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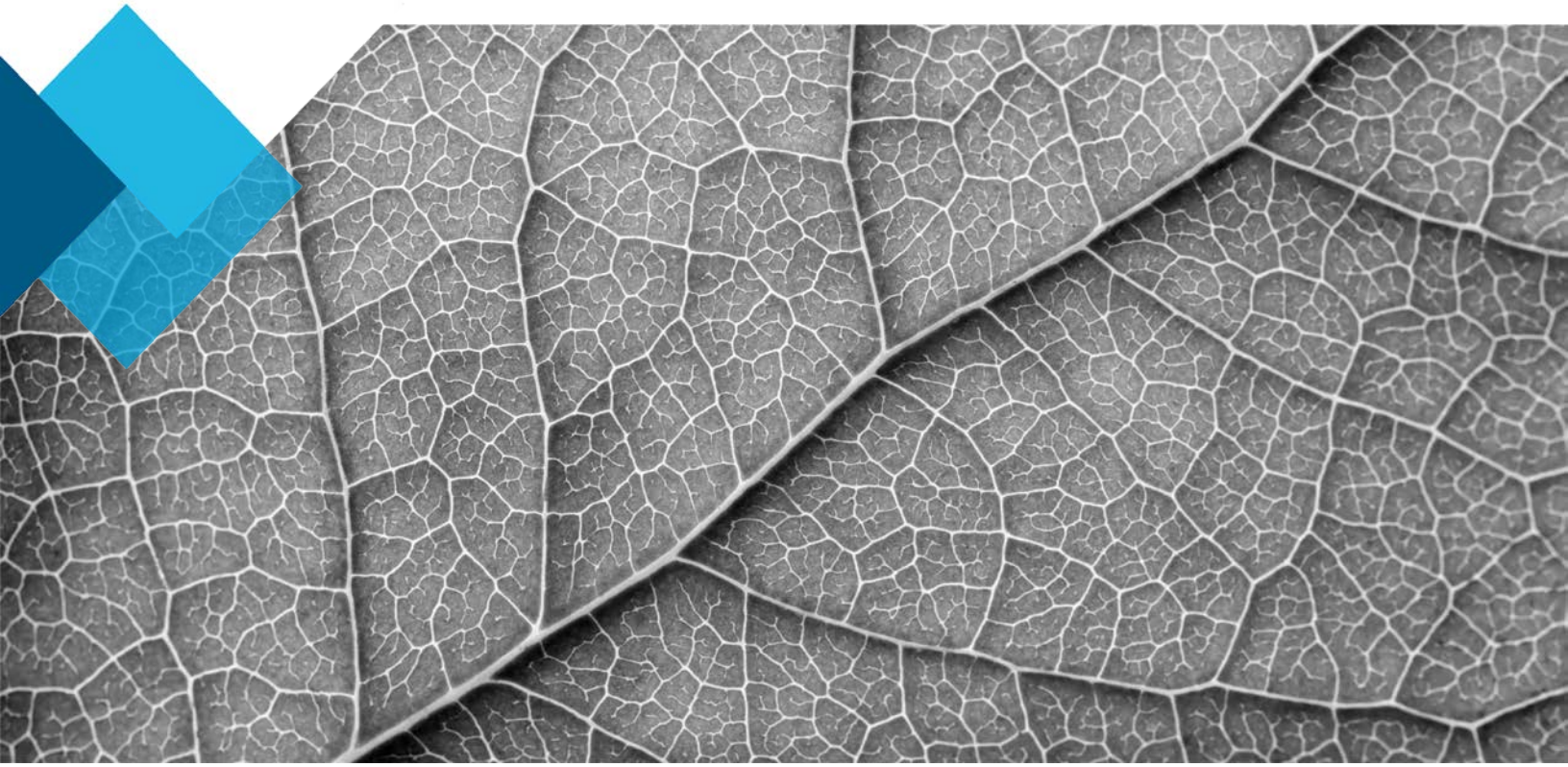
Muskrat Falls

Soil & Vegetation Removal from the Future Reservoir Area

Prepared for: Nalcor Energy



Environment & Geoscience

December 21, 2017

Internal Ref: 505573-0000-4GER-0001

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Executive Summary

This report presents the preliminary construction assessment carried out by SNC-Lavalin Inc. for the Muskrat Falls Hydroelectric Project reservoir (Site) located in the Lower Churchill Project (LCP) area. The constructability assessment considered technical and economic factors associated with the overburden soil and vegetation removal from the future reservoir area.

This report addresses the removal of all organic soil and vegetation, as requested by the Independent Expert Advisory Committee (IEAC). The purpose of the removal is to mitigate the potential for the transmission of methyl mercury into the water courses.

The analysis includes a review of current physical characteristics of the Muskrat Falls reservoir and its surrounding area using available GIS data and compilation of data from various reports and surveys. The analysis is focused on engineering requirements and constructability based on soil types, volumes and depths of the organic soil layer that can be removed safely in this new phase.

The schedule is short (6-7 months) and mobilisation will significantly reduce available time. Allowing 2 months for mobilisation is necessary but probably unrealistic. The volumes to be excavated are very large, even for just the organic materials they are large. The volumes of material estimated for excavation vary greatly if it is assumed that winter operation requires greater depths of excavations. This is probable and the rate of production makes it difficult to be limited in the removal and separation of frozen and other material.

The estimate of required equipment (Table 11.2) is very high. It will be a challenge to locate sufficient equipment to complete the work, the numbers represent a substantial proportion of the equipment available in Eastern Canada. Increasing the size of haul trucks and associated vehicles could increase productivity and reduce numbers of plant and operators. However, larger equipment requires longer mobilisation times and specialist support. For a short construction program it is likely that mobilisation time would be very high and an even higher premium on rates demanded for equipment.

Contractually the project may require a number of large contractors to be able to complete the work. Rates are likely to be high as there will be very little competition particularly if it is all to be completed in a short period of time. There is no incentive for longer term work and investment in additional plant and equipment if it sits idle after the project.

Environmentally the project faces a number challenges. Exposing large areas of the footprint is likely to result in environmental concerns stakeholder consultations, and issues related to obtaining necessary permit and clearances.

The clearance of all organics (trees, brush and organic soils) from the footprint of the reservoir to FSL is extremely costly and unlikely to be achievable within the schedule to allow impoundment for first power in July 2019. Increasing the reliability of delivery in that time period, without triggering a major landslide, is difficult. The act of removing organics (all trees, brush and organic soils) from the footprint may in itself cause instability of the slopes while construction proceeds.

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The overall program of organic soil and vegetation removal should be considered a major civil engineering activity in its own right. The clearing project should be considered in the context, it is on the scale of a large mine development conducted in less than one year rather than the more typical 5 to 10 years to first ore production from breaking ground. The short schedule drives the costs and the generation of extraordinary premiums for the work.

The program of works to remove all organics (soils, trees and brush) from the footprint of the FSL is very challenging and the cost extreme at up to $2.3 billion. The project constitutes an extreme civil engineering project (in short duration and cost) and would be perhaps unique in attempting to conduct such a large project of this nature amongst significant geohazards in so short a period of time.

The project may be achievable in one year with sufficient lead time for planning, engineering, procurement and regulatory requirements (consultation and approval). However, it should be considered a challenging and difficult project with a high risk of not delivering on schedule.

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1 Introduction

This report presents the preliminary construction assessment carried out by SNC-Lavalin Inc. for the Muskrat Falls Hydroelectric Project reservoir (Site) located in the Lower Churchill Project (LCP) area. The constructability assessment considered technical and economic factors associated with the overburden soil and vegetation removal from the future reservoir area.. It is also understood that the initial phase of vegetation removal (trees, bushes etc) has already been undertaken in part (and included less than 50% of the future reservoir area).

This report addresses an additional activity to remove soil and vegetation as requested by the Independent Expert Advisory Committee (IEAC). The purpose of the removal is to mitigate the potential for the transmission of methyl mercury into the water courses.

The analysis includes a review of current physical characteristics of the Muskrat Falls reservoir and its surrounding area using available GIS data and compilation of data from various reports and surveys. The analysis is focused on engineering requirements and constructability based on soil types, volumes and depths of the organic soil layer that can be removed safely in this new phase.

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2 Scope of work

A scope of work dated 11 October 2017 provided the basis for the analysis. The scope of work was developed in consultation with IEAC. The objective of the analysis is to assess the cost and effort required to safely removal all organics from the current unflooded footprint of the Full Supply Level (FSL) of the reservoir.

The following scope of work was requested by the client:

- Documentation of surficial geology and soil types for the future reservoir area;
- Identification of future reservoir area where soil and vegetation has already been removed in the initial-phase of construction;
- Soil and vegetation that can be removed considering two scenarios: a) complete removal, and b) targeted removal (not conducted at this stage);
- Analysis of the depths of the organic soil layer that can be removed based on available data;
- Review of the physical characteristics such as topography, surface and groundwater conditions (slopes, wetlands and wet areas, dense vegetation, existing terrestrial land classifications, geotechnical conditions, etc. of the future reservoir area) for the next phase of soil and vegetation removal;
- Definition of project scope of work after reviewing initial phase of work then working with IEAC in order to finalize the project scope and deliverables; and
- Conduct constructability analysis for the soil and vegetation removal that includes the following:

  I. Consideration given for available technology and methods;

  II. An assessment of Ecological Land Classification (ELC) in greater detail;

  III. An assessment of access requirements for each identified area;

  IV. An estimate of soil and vegetation quantities and review of logistics related to each subject area;

  V. Identification of potential disposal areas and transportation options;

  VI. Assessment of geotechnical constrains such as slope stability, access road subgrade capacity for the equipment etc.;

  VII. Review of safety standards and lesson learned from the initial-phase of soil and vegetation removal;

  VIII. Review of environmental impact due to the removal of soil and vegetation;

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IX. Review of applicable legislation;

X. Recommendation for site stabilization in terms of erosion, slumping, slope failures etc;

- Construction plan for the identified areas for this phase of soil and vegetation removal and recommended approach for removal along with various other removal methodologies/options;
- Cost estimate for the identified areas and total cost estimate for this phase of soil and vegetation removal.

It is understood that the consultant engineer is expected to work with the IEAC and be available to answer questions and provide any additional details that may be required in order to finalize the Draft Report. The Draft Report is due on December 20, 2017.

Items viii and ix have not been conducted at this time due to time constraints and are planned as future works. The other items were completed and are reported herein. This report is the following principal elements:

- Assumptions and options for the organic removal from the reservoir area (Section);
- Constructability and estimated quantities (Sections); and
- Cost estimate (Section);
- Discussion
- Conclusion

In the appendices for this report the supporting information for the study is presented:

- Appendix I: List of assumption used in the preliminary design and estimation process;
- Appendix II: Figures: Aerial photography, ELC classification, geology and preliminary civil engineering design (roads, disposal areas and areas requiring re-profiling).-
- Appendix III: Rates for construction activities supplied by Nalcor as basis for cost estimates
- Appendix IV: Typical sections Road, Slope Re-profiling and Sedimentation Pond used for the design and estimation process

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3 Site description

The project area is located near Happy Valley-Goose Bay, Newfoundland and Labrador. The 824 MW hydroelectric facility is located at the km 43 of Churchill River, approximately 30 km southwest of Happy Valley-Goose Bay area.

The reservoir's Full Supply Level (FSL) will be at Elevation (El.) 39.0 m above mean sea level (amsl). The planned water level for the reservoir was El. 25 m amsl after scheduled first impoundment, scheduled for October 2016. The current water level near the dam construction site is at about El. 22.5 m amsl. At FSL, the reservoir will cover an area of approximately 107 km^2 at full supply level extending between the dam and the outlet of the future Gull Island Hydroelectric Facility upstream, as shown in **Figure 3.1**. A projected approximately 41 km^2 area will be inundated at the FSL.

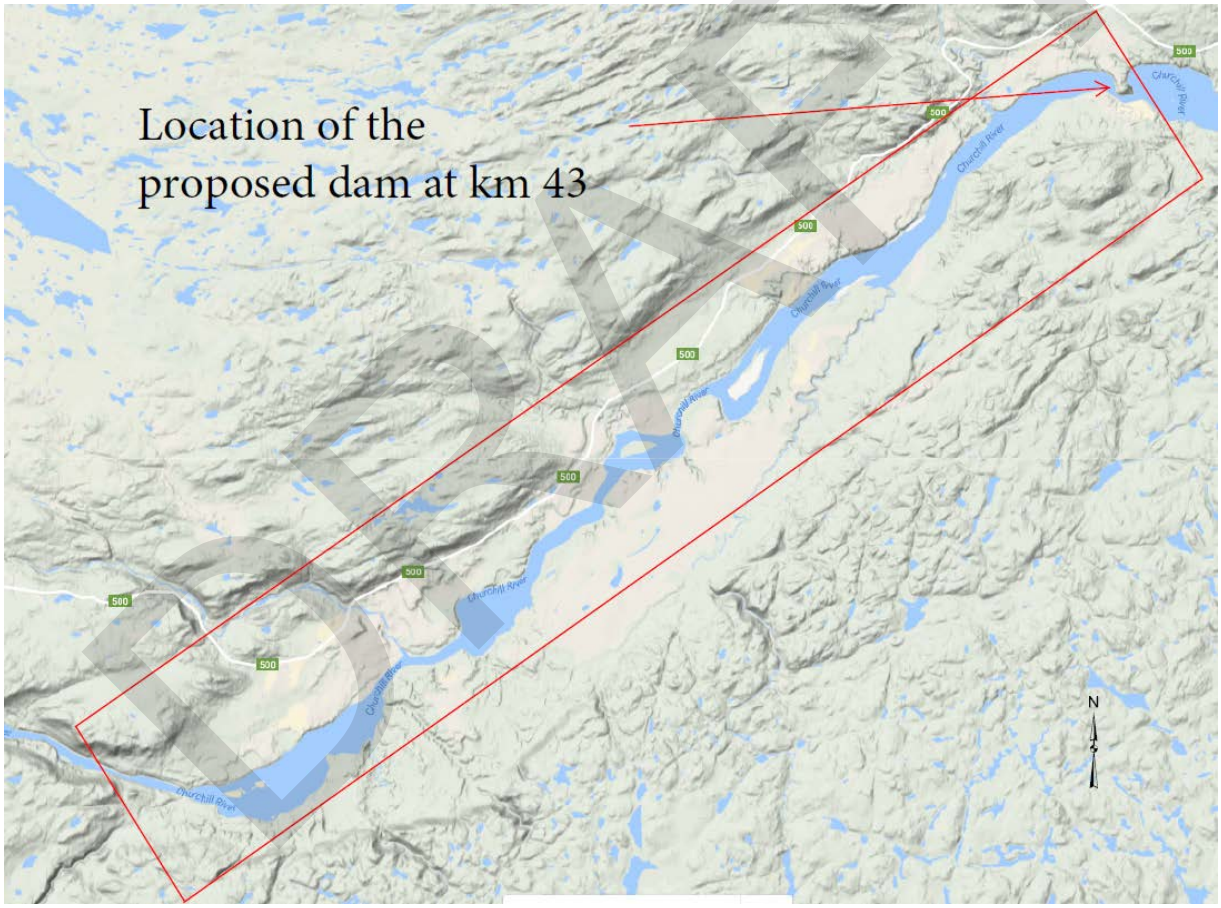

Figure 3.1 Proposed reservoir study area.

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The Churchill River Lowlands (downstream from Gull Island) is a wide bedrock valley. Its width varies from 3 to 8 km. The rocky walls of the valley rise several hundred metres above the valley floor. The valley is filled with few hundred metres of drift. The following is an extract from the AMEC report "Bank Stability Study, Lower Churchill River Hydroelectric Generation Project" (June 2008, TF6110449)

"The Churchill River Lowlands are characterized by continuous deep accumulation of fine textured estuarine sediments. The total thickness of estuarine clay is unknown, but depths in excess of 1000 m have been reported.

From the remnants of terraces along the valley sides, it is estimated that at one time estuarine and fluvial sediments may have completely filled the valley to approximately 110 m at Muskrat Falls and to 120 m at Gull Island. Subsequently, much of these deposits have been eroded by fluvial action.

Near Muskrat Falls the estuarine sediments rest on bedrock, but elsewhere the sediments rest on glacial, glaciofluvial drift and occasionally on bedrock ridges. The sea bottom was largely a glacial landscape which was flooded as the ice retreated inland. The full range of glacial deposits and morphology exist on the basin floor. As the ice retreated up the wide Churchill Valley above Muskrat Falls, it deposited intermittent loads of sediment in a series of recessional moraines. A number of these moraines are apparent at river level as boulder rapids.

Where streams entered the embayment, large deltas were built with the sediments growing finer downward and outward from the delta. Thin bedded silts and sands are common in the deltaic environment.

Wherever glacial deposits appeared above the surface, they were attacked by waves and currents and their erosion supplied sediment. The glacial deposits themselves were often reduced to a lag deposit of boulders and gravel while fine sediments were carried into deeper water.

Nearly everywhere, the estuarine sediments are mantled with an accumulation of well sorted sands of littoral, deltaic and near shore origin, numbering a few metres in thickness, but thinning upstream. The major sediment sources were outwash streams from the interior plateau. Most of the estuarine sediments were deposited in slow moving, non-turbulent water, and as a result, are primarily silt and clay size. Silt is more abundant than clay. Thin layers of fine sand, most of which are no more than sand partings, are common. The sand partings have little cohesion and are planes of weakness along which the soil is easily parted.

The water in which the estuarine sediments were deposited is believed to have been brackish rather than fully marine, as the location of deposition was near the head of an estuary and great additions of melt water fed directly from the retreating ice. Salinity decreased further as sea level dropped and the shoreline regressed. This brackish environment during deposition, plus the subsequent leaching of the salt from pore water contained in the soil, is known to have a very pronounced effect on the physical properties of fine grained soil, such as these estuarine sediments, and contributes to their landslide susceptibility."

The extract describes provides evidence of the slope stability issues that are associated with the sensitive estuarine and glaciofluvial clays which are identified as natural hazards.

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4 Reference Data

The study of soil and vegetation removal from the future reservoir area started in November 2017 with available GIS data and associated reports after initial phase of plants and vegetation removal. Selected available reports were reviewed. Some reports of particular relevance to this analysis are:

October 23, 2017	"Muskrat Falls Soil Sampling Program 2016", Amec Foster Wheeler Report # TF13104119.5600
June 15, 2013	"Landslide Generated Waves in Muskrat Falls Reservoir", SNC-Lavalin, RP-0009-01
December 23, 2008	"Lower Churchill Hydroelectric Generation Project, Project Area Ecological Land Classification", Jacques Whitford Report # MIN0315.01
June 2008	"Bank Stability Study Lower Churchill River Hydroelectric Generation Project", AMEC Report # TF6110449

Following are the project GIS data that was available prior to this report:

- 2006 LiDAR — High resolution imagery (individual tiles and raster catalog)

  LiDAR = Laser Imaging Detection and Ranging or Light Detection And Ranging

  - Digital Elevation Model (DEM) – integer, DEM tiles – float
  - Hillshade
  - 1m contours
  - Classified slope (0-8%, 8-12%, 12-20%, 20-30% 30+%)
- 2016 LiDAR — High resolution imagery individual tiles and raster catalog
- Forestry/Land Cover
  - Original forest inventory
  - Cleared area
  - Existing access roads/trails
  - Ecological land classification (2008 – Stantec)
  - Soil sample data (2017 AMEC foster wheeler)
- 39 m contour – full supply level
- Buffered rivers and water bodies

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- Surficial geology
- Bedrock geology
- Quarries

The above information was reviewed during the preparation of this desktop report. No field survey or field verification was carried out to verify data received.

Cost data was provided by Nalcor from the Muskrat Falls project for earthworks and other activities covered by this study and reflect actual project costs and unit prices. Where data for rates was not available, published rates were utilized and modified based on the project specific knowledge and circumstances.

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5 Methodology

The approach to the study is necessarily high level due to the short period of time available for the study and the limited ground information available for the areas to be cleared or modified.

In order to develop the study, a number of assumptions were made based on specific past experience of the site and general experience of such projects and activities as are planned. The assumptions made are documented primarily in Section 6 and Appendix I, but also reported throughout where relevant. The assumptions were discussed with those with experience of the project and the site to test their validity and were modified throughout the study to address new items as they arose and to account for additional information gained.

Using the assumptions, a feasibility level design for the necessary infrastructure to achieve the objective was developed. The design included:

- A network of access roads
- Potential camps
- Identification of areas where particular construction methods are appropriate, or required, to remove organics removed (trees, brush, muskeg, organic clays, etc.) from each zone
- Identify and preliminary design of the stabilisation of potential instability areas where additional measures are required
- Landing areas for barges
- Feasibility level design of drainage and sedimentation management for surface water during the construction and until the slopes are submerged by the reservoir
- Feasibility level design of borrow pits and disposal areas above the FSL.

The solutions developed were heavily influenced the following primary factors:

- Safety and reliability of the design and construction;
- The nature and extent of the materials to be removed (trees, brush, muskeg, organic clays, etc.);
- Available schedule (August 2018 to first power objective July 2019);
- Weather and environmental considerations;
- The presence of sensitive clays which may trigger landslides.

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Following the development of a preliminary solution, this was refined and options for the removal developed. The availability of plant, equipment and personnel was not taken as a limitation on the construction program. However, issues related to mobilization and availability are discussed within this report as they are likely to present considerable challenges. Contractor engagement has not been conducted at this stage. However, engagement with contractors engaged in earth moving contracts and forestry clearance is advisable throughout future development of the design and contracting process. The works to be completed are substantial and their input on available plant and equipment (as well as engineering methods) would be beneficial to the success of the work. Contractors will also provide additional understanding of any risks related to construction and delivery on schedule.

Obtaining permits and approvals has not been discussed except at a high level. It is assumed that all of these can be achieved to allow near uninterrupted construction programs starting on schedule. The following subsections discuss general construction methods for the soil and vegetation removal.

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6 Assumptions and limitations

A list of assumptions made in developing this report are provided in Appendix I. The following key assumptions are extracted from those presented in Appendix I and discussed in more detail.

6.1 Schedule

6.1.1 Contract start date and mobilisation

Contract award will be August 2018 and mobilisation will commence within August. August is considered the earliest that the work would start following all internal and external approvals to proceed as well as contractor procurement and award. This is a challenging schedule to achieve and relies heavily on all stakeholder consultations, budget approvals, regulatory approvals, permits and licenses having been achieved. Contract set up and tendering will also be extremely challenging to achieve in the time allotted. We have assumed one contract with subcontracts organised by the successful bidder but it may be necessary to consider that multiple contractors with interfaces will need to be appointed and managed. Vegetation clearance and road construction must be commenced (preferably completed) before others mobilise to site to remove organic bearing soils.

It is assumed that all necessary equipment, personnel, etc. will be available and can be mobilized for this phase of soil and vegetation removal. This may be considered a difficult to extreme task for such a short and relatively large programme of removal of material. This represents a significant risk to the successful delivery of the works on schedule.

6.1.2 First Power

Impoundment for first power for the project will be July 2019 by which time the reservoir will have reached full supply level. Missing this deadline would have huge costs in lost power and revenue generated.

6.1.3 Construction period

All bodies of water will be frozen by December and will not reopen until after April 2019. This limits access to shore front and the opportunity to use barges and water borne access and removal to a narrow window between September and November. To be confident of demobilisation before winter “freeze” the programme on water should assume no more than 8 weeks including mobilisation and demobilisation.

The construction period (including: mobilisation, demobilisation clearance, road construction and vegetation clearance) will be from September 2018 until March 2019. This is a short construction programme during a challenging period of the year; there may be significant delays due to weather events (“white outs”).

In our estimation of volumes consideration is given to excavation of material being different when the ground is frozen and when it is not. Frozen ground is likely to arise in larger units when excavated or pushed, resulting in larger volumes of soil being excavated when temperatures are consistently sub-zero. The period of the schedule where the ground is not frozen lies mostly within the mobilisation period (August, September and October), In addition, vegetation clearing will occur before construction further reducing the reducing the period when exposed soil can be excavated.

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Environment Canada reports average temperatures below -4°C from November until April for Goose Bay. Therefore, all numbers presented for excavation with non-frozen ground are likely only illustrative. Less than 1/3 of the schedule is likely to be before the ground freezes to some depth.

6.1.4 Maintenance and design for reliability

There is a very limited period for construction. As previously stated it is assumed that the slopes below elevation El. 42 m amsl will be flooded by July 2019. In designing it is necessary to consider the possibility that a change may occur and accommodate the risk as necessary. In this case should the slopes remain exposed and submerged the stability of the slopes would change. A submerged slope is relatively protected from the elements and experiences less erosion; it is also supported by the mass of water improving its factor of safety against failure. Should the reservoir not rise to submerge these slopes the remedial measures must be in place before Spring 2019. It would be difficult (perhaps impossible) and more costly to apply design modifications later when the works for the design assumption of flooding 2019 have been completed.

The slope designs accommodate the possibility that they may be unsupported by the reservoir for a period of time beyond April 2019. This assumes up to 1 year before the reservoir impoundment for the Muskrat Falls project reaches FSL. 3H:1V slope profiles are designed to accommodate unsupported slopes (not submerged) and to lower the maintenance to acceptable levels with limited intervention after initial grading. In addition, slope protection and sedimentation control measures are planned to address issues that may arise if the slope is exposed beyond the winter construction of 2018/19. As part of the planning and risk management that is required for due diligence a maintenance period for slopes and drainage was allowed for in the design; a period of up to one year beyond July 2019. This is not a planned delay but used as a contingency for planning of equipment and estimation of costs. Section 6.5 provides additional on details on the stability of the reprofiling of slopes.

6.1.5 Downtime due to weather and other unforeseen circumstances

We have assumed up to 15% of project time will be delays for weather, breakdowns and other stoppages to production.

6.2 Regulatory permissions

All planning and regulatory approvals will be received by start of contract mobilisation in August 2018. This presents number of risks to schedule if not achieved. The area to be cleared is large and the environmental impact unknown. Should an environmental assessment for this task be required the schedule may be unachievable, the engagement and assessment process as well as lead time would have to run parallel to the tendering process. In addition numerous permits, and approvals and studies may be required.

6.3 Organic matter removal -Trees, brush and organic soils

It is assumed that all organics (trees & bushes, Horizon O [humus organic matter] and A [topsoil]) are to be removed up to El. 42 m amsl for this analysis.

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Existing mapped input parameters were used for conceptual modelling, planning, and cost calculations. LiDAR data was reprocessed to correct for errors found in original client supplied DEM and derived terrain products. The decision to reprocess was made based on observed visual anomalies including terracing in client supplied DEM and slope model. The reprocessing cleaned the derived data of these anomalies conjectured to be artifacts introduced by earlier geo-processing steps. For the soil and vegetation removal quantities, El. 39.0 m amsl elevation was considered with a multiplier of 8% (with contingency of ±1%) if the clearing extends to another 15 m of horizontal buffer zone from the El. 39 m amsl.

For frozen ground, over excavation of the organic soil layer was assumed (generally 1.5 m) although the thickness identified in the field was relatively low. Frozen ground would be challenging to excavate without larger masses rising in the operation, over excavation would occur. It would not be possible to separate frozen organic soils from frozen inorganic soils.

For non-frozen excavations, it is possible to reduce the depth of excavation but it is still highly likely that some over excavation would occur. First the depth of excavation would proceed until all organic soils are removed. Secondly, earthmoving equipment performing large earthworks would be unlikely to achieve accuracies higher than 100 mm over dig and probably higher. Finally, the nature of soils and the interaction with trees (root balls) make the depths excavated much larger than the shallow estimated provided in the ELC assessment. We have assumed a minimum excavation of 0.5 m will occur across the site in unfrozen conditions.

For the wetland ELC, the estimated reported depth (AMEC 2008) is 0.08 m. These appear low and may not account for channels, muskeg and soft inorganic clays which may need to be excavated to provide access. We have assumed in the frozen and non-frozen case that an average depth of 2.2 m will be removed where this ELC is encountered. The ELC is a proportion of the overall area of the site, this change makes a small difference to the volumes excavated in the frozen condition but does increase the volumes more significantly where examining a programme that consider all excavation occurs in an unfrozen condition.

The ELCs such as Water, Gravel Bar, and Anthropogenic areas are not considered for the removal operation. The study has assumed that the organic disposal permits are achievable for the locations for the disposal for this phase of soil and vegetation removal operation. Disposal locations are sited above the FSL (El. 39 m amsl). Roads, crossings etc. are conceptual and are located as needed to meet transportation distances. Final locations for disposal sites are to be field verified and designs modified according to ground conditions encountered. Transport of waste to disposal sites above the FSL is designed to be generally less than 3 km to reduce costs and transport times.

For the access roads, the British Columbia and the Forestry Commission (UK) Forestry Civil Engineering forest road manuals is considered as a guideline for the temporary access road construction. It is assumed no aggregates will be available – or only what can be found on site. All materials used to build earthworks and roads will come from site except geosynthetics and culverts. Surface drainage measures will be temporary (less than one year September 2018 to Apr 2019).

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6.4 Vegetation removal and landscaping

There will be no tree planting, hydro seeding above El. 42 m amsl and only 0.5 m sandy clay protection is assumed at the finished slope. Below El. 42 m amsl, there will be no planting or seeding. There will be no riprap at the FSL (El. 39 m amsl) line, natural process is considered to eventually establish the future shore line.

The soil and vegetation removal contract is planned to start in August/September 2018 and completed by April 2019.

For vegetation removal 12 hour day time shift (approx. 10 hrs worked by equipment) and productivity of 0.2 ha/shift is considered.

For organic soil removal work (excavation, road construction, waste disposal and general re-profiling) is assumed to be conducted 24/7 in 12 hr shifts (10 hrs operational).

6.5 Slope Stabilisation

We have used the North Spur design as a basis for the stabilisation measures that may be required for sensitive clay soil slopes along the site. For the re-profiling, areas where slope are approximately 30% or higher below 42 masl and soil is classified as sensitive clay within the future reservoir area, were identified for re-profiling. In order to identify sensitive clay throughout the future reservoir area available GIS data for 3 Soil types - glaciofluvial, glaciomarine, and till was considered. These identified locations shall be field verified by a geotechnical engineer for an assessment of sensitive clay once the areas are exposed. These deposits may contain higher coarse grain materials than the anticipated fine grain materials. More specifically, till in the area may contain sand instead of clay. High erosion prone areas and sensitive terrain areas were not excluded at this time in order to identify the areas for re-profiling. The 3H:1V or higher slope re-profiling for sensitive clays was determined using ELC2008 data (for 3 Soil types - glaciofluvial, glaciomarine, and till) and slope model derived from corrected DEM. Areas/polygons identified below El. 42 m amsl for entire future reservoir area. The slope angle selected is based on the assumption that for a period of up to one year beyond construction the slopes will be above reservoir water level.

High erosion prone areas and sensitive terrain areas were not excluded from clearance. Volume estimates for the re-profiling is based on 4 typical cross-sections (2 south bank and 2 north bank of reservoir) conducted in AutoCAD Civil 3D. The quantities cut and fill were estimated from the assumptions.

Finished regraded surfaced will be covered with a 0.5 m inorganic clay/sand mix to provide limited erosion protection and to allow vegetation to regrow on upper slopes (above El. 42 m amsl).

As indicated in section 6.1.4, the slopes are designed for low maintenance in the event that the slopes remain unsupported for a period of up to one year beyond the planned impoundment of the reservoir in July 2019. This is a due diligence consideration for the design of safe slopes.

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Due to schedule constraints, it has been assumed that a geotechnical drilling and sampling programme will not occur prior to the commencement of works. This leads to a conservative design solutions and increased costs. Designing, implementing and reporting a ground investigation before contract award for the clearance and excavation of organic soils would be beneficial. In the absence of reliable geotechnical investigation information, contractors will price in perceived risk associated with ground conditions. The ground investigation would improve safety and reliability during construction. Contractor pricing of perceived risk would be moderated.

During the ground investigation instrumentation could be installed to aid in the monitoring of the slopes which would enhance knowledge of the slope properties and behaviour and improve safety of works conducted on the slopes.

The ground investigation does not need to be completed for the completion of the design of the clearance and stabilisation activities; an observational approach can be adopted.

6.6 Site drainage

Sedimentation ponds to be built on average, every 1.5 km along the shore line with a range of 1 km to 2 km. Sedimentation ponds are temporary and intended as mitigation for sedimentation from surface erosion which will occur before reservoir fill. Surface drainage measures (such as ditches and culverts) will be constructed on the slopes to limit sheet flow on surface and will be temporary with maintenance limited to the period to reservoir fill.

Water crossings will be temporary structures wherever possible and will be removed when an area is cleared. An allowance has been made for the use of culverts for identified crossings but “bailey” bridges may be more appropriate for some locations.

6.7 Cost Estimates

The cost estimates provided in this report are expected to vary by at least ±50%; this is optimistic given the unique nature of the project and the likely premium that contractors capable of supporting the work will apply to their bids. The variation in cost is more likely to be in the order of minus 25% to plus 75%. Costs and volumes have therefore erred on the higher side; a range has been provided. Detailed design and engagement with contractors will allow a more accurate cost to be developed.

Rates used as initial basis for cost estimate are from the original reservoir clearing contract. Spon’s Civil Engineering and Highway Works Price Book is used to estimate rates for basic earthworks not covered by rates available to the contractor. It is anticipated that approximately 20% of the area for clearing will need barge access. The thickness of the excavated soil layer was assumed generally 1.5 m for cost estimates in frozen ground and 0.5 m in unfrozen ground, except in wetlands where an average of 2.2m has been assumed. Road maintenance will be required for the duration of the work (graders and haul trucks). A typical road cross-section was assumed to determine cost per lineal meter for road upgrade, new road build, new road build – cut and fill.

Temporary camps will be required for site personnel. An amount of $90 for accommodation and food per day per person is used to estimate living costs. Preliminary estimates of personnel on site have assumed approx. 3.5 people per unit of plant (piece of equipment).

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An allowance 5 to 8% of capital cost/expenditure (CAPEX) for engineering support and supervision has been applied. Generally large projects see a drop in costs of engineering and supervision with overall CAPEX increase. This may not occur for this project. The duration and the need for a high level of contractor and engineering supervision are likely to result in higher than average engineering costs for these items.

Mobilisation of plant and equipment is estimated at 10% to 15% of CAPEX has been allowed for in the estimate. This is checked against a cost per unit but estimates may vary significantly as this is an almost unique mobilisation of equipment with a vast number of plant and equipment mobilised for a short period of time. Items such as lighting, generators, welfare facilities, emergency vehicles, etc. have not been itemised and are within this overall item.

The cost for tree and brush clearance is an all-inclusive rate by hectare and includes mobilisation of plant equipment and personnel.

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7 Options considered

The following describes a number of options considered in the feasibility assessment of organic soil and vegetation removal.

7.1 Removal of only organic materials - trees, brush and organic soils

This report provided two options for removal of organic materials (trees, brush and organic soils):

- Only removal of organics (trees, brush and organic soils);
- Removal of organics and an over excavation of frozen ground.

It is likely that to ensure complete removal of the required material some over dig will be required as testing in situ will be difficult and would delay operations. Conservative judgement by those inspecting will be required. In addition, civil engineering earthworks do not generally operate at high accuracy and ±100mm for large earthworks civil engineering is considered high accuracy. Under excavation is not acceptable and the depths specified become minima. Minimum excavation in non-frozen ground is assumed to be a minimum of 0.5 m in all ELC's except wetland where the depth is assumed to be 2.2 m (frozen or thawed).

Much of the work will occur in winter which alters the ability to remove thin layers of material. Working in frozen conditions changes the behaviour of the soils, when excavating blocks will be lifted and removed. The frozen ground can be considered on average 1.5 m deep and in estimating it should be assumed that once raised this material is removed for disposal. This provides an upper value for estimation of excavation with some fluctuation of deeper soft organic clays and muskeg that may be encountered (these could be deeper but localised and a small portion of the total volume excavated).

The study provides both estimates of volumes excavated for the purpose of assessing: plant requirements, schedule and disposal areas required.

The estimate for excavation in non-frozen conditions is for comparison only. The previously described constraints preclude working in only non-frozen conditions and achieving the schedule completion date: schedule, mobilisation, vegetation clearance and climate (below -4°C from reported average temperature from November to March, Environmental Canada).

7.2 Barge operation and access

Significant areas of the waterfront may be best accessed from the water rather than the land. Although many of these areas are steep, and with little to no vegetation, the crests often fall within the El. 42 m amsl clearance zone and, applying the rule of 100% organic removal, they should also be cleared. Barges may be of various configurations. We have assumed landing barges for equipment, towed barges with tugs for waste and excavators mounted on pontoon barges (or equivalent) may be employed for the various activities.

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Two possibilities exist for barge operations:

- Access and removal of materials
- Working from pontoons/pontoon barges.

The roads constructed as part of earlier operations provide the opportunity to reduce the length of roads that must be produced. However, remote areas have limited or no existing road access. Water access may be used to access and remove organic material by water to a disposal location prepared elsewhere, reducing the need for new roads. This is more beneficial upstream where the access by road is limited. However, the draft of the barge is a limitation for work upstream. The water levels are reduced limited upstream and this may limit access; particularly for barges loaded reducing the effectiveness removing material. The opportunity to make a landing at one or both ends of a slope to be reprofiled and organics removed allows more operating fronts to be opened reducing congestion. In this procedure a shallow slope would be used to access and forge a road up the slope before working laterally along the slope re-profiling it in terraces (top down) to a 3H:1V slope. Non organic material could be placed at the toe of the slope in this process which would be more costs effective than removal to a disposal site. In our estimating we have assumed all excavated material will be removed from within the footprint of the FSL.

The second approach uses barges to access more remote areas from the shoreline with an excavator mounted onboard. This can be done safely and is often used in areas at ice break up or for dredging in rivers or other water bodies.

In our study we have compared the various options and generally adopted the more conservative in costs or schedule to provide a reliable assessment of the feasibility of removing organic material from the footprint.

A challenge to the use of the barges is the work will start late in the open water season. The narrow window of opportunity is also a period when severe storms can develop quickly. Therefore, we have limited the use of barge operations to that which may be feasible in a very short operating window assuming a rapid mobilisation of plant, equipment and personnel. It may be more realistic to assume that this cannot be achieved. However some areas may only be approachable from the shore.

7.3 Working on ice

Once winter has set in and the open water has frozen, it is possible that access to remote areas can be achieved over ice. Shore ice is very uneven but this can be addressed by placing sand on the surface to provide access for all equipment or by producing a road and access formed from ice. This method has benefits in cost and perhaps safety once the ice is frozen to greater than 1 m. The extent to which the method can be used is limited by the weather; it is the inverse of barge access. The method is likely to reduce costs and will be subject to starting when safe operations permit. This is assumed to be December to the end of March.

This method has not been assumed in our cost estimate due to concerns related to reliability (weather) and possible safety concerns. Any plan which utilises work on ice will require rigorous justification, planning and design to be achieved safely.

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7.4 Road building

In general road building for the project considers:

- Upgrade of existing reservoir clearing roads
- Upgrade of existing haul roads
- Construction of new haul roads

In the detailed design of the roads a number of roads will be identified as main haul roads, spines for the excavation project. These will be built to a higher standard than other roads to maintain flow of traffic. However, the intent is to work an area of excavation and move waste to a safe location outside of the FSL for disposal in a borrow pit. The borrow locations are located to provide construction materials for roads and other access requirements; they will be as close to the FSL as can be achieved, providing slope stability is not affected.

Low quality access roads are assumed throughout. The roads are temporary and are designed to allow haulage using construction equipment such as articulated tri-axle dump trucks with some maintenance. Road haulage traffic was not considered for haulage within the site, road haulage exerts higher bearing pressure on the ground than road civil engineering equipment. The roads are not intended to outlast the construction. However, this does negatively impact the production rate of transportation and energy consumption.

Road access (public unpaved roads) standards are not applied in the design to reduce the monetary cost of roads. We have assumed that if road traffic haulage is to be used they will be low ground pressure (variable pressure tires) or will accept the increased risk of damage and delay. Construction site traffic will be able to use the roads.

All roads are designed to be 10 m wide (nominal) with passing places. Existing roads are widened when less than 10 m (typical forestry roads are 5 m nominal). Widened areas will be cleared of organics and to mineral soil and roads will be constructed from in situ sands to allow traffic by tri-axle articulated dumpers (or similar).

New roads on sands will be constructed by removing organics and side casting material. Weak spots (such as soft clays) will be treated differently depending on air temperature. When air temperature has dropped below -20°C the frost will be beaten down into the ground to freeze the road in. Generally this is sufficient but a layer of sand will also be applied to the surface to provide higher traction. If the freezing the subgrade is not possible the weak materials (clay or muskeg) will be excavated if less than 2m deep. For greater depths a geogrid will be laid down a road constructed over the soft zone. It should be noted that no deep soft deposits have been noted in the studies provided to date.

On sands or frozen ground, roads can be widened to the required width with little to no increase in cost if sand is used as the trafficable material. Weak clays will be frozen in or excavated. 10m wide roads have been allowed for in this study, 26t articulated dump trucks are 3 m wide and 40t are 3.5 m widening the roads to 12 m and 15 m wide would allow two way traffic in area of high traffic. Increasing the cost of roads by 20% to 50% would allow for two way traffic in most areas – a cost benefit analysis and detailed design would determine the areas where two-way traffic is advantageous.

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Corduroy roads using timber (logs and upending felled roots/trucks) as a base layer for the construction of roads across weak layers has been considered. However, it was excluded in our cost estimate as it is likely to leave organics within the footprint. Any attempt to remove the roads and the underlying material is unlikely to be 100% successful.

7.5 Stone in road construction

Permanent unpaved roads have a lower impact (damage) on construction traffic fuel consumption and damage to vehicles. Rates of transportation are also higher. However, to produce a relatively low cost road with 600 mm of stone and a geogrid would increase costs by $100 million - $280 million. This is perhaps a low estimate as the distances involved in transporting such material would be large. Identifying a quarry with suitable material in such quantities that could supply such a large volume in a short period of time will be difficult. It is likely that multiple quarries will be required and considerable capital investment by suppliers. There may also be issues with limits on current licences and planning approvals which may limit access to resources.

In addition to the sourcing of the stone, any stone transported to the site will likely have a significant impact on public roads. It is probable that the estimated number of axle loads travelling along the public roads will cause measurable deterioration of the road conditions which may result in additional payment to the local government for maintenance and repair.

7.6 Large haul trucks (100t capacity and greater)

We have considered in our estimate the use of 26 t articulated dump trucks “wiggle wagons” (E.g. Cat 720 series) to 40 t dump trucks (e.g. CAT 740). These are large for most construction projects but larger equipment can take up to 400 t per load (such as 797D’s). The near 20 fold increase is a significant increase in efficiency if employed appropriately. These haul trucks are generally used in mining operations with larger excavators/shovels and have high production rates. A fleet of 60 haul trucks at a mine operation can move up to 1 million tonnes per day (24/7 operation). However, the excavators are large and the operation tends to be useful where large volumes are excavated are large (deep and broad).Precision is not a high priority, over dig is normal in such operations. Mobilising such equipment can be a long lead item. Smaller haul trucks such as CAT777 (or equivalent) can carry 100 t per load. This would substantially reduce personnel requirement and increase capacity. However, although more available than the largest of haul trucks they should still be considered long lead items.

An additional challenge of the larger hauls trucks is that they tend to require slightly higher capacity in subgrades. One reason for this is the suspension system and number of axles when compared with 26 t dump trucks. The smaller trucks have lower impact on uneven ground (reducing rutting and punching failure) and require a lower bearing capacity. On frozen ground the dumpers will have a wider range of accessibility than the large vehicles and can be more flexible,

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A combined fleet of 777 (and larger) haul trucks with 40 t dump trucks will probably provide the most effective fleet. For this exercise we have used the smaller vehicles, they are more likely available within the schedule and the higher number of stuff allows planning for possible accommodation. Using large vehicle will increase lead time for procurement (and mobilisation) and benefits in cost savings would be partially offset by wider roads (cost), schedule delays (increasing mobilisation time and cost) and other items. Using a variable mobilisation percentage and cost per metre cube for excavation allows for this variation.

7.7 Use of scrapers

Scrapers were considered but, after review, excluded from the options considered in the study. They are likely to struggle in frozen ground or where larger organic material is likely to block the feed. Downtime is assumed to be too high in such ground conditions and the benefits (increased productivity and controlled/limited depth of excavation) will not be realised.

7.8 Slope angle in areas of remediation

It is possible to use a steeper slope angle when re-profiling sensitive clays in some areas of the site where ground conditions allow. This would be determined by inspection and additional ground investigation and testing. Given the time scales available we have assumed that steeper slopes (2.5H:1V) would not be used to avoid the risk associated with local failures which may trigger larger failures. For the same reason compound slopes with steeper slope angles in sands have been avoided. In the estimation process a slope of 30% has been used, slightly less than the 33% of a 3H:1V slope. The over excavation represents the need to reprofile for drainage and where groundwater seepage is encountered.

7.9 Schedule

Generally rural construction for forestry activities are executed slowly in a phased advance:

- Year 1: Clear trees along proposed route
- Year 2: Construct subgrade for road
- Year 3: Construct surfacing of road and start clearing of forestry and brush
- Year 4: Complete clearance of forestry and brush. Commence earthworks on slopes.
- Years 5 to X: multiple years of construction

A multi-year construction allows saving and refinement using only those periods of the year most suitable for construction. Plant, equipment and personnel rates are lower (contractors bid lower for long term sustained work and income). The engineering design is adapted to the conditions encountered and a more cost effective observational approach to the construction can be adopted.

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Comparing this work with the development of a large mine to first ore production, it is worth noting that a 5 to 10 year period of development would be typical.

This method has not been applied in the study as the timescale (schedule) does not allow this approach. In addition to the above, a large scale construction schedule start up would be unlikely to commence in 2018. Design and procurement would likely result in 2019 as a more realistic start date.

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8 Constructability

The following discusses some general methods used in the construction operation. Specifics will be required based on a detailed design. Considerable opportunity and risk exists for change at this early stage in the design.

8.1 Safety Considerations

Nalcor's safety standards shall be followed for any construction activities at the Muskrat Falls project. A detailed safety plan will be developed prior to construction. The site activities include areas up to 50 km from the current welfare facilities and construction. At the furthest distance from the current emergency services this could be up 1½ hrs travel via the construction access roads. Additional measures are likely to be required to address health and safety and, in particular, incidents. Measures required may include:

- Provision of a full time off road paramedic vehicles north and south of the river;
- Paramedics with appropriately equipped vehicles stationed near work fronts;
- Access to an emergency helicopter to transport to Accident and Emergency facilities.

Specific accident and emergency response plans must be developed with the contractor and will a key element in the assessment of any contract award.

8.2 Construction Method

This phase of soil and vegetation removal is expected to start in August/September 2018 and completed by April 2019.

Prior to the removal operation, geohazard areas where recent landslides have happened should be assessed prior to disturbing any natural ground and its covering. Environmental and regulatory permitting will also be completed prior to the operation.

Typical cross-section of roads, sedimentation pond for erosion mitigation and slope re-grading or re-profiling within the future reservoir area, are presented in Appendix IV.

The forest roads manual can be considered as guidance for access road construction. Existing roads used in previous phases will be integrated into this soil and vegetation removal programme where possible.

Roads shall be constructed to minimum 10 m wide with turning areas and passing areas if required. An allowance has been made for widening of 50% of the road length to 15 m.

Roads to be less than 8% slope wherever possible minimum road is 2% if possible absolute maximum 12% slope.

- Road crossings of watercourses and ravines are temporary.

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- Culverts (CSP or HDPE) only to be installed where road will be used in autumn or spring.
- Roads to be cut to mineral (sand) or clay if required. Freeze-in clay areas and side cast waste.
- Only cut drainage trenches along roads where inflow occurs.
- Use mineral soils from waste dump excavations and borrows near roads to build roads and earthworks.
- Only use geogrids to provide road support if required. Narrow crossings are to be bridged with earthworks/ice.
- Use largest equipment feasible to reduce rate/m³ moved.
- All equipment will have to be mobilized to site.

Roads will follow slope contours where possible - Follow contours for roads as per forest roads manual.

8.3 Geotechnical Stability

Amec Foster Wheeler ("Bank Stability Study Lower Churchill River Hydroelectric Generation Project", June 2008) identified a number of areas that were considered sensitive in terms of: terrain stability, soil erosion potential and shoreline erosion potential zones. We have considered this in our review of areas likely to require re-profiling. Shore line erosion protection is not applied in this study on the basis that the shore line is considered to form a natural stable slope over time, as advised by Nalcor and contained within the assumptions for the design.

Access road construction has been designed to follow contours where possible and crossing them at angles that maintain roads at less than 8% wherever possible (max 12%). The North Spur remediation is the basis for stabilizing slopes. In general, the construction operation shall avoid erosion, traffic, and minimize re-profiling/grading as much as possible. Any geotechnical instability indicators (unsuitable or soft ground conditions, cracking, slope deformation) encountered during the operation should be reported to the project geotechnical engineer for reassessment.

8.4 Water Management

Drains will be constructed once roads are built and clearance is completed. No permanent pipes will be left in place. As mentioned in the assumptions, sedimentation ponds are to be built every 1-2 km on both banks of the river. Sedimentation ponds are temporary to deal with freshet and reservoir fill. Temporary surface drainage measures will be constructed on the slopes to limit erosion. Permit and licenses for the design (including discharge to the river) are assumed to be received before the start of construction.

8.5 Environmental Considerations

The study assumes that the environmental approvals for the current development would cover all aspects of this work, on and off site. This has not been investigated and concerns may be raised related to the organics (trees, brush and organic soils) removal operation.

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In particular, water management will be a challenge, as it has been on the smaller scale Muskrat Falls main site. Sedimentation issues may occur even with comprehensive water management infrastructure. Water quality is potentially compromised due to the number of stream crossing installations and removals. Greenhouse gas releases from the large fleet of equipment will be a significant effect. The effects to wildlife during clearing need to be considered, including species at risk in the project area (e.g. Red Wine Mountains Caribou herd and avifauna species).

Operating over 1000 pieces of equipment across the site is itself an environmental consideration. Minor spills and leaks are a part of general construction operations due to equipment malfunction (e.g. hose failures). The risk of hydrocarbons entering the water course is highest near (within 100 m) the river and a large proportion of the works lie within this zone. In addition, due to the significant amount of equipment and fuelling operations there is an elevated risk of hydrocarbon releases into the environment.

During the operation rigorous measures will be required to limit the risk of hydrocarbon spills. All storage and refuelling areas will implement spill control procedures to manage any unplanned release.

Finally, the effects on fish and fish habitat during construction and operation of a “cleared” surface within the reservoir drainage catchment are unknown.

8.6 Regulatory Considerations

Permits, licenses and approvals are assumed to be granted in time to allows works to commence before September 2018.

There exists significant uncertainty regarding the regulatory requirements and environmental impacts. The removal or organic materials (soils, vegetation and brush) was not included in the original scope of the project reviewed during the original environmental assessment process. The works are an unique and large undertaking. A revised effects assessment may be required and the revised assessment would be subject to both provincial and federal legislation. The project would likely be subject to the provincial Environmental Assessment Regulations, under the Environmental Protection Act.

Environmental protection is integral with this scope and must be considered during an environmental assessment with the potential benefits of a soil removal mitigation program. Should an assessment be required, this process would require environmental registration and engagement of stakeholders, with the potential for an Environmental Preview Report or Environmental Impact Statement.

The creation of the Muskrat Falls reservoir is currently governed by an authorisation under the Fisheries Act, which includes physical compensation and monitoring requirements. The current authorisation may be considered null by the proposed scope (given the unknown impact to fish and fish habitat). A reassessment (if required) under the Fisheries Act would require a new review to confirm the applicability of the Canadian Environmental Assessment Act. All these processes have historically protracted timelines. For the purpose of this report it was assumed that these reviews would be completed in sufficient time to allow project schedule described herein.

It should be noted that the regulatory approvals may present a significant risk to the project.

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8.7 Geohazard Considerations

The construction of the slopes has assumed a similar design approach to geohazards as the North Spur. Previous reports have highlighted risks and a relatively conservative approach has been adopted along the shore line. If sensitive clay slopes are encountered we have assumed they will have to be remediated to a 30% slope (approx. 3H:1V). This approach does not eliminate the risks associated with working adjacent to, or on, geohazards such as potential landslide areas. Some risk will always remain and operational procedures and monitoring will be required to limit the risk during construction and after.

8.8 Site Stabilization and Erosion Control

As described in our assumptions and other preceding sections on construction, the slopes are to be constructed in one winter season. It is assumed that the water levels for the reservoir will rise to FSL by July 2019. This is required to plan construction. If this does occur then a significant proportion of the exposed slopes will be flooded quickly providing protection and support. If this schedule could be guaranteed, slope angles could perhaps be reduced and erosion protection reduced.

However, to design the slopes it was necessary to assume that the slopes may be unsupported by water (or other stabilisation) for a period up to one year from July 2019. This requires slope stability design to assume that slopes will not be submerged and that the surface of the slopes must be designed for a limited slope protection and some sediment control (for recently cut slopes). See Sections 6.1.4 and 6.4 for additional details on the slope stability.

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9 Volumes

The general arrangement drawings for the proposed works are presented in Appendix II including: access roads, areas for barge operation, re-profiling slopes. Typical sections are provided in Appendix V. All quantities presented in this section are for initial estimates only. Variation in the quantity depends on various factors such as construction method, operation convenience, resources, field conditions, etc. There should be no standard or usual variation percentage. Contractor shall delivery specified quantity of items in a fixed-price contract, within allowable variations, if any.

9.1 Land Classification and Areas to be Cleared

For organic soil and vegetation removal from the future reservoir area, a total of nine ELC have been considered only within the FSL boundary of the Muskrat Falls reservoir area. Although some of the clearing is being done beyond the FSL elevation, in the initial phase of clearing for the next phase of clearing only areas below the FSL elevation (El. 39 m amsl) were considered. The ELCs and their estimated areas have been presented in **Table 9.1**.

Table 9.1 Summary of Ecological Land Classifications (ELCs) and estimated areas.

Ecological Land Classification	Total Area (ha)	Area Cleared[2] (ha)	Area to be Cleared (ha)
Black Spruce/Feathermoss Forest	860.0	502.6	357.4
Black Spruce/Lichen Woodland	90.6	42.9	47.7
Black Spruce/Sphagnum Woodland	20.1	14.8	5.3
Fir-White Spruce Forest	814.6	407.0	407.6
Hardwood Forest	220.9	165.9	55.0
Mixedwood Forest	696.6	436.9	259.7
Riparian	656.7	71.0	585.7
Spruce Fir/Feathermoss Forest	116.2	50.3	65.9
Wetland	219.0	65.2	153.8
Total[1]	**3,694.7**	**1756.6**	**1938.1**

1. ELCs, such as gravel bar and non-vegetated areas have been excluded for soil and vegetation removal estimation.

2. Cleared areas is assumed to be areas of trees and bushes that have been cleared during the initial phase, no organics Horizon O or A was removed. Areas of vegetation cleared above FSL elevation of 39.0 m during the initial phase of clearing weren't considered for these area estimates.

3. All quantities are derived from client provided GIS data.

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9.2 Access Roads and Crossings

New roads and secondary haul roads are laid out using available GIS data for the next phase of soil and vegetation removal from the future reservoir area. The existing and possible new roads and potential road crossing are summarized and presented in **Table 9.2**. An estimated approximately 846 ha area may require barge access out of a total of 3,695 ha area that requires soil and vegetation removal from the future reservoir area.

Table 9.2 Summary of existing and possible new roads and watercourse crossings.

Roads	Length (km)	Road Crossings[3]
Possible New Road (Land Access)[2]	220	143
Possible New Road (Barge Access)[2]	50	19
Sub Total (Possible New Road)	**270**	**162**
As-Built Access (Existing) Road[1]	191	97
Total	**461**	**259**

1. As-Built access is the GIS data that was available for use.

2. Possible new access roads were created generally using the elevation contour lines, roughly parallel to the main roads at 100 or 200 m intervals until 100 m from the natural water line.

3. Watercourse crossings were determined from intersection of provided as-built access roads, conceptual possible new roads and derived centerline from provided LakesStreams_Buf15m data set.

9.3 Soil and Vegetation Removal Quantities

An estimated 1760 ha was cleared (of only trees and bushes) during the initial phase of clearing from the future reservoir area. During this phase of soil and vegetation removal all surficial trees and bushes, organics (Horizon O – humus organic matter), and organic soil (Horizon A – topsoil) have to be removed. At this phase of soil and vegetation removal, within the 9 ELCs of the future reservoir area an estimated total of 3,700 ha was identified for tree, organics, and organic soil removal. The soil and vegetation removal quantities estimated for this phase is presented in **Table 9.3**.

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Table 9.3 Summary of estimated soil and vegetation removal quantities.

Ecological Land Classification	Area (ha)	Horizon O[1]		Horizon A[1]		Estimated Excavation (min. 0.5 m depth)		Estimated Excavation (Winter construction)	
		Thickness (m)	Volume (m^3)	Thickness (m)	Volume (m^3)	Thickness[2] (m)	Volume (m^3)	Thickness[3] (m)	Volume (m^3)
Black Spruce/Feathermoss Forest	860.0	0.08	687,927	0.09	773,918	0.5	4,299,542	1.5	12,898,626
Black Spruce/Lichen Woodland	90.6	0.08	72,507	0.05	45,317	0.5	453,169	1.5	1,359,506
Black Spruce/Sphagnum Woodland	20.1	0.10	20,139	0.08	16,111	0.5	100,695	1.5	302,085
Fir-White Spruce Forest	814.6	0.11	896,070	0.06	488,766	0.5	4,073,046	1.5	12,219,138
Hardwood Forest	220.9	0.03	66,270	0.15	331,352	0.5	1,104,507	1.5	3,313,523
Mixedwood Forest	696.6	0.10	696,567	0.06	417,940	0.5	3,482,837	1.5	10,448,510
Riparian	656.7	0	0	0	0	0.5	3,283,710	1.0	6,567,421
Spruce Fir/Feathermoss Forest	116.2	0.18	209,177	0.13	151,072	0.5	581,048	1.5	1,743,143
Wetland	219.0	0.08	175,192	0.11	240,888	2.2	4,817,769	2.2	4,817,769
Subtotal		**2,823,849**		**2,465,365**		**-**		**-**	
Total	**3,694**	**5,289,214**				**22,196,323**		**53,669,719**	

1. *Muskrat Falls Soil Sampling Program 2018, Amec Foster Wheeler*
2. *Min. 0.5 m thickness estimation and comparison with likely winter excavation quantities*
3. *The thickness considered for winter construction estimation only*

A total of 74 disposal locations have been identified along the clearing operation locations.

9.4 Re-profiling and Estimated Quantities

Areas where slope are 30% or higher and sensitive clay identified within the future reservoir area, were identified for re-profiling. The re-profiling was determined using GIS data below 42 masl for entire future reservoir area. Approximately 200 ha were identified for re-profiling within the future reservoir area. High erosion prone areas and sensitive terrain areas were not excluded for this estimation.

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After identifying the possible re-profiling areas, volume was estimated based on randomly selected 4 cross-sections sample areas (2 south bank and 2 north bank of reservoir) conducted in AutoCAD Civil 3D. An approximately 13.5 million m^3 of sensitive clay may require cut and fill for re-profiling the future reservoir area.

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10 Cost estimate

All costs presented in this section are for initial estimates only. These are our best estimates based on the volumes and quantities calculated from the previous sections and the many assumptions noted. The rates used in the estimates were derived from Nalcor supplied previous Civil and Earth Works contracts, previous timber contracts and experience with similar work. These rates are provided in Appendix IV.

Cost estimates were prepared for two scenarios. The two scenarios are:

- Complete removal of all organic material removed (trees, brush, muskeg, organic clays) during frozen conditions resulting in over excavation of frozen material; and
- Complete removal of all organic removed (trees, brush, muskeg, organic clays, etc.) material with no over excavation.

Each estimate has a low and a high range to account for variability and uncertainty in quantities and rates. The estimated costs vary significantly between the scenarios considered. The higher bound costs vary from approximately $1,233,000,000 for complete removal to $2,329,000,000 for complete removal in frozen conditions. The main factor influencing the costs between these two scenarios is the volume of organics (O and A horizon) to be removed. If the removal can be completed in thawed conditions the costs are about one third the costs for removal during frozen conditions. This cannot be achieved in the schedule available (it would not meet first power) and would require perhaps several years due to other constraints, including (but not limited to): nesting birds, historic resources assessment, working in and around watercourses, freshet, and precipitation.

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Table 10.1 Complete removal of all organic materials in frozen conditions (over excavation of frozen material).

Construction Costs							
Item	Description	Unit	Quantity	Low Estimate Unit Cost	High Estimate Unit Cost	Low	High
1	**Mobilization**						
1a	Contractor Mobilization/demobilization	% of Capex	1	$ 121,392,481	$ 182,088,721	$ 121,392,481	$ 182,088,721
1b	Contractor Compound	Lump	1	$ 3,000,000	$ 4,500,000	$ 3,000,000	$ 4,500,000
1c	Work Camp	Lump	1	$ 157,500,000	$ 280,000,000	$ 157,500,000	$ 280,000,000
1d	Summer Season Road Maintenace	$/day	120	$ 3,000	$ 6,500	$ 360,000	$ 780,000
1e	Engineering design and construction support	% of Capex	1	$ 69,800,676	$ 111,681,082	$ 69,800,676	$ 111,681,082
						$ 352,053,157	**$ 579,049,803**
2	**Site Clearing**						
2a	Timber (all inclusive rate)	$/ha	1,938	$ 40,000	$ 65,000	$ 77,520,000	$ 125,970,000
2b	Overburden Excavation (includes O and A)	$/m3	17,757,058	$ 7.00	$ 15.00	$ 124,299,406	$ 266,355,870
						$ 201,819,406	**$ 392,325,870**
3	**Site Clearing (Barge) - Quantities 20% of total site clearing**						
3a	Overburden Excavation (includes O and A)	$/m3	4,439,265	$ 14.00	$ 30.00	$ 62,149,703	$ 133,177,935
						$ 62,149,703	**$ 133,177,935**
4	**Road Construction**						
4a	New Roads	$/lineal m	270,000	$ 150.00	$ 200.00	$ 40,500,000	$ 54,000,000
4b	Upgrade existing roads	$/lineal m	191,000	$ 51.00	$ 60.00	$ 9,741,000	$ 11,460,000
4c	Water crossing (900mm CSP)	Lump	143	$ 6,000	$ 12,000	$ 858,000	$ 1,716,000
4d	Road Maintenance (fall -winter- apr)	$/day	300	$ 13,000	$ 20,000	$ 3,900,000	$ 6,000,000
4e	Contingency for dualling of upto 50% of haul roads	$/lineal m	230,500	$ 101.00	$ 130.00	$ 23,280,500	$ 29,965,000
						$ 78,279,500	**$ 103,141,000**
5	**General Excavation**						
5a	Sedimentation Ponds	$/m3	800,000	$ 7.00	$ 15.00	$ 5,600,000	$ 12,000,000
5b	Clay Slope Cutback to 3:1	$/m3	13,500,000	$ 7.00	$ 15.00	$ 94,500,000	$ 202,500,000
5c	Clay Slope Protection	$/m2	1,350,000	$ 5.00	$ 10.00	$ 6,750,000	$ 13,500,000
5d	Disposal Site Clearing, Excavation and Cover	$/m3	3,000,000	$ 12.00	$ 24.00	$ 36,000,000	$ 72,000,000
						$ 142,850,000	**$ 300,000,000**
	Construction Total					**$ 796,651,766**	**$ 1,453,694,608**

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Table 10.2 Complete removal of all organic materials (no over excavation)

Construction Costs							
Item	Description	Unit	Quantity	Low Estimate Unit Cost	High Estimate Unit Cost	Low	High
1	**Mobilization**						
1a	Contractor Mobilization/demobilization	% of Capex	1	$ 191,848,094	$ 287,772,141	$ 191,848,094	$ 287,772,141
1b	Contractor Compound	Lump	1	$ 3,000,000	$ 4,500,000	$ 3,000,000	$ 4,500,000
1c	Work Camp	Lump	1	$ 157,500,000	$ 280,000,000	$ 157,500,000	$ 280,000,000
1d	Summer Season Road Maintenace	$/day	120	$ 3,000	$ 6,500	$ 360,000	$ 780,000
1e	Engineering design and construction support	% of Capex	1	$ 110,312,654	$ 176,500,247	$ 110,312,654	$ 176,500,247
						$ 463,020,748	**$ 749,552,388**
2	**Site Clearing**						
2a	Timber (all inclusive rate)	$/ha	1,938	$ 40,000	$ 65,000	$ 77,520,000	$ 125,970,000
2b	Overburden Excavation (includes O and A)	$/m3	42,935,775	$ 7.00	$ 15.00	$ 300,550,426	$ 644,036,628
						$ 378,070,426	**$ 770,006,628**
3	**Site Clearing (Barge) - Quantities 20% of total site clearing**						
3a	Overburden Excavation (includes O and A)	$/m3	10,733,944	$ 14.00	$ 30.00	$ 150,275,213	$ 322,018,314
						$ 150,275,213	**$ 322,018,314**
4	**Road Construction**						
4a	New Roads	$/lineal m	270,000	$ 150.00	$ 200.00	$ 40,500,000	$ 54,000,000
4b	Upgrade existing roads	$/lineal m	191,000	$ 51.00	$ 60.00	$ 9,741,000	$ 11,460,000
4c	Water crossing (900mm CSP)	Lump	143	$ 6,000	$ 12,000	$ 858,000	$ 1,716,000
4d	Road Maintenance (fall -winter- apr)	$/day	300	$ 13,000	$ 20,000	$ 3,900,000	$ 6,000,000
4e	Contingency for dualling of upto 50% of haul roads	$/lineal m	-	$ 101.00	$ 130.00	$ -	$ -
						$ 54,999,000	**$ 73,176,000**
5	**General Excavation**						
5a	Sedimentation Ponds	$/m3	800,000	$ 7.00	$ 15.00	$ 5,600,000	$ 12,000,000
5b	Clay Slope Cutback to 3:1	$/m3	13,500,000	$ 7.00	$ 15.00	$ 94,500,000	$ 202,500,000
5c	Clay Slope Protection	$/m2	1,350,000	$ 5.00	$ 10.00	$ 6,750,000	$ 13,500,000
5d	Disposal Site Clearing, Excavation and Cover	$/m3	10,000,000	$ 12.00	$ 24.00	$ 120,000,000	$ 240,000,000
						$ 226,850,000	**$ 468,000,000**
	Construction Total					**$ 1,232,715,388**	**$ 2,328,753,330**

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The following assumptions were used to estimate the costs of the removal of organic materials:

- Used a typical road cross-section to determine cost per lineal meter for road upgrade ($3m^3$ per meter);
- Typical road cross-section to determine cost per lineal meter for new road build;
- All equipment will have to be remobilized to site;
- Temporary camp will be required (~3500 person for most intense program of works and largest excavation);
- Contractor will require a compound closer to work area;
- Road maintenance will be required for the duration of the work (graders and haul trucks);
- Quantities calculated for removal up to El. 39 m amsl, Quantities to El. 42 m amsl add 8% of calculated;
- During excavation in winter, it will not be feasible to limit excavation depth to just A and O horizon (1.5 m depth versus 0.2 m);
- 20% of the area for clearing will need to be accessed with a barge;
- Rates for site clearing to be accessed with a barge were doubled as the production rate would be reduced by 50%.

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11 Equipment and schedule

In order to complete the contractibility analysis the amount of effort (equipment) required for the project duration needs to be assessed. The following assumptions were used to assess the number of equipment required:

- Timber crew will clear 0.2 ha/day;
- Timber clearance to be day time only;
- Barge crew (3 excavators, 2 loaders, 1 barge, 1 scow, 1 tug boat) can move 1,500m^3/day – day time work only;
- Excavation crew (1 excavator, 1 dozer, and 4 trucks (26 t articulated tri-axle)) can move 1,320 m^3/day (24/7 operation);
- Road Construction crew (2 dozers, 1 excavator, 2 trucks and 1 grader) can construct 500 m of road per day;
- General excavation crew (1 excavator, 4 trucks and 1 dozer) can mover 1,320 m^3/day;
- Motorized scraper crew (5 scrapers and 1 dozer) can move 3,750 m^3/day;
- Road maintenance crew (6 graders, 2 excavators, 4 trucks);
- Construction schedule from Aug. 2018 to Mar. 2019;
- Construction schedule expanded to Oct. 2019 for site clearing only during thawed conditions;
- Camps to accommodate approx. 3500 people at one time.

For each of the two scenarios, the assumptions made for production rates were used to determine how many crews/equipment would be required to complete the work within the potential schedules. The following tables (**Table 11.1** and **Table 11.2**) summarize the schedules and the estimated equipment required.

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Table 11.1 Preliminary Schedule

	2018								2019										
	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Construction Activity																			
Complete Removal																			
Mobilization																			
Timber Clearing																			
Road Building																			
Site Clearing (Barge)																			
Site Clearing																			
General Excavation																			
Complete Removal (Winter)																			
Mobilization																			
Timber Clearing																			
Road Building																			
Site Clearing (Barge)																			
Site Clearing																			
General Excavation																			

Table 11.2 Construction Equipment Estimates

	Equipment Estimate								
	Excavator	Haul Truck	Dozer	Grader	Loaders	Timber Crew	Tug Boat	Scow	Barge
Complete Removal									
Timber Clearing						12			
Road Building	3	6	6	3					
Site Clearing (Barge)	30				20		5	10	10
Site Clearing	12	48	12						
General Excavation	31	124	31						
Total	**76**	**178**	**49**	**3**	**20**	**12**	**5**	**10**	**10**
Complete Removal in Frozen Conditions									
Timber Clearing						12			
Road Building	3	6	6	3					
Site Clearing (Barge)	30				20		5	10	10
Site Clearing	117	468	117						
General Excavation	31	124	31						
Total	**181**	**598**	**154**	**3**	**20**	**12**	**5**	**10**	**10**

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12 Discussion

The program of works to remove all organics (soils, trees and brush) from the footprint of the FSL is very challenging and the cost extreme at up to $2.3 billion. The project constitutes an extreme civil engineering project (in short duration and cost) and would be perhaps unique in attempting to conduct such a large project of this nature amongst significant geohazards in so short a period of time.

The schedule should be considered very short (6-7 months) and mobilisation will significantly reduce available time. Allowing 2 months for mobilisation is necessary but probably unrealistic.

We have allowed for 1 in 7 shifts being lost due to weather or other delays. The schedule leads to mostly winter work which makes the option of using barges to access and remove material from some areas difficult. To meet the target date the programme will have to allow for redundancy and additional capacity in equipment. The study has attempted to do this by using smaller plant and equipment and not adopting larger equipment which could increase productivity but at the cost of increased lead time for the mobilisation of individual plant, as well increased road widths and depth of construction.

The clearing project should be considered in context, it is on the scale of a large mine development conducted in less than one year rather than the more typical 5 to 10 years to first ore production from breaking ground. The short schedule drives the costs and the generation of extraordinary premiums for the work.

The volumes to be excavated are very large, even for just the organic components (soils, trees and brush) they are large. The volumes of material estimated for excavation vary greatly if it is assumed that winter operation requires greater depths of excavations. This is probable and the rate of production makes it difficult to be limited in the removal and separation of frozen and other material.

The estimate of required equipment (Table 11.2) is very high. It will be a challenge to locate sufficient equipment to complete the work, the numbers represent a substantial proportion of the equipment available in Eastern Canada. Increasing the size of haul trucks and associated vehicles could increase productivity and reduce numbers of plant and operators. However, larger equipment requires longer mobilisation times and specialist support. For a short construction program it is likely that mobilisation time would be very high and an even higher premium on rates demanded for equipment.

Contractually the project may require a number of large contractors to be able to complete the work. Rates are likely to be high as there will be very little competition particularly if it is all to be completed in a short period of time. There is no incentive for longer term work and investment in additional plant and equipment if it sits idle after the project.

Environmentally the project faces a number challenges. The greenhouse gasses produced from the clearance operation is likely to be large. Exposing large areas of the footprint is likely to result in environmental concerns stakeholder consultations, and issues related to obtaining necessary permit and clearances.

There is some risk that during removal operations cultural heritage may be encountered and possibly damaged. Material will be removed very quickly and without inspection. Any necessary cultural surveys, permits and clearance would have to be completed by August 2018.

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It is assumed in this report that camps will be mobilised in time for the excavation operation. However, this in itself is a major engineering exercise requiring power, accommodation, sewage treatment and other facilities. For 1000 plant and equipment accommodation for at least 3500-4500 personnel (operators, supervisors, engineers, maintenance crews and support staff) will be required. These will also require multiple shifts on rotation.

An additional item to consider is the impact of the construction on local infrastructure, mobilisation and demobilisation traffic alone will increase maintenance requirements for local public roads

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13 Recommendations

To achieve removal of all organics (trees, brush and organic soils) will require over excavation to limit rework and defects which may cause later concern. If the work were to be completed more slowly, it is possible that the costs could be reduced; in part because excavation would be more limited and mobilization costs would be significantly lower with more competitive hourly rates. This would not meet the schedule.

The clearance of all organics (trees, brush and organic soils) from the footprint of the FSL is costly and unlikely to be achievable within the schedule to allow first power in July 2019. Increasing the reliability of delivery in that time period without triggering a major landslide is difficult. The act of removing organics (all trees, brush and organic soils) from the footprint may in itself cause instability of the slopes while construction proceeds. This presents a risk to humans involved in the construction but also presents a risk that any landslide would transport vegetation into the river which could then not be removed. Each mass soil movement (landslide) has historically transported large quantities of organics into the water course to decay; it is a natural process.

The overall program of removal of all organic soil and vegetation should be considered a major civil engineering activity in its own right. Such a program would typically be built over 5 or more years the activity would be much more manageable but still costly.

Designing, implementing and reporting a ground investigation before contract award for the clearance and excavation of organic soils would be beneficial. The absence of a ground investigation generates uncertainty and is likely to lead to contractors pricing this in as a contract risk, increasing costs for the required equipment. SNC-Lavalin recommends that gathering additional information on the current ground conditions, particularly the distribution of sensitive clays, is likely to give greater reliability to the construction programme and costs. In the absence of reliable information contractors will price in perceived risk associated with ground conditions. The ground investigation would improve safety and reliability during construction. Contractor pricing of perceived risk would be moderated.

During the ground investigation instrumentation could be installed to aid in the monitoring of the slopes which would enhance knowledge of the slope properties and behaviour and improve safety of works conducted on the slopes.

The ground investigation does not need to be completed for the completion of the design of the clearance and stabilisation activities; an observational approach can be adopted.

Full time field supervision by experienced geotechnical engineers is recommended for all work fronts where clearing is occurring. The engineers will assess whether organics have been removed and identify sensitive clays have been encountered. Using an observational approach with suitable engineering solutions depending on the ground type encountered it will be possible to: limit excavation to what is necessary and re-profiling to appropriate safe slope angles for construction and temporary/permanent stability requirements.

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14 Conclusions

The project may be achievable in one year with sufficient lead time for planning, engineering, procurement and regulatory requirements (consultation and approval). However, it should be considered a challenging and difficult project with a high risk of not delivering on schedule.

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15 Closure

Prepared by:

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Appendix I

List of assumption used in the preliminary design and estimation process

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Cost estimates Assumption
±50% cost estimate
Use rates from original contract as initial basis for cost estimate
Used material volumes from complete soil and vegetation removal
Assumed up to 10% of project time will be delays for environmental/archeological and weather. Allow in costing, schedule and resourcing.
Used a typical road cross-section to determine cost per lineal meter for road upgrade (3m³ per meter)
Used a typical road cross-section to determine cost per lineal meter for new road build (12m³ per meter - gravel)
Used a typical road cross-section to determine cost per lineal meter for new road build (1.5m³ per meter – cut & fill clay/sand)
Use Nalcor rates as base cost (Civil works Rates and Earthwork Rates
Check with Spon's Civil Engineering and Highway Works Price Book used to estimate basic earthworks
All equipment will have to be remobilised to site
Quantities calculated for El39 masl, Quantities to El42 masl add 8% of calculated.
Assume average of 2 m of excavation on cut slopes to stabilise – checked with 4m
Temporary camp will be required (~75 person)
Contractor will require a compound closer to work area
Road maintenance will be required for the duration of the work (graders and haul trucks)
Excavation in winter will not be feasible to limit excavation depth to just A and O horizon (1.5m depth versus 0.2m)
20% of the area for clearing will need to be access with a barge
$90-$160 accommodation and food per day per person
5-8% of CAPEX for engineering support and supervision
Mobilisation based on 10% to 15% of CAPEX

Schedule Assumption
No water access to beaches during winter
Start in August/Sept 2018
Complete by April 2019
Increase equipment to meet schedule
Assumed high LD's for not meeting schedule
Assumed up to 15% of project time will be delays for environmental/archeological and weather. Allow in costing, schedule and resourcing.
Maintenance period for slopes, drainage and sedimentation ponds through till July of 2020
0.2ha/shift to 1ha/shift – average 0.5 ha. Use 0.2ha/shift for costing and scheduling purposes.

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GIS data Assumption
LiDAR data was reprocessed to correct for errors found in original client supplied DEM and derived terrain products. The decision to reprocess was made based on observed visual anomalies including terracing in client supplied DEM and slope model. The reprocessing cleaned the derived data of these anomalies conjectured to be artifacts introduced by earlier geo-processing steps.
All provided mapped environmental GIS features shall be field verified
Only these mapped inputs were considered for conceptual modelling, planning, and cost calculations
LiDAR data was reprocessed to correct for errors found in original client supplied DEM and derived terrain products
Disposal locations, roads, crossings etc. are conceptual and as needed and to be field verified
Stream crossings were determined from intersection of provided as-built access roads, conceptual haul roads, and derived centreline from provided LakesStreams_Buf15m data set
Conceptual haul roads were located to follow 39 masl full supply level. Where appropriate Roads were conceived to cross over areas with small streams and ravines instead of following full supply contour. Where further than 200m from the natural water line, branch roads were created. Where required secondary haul roads were created roughly parallel to the main roads at 100 m or 200 m intervals until 100 meters from the natural water line.
3H:1V or higher slope re-profiling for sensitive clays was determined using ELC2008 data (3 Soil types - glaciofluvial, glaciomarine, and Till) and slope model derived from corrected DEM (see above). Areas identified were >30% slope and below 42 masl for entire future reservoir area. High erosion prone areas and sensitive terrain areas were not excluded.
Volume estimates for re- profiling is based on 4 cross-sections sample areas (2 south bank and 2 north bank of reservoir) conducted in AutoCAD Civil 3d.

Construction (methods and materials) Assumption
All organics are to be removed up to elevation 39 masl
Disposal of organics shall be above the FSL (39 masl)
El39m to 42m to be cleared to the limit of 15 m horizontal from the FSL at EL 39 masl
Use largest equipment feasible to reduce rate/m³ moved
Use forest roads manual as guidance for roads
Assumed haulage by 3 axle tri axle articulated trucks
200 m max push with a dozer, ideal 100-150m
Existing roads used in previous phases will be integrated into removal programme where possible
Roads to min 10 m wide with turning areas and passing areas if required. Allow for 50% of roads to be widened to 15m for two way traffic by CAT 720 (or equivalent) articulated 3 axle dump trucks.
Roads to be less than 8% slope wherever possible minimum road is 2% if possible abs. max 12% slope
Excavate material less than 1.5m with dozer and loader
Excavate with backhoe of any size bigger than 400
Barges can be used to access sites along the river (north and south banks as well as islands).
Barge access limited – no barge access after early November till freshet
Transport of waste to be less than 5 km, aim for 3 km Frozen ground containing organics assumed to be excavated to 1.5 m (over excavation due to frozen ground)

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Construction (methods and materials) Assumption
In non-frozen ground excavated material to be a minimum of 0.5 m - limitation of equipment, operators conducting rapid excavation and surface obstructions/features (e.g. root balls).
Wetland assumed to be excavated to 2.2 m – 0.3 m provided in AMEC ELC assessment but an allowance has been made for an average assuming deeper deposits and
Reduce transport between areas along the river to a minimum – if there is a break between organic clearance areas the aim should be to not build roads between the areas of access is cheaper by barge or to meet time constraints
Follow slope contours where possible - Follow contours for roads
Use forest roads manual
Road crossings of water courses and ravines to be temporary
Narrow crossings to be bridged with earthworks/ice
Culverts (CSP or HDPE) only to be installed where road will be used in autumn or spring.
Cut and fill balance for earthworks
Roads to be cut to mineral (sand) or clay if required. – Freeze-in clay areas – side cast waste
Only cut drainage trenches along roads where inflow occurs.
Use mineral material from waste dump excavations and borrows near roads to build roads and earthworks
Only use geogrids to provide road support if required
All equipment will have to be remobilised to site
24/7 hr work each shift has 10 hrs operation (assume vehicle 90% utilisation)
3:1 slopes for sensitive clays, reduce to 30% to account for slopes that encounter seepage and drainage measures
Sensitive clay slopes require erosion protection is left exposed (particularly more than 2 months past March 2019)

Geotechnical stability Assumption
Sensitive clays - avoid changes in stresses
Avoid erosion
Avoid traffic
Avoid construction and reprofiling/grading
Follow contours for roads
Any unsuitable/soft ground, cracking, slope instability, etc. conditions encountered should be reported to the project geotechnical engineer during the clearing operation.
Use North spur remediation approach used as basis for stabilising other slopes
Re-profiled slopes to be not greater than 3H:1V, design to use 30% slope to accommodate potential instability from seepage and weaker than anticipated soils. Slope to be designed to have reduced risk of slope movements when not submerged.

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Soil and vegetation to be removed (soils containing carbon) Assumption
Geohazard areas where recent landslide happened should be assessed prior to the removal operation.
For erosion control, surface runoff management should be considered during and after removal operation at each geomorphic unit/ELC.
It is understood that in previous phases only trees and bushes were removed from the future FSL reservoir area and this was only partial during the initial phase of clearing. In this phase, all of the trees & bushes, Horizon O and Horizon A will be removed.
Any existing natural drainage should be protected.
For the soil and vegetation removal quantities estimate up to elevation 39.0 m is considered, a multiplier of 8% (with contingency of ±1%) is the clearing extends to another 15 m of horizontal buffer zone from the EL39 masl.
ELCs such as Water, Gravel Bar, and Anthropogenic areas are not considered for the removal operation.
ELCs could be ranked/categorized for the removal operation based on TOC data, e.g., Black Spruce/Sphagnum Woodland contains highest TOC of 46%
Environmental permit and archaeological permit assessments shall be completed prior to the operation
For budgeting purpose, excavation thickness in frozen ground to remove organic soil are as follows when : • Black Spruce/Feathermoss Forest – 1.5 m • Black Spruce/Lichen Woodland – 1.5 m • Black Spruce/Sphagnum Woodland – 1.5 m • Fir-White Spruce Forest – 1.5 m • Hardwood Forest – 1.5 m • Mixed wood Forest – 1.5 m • Riparian – 1.0 m • Spruce Fir/Feathermoss Forest – 1.5 m • Wetland – 2.2 m
For budgeting purpose, excavation thickness in non-frozen ground to remove organic soil are as follows when : • Black Spruce/Feathermoss Forest – 0.5 m • Black Spruce/Lichen Woodland – 0.5 m • Black Spruce/Sphagnum Woodland – 0.5 m • Fir-White Spruce Forest – 0.5 m • Hardwood Forest – 0.5 m • Mixed wood Forest – 0.5 m • Riparian – 0.0 m • Spruce Fir/Feathermoss Forest – 0.5 m • Wetland – 0.5 m

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Water management Assumption
Surface drainage measures will be temporary (less than one year sept 2018 to Apr 2019)
Drains will be constructed once roads are and clearance is completed
No pipes/culverts to be left in place after completion of excavation in an area
Sedimentation ponds are temporary to deal with freshet and until reservoir fill
Sedimentation ponds every 1.5km minimum (range between 1km 3km)

Resources Assumption
Assume new mobilisation of equipment to site
Whatever is required can and will be mobilised
No aggregates available – or only what can be found on site
All materials used to build earthworks and roads will come from site except geosynthetics and culverts
No harvestable timber with value to market – get a price for timber - $65,000/ha
Assumed up to 10% of project time will be delays for environmental/archeological and weather. Allow in costing, schedule and resourcing.

Disposal Assumption
Excavate out disposal hole and cap with clay or sand mineral (above the FSL)– surcharge to compress organics
Outline design for storage – assume borrow and backfill and permitting achievable
Disposal areas to be within 3km of extraction point – possibly further if along river
Permits can be obtained for disposal of organics in time scales

Equipment estimates Assumption
Timber crew can clear 0.2 ha/day (range of 0.2ha to 1.2ha per day, use lower bound based on weather and operational concerns.
Barge crew (3 excavators, 2 loaders, 1 barge, 1 scow, 1 tug boat) can move 1500m^3/day
Excavation crew (1 excavator, 1 dozer, and 4 trucks) can move 1320m^3/day
Road Construction crew (2 dozers, 1 excavator, 2 trucks and 1 grader) can construct 500m of road per day
General excavation crew (1 excavator, 4 trucks and 1 dozer) can mover 1320m^3/day
Motorized scraper crew (5 scrapers and 1 dozer) can move 3750m^3/day
Road maintenance crew (6 graders, 2 excavators, 4 trucks)

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Finished slopes Assumption
Below El.42 masl: 0.5m protection clay sand layer finish No planting or seeding
Above El.42 masl: 0.5m protection clay sand layer finish No tree planting Hydroseeding of slopes
No riprap at FSL (throughout variable waterline) – natural processes to establish slope/beach

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Appendix II

Figures: Aerial Photography, Elc Classification, Geology and Preliminary Civil Engineering Design (Roads, Disposal Areas And Areas Requiring Re-Profiling)

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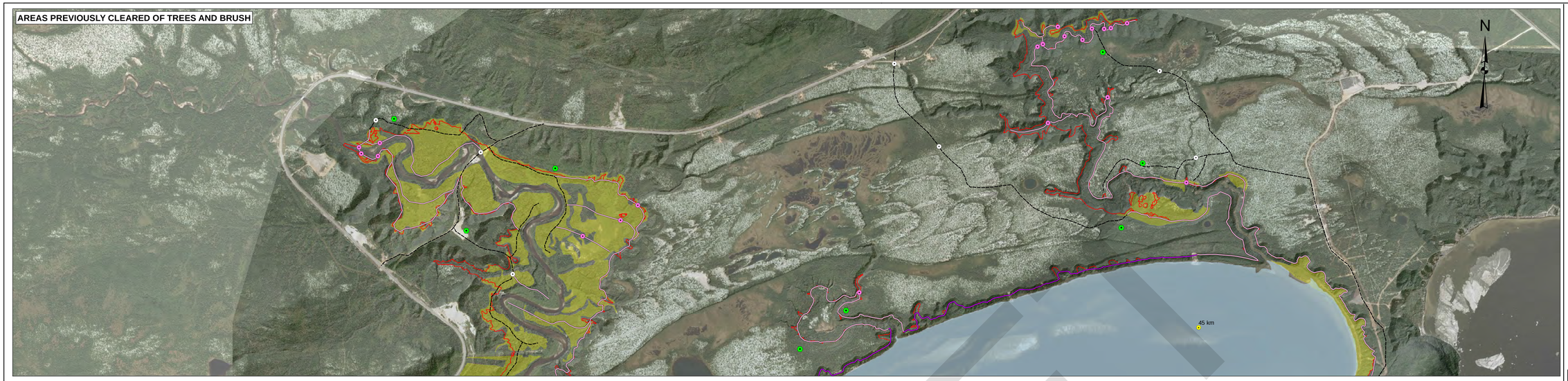

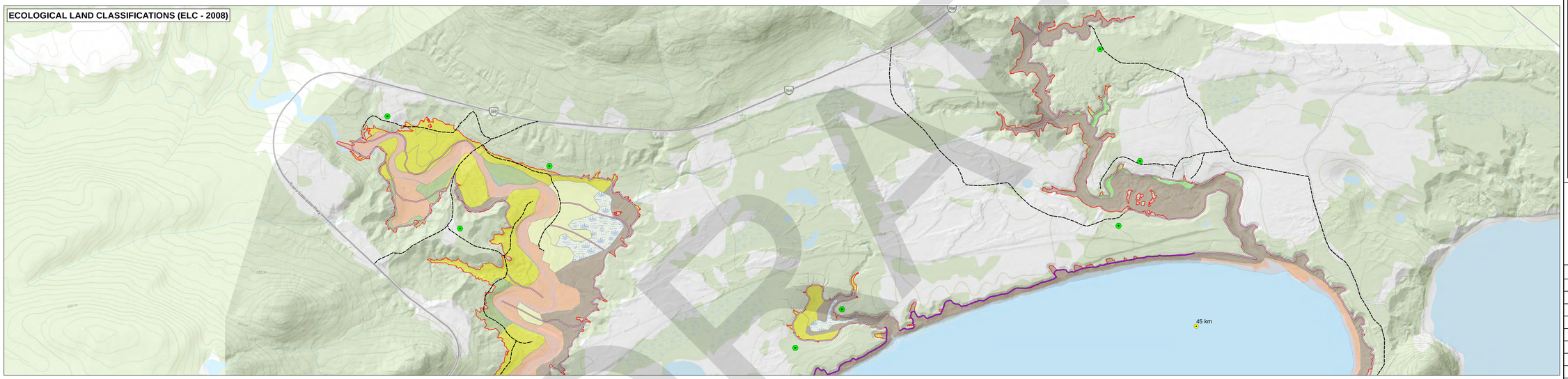

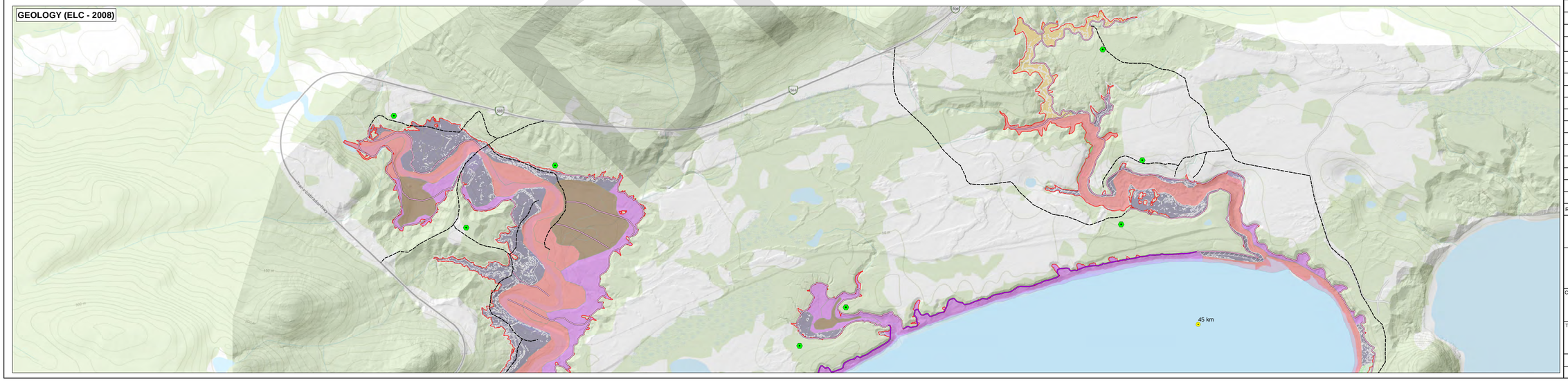

LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
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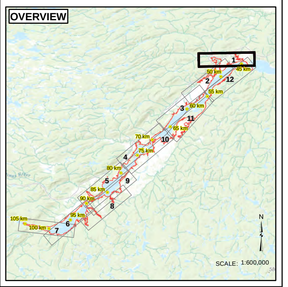
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS

OVERVIEW



NOTES

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3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

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SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 1 OF 12

DES BY AJ / RI	DRN BY WH	CHK BY	DATE 2017 12 19
SIZE 22 x 34	FIG. No. 1	DWG No 505573-G-08-E-001 (Series)	REV 0

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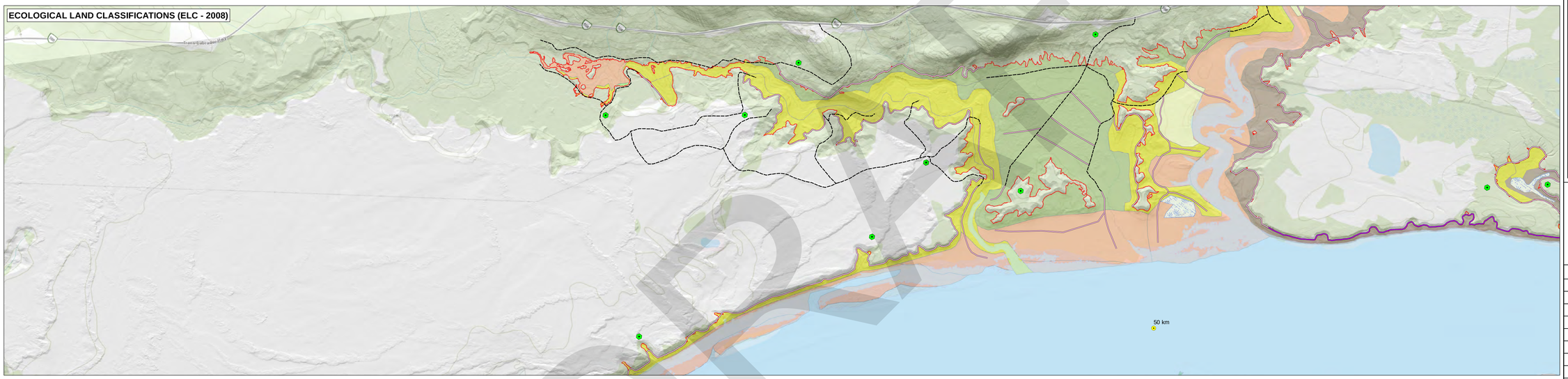

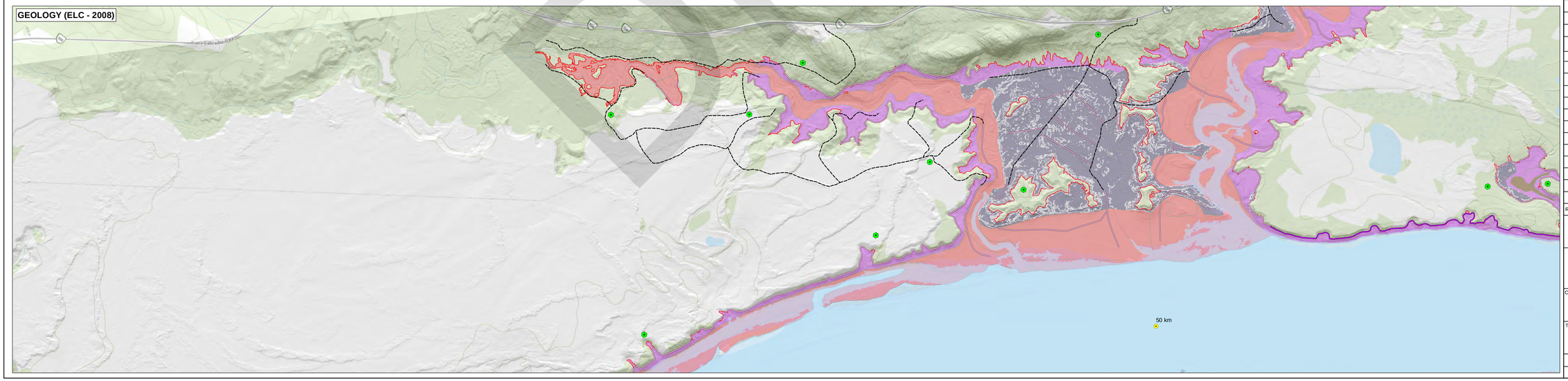

LEGEND

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- WATER BODY
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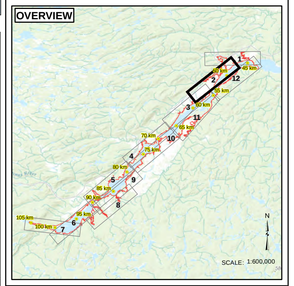
OVERVIEW



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DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

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SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 2 OF 12

DES BY AJ / RI	DRN BY WH	CHK BY	DATE 2017 12 19
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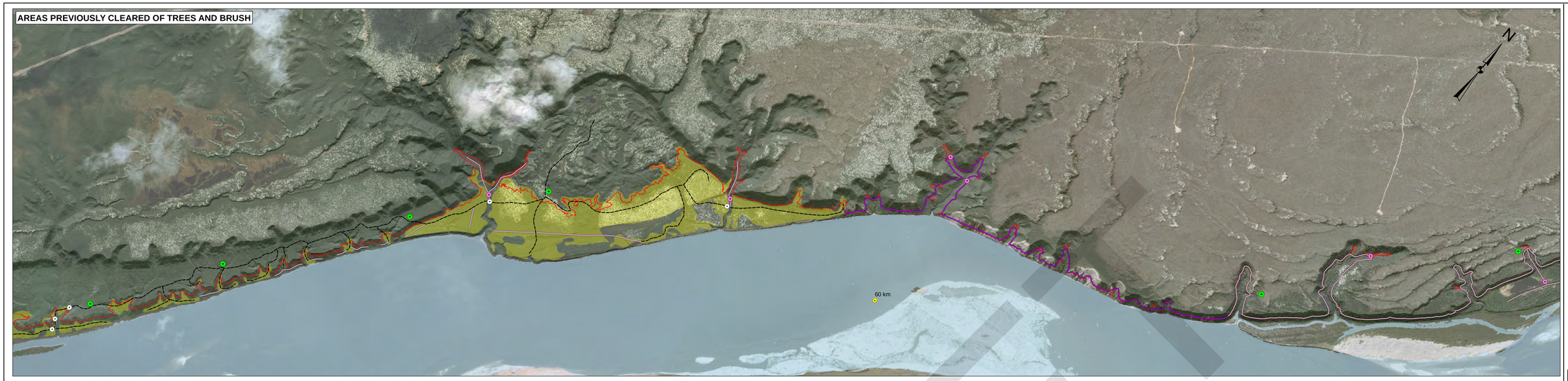

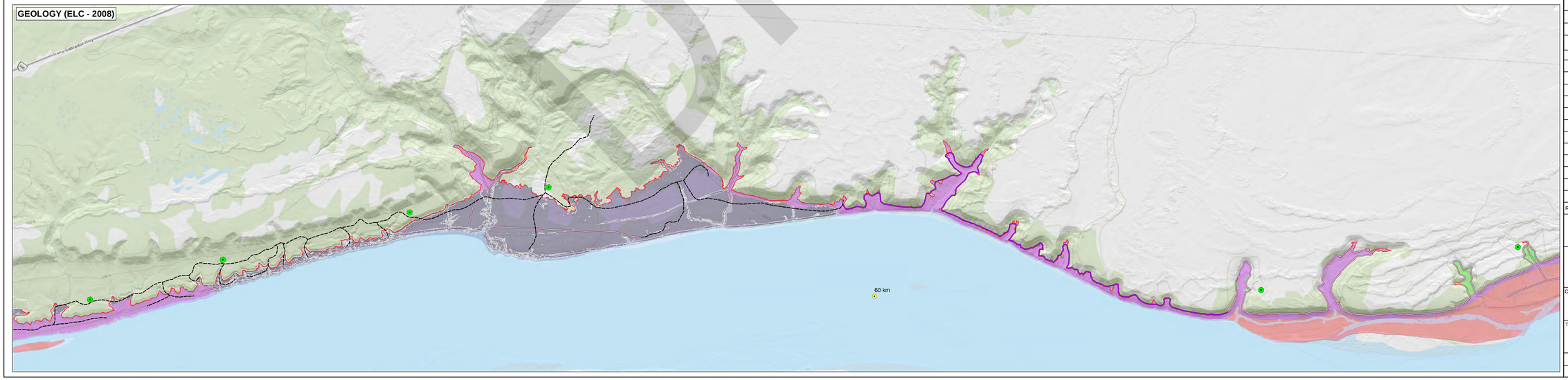

LEGEND

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POTENTIAL ACCESS

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- WATER BODY
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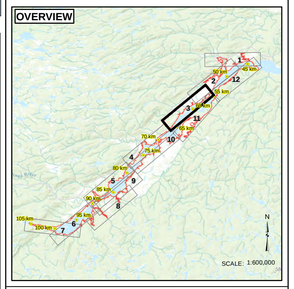
OVERVIEW



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REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

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SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE

MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 3 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
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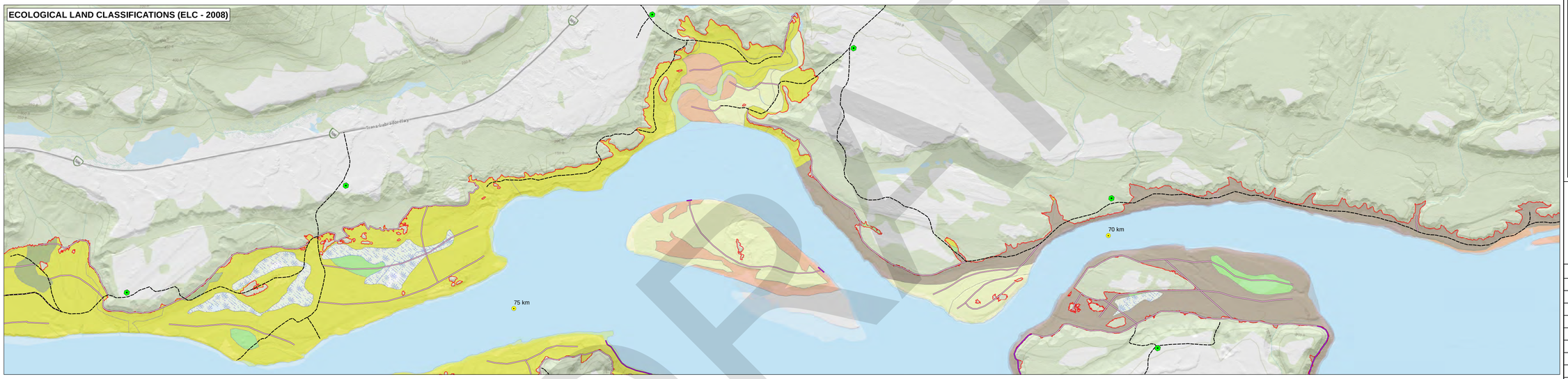

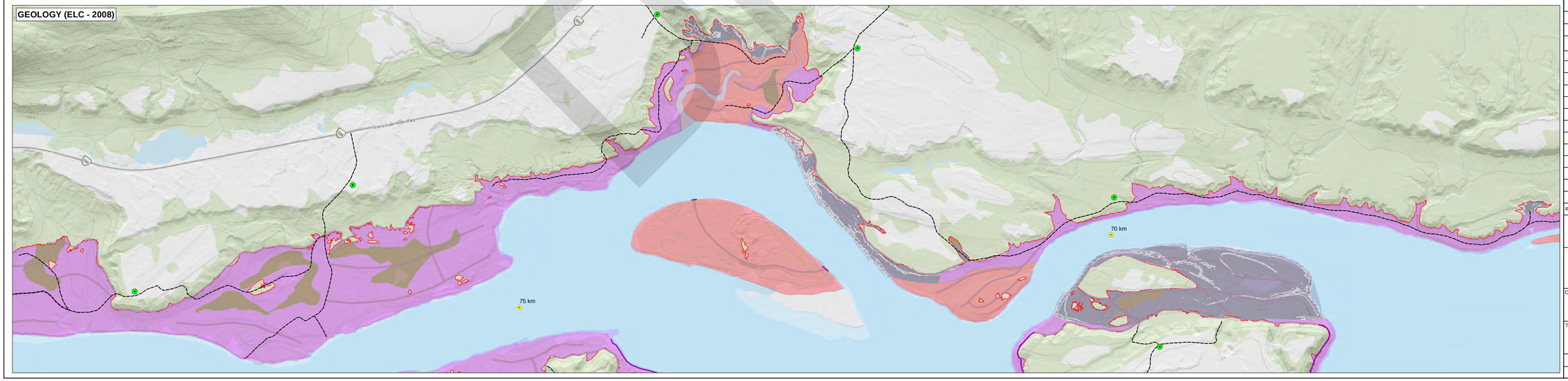

LEGEND

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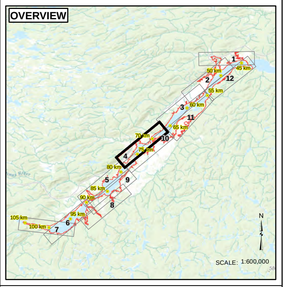
OVERVIEW



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REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

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SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE

MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 4 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
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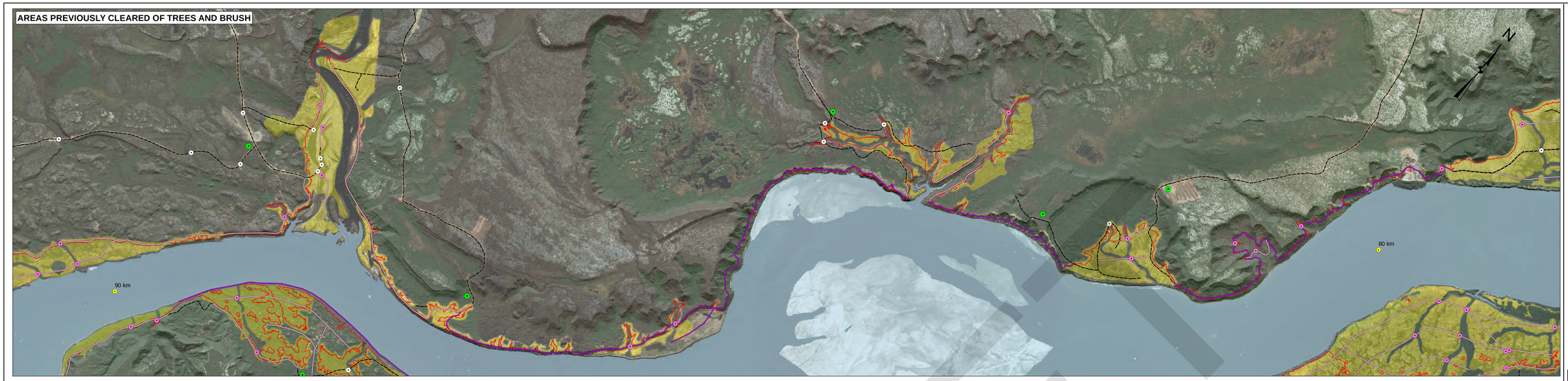

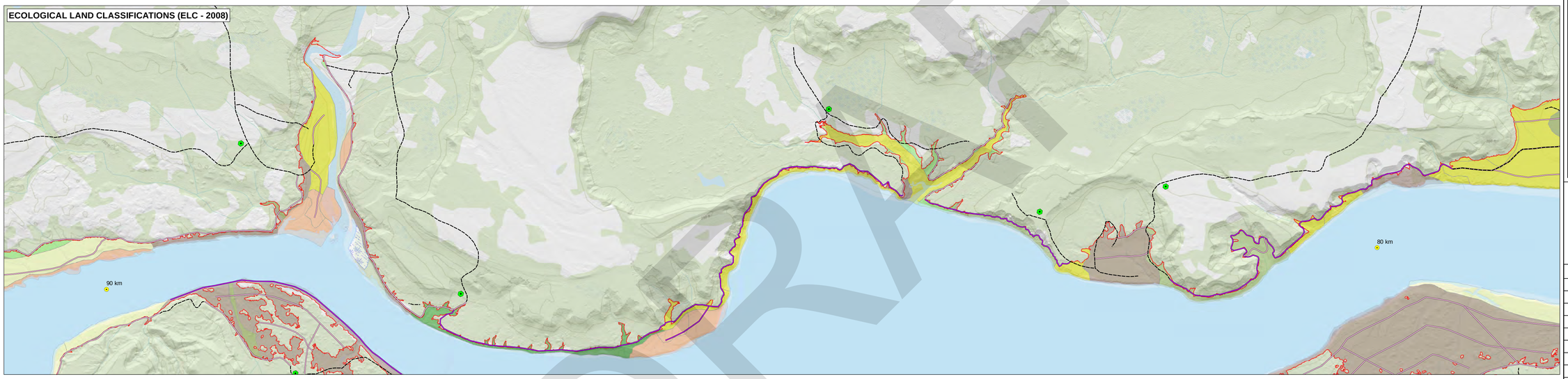

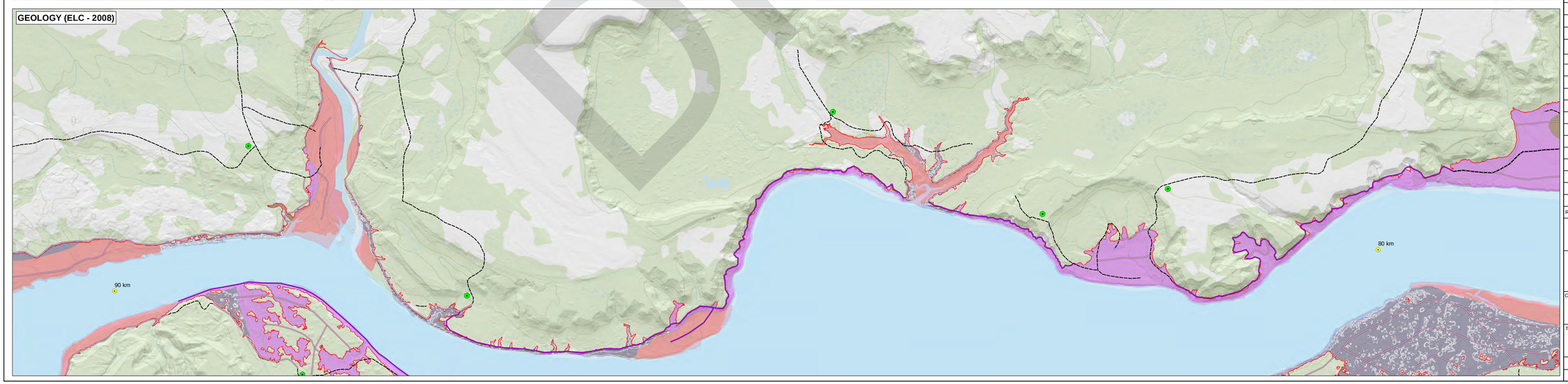

LEGEND

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- POTENTIAL AS NEEDED ACCESS WATER CROSSING
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POTENTIAL ACCESS

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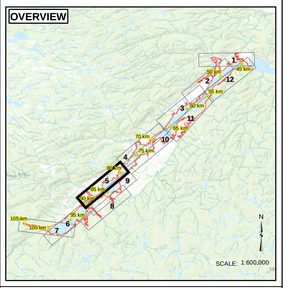
OVERVIEW



NOTES

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REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

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SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 5 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
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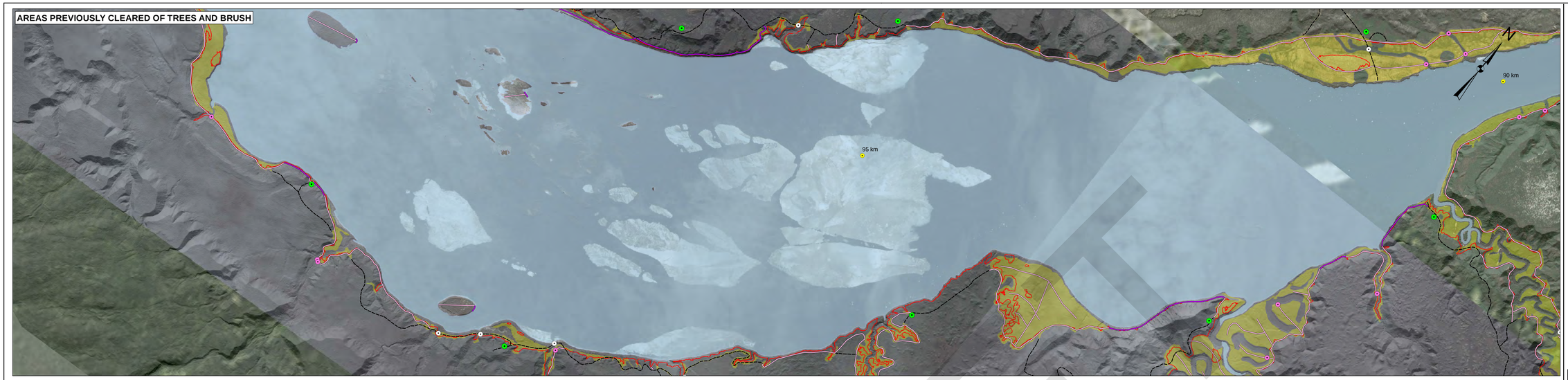

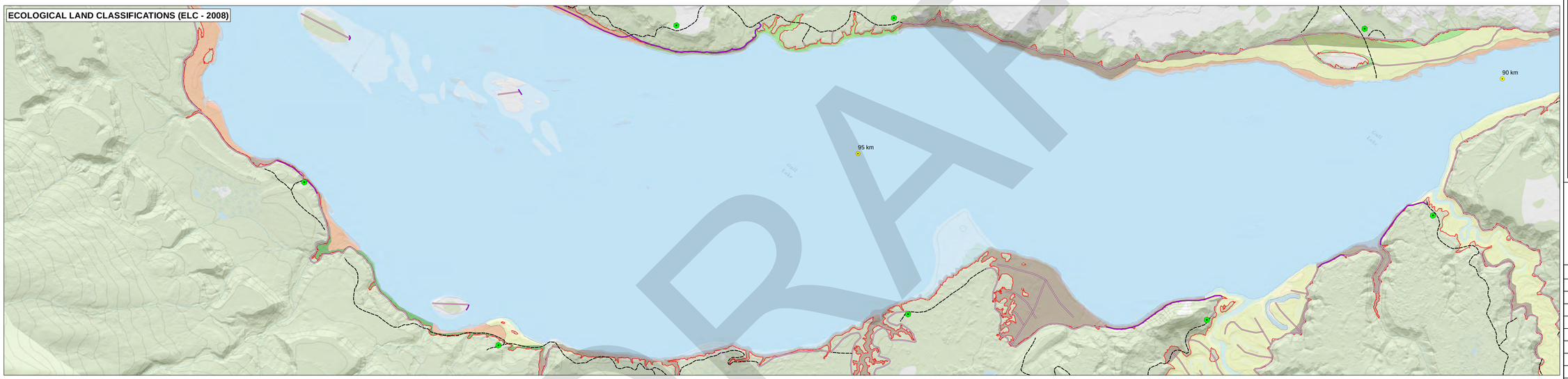

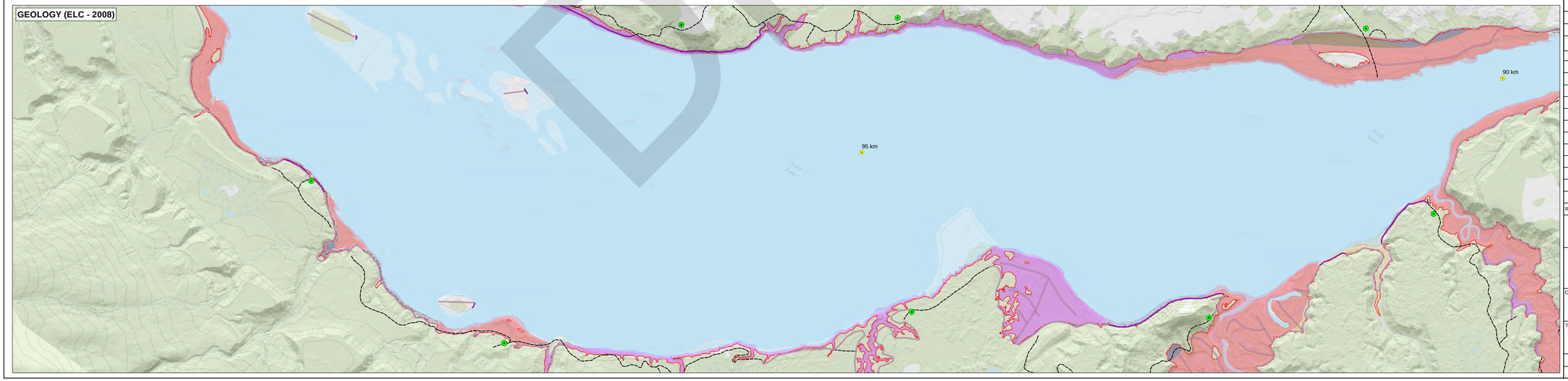

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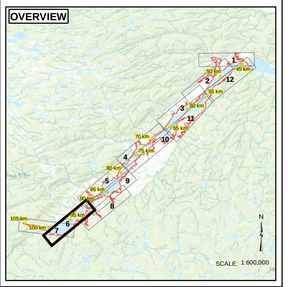
- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS

OVERVIEW



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWING NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE

MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 6 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
SIZE	22 x 34	FIG. No.	6	DWG No 505573-G-08-E-001 (Series)		REV	0

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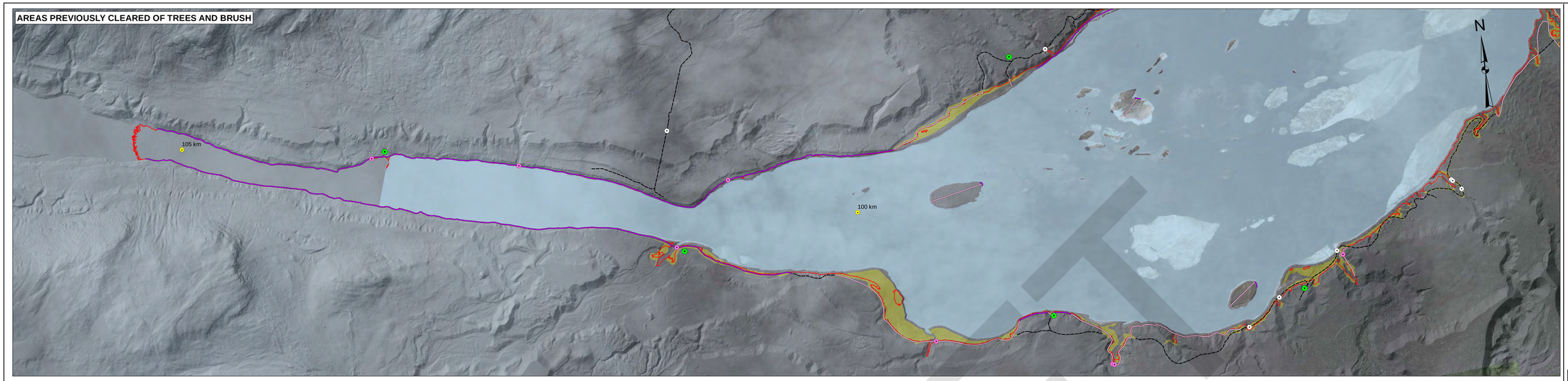
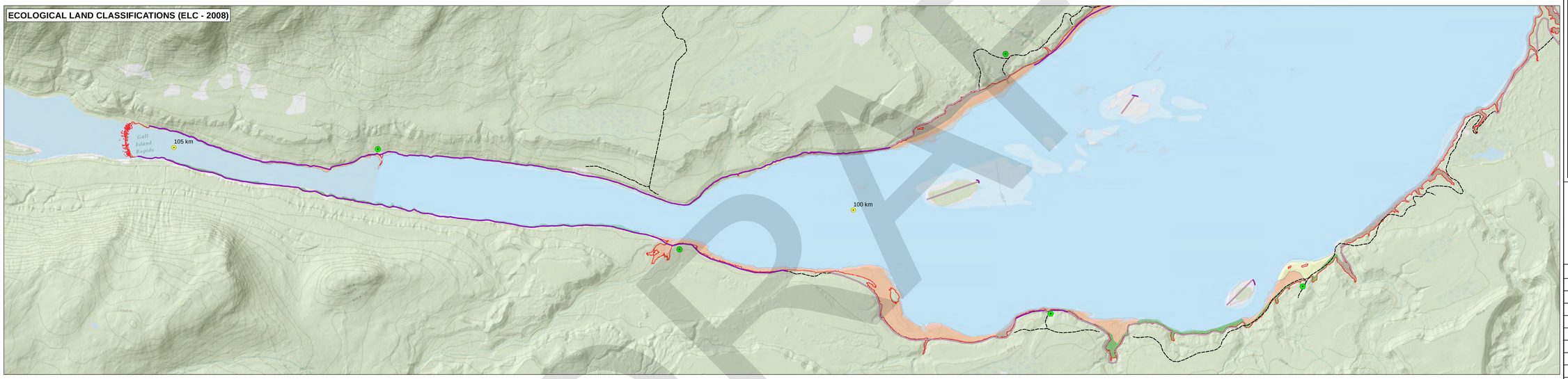
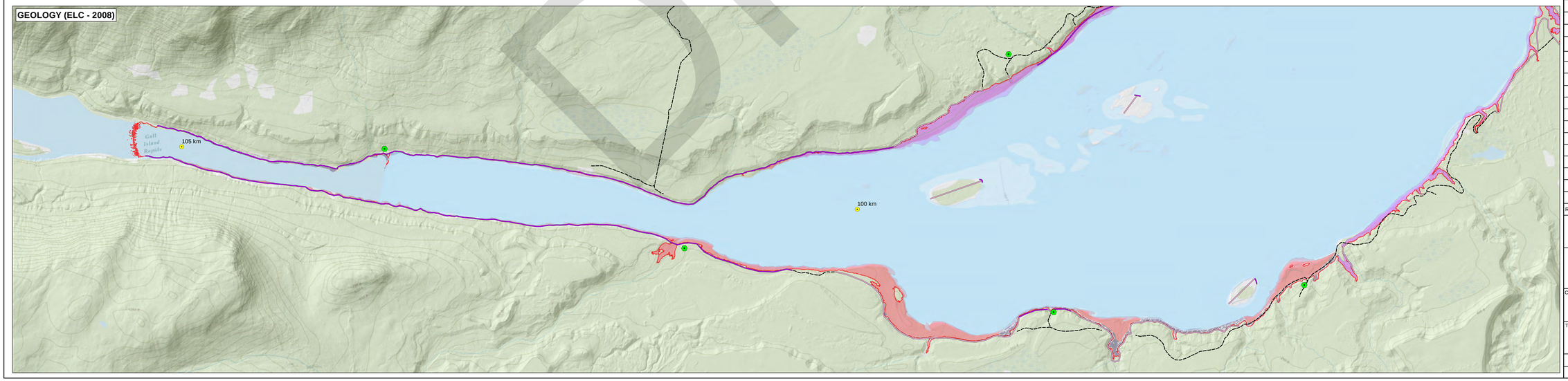






LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

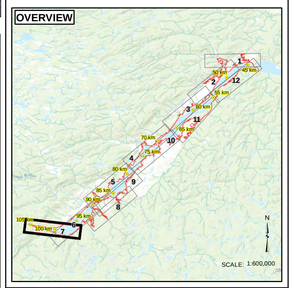
ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS

OVERVIEW



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWING NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 7 OF 12

DES BY AJ / RI	DRN BY WH	CHK BY	DATE 2017 12 19
SIZE 22 x 34	FIG. No. 7	DWG No 505573-G-08-E-001 (Series)	REV 0

Path: Y:\Nalcor LCP SOM removal\GIS\Drawings\505573_G_08_E_001\Map Series\171219_DRAFT TIA\TEMP\COPY.mxd

LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

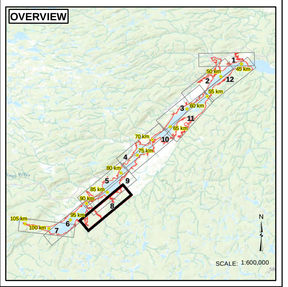
ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS

OVERVIEW



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWING NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE

MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 8 OF 12

DES BY AJ / RI	DRN BY WH	CHK BY	DATE 2017 12 19
SIZE 22 x 34	FIG. No. 8	DWG No 505573-G-08-E-001 (Series)	REV 0

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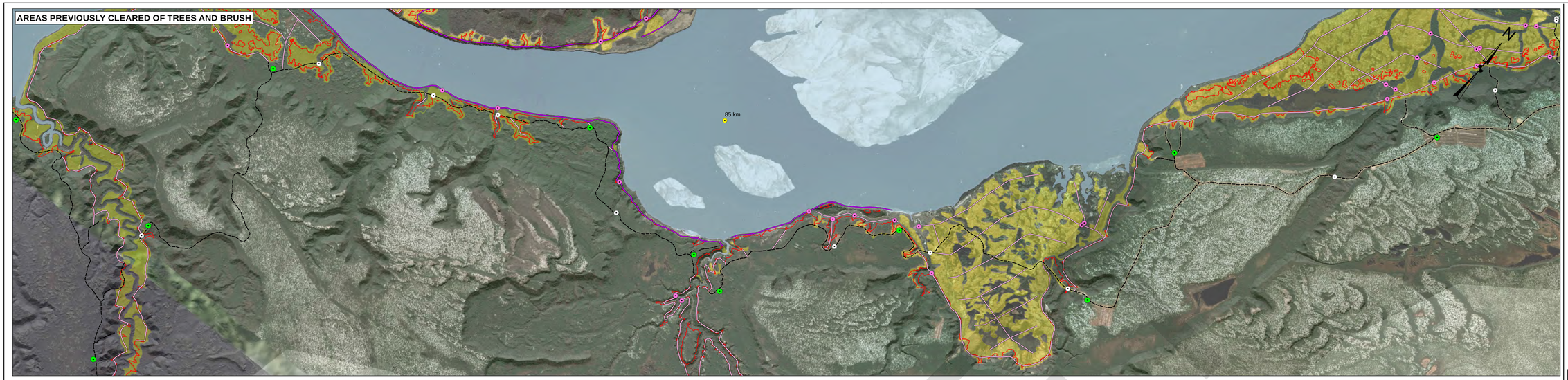
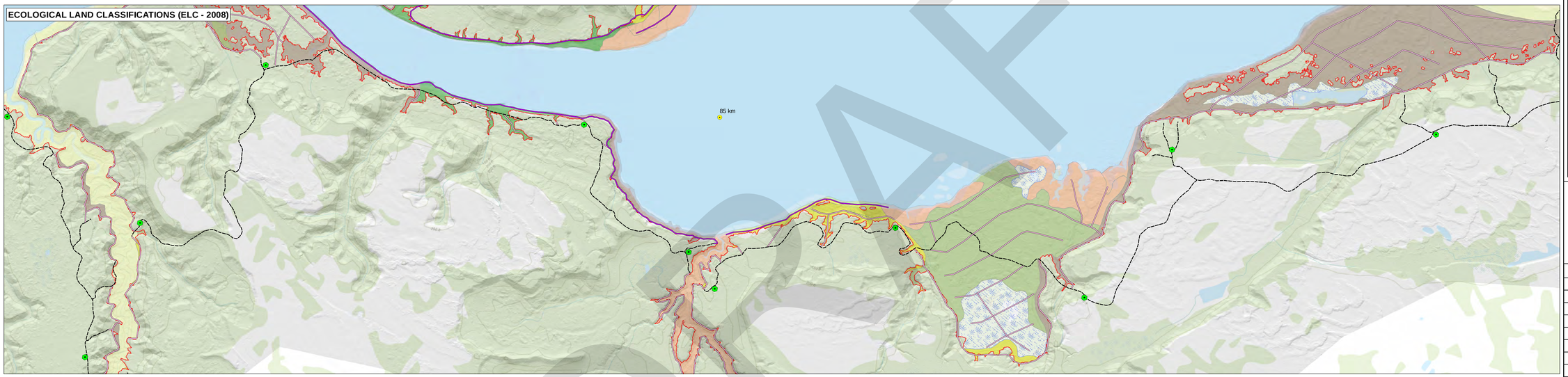
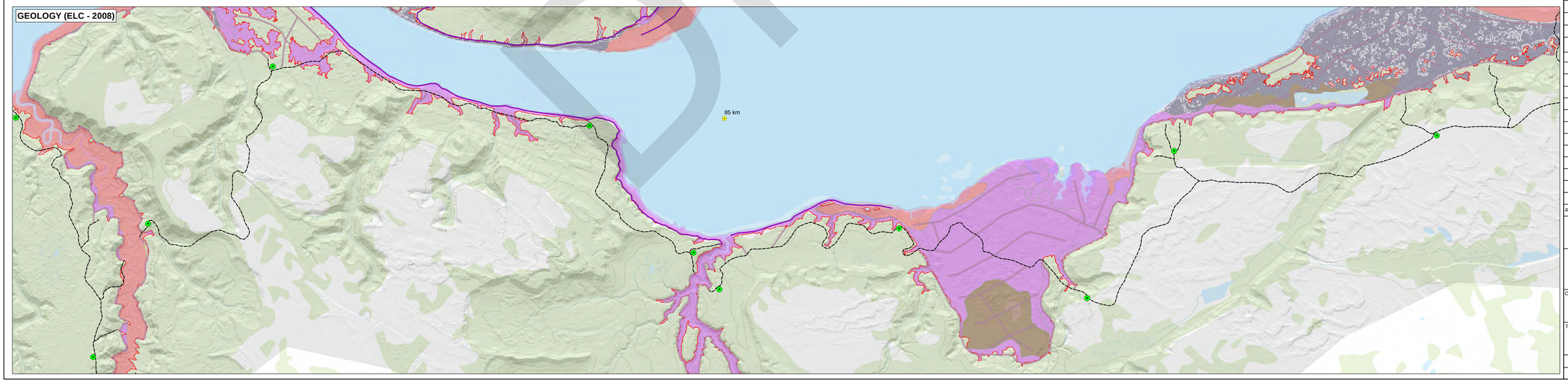






LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

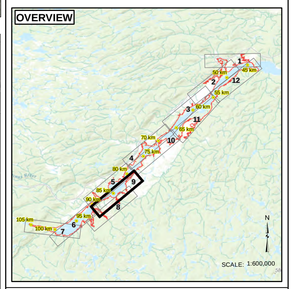
- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWING NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 9 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
SIZE	22 x 34	FIG. No.	9	DWG No 505573-G-08-E-001 (Series)			REV 0

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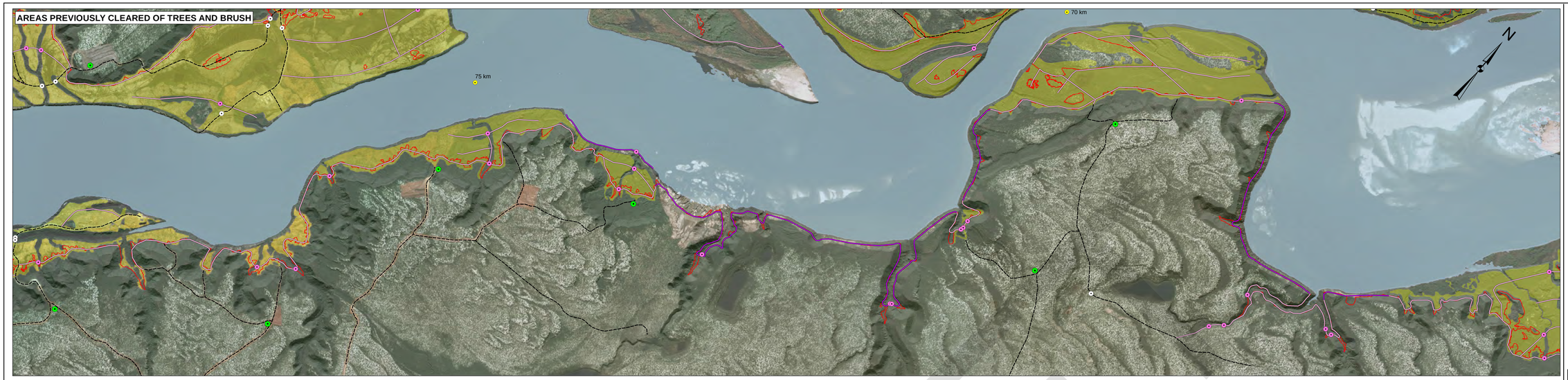
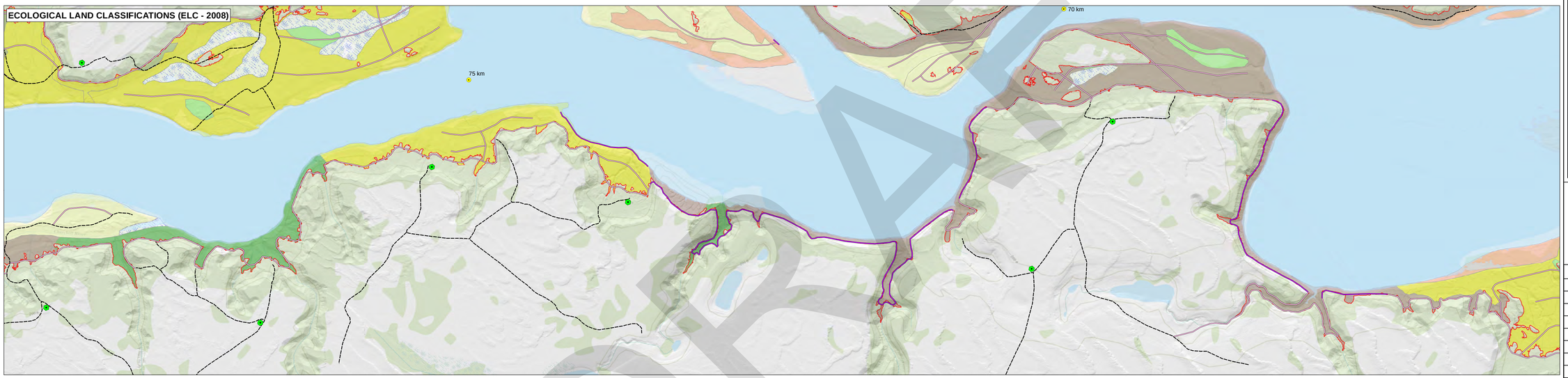
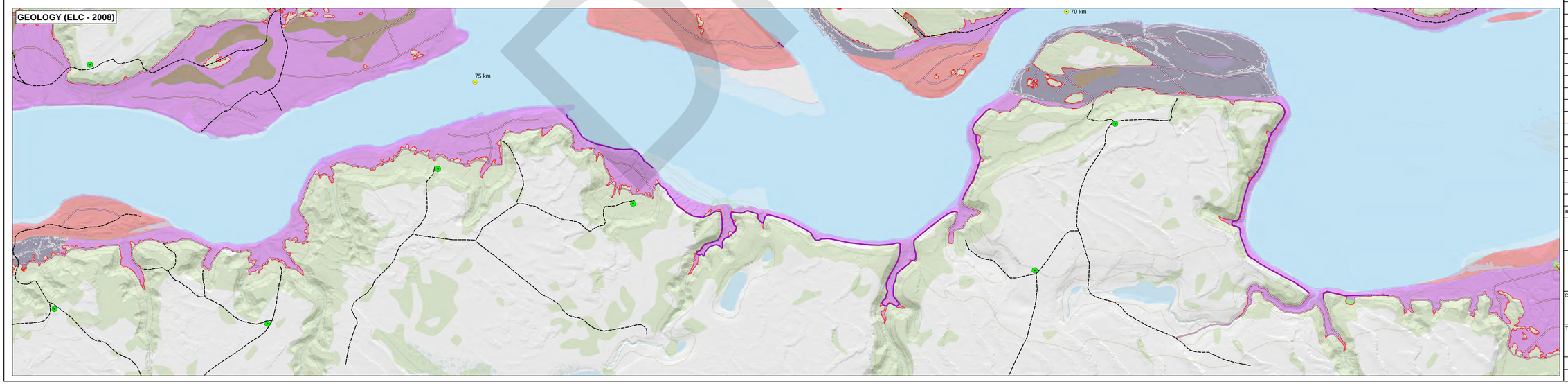






LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

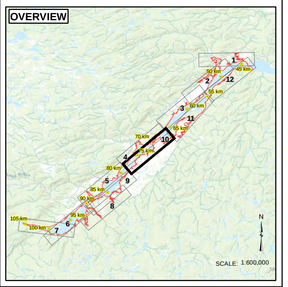
ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS

OVERVIEW



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWING NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE

MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 10 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
SIZE	22 x 34	FIG. No.	10	DWG No 505573-G-08-E-001 (Series)		REV	0

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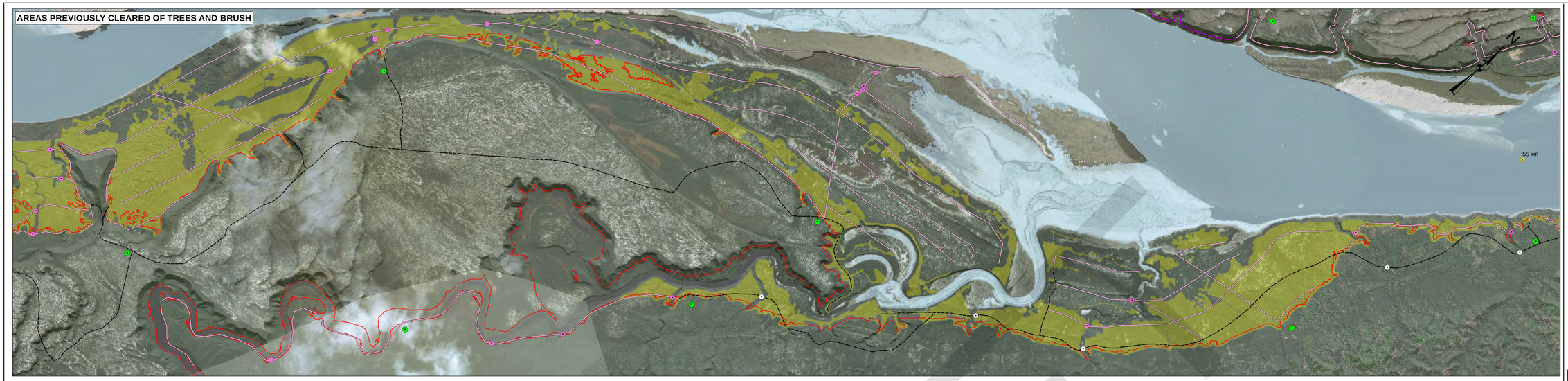
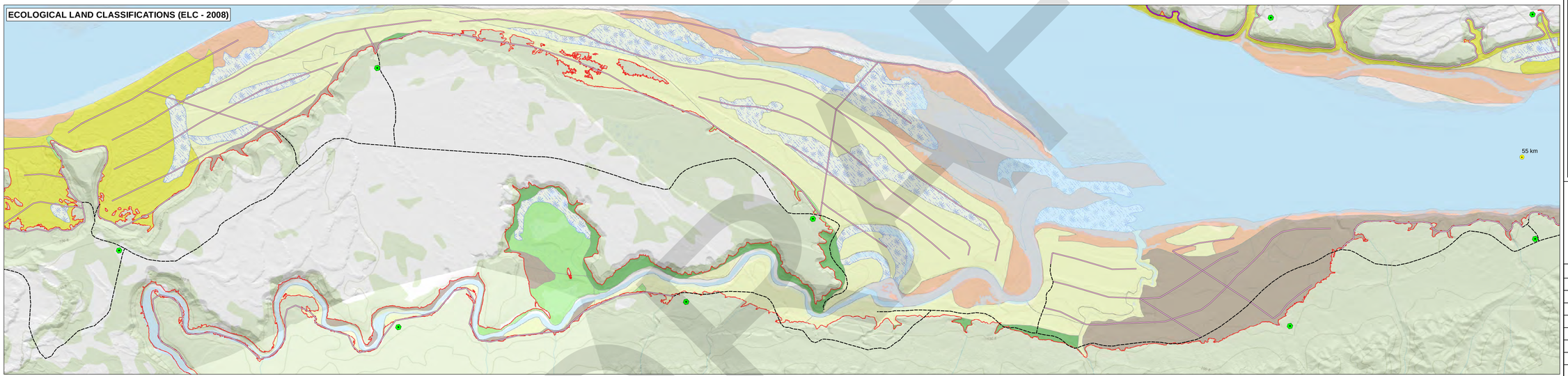
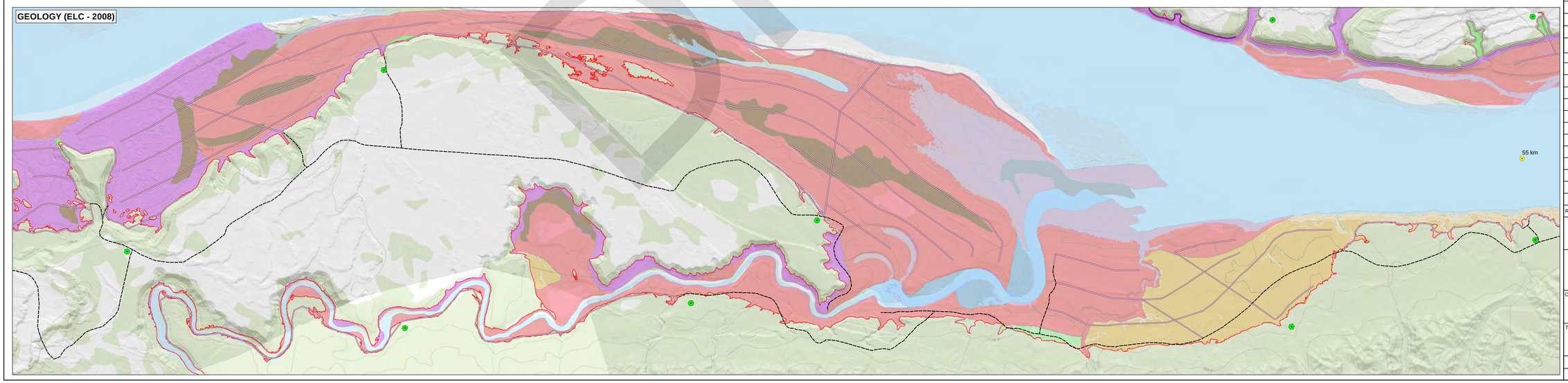






LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

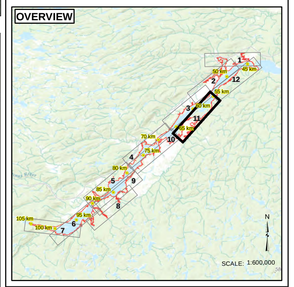
ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS

OVERVIEW



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWNG NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
4. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

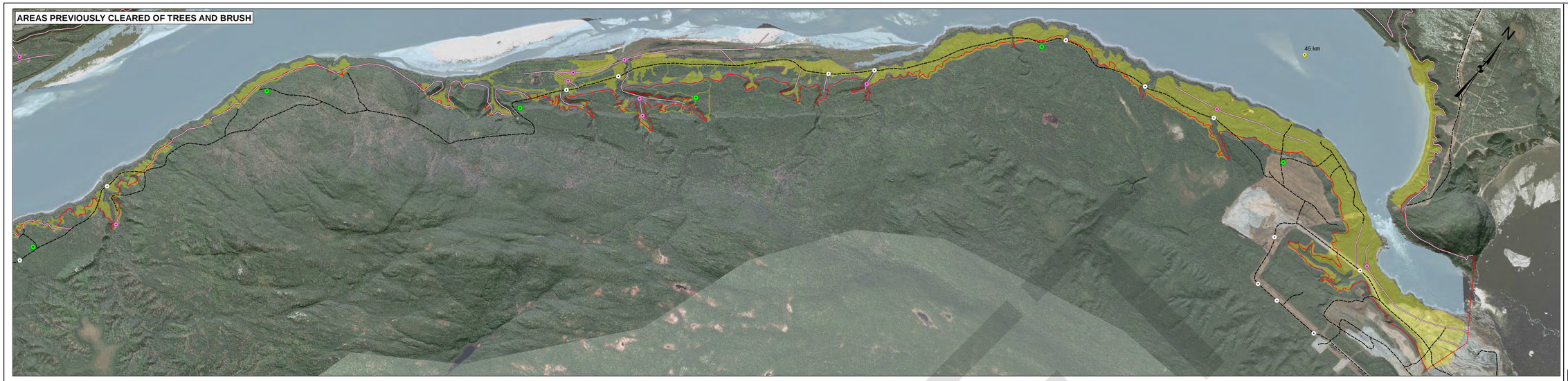
SNC·LAVALIN

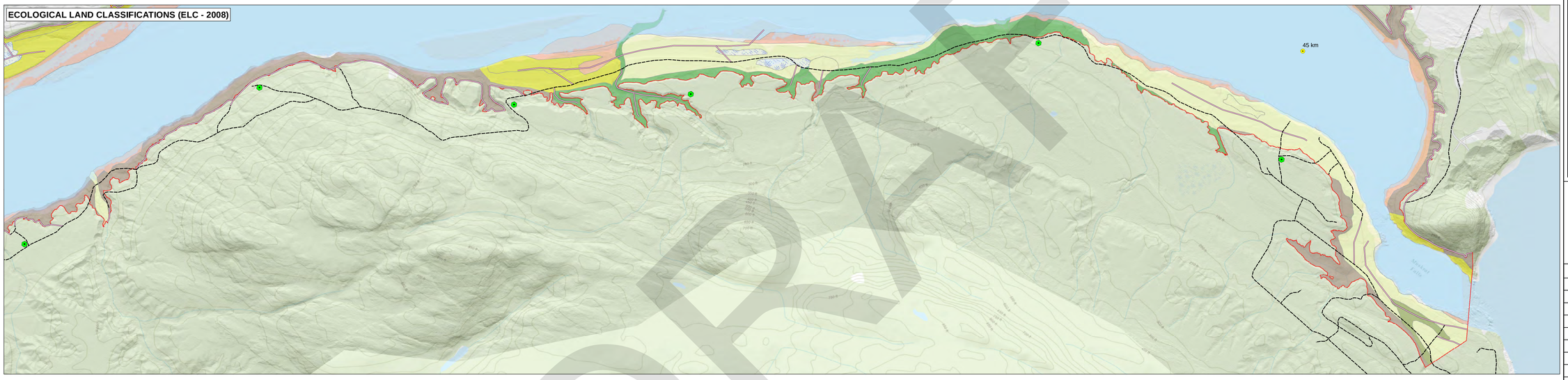
CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

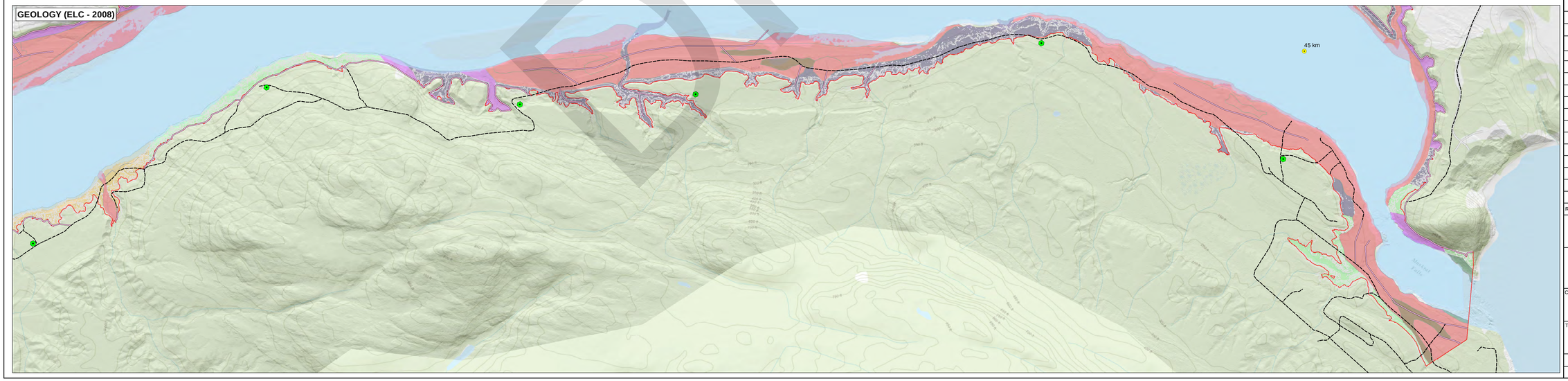
TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 11 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
SIZE	22 x 34	FIG. No.	11	DWG No 505573-G-08-E-001 (Series)		REV	0

Path: \\Mabcor LCP-SGM remote\GIS\Drawing\P505573_G_08_E_001 Map Series\171219_DRAFT 100-TEMPCOPY.mxd







LEGEND

- KILOMETER POST
- AS-BUILT ACCESS WATER CROSSING
- POTENTIAL AS NEEDED ACCESS WATER CROSSING
- POTENTIAL ORGANIC (SOILS, TREES, & BRUSH) DISPOSAL LOCATION
- AS-BUILT ACCESS

POTENTIAL ACCESS

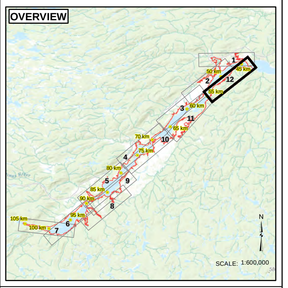
- AS NEEDED ACCESS
- POSSIBLE BARGE ACCESS
- CLEARED LAND (TREES & BRUSH ONLY)
- FULL SUPPLY WATER LEVEL (39 MASL)
- PRE-IMPOUNDMENT WATER LEVEL

ECOLOGICAL LAND CLASSIFICATIONS (ELC - 2008)

- BLACK SPRUCE / FEATHERMOSS FOREST
- BLACK SPRUCE / SPHAGNUM WOODLAND
- BLACK SPRUCE / LICHEN WOODLAND
- SPRUCE FIR / FEATHERMOSS FOREST
- FIR - WHITE SPRUCE FOREST
- HARDWOOD FOREST
- MIXEDWOOD FOREST
- WETLAND
- RIPARIAN

GEOLOGY (ELC - 2008)

- BEDROCK
- COLLUVIAL
- AEOLIAN SAND
- FLUVIAL
- GLACIOFLUVIAL (ASSUMED SENSITIVE CLAY)
- GLACIOMARINE (ASSUMED SENSITIVE CLAY)
- ORGANIC
- TILL (ASSUMED POSSIBLE SENSITIVE CLAY)
- WATER BODY
- POTENTIAL CLAY SLOPE RE-PROFILING AREAS



NOTES

1. COORDINATE SYSTEM: NAD 1983 CSRS UTM ZONE 20N.
2. **DRAWING NOT FOR CONSTRUCTION PURPOSES**
3. CLIENT SUPPLIED DATA LAYERS INCLUDE: ELC2008, FULL SUPPLY WATER LEVEL, CLEARED AREAS, AS-BUILT ACCESS, NATURAL CONDITIONS RESERVOIR LEVEL, DIGITAL ELEVATION MODEL
3. SERVICE LAYER CREDITS: ESRI AND ITS DATA SUPPLIERS

REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP

DRAFT

0 250 500 1,000 Metres

SCALE: 1:15,000

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: ORGANIC REMOVAL FROM THE FUTURE RESERVOIR FULL SERVICE LEVEL (FSL) FOOTPRINT AREA - MAPSHEET: 12 OF 12

DES BY	AJ / RI	DRN BY	WH	CHK BY		DATE	2017 12 19
SIZE	22 x 34	FIG. No.	12	DWG No 505573-G-08-E-001 (Series)		REV	0

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Appendix III

Rates For Construction Activities Supplied By Nalcor As Basis For Cost Estimates

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Earthworks Unit Rates

Item	Contract B Unit rate	UOM
Cofferdam Excavation	$ 12.63	m^3
Overburden Excavation	$ 12.02	m^3
Fill Placement rate	$ 15.50	m^3
Roads - Cut to Fill	$ 17.03	m^3
Maintenance Grade 3	$ 69.95	m^3
Culverts - 900mm	$ 728.85	m^3
Ditch Overburden Excavation	$ 64.07	m^3
Ditch Rock Protection - 100-250mm	$ 87.88	m^3
Rock Excavation including dental excavation	$ 219.90	m^3
Bulk Excavation - Rock	$ 31.73	m^3
Overhaul Rate	$ 2.00	m3/km
Drill & Blast Rock	$ 15.00	m^3
Geotextile non-Woven - 300g/m2	$ 12.14	m^2

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Appendix IV

Typical Sections for Road, Slope Re-Profiling and Sedimentation Ponds Used for the Estimation Process

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		Total Direct Craft Hours 228,980					
PRICE ITEM DESCRIPTION	UOM	MANPOWER COST Unit Rate	MATERIALS COST	EQUIPMENT COST Unit Rate	OTHERS / SUB COST	TOTAL Unit Rate	Comments
INDIRECT COSTS							
Contractor Equipment for Indirects	LS	0.02	1.98	23.92	(0.57)	25.35	Based on Cost per Direct Man-hour
Temporary Works	LS	7.50	0.69	10.01	1.59	19.79	
Winter Protection	LS	0.54	0.09	0.55	-	1.18	
Management and Staff	LS	52.23	0.15	1.83	0.50	54.72	
Statutory Holiday	LS	3.37	-	-	-	3.37	
Night Shift Premium	LS	0.50	-	-	-	0.50	
Design and Technical Assistance	LS	3.72	0.20	0.00	-	3.92	
Attendant labour	LS	57.39	6.95	0.08	-	64.42	
Employee Training	LS	2.36	0.02	0.00	-	2.38	
Health and Safety Requirements	LS	3.61	2.95	0.00	0.14	6.70	
Environmental Requirements	LS	0.12	0.86	0.00	-	0.98	
Quality Assurance / Quality Control	LS	2.65	-	-	-	2.65	
Performance Bond	LS	-	-	-	1.76	1.76	
Not Used	NA	-	-	-	-	-	
Site Maintenance	LS	4.73	0.07	6.32	-	11.12	
Holdback Release Bond	LS	-	-	-	1.10	1.10	
Security Services	LS	-	0.34	-	-	0.34	
Not Used	NA	-	-	-	-	-	
Waste Management Services	LS	0.00	1.30	0.00	-	1.30	
Room and Board	Per/Day	1.45	0.16	-	43.51	45.12	
Not Used	NA	-	-	-	-	-	
Travel Allowances	R	-	0.09	-	20.45	20.54	
SUB-TOTAL INDIRECT COSTS		140.19	15.84	42.71	68.49	267.23	
PERMANENT ACCESS ROADS							
Overburden Excavation	m^3	11.77	-	12.47	-	24.24	
Granular "B" Material	m^3	5.85	0.60	6.07	0.05	12.57	
Maintenance Grade No 3 Material	m^3	22.03	1.93	28.49	0.18	52.62	
CSP Culvert 600 mm	m	361.82	89.08	316.30	2.20	769.40	
CSP Culvert 900 mm	m	248.97	162.77	168.99	0.59	581.32	
Guard rail	m						

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		Total Direct Craft Hours 228,980					
PRICE ITEM DESCRIPTION	UOM	MANPOWER COST Unit Rate	MATERIALS COST	EQUIPMENT COST Unit Rate	OTHERS / SUB COST	TOTAL Unit Rate	Comments
SUB-TOTAL PERMANENT ACCESS ROADS		10.26	1.58	10.71	0.06	22.61	
LAYDOWN AND SPOIL DISPOSAL AREAS							
Overburden Excavation	m^3	5.94	-	9.42	-	15.36	
SUB-TOTAL LAYDOWN AND SPOIL DISPOSAL AREAS		5.94	-	9.42	-	15.36	
UPSTREAM BERM							
Overburden Excavation - Zones 2F and 2G Material	m^3	1.16	-	2.55	-	3.71	
Overburden Excavation	m^3	5.45	-	8.07	-	13.52	
Rock Excavation	m^3						
Dental Excavation	m^3						
Water/Air Jet Cleaning of Bedrock	m^2	27.86	0.23	6.12	-	34.21	
Dry Pack	m^3	-	212.12	-	-	212.12	
Slush Grout	m^2	28.53	2.03	0.15	-	30.71	
Grouting Holes	m						
Grouting - Successful Connections	Unit						
Dry Cement for Grouting	kg						
Zone 1 Material	m^3	6.79	-	10.16	0.96	17.91	
Zone 1C Material	m^3	40.46	0.52	45.72	-	86.70	
Zone 2C Material	m^3	16.95	-	18.37	1.28	36.60	
Zone 2F Material	m^3	4.85	-	5.63	-	10.48	
Zone 2G Material	m^3	1.99	-	2.11	-	4.10	
Zone 3C Material	m^3	10.82	2.15	14.03	0.20	27.20	
Zone 3D Material	m^3	7.98	2.10	10.61	0.19	20.88	
Zone 3E Material	m^3	14.46	4.36	18.30	0.40	37.52	
Zone 4 Class 1 Material	m^3	27.66	2.51	38.48	0.23	68.88	
Zone 4 Class 2 Material	m^3	33.62	2.05	42.54	0.17	78.39	
Maintenance Grade No 3 Material	m^3	24.99	3.31	41.61	0.30	70.21	
Upstream Cement Bentonite Cut-Off Wall - Contractor Support	m^2	5.42	-	29.09	-	34.51	

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		Total Direct Craft Hours 228,980					
PRICE ITEM DESCRIPTION	UOM	MANPOWER COST Unit Rate	MATERIALS COST	EQUIPMENT COST Unit Rate	OTHERS / SUB COST	TOTAL Unit Rate	Comments
Geotextile Non-Woven Min. 300 g/m^2	m^2	1.93	3.47	0.31	-	5.71	Cost per UOM
DOWNSTREAM STABILIZATION							
Overburden Excavation - Zones 2F and 2G Material	m^3	4.44	-	6.99	-	11.43	
Overburden Excavation	m^3	3.90	-	6.09	-	9.99	
Zone 2A Material	m^3	18.77	0.00	19.96	1.69	40.42	
Zone 2C Material	m^3	19.27	-	21.68	2.46	43.42	
Zone 2E Material	m^3	24.79	-	27.35	2.67	54.81	
Zone 2F Material	m^3	2.89	-	3.41	-	6.30	
Zone 3A Material	m^3	19.08	2.99	27.15	0.27	49.49	
Zone 3C Material	m^3	10.26	2.67	13.23	0.24	26.41	
Zone 3D Material	m^3	6.47	1.90	8.54	0.17	17.08	
Zone 3E Material	m^3	8.29	1.49	12.46	0.14	22.38	
Zone 4 Class 3 Material	m^3	25.89	2.10	34.62	0.19	62.80	
Maintenance Grade No 3 Material	m^3	31.71	5.11	57.24	0.47	94.53	
Overburden Excavation Finger Drains	m^3	3.02	0.00	4.81	-	7.83	
Zone 2A Material	m^3	23.59	0.00	26.24	2.37	52.20	
Zone 2F Material	m^3	4.34	-	5.65	-	9.99	
Zone 3A Material	m^3	34.29	5.60	49.50	0.51	89.90	
Refurbishment of Existing Piezometer Shelter	Unit	-	68.27	-	-	68.27	
Multiconductor Cable, 4-conductor, 2 twisted pairs	m	11.86	-	6.05	-	17.91	
Multiconductor Cable, 10-conductor, 5 twisted pairs	m	9.74	-	4.38	-	14.11	
Instrumentation Shelter	Unit	3,369.75	149.36	2,176.60	8.58	5,704.29	
Relief Well	Unit						
Geotextile Non-Woven Min. 300 g/m^2	m^2	3.33	2.04	0.25	-	5.62	
Geotextile Non-Woven Min. 530 g/m^2	m^2	-	5.86	-	-	5.86	
SUB-TOTAL DOWNSTREAM STABILIZATION		6.55	0.51	8.82	0.16	16.04	
CREST							
Overburden Excavation - Zones 2F and 2G Material	m^3	1.37	-	1.83	-	3.20	
Overburden Excavation	m^3	6.99	-	9.92	-	16.91	

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		Total Direct Craft Hours 228,980					
PRICE ITEM DESCRIPTION	UOM	MANPOWER COST Unit Rate	MATERIALS COST	EQUIPMENT COST Unit Rate	OTHERS / SUB COST	TOTAL Unit Rate	Comments
North-West Cement Bentonite Cut-Off Wall - Contractor Support	m^2	7.73	-	7.47	-	15.20	
Zone 2F Material	m^3	4.62	-	5.52	-	10.14	
Sub Total CREST		3.27	-	3.99	-	7.26	
LAKES STABILIZATION							
Overburden Excavation - Zones 2F and 2G Material	m^3	1.94	-	3.04	-	4.97	
Overburden Excavation	m^3	5.60	-	8.38	-	13.98	
Zone 2C Material	m^3	6.75	-	10.13	0.52	17.40	
Zone 3C Material	m^3	5.69	1.05	9.00	0.10	15.84	
Zone 4 Class 3 Material	m^3	13.98	0.43	17.49	0.04	31.94	
Rockfill Type 1 Material	m^3	22.48	1.66	37.94	0.15	62.23	
Rockfill Type 2 Material	m^3	12.31	1.23	16.53	0.11	30.18	
Geotextile Non-Woven Min. 300 g/m^2	m^2	1.92	1.34	0.01	-	3.27	

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			First Shift				Second Shift			
Equipment	**Manufacturer & Model Number**	**Size**	**Hour $CAD**	**Day $CAD**	**Week $CAD**	**Month $CAD**	**Hour $CAD**	**Day $CAD**	**Week $CAD**	**Month $CAD**
Articulated Truck	Cat 740	40T	$230	$2,300	$11,500	$40,480	$196	$1,955	$9,775	$34,408
Boom Truck	International	30 Ton	$190	$1,900	$9,500	$33,440	$162	$1,615	$8,075	$28,424
Compressor	TBD	185 CFM	$45	$450	$2,250	$7,920	$38	$383	$1,913	$6,732
Concrete Mixer Truck	TBD		$140	$1,400	$7,000	$24,640	$119	$1,190	$5,950	$20,944
Crane	TBD	250 Ton	$425	$4,250	$21,250	$74,800	$361	$3,613	$18,063	$63,580
Crane	TBD	275 Ton	$445	$4,450	$22,250	$78,320	$378	$3,783	$18,913	$66,572
Crane	TBD	60 Ton	$220	$2,200	$11,000	$38,720	$187	$1,870	$9,350	$32,912
Crane	TBD	90 Ton	$300	$3,000	$15,000	$52,800	$255	$2,550	$12,750	$44,880
Aggregate Proccessing Plant	TBD		$3,600	$36,000	$180,000	$633,600	$3,060	$30,600	$153,000	$538,560
Dozer	Cat D5		$185	$1,850	$9,250	$32,560	$157	$1,573	$7,863	$27,676
Dozer	Cat D6	20T	$214	$2,140	$10,700	$37,664	$182	$1,819	$9,095	$32,014
Dozer	Cat D8/Kom 155	40T	$350	$3,500	$17,500	$61,600	$298	$2,975	$14,875	$52,360
Dozer	Cat D9		$450	$4,500	$22,500	$79,200	$383	$3,825	$19,125	$67,320
Excavator	Takeuchi	3T	$72	$720	$3,600	$12,672	$61	$612	$3,060	$10,771
Excavator	Cat 308	8T	$100	$1,000	$5,000	$17,600	$85	$850	$4,250	$14,960
Excavator	Cat 315		$160	$1,600	$8,000	$28,160	$136	$1,360	$6,800	$23,936
Excavator	Cat 320	20T	$180	$1,800	$9,000	$31,680	$153	$1,530	$7,650	$26,928
Excavator	Cat 330/336		$230	$2,300	$11,500	$40,480	$196	$1,955	$9,775	$34,408
Excavator	John Deere	30T	$230	$2,300	$11,500	$40,480	$196	$1,955	$9,775	$34,408
Excavator	Cat 345	45T	$350	$3,500	$17,500	$61,600	$298	$2,975	$14,875	$52,360
Excavator	Cat 365/374		$380	$3,800	$19,000	$66,880	$323	$3,230	$16,150	$56,848
Excavator	Cat 385/390		$500	$5,000	$25,000	$88,000	$425	$4,250	$21,250	$74,800
Excavator	Cat 430		$100	$1,000	$5,000	$17,600	$85	$850	$4,250	$14,960
Excavator	Komatsu PC600	65T	$380	$3,800	$19,000	$66,880	$323	$3,230	$16,150	$56,848
Excavator	Komatsu PC1250		$600	$6,000	$30,000	$105,600	$510	$5,100	$25,500	$89,760
Forklift Variable Reach	TBD	varies	$125	$1,250	$6,250	$22,000	$106	$1,063	$5,313	$18,700
Front End Loader 216Hp	Cat 950	2.68	$165	$1,650	$8,250	$29,040	$140	$1,403	$7,013	$24,684
Front End Loader 283Hp	Cat 966	3.6	$200	$2,000	$10,000	$35,200	$170	$1,700	$8,500	$29,920
Front End Loader 392Hp	Cat 980	4.2	$350	$3,500	$17,500	$61,600	$298	$2,975	$14,875	$52,360
Front End Loader 555Hp	Cat 988	6	$390	$3,900	$19,500	$68,640	$332	$3,315	$16,575	$58,344
Generator	TBD	10 KW	$20	$200	$1,000	$3,520	$17	$170	$850	$2,992
Generator	TBD	15 KW	$29	$290	$1,450	$5,104	$25	$247	$1,233	$4,338
Generator	TBD	25 KW	$33	$330	$1,650	$5,808	$28	$281	$1,403	$4,937
Generator	TBD	45 KW	$45	$450	$2,250	$7,920	$38	$383	$1,913	$6,732
Generator	TBD	185 KW	$150	$1,500	$7,500	$26,400	$128	$1,275	$6,375	$22,440
Heater	TBD	350,000 BTU	$32	$320	$1,600	$5,632	$27	$272	$1,360	$4,787
Heater	TBD	400,000 BTU	$32	$320	$1,600	$5,632	$27	$272	$1,360	$4,787
Heater	TBD	500,000 BTU	$33	$330	$1,650	$5,808	$28	$281	$1,403	$4,937
Haul Truck	Cat 773	60 Ton	$310	$3,100	$15,500	$54,560	$264	$2,635	$13,175	$46,376
Haul Truck	Cat 775	70 Ton	$350	$3,500	$17,500	$61,600	$298	$2,975	$14,875	$52,360
Hydraulic Breaker for 330 Exc.	Cat	H-140	$155	$1,550	$7,750	$27,280	$132	$1,318	$6,588	$23,188
Hydraulic Breaker for 345 Exc.	Cat		$200	$2,000	$10,000	$35,200	$170	$1,700	$8,500	$29,920
JLG (Boom Lift)	TBD	60 ft.	$60	$600	$3,000	$10,560	$51	$510	$2,550	$8,976
JLG (Boom Lift)	TBD	80 ft.	$128	$1,280	$6,400	$22,528	$109	$1,088	$5,440	$19,149
Light Towers	TBD	4000W	$34	$340	$1,700	$5,984	$29	$289	$1,445	$5,086
Motor Grader	Cat 14H	14H	$120	$1,200	$6,000	$21,120	$102	$1,020	$5,100	$17,952

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Equipment	Manufacturer & Model Number	Size	Hour $CAD	Day $CAD	Week $CAD	Month $CAD	Hour $CAD	Day $CAD	Week $CAD	Month $CAD
Oil/Fuel Truck	TBD		$220	$2,200	$11,000	$38,720	$187	$1,870	$9,350	$32,912
Pickup	Ford F-150	3/4 T	$25	$250	$1,250	$4,400	$21	$213	$1,063	$3,740
Pressure Washer	TBD	10,000 PSI	$75	$750	$3,750	$13,200	$64	$638	$3,188	$11,220
Pump	TBD	4"	$20	$200	$1,000	$3,520	$17	$170	$850	$2,992
Pump	TBD	6"	$28	$280	$1,400	$4,928	$24	$238	$1,190	$4,189
RCC Batch Plant Only	TBD		$2,000	$20,000	$100,000	$352,000	$1,700	$17,000	$85,000	$299,200
Rock Drill	TBD		$220	$2,200	$11,000	$38,720	$187	$1,870	$9,350	$32,912
Shuttle Bus (20 Passenger)	TBD	TBD	$50	$500	$2,500	$8,800	$43	$425	$2,125	$7,480
Skid Steer Loader	Cat	279	$45	$450	$2,250	$7,920	$38	$383	$1,913	$6,732
Tandem	Various	15T	$150	$1,500	$7,500	$26,400	$128	$1,275	$6,375	$22,440
Tandem Tandem	Various	20T	$175	$1,750	$8,750	$30,800	$149	$1,488	$7,438	$26,180
Telebelt	Putzmiester		$250	$2,500	$12,500	$44,000	$213	$2,125	$10,625	$37,400
Tractor	John Deere	9520	$150	$1,500	$7,500	$26,400	$128	$1,275	$6,375	$22,440
Tractor/Trailer	TBD	TBD	$175	$1,750	$8,750	$30,800	$149	$1,488	$7,438	$26,180
Van (12 Passenger)	TBD	TBD	$28	$280	$1,400	$4,928	$24	$238	$1,190	$4,189
Vacuum Truck	TBD		$160	$1,600	$8,000	$28,160	$136	$1,360	$6,800	$23,936
Vibratory Roller	Cat CS56	12T	$92	$920	$4,600	$16,192	$78	$782	$3,910	$13,763
Vibratory Roller	Cat CS583		$140	$1,400	$7,000	$24,640	$119	$1,190	$5,950	$20,944
Water Truck	International	TBD	$80	$800	$4,000	$14,080	$68	$680	$3,400	$11,968

Notes:

1. The rates include:
   - Cost of equipment rental
   - fuel and lubricants
   - labour & equipment for fueling
   - spare parts and installation
   - transportation and handling of equipment
   - general overhead, mark-up and profit
   - insurance
2. The rates exclude operator's labour costs
3. Daily Rates are based on 10 hours
4. Weekly Rates are based on 70 hours

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Appendix V

Typical Section for Road, Slope Re-Profiling and Sedimentation Pond

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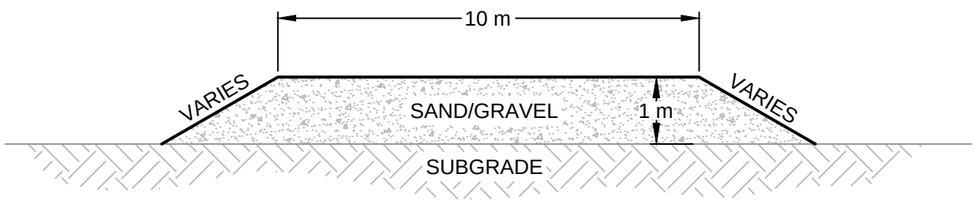
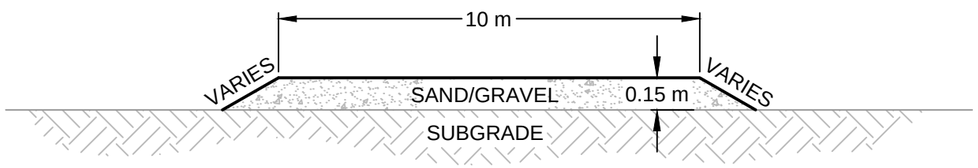
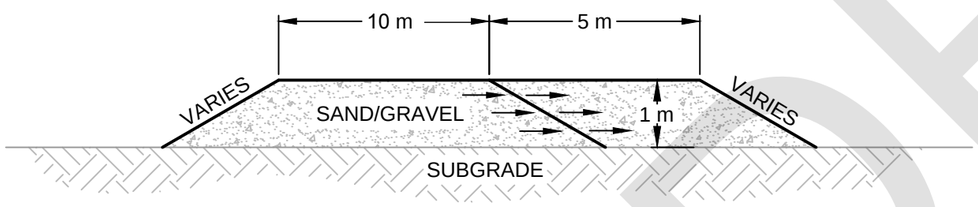
TYPICAL ROAD CONSTRUCTION DETAILS



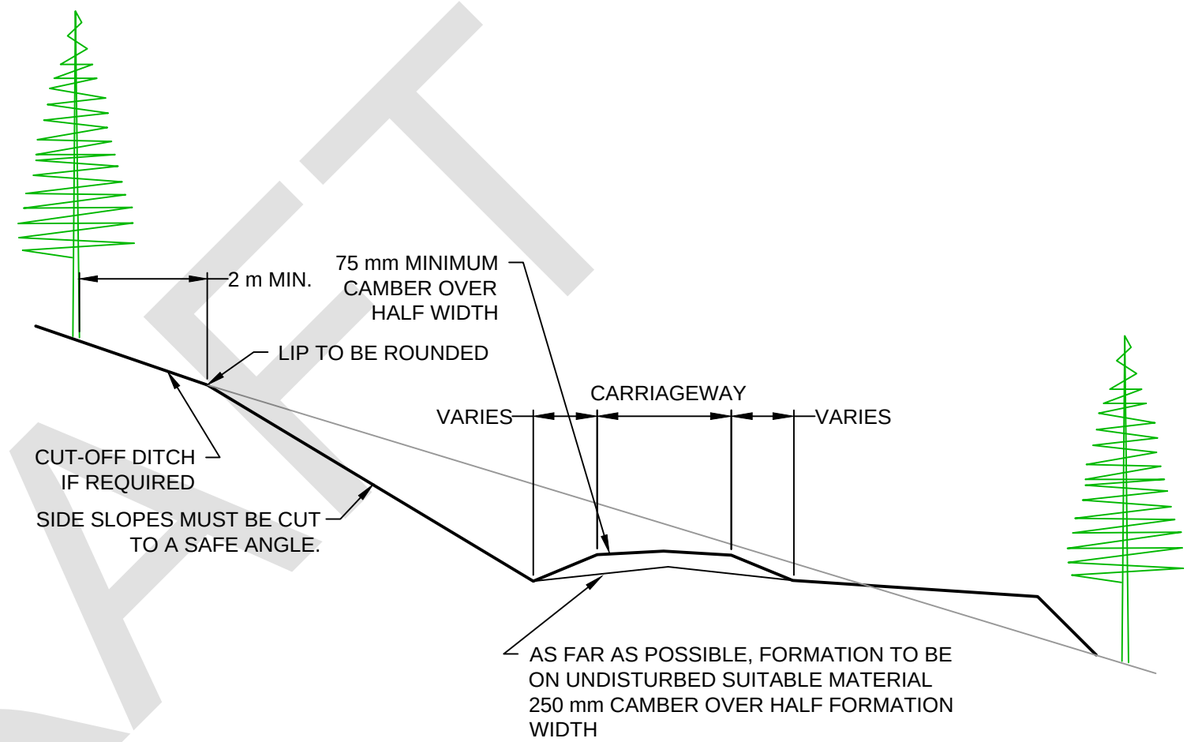
ABOVE GRADE



FROZEN SUBGRADE



WIDENED SECTION



TYPICAL ROAD CROSS-SECTIONAL DETAILS

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NOT FOR CONSTRUCTION

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NOTES

1. ROADS WILL BE CONSTRUCTED FROM SAND IF THEY ARE ABOVE GRADE, SURFACING WILL BE SAND OR GRAVEL.
2. IF ROADS ARE CONSTRUCTED ON WEAK BUT FROZEN CLAYS SOME SAND OR GRAVEL FOR TRAFFICABILITY.
3. ROADS CONSTRUCTED ON SAND CAN BE CONSTRUCTED DOWN THROUGH THE ORGANICS ONTO CLAYS.
4. A 10 m NOMINAL WIDTH AND WIDEN TO 15 m WHERE REQUIRED TO ALLOW PASSING AND TWO WAY TRAFFIC.
5. THESE ARE PROVISIONAL AND TYPICAL SECTIONS USED TO GENERATE VOLUMES AND COST ESTIMATES.
6. THE DIMENSIONS ARE PRELIMINARY DESIGN AND FOR COST ESTIMATION, DETAILS WILL VARY DEPENDING ON LOCAL TOPOGRAPHY AND GROUND CONDITIONS

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP
0	-	-	-	-	-

REFERENCE DRAWINGS

DWG No	DESCRIPTION
-	-

NOT TO SCALE

SNC·LAVALIN

CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE: MUSKRAT FALLS: TYPICAL ROAD CROSS-SECTIONS

DES BY WH	DRN BY AC	DATE 2017 12 20	FIG No -	REV 0
CHK BY -	APP BY -	DWG No -		11X17

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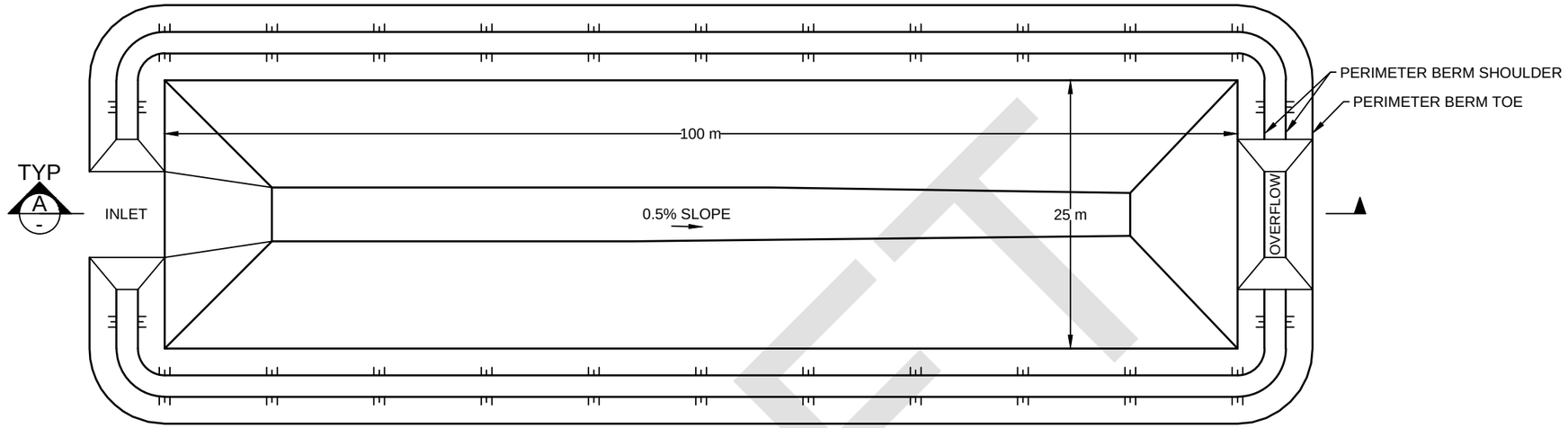

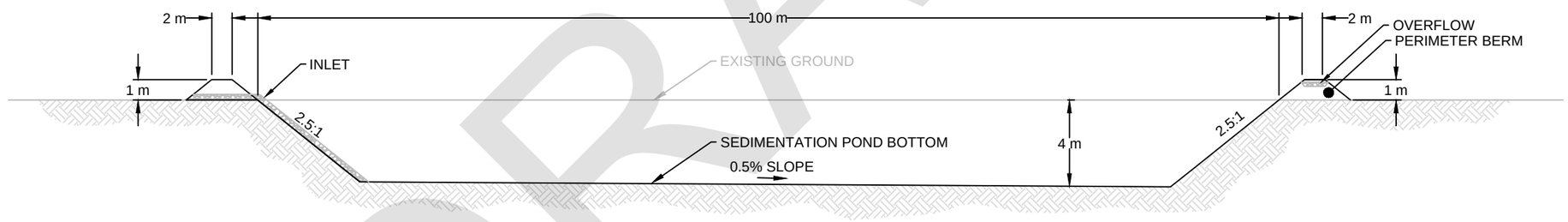

A
-
SECTION VIEW
SCALE H 1:500
V 1:250

NOT FOR CONSTRUCTION

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NOTES

1. SEDIMENTATION PONDS TO BE BUILT, ON AVERAGE, EVERY 1.5 km WITH RANGE OF 1 km TO 2 km.
2. SIZE OF POND DEPENDS ON SOIL TYPE IN THE AREA.
3. FOR SAND OR SILT SOIL TYPES, IT MUST BE IN LOW LYING AREAS SO THAT IT CAN BE DETAINED BEFORE RUN DOWN TO THE RIVER.
4. A 4 m DEPTH HAS BEEN ASSUMED FOR COST ESTIMATES.
5. BERMS CAN BE CONSTRUCTED FROM EXCAVATED MATERIAL. DEPTHS AND OTHER DIMENSIONS WILL BE MODIFIED BASED ON GROUND CONDITIONS AND SITE SPECIFIC ISSUES SUCH AS TOPOGRAPHIC LIMITATIONS.

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP
0	-	-	-	-	-

REFERENCE DRAWINGS

DWG No	DESCRIPTION
-	-

1:500 0 5 10 15 20 m
1:250 0 2.5 5 7.5 10 m

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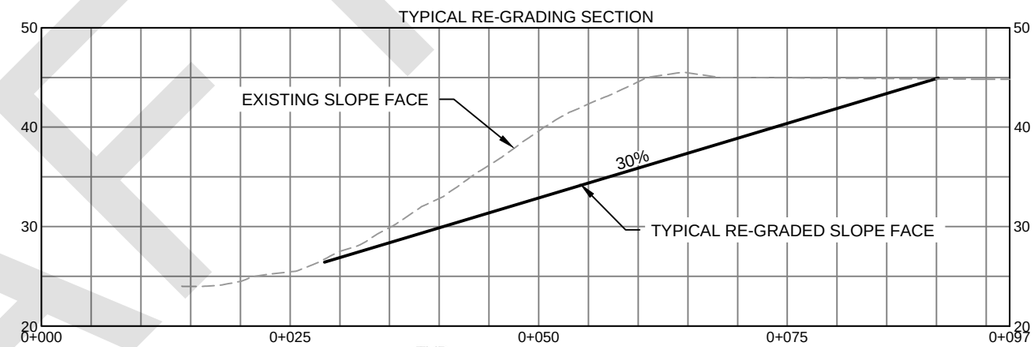
CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: TYPICAL SEDIMENTATION POND DETAIL

DES BY	WH	DRN BY	AC	DATE	2017 12 20	FIG No	-	REV	0
CHK BY	-	APP BY	-	DWG No	-			11X17	

G:\CADD_Data\505573-CAD\505573.dwg

PLAN VIEW
SCALE 1:5,000



TYP
A
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SECTION VIEW
SCALE 1:600

NOT FOR CONSTRUCTION

DRAFT

NOTES

1. A 30% SLOPE BELOW 42 m WAS CONSIDERED FOR RE-PROFILING FOR THE AREAS IDENTIFIED WITH SENSITIVE CLAYS.
2. VOLUME ESTIMATES FOR THE RE-PROFILING IS BASED ON 4 TYPICAL CROSS-SECTIONS THAT ARE RANDOMLY SELECTED FROM THE SOUTH AND NORTH BANK.
3. IN ORDER TO IDENTIFY SENSITIVE CLAY THROUGHOUT THE FUTURE RESERVOIR AREA AVAILABLE GIS DATA FOR 3 SOIL TYPES - GLACIOFLUVIAL, GLACIOMARINE, AND TILL WAS CONSIDERED.
4. THE SLOPE ANGLE SELECTED IS BASED ON THE ASSUMPTION THAT FOR A PERIOD OF UP TO ONE YEAR BEYOND CONSTRUCTION THE SLOPES WILL BE ABOVE RESERVOIR WATER LEVEL.
5. FINISHED REGRADED SURFACE WILL BE COVERED WITH 0.5 m CLAY/SAND MIX TO PROVIDE LIMITED EROSION PROTECTION AND MATERIAL TO ALLOW VEGETATION TO REGROW ON UPPER SLOPES (ABOVE 42 masl).
6. A MAINTENANCE PERIOD FOR SLOPES, DRAINAGE AND SEDIMENTATION PONDS IS ASSUMED WHICH WILL CONTINUE UNTIL JULY OF 2020.

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	APP
0	-	-	-	-	-

REFERENCE DRAWINGS

DWG No	DESCRIPTION
-	-

1:600 0 5 10 15 20 25 m
1:5,000 0 50 100 150 200 m

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CLIENT	PROJECT LOCATION
NALCOR ENERGY	MUSKRAT FALLS, NL

TITLE
MUSKRAT FALLS: TYPICAL
PLAN & PROFILE VIEW OF 30% RE-PROFILING

DES BY	WH	DRN BY	AC	DATE	2017 12 20	FIG No	-	REV	0
CHK BY	-	APP BY	-	DWG No	-			11X17	

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