Keeyask Generation Project

Causeway to Borrow N-5 – Description of Repair

Manitoba Hydro, in its delegated authority to manage construction of the Keeyask Generation Project on behalf of the Keeyask Hydropower Limited Partnership, is submitting the proposed repairs to the causeway to Borrow N-5. These modifications are in response to the high ice and water levels experienced in the winter of 2014/15 and the risk that a stable ice cover does not develop upstream of Gull Rapids in future years when construction is occurring. Manitoba Hydro is requesting that culverts not be re-installed in the causeway to Borrow N-5 (Map 1) and is including information regarding the repairs to the abutments.

The timing of this work is anticipated to occur in September 2015.

Background

The construction design flood (CDF) was established for each temporary structure so that the design provided a reasonable degree of protection against high flows that could occur during the construction phase of the Project. The Project temporary structures, including the causeway to Borrow N-5, were designed to withstand flows and water levels associated with a flood expected to have a 5-10% probability of occurring each year or a frequency of once every 10-20 years on average. It should be noted that the CDF water levels were based on a stable ice cover forming upstream of Gull Rapids. To assist in the development of stable ice cover an ice boom was installed. A test ice boom was installed in fall 2013 for a one year test period. The anchor system failed at the end of the spring breakup season (May 2014) due to a stronger than normal ice cover (due to the cold winter and late spring) and the very high spring flows arriving from the south in late May. Design modifications were incorporated to improve the effectiveness of the ice boom in developing a stable ice cover upstream of the construction site. This included a realignment of the boom to a location slightly upstream of the test location. The boom was installed in the summer of 2014. On November 10, 2014, there was a partial failure of the ice boom. This resulted in no stable ice cover formation upstream of Gull Rapids (portions of the Nelson River remained open from Gull Rapids to Split Lake until late January 2015) causing water levels at the construction site to rise well above the design water levels with a functioning ice boom. During this time the causeway to Borrow N-5, constructed to an elevation of 145.0m, was overtopped and erosion of the rock fill occurred at the south abutment and at the culvert locations. The causeway was repaired in February 2015 without replacing the culverts. It was anticipated that the culverts would be replaced in the summer of 2015 when it was safe to do so.

During the winter of 2014/15, additional analysis of the hydraulic and ice conditions occurred and it was determined that two additional ice booms are required to promote the formation of a stable ice cover; these ice booms were installed during the summer of 2015.

Description of Proposed Changed

The causeway to Borrow N-5 is a rock fill embankment structure consisting of a free draining rock fill groin designed to accommodate two-way traffic for large haul trucks and light duty vehicles. The rock fill in this structure is Class C1 which consists of rock ranging in size from 4.75mm to 1m. Table 1 provides the gradation for Class C1.

Table 1: Rock Fill Gradations

Particle Size	Percent Passing by Weight		
	Class C1	Select Class C1	Class C2
1000 mm	100	100	100
800 mm			50-100
500 mm			0-100
300 mm	35-95	35-95	0-50
100 mm	0-80	0-80	
75 mm		0-10	0-10
19 mm	0-35	0	0
4.75 mm	0-10	0	0

As stated earlier, the construction design flood water levels were based on a stable ice cover forming upstream of Gull Rapids. As a result of no stable ice cover formation upstream of Gull Rapids until late in January 2015, water levels at the causeway were higher than anticipated resulting in erosion at the culvert locations and the south abutment. The erosion caused sink holes to form in the causeway which impacted the safety of workers driving the causeway. The culverts were placed on and backfilled with finer bedding material which was not able to withstand the high seepage velocities around the culvert caused by the high water level. The abutment was constructed on fine grained sandy silt. High water levels created high seepage velocities that eroded the overburden material. The causeway was also overtopped near the south abutment which shut down access to the causeway for a period of time.

Even though additional measures have been put in place to promote the formation of a stable ice cover early in the winter season, there is still the risk that it will not form. If this occurs, there is a high potential that any new culverts placed into the causeway to Borrow N-5 would again experience erosion causing sink holes to form in the causeway. As well, additional work must be done to repair the damage occurred in the winter of 2014/15.

Abutment Repair and Protection

In order to prevent additional erosion of the south abutment and shore line the measures listed below will be implemented. These measures are shown in Figure 1.

- Granular and impervious material will be placed on the east side to reduce seepage through the abutment.
- A cut-off trenched filled with impervious material will be placed on the east side and will reduce

seepage through the abutment.
- Granular material will be placed on the west side of the abutment to prevent abutment soils from washing away.
- Rock fill will be placed along the shoreline to protect the newly placed granular and impervious material.

Measures are also being developed to prevent erosion at the north abutment of the causeway to Borrow N-5 and both abutments of the causeway to Borrow G-3. Imperious fill, granular material and rock fill would reduce seepage through the overburden material at the abutments. These are shown on Figures 2 and 3.

The timing of this work is anticipated to occur September 2015.

Culverts

The EIS identified that the causeway to Borrow N-5 crossed a perennial watercourse with a channel of scoured bedrock. The channel was in existence for approximately a decade and was created when an ice dam downstream of Gull Rapids forced flow to the north of the river channel. At the time, there were no risks identified to construction or safety by placing culverts in the causeway, therefore studies were not undertaken to confirm the previous route was still accessible and the Keeyask Application for Fisheries Act Authorization (Section 9.2.2) indicated that three culverts would be installed in the causeway to Borrow N-5. The high ice and water levels experienced during the winter of 2014/15 indicate both a safety and construction risk, therefore a bathymetric survey was completed in July 2015 to confirm that fish could still utilize O'Neil Bay, the results are in the Potential Environmental Effects section.

Table 1 summarizes the estimated water velocity within the culverts. During open water conditions the water level on either side of the causeway is the same most of the time resulting in no flow of water through the culverts. During rapid changes in water level on Stephens Lake due to operation of the Kettle Generating Station there may be flow through the culverts with velocities as high as 0.24 m/s. During winter conditions, the velocities are estimated to be as high as 4.7 m/s with a functional ice boom and 5.8 m/s without a functional ice boom.

Table 2 – Estimated Water Velocities at Causeway to Borrow N-5 Culverts

Condition	Water Velocity at Culvert
Open Water (Spring, Summer and Fall)	0 to 0.24 m/s
Winter – With Functional Ice Boom	0 to 4.7 m/s
Winter – Without Functional Ice Boom	0 to 5.8 m/s

Four options have been evaluated regarding a design for the causeway to Borrow N-5 culverts, refer to Table 2. Option 3, capping all three culverts, is Manitoba Hydro's preferred option. For all options at the causeway will be removed at end of construction and some of the rock material would be used to create spawning habitat at the causeway location, as described in the KAFA (Section 13.1.1) and

required by the *Fisheries Act* Authorization (Clause 4.1.1).

Replacing or removing culverts will impact access on the causeway. Replacing a culvert requires partial closure of the causeway to excavate down to the culvert. A crane would be required to lift the old culvert out of the trench and to lift a new culvert into the trench requiring access to the causeway to be fully closed. Removal of a culvert is similar however it requires less time to complete because no culvert is set back into the trench.

Capping the existing culverts would entail flattening each end of the culvert and covering with layers of Class 1, Select Class C1 and Class C2 rock fill as shown in Figure 4. The different layers of rock in the caps will be graded to prevent further erosion of material around the culvert and avoid development of sink holes. Much of the fine material washed out during the winter of 2014/15 which further reduces the potential for erosion at the culverts.

Potential Environmental Effects

The causeway to Borrow N-5 crosses a perennial watercourse with a channel of scoured bedrock. This channel has been in existence for approximately a decade and was created when an ice dam downstream of Gull Rapids forced flow to the north of the river channel. Fish can also access habitat in Looking Back Creek via O'Neil Bay on Stephens Lake (Map 1). At the time the EIS was developed, there were no risks identified to construction or safety by placing culverts in the causeway and the Keeyask Application for Fisheries Act Authorization (Section 9.2.2) indicated that three culverts would be installed in the causeway to Borrow N-5. The high ice and water levels experienced during the winter of 2014-15 indicate both a safety and construction risk.

Fish in Looking Back Creek and associated ponds may need to leave this area in winter if ice freezes to the bottom in shallow areas or if dissolved oxygen levels reach critically low levels. Prior to formation of the channel from the Nelson River, fish would have left via O'Neil Bay. At the time the EIS was prepared, installation of culverts in the causeway was not considered to pose a safety or construction risk therefore there was no need to confirm that fish egress through O'Neil Bay was still feasible. As a result of the high ice and water levels experienced in the winter of 2014/15, it has been determined that culverts in the causeway pose a safety and construction risk. As a result, a bathymetric survey was conducted in July 2015, this confirmed that a channel of sufficient depth still exists through O'Neil Bay such that even under extreme low winter water levels on Stephens Lake and maximum ice thickness, fish would have at least 1 m of water to pass through O'Neil Bay. Water depth at the mouth of the bay at Stephens Lake under worst case conditions would decrease to 0.5 m; however, fish would be able to pass this area and into the deeper waters of Stephens Lake.

Evaluation of the potential effect on fish stocks

Walleye and other fish species moving into the Looking Back Creek area to spawn from the Nelson River would need to either move to this area via Stephens Lake or find alternate spawning habitat in the mainstem of the Nelson River. This altered access to spawning habitat is in addition to losses and

alterations at Gull Rapids due to cofferdam construction. As noted in the KAFA (Section 8.1.6), Walleye have alternate spawning habitat in Stephens Lake; however, there may be years with reduced recruitment due to the reduction in total available spawning habitat. It is difficult to determine whether reduced access to Looking Back Creek would result in a decline in spawning by Walleye since they can access Looking Back Creek via Stephens Lake and also have habitat available to them in the Nelson River downstream of the construction site, and rockfill associated with the causeway and cofferdams may also provide additional spawning substrate. Given the size of Stephens Lake, the presence of numerous islands with rocky shoals and the North and South Moswakot rivers, and the presence of habitat within the Nelson River, it is expected that the reduction in access to spawning habitat in Looking Back Creek would not affect the long term viability of the population.

Evaluation of the potential for "serious harm"

The *Fisheries Act* prohibits serious harm to fish, defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat". This prohibition refers to:

- the death of fish;
- the permanent alteration to fish habitat as an alteration of such duration that limits or diminishes the ability of fish to carry out one or more of their life processes; and,
- the destruction of fish habitat as an elimination of habitat such that fish can no longer rely on this habitat to carry out one or more of their life processes.

Review of the Keeyask Authorization and the above requirements indicates that repair of the causeway without re-installation of culverts is not expected to require a change in the Authorization for the following reasons:

- *Prohibition on causing the death of fish*. As described in the preceding section, if fish cannot leave Looking Back Creek or the channel area during the winter months, they would be vulnerable to mortality. Given that the channel through O'Neil Bay is sufficiently deep to allow fish egress, the absence of passage via the causeway will not result in the death of fish.
- *The permanent alteration of fish habitat.* Access to the channel and Looking Back Creek will no longer be available from the Nelson River for the duration of the construction period. As discussed in the preceding section, this change is not expected to affect the reproductive success of Walleye due to the presence of alternate spawning habitat. The permanent alteration of habitat due to infilling for causeway construction (*in situ* 5-8 years) was authorized under the Keeyask Authorization.
- *The destruction of fish habitat.* As per the Authorization, the presence of the causeway is not considered destruction of fish habitat as it is not a permanent feature.

Table 3: Summary of Options for the Causeway to Borrow N-5

Option	Effects on Fish	Risks & Impacts on Project	Other Considerations
1. Replace 3 existing culverts (1500 mm, 1000 mm and 1000 mm) with 3 new culverts (1500 mm, 1000 mm and 1000 mm).	Access to/from Stephens Lake and Looking Back Creek Open Water (Spring, Summer and Fall) – O'Neil Bay and at causeway through culverts Winter – O'Neil Bay **The following applies to all options:** Section 5.4.1.2.3 of the Keeyask Aquatic Environment Supporting Volume stated that the construction of a temporary causeway to access the N-5 borrow area has the potential to trap fish. A bathymetric survey was conducted in July 2015, it confirmed that a channel of sufficient depth exists through O'Neil Bay such that even under extreme low winter water levels on Stephens Lake and maximum ice thickness, fish would have at least 1 m of water to pass through O'Neil Bay.	- There would be risk of erosion at each culvert potentially causing sinkholes and risk to worker safety when travelling on the causeway. - If sinkholes develop or culvert material washout occurs, access to Borrow N-5 and G-3 would be interrupted which would impact winter construction activities. - Causeway would be shut down for approximately 6 days to replace the 3 culverts. This could impact concrete aggregate production for the powerhouse and completion of the cofferdams.	- Not preferred as there is risk of sinkhole development or culvert washout posing safety risks.
2. Cap the two existing 1000 mm culverts and replace the 1500 mm culvert.	Access to/from Stephens Lake and Looking Back Creek Spring – O'Neil Bay and causeway through culverts Summer – O'Neil Bay and at causeway through culverts Winter – O'Neil Bay	- Same impacts as Option 1 but less risk because there are less culverts. - Causeway would be shut down for approximately 2 days to replace the culvert.	- Not preferred as there is risk of sinkhole development or culvert washout posing safety risks.
3. Cap 3 existing culverts.	Access to/from Stephens Lake and Looking Back Creek Spring – O'Neil Bay Summer – O'Neil Bay Winter – O'Neil Bay **The following applies to Options 3 and 4:** Walleye and other fish species could access Looking Back Creek via O'Neil Bay or find alternate spawning habitat in the mainstem of the Nelson River. Walleye have alternate spawning habitat in Stephens Lake; however, there may be years with reduced recruitment due to the reduction in total available spawning habitat. Given the size of Stephens Lake, the presence of numerous islands with rocky shoals and the North and South Moswakot rivers, and the presence of habitat within the Nelson River, it is expected that the reduction in access to spawning habitat in Looking Back Creek would not affect the long term viability of the population.	- Much of the fine material around culverts washed out during the winter of 2014/15 which reduces the risk of further erosion. Capping the 3 existing culverts further prevents erosion at the culverts and minimizes safety risks for workers travelling on causeway. - The risk of temporarily closing access to causeway during winter to repair sinkholes less than Options 1 and 2.	- Option 3 is the preferred option. Access to/from Stephens lake and Looking Back Creek is maintained through O'Neil Bay. This option requires considerably less effort, is least costly and has the least impact on other construction activities.
4. Remove 3 existing culverts	Access to/from Stephens Lake and Looking Back Creek Spring – O'Neil Bay Summer – O'Neil Bay Winter – O'Neil Bay	- Removing the 3 culverts prevents further erosion and sinkholes at the culvert locations and minimizes safety risks for workers travelling on causeway. - Partial and full closure of causeway for 2 days to remove culverts impacts other key construction activities.	- Option 4 is more costly and impacts other construction activities relative to Option 3.

KEEYASK

DATA SOURCE:
Manitoba Hydro; Government of Manitoba; Government of Canada;

CREATED BY:
Manitoba Hydro - GIS Studies

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	07-AUG-15	
0 0.3 0.6 Kilometres 0 0.25 0.5 Miles	VERSION NO: 1.0	QA/QC:

Legend

- Haul Road
- Borrow Area
- Site Layout

Keeyask G.S.

Causeway to Borrow N-5 Culverts Construction and Potential Environmental Effects

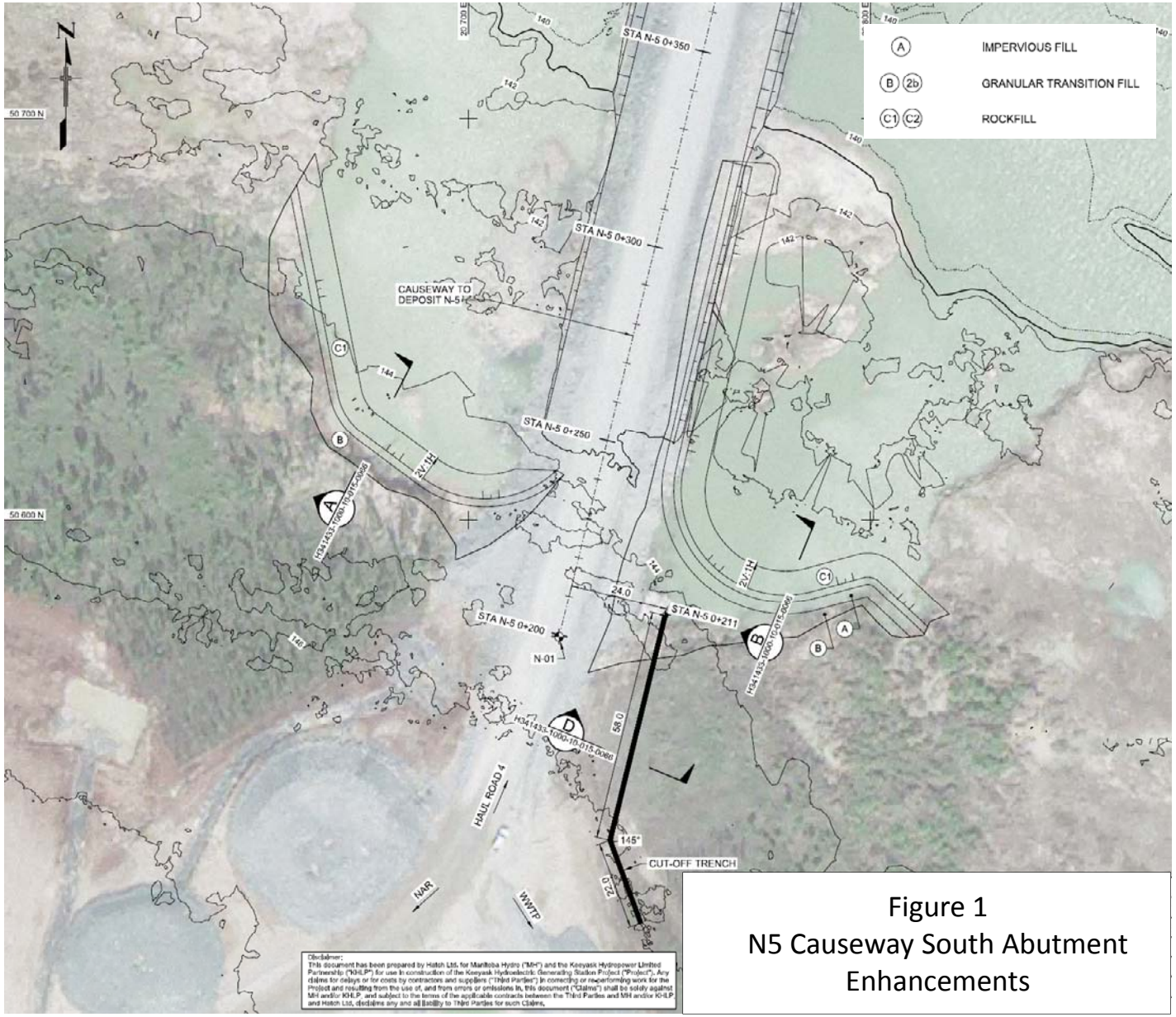


Figure 1
N5 Causeway South Abutment Enhancements

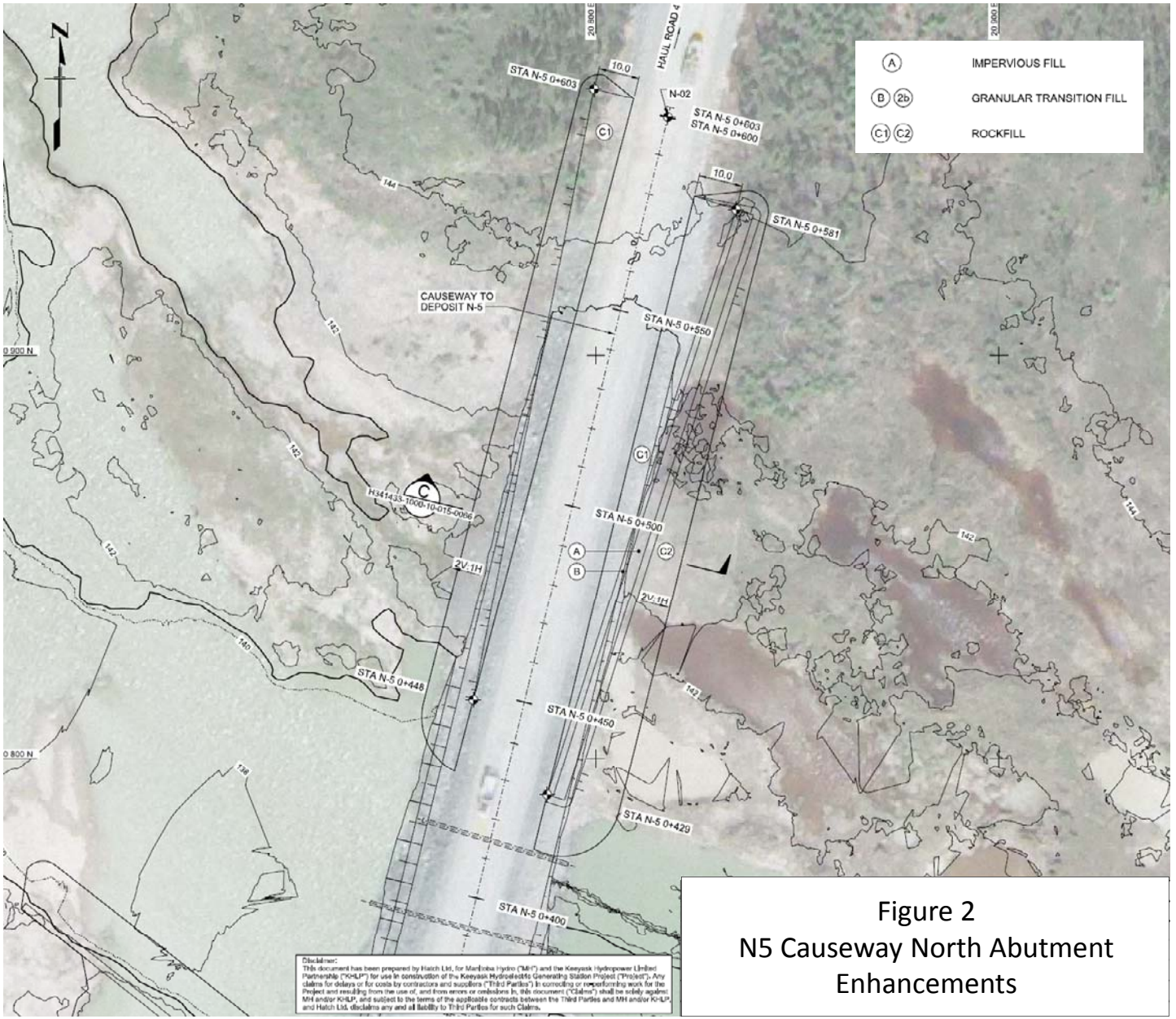


Figure 2
N5 Causeway North Abutment Enhancements

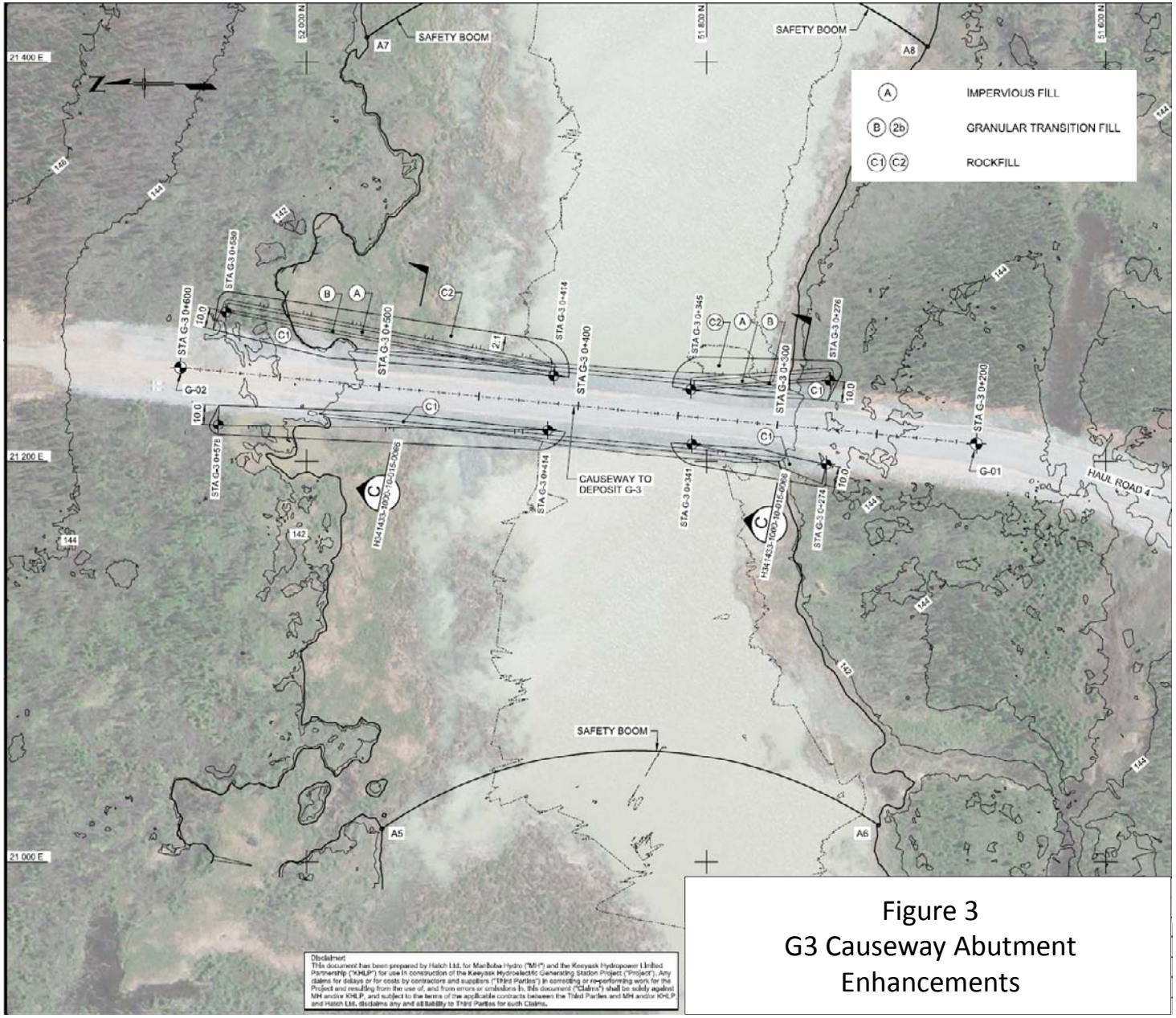
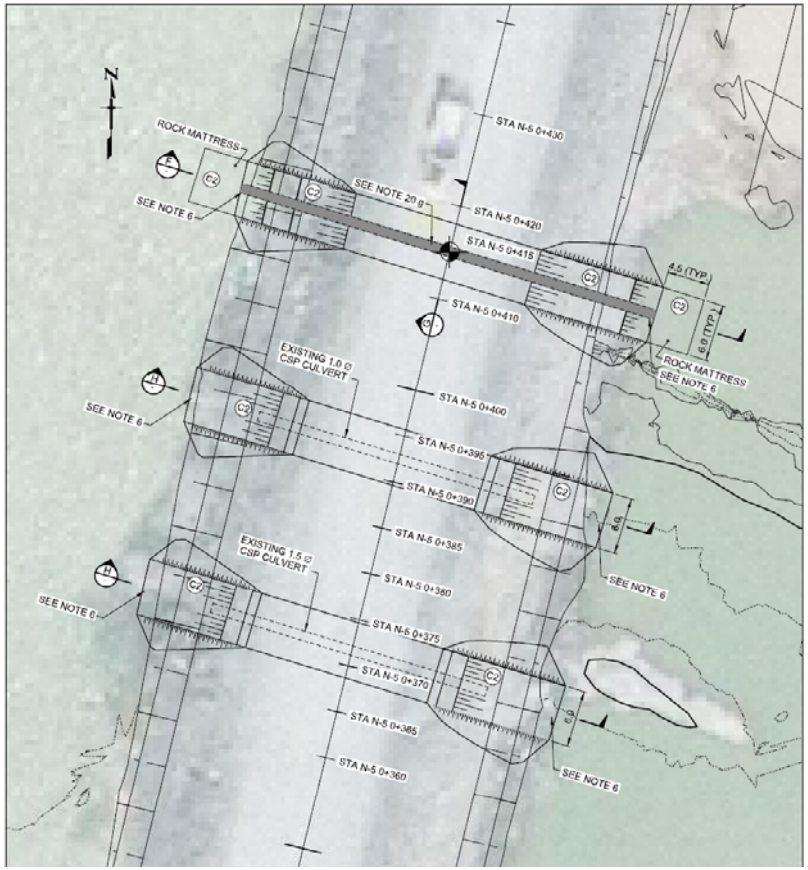
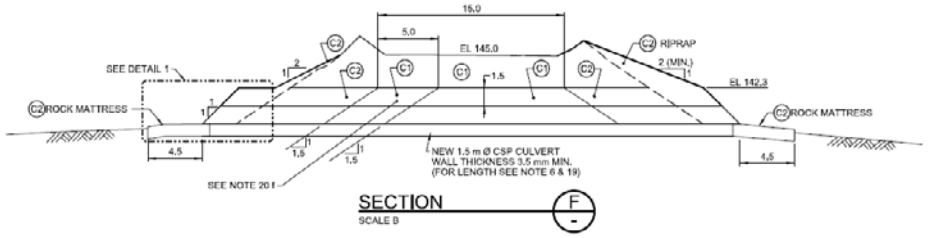
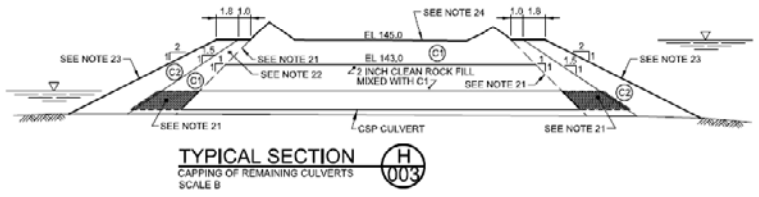


Figure 3
G3 Causeway Abutment Enhancements







NOTES:

20. CONSTRUCTION WORK FOR THE N-5 CAUSEWAY CULVERT REPLACEMENT SHALL IN GENERAL INCLUDE THE FOLLOWING KEY STEPS:

    a. ALL EXCAVATION WORK SHALL AT MIN. COMPLY WITH THE WORKPLACE SAFETY AND HEALTH ACT INCLUDING THE GUIDELINES FOR EXCAVATION.

    b. REMOVE TRENCH BACKFILL TO THE ORIGINAL TRENCH WIDTH EXPOSING THE C1 ROCKFILL TRENCH FACES. ALL 2 INCH CLEAN ROCKFILL TO BE REMOVED.

    c. REMOVE EXISTING 1.0m Ø CSP CULVERT.

    d. CONSTRUCT THE ROCK MATTRESSES AT THE TOE OF EACH SLOPE BY PLACING C2 ROCKFILL TO EL 139.3.

    e. CULVERT BEDDING MATERIAL TO CONSIST OF C1 ROCKFILL TO EL 139.3.

    f. BACKFILL 15.0 m CENTER OF THE TRENCH WITH C1 ROCKFILL. THE DOWNSTREAM 5.0 m PORTION TO BE BACKFILLED WITH SELECT WITH SELECT C1 ROCKFILL (i.e., >75 mm). BACKFILL THE REMAINING ENDS OF THE TRENCH BY PLACING C2 ROCKFILL TO EL 142.3.

    g. THE METHOD USED TO BACKFILL THE TRENCH SHALL NOT DAMAGE THE CULVERT AND BE APPROVED BY THE ENGINEER PRIOR TO WORK COMMENCING.

    h. BACKFILL THE TRENCH AND RESTORE THE CAUSEWAY TO EL 145 WITH C1 ROCKFILL.

    i. PLACE C2 ROCKFILL TO FROM THE OUTER SHELL OF THE CAUSEWAY.

21. REMOVE EXISTING CULVERT (AS NEEDED) AND SLOPE TO 1:1.

22. BACKFILL WITH SELECT C1 ROCK FILL (D>75 mm).

23. BACKFILL WITH C2 RIPRAP.

24. APPLY HIGH AMPLITUDE VIBRATORY COMPACTION AS THE TRENCH LINE IN AN EFFORT TO COLLAPSE ANY NEAR SURFACE VOIDS. BACKFILL VOIDS TO RESTORE CREST ELEVATION AS NECESSARY.

Figure 4
N5 Causeway Culvert Removal
& Capping Details