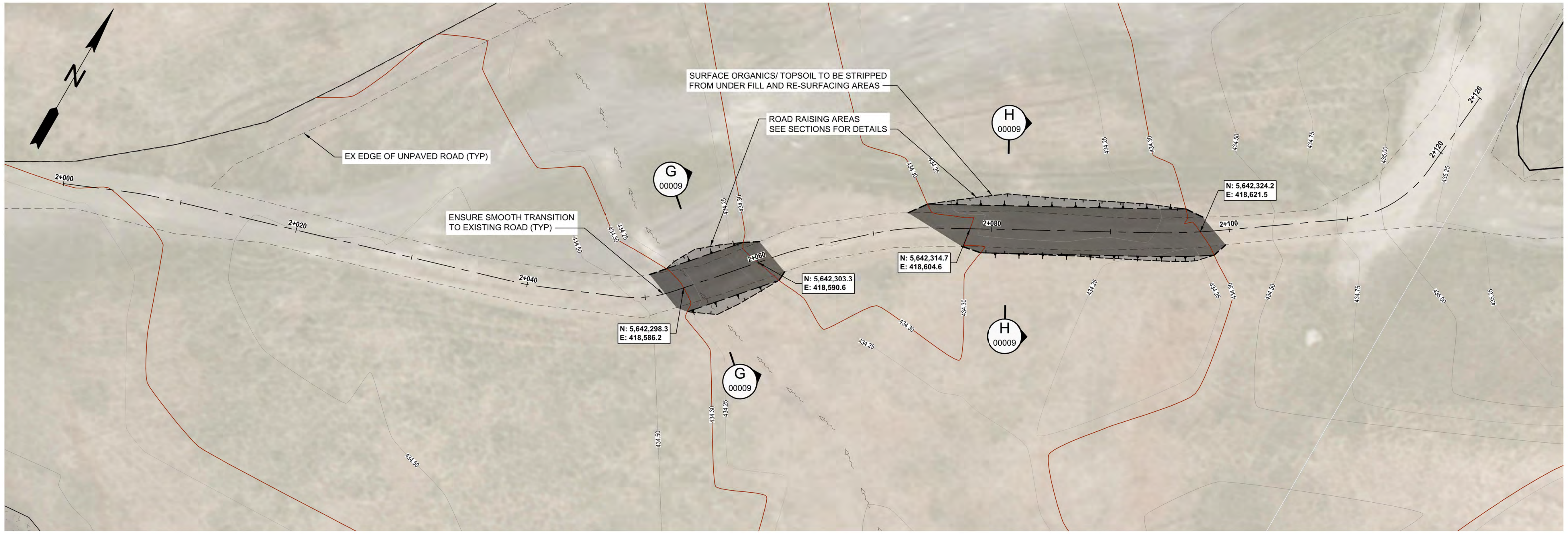

AREA A ROAD RAISING - PLAN

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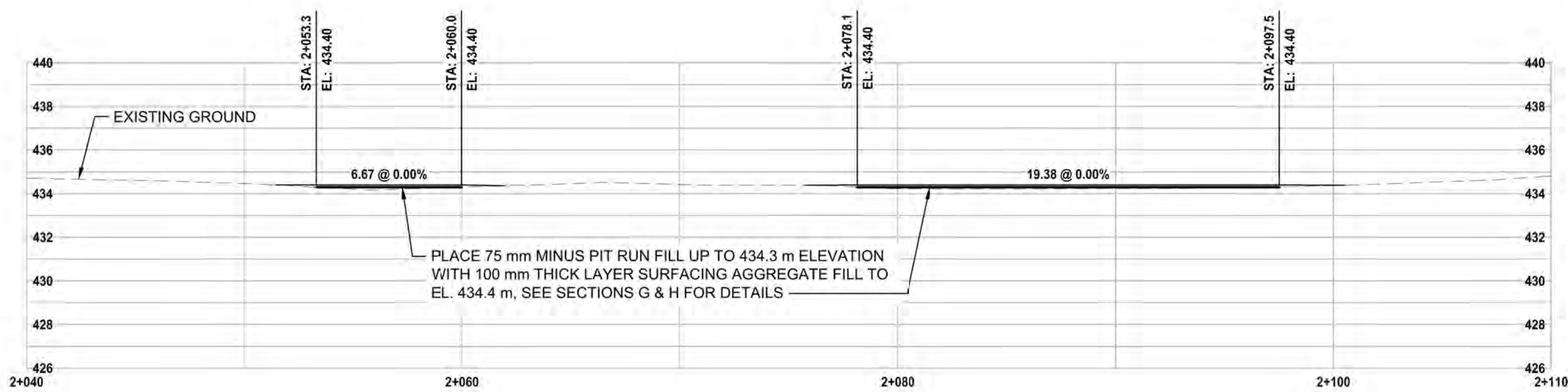

AREA A ROAD RAISING - PROFILE

1:200

NOTES:

1. ORTHO PHOTO TAKEN BY PEREGRINE AERIAL SURVEYS INC. ON MAY 9 & 10, 2019 FOR BC HYDRO.
2. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

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SCALE: 0 — 10m
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consulting engineers

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REFERENCE DRAWINGS		

NO	REMARKS
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REVISIONS	

DESIGN NUMBER	
WORK ORDER NUMBER	
CSA S250 ACCURACY NAD 83 - 11UTM	
BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, L. T. MACKLE # 54686, Permit to Practice #1000696, 2022-03-11

BC Hydro

ARROW LAKE RESERVOIR

CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
AREA A ROAD RAISING
PLAN AND PROFILE

DATE	DIST	DRAWING NUMBER	REPORT NUMBER	FIG NO	SIZE	REV
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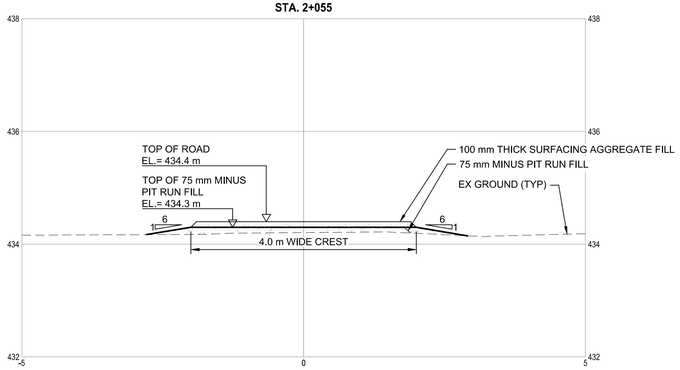

SOUTH WEST ROAD SEGMENT

SECTION G
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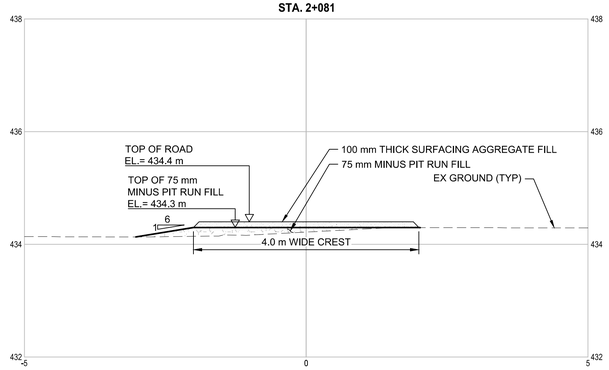

NORTH EAST ROAD SEGMENT

SECTION H
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NOTES:
1. SURVEYED BY MONASHEE SURVEY GEOMATICS ON APRIL 14, 2021. SEE DRAWING 00001 FOR ADDITIONAL INFORMATION.

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SCALE: 1:50 — 0 2.5m

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consulting engineers

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BASE ACCURACY LEVEL:	
ASB ACCURACY LEVEL:	

DSGN	L. MACKLE
INDEP CHK	S. JOYCE
DFTG	P. COLLINS
DFTG CHK	
INSP	
REV	
ACPT	

PROFESSIONAL ENGINEER — PROVINCE OF B.C. — L. T. MACKLE # 54686 — COLUMBIA — Permit to Practice #1000666 — 2022-03-11

BC Hydro

ARROW LAKE RESERVOIR

CARTIER BAY SITE 15a
MODIFICATION & MITIGATION WORKS
AREA A ROAD RAISING
SECTIONS

DATE	DIST	DRAWING NUMBER	REPORT NUMBER	FIG NO	SIZE	REV
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Drawing Unit = Metric (6)
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3/10/2022 10:51 AM

KERR WOOD LEIDAL
consulting engineers

Appendix C

Cost Estimate

Arrow Lake Reservoir
CLBWORKS 30A Cartier Bay Site 15a
Mitigation Works - Detailed Design
KWL File: 0478.237
Dated March 28, 2022

Table C1: Class A Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	Total Cost	Comments
1	**General**					
1.1	Mob./Demob., Bonding and Insurance	L.S.	1	$ 55,000.00	$ 55,000.00	Mobilization, demobilization, bonding, & insurance. Site access and swamp mats, as required. General site and access restoration. Site office *{if required by BC Hydro}*.
1.2	Survey	L.S.	1	$ 20,000.00	$ 20,000.00	Layout and record surveys. *{Could be included in Mob/Demob}*
1.3	Erosion and Sediment Control	L.S.	1	$ 5,000.00	$ 5,000.00	Labour and materials (set up and take down). *{Could be included in Mob/Demob.}*
1.4	Water Control	L.S.	1	$ 50,000.00	$ 50,000.00	Isolate work area(s) and pumping, if required (based on wetland water levels). *{Could be included in Mob/Demob, could be provisional.}*
	SUBTOTAL FOR ITEM 1				**$ 130,000**	
2	**Site 15a Dam**					
2.1	Outlet Railbed Excavation	m^3	23	$ 15.00	$ 345.00	Excavation, hauling, and temporary stockpile.
2.2	Outlet Riprap Excavation	m^3	19	$ 18.00	$ 342.00	Excavation, hauling, and temporary stockpile.
2.3a	Articulated Concrete Block Mattress (ACBM) Supply	L.S.	1	$ 10,000.00	$ 10,000.00	Assumes BC Hydro covers cost of supply and delivery.
2.3b	Articulated Concrete Block Mattress (ACBM) Preparation and Installation	L.S.	1	$ 5,000.00	$ 5,000.00	Includes labour and equipment (incl. spreader bar rental). Assumes BC Hydro covers cost of supply and delivery.
2.4	Geotextile	m^2	30	$ 6.00	$ 180.00	Supply and placement. Area excludes overlap.
2.5	200 mm Minus Granular Fill	m^3	12	$ 160.00	$ 1,968.00	Supply and placement.
2.6	25 mm Minus Surfacing Aggregate Fill for ACBM voids	m^3	1	$ 80.00	$ 56.00	Supply and placement.
	SUBTOTAL FOR ITEM 2				**$ 17,891**	
3	**Area A & Area B**					
Area A Road Raising						
3.1	Stripping and Grubbing	m^2	59	$ 3.50	$ 206.50	Assumed 0.1 to 0.3 m depth of stripping. For volumes, assumed 0.1 m strip depth. Stripping area to be the vegetated area outside of existing road footprint. Includes temporary stockpile. Material to be reused as either excavated channel fill or salvaged fill for riprap voids.
3.2	Road Fill - 75 mm Minus Pit Run Fill	m^3	8	$ 105.00	$ 840.00	Supply and placement.
3.3	25 mm Minus Surfacing Aggregate	m^3	13	$ 80.00	$ 1,040.00	Supply and placement.
Area B Saddle Dam						
3.4	Stripping and Grubbing	m^2	314	$ 8.50	$ 2,669.00	Assumed 0.1 to 0.3 m depth of stripping. For volumes assumed 0.1 m strip depth. Includes temporary stockpile. Material to be reused as either excavated channel fill or salvaged fill for riprap voids. Includes salvage and storage of stripped vegetation.
3.5	Excavation	m^3	35	$ 15.00	$ 525.00	Assume excavation of 0.5 m, less stripping depth (assumed 0.1 m for volume calculations). Material to be reused as either excavated channel fill or salvaged fill for riprap voids. Stockpile separately from stripped material.
3.6	Remove Riprap / Coarse Aggregate at Temporary Bulk Bag Berm and at Area B Road	m^3	18	$ 18.00	$ 324.00	Remove/excavate riprap / coarse aggregate at temporary saddle dam and at Area B road, and temporarily stockpile for reuse as Riprap at saddle dam.
3.7	Remove Temporary Bulk Bag Berm (excluding riprap)	L.S.	1	$ 2,000.00	$ 2,000.00	Haul and dispose of bulk bags. Stockpile bulk bag fill materials (assumed ~3 m3) for reuse in channel infill. Salvage and temporarily stockpile riprap for reuse in Saddle Dam riprap.
3.8	Saddle Dam Fill - Imported 75 mm Minus Pit Run Fill	m^3	67	$ 105.00	$ 7,035.00	Supply and place 75 mm Minus Pit Run Fill.
3.9	Saddle Dam Fill - Salvaged Dam Fill	m^3	23	$ 45.00	$ 1,035.00	Handle and place stockpiled fill from Site 15a excavation (embankment fill material, not riprap).
3.10	Geotextile	m^2	400	$ 6.00	$ 2,400.00	Supply and placement. Area excludes overlapping.
3.11	Riprap - Imported	m^3	24	$ 145.00	$ 3,480.00	Supply and placement.
3.12	Riprap - Salvaged	m^3	35	$ 45.00	$ 1,575.00	Handle and place riprap salvaged from Site 15a, Area B road fill, and temporary bulk bag berm.
3.13	Boulders on Saddle Dam Crest	m^3	2	$ 45.00	$ 90.00	Handle and place boulders on saddle dam crest sourced from riprap salvaged from Site 15a, Area B road fill, and temporary bulk bag berm.
3.14	Riprap Void Fill	m^3	6	$ 30.00	$ 180.00	Handle and place material sourced from Salvaged Fill. Assumed ~10% of total riprap volume.
3.15	200 mm Minus Granular Fill	m^3	41	$ 160.00	$ 6,560.00	Supply and placement.
Eroded Channel & Area B Road Fill						
3.16	Eroded Channel Fill - Imported 75 mm Minus Pit Run Fill	m^3	0	$ 105.00	$ -	Supply and placement in eroded channel and at road. Required only if insufficient material from stripping.
3.17	Eroded Channel Fill - Salvaged Fill	m^3	69	$ 30.00	$ 2,070.00	Handle, mix, and place salvaged stockpiled material. Approximate assumed volume. Approximately 50 to 80 m3. Assumed that all material excavated from the stripped Saddle Dam footprint and Area A road, salvaged bulk bag material (assumed ~3 m3), and Saddle Dam excavation. Includes placement of salvage vegetation at direction of Hydro's representative
3.18	Eroded Area B Road Fill - Imported 75 mm Minus Pit Run Fill	m^3	9	$ 105.00	$ 945.00	Supply and placement in eroded channel and at road.
3.19	Place salvaged vegetation	L.S.	1	$ 1,500.00	$ 1,500.00	Place salvaged vegetation at direction of Hydro's Representative. *{Placeholder for BC Hydro to include if desired.}*
	SUBTOTAL FOR ITEM 3				**$ 34,475**	
	SUBTOTAL ALL ITEMS				**$ 182,000**	**Rounded to the nearest $1,000**
	Contingency Allowance - Class A Cost Estimate	10%			$ 18,200	
	Contingency Allowance - Market Uncertainty	20%			$ 36,400	
	SUBTOTAL FOR CONTINGENCIES	**30%**			**$ 55,000**	**Rounded to the nearest $1,000**
	TOTAL AMOUNT (excl. GST)				**$ 237,000**	**Rounded to the nearest $1,000**