HWY 535 WATER MANAGEMENT PLAN

PROJECT HIGHLIGHTS

LEA | water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD. | Ontario

Table of CONTENTS

LOOK FOR (#) ON PHOTOS THROUGHOUT THE BROCHURE. THE PHOTO NUMBER CORRESPONDS WITH THE FILE NAME OF THE FILES SUBMITTED TO CCE.

Project Summary

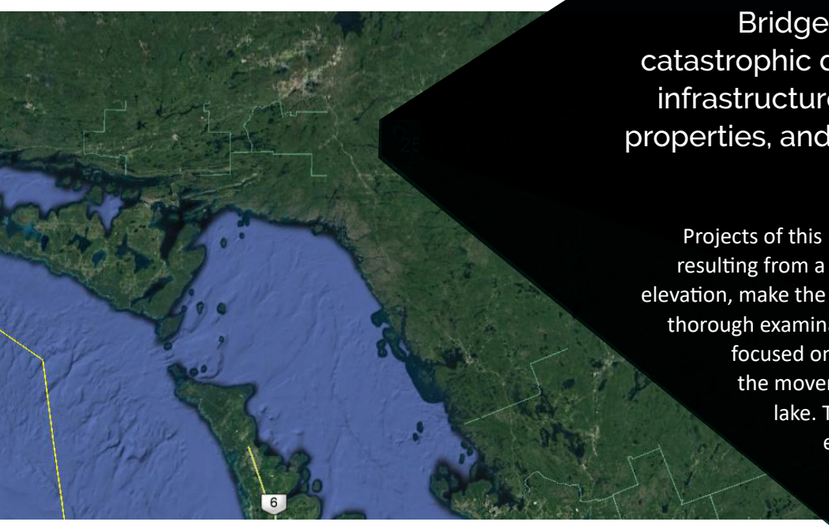
"Beaver dam failures and washouts in 2011, 2014 and 2019, resulted in sediment transport into the Southwest Arm of Lake Nipissing. Fish habitat within the beaver pond, upstream of the dam, and along the downstream flow path, was determined to be sensitive and a priority to the Department of Fisheries and Oceans, as migratory, top predator, and bait/forage fish species were confirmed to be present throughout.

PROJECT NAME: Water Management Plan by Site 46X-0176/BO
PROJECT LOCATION: Vicinity of 2529 Hwy 535 and Southwest Arm of Lake Nipissing Bridge on Hwy 535 (Lot 1, Concession 5 of Geographic Township of Cherriman)

Torrential flows due to beaver dam failures resulted in washouts of Highway 535 and the transport of 803m3 of sediments into Lake Nipissing. These events caused catastrophic damage to the highway, private properties, and fisheries. Retained by the MTO, LEA completed a hydraulic analysis and a subconsultant provided a sediment transport model, to support LEA's development and evaluation of design alternatives that address water management challenges, protect fisheries, and stop sediment from entering the lake.

PROJECT Summary

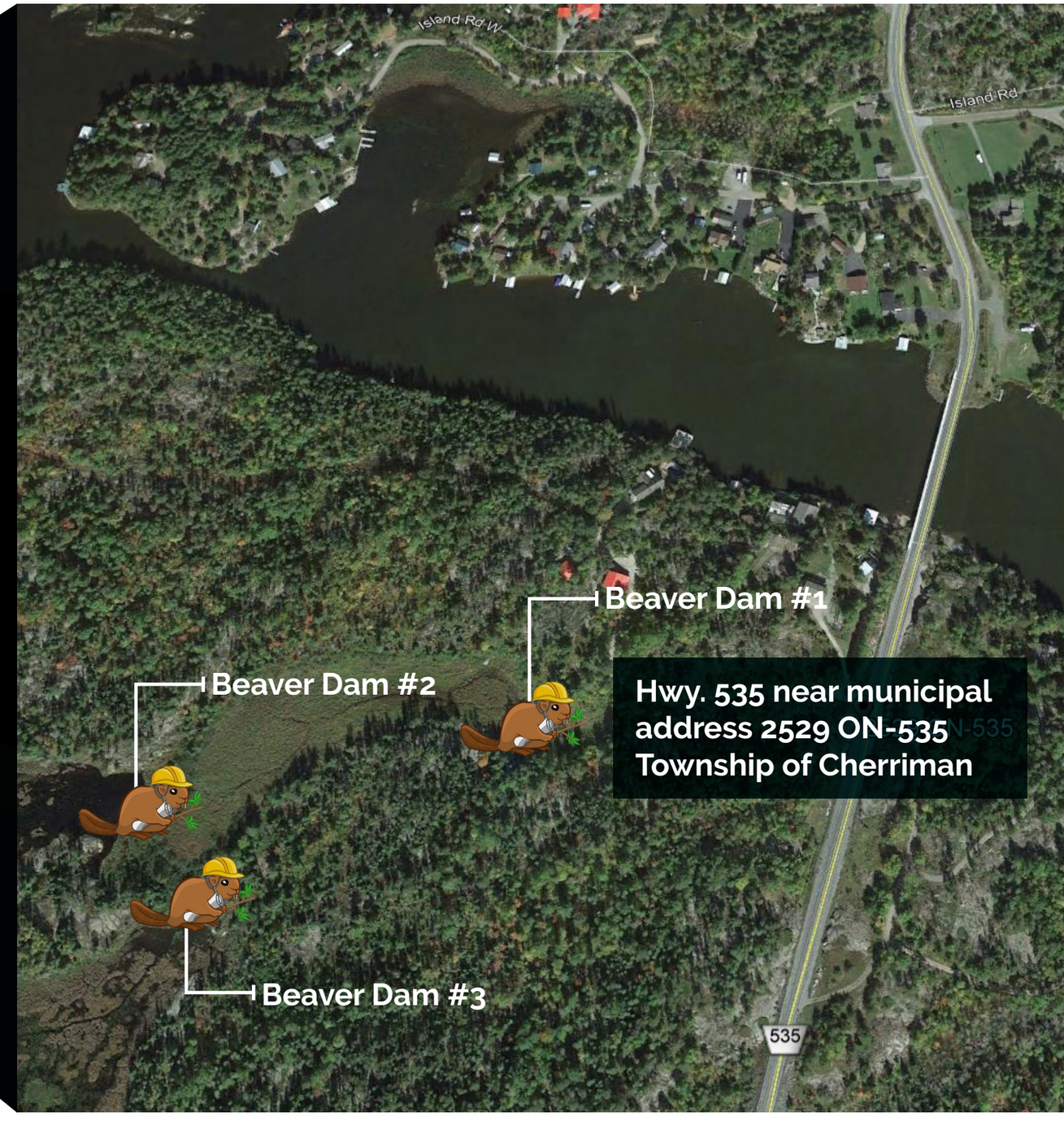
Project Site



After recurring beaver dam failures and washouts near Highway 535 and the Southwest Arm of Lake Nipissing Bridge, the resulting flows created catastrophic damage to nearby provincial infrastructure, affected access to private properties, and caused sediment transport into the lake.

Projects of this nature and the magnitude of destruction resulting from a failure of beaver dam located at a higher elevation, make the existing project unique. LEA conducted a thorough examination of eight existing design alternatives focused on the local water management issues and the movement of sediment and aggregate into the lake. Through an evaluation matrix, LEA scored each design option in different categories to support their selection of a preferred design alternative.

Following the preferred alternative selection meeting with MTO staff on March 31, 2020, MTO issued a new work order (for LEA) to investigate an additional option set forward by MTO's Operations staff. The new alternative optimizes materials currently available to MTO while limiting the drainage system changes to the available property.



Project CHALLENGES

Modelling an existing conveyance system that could not contain washouts and developing a flow conveyance system that was feasible to implement and could safely contain catastrophic flows, were the biggest challenges on this project. The complexity evolved as LEA had to develop a proper baseline model with limited survey data and information on past washouts.

LEA's hydrologic analysis indicated that the catchment area/soil type/land use considerations were not fully responsible for the level of past flooding. Therefore, flows released during and after a dam failure were calculated based on the opening of the broken beaver dam as a weir.

The hydraulic analysis was undertaken for eight alternatives considering a range of flows, and conceptual drawings were developed for each alternative, including flood line delineation. Using the site photographs, the extent of flooding in the existing condition was assessed and the hydraulic model was refined to represent low flow conditions and extreme flows experienced during a dam failure event and subsequent washouts.

The sediment transport analysis provided by subconsultant, Water's Edge, required a novel approach to develop an appropriate model and subsequently estimate sediment delivery following future dam failures. 16 sediment transport equations comprised the initial suitably evaluation. The sediment transport models were assessed for appropriateness and run to provide a comparison. Total sediment loadings were determined using discretized time steps for 2-hour events for each equation. The total loadings were compared for confirmation of the model to the estimated volume of deposited sediment resulting from the 2019 dam failure.

Summary of Alternatives

LEA was retained to develop and evaluate eight design alternatives, including a cost and impact assessment, and to select a preferred alternative. Assessments were completed for all alternatives and included a weighted matrix to score each option using eight criteria: environmental impact, constructability, overall hydraulic effectiveness, construction initial cost, risk, life cycle cost, maintenance, and life span. Each measure was assigned a weight and an overall score was calculated for the options analyzed. Conceptual design drawings were also included to illustrate the proposed infrastructure improvements, property acquisitions as needed, and identify areas of concern related to rock cut and illustrate the extent of flooding expected for the range of flows considered in the analysis.

ALTERNATIVES	CULVERT SIZE DIA. / (HXW) M	TOTAL SCORE	RANK
1 - Manmade Dam	N/A	265	4
3A - Pipe Under BD 2	0.45	260	5
3B - East Hwy (WLCDs)	3.0 x 1.25	245	6
3C - West Hwy (WLCDs)	3.0 x 1.5	280	2
10 - East Hwy (Extreme Flow)	2 barrels 4.5 x 1.75	270	3
14A - West Hwy & No Rock Cutting (Extreme Flow)	6.0 x 2.0	240	7
14B - West Hwy & Rock Cutting (Extreme Flow)	6.0 x 2.0	290	1

Following the preferred alternative selection meeting with MTO staff on March 31, 2020, MTO issued a new work order (for LEA) to investigate an additional option set forward by MTO's Operations staff. The new alternative optimizes materials currently available to MTO while limiting the drainage system changes to the available property.

Existing Conditions

Photo of Beaver Dam #1, with beaver deceivers/water level control devices installed by MTO, November 2019.

3

6

Ditch along Hwy. 535, west side, facing north, November 2019.

Photo of Beaver Dam #2, facing south, November 2019.

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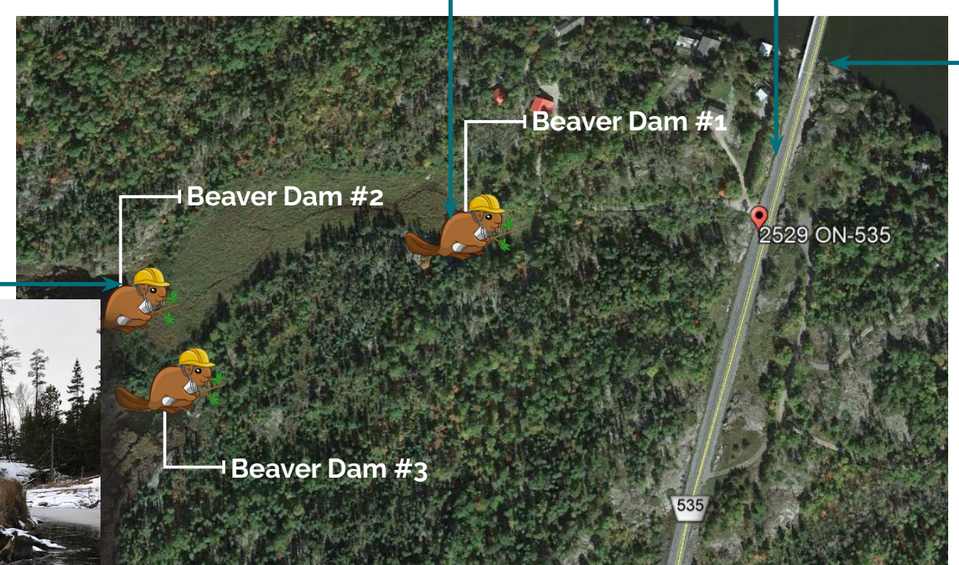
A closer look at the broken Beaver Dam, November 2019.



Settled material, east of the bridge, June 2019.

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Existing Conditions

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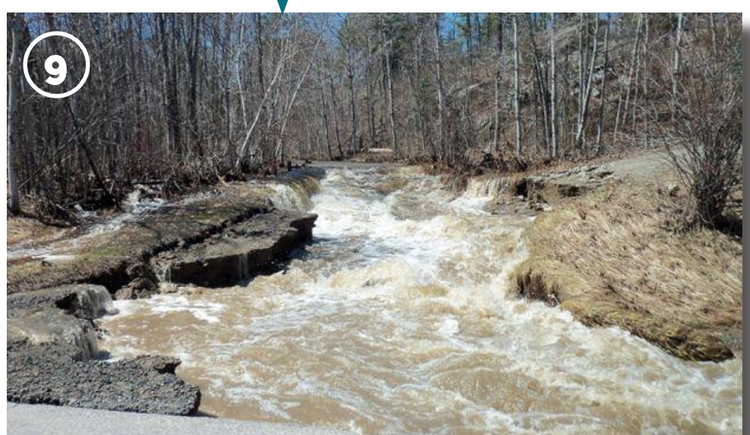
November 2019 Site visit, looking west, facing the driveway. Photo below: same direction, after May 2011 washout.



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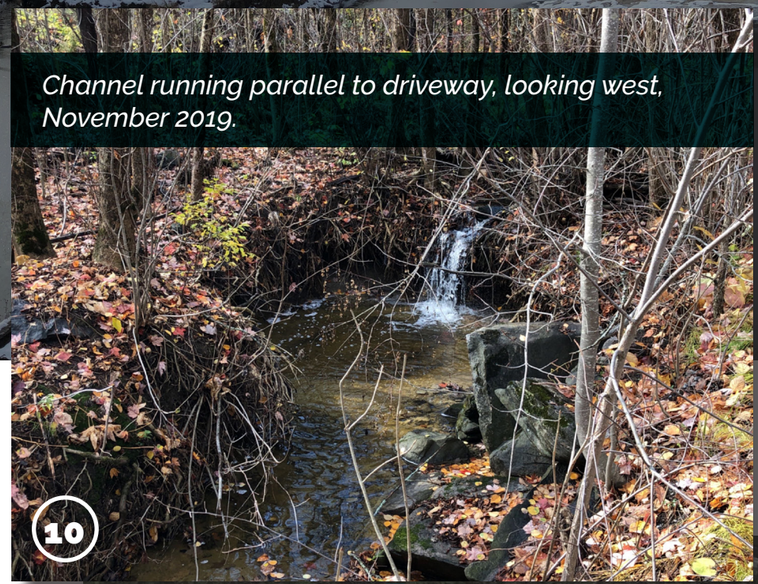

Channel running parallel to driveway, looking west, November 2019.

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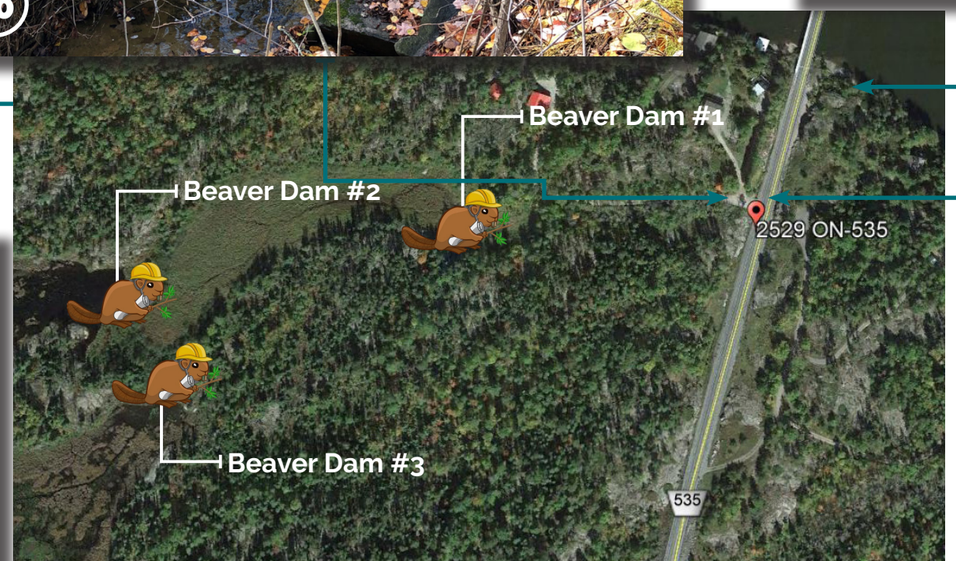
East side ditch of the Hwy, picture looking south, November 2019.



Damage to the Hwy after June 2019 washout.

12

Existing Conditions

Photo 1: on Hwy 535, facing north, November 2019.

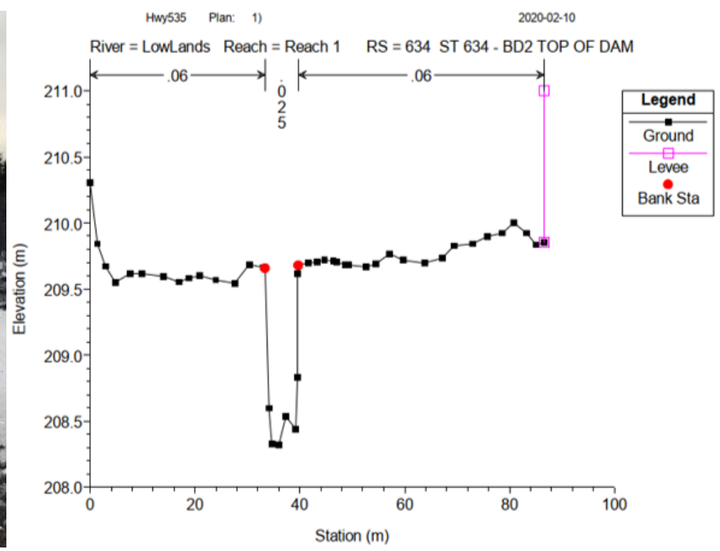
Photo 2: similar direction to photo 1, during the 2019 washout

Photo 3: similar direction to photos 1 and 2, during 2011 washout

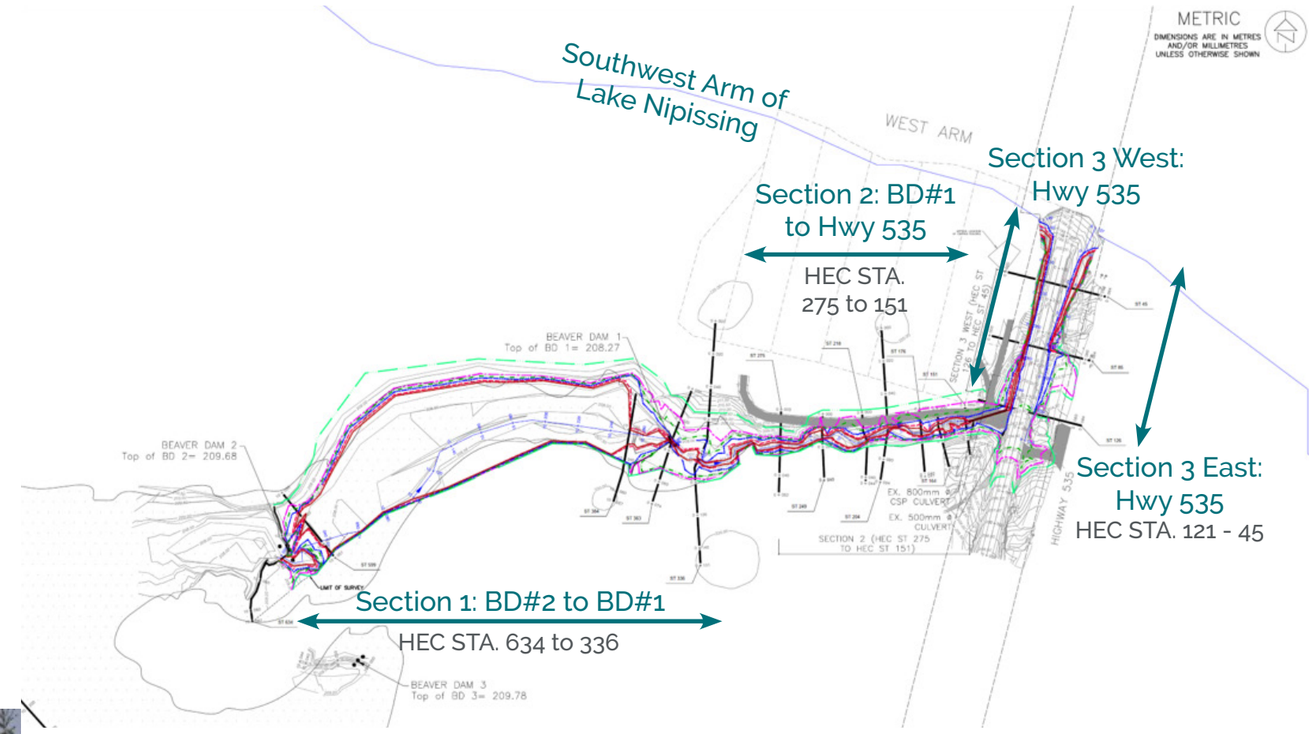
Existing Conditions

Hydraulics

NO.	HEAD AT BD#2 (M)	FLOW Q (M^3/S)	RESULTS
1	0.021	0.129	Existing Conditions (no flooding)
2	0.039	0.328	No flooding
3	0.122	1.812	Channel is overflowing in section 1 & 2 800mm ex. culvert is submerged
4	0.212	4.151	Flooding
5	0.305	7.163	Flooding
6	1.08	47.726	Flooding (extreme flows/washouts)

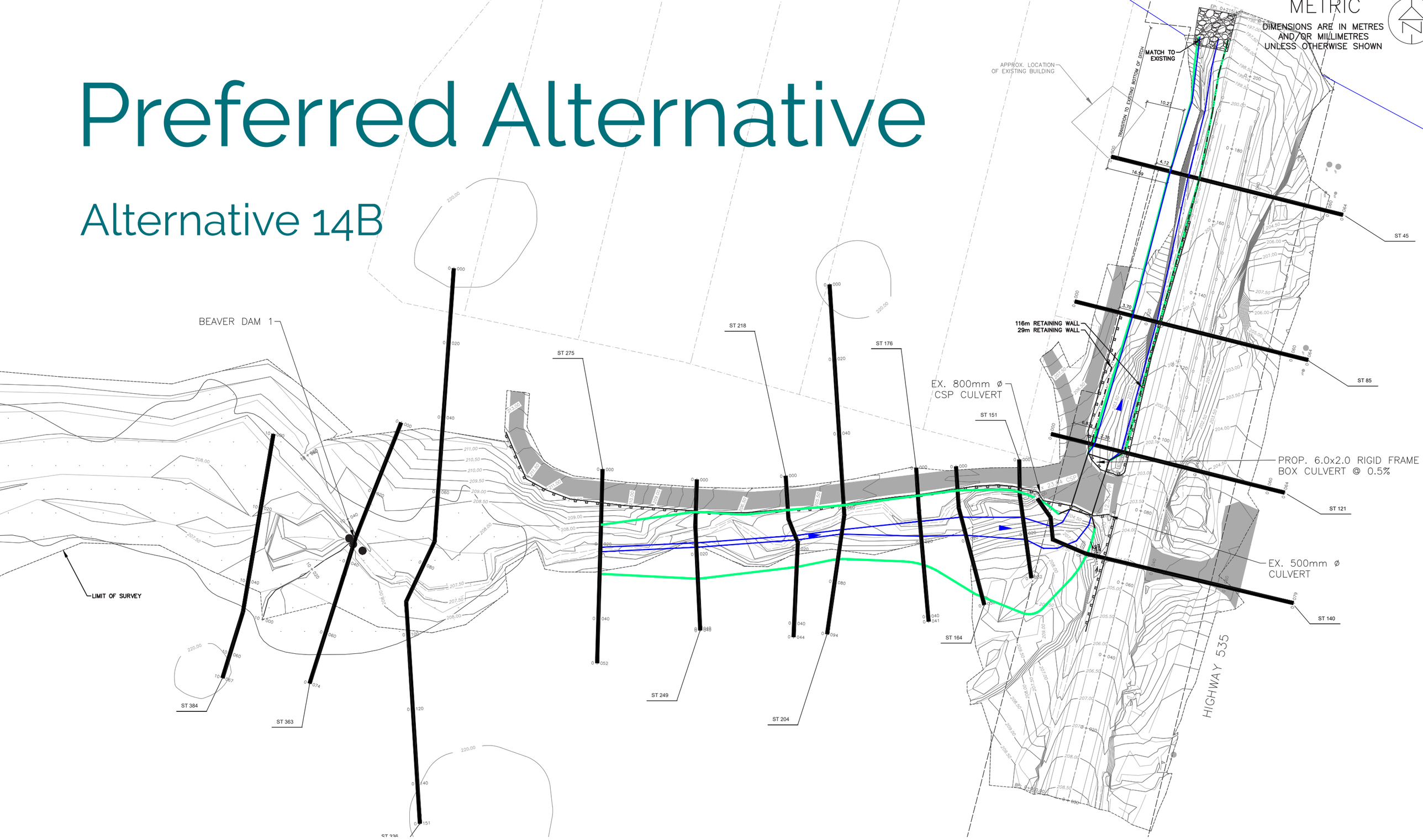


Floodlines



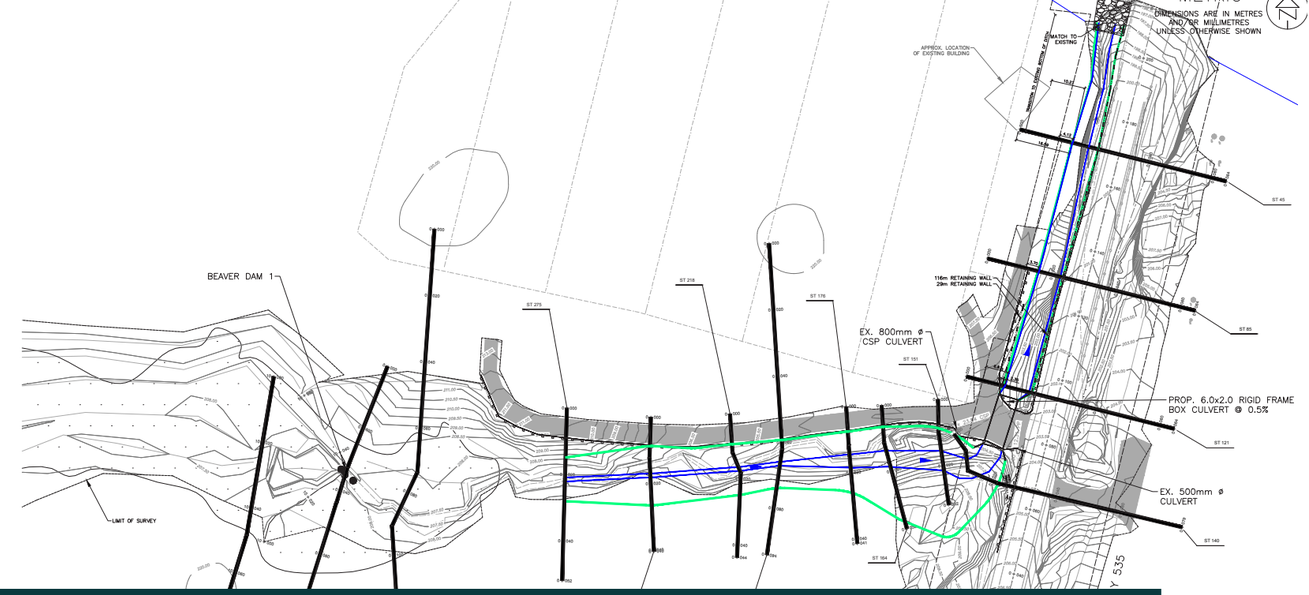
Preferred Alternative

Alternative 14B



Preferred Alternative

Alternative 14B



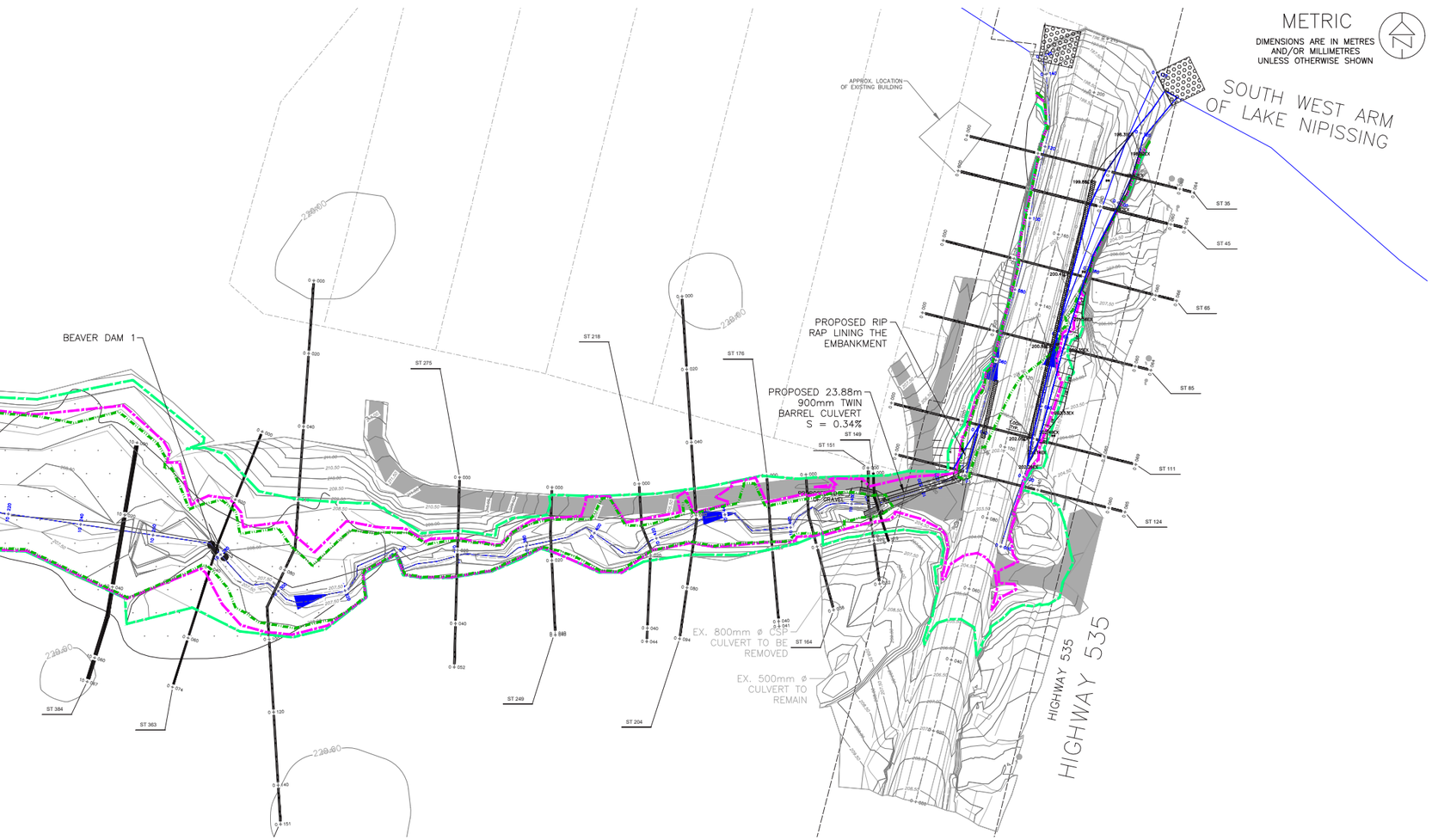
CRITERIA	CRITERIA WEIGHT	SCORE	TOTAL	NOTES
Alternative 14B - West Side Ditching with Rock Cutting (High Flow, no WLCDs)				
1 - Environmental	25	2	50	• Fish and Fish Habitat – High impacts due to new culvert, larger modification to Section 2 watercourse and larger alteration to west ditch line. • Terrestrial – High impacts due to larger modification to Section 2 watercourse and associated terrestrial areas. • Socio-Economic – Moderate/high impacts due to rock cutting with visible impacts to ROW. Section 2 infrastructure not visible from highway or from adjacent private properties. • Cultural – Low impacts as no resources are anticipated to be present. • Archaeological – Potential for impacts as work is to occur outside of ROW. • Permitting/Approvals – Numerous environmental approvals required to support work.
2 - Constructability	25	3	75	• Reconstruction of the access road will be required • Regrading of the channel section 2 will be required to redirect flow towards the ditch/culvert outlet • Rock blasting required; Vibratory impacts need to be mitigated for one property located closer to R.O.W. • All ditching will need to ensure roadway granulars are drained by providing a ditch elevation according to OPSD standards 0.5 m below the subgrade elevation. Channel erosion control measures shall be designed to still permit drainage out of the roadbed. • Gabion walls needed for embankment protection; box culvert to have wingwalls at inlet and outlet • Property impacts anticipated on Crown Lands for channel construction **Geotechnical Input:** • Hand auger holes would need to be taken every 20 m on the top of the rock to determine overburden depth to be stripped prior to rock cutting. Boreholes would also be required every 20 m in from of the rock cut and in the existing rounding to determine depth to rock to ensure drainage paths are not blocked. Depending on the location of the rock encountered, excavation of the existing shoulder of Hwy 535 may be required to remove any rock which is blocking drainage out from the roadway. Rock shall be removed level with the bottom of the new ditch and then shattered for an additional 300 mm. Typically rock cutting could be completed by either blasting or hoe ramming.

Preferred Alternative

Alternative 14B

CRITERIA	CRITERIA WEIGHT	SCORE	TOTAL	NOTES
Alternative 14B - West Side Ditching with Rock Cutting (High Flow, no WLCDs)				
3 - Hydraulic Effectiveness	15	5	75	• Highly Effective to convey extreme flows – No overtopping (localized above the culvert) • Alternative assumes beaver dam opening will be covered by beavers and future breakage would be similar to current BD2 opening; new infrastructure designed is capable to withstand the flows and velocities, rock check dams spaced according to slopes of the channel to provide erosion control; high effectiveness • Flows used in the design are the most extreme ones, potentially higher than the flows experienced during past washout events
4 - Construction Initial Cost	15	2	30	• Expensive option (cost rank = 2)
5 - Risk	10	1	10	• Risk due to rock blasting close to property, Rock engineering required to confirm risk levels • Geotechnical investigation is required to ensure slope stability • Significant roadside hazard created by proposed channel due to the depth; roadside protection measures must be implemented • Highway embankment protection required opposition from residents • Property required for channel modifications (crown lands)
6 - Lifecycle Analysis	5	5	10	• May require repair or replacement of gabion baskets as they may deteriorate over time due to unforeseen events • Gabion retaining walls may require replacement if deteriorated • Minimal cost expected over 50-yr duration
7 - Maintenance	5	5	25	• Regular inspection of culvert and retaining walls once every 5 years • Infrastructure visible from the highway • PVC coated and galvanized gabions have been tested to a 75-year design life (Input obtained from Maccaferri) • May require repair or replacement of gabion baskets as they may deteriorate over time due to unforeseen events
TOTAL	**100**		**290**	

NEW Study Option & Next Steps



As requested by MTO's Maintenance staff, LEA studied a new option/design alternative.

LEA's study found that the design option would:

- Provide an adequate conveyance system for flows up to 4.15m3/s but the ditches are not capable to convey extreme flows and risk of future washout still exists
- Considerably improve the existing condition in minimizing the risk of sediment transport
- Require gabion walls and mats to prevent erosion and sediment transport
- Cause minimal encroachment into Crown Lands.

LEA successfully completed the assessment to allow MTO to make an informed decision to manage flow conveyance, highway protection, and fisheries.

Next steps

MTO to evaluate the preferred alternative as well as the last design option as proposed by MTO's Operations' staff and determine next steps moving forward.

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