Webequie Supply Road Project

Webequie First Nation

January 15, 2026

AtkinsRéalis Ref: 661910

APPENDIX D-1: PRELIMINARY ENGINEERING DESIGN REPORT

AtkinsRéalis

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE FIRST NATION

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Preface

This document is an interim edition of the Preliminary Engineering Design Report (PEDR) for the Webequie Supply Road Project (WSR, “the Project”). It is based on engineering investigations conducted during the coordinated provincial Environmental Assessment (EA) and federal Impact Assessment (IA) process for the Project and should be read in conjunction with the EA Terms of Reference, federal Tailored Impact Statement Guidelines for the Project and draft Environmental Assessment Report/Impact Statement. The approaches to and results of the investigations have been informed by input from the Project Team discipline specialists, as well as the outcomes of the engagement and consultation activities completed as part of the EA/IA for the Project.

The purpose of the Interim PEDR is to document the engineering design completed to date for the Project, which includes a description of design considerations, applicable design criteria and the preliminary design components of the road. The design work has focussed on the set of supply road alternative routes within the preliminary proposed corridor identified in the Terms of Reference (ToR) and federal Detailed Project Description for further evaluation in the EA/IA.

As the Project proceeds through the EA/IA process, additional refinements to the existing route alternatives and/or to recommended design components may be considered. This may result in modifications to the findings and proposals presented in this Interim PEDR. Related changes will be documented and included in the final PEDR, as will EA/IA commitments applicable to mitigation; further technical investigations; and consultation activities that may affect the detail design and implementation of the Project.

Executive Summary

Webequie First Nation retained AtkinsRéalis Canada Inc.[1] (AtkinsRéalis) to carry out a provincial Environment Assessment (EA) and federal Impact Assessment (IA) for the Webequie Supply Road Project, including the supportive preliminary engineering design for the road. The Project is located in north-western Ontario on un-surveyed Ontario Crown lands and Webequie First Nation Reserve lands approximately 525 km northeast of the City of Thunder Bay as shown in **Figure 1.1**.

The Project will serve to link the Webequie First Nation community to the McFaulds Lake area facilitating the movement of materials, supplies and people from the Webequie Airport to the area of existing mineral exploration activities and proposed mine developments. The Webequie Supply Road is also proposed to connect to other proposed projects in the region, specifically the Northern Road Link Project and Marten Community Access Road project that would allow for connection to the Ontario highway network.

The proposed Webequie Supply Road is a new two-lane all-season road within a cleared right-of-way (ROW) of approximately 35 metres (m) in width and approximately 107 km in length. The preliminary recommended preferred route for the road consists of a northwest-southeast segment running 51 km from the Webequie First Nation Reserve to a 56 km segment running East-West before terminating near the McFaulds Lake within the mineralized deposit area known as the Ring of Fire. A total of 17 km of the WSR is within the Webequie First Nation Reserve lands, with the remainder of the road located on un-surveyed Ontario Crown lands.

Webequie First Nation is completing a coordinated EA under Ontario's *Environmental Assessment Act* (EA Act) and IA under Canada's *Impact Assessment Act* (IA Act) for the proposed Webequie Supply Road. For the Project, the two levels of government have indicated a willingness to follow a coordinated assessment process to the extent possible, and for the proponent (i.e., Webequie First Nation) to produce one body of documentation, referred to as the Environmental Assessment Report/Impact Statement (EAR/IS). To help facilitate a coordinated process, an EA Coordination Team has been established for the Project and includes representatives of both the federal and provincial governments. The purpose of this team is to address and coordinate the requirements of both processes in an efficient manner.

The Webequie Supply Road will be designed and constructed to Ontario Ministry of Transportation (MTO) standards and guidelines. The WSR is classified as a Rural Collector Undivided with an 80 km/h design speed and posted at 80 km/h as is the Ministry's practice in Northeastern Region on similar highways.

The purpose of this Interim Preliminary Engineering Design Report (PEDR) is to document the engineering design completed to date for the Project, which includes, development of route alternatives, a general description of design considerations and design criteria as well as the design components of the proposed preliminary preferred route for the Webequie Supply Road. The PEDR should be read in conjunction with the draft EAR/IS to fully understand existing environmental conditions and sensitivities, consideration and evaluation of alternatives, effects assessment and the engagement and consultation conducted to date to seek feedback during the EA/IA process.

As part of the EA/IA process requirement, the Project Team identified and evaluated alternative methods of carrying out the undertaking, including route alternatives and aggregate sources areas needed for construction and operations of the Webequie Supply Road. Having identified a preliminary preferred corridor for the Webequie Supply Road during the EA ToR phase and Planning Phase of the IA, the Project Team evaluated three alternative routes that were given numeric identifiers, as follows: Webequie First Nation Community Preferred Route (Alternative 1); Optimized Geotechnical Route (OGR - Alternative 2) and Optimized Engineering Route (OER, Alternative 3). From this evaluation

[1] Formerly known as SNC-Lavalin Inc.

the recommended preliminary preferred route for the WSR is the Optimized Engineering Route – Alternative 3, which is the focus of this PEDR.

To support EA's/IA's for transportation infrastructure projects, engineering design is typically completed to the preliminary design level. For this Project, engineering has been completed to a higher level of design, but detail design has not been completed. Depending on the Project component, engineering has been completed to the preliminary design level and some components advance to a 60 and 80 percent design level. The purpose of this additional advance engineering is to address key risk components and ensure appropriate design consideration and mitigation has been completed. Given the remote location, this additional engineering work will ensure that the detail design phase for the Project can be completed in an efficient manner, and that environmental issues have been clearly and thoroughly evaluated, including identifying mitigation to minimize and/or avoid adverse effects.

There are 31 water crossings anticipated for the Project, including two large bridge crossings at Winisk Lake and the Muketei River, both of which have been developed to allow for larger boat navigation. There is a proposed total of six (6) bridge structures, 19 steel box culverts (steel plate arches) and six (6) large diameter corrugated steel pipe culverts identified. This will be in addition to smaller locally situated culverts used for smaller watercourses plus additional small culverts for equalization, and overland sheet flow. It is anticipated that the bridge structures will consist of a concrete slab on steel girder type for consistency.

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E: Preliminary Design Criteria
F: Hydrologic and Hydraulic Analysis for the Webequie First Nation Supply Road
G: Horizontal Alignment Data Report
H: Vertical Alignment Data Report
I: Optimized Engineering Route Plan Drawings
J: Structural General Arrangement Drawings

1 Overview of the Undertaking

1.1 Summary Description of the Undertaking

The proposed Webequie Supply Road (WSR) Project is a new all-season road of approximately 107 km in length from Webequie First Nation to the mineral deposit area near McFaulds Lake (also referred to as the Ring of Fire) in north-western Ontario. A Location Plan for the Project is shown on **Figure 1.1**.

The preliminary recommended preferred route for the road consists of a northwest-southeast segment running approximately 51 km from Webequie First Nation to an approximately 56 km segment running east, before terminating near McFaulds Lake. The first 17 km of the corridor from its western origin is located within Webequie First Nation Reserve lands. The Project will also include temporary and permanent supportive infrastructure elements, such as aggregate extraction and processing areas, Maintenance and Storage Facility, respite areas, access roads, laydown/storage yards and construction camps.

The Project proponent is Webequie First Nation, an Ojibway community located approximately 525 km north of Thunder Bay. Webequie is a fly-in community with no summer road access, and a total registered on-reserve population of 923 people (Indigenous Services Canada, 2019). Webequie is a fly-in remote community with a seasonal winter road used for access during the months of January and February.

Based on the scale and complexity of the Project, and the potential for significant environmental effects, a comprehensive provincial Environmental Assessment (EA) must be completed for approval under the Ontario *Environmental Assessment Act* (EA Act). In October 2021, a Notice of Approval of the Terms of Reference (ToR) for Webequie Supply Road was issued by the Ministry of the Environment, Conservation and Parks (MECP), defining the framework for preparing the EA for the Project. The Webequie Supply Road is also subject to approval under the federal *Impact Assessment Act (*IA Act). From a review of the Detailed Project Description, and the results of associated engagement and consultation activities, the Impact Assessment Agency of Canada (“the Agency”) on December 2, 2019 issued a Notice of Decision that a federal IA must be prepared, based on the significance of anticipated project effects. Following completion of the Planning Phase of the IA the Agency posted a Notice of Commencement of the IA for the Project to their Registry on February 24, 2020. The status and overview of the provincial EA and federal IA for the Project is described in **Section 2**.

1.1.1 Project Background and Context

To provide context and background for the proposed development of the Webequie Supply Road it is important to understand the various relevant road/transportation studies that have been completed in the region. These studies include:

- Winter Road Re-Alignment Study (2008);
- Cliffs Ferroalloys Black Thor Mine Integrated Transportation System (2011);
- Noront Resources Eagle’s Nest Mine Access Road (2013);
- All-Season Community Road Study (2016);
- All-Season Community Road Study – Phase 2 (2017);
- Update of Cliff Natural Resources 2013 All Weather Roads Operations Strategy for First Nations Road Proponents (2019); and
- Noront Resources Eagles Nest Access Road Traffic Study (2022).

The reader can find detailed descriptions of these studies in the draft EAR/IS for the Project. The above studies, as background and context, provide the foundation for the development of the proposed WSR, and are linked to the significant mineral potential in and around the McFaulds Lake area (also referred to as Ring of Fire Area) that has been well documented. In particular, the All-Season Community Road Study and refined Phase 2 study helped to guide Webequie First Nation to identify the current preferred corridor for the Project, including consideration of alternatives.

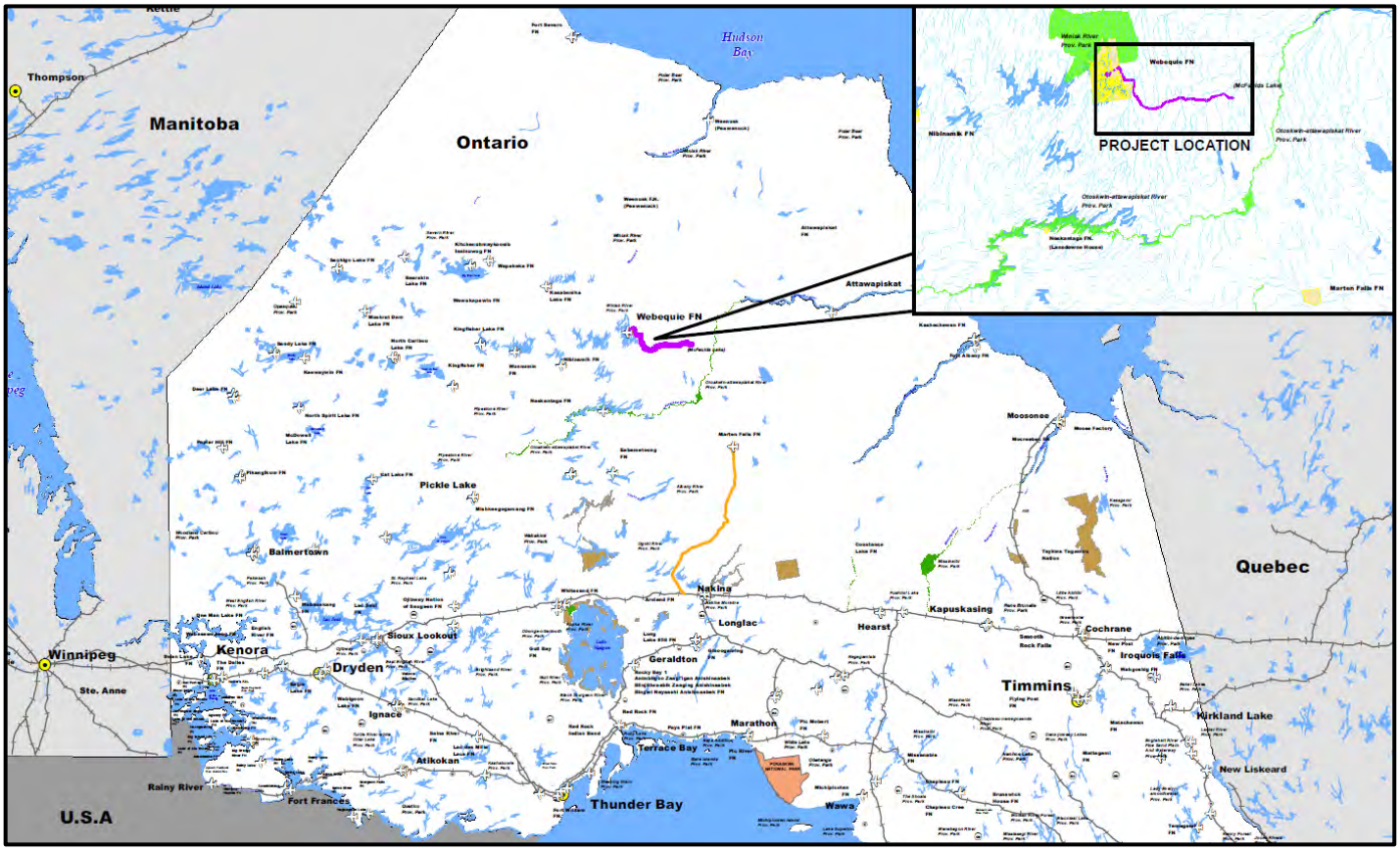
In these studies, routing considerations, such as distance (and cost) to access either the provincial highway system and/or the national railway system, were examined, as were other factors considered to be important for identifying the optimum routes for connecting infrastructure, including but not limited to:

- Potential social and economic impacts and benefits to First Nation communities in the region;
- Environmental impacts;
- Constructability (such as the availability of well-drained land and access to aggregate materials);
- Distance to potential processing facilities; and
- Safety of road users (i.e., dedicated versus mixed commercial and non-commercial traffic).

In summary, the cited studies examined alternative road connections between the provincial highway system near Pickle Lake, several First Nations to the north, and the proposed Noront Resources Eagle's Nest mine in the McFaulds Lake area. The preferred road corridor coming out of these studies is commonly referred to as the East-West alignment.

In 2018, studies were initiated to further examine an all-season road interconnection between Nakina (near Geraldton) in the Greenstone Region and the Marten Falls First Nation, with longer term consideration of a continuation of that road north to the Ring of Fire Area. Marten Falls First Nation is currently leading a coordinated federal-provincial EA/IA process for the Marten Falls Community Access Road, which would connect Marten Falls First Nation to the provincial highway network via a connection to Painter Lake Road. This EA/IA is ongoing at the same time as the Webequie Supply Road EA/IA. In addition, as a separate project, Marten Falls First Nation and Webequie First Nation in 2021 initiated a federal-provincial EA/IA for an all-season road that would link the Marten Falls Community Access Road and Webequie Supply Road, referred to as the Northern Road Link (NRL) project. The purpose of the NRL project is to: connect the Ring of Fire mineral deposit in the McFaulds Lake area to the highway network via Marten Falls Community Access Road; provide an opportunity to connect Webequie First Nation to the highway network; and to enable a broader range of economic activity by facilitating the transport of goods, services and resources.

Figure 1.1: Project Location

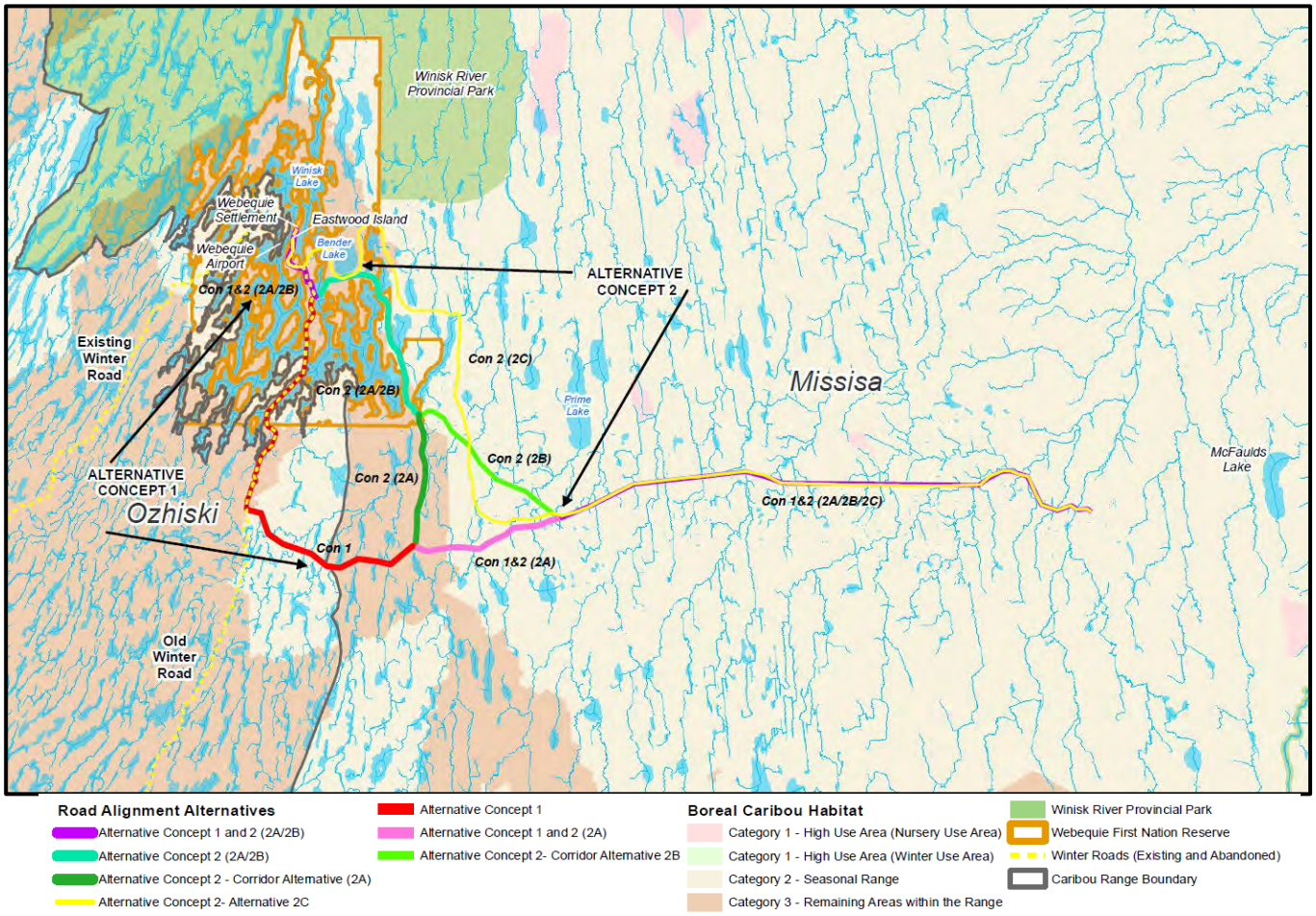


1.2 Summary of Project Alternatives and Assessment to Date

During preparation of the ToR, and as presented in Section 3 the draft EAR/IS, the Project Team assessed the advantages and disadvantages of a range of “alternatives to” the Project (i.e., functionally different ways of approaching the opportunities identified by Webequie First Nation to improve the community’s economic and social well-being) and concluded that the preferred option is the construction of a new all-season road between Webequie and the McFaulds Lake area.

Alternative methods of implementing the new all-season road, referred to as “Alternative Concepts”, were developed based on the aforementioned road/transportation studies, and are considered to be complementary to Webequie First Nation’s draft Community Based Land Use Plan. Each road corridor under consideration is approximately 2 km in width, within which the Webequie Suppl Road (35 m right-of-way [ROW]) is proposed to be located generally along the centreline of the corridor. The two (2) sets of supply road corridors considered (Alternative Concepts 1 and 2) are shown in **Figure 1.2**. The Alternative Concepts were initially screened using criteria important to Webequie First Nation community members, as well as a broader range of criteria required under the EA Act, to identify a “community preferred” corridor (identified as Alternative 2C and C Series (yellow option) in **Figure 1.2**).

Figure 1.2: Corridor Alternative Concepts



Having identified the preliminary preferred corridor for the WSR (Alternative 2C), the Project Team moved to the next step of identifying route alternatives within the approximately 2 km wide corridor for further evaluation in the EA/IA with consideration and input from stakeholders and Indigenous communities.

The alternate routes within the preferred corridor that were identified for evaluation included the Webequie First Nation community's preferred route, the optimal geotechnical route, and the optimal engineering route shown on **Figure 1.3**. All three of these potential routes were standardized to a 35 m ROW to allow for a fair comparison. The potential routes were given numeric identifiers as follows:

- Alternative 1 = Webequie First Nation community's preferred route;
- Alternative 2 = Optimal Geotechnical Route; and
- Alternative 3 = Optimal Engineering Route.

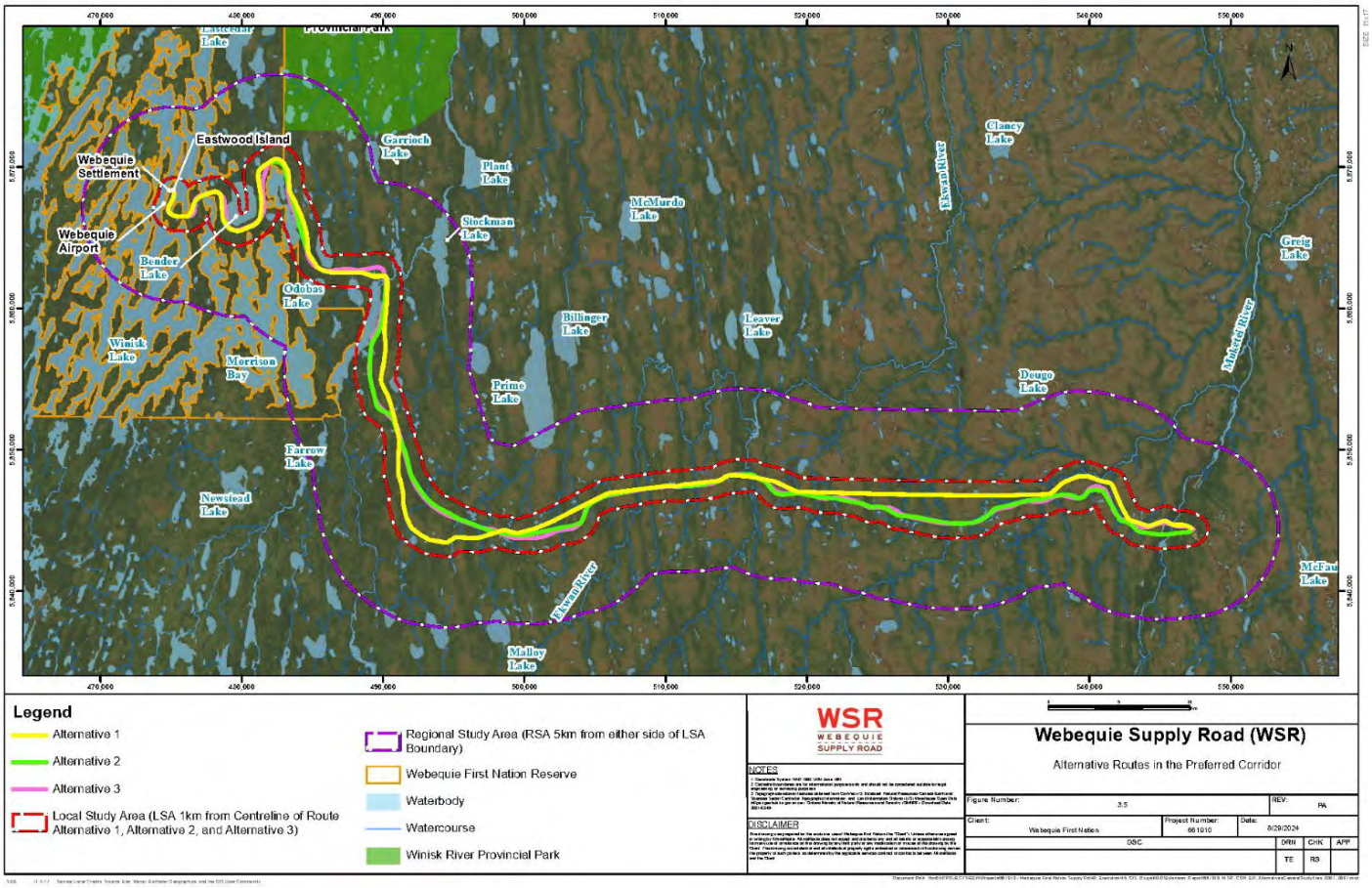
The evaluation of the alternative routes within the preferred corridor for WSR was structured on the basis of Factors, Disciplines, Criteria and Indicators with consideration of feedback received from the public, stakeholder and Indigenous communities. The factors, criteria and indicators for the route selection are anchored in those presented in the ToR and the Valued Components identified for the EA/IA. Route selection indicators were identified by subject matter experts considering their value/ability to discern meaningful differences between the route alternatives and enable comparison and route selection decisions. The broad categories or factors used for evaluation of the route alternatives were:

- Indigenous Land Use and Interests;

- Biological Environment;
- Physical Environment;
- Socio-Economic Environment; and
- Technical Considerations (cost, constructability, safety, etc.).

Further details on the assessment of Project alternatives, including the criteria and indicators used, are presented in Section 3 and Appendix 3B of the draft EAR/IS. Based on the evaluation of route alternatives, the recommended preliminary preferred route for the Webequie Supply Road is Alternative 3 – Optimal Engineering Route.

Figure 1.3: Webequie Supply Road Route Alternatives



1.3 Purpose of the Project

The goals and objectives of the Webequie Supply Road Project are as follows:

- To facilitate the movement of materials, supplies and people from the Webequie Airport to the area of existing mineral exploration activities and proposed mine developments in the McFaulds Lake area;
- To provide employment and other economic development opportunities to Webequie First Nation community members and businesses that reside in or around the community's reserve and traditional territory, while preserving their language and culture; and
- To provide experience/training opportunities for youth to help encourage pursuit of additional skills through post-secondary education.

1.4 Purpose and Outline of the Report

The purpose of this Interim Preliminary Engineering Design Report (PEDR) is to document the engineering design process for the Project, which includes examination of alternative routes, a description of design considerations, development of design criteria and description of the preliminary design components of the recommended preliminary preferred route for the Webequie Supply Road (Alternative 3 - Optimal Engineering Route).

The Interim PEDR is organized into the following sections:

- **Section 1** – Overview of the WSR Project, project background and context, and purpose of the report;
- **Section 2** – Overview and status of the coordinated provincial EA and federal IA for the Project;
- **Section 3** – Preliminary design approach and considerations, including development of the preferred route; and
- **Section 4** – Description of the optimized preliminary design features/components including cost estimate.

2 Overview and Status of Environmental Assessment

2.1 Regulatory Framework

2.1.1 Ontario Environmental Assessment Act

The Ontario EA Act embodies and enables a planning and decision-making process to ensure the protection, conservation, and wise management of the environment.

Projects can be classified as falling under either a Class Environmental Assessment (EA) process or a Comprehensive EA process.

Class Environmental Assessments apply to those projects that are deemed approved subject to compliance with an approved standardized planning process. This standardized planning process is for classes or groups of projects that are carried out routinely and have predictable environmental effects that can be largely mitigated. No formal approval under the Ontario EA Act is required, provided the procedural requirements of Class EA parent documents are followed, and a request to the Ontario MECP to make the Project subject to Part II of the EA Act (the preparation of a Comprehensive EA) is not granted.

Comprehensive Environmental Assessments are completed for those projects that are complex in nature, with the potential for significant environmental effects and require a decision by the Minister of the Environment, Conservation and Parks under the EA Act.

As noted in **Section 1.1**, the Webequie First Nation is undertaking a Comprehensive EA for the Webequie Supply Road Project. As part of the EA planning process, Webequie First Nation prepared and made available for review a draft ToR in September 2019 to seek input from the public, stakeholders and Indigenous communities and groups. The ToR is a document that establishes the framework for the planning and decision-making process during the EA and is submitted to the MECP for review and approval. The EA ToR for the Webequie Supply Road Project was approved in October 2021 and the formal Commencement of the EA occurred in November 2021. At the time of this report, Webequie First Nation is currently in the processing of releasing the Webequie Supply Road draft EAR/IS for review by the public, stakeholders and Indigenous communities.

2.1.2 Canada Impact Assessment Act

The Webequie Supply Road Project is also subject to the requirements under the federal IA Act. From a review of the Detailed Project Description, and the results of associated engagement and consultation activities, the Agency determined on November 29, 2019, that a federal IA must be prepared for the Webequie Supply Road Project. The principal steps in the IA process leading to a decision on the IA typically include:

- The Agency develops draft Tailored Impact Statement Guidelines (including the scope of the factors that are to be considered by the proponent in its Impact Statement as part of an Impact Assessment [IA]) and plans that will guide consultation and engagement, and consults with participating parties on these documents. Once finalized, the Agency provides the Tailored Impact Statement Guidelines and the plans to the proponent and posts the documents to the Impact Assessment Registry with the Notice of Commencement (end of the 180-day **Planning phase**; commencement of the **Impact Statement phase**). These activities occurred on February 24, 2020.
- Webequie First Nation is currently in the Impact Statement phase of the IA process and has three years to prepare and submit a satisfactory Impact Statement (EAR/IS) in accordance with the Tailored Impact Statement Guidelines. Due to the COVID-19 global pandemic, Webequie First Nation requested an extension to the Impact Statement phase. The date to submit a satisfactory EAR/IS to the Agency is January 6, 2027.

Once the Agency is satisfied with the content of the Impact Statement, the 300-day **Impact Assessment phase** begins, and the Agency prepares a draft Impact Assessment Report (IAR). The Agency considers comments received on the draft IAR, finalizes the IAR and potential conditions, and provides the IAR, potential conditions and Consultation Report to the Minister of Environment and Climate Change for a decision.

The status of the Impact Assessment Agency process for the Project can be accessed through the following link: https://iaac-aeic.gc.ca/050/evaluations/proj/80183.

3 Preliminary Engineering Approach

The approach to the development of the preliminary design was based upon the development of an Optimized Geotechnical Route (OGR, Alternative 2) using the Webequie First Nation community's preferred route as a reference point. Having identified the OGR the Project Team used this as the basis for development of the Optimized Engineering Route (OER, Alternative 3), which involved geometric optimization of the vertical and horizontal alignments, avoidance of sensitive environmental areas, and local adjustments to minimize the distance to potential aggregate sources.

3.1 Optimal Geotechnical Route

The optimal routing from a geotechnical standpoint was developed and presented in the report entitled *Webequie Supply Road: Terrain Analysis, Potential Aggregate Sources & Identification of Route Alternatives,* dated March 2019, and prepared by J.D. Mollard and Associates (JDMA). This report is provided in **Appendix A**.

In general, the OGR was identified through the use of terrain mapping and interpretation of remotely sensed imagery (air photos and satellite imagery) and digital elevation data, supplemented with surficial geology, hydrology, and land cover data, to characterize the landforms, surficial materials, topography, hydrology, etc. Field investigations were conducted to determine peat thickness, peat characteristics, permafrost locations/extent, surface water conditions, groundwater conditions and assess potential aggregate resources.

Subsurface materials and geotechnical conditions were inferred from available desktop and field data for mineral soil, organic (bog and fen) and potential permafrost-affected terrains to help identify route options that minimize length over organic and permafrost terrain and maximize length over mineral soils. Where organic terrains were predominant, they were further subdivided into different constructability rankings to optimize routing over areas where peat depths were interpreted to be shallower and had better bearing capacity for a roadway, while areas with deeper peat and a higher water table were avoided to the greatest extent possible without adding significant length to the overall route. The proximity of route options to potential aggregate sources (sand & gravel and bedrock) was also considered when identifying route alternatives.

The optimal route from a geotechnical perspective was selected by selecting connecting segments from the six alternative routes under consideration that best met the major criteria of route length, environmental avoidance, terrain conditions, watercourse crossings, and proximity to aggregate sources. Overall, the optimal route was selected to minimize the length of route crossing terrain units considered to have a poor constructability ranking, in particular the various types of fens with thicker peat and shallow water table at surface.

3.2 Optimal Engineering Route

With the use of Light Detection and Ranging (LiDAR) topographic data and environmental sensitivity and constraints mapping, a route analysis was conducted and various select areas of the OGR to arrive at the OER. The process enabled the team to optimize an alignment that considered the following factors:

- Geophysical investigations conducted by JDMA to define the OGR (**Appendix A**):
  1. Adjustment of the JDMA routing to avoid caribou habitats and other environmental constraints;
  2. Further adjustment to reduce the distance to potential aggregate sources;
  3. Alignment optimizations at watercourse crossings to minimize watercourse crossing spans;
  4. Alignment optimizations to minimize hydrology issues at watercourse crossings;

5. Horizontal and vertical alignment adjustments to conform to the surrounding terrain; and
6. Final adjustments to the vertical profile to accommodate structures, culverts and to balance cut and fill quantities.

- The above process was optimization rather than the development of additional alternatives.
- While using the OGR as the primary routing, other engineering and the environmental multifactor factors analysis (refer to **Section 1.2**) were also considered to ensure those routes passed through the best possible terrain types and adjustments to better match the alignments to the surrounding topography.

3.2.1 Evaluation and Selection of the Optimal Engineering Route

Preliminary engineering approach focussed on developing an OGR (**Appendix A**) based on minimizing poor constructability rankings, especially in areas with organic soils and high-water tables. The OGR was considered as the basis for the OER.

Evaluation criteria for defining the OER include the following factors:

Route Optimization Criteria:

- Maximize passage over more constructible soil conditions;
- Minimize the number of water crossings;
- Minimize span lengths at water crossings;
- Avoid environmentally sensitive areas, particularly caribou habitats; and
- Minimize distance to potential aggregate sources.

Soil Conditions Impact, Road Base Constructability:

- Peat lands have poor constructability, requiring more fill for stable road base;
- Peat depth directly affects the amount of fill needed to compensate for settlement;
- Preliminary routing aimed to minimize passage over deep peat thicknesses with poor constructability; and
- Shift alignment to areas of better constructability if possible.

Water Crossings:

- Alignments were routed to reduce the number of water crossings, especially in areas with multiple watercourses; and
- Adjustments made to minimize span lengths at water crossings, optimizing bridge and culvert placement.

Environmental Considerations:

- Concern for caribou and other species at risk habitats guided alignment adjustments to avoid encroachments;
- Minimize traversal distance through habitats if they span across the study area;
- Limit impact to peatlands; and
- Areas of interests and sensitivity to indigenous communities (e.g., hunting areas, spiritual sites, etc.).

Aggregate Sources:

- Sources with materials suitable and sufficient to meet the significant need for peat land backfill;
- Alignment adjusted reduce access road construction and haul distances to these sources; and
- Where possible, alignments passed as close as possible to support direct extraction.

Subsurface Considerations

A series of on-site and desktop studies, and geotechnical field investigations were carried out to prepare the geotechnical engineering database to support the EA/IA, and preliminary engineering and design for the Project. These studies and investigations are reported in separate documents presented as **Appendix A**, **Appendix B** and **Appendix C** to this report. These studies are documented as follows:

- J.D. Mollard and Associates (2019a): The terrain analysis, potential aggregate sources & identification of route alternatives. (**Appendix A**);
- J.D. Mollard and Associates (2019b): The field investigation of peat thickness and potential aggregate sources (**Appendix B**); and
- SNC-Lavalin (2019). The geotechnical investigation factual report. (**Appendix C**).

The proposed preliminary preferred route crosses through an area of extensive wetlands, organic soils and several watercourses, including a few large waterbodies. The road alignment can be broadly described as comprising two sectors, namely the North-South sector and the East-West sector. In general, the North-South sector of the road alignment passes through a higher relief area with better ground conditions on glacial moraine deposits (till), while the East-West sector passes through a low-relief area with poorly drained ground conditions consisting mostly of bog and fen wetlands and numerous stream crossings. The aim of terrain and geotechnical studies was to establish the following:

- The subsurface conditions (e.g., material types and geotechnical properties, groundwater and permafrost) along the proposed road alignment and at the associated stream crossings;
- The potential aggregate and bedrock quarry locations for construction and maintenance of the road, including consideration of the proximity of source locations to the main supply road corridor, relative to access road logistics;
- Design and construction recommendations for the road structure and its foundation;
- Design and construction recommendations for the potential water crossing structures foundations; and
- Design and construction recommendations for the development of aggregate sources, bedrock quarries and required access roads.

Water Crossing and Drainage Structures

Following the initial route optimization, a total of 31 water crossings were identified along the proposed preferred route for the road. These crossings are categorized based on their widths. To optimize structure types at each crossing, crossing structure types were developed that account for the availability of materials, supply and delivery logistics and constructability in remote areas.

Based on the above, the type and size of structure at each water crossing is selected based on the soil conditions, Design Flow freeboard and clearance requirements, and bankfull flow hydraulic, fish passage, and navigation requirements. As navigation requirements for each watercourse have not been identified, it was assumed that if the watercourse has sufficient water to float a canoe, it would be designed sufficiently large to accommodate such a vessel. The Winisk Lake and Muketei River crossings are larger and will be designed to accommodate larger vessels.

In addition to conventional stream crossings, the proposed route for the Webequie Supply Road crosses several string fens of varying width. String fens are characterized by thicker peat layers, which can be several metres thick, water table levels near or above the peat surface (under peat ridges that form the ‘strings’ in pools between them), and gentle groundwater gradients that result in slow-moving groundwater flow within the fen peat. Given the high compressibility of the peat in string fens, and the groundwater conditions, equalization culverts or other engineered structures may be required for these crossings. The preferred embankment design in peatland areas will result in the roadway being built on top of the peatland without excavation, while still ensuring the continued flow of local groundwater under the roadway. Field investigations identified local groundwater conditions and peatland characteristics which were addressed in the roadway design.

Consideration of Aggregate Sources

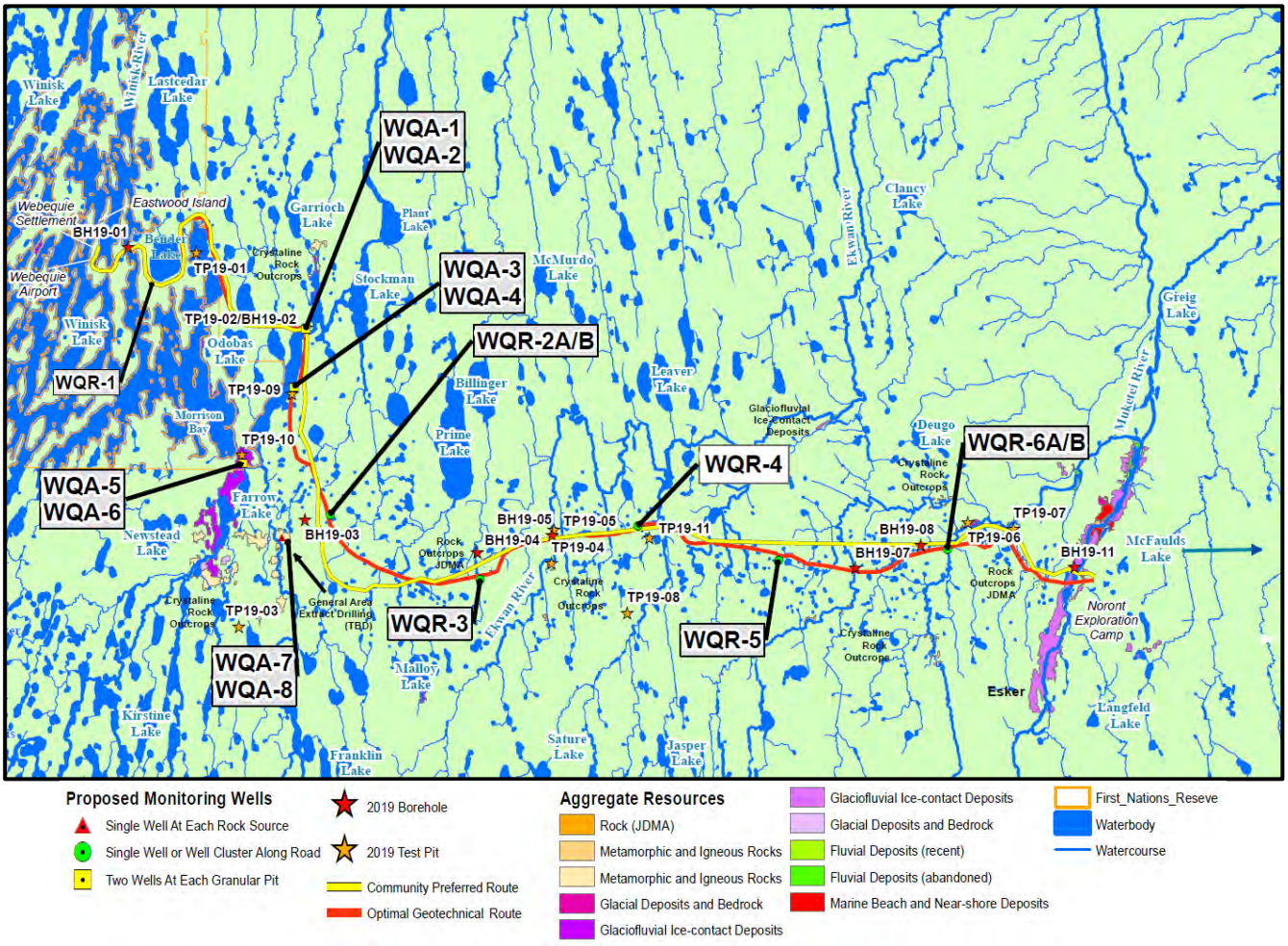
Aggregate prospects for the WSR were summarized by JDMA (2019) based on reviews of existing surficial geology mapping by the Ontario Geological Survey and terrain analysis using digital imagery and LiDAR within the route corridor. Fieldwork was undertaken to confirm the extend of the sources and the suitability of the aggregate/bedrock material for construction. Although the eastern portion of the route is covered by organic terrain, occurrences of ice-contact glaciofluvial landforms and bedrock outcrops offer potential aggregate sources in the western portion of the route. Among these prospects are ice-contact glaciofluvial landforms created by meltwater processes during deglaciation that are typically composed of sorted granular material. The characteristics of these granular deposits (overburden thickness, stratigraphy, gradation, etc.) were evaluated from shallow test holes dug with either a mini-excavator or manually with a shovel. Where access and timing allowed, the mini-excavator was brought in to dig test pits to a depth of about 2 m. At other locations, where logistical challenges restricted slinging in the mini-excavator, test holes were dug manually to a depth of 30-90 cm. Drill rigs at selected locations drilled deeper holes and at some of these, additional monitoring wells were installed. SkyTem EM analysis (based on Air Borne Geophysical Survey) was used to better scope the extend of the aggregate source.

Bedrock outcrops identified and mapped as potential quarry sites were visited in the field to determine the lithology and structural elements (fractures, bedding, foliation, etc.) visible at surface to make an initial assessment of bedrock suitability for aggregate production. Geology and potential aggregate source sites are shown in **Figure 3.1**. As noted above, additional drilling was undertaken in the bedrock areas. SkyTem EM analysis was also used to better scope the extend of the bedrock source.

The Project will require construction materials for several engineering/construction purposes including subgrade, pavement structure, water crossing embankments, road embankments (on mineral soils, low-lying areas (seasonal flooding), peatland and water-logged areas), and for the construction of respite and maintenance turn-around areas, Maintenance and Storage Facility s, temporary/permanent access roads and construction camps with laydown areas. There are currently no approved, established or commercial pits and quarries along the WSR route.

The WSR is proposed to be built as close as possible to the natural terrain contours to limit the volume of earthworks and aggregate material required for the road surface. Construction camps, respite areas, and temporary/permanent access roads will also be graded in a manner that minimizes the volume of the construction material needed. Naturally occurring till material can be used as subgrade or for subgrade embankment construction. Aggregate will be required for pavement construction; sand and gravel will be required to maintain and operate the WSR.

Figure 3.1: Geology and Aggregate Sources



3.3 Supply Road Design Criteria and Considerations

This section describes the existing transportation conditions within the study area and provides an overview of the terrain and other challenges faced with traversing this area. On the advice of the Ministry of Transportation, the design standards for the proposed Webequie Supply Road will be consistent with other similar roads in the Northeastern and north-western regions and will be classified as a Rural Collector Undivided with a 100 km/h design speed (RCU100).

Typical design standards that will be applicable to the Project are presented in **Table 3-1**. The full design criteria document is provided in **Appendix E**.

Table 3-1: Proposed Design Standards

Design Element	Proposed Standards
Functional Highway Classification	RCU100 km/h
Minimum Stopping Sight Distance	185 m
Minimum Passing Sight Distance Minimum K Factor for Crest Vertical Curves	320 m K = 60 (Stopping Sight Distance)
Minimum K Factor for Sag Vertical Curves	K = 45 Stopping Sight Distance)
Minimum K Factor for Crest Vertical Curves	K=119 (Passing Sight Distance)
Maximum Grades	6%
Minimum Grades	0.1 – 0.5%
Minimum Curve Radii	450 m at a 6% maximum superelevation
Travelled Pavement Width	2 x 3.50 m travelled lanes
Shoulder Width	2.0 m
Shoulder Rounding	0.5 m
Right-of-Way Width	35 m
Posted Speed	80 km/h
Minimum Cross Slope	2-4% depending on type of surface

3.3.1 Highway Considerations

3.3.1.1 Traffic

Based on the surrounding population density and the intended purpose of the Webequie Supply Road, an average annual daily traffic (AADT) volume of less than 500 vehicles has been assumed for the Project. This was determined based upon current traffic volumes along the winter road, current air passenger and cargo traffic and potential induced demand. It is expected that traffic during the operations phase will comprise light to medium personal and commercial vehicles, and heavier trucks carrying industrial (mining) supplies and equipment.

3.3.1.2 Geometric Design Considerations

The following section describes the physical and geometric conditions and constraints that will need to be addressed for development of the ultimate alignment and other aspects of the roadway.

Horizontal Alignment

Several factors influence the optimization of horizontal alignment in a road or highway project:

- Terrain and topography significantly influence alignment choices, with factors such as steep slopes, valleys, and uneven terrain impacting the project's direction. Adherence to geometric design standards, as outlined by MTO design standards in the form of General Design Criteria is crucial. These standards dictate curve radii, design speed, superelevation, sight distance, lane widths, tangent length, and grade, ensuring safety and functionality.
- Considerations regarding traffic volume and speed are essential, as higher volumes and speeds may require wider curves and smoother transitions.
- Alignment considerations are influenced by cost, necessitating a balance between cost-effectiveness, safety, and functionality.
- Safety considerations are paramount, encompassing factors like sight distances, clear zones, and visibility at intersections.
- Aesthetic and community considerations also play a role, particularly in urban or scenic areas, where alignments enhancing visual appeal or preserving community character may be prioritized. Ensuring accessibility and inclusivity for all users, including Indigenous land users, pedestrians, cyclists, and individuals with disabilities, is a critical factor.

Lastly, public, stakeholder and Indigenous input are vital, as community feedback and concerns can influence alignment decisions.

In general, the route for the WSR will follow a linear envelope defined under the TPA1B Webequie Community Supply Road Report dated January 2018 framework. From west to east, it will commence near the vicinity of Webequie Airport on Eastwood Island, crossing Winisk Lake, looping around the south end of Bender Lake, and then proceeding northward above Manson Bay on Winisk Lake. From there, it will take a southerly route before turning eastward. The final segment will continue eastward to its terminus near the existing Esker Camp operated by Noront Resources in the McFaulds Lake area.

The western half of the road will traverse mildly rolling terrain on mineral soils, whereas the eastern half will traverse a relatively flat muskeg landscape. The initial 3 kilometres will coincide with the existing gravel roadway (Eastwood Island Road/Road M), providing access to the community’s landfill site and adjacent bush areas for resource utilization. There is no existing roadway for the remainder of the route.

The route will encounter several water crossings (refer to **Appendix F** – Hydrologic and Hydraulic Analysis for the Webequie First Nation Supply Road; **Appendix I** – Recommended Alternative Grading Drawings; and **Table 3-2** – Watercourse Characteristics), notable crossings at Winisk Lake (WC-1) and the Muketei River (WC-26). The routing of the eastern half was designed to minimize crossings over the poorest muskeg soil conditions, guided by geophysical investigations conducted by JDMA.

Overall, the routing and terrain conditions allow for the development of a horizontal alignment fully compliant with the applicable design standards for this roadway classification.

Vertical Alignment

Several constraints may impact the vertical alignment optimization of the WSR in the north of Ontario. Environmental factors such as protected habitats, wetlands, and sensitive areas require special consideration to minimize ecological impact. Geological features like rock formations and unstable slopes pose challenges that must be addressed to ensure road safety and stability. There may be trade-offs between safety, environmental concerns, engineering requirements, watercourse constraints and construction costs, requiring careful balancing of project objectives.

Safety considerations, including sight distance and grade changes, are crucial to optimize road safety. Traffic patterns and volumes must be accommodated to ensure efficient traffic flow and minimize risks. Additionally, ROW availability and location may limit alignment options, requiring innovative solutions to optimize road design within these constraints. Addressing these factors during planning and design phases is essential for optimizing the vertical alignment of the WSR.

The vertical alignment optimization process involves several key factors and considerations. These include:

- Evaluating the ground surface, preliminary horizontal alignment, design parameters, and other constraints;
- Aggregate locations and the potential for side casting;
- Material movements, including haul/overhaul distances and constraints such as direction, and water crossings;
- Ground type, peat characteristics and peat depths, stripping/overburden removal, and acceptable fill/aggregate material and its usage; and
- Expansion/compaction factors, cross-section geometry's functionality in capturing soil layers and properties, and unit costs.

Reducing overtopping/roadway flooding impacts the vertical alignment optimization of roads; this can occur when water flows over the surface during heavy rains or floods if not properly designed. It causes erosion, reducing road lifespan and necessitating costly repairs, while also compromising safety and the ability to keep the road operational. Inadequate design can lead to standing water, drainage issues, and structural damage to infrastructure like bridges and culverts. Safety risks include reduced visibility and increased accident potential. Criteria for handling overtopping on the WSR depend on factors like design standards, road classification, terrain, drainage infrastructure, and available resources. The design balances safety, efficiency, and resource allocation when developing criteria to mitigate overtopping risks.

The roadway's western portion traverses mildly rolling terrain, necessitating a vertical alignment to accommodate minor elevation changes. LiDAR survey data indicates no significant elevation fluctuations, minimizing the need for major cuts or fills along this section. The initial 3 km follows an existing gravel track profile. The eastern half crosses fairly flat peatland terrain, resulting in a predominantly flat vertical alignment. To navigate the Muketei River crossing, a cut through the western ridge and an embankment on the opposite bank is required to traverse the floodplain. Overall, the routing and terrain conditions allow for the development of a vertical alignment fully compliant with the roadway's classification design standards.

Cross-Section

To accommodate the anticipated regular two-way traffic, including transport truck traffic, the cross-section will consist of two lanes (2 x 3.50 m) with shoulders (2 x 2.00 m) for a total roadway width of 11 m between shoulder roundings.

Cross-Fall

For positive drainage purposes on the unpaved gravel surface, a cross-fall of 4% is recommended. This steeper cross-fall allows for the normal deterioration of the loose surface over time, allowing it to continue shedding water until seasonal maintenance operations crews return to reshape the roadway.

Superelevation

Maximum superelevation will be 6% on curves to allow for maintaining a consistent operating speed on the full length of the roadway.

Pavement / Road Surface

The road and shoulders of the Webequie Supply Road will be surfaced treated. The surface treatment or pavement design aims to develop a cost-effective structure tailored to meet specific performance, serviceability, and safety requirements. This requires an evaluation of the soils and paving materials under various traffic and climatic conditions. Key factors influencing pavement performance include traffic loading—such as traffic volume, growth rates, axle loads and distribution, tire pressures, and vehicle suspension characteristics—along with environmental influences like precipitation, temperature variations, moisture in pavement layers, and freeze-thaw cycles. Additionally, the type and properties of subgrade soil are crucial in determining the pavement's design.

For the west half of the Webequie Supply Road (KM 0 to KM 48), situated in areas with stable soil conditions, a chip seal treatment is proposed as the driving surface, similar to asphalt pavement and consisting of a tar slurry mixed with gravel. The east half of the road (KM 48 to KM 107), which traverses peatlands with less stable soil conditions, will initially utilize a gravel surface. This section will undergo monitoring during the operational phase to assess performance, settlement, serviceability, and safety, particularly concerning dust control along the corridor. Based on these assessments, the gravel surface may be upgraded within 3 to 5 years to a more durable treatment, such as chip seal or asphalt pavement, to ensure longevity and optimal performance. Notably, partially paved shoulders, which are generally not recommended for secondary highways, will not be used in the WSR Project.

Roadside Safety

Roadside safety design shall be according to the MTO Roadside Design Guide (December 2017) and will be determined during detail design.

Signage

Signage shall be according to the Ontario Traffic Manuals for Regulatory, Warning and Guide signage and will be determined during detail design.

Illumination

Localized illumination requirements will be determined during detail design. Continuous full illumination is not anticipated due to practicality and/or availability of stable hydroelectric connections.

Traffic Signals

Not anticipated for this project.

Entrances

Entrance design will conform with Ontario Provincial Standard Specifications and/or the MTO Commercial Site Access Policy and Standards Design Manual, as required. Aggregate source access road interfaces to the main roadway will be considered as entrances and not intersections.

Intersections

There are no intermediate intersections anticipated as part of this study. Upon final determination of the eastern terminus of this roadway, intersection considerations will be determined at that time.

Fencing

Not anticipated for this project.

Sidewalks

Not anticipated for this project.

Curb and Gutter

Curb and gutters may be required to facilitate drainage and minimize erosion at the approaches to bridge structures. This will be further assessed during detail design.

Active Transportation Infrastructure

Not anticipated for this project.

Railway Crossings

Not anticipated for this project.

Utilities and Pipelines

Utility crossings are not located within the study area.

Wildlife Control Measures and Crossings

Based upon the environmental surveys and habitat assessments completed to date as part of the EA/IA process, designated wildlife crossings are not deemed to be required.

3.3.2 Maintenance Considerations

Year-round maintenance considerations for the Webequie Supply Road generally includes winter snow removal and sanding operations, and summer operations to ensure the roadway continues to meet operational and maintenance requirements.

Winter Maintenance Considerations

Using the Minimum Maintenance Standards for Municipal Highways (O.Reg. 239/02) as the basis for classification for winter maintenance, with a posted speed limit of 80 km/h and Average Daily Traffic volumes reasonably expected to be less than 500 vehicles per day, the roadway is expected to be classified as a Class 4 Highway. The classification determines the level of maintenance to be expected of the given roadway following a snowfall event. In general, a Class 4 Highway with two lanes shall be cleared to a minimum width of 5 m within 16 hours of 8 cm of snow accumulation.

Winter maintenance will be required on a seasonal basis to ensure that the road is passable year-round and will include plowing and sanding operations.

A snow drifting analysis is not included as part of the current engineering design for the road. However, based on the long stretches of straight and flat roadway, particularly the East-West leg, it is recommended that a prevailing wind analysis be conducted during Detail Design Phase of the Project, with allowances for snow drifting mitigative measures, where necessary.

Snow storage will be achieved by plowing accumulated snow outward and toward the ditches. Significant windrow buildups shall be back bladed and benched as necessary throughout the winter season as accumulations continue.

Piled snow along the roadside can affect ground temperature and thawing of permafrost, where it is located close to ground surface. However, in the sporadic permafrost band where the project area is located, permafrost occurs in islands and ground ice content in the active layer is not significant. Therefore, given the general lack of permafrost in the area and the limited width of road surface to be cleared of snow (~11 m), the insulating effects of snow on warming of permafrost are not expected to be problematic. Similarly, any permafrost that exists in the project area is not anticipated to have a measurable destabilizing effect on the road infrastructure.

Application of materials during the winter season will be based on MTO specifications for similar types of roads in Northwest Ontario that are considered Class 4 provincial highways.

Winter Maintenance Infrastructure

To address the need for snow plowing operations, suitable infrastructure will be required for operations and maintenance, which will currently include one Maintenance and Storage Facility (MSF) and use of the two maintenance areas for sand storage domes and snowplow turnarounds situated along the length of the roadway. Based on the 100+ km length of the roadway, the main MSF is proposed to be located relatively close to the community of Webequie to allow snowplow drivers quick and easy access to their vehicle(s).

Warm Season Maintenance Considerations

Although the roadway will be surface treated, the roadway in the peatland area may remain gravel for a few years until it has settled sufficiently to support surface treatment. During that time frame to maintain the roadway surface in an acceptable condition for high-speed travel, seasonal grading operations will need to be carried out to maintain the surface cross-fall at 4%. This allows for consistent surface drainage and helps prevent erosion.

3.3.3 Drainage Considerations

The project area is situated within the primary Southwestern Hudson Bay watershed and has many different types of waterbodies, including streams, rivers, lakes, ponds, and wetlands (over 50% of the ecoregion – Big Trout Ecoregion – is covered by wetlands). Bogs and fens dominate the eastern part of the region. To the west, forest stands occupy higher ground formed on glacial materials, such as eskers, and on better-drained slopes next to rivers. Portions of the preferred corridor for the all-season road traverse intact boreal forest (including treed bogs and fens). The terrain is generally low gradient with large wetland areas, several lakes and ponds, and slow flowing, often meandering streams and rivers. Annual precipitation levels in the area tend to exceed 700 mm, of which over 200 mm is typically snow.

The stream banks are typical of low gradient watercourses in the region and are well defined by boulders, bedrock outcrops, and natural levees that were the result of historical glacial activity. Beaver dams are common features on small to medium sized streams. Stream flow peaks in the spring as a result of snowmelt runoff and rainfall runoff from saturated soils. Flows recede through the summer and increase in the fall due to an increase in rainfall and a decrease in evaporation. Flows are normally lowest in winter, and some small streams freeze completely to the stream channel bed.

The peak discharge for each crossing was estimated using the Index Flood Method and Rational Method as presented in the project's Hydrology Memorandum (**Appendix F**). **Table 3-2** provides a summary of the watercourse characteristics and the estimated peak discharges.

Table 3-2: Watercourse Characteristics and Estimated Peak Discharges

Watercourse Crossing	Drainage Area (km^2)	Slope of Main Channel (%)	Mean Annual Flow (m^3/s)	25 Year Peak Flow (m^3/s)	50 Year Peak Flow (m^3/s)	100 Year Peak Flow (m^3/s)
WC-1	258.8	Lake	-	-	-	-
WC-1A	0.6	0.60	-	0.5	0.6	0.7
WC-1B	1.2	0.44	-	0.5	0.6	0.7
WC-2	50.3	0.09	0.47	12.6	15.4	18.0
WC-2A	1.2	0.24	-	0.8	0.9	1.0
WC-3	1773.8	0.07	16.71	156.5	191.8	224.2
WC-4	1.9	0.04	0.01	1.0	1.3	1.5
WC-5	13.2	0.16	0.13	5.0	6.1	7.1
WC-6	34.5	0.11	0.32	9.7	11.9	14.0
WC-6A	1.6	0.30	-	1.3	1.4	1.6
WC-7	3.7	0.41	0.04	2.0	2.5	2.9
WC-8	17.8	0.16	0.16	5.9	7.2	8.4
WC-9	5.6	0.03	0.05	2.7	3.3	3.8
WC-10	542.6	0.15	5.07	68.1	83.4	97.5
WC-11	17.0	0.08	0.14	5.5	6.7	7.8
WC-12	13.4	0.06	0.12	4.9	6.0	7.1
WC-13	349.4	0.08	3.25	49.9	61.1	71.4
WC-14	14.8	0.08	0.14	5.3	6.5	7.6
WC-15	18.7	0.03	0.17	6.3	7.7	9.0
WC-16	13.2	0.08	0.12	4.9	6.0	7.0
WC-17	8.1	0.16	0.07	3.3	4.1	4.8
WC-18	10.1	0.17	0.10	4.2	5.2	6.0
WC-19	491.6	0.11	4.43	63.3	77.6	90.6
WC-20	16.4	0.07	0.13	5.1	6.3	7.3
WC-21	897.6	0.05	8.33	97.4	119.3	139.4
WC-22	13.5	0.63	0.13	5.2	6.4	7.5
WC-23	8.9	0.13	0.08	3.7	4.5	5.3
WC-24	23.6	0.06	0.22	7.4	9.1	10.6
WC-25	17.6	0.07	0.16	5.9	7.2	8.4
WC-26	529.4	0.06	4.91	66.6	81.6	95.4
WC-27	1668.0	0.07	15.7	151.8	186.0	217.4

Climate Change Considerations

As Ontario's climate changes over time, it is critical for infrastructure to be robust and be designed and constructed with potential future climate in mind. Risk and vulnerability levels to the road infrastructure will vary during the construction and operations phases, in the context of trending severe weather events. The longevity of the road from an integral/structural perspective, as well as reducing the potential for future issues to arise, will depend on the understanding of potential climate changes, particularly those processes associated with severe precipitation patterns and the effect on runoff.

A climate change resiliency assessment has been completed to gather and analyze the information required to support the EA/IA and preliminary engineering components in terms of climate change effects on the Project, including:

- Review historical and present climate data for the project site and Northern Ontario;
- Analyze future climate projections and assess the potential change in temperature and precipitation;
- Assess the effect on runoff and peak flows;
- Assess the risks and the ability to design Project to be resilient; and
- Develop robust design criteria taking into account realistic climate scenarios and developing appropriate adaptive measures (e.g., larger structure size).

The wide range of Ontario-specific climate data and climate models that are available are being reviewed. The Ontario Climate Data Portal will be utilized, particularly the Representative Concentration Pathways (RPC) emission scenario models, to identify potential future climate conditions. MTO Intensity Duration Frequency data will also be reviewed, with a focus on expected future trends. As outlined by MTO, future temperature and precipitation values for the year corresponding to the end of the Design Service Life of structures will be used to assess the effect on peak flow and in the design for conveyance, erosion, scour, and stormwater management components. Accordingly, it is anticipated that the 2050 and 2080 projects will be reviewed and assessed.

While increasing temperatures, solar radiation and heat days are likely to be an issue in the future, in the context of the Project and climate effects on the Project, temperature, precipitation, and runoff are anticipated to have a significantly larger effect than other climate changes. The review of climate projections will primarily focus on hydrometeorological changes. The recommended actions were also based on the remote location of the roadway, the difficulty in making repairs and the low tolerance for any road closures.

3.3.4 Structural Considerations

There are no existing structures along the recommended preferred route for the Webequie Supply Road. To optimize the categorization of water crossings and assign an optimum crossing type, the initial step consisted of developing a matrix of appropriate structure types that takes into consideration such factors as constructability, remoteness of location, availability of materials and suitability for the given terrain and insert reference the advantages and disadvantages of the structural types under consideration for short and long span crossings on the Project.

Bridge options which have been considered in the selection are described below with respect to the requirements of the Project.

3.3.4.1 Options for Short Span Structures

Reinforced Concrete Beam Bridge

This structure consists of ribbed reinforced concrete slab spanning between reinforced concrete abutment or piers. It is suitable for short distance and relatively cheap to construct. However, the bridge requires deeper sections when compared to most other bridges and takes longer to construct owing to the preparation of formwork and casting at site. Casting at site further compromise the quality and durability of the bridge. Bearings and expansion joints in the bridge required frequent maintenance and may cause durability issues.

Reinforced Concrete Box Culverts

Box culverts are torsionally stiff and more capable of accommodating large settlements. They are much less susceptible to scour and differential settlements and are more suitable for sites where the soil bearing capacity is low as they distribute the loads uniformly over a large area. Expansion joints and bearings can be avoided in the structure. Box culverts can be designed to allow for fish passage by embedding or countersinking the structure below the streambed. The disadvantage would be the casting at site as discussed above. Precast Culverts could be used as an alternative. However, site suitability, geometry, joint details, future rehabilitation, size, and weight limitations for transportation are some of the issues that need consideration.

Wooden Bridges

Wooden bridges have the advantage of cheap and easily availability of raw materials. Proper detailing for durability and protection of the structures is the key to their longevity. To achieve these long lifespans in bridges, it requires care in design and maintenance. Permanent treatment of timber elements to prevent decay from high moisture conditions and pest attack is required in addition to having replaceable elements. Moreover, wooden bridges as highly vulnerable, as it can be washed away or significantly damaged during floods.

Masonry Bridges

The main load-bearing structures of a masonry bridge are made of natural stone, brick, or concrete blocks. Such a bridge is always arched, with massive supports. The major advantage of a masonry bridge is its durability. Masonry bridges are known to have been in use for more than 1,000 years. The basic shortcomings that limit the use of masonry bridges are their complexity and labour-intensiveness of construction.

Open Bottom Steel Box Culvert

Steel culverts commonly used include structural steel plate with a plain galvanized coating and corrugated steel pipe or spiral rib steel pipe which can have a plain galvanized, aluminium or polymer laminated coating. The structure has several advantages making it a preferred option for short span water crossings. The option has been evaluated against different aspects as shown below:

Table 3-3: Preferred Short Span Structure Type

Aspects	Open Bottom Steel Box Culvert (OBSBC)
Economy	An Open Bottom Steel Box Culvert on shallow foundation is a cost-effective solution when compared to other structure types. In addition to low material costs, quick installation ensures considerable savings in construction cost. A typical OBSBC can be installed in two days or less, with subsequent immediate backfilling. It also eliminates the bridge deck, approach slabs and expansion joints common in traditional bridge design, significantly reducing maintenance and total life cycle costs. When site costs and foundation costs are factored into the total cost equation, the steel option can be significantly less expensive than a precast structure, sometimes on the order of 40 percent to 50 percent.

Structural Efficiency	OBSBC can accommodate higher differential settlement than rigid structures like precast concrete and most traditional bridges. It can carry heavy loads by load distribution through the cover and has increased resilience through redundant systems. The culvert structure and the backfill soils surrounding it interact with each other to support the loads. Because of this interaction, the structure is typically lighter. Unless foundation soil conditions are poor, they do not typically require deep foundations.
Constructability	The lightweight box culverts with corrugated plates can be easily transported to site and are bolted together in the field and backfilled with graded granular material. In most cases, the steel structure can be shipped to the project location on a single flatbed truck. The plates stack easily on the truck. At the site, individual plates can be handled with skid steer loaders, forklift trucks, backhoes, and other light equipment, and no heavy lifting equipment is required for assembly. Locally available materials can often be used in construction, and the structure can be tailored to fit the needs of the site.
Maintenance/Service Life	Since the structure has no abutment or expansion joint, there is very little differential settlement, which eliminates any bump at the end of the structure. As a result, maintenance is essentially the same as it would be for any other section of the road, while a traditional bridge requires maintenance of the bridge deck, bearings, approaches, joints, and other elements. The service life of culverts greatly depends on the performance of the invert. Absence of an invert and provision of galvanization/polymer coating on the steel results in longer service life.
Navigation	The flexibility in selecting span and rise of the profile helps to meet navigational clearance requirements.
Environment	The structure limits disturbance to the surrounding area and restoration of natural stream beds to facilitate passage of aquatic organisms. Steel structures can be recycled into other steel structures. Also, more energy is required to produce cement and other components that make up concrete structures. Much less energy and pollution are involved in the shipping process for steel structures vs. concrete.

3.3.4.2 Options for Long Span Structures

Prestressed Concrete Beams Bridge

Prestressed concrete involves the pre-tensioning of steel tendons using jacks which places the entire concrete section into compression, with the aim of preventing cracking in service. Prestressed concrete is highly efficient when compared to conventional reinforced concrete with significant reduction in material use and deflection under load. I-shaped pre-tensioned beam and in situ slab is a typical arrangement for prestressed concrete bridge decks. However, they have limitations such as the large steps in girder depth size available from precast suppliers, which can result in unnecessary structural depth and overprovision of capacities. The remoteness of site can pose challenges in transportation of the heavy girders and increase the overall cost.

Post Tensioned Concrete Box

Post tensioning is where the tendons are tensioned after the concrete has reached a suitable strength. The tendons are threaded through ducts and bonded to the concrete by injecting grout. It is commonly adopted for long span bridges. Voided slab bridges may be adopted to reduce the self-weight of the bridge. Voided post tensioned slabs, may be adopted for long spans. The voids are usually circular with the depth of voids generally restricted to sixty per cent of the depth of the slab so that the slab continues to behave like a single plate. If this limit of void depth is exceeded, the slab may behave more like a cellular deck. The voids may be provided in the central span length only so that a solid section is available near the supports where shear governs the design. However, this construction form requires substantial formwork and temporary works, and casting is done at site.

Steel Truss Bridge / Bailey Bridge

Common truss bridges and Bailey bridges are characterized by their interconnecting triangular structures, which give them the strength to withstand heavier and more dynamic load. The structure is highly efficient and can be a very economical option. It spans great length and could be transported to site in parts. However, it has a few disadvantages that include: it is bulky; the structure of a truss bridge is, by design, large; high maintenance costs; and will require regular and detailed maintenance.

Steel Composite Box Girder

A box girder bridge is where the principal structural elements are closed cells conventionally acting compositely with a reinforced concrete deck slab. The box section is built up from thin plates which are stiffened to resist compression and shear buckling/Transverse stiffness is provided by diaphragms conventionally spaced every 3 m. The cross-section of a box girder with open topped trapezoidal sections are commonly adopted. A closed cell is formed by the reinforced concrete deck which spans between the inclined webs. This is an efficient configuration to minimize dead weights. Disadvantages of a box girder includes greater fabrication cost due to reduced scope for automated fabrication, challenges associated with fabrication at site and coating, and risks associated with working in enclosed spaces.

Steel Composite Girder with Reinforced Concrete Slab

Steel-concrete composite bridge construction is an economic option. The bridge can be either a multi-girder or ladder deck configuration. The option after considering against the aspects below is a preferred option when compared to the other bridge types discussed.

Table 3-4: Long Span Structure Type

Aspects	Steel Composite Girder with Reinforced Concrete Slab
Economy	Unlike the Open Bottom Steel Box Culvert, a girder bridge does not require horizontal thrust at the foundation, and hence a single row of piles is enough for deep foundation. Moreover, selection of steel girders results in weight savings, which means lower erection costs, since the bridge pieces can be handled with lighter equipment.
Structural Efficiency	Steel girders permit cost-effective longer spans. Lighter weight of steel will allow lighter foundations than for concrete girders.
Constructability	Steel components are made to closer tolerances, which often translates into faster erection. Long span girders could be transported to remote locations and spliced at site. It can be handled with lighter equipment. Construction of integral bridges is simple and rapid. Lesser tolerance restriction in integral bridges due to elimination of bearings and expansion joints.
Maintenance/Service Life	At water crossings, it is easier to inspect and determine the structural state of a steel bridge where all the components are visible. The integral abutment proposed on deep foundations eliminates expansion joints and the associated inspections and maintenance. Semi-integral bridges proposed with shallow foundation eliminate the expansion joint at the deck ends and hence avoid leakage through the joint to the bearings. The vehicle riding quality on integral bridge is more comfortable and smoother since there are no expansion joints.
Navigation	For the same span and load, a steel girder requires less depth than a concrete girder, which can be helpful when constrained by vertical clearance requirements.
Environment	The long spans may eliminate or at least minimize environmental impact. In some cases, the longer spans possible with a steel bridge can avoid direct impacts to waterbodies by eliminating the need piers with multiple spans. Steel bridge structures can be erected quickly, which may facilitate meeting seasonal construction operational constraints/restrictions associated with wildlife/aquatic species migration, reproduction and hibernation periods. Concrete slab adds higher mass, which induces fewer vibrations and noise.

As part of the initial design, a short list of crossing types was developed based primarily on the width of the waterbody and anticipated span requirements, along with options for structure types appropriate to the span lengths, as presented in **Table D-3-5**. After completing a high-level review of the structure types identified as possibilities for the WSR, they were categorized by the length of overall span, and described in terms of practicality, constructability, and anticipated cost. In order to minimize the need for numerous and differing complex construction techniques and materials, the most appropriate bridge types were narrowed down to three kinds. For longer spans, a Composite Concrete Deck with Steel Plate Girders was selected. For shorter spans, an OBSBC or corrugated steel pipe were selected (depending on design criteria). Both concrete deck and steel box culvert types are fully scalable for their span range and will allow for efficiencies to be realized as construction progresses. Corrugated steel pipe types are used for smaller spans and smaller design flows.

Structure types identified in **Table 3-5** as optimal are considered to be the lowest cost and most constructible, given the terrain and soil conditions within the WSR study area. They allow for economies of scale by applying a uniform structure type to many similarly categorized water crossings without the need for custom designs and fabrications at differing crossings. For very narrow crossings and small design flows, simple steel and/or high-density polyethylene (HDPE) pipe culverts are relatively easy to procure, transport and install without the need for complex and cumbersome equipment.

For small and moderate spans, steel box culverts (steel plate arches) lend themselves well to ease of procurement and transportation, with only the need for small hoisting equipment essentially needed to aid in erection.

For longer water crossings, single or multi-span composite concrete/steel bridges are identified due to the relative ease of splicing shorter sections of steel girder. In comparison, precast concrete girders can be spliced, however will require more cumbersome equipment and curing time on the ground before loads can be applied, whereas steel girder splices can be carried out in the air with the use of cranes and can be loaded immediately upon fastening.

It is assumed that a mobile concrete batching plant may be required for the project, as the need for cast-in-place concrete exists for the purposes of foundation construction, as well as fabrication of bridge sub- and superstructure components.

Table 3-5: Matrix of Structure Types

Span Type	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Span Width (m)	0-3	3-12	12-20	20-35	35-50	260 (WC-1 Only)
Optimal Structure Types	Corrugated steel pipe (CSP) culverts or Single span steel box culverts (steel plate arch)	Single span steel box culverts (steel plate arch)	Single span steel box culverts (steel plate arch)	Single span composite steel-concrete bridge with integral abutments	Multi-span composite steel-concrete bridge with integral abutments	7 span composite continuous steel-concrete bridge with integral abutments
Primary Structure Alternatives	Precast concrete box culverts	Multi-barrel steel pipe culverts	Precast concrete arch	Multi-span steel box culverts (steel plate arch)	Multi-span steel box culverts (steel plate arch)	7 span simply supported composite steel-concrete bridge
Secondary Structure Alternatives	Precast concrete and/or HDPE pipe culverts	Precast concrete arch	Precast concrete/ steel beam bridge with integral abutments	Multi-span precast concrete arch	Multi-span precast concrete arch	5 span through truss bridge

3.3.4.3 Optimal Structure Types Proposed

Composite Concrete Deck with Steel Plate Girders

This type of bridge consists of a substructure comprising the foundations, abutments and piers, all supporting the superstructure, which consists of the steel plate girders, the deck and the barriers. The deck supports the roadway surface and will be composed of reinforced concrete. The steel plate girders will support the deck spans between abutments and piers. The use of steel allows for longer spans in comparison to the precast concrete girders as they can be brought to site in short sections and spliced as necessary. **Figure 3.2** and **Figure 3.3** illustrate examples of this type of structure.

Figure 3.2: Typical Composite Bridge Cross-Section

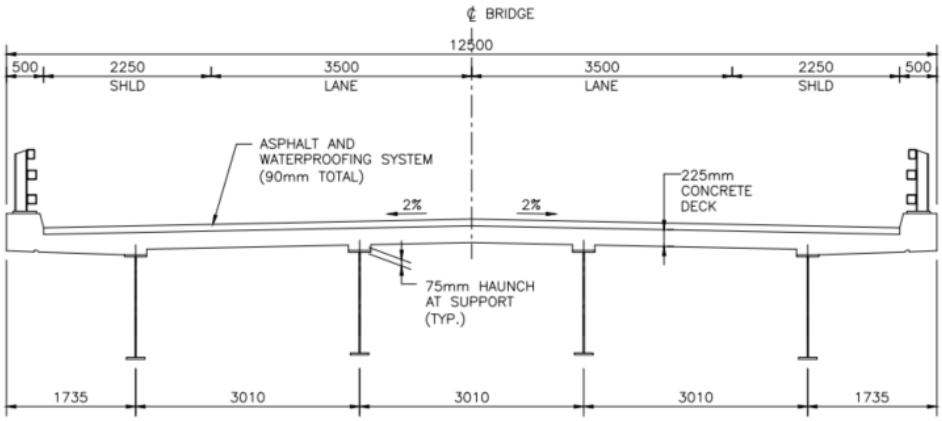


Figure 3.3: Composite Bridge Elevation

Open Bottom Steel Box Culvert

Open bottom steel box culverts, also known as steel plate arch culverts, are constructed with corrugated steel and can be fabricated for a full arch width or can be assembled and bolted together with plate sections. The arch structure provides high ring compression, transferring the load to the surrounding soil along the circumference. **Figure 3.4** illustrates the construction of an OBSBC complete with footings. **Figure 3.5** illustrates a completed OBSBC in service.

Figure 3.4: Open Bottom Steel Box Culvert Under Construction

Figure 3.5: Completed Open Bottom Steel Box Culvert

For moderately narrow water crossings (under 20 m), Open Bottom Steel Box Culvert is considered to be the optimal structure type when evaluated against the factors listed in **Table 3-3**. Where the structure cannot be founded on open footing, pile foundation may not be an economical option to provide the required horizontal thrust for the box culvert. At such locations, Composite Concrete Deck with Steel Plate Girders is recommended. Also, at water crossings where waterbody widths are greater than 20 m, Steel Box Culverts are not structurally and economically feasible. Composite Concrete Deck with Steel Plate Girders on integral abutment supported by single row of piles is recommended.

Integral abutments eliminate expansion joints and associated maintenance on the deck. However, integral abutments need to be flexible to avoid excessive restraining moments in the bridge, which is achieved by providing single row of long H-piles. At locations where shallow foundation is proposed, the abutment and piers tend to be short and stiff, and the required flexibility cannot be achieved. At such water crossings, semi-integral abutments are recommended for allowing the horizontal and rotational movements, and still eliminates the expansion joint at deck/abutment ends. The selection of Composite Concrete Deck with Steel Plate Girders is based on the parameters discussed in **Table 3-4**.

Corrugated steel pipe (CSP) or steel box (arch) culverts are proposed at crossings where the width of waterbody is less than 20 m. Water crossings with width greater than 20 m will require a composite bridge with concrete deck supported on steel plate girders. Abutments will be Integral for deep foundations and semi-integral for shallow foundations. For intermediate spans where the structure can be supported by a shallow foundation, OBSBCs are found to be the preferable option, and a composite bridge with concrete deck on steel plate girders are suitable where deep foundations are required. The type of structures proposed for water crossings, based on the span and foundation requirement, are as shown in **Table 3-6**.

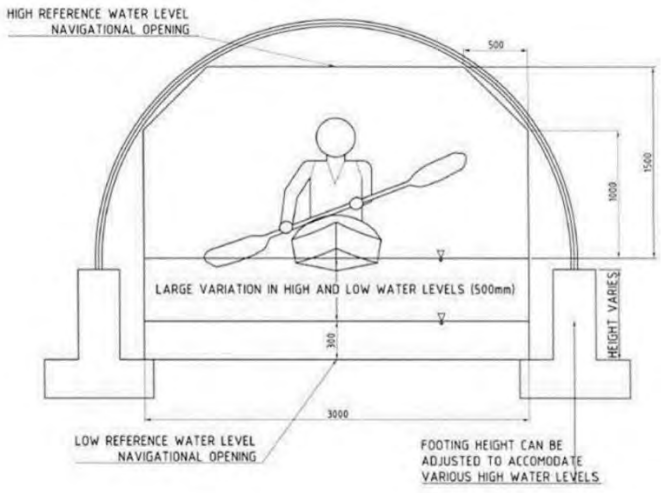
Table 3-6: Water Crossing Foundation Types

Foundation Type	Width: Under 20 m	Width >20 m
Shallow Foundation	Open Bottom Steel Box Culvert or CSP	Composite Concrete Deck with Steel Plate Girders on Sem-Integral Abutment
Deep Foundation	Composite Concrete Deck with Steel Plate Girders on Integral Abutment	Composite Concrete Deck with Steel Plate Girders on Integral Abutment

Navigable Waterways

It is understood that there are no waterways designated under the *Canadian Navigable Waters Act.* However, based on historical uses and anecdotal information gathered to date, small craft have been known to use the various watercourses. As such, two of the bridge designs have been developed in order to provide a minimum 3 m of clearance during the bankfull flow condition at Winisk Lake (WC-1) and the Muketei River (WC-26), while the remaining bridges were designed to a 1.5 m clearance. Larger culvert crossings were also designed to accommodate a minimum 1.5 m navigational opening for unpowered watercraft passage during the bankfull flow condition, as per **Figure 3.6**.

Figure 3.6: Navigational Opening at Culverts for Unpowered Small Craft



3.4 Development of the Optimal Engineering Route

Road Base Constructability

The East-West portion of the previously defined route band traverses peat lands with characteristically poor soil conditions for construction. These areas of poor soil constructability are characterized by peat depths which results in higher volumes of fill required to build a stable road base. Peat is a very compressible soil type, and the depth directly affects the amount of fill material required to compensate for settlement. Lesser peat depths will require lower volumes of fill to compensate for lower settlements. As per the JDMA report, a preliminary routing was identified that minimized passage over deeper peat thicknesses (which are characterized as being of poorer constructability) and shifted the alignment laterally onto areas of better constructability where possible. Soils with poorer constructability normally require higher importation of fills to compensate for the higher settlements expected.

The North-South leg at the west end of the study area generally exhibits soil conditions that are considered to be of good constructability. These mineral soils allow for construction directly over the ground with minimal settlement and are conducive to conventional cut/fill road building techniques with very little spoil other than the organic topsoil layer. Soils with better constructability do not normally require imported fill materials unless other constraints warrant it.

Number of Water Crossings

Using guidance from the JDMA reports, the alignments were routed in such a manner that reduced the number and width of water crossings. Major watercourses are generally oriented perpendicular to the road route (i.e., North-South) and therefore, cannot be avoided with the dominantly East-West route. Smaller streams flowing into and out of wetlands are avoided as best as possible while minimizing additional length and curves on the route.

Water Crossing Span

Designing an optimal engineering route at water crossings involves conducting hydraulic analysis, evaluating site conditions, selecting bridge or culvert based on span length and environmental factors, balancing structural integrity and cost, choosing materials for durability and environmental impact, mitigating environmental effects with fish passages and erosion control, ensuring compliance with safety regulations, evaluating economic feasibility, engaging stakeholders, implementing environmentally friendly construction practices, and monitoring post-construction performance and ancillary impacts. The optimal engineering route meets technical, environmental, and economic needs for a sustainable water crossing solution.

Environmentally Sensitive Areas

Of particular concern for developing the alignment was the proximity to and encroachments into caribou and other species at risk and other significant wildlife habitats. Habitat mapping was used to adjust alignments to avoid encroachments, and to minimize traversal distance if habitats spanned across the study area.

Distance to Aggregate Sources

To reduce the impacts of hauling aggregate to the construction site, it is preferred that the distance to aggregate sources be minimized. Efforts were made were possible to locate the preferred alignment close to the alignment; as aggregate sources that contain sufficient quantities of acceptable materials are very limited on the Project, it was important to ensure that the preferred alignment is reasonably accessible.

4 Description of the Optimal Engineering Route

The Optimal Engineering Route, deemed to be the preferred route for the WSR, runs for 106.25 km from its western terminus near the Webequie Airport to its eastern terminus in the McFaulds Lake area. It follows a curvilinear alignment that traverses approximately 47 km of mineral soils, with the remainder over softer peatlands.

There are 31 water crossings, including two significant crossings at Winisk Lake and the Muketei River. There are a total of eight (8) composite slab on steel plate girder bridges, 19 open bottom steel box culverts (arches), and four (4) CSP culverts. This will be in addition to local culverts used for flow equalization in wetlands and overland sheet flow.

The proposed typical road and structures drawings are provided in **Appendix I** and **Appendix J**. Geometric and engineering design criteria are presented in **Appendix E**.

4.1 Major Features of the Optimal Engineering Route

4.1.1 Roadway

Geometric design of the OER was focussed on providing a curvilinear alignment with long sweeping curves to enhance the aesthetic appearance of the roadway, as per Transportation Association of Canada guidelines. A more aesthetically pleasing roadway enhances driver experience and is shown to improve operating safety.

Horizontal and Vertical Alignments

Horizontal and vertical curvatures are selected to meet a design speed of 100 km/h. Detailed horizontal alignment data are provided in **Appendix G**, and detailed vertical alignment data are provided in **Appendix H**.

Cross-Section

The cross-section for the road, as shown in **Figure 4.1** and **Figure 4.2**, will comprise an unmarked gravel surface of a width sufficient to provide two 3.50 m wide lanes and two 2.00 m wide shoulders generally within a 35 m ROW.

Figure 4.1: Webequie Supply Road Cross-Section – Tangent

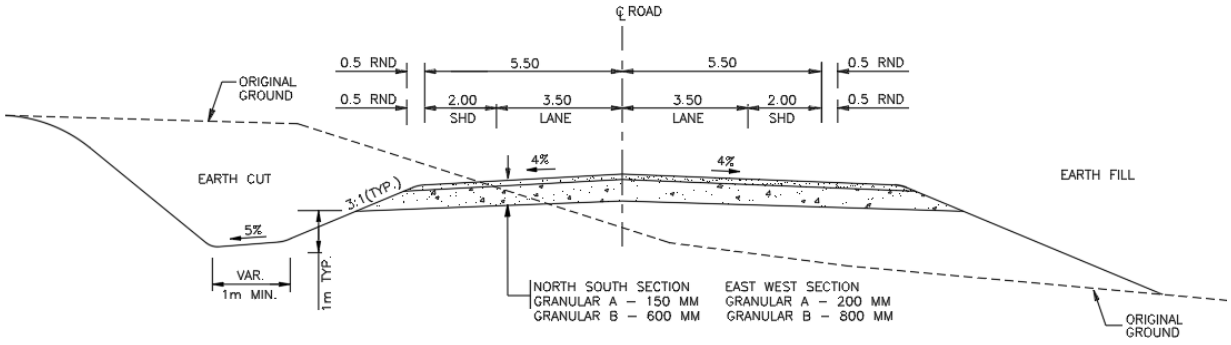
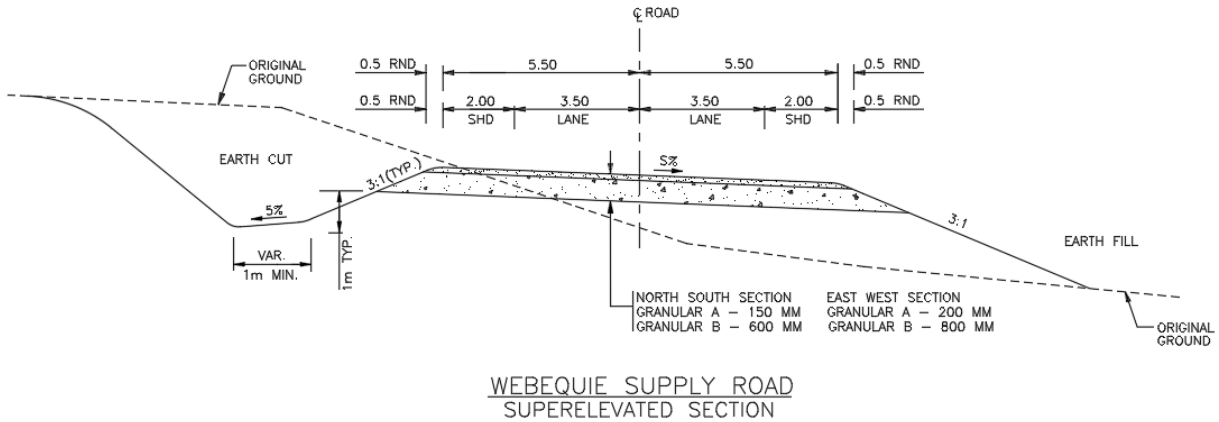


Figure 4.2: Webequie Supply Road Cross-Section – Superelevated



Sidewalks

Not applicable to the Project.

Utilities

No utilities are present within the study area. The proposed ROW will be sufficiently wide enough to permit the construction of a hydro transmission line alongside the road. Further coordination with subject matter experts in hydroelectric transmission design will need to be carried out during detail design.

Signage and Pavement Markings

Signage is to be determined during detail design including maintenance and rest areas.

Illumination

Illumination requirements are to be determined during detail design. Continuous full illumination is not anticipated due to practicality and/or availability of stable hydroelectric connections. At this time, it does not appear that illumination warrants according to MTO Directive PLNG-B-05 will be met.

Traffic Signals

Not applicable to the Project.

Fencing

Not applicable to the Project.

Landscaping

To be determined during detail design.

Active Transportation Infrastructure

Not applicable to the Project.

Construction Staging / Detouring

To be updated once alignment has been finalized to consider impacts.

4.1.2 Drainage

The hydrologic and hydraulic analysis is provided in a detailed report under **Appendix F**.

Ditches

Roadside ditches shall be sized to accommodate a minimum 10-year Minor System Design Flow, and a minimum 100-year Major System Design Flow (MTO Drainage Standards SD-1, SD-9). In most areas, roadside ditches will not be practical due to the wet terrain. Ditching will be provided primarily in the western areas of mineral soil. Equalization culverts will be required in peatland areas to convey groundwater flow.

Water Crossings

Pipe or open footing arch/box culverts will be used for watercourse crossings that have been determined to be small or moderate (i.e., not a bridge structure). The size of hydraulic opening for the culverts was assessed using 1-dimensional hydraulic models developed with Hydrological Engineering Centre's River Analysis System (HEC-RAS). HEC-RAS is developed by the U.S. Army Corps of Engineers, and it is widely used in the industry to model hydraulics of water flow through natural rivers and other channels. Model geometry was developed using topographical data and observations obtained during site visits and from other available sources (e.g., OWIT, LiDAR, etc.).

The structure size was based on:

- Freeboard of the Design Flow is 1.0 m.
- Clearance of the Design Flow is 1.0 m for bridges and 0.3 m for culverts.
- Bankfull Flow (typically 1 in 2-year flow) velocity in the culvert does not exceed natural channel velocity.
- Bankfull Flow depth in the culvert is consistent with average natural channel depth and there are no sudden drops in water surface exceeding 0.15 m.
- Minimum culvert width sufficient to maintain natural Bankfull Flow width.
- A 1.5 m clearance for navigation on streams of 3 m width or greater.

The Design Flow used was the 1 in 100-year flow, which is greater than the MTO Highway Drainage Design Standards (2024) recommendation of 1 in 50-year flow. This low risk-tolerant approach was taken to manage impacts that could result in roadway disconnections.

A preliminary review of the Ontario-specific climate models on the Ontario Climate Data Portal identified that future increases in rainfall intensities could be expected and could be as high as 40% from current meteorological conditions. To understand how increased precipitation will increase the runoff (e.g., Design Flow), a hydrological model representing local catchments will be developed. Observed flow at a nearby gauge will be recreated using observed climate data. The model will then be run again with future projections for temperature and precipitation to understand the potential increases in runoff. A percent increase in runoff will be used to increase the Design Flow peaks to account for climate change.

Table 4-1: Culvert and Bridge Crossing Parameters

Water Crossing	Type of Structure (Descriptions in Section 1.3)	Super-Structure Depth	Watercourse Width (m)	Span (m)	Diam / Rise (m)
WC-1	Composite Concrete Deck with Steel Plate Girders	2.35	250	253.75	R: Varies Max. 3m above HWL
WC-1A	Open bottom steel box culvert	0.15	1.90	2.10	1.60
WC-1B	Open bottom steel box culvert	0.15	0.70	1.80	1.60

Table 4-1 (Cont'd): Culvert and Bridge Crossing Parameters

Water Crossing	Type of Structure (Descriptions in Section 1.3)	Super-Structure Depth	Watercourse Width (m)	Span (m)	Diam / Rise (m)
WC-2	Open bottom steel box culvert	0.15	10.7	10.7	3.30
WC-2A	Open bottom steel box culvert	0.15	0.5	1.90	1.80
WC-3	Composite Concrete Deck with Steel Plate Girders (bridge)	1.25	46	48	5.1 m above bed
WC-4	CSP pipe culvert	0.15	2.22	2.40	2.40
WC-5	Open bottom steel box culvert	0.15	2.20	2.70	3.30
WC-6	Open bottom steel box culvert	0.15	12.20	14.00	2.70
WC-6A	Two CSP pipe culverts	0.15	No channel	2 x 1.9	2 x 1.9
WC-7	Open bottom steel box culvert	0.15	3.30	3.70	2.20
WC-8	Open bottom steel box culvert	0.15	4.30	5.00	2.70
WC-9	Open bottom steel box culvert	0.15	2.5	6.5	2.5
WC-10	Composite Concrete Deck with Steel Plate Girders	1.1	15	18 m	5.26 m above bed
WC-11	Open Bottom Steel Box Culvert	0.15	5.00	5.00	2.75
WC-12	Open Bottom Steel Box Culvert	0.15	7.00	7.00	2.60
WC-13	Composite Concrete Deck with Steel Plate Girders	1.35	20.0	22.8	3.69 m above bed
WC-14	Open Bottom Steel Box Culvert	0.15	4.00	4.50	3.20
WC-15	Open Bottom Steel Box Culvert	0.15	5.00	7.50	2.65
WC-16	Open Bottom Steel Box Culvert	0.15	7.00	7.00	2.60
WC-17	CSP Pipe culvert	0.15	2.00	3.00	3.00
WC-18	Open Bottom Steel Box Culvert	0.15	4.00	5.50	2.50
WC-19	Composite Concrete Deck with Steel Plate Girders	0.15	20.00	20.00	4.89 m above bed
WC-20	Open Bottom Steel Box Culvert	0.15	3.40	5.00	3.00
WC-21	Composite Concrete Deck with Steel Plate Girders	0.15	23.90	24.00	5.95 m above bed
WC-22	Open Bottom Steel Box Culvert	0.15	3.50	3.50	2.90
WC-23	Open Bottom Steel Box Culvert	0.15	3.30	3.30	2.80
WC-24	Open Bottom Steel Box Culvert	0.15	5.00	5.00	3.25
WC-25	2 Open Bottom Steel Box Culverts	0.15	4.24	6.00 and 4.00	2.50 and 1.85
WC-26	Composite Concrete Deck with Steel Plate Girders	1.75	30	32.9 m	3.83 m above bed
WC-27	Composite Concrete Deck with Steel Plate Girders	1.25	48	48.00	5 m above bed

Sewers

Not applicable to the Project.

Outlets

Not applicable to the Project.

Tile Drainage, Piped Frontages

Not applicable to the Project.

Municipal Drains

Not applicable to the Project.

Stormwater Management (Including Floodplains)

In order to maintain existing flow paths through the flat floodplains of the East-West segment of the road, it is anticipated that additional drainage features will be needed. Equalization culverts (approximately 1 m diam.) will be placed within the road as required to maintain localized minor flow paths across the road corridor.

4.1.3 Structures

Having optimized the structure types that would be most practical for the Project, each water crossing was reviewed for span requirements, hydrological considerations and navigational needs to arrive at a structural arrangement as described in **Table 4-2**. Structural general arrangement drawings are provided in **Appendix J**.

Table 4-2: Structure Types

WC Number	Width (m)	Maximum Span (m)	Number of Spans	Foundation Type	Structural Type
WC-1	253	253	7	Footing	Composite Concrete Deck with Steel Plate Girders
WC-1A	2.1	2.1	1	Footing	Open Bottom Steel Box Culvert
WC-1B	1.8	1.8	1	Footing	Open Bottom Steel Box Culvert
WC-2	10.7	12.9	1	Footing	Open Bottom Steel Box Culvert
WC-2A	1.9	1.9	1	Footing	Open Bottom Steel Box Culvert
WC-3	48	48	2	Footing	Composite Concrete Deck with Steel Plate Girders
WC-4	2.4	2.4	1	Footing	CSP Pipe culvert
WC-5	2.7	2.7	1	Footing	Open Bottom Steel Box Culvert
WC-6	12.2	14.0	1	Footing	Open Bottom Steel Box Culvert
WC-6A	2 x 1.9	2 x 1.9	2	Footing	2 CSP Pipe culverts
WC-7	3.7	4.0	1	Footing	Open Bottom Steel Box Culvert
WC-8	4.3	5.0	1	Footing	Open Bottom Steel Box Culvert
WC-9	2.5	6.5	1	Footing	Open Bottom Steel Box Culvert
WC-10	21.2	18	1	Pile	Composite Concrete Deck with Steel Plate Girders

Table 4-2 (Cont'd): Structure Types

WC Number	Width (m)	Maximum Span (m)	Number of Spans	Foundation Type	Structural Type
WC-11	5.0	5.0	1	Footing	Open Bottom Steel Box Culvert
WC-12	7.0	7.0	1	Footing	Open Bottom Steel Box Culvert
WC-13	23.0	23.0	1	Pile	Composite Concrete Deck with Steel Plate Girders
WC-14	4.0	4.5	1	Footing	Open Bottom Steel Box Culvert
WC-15	5.0	7.5	1	Footing	Open Bottom Steel Box Culvert
WC-16	7.0	7.0	1	Footing	Open Bottom Steel Box Culvert
WC-17	2.0	3.0	1	Footing	CSP Pipe culvert
WC-18	4.0	5.5	1	Footing	Open Bottom Steel Box Culvert
WC-19	20	23.0	1	Pile	Composite Concrete Deck with Steel Plate Girders
WC-20	3.4	5.0	1	Footing	Open Bottom Steel Box Culvert
WC-21	24	24	1	Footing	Composite Concrete Deck with Steel Plate Girders
WC-22	3.5	3.5	1	Footing	Open Bottom Steel Box Culvert
WC-23	3.3	3.3	1	Footing	Open Bottom Steel Box Culvert
WC-24	5.0	5.0	1	Footing	Open Bottom Steel Box Culvert
WC-25	4.24	6 and 4	2	Footing	2 Open Bottom Steel Box Culvert
WC-26	35.0	35.0	1	Footing	Composite Concrete Deck with Steel Plate Girders
WC-27	48	48	2	Footing	Composite Concrete Deck with Steel Plate Girders

Repairs to Existing

Not applicable to this assignment as there are no existing structures within the study limits or along the of the preliminary preferred route or OER for the Webequie Supply Road.

Cross-Section

The cross-section of the structures is shown in **Figure 3.2**.

Staging

As there are no existing structures in the along the preferred route for the road, each bridge can be constructed independently and with no additional considerations required for accommodating existing traffic. The westernmost segment of the road coincides with the existing community road (Eastwood Island Road / Road M) which provides access to the landfill site and other service / resource areas. It is expected that local traffic will be able to use the existing roads during construction.

Retaining Walls

The need for retaining walls will be determined during detail design.

Temporary Roadway Protection

As there is no existing road for the majority of the proposed route alignment, temporary roadway protection is not anticipated for bridge construction staging purposes.

4.1.4 Geotechnical and Foundations

4.1.4.1 Pavement Structure

The following site-specific factors will likely govern the design of the roadway structure in addition to the stability under traffic loading considerations.

- Surface and Subsurface Drainage;
- Seasonal Freezing and Thawing;
- Thermal changes in Discontinuous Permafrost;
- Muskeg/Peat Subgrade; and
- Availability of the Construction Materials.

Since most of the road alignment passes through low-relief area and the proposed surface profile closely follows the existing topography, surface and subsurface drainage will require careful planning. Embankment heights are small, minimizing any requirements for benches or drainage on benches. The underlying till is typically clayey and dense, representing very poor subsurface drainage characteristics.

The project area is situated near the southern boundary of the Sporadic Discontinuous Permafrost Zone of Canada's permafrost region (National Atlas of Canada, 5th Edition (1995): Canada Permafrost). In the Sporadic Discontinuous Zone, some areas beneath the land surface have permafrost and while most areas are free of permafrost, with permafrost occurring in islands or patches with approximately 10-50 % of the land area is underlain by permafrost. Permafrost varies in thickness (estimated at a few meters in the project area) and ground ice content in the upper 10-20 m of the ground is categorized as low (less than 10%). Locally, the thickness of the permafrost may be influenced by soil and rock type, snow cover and proximity to waterbodies.

A main concern is the potential for frost heave during annual freezing cycles and subgrade weakening during thawing. Frost heave requires freezing temperatures, frost susceptible soils and water availability. Shallow groundwater tables provide water to the freezing front. The upper 3 m of the pavement/subgrade profile will require detailed assessment to minimize impacts due to seasonal freezing and thawing. Esker materials with limited fines and crushed aggregates are potentially non-frost susceptible, while silt or silty materials are typically frost susceptible. Where frost susceptible subgrade exists within the predicted frost depth and its replacement with non-frost susceptible material is not feasible, the use of insulting layers will be considered. The presence of ice or ice rich soils will impact the stability and performance of the pavement due to the potential for thaw settlement and will be assessed along the road alignment during detail design.

Conventional pavement structure consists of layers of subbase (normally Granular B), base (normally Granular A) and surface course. The base layer (Granular A) will act as the surface layer as well; therefore, the surface course is almost absent. These layers will be founded on a subgrade having enough strength to support the traffic load and distribute it across the roadbed. For pavement, granular course thickness is typically 150 mm, while the combined thickness of base and subbase is dependent on traffic considerations and subgrade support characteristics. For the preliminary pavement structural assessment, the traffic loading can be considered as an 18 T truck, and for subgrade support characterization the road alignment can be divided into two sections. The North-South section exhibits "fair to good subgrade" and East-West section can be characterized as "poor to very poor".

Table 4-3: Pavement Structure

North – South Section	East – West Section
▪ Base Layer – Granular A: 150 mm ▪ Subbase Layer – Granular B: 600 mm ▪ Combined Cover Thickness: 750 mm	▪ Base Layer – Granular A: 200 mm ▪ Subbase Layer – Granular B: 800 mm ▪ Combined Cover Thickness: 1000 mm

The above recommended pavement structures are for preliminary quantities estimate and costing for current EA/IA study and are subject to further evaluations in the next development and design stage of the Project.

4.1.4.2 Roadway Driving Surface

Reference can be made to **Appendix D** – Geotechnical Engineering Report for detailed discussion and recommendations on driving surface or the roadway. For low volume (AADT under 2000) and Rural Collector Undivided roadway, Table 3.5.2 and Table 1,4.5 included in the MTO Pavement Design and Rehabilitation Manual – (2nd Edition, 2013) illustrates the secondary highway categories and their associated driving surface types.

For the west half of the WSR in stable soil conditions, the surface layer of the road that represents the driving surface for vehicles will be a chip seal treatment, which is a rapid setting bituminous emulsion sprayed onto the roadway surface followed by rolling in the high quality, washed, crushed and single-sized aggregate typically 9.5 mm or 6.7 mm. For the east half of the road in the peatlands with poor soil conditions it is proposed the driving surface be initially gravelled to accommodate potential embankment foundation settlements upon roadway open to traffic and allow time for settlement to be stabilized. During the operations phase, monitoring of the east half of the WSR in the peatlands will be conducted to assess performance/settlement, serviceability, and safety issues/concerns related to dust along the corridor. Depending on the outcome of this monitoring, the gravel driving surface may be replaced in future with an alternative surface treatment such as chip seal treatment, as proposed for the west half of the road, or asphalt pavement.

4.1.4.3 Aggregate Pits and Bedrock Quarries

Based on the review of geological maps of the area, terrain analysis using digital imagery and LiDAR, site visits and on-site drilling, sampling with rock coring, and test pit excavation, an assessment of the potential aggregate sources and bedrock quarries has been made. The North-South section of the road is located on higher relief terrain in comparison to the East-West section. The North-South section area has several nearby sand and gravel deposits. These are located along and in the proximity of the alignment of the North-South section. Some of the potential rock areas identified through the desktop review along the North-South section were confirmed with drilling and sampling of rock cores. Three boreholes were targeted in this section; 2 boreholes confirmed bedrock presence below 1.5 to 2.0 m depth of till overburden, and the bedrock coring was carried to 3 m into the bedrock. Through the northern portion of the North-South section, near the Webequie Community, several sand and gravel pits have been excavated for infrastructure development in the Webequie Community area. All these deposits are from the existing ground surface and exhibit minimal surface organics.

The East-West section is generally situated on a low-relief area with no significant visible aggregate borrow sources or bedrock outcrops. Minor outcrops were present towards both ends of this section. Towards the west end, out of three boreholes, 2 boreholes encountered rock; in one, under a 1.5 m till overburden and, in the second, at depth of 8 m. Shallow bedrock is more economical for quarry operations in comparison to at depths, given the requirement of continuous dewatering for deeper operations. Rock cores were obtained for 3 to 5 m depths into the rock. No rock coring was possible on the east end of this section, but there are visible rock outcrops in this area. Rock deposits were described as granite and gneiss of fair to good quality. Some local outcrops and boulders were also noted. No major aggregate or bedrock sources were identified in the eastern part of the East-West section.

A preliminary estimate of the total quantity of construction materials, including fill, aggregate, blast rock for peatland areas, and rip-rap material for erosion protection on water crossings is presented in **Section 4.1.7** and will be further refined during the detail design phase for the Project. Till deposits are located through most of the North-South section, the west and east ends of the East-West section, and in some isolated areas in the middle part of the East-West section. Most of the middle part of the East-West section is organic deposits. Large amounts of till will be required as a part of earthworks to prepare the subgrade. Till deposits are typically a sandy silt to silt matrix and would be suitable for subgrade construction. These deposits form suitable subgrade and subgrade material. However, they do not form any raised relief that could constitute likely major borrow sources.

As a result of the geotechnical investigations and the evaluation alternative locations for supportive infrastructure for the proposed WSR, two aggregate sources areas, referred to as ARA-2 and ARA-4, are recommended for development of pits and/or quarries. Details of the evaluation of alternative aggregate sources and rationale for selection of the sites for development are presented in Section 3 of the EAR/IS. The locations of ARA-2 and ARA-4 are presented in **Figure 4.3** and **Figure 4.4**. The following is a summary of the physical site characteristics at ARA-2 and ARA-4 with regards to the quality and volume of material to be extracted for the Project. Further details for these sites are presented in the WSR Exploration of Potential Aggregate Development Sites Report (July 2020) contained in insert appendix.

4.1.4.3.1 Aggregate Source Area ARA-2

ARA-2 is situated and intersects the north to south section of the preferred route for the WSR and is adjacent to an unnamed lake. The site is located on Crown land and there are no existing human-made features or building/structures on or near the site. Vegetation at the site is primarily coniferous forest with swamp thicket located at the shoreline area of the unnamed lake. The site consists of an elevated large landform area (refer to cross-sections E to I, **Figure 4.3**) and several small hills isolated along a north-trending ridge (refer to cross-sections A, B, C and D, **Figure 4.3**). The isolated smaller areas within the ARA-2 site were found to contain sand and/or gravel present, as well as bedrock beneath. However, these areas are not considered collectively to represent a significant volume of material for extraction and would require a network of access roads to connect the areas, and as such are excluded at this time as potential sources within the ARA-2 site. Access to ARA-2 will be from the preferred route for the WSR as it is developed, and therefore there is no temporary access road required from the road corridor to the site.

In the elevated large landform proposed for development, cross-section E is through a sand ridge standing up to 4.5 m above the surrounding terrain. Sand was observed in several locations along the length of this ridge. Terrain and soil investigations in this area revealed fine to very coarse sand with trace fine gravel. Sections F and G extend through the central part of the deposit and found bedrock was exposed along the northwest edge of the complex as well as in a local topographic high northwest of the complex. Section F is taken as indicating depth to bedrock in that location and found clayey silt and very fine sand grading down to fine to medium sand with some silt. Many locations in the south half of the complex show boulders at the surface. Overall, the terrain and soil investigations (cross-sections E to I, **Figure 4.3**) revealed a mixture of materials that include bedrock, sand, sand and boulders, gravel, till, and marine sandy mud.

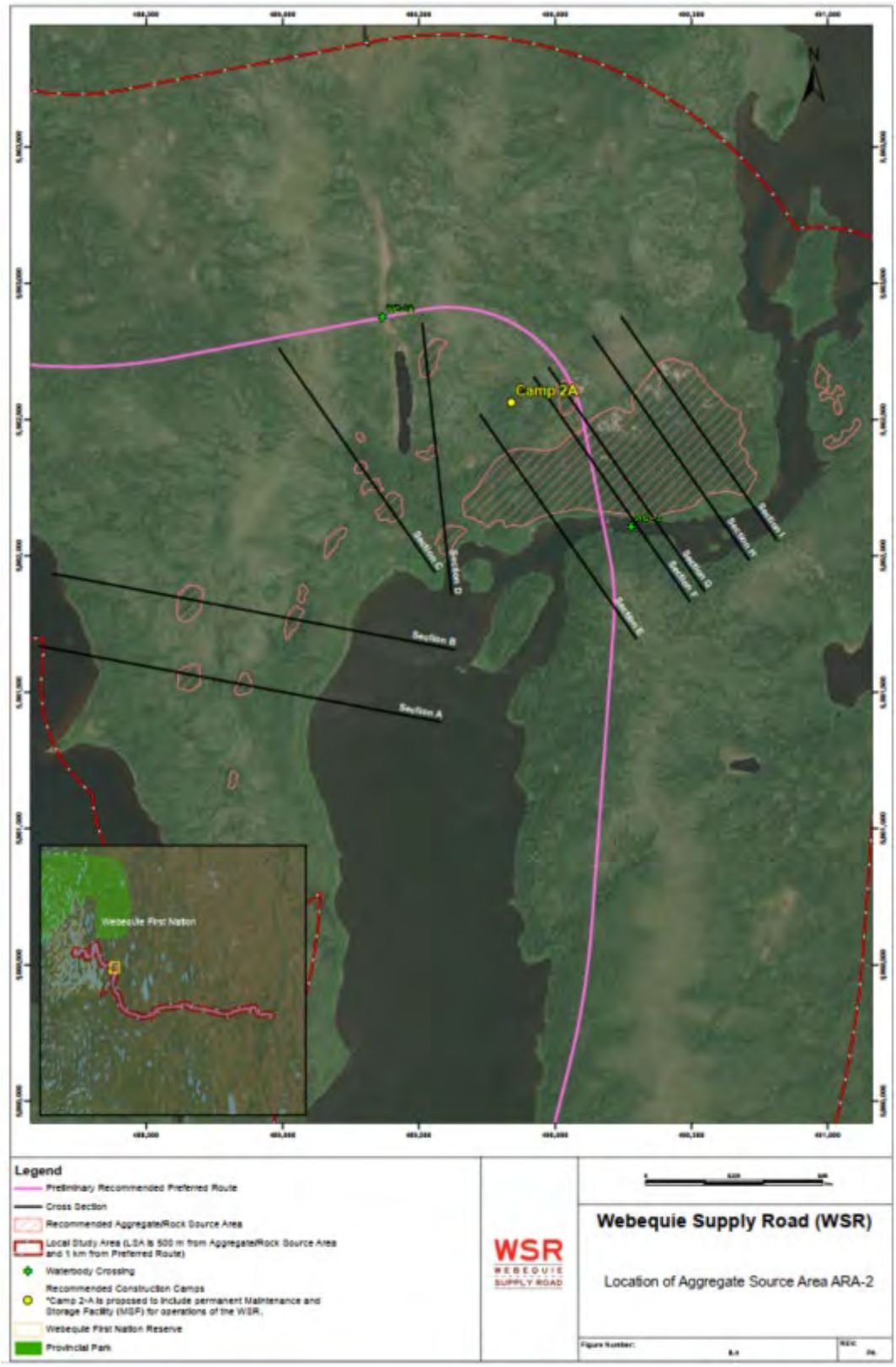
The volume of material available at the elevated large landform within ARA-2 is presented in **Table 4-4**. In this table, volumes are presented as a function of the depth to which mining, or extraction of material, is completed. The unnamed lake in this area had a water level in the range of 191.0 m to 191.6 m elevation at the time of the LiDAR survey in 2019. Given these water surface elevations, a conservative estimate of available material has been made by assuming that no mining would be done below the lake water level elevation of 193 m in order to mitigate against potential flooding into the aggregate pit/quarry. In addition, the development of this aggregate/rock source area will include retaining an existing vegetation buffer zone of a minimum of 100 m in width from the unnamed lake. Although it may be possible to mine below that lake water level with special drainage provisions, a more detailed study in the Detail Design Phase of the Project is recommended to confirm and assess feasibility. Also included in Table 46 are reduced volumes based on assumed percentages of spoil within the complex. It is assumed that the marine sandy muds and perhaps some of the till will represent spoil, and spoil volumes may exceed those presented in the table. In addition, organic material would also contribute to the percentage of spoil within the complex.

Table 4-4: Volume of Aggregate Material at ARA-2

Lower-Bound Elevation Defining Volume (m)	Volume Reduced Based on Percentage of Spoil Within Complex							
	Volume (m^3)	Surface Area (m^2)	5%	10%	15%	20%	25%	30%
192	1,764,947	519,714	1,676,700	1,588,452	1,500,205	1,411,958	1,323,710	1,235,463
193	1,276,375	454,126	1,212,556	1,148,738	1,084,919	1,021,100	957,281	893,463
194	857,139	368,261	814,282	771,425	728,569	685,712	642,855	599,998
195	527,977	287,628	501,578	475,179	448,780	422,381	395,983	369,584
196	271,906	203,413	258,311	244,716	231,120	217,525	203,930	190,334
197	101,302	123,408	96,237	91,172	86,107	81,042	75,977	70,912
198	21,519	32,308	20,443	19,367	18,291	17,215	16,139	15,063
199	4,298	6,535	4,083	3,868	3,653	3,438	3,223	3,008
200	462	1,080	439	416	393	370	347	323

Based on potential spoil of material, documented groundwater level at the site and approach of no mining below the elevation of 193 m, the volume of aggregate and bedrock aggregate expected to be feasible to extract at ARA-2 is estimated to be approximately between 893,463 m^3 to 1,276,375 m^3. Based on this assumption the total surface area proposed for development at ARA-2 is approximately 45.41 hectares (ha).

Figure 4.3: Aggregate Resource Area – ARA-2



4.1.4.3.2 Aggregates Source Area - ARA-4

ARA-4 is a large ridge located southeast of Winisk Lake and is approximately 5 km west of the WSR (refer to **Figure 4.4**). ARA-4 is located on Crown land and on Webequie First Nation Reserve lands under federal jurisdiction. Vegetation at the site is primarily coniferous forest with some areas of coniferous swamp and there are no existing human-made features or building/structures on or near the site. ARA-4 is among the largest glaciofluvial landforms mapped in the area and offers one of the largest potential sources of sand and gravel material. From the air, the landform appears heavily covered with forest, and the types of trees present indicate a thin layer of organics over mineral soils and sediment are present at the site. Based on the available topographic data, the central part of the ridge stands in the order of 25 m high above the surrounding low-relief.

From the soil and terrain investigations completed, ARA-4 is considered a significant reserve of sand and gravel. Groundwater monitoring wells drilled at site were observed to be dry during the 2020 and 2021 monitoring period, suggesting the management of groundwater is unlikely to be a concern during the mining/extraction of materials at the site.

The volume of potential material available at ARA-4 is presented in **Table 4-5**. In this table, volumes are presented as a function of the depth to which mining, or extraction of material, is completed. Similar to ARA2, the volume reductions are included in the table to provide a possible range of volumes that account for various percentages of spoil within the complex. The volume data were computed based on the assumption that the landform is predominantly composed of sand and gravel with no more than 30% being composed of spoil.

Table 4-5: Volume of Aggregate Material at ARA-4

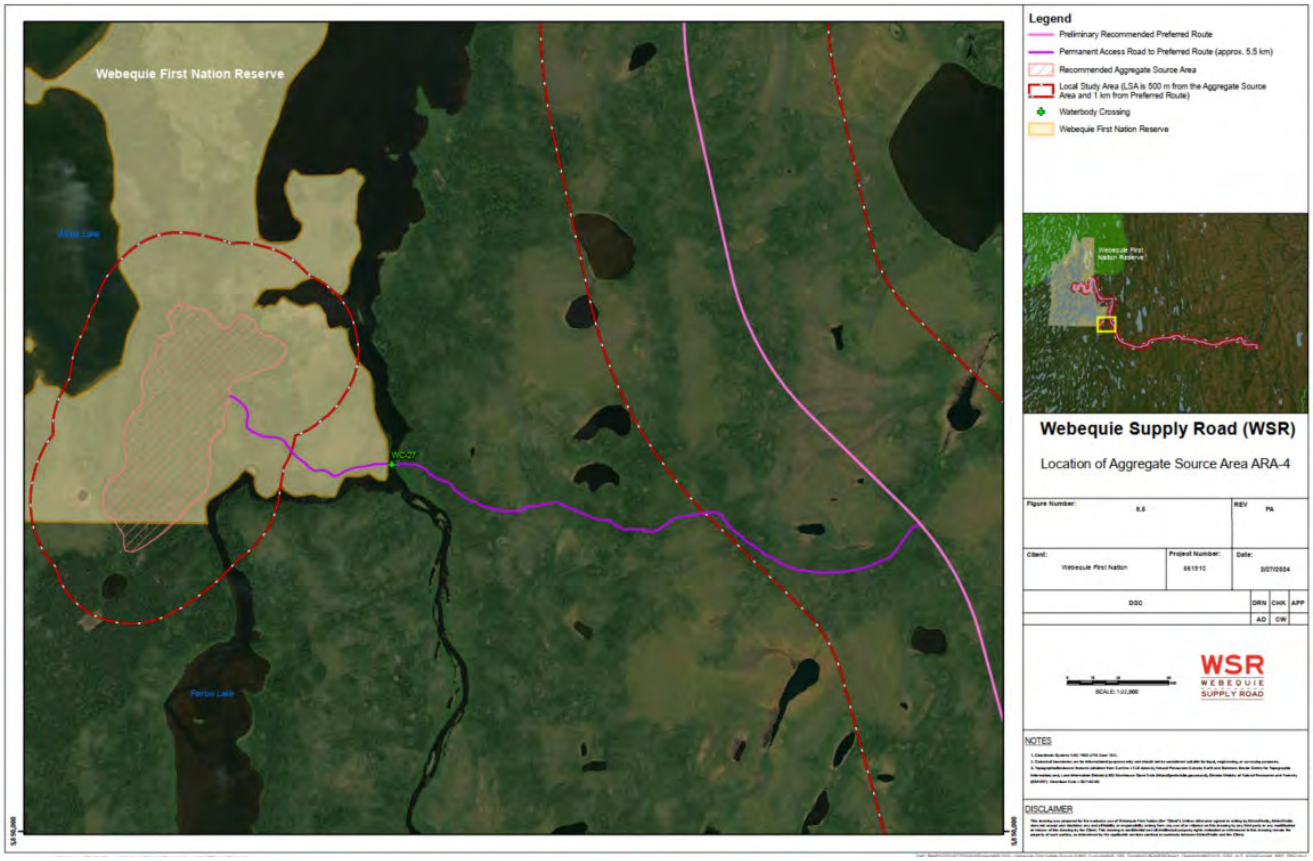
Lower-Bound Elevation Defining Volume (m)	Volume (m^3)	Surface Area (m^2)	Volume Reduced Based on Percentage of Spoil Within Complex					
			5%	10%	15%	20%	25%	30%
196	12,626,167	923,005	11,994,859	11,363,550	10,732,242	10,100,934	9,469,625	8,838,317
198	10,783,714	921,620	10,244,528	9,705,343	9,166,157	8,626,971	8,087,786	7,548,600
200	8,946,810	913,839	8,499,470	8,052,129	7,604,789	7,157,448	6,710,108	6,262,767
202	7,142,285	891,465	6,785,171	6,428,057	6,070,942	5,713,828	5,356,714	4,999,600
204	5,404,120	842,448	5,133,914	4,863,708	4,593,502	4,323,296	4,053,090	3,782,884
206	3,813,600	736,784	3,622,920	3,432,240	3,241,560	3,050,880	2,860,200	2,669,520
208	2,469,039	605,057	2,345,587	2,222,135	2,098,683	1,975,231	1,851,779	1,728,327
210	1,434,406	414,878	1,362,686	1,290,965	1,219,245	1,147,525	1,075,805	1,004,084
212	801,360	245,580	761,292	721,224	681,156	641,088	601,020	560,952
214	410,275	155,452	389,761	369,248	348,734	328,220	307,706	287,193
216	176,443	83,850	167,621	158,799	149,977	141,154	132,332	123,510

Mining to an elevation of 206 m at ARA-4 would yield 3,813,600 m^3 of material, and with the assumed volume available at ARA-2 would be adequate to meet the required total volume of material (4,854,500 m^3) needed for construction and operations of the Project. However, regional elevation data were used for volume calculations at ARA-4, which includes a larger margin of error as compared to the calculations made using LiDAR data at ARA-2. To account for a potential greater margin of error in the volume estimate at ARA-4, it is proposed that mining to elevation of 204 m be carried forward for the purposes of the effect assessment. Therefore, the volume of sand and gravel expected to be feasible to mine at ARA-4 based on mining to elevation of 204 m is approximately 3,782,884 m^3 to 5,404,120 m^3. Based on this assumption the total surface area proposed for development at ARA-4 is approximately 84.24 ha.

ARA-4 will provide a source of aggregate/rock material for construction of the road as well as a source of material for the assumed 75-year operation and maintenance life cycle for the Project. An access road from the preferred route is required for the development of ARA-4 during construction phase and this road would also serve as permanent access to transport of aggregate to the road during the operations phase. The access road to ARA-4 site is approximately 5.5 km in length and would require a waterbody crossing with a bridge.

More detailed geotechnical and geo-mechanical data is presented in the geotechnical report and the field and geophysical observations of potential aggregate and quarry areas are presented in JDMA (2019a) (**Appendix A**).

Figure 4.4: Aggregate Resource Area – ARA-4



Based on **Appendix A** – Terrain Analysis, Potential Aggregate Sources and Identification of Route Alternatives and **Appendix B** – Field Investigation of Peat Thickness and Potential Aggregate Sources (JDMA 2019), organics and peat exist along 60% of the road corridor under study. Through most of the East-West section, peat thicknesses vary from 0.5 to 5.0 m in bogs and from 1.0 to 4.7 m in fens. Excavation and replacement with suitable material is not considered acceptable from both engineering and environmental perspectives.

Road design and construction with peat left in place (or floating road) which avoids the disadvantage of bulk earthwork related to peat removal and backfill are considered more viable solutions and are widely acceptable in road engineering in the last two decades. To implement the design and construction option of leave the peat in place, the following methods and techniques that shall be considered in the design including: strength improvement during construction by staged construction, preloading, surcharging; installation of vertical drainage to speed up the consolidation; Reinforcement with geosynthetics including geofabrics and geogrids; Mass/ground improvements; load reduction by light weight fills or limit the embankment height and increase the embankment side.

In general, materials with negligible to low fines content are suitable for road base construction as is, or as blended with crushed rock products. Crushed rock products are suitable for road base construction. The existing till or suitable fine-grained soils can be used for subgrade as is, or as blended with crushed rock products. The clayey or silty wet material is not suitable within the upper 3 m of the road profile.

Based on the data gathered so far, bedrock along the North-South section is typically located at shallow depth and consists of strong, durable granitic rock. A few outcrops were also observed along the East-West section. Again, given the absence of any high relief and the presence of shallow groundwater in the region, the evaluation and development of several quarries locations was evaluated. Locations where bedrock was present at greater depths were not considered as potential quarries, as these would require extensive excavation and dewatering.

Geotechnical and geo-mechanical data for these materials are presented in geotechnical factual report (**Appendix C**), and the field and geophysical observations of potential borrow pits and quarries is presented in JDMA report (**Appendix A**).

4.1.4.4 Peatland Areas

Peat/muskeg/organic soils/topsoil are problematic under road embankment. These materials have high compressibility and low shear strength; hence, they have the potential to cause excessive deformations and stability problems. In addition to these immediate construction phase challenges, organic material decays over time and results in pavement distress and maintenance issues.

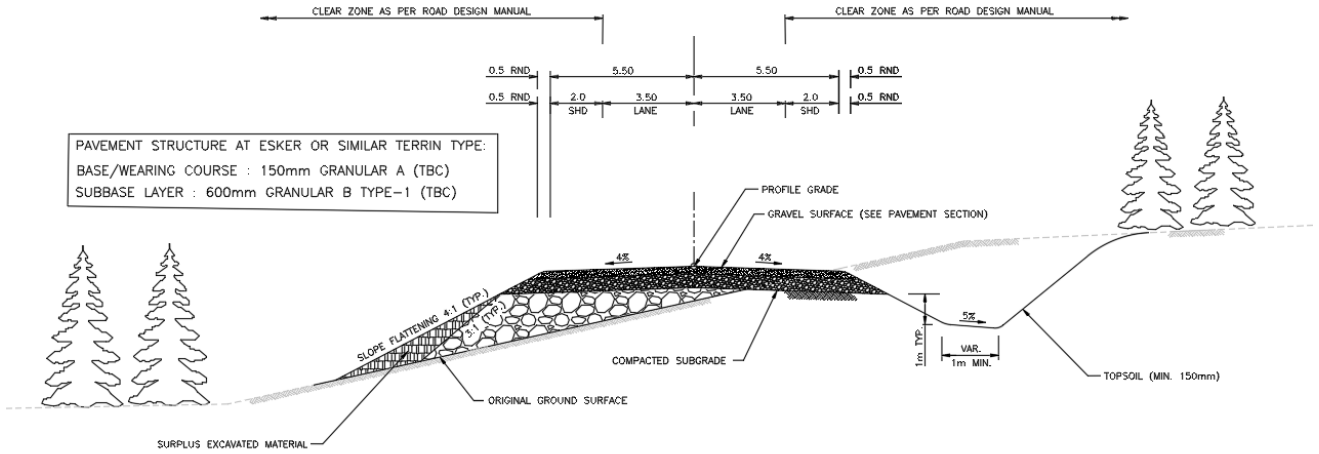
Along the major portion of the North-South section, the potential thickness of this unsuitable material, for majority of the road alignment, is < 0.5m. Suitable aggregate material is located close by the road alignment through this section (refer to **Figure 4.5**).

The thickness of this difficult but environmentally sensitive material along the major portion of the East-West section is 2 m to 4+ m. The entire East-West section is situated within the James Bay Lowland and construction of the road over peatland is unavoidable. The road embankment height in this section is typically about 1.5 m and will be built over the peat (refer to **Figure 4.6**).

It is a relatively light loading, if no reinforcement is used and the material is placed will cause gravity displacement. It has been assumed that embankment loading may result in 40% to 50% of the peat thickness compressing; additional compensation fill will be placed to maintain the required grade. Geo-fabric/geo-grid reinforcement will be applied at the road base-peat interface and permeable fill material placed over it; an assumption being made that it may result in at least 40% compression. This design would involve no removal/replacement of in situ peat.

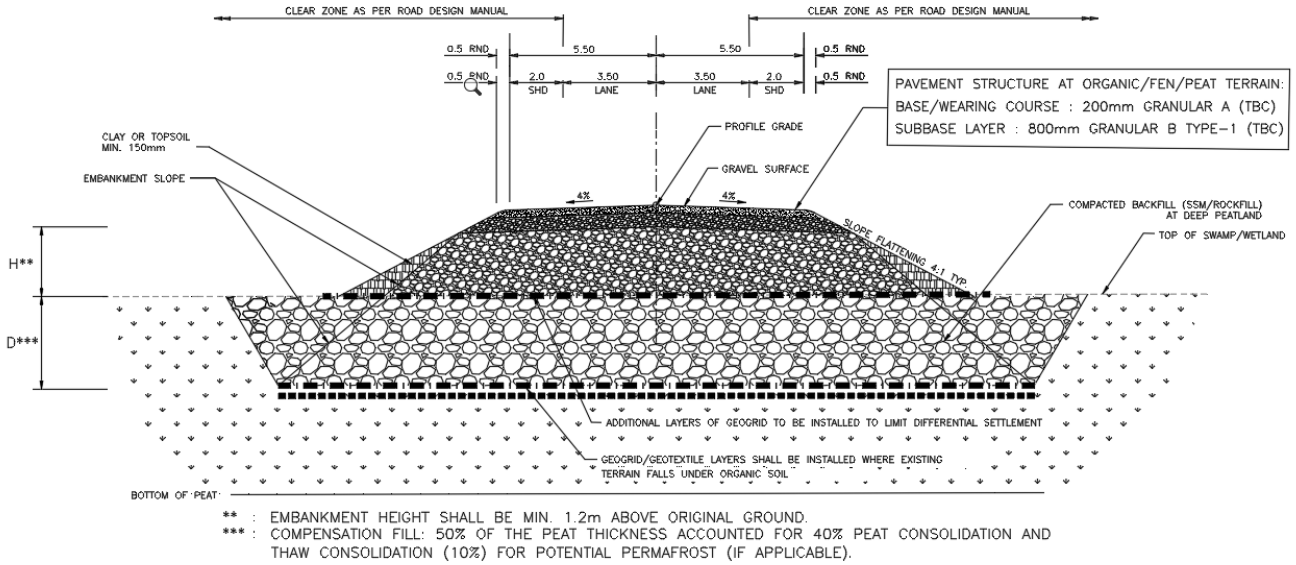
Other techniques to build road embankment over peat that were considered include preloading with surcharge, staged construction, wick/sand drains and surcharge, stabilization, floating foundations, and piled foundation. Additional field investigations and testing will confirm if the proposed design will be suitable for all peatland areas or if additional engineering is required at specific locations. Testing included von Post classification of the peat, peat compressibility, shear strength and hydraulic conductivity using in situ and laboratory testing methods as well as testing of the groundwater in the peatland.

Figure 4.5: Conventional Cut/Fill Section

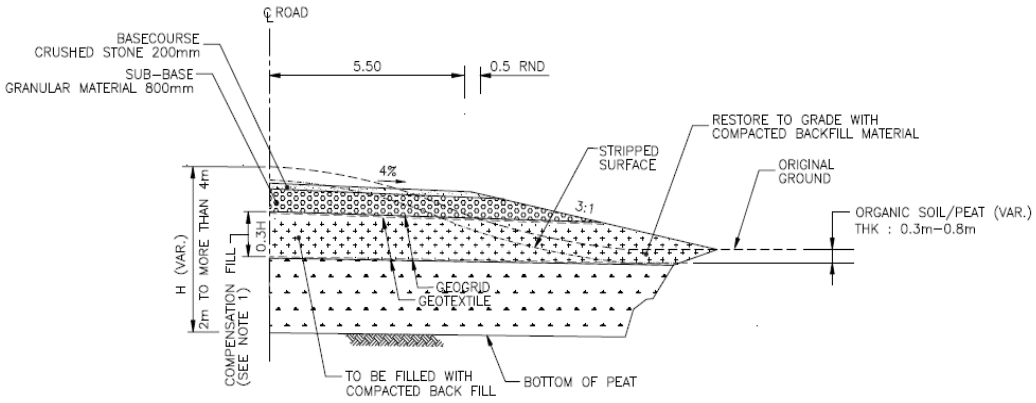


EMBANKMENT CROSS SECTION – MINERAL SOIL SUB-GRADE (TYP.)
UPLAND AREA (NORTH-SOUTH SECTION) FROM STA. 0+000 TO STA. 47+850

Figure 4.6: Peatland Treatment



EMBANKMENT ROCKFILL – DEEP PEATLAND (>1m) CROSS SETION (TYP.)
LOWLAND AREA (EAST–WEST SECTION) FROM STA. 47+850 TO STA. 106+030



WEBEQUIE SUPPLY ROAD
JAMES BAY LOWLAND AREA (EAST–WEST SECTION)
STA. 47+850 TO STA. 106+240

4.1.4.5 Foundations

Where dense till or bedrock or dense till over bedrock is encountered at shallow depths, shallow foundations may be used for major water crossing structures placed directly on the dense till, bedrock or dense till over bed rock, or on engineered fill over the former ground conditions. For major water crossings where peat or soft soils extended to 6 m or greater, driven steel piles, concrete piles, or bored piles may be preferred such as Winisk Lake or the Muketei River. At minor water crossing where there is either peat or soft soils over dense till, these materials may be replaced with suitable engineered fill to place the culverts over prepared ground. See **Appendix J** for Bridge General Arrangement Drawings.

4.1.4.6 Shallow Foundations

Based on the subsurface conditions reported at the site, spread footings could be placed on compact to dense till material, or on bedrock, depending on the depth of the bedrock surface. Where dense till or bedrock is deeper (3 – 4 m depth), excavations may be made to this level and the organics or loose/soft soils above replaced by compacted engineered fill to the desired foundation level. In case the footings are placed on the native till material or engineered fill material, the depth of the footing should be below the frost depth, or below the zone of influence of the creek bank erosion and a secure depth below the creek water table, whichever is deeper. The following serviceability bearing capacities are recommended:

- Allowable or Serviceability Limit State bearing capacity on native dense till/compacted structural fill: 150 kPa; and
- Allowable or Serviceability Limit State bearing capacity on rock formation: 1000 kPa.

4.1.4.7 Deep Pile Foundations

Although the use of conventional spread footing would likely be the preferred approach, consideration was given to the use of a pile foundation system for major and significant water crossings where bedrock is deeper than ±10m, and the soils above are either soft/loose or organics/peat and replacement of such soils is not possible. Driven H-piles or tubular pipe piles can be used. The following ultimate pile capacity parameters shall be considered:

- Unit shaft friction through dense till: 100 kPa; and
- Unit end bearing on bedrock: 10 mPa.

For long span crossings, such as Winisk Lake, where construction over water may be an option, bored piles (or caissons) may be considered. Bedrock is typically shallow and, for such piles, only end bearing capacity may be considered.

Freeze forces on piles or buried foundation surfaces through the frost penetration depths shall be considered for the design.

Settlement of road embankment may induce negative skin friction and drag load on foundations for water crossing structures. These shall be examined wherever applicable.

4.1.5 Right-of-Way Requirements

Proposed and Potential Right-of-Way Needs

In the future, the proposed 35 m wide Webequie Supply Road right-of-way (ROW) could also be used to accommodate power transmission lines and broadband infrastructure. However, given the current uncertainty as to how and when power and communications infrastructure will be extended into the project area, these components have not been included in the scope of the Project.

Property Requirements

The 35 m wide ROW was defined based upon the preliminary preferred route determined during the EA/IA study.

4.1.6 Construction

Construction Schedule

The Ministry of Transportation's Production Rates Manual (2011) was used as the basis for developing the estimated construction schedule for the proposed Webequie Supply Road. Standard summer/fall working days in the region based on weather will be approximately 117 but it is anticipated that work will continue year-round. Following the major item quantities for the proposed road (refer to **Table 4-5**), it is estimated that road construction will take approximately 5 to 6 years to complete. The following assumptions form part of the construction schedule estimate:

- Contractor will use temporary water crossings such as Bailey Bridges to bypass bridge construction sites to permit continuous grading operations;
- Construction will likely proceed from the west end of the Project; multiple crews working simultaneously will support a faster completion schedule; and
- Water crossing construction is not on the critical path, as the Contractor will likely employ temporary crossings for the purposes of road base construction while bridge construction is underway.

It is likely that quarry and aggregate source site preparation, and initial material stockpiling will precede construction.

Generally, the calculated working days for the major item quantities are shown in **Table 4-6**. The working days estimates account for either a single operation working from one end only toward other or a double operation working from both ends toward a common meeting point. It is expected that the Contractor will employ a double operation working from both ends in order to expedite construction.

Table 4-6: Working Days Estimation

Item		Quantity (m^3)	Daily Average (m^3/day)	Single Op. (days)	Double Op. (days)
Earth Excavation incl. Organics	2,277,000	4,800		474	237
Fill Required incl. Organics Replacement	1,850,919	4,800		385	192
Gravel Base and Surfacing	328,480	4,000		82	41
Gravel Subbase	1,539,088	4,800		320	160
Compensation fill to cover consolidations/settlements Fill		1,536,930	4,800	320	160

It is anticipated that work will commence with initial excavation and filling operations staggered slightly, with peat backfilling operation following where required. This will culminate in the placement of the granular road base, also staggered slightly following progression of the earth excavation and filling operation.

Contract Procurement Alternatives

For an undertaking of this size, it may be beneficial to consider awarding multiple contracts to help spread our construction capacity. This would ensure that multiple that multiple construction operations can occur simultaneously, albeit in different areas. The project delivery options will be evaluated based on various factors at the detail design stage. For such types of road construction projects, options may include "Design-Build" or "Design-Build-Finance".

In general, the possible contracting scenarios may include:

- Single contract: whereby a single General Contractor is hired to complete the entirety of the work;

- Two contracts: whereby the road is divided into two segments, each of which are tendered and awarded separately, and constructed simultaneously meeting in the middle;
- Three contracts: whereby the road is divided into three segments, each of which are tendered and awarded separately. The outer two contracts would be constructed simultaneously, and then followed by the third contract when at least one of the links is complete;
- Multiple/Four or more contracts: whereby the road is divided into segments, each of which are tendered and awarded separately. The outer contracts would be constructed simultaneously, and then followed by the inner contracts when the adjoining links are complete.

Smaller contracts would open the market up to more eligible and qualified firms that may not necessarily have the capacity to carry out the entirety of the road construction, or larger segments by themselves. This will be further evaluated as the project progresses and appropriate segmentation by estimated value and scoping will be explored during detail design.

Temporary Construction Facilities

As the design progresses and the procurement model is selected, the need for and situation of temporary construction facilities as identified in the EA/IA study to date will be further evaluated. This may include:

- Construction camps (number of camps and locations);
- Crushing facilities, stationary or mobile at aggregate source areas and at structure water crossing sites;
- Temporary concrete plants, stationary or mobile at aggregate source areas and at structure water crossing sites;
- Storage and laydown sites beyond those identified at temporary construction camps;
- Temporary access roads; and
- Temporary water crossings.

Further consideration should be given to the means of deployment for temporary facilities that may include the assignment of individual stationary crushing or concrete plants that will stay in one place for the duration of construction or mobile plants that will travel to new sites as construction progresses to reduce trucking cycle times.

Once the final procurement alternative and contract segmentation approach is established, additional consideration should then be given to the number of temporary facilities that will be constructed and the logistics of how they will be used by each of the Contractors awarded the work. This will include separate contract arrangements defining exclusive use or shared use.

Temporary access roads will be developed during the Detail Design Phase of the Project.

Remote Access Considerations

The remote nature of this study area will necessitate the use of winter roads for the purposes of general mobilization of plant and equipment, and supply of materials outside of locally sourced aggregate. It is understood that an existing network of winter roads can link the project site to the provincial highway network. Some road segments may be subject to separate agreements and/or upgrades prior to use.

Winter road capacities for mass and external dimension will need to be established at detail design to ensure large equipment and prefabricated structural elements are sized appropriately for delivery via the winter road network.

4.1.7 Cost Estimate

The preliminary estimated capital cost for construction of the proposed design is approximately $700M or over $5 M per centreline km. At this preliminary engineering design stage for the Project the accuracy of estimated cost is anticipated to be 40% +/- on the low side and high side. Based on the MTO parametric estimating guidelines (2016), the average cost for 2-lane new construction in north-western Region is $2.9M per centreline kilometre; however, this includes other elements that are not included in this assignment, such as hot-mix paving, illumination, and traffic signalization. This cost is based on major quantities shown in **Table 4-7** and broken down in **Table 4-8**.

Table 4-7: Preliminary Earth Quantities

Item	Total Net Volume	Total Volume Including 20% Swell (m^3)	Total Volume Including 20% Contingency
Earth Excavation incl. Organics	1,581,250	1,897,500	2,277,000
Fill Required incl. Organics Replacement	1,285,360	1,542,432	1,850,919
Gravel Base and Surfacing	1,067,312	1,280,775	328,480
Gravel Subbase	1,068,811	1,282,573	1,539,088
Compensation fill to cover consolidations/settlements Fill	228,111	2,737,335	1,536,930

Table 4-8: Construction Cost Breakdown

Item	Total Cost
Earth Excavation and Placement	$255M
Aggregate Subbase, Base and Surfacing	$105M
Compensation Fill in Peatlands	$85M
Large Structures	$55M
Smaller Structures	$32M
Other Construction Costs	$168M
Total	**$700M**

For budgetary purposes, other project construction costs include but is not limited to the following:

- Construction mobilization and demobilization;
- Construction administration costs at approximately 10% of construction value;
- Engineering Detail Design Costs at approximately 5% of construction value;
- Construction camps and supportive infrastructure;
- Developing concrete and asphalt batch plants;
- Developing aggregate sources and producing aggregates including access roads; and
- Personnel support requirements (e.g., Medivac, travel to/from site, etc.).

APPENDIX A

Terrain Analysis, Potential Aggregate Sources and Identification of Route Alternatives

WEBEQUIE SUPPLY ROAD: TERRAIN ANALYSIS, POTENTIAL AGGREGATE SOURCES & IDENTIFICATION OF ROUTE ALTERNATIVES

DRAFT REPORT

March 29, 2019

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Appendix 1: Terrain maps
Appendix 2: Water crossings

1 INTRODUCTION

Webequie First Nation, located approximately 500 km north of Thunder Bay, is developing an all-season road between the community of Webequie and the proposed Ring of Fire mining development around Esker Camp just to the east of the Mukutei River, known as the Webequie First Nation Supply Road Project (Figure 1). The Webequie Supply Road will offer year-round movement between the community and future mine sites and will facilitate economic opportunities for the community.

Preliminary corridor alternatives were identified and a preferred corridor was selected by the community based on engagement with the community as a whole, youth representatives, elders, and the Webequie land use planning committee. The preferred corridor, selected by the community, is approximately 107 km in length (extending about 51 km toward the south-southeast from Webequie before turning east for about 56 km toward Esker Camp), and 2 km in width. It is within this preferred corridor that the road route is to be selected.

As part of the Environmental Assessment and Preliminary Engineering Services for Webequie First Nation's Supply Road Project, J.D. Mollard and Associates (2010) Limited was sub-contracted by SNC Lavalin to conduct terrain mapping within the proposed community corridor to facilitate identification of potential aggregate sources, characterization of stream crossings, mapping of several competing route alternatives, and identification of an optimal route based on terrain and engineering considerations. This report provides the results of these studies.

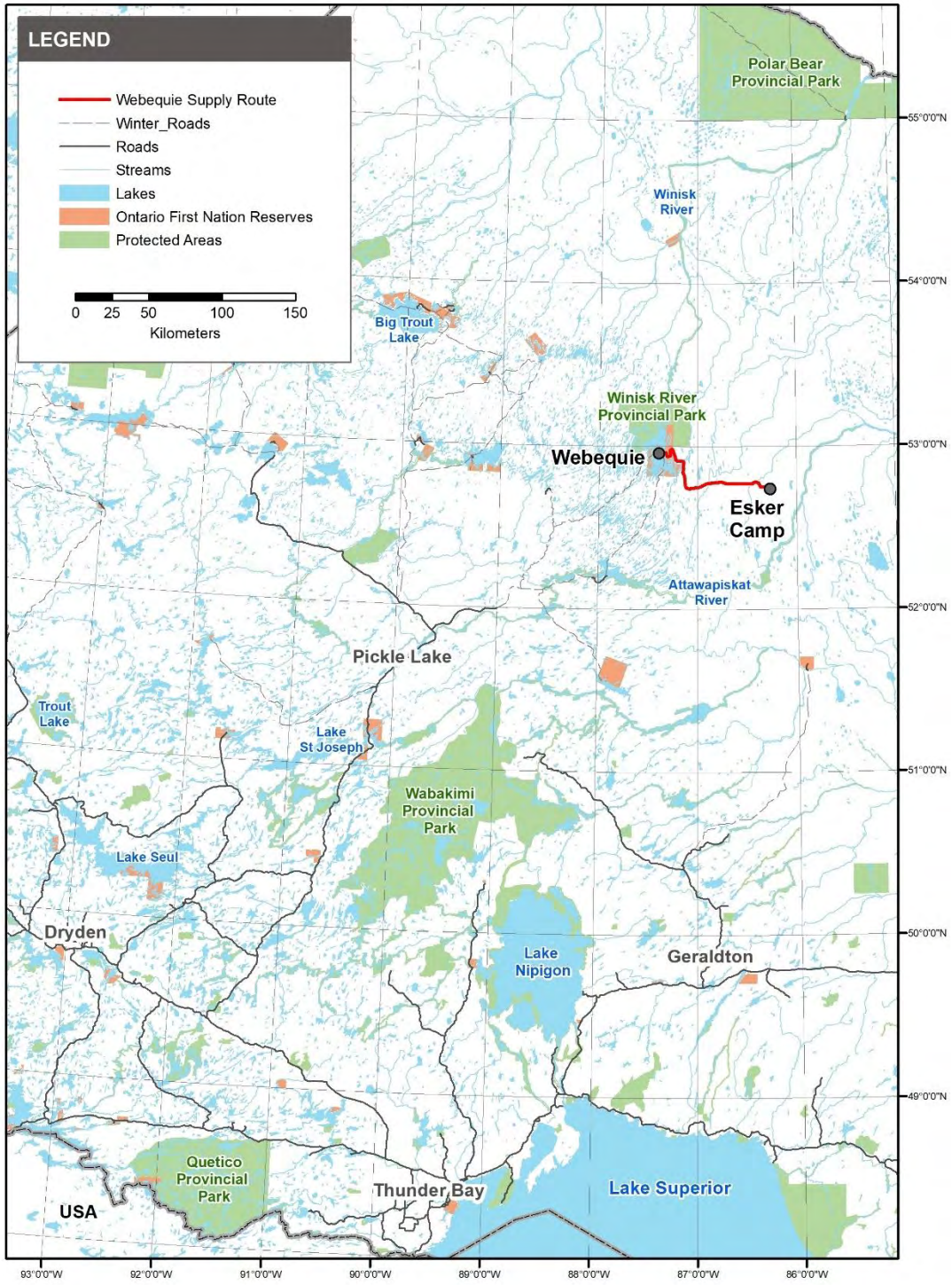


Figure 1: Location of the Webequie First Nation Supply Road Project.

2 DATA SOURCES

Terrain analysis was conducted using aerial and satellite imagery and digital elevation data. The primary source of desktop information for terrain mapping was high-resolution orthoimagery (20 cm resolution) and LiDAR elevation data (1 m resolution) acquired within the 2-km wide corridor for the project in October 2018. Satellite imagery available through ESRI World Imagery Basemap and Google Earth offered supplemental imagery at high-resolution. Air photo interpretation was also conducted at select locations using 1954 black & white photos at 1:60,000 scale, which when viewed stereoscopically provide 3-D perspectives to evaluate terrain and topographic conditions. These multiple sources of imagery assist with the terrain unit classification, particularly with resolving the wetlands and permafrost-affected terrain.

- Black & White air photos. Scale: 1:60,000. Year: 1954.
- ESRI World Imagery Basemap. Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
- Google Earth Pro V7.3.2.5491.
- Orthoimagery captured with LiDAR data. 20 cm resolution. October, 2018.

Elevation data covering the 2-km wide route corridor was provided by LiDAR (light detection and ranging) and processed at a spatial resolution of 1 m. Using the LiDAR data, shaded-relief and slope rasters were generated in ArcGIS to assist with the interpretation terrain units.

- LiDAR (light detection and ranging)
- Shaded-relief and slope rasters

Information on the surficial and Quaternary geology was obtained from the following published maps.

- Ontario Geological Survey, 1997. Quaternary geology, seamless coverage of the province of Ontario: Ontario Geological Survey, Data Set 14.
- Barnett, P.J. *et al*., 2013. Surficial Geology of the Lansdowne House Area Northeast, Northern Ontario. 1:100,000. P3697.
- Barnett, P.J. *et al*., 2013. Surficial Geology of the Lansdowne House Area Northwest, Northern Ontario. 1:100,000. P3696.

Hydrological information was obtained from the following sources.

- Ontario Hydro Network – Waterbodies. Land Information Ontario (LIO) Warehouse.
- Ontario Wetlands: Ontario Ministry of Natural Resources.
- Provincial Land Cover (2000) Database: Ontario Ministry of Natural Resources.

Information from previous JDMA terrain studies, particularly the terrain units and legend, was obtained from the following reports:

- McFaulds Lake Project – Webequie to Esker Camp road route location: Report on mineral and organic terrain mapping in a 10 km radius around esker camp. 2010. J.D. Mollard and Associates (2010) Limited. September 23, 2010. Report No. 1675.
- McFaulds Lake Project – McFaulds Lake Peat Sampling Field Trip Report. J.D. Mollard and Associates (2010) Limited. September 17, 2010.

3 METHODOLOGY

3.1 TERRAIN MAPPING

Terrain mapping within the proposed route corridor involved the interpretation of remotely sensed imagery (air photos and satellite images) and digital elevation data, supplemented with surficial geology, hydrology, and land cover data, to characterize the landforms, surficial materials, topography, hydrology, *etc*. Geospatial data sources available for this study were compiled in a geographic information system (GIS) and terrain units were manually digitized over base layers of imagery (air photos and satellite) and elevation data (elevation, shaded-relief, and slope rasters).

Terrain units were mapped and classified according to a legend developed for this area based on a compilation of previous reports and existing mapping (JDMA, 2010). The route corridor crosses extensive organic terrains of various bogs and fens along the east-west section of the corridor west of Esker Camp and glacial terrains with mineral soils on the roughly north-south section leading to the community of Webequie. Mineral terrains include till with a discontinuous lacustrine clay veneer, glaciofluvial ice-contact, esker ridges, and alluvial floodplains. Organic terrains include bogs and fens with tremendous diversity and extent.

Following is a description of the terrain units mapped within the routing corridor.

MINERAL TERRAINS

TL (Till and glacial lake clay): silty till (T) on a N-S fluted plain with a mostly thin, discontinuous cover of soft, sticky plastic lacustrine (L) silty clay. Extensive cover over the N-S section of the route corridor with some areas of thin bog or fen cover.

ER (Esker ridge): the esker core near Esker Camp consists of thick sand over gravel, reaching a total depth of more than 20m, with a discontinuous cover of glacial-lake clay on sideslopes. The esker system is segmented, with mostly short gaps and three notable local expansions called “bulges” (esker fans and deltas), resulting in very large volumes of nearby granular material.

GF (Glaciofluvial): Ice-contact glaciofluvial deposits (kames and eskers) consisting of sorted granular material.

AF (Alluvial floodplain): Varying mineral-soil textures along small creek channels whose floodplains are discontinuous and around the periodically flooded perimeters of water bodies. Relatively thin peat over alluvium, stream-eroded till, and intermittently flooded mineral soil. Mostly narrow and subject to flooding. Some creek channels are linear, following abandoned flute depressions or ice-keel scour depressions.

ORGANIC TERRAINS

BOG TYPE TERRAINS

DB (Domed bog): Oval, lenticular, teardrop, balloon and irregular-outlined domed shapes; common occurrence; usually greater than 500m in longest dimension; notably convex surface with crest up to several metres higher than bog edges and the surrounding terrain. Multiple drainage lines (*e.g.,* watertracks) commonly radiate outward from the bog summit. Clusters of bog pools on DB are less common than they are on PB, also with smaller pools and smaller and less well-defined clusters. Peat depth may exceed 3m near the DB central area. Stratified Sphagnum-sedge-woody shrub peats with large Sphagnum lawn and black spruce areas at ground surface.

PB (Northern plateau bog): Typically large, slightly raised (0.5 to 1 m) bog above the surrounding terrain with steep edges -- thus plateau-like in appearance with a commonly irregular outline edge in plan. Numerous larger bog pools usually occur in larger clusters than observed on DB. Distinct pool clusters are also more common on PB than on DB, forming net (reticulate) patterns of narrow peaty ridges between large pools (NB), occasionally transitioning downslope to string bogs (SB) and then downslope to string (ribbed) fens. Includes flat bog, not raised above the surrounding surface with peat depth generally uniform and with less common net bog (NB). Light grey air photo tones result from extensive Sphagnum moss lawns with sparse black spruce trees and shrubs. Common stratified peat depths are 2 to 4 m, consisting of moderately decomposed Sphagnum peat over Sphagnum and sedge peats.

NB (Net bogs): component of northern plateau bogs (PB), located at one or more locations on flat-topped bog summits, includes minor string bog and string fen. The pattern consists of a network of reticulate narrow (2 to 3 m wide) peaty ridges about 1m high, separating numerous small to large bog pools having irregular and linear shapes (NB). Pools are occasionally aligned in parallel strings at right angles to surface-water runoff and to groundwater flow (SB). In this study, NB included SB in the terrain mapping. Pools vary from shallow to very deep.

TB (Treed bog): Areas of extensive tree cover developed on relatively thin organic material over mineral soils. Typically occur along the margins of streams and watercourses.

TK (Thermokarst bog, also called collapse scar bog, often associated with treed bog (TB)): Slightly raised perennially frozen peatland (permafrost-affected) with small, uniform-sized, roundish ground-ice-thawed collapse holes containing water or wet fen vegetation, called “collapse scars”. The resulting spotty speckled or mottled air photo pattern of whitish collapse holes is caused by subsidence upon melting of ground ice and possibly melting of palsas in a few places. This unit

tends to occur along the sloping margins of small and large creek drainages, and is also found as small isolated randomly distributed patches in neighbouring upland areas.

FEN TYPE TERRAINS

SF (String fen): on sloping terrain; narrow subparallel stringy peat ridges enclosing slit-like depressions with open water or wet fen vegetation (mostly sedge with shrubs and tamarack trees). Strings are aligned at right angles to the slope and in the direction of surface-water runoff and groundwater flow. SF areas are larger than ladder fens. String width becomes narrower and more closely spaced as slope gradient increases downslope. Peat depth is commonly over 2 m.

LF (Ladder fen): subtype of string fen, thus similar to string fens in appearance but smaller with narrower pools, often along the margin of domed and plateau bogs. Peat thickness is commonly 1 to 2 m.

CF (Channel fen): fens occupying generally well-defined longer and wider channels, including abandoned glacial meltwater channels, with and without small streams. Peat depth may exceed 2 m in some CF fens.

WF (Watertrack fen): A flowing pattern of narrow slightly concave surface runoff courses and groundwater seepage on slopes, radiating from the summits of domed and plateau bogs. WF may also originate from springs and seeps. Common peat depths of 1 to 2 m.

HF (Horizontal fen): broad, featureless gentle slopes. Commonly uniformly forested with trees, shrubs, coarse grasses and sedges. Commonly transitional to swamps (swamp-fens). Common peat thickness of 2 to 3 m.

Peat depths described in some of the terrain units are from the Canadian Wetland Classification System, University of Waterloo, Wetlands Research Centre, 1997. These depths are supported by soil probe data collected previously by JDMA from field sites south of the proposed corridor. Peat depths were also evaluated within the Webequie road corridor using ground penetrating radar in February 2019 as part of this study (See Section 3.2).

3.2 GROUND PENETRATING RADAR (GPR) SURVEYS

Ground penetrating radar (GPR) surveys were carried out at representative peatlands within the routing corridor to help characterize the depth and variability of the peat layer over bedrock or glacial sediment. GPR surveys were conducted from February 18-23, 2019.

Prior to the GPR field work, representative survey sites along the routing corridor were identified from the air photo terrain analysis and mapping work. At each survey site, two or more GPR transects were identified. Waypoints for equipment and personnel drop-off and transect start/stop points were provided to the GPR crew for location and navigation in the field. Access to each site was via helicopter, which brought in the survey crew, equipment, snowmobiles and fuel needed to conduct the surveys. There were three members of the GPR crew: Troy Zimmer and Jason Cosford, of JDMA, and Eric Jacob, of the Webequie First Nation community. A total of five (5) peatland areas were surveyed during the February 2019 field work (Figure 2). Sixteen (16) survey transects were collected in the field, capturing approximately 22 km of GPR profile data.

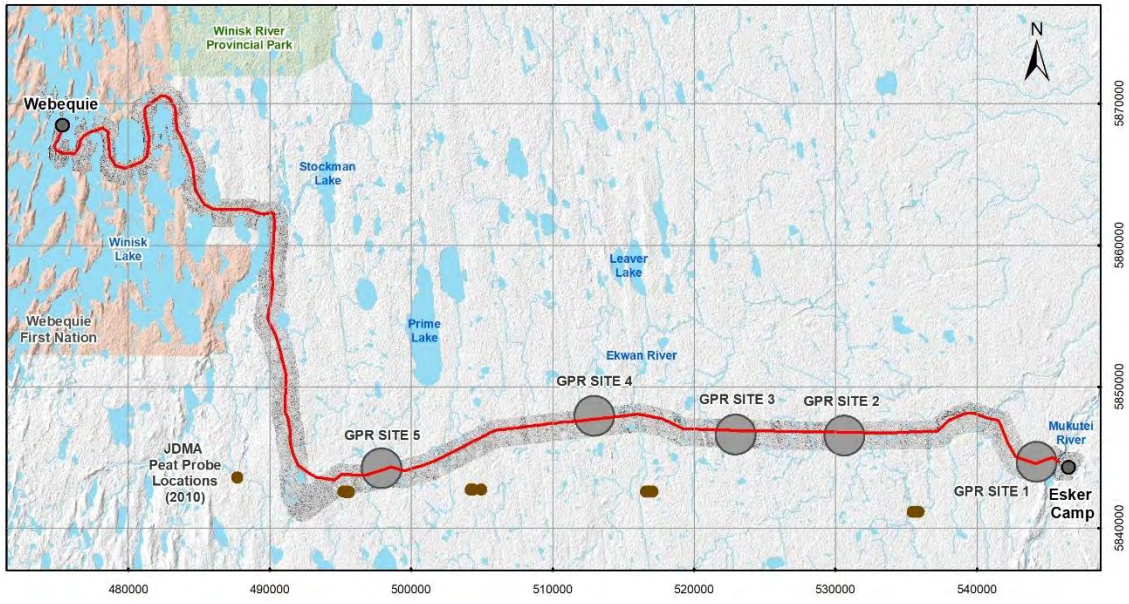


Figure 2. GPR and peat probe locations. Locations of the five peatland sites surveyed with GPR during the February 2019 field work (large grey circles) and peat probe locations from 2010 (small brown circles).

The field surveys were conducted used a Sensors & Software Noggin™ 100MHz GPR system mounted on custom skies and towed by snowmobile. A TopCon DGPS unit provided submeter geographic positioning for the GPR reflectance data as it was collected along each survey transect. The radar reflectance data for each survey transect was processed using Sensors & Software Ekko_Project v5.3 GPR software suite.

Figure 3. Field photographs of the GPR and peat probe. Left: Noggin 100MHz GPR system and ski mount being pulled by snowmobile at one of the GPR survey sites. Right: using a peat probe to try and measure depth to mineral soil / bedrock at the start of Transect 2-1.

The GPR survey crew attempted to use a hammer-style peat probe to measure actual peat depth at the first survey transect but were unable to push through the frozen peat to reach the top of the bedrock or glacial sediment. As a result, the processed GPR profiles assume a return radar wave velocity of 0.040 m/ns, a typical value cited in the literature for peatlands in northern Ontario. Because return wave velocity determines depth-below-surface measurements for features shown in the GPR profiles, it is recommended that sample peat depths be taken at points along selected survey transects during the summer so that the wave velocity and depths can be more accurately calculated and applied to the GPR profiles.

For each survey transect, the top of bedrock or glacial sediment was identified based on the distinctive reflectance pattern produced in the GPR profile when the radar pulse crosses the interface between the bottom of the water-saturated peat layers (with has relatively high dielectric values) into the much more dense, low-dielectric material below (Figure 4). The interpreted peat depths along each transect line are displayed as colour-coded depth points on the transect maps for each site (see Results, below). Since most survey transects cross several peatland terrain types (as interpreted by the air photo mapping work), statistics on the minimum, maximum and average peat depths for each terrain type were also compiled, for both individual transects and for the study sites as a whole.

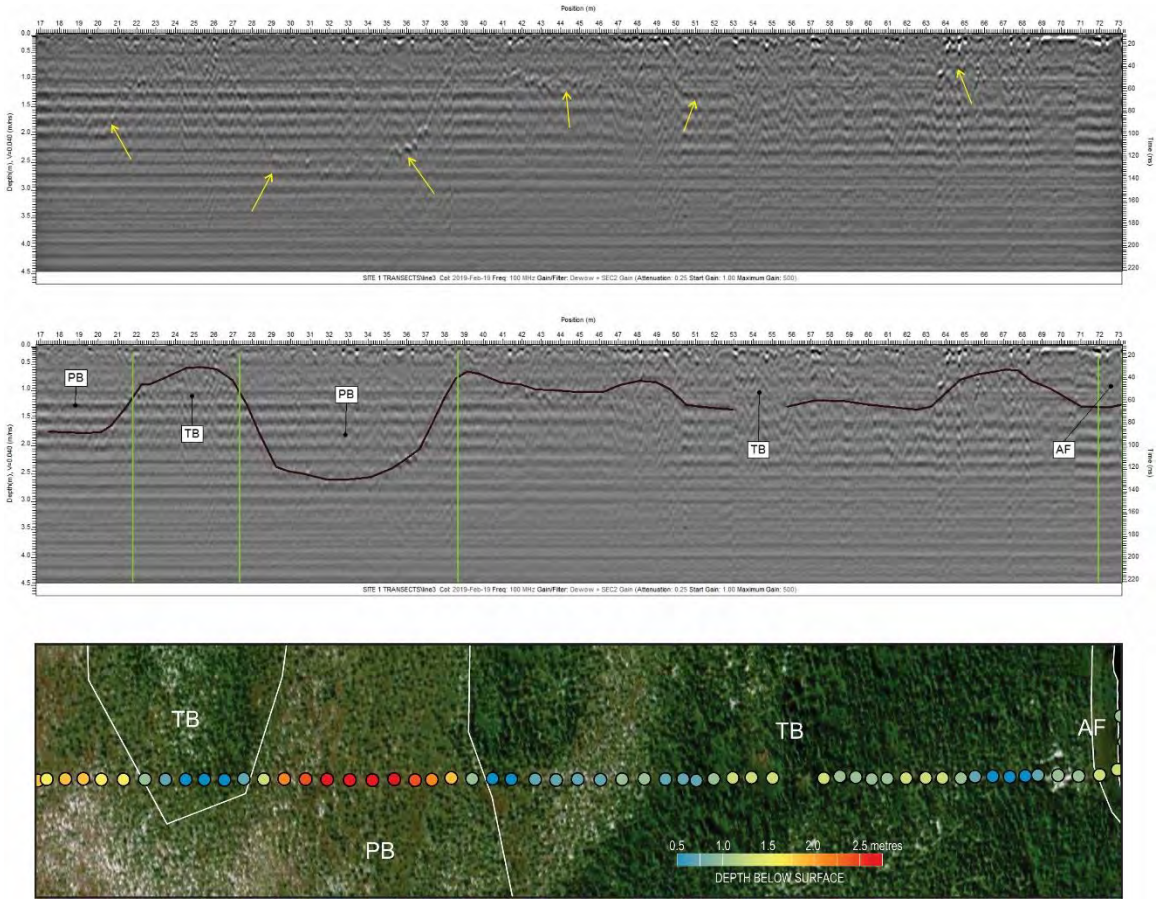


Figure 4. Portion of the GPR profile collected along a survey transect at SITE 1. TOP: GPR profile before interpretation; the reflector generated by the interface between the peat and the mineral soil / bedrock layers (indicated by the yellow arrows) shows up as a distinct white line within the profile stratigraphy. MIDDLE: Annotated profile with interpretation of the location of the peat / mineral interface (brown line); the interpretation polygon was used to generate the depth maps and statistics for each site, while the terrain type boundaries (in green) and terrain annotation was added to help with summarizing the statistical results. BOTTOM: The final colour-coded depth points (generated from the interpretation polyline), overlain on satellite orthoimagery and the terrain mapping datasets; the points represent the depth below surface (in metres) of the interpreted interface for every metre along the survey transect.

3.3 IDENTIFICATION OF ALTERNATIVE ROUTES

The selection of a final road route between Webequie First Nation and Esker Camp will rely on various social, culture, environmental, and engineering considerations. An initial road route provided by the community was used to establish a 2-km-wide corridor within which LiDAR data and orthoimagery were collected. In this study, the identification of route alternatives and the selection of an optimal route within the proposed route corridor from a terrain perspective follows the interpretation of terrain conditions and consideration of related engineering considerations. Terrain mapping characterized the landforms, surficial materials, topography, hydrology and groundwater conditions within the proposed corridor, which provided the basis for evaluating the favourability for route location and construction. Detailed engineering design, environmental, social and cultural factors will be considered by others in separate study components.

The following considerations served to guide the evaluation of all-weather road route alternatives in this study:

- Route length
- Surficial material (mineral vs organic soils)
- Bogs vs fens
- Topographic relief and slopes
- Ice-rich peat bogs and fens
- Extensive wetland & thermokarst-affected terrain
- Characteristics of river and stream crossings (width, approach slopes, *etc.)*
- Proximity to potential aggregate sources

Several route alternatives were identified with consideration to minimize the total route length, to follow routes that maximize terrain units of favourable constructability (*e.g.,* mineral soils), minimize units of poor constructability (*e.g.,* fens), minimize the number and widths of stream crossings, and minimize aggregate haul distances. While a shorter route is typically preferred, *ceteris paribus*, there can be environmental, engineering, social and economic advantages of an overall longer route that follows favourable terrain units and minimizes stream crossings. Terrain units with mineral soils are considered favourable for route construction, while those units with organic soils are considered unfavourable (Table 1). Bogs are preferred over fens because bogs typically have a lower water table and fewer open water areas. Treed bogs are considered more favourable than other bogs because the extensive tree cover hints at thinner organic cover with better drainage and roots anchored in mineral soils.

Table 1. Constructability Ranking

Constructability Ranking	Terrain units
Good	TL, ER, GF, AF*
Fair	TB, TK
Poor	DB, PB, NB, AF*
Very Poor	SF, CF, LF, HF, WF, AF*

*Alluvial floodplains exhibit various constructability rankings due to the variability observed in the imagery, ranging from mineral soils to aquatic vegetation.

3.4 WATER CROSSINGS

Surficial hydrology within the route corridor includes numerous streams, fens and bogs that will require various engineered water crossings. Overall, drainage of the area trends south to north, following the orientation of the fabric of glaciated landforms and ultimately draining into Hudson Bay. Stream crossings include both open water and flat alluvial floodplains. Many of the alluvial floodplains appear to feature extensive aquatic vegetation floating as a mat along the margins of the main open water channels. At these locations, the width of the water crossings should consider the area mapped as alluvial plain. Fens, particularly channel and ladder fens, having water tables at or near the surface and flowing groundwater gradients may also need to be treated as "water crossings" when considering engineering design options.

Stream crossings were characterized using the orthoimagery and LiDAR elevation data to describe the open water width, alluvial floodplain width, maximum slope, bank height, and terrain unit.

3.5 POTENTIAL AGGREGATE SOURCES

The road route corridor crosses an area of extensive wetlands and organic soils that limit prospects for potential aggregate sources. Aggregate prospects were identified while terrain mapping the route corridor. Air photo and satellite imagery, along with existing surficial geology maps, were used to identify granular landforms as potential sources of aggregate. Landforms created by meltwater processes during deglaciation are typically composed of sorted granular material. It is this relationship between landforms and materials that allows for granular prospects to be mapped by terrain analysis. Bedrock outcrops, with or without minimal overburden were identified and mapped as potential quarry sites.

The characteristics of the granular deposits and suitability and location of potential bedrock sources are as yet unproven. Field reconnaissance is required to describe and characterize the materials. At granular prospects, shallow test holes can be dug manually to a depth of a 30-60 cm to make an

initial assessment of material gradation and quality. At potential quarry sites, the lithology of rock and structural elements (fractures, bedding, foliation, *etc*.) visible at surface can be described to make an initial assessment of bedrock suitability for aggregate production. At the most promising sites drilling or deeper test pits would be required to fully assess the potential aggregate sources.

At the planning stage, the availability and distribution of construction material along a proposed route provides an important input to construction and maintenance cost estimates. Information compiled from the aggregate assessment will be provided regarding the material quality (gradation of granular material and lithology of bedrock), distance of source from the ROW, spacing along the ROW that can be used to optimize potential borrow sources, and potential access routes.

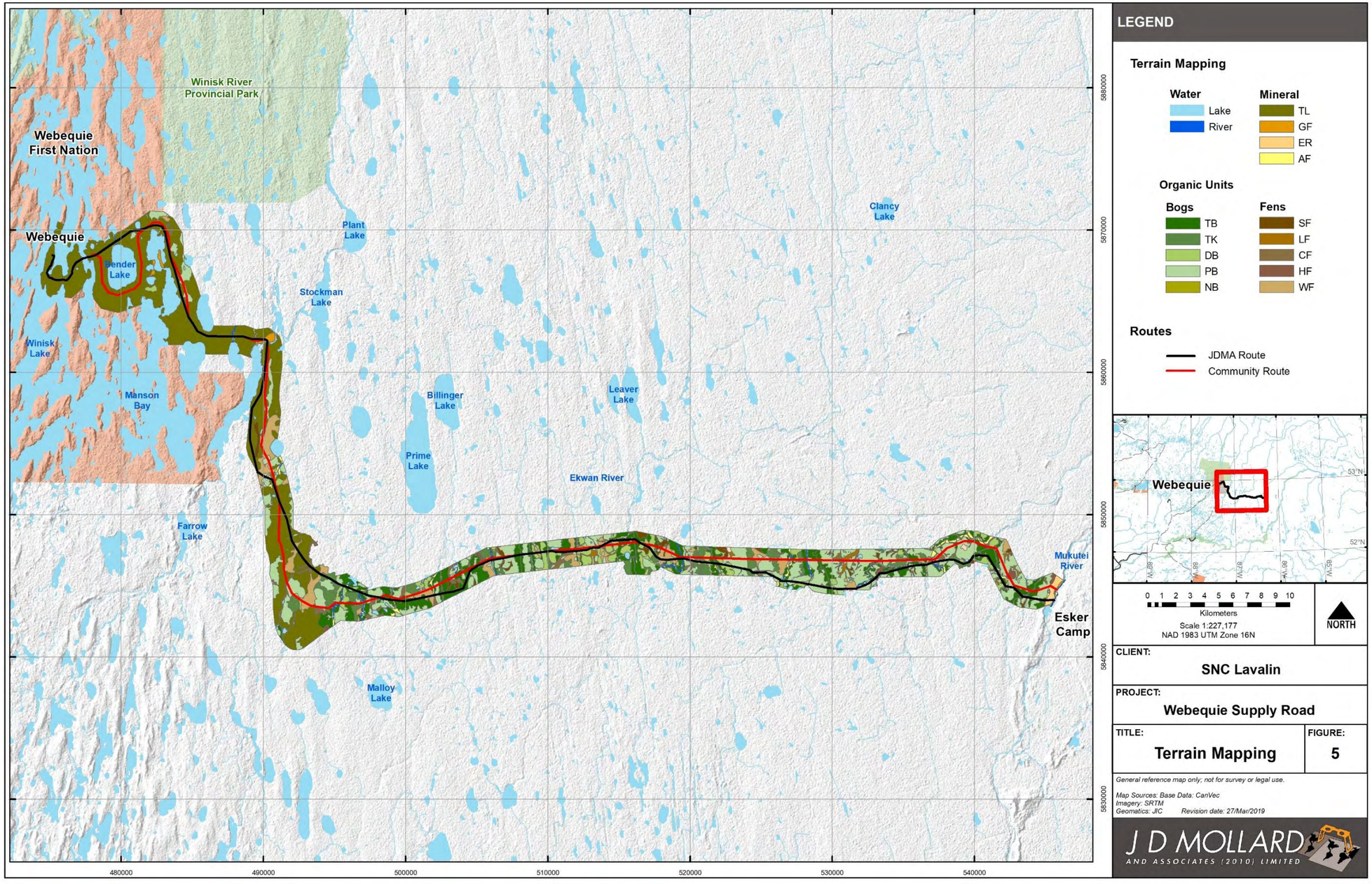
4 RESULTS

4.1 TERRAIN MAPPING

Terrain mapping was completed within the 2-km-wide corridor between the community of Webequie and the Mukutei River near Esker Camp (Figure 5). Large-scale maps are provided in Appendix 1. The total area mapped is 255.48 km^2, of which mineral terrains cover 87.12 km^2, organic terrains cover 133.33 km^2, and water (lakes and rivers) covers 35.03 km^2 (Table 2).

Table 2: Terrain units and area covered within the 2-km-wide Webequie Supply Road corridor

Terrain Units	Area (km^2)
Mineral Terrains	
TL	78.06
ER	0.95
GF	0.98
AF	7.13
Total Mineral Terrains	87.12
Organic Terrains	
Bogs	
DB	12.87
PB	51.32
TB	31.93
NB	0.22
TK	11.66
Total Bog Terrains	108.00
Fens	
SF	3.89
LF	1.72
CF	5.67
WF	12.84
HF	1.21
Total Fen Terrains	25.33
Total Organic Terrain	133.33
Water	
Lake	33.98
River	1.05
Total Water Terrains	35.03
Total	
Total	255.48



LEGEND

Terrain Mapping

Water	Mineral
Lake	TL
River	GF
	ER
	AF

Organic Units

Bogs	Fens
TB	SF
TK	LF
DB	CF
PB	HF
NB	WF

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
NAD 1983 UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: 5

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 27/Mar/2019*

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4.2 GROUND PENETRATING RADAR

Figure 2 shows the locations where GPR surveys were conducted. Results are summarized below.

SITE 1

GPR SITE 1 is located on a long, narrow northern plateau bog near the eastern terminus of the proposed road route (Figure 6). The plateau bog is bordered to the east by a high esker ridge that overlooks the Muketei River and Noront's Esker Camp. The west border of the plateau bog is a series of narrow treed bogs draining into the small, unnamed creek to the west. GPR SITE 1 was considered one of two highest-priority sites for GPR data collection during the field program.

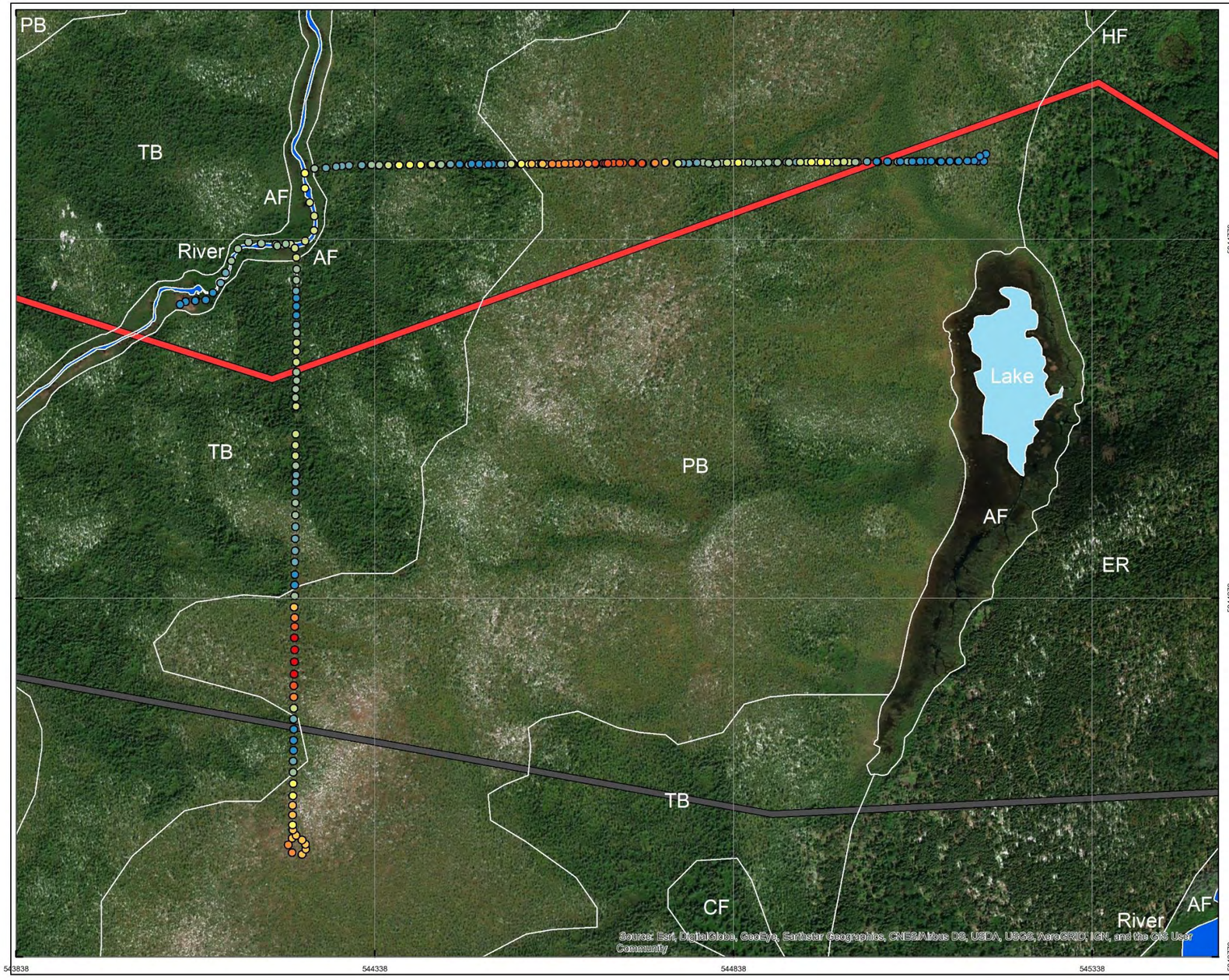
Two (2) GPR transects were surveyed at SITE 1, both taking advantage of existing seismic cut lines that allowed easy access through the dense forest on the treed bogs. Table 3a shows the average peat depth below for the two transects, along with the minimum and maximum depths observed and measure of standard deviation. Table 3b summarizes the average peat depth (and related statistics) for all transects in SITE 1.

Table 3a. GPR Site 1 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 1-1				
Northern Plateau Bog (PB)	2.0 m	1.1 m	2.6 m	0.4
Treed Bog (TB)	1.0 m	0.6 m	2.6 m	0.2
Transect 1-2				
Northern Plateau Bog (PB)	1.3 m	0.5 m	2.3 m	0.6
Treed Bog (TB)	1.0 m	0.5 m	1.7 m	0.3

Table 3b. GPR Site 1 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	1.5 m	0.5 m	2.6 m	0.6
Treed Bog (TB)	1.0 m	0.5 m	1.7 m	0.3



LEGEND

Routes

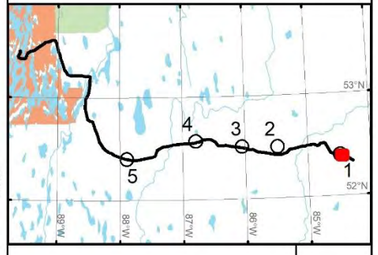
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 0.75 m
- 0.75 - 1.0
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- > 2.5 m

0 100 200 300
Meters



Scale 1:5,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: **SNC Lavalin**

PROJECT: **Webequie Supply Road**

TITLE: **GPR RESULTS SITE 1**

FIGURE: **6**

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 2

GPR SITE 2 is located approximately 20 km west of SITE 1, on an extensive northern plateau bog dissected by a complex series of long, narrow ladder fens, watertrack fens, string fens, and channel fens (Figure 7). Several small ponds and areas of thermokarst are also scattered across the plateau. SITE 2 was considered the highest-priority site for GPR data collection during the field program.

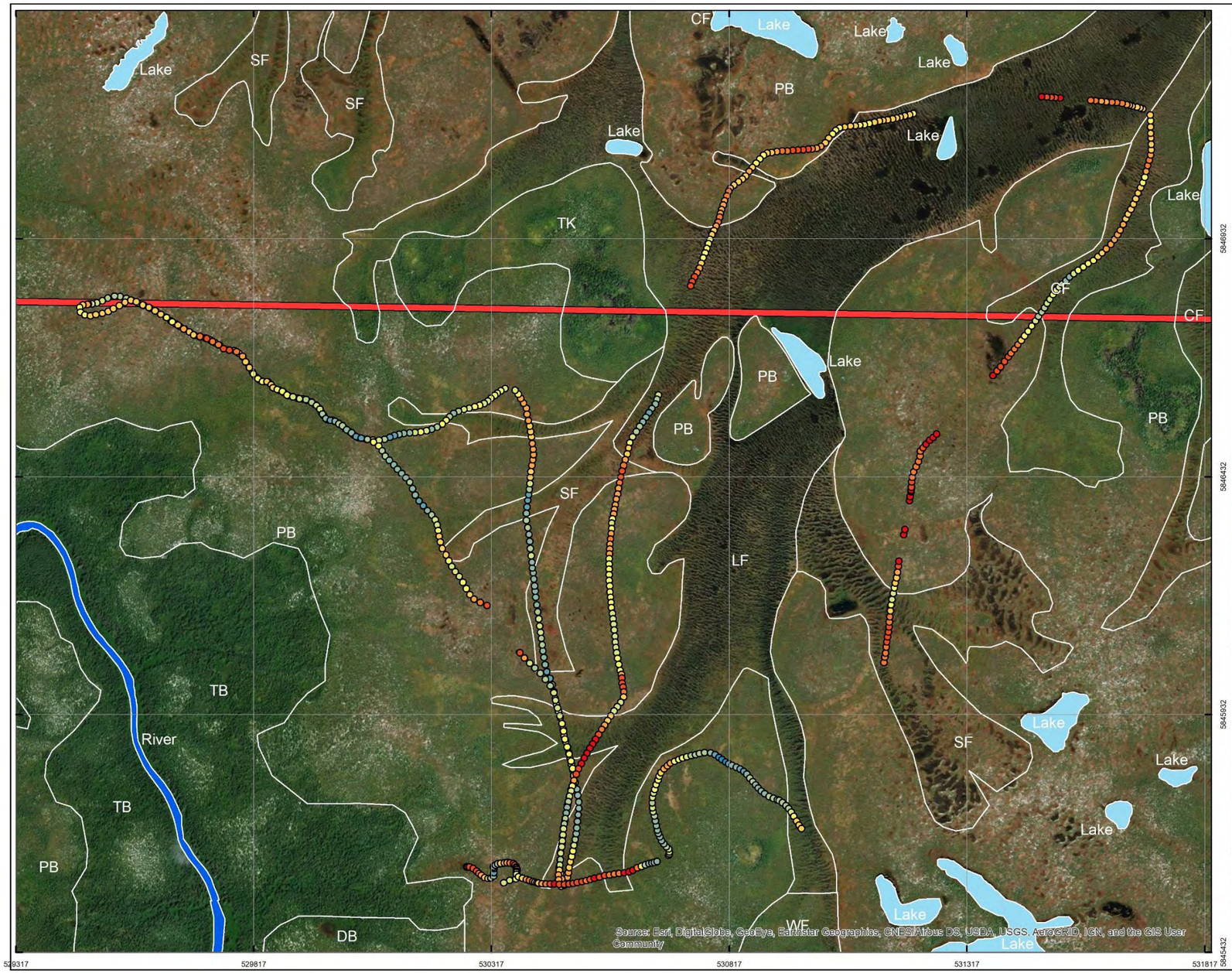
Four (4) GPR transects were surveyed at SITE 2, one running approximately west-east, two running approximately north-south, and the final one running northwest-southeast. Table 4a shows the average peat depth for each terrain type encountered, along with the minimum and maximum depths and measure of standard deviation. Table 4b summarizes the average depth, per terrain type, for all transects collected at SITE 2 combined.

Table 4a. GPR Site 2 Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 2-1				
Northern Plateau Bog (PB)	2.6 m	1.4 m	3.8 m	0.7
Ladder Fen (LF)	3.3 m	2.4 m	3.9 m	0.5
Transect 2-2				
Northern Plateau Bog (PB)	3.6 m	2.2 m	5.0 m	0.6
String Fen (SF)	3.3 m	2.4 m	3.7 m	0.4
Channel Fen (F)	2.7 m	1.8 m	3.3 m	0.3
Transect 2-3				
Northern Plateau Bog (PB)	2.9 m	1.9 m	3.9 m	0.4
Ladder Fen (LF)	3.1 m	1.7 m	4.7 m	0.7
Channel Fen (F)	3.0 m	2.9 m	3.0 m	> 0.1
String Fen (SF)	3.5 m	3.3 m	3.6 m	0.1
Transect 2-4				
Northern Plateau Bog (PB)	2.5 m	1.6 m	3.8 m	0.6
Ladder Fen (LF)	2.3 m	1.8 m	3.0 m	0.4
String Fen (SF)	2.1 m	1.7 m	3.0 m	0.4

Table 4b. GPR Site 2 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.8 m	1.4 m	5.0 m	0.7
String Fen (SF)	2.6 m	1.7 m	3.7 m	0.7
Ladder Fen (LF)	3.0 m	1.7 m	4.7 m	0.7
Channel Fen (CF)	2.7 m	1.8 m	3.3 m	0.3



LEGEND

Routes

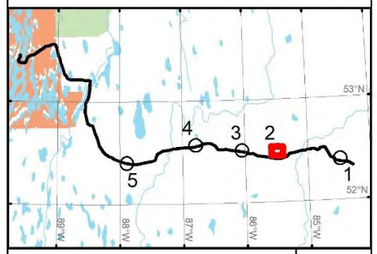
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.5 m
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- > 3.75 m

0 100 200 300 400
Meters



Scale 1:7,500
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT:
SNC Lavalin

PROJECT:
Webequie Supply Road

TITLE:
GPR RESULTS SITE 2

FIGURE:
7

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 3

GPR SITE 3 is located approximately 7 km west of SITE 2. The area contains a mix of northern plateau and domed bogs with a few small, scattered areas of open water, treed bog and thin channels of string fen (Figure 8). SITE 3 is one of the widest (continuous) expanses of peatland within the proposed route corridor and so was considered high-priority for GPR data collection.

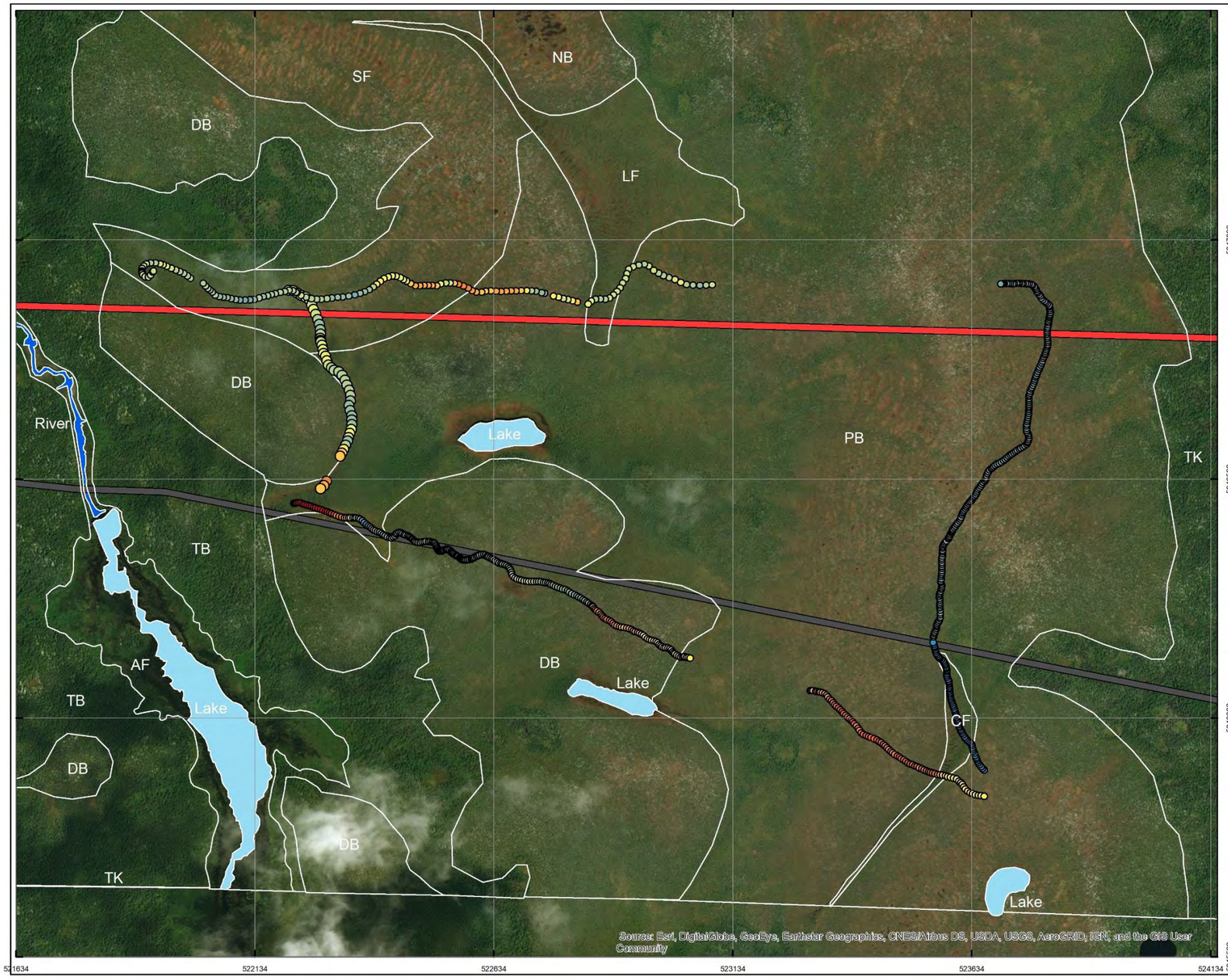
Four (4) GPR transects were surveyed at SITE 3, two running approximately west-east and two more running approximately north-south. Table 5a shows the average peat depth (along with minimum and maximum depths and measure of standard deviation), by terrain type, for each of the SITE 3 transects. Table 5b summarizes these statistics for all SITE 3 transects combined.

Table 5a. GPR Site 3 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 3-1				
Northern Plateau Bog (PB)	3.3 m	1.2 m	4.3 m	0.8
Domed Bog (DB)	2.2 m	1.2 m	3.7 m	0.7
Channel Fen (CF)	3.0 m	2.8 m	3.2 m	0.2
Transect 3-2				
Northern Plateau Bog (PB)	1.5 m	1.2 m	1.7 m	0.1
Channel Fen (CF)	1.2 m	1.1m	1.3m	> 0.1
Transect 3-3				
Northern Plateau Bog (PB)	2.4 m	1.7 m	3.6 m	0.5
Ladder Fen (LF)	2.3 m	2.1 m	2.7 m	0.1
Transect 3-4				
Northern Plateau Bog (PB)	2.4 m	2.0 m	3.6 m	0.5
Domed Bog (DB)	2.4 m	1.9 m	3.1 m	0.4
Ladder Fen (LF)	2.3 m	1.8 m	2.6 m	0.2

Table 5b. GPR Site 3 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.2 m	1.2 m	4.3 m	0.9
Domed Bog (DB)	2.2 m	1.2 m	3.7 m	0.7
Ladder Fen (LF)	2.3 m	1.8 m	2.7 m	0.2
Channel Fen (CF)	1.3 m	1.2 m	3.2 m	0.4



LEGEND

Routes

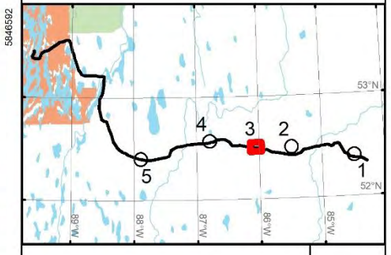
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.25 m
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4.0
- 4.0 - 4.25
- > 4.25 m

0 100 200 300 400
Meters



Scale 1:7,500
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: **SNC Lavalin**

PROJECT: **Webequie Supply Road**

TITLE: **GPR RESULTS SITE 3**

FIGURE: **8**

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 4

GPR SITE 4 is located approximately 5 km east of the Ekwan River, and approximately 10 km west of SITE 3. The site is a complex mix of domed bogs and northern plateau bogs, with the different bog types separated by thin channels of ladder fen and string fen that radiate out from an extensive ladder fen on the southeast side of the site (Figure 9). A thin line of treed bog borders the site to the west.

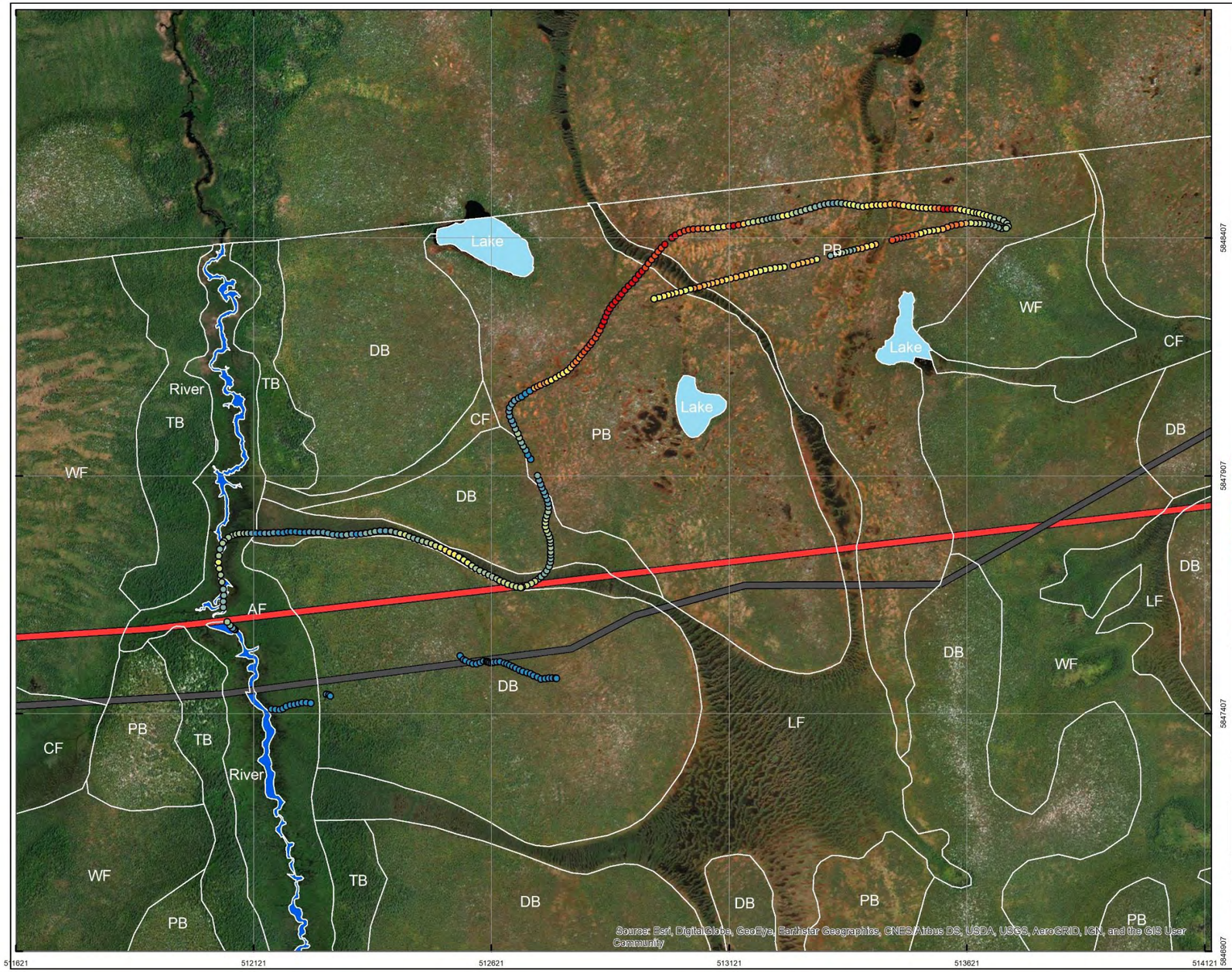
Three (3) GPR transects were surveyed at SITE 4, all running approximately west-east across the survey site. Table 6a shows the average peat depth (along with minimum and maximum depths and measure of standard deviation), by terrain type, for each of the SITE 4 transects. Table 6b summarizes these statistics for all SITE 4 transects combined.

Table 6a. GPR Site 4 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 4-1				
Domed Bog (DB)	1.0 m	0.7 m	1.3 m	0.2
Treed Bog (TB)	1.0 m	1.0 m	1.0 m	0.01
Transect 4-2				
Northern Plateau Bog (PB)	2.6 m	1.2 m	3.9 m	0.9
Domed Bog (DB)	1.8 m	1.3 m	2.0 m	0.3
Ladder Fen (LF)	1.9 m	1.0 m	3.7 m	0.7
Transect 4-3				
Northern Plateau Bog (PB)	2.6 m	1.5 m	3.6 m	0.5
Ladder Fen (LF)	1.9 m	1.1 m	3.3 m	0.5

Table 6b. GPR Site 4 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.6 m	1.2 m	3.9 m	0.8
Domed Bog (DB)	1.1 m	0.7 m	2.0 m	0.3
Treed Bog (TB)	1.0 m	1.0 m	1.0 m	> 0.1
Ladder Fen (LF)	1.9 m	1.0 m	3.7 m	0.6



LEGEND

Routes

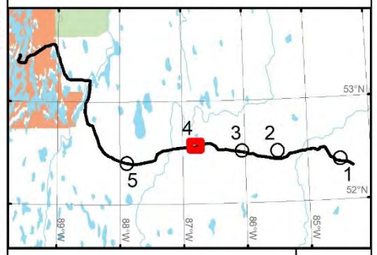
JDMA Route
Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.25 m
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- > 3.75 m

0 100 200 300 400
Meters



Scale 1:7,500
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT:
SNC Lavalin

PROJECT:
Webequie Supply Road

TITLE:
GPR RESULTS SITE 4

FIGURE:
9

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

J D MOLLARD AND ASSOCIATES (2010) LIMITED

SITE 5

GPR SITE 5 is the western-most of the sites surveyed, located approximately 5 km west of the Ekwan River, and within a few kilometres of where the proposed route makes its main turn from north-south to east-west. SITE 5 consists of extensive areas of northern plateau bog dissected by bands of treed bog, channelized fens and open water (Figure 10). Areas of thermokarst terrain are also present along the edge of the treed bogs that border the site to the east.

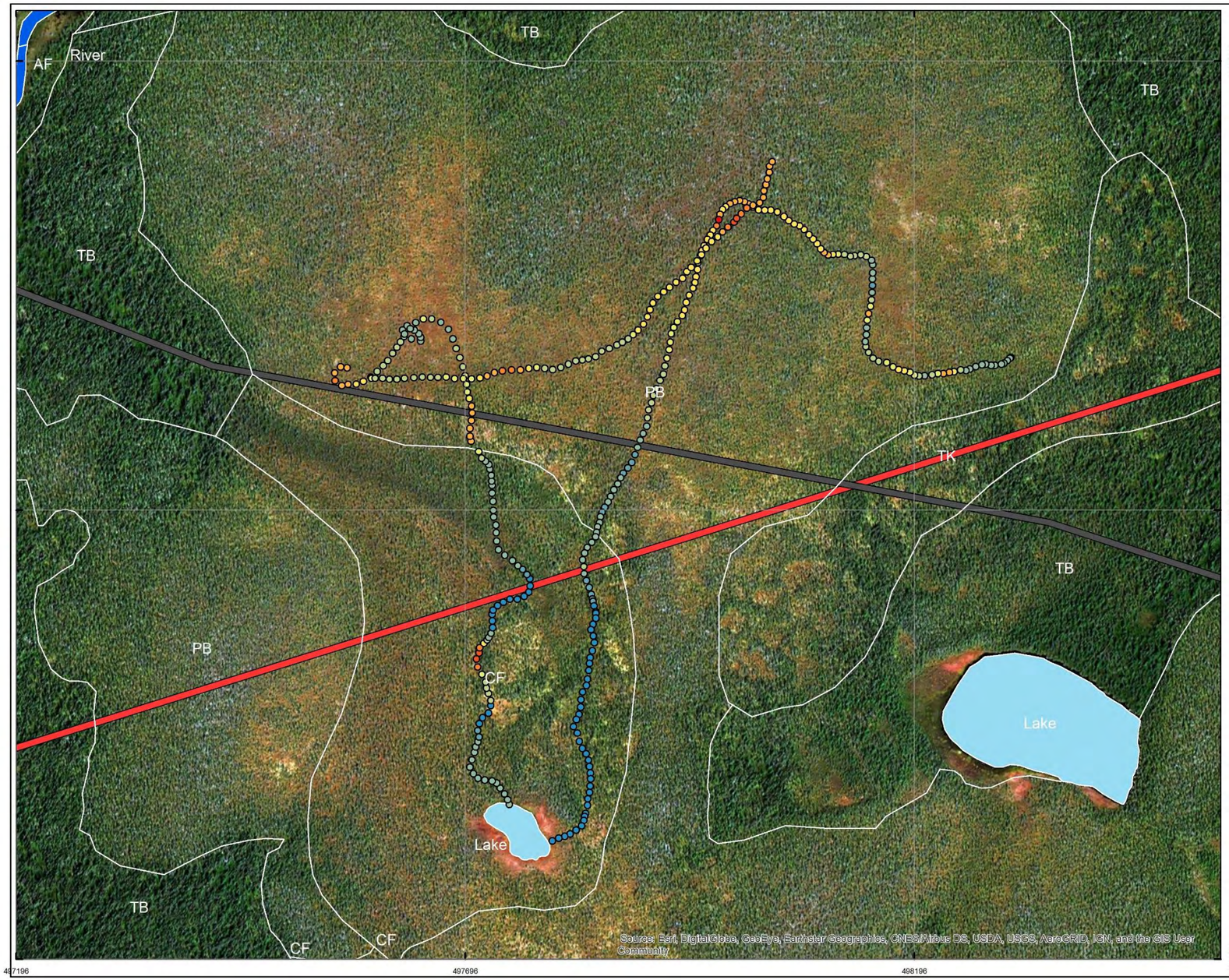
Three (3) GPR transects were surveyed at SITE 5, one running approximately west-east and the other two running approximately north-south. Table 7a shows the average peat depth (along with minimum and maximum depths and measure of standard deviation), by terrain type, for each of the SITE 5 transects. Table 7b summarizes these statistics for all SITE 5 transects combined.

Table 7a. GPR Site 5 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 5-1				
Northern Plateau Bog (PB)	2.3 m	1.6 m	3.2 m	0.4 m
Transect 5-2				
Northern Plateau Bog (PB)	2.0 m	1.4 m	3.3 m	0.4
Channel Fen (CF)	1.2 m	1.0 m	1.8 m	0.2
Transect 5-3				
Channel Fen (CF)	1.7 m	1.2 m	3.1 m	0.5

Table 7b. GPR Site 5 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.1 m	1.4 m	3.3 m	0.4
Channel Fen (CF)	1.6 m	1.0 m	3.1 m	0.5



LEGEND

Routes

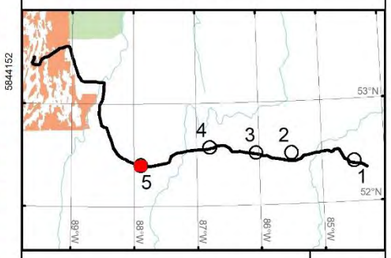
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.25 metres
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- > 3.25 metres

0 100 200
Meters



Scale 1:4,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT:
SNC Lavalin

PROJECT:
Webequie Supply Road

TITLE: **GPR RESULTS SITE 5**

FIGURE: **10**

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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Peat Thickness Summary

Peat thickness varied for each of the terrain units at the five GPR testing areas, with depths ranging from 0.5 m to 5.0 m (Tables 8a and 8b). Overall these observations suggest that, with the exception of treed bogs, peat thickness is similar in bogs and fens with common thicknesses of 1-3 m and maximum thicknesses up to 5 m. Peat thickness in treed bogs is generally less than 2 m.

Table 8a. Summaries of peat depths for terrain units at each of the five survey sites

	SITE 1			SITE 2			SITE 3			SITE 4			SITE 5		
TERRAIN TYPE	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth
Domed Bog (DB)	---	---	---	---	---	---	2.2 m	1.2 m	3.7 m	1.1 m	0.7 m	2.0 m	---	---	---
Plateau Bog (PB)	1.5 m	0.5 m	2.6 m	2.8 m	1.4 m	5.0 m	2.2 m	1.2 m	4.3 m	2.6 m	1.2 m	3.9 m	2.1 m	1.4 m	3.3 m
Treed Bog (TB)	1.0 m	0.5 m	1.7 m	---	---	---	---	---	---	1.0 m	1.0 m	1.0 m	---	---	---
String Fen (SF)	---	---	---	2.6 m	1.7 m	3.7 m	---	---	---	---	---	---	---	---	---
Ladder Fen (LF)	---	---	---	3.0 m	1.7 m	4.7 m	2.3 m	1.8 m	2.7 m	1.9 m	1.0 m	3.7 m	---	---	---
Channel Fen (CF)	---	---	---	2.7 m	1.8 m	3.3 m	1.3 m	1.2 m	3.2 m	---	---	---	1.6 m	1.0 m	3.1 m

The range of values observed for each of the terrain units at all of the testing locations is summarized in Table 8b. In 2010, JDMA conducted field work, including peat probing, outside of the Webequie route corridor to the south (see Figure 2), but within similar terrain units. At these sites of peat probing, peat thickness was observed between 1.0 and 4.7 m, which is consistent with the range of thicknesses observed with the GPR data.

Table 8b. Summary of peat depths for all five GPR survey sites. Note the last row shows the range of peat depths measured from peat probing in 2010.

Summary of peat depth ranges		
Terrain Type	**Min Depth**	**Max Depth**
Domed Bog (DB)	0.7 m	3.7 m
Plateau Bog (PB)	0.5 m	5.0 m
Treed Bog (TB)	0.5 m	1.0 m
String Fen (SF)	1.7 m	3.7 m
Ladder Fen (LF)	1.0 m	4.7 m
Channel Fen (CF)	1.0 m	3.3 m
Peat depths measured in 2010 (Figure 2)	1.0 m	4.7 m

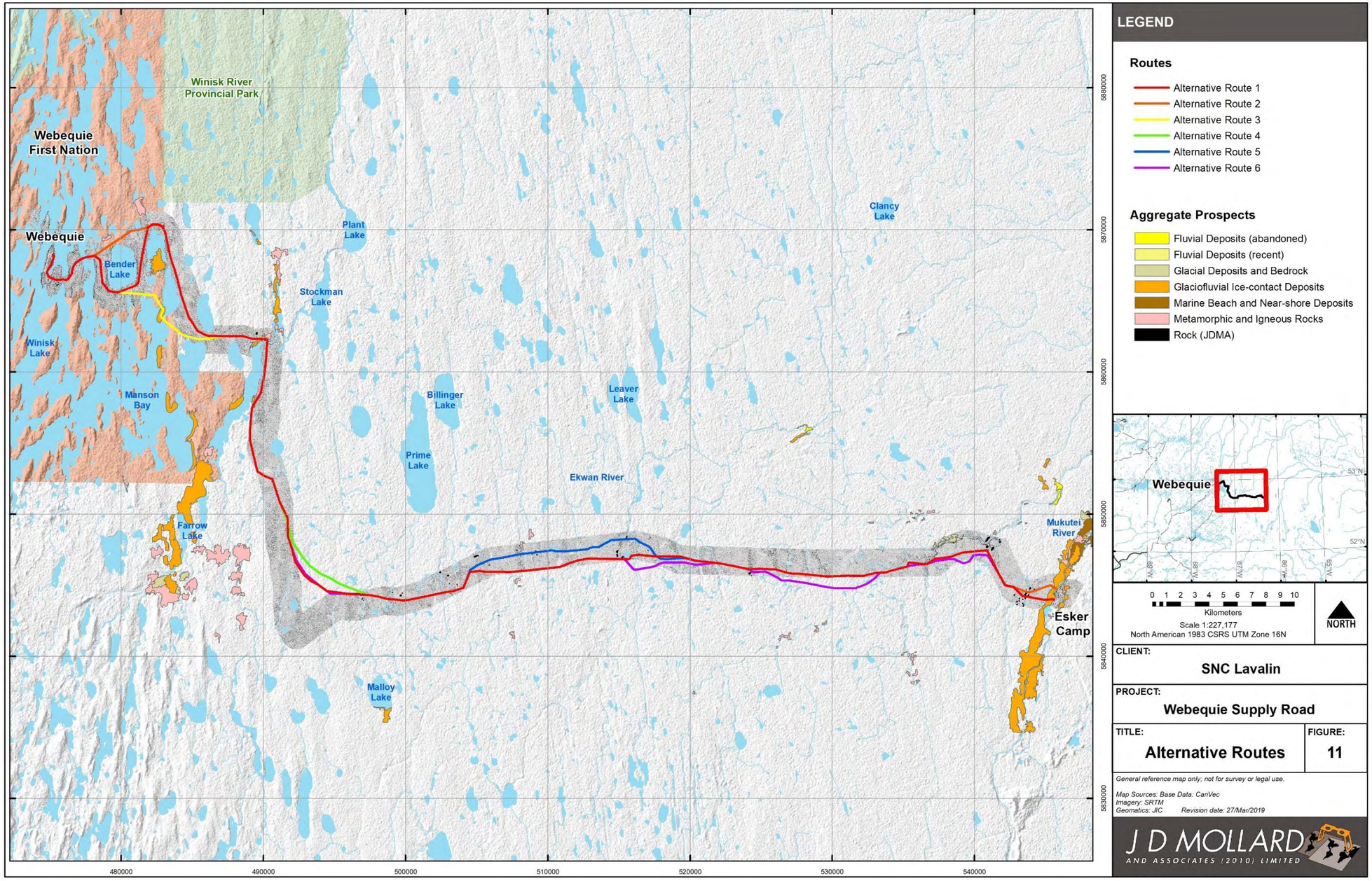
4.3 ROUTING

4.3.1 ROUTE ALTERNATIVES

A total of six alternative routes were mapped within the proposed corridor, each of which share various common segments and differ along other segments that offer advantages and disadvantages. An overview map of the routes is provided in Figure 11 and more detailed maps are included in Appendix 1. Table 9 provides a summary of lengths of route over each terrain unit. Routes 1, 2, and 3 differ only in the westernmost portions around Winisk Lake and Bender Lake in the approach to Webequie (Figure 11). Routes 1 and 2 diverge around Bender Lake, with Route 1 following a longer path around the south of the lake and Route 2 taking the shorter path to the north that requires a small channel crossing. The advantages of Route 1 are that it avoids a small stream crossing and provides access to the south side of Bender Lake, but at the disadvantage of a longer route. Nevertheless, the community has expressed preference for the route to follow south of Bender Lake. East of Bender Lake, these routes both pass around the northern end of a long embayment of Winisk Lake. Route 3 cuts across a narrow potion of this embayment of Winisk Lake and passes to the south of Bender Lake, which results in a much shorter route, but requires a channel crossing over the embayment.

Routes 4, 5, and 6 share the same path east from Webequie and along the main north-south segment (Figure 11). These routes differ mainly along the west-east segment that crosses the extensive organic terrains and in the point of crossing the Mukutei River. The challenge along this portion of the route corridor is minimizing routing across the extensive fens and water crossings. Among the most significant fens occurs just west of the Mukutei River tributary where multiple fens extend north-south nearly across the entire width of the corridor. Routes 4 and 5 avoid most of the fens by diverting to the south and following an alignment between two fens, while staying within the proposed route corridor. Route 5 diverts farther south, outside the proposed corridor, to limit these fen crossings. The southern path of this route also avoids other fens to the west before re-joining with Routes 4 and 5 (Figure 11).

Another difference in routes occurs along the section of the corridor crossed by multiple tributaries of the Ekwan River where there are extensive fens. Routes 4 and 6 divert to the south within the corridor while Route 5 follows a more central location (Figure 11).



LEGEND

Routes

- Alternative Route 1
- Alternative Route 2
- Alternative Route 3
- Alternative Route 4
- Alternative Route 5
- Alternative Route 6

Aggregate Prospects

- Fluvial Deposits (abandoned)
- Fluvial Deposits (recent)
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-contact Deposits
- Marine Beach and Near-shore Deposits
- Metamorphic and Igneous Rocks
- Rock (JDMA)

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Alternative Routes

FIGURE: 11

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 27/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

Table 9. Terrain unit length (km) on route alternatives.

Terrain Units	Route 1 Length (km)	Route 2 Length (km)	Route 3 Length (km)	Route 4 Length (km)	Route 5 Length (km)	Route 6 Length (km)
Mineral Terrains						
TL	44.78	39.88	37.48	44.36	44.78	44.51
ER	0.55	0.56	0.56	0.56	0.56	0.56
GF	0.61	0.65	0.65	0.65	0.65	0.65
AF	2.13	2.13	2.01	2.01	2.21	1.82
Organic Terrains						
Bogs						
DB	5.37	5.37	5.39	5.53	5.22	5.95
PB	15.09	15.35	15.33	15.61	14.99	14.25
TB	20.01	19.94	19.94	20.37	22.02	19.82
TK	6.33	6.33	6.33	5.34	5.46	7.87
Fens						
SF	0.38	0.38	0.38	0.38	0.53	0.61
LF	0.30	0.30	0.30	0.30	0.29	0.08
CF	2.18	2.11	2.09	2.19	2.00	1.87
WF	4.89	4.89	4.89	4.77	4.59	5.11
HF	0.34	0.34	0.34	0.34	0.56	0.49
Water Crossings						
Water	0.68	0.68	0.85	0.68	0.67	0.58
Total						
Total	103.63	98.89	96.52	102.98	104.52	104.18

4.3.2 Optimal Route from Terrain Analysis

An optimal route from a terrain perspective was identified by picking segments from the competing alternative routes that meet the major criteria of route length, terrain conditions, stream crossings, and proximity to aggregate sources (Figure 12 and Table 10). Appendix 1 provides enlarged maps of the route. The optimal route minimizes total length in two main locations. The first is in the area southwest of Prime Lake, where the corridor transitions from north-south to east-west at nearly a right angle. By crossing outside of the corridor to the north, the optimal route cuts the overall length without adding additional water crossings. The second key location is around Bender Lake, where the optimal route crosses the shorter path northward around the lake.

The optimal route minimizes the length of route crossing terrain units considered to have a poor constructability ranking (see Tables 1 and 11), in particular the various types of fens that feature organic soils and a water table at surface. Overall, this results in a route that is slightly south of the

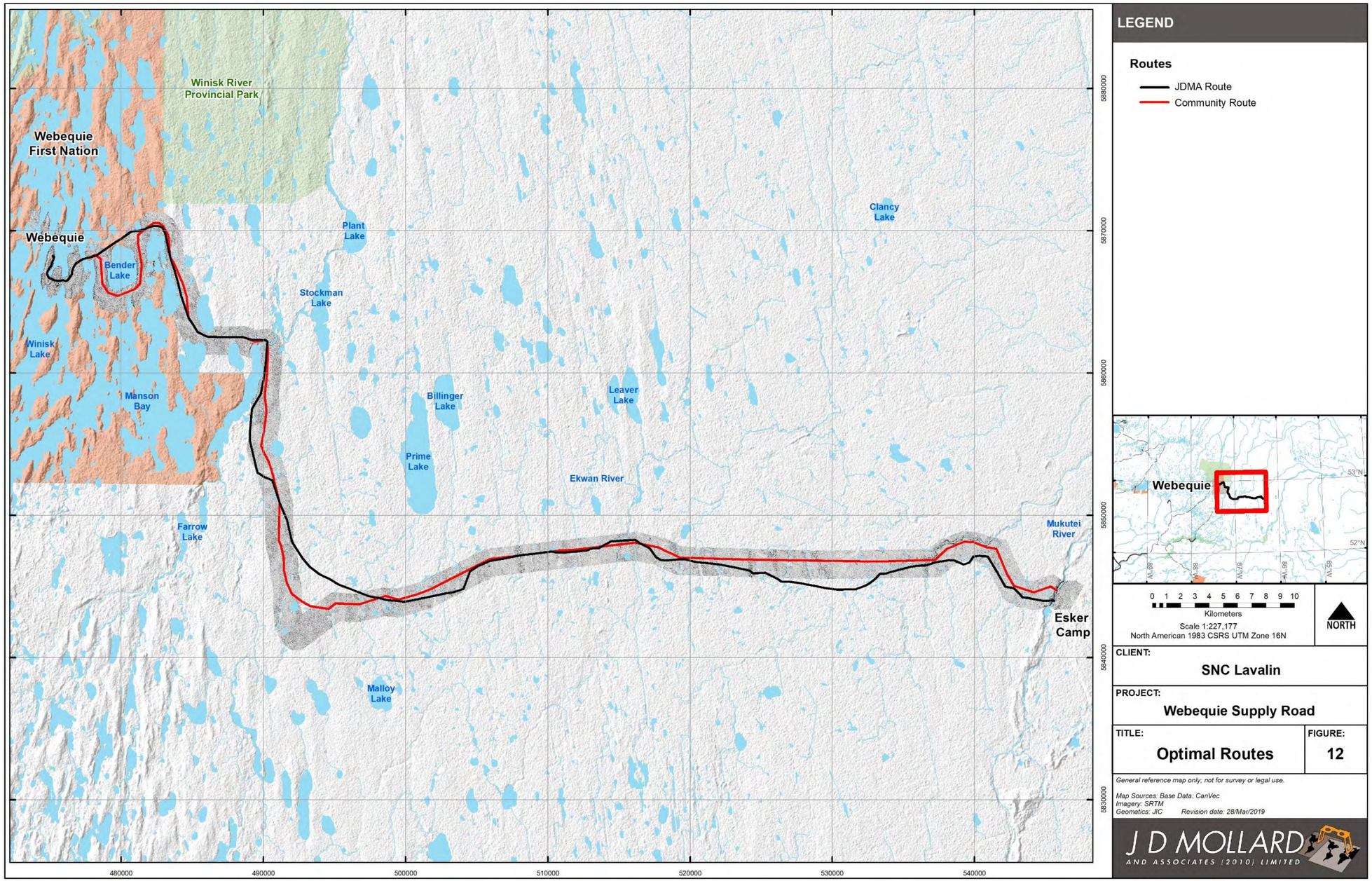
original community-selected route along the east-west extent and that lies outside of the 2-km-wide LiDAR corridor along a small portion of the route.

Table 10. Route length of terrain units on the optimal JDMA route and the community route.

Terrain Units	Optimal JDMA Route Length (km)	Community Route Length (km)
Mineral Terrains		
TL	39.33	41.13
ER	0.56	0.56
GF	0.61	0.69
AF	2.11	2.20
Organic Terrains		
Bogs		
DB	6.44	7.43
PB	13.89	22.94
TB	21.95	13.30
TK	4.94	4.95
Fens		
SF	0.77	1.20
LF	0.06	0.78
CF	1.76	2.49
WF	5.37	6.74
HF	0.71	0.54
Water Crossings		
Water	0.53	0.92
Total		
Total	99.04	105.88

Table 11. Length of constructability rankings on the optimal JDMA route and the community route.

Constructability Ranking	Optimal JDMA Route Length (km)	Community Route Length (km)
Good	40.50	42.39
Fair	26.89	18.26
Poor	20.83	31.18
Very Poor	10.29	13.13
Water Crossing	0.53	0.92
Total	99.04	105.88



LEGEND

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Optimal Routes

FIGURE: 12

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 28/Mar/2019*

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4.4 WATER CROSSINGS

Water crossings, shown in Figure 13, were characterized by open water width, alluvial floodplain width, maximum slope, bank height, and adjacent terrain types. Table 12 summarizes crossings for the community route (C1 to C23) and Table 13 summarizes the result for the optimal JDMA route (J1 to J23). Appendix 2 provides a large-scale image, slope raster, and cross-sections for each of the water crossings along both the community and JDMA routes. Drainage across the east-west portion of the corridor, flows typically toward the north-northeast, draining northward into larger lakes like Prime Lake or Billinger Lake or into one of the larger river systems like the Ekwan River and the Mukutei River. Along the western portion of the corridor, which trends north-south and is covered largely by glacial terrains, the surficial drainage features fewer stream crossings than the east-west section of the corridor.

Most stream crossings exhibit relief of less than a few metres and cross flat alluvial floodplains that feature floating aquatic vegetation, have water tables near the surface, and are subject to flooding. The widest crossing, spanning approximately 250 m, is from Eastwood Island to the mainland (J23 and C23). Two of the most deeply incised stream crossings on both the optimal JDMA route and the community route, crossings 1 and 21 in both cases, appear to cut into glacial deposits (including glaciofluvial material) over bedrock. The Mukutei River (J1 and C1) crossing encounters the greatest bank heights of up to 20 m and slopes of up to 30 degrees on the west bank that consists of a large ice-contact glaciofluvial landform. The river crossing entering Stockman Lake (J21 and C21) spans a channel between two lakes and exhibits bank heights of up to 7.5 m and slopes of up to 23 degrees. The channel is cut through glacial sediment, with till on the south bank and glaciofluvial deposits on the north bank.

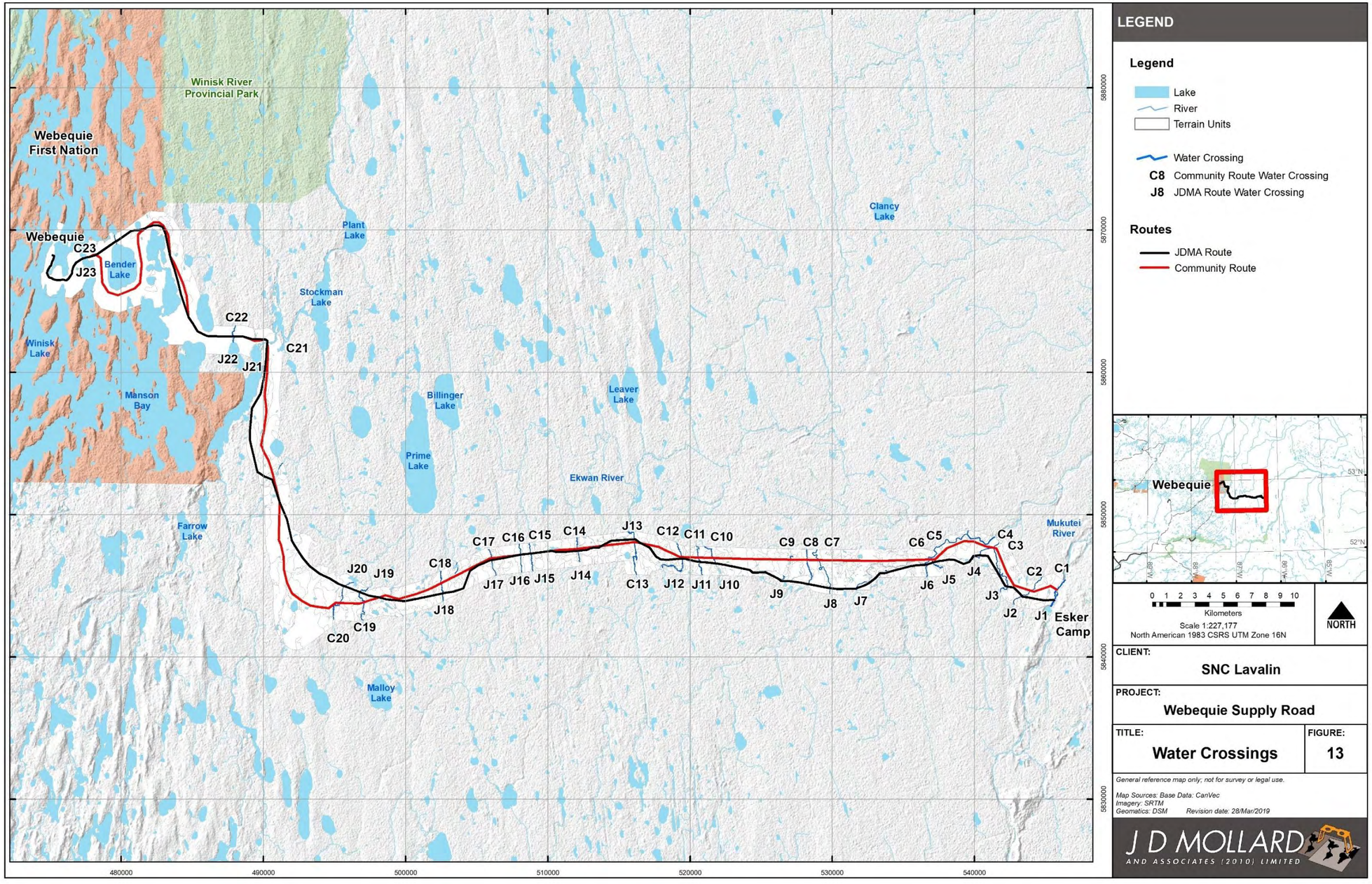
Table 12. Summary of water crossings along the community route

ID	Easting	Northing	Open Water Width	Alluvial Floodplain Width	Slope Max (degree)	Bank Height	Material
C1	545790	6844725	22	-	28	14	Esker: large steep slope
C2	544000	5844646	2.5	33	15	1	Treed Bog
C3	541370	5847665	28	49	11	2.5	Treed Bog
C4	541304	5847678	1.5	14	8	1	Treed Bog
C5	537013	5846847	5	53	26	4	Bog: Eroded valley
C6	536820	5846842	18	-	35	6	Till-Alluvial floodplain
C7	529066	5846800	16	-	28	3.5	Treed bog: channel
C8	528230	5846815	9	55	6	1	Treed-Plateau Bog
C9	527015	5846833	5	62	8	1	Treed Bog

C10	521566	5846956	8	48	8	1	Treed Bog
C11	520605	5846983	4.5	50	4	0.5	Thermokarst
C12	519420	5847015	12	108	6	0.5	Treed Bog
C13	516070	5848070	38	-	18	2.5	Treed Bog
C14	512045	5847600	30	200	6	0.5	Alluvial flood plain
C15	508765	5847270	8	100	9	1.5	Treed Bog
C16	508110	5847190	25	-	18	3.5	Treed Bog: channel
C17	506030	5846930	3	100	4	0.5	Bog-Fen: flat
C18	502472	5845167	12	62	12	2	Treed Bog
C19	497088	5843853	47	150	6	1	Treed Bog
C20	495405	5843792	3	41	8	1.5	Bog
C21	490280	5862110	44	54	23	7.5	Till-Glaciofluvial
C22	487910	5862520	15	102	14	1.5	Till
C23	477505	5868075	250	-	10	6	Till

Table 13. Summary of water crossings along the optimal JDMA Route

ID	Easting	Northing	Open Water Width	Alluvial Floodplain Width	Slope Max (degree)	Bank Height	Material
J1	545600	5843980	21	-	26	20	Esker: large steep slope
J2	543340	5844285	4	35	6	0.5	Treed Bog
J3	542295	5844955	10	145	6	0.5	Alluvial flood plain
J4	540430	5847145	1.5	100	11	1	Alluvial flood plain
J5	537080	5846650	3	50	16	4.5	Till-Bog: Eroded valley
J6	536645	5846490	21	200	26	7.5	Plateau Bog
J7	531690	5844820	4.5	32	-	-	Bog-Fen: flat
J8	529807	5844837	10	-	-	-	Treed Bog
J9	526262	5845452	2	140	-	-	Alluvial flood plain
J10	521777	5846572	7	29	7	-	Treed Bog
J11	520715	5846680	5	190	2	0.5	Alluvial flood plain
J12	519430	5846905	6	80	4	1.5	Treed Bog
J13	516050	5848263	13	-	22	3.5	Treed Bog
J14	512115	5847455	7.5	200	3	0.5	Alluvial flood plain
J15	508765	5847268	8	102	9	2.5	Alluvial flood plain
J16	508108	5847268	26	-	18	3.5	Treed Bog: channel
J17	506053	5846810	3	100	4	0.5	Fen-Bog: Flat
J18	502597	5844467	10	85	12	1	Treed Bog
J19	496850	5844530	15	42	8	1.5	Treed Bog
J20	495687	5844978	3	46	-	-	Treed Bog
J21	490280	5862110	44	54	23	7.5	Till-Glaciofluvial
J22	487910	5862520	15	102	14	1.5	Till
J23	477505	5868075	250	-	10	6	Till



LEGEND

Legend

- Lake
- River
- Terrain Units
- Water Crossing
- **C8** Community Route Water Crossing
- **J8** JDMA Route Water Crossing

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Water Crossings

FIGURE: 13

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: DSM *Revision date: 28/Mar/2019*

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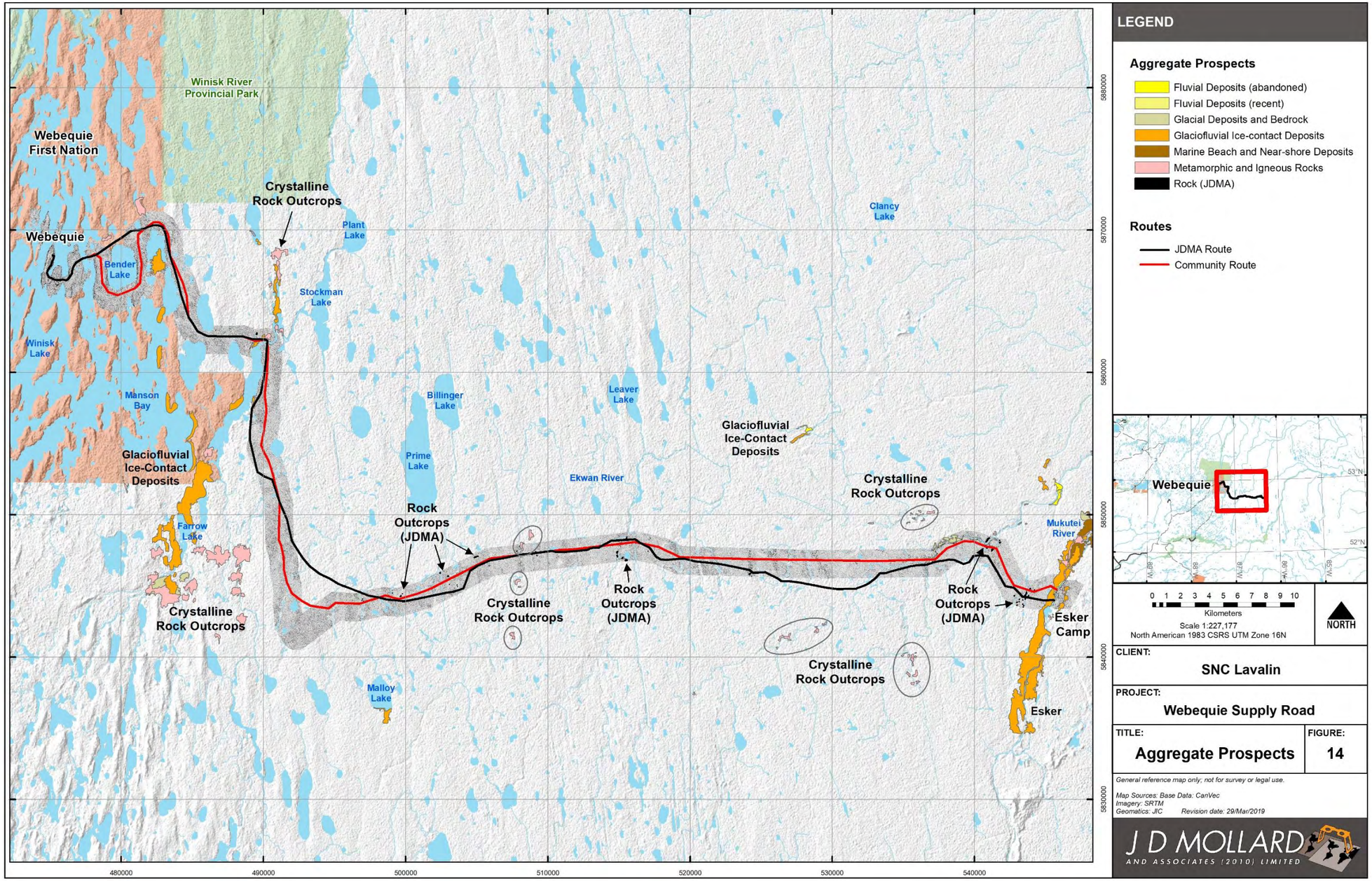
4.5 POTENTIAL AGGREGATE SOURCES

The Webequie Supply Road corridor crosses mostly glacial till along the north-south trending western section and extensive peatlands and organic soils along the east-west trending eastern section, which make identifying potential aggregate prospects a challenge. Potential aggregate sources are shown in Figure 14. Extensive, roughly north-south trending, ice-contact glaciofluvial systems are known to exist near the east and west ends of the proposed corridor and may provide a source of surficial granular material (Barnett *et al*., 2013, Surficial Maps P3696 and P3697). Near Esker Camp, on the west side of the Mukutei River, there is a large esker/ice-contact glaciofluvial deposit that trends north-northeast and is among the largest granular prospects in the region. The gradation of this feature needs to be field tested because despite being of glaciofluvial origin, discussions with people at Esker Camp suggest that the esker material is silty and lacks a significant coarse fraction. Near the western section of the route, there is an ice-contact glaciofluvial deposit that is most extensive to the west and north of Farrow Lake and that extends discontinuously northward along the eastern side of Manson Bay on Winisk Lake. In addition to these two large prospects, a smaller ice-contact glaciofluvial landform occurs within the corridor and extends northward west of Stockman Lake. Given that these are ice-contact glaciofluvial landforms, which are typically associated with granular material, and their proximity to the corridor, these landforms should be considered aggregate prospects and tested in the field to determine the material properties.

Bedrock outcrops scattered across the length of the corridor and in proximity to route alternatives offer potential quarry rock sources. The lithology of rock in the area is mapped as metamorphic and igneous. The largest outcrops occur south and east of Farrow Lake located west of the corridor. These areas likely provide the most surficial exposure to characterize the bedrock. Other bedrock outcrops are smaller and occur both inside and outside the corridor. While these smaller outcrops offer less exposure to characterize the bedrock, the bedrock will extend to great depth and lateral extent beyond the outcrop.

The characteristics of the granular deposits and suitability and location of potential bedrock sources are as yet unproven by field testing. Field reconnaissance is required to describe and characterize the material. Without drilling equipment, a simple initial field program is recommended where granular prospects are tested by digging shallow test holes to depths of 30-60 cm to assess the material gradation and quality. Where rock or quarry prospects are visited, the lithology and structural elements (fractures, bedding, foliation, *etc*.) visible at surface can be described.



LEGEND

Aggregate Prospects

- Fluvial Deposits (abandoned)
- Fluvial Deposits (recent)
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-contact Deposits
- Marine Beach and Near-shore Deposits
- Metamorphic and Igneous Rocks
- Rock (JDMA)

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Aggregate Prospects

FIGURE: 14

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

5 SUMMARY

This study was undertaken as part of the Environmental Assessment and Preliminary Engineering Services for Webequie First Nation's Supply Road Project. J.D. Mollard and Associates (2010) Limited was sub-contracted by SNC Lavalin to conduct terrain mapping within the proposed community corridor to facilitate identification of potential aggregate sources, characterize stream crossings, map competing route alternatives, and identify an optimal route based on terrain and related engineering considerations.

Terrain studies focussed on a 2-km-wide routing corridor that was selected by community members based on engagement with the community as a whole, youth representatives, elders, and the Webequie land use planning committee. The corridor selected by the community is approximately 107 km in length (extending about 51 km toward the south-southeast from Webequie before turning east for about 56 km toward Esker Camp), and 2 km in width.

Six viable route alternatives were identified within the community-selected routing corridor and an optimal route was identified that provides a balance of length, terrain conditions for road construction and maintenance, stream crossings and proximity to potential aggregate sources. The optimal route is 99 km in length crossing approximately 67 km of terrain with fair to good constructability, 21 km of poor constructability, 10 km of very poor constructability and 0.5 km of water crossings.

Twenty-three stream crossings were identified on the optimal route with the majority having less than 3 m of relief and open water widths ranging from 3 to 250 m. The maximum crossing relief is 20 m at the Mutukei River. The widest crossing is 250 m from Eastwood Island to the mainland.

Peat thicknesses from ground penetrating radar surveys range from 0.5 to 5.0 m in bogs and from 1.0 to 4.7 m in fens. These depths are consistent with peat depths measured south of the corridor in 2010 but they have not been confirmed in the field. This is recommended in subsequent field studies.

A number of potential aggregate sources have been identified including glacial granular deposits and bedrock outcrops. Glacial granular sources are concentrated in large glaciofluvial deposits at the east and west ends of the study area. Bedrock outcrops are present within and outside of the routing corridor and are distributed across the study area. Field reconnaissance of these locations is required to better assess their potential.

Although an optimal route has been identified based on terrain and related engineering factors, selection of a final preferred route will require consideration of detailed engineering, social, cultural and environmental factors in additional studies.

REPORT SIGNATURE PAGE

J.D. Mollard and Associates (2010) Limited

Jason Cosford, Ph.D., P.Geo.

Lynden Penner, M.Sc., P.Eng., P.Geo.

Troy Zimmer, B.Sc., Hons. Dpl. (Bioscience), MCRSS

APPENDIX 1: Terrain Mapping

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

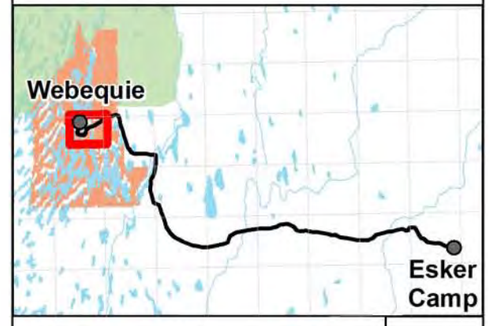
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

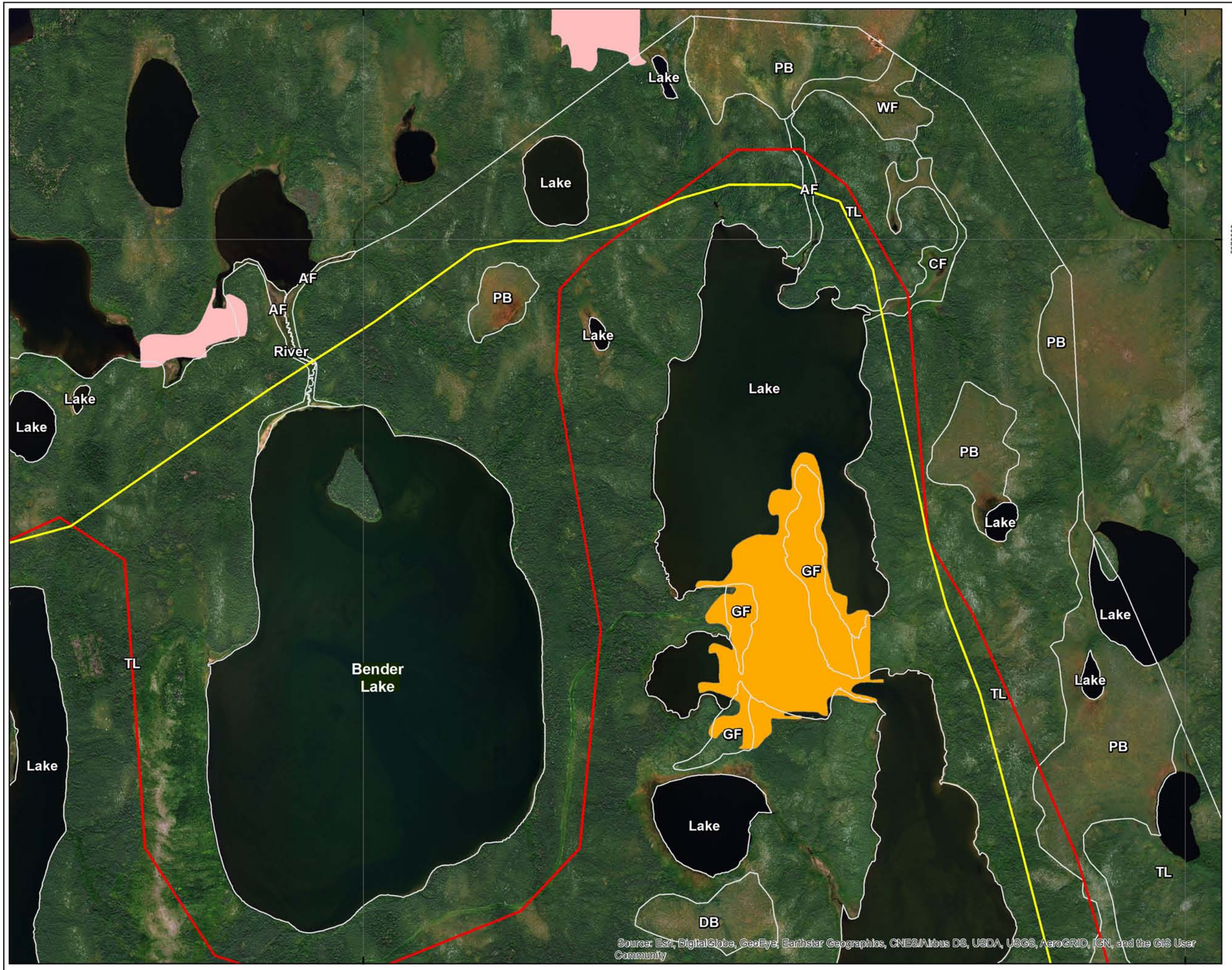
TITLE: Terrain Mapping

FIGURE: TM1

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

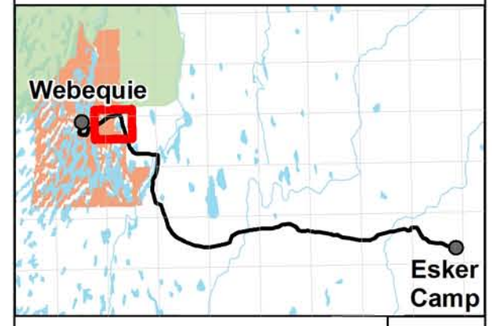
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

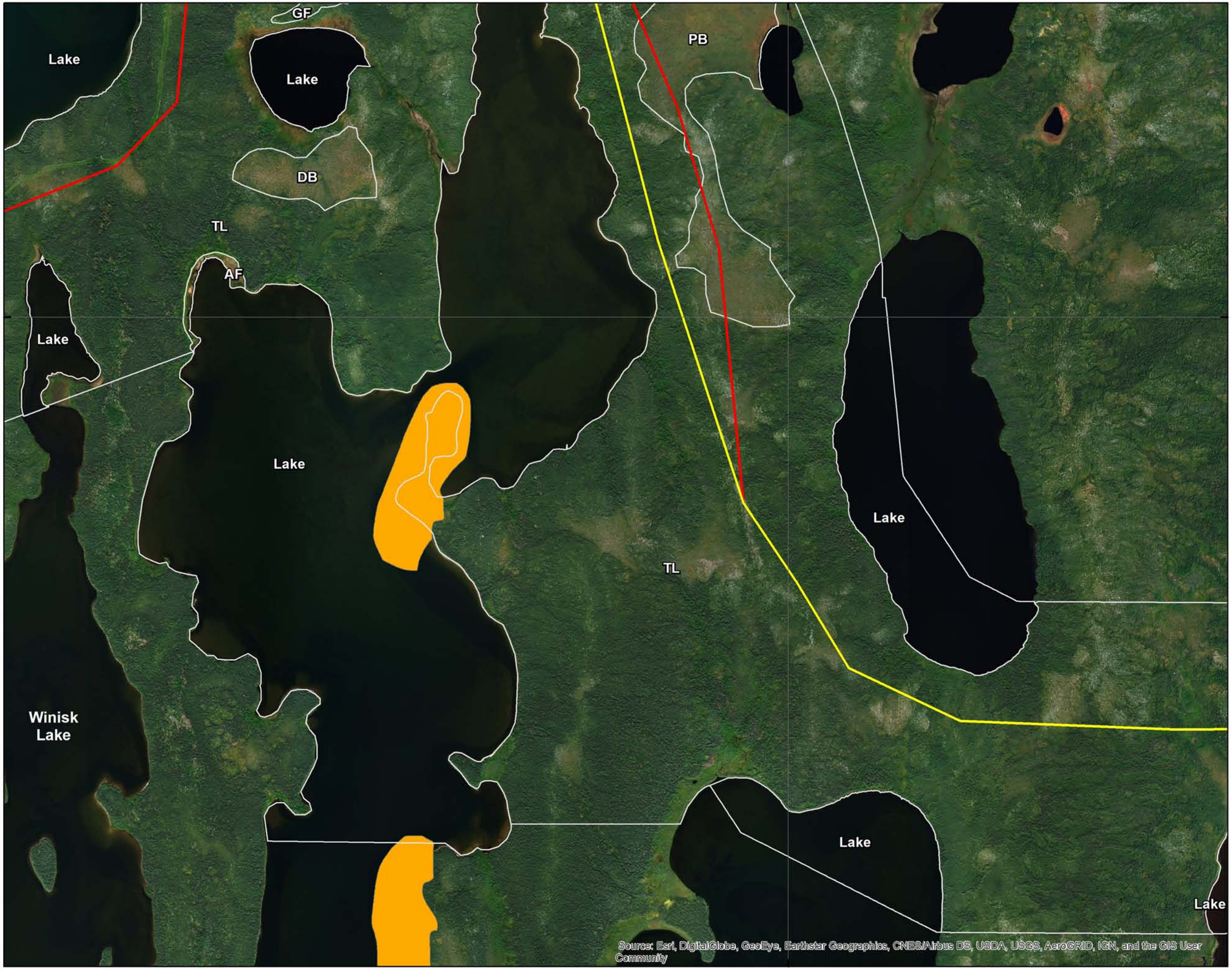
TITLE: Terrain Mapping

FIGURE: TM2

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

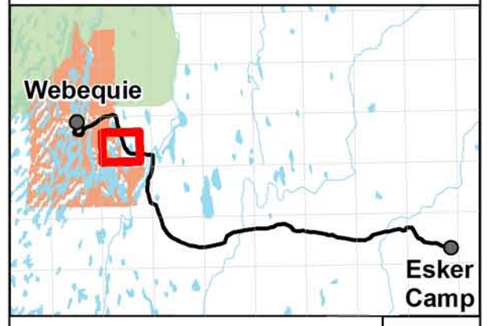
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

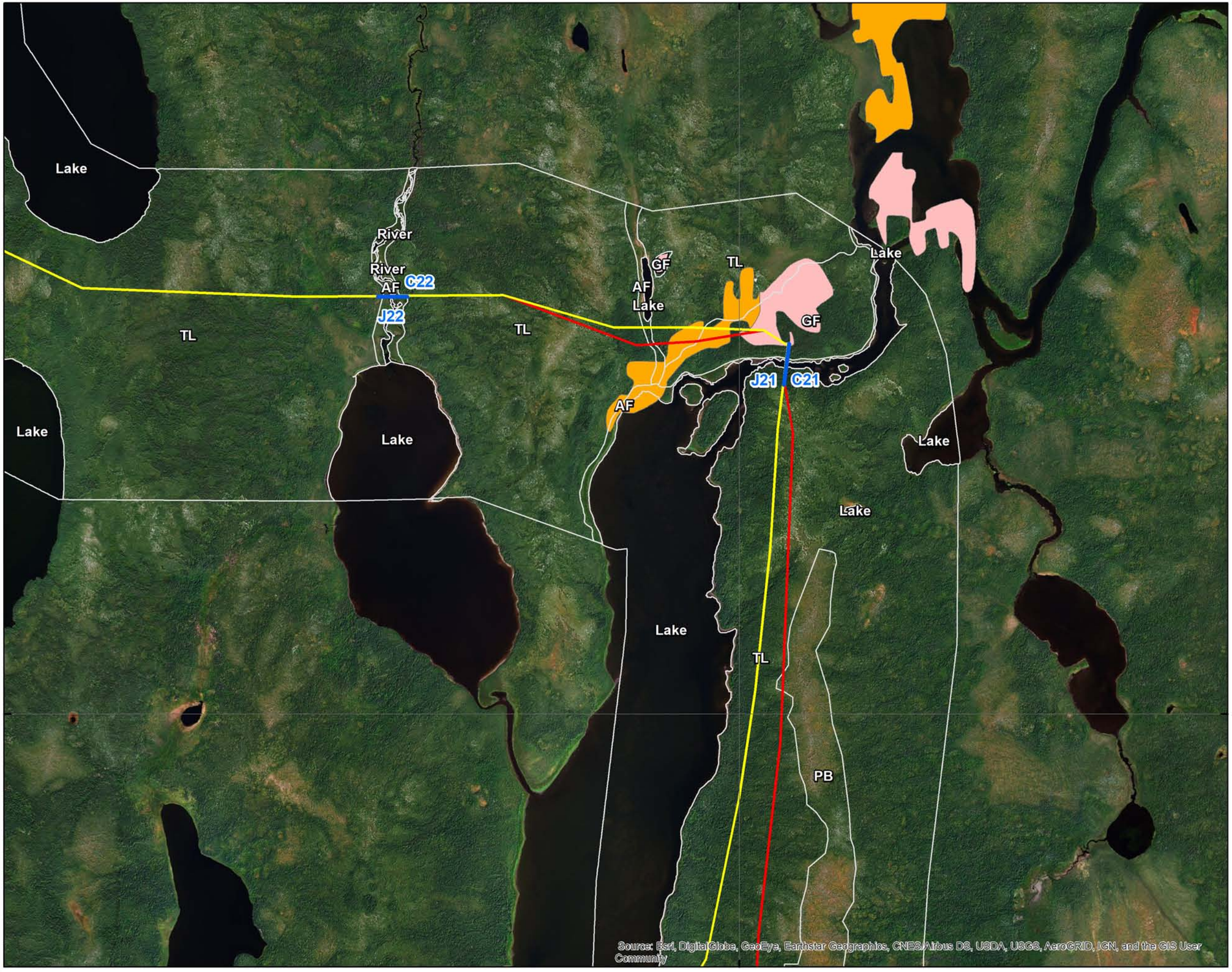
TITLE: Terrain Mapping

FIGURE: TM3

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

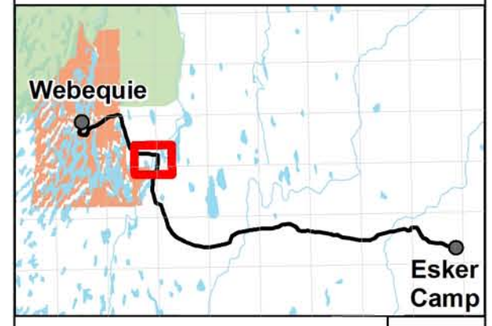
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

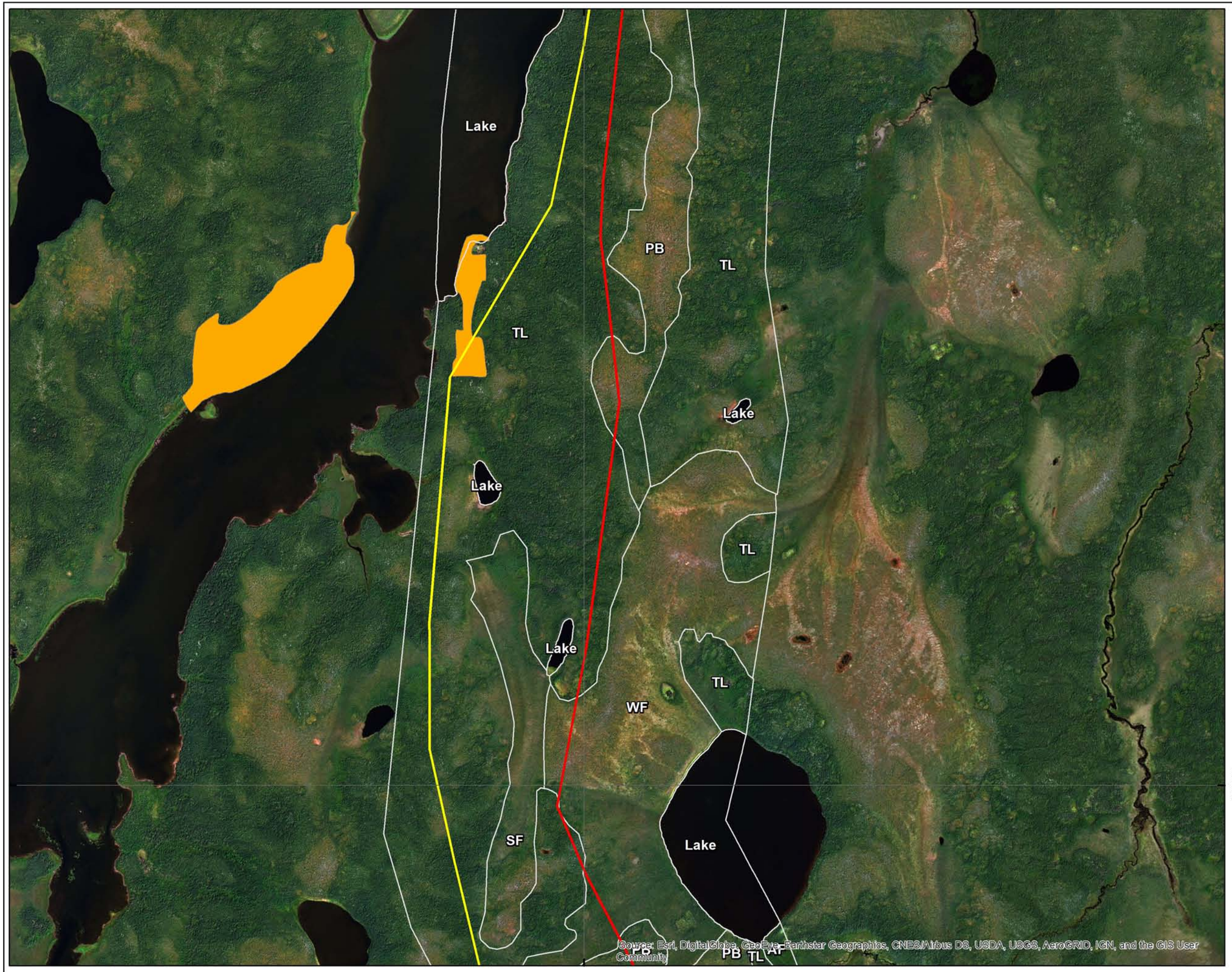
TITLE: Terrain Mapping

FIGURE: TM4

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

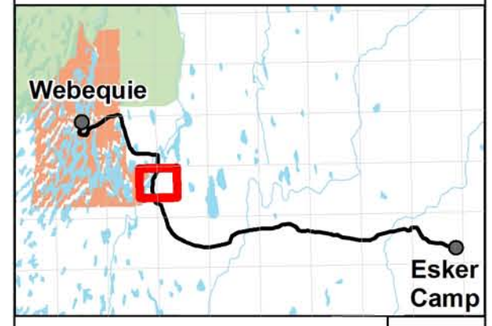
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial tilll	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

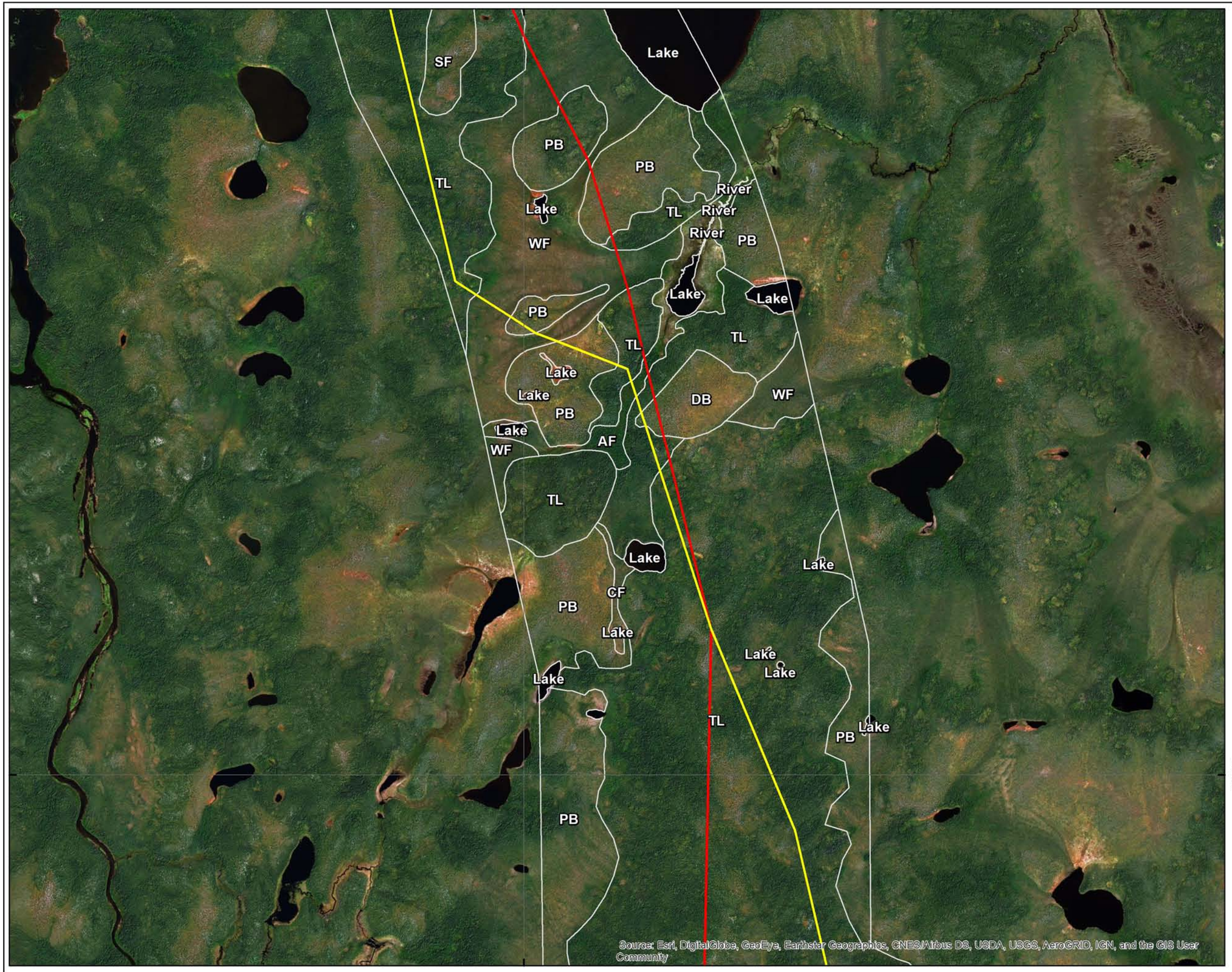
TITLE: Terrain Mapping

FIGURE: TM5

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial tilll
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

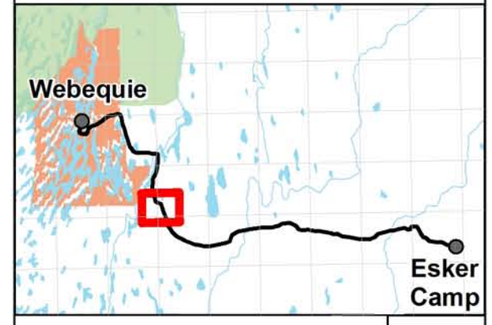
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

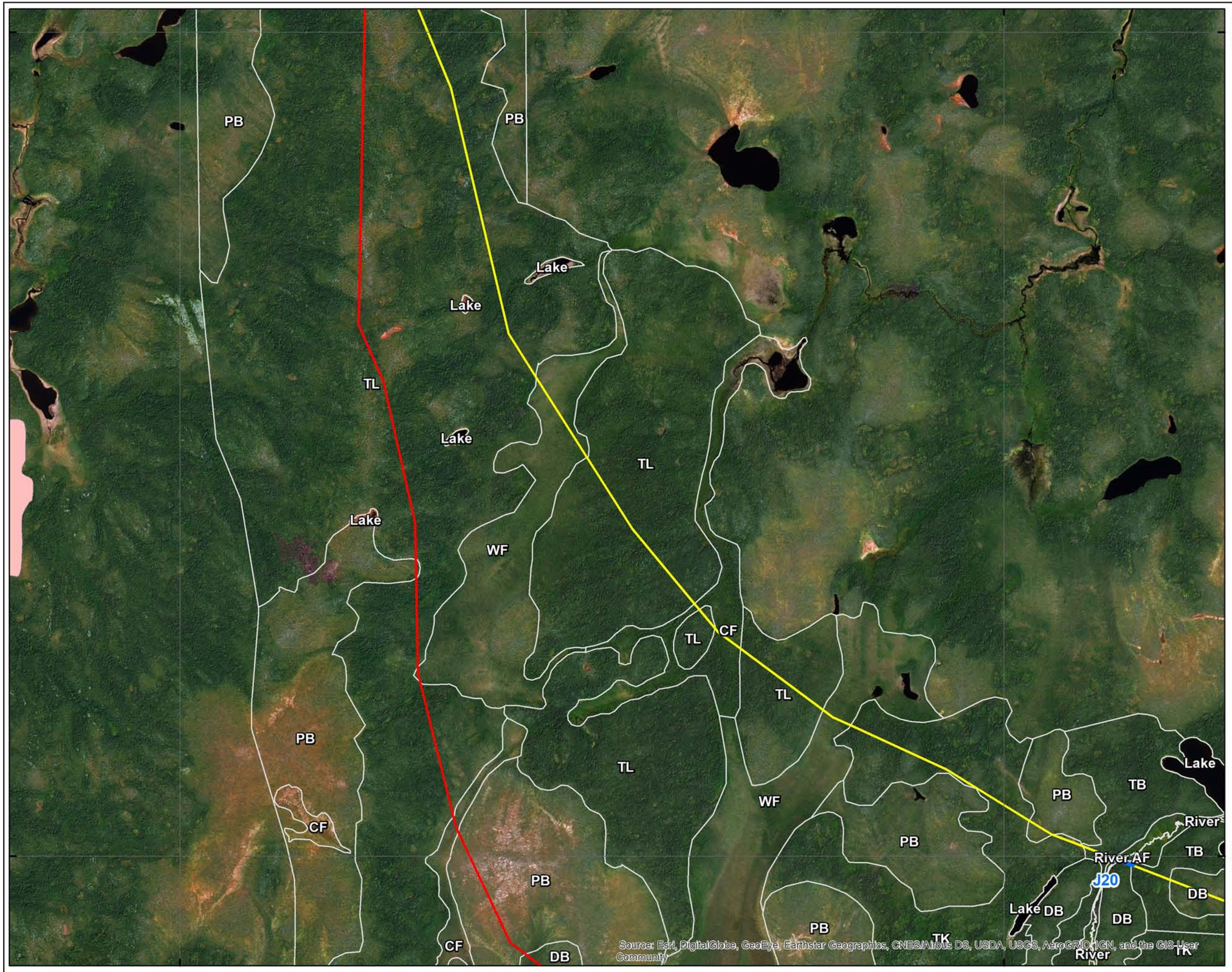
TITLE: Terrain Mapping

FIGURE: TM6

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

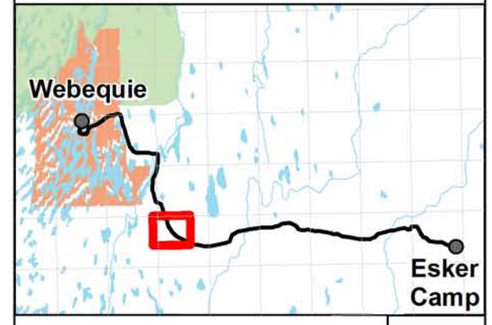
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial tilll	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

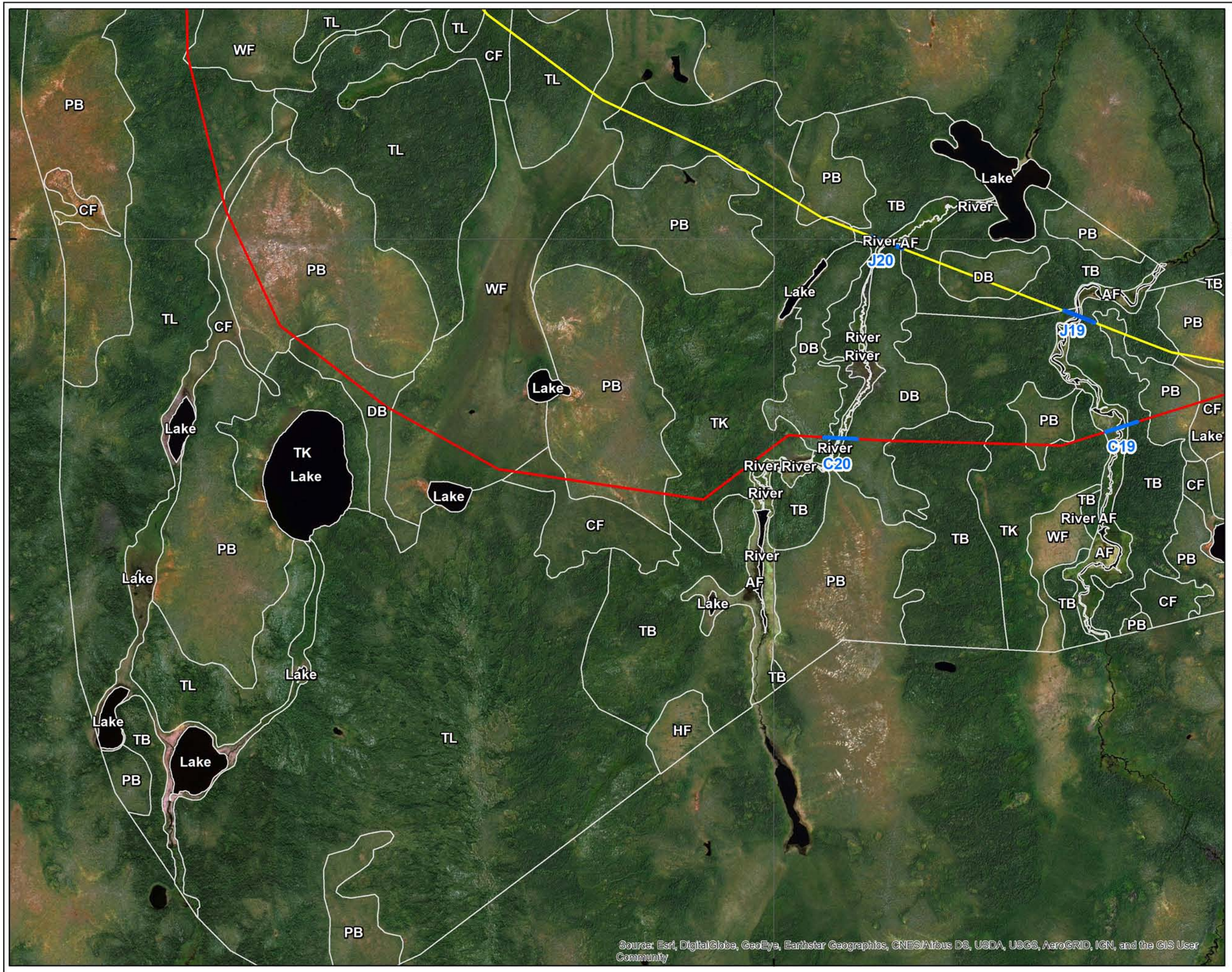
TITLE: Terrain Mapping

FIGURE: TM7

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

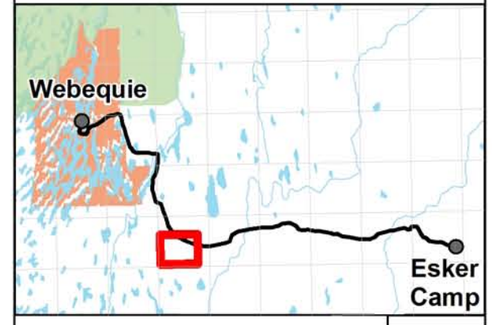
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

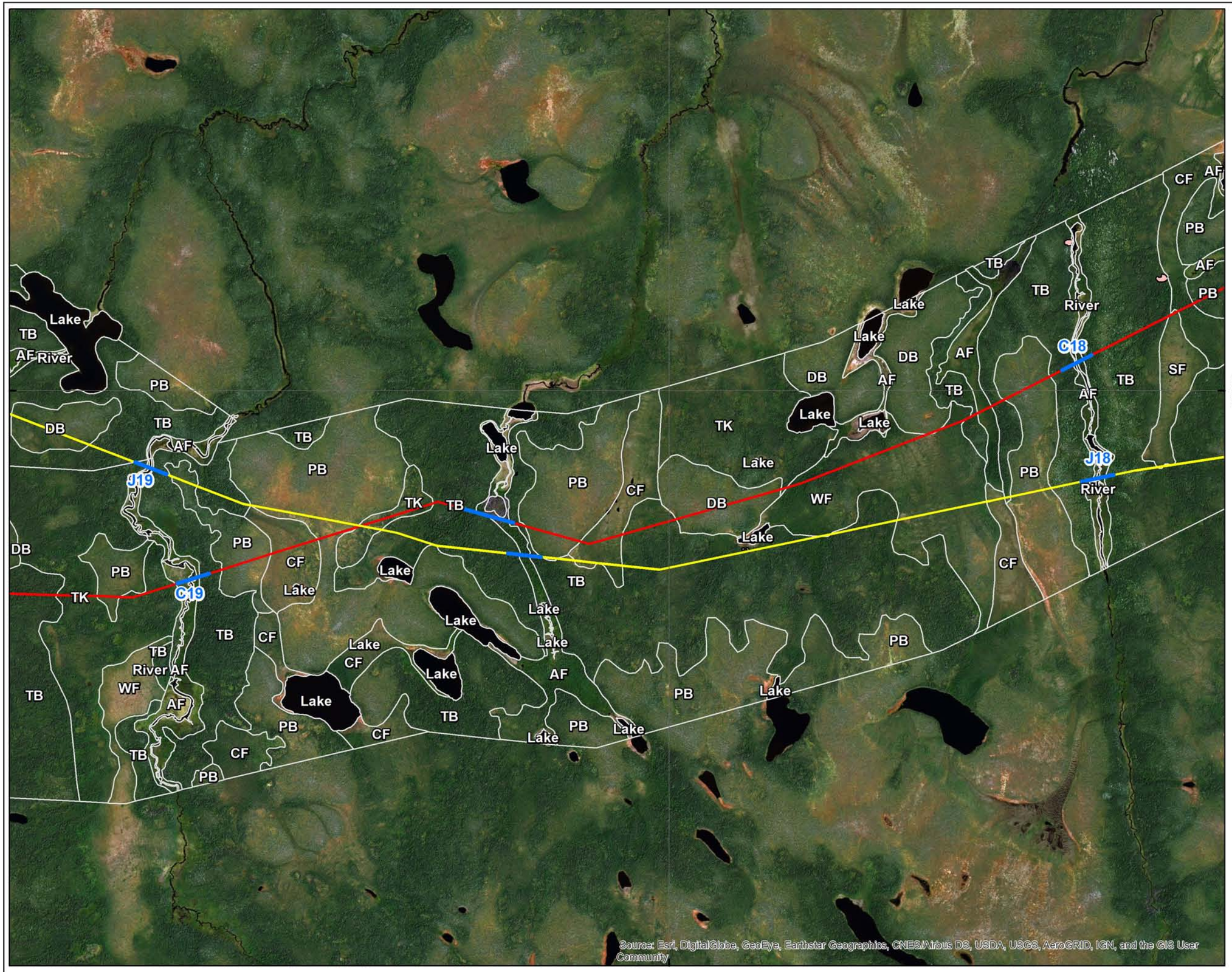
TITLE: Terrain Mapping

FIGURE: TM8

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial till
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

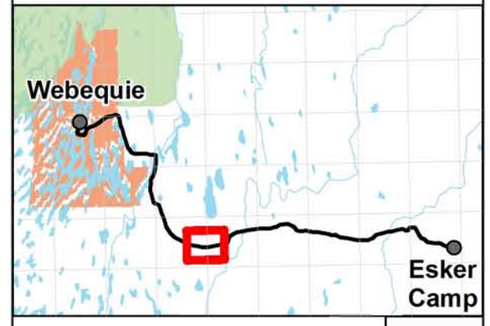
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: **SNC Lavalin**

PROJECT: **Webequie Supply Road**

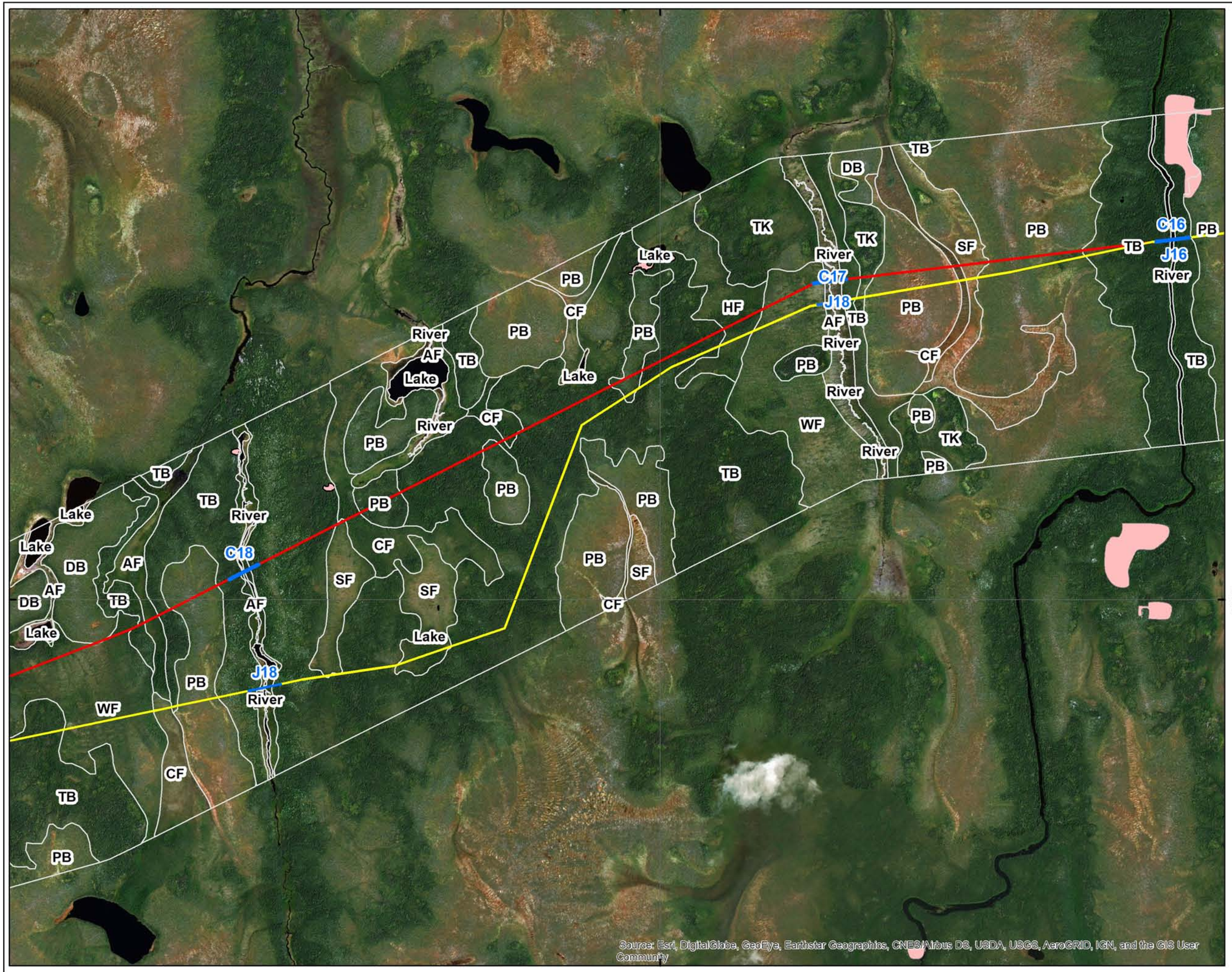
TITLE: **Terrain Mapping**

FIGURE: **TM9**

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

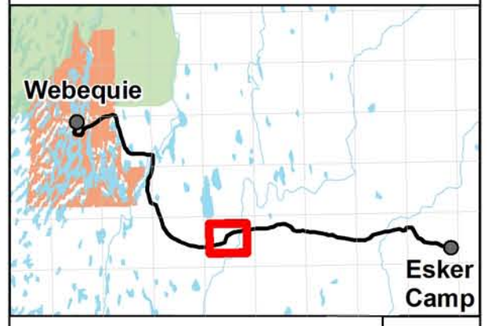
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: TM10

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

5850000

5845000

510000

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial tilll
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

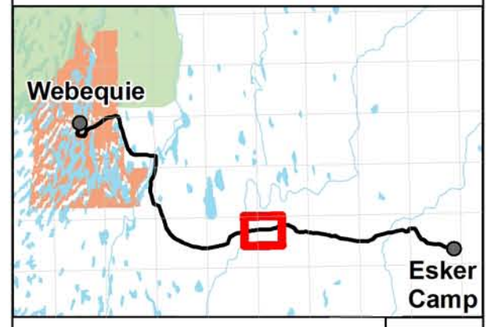
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: TM11

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial tilll
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

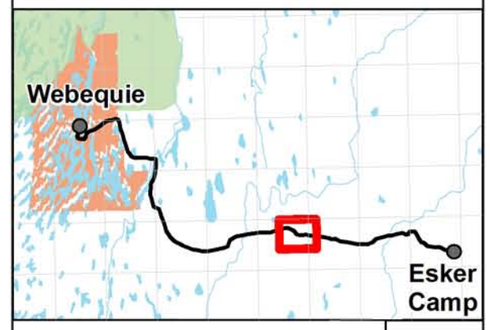
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: TM12

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

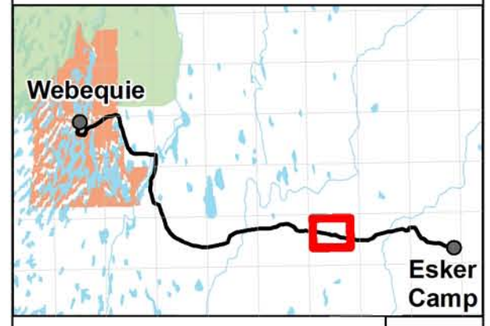
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

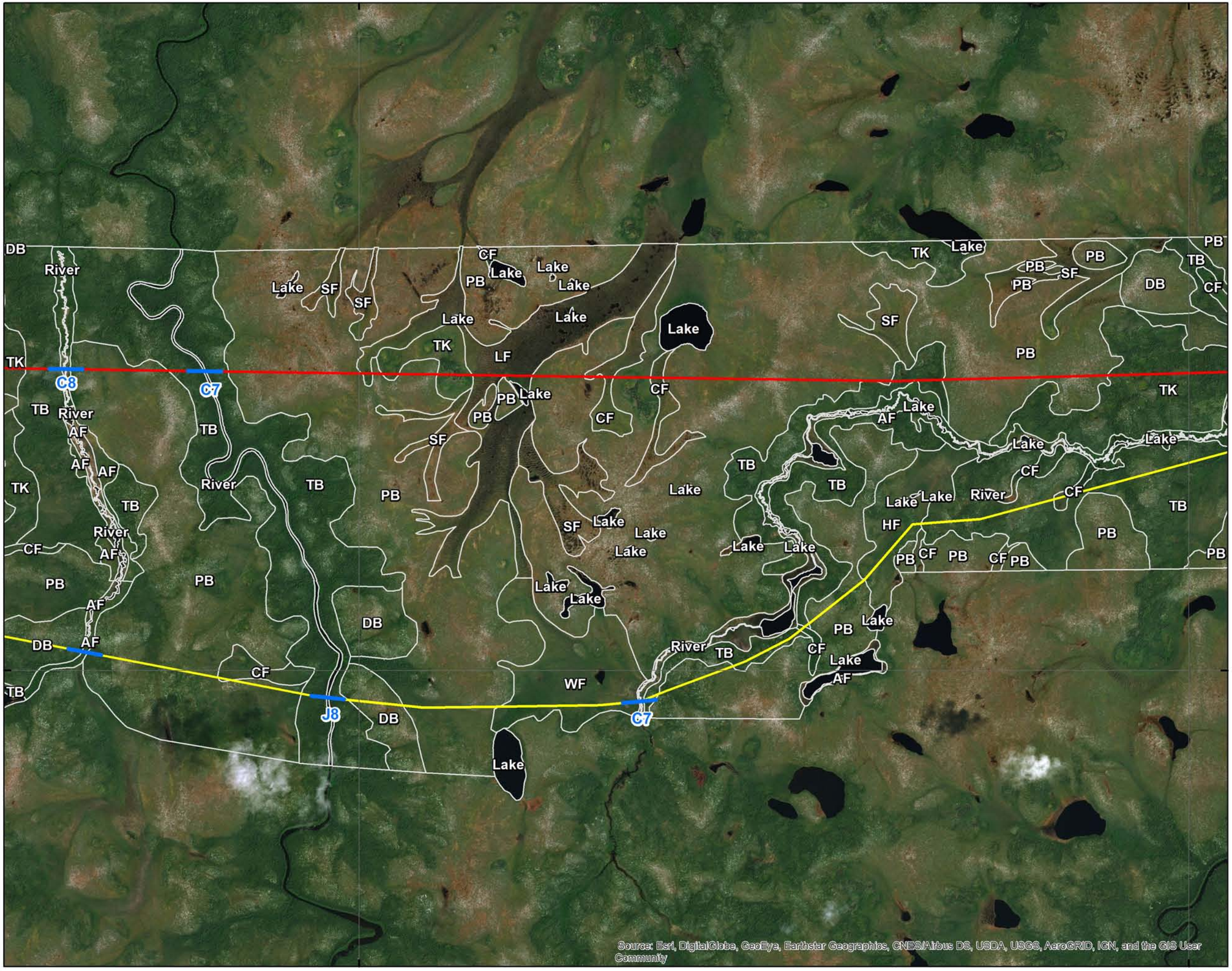
TITLE: Terrain Mapping

FIGURE: TM13

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED


DB
River
Lake
SF
SF
CF
PB
Lake
Lake
Lake
Lake
Lake
TK
LF
TK
C8
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TB
River
AF
AF
AF
TB
River
TB
PB
SF
PB
Lake
CF
CF
Lake
TK
Lake
PB
PB
SF
PB
DB
TB
CF
PB
SF
PB
TK
TB
TB
Lake
Lake
AF
Lake
Lake
CF
Lake
Lake
River
CF
HF
TB
PB
PB
CF
PB
CF
PB
PB
TK
River
TB
PB
TB
River
AF
CF
PB
PB
AF
DB
AF
DB
CF
TB
WF
J8
DB
C7
Lake
PB
Lake
AF
Lake
Lake
Lake
Lake
Lake

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

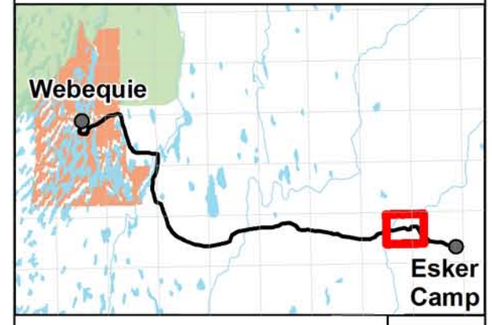
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

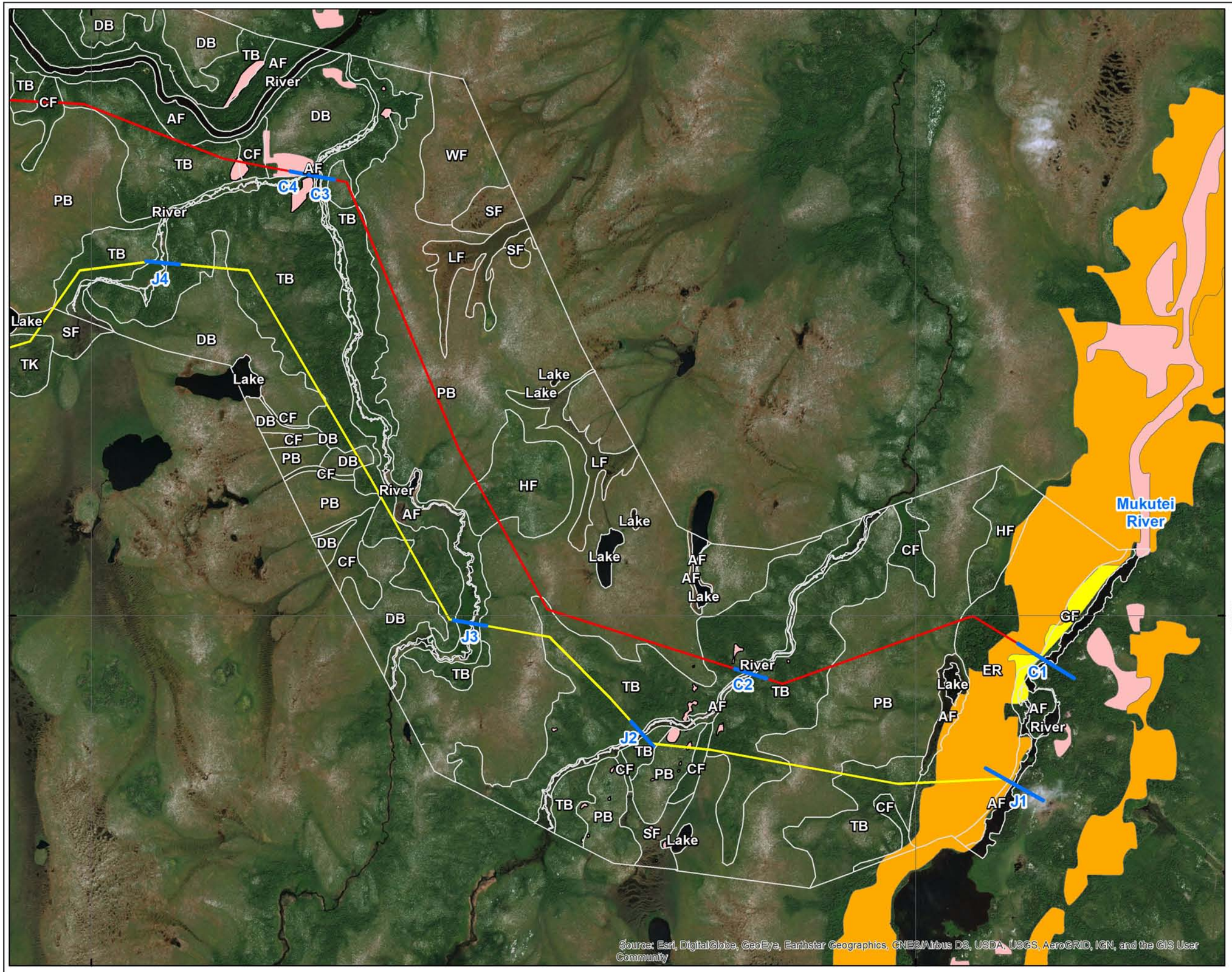
TITLE: Terrain Mapping

FIGURE: TM15

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

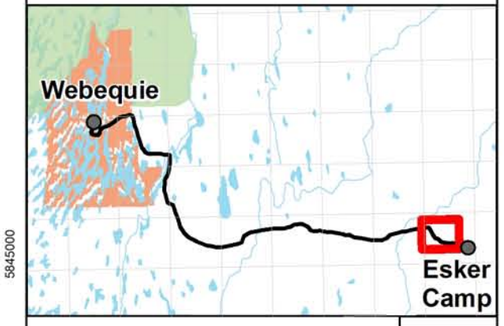
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



0 500 1,000
Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

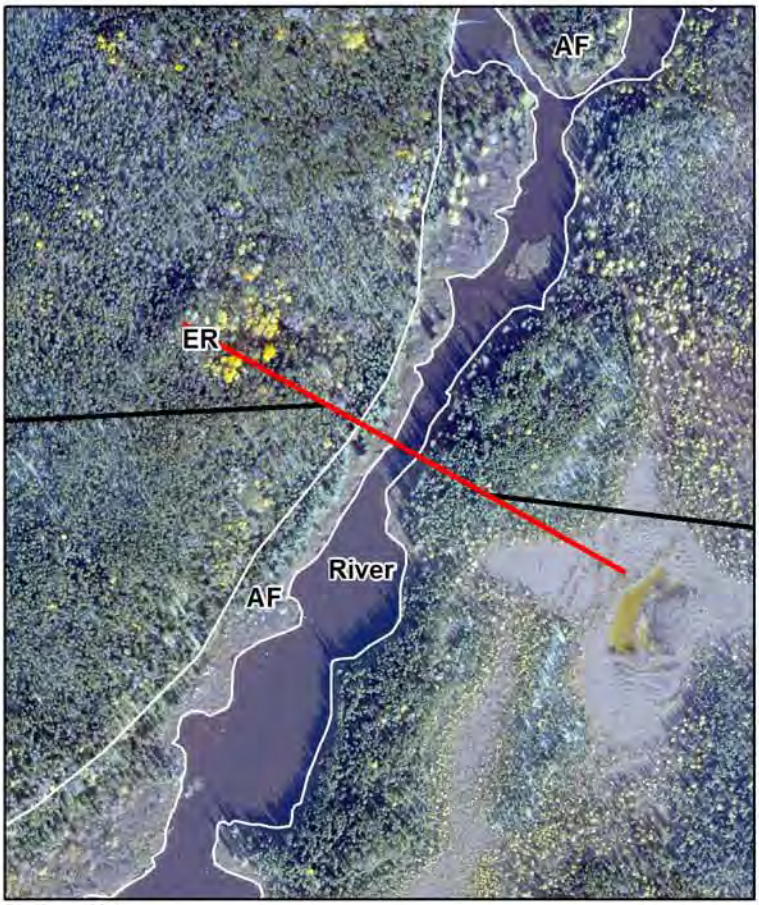
FIGURE: TM16

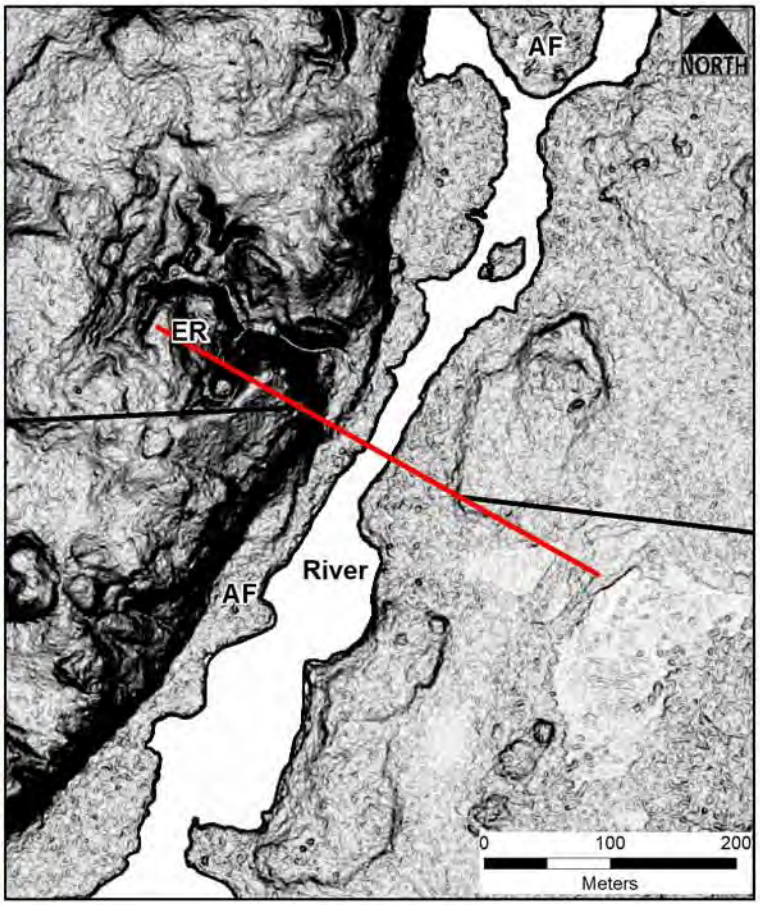
General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

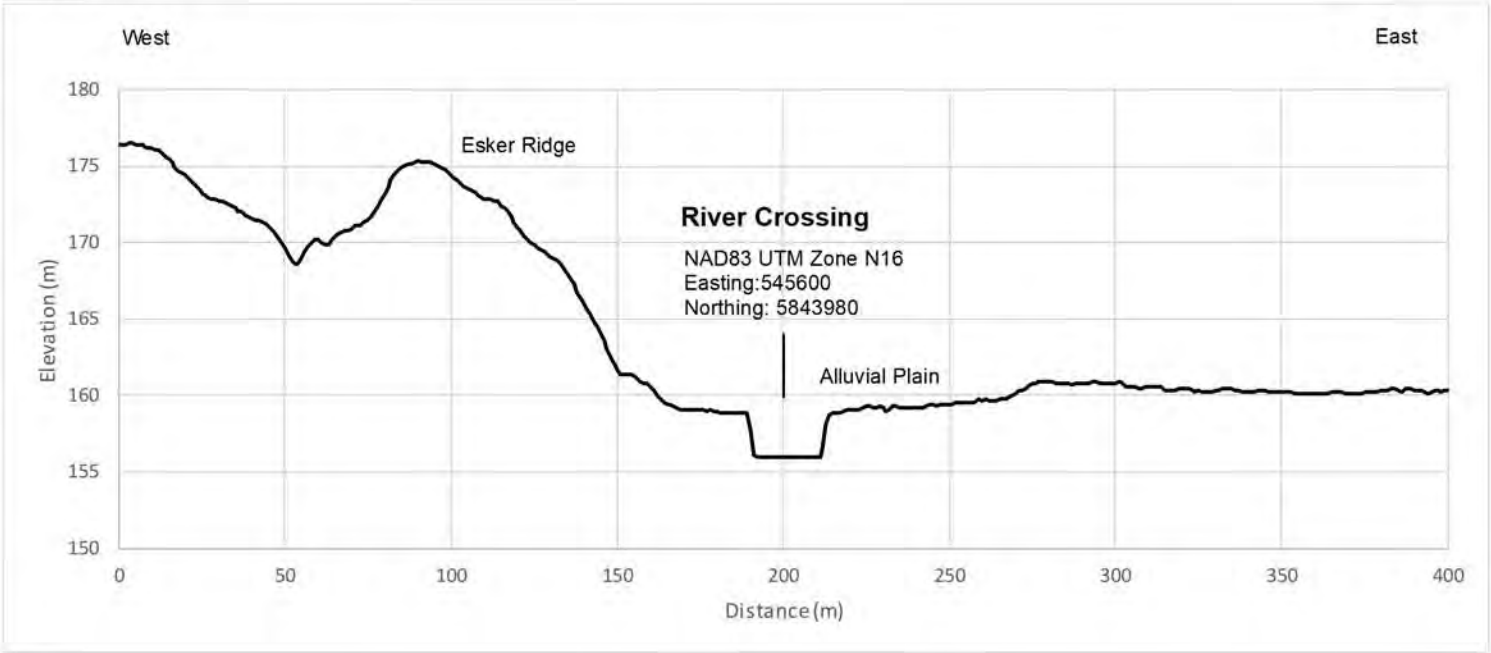
J D MOLLARD AND ASSOCIATES (2010) LIMITED

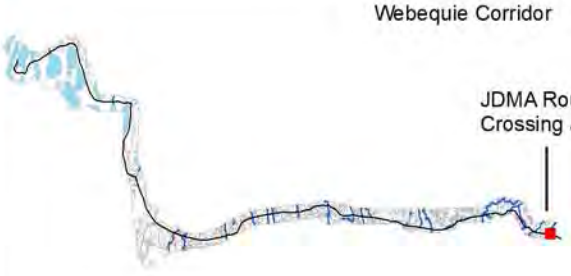
APPENDIX 2: Water Crossings





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

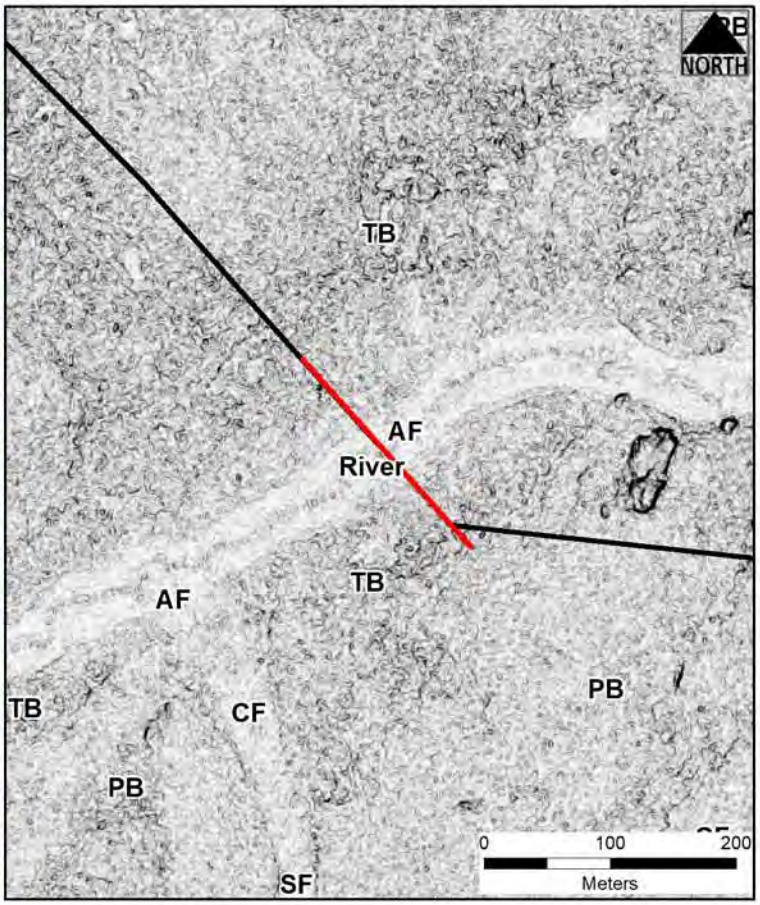
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

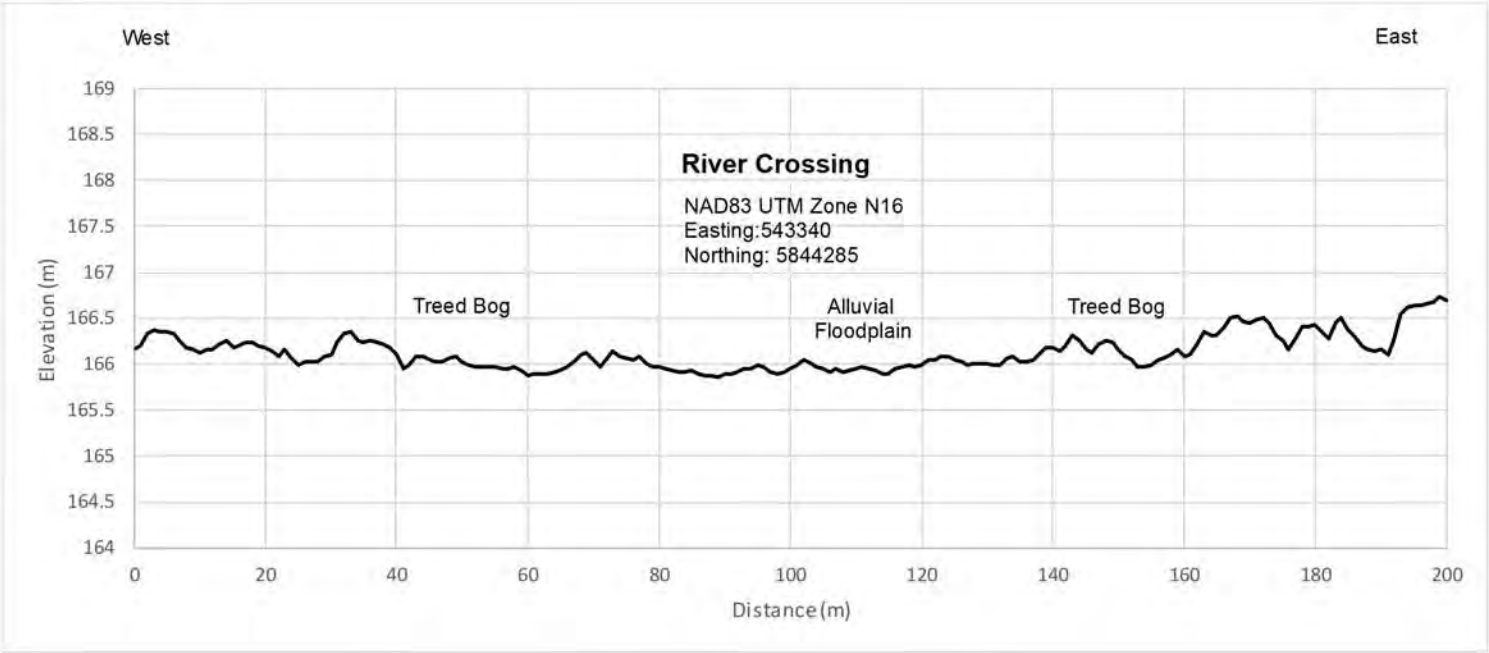
CROSSING:

J1

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

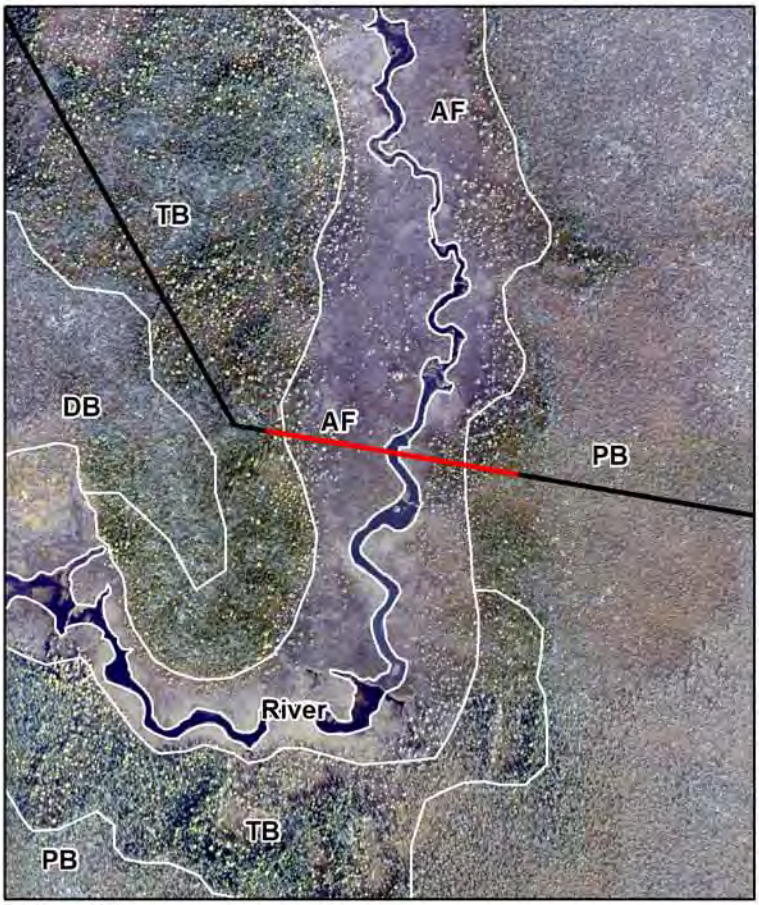
General reference map only; not for survey or legal use.

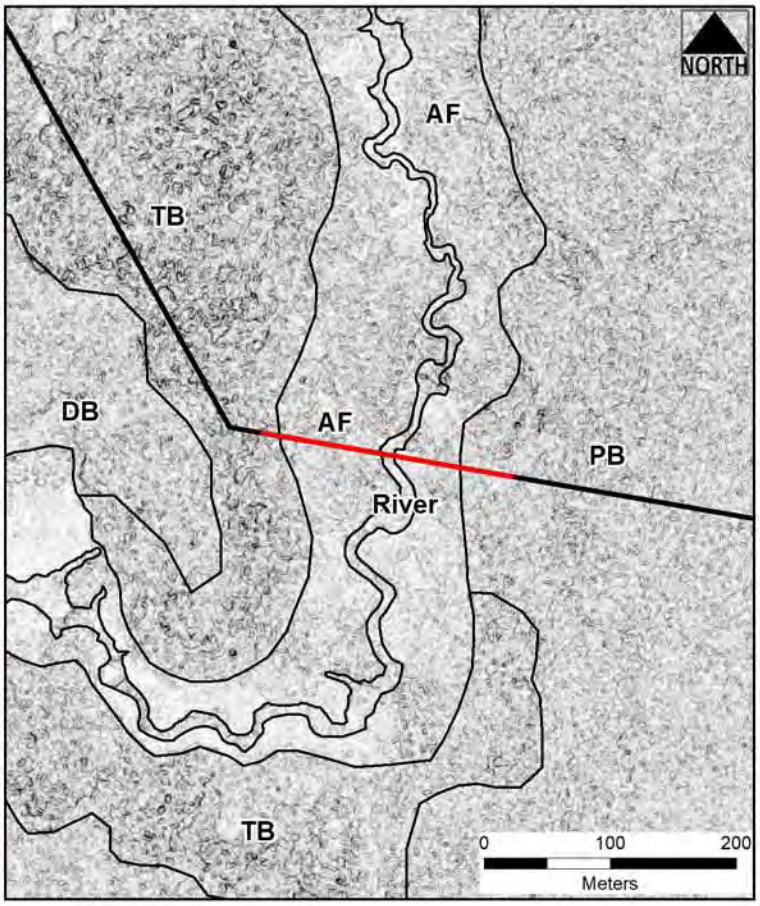
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

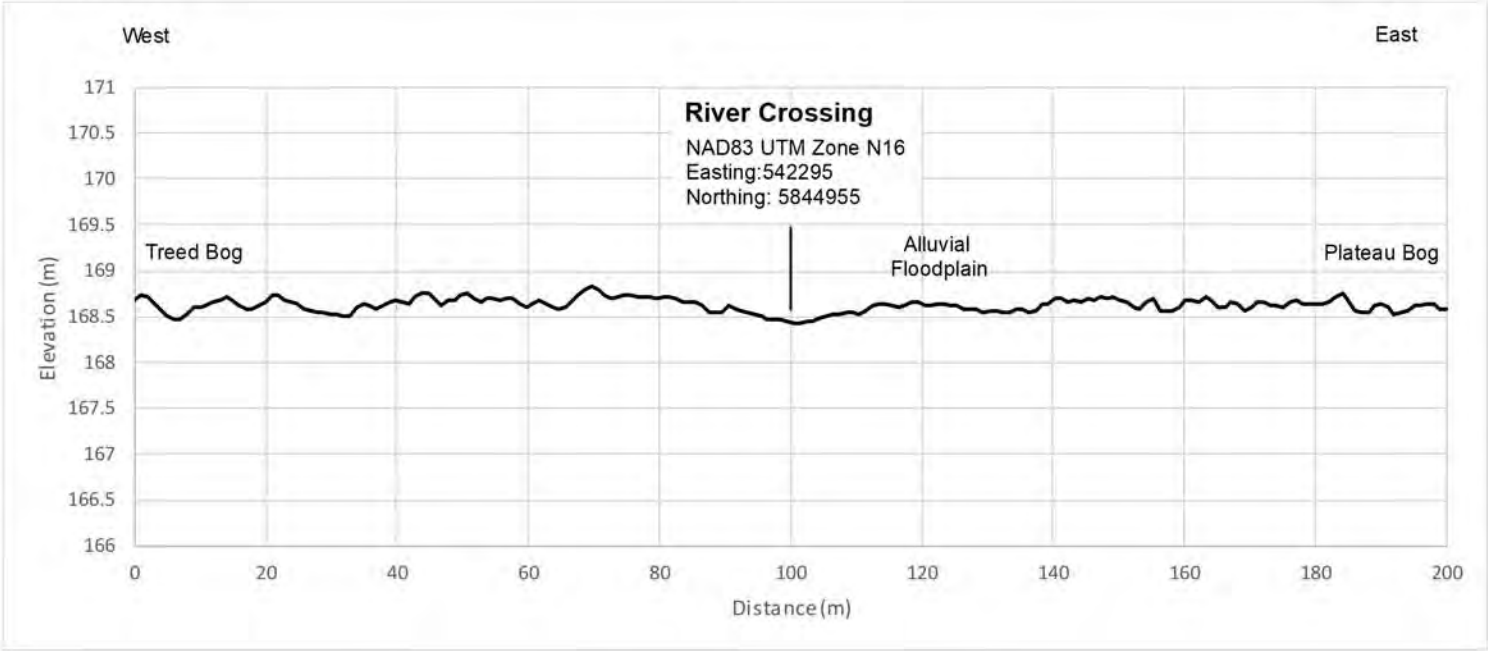
J2

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

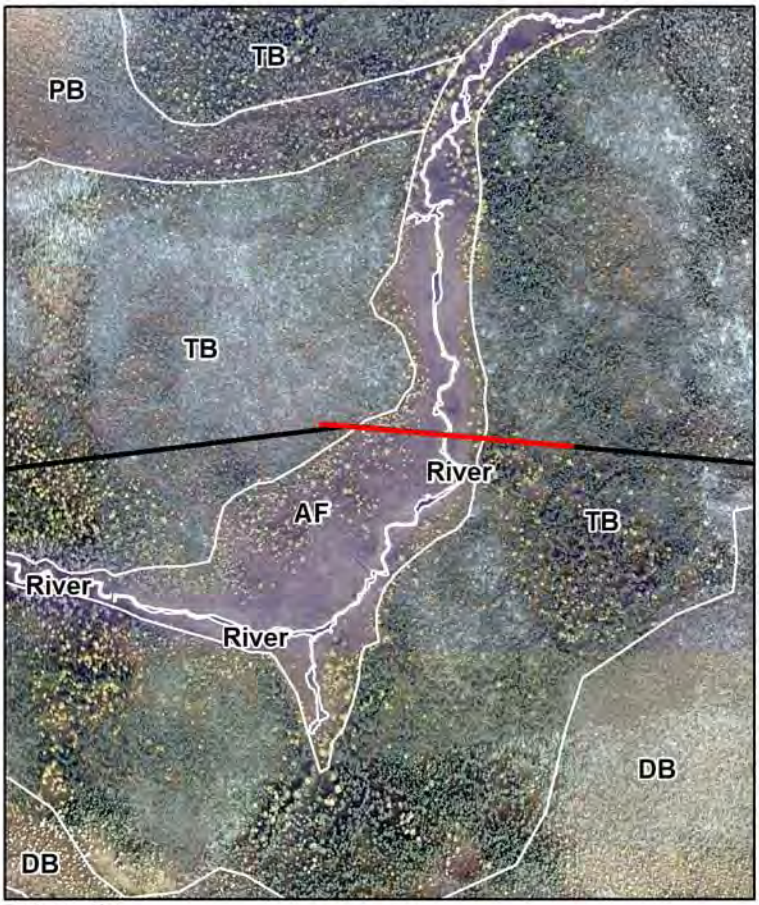
General reference map only; not for survey or legal use.

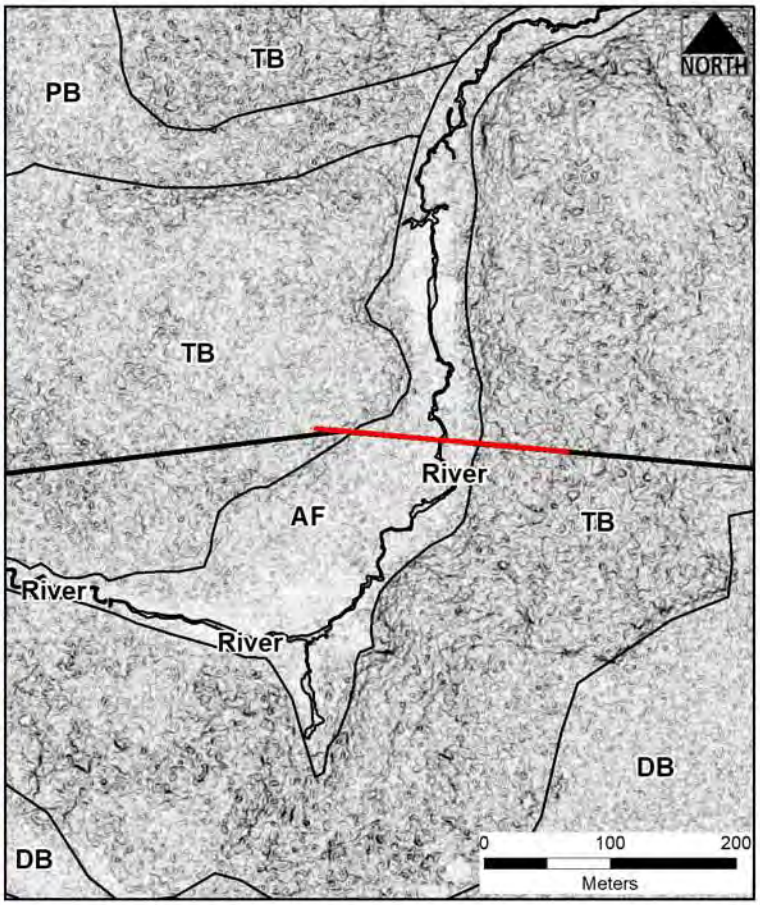
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

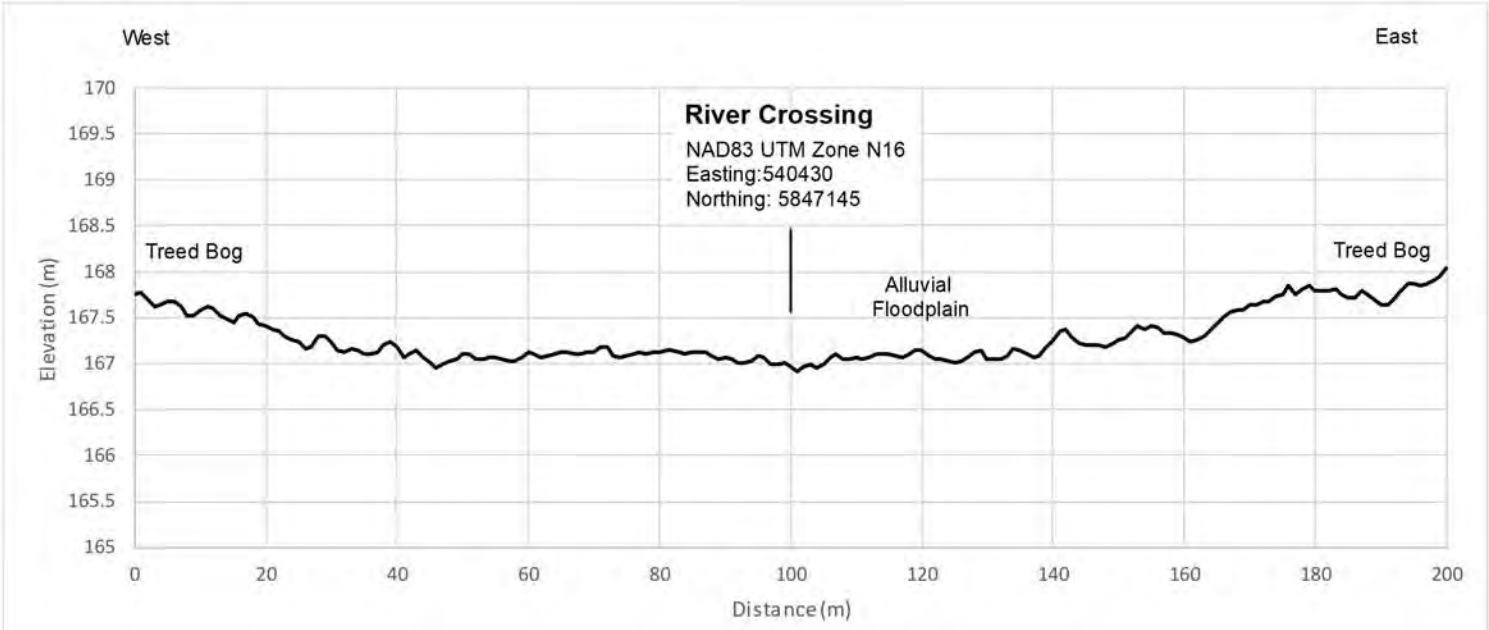
J3

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

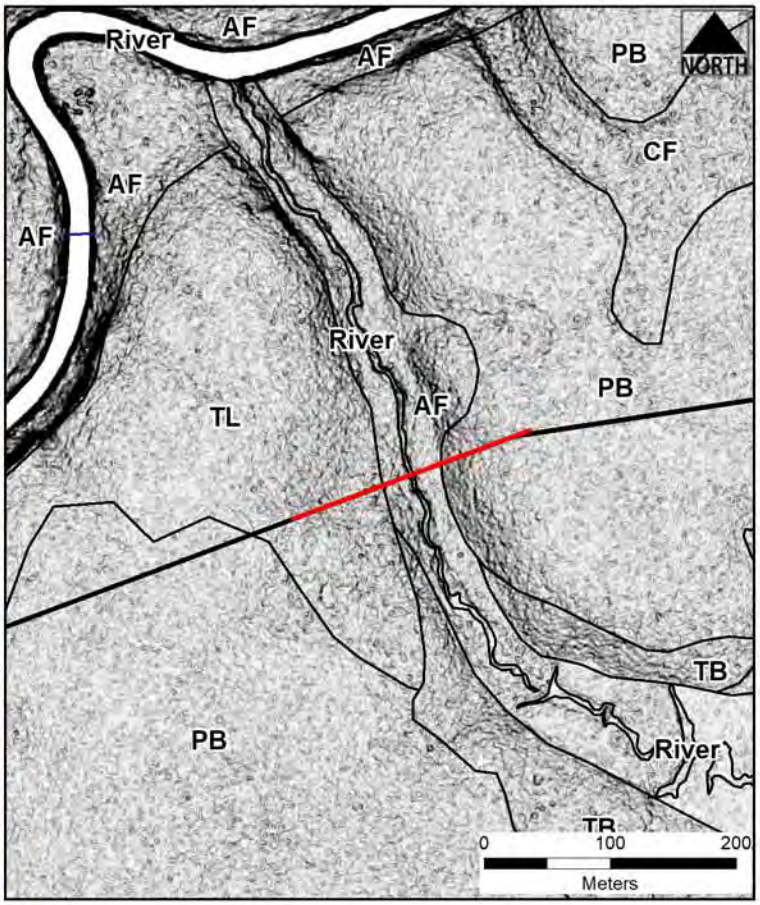
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

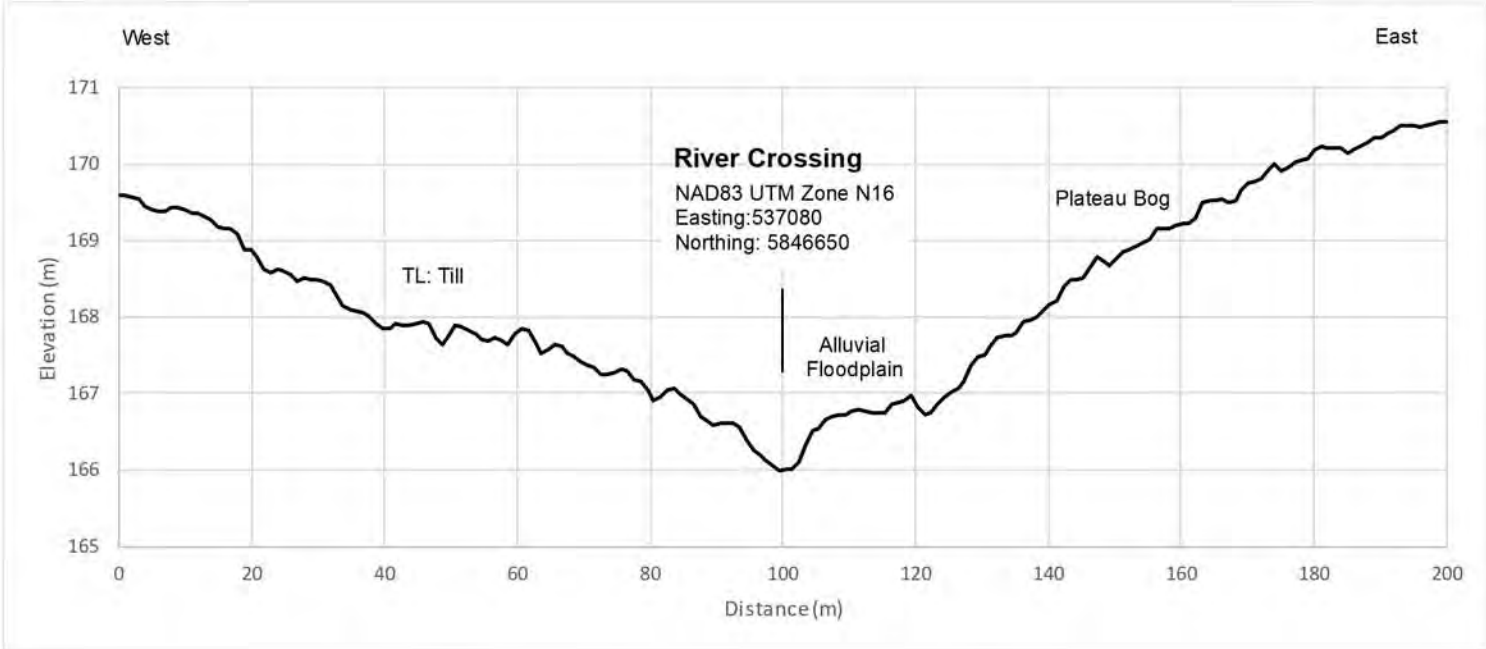
CROSSING:

J4

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

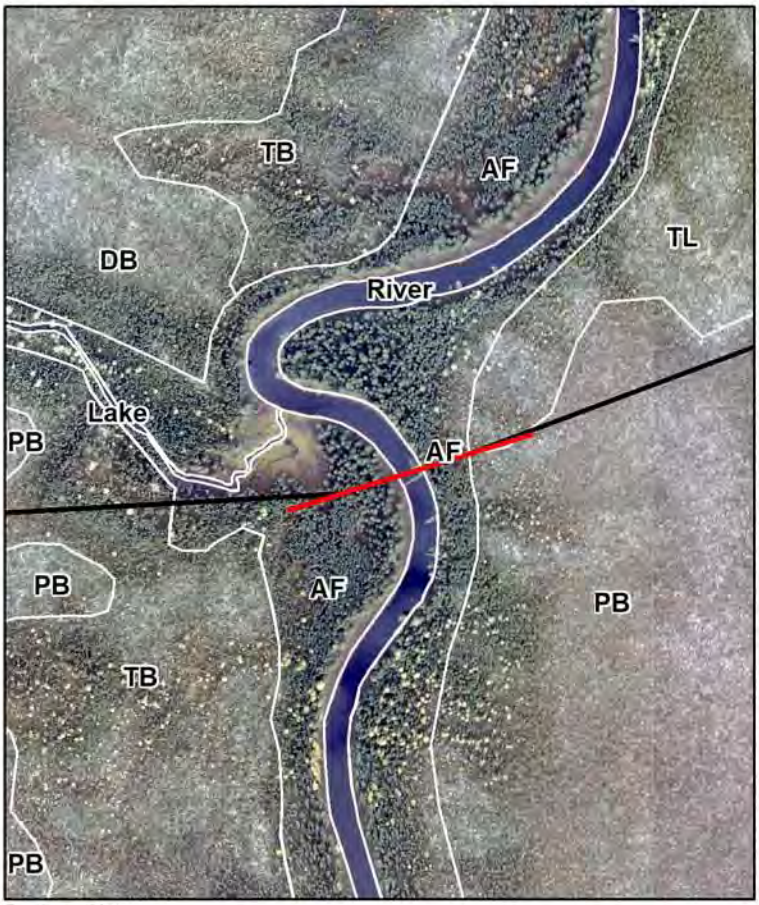
General reference map only; not for survey or legal use.

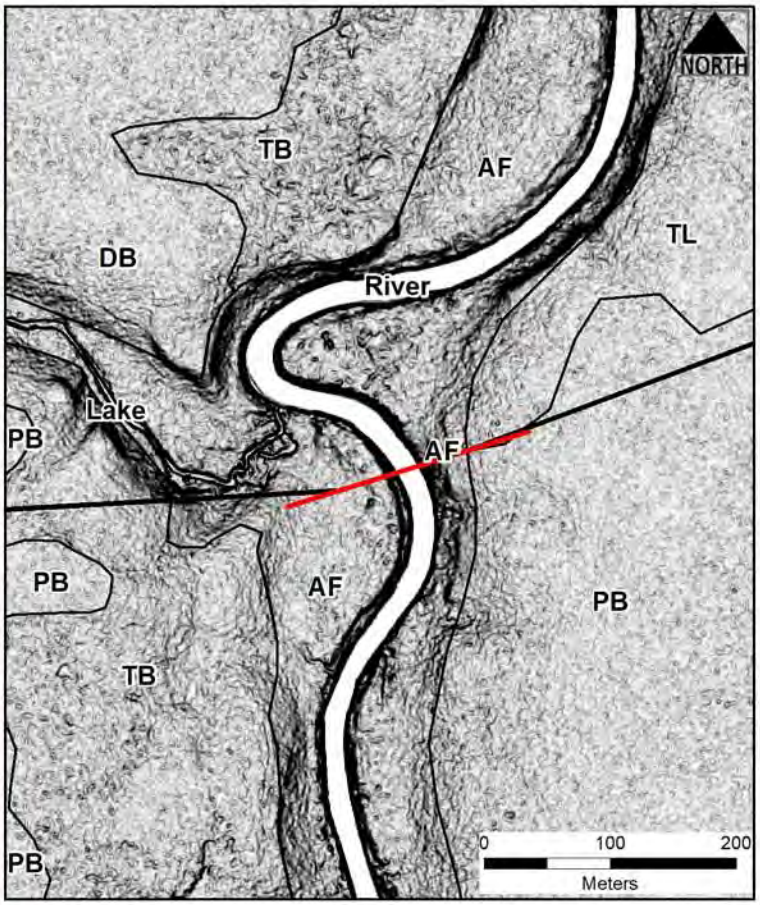
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 21/Mar/2019*

CROSSING:

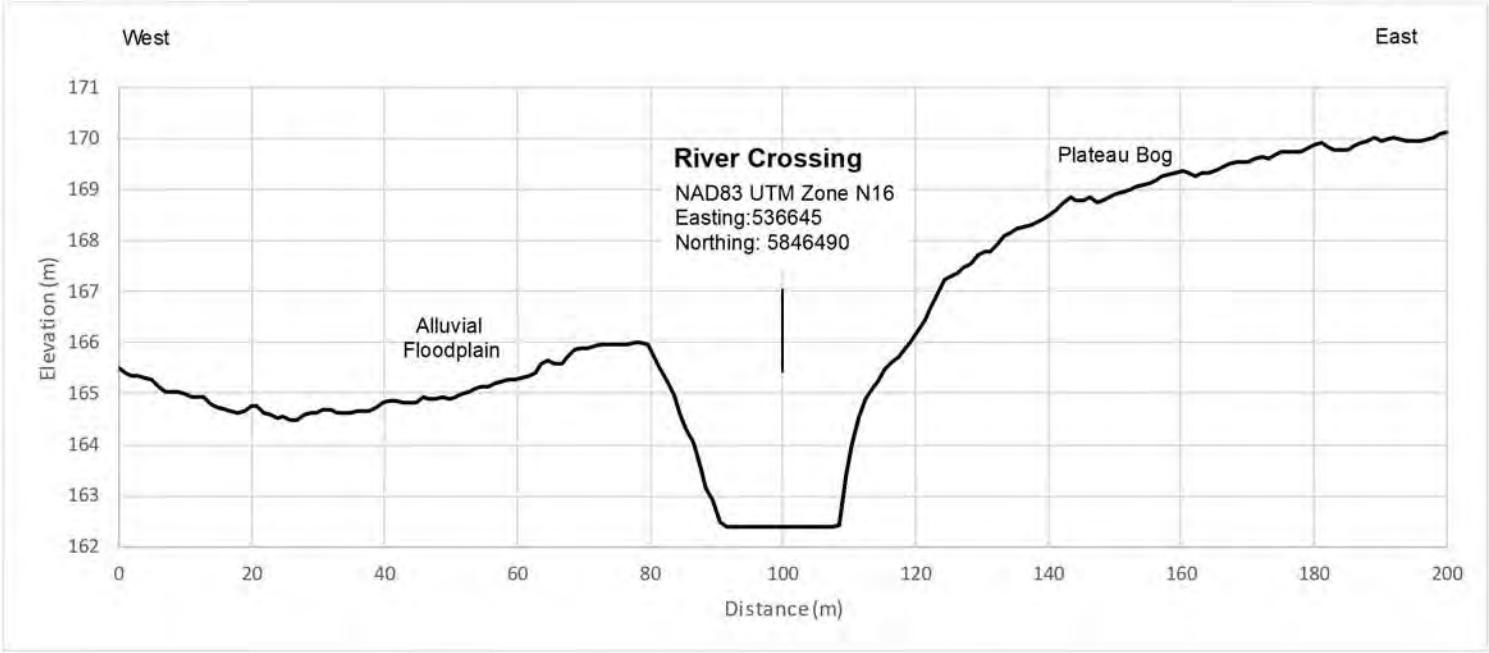
J5

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

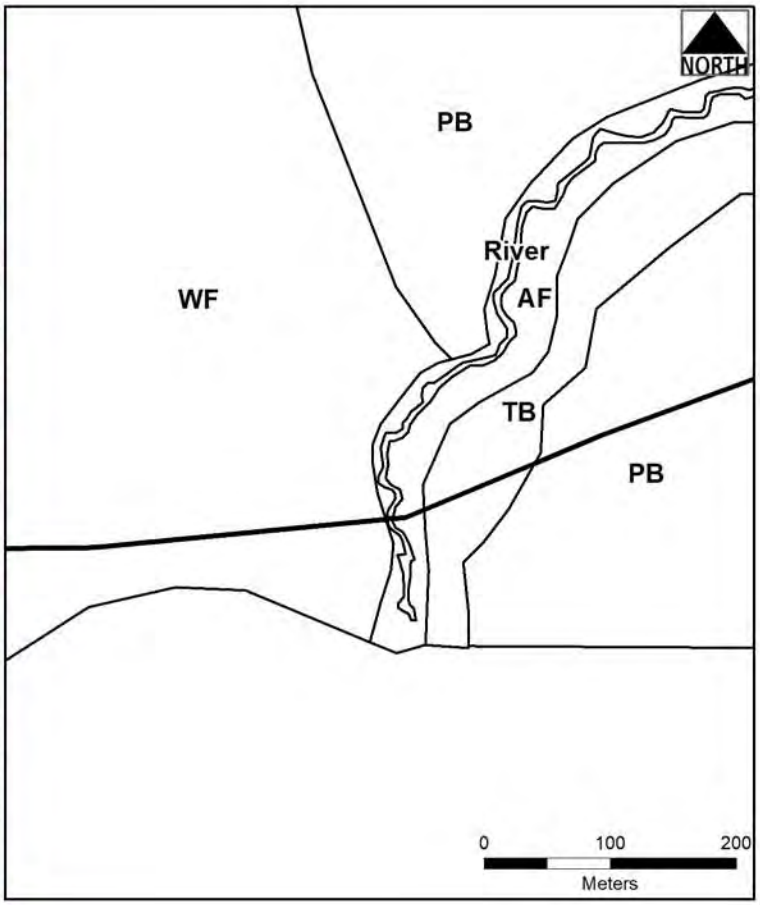
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J6

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:531690
Northing: 5844820

No LiDAR Data

LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)

High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

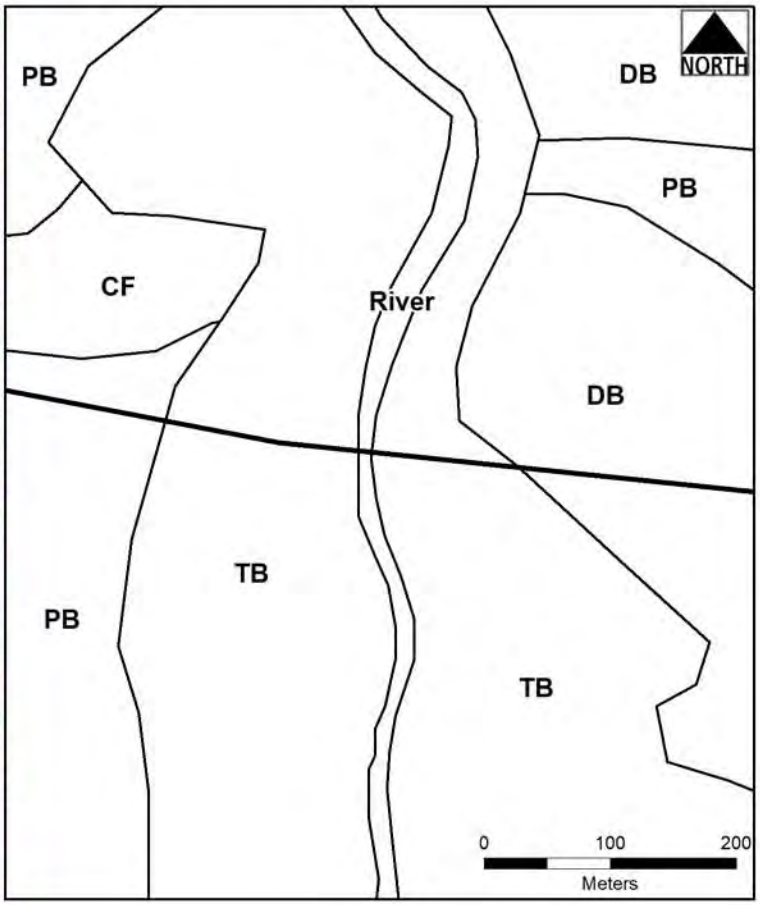
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J7

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:529807
Northing: 5844837

No LiDAR Data

LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)

High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

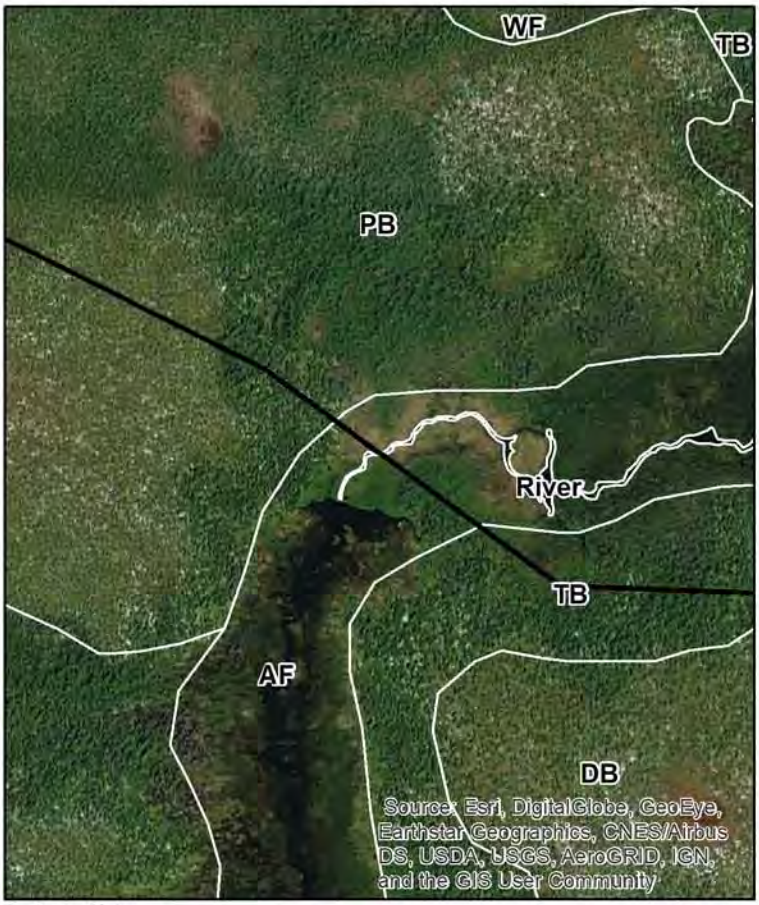
General reference map only; not for survey or legal use.

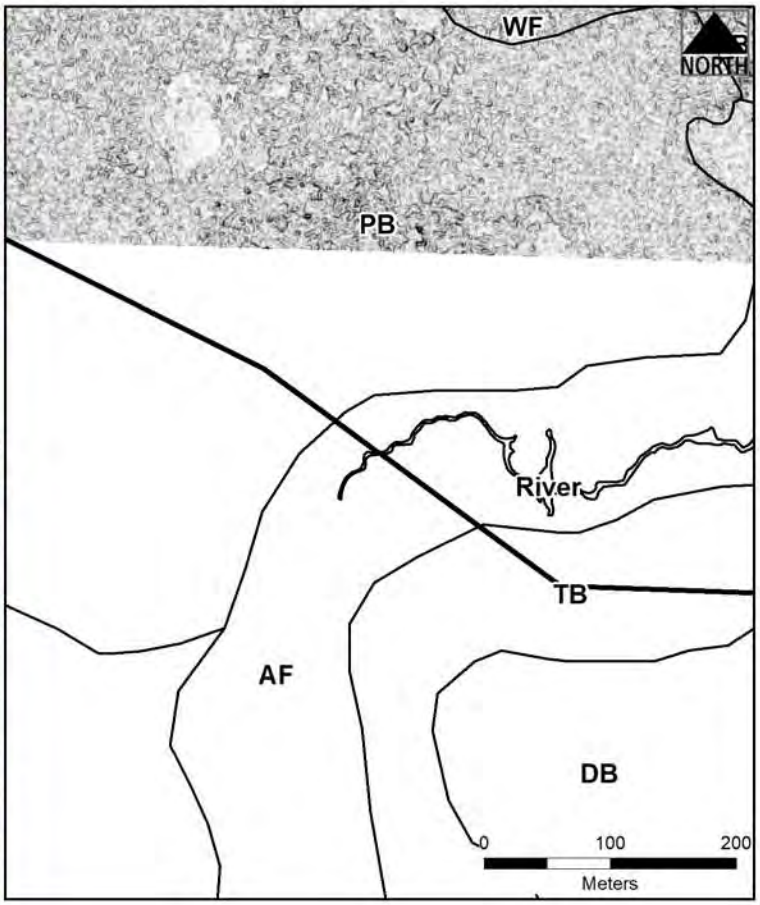
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J8

J D MOLLARD AND ASSOCIATES (2010) LIMITED



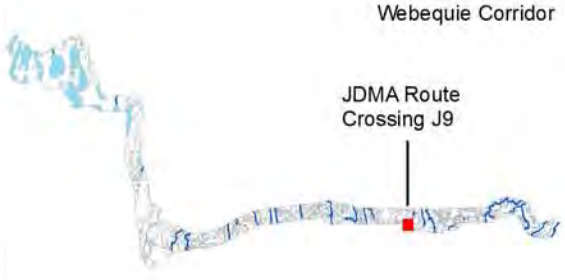


Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:526262
Northing: 5845452

No LiDAR Data



LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)

High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

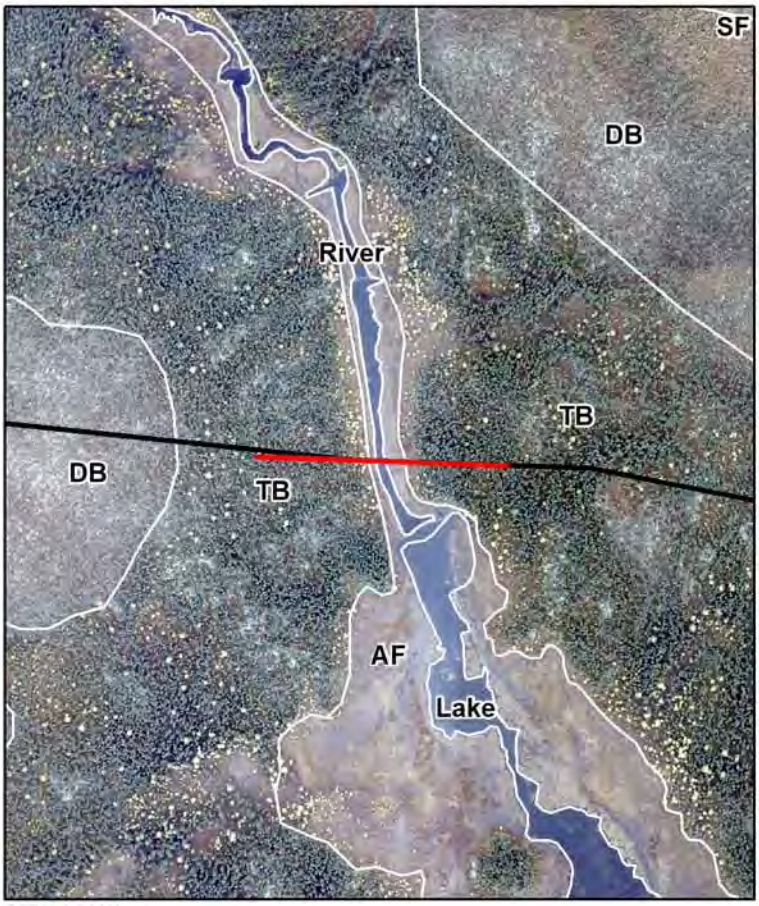
General reference map only; not for survey or legal use.

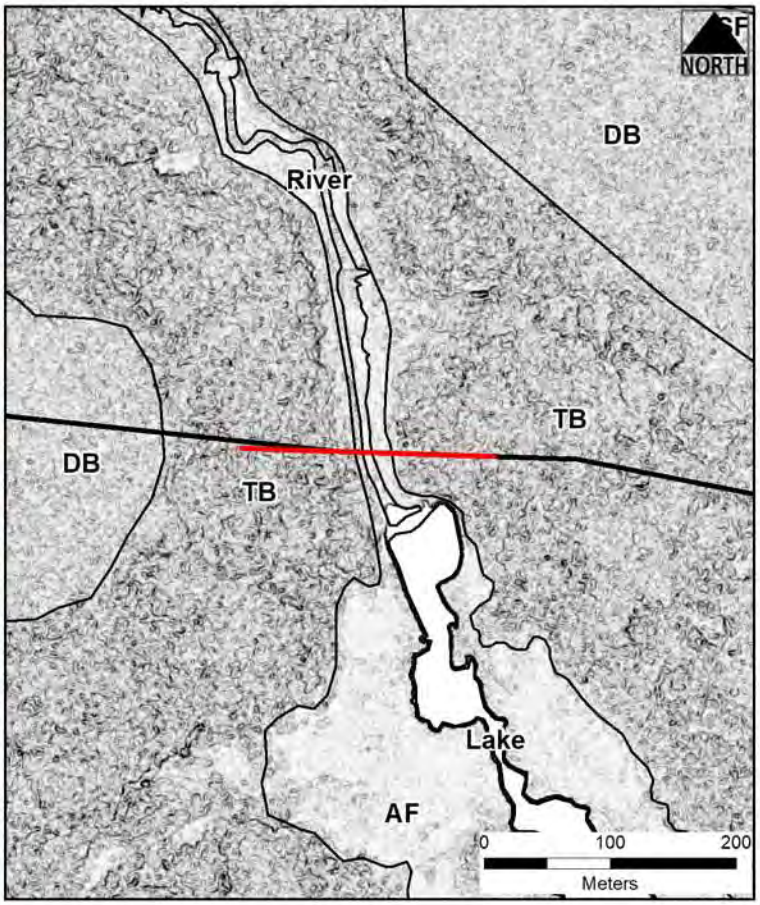
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

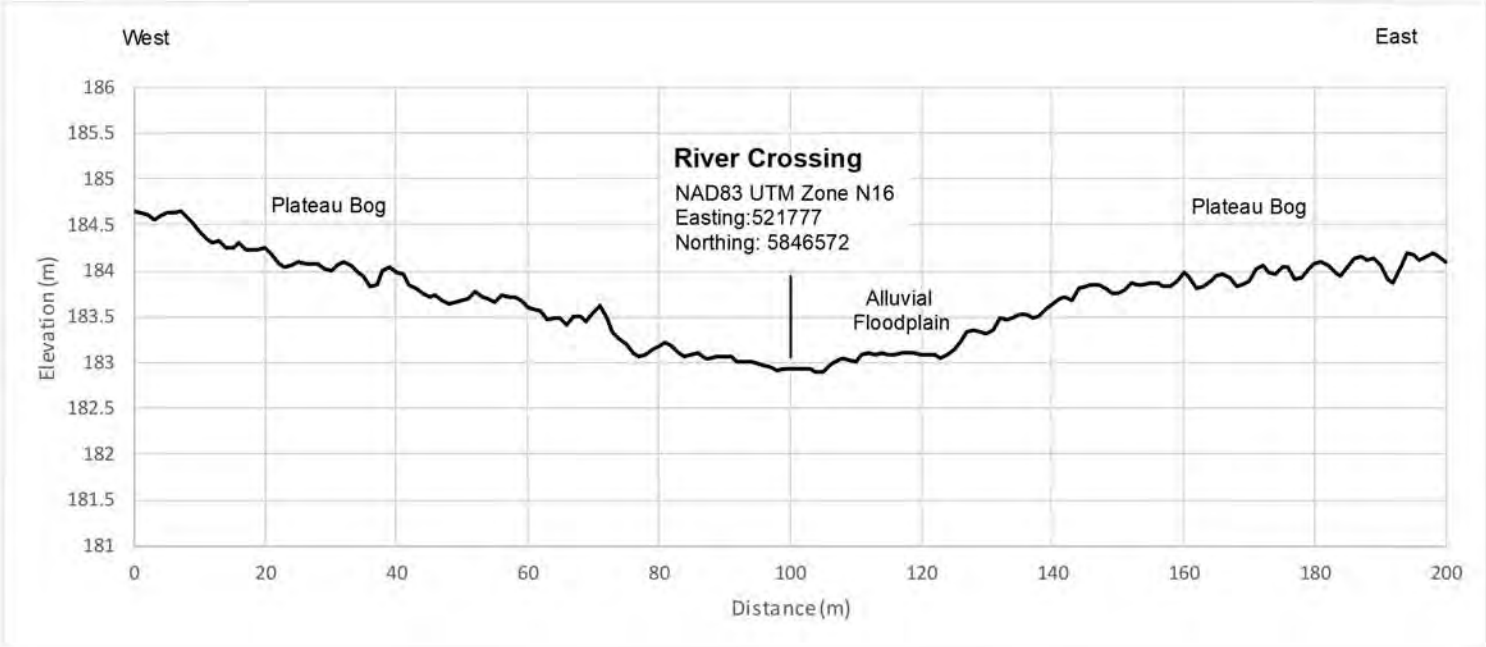
J9

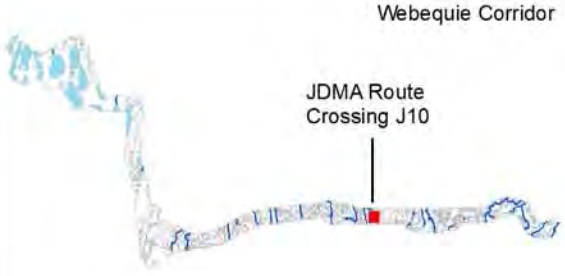
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

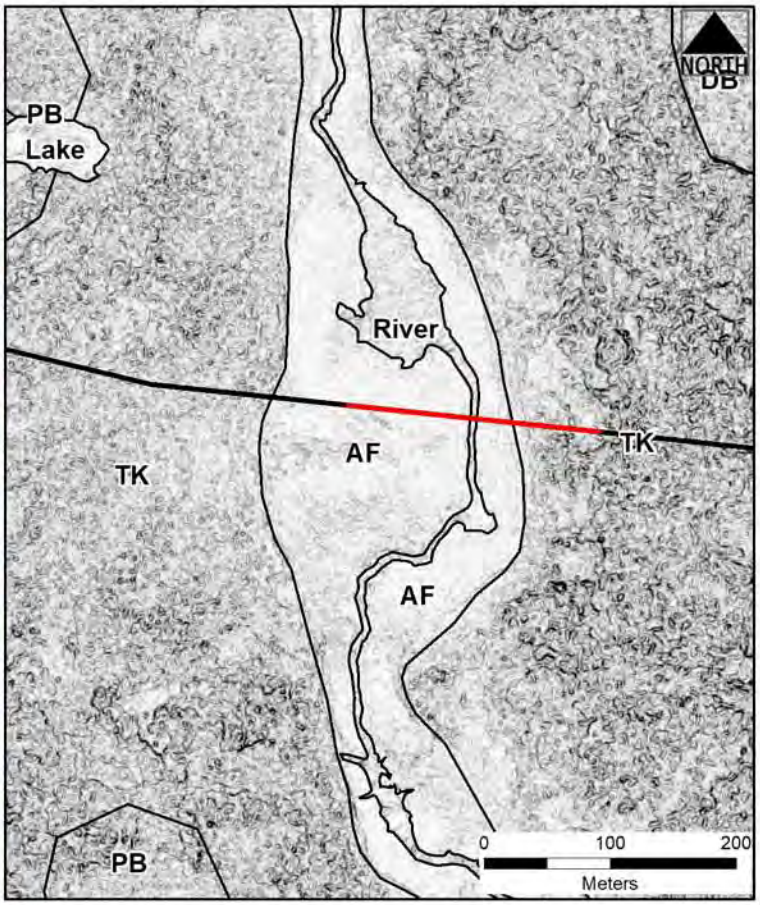
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

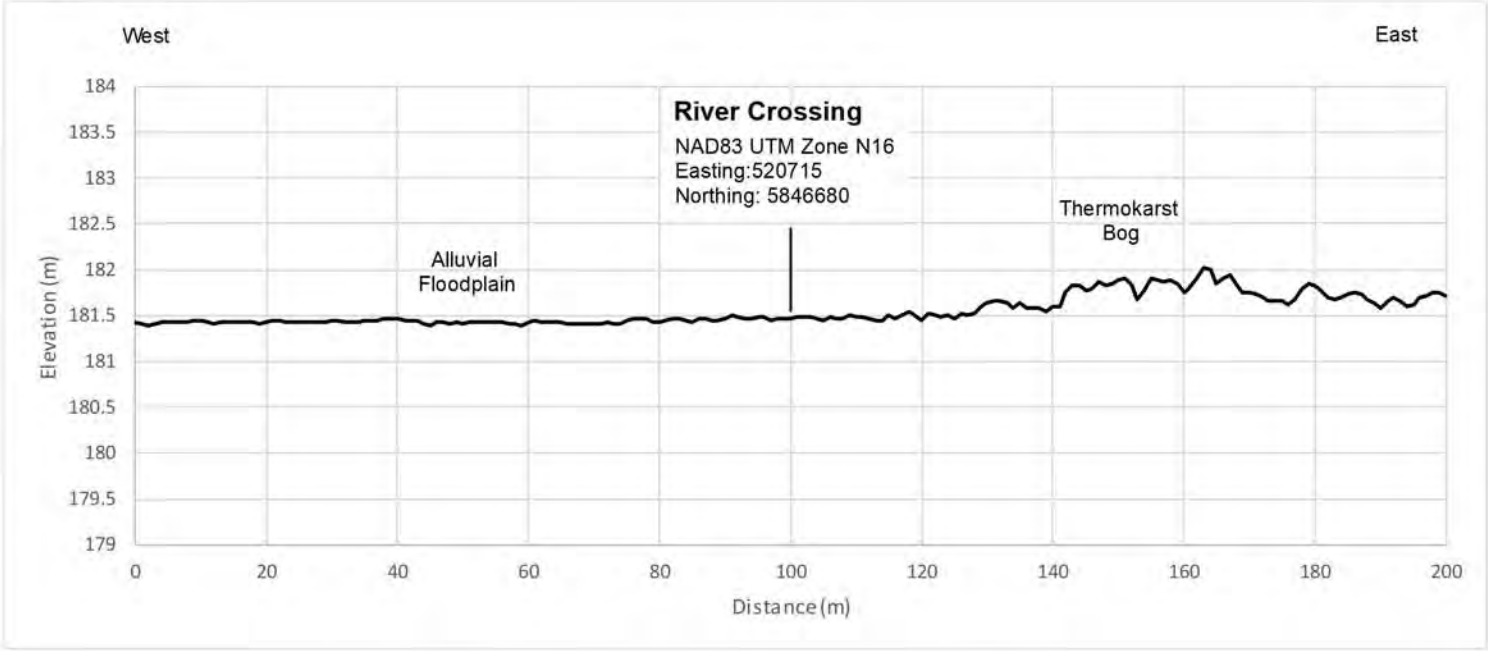
CROSSING:

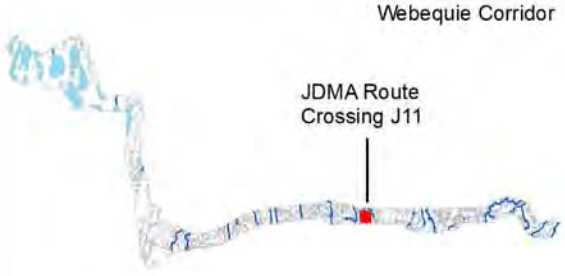
J10

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

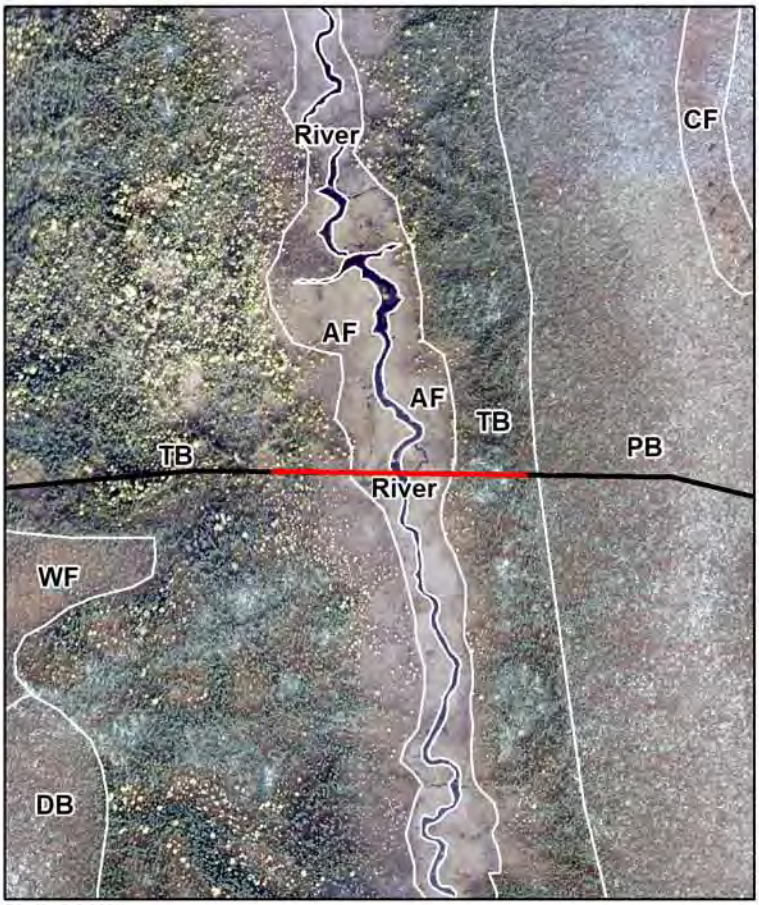
General reference map only; not for survey or legal use.

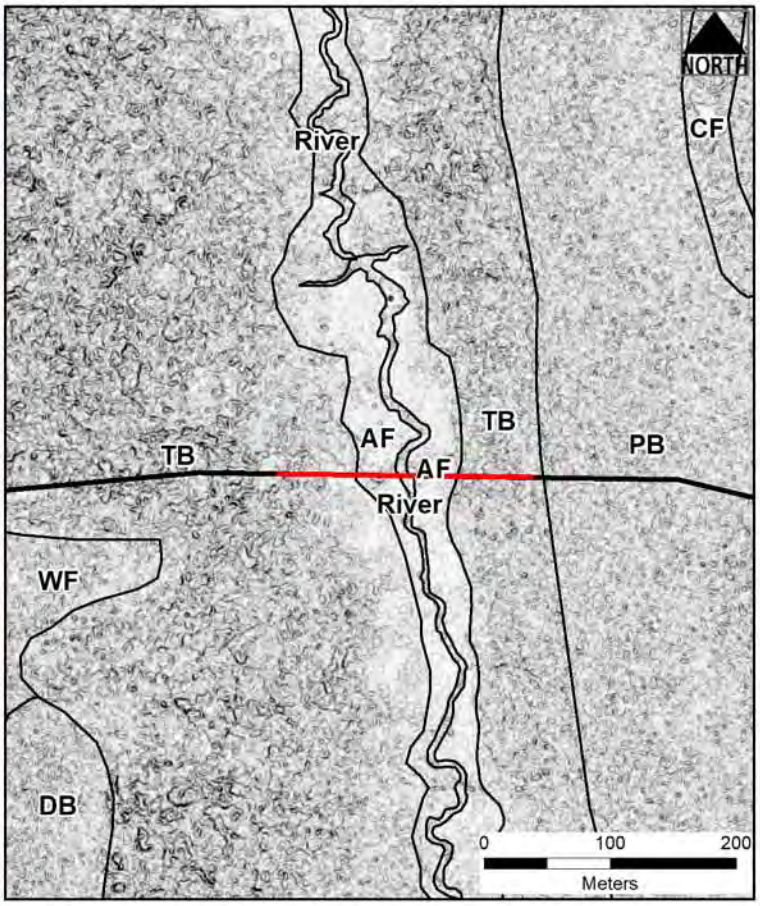
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

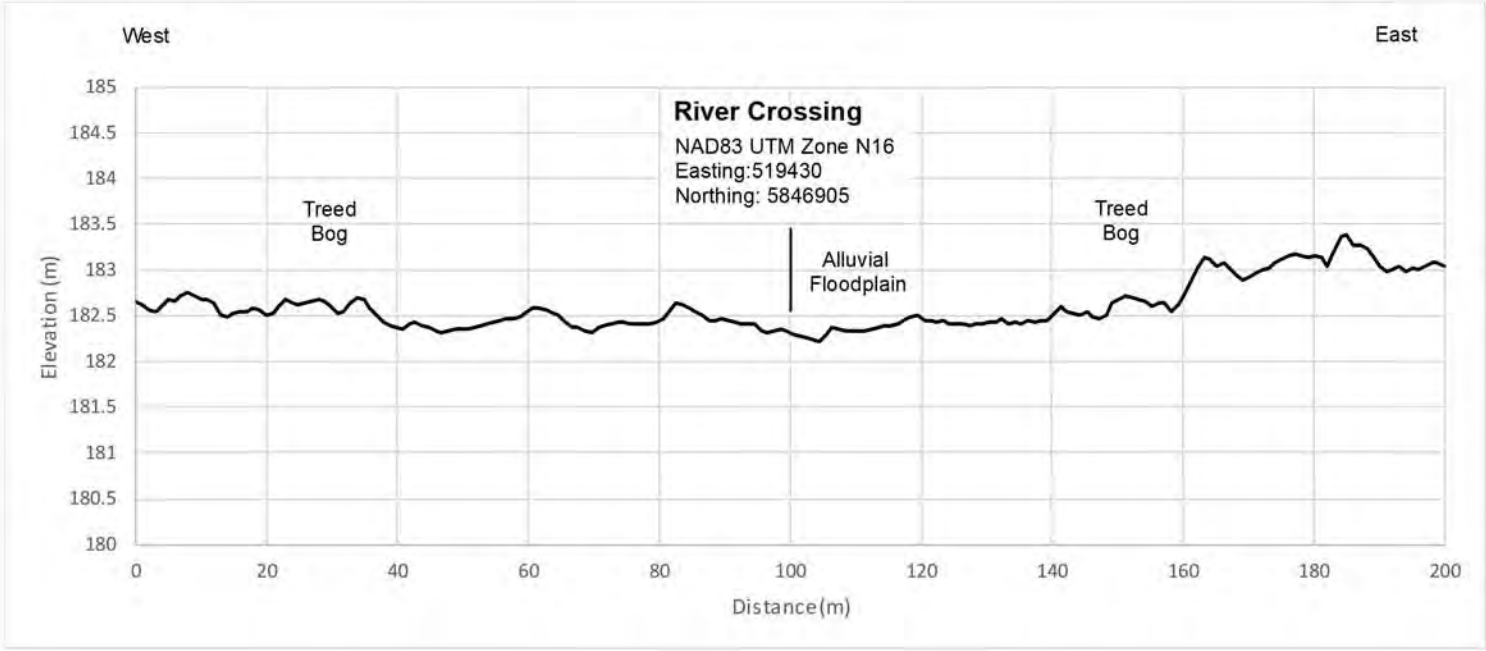
J11

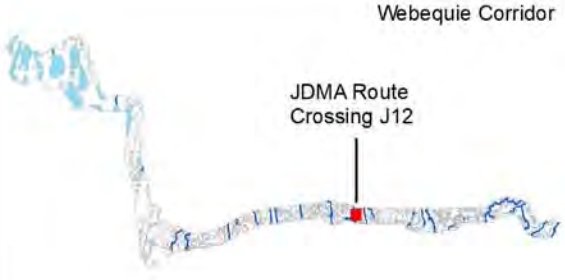
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

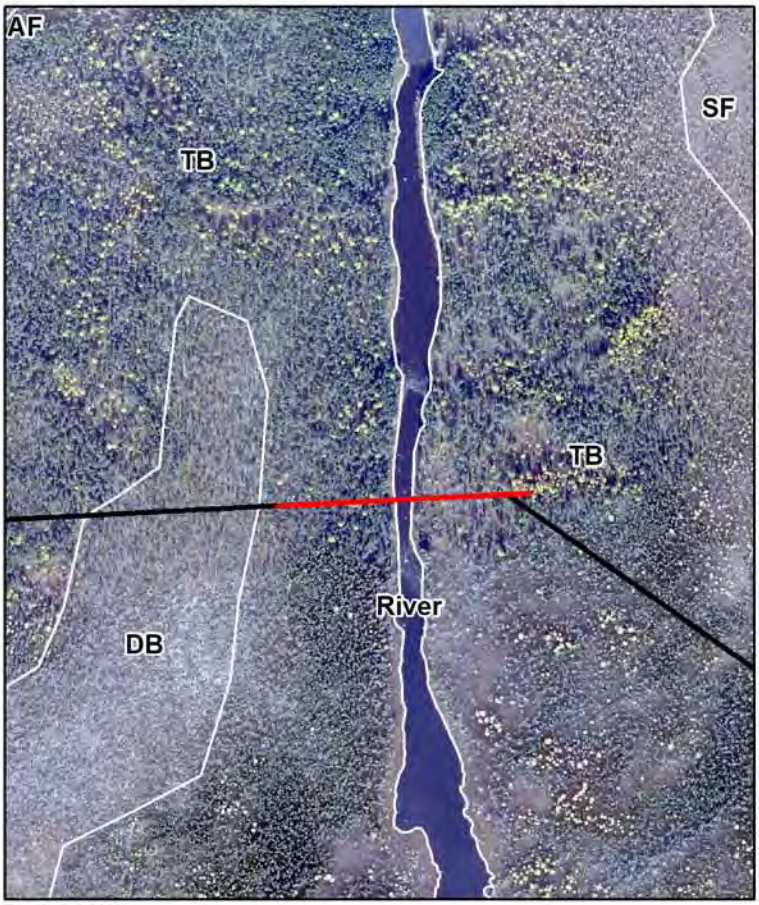
General reference map only; not for survey or legal use.

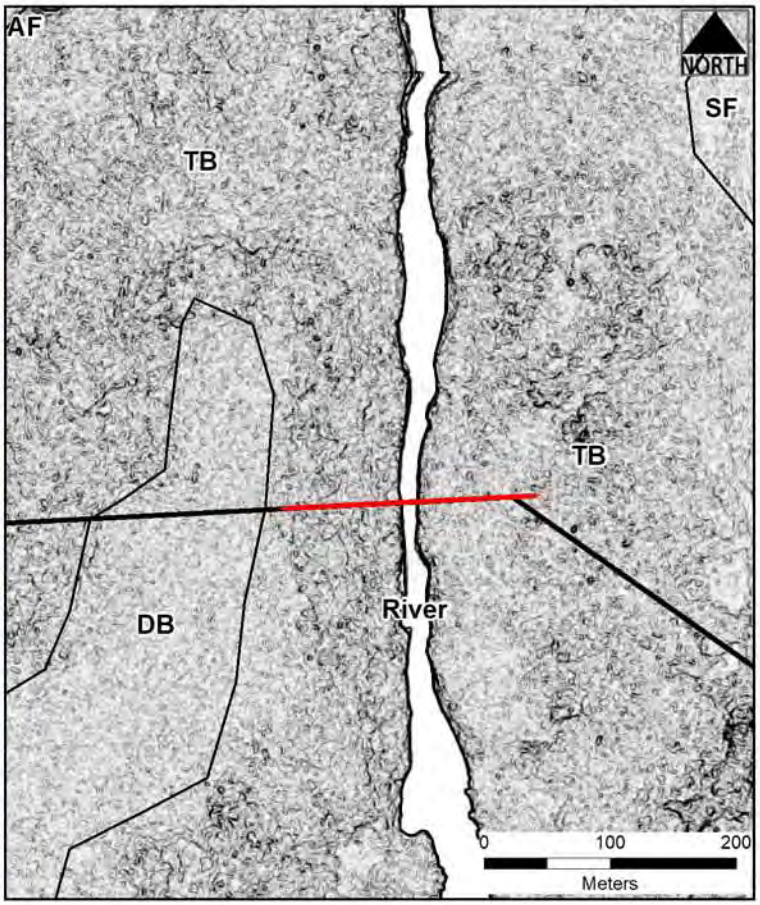
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

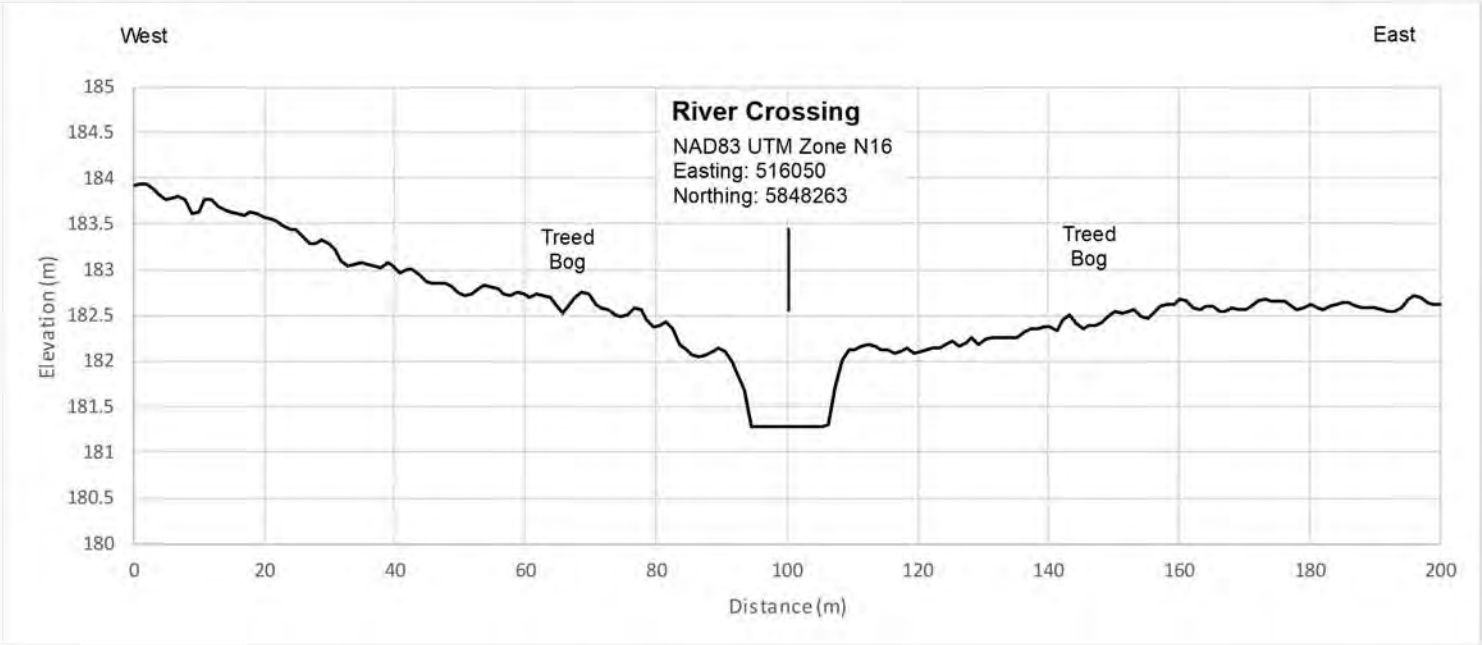
J12

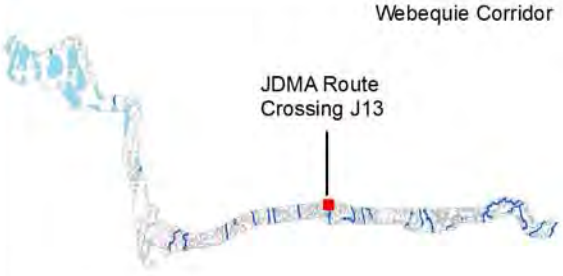
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

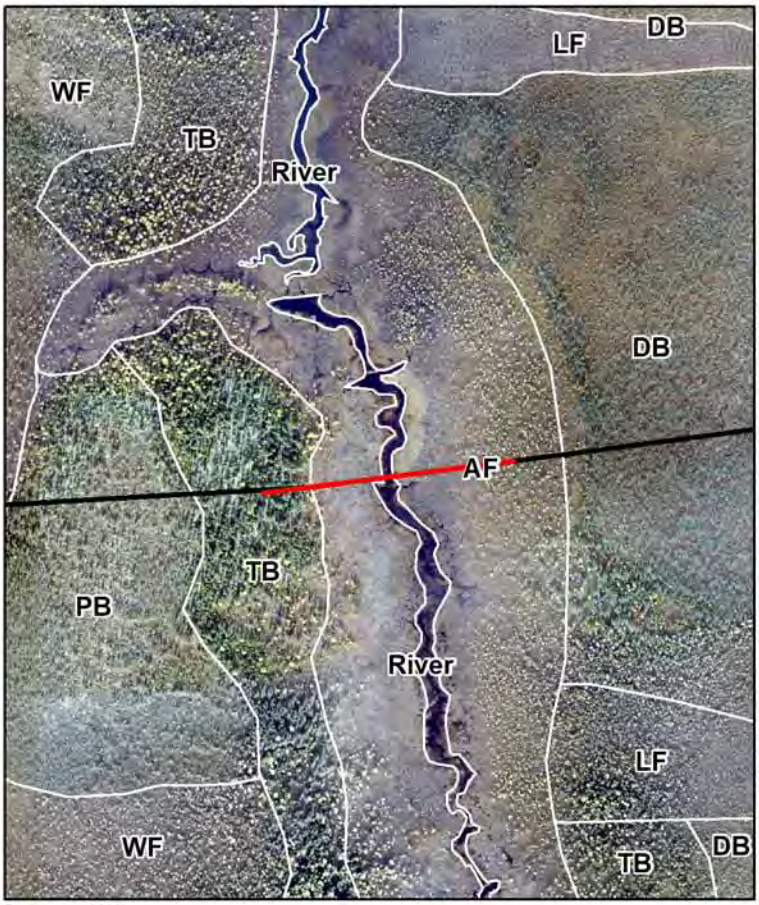
General reference map only; not for survey or legal use.

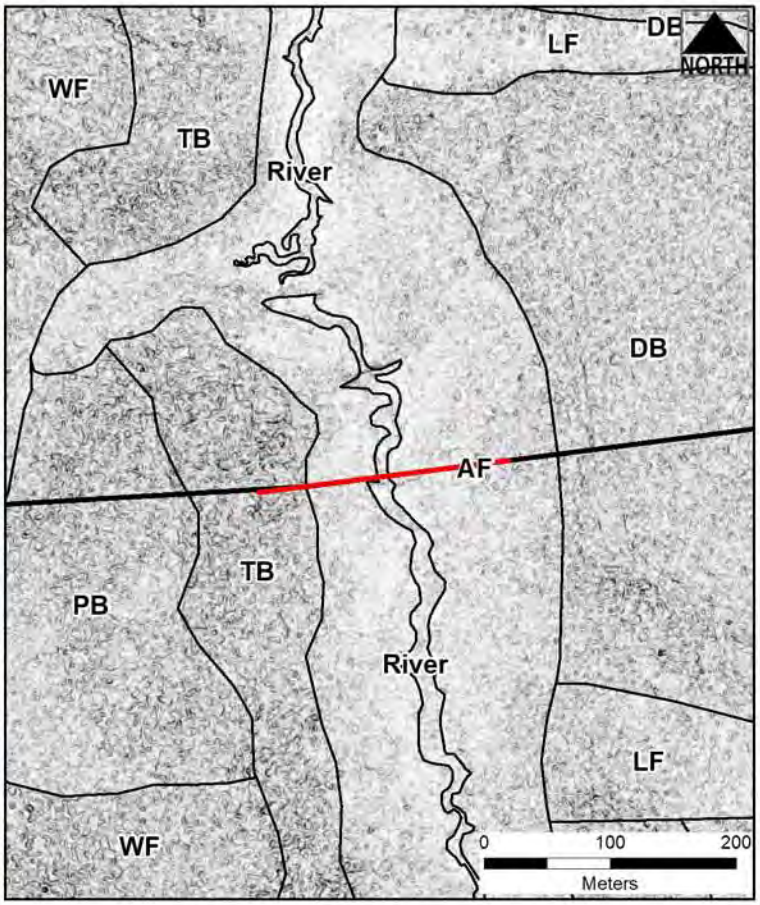
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

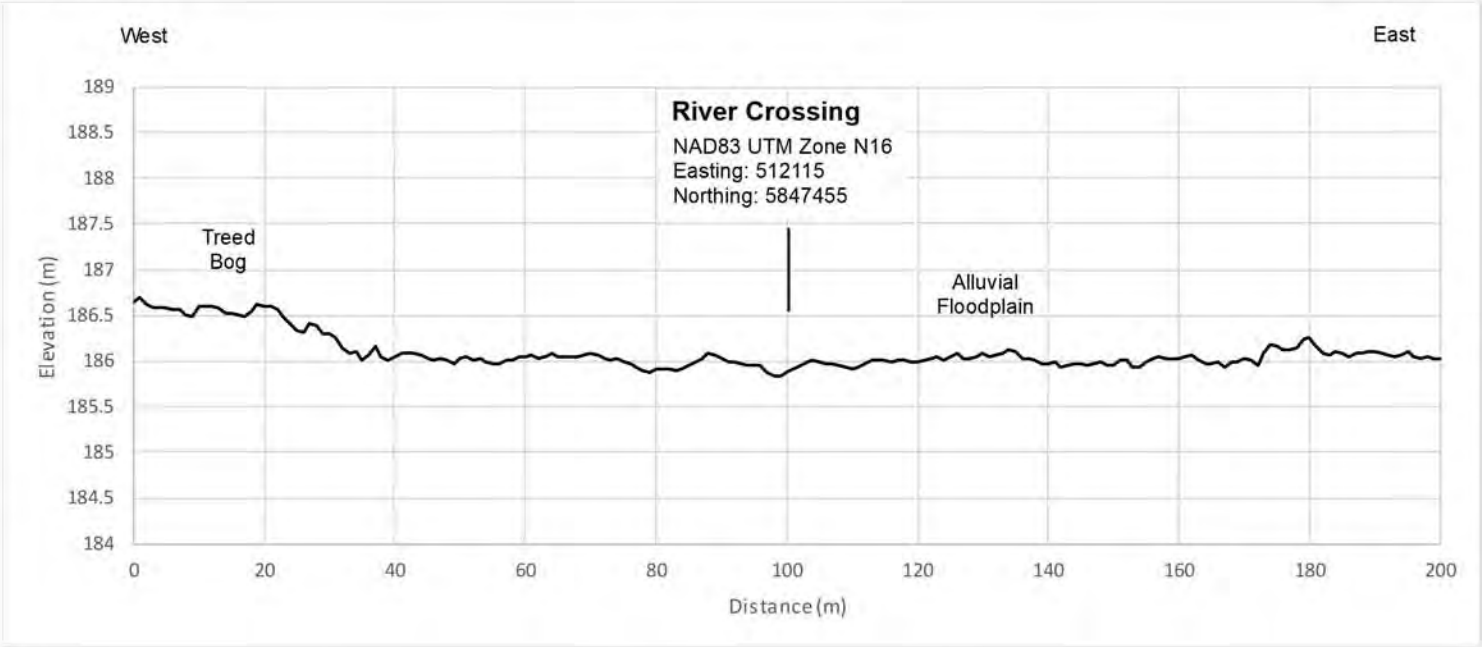
J13

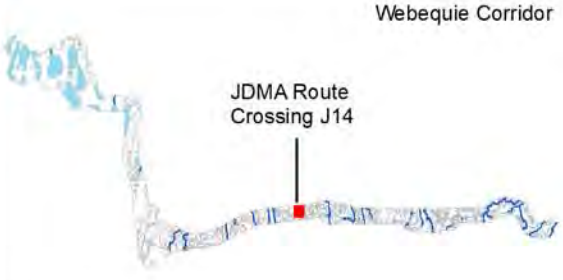
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

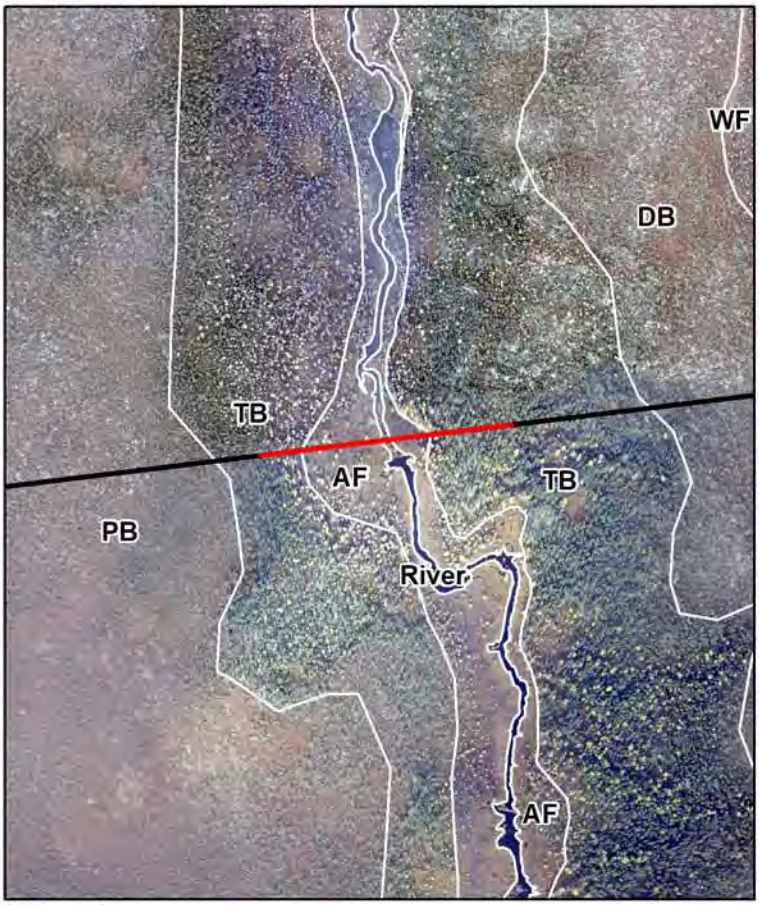
General reference map only; not for survey or legal use.

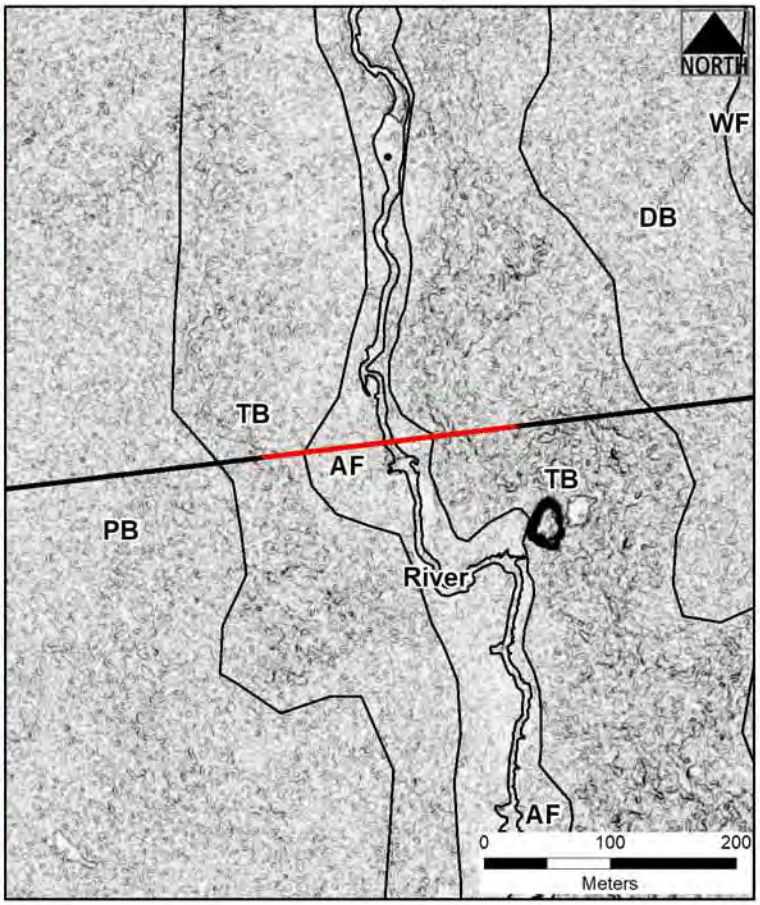
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

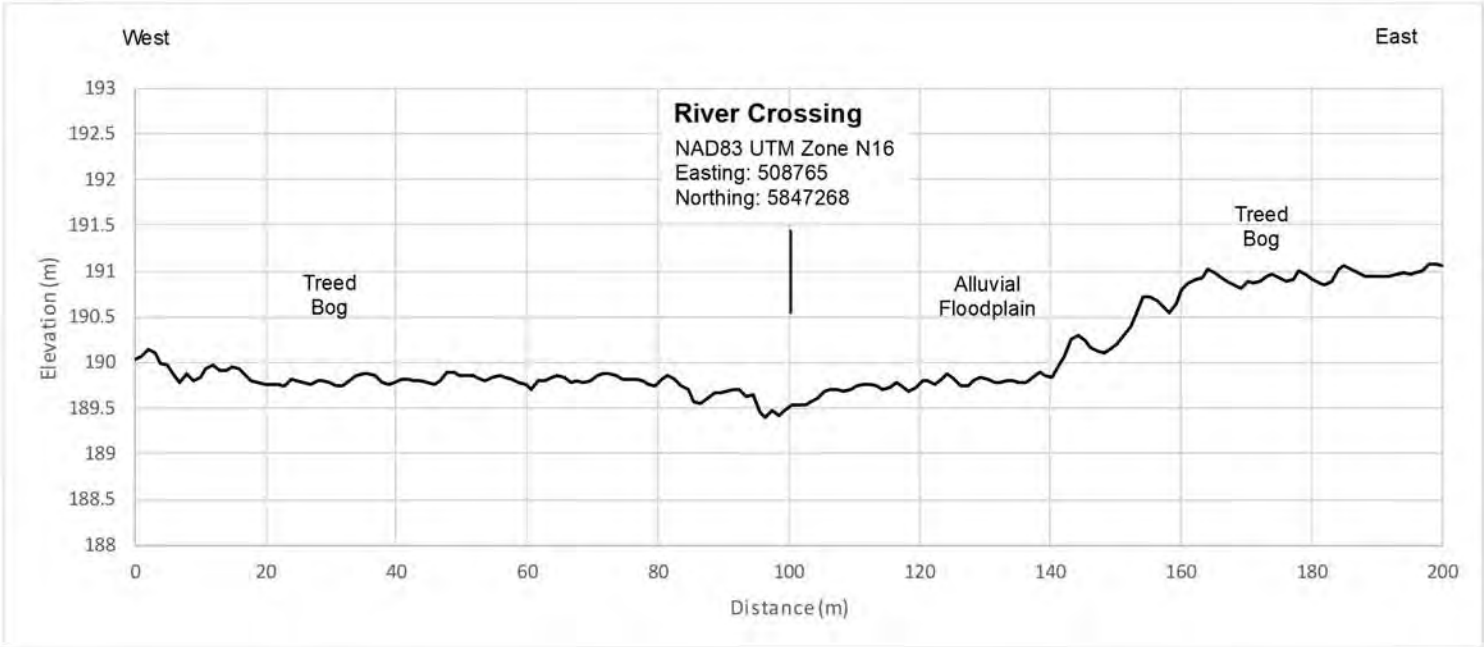
J14

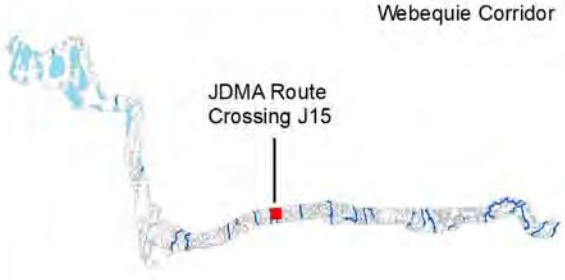
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

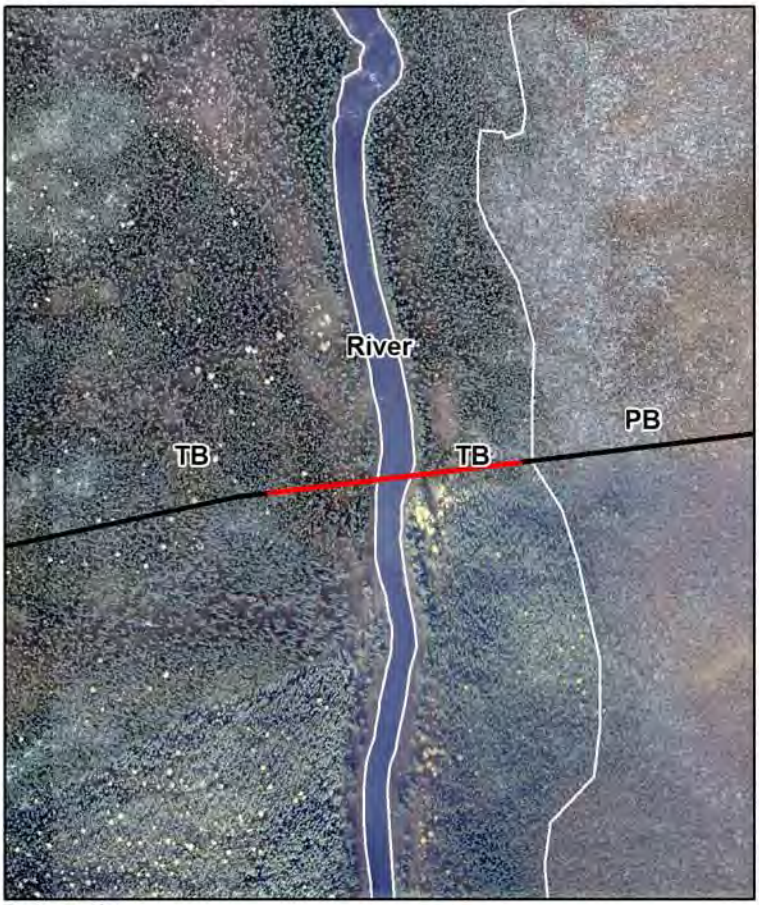
General reference map only; not for survey or legal use.

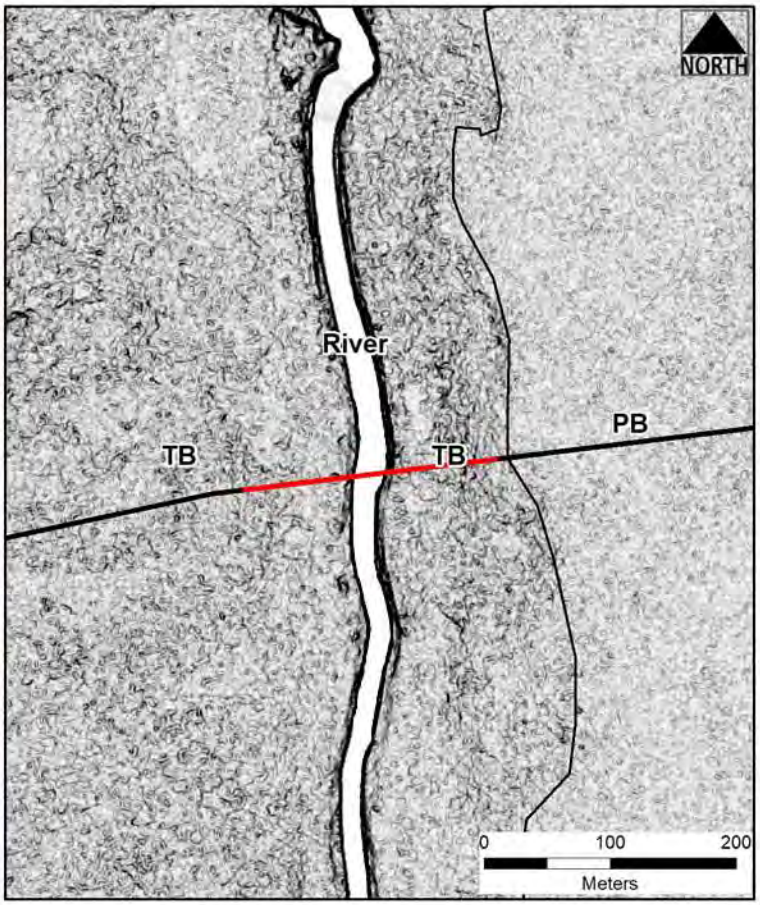
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

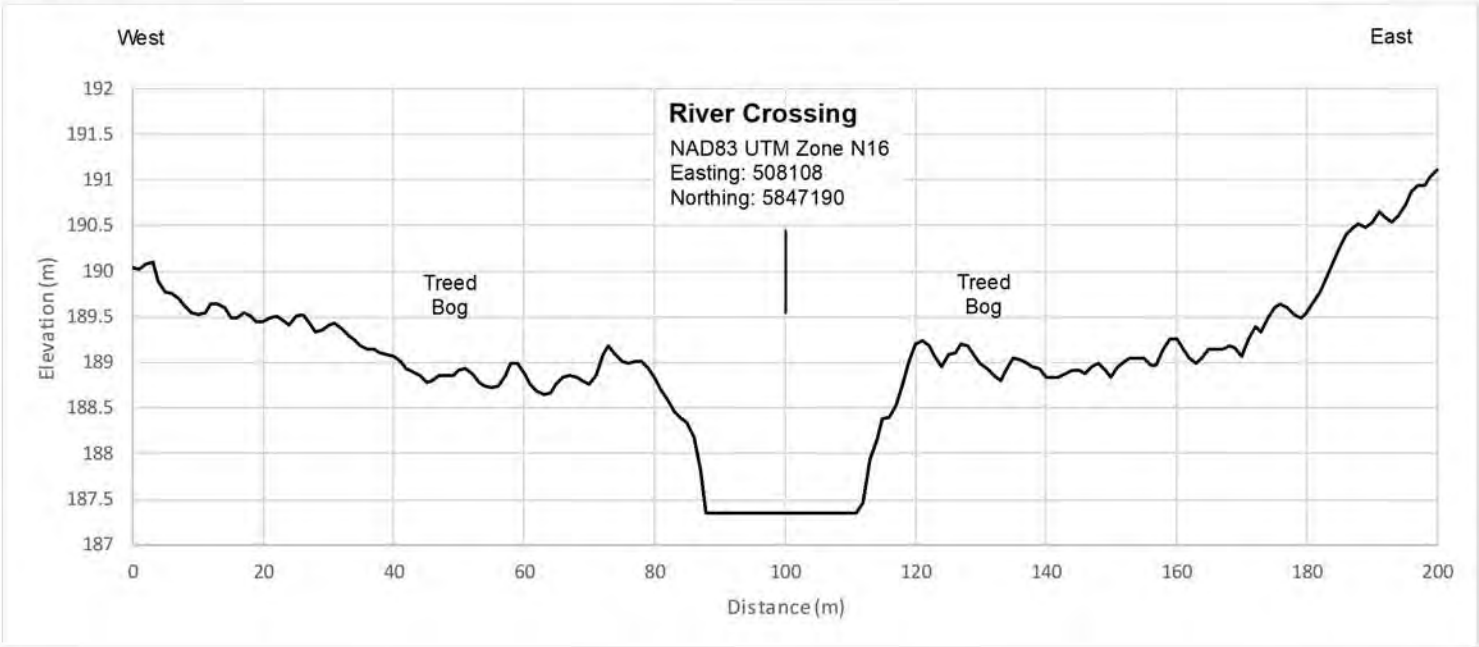
J15

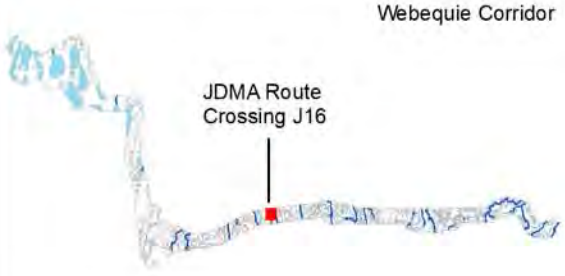
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

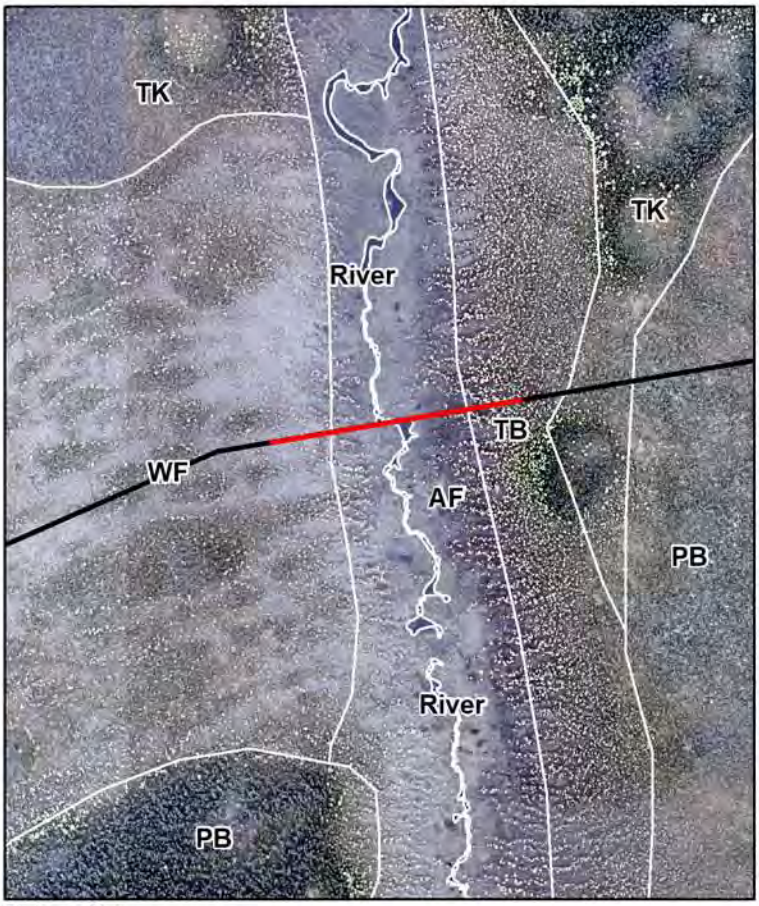
General reference map only; not for survey or legal use.

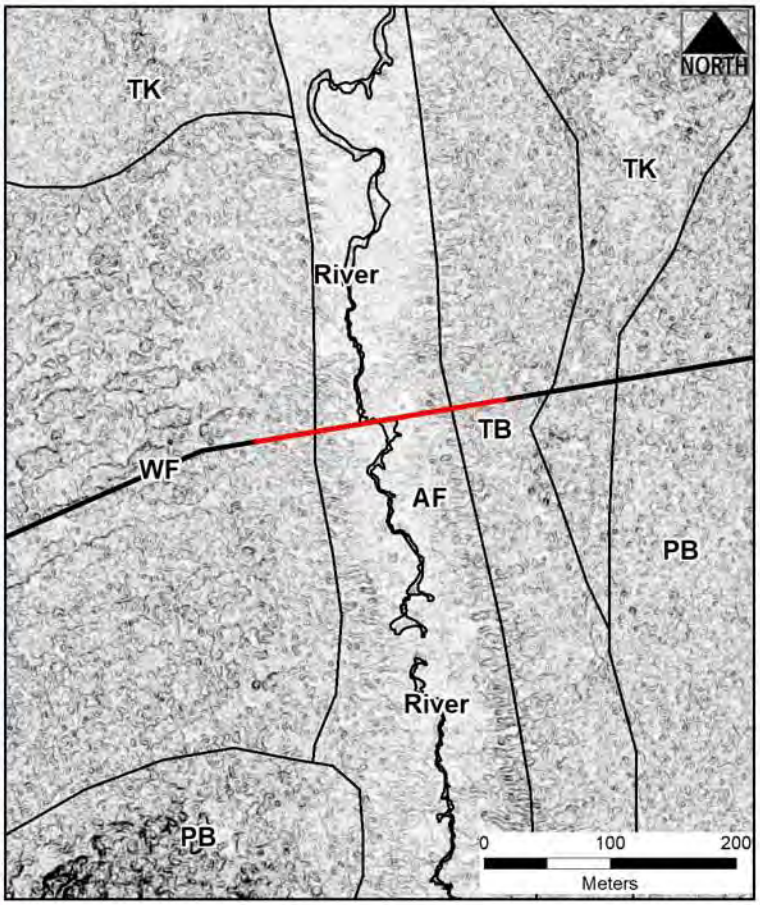
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

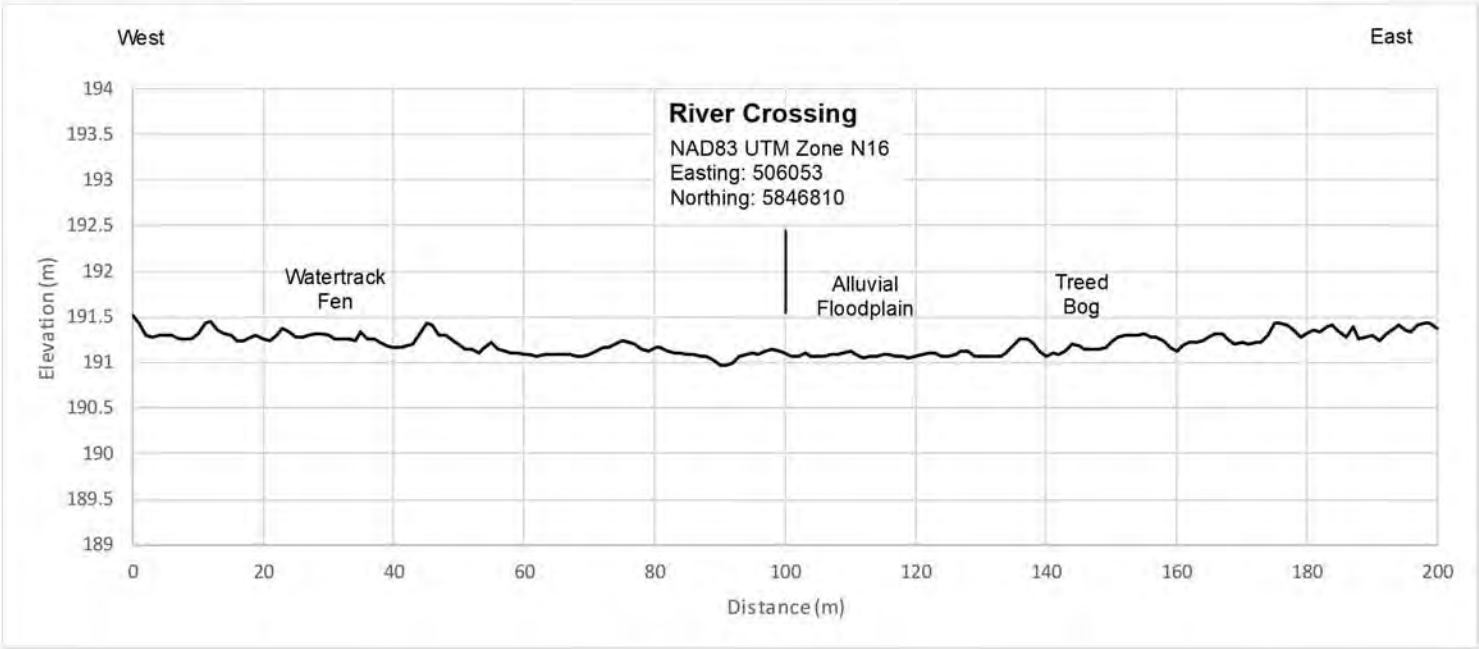
J16

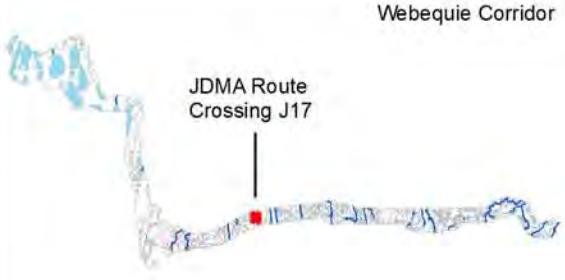
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

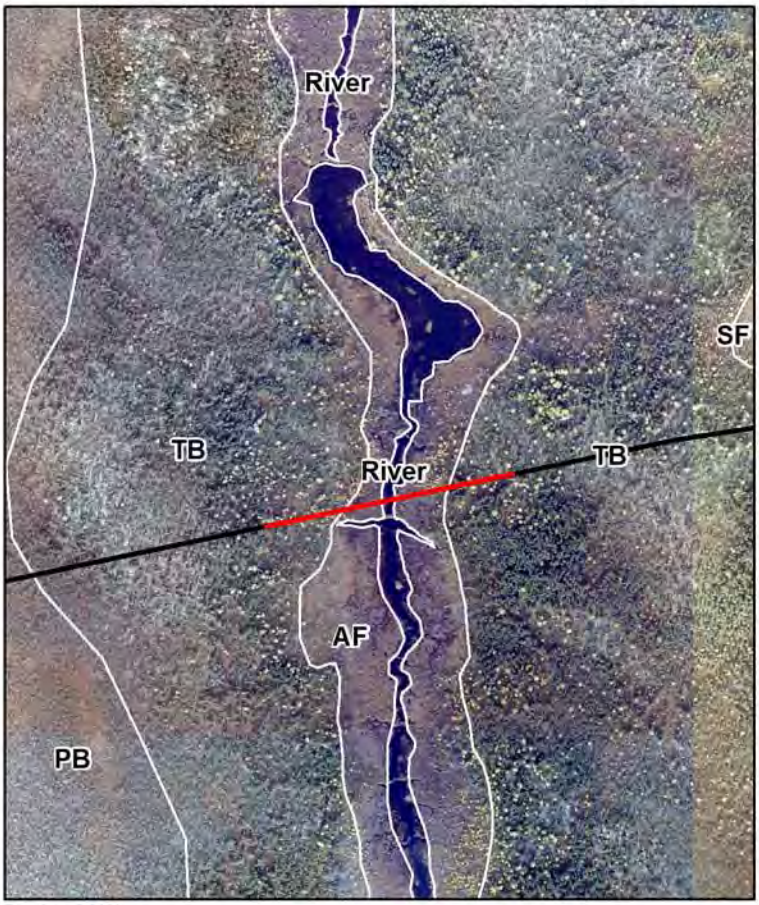
General reference map only; not for survey or legal use.

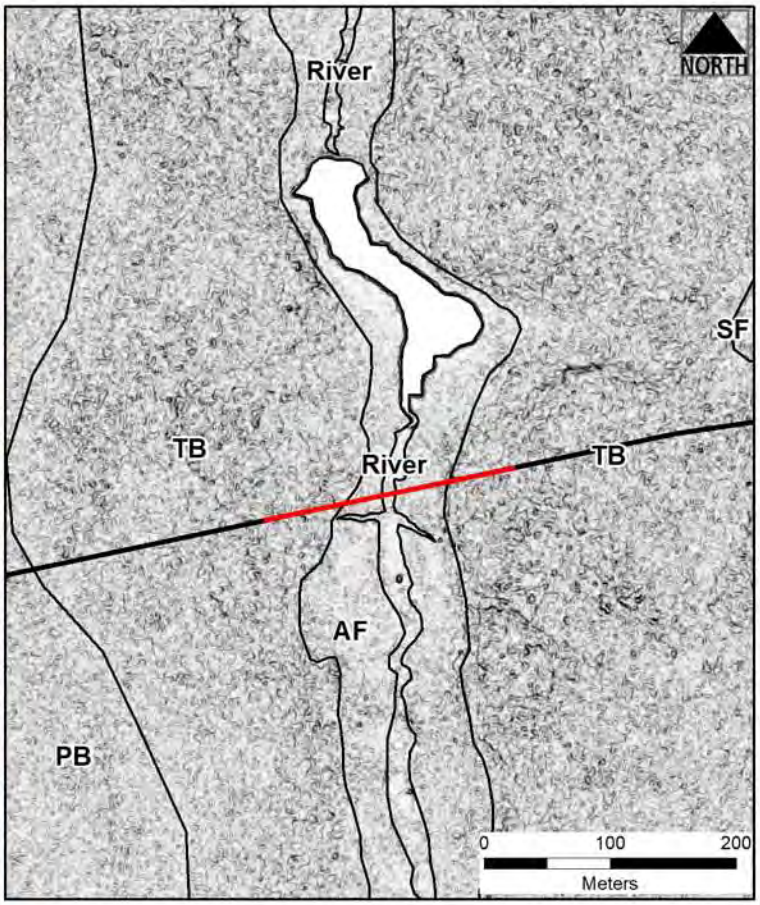
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

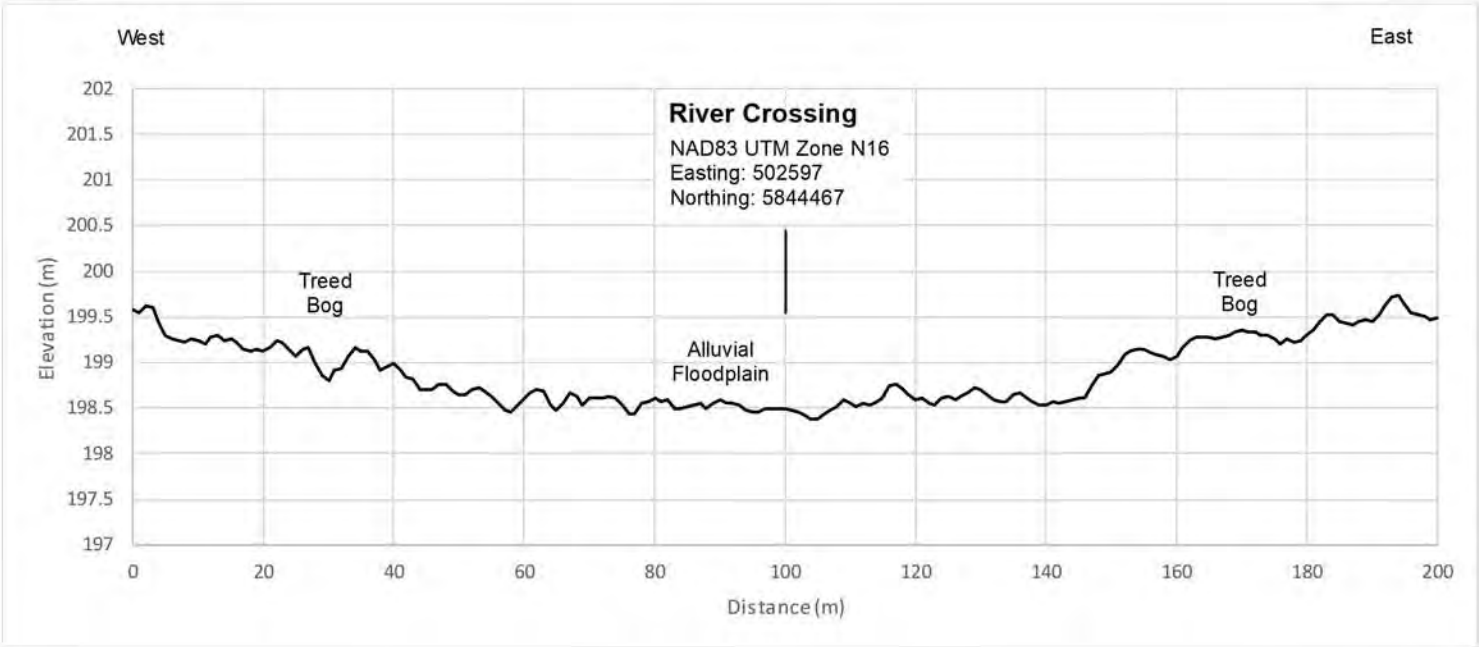
J17

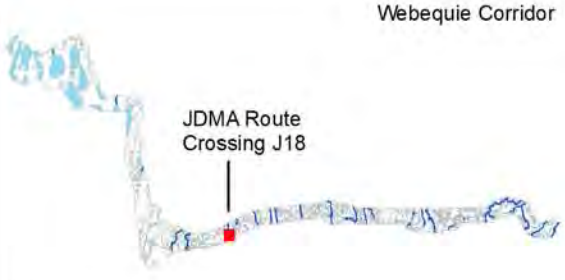
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

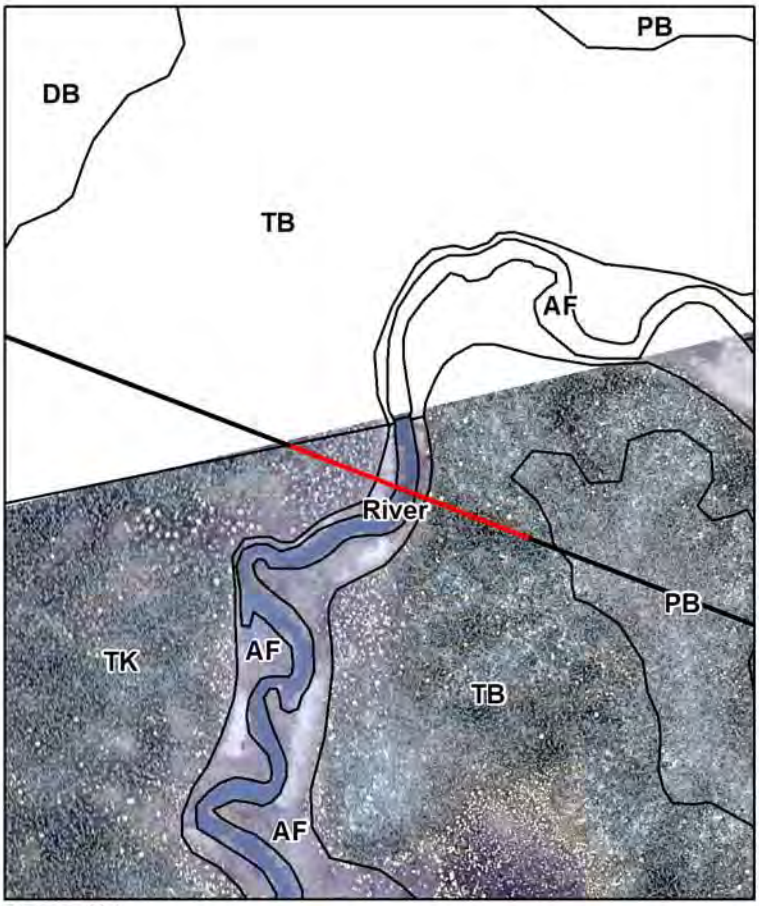
General reference map only; not for survey or legal use.

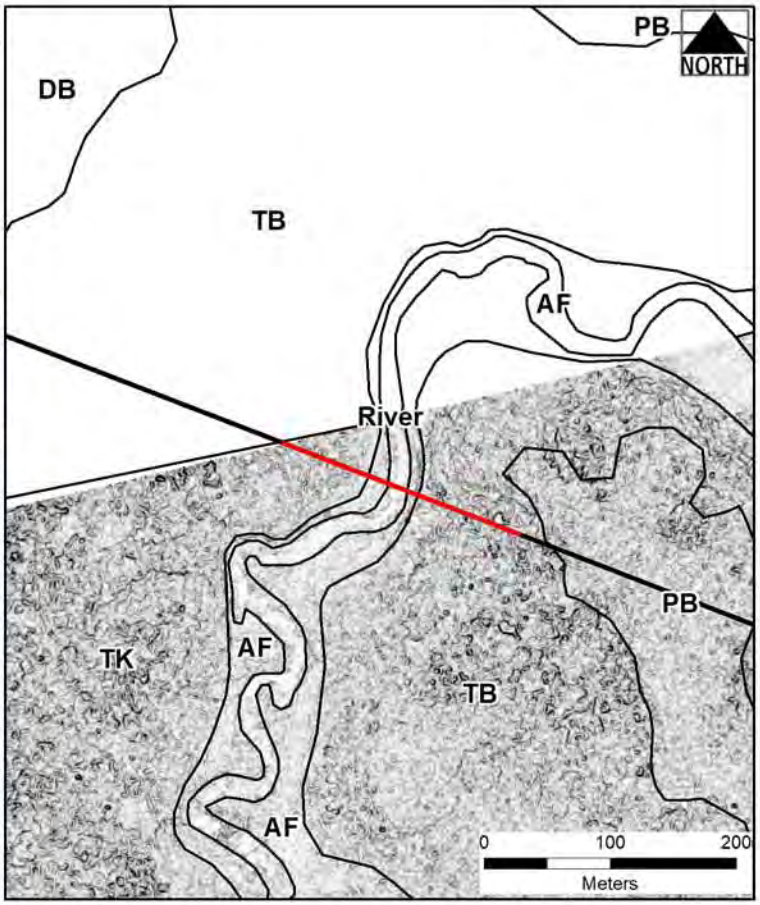
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

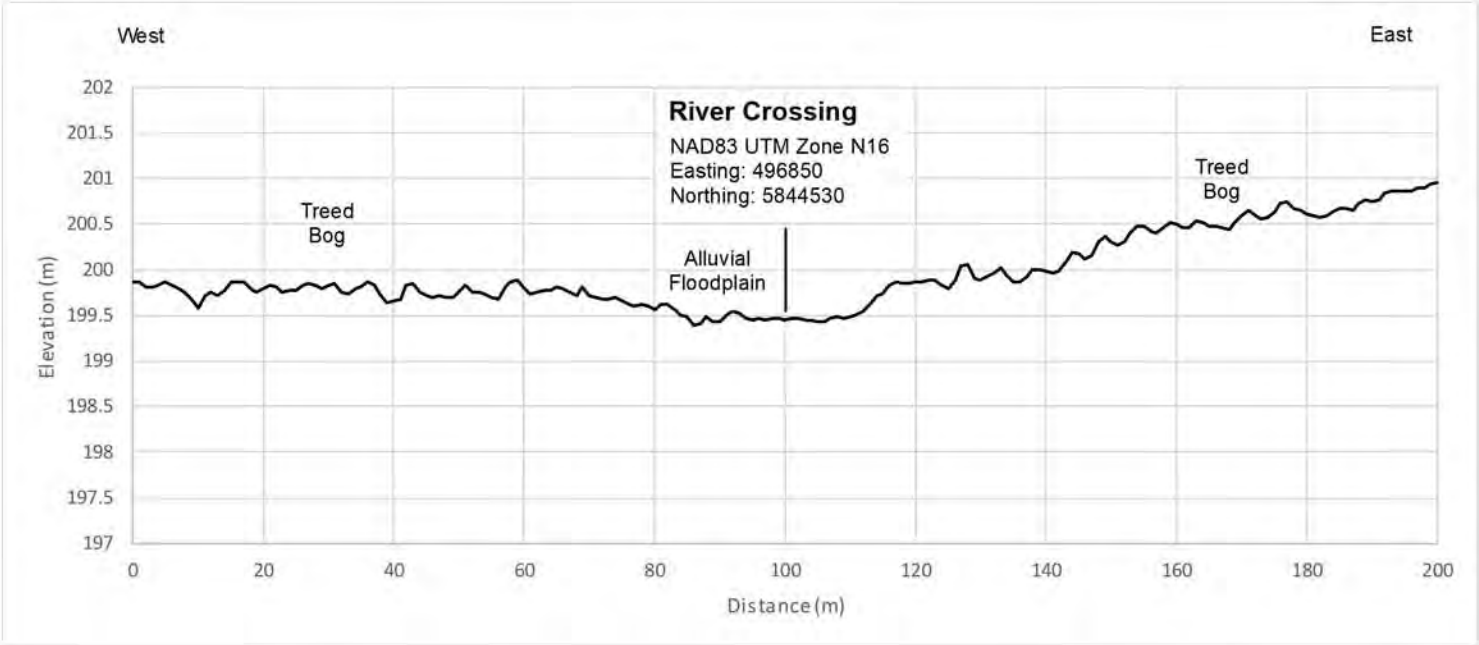
J18

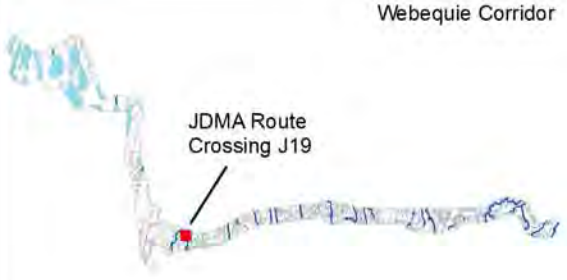
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

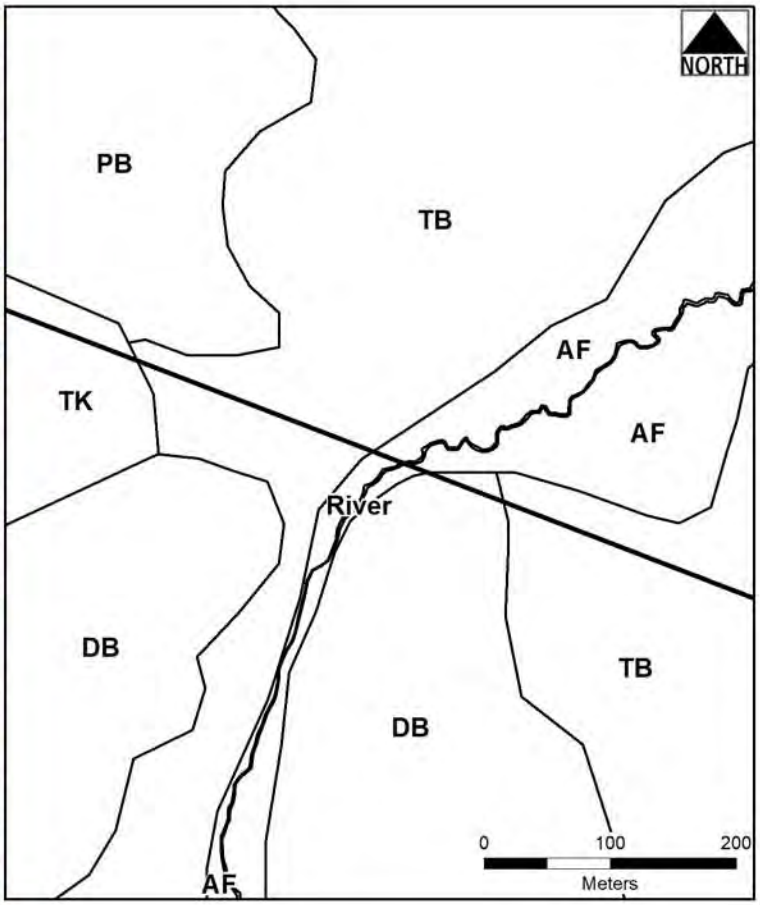
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J19

J D MOLLARD AND ASSOCIATES (2010) LIMITED

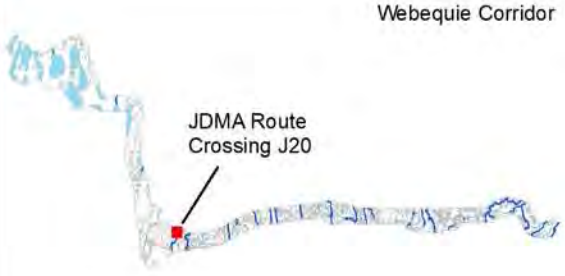


Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:495687
Northing: 5844978

No LiDAR Data



LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)
High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

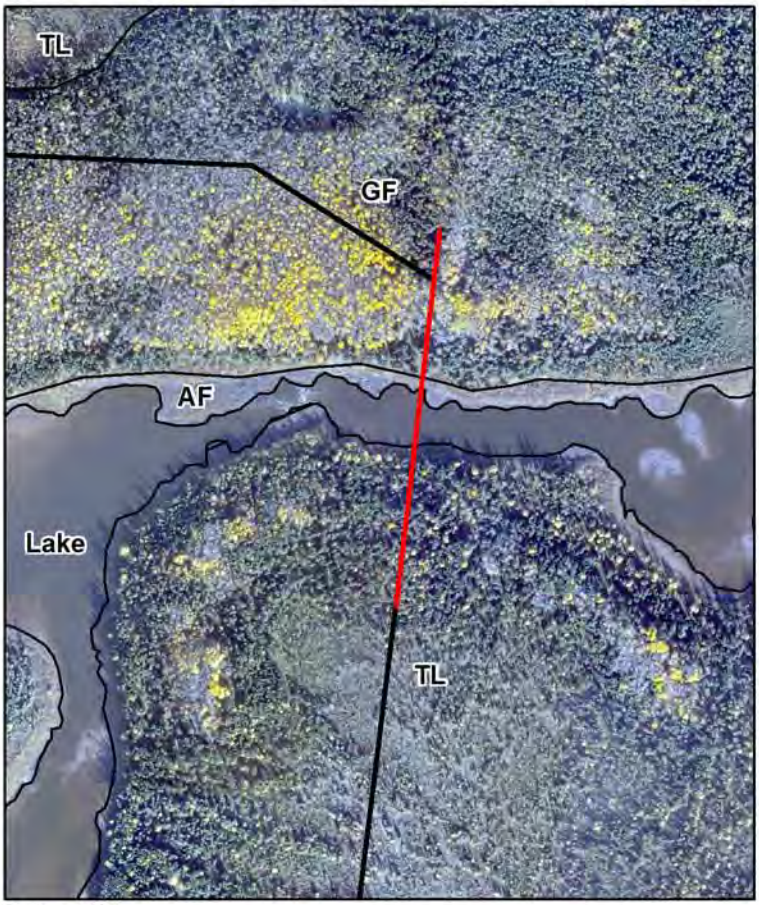
General reference map only; not for survey or legal use.

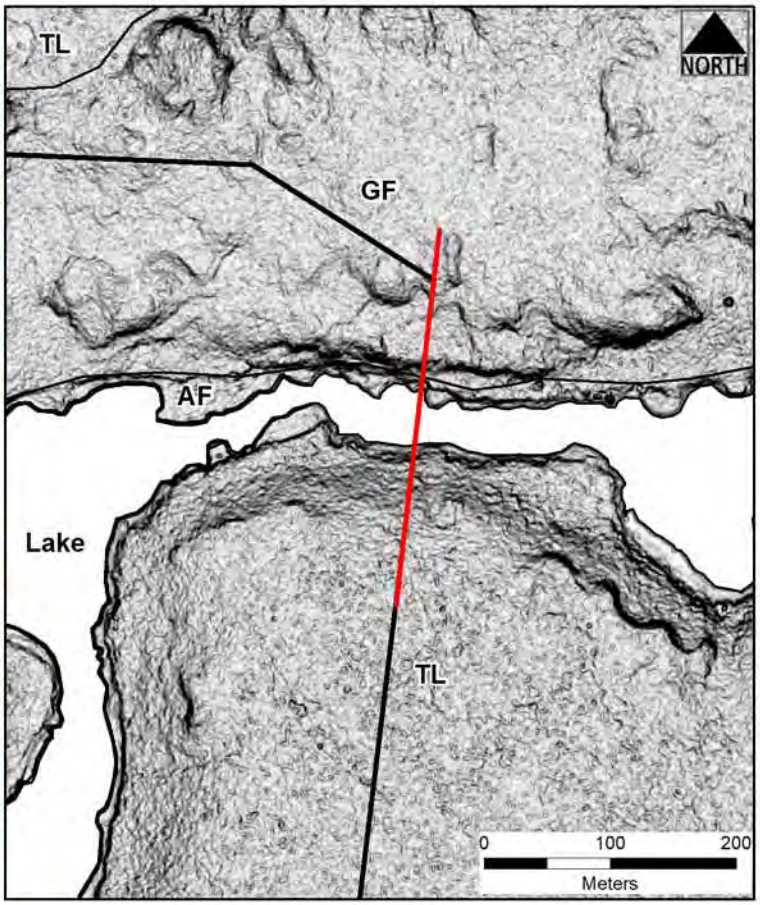
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J20

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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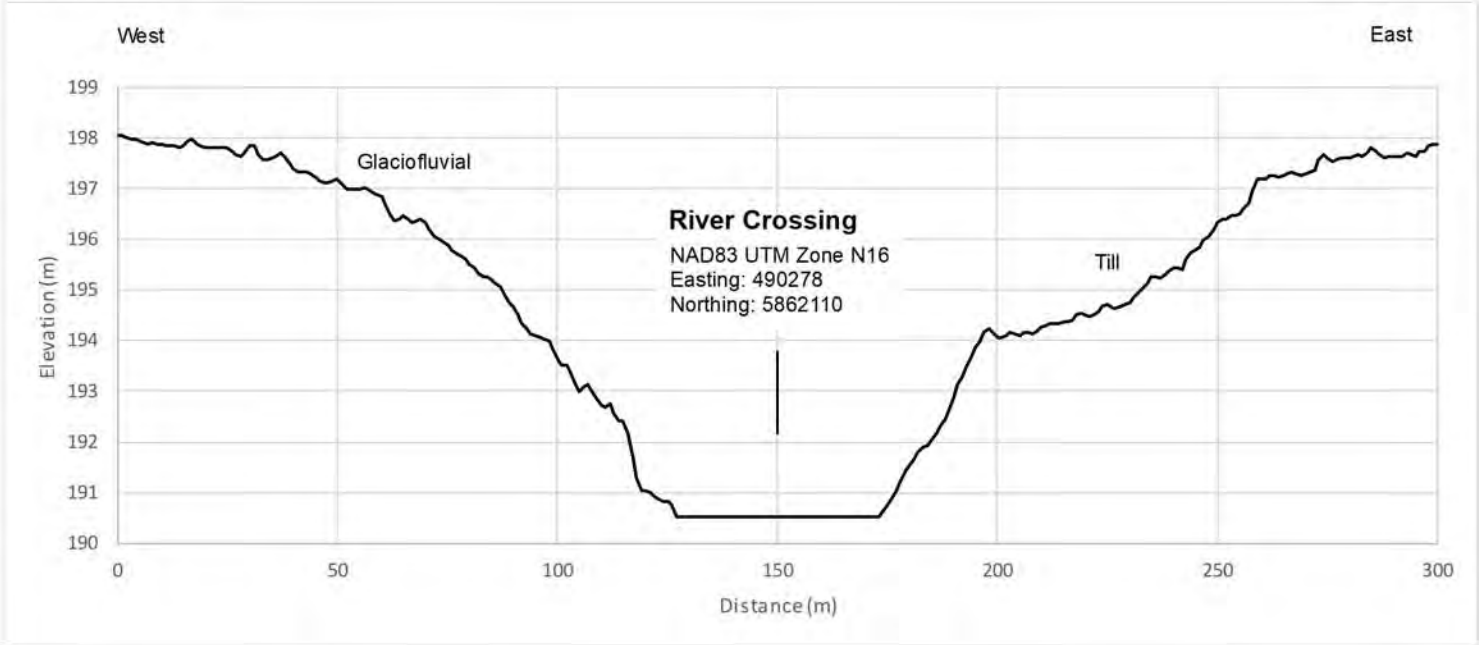
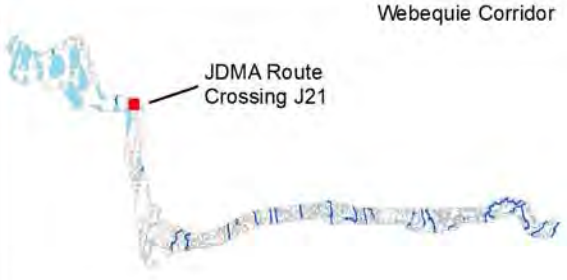




LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

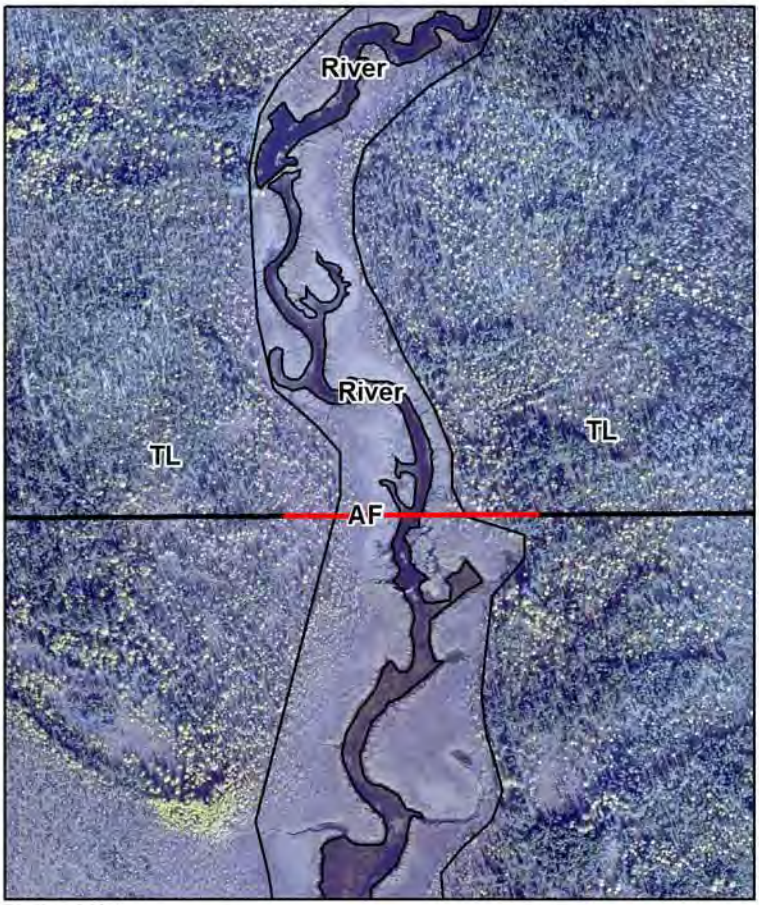
General reference map only; not for survey or legal use.

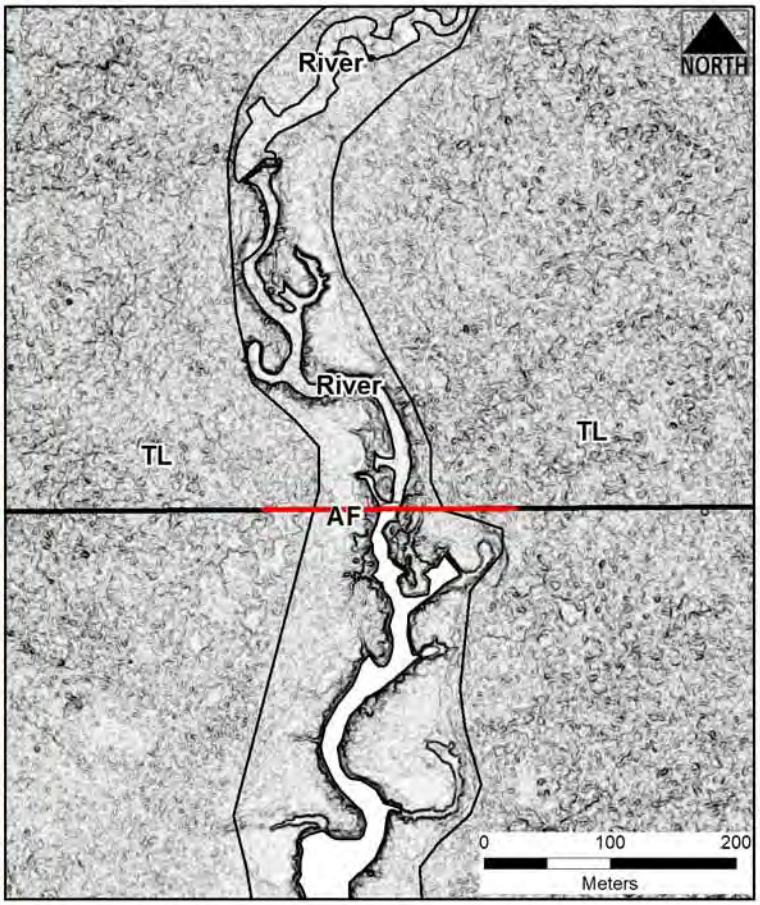
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

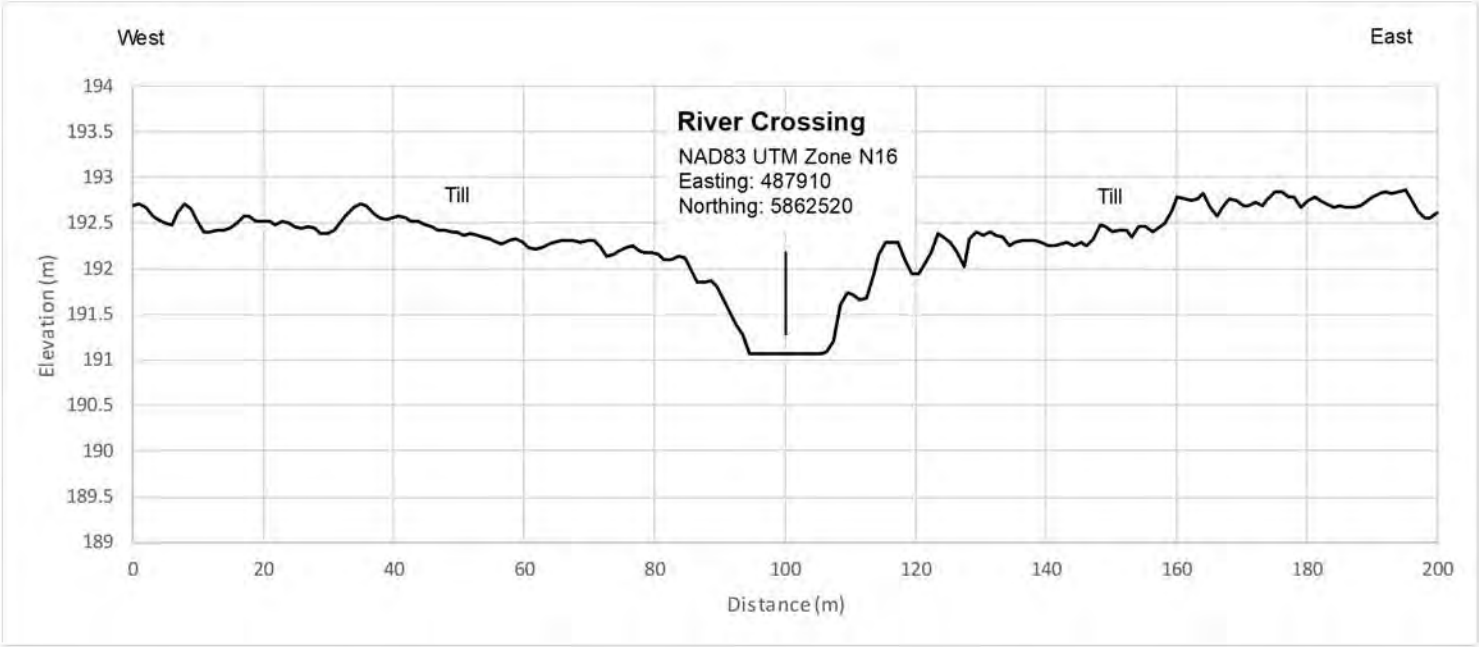
J21

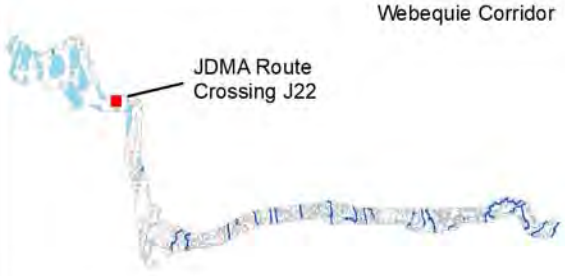
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

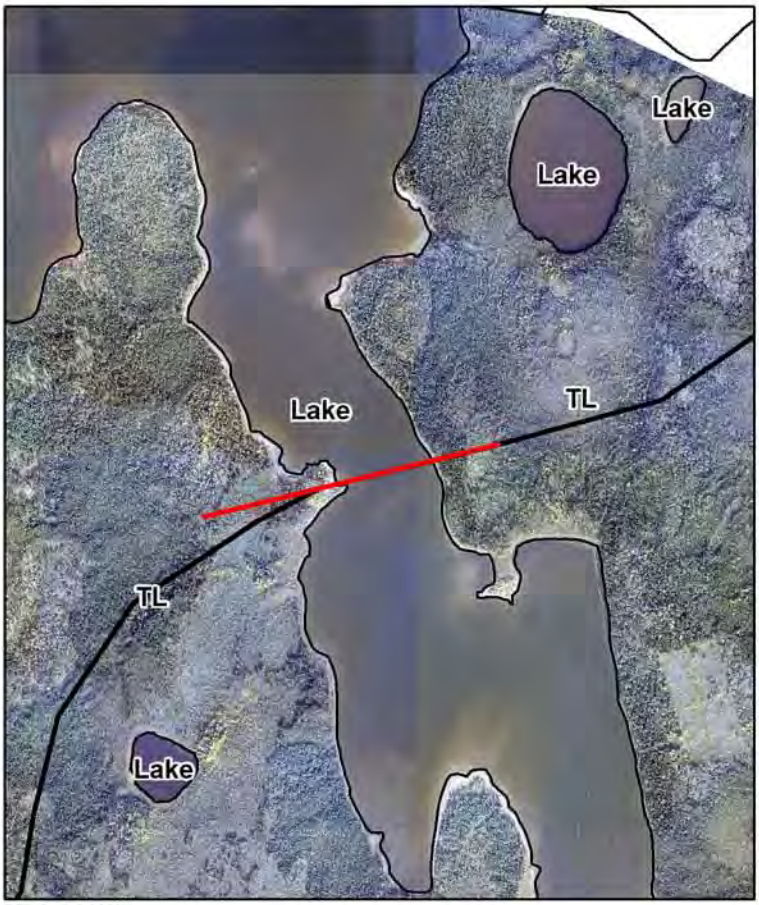
General reference map only; not for survey or legal use.

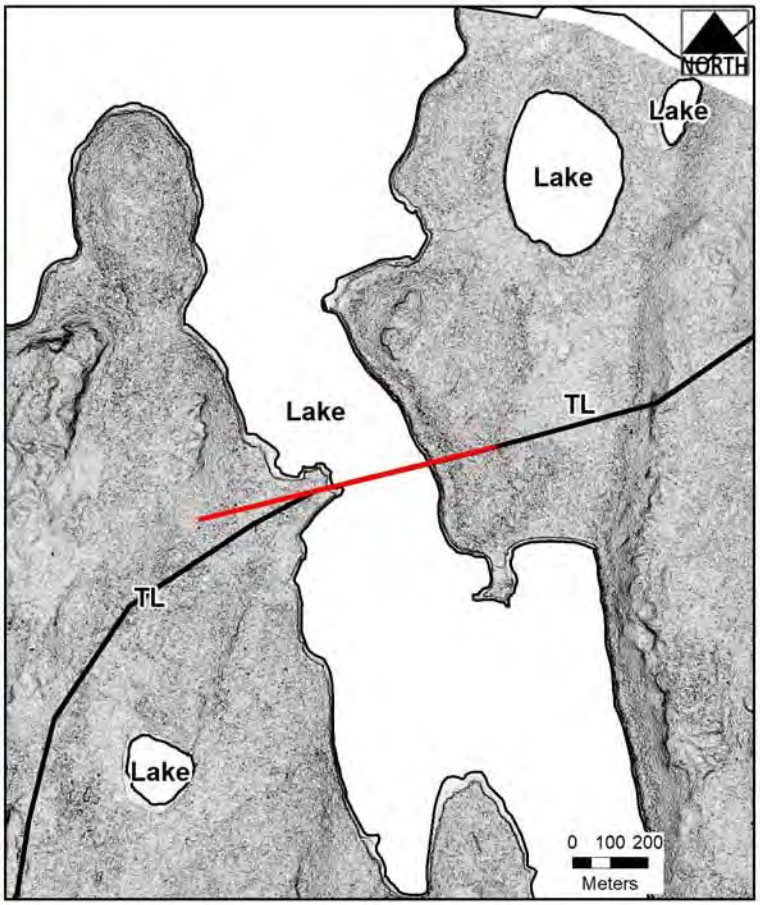
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

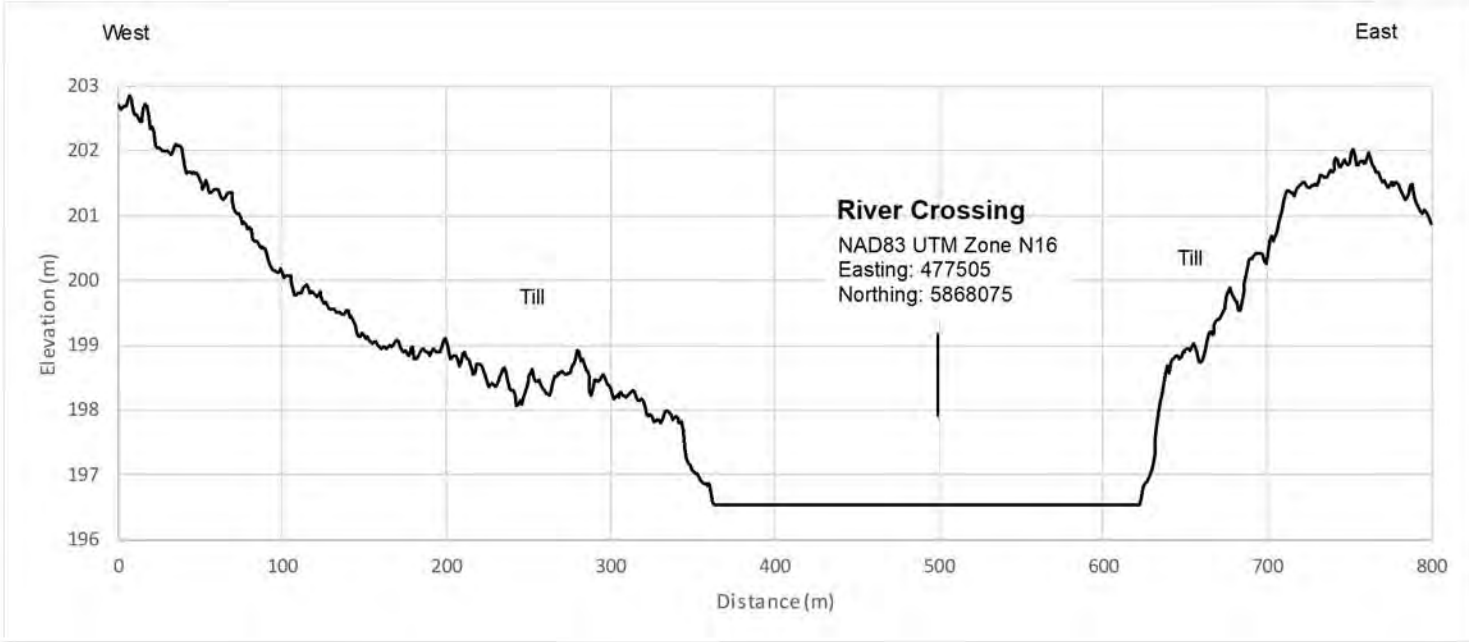
J22

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

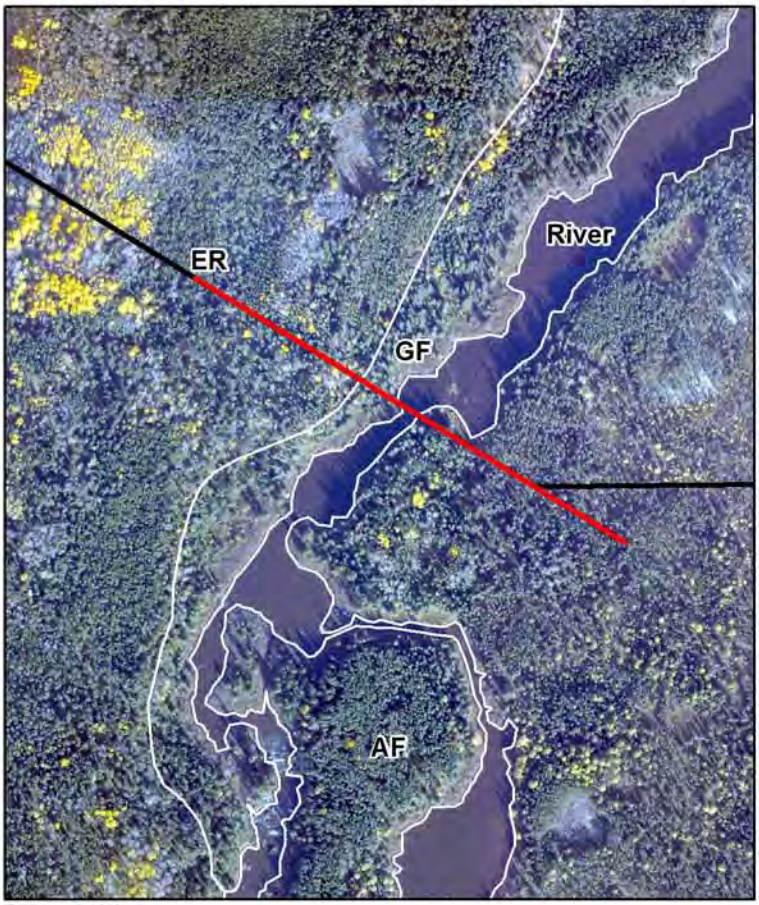
General reference map only; not for survey or legal use.

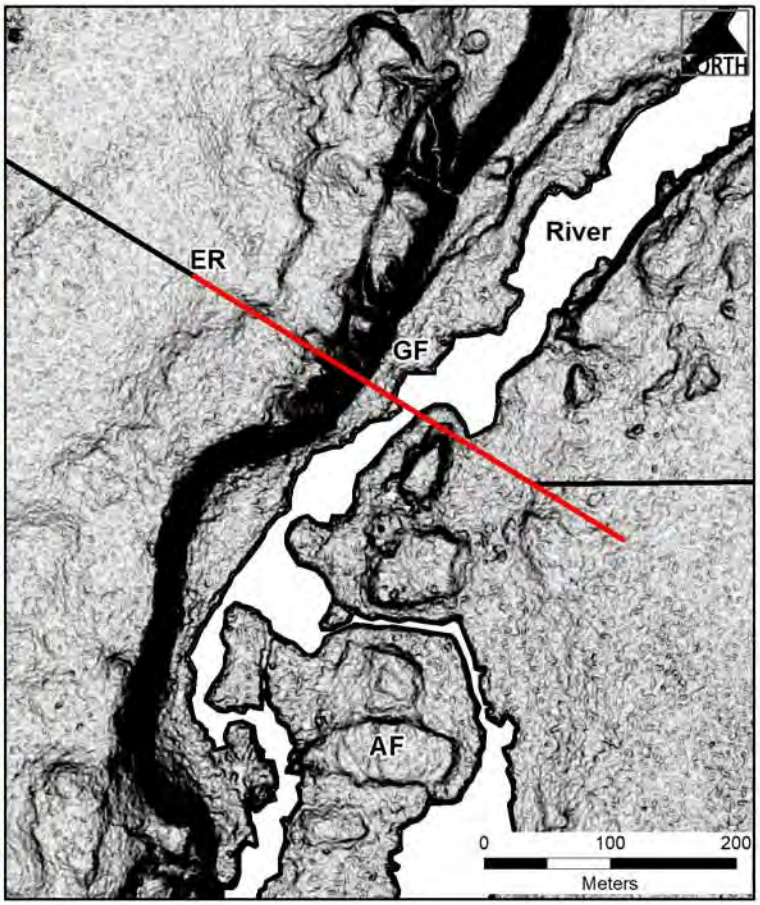
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J23

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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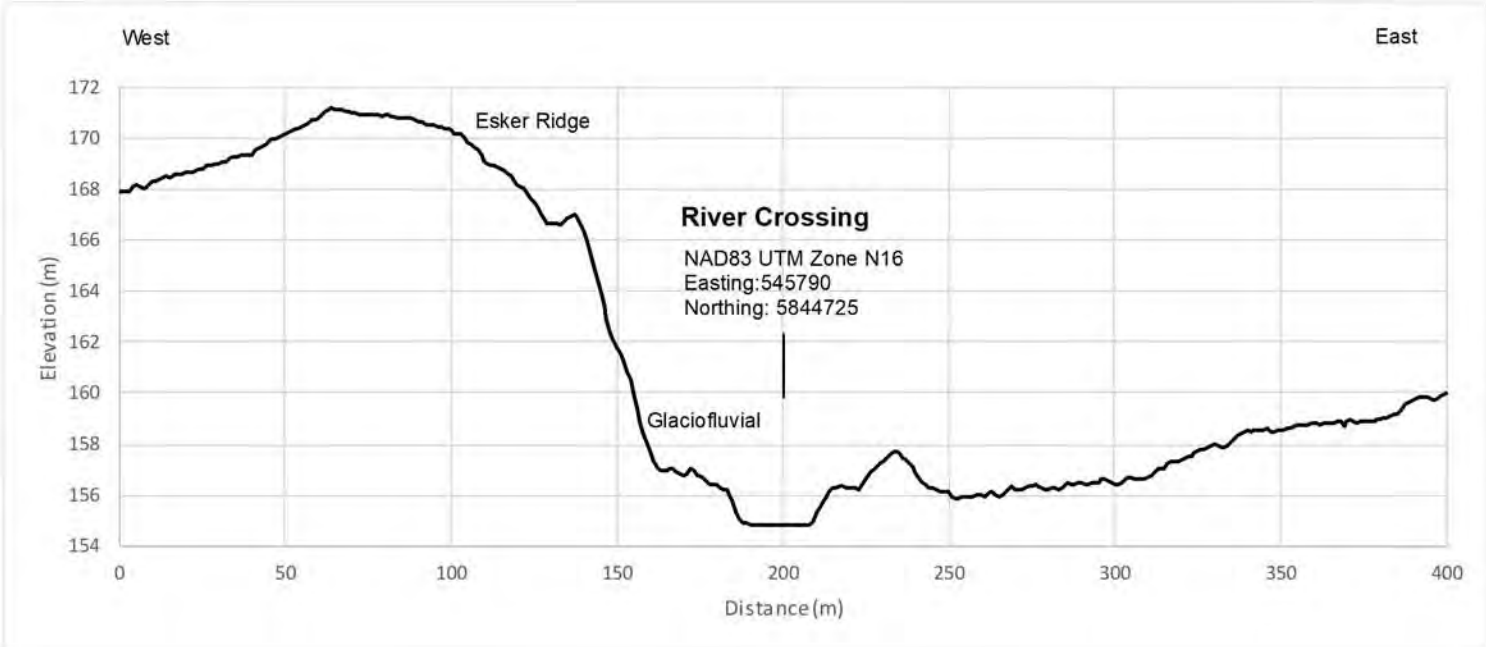
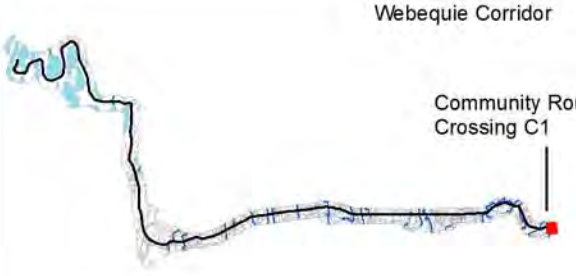




LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

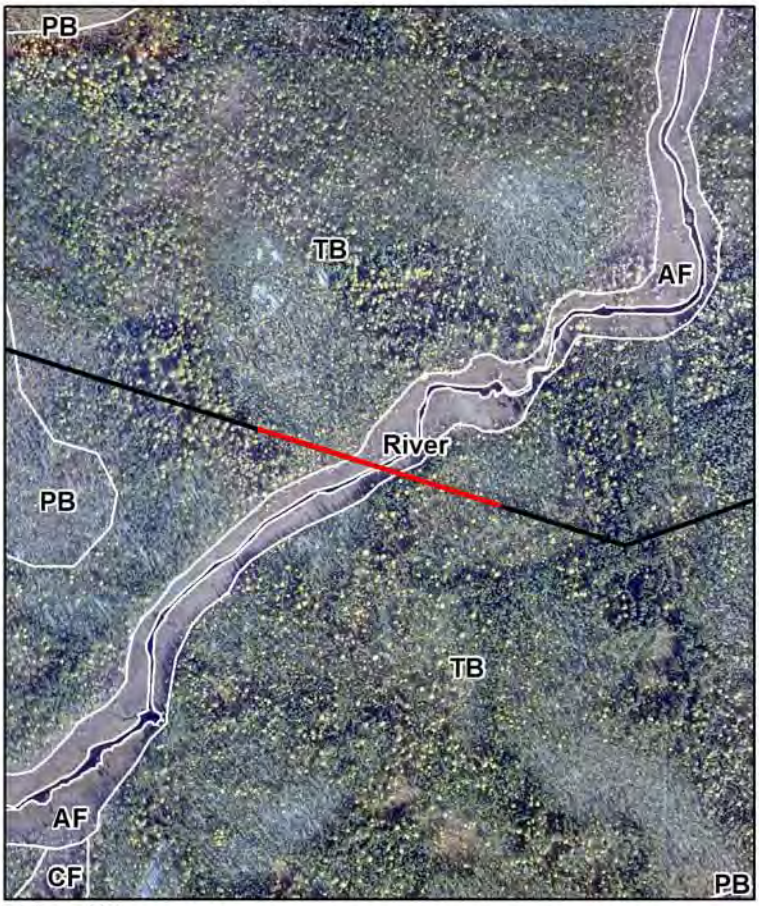
General reference map only; not for survey or legal use.

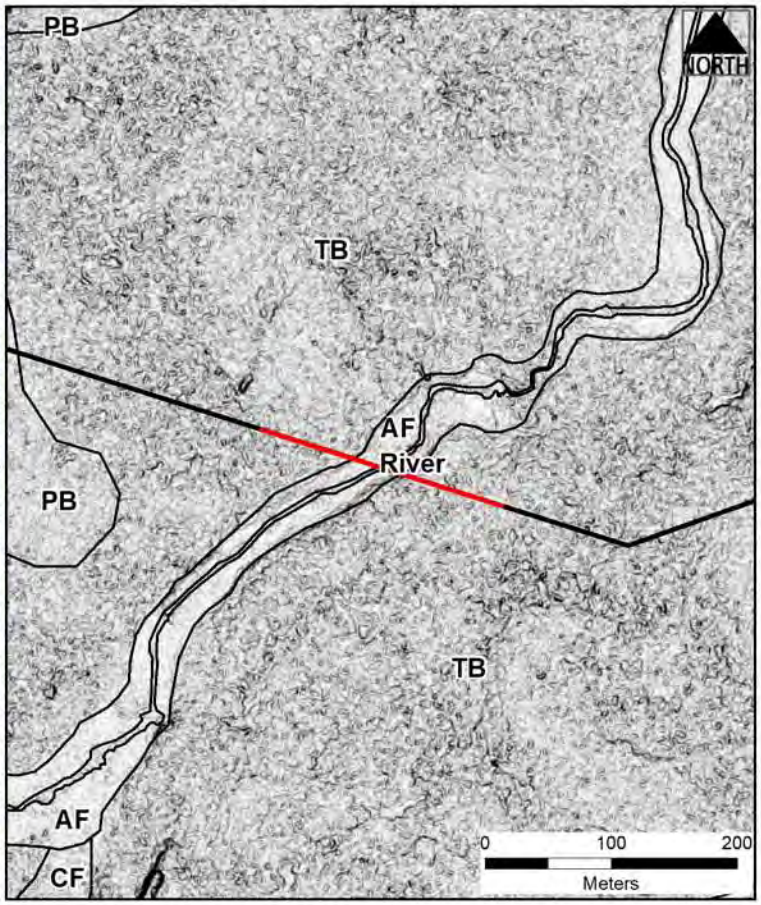
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

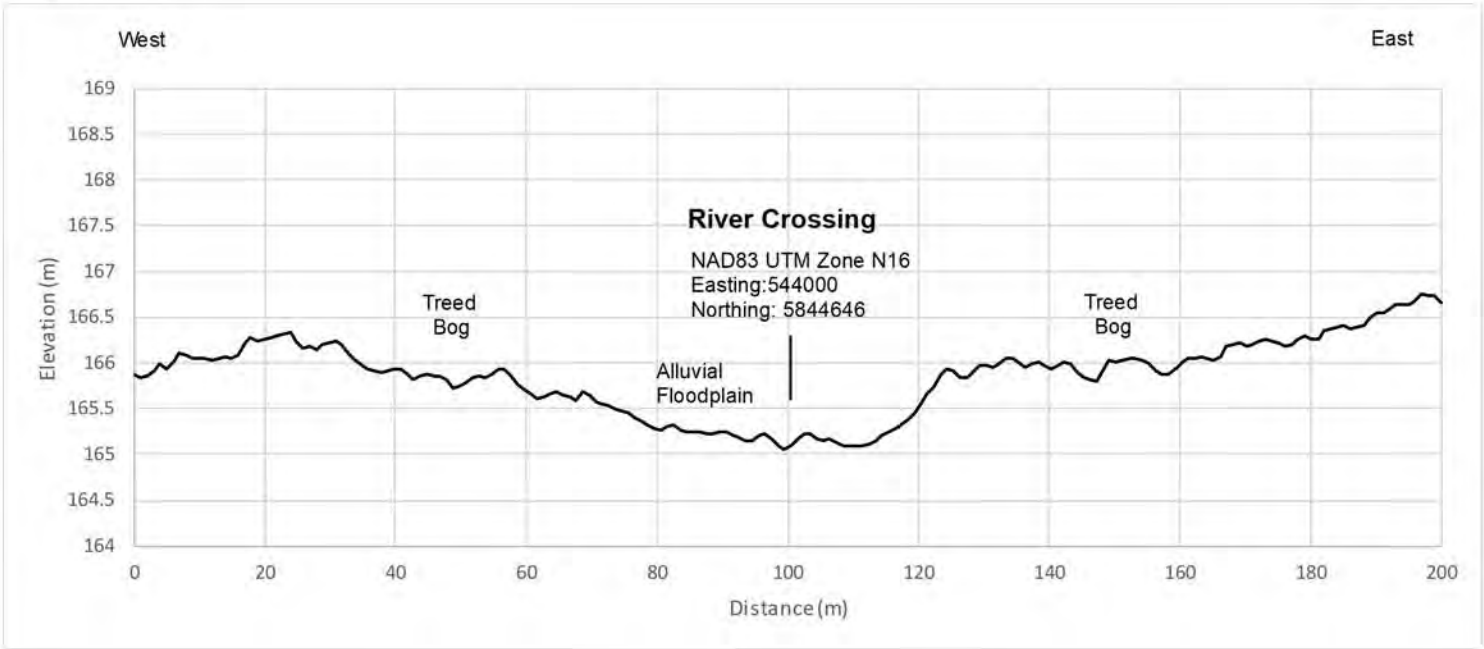
C1

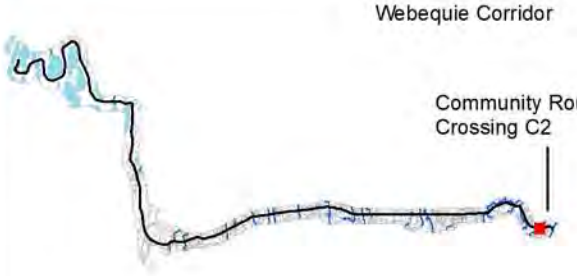
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

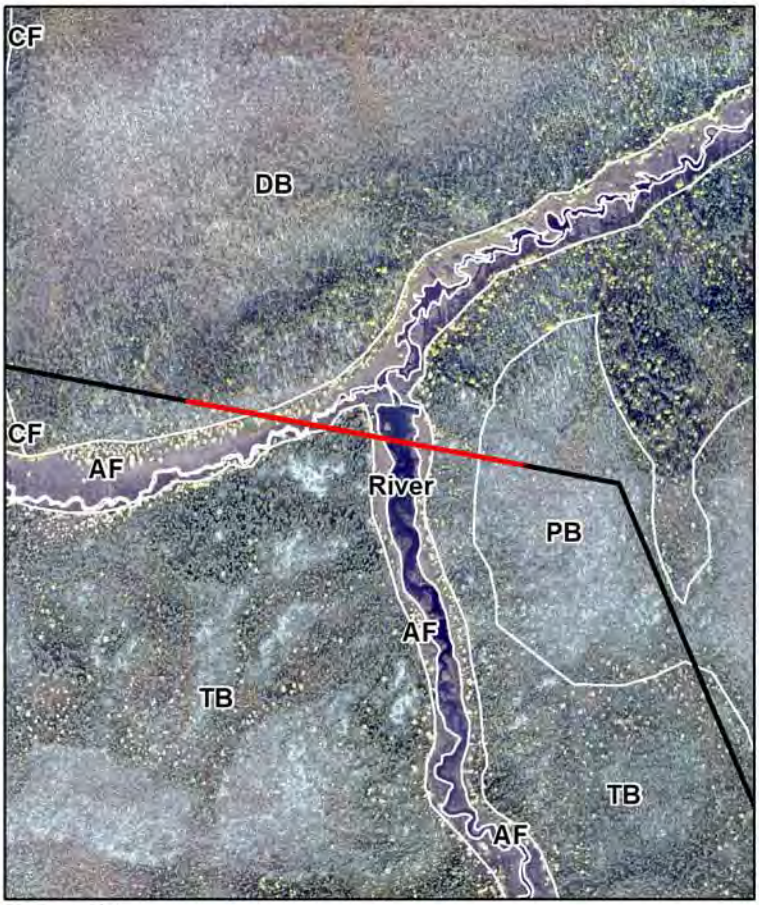
General reference map only; not for survey or legal use.

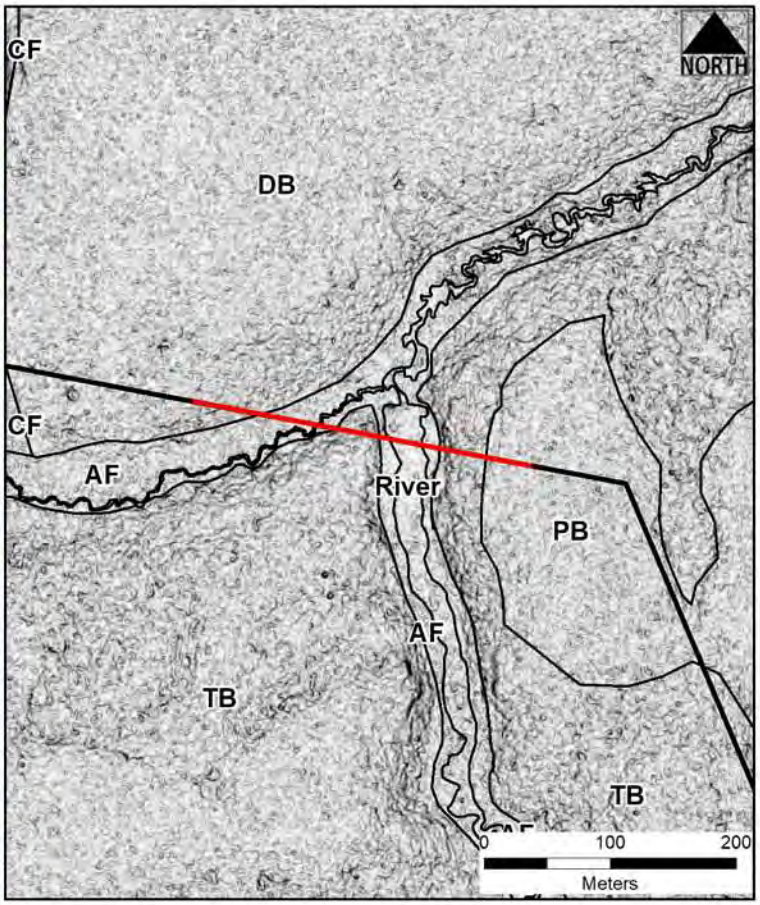
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C2

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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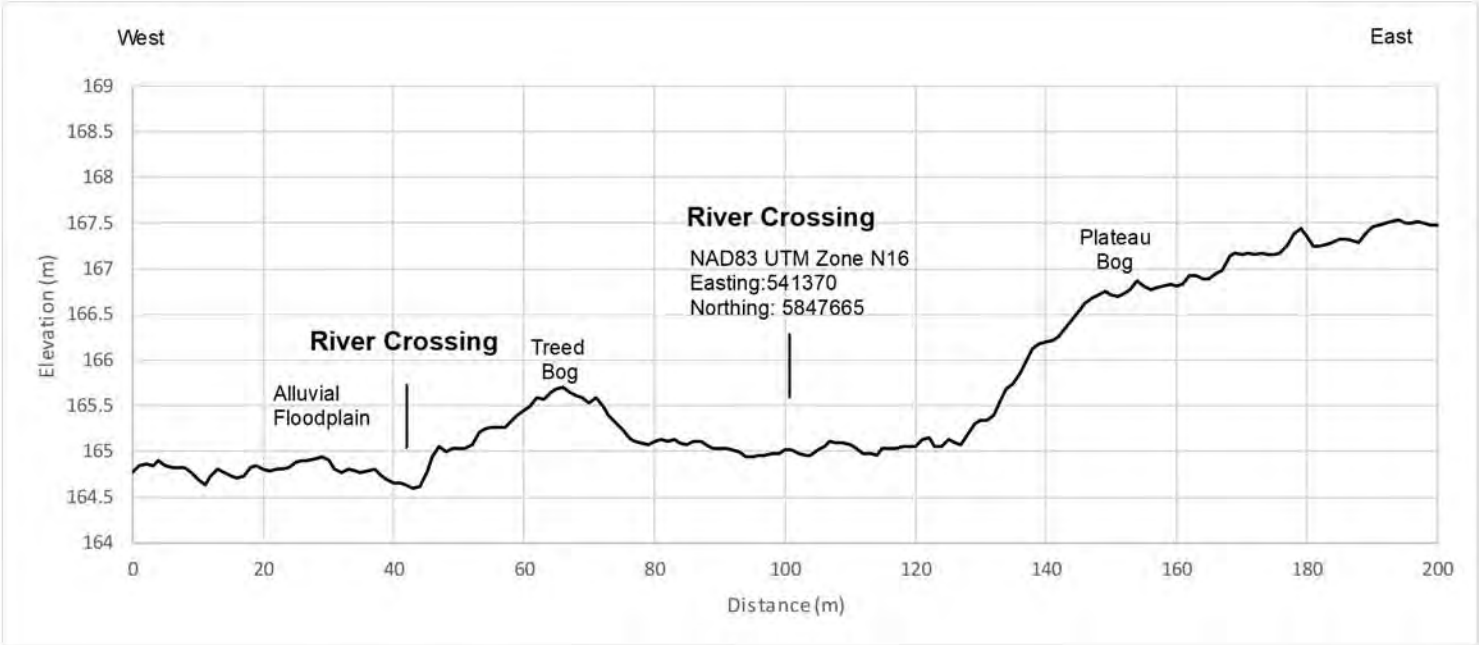
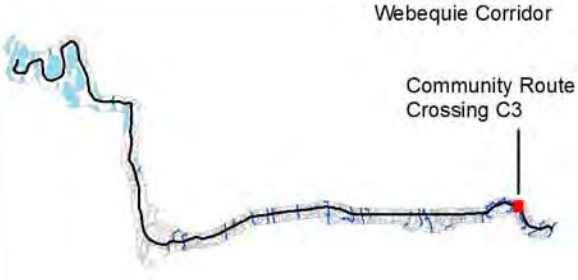




LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

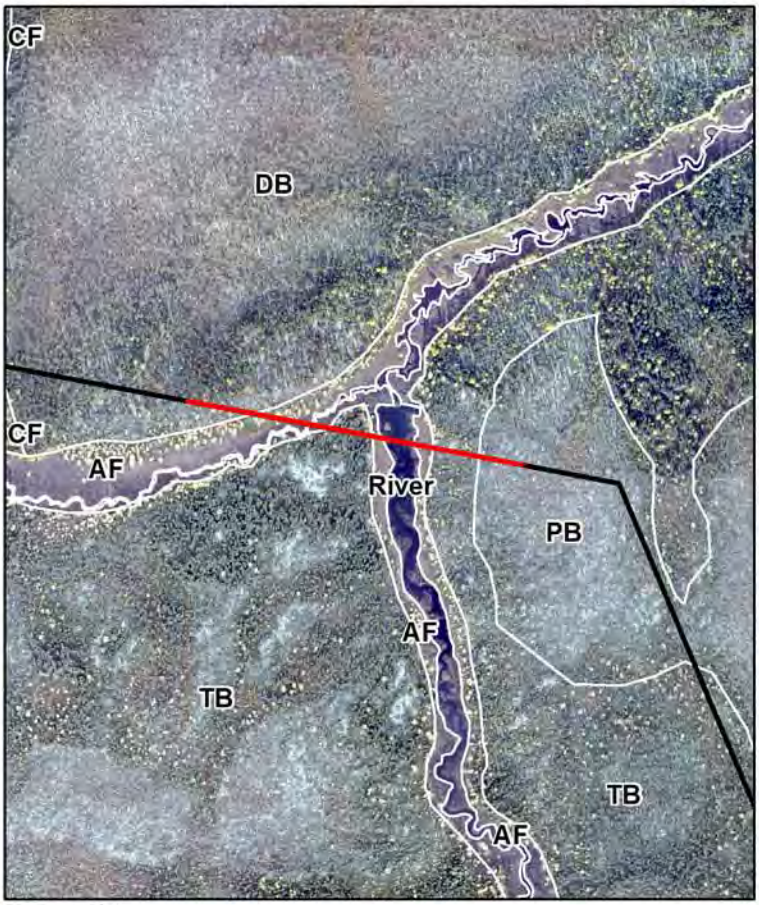
General reference map only; not for survey or legal use.

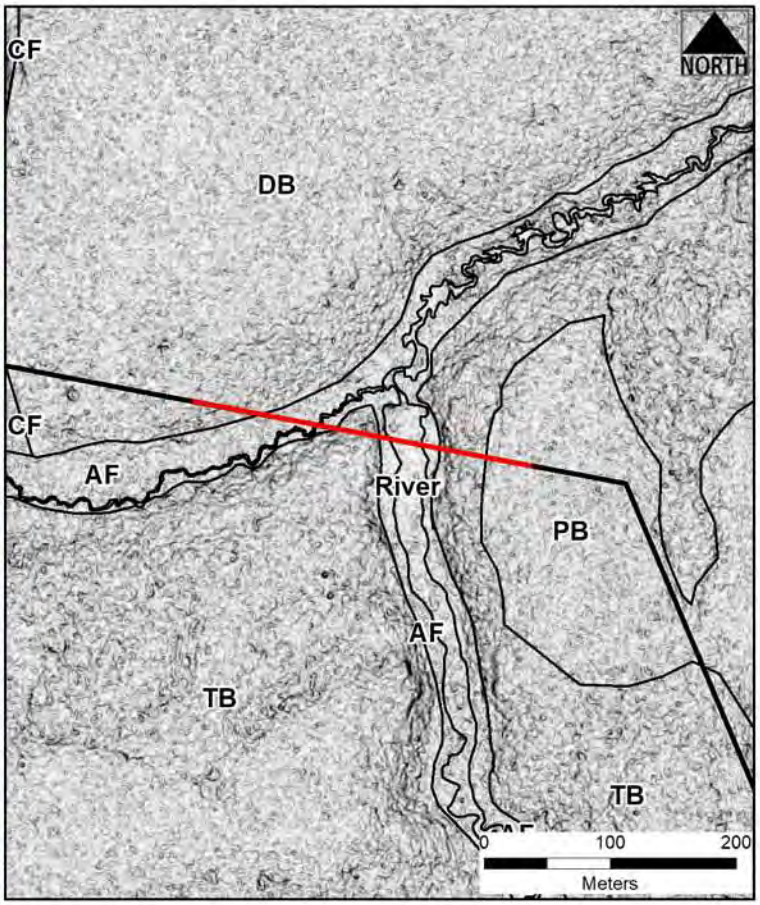
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

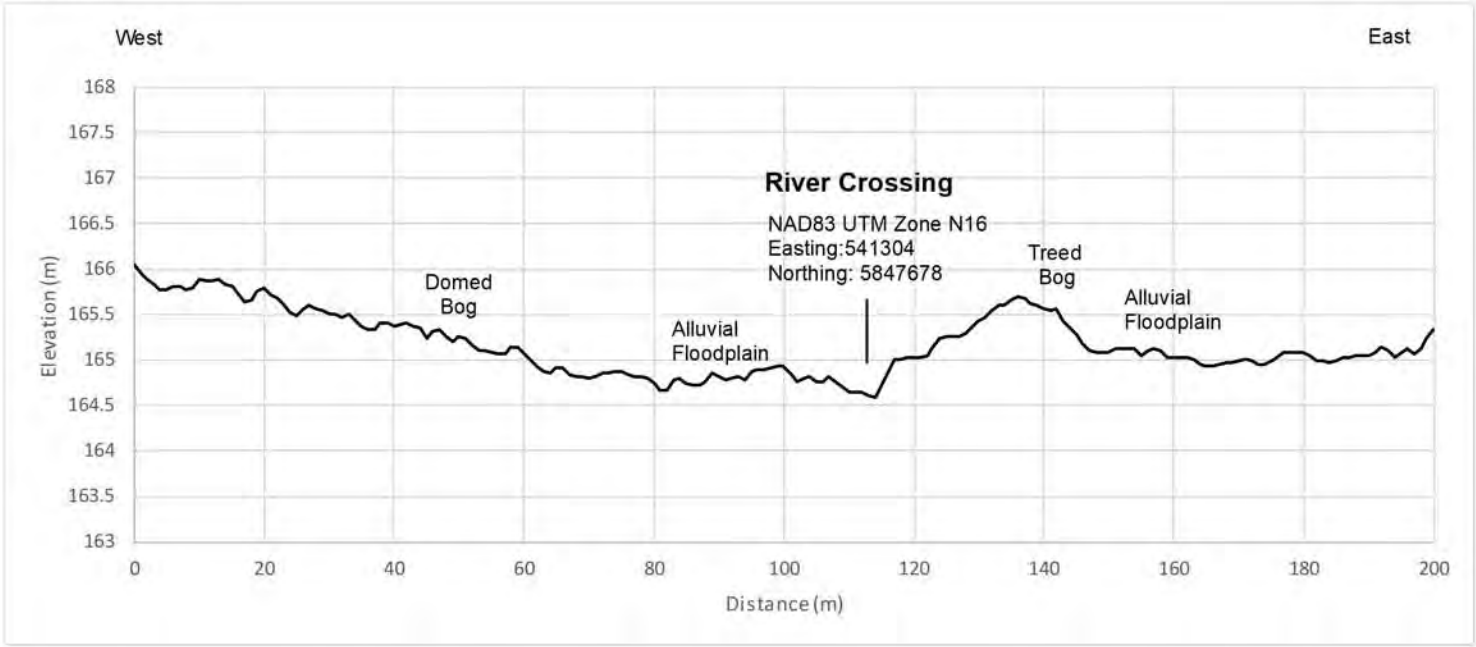
C3

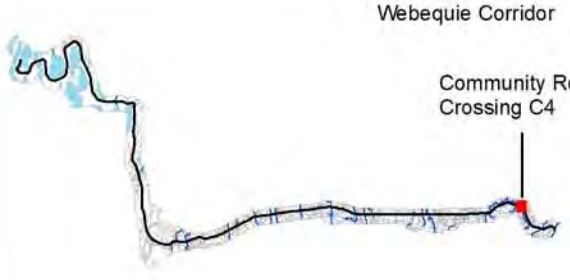
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

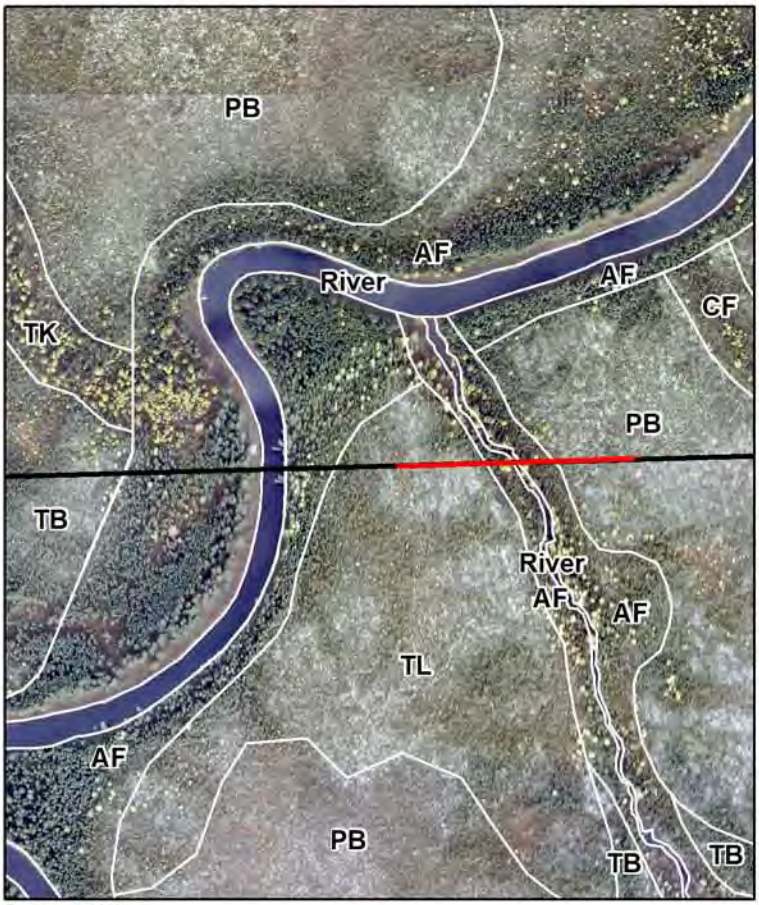
General reference map only; not for survey or legal use.

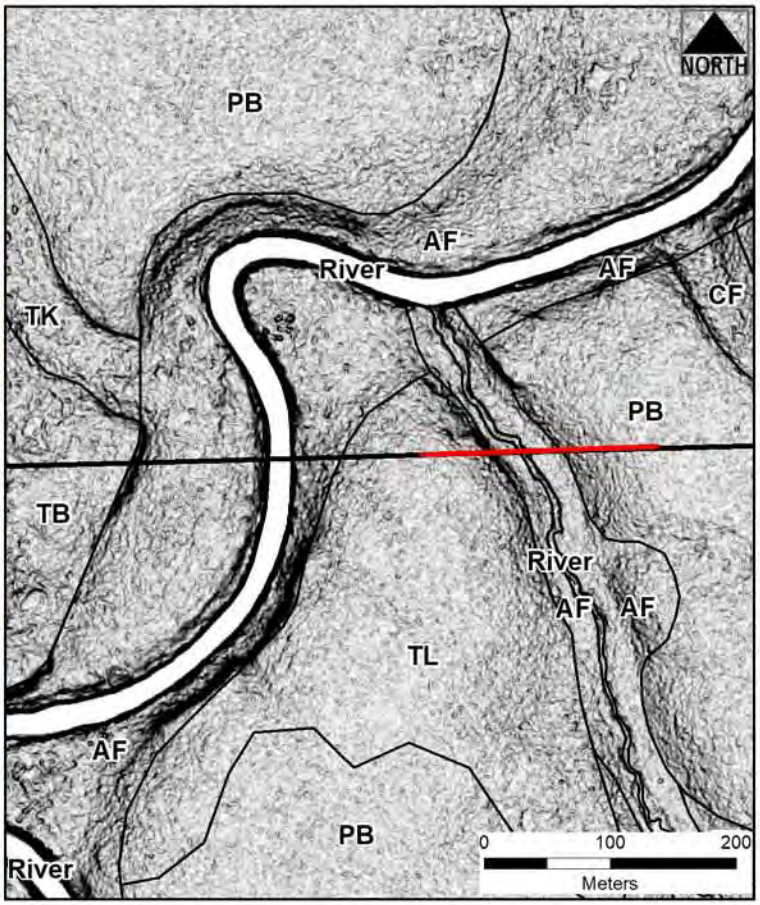
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 29/Mar/2019*

CROSSING:

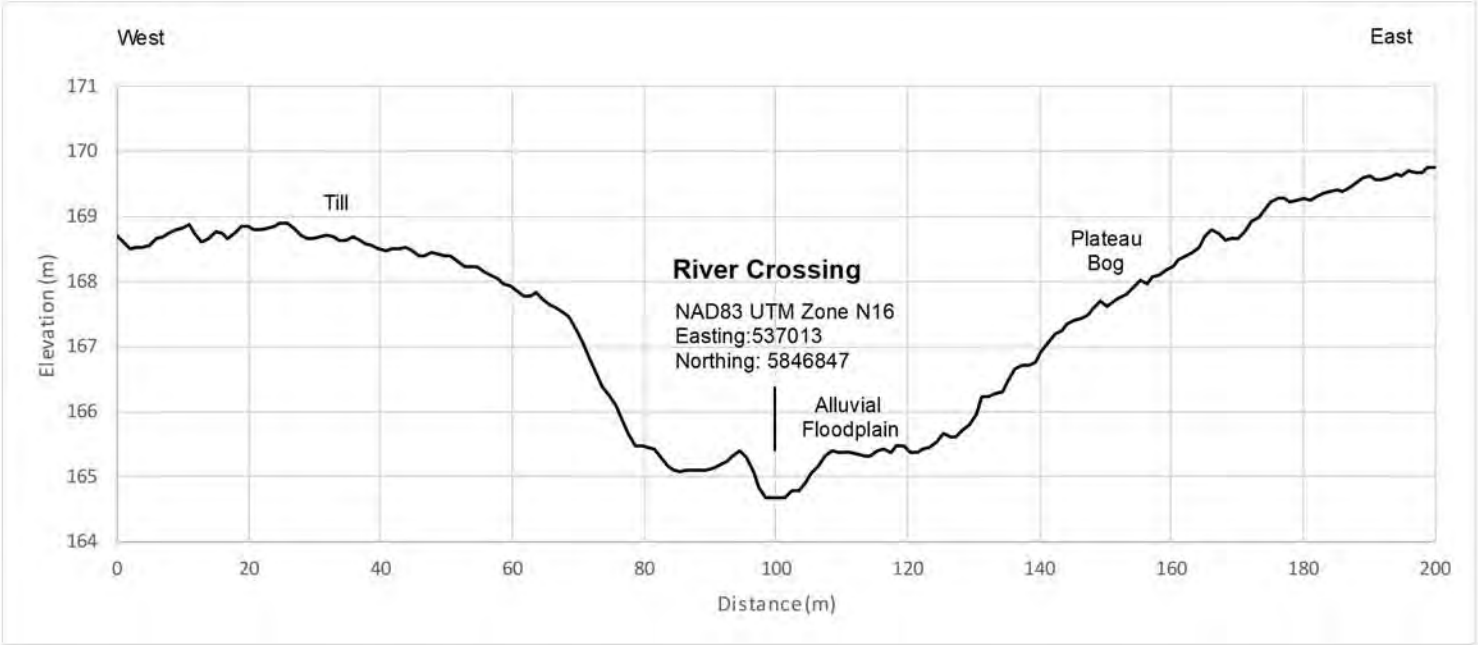
C4

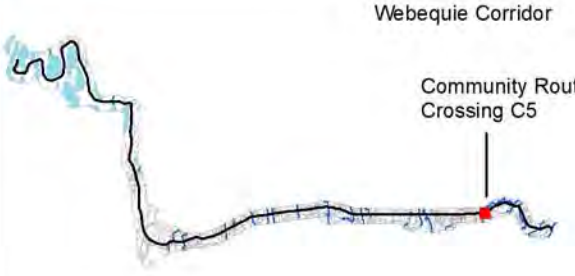
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

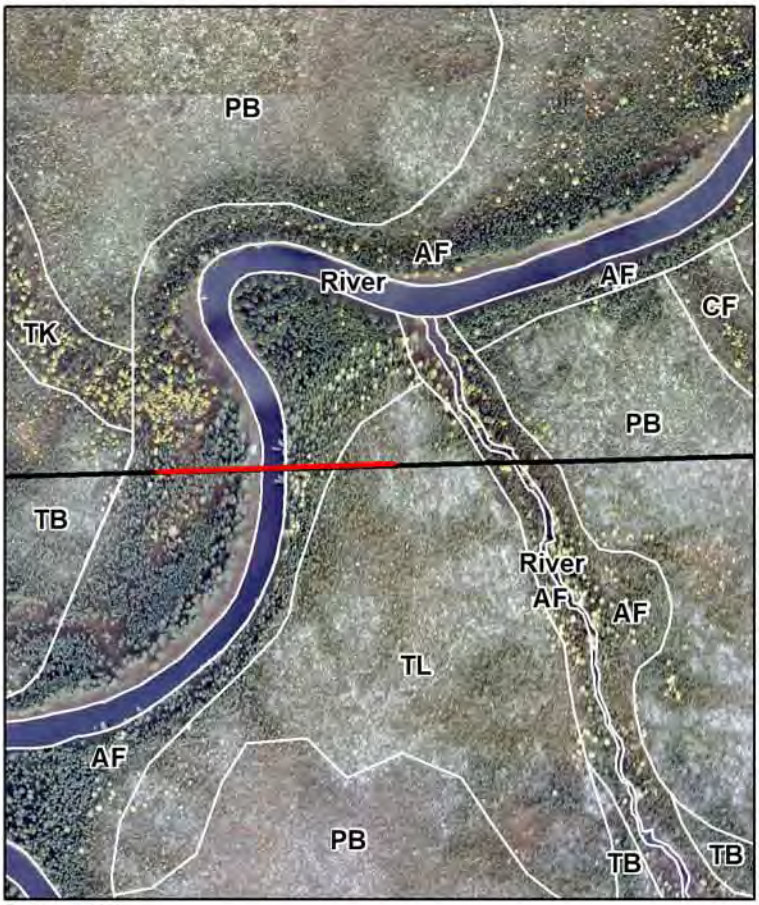
General reference map only; not for survey or legal use.

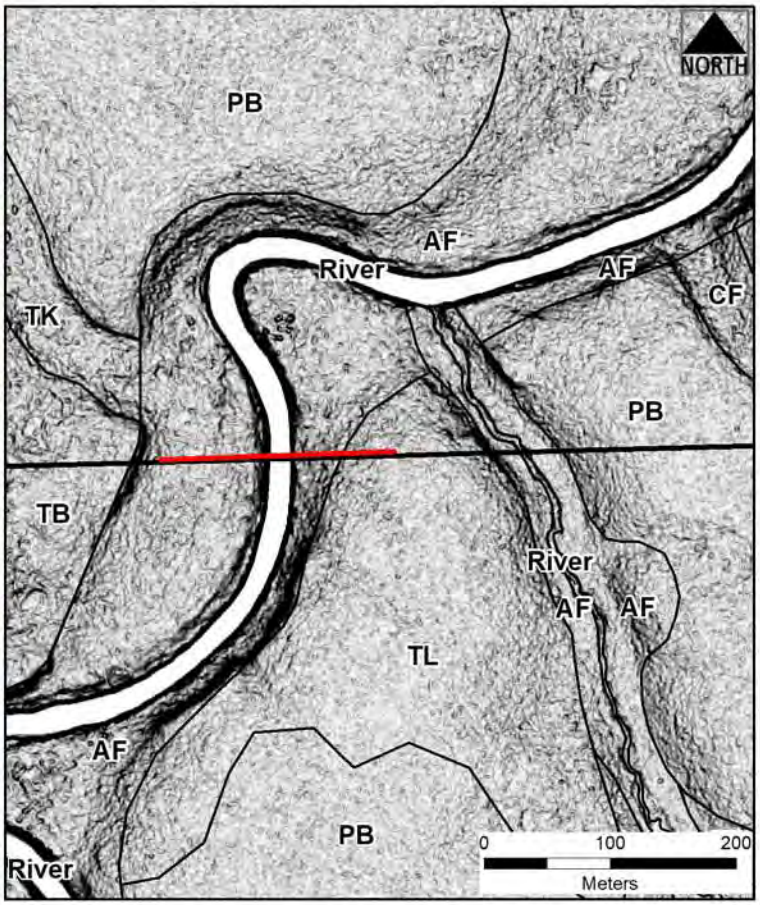
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

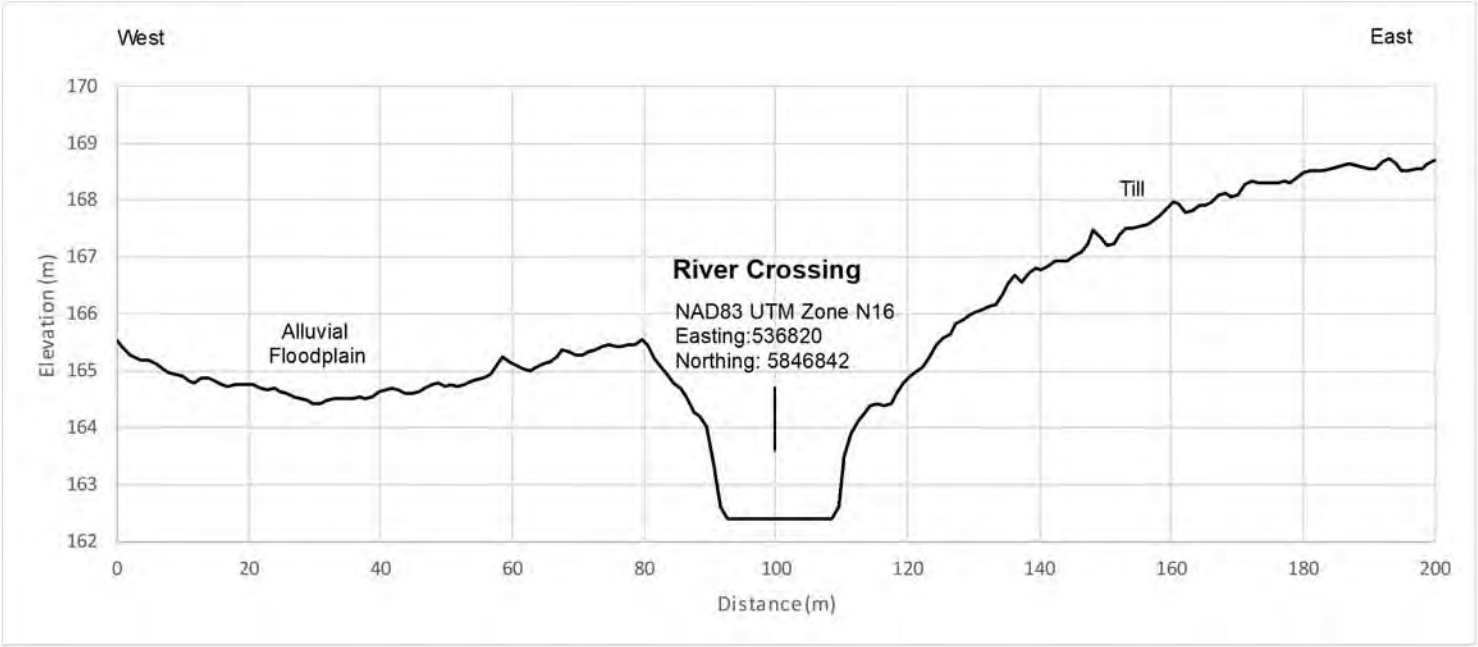
C5

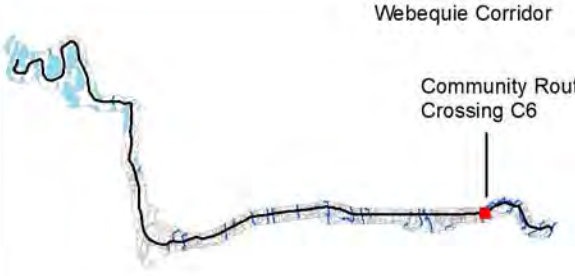
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

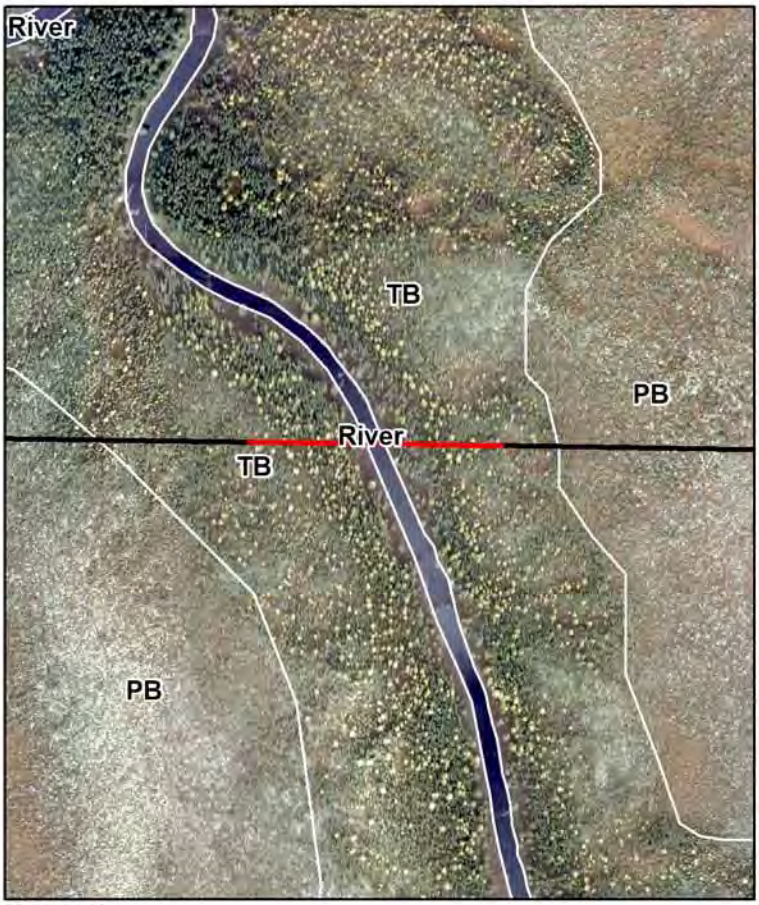
General reference map only; not for survey or legal use.

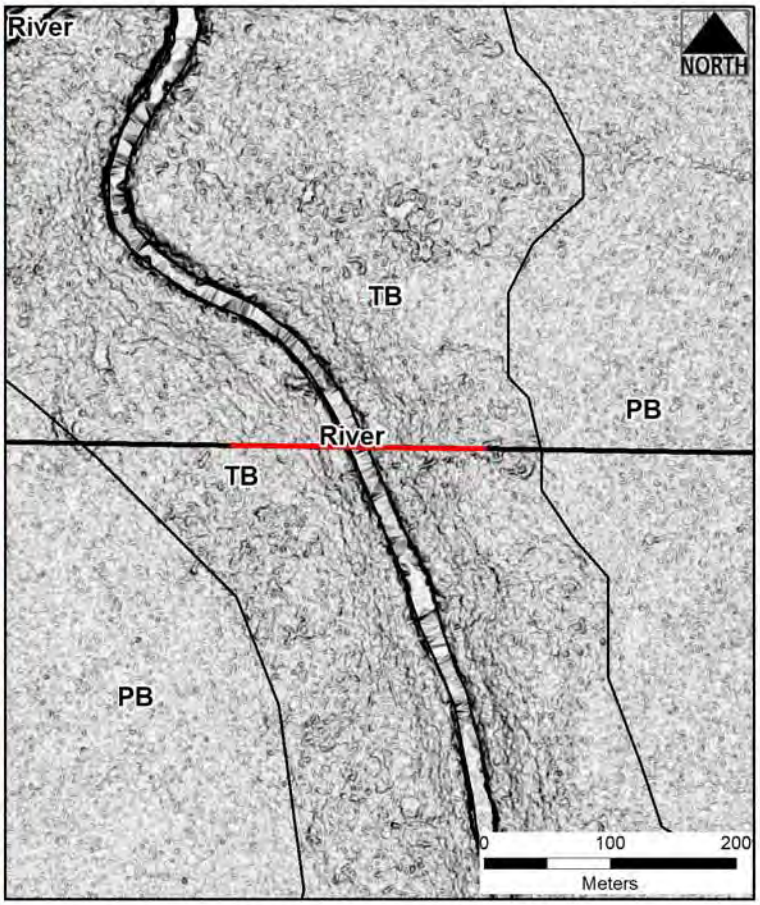
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

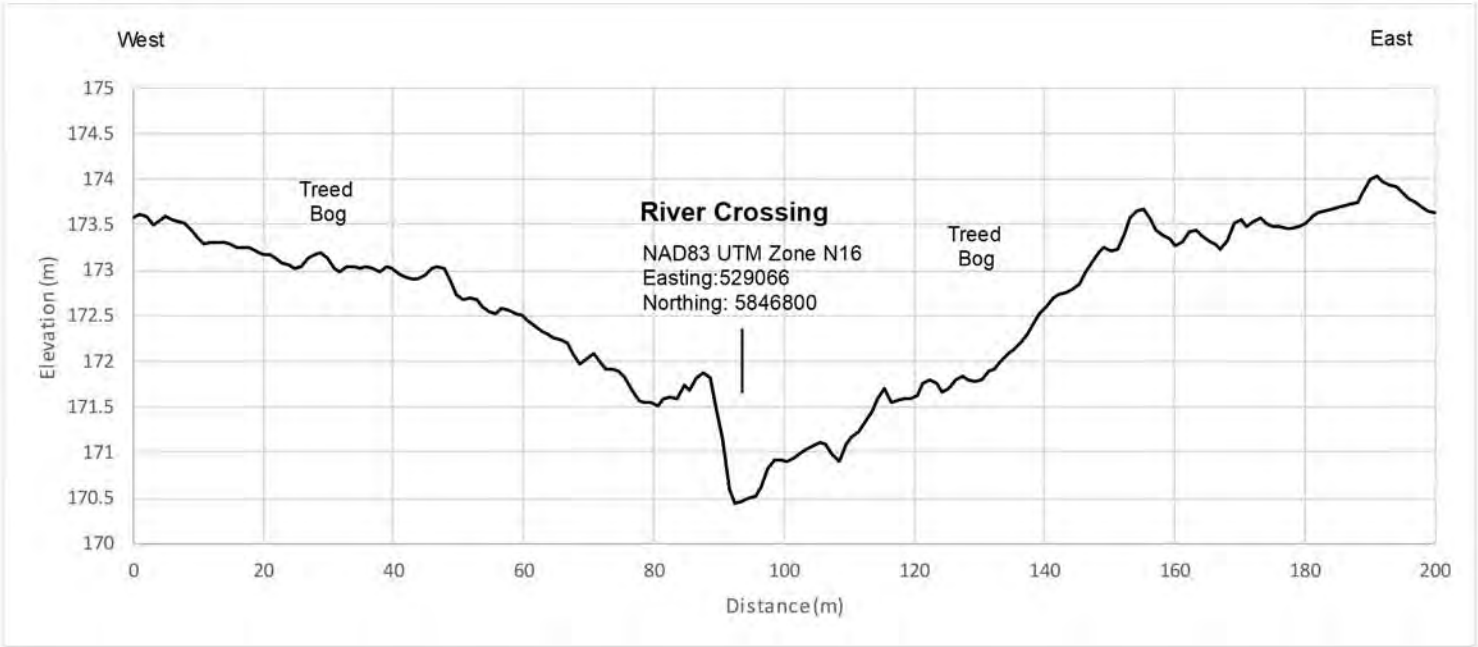
C6

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

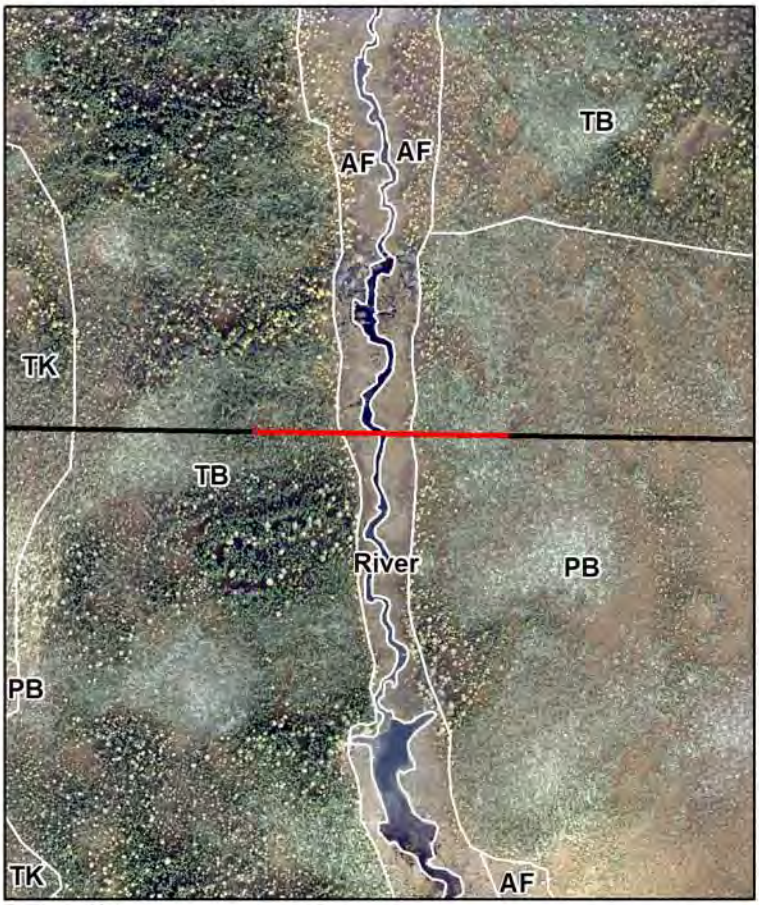
General reference map only; not for survey or legal use.

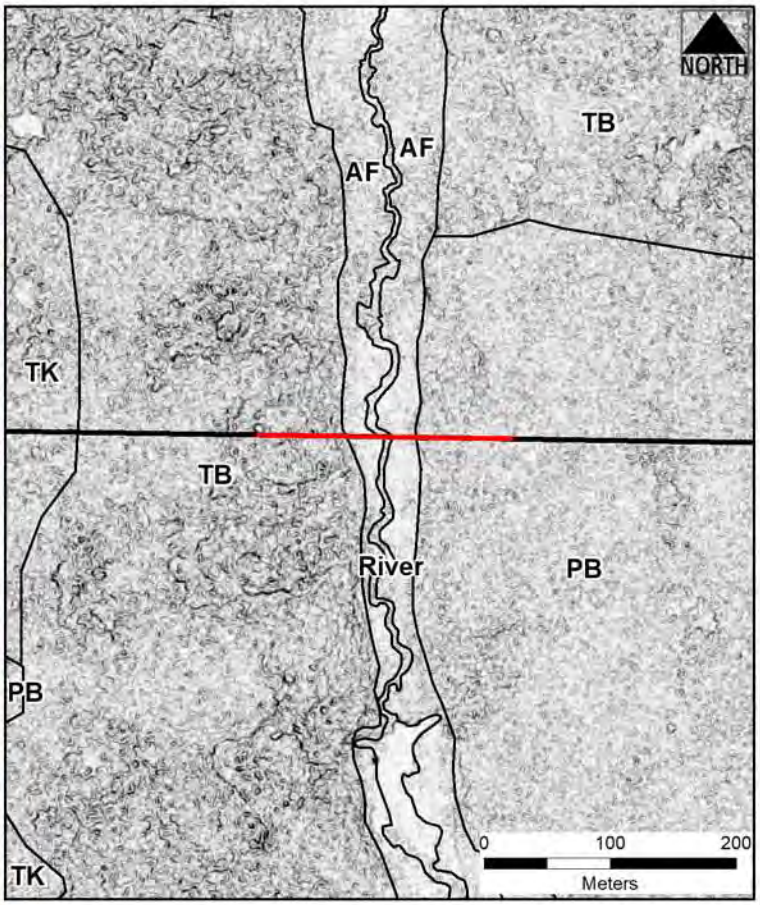
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

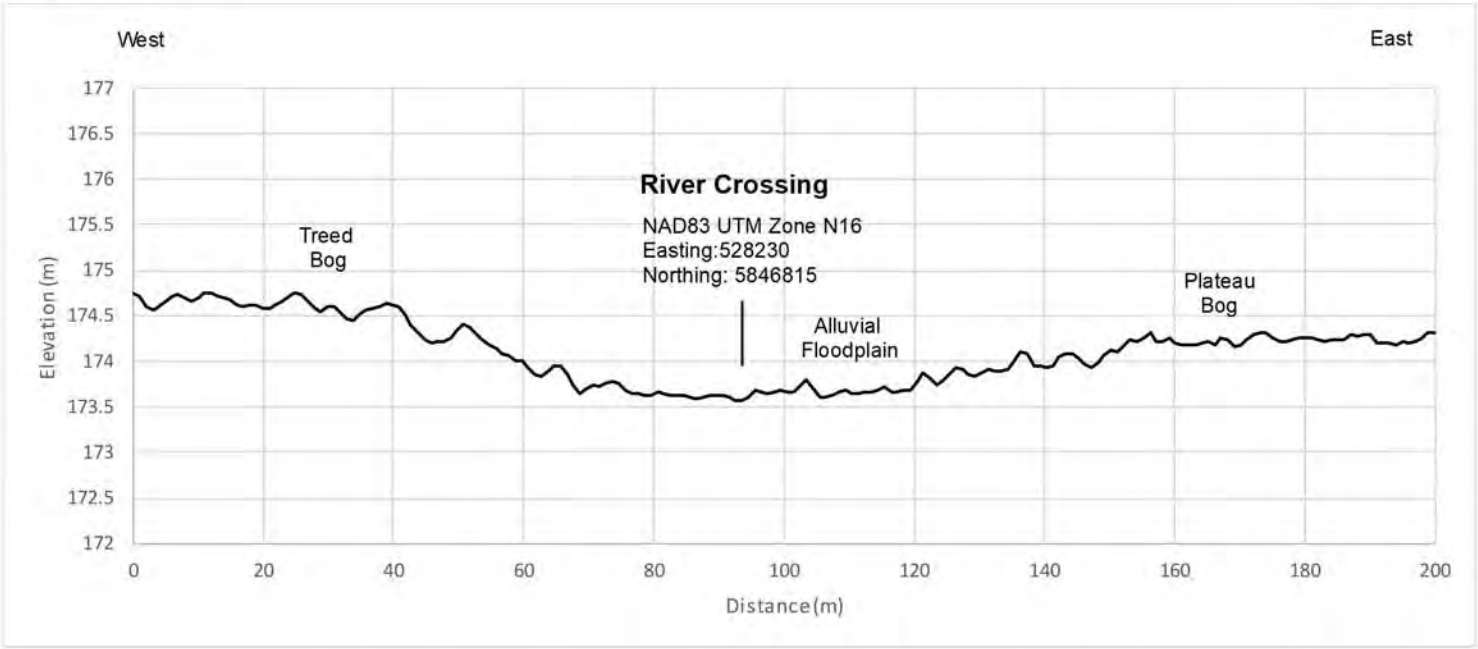
C7

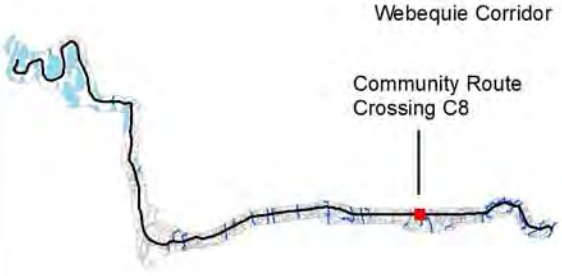
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

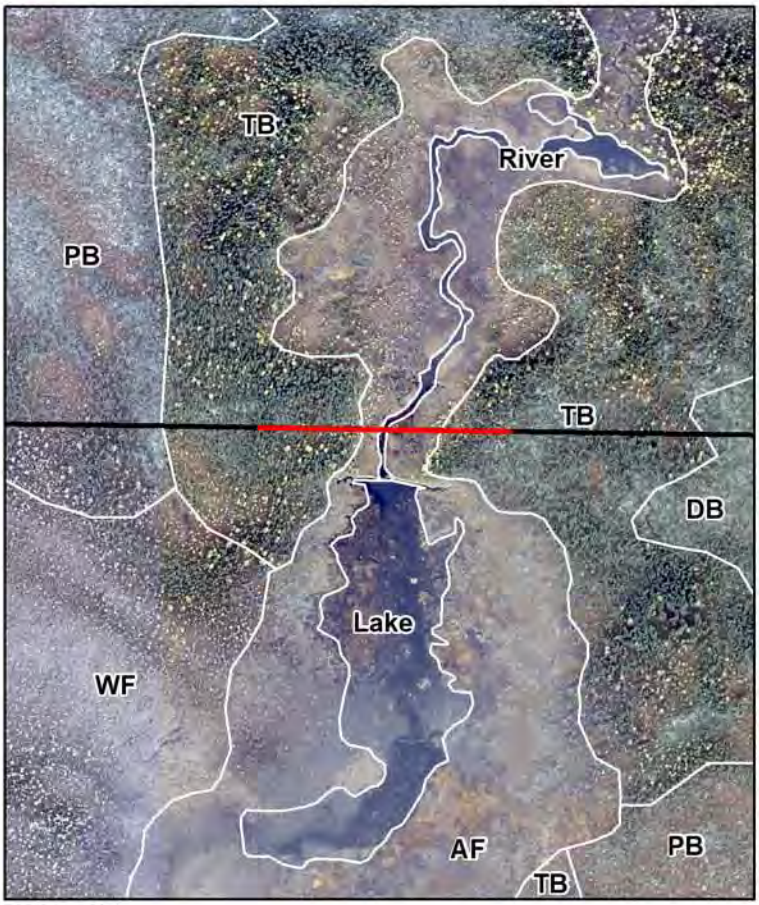
General reference map only; not for survey or legal use.

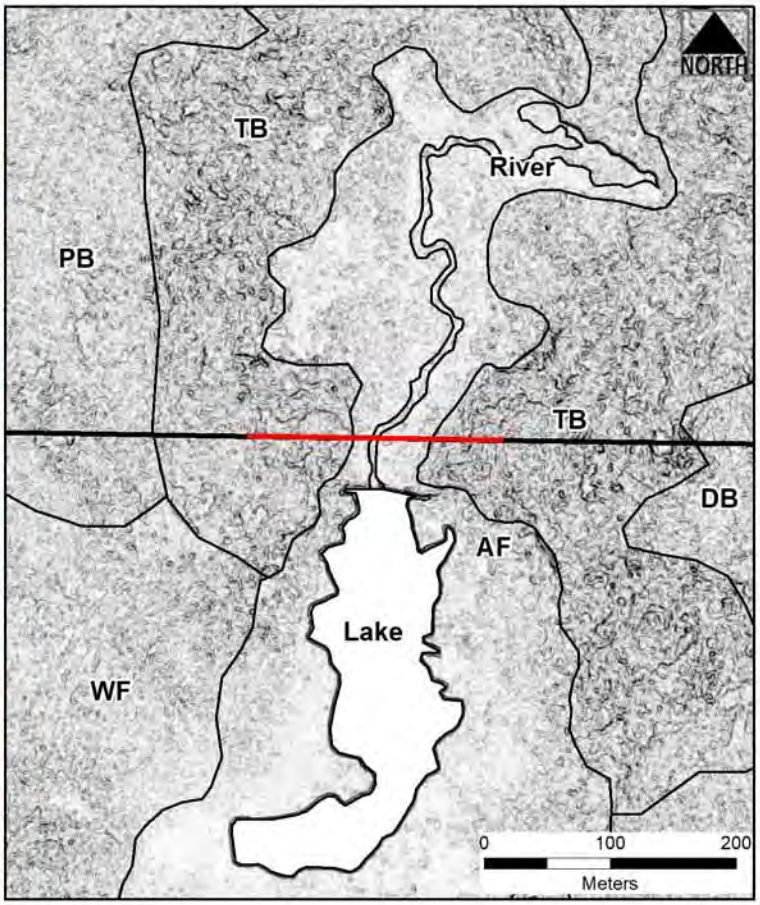
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

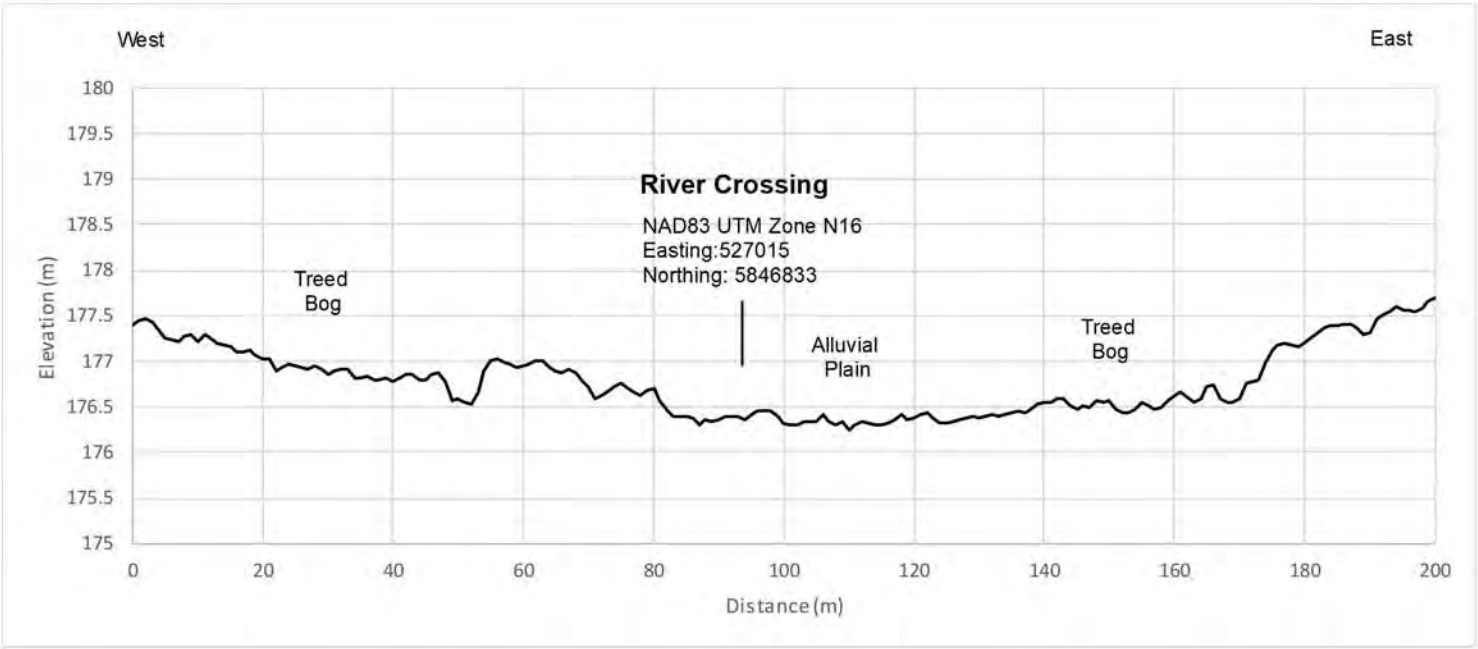
C8

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

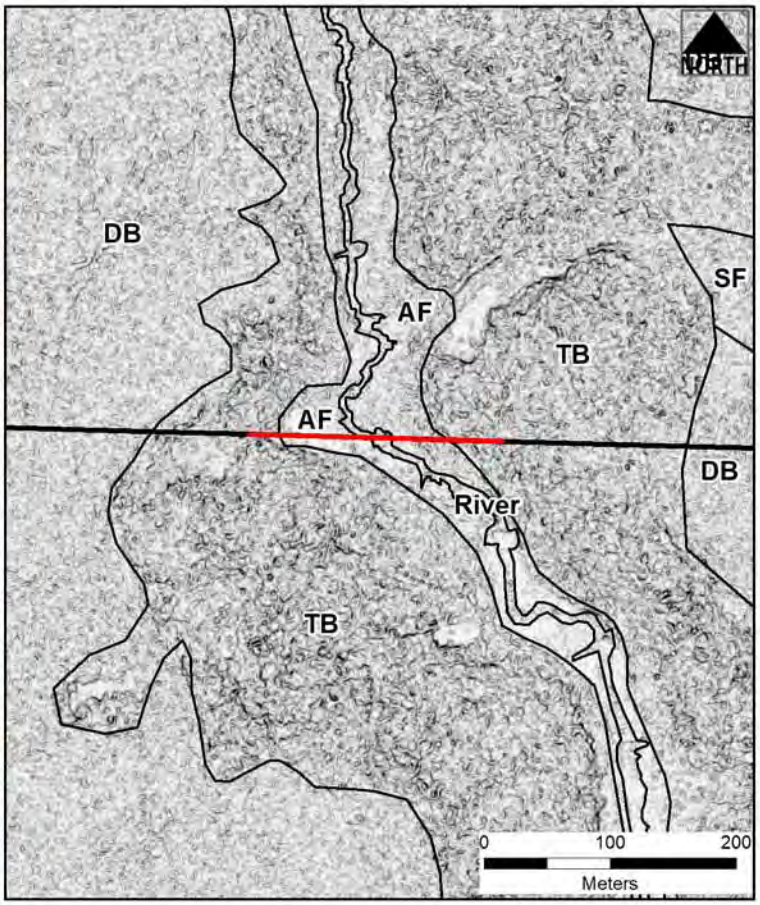
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C9

J D MOLLARD AND ASSOCIATES (2010) LIMITED



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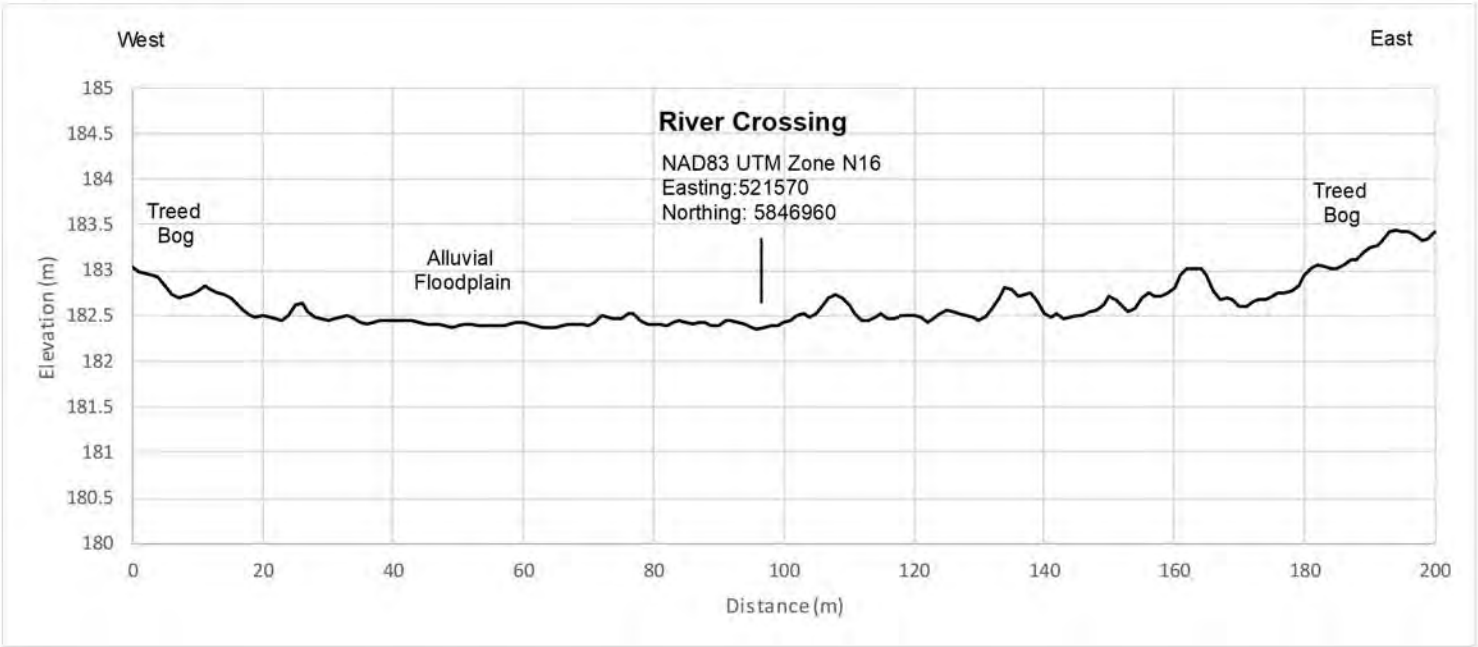


LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

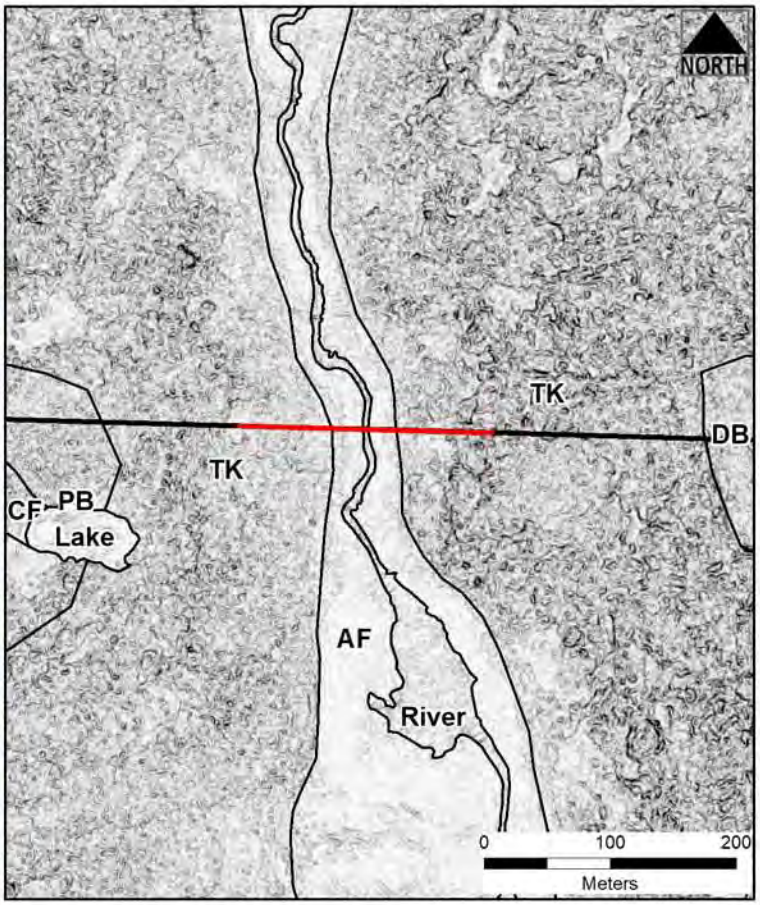
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C10

J D MOLLARD AND ASSOCIATES (2010) LIMITED



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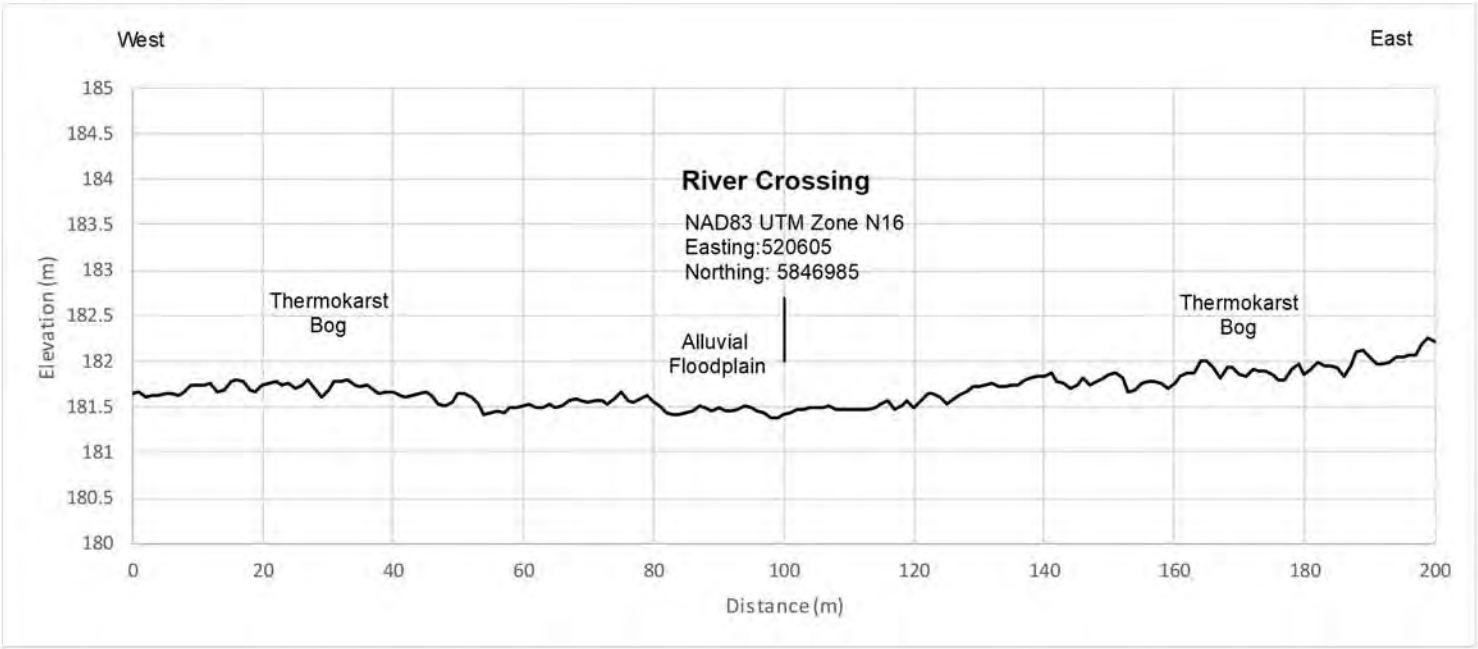
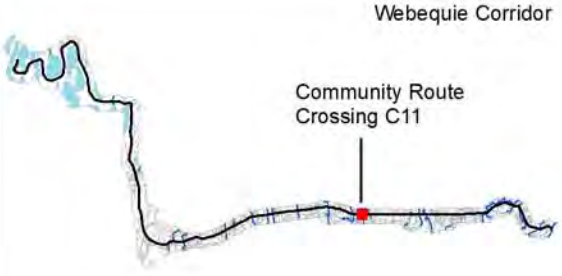




LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

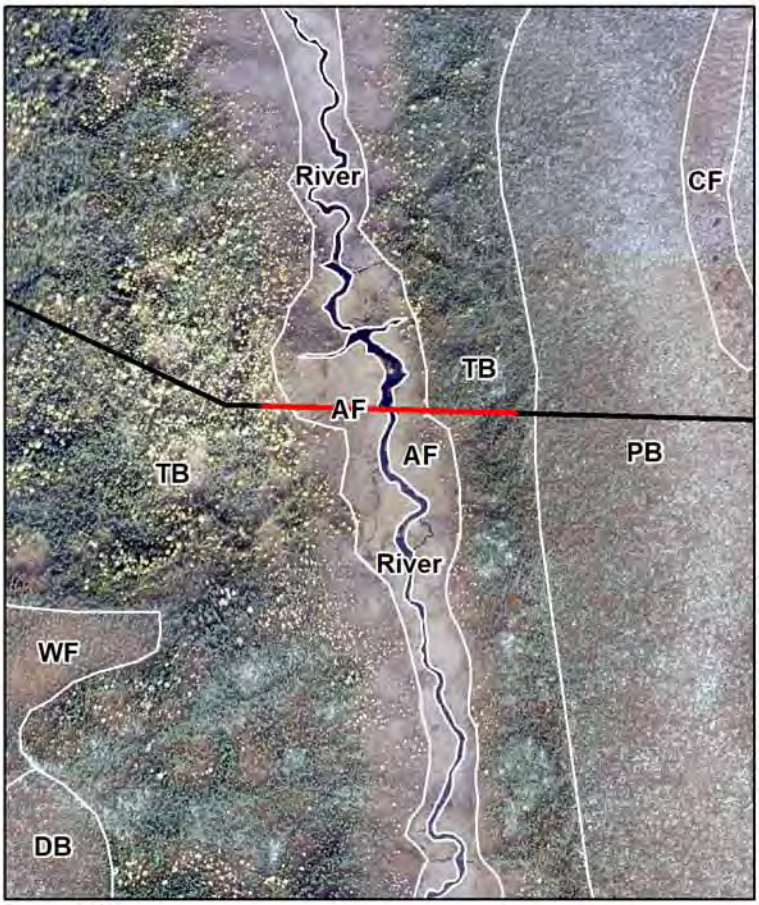
General reference map only; not for survey or legal use.

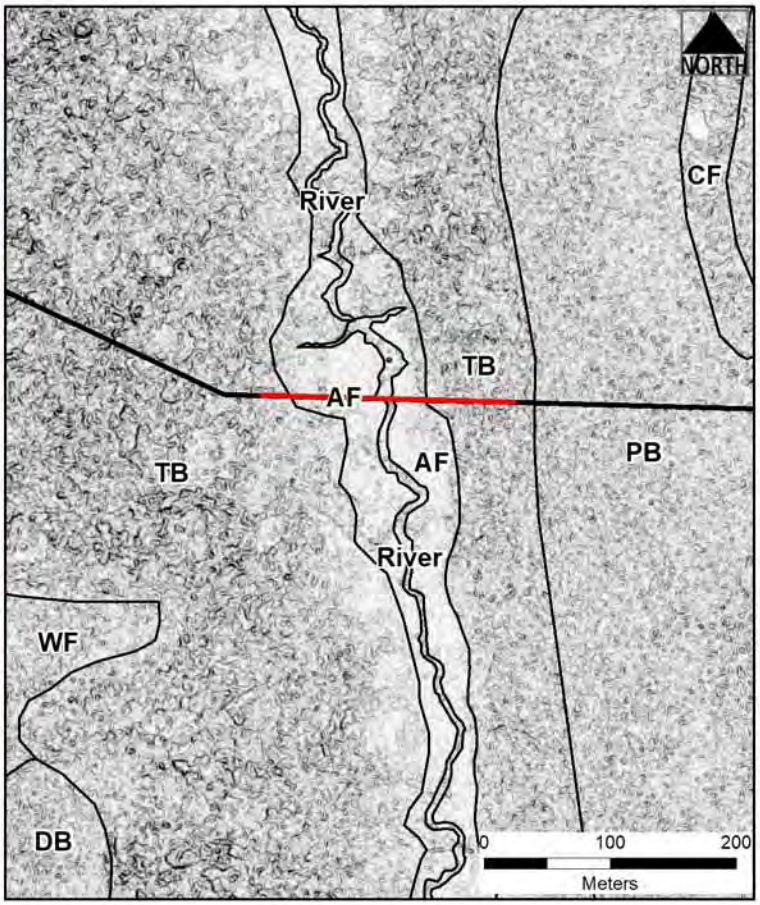
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

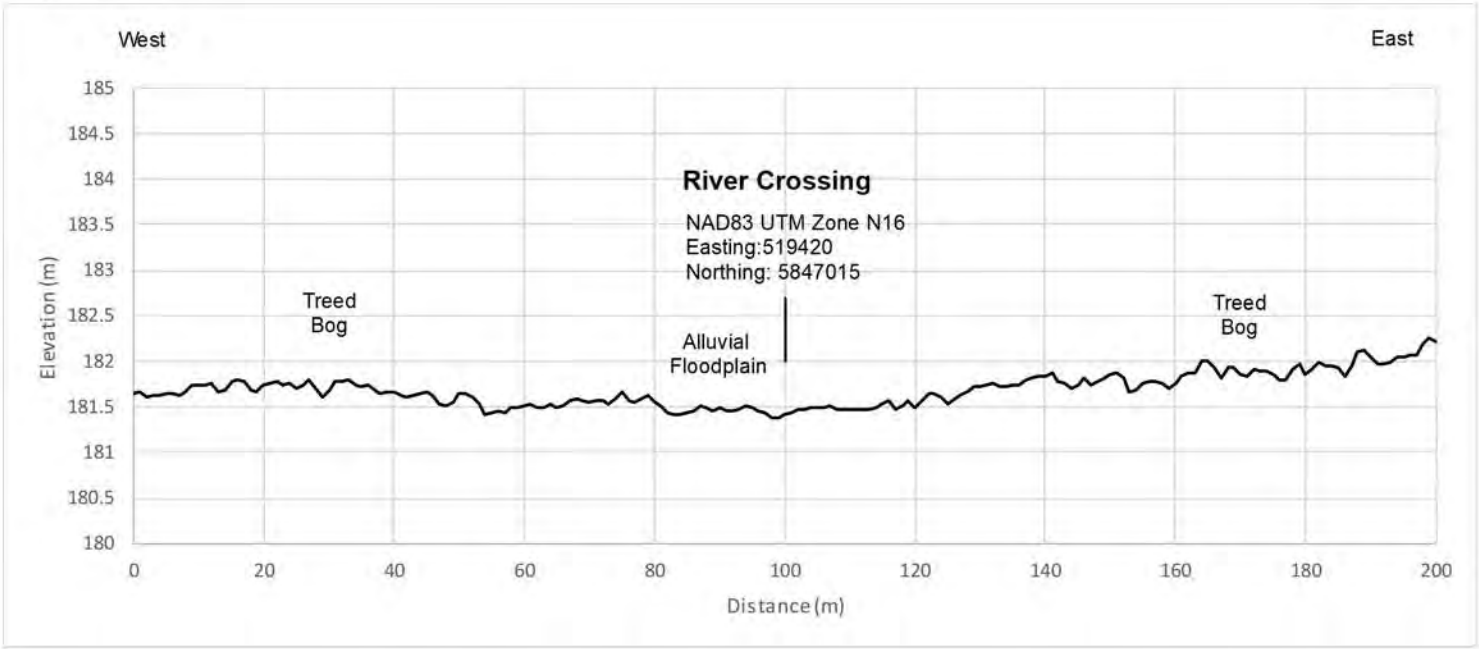
C11

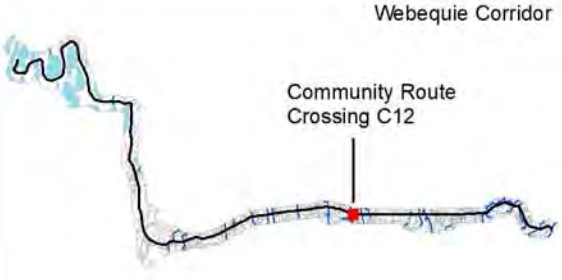
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

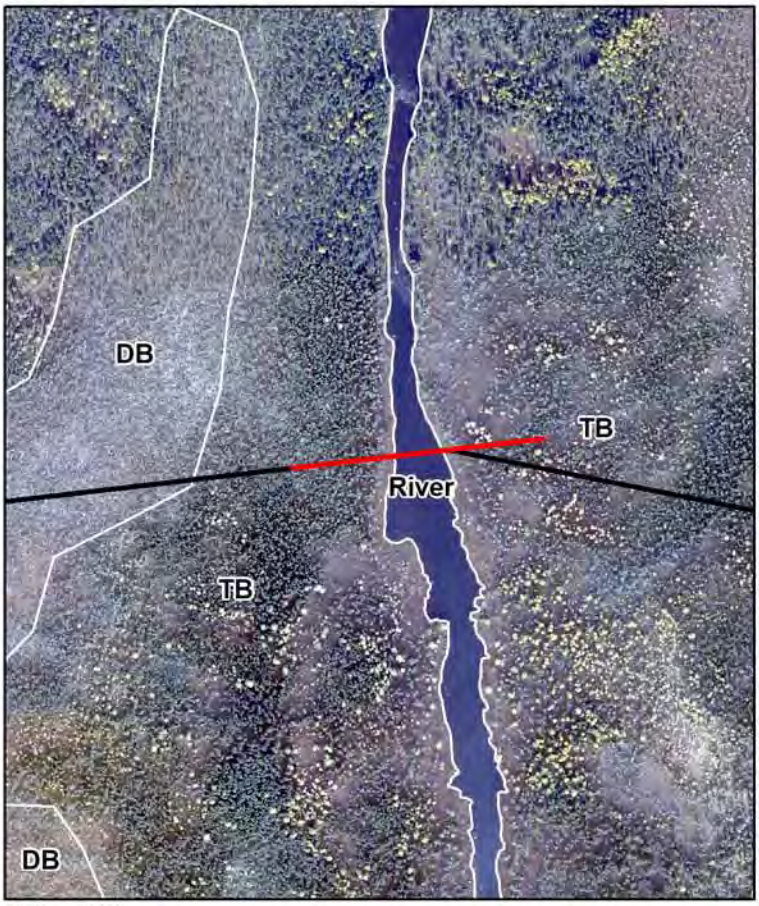
General reference map only; not for survey or legal use.

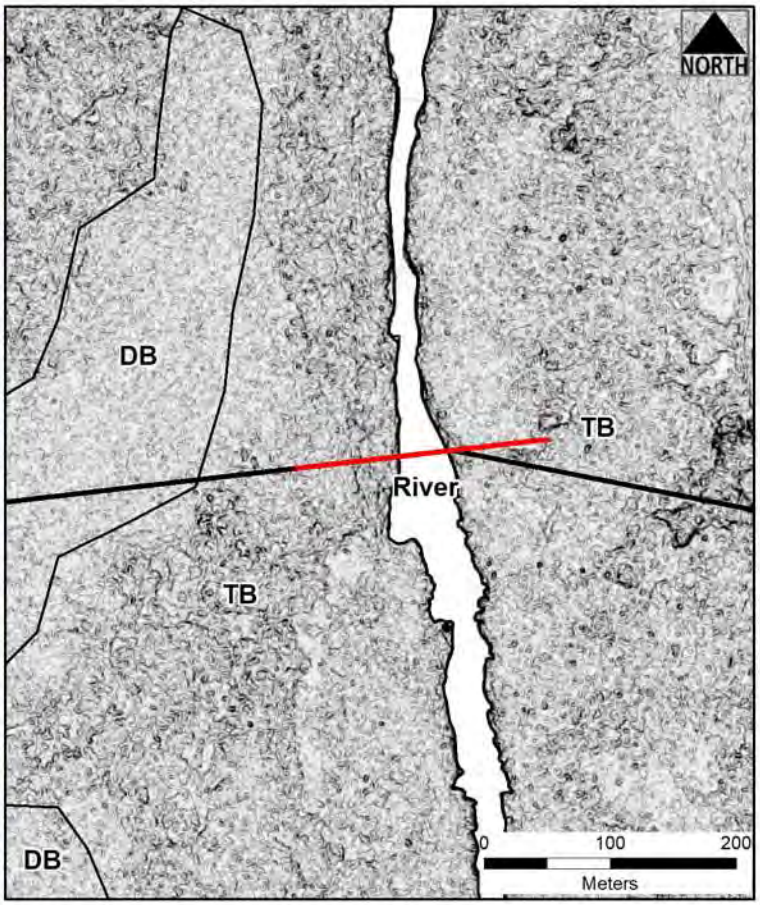
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C12

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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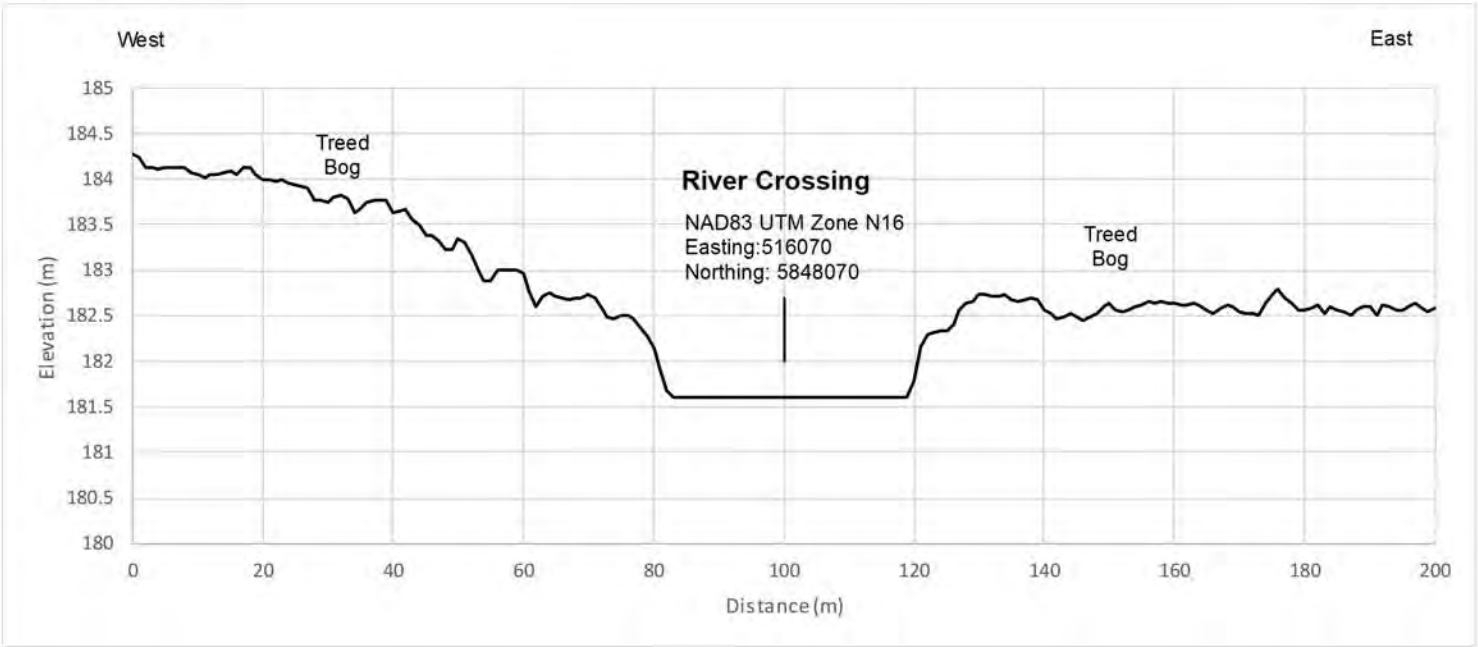


LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

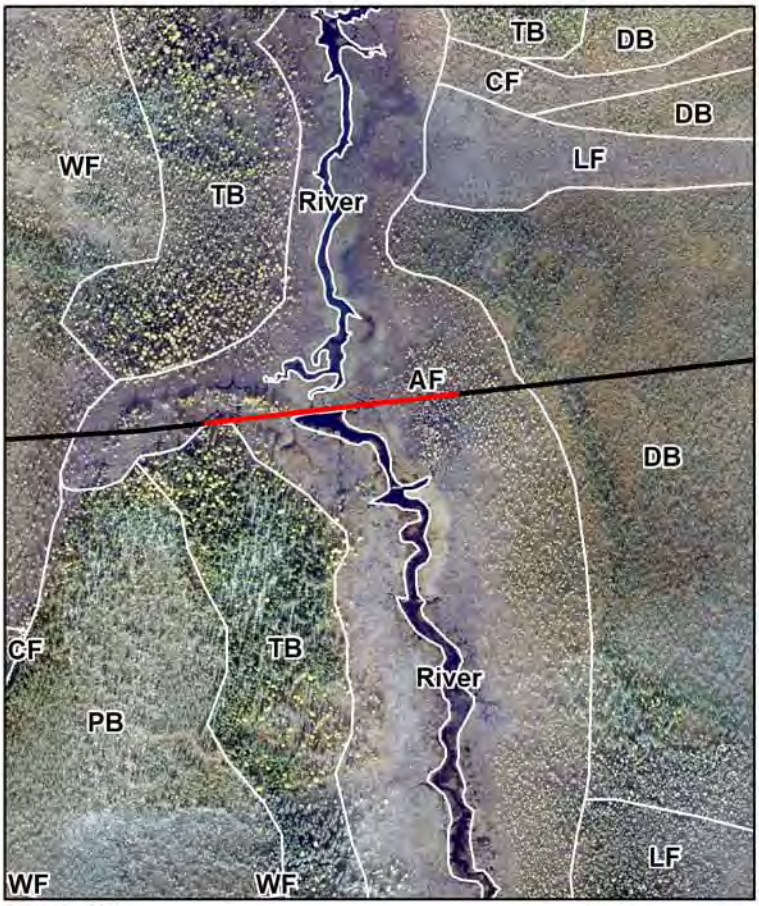
General reference map only; not for survey or legal use.

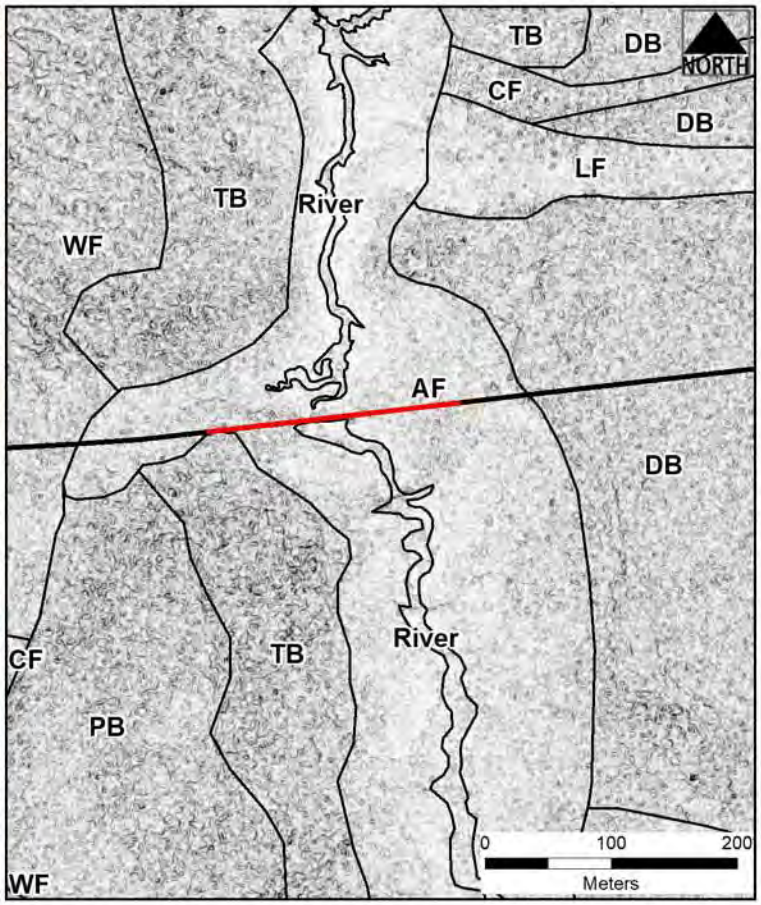
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C13

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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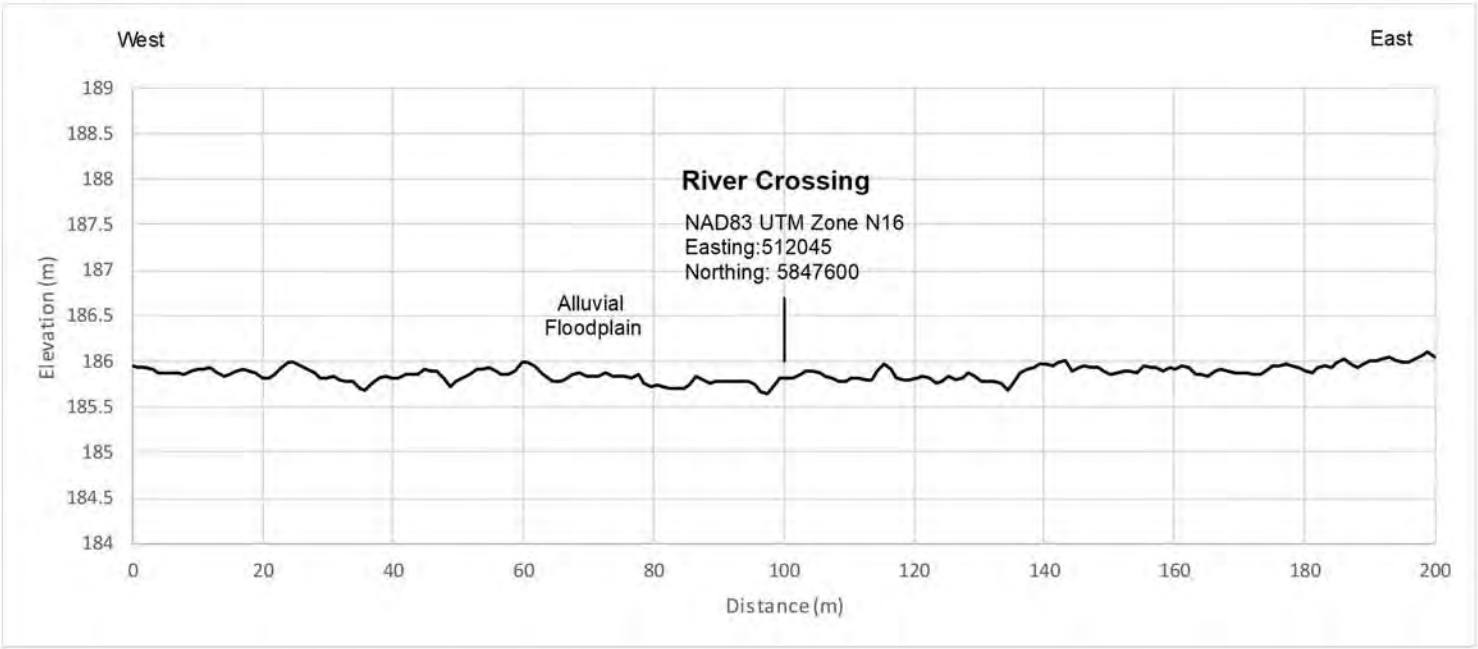


LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

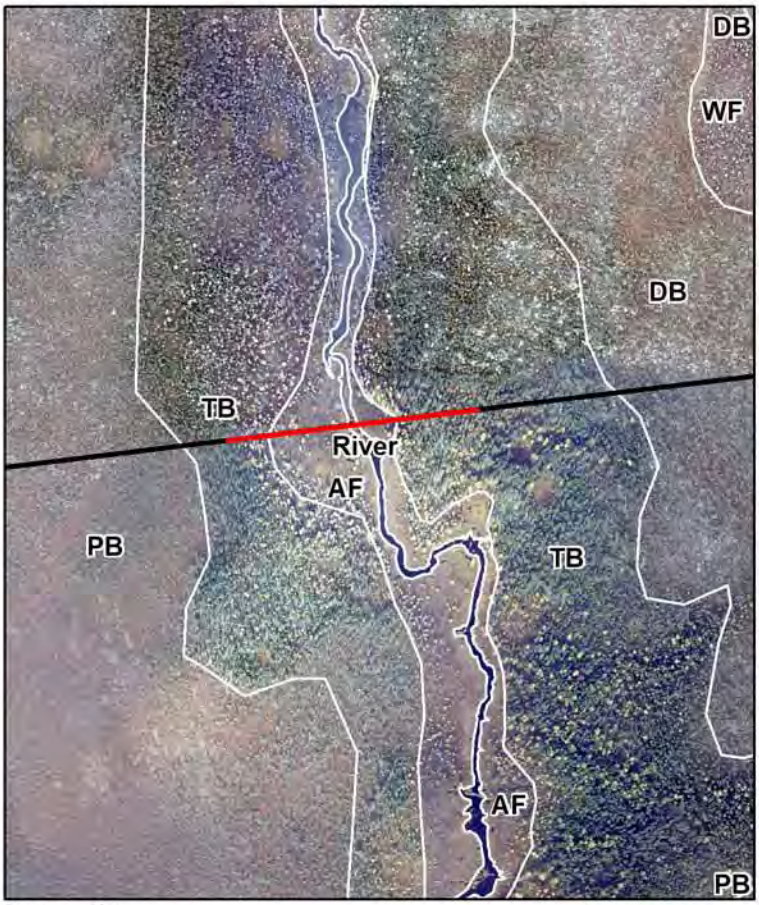
General reference map only; not for survey or legal use.

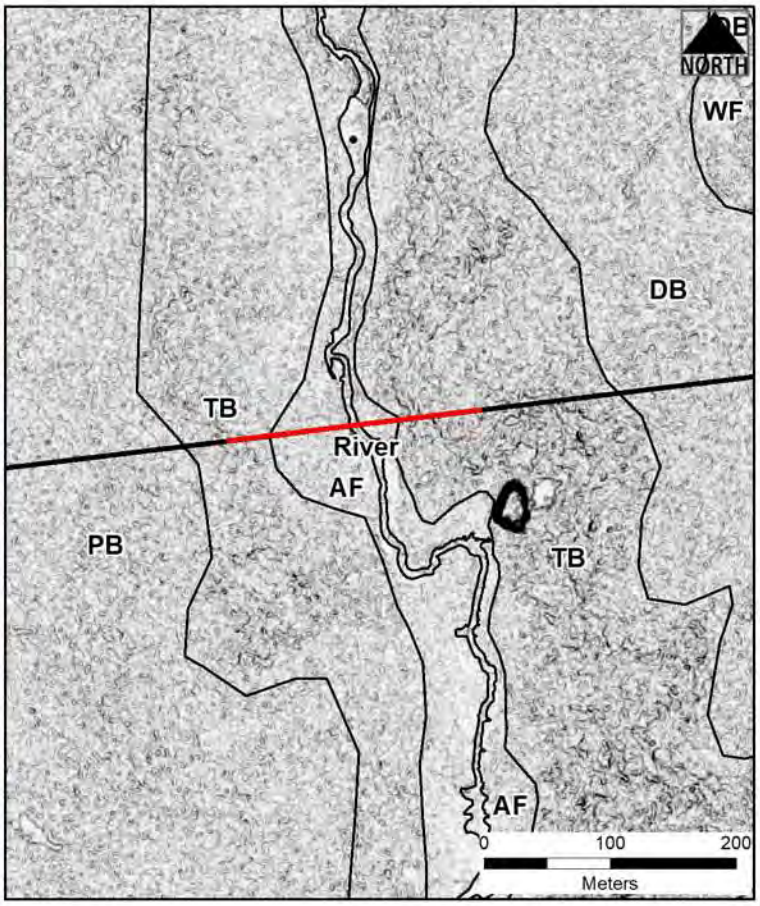
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C14

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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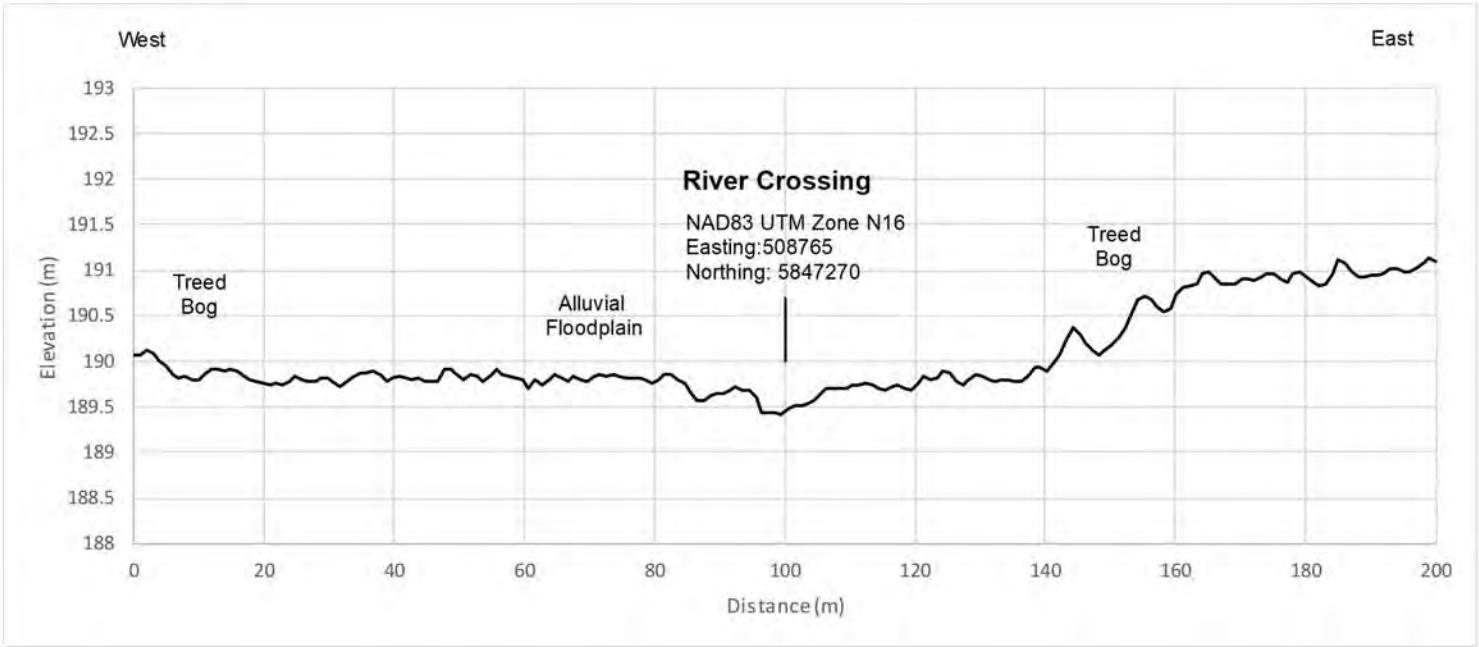


LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

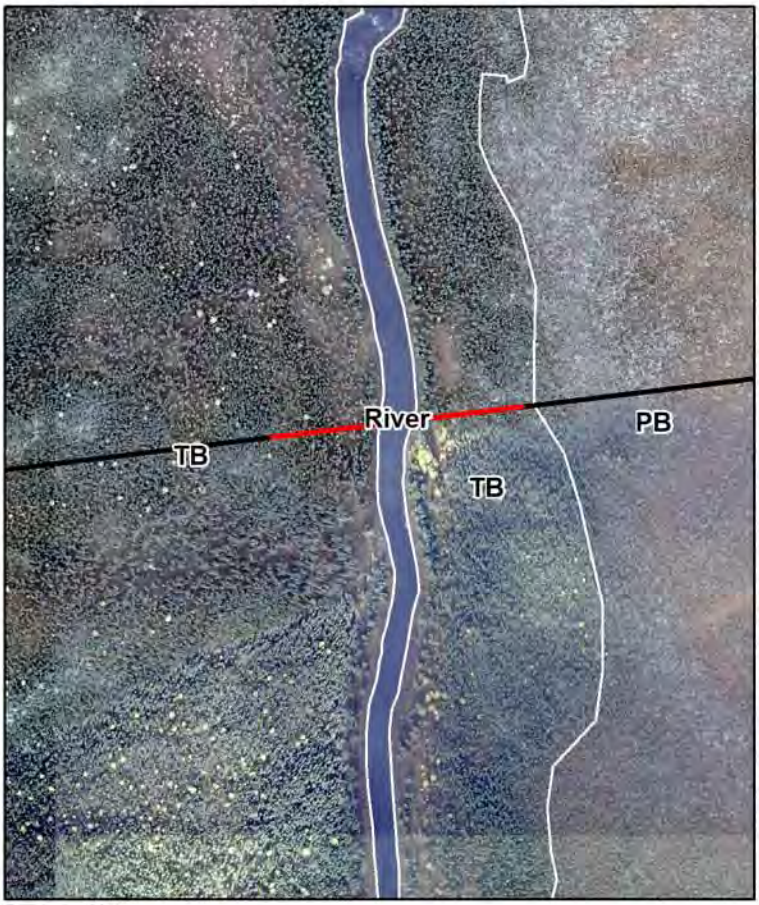
General reference map only; not for survey or legal use.

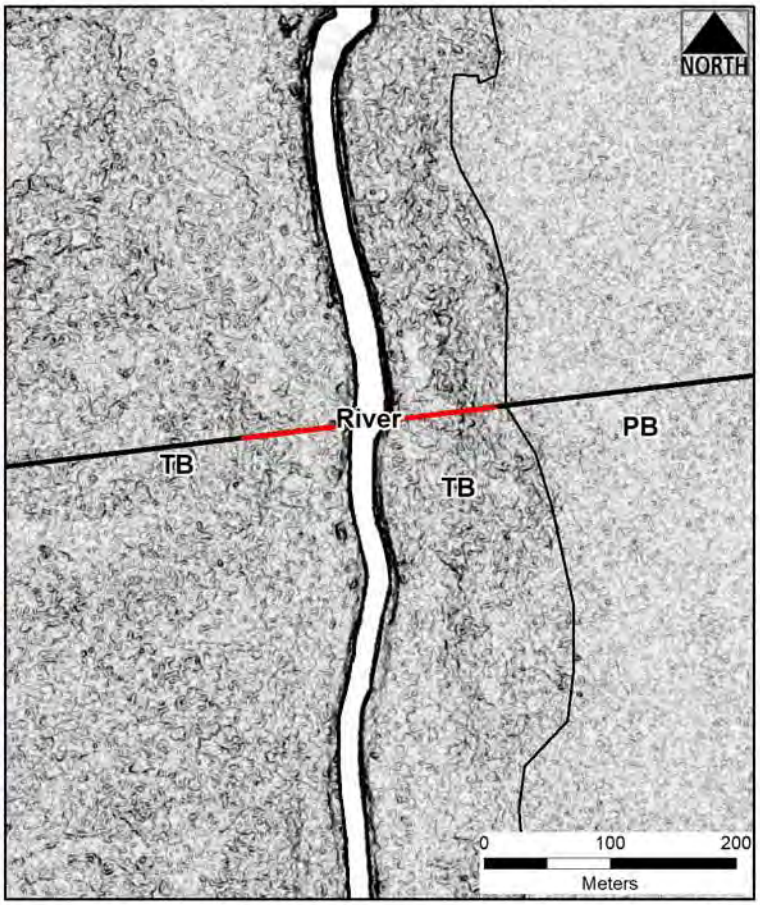
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C15

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)

LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

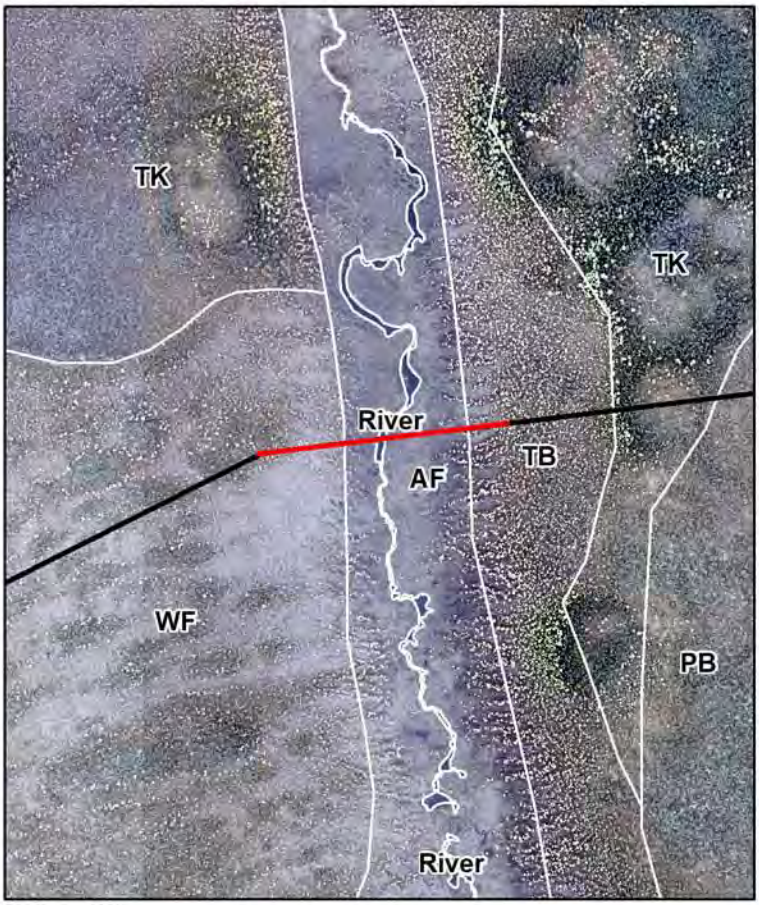
General reference map only; not for survey or legal use.

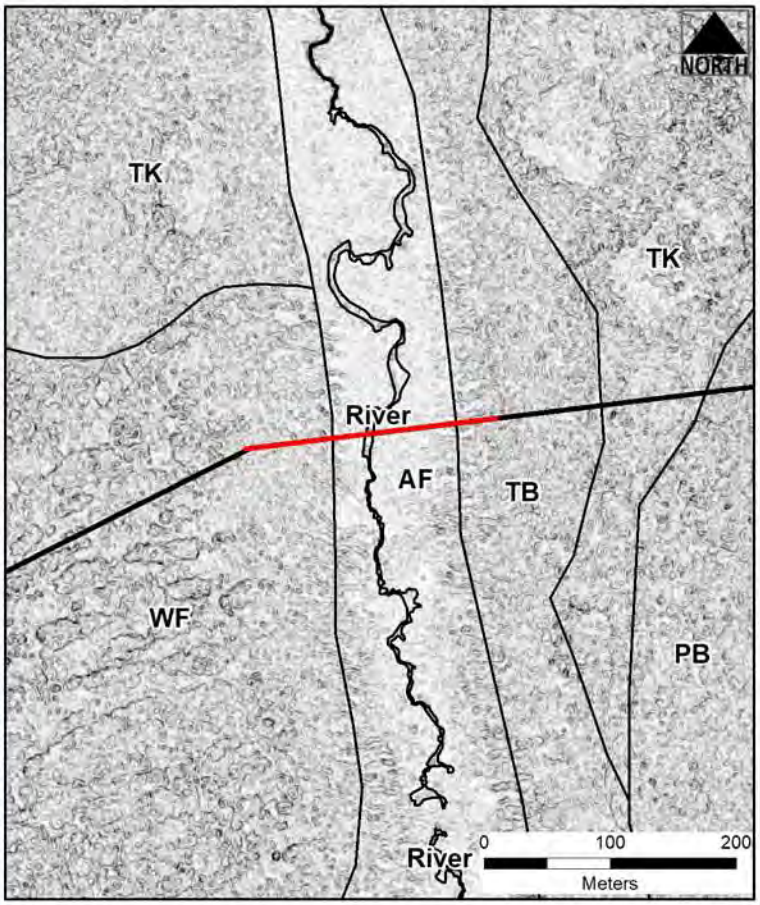
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

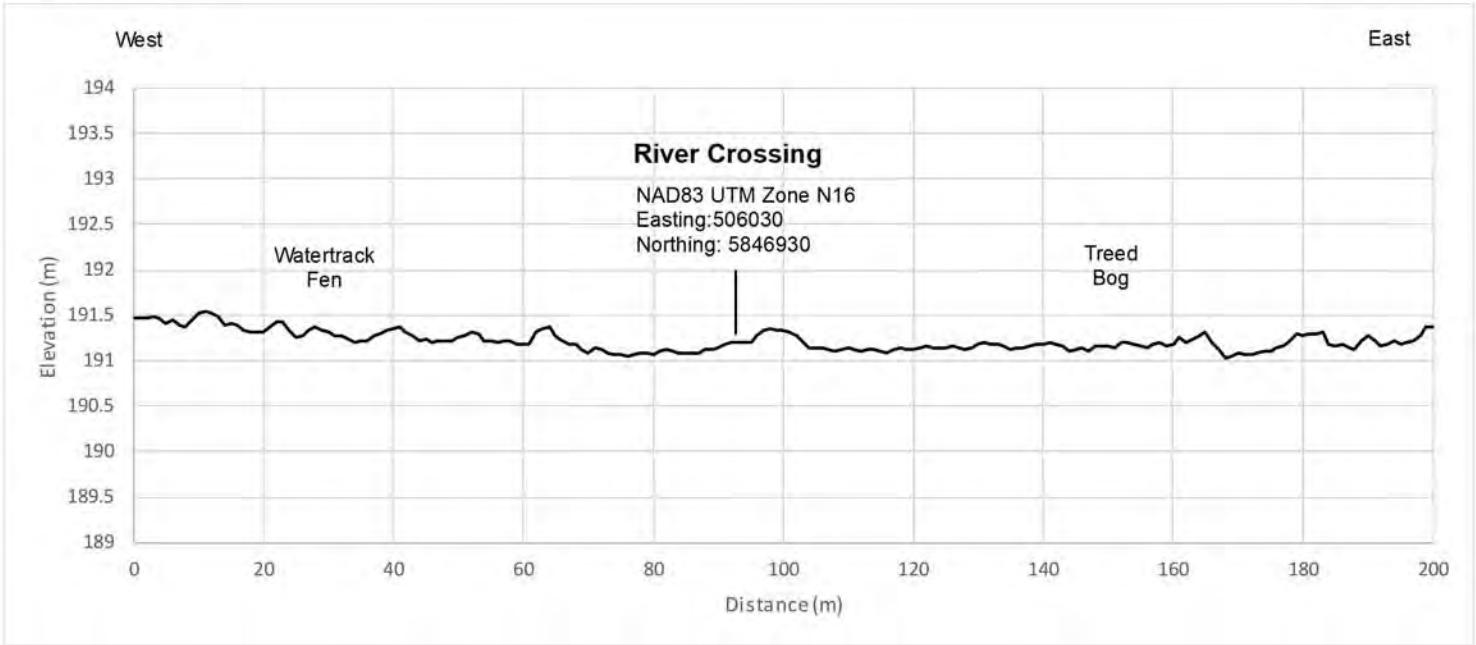
C16

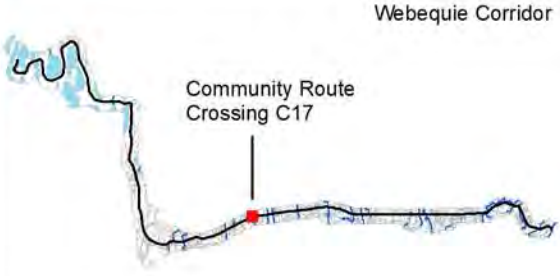
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

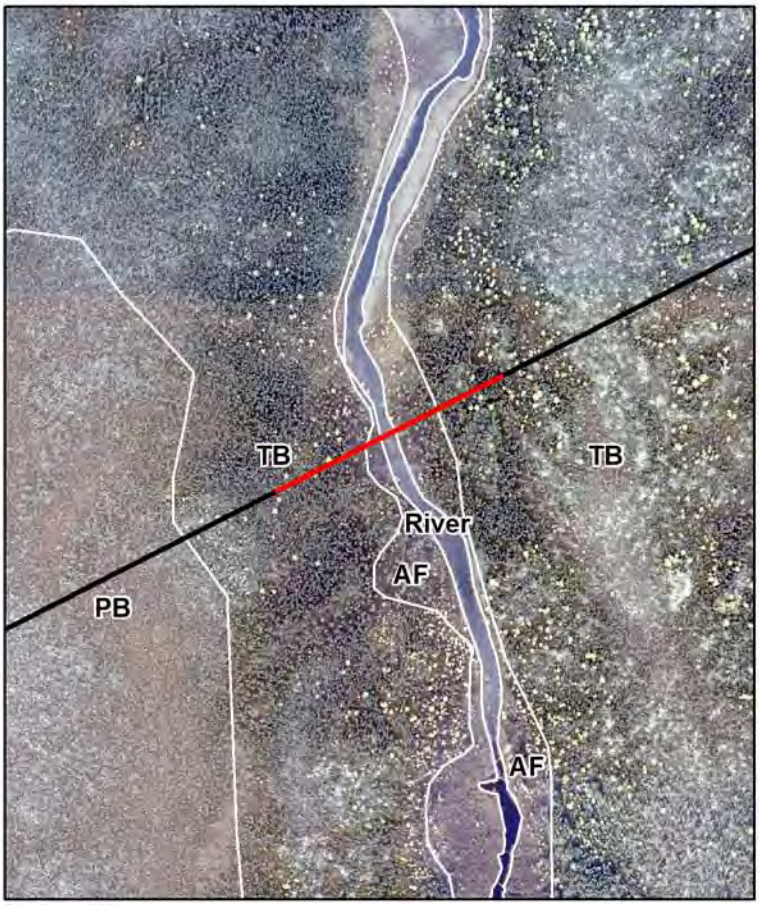
General reference map only; not for survey or legal use.

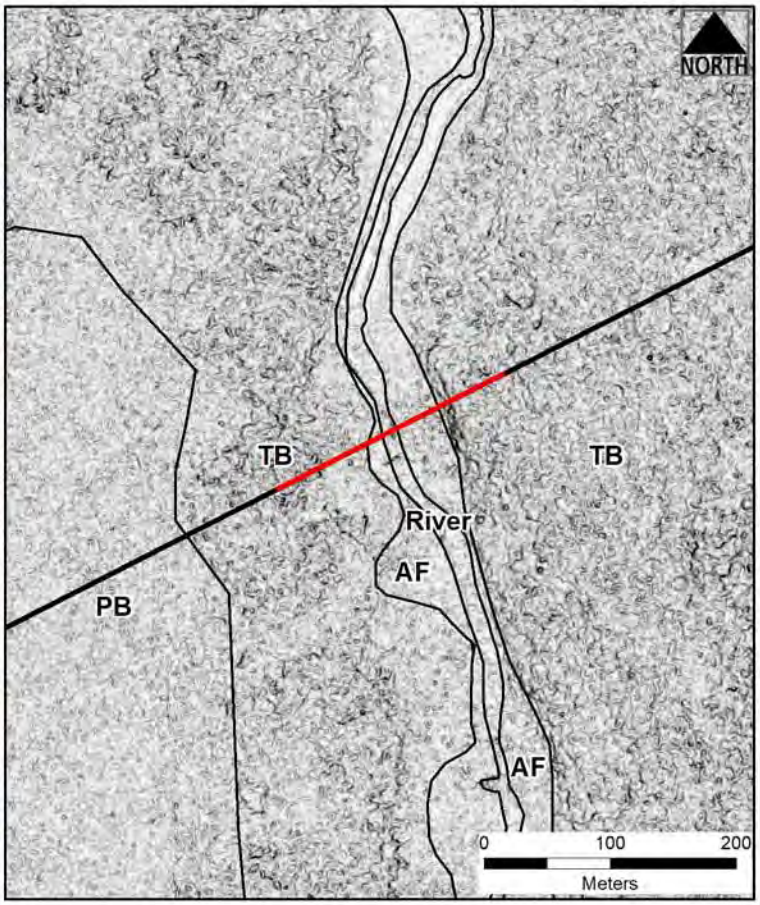
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

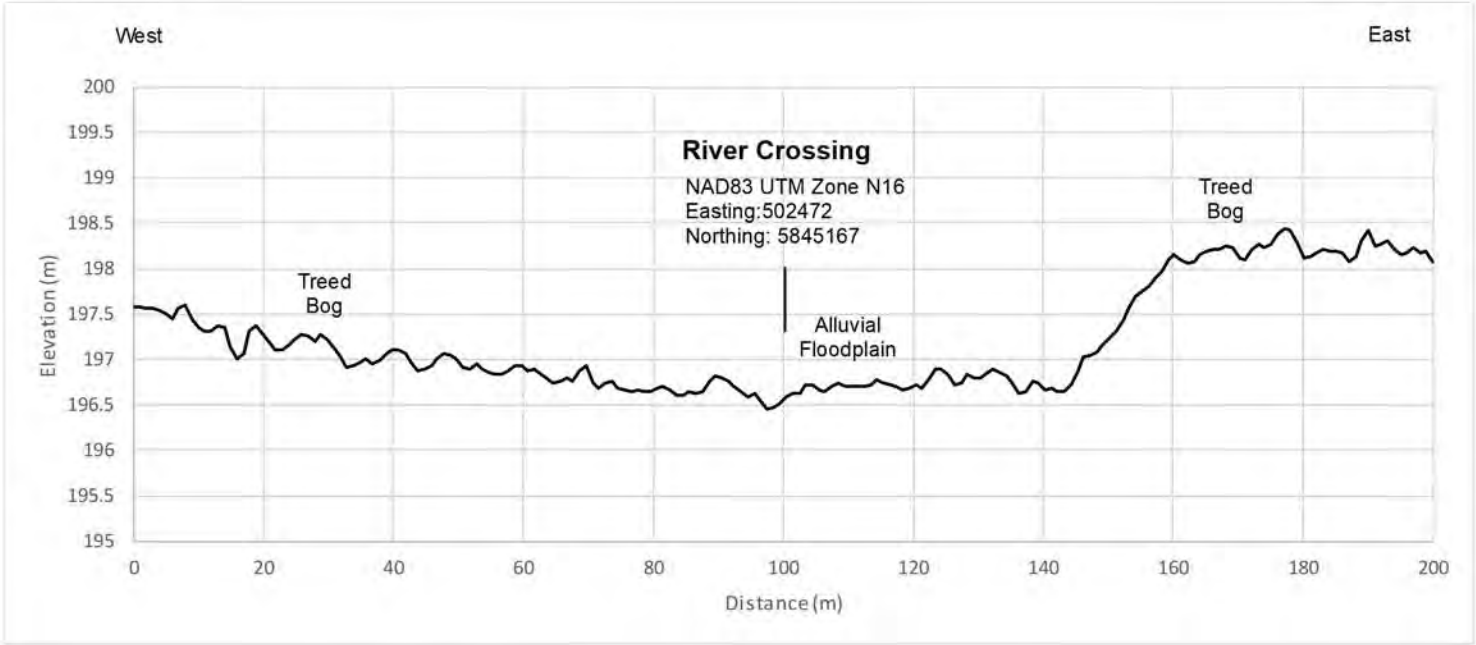
C17

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

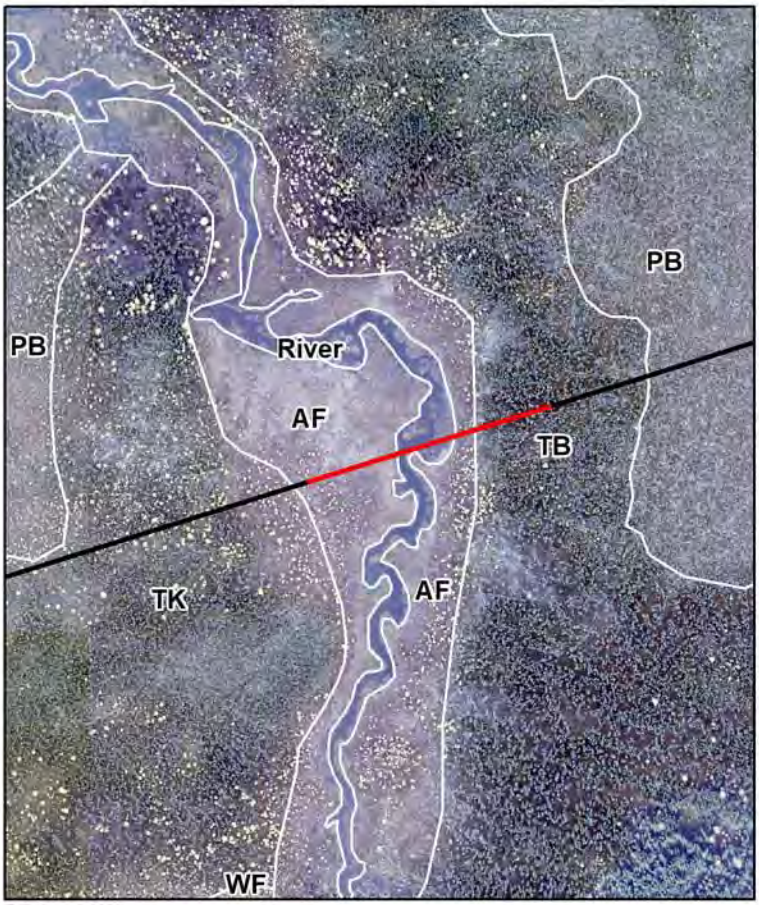
General reference map only; not for survey or legal use.

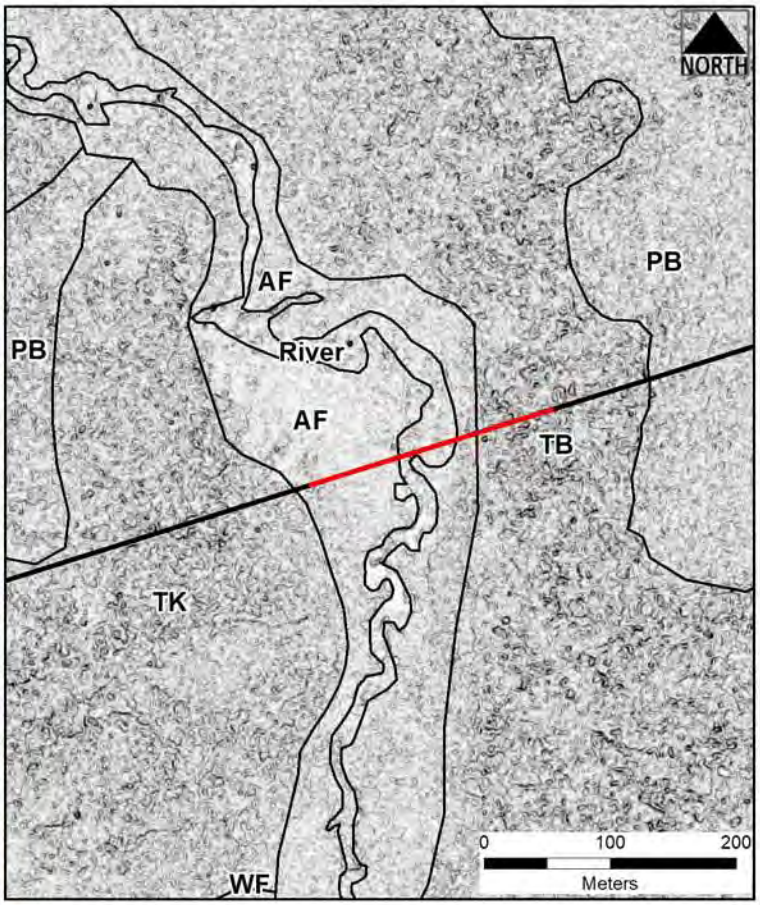
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C18

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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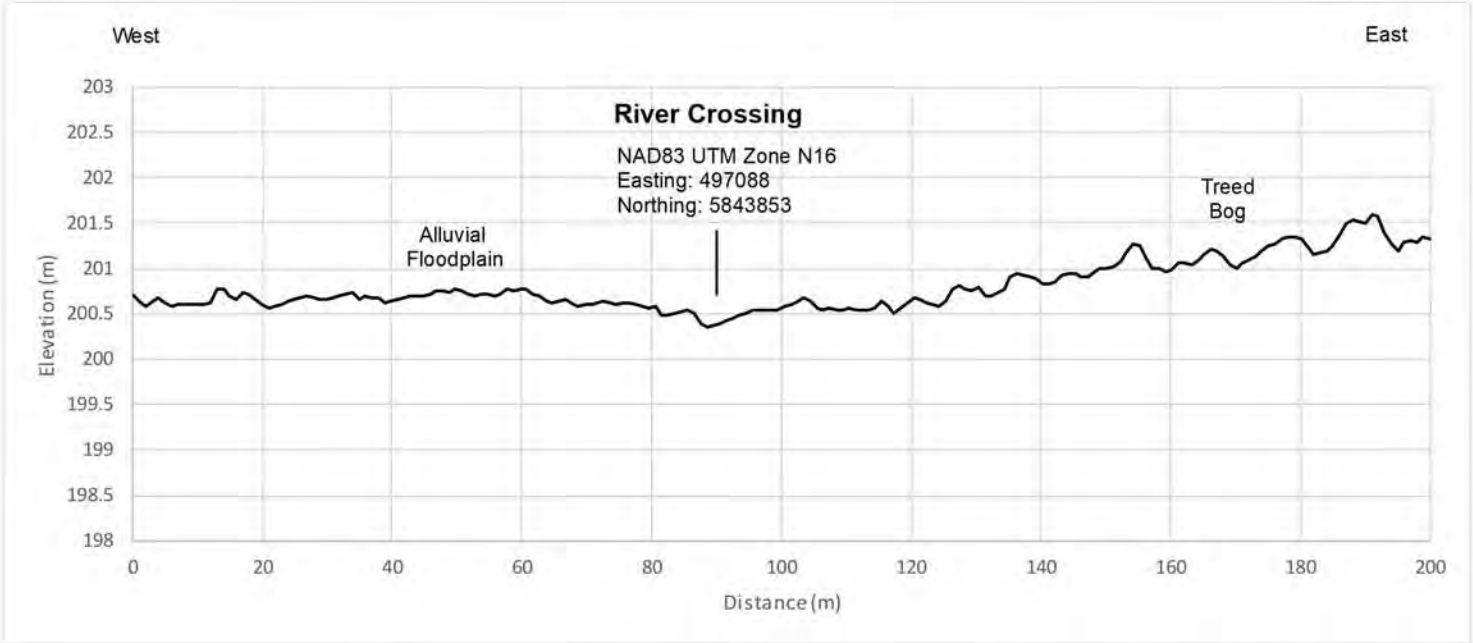


LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

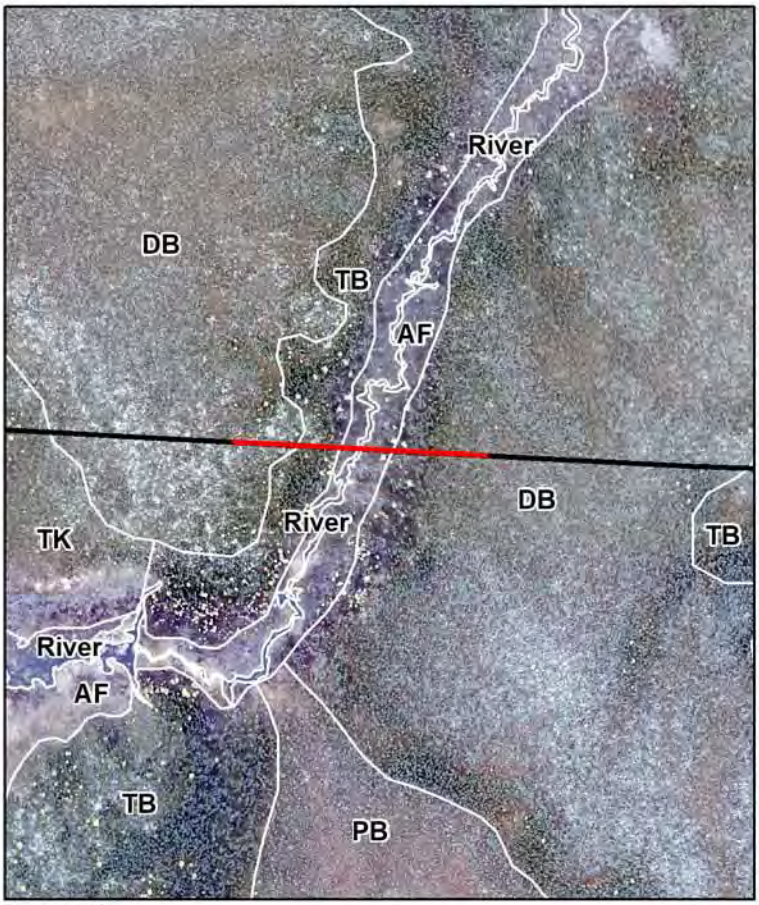
General reference map only; not for survey or legal use.

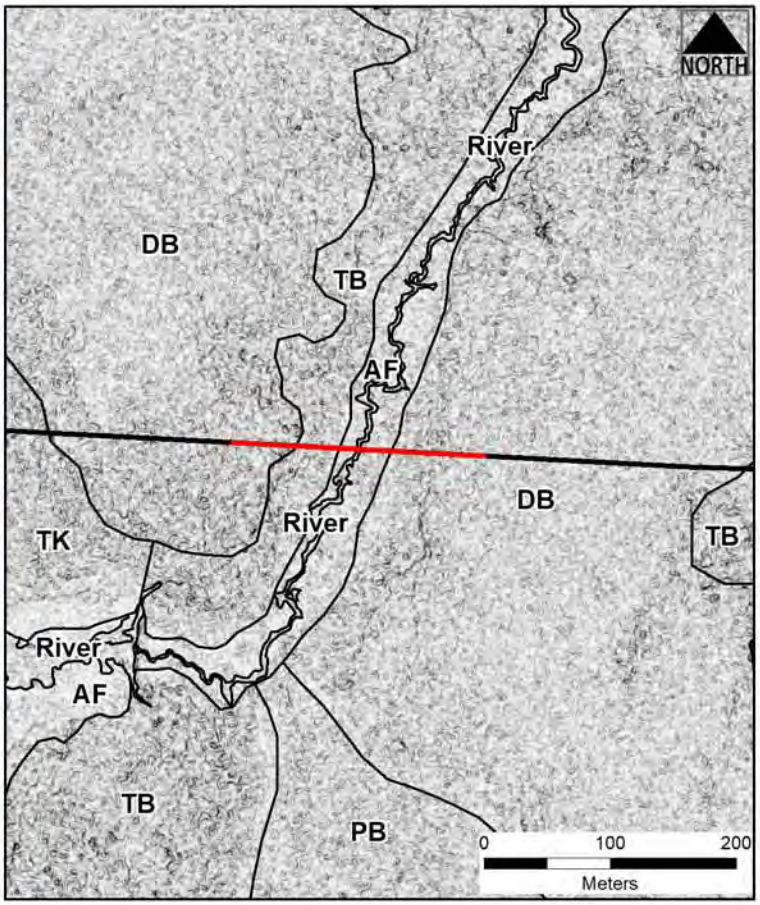
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C19

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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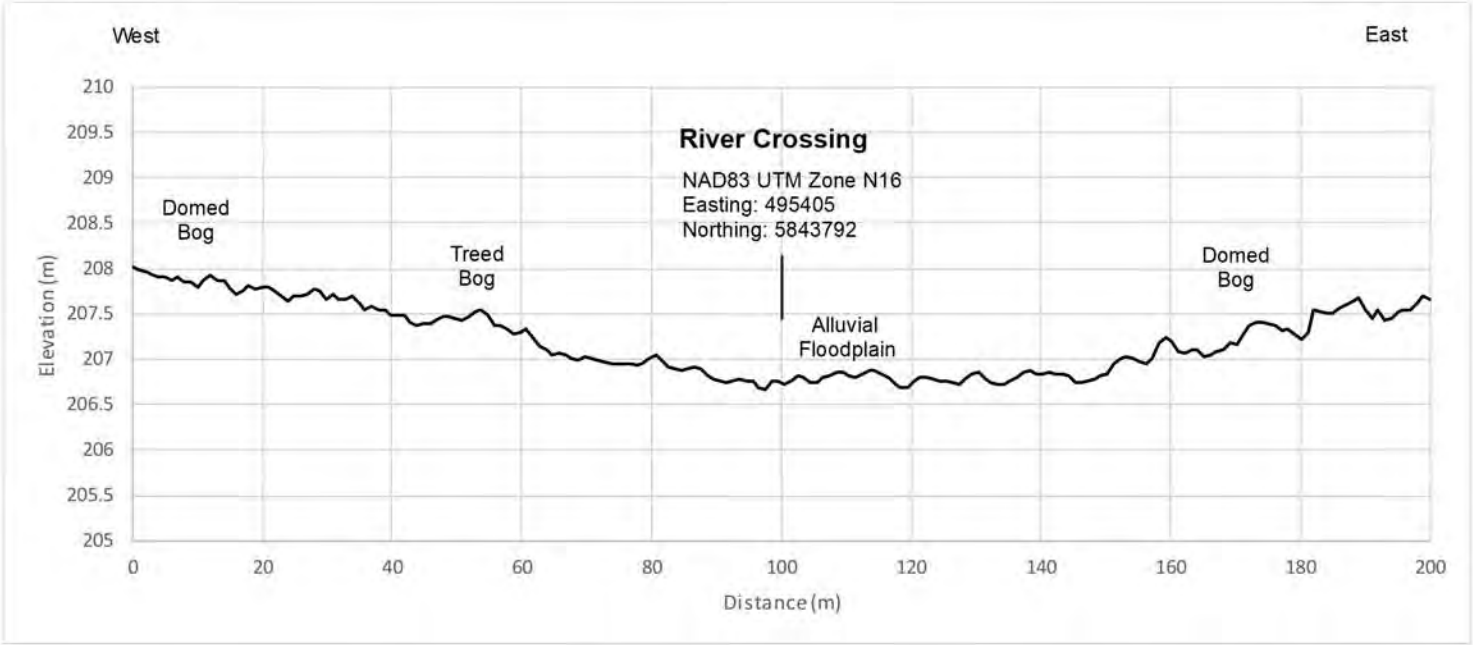


LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

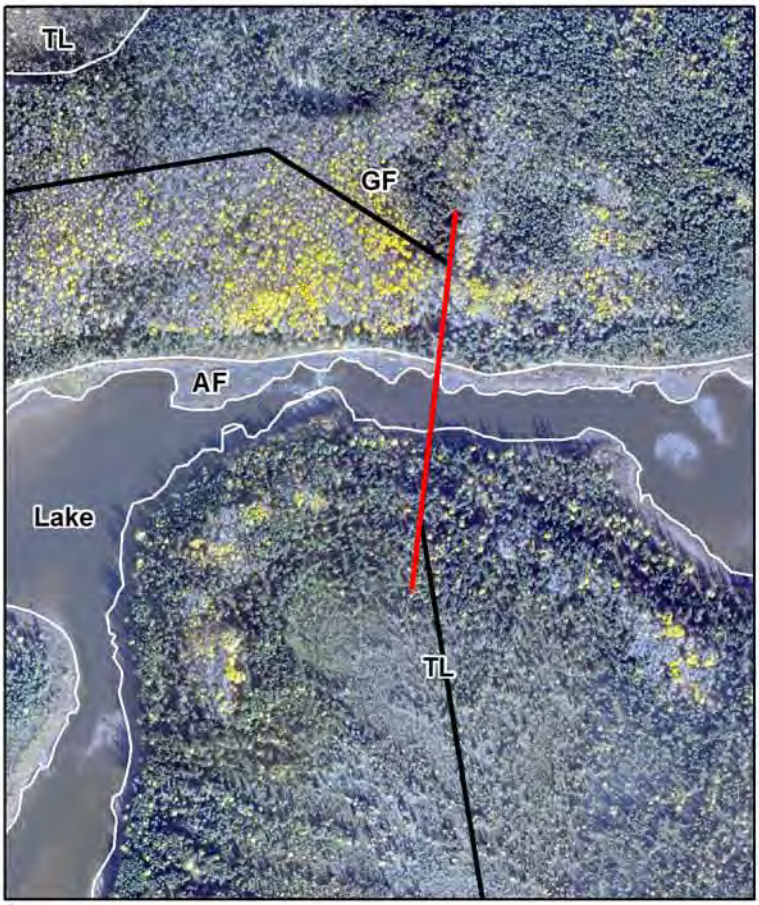
General reference map only; not for survey or legal use.

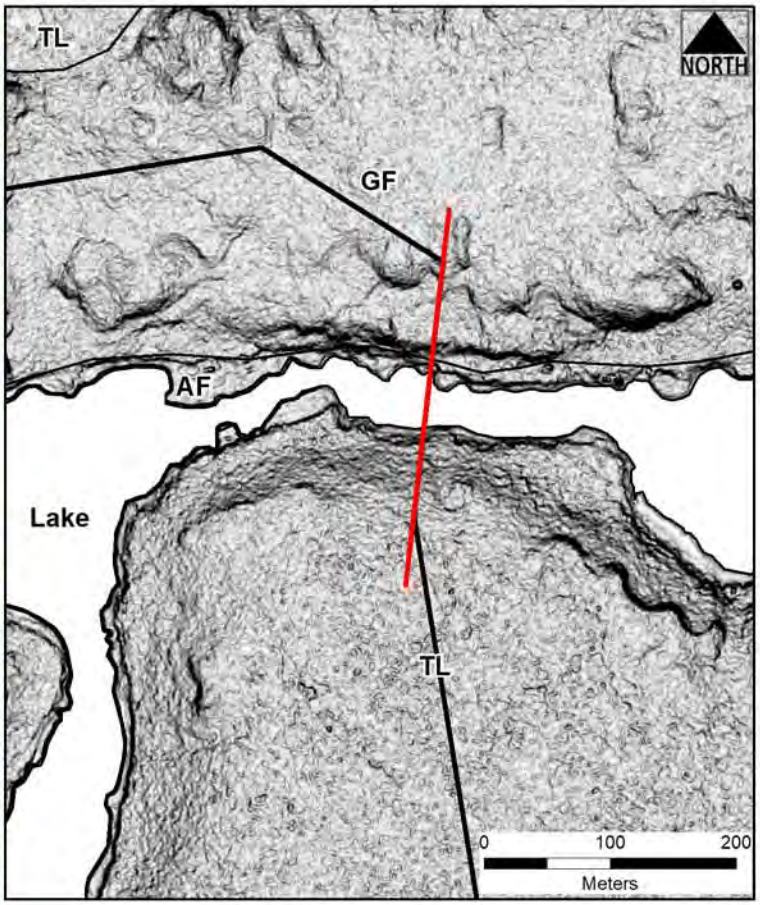
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C20

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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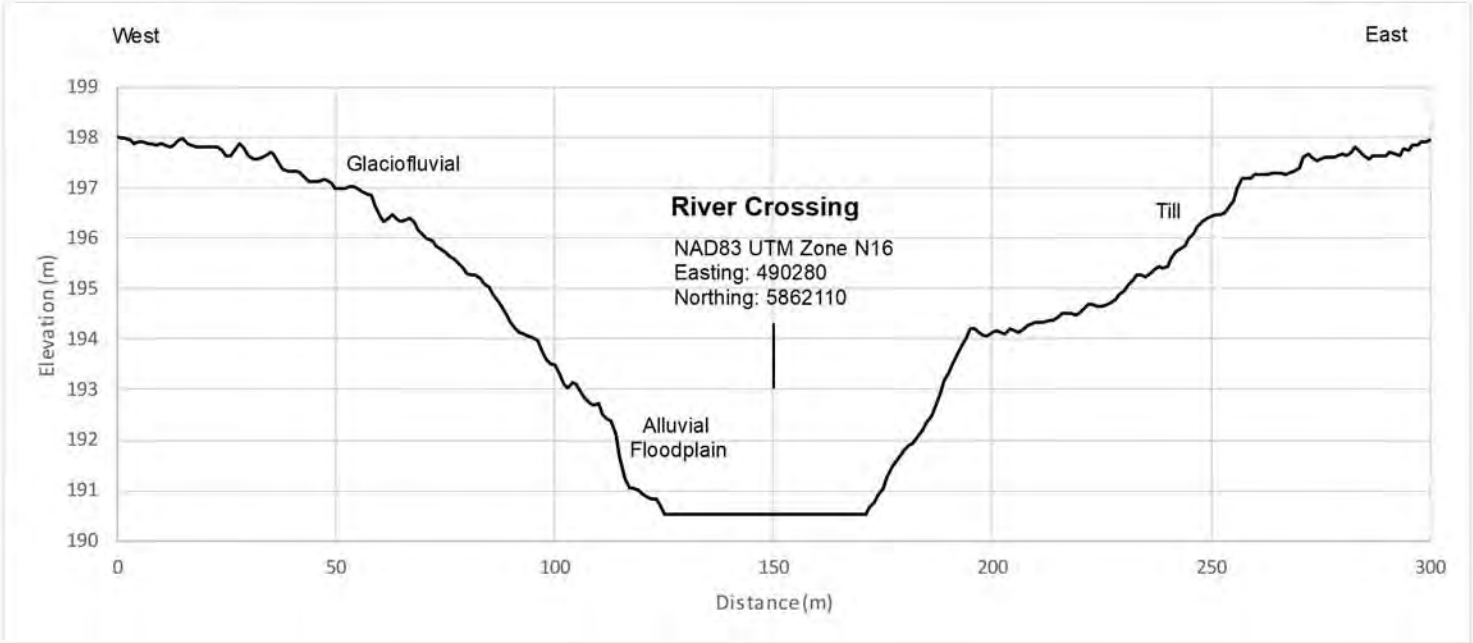
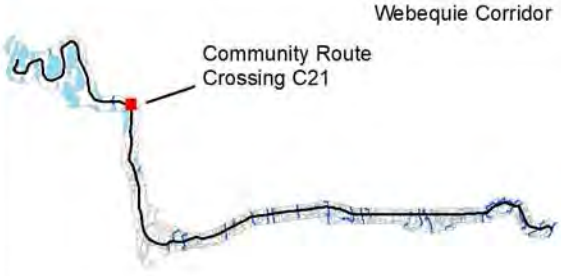




LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

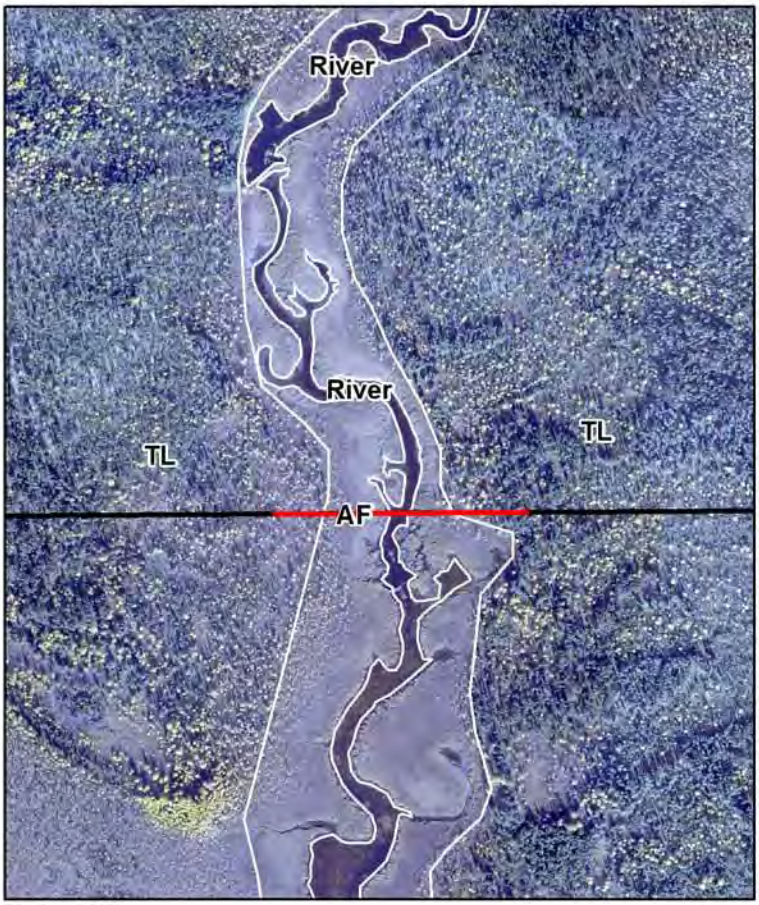
General reference map only; not for survey or legal use.

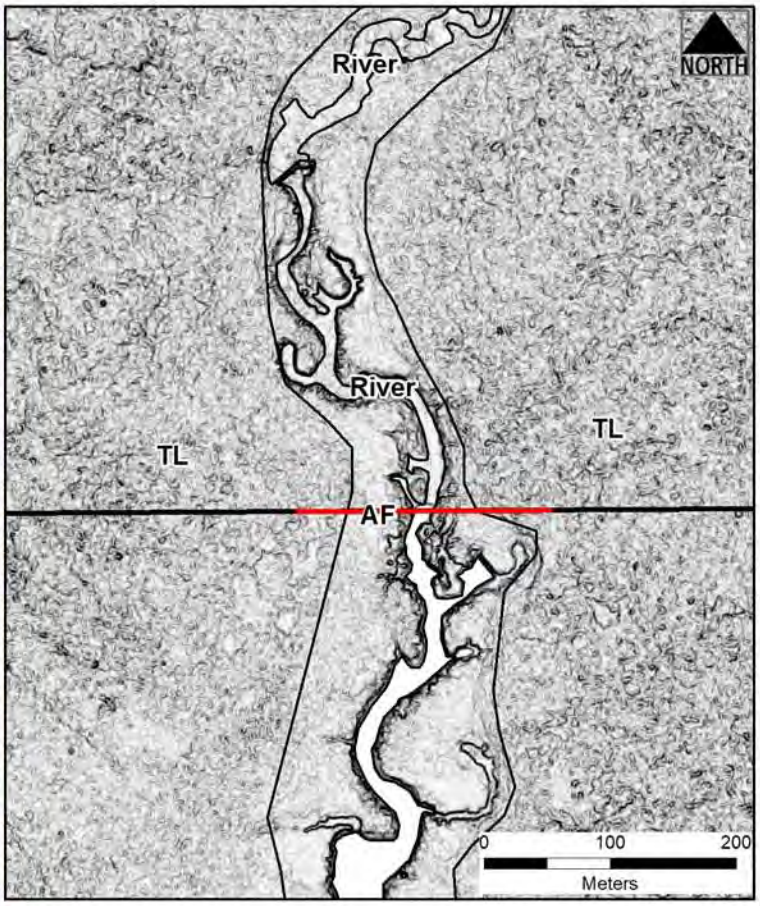
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C21

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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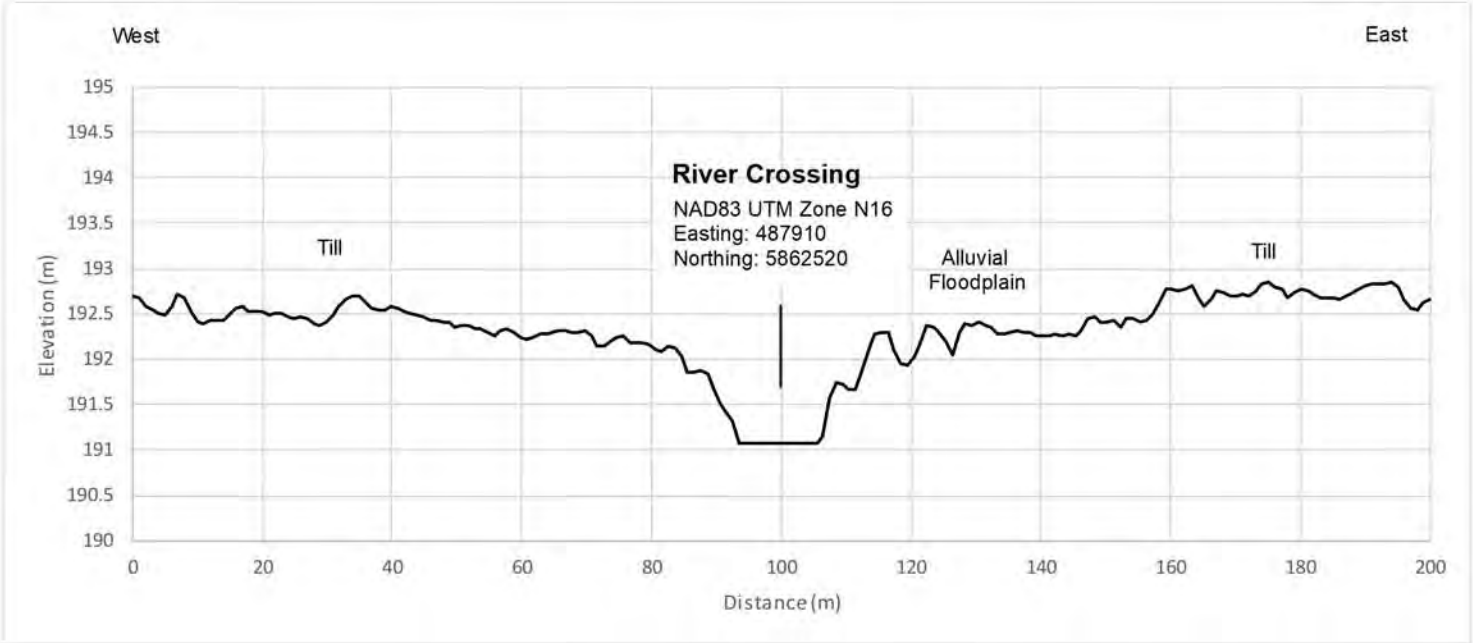

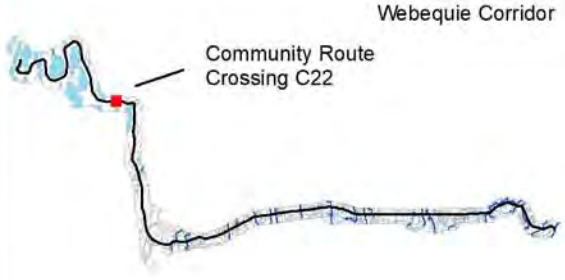

LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C22

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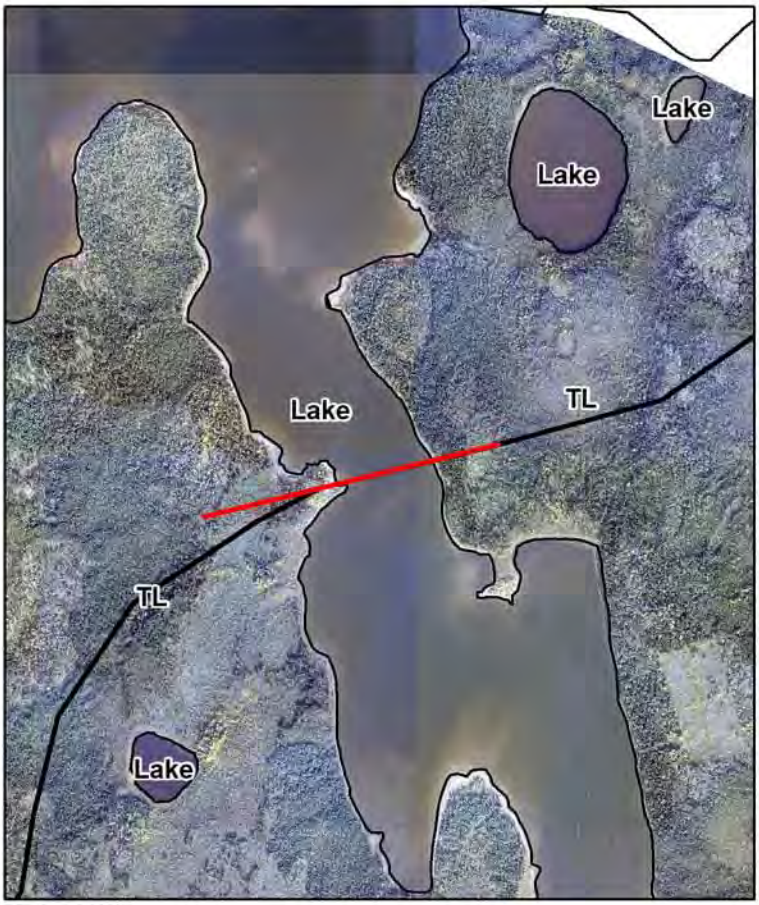
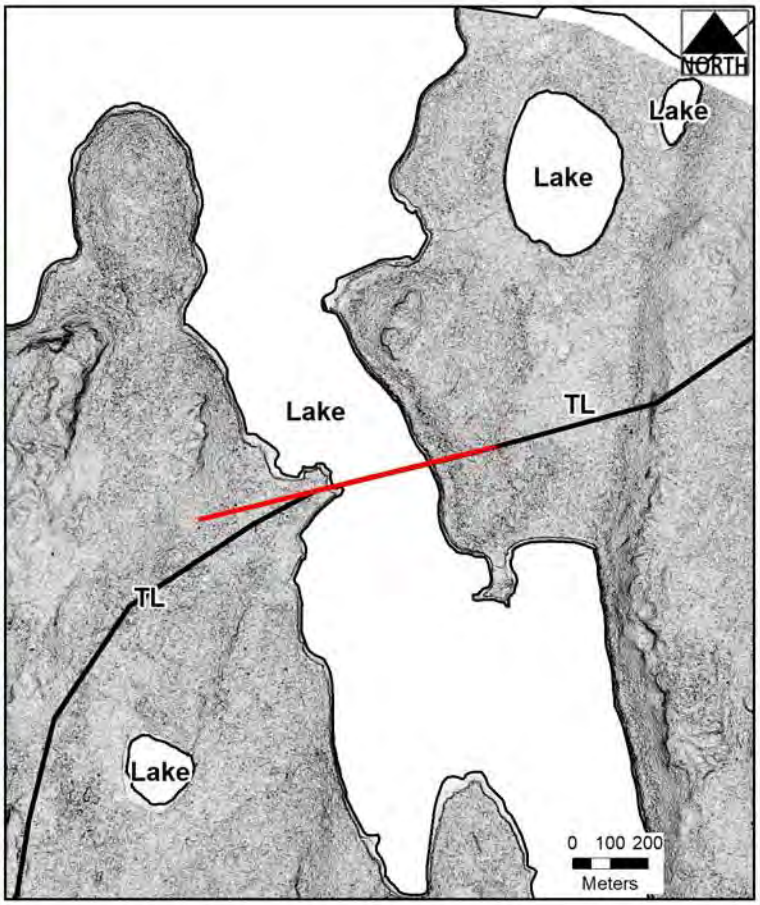
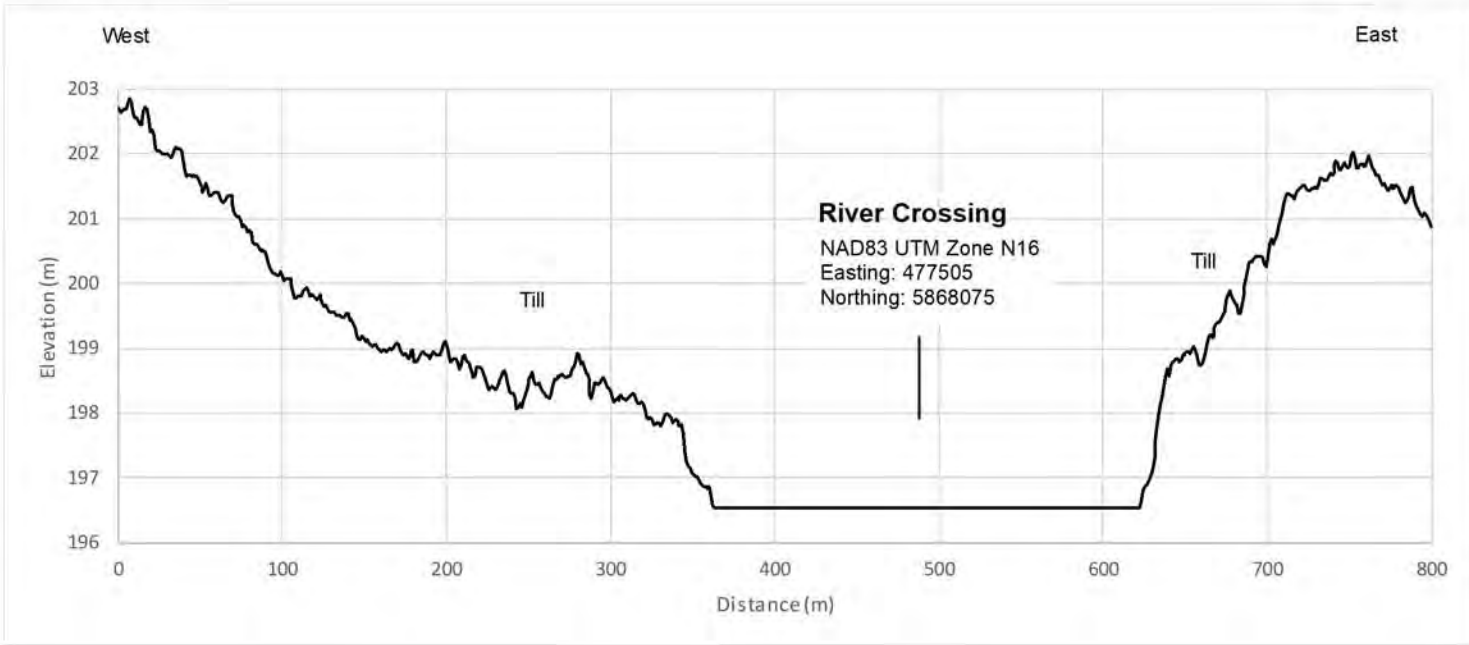
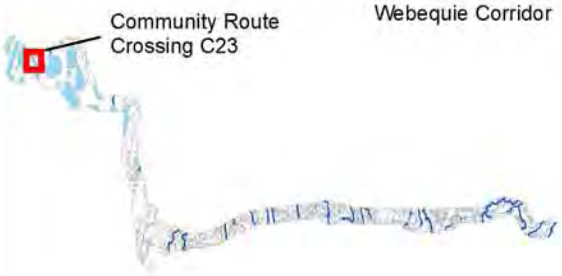




Chainages (Km)





LEGEND:

Community Preferred

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C23

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APPENDIX B

Field Investigation of Peat Thickness and Potential Aggregate Sources

WEBEQUIE SUPPLY ROAD: FIELD INVESTIGATION OF PEAT THICKNESS AND POTENTIAL AGGREGATE SOURCES

DRAFT REPORT

November 8, 2019

Prepared for:

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1 INTRODUCTION

The Webequie First Nation Supply Road Project connects the community of Webequie, located approximately 500 km north of Thunder Bay, with an all-season road to the proposed Ring of Fire mining development around Esker Camp (Figure 1). The road corridor crosses an area of extensive wetlands and organic soils that pose challenges to engineering design and construction. As part of the Environmental Assessment and Preliminary Engineering Services for Webequie First Nation's Supply Road Project, JDMA (2019) conducted terrain mapping within a 2-km-wide route corridor to facilitate selection of an optimal route by evaluating terrain conditions, characterizing stream crossings, and identifying potential aggregate sources.

Based on the initial terrain analysis, JDMA proposed field work with the specific objectives to confirm peat thickness of organic terrains and to evaluate potential aggregate sources.

Organic terrain units (bogs and fens) were mapped over significant portions of the corridor with peat depths estimated to vary from 0.5-5.0 m based on published wetland classifications and previous field work using ground penetrating radar and soil probes at similar sites located outside of the corridor to the south. Given the importance of understanding the organic terrain units for engineering design, JDMA (2019) recommended to confirm peat thickness at several sites, over bogs and fens, using a peat probe to push through the organics and into the underlying mineral soil.

Potential aggregate sources were identified from existing surficial geology maps provided by the Ontario Geological Survey and from terrain analysis using orthoimagery and lidar of the route corridor. Among the potential aggregate sources are granular ice-contact glaciofluvial deposits and bedrock outcrops that may be blasted and crushed. JDMA (2019) recommended digging test pits in the granular deposits to determine the gradation of material and to visit the bedrock outcrops to determine the lithology and structure of the bedrock to assess the potential for crushing.

In September 2019, based on these recommendations, JDMA conducted field studies to measure peat thickness in select organic terrain units and to field test aggregate prospects to assess their potential as material sources. This study provides the results of this field work.

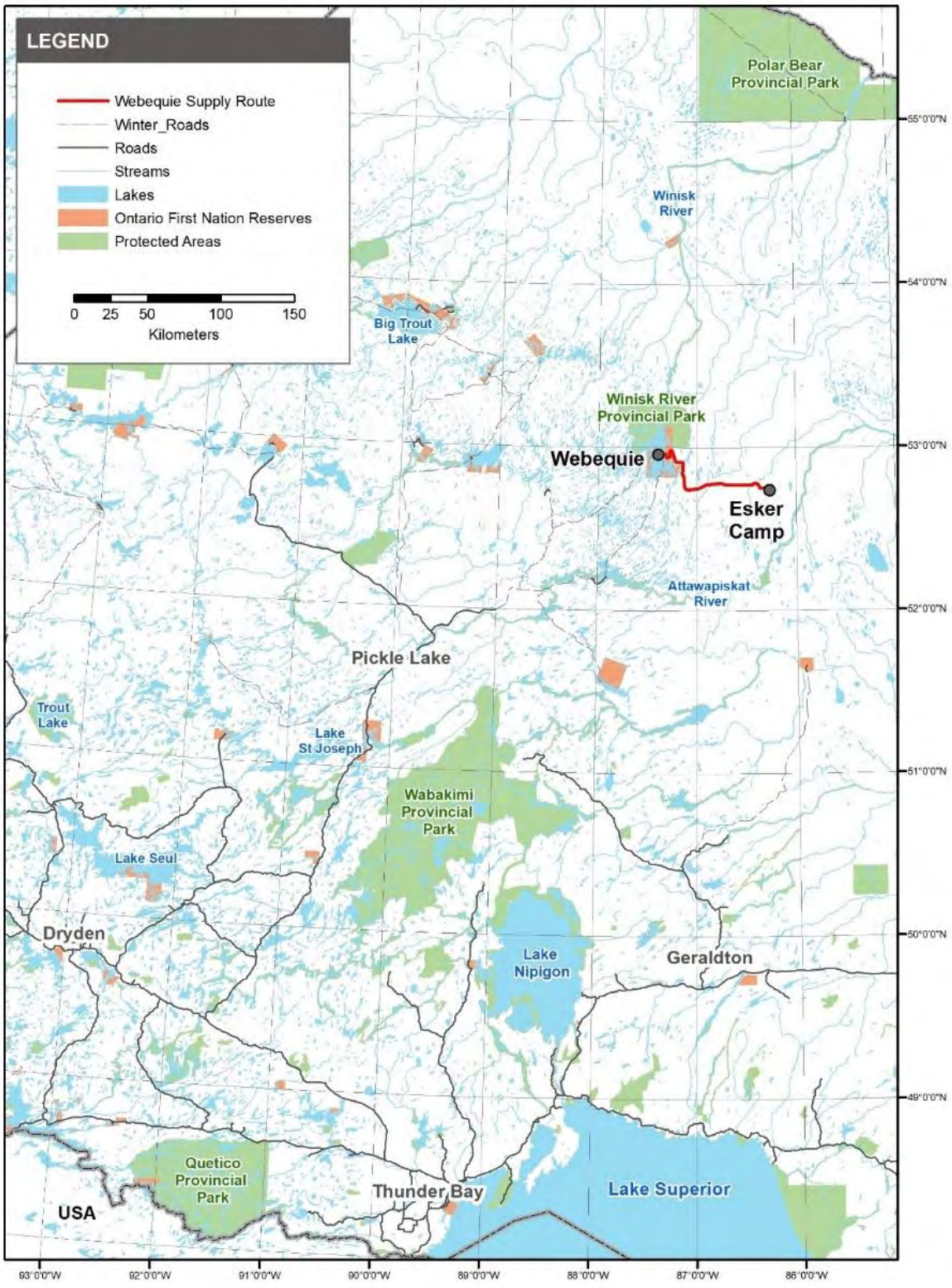


Figure 1: Location of the Webequie First Nation Supply Road Project.

2 METHODOLOGY

2.1 PEAT THICKNESS

Peat thickness was expected to range from 1-5 m depending on the landform or terrain unit based on several data sources: 1) The Canadian Wetland Classification System, University of Waterloo, Wetlands Research Centre, 1997; 2) soil probe data collected previously by JDMA from field sites south of the proposed corridor; and 3) peat depths evaluated by JDMA within the Webequie road corridor using ground penetrating radar in February 2019. During this field trip, several sites were selected to confirm the peat thickness.

Peat thickness was measured using a soil probe that was pushed manually into the organic soils of bogs and fens. Rather than a soil sampler, a rock splitter attachment was fitted to the drive rods to simply penetrate the organics with the intention of reaching the underlying mineral soil. Where the drives would meet resistance, and mineral soil expected, and the splitter would be brought back to surface to check for evidence of mineral soil.

2.2 POTENTIAL AGGREGATE SOURCES

Aggregate prospects for the Webequie Supply Road were summarized by JDMA (2019) based on reviews of existing surficial geology mapping by the Ontario Geological Survey and terrain analysis using digital imagery and lidar within the route corridor. Although most of the route is covered by organic terrain, limited occurrences of ice-contact glaciofluvial landforms and bedrock outcrops offer potential aggregate sources. Among these prospects are ice-contact glaciofluvial landforms created by meltwater processes during deglaciation that are typically composed of sorted granular material. The characteristics of these granular deposits (overburden thickness, stratigraphy, gradation, *etc*.) was evaluated from shallow test holes dug with either a mini-excavator or manually with a shovel. Where access and timing allowed, the mini-excavator was brought in to dig test pits to a depth of about 2 m. At other locations, where logistical challenges restricted slinging in the mini-excavator, test holes were dug manually to a depth of 30-90 cm.

Bedrock outcrops identified and mapped as potential quarry sites were visited in the field to describe the lithology and structural elements (fractures, bedding, foliation, *etc*.) visible at surface to make an initial assessment of bedrock suitability for aggregate production.

3 RESULTS

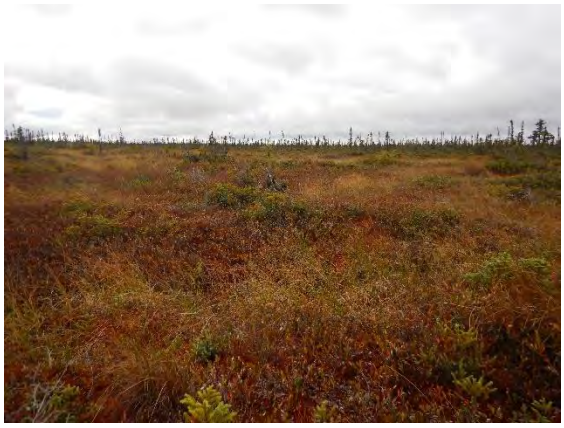
3.1 PEAT THICKNESS

Table 1 provides sample locations and peat thickness measurements. Peat thickness was measured at several sites over 5 areas. Figure 2 provides a map of the sample areas, while Figures 3-7 provide photographs of the specific sampling sites. At most of the sample locations, the peat probe penetrated the organic material and stopped in clay-rich mineral soil, which was evidenced by a smear of clay on the sampling probe head. Where clay was encountered, peat thickness ranged from 1.2 to 3.6 m. At sample sites C2 and C3, located on a bog near the margin of a fen, the soil probe was stopped at a depth of 2.5 m in the organic material without encountering a bottom in mineral soil. Similarly, a mineral soil was not encountered at sample location C11, located on the edge of an extensive fen. Here, the sampling probe was stopped at a depth of 4.3 m, presumably by organic matter as no clay was observed on the sampling head.

Table 1: Location of peat thickness probes.

ID	Easting	Northing	Depth	
Area 1				
C1	497666	5844355	1.2 m	Bog: clay bottom
C2	497699	5844201	2.5 m	Bog near margin of fen: no bottom encountered
C3	497679	5844202	2.5 m	Bog near margin of fen: no bottom encountered
Area 2				
C4	512767	5847526	3.6 m	Bog: grey clay bottom
C5	512745	5847332	3.6 m	Bog: grey clay bottom
C6	512773	5847656	2.5 m	Fen: grey clay bottom
Area 3				
C7	522602	5847044	2.5 m	Fen: grey clay bottom
C8	522684	5846921	1.8 m	Bog: grey clay bottom
C9	522528	5846941	1.8 m	Bog: grey clay bottom
Area 4				
C10	531218	5846471	3.2 m	Bog: grey clay bottom
C11	531027	5846413	4.3 m	Fen: no bottom encountered
Area 5				
C12	545188	5844770	1.2 m	Bog: grey clay bottom
C13	545176	5844810	1.2 m	Bog: grey clay bottom

Figure 2: Location of peat probes.



C1: Bog with 1.2 m of peat over clay

C2 and C3: Bog near margin of a fen, with 2.5 m of peat and no mineral soil encountered.

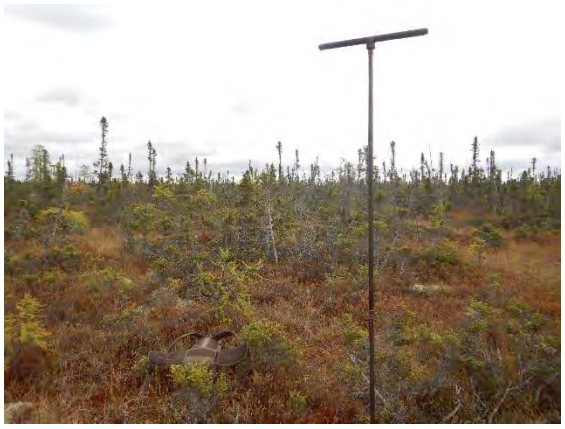
Figure 3: Peat probing at Area 1.

C4 and C5: Bog with 3.6 m of organic matter over clay.

C6: Fen with 2.5 m of organics matter over clay.

Figure 4: Peat probing at Area 2

C6: Fen with 2.5 m of organic matter over clay



C8: Bog with 1.8 m of organic matter over clay.

C9: Bog with 1.8 m of organic matter over clay.

Figure 5: Peat probing at Area 3.

C10: Bog with 3.2 m of peat over clay.

C11: Fen with 4.3 m of organic matter and no mineral bottom encountered.

Figure 6: Peat probing at Area 4.

C12: Bog with 1.2 m of organic matter over brown clay.

C13: Bog with 1.2 m of organic matter over brown clay.

Figure 7: Peat probing at Area 5.

3.2 POTENTIAL AGGREGATE SOURCES

Potential aggregate sources tested in the field include 6 ice-contact glaciofluvial landforms and 5 bedrock locations, as summarized in Table 2 and shown on Figure 8.

Along the western section of the route, there are multiple, small, discontinuous, ice-contact glaciofluvial deposits trending generally north-south, including to the west and north of Farrow Lake and northward along the eastern side of Manson Bay on Winisk Lake. Test pits TP19-01, TP19-02, TP19-09, and TP19-10 targeted these glaciofluvial features. TP19-03 is located well to the south and was not visited on the ground during this field work, but descriptions of the site are provided in previous work (Volume 2 EIS/EA report B216).

Near the middle of the route, where glaciofluvial landforms were not mapped, four test sites were visited (TP19-04, TP19-05, TP19-08, and TP19-11) where bedrock exposure had been mapped previously by the Ontario Geological Survey or had been identified from imagery and lidar in the terrain mapping (JDMA, 2019).

Near the eastern end of the route, two test sites (TP19-06 and TP19-07) were visited based on indications of surficial expressions of glacial sediments and bedrock. The large esker complex on the west side of the Mukutei River, near Esker camp, is among the largest granular prospects in the region and was selected for testing by the drilling crew.

Table 2: Location of aggregate testing sites.

ID	Easting	Northing	Mapped Unit	Observed Material
TP19-01	482271	5867792	Glaciofluvial Deposits	Sand and Gravel
TP19-02	490185	5862355	Glaciofluvial Deposits	Sand and Bedrock
TP19-03*	485425	5840765	Glaciofluvial (Volume 2 EIS/EA report B216)	N/A
TP19-04	507989	5845403	Bedrock	Till
TP19-05	508128	5847803	Bedrock	Till and Bedrock
TP19-06	537987	5848399	Glaciofluvial Deposits + bedrock	Silt
TP19-07	541253	5847878	Bedrock	N/A
TP19-08*	513429	5841840	Bedrock (Volume 2 EIS/EA report Q245S)	Bedrock
TP19-09	489236	5857600	Glaciofluvial Deposits	Sand
TP19-10	485640	5853170	Glaciofluvial Deposits	Sand and Gravel
TP19-11	514998	5847294	Bedrock	Gravel

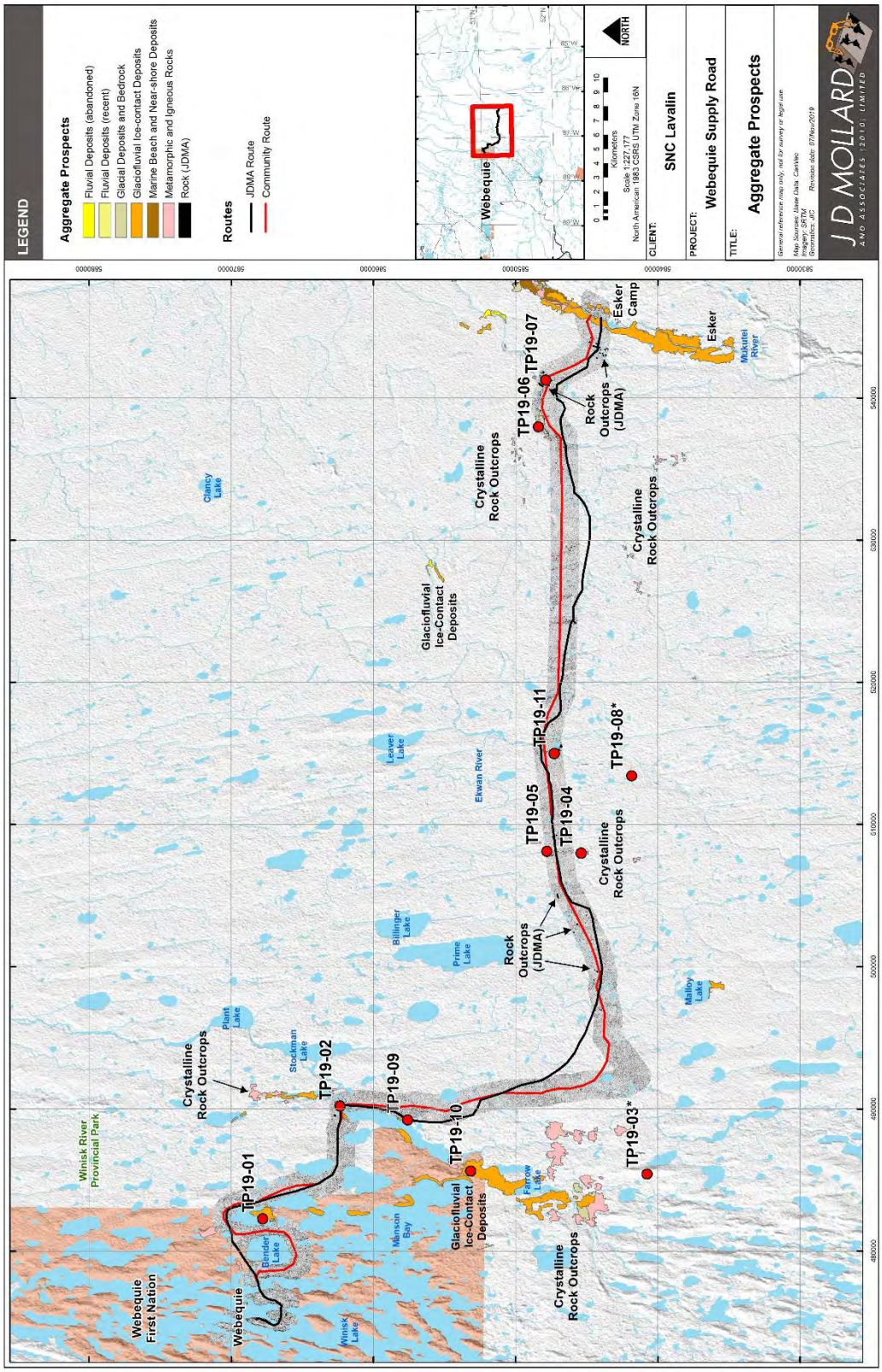


Figure 8: Location of aggregate potential sources.

TP19-01

Test pit site TP19-01 was chosen at the existing/abandoned gravel pit located east of Webequie (Figure 9). The deposit occurs as a discreet landform that is part of the discontinuous esker running north-south along the side of Manson Bay. There is an access road that is currently overgrown with vegetation, but this would provide ready access to the proposed community road (located about 600 m to the west) where it wraps around the south end of Bender Lake. Three test pits were dug at this site: 1) at the bottom of the pit to assess the remaining material (Figures 10-14); 2) at the western edge of the pit near the outlet to the access road (Figures 15-17); and 3) at the southern side of the pit into the south pit face (Figures 18-20).

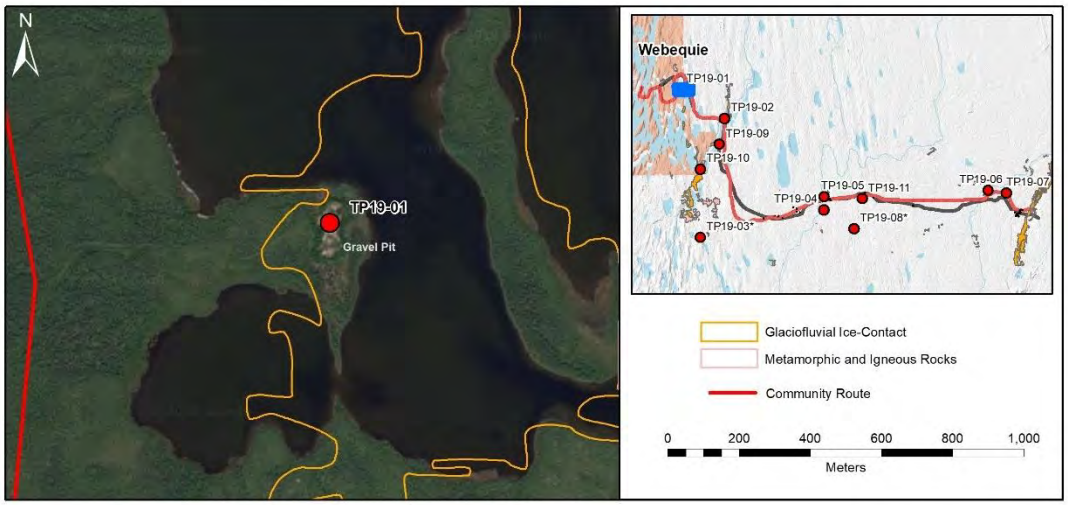


Figure 9: Location of TP19-01

Site 1: Bottom of Pit (482274E, 5867791N)

0.0-1.0 m: SAND

Medium to coarse sand, trace fine gravel, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, homogeneous, not cemented. No topsoil or overburden. (Sample #1; Figure 10)

1.0-1.5 m: GRAVEL

Fine gravel to coarse sand, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, weakly stratified, not cemented, gravel clasts of crystalline igneous rock and shale up to 30 mm. Water table at 1.3 m. (Ice contact glaciofluvial).

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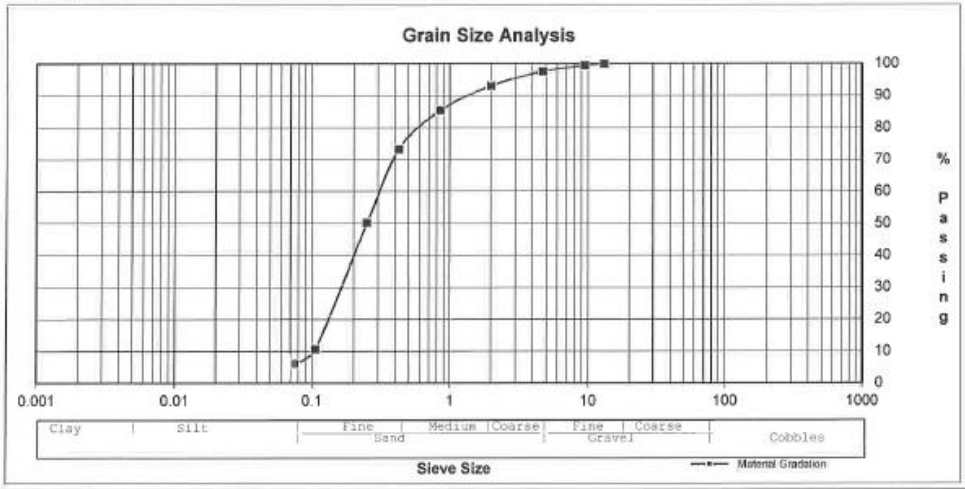
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1670
	Webequie Supply Road	B.H./T.P. No.:	TP19-01
Report to:	Muhammad Saleem	Sample No.:	#1 Site 1 Bottom Pit
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	99.5
4.75 mm	97.6
2.00 mm	93.0
.850 mm	85.3
.425 mm	73.2
.250 mm	50.1
.106 mm	10.7
.075 mm	6.1



% Gravel	2.4		
% Sand	91.5	Natural Moisture Content:	12.8%
% Silt & Clay	6.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 10: TP19-01 (Bit Bottom) Gradation

Figure 11: TP19-01 existing pit

Figure 12: Bottom of existing gravel pit.

Figure 13: Trench at bottom of existing pit returned sand to depth of 1.5 m.

Figure 14: Test pit filled in and smoothed after completion.

Site 2: East side of pit near access road (482237, 5867790)

0.0-1.2 m: GRAVEL

Fine to medium gravel with coarse sand matrix, gap graded, loose, rounded and equidimensional gravel clasts, light brown, moist, stratified with a 30 cm layer of coarse to medium sand, not cemented, gravel clasts of crystalline igneous rock up to a maximum clast size of 80 mm. (Ice contact glaciofluvial). (Sample #2)

1.2-1.5 m: CLAY

Clay, silty, low plasticity, firm, light grey, homogeneous, weakly compacted, unoxidized, no foreign materials, no odour. Water table at 1.3 m.

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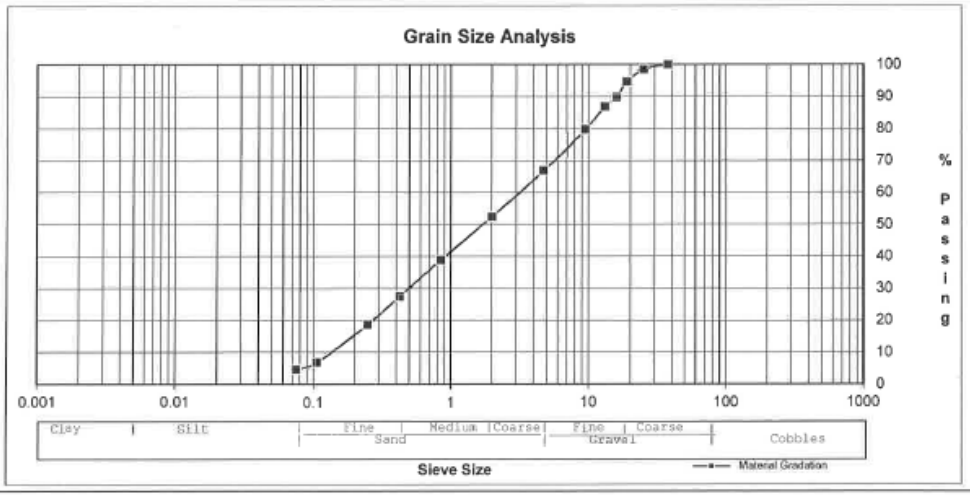
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1671
	Webequie Supply Road	B.H./T.P. No.:	TP19-01
Report to:	Muhammad Saleem	Sample No.:	#2 Site 2
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	98.4
19.0 mm	94.7
16.0 mm	89.7
13.2 mm	87.0
9.5 mm	79.6
4.75 mm	66.8
2.00 mm	52.4
.850 mm	38.9
.425 mm	27.5
.250 mm	18.8
.106 mm	6.8
.075 mm	4.6



% Gravel	33.2		
% Sand	62.2	Natural Moisture Content:	6.5%
% Silt & Clay	4.6	Soil Classification:	SP

Remarks: Test Method LS 602, 701/ASTM C136, D2216

CCIL & CSA Certified

R10520-Rev.0603

Figure 15: TP19-01 (Site 2) gradation.

Figure 16: Test pit at west side of existing pit.

Figure 17: Test pit filled in and smoothed after completion.

Site 3: South side of pit (482267, 5867693)

0.0-1.8 m: GRAVEL

Fine to medium gravel with coarse sand matrix, gap graded, loose, rounded and equidimensional gravel clasts, brown, moist, homogeneous to weakly stratified, not cemented, gravel clasts of crystalline igneous rock, maximum size of 70 mm.

Figure 18: Gravel on the south pit face.

Figure 19: Pit face on south side of existing gravel pit.

Figure 20: Gravel and coarse sand in the pit face on the south side of existing pit.

TP19-02

Test pit site TP19-02 is located north of the stream crossing between Webequie and Stockman Lake (Figure 21). Aggregate sources mapped by the Ontario Geological Society include both ice-contact glaciofluvial deposits and bedrock at this location, which are within 100 m from the proposed routes and offer short haul distances. Bedrock exposures (490178 5862361) were observed from the air and were accessed from the stream channel. Crystalline igneous outcrop composed of granitic to pegmatitic composition, massive and unfractured (Figure 23-24). Ice-contact glaciofluvial deposits of sand surround the bedrock outcrop, into which two test pits were dug (Figures 25-28).

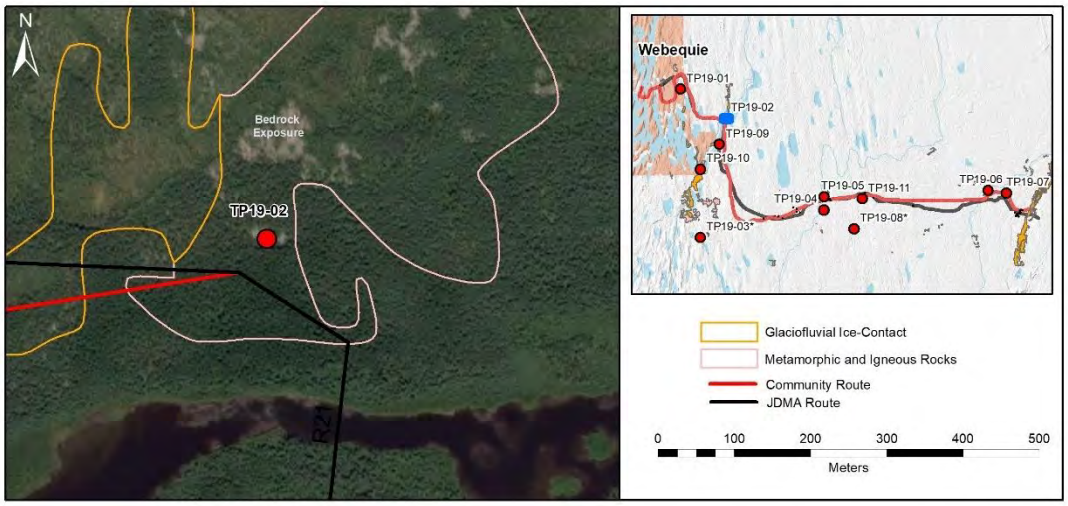


Figure 21: Location of TP19-02.

Site 1 (490175 5862389):

0.0-1.8 m: SAND

Medium to coarse sand, trace fine gravel, uniformly graded, loose, light brown, moist, homogeneous, not cemented. Organic horizon and topsoil approximately 15 cm thick. (Ice contact glaciofluvial). (Sample #3; Figure 22).

Site 2 (490187 5862337):

0.0-2.0 m: SAND

Medium to coarse sand, trace fine gravel, uniformly graded, loose, light brown, moist, homogeneous, not cemented, oxidized from 1.8-2.0 m. Organic horizon and topsoil approximately 15 cm thick. (Ice contact glaciofluvial).

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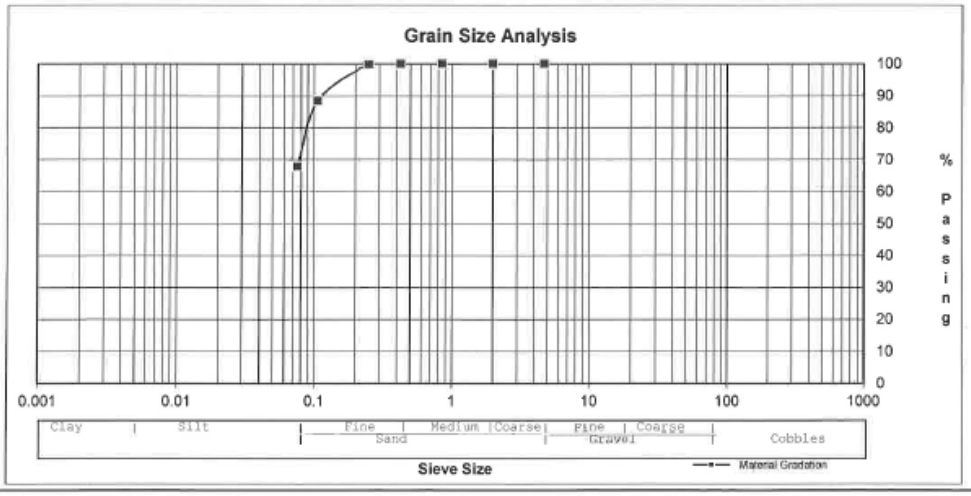
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1672
	Webequie Supply Road	B.H./T.P. No.:	TP19-02
Report to:	Muhammad Saleem	Sample No.:	#3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	100.0
.850 mm	100.0
.425 mm	99.9
.250 mm	99.7
.106 mm	88.5
.075 mm	68.0



% Gravel	0.0		
% Sand	32.0	Natural Moisture Content:	11.6%
% Silt & Clay	68.0	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 22: TP19-02 (Site 1) gradation

Figure 23: Crystalline igneous bedrock exposure.

Figure 24: Bedrock exposure beneath moss cover.

Figure 25: TP19-02 Site 1.

Figure 26: TP19-02 Site 1 backfilled and smoothed.

Figure 27: TP19-02 Site 2.

Figure 28: TP19-02 Site 2. Note iron staining from bottom of test pit.

TP19-04

Test pit site TP19-04 (Figure 29) targeted bedrock mapped by the Ontario Geological Survey. Access to the site was from the nearby stream as tree cover prevented the helicopter from landing on the feature. Despite being mapped as a bedrock feature, no bedrock was encountered along a transect across the feature. In several places where tree cover thinned, the ground was covered with white moss that gives the appearance of bedrock in the imagery and in the air from the helicopter (Figure 30). On the ground, however, these areas exhibited scattered boulders at surface set within a clay till. Small test pits dug with a shovel revealed a brown clay till beneath the moss (Figure 31-33).

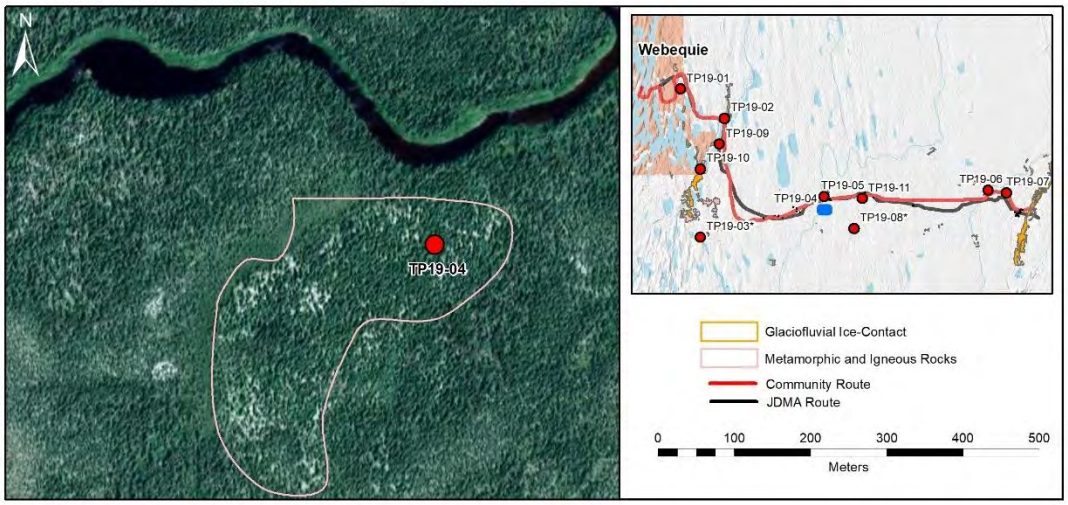

Figure 29: Location of TP19-04.

Site 1 (508053 5845458)

TILL: Clay, high plasticity, firm, brown, drier than plastic limit, homogeneous, no dilatancy, clasts of cobble to boulder size, rounded, crystalline igneous composition.

Site 2 (507891 5845258)

TILL: Clay, high plasticity, firm, brown, drier than plastic limit, homogeneous, no dilatancy, clasts of cobble to boulder size, rounded, crystalline igneous composition.

Figure 30: Location of TP19-04 from above.

Figure 31: Brown till at TP19-04.

Figure 32: Clay till at TP19-04

Figure 33: TP19-04

TP19-05

Test pit site TP19-05 is located on an area mapped as bedrock by the Ontario Geological Survey (Figure 34). The feature occurs as a small hill or upland along the eastern side of a small stream and is entirely covered with trees. Access to the site is from the banks of the small stream. Along the western side of the feature, leading down toward the stream, there is an accumulation of large boulders up to several metres in diameter (Figure 35). From the imagery and from the helicopter, these boulders appear as bedrock, but they are not *in situ* and are not embedded in a fine-grained matrix. Based on their large size and angular shape, these boulders were likely transported very short distances from their source and suggest *in situ* bedrock in close proximity. Adjacent to the boulders, the area is covered by clay till (Figure 36).

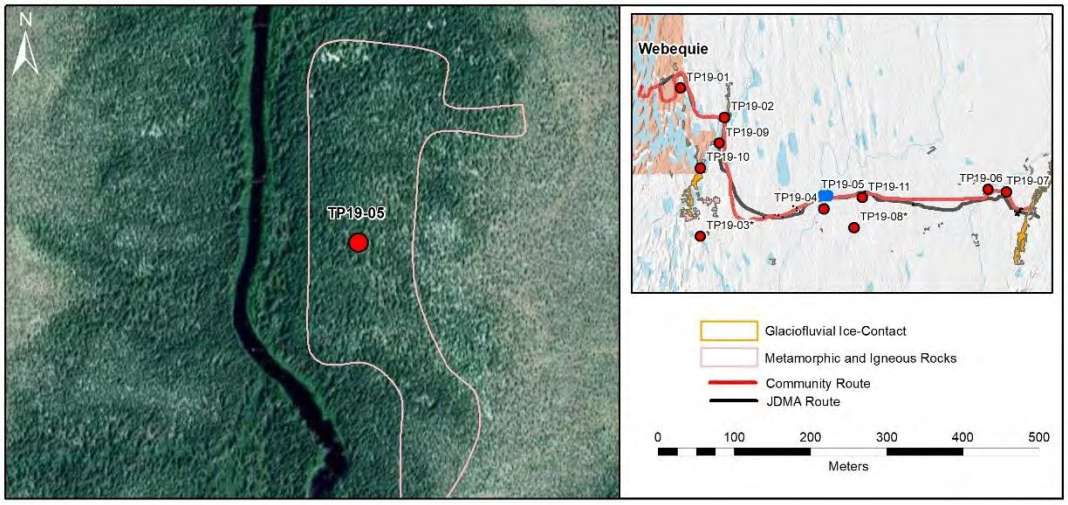

Figure 34: Location of TP19-05.

Site 1 (508071 5847795):

BOULDERS: crystalline, felsic igneous rock, massive, homogeneous. Irregular and angular faces on the boulders suggest minimal transport and close proximity to the *in situ* bedrock source.

Site 2 (508197 5847852):

TILL: Clay, high plasticity, firm, brown, near plastic limit, homogeneous, no dilatancy, clasts of cobble to boulder size, rounded, crystalline igneous composition.

Figure 35: Boulders of felsic plutonic rock.

Figure 36: Brown clay till at surface across the test site.

TP19-06

Test pit site TP19-06 is located on an area mapped as a unit of glacial deposits and bedrock by the Ontario Geological Survey (Figure 37). Along the eroding banks of the adjacent stream channel to the south, mineral soils are observed from the air. Access to the site was from the bog to the north. Two test pits were dug at this location: 1) along the margin of the bog where it transitioned to the forest (Figure 38-39) and 2) within the forest and along a ridge close to the banks of the adjacent stream channel (Figures 40-42).

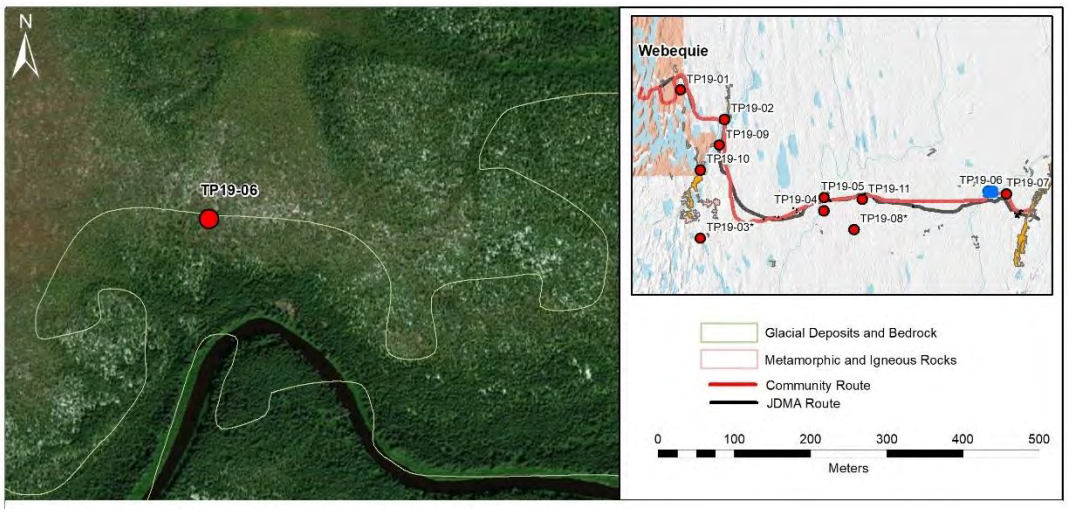

Figure 37: Location of TP19-06.

Site 1 (537989 5848403):

0.0-1.2 m: ORGANICS

1.2-1.4 m: CLAY

Clay, plastic, firm, light grey, homogeneous, unoxidized, no foreign materials, organic odour. Water table at 0.7 m.

Site 2 (538025 5848291):

0.0-0.2 m: ORGANICS

0.2-0.6 m: SILT

Silt, clayey, low plasticity, firm, light brown, laminated, fissile, unoxidized, no foreign materials, organic odour. Water table at 0.7 m.

Figure 38: Organic matter at TP19-06 Site 1.

Figure 39: Clay bottom of TP19-06 Site 1.

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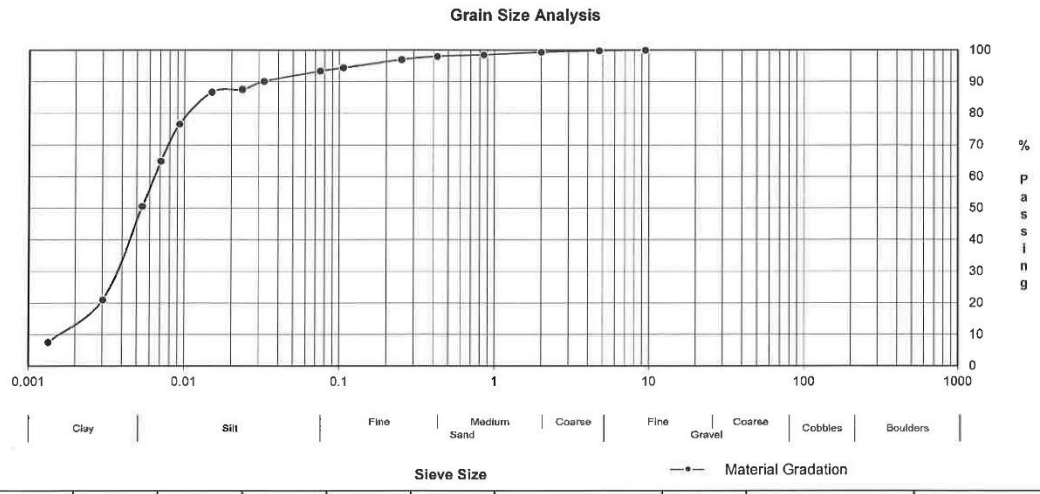
Particle Size Analysis of Soil By Hydrometer

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1673
Location:	Webequie Supply Road	Sample Location	TP19-06 Sample # 4
Report To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0			
37.5		0.032512	90.1
25.0		0.023465	87.6
19.0		0.014939	86.7
13.2		0.009283	76.6
9.5	100.0	0.007068	64.9
4.75	99.8	0.005399	50.5
2.00	99.4	0.003027	21.1
0.850	98.5	0.001333	7.6
0.425	98.0		
0.250	97.0	5 µm	44.0
0.106	94.5	2 µm	18.0
0.075	93.5		



%Gravel	0.2	% Silt	85.9	% NMC	19.1	Frost Heave Susc.		Material Suitability	
% Sand	6.4	% Clay	44.0	PI	NP	Erodibility (k)		Soil Classification	ML

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

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Figure 40: TP19-06 (Site 1) gradation.

Figure 41: Site 2 at TP19-06.

Figure 42: Clayey silt at TP19-06.

TP19-07

Test pit site TP9-07 was targets an area mapped as bedrock by the Ontario Geological Survey (Figure 43). The area was visited only from the air and not on the ground. Visual inspection from the helicopter did not identify bedrock outcrops; rather, most of the area is covered with thin tree cover and white moss that mimics bedrock in the imagery (Figures 44-45). Although no outcrops of bedrock were observed, it is possible that there is bedrock along the margins of the nearby streams where tree cover may obscure exposure. Along the banks of the nearby stream to the north, eroding mineral soil is exposed and no bedrock is observed.

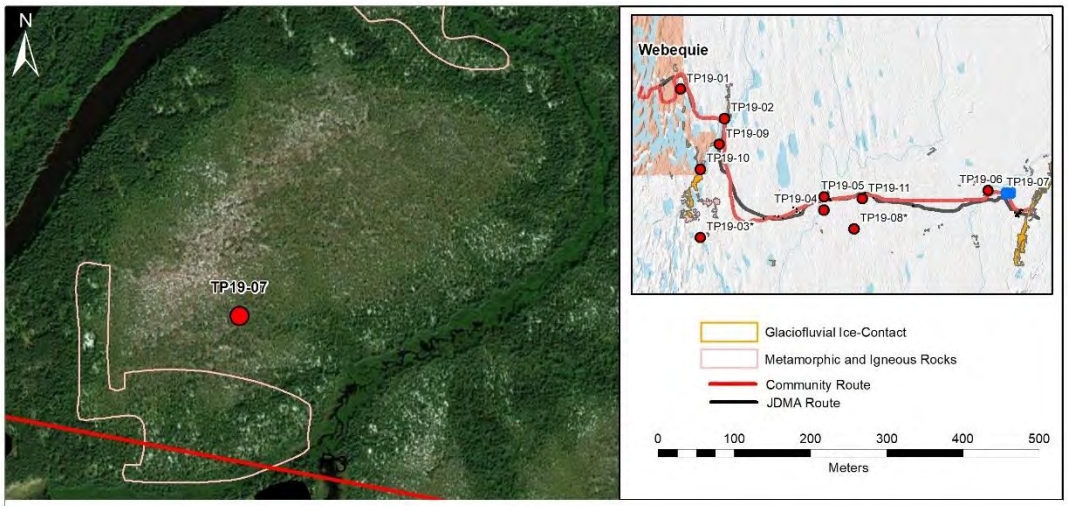

Figure 43: Location of TP19-07.

Figure 44: Eroding mineral banks near TP19-07.

Figure 45: Extensive white moss over TP19-07.

TP19-08

Test pit site TP19-08 (Figure 46) is located south of the community route and near an area of bedrock exposure described previously as bedrock (Volume 2 EIS/EA report Q245S). The site was visited from the air only. Visual inspections from the helicopter reveal a relatively large hill covered with trees that include stands of aspen that are often associated with glacial sediments or areas of bedrock (Figures 47-48). Much of the area appears to have white moss on the surface that obscure the identification of surficial materials. However, exposures of bedrock were observed in the general area, including areas to the west and east. The large fen to the west also exhibits large boulders in the centre and along the margins.

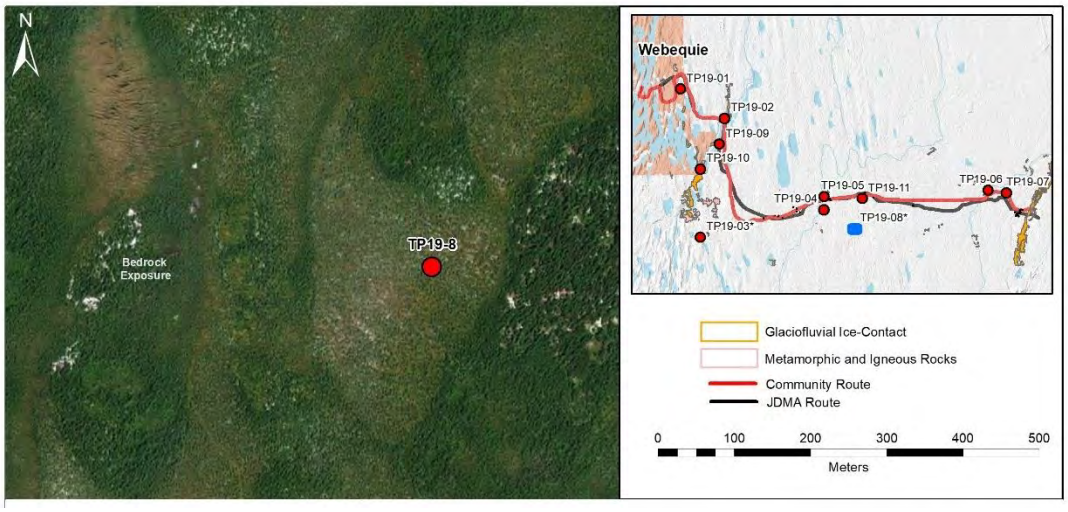

Figure 46: Location of TP19-08.

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Figure 47: TP19-08 from above.

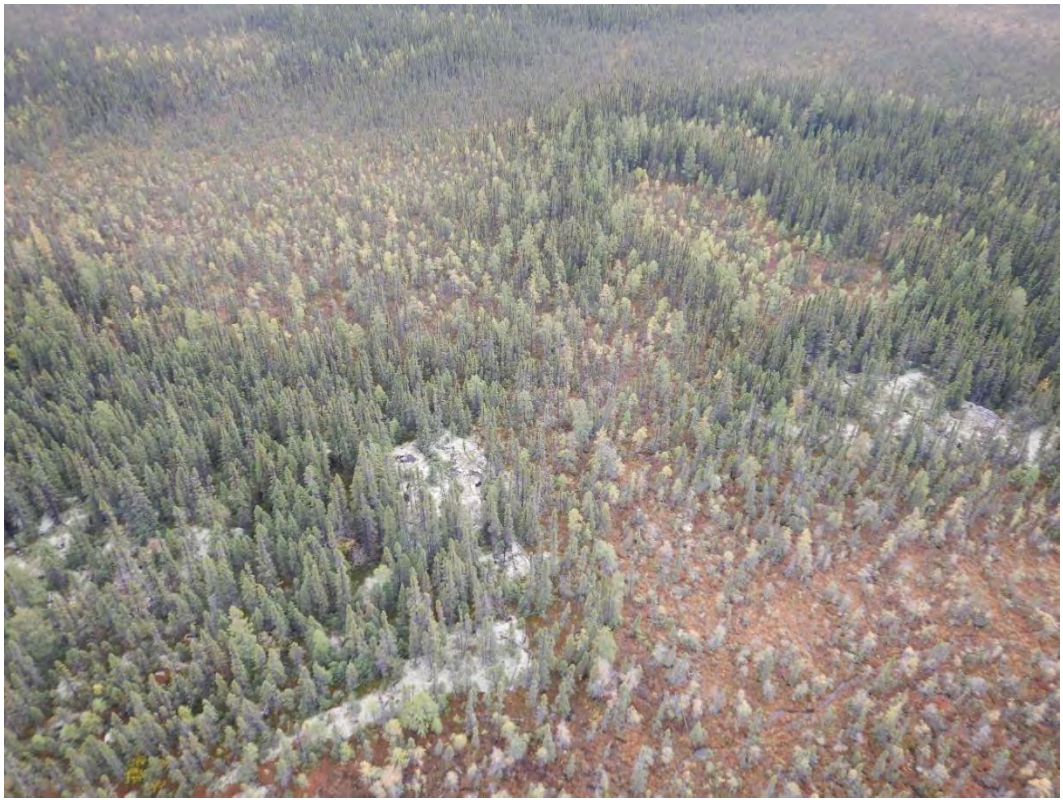

Figure 48: TP19-08 showing bedrock.

TP19-09

Test pit site TP19-09 was selected to test an area mapped as an ice-contact glaciofluvial deposit by the Ontario Geological Survey (Figure 49). Access to the site was from the east shore of lake to the west. This prospect is crossed by the JDMA proposed route and is approximately 1 km from the Community route, which limits the haul distance for construction. Two sites were tested using a shovel. The first site is located on the first ridge that rises above the lake while the second site is farther inland and higher on the topographic ridge (Figures 50-54).

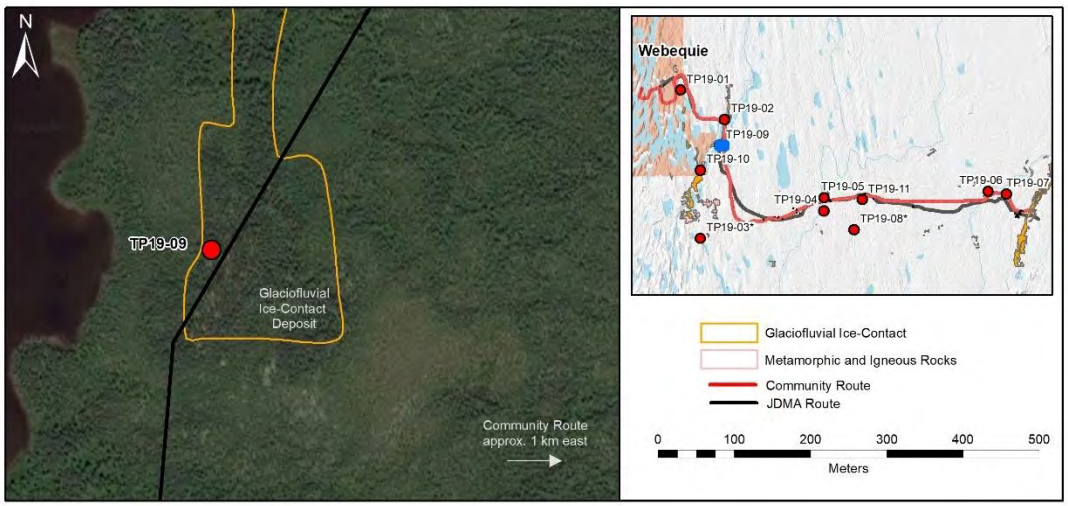

Figure 49: Location of TP19-09

Site 1 (489124 5857897)

0.0-0.4 m: SAND

Coarse sand, some fine to medium gravel, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, homogeneous, not cemented, gravel clasts up to 25 mm. Thin topsoil and no overburden.

Site 2 (489254 5857591)

0.0-0.5 m: SAND

Medium sand, trace fine gravel, uniformly graded, loose, light brown, moist, homogeneous, not cemented, oxidized upper 20 cm, thin topsoil and no overburden.

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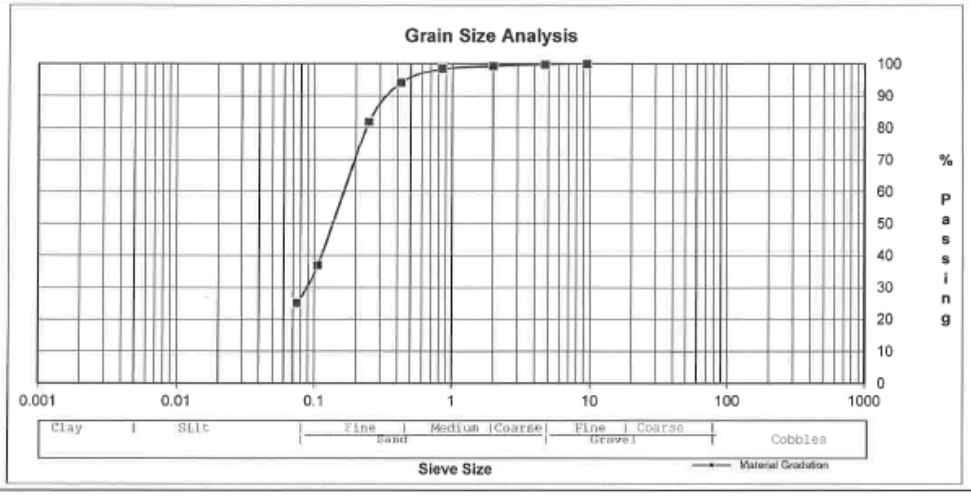
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1674
	Webequie Supply Road	B.H./T.P. No.:	TP19-09
Report to:	Muhammad Saleem	Sample No.:	#5
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	100.0
4.75 mm	99.8
2.00 mm	99.2
.850 mm	98.3
.425 mm	94.1
.250 mm	81.9
.106 mm	36.9
.075 mm	25.1



% Gravel	0.2		
% Sand	74.7	Natural Moisture Content:	4.9%
% Silt & Clay	25.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 50: TP19-09 (Site 2) gradation.

Figure 51: Sand with cobbles.

Figure 52: Sand with cobbles.

.

Figure 53: Esker ridge.

Figure 54: Sand of the esker ridge at TP19-09.

TP19-10

Test pit site TP19-10 targets a large ice-contact glaciofluvial landform mapped by the Ontario Geological Survey that is located southeast of Winisk Lake and on the west side of the north-south section of the proposed route (Figure 55). The feature is among the largest glaciofluvial landforms mapped in the area and offers one of the largest potential sources of granular material, but it is approximately 4 km from the proposed route and would require a considerable water crossing.

From the air, the landform appears heavily covered with trees, including aspen trees that are quite distinct and indicate thin organics over mineral soils and sediment. Access to the site was from the shore of a small lake to the west of the landform. From the shores of the small lake, the topography rises and the vegetation transitions to forest. The overall landform consists of multiple ridges on which three test pits were dug and sampled. Test pit one was dug on the first ridge and consisted of a clayey silt (Figure 56). The other two test pits were dug farther along and higher on the landform and exposed mostly sand with trace gravel clasts (Figure 57-60).

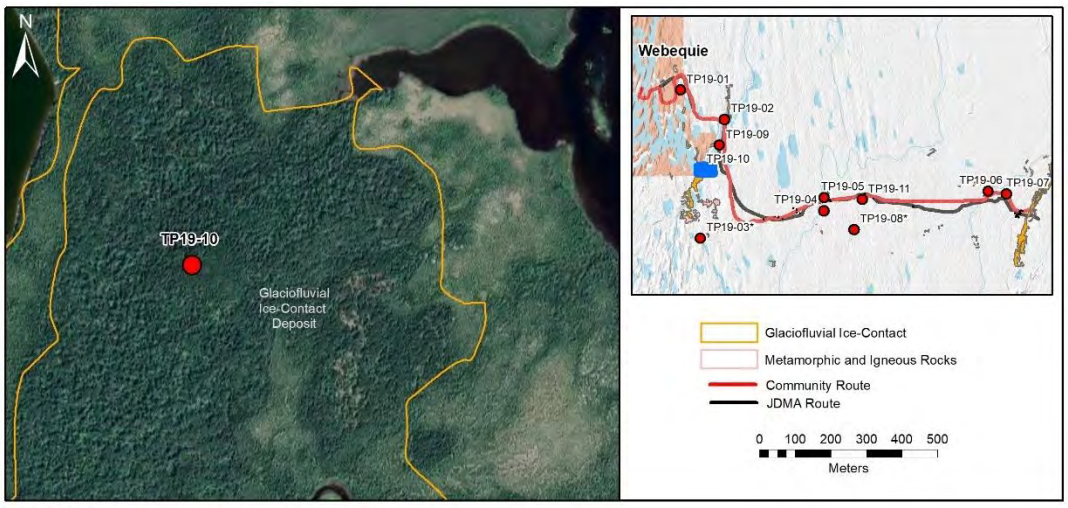

Figure 55: Location of TP19-10.

Site 1 (485038 5852324)

0.0-0.4 m: SILT

Silt, clayey, loose, light brown, moist, homogeneous, oxidized, not cemented. Thin topsoil and no overburden.

Figure 56: Figure TP19-10 Site 1.

Site 2 (485083 5852382)

0.0-0.6 m: SAND

Medium sand, trace medium gravel, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, homogeneous, oxidized, not cemented, gravel clasts up to 50 mm. Thin topsoil and no overburden.

Figure 57: Figure TP19-10 Site 2.

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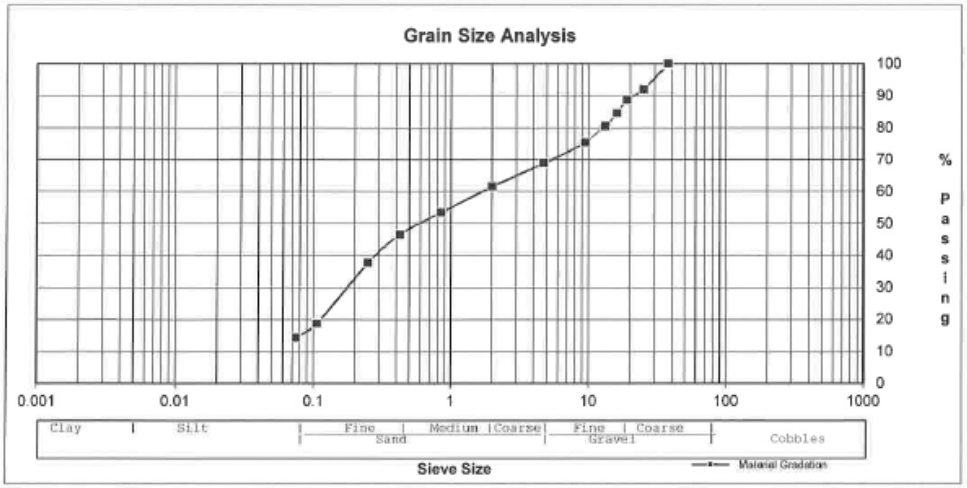
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1675
	Webequie Supply Road	B.H./T.P. No.:	TP19-10
Report to:	Muhammad Saleem	Sample No.:	#6 Site #2
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	92.0
19.0 mm	88.8
16.0 mm	84.5
13.2 mm	80.4
9.5 mm	75.4
4.75 mm	68.9
2.00 mm	61.5
.850 mm	53.4
.425 mm	46.5
.250 mm	37.7
.106 mm	18.7
.075 mm	14.3



% Gravel	31.1		
% Sand	54.6	Natural Moisture Content:	4.7%
% Silt & Clay	14.3	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 58: TP19-10 (Site 2) gradation.

Site 3 (485212 5852482)

0.0-0.6 m: SAND

Medium sand, some medium gravel, gap graded, loose, light brown, moist, homogeneous, not cemented, oxidized, maximum clast size of 100 mm and 1% oversize (80-160 mm), thin topsoil and no overburden.

Figure 59: TP19-10 Site 3

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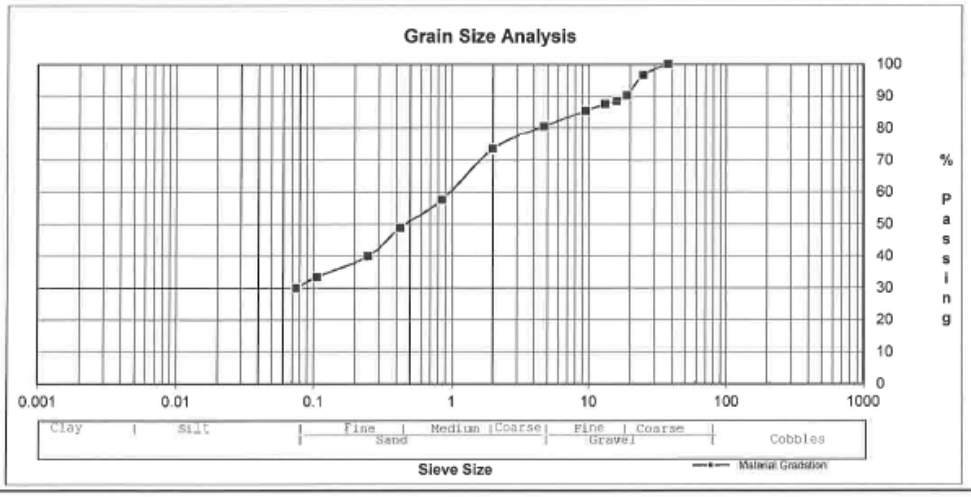
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1676
	Webequie Supply Road	B.H./T.P. No.:	TP19-10
Report to:	Muhammad Saleem	Sample No.:	#7 Site #3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	96.7
19.0 mm	90.3
16.0 mm	88.6
13.2 mm	87.5
9.5 mm	85.5
4.75 mm	80.6
2.00 mm	73.6
.850 mm	57.6
.425 mm	48.9
.250 mm	40.0
.106 mm	33.5
.075 mm	30.0



% Gravel	19.4		
% Sand	50.6	Natural Moisture Content:	10.6%
% Silt & Clay	30.0	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 60: TP19-10 (Site 3) gradation.

TP19-11

Test pit site TP19-11 is located roughly half-way along the west-east section of the route and was selected on a prominent hill (Figure 61). Access to the site is from the fen adjacent to a small lake. The hill appears to be composed of granular material deposited by ice-contact glaciofluvial and surrounded by organic soils. Although small in scale, extending roughly 75 m long by 40 m wide and 3 m high, the granular material observed in this landform appears to be the coarsest encountered of all the test pits (Figures 62-66). Based on the approximate dimensions of the landform and the observed material, this feature offers a potential volume of roughly 10,000 m^3, with limited haul distance to the proposed route locations.

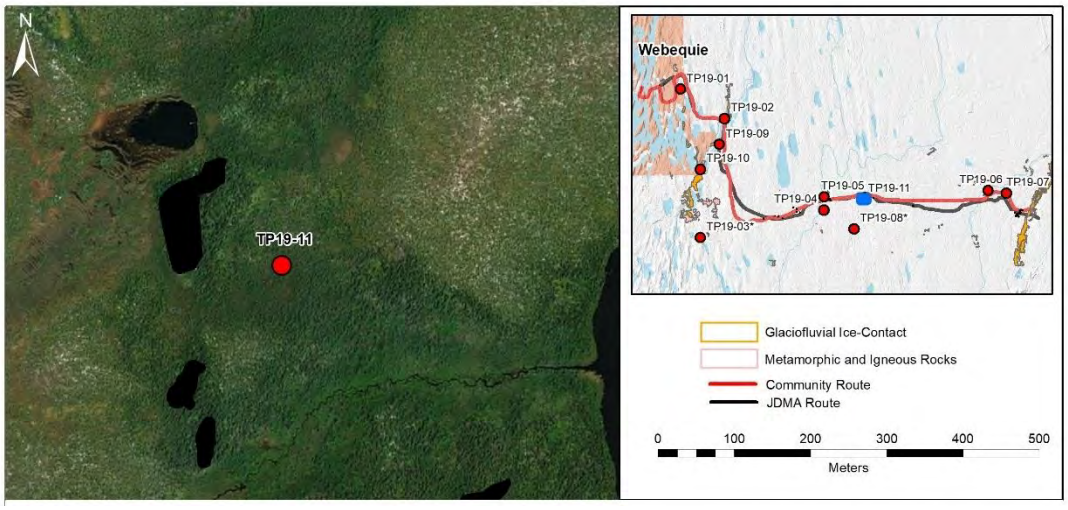

Figure 61: Location of TP19-11.

Site 1: Top of Ridge (514868 5847343)

0.0-1.2 m: GRAVEL

Fine to medium gravel with coarse sand matrix, gap graded, loose, rounded and equidimensional gravel clasts, light brown, dry, not cemented, oxidized, maximum clast size of 150 mm.

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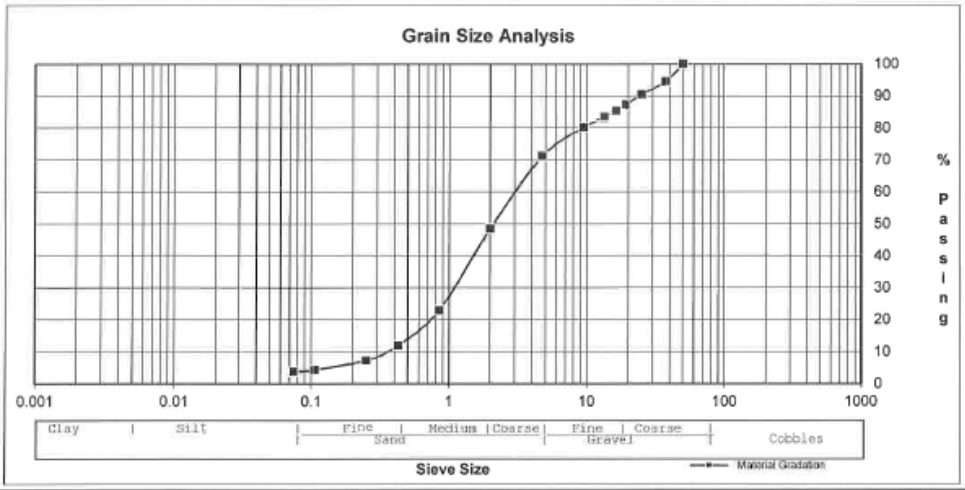
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1677
	Webequie Supply Road	B.H./T.P. No.:	TP19-11
Report to:	Muhammad Saleem	Sample No.:	#8
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	100.0
37.5 mm	94.5
25.0 mm	90.5
19.0 mm	87.0
16.0 mm	85.0
13.2 mm	83.2
9.5 mm	80.2
4.75 mm	71.2
2.00 mm	48.5
.850 mm	23.0
.425 mm	12.0
.250 mm	7.3
.106 mm	4.3
.075 mm	3.8



% Gravel	28.8		
% Sand	67.4	Natural Moisture Content:	2.3%
% Silt & Clay	3.8	Soil Classification:	SW

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 62: TP19-11 gradation.

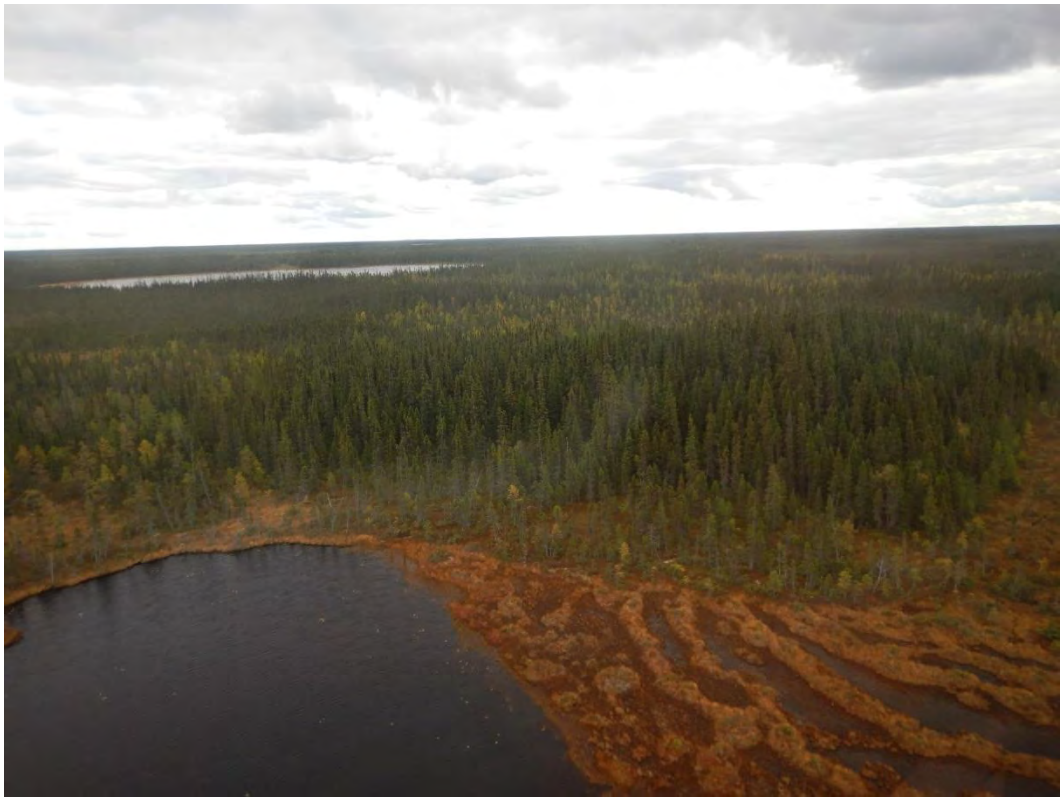

Figure 63: Location of TP19-11.

Figure 64: Crest of the ridge of the ice-contact glaciofluvial landform.

Figure 65: Test pit at TP19-11.

Figure 66: Gravel at TP19-11.

4 SUMMARY

Peat thickness measured from a soil probe returned values typically from 1 to 4 m, which is consistent with reported values from the wetlands classification system and previous observations from ground penetrating radar and peat probing. At most of the sampling sites, the peat probe penetrated the organic material and was stopped in underlying clay or clayey till.

Potential aggregate sources identified from published surficial mapping and recent terrain analysis using digital air photos and lidar include ice-contact glaciofluvial landforms and bedrock outcrops. Ice-contact glaciofluvial landforms on the west side of the route (TP19-01, TP19-02, TP19-09, and TP19-10) are primarily composed of clean medium to coarse sand and occur at locations close to the proposed routes. TP19-11, located near the middle of the route, is also an ice-contact glaciofluvial landform with good granular material. TP19-06 returned a clayey silt and no indication of bedrock.

Where granular material was encountered, the shallow test pits provide limited value to characterize the entire landforms on which they were dug. Further testing with drilling equipment would be required to evaluate the total thickness of the deposits and to calculate a volume of granular material. Test pits TP19-01, TP19-02, TP19-09 and TP19-11 are notable for being composed of granular material and for the relatively close proximity to the proposed routes, which will limit the haul distances of these aggregate sources. TP19-10 returned granular material and occurs on the one of the largest ice-contact glaciofluvial landforms, but it is located several kilometres from the proposed route and would require a stream crossing. TP19-11 is located near the half-way point of the route, but the landform is quite small and offers a limited volume of aggregate.

Bedrock outcrops are present within and outside of the routing corridor and are distributed across the study area (TP19-02, TP19-05, and TP19-08). At TP19-05, mapped as bedrock, there were boulder fields and till. Bedrock observed at the test sites was felsic plutonic (granitic), massive, and homogeneous, which should be suitable for aggregate production.

REPORT SIGNATURE PAGE

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APPENDIX C

Geotechnical Investigation Factual Report of Webequie First Nations Proposed Supply Road

Webequie Supply Road Project

Webequie First Nation

October 16, 2024

AtkinsRéalis Ref: 661910

APPENDIX C – GEOTECHNICAL INVESTIGATION FACTUAL REPORT

Signature Page

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Environment Practice
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1. Purpose

This foundation investigation report (FIR) presents the factual data and results from the field investigation and laboratory testing programs carried out to support the Environmental Assessment (EA) and Preliminary Engineering and Design for the proposed 107 km long all-season road connecting Webequie First Nation to existing mineral exploration activities and proposed future mining development in the McFaulds Lake area. A foundation design report (FDR) under separate cover will be provided.

The purpose of the field and laboratory investigation is for:

- Preliminary assessment of the subsurface condition along the proposed road and associated water body crossings;
- Preliminary aggregate potential assessment of some of the borrow sources identified as potential aggregate sources for the road construction; and
- Monitoring Well installations and water sampling to assess the impact of the proposed road on groundwater.

2. Background

The proposed 107 km long all-season road that extends in a southeast direction from the Webequie community then easterly to a termination point near McFaulds Lake is shown in Appendix A.1- Project Location Plan. The proposed road corridor crosses an area of extensive wetlands and organic soils Terrain. The proposed corridor passes through a large number of watercourse crossings and a number of large water bodies.

AtkinsRéalis (previously SNC-Lavalin Inc.) had carried out three all-season road studies in the project area previously, namely: the All-Season Community Road Study (ASCRS, 2015-16); the TPA1A Nibinamik-Webequie Community Road Project; and the TPA1B Webequie Community Supply Road Project. These studies provided a unique understanding of transportation needs and issues in both the local and the broader sub-regional contexts.

The current investigation is the continuation of a series of previous investigations carried out to support the Environmental Assessment (EA) and Preliminary Engineering and Design of the WSR project. This campaign was more focussed on hydrogeological related investigations and for further refinements to the existing geotechnical database.

3. Roles and Responsibilities

The following table provides a summary of the roles and responsibilities of key organizations involved in the project.

Table 3-1: Roles and Responsibilities

Company	Roles/Responsibilities
Webequie First Nation	- Owner
AtkinsRéalis	- Consultant to Webequie First Nation - Environmental Assessment (EA) and Preliminary Engineering Design for the road and its associated crossing structures for the proposed 107 km long all-season road connection development between Webequie First Nation and the McFaulds Lake area - Supervise the geotechnical drilling
Wisk-Air	- Provide helicopter support for the geotechnical investigation
TBT Engineering	- Subcontractor to AtkinsRéalis - Provide geotechnical drilling/sampling/laboratory testing service

4. Geology

4.1 Regional Geology

The project area is part of the Western Superior region that comprises area extending from Phanerozoic cover in the west and north to Lake Superior in the southeast (Percival et al., 2012). This area is underlain by rocks of the northwestern part of the Archean Superior Province. The northwestern Superior Province is composed of a series of major Mesoarchean volcanic and plutonic belts trending from east-west.

The road alignment mainly passes on the Oxford-Stull domain that represents the largely juvenile, 2.88 – 2.73 Ga continental northern margin of the North Caribou terrain that was tectonically implicated with oceanic crustal fragments prior to 2734 Ma (Percival et al., 2012). It also contains the “Ring of Fire” volcanic-intrusive. The local bedrock along the proposed road route mainly consists of Biotite tonalite to granodiorite and a few isolated locations gabbro, anorthosite, ultramafic rocks, metavolcanic rocks and minor metasedimentary rock. The local bedrock along the proposed road route is shown in Appendix B.1 - Bedrock Geology

4.2 Surficial Deposits

Surficial deposits along the proposed supply road consist of stratified and unstratified Pleistocene tills and Quaternary organic deposits. The till deposited on North-South section and West part of the East-West section and some isolated areas in the remaining section of the proposed road. The organic terrain presents on central and east part of the East West section of the proposed road. The surficial deposits along with the proposed road are shown in Appendix B.2- Surficial Geology Map.

The composition of the till on the North-South section and western part of the proposed road is undifferentiated, predominately sandy silt to silt matrix, high content of clasts, often low in matrix carbonate content become fine grained, predominately silty clay to silt matrix, commonly clast poor, high carbonate content towards central part of the proposed road. The organic deposits on the East and central part of the East-West section of the proposed road composed of peat, muck and marl.

5. Geotechnical Investigation

Prior to start drilling work, permission was obtained from the Ministry of Natural Resources and Forestry and field work was completed in three stages from February 15, 2019 to March 1, 2019, September 20, 2019 to October 30, 2019 and from July 2, 2020 to August 1, 2020.

During the first stage of the geotechnical investigation program, from February 15, 2019 to March 1, 2019, a total of six (6) boreholes were advanced to a depth ranging from 1.8 m to 15.3 m.

During second stage of the geotechnical investigation program a total of four (4) boreholes were advanced to a depth ranging from 5.8 m to 15.2 m. Test pitting program was also conducted at the same time which was supervised by JDMA. Test pitting program was completed by hand digging / machine excavation. Wacker Neuson 803 mini excavator was provided by TBT engineering for this task.

During the first two stages, the combined field program consists of drilling ten (10) boreholes, nine (9) boreholes, namely BH19-01 to BH19-08, BH-19-10 were drilled with SIMCO 2400 SK-1 drilling rig and one (1) BH19-P1, was drilled with Pionjar (Jack hammer type).

During the third stage, field program was divided into two substages:

a. During first half of the program, ten (10) boreholes were drilled and sampled to assess the potential rock quarry and borrow source sites. At five (5) of the ten (10) drilled boreholes, monitoring wells were installed to monitor the water level and to collect the water samples for environmental testing. Other than borehole drilling, JDMA also conducted some shallow test holes using hand auger and some surface observations in the potential aggregate and borrow source areas. Overview of the potential aggregate source and borrow areas are presented in this report and the detailed discussion and estimated available material quantities are presented in JDMA aggregate assessment report (a stand-alone separate report).
b. After completion of drilling program for potential aggregate and borrow sites, started drilling campaign for installation of monitoring wells along the proposed corridor. Total of eight (8) monitoring wells were installed at six (6) different locations. A 1” or 2” monitoring well was installed with 5’ / 10’ prepack screen based on the site conditions and drilling method.

Three (3) Solinst piezometers were also installed within the peat besides the monitoring well (WQA-02, WQR-04 and WQR-05) to monitor the water level inside the peat. The construction details and soil stratigraphy are presented in this report and the ground water conditions including water sampling and results will be discussed in the hydrogeology assessment report (a stand-alone separate report). This report will also include discussions on geochemical testing on soil, rocks and ground water, its results and commentary.

The geotechnical investigation program consists of borehole drilling and coring, in-situ or field testing and laboratory tests. AtkinsRéalis personnel supervised the drilling program, Wisk-air provided helicopter support to move drilling rig and associated stuff, and staff needed, and TBT Engineering provided the drilling services.

The Simco 2400 SK-1 multi-purpose shallow depth drill rig used a combination of hollow stem auger, solid stem augers and advance casing (for soils) and rock coring (for rock) methods. The borehole locations are shown in Appendix A.2 – Borehole Locations and Water Crossing Location Plan and borehole coordinates and depth are summarized in Table 5-1.

Table 5-1: Summary of Borehole Locations and Drilled Depth

Borehole ID	Coordinates		Drilled Depth (m)	Rational
	Northing (m)	Easting (m)		
BH19-01	5868021	477353	4.9	Adjacent to WB-1, for bridge foundation
BH19-02	5862121	490304	4.5	Adjacent to WC-3, for bridge foundation
BH19-03	5848318	490113	8.1	For aggregate source
BH19-04	5845992	502521	5.8	For aggregate source
BH19-05	5847251	508084	10.5	Adjacent to WC-10, for bridge foundation
BH19-06	5848106	516049	15.3	Adjacent to WC-13, for bridge foundation
BH19-07	5844967	529918	10	Adjacent to WC-19, for bridge foundation
BH19-08	5846513	536543	15.2	Adjacent to WC-21, for bridge foundation
BH19-10	5844902	545749	9.6	For potential rock quarry and borrow source
BH19-P1	5844938	545634	1.8	For potential rock quarry and borrow source
BH20-01	5862412	490548	2.1	For potential rock quarry and borrow source; Adjacent to WC-3, can be used for bridge footing
BH20-02	5857978	489278	4.8	For potential rock quarry and borrow source
BH20-03	5853161	485566	5.8	For potential rock quarry and borrow source
WQA-01	5862249	490294	5.2	For potential rock quarry and borrow source, can be used for WC-3 bridge foundation
WQA-02	5861787	488808	5.2	For potential rock quarry and borrow source
WQA-03	5857493	489224	5.2	For potential rock quarry and borrow source
WQA-04	5857117	488976	7.7	For potential rock quarry and borrow source; Adjacent to WC-4
WQA-05	5852807	485494	6.5	For potential rock quarry and borrow source
WQA-06	5853367	486193	3.5	For potential rock quarry and borrow source
WQA-07	5847291	488545	5.0	For potential rock quarry and borrow source
WQR-1	5865570	479568	6.5	For monitoring well installation
WQR-2A	5848589	492188	4.3	For monitoring well installation
WQR-2B	5848589	492188	8.1	For monitoring well installation
WQR-3	5844309	502669	7.6	For monitoring well installation; Adjacent to WC-8
WQR-4	5848039	514301	7.9	For monitoring well installation
WQR-5	5845596	524762	4.7	For monitoring well installation
WQR-6A	5846453	536555	6.7	For monitoring well installation; Adjacent to WC-21, can be for bridge footing

Borehole ID	Coordinates		Drilled Depth (m)	Rational
	Northing (m)	Easting (m)		
WQR-6B	5846453	536555	10.4	For monitoring well installation; Adjacent to WC-21, can be for bridge footing

Standard Penetration Testing (SPT) and split spoon soil sampling were carried out at regular intervals, according to ASTM standard procedures (ASTM D1586). All borehole termination depth is indicated in Table 5-1. SPT sampling was conducted from near-surface elevation to the top of the bedrock elevation or to the termination depth in boreholes BH19-01, BH19-02, BH19-05, BH19-06, BH19-07, BH19-08, BH19-10, BH20-01 to BH20-03, WQA-01 to WQA-07 and WQR-01 to WQR-06. At BH19-04, casing was pushed down to the bedrock (1.35 m below ground elevation) depth without taking soil samples and started rock coring. At BH19-03 and BH19-P1 location the split spoon was pushed into the ground with jack hammer or drilling rig head without measuring SPT N-Value. Bedrock was confirmed by coring 3 m (10 ft.) of rock core using BQ core barrel and 35 mm diameter rock cores were retrieved.

Field observations were made during drilling and upon completion of borings with respect to groundwater conditions. All boreholes were backfilled in accordance with the Ontario Regulation 903 with bentonite pellets up to 0.3 m below ground surface and the top 0.3 m backfilled using soil cuttings except for boreholes where monitoring wells were installed.

Sampling was carried out with a split spoon sampler driven to a length of 0.61 / 0.46 m at selected depth to obtain soil samples for soil classification and geotechnical laboratory testing purpose. Some auger samples were also collected as bulk samples for standard proctor testing.

Four (4) rock samples from WQA-01, WQR-03, WQR-04 and WQR-06B and six (6) soil samples from WQA-03, WQA-06, WQR-01, WQR-02A, WQR-03 and WQR-05 were selected for acid rock drainage (ARD) and metal leaching testing. Collected samples were delivered to ALS lab and results will be included in environmental assessment report.

Recovered soil samples were logged, photographed and examined on the field as per the USCS (unified soil classification system) and placed into re-sealable plastic bags and labeled. Recovered rock core samples were put into core box where RQD (Rock Quality Designation), SCR (Solid Core Recovery) and TCR (Total Core Recovery) were recorded. The soil/rock samples were shipped to a geotechnical laboratory for further testing.

Logs of boreholes advanced at the crossing locations, quarry / borrow and hydrogeological investigation area are included in Appendix C and typical Photos of drilling and sampling are presented in Appendix D. The laboratory test results are summarized in Table 5-2 and attached in Appendix E.

Table 5-2: Summary of Soil Lab Tests

Borehole ID	Sample No.	Particle Size Distribution			Atterberg Limit			Standard Proctor MDD (kg/m^3)
		Gravel	Sand	Silt & Clay	LL	PL	PI	
BH19-01	SS2	5.3	57	37.7	23	14	9	
BH19-02	SS2	34.5	40.8	24.7				
BH19-03	PS3	0.6	46.7	52.7				
BH19-03	PS5	18.9	33.4	47.7				
BH19-05	SS2	1.3	55.4	43.3				

Borehole ID	Sample No.	Particle Size Distribution			Atterberg Limit			Standard Proctor MDD (kg/m^3)
		Gravel	Sand	Silt & Clay	LL	PL	PI	
BH19-05	SS4	6.6	23.6	69.8				
BH19-06	SS2	11	33.1	55.9				
BH19-06	SS5	47.7	38.1	14.2				
BH19-06	SS9	5.6	62.6	31.8				
BH19-07	SS3	9.7	27.4	62.9	18	13	5	
BH19-08	SS3	0	67.9	32.1				
BH19-08	SS8	4.6	35.2	60.2				
BH19-08	SS9	4.7	29.1	66.2	19	12	7	
BH19-10	SS4	0	67	33				
BH19-10	SS8	0	89.6	10.4				
BH19-P1	SS2	0.0	22.9	77.1				
BH20-01	SS2	0.9	15.8	83.3				
BH20-02	SS5	34.5	53.5	12.0				
BH20-03	SS3	10	54.4	35.6				
WQA-01	SS2	37.1	48.2	14.7				
WQA-02	SS5	6.1	35.2	58.7				
WQA-03	SS2	28.1	63.5	8.4				2200
WQA-03	SS3	6.2	82.8	11				
WQA-04	SS3	12.6	15.8	71.6				
WQA-04	SS7	7.8	33.4	58.8				
WQA-05	SS2	2.2	22.7	75.1				
WQA-05	SS5	23.1	68.2	8.7				
WQR-1	SS4	12.4	15.5	72.1	23	14	9	
WQR-1	SS7	5.7	30.6	63.7				
WQR-2A	SS5	10.5	33.6	55.9				
WQR-3	SS2	8.1	35.3	56.6				
WQR-5	SS3	1.2	16.4	82.4	26	15	11	
WQR-5	SS5	8.9	28.5	62.6				
WQR-6B	SS7	13.4	36.3	50.3				

5.1 Subsurface Conditions

The subsurface stratigraphy encountered at site consists of Surficial Organic layer, Peat, Organic Silt, Silt and Sand Till, Sandy Silt / Silty Sand Till, Silty Gravelly Sand Till, Clayey Sandy Silt Till, Sand and Sandy Silt deposits overlain Granite / Gneiss bedrock. Reference should be made to Borehole Logs in Appendix B for detailed information at each borehole location including the thickness of each stratigraphic unit, field and laboratory test results, the SPT N-values of each soil unit and observed groundwater conditions.

Detailed subsurface conditions encountered during the geotechnical investigation are presented in the following sections.

5.1.1 Organics

Surficial frozen organic layer encountered at all borehole locations with thickness ranges from 0.2 m to 0.8 m depth except for boreholes drilled during the summer. Snow cover of about 0.6 m to 1.2 m encountered at all borehole locations during winter drilling.

5.1.2 Peat

About 0.6 m to 2.6 m thick layer of organic peat encountered in Borehole BH19-05, WQA-02, WQA-06, WQR-01, WQR-04 and WQR-05. Standard Penetration Test (SPT) N-values recorded in the peat layer ranged from 0 to 8 blows per 0.3 m spoon penetration, indicating very soft or loose condition. At WQA 6, WQR-04 and WQR-05 spoon penetrated in peat by self-weight of hammer. The natural moisture contents of the tested samples typically varied from 56.9% to 360%, while very high moisture content of up to 958% measured at WQR-04 indication of wet conditions.

5.1.3 Organic Silt and Sand

About 0.9 m thick layer of Organic Silt and Sand encountered in Borehole BH19-05 underlying peat layer. Standard Penetration Test (SPT) N-values recorded in the organic silt and sand layer was 9 blows per 0.3 m spoon penetration, indicating loose condition. The natural moisture contents of the single tested sample 29.1% indication of moist to wet condition.

5.1.4 Silt and Sand Till

Silt and sand till with trace to some clay and gravel was encountered underlying the organics soil / peat layer in BH19-01, BH19-03, WQA-02, WQR-03 and WQR-06 and underlying Silty Sand in BH19-08. Silt and sand layer extended to bedrock depth of 2.1 m, 5.2 m, 4.2 m and 7.3 m in BH19-01, WQA-02, WQR-03 and WQR-06 respectively and to a depth of 2.6 m and 9.1 m in BH19-03 and BH19-08 respectively.

SPT N-values of 5 to more than 50 blows per 0.3 m spoon penetration were recorded in these deposits, indicating loose to very dense condition. Based on the single Atterberg limit tested, liquid and plastic limit for the material in this layer was found to be 23 and 14 respectively, indicating low plastic material. The natural moisture contents of the tested samples typically varied from 4.9% to 19.7%, indicating moist condition.

5.1.5 Sand Till

Sand till, some gravel and cobbles trace silt was encountered underlying gravelly sand layer in BH20-02 and WQA-03. The material in this layer was brown to grey in color and extended to termination depth of 4.8 m and 5.2 m below ground surface.

SPT N-values of 20 to greater than 50 blows per 0.3 m spoon penetration were recorded in these deposits, indication of compact to very dense condition. The natural moisture contents of the tested samples typically varied from 3.2% to 12% indicating moist condition.

5.1.6 Silty Gravelly Sand Till

Silty gravelly sand till with trace clay layer was encountered underlying organics in BH19-02. The material in this layer was brown in color and extended to bedrock depth of 1.5 m.

SPT N-values of 29 blows per 0.3 m spoon penetration were recorded in these deposits, indication of compact condition. The natural moisture content of the single tested sample was recorded 8.1%, indications of moist condition.

5.1.7 Sandy Silt Till

Sandy silt till, trace clay and gravel was encountered underlying organic layer in BH19-06, BH19-07, BH19-10 and BH19-P1, below silt and sand layer in BH19-03 and BH19-05 and below clay and silt layer in WQA-04, WQA- 05, WQR-01, WQR-02 and WQR-05. The material in this layer was, brown to grey in color and extended to depth 8.1 m, 8.0 m, 4.1 m, 1.4 m, 2.1 m and 1.8 m in BH19-03, BH19-05, BH19-06, BH19-07, BH19-10 and WQA- 05 respectively and to termination depth of 1.8 m, 7.7 m, 6.5 m, 8.1 m and 4.7 m below ground surface in borehole BH19-P1, WQA-04, WQR-01, WQR-02 and WQR-05 respectively.

SPT N-Value of 4 to more than 50 blows per 0.3 m spoon penetration were recorded, indicating loose to very dense condition, with the exception of BH19-05 where SPT N-values of 0 to 1 recorded at depth below 6 m to the bedrock depth of 8 m indication of very loose conditions. The natural moisture contents of the tested samples typically varied between 7.4% and 20.4%, indication of moist conditions.

5.1.8 Clayey Silt / Silty Clay / Clay and Silt Till

Clayey silt / silty clay / clay and silt till, some sand trace to some gravel, trace rootlets was encountered underlying organics in WQA-05, WQA-07 and WQR-02 and below peat layer in WQA-06, WQR-01 and WQR-05. The material in this layer was brown in color and extended to 0.8, 1.5 m, 3.2 m, 3.0 m, 0.8 m and 2.0 m below ground surface in WQA-05, WQA-06, WQA-07, WQR-01, WQR-02 and WQR-05 respectively.

SPT N-values of 1 to 33 blows per 0.3 m spoon penetration were recorded in these deposits, indication of very soft to hard condition. Based on the Atterberg limit tested at two samples in this material, liquid limit ranged from 23 to 26 and plastic limit ranged from 14 to 15, indicating low plastic material. The natural moisture contents of the tested samples typically varied between is 9.7% and 22.8% indications of moist condition while higher moisture content of 90% in SS1 of WQA-07 possible due to inclusion of organics.

5.1.9 Silt Till

Silt till, some clay and sand, trace gravel was encountered underlying organics in BH20-01 and underlying silty sand in WQA-04. The material in this layer was brown in color and extended to 1.2 m and 2.1 m below ground surface in BH20-01 and WQA-04 respectively.

SPT N-values of 7 to 37 blows per 0.3 m spoon penetration were recorded in these deposits, indication of firm to hard condition. The natural moisture contents of the tested samples typically varied between 10.7 and 67.3, indications of moist to wet conditions. The higher moisture content in the first sample possible due to inclusion of organics with higher moisture content.

5.1.10 Silty Sand Till

Silty sand till, trace gravel was encountered underlying gravelly sand layer in BH19-06, below sandy silt layer in BH19-10, below silty clay layer in WQA-06 and WQA-07 and below organics or peat layer in BH19-08, BH20-03, WQA-04 and WQR-04. The material in this layer was, brown to grey in color and extended to termination depth of 15.3 m, 3.5 m and 5.0 m in BH19-06, WQA-06 and WQA-07 respectively, to 3.0 m, 7.6 m, 3.0 m and 1.4 m depth in BH19-08, BH19-10, BH20-03 and WQA-04 respectively and to bedrock depth of 3.8 m in WQR-04.

SPT N-values of 2 to more than 50 blows per 0.3 m spoon penetration were recorded in these deposits, indication of very loose to very dense condition. In general, low N-values encountered within top 3 m below organics or peat layer. The natural moisture contents of the tested samples varying from 6.4% to 20.5% in BH19-06, BH19-10, BH20-03, WQA-06, WQA-07 and WQR-04 indications of moist condition while the natural moisture contents of 25.8% to 43.2 % indicating moist to wet condition in BH19-08.

5.1.11 Sand and Gravel / Gravelly Sand Till

Sand and gravel / gravelly sand till, trace silt, occasional cobble and boulders was encountered underlying sandy silt in BH19-06, below silt layer in BH20-01, below organics in BH20-02, WQA-01, WQA-03, below silty sand layer in BH20-03 and below sandy silt in WQA-05. The material in this layer was brown to grey in color, extended to 10.7 m, 3.7 m and 1.5 m below ground surface in BH19-06, BH20-02 and WQA-03 respectively, to termination depth of 2.1 m, 5.8 m, and 6.5 m in BH20-01, BH20-03 and WQA-05 respectively and to bedrock depth of 2.4 m in WQA-01.

SPT N-Value of 8 to more than 50 blows per 0.3 m spoon penetration were recorded, indicating loose to very dense condition. The natural moisture contents of the tested samples typically varied between 1.1% and 8.3%, indication of moist condition.

5.1.12 Clayey Sandy Silt Till

The Clayey Sandy Silt Till, trace gravel, occasional cobble and boulders was encountered underlying sandy silt and silt and sand layer in BH19-07 and BH19-08 respectively. The material in this layer was grey in color, extended to a termination depth of 10 m and 15.2 m in BH19-07 and BH19-08 respectively.

SPT N-Value of 15 to more than 50 blows per 0.3 m spoon penetration were recorded, indicating compact to very dense condition. Based on the Atterberg limit tested in this material at two samples, liquid limit ranged from 18 to 19 and plastic limit ranged from 12 to 13, indicating low plastic material. The natural moisture contents of the tested samples typically varied between 6.8% and 11.3%, indication of moist condition.

5.1.13 Sand

Sand, some silt, was encountered underlying Silty Sand in BH19-10. The material in this layer was brown in colour, extended to the termination depth of 9.6 m below ground surface.

The single SPT N-Value of 42 blows per 0.3 m spoon penetration were recorded, indicating dense condition. The natural moisture contents of the single tested sample were recorded 17.5%, indication of moist condition.

5.1.14 Bedrock

Bedrock was encountered in boreholes BH19-01, BH19-02, BH19-04, BH19-05, WQA-01, WQR-03, WQR-04 and WQR-06B at depth 2.1 m, 1.5 m, 1.4 m, 8 m, 2.4 m, 4.2 m, 3.8 m and 7.3 m from the ground surface respectively. The bedrock encountered during investigation can be described as granite. The granite was reddish brown and pink in BH19-01 BH19-02 and WQA-01, black and grey in BH19-04, WQR-03, WQR-04 and WQR-06B and white and grey in BH19-05. The quality of the rock as classified by the Rock Quality Designation (ASTM D6032 - Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core was assessed using recovered rock cores in the field. Detail of RQD and Total Core Recovery (TCR) values can be referred from the borehole logs attached in Appendix C. Table 5-3 is a summary of the results for each borehole, showing the 33rd percentile values of each borehole data set, indicating that two-thirds of the RQD measurements exceed the value presented in Table 5-3. Based on these results, the rock can be described as “Very Poor to Good”, as prescribed by Table 3.10 of the Canadian Foundation Engineering Manual (4th Ed, 2006), with lesser quality rock being reported near the ground surface or at joints and seams. Core box photographs are presented in Appendix D.

Table 5-3: Summary of RQD Data by Borehole

Borehole ID	[1]RQD – 33rd Percentile (%)	[2]RQD Classification
BH19-01	73	Fair
BH19-02	71	Fair
BH19-04	77	Good
BH19-05	73	Fair
WQA-01	87	Good
WQR-3	76	Good
WOR-4	23	Very Poor
WQR-6B	90	Good

Notes: [1]67% of observed RQD values exceed the 33rd percentile, indicating that rock quality is likely equal or better.
[2]RQD Classification as per Table 3.10 of the Canadian Foundation Engineering Manual (4th Ed, 2006).

5.2 Groundwater

Ground water table depth was recorded upon the completion of drilling or during the drilling at each borehole and water was present in all boreholes except BH20-01, BH20-03 and WQA-05. It should be noted that the presence of water is possibly influenced by the frost depth, water used during drilling, and is not necessarily indicative of the existing static ground water table. The locations where monitoring wells were installed, water level was also measured just before the well development and before water sampling which represent more realistic water depth.

A summary of measured water levels from ground surface are presented in Table 5-4.

Table 5-4: Recorded Depth to Water Level in Boreholes

Borehole ID	Recorded Depth to Water during or after drilling completion (m bgs)	Recorded Depth to Water before Well Development (m bgs)	Recorded Depth to Water before Water Sampling (m bgs)
BH19-01	0.30		
BH19-02	0.46		
BH19-03	1.67		
BH19-04	0.30		
BH19-05	1.82		
BH19-06	1.22		
BH19-07	1.99		
BH19-08	1.50		
BH19-10	9.10		
BH20-01	DRY		
BH20-02	3.60		
BH20-03	DRY		
WQA-01	NA	2.33	3.16
WQA-02	0.30	1.05	1.16
WQA-03	2.90	2.79	2.95
WQA-04	1.50	1.57	2.27
WQA-05	DRY	DRY	DRY
WQA-06	1.10		
WQA-07	2.10		
WQR-1	3.00	0.49	0.34
WQR-2A	1.50	0.35	0.29
WQR-2B	1.50	0.24	0.27
WQR-3	0.76	0.20	0.00
WQR-4	0.90	0.49	0.44
WQR-5	0.30	0.17	0.12
WQR-6A	6.10	0.10	0.52
WQR-6B	6.10	0.30	0.29

5.3 Monitoring Well Installation

A total of sixteen (16) monitoring wells were planned to install at aggregate and borrow source locations and along the proposed corridor. Only five (5) monitoring wells installed at three (3) anticipated borrow source locations (TP19-02, TP19-09 and TP19-10 area), one of then came out as dry well and at one location well could not be installed due to sand heave inside the casings (this proposed well was only to see the water elevation and consistency of the overburden material at lower elevation as the boreholes drilled in the area at higher elevation were dry). The monitoring wells at fourth anticipated location (TP19-03) for rock source were not installed as the bedrock was not encountered at this location as expected. Eight (8) monitoring wells were installed along the proposed corridor at six (6) different locations.

Monitoring wells were installed to allow water sampling and monitor water level using 2.5 cm or 5 cm diameter well with 1.5 m or 3 m long prepack screen and PVC risers based on the stratigraphy of the overburden material and drilling technique with stick up above ground. Protective casings were installed at all locations except WQA- 05 where only above ground riser was installed. Well screen installed either completely in the bedrock or in the overburden. When well screen installed in the rock the top of the screen kept equal to or greater than 1 m below the top of the bedrock surface.

After drilling completed, the Well screen attached with riser pipe lowered down in the hole and then sand pack installed to about 0.3 m to 0.9 m above top of the screen by slowly pouring sand and pulling casing / augers simultaneously. Bentonite seal was placed to 0.6 to 1.2 m above sand pack. After bentonite seal installed, casing / augers completely removed from ground and rest of the hole backfilled with bentonite or mix of bentonite and cuttings. The monitoring well locations are shown in Appendix A.2 and construction details are summarizes in Table 5-5.

Table 5-5: Summary of Monitoring Well Construction Details

Well ID	Date Installed	Bottom of the hole (m bgs)	Bottom of Well (m bgs)	Screen Length (m)	Well Diameter (m)	Stratigraphic Unit (Overburden/ Bedrock/ Peat)	Stick up (m)	Notes
WQA-01	July 6, 2020	5.20	5.15	1.52	0.025	Bedrock	0.90	Protective casing installed
WQA-02	July 8, 2020	5.20	5.00	1.52	0.025	Overburden	0.89	Protective casing installed
WQA-03	July 9, 2020	5.20	4.40	3.04	0.050	Overburden	0.90	Protective casing installed
WQA-04	July 9, 2020	7.70	7.46	3.04	0.050	Overburden	0.90	Protective casing installed
WQA-05	July 13, 2020	6.50	6.00	3.04	0.050	Overburden	1.10	No protective casing only stick up

WQR-1	July 24, 2020	6.50	5.86	1.52	0.050	Overburden	0.74	Protective casing installed
WQR-2A	July 11, 2020	4.30	4.30	3.04	0.025	Overburden	0.84	Protective casing installed
WQR-2B	July 12, 2020	8.10	8.00	3.04	0.025	Overburden	1.10	Protective casing installed
WQR-3	July 23, 2020	7.60	7.51	1.52	0.025	Bedrock	0.99	Protective casing installed
WQR-4	July 21, 2020	7.90	6.74	1.52	0.025	Bedrock	1.01	Protective casing installed
WQR-5	July 17, 2020	4.70	4.67	1.52	0.025	Overburden	1.10	Protective casing installed
WQR-6A	July 20, 2020	6.70	6.40	3.0	0.050	Overburden	0.84	Protective casing installed
WQR-6B	July 20, 2020	10.40	10.37	1.52	0.025	Bedrock	0.84	Protective casing installed
SP-01	July 8, 2020		1.98	0.15	0.025	Peat	0.76	Steel pipe stick up
SP-02	July 21, 2020		2.60	0.15	0.025	Peat	0.91	Steel pipe stick up
SP-03	July 17, 2020		0.90	0.15	0.025	Peat	0.76	Steel pipe stick up

5.3.1 Well Development

Monitoring wells were developed after more than 24 hours of the installation to remove fines from the completion zone to enhance the flow of formation water through the well and to provide water samples with a minimum amount of suspended solids by removing three to five times the total volume of water in the well and sand pack or until the visibly clear water start coming out. Well development was completed with Waterra tube fitted with foot valve at the bottom. Waterra tube left on site inside the well or packed in the plastic bag at each location for future use.

5.3.2 Water Sampling

Monitoring wells purged by removing the water equal to three times the water in the well by keeping bottom of the Waterra tube about 0.5 m above the bottom of the well to avoid disturbance of the sediments at the bottom of the well.

Where low recovery expected, water samples collected without purging. Water samples were collected after minimum of twenty-four (24) hours of well development.

Water samples for petroleum hydrocarbons (PHCs) including BETEX and F1 to F4 collected first and then collected for PHAs and other parameters. 0.45-micron filter was used for samples requiring field filtration. All the collected samples kept in coolers with ice pack.

6. Laboratory Testing

A program of laboratory testing was performed on selected soil samples obtained during the field work. Test results have been used to assist with classification and determination of relevant soil properties. Laboratory testing has been performed in accordance with the ASTM standard procedures. Laboratory testing was carried out by TBT engineering and consultant soil lab located in Thunder Bay, Ontario.

Table 6-1: Summary of the Laboratory Tests

Test Type	ASTM Standard	Number of Tests
Standard test methods for laboratory determination of water (moisture) content of soil and rock by mass	D2216-10	132
Standard test methods for liquid limit, plastic limit, and plasticity index of soils	D4318-10	5
Standard tests method for particle size analysis of soils.	ASTM C136	34
Standard test method for Laboratory compaction	ASTM D698	1
C A Micro Deval Test	ASTM D6928	4
Soundness Test	ASTM D5312	4
Point Load Test	ASTM D5731-16	6
UCS (unconfined compression test)	ASTM D2938	6

All field samples were properly sealed labelled and identified. A schedule of testing requirement was prepared by our geotechnical engineer and shipped to soil laboratory for testing. Effort was made to select representative sample and to provide the laboratory with sufficient sample quantities required for testing.

AtkinsRéalis geotechnical engineer coordinated all technical communications with the soil laboratory including obtaining and reviewing the laboratory results upon completion. A summary of laboratory test results is presented in the relevant Borehole logs and details of the tests are attached as Appendix E.

6.1 Sieve Analysis

A total of thirty-four (34) soil samples were selected for sieve analysis as per ASTM C136 during winter and summer program. Summary of the sieve analysis test results are presented in Table 5-2.

6.2 Atterberg Limit

Atterberg Limit test was performed on sample SS-2 taken from Borehole BH19-01 during winter 2019 program, SS3 of BH19-07 and SS9 of BH19-08 during summer 2019 program and SS4 of WQR-1 and SS3 of WQR-5 during summer 2020 drilling program as per ASTM D4318 The result indicate plasticity index of 9, 5, 7, 9 and 11 respectively indicating low plastic soil. Summary of the test results are presented in Table 5-2.

6.3 Standard Proctor

Stander Proctor test was performed as per ASTM D698. Due to limited quantity of soil sample for the test, similar material from BH20-02 and WQA-03 was mixed to obtain enough sample for the test. Maximum dry density of the material at optimum moisture content was calculated by drawing moisture density relationship curve. Maximum dry density of 2200 kg/m3 was calculated at optimum moisture content of 7.4%.

6.4 CA Micro Deval Test

Coarse Aggregates (CA) to degradation by abrasion by Micro Deval test was performed as per ASTM D6928. Due to limited quantity of rock core sample for the test, Micro Deval test was performed on combined rock core samples from Borehole BH19-01 and BH19-02 during winter 2019 program, BH19-04 during summer program and WQR-04 and WQR-06B during summer 2020 program. The test results show 5.4%, 7.7%, 6.7% and 5.7% material loss respectively indicating excellent quality of rock for road construction material.

6.5 Soundness Test

Soundness test was performed as per ASTM D5312. Soundness test (Freeze / thaw) was performed on combined rock sample from Borehole BH19-01 and BH19-02 during winter 2019 program, BH19-04 during summer 2019 program and WQR-04 and WQR-06B during summer 2020 program. The test results show material loss in the range of 0.4% to 3.5% indicated excellent quality of rock for road construction material.

6.6 Point Load Test

A total of six (6) point load tests were carried out on one sample from each borehole BH19-01, BH19-02, BH19-04, BH19-05, WQR-04, and WQR-06B as per ASTM D5731. The test results indicated that the UCS of the rock varies from 150 MPa to 314 MPa, with an average value of 247 MPa. The point load test results are presented in appendix E.

The point load test results indicated that the rock can be classified as grade “R5 - Very Strong” as per ISRM.

6.7 Geochemistry Test

A full suite of geochemical testing has been carried out on selected soil, rock and groundwater samples. These are presented and discussed in detail in Hydrogeology Report. Here only limited tests on soil and rock samples are briefly presented and discussed in relation to its potential to Acid Rock Drainage Metal Leaching (ARD/ML) as construction material or excavations.

A total of ten (10) soil and bedrock samples have been selected for ARD/ML assessment, see Table 6.2 below the summary of selected samples for the geochemical testing and Appendix E for results. These are spread over the length of the designated corridor and cover vertical extent from near surface to about 10 m depth. Geochemical testing has been completed and the results are being assessed and analyzed for ARD/ML assessment. It shall be noted here, ground water table is typically shallow and there are no high relief areas for use of borrow pits and quarries. It is expected that these would be several and would typically be shallow.

Early indications are that the Sulphur content S (%) is very low (< 0.2%), therefore the potential for ARD/ML either at the potential borrow pits/quarries or at the excavations is low, and therefore, site excavated materials to be used for road embankment fill and other pavement section constructions is low.

Table 6-2: Summary Selected Rock and Soil Samples for the Geochemical Testing

Sample Location	Material Type
WQA-01 (FROM 14’2”-15’)	ROCK
WQR-3 (FROM 10’-18’9”)	ROCK
WQR-4 (FROM 20’7”-21’6”)	ROCK
WQR-6B (FROM 28’-28’9”)	ROCK
WQA-03 (FROM 10’-12’)	SOIL
WQA-05 (FROM 15’-16’6”)	SOIL
WQR-1 (FROM 15’-17’)	SOIL
WQR-2A (FROM 5’-7’)	SOIL
WQR-3 (FROM 7’6”-9’6”)	SOIL
WQR-5 (FROM 7’6”-9’6”)	SOIL

7. Potential Aggregate and Borrow Source

In July 2020 ten (10) boreholes were drilled and sampled to assess the potential rock quarry and borrow source at four (4) different locations (TP19-02, TP19-03, TP19-09 and TP19-10). Other than borehole drilling JDMA also conducted thirty-nine (39) shallow test holes using hand auger and some surface observation in the potential aggregate and borrow source areas. A brief understanding of the potential aggregate and borrow areas is discussed in this report and the detailed discussion and estimated available material quantities are presented in JDMA aggregate assessment report.

7.1 TP19-02

Three (3) boreholes and twenty-eight (28) hand augured test holes were drilled in TP19-02 area. In addition, many surface observations were made in the area to delineate the limits of the expected aggregate and borrow sites.

The location of TP19-02 explored in September 2019 is an area of elevated land where a wide range of surface materials are present including bedrock, sand, sandy gravel and till material.

The combined volume of borrow and bedrock aggregate expected to be feasible to excavate at this location is estimated about 500,000 to 1,000,000 cubic meters. In addition to this about 40,000 to 50,000 cubic meters of sand and gravel and 60,000 to 120,000 cubic meters of aggregate source expected among five (5) different hills in the surrounding area.

7.2 TP19-03

This site had been identified as possible location for surface or shallow depth bedrock based on the desktop study. One (1) borehole and three (3) hand augured holes were drilled in addition to many surface observations were made in the area to delineate the limits of the expected borrow sites.

No bedrock was found at surface or to a depth of 5 m. The material observed in the hand augured holes and in the drilled hole was silty sand to clayey silt and was not suitable to build as borrow site.

7.3 TP19-09

Three (3) boreholes and seven (7) hand augured test holes were drilled in TP19-09 area. In addition, many surface observations were made in the area to delineate the limits of the expected borrow sites.

TP19-09 area was explored in September 2019 represents a south and north component. The south part shows generally clean sand and sandy gravel whereas the north part shows cobble and boulders at surface covering sandy gravel.

The sand and gravel volume expected to be feasible to excavate at this location is estimated about 150,000 to 500,000 cubic meters.

7.4 TP19-10

Three (3) boreholes and one (1) hand augured test holes were drilled in TP19-10 area. In addition, many surface observations were made in the area to delineate the limits of the expected borrow sites.

TP19-10 area is a large ridge located from 4 to 4.9 km west of the nearest point on the proposed road corridor. Test Pits from September 2019 and boreholes and surface observation from July 2020 indicate a significant reserve of sand and gravel at this site. The sand and gravel volume expected to be feasible to excavate at this location estimated about 4,000,000 to 8,000,000 cubic meters.

The access to this site required stream crossing. This site is investigated as additional reserve as a last resource if needed during the construction and the preference would be given to obtained required borrow and aggregate material from the pits those didn't require additional access roads and stream crossings to access the site.

8. Summary of Findings

A geotechnical investigation program consisting of field investigation and laboratory testing was carried out for preliminary assessment of the subsurface condition and aggregate potential for the Webequie Supply Road project.

The field program for the all-season supply road consisted of ten (10) boreholes, in which nine (9) boreholes were drilled with SIMCO 2400 SK-1 drilling rig and one borehole was drilled with Pionjar (Jack hammer type). Six (6) boreholes were drilled at water crossing locations one on each side and four (4) boreholes were drilled for quarry and borrow search. Borehole at the water crossing near the Esker camp was not drilled as the data was available on the east side of the river from the existing geotechnical database (2010-2012 Knight Piesold report).

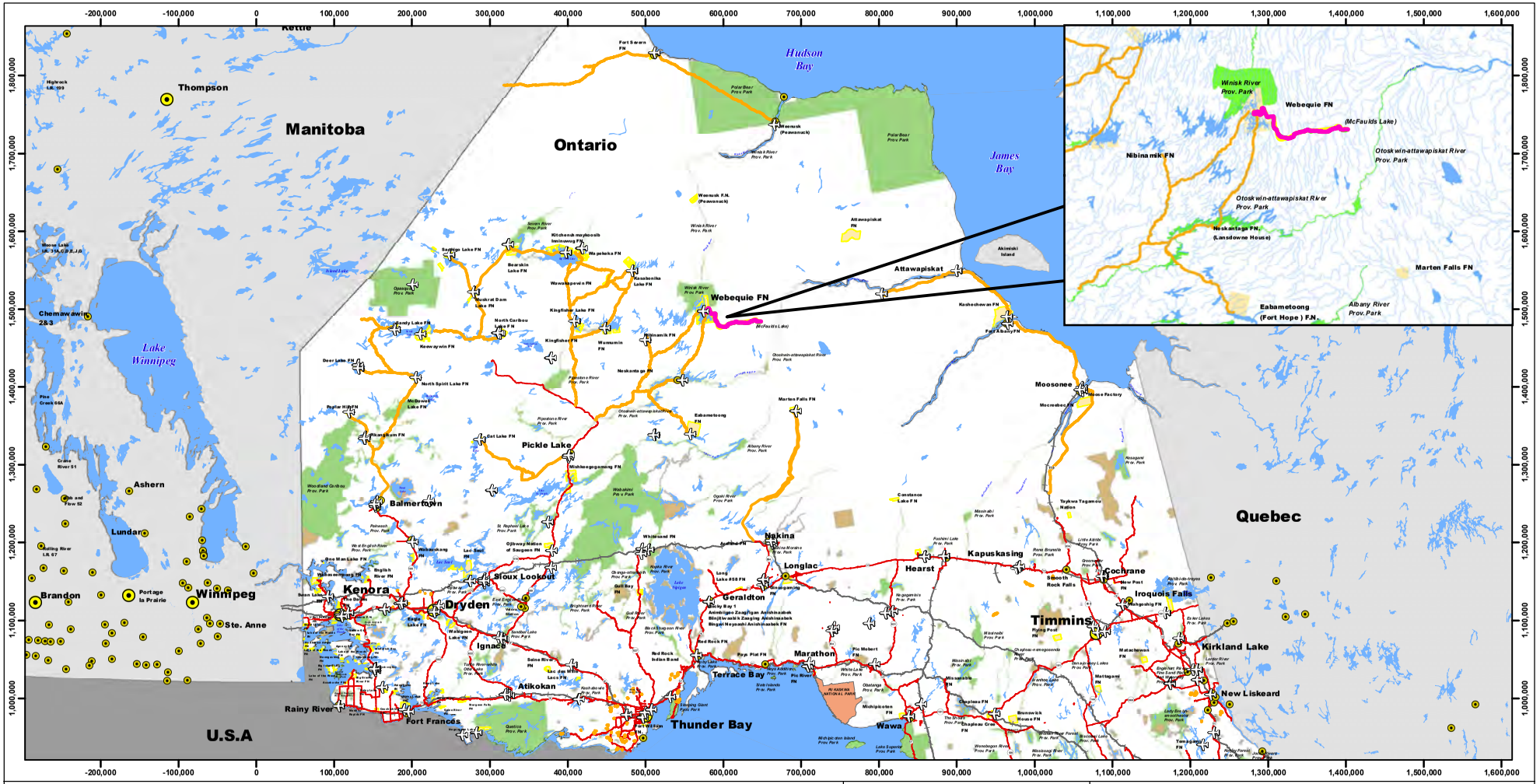
The following is a summary of the findings from geotechnical investigation program along the Webequie Supply Road corridor:

- Road crosses an area of extensive wetlands, organic soils and passes through many watercourse crossings and a number of large water bodies.
- The overburden deposits consist of stratified and unstratified Pleistocene tills and Quaternary organic deposits. The till deposited on North-South section and West part of the East-West section and some isolated areas in the remaining section of the proposed road. The organic deposits on central and East part of the East West section of the proposed road.
- The overburden till material encountered in the boreholes can be used as embankment fill for the proposed road.
- Bedrock encountered in the area is mostly strong rock and may be suitable for aggregate production.
- The organic soil may require removal or ground improvement to use as subgrade for the road construction.
- Most of the central and east part of the proposed road passes through surficial boggy area with water table close to the surface. JDMA conducted investigation to evaluate the peat thickness in different areas and test pitting to assess the availability of construction material along the proposed corridor.
- Four boreholes BH19-03, BH19-04, BH19-10 and BH19-P1 were drilled for borrow and quarry source.
    - Bedrock was encountered in BH19-02 at 1.5 m depth and ground elevation rises as moving away from river. A quarry could be developed around this area to produce aggregate for the road construction. Quarry could be developed within the proposed corridor and no additional access road needed to transport material.
    - Till was encountered in BH19-03 underlying 0.6 m of organic material but the water table is very shallow at 1.67 m below existing ground which make this site unsuitable to be used for borrow source.
    - Bedrock was encountered in BH19-04 at 1.4 m depth with water table close to surface but in overall the ground is rising as moving away from water body with bedrock at or very close to surface. Lot of surficial boulders were noticed across the site. This site is located in almost in the middle section of the proposed corridor and just about 1.5 Km offset from proposed corridor. With further investigation more precise location can be determined closer to the corridor. This location can be potentially developed to produce aggregate for the project.
    - BH19-10 is drilled on the esker located west side of the Muketie River and runs in kilometres along the embankment of the river. Material encountered at this location is Sandy silt near surface and becomes Silty sand to sand with depth. This material can be used as backfill or mixed with granular material to produced required gradation.
    - Based on the July 2020 investigation JDMA estimated the availability of about 750,000 cubic meters of aggregates and borrow material along the north-south section of proposed road which can be increased to 1,170,000 cubic meters by managing ground water.
    - About 4 to 8 million cubic meters of borrow material can be extracted from area located about 5 km west of the north-south to east-west bend of the proposed corridor that required stream crossing.

- Based on the desktop study and the draft Terrain Analysis Report (J.D Mollard, March 2019), a total of twenty-three (23) water crossings were determined. However, according to OFAT (Ontario flow assessment tool), the AtkinsRéalis Bathymetric survey identified a total of thirty-one (31) water crossings. Field investigation in September 2019 confirmed that, among the thirty-one (31) water crossings, there are twenty-six (26) water crossings that required culvert installation and single or multi span bridge crossing.
- Based on water flow and streams dimension, nineteen (19) locations were determined to require culvert crossings and seven (7) locations to require single or multi span bridge crossings.
- No drilling or test pitting was performed at the culvert locations to date. Based on the geophysical terrain analysis report and drilled boreholes at the major water crossing locations it is anticipated that the culvert would be founded on the native till material along the North-South section of the proposed corridor and along the East-West section of the corridor at majority of the locations peat or loose to compact material may be encountered at the founding depth.

APPENDIX A

A.1 Project Site Location Plan
A.2 Borehole and Water Crossing Location Plan



Legend:

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Airports
- City/Town
- Winter Roads
- All-Season Roads
- Rail
- Federal National Park
- Waterbody
- First Nations Reserve
- Provincial Park
- Conservation Reserve

WSR WEBEQUIE SUPPLY ROAD

SCALE: 1:4,869,256

Webequie Supply Road (WSR)

Project Location

NOTES

1. Coordinate System: Canada Lambert Conformal Conic.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographical and cover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF). Download Date: 2021-02-04

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Figure Number:	REV:
A.1	PA

Client:	Project Number:	Date:
Webequie First Nation	661910	10/15/2024

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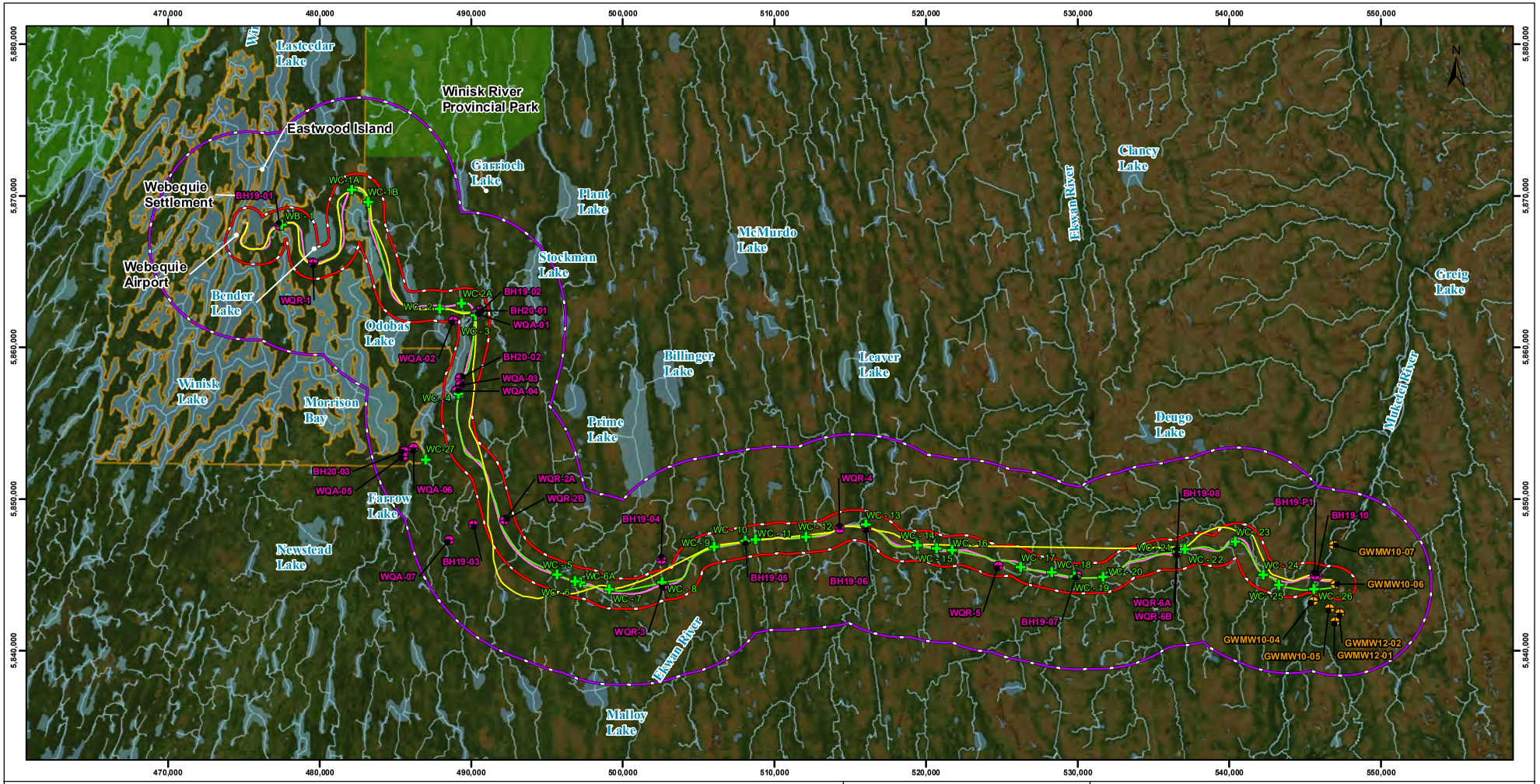

Legend

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Waterbody Crossing
- Boreholes (KCP)
- Boreholes (AtkinsRealis)
- Local Study Area (LSA 1km from the Preferred Route)
- Regional Study Area (RSA 5km from either side of LSA Boundary)
- Webequie First Nation Reserve
- Waterbody
- Watercourse
- Winisk River Provincial Park

WSR WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic landcover features obtained from CanVec v1.2.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF). Download Date : 2021-02-04

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0 10 20 Km

Webequie Supply Road (WSR)

Potential Water Crossings and Geotechnical Data Points

Figure Number:	REV:
A.2	

Client:	Project Number:	Date:
Webequie First Nation	661910	10/15/2024

DRN	CHK	APP
FO	CX	TX

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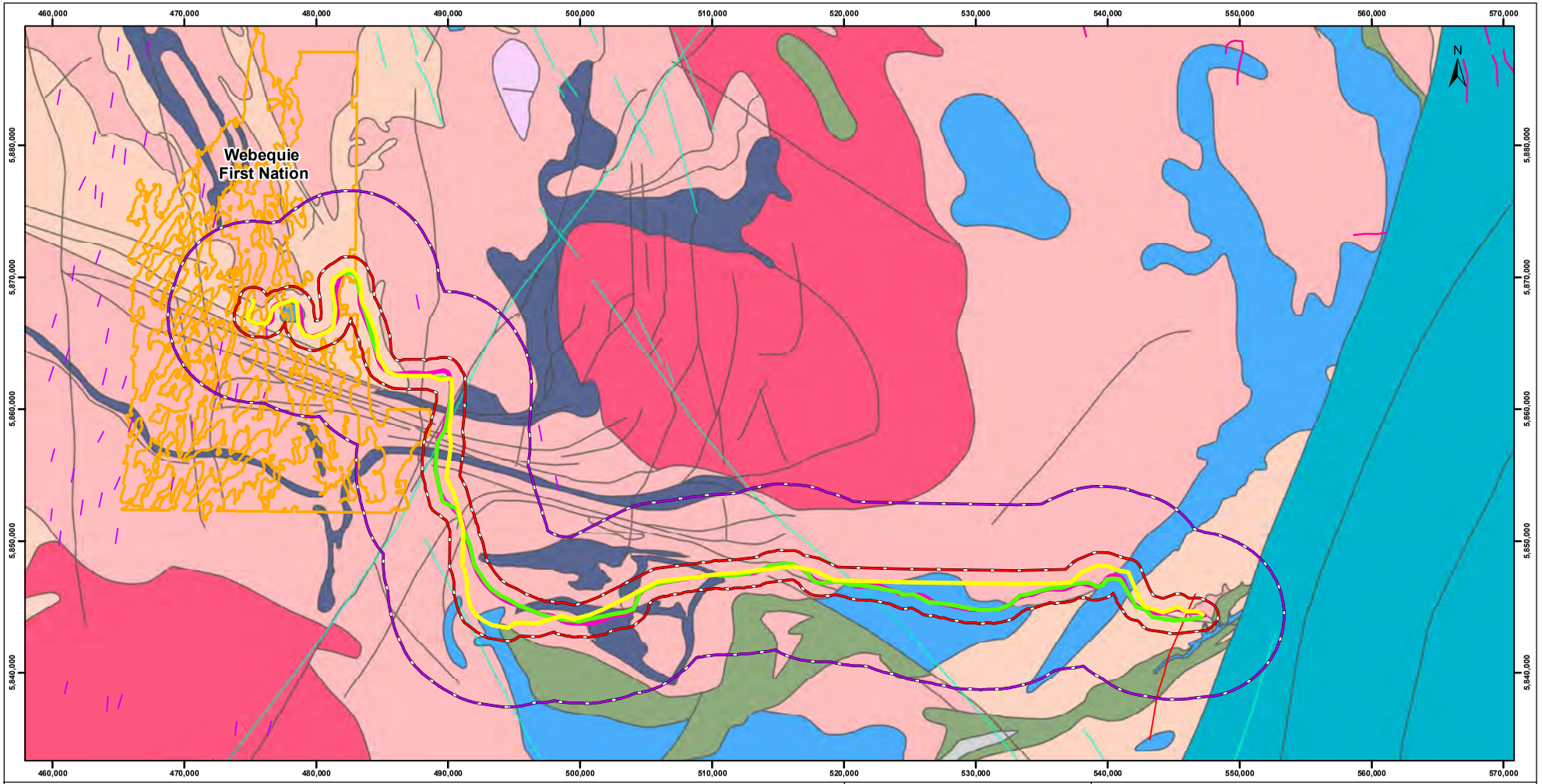
APPENDIX B

B.1 Bedrock Geology
B.2 Surficial Geology



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Legend

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Local Study Area (LSA 1km from Centreline of Route Alternatives)
- Regional Study Area (RSA 5km from either side of LSA Boundary)
- Webequie First Nation Reserve
- Beach, bar or spit
- Drumlin or area of drumlins
- Esker or area of eskers
- Dikes
- Faults
- 55: Sandstone, dolostone, limestone
- 16: Hornblendite - nepheline syenite suite (saturated to undersaturated suite)
- 15: Massive granodiorite to granite
- 12: Foliated tonalite suite
- 11: Gneissic tonalite suite
- 10: Mafic and ultramafic rocks
- 8: Migmatized supracrustal rocks
- 7: Metasedimentary rocks
- 5:Mafic to intermediate metavolcanic rocks

WSR WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic and cover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF); and, Ontario Geological Survey. 2011. 1:250 000 scale bedrock geology of Ontario. Ontario Geological Survey, Miscellaneous Release—Data 126-Revision 1. Download Date : 2021-02-04

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0 10 20 km

Webequie Supply Road (WSR)

Bedrock Geology

Figure Number:	REV:
B.1	

Client:	Project Number:	Date:
Webequie First Nation	661910	10/15/2024

DSC	DRN	CHK	APP
	AD	CB	CB

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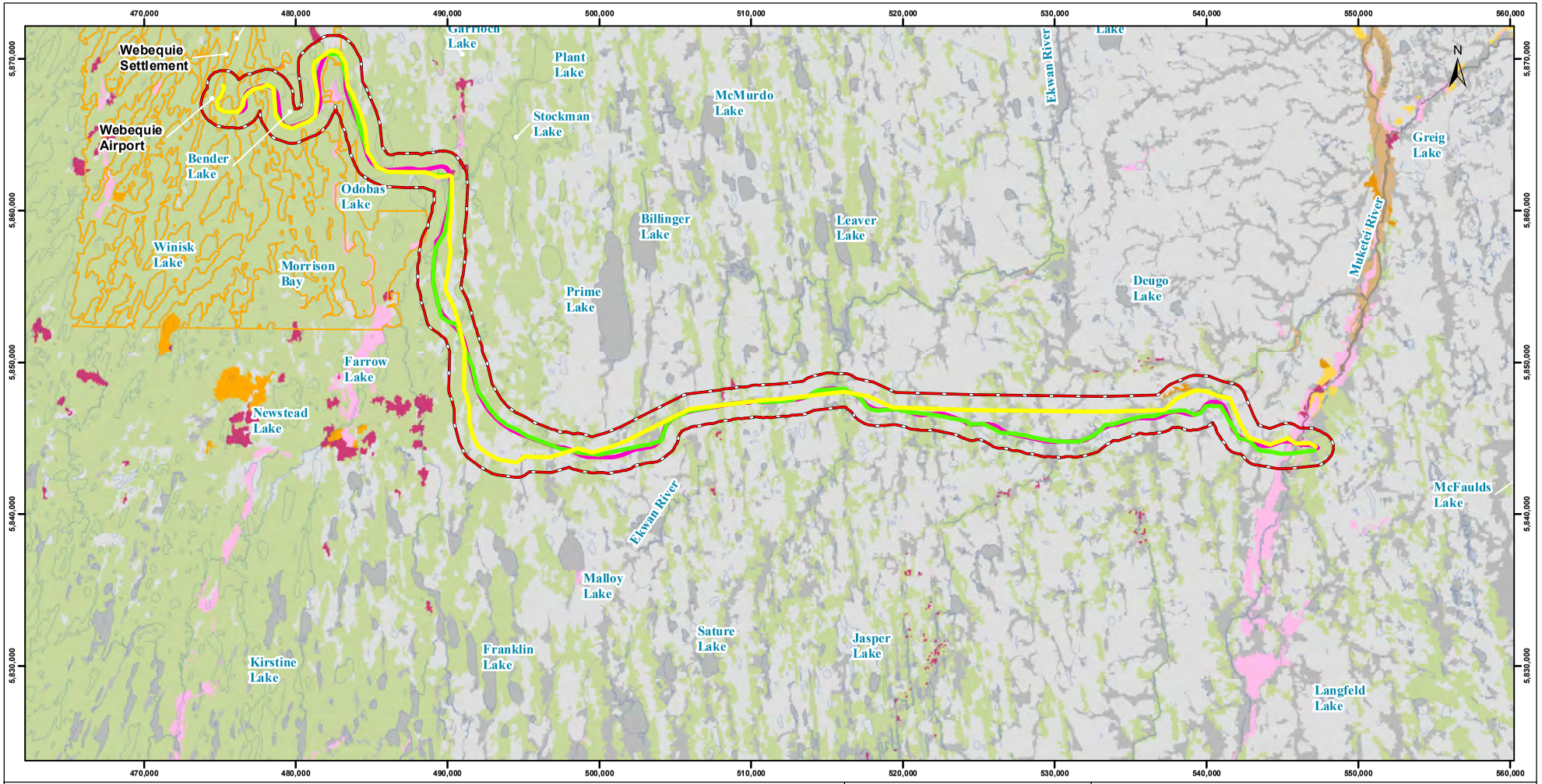

Legend

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Local Study Area (LSA 1km from Centreline of Route Alternatives)
- Webequie First Nation Reserve
- Waterbody
- Organic Deposits (Fen)
- Organic Deposits (Bog)
- Fluvial Deposits (Recent)
- Fluvial Deposits (Abandoned)
- Marine Beach and Near-shore Deposits
- Glaciofluvial Ice-contact Deposits
- Glacial Deposits
- Glacial Deposits and Bedrock
- Metamorphic and Igneous Rocks

WSR WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Cadastral boundaries are for informative purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v1.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/); Ontario Ministry of Natural Resources and Forestry (OMNRF); and, Barnett, P.J., Young, K.N., McCallum, J.D. 2013a. Surficial geology of Webequie Supply Road Area, Northern Ontario; Ontario Geological Survey, Preliminary Map P.3686, scale 1: 100 000 and Barnett, P.J., Young, K.N., McCallum, J.D. 2013b. Surficial Geology of the Lansdowne House Area Northeast, Northern Ontario, 1:100 000; Ontario Geological Survey, P.3697. Download Date : 2021-02-04

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0 10 20 Km

Webequie Supply Road (WSR)

Surficial Geology

Figure Number:	REV:
B.2	

Client:	Project Number:	Date:
Webequie First Nation	661910	10/15/2024

DSC	DRN	CHK	APP
	AD	CW	CW

SIZE 11 X 17 Service Layer Credits:

Document Path: \\cor01\PROJECTS\EAW\Projects\661910 - Webequie First Nation Supply Rd\40_Execution\45_GIS_Dwgs\MXD\Geotech\661910_WSR_BIO_BIL_GEO_SurficialGeology_000 1_0004.mxd

SIZE 11x17

APPENDIX C

Borehole Logs

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EXPLANATION OF THE FORM BORING LOG

This form summarizes both field information and selected laboratory test results obtained from each boring. An explanation of the various columns of the boring log form follows:

DEPTH

This column gives the depth scale of the boring.

ELEVATION AND DEPTH

This column gives the elevation and depth of inferred geologic contacts. The elevation is referred to the datum shown in the general heading.

DESCRIPTION

This column gives a description of the soils and rocks based on a visual examination of the samples and laboratory tests. Each stratum is described according to the following format for soil and rock:

Soils

Consistency/ compactness condition, color, secondary constituents, grain size (granular soils), SOIL TYPE, minor constituents, and additional information.

Eg. Very dense, grey, clayey, fine to medium SAND, with shell fragments and occasional irregular gravel.

Eg. Soft, greenish grey, silty CLAY, high plasticity, with shells and occasional sandy lenses.

The compactness condition of cohesionless soils and the consistency of cohesive soils are defined according to the Canadian Foundation Engineering Manual (CFEM – 2006), as following:

Compactness Condition of Cohesionless Soils

Compactness Condition	Standard Penetration Resistance "N-value" (Blows/0.3 m or Blows/foot)
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

Consistency of Cohesive Soils

**The compressive strength obtained from the quick (Q) triaxial test is equal to twice the shear strength of the clay.*

Consistency	Undrained Shear Strength* (kPa)	Standard Penetration Resistance "N-value" (Blows/0.3 m or Blows/foot)	Field Identification
Very soft	0 to 12	< 2	Easily penetrates several cm by fist
Soft	12 to 25	2 to 4	Easily penetrates several cm by thumb
Firm	25 to 50	4 to 8	Can be penetrated several cm by thumb with moderate effort
Stiff	50 to 100	8 to 15	Readily indented by thumb but penetrated only with great difficulty
Very Stiff	100 to 200	15 to 30	Readily indented by thumb nail
Hard	over 200	> 30	Indented with difficulty by thumb nail

Continued on page 2

Color: in comparison with Munsell soil color charts (if requested), otherwise visual observation

Soil Classification: in accordance to Unified Soil Classification System (USCS), briefly described on Page 3-4.

Rocks

Strength, color, weathering (if appropriate), secondary constituent (if applicable), grain size (if determinable) ROCK TYPE, fracture state, secondary constituents, and additional information.

Eg. Weak, pale grey, silty, fine to medium SANDSTONE, medium to widely fractured, occasional shells and embedded corals (to 100mm).

Rock strength

Rock strength is based on unconfined compressive strength (UCS) and defined according to Canadian Foundation Engineering Manual (CFEM 2006), as following:

Strength	Range of UCS (MPa)	Field Identification Method
Extremely weak	< 1	Indented by thumbnail
Very weak	1 - 5	Can be peeled with a pocketknife; crumbles under firm blows of geological hammer
Weak	5 - 25	Can be peeled with a pocketknife with difficulty; shallow indentation made by a firm blows of geological hammer
Medium strong	25 - 50	Cannot be scraped or peeled with a pocketknife; specimen can be fractured with a single firm blow of geological hammer
Strong	50 - 100	Specimen requires more than one blow of geological hammer to fracture
Very strong	100 - 250	Specimen requires many blows of geological hammer to fracture
Extremely strong	>250	Specimen can only be chipped by geological hammer

Color: in comparison with Munsell soil color charts (if requested), otherwise visual observation

Weathering

Weathering	Field Identification Method
Fresh	No visible sign of rock material weathering
Faintly weathered	Discoloration indicates weathering of rock and discontinuity surfaces
Moderately weathered	Less than half of the rock material is decomposed or disintegrated to a soil
Highly weathered	More than half of the rock material is decomposed or disintegrated to a soil
Completely weathered	All rock material is decomposed and or disintegrated to soil
Residual soil	All rock material is converted to soil

Discontinuities and structure

Discontinuity Spacing	
Spacing width (m)	**Classification**
<0.02	Extremely close
0.02 – 0.06	Very close
0.06 – 0.20	Close
0.2 – 0.6	Moderately close
0.6 – 2.0	Wide
2.0 – 6.0	Very wide
> 6.0	Extremely wide

structure	
Spacing (mm)	**Classification**
<0.3	Thinly laminated
0.3 – 3	Laminated
3 – 30	Thin bedded
30 – 300	Thick bedded
>300	Thick bedded
No bedding	Massive

STRATIGRAPHIC PLOT

The column describes the stratigraphy of the soil and rock strata, using standard symbols.

PIEZOMETER INSTALLATION AND WATER LEVEL

This column shows the groundwater level in the boring measured on the date indicated. In impervious soils the accurate determination of ground water elevations by standpipe, casing or open-hole readings is not possible within the normal time frame of the completion of the site work, and the true groundwater level may be higher or lower than indicated. Where both pervious and impervious soil strata are penetrated, the groundwater levels in each layer may be at different levels and sealed piezometers or standpipes within the individual layers are required to establish true groundwater conditions. Water levels determined by a piezometer can be considered as reliable groundwater levels for the layer in which the piezometer tip is located. Piezometer construction and installation details are also shown in this column, as applicable.

TESTS

The central section of the log forms a graph which is used to plot selected field and laboratory test results, at the elevation at which they were carried out. The symbols and scales for the plotting are shown at the head of the column.

OTHER TESTS

This column shows the results or abbreviations of other field or laboratory tests which have been performed. An explanation of some abbreviations is given on the top of the form, and others include G for Specific Gravity, C for Consolidation, CH for Chemical Analysis. The results of other tests not plotted on the form and detailed test results are given in an Appendix B to the report.

SAMPLES

The first two columns describe the condition, type and number of each sample. The location and condition of each sample is plotted to scale. The legend for sample condition is explained on the top left side of the form. The third column shows the “N” value of the soil as determined by the Standard Penetration Test. The “N” value corresponds to the number of blows required to drive the last 0.3 m (1 foot) of a 51 mm (2 in.) diameter standard split spoon sampler with an energy of 480 joules (4200 lb.-in.). The Standard Penetration Test is carried out according to ASTM D1586. The weight of the hammer being 63.5kg and a free fall of 0.76m. The last two column record the recovery and RQD of each run of rock core, both expressed as percentage: recovery being the ratio of length of core recovered to the total length of core run; RQD being the ratio of the length of core recovered greater than 0.10m to the total length of core,

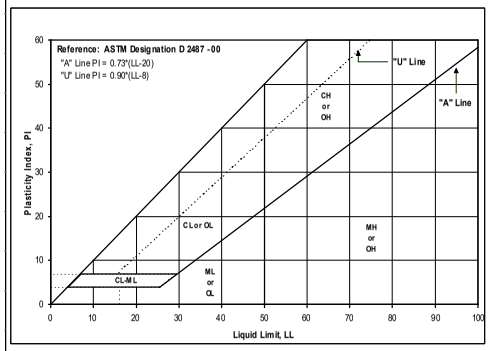
UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			Laboratory Classification Criteria	GROUP SYMBOL	GROUP NAME
COARSE – GRAINED SOILS >50% retained on #200 sieve	**GRAVEL** >50% of coarse fraction retained on #4 sieve	**CLEAN GRAVEL** Fines < 5%	Cu ≥4 & 1≤Cc≤3	**GW**	Well-graded GRAVEL
			Cu<4 &/or 1>Cc>3	**GP**	Poorley-graded GRAVEL
		GRAVEL WITH FINES Fines>12%	Fines classify as ML or MH	**GM**	Silty GRAVEL
			Fines classify as CL or CH	**GC**	Clayey GRAVEL
	SAND >50% of coarse fraction passing #4 sieve	**CLEAN SAND** Fines < 5%	Cu ≥6 & 1≤Cc≤3	**SW**	Well-graded SAND
			Cu<6 &/or 1>Cc>3	**SP**	Poorly Graded SAND
		SAND WITH FINES Fines>12%	Fines classify as ML or MH	**SM**	Silty SAND
			Fines classify as CL or CH	**SC**	Clayey SAND
FINE-GRAINED >50% passing #200 sieve	**SILT & CLAY** LL<50	**INORGANIC**	PI>7 & plots on or above "A" line	**CL**	Lean CLAY
			PI<4 or below "A" line	**ML**	SILT
		ORGANIC	LL (oven dried)/LL (not dried) <0.75	**OL**	Organic CLAY/SILT of low plasticity
	SILT & CLAY LL>50	**INORGANIC**	PI plots on or above "A" line	**CH**	Fat CLAY
			PI plots below "A" line	**MH**	Elastic SILT
		ORGANIC	LL (oven dried)/LL (not dried) <0.75	**OH**	Organic CLAY
HIGHLY ORGANIC SOIL			Primarily organic matter, dark in colour, and organic odor	**PT**	PEAT

NOTES:

1. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name
2. Cu = D60/D10 & Cc = $(D30)^2/(D10*D60)$
3. If coarse soil contains 15% sand or gravel, add "with sand or gravel" to group name
4. Coarse soils with 5-12% fines require dual symbols: GW-GC well-graded gravel with clay
5. If fines classify CL-ML, use dual symbol GC-GM, or SC-SM
6. If fines are organic, add "with organic fines to group name"
7. If fine soil contains 15-29% above #200, add "with sand or gravel", whichever is predominant
8. If fine soil contains ≥30% above #200 sieve, add "with sandy or gravely", whichever is predominant

PLASTICITY CHART



	Particle Size			
	Lower Limit		Upper Limit	
	mm	Sieve	mm	Sieve
SAND				
Fine	0.075	200	0.425	40
Medium	0.425	40	2.00	10
Coarse	2.00	10	4.75	4
GRAVEL				
Fine	4.75	4	19	¾"
Coarse	19	¾"	75	3"
COBBLES	75	3"	300	12"
BOULDERS	300	12"	914.4	36"

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA & coring**
Location
Coord. **N 5868021 E 477353**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-01**
Page **1 of 1**
Start Date **2019-02-20** (yyyy-mm-dd)
End Date **2019-02-20** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○ — Field Vane: Intact ▲ / Remold ◆ — Lab. Vane: Intact △ / Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
		ORGANICS		▼			AS01						
	0.3	**TILL** Silt and Sand, trace gravel, brown, moist											
1							SS02	1 5 7 10	12	47			5.3 57 37.7
2							SS03	10 15 30	45	53			
	2.1	**BEDROCK** Granite, strong, closely jointed, fair quality, reddish brown and pink, slightly weathered					RC04			100	73		
3							RC05			100	64		
							RC06			100	75		
4		good quality					RC07			100	87		
5	4.9	**END OF BOREHOLE** Notes: - About 0.61 m frost depth - Water level measured on 21-Feb-2019 @ 10 AM at 0.3 m below ground - Cave in was 0.76 m											

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5862141 E 490304**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-02**
Page **1 of 1**
Start Date **2019-02-22** (yyyy-mm-dd)
End Date **2019-02-22** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed | Undisturbed | Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3); D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80								
		ORGANIC					AS01						
	0.3	**TILL** Silty Gravelly Sand, trace clay, brown, moist, compact		▼	⊗		SS02	8 11 18 22	29	42			34.5 40.8 24.7
1													
	1.5	**BEDROCK** Granite, trace quartz, coarse grained, strong, widely jointed, excellent quality, blackish, reddish brown and pink Closely jointed, fair quality					RC03			100	100		
2							RC04			100	71		
3		Closely jointed, good quality											
							RC05			100	84		
4													
	4.5	**END OF BOREHOLE** Notes: - About 0.46 m frost depth - Water level measured on 23-Feb-2019 @ 8 AM was at 0.46 m below ground											

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5848318 E 490113**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-03**
Page **1 of 1**
Start Date **2019-02-23** (yyyy-mm-dd)
End Date **2019-02-23** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Stratigraphy | Field Undrained Shear C_u/Lab Tests | Samples/Field Tests

Field Undrained Shear C_u/Lab Tests: ■ Lab UCS; □ Q Test; ○ P.P. (US); *Field Vane* ▲ Intact, ◆ Remold; *Lab. Vane* △ Intact, ◇ Remoulded; 100 200 300 400 kPa
Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface										
		ORGANIC				SS01			84			
	0.6	**TILL** Silt and Sand trace clay and gravel, brown, moist				SS02			49			
1												
				▼		SS03			59			.6 46.7 52.7
2												
	2.6	**TILL** Sandy Silt, trace clay, some gravel, brown, moist				SS04			33			
3		Boulder, no sample recovery										
4												
5		grey				SS05			100			18.9 33.4 47.7
		Boulder, no sample recovery										
6												
7												
8						SS06			0			
	8.1	**END OF BOREHOLE**										

Notes:
- water level measured on 25-Feb-2019 @ 12:30 PM was at 1.67 m below ground
- Cave in was 3 m

BOREHOLE LOG 661910-WEBEQUIE - REV1.GPJ GEOTECH.GDT 17-9-20

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5845992 E 502521**
Logged/ Reviewed by **M. Saleem**

Borehole ID **Bh19-04**
Page **1 of 1**
Start Date **2019-09-26** (yyyy-mm-dd)
End Date **2019-09-26** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80								
		ORGANICS		▼									
	0.5	**TILL** Sand and Gravel, brown, saturated											
1													
	1.4	**BEDROCK** Granite, strong, moderatly jointed, excellent quality, black and grey, slightly weathered good quality slightly fractured					RC01			100	92		
2													
							RC02			100	83		
3													
4							RC03			100	77		
		moderately fractured fair quality											
5							RC04			100	56		
	5.8	**END OF BOREHOLE**											

Notes:
- ground elevation rise by about 5 degree moving away from water body
- water table near surface at borehole location but dry about 10 m towards east (away from water body) with bedrock at about 0.1 m below surface

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5847251 E 508084**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-05**
Page **1 of 2**
Start Date **2019-02-26** (yyyy-mm-dd)
End Date **2019-02-26** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane: Intact ▲ Remold ◆ — Lab. Vane: Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
		ORGANIC Top 0.3 m frozen and wood root extend up to 0.61 m											
1	0.8	**PEAT** Dark brown, loose			⊗		SS01	1 3 5	8	65			
2	1.2	**ORGANIC SILT AND SAND** trace clay and gravel, Organic, dark brown, moist, loose		▼	⊗		SS02	3 3 6 7	9	62			1.3 55.4 43.3
3	2.1	**TILL** Sandy silt, trace clay and gravel, brown, moist, compact			⊗		SS03	5 9 12 13	21	75			
		Dense			⊗		04	10 18 18 44	36	67			6.6 23.6 69.8
4		Compact											
5					⊗		SS05	14 13 10 9	23	67			
6		very loose, gravel at tip of the spoon			⊗		SS06	1 0 1 0	1	54			
7													
8		gravel at tip of the spoon			⊗		SS07	0 0 >50	0	100			
	8.0	BEDROCK Gneiss, fresh, strong, widely jointed, excellent quality, white and grey					RC08			100	100		
9		Become closely to widely jointed, fair quality, slightly weathered											
							Rc09			100	73		
10													

BOREHOLE LOG 661910-WEBEQUIE - REV1.GPJ GEOTECH.GDT 17-9-20

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5847251 E 508084**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-05**
Page **2 of 2**
Start Date **2019-02-26** (yyyy-mm-dd)
End Date **2019-02-26** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Stratigraphy: Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Samples/Field Tests: Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
					Lab UCS; Q Test; P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80								
	10.5	**END OF BOREHOLE** Notes: - About 0.3 m frost depth - water level measured on 27-Feb-2019 @ 10:30 AM was at 1.82 m below ground - Cave in was 2.6 m											

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5848106 E 516049**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-06**
Page **1 of 2**
Start Date **2019-02-27** (yyyy-mm-dd)
End Date **2019-03-01** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○ 100 200 300 400 kPa; Field Vane: Intact ▲ Remold ◆; Lab. Vane: Intact △ Remoulded ◇; Water Content (%) ⊗ 20 40 60 80; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣								
		ORGANIC Frozen											
	0.6	**TILL** Sandy Silt and Clay, trace gravel, top 0.15 m frozen, brown, moist, loose to compact		▼	⊗		SS01	10 3 2 4	5	57			
1													
					⊗		SS02	15 11 15 23	26	79			11 33.1 55.9
2													
					⊗		SS03	14 15 14 16	29	79			
3		Saturated											
					⊗		SS04	45 11 10 10	21	33			
4													
	4.1	**TILL** Sand and Gravel some silt, grey, moist, dense			⊗		SS05	13 14 22	36	33			47.7 38.1 14.2
5													
	5.5	**TILL** Gravelly sand, trace silt, occassional cobble and boulders, grey, moist, very dense			⊗		SS06	32 50		65			
6													
7													
		Boulder											
8													
9													
		No sample recovery, possible cobble pushing down					SS07	40 50		0			
10													

BOREHOLE LOG 661910-WEBEQUIE - REV1.GPJ GEOTECH.GDT 17-9-20

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5848106 E 516049**
Logged/ Reviewed by **D. Meles**

Borehole ID **BH19-06**
Page **2 of 2**
Start Date **2019-02-27** (yyyy-mm-dd)
End Date **2019-03-01** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests: Lab UCS, Q Test, P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
11	10.7	**TILL** Silty Sand, trace gravel, grey, moist, very dense					SS08	10 14 50	>50	0			
12					⊗		SS09	10 40 50	>50	100			5.6 62.6 31.8
13													
14					⊗		SS10	20 33 50	>50	95			
15													
	15.3	**END OF BOREHOLE** Notes: - Frost depth was 0.91 m - Water level measured on 01-March-2019 @ 5:30 PM was at 1.22 m below ground - Cave in was 2.9 m			⊗		SS11	45 50		100			

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5844967 E 529918**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-07**
Page **1 of 2**
Start Date **2019-09-23** (yyyy-mm-dd)
End Date **2019-09-23** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed, Undisturbed, Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³); D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests (Lab UCS, Q Test, P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–80)	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
		ORGANIC											
	0.3	**TILL** Sandy Silt, trace gravel, brown, moist, loose to compact some clay					SS01	1 1 3 6	4	41			
1							SS02	5 8 7 6	15	54			
	1.4	**TILL** Clayey Sandy Silt, trace gravel, grey, moist, compact to dense					SS03	6 7 8 13	15	75			9.7 27.4 40.9 22
2							04	20 36 33	>50	89			
3							SS05	>50		100			
4													
							SS06	>50		100			
5													
6		no recovery, possible cobble or boilder					SS07	>50					
7													
		no recovery, possible cobble or boilder					SS08	>50					
8													
9													
		no recovery, possible cobble or boilder					SS09	>50					

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5844967 E 529918**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-07**
Page **2 of 2**
Start Date **2019-09-23** (yyyy-mm-dd)
End Date **2019-09-23** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests: Lab UCS, Q Test, P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa; Water Content (%), Plastic Limit (%), Liquid Limit (%); 20 40 60 80	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
	10.0	sample lost, possible due to bouncing on cobble or boulder **END OF BOREHOLE** Notes: switch to coring from 4.57 m due to very hard till and casing advancer refusal - Water level measured on 24-September-2019 @ 8:30 AM was at 1.99 m below ground - Cave in was 5.18 m					SS10	30 >50		0			

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5846513 E 536543**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-08**
Page **1 of 2**
Start Date **2019-09-24** (yyyy-mm-dd)
End Date **2019-09-24** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○ — Field Vane: Intact ▲, Remold ◆ — Lab. Vane: Intact △, Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
		ORGANIC			⊗		SS01	1 1 2 3	3	33			
	0.5	**SILTY SAND** Silty fine Sand, brown, moist, loose to very loose			⊗		SS02	2 2 2 2	4	33			
1		trace rootlets		▼									
2					⊗		SS03	1 1 1 1	2	87			0 67.9 32.1
		grey trace rootlets and gravel			⊗		04	2 4 5 18	9	57			
3	3.0	**TILL** Silt and Sand, some clay, trace gravel, grey, moist, compact to very dense					SS05	6 7 8 8	15	57			
4													
					⊗		SS06	>50		100			
5													
6													
		sample lost					SS07	30 26 27	>50	0			
7													
8					⊗		SS08	31 31 38	>50	87			4.6 35.2 60.2
9													
	9.1	**TILL** Clayey Sandy Silt, trace gravel, grey, moist, very dense											
10													

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5846513 E 536543**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-08**
Page **2 of 2**
Start Date **2019-09-24** (yyyy-mm-dd)
End Date **2019-09-24** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
11					Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲ / Remold ◆; Lab. Vane: Intact △ / Remoulded ◇; 100 200 300 400 kPa		SS09	31 27 34 50	>50	75			4.7 29.1 35.2 31
12					Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80		SS10	18 25 31 35	>50	100			
13													
14													
15													
	15.2	**END OF BOREHOLE**					SS11	>50					

Notes:
- Water level measured on 25-September-2019 @ 9:50 AM was at 1.5 m below ground
- Cave in was 3.9 m

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5844902 E 545749**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-10**
Page **1 of 2**
Start Date **2019-09-25** (yyyy-mm-dd)
End Date **2019-09-25** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane: Intact ▲ Remold ◆ — Lab. Vane: Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
		ORGANIC											
	0.3	**SANDY SILT** trace clay and rootlets, brown, moist, compact to dense			⊗		SS01	2 9 5 5	14	41			
1					⊗		SS02	8 16 23 17	39	75			
2					⊗		SS03	33 31 34	>50	78			
	2.1	**SILTY SAND** brown, moist, dense			⊗		04	28 38 37	>50	72			0 67 33
3					⊗		SS05	24 24 33	>50	72			
4													
5					⊗		SS06	22 33 36	>50	72			
6													
7					⊗		SS07	18 25 25	50	65			
	7.6	**SAND** some silt, brown, saturated, dense		▼									
8													
9					⊗		SS08	13 20 22	42	78			0 89.6 10
	9.6	**END OF BOREHOLE**											

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**

Contract **661910**

Drilling Company **TBT**

Drill Rig **SIMCO 2400 SK-1**

Method **Advanced casing & coring**

Location

Coord. **N 5844902 E 545749**

Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-10**

Page **2 of 2**

Start Date **2019-09-25** (yyyy-mm-dd)

End Date **2019-09-25** (yyyy-mm-dd)

Azimuth

Dip

Sample Condition

Disturbed | Undisturbed | Lost

Sample Types

SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations

PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Stratigraphy					Field Undrained Shear C_u/Lab Tests	Samples/Field Tests							
Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	■ Lab UCS, □ Q Test, ● P.P. (US); *Field Vane* ▲ Intact ◆ Remold; *Lab. Vane* △ Intact ◇ Remoulded; 100 200 300 400 kPa; ⊗ Water Content (%); ⊢ Plastic Limit (%) ⊣ Liquid Limit (%); 20 40 60 80	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Notes: - start using drilling mud at 4.57 m depth - At 9.1 m depth sand heaved inside the casing to, used tremi pipe to clean - borehole stopped due to casing locked in the sand at 9.1 m depth, probably the water is at 9.1 m depth											

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **Pionjar**
Method **jackhammer**
Location
Coord. **N 5844938 E 545634**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH19-P1**
Page **1 of 1**
Start Date **2019-03-01** (yyyy-mm-dd)
End Date **2019-03-01** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS / Q Test / P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa								
					Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80								
	0.2	**ORGANIC** frozen											
1		**SANDY SILT** trace clay and gravel, traces of roots on top part of spoon, brown, moist			⊗		SS1			100			
					⊗		SS2			50			22.9 77.7
					⊗		SS3			100			
	1.8	**END OF BOREHOLE**											

Notes:
- Dry upon completion

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **SSA**
Location
Coord. **N 5862412 E 490548**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH20-01**
Page **1 of 1**
Start Date **2020-07-06** (yyyy-mm-dd)
End Date **2020-07-06** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲ / Remold ◆; Lab. Vane: Intact △ / Remoulded ◇; 100 200 300 400 kPa; Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80								
	0.2	**ORGANIC**											
1		**TILL** Silt, some clay and sand, trace gravel, brown, moist, compact			⊗ at 60		SS01	2 3 4 6	7	59			
					⊗ at 20		SS02	3 5 20 21	25	54			0.9 15.8 83.3
	1.2	**TILL** Gravelly Sand, some silt, trace clay, brown, moist											
2					⊗ at 20		AS03						
	2.1	**END OF BOREHOLE** Notes: - auger refusal at 2.1 m bgs on possible boulder / bedrock - hole stayed open and dry after completion											

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **SSA**
Location
Coord. **N 5857978 E 489278**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH20-02**
Page **1 of 1**
Start Date **2020-07-10** (yyyy-mm-dd)
End Date **2020-07-10** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲ / Remold ◆; Lab. Vane: Intact △ / Remoulded ◇; 100 200 300 400 kPa; Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80								
	0.2	**ORGANIC**											
		TILL Gravely Sand trace silt, brown, moist, compact			⊗		SS01	1 3 8 11	11	33			
1		auger sample collected from 2.5' to 5'			⊗		SS02	1 4 16 20	20	33			
		trace cobbles			⊗		SS03	9 16 20 16	36	54			
2					⊗		SS04	13 50		64			
3				▼	⊗		SS05	20 30 31	>50	54			34.5 53.5 12
4	3.7	**TILL** Sand, some gravel, trace cobbles, grey, saturated											
		spoon wet			⊗		SS06	4 >50		72			
	4.8	**END OF BOREHOLE**											

Notes:
- water level observed during drilling at 3.6 m bgs
- hole caved to 2.1 bgs

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5853161 E 485566**
Logged/ Reviewed by **M. Saleem**

Borehole ID **BH20-03**
Page **1 of 1**
Start Date **2020-07-13** (yyyy-mm-dd)
End Date **2020-07-14** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed, Undisturbed, Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3); D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests (Lab UCS, Q Test, P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–80)	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % (GR SA SI CL)
		Ground Surface											
		ORGANIC											
	0.3	**TILL** Silty Sand some gravel, brown, moist, compact piece of gravel at tip of the spoon SS2			⊗		SS01	1 1 2 3	3	25			
1					⊗		SS02	4 5 9 19	14	49			
2		boulder from 7.5' to 9'			⊗		SS03	15 25 28 30	>50	75			10 54.4 35.6
3	3.0	**TILL** Gravelly Sand, grey, moist, very dense			⊗		SS04	40 40 50	>50	65			
4													
5		piece of cobble at tip of SS5			⊗		SS05	32 50		83			
	5.8	**END OF BOREHOLE**											

Notes:
- hole was dry after completion'
- hole caved to 3.1 m bgs

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA, Advanced casing & coring**
Location
Coord. **N 5862249 E 490294**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-1**
Page **1 of 1**
Start Date **2020-07-04** (yyyy-mm-dd)
End Date **2020-07-05** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed, Undisturbed, Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³); D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests (Lab UCS, Q Test, P.P. (US); Field Vane Intact, Remold; Lab. Vane Intact, Remoulded; 100–400 kPa; Water Content (%), Plastic Limit (%), Liquid Limit (%); 20–80)	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
	0.2	**ORGANIC**											
		TILL Sand and Gravel, some silt, trace cobbles, brown, moist, dense			⊗		SS01	1 3 10 14	13	33			
1		auger sample collected from 2.5' to 5'			⊗		SS02	12 20 32 48	>50	33			37.1 48.2 14.7
		lot of cobble and boulders below 5'			⊗		SS03	50		220			
2				▼									
	2.4	BEDROCK Granodiorite, modrately fractured and weathered, coarse grained, strong, poor quality, pink and reddish brown					RC04			100	31		
3		Highly fractured very poor quality					RC05			67	11		
4							RC06			87	46		
		fair quality					RC07			100	69		
5													
	5.2	**END OF BOREHOLE**											

Notes:
- switch to case advancer at 1.5 m due to cobble and boulders
- hole observed dry after completion of overburden drilling
- 25.4 mm monitoring well installed with 1.52 m prepack screen.
- Water level measured at 2.33 m bgs before well development on July 10, 2020

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **SSA & Advanced casing**
Location
Coord. **N 5861787 E 488808**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-2**
Page **1 of 1**
Start Date **2020-07-07** (yyyy-mm-dd)
End Date **2020-07-07** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○ — Field Vane: Intact ▲ Remold ◆ — Lab. Vane: Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
		ORGANIC vegetation and rootlets					SS01	0 1 0 1	1	0			
1	0.8	**PEAT** dark brown					SS02	1 0 3 2	3	33			
2	2.0	**TILL** Silt and Sand, trace clay and gravel, light brown, moist to wet, loose to compact					SS03	1 2 6 11	8	70			
		light grey trace clay					SS04	2 12 14 16	26	41			
3		dense					SS05	7 23 20 40	43	46			6.1 35.2 58.7
4													
5							SS06	28 44 >50	0	88			
	5.2	**END OF BOREHOLE**											

Notes:
- water level observed during drilling at 0.3 m bgs
- hole caved to 4.2 m bgs
- switch to case advancer due to hole collaps to install MW.
- 25.4 mm monitoring well installed with 1.52 m prepack screen.
- solinst piezometer installed at about 1 m from WQR2 at 1.98 m bgs with 0.76 m stick up
- water level measured in solinst piezometer at 0.6 m bgs on July 14, 2020
- water level measured at 1.05 m bgs before well development on July 14, 2020

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5857493 E 489224**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-3**
Page **1 of 1**
Start Date **2020-07-09** (yyyy-mm-dd)
End Date **2020-07-09** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³)
D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲ / Remold ◆; Lab. Vane: Intact △ / Remoulded ◇; 100 200 300 400 kPa; Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80								
	0.1	**ORGANIC**											
1		**TILL** Gravelly Sand, trace silt, brown, moist, loose to compact			⊗		SS01	1 3 5 5	8	41			
					⊗		SS02	6 11 10 10	21	49			28.1 63.5 8.4
	1.5	**TILL** Sand, some silt, trace gravel, brown, moist, compact			⊗		SS03	8 8 12 13	20	46			6.2 82.8 11
2		grey											
					⊗		SS04	7 10 17 19	27	66			
3		spoon wet dense											
							SS05	4 17 20 20	37	66			
4													
					⊗		SS06	3 10 23 25	33	74			
5													
	5.2	**END OF BOREHOLE**											

Notes:
- sample SS5 selected for ARD testing
- water level observed during drilling at 2.9 m bgs
- 50.8 mm monitoring well installed with 3 m prepack screen.
- water level measured at 2.79 m bgs before well development on July 14, 2020

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5857117 E 488976**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-4**
Page **1 of 1**
Start Date **2020-07-08** (yyyy-mm-dd)
End Date **2020-07-08** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed | Undisturbed | Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³); D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests (Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100–200–300–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–40–60–80)	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
	0.2	**ORGANIC**											
		TILL Silty Sand, some gravel, brown, moist, loose to compact			⊗		SS01	1 2 4 5	6	41			
1					⊗		SS02	8 10 14 12	24	30			
	1.4	**TILL** Silt, some clay, sand and gravel, brown, moist, hard spoon wet		▼	⊗		SS03	10 16 21 18	37	62			12.6 15.8 71.6
2	2.1	**TILL** Sandy Silt, trace clay and gravel brown, moist, dense			⊗		SS04	13 16 20 20	36	84			
3		trace clay			⊗		SS05	14 15 18 17	33	84			
4													
		grey some gravel, trace clay			⊗		SS06	8 16 16 5	32	66			
5													
6					⊗		SS07	9 8 10	18	100			7.8 33.4 58.8
7													
	7.7	spoon bouncing			⊗		SS08	>50		100			
		END OF BOREHOLE											

Notes:
- water level observed during drilling at 1.5 m bgs
- 50.8 mm monitoring well installed with 3 m prepack screen.
- water level measured at 1.57 m bgs before well development on July 13, 2020

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5852807 E 485494**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-5**
Page **1 of 1**
Start Date **2020-07-13** (yyyy-mm-dd)
End Date **2020-07-13** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed, Undisturbed, Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³); D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests (Lab UCS, Q Test, P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remolded; 100–400 kPa; Water Content (%), Plastic Limit (%), Liquid Limit (%); 20–80)	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
	0.2	**ORGANIC**											
		TILL Clayey Silt some sand, trace rootlets, brown, moist, soft			⊗		SS01	2 2 1 7	3	33			
	0.8	**TILL** Sandy Silt, trace clay and gravel, brown, moist, dense high N-Value possible due to cobble boulder from 5' to 6'			⊗		SS02	3 6 32 10	38	59			2.2 22.7 75.1
2	1.8	**TILL** Gravelly Sand, trace silt, browm, moist, dense to very dense auger sample selected from 6' to 7.5'			⊗		SS03	8 16 22 12	38	54			
					⊗		SS04	12 20 28	48	83			
3					⊗		SS05	13 28 36	>50	83			23.1 68.2 8.7
4		SS6 selected for ARD testing											
					⊗		SS06	17 37 42	>50	54			
5													
6					⊗		SS07	23 40 45	>50	87			
	6.5	**END OF BOREHOLE** Notes: - hole was dry after completion - 50.8 mm monitoring well installed with 3 m prepack screen. - monitoring well was dry on July 28, 2020											

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5853367 E 486193**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-6**
Page **1 of 1**
Start Date **2020-07-16** (yyyy-mm-dd)
End Date **2020-07-16** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○ — Field Vane: Intact ▲, Remold ◆ — Lab. Vane: Intact △, Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
	0.2	**ORGANIC** **PEAT** dark grey			⊗		SS01	1 0 0 0	0	21			
1	0.8	**TILL** Silty Clay trace sand, occassional cobble and boulders, moist, hard		▼	⊗		SS02	4 5 28 15	33	59			
2	1.5	**TILL** Silty Sand, trace clay, gravel and cobbles, grey,saturated, dense spoon wet at 5'			⊗		SS03	13 20 16	36	33			
3					⊗		SS04	16 16 18	34	33			
	3.5	**END OF BOREHOLE** Notes: - sand heave about 1.5 m inside the augers, pull the augers and able to push spoon to the bottom but could not install MW. - at 1.5 m due to boulder, hole moved about 2 m towards north. - water at 1.1 m and hole caved to 3.1 m bgs after completion on July 16, 2020											

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **SSA**
Location
Coord. **N 5847291 E 488545**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQA-7**
Page **1 of 1**
Start Date **2020-07-11** (yyyy-mm-dd)
End Date **2020-07-11** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲, Remold ◆; Lab. Vane: Intact △, Remoulded ◇; 100–200–300–400 kPa; Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20–40–60–80								
		ORGANIC organics and moss											
	0.5	**TILL** Silty Clay, trace sand and gravel,brown, moist, stiff											
1					⊗		SS01	3 5 5	10	62			
					⊗		SS02	2 5 6	11	61			
2				▼									
3		spoon wet											
	3.2	**TILL** Silty Sand, trace gravel brown, moist, dense			⊗		SS03	4 21 25	46	83			
4		spoon wet at 5'											
		grey very dense			⊗		SS04	23 33 48	>50	78			
5	5.0	**END OF BOREHOLE**											

Notes:
- water at 2.1 m bgs and holes caved to 3 m bgs after completion
- this site was soppoed to be surface bedrock but no bedrock encountered to the termination depth of the hole and MW was not installed.

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5865570 E 479568**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-1**
Page **1 of 1**
Start Date **2020-07-24** (yyyy-mm-dd)
End Date **2020-07-24** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ Field Vane ▲ Intact ◆ Remold Lab. Vane △ Intact ◇ Remoulded 100 200 300 400 kPa; Water Content (%) ⊗ Plastic Limit (%) ⊢ Liquid Limit (%) ⊣ 20 40 60 80								
		PEAT surficial organics and then dark brown peat. auger sample collected from 0 to 2.5'					AS01						
1		no rcovery at SS2 auger sample collected from 2.5' to 5'					SS02	1 0 1 0	1	0			
2	1.7	**TILL** Clay and Silt, some sand and gravel, trace piece of cobble at tip of spoon, grey, moist, firm					SS03	0 2 4 3	6	54			
3							SS04	1 1 4 10	5	87			12.4 15.5 35.1 37
4	3.0	**TILL** Sandy Silt, trace clay and gravel, grey, saturated, loose					SS05	4 2 2 2	4	26			
5		dense trace occassional cobbles SS 6 selected for ARD testing					SS06	11 17 15 12	32	54			
6		very dense					SS07	22 30 45	>50	87			5.7 30.6 63.7
	6.5	**END OF BOREHOLE**											

Notes:
- water observed at 3 m bgs during drilling
- 50.8 mm monitoring well installed with 1.52 m prepack screen.
- water level measured at 0.49 m bgs before well development on July 25, 2020

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5848589 E 492188**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-2A**
Page **1 of 1**
Start Date **2020-07-11** (yyyy-mm-dd)
End Date **2020-07-11** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲, Remold ◆; Lab. Vane: Intact △, Remoulded ◇; 100 200 300 400 kPa; Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80								
		ORGANICS organics and moss to 1.5'			⊗		SS01	1 0 1 0	1	41			
	0.5	**TILL** Silty Clay, trace rootlets, brown, moist, soft											
1	0.8	**TILL** Sandy Silt, some clay and gravel, brown, moist, loose			⊗		SS02	2 3 3 3	6	20			
		spoon wet at 5' SS 3 selected for ARD testing					SS03	2 2 3 5	5	46			
2		compact											
					⊗		SS04	3 7 14 15	21	49			
3													
					⊗		SS05	6 15 13 13	28	75			10.5 33.6 55.9
4													
	4.3	**END OF BOREHOLE**											

Notes:
- auger refusal on boulder at 4.3 m bgs
- water level observed during drilling at 1.5 m bgs
- 25.4 mm monitoring well installed with 3 m prepack screen.
- water level measured at 0.35 m bgs before well development on July 23, 2020

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Borehole Log

Project **WSR Ontario**

Contract **661910**

Drilling Company **TBT**

Drill Rig **SIMCO 2400 SK-1**

Method **Advanced casing**

Location

Coord. **N 5848589 E 492188**

Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-2B**

Page **1 of 1**

Start Date **2020-07-12** (yyyy-mm-dd)

End Date **2020-07-12** (yyyy-mm-dd)

Azimuth

Dip

Sample Condition

Disturbed | Undisturbed | Lost

Sample Types

SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations

PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3); D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests: Lab UCS; Q Test; P.P. (US); Field Vane Intact; Field Vane Remold; Lab. Vane Intact; Lab. Vane Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
1		same as WQR 2A											
2													
3													
4													
5	4.3	**TILL** Sandy Silt, trace to some clay and gravel, grey, saturated, loose			⊗		SS01	6 4 3 5	7	41			
6		very dense high N-value possible due to gravel at SS2 sppon tip			⊗		SS02	20 50		93			
7													
8		very dense			⊗		SS03	33 40 50	>50	65			
	8.1	**END OF BOREHOLE**											

Notes:
- 0-10' samples were taken at WQR 2A
- water level observed during drilling at 1.5 m bgs
- 25.4 mm monitoring well installed with 3 m prepack screen.
- water level measured at 0.24 m bgs before well development on July 23, 2020

BOREHOLE LOG 661910-WEBEQUIE - REV1.GPJ GEOTECH.GDT 17-9-20

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**

Contract **661910**

Drilling Company **TBT**

Drill Rig **SIMCO 2400 SK-1**

Method **Advanced casing & coring**

Location

Coord. **N 5844309 E 502669**

Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-3**

Page **1 of 1**

Start Date **2020-07-22** (yyyy-mm-dd)

End Date **2020-07-23** (yyyy-mm-dd)

Azimuth

Dip

Sample Condition

Disturbed | Undisturbed | Lost

Sample Types

SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations

PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3); D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests: Lab UCS; Q Test; P.P. (US); Field Vane Intact; Field Vane Remold; Lab. Vane Intact; Lab. Vane Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
		ORGANIC about 2' thick moss											
	0.6	**TILL** Silt and Sand trace clay and gravel, brown, moist, compact spoon wet			⊗		SS01	7 7 4 5	11	20			
1		high N-value possible due to cobble			⊗		SS02	8 10 >50	0	61			8.1 35.3 56.6
2							SS03	11 12 8 6	20	36			
3					⊗		SS04	6 10 15 11	25	25	31		
4	4.2	BEDROCK Granodiorite, modrately fractured and weathered, coarse grained, strong, good quality, black to grey and white excellent quality					RC05			91	76		
5													
							RC06			100	93		
6													
7							RC07			100	90		
	7.6	**END OF BOREHOLE**											

Notes:
- rock sample from 18' to 18' 9" selected for ARD testing
- water level observed during drilling at 0.76 m bgs
- case advancer stuck in casing and hole collapsed when pull casings to clean. Hole drilled and cored beside previously drilled hole in overburden.
- 25.4 mm monitoring well installed with 1.52 m prepack screen.
- water level measured at 0.2 m bgs before well development on July 24, 2020

BOREHOLE LOG 661910-WEBEQUIE - REV1.GPJ GEOTECH.GDT 17-9-20

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5848039 E 514301**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-4**
Page **1 of 2**
Start Date **2020-07-21** (yyyy-mm-dd)
End Date **2020-07-21** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane: Intact ▲ / Remold ◆; Lab. Vane: Intact △ / Remoulded ◇; 100 200 300 400 kPa; Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80								
		PEAT dark brown peat, very soft and saturated spoon went down with the weight of the hammer		▼			AS01						
1							SS02	0 0 0 0	0	20			
2							SS03	1 0 0 0	0	33			
	2.6	**TILL** Silty Sand trace clay and gravel, grey, saturated, loose to compact high N-value at SS5 possible due to cobble pushing down					SS04	0 1 3 4	4	36			
3					⊗		SS05	16 17 10 6	27	25	31		
4	3.8	BEDROCK Granodiorite, fresh, strong, excellent quality, grey and white					RC06			100	100		
5													
							RC07			100	100		
6		moderatly to highly fractured, vertical fracture, very poor quality											
7							RC08			100	23		
	7.9	**END OF BOREHOLE**											

Notes:
-rock sample from 20' 7" to 21' 6" selected for ARD testing
- water level observed during drilling at 0.9 m bgs
- 25.4 mm monitoring well installed with 1.52 m prepack screen.
- solinst piezometer installed at about 1 m from WQR4 at 2.6 m bgs with 0.91 m stick up
- water level measured in solinst

BOREHOLE LOG 661910-WEBEQUIE - REV1.GPJ GEOTECH.GDT 17-9-20

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing & coring**
Location
Coord. **N 5848039 E 514301**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-4**
Page **2 of 2**
Start Date **2020-07-21** (yyyy-mm-dd)
End Date **2020-07-21** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Stratigraphy: Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests: Lab UCS, Q Test, P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa; Water Content (%), Plastic Limit (%), Liquid Limit (%); 20 40 60 80	Samples/Field Tests: Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		piezometer at 1.53 m bgs on July 26, 2020 - water level measured at 0.49 m bgs before well development on July 22, 2020											

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **Advanced casing**
Location
Coord. **N 5845596 E 524762**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-5**
Page **1 of 1**
Start Date **2020-07-17** (yyyy-mm-dd)
End Date **2020-07-17** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed, Undisturbed, Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³); D - Dry Unit Weight (kN/m³)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane: Intact ▲ Remold ◆ — Lab. Vane: Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80								
		PEAT dark brown peat about 2' thick moss above peat		▼			SS01	1 0 1 0	1	0			
1	0.9	**TILL** Silty Clay, some sand trace gravel, trace organics, brown, wet, very soft			⊗		SS02	0 0 0 0	0	33			
					⊢⊗⊣		SS03	1 1 1 1	2	49			1.2 16.4 33.9 48.5
2	2.0	**TILL** Sandy Silt trace clay and gravel, brown, moist, loose to very dense SS4 selected for ARD testing					SS04	1 1 4 10	5	49			
3		high N-value at SS5 possible due to coble or boulder			⊗		SS05	14 28 36	>50	65			8.9 28.5 62.6
4													
	4.7	**END OF BOREHOLE**											

Notes:
- water level observed during drilling at 0.3 m bgs
- switch to case advancer due to boulder at 3.6 m bgs.
- 25.4 mm monitoring well installed with 1.52 m prepack screen.
- solinst piezometer installed at about 1 m from WQR5 at 0.9 m bgs with 0.76 m stick up
- water level measured in solinst piezometer at 0.17 m bgs on July 18, 2020
- water level measured at 0.17 m bgs before well development on July 18, 2020

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Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA**
Location
Coord. **N 5846453 E 536555**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-6A**
Page **1 of 1**
Start Date **2020-07-20** (yyyy-mm-dd)
End Date **2020-07-20** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; RC - Rock Core; BU - Bulk
CS - Core Sample; WS - Wash Sample
AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane: Intact, Remold; Lab. Vane: Intact, Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80								
0		same as WQR 6A augered down to 22' and installed MW.											
1													
2													
3													
4													
5													
6													
6.7	6.7	**END OF BOREHOLE** - water level observed during drilling at 6.1 m bgs. - 50.8 mm monitoring well installed with 3 m prepack screen. - water level measured at 0.1 m bgs before well development on July 21, 2020											

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**
Contract **661910**

Drilling Company **TBT**
Drill Rig **SIMCO 2400 SK-1**
Method **HSA, Advanced casing & coring**
Location
Coord. **N 5846453 E 536555**
Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-6B**
Page **1 of 2**
Start Date **2020-07-18** (yyyy-mm-dd)
End Date **2020-07-19** (yyyy-mm-dd)
Azimuth
Dip

Sample Condition: Disturbed, Undisturbed, Lost

Sample Types: SS - Split Spoon; RC - Rock Core; BU - Bulk; CS - Core Sample; WS - Wash Sample; AU - Auger; ST - Thin Walled Open (Shelby)

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3); D - Dry Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	Field Undrained Shear C_u/Lab Tests: Water Content (%) 20 40 60 80; Lab UCS, Q Test, P.P. (US); Field Vane Intact, Remold; Lab. Vane Intact, Remoulded; 100 200 300 400 kPa	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
		Ground Surface											
	0.3	**ORGANICS** about 1' thick organics					AS01						
1		**TILL** Silt and Sand some clay and gravel, brown, moist, loose					SS02	1 3 3 4	6	46			
2							SS03	1 2 3 3	5	41			
		compact					SS04	5 6 6 8	12	33			
3		grey					SS05	1 7 12 8	19	33			
4							SS06	>50					
		SS6 spoon bouncing on boulder											
5													
6							SS07	6 6 9	15	100			13.4 36.3 50.3
7	7.3	BEDROCK Granodiorite, fresh, strong, excellent quality, grey and white					RC08			100	90		
8							RC09			100	93		
9							RC10			100	98		
		slightly fractured, good quality											
10													

SNC·LAVALIN

Borehole Log

Project **WSR Ontario**

Contract **661910**

Drilling Company **TBT**

Drill Rig **SIMCO 2400 SK-1**

Method **HSA, Advanced casing & coring**

Location

Coord. **N 5846453 E 536555**

Logged/ Reviewed by **M. Saleem**

Borehole ID **WQR-6B**

Page **2 of 2**

Start Date **2020-07-18** (yyyy-mm-dd)

End Date **2020-07-19** (yyyy-mm-dd)

Azimuth

Dip

Sample Condition

Disturbed | Undisturbed | Lost

Sample Types

SS - Split Spoon | RC - Rock Core | BU - Bulk
CS - Core Sample | WS - Wash Sample
AU - Auger | ST - Thin Walled Open (Shelby)

Abbreviations

PP - Pocket Penetrometer | RQD - Rock Quality Designation | SPT - Standard Penetration Test
PT - Standard Proctor Test | DS - Direct Shear | Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s) | GS - Grain Size Analysis | U - Wet Unit Weight (kN/m^3)
D - Dry Unit Weight (kN/m^3)

Stratigraphy					Field Undrained Shear C_u/Lab Tests	Samples/Field Tests							
Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level (latest-solid, previous-hollow)	■ Lab UCS, □ Q Test, ● P.P. (US); Field Vane ▲ Intact ◆ Remold; Lab. Vane △ Intact ◇ Remoulded; 100 200 300 400 kPa; ⊗ Water Content (%); ⊢ Plastic Limit (%) ⊣ Liquid Limit (%); 20 40 60 80	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Other Tests	Remarks and Grain Size Distribution % GR SA SI CL
							RC11			100	88		
	10.4	**END OF BOREHOLE** Notes: - rock sample from 20' 7" to 21' 6" selected for ARD testing - water level observed during drilling at 6.1 m bgs - 25.4 mm monitoring well installed with 1.52 m prepack screen. - water level measured at 0.3 m bgs before well development on July 21, 2020											

Project: EAGLE'S NEST PROJECT

Contractor: DETERMINATION DRILLING

Location: NORTH OF STOCKPILE (AGGREGATES)

Coordinates: 5,843,275 N , 545,499 E

Drillhole No.: GWMW10-04

Drill Type: CME 55

Total Depth: 18.65 m

Elevation: 160 m

Inclination: -90

Page: 1 of 2

Date Started: 25 Oct 10

Date Completed: 27 Oct 10

Logged by: SLD

Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	MATERIAL DESCRIPTION	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
		ORGANICS (0 to 0.25) ORGANICS, peat.	AU-1		60							0.3	
		SAND (0.25 to 0.75) SAND, fine to coarse, trace silt, trace gravel, fine, subrounded, well graded, greyish brown, compact, massive, moist.	SPT-1		50					5/10/11/24	21		
2.0	158	**GRAVELLY SAND** (0.75 to 1.35) Gravelly SAND, fine to coarse, subangular, well graded, beige/dark grey/brownish grey/reddish brown, compact, massive, wet.	SPT-2		28					8/14/21/16	35		
			SPT-3		100					10/R/-/-			
			1		100							2.9	
4.0	156	**GRAVEL** (1.35 to 2.55) GRAVEL, fine to coarse, some sand, fine to coarse, subangular, poorly graded, beige/grey/reddish brown, dense, massive, saturated.	2		39			1		10		3.65	
		BOULDERS AND COBBLES (2.55 to 3.45) BOULDERS and COBBLES, subrounded, poorly graded, light to dark grey, pinkish orange speckled with fine black striations. Suspect fines washed at joints.										4.2	
												4.5	
												4.95	
6.0	154	(3.45 to 6.2) Rock Type: Igneous/metamorphic Colour: Dark grey with reddish brown, white Fabric and Textures: Medium grained matrix with phenocrysts, porous Weathering: Highly weathered to decomposed Discont. Type: Joints Other: Mainly highly weathered/ decomposed. Few gravel sized pieces at top of unit.	3a		92			1		56			
			3b		100			7		100		6.45	
			4		100			7		87			
	152		5		100			1		23		7.45	
8.0		(6.2 to 8.1) Rock Type: Igneous/metamorphic Colour: White, black, reddish brown. Striated by colour. Fabric and Textures: Medium to coarse grained. Minor veining. Weathering: Slightly to highly weathered Discont. Type: Joints Other: Infill of sand, gouge-like material and black staining. Few sections of highly weathered rock town bottom portion of unit.	6a		70			0		0			
			6b		100			7		53			
	150		6c		100			0		0			
10.0			7		60			0		0			
		(8.1 to 9.1) Rock Type: Igneous/metamorphic Colour: Green, white Weathering: Decomposed to residual soil Discont. Type: No identifiable joints Other: All decomposed to soil. No rock	8a		56			0		0			
	148												

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES

PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.4

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Contractor: DETERMINATION DRILLING
Location: NORTH OF STOCKPILE (AGGREGATES)
Coordinates: 5,843,275 N , 545,499 E

Drillhole No.: GWMW10-04
Drill Type: CME 55
Total Depth: 18.65 m
Elevation: 160 m
Inclination: -90

Page: 2 of 2
Date Started: 25 Oct 10
Date Completed: 27 Oct 10
Logged by: SLD
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			fragements observed. Moist. Strength and consistency similar to stiff clay.		8b		100			7		39			12.3	
	146		(9.1 to 9.5) Rock Type: Quartz Colour: Opaque white Weathering: Slightly weathered Discont. Type: Joints Other: Vein of pure quartz		9		100			7		53				
14.0			(9.5 to 11.55) Rock Type: Igneous/metamorphic Colour: Green with white Fabric and Textures: Strength and consistency similar to stiff clay Weathering: Highly weathered/decomposed Discont. Type: No identifiable joints. Other: All decomposed to soil. Few fine gravel sized pieces of quartz towards middle of unit.		10		100			7		90			14.1	
	144															
16.0			(11.55 to 18.65) Rock Type: Igneous/metamorphic Colour: Dark greenish grey matrix with reddish brown, healed veins of dark infill and quartz. Fabric and Textures: Fine grained matrix with coarse grains with spotted/mottled appearance, minor healed veins with infill. Porous. Weathering: Slightly to moderately weathered Discont. Type: Joints Other: Infill is sand, soft white mineral, clay with black and rust coloured staining. Few joints moderately weathered with porous texture.		11		100			7		61			17.1	
	142															
18.0					12		100			7		44			18.65	
	140		End of Drillhole: 18.65 m													
20.0			Notes: 1. Number of Discontinuities parameter not recorded during field logging 2. Two monitoring wells installed at site. GWMW10-04OVB (shallow well) installed approximately 6 m to the south of GWMW10-04BR (deep well). 3. Coordinates of monitoring wells taken from handheld GPS unit. Accuracy of coordinates +/-5 m. 4. One water level logger installed in each monitoring well														
	138															
22.0																
	136															

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR
SPT TEST 'N' VALUES ×
PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.4

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Contractor: DETERMINATION DRILLING
Location: EAST OF STOCKPILE (AGGREGATES)
Coordinates: 5,842,790 N , 546,588 E

Drillhole No.: GWMW10-05
Drill Type: CME 55
Total Depth: 14.20 m
Elevation: 175 m
Inclination: -90

Page: 1 of 2
Date Started: 2 Nov 10
Date Completed: 5 Nov 10
Logged by: SLD
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	MATERIAL DESCRIPTION	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
0	175	**ORGANICS** (0 to 0.15) ORGANICS, peat.	SPT-1a	▼	67					1/2/2/4	4	0.3	
	174	**CLAY** (0.15 to 5.95) CLAY, trace to some sand, fine to coarse, trace gravel, fine, rounded to subangular, trace silt, poorly graded, low to high plasticity, medium brown to greyish brown, firm to very stiff, massive, moist.	SPT-1		92					2/4/4/5	8		
			ST-1		100								
2.0			SPT-2		92					3/4/5/6	9		
	172		SPT-3		100					2/4/6/8	10		
			SPT-4		100					4/7/6/9	13		
4.0			SPT-5		100					5/10/15/R	25		
	170		SPT-2a		100					4/6/11/18	17		
			SPT-3a		67					10/15/19/19	34		
6.0		**SILT AND CLAY** (5.95 to 9.5) SILT AND CLAY, trace to some sand, fine to coarse, trace to some gravel, fine, subrounded, poorly graded to well graded, no to low plasticity, grey, firm to very stiff, massive, moist.	SPT-4a		92					7/9/13/12	22		
	168		SPT-7		88					9/13/15/21	28		
8.0			SPT-5a		100					18/32/40/49	72	7.9	
			SPT-6a		100					12/26/30/R	56		
	166		1		50								
10.0		**GRAVEL** (9.5 to 10) GRAVEL, some sand, fine to coarse, subangular, well graded, brownish grey, very dense, massive, moist. Rock is highly weathered/decomposed.	SPT-8		70					25/36/23/R	59	9.7	
			SPT-7a		100					R/-/-/-			
	164	**SAND** (10 to 10.8) SAND, fine to coarse, some clay, trace gravel, fine to coarse, poorly graded, non-plastic, greenish grey/grey/white, massive, moist. Possibly highly	1a		67							11	
			2a		93			2		0			

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR
SPT TEST 'N' VALUES
PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.5

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Drillhole No.: GWMW10-05
Page: 2 of 2

Contractor: DETERMINATION DRILLING
Drill Type: CME 55
Date Started: 2 Nov 10

Location: EAST OF STOCKPILE (AGGREGATES)
Total Depth: 14.20 m
Date Completed: 5 Nov 10

Coordinates: 5,842,790 N , 546,588 E
Elevation: 175 m
Logged by: SLD

Inclination: -90
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			weathered/decomposed rock.													
			GRAVEL (10.8 to 11.25) GRAVEL, fine to coarse, suspect fines washed, poorly graded, dark grey, subangular, massive. Unweathered with joint infills of soft white mineral.		2b		100			7		66				
	162															
			(11.25 to 12) Rock Type: Igneous/metamorphic Colour: Light to dark grey Fabric and Textures: Fine to coarse grained matrix with coarse grains Weathering: Slightly weathered to decomposed Discont. Type: Few identifiable joints Other: Layers between slightly weathered to highly weathered/decomposed rock with few gravel sized pieces.		3a		100			7		86				
14.0															12.5	
	160		(12 to 14.2) Rock Type: Igneous/metamorphic Colour: Dark grey to black, white Fabric and Textures: Fine grained matrix with few coarse grains and few phenocrysts Weathering: Unweathered to highly weathered Discont. Type: Joints Other: Two highly weathered joints toward bottom of unit with stratified layers (10 cm thick) of pinkish grey, weak rock, and soft gouge-like infill. Gypsum infill at other joints.											14.2	
16.0																
	158															
18.0																
	156		End of Drillhole: 14.2 m													
			Notes: 1. ST-1: Shelby tube samples collected for laboratory hydraulic conductivity testing 2. Number of Discontinuities parameter not recorded during field logging 3. One monitoring well installed at site 4. Coordinates of monitoring wells taken from handheld GPS unit. Accuracy of coordinates +/-5 m. 5. One water level logger installed in monitoring well 6. First hole drilled encountered a boulder at 10.0 m. Drill moved approximately 2 m, and resumed drilling. Standard Penetration Tests completed during second hole are noted with 'a' in name (eg. SPT-1a)														
20.0	154															
22.0	152															

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR
SPT TEST 'N' VALUES
PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.5

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Contractor: DETERMINATION DRILLING
Location: NORTH OF PERMANENT CAMP
Coordinates: 5,844,380 N , 546,961 E

Drillhole No.: GWMW10-06
Drill Type: CME 55
Total Depth: 8.55 m
Elevation: 170 m
Inclination: -90

Page: 1 of 2
Date Started: 6 Nov 10
Date Completed: 7 Nov 10
Logged by: SLD
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	MATERIAL DESCRIPTION	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	LABORATORY TESTS	FROZEN SOIL DESCRIPTION	UCS RATING	FIELD TESTS	NoD	BLOW COUNTS (PER 0.15m)	RQD (%)	SPT 'N' VALUE	RMR
0.0	170	**ORGANICS** (0 to 2.3) ORGANICS, peat.	AU-1		20									
2.0	168	**CLAY** (2.3 to 3.65) CLAY, trace sand, fine, poorly graded, high plasticity, brownish grey, very soft, massive, moist.	SPT-1		43						1/1/1/1		2	
			ST-1		100									
4.0	166	**GRAVEL** (3.65 to 3.9) GRAVEL, fine, angular, trace sand, fine to coarse, poorly graded, beige/grey, very dense, laminated.	SPT-2		100						R/-/-/-			
			1		56									
		COBBLES (3.9 to 4.4) COBBLES, subangular, greyish beige, dense, laminated by colour.	2		30									
6.0	164	**GRAVEL** (4.4 to 5.7) GRAVEL, fine to coarse, trace cobbles, angular to rounded, poorly graded, very dense, massive.	3		83									
			4a		50									
			4b		88		4				88			
		COBBLES (5.7 to 6.3) COBBLES, subangular, greyish beige, dense, laminated by colour.	4c		100		7				79			
8.0	162	**GRAVEL** (6.3 to 6.4) GRAVEL, fine to coarse, trace cobbles, angular to rounded, poorly graded, very dense, massive.	5		57		4				16			
		(6.4 to 6.8) Rock Type: Sedimentary Colour: Greyish beige Fabric and Textures: Fine grained, banded by colour Weathering: Slightly weathered Discont. Type: Joints												
10.0	160	(6.8 to 8.55) Rock Type: Sedimentary Colour: Light to dark grey Fabric and Textures: Fine to medium grained, mottled Weathering: Slightly to moderately weathered Discont. Type: Joints Other: Infill is sand and gravel sized pieces of rock. Suspect significant amount of material washed during drilling.												
12.0	158	End of Drillhole: 8.55 m												

KEY ROCK MASS CHARACTERISTICS
RECOVERY
RQD
RMR
SPT TEST 'N' VALUES
PL MC LL (%)
20 40 60 80

INSTRUMENTATION / WELL DEPTHS (m): 0.3, 3.05, 4.1, 5.9, 7.4, 8.55

INSTRUMENTATION / WELL DETAILS

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

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EAGLE'S NEST PROJECT

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Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.6

I:\1\02\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\1\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Contractor: DETERMINATION DRILLING
Location: NORTH OF PERMANENT CAMP
Coordinates: 5,844,380 N , 546,961 E

Drillhole No.: GWMW10-06
Drill Type: CME 55
Total Depth: 8.55 m
Elevation: 170 m
Inclination: -90

Page: 2 of 2
Date Started: 6 Nov 10
Date Completed: 7 Nov 10
Logged by: SLD
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES; PL MC LL (%) 20 40 60 80	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
14.0	156		Notes: 1. ST-1: Shelby tube samples collected for laboratory hydraulic conductivity testing 2. Number of Discontinuities parameter not recorded during field logging 3. One monitoring well installed at site 4. Coordinates of monitoring wells taken from handheld GPS unit. Accuracy of coordinates +/-5 m. 5. One water level logger installed in monitoring well													
16.0	154															
18.0	152															
20.0	150															
22.0	148															
24.0	146															

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.6

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Contractor: DETERMINATION DRILLING
Location: WEST OF AIRSTRIP
Coordinates: 5,846,962 N , 546,873 E

Drillhole No.: GWMW10-07
Drill Type: CME 55
Total Depth: 9.35 m
Elevation: 161 m
Inclination: -90

Page: 1 of 2
Date Started: 8 Nov 10
Date Completed: 9 Nov 10
Logged by: SLD
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES; PL MC LL (%) 20 40 60 80	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			ORGANICS (0 to 0.1) ORGANICS, peat.		AU-1		100								0.3	
					AU-2		31									
	160		**SAND** (0.1 to 2.9) SAND, fine to medium, trace to some silt, trace gravel, fine, subrounded, trace clay, poorly graded, no plasticity, organish/brownish grey, loose to compact, massive, dry.		SPT-1		72					2/6/7/11	13			
2.0					SPT-2		65					2/6/6/8	12			
					SPT-3		75					2/4/6/9	10			
	158		**SAND** (2.9 to 4.3) SAND, fine to coarse, some gravel, fine, subrounded, poorly graded, brownish grey, compact, stratified with finer material towards bottom of unit, dry.		SPT-4		88					9/14/10/10	24		3.35	
4.0					SPT-5		75					8/6/5/8	11		3.9	
			CLAY (4.3 to 4.7) CLAY, low to medium plasticity, brown, stiff, massive, moist.		SPT-6	▼	58					4/5/5/6	10			
	156		**SAND** (4.7 to 7.45) SAND, fine to coarse, trace clay, trace gravel, coarse, subangular, poorly graded, brown/grey/reddish brown, loose to compact, laminated with finer layers toward bottom of unit, moist.		SPT-7		100					5/7/7/8	14			
6.0					SPT-8		100					3/4/4/11	8			
	154				SPT-9		100					19/14/16/16	30			
					SPT-10		0					R/-/-/-				
8.0			**GRAVEL** (7.45 to 8.45) GRAVEL, fine to coarse, some cobbles, subrounded, poorly graded (suspect fines washed), dark grey/pinkish red, very dense, massive, saturated.		1		30								7.9	
					2		73									
	152		**GRAVEL AND COBBLES** (8.45 to 9) GRAVEL, coarse and COBBLES, subrounded, poorly graded (suspect fines washed), porphyritic with pinkish organge/brown/dark grey, very dense, stratified, saturated.		3		100								9.4	
10.0			**GRAVEL** (9 to 9.35) GRAVEL, fine to coarse, subrounded, poorly graded (suspect fines washed), fine to coarse grained, dark to light grey/organish brown/greenish grey, very dense, stratified, saturated.												9.4	
	150		End of Drillhole: 9.35 m													
12.0																

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.7

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT
Drillhole No.: GWMW10-07
Page: 2 of 2

Contractor: DETERMINATION DRILLING
Drill Type: CME 55
Date Started: 8 Nov 10

Location: WEST OF AIRSTRIP
Total Depth: 9.35 m
Date Completed: 9 Nov 10

Coordinates: 5,846,962 N , 546,873 E
Elevation: 161 m
Logged by: SLD

Inclination: -90
Reviewed by: RDW

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	WATER LEVEL (m)	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES; PL MC LL (%) 20 40 60 80	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
14.0	146		Notes: 1. Unable to advance drillhole into bedrock due to frequent caving from 8.3 to 9.3m. 2. Number of Discontinuities parameter not recorded during field logging 3. One monitoring well installed at site 4. Coordinates of monitoring wells taken from handheld GPS unit. Accuracy of coordinates +/-5 m. 5. One water level logger installed in monitoring well													
16.0	144															
18.0	142															
20.0	140															
22.0	138															
24.0	136															

SAMPLE SYMBOLS: BULK, SPLITSPOON, THERMISTOR, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	5	0

FIGURE A.7

I:\102\00390\01\DATA\WORK FILES\WF1 - GINT\EAGLES NEST LOGS.GPJ
I:\0\GINT\LIBRARY\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 2 Mar 11

Project: EAGLE'S NEST PROJECT

Contractor: CYR Drilling International Ltd.

Location: Northwest of Temp Magazine Sites

Coordinates: 5,841,930 N , 546,947 E

Drillhole No.: GWMW-12-01 **Page:** 1 of 2

Drill Type: Zinex A5 Date Started: 24-Oct-12

Total Depth: 11.45 m Date Completed: 26-Oct-12

Elevation: 178.47 m Logged by: RWT

Azimuth , Inclination: 0 , -90 Reviewed by: KDL

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	PERMEABILITY TESTING (cm/s)	UCS	FIELD TESTS	NoD	BLOW COUNTS (PER 0.15m)	RQD (%)	SPT 'N' VALUE	RMR	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
0	178.0		**ORGANICS** (0 to 2.38) PEAT; spongy, dark reddish brown, fibrous, wet. With root inclusions.		SPT 1		0						1/0/1/0		1			0.1 0.15	
1.0	177.0																		
2.0					SPT 2		38						1/0/1/1		1			2.1	
	176.0		**SILT AND CLAY** (2.38 to 4.88) clayey; SILT; some sand, fine to coarse grained, trace gravel, fine grained, angular to subangular; highly plastic, grey/mottled brown, firm to stiff, massive/stratified, moist. Trace stratification of colour and fines.																
3.0																		3	
	175.0				SPT 3		60						7/7/10/15		17				
4.0	174.0																	4.55 4.6	
5.0			**SAND** (4.88 to 5.03) gravelly, fine to coarse grained, angular to subangular; SAND, fine to coarse; some silt; some clay; well graded, bluish to brownish grey, dense to very dense, massive, saturated. Coarse material composed of weathered bedrock.		SPT 4		100						18/26/R/-		R				
	173.0		(5.03 to 10.12) Rock Type: DUNITE Colour: Green. Fabric and Textures: Coarse grained, massive. Weathering: Highly weathered. Discont. Type: Rubble Zone. Other: Strongly magnetic. Hematite within the magnesite-magnetite veins and stringers. 1.62 m core loss.																
6.0	172.0																	6.9	

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON; SLOUGH; BENTONITE (PEL-PLUG); CORE; WELL; SAND; BENTONITE (HOLE-PLUG)

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	42	0

FIGURE A.1

I:\1\02\00390\01\DATA\WORK FILES\WF14-2012 MONITORING WELLS\GINT\FALL 2012-MONITORING WELLS-RDW.GPJ
I:\1\02\00309\05\DATA\DRILLHOLE LOGS\KP LIB.GLB, EAGLES NEST MONITORING WELL, KP DATA TEMPLATE.GDT, 18-Jun-13

Project: EAGLE'S NEST PROJECT

Contractor: CYR Drilling International Ltd.

Location: Northwest of Temp Magazine Sites

Coordinates: 5,841,930 N , 546,947 E

Drillhole No.: GWMW-12-01 **Page:** 2 of 2

Drill Type: Zinex A5 Date Started: 24-Oct-12

Total Depth: 11.45 m Date Completed: 26-Oct-12

Elevation: 178.47 m Logged by: RWT

Azimuth , Inclination: 0 , -90 Reviewed by: KDL

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	PERMEABILITY TESTING (cm/s)	UCS	NoD	RQD (%)	RMR	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
										FIELD TESTS		BLOW COUNTS (PER 0.15m)	SPT 'N' VALUE	PL MC LL (%) 20 40 60 80		
8.0	171.0				1		100			50	1	0	43		7.4	
9.0	170.0														8.26	
10.0	169.0				2		0			50	1	0	31			
11.0	168.0		(10.12 to 11.45) Rock Type: DUNITE Colour: Green. Fabric and Textures: Coarse grained, massive. Weathering: Fresh to highly weathered. Discont. Type: Joint, Spun Joint, Rubble Zone, Unmatched Joint, Vein. Other: Strongly magnetic. Hematite within the magnesite-magnetite veins and stringers. Rubble zone from 10.35 - 10.48 m and 10.77 to 10.87 m. Soft white clay and calcite infill.		3		100			50	16	47.4	38		11.31	
12.0	167.0		End of Drillhole Log: 11.45 m												11.45	
13.0	166.0															
	165.0															

SYMBOLS:

SPLITSPOON SLOUGH BENTONITE (PEL-PLUG)

CORE WELL SAND BENTONITE (HOLE-PLUG)

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	42	0

FIGURE A.1

I:\1\02\00390\01\ADATA\WORK FILES\WF14-2012 MONITORING WELLS\GINT\FALL 2012-MONITORING WELLS-RDW.GPJ
I:\1\02\00309\05\ADATA\DRILLHOLE LOGS\KP LIB.GLB, EAGLES NEST MONITORING WELL, KP DATA TEMPLATE.GDT, 18-Jun-13

Project: EAGLE'S NEST PROJECT

Contractor: CYR Drilling International Ltd.

Location: East of Portal and Infrastructure

Coordinates: 5,842,467 N , 547,253 E

Drillhole No.: GWMW-12-02 **Page:** 1 of 2

Drill Type: Zinex A5 Date Started: 18-Oct-12

Total Depth: 9.91 m Date Completed: 18-Oct-12

Elevation: 177.86 m Logged by: RWT

Azimuth , Inclination: 0 , -90 Reviewed by: KDL

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	PERMEABILITY TESTING (cm/s)	UCS	NoD	RQD (%)	RMR	FIELD TESTS / BLOW COUNTS (PER 0.15m)	SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
0			**ORGANICS** (0 to 0.46) ORGANICS; peat, spongy, dark brown, fibrous, saturated. Root inclusions present.		SPT 1		67							2/4/4/6	8			
1.0	177.0		**SILT AND CLAY** (0.46 to 1.93) SILT AND CLAY; some sand, fine grained, low plasticity, orangish brown, soft, massive, wet. Root inclusions present.															
2.0	176.0		**SILT** (1.93 to 3.45) sandy, fine to coarse grained; SILT; some clay; trace gravel, fine grained; high plasticity, light brown, soft to firm, massive, wet.		SPT 2		92							2/3/4/5	7			
3.0	175.0																	
4.0	174.0		**SILT AND CLAY** (3.45 to 3.92) SILT AND CLAY; some sand, fine to coarse grained, trace gravel, angular to subrounded, fine grained, medium plasticity, reddish brown, hard, massive, wet.		SPT 3		100							21/48/R/-	R			
			(3.92 to 5.51) Rock Type: DUNITE Colour: Green, greenish blue. Fabric and Textures: Coarse grained, massive. Weathering: Fresh to moderately weathered. Discont. Type: Joint. Other: Serpentinized and magnesite altered dunite. Strongly magnetic. Soft white clay and calcite infill.		1		98.7			20	8	88.1	52					
5.0	173.0																	
	172.0		(5.51 to 6) Rock Type: DUNITE Colour: Green, greenish blue. Fabric and Textures: Coarse grained, massive.		2		85.7			10	3	36.7	35					

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

INSTRUMENTATION / WELL DEPTHS (m): 1.31, 1.77, 3.29, 3.65, 3.81

SYMBOLS:

SPLITSPOON, SLOUGH, BENTONITE (PEL-PLUG), CORE, WELL, SAND, BENTONITE (HOLE-PLUG)

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	42	0

FIGURE A.2

I:\1\02\00390\01\DATA\WORK FILES\WF14-2012 MONITORING WELLS\GINT\FALL 2012-MONITORING WELLS-RDW.GPJ
I:\1\02\00309\05\DATA\DRILLHOLE LOGS\KP LIB.GLB, EAGLES NEST MONITORING WELL, KP DATA TEMPLATE.GDT, 18-Jun-13

Project: EAGLE'S NEST PROJECT

Contractor: CYR Drilling International Ltd.

Location: East of Portal and Infrastructure

Coordinates: 5,842,467 N , 547,253 E

Drillhole No.: GWMW-12-02 **Page:** 2 of 2

Drill Type: Zinex A5 Date Started: 18-Oct-12

Total Depth: 9.91 m Date Completed: 18-Oct-12

Elevation: 177.86 m Logged by: RWT

Azimuth , Inclination: 0 , -90 Reviewed by: KDL

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	PERMEABILITY TESTING (cm/s)	UCS	NoD	RQD (%)	RMR	SPT 'N' VALUE	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			Weathering: Slightly to moderately weathered. Discont. Type: Broken Zone, Unmatched Joint. Other: Serpentinized and magnesite altered dunite. Strongly magnetic. Soft white clay and calcite infill.		3		100			20	8	66	42		6.11	
			(6 to 9.91) Rock Type: DUNITE Colour: Green, greenish blue. Fabric and Textures: Coarse grained, massive. Weathering: Fresh to moderately weatherd. Discont. Type: Joint, Spun Joint, Broken Zone, Veinlette, Vein, Unmatched Joint. Other: Serpentinized and magnesite altered dunite. Strongly magnetic. Magnesite veins and stringers. Broken zones from 6.78 to 6.87 m and 8.50 to 8.60 m. Soft white clay and calcite infill.												6.75	
7.0	171.0				4		100			80	8	100	53			
8.0	170.0				5		0			50	1	0	31			
9.0	169.0				6		100			90	6	95.5	52			
10.0	168.0		End of Drillhole Log: 9.91 m												9.79 9.91	
11.0	167.0		Complications with bentonite pellets bridging within drillhole. After two unsuccessful well installation attempts, drillhole became unfit for well installation. Moved drill, cored new hole and successfully installed one monitoring well. Second hole was not logged.													
	166.0															

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON, SLOUGH, BENTONITE (PEL-PLUG), CORE, WELL, SAND, BENTONITE (HOLE-PLUG)

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	42	0

FIGURE A.2

I:\1\02\00390\01\DATA\WORK FILES\WF14-2012 MONITORING WELLS\GINT\FALL 2012-MONITORING WELLS-RDW.GPJ
I:\1\02\00309\05\DATA\DRILLHOLE LOGS\KP LIB.GLB, EAGLES NEST MONITORING WELL, KP DATA TEMPLATE.GDT, 18-Jun-13

Project: EAGLE'S NEST PROJECT

Contractor: CYR Drilling International Ltd.

Location: West of Portal and Infrastructure

Coordinates: N , E

Drillhole No.: GWMW-12-03 **Page:** 1 of 2

Drill Type: Zinex A5 Date Started: 27-Oct-12

Total Depth: 11.65 m Date Completed: 29-Oct-12

Elevation: Logged by: RWT

Azimuth , Inclination: 0 , -90 Reviewed by: KDL

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	PERMEABILITY TESTING (cm/s)	UCS	NoD	FIELD TESTS	RQD (%)	BLOW COUNTS (PER 0.15m)	RMR	SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
0			**PEAT** (0 to 0.61) PEAT; spongy, dark brown, fibrous, wet. With root/moss inclusions.		SPT 1		21							1/0/0/1		0		0.1	
0.61			**SILT AND SAND** (0.61 to 3.66) SILT; and SAND, fine to coarse grained; some clay; some gravel, fine grained, angular to subrounded; medium plasticity, grey, soft, massive, saturated.															0.8	
1.0																		1.3	
2.0					SPT 2		38							1/6/13/2		19			
2.8																		2.8	
3.0																		3	
3.66			**BOULDERS** (3.66 to 8) BOULDERS, subangular; poorly graded, very dense, massive, saturated. Suspect fines washed by drilling.		SPT 3		0 0							R/ / /		R			
4.0																		4.7	
5.0																		5.54	
6.0																			
7.0																		7.06	
																		7.3	

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON SLOUGH BENTONITE (PEL-PLUG)

CORE WELL SAND BENTONITE (HOLE-PLUG)

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	42	0

FIGURE A.3

I:\1\02\00390\01\DATA\WORK FILES\WF14-2012 MONITORING WELLS\GINT\FALL 2012-MONITORING WELLS-RDW.GPJ
I:\1\02\00309\05\DATA\DRILLHOLE LOGS\KP LIB.GLB, EAGLES NEST MONITORING WELL, KP DATA TEMPLATE.GDT, 18-Jun-13

Project: EAGLE'S NEST PROJECT

Contractor: CYR Drilling International Ltd.

Location: West of Portal and Infrastructure

Coordinates: N , E

Drillhole No.: GWMW-12-03 **Page:** 2 of 2

Drill Type: Zinex A5 Date Started: 27-Oct-12

Total Depth: 11.65 m Date Completed: 29-Oct-12

Elevation: Logged by: RWT

Azimuth , Inclination: 0 , -90 Reviewed by: KDL

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	PERMEABILITY TESTING (cm/s)	UCS	NoD	RQD (%)	RMR	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
										FIELD TESTS		BLOW COUNTS (PER 0.15m)	SPT 'N' VALUE			
9.0					1		91.3			30	15	48	42			
10.0					2		100			50	0	0	34			
11.0					3		100			70	5	96.2	68			
			End of Drillhole Log: 11.65 m												11.65	
12.0																
13.0																
14.0			First BR well installation attempt from 10.9 - 7.9 m was unsuccessful.													
15.0			Well damaged while rods were being removed during installation. Removed intact standpipe, sealed abandonned screen with bentonite and installed new well above.													
			Bedrock descriptions from 8.0 - 11.65 m and coordinate/elevation information will be updated upon receival of geological logs.													

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON SLOUGH BENTONITE (PEL-PLUG)

CORE WELL SAND BENTONITE (HOLE-PLUG)

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	42	0

FIGURE A.3

I:\1\02\00390\01\DATA\WORK FILES\WF14-2012 MONITORING WELLS\GINT\FALL 2012-MONITORING WELLS-RDW.GPJ
I:\1\02\00309\05\DATA\DRILLHOLE LOGS\KP LIB.GLB, EAGLES NEST MONITORING WELL, KP DATA TEMPLATE.GDT, 18-Jun-13

Project: EAGLE'S NEST PROJECT

Contractor: ABRAFLEX

Location: North of main CN crossing on site

Coordinates: 5,567,377 N , 669,336 E

Drillhole No.: SLMW11-01

Drill Type: CME 55

Total Depth: 7.64 m

Elevation: 441 m

Inclination: -90

Page: 1 of 1

Date Started: Nov 6, 11

Date Completed: Nov 6, 11

Logged by: SRB

Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - × / PL MC LL (%)	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
1.0	440		**SAND (AND SILT)** (0 to 6.6) SAND, fine to medium; ranging from trace silt to SAND AND SILT; poorly graded, non-plastic, light brown to grey, very loose to compact, massive, dry to saturated (water table at 3.5 m depth).		AUG 1		0								0.3	
2.0	439				SPT 1		47					2/2/2/3	4	×		
					AUG 2		0								2.44	
3.0	438			▼	SPT 2		72					2/3/4/5	7	×		
4.0	437				AUG 3		0									
5.0	436				SPT 3		67					5/8/7/8	15	×		
					AUG 4		0								5.49	
6.0	435				SPT 4		100					0.5/0.5/2/3	2.5	×	6.14	
7.0	434		**NO RECOVERY** (6.6 to 7.64) NO RECOVERY, advancing augers.		AUG 5		0									
			End of Drillhole: 7.64 m												7.64	
8.0	433		Notes: 1. One monitoring well installed at this site.													

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.1

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT

Contractor: ABRAFLEX

Location: Northeast corner of CN site

Coordinates: 5,567,252 N , 669,274 E

Drillhole No.: SLMW11-02

Drill Type: CME 55

Total Depth: 19.70 m

Elevation: 443 m

Inclination: -90

Page: 1 of 2

Date Started: Nov 3, 11

Date Completed: Nov 4, 11

Logged by: SRB

Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			ORGANICS (0 to 0.05) ORGANICS, peat.		AUG 1		0								0.3 0.4	
	442		**SAND** (0.05 to 2.1) Silty SAND, fine to medium; poorly graded, non-plastic, light brown to tan, loose, massive, dry to moist.		SPT 1		83					3/4/6/9	10		1.5	
2.0			**SAND AND SILT** (2.1 to 9.6) SAND, fine; AND SILT; trace clay; poorly graded, non-plastic, light brown/tan/grey, very loose to very dense, massive, moist to saturated.		AUG 2		0									
	440				SPT 2		67					16/40/50/R	90			
4.0					AUG 3		0									
	438				SPT 3		100					12/24/20/20	44			
					AUG 4		0									
6.0					SPT 4		83					3/8/8/7	16			
	436				AUG 5		0								6.9	
					SPT 5		75					4/7/7/8	14			
8.0					AUG 6		0								8.2 8.65	
	434				SPT 6		83					0.5/0.5/2/2	2.5			
10.0			**NO RECOVERY** (9.6 to 17.7) NO RECOVERY, continuous dynamic cone penetration test performed from 10.7 m to 19.7 m at shallow well location, no samples collected. SPT 7 performed at deep well location		AUG 7		0								10.15	
	432															

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.2

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT
Contractor: ABRAFLEX
Location: Northeast corner of CN site
Coordinates: 5,567,252 N , 669,274 E

Drillhole No.: SLMW11-02
Drill Type: CME 55
Total Depth: 19.70 m
Elevation: 443 m
Inclination: -90

Page: 2 of 2
Date Started: Nov 3, 11
Date Completed: Nov 4, 11
Logged by: SRB
Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
	430		**NO RECOVERY** (9.6 to 17.7) NO RECOVERY, continuous dynamic cone penetration test performed from 10.7 m to 19.7 m at shallow well location, no samples collected. SPT 7 performed at deep well location													
14.0					DCP		0									
	428															
16.0																
	426															
			SILT (17.7 to 18.3) Sandy SILT, fine; poorly graded, non-plastic, light brown to grey, compact, massive, saturated.		SPT 7		57					9/12/12/14	24			
18.0			**NO RECOVERY** (18.3 to 19.7) NO RECOVERY, continuous dynamic cone penetration test performed from 10.7 m to 19.7 m at shallow well location, no samples collected.		DCP		0									
	424		End of Drillhole: 19.7 m													
20.0																
	422															
22.0																
	420															

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR
SPT TEST 'N' VALUES - ×
PL MC LL (%)
20 40 60 80

INSTRUMENTATION / WELL DEPTHS (m): 14.2; 15.9; 17.4; 17.6; 18.3; 19.7

Notes:
1. Two monitoring wells installed at this site.
2. Coordinates of monitoring wells taken from handheld GPS unit. Accuracy of coordinates +/-5 m (shown on Table 2.1). Average of coordinates shown on drillhole log.
3. Water level measured in SLMW11-02D is 6.85 m and in SLMW11-02S is 7.41 m.

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.2

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT

Contractor: ABRAFLEX

Location: Approx. 5 m north of south access road

Coordinates: 5,567,119 N , 669,168 E

Drillhole No.: SLMW11-03

Drill Type: CME 55

Total Depth: 11.27 m

Elevation: 447 m

Inclination: -90

Page: 1 of 2

Date Started: Nov 2, 11

Date Completed: Nov 2, 11

Logged by: SRB

Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			FILL (0 to 0.2) GRAVEL, fine to course, subrounded; well graded, massive, fill.												0.3	
1.0	446		**SAND AND SILT** (0.2 to 11.27) SAND, fine to course; AND SILT; trace clay; poorly graded, light brown/tan/light grey, loose to compact, massive, dry to saturated (water table at approx. 6.6 m depth).		AUG 1		0									
2.0	445				SPT 1		75					5/9/10/10	19			
					AUG 2		0								2.7	
3.0	444				SPT 2		92					3/12/12/14	24			
4.0	443				AUG 3		0									
					SPT 3		83					5/10/8/10	18			
5.0	442				AUG 4		0									
6.0	441				SPT 4		83					6/12/13/16	25			

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.3

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT

Contractor: ABRAFLEX

Location: Approx. 5 m north of south access road

Coordinates: 5,567,119 N , 669,168 E

Drillhole No.: SLMW11-03

Drill Type: CME 55

Total Depth: 11.27 m

Elevation: 447 m

Inclination: -90

Page: 2 of 2

Date Started: Nov 2, 11

Date Completed: Nov 2, 11

Logged by: SRB

Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - × / PL MC LL (%)	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			SAND AND SILT (0.2 to 11.27) SAND, fine to course; AND SILT; trace clay; poorly graded, light brown/tan/light grey, loose to compact, massive, dry to saturated (water table at approx. 6.6 m depth).		AUG 5		0									
8.0	439				SPT 5		78					5/6/6/7	12			
					AUG 6		0								8.4	
9.0	438				SPT 6		66					5/7/7/8	14		9	
10.0	437				AUG 7		0									
					SPT 7		100					1/1/7/6	8		10.5	
11.0	436				CONE		0								11.27	
			End of Drillhole: 11.27 m Notes: 1. Hammered AJ rods with cone and hit refusal at 11.27 m - possible bedrock. 2. One monitoring well installed at this site.													
12.0	435															
13.0	434															

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.3

I:\102\00390\01\DATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT
Drillhole No.: SLMW11-04
Page: 1 of 2

Contractor: ABRAFLEX
Drill Type: CME 55
Date Started: Nov 6, 11

Location: Centered between SLMW11-02 and SLMW11-06
Total Depth: 11.10 m
Date Completed: Nov 6, 11

Coordinates: 5,567,240 N , 669,081 E
Elevation: 443 m
Logged by: SRB

Inclination: -90
Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			ORGANICS (0 to 0.1) ORGANICS, peat.											RECOVERY / RQD / RMR; PL MC LL (%) 20 40 60 80		
			FILL (0.1 to 0.5) Sandy GRAVEL, fine to coarse; well graded, dry, fill.												0.3	
1.0	442		**SAND** (0.5 to 3.6) SAND, fine to medium; no silt to silty; trace clay; poorly graded, non-plastic, tan/light grey/light brown, loose to compact, massive, dry to moist. Grain size of sand decreases with depth and silt content increases with depth. Moisture in sample is possibly due to rain.		AUG 1		0									
					SPT 1		75					5/10/7/8	17			
2.0	441				AUG 2		0									
3.0	440				SPT 2		92					2/2/5/5	7			
			SILT (3.6 to 9) Sandy SILT, fine; trace clay; poorly graded, non-plastic, grey to light brown, compact to dense, massive, dry to saturated.		AUG 3		0								4.6	
4.0	439				SPT 3		85					7/19/19/22	38			
5.0	438				AUG 4		0									

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.4

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT
Contractor: ABRAFLEX
Location: Centered between SLMW11-02 and SLMW11-06
Coordinates: 5,567,240 N , 669,081 E

Drillhole No.: SLMW11-04
Drill Type: CME 55
Total Depth: 11.10 m
Elevation: 443 m
Inclination: -90

Page: 2 of 2
Date Started: Nov 6, 11
Date Completed: Nov 6, 11
Logged by: SRB
Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			SILT (3.6 to 9) Sandy SILT, fine; trace clay; poorly graded, non-plastic, grey to light brown, compact to dense, massive, dry to saturated.		SPT 4		83					5/9/12/13	21			
7.0	436			▼	AUG 5		0									
					SPT 5		75					7/10/11/12	21			
8.0	435				AUG 6		0								8.3	
9.0	434		**SILT AND SAND** (9 to 11.1) SILT; AND SAND, fine; poorly graded, non-plastic, grey to light brown, compact to dense, massive, saturated.		SPT 6		95					8/15/18/19	33		9.1	
10.0	433				AUG 7		0									
					SPT 7		60					3/3/12/9	15		10.6	
11.0	432		End of Drillhole: 11.1 m Notes: 1. One monitoring well installed at this site.												11.1	

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR
SPT TEST 'N' VALUES - ×
PL MC LL (%) 20 40 60 80

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.4

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT

Contractor: ABRAFLEX

Location: West side of site, ~ 20 m north of south access

Coordinates: 5,567,131 N , 668,982 E

Drillhole No.: SLMW11-05

Drill Type: CME 55

Total Depth: 10.50 m

Elevation: 446 m

Inclination: -90

Page: 1 of 1

Date Started: Nov 2, 11

Date Completed: Nov 2, 11

Logged by: SRB

Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	MATERIAL DESCRIPTION	SAMPLE / RUN No.	RECOVERY (%)	BLOW COUNTS (PER 0.15m)	SPT 'N' VALUE	RQD (%)	RMR
0		**ORGANICS** (0 to 0.2) ORGANICS, peat.						
		SAND (0.2 to 9.6) SAND, fine to coarse; trace silt; poorly graded, non-plastic, light to dark brown and tan, very loose to compact, massive, dry to saturated.	AUG 1	0				
2.0	444		SPT 1	92	6/13/13/16	26		
			AUG 2	0				
			SPT 2	63	3/7/7/10	14		
4.0	442		AUG 3	0				
			SPT 3	100	2/7/6/9	13		
			AUG 4	0				
6.0	440		SPT 4	83	3/5/5/5	10		
			AUG 5	0				
			SPT 5	28	0.33/0.33/0.33/0.7			
8.0	438		AUG 6	0				
			SPT 6	66	2/4/7/10	11		
		NO RECOVERY (9.6 to 10.5) NO RECOVERY, advancing augers.	AUG 7	0				
10.0	436	End of Drillhole: 10.5 m						

Notes:
1. One monitoring well installed at this site.

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

INSTRUMENTATION / WELL DEPTHS (m): 0.2, 5.2, 7.1, 7.8, 9.3, 10.5

INSTRUMENTATION / WELL DETAILS

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.5

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT
Contractor: ABRAFLEX
Location: Northwest side of site, ~ 5 m north of access
Coordinates: 5,567,208 N , 668,864 E

Drillhole No.: SLMW11-06
Drill Type: CME 55
Total Depth: 18.55 m
Elevation: 449 m
Inclination: -90

Page: 1 of 2
Date Started: Nov 3, 11
Date Completed: Nov 5, 11
Logged by: SRB
Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	MATERIAL DESCRIPTION	SAMPLE / RUN No.	RECOVERY (%)	BLOW COUNTS (PER 0.15m)	SPT 'N' VALUE	RQD (%)	RMR
0	448	**ORGANICS** (0 to 0.1) ORGANICS, peat. **FILL** (0.1 to 1.6) GRAVEL, fine; some sand, fine to course; trace organics; well graded, dry, fill.	AUG 1	0				
2.0	446	**SAND** (1.6 to 3.15) Silty SAND, fine to medium; poorly graded, non-plastic, tan/light brown with rusty staining, loose to compact, massive, dry.	SPT 1	83	2/4/5/5	9		
			AUG 2	0				
4.0	444	**SILT** (3.15 to 6) SILT; some sand, fine to medium; trace clay; poorly graded, non-plastic, grey to light brown, compact to very dense, massive, dry to moist.	SPT 2	87	4/6/9/12	15		
			AUG 3	0				
			SPT 3	100	11/22/29/36	51		
			AUG 4	0				
6.0	442	**SILT** (6 to 9.6) Sandy SILT, fine; trace clay; poorly graded, non-plastic, light grey to light brown, very loose to compact, massive, saturated.	SPT 4	83	8/11/9/10	20		
			AUG 5	0				
8.0	440		SPT 5	58	4/6/4/2	10		
			AUG 6	0				
			SPT 6	67	0/1/2/1	3		
10.0	438	**NO RECOVERY** (9.6 to 18.55) NO RECOVERY, continuous dynamic cone penetration test performed from 10.8 m to 18.55 m at shallow well location, no samples collected. SPT 7 at deep well location did not return any sample.	AUG 7	0				

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR
SPT TEST 'N' VALUES - ×
PL MC LL (%) 20 40 60 80

INSTRUMENTATION / WELL DEPTHS (m): 0.2, 0.3, 0.6, 3.7, 7.5, 10.24, 10.24
INSTRUMENTATION / WELL DETAILS: FLUSH MOUNT CASING, BENTONITE SEAL, SAND, SLOUGH

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.6

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: EAGLE'S NEST PROJECT
Contractor: ABRAFLEX
Location: Northwest side of site, ~ 5 m north of access
Coordinates: 5,567,208 N , 668,864 E

Drillhole No.: SLMW11-06
Drill Type: CME 55
Total Depth: 18.55 m
Elevation: 449 m
Inclination: -90

Page: 2 of 2
Date Started: Nov 3, 11
Date Completed: Nov 5, 11
Logged by: SRB
Reviewed by: RSM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
	436		**NO RECOVERY** (9.6 to 18.55) NO RECOVERY, continuous dynamic cone penetration test performed from 10.8 m to 18.55 m at shallow well location, no samples collected. SPT 7 at deep well location did not return any sample.		DCP		0							RECOVERY RQD RMR PL MC LL (%) 20 40 60 80	13.7	
14.0															15.15	
	434															
16.0					SPT 7		0					24/21/26/17	47		16.65	
	432														17 17.2	
18.0					DCP		0									
			End of Drillhole: 18.55 m Notes: 1. Two monitoring wells installed at this site. 2. Coordinates of monitoring wells taken from handheld GPS unit. Accuracy of coordinates +/-5 m (shown on Table 2.1). Average of coordinates shown on drillhole log. 3. Water level measured in SLMW11-06D is 6.25 m and in SLMW11-06S is 5.9 m.												18.55	
	430															
20.0																
	428															
22.0																
	426															

SAMPLE SYMBOLS: AUGER, SPLITSPOON, CORE, SHELBY TUBE

WELL SYMBOLS: GROUT, BENTONITE, SLOUGH, SAND, CONCRETE, WELL

NORONT RESOURCES LTD.
EAGLE'S NEST PROJECT

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	11	0

Figure A.6

I:\1\02\00390\01\ADATA\WORK FILES\WF2 - SAVANT LAKE DRILLING\GINT\SAVANT LAKE SI PROJECT - NOV. 2011.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST PROJECT, KP DATA TEMPLATE.GDT, 13-Jan-12

Project: Eagle's Nest Project
Contractor: Abraflex
Location: Proposed Trans-Load Facility
Coordinates: ~~498,073 N~~ ; ~~5,564,492 E~~

Drillhole No.: KPMW12-101
Drill Type: Morooka MST 1100
Total Depth: 17.68 m
Elevation:
Inclination:

Page: 1 of 2
Date Started: 10 Aug 12
Date Completed: 12 Aug 12
Logged by: ML
Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
0			**SAND** (0 to 2.13) Gravely (fine to coarse) SAND (fine to coarse); trace silt, well graded, dark brown to beige, massive, compact, trace organic at surface (top 2 cm), dry to moist		SPT1		50					8/18/10/12	28		0.3	
1.0					SPT2		54					8/9/7/8	16			
2.0				▼	SPT3		67					7/14/15/15	29			
			SAND (2.13 to 5.6) SAND (fine to coarse); some gravel (fine), trace silt, poorly graded, black, white, pink, orange grains, massive, compact, saturated	▼	SPT4		42					6/9/9/6	18		2.4 2.7	
3.0					SPT5		29					6/13/10/12	23		3	
4.0					SPT6		33					5/9/13/18	22			
5.0					SPT7		79					10/18/39	28			
			SAND (5.6 to 7.01) SAND (fine to coarse); some gravel (fine to coarse), some silt. trace clay, well graded, low plasticity, grey, massive, compact, saturated		SPT8		50					17/10/7/10	17			
6.0					SPT9		71					5/5/7/15	12		6.1 6.1	
7.0			**GRAVEL** (7.01 to 8.99) GRAVEL; some cobbles; some sand; some silt, trace clay, well graded (SPT+Washed Sample)													
8.0					SPT10 RUN1		33 25					19/R	R			
					RUN2		63									
9.0																

PL MC LL (%) 20 40 60 80

SYMBOLS:
SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.1

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: ~~498,073 N~~ ; ~~5,564,492 E~~

Drillhole No.: KPMW12-101

Drill Type: Morooka MST 1100

Total Depth: 17.68 m

Elevation:

Inclination:

Page: 2 of 2

Date Started: 10 Aug 12

Date Completed: 12 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES - × ; PL MC LL (%) 20 40 60 80	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
11.0			**SILT** (8.99 to 14.33) Sandy(fine) SILT; some gravel; some cobbles, well graded, medium plasticity, grey, massive, compact, saturated (glacial till) (Washed Sample)		RUN3		38									
12.0																
13.0															13.4	
14.0			(14.33 to 17.68) Rock Type: Biotite Gneiss Colour: Charcoal Grey, Grey, White and Red Fabric and Textures: Fine Grained Weathering: Fresh Discont. Type: Joints Discont. Orientation: Jointing at 30o, 45o, 60o. Other: Intermittent mafic dykes (</=10cm) stringers of calcite Quartz veinlets Minor hematite staining (most likely from weathering of the biotite)		RUN4		95			7		88			14.2 14.4	
15.0																
16.0					RUN5		87.5			7		84.7				
17.0					RUN6		100			7		100			17.4 17.4	
18.0			End of Drillhole: 17.68 m Bedrock starts at 14.33 m. KPMW 12-101S EOH at 7.62 m. KPMW12-101D EOH at 17.68 m. KPMW12-101D was installed in an adjacent hole.													
19.0																

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.1

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: ~~498,351 N~~ ; ~~5,564,465 E~~

Drillhole No.: KPMW12-102

Drill Type: Morooka MST 1100

Total Depth: 16.15 m

Elevation:

Inclination:

Page: 1 of 2

Date Started: 08 Aug 12

Date Completed: 10 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
0			**GRAVEL** (0 to 1.37) Sandy (fine to coarse) GRAVEL(fine to coarse); trace silt, poorly graded, brown, massive, compact, dry to saturated		SPT1		50					4/15/16/16	31		0.3	
1.0					SPT2		42					4/6/6/4	12			
			GRAVEL AND SAND (1.37 to 3.2) GRAVEL (fine, rounded) and SAND (fine to coarse), trace silt, poorly graded, brown, massive, compact, saturated		SPT3		21					14/8/5/6	13			
2.0				▼												
				▼	SPT4		42					6/3/7/8	10			
3.0			**SAND** (3.2 to 4.57) SAND (fine to coarse); some silt, trace gravel (fine), poorly graded, beige, massive, saturated (Spongy texture)		SPT5		58					5/8/11/12	19			
4.0					SPT6		8					8/15/16/12	31			
			SAND (4.57 to 11.58) SAND (fine to coarse); trace silt, trace gravel (fine), poorly graded, beige, massive, loose to compact, saturated		SPT7		62					1/10/10/13	20			
5.0					SPT8		6					8/15/15/13	30			
6.0					SPT9		42					1/2/6/13	8			
7.0															7.6	
8.0					SPT10		4					1/3/6/14	9		8.4	
9.0					SPT11		2					0/1/11/15	12			

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.2

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project
Contractor: Abraflex
Location: Proposed Trans-Load Facility
Coordinates: 498,351 N , 5,564,465 E

Drillhole No.: KPMW12-102
Drill Type: Morooka MST 1100
Total Depth: 16.15 m
Elevation:
Inclination:

Page: 2 of 2
Date Started: 08 Aug 12
Date Completed: 10 Aug 12
Logged by: ML
Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
11.0			**SAND** (4.57 to 11.58) SAND (fine to coarse); trace silt, trace gravel (fine), poorly graded, beige, massive, loose to compact, saturated												10.1 10.4 11.4	
12.0			(11.58 to 12.14) Rock Type: Biotite Gneiss Colour: Charcoal Grey, Grey and White Fabric and Textures: Fine Grained Weathering: Slightly Weathered Discont. Type: Joints Discont. Orientation: Jointing at 45o and 90o Other: Soft Black infill < 5 mm		RUN1		100			7		33.31			11.4 12	
13.0			(12.14 to 16.15) Rock Type: Biotite Gneiss Colour: Charcoal Grey, Grey and White Fabric and Textures: Fine Grained Weathering: Fresh Discont. Type: Joints Discont. Orientation: Jointing at 90o Other: Some quartz stringers Calcite on joint surfaces Some felsic-rich, minor mafic, light banding - due to diff degrees of metamorphism or migrating fluids. Majority very tightly banded-mafic rich Trace hematite staining. Some areas o		RUN2		100			7		100			13.1	
14.0					RUN3		91			7		91				
15.0					RUN4		100			7		100				
16.0					RUN5		100			7		100			16.1 16.2	
17.0			End of Drillhole: 16.15 m Bedrock starts at 11.58 m. KPMW 12-102S EOH at 12.22 m. KPMW12-102D EOH at 16.15 m. KPMW12-102D was installed in an adjacent hole.													
18.0																
19.0																

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.2

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: ~~498,209 N~~ ; ~~5,564,400 E~~

Drillhole No.: KPMW12-103

Drill Type: Morooka MST 1100

Total Depth: 11.05 m

Elevation:

Inclination:

Page: 1 of 2

Date Started: 12 Aug 12

Date Completed: 12 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			TOPSOIL (0 to 0.1) TOPSOIL; dark brown, moist, trace roots		SPT1		71					7/7/7/8	14		0.3	
1.0			**SAND** (0.1 to 1.6) SAND (fine to coarse); trace silt, poorly graded, dark beige, massive, compact, dry to moist		SPT2		79					5/5/7/6	12			
2.0			**SAND** (1.6 to 11.05) SAND (fine to coarse); trace silt, trace gravel (fine), poorly graded, white, black, brown, orange grains, massive, compact to very loose, saturated		SPT3		63					2/4/5/5	9			
					SPT4		92					4/7/9/10	16			
3.0					SPT5		42					1/3/6/4	9			
4.0					SPT6		2					0/0/0/1	0			
5.0					SPT7		2					0/2/7/8	9			
6.0					SPT8		38					9/7/2/9	9		6.3	
7.0															6.8	
8.0					SPT9		2					0/0/2/4	2			
9.0					SPT10		67					4/2/7/12	9		9.8	

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.3

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project
Contractor: Abraflex
Location: Proposed Trans-Load Facility
Coordinates: 498,209 N , 5,564,400 E

Drillhole No.: KPMW12-103
Drill Type: Morooka MST 1100
Total Depth: 11.05 m
Elevation:
Inclination:

Page: 2 of 2
Date Started: 12 Aug 12
Date Completed: 12 Aug 12
Logged by: ML
Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR; SPT TEST 'N' VALUES - ×; PL MC LL (%) 20 40 60 80	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			SAND (1.6 to 11.05) SAND (fine to coarse); trace silt, trace gravel (fine), poorly graded, white, black, brown, orange grains, massive, compact to very loose, saturated												9.8	
11.0					CONE11							8/R	R			
			End of Drillhole: 11.05 m Refusal Confirmed with CPT at 11.05 m. KPMW 12-103S EOH at 11.05 m.													
12.0																
13.0																
14.0																
15.0																
16.0																
17.0																
18.0																
19.0																

SYMBOLS:

SPLITSPOON BENTONITE GROUT SLOUGH
CORE CEMENT FILL SAND WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.3

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project
Contractor: Abraflex
Location: Proposed Trans-Load Facility
Coordinates: ~~498,228 N~~ , ~~5,564,302 E~~

Drillhole No.: KPMW12-104
Drill Type: Morooka MST 1100
Total Depth: 13.16 m
Elevation:
Inclination:

Page: 1 of 2
Date Started: 12 Aug 12
Date Completed: 14 Aug 12
Logged by: ML
Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			TOPSOIL (0 to 0.15) TOPSOIL; dark brown, moist, root intrusion		SPT1		92					2/5/9/10	14		0.3	
1.0			**SAND** (0.15 to 2.64) SAND (fine to medium); trace silt, poorly graded, beige brown, massive, compact, dry to moist, saturated at 2.6 m depth		SPT2		80					4/5/6/6	11			
				▼	SPT3		67					5/5/5/5	10		1.8	
2.0					SPT4		92					3/3/8/8	11			
3.0			**SAND** (2.64 to 8.53) SAND (fine to coarse); trace gravel (fine), trace silt, poorly graded, beige brown, massive, compact, saturated		SPT5		75					2/5/13/7	18			
4.0					SPT6		67					1/3/8/7	11		4	
															4.3	
5.0					SPT7		58					0/0/11/12	11			
					SPT8		79					0/6/10/16	16			
6.0					SPT9		58					3/9/16/9	25			
7.0															7.3	
					SPT10		17					5/5/7/7	12		7.4	
8.0															8.5	
9.0			**BOULDER** (8.53 to 8.89) BOULDER; some sand (fine to coarse), some gravel (fine to coarse), washed sample													
			SAND AND GRAVEL (8.89 to 9.25) SAND and GRAVEL; washed sample		RUN1		100			4		44.1			9.3	
					RUN1		100			7		0			9.8	

KEY ROCK MASS CHARACTERISTICS: RECOVERY, RQD, RMR
SPT TEST 'N' VALUES - ×
PL MC LL (%) 20 40 60 80

SYMBOLS:
SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.4

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: 498,228 N , 5,564,302 E

Drillhole No.: KPMW12-104

Drill Type: Morooka MST 1100

Total Depth: 13.16 m

Elevation:

Inclination:

Page: 2 of 2

Date Started: 12 Aug 12

Date Completed: 14 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SOIL / ROCK	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
11.0			(9.25 to 9.55) Rock Type: Biotite Gneiss Colour: Charcoal Grey, Grey and White Fabric and Textures: Fine Grained Weathering: Fresh Discont. Type: Joints Discont. Orientation: Jointing at 30o and 90o Other: Small cross cutting mafic dyke Chlorite alteration near contact with biotite schist (minor unit ~25cm) at ~40.5 feet. Trace hematite staining - majority near jt surfaces. Slight deformation in some bands Thicker bands of felsics at 39'		RUN1		100			4		100		KEY ROCK MASS CHARACTERISTICS RECOVERY RQD RMR SPT TEST 'N' VALUES - × PL MC LL (%) 20 40 60 80	10.1	
					RUN2		100			7		100				
					RUN3		100			7		100				
12.0					RUN4		100			7		100				
					RUN5		91.2			7		91.2				
13.0			(9.55 to 9.93) Rock Type: Biotite Gneiss Colour: Charcoal Grey, Grey and White Fabric and Textures: Fine Grained Weathering: Highly Weathered Discont. Type: Broken Zone Other: Soft green infill < 5 mm												13.1 13.1	
14.0			(9.93 to 13.16) Rock Type: Biotite Gneiss Colour: Charcoal Grey, Grey and White Fabric and Textures: Fine Grained Weathering: Fresh Discont. Type: Joints Discont. Orientation: Jointing at 45o and 90o Other: Small cross cutting mafic dyke Chlorite alteration near contact with biotite schist (minor unit ~25cm) at ~40.5 feet. Trace hematite staining - majority near jt surfaces. Slight deformation in some bands Thicker bands of felsics at 39'													
15.0																
16.0																
17.0			End of Drillhole: 13.16 m Bedrock starts at 9.25 m. KPMW 12-104S EOH at 8.53 m. KPMW12-104D EOH at 13.16 m. KPMW12-104D was installed in an adjacent hole.													
18.0																
19.0																

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.4

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project
Contractor: Abraflex
Location: Proposed Trans-Load Facility
Coordinates: ~~498,389 N~~ ; ~~5,564,315 E~~

Drillhole No.: KPMW12-105
Drill Type: Morooka MST 1100
Total Depth: 10.67 m
Elevation:
Inclination:

Page: 1 of 2
Date Started: 14 Aug 12
Date Completed: 14 Aug 12
Logged by: ML
Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			TOPSOIL (0 to 0.15) TOPSOIL; dark brown, moist, root intrusion, dry to moist		SPT1		58					17/16/8/8	24		0.3	
1.0			**SAND AND GRAVEL** (0.15 to 0.61) SAND (fine to coarse) and GRAVEL, poorly graded, grey, brown, massive, compact, dry to moist		SPT2		67					4/5/6/5	11			
2.0			**SAND** (0.61 to 1.52) SAND (fine to coarse); trace gravel (fine), trace silt, poorly graded, brown, massive, compact, moist to wet		SPT3		75					2/4/5/5	9			
			SAND (1.52 to 2.64) SAND (fine to coarse); trace silt, poorly graded, black, white, brown, orange grains, massive, compact, saturated		SPT4		63					5/4/4/9	8			
3.0			**SAND** (2.64 to 8.53) SAND (fine to coarse); some gravel (fine), trace silt, poorly graded, black, white, brown, orange grains, massive, loose to dense, saturated, some gravel at 6.5m depth		SPT5		79					3/2/5/12	7			
4.0					SPT6		42					0/3/6/10	9			
5.0					SPT7		42					0/3/9/13	12			
					SPT8		50					4/5/9/17	14			
6.0					SPT9		42					3/10/12/10	22		6.1	
7.0															7	
8.0					SPT10		2					9/21/30/25	51		7.5	
			SAND (8.53 to 10.67) SAND (fine to coarse); trace gravel (fine), trace silt, poorly graded, black, white, brown, orange grains, massive, saturated		SPT11		75					7/9/14/12	23			
9.0																

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR
SPT TEST 'N' VALUES - ×
PL MC LL (%) 20 40 60 80

SYMBOLS:
SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.5

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: ~~498,389 N~~ ; ~~5,564,315 E~~

Drillhole No.: KPMW12-105

Drill Type: Morooka MST 1100

Total Depth: 10.67 m

Elevation:

Inclination:

Page: 2 of 2

Date Started: 14 Aug 12

Date Completed: 14 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			End of Drillhole: 10.67 m Refusal Confirmed with CPT at 10.67 m. KPMW 12-105S EOH at 10.67 m.											PL MC LL (%) 20 40 60 80	10.5 10.6 10.7	

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.5

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: ~~498,572 N~~ ; ~~5,564,218 E~~

Drillhole No.: KPMW12-106

Drill Type: Morooka MST 1100

Total Depth: 15.24 m

Elevation:

Inclination:

Page: 1 of 2

Date Started: 14 Aug 12

Date Completed: 15 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES - ×	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
			SAND AND GRAVEL (0 to 0.13) SAND (fine to coarse) and GRAVEL; poorly graded, grey, massive, dry		SPT1		67					4/15/12/11	27		0.3	
			TOPSOIL (0.13 to 0.28) TOPSOIL; dark brown, moist, root intrusion, dry to moist												0.6	
1.0					SPT2		67					6/7/6/6	13			
			SAND (0.28 to 2.29) SAND (fine to coarse); trace gravel (fine), trace silt, black, white, brown and orange grains, poorly graded, massive, compact, dry to wet		SPT3		79					4/5/6/6	11			
2.0																
			SAND (2.29 to 6.1) SAND (fine to coarse); some gravel (fine), trace silt, poorly graded, black, white brown and orange grains, massive, compact, saturated	▼	SPT4		63					4/7/7/6	14			
3.0															3	
					SPT5		17					2/6/5/5	11			
4.0					SPT6		71					0/9/13/16	22			
					SPT7		38					0/9/13/11	22			
5.0					SPT8		58					2/9/17/13	26			
6.0			**SAND** (6.1 to 7.62) SAND (fine to medium); some silt, poorly graded, brown, massive, saturated		SPT9		13					0/3/10/7	13		6.7	
7.0															7.2	
			SAND (7.62 to 9.14) SAND (fine to coarse); some gravel (fine to coarse), trace silt, poorly graded, black, white brown and orange grains, massive, saturated		SPT10		29					5/10/15/10	25		8.2	
8.0																
9.0			**SAND** (9.14 to 13.89) SAND (fine to coarse); trace silt, poorly graded, black, white brown and orange grains, massive, saturated		SPT11		21					5/15/18/13	33			

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%) 20 40 60 80

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.6

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB; DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT; 04-Feb-13

Project: Eagle's Nest Project

Contractor: Abraflex

Location: Proposed Trans-Load Facility

Coordinates: 498,572 N , 5,564,218 E

Drillhole No.: KPMW12-106

Drill Type: Morooka MST 1100

Total Depth: 15.24 m

Elevation:

Inclination:

Page: 2 of 2

Date Started: 14 Aug 12

Date Completed: 15 Aug 12

Logged by: ML

Reviewed by: JAM

DEPTH - (m)	ELEVATION - (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	ROCK / SOIL	SAMPLE / RUN No.	SAMPLED CORE	RECOVERY (%)	RECOVERED SAMPLE TYPE	LABORATORY TESTS	UCS RATING / FROZEN SOIL DESCRIPTION	NoD / FIELD TESTS	RQD (%) / BLOW COUNTS (PER 0.15m)	RMR / SPT 'N' VALUE	KEY ROCK MASS CHARACTERISTICS / SPT TEST 'N' VALUES	INSTRUMENTATION / WELL DEPTHS (m)	INSTRUMENTATION / WELL DETAILS
11.0			**SAND** (9.14 to 13.89) SAND (fine to coarse); trace silt, poorly graded, black, white brown and orange grains, massive, saturated		SPT12		2					1/3/5/10	8		11.2 11.2	
12.0																
13.0																
14.0			**SILT** (13.89 to 15.24) SILT; trace sand (fine to medium), trace clay, poorly graded, medium to high plasticity, grey, spongy texture, massive, saturated		SPT13		71					11/11/13/13	24			
15.0			End of Drillhole: 15.24 m Refusal Confirmed with CPT at 15.24 m. KPMW 12-106S EOH at 15.24 m.												15.2	
16.0																
17.0																
18.0																
19.0																

KEY ROCK MASS CHARACTERISTICS: RECOVERY; RQD; RMR

SPT TEST 'N' VALUES - ×

PL MC LL (%)

20 40 60 80

SYMBOLS:

SPLITSPOON, BENTONITE, GROUT, SLOUGH, CORE, CEMENT FILL, SAND, WELL

Noront Resources Ltd.
Eagle's Nest Project

Knight Piésold CONSULTING

Project No.	Ref. No.	Rev.
NB102-390/1	26	0

Figure A.6

I:\1\02\00390\01\ADATA\WORK FILES\WF06- 2012 NAKINA GEOTECH\NAKINA 2012 SUMMER GEOTECH.GPJ
I:\0\GINT\LIBRARY\EAGLE'S NEST TEMP\KP LIB.GLB, DRILLHOLE LOG_EAGLE'S NEST NO FROZ, KP DATA TEMPLATE.GDT, 04-Feb-13

APPENDIX D

Photographs

Picture 1: BH19-01 Silt and Sand TILL at 2.5’

Picture 2: BH19-01 Silt and Sand TILL at 5’

Picture 3: BH19-02, Silty Gravelly Sand Till at 2.5'

Picture 4: BH19-03, Silt and Sand TILL at 5'

Picture 5: BH19-03 Sandy Silt TILL at 10’

Picture 6: BH19-03, Sandy Silt TILL at 16’

Picture 7: BH19-05, Peat at 2.5’

Picture 8: BH19-05, Organic Silt and sand at 5’

Picture 9: BH19-05, Sandy Silt TILL at 7.5'

Picture 10: BH19-05, Sandy Silt TILL at 15'

Picture 11: BH19-06, Sandy Silt TILL at 2.5'

Picture 12, BH19-06, Sandy Silt TILL at 5'

Picture 13: BH19-06, Sand and Gravel TILL at 15’

Picture 14: BH19-06, Gravelly Sand TILL at 20’

Picture 15: BH19-06, Silty Sand TILL at 40'

Picture 16: BH19-P1, Sandy Silt trace rootlets at 0.5'

Picture 17: BH19-P1, Sandy Silt at 2’

Picture 16: BH19-07, organics at surface and Silty Sand at 1’

Picture 17: BH19-07, Sandy Silt Till at 2’

Picture 18: BH19-07, Clayey Silt TILL at 5’

Picture 19: BH19-08, Organics at surface

Picture 20: BH19-08, Silty Sand at 2’

Picture 21: BH19-08, Sand some Silt at 7.5’

Picture 22: BH19-08, Silty Sand TILL at 10’

Picture 23: BH19-08, Clayey Silt TILL at 35’

Picture 24: BH19-10, Organics at surface and Sandy Silt at 1’

Picture 25: BH19-10, Silty Sand at 7.5’

Picture 26: BH19-10, Sand at 20’

BH19-01, Rock Core sample from 7’ – 16.04’

BH19-02, Rock Core sample from 5’ – 14.75’

BH19-05, Rock Core sample from 26.3’ – 34.6’

BH19-04, Rock Core sample from 4.5’ – 19.08’

Picture 1: Rig Setup at BH19-01

Picture 2: Searching for Water near BH19-01

Picture 3: Assembling Rig at BH19-02

Picture 4: Moving equipment with Helicopter

Picture 5: Pushing spoon with Pionjar at Bh19-03

Picture 6: Rig setup at BH19-05

Picture 7: Rig Covered with Tarp to protect from extreme cold at BH19-05

Picture 8: Advancing hole using wash boring method at BH19-06

Picture 9: Backfilling Hole with Bentonite at BH19-06

Picture 10: clearing snow for test hole at BH19-P1

Picture 11: Pushing Spoon with Pionjar at BH19-P1

Picture 12, Retrieving spoon using Jack at BH19-P1

Picture 13, Guiding Pilot to set up rig base at BH19-08

Picture 14, Erosion at the river embankment near BH19-08

Picture 15, Trying to retrieve the locked casing in sand at BH19-10

Picture 16, Surficial boulders near BH19-04

Picture 17, Bedrock under thin organic layer about 10 m east of BH19-04

Picture 18, Demob rig from BH19-04 to Webequie

APPENDIX E

Laboratory Test Results

TBT ENGINEERING
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274 Kingston St.,Thunder Bay, ON P7E 3P7
PH: (807) 624-5162 FAX: (807) 624-5161
E-Mail: info@tbte.ca

Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	19-017
Client Project No.:	WSR	Tested By/Date:	F. Valela / March 13, 2019
Project Description:	Supply Road Project	Reported By:	Forch Valela
Report To:	Muhammad Saleem	Reviewed By:	Forch Valela

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
19-054	19-01	AS 1	0 - 1'	**85.1**	Organic
19-055	19-01	SS 2	2'6" - 4'	**13.9**	
19-056	19-01	SS 3	5' - 6'3"	**11.8**	
19-057	19-02	AS 1	0 - 2'	**168.2**	Organic
19-058	19-02	SS 2	2'6" - 4'6"	**8.1**	
19-059	19-03	PS 1	0 - 1'	**640.9**	Organic
19-060	19-03	PS 2	2' - 4'	**19.7**	
19-061	19-03	PS 3	5' - 7'	**16.6**	
19-062	19-03	PS 4	10' - 11'6"	**10.0**	
19-063	19-03	PS 5	16' - 17'	**8.2**	
19-064	19-05	SS 1	2' 6"- 4'	**56.9**	Organic
19-065	19-05	SS 2	5'- 7'	**29.1**	
19-066	19-05	SS 3	7' 6"- 9'6"	**14.2**	
19-067	19-05	SS 4	10'- 12'	**12.0**	
19-068	19-05	SS 5	15'- 17'	**9.2**	
19-069	19-05	SS 6	20' - 22'	**10.6**	
19-070	19-05	SS 7	24' - 26'6"	**13.3**	
19-071	19-06	SS 1	2'6" - 4'6"	**20.4**	
19-072	19-06	SS 2	5' - 7'	**12.5**	
19-073	19-06	SS 3	7'6" - 9'6"	**9.2**	
19-074	19-06	SS 4	10' - 12'	**14.0**	

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Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	19-017
Client Project No.:	WSR	Tested By/Date:	F. Valela / March 13, 2019
Project Description:	Supply Road Project	Reported By:	Forch Valela
Report To:	Muhammad Saleem	Reviewed By:	Forch Valela

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
19-075	19-06	SS 5	15' - 16'6"	**4.6**	
19-076	19-06	SS 6	20' - 20'9"	**7.3**	
19-077	19-06	SS 9	40' - 41'6"	**20.5**	
19-078	19-06	SS 10	45' - 46'3"	**17.6**	
19-079	19-06	SS 11	50'-50'10"	**14.1**	
19-080	19-P1	SS 1	0' - 2'	**20.0**	
19-081	19-P2	SS 2	2' - 4'	**14.2**	
19-082	19-P3	SS 3	4' - 6'	**12.8**	

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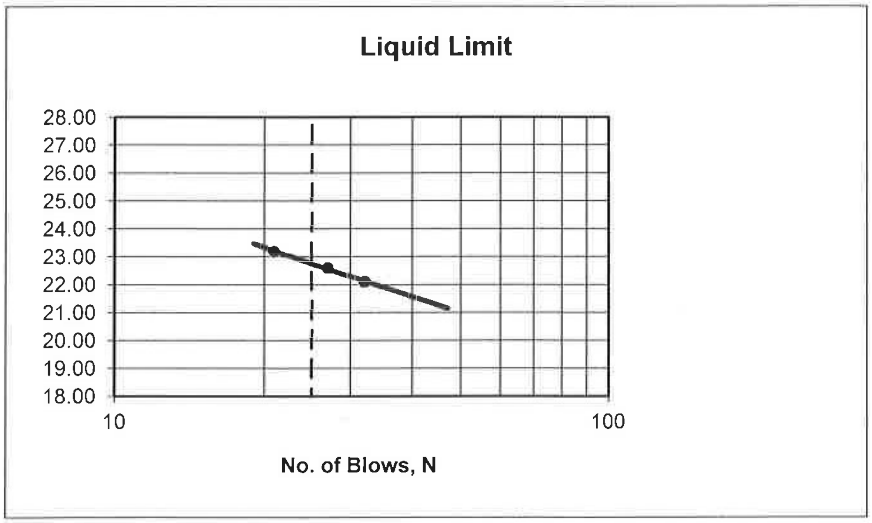
Atterberg Limits

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-055
	Supply Road Project	B.H./T.P. No.:	19-01
Report to:	Muhammad Saleem	Sample No.:	SS 2
Tested By/Date:	MM / March 13, 2019	Depth (ft):	2' 6" - 4'
Reported By:	Forch Valela	Reviewed By:	Forch Valela AV

Liquid Limit Determination

Dish No.:	AA	JJ	ZZ		Liquid Limit 25 Blows
Wet Soil + Dish:	44.331	42.612	39.636		
Dry Soil + Dish:	41.33	40.048	37.62		
Moisture:	3.001	2.564	2.016		
Dish:	28.394	28.71	28.503		
Dry Soil:	12.936	11.338	9.117		
% Moisture:	23.20	22.61	22.11		
No. of Blows:	21	27	32		
Liquid Limits:	23	23	23		23



Liquid Limit, %:	23
Plastic Limit, %:	14
Plasticity Index:	9

Plastic Limit Determination

Dish No.:	1	2			Natural Moisture F
Wet Soil + Dish:	26.853	26.561			610
Dry Soil + Dish:	25.958	25.672			565.3
Moisture:	0.895	0.889			44.7
Dish:	19.502	19.221			244.2
Dry Soil:	6.456	6.451			321.1
% Moisture:	13.86	13.78			13.9
Average:	14				

Test Method : ASTM: D4318, D2216

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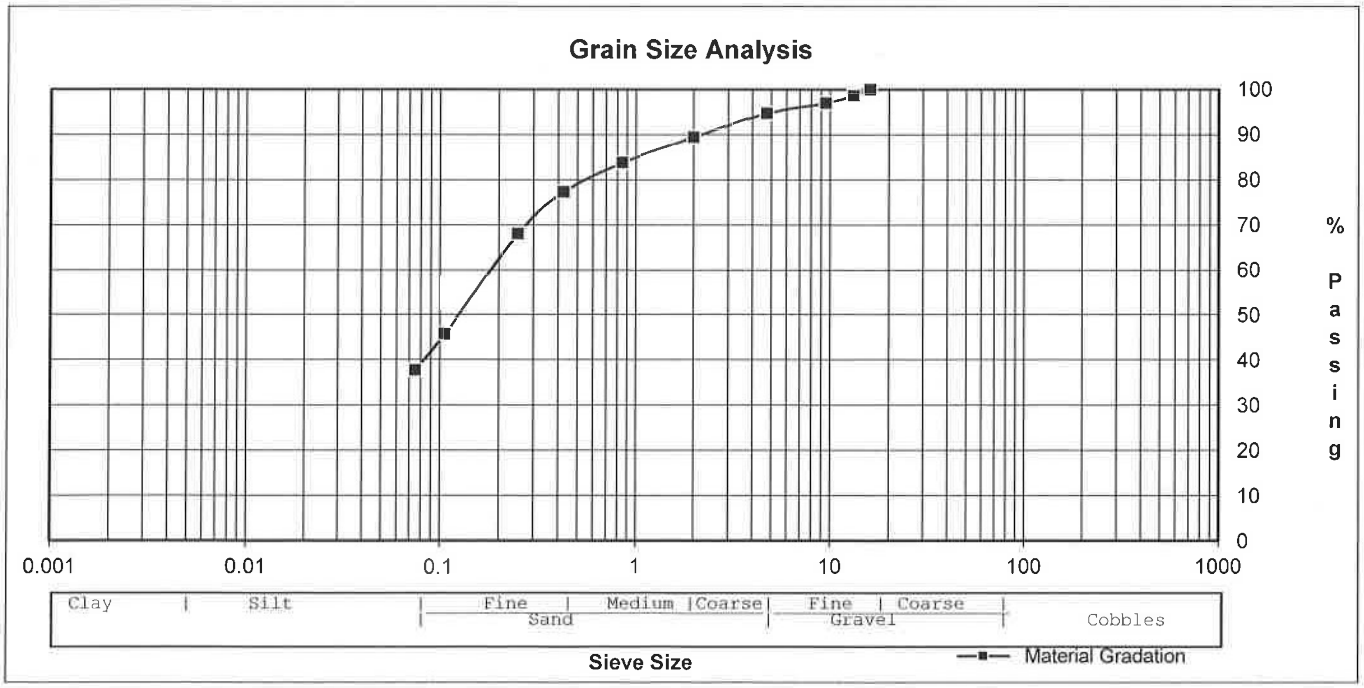
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-055
	Supply Road Project	B.H./T.P. No.:	19-01
Report to:	Muhammad Saleem	Sample No.:	SS 2
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	2' 6" - 4'
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	100.0
13.2 mm	98.7
9.5 mm	97.0
4.75 mm	94.7
2.00 mm	89.4
.850 mm	83.8
.425 mm	77.3
.250 mm	68.1
.106 mm	45.7
.075 mm	37.7



% Gravel	5.3		
% Sand	57.0	Natural Moisture Content %	
% Silt & Clay	37.7	13.9	

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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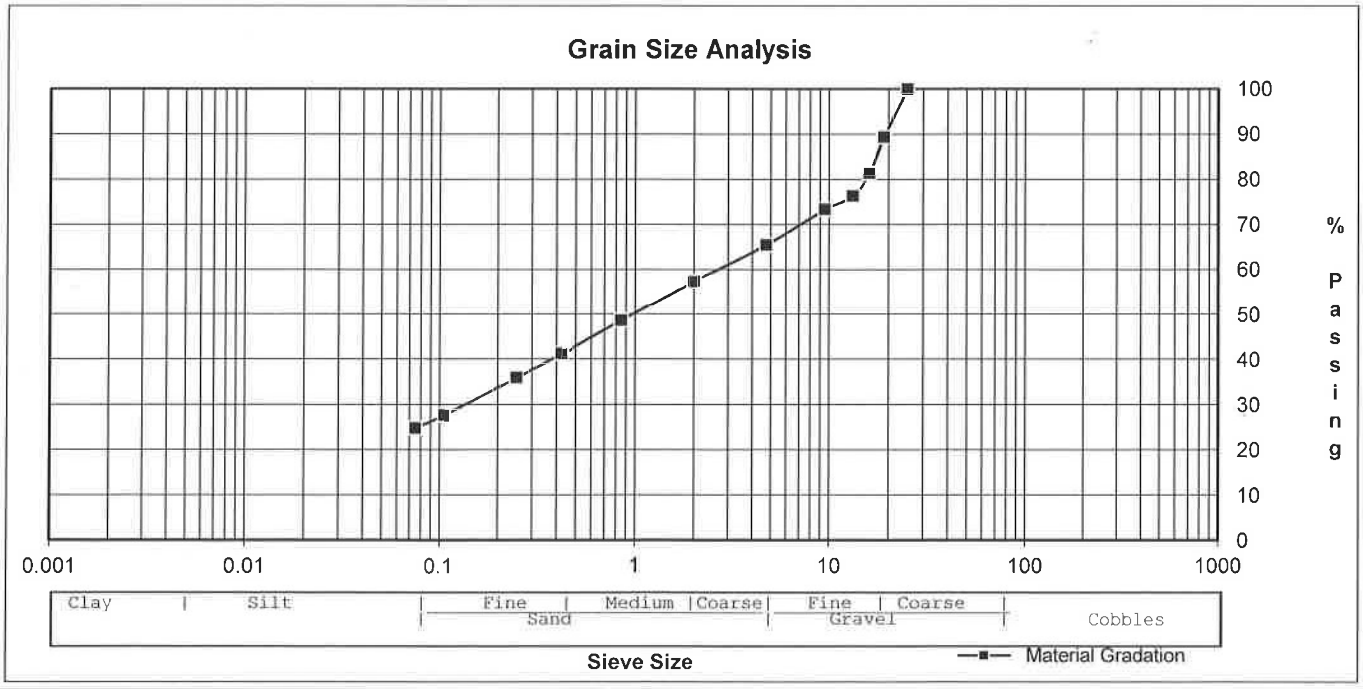
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-058
	Supply Road Project	B.H./T.P. No.:	19-02
Report to:	Muhammad Saleem	Sample No.:	SS 2
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	2' 6" - 4' 6"
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	89.3
16.0 mm	81.3
13.2 mm	76.3
9.5 mm	73.3
4.75 mm	65.5
2.00 mm	57.3
.850 mm	48.6
.425 mm	41.2
.250 mm	35.9
.106 mm	27.7
.075 mm	24.7



% Gravel	34.5		
% Sand	40.8	Natural Moisture Content %	
% Silt & Clay	24.7	8.1	

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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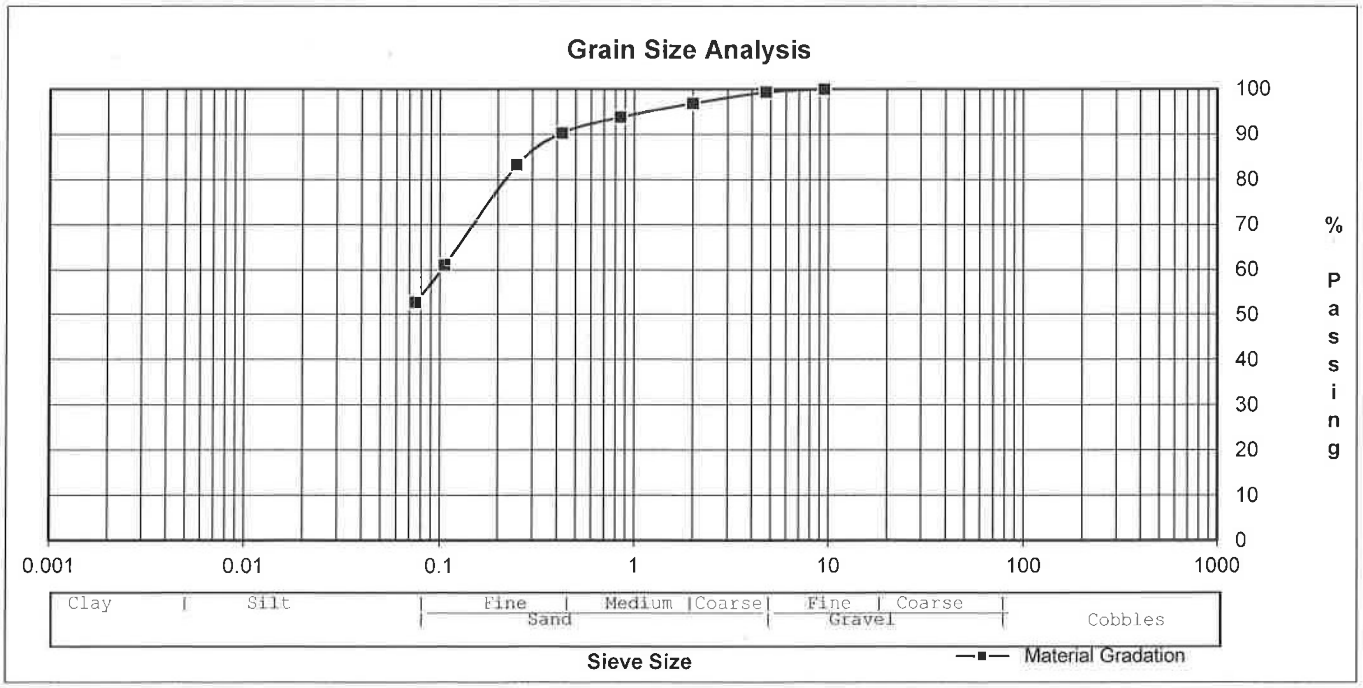
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-061
	Supply Road Project	B.H./T.P. No.:	19-03
Report to:	Muhammad Saleem	Sample No.:	PS 3
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	5' - 7'
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	100.0
4.75 mm	99.4
2.00 mm	96.9
.850 mm	93.8
.425 mm	90.3
.250 mm	83.2
.106 mm	61.0
.075 mm	52.7



% Gravel	0.6		
% Sand	46.7	Natural Moisture Content %	
% Silt & Clay	52.7		16.6

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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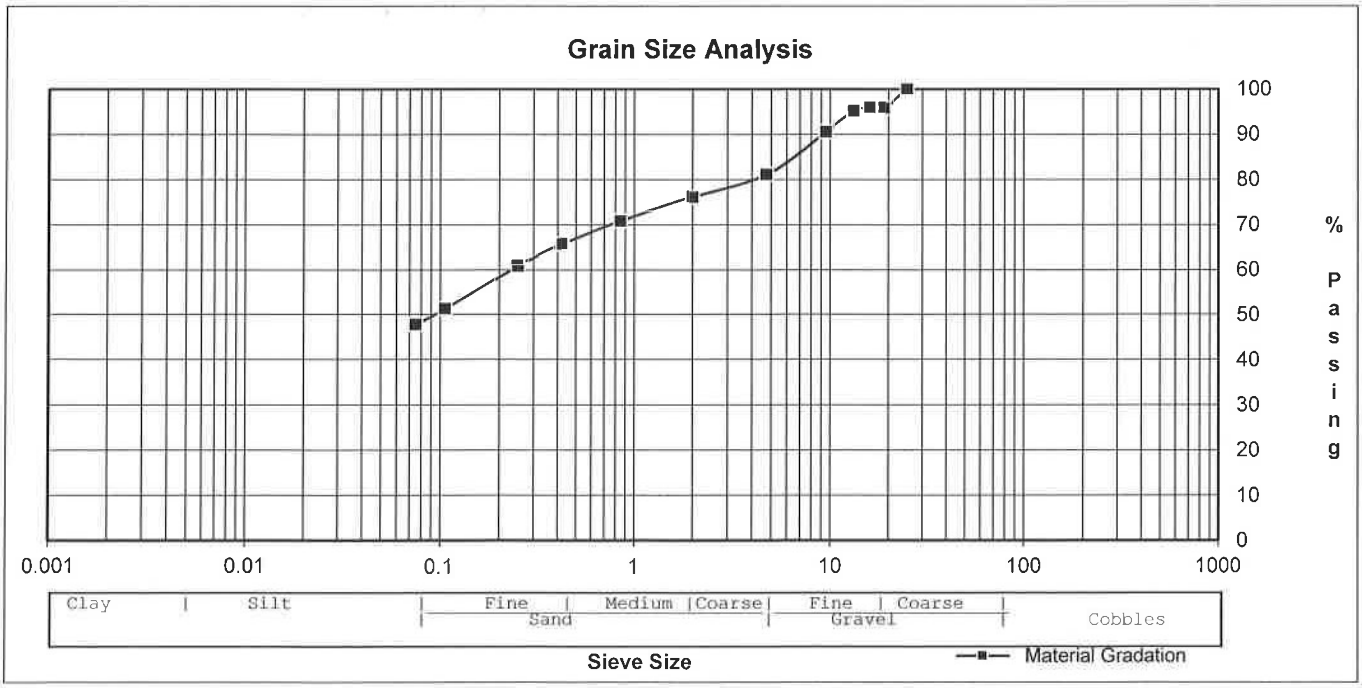
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-063
	Supply Road Project	B.H./T.P. No.:	19-03
Report to:	Muhammad Saleem	Sample No.:	PS 5
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	16' - 17'
Reported By:	Forch Valela	Reviewed By:	Forch Valela AJ

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	95.8
16.0 mm	95.8
13.2 mm	95.0
9.5 mm	90.5
4.75 mm	81.1
2.00 mm	76.1
.850 mm	70.9
.425 mm	65.8
.250 mm	60.9
.106 mm	51.2
.075 mm	47.7



% Gravel	18.9		
% Sand	33.4	Natural Moisture Content %	
% Silt & Clay	47.7	8.2	

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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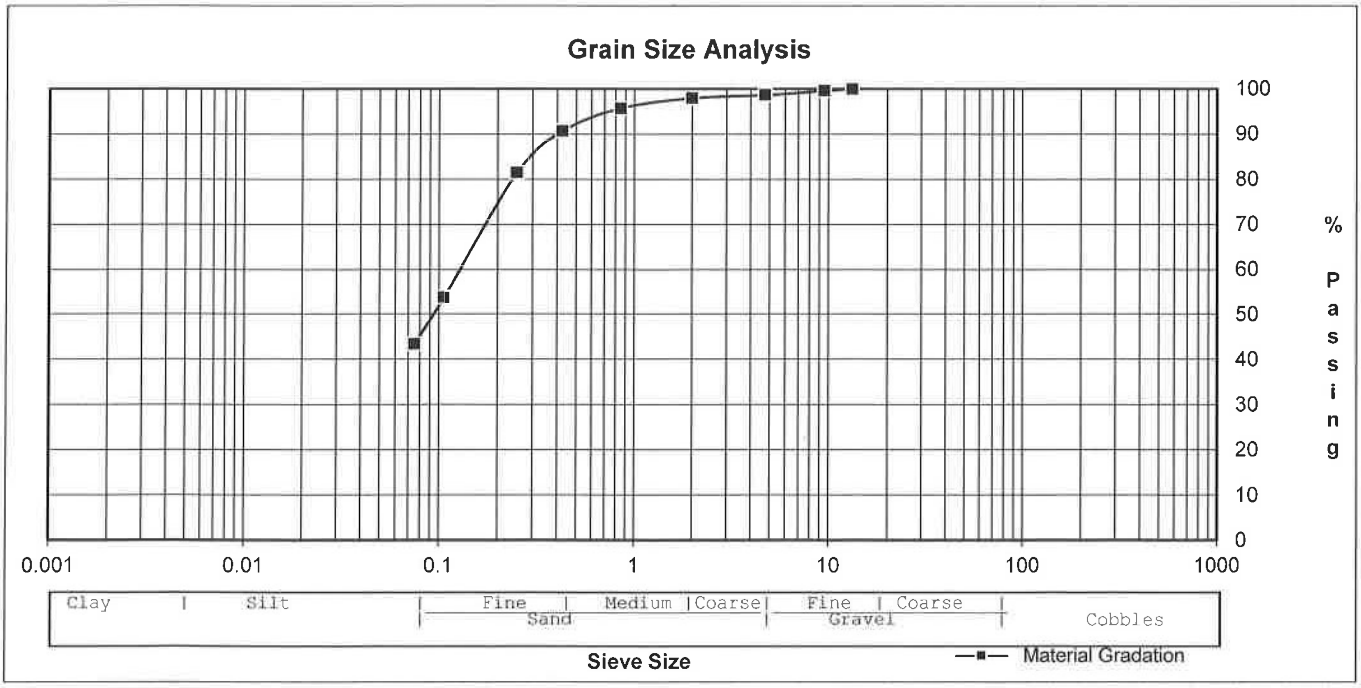
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-065
	Supply Road Project	B.H./T.P. No.:	19-05
Report to:	Muhammad Saleem	Sample No.:	SS 2
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	5' - 7'
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	99.6
4.75 mm	98.7
2.00 mm	98.0
.850 mm	95.7
.425 mm	90.7
.250 mm	81.5
.106 mm	53.7
.075 mm	43.3



% Gravel	1.3		
% Sand	55.4	Natural Moisture Content %	
% Silt & Clay	43.3		29.1

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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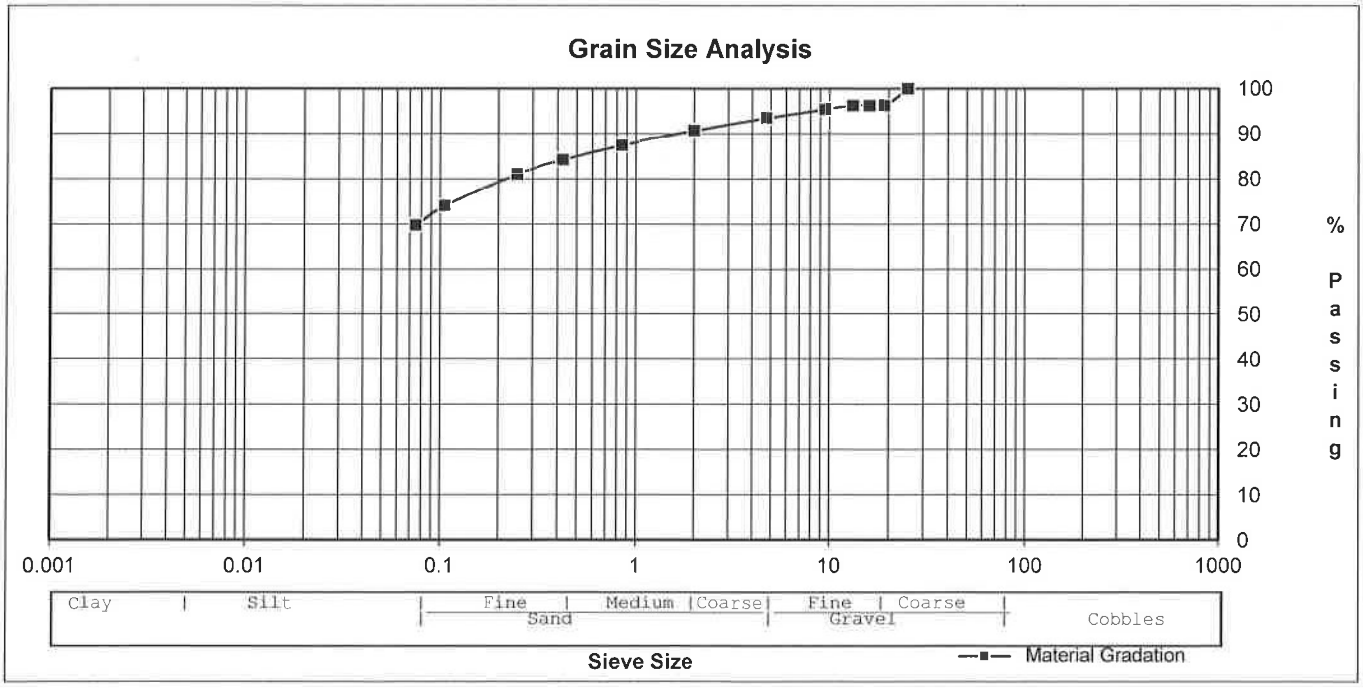
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-067
	Supply Road Project	B.H./T.P. No.:	19-05
Report to:	Muhammad Saleem	Sample No.:	SS 4
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	10' - 12'
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	96.2
16.0 mm	96.2
13.2 mm	96.2
9.5 mm	95.4
4.75 mm	93.4
2.00 mm	90.7
.850 mm	87.5
.425 mm	84.3
.250 mm	81.0
.106 mm	74.1
.075 mm	69.8



% Gravel	6.6		
% Sand	23.6	Natural Moisture Content %	
% Silt & Clay	69.8	12.0	

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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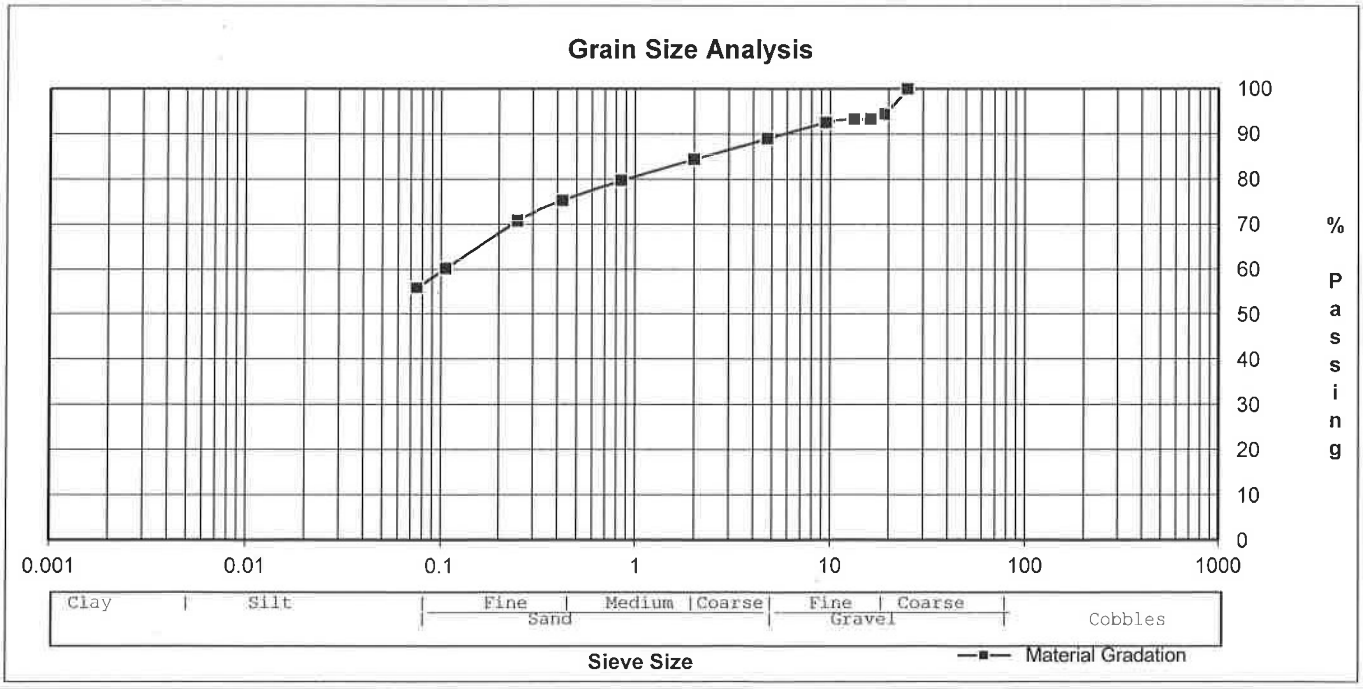
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-072
	Supply Road Project	B.H./T.P. No.:	19-06
Report to:	Muhammad Saleem	Sample No.:	SS 2
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	5' - 7'
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	94.3
16.0 mm	93.2
13.2 mm	93.2
9.5 mm	92.5
4.75 mm	89.0
2.00 mm	84.4
.850 mm	79.7
.425 mm	75.3
.250 mm	70.7
.106 mm	60.2
.075 mm	55.9



% Gravel	11.0		
% Sand	33.1	Natural Moisture Content %	
% Silt & Clay	55.9		12.5

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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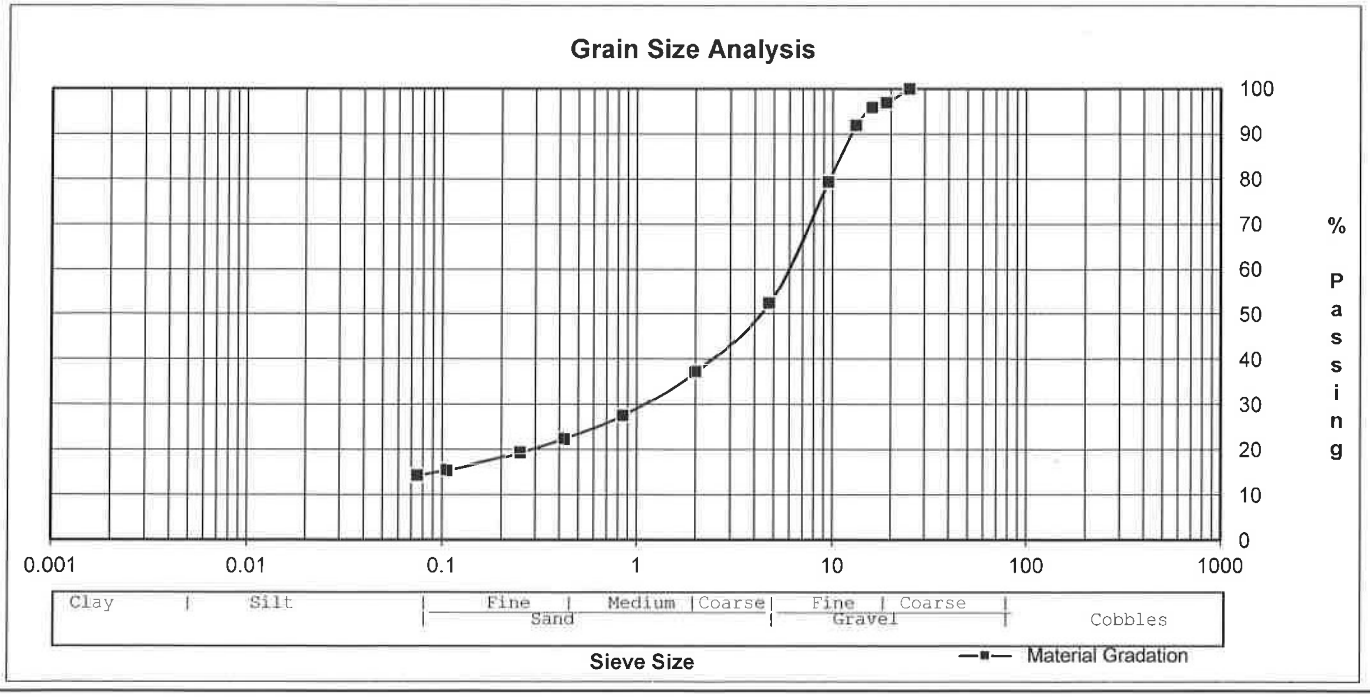
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-075
	Supply Road Project	B.H./T.P. No.:	19-06
Report to:	Muhammad Saleem	Sample No.:	SS 5
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	15' - 16' 6"
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	96.9
16.0 mm	95.8
13.2 mm	91.9
9.5 mm	79.4
4.75 mm	52.3
2.00 mm	37.2
.850 mm	27.5
.425 mm	22.4
.250 mm	19.3
.106 mm	15.5
.075 mm	14.2



% Gravel	47.7		
% Sand	38.1	Natural Moisture Content %	
% Silt & Clay	14.2	4.6	

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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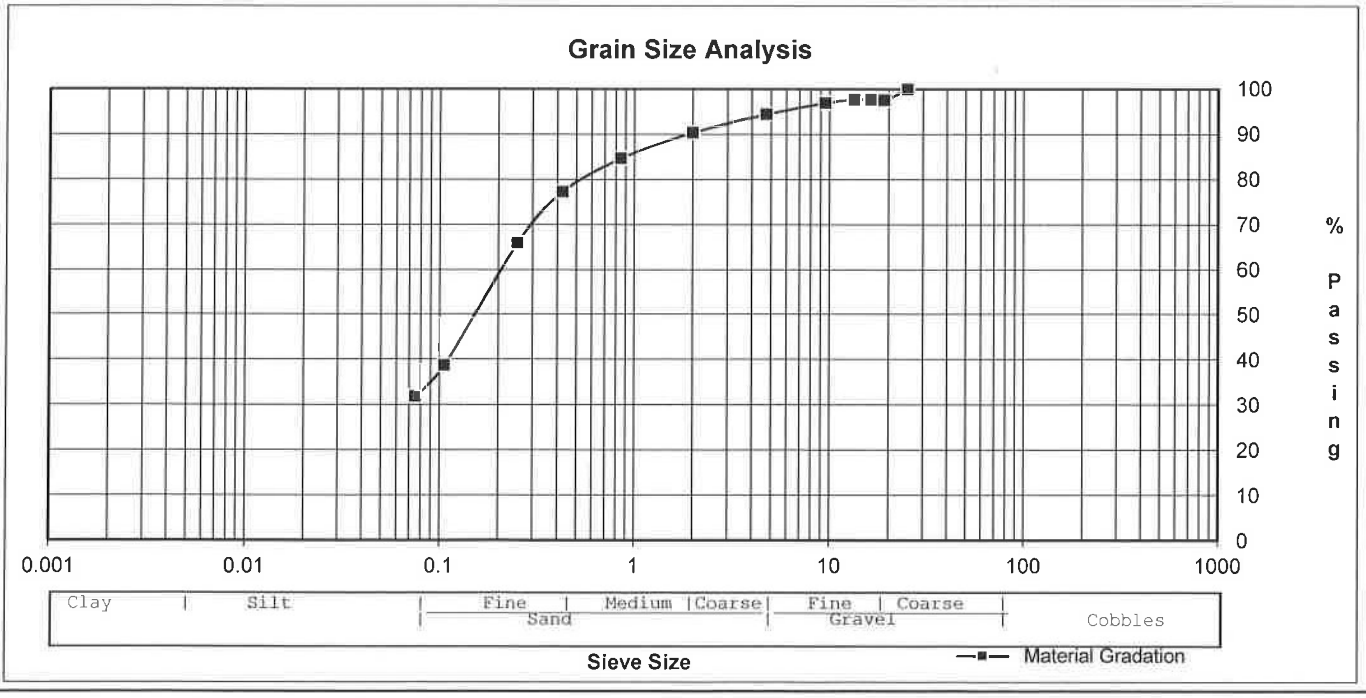
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-077
	Supply Road Project	B.H./T.P. No.:	19-06
Report to:	Muhammad Saleem	Sample No.:	SS 9
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	40' - 41' 6"
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	97.6
16.0 mm	97.6
13.2 mm	97.6
9.5 mm	96.9
4.75 mm	94.4
2.00 mm	90.4
.850 mm	84.6
.425 mm	77.2
.250 mm	65.9
.106 mm	38.7
.075 mm	31.8



% Gravel	5.6		
% Sand	62.6	Natural Moisture Content %	
% Silt & Clay	31.8		20.5

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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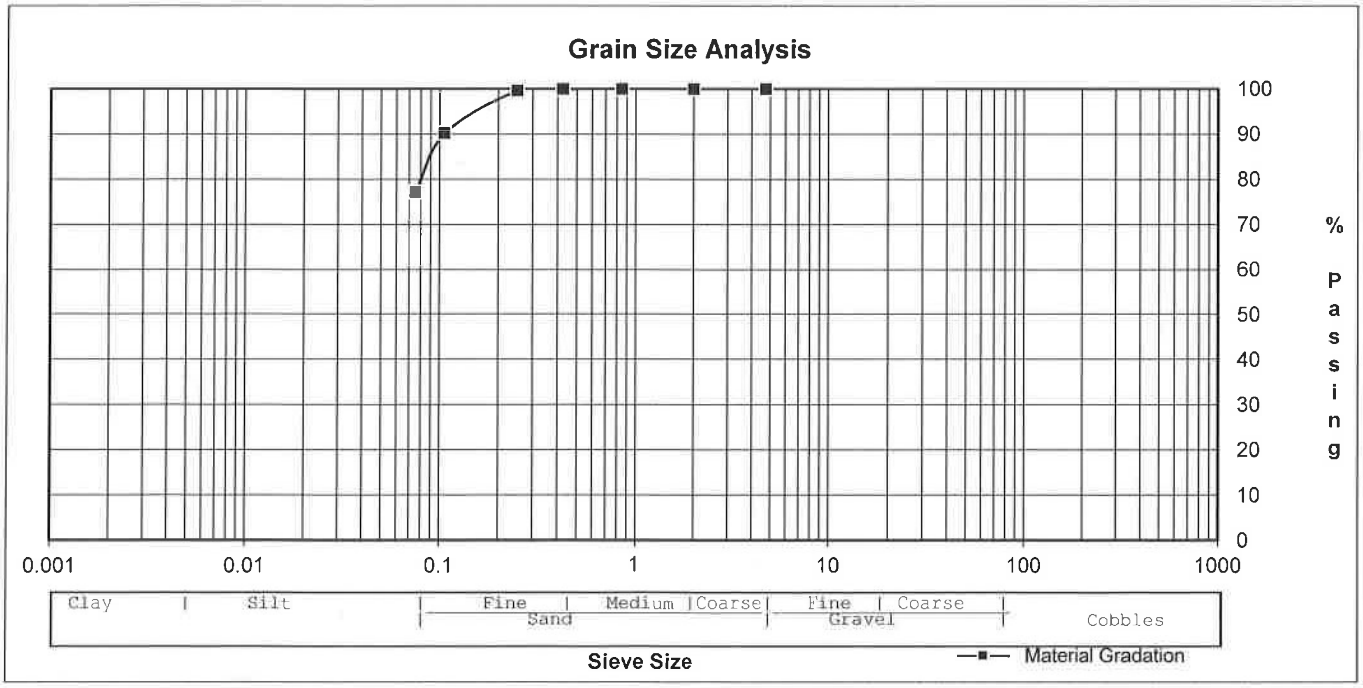
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-017
Project Description:	WSR	Lab No.:	19-081
	Supply Road Project	B.H./T.P. No.:	19-P2
Report to:	Muhammad Saleem	Sample No.:	SS 2
Tested By/Date:	FV / GH / March 13, 2019	Depth: (ft)	2' - 4'
Reported By:	Forch Valela	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	100.0
.850 mm	100.0
.425 mm	100.0
.250 mm	99.6
.106 mm	90.2
.075 mm	77.1



% Gravel	0.0		
% Sand	22.9	Natural Moisture Content %	
% Silt & Clay	77.1		14.2

Remarks: Test Method LS 602, 701/ASTM C136, D2216

CCIL & CSA Certified

TBT ENGINEERING
CONSULTING GROUP

March 14, 2019
TBTE Ref. No. 19-017

Muhammad Saleem
SNC-Lavalin
195 The West Mall
Toronto, ON
M9C 5K1

Re: Rock Strength Testing Results to March 14, 2019
Webequie First Nation's Supply Road
Webequie, Ontario

TBT Engineering (TBTE) has completed a subsurface investigation for Webequie First Nation's Supply Road, which consisted of drilling a total of six boreholes. Where bedrock was encountered, TBTE sampled the bedrock using diamond drilling techniques and completed detailed logging of the cores. Rock strength testing was conducted at TBTE's laboratory in Thunder Bay, Ontario. One core sample from each borehole was selected for diametral point load testing (uniaxial) and another for unconfined compression testing. Table 1 summarizes the rock strength testing results.

Table 1: Rock Strength Testing Results.

Borehole	Depth from Ground Surface (m)	Estimated Uniaxial Compressive Strength* (MPa)	Unconfined Compressive Strength (MPa)
BH-19-01	2.94	150	-
	3.03	-	90
BH-19-02	2.70	254	-
	2.32	-	111
BH-19-05	8.42	298	-
	8.51	-	188

* Estimated in accordance with ASTM D5731-16.

TBT Engineering 1918 Yonge Street, Thunder Bay, ON P7E 6T9 807-624-5160

Closure:
We trust the above addresses your project requirements at this time. Please contact us at your convenience should you have any questions.

Yours truly,
For TBT Engineering,

<original signed by>

Steven Anderson, EIT

TBT Engineering 1918 Yonge Street, Thunder Bay, ON P7E 6T9 807-624-5160

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TEST SUMMARY FOR ROCK CORE INVESTIGATION

TBTE J19-017 Webequie
Project # 661910

Lab No.	Field No.	*Control Coarse Aggregate Micro Deval*	Coarse Aggregate Micro Deval	*Control Coarse Aggregate Relative Density*	Coarse Aggregate Relative Density	*Control Absorption*	Absorption	*Control Freeze/Thaw*	Freeze/Thaw	Petrographic Number
19-083-084	BH 1 BH 2	*12.6*	5.4					*8.7*	0.4	

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LABORATORY TEST SHEET 1 OF 1 SCHEDULE OF TESTS

Compiled by: Muhammad Saleem Received by:	Date: 03-Oct-2019	Project #: 661910

IAB # 19-1647 - 1677

J19-482

Borehole / Test Pit No.	Sample No.	Type of Sample	Depth	Sample Description	Natural Moisture Content	Unit Weight	Micro Deval	Soundness test	Point Load Test	UCS (unconfined compression)	Sieve Grain Size	Hydrometer Grain Size	Atterberg Limits	Standard Proctor	CBR	Remarks
1646 BH19-04		CORE	5.5' –10.5'	ROCK					X	X						
1646 BH19-04		CORE	10.5'– 19'	ROCK			X	X								Crush whole core if required to get enough sample
BH19-07	ALL	SS		SOIL	X											
1649 BH19-07	3	SS	5'-7'	SOIL								X	X			
BH19-08	ALL	SS		SOIL	X											
1656 BH19-08	3	SS	5'-7'	SOIL							X					
1659 BH19-08	8	SS	25 - 31½'	SOIL							X					
1660 BH19-08	9	SS	35' – 37'	SOIL								X	X			
BH19-10	ALL	SS		SOIL	X											
1665 BH19-10	4	SS	7.5'-9'	SOIL							X					
1669 BH19-10	8	SS	30'-31.5'	SOIL							X					
1670 TP19-01	1	Bulk sampl		SOIL							X			X		Combine sample 1 and 2 if not enough sample
1671 TP19-01	2	Bulk sampl		SOIL							X					
1672 TP19-02	3	Bulk sampl		SOIL							X					
1673 TP19-06	4	Bulk sampl		SOIL								X	X			
1674 TP19-09	5	Bulk sampl		SOIL							X					
1675 TP19-10	6	Bulk sampl		SOIL							X					
1676 TP19-10	7	Bulk sampl		SOIL							X					
1677 TP19-11	8	Bulk sampl		SOIL							X					
ESTIMATE OF COSTS			Total No.													
			Unit Price $													
			Cost $													$ **Total**

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Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	19-482
Client Project No.:	661910	Tested By/Date:	F. Valela / October 10, 2019
Project Description:	Webequie Supply Road	Reported By:	Madison Murphy
Report To:	Muhammad Saleem	Reviewed By:	Forch Valela

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
19-1647	BH 19-07	SS1	0-2	**133.7**	Organic
19-1648	BH 19-07	SS2	2-4	**13.7**	
19-1649	BH 19-07	SS3	5-7	**11.3**	
19-1650	BH 19-07	SS4	7.5-9	**8.4**	
19-1651	BH 19-07	SS5	10-10.5	**8.4**	
19-1652	BH 19-07	SS5	10-12	**10.4**	
19-1653	BH 19-07	SS6	15-15.4	**6.8**	
19-1654	BH 19-08	SS1	0-2	**74.2**	Organic
19-1655	BH 19-08	SS2	2-4	**25.8**	
19-1656	BH 19-08	SS3	5-7	**28.8**	
19-1657	BH 19-08	SS4	7.5-9.5	**43.2**	
19-1658	BH 19-08	SS6	15-15.5	**9.0**	
19-1659	BH 19-08	SS8	25-26.5	**10.4**	
19-1660	BH 19-08	SS9	35-37	**11.0**	
19-1661	BH 19-08	SS10	40-42	**9.8**	
19-1662	BH 19-10	SS1	0-2	**19.3**	
19-1663	BH 19-10	SS2	2-4	**14.0**	
19-1664	BH 19-10	SS3	5-6.5	**17.5**	
19-1665	BH 19-10	SS4	7.5-9	**13.2**	
19-1666	BH 19-10	SS5	10-11.5	**15.0**	
19-1667	BH 19-10	SS6	15-16.5	**12.9**	

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Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	19-482
Client Project No.:	661910	Tested By/Date:	F. Valela / October 10, 2019
Project Description:	Webequie Supply Road	Reported By:	Madison Murphy
Report To:	Muhammad Saleem	Reviewed By:	Forch Valela

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
19-1668	BH 19-10	SS7	20-21.5	**16.5**	
19-1669	BH 19-10	SS8	30-31.5	**17.5**	
19-1670	TP 19-01	#1(Site1)	N/A	**12.8**	
19-1671	TP 19-01	#2 (Site2)	N/A	**6.5**	
19-1672	TP 19-02	#3	N/A	**11.6**	
19-1673	TP 19-06	#4	N/A	**19.1**	
19-1674	TP 19-09	#5	N/A	**4.9**	
19-1675	TP 19-10	#6(Site2)	N/A	**4.7**	
19-1676	TP 19-10	#7(Site3)	N/A	**10.6**	
19-1677	TP 19-11	#8	N/A	**2.3**	

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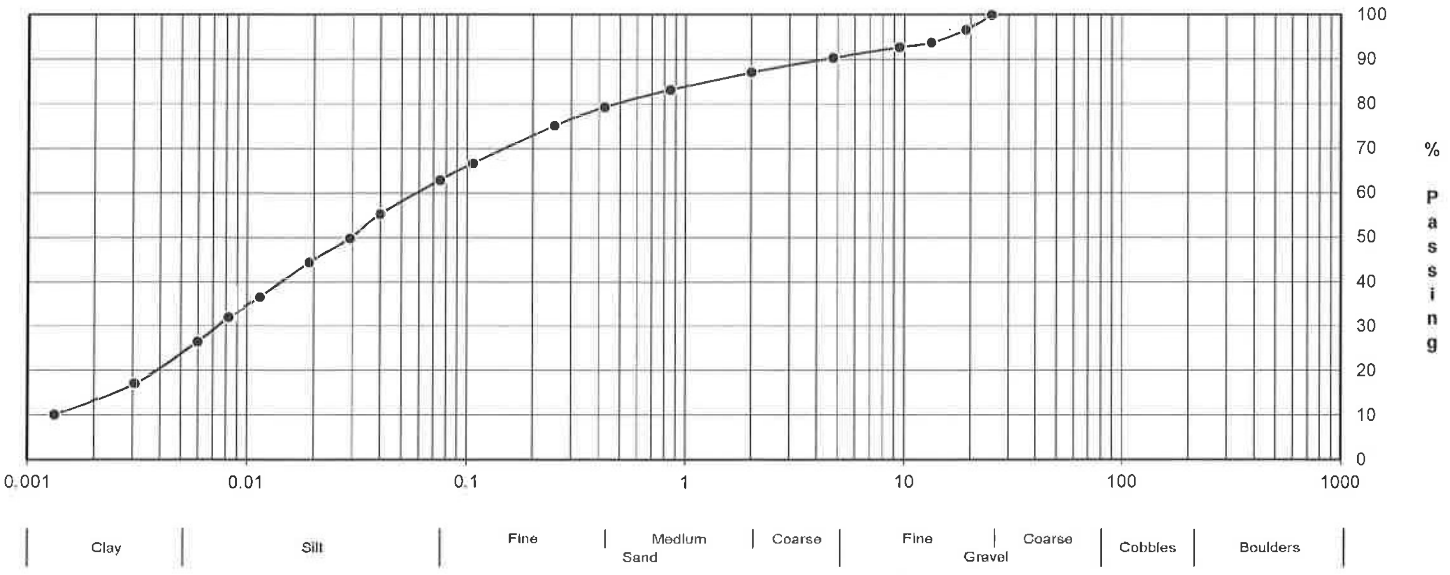
Particle Size Analysis of Soil By Hydrometer

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1649
Location:	Webequie Supply Road	Sample Location	BH 19-07 SS3 5'-7'
Report To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client / September 25, 2019	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0			
37.5		0.039895	55.3
25.0	100.0	0.029109	49.9
19.0	96.6	0.018962	44.4
13.2	93.8	0.011387	36.6
9.5	92.7	0.008233	31.9
4.75	90.3	0.005967	26.5
2.00	87.1	0.003060	17.1
0.850	83.2	0.001319	10.1
0.425	79.3		
0.250	75.1	5 µm	22.0
0.106	66.7	2 µm	15.0
0.075	62.9		

Grain Size Analysis



%Gravel	9.7	% Silt	40.9	% NMC	11.3	Frost Heave Susc.		Material Suitability	
% Sand	27.4	% Clay	22.0	PI	5	Erodibility (k)		Soil Classification	CL-ML

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

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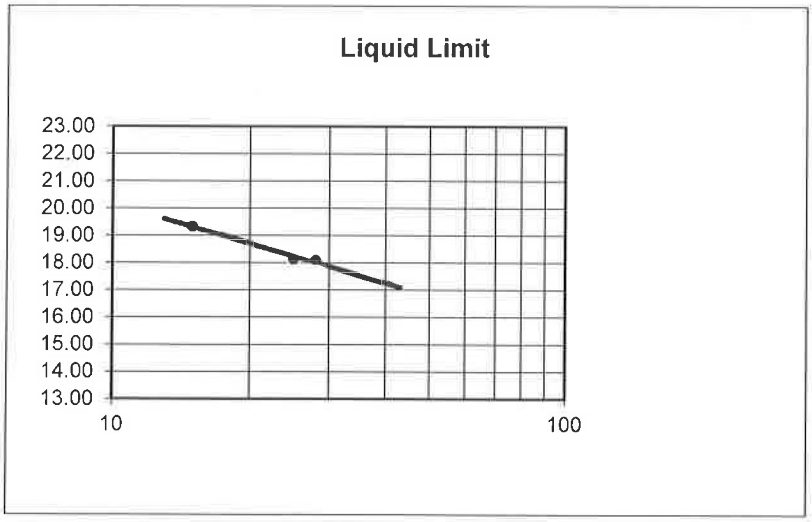
Atterberg Limits

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1649
Location:		Sample Location:	BH 19-07 SS3 5'-7'
Reported To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client / September 25, 2019	Reviewed By:	Forch Valela

Liquid Limit Determination

Dish No.:	GH	UU	VV		Liquid Limit 25 Blows
Wet Soil + Dish:	43.528	42.333	43.098		
Dry Soil + Dish:	41.071	40.187	40.845		
Moisture:	2.457	2.146	2.253		
Dish:	28.378	28.355	28.405		
Dry Soil:	12.693	11.832	12.44		
% Moisture:	19.36	18.14	18.11		
No. of Blows:	15	25	28		
Liquid Limits:	18	18	18		18



Liquid Limit, %:	18
Plastic Limit, %:	13
Plasticity Index:	5

Plastic Limit Determination

Dish No.:	1	2			Natural Moisture
Wet Soil + Dish:	28.221	28.859			A3
Dry Soil + Dish:	27.187	27.716			766.3
Moisture:	1.034	1.143			712.2
Dish:	19.503	19.216			54.1
Dry Soil:	7.684	8.5			235.4
% Moisture:	13.46	13.45			476.8
Average:	13				11.3

Test Method : ASTM: D4318, D2216

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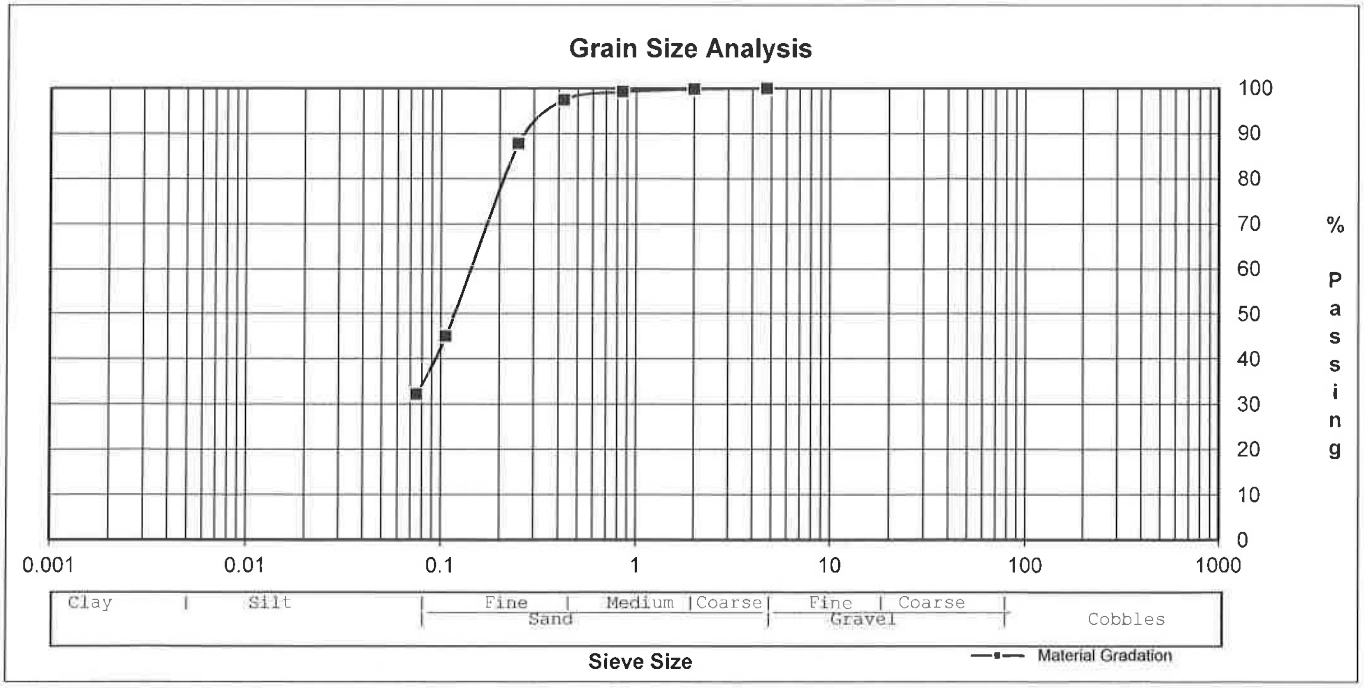
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1656
	Webequie Supply Road	B.H./T.P. No.:	BH 19-08
Report to:	Muhammad Saleem	Sample No.:	SS 3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	5'-7'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	99.8
.850 mm	99.2
.425 mm	97.4
.250 mm	87.8
.106 mm	45.0
.075 mm	32.1



% Gravel	0.0		
% Sand	67.9	Natural Moisture Content:	28.8%
% Silt & Clay	32.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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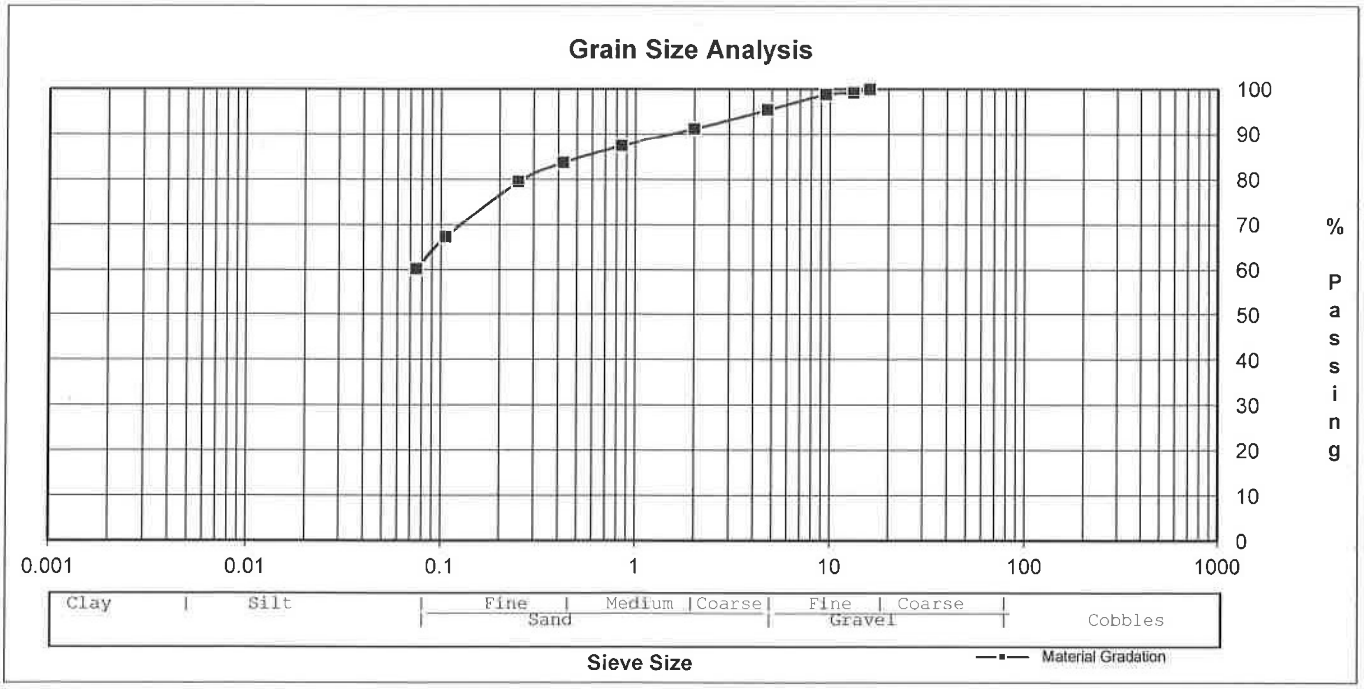
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1659
	Webequie Supply Road	B.H./T.P. No.:	BH 19-08
Report to:	Muhammad Saleem	Sample No.:	SS 8
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	25'-26'6"
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	100.0
13.2 mm	99.2
9.5 mm	98.8
4.75 mm	95.4
2.00 mm	91.2
.850 mm	87.5
.425 mm	83.7
.250 mm	79.5
.106 mm	67.3
.075 mm	60.2



% Gravel	4.6		
% Sand	35.2	Natural Moisture Content:	10.4%
% Silt & Clay	60.2	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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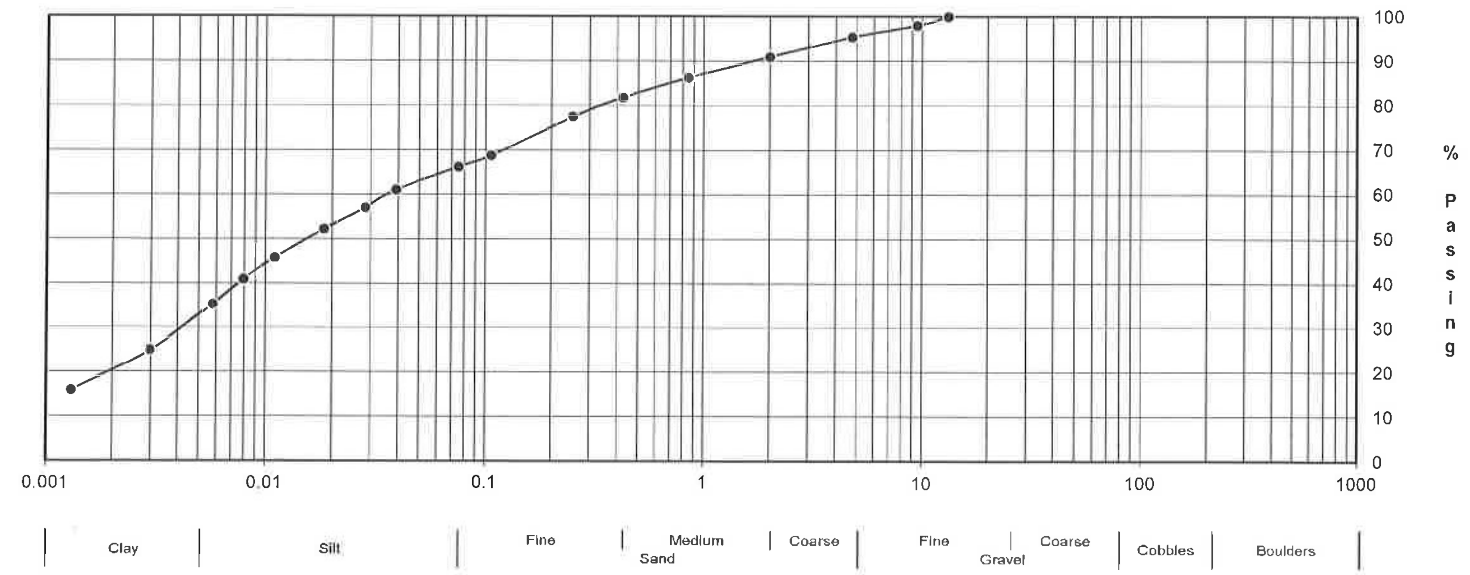
Particle Size Analysis of Soil By Hydrometer

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1660
Location:	Webequie Supply Road	Sample Location	BH 19-08 SS9 35'-37'
Report To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client / September 25, 2019	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0			
37.5		0.039044	61.0
25.0		0.028267	57.0
19.0		0.018365	52.2
13.2	100.0	0.010967	45.8
9.5	98.0	0.007943	41.0
4.75	95.3	0.005767	35.3
2.00	90.9	0.002975	24.9
0.850	86.3	0.001292	16.1
0.425	81.8		
0.250	77.5	5 µm	31.0
0.106	68.8	2 µm	22.0
0.075	66.2		

Grain Size Analysis



%Gravel	4.7	% Silt	35.2	% NMC	11.0	Frost Heave Susc.		Material Suitability	
% Sand	29.1	% Clay	31.0	PI	7	Erodibility (k)		Soil Classification	CL

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

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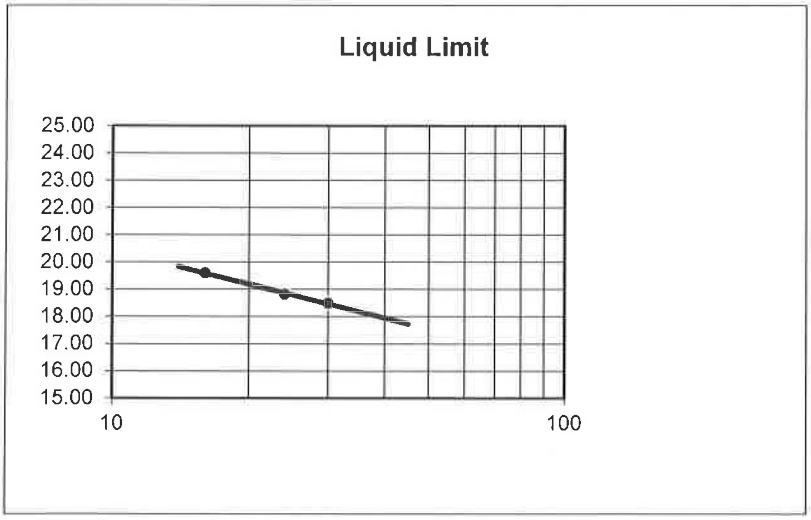
Atterberg Limits

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1660
Location:		Sample Location:	BH 19-08 SS9 35'-37'
Reported To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client / September 25, 2019	Reviewed By:	Forch Valela

Liquid Limit Determination

Dish No.:	UU	VV	GH		Liquid Limit 25 Blows
Wet Soil + Dish:	44.232	45.117	45.528		
Dry Soil + Dish:	41.752	42.469	42.716		
Moisture:	2.48	2.648	2.812		
Dish:	28.342	28.408	28.377		
Dry Soil:	13.41	14.061	14.339		
% Moisture:	18.49	18.83	19.61		
No. of Blows:	30	24	16		
Liquid Limits:	19	19	19		19



Liquid Limit, %:	19
Plastic Limit, %:	12
Plasticity Index:	7

Plastic Limit Determination

Dish No.:	1	2			Natural Moisture
Wet Soil + Dish:	27.83	27.421			A2
Dry Soil + Dish:	26.91	26.515			840.8
Moisture:	0.92	0.906			792.6
Dish:	19.502	19.221			48.2
Dry Soil:	7.408	7.294			353.2
% Moisture:	12.42	12.42			439.4
Average:	12				11.0

Test Method : ASTM: D4318, D2216

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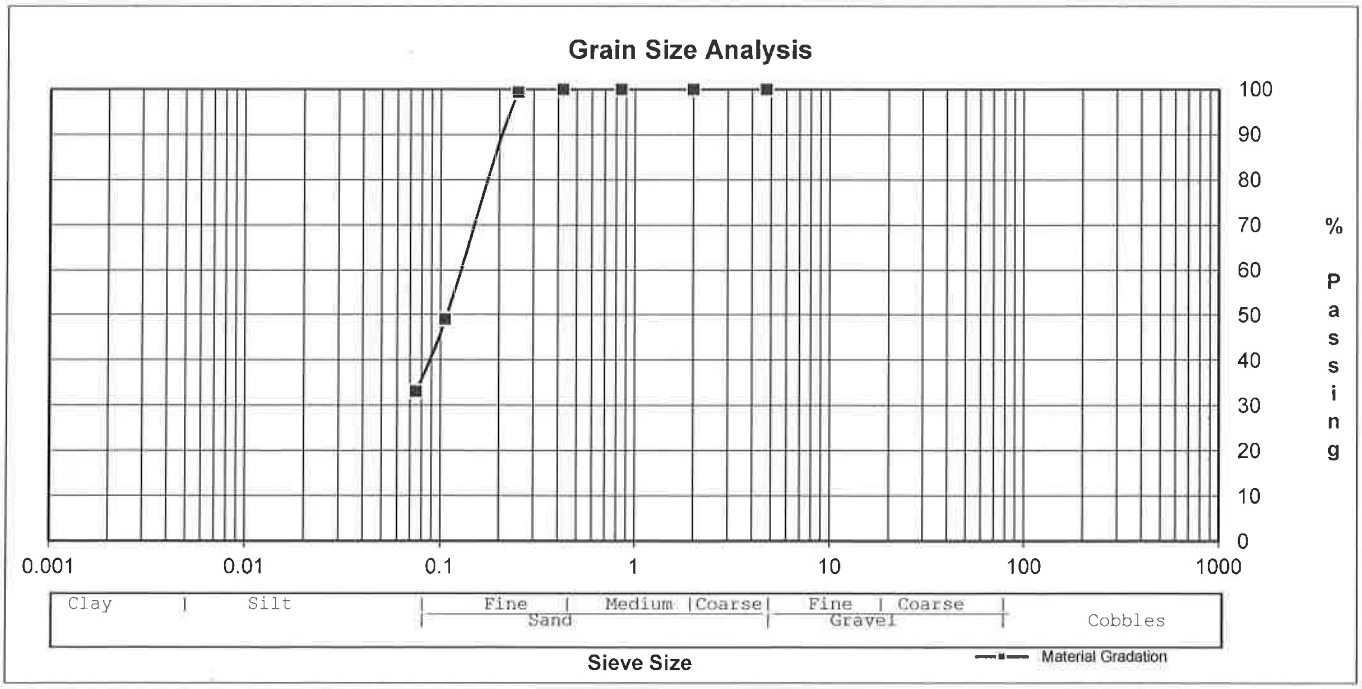
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1665
	Webequie Supply Road	B.H./T.P. No.:	BH 19-10
Report to:	Muhammad Saleem	Sample No.:	SS4
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	7'6" - 9'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	100.0
.850 mm	100.0
.425 mm	99.9
.250 mm	99.3
.106 mm	49.0
.075 mm	33.0



% Gravel	0.0		
% Sand	67.0	Natural Moisture Content:	13.2%
% Silt & Clay	33.0	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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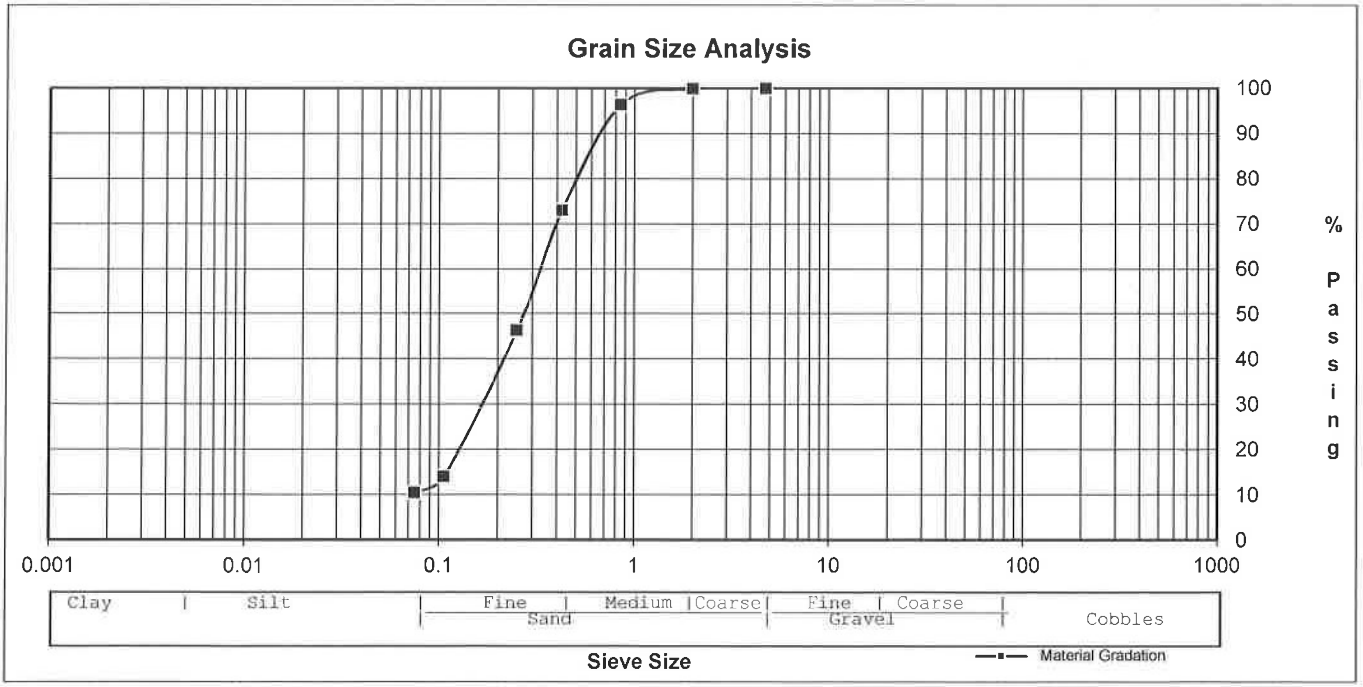
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1669
	Webequie Supply Road	B.H./T.P. No.:	BH 19-10
Report to:	Muhammad Saleem	Sample No.:	SS8
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	30' - 31'6"
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	99.9
.850 mm	96.4
.425 mm	73.0
.250 mm	46.3
.106 mm	13.9
.075 mm	10.4



% Gravel	0.0		
% Sand	89.6	Natural Moisture Content:	17.5%
% Silt & Clay	10.4	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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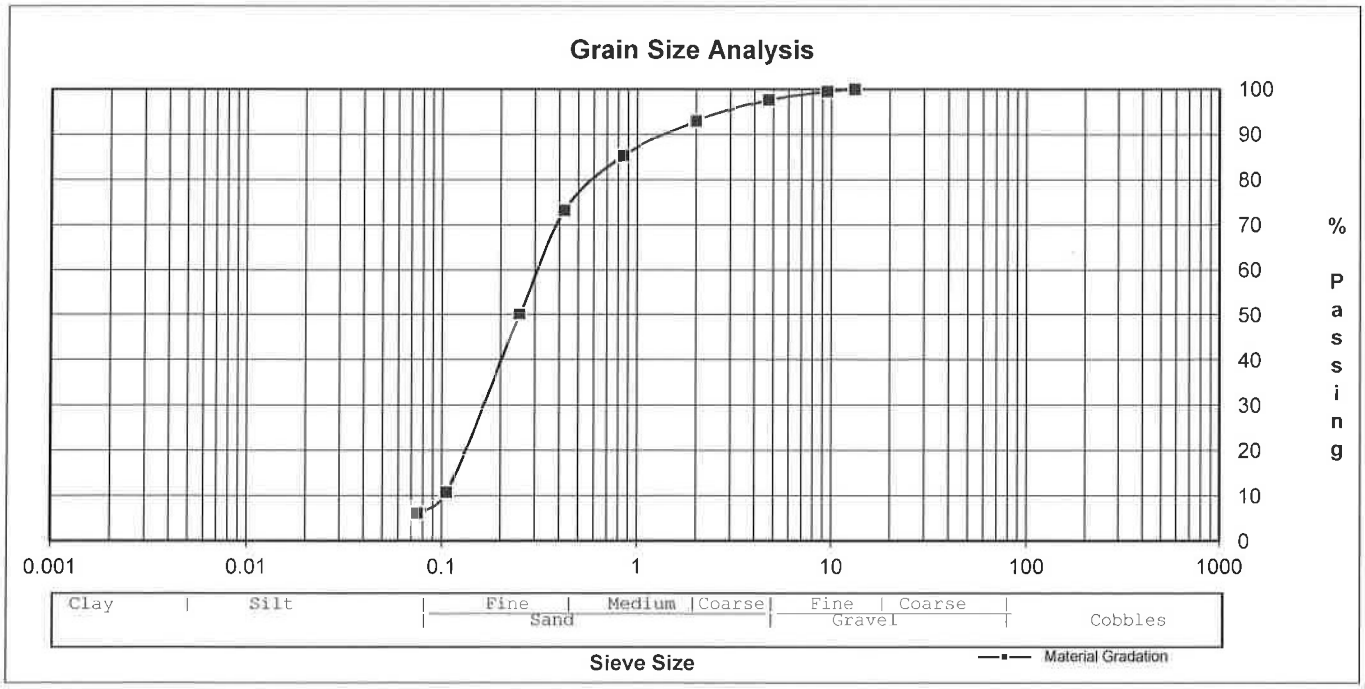
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1670
	Webequie Supply Road	B.H./T.P. No.:	TP19-01
Report to:	Muhammad Saleem	Sample No.:	#1 Site 1 Bottom Pit
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela AV

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	99.5
4.75 mm	97.6
2.00 mm	93.0
.850 mm	85.3
.425 mm	73.2
.250 mm	50.1
.106 mm	10.7
.075 mm	6.1



% Gravel	2.4		
% Sand	91.5	Natural Moisture Content:	12.8%
% Silt & Clay	6.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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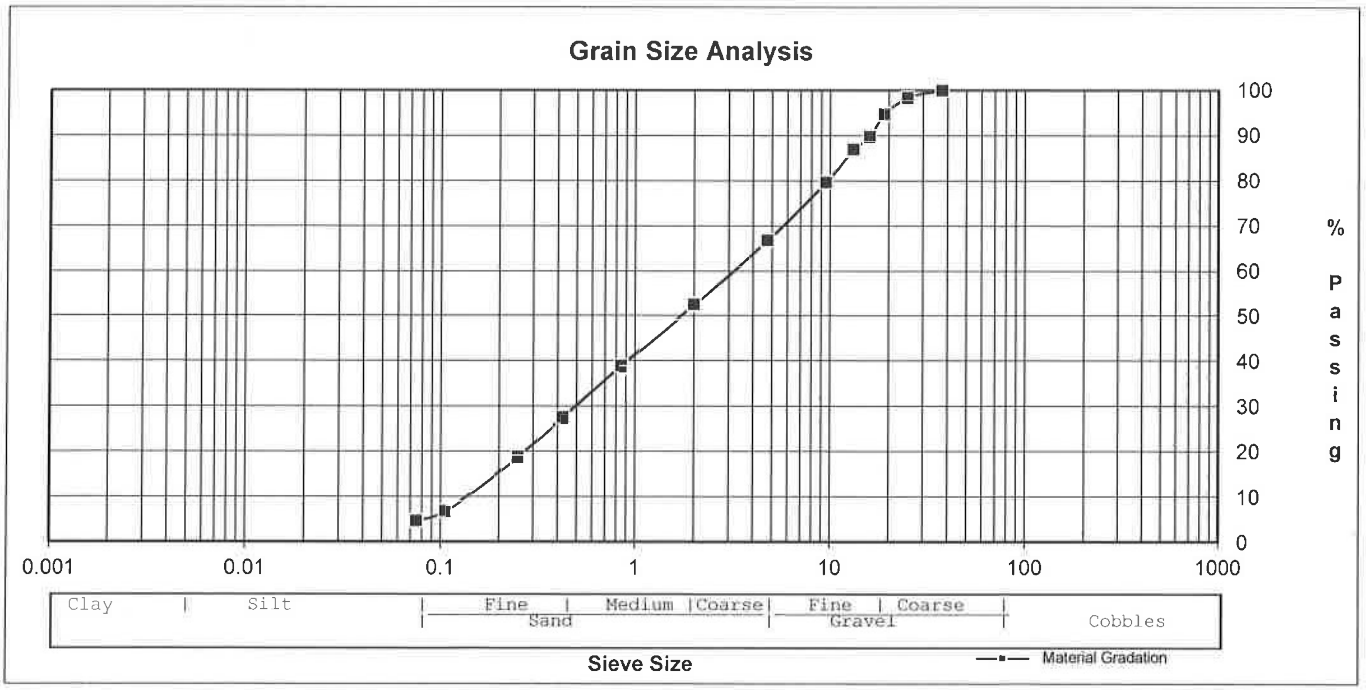
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1671
	Webequie Supply Road	B.H./T.P. No.:	TP19-01
Report to:	Muhammad Saleem	Sample No.:	#2 Site 2
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	98.4
19.0 mm	94.7
16.0 mm	89.7
13.2 mm	87.0
9.5 mm	79.6
4.75 mm	66.8
2.00 mm	52.4
.850 mm	38.9
.425 mm	27.5
.250 mm	18.8
.106 mm	6.8
.075 mm	4.6



% Gravel	33.2		
% Sand	62.2	Natural Moisture Content:	6.5%
% Silt & Clay	4.6	Soil Classification:	SP

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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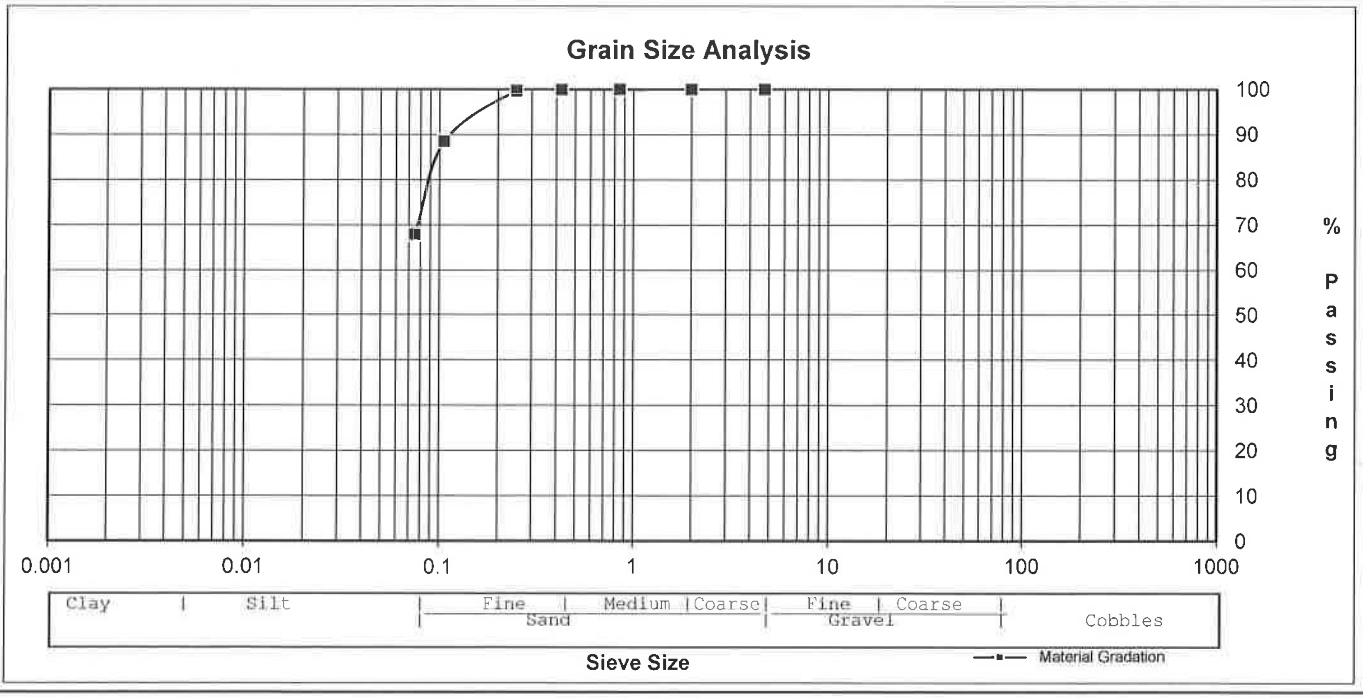
TBT ENGINEERING
CONSULTING GROUP

TBT Engineering Limited
LABORATORY
274 Kingston St.,Thunder Bay, ON P73 3P7
PH: (807) 624-5162 FAX: (807) 624-5161
E-Mail: info@tbte.ca

Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1672
	Webequie Supply Road	B.H./T.P. No.:	TP19-02
Report to:	Muhammad Saleem	Sample No.:	#3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	100.0
.850 mm	100.0
.425 mm	99.9
.250 mm	99.7
.106 mm	88.5
.075 mm	68.0



% Gravel	0.0		
% Sand	32.0	Natural Moisture Content:	11.6%
% Silt & Clay	68.0	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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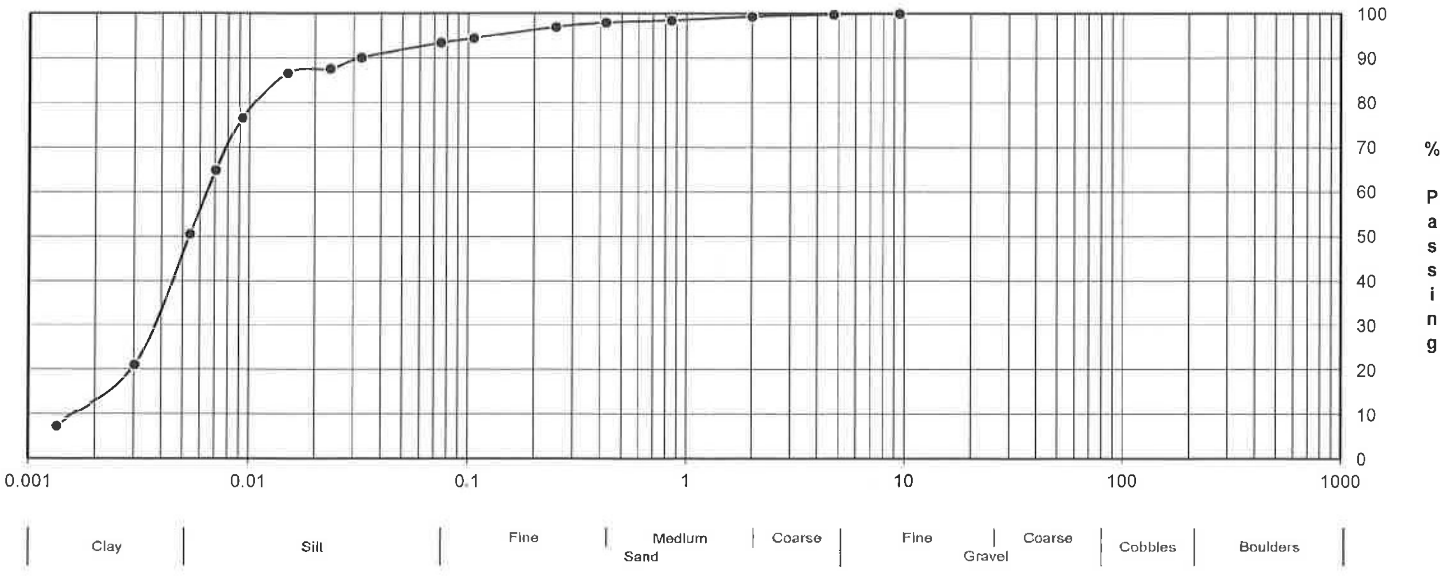
Particle Size Analysis of Soil By Hydrometer

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1673
Location:	Webequie Supply Road	Sample Location	TP 19-06 Sample # 4
Report To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0			
37.5		0.032512	90.1
25.0		0.023465	87.6
19.0		0.014939	86.7
13.2		0.009283	76.6
9.5	100.0	0.007068	64.9
4.75	99.8	0.005399	50.5
2.00	99.4	0.003027	21.1
0.850	98.5	0.001333	7.6
0.425	98.0		
0.250	97.0	5 µm	44.2
0.106	94.5	2 µm	18.0
0.075	93.5		

Grain Size Analysis



%Gravel	0.2	% Silt	49.3	% NMC	19.1	Frost Heave Susc.		Material Suitability	
% Sand	6.3	% Clay	44.2	PI	NP	Erodibility (k)		Soil Classification	ML

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

CCIL Certified

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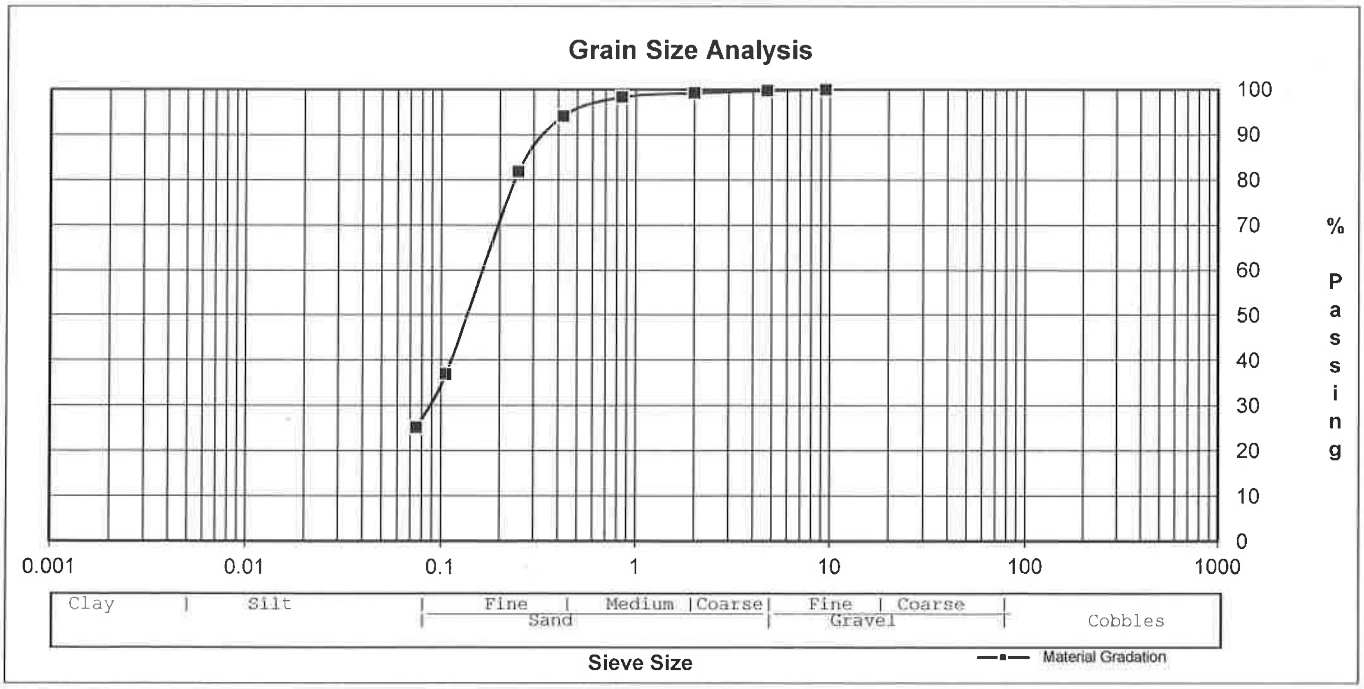
E-Mail: info@tbte.ca

Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1674
	Webequie Supply Road	B.H./T.P. No.:	TP19-09
Report to:	Muhammad Saleem	Sample No.:	#5
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	100.0
4.75 mm	99.8
2.00 mm	99.2
.850 mm	98.3
.425 mm	94.1
.250 mm	81.9
.106 mm	36.9
.075 mm	25.1



% Gravel	0.2		
% Sand	74.7	Natural Moisture Content:	4.9%
% Silt & Clay	25.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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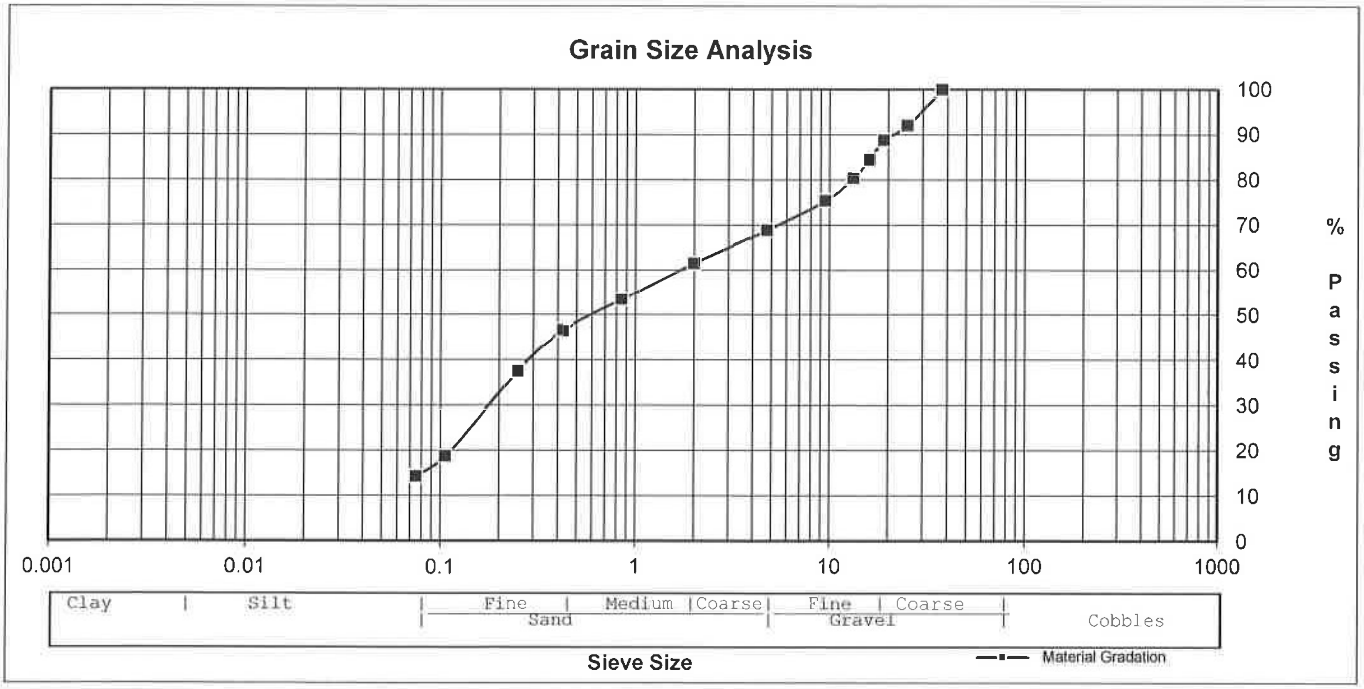
E-Mail: info@tbte.ca

Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1675
	Webequie Supply Road	B.H./T.P. No.:	TP19-10
Report to:	Muhammad Saleem	Sample No.:	#6 Site #2
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	92.0
19.0 mm	88.8
16.0 mm	84.5
13.2 mm	80.4
9.5 mm	75.4
4.75 mm	68.9
2.00 mm	61.5
.850 mm	53.4
.425 mm	46.5
.250 mm	37.7
.106 mm	18.7
.075 mm	14.3



% Gravel	31.1		
% Sand	54.6	Natural Moisture Content:	4.7%
% Silt & Clay	14.3	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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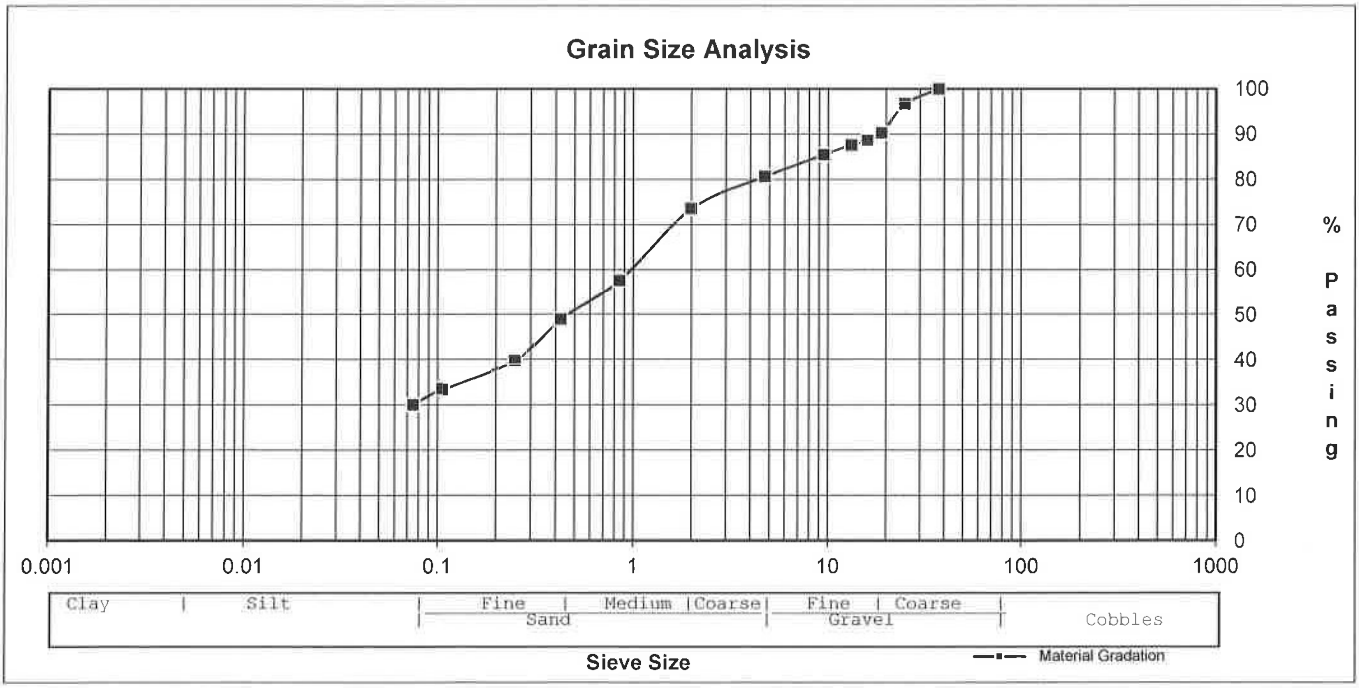
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1676
	Webequie Supply Road	B.H./T.P. No.:	TP19-10
Report to:	Muhammad Saleem	Sample No.:	#7 Site #3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	96.7
19.0 mm	90.3
16.0 mm	88.6
13.2 mm	87.5
9.5 mm	85.5
4.75 mm	80.6
2.00 mm	73.6
.850 mm	57.6
.425 mm	48.9
.250 mm	40.0
.106 mm	33.5
.075 mm	30.0



% Gravel	19.4		
% Sand	50.6	Natural Moisture Content:	10.6%
% Silt & Clay	30.0	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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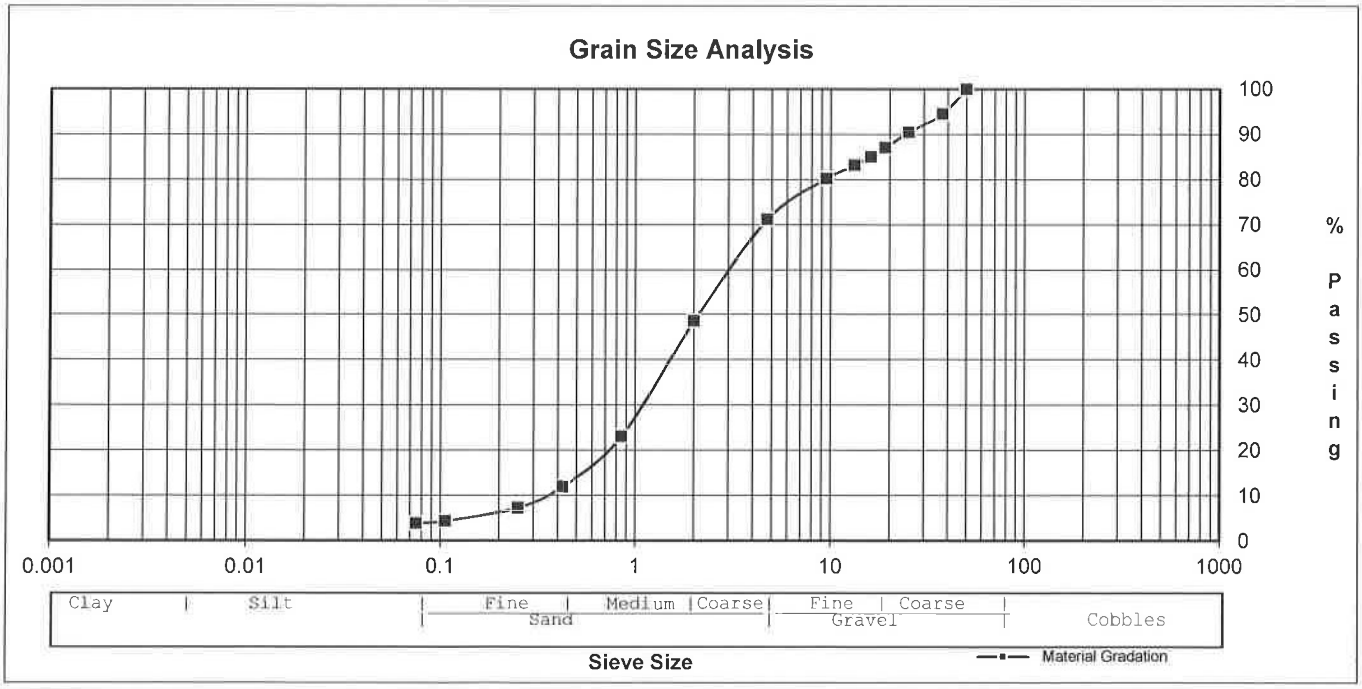
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1677
	Webequie Supply Road	B.H./T.P. No.:	TP19-11
Report to:	Muhammad Saleem	Sample No.:	#8
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	100.0
37.5 mm	94.5
25.0 mm	90.5
19.0 mm	87.0
16.0 mm	85.0
13.2 mm	83.2
9.5 mm	80.2
4.75 mm	71.2
2.00 mm	48.5
.850 mm	23.0
.425 mm	12.0
.250 mm	7.3
.106 mm	4.3
.075 mm	3.8



% Gravel	28.8		
% Sand	67.4	Natural Moisture Content:	2.3%
% Silt & Clay	3.8	Soil Classification:	SW

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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TBT ENGINEERING
CONSULTING GROUP

October 16, 2019
TBTE Ref. No. 19-482

Muhammad Saleem
SNC-Lavalin
195 The West Mall
Toronto, ON
M9C 5K1

Re: Rock Strength Testing Results to October 16, 2019
Webequie First Nation's Supply Road
Webequie, Ontario

TBT Engineering (TBTE) has completed a subsurface investigation for Webequie First Nation's Supply Road. Where bedrock was encountered, TBTE sampled the bedrock using diamond drilling techniques and completed detailed logging of the cores. Rock strength testing was conducted at TBTE's laboratory in Thunder Bay, Ontario. One core sample from each borehole was selected for diametral point load testing and another for axial point load testing. Table 1 summarizes the rock strength testing results.

Table 1: Rock Strength Testing Results.

Borehole	Depth from Ground Surface (m)	Estimated Uniaxial Compressive Strength* (MPa)	
		Diametral	Axial
BH-19-04	1.70	-	192
	2.07	265	-

* Estimated in accordance with ASTM D5731-16.

Closure:
We trust the above addresses your project requirements at this time. Please contact us at your convenience should you have any questions.

Yours truly,
For TBT Engineering,

<original signed by>

Steven Anderson, EIT

TBT Engineering 1918 Yonge Street, Thunder Bay, ON P7E 6T9 807-624-5160

Ontario

Ministry of Transportation

AGGREGATE TEST DATA – CONCRETE
Physical Properties – Coarse Aggregate

Contract No.: 19-482	Contractor:	Contract Location: Webequie First Nation Supply Road	
Testing Laboratory: TBT Engineering		Telephone No.: (807) 624-5162	Fax No.: (807) 624-5161
Sampled by (Print Name): Client		Date Sampled: (YY/MM/DD)	TBT Lab No.: 19-1646
Nominal maximum Size:	Lot No.:	Quantity (tonnes):	
Source Name/ Location:		Aggregate Inventory Number (AIN):	

Laboratory Test and Number	Requirement		Concrete ASL (✓)	Test Result		
	Pavement *(see Note 1)*	Structures, Sidewalks, Curb & Gutter, Concrete Base		Reference Material	Sample	Meets Requirement (Y / N)
Salt Scaling, maximum loss @ 50 cycles, LS-412 (see Notes 2, 3 and 4)	0.80 kg/m^2					
Wash Pass 75 µm sieve, % maximum, LS-601	1.0 (gravel) 2.0 (crushed rock)					
Absorption, % maximum, LS-604 or CSA A23.2-12A	2.0 (see note 5)					
Flat & Elongated Particles, % maximum, LS-608	20					
Petrographic Number, Concrete, maximum, LS-609	125 (Attach PN report)	140 (Attach PN report)				
Unconfined Freeze-Thaw loss, % maximum LS-614 or CSA A23.2-24A (see Note 6)	6			8.6	0.4	Y
Micro-Deval Abrasion loss, % maximum, LS-618 or CSA A23.2-29A	14	17 (see Note 7)		12.6	7.7	Y
Accelerated Mortar Bar Expansion, % maximum @ 14 days, LS-620 or CSA A23.2-25A (see Notes 3 and 8)	0.150 (see Notes 9 and 10)					
Concrete Prism Expansion, % maximum @ 1 year, CSA A23.2-14A (see Notes 3, 8, 11)	0.040					
Potential Alkali-Carbonate Reactivity, Carbonate Rock, CSA A23.2-26A (see Note 12)	Chemical composition must plot in non-expansive field of Fig. 1			Attach data	Attach graph	
Concrete Freeze-Thaw, ASTM C666, Procedure A (see Notes 3 and 13)	Average Δ length ≤ ± 0.0350% Average FTF ≥ 90% of FTF @ 14 days					

Alternative Requirement to Unconfined Freeze-Thaw (LS–614 or CSA A23.2-24A)					
Magnesium Sulphate Soundness loss, 5 cycles % maximum, LS-606 (see Note 6)	12				

Issued by (Testing Laboratory Representative):

Forch Valela	<original signed by>	October 29, 2019
PRINT NAME	SIGNATURE	DATE

Received by (Contract Administrator Representative):

PRINT NAME	SIGNATURE	DATE

Copies to: ☐ Contract Administrator; ☐ Contractor; ☐ Regional Quality Assurance; ☐ Regional Geotechnical; ☐ MERO (Soils and Aggregates)

AGGREGATE TEST DATA – CONCRETE

Physical Properties – Coarse Aggregate (OPSS.PROV 1002)

Notes:

1. Where a concrete surface is exposed to vehicular traffic, the physical requirements for "Pavement" shall apply to the aggregate used.
2. This test only needs to be done at the time of first use of a source for concrete aggregate.
3. Compliance with this requirement is waived if the aggregate source is on the MTO regional Aggregate Source List for Structural Concrete - Fine and Coarse Aggregates, or the MTO regional Aggregate Source List for Concrete Base/Pavement Coarse Aggregates.
4. Coarse aggregate composed of more than 80% siliceous aggregates, as determined by petrographic examination (LS-609), shall be tested, together with either the fine aggregate that the coarse aggregate is intended to be used with, or a fine aggregate from the same geographic area as the coarse aggregate. The concrete shall be proportioned with 355 kg/m^3 of Type GU hydraulic cement, shall have a plastic air content of 7.0 ±1.5% and a slump of 80 ± 20 mm.
5. For air-cooled blast-furnace slag aggregate, the allowable maximum value for absorption shall conform to the Owner's requirements for slag aggregate.
6. Compliance with the unconfined freeze-thaw test, LS-614 or CSA A23.2-24A is waived if the aggregate meets the alternative requirement for magnesium sulphate soundness loss, LS-606.
7. For air-cooled blast-furnace slag aggregate, the allowable maximum value for Micro-Deval shall be 21% for structures.
8. If the aggregate is potentially expansive due to alkali-carbonate reaction as determined by CSA A23.2-26A, the aggregate must meet the requirement of CSA A23.2-14A, even though it may be shown as a coarse aggregate on the MTO regional Aggregate Sources List for Structural Concrete Fine and Coarse Aggregates or the Aggregate Sources List for Concrete Base/Pavement Coarse Aggregates.
9. If the aggregate is a quarried sandstone, siltstone, granite or gneiss, the expansion shall be less than 0.080% after 14 days. For quarried aggregates of the Gull River, Bobcaygeon, Verulam and Lindsay Formations, the expansion shall be less than 0.100% after 14 days.
10. An aggregate that fails this requirement may be accepted provided the requirement for CSA A23.2-14A is met.
11. An aggregate needs to meet the requirement for CSA A23.2-14A only if it fails the requirements of either CSA A23.2-25A or CSA A23.2-26A. If this test is conducted for an aggregate deemed potentially expansive according to CSA A23.2-26A, then a chemical analysis (CSA A23.2-26A) shall be provided to show that the aggregate intended for use has the same chemical composition as the material tested. Test data shall have been obtained within the past 18 months from aggregate from the same location within the source as that to be used in the work
12. This requirement only applies to aggregates quarried from the Gull River and Bobcaygeon Formations of southern and eastern Ontario. These dolomitic limestones outcrop on the southern margin of the Canadian Shield from Midland to Kingston and in the Ottawa-St Lawrence Lowlands near Cornwall.
13. The following apply to this test:
    - Coarse aggregates from limestone and dolostone bedrock quarries for concrete pavement and concrete base shall be tested, except for aggregate produced from the Oxford, Gull River or Bobcaygeon Formations.
    - The fine aggregate shall be either the fine aggregate intended for use or a fine aggregate from the same geographic area as the coarse aggregate.
    - The bench within the quarry from which the aggregate is selected for testing shall be defined. Acceptance will only apply to the bench of the quarry from which the selected aggregate was taken. Aggregate processed from other benches within the same quarry will require further testing prior to use.
    - The concrete for the test shall be proportioned with 37.5 – 4.75 mm stone meeting the combined grading shown in Table 4, of OPSS.PROV 1002, with 325 kg/m^3 of Type GU hydraulic cement, a plastic air content of 6.5 ± 1.5%, and a slump of 50 ± 20 mm.
    - Procedure A shall be modified so that each freeze cycle takes 10.5 ± 1 hours; and the test shall be conducted for 350 cycles.

TBT ENGINEERING
CONSULTING GROUP

September 8, 2020
TBTE Ref. No. 20-269

Muhammad Saleem, M.Eng., P.Eng.
SNC-Lavalin
195 The West Mall
Toronto, ON
M9C 5K1

Re: Rock Core Strength Testing
Webequie Supply Road

TBT Engineering (TBTE) was retained to perform a subsurface investigation for a portion of the Webequie Supply Road. Bedrock was encountered at Boreholes WQR 4 and WQR 6B. TBTE sampled the bedrock using diamond drilling techniques and completed detailed logging of the cores. Rock strength testing was conducted at TBTE's laboratory in Thunder Bay, Ontario. Two core samples from each borehole were selected for testing. At each borehole, one core sample was selected for unconfined compression strength testing and the other for uniaxial compression strength (point load) testing. The tables below summarize the rock strength testing results.

Table 1: Unconfined Compressive Strength (UCS) Testing Results.

Borehole	Depth from Ground Surface (m)	UCS (MPa)
WQR 4	5.77	79
WQR 6B	9.16	118

Table 2: Estimated Uniaxial Compressive Strength (Point Load) Testing Results.

Borehole	Depth from Ground Surface (m)	Estimated Uniaxial Compressive Strength* (MPa)
WQR 4	4.96	314
WQR 6B	7.70	201

* Estimated in accordance with ASTM D5731-16.

Closure:

We trust the above addresses your project requirements at this time. Please contact us at your convenience should you have any questions.

Yours truly,
For TBT Engineering,

<original signed by>

Steven Anderson, EIT

TBT Engineering 1918 Yonge Street, Thunder Bay, ON P7E 6T9 807-624-5160

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Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	20-269
Client Project No.:	WSR 661910	Tested By/Date:	F. Valela / September 5, 2020
Project Description:	Webequie First National Supply F	Reported By:	Forch Valela
Report To:	Muhammad Saleem	Reviewed By:	Madison Murphy MM

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
20-3605	BH20-1	SS1	0-2'	**67.3**	Organic
20-3606	BH20-1	SS2	2.5-4.5'	**15.7**	
20-3607	BH20-1	Auger Sample	5-7'	**7.6**	
20-3608	BH20-2	SS1	0-2'	**8.3**	
20-3609	BH20-2	SS2	2.5-4.5	**4.8**	
20-3610	BH20-2	SS3	5-7'	**3.9**	
20-3611	BH20-2	SS4	7.5-8.5'	**1.1**	
20-3612	BH20-2	SS5	10-11.5'	**3.8**	
20-3613	BH20-2	SS6	15-15'10"	**6.2**	
20-3614	BH20-2	Auger Sample	2.5-5'	**4.9**	
20-3615	BH20-3	SS1	0-2'	**8.4**	
20-3616	BH20-3	SS2	2.5-4.5'	**6.4**	
20-3617	BH20-3	SS3	5-7'	**9.4**	
20-3618	BH20-3	SS3	10-11.5'	**3.1**	
20-3619	BH20-3	SS5	15-16'	**2.7**	
20-3560	WQA1	SS1	0-2'	**68.12**	
20-3561	WQA1	SS2	2.5-4.5'	**4.09**	
20-3562	WQA1	SS3	4.5-5'	**3.70**	
20-3563	WQA1	Auger Sample	5-5.5'	**4.94**	
20-3564	WQA2	SS2	N/A	**136.94**	Organic
20-3565	WQA2	SS3	5-7'	**18.89**	

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Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	20-269
Client Project No.:	WSR 661910	Tested By/Date:	F. Valela / September 5, 2020
Project Description:	Webequie First National Supply F	Reported By:	Forch Valela
Report To:	Muhammad Saleem	Reviewed By:	Madison Murphy MM

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
20-3566	WQA2	SS4	5-5.5'	**4.94**	
20-3567	WQA2	SS5	N/A	**10.90**	
20-3568	WQA2	SS6	15-16'	**10.3**	
20-3569	WQA3	SS1	0-2'	**6.6**	
20-3570	WQA3	SS2	2.5-4.5'	**4.5**	
20-3571	WQA3	SS3	5-7'	**3.2**	
20-3572	WQA3	SS4	7.5-9.5'	**12.0**	
20-3573	WQA3	SS6	15-17'	**8.7**	
20-3574	WQA3	Auger Sample	2.5-5'	**3.3**	
20-3851	WQA4	SS1	0-2'	**15.7**	
20-3852	WQA4	SS2	2.5-4'	**8.0**	
20-3853	WQA4	SS3	5-7'	**10.7**	
20-3854	WQA4	SS4	7-9.5'	**13.1**	
20-3855	WQA4	SS5	N/A	**11.1**	
20-3856	WQA4	SS6	15-17'	**11.4**	
20-3857	WQA4	SS7	20-21.5'	**11.0**	
20-3858	WQA4	SS8	25-25.5'	**10.7**	
20-3890	WQA5	SS1	0-2'	**16.3**	
20-3891	WQA5	SS2	3.5-4'	**17.1**	
20-3892	WQA5	SS3	6-7'	**3.2**	
20-3893	WQA5	SS4	7.5-9'	**4.1**	

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E-Mail: info@tbte.ca

Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	20-269
Client Project No.:	WSR 661910	Tested By/Date:	F. Valela / September 5, 2020
Project Description:	Webequie First National Supply F	Reported By:	Forch Valela
Report To:	Muhammad Saleem	Reviewed By:	Madison Murphy MM

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
20-3894	WQA5	SS5	10-11.5'	**2.6**	
20-3895	WQA5	SS6	N/A	**5.4**	
20-3896	WQA5	SS7	20-21.5'	**2.4**	
20-3897	WQA6	SS1	0-2'	**97.1**	Organic
20-3898	WQA6	SS2	2-4'	**22.7**	
20-3899	WQA6	SS3	5-6.5'	**13.3**	
20-3900	WQA6	SS4	10-11.5'	**7.3**	
20-3901	WQA7	SS1	5-7'	**90.0**	
20-3902	WQA7	SS2	5-6.5'	**15.3**	
20-3903	WQA7	SS3	10-11.5'	**12.4**	
20-3904	WQA7	SS4	15-16.5'	**7.2**	
20-3575	WQR1	AS1	N/A	**360.4**	Organic
20-3576	WQR1	AS2	2.5-4.5'	**387.9**	Organic
20-3577	WQR1	SS3	5-7'	**90.0**	
20-3578	WQR1	SS4	5-7'	**15.5**	
20-3579	WQR1	SS5	10-12'	**11.4**	
20-3580	WQR1	SS7	20-21.5'	**11.2**	
20-3581	WQR 2A	SS1	25-26'	**9.7**	Organic
20-3582	WQR 2A	SS2	2.5-4.5'	**10.2**	
20-3583	WQR 2A	SS4	7.5-9.5'	**10.5**	
20-3584	WQR 2A	SS5	10-12'	**9.2**	

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Natural Moisture Content Determination

Client:	SNC Lavalin	TBTE Project No.	20-269
Client Project No.:	WSR 661910	Tested By/Date:	F. Valela / September 5, 2020
Project Description:	Webequie First National Supply F	Reported By:	Forch Valela
Report To:	Muhammad Saleem	Reviewed By:	Madison Murphy MM

Lab No.	BH / TP No.	Sample No.	Depth (m)	Moisture	Remarks
20-3585	WQR 2B	SS1	15'-17'	**8.2**	
20-3586	WQR 2B	SS2	2.5-4.5'	**7.4**	
20-3587	WQR 2B	SS3	25-26'	**9.7**	
20-3588	WQR3	SS1	2.5-4.5	**9.3**	
20-3589	WQR3	SS2	5-6'1"	**9.9**	
20-3590	WQR3	SS4	10-12'	**6.2**	
20-3591	WQR4	AS1	4-6'	**256.7**	Organic
20-3592	WQR4	SS2	2.5-4.5'	**671.0**	Organic
20-3593	WQR4	SS3	5-7'	**958.3**	Organic
20-3594	WQR4	SS4	7.5-9.5'	**298.3**	Organic
20-3595	WQR4	SS5	10-12'	**14.5**	
20-3596	WQR5	SS2	7.5-9.5'	**49.7**	Organic
20-3597	WQR5	SS3	4-6'	**22.8**	
20-3598	WQR5	SS5	10-11.5'	**10.1**	
20-3599	WQR6B	AS1	1'	**18.8**	
20-3600	WQR6B	SS2	2.5-4.5'	**11.2**	
20-3601	WQR6B	SS3	0.0	**11.9**	
20-3602	WQR6B	SS4	7.5-9.5'	**10.9**	
20-3603	WQR6B	SS5	10-12'	**9.5**	
20-3604	WQR6B	SS7	20-21.5'	**9.7**	

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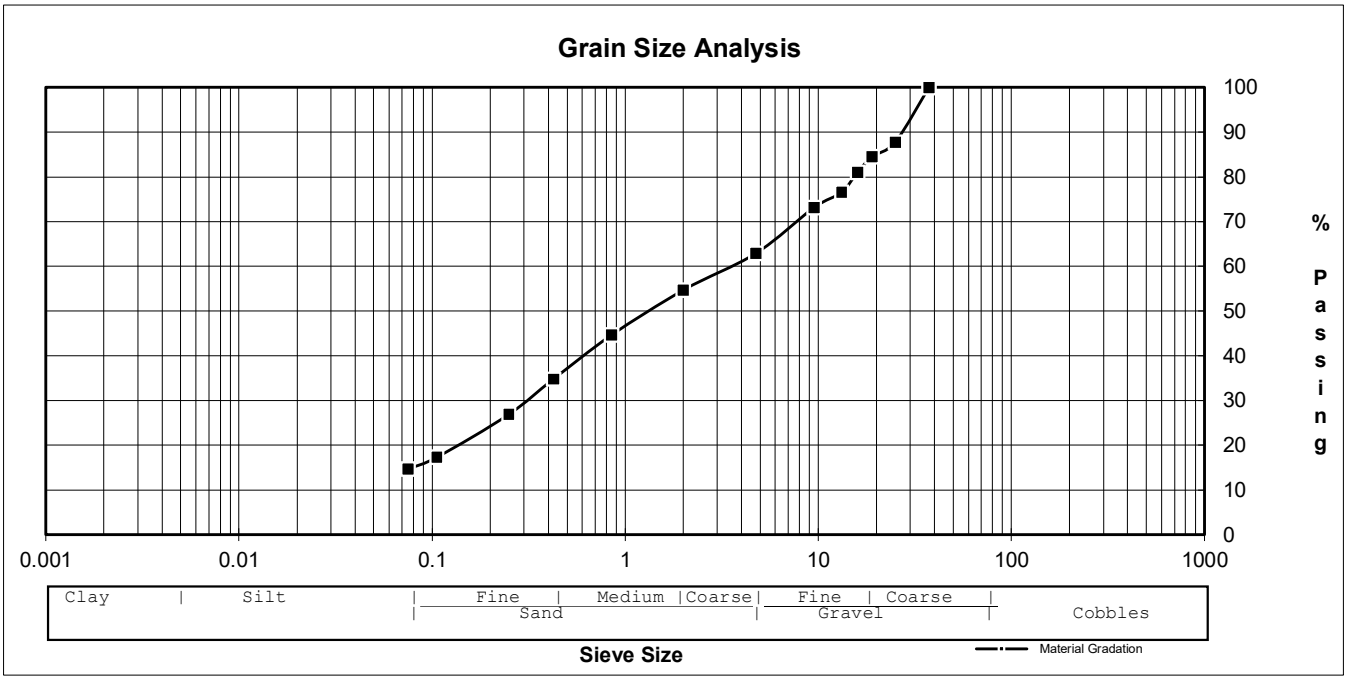
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3561
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA1
Report to:	Muhammad Saleem	Sample No.:	SS2
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	2.5' - 4.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	87.7
19.0 mm	84.5
16.0 mm	81.1
13.2 mm	76.5
9.5 mm	73.1
4.75 mm	62.9
2.00 mm	54.7
.850 mm	44.6
.425 mm	34.8
.250 mm	26.9
.106 mm	17.3
.075 mm	14.7



% Gravel	37.1		
% Sand	48.2	Natural Moisture Content:	4.1%
% Silt & Clay	14.7	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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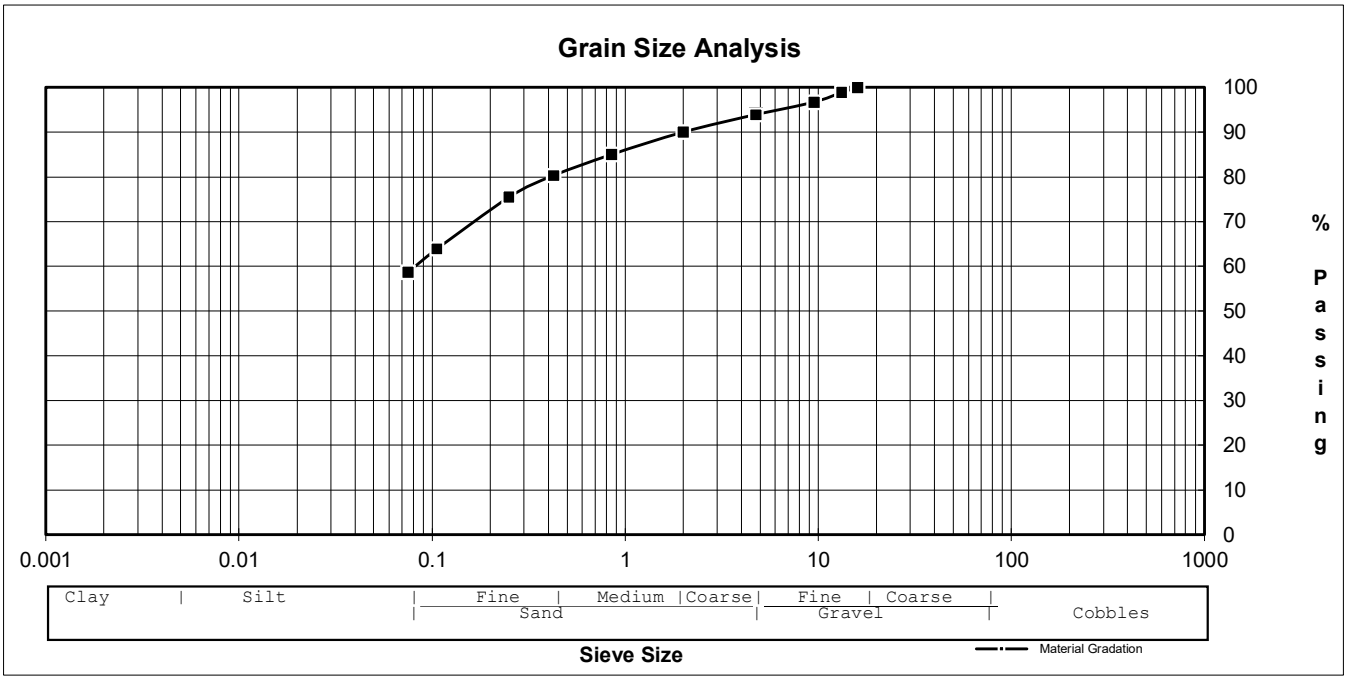
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3567
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA2
Report to:	Muhammad Saleem	Sample No.:	SS5
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	10' - 12'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	100.0
13.2 mm	98.9
9.5 mm	96.7
4.75 mm	93.9
2.00 mm	90.0
.850 mm	85.0
.425 mm	80.3
.250 mm	75.4
.106 mm	63.9
.075 mm	58.7



% Gravel	6.1		
% Sand	35.2	Natural Moisture Content:	10.9%
% Silt & Clay	58.7	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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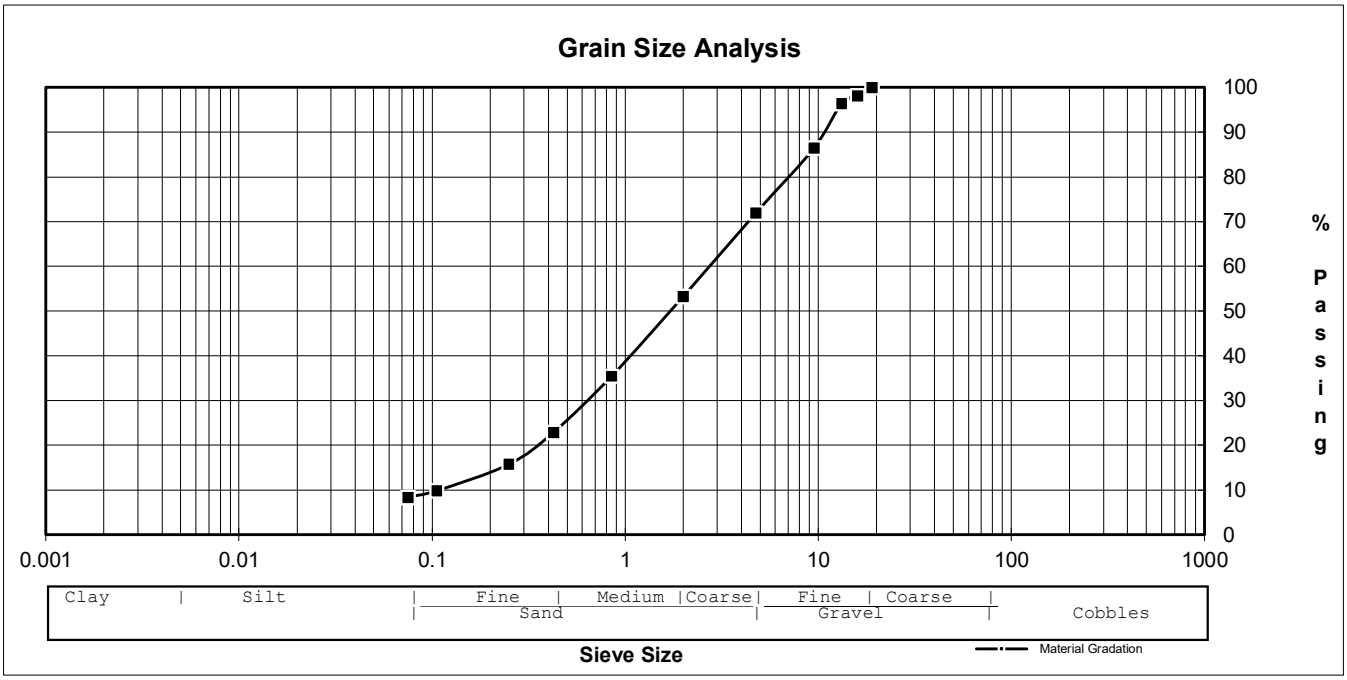
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3570
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA3
Report to:	Muhammad Saleem	Sample No.:	SS2
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	2.5' - 4.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	100.0
16.0 mm	98.1
13.2 mm	96.4
9.5 mm	86.4
4.75 mm	71.9
2.00 mm	53.3
.850 mm	35.4
.425 mm	22.9
.250 mm	15.7
.106 mm	9.9
.075 mm	8.4



% Gravel	28.1		
% Sand	63.5	Natural Moisture Content:	4.5%
% Silt & Clay	8.4	Soil Classification:	SW-SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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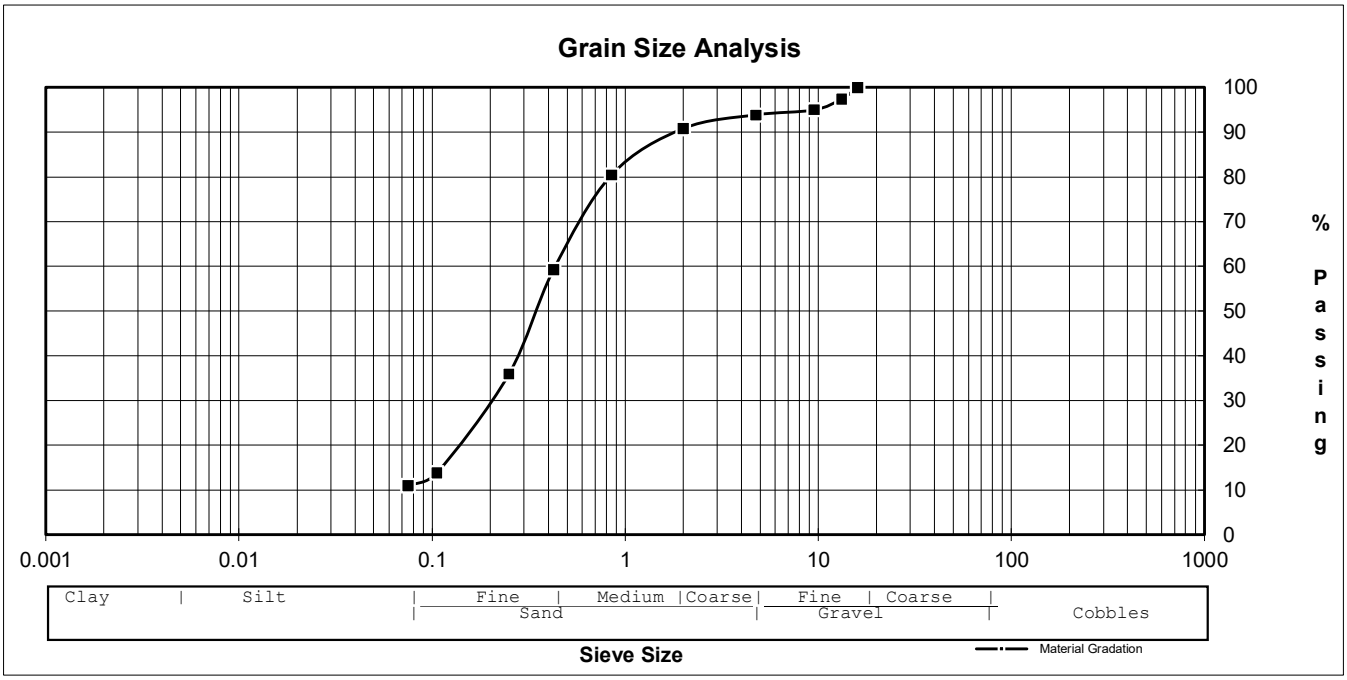
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3571
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA3
Report to:	Muhammad Saleem	Sample No.:	SS3
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	5' - 7'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	100.0
13.2 mm	97.4
9.5 mm	95.0
4.75 mm	93.8
2.00 mm	90.8
.850 mm	80.4
.425 mm	59.2
.250 mm	35.9
.106 mm	13.8
.075 mm	11.0



% Gravel	6.2		
% Sand	82.8	Natural Moisture Content:	3.2%
% Silt & Clay	11.0	Soil Classification:	SW-SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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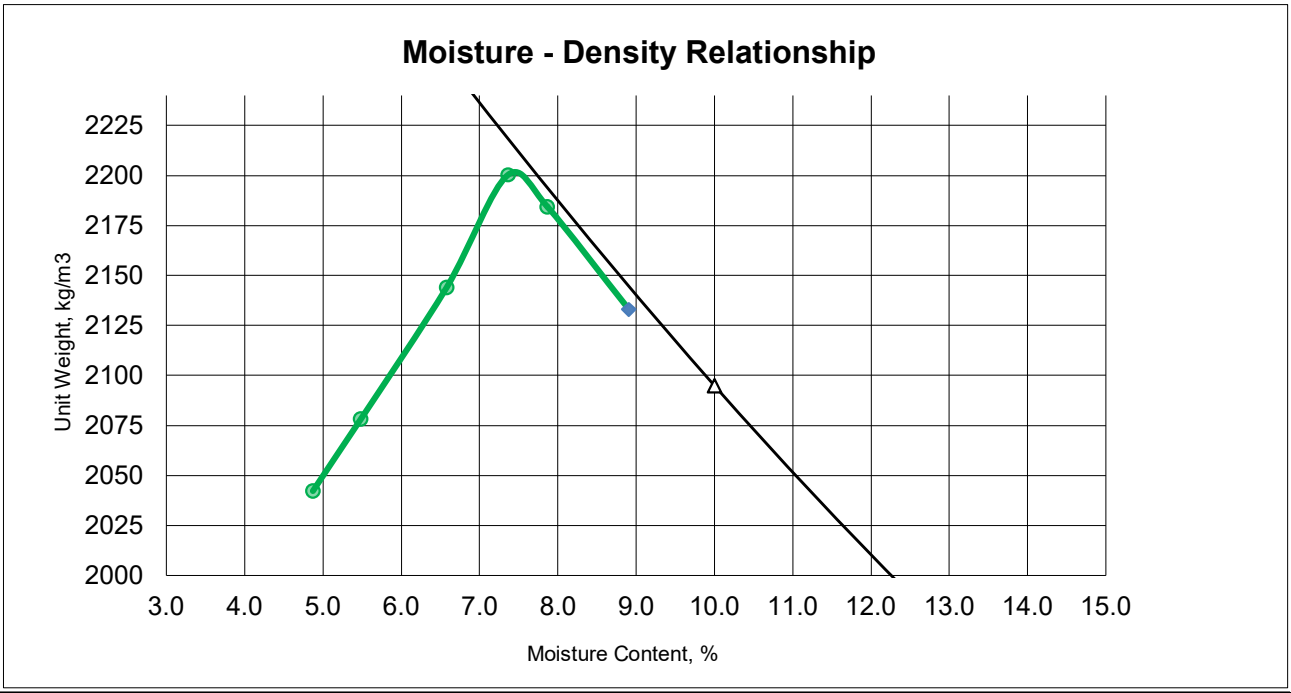
Laboratory Test for Soil Compaction - Proctor Method

Client:	SNC-Lavalin	TBTE Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3574/3614
Type of Material:	Native Soil	Contractor:	N/A
Source of Material:	WQA3-20-02 Combined	Sampled By/Date:	N/A
Report To:	Muhammad Saleem	Tested By/Date:	KL / September 4, 2020
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sample as Received:		Visual Soil Classification:	GP
Moisture Content:	0.00%	Assumed Specific Gravity:	2.65
		Preparation:	Moist
Procedure:	C		
Compaction Method:	Manual	Maximum Dry Density (MDD):	2200 kg/m3
Blows Per Layer:	56	Optimum Moisture Content:	7.4 %
Number of Layers:	3	STONE CORRECTION (ASTM D 4718)	
Mold Size:	152.4	Retained: 19	0.0 %
Volume of Mold:	2.124	Corrected Optimum Moisture:	7.4 %
Weight of Tamper:	2.5 kg	Corrected MDD:	2200 kg/m3

Test No.	1	2	3	4	5	6	7	8
Wet Density (kg/m3)	2142	2192	2285	2362	2356	2323		
Moisture Content (%)	4.87	5.48	6.58	7.36	7.87	8.91		
Dry Density (kg/m3)	2042	2078	2144	2200	2184	2133		



Remarks: Test Procedure LS 706 Rev. 33 /ASTM D698-12, D4718-15

TBTE Laboratory Technician: KL

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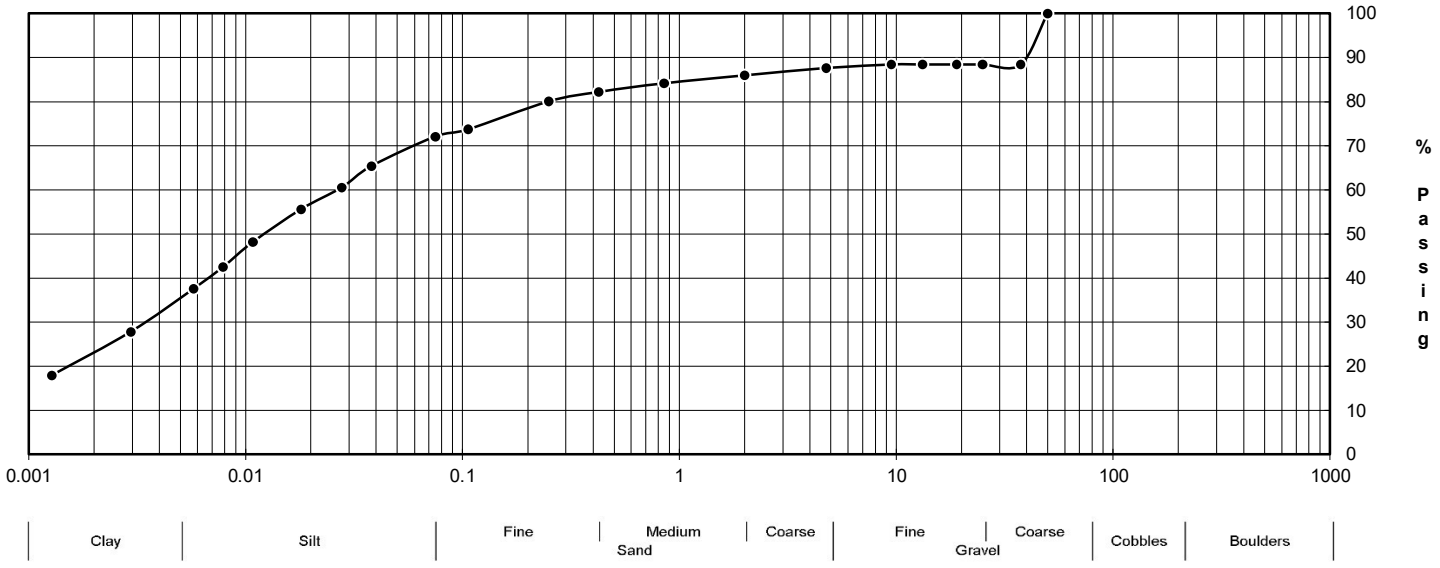
Particle Size Analysis of Soil By Hydrometer

Client:	SNC-Lavalin	TBTE Project No.:	20-269
Project:	WSR 661910	Lab No.:	20-3578
Location:	Webequie First National Supply Road	Sample Location	WQR1 SS4 5'-7'
Reported To:	Muhammad Saleem	Tested By/Date:	GH / September 5, 2020
Sampled By/Date:	N/A	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0	100.0		
37.5	88.4	0.038005	65.4
25.0	88.4	0.027683	60.5
19.0	88.4	0.018006	55.6
13.2	88.4	0.010812	48.3
9.5	88.4	0.007867	42.5
4.75	87.6	0.005761	37.6
2.00	86.0	0.002948	27.8
0.850	84.2	0.001278	18.0
0.425	82.2		
0.250	80.1	5 µm	37.0
0.106	73.7	2 µm	25.0
0.075	72.1		

Grain Size Analysis



%Gravel	12.4	% Silt	35.1	% NMC	15.5	Frost Heave Susc.		Material Suitability	
% Sand	15.5	% Clay	37.0	PI	9	Erodibility (k)		Soil Classification	CL

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

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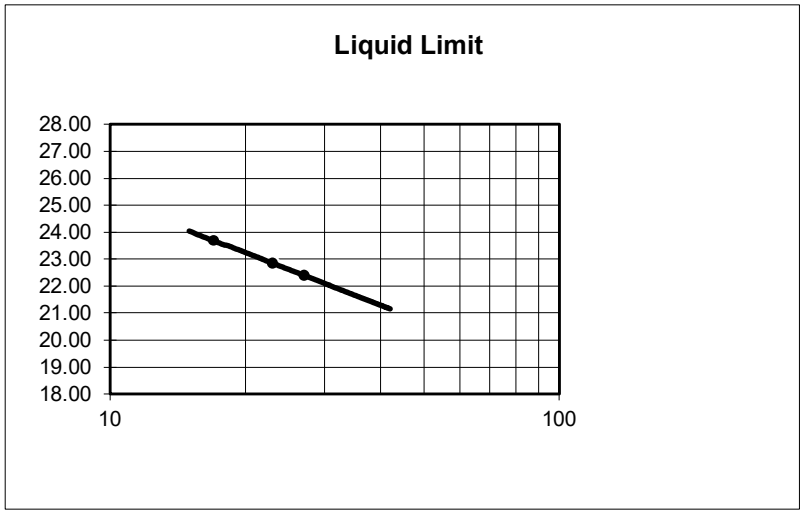
Atterberg Limits

Client:	SNC-Lavalin	TBTE Project No.:	20-269
Project:	WSR 661910	Lab No.:	20-3578
Location:	Webequie First National Supply I	Sample Location:	WQR1 SS4 5'-7'
Reported To:	Muhammad Saleem	Tested By/Date:	GH / September 5, 2020
Sampled By/Date:	N/A	Reviewed By:	Forch Valela

Liquid Limit Determination

Dish No.:	GH	SS	LA		Liquid Limit 25 Blows
Wet Soil + Dish:	39.77	40.57	40.224		
Dry Soil + Dish:	37.688	38.328	37.999		
Moisture:	2.082	2.242	2.225		
Dish:	28.392	28.516	28.607		
Dry Soil:	9.296	9.812	9.392		
% Moisture:	22.40	22.85	23.69		
No. of Blows:	27	23	17		
Liquid Limits:	23	23	23		23



Liquid Limit, %:	23
Plastic Limit, %:	14
Plasticity Index:	9

Plastic Limit Determination

Dish No.:	1	2			Natural Moisture A7
Wet Soil + Dish:	27.679	27.248			925
Dry Soil + Dish:	26.705	26.288			832.8
Moisture:	0.974	0.96			92.2
Dish:	19.501	19.217			237.6
Dry Soil:	7.204	7.071			595.2
% Moisture:	13.52	13.58			15.5
Average:	14				

Test Method : ASTM: D4318, D2216

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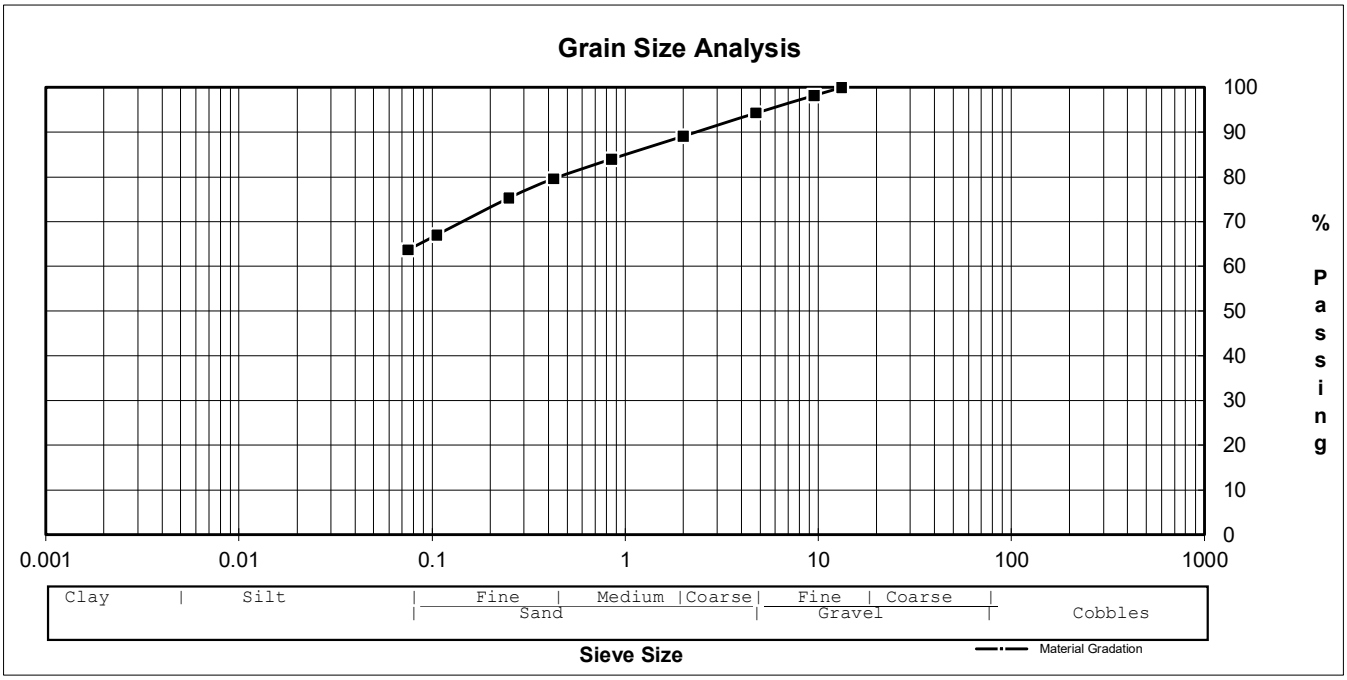
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3580
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQR1
Report to:	Muhammad Saleem	Sample No.:	SS7
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	20' - 21.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	98.2
4.75 mm	94.3
2.00 mm	89.1
.850 mm	84.0
.425 mm	79.6
.250 mm	75.3
.106 mm	67.0
.075 mm	63.7



% Gravel	5.7		
% Sand	30.6	Natural Moisture Content:	11.2%
% Silt & Clay	63.7	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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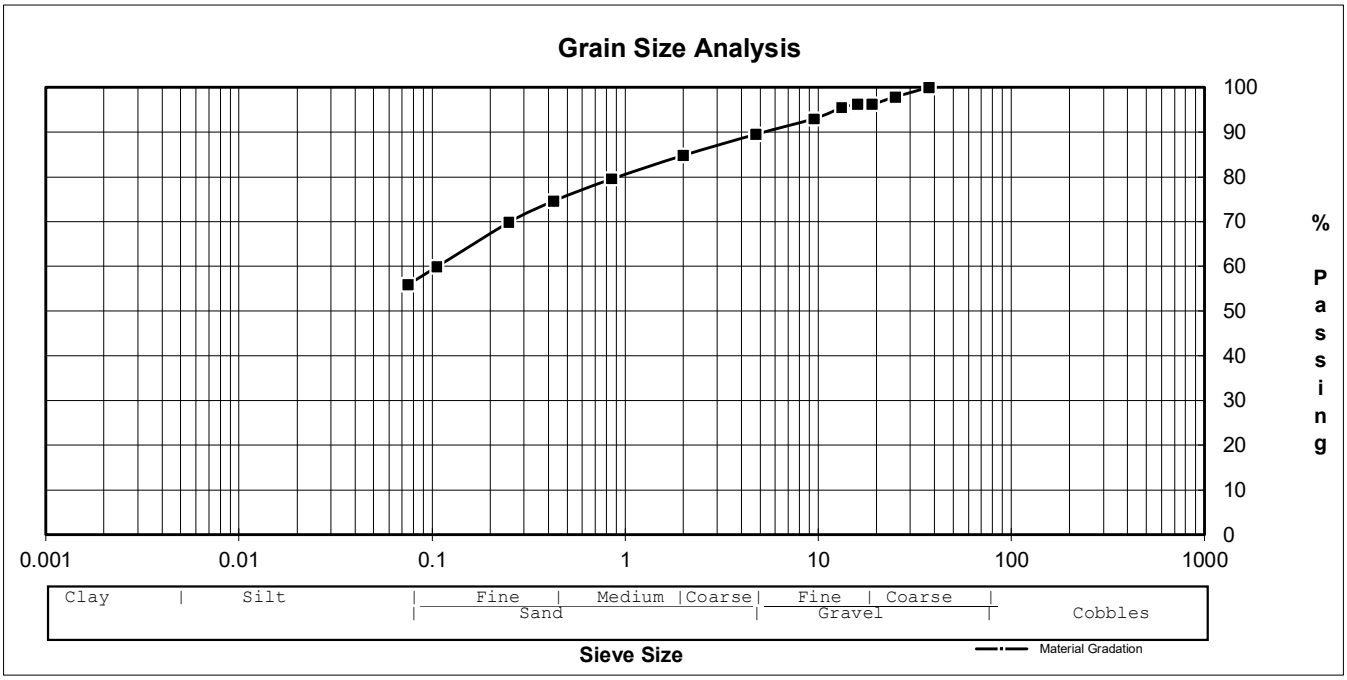
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3584
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQR 2A
Report to:	Muhammad Saleem	Sample No.:	SS5
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	10' - 12'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	97.9
19.0 mm	96.3
16.0 mm	96.3
13.2 mm	95.5
9.5 mm	93.0
4.75 mm	89.5
2.00 mm	84.8
.850 mm	79.5
.425 mm	74.5
.250 mm	69.8
.106 mm	59.9
.075 mm	55.9



% Gravel	10.5		
% Sand	33.6	Natural Moisture Content:	9.2%
% Silt & Clay	55.9	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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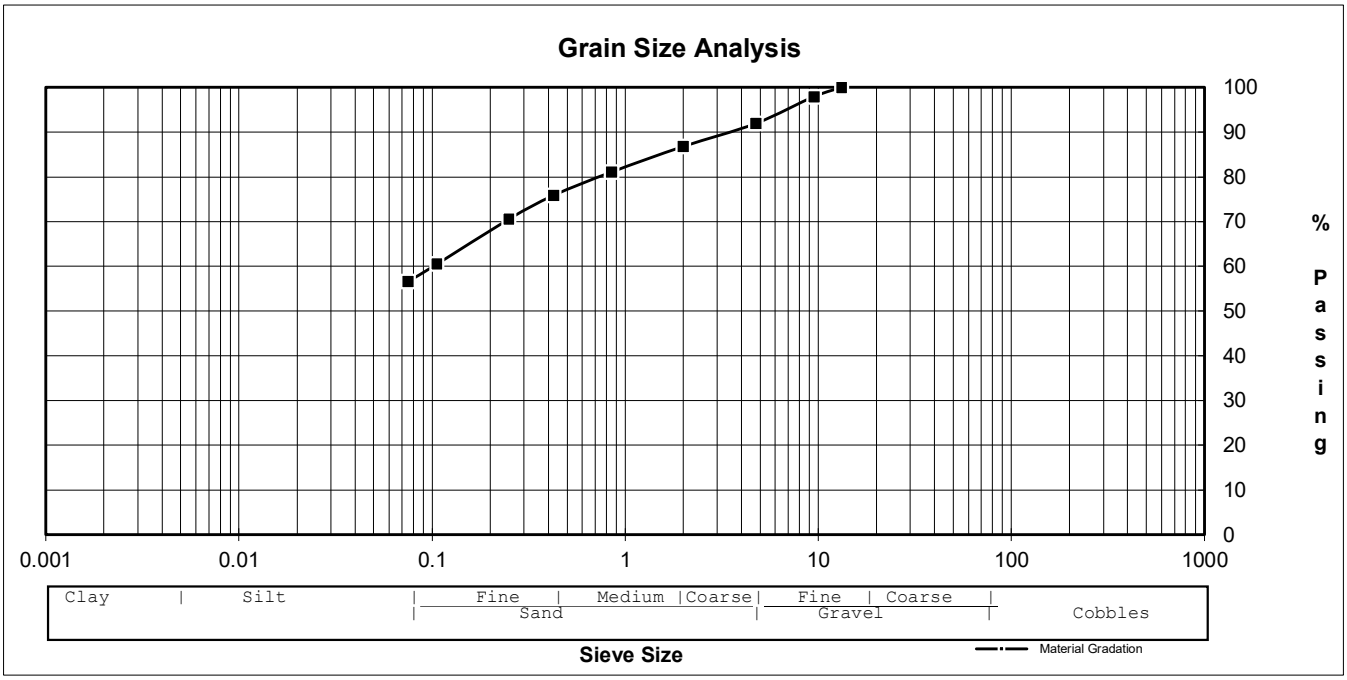
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3589
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQR3
Report to:	Muhammad Saleem	Sample No.:	SS2
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	5' - 7'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	97.9
4.75 mm	91.9
2.00 mm	86.8
.850 mm	81.1
.425 mm	75.8
.250 mm	70.6
.106 mm	60.5
.075 mm	56.6



% Gravel	8.1		
% Sand	35.3	Natural Moisture Content:	9.9%
% Silt & Clay	56.6	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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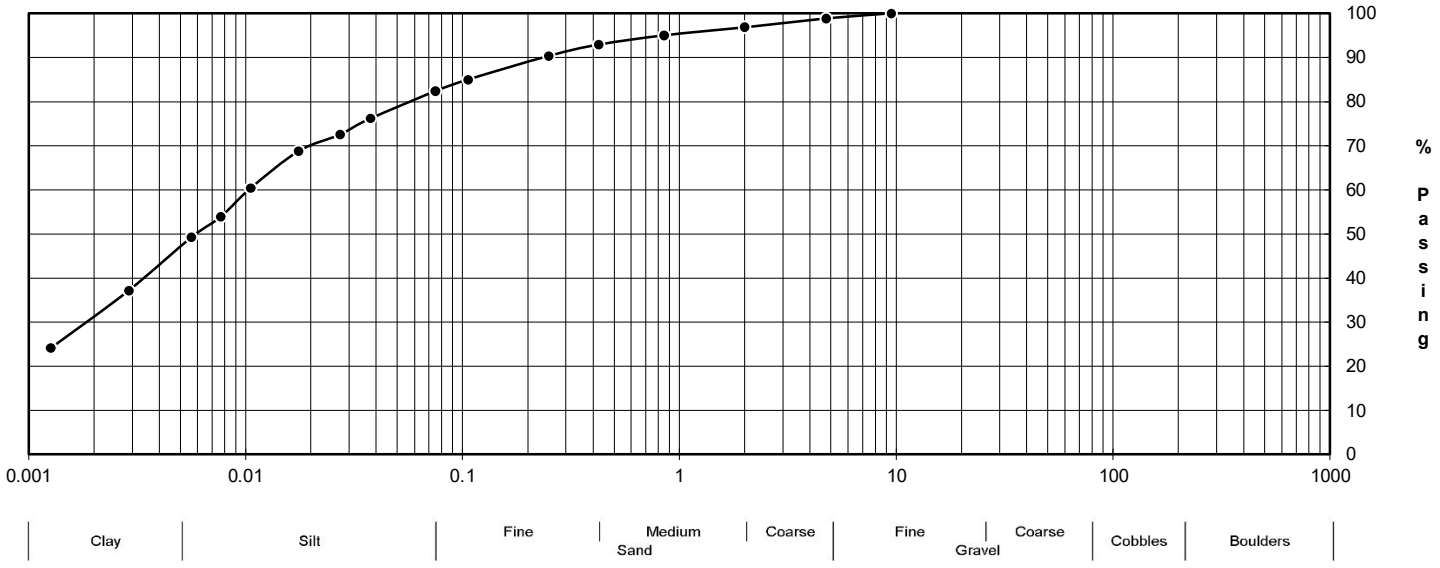
Particle Size Analysis of Soil By Hydrometer

Client:	SNC-Lavalin	TBTE Project No.:	20-269
Project:	WSR 661910	Lab No.:	20-3597
Location:	Webequie First National Supply Road	Sample Location	WQR5 SS3 4'-6'
Reported To:	Muhammad Saleem	Tested By/Date:	GH / September 5, 2020
Sampled By/Date:	N/A	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0			
37.5		0.037700	76.2
25.0		0.027205	72.5
19.0		0.017545	68.8
13.2		0.010557	60.4
9.5	100.0	0.007691	53.9
4.75	98.8	0.005616	49.3
2.00	96.9	0.002890	37.2
0.850	95.0	0.001264	24.2
0.425	93.0		
0.250	90.4	5 µm	48.5
0.106	85.0	2 µm	36.0
0.075	82.4		

Grain Size Analysis



%Gravel	1.2	% Silt	33.9	% NMC	22.8	Frost Heave Susc.		Material Suitability	
% Sand	16.4	% Clay	48.5	PI	11	Erodibility (k)		Soil Classification	CL

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

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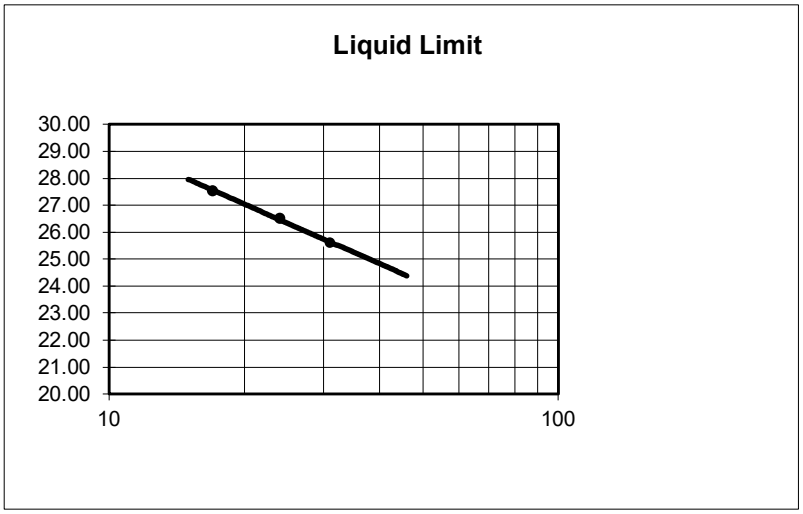
Atterberg Limits

Client:	SNC-Lavalin	TBTE Project No.:	20-269
Project:	WSR 661910	Lab No.:	20-3597
Location:	Webequie First National Supply I	Sample Location:	WQR5 SS3 4'-6'
Reported To:	Muhammad Saleem	Tested By/Date:	GH / September 5, 2020
Sampled By/Date:	N/A	Reviewed By:	Forch Valela

Liquid Limit Determination

Dish No.:	GW	DD	E		Liquid Limit 25 Blows
Wet Soil + Dish:	39.06	38.814	40.158		
Dry Soil + Dish:	36.89	36.672	37.609		
Moisture:	2.17	2.142	2.549		
Dish:	28.416	28.594	28.35		
Dry Soil:	8.474	8.078	9.259		
% Moisture:	25.61	26.52	27.53		
No. of Blows:	31	24	17		
Liquid Limits:	26	26	26		26



Liquid Limit, %:	26
Plastic Limit, %:	15
Plasticity Index:	11

Plastic Limit Determination

Dish No.:	3	4			Natural Moisture A1
Wet Soil + Dish:	27.394	27.869			697.8
Dry Soil + Dish:	26.317	26.807			612.7
Moisture:	1.077	1.062			85.1
Dish:	19.142	19.702			240.2
Dry Soil:	7.175	7.105			372.5
% Moisture:	15.01	14.95			22.8
Average:	15				

Test Method : ASTM: D4318, D2216

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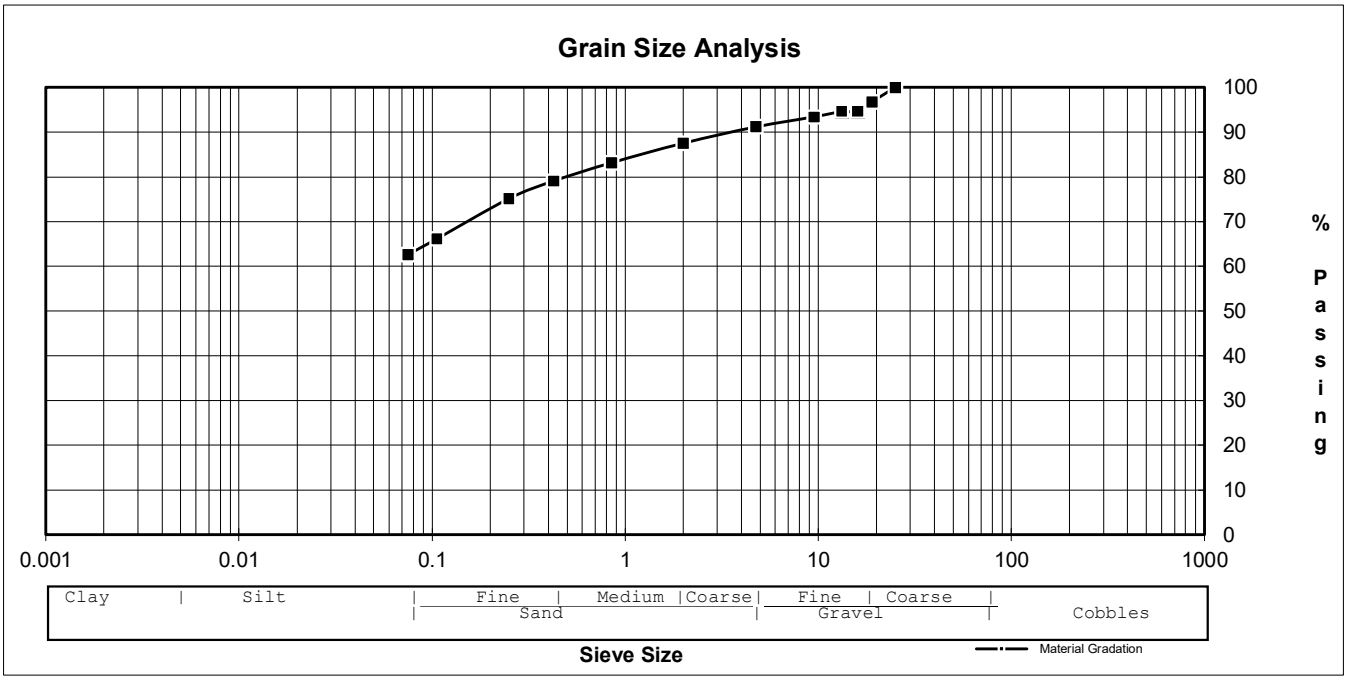
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3598
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQR5
Report to:	Muhammad Saleem	Sample No.:	SS5
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	10' - 12'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	96.8
16.0 mm	94.6
13.2 mm	94.6
9.5 mm	93.4
4.75 mm	91.1
2.00 mm	87.5
.850 mm	83.2
.425 mm	79.1
.250 mm	75.1
.106 mm	66.2
.075 mm	62.6



% Gravel	8.9		
% Sand	28.5	Natural Moisture Content:	10.1%
% Silt & Clay	62.6	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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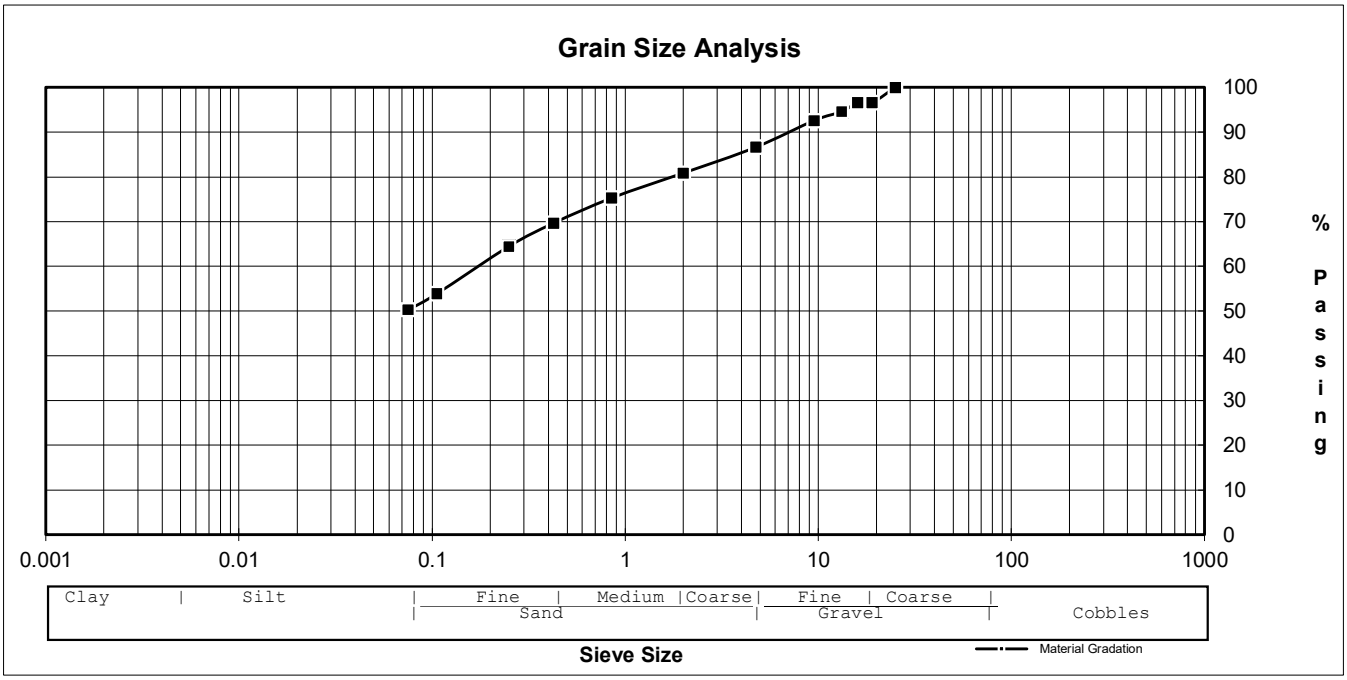
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3604
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQR 6B
Report to:	Muhammad Saleem	Sample No.:	SS7
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	20' - 21.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	96.6
16.0 mm	96.6
13.2 mm	94.6
9.5 mm	92.6
4.75 mm	86.6
2.00 mm	80.9
.850 mm	75.2
.425 mm	69.7
.250 mm	64.4
.106 mm	53.9
.075 mm	50.3



% Gravel	13.4		
% Sand	36.3	Natural Moisture Content:	9.7%
% Silt & Clay	50.3	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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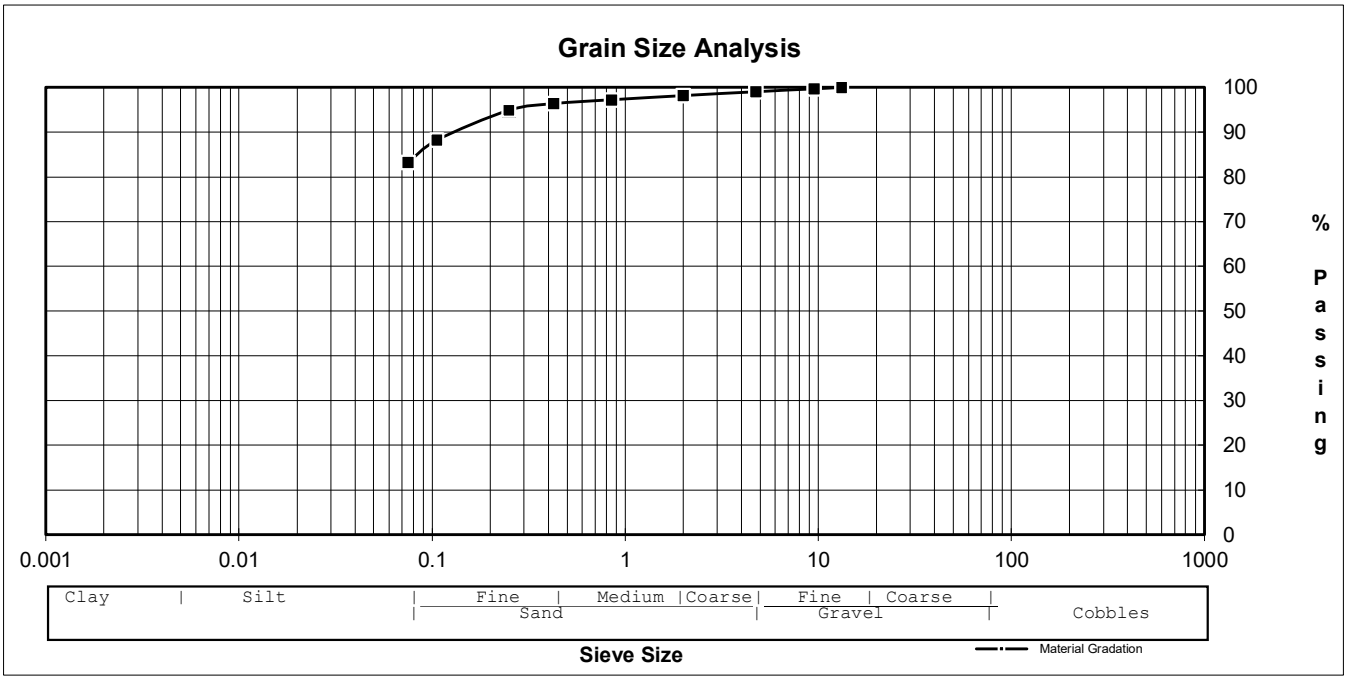
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3606
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	BH20-1
Report to:	Muhammad Saleem	Sample No.:	SS2
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	2.5' - 4.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	99.7
4.75 mm	99.1
2.00 mm	98.2
.850 mm	97.2
.425 mm	96.4
.250 mm	94.9
.106 mm	88.2
.075 mm	83.3



% Gravel	0.9		
% Sand	15.8	Natural Moisture Content:	15.7%
% Silt & Clay	83.3	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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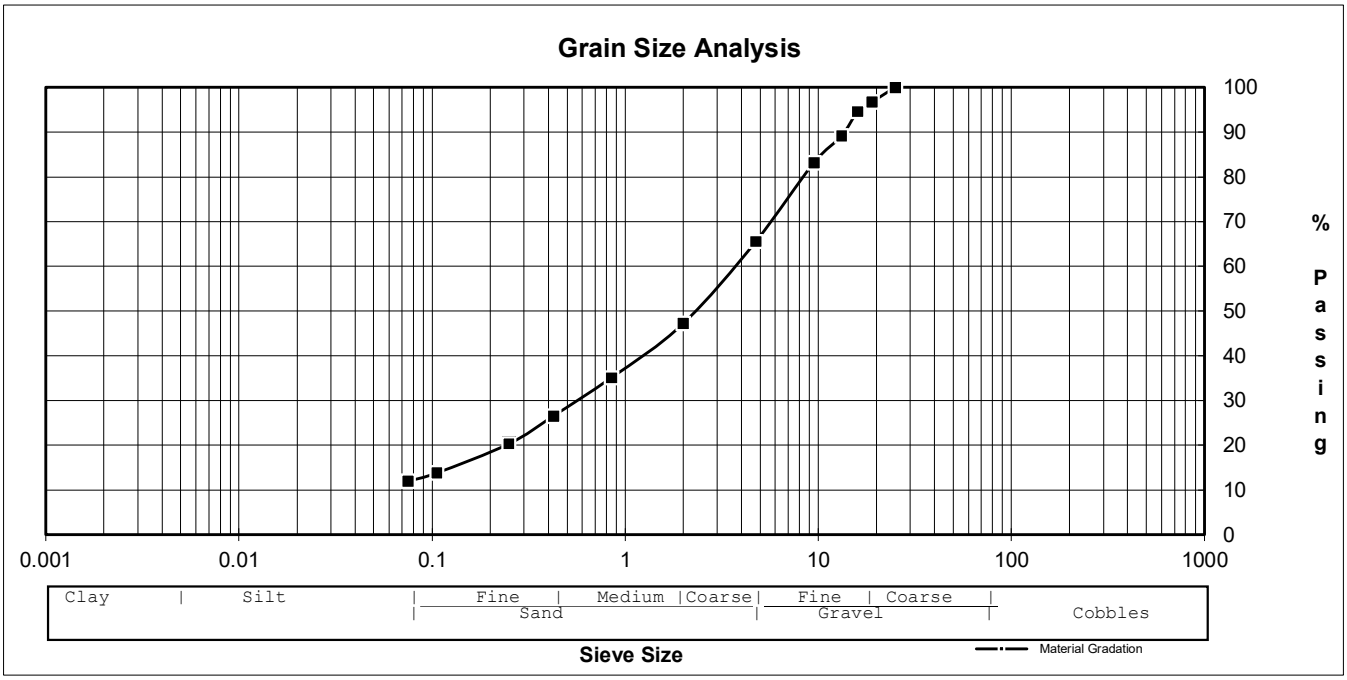
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3612
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	BH20-2
Report to:	Muhammad Saleem	Sample No.:	SS5
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	10' - 11.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	96.8
16.0 mm	94.6
13.2 mm	89.1
9.5 mm	83.2
4.75 mm	65.5
2.00 mm	47.2
.850 mm	35.1
.425 mm	26.5
.250 mm	20.3
.106 mm	13.8
.075 mm	12.0



% Gravel	34.5		
% Sand	53.5	Natural Moisture Content:	3.8%
% Silt & Clay	12.0	Soil Classification:	SW-SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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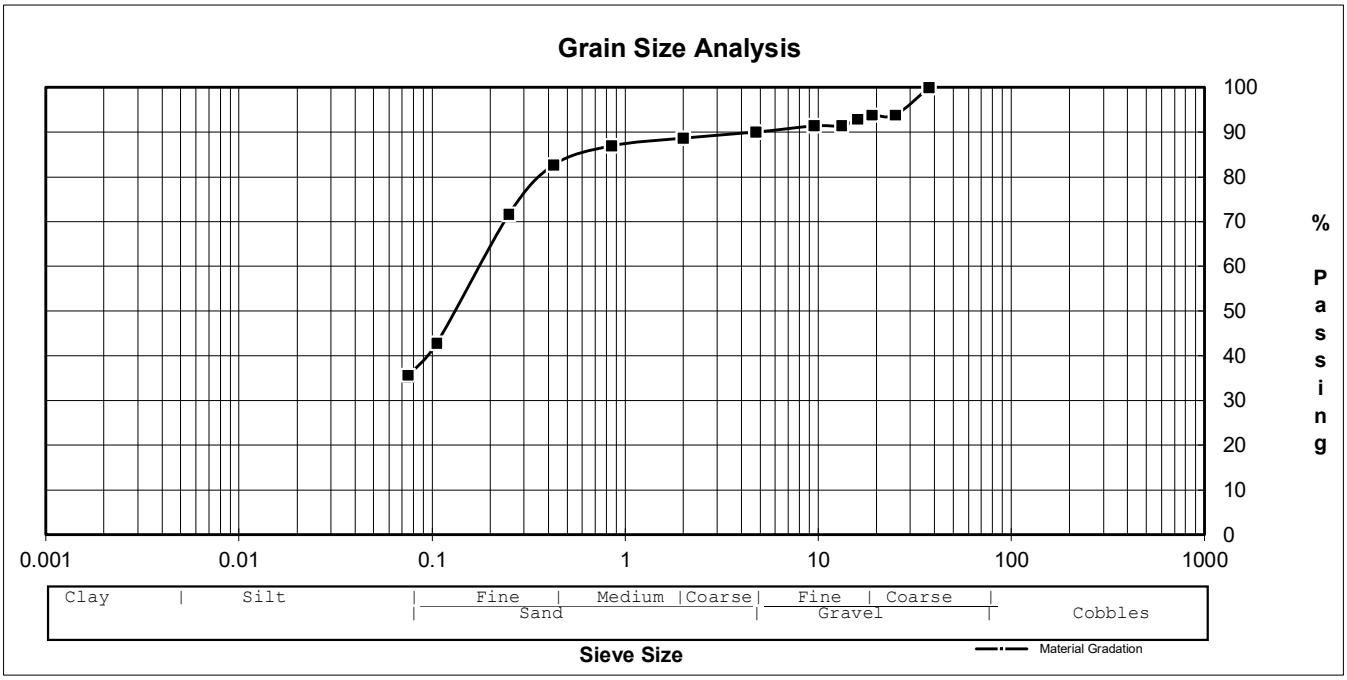
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3617
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	BH20-3
Report to:	Muhammad Saleem	Sample No.:	SS3
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	5' - 7'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	93.8
19.0 mm	93.8
16.0 mm	92.9
13.2 mm	91.4
9.5 mm	91.4
4.75 mm	90.0
2.00 mm	88.6
.850 mm	86.9
.425 mm	82.7
.250 mm	71.6
.106 mm	42.8
.075 mm	35.6



% Gravel	10.0		
% Sand	54.4	Natural Moisture Content:	9.4%
% Silt & Clay	35.6	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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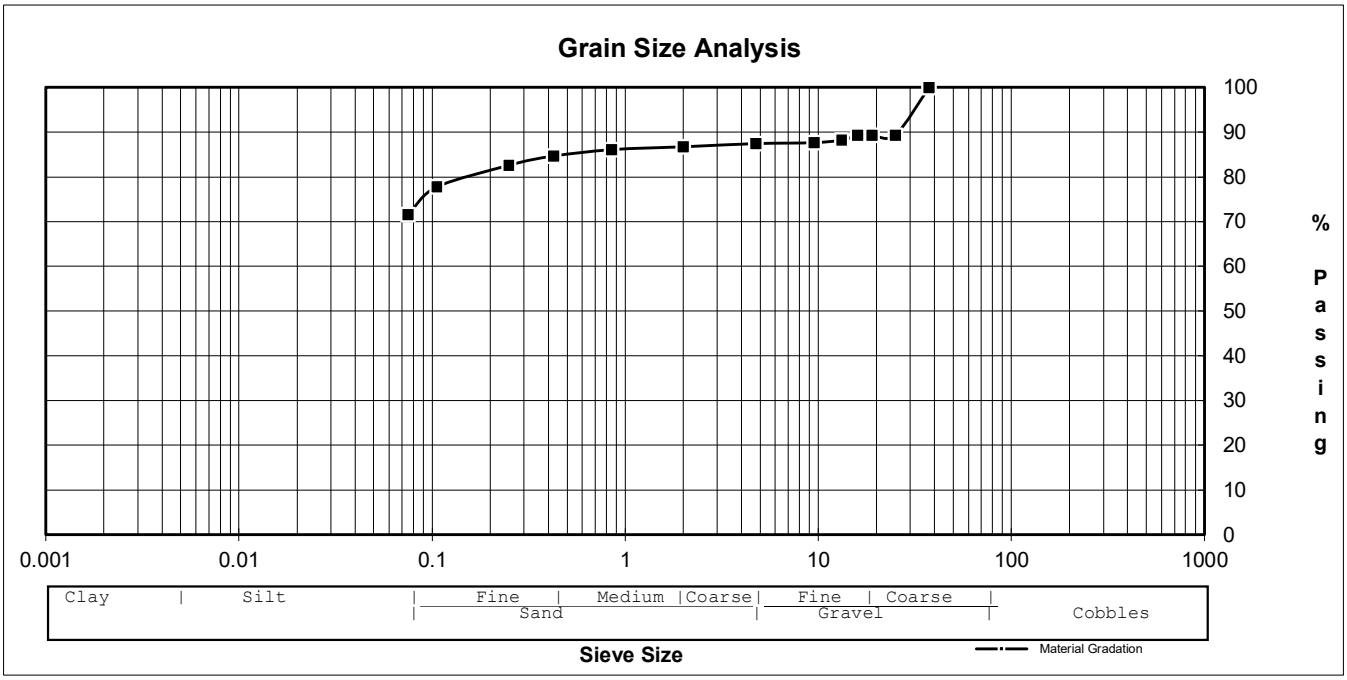
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3853
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA4
Report to:	Muhammad Saleem	Sample No.:	SS3
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	5' - 7'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	89.3
19.0 mm	89.3
16.0 mm	89.3
13.2 mm	88.2
9.5 mm	87.6
4.75 mm	87.4
2.00 mm	86.7
.850 mm	86.1
.425 mm	84.7
.250 mm	82.6
.106 mm	77.7
.075 mm	71.6



% Gravel	12.6		
% Sand	15.8	Natural Moisture Content:	10.7%
% Silt & Clay	71.6	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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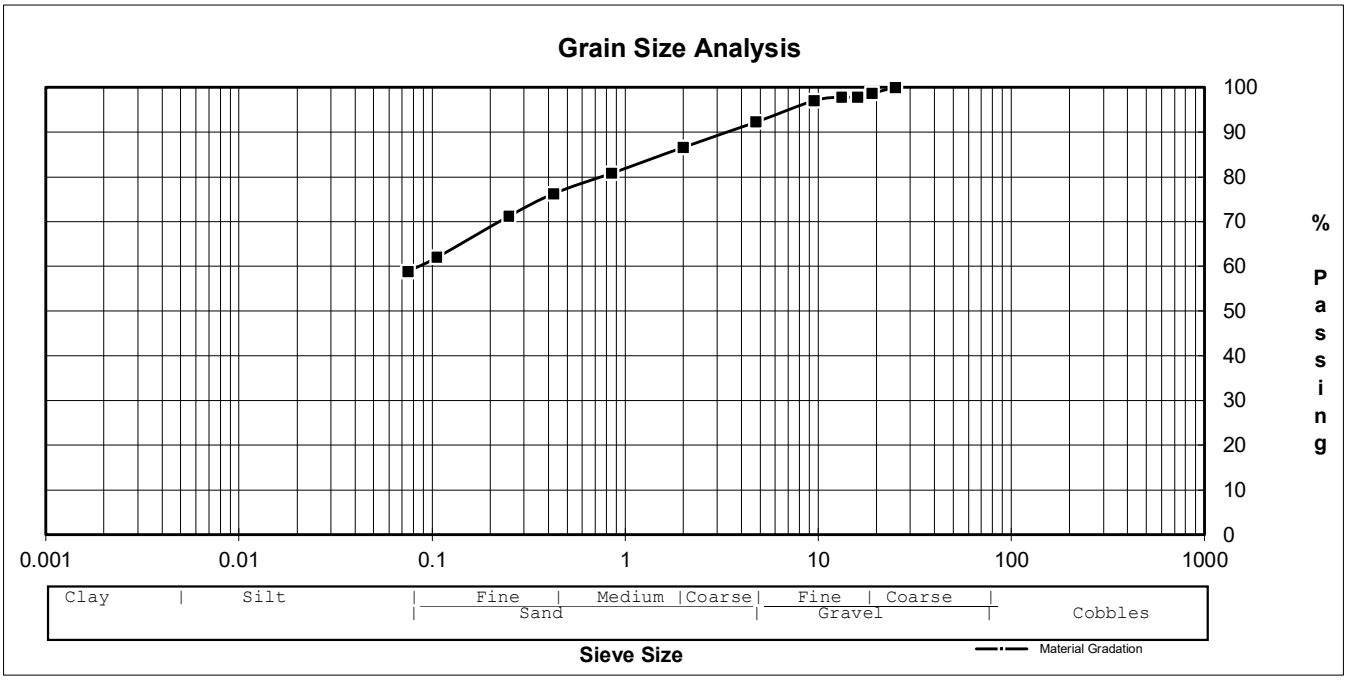
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3857
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA4
Report to:	Muhammad Saleem	Sample No.:	SS7
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	20' - 21.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	100.0
19.0 mm	98.7
16.0 mm	97.8
13.2 mm	97.8
9.5 mm	97.0
4.75 mm	92.2
2.00 mm	86.6
.850 mm	80.8
.425 mm	76.2
.250 mm	71.2
.106 mm	62.0
.075 mm	58.8



% Gravel	7.8		
% Sand	33.4	Natural Moisture Content:	11.0%
% Silt & Clay	58.8	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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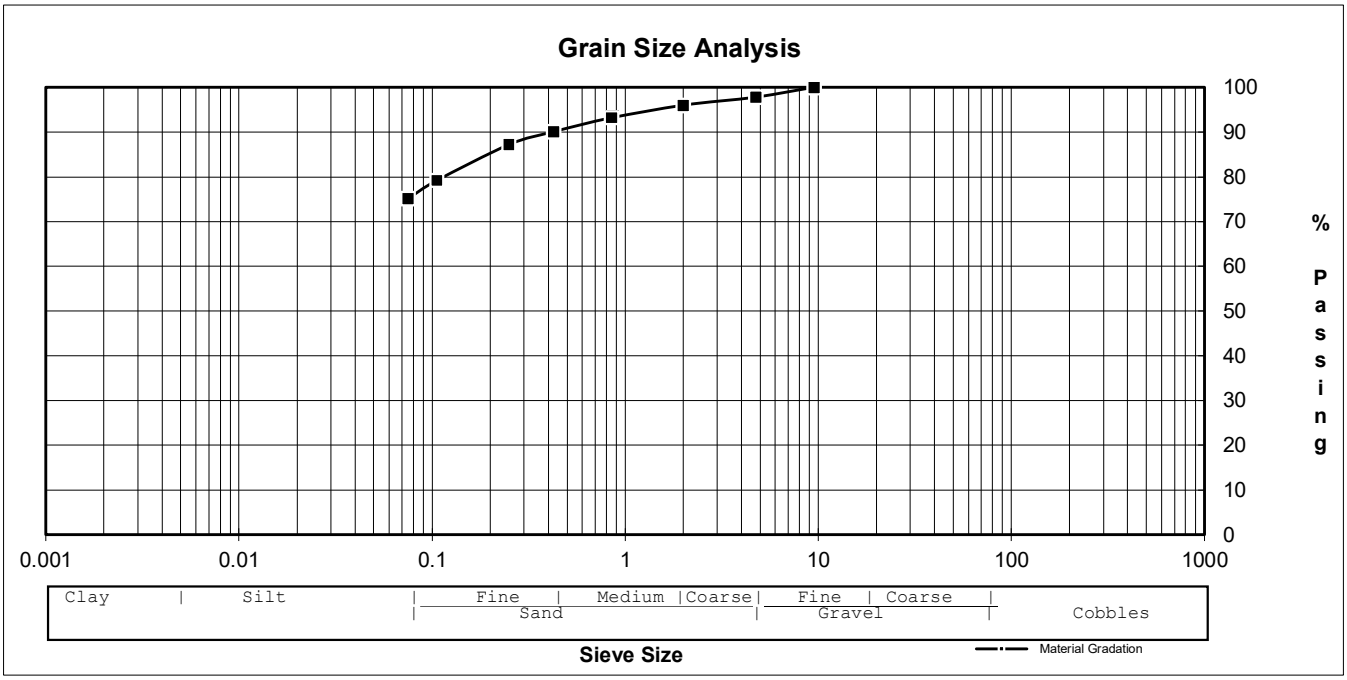
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3891
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA5
Report to:	Muhammad Saleem	Sample No.:	SS2
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	2.5' - 4.5'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	100.0
4.75 mm	97.8
2.00 mm	96.0
.850 mm	93.2
.425 mm	90.1
.250 mm	87.2
.106 mm	79.2
.075 mm	75.1



% Gravel	2.2		
% Sand	22.7	Natural Moisture Content:	17.1%
% Silt & Clay	75.1	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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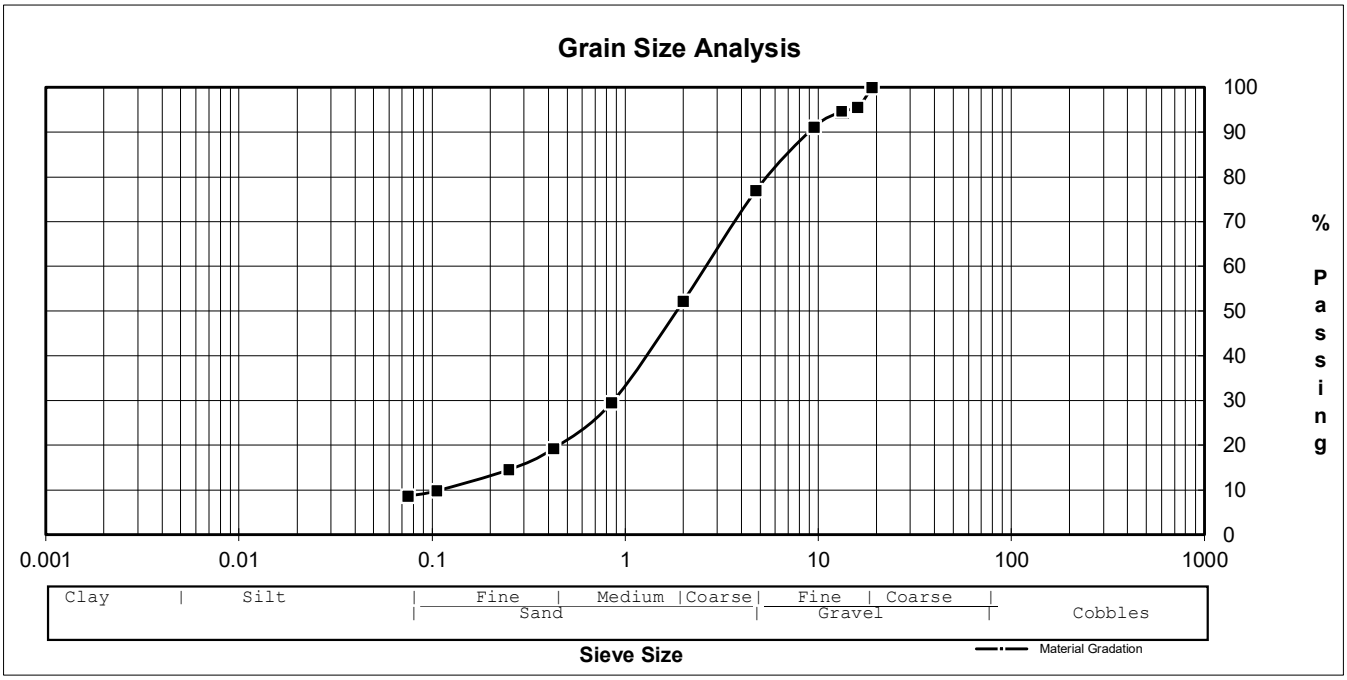
Grain Size Analysis

Client:	SNC-Lavalin	TBT Project No.:	20-269
Project Description:	WSR 661910	Lab No.:	20-3894
Project No.:	Webequie First National Supply Road	B.H./T.P. No.:	WQA5
Report to:	Muhammad Saleem	Sample No.:	SS5
Tested By/Date:	GH / September 5, 2020	Depth: (ft)	10' - 12'
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	100.0
16.0 mm	95.6
13.2 mm	94.6
9.5 mm	91.0
4.75 mm	76.9
2.00 mm	52.2
.850 mm	29.5
.425 mm	19.2
.250 mm	14.5
.106 mm	9.8
.075 mm	8.7



% Gravel	23.1		
% Sand	68.2	Natural Moisture Content:	2.6%
% Silt & Clay	8.7	Soil Classification:	SW-SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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TEST SUMMARY FOR SNC LAVALIN

TBTE J-20-269 Client Project #661910

Lab No.	Field No.	Depth	*Control Freeze/Thaw*	Freeze/Thaw	*Control Coarse Aggregate Relative Density*	Coarse Aggregate Relative Density	*Control Absorption*	Absorption	*Control Coarse Aggregate Micro Deval*	Coarse Aggregate Micro Deval	Permeability	*Control Fine Aggregate Micro Deval*	Fine Aggregate Micro Deval	PE % mica P/150-R/75	Uncompacted Void Content	Fine Aggregate Relative Density	Sand Equivalent Value
20-3729	WQR4	*12' 6" - 25' 10"*	*8.7*	0.7					*13.7*	6.7							
20-3730	WQR6B	*24' - 34'*	*8.7*	3.5					*13.7*	5.7							

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SNC- Lavalin Inc. (Sudbury/Toronto)
ATTN: Wilson Liu
195 The West Mall
Toronto ON M9C 5K1

Date Received: 27- JUL- 20
Report Date: 09- SEP- 20 14:29 (MT)
Version: FINAL

Client Phone: 416- 635- 5882

Certificate of Analysis

Lab Work Order #: L2479795

Project P.O. #: 12132
Job Reference: 661910
C of C Numbers:
Legal Site Desc: Task Code: Y3- 07- GEO1- 01- TEC

<original signed by>

Christine Paradis
Project Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-1 WQA-1 (FROM 14' 2"-15') Sampled By: MS on 05-JUL-20 @ 14:00 Matrix: Rock							
SPLP Metals							
Extraction Solution Initial pH	4.21		0.10	pH		04-SEP-20	R5211956
Final pH	7.97		0.10	pH		04-SEP-20	R5211956
Aluminum (Al)-Leachable	0.808		0.020	mg/L	04-SEP-20	06-SEP-20	R5213057
Antimony (Sb)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Arsenic (As)-Leachable	0.00021		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Barium (Ba)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Boron (B)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	04-SEP-20	06-SEP-20	R5213057
Calcium (Ca)-Leachable	4.34		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Chromium (Cr)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Cobalt (Co)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Copper (Cu)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Iron (Fe)-Leachable	0.210		0.030	mg/L	04-SEP-20	06-SEP-20	R5213057
Lead (Pb)-Leachable	0.00114		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Lithium (Li)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Magnesium (Mg)-Leachable	0.124		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Manganese (Mn)-Leachable	0.00355		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Molybdenum (Mo)-Leachable	0.00011		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Nickel (Ni)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	04-SEP-20	06-SEP-20	R5213057
Potassium (K)-Leachable	3.15		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Silicon (Si)-Leachable	3.77		0.20	mg/L	04-SEP-20	06-SEP-20	R5213057
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Sodium (Na)-Leachable	1.3		1.0	mg/L	04-SEP-20	06-SEP-20	R5213057
Strontium (Sr)-Leachable	0.0160		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Titanium (Ti)-Leachable	<0.010		0.010	mg/L	04-SEP-20	06-SEP-20	R5213057
Uranium (U)-Leachable	0.00115		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Vanadium (V)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-2 WQR-6B (FROM 28'-28',9") Sampled By: MS on 19-JUL-20 @ 14:30 Matrix: Rock							
SPLP Metals							
Extraction Solution Initial pH	4.21		0.10	pH		04-SEP-20	R5211956
Final pH	7.55		0.10	pH		04-SEP-20	R5211956

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-2 WQR-6B (FROM 28'-28',9") Sampled By: MS on 19-JUL-20 @ 14:30 Matrix: Rock							
SPLP Metals							
Aluminum (Al)-Leachable	0.700		0.020	mg/L	04-SEP-20	06-SEP-20	R5213057
Antimony (Sb)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Arsenic (As)-Leachable	0.00032		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Barium (Ba)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Boron (B)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	04-SEP-20	06-SEP-20	R5213057
Calcium (Ca)-Leachable	0.54		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Chromium (Cr)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Cobalt (Co)-Leachable	0.00021		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Copper (Cu)-Leachable	0.00064		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Iron (Fe)-Leachable	0.477		0.030	mg/L	04-SEP-20	06-SEP-20	R5213057
Lead (Pb)-Leachable	0.00011		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Lithium (Li)-Leachable	0.0030		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Magnesium (Mg)-Leachable	0.444		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Manganese (Mn)-Leachable	0.00748		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Molybdenum (Mo)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Nickel (Ni)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	04-SEP-20	06-SEP-20	R5213057
Potassium (K)-Leachable	3.69		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Silicon (Si)-Leachable	2.53		0.20	mg/L	04-SEP-20	06-SEP-20	R5213057
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Sodium (Na)-Leachable	1.1		1.0	mg/L	04-SEP-20	06-SEP-20	R5213057
Strontium (Sr)-Leachable	0.0040		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Titanium (Ti)-Leachable	0.035		0.010	mg/L	04-SEP-20	06-SEP-20	R5213057
Uranium (U)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Vanadium (V)-Leachable	0.0022		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-3 WQR-4 (FROM 20' 7"-21'-6") Sampled By: MS on 21-JUL-20 @ 15:15 Matrix: Rock							
SPLP Metals							
Extraction Solution Initial pH	4.21		0.10	pH		04-SEP-20	R5211956
Final pH	9.05		0.10	pH		04-SEP-20	R5211956
Aluminum (Al)-Leachable	0.808		0.020	mg/L	04-SEP-20	06-SEP-20	R5213057
Antimony (Sb)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-3 WQR-4 (FROM 20' 7"-21'-6") Sampled By: MS on 21-JUL-20 @ 15:15 Matrix: Rock							
SPLP Metals							
Arsenic (As)-Leachable	0.00020		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Barium (Ba)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Boron (B)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	04-SEP-20	06-SEP-20	R5213057
Calcium (Ca)-Leachable	3.36		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Chromium (Cr)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Cobalt (Co)-Leachable	0.00017		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Copper (Cu)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Iron (Fe)-Leachable	0.331		0.030	mg/L	04-SEP-20	06-SEP-20	R5213057
Lead (Pb)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Lithium (Li)-Leachable	0.0019		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Magnesium (Mg)-Leachable	0.436		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Manganese (Mn)-Leachable	0.00555		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Molybdenum (Mo)-Leachable	0.00040		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Nickel (Ni)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	04-SEP-20	06-SEP-20	R5213057
Potassium (K)-Leachable	4.78		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Silicon (Si)-Leachable	2.76		0.20	mg/L	04-SEP-20	06-SEP-20	R5213057
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Sodium (Na)-Leachable	1.3		1.0	mg/L	04-SEP-20	06-SEP-20	R5213057
Strontium (Sr)-Leachable	0.0100		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Titanium (Ti)-Leachable	0.035		0.010	mg/L	04-SEP-20	06-SEP-20	R5213057
Uranium (U)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Vanadium (V)-Leachable	0.0037		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-4 WQR-3 (FROM 10' - 18' 9") Sampled By: MS on 23-JUL-20 @ 11:00 Matrix: Rock							
SPLP Metals							
Extraction Solution Initial pH	4.21		0.10	pH		04-SEP-20	R5211956
Final pH	8.82		0.10	pH		04-SEP-20	R5211956
Aluminum (Al)-Leachable	0.818		0.020	mg/L	04-SEP-20	06-SEP-20	R5213057
Antimony (Sb)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Arsenic (As)-Leachable	0.00024		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Barium (Ba)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-4 WQR-3 (FROM 10' - 18' 9") Sampled By: MS on 23-JUL-20 @ 11:00 Matrix: Rock							
SPLP Metals							
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Boron (B)-Leachable	<0.10		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	04-SEP-20	06-SEP-20	R5213057
Calcium (Ca)-Leachable	3.99		0.10	mg/L	04-SEP-20	06-SEP-20	R5213057
Chromium (Cr)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Cobalt (Co)-Leachable	0.00011		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Copper (Cu)-Leachable	0.00080		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Iron (Fe)-Leachable	0.261		0.030	mg/L	04-SEP-20	06-SEP-20	R5213057
Lead (Pb)-Leachable	0.00011		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Lithium (Li)-Leachable	0.0035		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Magnesium (Mg)-Leachable	0.234		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Manganese (Mn)-Leachable	0.00416		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Molybdenum (Mo)-Leachable	0.00025		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Nickel (Ni)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	04-SEP-20	06-SEP-20	R5213057
Potassium (K)-Leachable	3.70		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	04-SEP-20	06-SEP-20	R5213057
Silicon (Si)-Leachable	2.94		0.20	mg/L	04-SEP-20	06-SEP-20	R5213057
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	04-SEP-20	06-SEP-20	R5213057
Sodium (Na)-Leachable	1.6		1.0	mg/L	04-SEP-20	06-SEP-20	R5213057
Strontium (Sr)-Leachable	0.0077		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Titanium (Ti)-Leachable	0.022		0.010	mg/L	04-SEP-20	06-SEP-20	R5213057
Uranium (U)-Leachable	<0.00010		0.00010	mg/L	04-SEP-20	06-SEP-20	R5213057
Vanadium (V)-Leachable	0.0033		0.0010	mg/L	04-SEP-20	06-SEP-20	R5213057
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	04-SEP-20	06-SEP-20	R5213057
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-5 WQA-3 (FROM 10'-12') Sampled By: MS on 09-JUL-20 @ 11:25 Matrix: Soil							
SPLP Metals							
Extraction Solution Initial pH	4.17		0.10	pH		07-AUG-20	R5176867
Final pH	9.18		0.10	pH		07-AUG-20	R5176867
Aluminum (Al)-Leachable	1.35		0.020	mg/L	05-AUG-20	07-AUG-20	R5176177
Antimony (Sb)-Leachable	<0.000050		0.000050	mg/L	05-AUG-20	07-AUG-20	R5176177
Arsenic (As)-Leachable	0.00082		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Barium (Ba)-Leachable	<0.10		0.10	mg/L	07-AUG-20	10-AUG-20	R5178640
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	07-AUG-20	R5176177
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	07-AUG-20	R5176177

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-5 WQA-3 (FROM 10'-12') Sampled By: MS on 09-JUL-20 @ 11:25 Matrix: Soil							
SPLP Metals							
Boron (B)-Leachable	<0.10		0.10	mg/L	05-AUG-20	07-AUG-20	R5176177
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	05-AUG-20	07-AUG-20	R5176177
Calcium (Ca)-Leachable	8.24		0.10	mg/L	05-AUG-20	07-AUG-20	R5176177
Chromium (Cr)-Leachable	0.00267		0.00050	mg/L	05-AUG-20	07-AUG-20	R5176177
Cobalt (Co)-Leachable	0.00074		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Copper (Cu)-Leachable	0.00355		0.00050	mg/L	05-AUG-20	07-AUG-20	R5176177
Iron (Fe)-Leachable	1.63		0.030	mg/L	07-AUG-20	10-AUG-20	R5178640
Lead (Pb)-Leachable	0.00077		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Lithium (Li)-Leachable	0.0017		0.0010	mg/L	05-AUG-20	07-AUG-20	R5176177
Magnesium (Mg)-Leachable	0.952		0.050	mg/L	07-AUG-20	10-AUG-20	R5178640
Manganese (Mn)-Leachable	0.0242		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Molybdenum (Mo)-Leachable	0.00124		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Nickel (Ni)-Leachable	0.00171		0.00050	mg/L	05-AUG-20	07-AUG-20	R5176177
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	05-AUG-20	07-AUG-20	R5176177
Potassium (K)-Leachable	0.465		0.050	mg/L	05-AUG-20	07-AUG-20	R5176177
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	07-AUG-20	R5176177
Silicon (Si)-Leachable	3.53		0.20	mg/L	05-AUG-20	07-AUG-20	R5176177
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	05-AUG-20	07-AUG-20	R5176177
Sodium (Na)-Leachable	1.1		1.0	mg/L	05-AUG-20	07-AUG-20	R5176177
Strontium (Sr)-Leachable	0.0080		0.0010	mg/L	05-AUG-20	07-AUG-20	R5176177
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	07-AUG-20	R5176177
Titanium (Ti)-Leachable	0.042		0.010	mg/L	05-AUG-20	07-AUG-20	R5176177
Uranium (U)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	07-AUG-20	R5176177
Vanadium (V)-Leachable	0.0027		0.0010	mg/L	05-AUG-20	07-AUG-20	R5176177
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	05-AUG-20	07-AUG-20	R5176177
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-6 WQR-2A (FROM 5'-7') Sampled By: MS on 11-JUL-20 @ 14:10 Matrix: Soil							
SPLP Metals							
Extraction Solution Initial pH	4.17		0.10	pH		05-AUG-20	R5175679
Final pH	8.73		0.10	pH		05-AUG-20	R5175679
Aluminum (Al)-Leachable	47.0		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Antimony (Sb)-Leachable	0.00039		0.00025	mg/L	05-AUG-20	06-AUG-20	R5175416
Arsenic (As)-Leachable	0.0116		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Barium (Ba)-Leachable	<0.50	DLA	0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Beryllium (Be)-Leachable	<0.0025	DLA	0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Bismuth (Bi)-Leachable	<0.0050	DLA	0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Boron (B)-Leachable	<0.50	DLA	0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Cadmium (Cd)-Leachable	0.00017		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-6 WQR-2A (FROM 5'-7') Sampled By: MS on 11-JUL-20 @ 14:10 Matrix: Soil							
SPLP Metals							
Calcium (Ca)-Leachable	36.5		0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Chromium (Cr)-Leachable	0.0758		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Cobalt (Co)-Leachable	0.0116		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Copper (Cu)-Leachable	0.0691		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Iron (Fe)-Leachable	41.0		0.15	mg/L	05-AUG-20	06-AUG-20	R5175416
Lead (Pb)-Leachable	0.0149		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Lithium (Li)-Leachable	0.0470		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Magnesium (Mg)-Leachable	13.7		0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Manganese (Mn)-Leachable	0.367		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Molybdenum (Mo)-Leachable	0.00252		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Nickel (Ni)-Leachable	0.0406		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Phosphorus (P)-Leachable	<1.5	DLA	1.5	mg/L	05-AUG-20	06-AUG-20	R5175416
Potassium (K)-Leachable	14.2		0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Selenium (Se)-Leachable	<0.0025	DLA	0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Silicon (Si)-Leachable	96.6		1.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Silver (Ag)-Leachable	<0.00025	DLA	0.00025	mg/L	05-AUG-20	06-AUG-20	R5175416
Sodium (Na)-Leachable	<5.0	DLA	5.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Strontium (Sr)-Leachable	0.0750		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Thallium (Tl)-Leachable	<0.00050	DLA	0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Tin (Sn)-Leachable	<0.0050	DLA	0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Titanium (Ti)-Leachable	1.56		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Uranium (U)-Leachable	0.00119		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Vanadium (V)-Leachable	0.0842		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Zinc (Zn)-Leachable	<0.25	DLA	0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-7 WQA-5 (FROM 15'-16' 6") Sampled By: MS on 13-JUL-20 @ 14:45 Matrix: Soil							
SPLP Metals							
Extraction Solution Initial pH	4.17		0.10	pH		05-AUG-20	R5175679
Final pH	9.15		0.10	pH		05-AUG-20	R5175679
Aluminum (Al)-Leachable	0.223		0.020	mg/L	05-AUG-20	06-AUG-20	R5175416
Antimony (Sb)-Leachable	<0.000050		0.000050	mg/L	05-AUG-20	06-AUG-20	R5175416
Arsenic (As)-Leachable	0.00057		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Barium (Ba)-Leachable	<0.10		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Boron (B)-Leachable	<0.10		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	05-AUG-20	06-AUG-20	R5175416
Calcium (Ca)-Leachable	6.89		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Chromium (Cr)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-7 WQA-5 (FROM 15'-16' 6") Sampled By: MS on 13-JUL-20 @ 14:45 Matrix: Soil							
SPLP Metals							
Cobalt (Co)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Copper (Cu)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Iron (Fe)-Leachable	<0.030		0.030	mg/L	05-AUG-20	06-AUG-20	R5175416
Lead (Pb)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Lithium (Li)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Magnesium (Mg)-Leachable	0.913		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Manganese (Mn)-Leachable	0.00025		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Molybdenum (Mo)-Leachable	0.00029		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Nickel (Ni)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	05-AUG-20	06-AUG-20	R5175416
Potassium (K)-Leachable	1.39		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Silicon (Si)-Leachable	1.27		0.20	mg/L	05-AUG-20	06-AUG-20	R5175416
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	05-AUG-20	06-AUG-20	R5175416
Sodium (Na)-Leachable	<1.0		1.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Strontium (Sr)-Leachable	0.0106		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Titanium (Ti)-Leachable	<0.010		0.010	mg/L	05-AUG-20	06-AUG-20	R5175416
Uranium (U)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Vanadium (V)-Leachable	0.0013		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-8 WQR-5 (FROM 7' 6"-9' 6") Sampled By: MS on 17-JUL-20 @ 09:40 Matrix: Soil							
SPLP Metals							
Extraction Solution Initial pH	4.17		0.10	pH		05-AUG-20	R5175679
Final pH	8.89		0.10	pH		05-AUG-20	R5175679
Aluminum (Al)-Leachable	57.2		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Antimony (Sb)-Leachable	0.00048		0.00025	mg/L	05-AUG-20	06-AUG-20	R5175416
Arsenic (As)-Leachable	0.0165		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Barium (Ba)-Leachable	<0.50	DLA	0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Beryllium (Be)-Leachable	<0.0025	DLA	0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Bismuth (Bi)-Leachable	<0.0050	DLA	0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Boron (B)-Leachable	<0.50	DLA	0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Cadmium (Cd)-Leachable	0.00016		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Calcium (Ca)-Leachable	38.9		0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Chromium (Cr)-Leachable	0.0977		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Cobalt (Co)-Leachable	0.0265		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Copper (Cu)-Leachable	0.0768		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-8 WQR-5 (FROM 7' 6"-9' 6") Sampled By: MS on 17-JUL-20 @ 09:40 Matrix: Soil							
SPLP Metals							
Iron (Fe)-Leachable	56.8		0.15	mg/L	05-AUG-20	06-AUG-20	R5175416
Lead (Pb)-Leachable	0.0265		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Lithium (Li)-Leachable	0.0620		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Magnesium (Mg)-Leachable	18.1		0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Manganese (Mn)-Leachable	0.804		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Molybdenum (Mo)-Leachable	0.00223		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Nickel (Ni)-Leachable	0.0645		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Phosphorus (P)-Leachable	<1.5	DLA	1.5	mg/L	05-AUG-20	06-AUG-20	R5175416
Potassium (K)-Leachable	17.3		0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Selenium (Se)-Leachable	<0.0025	DLA	0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Silicon (Si)-Leachable	117		1.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Silver (Ag)-Leachable	<0.00025	DLA	0.00025	mg/L	05-AUG-20	06-AUG-20	R5175416
Sodium (Na)-Leachable	<5.0	DLA	5.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Strontium (Sr)-Leachable	0.102		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Thallium (Tl)-Leachable	<0.00050	DLA	0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Tin (Sn)-Leachable	<0.0050	DLA	0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Titanium (Ti)-Leachable	1.89		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Uranium (U)-Leachable	0.00393		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Vanadium (V)-Leachable	0.114		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Zinc (Zn)-Leachable	<0.25	DLA	0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-9 WQR-3 (FROM 7' 6"-9' 6") Sampled By: MS on 22-JUL-20 @ 15:00 Matrix: Soil							
SPLP Metals							
Extraction Solution Initial pH	4.17		0.10	pH		05-AUG-20	R5175679
Final pH	8.87		0.10	pH		05-AUG-20	R5175679
Aluminum (Al)-Leachable	2.62		0.020	mg/L	05-AUG-20	06-AUG-20	R5175416
Antimony (Sb)-Leachable	0.000112		0.000050	mg/L	05-AUG-20	06-AUG-20	R5175416
Arsenic (As)-Leachable	0.00061		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Barium (Ba)-Leachable	<0.10		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Beryllium (Be)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Bismuth (Bi)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Boron (B)-Leachable	<0.10		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Cadmium (Cd)-Leachable	<0.000020		0.000020	mg/L	05-AUG-20	06-AUG-20	R5175416
Calcium (Ca)-Leachable	13.5		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Chromium (Cr)-Leachable	0.00390		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Cobalt (Co)-Leachable	0.00112		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Copper (Cu)-Leachable	0.00489		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Iron (Fe)-Leachable	2.28		0.030	mg/L	05-AUG-20	06-AUG-20	R5175416
Lead (Pb)-Leachable	0.00142		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-9 WQR-3 (FROM 7' 6"-9' 6") Sampled By: MS on 22-JUL-20 @ 15:00 Matrix: Soil							
SPLP Metals							
Lithium (Li)-Leachable	0.0025		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Magnesium (Mg)-Leachable	1.38		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Manganese (Mn)-Leachable	0.0368		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Molybdenum (Mo)-Leachable	0.00028		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Nickel (Ni)-Leachable	0.00236		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Phosphorus (P)-Leachable	<0.30		0.30	mg/L	05-AUG-20	06-AUG-20	R5175416
Potassium (K)-Leachable	1.21		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Selenium (Se)-Leachable	<0.00050		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Silicon (Si)-Leachable	6.34		0.20	mg/L	05-AUG-20	06-AUG-20	R5175416
Silver (Ag)-Leachable	<0.000050		0.000050	mg/L	05-AUG-20	06-AUG-20	R5175416
Sodium (Na)-Leachable	<1.0		1.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Strontium (Sr)-Leachable	0.0171		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Thallium (Tl)-Leachable	<0.00010		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Tin (Sn)-Leachable	<0.0010		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Titanium (Ti)-Leachable	0.128		0.010	mg/L	05-AUG-20	06-AUG-20	R5175416
Uranium (U)-Leachable	0.00022		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Vanadium (V)-Leachable	0.0074		0.0010	mg/L	05-AUG-20	06-AUG-20	R5175416
Zinc (Zn)-Leachable	<0.050		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850
L2479795-10 WQR1 (FROM 15'-17') Sampled By: MS on 24-JUL-20 @ 11:50 Matrix: Soil							
SPLP Metals							
Extraction Solution Initial pH	4.17		0.10	pH		05-AUG-20	R5175679
Final pH	8.97		0.10	pH		05-AUG-20	R5175679
Aluminum (Al)-Leachable	40.0		0.10	mg/L	05-AUG-20	06-AUG-20	R5175416
Antimony (Sb)-Leachable	0.00045		0.00025	mg/L	05-AUG-20	06-AUG-20	R5175416
Arsenic (As)-Leachable	0.0132		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Barium (Ba)-Leachable	<0.50	DLA	0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Beryllium (Be)-Leachable	<0.0025	DLA	0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Bismuth (Bi)-Leachable	<0.0050	DLA	0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Boron (B)-Leachable	<0.50	DLA	0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Cadmium (Cd)-Leachable	0.00015		0.00010	mg/L	05-AUG-20	06-AUG-20	R5175416
Calcium (Ca)-Leachable	38.7		0.50	mg/L	05-AUG-20	06-AUG-20	R5175416
Chromium (Cr)-Leachable	0.0699		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Cobalt (Co)-Leachable	0.0184		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Copper (Cu)-Leachable	0.0472		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Iron (Fe)-Leachable	39.0		0.15	mg/L	05-AUG-20	06-AUG-20	R5175416
Lead (Pb)-Leachable	0.0162		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Lithium (Li)-Leachable	0.0395		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Magnesium (Mg)-Leachable	13.5		0.25	mg/L	05-AUG-20	06-AUG-20	R5175416

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2479795-10 WQR1 (FROM 15'-17') Sampled By: MS on 24-JUL-20 @ 11:50 Matrix: Soil							
SPLP Metals							
Manganese (Mn)-Leachable	0.544		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Molybdenum (Mo)-Leachable	0.00129		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Nickel (Ni)-Leachable	0.0424		0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Phosphorus (P)-Leachable	<1.5	DLA	1.5	mg/L	05-AUG-20	06-AUG-20	R5175416
Potassium (K)-Leachable	11.6		0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Selenium (Se)-Leachable	<0.0025	DLA	0.0025	mg/L	05-AUG-20	06-AUG-20	R5175416
Silicon (Si)-Leachable	83.7		1.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Silver (Ag)-Leachable	<0.00025	DLA	0.00025	mg/L	05-AUG-20	06-AUG-20	R5175416
Sodium (Na)-Leachable	<5.0	DLA	5.0	mg/L	05-AUG-20	06-AUG-20	R5175416
Strontium (Sr)-Leachable	0.101		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Thallium (Tl)-Leachable	<0.00050	DLA	0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Tin (Sn)-Leachable	<0.0050	DLA	0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Titanium (Ti)-Leachable	1.45		0.050	mg/L	05-AUG-20	06-AUG-20	R5175416
Uranium (U)-Leachable	0.00109		0.00050	mg/L	05-AUG-20	06-AUG-20	R5175416
Vanadium (V)-Leachable	0.0820		0.0050	mg/L	05-AUG-20	06-AUG-20	R5175416
Zinc (Zn)-Leachable	<0.25	DLA	0.25	mg/L	05-AUG-20	06-AUG-20	R5175416
Miscellaneous							
Special Request	See Attached		1.0			26-AUG-20	R5202850

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Calcium (Ca)-Leachable	B	L2479795-10, -5, -6, -7, -8, -9
Matrix Spike	Aluminum (Al)-Leachable	MS-B	L2479795-10, -5, -6, -7, -8, -9
Matrix Spike	Aluminum (Al)-Leachable	MS-B	L2479795-5
Matrix Spike	Aluminum (Al)-Leachable	MS-B	L2479795-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L2479795-10, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L2479795-5
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L2479795-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Leachable	MS-B	L2479795-10, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Leachable	MS-B	L2479795-5
Matrix Spike	Titanium (Ti)-Leachable	MS-B	L2479795-10, -5, -6, -7, -8, -9
Matrix Spike	Titanium (Ti)-Leachable	MS-B	L2479795-5

Sample Parameter Qualifier key listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-SPLP-MS-VA	Soil	Metals by ICPMS (SPLP)	EPA 1312/6020A

This analysis is carried out in accordance with the extraction procedure outlined in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods Volume 1C" SW-846 EPA Method 1312, published by the United States Environmental Protection Agency (EPA). In summary, the sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using water adjusted to pH 5.0 or pH 4.20 (Depending of the sampling location relative to the Mississippi river) by adding drops of 60/40 weight percent mixture of sulfuric and nitric acids. The extract is then filtered through a 0.6 to 0.8 micron glass fibre filter and analysed using inductively coupled plasma - mass spectrometry (EPA Method 6020A).

SPECIAL REQUEST-AX	Misc.	Special Request ALS Minerals Vancouver	SEE SUBLET LAB RESULTS

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: SNC- Lavalin Inc. (Sudbury/Toronto)
195 The West Mall
Toronto ON M9C 5K1
Contact: Wilson Liu

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R5175416								
WG3377152-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	06-AUG-20
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	06-AUG-20
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Barium (Ba)-Leachable			<0.10		mg/L		0.1	06-AUG-20
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	06-AUG-20
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	06-AUG-20
Boron (B)-Leachable			<0.10		mg/L		0.1	06-AUG-20
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	06-AUG-20
Calcium (Ca)-Leachable			0.17	B	mg/L		0.1	06-AUG-20
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	06-AUG-20
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	06-AUG-20
Iron (Fe)-Leachable			<0.030		mg/L		0.03	06-AUG-20
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	06-AUG-20
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	06-AUG-20
Manganese (Mn)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	06-AUG-20
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	06-AUG-20
Potassium (K)-Leachable			<0.050		mg/L		0.05	06-AUG-20
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	06-AUG-20
Silicon (Si)-Leachable			<0.20		mg/L		0.2	06-AUG-20
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	06-AUG-20
Sodium (Na)-Leachable			<1.0		mg/L		1	06-AUG-20
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	06-AUG-20
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	06-AUG-20
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	06-AUG-20
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	06-AUG-20
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	06-AUG-20
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	06-AUG-20

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R5176177								
WG3377152-2 MS		**L2479795-5**						
Aluminum (Al)-Leachable			N/A	MS-B	%		-	07-AUG-20
Antimony (Sb)-Leachable			97.1		%		70-130	07-AUG-20
Arsenic (As)-Leachable			104.4		%		70-130	07-AUG-20
Beryllium (Be)-Leachable			99.5		%		70-130	07-AUG-20
Bismuth (Bi)-Leachable			95.9		%		70-130	07-AUG-20
Boron (B)-Leachable			76.1		%		70-130	07-AUG-20
Cadmium (Cd)-Leachable			96.9		%		70-130	07-AUG-20
Calcium (Ca)-Leachable			N/A	MS-B	%		-	07-AUG-20
Chromium (Cr)-Leachable			111.9		%		70-130	07-AUG-20
Cobalt (Co)-Leachable			104.6		%		70-130	07-AUG-20
Copper (Cu)-Leachable			123.4		%		70-130	07-AUG-20
Lead (Pb)-Leachable			98.8		%		70-130	07-AUG-20
Lithium (Li)-Leachable			97.8		%		70-130	07-AUG-20
Manganese (Mn)-Leachable			N/A	MS-B	%		-	07-AUG-20
Molybdenum (Mo)-Leachable			98.8		%		70-130	07-AUG-20
Nickel (Ni)-Leachable			106.0		%		70-130	07-AUG-20
Phosphorus (P)-Leachable			100.9		%		70-130	07-AUG-20
Potassium (K)-Leachable			128.7		%		70-130	07-AUG-20
Selenium (Se)-Leachable			94.3		%		70-130	07-AUG-20
Silicon (Si)-Leachable			127.7		%		70-130	07-AUG-20
Silver (Ag)-Leachable			98.0		%		70-130	07-AUG-20
Sodium (Na)-Leachable			70.9		%		70-130	07-AUG-20
Strontium (Sr)-Leachable			123.2		%		70-130	07-AUG-20
Thallium (Tl)-Leachable			92.1		%		70-130	07-AUG-20
Tin (Sn)-Leachable			96.7		%		70-130	07-AUG-20
Titanium (Ti)-Leachable			N/A	MS-B	%		-	07-AUG-20
Uranium (U)-Leachable			99.0		%		70-130	07-AUG-20
Vanadium (V)-Leachable			106.7		%		70-130	07-AUG-20
Zinc (Zn)-Leachable			101.8		%		70-130	07-AUG-20
Batch R5178640								
WG3379064-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	10-AUG-20
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	10-AUG-20
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R5178640								
WG3379064-1 MB								
Barium (Ba)-Leachable			<0.10		mg/L		0.1	10-AUG-20
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	10-AUG-20
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	10-AUG-20
Boron (B)-Leachable			<0.10		mg/L		0.1	10-AUG-20
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	10-AUG-20
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	10-AUG-20
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	10-AUG-20
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	10-AUG-20
Iron (Fe)-Leachable			<0.030		mg/L		0.03	10-AUG-20
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	10-AUG-20
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	10-AUG-20
Manganese (Mn)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	10-AUG-20
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	10-AUG-20
Potassium (K)-Leachable			<0.050		mg/L		0.05	10-AUG-20
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	10-AUG-20
Silicon (Si)-Leachable			<0.20		mg/L		0.2	10-AUG-20
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	10-AUG-20
Sodium (Na)-Leachable			<1.0		mg/L		1	10-AUG-20
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	10-AUG-20
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	10-AUG-20
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	10-AUG-20
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	10-AUG-20
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	10-AUG-20
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	10-AUG-20
WG3379064-2 MS		**L2479795-5**						
Aluminum (Al)-Leachable			N/A	MS-B	%		-	10-AUG-20
Antimony (Sb)-Leachable			100.6		%		70-130	10-AUG-20
Arsenic (As)-Leachable			90.7		%		70-130	10-AUG-20
Barium (Ba)-Leachable			105.3		%		70-130	10-AUG-20

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R5178640								
WG3379064-2 MS		**L2479795-5**						
Beryllium (Be)-Leachable			93.7		%		70-130	10-AUG-20
Bismuth (Bi)-Leachable			95.8		%		70-130	10-AUG-20
Boron (B)-Leachable			94.8		%		70-130	10-AUG-20
Cadmium (Cd)-Leachable			94.9		%		70-130	10-AUG-20
Calcium (Ca)-Leachable			N/A	MS-B	%		-	10-AUG-20
Chromium (Cr)-Leachable			96.1		%		70-130	10-AUG-20
Cobalt (Co)-Leachable			94.2		%		70-130	10-AUG-20
Copper (Cu)-Leachable			97.1		%		70-130	10-AUG-20
Iron (Fe)-Leachable			111.3		%		70-130	10-AUG-20
Lead (Pb)-Leachable			98.1		%		70-130	10-AUG-20
Lithium (Li)-Leachable			91.0		%		70-130	10-AUG-20
Magnesium (Mg)-Leachable			103.3		%		70-130	10-AUG-20
Manganese (Mn)-Leachable			N/A	MS-B	%		-	10-AUG-20
Molybdenum (Mo)-Leachable			97.8		%		70-130	10-AUG-20
Nickel (Ni)-Leachable			99.2		%		70-130	10-AUG-20
Phosphorus (P)-Leachable			97.1		%		70-130	10-AUG-20
Potassium (K)-Leachable			98.4		%		70-130	10-AUG-20
Selenium (Se)-Leachable			96.9		%		70-130	10-AUG-20
Silicon (Si)-Leachable			101.7		%		70-130	10-AUG-20
Silver (Ag)-Leachable			99.7		%		70-130	10-AUG-20
Sodium (Na)-Leachable			99.9		%		70-130	10-AUG-20
Strontium (Sr)-Leachable			99.4		%		70-130	10-AUG-20
Thallium (Tl)-Leachable			96.1		%		70-130	10-AUG-20
Tin (Sn)-Leachable			92.5		%		70-130	10-AUG-20
Titanium (Ti)-Leachable			N/A	MS-B	%		-	10-AUG-20
Uranium (U)-Leachable			98.4		%		70-130	10-AUG-20
Vanadium (V)-Leachable			94.5		%		70-130	10-AUG-20
Zinc (Zn)-Leachable			93.8		%		70-130	10-AUG-20
Batch R5213057								
WG3398944-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	06-SEP-20
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	06-SEP-20
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Barium (Ba)-Leachable			<0.10		mg/L		0.1	06-SEP-20

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R5213057								
WG3398944-1 MB								
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	06-SEP-20
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	06-SEP-20
Boron (B)-Leachable			<0.10		mg/L		0.1	06-SEP-20
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	06-SEP-20
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	06-SEP-20
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	06-SEP-20
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	06-SEP-20
Iron (Fe)-Leachable			<0.030		mg/L		0.03	06-SEP-20
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	06-SEP-20
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	06-SEP-20
Manganese (Mn)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	06-SEP-20
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	06-SEP-20
Potassium (K)-Leachable			<0.050		mg/L		0.05	06-SEP-20
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	06-SEP-20
Silicon (Si)-Leachable			<0.20		mg/L		0.2	06-SEP-20
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	06-SEP-20
Sodium (Na)-Leachable			<1.0		mg/L		1	06-SEP-20
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	06-SEP-20
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	06-SEP-20
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	06-SEP-20
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	06-SEP-20
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	06-SEP-20
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	06-SEP-20
WG3398944-2 MS		**L2479795-1**						
Aluminum (Al)-Leachable			N/A	MS-B	%		-	06-SEP-20
Antimony (Sb)-Leachable			95.7		%		70-130	06-SEP-20
Arsenic (As)-Leachable			90.2		%		70-130	06-SEP-20
Barium (Ba)-Leachable			91.8		%		70-130	06-SEP-20
Beryllium (Be)-Leachable			92.5		%		70-130	06-SEP-20

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R5213057								
WG3398944-2 MS		**L2479795-1**						
Bismuth (Bi)-Leachable			89.6		%		70-130	06-SEP-20
Boron (B)-Leachable			84.8		%		70-130	06-SEP-20
Cadmium (Cd)-Leachable			96.9		%		70-130	06-SEP-20
Calcium (Ca)-Leachable			N/A	MS-B	%		-	06-SEP-20
Chromium (Cr)-Leachable			89.6		%		70-130	06-SEP-20
Cobalt (Co)-Leachable			94.1		%		70-130	06-SEP-20
Copper (Cu)-Leachable			92.4		%		70-130	06-SEP-20
Iron (Fe)-Leachable			88.9		%		70-130	06-SEP-20
Lead (Pb)-Leachable			91.3		%		70-130	06-SEP-20
Lithium (Li)-Leachable			96.9		%		70-130	06-SEP-20
Magnesium (Mg)-Leachable			96.3		%		70-130	06-SEP-20
Manganese (Mn)-Leachable			92.0		%		70-130	06-SEP-20
Molybdenum (Mo)-Leachable			91.0		%		70-130	06-SEP-20
Nickel (Ni)-Leachable			93.7		%		70-130	06-SEP-20
Phosphorus (P)-Leachable			90.1		%		70-130	06-SEP-20
Potassium (K)-Leachable			100.8		%		70-130	06-SEP-20
Selenium (Se)-Leachable			92.8		%		70-130	06-SEP-20
Silicon (Si)-Leachable			89.7		%		70-130	06-SEP-20
Silver (Ag)-Leachable			93.4		%		70-130	06-SEP-20
Sodium (Na)-Leachable			100.3		%		70-130	06-SEP-20
Strontium (Sr)-Leachable			115.2		%		70-130	06-SEP-20
Thallium (Tl)-Leachable			90.0		%		70-130	06-SEP-20
Tin (Sn)-Leachable			93.2		%		70-130	06-SEP-20
Titanium (Ti)-Leachable			84.9		%		70-130	06-SEP-20
Uranium (U)-Leachable			87.5		%		70-130	06-SEP-20
Vanadium (V)-Leachable			92.3		%		70-130	06-SEP-20
Zinc (Zn)-Leachable			94.5		%		70-130	06-SEP-20

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

CERTIFICATE TB20158992

Project: L2479795

P.O. No.: L2479795

This report is for 4 Drill Core samples submitted to our lab in Thunder Bay, ON, Canada on 27-JUL-2020.

The following have access to data associated with this certificate:

ALS ENVIRONMENTAL		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize up to 250g 85% <75 um
CRU-QC	Crushing QC Test
PUL-QC	Pulverizing QC Test
SPL-21X	Addnl Crush Split w No Analysis

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
OA-VOL08	Basic Acid Base Accounting	
S-IR08	Total Sulphur (IR Spectroscopy)	LECO
OA-ELE07	Paste pH	
S-CAL06	Sufide Sulfur (calculated)	LECO
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ

<original signed by>

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Comments: L2479795

Signature:
Saa er

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

Project: L2479795

CERTIFICATE OF ANALYSIS TB20158992

Sample Description	Method Analyte Units LOD	WEI-21 Recvd Wt. kg 0.02	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
WQA-1 (14 feet, 2 inches-15 feet)		0.77	0.3	1	4	4	9.6	12.80	0.01	<0.01	0.01	0.01	<0.05	<0.2
WQR-6B (28 feet-28 feet ,9 inches)		0.53	<0.3	1	10	10	9.3	64.00	<0.01	<0.01	<0.01	<0.01	<0.05	<0.2
WQR-4 (20 ft, 7 inches-21 ft, 6 inches)		0.68	0.6	1	11	12	9.5	19.20	0.02	<0.01	<0.01	0.02	<0.05	<0.2
WQR-3 (18 feet-18 feet, 9 inches)		0.58	5.0	1	2	7	9.5	1.40	0.16	0.01	<0.01	0.15	<0.05	<0.2

Comments: L2479795

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

Project: L2479795

CERTIFICATE OF ANALYSIS TB20158992

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Processed at ALS Thunder Bay located at 645 Norah Crescent, Thunder Bay, ON, Canada

Applies to Method:				
	CRU-31	CRU-QC	LOG-22	PUL-31
	PUL-QC	SPL-21	SPL-21X	WEI-21

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:				
	C-GAS05	OA-ELE07	OA-VOL08	S-CAL06
	S-GRA06	S-GRA06a	S-IR08	

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 604 984 0221 Fax: +1 604 984 0218
www.alsglobal.com/geochemistry

To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

CERTIFICATE VA20162108

Project: L2479795

P.O. No.: L2479795

This report is for 6 Rock samples submitted to our lab in Vancouver, BC, Canada on 29-JUL-2020.

The following have access to data associated with this certificate:

ALS ENVIRONMENTAL	CHRISTINE PARADIS	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
PUL-31	Pulverize up to 250g 85% <75 um
DISP-01	Disposal of all sample fractions

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
OA-VOL08	Basic Acid Base Accounting	
S-IR08	Total Sulphur (IR Spectroscopy)	LECO
OA-ELE07	Paste pH	
S-CAL06	Sufide Sulfur (calculated)	LECO

<original signed by>

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Saa Traxler, General Manager, North Vancouver

ALS Canada Ltd.
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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

Project: L2479795

CERTIFICATE OF ANALYSIS VA20162108

Sample Description / Method / Analyte / Units / LOD	WEI-21 Recvd Wt. kg 0.02	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
L2479795-5 WQA-3 FROM 10-12	0.24	0.3	3	214	214	8.3	684.8	0.01	<0.01	<0.01	0.01	2.51	9.2
L2479795-6 WQR-2A FROM 5-7	0.24	0.3	3	381	381	8.1	1219.0	0.01	<0.01	<0.01	0.01	4.40	16.1
L2479795-7 WQA-5 FROM 15-16.6	0.24	0.6	3	357	358	8.2	572.8	0.02	<0.01	0.03	0.02	4.18	15.3
L2479795-8 WQR-5 FROM 7 6-9 6	0.24	0.3	3	404	404	8.1	1293.0	0.01	<0.01	0.02	0.01	4.77	17.5
L2479795-9 WQR-3 FROM 7 6-9 6	0.22	0.3	3	323	323	8.5	1033.5	0.01	<0.01	0.01	0.01	3.76	13.8
L2479795-10 WQR1- FROM 15-17	0.22	0.6	3	440	441	8.4	705.6	0.02	<0.01	0.03	0.02	5.27	19.3

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

Project: L2479795

CERTIFICATE OF ANALYSIS VA20162108

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:			
C-GAS05	CRU-31	DISP-01	LOG-22
OA-ELE07	OA-VOL08	PUL-31	S-CAL06
S-GRA06	S-GRA06a	S-IR08	WEI-21

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

QC CERTIFICATE TB20158992

Project: L2479795

P.O. No.: L2479795

This report is for 4 Drill Core samples submitted to our lab in Thunder Bay, ON, Canada on 27-JUL-2020.

The following have access to data associated with this certificate:

ALS ENVIRONMENTAL		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize up to 250g 85% <75 um
CRU-QC	Crushing QC Test
PUL-QC	Pulverizing QC Test
SPL-21X	Addnl Crush Split w No Analysis

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
OA-VOL08	Basic Acid Base Accounting	
S-IR08	Total Sulphur (IR Spectroscopy)	LECO
OA-ELE07	Paste pH	
S-CAL06	Sufide Sulfur (calculated)	LECO
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ

<original signed by>

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Comments: L2479795

Signature:
Saa Traxler, General Manager, North Vancouver

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 604 984 0221 Fax: +1 604 984 0218
www.alsglobal.com/geochemistry

To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS TB20158992

Sample Description	Method Analyte Units LOD	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
STANDARDS												
Buffer pH6						5.9						
Buffer pH6						6.1						
Target Range - Lower Bound						5.3						
Upper Bound						6.7						
DS-1								2.60				
Target Range - Lower Bound								2.51				
Upper Bound								2.71				
GS313-8								1.26				
Target Range - Lower Bound								1.19				
Upper Bound								1.29				
KZK-1		25.0	2	33	58		2.32					
KZK-1		25.0	2	34	59		2.36					
Target Range - Lower Bound		22.9		30	54		2.18					
Upper Bound		27.1		38	64		2.54					
SY-4											0.90	3.3
Target Range - Lower Bound											0.84	3.0
Upper Bound											1.08	4.0
UTS-1									0.91			
Target Range - Lower Bound									0.83			
Upper Bound									0.93			
UTS-1										0.91		
Target Range - Lower Bound										0.81		
Upper Bound										0.95		
UTS-4									1.75			
Target Range - Lower Bound									1.64			
Upper Bound									1.84			
UTS-4										1.74		
Target Range - Lower Bound										1.61		
Upper Bound										1.87		

Comments: L2479795

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS TB20158992

Sample Description	Method Analyte Units LOD	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
BLANKS												
BLANK											<0.05	<0.2
Target Range - Lower Bound											<0.05	<0.2
Upper Bound											0.10	0.4
BLANK						5.9						
Target Range - Lower Bound						5.5						
Upper Bound						6.9						
BLANK									<0.01			
Target Range - Lower Bound									<0.01			
Upper Bound									0.02			
BLANK										<0.01		
Target Range - Lower Bound										<0.01		
Upper Bound										0.02		
BLANK								0.01				
Target Range - Lower Bound								<0.01				
Upper Bound								0.02				
DUPLICATES												
ORIGINAL											0.38	1.4
DUP											0.38	1.4
Target Range - Lower Bound											0.31	1.1
Upper Bound											0.45	1.7
WQR-3 (18 feet-18 feet, 9 inches)								0.16				
DUP								0.15				
Target Range - Lower Bound								0.14				
Upper Bound								0.17				
ORIGINAL						8.1			<0.01	<0.01		
DUP						8.1			<0.01	<0.01		
Target Range - Lower Bound						7.6			<0.01	<0.01		
Upper Bound						8.6			0.02	0.02		
ORIGINAL		22.8	2	34	57		2.50					
DUP		22.8	2	34	57		2.50					
Target Range - Lower Bound		21.4	<1	31	53		2.37					
Upper Bound		24.2	3	37	61		2.64					

Comments: L2479795

***** See Appendix Page for comments regarding this certificate *****

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1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 26-AUG-2020
Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS TB20158992

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Processed at ALS Thunder Bay located at 645 Norah Crescent, Thunder Bay, ON, Canada

Applies to Method:				
	CRU-31	CRU-QC	LOG-22	PUL-31
	PUL-QC	SPL-21	SPL-21X	WEI-21

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:				
	C-GAS05	OA-ELE07	OA-VOL08	S-CAL06
	S-GRA06	S-GRA06a	S-IR08	

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

QC CERTIFICATE VA20162108

Project: L2479795

P.O. No.: L2479795

This report is for 6 Rock samples submitted to our lab in Vancouver, BC, Canada on 29-JUL-2020.

The following have access to data associated with this certificate:

ALS ENVIRONMENTAL	CHRISTINE PARADIS	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
PUL-31	Pulverize up to 250g 85% <75 um
DISP-01	Disposal of all sample fractions

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
OA-VOL08	Basic Acid Base Accounting	
S-IR08	Total Sulphur (IR Spectroscopy)	LECO
OA-ELE07	Paste pH	
S-CAL06	Sufide Sulfur (calculated)	LECO

<original signed by>

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Saa Traxler, General Manager, North Vancouver

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THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS VA20162108

Sample Description	Method Analyte Units LOD	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
STANDARDS												
Buffer pH6						6.0						
Buffer pH6						6.1						
Target Range - Lower Bound						5.3						
Upper Bound						6.7						
CO-ASSAY											0.50	1.8
Target Range - Lower Bound											0.42	1.5
Upper Bound											0.64	2.4
GS310-10								0.27				
Target Range - Lower Bound								0.25				
Upper Bound								0.29				
KZK-1		25.0	2	34	59		2.36					
Target Range - Lower Bound		22.9		30	54		2.18					
Upper Bound		27.1		38	64		2.54					
MA-1b								1.15				
Target Range - Lower Bound								1.12				
Upper Bound								1.22				
MA-2c											1.61	5.9
Target Range - Lower Bound											1.50	5.5
Upper Bound											1.84	6.8
NBM-1		8.8	2	41	50		5.71					
Target Range - Lower Bound		7.8		37	45		5.26					
Upper Bound		9.7		47	54		6.08					
UTS-1									0.90			
Target Range - Lower Bound									0.83			
Upper Bound									0.93			
UTS-1										0.91		
Target Range - Lower Bound										0.81		
Upper Bound										0.95		
UTS-4									1.74			
Target Range - Lower Bound									1.64			
Upper Bound									1.84			
UTS-4										1.73		
Target Range - Lower Bound										1.61		
Upper Bound										1.87		

***** See Appendix Page for comments regarding this certificate *****

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Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS VA20162108

Sample Description	Method / Analyte / Units / LOD	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
BLANKS												
BLANK											<0.05	<0.2
Target Range - Lower Bound											<0.05	<0.2
Upper Bound											0.10	0.4
BLANK						6.0						
Target Range - Lower Bound						5.5						
Upper Bound						6.9						
BLANK									<0.01			
Target Range - Lower Bound									<0.01			
Upper Bound									0.02			
BLANK										<0.01		
Target Range - Lower Bound										<0.01		
Upper Bound										0.02		
BLANK								0.01				
Target Range - Lower Bound								<0.01				
Upper Bound								0.02				
DUPLICATES												
ORIGINAL										0.57		
DUP										0.60		
Target Range - Lower Bound										0.55		
Upper Bound										0.62		
L2479795-5 WQA-3 FROM 10-12											2.51	9.2
DUP											2.51	9.2
Target Range - Lower Bound											2.33	8.5
Upper Bound											2.69	9.9
ORIGINAL		11.3	2	14	25		2.22					
DUP		11.3	2	14	25		2.22					
Target Range - Lower Bound		10.4	<1	12	23		2.10					
Upper Bound		12.2	3	16	27		2.34					
ORIGINAL									0.25			
DUP									0.25			
Target Range - Lower Bound									0.23			
Upper Bound									0.27			

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS VA20162108

Sample Description	Method / Analyte / Units / LOD	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2
DUPLICATES												
ORIGINAL						4.1		0.42				
DUP						4.2		0.41				
Target Range - Lower Bound						3.8		0.39				
Upper Bound						4.5		0.44				

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL -THUNDER BAY**
1081 BARTON STREET
THUNDER BAY ON P7B 5N3

Finalized Date: 30-AUG-2020
Account: ALSETB

Project: L2479795

QC CERTIFICATE OF ANALYSIS VA20162108

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Applies to Method: Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

C-GAS05	CRU-31	DISP-01	LOG-22
OA-ELE07	OA-VOL08	PUL-31	S-CAL06
S-GRA06	S-GRA06a	S-IR08	WEI-21

Chain of Custody (COC) / Analytical Request Form

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2479795-COFC

COC Number: 17 - 02

Page 2 of 1

Report To	Contact and company name below will appear on the final report
Company:	SNC Lavalin Inc.
Contact:	Wilson Liu
Phone:	416.635.5882 ext. 55806
	Company address below will appear on the final report
Street:	195 The West Mall
City/Province:	Toronto, ON
Postal Code:	M9C 5K1
Invoice To	Same as Report To ☐ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	SNC Lavalin Inc.
Contact:	payables@snclavalin.com

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1: Holly.Regier@snclavalin.com
Email 2: Wilson.Liu@snclavalin.com
Email 3:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1: payables@snclavalin.com
Email 2: Wilson.Liu@snclavalin.com

Project Information

ALS Account # / Quote #:	21736 / Q80740
Job #:	661910
PO / AFE:	12132
LSD:	Task Code: Y3-07-GEO1-01-TEC

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only): L2479795
ALS Contact:
Sampler: M. SALEEM

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E - 100%] ☐ | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Acid Rock Drainage - ABA Package 5	SPLP Metals and Prep	FIELD PH	FIELD TEMPERATURE	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	WQA-1 (From 14'2"– 15')	05-07-20	14:00	Rock	1	✓	✓				
	WQR-6B (From 28'– 28'9")	19-07-20	14:30	Rock	1	✓	✓				
	WQR-4 (From 20'7"– 21'-6")	21-07-20	15:15	Rock	1	✓	✓				
	WQR-3 (From 18'– 18'9")	23-07-20	11:00	Rock	1	✓	✓				
				~~Rock~~							
	WQA-3 (From 10' to 12')	09-07-20	11:25	Soil~~Rock~~	1	✓	✓				
	WQR-2A (From 5'–7')	11-07-20	14:10	Soil~~Rock~~	1	✓	✓				
	WQA-6 (From 15'– 16'6")	13-07-20	14:45	Soil ~~Rock~~	1	✓	✓				
	WQR-5 (From 7'6"–9'6")	17-07-20	9:40	Soil~~Rock~~	1	✓	✓				
	WQR-3 (From 7'6"–9'6")	22-07-20	15:00	Soil~~Rock~~	1	✓	✓				
	WQR-1 (From 15'–17')	24-07-20	11:50	Soil~~Rock~~	1	✓	✓				
				Rock							

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human consumption/ use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

100 grams minimum is required to complete ARD.
100grams minimum is required for Metals Leaching SPLP.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ | Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
6.9	

SHIPMENT RELEASE (client use)

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APPENDIX D

Geotechnical Engineering Report

Webequie Supply Road Project

Webequie First Nation

October 18, 2024

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APPENDIX D – GEOTECHNICAL ENGINEERING REPORT

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1. Introduction

This report presents an overview of the desktop studies, field and laboratory investigations carried out, and preliminary engineering to support the Environmental Assessment (EA) and Preliminary Engineering and Design of the proposed Webequie Supply Road (WSR) Project. The WSR is a 107 km long all-season road development between Webequie First Nation (Webequie) and mining exploration and future mining development in the McFaulds Lake area (locally known as the "Ring of Fire", a massive mineral development prospect in Northern Ontario) as shown in Figure 1-1 in **Appendix A**.

A series of onsite and desktop studies, geotechnical field investigations and laboratory testing programs were carried out to support the EA study and the preliminary design of the project. These studies and investigations are reported in separate documents presented as Appendix A to this report. The current geotechnical engineering database includes the following documents:

- J.D. Mollard and Associates (2019a): Terrain Analysis, Potential Aggregate Sources & Identification of Route Alternatives.
- J.D. Mollard and Associates (2019b): Field Investigation of Peat Thickness and Potential Aggregate Sources.
- AtkinsRéalis (2024). Geotechnical Investigation Factual Report.
- Available pertinent documentation from Eagle's Nest and McFaulds Lake Projects (Noront).

The aim of these studies, site investigations and preliminary engineering is to establish the following:

- Preliminary assessment of the subsurface conditions along the preliminary proposed road corridor and associated waterbody crossings.
- Identification and preliminary assessment of potential aggregate sources, borrow pits and quarry sources for the road construction.
- Preliminary design and construction recommendations for the road structure and its foundations.
- Preliminary design and construction recommendations for the potential water crossing structures foundations; and
- Preliminary design and construction recommendations for the development of potential aggregate sources, borrow pits and quarry sources, and their associated access roads.

The preliminary proposed road corridor and its prominent site features are shown in Figure 1-2 in **Appendix A**. The WSR has two distinct sections, namely the North-South trending section and the East-West trending section. The North-South section commences at the project's west terminus (Webequie Airport) and is about 50 km long and the rest (terminating at McFaulds Lake) is considered to be the East-West section.

The alternate routes within the preferred corridor included the Webequie First Nation community's preferred route, the optimal geotechnical route, and the optimal engineering route**.** All three of these potential routes were standardized to a 35 m right of way to allow for a fair comparison. The potential routes were given numeric identifiers as follows:

- Alternative 1 = Webequie First Nation Community's preferred Route;
- Alternative 2 = Optimal Geotechnical Route; and
- Alternative 3 = Optimal Engineering Route.

2. Terrain and Topography

The preliminary proposed supply road corridor crosses through an area of extensive wetlands, organic soils, and several watercourses, including a few large waterbodies. The terrain and topography along the preliminary proposed corridor are relatively flat with two distinct sections, namely the North-South trending section and the East-West trending section (see Figure 2-1 in **Appendix A**). In general, the North-South section of the road passes typically through an area of high relief and better ground conditions, while the East-West section passes typically through an area of low relief and poor ground conditions (wetland/peatland of bogs and fens, and waterbodies). Typical elevations in the North-South section are higher than 200 masl, while in the East-West section the typical elevation lower than 200 masl.

3. Geotechnical Database Overview

The following studies and investigations comprise the current geotechnical database for this project:

- J.D. Mollard and Associates (2019a): The terrain analysis, potential aggregate sources & identification of route alternatives.
- J.D. Mollard and Associates (2019b): The field investigation of peat thickness and potential aggregate sources.
- AtkinsRéalis (2024): The geotechnical investigation factual report.
- Eagle's Nest and McFaulds Lake Projects (Noront): Relevant available documentation.

A brief overview summary of these studies and investigation follows below.

3.1 J.D. Mollard and Associates (JDMA) Studies and Investigations

J.D. Mollard and Associates (2019a)

JDMA conducted terrain mapping within the preliminary proposed road corridor to facilitate identification of potential aggregate sources, characterization of stream crossings, mapping of several competing route alternatives, and identification of an optimal route based on terrain, soils and related engineering considerations. A two (2) km wide corridor was considered for this study and utilized LiDAR survey data with a spatial resolution of 1 m. The study also included an onsite GPR (ground penetrating radar) survey conducted in February 2019 when the ground was frozen and covered with snow.

The route corridor crosses extensive organic terrains of various bogs and fens along the east-west section of the corridor west of Esker Camp and glacial terrains with mineral soils on the roughly north-south section leading to the community of Webequie. Mineral terrains include till with a discontinuous lacustrine clay veneer, glaciofluvial ice-contact, esker ridges, and alluvial floodplains. Organic terrains include bogs and fens with tremendous diversity and extent. The organic terrains and waterbody crossing along the study corridor account approximately 45% of the total length of the proposed corridor.

Peat thicknesses from ground penetrating radar surveys range from 0.5 to 5 m. Overall these observations suggest that, except for treed bogs, peat thickness is similar in bogs and fens with common thicknesses of 1 -3 m and maximum thicknesses up to 5 m. Peat thickness in treed bogs is generally less than 2 m.

Most of the water crossings identified have relief less than 3 m and open water widths ranging from 3 to 250 m. The maximum crossing relief is 20 m at the Muketei River. The widest crossing is the Winisk Lake crossing, with width about 250 m.

Several potential aggregate sources have been identified, including glacial granular deposits and bedrock outcrops. Glacial granular sources are concentrated in large glaciofluvial deposits at the east and west ends of the project area. Bedrock outcrops are present within and outside of the routing corridor and are distributed across the project area. Reference can be made to **Appendix B**-1 for the details of this report.

J.D. Mollard and Associates (2019b)

JDMA further expanded the database by gathering onsite data for peat thickness, and for borrow pits and quarries. Peat thickness was measured using a peat probe to push through the organics and into the underlying mineral soil.

Where access and timing allowed, a mini excavator was used to dig test pits to a depth of about 2 m. At other locations, where logistical challenges restricted deployment of the mini-excavator, test pits were dug manually to a depth of 30-90 cm. Bedrock outcrops identified and mapped as potential quarry sites were visited in the field to describe the lithology and structural elements (fractures, bedding, foliation, etc.) visible at surface to make an initial assessment of bedrock suitability for aggregate and rip-rap material production.

Peat thickness measured from a soil probe returned values typically from 1 to 4 m, which is consistent with reported values from the wetlands classification system and previous observations from ground penetrating radar and peat probing. At most of the sampling sites, the peat probe penetrated the organic material and was stopped in underlying clay or clayey till.

Potential aggregate sources identified from published surficial mapping and recent terrain analysis using digital air photos and LiDAR include ice-contact glaciofluvial landforms and bedrock outcrops. Ice-contact glaciofluvial landforms, are primarily composed of clean medium to coarse sand and occur at locations close to the proposed routes. Where granular material was encountered, the shallow test pits provide limited value to characterize the entire landforms on which they were dug. Further testing with drilling equipment would be required to evaluate the total thickness of the deposits and to calculate a volume of granular material. It should be noted that the candidate deposits have been identified based on their granular material composition and for their relatively close proximity to the preliminary proposed supply road corridor, which will limit the haul distances of these aggregate materials during construction and/or maintenance activities. Several other granular material sources were identified, but these are located several kilometers from the proposed route and would require a stream crossing; therefore, they are not being considered for further assessment.

Bedrock outcrops are present within and outside of the routing corridor and are distributed across the project area. They have been mapped as bedrock, although there were boulder fields and till present. Bedrock observed at the test sites was felsic plutonic (granitic), massive, and homogeneous, which should be suitable for aggregate/rip-rap production. Reference can be made to Appendix B-2 for the details of this report.

3.2 AtkinsRéalis Studies and Investigations

A total of ten (10) boreholes were advanced in winter/fall 2019. Standard Penetration Testing (SPT) and split spoon soil sampling were carried out at regular intervals through the overburden. Recovered soil samples were logged, photographed, and examined in the field as per the ASTM D2487 - USCS (unified soil classification system) protocol. RQD (Rock Quality Designation), SCR (Solid Core Recovery) and TCR (Total Core Recovery) were recorded. Geotechnical laboratory testing was performed on selected soil and rock samples. The testing including primarily index tests for soils, such as gradation and Atterberg limit tests, unconfined compressive strength (UCS) and point load tests for rock core samples, and abrasion and soundness tests for potential aggregate samples were conducted. Field observations were made during drilling and upon completion of borings with respect to groundwater conditions. The results of the investigations were presented in a separate report.

3.3 Eagle’s Nest and McFaulds Lake Projects

A number of relevant reports available from the Eagle’s Nest and the McFaulds Lake Projects (Noront) also contributed to the database for WSR project. It should be noted that the focus of these projects was mainly on the eastern section of the supply road corridor and their preference for the road connectivity has been typically south and southwest relative to WSR corridor (i.e., a connection from the McFaulds Lake area to the provincial highway system at Nakina or Pickle Lake).

4. Overview of Subsurface Conditions

The subsurface stratigraphy encountered at site consists of surficial organics, local surficial to deep peat, predominantly fine-grained overburden soils (silt, sandy silt), silty/sandy gravel, till and clay, overlying granite / gneiss bedrock. Detailed subsurface conditions encountered during the geotechnical investigation are presented further below.

The subsurface stratigraphy encountered at site consists of surficial Organic layer, Peat, Organic Silt, Glacial Till, glacial and fluvial deposit of Sand and Sandy Silt deposits overlain Granite / Gneiss bedrock.

Reference should be made to WSR Geotechnical Investigation Factual Report (661910-0000-4GER-0001) for detailed information at each borehole location, subsurface stratigraphic units and their thickness, field, and laboratory test results, the SPT N-values of each soil unit and observed groundwater conditions.

4.1 Organics and Peat

Based on JDMA report - Field Investigation of Peat Thickness and Potential Aggregate Sources (**Appendix B-1**), organic terrain units (bogs and fens) were mapped over significant portions of the corridor with peat depths estimated to vary from 0.5 to 5.0 m.

In general, the thickness of organics and peat along the major portion of the North-South section is less than 1.0 m. The thickness of organics and peat along the major portion of the East-West section is from 2 m to greater than 4 to 5 m.

4.2 Overburden Mineral Soils

Overburden soils are predominantly fine grained, till and esker deposits. Fines predominantly have low plasticity. The overburden soil deposits consist of stratified and unstratified Pleistocene tills and Quaternary organic deposits. The till is deposited on North-South section, the west part of the East-West section, and some isolated areas in the remaining section of the proposed road.

4.3 Bedrock

The bedrock encountered during the geotechnical investigations can be described as strong rock of “Fair to Good” quality. Bedrock encountered in the area is mostly strong granodiorite and granite.

4.4 Groundwater

The groundwater table is generally shallow from 0.0 m to 1.5 m below existing ground surface, and a portion of the East-West section is water-logged.

5. Site Seismicity

5.1 Site Class

Based on available geotechnical data along the preliminary proposed supply road corridor, considering average properties to the upper 30 m, for deep foundation design, the project site for the most parts classified as Class C “Very dense soil and soft rock profile”, having average properties in the top 30 m, such as: Soil Shear Wave Velocity of 360 - 760 m/s or Standard Penetration Resistance SPT N-value >50, or Soil Undrained Shear Strength >100 kPa according to the National Building Code of Canada (NBCC 2020).

It should be recognized that the supply road passes through peat and/or organic clays greater than 3 m thick in some locations, where a soil classification of F “Other” is also applicable for road embankment design.

5.2 Earthquake Design Parameters

Seismic hazard values were adopted in accordance with the National Building Code of Canada, NBCC 2020, considering a representative geographic coordinate of the project site for earthquake design parameters as: 52.8°N and 86.3°W. In accordance with NBCC 2020, the mapped acceleration parameters for the project site for the 5%-damped horizontal spectral acceleration values and the horizontal peak ground acceleration values that have a 2% probability of being exceeded in 50 years (1 in 2,475-year return period) corresponding to site Class C are as follows:

- Spectral response acceleration at a period of 0.2 sec or Sa(0.2): 0.0854g;
- Spectral response acceleration at a period of 1 sec or Sa(1): 0.0277g;
- Peak Ground Acceleration, PGA: 0.0403g; and
- (Where g is acceleration due to gravity).

5.3 Geohazards

No landslide hazards were identified, nor were sinkholes or major geological depressions or geological anomalies observed.

In general, the site is in discontinuous permafrost regions, thaw weakening may be concern if ice rich soils were present under the road alignment.

Adfreeze forces on piles or buried foundation surfaces through the frost penetration depths shall be considered for the design.

Settlement of the road embankment may induce negative skin friction and drag load on foundations for water crossing structures.

6. Frost Depth and Permafrost

6.1 Freezing Index

The normal freezing index is estimated to be about 3000°C-days at Lansdowne House Station (based on Environment Canada data from 1971 to 2000).

6.2 Frost Depth

Based on Published Table of Frost Depths for Ontario by Location from MTO Research Publication RR 225, “Aspects of Prolonged Exposure to Sub-Zero Temperatures” dated December 1981, the frost penetration depth for the WSR Project site in Northern Ontario is estimated at 3 m. The conventional approach for protection of foundations against frost action is to locate foundations and/or the base of grade beams (supported on deep foundation) at a depth at least equal to the depth of frost penetration. Therefore, a minimum frost penetration depth of 3.0 m is recommended for all exposed load bearing foundations. Partial or complete frost protection may also be achieved by using rigid polystyrene insulation. Thermal insulation should also be considered for Perimeter Pile Cap/Piled-Mat Foundation, where applicable.

6.3 Permafrost

Based on the permafrost map of Canada, the site is in a discontinuous permafrost region of Canada (sporadic to isolated presence) with ground ice content defined as low. More specifically, the project area is situated within a band of sporadic permafrost that is part of the Discontinuous Permafrost Zone of Canada’s permafrost region (National Atlas of Canada, 5th Edition (1995): Canada Permafrost). In the Discontinuous Zone, some areas beneath the land surface have permafrost and other areas are free of permafrost. In the sporadic permafrost band where the project area is located, permafrost occurs in islands (10 to 50 % of the land area is underlain by permafrost); permafrost varies in thickness (estimated at a few meters in the project area); the active layer (the surface layer of soil or rock above the permafrost) may not extend down to the permafrost; and ground ice content in the upper 10-20 m of the ground is categorized as Low (less than 10%). In addition, the thickness of the permafrost may be influenced by soil and rock type, snow cover and proximity to waterbodies

6.4 Thaw Consolidation and Settlement

During the field investigations carried out so far, no frozen ground was encountered. During the next phase of the Project, if frozen ground is encountered below the active frost depth, thaw consolidation tests shall be considered on ice rich soils. Thaw consolidation tests have two components: the thaw test; and then the usual consolidation test and the tests are done in a conventional consolidation cell. A frozen soil sample is placed in a consolidation cell and is allowed to thaw under nominal or expected in situ stress, and then the conventional consolidation test is continued. This allows measuring the thaw strain during thaw testing and then the usual consolidation parameters during the consolidation process. The undrained shear strength at the end of consolidation shall also been measured. Dense/hard till and bedrock have no challenges with thaw consolidation. Overburden thickness is generally small; therefore, thaw strain may not be significant or a major design challenge.

7. Borrows and Quarries

The project will require construction materials for subgrade, pavement structure, water crossing embankments, road embankments through low-lying areas (with seasonal flooding), embankments through marsh/water-logged areas, and for the construction of temporary access roads and laydown areas/camps. There are no approved, established, or commercial borrow pits and quarries along the WSR corridor.

The WSR is proposed to be built as close as possible to the natural terrain contours to limit the volume of earthworks and aggregate material required for the road surface. Construction camps, storage yards and temporary/permanent access roads will also be graded in a manner that minimizes the volume of the construction material needed. Naturally occurring till material can be used as subgrade or for subgrade construction. Aggregates of sand and sand and gravel will be required for roadway construction and roadway maintenance and operation of the WSR. The total quantity of construction materials, including till, aggregates and rip-rap material for erosion protection on water crossings, is unknown at this time and will be determined during the detail design phase of the Project. Till deposits are located through most of the North-South section, the west and east parts of the East-West section, and some isolated areas in the middle of the East-West section. Most of the middle part of the East-West section is organic deposits. Large amounts of till will be required as a part of earthworks to prepare the subgrade. Till deposits are typically sandy silt to silt matrix and would be suitable for subgrade construction. These deposits form suitable subgrade and subgrade material. However, they do not form any raised relief that could constitute major borrows. Further, the groundwater table is shallow; therefore, smaller, and frequent borrows pits would be exploited as they are identified along the road.

Potential aggregate sources for the project were identified through desktop studies and verified through onsite investigations (boreholes and test pits). Based on JDMA's study **Appendix B-2**, primary known aggregate sources for the construction of the project are the large esker complex on the west side of the Mukutei River, near Esker camp, and a series of bedrock and glaciofluvial prospects that trend roughly north-south along the western section of the route. The locations of the potential aggregate sources for the project are presented in Figure 7-1 attached in **Appendix A**.

Geotechnical and geomechanically data for these materials are presented in the geotechnical report and the field and geophysical assessment of potential borrows and quarries prepared by JDMA in **Appendix B-2**.

At this stage of the Project, no geochemical investigations or groundwater hydrogeological studies have been carried out; these will be required as a part of development of borrow pits and quarries.

It should be noted that test pits provide bulk samples and are a relatively better assessment of esker deposits in comparison to the information based on boreholes, where limited sampling was possible, but penetration to sample at greater depths occurred.

8. Geochemistry – ARD

Geochemical laboratory analysis has been carried out on selected soil, rock and groundwater samples collected. These analyses are presented and discussed in detail in the Hydrogeology Report. Here, only limited tests on soil and rock samples are briefly presented and discussed in relation to its potential to acid rock drainage risk as construction material or exposed excavations. Geochemical analysis of ground water, soil, and rock pertinent to risk of ground aggressivity to the buried concrete and metal foundations for road infrastructure are also presented and discussed.

Acid Base Account (ABA) suite of geochemical testing has been carried out on selected soil and rock samples for Acid Rock Drain and Metal Leach (ARD/ML) predictions and risk assessment. A total of ten (10) soil and bedrock samples were selected for ARD/ML assessment (refer to Table 8-1 below for a summary of selected samples for the geochemical testing and Appendix C for test results). These are spread over the length of the designated corridor and cover a vertical extent from near surface to about a 10 m depth. Geochemical testing has been completed, and the results are being assessed and analyzed for the ARD/ML assessment. It shall be noted here that the groundwater table is typically shallow and there are no high relief areas for use as pits and quarries. It is expected that these would be several and would typically be shallow.

Early indication is that the Sulphur content (S %) is very low (< 0.2%); therefore, the potential for ARD/ML is low within the potential borrow pits/quarries, at the excavations, or the materials to be used as Fill for road embankment and other pavement structure section constructions.

Table 8-1: Summary of Selected Rock and Soil Samples for the Geochemical Testing

Sample Location	Material Type
WQA-1 (from 14’ 2" to 15’)	Rock
WQR-6B (from 28’ to 28’-9")	Rock
WQR-4 (from 20’-7" to 21’-6")	Rock
WQR-3 (from 10’ to 18’-9")	Rock
WQA-3 (from 10’ to 12’)	Soil
WQR-2A (from 5’ to 7’)	Soil
WQA-5 (from 15’ to 16’-6")	Soil
WQR-5 (from 7’-6" to 9’-6")	Soil
WQR-3 (from 7’-6" to 9’-6")	Soil
WQR1 (from 15’ to 17’)	Soil

9. Water Crossings

The nature of existing and potential water crossings along the preliminary proposed supply road corridor is variable and complex. Some of the crossings have a defined and visible shape and a watercourse cross section can be defined. Some have an irregular and undefined shape, which may require some form of river training works to create in a defined watercourse crossing. Some are low-lying areas (depressions) with potential for seasonal flooding, which may also require water crossings (in the form of culverts) for drainage equalization on either side of the road corridor. A total of thirty-one (31) water crossings have been identified (see Figure 9-1 in **Appendix A**). This figure also shows the borehole layout and the nearest borehole that was used to establish the preliminary subsurface conditions and foundation systems at each of these crossings. These and other details, such as anticipated widths, geotechnical conditions and proposed structural types and foundation options are presented in detail in **Appendix C**.

10. Foundation Design

Foundation systems will be required for the road embankment, water crossing structures and other infrastructure associated with the construction and operation of this road facility.

Both shallow and deep foundations are considered and bearing capacity recommendations are presented here.

10.1 Shallow Foundations

Based on the subsurface conditions reported in the project area, spread footings could be placed on compact to dense till material or on bedrock, depending on the depth to bedrock surface. Where dense till or bedrock is deeper (3 - 4 m depth), excavations may be made to this level, with organics or loose/soft soils above the bedrock removed and replaced by compacted engineered fill to the desired foundation level. In the case the footings are placed on the native till material or engineered fill material, the depth of the footing should be below the frost depth, or below the zone of influence by the creek bank erosion, or the secure depth below creek water table, whichever is deeper. The following geotechnical resistances at Ultimate Limit State (ULS) are recommended for preliminary design:

- ULS bearing capacity on native dense till/ compacted structural fill: 250 kPa.
- ULS bearing capacity on rock formation: 1000 kPa.

Geotechnical resistance factors presented in Table 6.2. in the Canadian Foundation Engineering Manual (CFEM 5th Edition, 2023) based on various degrees of site and model understanding shall be applied to the ULS to determine the factored geotechnical resistances at Ultimate Limit State (ULS) and Service Limit State (SLS).

For preliminary design using static analysis and limited data and information is available at this stage of the project, a geotechnical resistance factor of 0.45 for ULS and 0.70 for SLS will be applied as per Table 6.2 of the CFEM 2023.

10.2 Pile Foundations

Although the use of conventional spread footing would likely be the preferred approach, consideration could be given to use of a pile foundation system for major and significant water crossings where bedrock is deep, or groundwater is close to ground surface and groundwater control is required during the foundation excavation, and/or the soils above are either soft/loose or organics/peat and replacement of such soils is not possible.

For pile foundation design, reference can be made to the Canadian Foundation Engineering Manual (CFEM 5th Edition, 2023) and the Canadian Highway Bridge Design Code (CHBDC 2019) CSA S06-19.

10.2.1 Geotechnical Resistance of Single Pile in Compression

Driven H-piles or closed-ended pipe piles can be used for bridge foundations at majority of the water crossings. The following ULS pile capacity parameters shall be considered for the preliminary design:

Unit shaft friction through dense till: 100 kPa

Unit end bearing on bedrock: 10 MPa.

For a long span crossing such as Winisk Lake, where construction over water may be option, bored piles (or drilled cast-in-place concrete caissons) may be considered. Bedrock is typically shallow, and for such piles only end bearing capacity may be considered in the design.

The following axial geotechnical resistance design parameters (in compression) are recommended for bored piles with at least 1D (D: shaft diameter) or minimum of 2 m penetration into the slightly weathered/fresh bedrock:

- Ultimate unit end bearing resistance: up to 5,000 kPa;
- Ultimate unit bond stress/shaft friction: up to 750 kPa.

For preliminary design using static analysis and limited data and information is available at this stage of the project, a geotechnical resistance factor of 0.35 for ULS and 0.70 for SLS will be applied as per Table 6.2 of the CFEM 2023.

10.2.2 Geotechnical Resistance of a Single Pile in Tension

The following axial capacity design parameters (in tension/uplift) are recommended for bored piles with the shaft penetration into the slightly weathered/fresh bedrock for at least 1D (D: shaft diameter).

- Ultimate Limit State unit bond stress/shaft friction (rock/steel): up to 750 kPa.
- Design Adfreeze bond stress: 65 kPa for concrete structure and 100 kPa for steel

For preliminary design using static analysis and limited data and information is available at this stage of the project, a geotechnical resistance factor of 0.20 for ULS and 0.70 for SLS will be applied respectively as per Table 6.2 of the CFEM 2023.

Adfreeze forces on piles or buried foundation surfaces through the frost penetration depths shall be considered for the design.

Settlements of the road embankment may induce negative skin friction and drag load on foundations for water crossing structures. These shall be examined, wherever applicable.

Deep foundation units for bridge abutments and piers installed adjacent to or in flowing water should be carried to such a depth as to ensure both adequate geotechnical and structural resistance after scour.

10.2.3 Lateral Resistance of Pile

The following lateral resistance design parameters are recommended for Lateral Pile Load analysis using a software package such as L-PILE.

Table 10-1: Geotechnical Parameters used for Lateral Analysis

Soil Unit	Subgroup	Unit Weight (kN/m^3)	SPT N Values	Friction Angle, ϕ (deg)	Undrained Shear Strength, s_u (kPa)
Native Cohesionless	Sand to Silt	19.5	10 to 30	30 to 36	N/A
	Sand and Silt Till	21.0	30 to 50	36 to 41	
Native Cohesive	Medium Stiff Clay	19.0	4 to 8	N/A	24 to 48
	Stiff to Very Stiff Clay		10 to 30		48 to 192

For preliminary design using static analysis and limited data and information is available at this stage of the project, a geotechnical resistance factor of 0.45 for ULS and 0.70 for SLS will be applied to the ULS as per Table 6.2 of the CFEM 2023.

11. Pavement Structure

The objective of pavement design is to develop a cost-effective pavement structure that addresses roadway performance, serviceability and safety requirements. Conventional pavement structure consists of layers of granular subbase course, granular base course, and surface course from bottom to up. The subbase materials usually consist of Ontario Provincial Standard Specifications (OPSS) 1010 Granular B materials, and base materials usually consist of OPSS 1010 Granular A materials. The surface course could be asphaltic material, concrete material, or treated surface depending on the pavement structure design. These layers are founded on a subgrade (foundation of the pavement structures) having sufficient strength to support the traffic load and distribute it across the roadbed.

References should be made to Pavement Design and Rehabilitation Manual (PDRM, Second Edition MTO 2013) for pavement design.

The following site-specific factors are likely to govern the design of the pavement structure in addition to the stability under traffic loading considerations.

- Surface and Sub-surface Drainage
- Seasonal Freezing and Thawing
- Thermal changes in Discontinuous Permafrost
- Muskeg/Peat Subgrade
- Availability of the Construction Materials

11.1 Roadway Over Mineral Soils

Since most of the preliminary proposed road corridor passes through low relief area and the surface profile follows close to the existing topography, surface and subsurface drainage will require careful planning. The esker material under consideration is typically sand or sandy gravel and will form good pavement or subgrade material from drainage considerations. Embankment heights are small; therefore, they are less likely to require benches or drainage on benches. The underlying till is typically clayey and dense, representing very poor sub-surface drainage characteristics.

The project area is in a seasonal frost and discontinuous permafrost area, with severe sub-zero temperatures. The main concerns are frost heave during annual freezing and subgrade weakening during thawing. Frost heave requires the existence of freezing temperatures, frost-susceptible soils, and availability of water. The groundwater table is shallow and will provide water to the freezing front. The upper 3 m of the pavement/subgrade profile will require detailed assessment to minimize impacts due to seasonal freezing and thawing. Esker materials with limited fines and crushed aggregates are potentially non-frost susceptible, while silt or silty material are typically frost-susceptible. Where frost-susceptible subgrade exists within the predicted frost depth, and its replacement with non-frost susceptible material is not feasible, the use of insulating layers shall be considered. The presence of ice or ice rich soils will impact the stability and performance of the pavement; this needs to be examined along the road corridor.

Organics and peat exist along most of the road corridor. Through most of the North-South section and limited parts of the East-West section, organics thickness is typically <0.5 m; hence, it should be manageable to excavate and replace. Through most of the East-West section, organics thickness is significant (up to about 4 m). Replacing it with suitable material will not be economically feasible; therefore, it can be management through a combination of lightweight embankment, partial replacement and or soil improvements.

In general, the esker materials with negligible to low fines content are suitable for road base construction as is, or as blended with crushed rock products, which are suitable for road base construction. The existing till or suitable fine-

grained soils can be used for subgrade as is, or as blended with crushed rock products. The clayey or silty wet material is not suitable within the upper 3 m of the road profile.

The North-South section is characterized as “fair to good subgrade” and East-West section is characterized as “poor to very poor”. The following preliminary pavement structures may be considered based on design methods presented in the Pavement Design and Rehabilitation Manual (MTO 2013):

North -South section:

- Base Layer – Granular A: 150 mm
- Sub-base Layer – Granular B: 600 mm
- Combined Cover Thickness: 750 mm

East - West section:

- Base Layer – Granular A: 200 mm
- Sub-base Layer – Granular B: 800 mm
- Combined Cover Thickness: 1000 mm

The above recommended pavement structures are for preliminary quantities estimate and costing for current EA study and are subject to further evaluations in the next stage of the project.

11.2 Roadway Over Peatlands

Peat/Muskeg/Organic soils/Topsoil are problematic under road embankments. These materials have high compressibility and low shear strength; hence, they cause excessive deformations and stability problems. In addition to these immediate construction phase challenges, the organic material decays over time and results in pavement distress and maintenance issues.

The entire East-West section is situated on the James Bay Lowland and construction over the peat is unavoidable; nor will it be particularly economical to excavate it and replace it with suitable road construction material. The road embankment height in this section is typically about 1 m and will have to be built over peat. Road embankment loading is relatively light, if no reinforcement or replacement of peat is used and the road embankment fill material is placed directly on the peat to cause gravity displacement of the underlying peat. For this option, an assumption is being made that it may result in 50% of the peat thickness compression, which has to be replaced with compensation fill to maintain the existing grade. Alternatively, if geo-fabric/geo-grid reinforcement is applied at the interface and road embankment fill material placed over it, an assumption is made that it may result in 30% of the peat thickness compression, which has to be replaced with compensation fill to maintain the existing grade. These scenarios would involve no removal/replacement of in situ peat. Other techniques to build road embankments over peat include pre-loading with surcharge, wick/sand drains and surcharge, stabilization, floating foundations, and pile foundation. To determine the most suitable option, a better engineering characterization of the peat will be required during the next phase of the Project.

11.3 Driving Surface

For low volume road design (under 2000 AADT), Table 3.5.2 below from the Pavement Design and Rehabilitation Manual – (MTO 2013) illustrates the secondary highway categories and their associated driving surface types.

Table 3.5.2 Secondary Highway Categories and Their Surface Types

Secondary Highway Categories	Driving Surface Type Design Options
MAJOR - Arterial highways serving regional economic centres, communities and resource areas. - Traffic volumes are generally greater than 1000 AADT. - Lower volume highways may be included based on route length, lack of alternative routes and economic significance. - Typical functional classification is rural arterial undivided.	Hot Mix
INTERMEDIATE - Collector highways serving small towns and or villages, recreational or resource areas. - Traffic volumes are generally 400-1000 AADT. - Typical functional classifications are: - Rural collector undivided - Rural local undivided	Surface Treatment,
MINOR - Local highways providing access to recreational or resource areas or paralleling a higher class provincial facility. - Traffic volumes are generally less than 400 AADT. - Typical functional classification is rural local undivided.	Gravel, Surface Treatment

The selection of the surface type for each category is dependent on roadway use, truck volume, time of construction and local concerns.

Reference can be made to Table 1.4.5 of the Pavement Design and Rehabilitation Manual – (MTO 2013) for surface treatment types of for low volume Rural Collector Undivided (RCU).

Table 1.4.5 Surface Treatments

PRIME AND SURFACE TREATMENT APPLICATIONS FOR GRANUAR SURFACES		
Applications	**OPSS Specs**	**Remarks**
DST[1] with Class 2 Aggregates	304	Economical, durable, good skid resistance
P & SST[2] with Class 2 Aggregates	302 & 304	More expensive than DST
P & SST with Class 1 Aggregates	302 & 304	Used by Municipalities
P & DST[3] with Class 3 & 4 Aggregates	302 & 304	Used by Municipalities
P & DST with Class 3 & 5 Aggregates	302 & 304	Used by Municipalities
Prime	302	No longer used as a riding surface by MTO
Notes: 1 Double Surface Treatment 2 Prime and Single Surface Treatment 3 Prime and Double Surface Treatment		

Other types of asphalt surface treatments include slurry seal, micro-surfacing, chip seal, fog seal, primer, tack coat and granular sealing. Apart from the primer, tack coat and granular sealing, these treatments are used by the ministry as pavement preservation treatments.

For the west half of the WSR in stable soil conditions, the surface layer of the road that represents the driving surface for vehicles will be a chip seal treatment, which is a rapid setting bituminous emulsion sprayed onto the roadway surface followed by rolling in the high quality, washed, crushed and single-sized aggregate typically 9.5 mm or 6.7 mm. For the east half of the road in the peatlands with poor soil conditions it is proposed the driving surface be initially gravel to accommodate potential embankment foundation settlements upon roadway open to traffic and allow time for settlement to be stabilized. During the operations phase, monitoring of the east half of the WSR in the peatlands will be conducted to assess performance/settlement, serviceability, and safety issues/concerns related to dust along the corridor. Depending on the outcome of this monitoring, the gravel driving surface may be replaced in future with an alternative surface treatment such as chip seal treatment, as proposed for the west half of the road, or asphalt pavement.

12. Construction Considerations

12.1 Roadbed Construction

Other than peat, organics, and soft clays, most of the native soils form suitable subgrade for the road embankment. Treatment or managing these unsuitable soils has been detailed earlier in **Section 5.1**.

12.2 Barrows and Quarries

Given in general relatively a flat terrain and shallow groundwater table, the following governs the choice pits and quarries development:

- Proximity of the aggregate and bedrock source to the supply road corridor (to minimize building temporary access roads, water crossings and dealing with organics); and
- Pits and quarries should preferably be shallow (<5 m) to minimize dewatering and water management challenges.

Therefore, several shallow and relatively large area pits and quarries may be developed along and in proximity to the supply road corridor. The North-South section, and the east and west ends of the East-West section are suitable, while there are limited options through the central stretch of East-West section.

Water management will form a major consideration for pits and quarries development, and these may result in new waterbodies in the region.

12.3 Water Crossings

In general, most of the water crossings have shallow relief, with the exception at Muketei River. Some water crossings are defined watercourses and will require limited watercourse training works, while most are undefined and appear wider; these will need watercourse training works to create a practical crossing dimension. Special attention shall be paid to dealing with peat/organics at each water crossing.

12.4 Unsuitable Soil Stockpiles

Almost the entire alignment of the proposed road passes through vegetation cover, organics, and trees. Road construction, development of pits and quarries and construction of temporary infrastructure will generate a large volume of unsuitable organic material. These will require or result in several storage stockpiles or may require the implementation of appropriate spreading techniques.

13. Summary

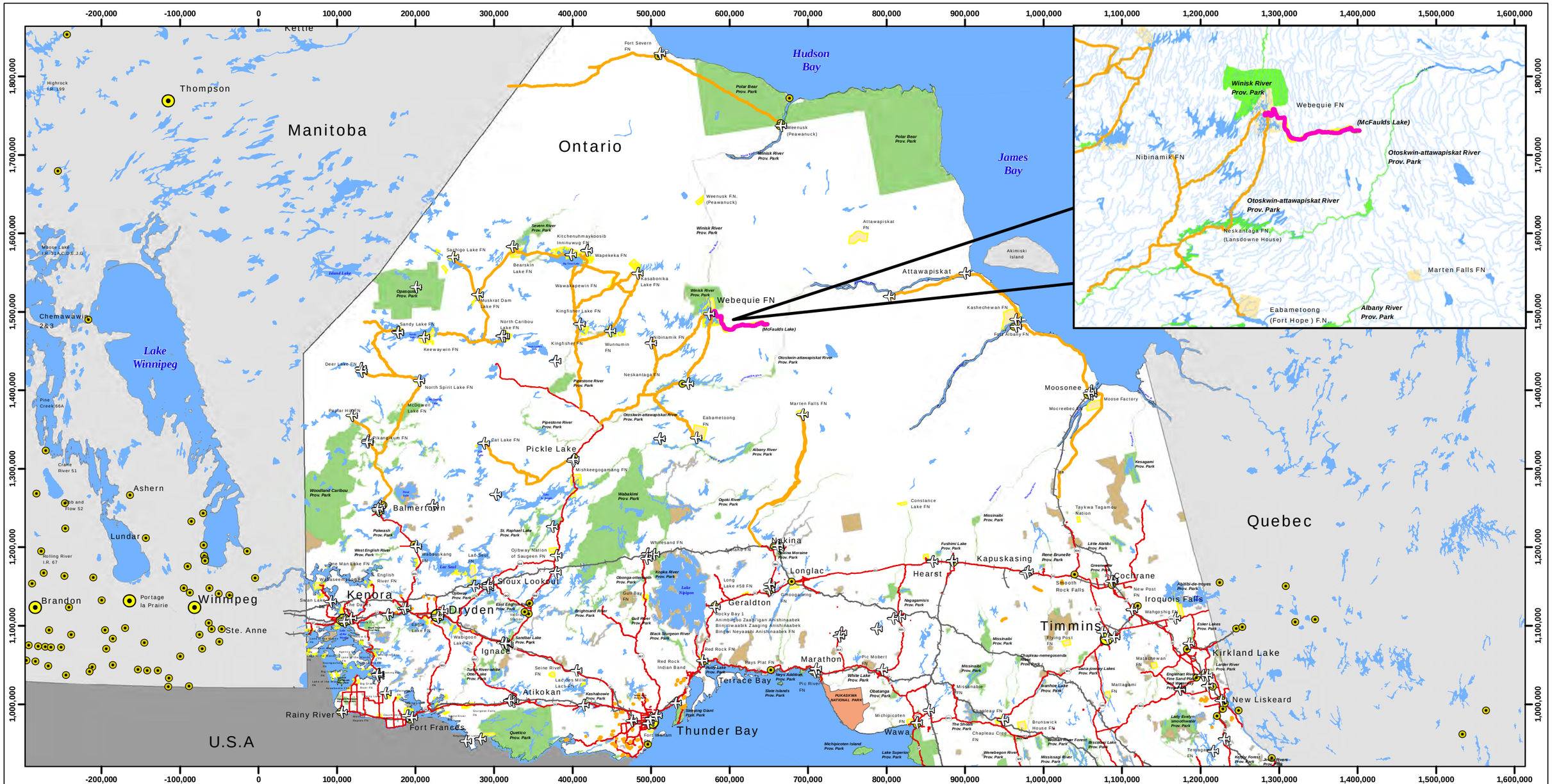
- A geotechnical database has been compiled and established for this project, which includes desktop studies, field and laboratory investigations and available pertinent documentation from McFaulds Lake Projects (Ring of Fire).
- Field investigation included standard geotechnical exploratory boreholes with SPTs in overburden and rock coring through bedrock, test pits with an excavator, manual test pits, and other field exploratory observations. Laboratory investigations included index testing of soil samples, strength, soundness, and abrasion testing on rock samples. Groundwater monitoring observations were made during the field work periods. Geochemical testing on aggregate material will include assessment of the potential for ARD/ML is in progress.
- Potential pits and quarry's locations have been identified and investigated along the proposed road alignment. Given the flat terrain and shallow groundwater table, the choice for the development of these is to develop shallow sites along and in proximity to the road corridor. The North-South section and the east and west ends of the East-West section have suitable options for pits and quarries development, while there are limited options through the central stretch of East-West section. Water management will form a major consideration for pits and quarries development, and these may result in new waterbodies in the region.
- Preliminary engineering and construction considerations are presented for foundations, earthworks and dealing with organics and peat.
- Foundation type and bearing capacity recommendations are presented for water crossing structures and other/supporting infrastructure.

14. Reference

1. J.D. Mollard and Associates (2019a), Terrain Analysis, Potential Aggregate Sources & Identification of Route Alternatives.
2. J.D. Mollard and Associates (2019b), Field Investigation of Peat Thickness and Potential Aggregate Sources.
3. AtkinsRéalis (2024), Geotechnical Investigation Factual Report.
4. Noront Resources Ltd. (2013). Eagle's Nest Project Environmental Impact Statement/Environmental Assessment Report – Draft Copy.
5. Ministry of Transportation of Ontario (MTO 2013), Pavement Design and Rehabilitation Manual – (Second Edition)
6. Canadian Foundation Engineering Manual (5th edition, 2023)
7. Canadian Highway Bridge Design Code (CHBDC, CSA S06-19)

APPENDIX A

Figures



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Legend:

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Airports
- City/Town
- Winter Roads
- All-Season Roads
- Rail
- Federal National Park
- Waterbody
- First Nations Reserve
- Provincial Park
- Conservation Reserve

WSR WEBEQUIE SUPPLY ROAD

SCALE: 1:4,869,256

Webequie Supply Road (WSR)

Project Location

NOTES

1. Coordinate System: Canada Lambert Conformal Conic.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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Figure Number: 1.1			**REV:** PA
Client: Webequie First Nation	**Project Number:** 661910	**Date:** 10/15/2024	
DSC		**DRN**	**CHK** / **APP**

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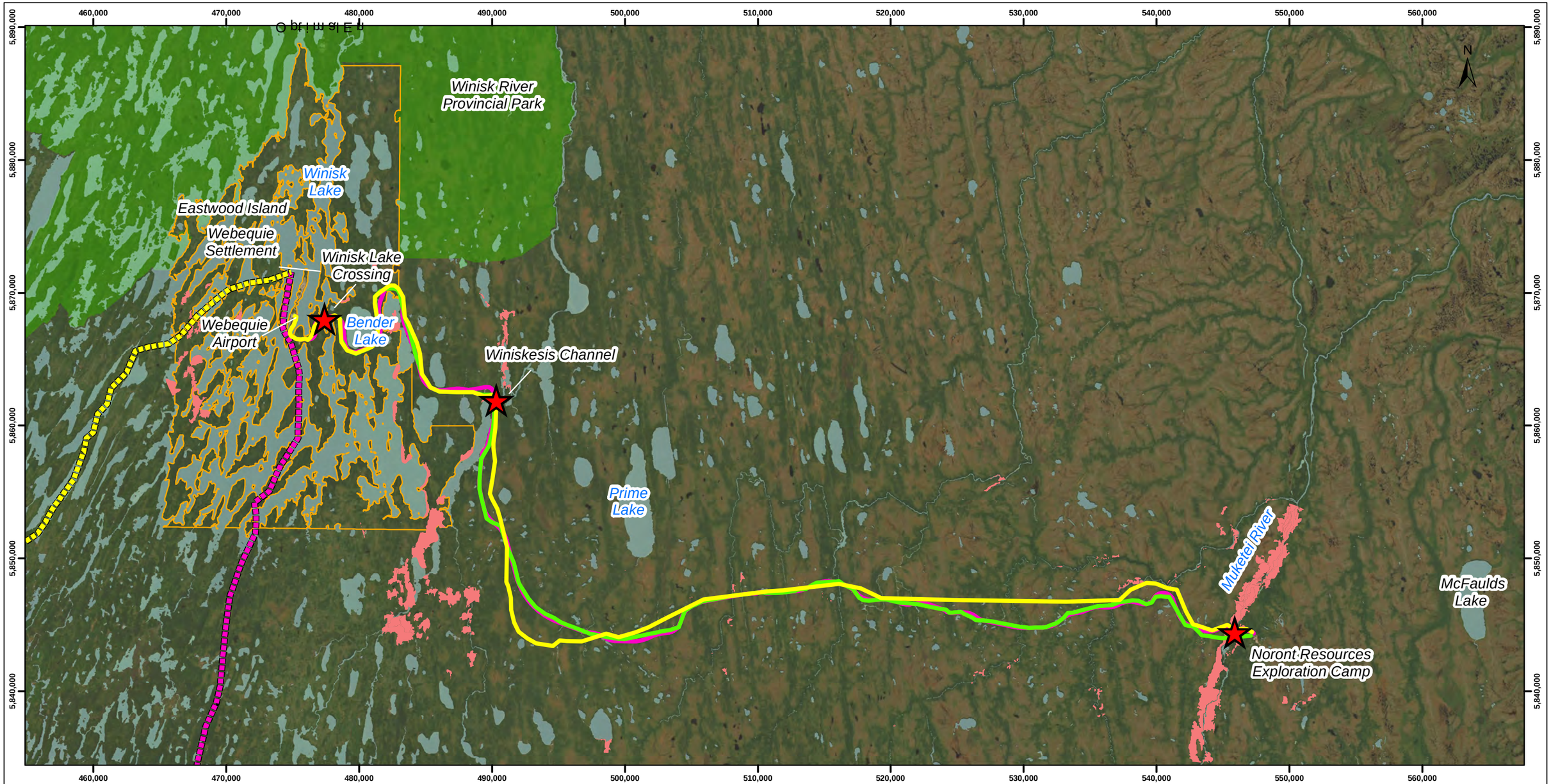

Legend

- Proposed Major Water Crossings
- Existing Winter Road
- Old Winter Road
- Potential Aggregate Sources
- Webequie First Nation Reserve Limits
- Waterbody
- Winisk River Provincial Park

Route Label

- Alternative 1 — Webequie First Nation Community's preferred Route
- Alternative 2 — Optimal Geotechnical Route
- Alternative 3 — Optimal Engineering Route

WSR WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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SCALE: 1:287,479

Webequie Supply Road (WSR)

Alternative Routes and Project Area Features / Sensitivities

Figure Number:	1.2	REV:	PA
Client: Webequie First Nation	Project Number: 661910	Date: 10/15/2024	

DSC	DRN	CHK	APP

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460,000 470,000 480,000 490,000 500,000 510,000 520,000 530,000 540,000 550,000 560,000 570,000

5,880,000 5,870,000 5,860,000 5,850,000 5,840,000

N

Winisk River
Winisk River Provincial Park
Lastcedar Lake
Eastwood Island
Webequie Settlement
Webequie Airport
Bender Lake
Odobas Lake
Winisk Lake
Morrison Bay
Farrow Lake
Newstead Lake
Garrioch Lake
Plant Lake
Stockman Lake
McMurdo Lake
Billinger Lake
Prime Lake
Ekwan River
Malloy Lake
Leaver Lake
Clancy Lake
Ekwan River
Deugo Lake
Muketei River
Greig Lake
McFaulds Lake

SIZE 11x17

Legend

- Engineering Route
- Geotechnically Preferred Route
- Community Preferred Route
- Local Study Area
- Webequie First Nation Reserve
- Waterbody
- Winisk River Provincial Park

Elevation (MASL)

High : 275

Low : 129

WSR WEBEQUIE SUPPLY ROAD

0 10 20 Km

Webequie Supply Road (WSR)

Topographic Map

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
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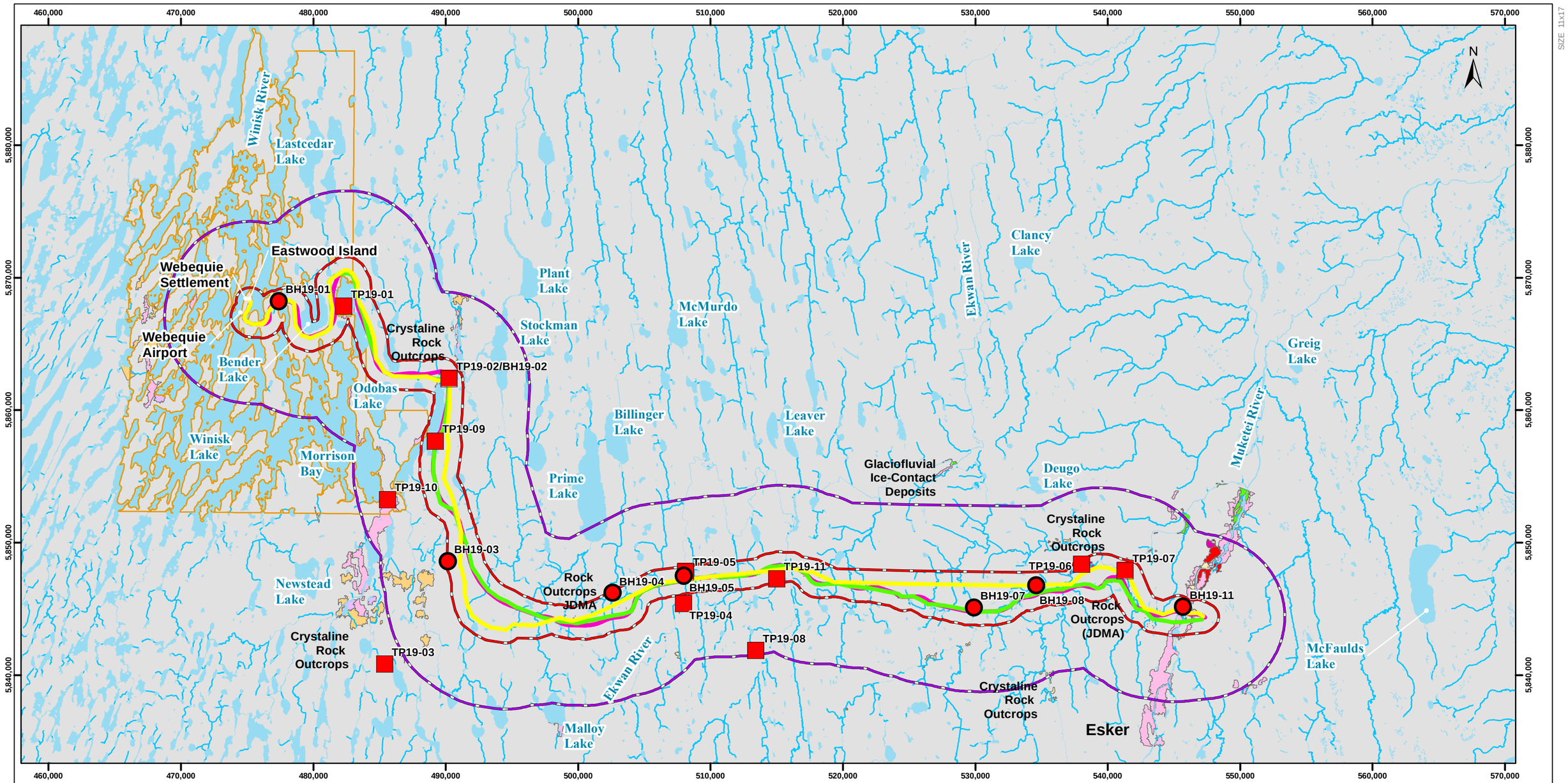

Legend

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Local Study Area (LSA 1km from Centreline of Route Alternatives)
- Regional Study Area (RSA 5km from either side of LSA Boundary)
- Webequie First Nation Reserve
- Waterbody
- Watercourse
- 2019 Borehole
- 2019 Test Pit
- Rock (JDMA)
- Metamorphic and Igneous Rocks
- Metamorphic and Igneous Rocks
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-contact Deposits
- Glacial Deposits and Bedrock
- Fluvial Deposits (recent)
- Fluvial Deposits (abandoned)
- Marine Beach and Near-shore Deposits

WSR WEBEQUIE SUPPLY ROAD

0 10 20 Km

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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Webequie Supply Road (WSR)

Potential Aggregate Sources

Figure Number:	REV:
7.1	PA

Client:	Project Number:	Date:
Webequie First Nation	661910	10/15/2024

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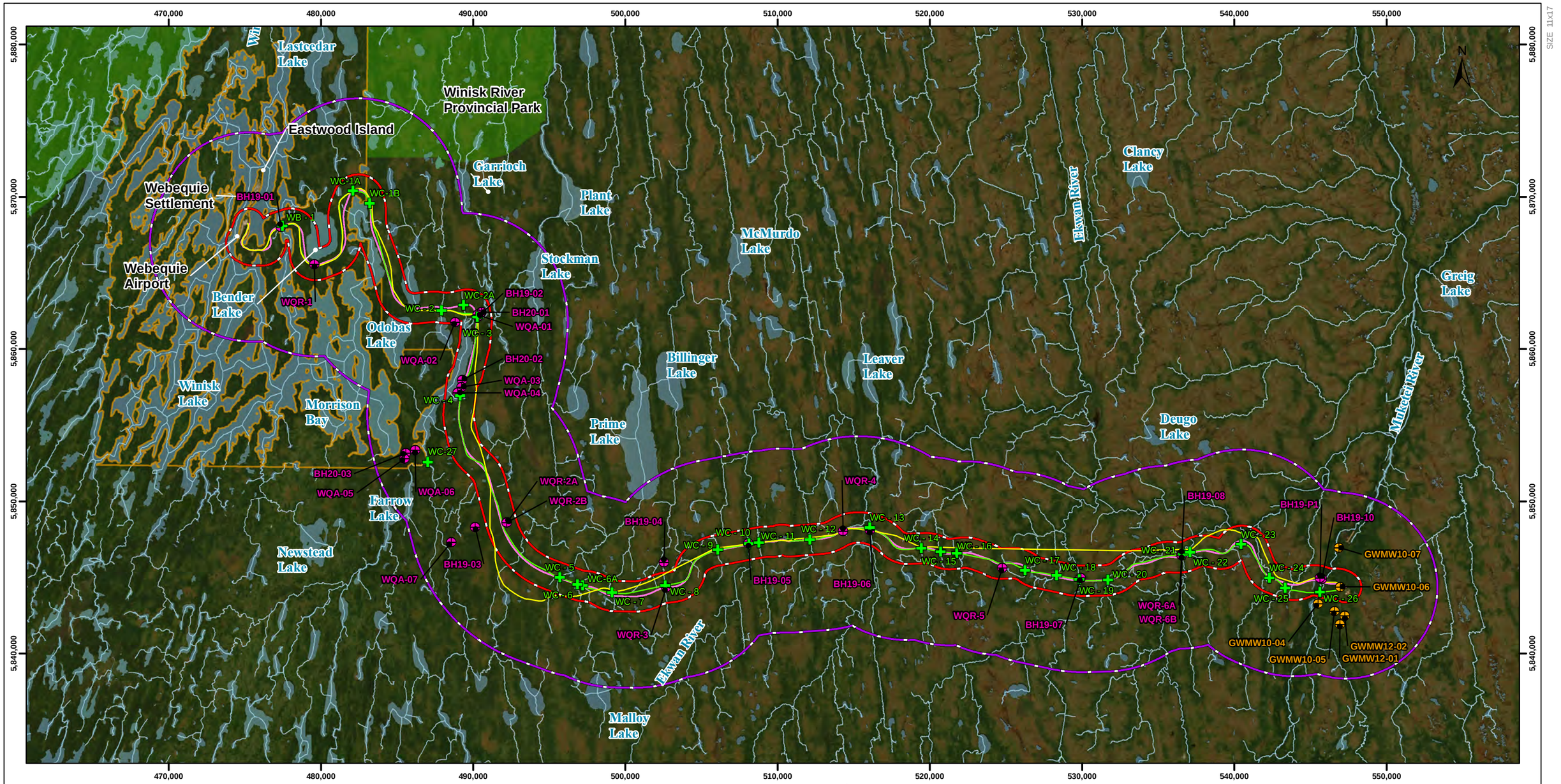

Legend

Route Label

- Alternative 1
- Alternative 2
- Alternative 3
- Waterbody Crossing
- Boreholes (KCP)
- Boreholes (AtkinsRealis)
- Local Study Area (LSA 1km from the Preferred Route)
- Regional Study Area (RSA 5km from either side of LSA Boundary)
- Webequie First Nation Reserve
- Waterbody
- Watercourse
- Winisk River Provincial Park

WSR WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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0 10 20 Km

Webequie Supply Road (WSR)

Potential Water Crossings and Geotechnical Data Points

Figure Number:	REV:
9.1	PA

Client:	Project Number:	Date:
Webequie First Nation	661910	1/19/2024

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APPENDIX B

Geotechnical Investigation Related Studies

WEBEQUIE SUPPLY ROAD: TERRAIN ANALYSIS, POTENTIAL AGGREGATE SOURCES & IDENTIFICATION OF ROUTE ALTERNATIVES

DRAFT REPORT

March 29, 2019

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1 INTRODUCTION

Webequie First Nation, located approximately 500 km north of Thunder Bay, is developing an all-season road between the community of Webequie and the proposed Ring of Fire mining development around Esker Camp just to the east of the Mukutei River, known as the Webequie First Nation Supply Road Project (Figure 1). The Webequie Supply Road will offer year-round movement between the community and future mine sites and will facilitate economic opportunities for the community.

Preliminary corridor alternatives were identified and a preferred corridor was selected by the community based on engagement with the community as a whole, youth representatives, elders, and the Webequie land use planning committee. The preferred corridor, selected by the community, is approximately 107 km in length (extending about 51 km toward the south-southeast from Webequie before turning east for about 56 km toward Esker Camp), and 2 km in width. It is within this preferred corridor that the road route is to be selected.

As part of the Environmental Assessment and Preliminary Engineering Services for Webequie First Nation's Supply Road Project, J.D. Mollard and Associates (2010) Limited was sub-contracted by SNC Lavalin to conduct terrain mapping within the proposed community corridor to facilitate identification of potential aggregate sources, characterization of stream crossings, mapping of several competing route alternatives, and identification of an optimal route based on terrain and engineering considerations. This report provides the results of these studies.

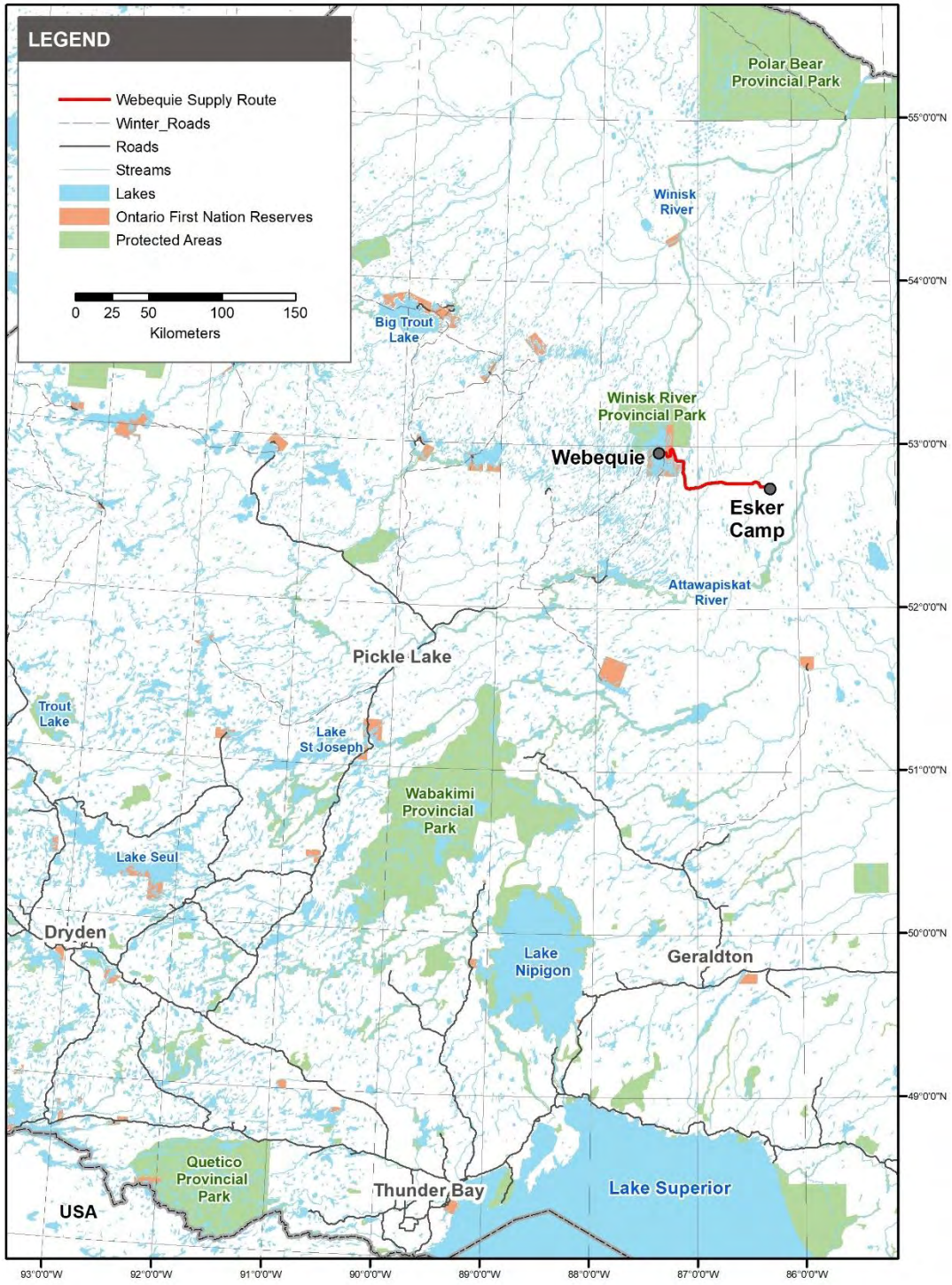


Figure 1: Location of the Webequie First Nation Supply Road Project.

2 DATA SOURCES

Terrain analysis was conducted using aerial and satellite imagery and digital elevation data. The primary source of desktop information for terrain mapping was high-resolution orthoimagery (20 cm resolution) and LiDAR elevation data (1 m resolution) acquired within the 2-km wide corridor for the project in October 2018. Satellite imagery available through ESRI World Imagery Basemap and Google Earth offered supplemental imagery at high-resolution. Air photo interpretation was also conducted at select locations using 1954 black & white photos at 1:60,000 scale, which when viewed stereoscopically provide 3-D perspectives to evaluate terrain and topographic conditions. These multiple sources of imagery assist with the terrain unit classification, particularly with resolving the wetlands and permafrost-affected terrain.

- Black & White air photos. Scale: 1:60,000. Year: 1954.
- ESRI World Imagery Basemap. Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
- Google Earth Pro V7.3.2.5491.
- Orthoimagery captured with LiDAR data. 20 cm resolution. October, 2018.

Elevation data covering the 2-km wide route corridor was provided by LiDAR (light detection and ranging) and processed at a spatial resolution of 1 m. Using the LiDAR data, shaded-relief and slope rasters were generated in ArcGIS to assist with the interpretation terrain units.

- LiDAR (light detection and ranging)
- Shaded-relief and slope rasters

Information on the surficial and Quaternary geology was obtained from the following published maps.

- Ontario Geological Survey, 1997. Quaternary geology, seamless coverage of the province of Ontario: Ontario Geological Survey, Data Set 14.
- Barnett, P.J. *et al*., 2013. Surficial Geology of the Lansdowne House Area Northeast, Northern Ontario. 1:100,000. P3697.
- Barnett, P.J. *et al*., 2013. Surficial Geology of the Lansdowne House Area Northwest, Northern Ontario. 1:100,000. P3696.

Hydrological information was obtained from the following sources.

- Ontario Hydro Network – Waterbodies. Land Information Ontario (LIO) Warehouse.
- Ontario Wetlands: Ontario Ministry of Natural Resources.
- Provincial Land Cover (2000) Database: Ontario Ministry of Natural Resources.

Information from previous JDMA terrain studies, particularly the terrain units and legend, was obtained from the following reports:

- McFaulds Lake Project – Webequie to Esker Camp road route location: Report on mineral and organic terrain mapping in a 10 km radius around esker camp. 2010. J.D. Mollard and Associates (2010) Limited. September 23, 2010. Report No. 1675.
- McFaulds Lake Project – McFaulds Lake Peat Sampling Field Trip Report. J.D. Mollard and Associates (2010) Limited. September 17, 2010.

3 METHODOLOGY

3.1 TERRAIN MAPPING

Terrain mapping within the proposed route corridor involved the interpretation of remotely sensed imagery (air photos and satellite images) and digital elevation data, supplemented with surficial geology, hydrology, and land cover data, to characterize the landforms, surficial materials, topography, hydrology, *etc*. Geospatial data sources available for this study were compiled in a geographic information system (GIS) and terrain units were manually digitized over base layers of imagery (air photos and satellite) and elevation data (elevation, shaded-relief, and slope rasters).

Terrain units were mapped and classified according to a legend developed for this area based on a compilation of previous reports and existing mapping (JDMA, 2010). The route corridor crosses extensive organic terrains of various bogs and fens along the east-west section of the corridor west of Esker Camp and glacial terrains with mineral soils on the roughly north-south section leading to the community of Webequie. Mineral terrains include till with a discontinuous lacustrine clay veneer, glaciofluvial ice-contact, esker ridges, and alluvial floodplains. Organic terrains include bogs and fens with tremendous diversity and extent.

Following is a description of the terrain units mapped within the routing corridor.

MINERAL TERRAINS

TL (Till and glacial lake clay): silty till (T) on a N-S fluted plain with a mostly thin, discontinuous cover of soft, sticky plastic lacustrine (L) silty clay. Extensive cover over the N-S section of the route corridor with some areas of thin bog or fen cover.

ER (Esker ridge): the esker core near Esker Camp consists of thick sand over gravel, reaching a total depth of more than 20m, with a discontinuous cover of glacial-lake clay on sideslopes. The esker system is segmented, with mostly short gaps and three notable local expansions called “bulges” (esker fans and deltas), resulting in very large volumes of nearby granular material.

GF (Glaciofluvial): Ice-contact glaciofluvial deposits (kames and eskers) consisting of sorted granular material.

AF (Alluvial floodplain): Varying mineral-soil textures along small creek channels whose floodplains are discontinuous and around the periodically flooded perimeters of water bodies. Relatively thin peat over alluvium, stream-eroded till, and intermittently flooded mineral soil. Mostly narrow and subject to flooding. Some creek channels are linear, following abandoned flute depressions or ice-keel scour depressions.

ORGANIC TERRAINS

BOG TYPE TERRAINS

DB (Domed bog): Oval, lenticular, teardrop, balloon and irregular-outlined domed shapes; common occurrence; usually greater than 500m in longest dimension; notably convex surface with crest up to several metres higher than bog edges and the surrounding terrain. Multiple drainage lines (*e.g.,* watertracks) commonly radiate outward from the bog summit. Clusters of bog pools on DB are less common than they are on PB, also with smaller pools and smaller and less well-defined clusters. Peat depth may exceed 3m near the DB central area. Stratified Sphagnum-sedge-woody shrub peats with large Sphagnum lawn and black spruce areas at ground surface.

PB (Northern plateau bog): Typically large, slightly raised (0.5 to 1 m) bog above the surrounding terrain with steep edges -- thus plateau-like in appearance with a commonly irregular outline edge in plan. Numerous larger bog pools usually occur in larger clusters than observed on DB. Distinct pool clusters are also more common on PB than on DB, forming net (reticulate) patterns of narrow peaty ridges between large pools (NB), occasionally transitioning downslope to string bogs (SB) and then downslope to string (ribbed) fens. Includes flat bog, not raised above the surrounding surface with peat depth generally uniform and with less common net bog (NB). Light grey air photo tones result from extensive Sphagnum moss lawns with sparse black spruce trees and shrubs. Common stratified peat depths are 2 to 4 m, consisting of moderately decomposed Sphagnum peat over Sphagnum and sedge peats.

NB (Net bogs): component of northern plateau bogs (PB), located at one or more locations on flat-topped bog summits, includes minor string bog and string fen. The pattern consists of a network of reticulate narrow (2 to 3 m wide) peaty ridges about 1m high, separating numerous small to large bog pools having irregular and linear shapes (NB). Pools are occasionally aligned in parallel strings at right angles to surface-water runoff and to groundwater flow (SB). In this study, NB included SB in the terrain mapping. Pools vary from shallow to very deep.

TB (Treed bog): Areas of extensive tree cover developed on relatively thin organic material over mineral soils. Typically occur along the margins of streams and watercourses.

TK (Thermokarst bog, also called collapse scar bog, often associated with treed bog (TB)): Slightly raised perennially frozen peatland (permafrost-affected) with small, uniform-sized, roundish ground-ice-thawed collapse holes containing water or wet fen vegetation, called “collapse scars”. The resulting spotty speckled or mottled air photo pattern of whitish collapse holes is caused by subsidence upon melting of ground ice and possibly melting of palsas in a few places. This unit

tends to occur along the sloping margins of small and large creek drainages, and is also found as small isolated randomly distributed patches in neighbouring upland areas.

FEN TYPE TERRAINS

SF (String fen): on sloping terrain; narrow subparallel stringy peat ridges enclosing slit-like depressions with open water or wet fen vegetation (mostly sedge with shrubs and tamarack trees). Strings are aligned at right angles to the slope and in the direction of surface-water runoff and groundwater flow. SF areas are larger than ladder fens. String width becomes narrower and more closely spaced as slope gradient increases downslope. Peat depth is commonly over 2 m.

LF (Ladder fen): subtype of string fen, thus similar to string fens in appearance but smaller with narrower pools, often along the margin of domed and plateau bogs. Peat thickness is commonly 1 to 2 m.

CF (Channel fen): fens occupying generally well-defined longer and wider channels, including abandoned glacial meltwater channels, with and without small streams. Peat depth may exceed 2 m in some CF fens.

WF (Watertrack fen): A flowing pattern of narrow slightly concave surface runoff courses and groundwater seepage on slopes, radiating from the summits of domed and plateau bogs. WF may also originate from springs and seeps. Common peat depths of 1 to 2 m.

HF (Horizontal fen): broad, featureless gentle slopes. Commonly uniformly forested with trees, shrubs, coarse grasses and sedges. Commonly transitional to swamps (swamp-fens). Common peat thickness of 2 to 3 m.

Peat depths described in some of the terrain units are from the Canadian Wetland Classification System, University of Waterloo, Wetlands Research Centre, 1997. These depths are supported by soil probe data collected previously by JDMA from field sites south of the proposed corridor. Peat depths were also evaluated within the Webequie road corridor using ground penetrating radar in February 2019 as part of this study (See Section 3.2).

3.2 GROUND PENETRATING RADAR (GPR) SURVEYS

Ground penetrating radar (GPR) surveys were carried out at representative peatlands within the routing corridor to help characterize the depth and variability of the peat layer over bedrock or glacial sediment. GPR surveys were conducted from February 18-23, 2019.

Prior to the GPR field work, representative survey sites along the routing corridor were identified from the air photo terrain analysis and mapping work. At each survey site, two or more GPR transects were identified. Waypoints for equipment and personnel drop-off and transect start/stop points were provided to the GPR crew for location and navigation in the field. Access to each site was via helicopter, which brought in the survey crew, equipment, snowmobiles and fuel needed to conduct the surveys. There were three members of the GPR crew: Troy Zimmer and Jason Cosford, of JDMA, and Eric Jacob, of the Webequie First Nation community. A total of five (5) peatland areas were surveyed during the February 2019 field work (Figure 2). Sixteen (16) survey transects were collected in the field, capturing approximately 22 km of GPR profile data.

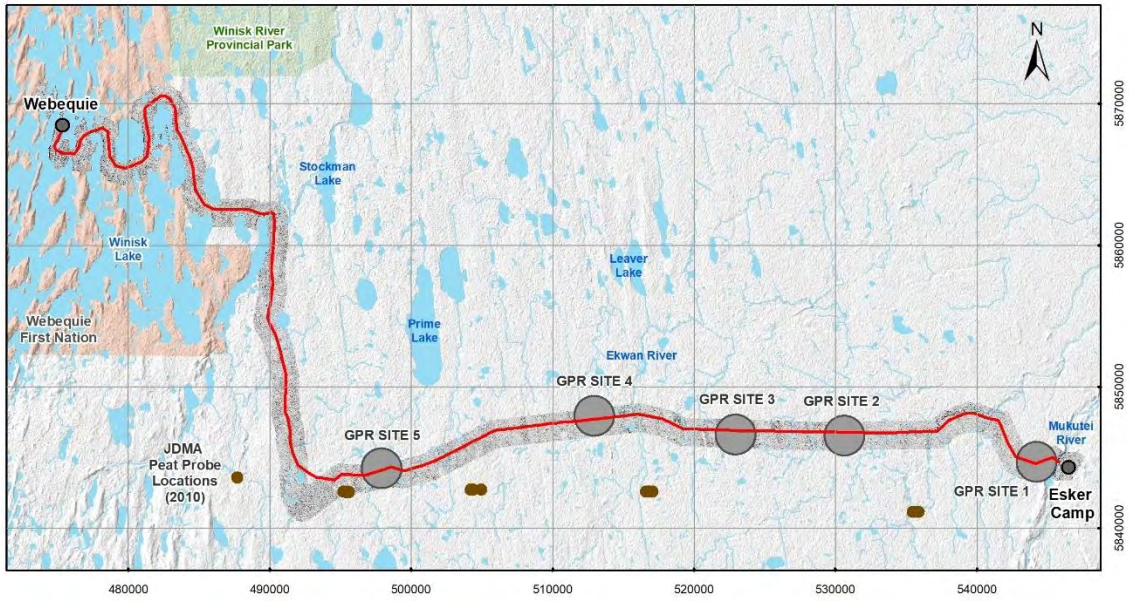


Figure 2. GPR and peat probe locations. Locations of the five peatland sites surveyed with GPR during the February 2019 field work (large grey circles) and peat probe locations from 2010 (small brown circles).

The field surveys were conducted used a Sensors & Software Noggin™ 100MHz GPR system mounted on custom skies and towed by snowmobile. A TopCon DGPS unit provided submeter geographic positioning for the GPR reflectance data as it was collected along each survey transect. The radar reflectance data for each survey transect was processed using Sensors & Software Ekko_Project v5.3 GPR software suite.

Figure 3. Field photographs of the GPR and peat probe. Left: Noggin 100MHz GPR system and ski mount being pulled by snowmobile at one of the GPR survey sites. Right: using a peat probe to try and measure depth to mineral soil / bedrock at the start of Transect 2-1.

The GPR survey crew attempted to use a hammer-style peat probe to measure actual peat depth at the first survey transect but were unable to push through the frozen peat to reach the top of the bedrock or glacial sediment. As a result, the processed GPR profiles assume a return radar wave velocity of 0.040 m/ns, a typical value cited in the literature for peatlands in northern Ontario. Because return wave velocity determines depth-below-surface measurements for features shown in the GPR profiles, it is recommended that sample peat depths be taken at points along selected survey transects during the summer so that the wave velocity and depths can be more accurately calculated and applied to the GPR profiles.

For each survey transect, the top of bedrock or glacial sediment was identified based on the distinctive reflectance pattern produced in the GPR profile when the radar pulse crosses the interface between the bottom of the water-saturated peat layers (with has relatively high dielectric values) into the much more dense, low-dielectric material below (Figure 4). The interpreted peat depths along each transect line are displayed as colour-coded depth points on the transect maps for each site (see Results, below). Since most survey transects cross several peatland terrain types (as interpreted by the air photo mapping work), statistics on the minimum, maximum and average peat depths for each terrain type were also compiled, for both individual transects and for the study sites as a whole.

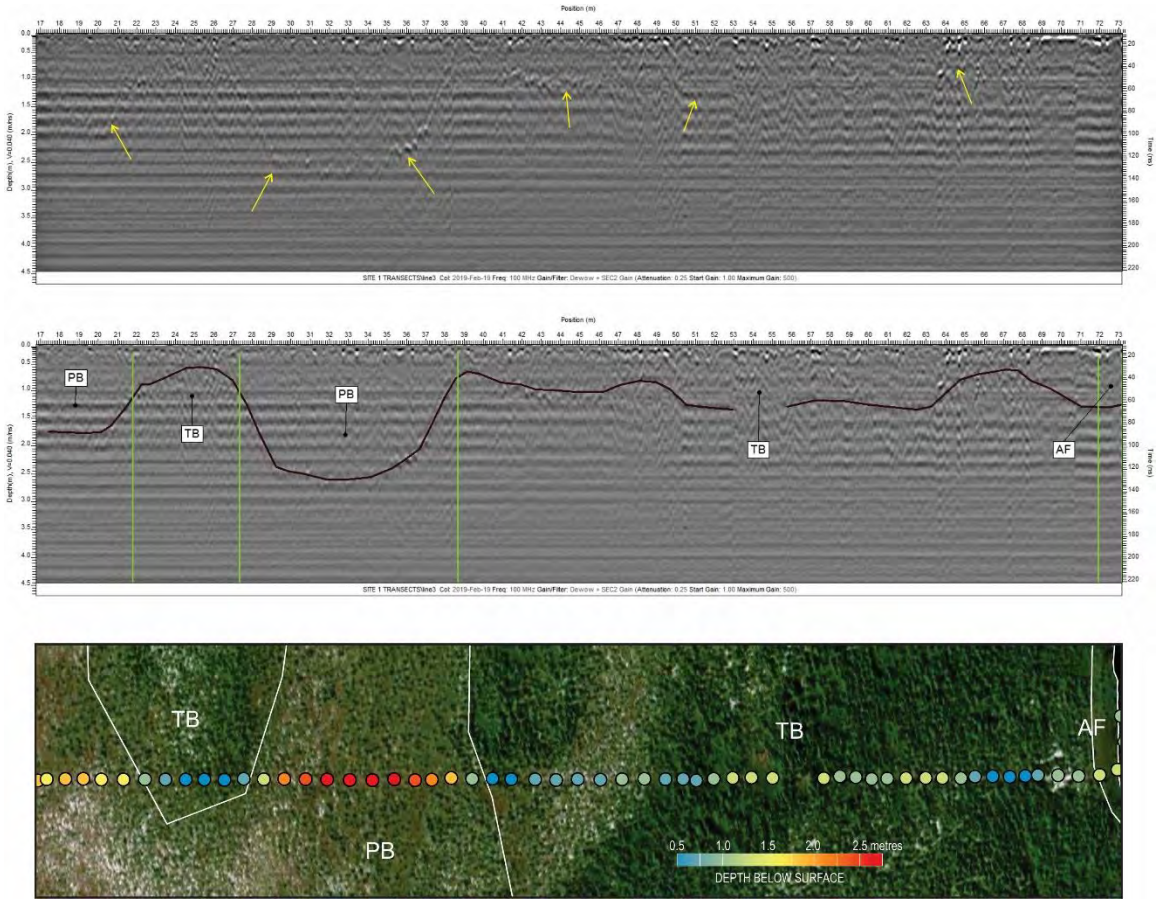


Figure 4. Portion of the GPR profile collected along a survey transect at SITE 1. TOP: GPR profile before interpretation; the reflector generated by the interface between the peat and the mineral soil / bedrock layers (indicated by the yellow arrows) shows up as a distinct white line within the profile stratigraphy. MIDDLE: Annotated profile with interpretation of the location of the peat / mineral interface (brown line); the interpretation polygon was used to generate the depth maps and statistics for each site, while the terrain type boundaries (in green) and terrain annotation was added to help with summarizing the statistical results. BOTTOM: The final colour-coded depth points (generated from the interpretation polyline), overlain on satellite orthoimagery and the terrain mapping datasets; the points represent the depth below surface (in metres) of the interpreted interface for every metre along the survey transect.

3.3 IDENTIFICATION OF ALTERNATIVE ROUTES

The selection of a final road route between Webequie First Nation and Esker Camp will rely on various social, culture, environmental, and engineering considerations. An initial road route provided by the community was used to establish a 2-km-wide corridor within which LiDAR data and orthoimagery were collected. In this study, the identification of route alternatives and the selection of an optimal route within the proposed route corridor from a terrain perspective follows the interpretation of terrain conditions and consideration of related engineering considerations. Terrain mapping characterized the landforms, surficial materials, topography, hydrology and groundwater conditions within the proposed corridor, which provided the basis for evaluating the favourability for route location and construction. Detailed engineering design, environmental, social and cultural factors will be considered by others in separate study components.

The following considerations served to guide the evaluation of all-weather road route alternatives in this study:

- Route length
- Surficial material (mineral vs organic soils)
- Bogs vs fens
- Topographic relief and slopes
- Ice-rich peat bogs and fens
- Extensive wetland & thermokarst-affected terrain
- Characteristics of river and stream crossings (width, approach slopes, *etc.)*
- Proximity to potential aggregate sources

Several route alternatives were identified with consideration to minimize the total route length, to follow routes that maximize terrain units of favourable constructability (*e.g.,* mineral soils), minimize units of poor constructability (*e.g.,* fens), minimize the number and widths of stream crossings, and minimize aggregate haul distances. While a shorter route is typically preferred, *ceteris paribus*, there can be environmental, engineering, social and economic advantages of an overall longer route that follows favourable terrain units and minimizes stream crossings. Terrain units with mineral soils are considered favourable for route construction, while those units with organic soils are considered unfavourable (Table 1). Bogs are preferred over fens because bogs typically have a lower water table and fewer open water areas. Treed bogs are considered more favourable than other bogs because the extensive tree cover hints at thinner organic cover with better drainage and roots anchored in mineral soils.

Table 1. Constructability Ranking

Constructability Ranking	Terrain units
Good	TL, ER, GF, AF*
Fair	TB, TK
Poor	DB, PB, NB, AF*
Very Poor	SF, CF, LF, HF, WF, AF*

*Alluvial floodplains exhibit various constructability rankings due to the variability observed in the imagery, ranging from mineral soils to aquatic vegetation.

3.4 WATER CROSSINGS

Surficial hydrology within the route corridor includes numerous streams, fens and bogs that will require various engineered water crossings. Overall, drainage of the area trends south to north, following the orientation of the fabric of glaciated landforms and ultimately draining into Hudson Bay. Stream crossings include both open water and flat alluvial floodplains. Many of the alluvial floodplains appear to feature extensive aquatic vegetation floating as a mat along the margins of the main open water channels. At these locations, the width of the water crossings should consider the area mapped as alluvial plain. Fens, particularly channel and ladder fens, having water tables at or near the surface and flowing groundwater gradients may also need to be treated as "water crossings" when considering engineering design options.

Stream crossings were characterized using the orthoimagery and LiDAR elevation data to describe the open water width, alluvial floodplain width, maximum slope, bank height, and terrain unit.

3.5 POTENTIAL AGGREGATE SOURCES

The road route corridor crosses an area of extensive wetlands and organic soils that limit prospects for potential aggregate sources. Aggregate prospects were identified while terrain mapping the route corridor. Air photo and satellite imagery, along with existing surficial geology maps, were used to identify granular landforms as potential sources of aggregate. Landforms created by meltwater processes during deglaciation are typically composed of sorted granular material. It is this relationship between landforms and materials that allows for granular prospects to be mapped by terrain analysis. Bedrock outcrops, with or without minimal overburden were identified and mapped as potential quarry sites.

The characteristics of the granular deposits and suitability and location of potential bedrock sources are as yet unproven. Field reconnaissance is required to describe and characterize the materials. At granular prospects, shallow test holes can be dug manually to a depth of a 30-60 cm to make an

initial assessment of material gradation and quality. At potential quarry sites, the lithology of rock and structural elements (fractures, bedding, foliation, *etc*.) visible at surface can be described to make an initial assessment of bedrock suitability for aggregate production. At the most promising sites drilling or deeper test pits would be required to fully assess the potential aggregate sources.

At the planning stage, the availability and distribution of construction material along a proposed route provides an important input to construction and maintenance cost estimates. Information compiled from the aggregate assessment will be provided regarding the material quality (gradation of granular material and lithology of bedrock), distance of source from the ROW, spacing along the ROW that can be used to optimize potential borrow sources, and potential access routes.

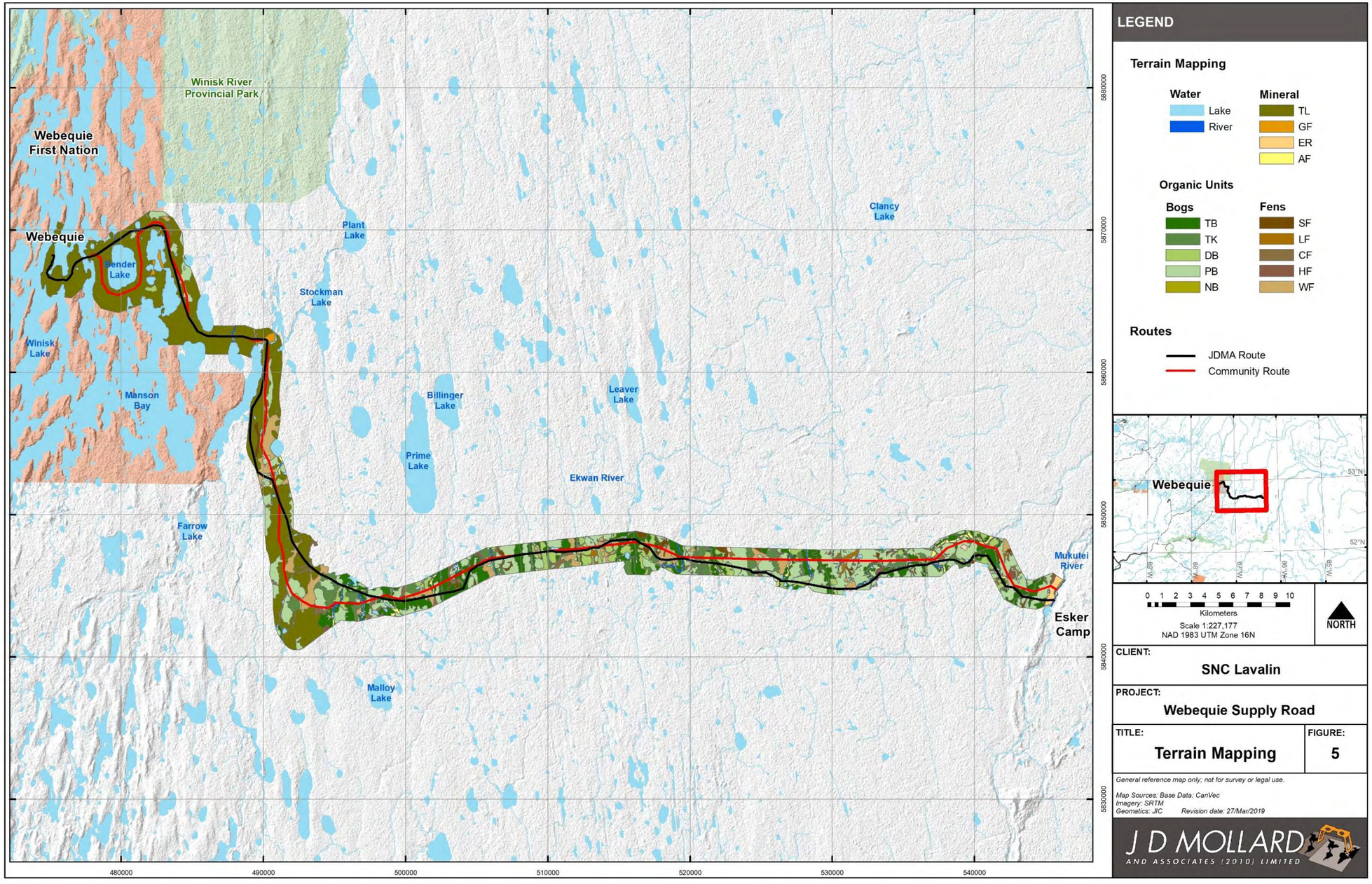
4 RESULTS

4.1 TERRAIN MAPPING

Terrain mapping was completed within the 2-km-wide corridor between the community of Webequie and the Mukutei River near Esker Camp (Figure 5). Large-scale maps are provided in Appendix 1. The total area mapped is 255.48 km^2, of which mineral terrains cover 87.12 km^2, organic terrains cover 133.33 km^2, and water (lakes and rivers) covers 35.03 km^2 (Table 2).

Table 2: Terrain units and area covered within the 2-km-wide Webequie Supply Road corridor

Terrain Units	Area (km^2)
Mineral Terrains	
TL	78.06
ER	0.95
GF	0.98
AF	7.13
Total Mineral Terrains	87.12
Organic Terrains	
Bogs	
DB	12.87
PB	51.32
TB	31.93
NB	0.22
TK	11.66
Total Bog Terrains	108.00
Fens	
SF	3.89
LF	1.72
CF	5.67
WF	12.84
HF	1.21
Total Fen Terrains	25.33
Total Organic Terrain	133.33
Water	
Lake	33.98
River	1.05
Total Water Terrains	35.03
Total	
Total	255.48



LEGEND

Terrain Mapping

Water	Mineral
Lake	TL
River	GF
	ER
	AF

Organic Units

Bogs	Fens
TB	SF
TK	LF
DB	CF
PB	HF
NB	WF

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
NAD 1983 UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: 5

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 27/Mar/2019*

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4.2 GROUND PENETRATING RADAR

Figure 2 shows the locations where GPR surveys were conducted. Results are summarized below.

SITE 1

GPR SITE 1 is located on a long, narrow northern plateau bog near the eastern terminus of the proposed road route (Figure 6). The plateau bog is bordered to the east by a high esker ridge that overlooks the Muketei River and Noront's Esker Camp. The west border of the plateau bog is a series of narrow treed bogs draining into the small, unnamed creek to the west. GPR SITE 1 was considered one of two highest-priority sites for GPR data collection during the field program.

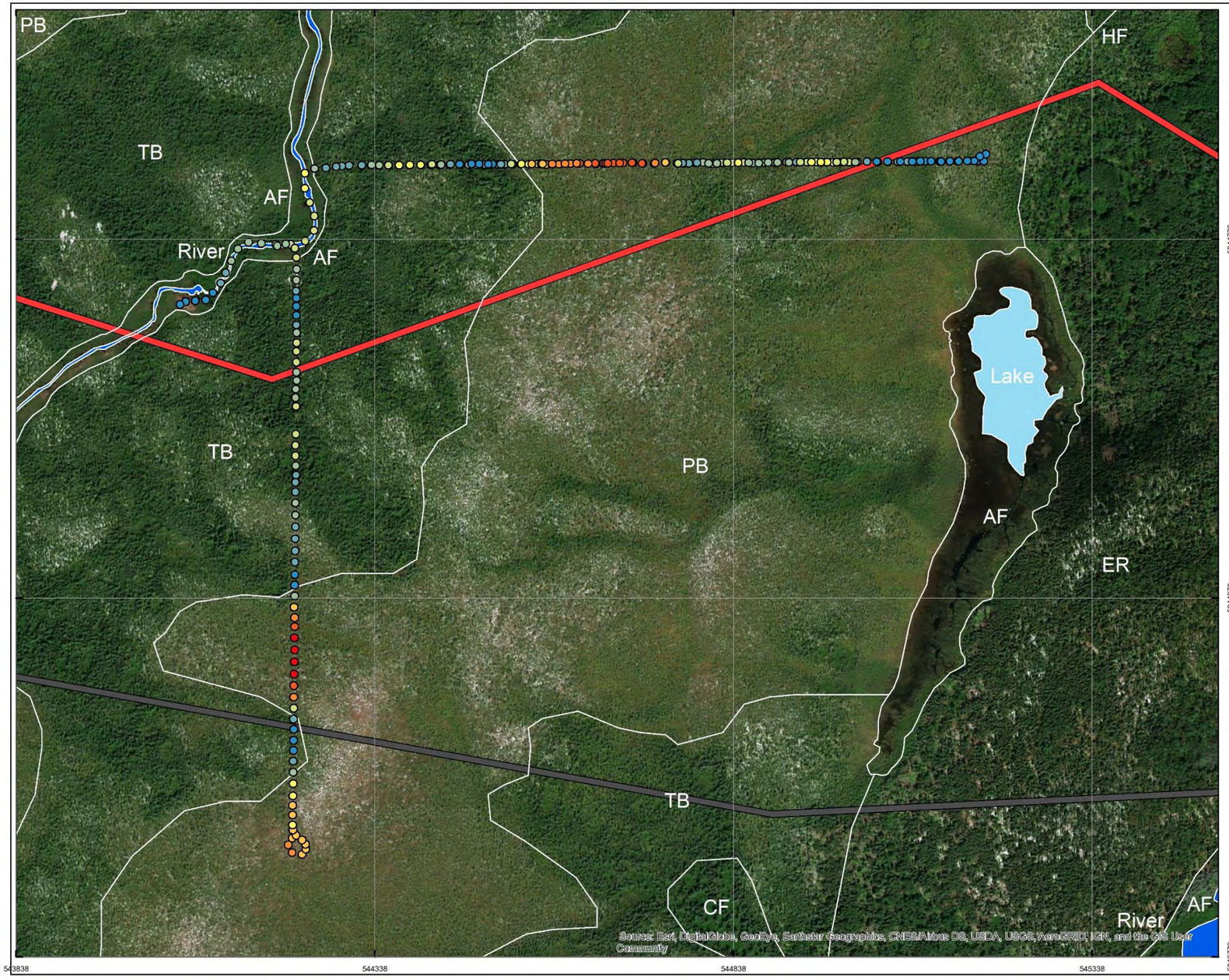
Two (2) GPR transects were surveyed at SITE 1, both taking advantage of existing seismic cut lines that allowed easy access through the dense forest on the treed bogs. Table 3a shows the average peat depth below for the two transects, along with the minimum and maximum depths observed and measure of standard deviation. Table 3b summarizes the average peat depth (and related statistics) for all transects in SITE 1.

Table 3a. GPR Site 1 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 1-1				
Northern Plateau Bog (PB)	2.0 m	1.1 m	2.6 m	0.4
Treed Bog (TB)	1.0 m	0.6 m	2.6 m	0.2
Transect 1-2				
Northern Plateau Bog (PB)	1.3 m	0.5 m	2.3 m	0.6
Treed Bog (TB)	1.0 m	0.5 m	1.7 m	0.3

Table 3b. GPR Site 1 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	1.5 m	0.5 m	2.6 m	0.6
Treed Bog (TB)	1.0 m	0.5 m	1.7 m	0.3



LEGEND

Routes

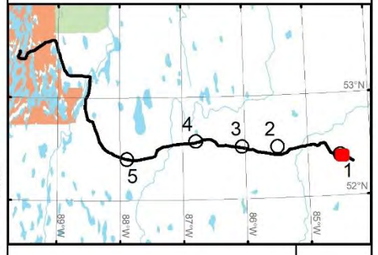
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 0.75 m
- 0.75 - 1.0
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- > 2.5 m

0 100 200 300
Meters



Scale 1:5,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: **SNC Lavalin**

PROJECT: **Webequie Supply Road**

TITLE: **GPR RESULTS SITE 1**

FIGURE: **6**

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 2

GPR SITE 2 is located approximately 20 km west of SITE 1, on an extensive northern plateau bog dissected by a complex series of long, narrow ladder fens, watertrack fens, string fens, and channel fens (Figure 7). Several small ponds and areas of thermokarst are also scattered across the plateau. SITE 2 was considered the highest-priority site for GPR data collection during the field program.

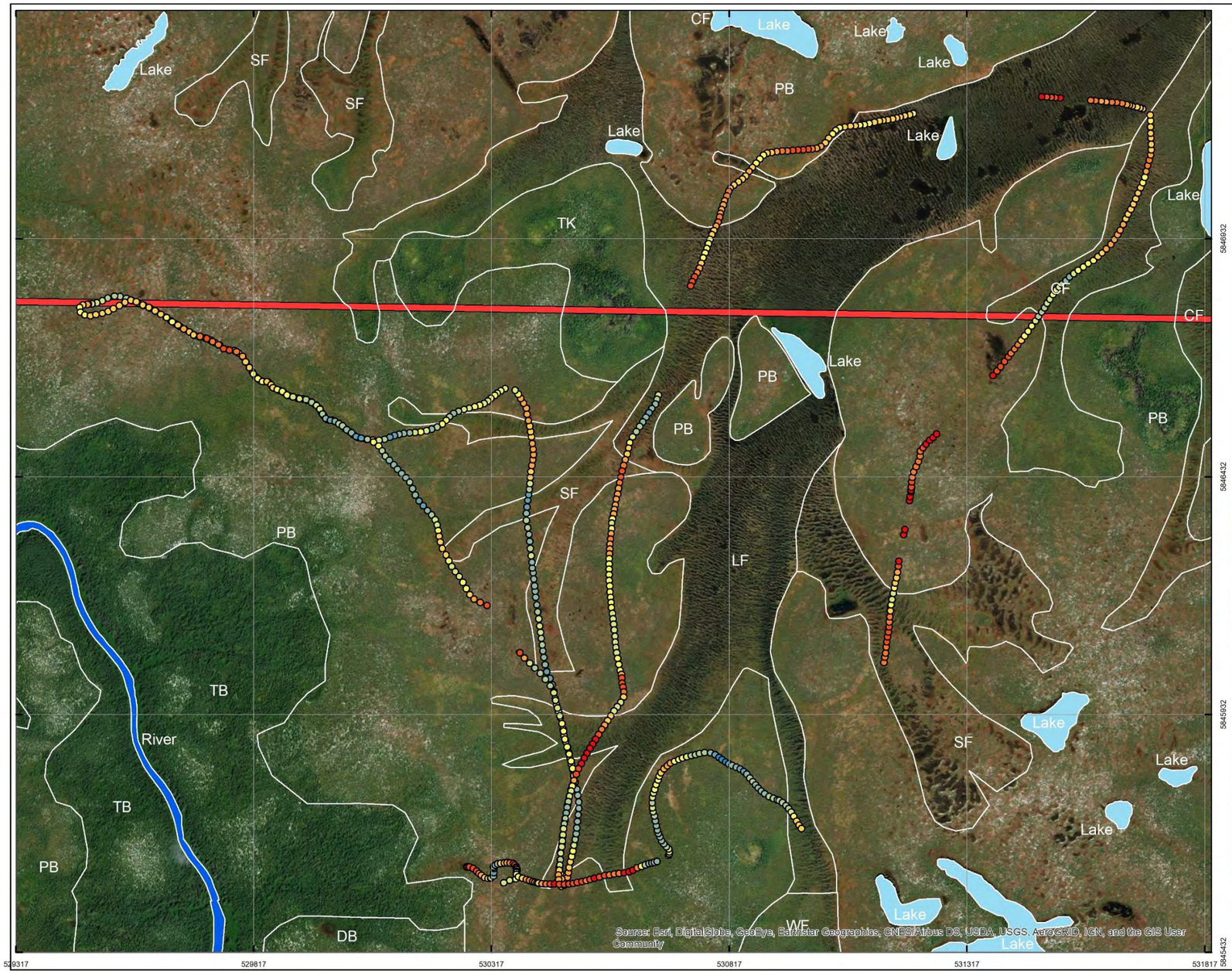
Four (4) GPR transects were surveyed at SITE 2, one running approximately west-east, two running approximately north-south, and the final one running northwest-southeast. Table 4a shows the average peat depth for each terrain type encountered, along with the minimum and maximum depths and measure of standard deviation. Table 4b summarizes the average depth, per terrain type, for all transects collected at SITE 2 combined.

Table 4a. GPR Site 2 Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 2-1				
Northern Plateau Bog (PB)	2.6 m	1.4 m	3.8 m	0.7
Ladder Fen (LF)	3.3 m	2.4 m	3.9 m	0.5
Transect 2-2				
Northern Plateau Bog (PB)	3.6 m	2.2 m	5.0 m	0.6
String Fen (SF)	3.3 m	2.4 m	3.7 m	0.4
Channel Fen (F)	2.7 m	1.8 m	3.3 m	0.3
Transect 2-3				
Northern Plateau Bog (PB)	2.9 m	1.9 m	3.9 m	0.4
Ladder Fen (LF)	3.1 m	1.7 m	4.7 m	0.7
Channel Fen (F)	3.0 m	2.9 m	3.0 m	> 0.1
String Fen (SF)	3.5 m	3.3 m	3.6 m	0.1
Transect 2-4				
Northern Plateau Bog (PB)	2.5 m	1.6 m	3.8 m	0.6
Ladder Fen (LF)	2.3 m	1.8 m	3.0 m	0.4
String Fen (SF)	2.1 m	1.7 m	3.0 m	0.4

Table 4b. GPR Site 2 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.8 m	1.4 m	5.0 m	0.7
String Fen (SF)	2.6 m	1.7 m	3.7 m	0.7
Ladder Fen (LF)	3.0 m	1.7 m	4.7 m	0.7
Channel Fen (CF)	2.7 m	1.8 m	3.3 m	0.3



LEGEND

Routes

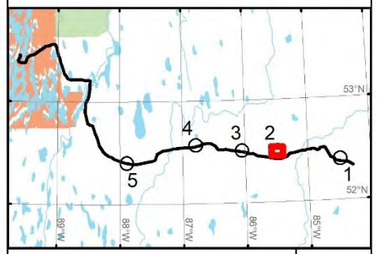
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.5 m
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- > 3.75 m

0 100 200 300 400
Meters



Scale 1:7,500
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT:
SNC Lavalin

PROJECT:
Webequie Supply Road

TITLE:
GPR RESULTS SITE 2

FIGURE:
7

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 3

GPR SITE 3 is located approximately 7 km west of SITE 2. The area contains a mix of northern plateau and domed bogs with a few small, scattered areas of open water, treed bog and thin channels of string fen (Figure 8). SITE 3 is one of the widest (continuous) expanses of peatland within the proposed route corridor and so was considered high-priority for GPR data collection.

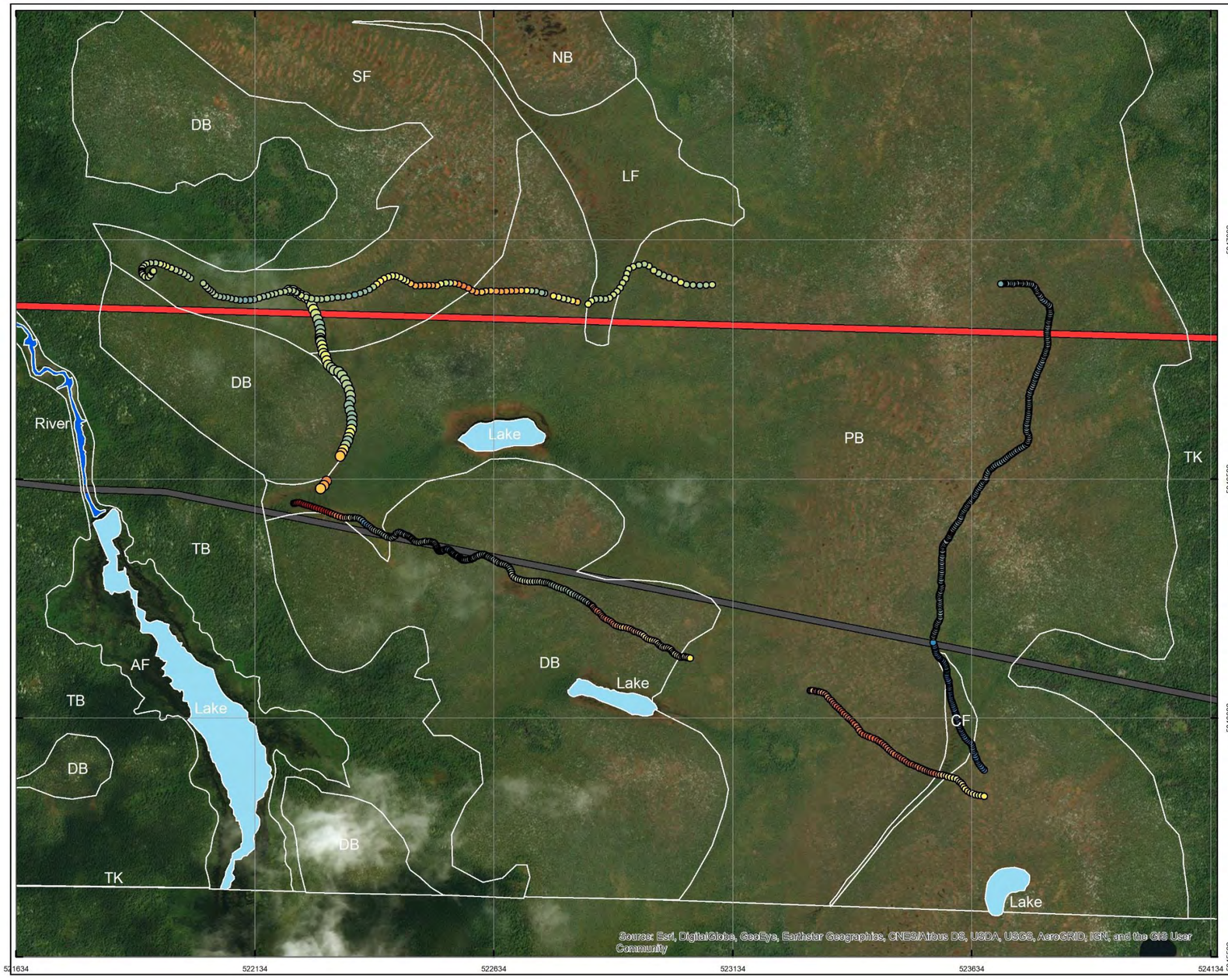
Four (4) GPR transects were surveyed at SITE 3, two running approximately west-east and two more running approximately north-south. Table 5a shows the average peat depth (along with minimum and maximum depths and measure of standard deviation), by terrain type, for each of the SITE 3 transects. Table 5b summarizes these statistics for all SITE 3 transects combined.

Table 5a. GPR Site 3 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 3-1				
Northern Plateau Bog (PB)	3.3 m	1.2 m	4.3 m	0.8
Domed Bog (DB)	2.2 m	1.2 m	3.7 m	0.7
Channel Fen (CF)	3.0 m	2.8 m	3.2 m	0.2
Transect 3-2				
Northern Plateau Bog (PB)	1.5 m	1.2 m	1.7 m	0.1
Channel Fen (CF)	1.2 m	1.1m	1.3m	> 0.1
Transect 3-3				
Northern Plateau Bog (PB)	2.4 m	1.7 m	3.6 m	0.5
Ladder Fen (LF)	2.3 m	2.1 m	2.7 m	0.1
Transect 3-4				
Northern Plateau Bog (PB)	2.4 m	2.0 m	3.6 m	0.5
Domed Bog (DB)	2.4 m	1.9 m	3.1 m	0.4
Ladder Fen (LF)	2.3 m	1.8 m	2.6 m	0.2

Table 5b. GPR Site 3 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.2 m	1.2 m	4.3 m	0.9
Domed Bog (DB)	2.2 m	1.2 m	3.7 m	0.7
Ladder Fen (LF)	2.3 m	1.8 m	2.7 m	0.2
Channel Fen (CF)	1.3 m	1.2 m	3.2 m	0.4



LEGEND

Routes

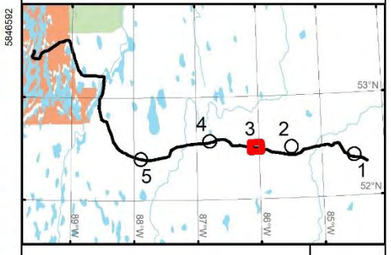
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.25 m
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4.0
- 4.0 - 4.25
- > 4.25 m

0 100 200 300 400
Meters



Scale 1:7,500
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: **SNC Lavalin**

PROJECT: **Webequie Supply Road**

TITLE: **GPR RESULTS SITE 3**

FIGURE: **8**

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 4

GPR SITE 4 is located approximately 5 km east of the Ekwan River, and approximately 10 km west of SITE 3. The site is a complex mix of domed bogs and northern plateau bogs, with the different bog types separated by thin channels of ladder fen and string fen that radiate out from an extensive ladder fen on the southeast side of the site (Figure 9). A thin line of treed bog borders the site to the west.

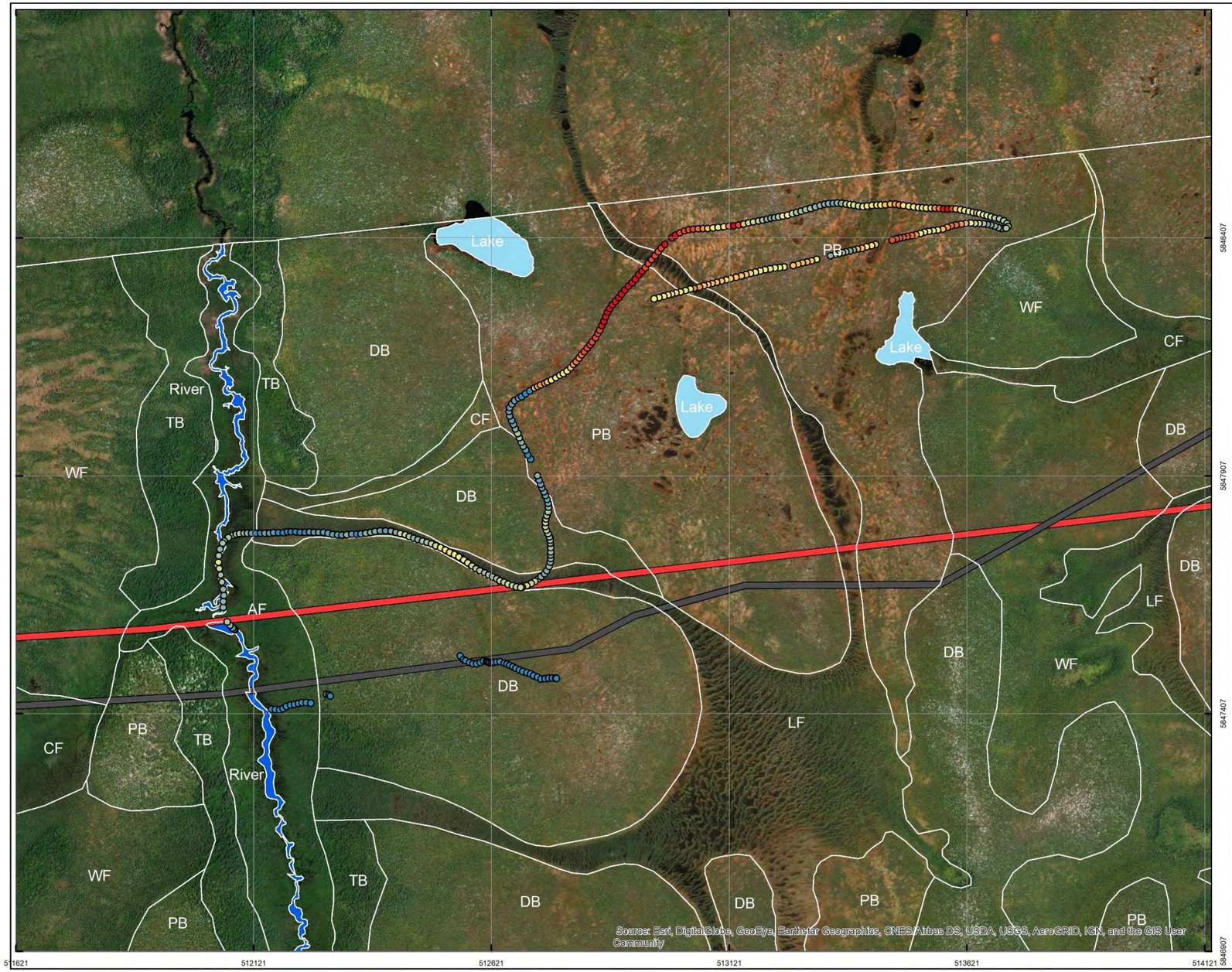
Three (3) GPR transects were surveyed at SITE 4, all running approximately west-east across the survey site. Table 6a shows the average peat depth (along with minimum and maximum depths and measure of standard deviation), by terrain type, for each of the SITE 4 transects. Table 6b summarizes these statistics for all SITE 4 transects combined.

Table 6a. GPR Site 4 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 4-1				
Domed Bog (DB)	1.0 m	0.7 m	1.3 m	0.2
Treed Bog (TB)	1.0 m	1.0 m	1.0 m	0.01
Transect 4-2				
Northern Plateau Bog (PB)	2.6 m	1.2 m	3.9 m	0.9
Domed Bog (DB)	1.8 m	1.3 m	2.0 m	0.3
Ladder Fen (LF)	1.9 m	1.0 m	3.7 m	0.7
Transect 4-3				
Northern Plateau Bog (PB)	2.6 m	1.5 m	3.6 m	0.5
Ladder Fen (LF)	1.9 m	1.1 m	3.3 m	0.5

Table 6b. GPR Site 4 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.6 m	1.2 m	3.9 m	0.8
Domed Bog (DB)	1.1 m	0.7 m	2.0 m	0.3
Treed Bog (TB)	1.0 m	1.0 m	1.0 m	> 0.1
Ladder Fen (LF)	1.9 m	1.0 m	3.7 m	0.6



LEGEND

Routes

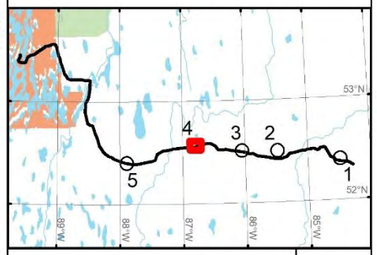
JDMA Route
Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.25 m
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- > 3.75 m

0 100 200 300 400
Meters



Scale 1:7,500
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT:
SNC Lavalin

PROJECT:
Webequie Supply Road

TITLE:
GPR RESULTS SITE 4

FIGURE:
9

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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SITE 5

GPR SITE 5 is the western-most of the sites surveyed, located approximately 5 km west of the Ekwan River, and within a few kilometres of where the proposed route makes its main turn from north-south to east-west. SITE 5 consists of extensive areas of northern plateau bog dissected by bands of treed bog, channelized fens and open water (Figure 10). Areas of thermokarst terrain are also present along the edge of the treed bogs that border the site to the east.

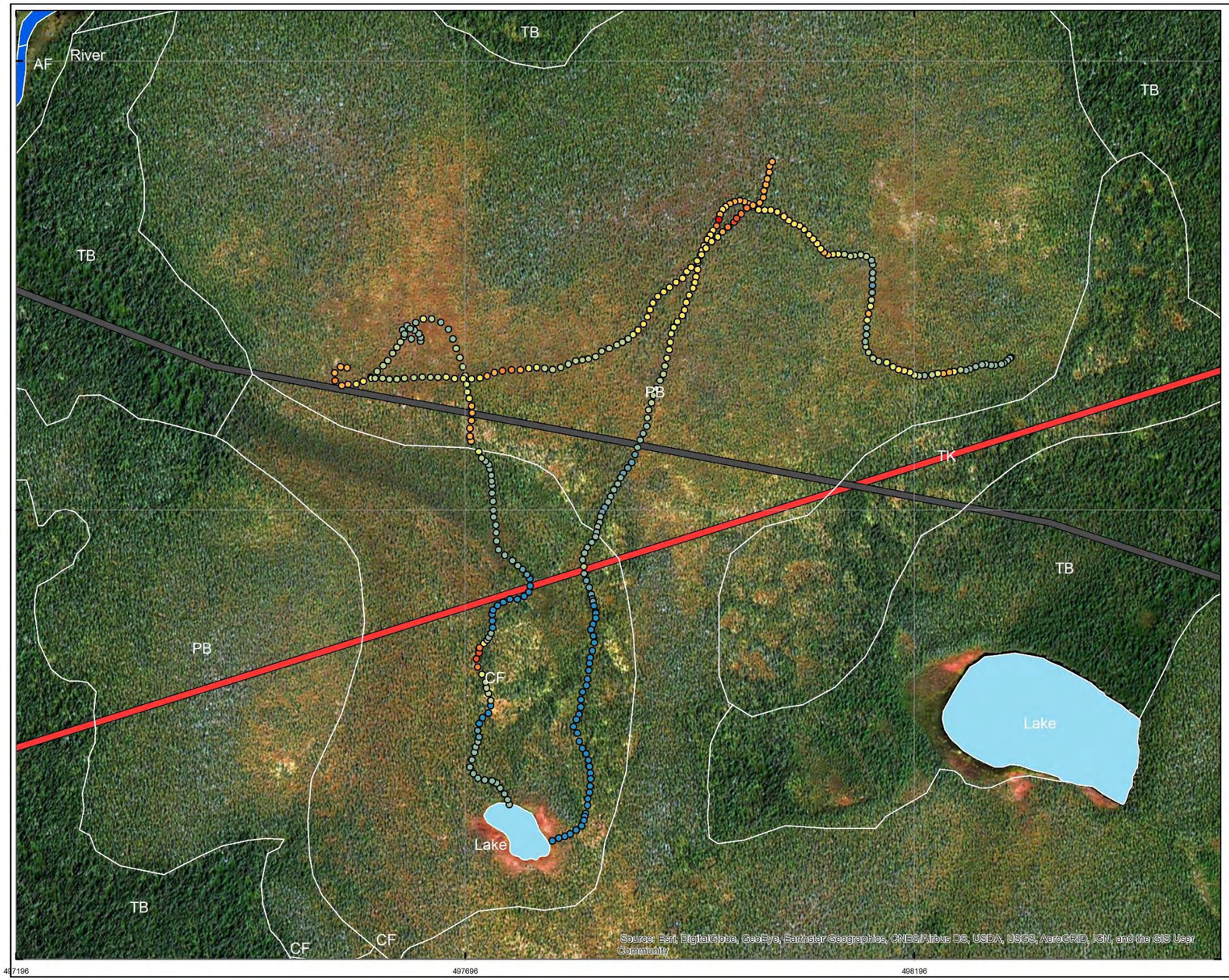
Three (3) GPR transects were surveyed at SITE 5, one running approximately west-east and the other two running approximately north-south. Table 7a shows the average peat depth (along with minimum and maximum depths and measure of standard deviation), by terrain type, for each of the SITE 5 transects. Table 7b summarizes these statistics for all SITE 5 transects combined.

Table 7a. GPR Site 5 – Summary of peat depth – by transect

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Transect 5-1				
Northern Plateau Bog (PB)	2.3 m	1.6 m	3.2 m	0.4 m
Transect 5-2				
Northern Plateau Bog (PB)	2.0 m	1.4 m	3.3 m	0.4
Channel Fen (CF)	1.2 m	1.0 m	1.8 m	0.2
Transect 5-3				
Channel Fen (CF)	1.7 m	1.2 m	3.1 m	0.5

Table 7b. GPR Site 5 – Summary of peat depth – all transects

Terrain Type	Avg Depth	Min Depth	Max Dept	STD DEV
Northern Plateau Bog (PB)	2.1 m	1.4 m	3.3 m	0.4
Channel Fen (CF)	1.6 m	1.0 m	3.1 m	0.5



LEGEND

Routes

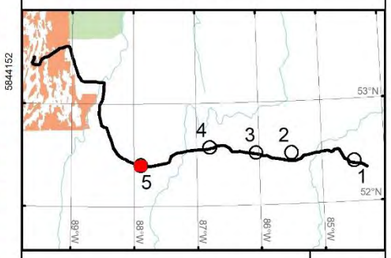
- JDMA Route
- Community Route

Interpreted Depth to Peat/Mineral Interface

Depth(m)

- < 1.25 metres
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.0
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3.0
- 3.0 - 3.25
- > 3.25 metres

0 100 200
Meters



Scale 1:4,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT:
SNC Lavalin

PROJECT:
Webequie Supply Road

TITLE: **GPR RESULTS SITE 5**

FIGURE: **10**

General reference map only; not for survey or legal use.

Map Sources: GPR Data: JDMA (c) 2019
Imagery: ESRI Base Imagery
Geomatics: TAZ Revision date: 28/Mar/2019

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Peat Thickness Summary

Peat thickness varied for each of the terrain units at the five GPR testing areas, with depths ranging from 0.5 m to 5.0 m (Tables 8a and 8b). Overall these observations suggest that, with the exception of treed bogs, peat thickness is similar in bogs and fens with common thicknesses of 1-3 m and maximum thicknesses up to 5 m. Peat thickness in treed bogs is generally less than 2 m.

Table 8a. Summaries of peat depths for terrain units at each of the five survey sites

	SITE 1			SITE 2			SITE 3			SITE 4			SITE 5		
TERRAIN TYPE	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth	AVG Depth	MIN Depth	MAX Depth
Domed Bog (DB)	---	---	---	---	---	---	2.2 m	1.2 m	3.7 m	1.1 m	0.7 m	2.0 m	---	---	---
Plateau Bog (PB)	1.5 m	0.5 m	2.6 m	2.8 m	1.4 m	5.0 m	2.2 m	1.2 m	4.3 m	2.6 m	1.2 m	3.9 m	2.1 m	1.4 m	3.3 m
Treed Bog (TB)	1.0 m	0.5 m	1.7 m	---	---	---	---	---	---	1.0 m	1.0 m	1.0 m	---	---	---
String Fen (SF)	---	---	---	2.6 m	1.7 m	3.7 m	---	---	---	---	---	---	---	---	---
Ladder Fen (LF)	---	---	---	3.0 m	1.7 m	4.7 m	2.3 m	1.8 m	2.7 m	1.9 m	1.0 m	3.7 m	---	---	---
Channel Fen (CF)	---	---	---	2.7 m	1.8 m	3.3 m	1.3 m	1.2 m	3.2 m	---	---	---	1.6 m	1.0 m	3.1 m

The range of values observed for each of the terrain units at all of the testing locations is summarized in Table 8b. In 2010, JDMA conducted field work, including peat probing, outside of the Webequie route corridor to the south (see Figure 2), but within similar terrain units. At these sites of peat probing, peat thickness was observed between 1.0 and 4.7 m, which is consistent with the range of thicknesses observed with the GPR data.

Table 8b. Summary of peat depths for all five GPR survey sites. Note the last row shows the range of peat depths measured from peat probing in 2010.

Summary of peat depth ranges		
Terrain Type	**Min Depth**	**Max Depth**
Domed Bog (DB)	0.7 m	3.7 m
Plateau Bog (PB)	0.5 m	5.0 m
Treed Bog (TB)	0.5 m	1.0 m
String Fen (SF)	1.7 m	3.7 m
Ladder Fen (LF)	1.0 m	4.7 m
Channel Fen (CF)	1.0 m	3.3 m
Peat depths measured in 2010 (Figure 2)	1.0 m	4.7 m

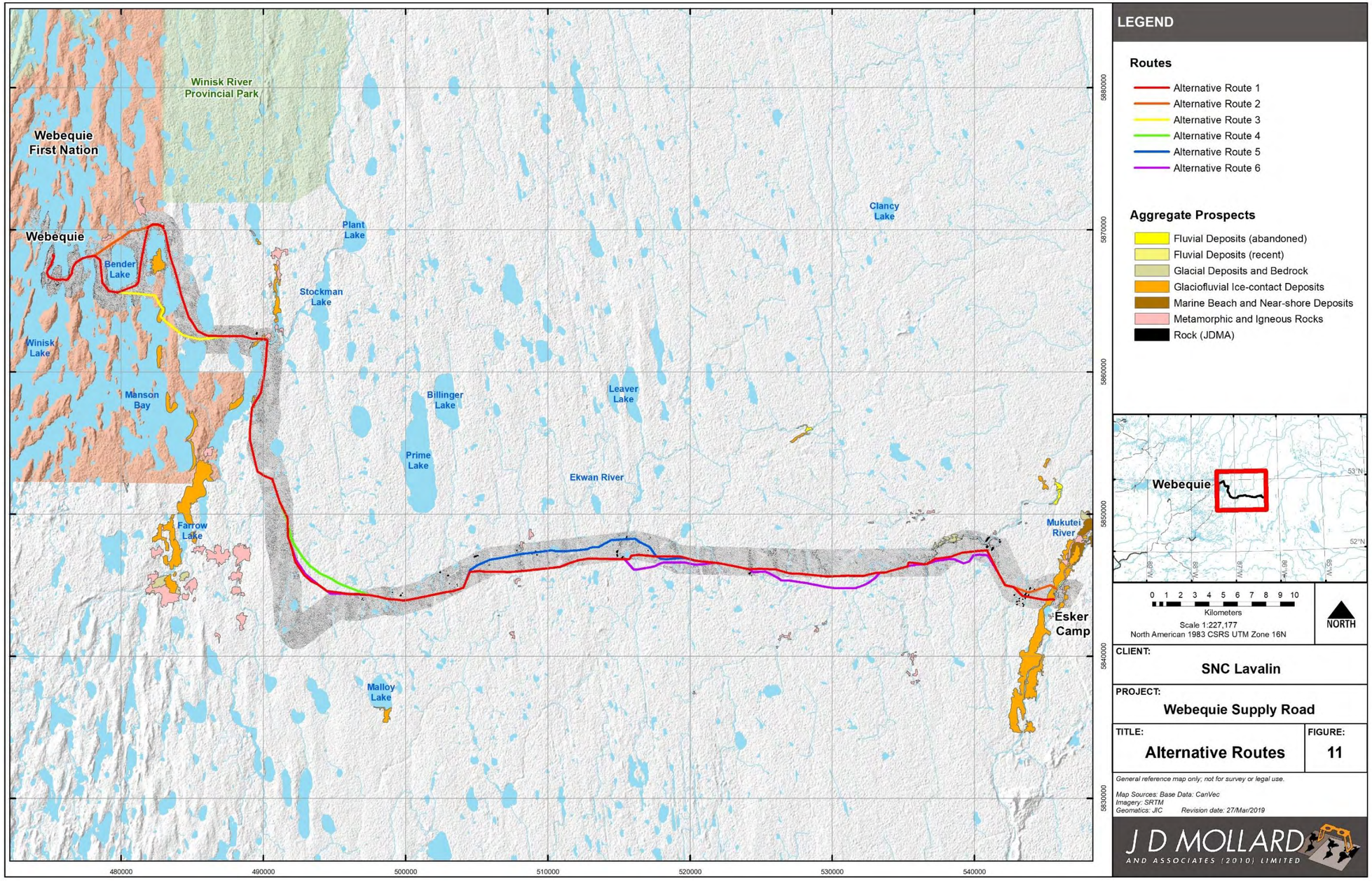
4.3 ROUTING

4.3.1 ROUTE ALTERNATIVES

A total of six alternative routes were mapped within the proposed corridor, each of which share various common segments and differ along other segments that offer advantages and disadvantages. An overview map of the routes is provided in Figure 11 and more detailed maps are included in Appendix 1. Table 9 provides a summary of lengths of route over each terrain unit. Routes 1, 2, and 3 differ only in the westernmost portions around Winisk Lake and Bender Lake in the approach to Webequie (Figure 11). Routes 1 and 2 diverge around Bender Lake, with Route 1 following a longer path around the south of the lake and Route 2 taking the shorter path to the north that requires a small channel crossing. The advantages of Route 1 are that it avoids a small stream crossing and provides access to the south side of Bender Lake, but at the disadvantage of a longer route. Nevertheless, the community has expressed preference for the route to follow south of Bender Lake. East of Bender Lake, these routes both pass around the northern end of a long embayment of Winisk Lake. Route 3 cuts across a narrow potion of this embayment of Winisk Lake and passes to the south of Bender Lake, which results in a much shorter route, but requires a channel crossing over the embayment.

Routes 4, 5, and 6 share the same path east from Webequie and along the main north-south segment (Figure 11). These routes differ mainly along the west-east segment that crosses the extensive organic terrains and in the point of crossing the Mukutei River. The challenge along this portion of the route corridor is minimizing routing across the extensive fens and water crossings. Among the most significant fens occurs just west of the Mukutei River tributary where multiple fens extend north-south nearly across the entire width of the corridor. Routes 4 and 5 avoid most of the fens by diverting to the south and following an alignment between two fens, while staying within the proposed route corridor. Route 5 diverts farther south, outside the proposed corridor, to limit these fen crossings. The southern path of this route also avoids other fens to the west before re-joining with Routes 4 and 5 (Figure 11).

Another difference in routes occurs along the section of the corridor crossed by multiple tributaries of the Ekwan River where there are extensive fens. Routes 4 and 6 divert to the south within the corridor while Route 5 follows a more central location (Figure 11).



LEGEND

Routes

- Alternative Route 1
- Alternative Route 2
- Alternative Route 3
- Alternative Route 4
- Alternative Route 5
- Alternative Route 6

Aggregate Prospects

- Fluvial Deposits (abandoned)
- Fluvial Deposits (recent)
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-contact Deposits
- Marine Beach and Near-shore Deposits
- Metamorphic and Igneous Rocks
- Rock (JDMA)

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Alternative Routes

FIGURE: 11

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 27/Mar/2019*

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Table 9. Terrain unit length (km) on route alternatives.

Terrain Units	Route 1 Length (km)	Route 2 Length (km)	Route 3 Length (km)	Route 4 Length (km)	Route 5 Length (km)	Route 6 Length (km)
Mineral Terrains						
TL	44.78	39.88	37.48	44.36	44.78	44.51
ER	0.55	0.56	0.56	0.56	0.56	0.56
GF	0.61	0.65	0.65	0.65	0.65	0.65
AF	2.13	2.13	2.01	2.01	2.21	1.82
Organic Terrains						
Bogs						
DB	5.37	5.37	5.39	5.53	5.22	5.95
PB	15.09	15.35	15.33	15.61	14.99	14.25
TB	20.01	19.94	19.94	20.37	22.02	19.82
TK	6.33	6.33	6.33	5.34	5.46	7.87
Fens						
SF	0.38	0.38	0.38	0.38	0.53	0.61
LF	0.30	0.30	0.30	0.30	0.29	0.08
CF	2.18	2.11	2.09	2.19	2.00	1.87
WF	4.89	4.89	4.89	4.77	4.59	5.11
HF	0.34	0.34	0.34	0.34	0.56	0.49
Water Crossings						
Water	0.68	0.68	0.85	0.68	0.67	0.58
Total						
Total	103.63	98.89	96.52	102.98	104.52	104.18

4.3.2 Optimal Route from Terrain Analysis

An optimal route from a terrain perspective was identified by picking segments from the competing alternative routes that meet the major criteria of route length, terrain conditions, stream crossings, and proximity to aggregate sources (Figure 12 and Table 10). Appendix 1 provides enlarged maps of the route. The optimal route minimizes total length in two main locations. The first is in the area southwest of Prime Lake, where the corridor transitions from north-south to east-west at nearly a right angle. By crossing outside of the corridor to the north, the optimal route cuts the overall length without adding additional water crossings. The second key location is around Bender Lake, where the optimal route crosses the shorter path northward around the lake.

The optimal route minimizes the length of route crossing terrain units considered to have a poor constructability ranking (see Tables 1 and 11), in particular the various types of fens that feature organic soils and a water table at surface. Overall, this results in a route that is slightly south of the

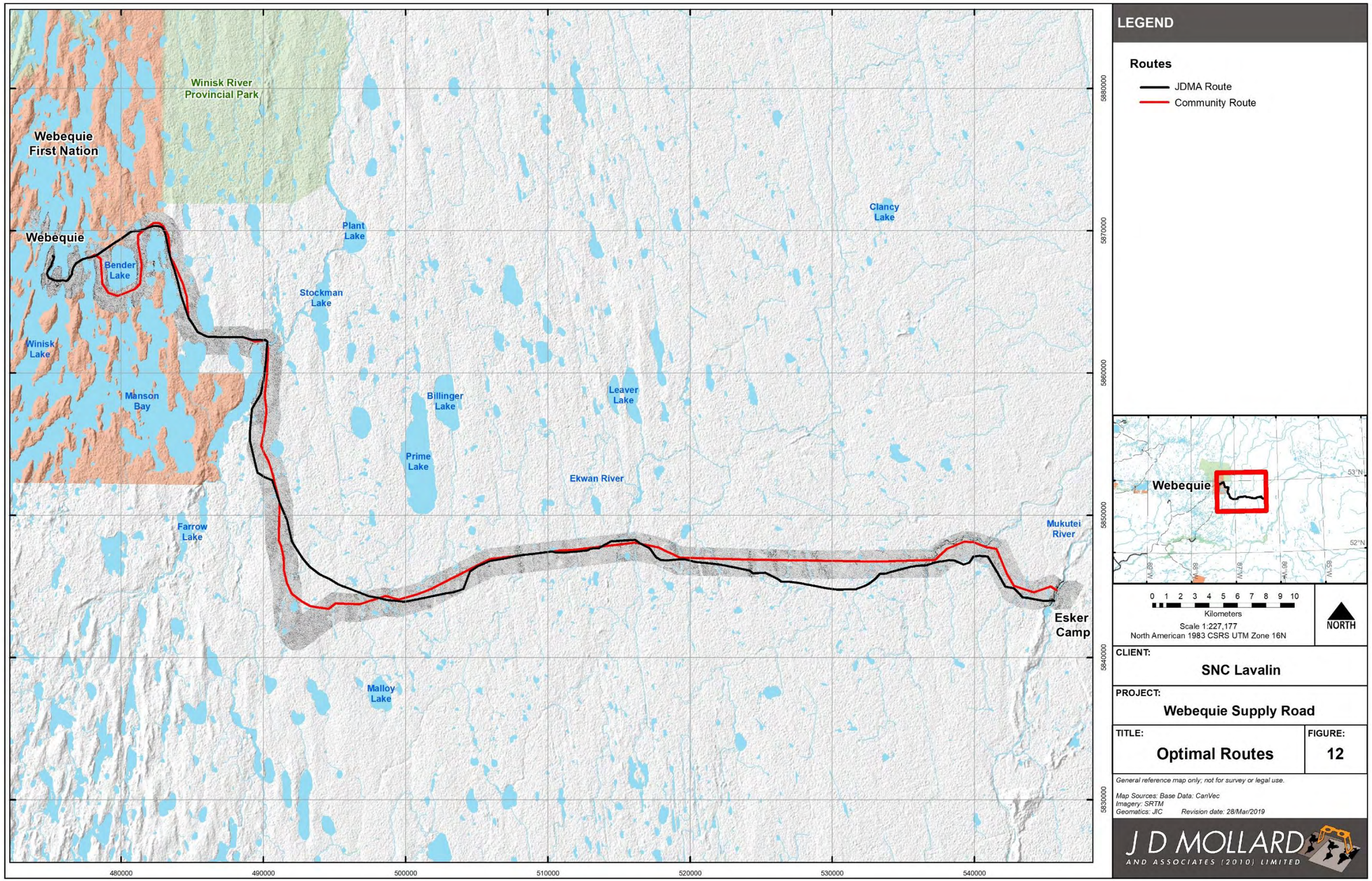
original community-selected route along the east-west extent and that lies outside of the 2-km-wide LiDAR corridor along a small portion of the route.

Table 10. Route length of terrain units on the optimal JDMA route and the community route.

Terrain Units	Optimal JDMA Route Length (km)	Community Route Length (km)
Mineral Terrains		
TL	39.33	41.13
ER	0.56	0.56
GF	0.61	0.69
AF	2.11	2.20
Organic Terrains		
Bogs		
DB	6.44	7.43
PB	13.89	22.94
TB	21.95	13.30
TK	4.94	4.95
Fens		
SF	0.77	1.20
LF	0.06	0.78
CF	1.76	2.49
WF	5.37	6.74
HF	0.71	0.54
Water Crossings		
Water	0.53	0.92
Total		
Total	99.04	105.88

Table 11. Length of constructability rankings on the optimal JDMA route and the community route.

Constructability Ranking	Optimal JDMA Route Length (km)	Community Route Length (km)
Good	40.50	42.39
Fair	26.89	18.26
Poor	20.83	31.18
Very Poor	10.29	13.13
Water Crossing	0.53	0.92
Total	99.04	105.88



LEGEND

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Optimal Routes

FIGURE: 12

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 28/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

4.4 WATER CROSSINGS

Water crossings, shown in Figure 13, were characterized by open water width, alluvial floodplain width, maximum slope, bank height, and adjacent terrain types. Table 12 summarizes crossings for the community route (C1 to C23) and Table 13 summarizes the result for the optimal JDMA route (J1 to J23). Appendix 2 provides a large-scale image, slope raster, and cross-sections for each of the water crossings along both the community and JDMA routes. Drainage across the east-west portion of the corridor, flows typically toward the north-northeast, draining northward into larger lakes like Prime Lake or Billinger Lake or into one of the larger river systems like the Ekwan River and the Mukutei River. Along the western portion of the corridor, which trends north-south and is covered largely by glacial terrains, the surficial drainage features fewer stream crossings than the east-west section of the corridor.

Most stream crossings exhibit relief of less than a few metres and cross flat alluvial floodplains that feature floating aquatic vegetation, have water tables near the surface, and are subject to flooding. The widest crossing, spanning approximately 250 m, is from Eastwood Island to the mainland (J23 and C23). Two of the most deeply incised stream crossings on both the optimal JDMA route and the community route, crossings 1 and 21 in both cases, appear to cut into glacial deposits (including glaciofluvial material) over bedrock. The Mukutei River (J1 and C1) crossing encounters the greatest bank heights of up to 20 m and slopes of up to 30 degrees on the west bank that consists of a large ice-contact glaciofluvial landform. The river crossing entering Stockman Lake (J21 and C21) spans a channel between two lakes and exhibits bank heights of up to 7.5 m and slopes of up to 23 degrees. The channel is cut through glacial sediment, with till on the south bank and glaciofluvial deposits on the north bank.

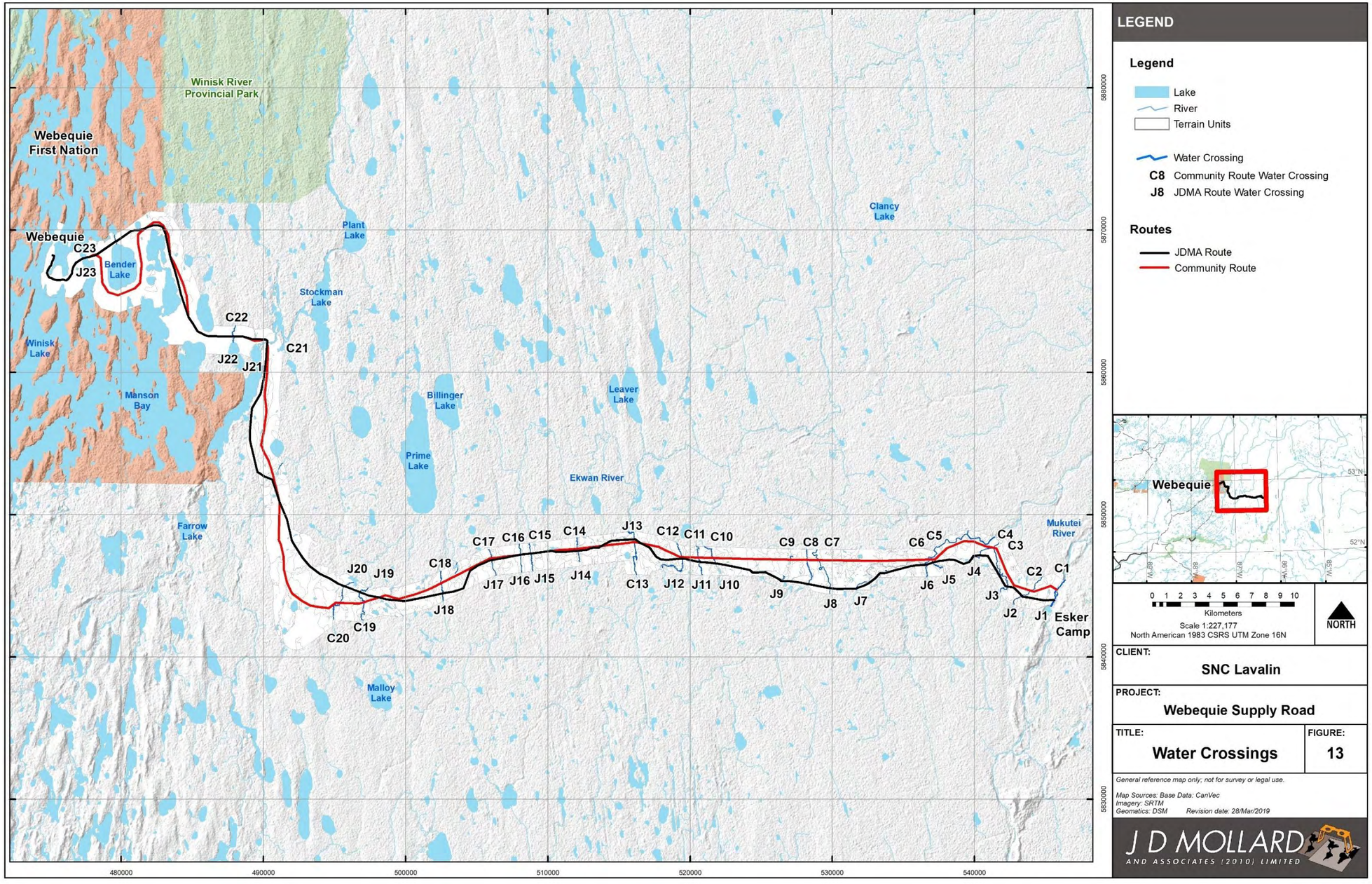
Table 12. Summary of water crossings along the community route

ID	Easting	Northing	Open Water Width	Alluvial Floodplain Width	Slope Max (degree)	Bank Height	Material
C1	545790	6844725	22	-	28	14	Esker: large steep slope
C2	544000	5844646	2.5	33	15	1	Treed Bog
C3	541370	5847665	28	49	11	2.5	Treed Bog
C4	541304	5847678	1.5	14	8	1	Treed Bog
C5	537013	5846847	5	53	26	4	Bog: Eroded valley
C6	536820	5846842	18	-	35	6	Till-Alluvial floodplain
C7	529066	5846800	16	-	28	3.5	Treed bog: channel
C8	528230	5846815	9	55	6	1	Treed-Plateau Bog
C9	527015	5846833	5	62	8	1	Treed Bog

C10	521566	5846956	8	48	8	1	Treed Bog
C11	520605	5846983	4.5	50	4	0.5	Thermokarst
C12	519420	5847015	12	108	6	0.5	Treed Bog
C13	516070	5848070	38	-	18	2.5	Treed Bog
C14	512045	5847600	30	200	6	0.5	Alluvial flood plain
C15	508765	5847270	8	100	9	1.5	Treed Bog
C16	508110	5847190	25	-	18	3.5	Treed Bog: channel
C17	506030	5846930	3	100	4	0.5	Bog-Fen: flat
C18	502472	5845167	12	62	12	2	Treed Bog
C19	497088	5843853	47	150	6	1	Treed Bog
C20	495405	5843792	3	41	8	1.5	Bog
C21	490280	5862110	44	54	23	7.5	Till-Glaciofluvial
C22	487910	5862520	15	102	14	1.5	Till
C23	477505	5868075	250	-	10	6	Till

Table 13. Summary of water crossings along the optimal JDMA Route

ID	Easting	Northing	Open Water Width	Alluvial Floodplain Width	Slope Max (degree)	Bank Height	Material
J1	545600	5843980	21	-	26	20	Esker: large steep slope
J2	543340	5844285	4	35	6	0.5	Treed Bog
J3	542295	5844955	10	145	6	0.5	Alluvial flood plain
J4	540430	5847145	1.5	100	11	1	Alluvial flood plain
J5	537080	5846650	3	50	16	4.5	Till-Bog: Eroded valley
J6	536645	5846490	21	200	26	7.5	Plateau Bog
J7	531690	5844820	4.5	32	-	-	Bog-Fen: flat
J8	529807	5844837	10	-	-	-	Treed Bog
J9	526262	5845452	2	140	-	-	Alluvial flood plain
J10	521777	5846572	7	29	7	-	Treed Bog
J11	520715	5846680	5	190	2	0.5	Alluvial flood plain
J12	519430	5846905	6	80	4	1.5	Treed Bog
J13	516050	5848263	13	-	22	3.5	Treed Bog
J14	512115	5847455	7.5	200	3	0.5	Alluvial flood plain
J15	508765	5847268	8	102	9	2.5	Alluvial flood plain
J16	508108	5847268	26	-	18	3.5	Treed Bog: channel
J17	506053	5846810	3	100	4	0.5	Fen-Bog: Flat
J18	502597	5844467	10	85	12	1	Treed Bog
J19	496850	5844530	15	42	8	1.5	Treed Bog
J20	495687	5844978	3	46	-	-	Treed Bog
J21	490280	5862110	44	54	23	7.5	Till-Glaciofluvial
J22	487910	5862520	15	102	14	1.5	Till
J23	477505	5868075	250	-	10	6	Till



LEGEND

Legend

- Lake
- River
- Terrain Units
- Water Crossing
- **C8** Community Route Water Crossing
- **J8** JDMA Route Water Crossing

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Water Crossings

FIGURE: 13

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: DSM *Revision date: 28/Mar/2019*

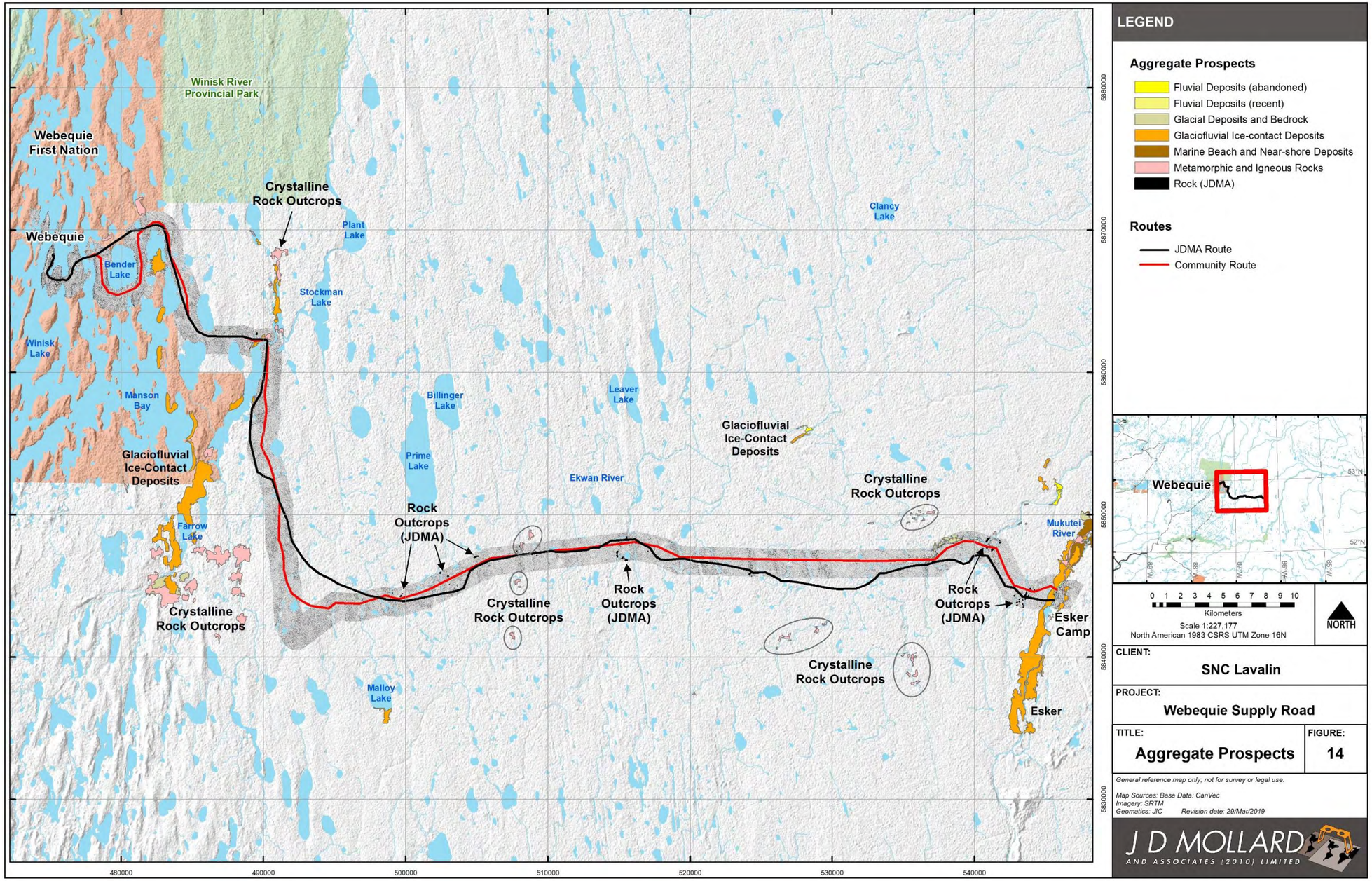
J D MOLLARD AND ASSOCIATES (2010) LIMITED

4.5 POTENTIAL AGGREGATE SOURCES

The Webequie Supply Road corridor crosses mostly glacial till along the north-south trending western section and extensive peatlands and organic soils along the east-west trending eastern section, which make identifying potential aggregate prospects a challenge. Potential aggregate sources are shown in Figure 14. Extensive, roughly north-south trending, ice-contact glaciofluvial systems are known to exist near the east and west ends of the proposed corridor and may provide a source of surficial granular material (Barnett *et al*., 2013, Surficial Maps P3696 and P3697). Near Esker Camp, on the west side of the Mukutei River, there is a large esker/ice-contact glaciofluvial deposit that trends north-northeast and is among the largest granular prospects in the region. The gradation of this feature needs to be field tested because despite being of glaciofluvial origin, discussions with people at Esker Camp suggest that the esker material is silty and lacks a significant coarse fraction. Near the western section of the route, there is an ice-contact glaciofluvial deposit that is most extensive to the west and north of Farrow Lake and that extends discontinuously northward along the eastern side of Manson Bay on Winisk Lake. In addition to these two large prospects, a smaller ice-contact glaciofluvial landform occurs within the corridor and extends northward west of Stockman Lake. Given that these are ice-contact glaciofluvial landforms, which are typically associated with granular material, and their proximity to the corridor, these landforms should be considered aggregate prospects and tested in the field to determine the material properties.

Bedrock outcrops scattered across the length of the corridor and in proximity to route alternatives offer potential quarry rock sources. The lithology of rock in the area is mapped as metamorphic and igneous. The largest outcrops occur south and east of Farrow Lake located west of the corridor. These areas likely provide the most surficial exposure to characterize the bedrock. Other bedrock outcrops are smaller and occur both inside and outside the corridor. While these smaller outcrops offer less exposure to characterize the bedrock, the bedrock will extend to great depth and lateral extent beyond the outcrop.

The characteristics of the granular deposits and suitability and location of potential bedrock sources are as yet unproven by field testing. Field reconnaissance is required to describe and characterize the material. Without drilling equipment, a simple initial field program is recommended where granular prospects are tested by digging shallow test holes to depths of 30-60 cm to assess the material gradation and quality. Where rock or quarry prospects are visited, the lithology and structural elements (fractures, bedding, foliation, *etc*.) visible at surface can be described.



LEGEND

Aggregate Prospects

- Fluvial Deposits (abandoned)
- Fluvial Deposits (recent)
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-contact Deposits
- Marine Beach and Near-shore Deposits
- Metamorphic and Igneous Rocks
- Rock (JDMA)

Routes

- JDMA Route
- Community Route

0 1 2 3 4 5 6 7 8 9 10
Kilometers
Scale 1:227,177
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Aggregate Prospects

FIGURE: 14

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: SRTM
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

5 SUMMARY

This study was undertaken as part of the Environmental Assessment and Preliminary Engineering Services for Webequie First Nation's Supply Road Project. J.D. Mollard and Associates (2010) Limited was sub-contracted by SNC Lavalin to conduct terrain mapping within the proposed community corridor to facilitate identification of potential aggregate sources, characterize stream crossings, map competing route alternatives, and identify an optimal route based on terrain and related engineering considerations.

Terrain studies focussed on a 2-km-wide routing corridor that was selected by community members based on engagement with the community as a whole, youth representatives, elders, and the Webequie land use planning committee. The corridor selected by the community is approximately 107 km in length (extending about 51 km toward the south-southeast from Webequie before turning east for about 56 km toward Esker Camp), and 2 km in width.

Six viable route alternatives were identified within the community-selected routing corridor and an optimal route was identified that provides a balance of length, terrain conditions for road construction and maintenance, stream crossings and proximity to potential aggregate sources. The optimal route is 99 km in length crossing approximately 67 km of terrain with fair to good constructability, 21 km of poor constructability, 10 km of very poor constructability and 0.5 km of water crossings.

Twenty-three stream crossings were identified on the optimal route with the majority having less than 3 m of relief and open water widths ranging from 3 to 250 m. The maximum crossing relief is 20 m at the Mutukei River. The widest crossing is 250 m from Eastwood Island to the mainland.

Peat thicknesses from ground penetrating radar surveys range from 0.5 to 5.0 m in bogs and from 1.0 to 4.7 m in fens. These depths are consistent with peat depths measured south of the corridor in 2010 but they have not been confirmed in the field. This is recommended in subsequent field studies.

A number of potential aggregate sources have been identified including glacial granular deposits and bedrock outcrops. Glacial granular sources are concentrated in large glaciofluvial deposits at the east and west ends of the study area. Bedrock outcrops are present within and outside of the routing corridor and are distributed across the study area. Field reconnaissance of these locations is required to better assess their potential.

Although an optimal route has been identified based on terrain and related engineering factors, selection of a final preferred route will require consideration of detailed engineering, social, cultural and environmental factors in additional studies.

REPORT SIGNATURE PAGE

J.D. Mollard and Associates (2010) Limited

Jason Cosford, Ph.D., P.Geo.

Lynden Penner, M.Sc., P.Eng., P.Geo.

Troy Zimmer, B.Sc., Hons. Dpl. (Bioscience), MCRSS

APPENDIX 1: Terrain Mapping

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

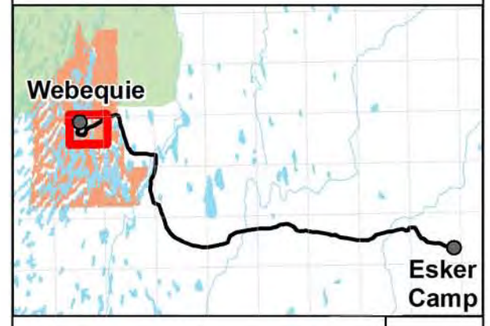
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

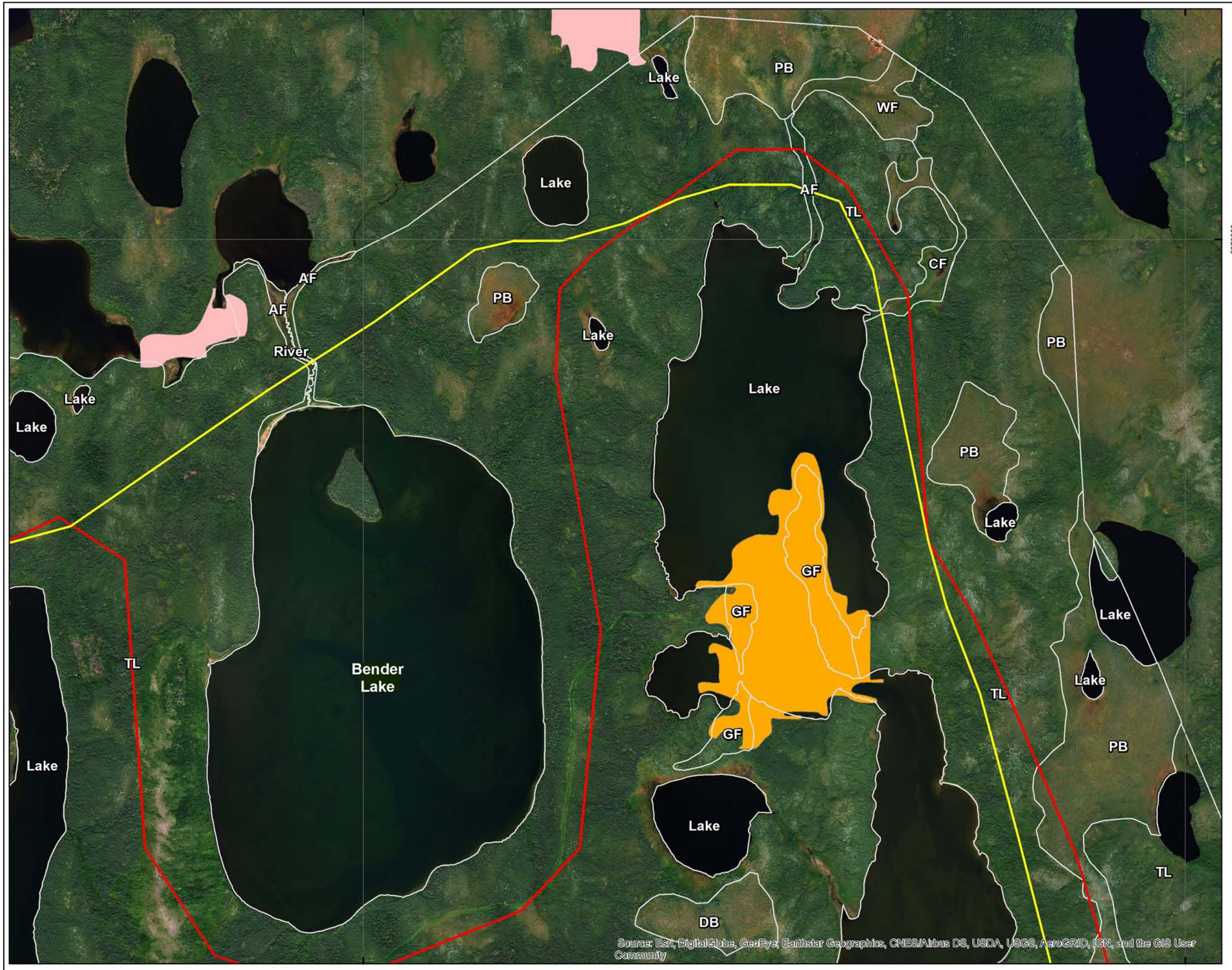
TITLE: Terrain Mapping

FIGURE: TM1

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

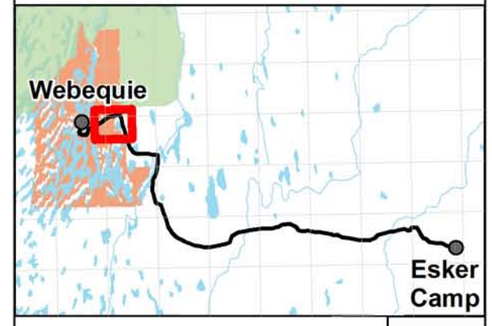
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

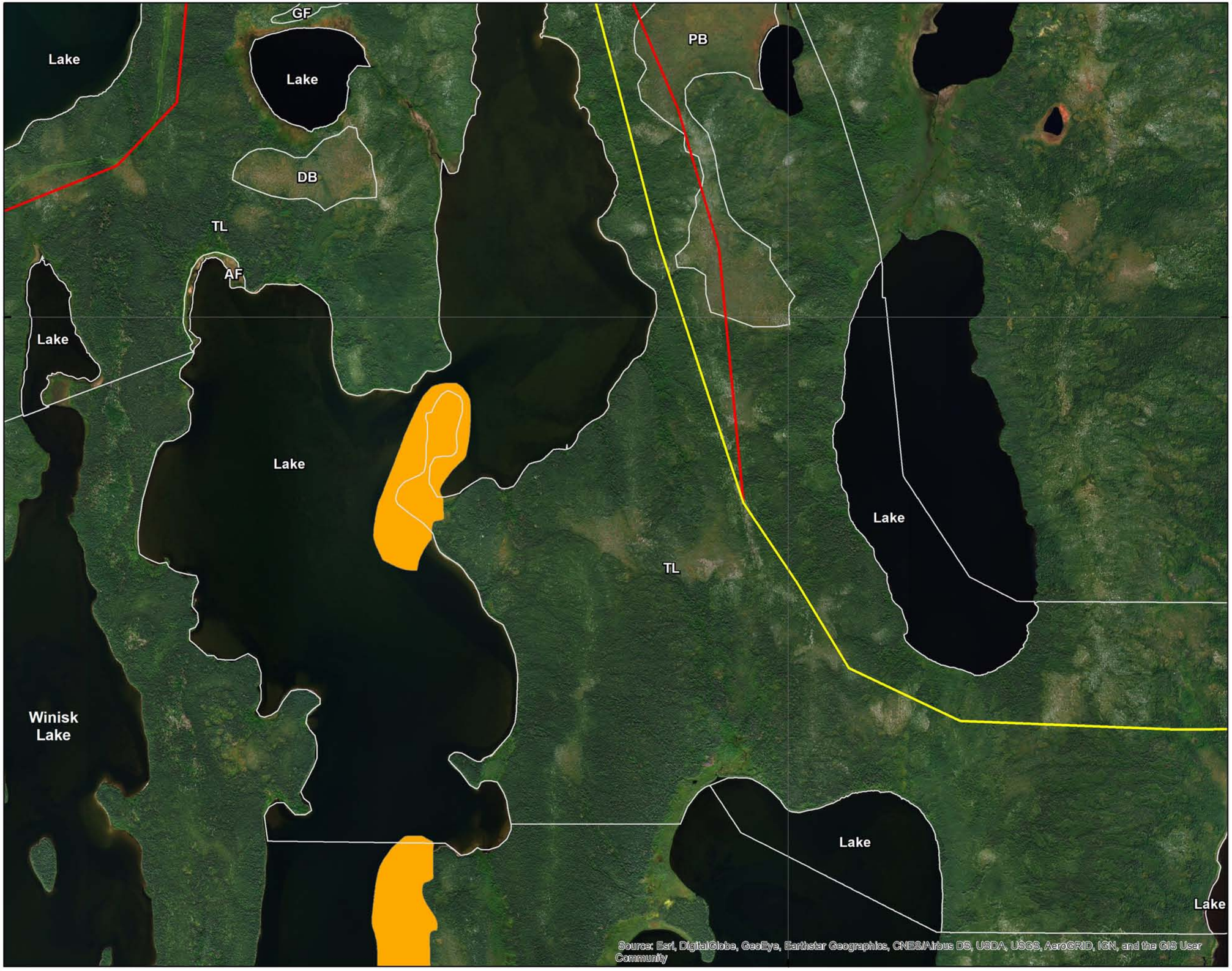
TITLE: Terrain Mapping

FIGURE: TM2

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

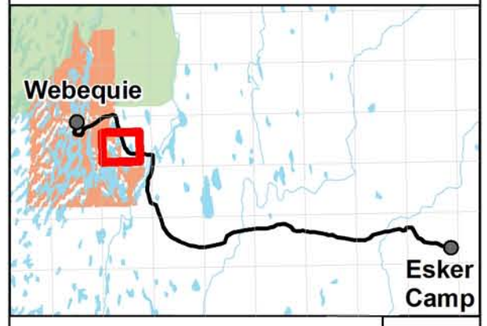
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

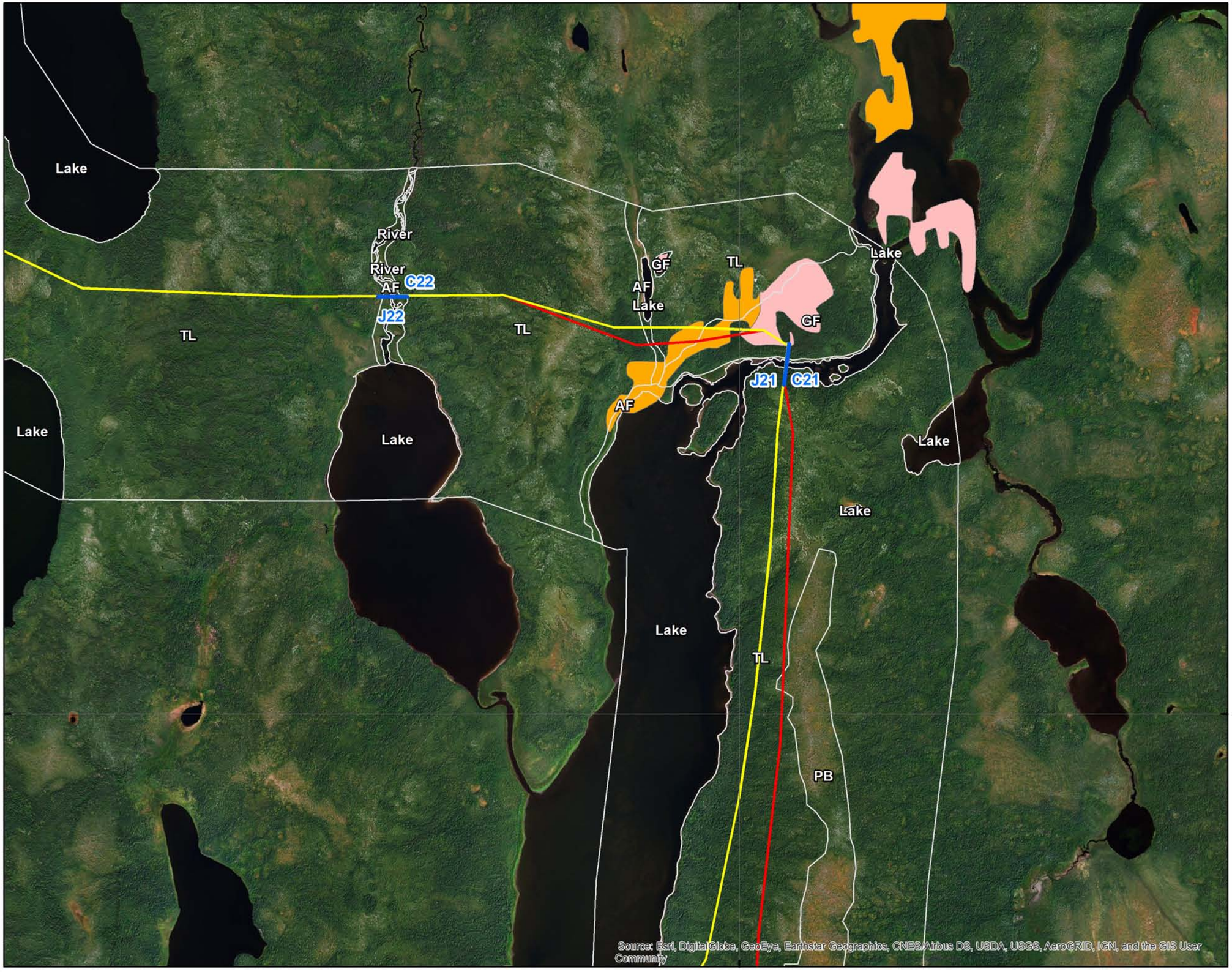
TITLE: Terrain Mapping

FIGURE: TM3

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

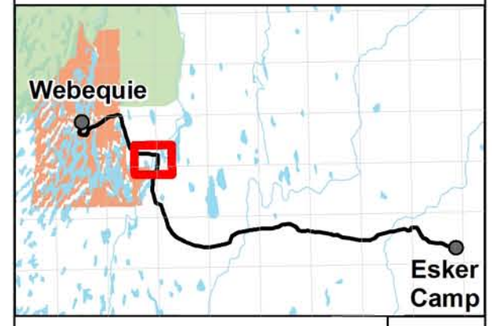
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

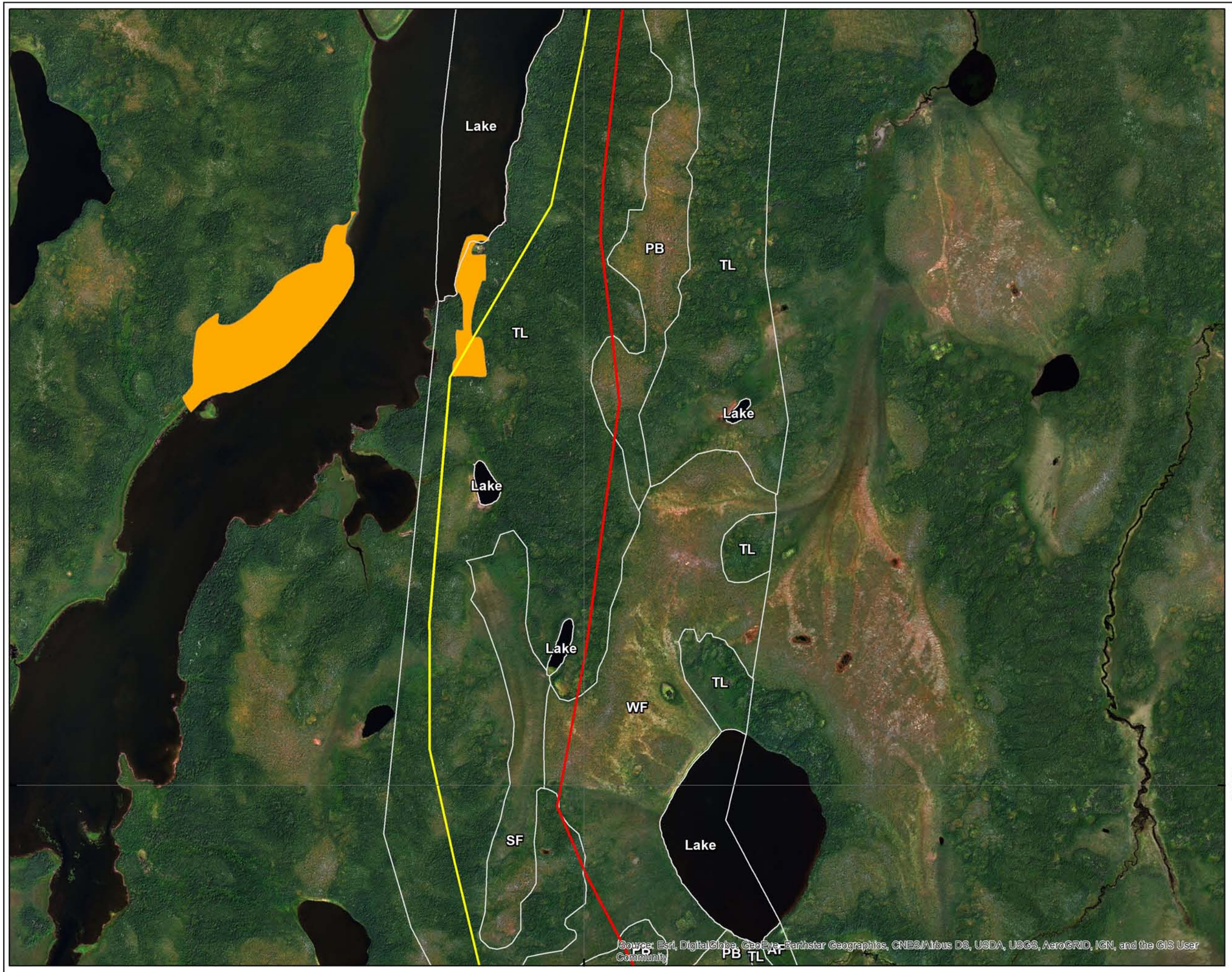
TITLE: Terrain Mapping

FIGURE: TM4

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

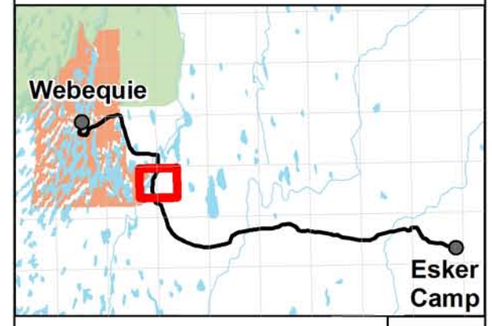
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial tilll	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

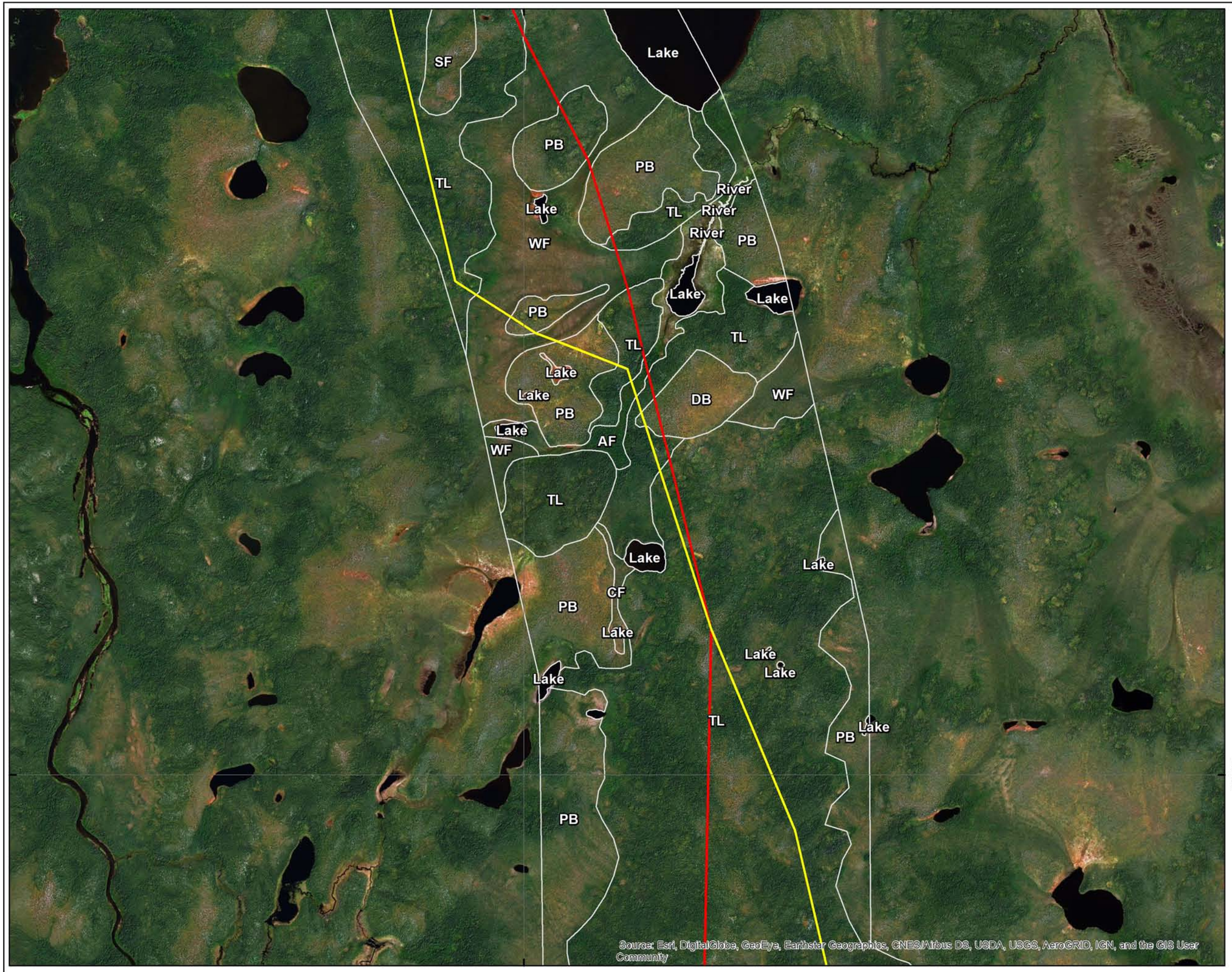
TITLE: Terrain Mapping

FIGURE: TM5

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial tilll
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

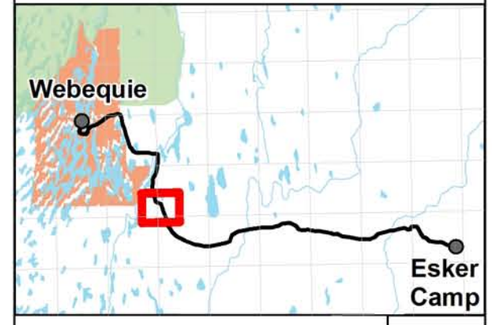
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

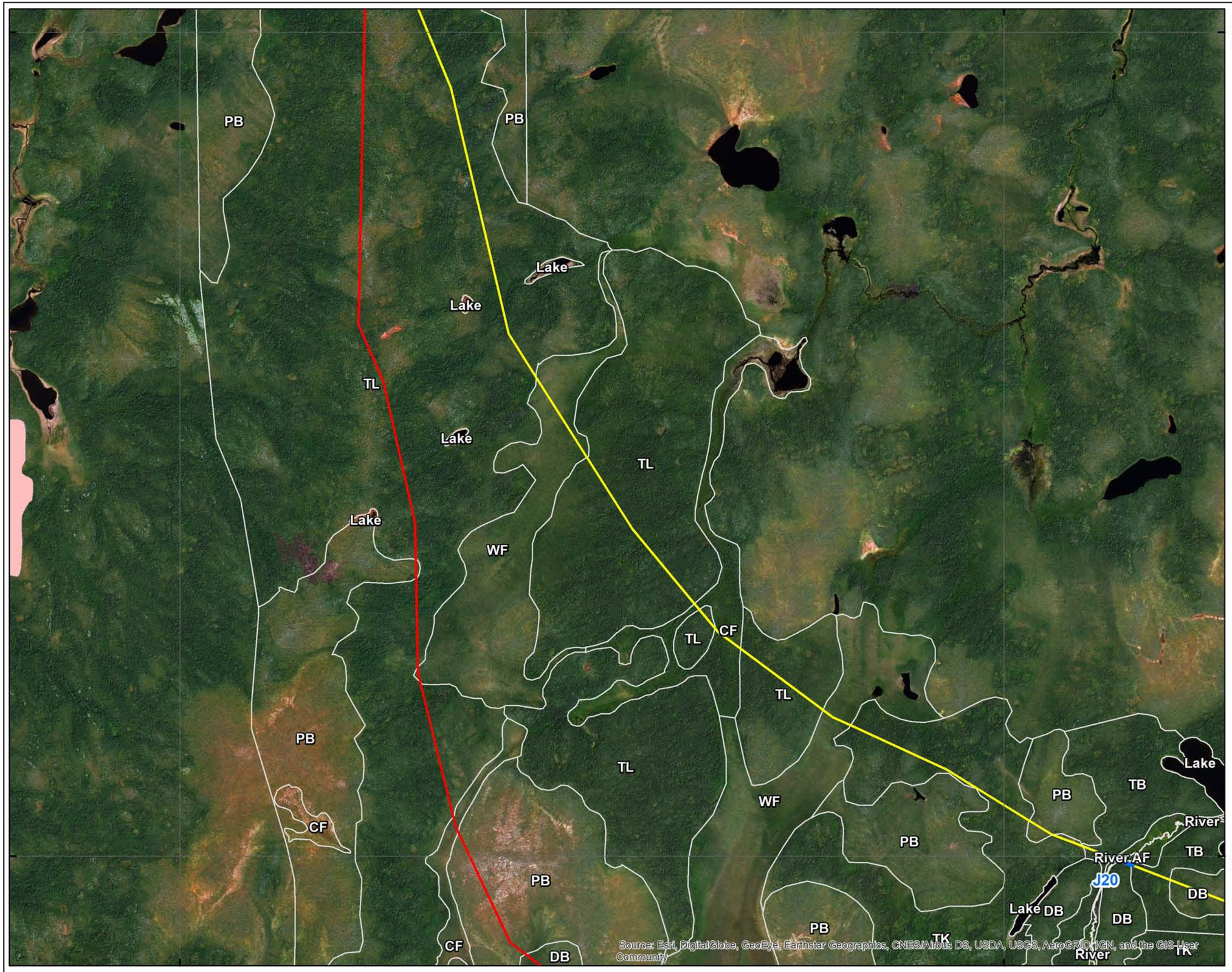
TITLE: Terrain Mapping

FIGURE: TM6

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

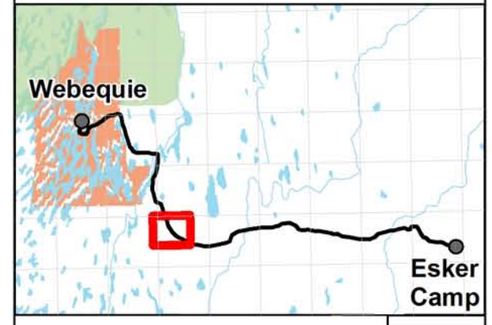
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial tilll	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

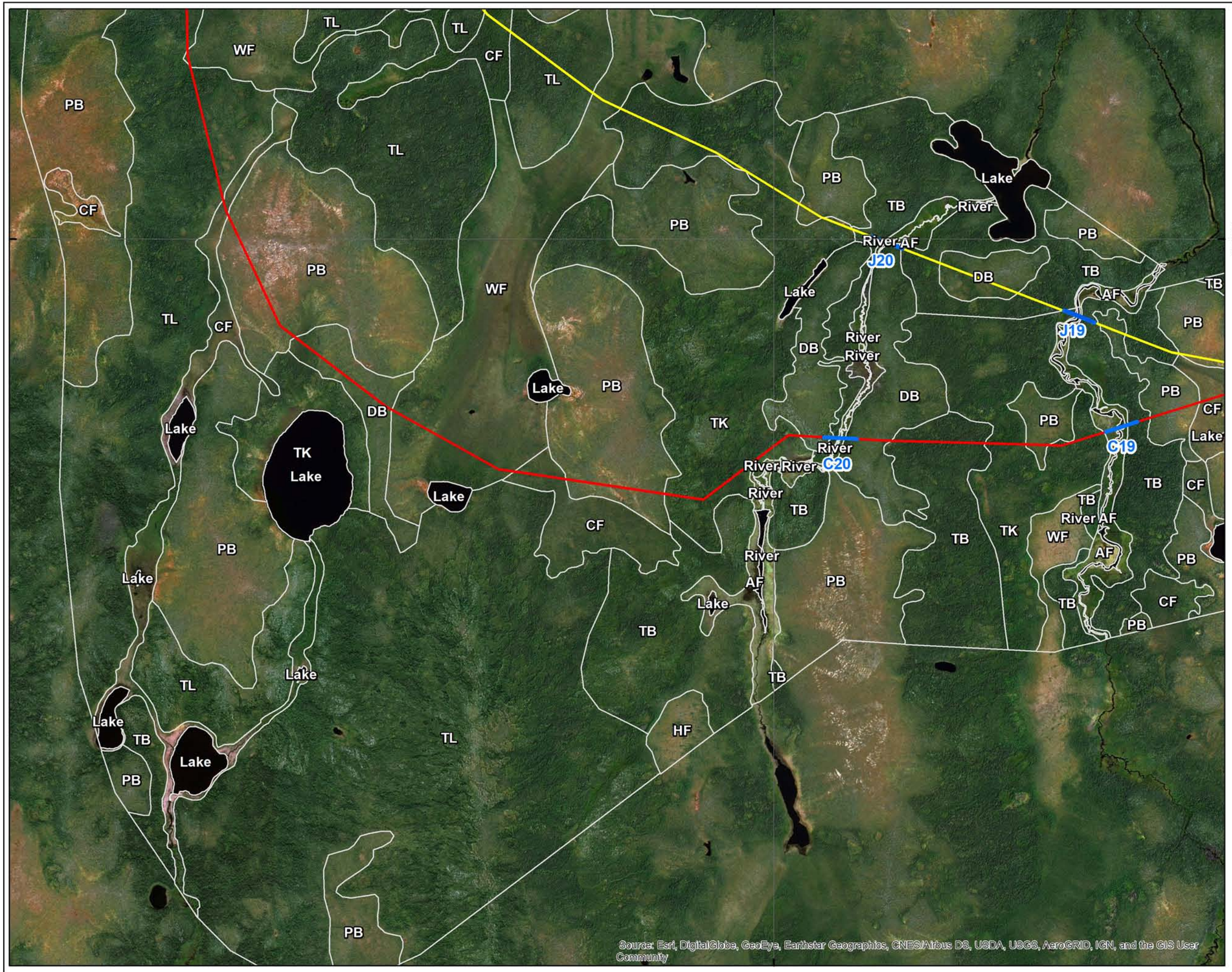
TITLE: Terrain Mapping

FIGURE: TM7

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

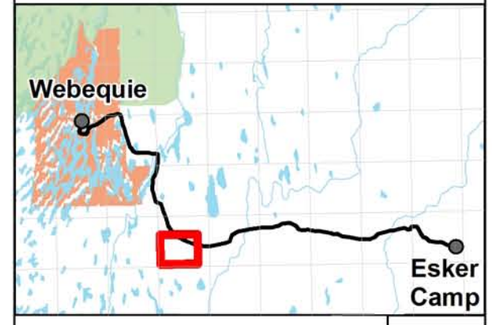
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

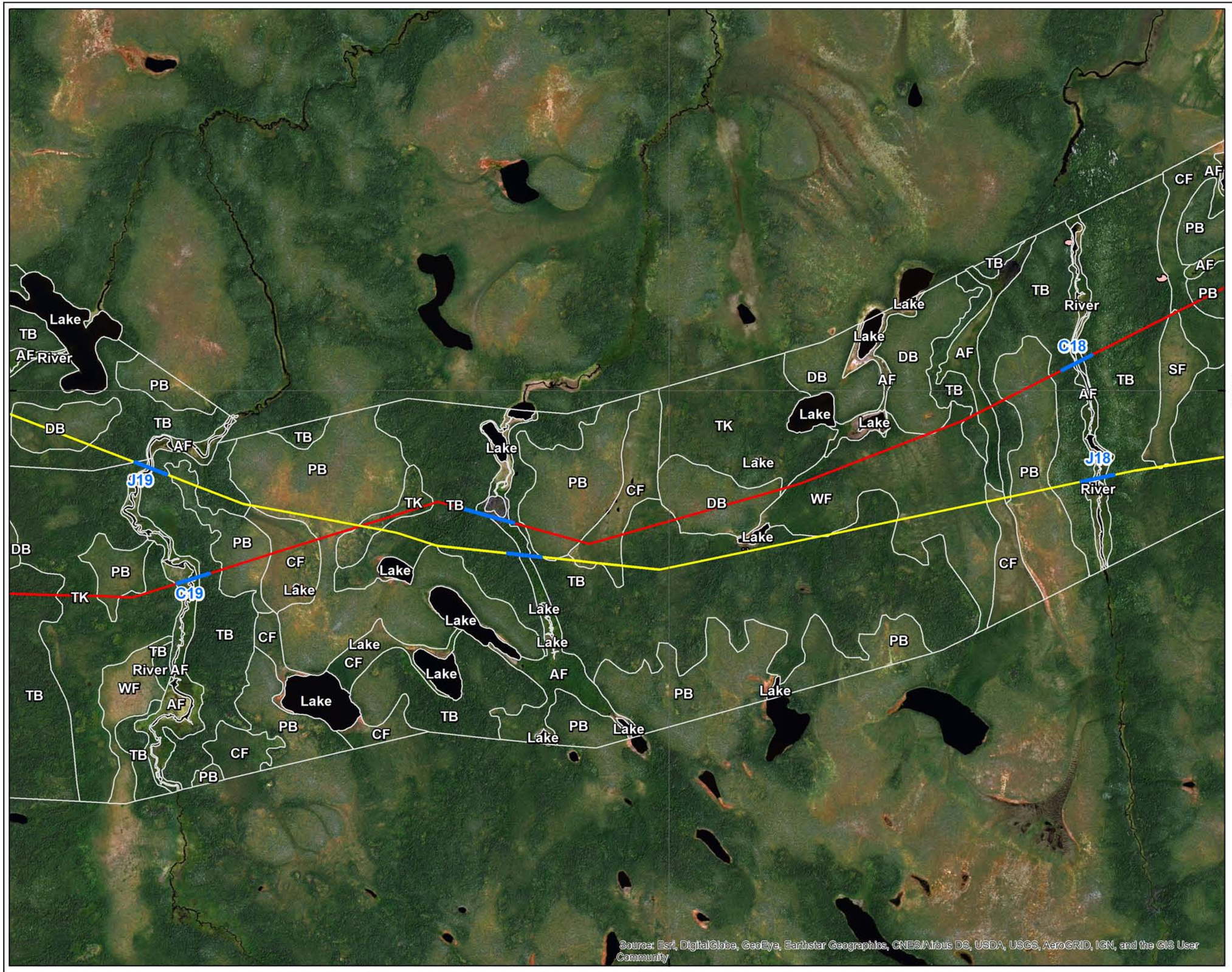
TITLE: Terrain Mapping

FIGURE: TM8

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial till
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

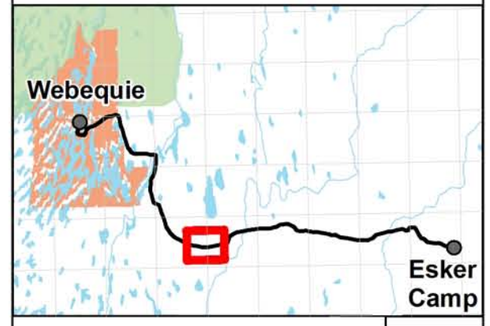
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: **SNC Lavalin**

PROJECT: **Webequie Supply Road**

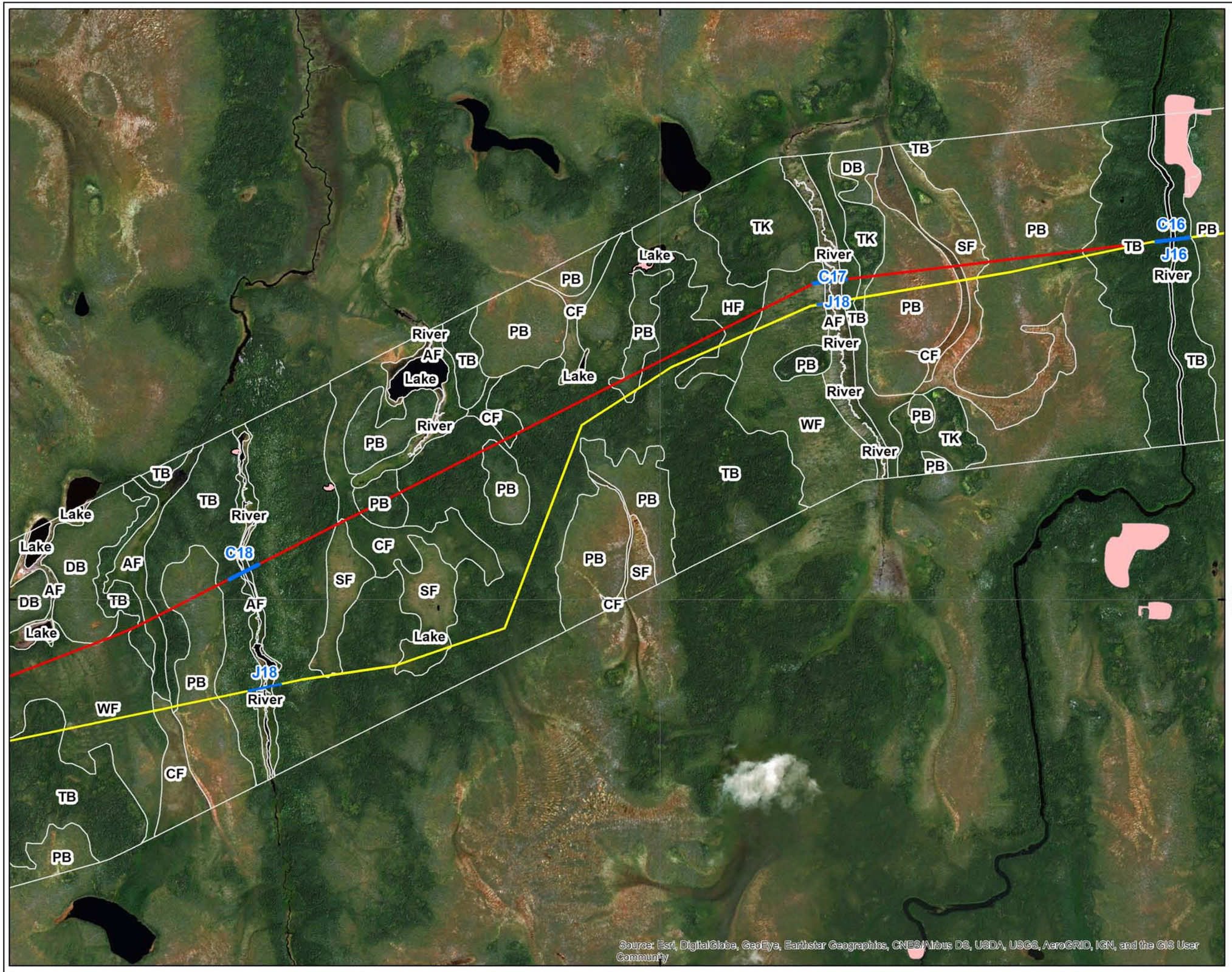
TITLE: **Terrain Mapping**

FIGURE: **TM9**

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
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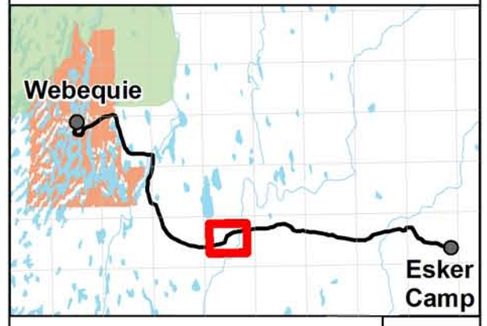
Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



0 500 1,000
Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: TM10

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

5850000

5845000

510000

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial tilll
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

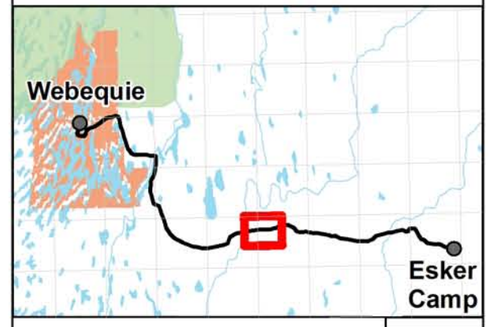
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: TM11

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

Mineral Terrains

TL: Glacial tilll
GF: Glaciofluvial
ER: Esker Ridge
AF: Alluvial Floodplain

Bog Terrains

TB: Treed Bog
TK: Thermokarst Bog
DB: Domed Bog
PB: Plateau Bog
NB: Net Bog

Fen Terrains

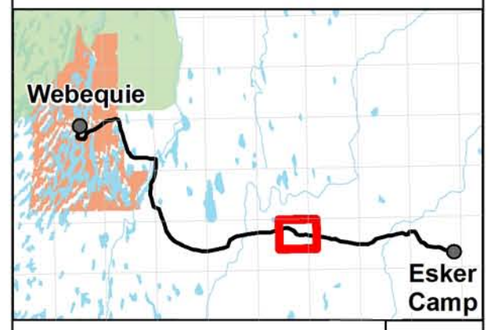
SF: String Fen
LF: Ladder Fen
CF: Channel Fen
HF: Horizontal Fen
WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

FIGURE: TM12

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

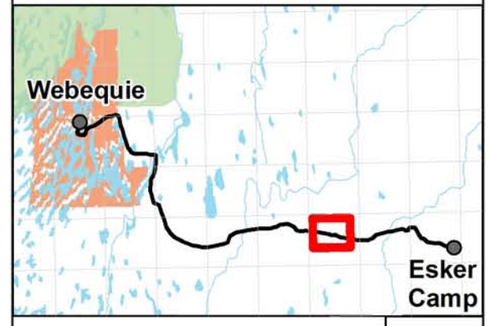
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

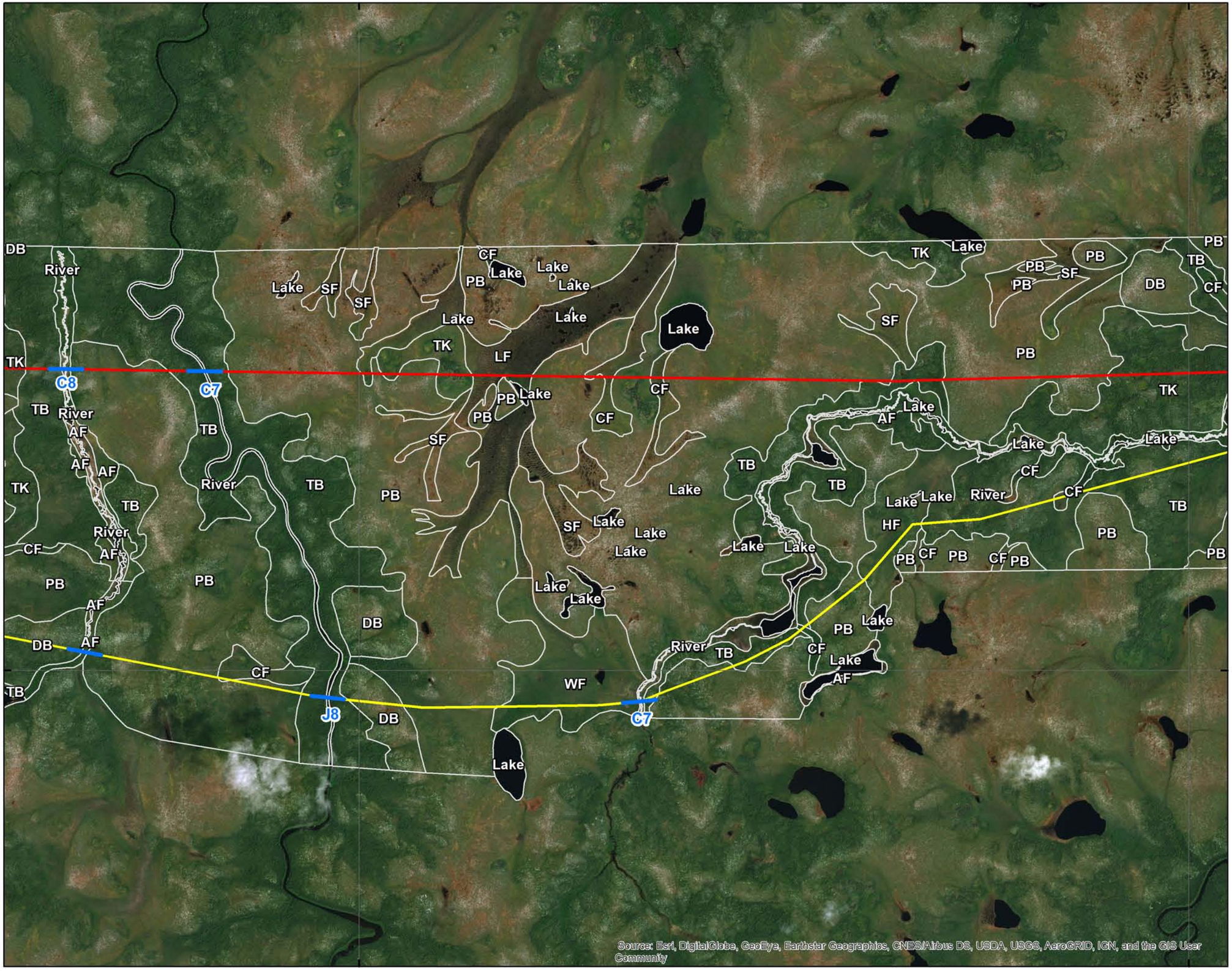
TITLE: Terrain Mapping

FIGURE: TM13

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED


DB
River
Lake
SF
SF
CF
PB
Lake
Lake
Lake
Lake
Lake
TK
LF
TK
C8
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TB
River
AF
AF
AF
TB
River
TB
PB
SF
PB
Lake
CF
CF
Lake
TK
Lake
PB
PB
SF
PB
DB
TB
CF
PB
SF
PB
TK
TB
TB
Lake
Lake
AF
Lake
Lake
CF
Lake
Lake
River
CF
HF
TB
PB
PB
CF
PB
CF
PB
PB
TK
River
TB
PB
TB
River
AF
CF
PB
PB
AF
DB
AF
DB
CF
TB
WF
J8
DB
C7
Lake
PB
Lake
AF
Lake
Lake
Lake
Lake
Lake

LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

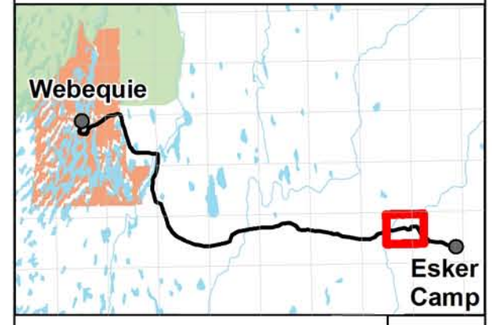
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



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Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

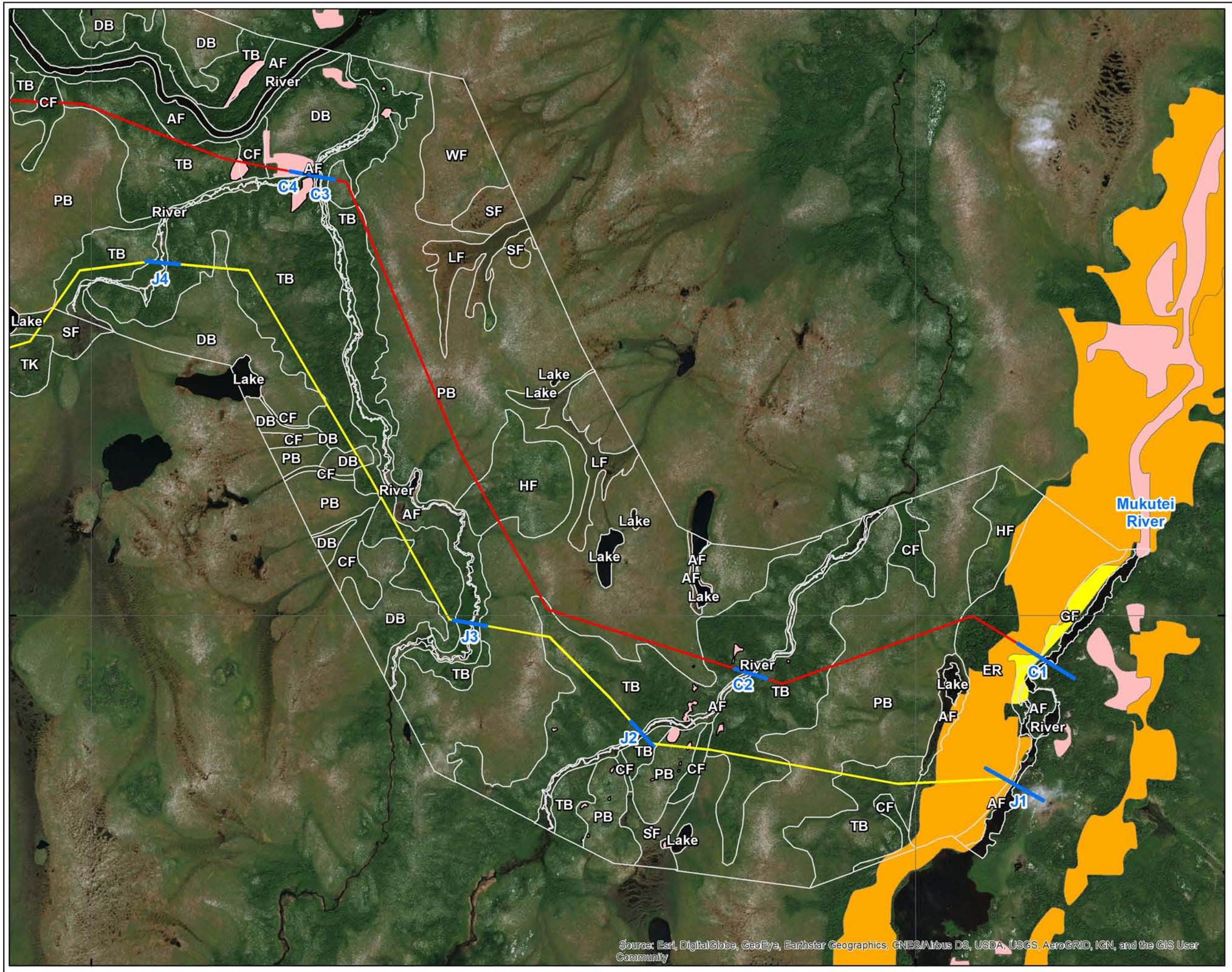
TITLE: Terrain Mapping

FIGURE: TM15

General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

J D MOLLARD AND ASSOCIATES (2010) LIMITED



LEGEND

Routes

- JDMA Route
- Community Route

Terrain Mapping

PB — Terrain Unit

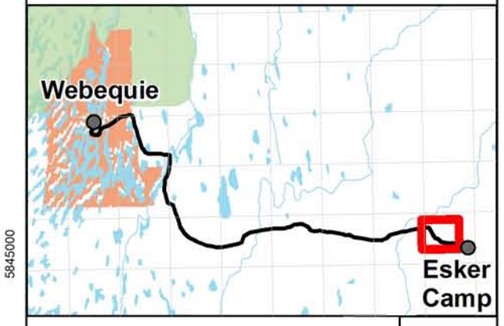
Mineral Terrains	Bog Terrains	Fen Terrains
TL: Glacial till	TB: Treed Bog	SF: String Fen
GF: Glaciofluvial	TK: Thermokarst Bog	LF: Ladder Fen
ER: Esker Ridge	DB: Domed Bog	CF: Channel Fen
AF: Alluvial Floodplain	PB: Plateau Bog	HF: Horizontal Fen
	NB: Net Bog	WF: Water Fen

Aggregate Prospects

- Fluvial Deposits
- Glacial Deposits and Bedrock
- Glaciofluvial Ice-Contact Deposits
- Crystalline Bedrock

Water Crossings

- J23 — JDMA Route Water Crossing
- C23 — Community Route Water Crossing



0 500 1,000
Meters
Scale 1:22,000
North American 1983 CSRS UTM Zone 16N

NORTH

CLIENT: SNC Lavalin

PROJECT: Webequie Supply Road

TITLE: Terrain Mapping

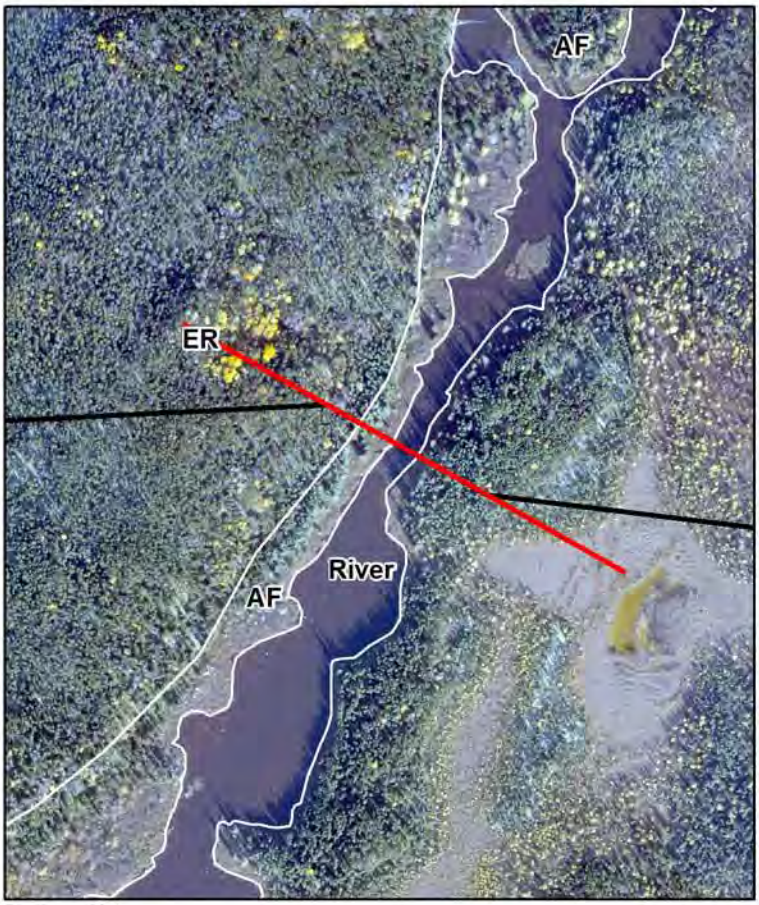
FIGURE: TM16

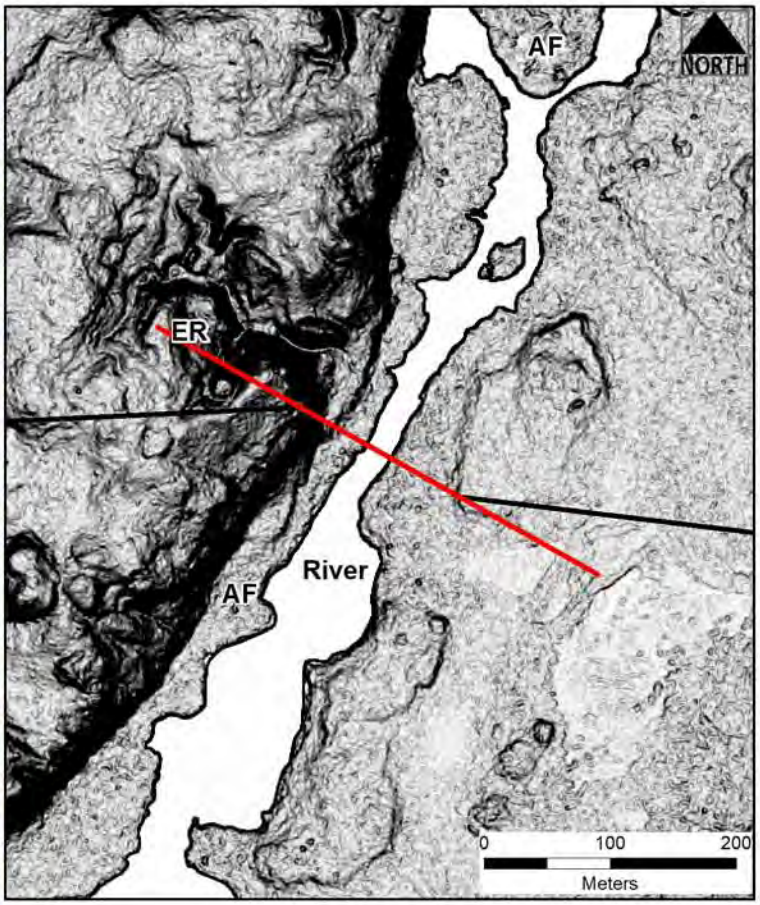
General reference map only; not for survey or legal use.

Map Sources: Base Data: CanVec
Imagery: ESRI
Geomatics: JIC *Revision date: 29/Mar/2019*

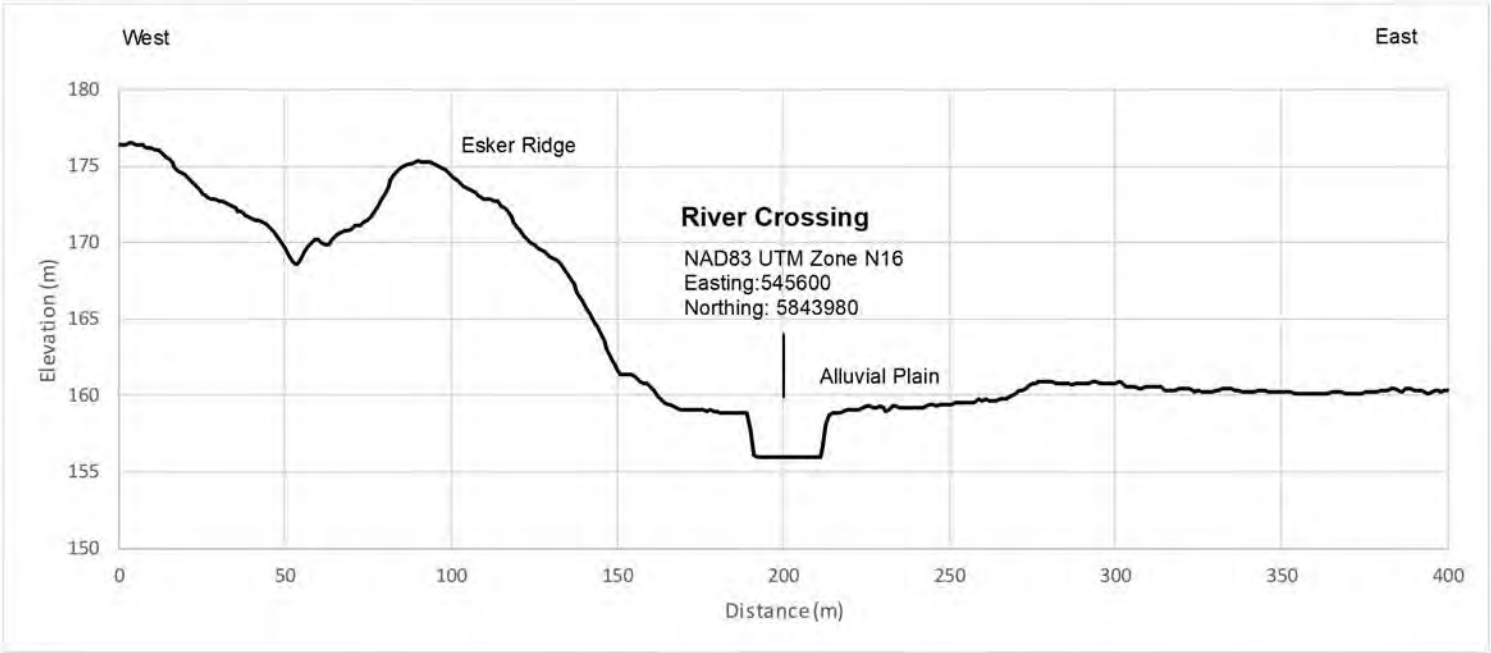
J D MOLLARD AND ASSOCIATES (2010) LIMITED

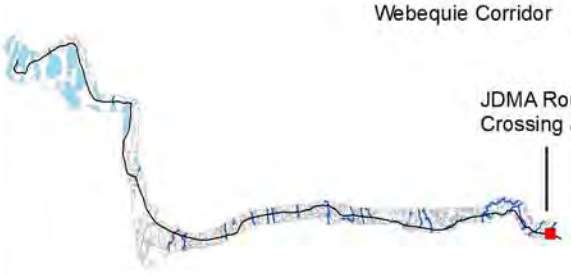
APPENDIX 2: Water Crossings





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

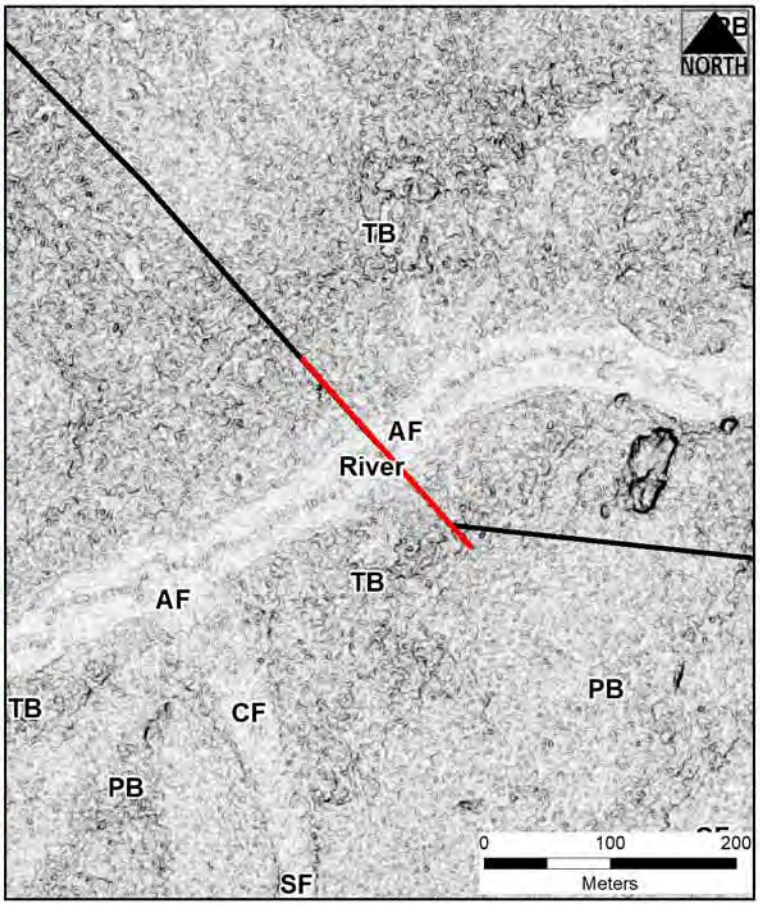
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

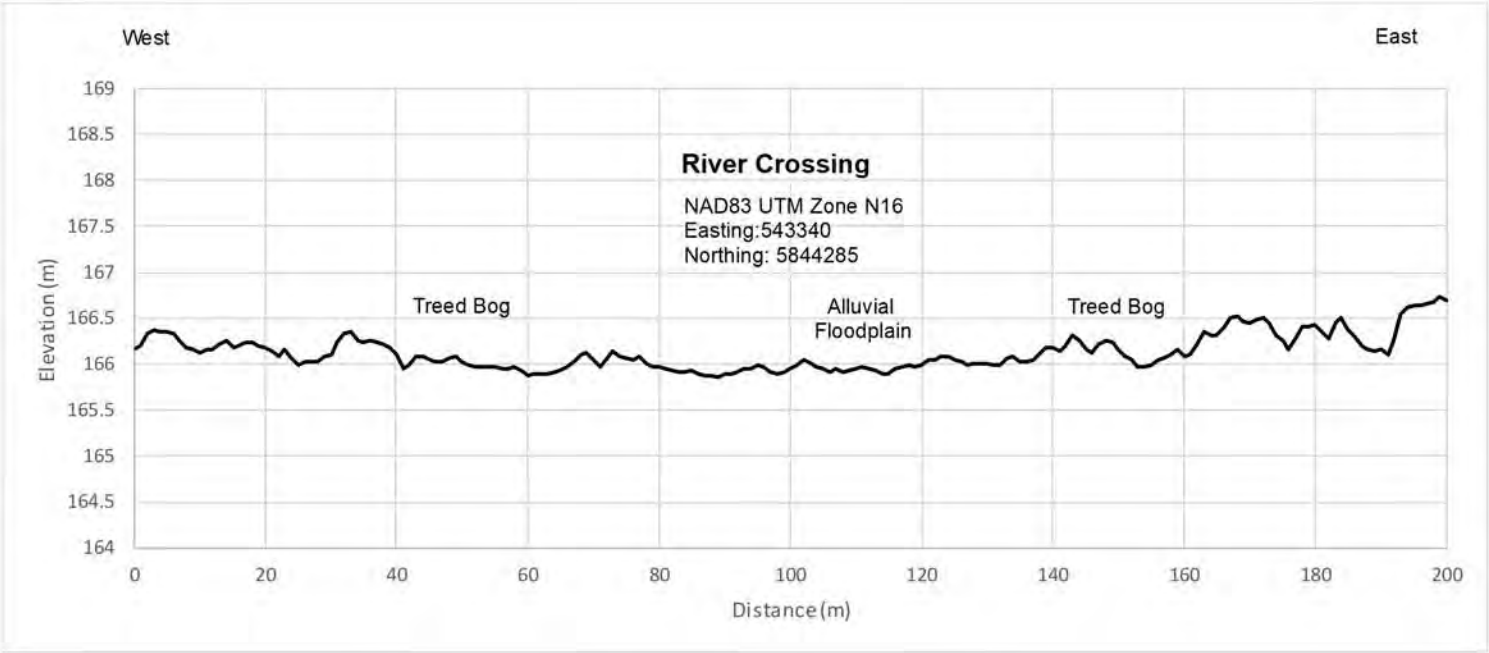
CROSSING:

J1

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

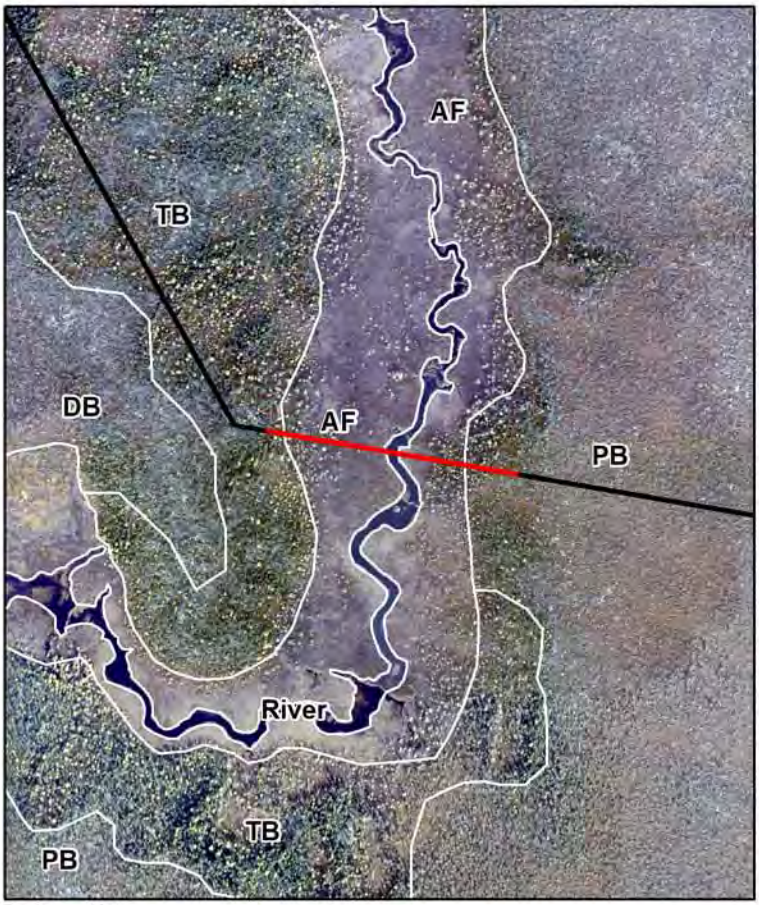
General reference map only; not for survey or legal use.

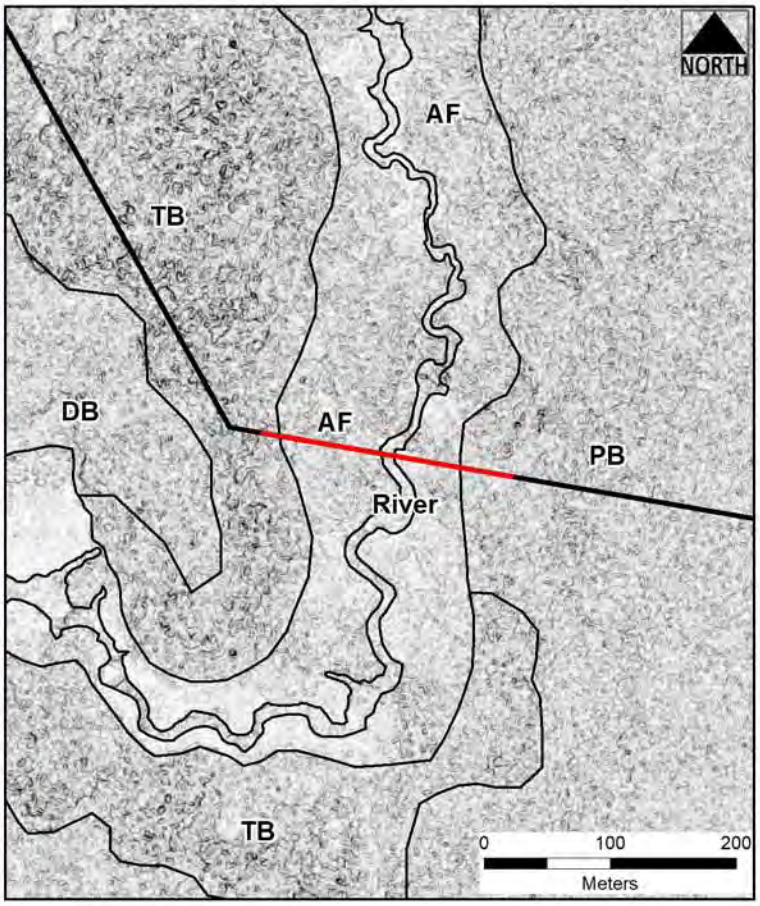
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

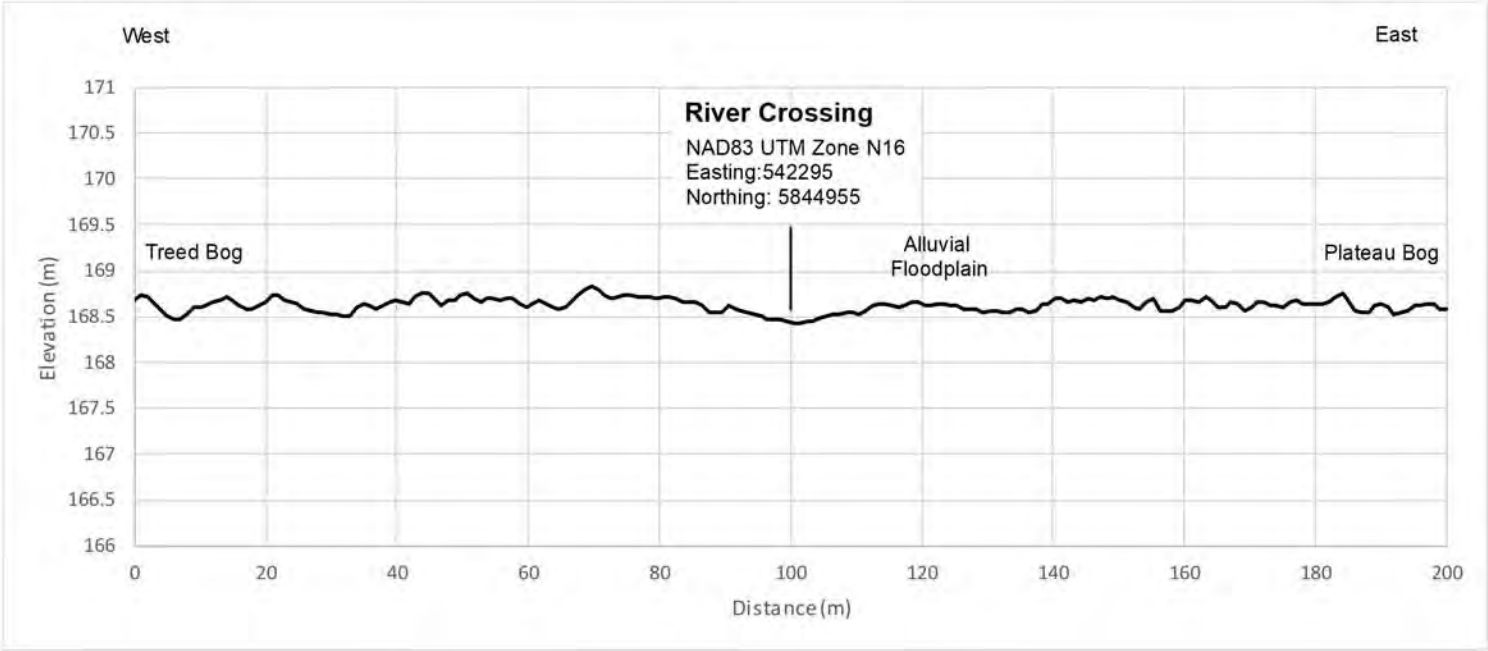
J2

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

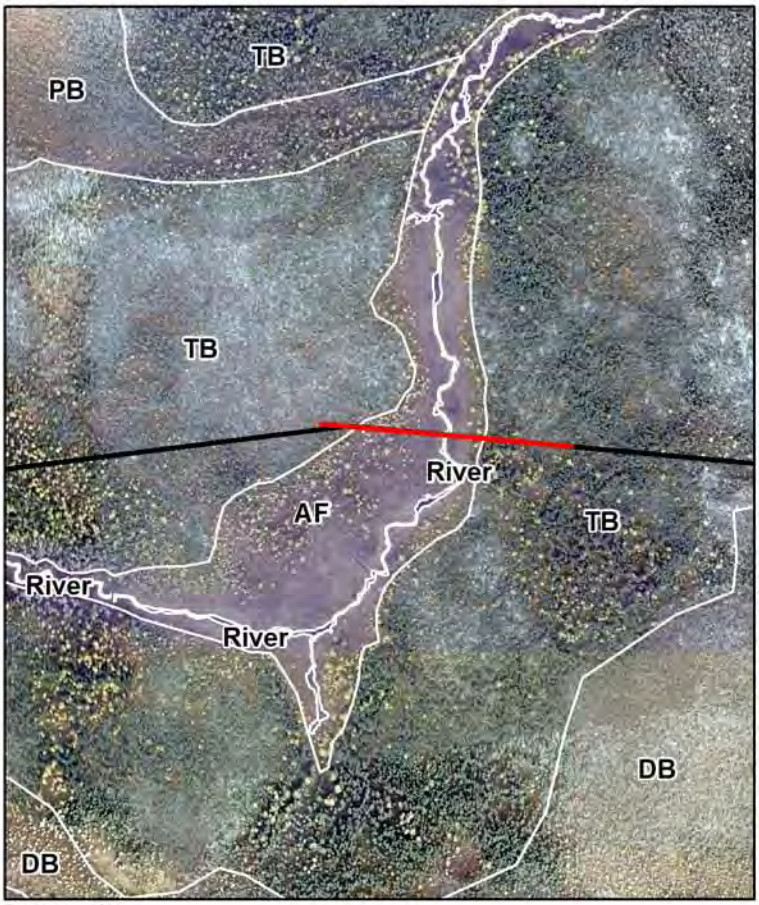
General reference map only; not for survey or legal use.

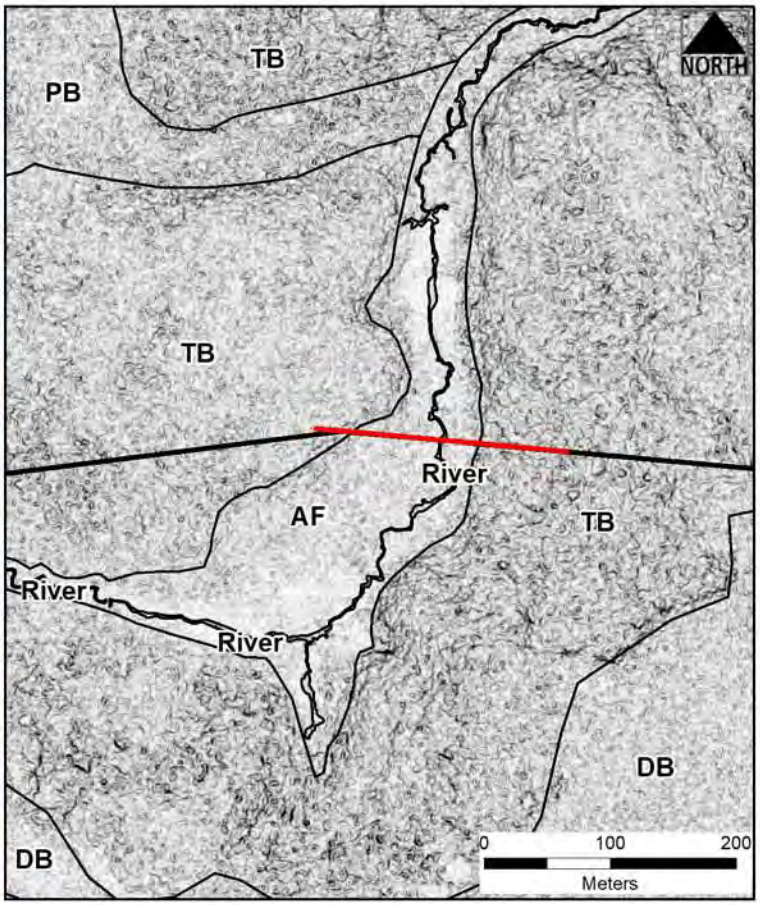
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J3

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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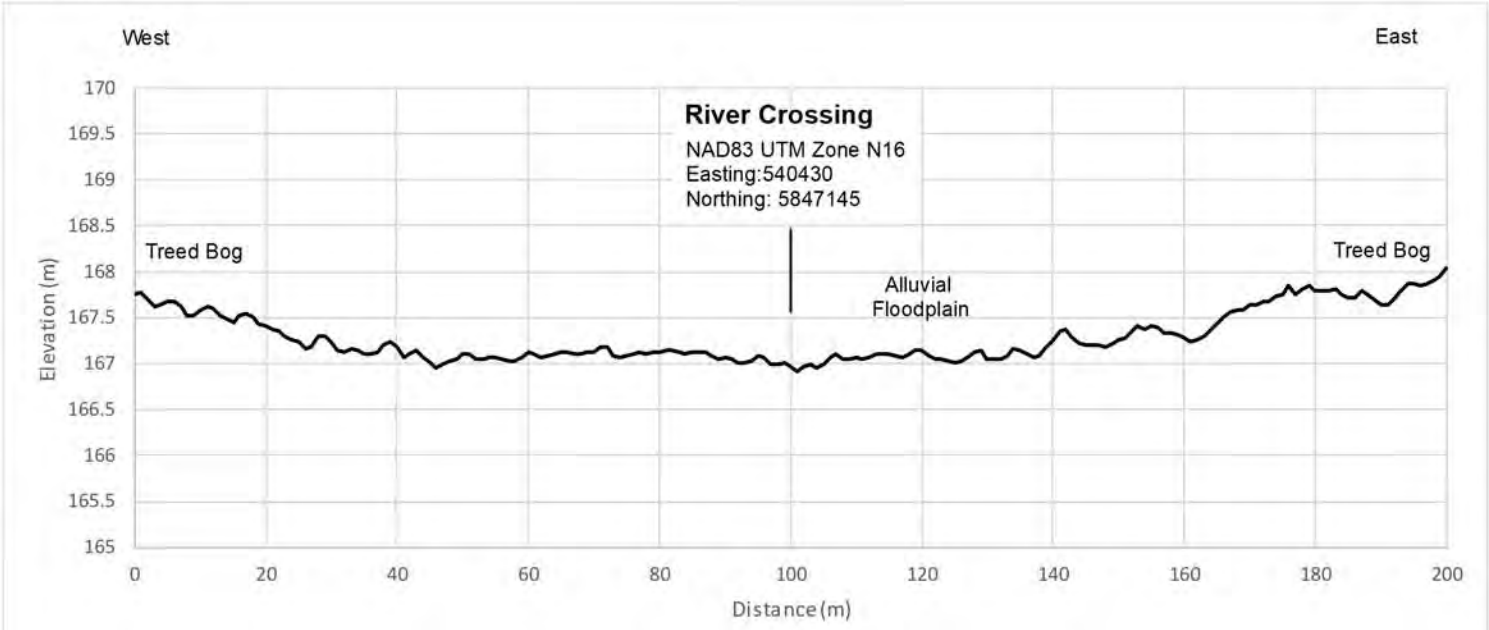


LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

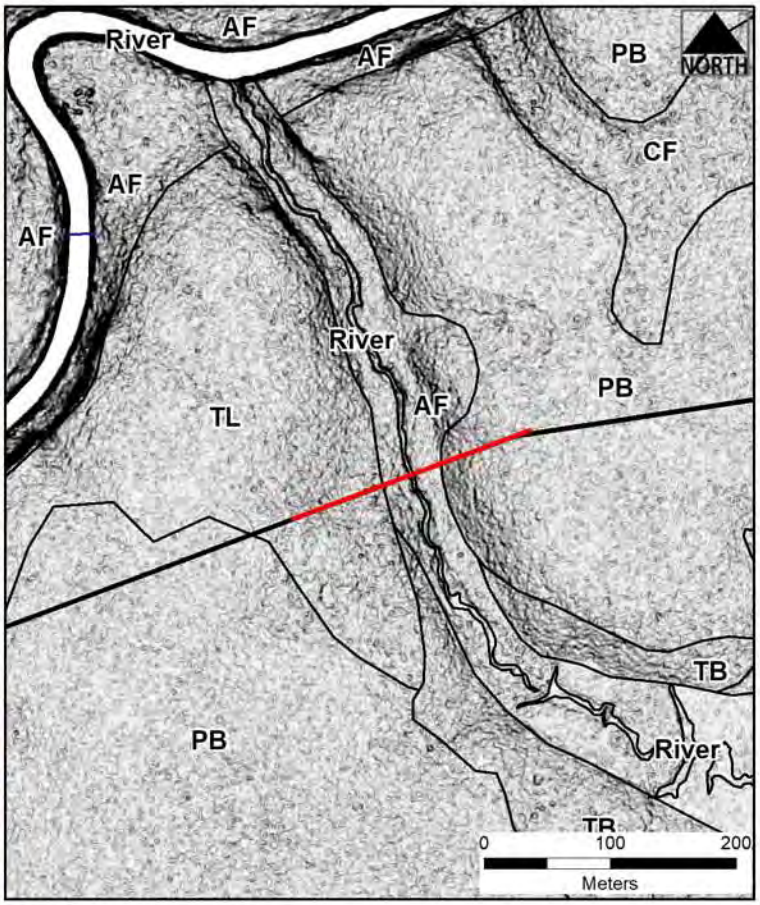
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J4

J D MOLLARD AND ASSOCIATES (2010) LIMITED



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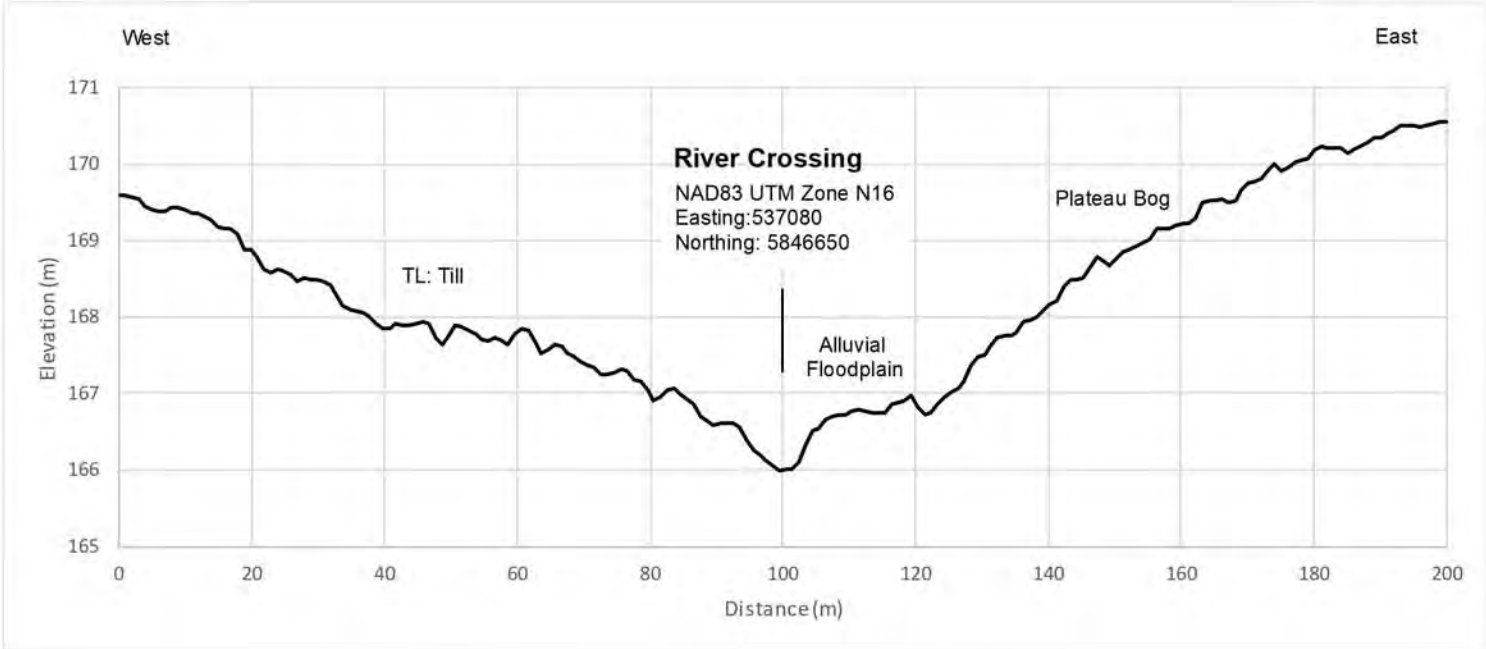


LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

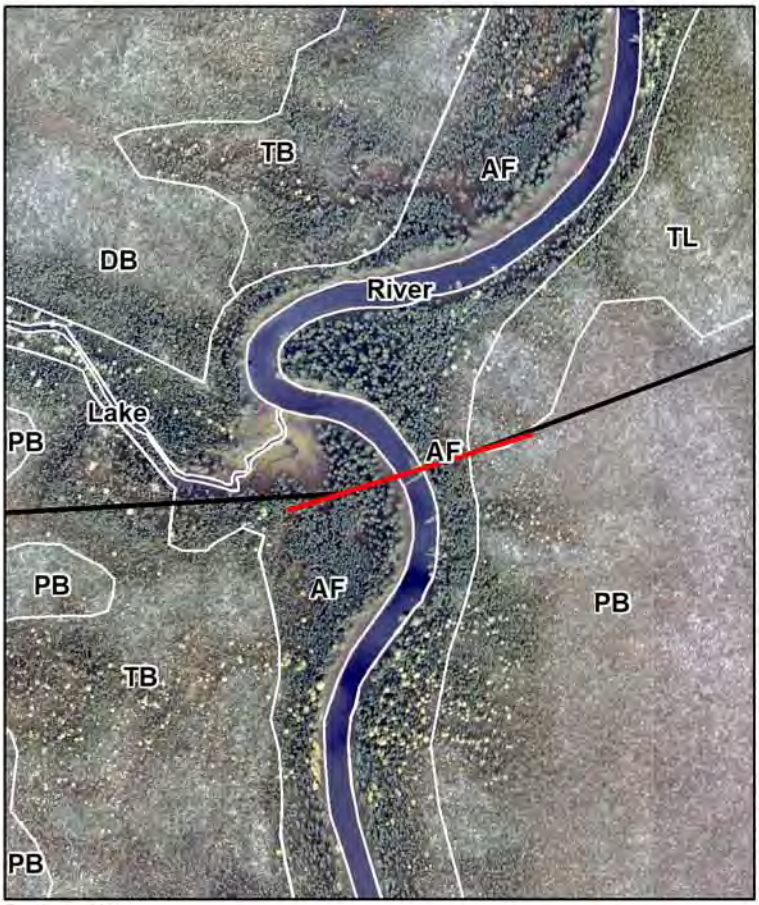
General reference map only; not for survey or legal use.

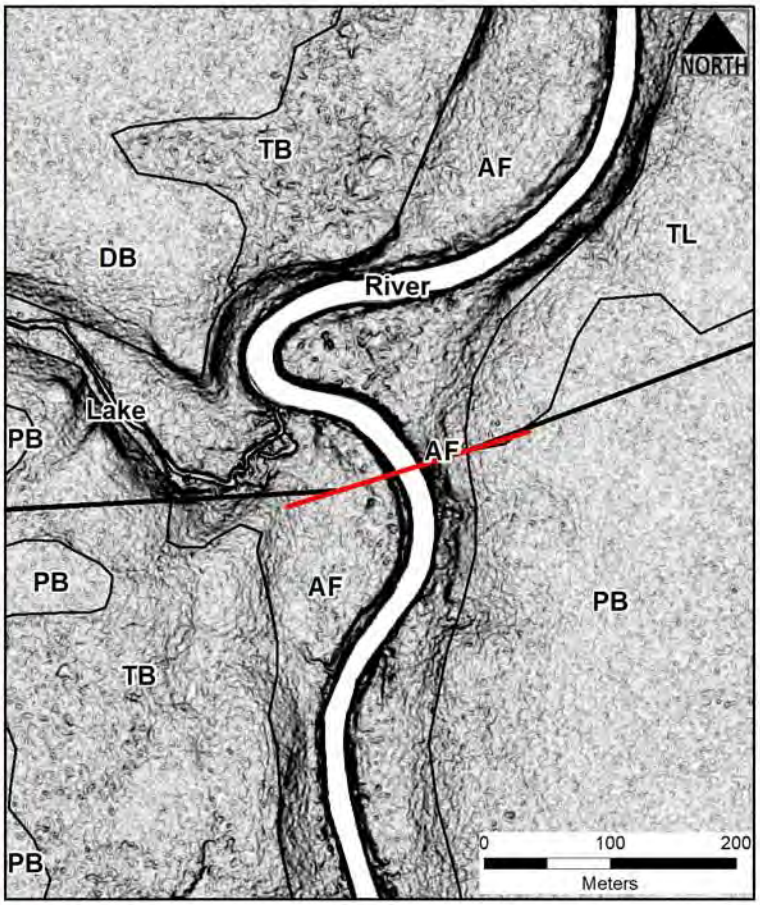
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 21/Mar/2019*

CROSSING:

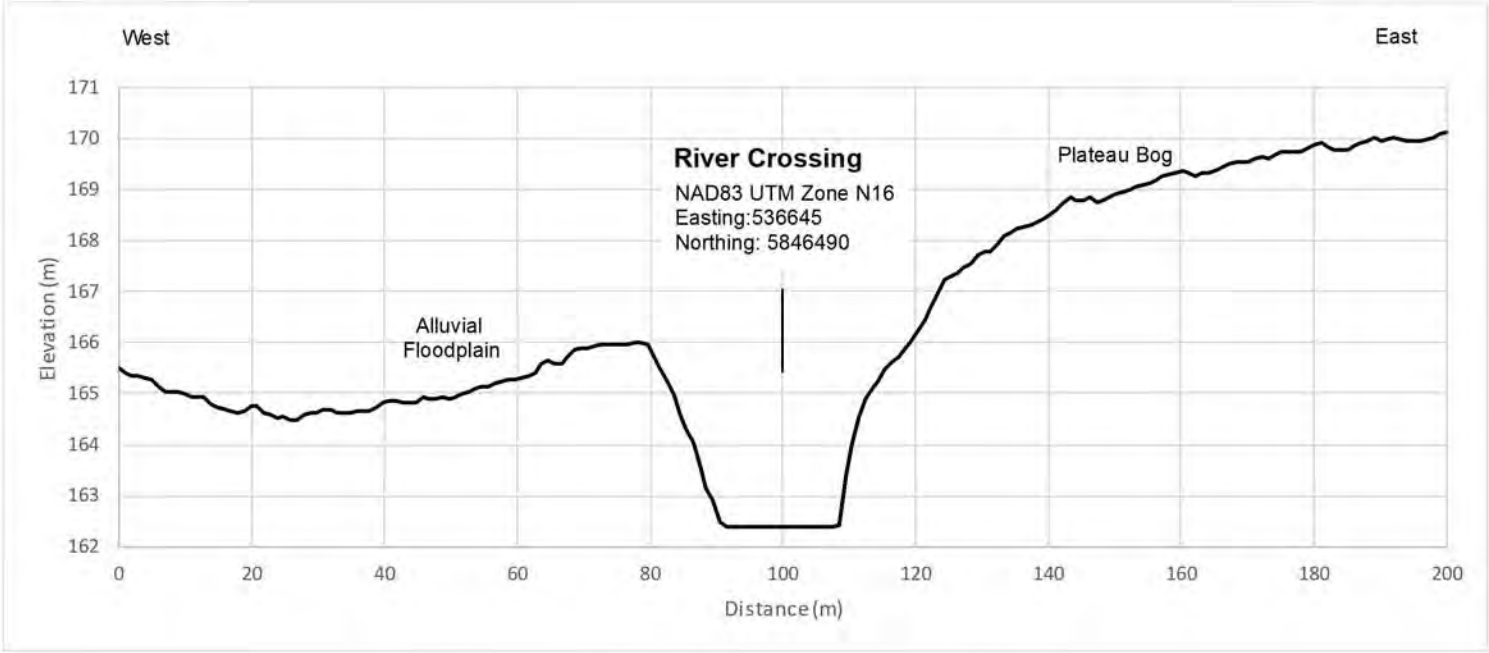
J5

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

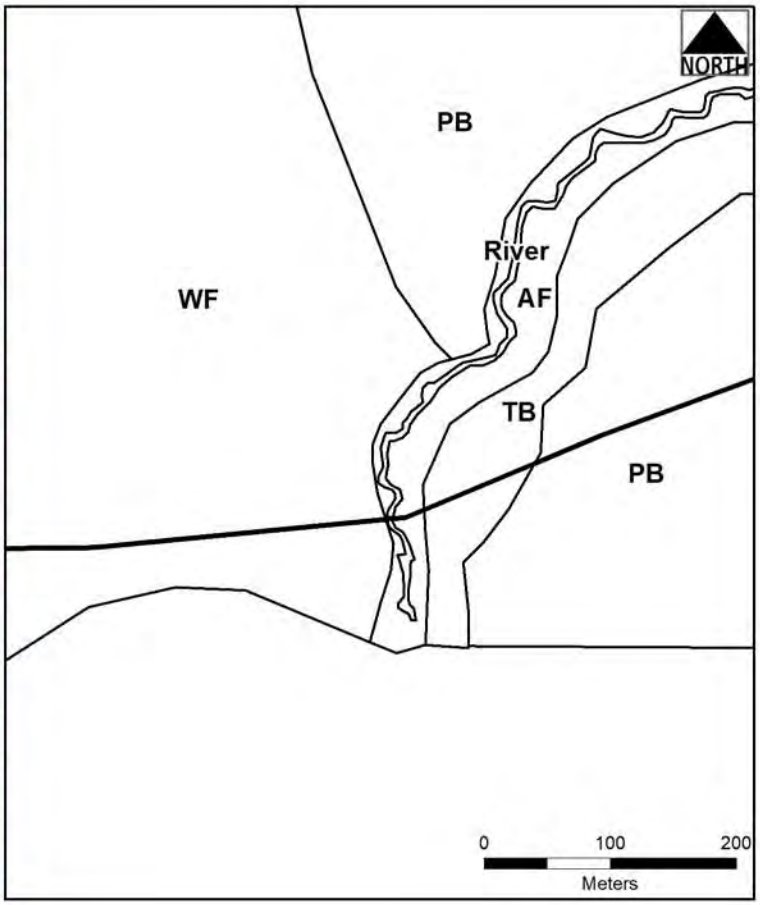
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J6

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:531690
Northing: 5844820

No LiDAR Data

LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)

High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

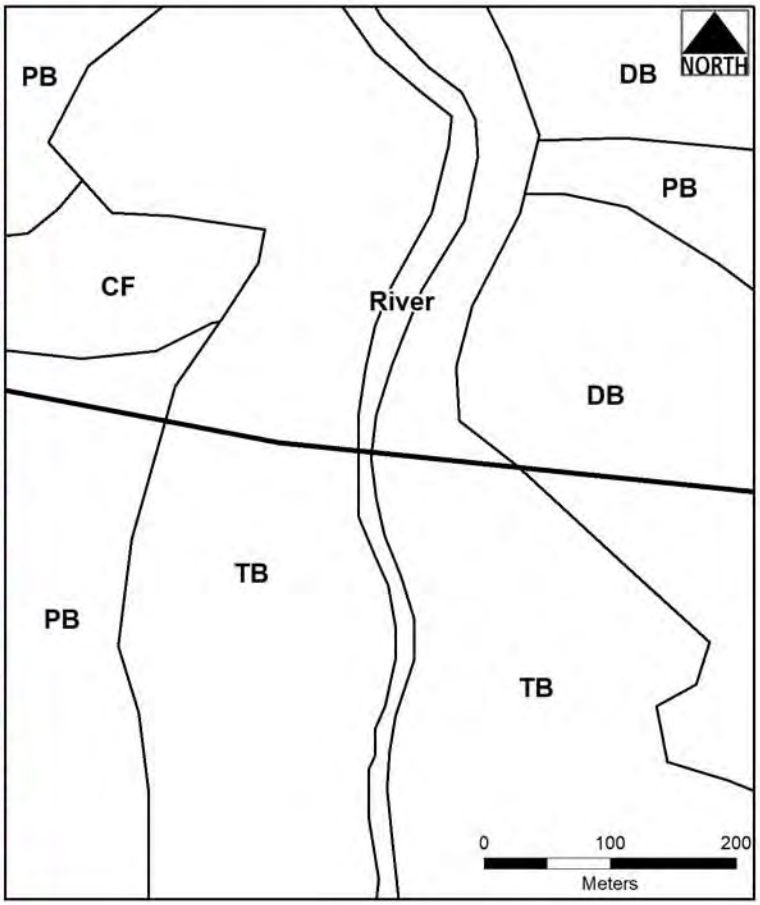
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J7

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:529807
Northing: 5844837

No LiDAR Data

LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)

High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

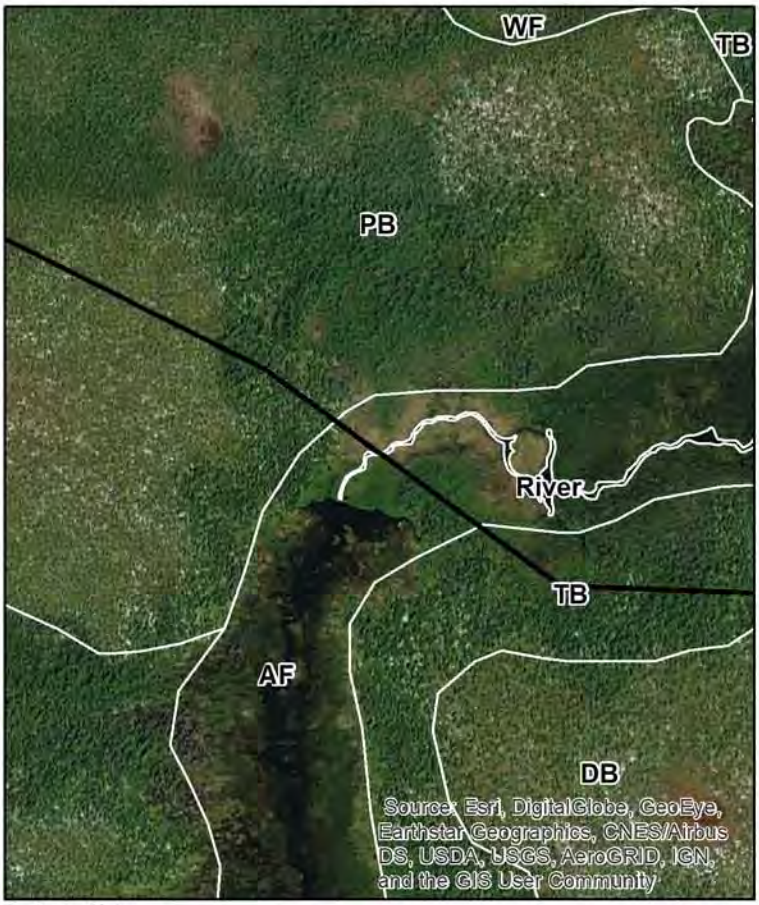
General reference map only; not for survey or legal use.

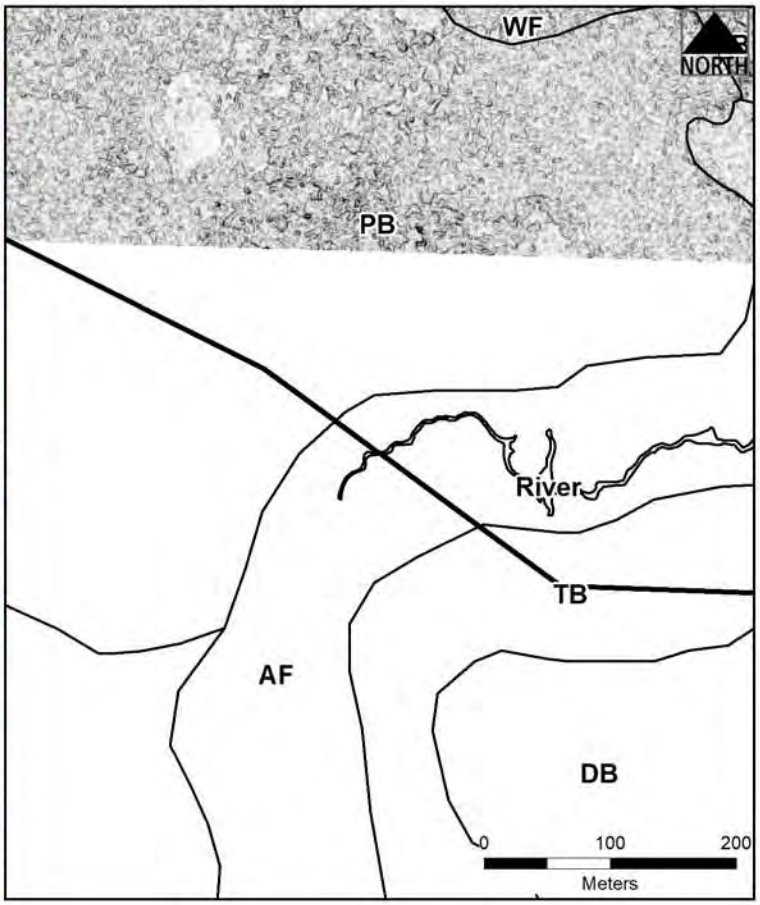
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J8

J D MOLLARD AND ASSOCIATES (2010) LIMITED



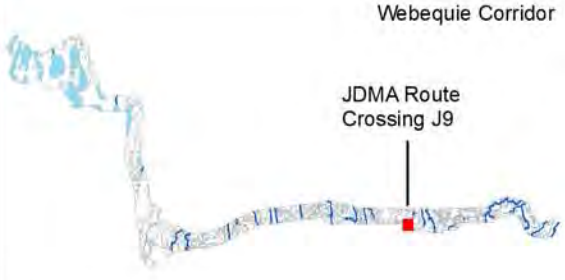


Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:526262
Northing: 5845452

No LiDAR Data



LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)

High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

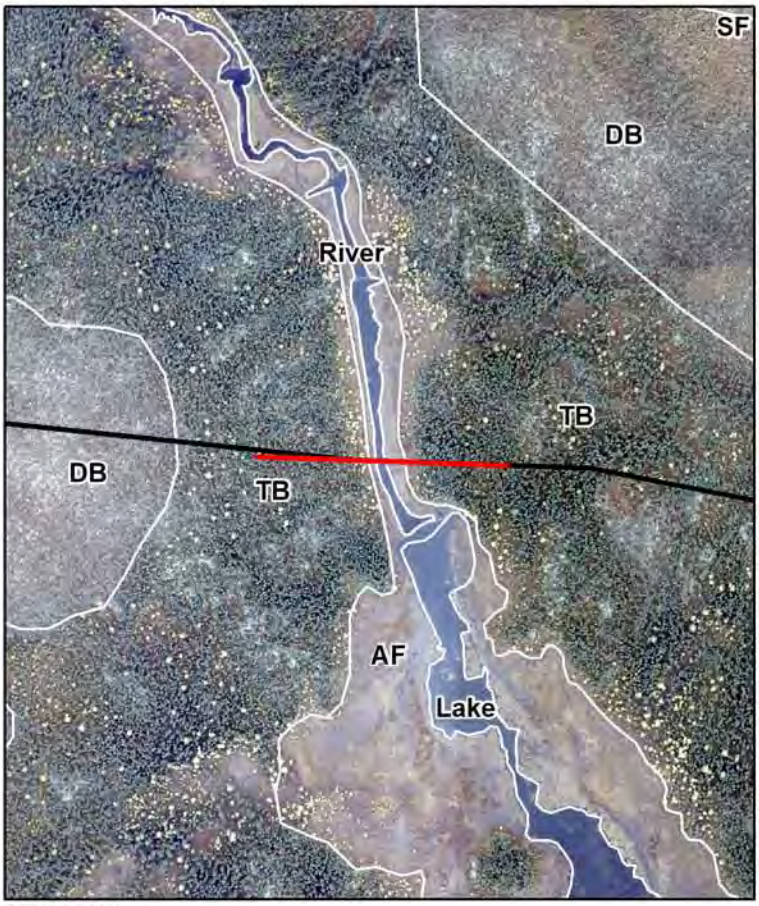
General reference map only; not for survey or legal use.

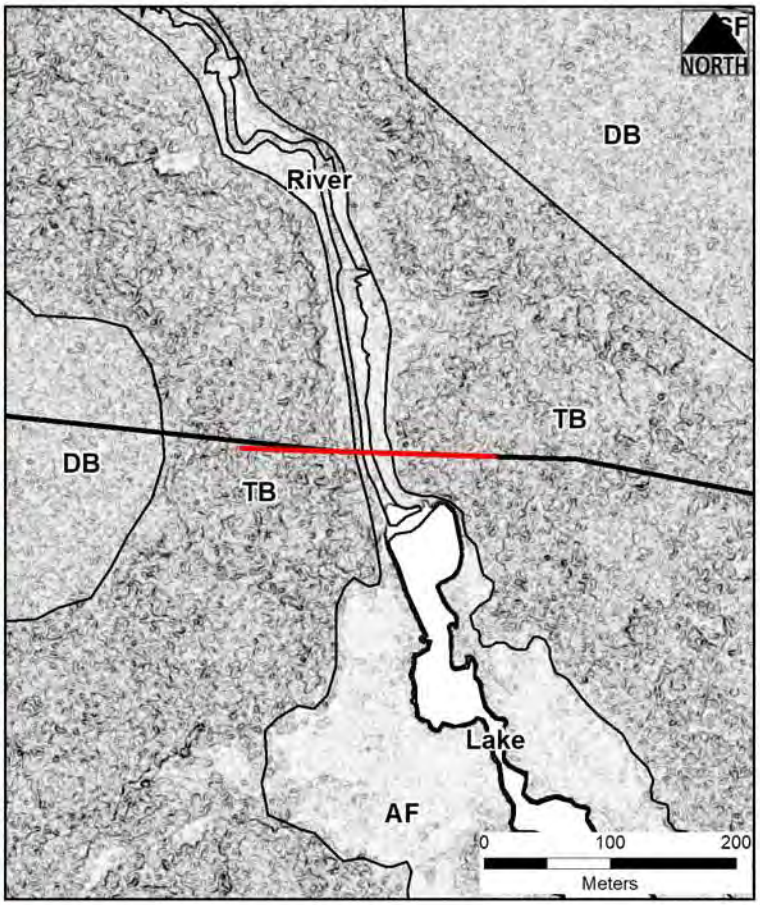
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

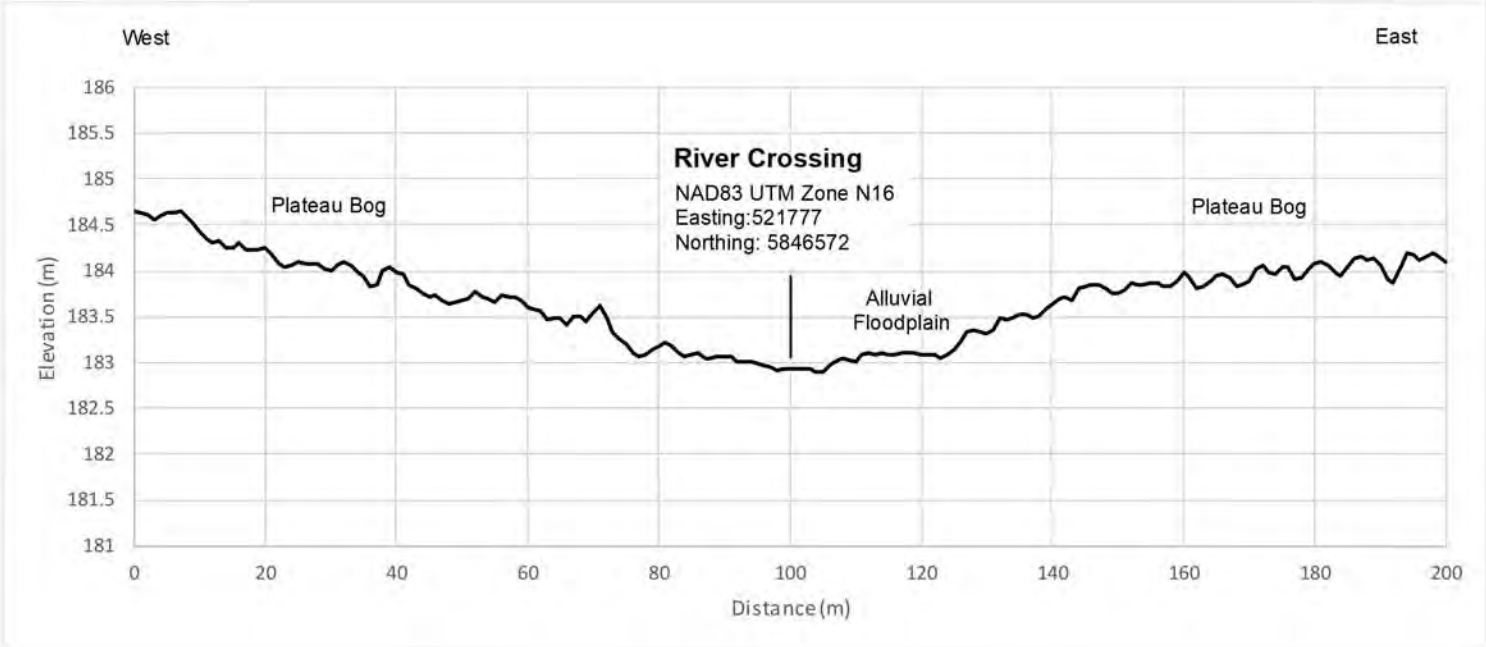
J9

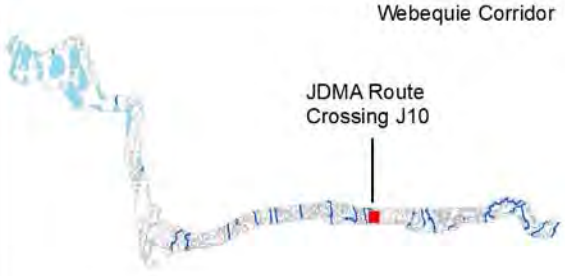
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

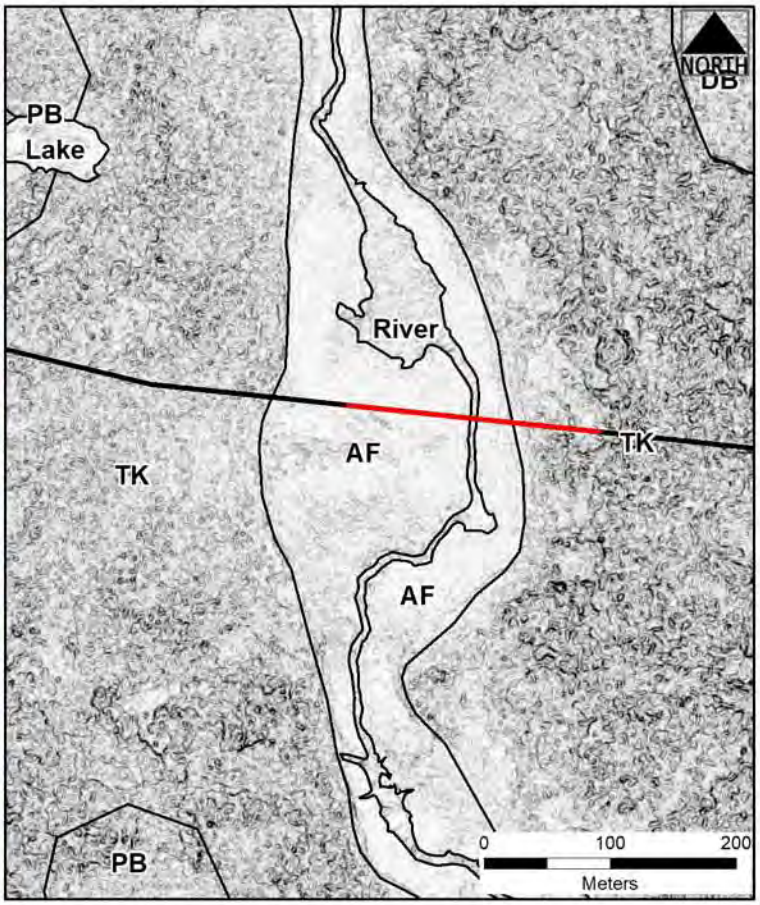
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

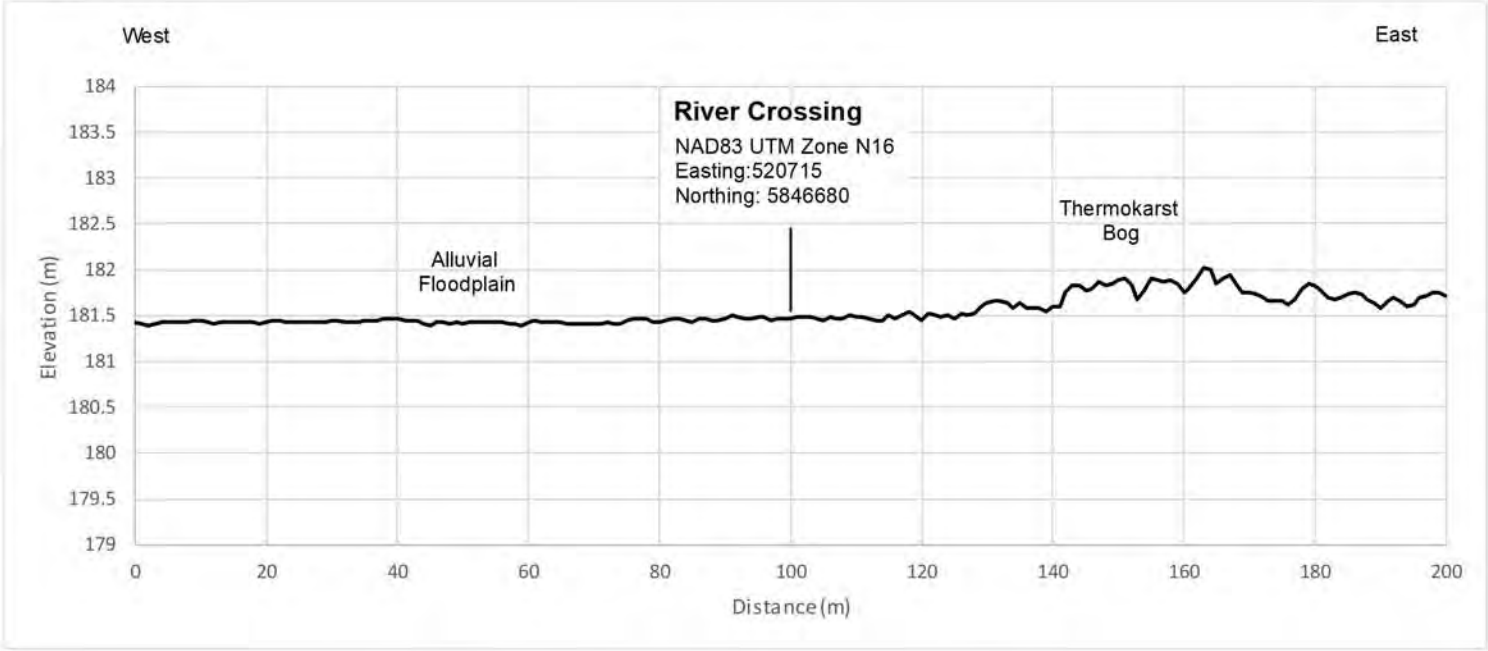
CROSSING:

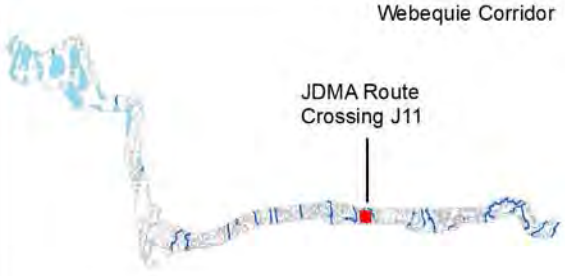
J10

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

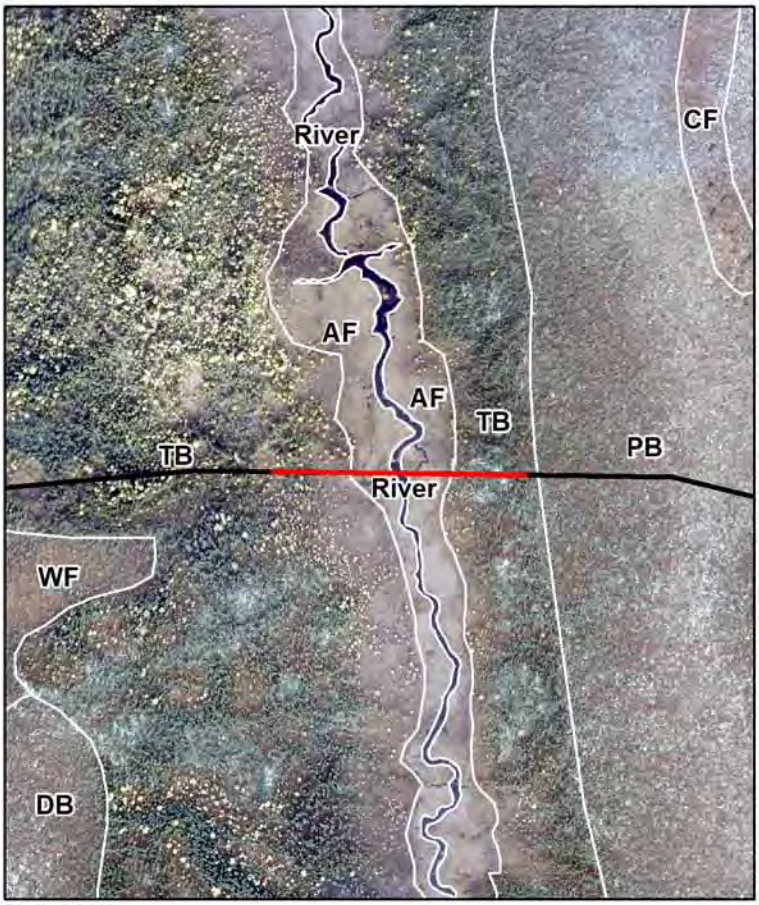
General reference map only; not for survey or legal use.

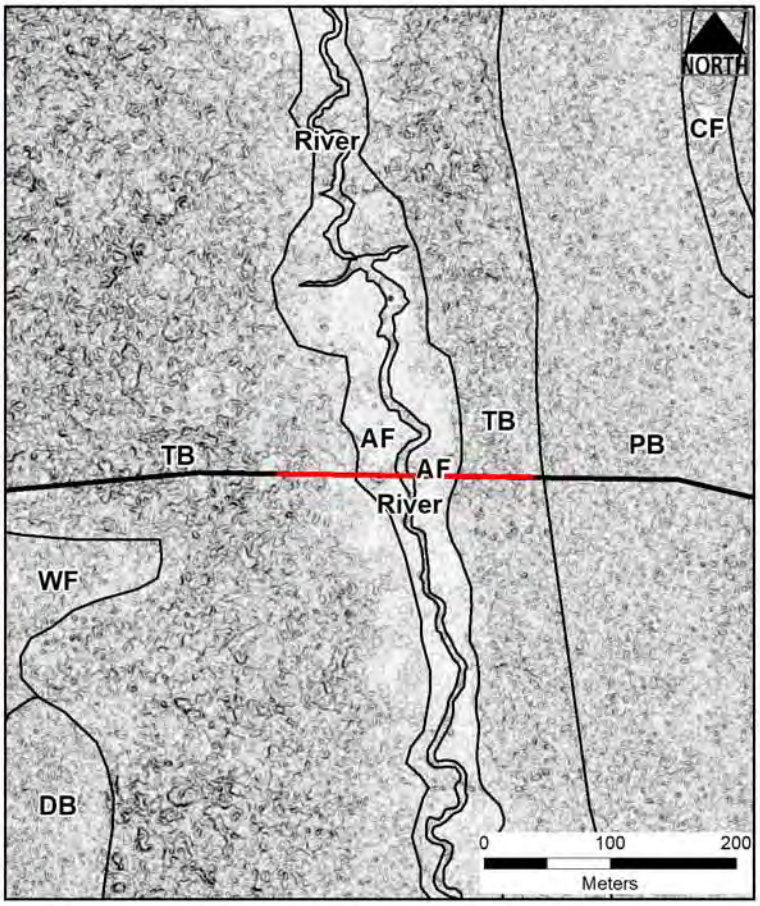
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

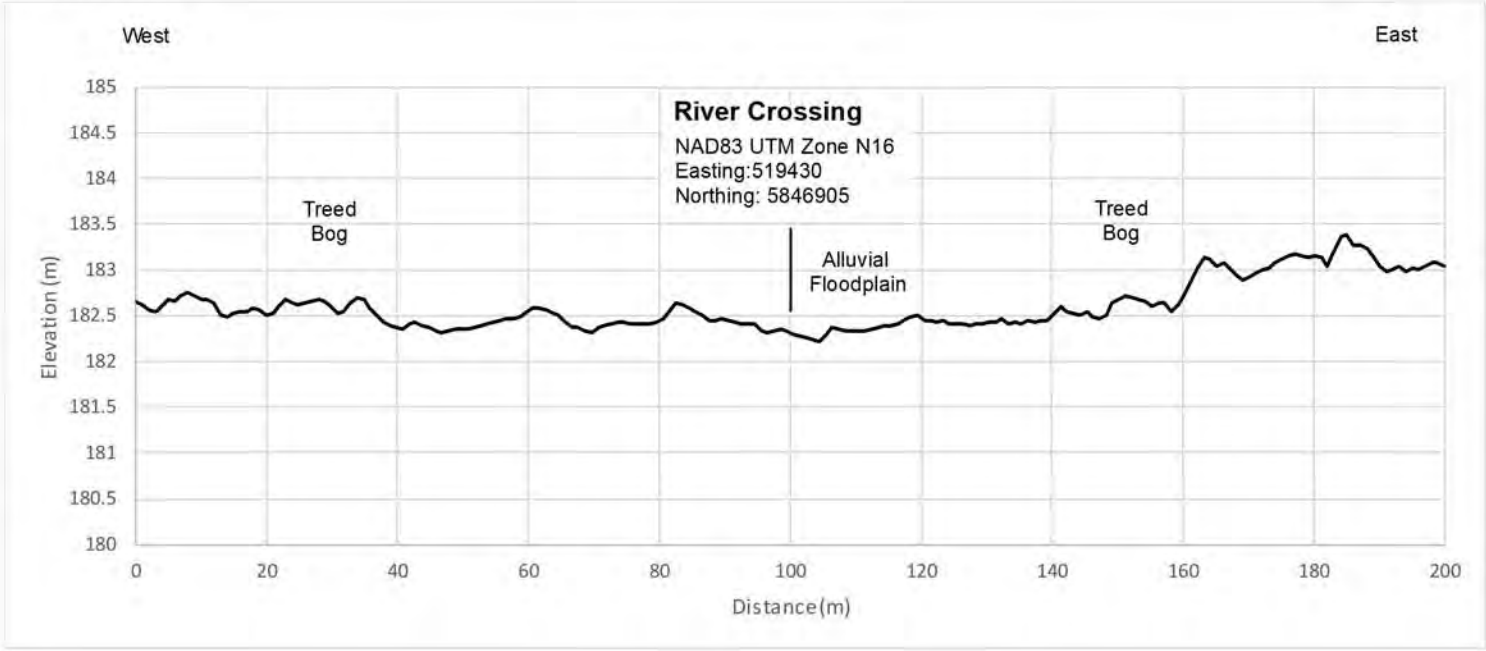
J11

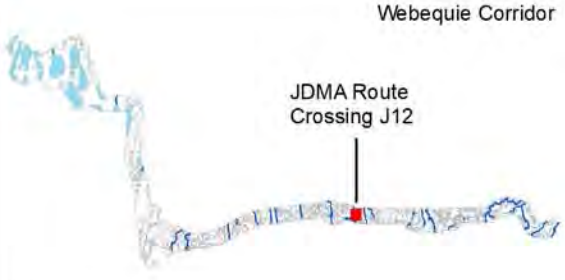
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

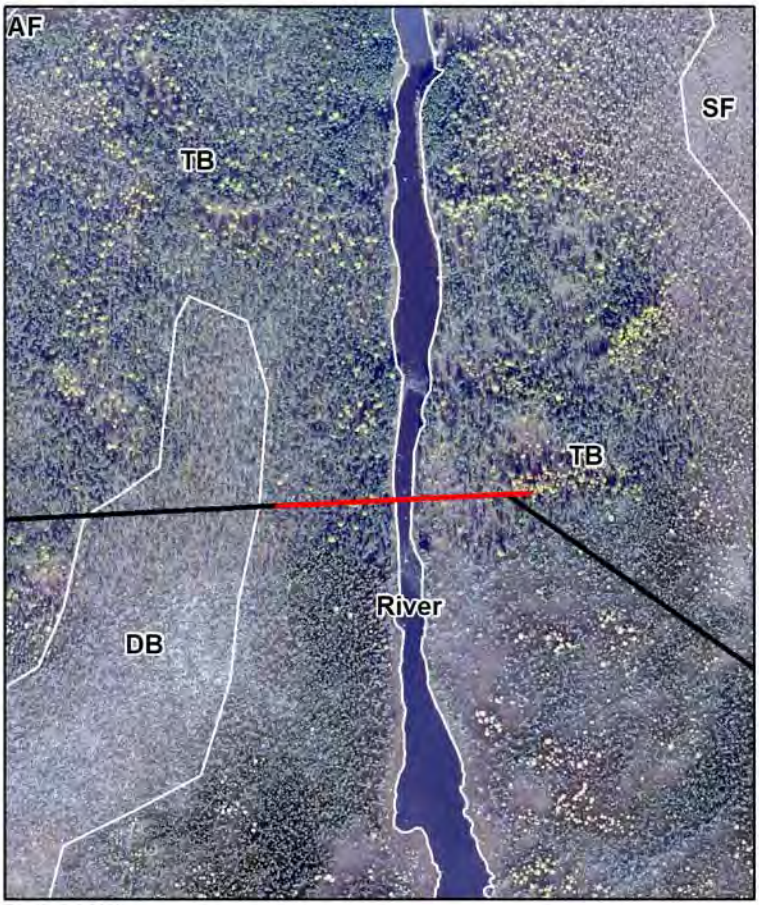
General reference map only; not for survey or legal use.

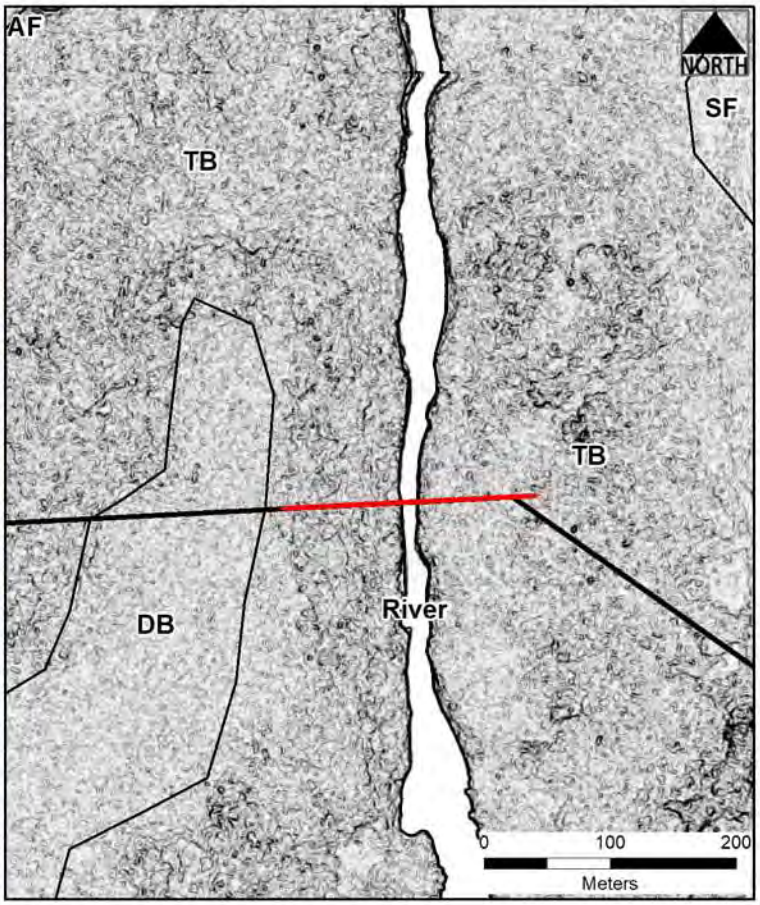
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

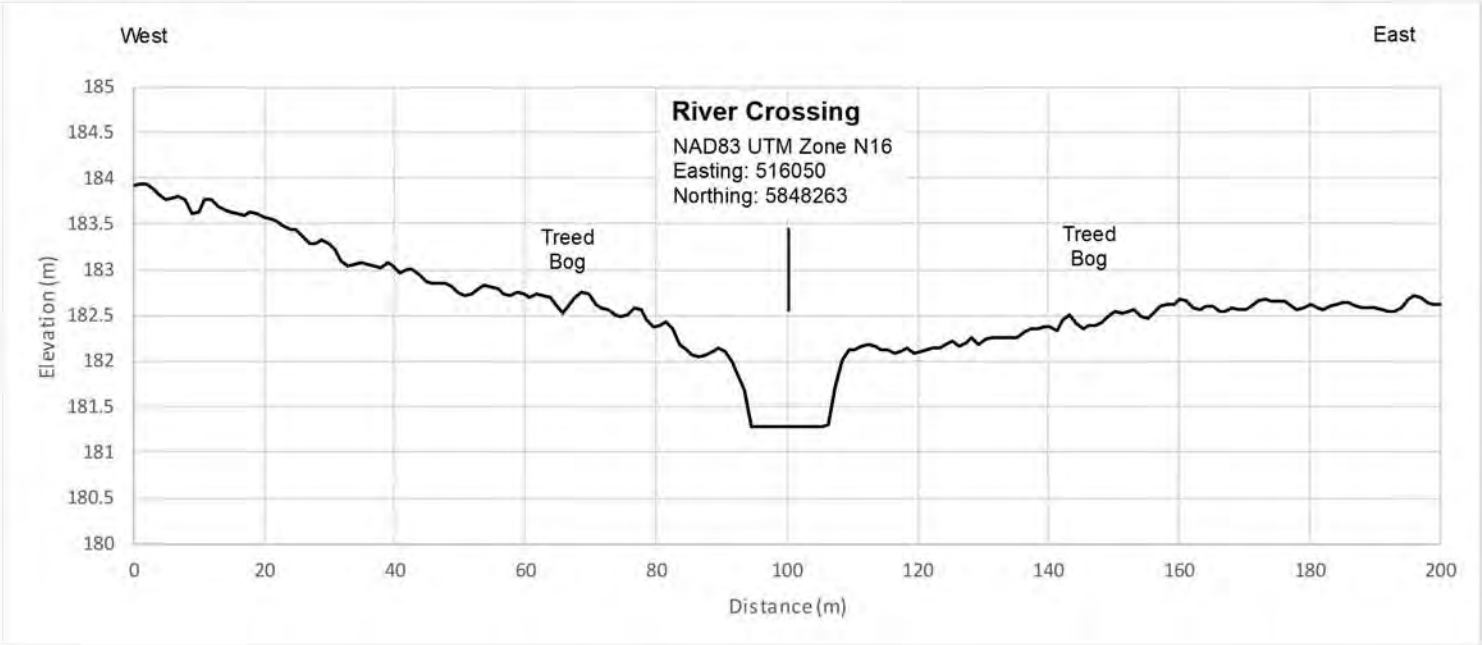
J12

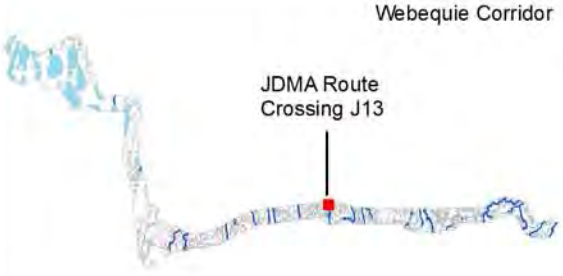
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

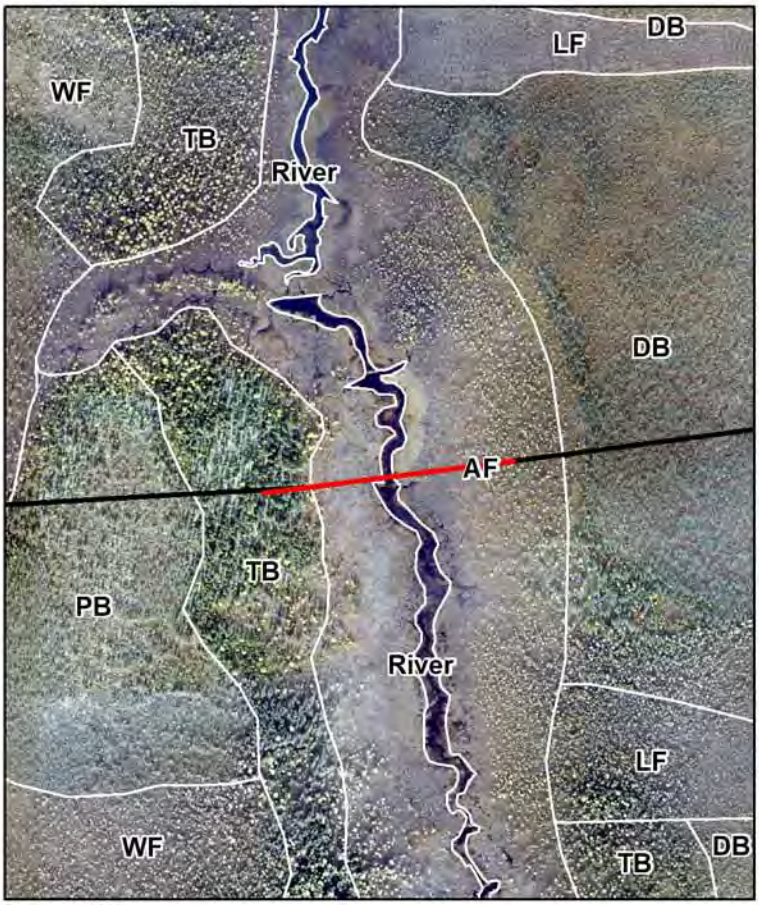
General reference map only; not for survey or legal use.

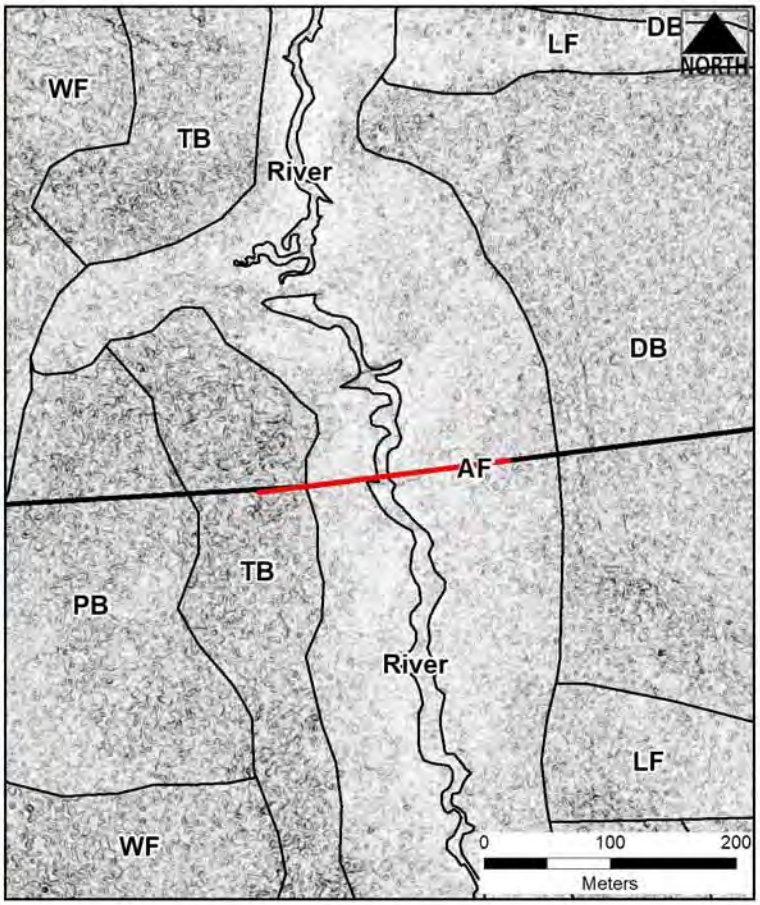
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

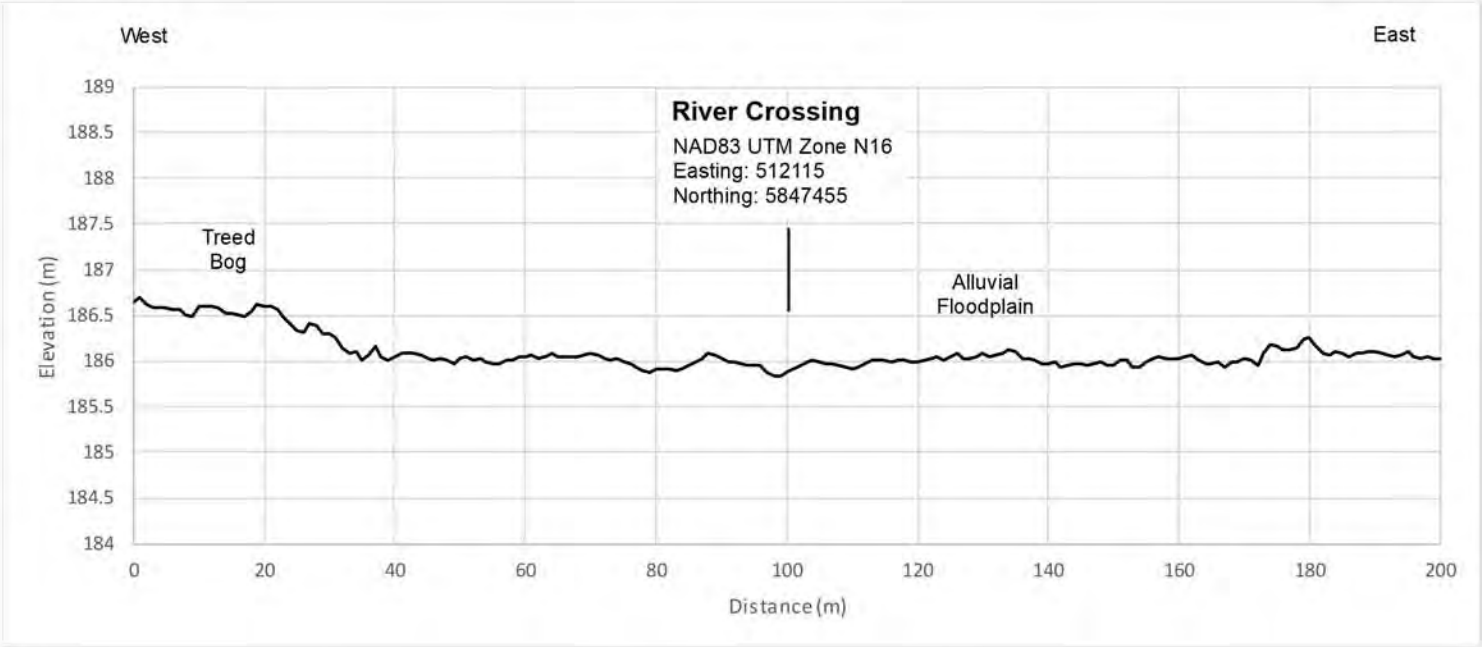
J13

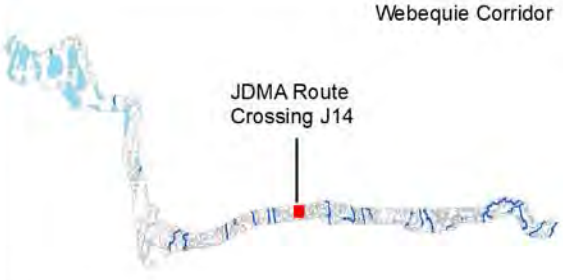
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

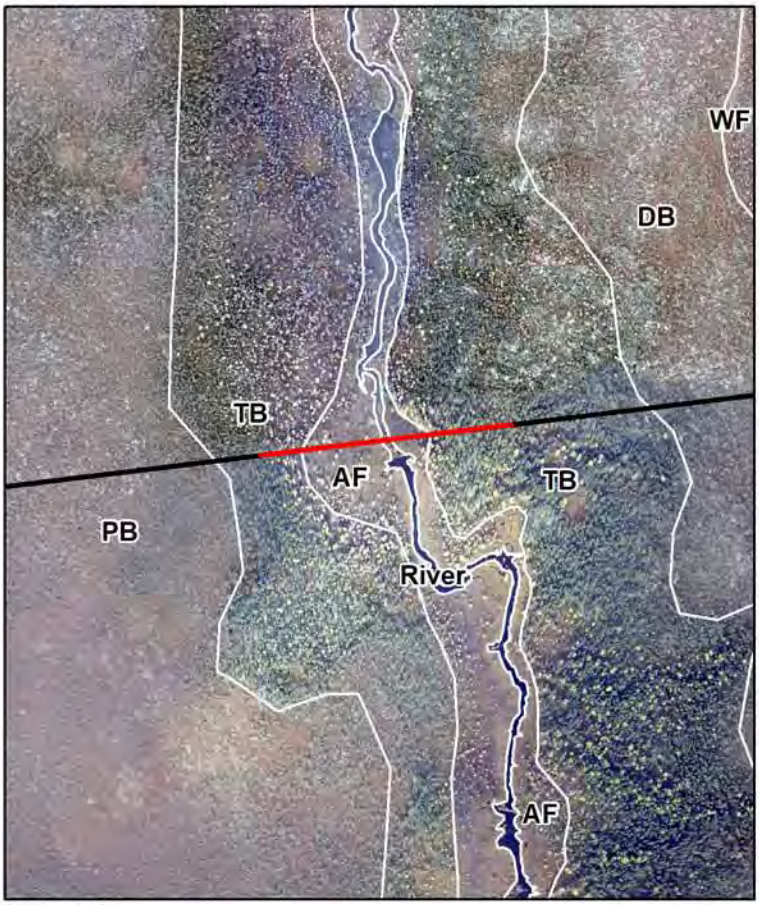
General reference map only; not for survey or legal use.

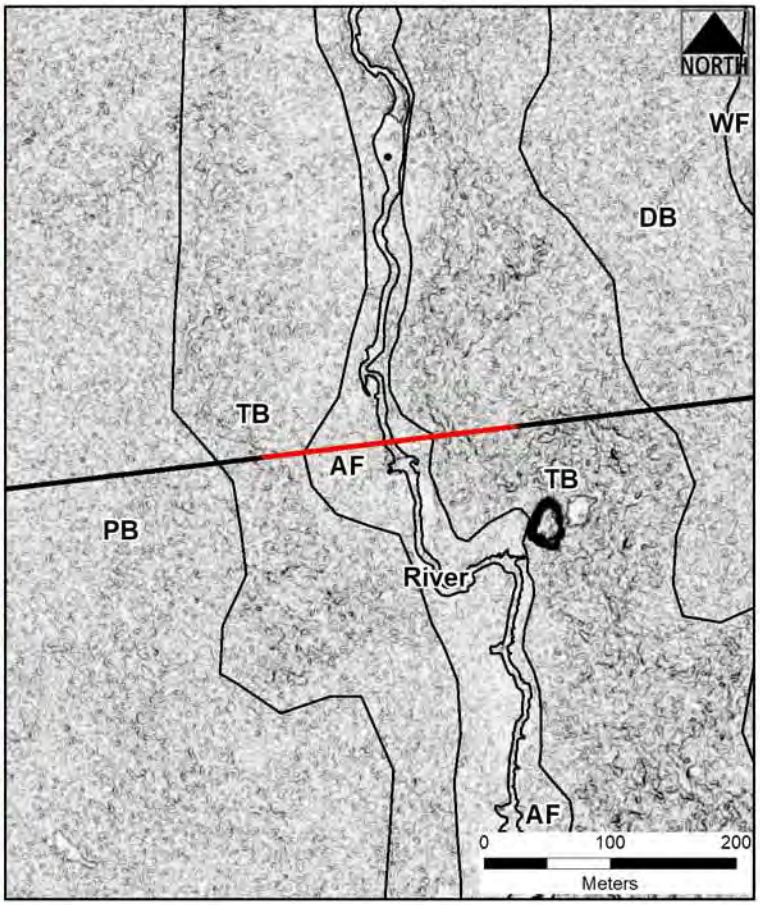
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

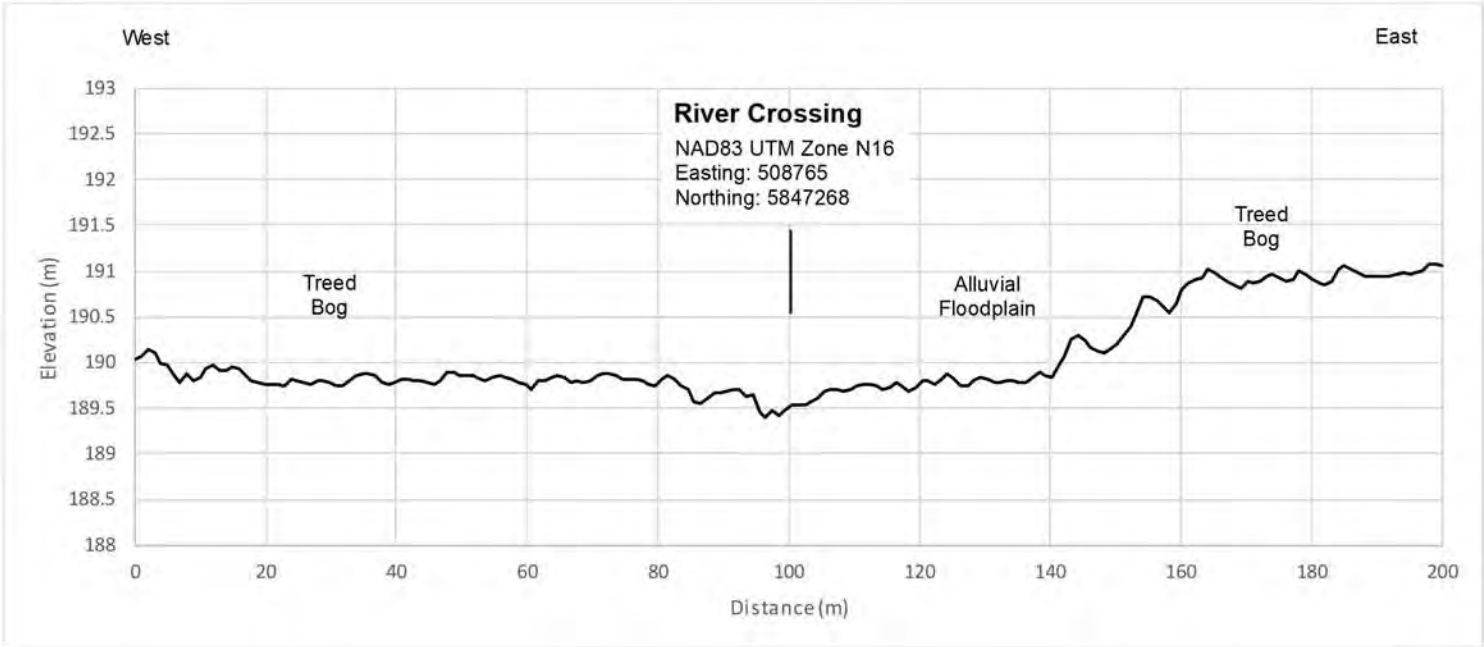
J14

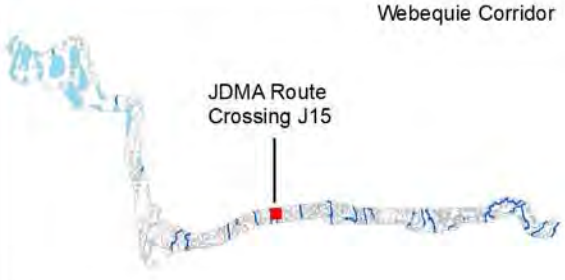
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

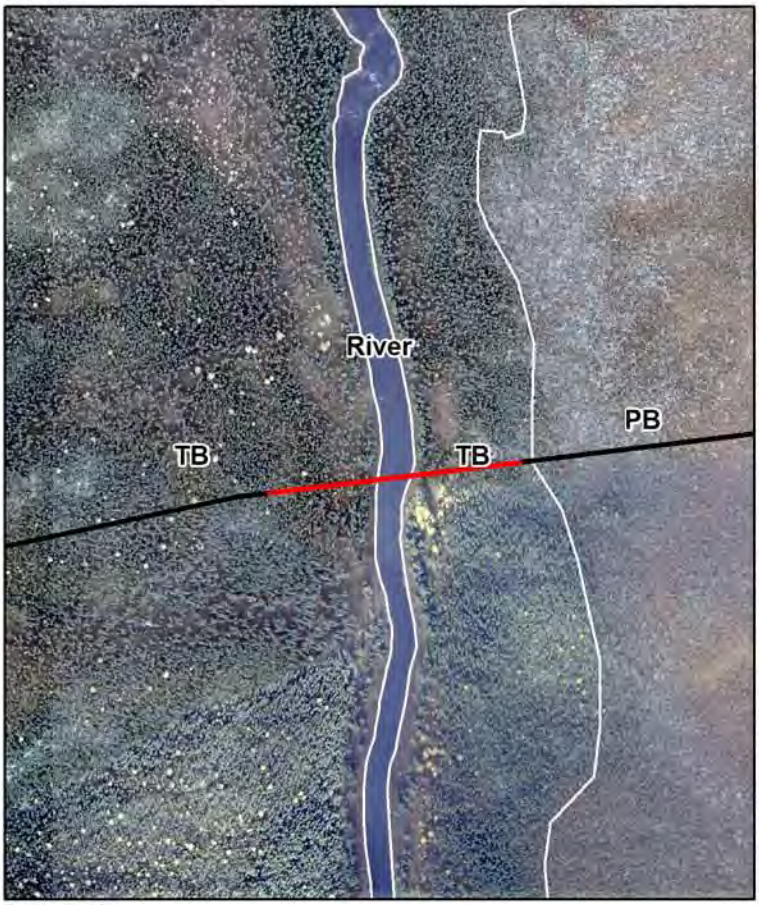
General reference map only; not for survey or legal use.

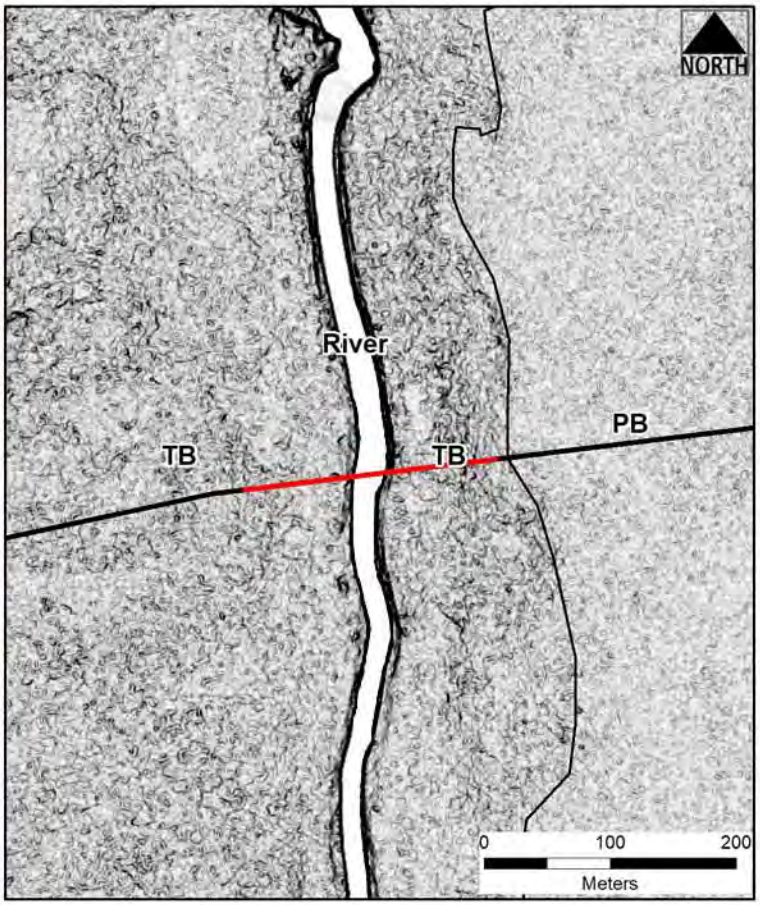
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

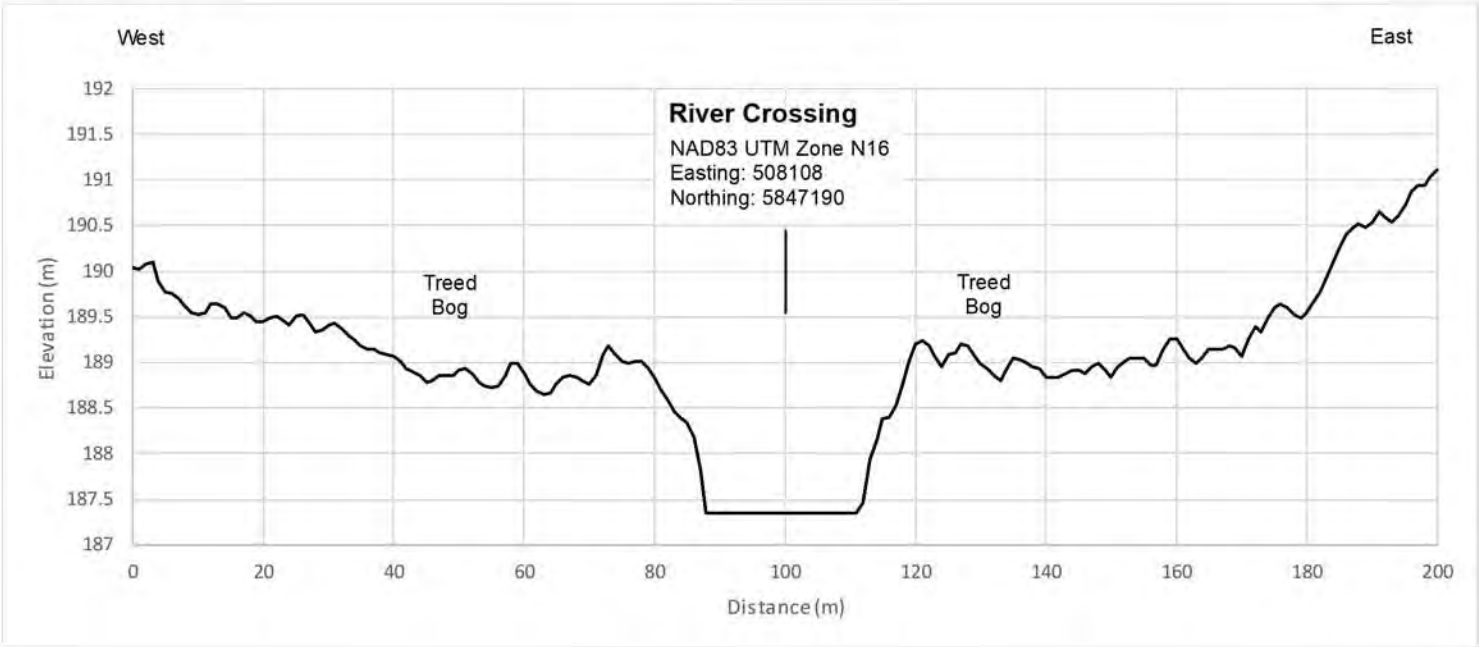
J15

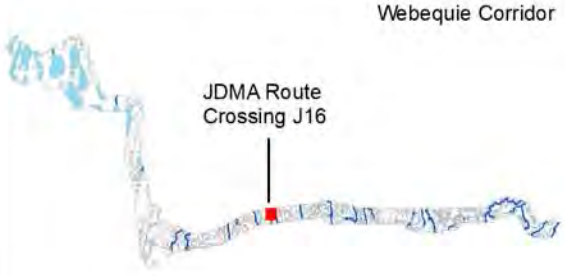
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

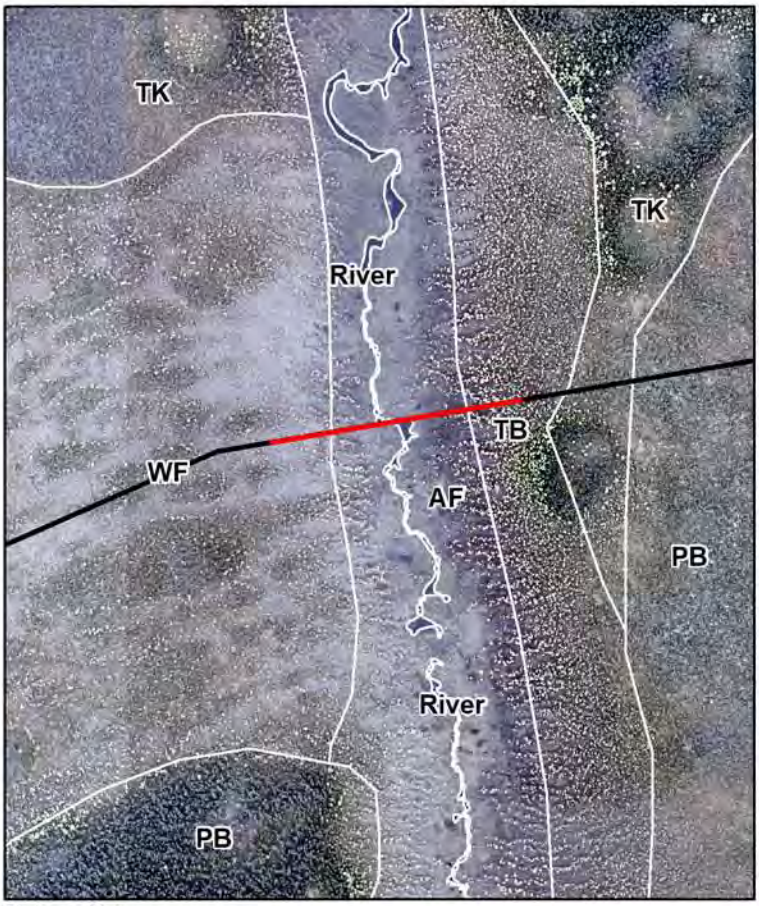
General reference map only; not for survey or legal use.

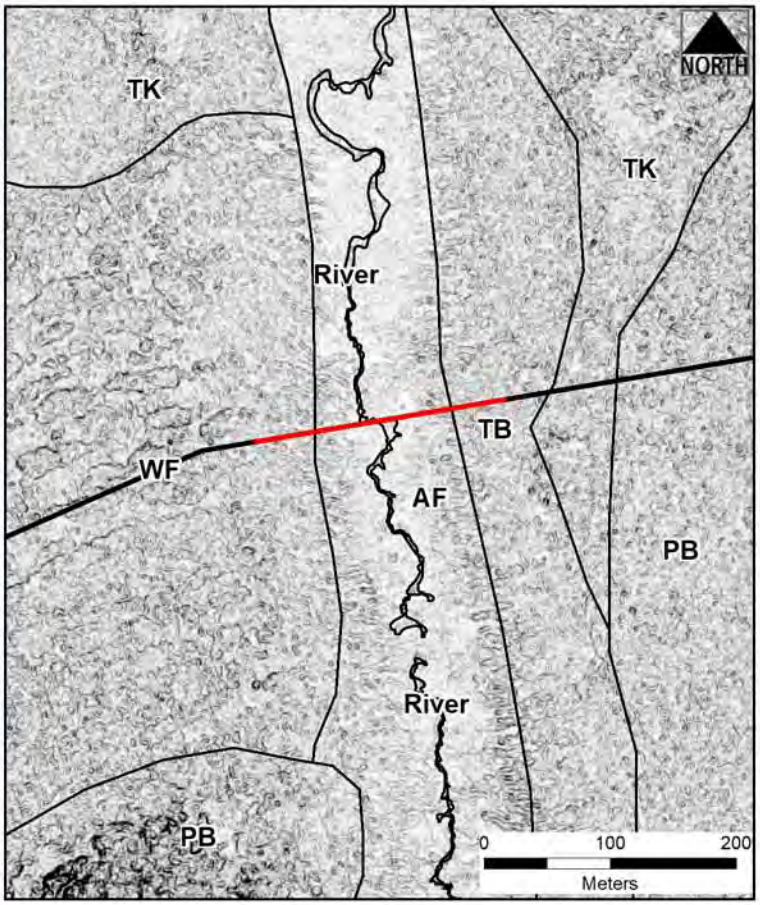
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

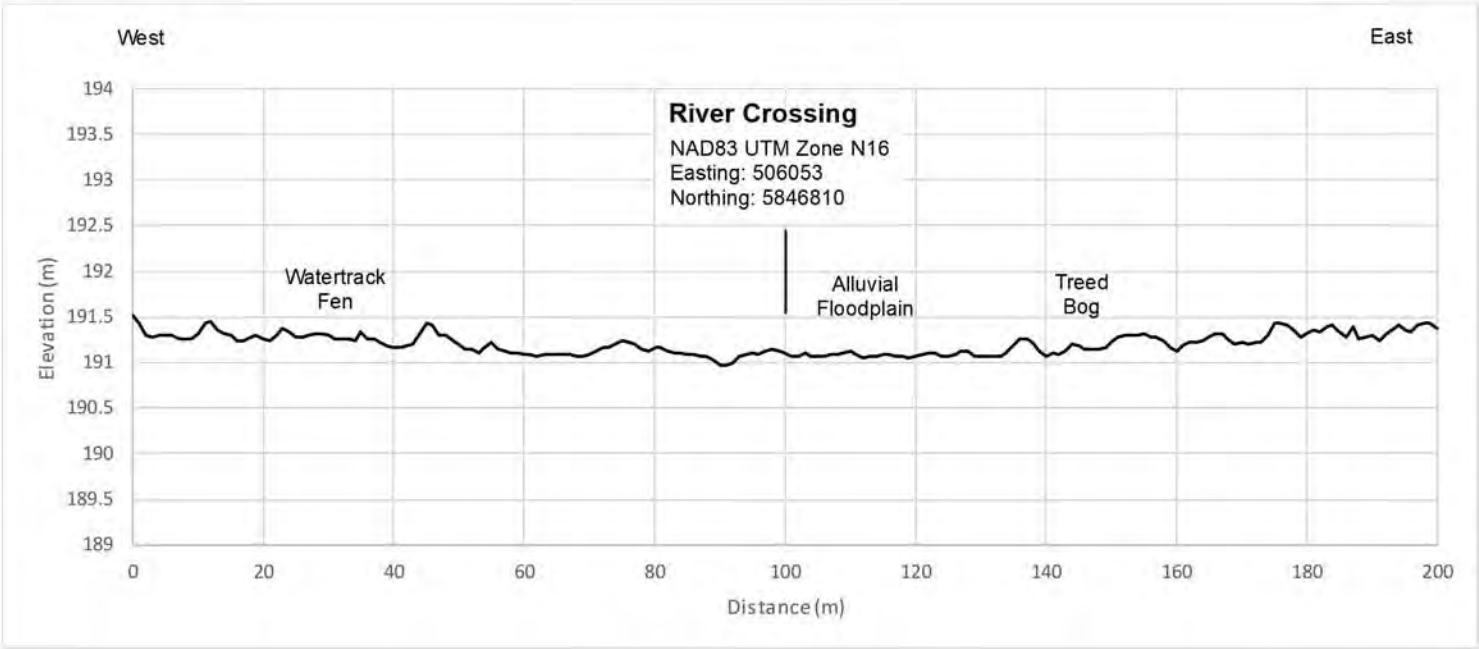
J16

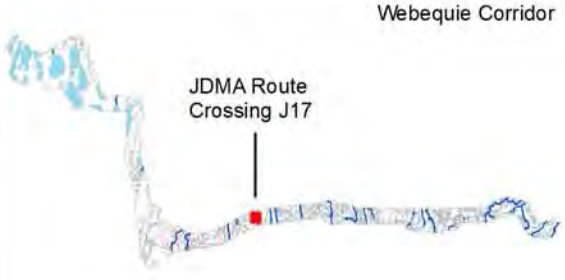
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

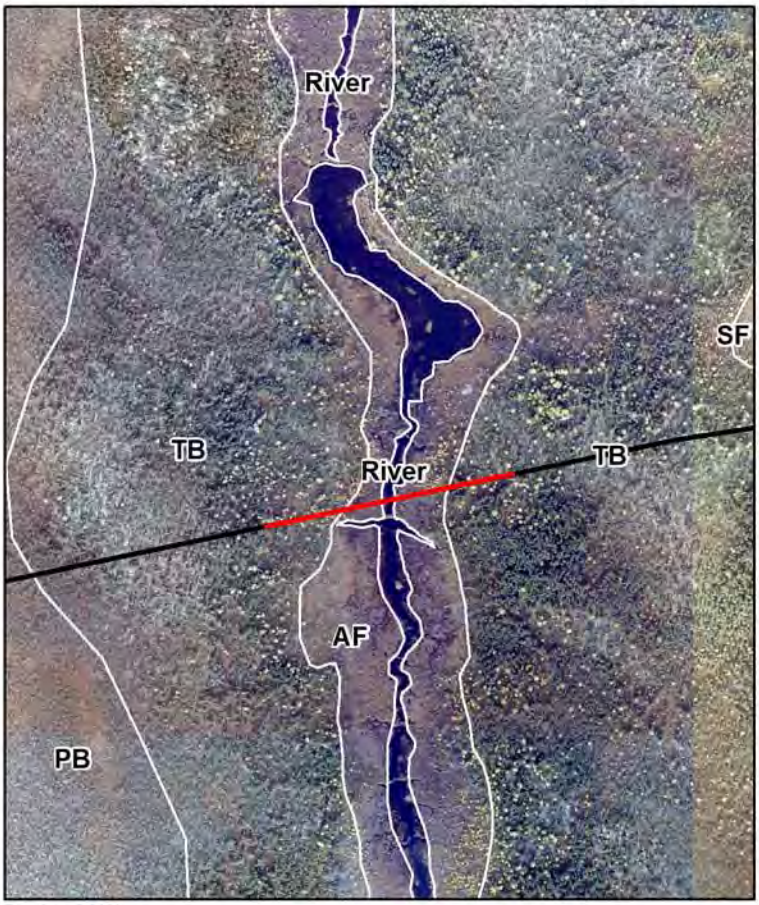
General reference map only; not for survey or legal use.

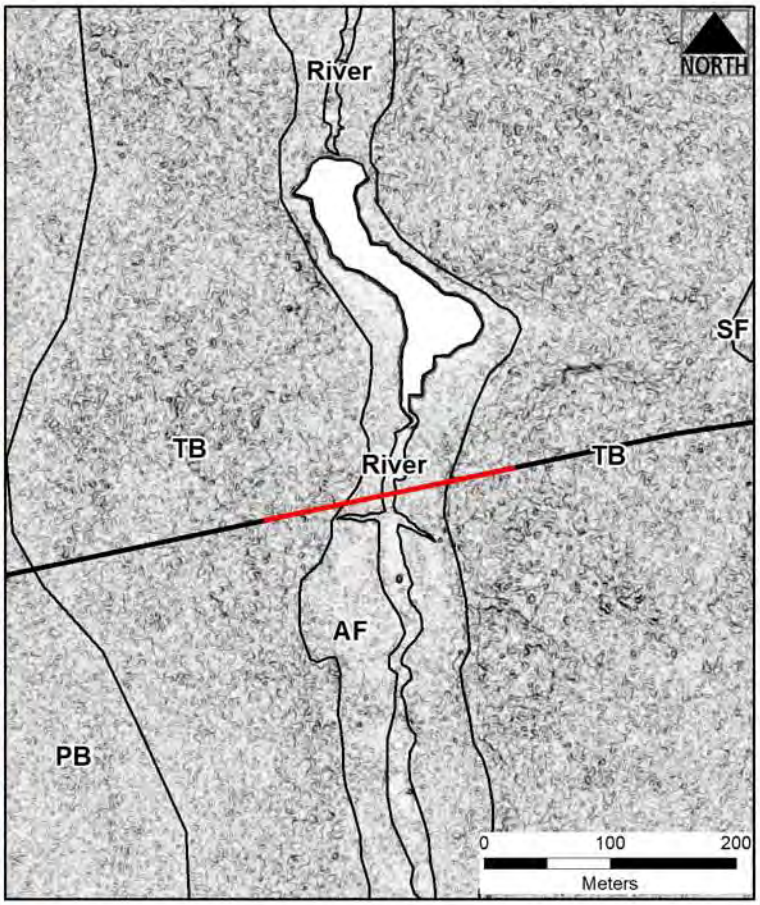
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

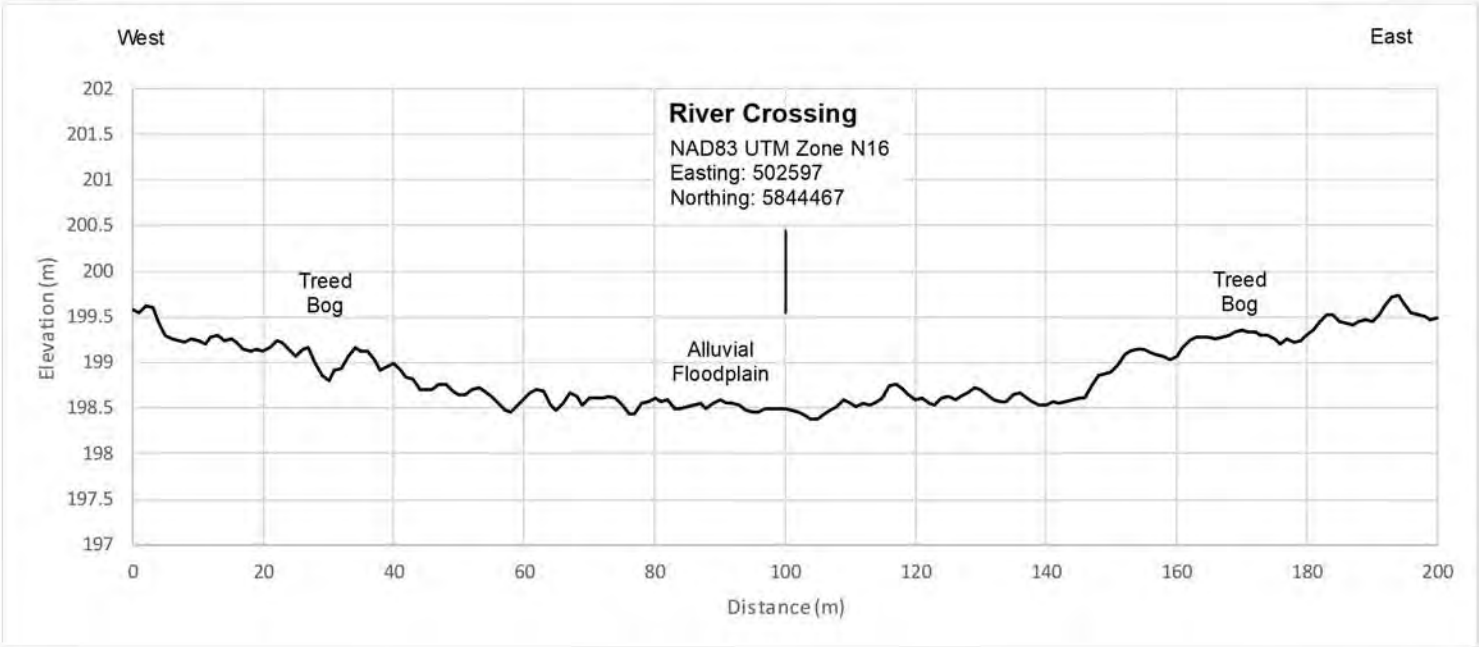
J17

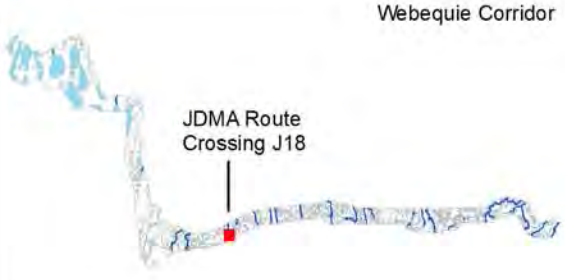
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

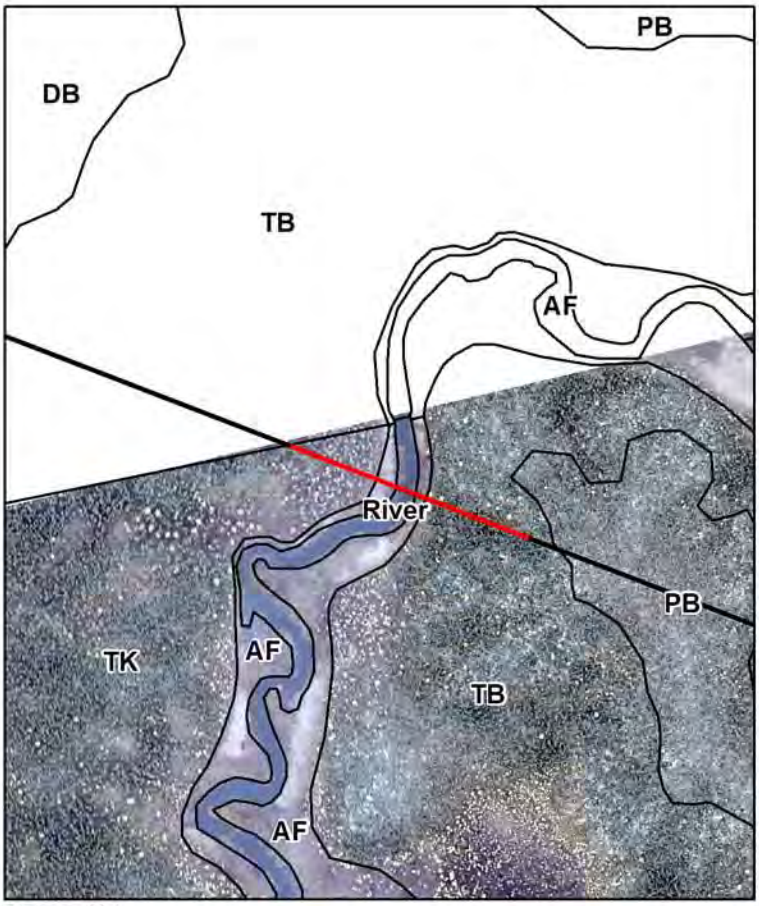
General reference map only; not for survey or legal use.

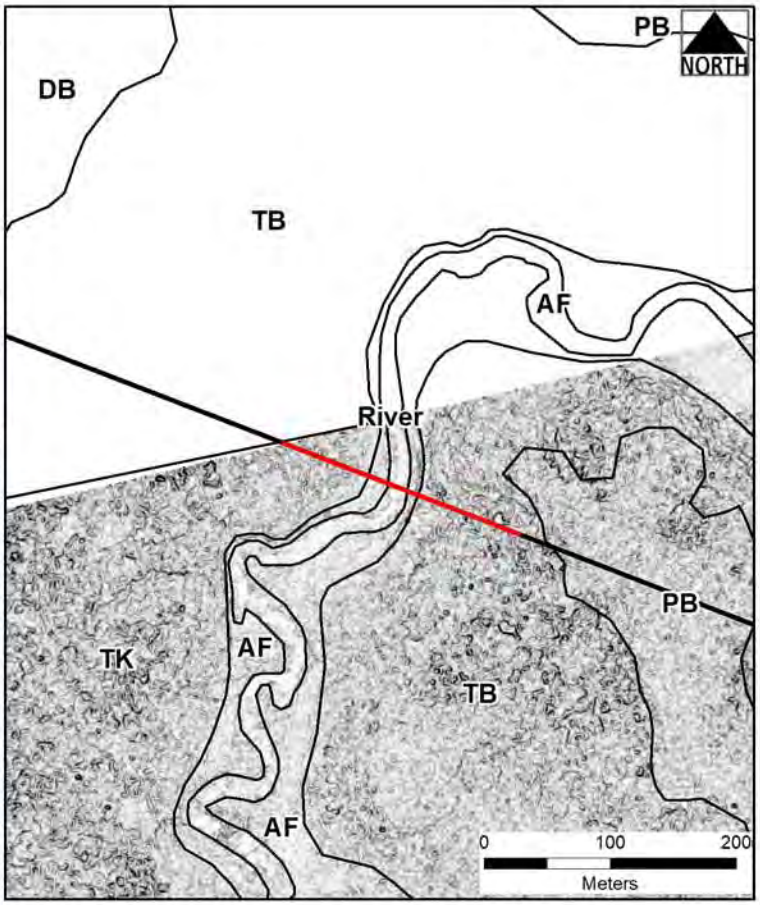
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

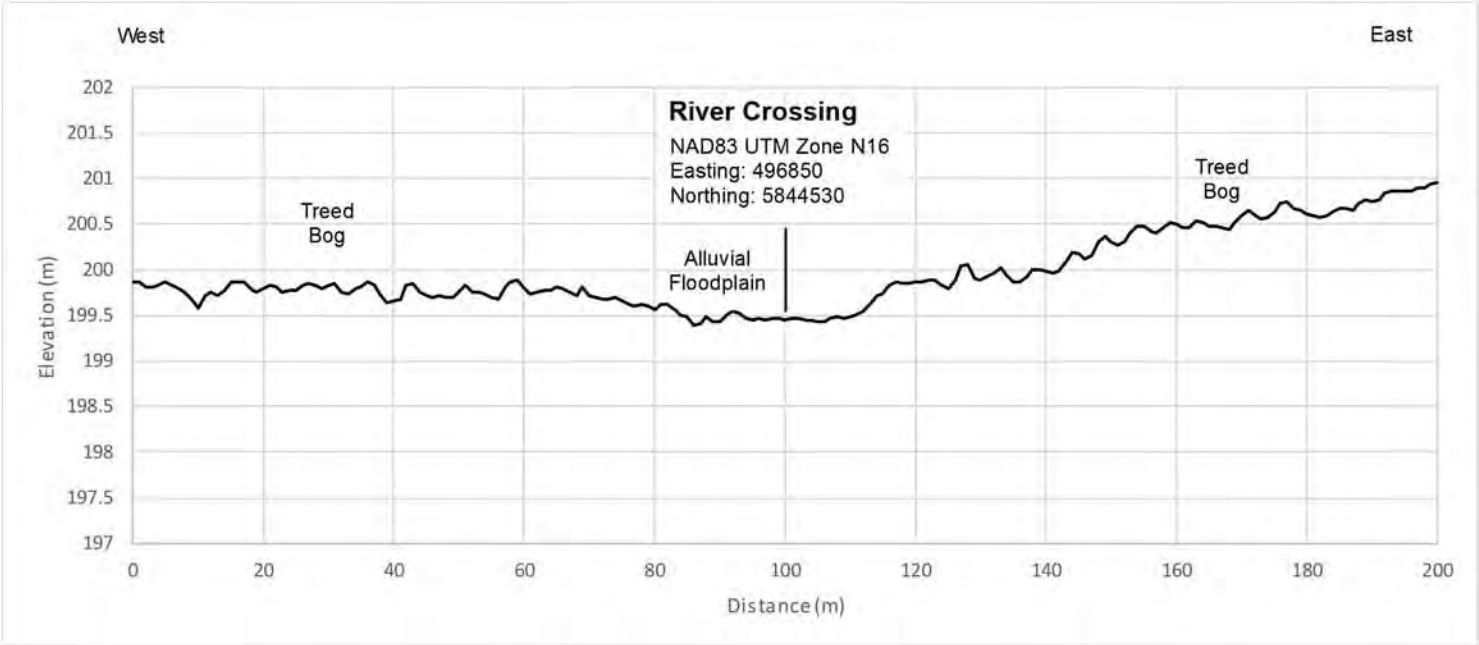
J18

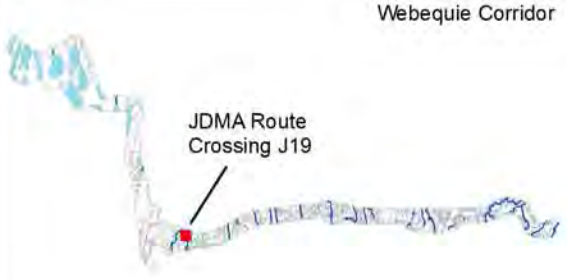
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

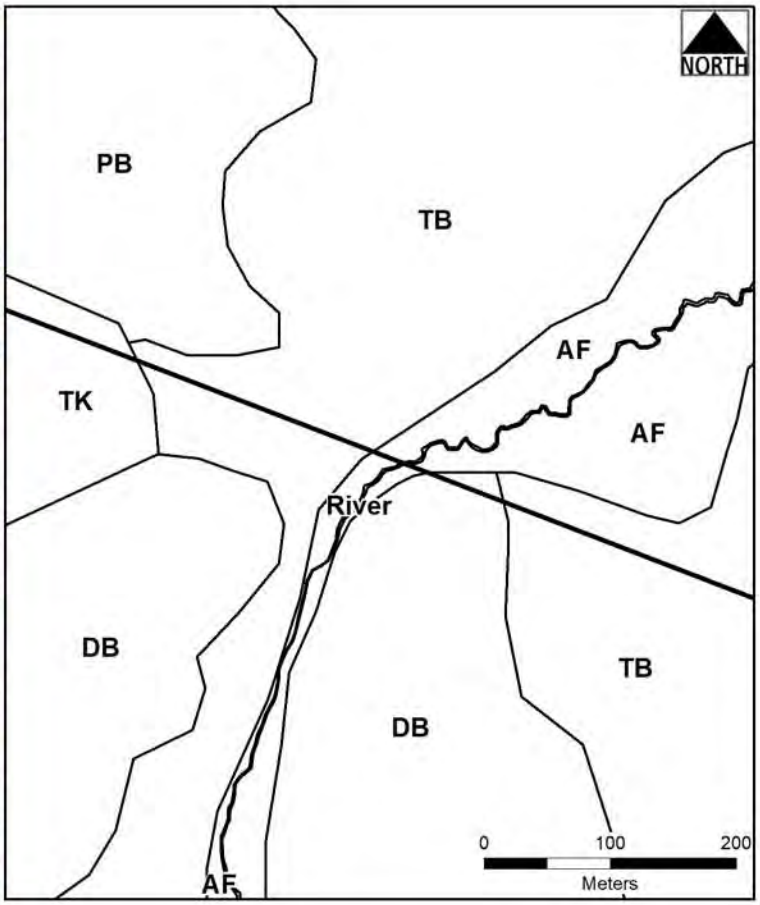
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

J19

J D MOLLARD AND ASSOCIATES (2010) LIMITED

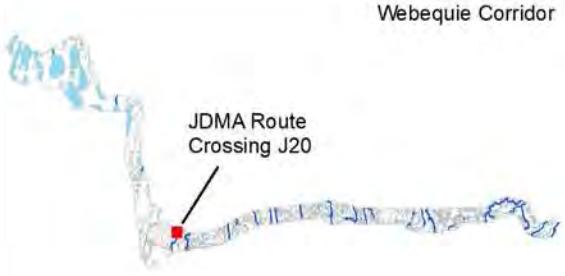


Chainages (Km)

River Crossing

NAD83 UTM Zone N16
Easting:495687
Northing: 5844978

No LiDAR Data



LEGEND:

JDMA Optimal (Feb, 2019)
Cross-Section

Slope (degrees)
High: 66.9
Low: 0

TITLE:

JDMA Route Crossings

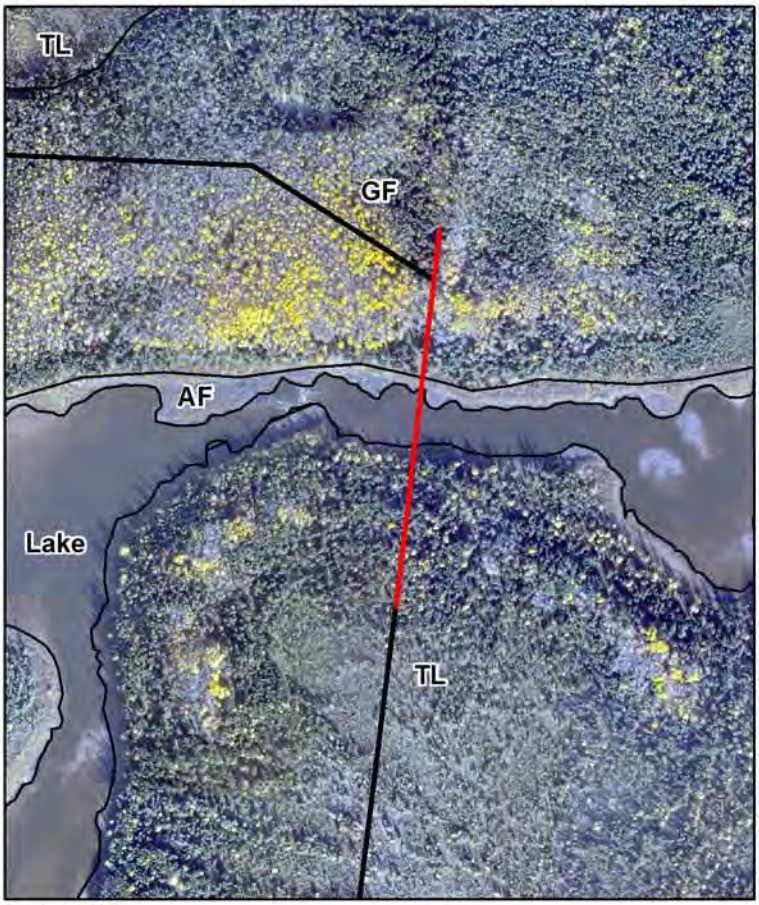
General reference map only; not for survey or legal use.

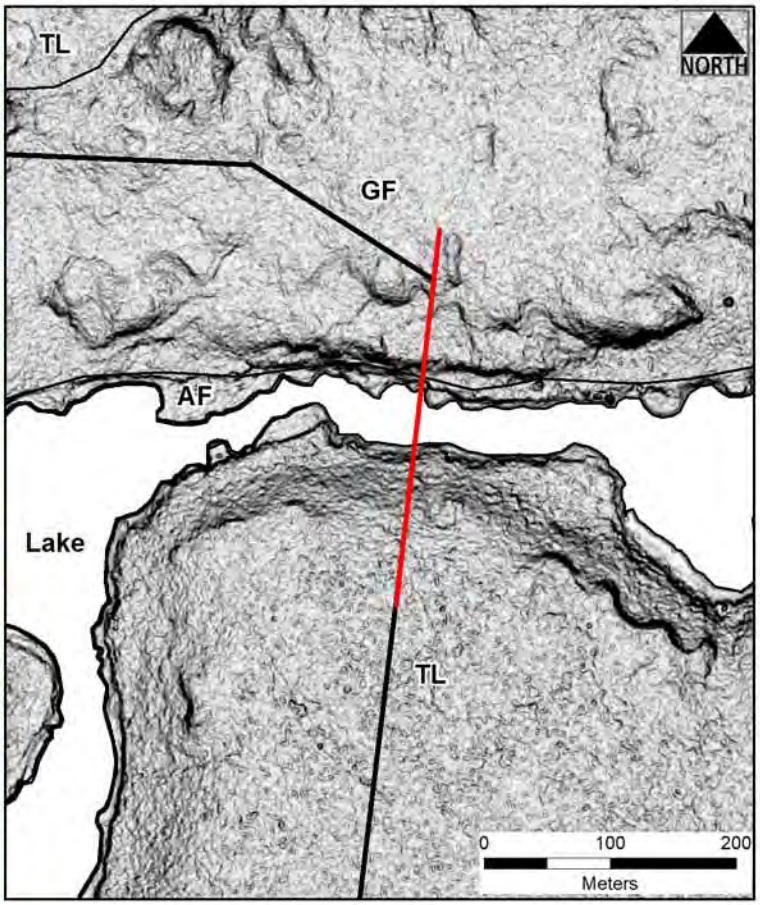
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

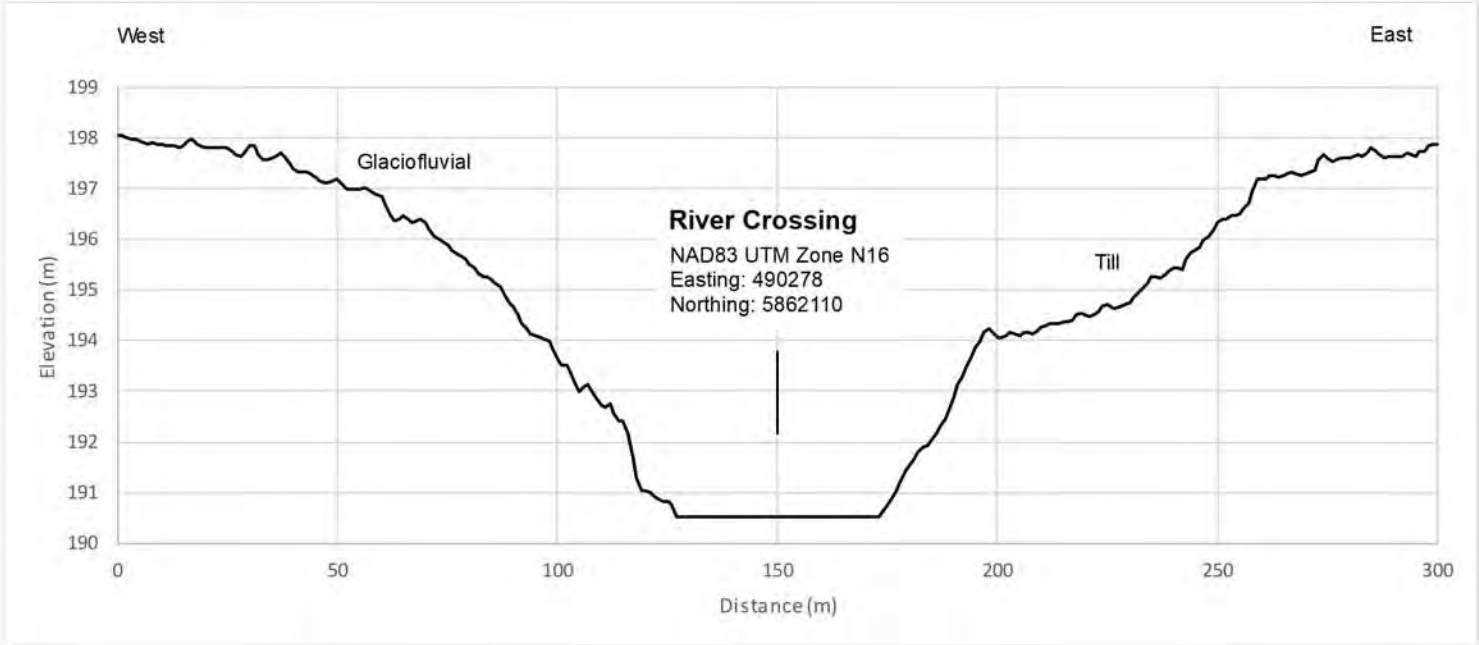
J20

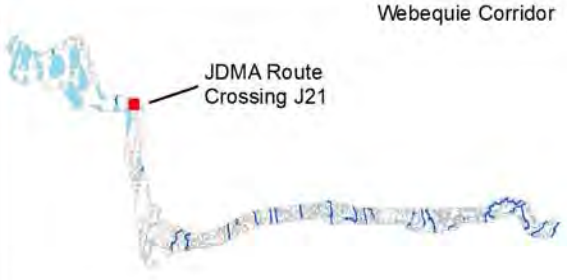
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

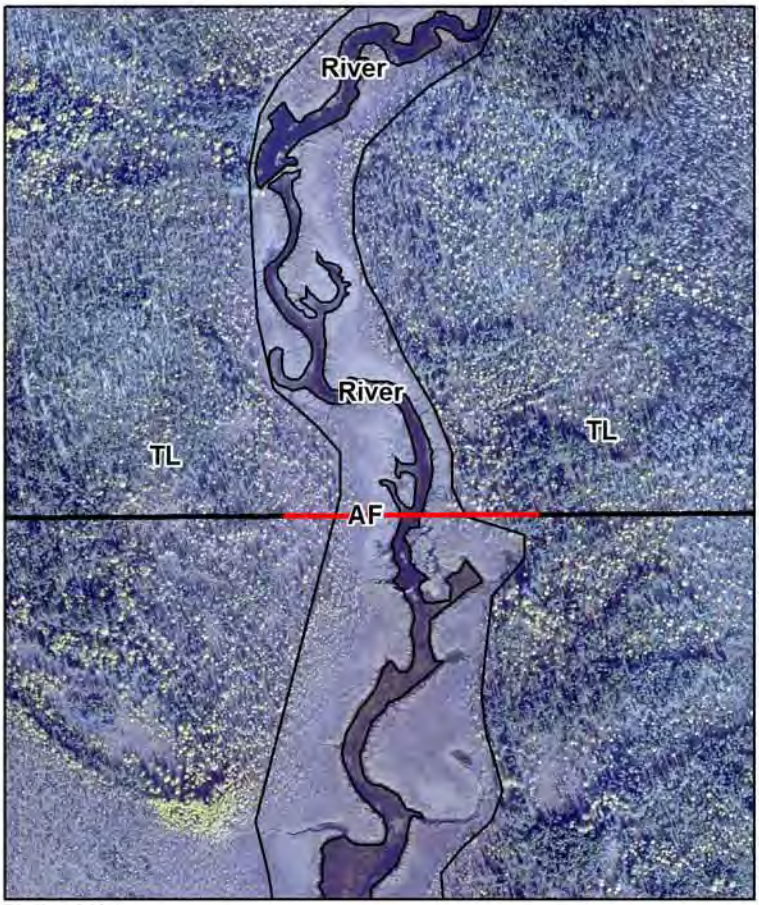
General reference map only; not for survey or legal use.

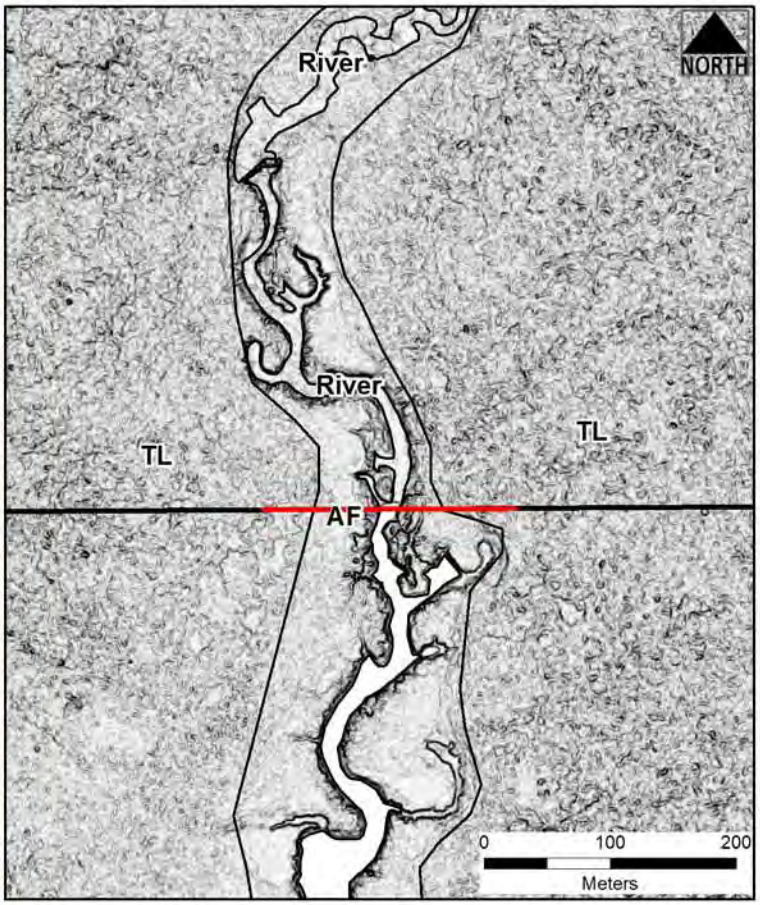
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

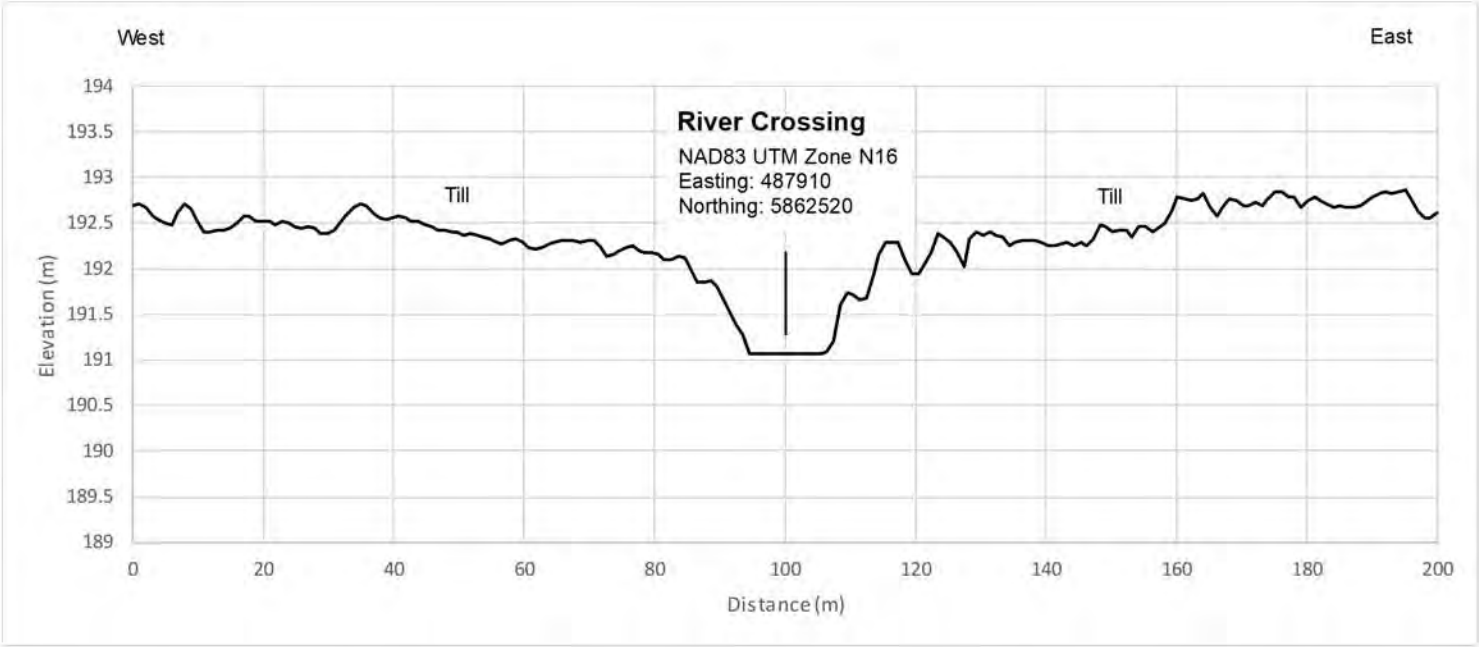
J21

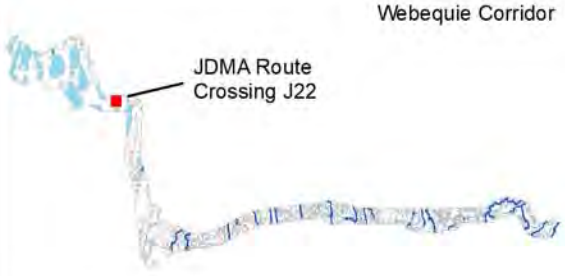
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

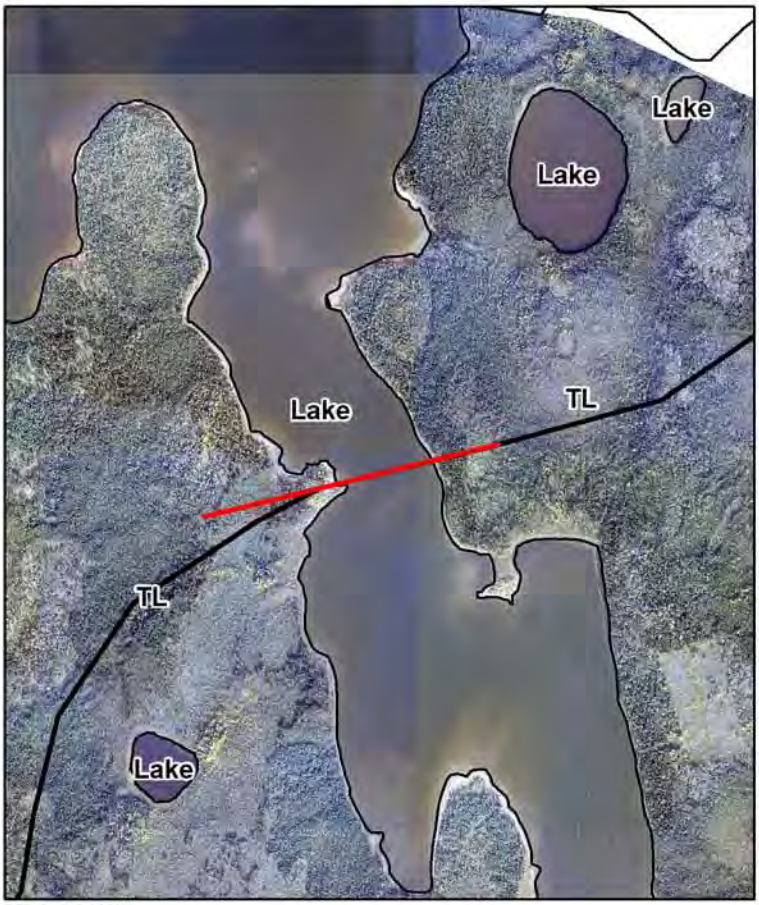
General reference map only; not for survey or legal use.

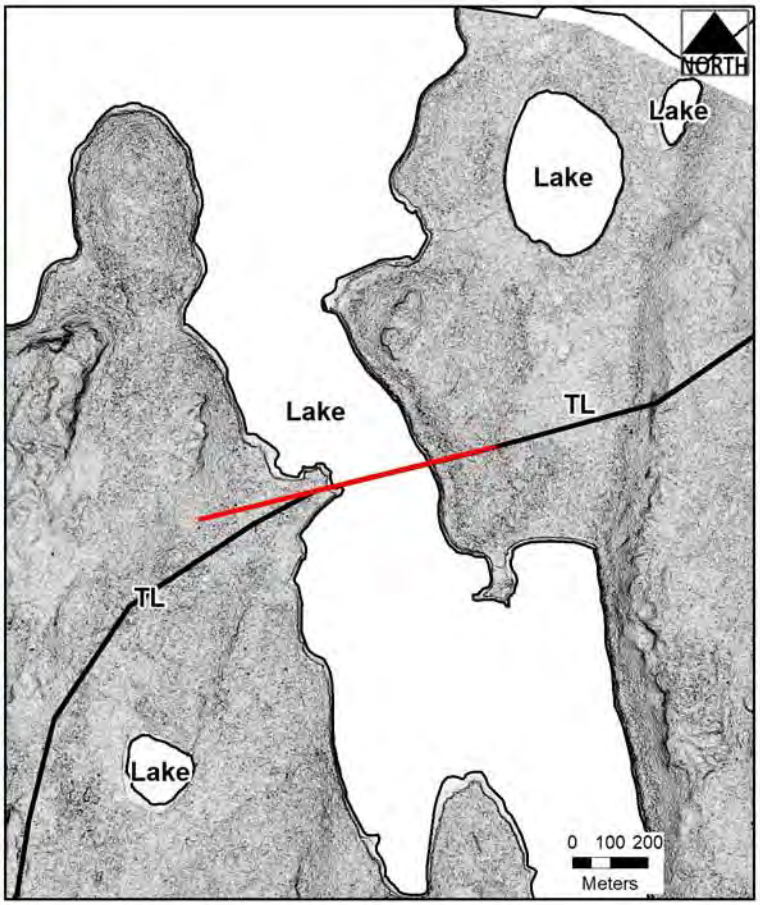
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

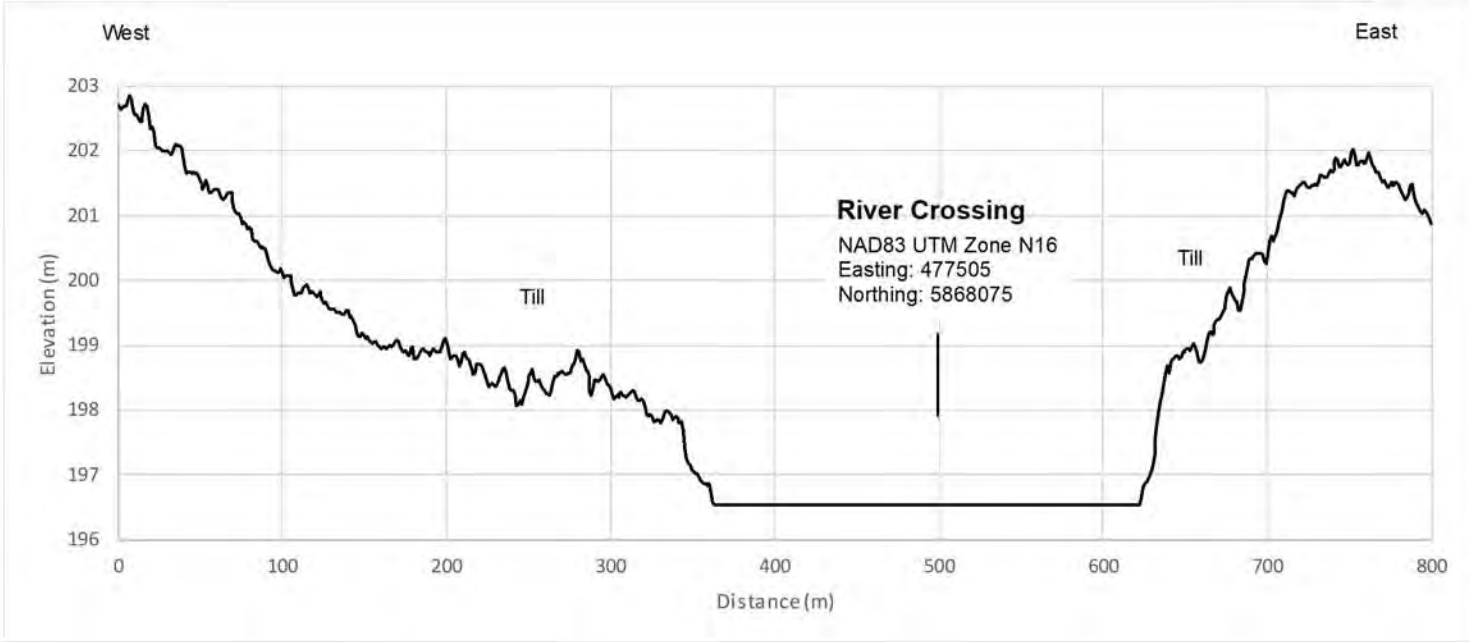
J22

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

JDMA Optimal (Feb, 2019)

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

JDMA Route Crossings

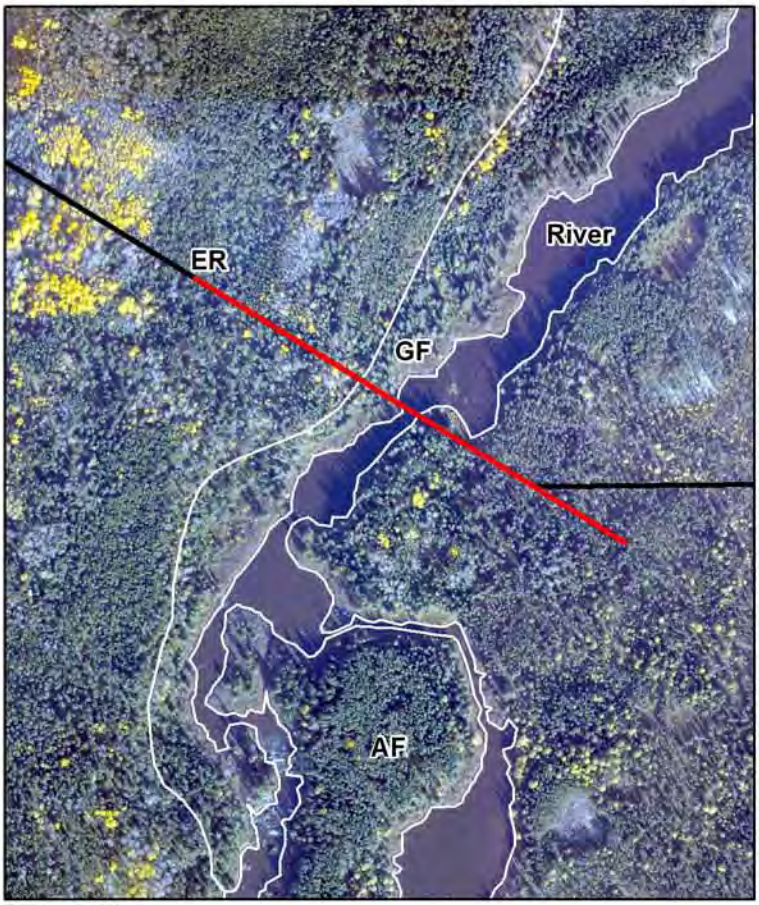
General reference map only; not for survey or legal use.

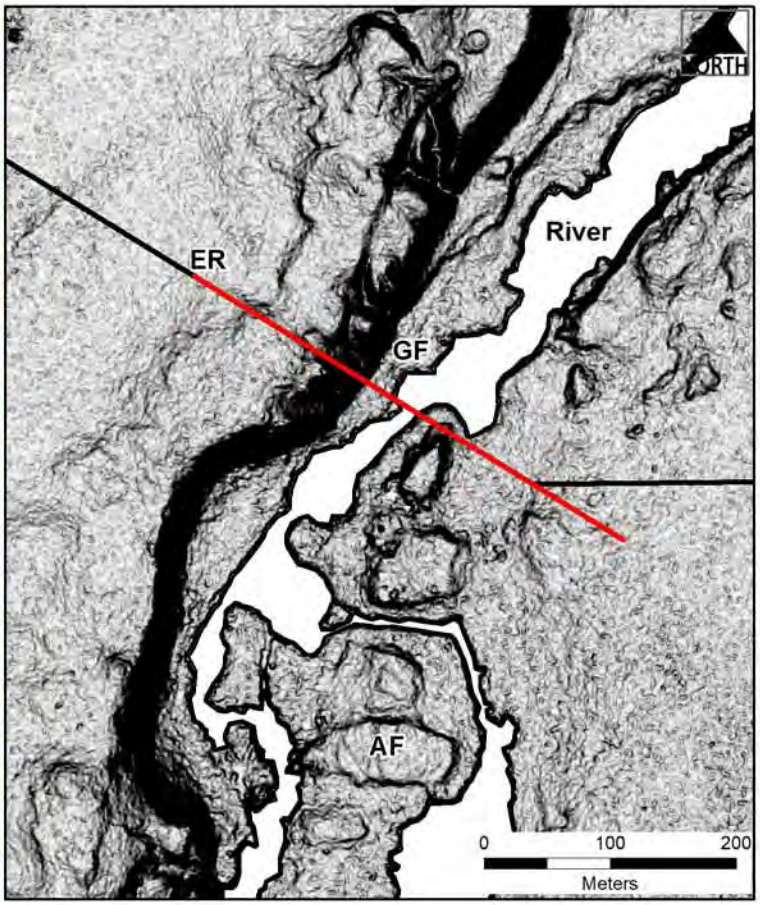
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

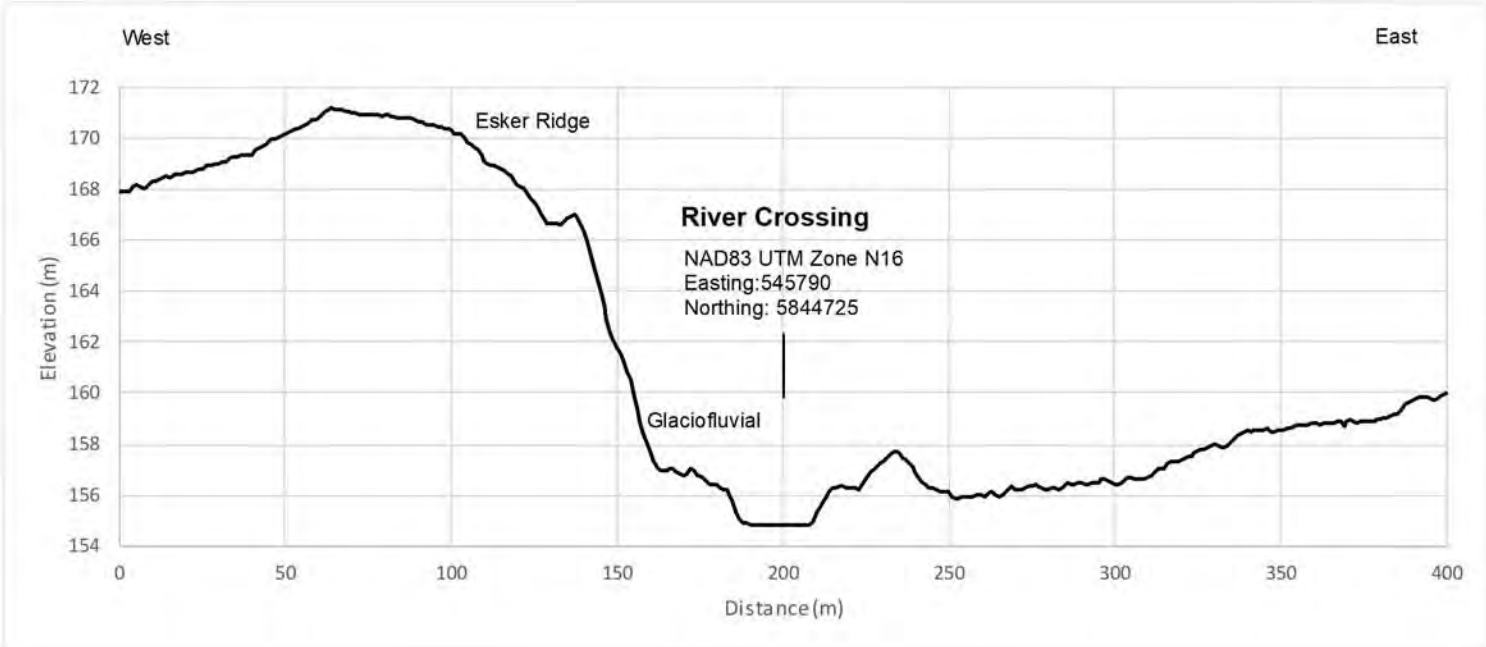
J23

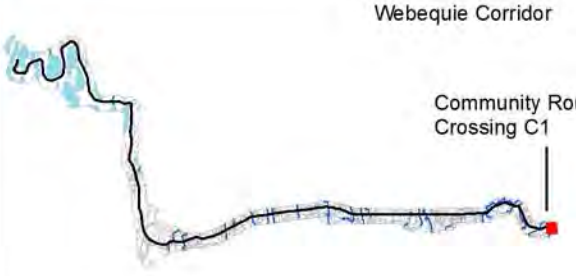
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

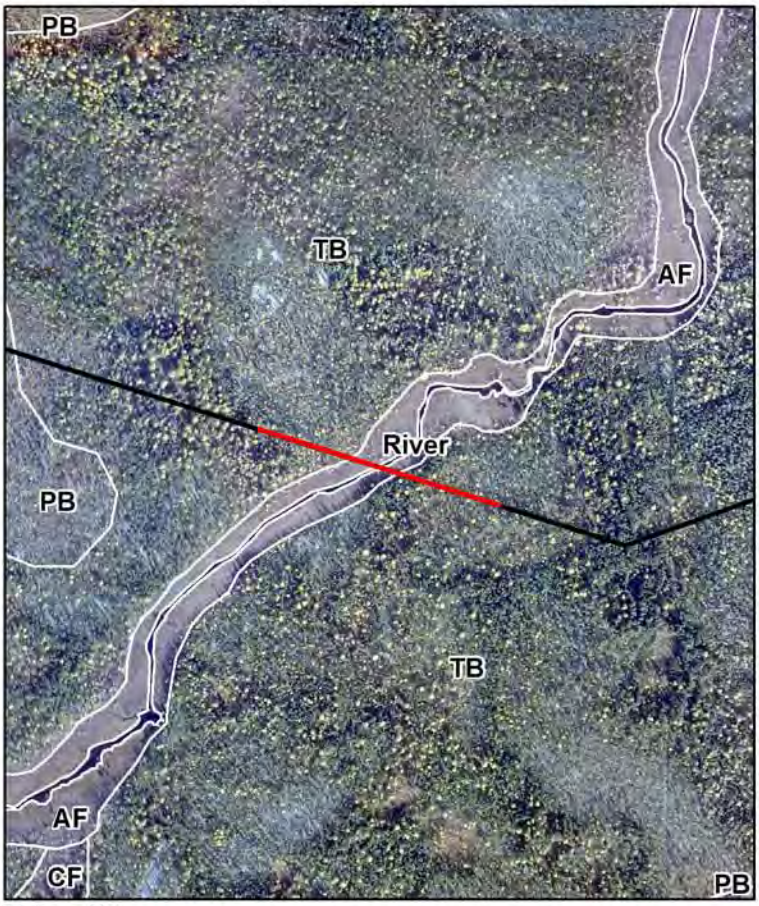
General reference map only; not for survey or legal use.

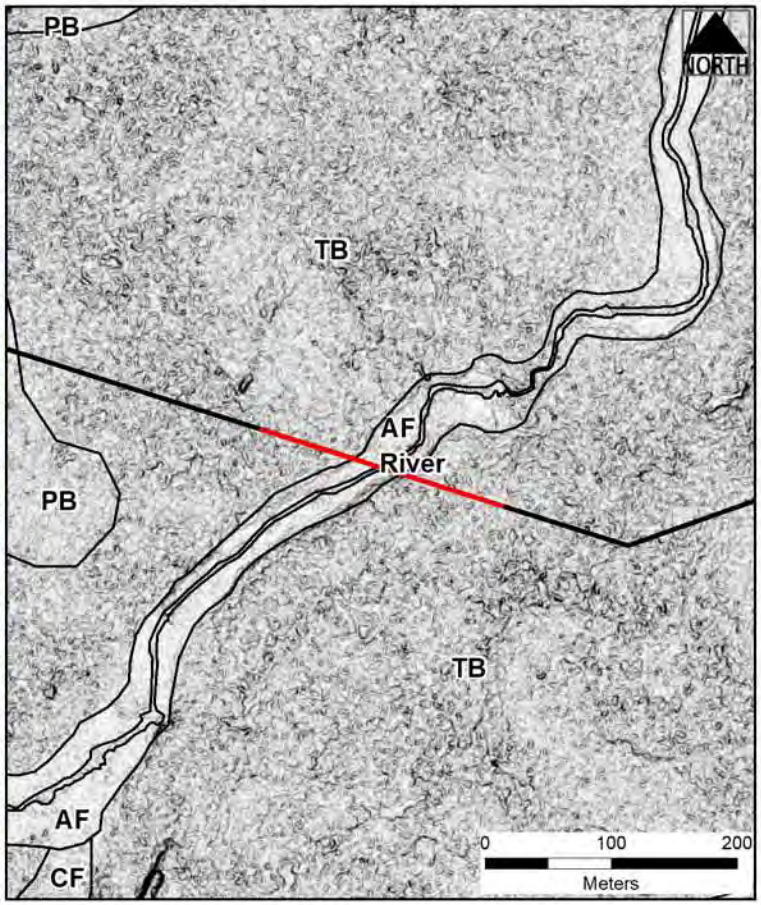
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

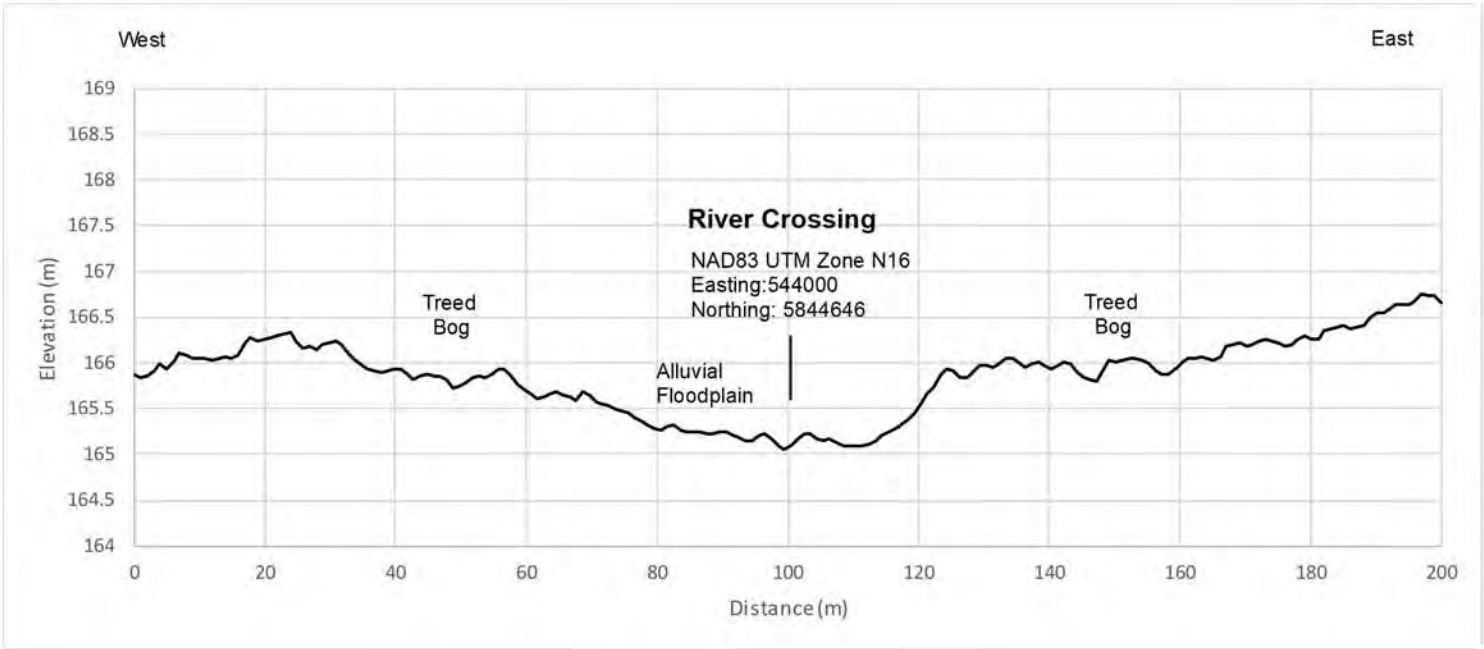
C1

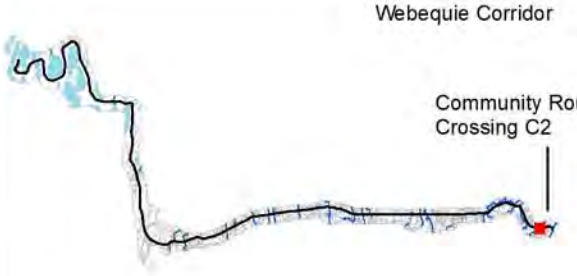
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

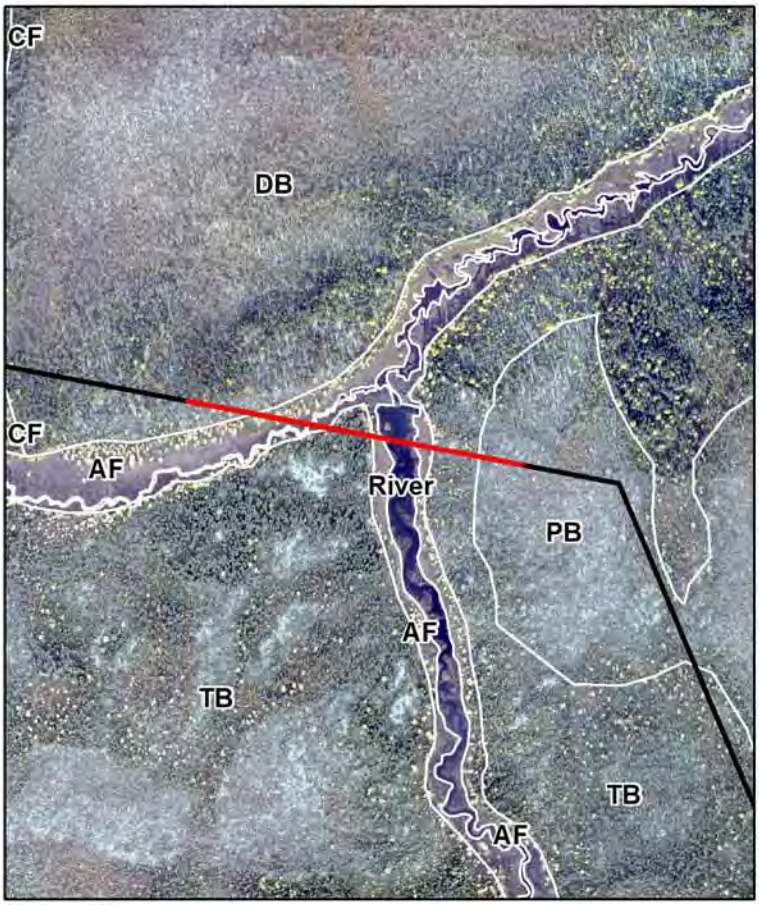
General reference map only; not for survey or legal use.

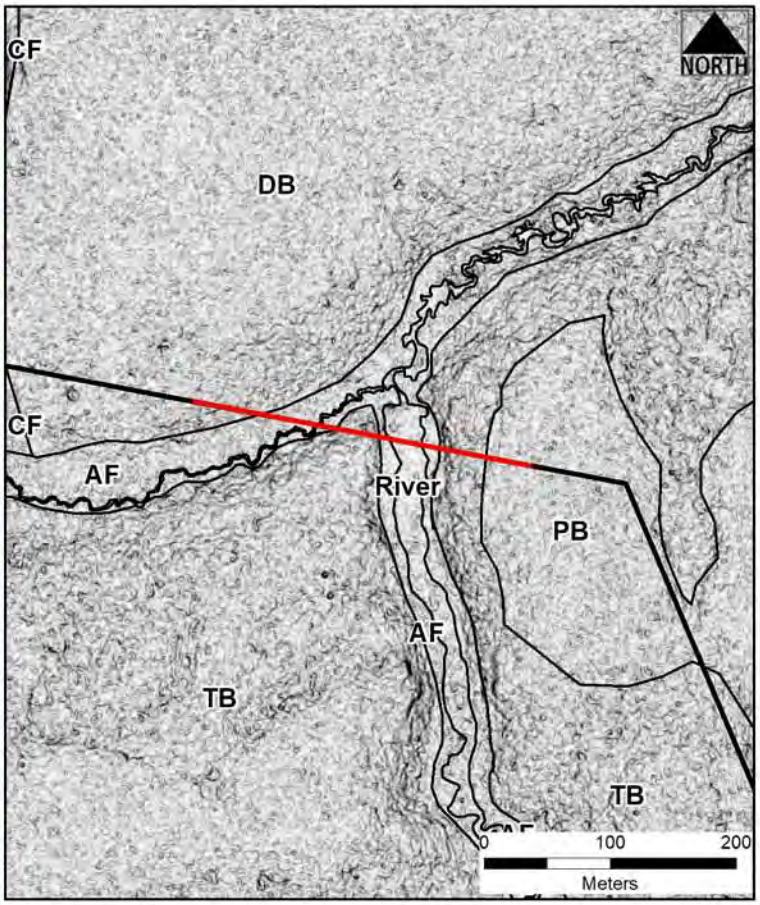
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

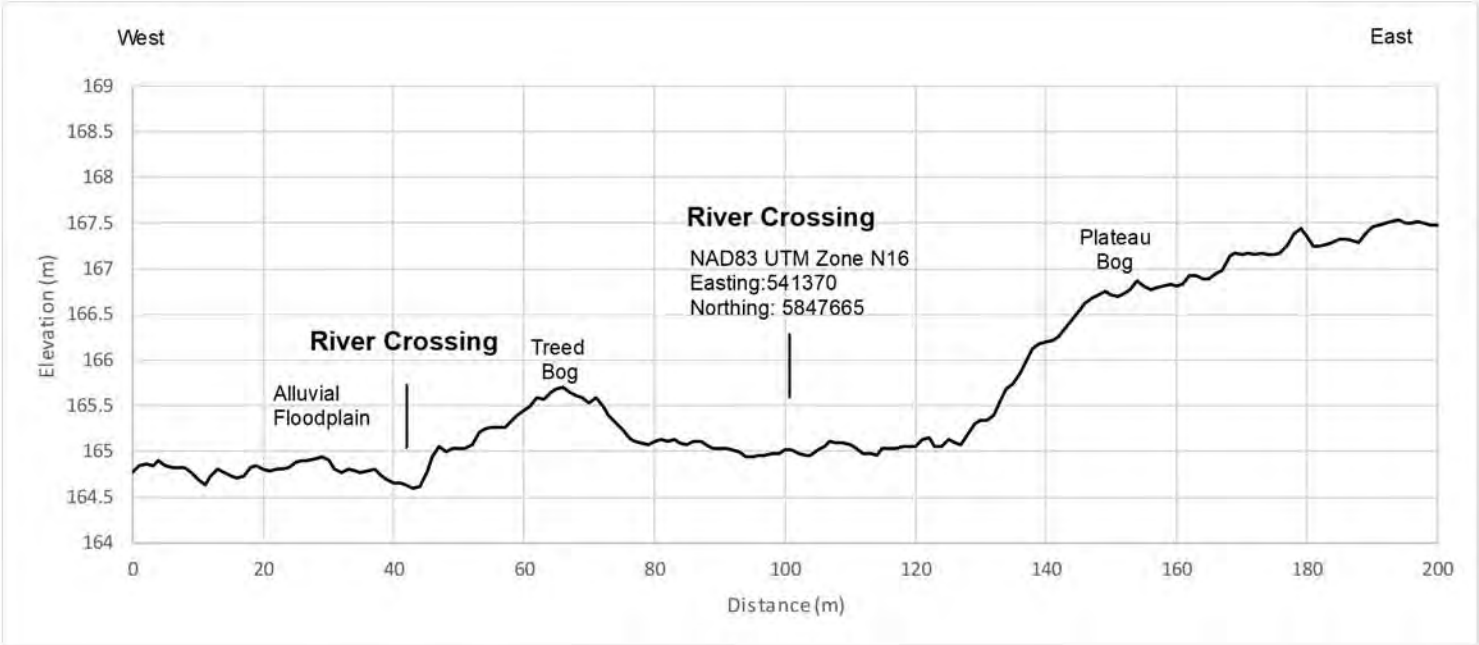
C2

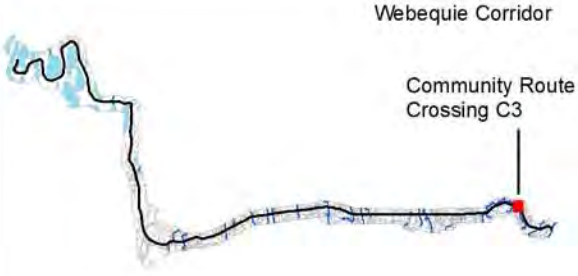
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

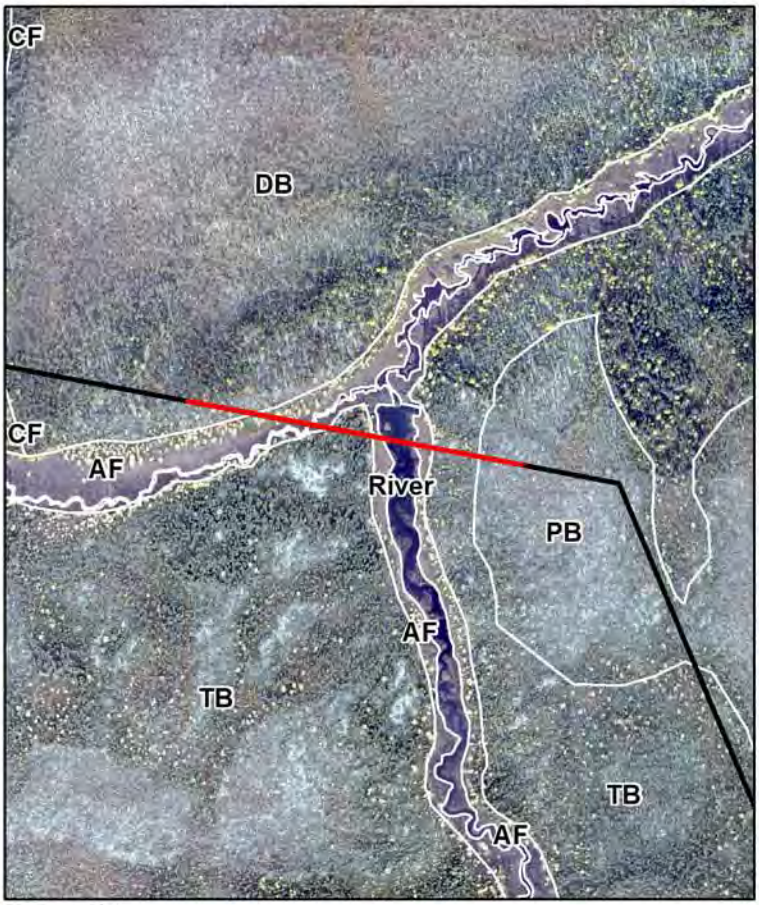
General reference map only; not for survey or legal use.

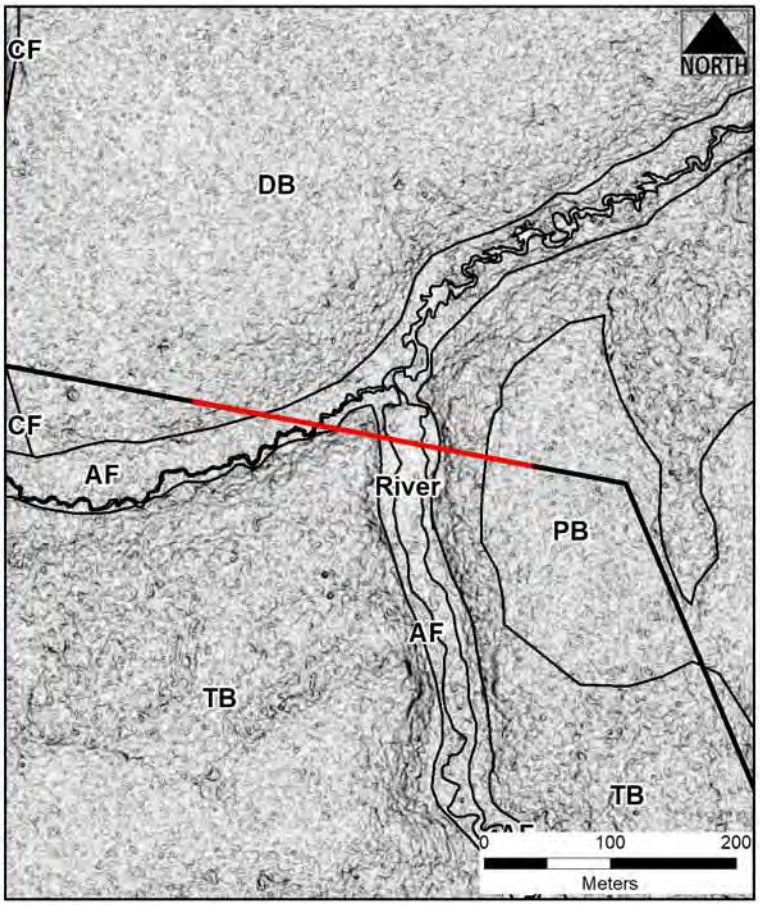
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

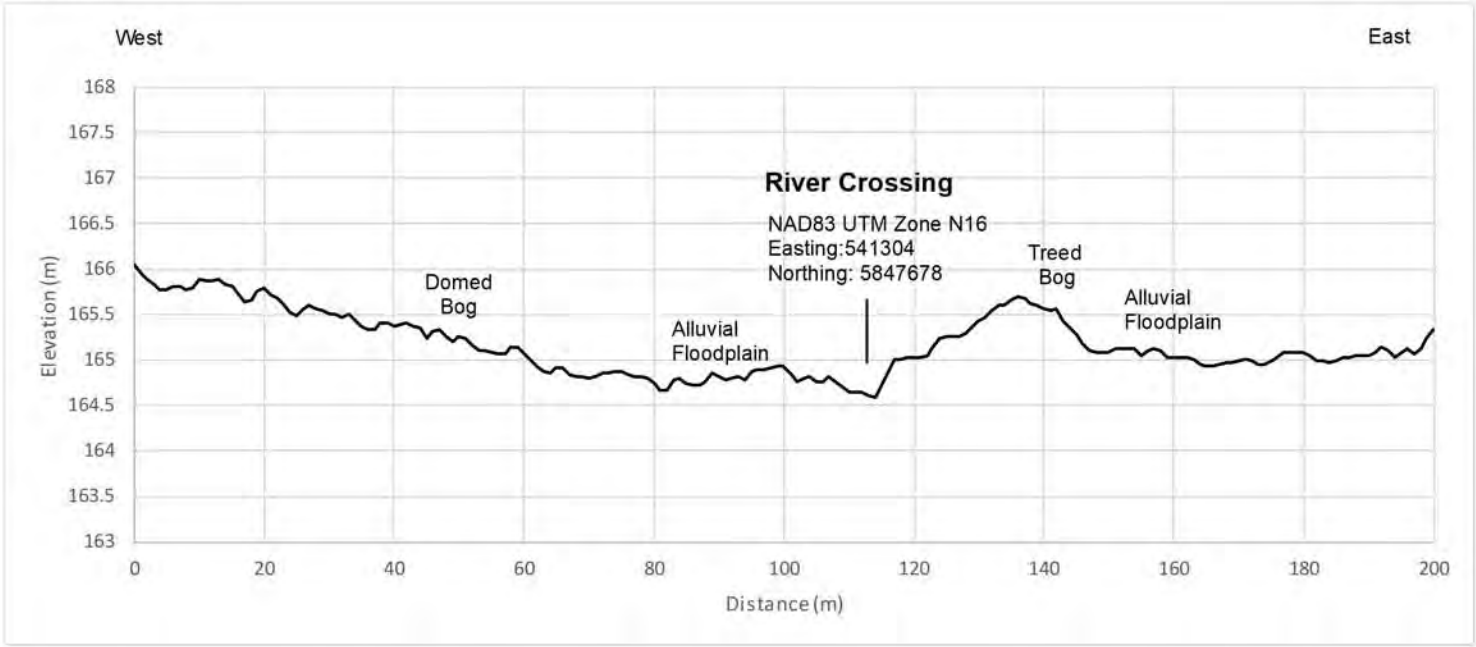
C3

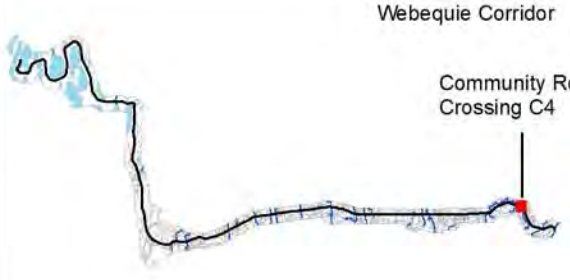
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

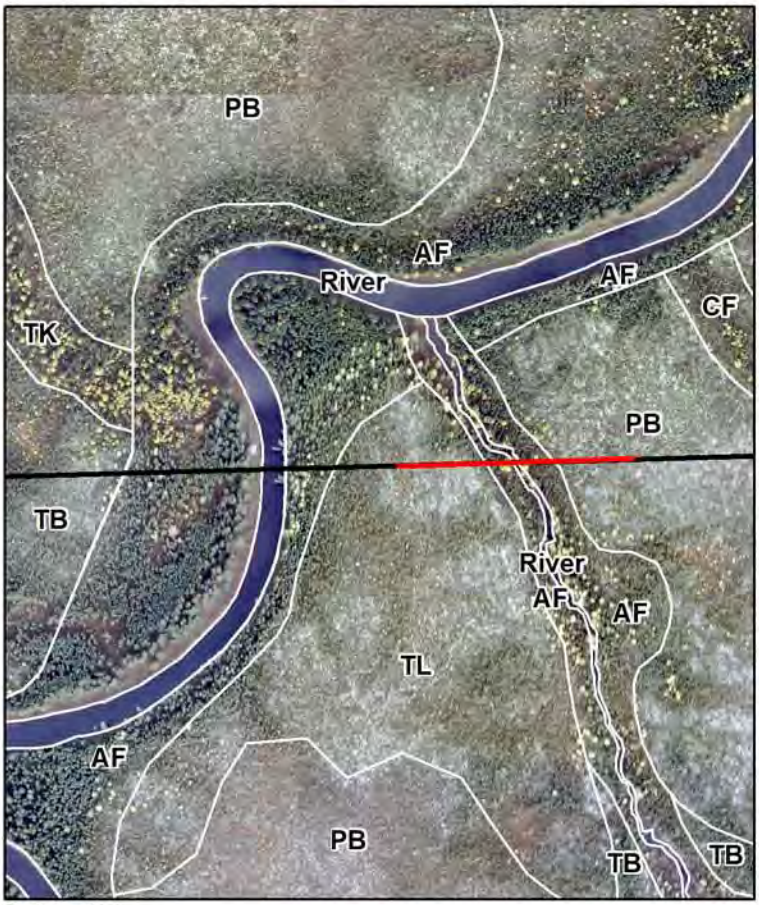
General reference map only; not for survey or legal use.

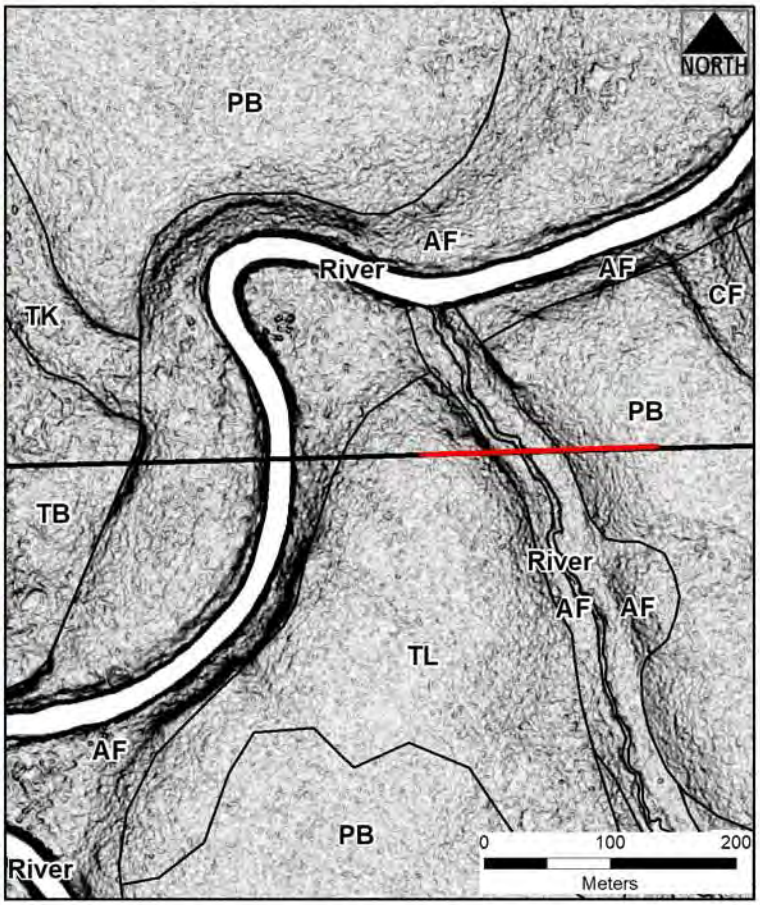
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 29/Mar/2019*

CROSSING:

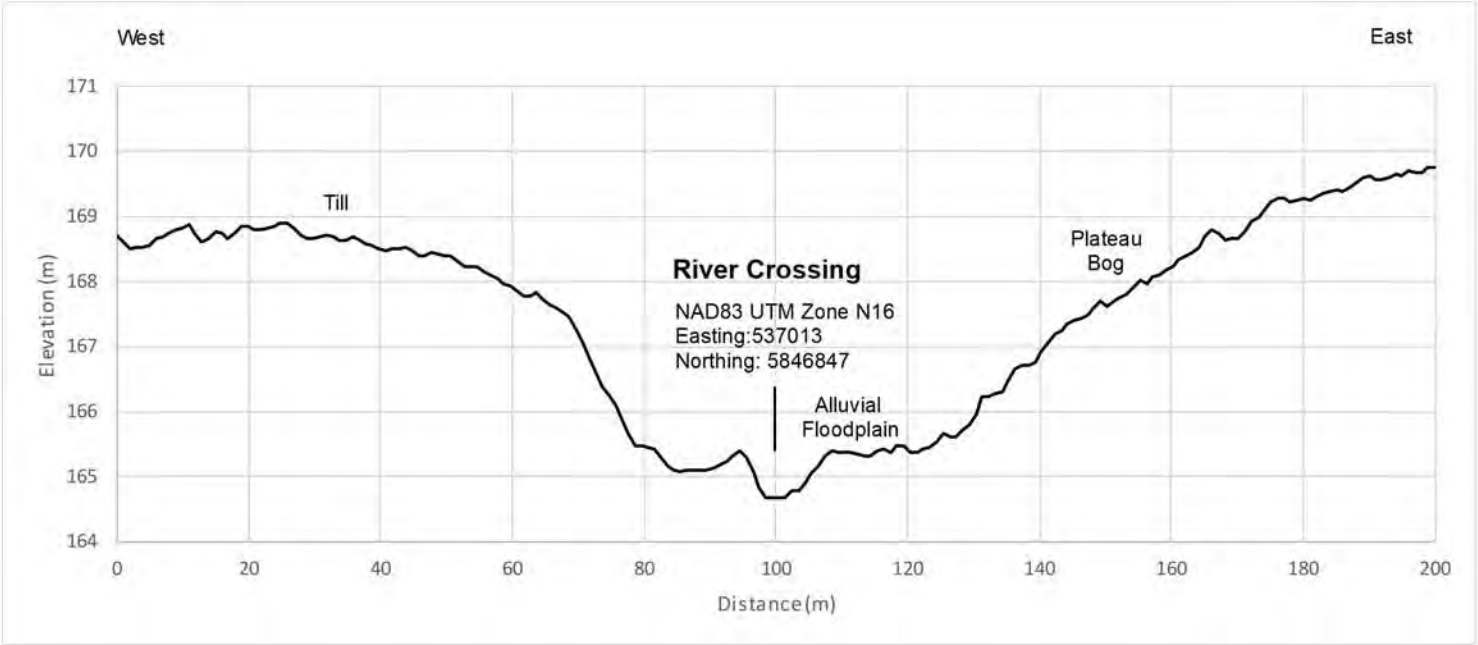
C4

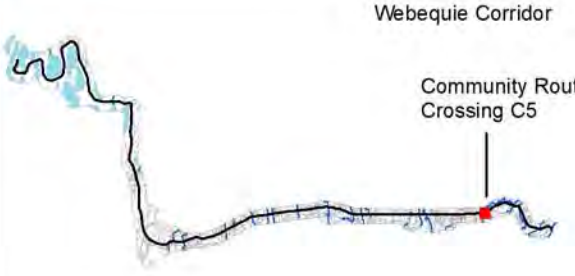
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

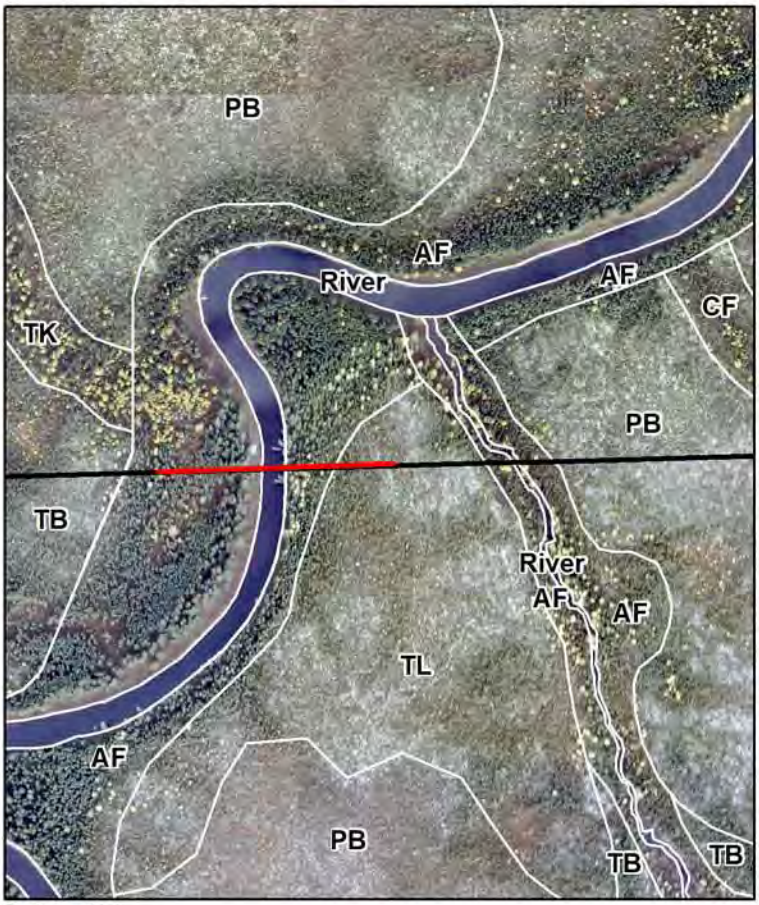
General reference map only; not for survey or legal use.

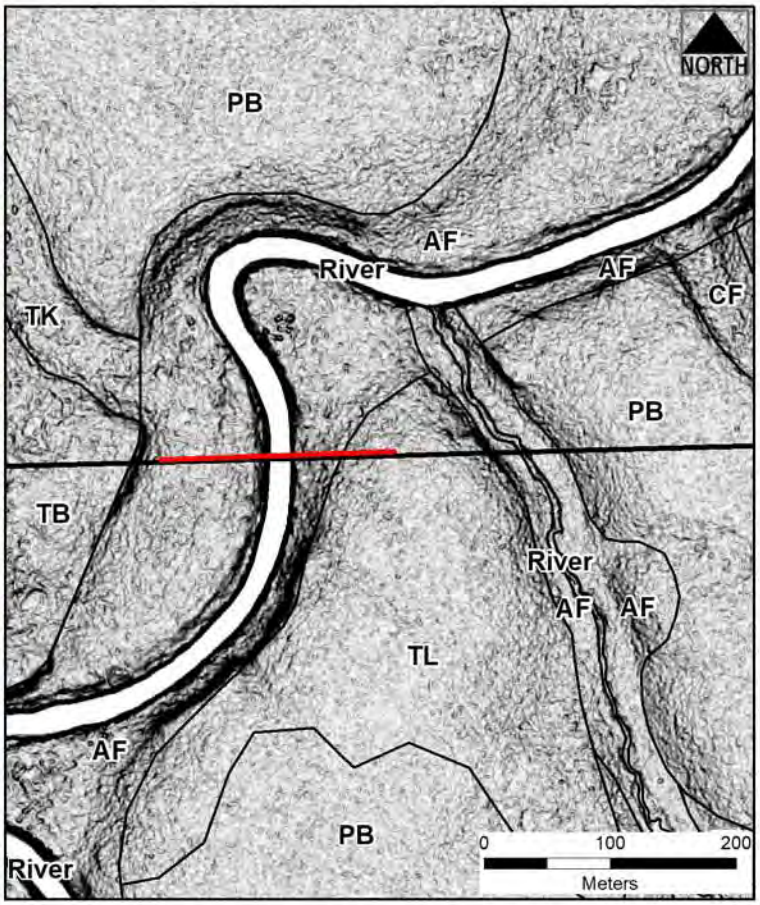
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

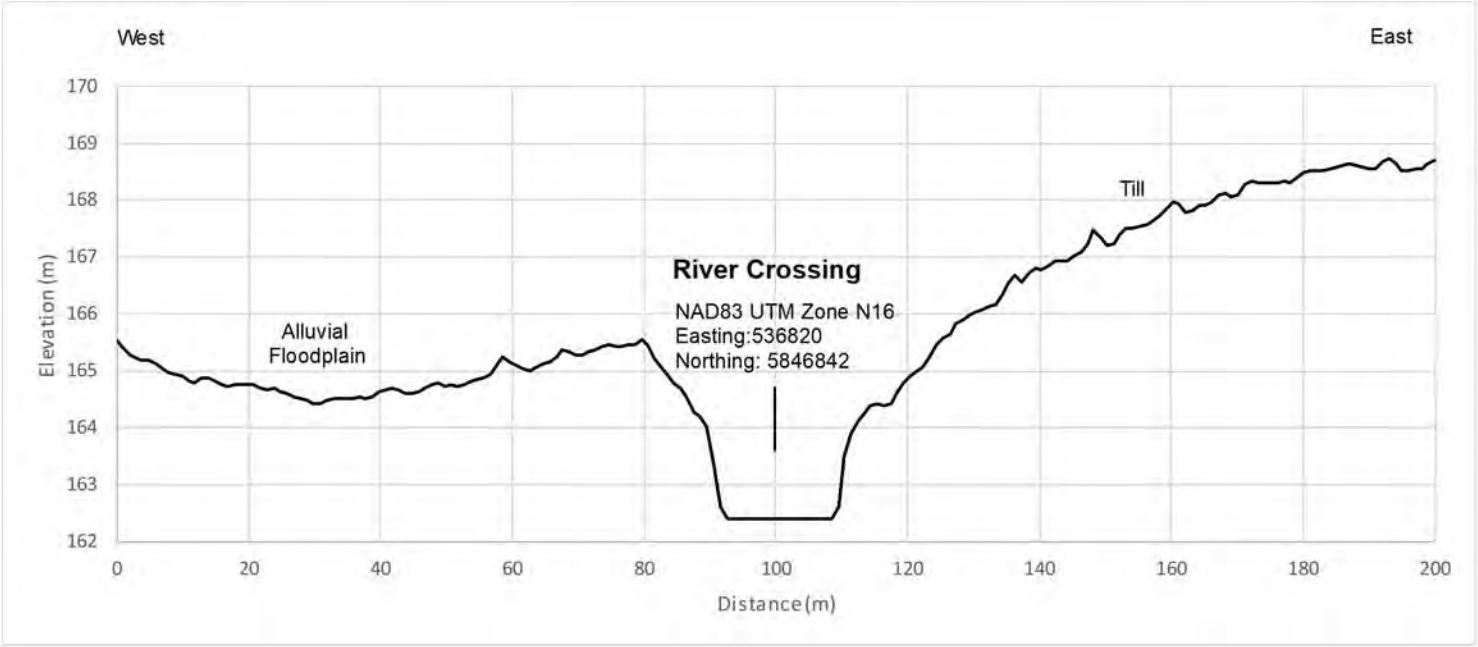
C5

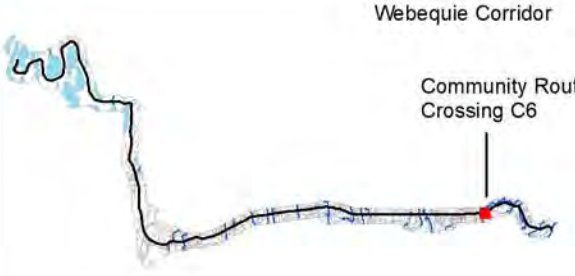
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

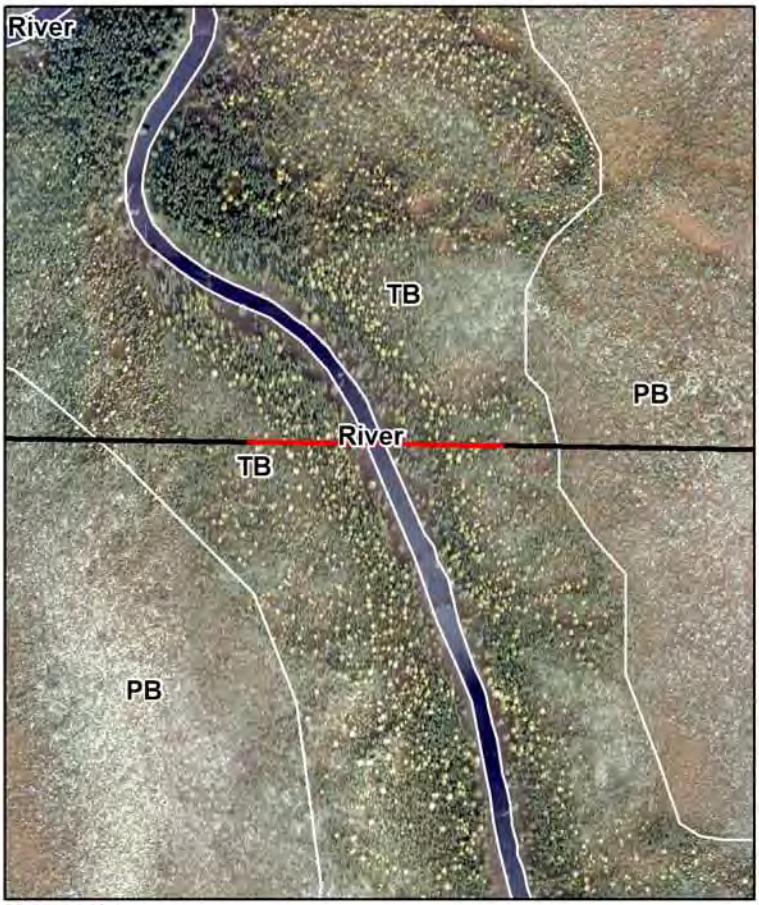
General reference map only; not for survey or legal use.

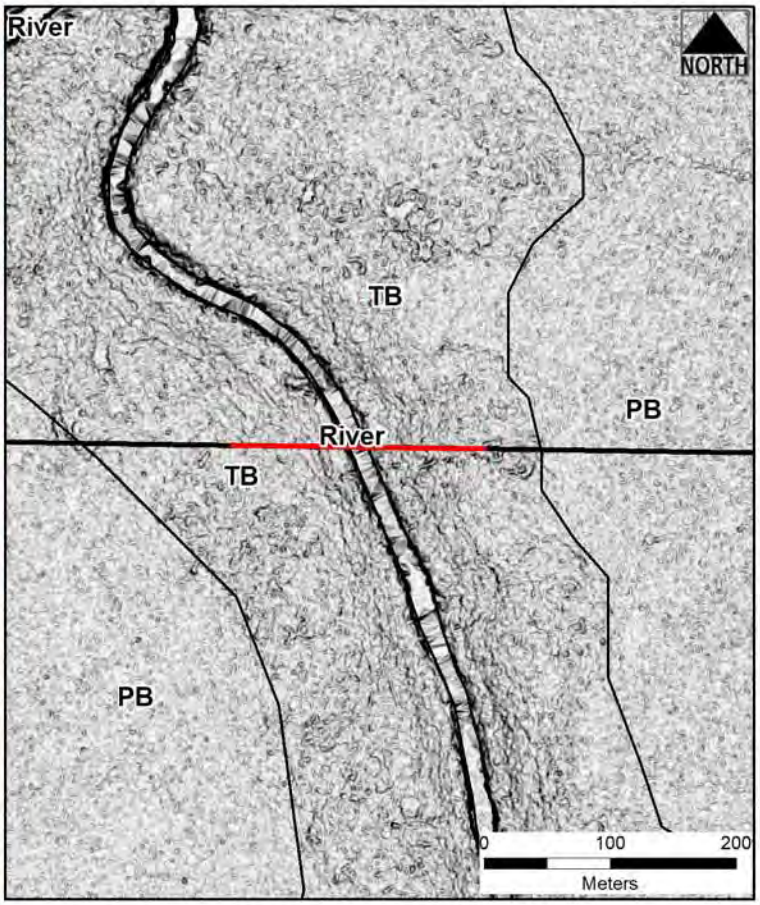
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

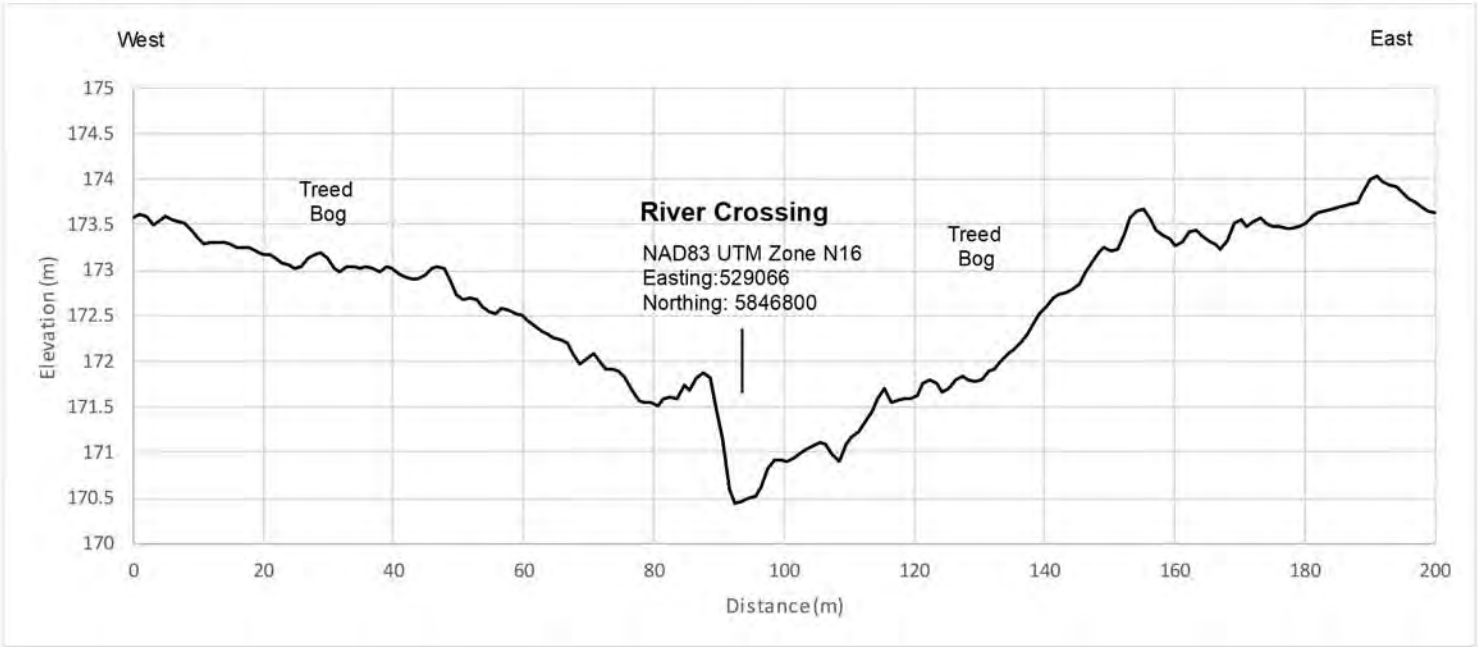
C6

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

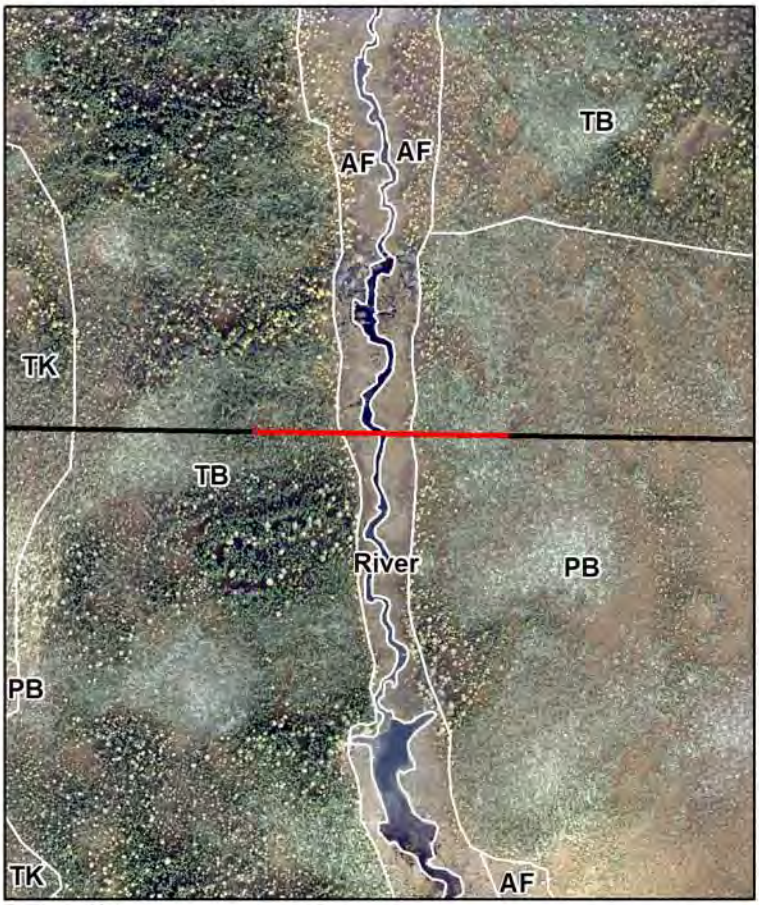
General reference map only; not for survey or legal use.

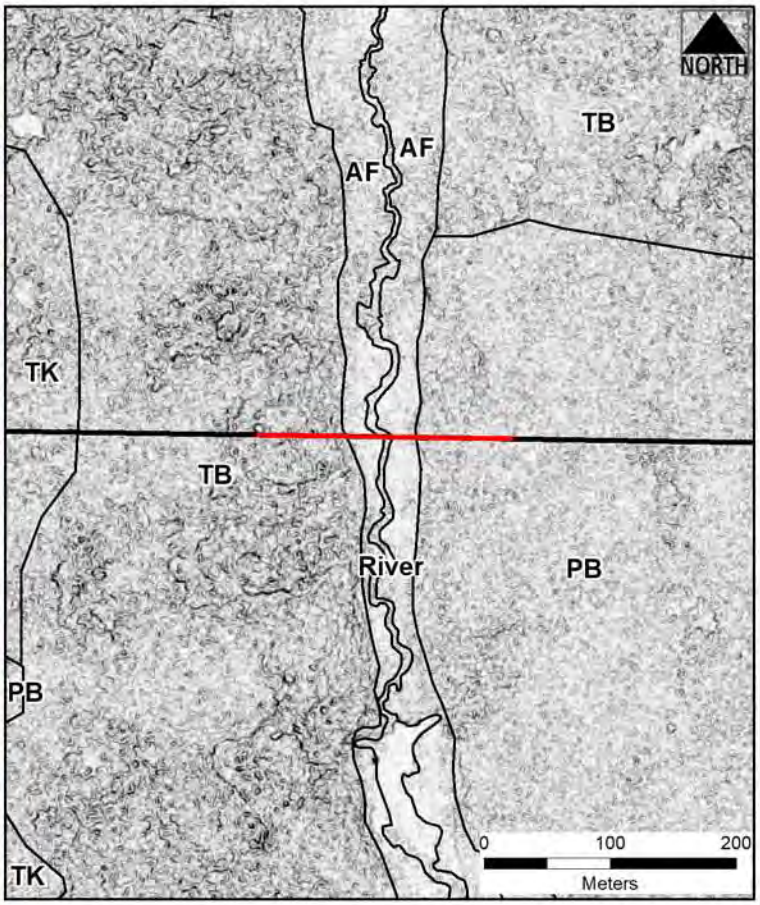
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C7

J D MOLLARD AND ASSOCIATES (2010) LIMITED





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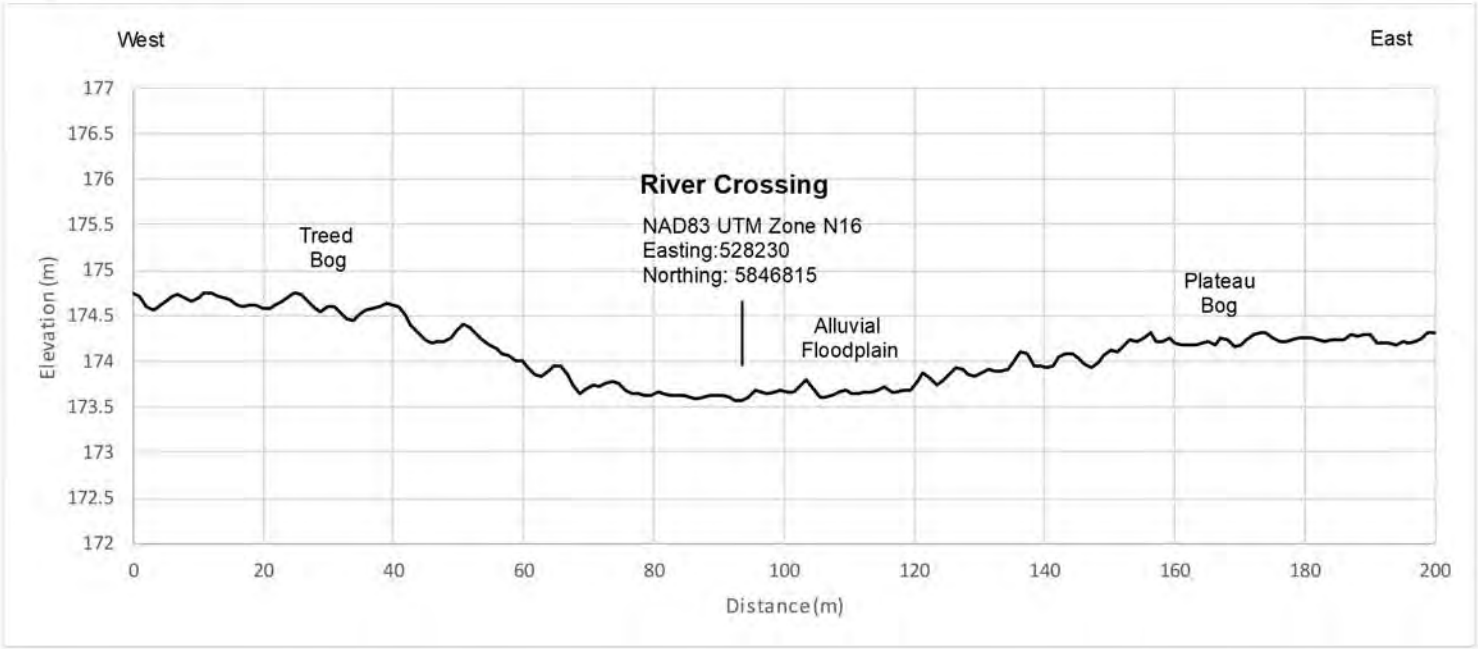
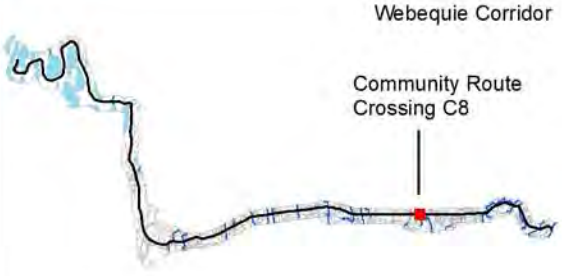




LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

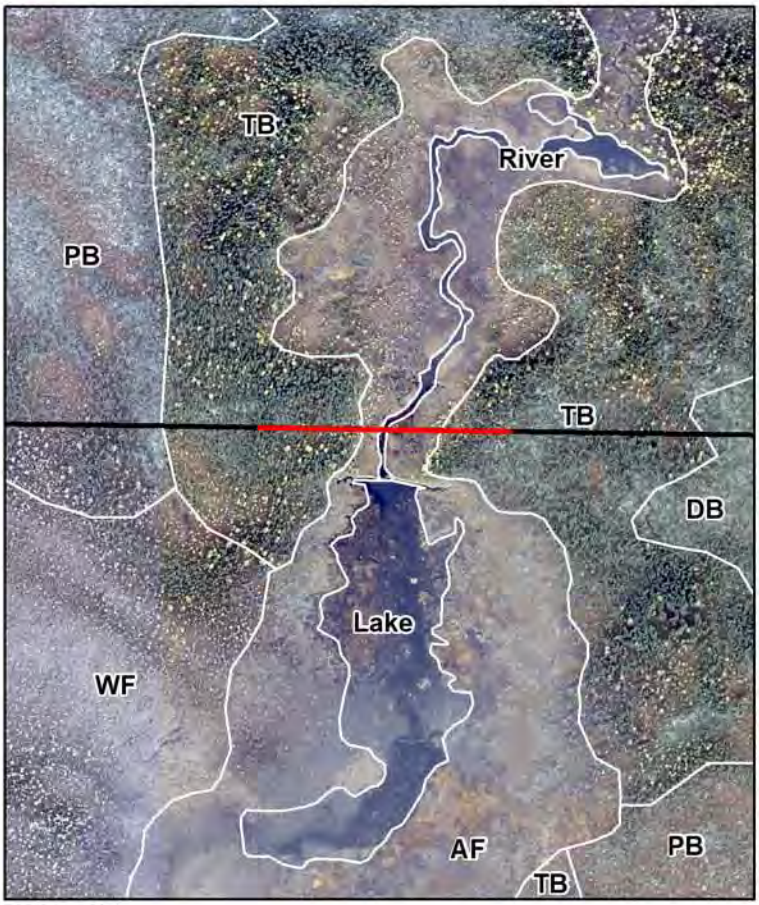
General reference map only; not for survey or legal use.

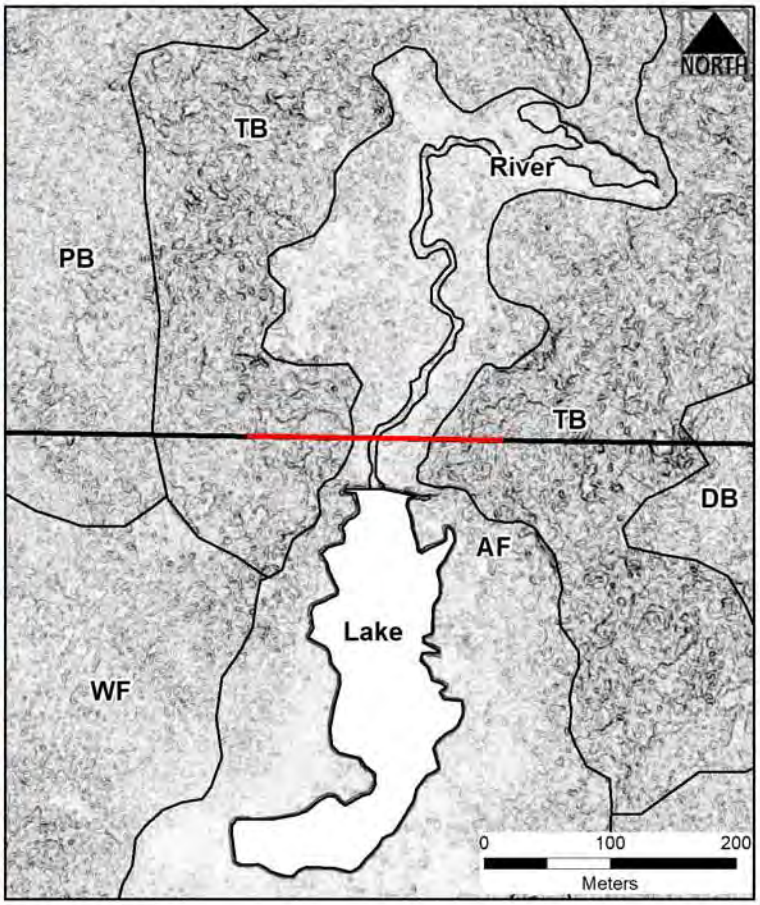
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

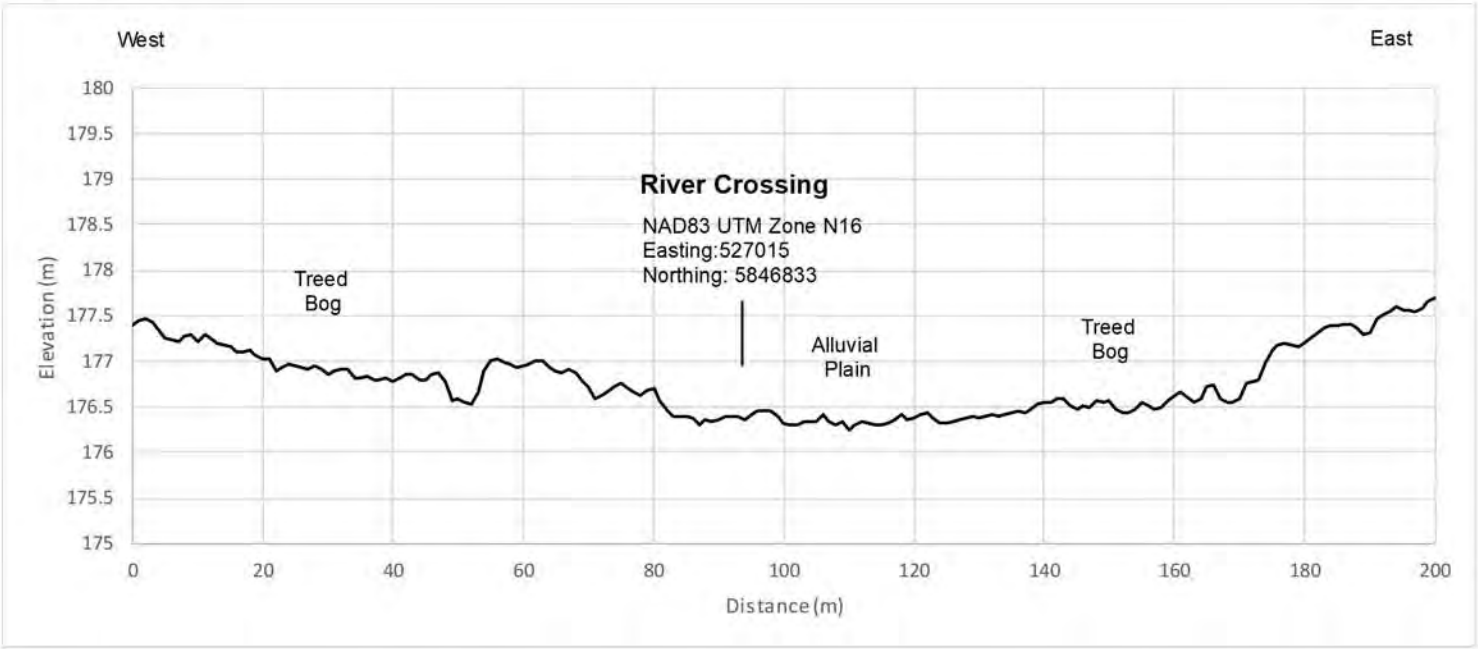
C8

J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)



LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

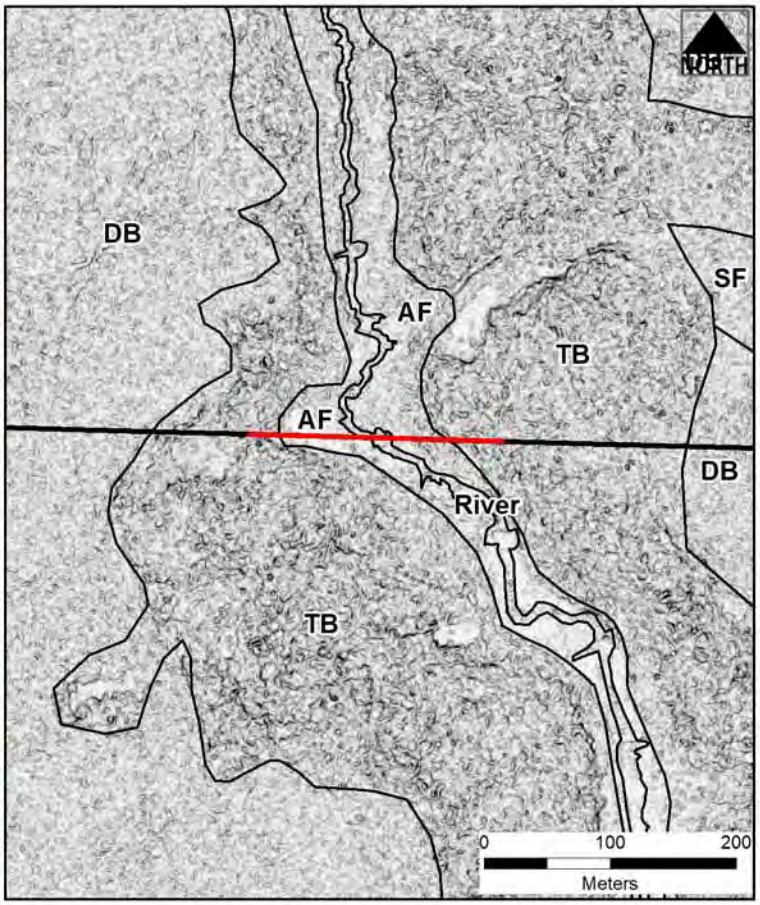
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

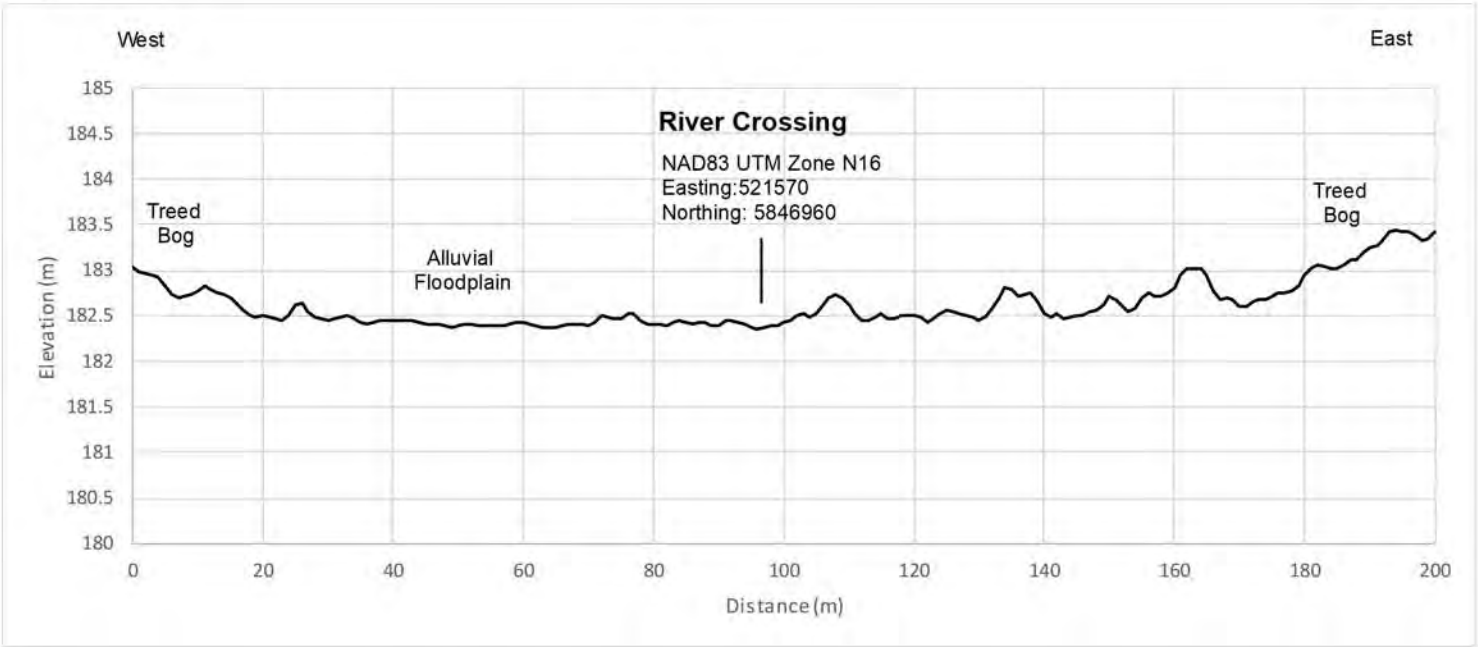
CROSSING:

C9

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)



LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

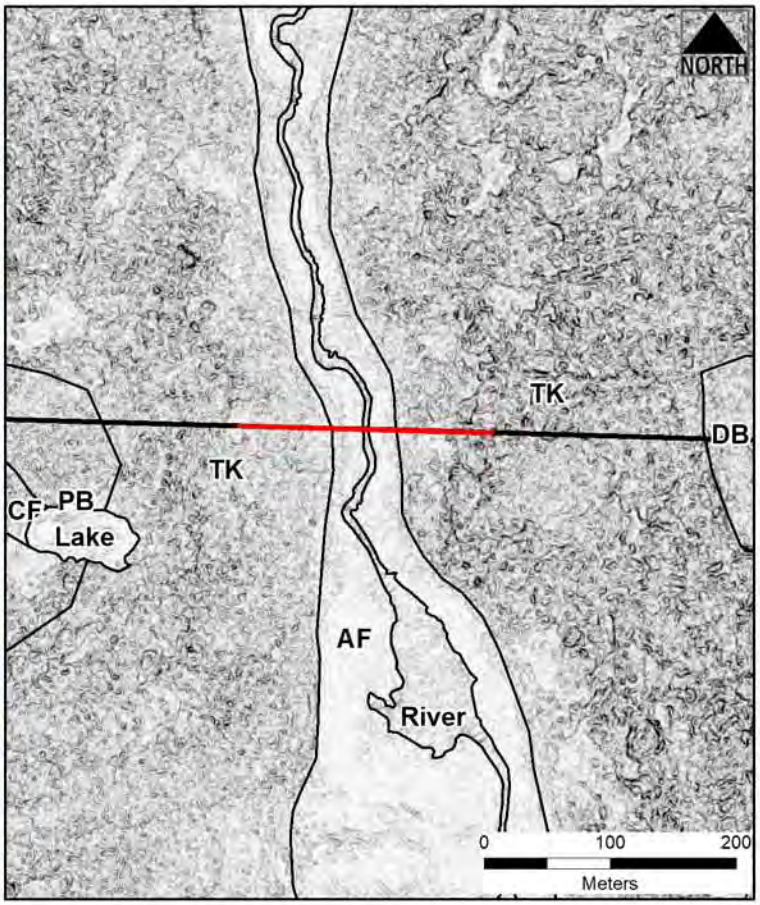
General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

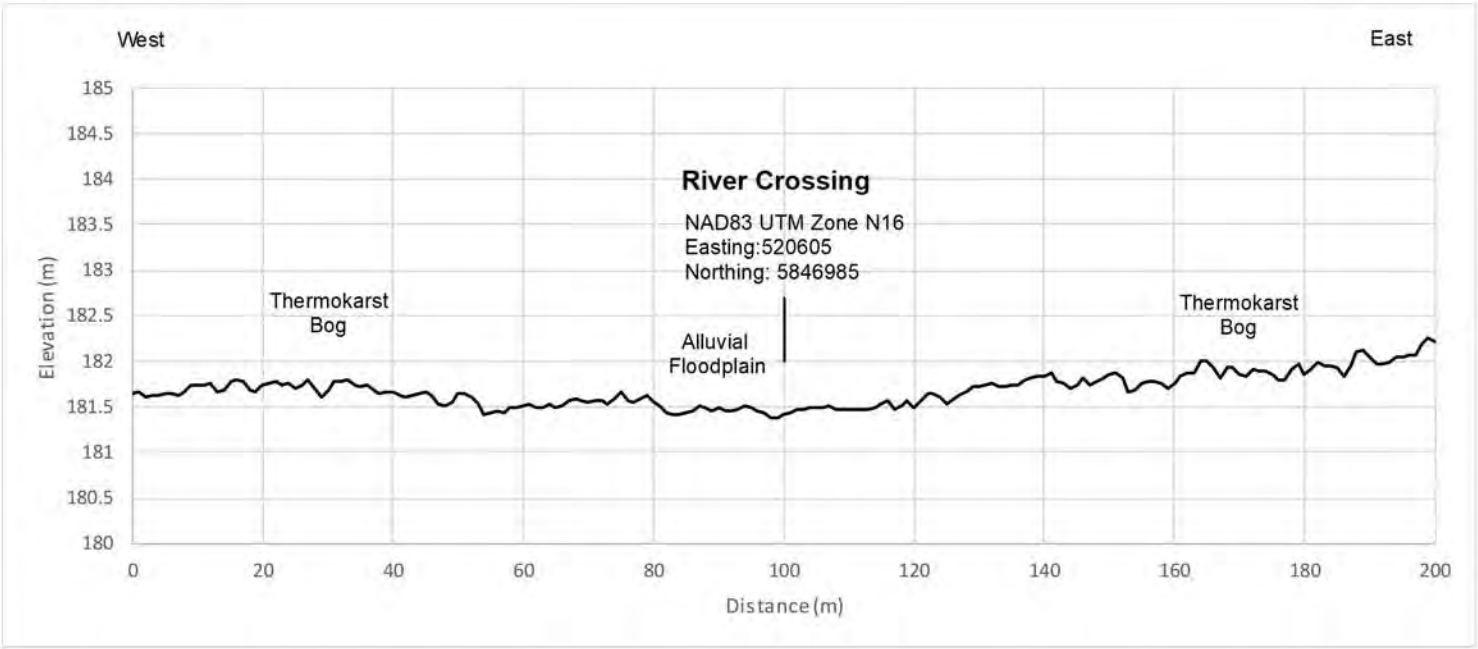
CROSSING:

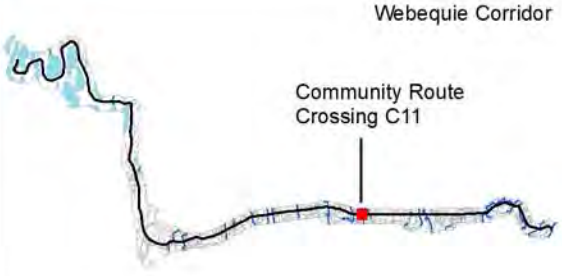
C10

J D MOLLARD AND ASSOCIATES (2010) LIMITED



Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

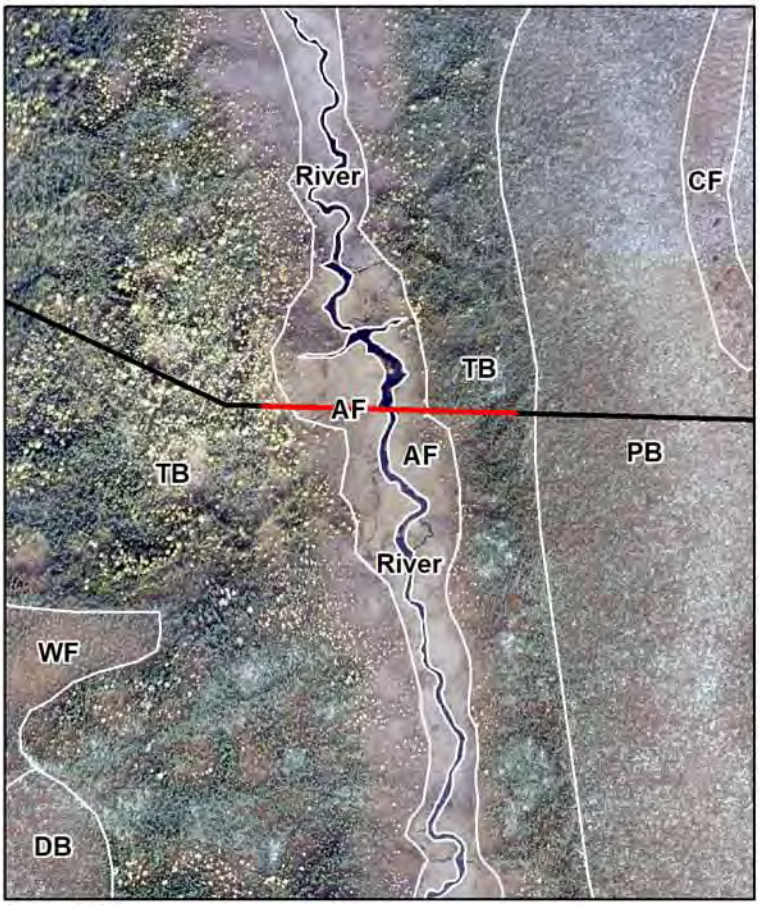
General reference map only; not for survey or legal use.

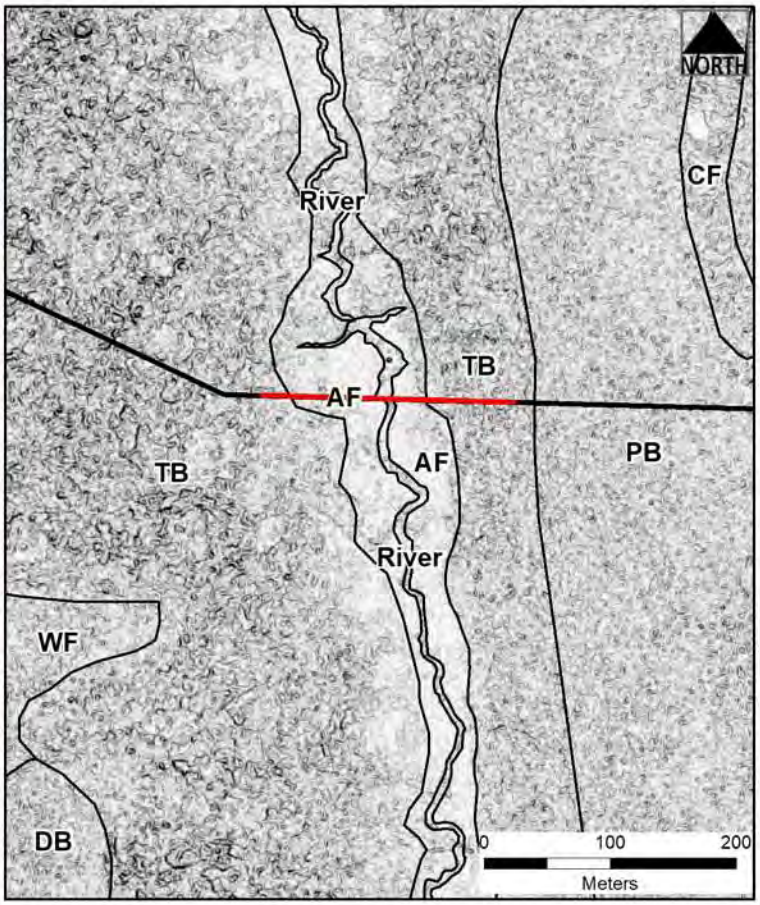
Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

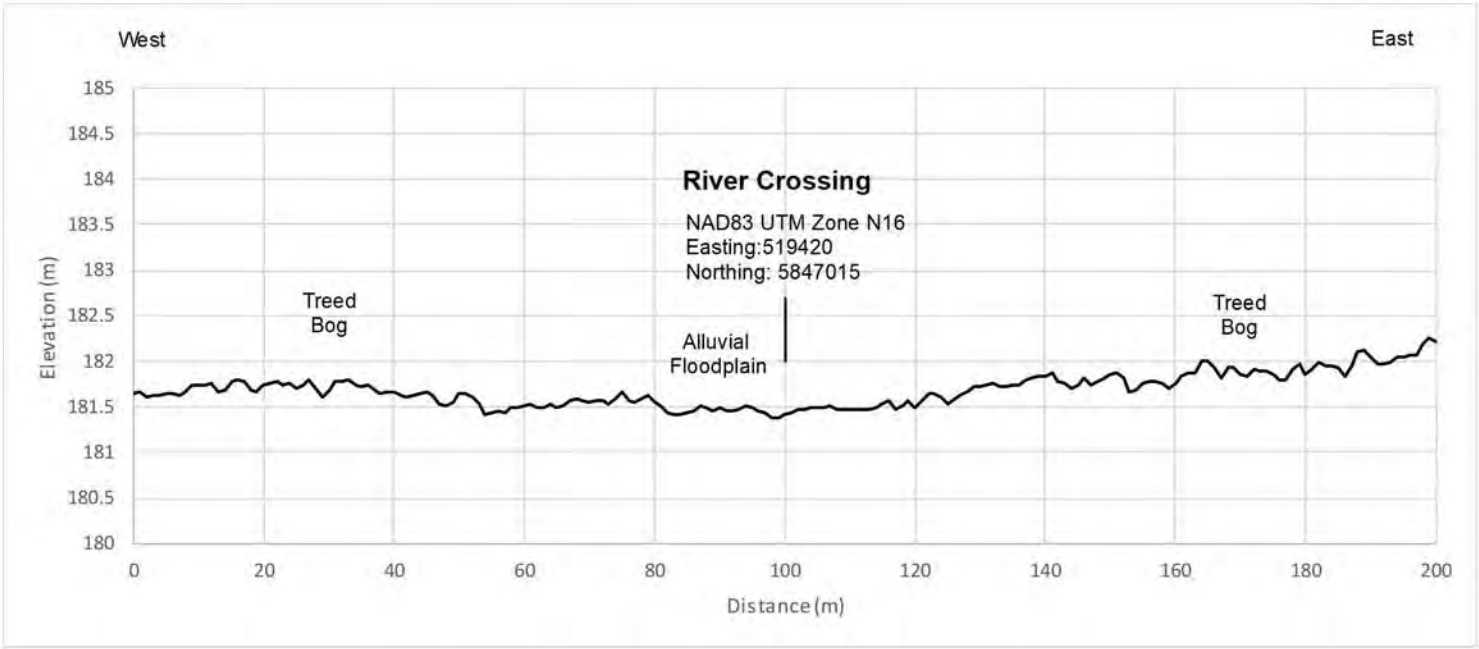
C11

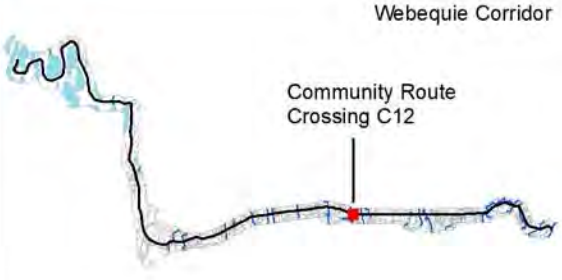
J D MOLLARD AND ASSOCIATES (2010) LIMITED





Chainages (Km)





LEGEND:

Community Route

Cross-Section

Slope (degrees)

High: 66.9

Low: 0

TITLE:

Community Route River Crossing

General reference map only; not for survey or legal use.

Map Sources:
Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

CROSSING:

C12

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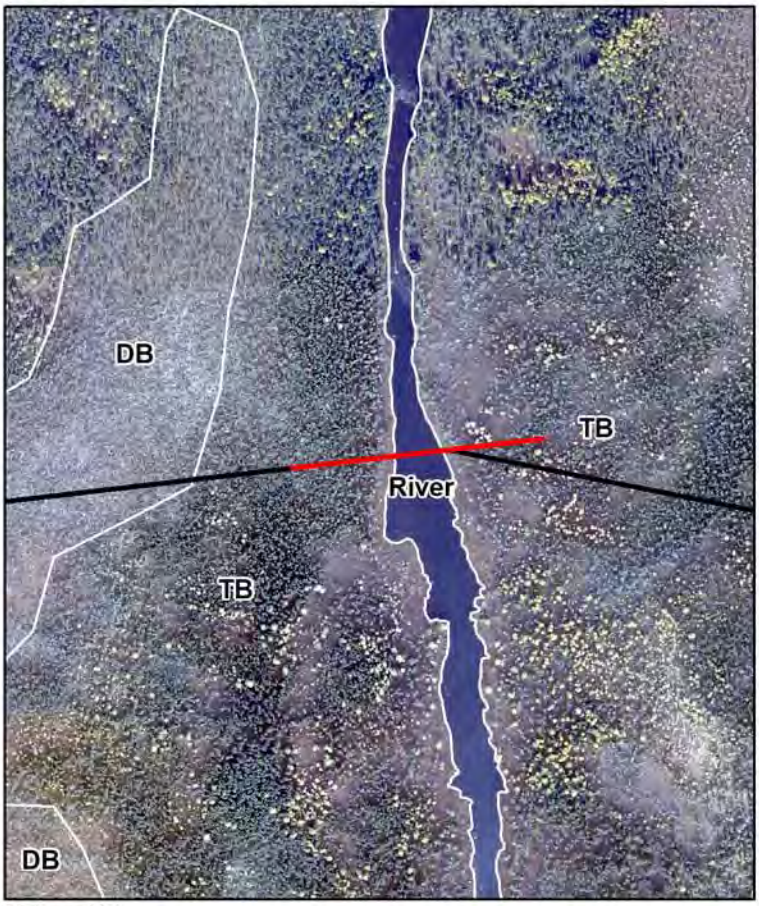

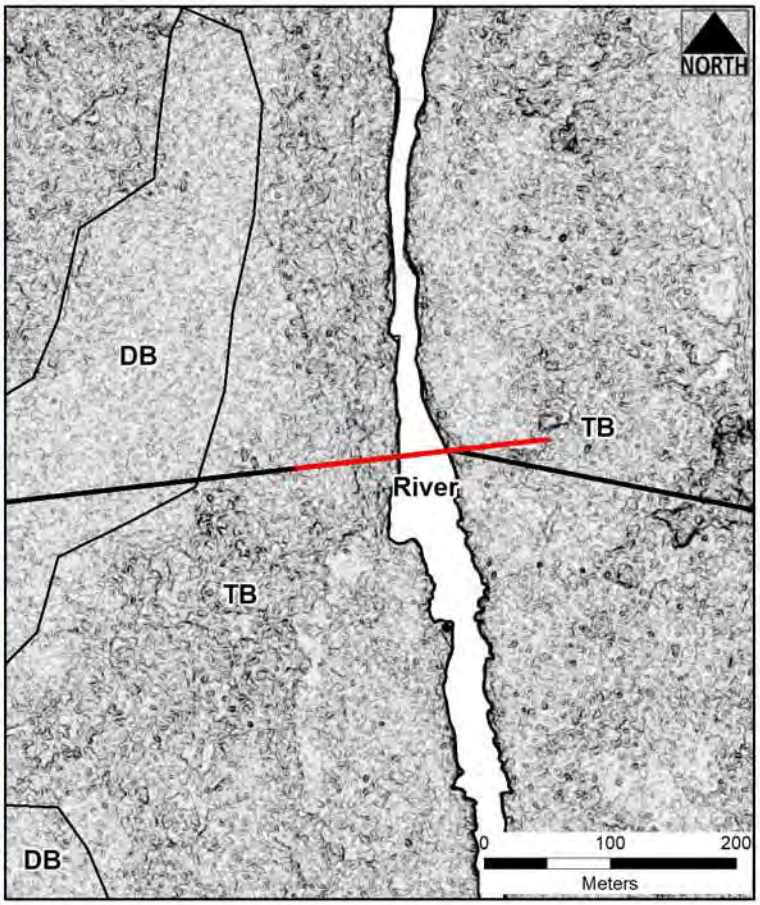

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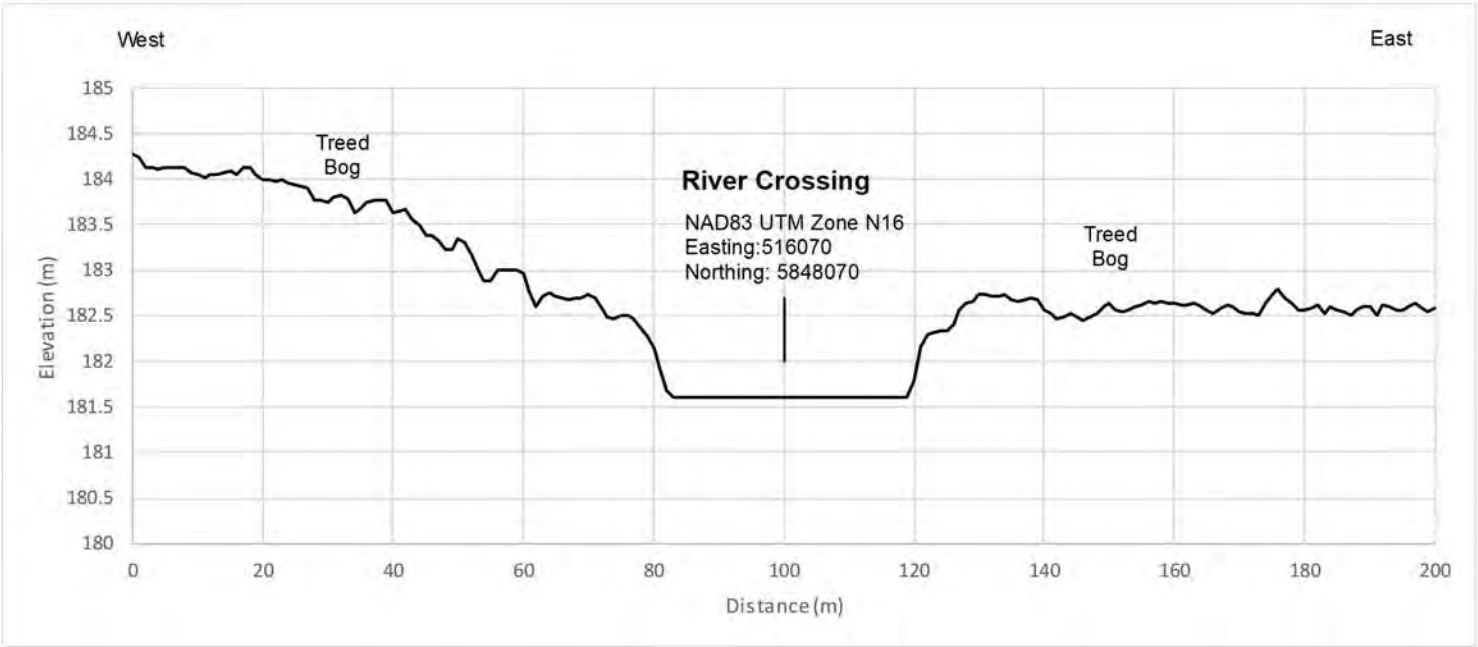

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Cross-Section

Slope (degrees)

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Low: 0

TITLE:

Community Route River Crossing

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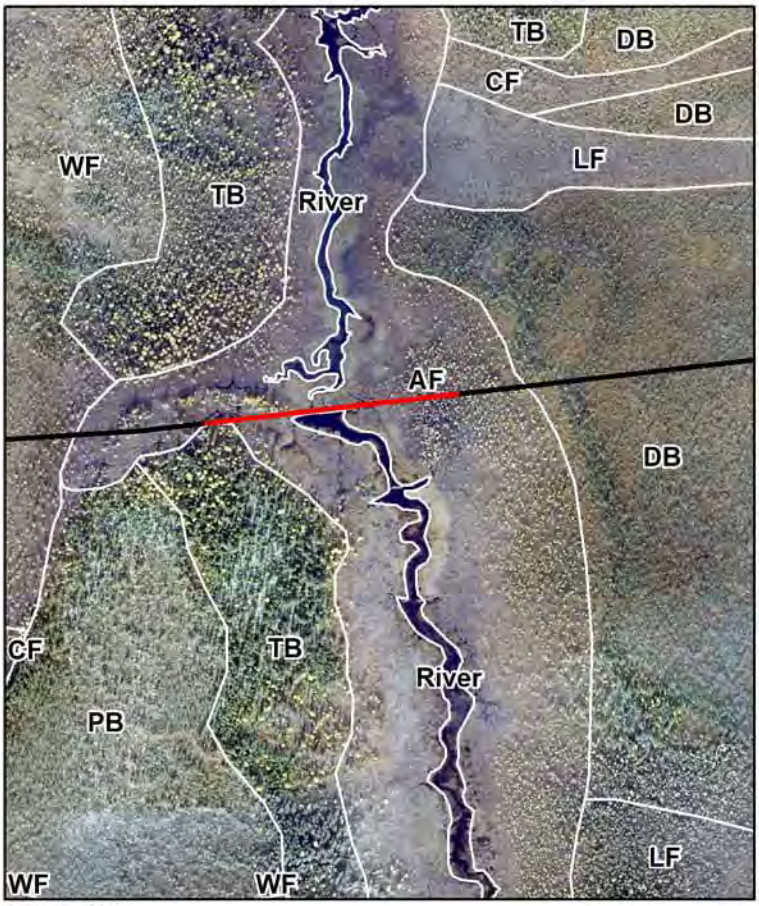

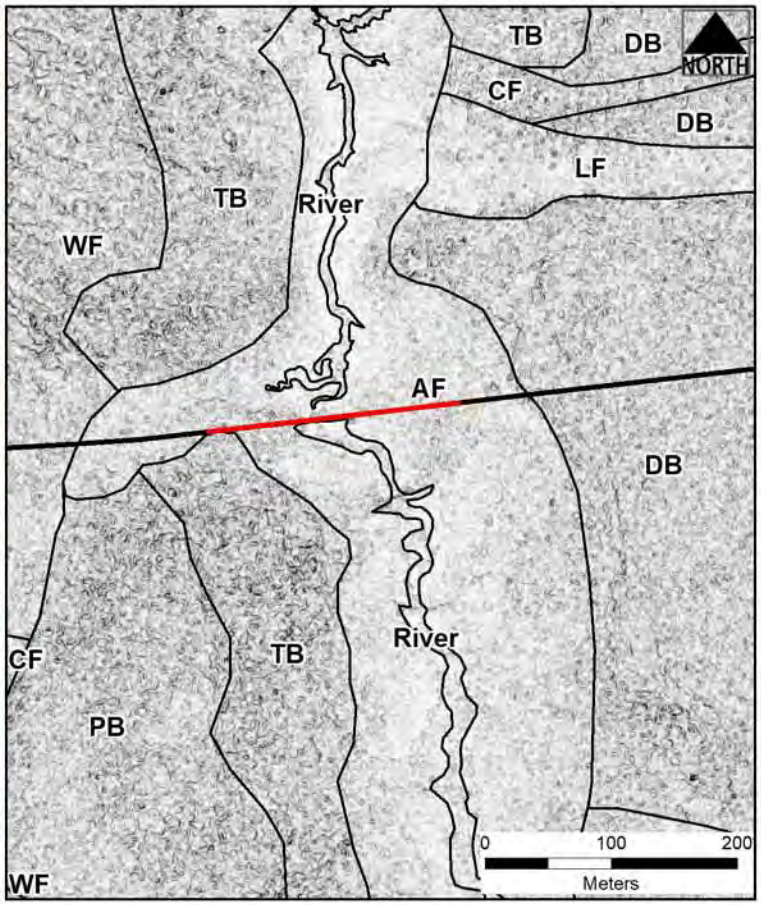

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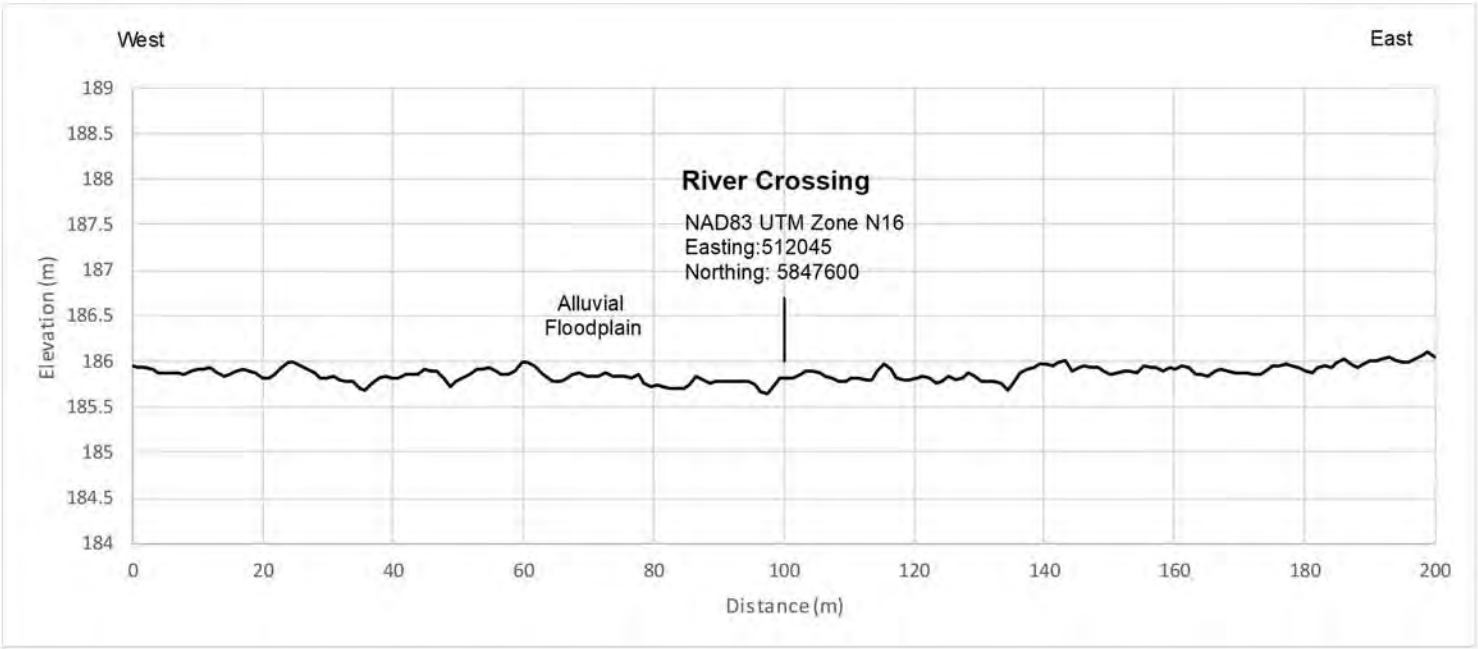

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Cross-Section

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Low: 0

TITLE:

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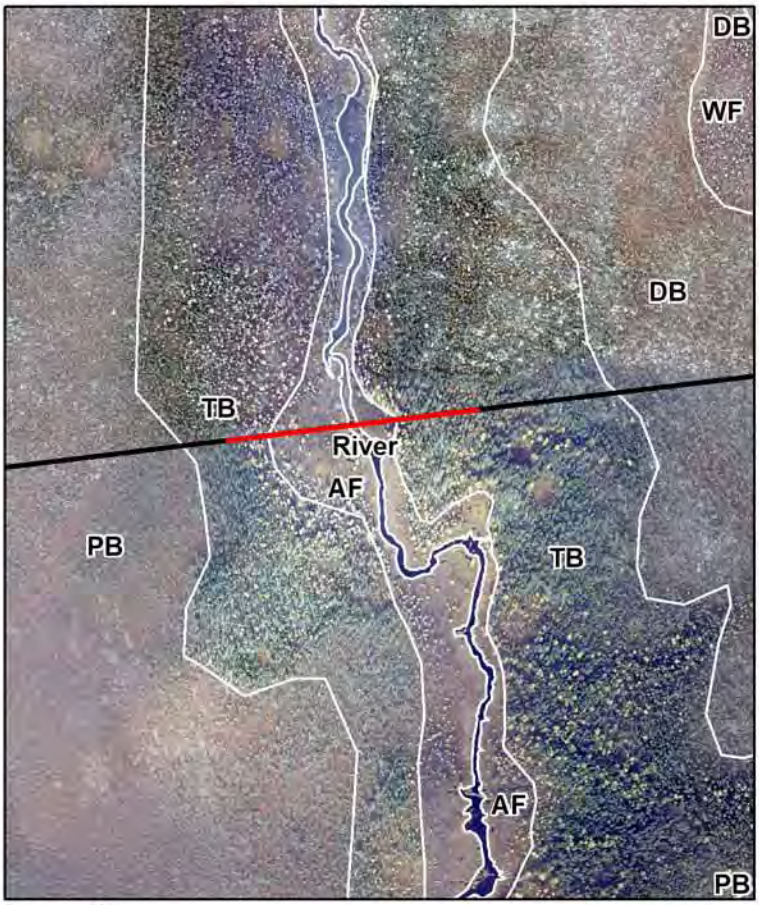

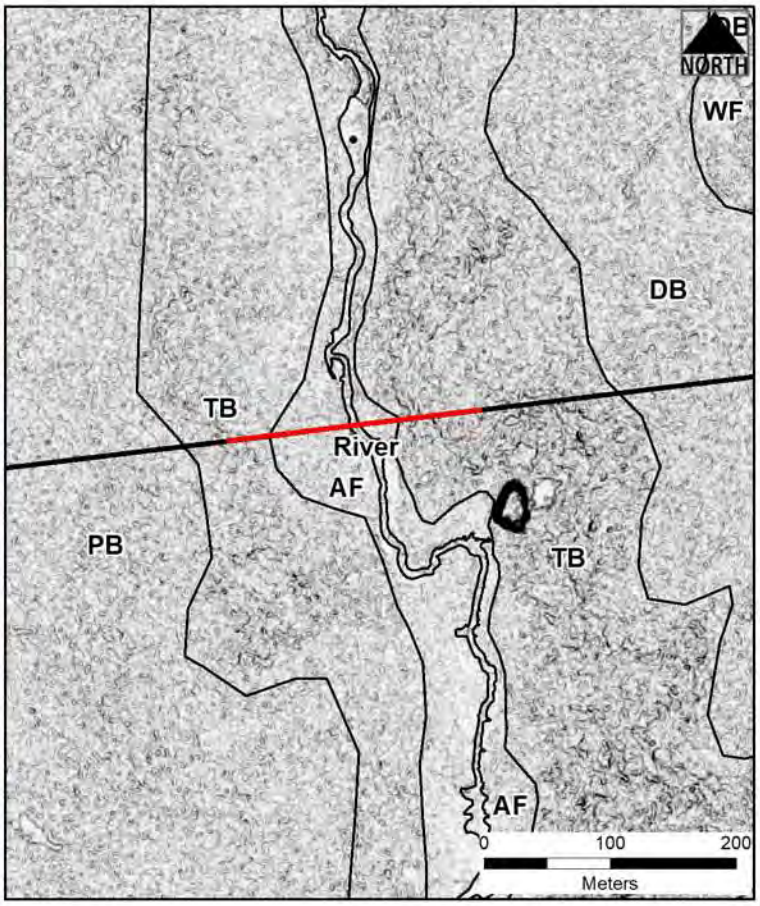

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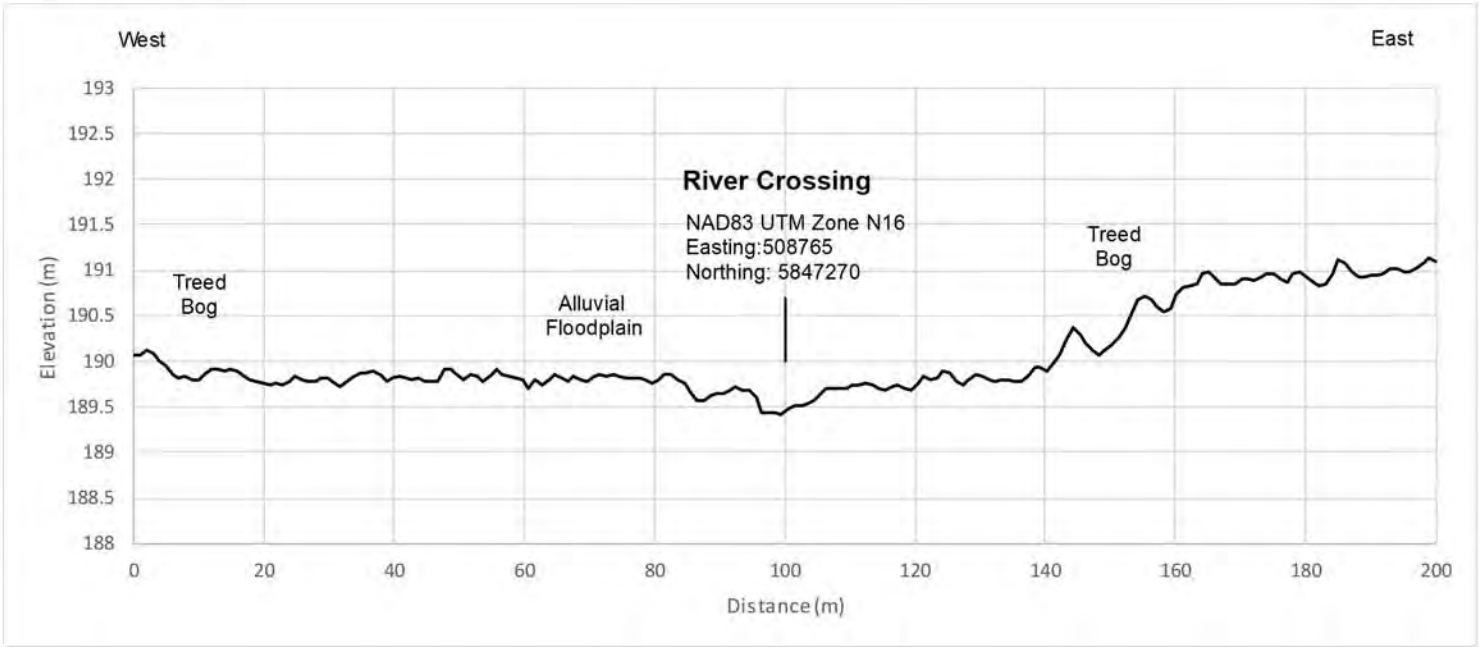

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Cross-Section

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TITLE:

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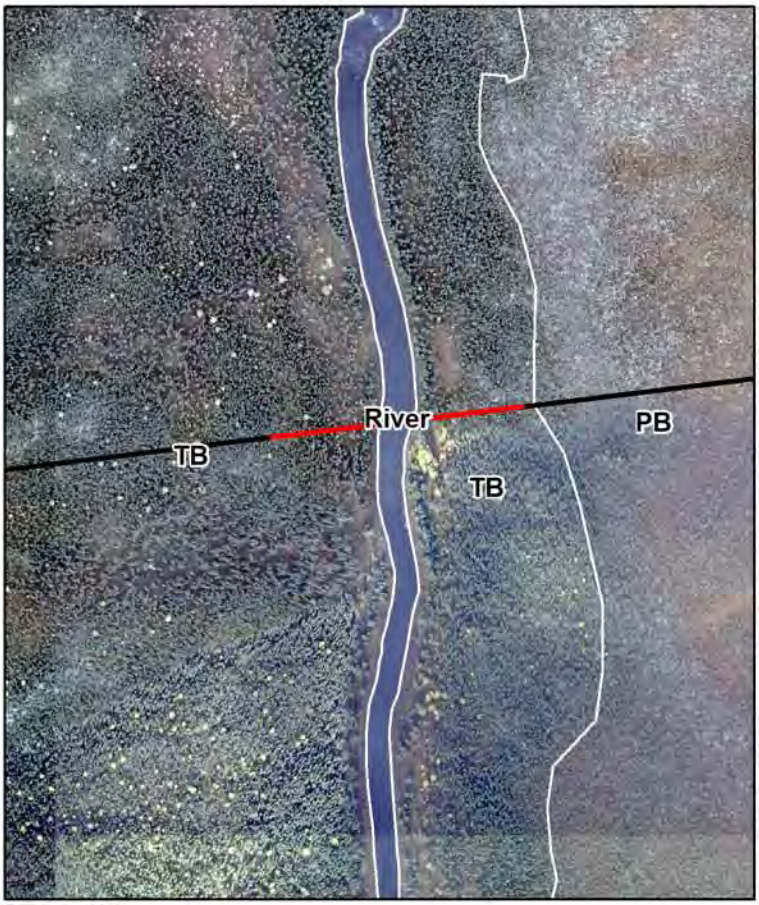

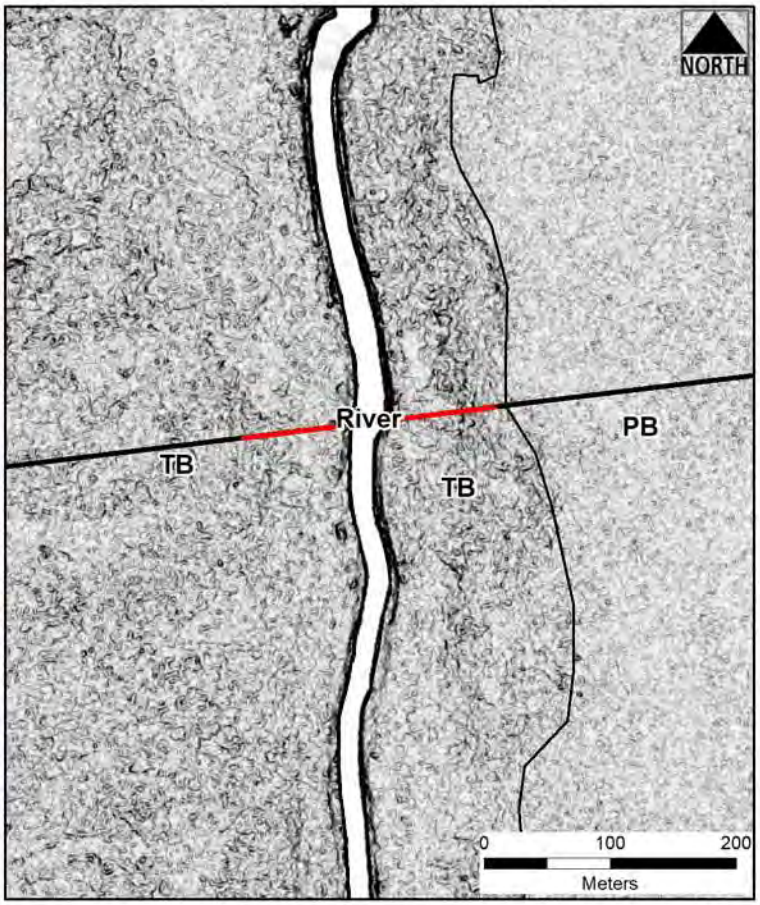

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Cross-Section

Slope (degrees)

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TITLE:

Community Route River Crossing

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Imagery: LiDAR slope raster
Geomatics: DSM *Revision date: 28/Mar/2019*

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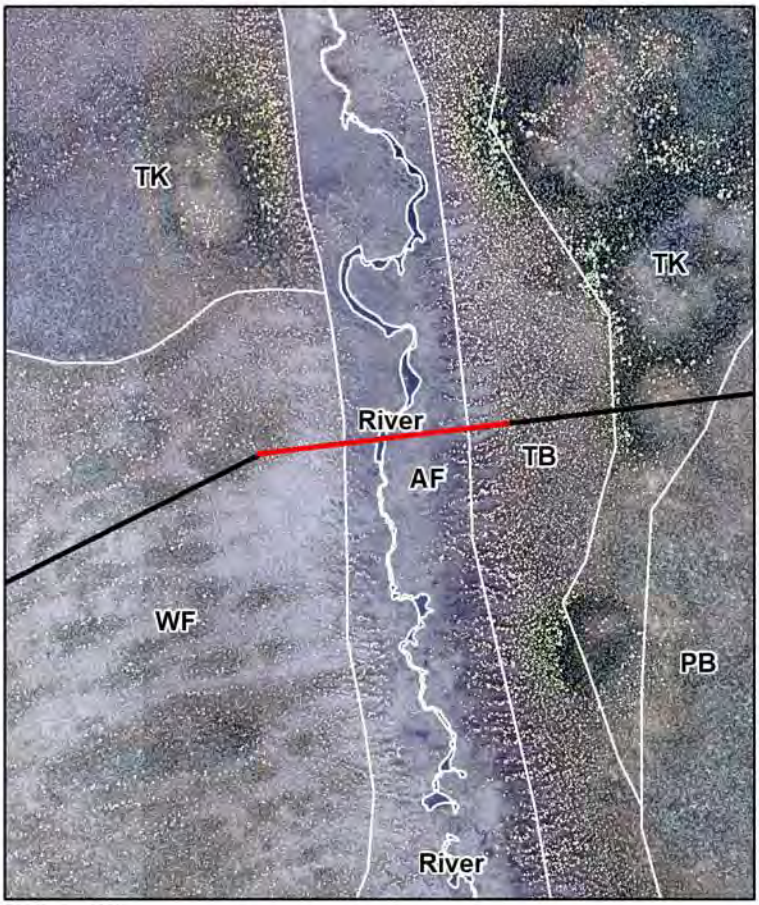

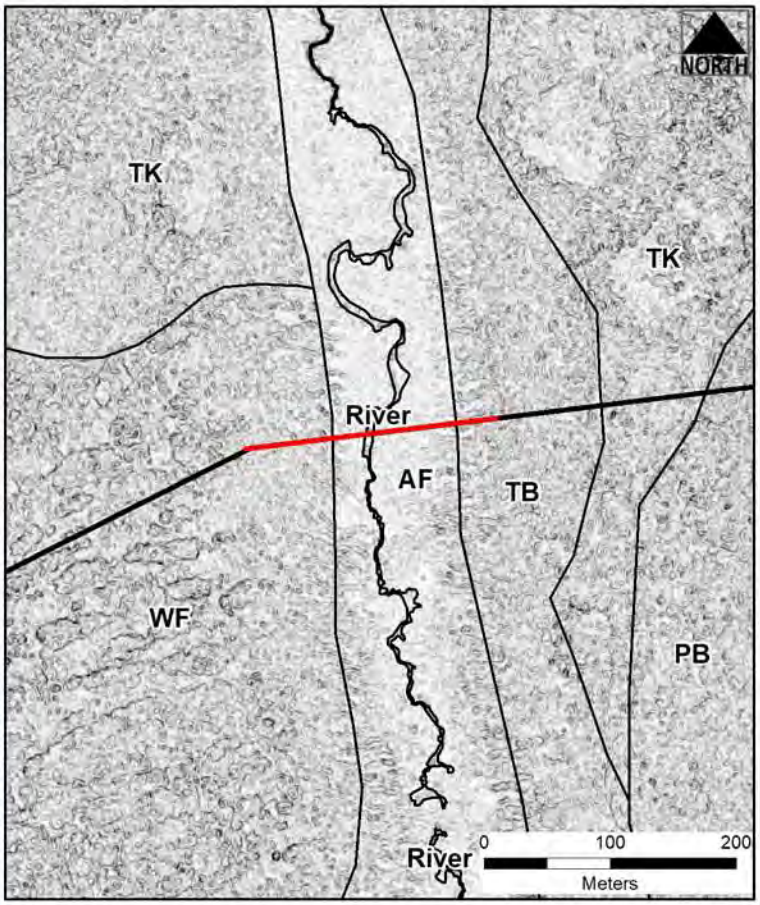

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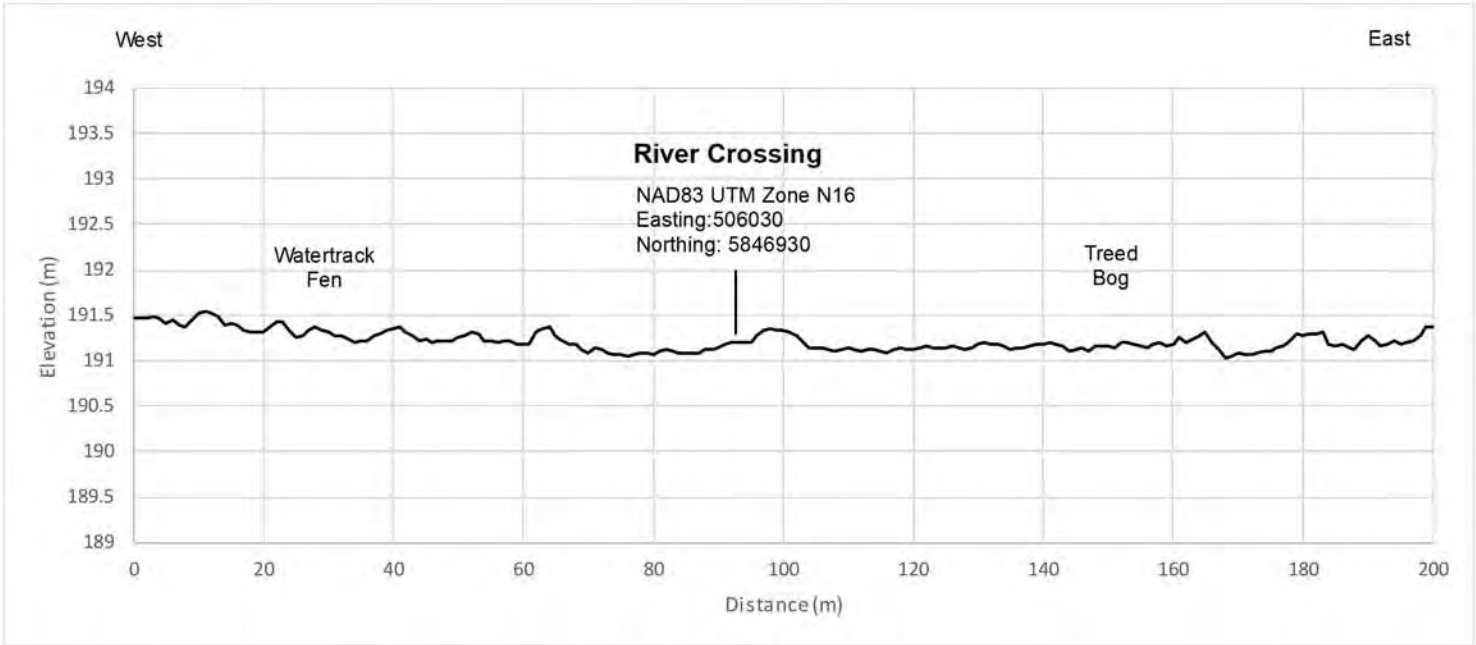

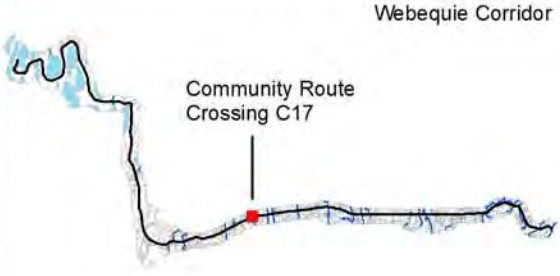

LEGEND:

Community Route

Cross-Section

Slope (degrees)

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Low: 0

TITLE:

Community Route River Crossing

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Geomatics: DSM *Revision date: 28/Mar/2019*

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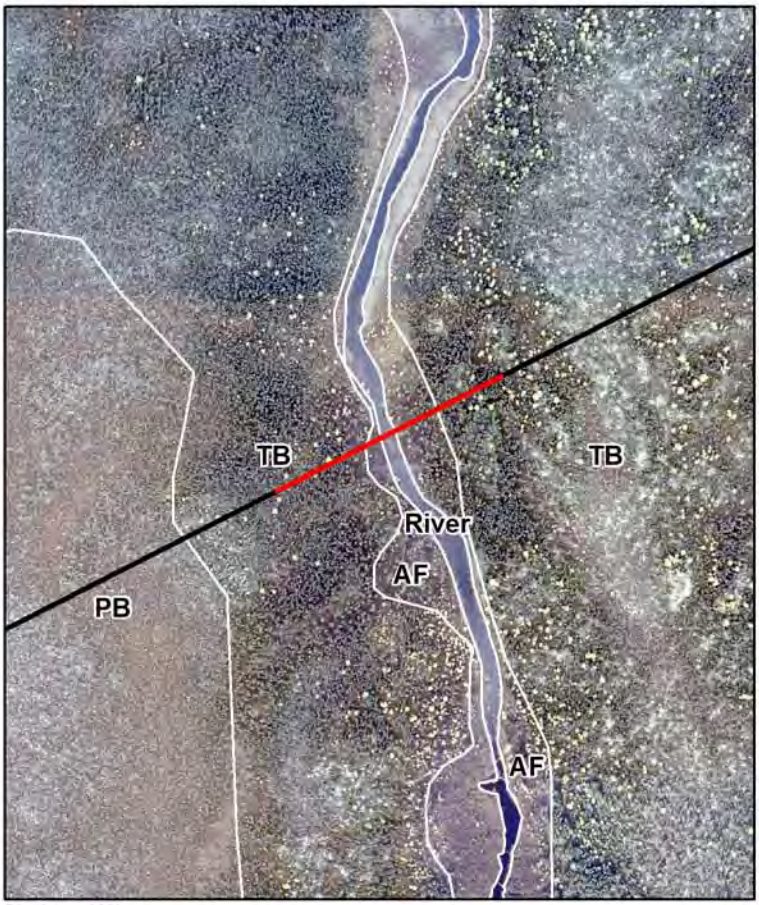

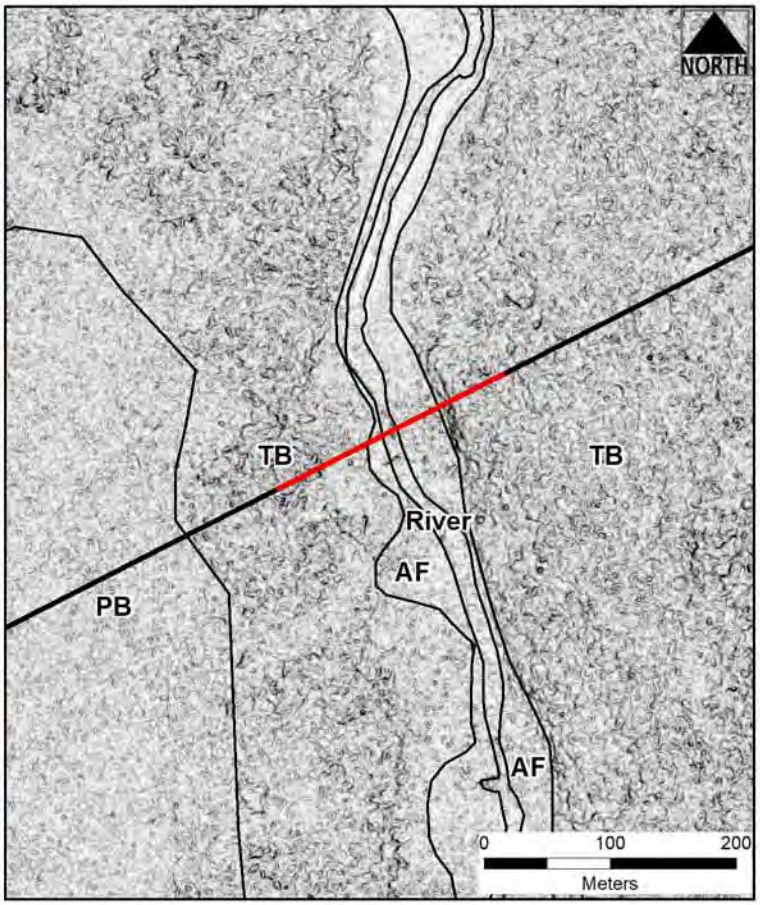

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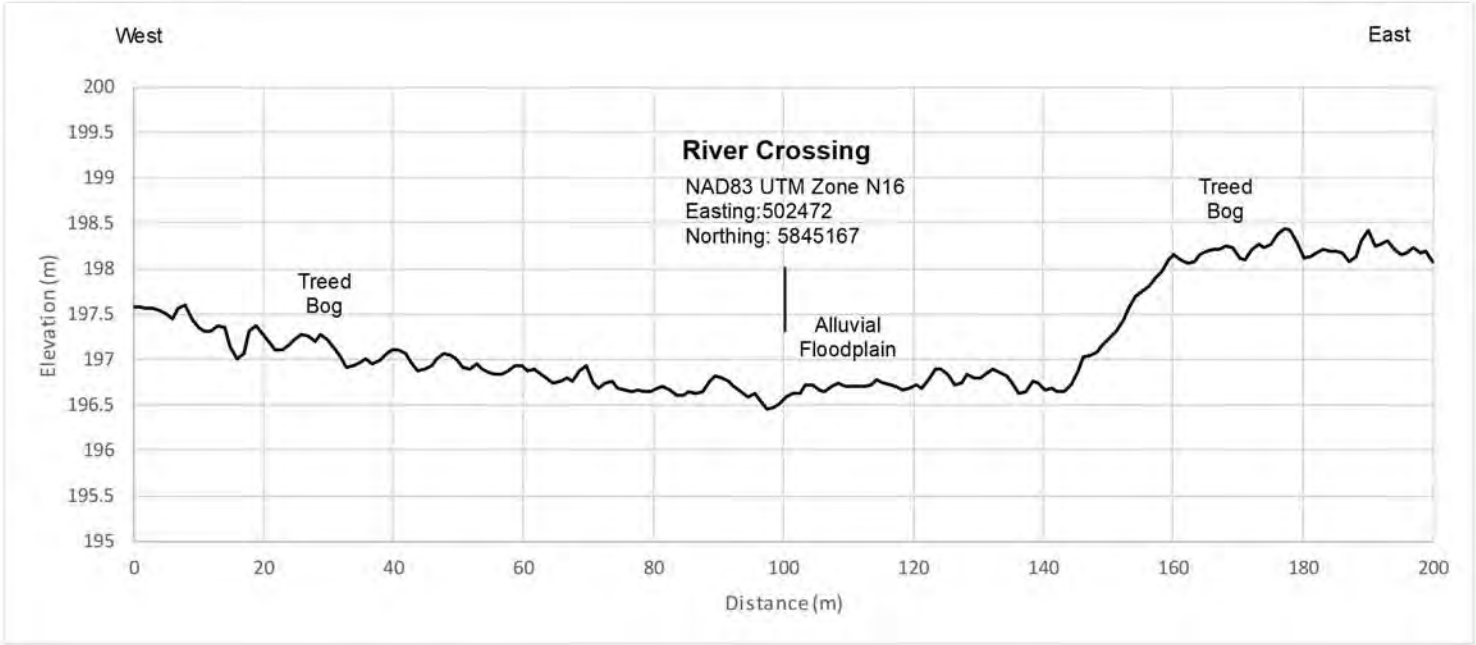

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Imagery: LiDAR slope raster
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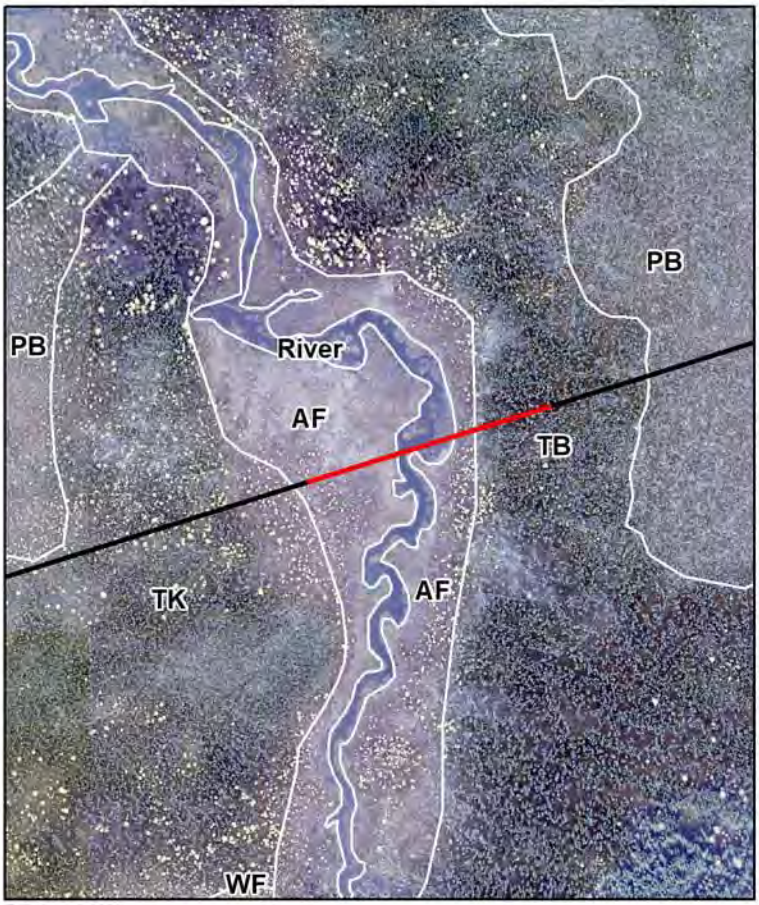

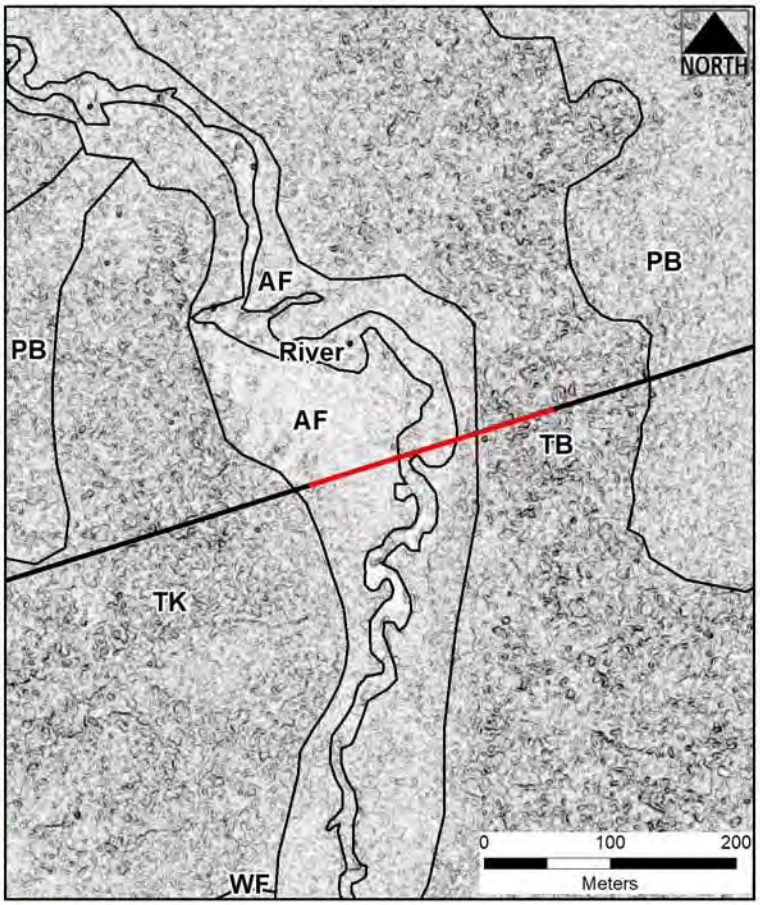

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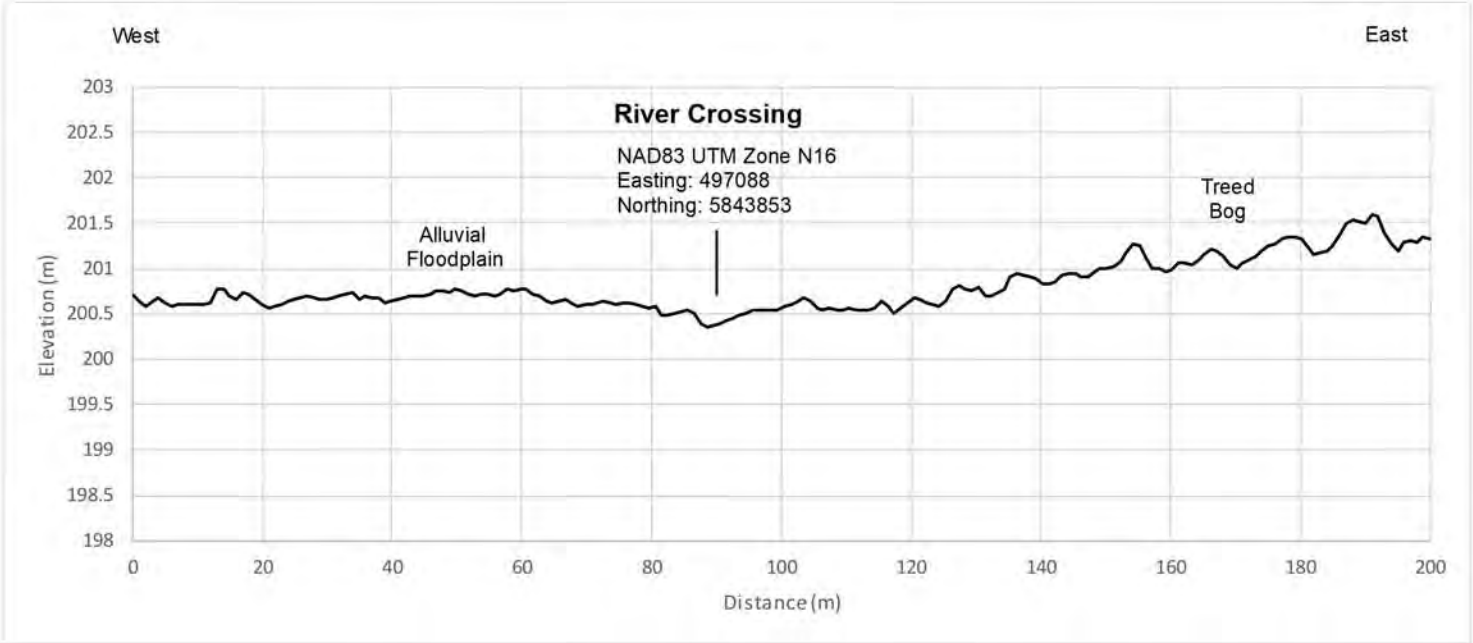

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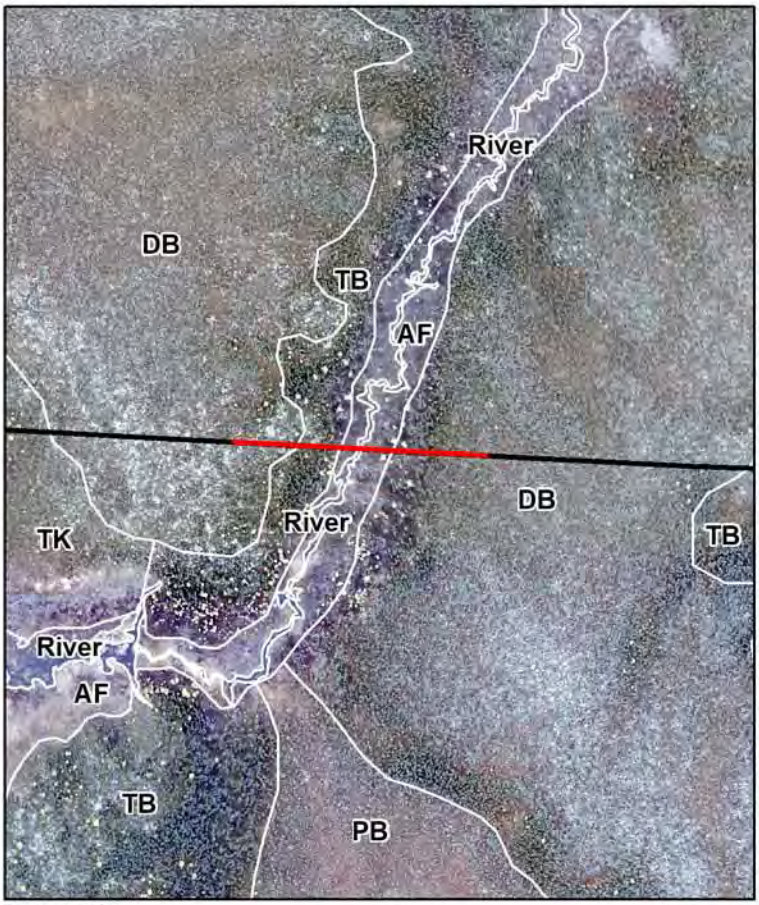

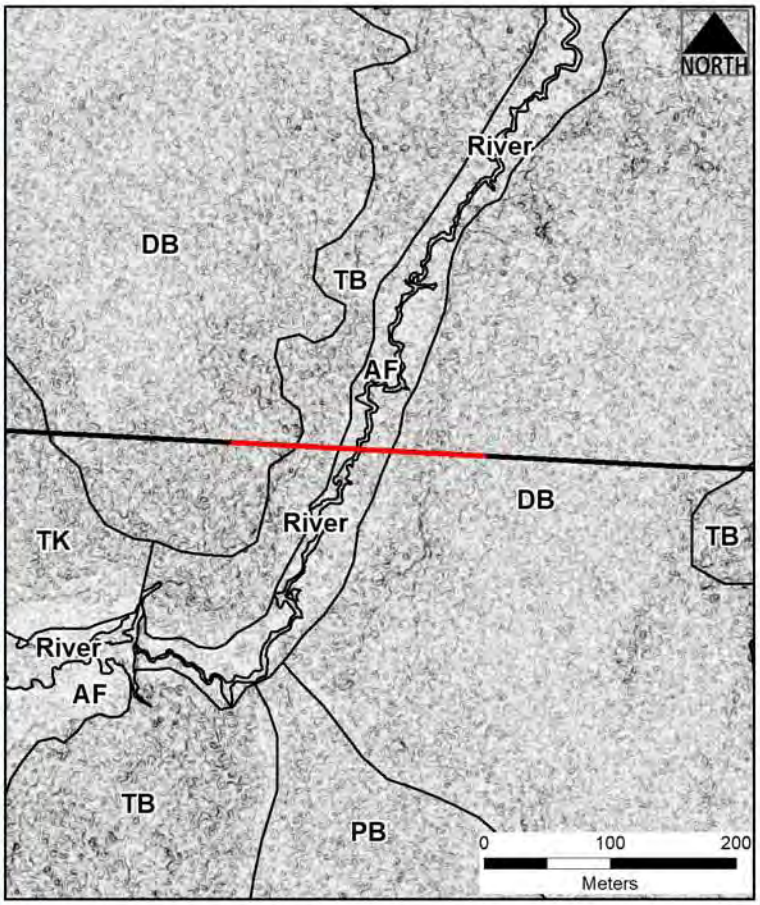

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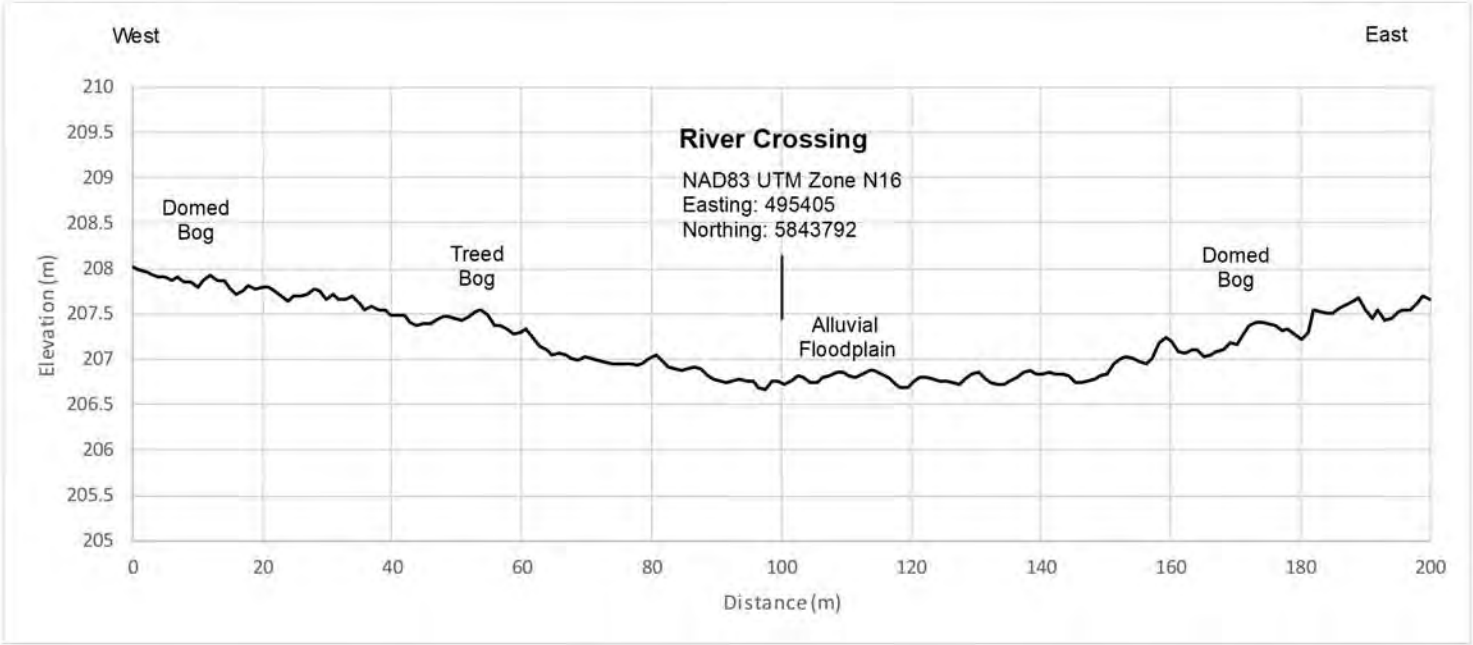

LEGEND:

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Cross-Section

Slope (degrees)

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Low: 0

TITLE:

Community Route River Crossing

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Map Sources:
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C20

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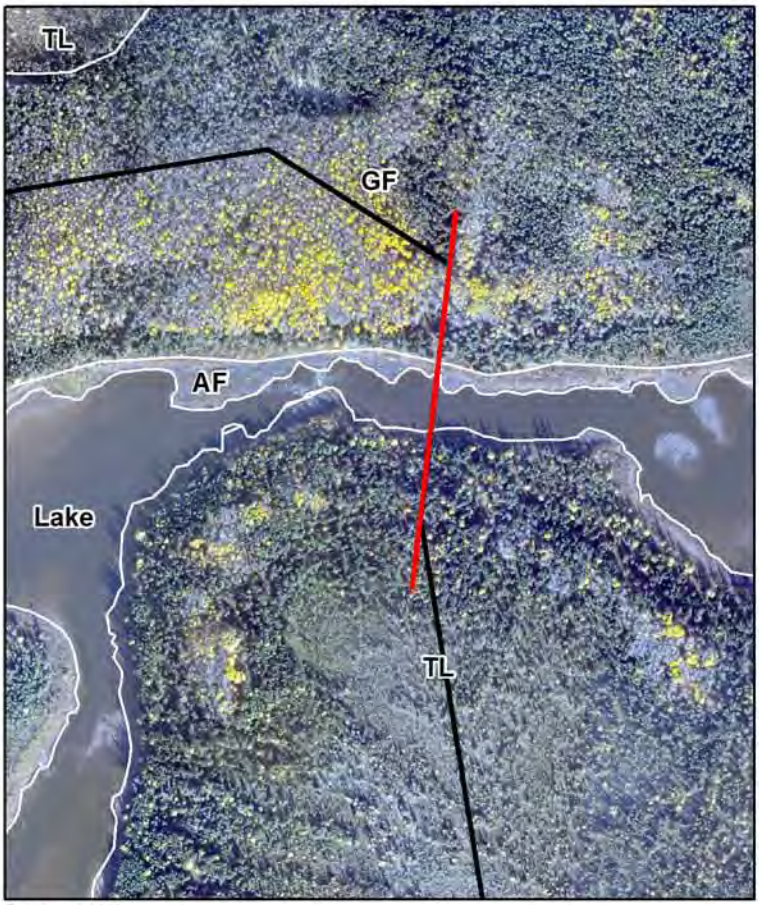

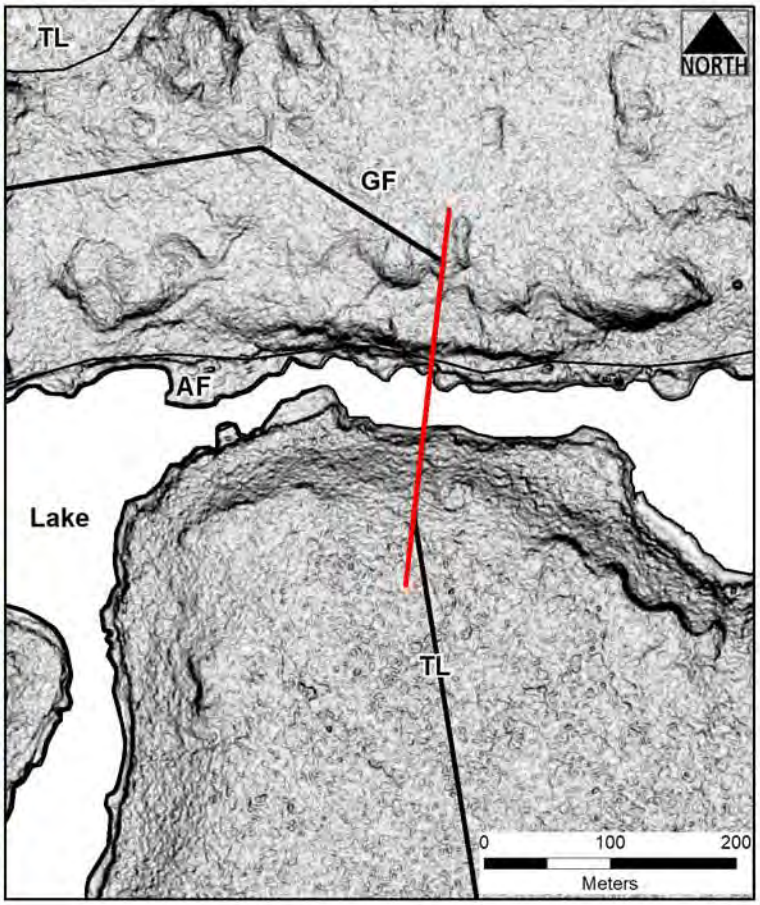

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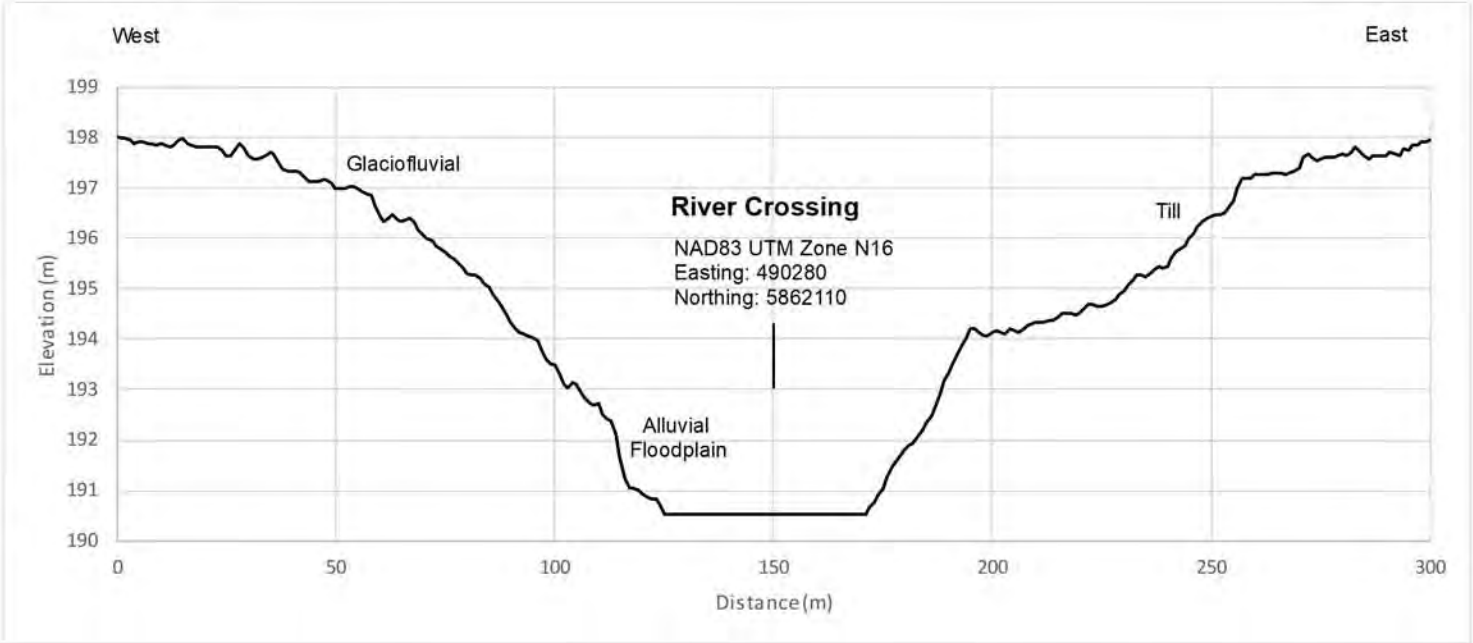

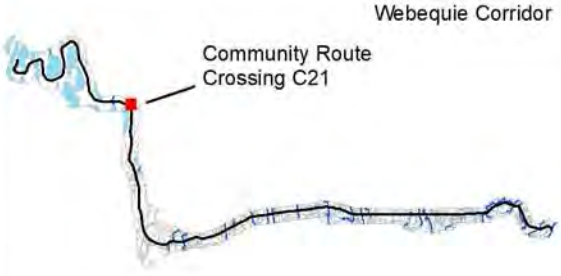

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Community Route River Crossing

General reference map only; not for survey or legal use.

Map Sources:
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Geomatics: DSM *Revision date: 28/Mar/2019*

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C21

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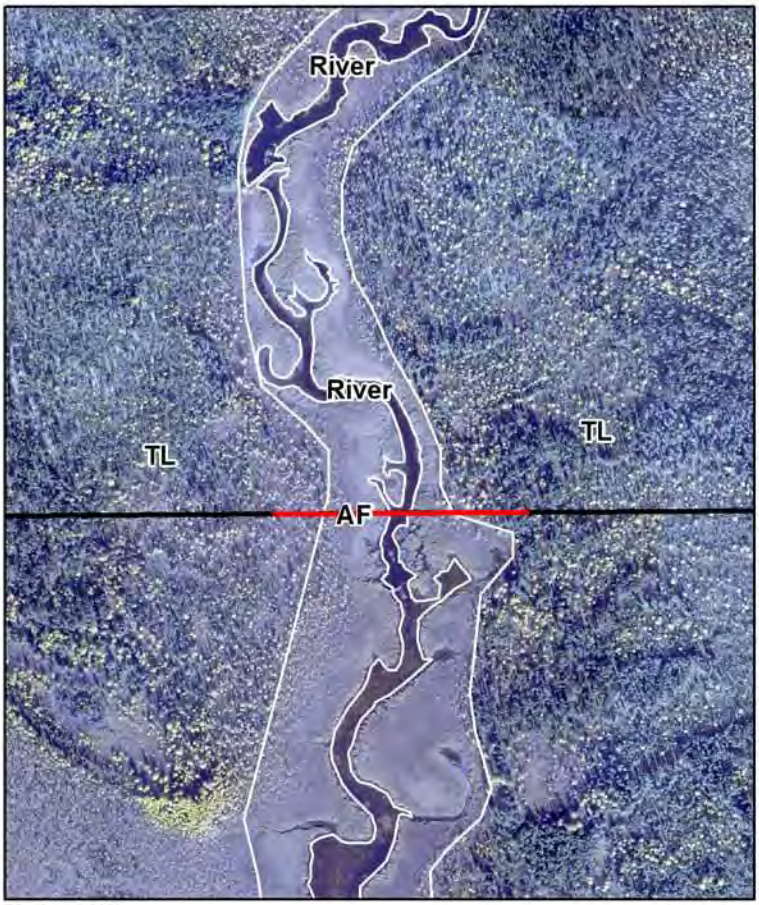

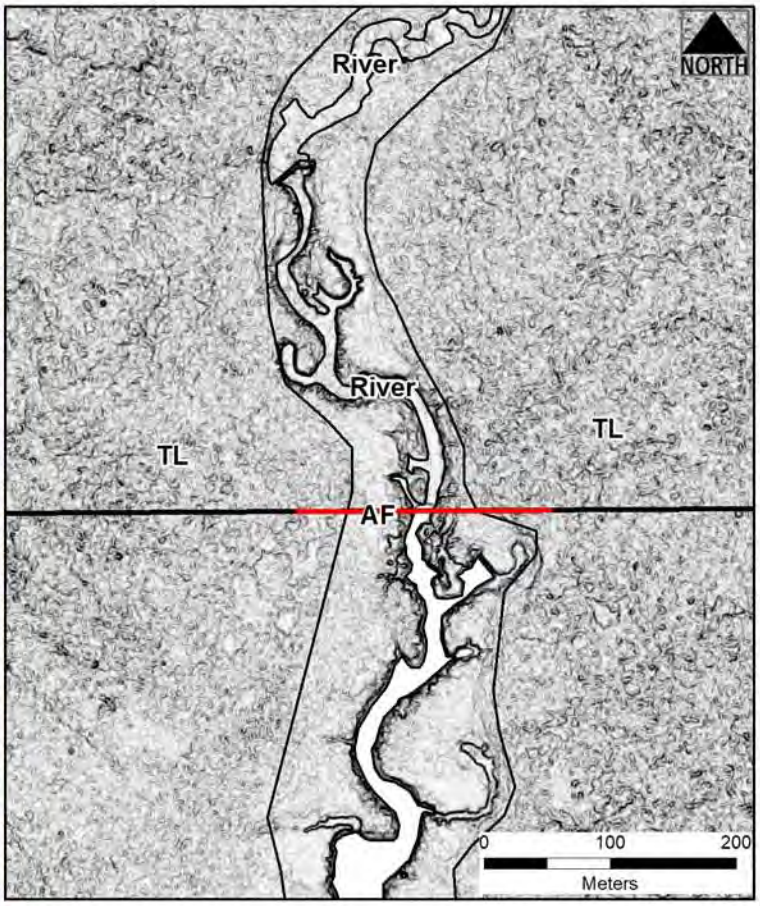

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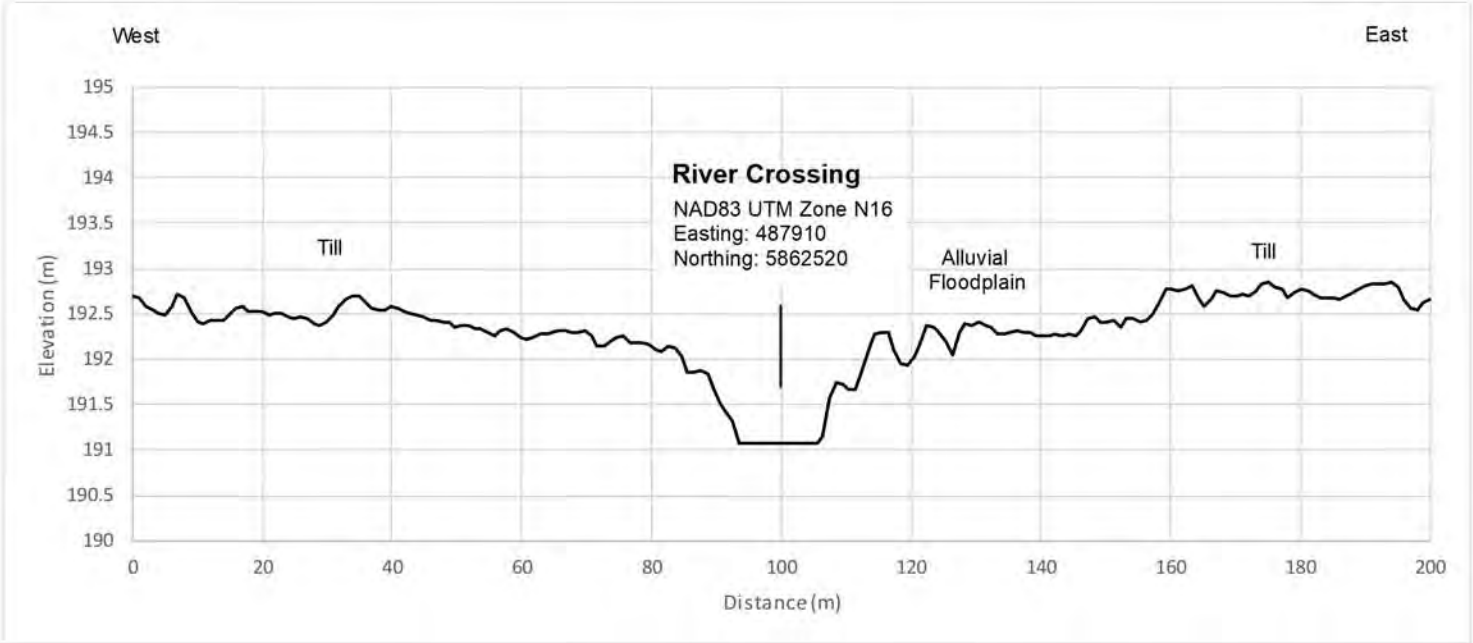

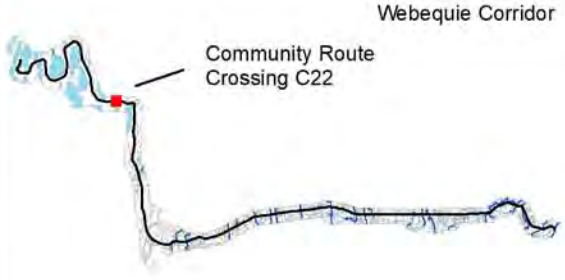

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Slope (degrees)

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Low: 0

TITLE:

Community Route River Crossing

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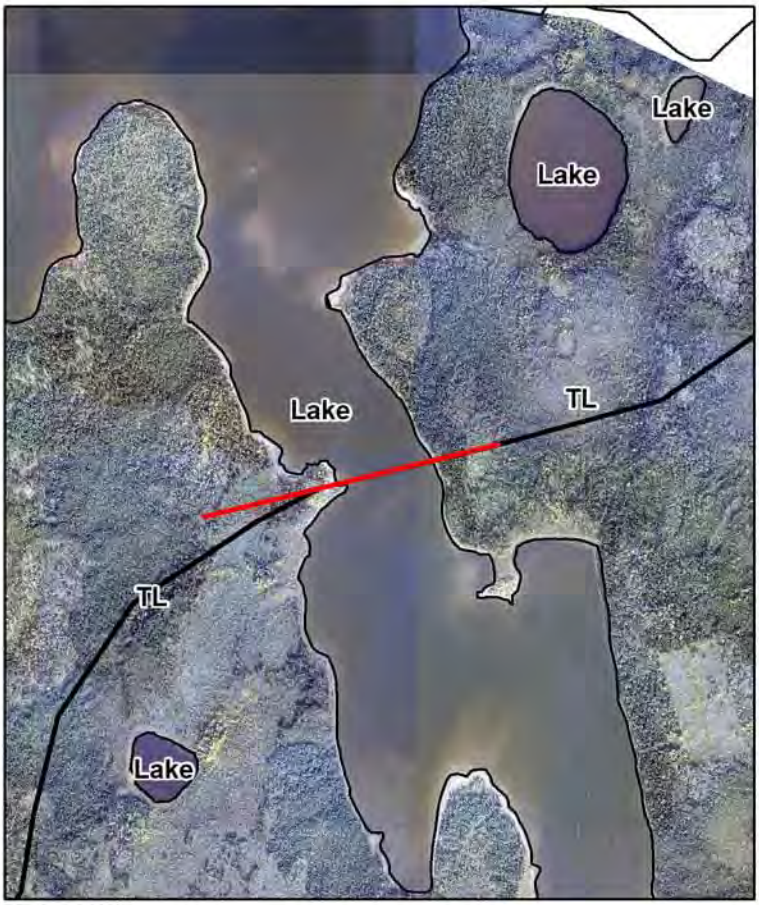

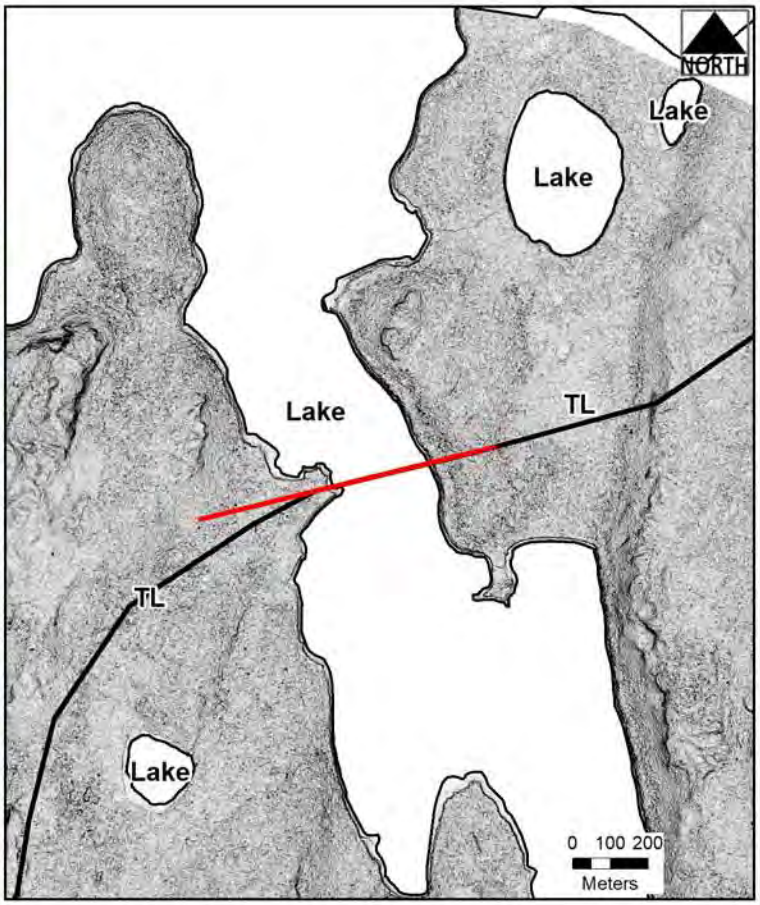

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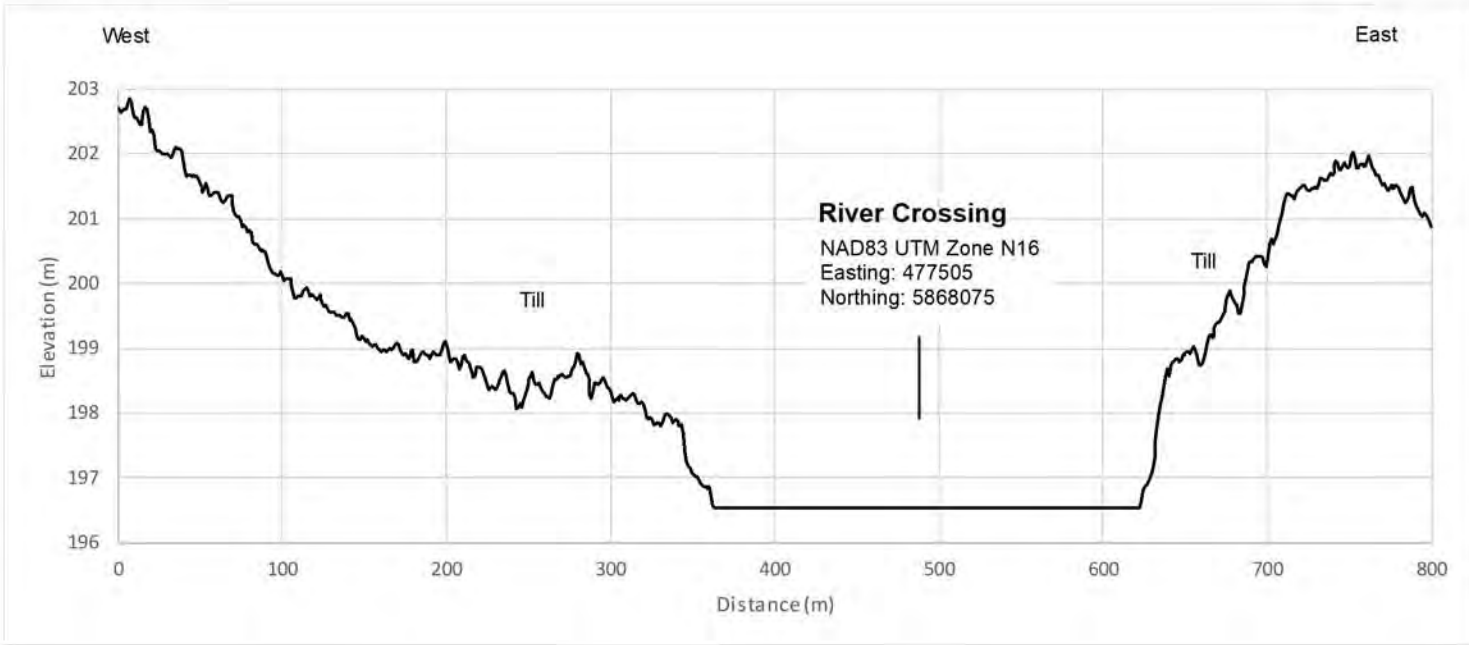

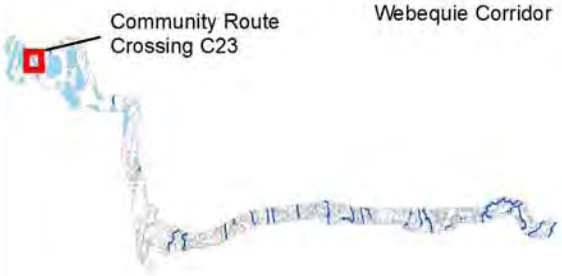

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Community Preferred

Cross-Section

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Low: 0

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CROSSING:

C23

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WEBEQUIE SUPPLY ROAD: FIELD INVESTIGATION OF PEAT THICKNESS AND POTENTIAL AGGREGATE SOURCES

DRAFT REPORT

November 8, 2019

Prepared for:

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M9C 5K1

Prepared by:

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J D MOLLARD
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1 INTRODUCTION

The Webequie First Nation Supply Road Project connects the community of Webequie, located approximately 500 km north of Thunder Bay, with an all-season road to the proposed Ring of Fire mining development around Esker Camp (Figure 1). The road corridor crosses an area of extensive wetlands and organic soils that pose challenges to engineering design and construction. As part of the Environmental Assessment and Preliminary Engineering Services for Webequie First Nation's Supply Road Project, JDMA (2019) conducted terrain mapping within a 2-km-wide route corridor to facilitate selection of an optimal route by evaluating terrain conditions, characterizing stream crossings, and identifying potential aggregate sources.

Based on the initial terrain analysis, JDMA proposed field work with the specific objectives to confirm peat thickness of organic terrains and to evaluate potential aggregate sources.

Organic terrain units (bogs and fens) were mapped over significant portions of the corridor with peat depths estimated to vary from 0.5-5.0 m based on published wetland classifications and previous field work using ground penetrating radar and soil probes at similar sites located outside of the corridor to the south. Given the importance of understanding the organic terrain units for engineering design, JDMA (2019) recommended to confirm peat thickness at several sites, over bogs and fens, using a peat probe to push through the organics and into the underlying mineral soil.

Potential aggregate sources were identified from existing surficial geology maps provided by the Ontario Geological Survey and from terrain analysis using orthoimagery and lidar of the route corridor. Among the potential aggregate sources are granular ice-contact glaciofluvial deposits and bedrock outcrops that may be blasted and crushed. JDMA (2019) recommended digging test pits in the granular deposits to determine the gradation of material and to visit the bedrock outcrops to determine the lithology and structure of the bedrock to assess the potential for crushing.

In September 2019, based on these recommendations, JDMA conducted field studies to measure peat thickness in select organic terrain units and to field test aggregate prospects to assess their potential as material sources. This study provides the results of this field work.

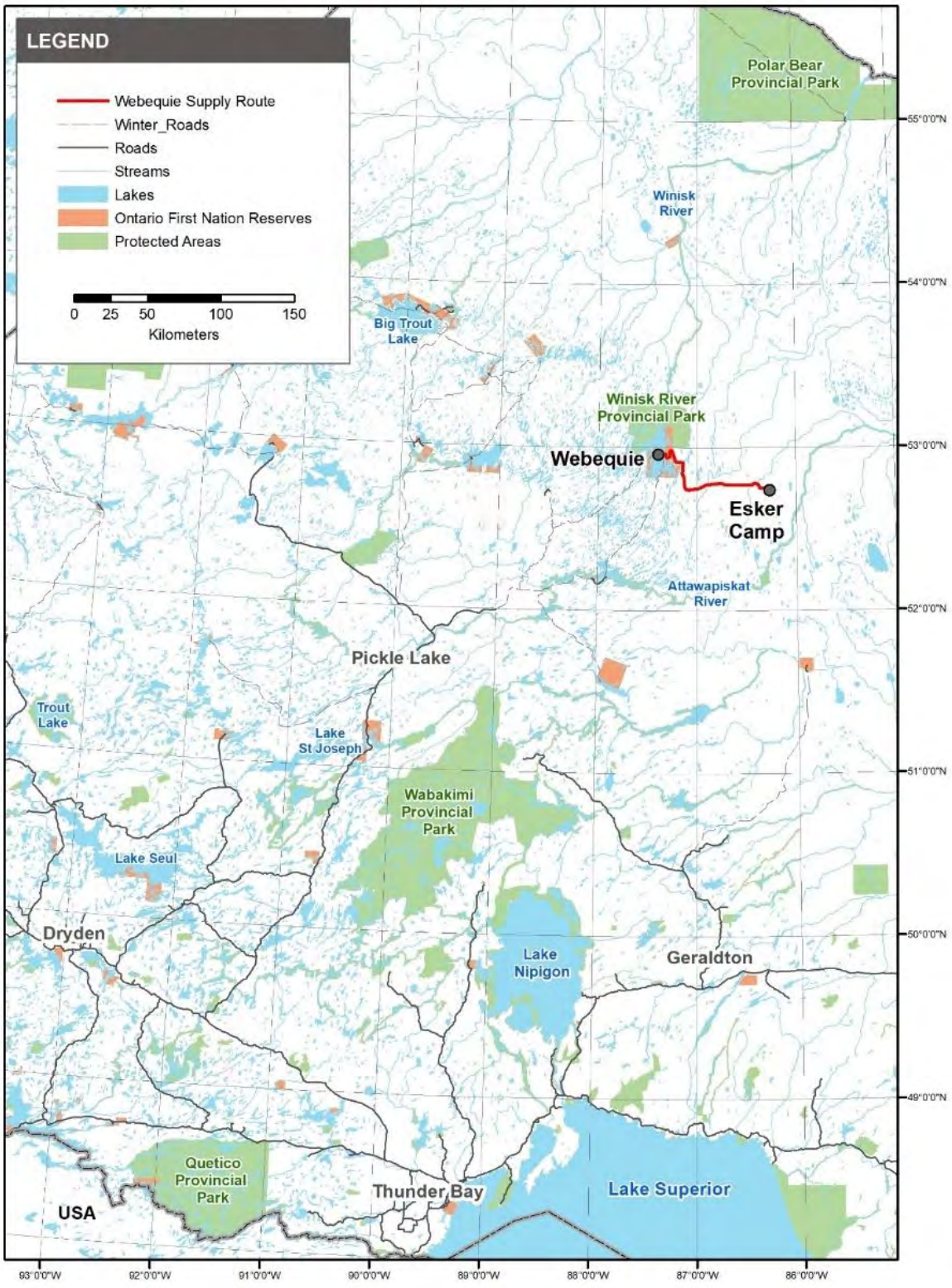


Figure 1: Location of the Webequie First Nation Supply Road Project.

2 METHODOLOGY

2.1 PEAT THICKNESS

Peat thickness was expected to range from 1-5 m depending on the landform or terrain unit based on several data sources: 1) The Canadian Wetland Classification System, University of Waterloo, Wetlands Research Centre, 1997; 2) soil probe data collected previously by JDMA from field sites south of the proposed corridor; and 3) peat depths evaluated by JDMA within the Webequie road corridor using ground penetrating radar in February 2019. During this field trip, several sites were selected to confirm the peat thickness.

Peat thickness was measured using a soil probe that was pushed manually into the organic soils of bogs and fens. Rather than a soil sampler, a rock splitter attachment was fitted to the drive rods to simply penetrate the organics with the intention of reaching the underlying mineral soil. Where the drives would meet resistance, and mineral soil expected, and the splitter would be brought back to surface to check for evidence of mineral soil.

2.2 POTENTIAL AGGREGATE SOURCES

Aggregate prospects for the Webequie Supply Road were summarized by JDMA (2019) based on reviews of existing surficial geology mapping by the Ontario Geological Survey and terrain analysis using digital imagery and lidar within the route corridor. Although most of the route is covered by organic terrain, limited occurrences of ice-contact glaciofluvial landforms and bedrock outcrops offer potential aggregate sources. Among these prospects are ice-contact glaciofluvial landforms created by meltwater processes during deglaciation that are typically composed of sorted granular material. The characteristics of these granular deposits (overburden thickness, stratigraphy, gradation, *etc*.) was evaluated from shallow test holes dug with either a mini-excavator or manually with a shovel. Where access and timing allowed, the mini-excavator was brought in to dig test pits to a depth of about 2 m. At other locations, where logistical challenges restricted slinging in the mini-excavator, test holes were dug manually to a depth of 30-90 cm.

Bedrock outcrops identified and mapped as potential quarry sites were visited in the field to describe the lithology and structural elements (fractures, bedding, foliation, *etc*.) visible at surface to make an initial assessment of bedrock suitability for aggregate production.

3 RESULTS

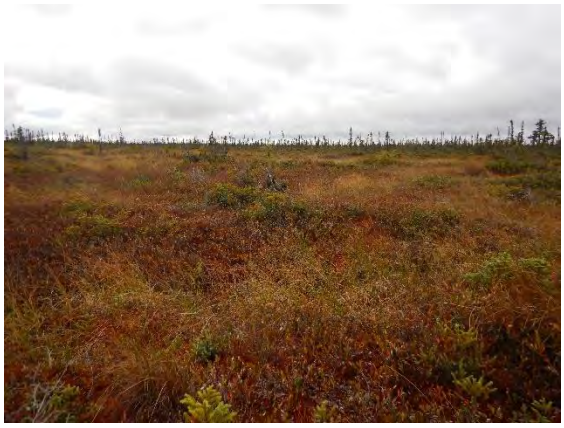
3.1 PEAT THICKNESS

Table 1 provides sample locations and peat thickness measurements. Peat thickness was measured at several sites over 5 areas. Figure 2 provides a map of the sample areas, while Figures 3-7 provide photographs of the specific sampling sites. At most of the sample locations, the peat probe penetrated the organic material and stopped in clay-rich mineral soil, which was evidenced by a smear of clay on the sampling probe head. Where clay was encountered, peat thickness ranged from 1.2 to 3.6 m. At sample sites C2 and C3, located on a bog near the margin of a fen, the soil probe was stopped at a depth of 2.5 m in the organic material without encountering a bottom in mineral soil. Similarly, a mineral soil was not encountered at sample location C11, located on the edge of an extensive fen. Here, the sampling probe was stopped at a depth of 4.3 m, presumably by organic matter as no clay was observed on the sampling head.

Table 1: Location of peat thickness probes.

ID	Easting	Northing	Depth	
Area 1				
C1	497666	5844355	1.2 m	Bog: clay bottom
C2	497699	5844201	2.5 m	Bog near margin of fen: no bottom encountered
C3	497679	5844202	2.5 m	Bog near margin of fen: no bottom encountered
Area 2				
C4	512767	5847526	3.6 m	Bog: grey clay bottom
C5	512745	5847332	3.6 m	Bog: grey clay bottom
C6	512773	5847656	2.5 m	Fen: grey clay bottom
Area 3				
C7	522602	5847044	2.5 m	Fen: grey clay bottom
C8	522684	5846921	1.8 m	Bog: grey clay bottom
C9	522528	5846941	1.8 m	Bog: grey clay bottom
Area 4				
C10	531218	5846471	3.2 m	Bog: grey clay bottom
C11	531027	5846413	4.3 m	Fen: no bottom encountered
Area 5				
C12	545188	5844770	1.2 m	Bog: grey clay bottom
C13	545176	5844810	1.2 m	Bog: grey clay bottom

Figure 2: Location of peat probes.



C1: Bog with 1.2 m of peat over clay

C2 and C3: Bog near margin of a fen, with 2.5 m of peat and no mineral soil encountered.

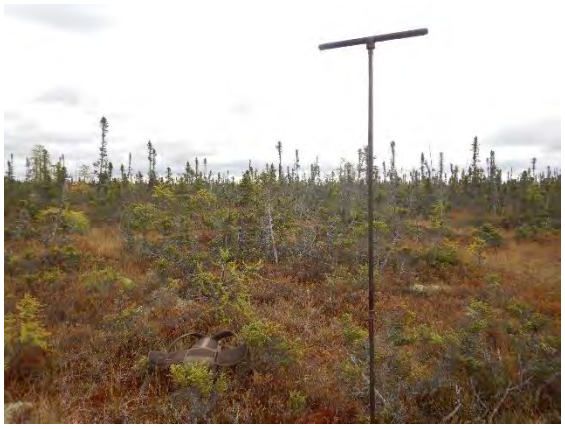
Figure 3: Peat probing at Area 1.

C4 and C5: Bog with 3.6 m of organic matter over clay.

C6: Fen with 2.5 m of organics matter over clay.

Figure 4: Peat probing at Area 2

C6: Fen with 2.5 m of organic matter over clay



C8: Bog with 1.8 m of organic matter over clay.

C9: Bog with 1.8 m of organic matter over clay.

Figure 5: Peat probing at Area 3.

C10: Bog with 3.2 m of peat over clay.

C11: Fen with 4.3 m of organic matter and no mineral bottom encountered.

Figure 6: Peat probing at Area 4.

C12: Bog with 1.2 m of organic matter over brown clay.

C13: Bog with 1.2 m of organic matter over brown clay.

Figure 7: Peat probing at Area 5.

3.2 POTENTIAL AGGREGATE SOURCES

Potential aggregate sources tested in the field include 6 ice-contact glaciofluvial landforms and 5 bedrock locations, as summarized in Table 2 and shown on Figure 8.

Along the western section of the route, there are multiple, small, discontinuous, ice-contact glaciofluvial deposits trending generally north-south, including to the west and north of Farrow Lake and northward along the eastern side of Manson Bay on Winisk Lake. Test pits TP19-01, TP19-02, TP19-09, and TP19-10 targeted these glaciofluvial features. TP19-03 is located well to the south and was not visited on the ground during this field work, but descriptions of the site are provided in previous work (Volume 2 EIS/EA report B216).

Near the middle of the route, where glaciofluvial landforms were not mapped, four test sites were visited (TP19-04, TP19-05, TP19-08, and TP19-11) where bedrock exposure had been mapped previously by the Ontario Geological Survey or had been identified from imagery and lidar in the terrain mapping (JDMA, 2019).

Near the eastern end of the route, two test sites (TP19-06 and TP19-07) were visited based on indications of surficial expressions of glacial sediments and bedrock. The large esker complex on the west side of the Mukutei River, near Esker camp, is among the largest granular prospects in the region and was selected for testing by the drilling crew.

Table 2: Location of aggregate testing sites.

ID	Easting	Northing	Mapped Unit	Observed Material
TP19-01	482271	5867792	Glaciofluvial Deposits	Sand and Gravel
TP19-02	490185	5862355	Glaciofluvial Deposits	Sand and Bedrock
TP19-03*	485425	5840765	Glaciofluvial (Volume 2 EIS/EA report B216)	N/A
TP19-04	507989	5845403	Bedrock	Till
TP19-05	508128	5847803	Bedrock	Till and Bedrock
TP19-06	537987	5848399	Glaciofluvial Deposits + bedrock	Silt
TP19-07	541253	5847878	Bedrock	N/A
TP19-08*	513429	5841840	Bedrock (Volume 2 EIS/EA report Q245S)	Bedrock
TP19-09	489236	5857600	Glaciofluvial Deposits	Sand
TP19-10	485640	5853170	Glaciofluvial Deposits	Sand and Gravel
TP19-11	514998	5847294	Bedrock	Gravel

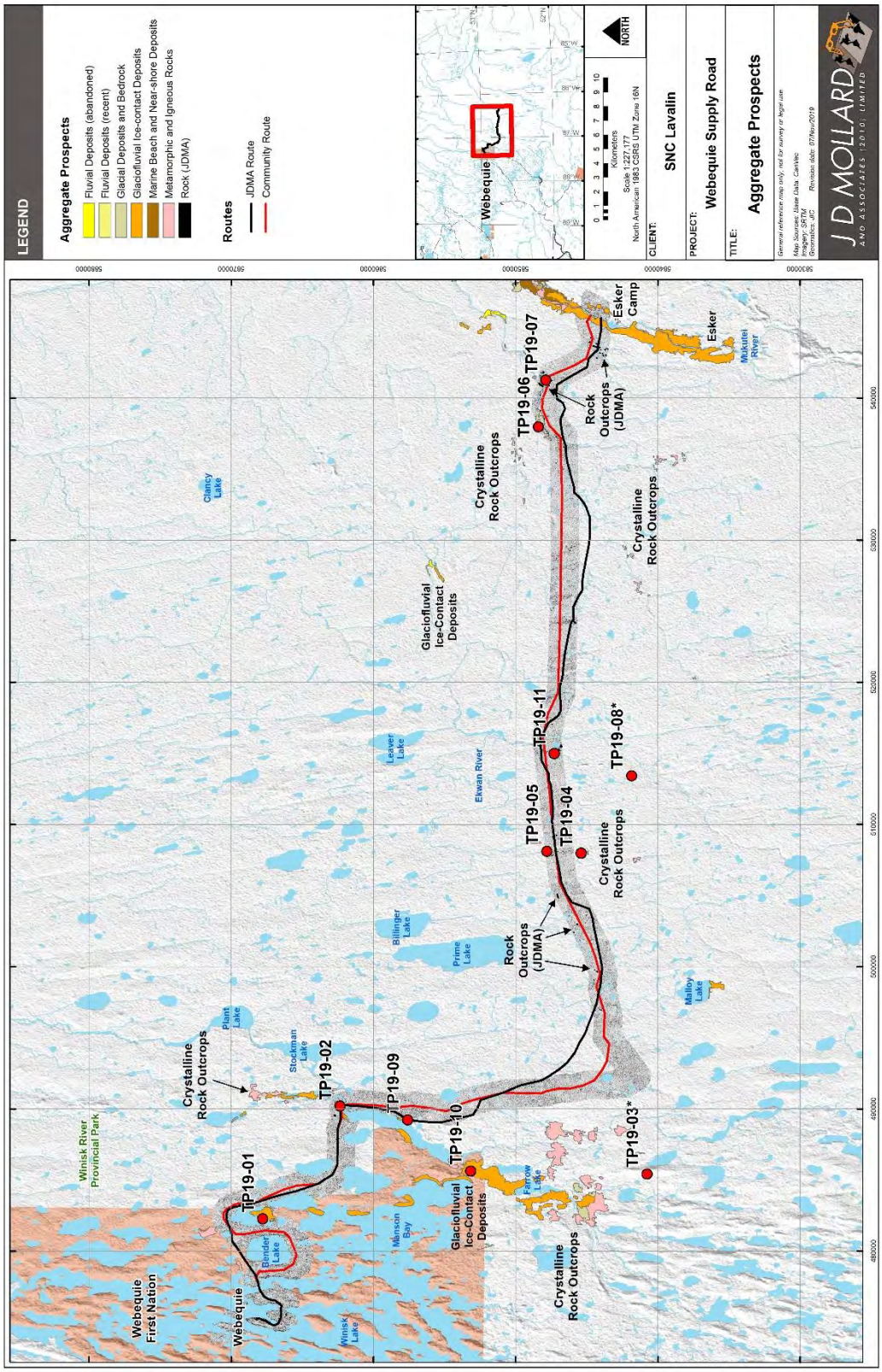


Figure 8: Location of aggregate potential sources.

TP19-01

Test pit site TP19-01 was chosen at the existing/abandoned gravel pit located east of Webequie (Figure 9). The deposit occurs as a discreet landform that is part of the discontinuous esker running north-south along the side of Manson Bay. There is an access road that is currently overgrown with vegetation, but this would provide ready access to the proposed community road (located about 600 m to the west) where it wraps around the south end of Bender Lake. Three test pits were dug at this site: 1) at the bottom of the pit to assess the remaining material (Figures 10-14); 2) at the western edge of the pit near the outlet to the access road (Figures 15-17); and 3) at the southern side of the pit into the south pit face (Figures 18-20).

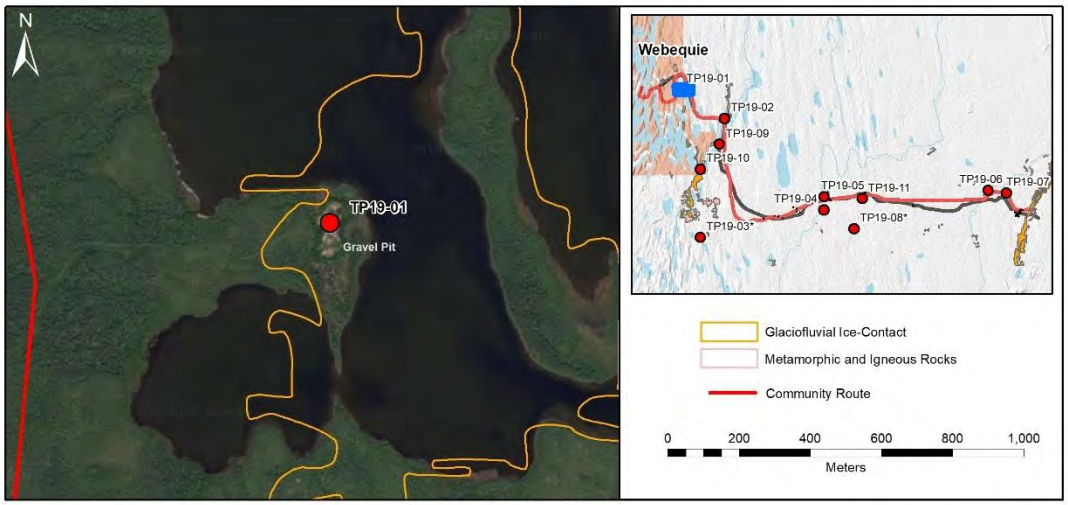


Figure 9: Location of TP19-01

Site 1: Bottom of Pit (482274E, 5867791N)

0.0-1.0 m: SAND

Medium to coarse sand, trace fine gravel, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, homogeneous, not cemented. No topsoil or overburden. (Sample #1; Figure 10)

1.0-1.5 m: GRAVEL

Fine gravel to coarse sand, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, weakly stratified, not cemented, gravel clasts of crystalline igneous rock and shale up to 30 mm. Water table at 1.3 m. (Ice contact glaciofluvial).

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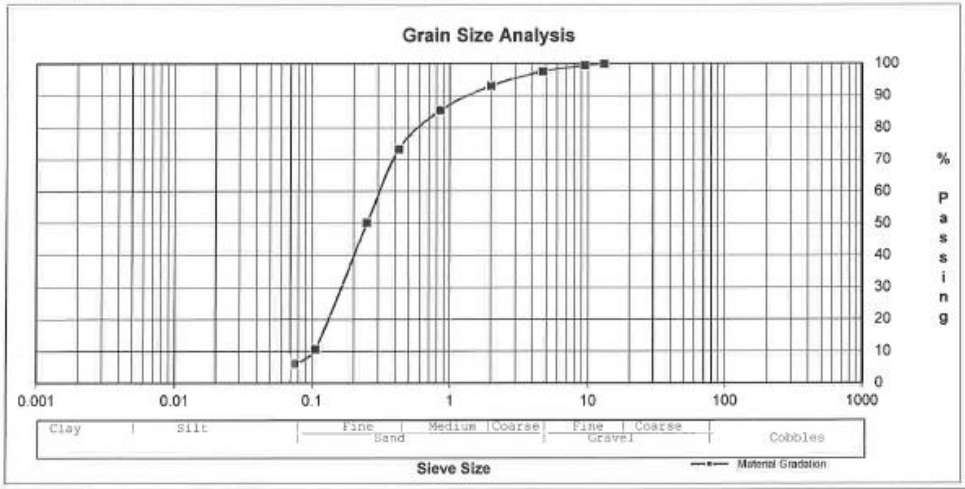
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1670
	Webequie Supply Road	B.H./T.P. No.:	TP19-01
Report to:	Muhammad Saleem	Sample No.:	#1 Site 1 Bottom Pit
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	100.0
9.5 mm	99.5
4.75 mm	97.6
2.00 mm	93.0
.850 mm	85.3
.425 mm	73.2
.250 mm	50.1
.106 mm	10.7
.075 mm	6.1



% Gravel	2.4		
% Sand	91.5	Natural Moisture Content:	12.8%
% Silt & Clay	6.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 10: TP19-01 (Bit Bottom) Gradation

Figure 11: TP19-01 existing pit

Figure 12: Bottom of existing gravel pit.

Figure 13: Trench at bottom of existing pit returned sand to depth of 1.5 m.

Figure 14: Test pit filled in and smoothed after completion.

Site 2: East side of pit near access road (482237, 5867790)

0.0-1.2 m: GRAVEL

Fine to medium gravel with coarse sand matrix, gap graded, loose, rounded and equidimensional gravel clasts, light brown, moist, stratified with a 30 cm layer of coarse to medium sand, not cemented, gravel clasts of crystalline igneous rock up to a maximum clast size of 80 mm. (Ice contact glaciofluvial). (Sample #2)

1.2-1.5 m: CLAY

Clay, silty, low plasticity, firm, light grey, homogeneous, weakly compacted, unoxidized, no foreign materials, no odour. Water table at 1.3 m.

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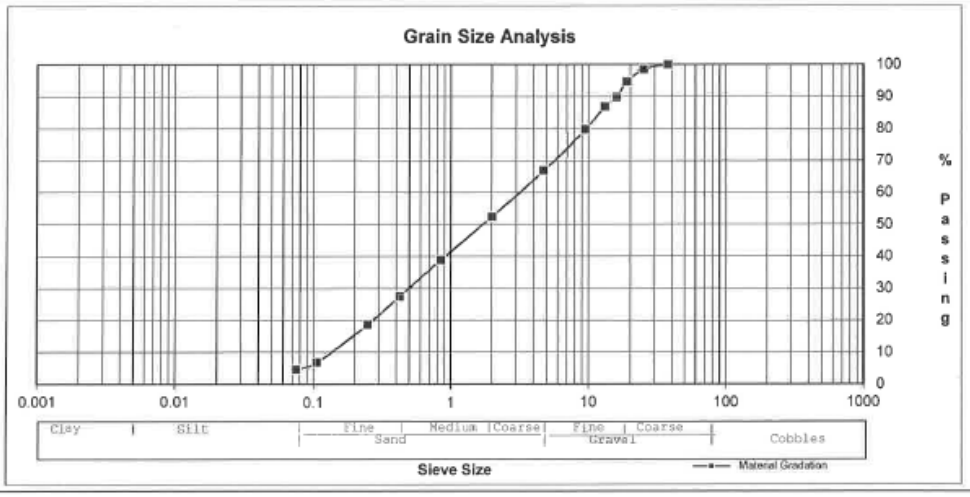
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1671
	Webequie Supply Road	B.H./T.P. No.:	TP19-01
Report to:	Muhammad Saleem	Sample No.:	#2 Site 2
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	98.4
19.0 mm	94.7
16.0 mm	89.7
13.2 mm	87.0
9.5 mm	79.6
4.75 mm	66.8
2.00 mm	52.4
.850 mm	38.9
.425 mm	27.5
.250 mm	18.8
.106 mm	6.8
.075 mm	4.6



% Gravel	33.2		
% Sand	62.2	Natural Moisture Content:	6.5%
% Silt & Clay	4.6	Soil Classification:	SP

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 15: TP19-01 (Site 2) gradation.

Figure 16: Test pit at west side of existing pit.

Figure 17: Test pit filled in and smoothed after completion.

Site 3: South side of pit (482267, 5867693)

0.0-1.8 m: GRAVEL

Fine to medium gravel with coarse sand matrix, gap graded, loose, rounded and equidimensional gravel clasts, brown, moist, homogeneous to weakly stratified, not cemented, gravel clasts of crystalline igneous rock, maximum size of 70 mm.

Figure 18: Gravel on the south pit face.

Figure 19: Pit face on south side of existing gravel pit.

Figure 20: Gravel and coarse sand in the pit face on the south side of existing pit.

TP19-02

Test pit site TP19-02 is located north of the stream crossing between Webequie and Stockman Lake (Figure 21). Aggregate sources mapped by the Ontario Geological Society include both ice-contact glaciofluvial deposits and bedrock at this location, which are within 100 m from the proposed routes and offer short haul distances. Bedrock exposures (490178 5862361) were observed from the air and were accessed from the stream channel. Crystalline igneous outcrop composed of granitic to pegmatitic composition, massive and unfractured (Figure 23-24). Ice-contact glaciofluvial deposits of sand surround the bedrock outcrop, into which two test pits were dug (Figures 25-28).

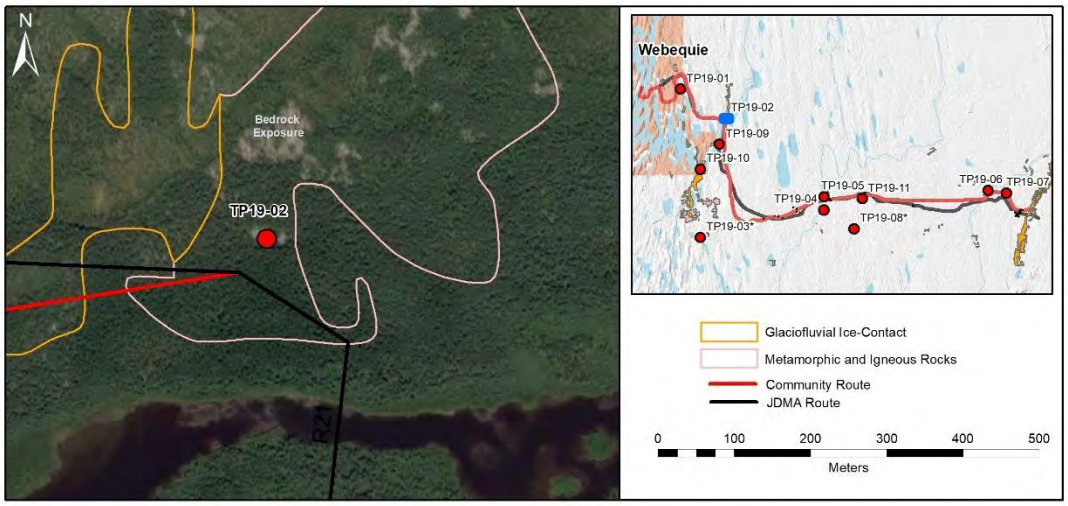

Figure 21: Location of TP19-02.

Site 1 (490175 5862389):

0.0-1.8 m: SAND

Medium to coarse sand, trace fine gravel, uniformly graded, loose, light brown, moist, homogeneous, not cemented. Organic horizon and topsoil approximately 15 cm thick. (Ice contact glaciofluvial). (Sample #3; Figure 22).

Site 2 (490187 5862337):

0.0-2.0 m: SAND

Medium to coarse sand, trace fine gravel, uniformly graded, loose, light brown, moist, homogeneous, not cemented, oxidized from 1.8-2.0 m. Organic horizon and topsoil approximately 15 cm thick. (Ice contact glaciofluvial).

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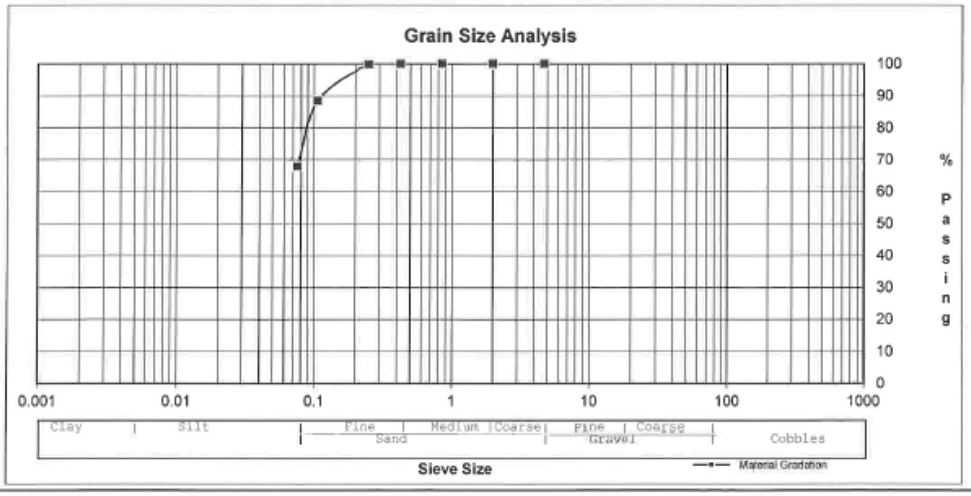
E-Mail: info@tbte.ca

Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1672
	Webequie Supply Road	B.H./T.P. No.:	TP19-02
Report to:	Muhammad Saleem	Sample No.:	#3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	
4.75 mm	100.0
2.00 mm	100.0
.850 mm	100.0
.425 mm	99.9
.250 mm	99.7
.106 mm	88.5
.075 mm	68.0



% Gravel	0.0		
% Sand	32.0	Natural Moisture Content:	11.6%
% Silt & Clay	68.0	Soil Classification:	ML

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 22: TP19-02 (Site 1) gradation

Figure 23: Crystalline igneous bedrock exposure.

Figure 24: Bedrock exposure beneath moss cover.

Figure 25: TP19-02 Site 1.

Figure 26: TP19-02 Site 1 backfilled and smoothed.

Figure 27: TP19-02 Site 2.

Figure 28: TP19-02 Site 2. Note iron staining from bottom of test pit.

TP19-04

Test pit site TP19-04 (Figure 29) targeted bedrock mapped by the Ontario Geological Survey. Access to the site was from the nearby stream as tree cover prevented the helicopter from landing on the feature. Despite being mapped as a bedrock feature, no bedrock was encountered along a transect across the feature. In several places where tree cover thinned, the ground was covered with white moss that gives the appearance of bedrock in the imagery and in the air from the helicopter (Figure 30). On the ground, however, these areas exhibited scattered boulders at surface set within a clay till. Small test pits dug with a shovel revealed a brown clay till beneath the moss (Figure 31-33).

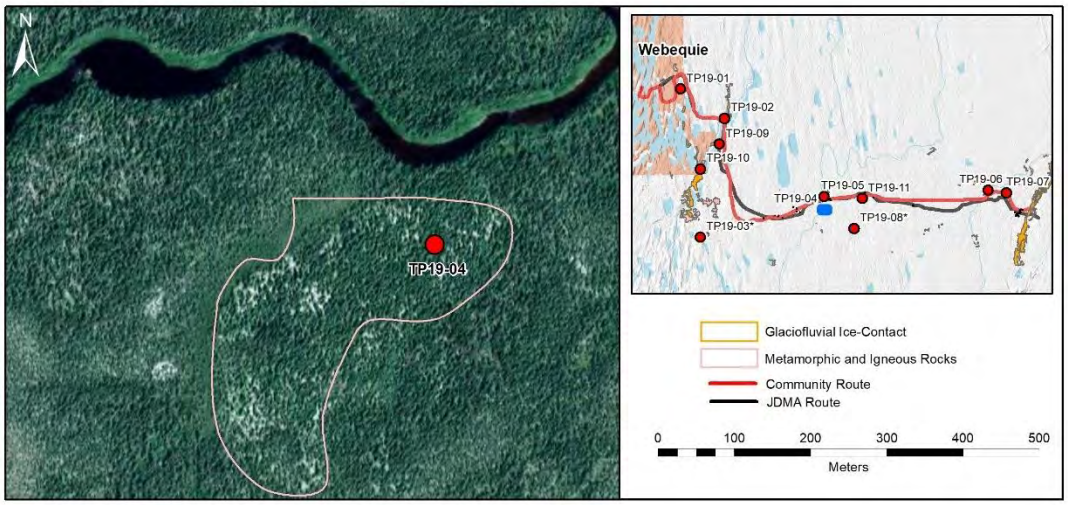

Figure 29: Location of TP19-04.

Site 1 (508053 5845458)

TILL: Clay, high plasticity, firm, brown, drier than plastic limit, homogeneous, no dilatancy, clasts of cobble to boulder size, rounded, crystalline igneous composition.

Site 2 (507891 5845258)

TILL: Clay, high plasticity, firm, brown, drier than plastic limit, homogeneous, no dilatancy, clasts of cobble to boulder size, rounded, crystalline igneous composition.

Figure 30: Location of TP19-04 from above.

Figure 31: Brown till at TP19-04.

Figure 32: Clay till at TP19-04

Figure 33: TP19-04

TP19-05

Test pit site TP19-05 is located on an area mapped as bedrock by the Ontario Geological Survey (Figure 34). The feature occurs as a small hill or upland along the eastern side of a small stream and is entirely covered with trees. Access to the site is from the banks of the small stream. Along the western side of the feature, leading down toward the stream, there is an accumulation of large boulders up to several metres in diameter (Figure 35). From the imagery and from the helicopter, these boulders appear as bedrock, but they are not *in situ* and are not embedded in a fine-grained matrix. Based on their large size and angular shape, these boulders were likely transported very short distances from their source and suggest *in situ* bedrock in close proximity. Adjacent to the boulders, the area is covered by clay till (Figure 36).

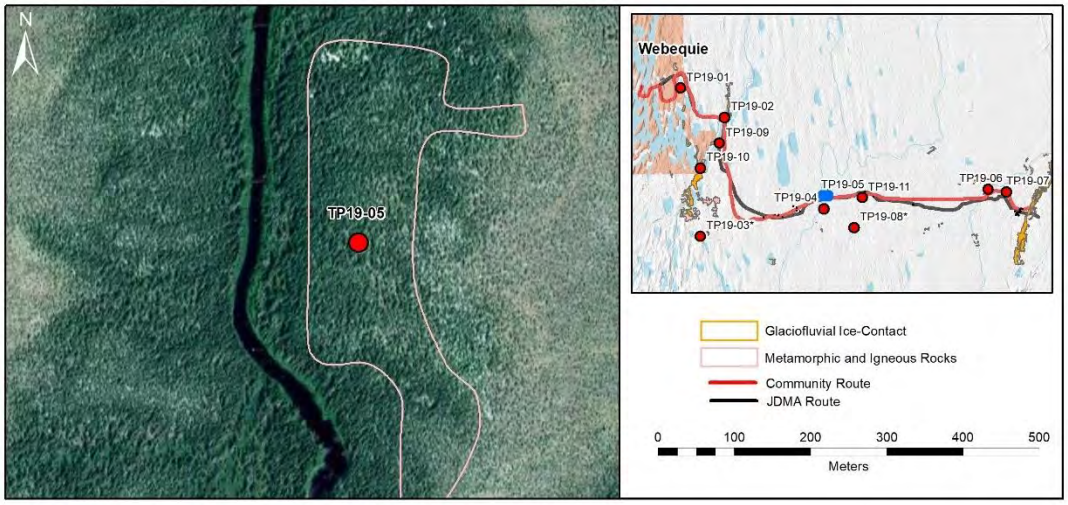

Figure 34: Location of TP19-05.

Site 1 (508071 5847795):

BOULDERS: crystalline, felsic igneous rock, massive, homogeneous. Irregular and angular faces on the boulders suggest minimal transport and close proximity to the *in situ* bedrock source.

Site 2 (508197 5847852):

TILL: Clay, high plasticity, firm, brown, near plastic limit, homogeneous, no dilatancy, clasts of cobble to boulder size, rounded, crystalline igneous composition.

Figure 35: Boulders of felsic plutonic rock.

Figure 36: Brown clay till at surface across the test site.

TP19-06

Test pit site TP19-06 is located on an area mapped as a unit of glacial deposits and bedrock by the Ontario Geological Survey (Figure 37). Along the eroding banks of the adjacent stream channel to the south, mineral soils are observed from the air. Access to the site was from the bog to the north. Two test pits were dug at this location: 1) along the margin of the bog where it transitioned to the forest (Figure 38-39) and 2) within the forest and along a ridge close to the banks of the adjacent stream channel (Figures 40-42).

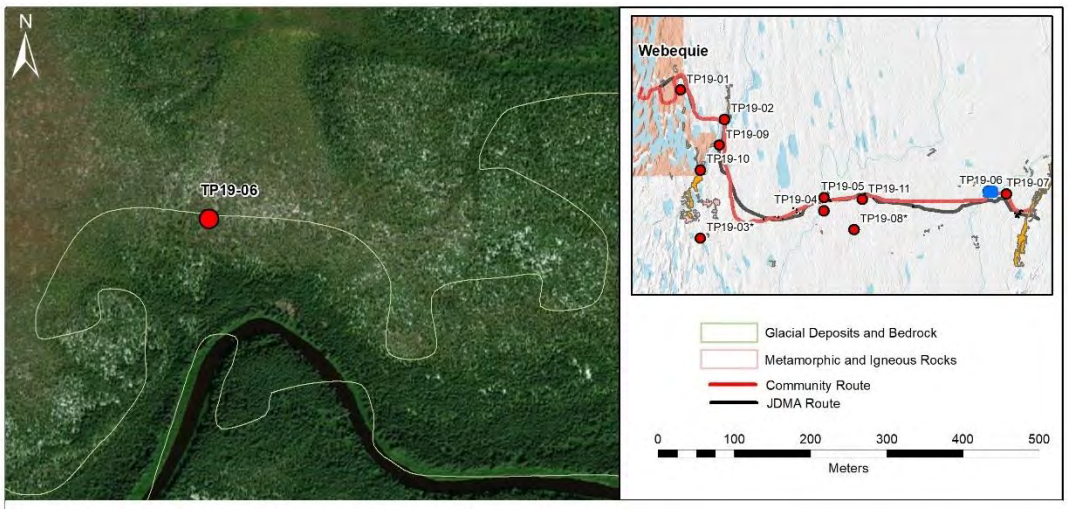

Figure 37: Location of TP19-06.

Site 1 (537989 5848403):

0.0-1.2 m: ORGANICS

1.2-1.4 m: CLAY

Clay, plastic, firm, light grey, homogeneous, unoxidized, no foreign materials, organic odour. Water table at 0.7 m.

Site 2 (538025 5848291):

0.0-0.2 m: ORGANICS

0.2-0.6 m: SILT

Silt, clayey, low plasticity, firm, light brown, laminated, fissile, unoxidized, no foreign materials, organic odour. Water table at 0.7 m.

Figure 38: Organic matter at TP19-06 Site 1.

Figure 39: Clay bottom of TP19-06 Site 1.

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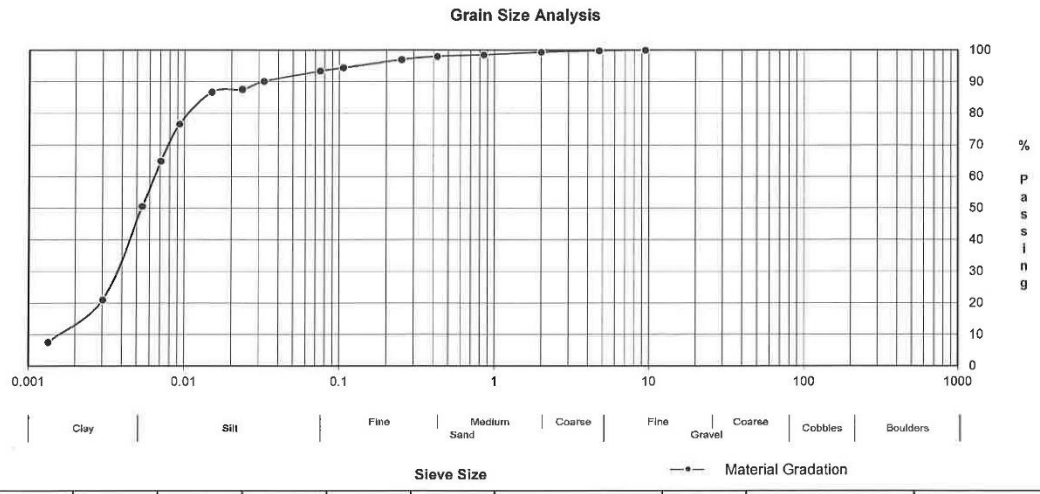
Particle Size Analysis of Soil By Hydrometer

Client:	SNC Lavalin	TBTE Project No.:	19-482
Project:	661910	Lab No.:	19-1673
Location:	Webequie Supply Road	Sample Location	TP19-06 Sample # 4
Report To:	Muhammad Saleem	Tested By/Date:	FV / GH / October 10, 2019
Sampled By/Date:	Client	Reviewed By:	Forch Valela

Sieve Analysis		Hydrometer Analysis	
Sieve (mm)	% Passing	Diameter (mm)	% Finer
100			
50.0			
37.5		0.032512	90.1
25.0		0.023465	87.6
19.0		0.014939	86.7
13.2		0.009283	76.6
9.5	100.0	0.007068	64.9
4.75	99.8	0.005399	50.5
2.00	99.4	0.003027	21.1
0.850	98.5	0.001333	7.6
0.425	98.0		
0.250	97.0	5 µm	44.0
0.106	94.5	2 µm	18.0
0.075	93.5		



%Gravel	0.2	% Silt	85.9	% NMC	19.1	Frost Heave Susc.		Material Suitability	
% Sand	6.4	% Clay	44.0	PI	NP	Erodibility (k)		Soil Classification	ML

Remarks: Test Method LS 701, 702, ASTM D2216, D4318

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Figure 40: TP19-06 (Site 1) gradation.

Figure 41: Site 2 at TP19-06.

Figure 42: Clayey silt at TP19-06.

TP19-07

Test pit site TP9-07 was targets an area mapped as bedrock by the Ontario Geological Survey (Figure 43). The area was visited only from the air and not on the ground. Visual inspection from the helicopter did not identify bedrock outcrops; rather, most of the area is covered with thin tree cover and white moss that mimics bedrock in the imagery (Figures 44-45). Although no outcrops of bedrock were observed, it is possible that there is bedrock along the margins of the nearby streams where tree cover may obscure exposure. Along the banks of the nearby stream to the north, eroding mineral soil is exposed and no bedrock is observed.

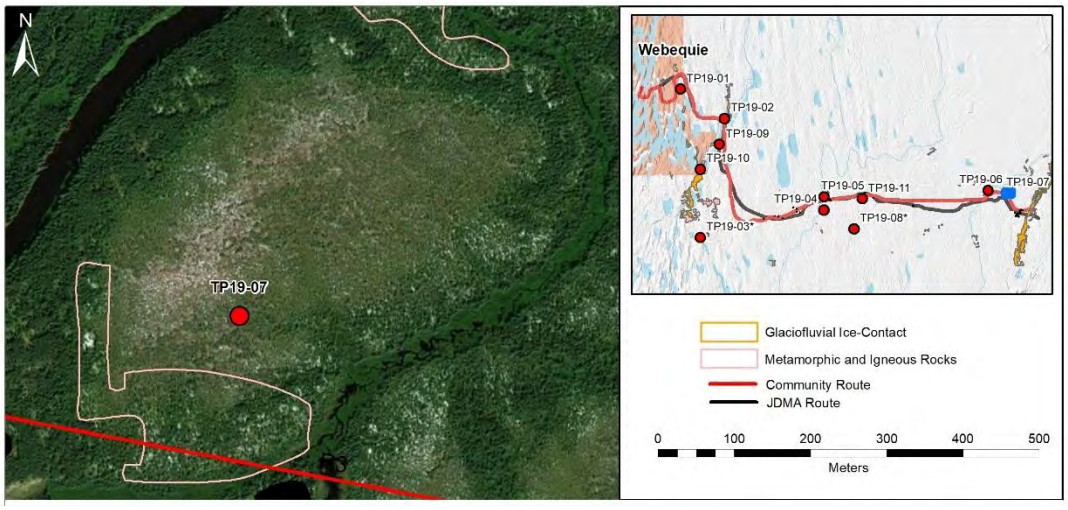

Figure 43: Location of TP19-07.

Figure 44: Eroding mineral banks near TP19-07.

Figure 45: Extensive white moss over TP19-07.

TP19-08

Test pit site TP19-08 (Figure 46) is located south of the community route and near an area of bedrock exposure described previously as bedrock (Volume 2 EIS/EA report Q245S). The site was visited from the air only. Visual inspections from the helicopter reveal a relatively large hill covered with trees that include stands of aspen that are often associated with glacial sediments or areas of bedrock (Figures 47-48). Much of the area appears to have white moss on the surface that obscure the identification of surficial materials. However, exposures of bedrock were observed in the general area, including areas to the west and east. The large fen to the west also exhibits large boulders in the centre and along the margins.

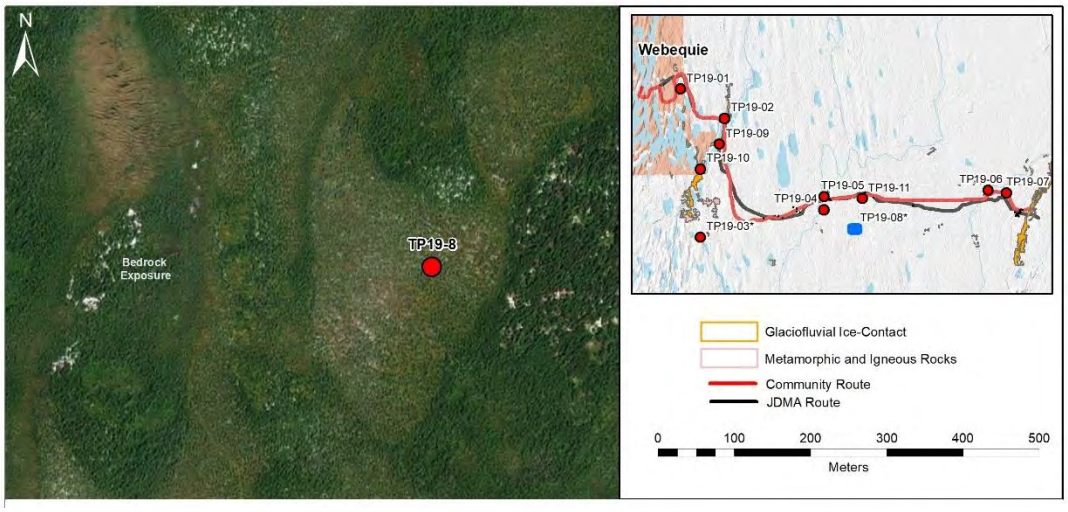

Figure 46: Location of TP19-08.

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Figure 47: TP19-08 from above.

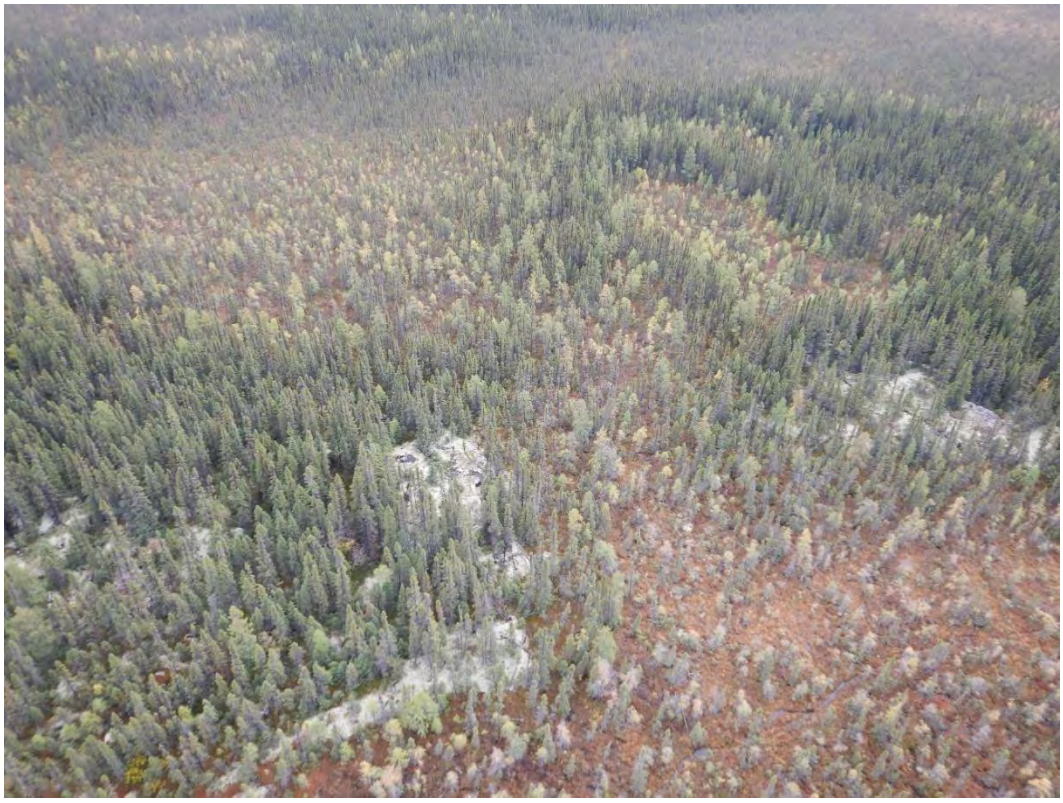

Figure 48: TP19-08 showing bedrock.

TP19-09

Test pit site TP19-09 was selected to test an area mapped as an ice-contact glaciofluvial deposit by the Ontario Geological Survey (Figure 49). Access to the site was from the east shore of lake to the west. This prospect is crossed by the JDMA proposed route and is approximately 1 km from the Community route, which limits the haul distance for construction. Two sites were tested using a shovel. The first site is located on the first ridge that rises above the lake while the second site is farther inland and higher on the topographic ridge (Figures 50-54).

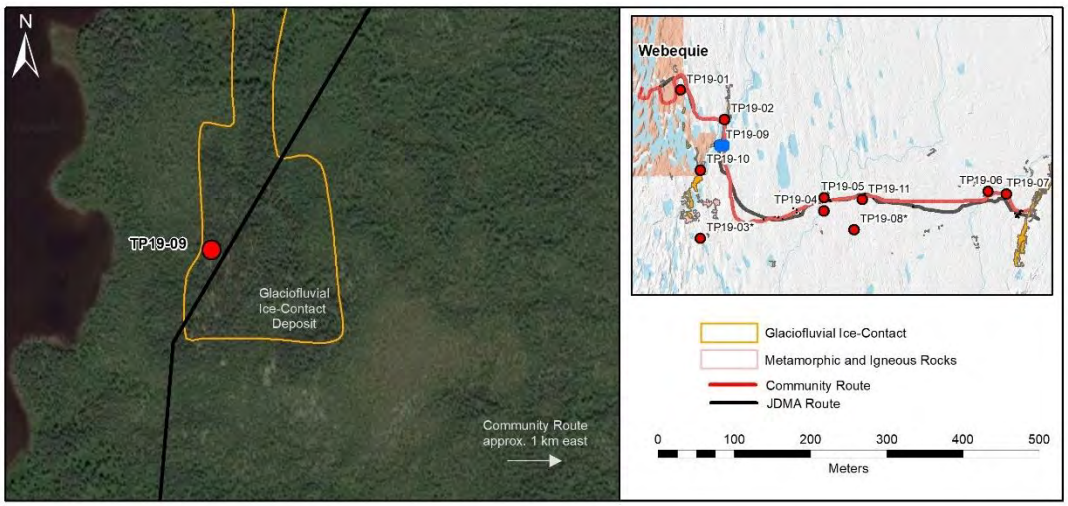

Figure 49: Location of TP19-09

Site 1 (489124 5857897)

0.0-0.4 m: SAND

Coarse sand, some fine to medium gravel, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, homogeneous, not cemented, gravel clasts up to 25 mm. Thin topsoil and no overburden.

Site 2 (489254 5857591)

0.0-0.5 m: SAND

Medium sand, trace fine gravel, uniformly graded, loose, light brown, moist, homogeneous, not cemented, oxidized upper 20 cm, thin topsoil and no overburden.

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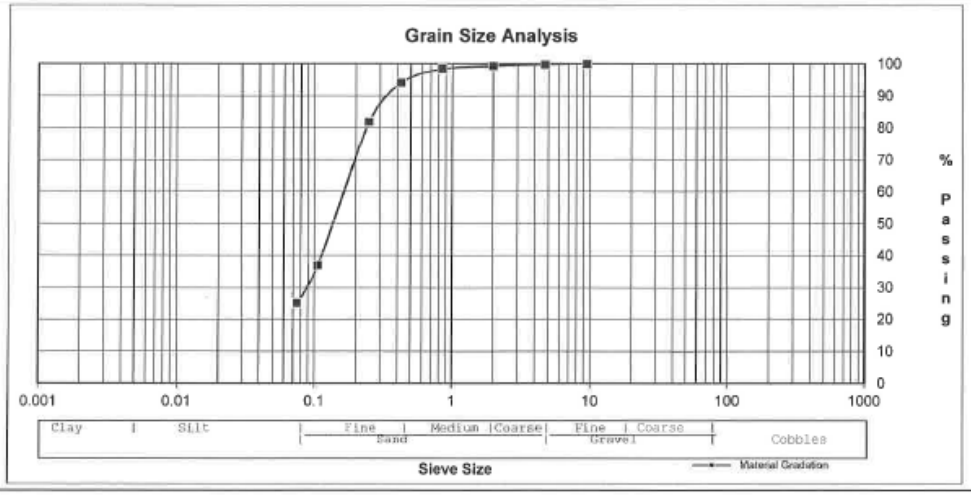
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1674
	Webequie Supply Road	B.H./T.P. No.:	TP19-09
Report to:	Muhammad Saleem	Sample No.:	#5
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	
25.0 mm	
19.0 mm	
16.0 mm	
13.2 mm	
9.5 mm	100.0
4.75 mm	99.8
2.00 mm	99.2
.850 mm	98.3
.425 mm	94.1
.250 mm	81.9
.106 mm	36.9
.075 mm	25.1



% Gravel	0.2		
% Sand	74.7	Natural Moisture Content:	4.9%
% Silt & Clay	25.1	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 50: TP19-09 (Site 2) gradation.

Figure 51: Sand with cobbles.

Figure 52: Sand with cobbles.

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Figure 53: Esker ridge.

Figure 54: Sand of the esker ridge at TP19-09.

TP19-10

Test pit site TP19-10 targets a large ice-contact glaciofluvial landform mapped by the Ontario Geological Survey that is located southeast of Winisk Lake and on the west side of the north-south section of the proposed route (Figure 55). The feature is among the largest glaciofluvial landforms mapped in the area and offers one of the largest potential sources of granular material, but it is approximately 4 km from the proposed route and would require a considerable water crossing.

From the air, the landform appears heavily covered with trees, including aspen trees that are quite distinct and indicate thin organics over mineral soils and sediment. Access to the site was from the shore of a small lake to the west of the landform. From the shores of the small lake, the topography rises and the vegetation transitions to forest. The overall landform consists of multiple ridges on which three test pits were dug and sampled. Test pit one was dug on the first ridge and consisted of a clayey silt (Figure 56). The other two test pits were dug farther along and higher on the landform and exposed mostly sand with trace gravel clasts (Figure 57-60).

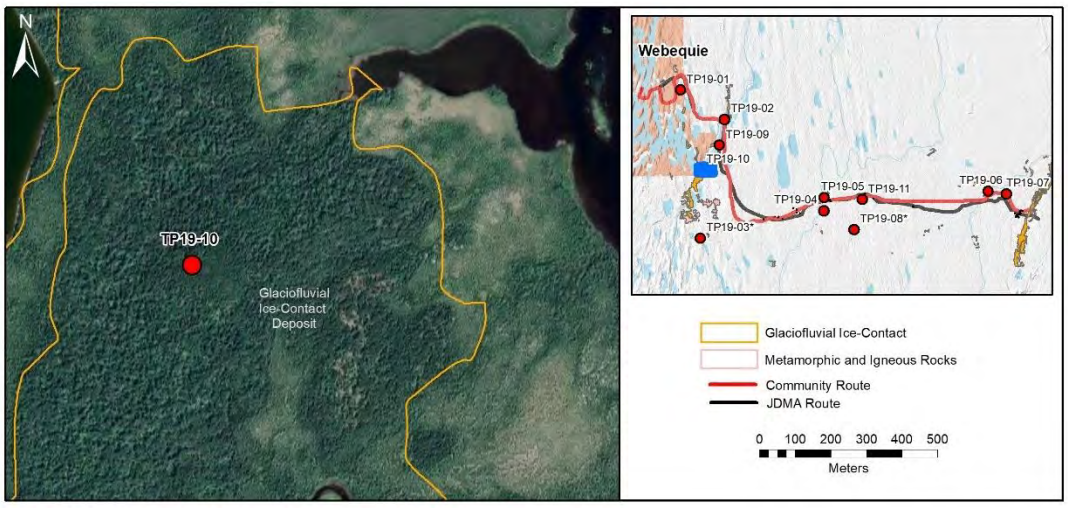

Figure 55: Location of TP19-10.

Site 1 (485038 5852324)

0.0-0.4 m: SILT

Silt, clayey, loose, light brown, moist, homogeneous, oxidized, not cemented. Thin topsoil and no overburden.

Figure 56: Figure TP19-10 Site 1.

Site 2 (485083 5852382)

0.0-0.6 m: SAND

Medium sand, trace medium gravel, gap graded, loose, sub-rounded to rounded gravel clasts, light brown, moist, homogeneous, oxidized, not cemented, gravel clasts up to 50 mm. Thin topsoil and no overburden.

Figure 57: Figure TP19-10 Site 2.

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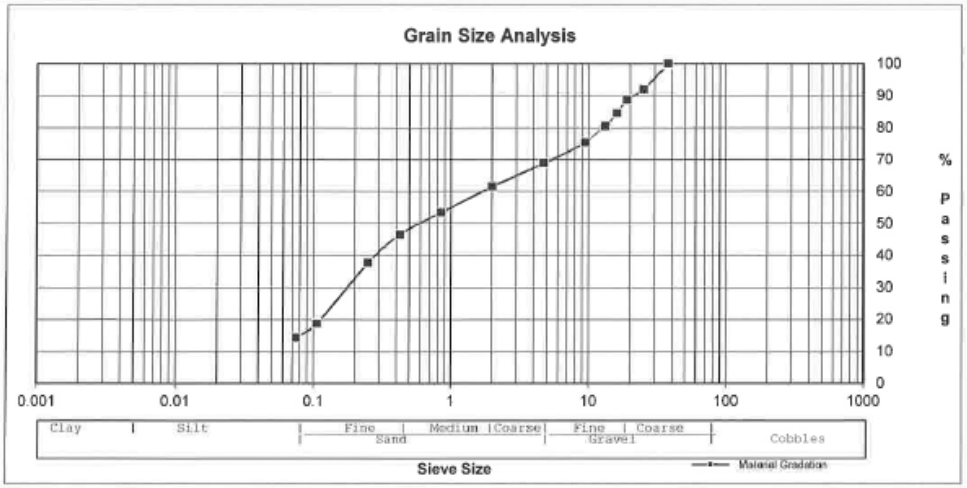
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1675
	Webequie Supply Road	B.H./T.P. No.:	TP19-10
Report to:	Muhammad Saleem	Sample No.:	#6 Site #2
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	92.0
19.0 mm	88.8
16.0 mm	84.5
13.2 mm	80.4
9.5 mm	75.4
4.75 mm	68.9
2.00 mm	61.5
.850 mm	53.4
.425 mm	46.5
.250 mm	37.7
.106 mm	18.7
.075 mm	14.3



% Gravel	31.1		
% Sand	54.6	Natural Moisture Content:	4.7%
% Silt & Clay	14.3	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 58: TP19-10 (Site 2) gradation.

Site 3 (485212 5852482)

0.0-0.6 m: SAND

Medium sand, some medium gravel, gap graded, loose, light brown, moist, homogeneous, not cemented, oxidized, maximum clast size of 100 mm and 1% oversize (80-160 mm), thin topsoil and no overburden.

Figure 59: TP19-10 Site 3

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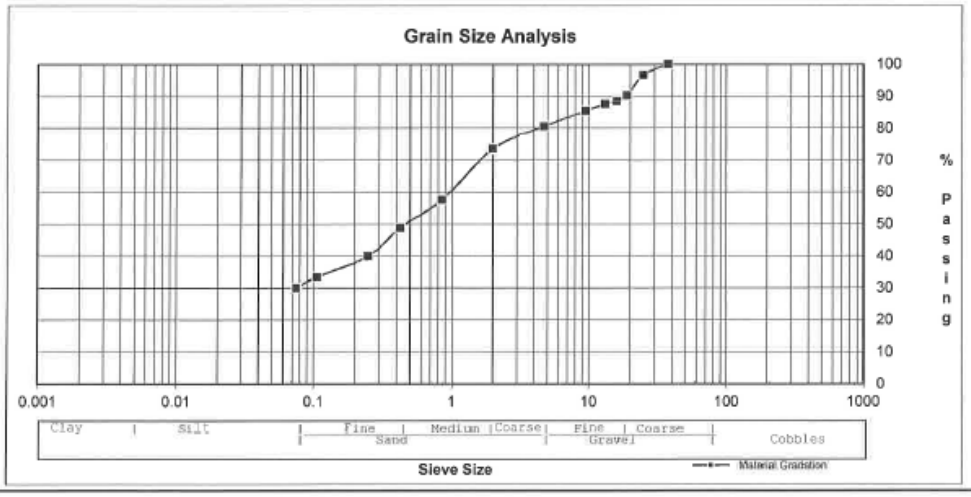
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1676
	Webequie Supply Road	B.H./T.P. No.:	TP19-10
Report to:	Muhammad Saleem	Sample No.:	#7 Site #3
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	
37.5 mm	100.0
25.0 mm	96.7
19.0 mm	90.3
16.0 mm	88.6
13.2 mm	87.5
9.5 mm	85.5
4.75 mm	80.6
2.00 mm	73.6
.850 mm	57.6
.425 mm	48.9
.250 mm	40.0
.106 mm	33.5
.075 mm	30.0



% Gravel	19.4		
% Sand	50.6	Natural Moisture Content:	10.6%
% Silt & Clay	30.0	Soil Classification:	SM

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 60: TP19-10 (Site 3) gradation.

TP19-11

Test pit site TP19-11 is located roughly half-way along the west-east section of the route and was selected on a prominent hill (Figure 61). Access to the site is from the fen adjacent to a small lake. The hill appears to be composed of granular material deposited by ice-contact glaciofluvial and surrounded by organic soils. Although small in scale, extending roughly 75 m long by 40 m wide and 3 m high, the granular material observed in this landform appears to be the coarsest encountered of all the test pits (Figures 62-66). Based on the approximate dimensions of the landform and the observed material, this feature offers a potential volume of roughly 10,000 m^3, with limited haul distance to the proposed route locations.

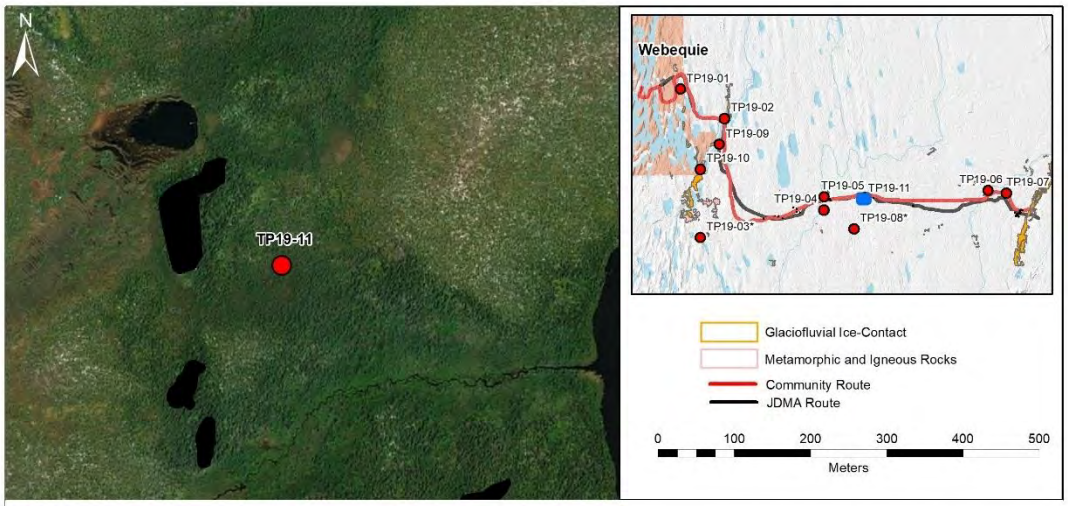

Figure 61: Location of TP19-11.

Site 1: Top of Ridge (514868 5847343)

0.0-1.2 m: GRAVEL

Fine to medium gravel with coarse sand matrix, gap graded, loose, rounded and equidimensional gravel clasts, light brown, dry, not cemented, oxidized, maximum clast size of 150 mm.

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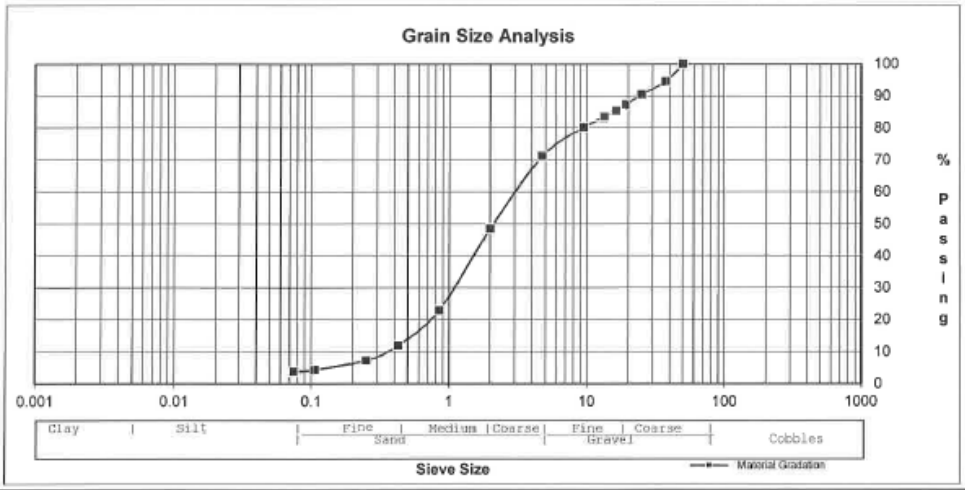
Grain Size Analysis

Client:	SNC Lavalin	TBT Project No.:	19-482
Project Description:	66110	Lab No.:	19-1677
	Webequie Supply Road	B.H./T.P. No.:	TP19-11
Report to:	Muhammad Saleem	Sample No.:	#8
Tested By/Date:	FV / GH / October 10, 2019	Depth: (m)	N/A
Reported By:	Madison Murphy	Reviewed By:	Forch Valela

Sieve Size	Percent Passing
75 mm	
50 mm	100.0
37.5 mm	94.5
25.0 mm	90.5
19.0 mm	87.0
16.0 mm	85.0
13.2 mm	83.2
9.5 mm	80.2
4.75 mm	71.2
2.00 mm	48.5
.850 mm	23.0
.425 mm	12.0
.250 mm	7.3
.106 mm	4.3
.075 mm	3.8



% Gravel	28.8		
% Sand	67.4	Natural Moisture Content:	2.3%
% Silt & Clay	3.8	Soil Classification:	SW

Remarks: Test Method LS 602, 701/ASTM C136, D2216

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Figure 62: TP19-11 gradation.

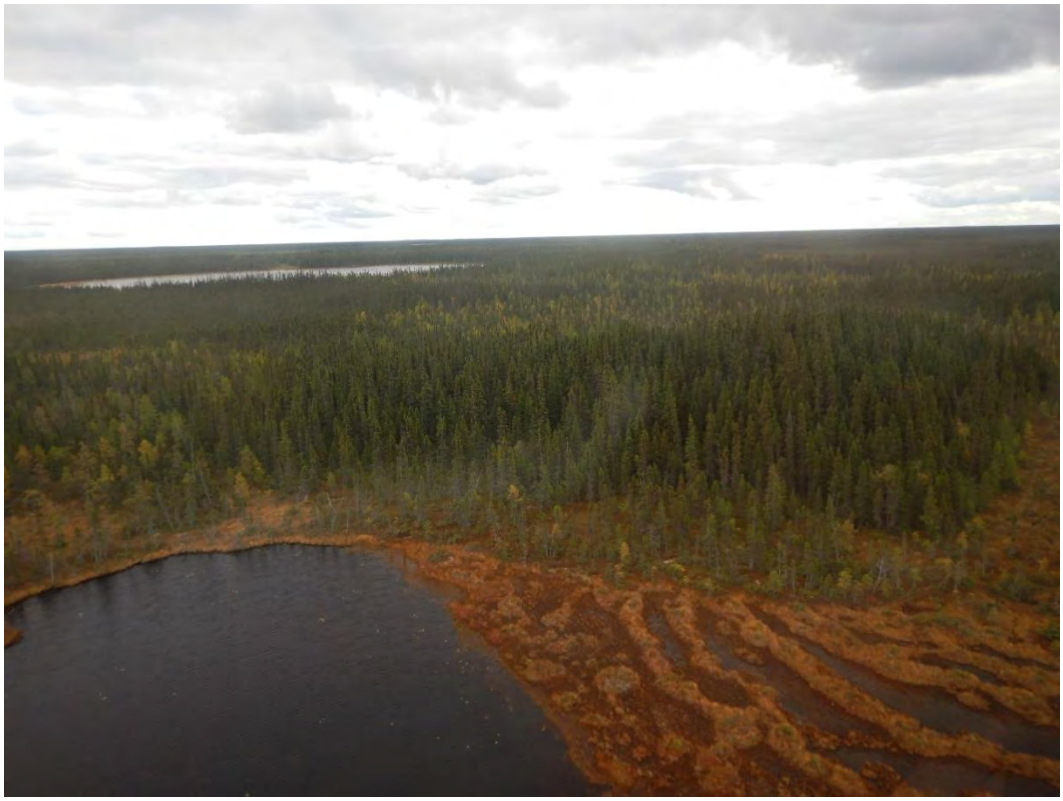

Figure 63: Location of TP19-11.

Figure 64: Crest of the ridge of the ice-contact glaciofluvial landform.

Figure 65: Test pit at TP19-11.

Figure 66: Gravel at TP19-11.

4 SUMMARY

Peat thickness measured from a soil probe returned values typically from 1 to 4 m, which is consistent with reported values from the wetlands classification system and previous observations from ground penetrating radar and peat probing. At most of the sampling sites, the peat probe penetrated the organic material and was stopped in underlying clay or clayey till.

Potential aggregate sources identified from published surficial mapping and recent terrain analysis using digital air photos and lidar include ice-contact glaciofluvial landforms and bedrock outcrops. Ice-contact glaciofluvial landforms on the west side of the route (TP19-01, TP19-02, TP19-09, and TP19-10) are primarily composed of clean medium to coarse sand and occur at locations close to the proposed routes. TP19-11, located near the middle of the route, is also an ice-contact glaciofluvial landform with good granular material. TP19-06 returned a clayey silt and no indication of bedrock.

Where granular material was encountered, the shallow test pits provide limited value to characterize the entire landforms on which they were dug. Further testing with drilling equipment would be required to evaluate the total thickness of the deposits and to calculate a volume of granular material. Test pits TP19-01, TP19-02, TP19-09 and TP19-11 are notable for being composed of granular material and for the relatively close proximity to the proposed routes, which will limit the haul distances of these aggregate sources. TP19-10 returned granular material and occurs on the one of the largest ice-contact glaciofluvial landforms, but it is located several kilometres from the proposed route and would require a stream crossing. TP19-11 is located near the half-way point of the route, but the landform is quite small and offers a limited volume of aggregate.

Bedrock outcrops are present within and outside of the routing corridor and are distributed across the study area (TP19-02, TP19-05, and TP19-08). At TP19-05, mapped as bedrock, there were boulder fields and till. Bedrock observed at the test sites was felsic plutonic (granitic), massive, and homogeneous, which should be suitable for aggregate production.

REPORT SIGNATURE PAGE

J.D. Mollard and Associates (2010) Limited

<original signed by>

Jason Cosford, Ph.D., P.Geo.

<original signed by>

<original signed by>

Lynden Penner, M.Sc. P.Eng., P.Geo.

APPENDIX C

Summary of Water Crossings

611910 Webequie Supply Road WSR Project

SUMMARY OF POTENTIAL WATERCOURSE CROSSING with width/geotechnical/foundation options

WC Number	Width (m)	Maximum Span (m)	Number of Spans	Foundation Type	Structural Type	Geotechnical
WC-1	253	253	7	Footing	Composite concrete deck with steel plate girders	BH19-01 0-0.3m organics, 0.3-2.1m compact to dense silt and sand till, 2.1m bedrock, WL at 0.3m bgs.
WC-1A	2.1	2.1	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-1B	1.8	1.8	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-2	10.7	12.9	1	Footing	Open Bottom Steel Box Culvert	No adjacent BH WQA-02 (approx. 1.2km away) 0-2.0m organics and peat, 2.0-5.2m compact to very dense silt and sand till, WL at 0.6m bgs
WC-2A	1.9	1.9	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-3	48	48	2	Footing	Composite concrete deck with steel plate girders	BH19-02, BH20-01. WQA-01 0-0.3m organics, 0.3-2.4m loose to very dense silty gravelly sand till, 2.4m bedrock, WL at 0.46m bgs.
WC-4	2.4	2.4	1	Footing	CSP Pipe culvert	BH20-02, WQA-03, WQA-04 0-0.2m organics, 0.2-7.7m loose to very dense sandy silt till, WL at 1.5m bgs.
WC-5	2.7	2.7	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-6	12.2	14.0	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-6A	2 x 1.9	2 x 1.9	2	Footing	2 CSP Pipe culverts	No BH information
WC-7	3.7	4.0	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-8	4.3	5.0	1	Footing	Open Bottom Steel Box Culvert	WQR-3 0-0.6m organics, 0.6-4.2m very loose to compact silt and sand till, 4.2m bedrock, WL at 0.76m bgs.
WC-9	2.5	6.5	1	Footing	Open Bottom Steel Box Culvert	No adjacent BH BH19-05 (approx. 2.1km away) 0-2.1m peat and organic soils, 2.1-8.0m dense to very loose sandy silt till, 8.0m bedrock, WL at 1.82m bgs.
WC-10	21.2	18	1	Pile	Composite concrete deck with steel plate girders	BH19-05 0-2.1m peat and organic soils, 2.1-8.0m dense to very loose sandy silt till, 8.0m bedrock, WL at 1.82m bgs.
WC-11	5.0	5.0	1	Footing	Open Bottom Steel Box Culvert	BH19-05 0-2.1m peat and organic soils, 2.1-8.0m dense to very loose sandy silt till, 8.0m bedrock, WL at 1.82m bgs.
WC-12	7.0	7.0	1	Footing	Open Bottom Steel Box Culvert	No adjacent BH WQR-4 (approx. 2.3km away) 0-2.6m peat, 2.6-3.8m loose to compact silty sand till, 3.8m bedrock, WL at 0.5m bgs.

WC Number	Width (m)	Maximum Span (m)	Number of Spans	Foundation Type	Structural Type	Geotechnical
WC-13	23.0	23.0	1	Pile	Composite concrete deck with steel plate girders	BH19-06 0-0.6m organics, 0.6-15m loose to very dense gravelly silty sand till, WL at 1.22m bgs
WC-14	4.0	4.5	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-15	5.0	7.5	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-16	7.0	7.0	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-17	2.0	3.0	1	Footing	CSP Pipe culvert	No adjacent BH WQR-5 (approx. 1.5km away) 0-0.9m peat, 0.9-2.0m very soft silty clay till, 2.0-4.7m loose to very dense sandy silt till, WL at 0.2m bgs.
WC-18	4.0	5.5	1	Footing	Open Bottom Steel Box Culvert	No adjacent BH BH19-07 (approx. 1.6km away) 0-0.3m organics, 0.3-10m loose to very dense silt till, WL at 1.99m bgs.
WC-19	20	23.0	1	Pile	Composite concrete deck with steel plate girders	BH19-07 0-0.3m organics, 0.3-10m loose to very dense silt till, WL at 1.99m bgs.
WC-20	3.4	5.0	1	Footing	Open Bottom Steel Box Culvert	No adjacent BH BH19-07 (approx. 1.8km away) 0-0.3m organics, 0.3-10m loose to very dense silt till, WL at 1.99m bgs.
WC-21	24	24	1	Footing	Composite concrete deck with steel plate girders	BH19-08, WQR-6A, WQR-6B 0-0.5m organics, 0.5-3m very loose to loose silty sand, 3-15.2m compact to very dense sandy silt to clayey silt till, WL at 1.5m bgs
WC-22	3.5	3.5	1	Footing	Open Bottom Steel Box Culvert	BH19-08, WQR-6A, WQR-6B 0-0.5m organics, 0.5-3m very loose to loose silty sand, 3-15.2m compact to very dense sandy silt to clayey silt till, WL at 1.5m bgs
WC-23	3.3	3.3	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-24	5.0	5.0	1	Footing	Open Bottom Steel Box Culvert	No BH information
WC-25	4.24	6 and 4	2	Footing	2 Open Bottom Steel Box Culvert	No adjacent BH GWMW10-04, BH19-10, BH19-P1 (Approx. 2.4-2.5m away) 0-0.3m organics, 0.3-2.6m compact to dense sand and gravel, 2.6m bedrock, WL at 0.3m bgs
WC-26	35.0	35.0	1	Footing	Composite concrete deck with steel plate girders	GWMW10-04, BH19-10, BH19-P1 0-0.3m organics, 0.3-2.6m compact to dense sand and gravel, 2.6m bedrock, WL at 0.3m bgs
WC-27	48	48	2	Footing	Composite concrete deck with steel plate girders	No BH information

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APPENDIX E

Preliminary Design Criteria

PROPONENT: ***Webequie First Nation***

PROJECT: ***Webequie First Nation Supply Road Project***

		SIGNATURE	DATE
PREPARED BY:	R. Manoochehri		
REVIEWED AND APPROVED BY:	R. Wargala		

ISSUE/REVISION INDEX

Issue Code	Revision					Revision Details
	No.	By	Rev'd.	App.	Date	
RR	PA	RC	RW	RW	2019-01-24	Released for Review and Comments
RR	PB	RM	RW	RW	2020-01-05	Released for Review and Comments

Issue Codes: RC = Released for Construction, RD = Released for Design, RF = Released for Fabrication, RI = Released for Information, RP = Released for Purchase, RQ = Released for Quotation, RR = Released for Review and Comments.

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13. COMMERCIAL ENTRANCES 3
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16. PAVEMENT WIDENING ON CURVES 3
17. PASSING LANES / TRUCK CLIMBING LANES 3
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Ministry of Transportation

Ministère des Transports

Ontario

DRAFT DESIGN CRITERIA

Preparation Date: February 28, 2019

WORK PROJECT NO. UNASSIGNED HWY NO. N/A TYPE OF PROJECT G, D, GB

LOCATION FROM WEBEQUIE FN, 107Km EASTERLY TO MCFAULDS LAKE AREA
WEBEQUIE FN, KENORA DISTRICT

		PRESENT CONDITIONS	DESIGN STANDARDS	PROPOSED STANDARDS
FUNCTIONAL HIGHWAY CLASSIFICATION		N/A	RCU80	RCU80
MINIMUM STOPPING SIGHT DISTANCE		N/A	130m	130m
EQUIVALENT MINIMUM "K" FACTOR	**CREST**	N/A	K=69[a]	K=69[a]
	SAG	N/A	K=30	K=30
GRADES MAXIMUM		N/A	6-8%[b]	6-8%[b]
RADIUS MINIMUM		N/A	250m e=6%	250m e=6%
PAVEMENT WIDTH		N/A	2x3.5m[c]	2x3.5m[c]
SHOULDER WIDTH		N/A	2.0m[d]	2.0m[d]
SHOULDER ROUNDING		N/A	0.5m	0.5m
MEDIAN WIDTH		N/A	N/A	N/A
R.O.W. WIDTH		N/A	45m	35m[e]
POSTED SPEED		N/A	80Km/h	80Km/h
MISCELLANEOUS		N/A	N/A	MIN. GRADE= 0.1%-0.5% CROSS SLOPE= 4%

RECOMMENDED BY:

Signature:

Printed Name:

Date:

MTO PROJECT MANAGER / ENGINEER

Signature:

Printed Name:

Date:

HEAD, PLANNING AND DESIGN or HEAD, STRUCTURAL

APPROVED BY:

Signature:

Printed Name:

Date:

REGIONAL MANAGER, ENGINEERING

Signature:

Printed Name:

Date:

REGIONAL MANAGER, TRAFFIC

WORK PROJECT NO. UNASSIGNED HWY NO. N/A TYPE OF PROJECT G, D, GB

TRAFFIC

The Webequie Supply Road (WSR) is expected to be a low volume road with an anticipated AADT of <500

NOTES

(a) Vertical curvature design for passing sight distance based on Exhibit 3-L TAC-MTO Design Supplement.
(b) Maximum grade based on Exhibit 3-H TAC-MTO Design Supplement.
(c) Minimum lane width based on Exhibit 4-B TAC-MTO Design Supplement.
(d) Minimum shoulder width based on Exhibit 4-G TAC-MTO Design Supplement.
(e) Right-of-way width to include accommodation for future power transmission line.

REMARKS

1. Project Purpose and Scope

This project will serve to link the Webequie First Nations community to the McFaulds Lake area, facilitating the movement of materials, supplies and people from the Webequie Airport to the area of existing mineral exploration activities and proposed mine developments. The road will consist of a corridor 35 m wide and approximately 107 km long, with accommodation for a future power transmission line. The road will take the form of a two-lane gravel surfaced facility.

2. Design Year

The Design Year is estimated to be 2025.

3. Related Studies and Adjacent Projects

An environmental assessment (EA) study has commenced for a North-South road linking the mineral exploration activities in the McFaulds Lake area to the Provincial highway network at Nakina.

4. Environmental Requirements

The Project is subject to the *Ontario Environmental Assessment Act* (OEAA) and the *Canadian Environmental Assessment Act, 2012* (CEAA). An EA Coordination Team, comprised of the Ministry of Energy, Northern Development and Mines; the Ministry of the Environment, Conservation and Parks; the Ministry of Natural Resources and Forestry; and the Canadian Environmental Assessment Agency, has been established to coordinate the requirements of both processes as efficiently as possible. Under the OEAA, an individual EA is required; the Terms of Reference phase commenced in January 2019.

5. Pavement

The road will be gravel surfaced, including shoulders. Materials will be sourced from local sand and gravel pits or quarries near the road.

6. Crossfall

For positive drainage purposes on the unpaved gravel surface, a cross-fall of 4% is recommended.

7. Superelevation

Maximum superelevation is 6%.

8. Drainage

Roadside ditches shall be sized to accommodate a minimum 10-year Minor System Design Flow, and a minimum 100-year Major System Design Flow (MTO Drainage Standards SD-1, SD-9).

Crossing culverts shall be sized to accommodate a minimum 25-year return period design flow for structures with a total span less than or equal to 6.0 m, and a minimum 50-year return period design flow for structures with a total span greater

than 6.0 m (MTO Drainage Standards WC-1, WC-7). A minimum culvert diameter or rise of 600 mm will be provided for circular, elliptical or arch culverts. A minimum 900 mm rise will be provided for box culverts (MTO Drainage Standards WC-8).

9. Roadside Safety

Roadside safety design shall be according to the MTO Roadside Design Guide (Dec 2017) and will be determined during detail design.

10. Signing

Signage is to be determined during detail design.

11. Illumination

Illumination requirements are to be determined during detail design. Continuous full illumination is not anticipated due to practicality and/or availability of stable hydroelectric connections. At this time, it does not appear that Illumination warrants according to MTO Directive PLNG-B-05 will be met.

12. Traffic Signals

Not applicable to this project.

13. Commercial Entrances

Commercial entrances are to be determined during detail design and as local development progresses.

14. Intersections

Intersection design shall be carried out in accordance with TAC Geometric Design standards and the MTO/TAC Supplenet. This will be determined during detail design.

15. Structures

Structural design for bridges and culverts exceeding a 3.0m clear span is to be carried out upon selection of a preferred alignment. Structural design shall further take into consideration remote access constraints and material availabilities and shall be done in accordance with the Canadian Highway Bridge Design Code.

16. Pavement Widening on Curves

Not applicable to this project.

17. Passing Lanes / Truck Climbing Lanes

Not applicable to this project.

18. Fencing

Not applicable to this project.

19. Active Transportation Infrastructure

Not applicable to this project.

20. Property Requirements

35m wide ROW to be defined upon selection of a preferred alignment to be determined as part of the study.

21. Railway Crossings

Not applicable to this project.

22. Utilities and Pipelines

Not applicable to this project.

WORK PROJECT NO. UNASSIGNED HWY NO. N/A TYPE OF PROJECT G, D, GB

23. Construction Staging

To be updated once alignment has been set to consider impacts.

24. Legal Agreements and Approvals

The Project requires approvals under the Ontario *Environmental Assessment Act* (OEAA) and the *Canadian Environmental Assessment Act, 2012* (CEAA). In addition, provincial and federal permits, licences, approvals and authorizations will be required, with the scope and conditions of these PLAA dependent upon the final alignment and potential impacts of the road.

25. ATMS

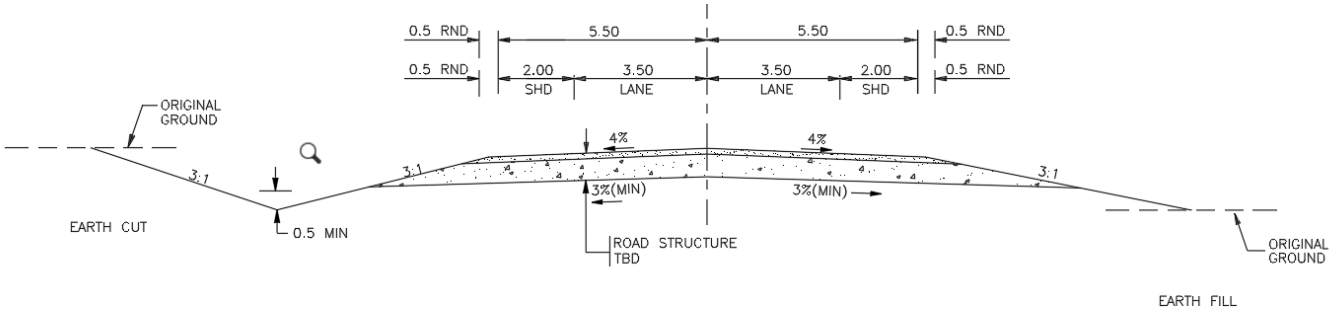
Advanced Traffic Management Systems are not applicable to this project.

26. Miscellaneous

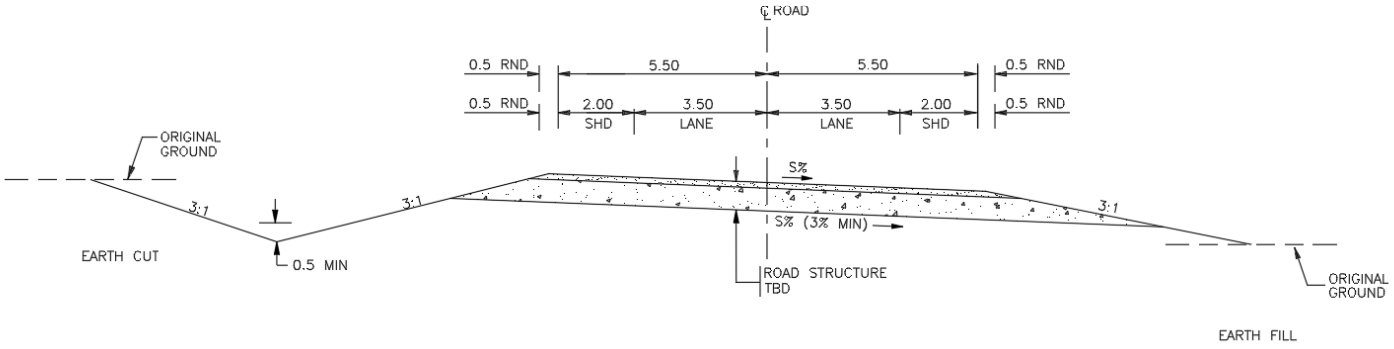
The design speed for this project is 80Km/h with a posted speed limit of 80Km/h.

WORK PROJECT NO. UNASSIGNED HWY NO. N/A TYPE OF PROJECT G, D, GB

Cross-Section



WEBEQUIE SERVICE ROAD
TANGENT SECTION



WEBEQUIE SERVICE ROAD
SUPERELEVATED SECTION

WORK PROJECT NO. UNASSIGNED HWY NO. N/A TYPE OF PROJECT G, D, GB

27. Key Plan (NTS)

APPENDIX F

Hydrologic and Hydraulic Analysis for the Webequie First Nation Supply Road

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To:	Webequie Supply Road Project File	**Date:**	August 16, 2024
Attention:			
cc:	Craig Wallace		
From:	Beth Robertson, Water Resources Engineer	**Project.:**	Webequie First Nation Supply Road - 661910
Subject:	**Hydrologic and Hydraulic Analysis for the Webequie First Nation Supply Road: Revision 2**		

This memorandum summarizes the preliminary hydrologic and hydraulic analysis of the watercourse crossings for the Webequie Supply Road Project ('the Project", "WSR"). The purpose of this memo is to summarize the hydrologic conditions for the Project and estimate the hydraulic characteristics and water levels under current/existing conditions and is intended to support the preliminary engineering design for the road.

The Webequie Supply Road (WSR) will extend in a southeast direction from the Webequie community, then easterly to a termination point near McFaulds Lake. The total length of the proposed corridor is approximately 107 km. The Project will also include temporary and permanent supportive infrastructure elements, such as aggregate access roads. The primary purpose of the Webequie Supply Road is to accommodate an all-season road that connects Webequie First Nation to existing mineral exploration and potential future mining activities in the McFaulds Lake area.

1 Introduction

1.1 Background Information

The following background information was reviewed in order to undertake the proposed work.

- Regional hydrology data obtained from the *Ontario Flow Assessment Tool* (MNRF, 2019, discontinued) and *Ontario Watershed Information Tool* (MNRF, 2023)
- Google Earth Satellite Imagery
- LiDAR data and orthoimagery collected along the corridor (collected October 6 – 7, 2017)
- Field notes from AtkinsRéalis site geotechnical and biological investigations reconnaissance
- NASA satellite-based water level fluctuation data, 10-day resolution, 4 lakes in Regional Study Area (Water Measurements Lakes and Reservoirs (nasa.gov)
- Environment Canada, Water Survey of Canada Monitoring Stations and Climate Data Stations
- Intensity, duration, frequency curves (Environment Canada, IDF_CC Tool, MTO)
- Ring of Fire Baseline Environmental Monitoring Program (Preliminary Report; MECP October 2019)

1.2 Site Conditions

The project area is situated within the primary Southwestern Hudson Bay watershed and has many different types of waterbodies, including streams, rivers, lakes, ponds, and wetlands (over 50% of the ecoregion - Big Trout Ecoregion - is covered by wetlands). Bogs and fens dominate the eastern part of the region. To the west, forest stands occupy higher ground formed on glacial materials, such as eskers, and on better-drained slopes next to rivers. Portions of the preferred corridor for the all-season road traverse intact boreal forest (including treed bogs and fens). The terrain is generally low gradient with large wetland areas, several lakes and ponds, and slow flowing, often meandering streams and rivers. Annual precipitation levels in the area tend to exceed 700 mm, of which over 200 mm is typically snow.

The stream banks are typical of low gradient watercourses in the region and are well defined by boulders, bedrock outcrops, and natural levees. Beaver dams are common features on small to medium sized streams. Stream flow peaks in the spring as a result of snowmelt runoff and rainfall runoff from saturated soils. Flows recede through the summer and increase in the fall due to an increase in rainfall and a decrease in evaporation. Flows are normally lowest in winter, and some small streams freeze completely to the stream channel bed.

1.3 Watershed Characteristics

Thirty-one (31) water crossings (watercourse/waterbody) have been identified for the proposed WSR and aggregate access roads. These crossings have been noted has having a defined channel/flow path and do not include wetlands or areas that may experience transient flow. The Ontario Flow Assessment Tool (OFAT) was utilized to calculate watershed characteristics. OFAT was developed by the Ontario Ministry of Natural Resources and Forestry (MNRF) and powered by Land Information Ontario, Queen's Printer for Ontario, 2013, re-launched in 2022 as Ontario Watershed Information Tool (OWIT). The water crossing locations of the preliminary preferred supply road corridor are shown in the **Figures** attachment at the end of this memorandum **(Figures F.1 to F.3)**, and details of each crossing watershed can be found in **Appendix A**.

1.4 Gauged Catchments

Environment Canada - Water Survey of Canada (WSC) maintains several hydrometric monitoring stations throughout northern Ontario. Environment Canada also maintains several climate stations. The locations of these stations within the vicinity of the project site are shown on **Figure 1-1** and the station details are summarized in **Table 1-1**.

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Figure 1-1 Water Survey of Canada Monitoring Stations and Climate Data Stations Locations

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Table 1-1 Environment Canada Flow and Climate Data

Station ID	Station No.	Drainage Area (km^2)	Operating Years
Water Survey of Canada Monitoring Stations			
Albany River above Nottik Island	04GD001	32,400	1966 - 2022
Asheweig River at Straight Lake	04DB001	7,950	1966 - 2022
Attawapiskat River below Attawapiskat Lake	04FB001	24,200	1965 - 2022
Attawapiskat River below Muketei River	04FC001	36,000	1968 - 2021
Blackwater River at Beardmore	02AD010	652	1971 - 2022
Brightsand River at Moberley	04GB005	1,140	1968 - 2022
Ekwan River below North Washagami River	04EA001	10,400	1967 - 2022
Fawn River below Big Trout Lake	04CE002	4,350	1966 - 1991
Kabinakagami River at Highway No. 11	04JA002	3,780	1950 - 1987
Kapuskasing River at Kapuskasing	04LF001	6,760	1918 - 2022
Kawinogans River near Pickle Crow	04FA002	1,540	1967 - 2023
Kenogami River near Mammamattawa	04JG001	26,200	1966 - 2022
Little Current River at Percy Lake	04JF001	5,300	1968 - 2022
Mattawishkwia River at Hearst	04LK001	1,170	1986 - 2022
Muswabik River at Outlet of Muswabik Lake	04GF001	1,890	1970 - 1995
Muketei River Near Otoskwin-Attawapiskat River Provincial Park	04FC003	2,310	2013 - 2022
Nagagami River at Highway No. 11	04JC002	2,180	1950 - 2023
Ogoki River above White Clay Lake	04GB004	11,200	1971 - 2023
Otoskwin River below Badesdawa	04FA001	9,010	1966 - 2023
Pagwachuan River at Highway No. 11	04JD002	2,120	1968 - 2022
Pashkokogan River at Outlet of Pashkokogan Lake	04GA003	2,230	1968 - 2022
Pineimuta River at Eyes Lake	04FA003	4,900	1966 - 2022
Pipestone River at Karl Lake	04DA001	5,960	1966 - 2023
Shamattawa River at Outlet of Shamattawa Lake	04DC002	4,710	1966 - 2023
Shekak River at Highway No. 11	04JC003	3,290	1950 - 1987
Whitesand River above Schreiber at Minova Mine	02BA005	10.8	1989 - 2023
Winisk River at Kanuchuan Rapids	04DA002	19,000	1967 - 2022
Winisk Lake at Webequie	04DA003	Unknown	1969 - 1972
Attawapiskat Lake at Lansdowne House	04FB002	Unknown	1966 - 1972
Historical Climate Data			
Big Trout Lake	6010738	-	1967 - 1992
Lansdowne House (Aut)	6014353	-	1992 - 2023
Ogoki Post A	6075786	-	2014 - 2022

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1.5 Design Criteria

The Ministry of Transportation (MTO) Highway Drainage Design Standards (MTO, 2008) will be applicable to the Project which will be used to design three main structure types at the water crossings:

- Bridge: Composite Concrete Deck with Steel Plate Girders.
- Open-Footing Culvert: Rectangular, High Span Arch, Low Span Arch.
- Round Corrugated Culvert.

1.5.1 Design Flow

It is understood that the road will be considered a **Collector Road**. The typical design flow criteria for water crossings under this classification is 1 in 50-year, as listed in Error! Reference source not found. (from MTO Standard WC-1: *Design Flows (Bridges and Culverts)*). Due to the remote location and roadway importance, a low risk-tolerant approach was taken to manage impacts that could result in roadway disconnections by using the highest road classification to determine the design flow.

A preliminary review of the Ontario-specific climate models on the Ontario Climate Data Portal identified that future increases in rainfall intensities could be expected and could be as high as 40% from current meteorological conditions.

Therefore, a **climate change affected 1 in 100-year design flow** was adopted for all the water crossings in the Project.

Table 1-2: MTO Design Flow Criteria (MTO, 2008)

Design Flow Return Period for Bridges and Culverts - Standard Road Classifications			
Functional Road Classification	**Return Period of Design Flows (Years) [1,2,3]**		**Check Flow for Scour**
	Total Span less than or equal to 6.0 m	**Total Span greater than 6.0 m**	
Freeway, Urban Arterial	50	100	130% of 100 year
Rural Arterial, Collector Road	25	50	115% of 100 year
Local Road	10	25	100% of 100 year

Note:
1. The listed design flows apply to roads under the jurisdiction of the Ministry of Transportation.
2. The Fish Passage Design Flow for culverts is defined in Standard WC-12 Fish Passage Requirements Through Culverts
3. Sometimes referred to as Normal Design Flow

1.5.2 Freeboard and Clearance

As per MTO Standards (WC-2: *Freeboard and Clearance at Bridge Crossings*), design criteria for bridges on freeways, arterials, and collector roads shall be:

- Freeboard greater than or equal to 1.0 m to the edge of the travelled lane.
- Clearance greater than or equal to 1.0 m.
- Water level used is the higher of:
    - Design Flow high water level.

- Ice Jam high water level.

As per MTO Standards (*WC-7: Culvert Crossings on a Watercourse*), design criteria for culverts on freeways, arterials, and collector roads shall be:

- Freeboard greater than or equal to 1.0 m to the edge of the travelled lane.
- Clearance for open footing rectangular cross section shall be 0.3 m.
- Clearance for open footing irregular cross section shall 0.3 m below effective rise (total flow area / effective span).
- Flood depth at upstream face (HW) of a culvert shall be:
  - for culvert diameters (D) <3.0 m; HW / D less than or equal to 1.5.
  - for diameters 3.0 m to 4.5 m; HW less than or equal to 4.5 m.
  - for diameters >4.5m; HW / D ≤1.0.

1.5.3 Fish Passage

As per MTO Highway Design Standards (2008; *WC-12: Fish Passage through Culverts*), design criteria for culverts on fish bearing streams shall be:

- Fish Passage Design Flow will be 1 in 2-year return period (to represent bankfull conditions).
- Velocity in culvert for Fish Passage Design Flow shall not exceed natural channel.
- Depth in culvert for Fish Passage Design Flow shall be consistent with upstream and downstream depth with no sudden drops exceeding 0.15 m.
- Culvert width shall be sufficient to maintain Fish Passage Design Flow width.

1.5.4 Navigation

Project has made clearance allowances for navigation for small watercraft, such as canoes or kayaks, in streams where the flow is enough to support them, which has been assumed to be streams with a width of 3.0 m or greater. Transport Canada has developed criteria for minimum navigational clearances required for unpowered (paddled) vessels, which shall be:

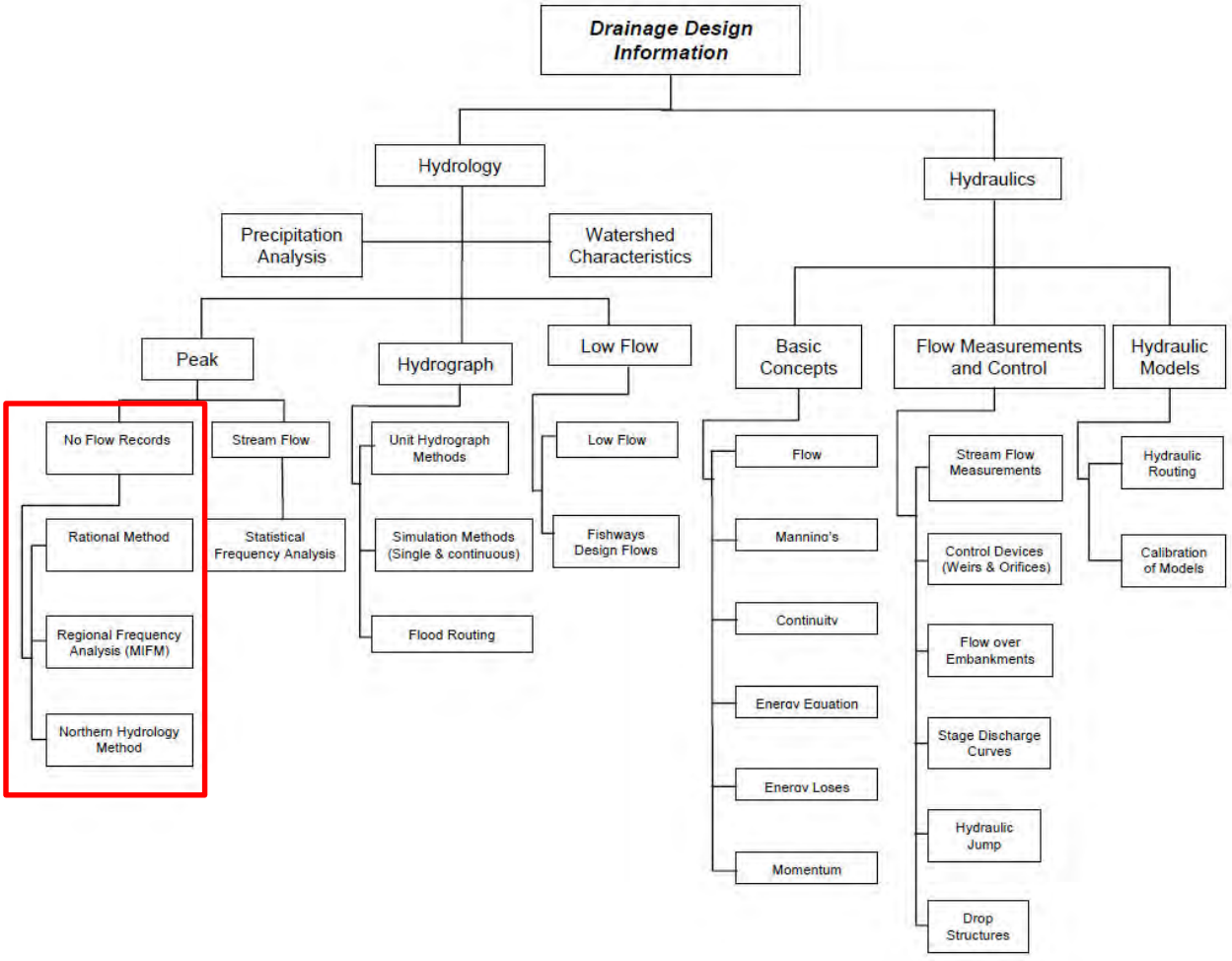
- Navigational Design Flow will be 1 in 2-year return period.
- Clearance for bridges at Navigational Design Flow will be 3.0 m.
- Clearance for culverts at Navigational Design Flow will be 1.5 m.

2 Peak Discharge Estimation

2.1 Methodology/Approach

The method of establishing the peak discharge for the water crossings depends on several factors such as available data, project location, and watershed catchment size. **Figure 2-1** outlines the general approach to identifying the methods to follow when estimating peak design flows for roads. To size the water crossing structures, a full hydrograph of the design flow is not required; the peak discharge is sufficient. Several methods, summarized below, are available to estimate the peak discharge. It should be noted that the proposed crossings are generally on streams that are not gauged (i.e., no flow records), except for Muketei River.

Figure 2-1 Computation Selection Procedure (source: MTO Drainage Management Manual)



2.1.1 Rational Method

When catchment areas are quite small, it can be assumed that the peak runoff event would result from a summer rainstorm. The Rational Method was used to estimate the peak runoff flow at small drainage areas with the following equation:

$$Q = 0.278\, CiA$$

where:

Q = peak runoff flow (m^3/s);
C = runoff coefficient;
i = rainfall intensity (mm/hr); and
A = catchment area (km^2).

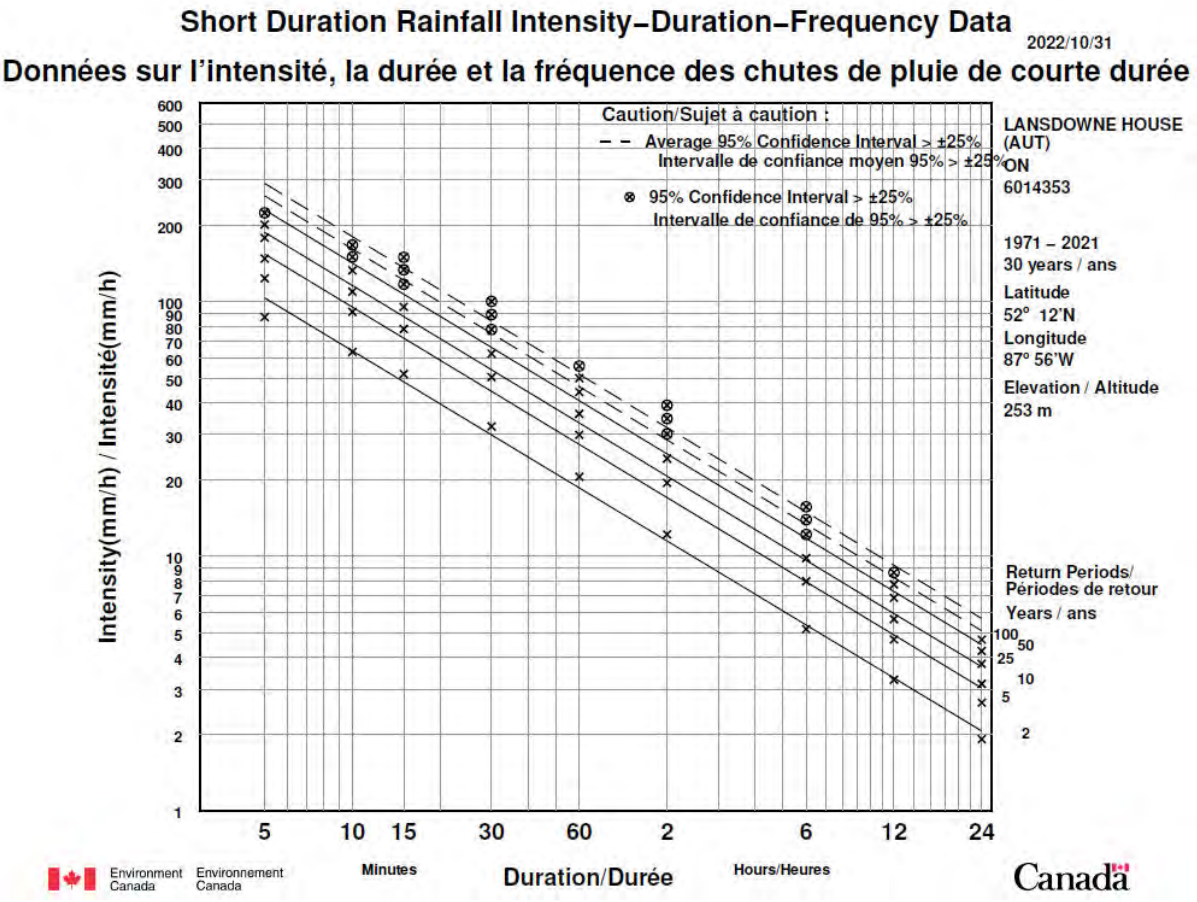
Runoff coefficients represent the proportion of the total rainfall that contributes to the catchment and it is affected by multiple variables such as underlying soil properties, ground cover, terrain slope, depression storage, and antecedent moisture. Available information on these variables were as follows:

- The soil properties for the catchment were obtained from the Draft WSR – Natural Environment Existing Conditions report (AtkinsRéalis 2023). Generally, the surficial soil consists of a silt matrix in the west and organic deposits in the west, with a gravel/sand deposit at the eastern terminus.
- The ground cover (trees, wetlands, lakes etc.) were delineated using orthoimagery collected in conjunction with the LiDAR data.
- The average terrain slope was estimated from LiDAR data.

Runoff coefficients for wetlands, lakes, and woodland were taken from the MTO Hydrotechnical Design Charts. Lakes and wetlands were assumed to have a runoff coefficient of 0.05 and woodland was assumed to have runoff coefficients ranging from 0.08 and 0.25, representing flat slopes (less than 5%) with open sand loam and silt loam.

The rainfall intensity for the peak runoff events were estimated from the Short Duration Rainfall Intensity-Duration-Frequency curve for Lansdowne House, ON (Environment Canada 2022) as shown in Figure 2-2. To obtain the rainfall intensity that will result in the peak runoff flow, the time of concentration (time it takes for runoff to flow from the remotest point to the mouth of the catchment) is needed. The average of several conventional equations was used to estimate the time of concentration based on the length and slope of the longest drainage path within the catchment. LiDAR data collected along the proposed alignment was used to delineate the flow path and average slope.

Figure 2-2 IDF Curve for Lansdowne House.



The 2-year, 25-year, 50-year, and 100-year peaks were calculated for the smaller WSR crossings (between from <1km^2 up to 10 km^2) using Rational Method and are presented in Section 2.1.8. Although MTO limits the use of Rational Method to drainage areas less than 100 ha (1 km^2), larger sizes were calculated for assessment of the applicability in comparison to other methods.

2.1.2 Index Flood Method

The Index Flood Method (IFM) was developed by U.S. Geological Service (Dalrymple 1960). This method involves the development of two curves. The first is a flood frequency curve, showing peak discharge versus recurrence interval to obtain the mean annual flood (1 in 2.33-year). The second curve relates the mean annual flood to drainage area (or other significant characteristics).

The IFM results were obtained from OFAT for most water crossings prior to the re-launching into OWIT and are presented in Section 2.1.8. The discharge estimate feature is no longer available in OWIT.

2.1.3 Modified Index Flood Method

The Modified Index Flood Method (MIFM) is based on the IFM described above and was developed by MTO (1986) and updated by Joy and Whiteley (1996) to estimate peak flows for the design of bridges and culverts in Ontario. The MIFM calculates an index flood (the 1 in 25-year) based on characteristics of the watershed upstream of the selected location (e.g. slope, shape, detention). The 1 in 25-year index flow was developed using regional frequency analysis of WSC gauges for medium to large watersheds. For other return periods, a ratio of Q_x / Q_{25} is specified to estimate Q_x, as shown in Table 2-1.

Table 2-1. MIFM frequency conversion (source: MTO 1997b)

Basin Type	Return Period (years)					
	2.33	5	10	25	50	100
Shield and Detentive type Southern Basins	0.54	0.70	0.84	1.00	1.12	1.25

The MIFM is applicable for watersheds larger than 25 km^2. For watersheds 5 – 25 km^2, it's recommended that results should be compared to other methods that are more applicable to smaller watersheds. The equation to estimate the Index Flood is as follows:

$$Q_{25} = C_{25}A^{0.75}$$

where:

Q_{25} = Peak flow of 1 in 25-year (m^3/s);
C_{25} = flood coefficient from a relationship connecting watershed characteristics to watershed class;
A = catchment area (km^2).

The frequency conversions for Northern Ontario basins are provided in Table 2-1.

The watershed class is based on the relative area of features that detain water (lakes and wetlands) to the total watershed area and how the lakes and wetlands are distributed throughout the catchment. The watershed class design chart used to define the watershed class is shown in Figure 2-3 and the flood coefficients applicable to each class are shown in Table 2-2.

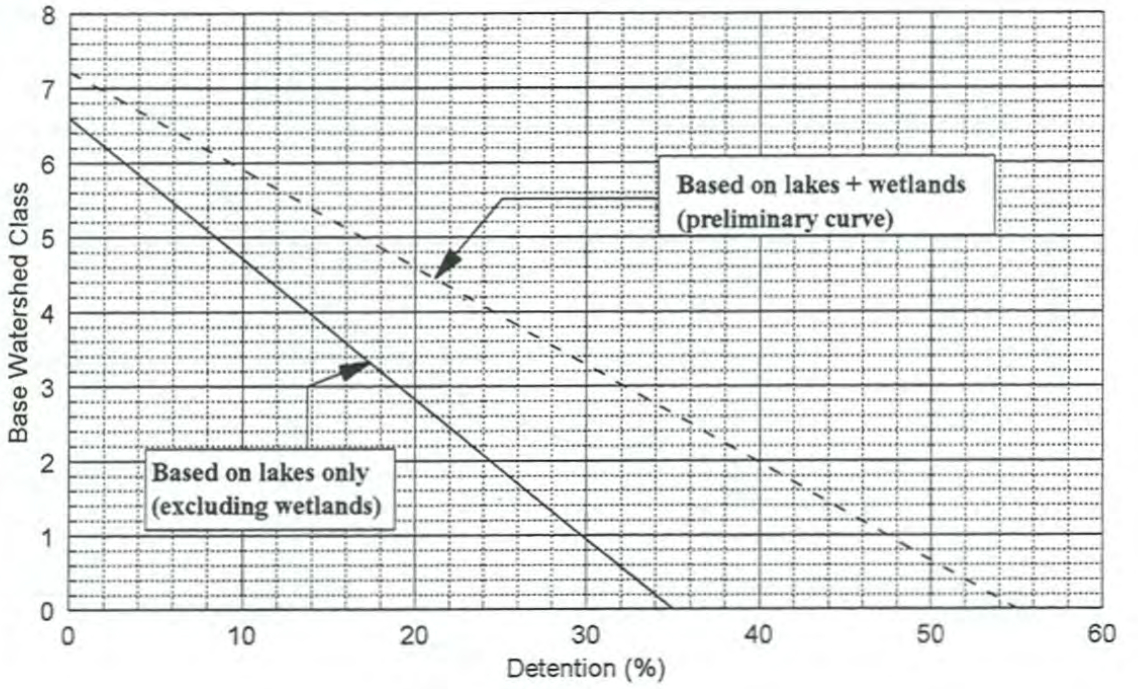


Figure 2-3 **Base watershed class design curves (source: MTO 1997a)**

Table 2-2 **Watershed classes and related flood coefficients (reproduced from: MTO 1997a)**

Watershed Class	Coefficient, C
1	0.15
2	0.22
3	0.31
4	0.44
5	0.63
6	0.90
7	1.29
8	1.84
9	2.62
10	3.74
11	5.34
12	7.63

In 1992, MTO commissioned University of Guelph to review the MIFM relationship and test the applicability through comparison of flow frequency analyses at 23 Northern Ontario stations, as shown in Figure 2-4. Note that all the reference stations are far from the Project area, and mostly along the southern portion of the Canadian Sheild. The wetland and lake area percentage of these stations ranged from 6.4% to 33.5%, generally lower than those of the Project crossing catchments.

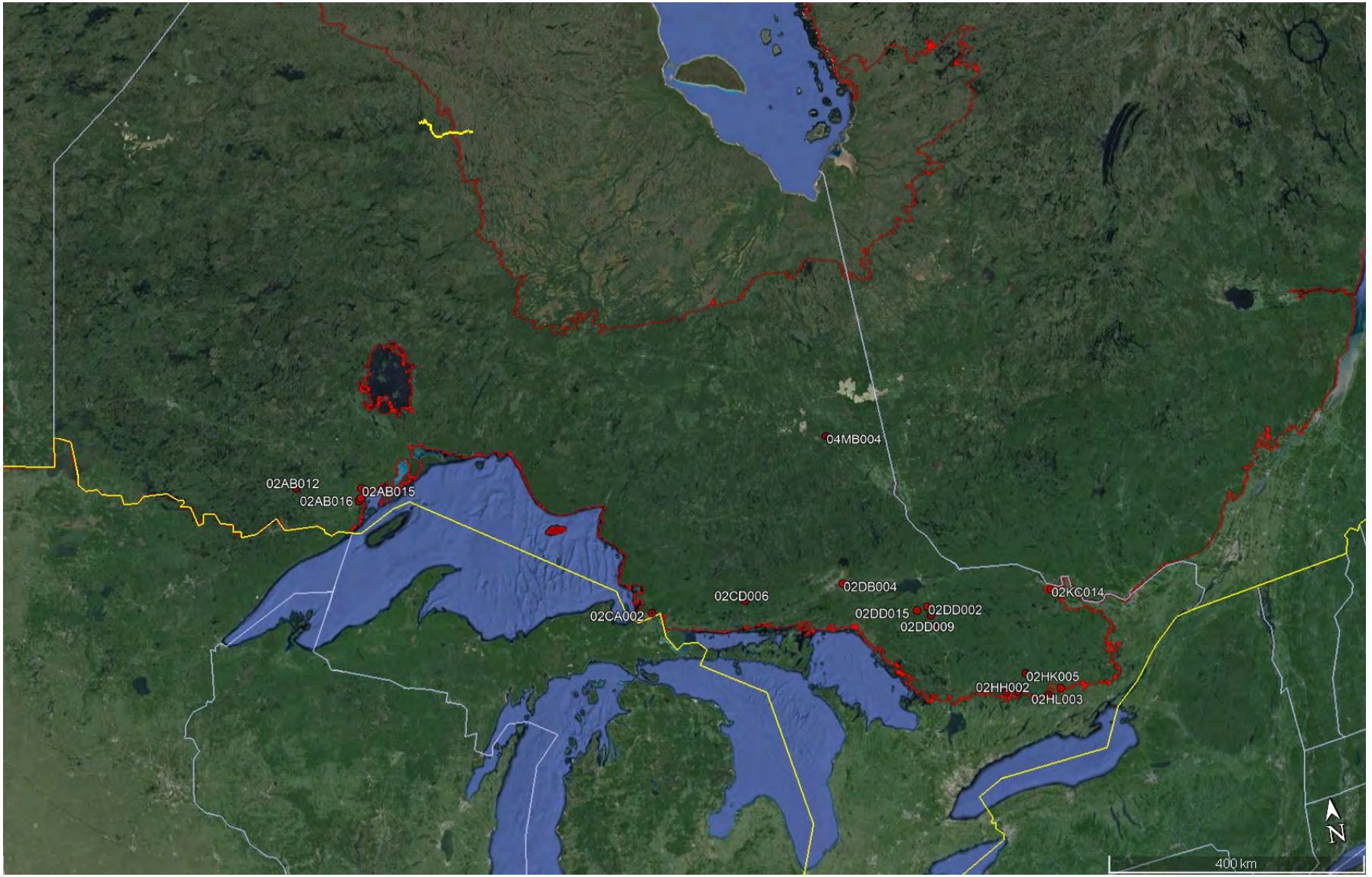


Figure 2-4 MIFM calibration stations, Canadian Shield outline (red), and proposed WSR roadway (yellow).

2.1.4 Transposition of Flood Discharges (using single station)

If a stream flow gauging station with a long period of record is available, Single Station Flow Frequency Analysis can be used to derive the design flow rate and transfer to the waterbody crossing of interest using relative drainage area sizes. The most reliable stream gauge data available from the nearest stream gauging station should be used for Single Station Frequency Analysis, and gauge data from an adjacent waterbody can be transposed to the crossing location, as long as the two watersheds are hydrologically equivalent.

A flow frequency analysis was done on three WSC gauges:

- Attawapiskat River below Attawapiskat Lake (04FB001); 24,200 km^2
- Attawapiskat River below Muketei River (04FC001); 36,000 km^2
- Winisk River at Kanuchuan Rapids (04DA002); 19,000 km^2

The stations were selected because they were near the project area and have long periods of record (>50 years). A flow frequency analysis was done using the annual maximum discharges and the flood peaks for various discharges using the best fit distribution. This was derived from OFAT for most water crossings prior to the re-launching into OWIT. The resulting peaks were transferred to each crossing using the following equation (MTO 2003):

$$Q_2 = Q_1 \times (A_2/A_1)^{0.75}$$

where:

Q_1 = known flow at gauge (m^3/s);
Q_2 = unknown flow at crossing (m^3/s);
A_1 = known catchment area at gauge (m^2); and
A_2 = known catchment area at crossing (m^2).

The three transposition of flood discharges results were averaged and are shown in Figure 2-18 and

Figure 2-19. Note that the WSC gauges had relatively large drainage areas (19, 000 km^2 to 36, 000 km^2) compared to the project crossing drainage areas (<1 km^2 to 1,774 km^2), so a more detailed regional flow frequency analysis was completed.

2.1.5 Transposition of Flood Discharges (using Regional Flow Frequency Analysis)

Regional flow frequency analysis (RFFA) was completed using 14 WSC gauges. All gauges near the study area with relatively long periods of record (e.g. at least 10 years of data), similar land use (mainly wetlands with some forest) and topography (flat terrain) were chosen. Stations with a large range of drainage areas were available, ranging from 10.8 km^2 to 4,900 km^2, as all of the water crossings along the WSR proposed alignment have drainage areas less than 2,000 km^2.

A list of the stations used is provided in Table 2-3. A linear regression between mean daily maximums and instantaneous maximums were established for each gauge to fill in missing years for the instantaneous maximum discharge records.

Table 2-3 Regional Flow Frequency Analysis WSC Gauges

Station ID	Station No.	Drainage Area (km^2)	Operating Years
Blackwater River at Beardmore	02AD010	652	1971 - 2022
Brightsand River at Moberley	04GB005	1,140	1968 - 2022
Fawn River below Big Trout Lake	04CE002	4,350	1966 - 1991
Kabinakagami River at Highway No. 11	04JA002	3,780	1950 - 1987
Kawinogans River near Pickle Crow	04FA002	1,540	1967 - 2023
Mattawishkwia River at Hearst	04LK001	1,170	1986 - 2022
Muswabik River at Outlet of Muswabik Lake	04GF001	1,890	1970 - 1995
Nagagami River at Highway No. 11	04JC002	2,180	1950 - 2023
Pagwachuan River at Highway No. 11	04JD002	2,120	1968 - 2022
Pashkokogan River at Outlet of Pashkokogan Lake	04GA003	2,230	1968 - 2022
Pineimuta River at Eyes Lake	04FA003	4,900	1966 - 2022
Shamattawa River at Outlet of Shamattawa Lake	04DC002	4,710	1966 - 2023
Shekak River at Highway No. 11	04JC003	3,290	1950 - 1987
Whitesand River above Schreiber at Minova Mine	02BA005	10.8	1989 - 2023

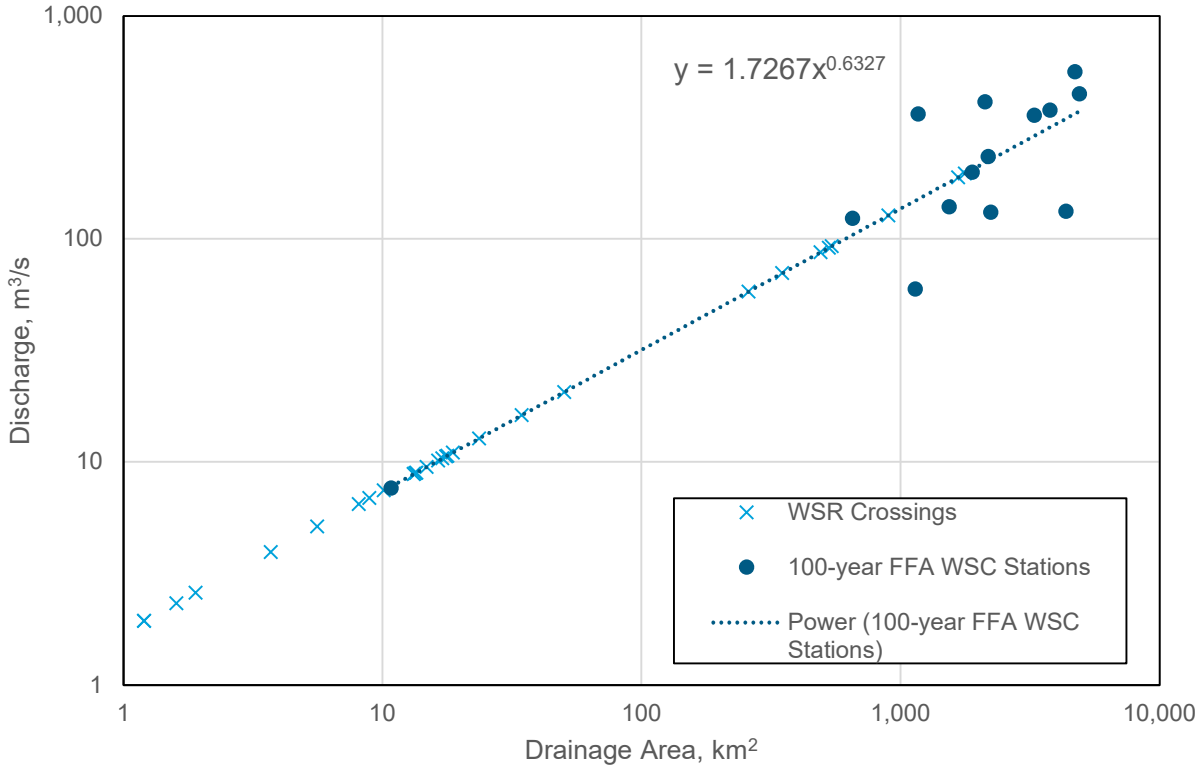
A flow frequency analysis was done on each station's dataset and the flood peaks for various return periods were computed using the distribution that best fit the historic instantaneous maximums. The resulting flood peaks for each return period were plotted against their drainage area on a log-log scale and fit with a power curve. For example, the resulting 100-year equation is:

$$Q_{100} = 1.7267DA^{0.6327}$$

as show in **Figure 2-5**. The WSR water crossing drainage areas (DA) were input into the power curve equations to get the flood peak discharge estimates. Note that there is limited observed data for the range of drainage areas at the proposed crossings (1 km^2 to 1,775 km^2).

The results of the Transposition of RFFA peak discharges are presented in Section 2.1.8.

Figure 2-5 Regional Flow Frequency Curve for 1 in 100-year.



2.1.6 Northern Ontario Hydrology Method

Northern Ontario Hydrology method (NOHM) was developed by Queen's University to determine peak flows on smaller, ungauged streams in northern Ontario within the Canadian Shield and with catchment areas ranging from 1 km^2 to 100 km^2. A series of equations are solved to get peak flows:

1. Calculate mean annual discharge: $Q_{mean} = 0.170 \times A^{1.06}(1 - A_d/A)^{2.07}$
2. Calculate coefficient of discharge: $C_v = 0.502 \times (1 - A_d/A)^{1.85}$
3. Calculate coefficient of skew: $C_s = -2.52 + [3.73 \times (1 - A_d/A)]$
4. Determine frequency factor: $k: from\ design\ chart, based\ on\ C_s$
5. Calculate maximum daily discharge: $Q_{max} = Q_{mean} \times (1 + 5 \times C_v)$
6. Calculate peaking factor: $Lake\ outlet: P_f = 1 + e^{[-22 \times (A_d/A - 0.06)]}$
   $Normal\ outlet: P_f = 1 + 6 \times A^{-0.36} \times e^{[-18 \times (A_d/A)]}$
7. Calculate max instantaneous discharge: $Q_{int} = Q_{max} \times P_f$

where:

A	=	drainage area, km^2
A_d	=	lake and wetland area, km^2
Lake Outlet	=	greater than 6% and skewed toward outlet
Normal Outlet	=	even distribution of lakes and wetlands.

The equations are based on 15 WSC stations with small drainage areas with over 10 years of record, as shown in Figure 2-6. The stations are mainly located along the southern border of the Canadian Shield, much further south than the project area. The drainage areas in the study ranged from 1.8 km^2 to 548 km^2, with percentages of lakes and wetlands ranging from 4% to 35%.

The NOHM for smaller water crossings (<100 km^2) was calculated using a series of equations and the drainage areas and lake/wetland areas obtained from OWIT. The percentage of lakes/wetlands for the Project water crossings ranged from 46% to 98%, much higher than the original study. This resulted in very small 100-year peak values, and are presented in Section 2.1.8.

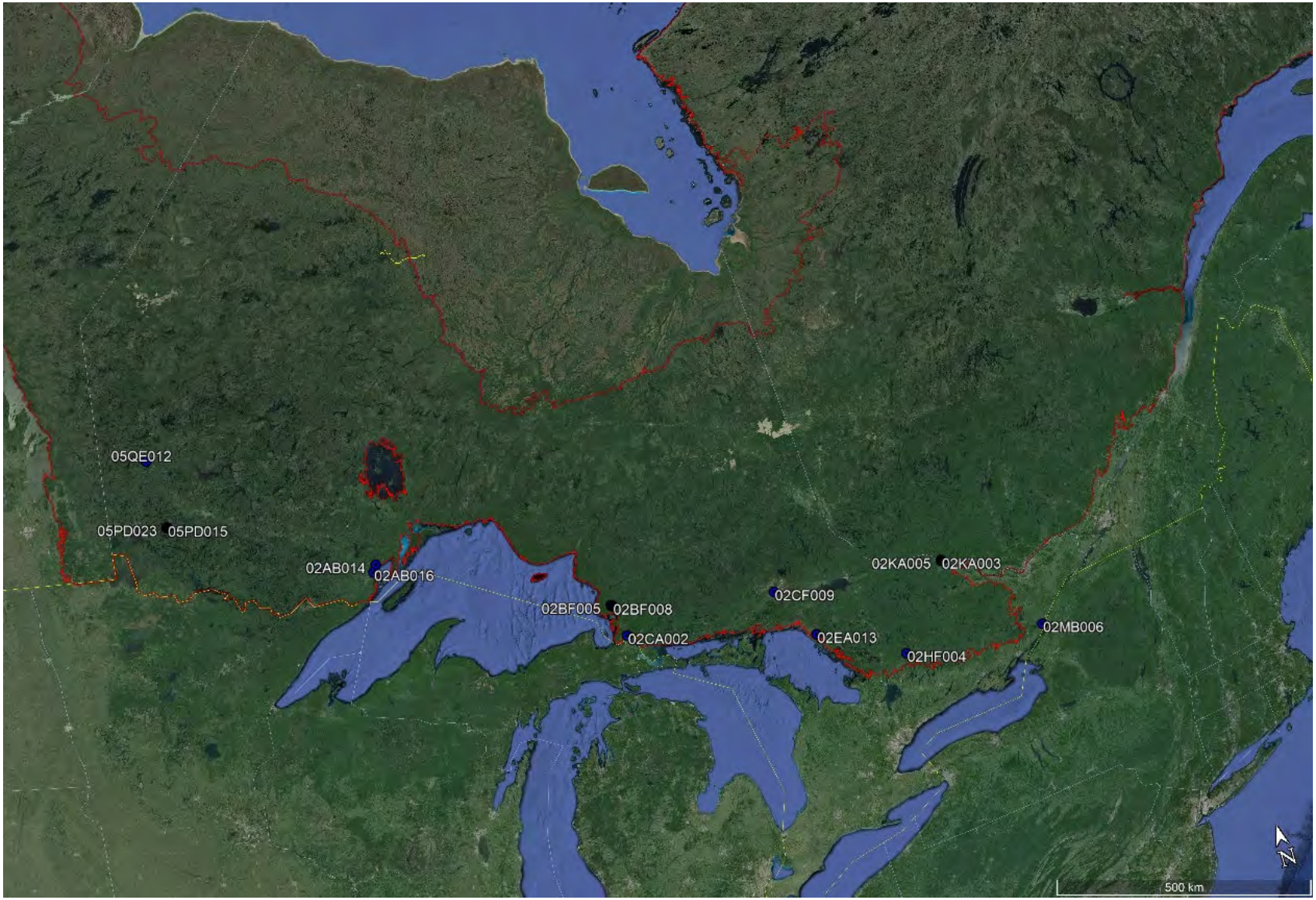


Figure 2-6 NOHM study stations, Canadian Shield outline (red), and proposed WSR roadway (yellow).

2.1.7 United Ontario Flood Method

The Unified Ontario Flood Method (UOFM) is a regression-based equation for regional flood frequency analysis (RFFA) which was developed by University of Toronto, as shown in the equation:

$$Q_{UOFM} = K_R \times A^a \times LI^b \times P^c$$

where:

Q_{UOFM} = annual flood with a T year return period (m^3/s) from the regression analysis;

A = drainage area (km^2);

P = mean annual precipitation (mm);

K_R = 10^x (x = constant obtained from the output of stepwise regression, see Table 2-4);

LI = lake attenuation index (dimensionless); and

a, b, and c are constants obtained from Table 2-4.

Lake attenuation index (LI) is an independent variable to represent lake storage and represents the attenuation effect of the lakes and wetlands on peak flows:

$$LI = 1 + \frac{WA}{A}$$

where:

A = total drainage area (km^2) and

WA = area of lakes and wetlands (km^2).

Table 2-4 Coefficients of the Regression Model and Range of Quantiles

Return Period (yr)	x	a	b	c	Lower limit	Upper limit
Ecozone: Boreal Shield						
2	-10.87	0.839	-4.633	3.583	-31%	44%
10	-8.583	0.795	-4.522	2.917	-33%	49%
25	-7.834	0.779	-4.51	2.703	-34%	52%
50	-7.371	0.769	-4.52	2.572	-35%	55%
100	-6.967	0.759	-4.541	2.457	-36%	57%
Ecozone: Mixed Wood Plains						
2	-5.483	0.756	-3.061	1.837	-29%	40%
10	-4.139	0.734	-3.78	1.491	-32%	46%
25	-3.68	0.728	-4.017	1.372	-33%	50%
50	-3.397	0.724	-4.162	1.299	-35%	53%
100	-3.151	0.721	-4.287	1.236	-36%	57%

The UOFM divided Ontario into three main ecozones, as shown in Figure 2-7. The WSR water crossings are mostly located within the ‘Boreal Shield’ ecozone, at the edge of the ‘Hudson Plains’ ecozone.

Figure 2-7 Ecozone map of Ontario.

The mean annual precipitation for the water crossings (750 - 800 mm) was obtained from an Isohyetal map of Ontario (MTO 2016).

The UOFM was also calculated using the regression-based equation and the drainage areas and lake/wetland areas obtained from OWIT. The original study used stations with significantly lower percentage of lakes/wetlands than the Project water crossings. The resulting flows are presented in Section 2.1.8. The resulting flows are very low as the W/A percentages of the crossings are generally higher than 70%.

To test the applicability of the UOFM in this region, the method was compared against flow frequency analysis (FFA) at individual WSC stations with varying degrees of lake and wetland area. The stations used are shown in Table 2-5 and locations are shown in Figure 2-8. The results of the UOFM peaks (with upper and lower limits) are plotted for the WSC stations with the FFA peaks in Figure 2-9 through Figure 2-17.

Table 2-5 Properties of the WSC stations used in the analysis.

Station	Drainage Area, A (km^2)	Lake and Wetland Area, WA (km^2)	WA / A
Blackwater	649	40.3	6%
Whitesand	11	0.6	6%
Brightsand	1,133	355	31%
Pineimuta	4,841	2,112	44%
Kawinogans	1,520	616	41%
Pagwachuan	2,102	496	24%
Pashkokogan	2,246	1,068	48%
Fawn	4,419	2,474	56%
Mattawishkwia	1,164	750	64%

Figure 2-8 Locations of WSR stations used in the analysis.

Figure 2-9 Blackwater River flows for different return periods

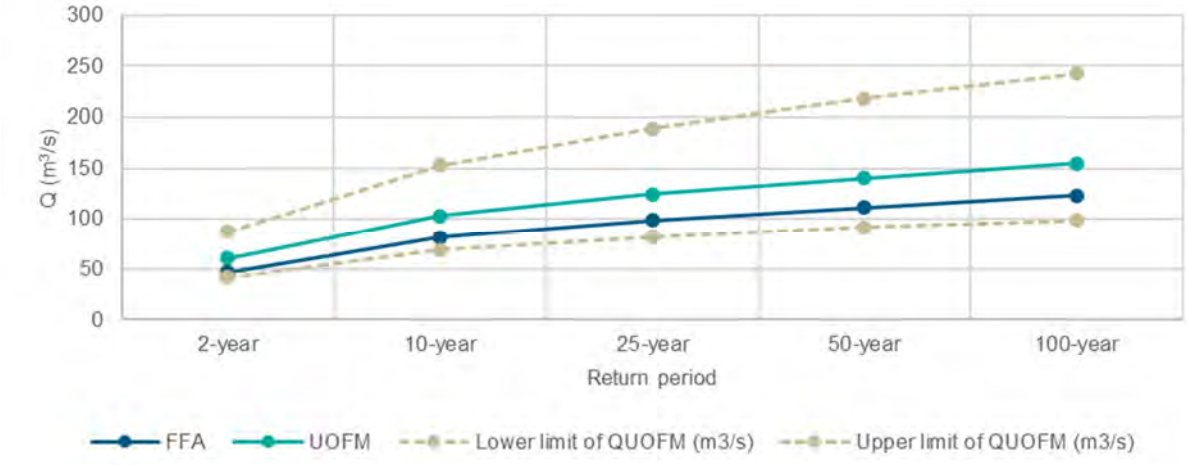


Figure 2-10 Whitesand River flows for different return periods

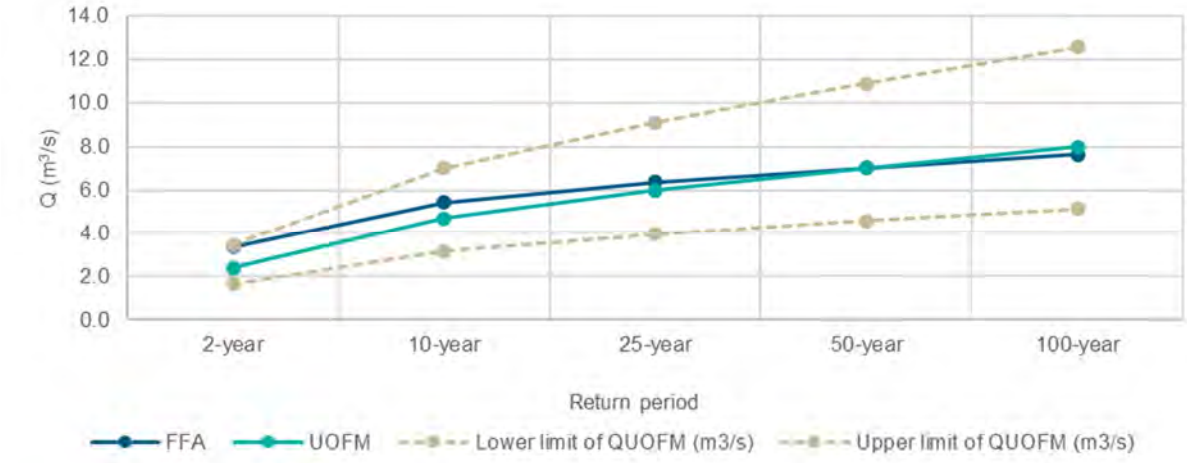


Figure 2-11 Brightsand River flows for different return periods

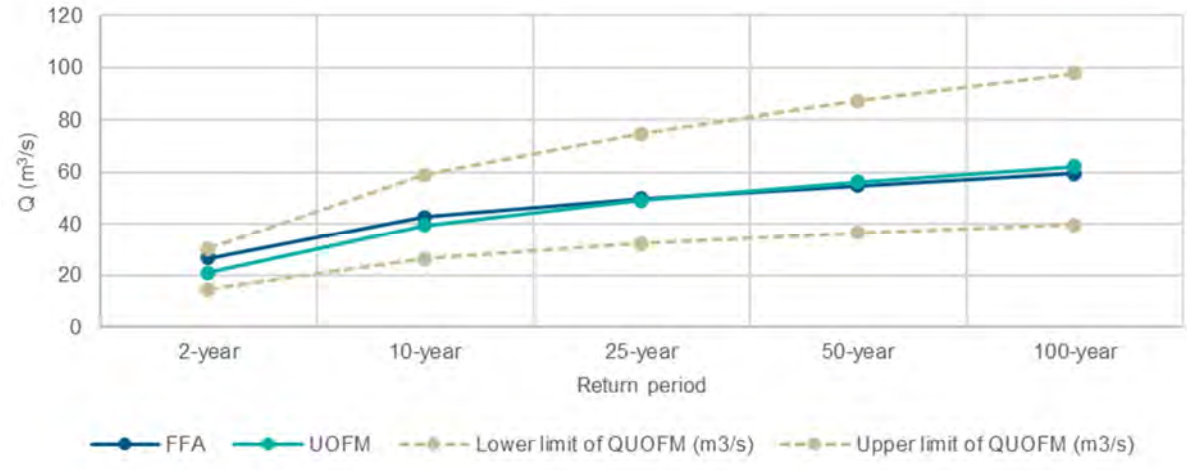


Figure 2-12 Pineimuta River flows for different return periods

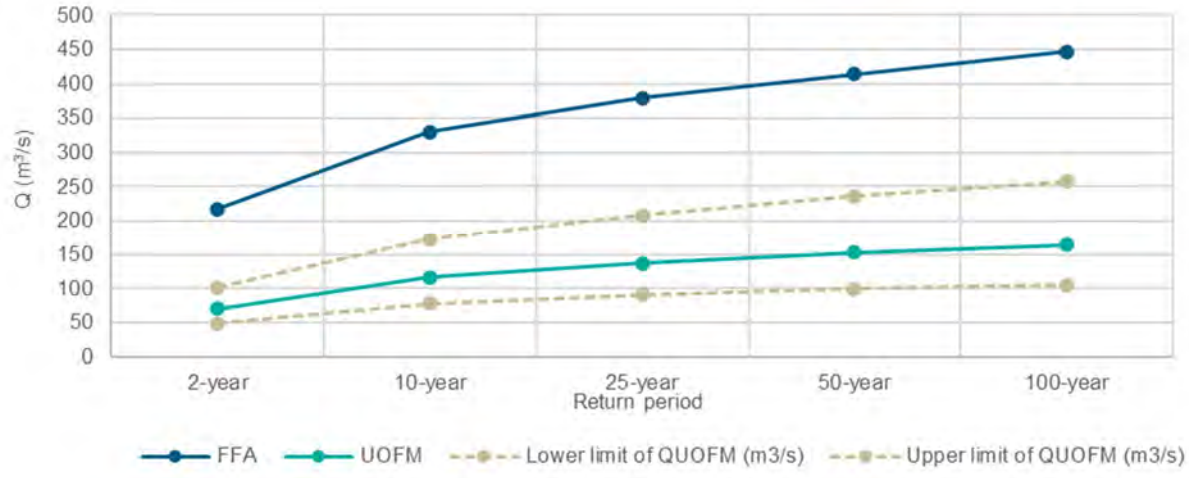


Figure 2-13 Kawinogans River flows for different return periods

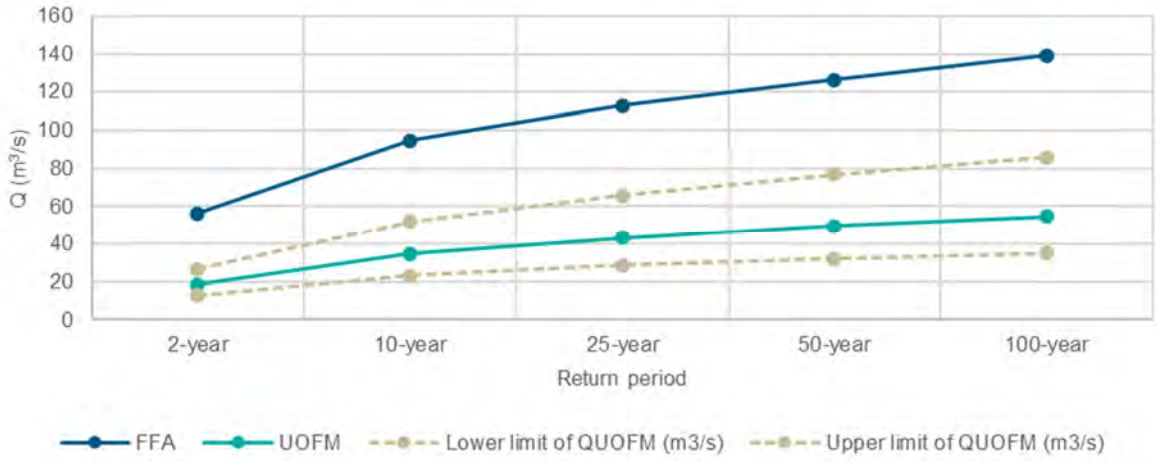


Figure 2-14 Pagwachuan River flows for different return periods

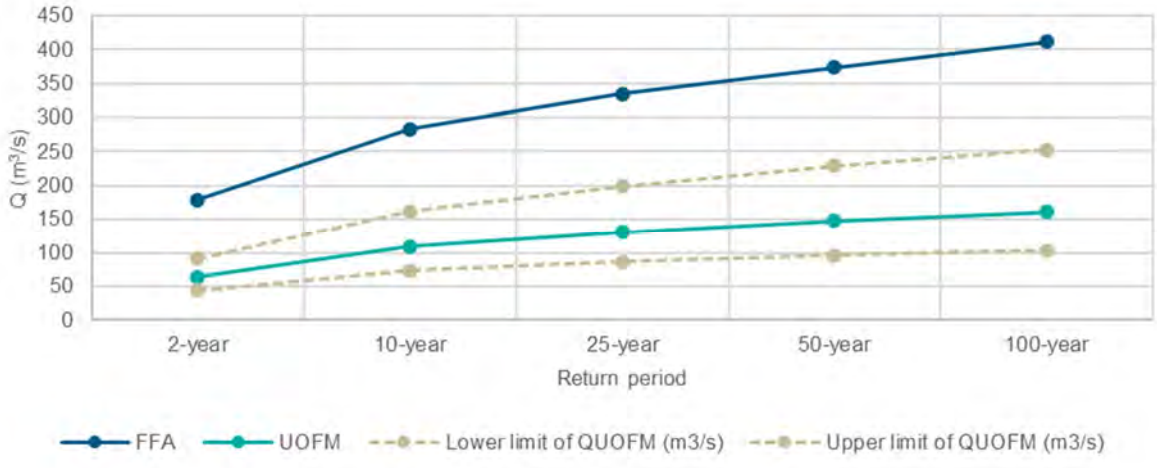


Figure 2-15 Pashkokogan River flows for different return periods

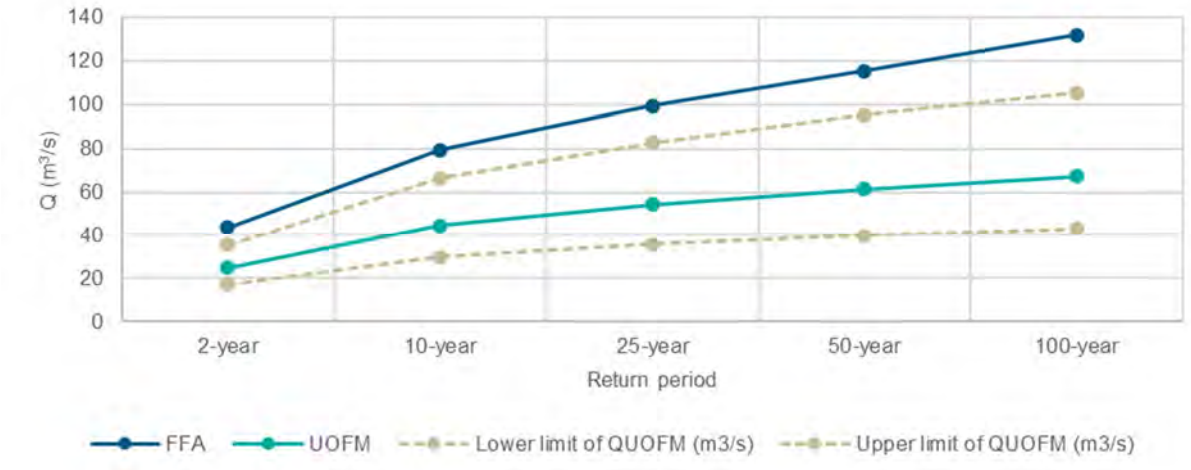


Figure 2-16 Fawn River flows for different return periods

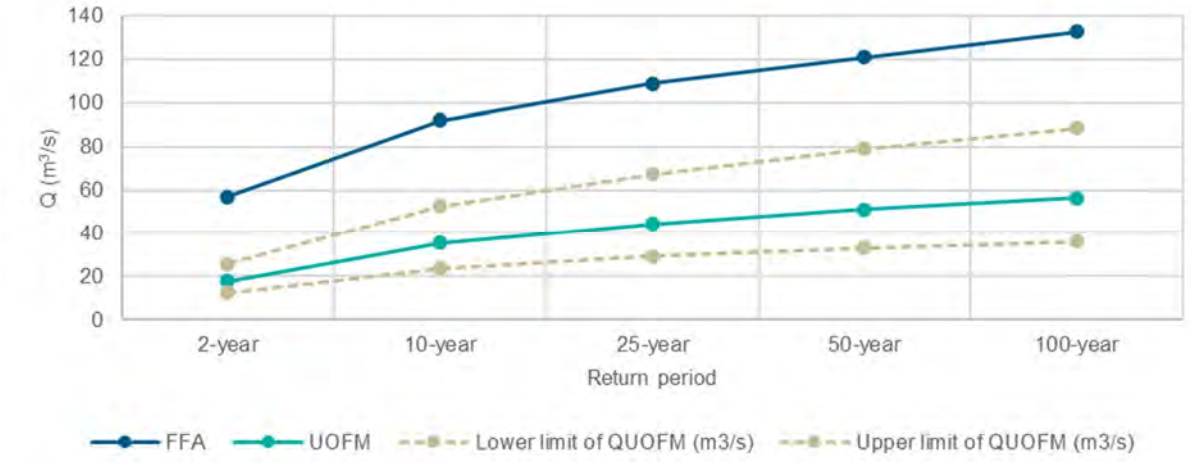
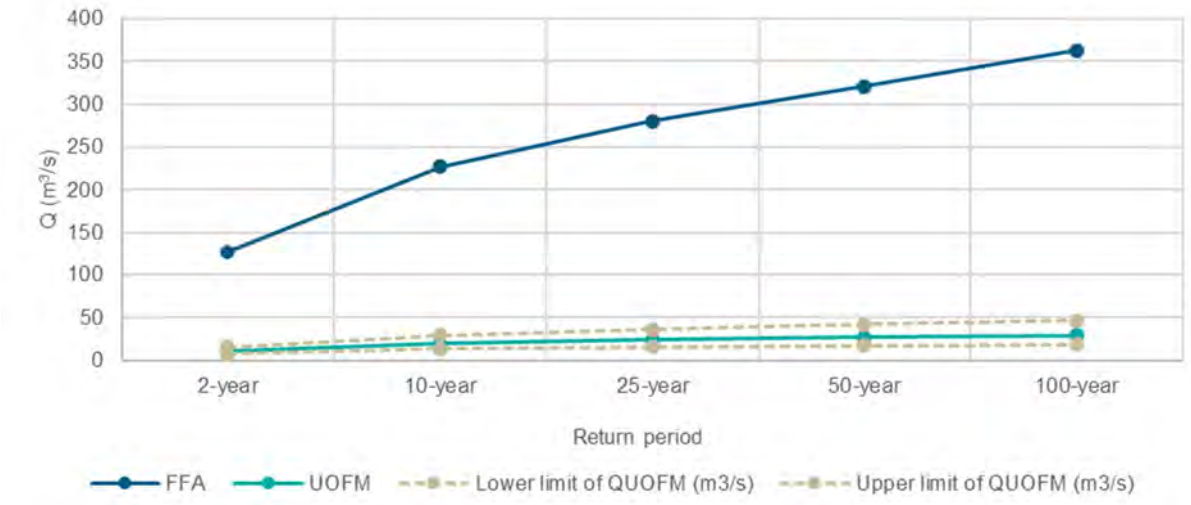


Figure 2-17 Mattawishkwia River flows for different return periods



Generally, the UOFM and FFA flows match when the lake and wetland area percentages are smaller and the stations are located further from the Hudson Plains boundary (see Brightsand, Blackwater, and Whitesand). As the lake and wetland percentages increase, and stations get closer to the boundary, the UOFM and FFA flows diverge and there are considerable differences between them. Considering the WA/A values which have been shown in the Table 2-5 and locations in Figure 2-8, it is apparent that the ratio of the WA/A highly affects the UOFM method results as well as the location relative to the Hudson Plains boundary. The WSR crossings are located near the Hudson Plain boundary which consist of a high percentage of lake and wetland areas, which is not predicted well using the UOFM.

2.1.8 Summary

The estimated 1 in 100-year peak discharge for each applicable method for crossings greater than 1 km^2 is shown in Figure 2-18, Figure 2-19, and Figure 2-20.

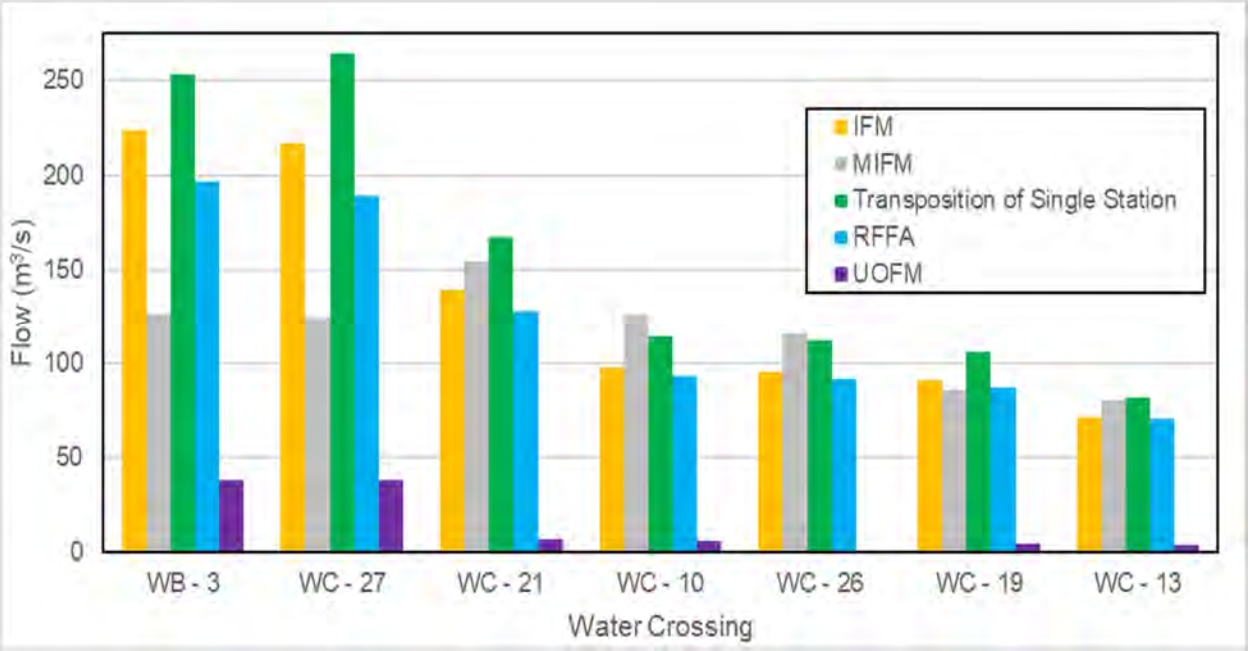


Figure 2-18: Comparison of 100-year peak discharges for water crossings with drainage areas >100 km^2 using various methods.

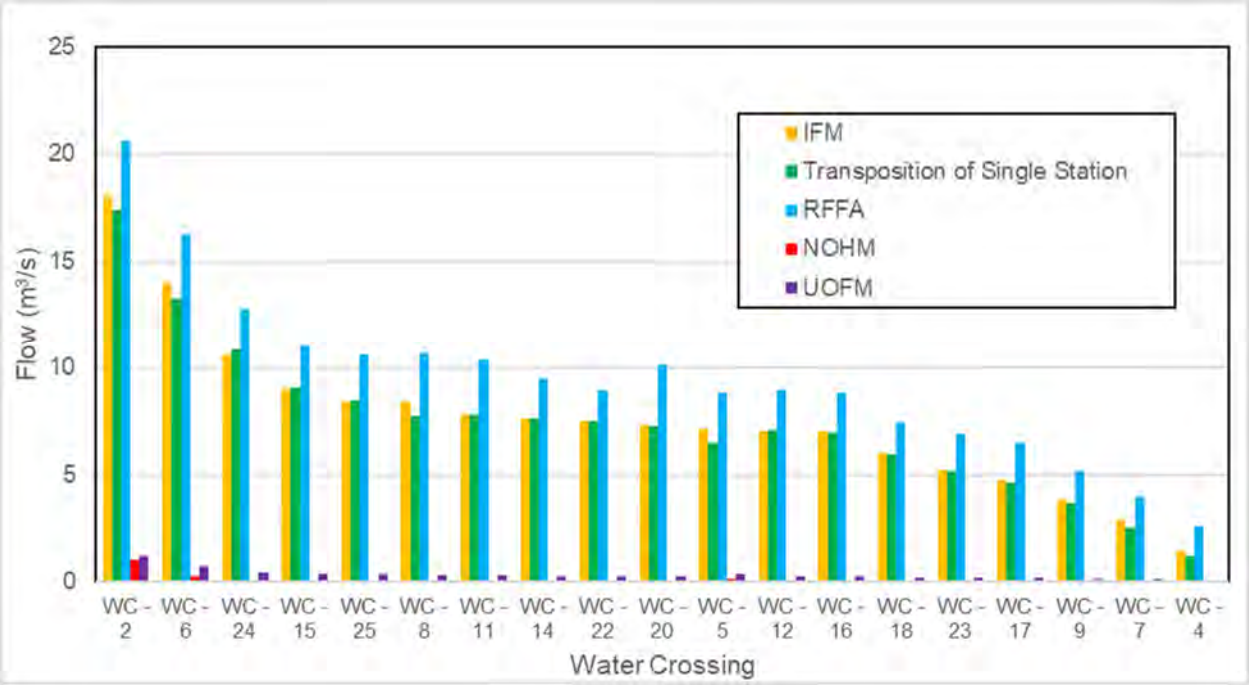


Figure 2-19: Comparison of 100-year peak discharges for water crossings with drainage areas between 1 km² and 100 km² using various methods.

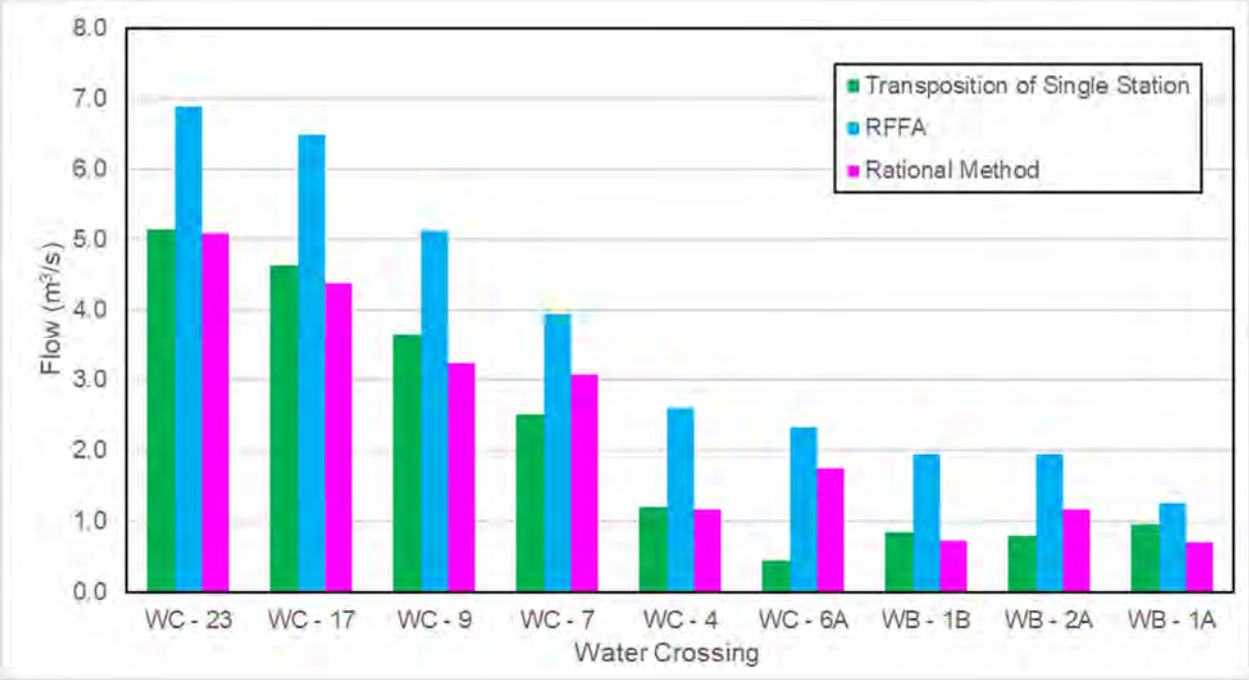


Figure 2-20: Comparison of 100-year peak discharges for water crossings with drainage areas <10 km² using various methods.

For drainage areas greater than 100 km², the IFM, MIFM, Transposition of Single Station, and RFFA yielded the best results. MIFM was about 15% higher than IFM for catchments from 100 km² to 1000 km²,

but over 40% higher for catchments greater than 1000 km^2. Transposition of Single Station was generally about 15% higher than IFM and RFFA was generally 10% lower than IFM. For drainage areas from 1 km^2 to 100 km^2 (MIFM not applicable), the Transposition of Single Station was generally about 20% lower than IFM results and RFFA were generally about 30% higher than IFM results.

The NOHM (only for catchments less than 100 km^2) and the UOFM results were more than 90% less than all other methods. NOHM and UOFM rely on the total area of lakes and wetlands within the catchment. However, the wetland areas for the project are quite large (47% to 95%), resulting in an overly reduced discharge, as the peak is effectively damped by the wetland area, and these methods were not considered further.

The Rational Method was used for catchments less than 10 km^2 and resulted in flows similar to Transposition of Single Station, with the exception of WC-6A, and less than the RFFA.

2.2 Adopted Peak Discharge Estimation

The IFM results were selected as the most representative of the watercourse peaks in watersheds with drainage area greater than 10 km^2, as they typically fell in the middle of all the results, and they were considered to be sufficiently conservative. The Rational Method was selected as the most representative for the smallest catchments because the Transposition of Single Station was slightly less conservative, and the reference catchment areas used in the RFFA are significantly larger (typically >1000 km^2) and may not be representative for areas less than 10 km^2. **Table 2-6** provides a summary of the water crossing characteristics and the estimated peak discharge for the 1in 25-year, 1 in 50-year, and 1 in 100-year peak discharges.

Table 2-6 Water Crossing Characteristics and Estimated Peak Discharges

Water Crossing	Coordinates		Drainage Area (km^2)	Slope of Main Channel (%)	Mean Annual Flow (m^3/s)	Peak Discharge[1] (m^3/s)		
	Northing	Easting				25-Year[2]	50-Year	100-Year
WB - 1[3]	5868060	477464	258.8	n/a	n/a	n/a	n/a	n/a
WC - 1A	5870366	482107	0.6	0.6	-	0.5	0.6	0.7
WC - 1B	5869579	483200	1.2	0.4	-	0.5	0.6	0.7
WC - 2	5862739	487814	50.3	0.09	0.5	12.6	15.4	18.0
WC - 2A	5862875	489368	1.2	0.24	-	0.8	0.9	1.0
WC - 3	5862120	490176	1773.8	0.07	16.7	156.5	191.8	224.2
WC - 4	5856914	489151	1.9	0.04	0.01	1.0	1.3	1.5
WC - 5	5844953	495657	13.2	0.16	0.1	5.0	6.1	7.1
WC - 6	5844572	496847	34.5	0.11	0.3	9.7	11.9	14.0
WC - 6A	5844435	497187	1.6	0.30	-	1.3	1.4	1.6
WC - 7	5843777	499208	3.7	0.41	0.04	2.0	2.5	2.9
WC - 8	5844304	502606	17.8	0.16	0.2	5.9	7.2	8.4
WC - 9	5846775	506051	5.6	0.03	0.1	2.7	3.3	3.8
WC - 10	5847157	508104	542.6	0.15	5.1	68.1	83.4	97.5
WC - 11	5847278	508758	17.0	0.08	0.1	5.5	6.7	7.8

Water Crossing	Coordinates		Drainage Area (km^2)	Slope of Main Channel (%)	Mean Annual Flow (m^3/s)	Peak Discharge[1] (m^3/s)		
	Northing	Easting				25-Year[2]	50-Year	100-Year
WC - 12	5847472	512123	13.4	0.06	0.1	4.9	6.0	7.1
WC - 13	5848174	516069	349.4	0.08	3.3	49.9	61.1	71.4
WC - 14	5846902	519434	14.8	0.08	0.1	5.3	6.5	7.6
WC - 15	5846634	520738	18.7	0.03	0.2	6.3	7.7	9.0
WC - 16	5846571	521782	13.2	0.08	0.1	4.9	6.0	7.0
WC - 17	5845482	526566	8.1	0.16	0.1	3.3	4.1	4.8
WC - 18	5845038	528286	10.1	0.17	0.1	4.2	5.2	6.0
WC - 19	5844773	529836	491.6	0.11	4.4	63.3	77.6	90.6
WC - 20	5844822	531692	16.4	0.07	0.1	5.1	6.3	7.3
WC - 21	5846333	536602	897.6	0.05	8.3	97.4	119.3	139.4
WC - 22	5846504	537147	13.5	0.63	0.1	5.2	6.4	7.5
WC - 23	5847388	540438	8.9	0.13	0.1	3.7	4.5	5.3
WC - 24	5845018	542333	23.6	0.16	0.2	7.4	9.1	10.6
WC - 25	5844508	543818	17.6	0.07	0.2	5.9	7.2	8.4
WC - 26	5844703	545767	529.4	0.06	4.9	66.6	81.6	95.4
WC - 27[4]	5852550	487000	1668.0	0.07	15.7	151.8	186.0	217.4

(1) From OFAT (MNRF, 2019a), except for WC-1A, WC-1B, WC-2A, and WC-6A, which are from Rational Method
(2) Interpolation between 1:20 year and 1:50 year flows
(3) Flows are not defined at WB – 1 because it is a lake crossing
(4) Based on transposition of the WC - 3 flows

3 Existing High Water Levels

3.1 Hydraulic Analysis

The existing 1 in 100-year High Water Level (HWL) for each of the water crossings was estimated using Hydraulic Engineering Center River Analysis System (HEC-RAS). HEC-RAS is developed by the U.S. Army Corps of Engineers and it is widely used in the industry to model hydraulics of water flow through natural rivers and other channels.

The bathymetric properties of each waterbody crossing were estimated for the geometry based on field reconnaissance, LiDAR, and background information. The streams are generally very flat (~0.002 m/m) and meandering with bed materials of fine sediments with occasional boulders (see Figure 3-1). Manning's n values were estimated from photographs of the water crossings and assumed to be 0.04 for the natural channels and 0.07 for the overbanks, based on recommended values listed in Chow (1959). There were no historic high water marks or measured flows, so the models could not be calibrated.

Figure 3-1. Typical stream characteristics (e.g. WC-10).

The streams were relatively flat, so only subcritical flow (slower, deeper) was expected. The downstream boundary condition was normal depth which was calculated from the slope obtained from the LiDAR data.

The calculated 1 in 100-year flood peak discharges were run in the model. The estimated HWL for the crossings are shown in Error! Reference source not found.. It should be noted that the cross-section area of the crossings are based on limited field data and may not be fully representative of the crossing. It is recommended that a survey of the crossings be taken during the next design stage to confirm the assumptions, as well as a flow measurement with corresponding water elevation so that hydraulic models can be calibrated.

3.2 NASA Satellite-Based Water Levels

The HWL at WB-1 (Winisk Lake) was estimated using 33 years of NASA satellite-based water level fluctuation data (approximately 10-day resolution). The NASA elevations (October 4 and October 13, 2017) were compared to LiDAR data water elevations (October 6 – 7, 2017) and adjusted to match (average -0.8 m offset).

The adjusted annual water levels (from NASA data) at WB-1 (Winisk Lake) ranged from 194.6 masl to 198.7 masl, and on average was at 196.6 masl, as shown in Figure 3-2. The estimated HWL is based on the maximum water elevation in the dataset and estimated depth of the lake obtained during field reconnaissance (assumed to be the average water level).

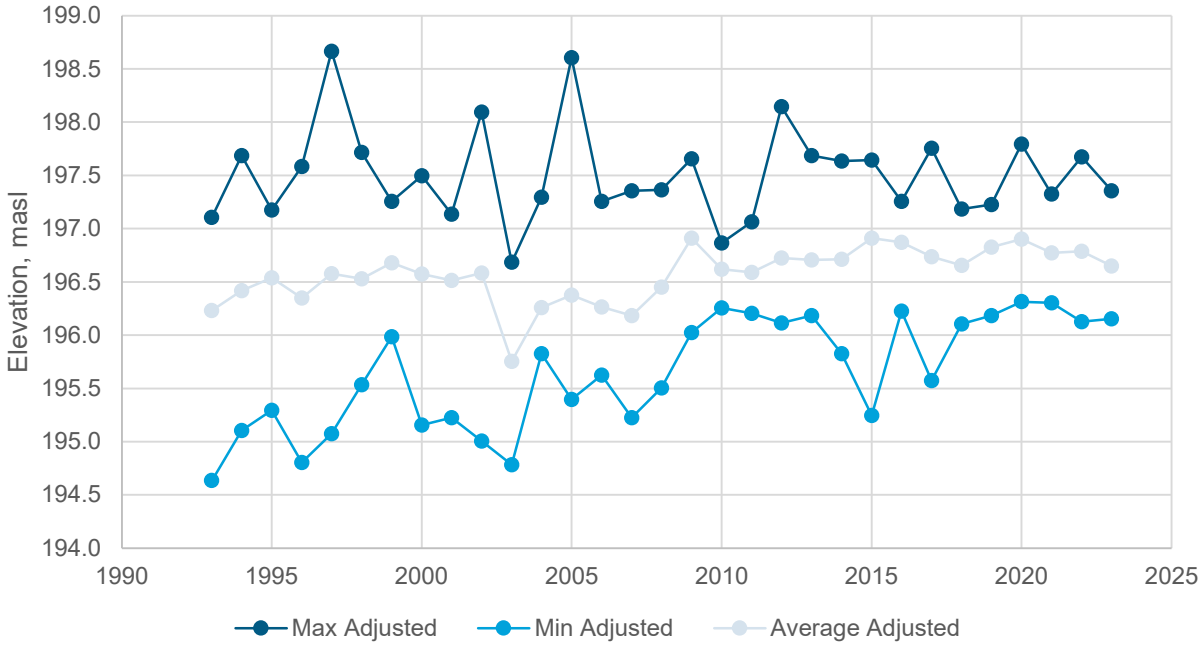


Figure 3-2: Annual Winisk Lake NASA satellite-based water levels

Table 3-1: Water Crossing Peak 1 in 100-year Discharge and estimated HWL

Water Crossing	Peak Discharge (1 in 100-year event; m^3/s)	Estimated High Water Level (HWL) (above base of water crossing; m)
WB - 1(1)	n/a	5.3
WC - 1A	0.7	0.3
WC - 1B	0.7	0.4
WC - 2	18.0	1.7
WC - 2A	1.0	0.5
WC - 3	224.2	3.0
WC - 4	1.5	1.3
WC - 5	7.1	1.6
WC - 6	14.0	1.4
WC - 6A	1.6	0.3
WC - 7	2.9	0.6
WC - 8	8.4	1.2
WC - 9	3.8	0.9
WC - 10	97.5	3.8
WC - 11	7.8	1.4
WC - 12	7.1	1.4
WC - 13	71.4	2.4
WC - 14	7.6	1.9
WC - 15	9.0	1.2
WC - 16	7.0	1.3
WC - 17	90.6	2.6
WC - 18	6.0	1.4

WC - 19	90.6	3.4
WC - 20	7.3	2.6
WC - 21	139.4	4.4
WC - 22	7.5	1.2
WC - 23	5.3	1.2
WC - 24	10.6	1.8
WC - 25	8.4	1.2
WC - 26	95.4	2.4
WC - 27	217.4	3.0

(1) Flows are not defined at WB – 1 because it is a lake crossing.

4 Next Steps and Recommendations

A preliminary review of the Ontario-specific climate models on the Ontario Climate Data Portal (ontarioccdp.ca) identified that future rainfall intensities could increase by up to 40% compared to current meteorological conditions. To understand how increased precipitation will increase the runoff (Design Flow), a hydrological model representing local catchments will be developed. The model will be calibrated using observed flow at a nearby gauge and observed climate data. The model will then be run again with future projections for temperature and precipitation to understand the potential increases in runoff. A percent increase in runoff will be used to increase the Design Flow peaks to account for climate change.

The current understanding of water crossing topography is based on aerial LiDAR that does not include water penetration and field observations. It is recommended to collect detailed bathymetry surveys at water crossings, including sections upstream and downstream of the proposed alignment. It is also recommended to collect flow measurements at each crossing to support calibration of the hydraulic models.

Once additional data is collected, hydraulic modelling should be updated at each water crossing to characterise high water levels for existing conditions. The same hydraulic models could then be used with preliminary culvert and bridge designs to predict high water levels for post-construction conditions and freeboard assessments.

5 References

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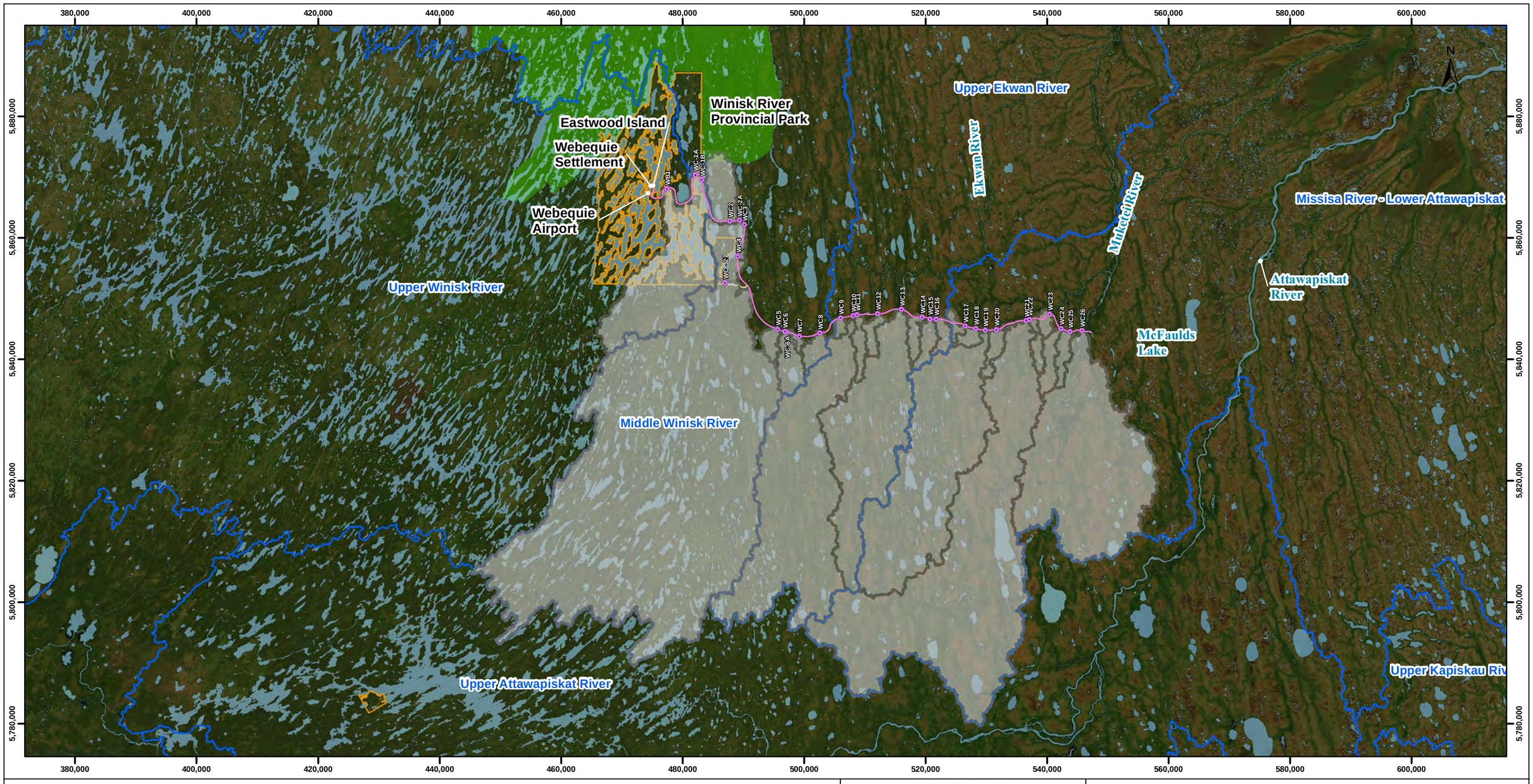
Figures

Water Crossing Locations and Watershed Areas



SIZE 11x17

Legend

- Preliminary Recommended Preferred Route
- Access Road
- Water Crossing
- First Nation Reserve
- Watershed of Water Crossing
- Waterbody
- Winisk River Provincial Park
- Tertiary Watershed

WSR WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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0 20 40 Km

Webequie Supply Road (WSR)

Waterbody Crossings and their Watersheds

Figure Number:		REV:
F-1		PA

Client:	Project Number:	Date:
Webequie First Nation	661910	8/19/2024

DSC	DRN	CHK	APP
	LZ	CB	CB

SIZE 11 X 17 Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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460,000 480,000 500,000

5,860,000

Webequie Settlement
Eastwood Island
Webequie Airport
Bender Lake
Winisk Lake
Odobas Lake
Morrison Bay
Newstead Lake
Farrow Lake
Stockman Lake
McMurdo Lake
Billinger Lake
Prime Lake

WB1
WC-1A
WC-1B
WC2
WC-2A
WC3
WC4
WC - 27
WC5
WC6
WC6A
WC7
WC8
WC9
WC10
WC11
WC12
WC13

N

SIZE 11x17

Legend

- Preliminary Recommended Preferred Route
- Access Road
- Water Crossing
- First Nation Reserve
- Watershed of Water Crossing
- Waterbody
- Winisk River Provincial Park
- Tertiary Watershed

WSR WEBEQUIE SUPPLY ROAD

NOTES

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3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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0 5 10 Km

Webequie Supply Road (WSR)

Watershed/Watercourse Crossings along WSR (Western Section)

Figure Number: F-2		**REV:** PA	
Client: Webequie First Nation	**Project Number:** 661910	**Date:** 8/19/2024	
DSC	**DRN**	**CHK**	**APP**
	LZ	CB	CB

SIZE 11 X 17 Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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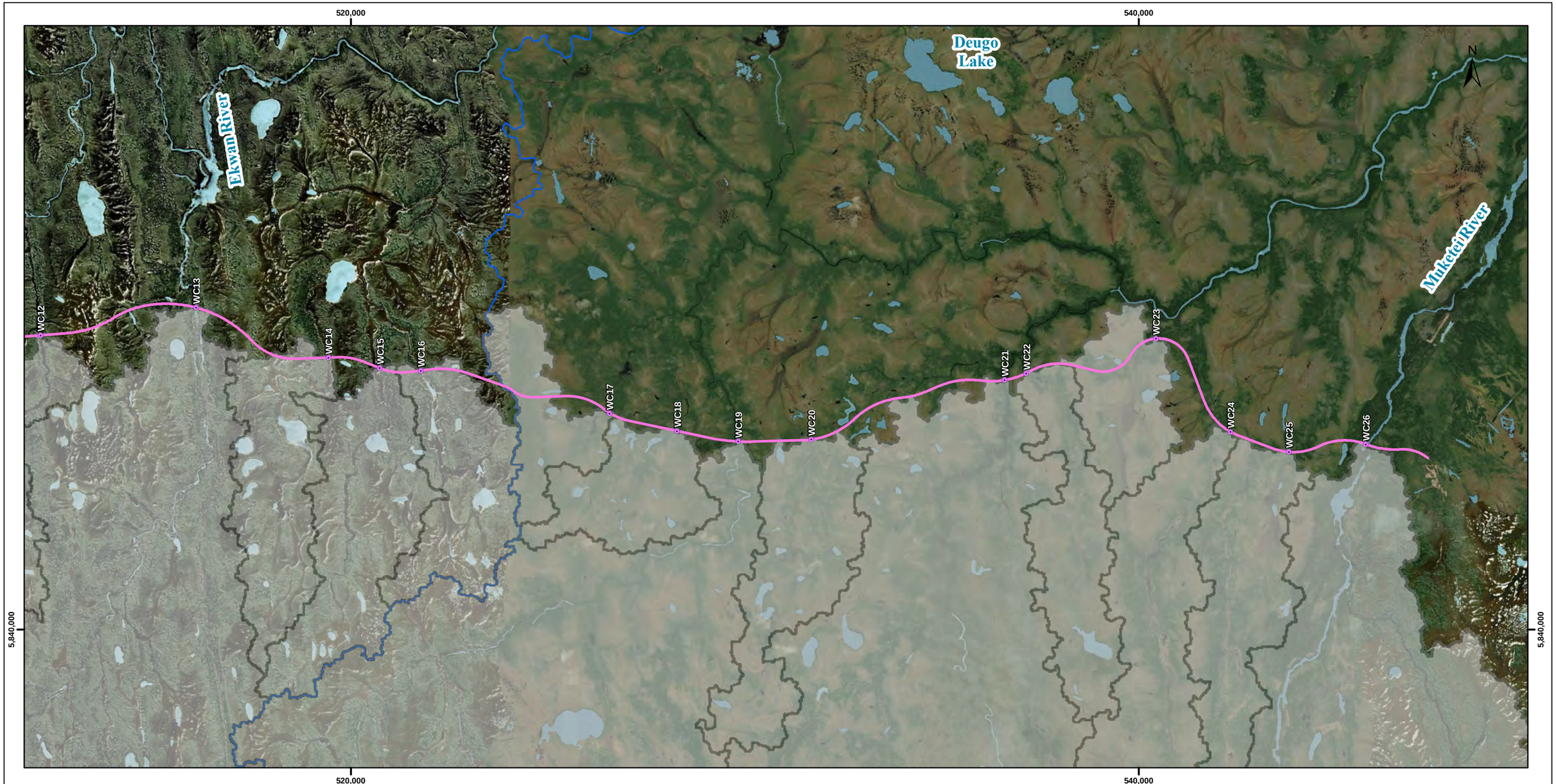

Legend

- Preliminary Recommended Preferred Route
- Access Road
- Water Crossing
- First Nation Reserve
- Watershed of Water Crossing
- Waterbody
- Winisk River Provincial Park
- Tertiary Watershed

WSR
WEBEQUIE SUPPLY ROAD

NOTES

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information; and, Land Information Ontario (LIO) Warehouse Open Data (https://geohub.lio.gov.on.ca/), Ontario Ministry of Natural Resources and Forestry (OMNRF) Download Date : 2021-02-04

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0 3.5 7 Km

Webequie Supply Road (WSR)

Watershed/Watercourse Crossings along WSR (Eastern Section)

Figure Number:	REV:
F-3	PA

Client:	Project Number:	Date:
Webequie First Nation	661910	8/19/2024

DSC	DRN	CHK	APP
	LZ	CB	CB

SIZE 11 X 17 Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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SIZE 11x17

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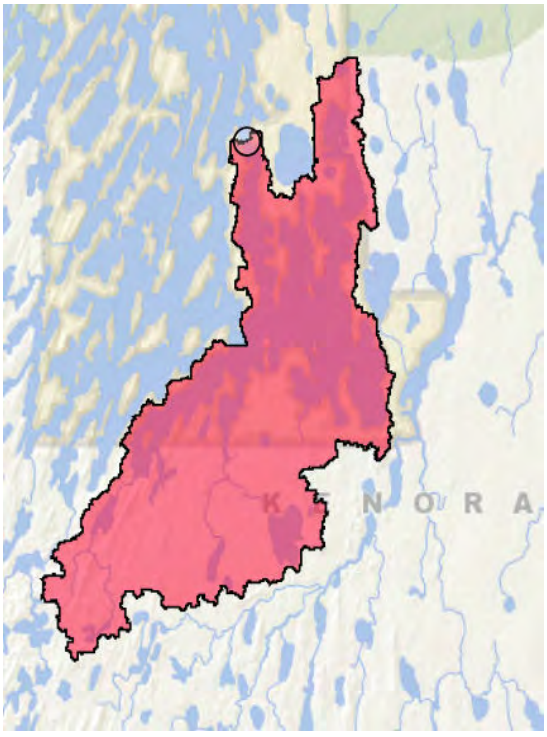
Appendix A

Water Crossing Drainage Area Characteristics

WB - 1

Characteristic	Value
Drainage Area (km2)	259.30
Shape Factor (-)	6.39
Length of Main Channel (km)	40.71
Maximum Channel Elevation (m)	245.10
Minimum Channel Elevation (m)	191.14
Slope of Main Channel (m/km)	1.33
Slope of Main Channel (%)	0.13
Area Lakes/Wetlands (km²)	148.11
Area - Lakes (km²)	81.35
Area - Wetlands (km²)	66.76
Mean Elevation (m)	204.48
Maximum Elevation (m)	254.68
Mean Slope (%)	2.49

(from OWIT)



WC - 1A

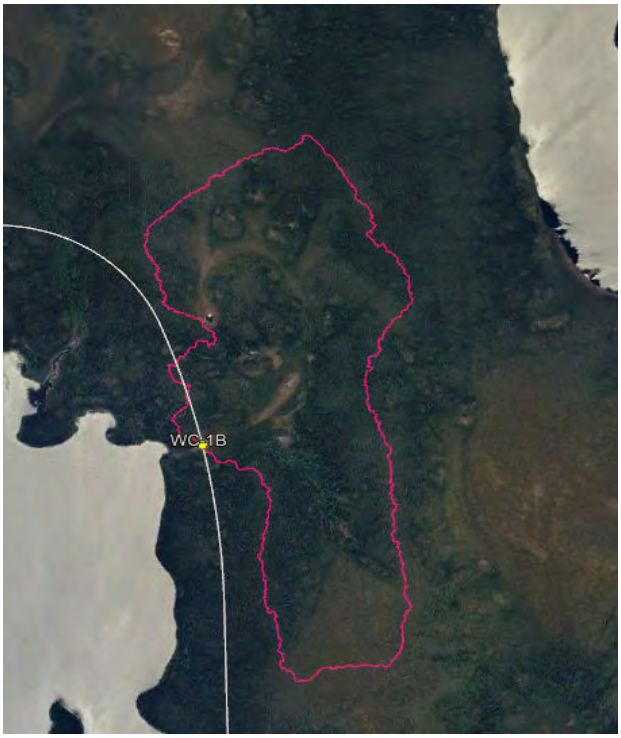
Characteristic	Value
Drainage Area (km2)	0.60
Slope of Main Channel (m/km)	6.00
Slope of Main Channel (%)	0.60

(from QGIS)

WC - 1B

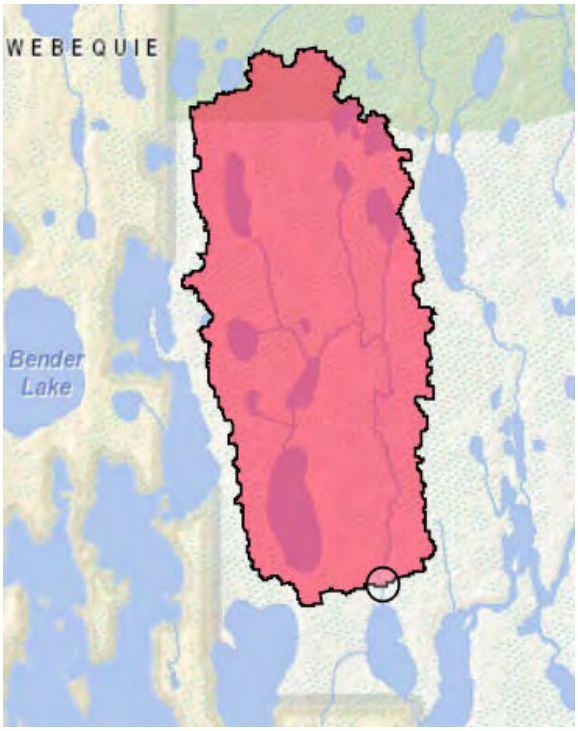
Characteristic	Value
Drainage Area (km2)	1.21
Maximum Channel Elevation (m)	
Minimum Channel Elevation (m)	
Slope of Main Channel (m/km)	4.40
Slope of Main Channel (%)	0.44

(from QGIS)



WC - 2

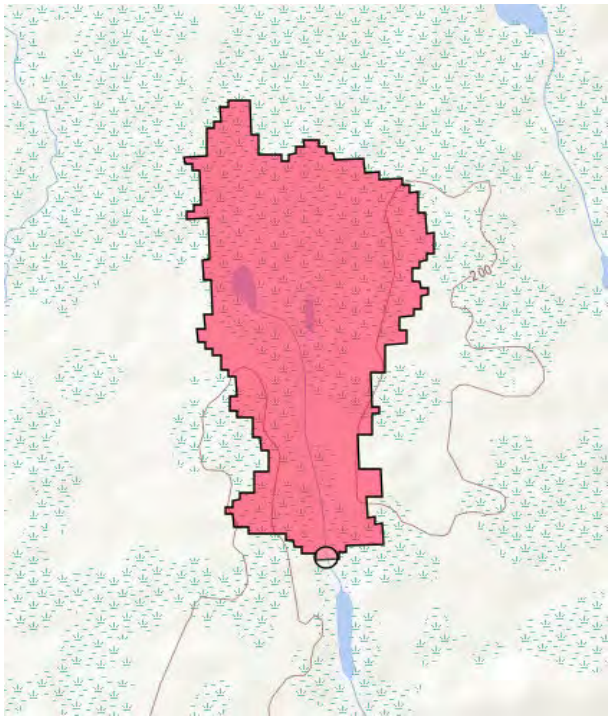
Characteristic	Value
Drainage Area (km2)	50.28
Shape Factor (-)	6.86
Length of Main Channel (km)	18.58
Maximum Channel Elevation (m)	204.85
Minimum Channel Elevation (m)	186.44
Slope of Main Channel (m/km)	0.99
Slope of Main Channel (%)	0.10
Area Lakes/Wetlands (km²)	34.97
Area - Lakes (km²)	3.35
Area - Wetlands (km²)	29.61
Mean Elevation (m)	196.95
Maximum Elevation (m)	214.76
Mean Slope (%)	1.98



(from OWIT)

WC - 2A

Characteristic	Value
Drainage Area (km2)	1.19
Shape Factor (-)	6.06
Length of Main Channel (km)	2.69
Maximum Channel Elevation (m)	198.15
Minimum Channel Elevation (m)	191.75
Slope of Main Channel (m/km)	2.38
Slope of Main Channel (%)	0.24
Area Lakes/Wetlands (km²)	0.98
Area - Lakes (km²)	0.02
Area - Wetlands (km²)	0.97
Mean Elevation (m)	196.90
Maximum Elevation (m)	201.00
Mean Slope (%)	2.37

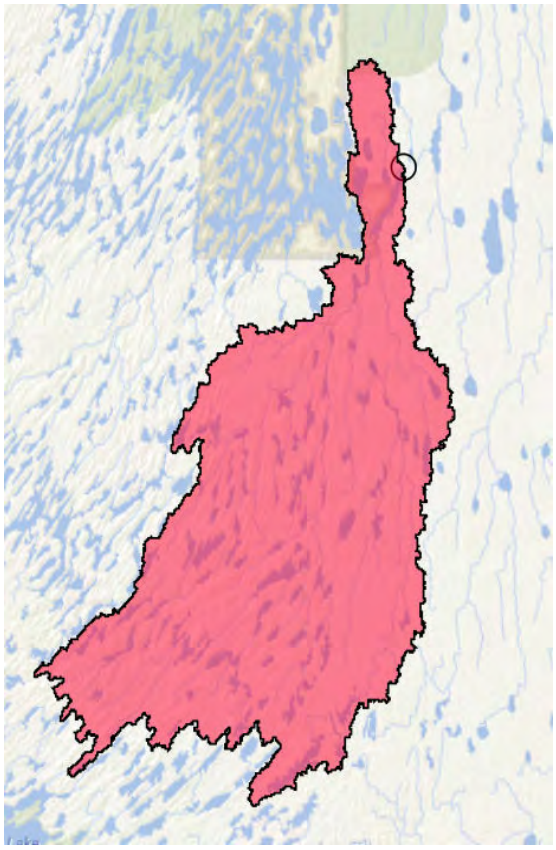


(from OFAT)

WC - 3

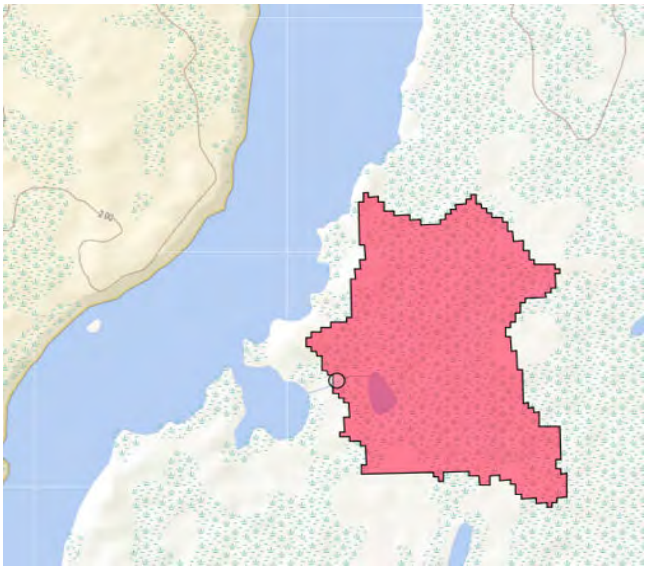
Characteristic	Value
Drainage Area (km2)	1773.75
Shape Factor (-)	7.86
Length of Main Channel (km)	118.06
Maximum Channel Elevation (m)	262.65
Minimum Channel Elevation (m)	185.56
Slope of Main Channel (m/km)	0.65
Slope of Main Channel (%)	0.07
Area Lakes/Wetlands (km²)	842.40
Area - Lakes (km²)	278.97
Area - Wetlands (km²)	563.43
Mean Elevation (m)	233.11
Maximum Elevation (m)	294.19
Mean Slope (%)	2.62

(from OWIT)



WC - 4

Characteristic	Value
Drainage Area (km2)	1.85
Shape Factor (-)	3.30
Length of Main Channel (km)	2.47
Maximum Channel Elevation (m)	200.06
Minimum Channel Elevation (m)	187.60
Slope of Main Channel (m/km)	5.04
Slope of Main Channel (%)	0.50
Area Lakes/Wetlands (km²)	1.64
Area - Lakes (km²)	0.03
Area - Wetlands (km²)	1.62
Mean Elevation (m)	196.11
Maximum Elevation (m)	203.36
Mean Slope (%)	2.13

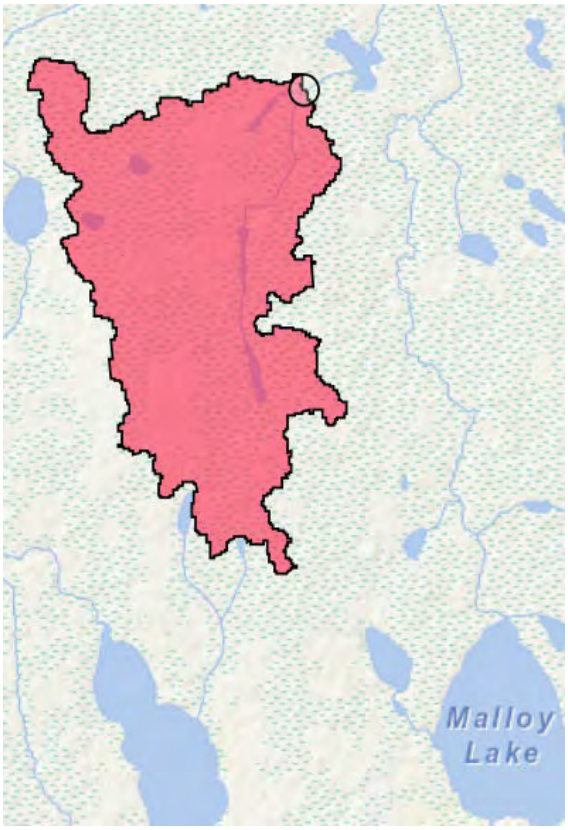


(from OWIT)

WC - 5

Characteristic	Value
Drainage Area (km2)	13.198
Shape Factor (-)	5.344
Length of Main Channel (km)	8.398
Maximum Channel Elevation (m)	215.17
Minimum Channel Elevation (m)	201.27
Slope of Main Channel (m/km)	1.65
Slope of Main Channel (%)	0.165
Area Lakes/Wetlands (km²)	10.201
Area - Lakes (km²)	0.206
Area - Wetlands (km²)	9.995
Mean Elevation (m)	210.345
Maximum Elevation (m)	223.231
Mean Slope (%)	1.766

(from OWIT)



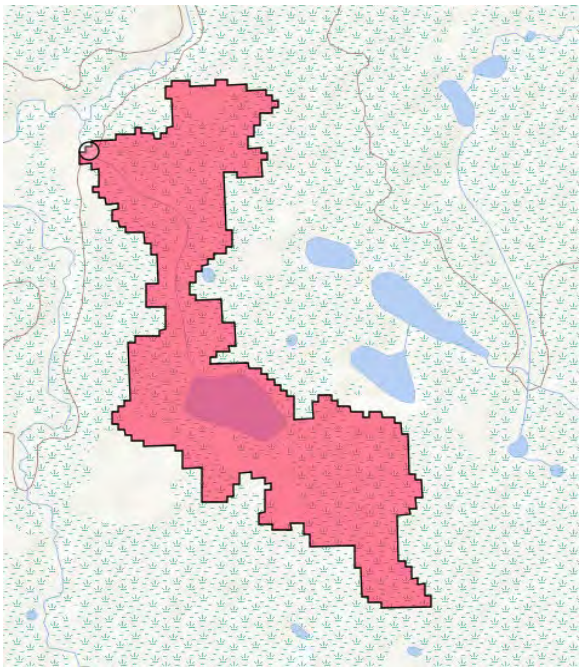
WC - 6

Characteristic	Value
Drainage Area (km2)	34.47
Shape Factor (-)	7.91
Length of Main Channel (km)	16.51
Maximum Channel Elevation (m)	216.94
Minimum Channel Elevation (m)	194.82
Slope of Main Channel (m/km)	1.34
Slope of Main Channel (%)	0.13
Area Lakes/Wetlands (km²)	27.75
Area - Lakes (km²)	3.89
Area - Wetlands (km²)	23.83
Mean Elevation (m)	207.16
Maximum Elevation (m)	218.27
Mean Slope (%)	1.71

(from OWIT)

WC - 6A

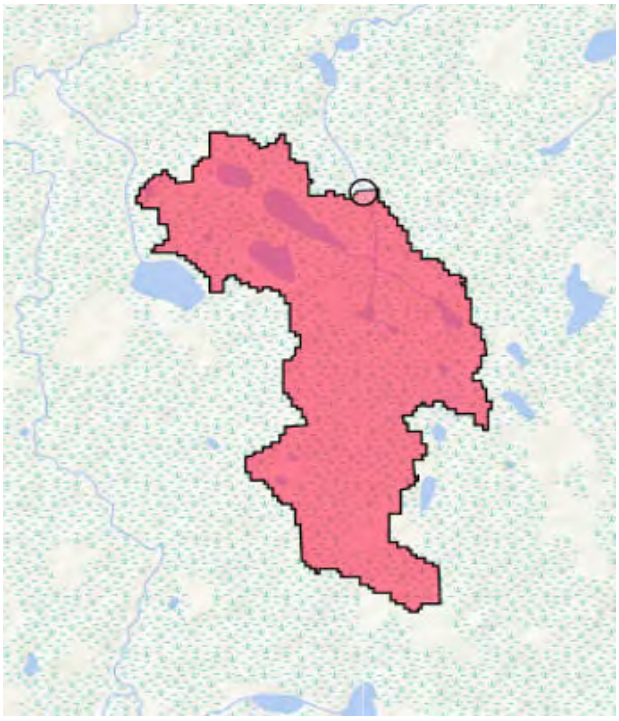
Characteristic	Value
Drainage Area (km2)	1.59
Shape Factor (-)	7.92
Length of Main Channel (km)	3.55
Maximum Channel Elevation (m)	208.21
Minimum Channel Elevation (m)	197.72
Slope of Main Channel (m/km)	2.96
Slope of Main Channel (%)	0.30
Area Lakes/Wetlands (km²)	1.34
Area - Lakes (km²)	0.11
Area - Wetlands (km²)	1.23
Mean Elevation (m)	202.19
Maximum Elevation (m)	208.22
Mean Slope (%)	1.97



(from OWIT)

WC - 7

Characteristic	Value
Drainage Area (km2)	3.725
Shape Factor (-)	4.863
Length of Main Channel (km)	4.256
Maximum Channel Elevation (m)	212.15
Minimum Channel Elevation (m)	195.54
Slope of Main Channel (m/km)	3.9
Slope of Main Channel (%)	0.39
Area Lakes/Wetlands (km²)	3.3
Area - Lakes (km²)	0.194
Area - Wetlands (km²)	3.106
Mean Elevation (m)	203.808
Maximum Elevation (m)	212.236
Mean Slope (%)	1.962

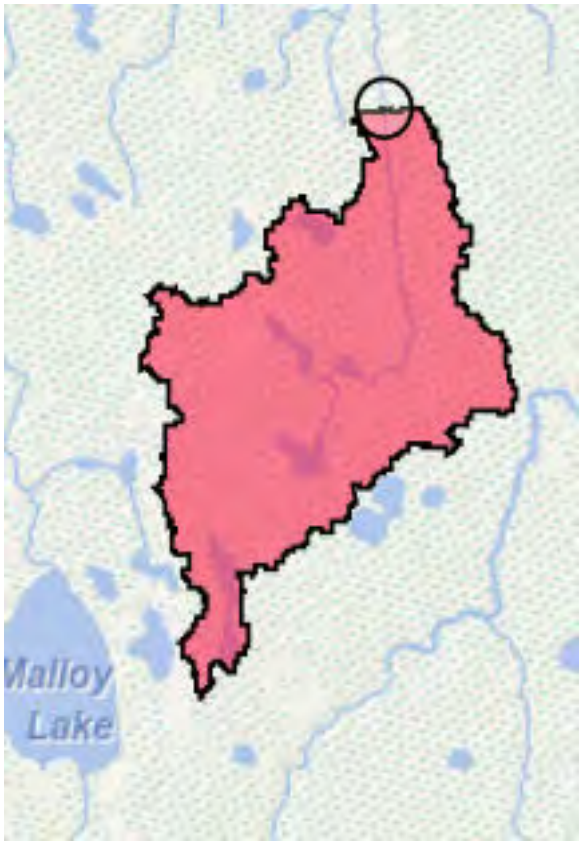


(from OWIT)

WC - 8

Characteristic	Value
Drainage Area (km2)	17.77
Shape Factor (-)	7.16
Length of Main Channel (km)	11.28
Maximum Channel Elevation (m)	213.10
Minimum Channel Elevation (m)	194.70
Slope of Main Channel (m/km)	1.63
Slope of Main Channel (%)	0.16
Area Lakes/Wetlands (km²)	16.49
Area - Lakes (km²)	0.75
Area - Wetlands (km²)	15.75
Mean Elevation (m)	203.93
Maximum Elevation (m)	213.61
Mean Slope (%)	1.87

(from OWIT)



WC - 9

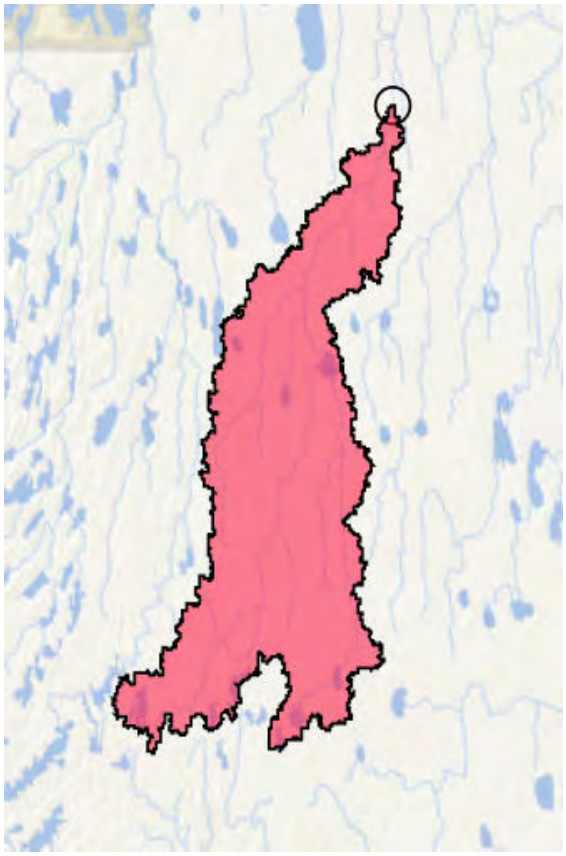
Characteristic	Value
Drainage Area (km2)	5.637
Shape Factor (-)	4.34
Length of Main Channel (km)	4.95
Maximum Channel Elevation (m)	203.10
Minimum Channel Elevation (m)	186.55
Slope of Main Channel (m/km)	3.34
Slope of Main Channel (%)	0.33
Area Lakes/Wetlands (km²)	5.47
Area - Lakes (km²)	0.00
Area - Wetlands (km²)	5.47
Mean Elevation (m)	195.00
Maximum Elevation (m)	204.36
Mean Slope (%)	1.86

(from OWIT)

WC - 10

Characteristic	Value
Drainage Area (km2)	542.64
Shape Factor (-)	18.27
Length of Main Channel (km)	99.58
Maximum Channel Elevation (m)	246.35
Minimum Channel Elevation (m)	186.21
Slope of Main Channel (m/km)	0.60
Slope of Main Channel (%)	0.06
Area Lakes/Wetlands (km²)	427.19
Area - Lakes (km²)	33.77
Area - Wetlands (km²)	393.42
Mean Elevation (m)	221.16
Maximum Elevation (m)	255.53
Mean Slope (%)	1.97

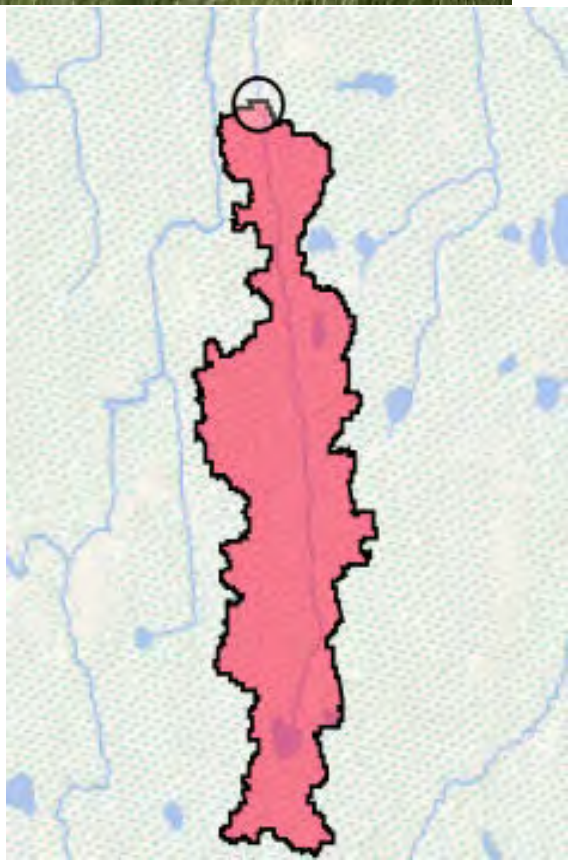
(from OWIT)



WC - 11

Characteristic	Value
Drainage Area (km2)	16.99
Shape Factor (-)	11.05
Length of Main Channel (km)	13.70
Maximum Channel Elevation (m)	205.71
Minimum Channel Elevation (m)	186.10
Slope of Main Channel (m/km)	1.43
Slope of Main Channel (%)	0.14
Area Lakes/Wetlands (km²)	16.08
Area - Lakes (km²)	0.41
Area - Wetlands (km²)	15.67
Mean Elevation (m)	196.47
Maximum Elevation (m)	207.33
Mean Slope (%)	1.85

(from OWIT)



WC - 12

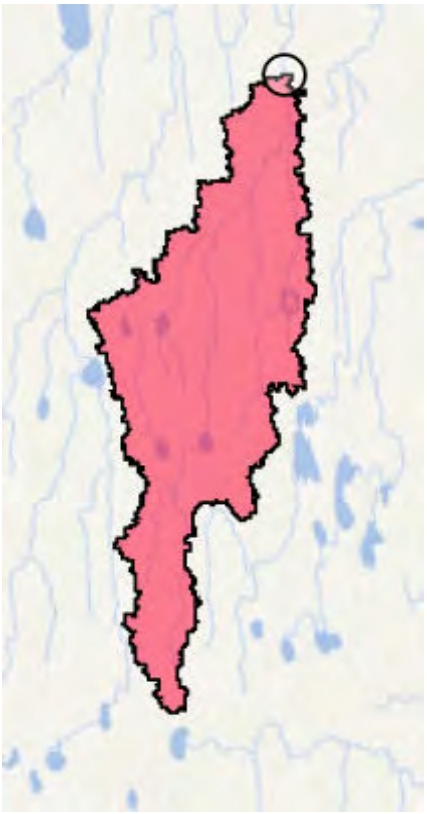
Characteristic	Value
Drainage Area (km2)	13.36
Shape Factor (-)	7.82
Length of Main Channel (km)	10.22
Maximum Channel Elevation (m)	201.42
Minimum Channel Elevation (m)	181.46
Slope of Main Channel (m/km)	1.95
Slope of Main Channel (%)	0.20
Area Lakes/Wetlands (km²)	12.66
Area - Lakes (km²)	0.44
Area - Wetlands (km²)	12.22
Mean Elevation (m)	192.89
Maximum Elevation (m)	202.36
Mean Slope (%)	1.87

(from OWIT)

WC - 13

Characteristic	Value
Drainage Area (km2)	349.36
Shape Factor (-)	14.69
Length of Main Channel (km)	71.64
Maximum Channel Elevation (m)	231.27
Minimum Channel Elevation (m)	177.78
Slope of Main Channel (m/km)	0.75
Slope of Main Channel (%)	0.08
Area Lakes/Wetlands (km²)	302.77
Area - Lakes (km²)	16.86
Area - Wetlands (km²)	285.92
Mean Elevation (m)	204.94
Maximum Elevation (m)	231.96
Mean Slope (%)	1.91

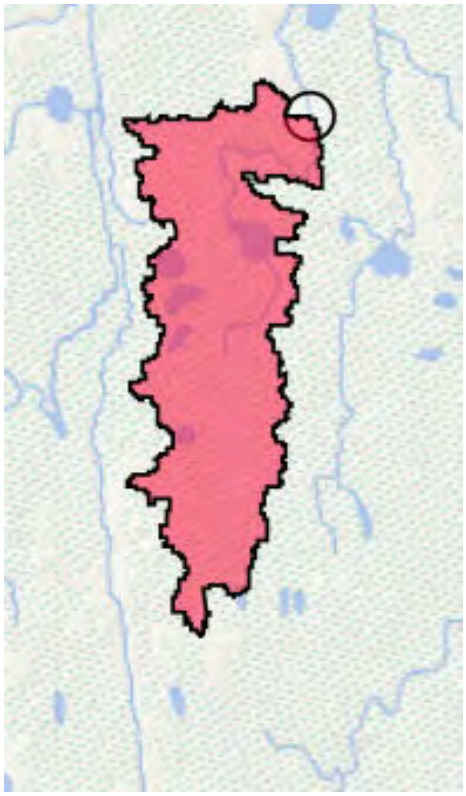
(from OWIT)



WC - 14

Characteristic	Value
Drainage Area (km2)	14.763
Shape Factor (-)	12.69
Length of Main Channel (km)	13.687
Maximum Channel Elevation (m)	198.75
Minimum Channel Elevation (m)	177.92
Slope of Main Channel (m/km)	1.52
Slope of Main Channel (%)	0.152
Area Lakes/Wetlands (km²)	14.16
Area - Lakes (km²)	0.796
Area - Wetlands (km²)	13.364
Mean Elevation (m)	186.202
Maximum Elevation (m)	198.748
Mean Slope (%)	1.813

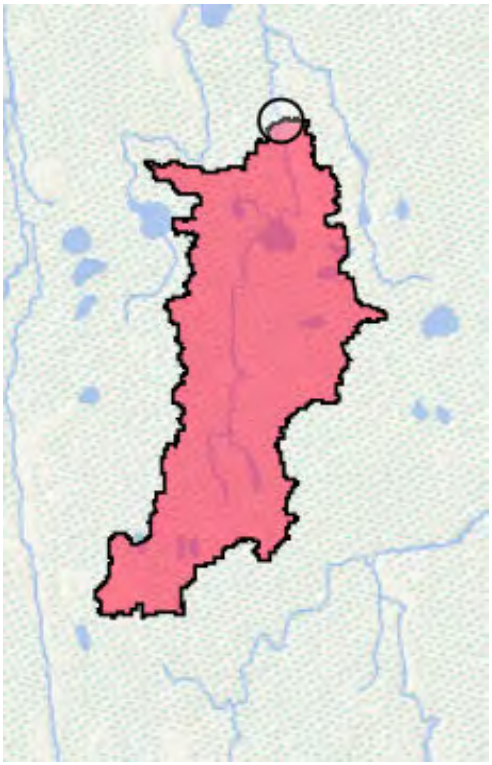
(from OWIT)



WC - 15

Characteristic	Value
Drainage Area (km2)	18.71
Shape Factor (-)	9.78
Length of Main Channel (km)	13.53
Maximum Channel Elevation (m)	197.07
Minimum Channel Elevation (m)	175.86
Slope of Main Channel (m/km)	1.57
Slope of Main Channel (%)	0.16
Area Lakes/Wetlands (km²)	16.93
Area - Lakes (km²)	0.60
Area - Wetlands (km²)	16.33
Mean Elevation (m)	186.08
Maximum Elevation (m)	199.03
Mean Slope (%)	1.90

(from OWIT)



WB - 16

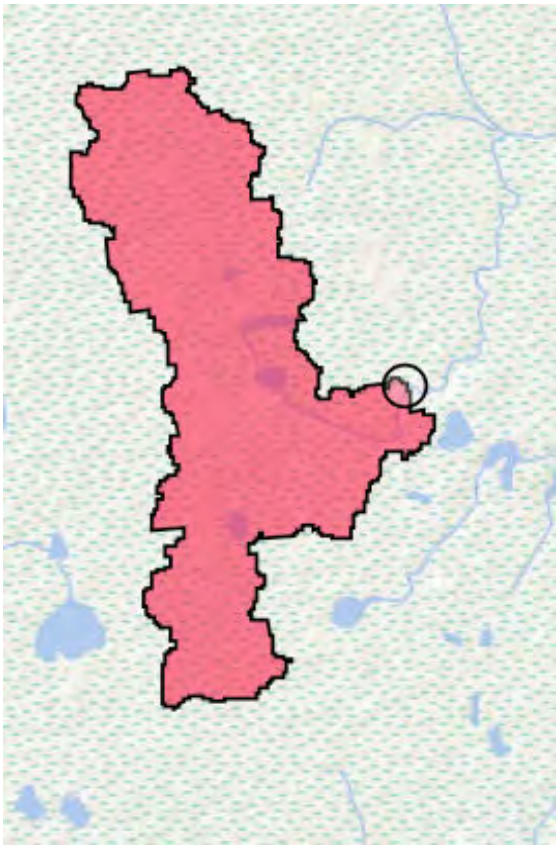
Characteristic	Value
Drainage Area (km2)	13.19
Shape Factor (-)	8.16
Length of Main Channel (km)	10.37
Maximum Channel Elevation (m)	190.01
Minimum Channel Elevation (m)	176.49
Slope of Main Channel (m/km)	1.30
Slope of Main Channel (%)	0.13
Area Lakes/Wetlands (km²)	12.22
Area - Lakes (km²)	0.48
Area - Wetlands (km²)	11.74
Mean Elevation (m)	184.67
Maximum Elevation (m)	190.27
Mean Slope (%)	1.92

(from OWIT)

WC - 17

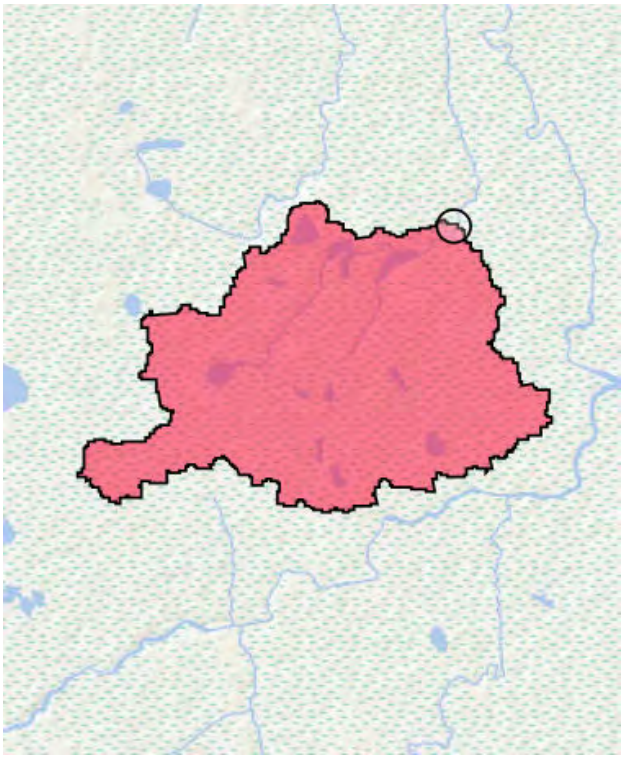
Characteristic	Value
Drainage Area (km2)	8.04
Shape Factor (-)	6.61
Length of Main Channel (km)	7.29
Maximum Channel Elevation (m)	186.69
Minimum Channel Elevation (m)	174.30
Slope of Main Channel (m/km)	1.70
Slope of Main Channel (%)	0.17
Area Lakes/Wetlands (km²)	7.30
Area - Lakes (km²)	0.14
Area - Wetlands (km²)	7.16
Mean Elevation (m)	182.64
Maximum Elevation (m)	188.93
Mean Slope (%)	1.92

(from OWIT)



WC - 18

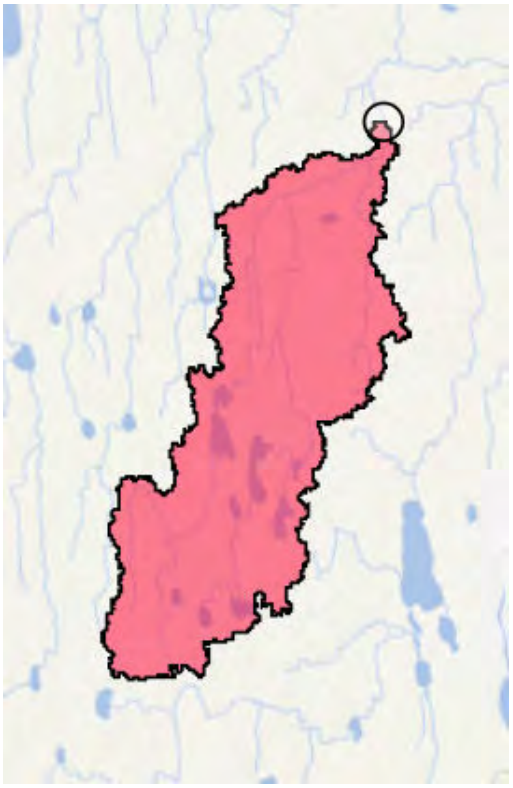
Characteristic	Value
Drainage Area (km2)	10.06
Shape Factor (-)	5.17
Length of Main Channel (km)	7.21
Maximum Channel Elevation (m)	188.03
Minimum Channel Elevation (m)	170.18
Slope of Main Channel (m/km)	2.47
Slope of Main Channel (%)	0.25
Area Lakes/Wetlands (km²)	9.68
Area - Lakes (km²)	0.34
Area - Wetlands (km²)	9.34
Mean Elevation (m)	179.89
Maximum Elevation (m)	188.16
Mean Slope (%)	1.91



(from OWIT)

WC - 19

Characteristic	Value
Drainage Area (km2)	491.60
Shape Factor (-)	14.28
Length of Main Channel (km)	83.79
Maximum Channel Elevation (m)	216.01
Minimum Channel Elevation (m)	171.25
Slope of Main Channel (m/km)	0.53
Slope of Main Channel (%)	0.05
Area Lakes/Wetlands (km²)	423.05
Area - Lakes (km²)	38.47
Area - Wetlands (km²)	384.58
Mean Elevation (m)	198.93
Maximum Elevation (m)	228.44
Mean Slope (%)	1.97

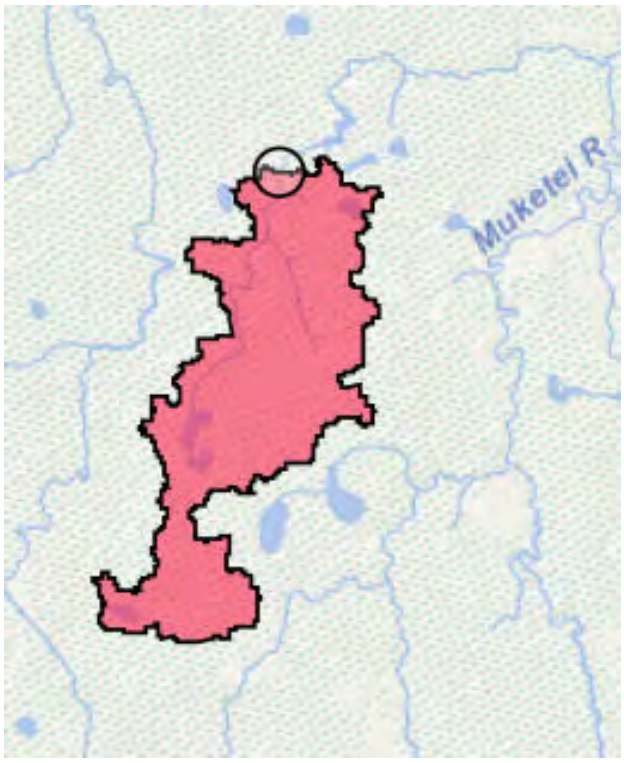


(from OWIT)

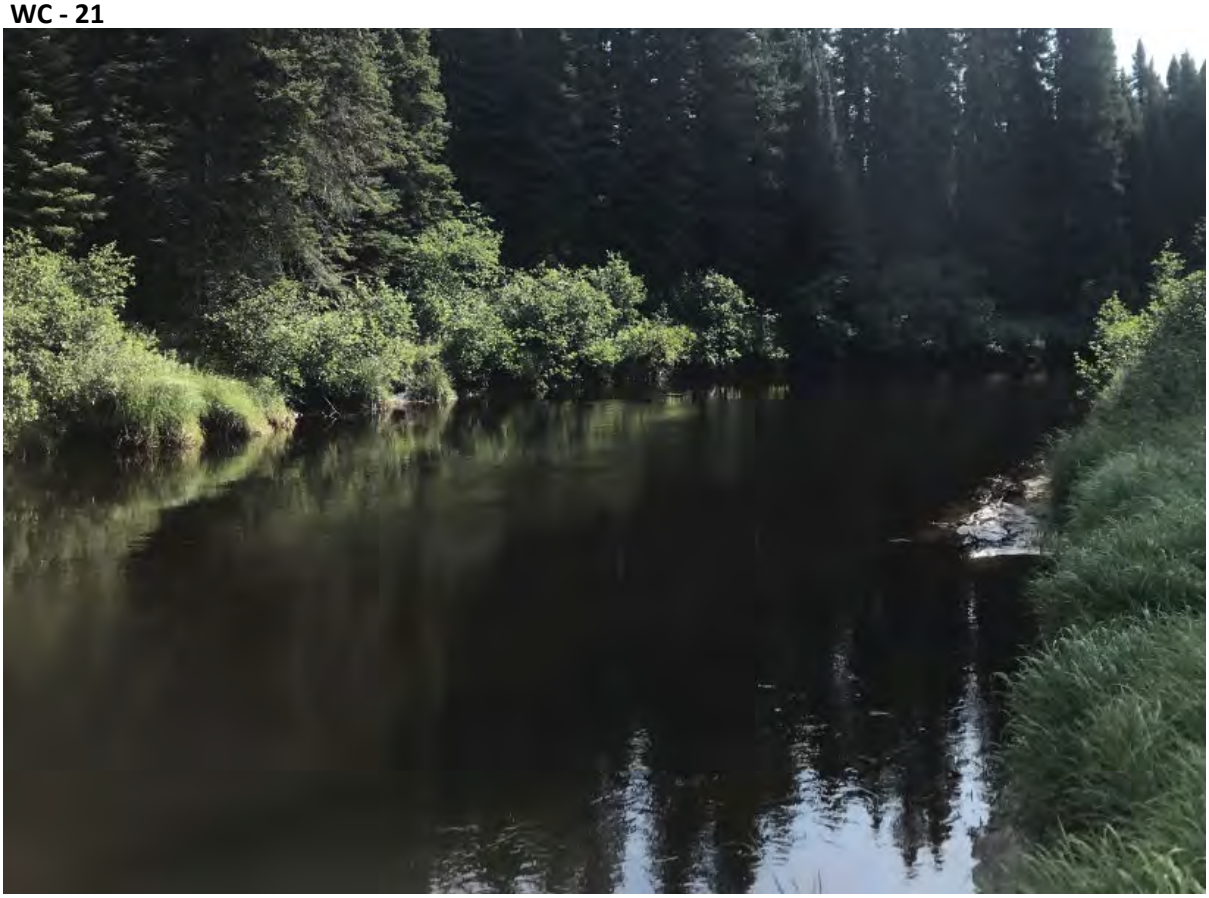
WC - 20

Characteristic	Value
Drainage Area (km2)	16.45
Shape Factor (-)	10.16
Length of Main Channel (km)	12.92
Maximum Channel Elevation (m)	187.08
Minimum Channel Elevation (m)	170.65
Slope of Main Channel (m/km)	1.27
Slope of Main Channel (%)	0.13
Area Lakes/Wetlands (km²)	15.89
Area - Lakes (km²)	0.54
Area - Wetlands (km²)	15.35
Mean Elevation (m)	179.50
Maximum Elevation (m)	188.01
Mean Slope (%)	1.87

(from OWIT)

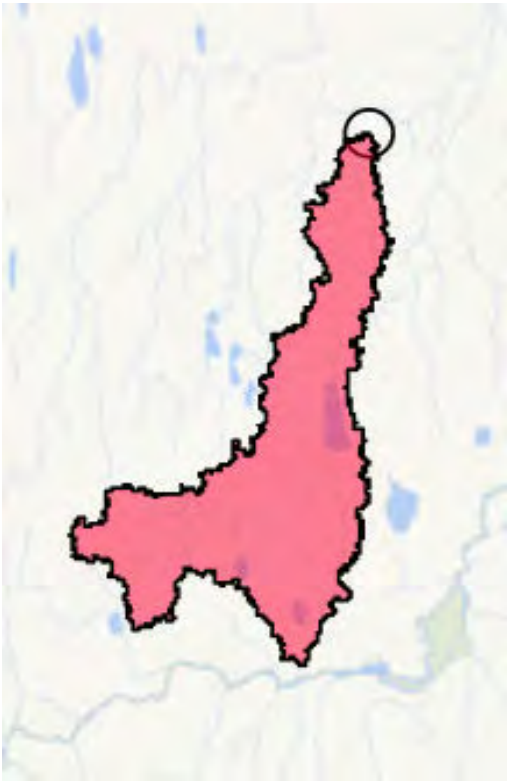


WC - 21



Characteristic	Value
Drainage Area (km2)	897.60
Shape Factor (-)	22.47
Length of Main Channel (km)	142.00
Maximum Channel Elevation (m)	237.74
Minimum Channel Elevation (m)	163.96
Slope of Main Channel (m/km)	0.52
Slope of Main Channel (%)	0.05
Area Lakes/Wetlands (km²)	839.76
Area - Lakes (km²)	56.12
Area - Wetlands (km²)	783.64
Mean Elevation (m)	195.71
Maximum Elevation (m)	240.98
Mean Slope (%)	1.98

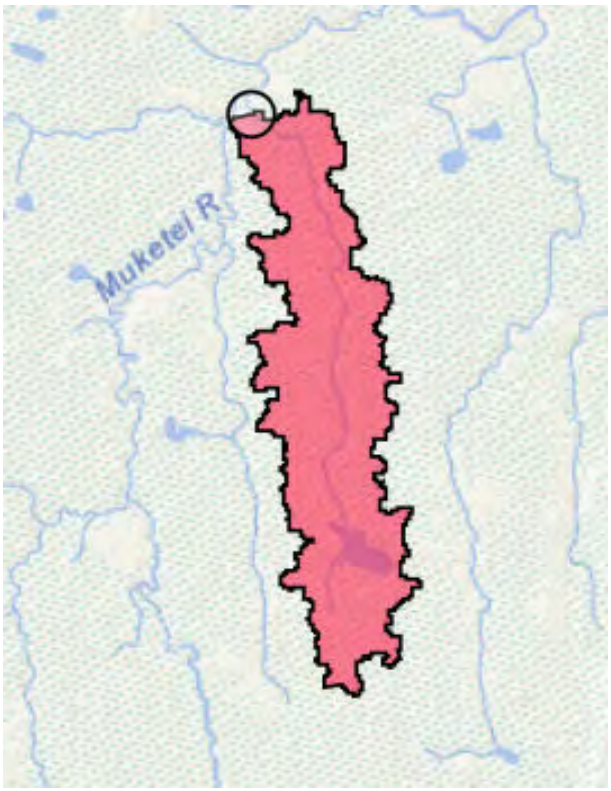
(from OWIT)



WC - 22

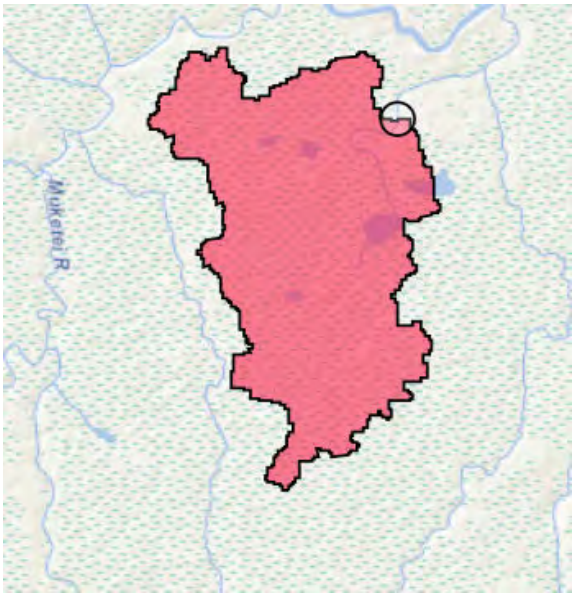
Characteristic	Value
Drainage Area (km2)	13.50
Shape Factor (-)	10.91
Length of Main Channel (km)	12.14
Maximum Channel Elevation (m)	179.49
Minimum Channel Elevation (m)	164.66
Slope of Main Channel (m/km)	1.22
Slope of Main Channel (%)	0.12
Area Lakes/Wetlands (km²)	12.86
Area - Lakes (km²)	0.35
Area - Wetlands (km²)	12.51
Mean Elevation (m)	173.15
Maximum Elevation (m)	180.12
Mean Slope (%)	1.93

(from OWIT)



WC - 23

Characteristic	Value
Drainage Area (km2)	8.90
Shape Factor (-)	4.93
Length of Main Channel (km)	6.62
Maximum Channel Elevation (m)	174.34
Minimum Channel Elevation (m)	163.55
Slope of Main Channel (m/km)	1.63
Slope of Main Channel (%)	0.16
Area Lakes/Wetlands (km²)	8.38
Area - Lakes (km²)	0.21
Area - Wetlands (km²)	8.17
Mean Elevation (m)	169.47
Maximum Elevation (m)	175.16
Mean Slope (%)	1.90

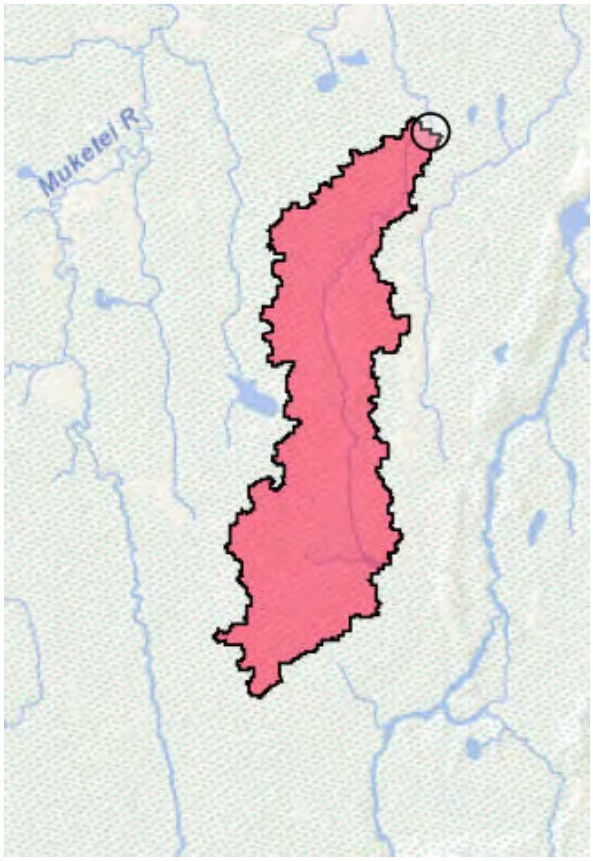


(from OWIT)

WC - 24

Characteristic	Value
Drainage Area (km2)	23.60
Shape Factor (-)	12.22
Length of Main Channel (km)	16.98
Maximum Channel Elevation (m)	181.53
Minimum Channel Elevation (m)	163.90
Slope of Main Channel (m/km)	1.04
Slope of Main Channel (%)	0.10
Area Lakes/Wetlands (km²)	21.44
Area - Lakes (km²)	0.12
Area - Wetlands (km²)	21.32
Mean Elevation (m)	174.46
Maximum Elevation (m)	183.10
Mean Slope (%)	1.86

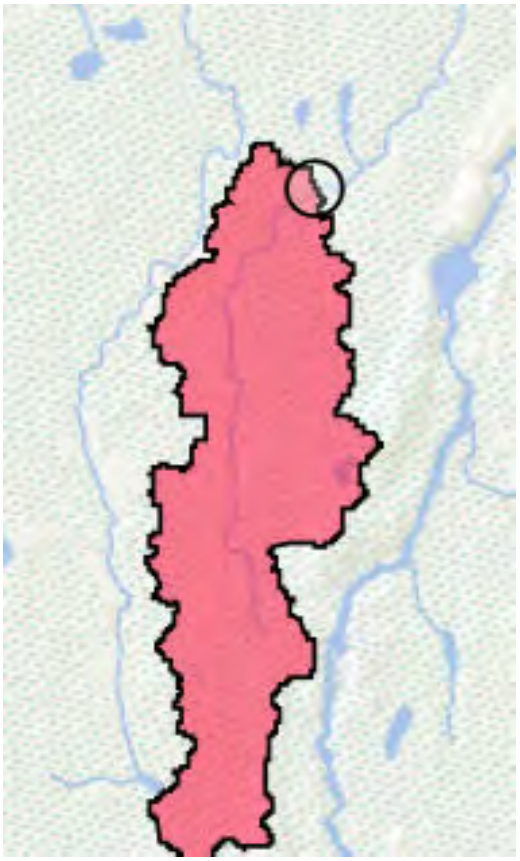
(from OWIT)



WC - 25

Characteristic	Value
Drainage Area (km2)	17.57
Shape Factor (-)	10.11
Length of Main Channel (km)	13.33
Maximum Channel Elevation (m)	176.88
Minimum Channel Elevation (m)	161.56
Slope of Main Channel (m/km)	1.15
Slope of Main Channel (%)	0.12
Area Lakes/Wetlands (km²)	15.17
Area - Lakes (km²)	0.14
Area - Wetlands (km²)	15.03
Mean Elevation (m)	171.25
Maximum Elevation (m)	198.17
Mean Slope (%)	2.20

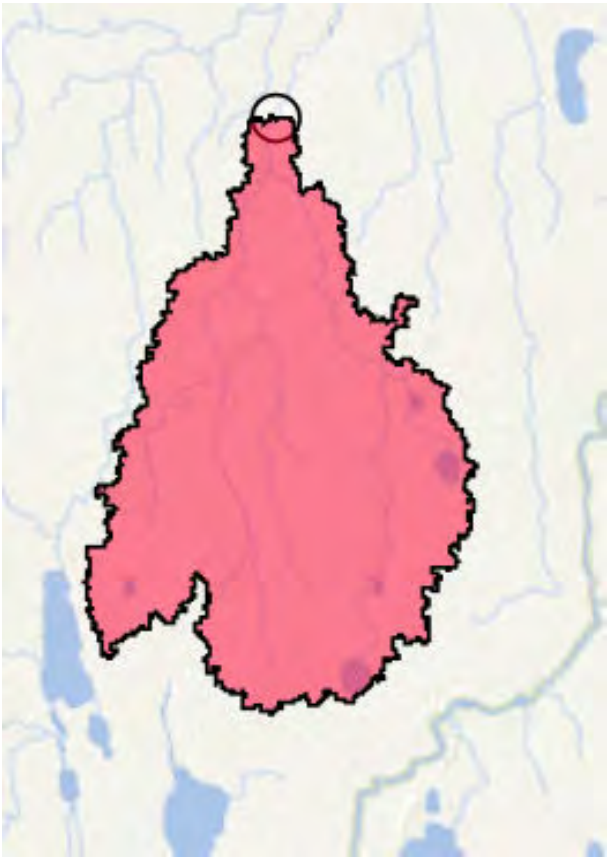
(from OWIT)



WC - 26

Characteristic	Value
Drainage Area (km2)	529.37
Shape Factor (-)	9.71
Length of Main Channel (km)	71.71
Maximum Channel Elevation (m)	192.42
Minimum Channel Elevation (m)	152.42
Slope of Main Channel (m/km)	0.56
Slope of Main Channel (%)	0.06
Area Lakes/Wetlands (km²)	512.81
Area - Lakes (km²)	21.85
Area - Wetlands (km²)	490.96
Mean Elevation (m)	180.95
Maximum Elevation (m)	231.16
Mean Slope (%)	2.34

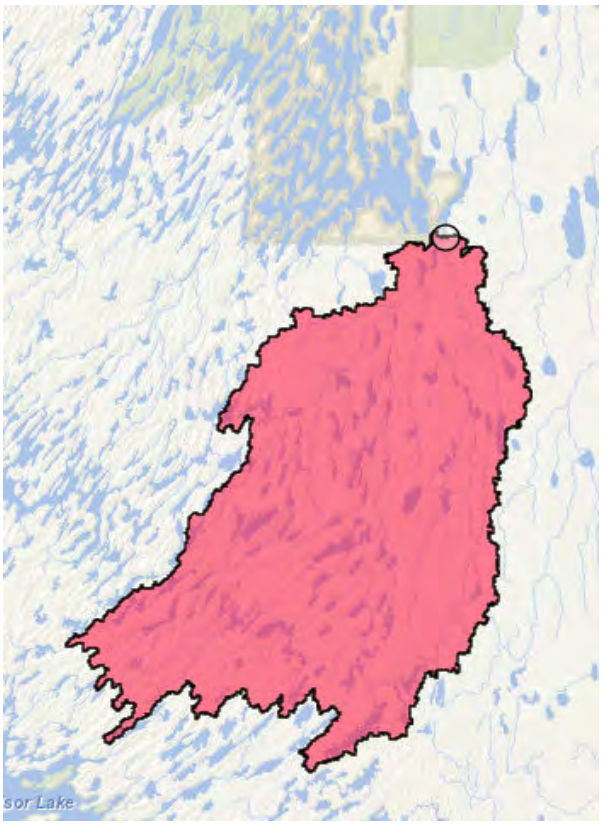
(from OWIT)



WC - 27

Characteristic	Value
Drainage Area (km2)	1667.979
Shape Factor (-)	6.768
Length of Main Channel (km)	106.247
Maximum Channel Elevation (m)	262.65
Minimum Channel Elevation (m)	185.89
Slope of Main Channel (m/km)	0.72
Slope of Main Channel (%)	0.072
Area Lakes/Wetlands (km²)	769.263
Area - Lakes (km²)	259.566
Area - Wetlands (km²)	509.697
Mean Elevation (m)	235.446
Maximum Elevation (m)	294.188
Mean Slope (%)	3.038

(from OWIT)



APPENDIX G

Horizontal Alignment Data Report

WSR - Horizontal ALIGNMENT REPORT

Report Created: Tuesday, August 20, 2024
Time: 7:26:07 PM

Project: WSR Horizontal Alignment Main Line
Description: Engineering Route - Horizontal Alignment Report
File Name: WSR-Corridor-C2E-Align3a.dgn
Last Revised: 8/20/2024 19:15

Note: All units in this report are in meters unless specified otherwise.

Element	Point Type	Point Number	Station	Northing	Easting	Radius	Length	Delta / Theta	Rotation Direction	K	P
Aligment Name:		WSR-Align 3a									
Description:											
Style:											
Tangent	START		0	5868225.146	475277.625						
Tangent	PC		691.126	5867566.03	475069.727						
Arc	PC		691.126	5867566.03	475069.727						
Arc	HPI		758.893	5867501.401	475049.342	250	132.354	30.333°	Right		
Arc	CC			5867641.232	474831.306						
Arc	PRC		823.48	5867455.915	474999.109						
Arc	PRC		823.48	5867455.915	474999.109						
Arc	HPI		881.095	5867417.243	474956.401	350	114.205	18.696°	Left		
Arc	CC			5867196.471	475234.032						
Arc	PT		937.685	5867366.923	474928.342						
Tangent	PT		937.685	5867366.923	474928.342						
Tangent	PC		1213.965	5867125.62	474793.793						
Arc	PC		1213.965	5867125.62	474793.793						
Arc	HPI		1364.848	5866993.839	474720.312	250	271.506	62.224°	Left		
Arc	CC			5867003.869	475012.143						
Arc	PT		1485.471	5866867.414	474802.667						
Tangent	PT		1485.471	5866867.414	474802.667						
Tangent	PC		1608.756	5866764.113	474869.958						
Arc	PC		1608.756	5866764.113	474869.958						
Arc	HPI		1718.422	5866672.223	474929.816	250	206.694	47.371°	Left		
Arc	CC			5866900.568	475079.434						
Arc	PRC		1815.45	5866654.031	475037.963						
Arc	PRC		1815.45	5866654.031	475037.963						
Arc	HPI		1863.383	5866646.08	475085.232	200	94.09	26.955°	Right		
Arc	CC			5866456.802	475004.786						
Arc	PT		1909.541	5866617.566	475123.761						
Tangent	PT		1909.541	5866617.566	475123.761						
Tangent	PC		1949.301	5866593.914	475155.721						
Arc	PC		1949.301	5866593.914	475155.721						
Arc	HPI		2103.664	5866502.088	475279.801	500	299.442	34.314°	Left		
Arc	CC			5866995.824	475453.157						
Arc	PT		2248.743	5866496.19	475434.051						
Tangent	PT		2248.743	5866496.19	475434.051						
Tangent	HPI		2306.165	5866493.995	475491.43						
Tangent	HPI		2306.165	5866493.995	475491.43						
Tangent	HPI		2332.862	5866491.789	475518.036						
Tangent	HPI		2332.862	5866491.789	475518.036						
Tangent	PC		2411.304	5866481.835	475595.844						
Arc	PC		2411.304	5866481.835	475595.844						
Arc	HPI		2470.001	5866474.387	475654.066	300	115.928	22.141°	Left		
Arc	CC			5866779.41	475633.914						
Arc	PT		2527.232	5866489.43	475710.802						

Tangent	PT		2527.232	5866489.43	475710.802						
Tangent	PC		2618.958	5866512.939	475799.463						
Arc	PC		2618.958	5866512.939	475799.463						
Arc	HPI		2708.257	5866535.826	475885.78	300	173.588	33.153°	Right		
Arc	CC			5866222.959	475876.351						
Arc	PRC		2792.545	5866507.782	475970.562						
Arc	PRC		2792.545	5866507.782	475970.562						
Arc	HPI		2963.435	5866454.117	476132.807	500	329.333	37.739°	Left		
Arc	CC			5866982.488	476127.579						
Arc	PT		3121.878	5866510.982	476293.958						
Tangent	PT		3121.878	5866510.982	476293.958						
Tangent	PC		3202.874	5866537.934	476370.338						
Arc	PC		3202.874	5866537.934	476370.338						
Arc	HPI		3611.733	5866673.985	476755.897	500	685.451	78.547°	Left		
Arc	CC			5867009.44	476203.959						
Arc	PT		3888.325	5867078.881	476699.114						
Tangent	PT		3888.325	5867078.881	476699.114						
Tangent	PC		4118.986	5867307.306	476667.079						
Arc	PC		4118.986	5867307.306	476667.079						
Arc	HPI		4614.255	5867797.776	476598.295	600	828.08	79.076°	Right		
Arc	CC			5867390.635	477261.264						
Arc	PT		4947.066	5867958.262	477066.842						
Tangent	PT		4947.066	5867958.262	477066.842						
Tangent	PC		5652.274	5868186.776	477734						
Arc	PC		5652.274	5868186.776	477734						
Arc	HPI		6638.397	5868506.318	478666.915	800	1422.765	101.898°	Right		
Arc	CC			5867429.941	477993.23						
Arc	PT		7075.039	5867527.565	478787.251						
Tangent	PT		7075.039	5867527.565	478787.251						
Tangent	PC		8477.957	5866135.131	478958.449						
Arc	PC		8477.957	5866135.131	478958.449						
Arc	HPI		9357.763	5865261.901	479065.811	700	1258.216	102.986°	Left		
Arc	CC			5866220.552	479653.217						
Arc	PT		9736.173	5865562.749	479892.581						
Tangent	PT		9736.173	5865562.749	479892.581						
Tangent	PC		10509.386	5865827.148	480619.184						
Arc	PC		10509.386	5865827.148	480619.184						
Arc	HPI		11681.927	5866228.096	481721.043	1500	1990.435	76.029°	Left		
Arc	CC			5867236.726	480106.262						
Arc	PT		12499.822	5867394.161	481597.977						
Tangent	PT		12499.822	5867394.161	481597.977						
Tangent	PC		13592.124	5868480.43	481483.333						
Arc	PC		13592.124	5868480.43	481483.333						
Arc	HPI		14067.394	5868953.074	481433.45	2000	933.23	26.735°	Right		
Arc	CC			5868690.343	483472.286						
Arc	PT		14525.354	5869397.632	481601.527						
Tangent	PT		14525.354	5869397.632	481601.527						
Tangent	PC		15219.031	5870046.484	481846.842						
Arc	PC		15219.031	5870046.484	481846.842						
Arc	HPI		16916.418	5871634.186	482447.114	650	1566.606	138.092°	Right		
Arc	CC			5869816.615	482454.839						
Arc	PCC		16785.637	5870051.644	483060.86						
Arc	PCC		16785.637	5870051.644	483060.86						
Arc	HPI		17348.948	5869526.447	483264.544	3000	1113.654	21.269°	Right		
Arc	CC			5868966.896	480263.84						
Arc	PT		17899.291	5868963.137	483263.838						

Tangent	PT		17899.291	5868963.137	483263.838						
Tangent	PC		18293.446	5868568.982	483263.344						
Arc	PC		18293.446	5868568.982	483263.344						
Arc	HPI		18848.781	5868013.648	483262.648	3000	1098.237	20.975°	Left		
Arc	CC			5868565.223	486263.342						
Arc	PT		19391.684	5867494.862	483460.784						
Tangent	PT		19391.684	5867494.862	483460.784						
Tangent	PC		21375.716	5865641.408	484168.661						
Arc	PC		21375.716	5865641.408	484168.661						
Arc	HPI		21532.219	5865495.204	484224.499	3000	312.724	5.973°	Right		
Arc	CC			5864571.047	481366.103						
Arc	PT		21688.44	5865343.984	484264.822						
Tangent	PT		21688.44	5865343.984	484264.822						
Tangent	PC		23310.274	5863776.904	484682.68						
Arc	PC		23310.274	5863776.904	484682.68						
Arc	HPI		24583.691	5862546.478	485010.77	1500	2111.644	80.659°	Left		
Arc	CC			5864163.372	486132.039						
Arc	PT		25421.917	5862670.504	486278.133						
Tangent	PT		25421.917	5862670.504	486278.133						
Tangent	PC		26394.184	5862765.199	487245.777						
Arc	PC		26394.184	5862765.199	487245.777						
Arc	HPI		26739.013	5862798.784	487588.967	2457.123	685.184	15.977°	Right		
Arc	CC			5860319.758	487485.092						
Arc	PRC		27079.368	5862736.606	487928.145						
Arc	PRC		27079.368	5862736.606	487928.145						
Arc	HPI		27455.872	5862668.717	488298.478	2000	744.299	21.323°	Left		
Arc	CC			5864703.825	488288.772						
Arc	PT		27823.666	5862740.136	488668.147						
Tangent	PT		27823.666	5862740.136	488668.147						
Tangent	PC		28685.43	5862903.602	489514.266						
Arc	PC		28685.43	5862903.602	489514.266						
Arc	HPI		29183.16	5862998.015	490002.959	500	783.123	89.739°	Right		
Arc	CC			5862412.679	489609.11						
Arc	PT		29468.553	5862509.756	490099.595						
Tangent	PT		29468.553	5862509.756	490099.595						
Tangent	PC		29975.434	5862012.52	490198.008						
Arc	PC		29975.434	5862012.52	490198.008						
Arc	HPI		30110.356	5861880.166	490224.203	1000	268.223	15.368°	Right		
Arc	CC			5861818.367	489217.037						
Arc	PT		30243.658	5861745.602	490214.386						
Tangent	PT		30243.658	5861745.602	490214.386						
Tangent	PC		31348.944	5860643.246	490133.96						
Arc	PC		31348.944	5860643.246	490133.96						
Arc	HPI		31610.452	5860382.431	490114.931	3000	521.697	9.964°	Right		
Arc	CC			5860861.541	487141.912						
Arc	PT		31870.641	5860128.843	490051.062						
Tangent	PT		31870.641	5860128.843	490051.062						
Tangent	PC		33623.952	5858428.628	489622.847						
Arc	PC		33623.952	5858428.628	489622.847						
Arc	HPI		33798.146	5858259.709	489580.303	500	335.237	38.415°	Right		
Arc	CC			5858550.744	489137.988						
Arc	PRC		33959.189	5858153.792	489442.01						
Arc	PRC		33959.189	5858153.792	489442.01						
Arc	HPI		34173.157	5858023.69	489272.14	500	404.355	46.336°	Left		
Arc	CC			5857756.84	489746.032						
Arc	PT		34363.544	5857810.98	489248.972						

Tangent	PT		34363.544	5857810.98	489248.972						
Tangent	PC		36171.817	5856013.339	489053.174						
Arc	PC		36171.817	5856013.339	489053.174						
Arc	HPI		36667.307	5855520.762	488999.523	3000	982.114	18.757°	Left		
Arc	CC			5855688.502	492035.536						
Arc	PT		37153.931	5855037.093	489107.112						
Tangent	PT		37153.931	5855037.093	489107.112						
Tangent	PC		38332.63	5853886.517	489363.051						
Arc	PC		38332.63	5853886.517	489363.051						
Arc	HPI		38926.678	5853306.642	489492.04	2000	1154.897	33.085°	Left		
Arc	CC			5854320.79	491315.333						
Arc	PT		39487.527	5852891.203	489916.662						
Tangent	PT		39487.527	5852891.203	489916.662						
Tangent	PC		40394.468	5852256.947	490564.937						
Arc	PC		40394.468	5852256.947	490564.937						
Arc	HPI		40939.521	5851875.772	490954.537	2000	1064.261	30.489°	Right		
Arc	CC			5850827.36	489166.265						
Arc	PT		41458.728	5851349.631	491096.87						
Tangent	PT		41458.728	5851349.631	491096.87						
Tangent	PC		44302.9	5848604.147	491839.584						
Arc	PC		44302.9	5848604.147	491839.584						
Arc	HPI		46127.936	5846842.435	492316.165	5000	3499.813	40.105°	Left		
Arc	CC			5849909.824	496666.094						
Arc	PCC		47802.713	5845801.97	493815.562						
Arc	PCC		47802.713	5845801.97	493815.562						
Arc	HPI		48256.805	5845543.089	494188.631	2000	893.044	25.584°	Left		
Arc	CC			5847445.111	494955.775						
Arc	PRC		48695.757	5845470.693	494636.915						
Arc	PRC		48695.757	5845470.693	494636.915						
Arc	HPI		49242.945	5845383.454	495177.104	2000	1068.236	30.603°	Right		
Arc	CC			5843496.275	494318.054						
Arc	PRC		49763.992	5845033.366	495597.644						
Arc	PRC		49763.992	5845033.366	495597.644						
Arc	HPI		50432.956	5844605.366	496111.773	2000	1291.135	36.988°	Left		
Arc	CC			5846570.457	496877.234						
Arc	PRC		51055.127	5844572.825	496779.944						
Arc	PRC		51055.127	5844572.825	496779.944						
Arc	HPI		51923.647	5844530.576	497647.436	2866.938	1686.648	33.708°	Right		
Arc	CC			5841709.281	496640.482						
Arc	PRC		52741.775	5844014.01	498345.638						
Arc	PRC		52741.775	5844014.01	498345.638						
Arc	HPI		53232.571	5843722.101	498740.189	1307.04	939.006	41.163°	Left		
Arc	CC			5845064.739	499123.02						
Arc	PRC		53680.781	5843762.032	499229.358						
Arc	PRC		53680.781	5843762.032	499229.358						
Arc	HPI		54374.723	5843818.489	499921	7792.057	1384.232	10.178°	Right		
Arc	CC			5835995.806	499863.304						
Arc	PRC		55065.013	5843751.836	500611.733						
Arc	PRC		55065.013	5843751.836	500611.733						
Arc	HPI		55730.367	5843687.929	501274.012	2000	1284.64	36.802°	Left		
Arc	CC			5845742.589	500803.834						
Arc	PRC		56349.653	5844033.498	501842.587						
Arc	PRC		56349.653	5844033.498	501842.587						
Arc	HPI		56761.369	5844247.334	502194.418	2000	812.088	23.265°	Right		
Arc	CC			5842324.407	502881.34						
Arc	PT		57161.741	5844304.818	502602.101						
Tangent	PT		57161.741	5844304.818	502602.101						

Tangent	PC		57788.678	5844392.35	503222.898						
Arc	PC		57788.678	5844392.35	503222.898						
Arc	HPI		58770.621	5844529.449	504195.222	1500	1738.866	66.420°	Left		
Arc	CC			5845877.658	503013.468						
Arc	PRC		59527.544	5845475.429	504458.533						
Arc	PRC		59527.544	5845475.429	504458.533						
Arc	HPI		60574.102	5846483.658	504739.17	1700	1876.212	63.235°	Right		
Arc	CC			5845019.57	506096.273						
Arc	PT		61403.757	5846687.131	505765.758						
Tangent	PT		61403.757	5846687.131	505765.758						
Tangent	PC		64311.913	5847252.537	508618.421						
Arc	PC		64311.913	5847252.537	508618.421						
Arc	HPI		64780.64	5847343.667	509078.204	5000	934.723	10.711°	Right		
Arc	CC			5842347.945	509590.525						
Arc	PT		65246.636	5847347.755	509546.913						
Tangent	PT		65246.636	5847347.755	509546.913						
Tangent	PC		65469.097	5847349.696	509769.366						
Arc	PC		65469.097	5847349.696	509769.366						
Arc	HPI		65579.52	5847350.659	509879.786	700	219.042	17.929°	Left		
Arc	CC			5848049.669	509763.261						
Arc	PRC		65688.139	5847385.566	509984.546						
Arc	PRC		65688.139	5847385.566	509984.546						
Arc	HPI		65934.139	5847463.332	510217.932	700	473.127	38.726°	Right		
Arc	CC			5846721.463	510205.832						
Arc	PRC		66161.265	5847377.996	510448.657						
Arc	PRC		66161.265	5847377.996	510448.657						
Arc	HPI		66320.13	5847322.887	510597.657	700	312.437	25.573°	Left		
Arc	CC			5848034.53	510691.482						
Arc	PT		66473.703	5847337.495	510755.849						
Tangent	PT		66473.703	5847337.495	510755.849						
Tangent	PC		68588.024	5847531.914	512861.212						
Arc	PC		68588.024	5847531.914	512861.212						
Arc	HPI		69177.208	5847586.091	513447.9	2500	1157.252	26.522°	Left		
Arc	CC			5850021.322	512631.33						
Arc	PRC		69745.276	5847896.549	513948.653						
Arc	PRC		69745.276	5847896.549	513948.653						
Arc	HPI		70349.483	5848214.924	514462.175	2500	1185.678	27.174°	Right		
Arc	CC			5845771.777	515265.977						
Arc	PCC		70930.954	5848263.638	515064.415						
Arc	PCC		70930.954	5848263.638	515064.415						
Arc	PCC		70930.954	5848263.638	515064.415						
Arc	HPI		72365.027	5848379.26	516493.819	3000	2675.477	51.098°	Right		
Arc	CC			5845273.405	515306.29						
Arc	PRC		73606.431	5847339.48	517481.453						
Arc	PRC		73606.431	5847339.48	517481.453						
Arc	HPI		74282.973	5846848.95	517947.381	1500	1271.124	48.553°	Left		
Arc	CC			5848372.517	518569.034						
Arc	PT		74877.556	5846873.505	518623.477						
Tangent	PT		74877.556	5846873.505	518623.477						
Tangent	PC		75952.142	5846912.508	519697.355						
Arc	PC		75952.142	5846912.508	519697.355						
Arc	HPI		76267.779	5846923.964	520012.784	1500	622.195	23.766°	Right		
Arc	CC			5845413.496	519751.798						
Arc	PT		76574.338	5846807.329	520306.08						
Tangent	PT		76574.338	5846807.329	520306.08						
Tangent	PC		77041.925	5846634.546	520740.572						
Arc	PC		77041.925	5846634.546	520740.572						
Arc	HPI		77419.261	5846495.112	521091.202	1500	739.332	28.240°	Left		

Arc	CC			5848028.379	521294.854						
Arc	PT		77781.257	5846538.183	521466.072						
Tangent	PT		77781.257	5846538.183	521466.072						
Tangent	PC		78395.248	5846608.267	522076.05						
Arc	PC		78395.248	5846608.267	522076.05						
Arc	HPI		78853.107	5846660.529	522530.916	2000	900.206	25.789°	Right		
Arc	CC			5844621.339	522304.34						
Arc	PT		79295.454	5846509.693	522963.217						
Tangent	PT		79295.454	5846509.693	522963.217						
Tangent	PC		80276.638	5846186.453	523889.628						
Arc	PC		80276.638	5846186.453	523889.628						
Arc	HPI		80406.125	5846143.795	524011.887	800	256.748	18.388°	Right		
Arc	CC			5845431.112	523626.077						
Arc	PRC		80533.386	5846064.748	524114.447						
Arc	PRC		80533.386	5846064.748	524114.447						
Arc	HPI		80821.179	5845889.061	524342.392	800	552.522	39.571°	Left		
Arc	CC			5846698.384	524602.816						
Arc	PT		81085.908	5845898.847	524630.018						
Tangent	PT		81085.908	5845898.847	524630.018						
Tangent	PC		81846.207	5845924.699	525389.877						
Arc	PC		81846.207	5845924.699	525389.877						
Arc	HPI		82400.323	5845943.54	525943.672	1500	1061.584	40.550°	Right		
Arc	CC			5844425.566	525440.881						
Arc	PRC		82907.791	5845597.831	526376.719						
Arc	PRC		82907.791	5845597.831	526376.719						
Arc	HPI		83265.64	5845374.572	526656.382	1500	702.567	26.836°	Left		
Arc	CC			5846770.097	527312.558						
Arc	PT		83610.357	5845301.608	527006.714						
Tangent	PT		83610.357	5845301.608	527006.714						
Tangent	PC		84694.091	5845080.639	528067.681						
Arc	PC		84694.091	5845080.639	528067.681						
Arc	HPI		86477.655	5844716.978	529813.778	12850.431	3544.485	15.804°	Left		
Arc	CC			5857661.116	530687.83						
Arc	PCC		88238.575	5844842.598	531592.913						
Arc	PCC		88238.575	5844842.598	531592.913						
Arc	HPI		88938.732	5844891.912	532291.331	2000	1346.979	38.588°	Left		
Arc	CC			5846837.631	531452.048						
Arc	PRC		89585.554	5845366.073	532806.492						
Arc	PRC		89585.554	5845366.073	532806.492						
Arc	HPI		90267.287	5845827.757	533308.096	2000	1314.059	37.645°	Right		
Arc	CC			5843894.515	534160.935						
Arc	PRC		90899.613	5845886.959	533987.253						
Arc	PRC		90899.613	5845886.959	533987.253						
Arc	HPI		91215.88	5845914.424	534302.325	2000	627.338	17.972°	Left		
Arc	CC			5847879.404	533813.571						
Arc	PT		91526.951	5846037.765	534593.549						
Tangent	PT		91526.951	5846037.765	534593.549						
Tangent	PC		91895.079	5846181.33	534932.528						
Arc	PC		91895.079	5846181.33	534932.528						
Arc	HPI		92542.362	5846433.764	535528.559	2000	1252.012	35.867°	Right		
Arc	CC			5844339.691	535712.506						
Arc	PRC		93147.09	5846289.107	536159.471						
Arc	PRC		93147.09	5846289.107	536159.471						
Arc	HPI		93682.46	5846169.461	536681.3	1200	1007.137	48.087°	Left		
Arc	CC			5847458.757	536427.651						
Arc	PRC		94154.228	5846477.864	537118.917						
Arc	PRC		94154.228	5846477.864	537118.917						

Arc	HPI		94421.843	5846632.026	537337.669	1500	529.658	20.231°	Right		
Arc	CC			5845251.749	537983.001						
Arc	PT		94683.886	5846701.029	537596.235						
Tangent	PT		94683.886	5846701.029	537596.235						
Tangent	PC		97127.308	5847331.049	539957.037						
Arc	PC		97127.308	5847331.049	539957.037						
Arc	HPI		98182.714	5847603.179	540976.756	1171.224	1718.022	84.045°	Right		
Arc	CC			5846199.428	540259.03						
Arc	PT		98845.33	5846617.196	541353.213						
Tangent	PT		98845.33	5846617.196	541353.213						
Tangent	PC		99802.91	5845722.604	541694.776						
Arc	PC		99802.91	5845722.604	541694.776						
Arc	HPI		100525.119	5845047.901	541952.383	1500	1346.149	51.419°	Left		
Arc	CC			5846257.645	543096.108						
Arc	PT		101149.059	5844828.522	542640.467						
Tangent	PT		101149.059	5844828.522	542640.467						
Tangent	PC		102108.103	5844537.202	543554.194						
Arc	PC		102108.103	5844537.202	543554.194						
Arc	HPI		102620.11	5844381.675	544042.008	1064.65	954.489	51.367°	Left		
Arc	CC			5845551.546	543877.593						
Arc	PRC		103062.592	5844665.638	544468.056						
Arc	PRC		103062.592	5844665.638	544468.056						
Arc	HPI		103835.376	5845094.229	545111.099	1250	1384.286	63.451°	Right		
Arc	CC			5843625.497	545161.315						
Arc	PRC		104446.877	5844710.559	545781.913						
Arc	PRC		104446.877	5844710.559	545781.913						
Arc	HPI		104865.146	5844502.897	546144.991	1200	804.933	38.433°	Left		
Arc	CC			5845752.217	546377.688						
Arc	PRC		105251.811	5844565.915	546558.485						
Arc	PRC		105251.811	5844565.915	546558.485						
Arc	HPI		105679.053	5844630.285	546980.85	1000	807.536	46.268°	Right		
Arc	CC			5843577.33	546709.15						
Arc	PT		106059.347	5844369.588	547319.336						
Tangent	PT		106059.347	5844369.588	547319.336						
Tangent	END		106090.557	5844350.544	547344.062						

APPENDIX H

Vertical Alignment Data Report

WSR - VERTICAL ALIGNMENT REPORT

Report Created: Tuesday, August 20, 2024

Project: **WSR Vertical Alignment Main Line**

Description: **Engineering Route - Vertical Alignment Report**

File Name: **WSR-Corridor-C2E-Align3a.dgn**

Note: All units in this report are in meters unless specified otherwise.

	Station	Elevation	Northing	Easting
Element: Linear				
START	0	200.515	5868225.146	475277.625
VPC	139.592	200.938	5868092.019	475235.634
Tangent Grade:	0.003			
Tangent Length:	139.592			
Element: Symmetrical Parabola				
VPC	139.592	200.938	5868092.019	475235.634
VPI	160	201	5868072.556	475229.495
VPT	180.408	200.943	5868053.093	475223.356
VHP	160.851	200.97		
Length:	40.816			
Entrance Grade:	0.003			
Exit Grade:	-0.003			
r = 100 * (g2 - g1) / L:	-1.425			
K = l / (g2 - g1):	70.156			
Middle Ordinate:	-0.03			
Element: Linear				
VPT	180.408	200.943	5868053.093	475223.356
VPC	262.786	200.713	5867974.531	475198.576
Tangent Grade:	-0.003			
Tangent Length:	82.378			
Element: Symmetrical Parabola				
VPC	262.786	200.713	5867974.531	475198.576
VPI	314	200.571	5867925.689	475183.171
VPT	365.214	201.477	5867876.847	475167.765
VLP	276.724	200.694		
Length:	102.428			
Entrance Grade:	-0.003			
Exit Grade:	0.018			
r = 100 * (g2 - g1) / L:	2			
K = l / (g2 - g1):	50			
Middle Ordinate:	0.262			
Element: Linear				
VPT	365.214	201.477	5867876.847	475167.765
VPC	397.968	202.057	5867845.61	475157.912
Tangent Grade:	0.018			
Tangent Length:	32.754			

Element: Symmetrical Parabola				
VPC	397.968	202.057	5867845.61	475157.912
VPI	440	202.801	5867805.525	475145.269
VPT	482.032	203.073	5867765.439	475132.625
Length:	84.064			
Entrance Grade:	0.018			
Exit Grade:	0.006			
r = 100 * (g2 - g1) / L:	-1.333			
K = l / (g2 - g1):	75			
Middle Ordinate:	-0.118			
Element: Linear				
VPT	482.032	203.073	5867765.439	475132.625
VPC	796.795	205.116	5867474.847	475017.897
Tangent Grade:	0.006			
Tangent Length:	314.763			
Element: Symmetrical Parabola				
VPC	796.795	205.116	5867474.847	475017.897
VPI	900	205.786	5867398.786	474948.43
VPT	1003.205	203.412	5867309.698	474896.434
VHP	842.222	205.263		
Length:	206.409			
Entrance Grade:	0.006			
Exit Grade:	-0.023			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.761			
Element: Linear				
VPT	1003.205	203.412	5867309.698	474896.434
VPC	1118.55	200.76	5867208.956	474840.261
Tangent Grade:	-0.023			
Tangent Length:	115.345			
Element: Symmetrical Parabola				
VPC	1118.55	200.76	5867208.956	474840.261
VPI	1248.537	197.77	5867094.359	474779.094
VPT	1378.525	198.16	5866966.613	474764.934
VLP	1348.525	198.115		
Length:	259.975			
Entrance Grade:	-0.023			
Exit Grade:	0.003			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			
Middle Ordinate:	0.845			
Element: Linear				
VPT	1378.525	198.16	5866966.613	474764.934
VPC	1775.582	199.351	5866663.745	474999.34
Tangent Grade:	0.003			
Tangent Length:	397.057			
Element: Symmetrical Parabola				
VPC	1775.582	199.351	5866663.745	474999.34

VPI	1866.007	199.623	5866639.466	475086.236
VPT	1956.432	201.938	5866589.713	475161.483
Length:	180.85			
Entrance Grade:	0.003			
Exit Grade:	0.026			
r = 100 * (g2 - g1) / L:	1.25			
K = l / (g2 - g1):	80			
Middle Ordinate:	0.511			
Element: Linear				
VPT	1956.432	201.938	5866589.713	475161.483
VPC	2187.82	207.863	5866502.216	475373.464
Tangent Grade:	0.026			
Tangent Length:	231.388			
Element: Symmetrical Parabola				
VPC	2187.82	207.863	5866502.216	475373.464
VPI	2393	213.117	5866484.158	475577.688
VPT	2598.18	206.343	5866507.614	475779.38
VHP	2367.064	210.158		
Length:	410.36			
Entrance Grade:	0.026			
Exit Grade:	-0.033			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-3.007			
Element: Linear				
VPT	2598.18	206.343	5866507.614	475779.38
VPC	2646.884	204.735	5866518.83	475826.751
Tangent Grade:	-0.033			
Tangent Length:	48.704			
Element: Symmetrical Parabola				
VPC	2646.884	204.735	5866518.83	475826.751
VPI	2760	201	5866516.308	475939.17
VPT	2873.116	202.952	5866488.74	476048.761
VLP	2795.458	202.282		
Length:	226.233			
Entrance Grade:	-0.033			
Exit Grade:	0.017			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	1.422			
Element: Linear				
VPT	2873.116	202.952	5866488.74	476048.761
VPC	3019.346	205.476	5866486.981	476194.459
Tangent Grade:	0.017			
Tangent Length:	146.229			
Element: Symmetrical Parabola				
VPC	3019.346	205.476	5866486.981	476194.459
VPI	3123.24	207.269	5866511.435	476295.242
VPT	3227.135	205.977	5866546.559	476393.011

VHP	3140.147	206.518		
Length:	207.789			
Entrance Grade:	0.017			
Exit Grade:	-0.012			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.771			
Element: Linear				
VPT	3227.135	205.977	5866546.559	476393.011
VPC	3278.78	205.336	5866568.518	476439.73
Tangent Grade:	-0.012			
Tangent Length:	51.646			
Element: Symmetrical Parabola				
VPC	3278.78	205.336	5866568.518	476439.73
VPI	3338.146	204.598	5866599.551	476490.299
VPT	3397.513	204.867	5866636.354	476536.836
VLP	3365.768	204.795		
Length:	118.732			
Entrance Grade:	-0.012			
Exit Grade:	0.005			
r = 100 * (g2 - g1) / L:	1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	0.252			
Element: Linear				
VPT	3397.513	204.867	5866636.354	476536.836
VPC	3763.411	206.527	5866954.304	476700.91
Tangent Grade:	0.005			
Tangent Length:	365.898			
Element: Symmetrical Parabola				
VPC	3763.411	206.527	5866954.304	476700.91
VPI	3800	206.692	5866990.786	476703.611
VPT	3836.589	206.591	5867027.367	476703.638
VHP	3808.76	206.629		
Length:	73.179			
Entrance Grade:	0.005			
Exit Grade:	-0.003			
r = 100 * (g2 - g1) / L:	-1			
K = l / (g2 - g1):	100			
Middle Ordinate:	-0.067			
Element: Linear				
VPT	3836.589	206.591	5867027.367	476703.638
VPC	4717.108	204.14	5867844.376	476868.684
Tangent Grade:	-0.003			
Tangent Length:	880.519			
Element: Symmetrical Parabola				
VPC	4717.108	204.14	5867844.376	476868.684
VPI	4767.505	204	5867875.713	476908.135
VPT	4817.903	203.352	5867903.629	476950.077
Length:	100.795			

Entrance Grade:	-0.003			
Exit Grade:	-0.013			
r = 100 * (g2 - g1) / L:	-1			
K = l / (g2 - g1):	100			
Middle Ordinate:	-0.127			
Element: Linear				
VPT	4817.903	203.352	5867903.629	476950.077
VPC	5027.728	200.653	5867984.399	477143.151
Tangent Grade:	-0.013			
Tangent Length:	209.825			
Element: Symmetrical Parabola				
VPC	5027.728	200.653	5867984.399	477143.151
VPI	5121.493	199.447	5868014.783	477231.858
VPT	5215.259	202.148	5868045.166	477320.564
VLP	5085.608	200.281		
Length:	187.531			
Entrance Grade:	-0.013			
Exit Grade:	0.029			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.977			
Element: Linear				
VPT	5215.259	202.148	5868045.166	477320.564
VPC	5265.456	203.595	5868061.432	477368.053
Tangent Grade:	0.029			
Tangent Length:	50.197			
Element: Symmetrical Parabola				
VPC	5265.456	203.595	5868061.432	477368.053
VPI	5378.339	206.847	5868098.011	477474.845
VPT	5491.221	203.742	5868134.589	477581.637
VHP	5380.954	205.258		
Length:	225.765			
Entrance Grade:	0.029			
Exit Grade:	-0.028			
r = 100 * (g2 - g1) / L:	-2.495			
K = l / (g2 - g1):	40.088			
Middle Ordinate:	-1.589			
Element: Linear				
VPT	5491.221	203.742	5868134.589	477581.637
VPC	5544.951	202.264	5868151.999	477632.467
Tangent Grade:	-0.028			
Tangent Length:	53.73			
Element: Symmetrical Parabola				
VPC	5544.951	202.264	5868151.999	477632.467
VPI	5610.078	200.473	5868173.103	477694.08
VPT	5675.204	200.566	5868193.895	477755.796
VLP	5668.729	200.562		
Length:	130.253			
Entrance Grade:	-0.028			

Exit Grade:	0.001			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.471			
Element: Linear				
VPT	5675.204	200.566	5868193.895	477755.796
VPC	5837.116	200.799	5868226.028	477914.205
Tangent Grade:	0.001			
Tangent Length:	161.911			
Element: Symmetrical Parabola				
VPC	5837.116	200.799	5868226.028	477914.205
VPI	5893.953	200.881	5868229.63	477970.916
VPT	5950.79	202.399	5868229.196	478027.74
Length:	113.675			
Entrance Grade:	0.001			
Exit Grade:	0.027			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.359			
Element: Linear				
VPT	5950.79	202.399	5868229.196	478027.74
VPC	6015.998	204.14	5868223.733	478092.7
Tangent Grade:	0.027			
Tangent Length:	65.208			
Element: Symmetrical Parabola				
VPC	6015.998	204.14	5868223.733	478092.7
VPI	6137.833	207.393	5868199.455	478211.972
VPT	6259.669	206.405	5868157.364	478326.18
VHP	6202.898	206.635		
Length:	243.671			
Entrance Grade:	0.027			
Exit Grade:	-0.008			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-1.06			
Element: Linear				
VPT	6259.669	206.405	5868157.364	478326.18
VPC	6484.284	204.583	5868036.621	478514.708
Tangent Grade:	-0.008			
Tangent Length:	224.615			
Element: Symmetrical Parabola				
VPC	6484.284	204.583	5868036.621	478514.708
VPI	6507.043	204.398	5868021.542	478531.754
VPT	6529.802	204.317	5868005.984	478548.364
Length:	45.519			
Entrance Grade:	-0.008			
Exit Grade:	-0.004			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			

Middle Ordinate:	0.026			
Element: Linear				
VPT	6529.802	204.317	5868005.984	478548.364
VPC	7002.103	202.637	5867599.45	478775.066
Tangent Grade:	-0.004			
Tangent Length:	472.301			
Element: Symmetrical Parabola				
VPC	7002.103	202.637	5867599.45	478775.066
VPI	7056.997	202.442	5867545.446	478784.848
VPT	7111.891	203.586	5867490.989	478791.748
VLP	7018.115	202.608		
Length:	109.787			
Entrance Grade:	-0.004			
Exit Grade:	0.021			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.335			
Element: Linear				
VPT	7111.891	203.586	5867490.989	478791.748
VPC	7430.694	210.229	5867174.568	478830.652
Tangent Grade:	0.021			
Tangent Length:	318.803			
Element: Symmetrical Parabola				
VPC	7430.694	210.229	5867174.568	478830.652
VPI	7506.405	211.807	5867099.423	478839.891
VPT	7582.116	211.747	5867024.277	478849.13
VHP	7576.567	211.749		
Length:	151.422			
Entrance Grade:	0.021			
Exit Grade:	-0.001			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.409			
Element: Linear				
VPT	7582.116	211.747	5867024.277	478849.13
VPI	8116.345	211.323	5866494.041	478914.321
Tangent Grade:	-0.001			
Tangent Length:	534.228			
Element: Linear				
VPI	8116.345	211.323	5866494.041	478914.321
VPC	8575.383	209.546	5866039.572	478977.018
Tangent Grade:	-0.004			
Tangent Length:	459.038			
Element: Symmetrical Parabola				
VPC	8575.383	209.546	5866039.572	478977.018
VPI	8650.027	209.257	5865968.63	479000.121
VPT	8724.671	208.411	5865900.55	479030.643
Length:	149.289			
Entrance Grade:	-0.004			

Exit Grade:	-0.011			
r = 100 * (g2 - g1) / L:	-0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	-0.139			
Element: Linear				
VPT	8724.671	208.411	5865900.55	479030.643
VPI	8992.136	205.378	5865691.492	479194.856
Tangent Grade:	-0.011			
Tangent Length:	267.464			
Element: Linear				
VPI	8992.136	205.378	5865691.492	479194.856
VPC	9446.706	202.1	5865522.009	479608.074
Tangent Grade:	-0.007			
Tangent Length:	454.57			
Element: Symmetrical Parabola				
VPC	9446.706	202.1	5865522.009	479608.074
VPI	9514.952	201.608	5865520.932	479676.285
VPT	9583.199	202.669	5865526.5	479744.277
VLP	9489.973	201.944		
Length:	136.493			
Entrance Grade:	-0.007			
Exit Grade:	0.016			
r = 100 * (g2 - g1) / L:	1.667			
K = l / (g2 - g1):	60			
Middle Ordinate:	0.388			
Element: Linear				
VPT	9583.199	202.669	5865526.5	479744.277
VPC	9808.184	206.164	5865587.373	479960.251
Tangent Grade:	0.016			
Tangent Length:	224.985			
Element: Symmetrical Parabola				
VPC	9808.184	206.164	5865587.373	479960.251
VPI	9952.316	208.404	5865636.658	480095.694
VPT	10096.447	204.708	5865685.944	480231.138
VHP	9916.947	207.009		
Length:	288.263			
Entrance Grade:	0.016			
Exit Grade:	-0.026			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-1.484			
Element: Linear				
VPT	10096.447	204.708	5865685.944	480231.138
VPC	10184.054	202.461	5865715.901	480313.463
Tangent Grade:	-0.026			
Tangent Length:	87.607			
Element: Symmetrical Parabola				
VPC	10184.054	202.461	5865715.901	480313.463
VPI	10268.31	200.301	5865744.712	480392.641

VPT	10352.567	201.295	5865773.524	480471.818
VLP	10299.447	200.982		
Length:	168.512			
Entrance Grade:	-0.026			
Exit Grade:	0.012			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.789			
Element: Linear				
VPT	10352.567	201.295	5865773.524	480471.818
VPC	10661.815	204.946	5865886.453	480759.532
Tangent Grade:	0.012			
Tangent Length:	309.248			
Element: Symmetrical Parabola				
VPC	10661.815	204.946	5865886.453	480759.532
VPI	10729.269	205.742	5865917.185	480819.572
VPT	10796.723	205.238	5865950.585	480878.17
VHP	10744.445	205.434		
Length:	134.909			
Entrance Grade:	0.012			
Exit Grade:	-0.007			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.325			
Element: Linear				
VPT	10796.723	205.238	5865950.585	480878.17
VPI	10900.462	204.464	5866007.002	480965.202
Tangent Grade:	-0.007			
Tangent Length:	103.739			
Element: Linear				
VPI	10900.462	204.464	5866007.002	480965.202
VPC	10975.868	204.104	5866051.717	481025.91
Tangent Grade:	-0.005			
Tangent Length:	75.406			
Element: Symmetrical Parabola				
VPC	10975.868	204.104	5866051.717	481025.91
VPI	11040	203.799	5866092.107	481075.719
VPT	11104.132	205.321	5866134.589	481123.755
VLP	10997.311	204.053		
Length:	128.263			
Entrance Grade:	-0.005			
Exit Grade:	0.024			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.457			
Element: Linear				
VPT	11104.132	205.321	5866134.589	481123.755
VPC	11123.078	205.771	5866147.528	481137.595
Tangent Grade:	0.024			

Tangent Length:	18.946			
Element: Symmetrical Parabola				
VPC	11123.078	205.771	5866147.528	481137.595
VPI	11253.078	208.857	5866240.887	481228.003
VPT	11383.078	207.114	5866341.721	481309.991
VHP	11289.242	207.743		
Length:	260.001			
Entrance Grade:	0.024			
Exit Grade:	-0.013			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-1.207			
Element: Linear				
VPT	11383.078	207.114	5866341.721	481309.991
VPC	11607.291	204.108	5866530.959	481429.852
Tangent Grade:	-0.013			
Tangent Length:	224.213			
Element: Symmetrical Parabola				
VPC	11607.291	204.108	5866530.959	481429.852
VPI	11637.579	203.702	5866557.827	481443.833
VPT	11667.867	203.704	5866584.971	481457.267
VLP	11667.614	203.704		
Length:	60.576			
Entrance Grade:	-0.013			
Exit Grade:	0			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.102			
Element: Linear				
VPT	11667.867	203.704	5866584.971	481457.267
VPC	12051.335	203.726	5866947.782	481578.169
Tangent Grade:	0			
Tangent Length:	383.468			
Element: Symmetrical Parabola				
VPC	12051.335	203.726	5866947.782	481578.169
VPI	12091.119	203.728	5866986.918	481585.314
VPT	12130.903	203.414	5867026.229	481591.419
VHP	12051.896	203.726		
Length:	79.568			
Entrance Grade:	0			
Exit Grade:	-0.008			
r = 100 * (g2 - g1) / L:	-1			
K = l / (g2 - g1):	100			
Middle Ordinate:	-0.079			
Element: Linear				
VPT	12130.903	203.414	5867026.229	481591.419
VPC	12560.657	200.018	5867454.66	481591.592
Tangent Grade:	-0.008			
Tangent Length:	429.754			

Element: Symmetrical Parabola				
VPC	12560.657	200.018	5867454.66	481591.592
VPI	12604.429	199.672	5867498.19	481586.998
VPT	12648.201	200.178	5867541.72	481582.404
VLP	12596.21	199.878		
Length:	87.544			
Entrance Grade:	-0.008			
Exit Grade:	0.012			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.213			
Element: Linear				
VPT	12648.201	200.178	5867541.72	481582.404
VPC	12939.802	203.547	5867831.711	481551.798
Tangent Grade:	0.012			
Tangent Length:	291.601			
Element: Symmetrical Parabola				
VPC	12939.802	203.547	5867831.711	481551.798
VPI	12988.359	204.108	5867880	481546.702
VPT	13036.917	203.995	5867928.289	481541.605
VHP	13020.676	204.014		
Length:	97.115			
Entrance Grade:	0.012			
Exit Grade:	-0.002			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.168			
Element: Linear				
VPT	13036.917	203.995	5867928.289	481541.605
VPI	13402.926	203.146	5868292.277	481503.19
Tangent Grade:	-0.002			
Tangent Length:	366.009			
Element: Linear				
VPI	13402.926	203.146	5868292.277	481503.19
VPI	13994.862	203.616	5868882.484	481481.537
Tangent Grade:	0.001			
Tangent Length:	591.936			
Element: Linear				
VPI	13994.862	203.616	5868882.484	481481.537
VPC	14833.952	202.599	5869686.289	481710.661
Tangent Grade:	-0.001			
Tangent Length:	839.09			
Element: Symmetrical Parabola				
VPC	14833.952	202.599	5869686.289	481710.661
VPI	14893.477	202.527	5869741.968	481731.712
VPT	14953.003	203.164	5869797.646	481752.763
VLP	14846.066	202.592		
Length:	119.05			
Entrance Grade:	-0.001			

Exit Grade:	0.011			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			
Middle Ordinate:	0.177			
Element: Linear				
VPT	14953.003	203.164	5869797.646	481752.763
VPC	15135.887	205.12	5869968.713	481817.439
Tangent Grade:	0.011			
Tangent Length:	182.885			
Element: Symmetrical Parabola				
VPC	15135.887	205.12	5869968.713	481817.439
VPI	15218.215	206	5870045.721	481846.554
VPT	15300.543	204.944	5870120.724	481880.368
VHP	15210.743	205.52		
Length:	164.656			
Entrance Grade:	0.011			
Exit Grade:	-0.013			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.484			
Element: Linear				
VPT	15300.543	204.944	5870120.724	481880.368
VPC	15505.277	202.317	5870283.73	482002.84
Tangent Grade:	-0.013			
Tangent Length:	204.734			
Element: Symmetrical Parabola				
VPC	15505.277	202.317	5870283.73	482002.84
VPI	15625.396	200.776	5870358.831	482096.367
VPT	15745.515	201.64	5870415.467	482202.102
VLP	15659.221	201.33		
Length:	240.237			
Entrance Grade:	-0.013			
Exit Grade:	0.007			
r = 100 * (g2 - g1) / L:	0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	0.601			
Element: Linear				
VPT	15745.515	201.64	5870415.467	482202.102
VPC	15875.91	202.578	5870453.819	482326.501
Tangent Grade:	0.007			
Tangent Length:	130.395			
Element: Symmetrical Parabola				
VPC	15875.91	202.578	5870453.819	482326.501
VPI	15938.487	203.028	5870463.205	482388.346
VPT	16001.064	202.359	5870466.603	482450.806
VHP	15926.248	202.759		
Length:	125.154			
Entrance Grade:	0.007			
Exit Grade:	-0.011			

r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.28			
Element: Linear				
VPT	16001.064	202.359	5870466.603	482450.806
VPC	16236.719	199.84	5870425.782	482681.591
Tangent Grade:	-0.011			
Tangent Length:	235.655			
Element: Symmetrical Parabola				
VPC	16236.719	199.84	5870425.782	482681.591
VPI	16301.083	199.152	5870400.381	482740.702
VPT	16365.447	200.306	5870369.261	482797.013
VLP	16284.815	199.583		
Length:	128.728			
Entrance Grade:	-0.011			
Exit Grade:	0.018			
r = 100 * (g2 - g1) / L:	2.222			
K = l / (g2 - g1):	45			
Middle Ordinate:	0.46			
Element: Linear				
VPT	16365.447	200.306	5870369.261	482797.013
VPC	16398.476	200.898	5870351.168	482824.641
Tangent Grade:	0.018			
Tangent Length:	33.029			
Element: Symmetrical Parabola				
VPC	16398.476	200.898	5870351.168	482824.641
VPI	16460	202	5870313.825	482873.507
VPT	16521.524	202.021	5870272.031	482918.625
Length:	123.048			
Entrance Grade:	0.018			
Exit Grade:	0			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.27			
Element: Linear				
VPT	16521.524	202.021	5870272.031	482918.625
VPC	16681.886	202.075	5870144.977	483015.801
Tangent Grade:	0			
Tangent Length:	160.362			
Element: Symmetrical Parabola				
VPC	16681.886	202.075	5870144.977	483015.801
VPI	16721.971	202.089	5870109.781	483034.972
VPT	16762.056	201.835	5870073.471	483051.937
VHP	16685.965	202.076		
Length:	80.169			
Entrance Grade:	0			
Exit Grade:	-0.006			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			

Middle Ordinate:	-0.067			
Element: Linear				
VPT	16762.056	201.835	5870073.471	483051.937
VPI	16905.224	200.927	5869939.316	483101.867
Tangent Grade:	-0.006			
Tangent Length:	143.168			
Element: Linear				
VPI	16905.224	200.927	5869939.316	483101.867
VPI	17094.986	200.15	5869757.975	483157.66
Tangent Grade:	-0.004			
Tangent Length:	189.762			
Element: Linear				
VPI	17094.986	200.15	5869757.975	483157.66
VPC	17271.252	200.305	5869586.68	483199.12
Tangent Grade:	0.001			
Tangent Length:	176.267			
Element: Symmetrical Parabola				
VPC	17271.252	200.305	5869586.68	483199.12
VPI	17303.893	200.333	5869554.707	483205.689
VPT	17336.534	200.54	5869522.665	483211.911
Length:	65.281			
Entrance Grade:	0.001			
Exit Grade:	0.006			
r = 100 * (g2 - g1) / L:	0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	0.044			
Element: Linear				
VPT	17336.534	200.54	5869522.665	483211.911
VPC	17638.611	202.449	5869223.503	483252.845
Tangent Grade:	0.006			
Tangent Length:	302.077			
Element: Symmetrical Parabola				
VPC	17638.611	202.449	5869223.503	483252.845
VPI	17682.996	202.729	5869179.253	483256.315
VPT	17727.382	202.681	5869134.957	483259.129
VHP	17714.445	202.688		
Length:	88.772			
Entrance Grade:	0.006			
Exit Grade:	-0.001			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	-0.082			
Element: Linear				
VPT	17727.382	202.681	5869134.957	483259.129
VPC	17852.414	202.547	5869010.012	483263.53
Tangent Grade:	-0.001			
Tangent Length:	125.031			
Element: Symmetrical Parabola				
VPC	17852.414	202.547	5869010.012	483263.53

VPI	17863.956	202.534	5868998.471	483263.674
VPT	17875.498	202.495	5868986.93	483263.773
Length:	23.084			
Entrance Grade:	-0.001			
Exit Grade:	-0.003			
r = 100 * (g2 - g1) / L:	-1			
K = l / (g2 - g1):	100			
Middle Ordinate:	-0.007			
Element: Linear				
VPT	17875.498	202.495	5868986.93	483263.773
VPC	18188.264	201.436	5868674.163	483263.476
Tangent Grade:	-0.003			
Tangent Length:	312.767			
Element: Symmetrical Parabola				
VPC	18188.264	201.436	5868674.163	483263.476
VPI	18217.439	201.337	5868644.989	483263.439
VPT	18246.613	201.481	5868615.815	483263.403
VLP	18211.97	201.396		
Length:	58.349			
Entrance Grade:	-0.003			
Exit Grade:	0.005			
r = 100 * (g2 - g1) / L:	1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	0.061			
Element: Linear				
VPT	18246.613	201.481	5868615.815	483263.403
VPC	18734.236	203.895	5868129.736	483295.118
Tangent Grade:	0.005			
Tangent Length:	487.623			
Element: Symmetrical Parabola				
VPC	18734.236	203.895	5868129.736	483295.118
VPI	18790.628	204.174	5868074.022	483303.828
VPT	18847.02	203.544	5868018.481	483313.583
VHP	18768.88	203.98		
Length:	112.784			
Entrance Grade:	0.005			
Exit Grade:	-0.011			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.227			
Element: Linear				
VPT	18847.02	203.544	5868018.481	483313.583
VPI	19074.947	201	5867796.164	483363.592
Tangent Grade:	-0.011			
Tangent Length:	227.927			
Element: Linear				
VPI	19074.947	201	5867796.164	483363.592
VPC	19327.652	199.167	5867554.918	483438.579
Tangent Grade:	-0.007			

Tangent Length:	252.705			
Element: Symmetrical Parabola				
VPC	19327.652	199.167	5867554.918	483438.579
VPI	19395.176	198.677	5867491.599	483462.03
VPT	19462.7	198.795	5867428.519	483486.122
VLP	19436.456	198.772		
Length:	135.048			
Entrance Grade:	-0.007			
Exit Grade:	0.002			
r = 100 * (g2 - g1) / L:	0.667			
K = l / (g2 - g1):	150			
Middle Ordinate:	0.152			
Element: Linear				
VPT	19462.7	198.795	5867428.519	483486.122
VPI	19845.755	199.466	5867070.675	483622.791
Tangent Grade:	0.002			
Tangent Length:	383.055			
Element: Linear				
VPI	19845.755	199.466	5867070.675	483622.791
VPC	20058.722	200.121	5866871.725	483698.774
Tangent Grade:	0.003			
Tangent Length:	212.967			
Element: Symmetrical Parabola				
VPC	20058.722	200.121	5866871.725	483698.774
VPI	20097.719	200.241	5866835.294	483712.688
VPT	20136.716	200.108	5866798.864	483726.602
VHP	20095.658	200.178		
Length:	77.994			
Entrance Grade:	0.003			
Exit Grade:	-0.003			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	-0.063			
Element: Linear				
VPT	20136.716	200.108	5866798.864	483726.602
VPC	20328.542	199.451	5866619.663	483795.043
Tangent Grade:	-0.003			
Tangent Length:	191.826			
Element: Symmetrical Parabola				
VPC	20328.542	199.451	5866619.663	483795.043
VPI	20370.571	199.308	5866580.399	483810.038
VPT	20412.601	199.34	5866541.135	483825.034
VLP	20396.97	199.334		
Length:	84.06			
Entrance Grade:	-0.003			
Exit Grade:	0.001			
r = 100 * (g2 - g1) / L:	0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	0.044			

Element: Linear				
VPT	20412.601	199.34	5866541.135	483825.034
VPC	21277.45	200.016	5865733.206	484133.601
Tangent Grade:	0.001			
Tangent Length:	864.848			
Element: Symmetrical Parabola				
VPC	21277.45	200.016	5865733.206	484133.601
VPI	21292.504	200.028	5865719.143	484138.972
VPT	21307.558	200.085	5865705.08	484144.343
Length:	30.108			
Entrance Grade:	0.001			
Exit Grade:	0.004			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			
Middle Ordinate:	0.011			
Element: Linear				
VPT	21307.558	200.085	5865705.08	484144.343
VPC	21599.034	201.191	5865430.015	484240.503
Tangent Grade:	0.004			
Tangent Length:	291.477			
Element: Symmetrical Parabola				
VPC	21599.034	201.191	5865430.015	484240.503
VPI	21635.003	201.327	5865395.491	484250.595
VPT	21670.971	201.248	5865360.849	484260.272
VHP	21644.543	201.277		
Length:	71.937			
Entrance Grade:	0.004			
Exit Grade:	-0.002			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	-0.054			
Element: Linear				
VPT	21670.971	201.248	5865360.849	484260.272
VPC	21823.325	200.912	5865213.652	484299.574
Tangent Grade:	-0.002			
Tangent Length:	152.354			
Element: Symmetrical Parabola				
VPC	21823.325	200.912	5865213.652	484299.574
VPI	21858.987	200.834	5865179.194	484308.762
VPT	21894.65	201.073	5865144.736	484317.951
VLP	21840.945	200.893		
Length:	71.324			
Entrance Grade:	-0.002			
Exit Grade:	0.007			
r = 100 * (g2 - g1) / L:	1.25			
K = l / (g2 - g1):	80			
Middle Ordinate:	0.079			
Element: Linear				
VPT	21894.65	201.073	5865144.736	484317.951

VPC	22035.034	202.015	5865009.091	484354.12
Tangent Grade:	0.007			
Tangent Length:	140.384			
Element: Symmetrical Parabola				
VPC	22035.034	202.015	5865009.091	484354.12
VPI	22086.468	202.361	5864959.393	484367.372
VPT	22137.903	202.353	5864909.695	484380.624
VHP	22135.731	202.353		
Length:	102.869			
Entrance Grade:	0.007			
Exit Grade:	0			
r = 100 * (g2 - g1) / L:	-0.667			
K = l / (g2 - g1):	150			
Middle Ordinate:	-0.088			
Element: Linear				
VPT	22137.903	202.353	5864909.695	484380.624
VPC	22446.25	202.309	5864611.758	484460.068
Tangent Grade:	0			
Tangent Length:	308.347			
Element: Symmetrical Parabola				
VPC	22446.25	202.309	5864611.758	484460.068
VPI	22506	202.3	5864554.025	484475.462
VPT	22565.75	203.005	5864496.292	484490.857
VLP	22447.698	202.309		
Length:	119.501			
Entrance Grade:	0			
Exit Grade:	0.012			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			
Middle Ordinate:	0.179			
Element: Linear				
VPT	22565.75	203.005	5864496.292	484490.857
VPC	22704.934	204.648	5864361.807	484526.717
Tangent Grade:	0.012			
Tangent Length:	139.184			
Element: Symmetrical Parabola				
VPC	22704.934	204.648	5864361.807	484526.717
VPI	22749.647	205.176	5864318.603	484538.237
VPT	22794.36	205.304	5864275.4	484549.757
Length:	89.426			
Entrance Grade:	0.012			
Exit Grade:	0.003			
r = 100 * (g2 - g1) / L:	-1			
K = l / (g2 - g1):	100			
Middle Ordinate:	-0.1			
Element: Linear				
VPT	22794.36	205.304	5864275.4	484549.757
VPC	23423.985	207.107	5863668.247	484716.112
Tangent Grade:	0.003			

Tangent Length:	629.624			
Element: Symmetrical Parabola				
VPC	23423.985	207.107	5863668.247	484716.112
VPI	23467.078	207.23	5863627.778	484730.919
VPT	23510.172	207.044	5863587.752	484746.882
VHP	23458.336	207.156		
Length:	86.188			
Entrance Grade:	0.003			
Exit Grade:	-0.004			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	-0.077			
Element: Linear				
VPT	23510.172	207.044	5863587.752	484746.882
VPC	24876.484	201.142	5862716.155	485737.625
Tangent Grade:	-0.004			
Tangent Length:	1366.312			
Element: Symmetrical Parabola				
VPC	24876.484	201.142	5862716.155	485737.625
VPI	24955.442	200.801	5862697.408	485814.315
VPT	25034.4	200.772	5862682.722	485891.886
Length:	157.916			
Entrance Grade:	-0.004			
Exit Grade:	0			
r = 100 * (g2 - g1) / L:	0.25			
K = l / (g2 - g1):	400			
Middle Ordinate:	0.078			
Element: Linear				
VPT	25034.4	200.772	5862682.722	485891.886
VPI	26115.911	200.369	5862738.096	486968.827
Tangent Grade:	0			
Tangent Length:	1081.511			
Element: Linear				
VPI	26115.911	200.369	5862738.096	486968.827
VPC	26930.157	196.771	5862759.04	487780.653
Tangent Grade:	-0.004			
Tangent Length:	814.246			
Element: Symmetrical Parabola				
VPC	26930.157	196.771	5862759.04	487780.653
VPI	26980	196.551	5862752.543	487830.07
VPT	27029.843	196.745	5862745.045	487879.345
VLP	26983.185	196.654		
Length:	99.686			
Entrance Grade:	-0.004			
Exit Grade:	0.004			
r = 100 * (g2 - g1) / L:	0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	0.104			
Element: Linear				

VPT	27029.843	196.745	5862745.045	487879.345
VPC	28123.289	200.996	5862796.97	488962.331
Tangent Grade:	0.004			
Tangent Length:	1093.446			
Element: Symmetrical Parabola				
VPC	28123.289	200.996	5862796.97	488962.331
VPI	28256.614	201.515	5862822.26	489093.235
VPT	28389.939	200.417	5862847.551	489224.14
VHP	28208.829	201.163		
Length:	266.65			
Entrance Grade:	0.004			
Exit Grade:	-0.008			
r = 100 * (g2 - g1) / L:	-0.455			
K = l / (g2 - g1):	220			
Middle Ordinate:	-0.404			
Element: Linear				
VPT	28389.939	200.417	5862847.551	489224.14
VPC	28420.854	200.163	5862853.415	489254.493
Tangent Grade:	-0.008			
Tangent Length:	30.915			
Element: Symmetrical Parabola				
VPC	28420.854	200.163	5862853.415	489254.493
VPI	28533.052	199.239	5862874.697	489364.654
VPT	28645.25	199.574	5862895.98	489474.814
VLP	28585.5	199.485		
Length:	224.395			
Entrance Grade:	-0.008			
Exit Grade:	0.003			
r = 100 * (g2 - g1) / L:	0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	0.315			
Element: Linear				
VPT	28645.25	199.574	5862895.98	489474.814
VPC	28791.124	200.01	5862912.574	489619.381
Tangent Grade:	0.003			
Tangent Length:	145.875			
Element: Symmetrical Parabola				
VPC	28791.124	200.01	5862912.574	489619.381
VPI	28907.446	200.358	5862896.739	489734.355
VPT	29023.768	199.352	5862854.823	489842.582
VHP	28850.874	200.099		
Length:	232.644			
Entrance Grade:	0.003			
Exit Grade:	-0.009			
r = 100 * (g2 - g1) / L:	-0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	-0.338			
Element: Linear				
VPT	29023.768	199.352	5862854.823	489842.582

VPC	29176.269	198.034	5862764.306	489964.579
Tangent Grade:	-0.009			
Tangent Length:	152.501			
Element: Symmetrical Parabola				
VPC	29176.269	198.034	5862764.306	489964.579
VPI	29230.41	197.566	5862723.831	490000.498
VPT	29284.552	197.83	5862679.71	490031.832
VLP	29245.426	197.735		
Length:	108.283			
Entrance Grade:	-0.009			
Exit Grade:	0.005			
r = 100 * (g2 - g1) / L:	1.25			
K = l / (g2 - g1):	80			
Middle Ordinate:	0.183			
Element: Linear				
VPT	29284.552	197.83	5862679.71	490031.832
VPC	29506.654	198.917	5862472.38	490106.993
Tangent Grade:	0.005			
Tangent Length:	222.102			
Element: Symmetrical Parabola				
VPC	29506.654	198.917	5862472.38	490106.993
VPI	29557.199	199.164	5862422.797	490116.806
VPT	29607.744	198.681	5862373.214	490126.62
VHP	29540.889	199		
Length:	101.09			
Entrance Grade:	0.005			
Exit Grade:	-0.01			
r = 100 * (g2 - g1) / L:	-1.429			
K = l / (g2 - g1):	70			
Middle Ordinate:	-0.182			
Element: Linear				
VPT	29607.744	198.681	5862373.214	490126.62
VPC	29788.461	196.955	5862195.936	490161.706
Tangent Grade:	-0.01			
Tangent Length:	180.717			
Element: Symmetrical Parabola				
VPC	29788.461	196.955	5862195.936	490161.706
VPI	29864.334	196.23	5862121.507	490176.437
VPT	29940.206	196.945	5862047.078	490191.168
VLP	29864.867	196.59		
Length:	151.745			
Entrance Grade:	-0.01			
Exit Grade:	0.009			
r = 100 * (g2 - g1) / L:	1.25			
K = l / (g2 - g1):	80			
Middle Ordinate:	0.36			
Element: Linear				
VPT	29940.206	196.945	5862047.078	490191.168
VPC	30187.276	199.272	5861801.921	490216.901

Tangent Grade:	0.009			
Tangent Length:	247.07			
Element: Symmetrical Parabola				
VPC	30187.276	199.272	5861801.921	490216.901
VPI	30241.872	199.786	5861747.383	490214.514
VPT	30296.468	199.803	5861692.932	490210.543
Length:	109.192			
Entrance Grade:	0.009			
Exit Grade:	0			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	-0.124			
Element: Linear				
VPT	30296.468	199.803	5861692.932	490210.543
VPC	31007.21	200.029	5860984.074	490158.826
Tangent Grade:	0			
Tangent Length:	710.742			
Element: Symmetrical Parabola				
VPC	31007.21	200.029	5860984.074	490158.826
VPI	31069.152	200.049	5860922.296	490154.319
VPT	31131.094	199.429	5860860.519	490149.812
VHP	31011.025	200.03		
Length:	123.884			
Entrance Grade:	0			
Exit Grade:	-0.01			
r = 100 * (g2 - g1) / L:	-0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	-0.16			
Element: Linear				
VPT	31131.094	199.429	5860860.519	490149.812
VPC	31388.001	196.859	5860604.312	490130.864
Tangent Grade:	-0.01			
Tangent Length:	256.908			
Element: Symmetrical Parabola				
VPC	31388.001	196.859	5860604.312	490130.864
VPI	31422.04	196.518	5860570.416	490127.753
VPT	31456.079	196.564	5860536.557	490124.258
VLP	31448.036	196.558		
Length:	68.077			
Entrance Grade:	-0.01			
Exit Grade:	0.001			
r = 100 * (g2 - g1) / L:	1.667			
K = l / (g2 - g1):	60			
Middle Ordinate:	0.097			
Element: Linear				
VPT	31456.079	196.564	5860536.557	490124.258
VPC	31814.146	197.044	5860183.753	490064.344
Tangent Grade:	0.001			
Tangent Length:	358.067			

Element: Symmetrical Parabola				
VPC	31814.146	197.044	5860183.753	490064.344
VPI	31842.536	197.082	5860156.129	490057.799
VPT	31870.925	197.055	5860128.567	490050.993
VHP	31847.66	197.066		
Length:	56.779			
Entrance Grade:	0.001			
Exit Grade:	-0.001			
r = 100 * (g2 - g1) / L:	-0.4			
K = l / (g2 - g1):	250			
Middle Ordinate:	-0.016			
Element: Linear				
VPT	31870.925	197.055	5860128.567	490050.993
VPI	33131.694	195.882	5858905.979	489743.072
Tangent Grade:	-0.001			
Tangent Length:	1260.769			
Element: Linear				
VPI	33131.694	195.882	5858905.979	489743.072
VPC	33480.337	195.192	5858567.894	489657.922
Tangent Grade:	-0.002			
Tangent Length:	348.643			
Element: Symmetrical Parabola				
VPC	33480.337	195.192	5858567.894	489657.922
VPI	33517.975	195.118	5858531.396	489648.73
VPT	33555.613	195.157	5858494.897	489639.537
VLP	33529.778	195.144		
Length:	75.276			
Entrance Grade:	-0.002			
Exit Grade:	0.001			
r = 100 * (g2 - g1) / L:	0.4			
K = l / (g2 - g1):	250			
Middle Ordinate:	0.028			
Element: Linear				
VPT	33555.613	195.157	5858494.897	489639.537
VPI	34059.391	195.678	5858085.327	489369.076
Tangent Grade:	0.001			
Tangent Length:	503.778			
Element: Linear				
VPI	34059.391	195.678	5858085.327	489369.076
VPI	35270	195.9	5856909.854	489150.822
Tangent Grade:	0			
Tangent Length:	1210.609			
Element: Linear				
VPI	35270	195.9	5856909.854	489150.822
VPC	36617.935	198.069	5855567.891	489037.962
Tangent Grade:	0.002			
Tangent Length:	1347.935			
Element: Symmetrical Parabola				
VPC	36617.935	198.069	5855567.891	489037.962

VPI	36669.821	198.152	5855516.068	489040.496
VPT	36721.707	198.535	5855464.296	489043.926
Length:	103.772			
Entrance Grade:	0.002			
Exit Grade:	0.007			
r = 100 * (g2 - g1) / L:	0.556			
K = l / (g2 - g1):	180			
Middle Ordinate:	0.075			
Element: Linear				
VPT	36721.707	198.535	5855464.296	489043.926
VPC	37297.525	202.781	5854896.925	489138.292
Tangent Grade:	0.007			
Tangent Length:	575.818			
Element: Symmetrical Parabola				
VPC	37297.525	202.781	5854896.925	489138.292
VPI	37355.222	203.206	5854840.605	489150.82
VPT	37412.919	203.215	5854784.285	489163.348
Length:	115.393			
Entrance Grade:	0.007			
Exit Grade:	0			
r = 100 * (g2 - g1) / L:	-0.625			
K = l / (g2 - g1):	160			
Middle Ordinate:	-0.104			
Element: Linear				
VPT	37412.919	203.215	5854784.285	489163.348
VPI	37845.857	203.285	5854361.676	489257.355
Tangent Grade:	0			
Tangent Length:	432.939			
Element: Linear				
VPI	37845.857	203.285	5854361.676	489257.355
VPI	38428.895	202.919	5853793.088	489386.206
Tangent Grade:	-0.001			
Tangent Length:	583.038			
Element: Linear				
VPI	38428.895	202.919	5853793.088	489386.206
VPI	39915.79	199.464	5852591.703	490222.781
Tangent Grade:	-0.002			
Tangent Length:	1486.895			
Element: Linear				
VPI	39915.79	199.464	5852591.703	490222.781
VPC	40394.009	200.639	5852257.268	490564.609
Tangent Grade:	0.002			
Tangent Length:	478.218			
Element: Symmetrical Parabola				
VPC	40394.009	200.639	5852257.268	490564.609
VPI	40459.955	200.801	5852210.391	490610.989
VPT	40525.902	200.615	5852162.011	490655.798
VHP	40455.445	200.714		
Length:	131.893			

Entrance Grade:	0.002			
Exit Grade:	-0.003			
r = 100 * (g2 - g1) / L:	-0.4			
K = l / (g2 - g1):	250			
Middle Ordinate:	-0.087			
Element: Linear				
VPT	40525.902	200.615	5852162.011	490655.798
VPC	40795.307	199.856	5851949.883	490821.543
Tangent Grade:	-0.003			
Tangent Length:	269.406			
Element: Symmetrical Parabola				
VPC	40795.307	199.856	5851949.883	490821.543
VPI	40831.395	199.754	5851919.834	490841.527
VPT	40867.483	199.87	5851889.43	490860.965
VLP	40829.126	199.808		
Length:	72.175			
Entrance Grade:	-0.003			
Exit Grade:	0.003			
r = 100 * (g2 - g1) / L:	0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	0.054			
Element: Linear				
VPT	40867.483	199.87	5851889.43	490860.965
VPI	43351.604	207.81	5849522.434	491591.167
Tangent Grade:	0.003			
Tangent Length:	2484.121			
Element: Linear				
VPI	43351.604	207.81	5849522.434	491591.167
VPI	44851.423	208.511	5848083.566	492011.55
Tangent Grade:	0			
Tangent Length:	1499.819			
Element: Linear				
VPI	44851.423	208.511	5848083.566	492011.55
VPI	45200	208	5847763.772	492150.072
Tangent Grade:	-0.001			
Tangent Length:	348.577			
Element: Linear				
VPI	45200	208	5847763.772	492150.072
VPI	49809.987	207.032	5845055.45	495655.773
Tangent Grade:	0			
Tangent Length:	4609.987			
Element: Linear				
VPI	49809.987	207.032	5845055.45	495655.773
VPC	51065.942	202.304	5844579.882	496796.312
Tangent Grade:	-0.004			
Tangent Length:	1255.955			
Element: Symmetrical Parabola				
VPC	51065.942	202.304	5844579.882	496796.312
VPI	51100.154	202.175	5844577.376	496830.432

VPT	51134.365	202.28	5844575.454	496864.589
VLP	51103.591	202.233		
Length:	68.424			
Entrance Grade:	-0.004			
Exit Grade:	0.003			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			
Middle Ordinate:	0.059			
Element: Linear				
VPT	51134.365	202.28	5844575.454	496864.589
VPI	51426.679	203.18	5844562.152	497156.479
Tangent Grade:	0.003			
Tangent Length:	292.313			
Element: Linear				
VPI	51426.679	203.18	5844562.152	497156.479
VPI	51866.47	203.505	5844468.454	497585.266
Tangent Grade:	0.001			
Tangent Length:	439.791			
Element: Linear				
VPI	51866.47	203.505	5844468.454	497585.266
VPI	53152.704	202.531	5843897.858	498731.64
Tangent Grade:	-0.001			
Tangent Length:	1286.234			
Element: Linear				
VPI	53152.704	202.531	5843897.858	498731.64
VPI	53679.791	202.817	5843820.92	499251.541
Tangent Grade:	0.001			
Tangent Length:	527.087			
Element: Linear				
VPI	53679.791	202.817	5843820.92	499251.541
VPI	54080	203.191	5843823.754	499651.712
Tangent Grade:	0.001			
Tangent Length:	400.209			
Element: Linear				
VPI	54080	203.191	5843823.754	499651.712
VPI	57132.49	202.226	5844303.814	502595.074
Tangent Grade:	0			
Tangent Length:	3052.49			
Element: Linear				
VPI	57132.49	202.226	5844303.814	502595.074
VPI	57960	203	5844431.627	503412.207
Tangent Grade:	0.001			
Tangent Length:	827.51			
Element: Linear				
VPI	57960	203	5844431.627	503412.207
VPI	60566.891	198.024	5846346.868	505034.067
Tangent Grade:	-0.002			
Tangent Length:	2606.891			
Element: Linear				

VPI	60566.891	198.024	5846346.868	505034.067
VPI	61697.86	194.123	5846748.617	506075.979
Tangent Grade:	-0.003			
Tangent Length:	1130.968			
Element: Linear				
VPI	61697.86	194.123	5846748.617	506075.979
VPI	62720	195	5846947.343	507078.615
Tangent Grade:	0.001			
Tangent Length:	1022.14			
Element: Linear				
VPI	62720	195	5846947.343	507078.615
VPI	63765.564	195.002	5847150.622	508104.227
Tangent Grade:	0			
Tangent Length:	1045.564			
Element: Linear				
VPI	63765.564	195.002	5847150.622	508104.227
VPC	64378.792	192.804	5847269.068	508705.904
Tangent Grade:	-0.004			
Tangent Length:	613.228			
Element: Symmetrical Parabola				
VPC	64378.792	192.804	5847269.068	508705.904
VPI	64439.223	192.588	5847279.4	508765.444
VPT	64499.653	192.737	5847289.011	508825.105
VLP	64450.466	192.676		
Length:	120.861			
Entrance Grade:	-0.004			
Exit Grade:	0.002			
r = 100 * (g2 - g1) / L:	0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	0.091			
Element: Linear				
VPT	64499.653	192.737	5847289.011	508825.105
VPI	65420	195	5847349.461	509742.423
Tangent Grade:	0.002			
Tangent Length:	920.347			
Element: Linear				
VPI	65420	195	5847349.461	509742.423
VPI	67895.288	189.012	5847470.251	512193.47
Tangent Grade:	-0.002			
Tangent Length:	2475.288			
Element: Linear				
VPI	67895.288	189.012	5847470.251	512193.47
VPI	69180	190	5847662.553	513459.706
Tangent Grade:	0.001			
Tangent Length:	1284.712			
Element: Linear				
VPI	69180	190	5847662.553	513459.706
VPI	71342.293	184.993	5848246.397	515488.379
Tangent Grade:	-0.002			

Tangent Length:	2162.293			
Element: Linear				
VPI	71342.293	184.993	5848246.397	515488.379
VPI	71915.305	185.817	5848214.099	516060.311
Tangent Grade:	0.001			
Tangent Length:	573.012			
Element: Linear				
VPI	71915.305	185.817	5848214.099	516060.311
VPI	73530.87	187.401	5847414.791	517414.582
Tangent Grade:	0.001			
Tangent Length:	1615.565			
Element: Linear				
VPI	73530.87	187.401	5847414.791	517414.582
VPI	75720	185.423	5846891.696	519440.546
Tangent Grade:	-0.001			
Tangent Length:	2189.13			
Element: Linear				
VPI	75720	185.423	5846891.696	519440.546
VPI	76960	184.948	5846673.126	520643.96
Tangent Grade:	0			
Tangent Length:	1240			
Element: Linear				
VPI	76960	184.948	5846673.126	520643.96
VPI	77783.242	186.767	5846536.021	521446.068
Tangent Grade:	0.002			
Tangent Length:	823.242			
Element: Linear				
VPI	77783.242	186.767	5846536.021	521446.068
VPI	78102.693	186.282	5846572.35	521763.446
Tangent Grade:	-0.002			
Tangent Length:	319.451			
Element: Linear				
VPI	78102.693	186.282	5846572.35	521763.446
VPI	78780	186.6	5846616.861	522438.097
Tangent Grade:	0			
Tangent Length:	677.307			
Element: Linear				
VPI	78780	186.6	5846616.861	522438.097
VPC	79836.921	189.561	5846338.595	523453.585
Tangent Grade:	0.003			
Tangent Length:	1056.921			
Element: Symmetrical Parabola				
VPC	79836.921	189.561	5846338.595	523453.585
VPI	79907.815	189.76	5846315.24	523520.522
VPT	79978.71	189.556	5846291.885	523587.459
VHP	79906.959	189.659		
Length:	141.79			
Entrance Grade:	0.003			
Exit Grade:	-0.003			

r = 100 * (g2 - g1) / L:	-0.4			
K = l / (g2 - g1):	250			
Middle Ordinate:	-0.101			
Element: Linear				
VPT	79978.71	189.556	5846291.885	523587.459
VPI	82960	181	5845579.287	526400.433
Tangent Grade:	-0.003			
Tangent Length:	2981.29			
Element: Linear				
VPI	82960	181	5845579.287	526400.433
VPI	83140.167	181.477	5845478.573	526549.691
Tangent Grade:	0.003			
Tangent Length:	180.167			
Element: Linear				
VPI	83140.167	181.477	5845478.573	526549.691
VPI	88344.14	178.489	5844850.211	531676.017
Tangent Grade:	-0.001			
Tangent Length:	5203.972			
Element: Linear				
VPI	88344.14	178.489	5844850.211	531676.017
VPI	92208.2	173.052	5846274.962	535207.799
Tangent Grade:	-0.001			
Tangent Length:	3864.061			
Element: Linear				
VPI	92208.2	173.052	5846274.962	535207.799
VPC	93112.03	173.659	5846301.085	536103.577
Tangent Grade:	0.001			
Tangent Length:	903.83			
Element: Symmetrical Parabola				
VPC	93112.03	173.659	5846301.085	536103.577
VPI	93143.554	173.681	5846294.677	536134.442
VPT	93175.077	173.503	5846287.807	536165.207
VHP	93118.75	173.662		
Length:	63.047			
Entrance Grade:	0.001			
Exit Grade:	-0.006			
r = 100 * (g2 - g1) / L:	-1			
K = l / (g2 - g1):	100			
Middle Ordinate:	-0.05			
Element: Linear				
VPT	93175.077	173.503	5846287.807	536165.207
VPC	93589.554	171.168	5846268.106	536577.156
Tangent Grade:	-0.006			
Tangent Length:	414.477			
Element: Symmetrical Parabola				
VPC	93589.554	171.168	5846268.106	536577.156
VPI	93620	170.997	5846272.282	536607.313
VPT	93650.446	170.98	5846277.222	536637.355
Length:	60.892			

Entrance Grade:	-0.006			
Exit Grade:	-0.001			
r = 100 * (g2 - g1) / L:	0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	0.039			
Element: Linear				
VPT	93650.446	170.98	5846277.222	536637.355
VPC	94330.285	170.6	5846559.941	537249.086
Tangent Grade:	-0.001			
Tangent Length:	679.839			
Element: Symmetrical Parabola				
VPC	94330.285	170.6	5846559.941	537249.086
VPI	94360	170.584	5846574.222	537275.143
VPT	94389.715	170.714	5846587.985	537301.478
VLP	94336.986	170.598		
Length:	59.43			
Entrance Grade:	-0.001			
Exit Grade:	0.004			
r = 100 * (g2 - g1) / L:	0.833			
K = l / (g2 - g1):	120			
Middle Ordinate:	0.037			
Element: Linear				
VPT	94389.715	170.714	5846587.985	537301.478
VPC	94753.817	172.314	5846713.36	537642.444
Tangent Grade:	0.004			
Tangent Length:	364.102			
Element: Symmetrical Parabola				
VPC	94753.817	172.314	5846713.36	537642.444
VPI	94805.159	172.54	5846726.598	537692.05
VPT	94856.501	172.502	5846739.837	537741.656
VHP	94841.698	172.507		
Length:	102.685			
Entrance Grade:	0.004			
Exit Grade:	-0.001			
r = 100 * (g2 - g1) / L:	-0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	-0.066			
Element: Linear				
VPT	94856.501	172.502	5846739.837	537741.656
VPI	96151.085	171.544	5847073.637	538992.466
Tangent Grade:	-0.001			
Tangent Length:	1294.584			
Element: Linear				
VPI	96151.085	171.544	5847073.637	538992.466
VPI	97020	169.848	5847297.681	539832
Tangent Grade:	-0.002			
Tangent Length:	868.915			
Element: Linear				
VPI	97020	169.848	5847297.681	539832

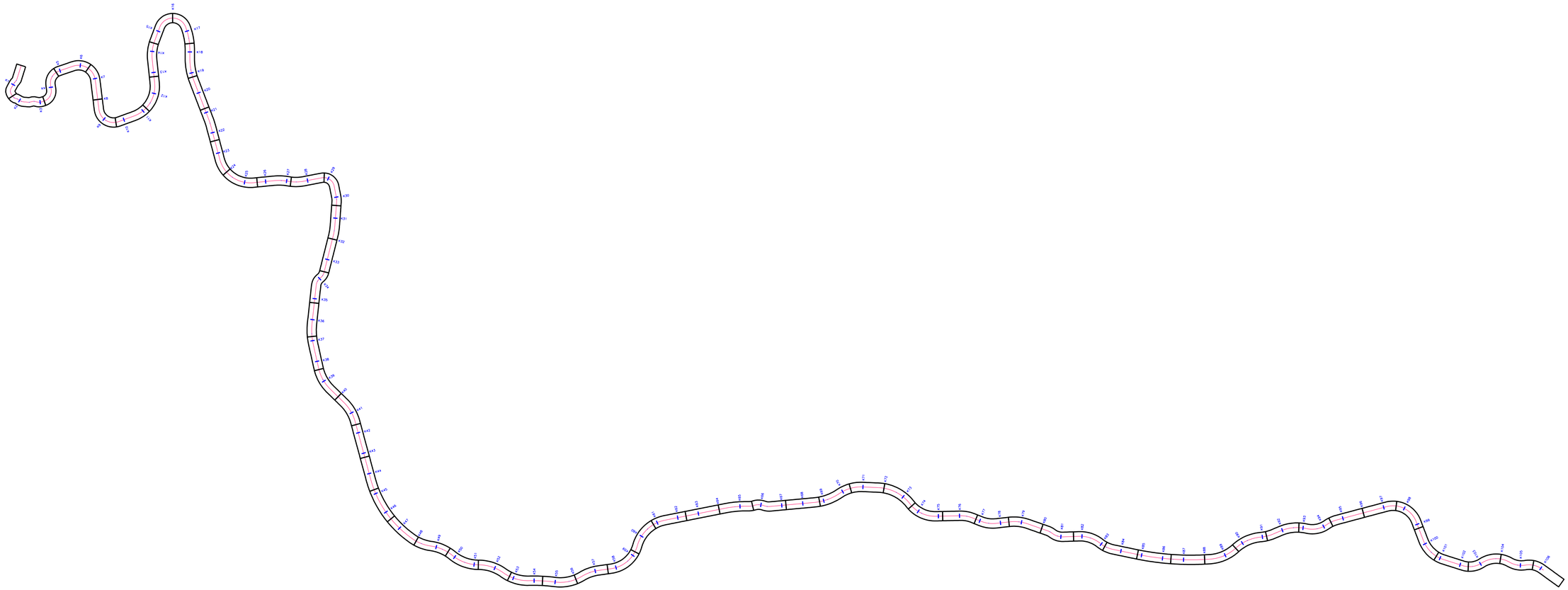
VPI	97610.055	169.776	5847360.385	540413.774
Tangent Grade:	0			
Tangent Length:	590.055			
Element: Linear				
VPI	97610.055	169.776	5847360.385	540413.774
VPI	99820	171	5845727.29	541692.987
Tangent Grade:	0.001			
Tangent Length:	2209.945			
Element: Linear				
VPI	99820	171	5845727.29	541692.987
VPI	100809.711	171.685	5844978.549	542312.581
Tangent Grade:	0.001			
Tangent Length:	989.711			
Element: Linear				
VPI	100809.711	171.685	5844978.549	542312.581
VPI	101280	171.709	5844795.462	542744.16
Tangent Grade:	0			
Tangent Length:	470.289			
Element: Linear				
VPI	101280	171.709	5844795.462	542744.16
VPI	101944.188	169.462	5844593.708	543376.964
Tangent Grade:	-0.003			
Tangent Length:	664.188			
Element: Linear				
VPI	101944.188	169.462	5844593.708	543376.964
VPI	102380	169	5844489.811	543798.866
Tangent Grade:	-0.001			
Tangent Length:	435.812			
Element: Linear				
VPI	102380	169	5844489.811	543798.866
VPC	103441.094	170.744	5844814.707	544790.458
Tangent Grade:	0.002			
Tangent Length:	1061.094			
Element: Symmetrical Parabola				
VPC	103441.094	170.744	5844814.707	544790.458
VPI	103479.067	170.807	5844825.035	544826.998
VPT	103517.04	170.725	5844834.248	544863.835
VHP	103473.973	170.771		
Length:	75.946			
Entrance Grade:	0.002			
Exit Grade:	-0.002			
r = 100 * (g2 - g1) / L:	-0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	-0.036			
Element: Linear				
VPT	103517.04	170.725	5844834.248	544863.835
VPC	103920.244	169.857	5844861.772	545264.349
Tangent Grade:	-0.002			
Tangent Length:	403.204			

Element: Symmetrical Parabola				
VPC	103920.244	169.857	5844861.772	545264.349
VPI	104000	169.685	5844851.864	545343.473
VPT	104079.756	168.877	5844836.931	545421.805
Length:	159.511			
Entrance Grade:	-0.002			
Exit Grade:	-0.01			
r = 100 * (g2 - g1) / L:	-0.5			
K = l / (g2 - g1):	200			
Middle Ordinate:	-0.159			
Element: Linear				
VPT	104079.756	168.877	5844836.931	545421.805
VPC	104549.242	164.122	5844657.043	545853.299
Tangent Grade:	-0.01			
Tangent Length:	469.486			
Element: Symmetrical Parabola				
VPC	104549.242	164.122	5844657.043	545853.299
VPI	104660	163	5844613.712	545955.18
VPT	104770.758	164.332	5844580.635	546060.837
VLP	104650.531	163.609		
Length:	221.516			
Entrance Grade:	-0.01			
Exit Grade:	0.012			
r = 100 * (g2 - g1) / L:	1			
K = l / (g2 - g1):	100			
Middle Ordinate:	0.613			
Element: Linear				
VPT	104770.758	164.332	5844580.635	546060.837
VPI	105143.22	168.81	5844548.044	546430.155
Tangent Grade:	0.012			
Tangent Length:	372.462			
Element: Linear				
VPI	105143.22	168.81	5844548.044	546430.155
VPI	105575.626	170.334	5844563.086	546860.24
Tangent Grade:	0.004			
Tangent Length:	432.405			
Element: Linear				
VPI	105575.626	170.334	5844563.086	546860.24
END	106062.617	172.489	5844374.958	547304.265
Tangent Grade:	0.004			
Tangent Length:	486.991			

APPENDIX I

Optimized Engineering Route Plan Drawings

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/08/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/16	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

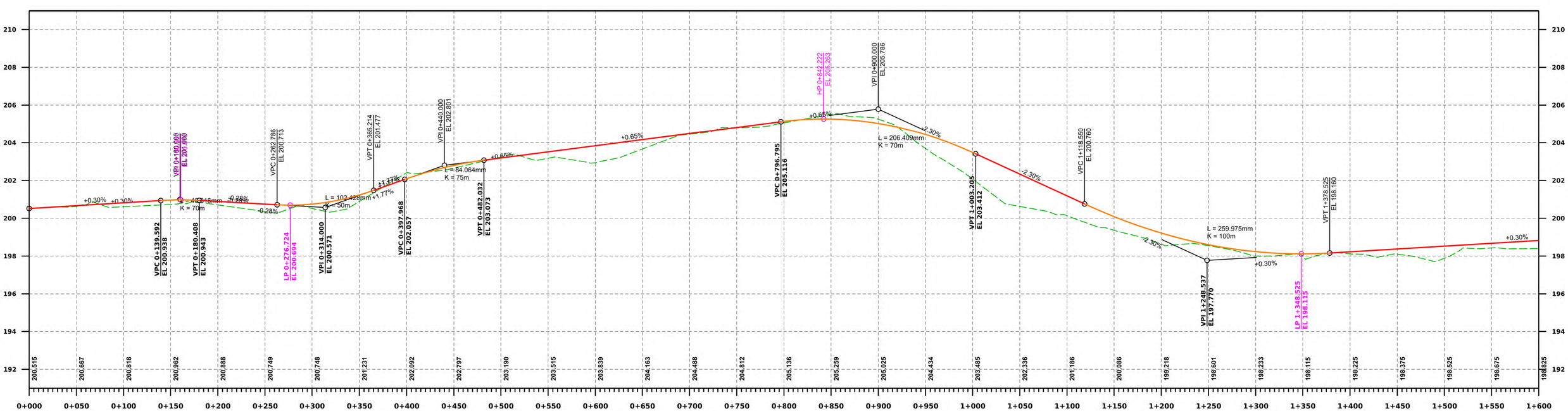
SCALES
1:100000

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

OPTIMIZED ENGINEERING ROUTE
PLAN AND PROFILE DRAWINGS
KEY PLAN

DWG. NO.
CONT. NO.
SHEET NO. A001

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

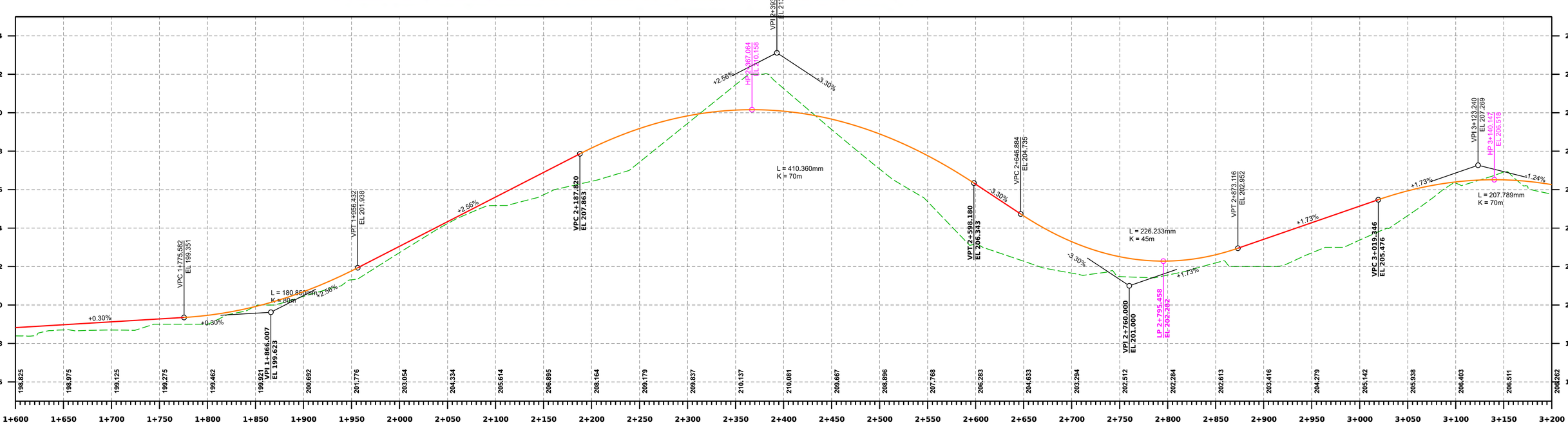
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP1
CONT. NO.
SHEET NO. A002

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP2
CONT. NO.
SHEET NO. A003

METRIC

MATCHLINE STA. 3+200 SEE SHT A002

PC 3+202.874

PI 3+611.733
Δ 78°32'48.8" LT
T 408.858m
L 685.451m
R 500.000m
PC 3+202.874
PT 3+888.325

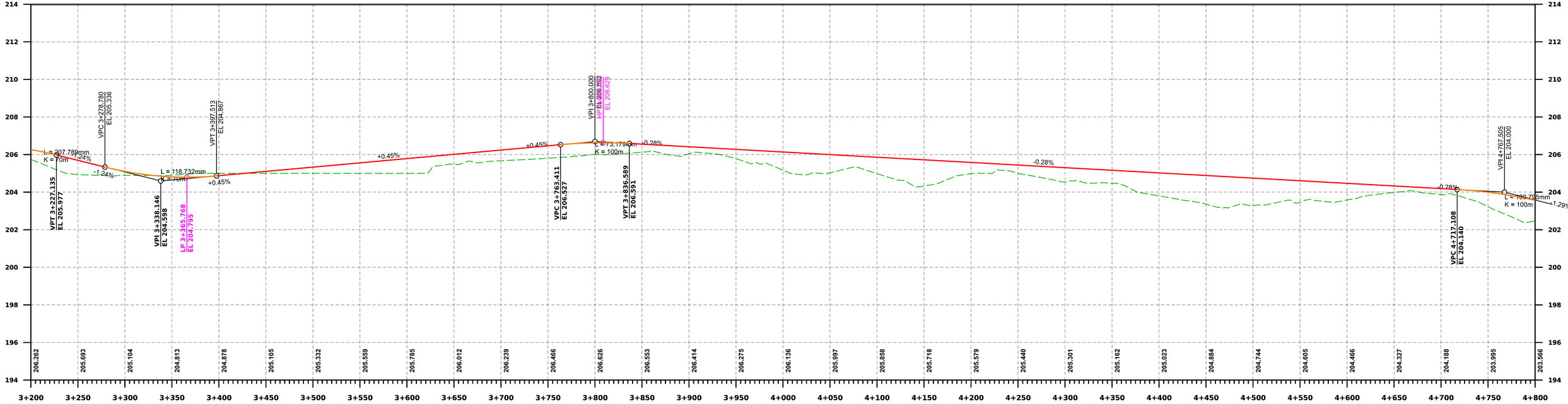
PT 3+888.325

N07°58'53.3"W
230.661m

PI 4+614.255
Δ 79°04'33.0" RT
T 495.269m
L 828.080m
R 600.000m
PC 4+118.986
PT 4+947.066

PC 4+118.986

MATCHLINE STA. 4+800 SEE SHT A004



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

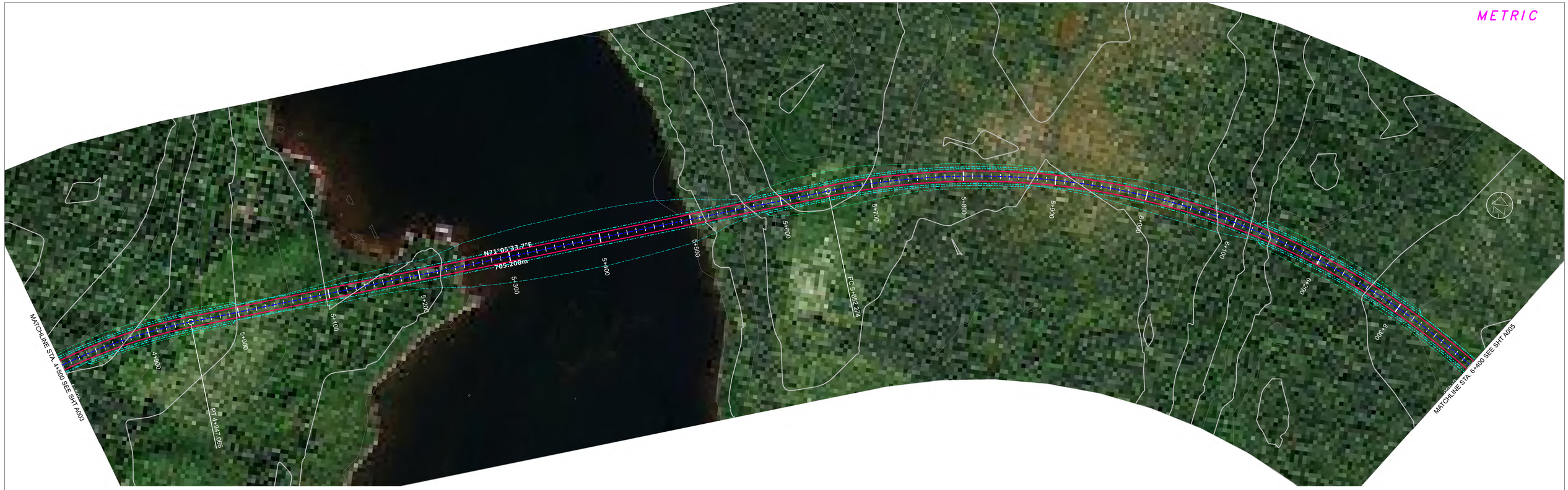
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

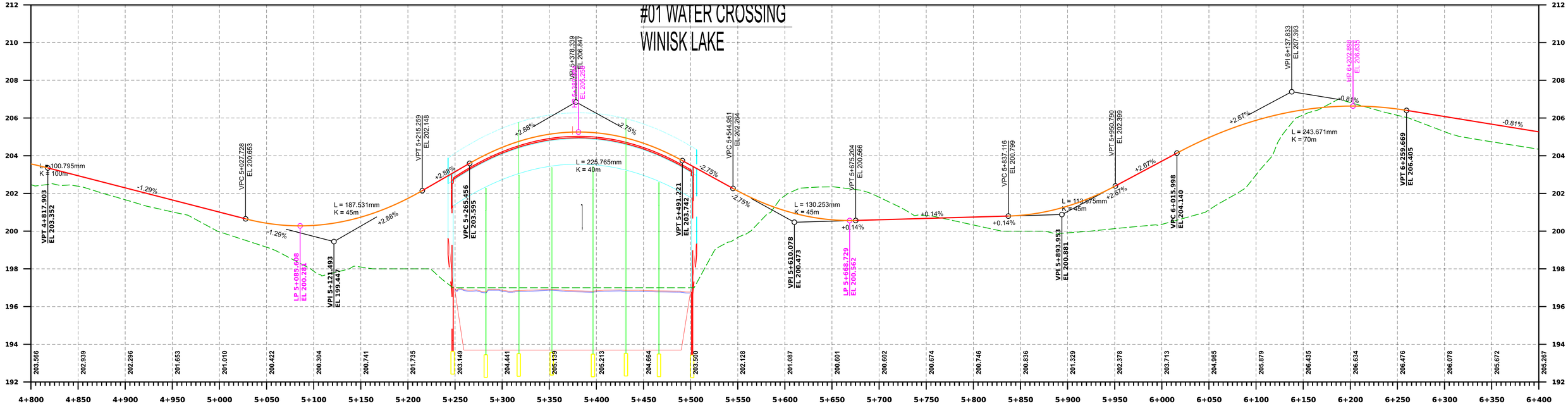
PLAN AND PROFILE DRAWINGS

DWG. NO. PP3
CONT. NO.
SHEET NO. A004

METRIC



#01 WATER CROSSING
WINISK LAKE



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

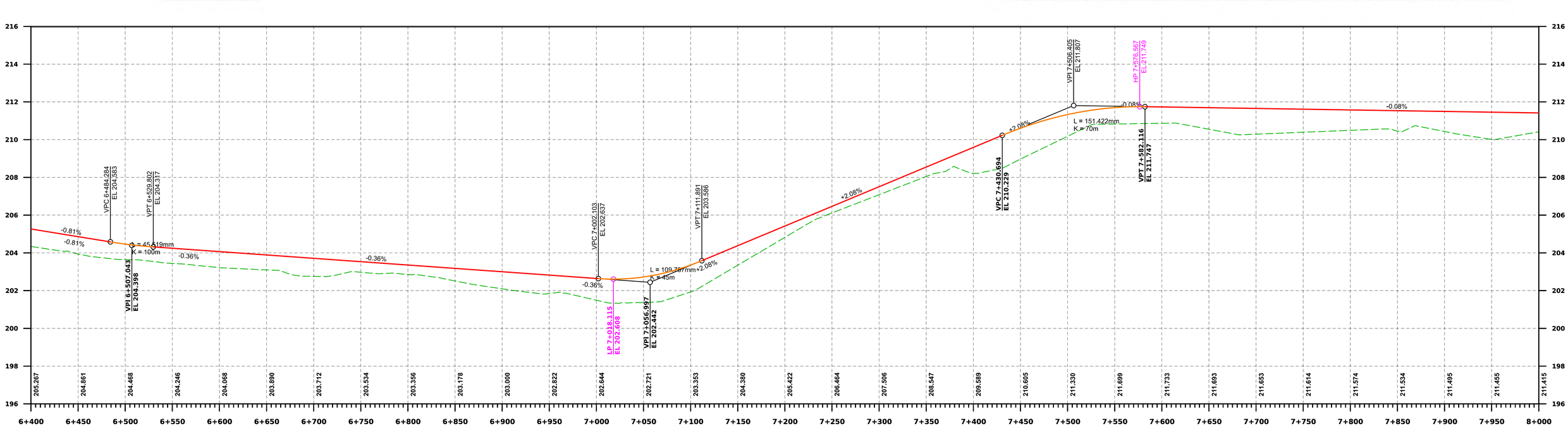
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP4
CONT. NO.
SHEET NO. A005

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

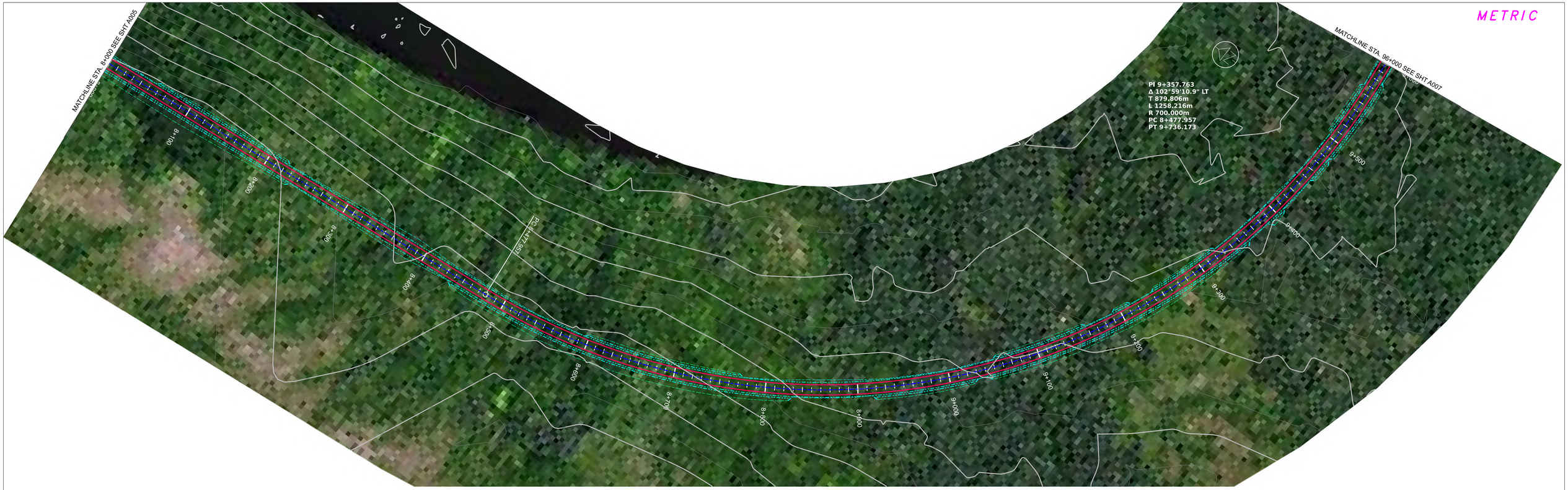
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

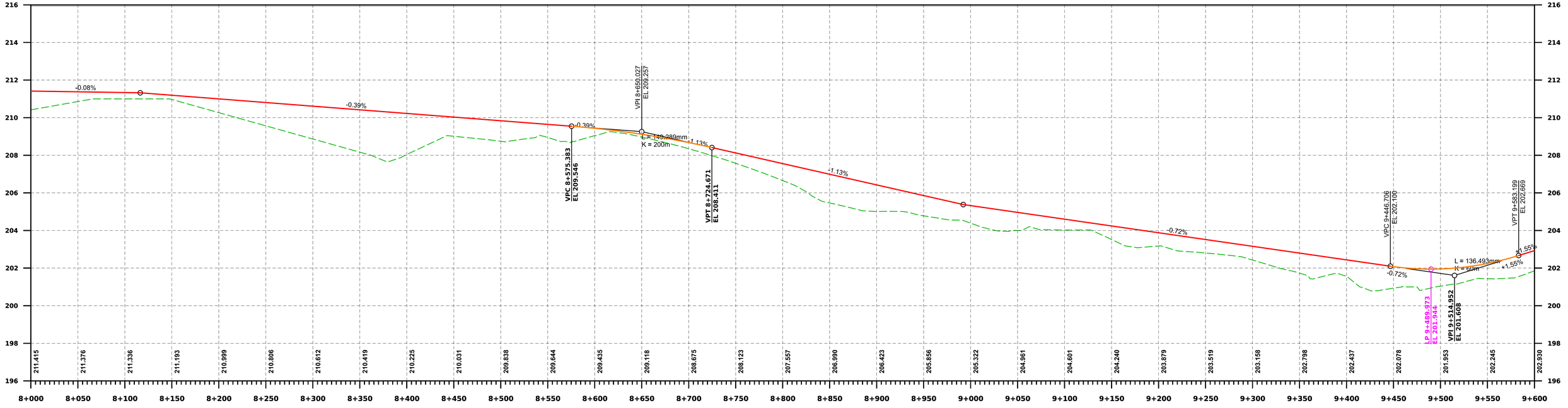
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP5
CONT. NO.
SHEET NO. A006

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

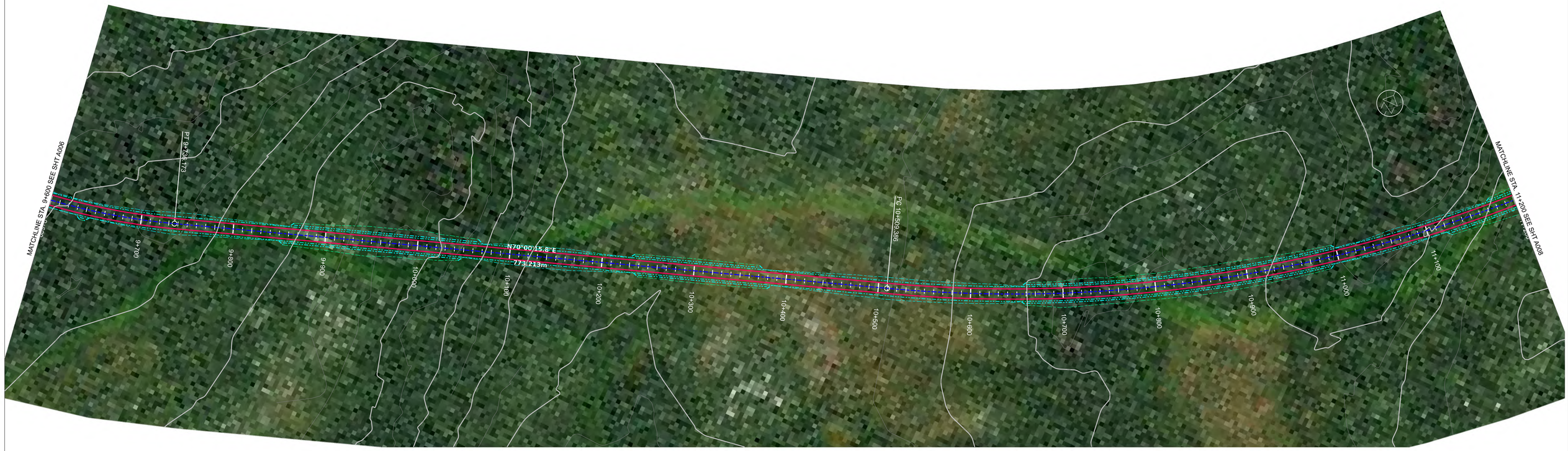
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

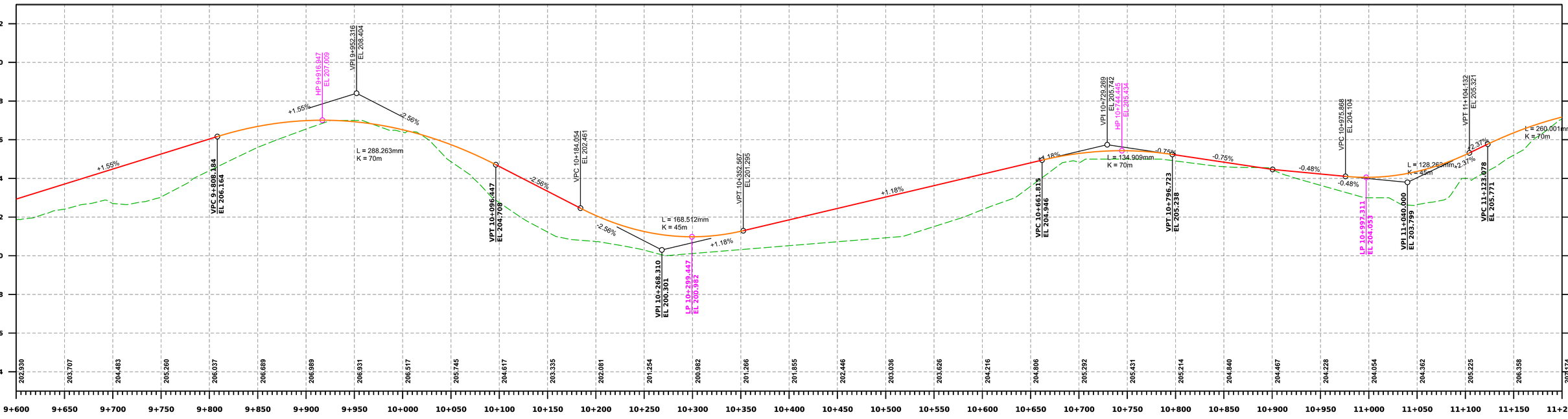
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP6
CONT. NO.
SHEET NO. A007

METRIC





No.	DATE	REVISIONS	BY
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PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

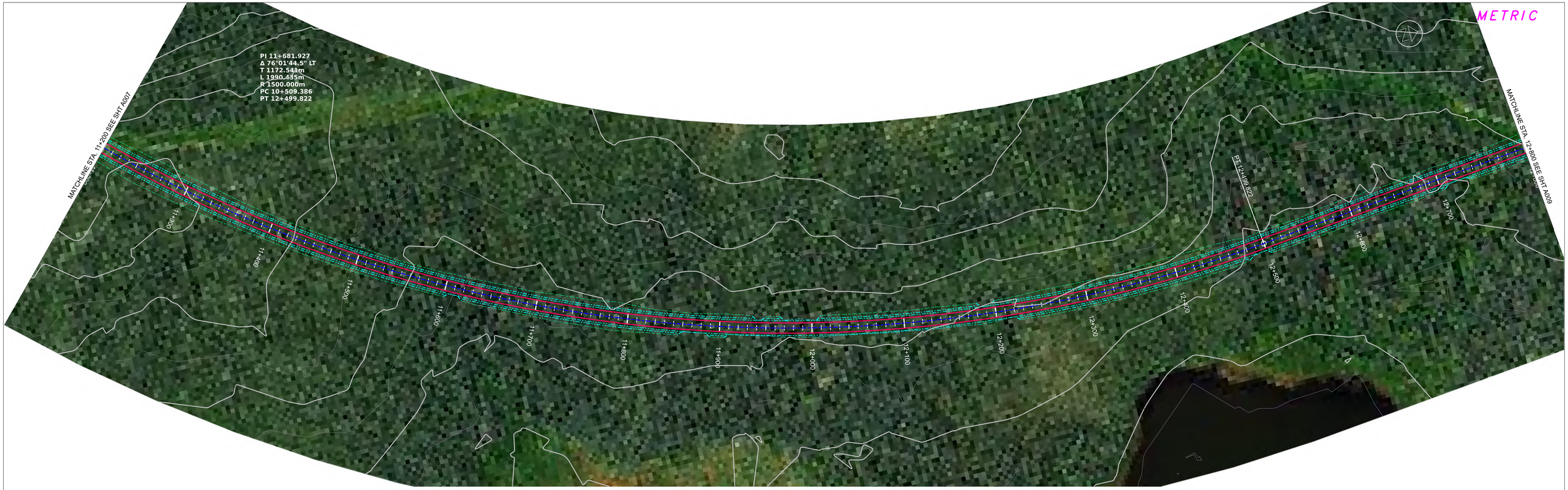
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

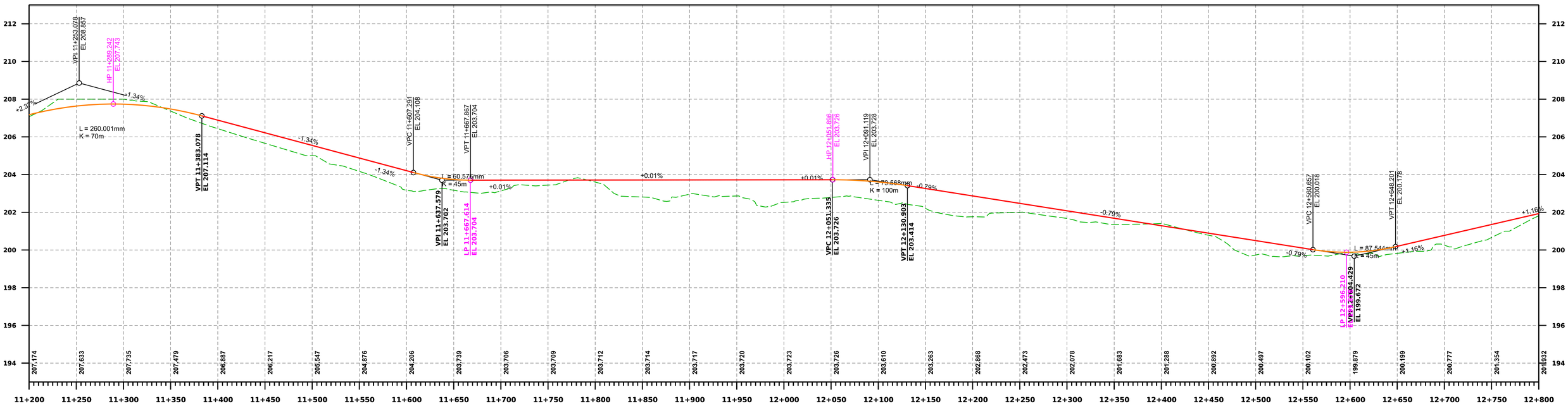
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP7
CONT. NO.
SHEET NO. A008

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

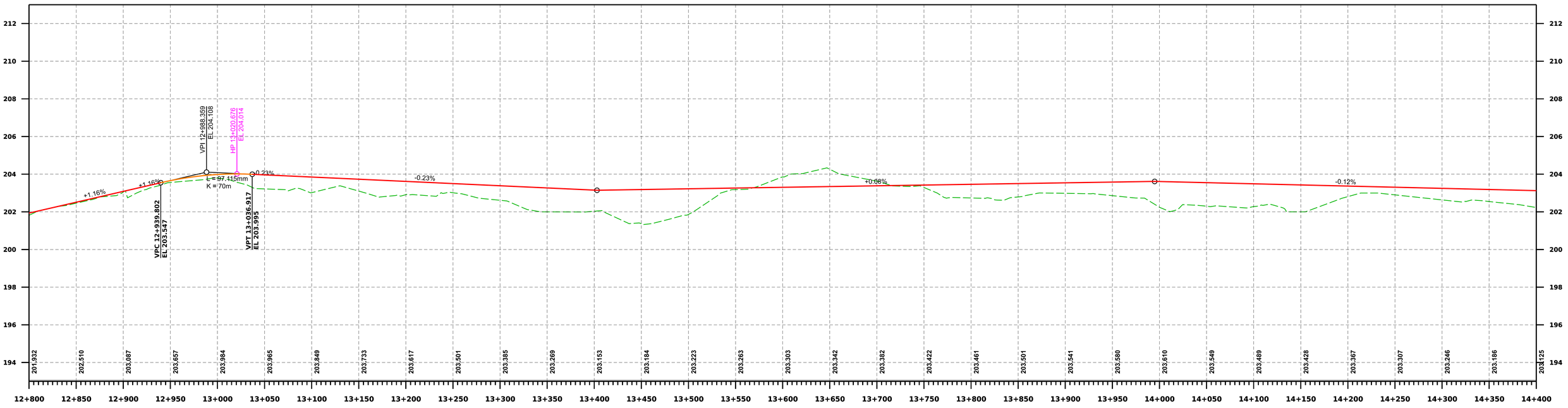
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP8
CONT. NO.
SHEET NO. A009

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

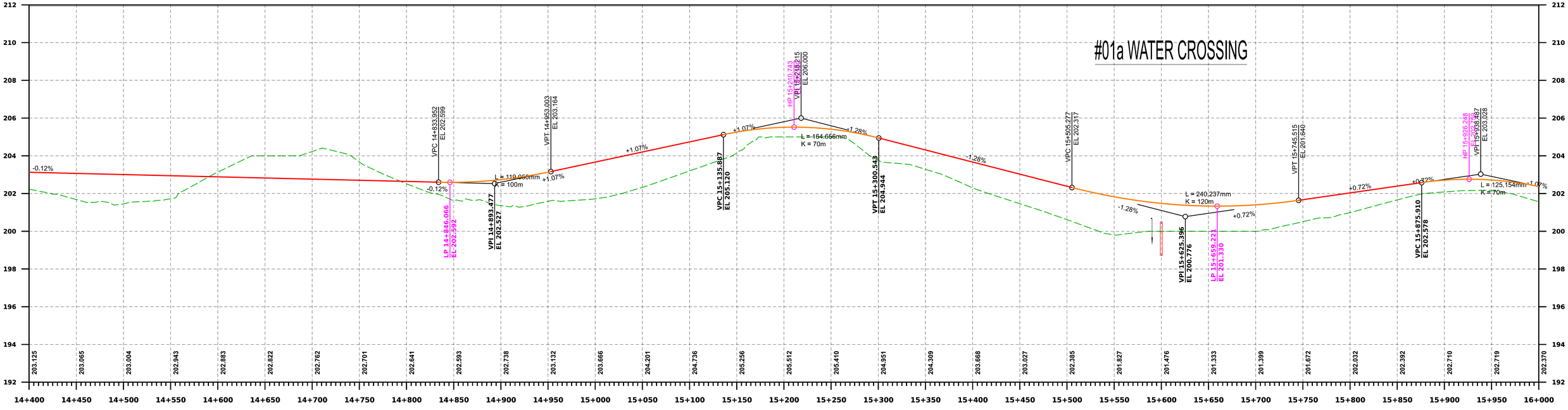
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP9
CONT. NO.
SHEET NO. A010

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

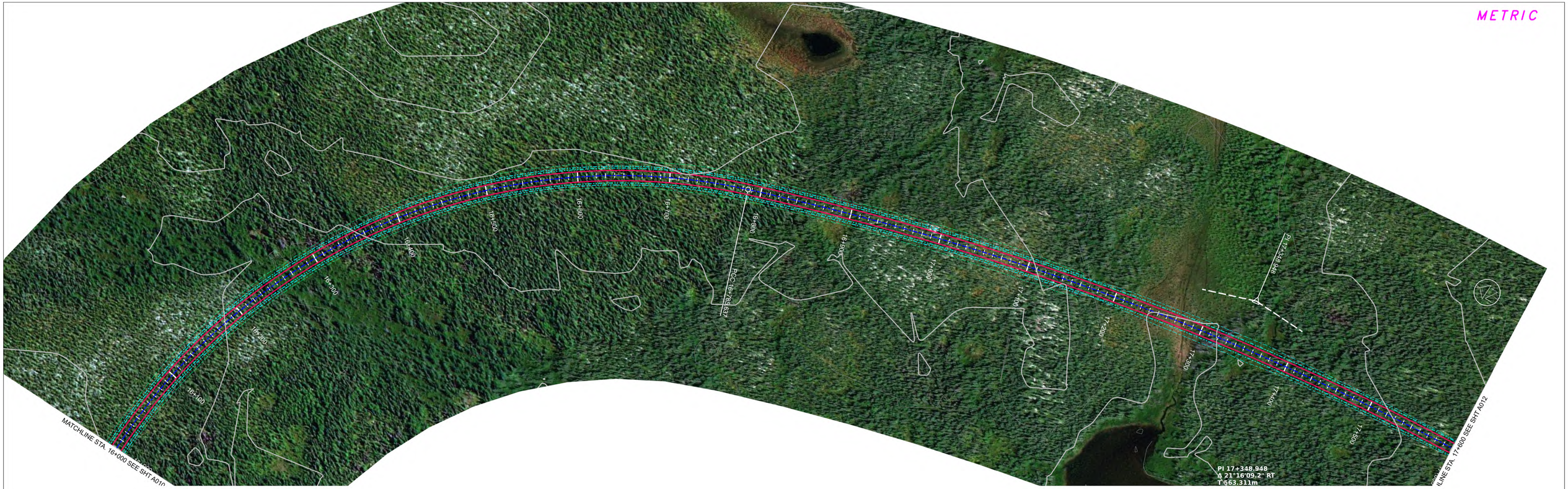
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

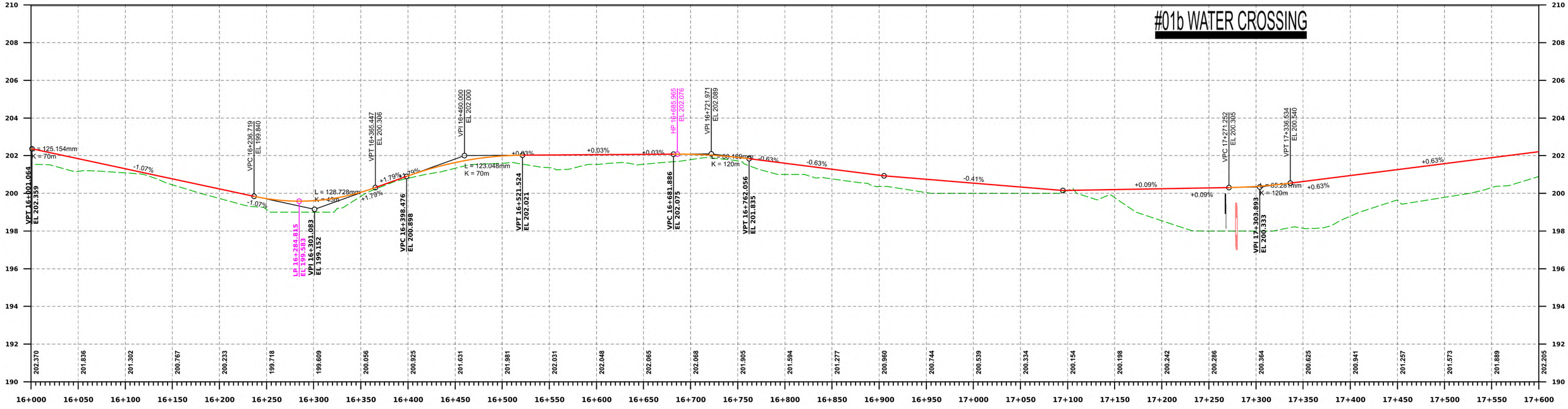
PLAN AND PROFILE DRAWINGS

DWG. NO. PP10
CONT. NO.
SHEET NO. A011

METRIC



#01b WATER CROSSING



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

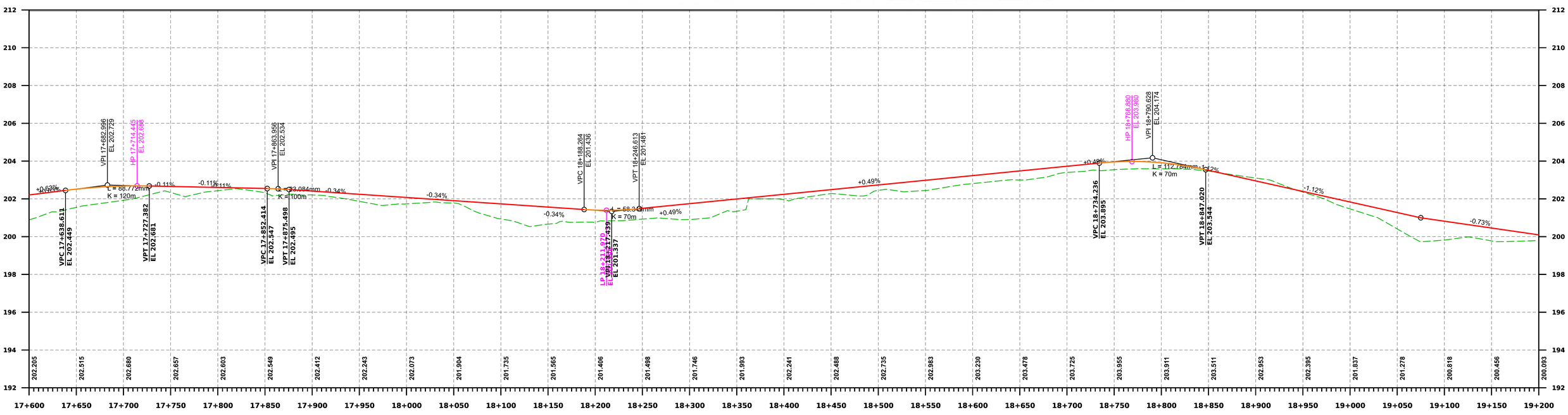
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP11
CONT. NO.
SHEET NO. A012

METRIC



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PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

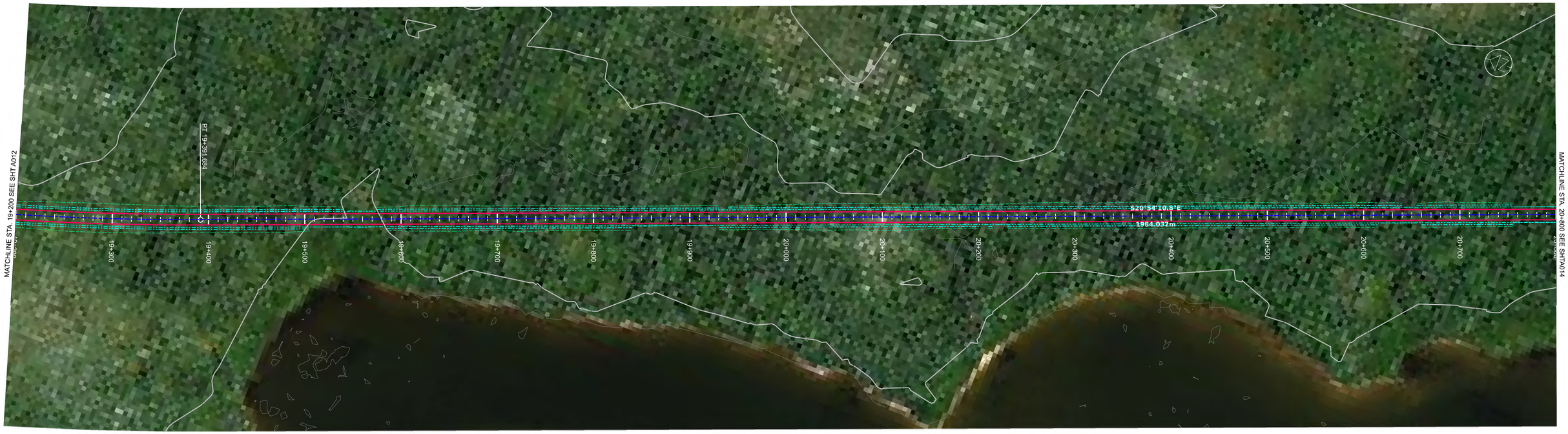
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

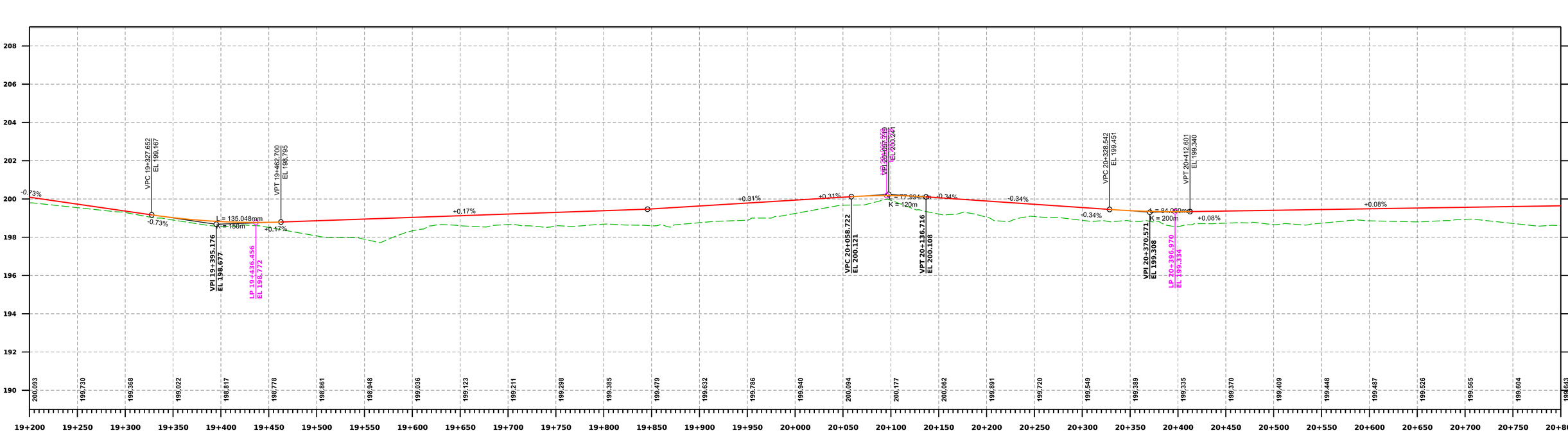
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP12
CONT. NO.
SHEET NO. A013

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

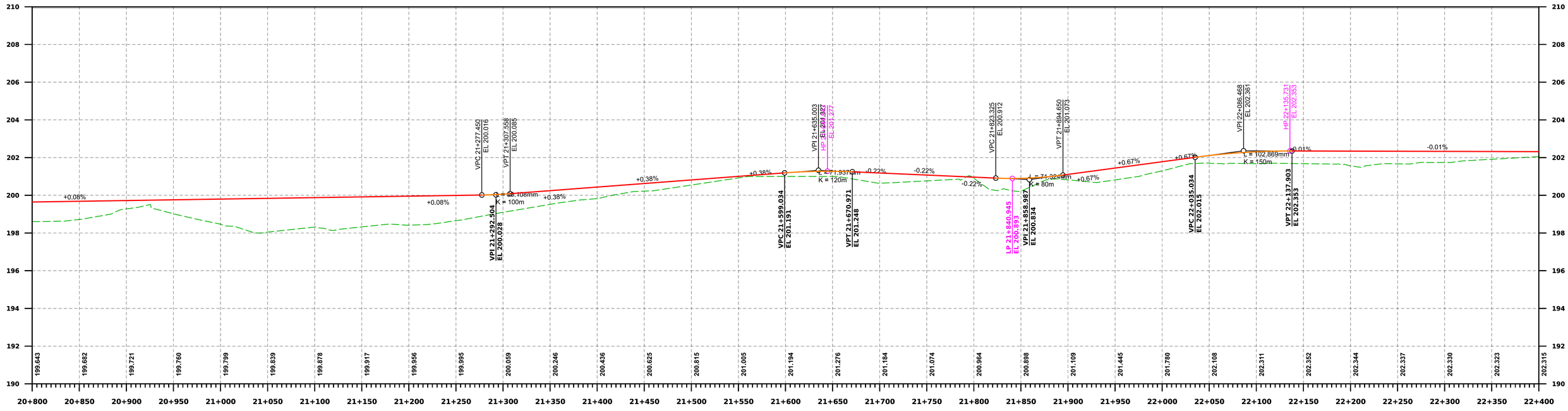
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP13
CONT. NO.
SHEET NO. A014

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

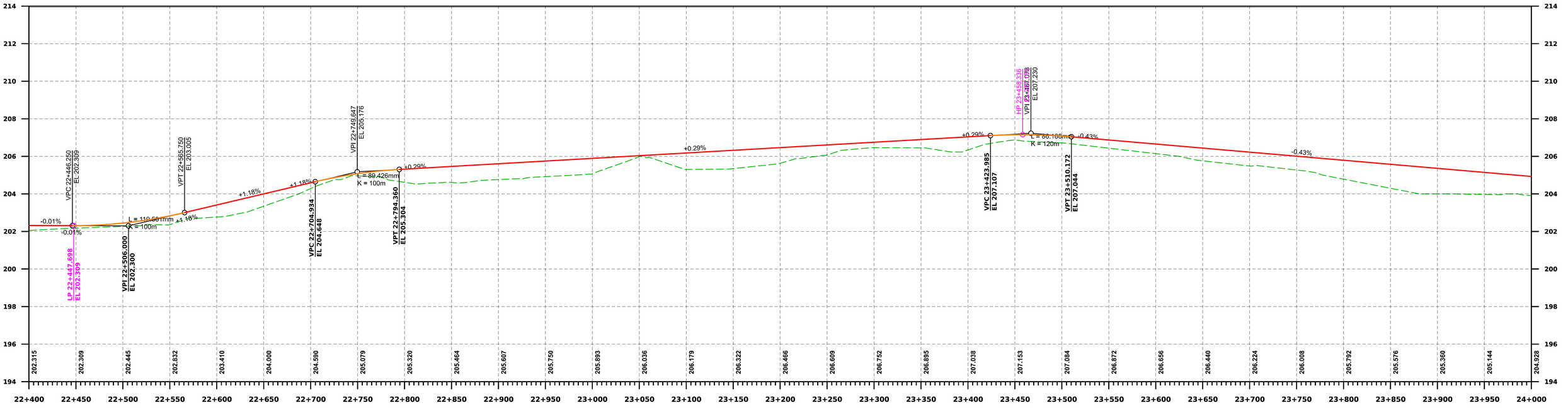
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP14
CONT. NO.
SHEET NO. A015

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
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PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

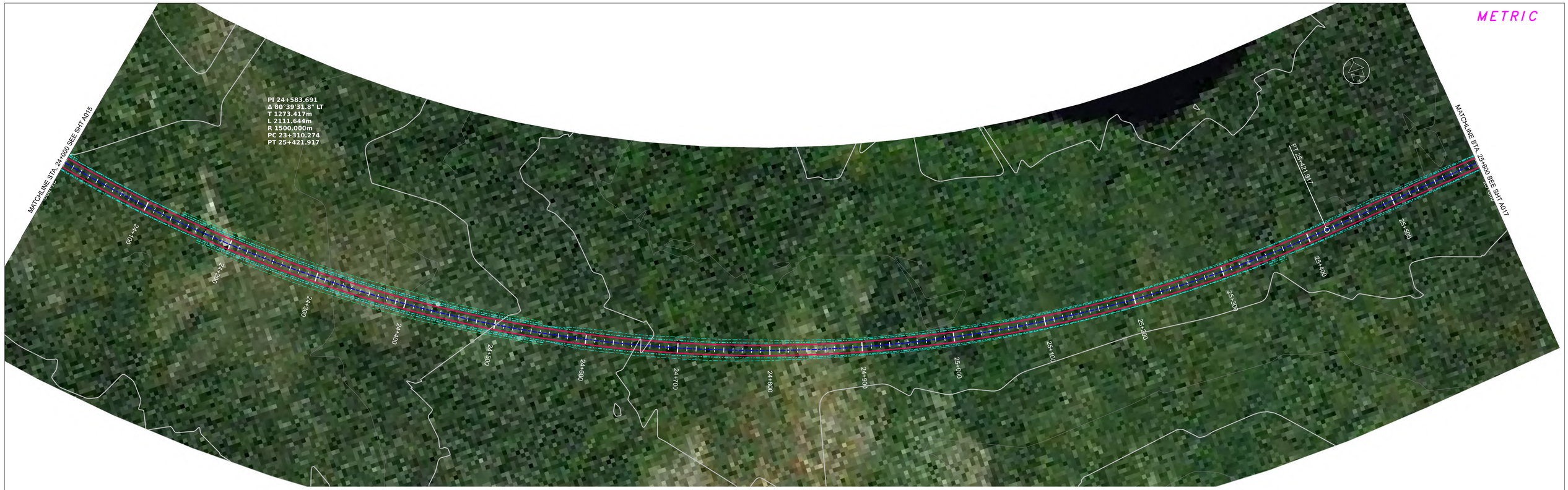
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

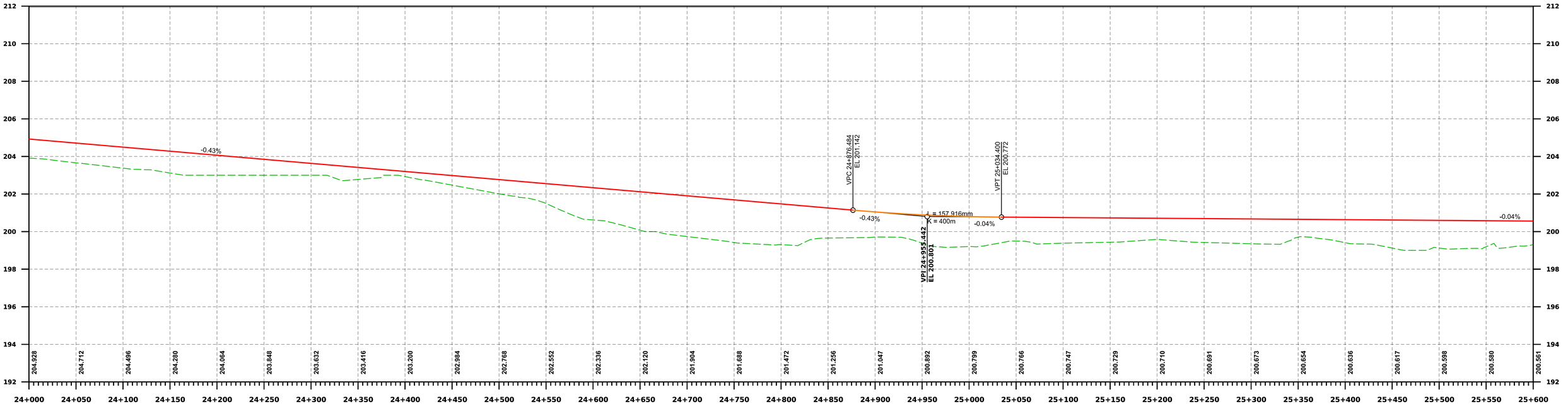
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP15
CONT. NO.
SHEET NO. A016

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

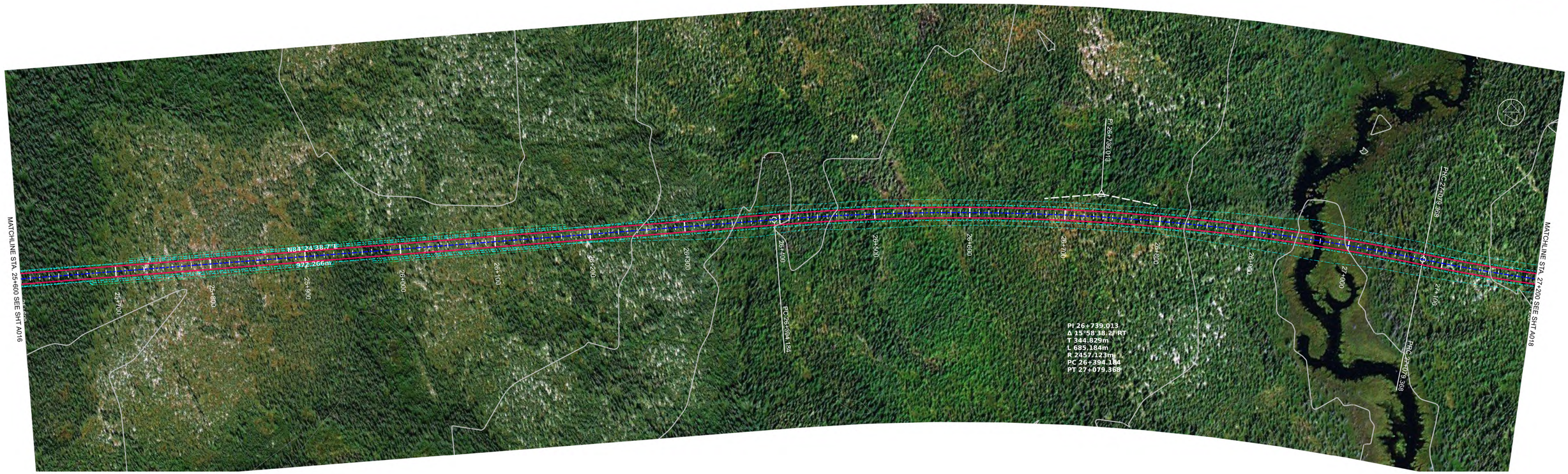
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

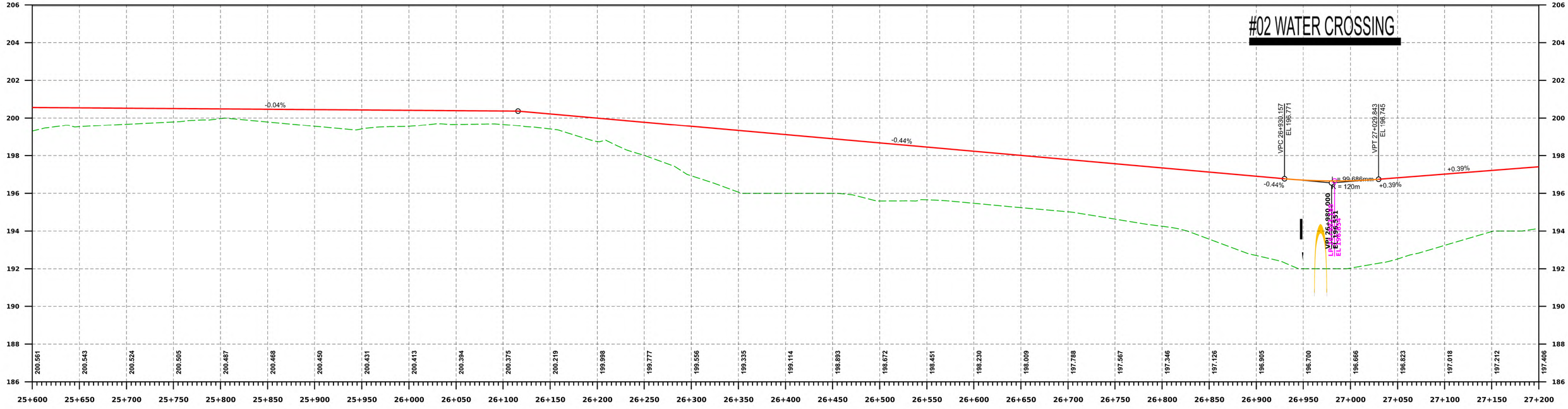
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP16
CONT. NO.
SHEET NO. A017

METRIC





No.	DATE	REVISIONS	BY
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PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
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PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

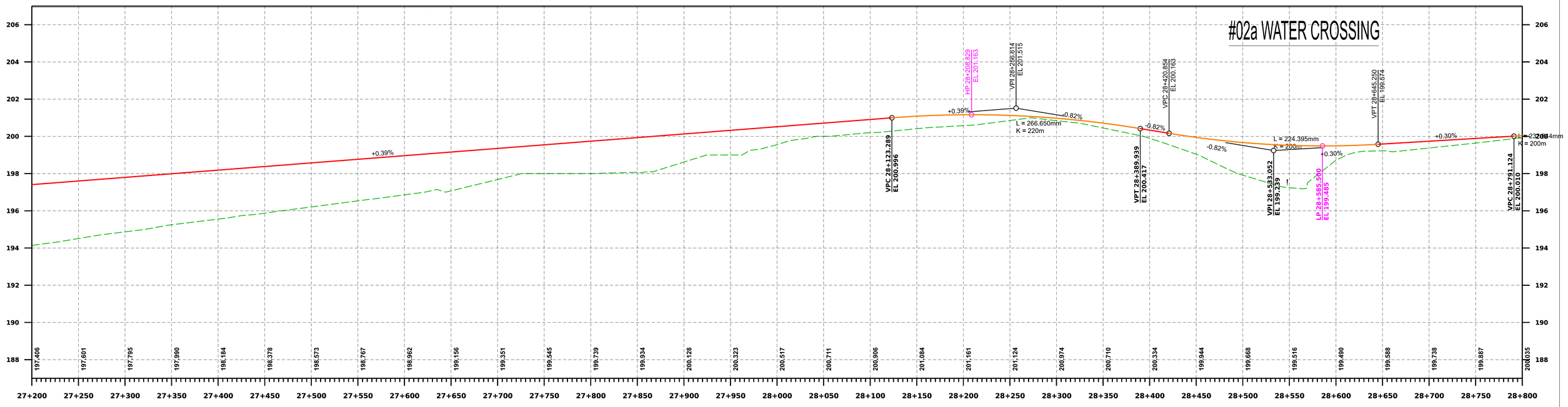
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP17
CONT. NO.
SHEET NO. A018

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

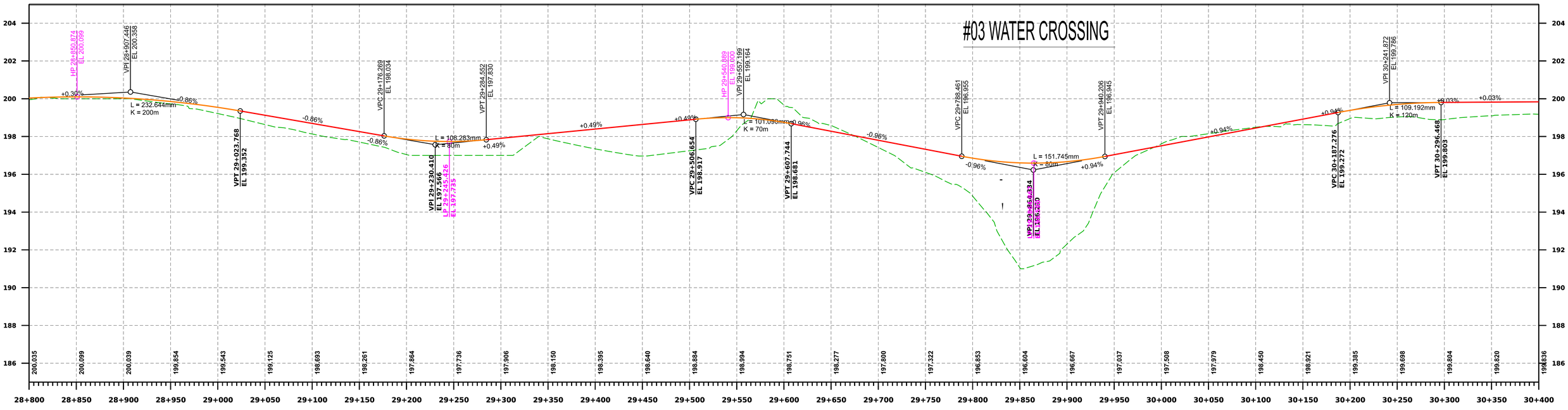
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP18
CONT. NO.
SHEET NO. A019

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

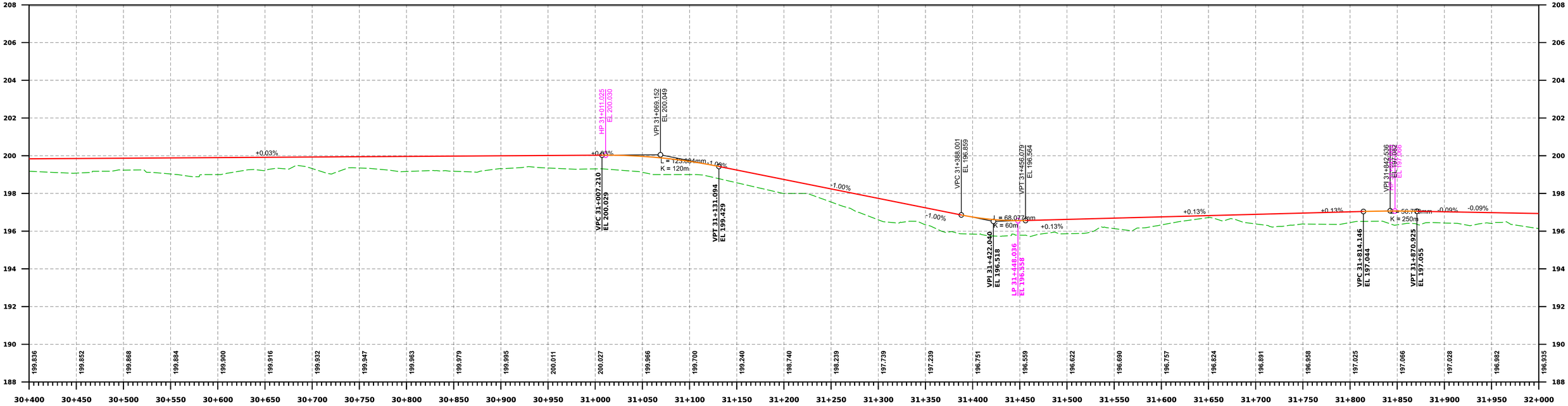
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP19
CONT. NO.
SHEET NO. A020

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

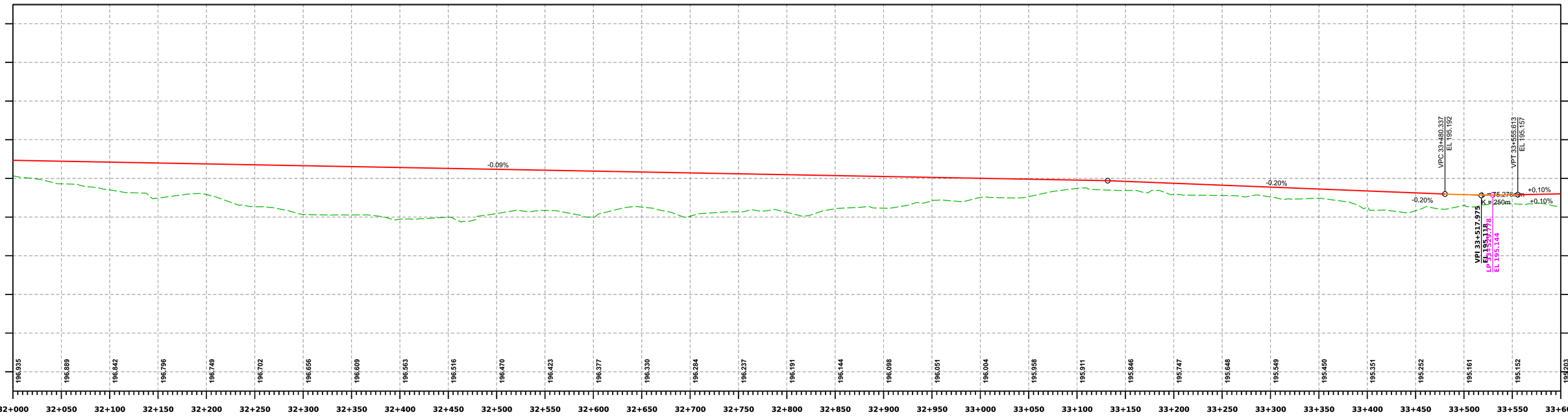
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP20
CONT. NO.
SHEET NO. A021

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

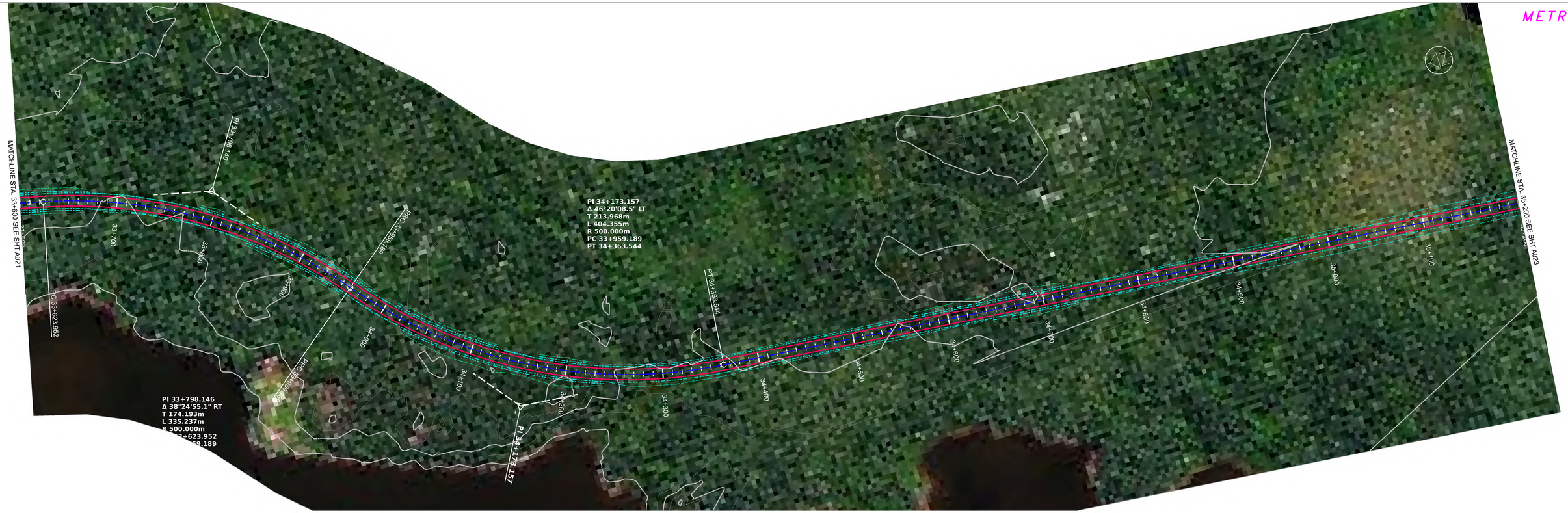
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

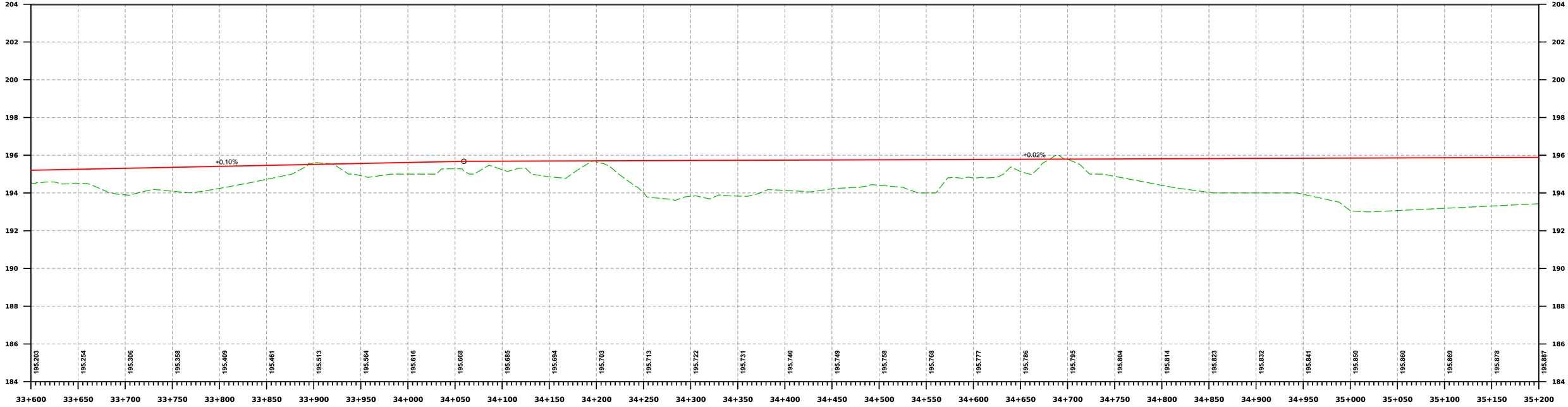
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP21
CONT. NO.
SHEET NO. A022

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

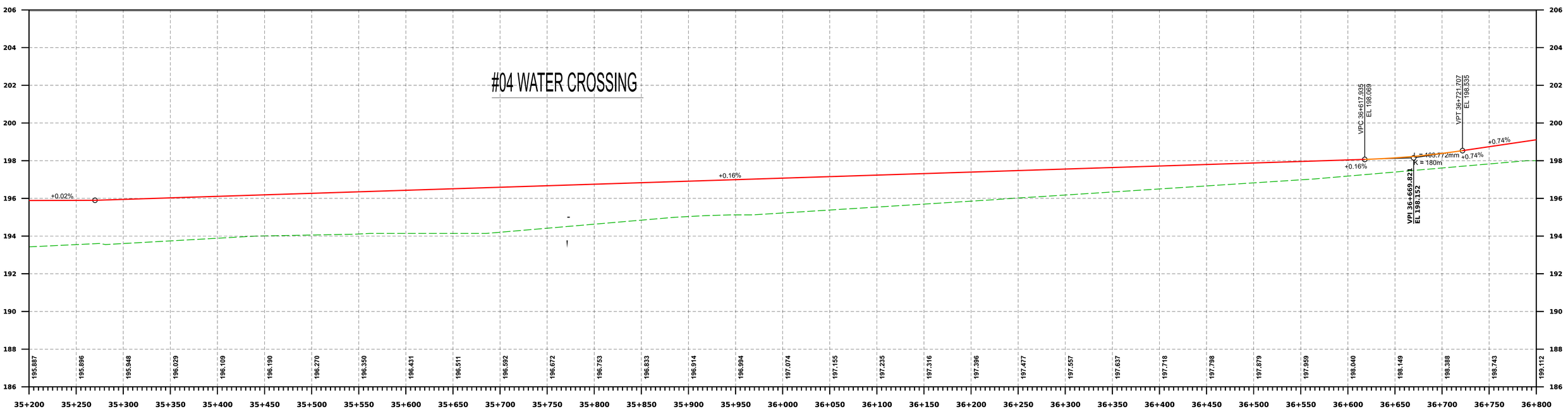
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP22
CONT. NO.
SHEET NO. A023

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

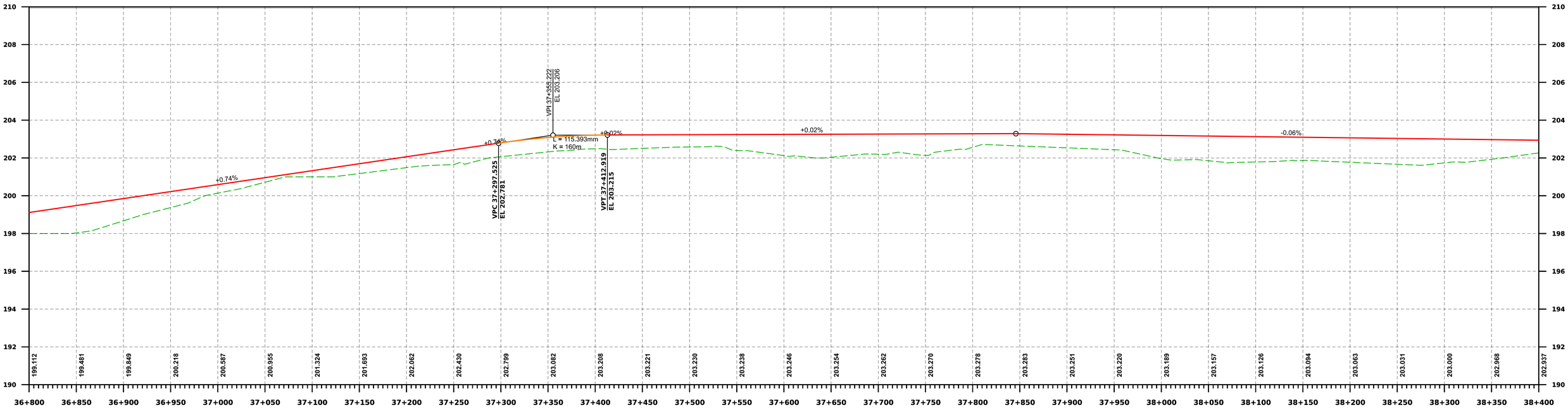
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP23
CONT. NO.
SHEET NO. A024

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

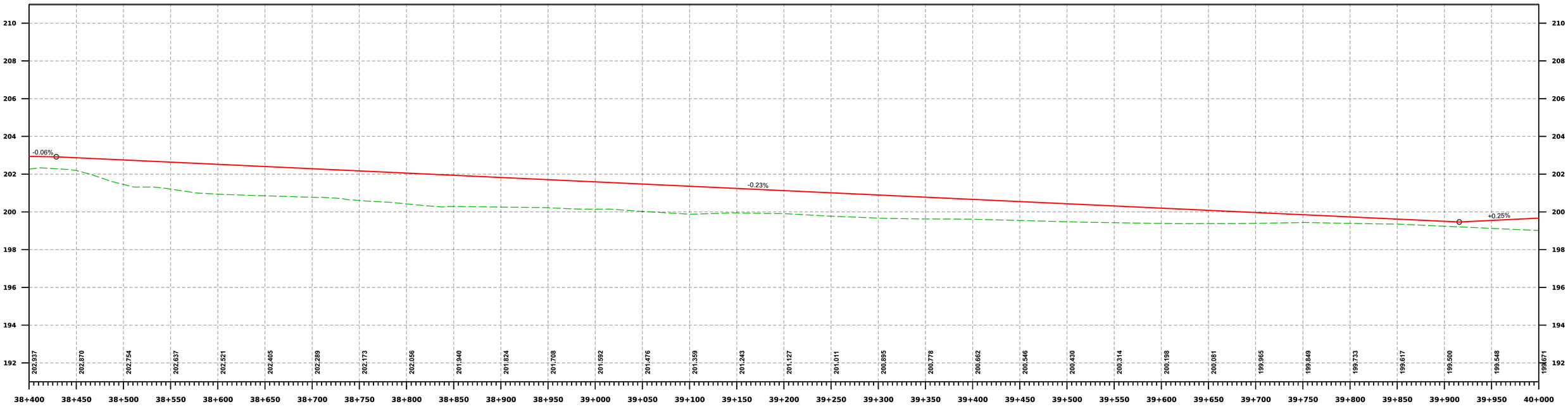
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP24
CONT. NO.
SHEET NO. A025

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

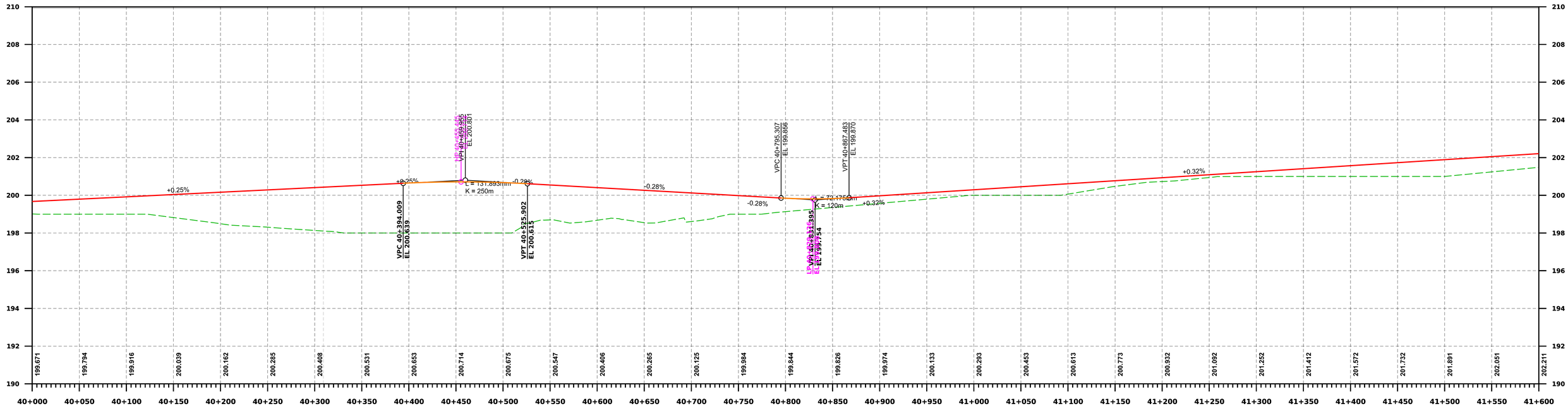
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP25
CONT. NO.
SHEET NO. A026

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

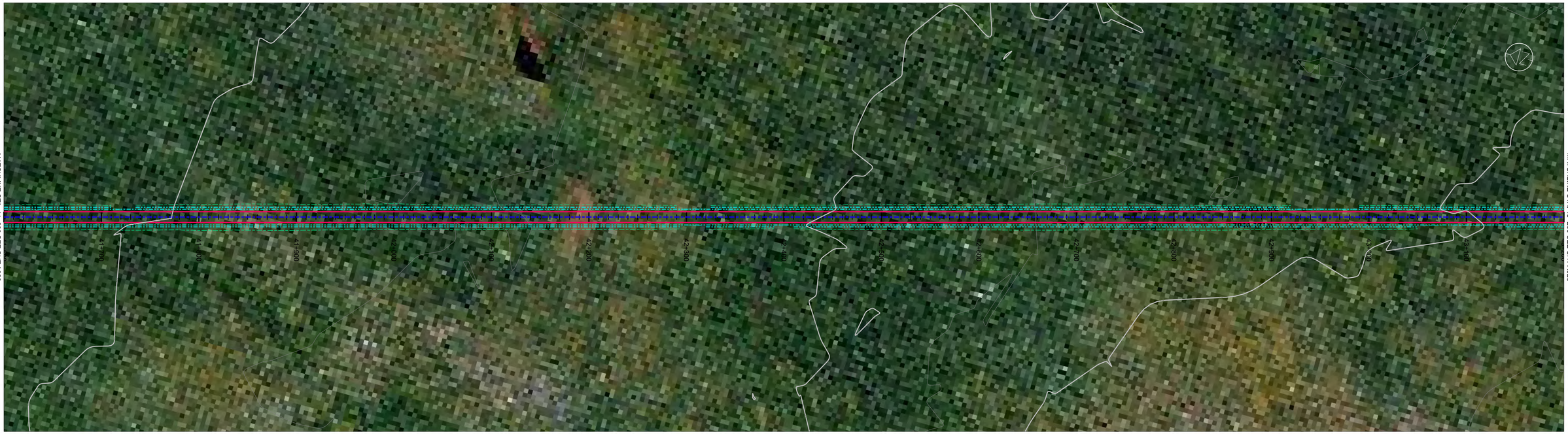
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP26
CONT. NO.
SHEET NO. A027

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

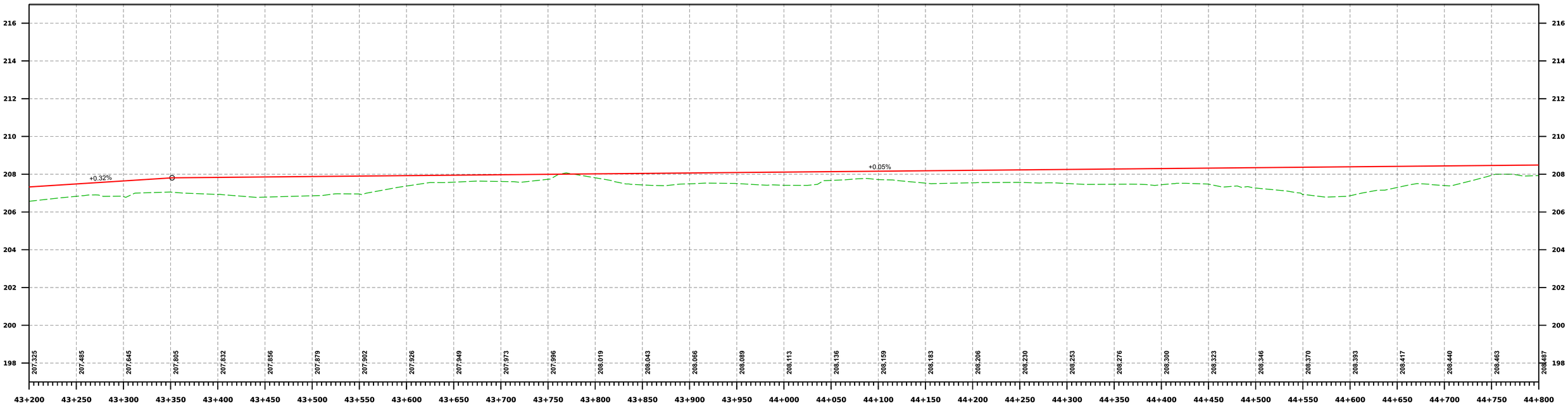
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP27
CONT. NO.
SHEET NO. A028

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

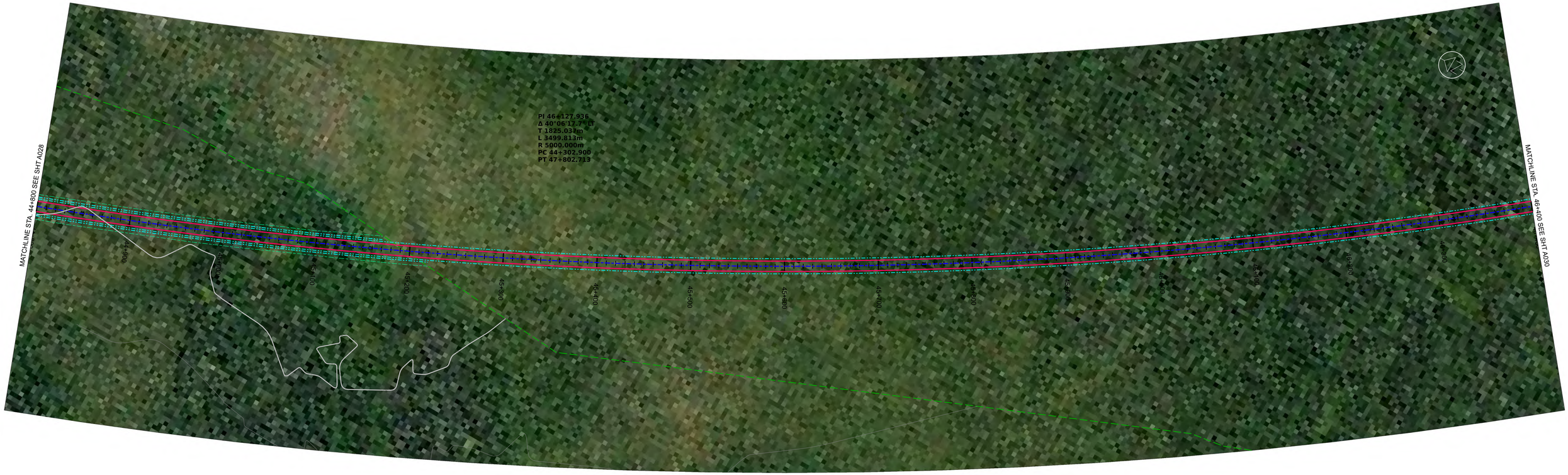
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

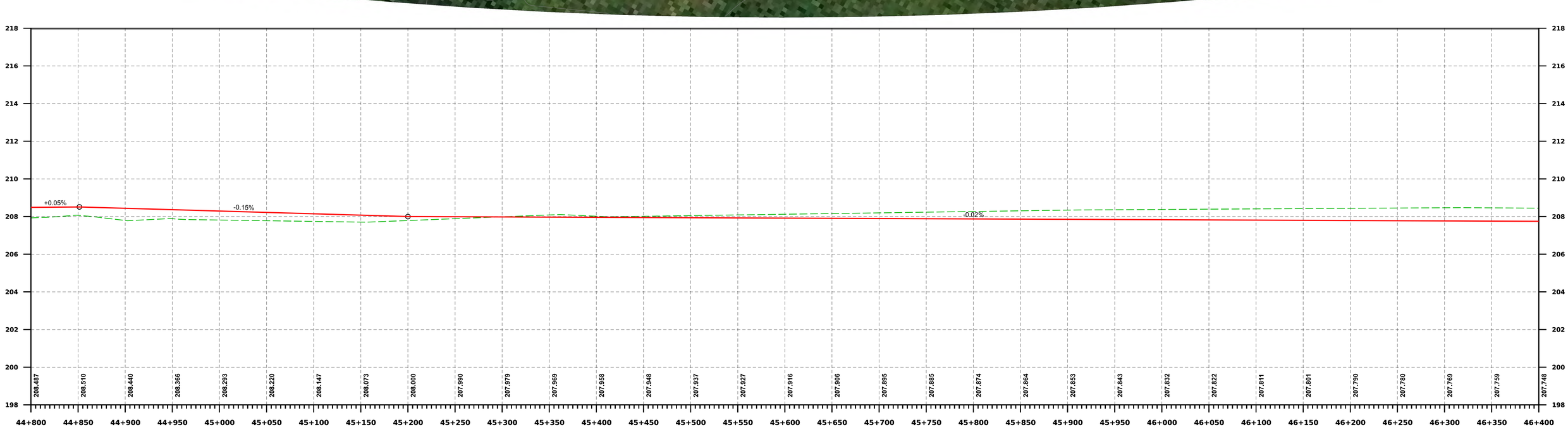
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP28
CONT. NO.
SHEET NO. A029

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

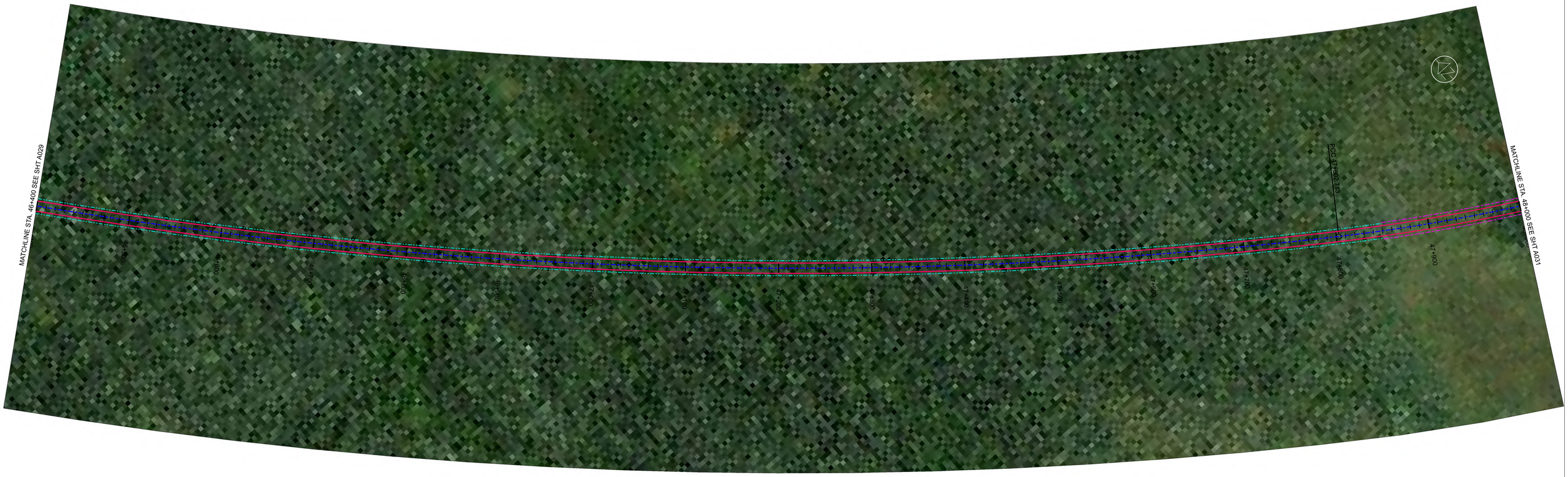
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

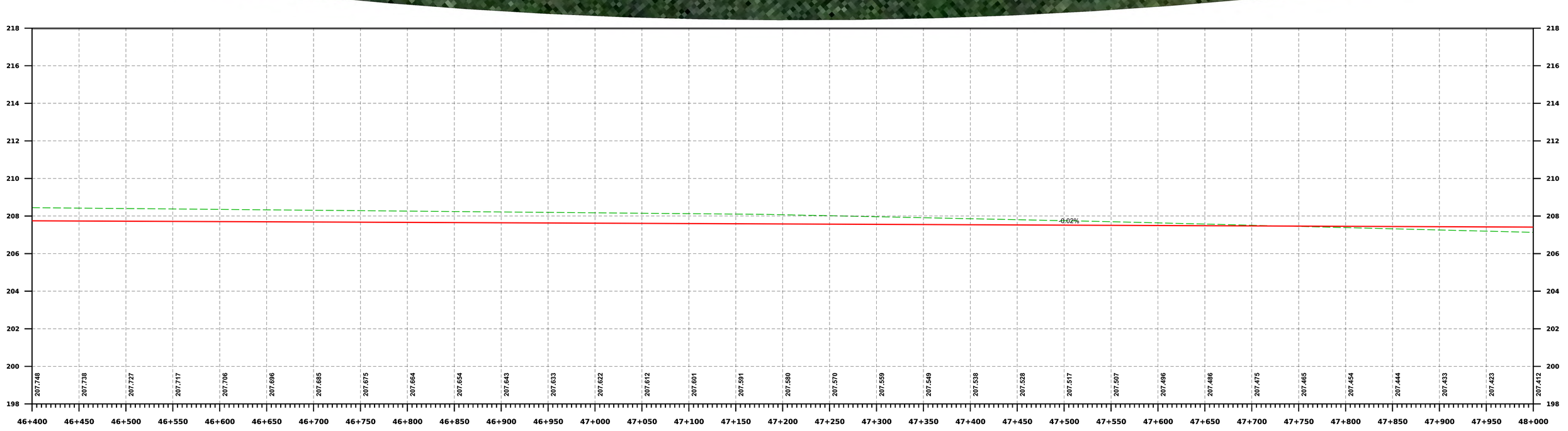
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP29
CONT. NO.
SHEET NO. A030

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

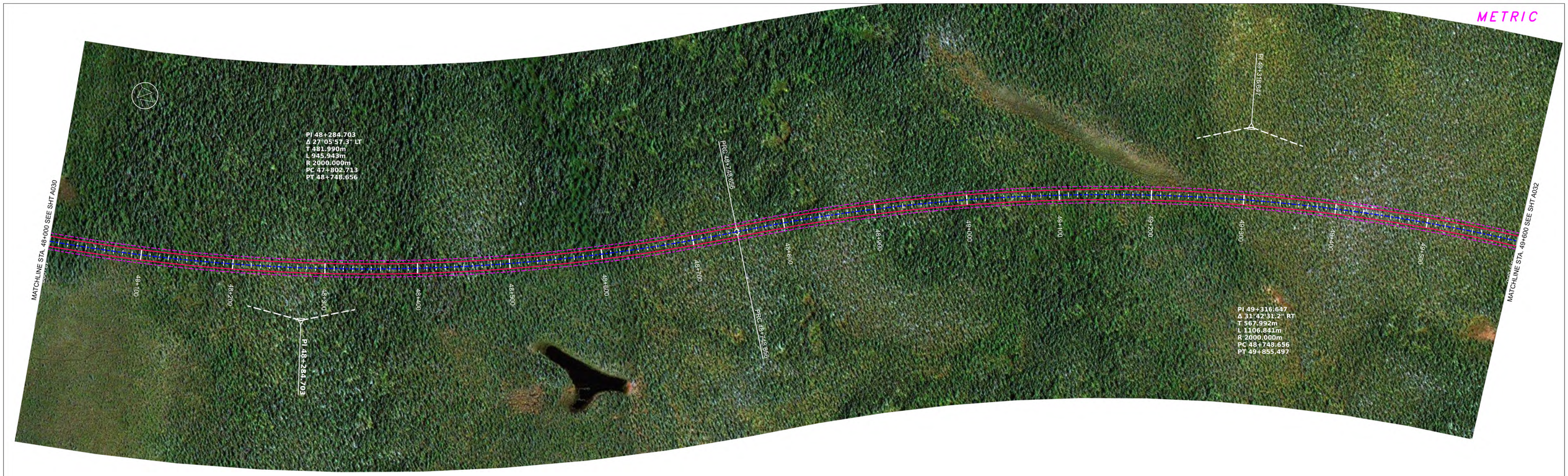
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

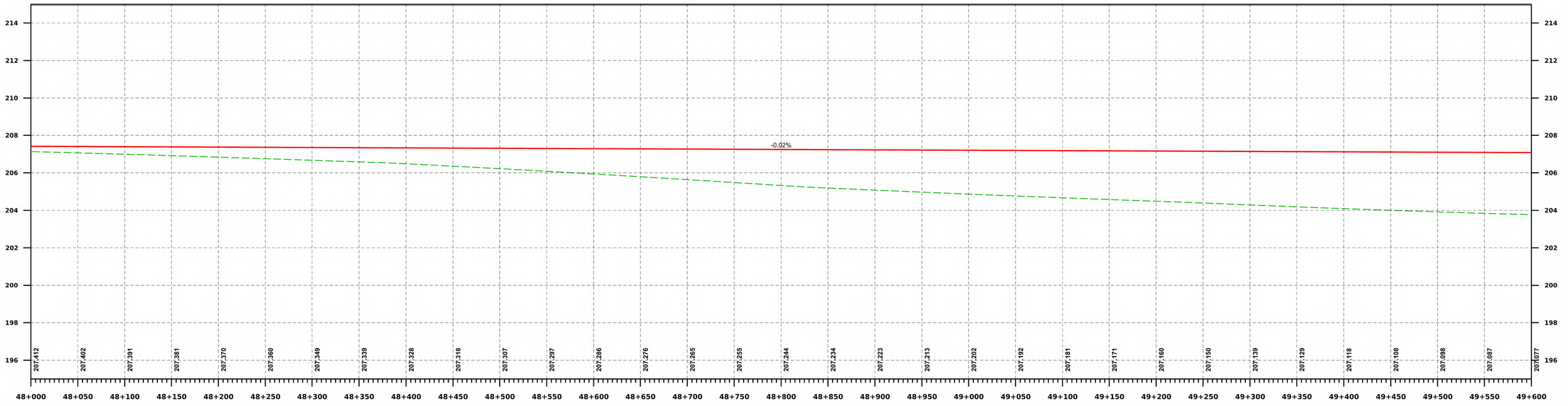
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP30
CONT. NO.
SHEET NO. A031

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

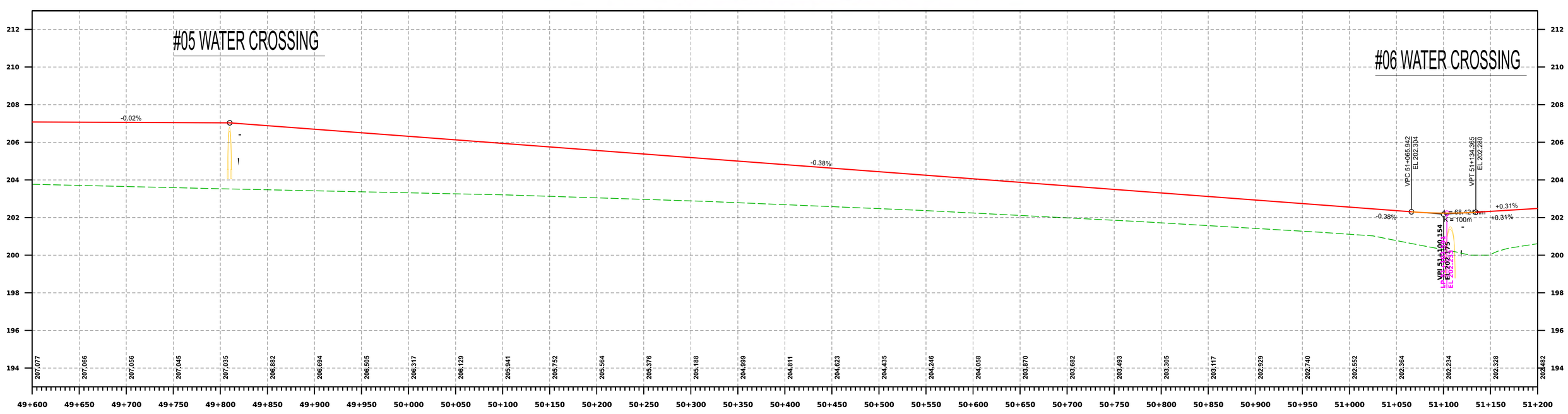
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP31
CONT. NO.
SHEET NO. A032

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

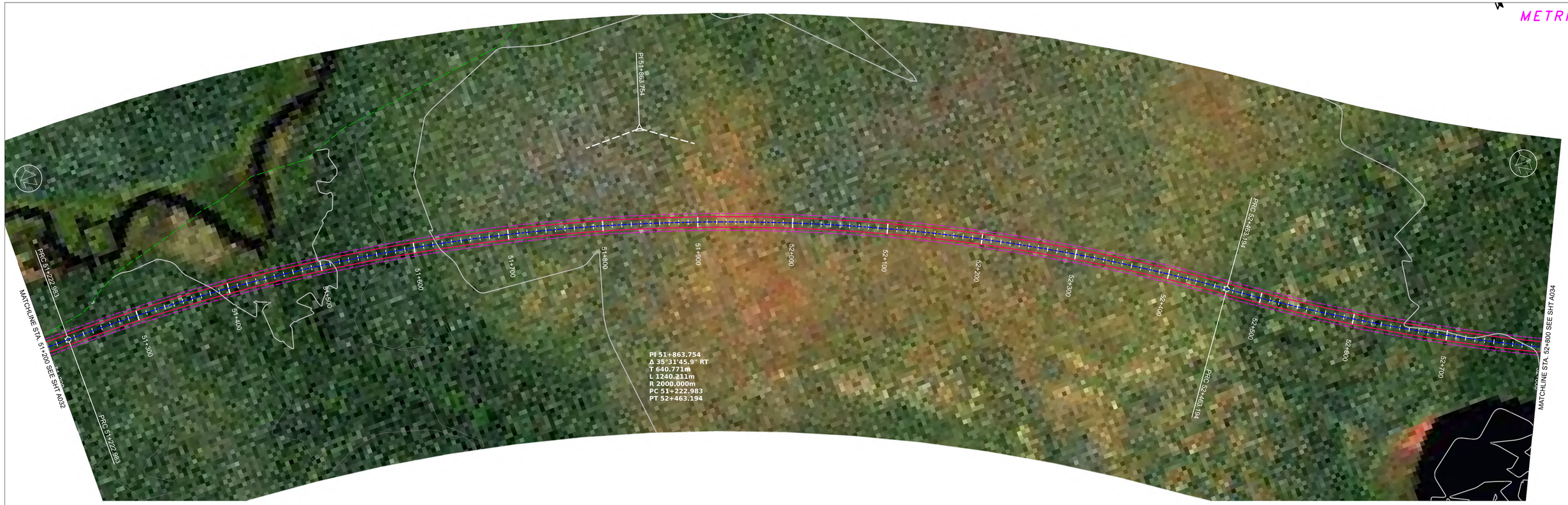
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

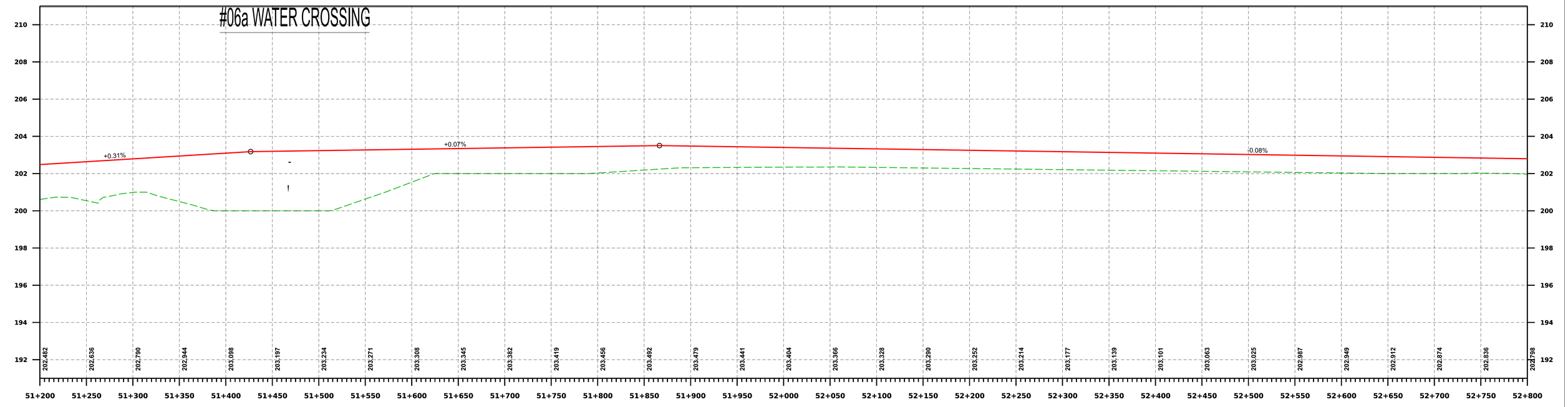
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP32
CONT. NO.
SHEET NO. A033

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

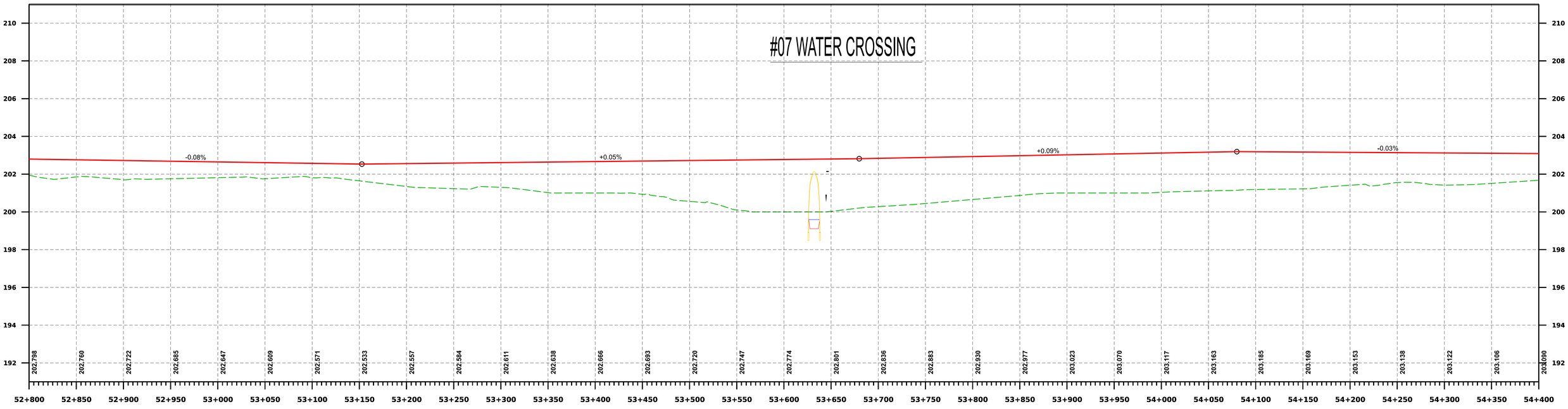
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP33
CONT. NO.
SHEET NO. A034

METRIC

#07 WATER CROSSING



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

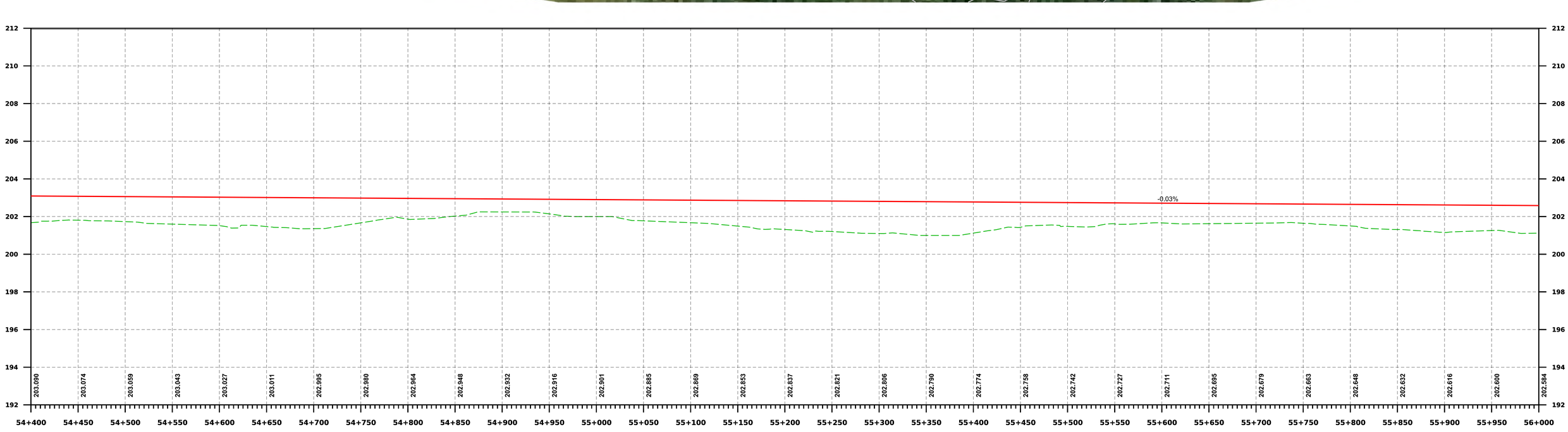
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP34
CONT. NO.
SHEET NO. A035

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

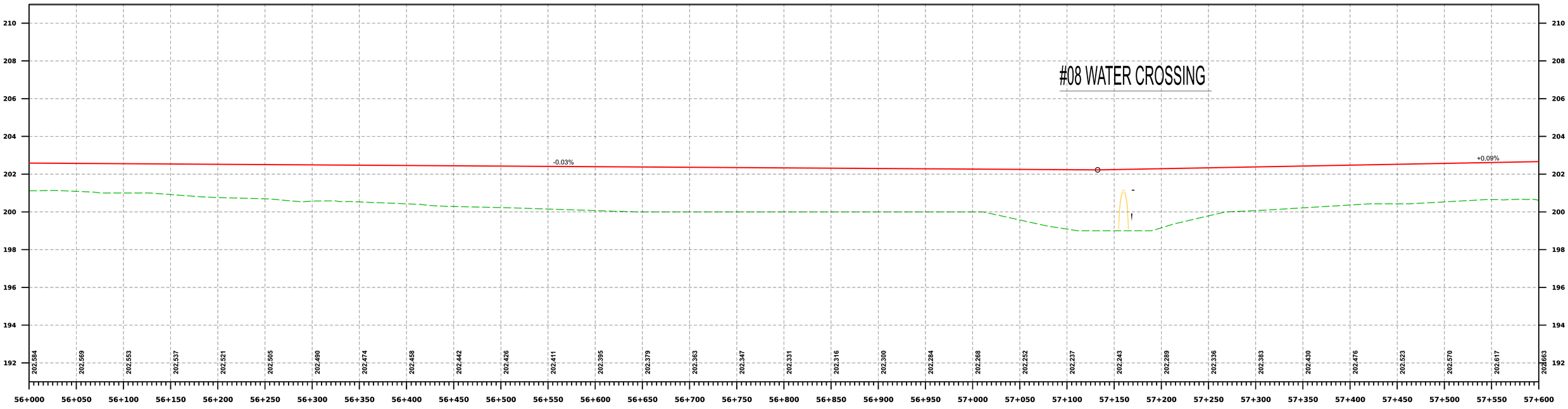
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP35
CONT. NO.
SHEET NO. A036

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

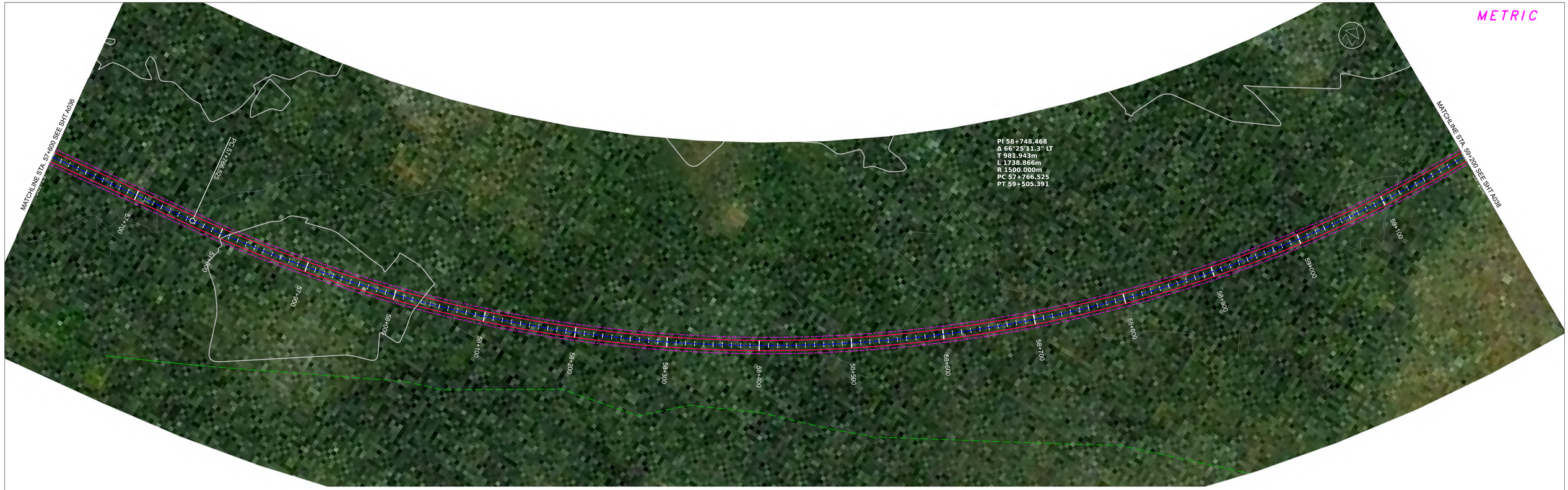
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

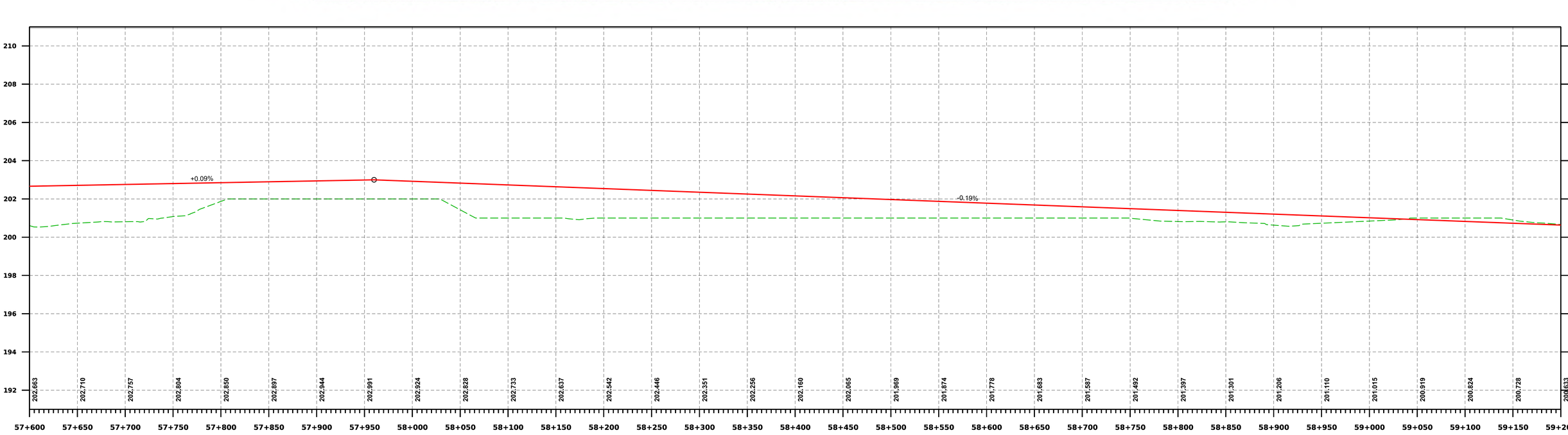
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP36
CONT. NO.
SHEET NO. A037

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

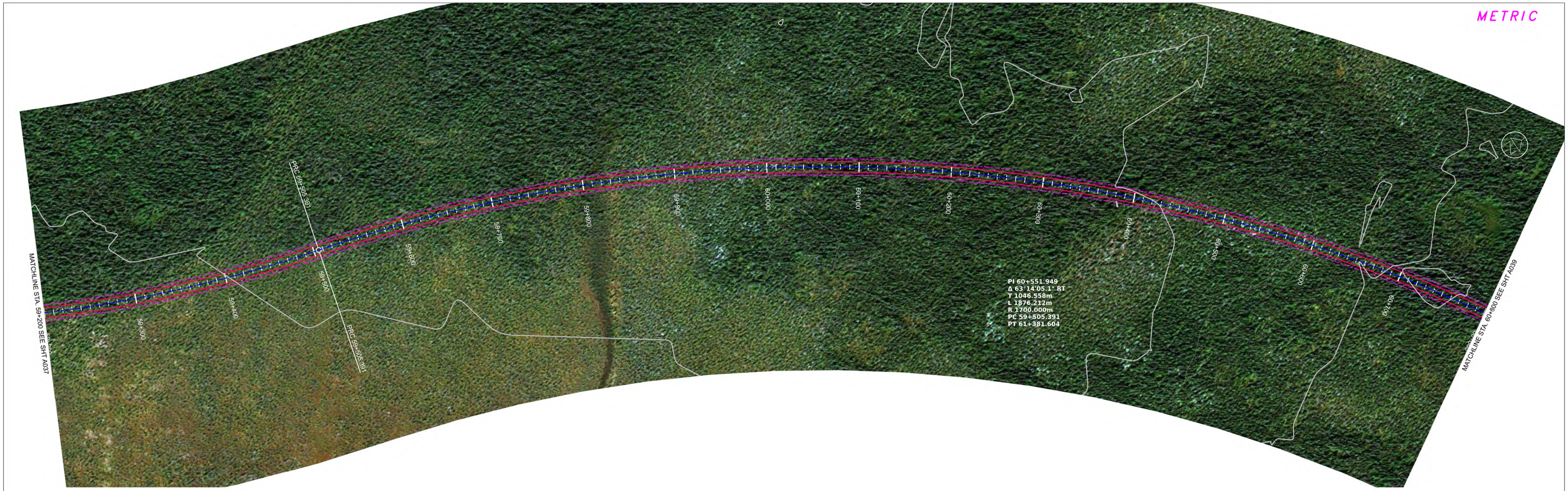
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

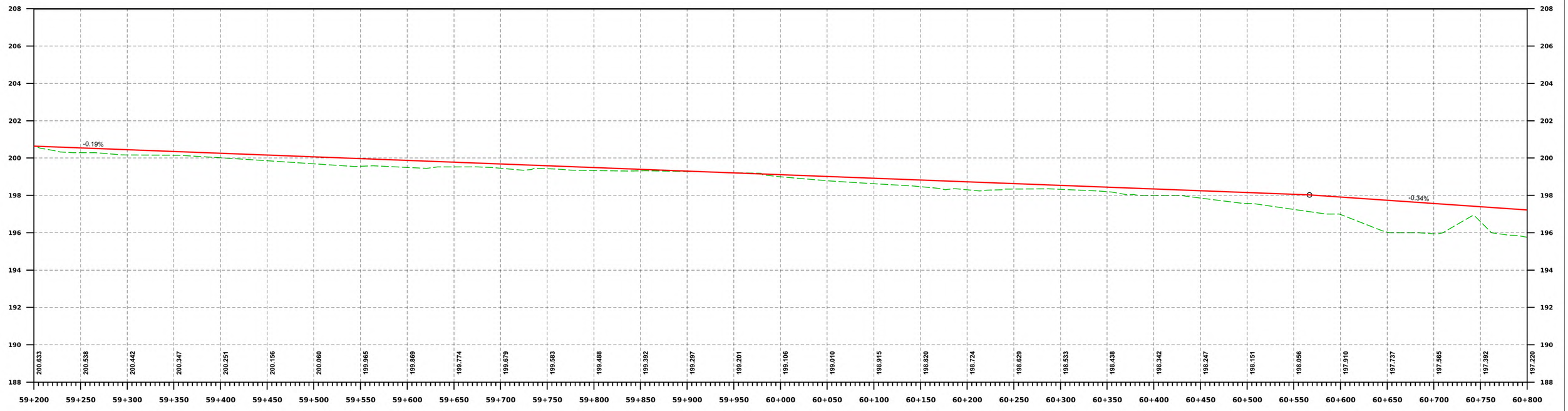
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP37
CONT. NO.
SHEET NO. A038

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

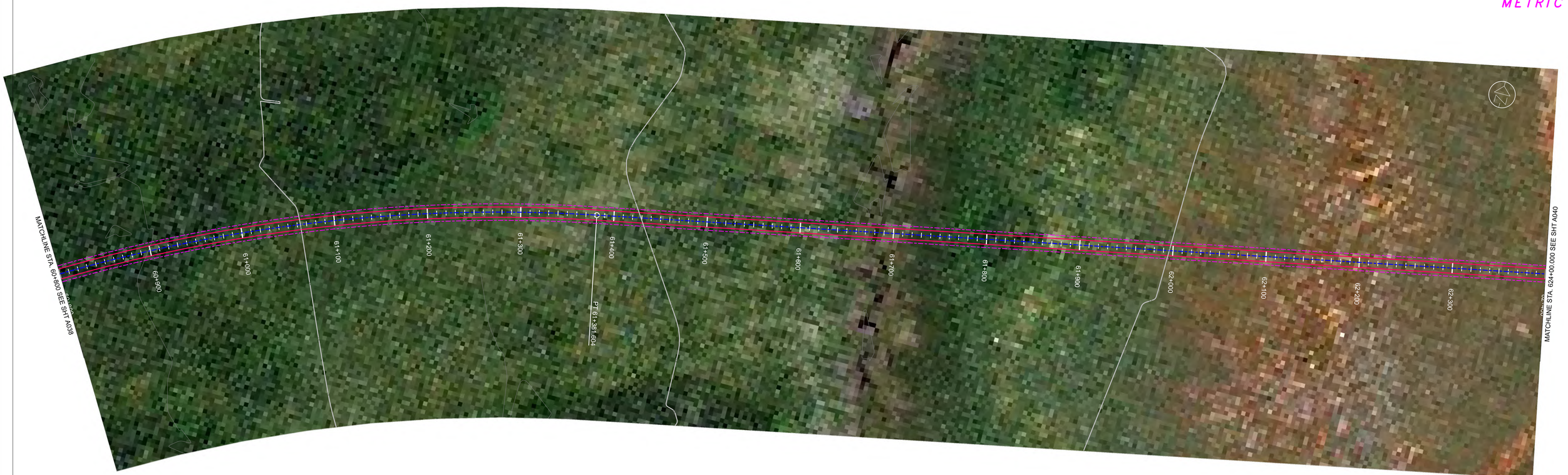
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP38
CONT. NO.
SHEET NO. A039

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

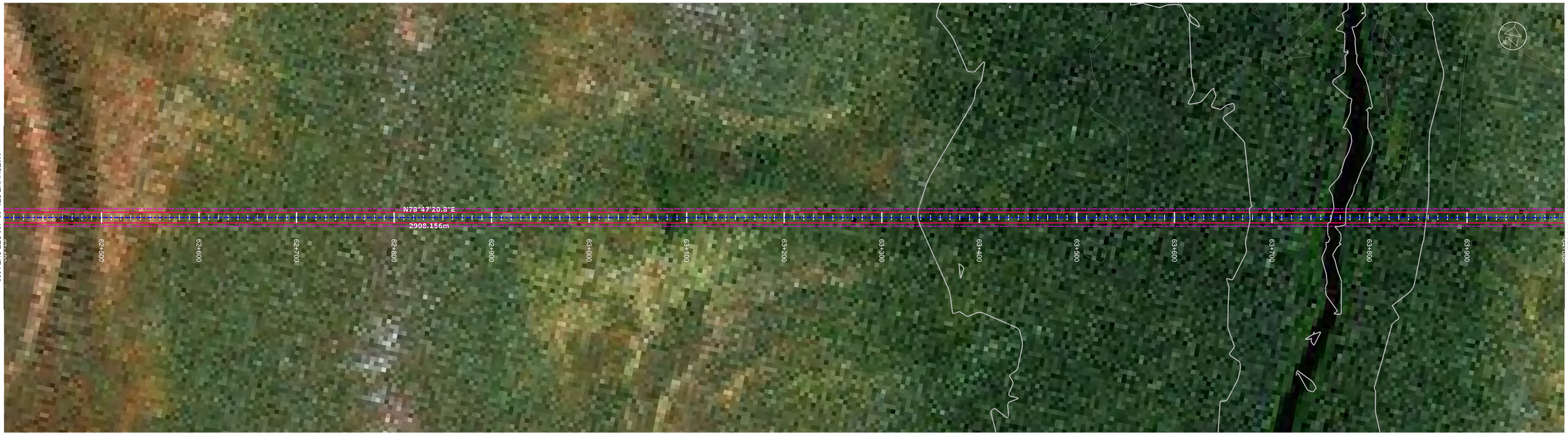
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

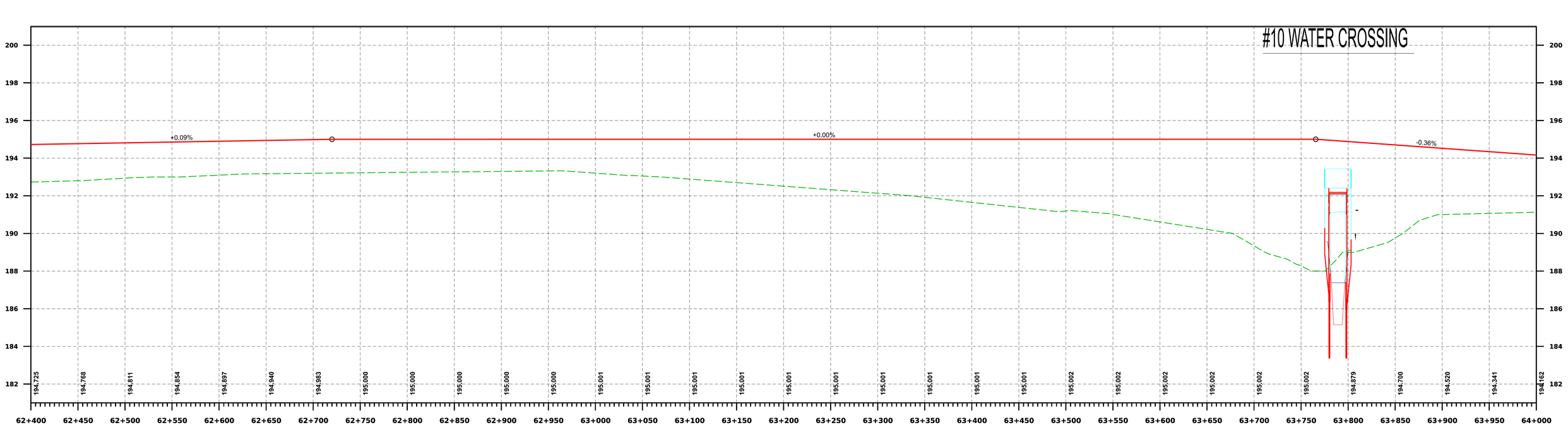
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP39
CONT. NO.
SHEET NO. A040

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

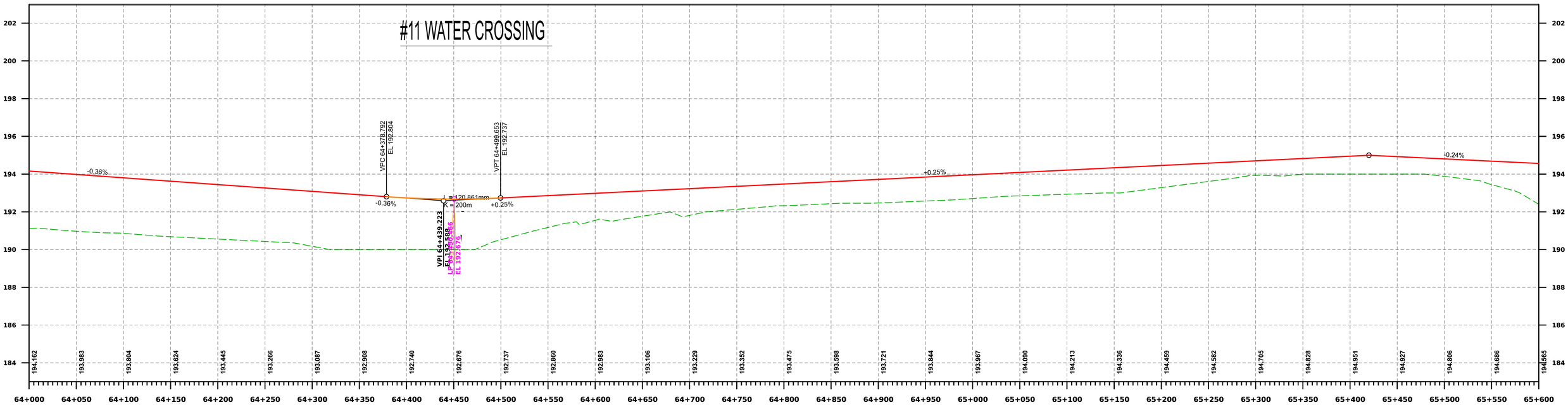
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP40
CONT. NO.
SHEET NO. A041

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

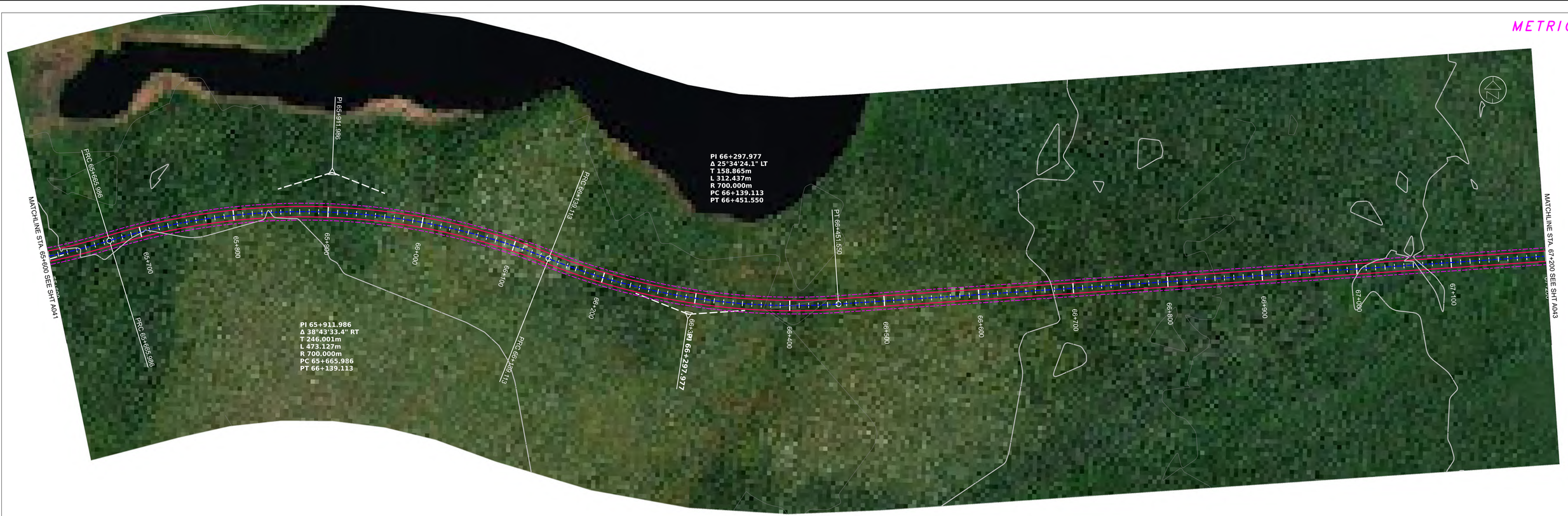
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

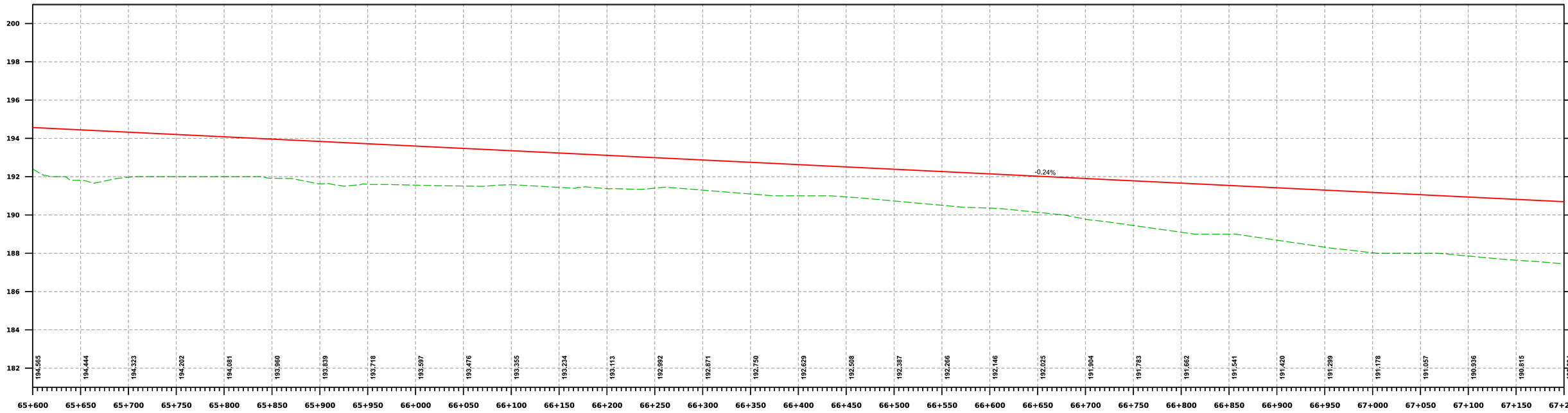
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP41
CONT. NO.
SHEET NO. A042

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

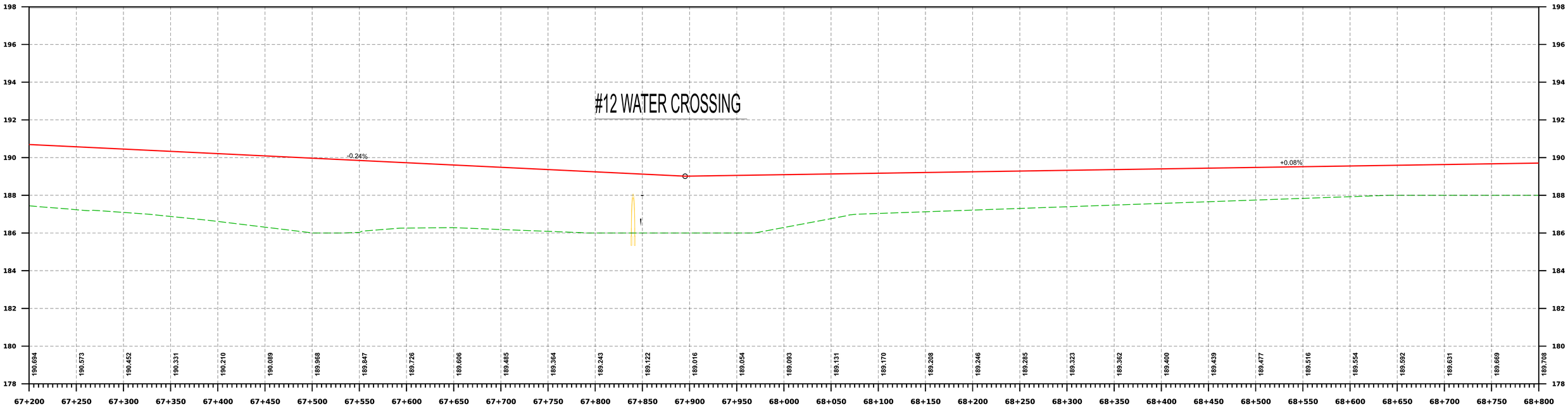
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP42
CONT. NO.
SHEET NO. A043

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

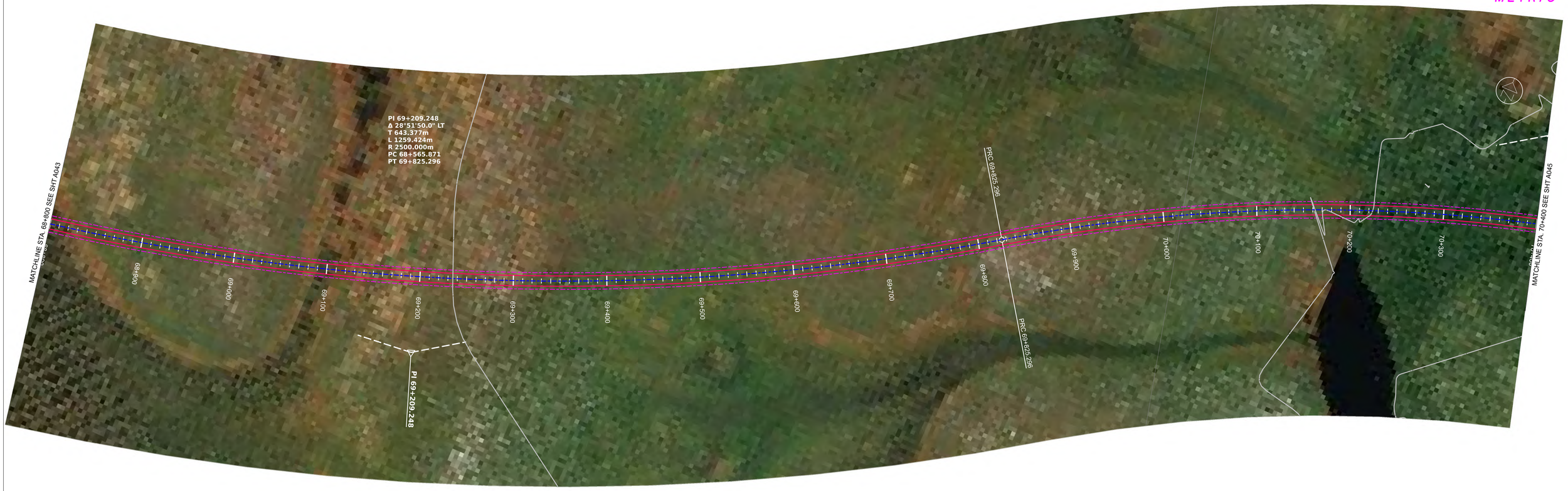
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

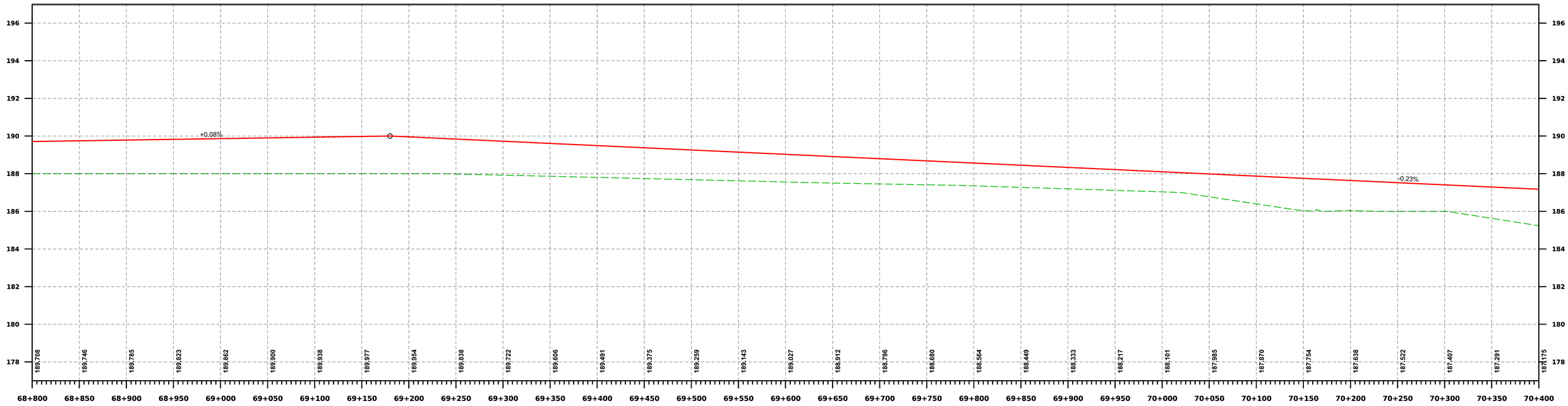
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP43
CONT. NO.
SHEET NO. A044

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

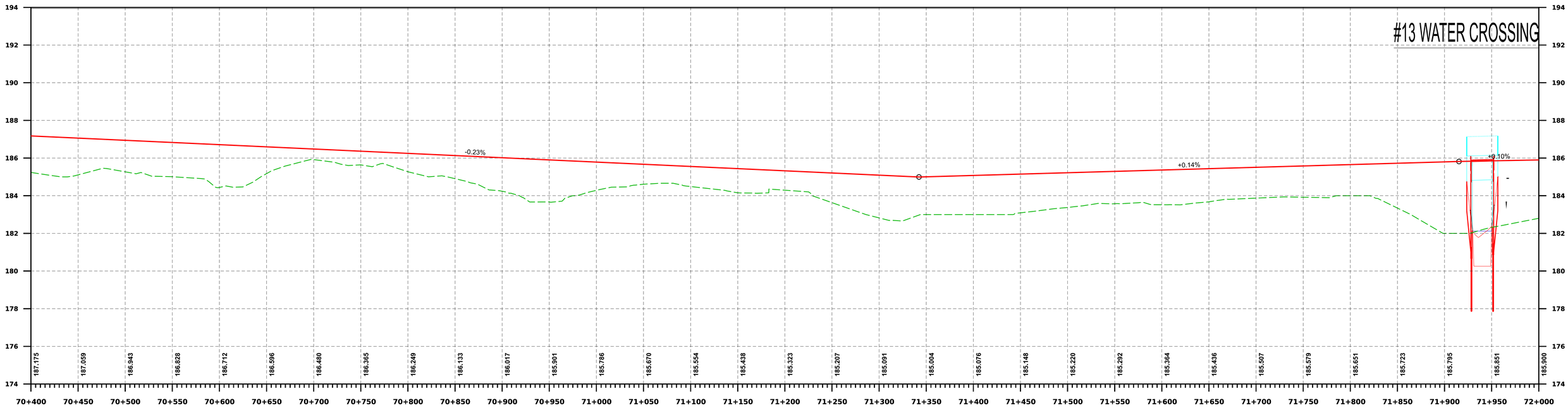
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP44
CONT. NO.
SHEET NO. A045

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

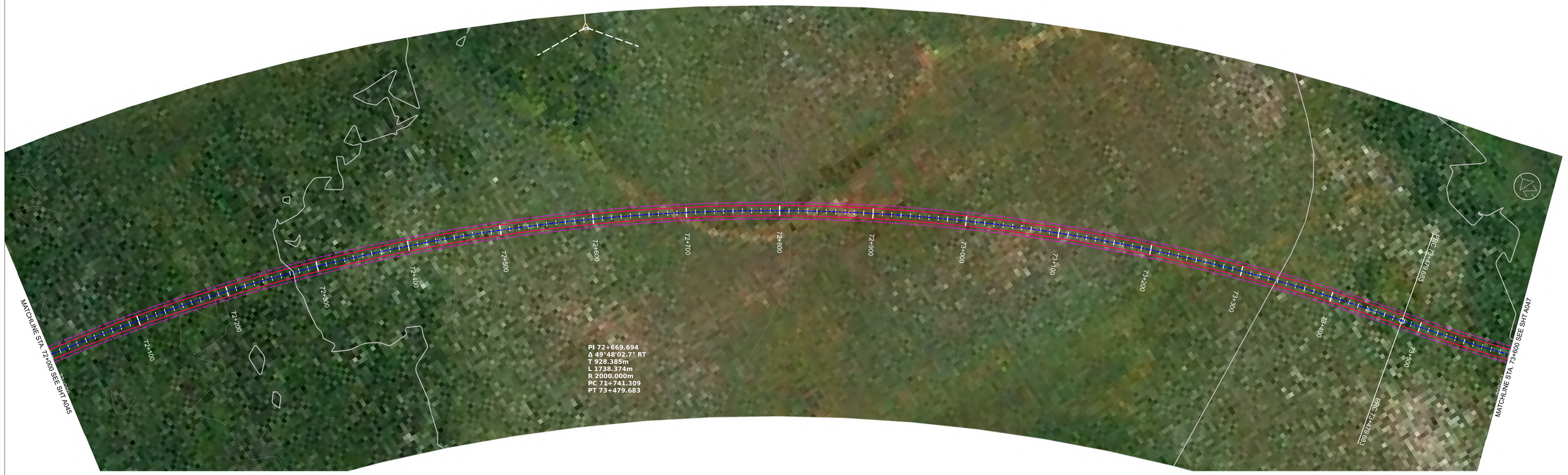
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

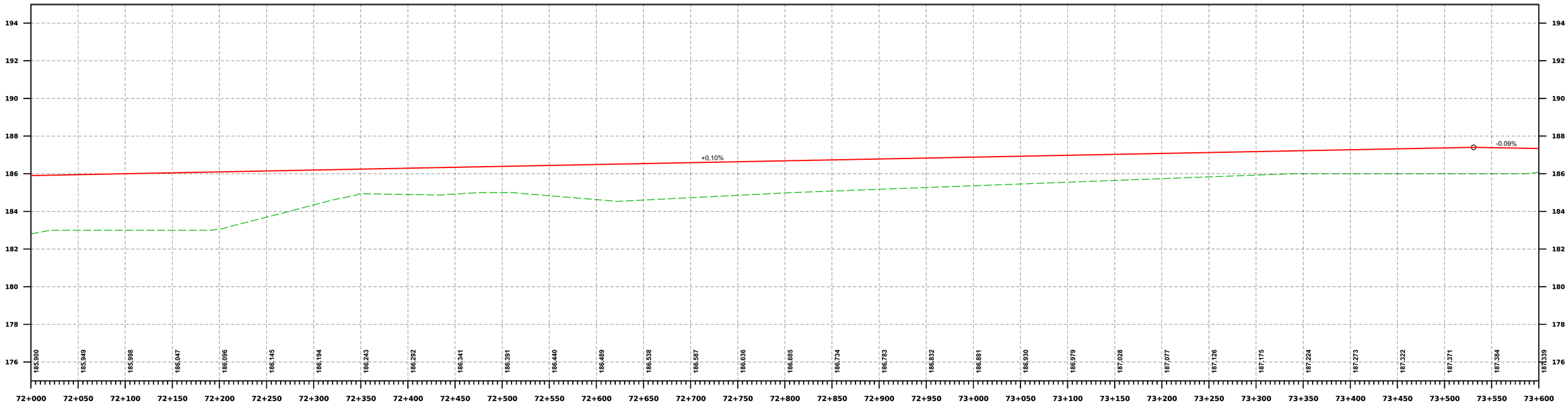
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP45
CONT. NO.
SHEET NO. A046

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

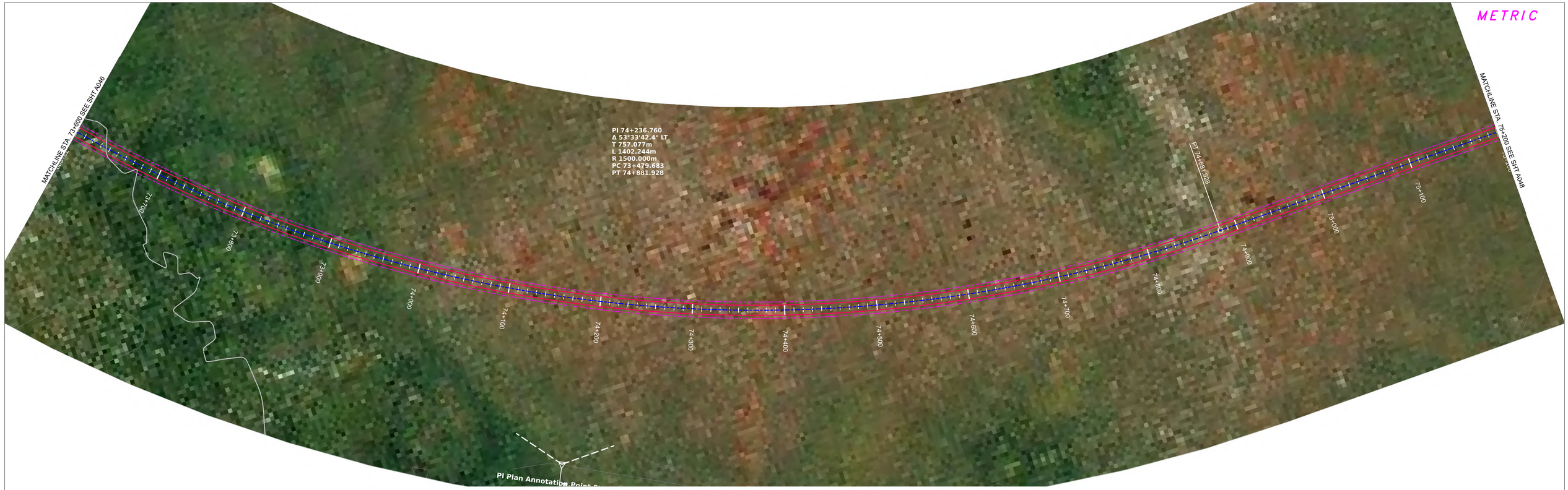
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP46
CONT. NO.
SHEET NO. A047

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

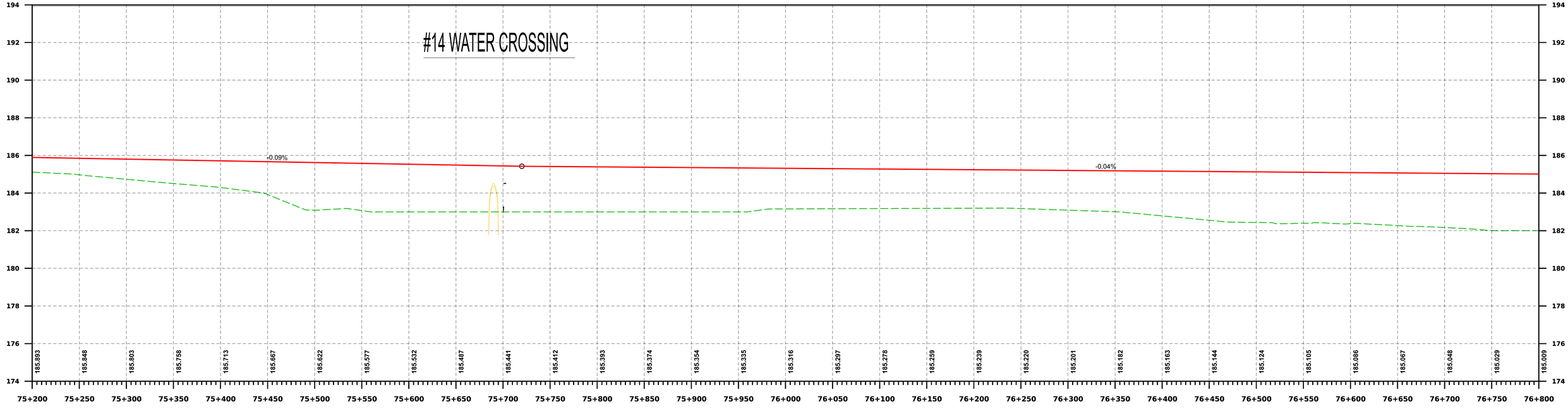
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP47
CONT. NO.
SHEET NO. A048

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

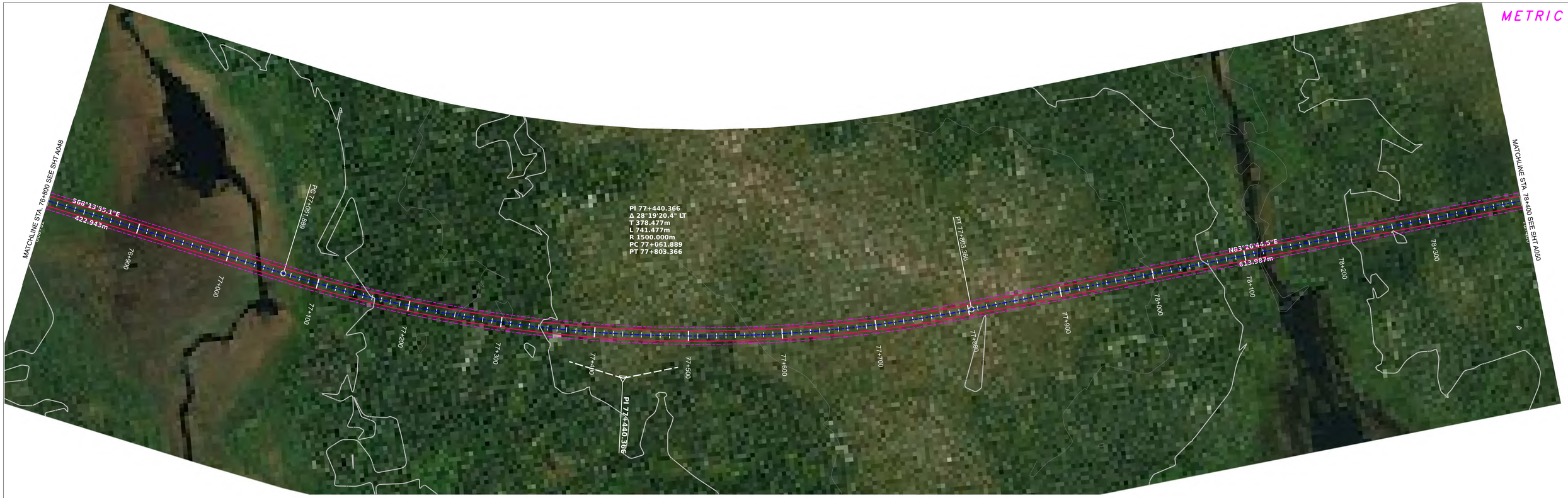
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP48
CONT. NO.
SHEET NO. A049

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

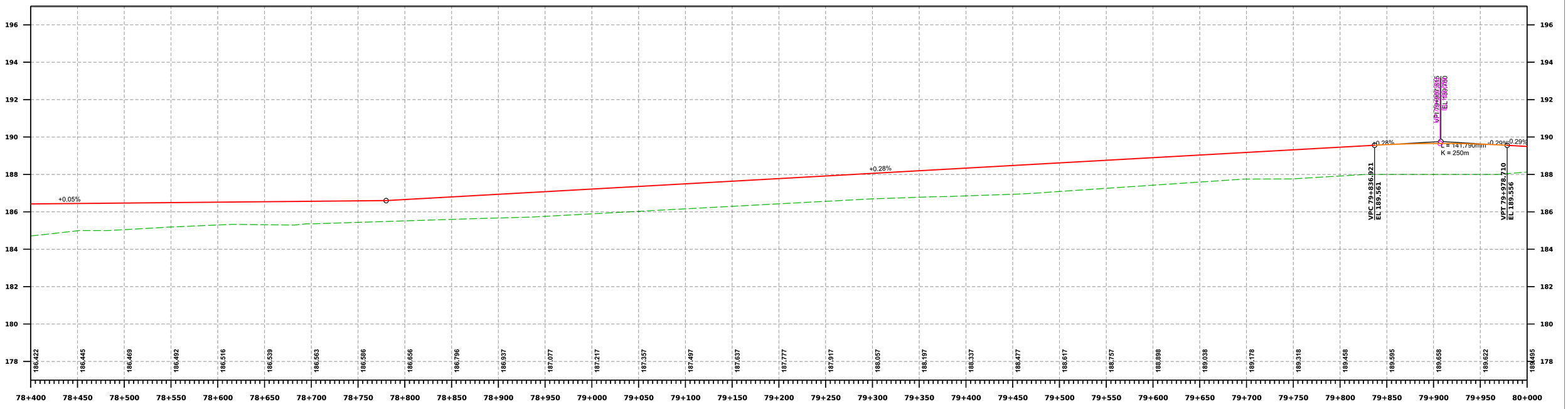
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP49
CONT. NO.
SHEET NO. A050

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

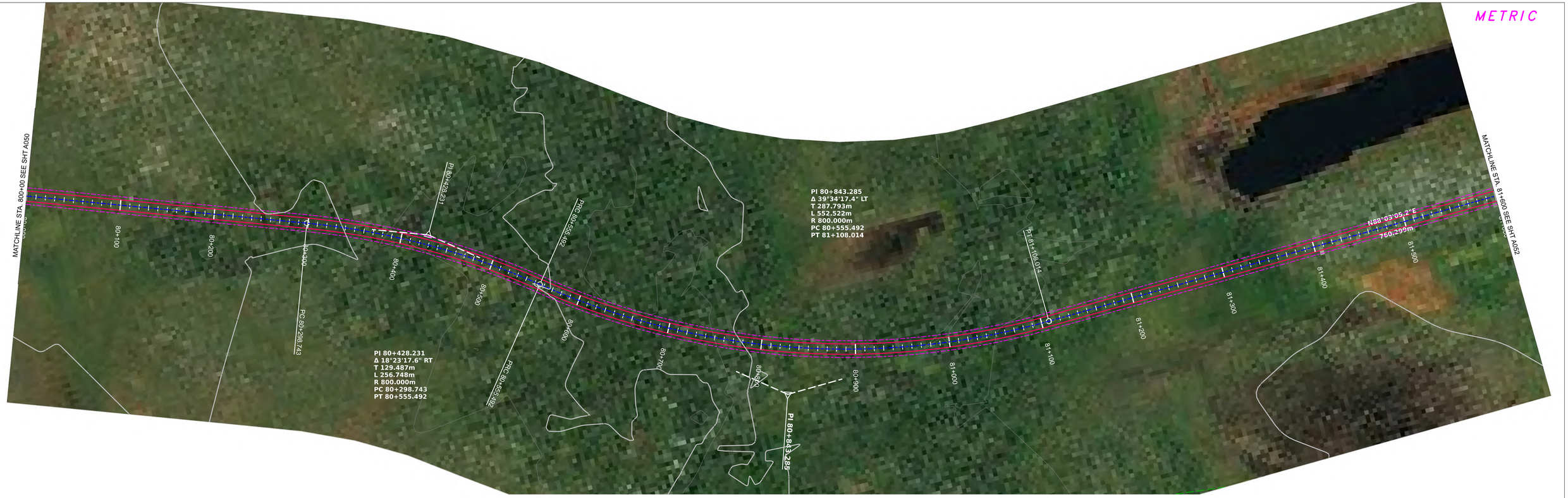
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

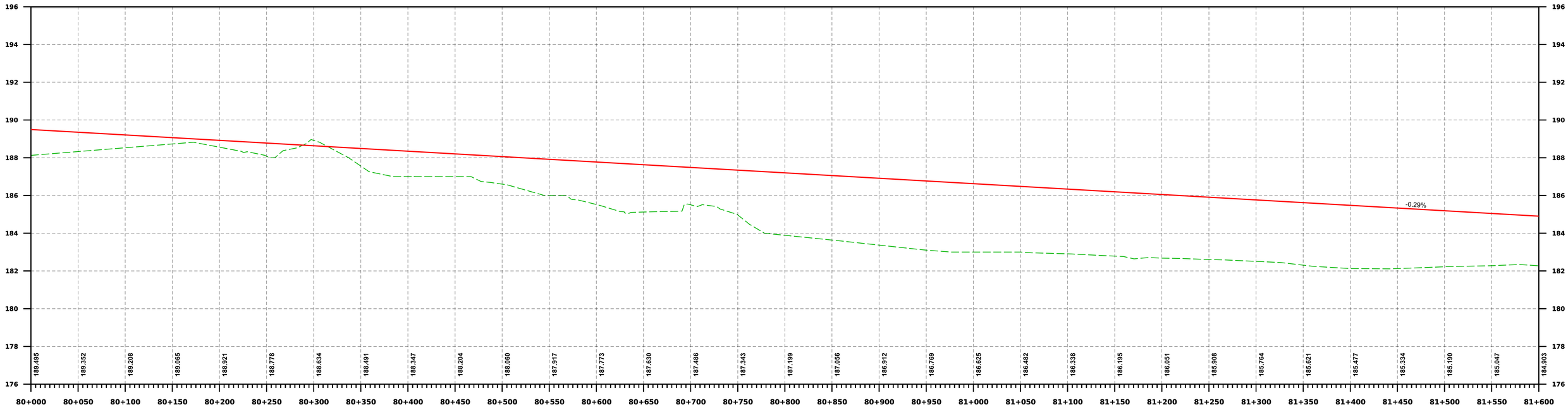
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP50
CONT. NO.
SHEET NO. A051

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

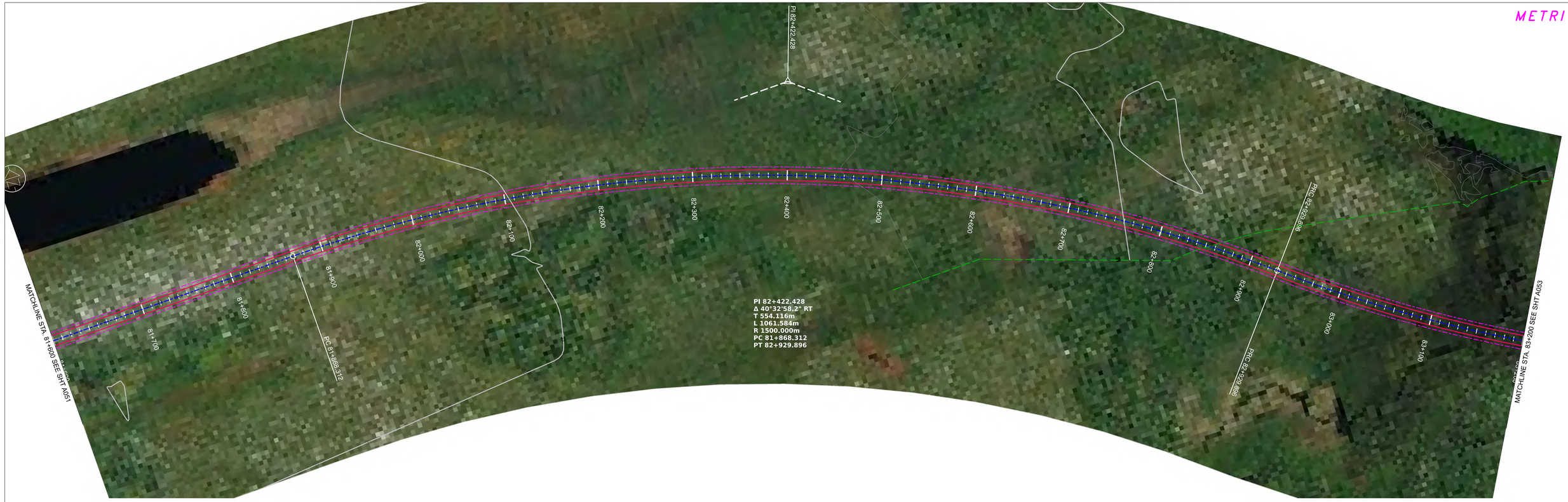
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

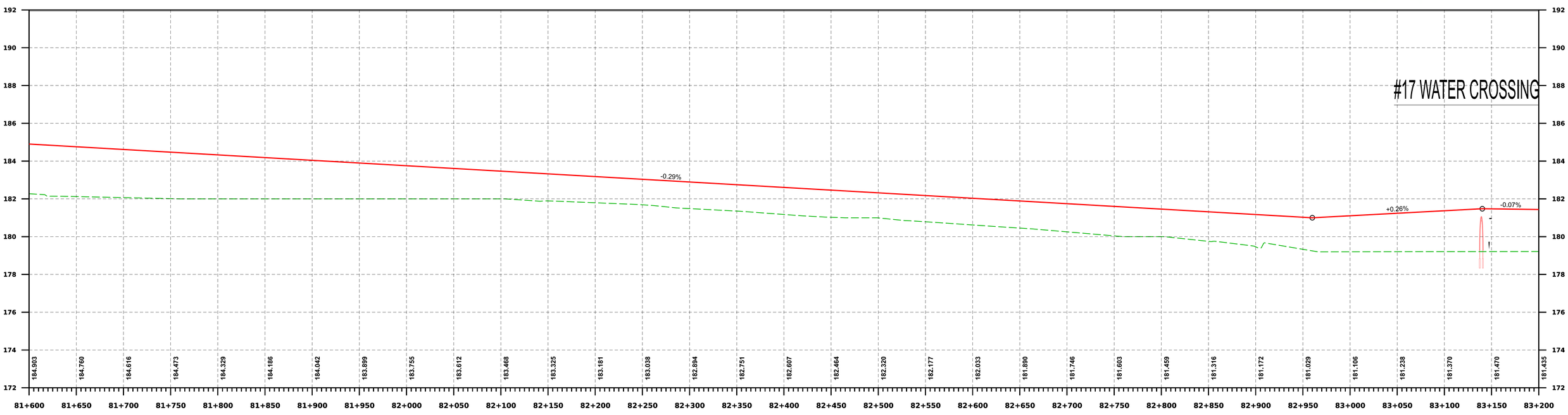
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP51
CONT. NO.
SHEET NO. A052

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

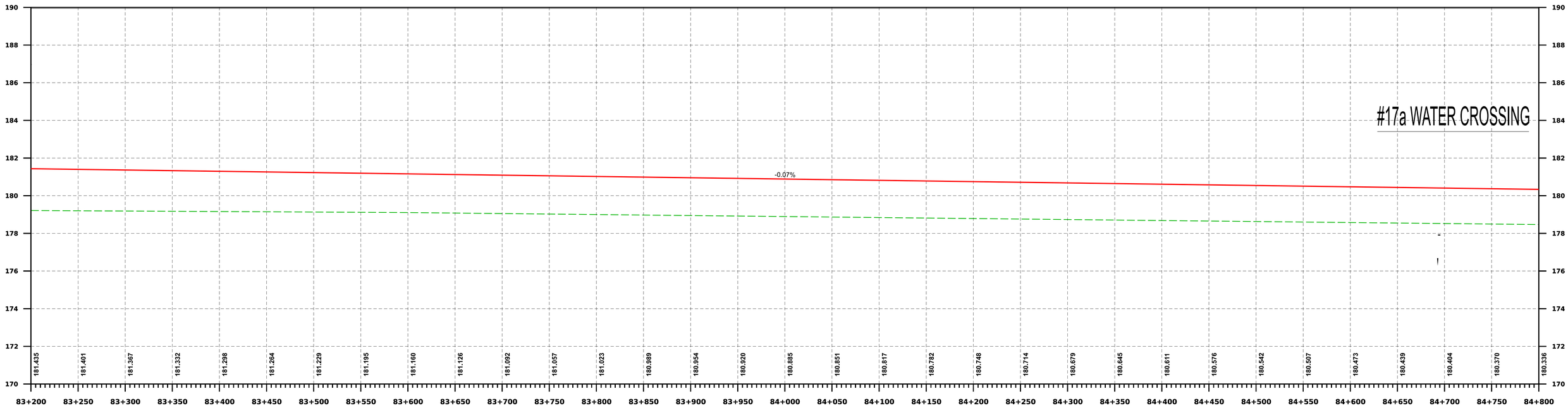
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP52
CONT. NO.
SHEET NO. A053

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

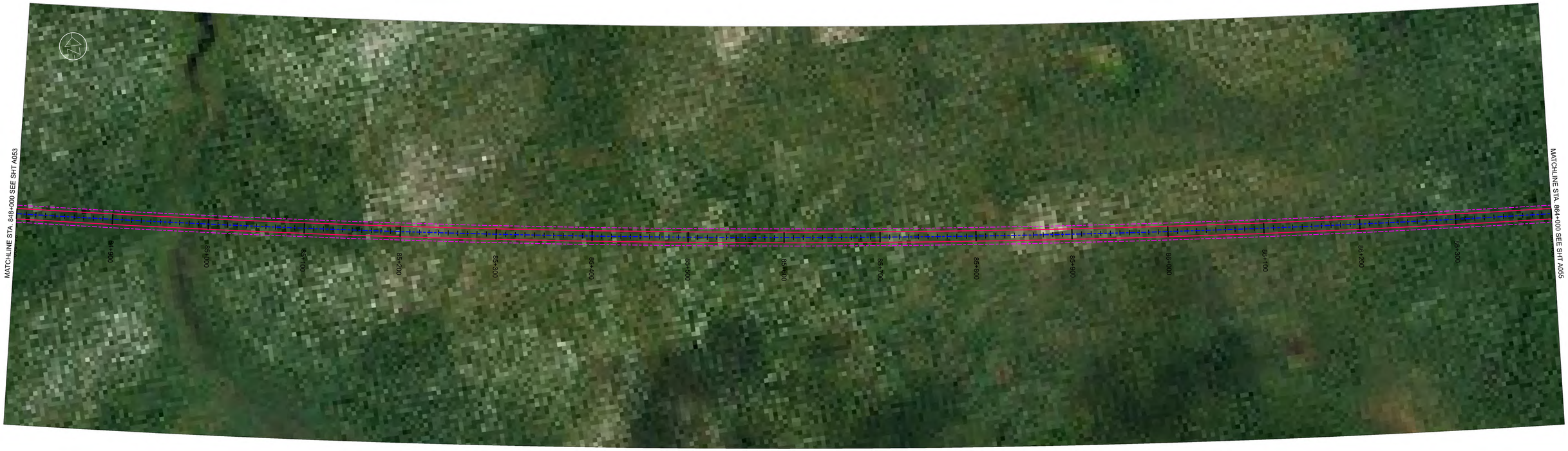
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

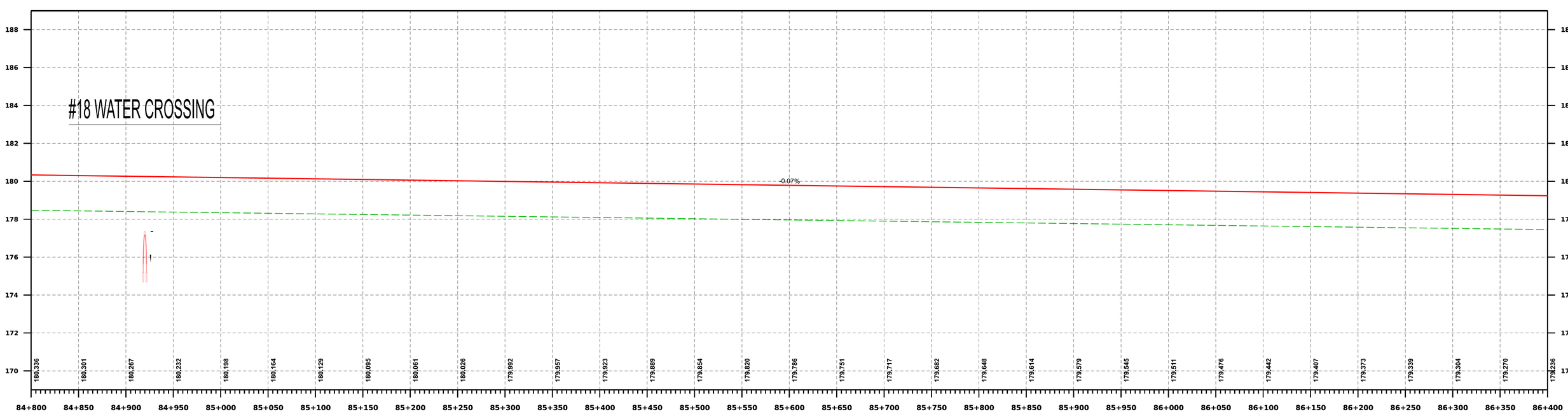
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP53
CONT. NO.
SHEET NO. A054

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

GeomBL
84+800.00 - 86+400.00

AtkinsRéalis

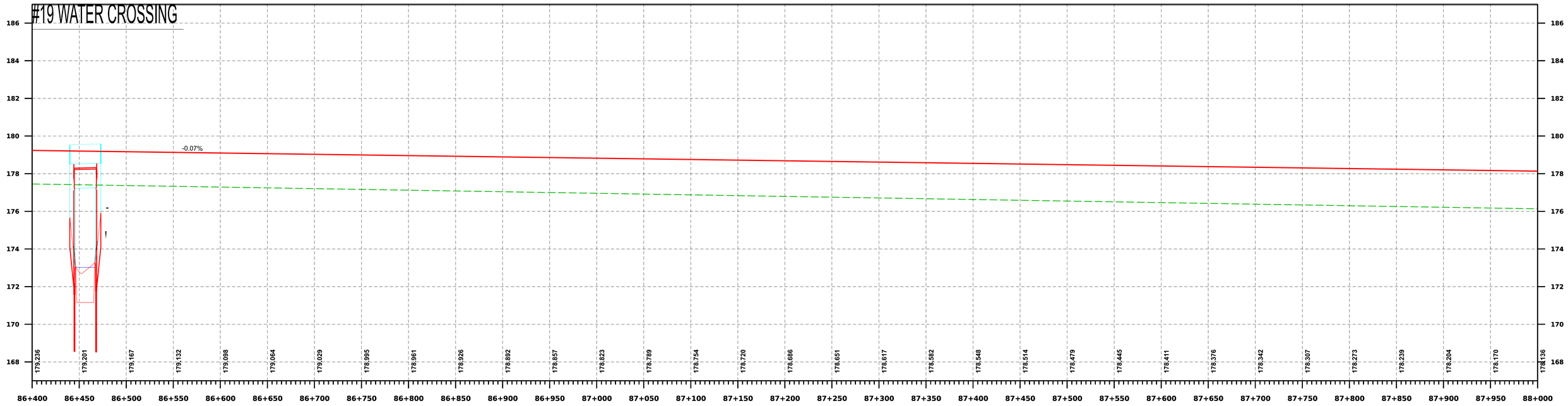
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP54
CONT. NO.
SHEET NO. A055

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

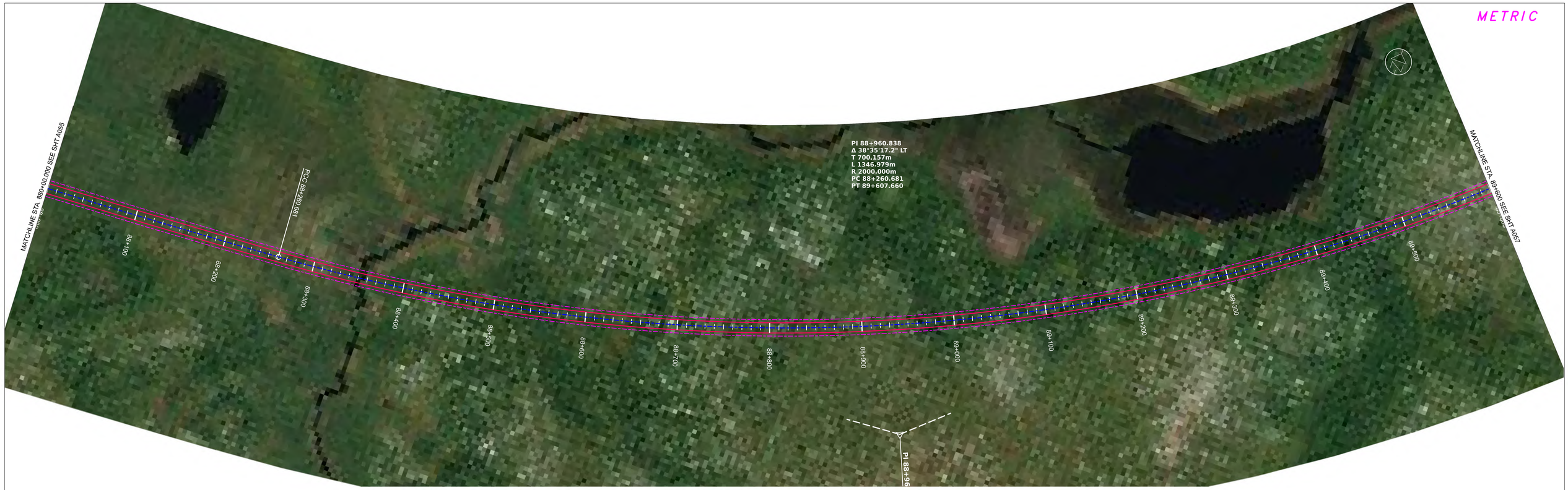
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

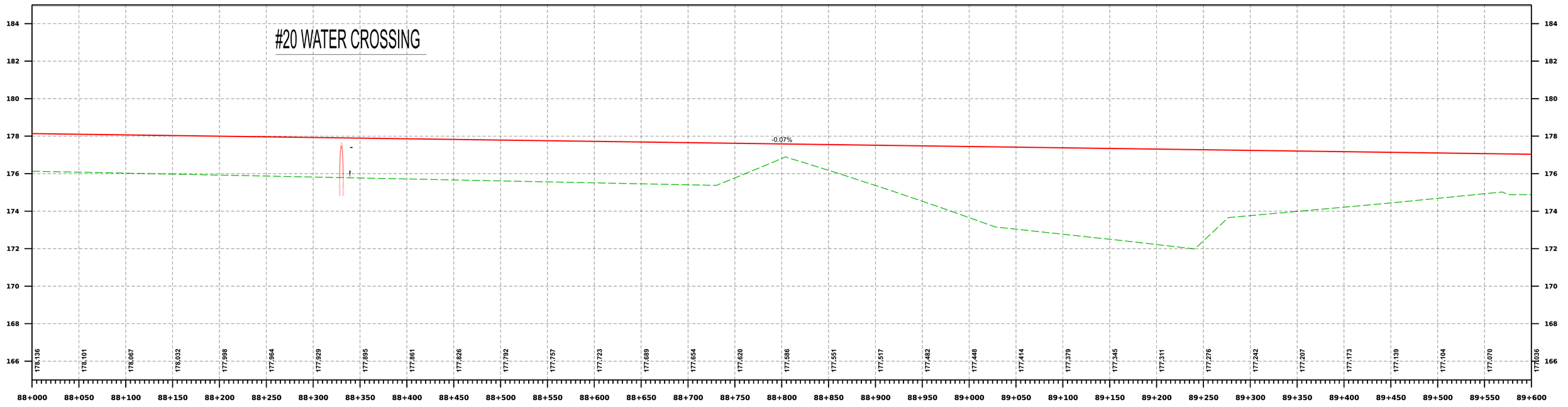
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP55
CONT. NO.
SHEET NO. A056

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

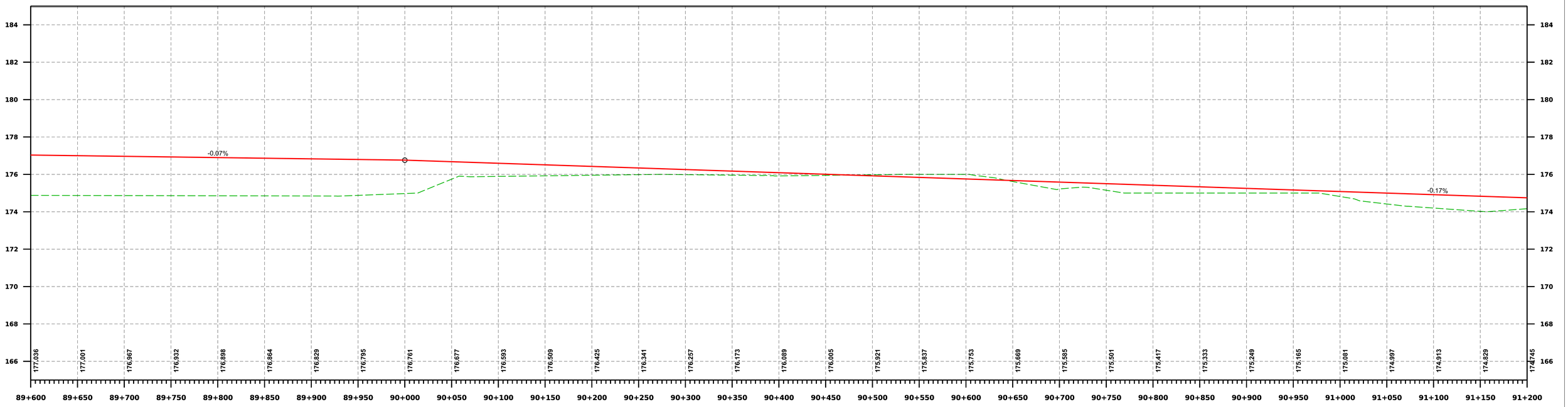
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP56
CONT. NO.
SHEET NO. A057

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

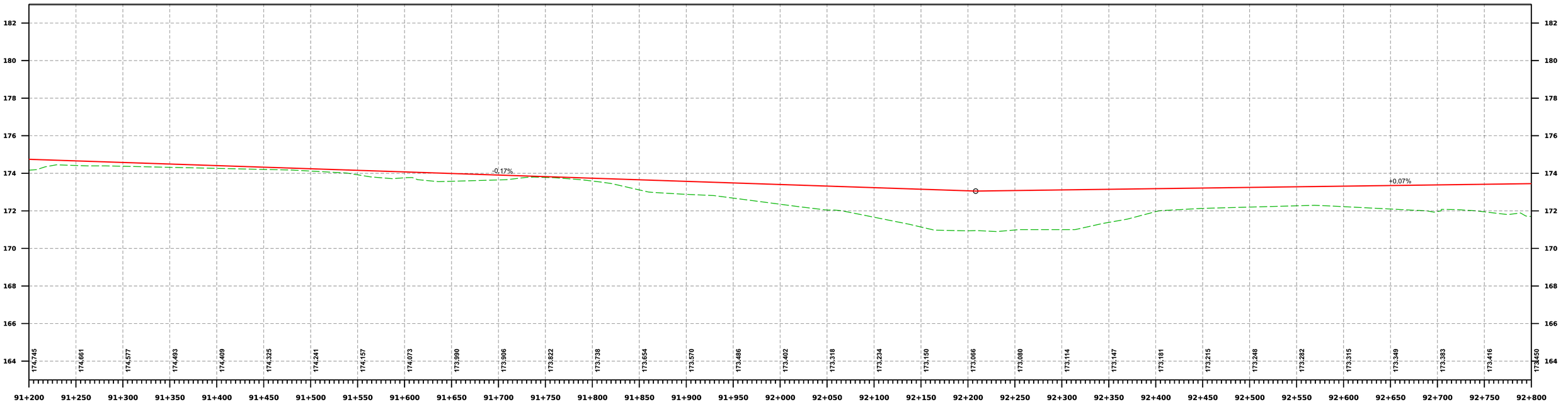
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP57
CONT. NO.
SHEET NO. A058

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

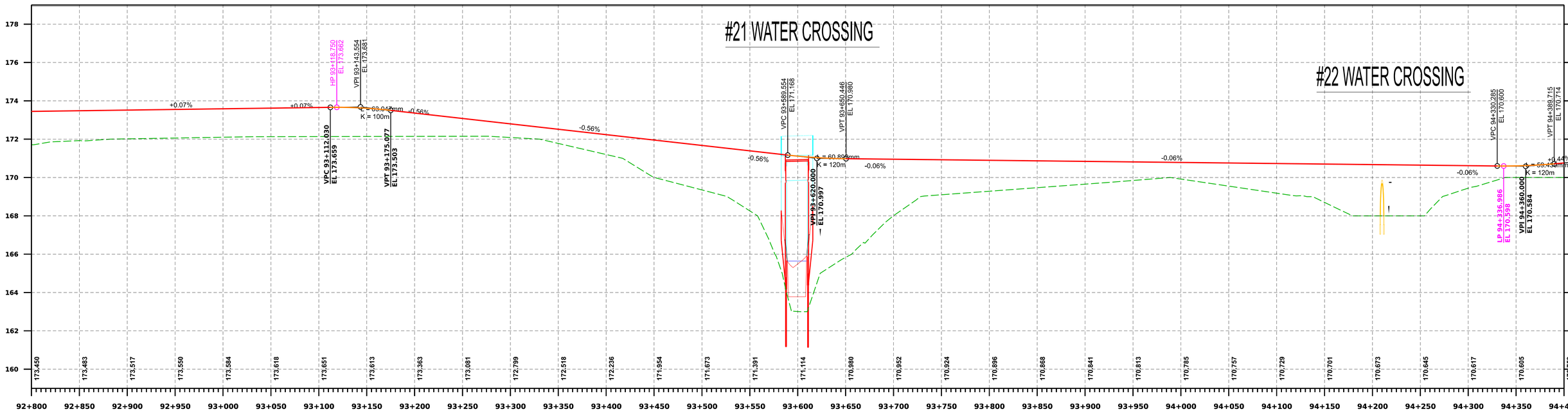
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP58
CONT. NO.
SHEET NO. A059

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

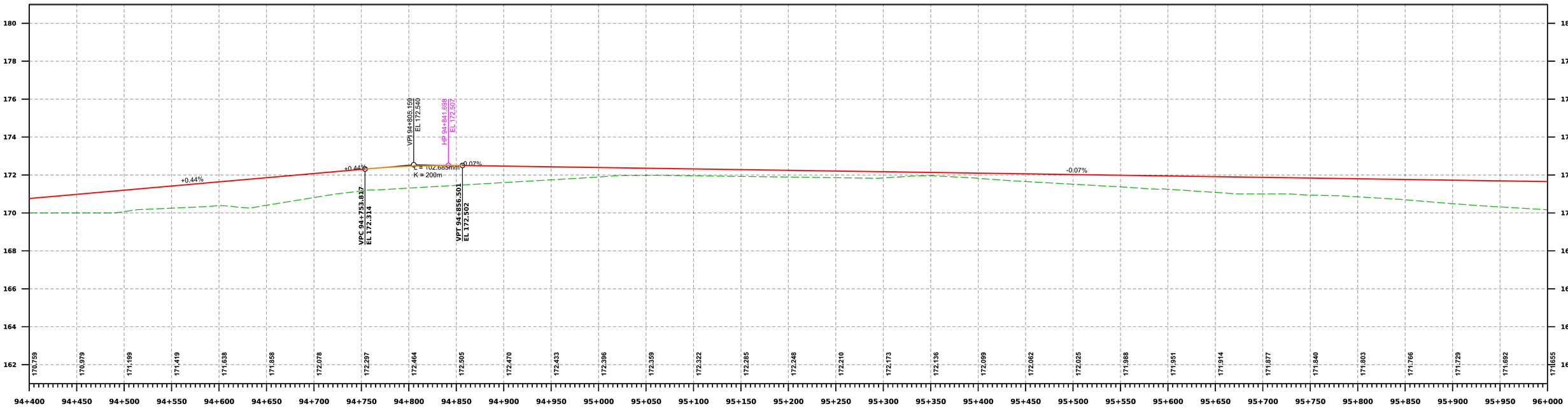
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP59
CONT. NO.
SHEET NO. A060

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

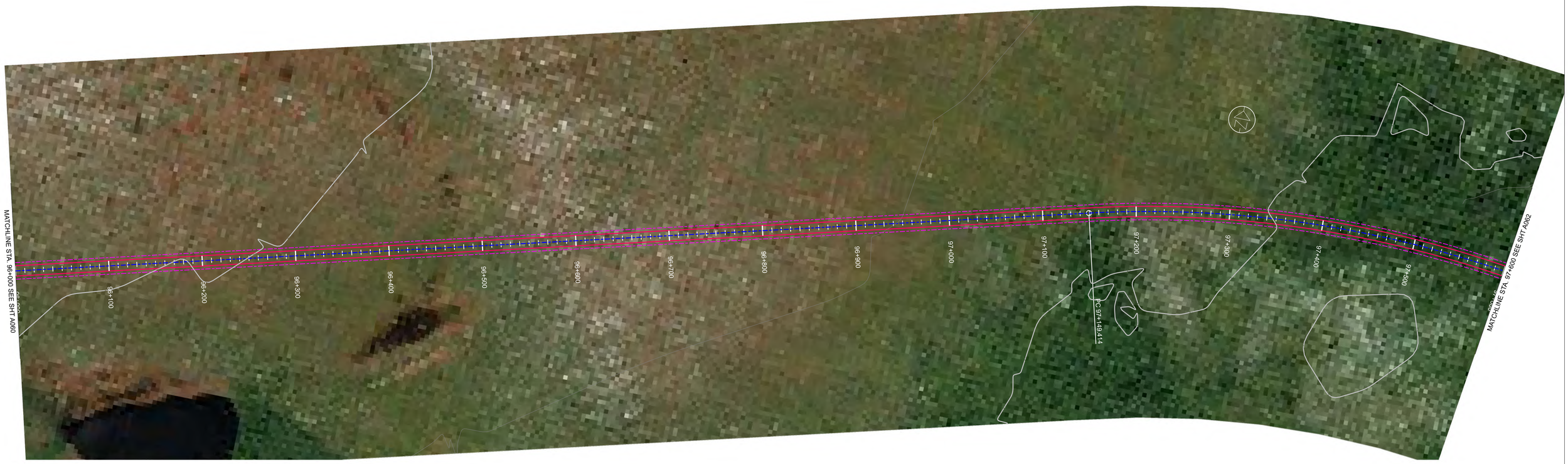
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

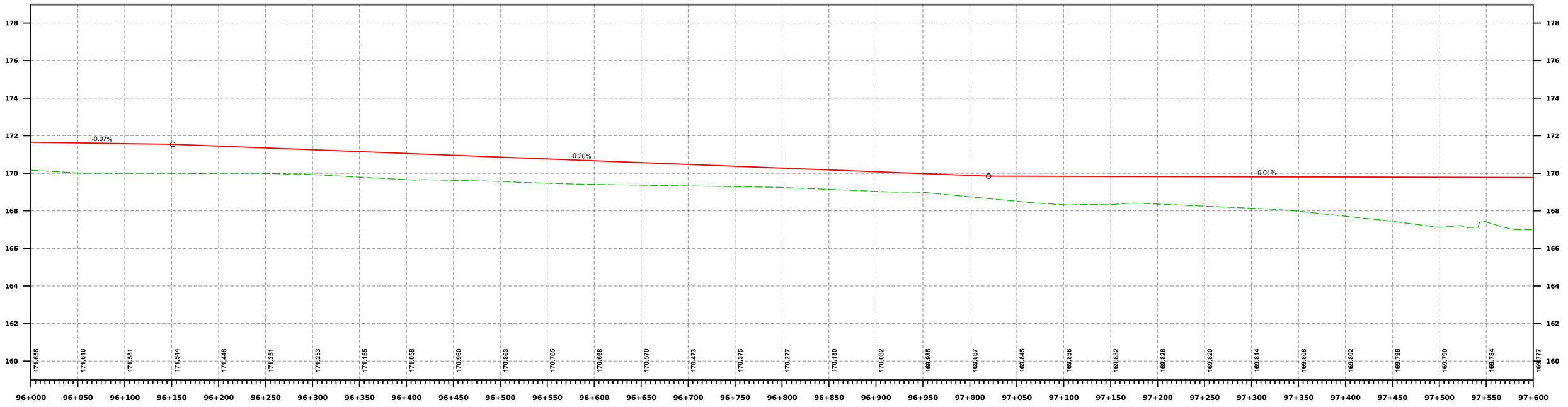
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP60
CONT. NO.
SHEET NO. A061

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

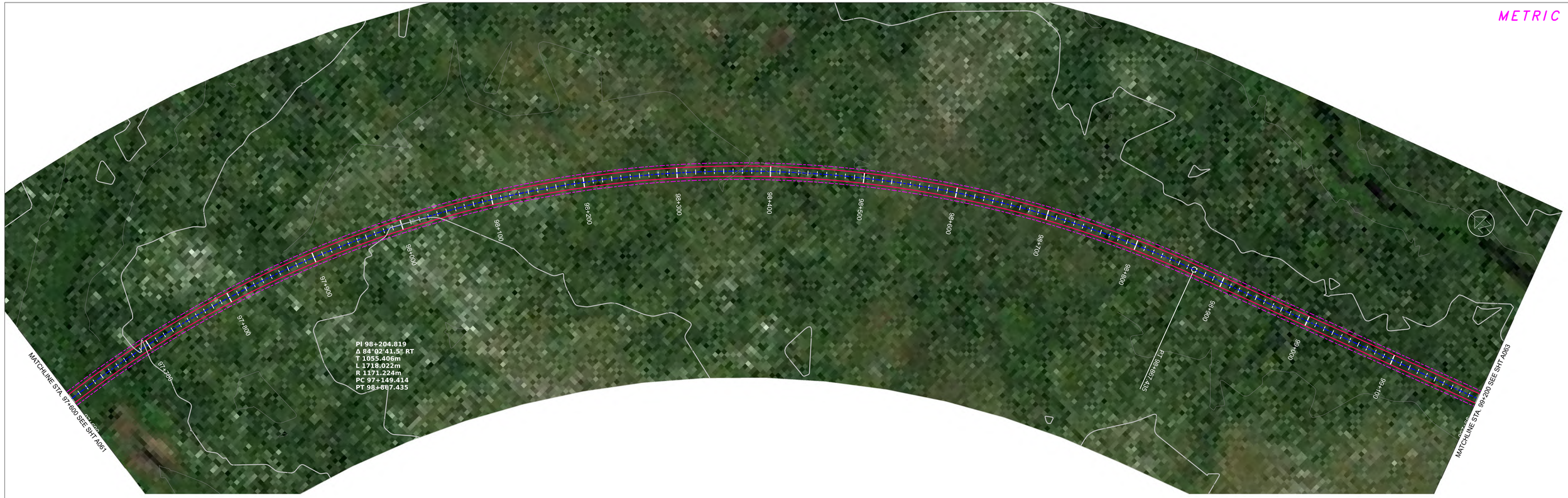
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

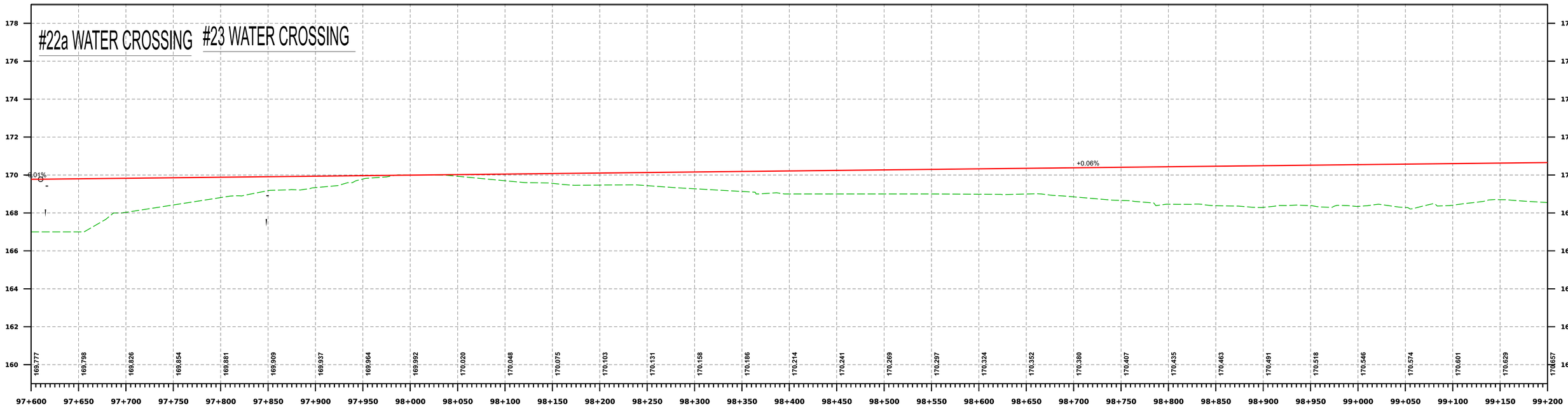
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP61
CONT. NO.
SHEET NO. A062

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

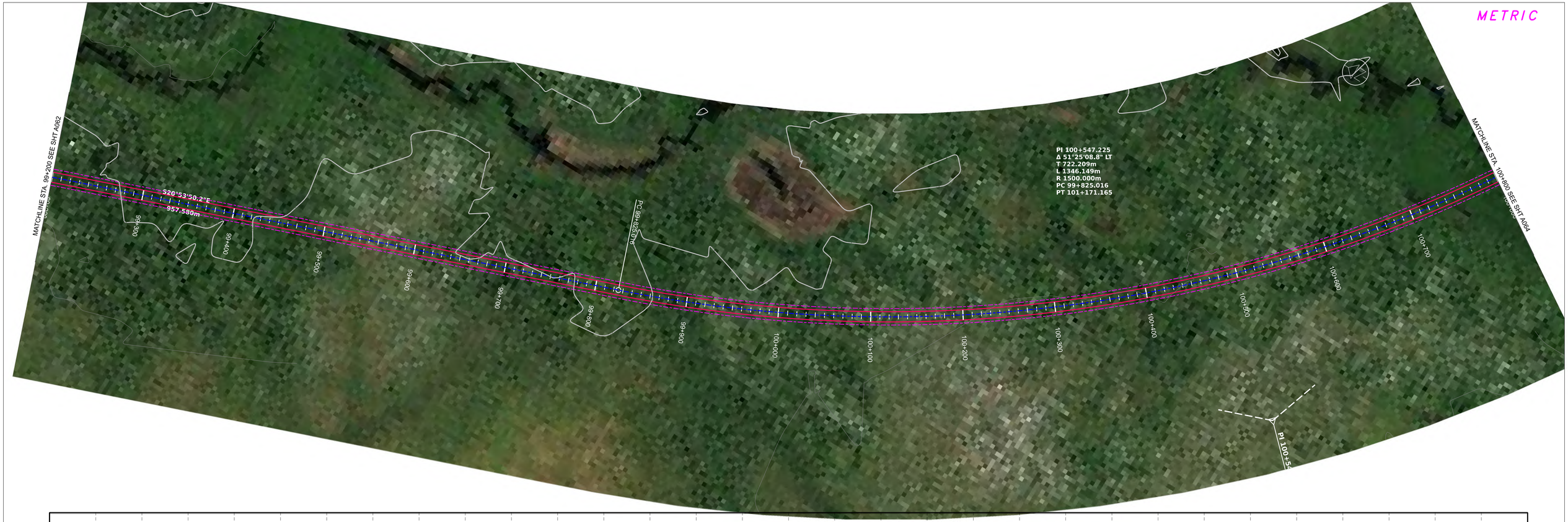
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

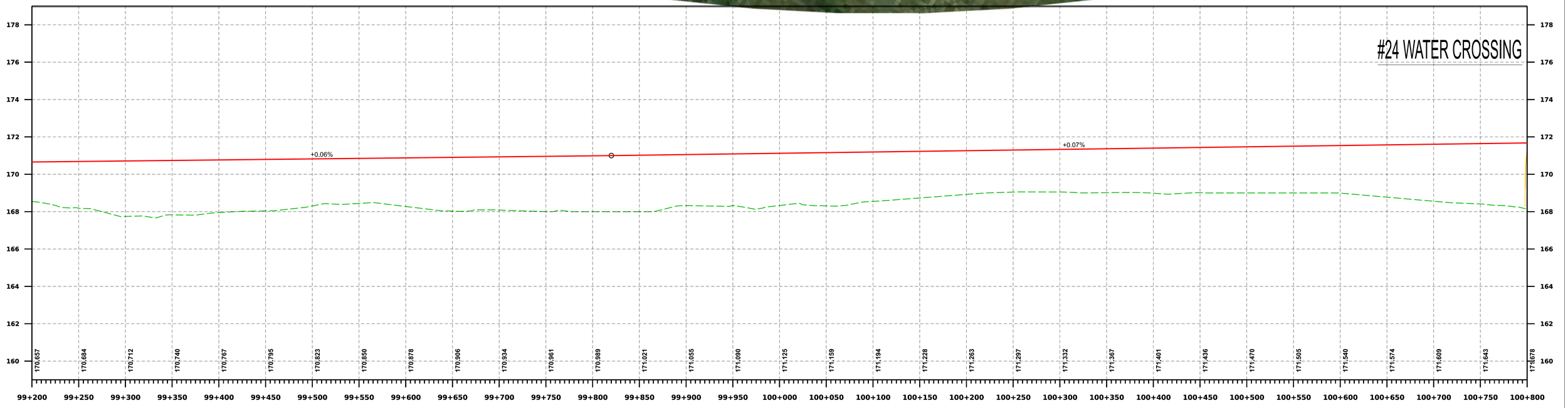
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP62
CONT. NO.
SHEET NO. A063

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP63
CONT. NO.
SHEET NO. A064

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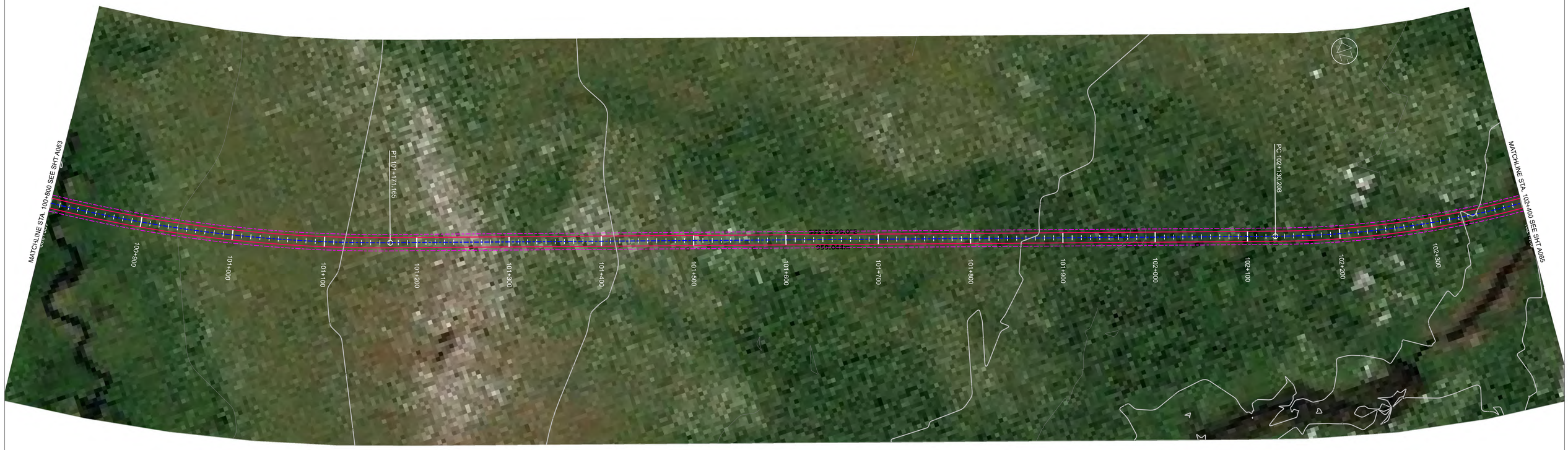
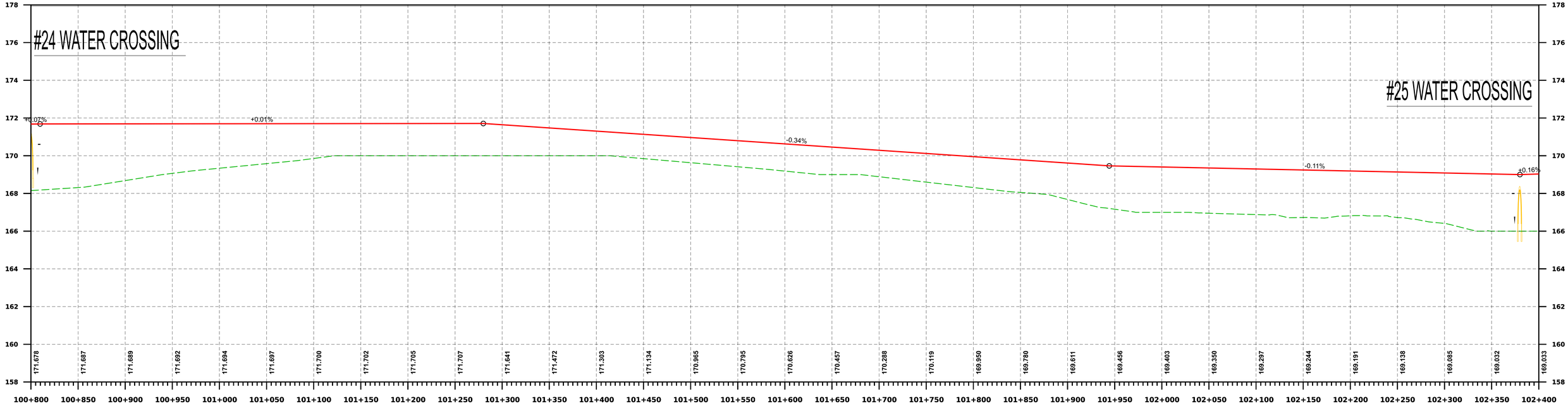
METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD

PRELIMINARY DESIGN

GeomBL

100+800.00 - 102+400.00

AtkinsRéalis

SCALES

20m 0 40m Horizontal

1.0m 0 2.0m Vertical

DESIGN R.M.

DRAWN K.PH

CHECKED I.R.

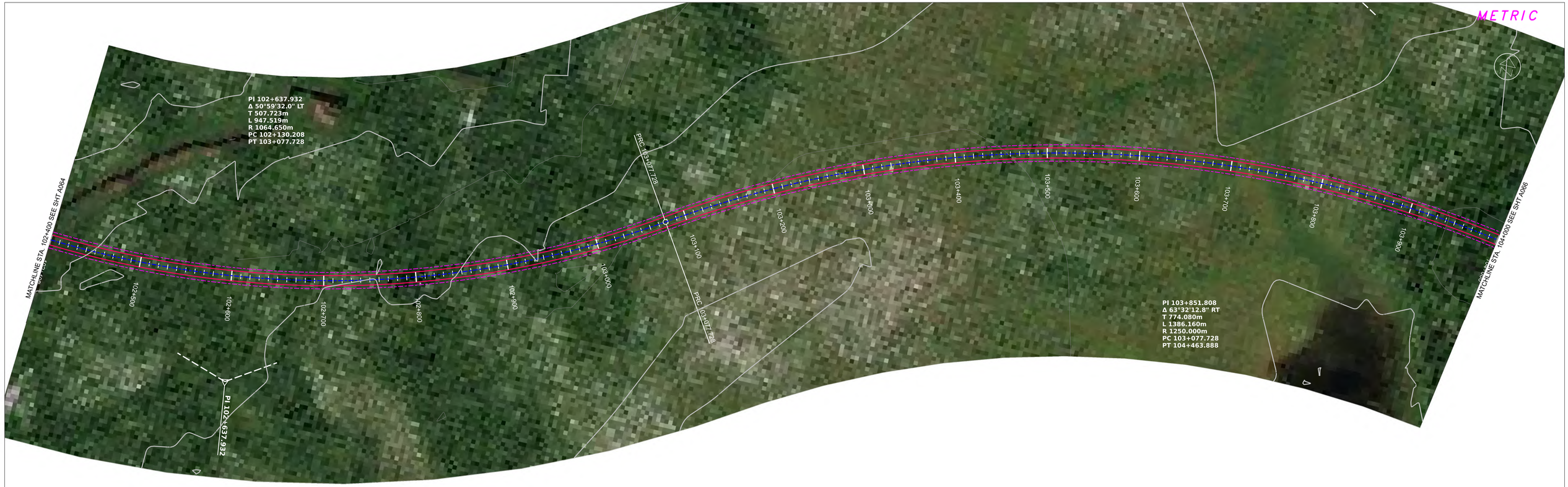
PLAN AND PROFILE DRAWINGS

DWG. NO. PP64

CONT. NO.

SHEET NO. A065

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD

PRELIMINARY DESIGN

GeomBL
102+400.00 - 104+000.00

AtkinsRéalis

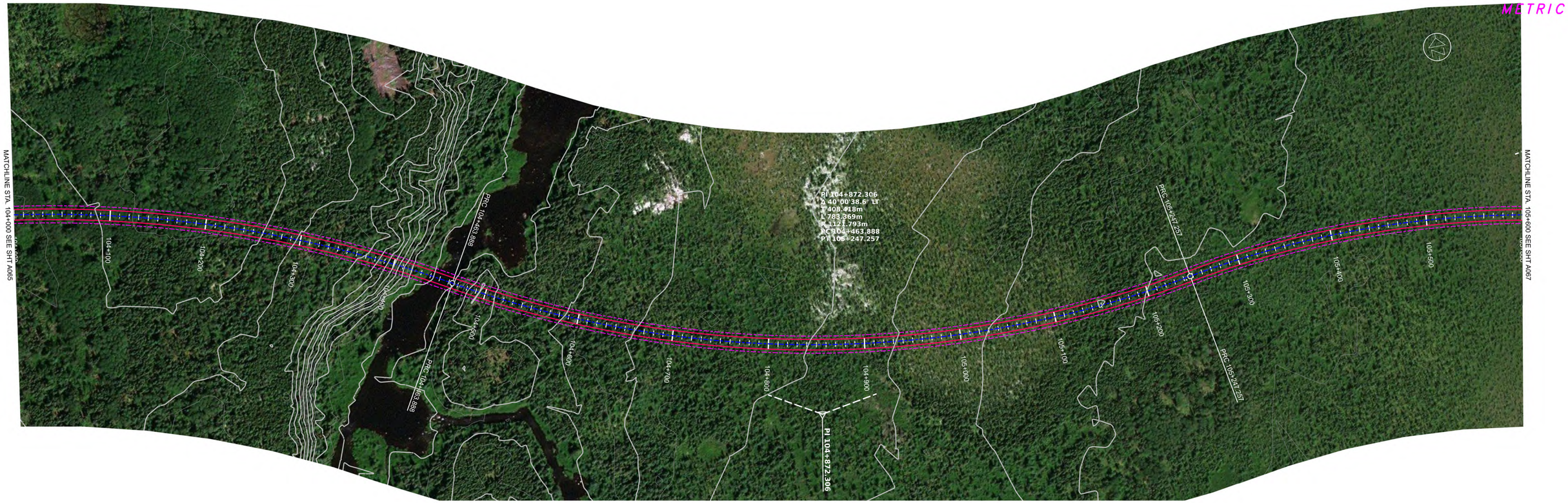
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

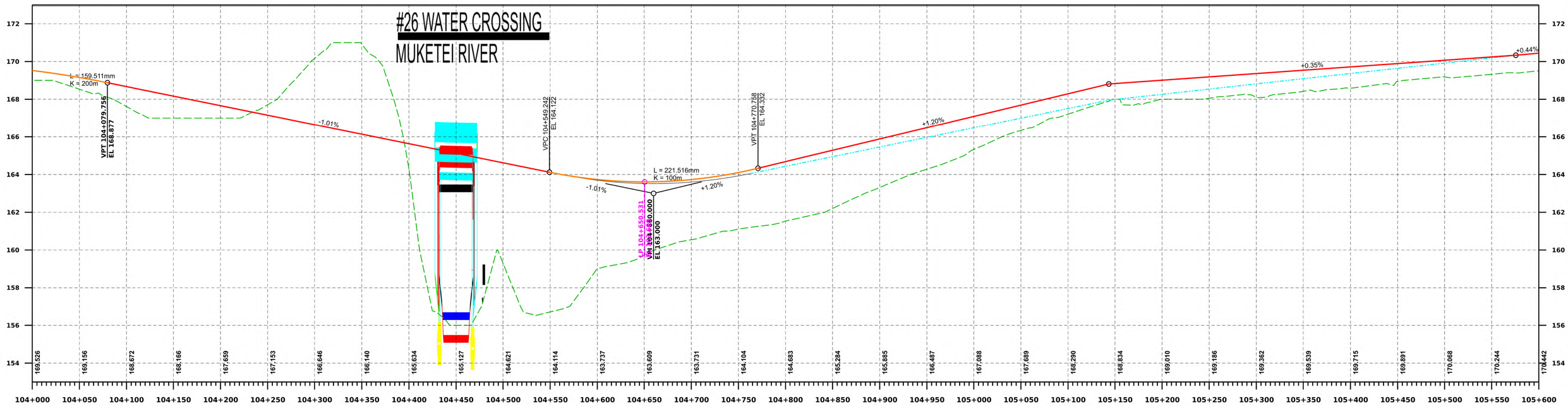
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP65
CONT. NO.
SHEET NO. A066

METRIC





No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

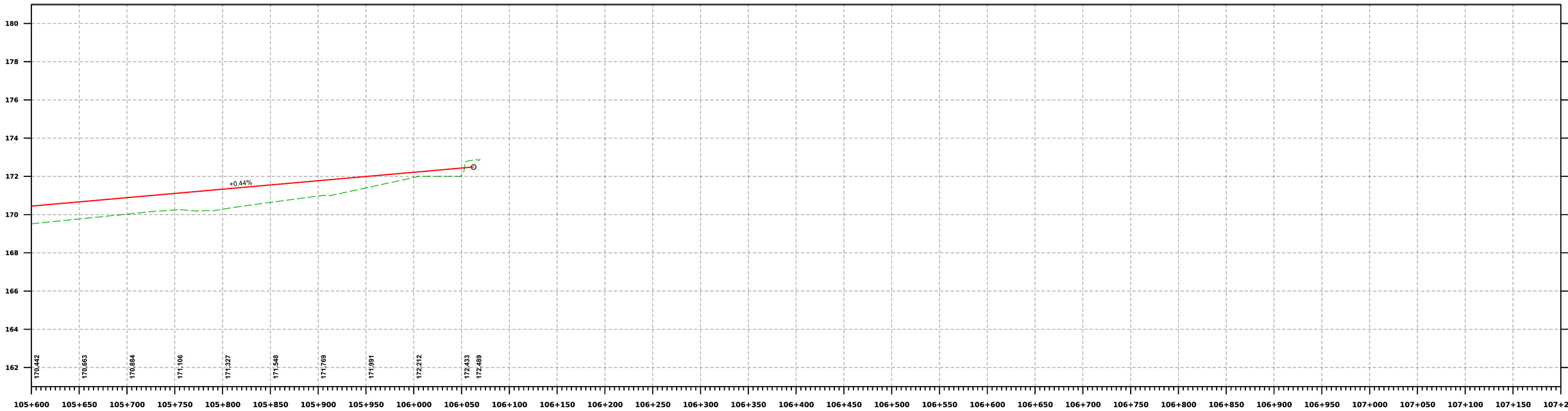
SCALES
20m 0 40m
Horizontal
1.0m 0 2.0m
Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

DWG. NO. PP66
CONT. NO.
SHEET NO. A067

METRIC



No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/08/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

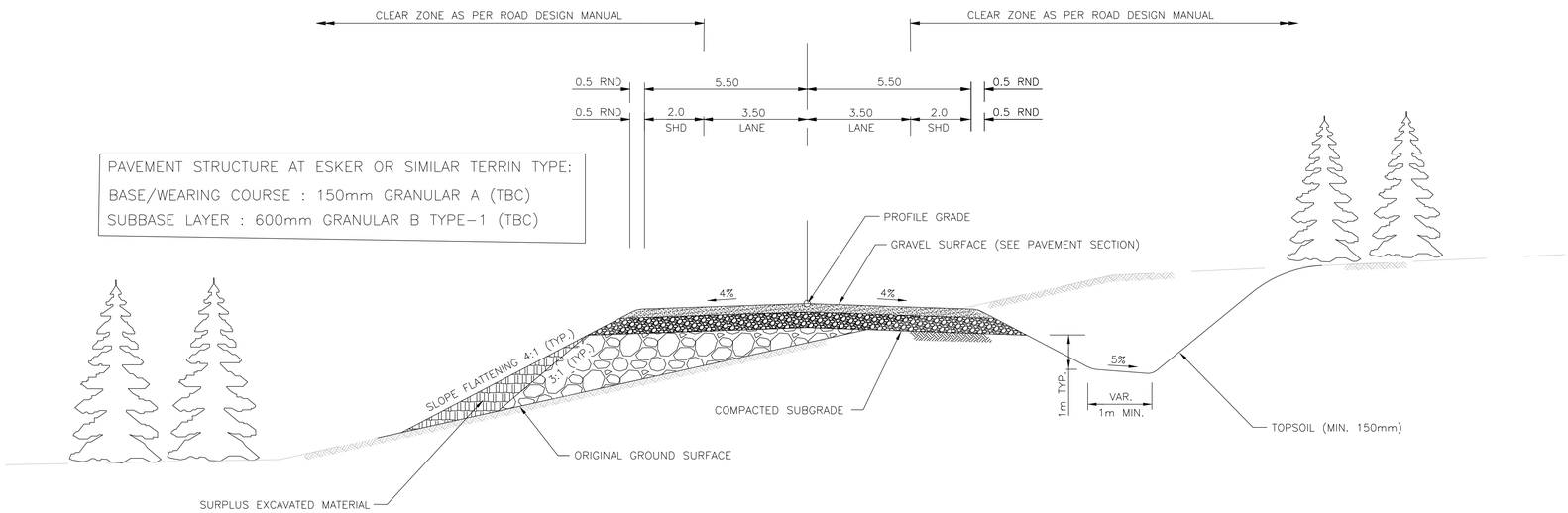
SCALES
20m 0 40m Horizontal
1.0m 0 2.0m Vertical

DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

PLAN AND PROFILE DRAWINGS

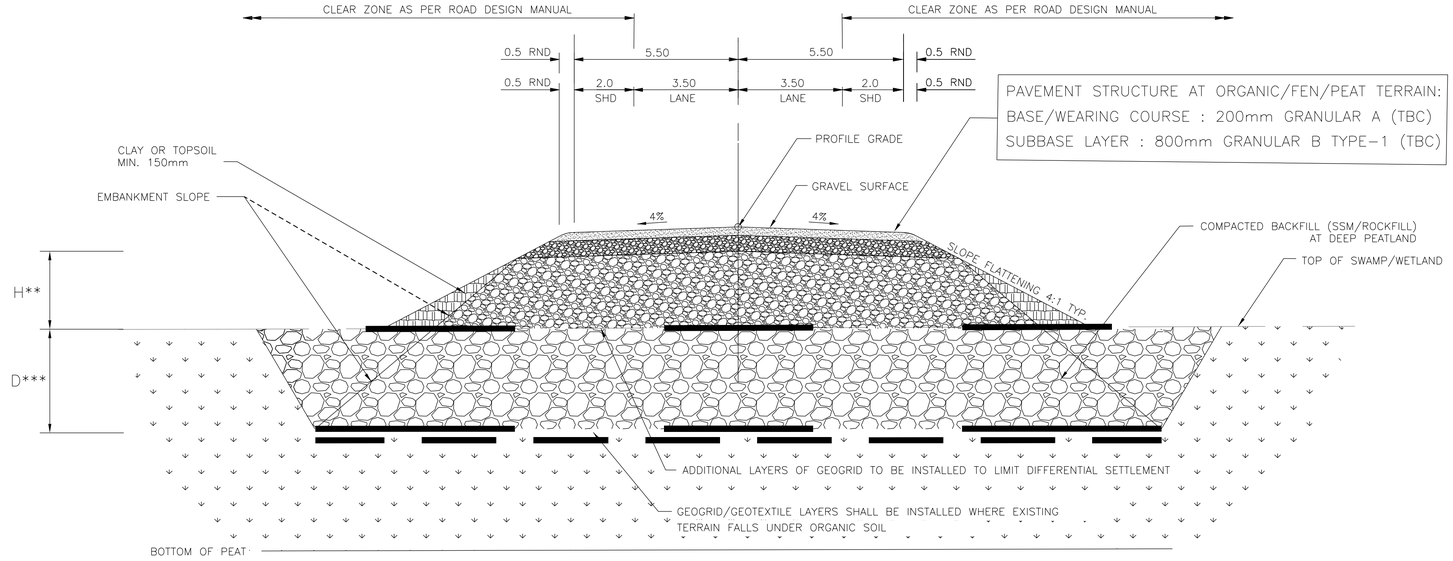
DWG. NO. PP67
CONT. NO.
SHEET NO. A068

METRIC



EMBANKMENT CROSS SECTION – MINERAL SOIL SUB-GRADE (TYP.)

UPLAND AREA (NORTH-SOUTH SECTION) FROM STA. 0+000 TO STA. 47+850



** : EMBANKMENT HEIGHT SHALL BE MIN. 1.2m ABOVE ORIGINAL GROUND.

*** : COMPENSATION FILL: 50% OF THE PEAT THICKNESS ACCOUNTED FOR 40% PEAT CONSOLIDATION AND THAW CONSOLIDATION (10%) FOR POTENTIAL PERMAFROST (IF APPLICABLE).

EMBANKMENT ROCKFILL – DEEP PEATLAND (>1m) CROSS SETION (TYP.)

LOWLAND AREA (EAST-WEST SECTION) FROM STA. 47+850 TO STA. 106+158

No.	DATE	REVISIONS	BY
PA	2020/02/14	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PB	2020/04/08	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PC	2020/06/22	PLAN PROFILE & TYPICAL SECTIONS	R.W.
PD	2024/09/10	PLAN PROFILE & TYPICAL SECTIONS	R.M.

WEBEQUIE FIRST NATION

WSR WEBEQUIE SUPPLY ROAD

WEBEQUIE SUPPLY ROAD
PRELIMINARY DESIGN

AtkinsRéalis

SCALES
1m 0 2m
Horizontal

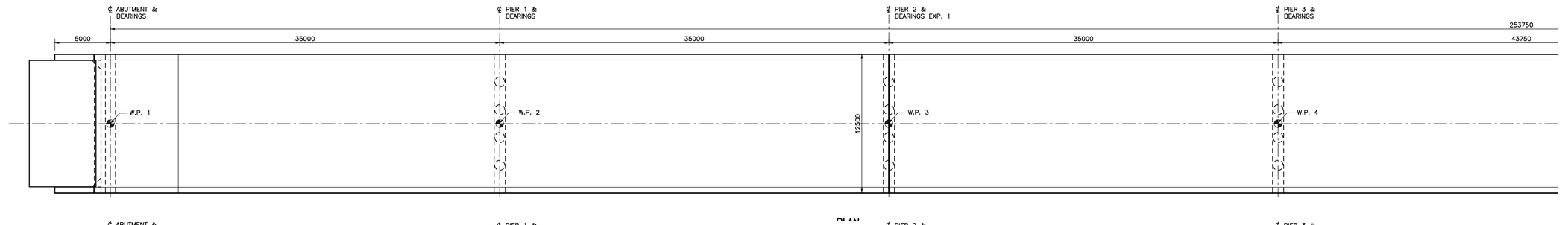
DESIGN R.M.
DRAWN K.PH
CHECKED I.R.

OPTIMIZED ENGINEERING ROUTE
TYPICAL CROSS SECTION

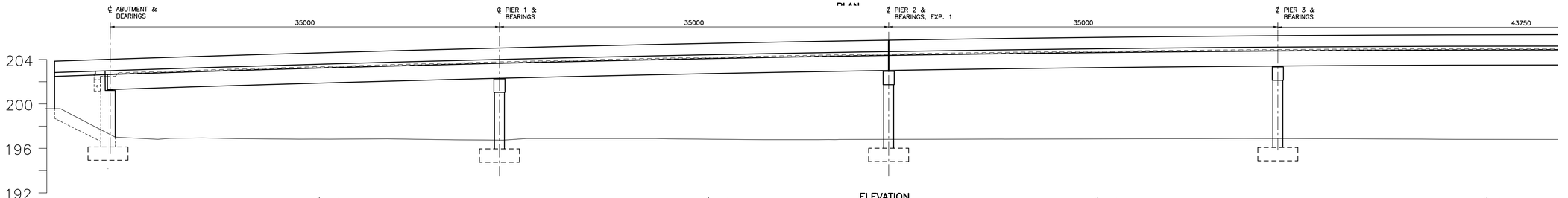
DWG. NO. DET1
CONT. NO.
SHEET NO. A069

APPENDIX J

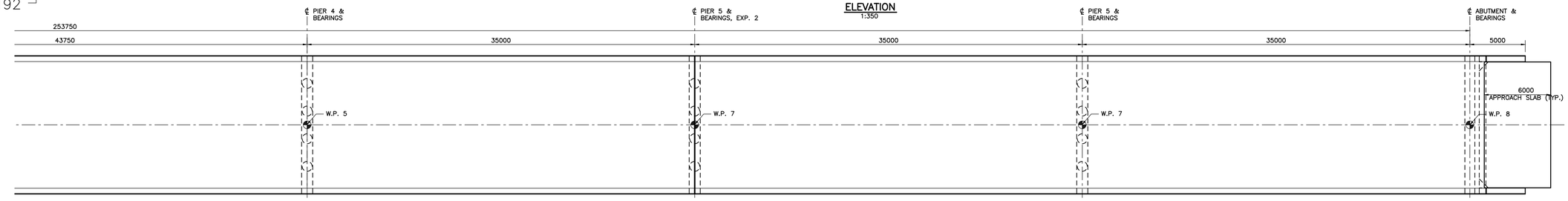
Structural General Arrangement Drawings



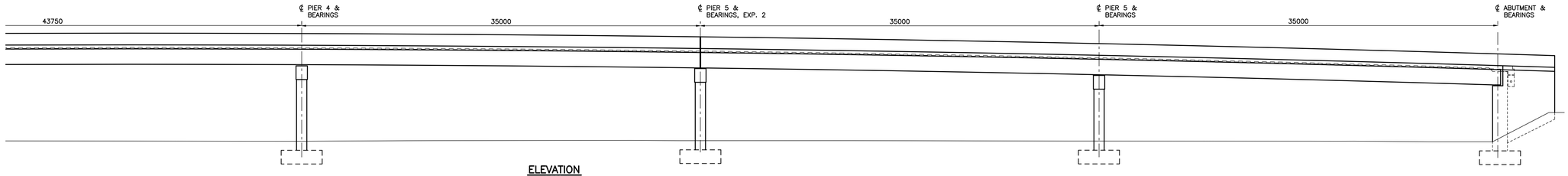
PLAN
1:200



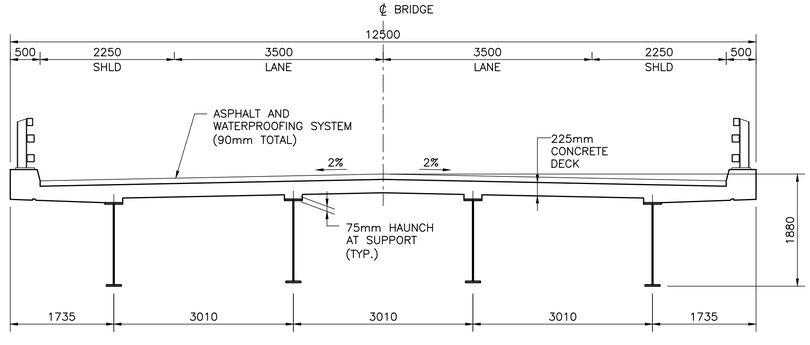
ELEVATION
1:350



PLAN
1:200



ELEVATION
1:350



WC – 1

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

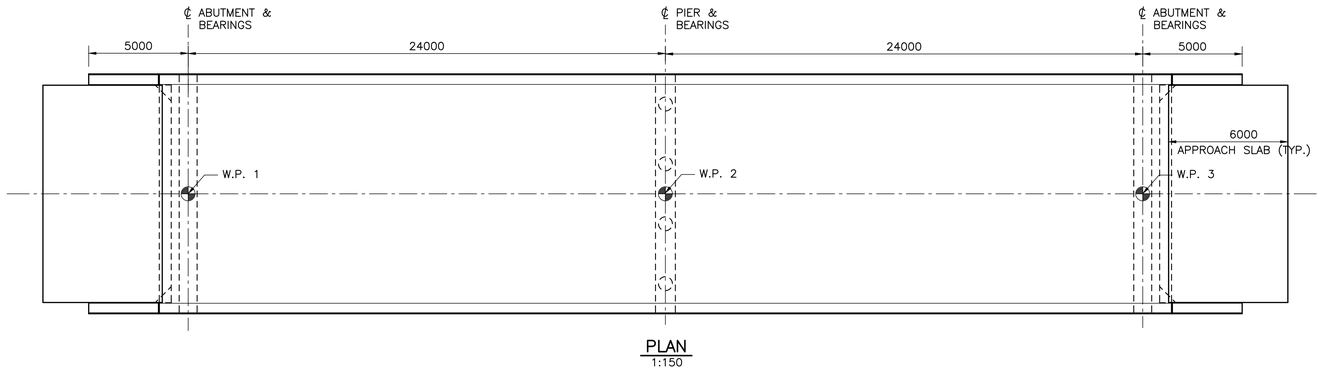
DRAWING NAME: \\TOR01\PROJECTS\E&W\PROJECTS\661910 – WEBEQUIE FIRST NATION SUPPLY RD\40_EXECUTION\42_ENG\42_03 STRUCTURES\EB–DESIGN BRIEF–CALCULATIONS\GA\WATER CROSSING DWG\2024–08–20 GA WATER CROSSING – 1.DWG DATE: 2024/08/26 TIME: 10:11 AM BY: Chen, Dennis

DRAWING NAME: \\TOR01\PROJECTS\E&W\PROJECTS\661910 - WEBEQUIE FIRST NATION SUPPLY RD\40_EXECUTION\42_ENG\42_03 STRUCTURES\EB-DESIGN BRIEF-CALCULATIONS\GA\WATER CROSSING DWG\2024-08-20 GA WATER CROSSING - 3-27.DWG DATE:2024/08/26 TIME:10:11 AM BY:Chen, Dennis

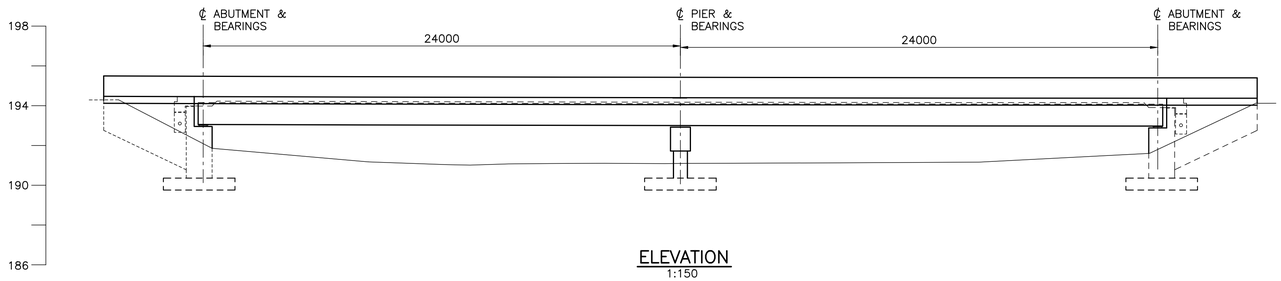
METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

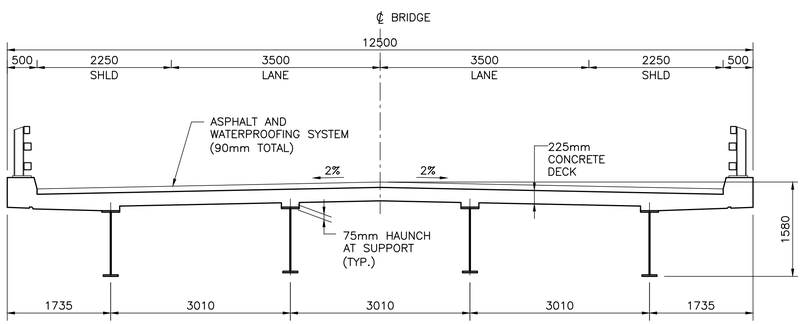
WC – 3
WC – 27



PLAN
1:150



ELEVATION
1:150



TYPICAL CROOS SECTION
1:50

STRUCTURE	SPAN L (mm)	SUPERSTRUCTURE DEPTH D (mm)
WC 3	24000	1580
WC 27	24000	1580

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

AtkinsRéalis

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Toronto, ON M9C 5L6
Canada
416.252.5315

atkinsrealis.com

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