



**LA GRANDE ALLIANCE FEASIBILITY  
STUDY – PHASE I**

POTENTIAL BORROW SOURCES  
AND QUARRY SITES ASSESSMENT –  
WASKAGANISH ACCESS ROAD

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ROAD**

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## **1.0 Introduction**

### **1.1 General**

La Grande Alliance refers to the *Memorandum of Understanding (MOU) on the Cree-Québec Sustainable Infrastructure Program in Eeyou Istchee Baie-James*, signed between the Cree Nation Government (CNG) and the Government of Québec on February 17, 2020. The purpose of the MOU is to provide a framework for Cree local and regional entities to work closely with relevant Québec government ministries to connect, develop and protect the territory of the Eeyou Istchee Baie-James region of northern Québec in an inclusive and participatory manner. The main objective of La Grande Alliance is to build a promising program for the strategic, predictable, and sustainable development of the territory over a 30-year time horizon.

Infrastructure development is a major component of La Grand Alliance. The program aims at improving and building major transportation infrastructures on the territory, including the implementation of a railway alongside the Billy Diamond Highway to Whapmagoostui, where the construction of a deepwater port will be considered. The current study is divided into three phases, Phase I being carried out by the Vision Eeyou Istchee Consortium, focusing on the feasibility design of the following infrastructures:

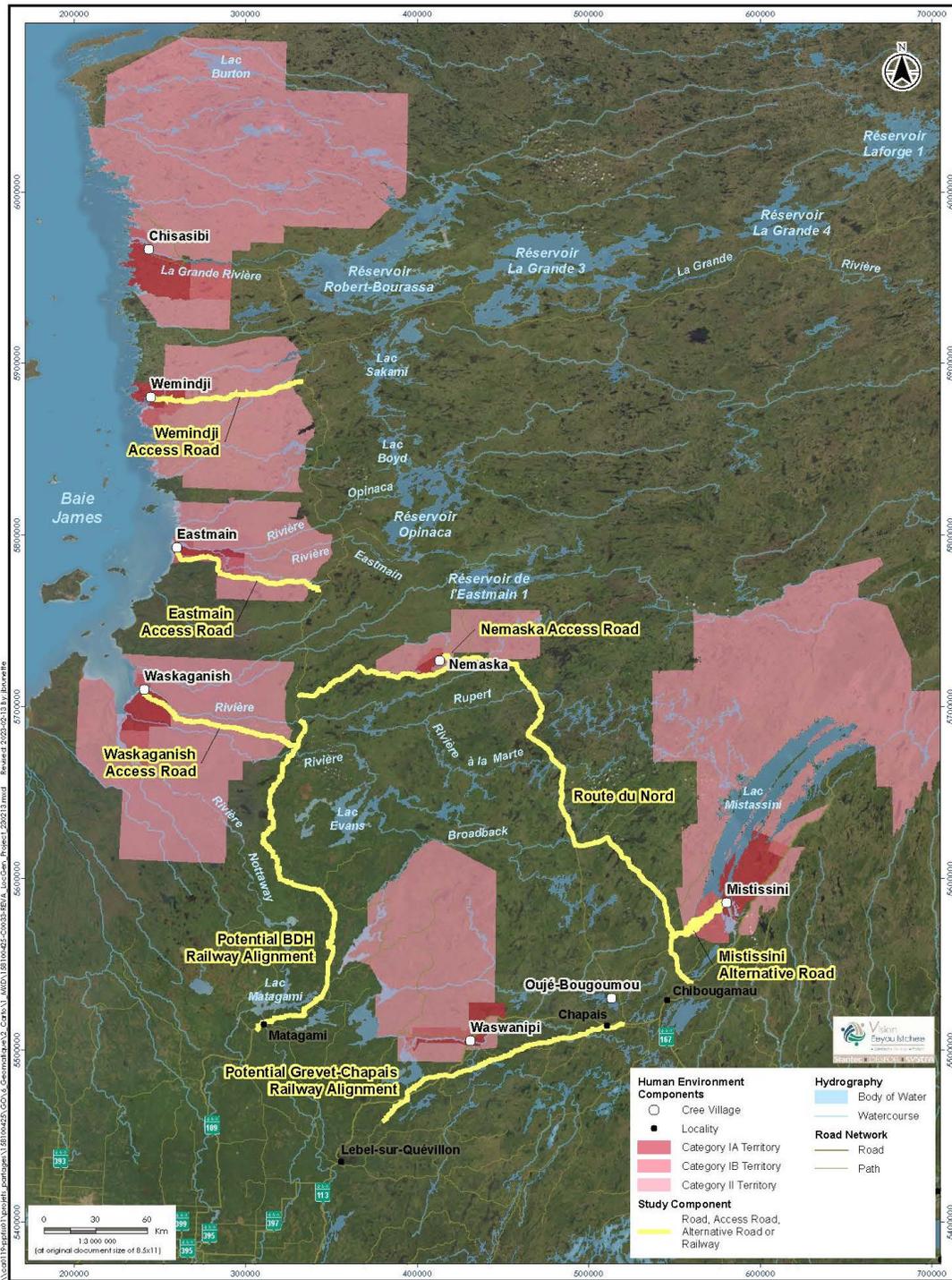
- Upgrade of the existing access roads between the Billy Diamond Highway and the Cree communities of Waskaganish, Eastmain and Wemindji;
- Upgrade of the existing access road between the Route du Nord and the community of Nemaska;
- New railway along the Billy Diamond Highway (BDH) between the town of Matagami and KP 257 of the same highway (Rupert River Bridge);
- Recommissioning of the railway line from Grevet (Lebel-sur-Quévillon) to Chapais (approximately 225 km);
- Construction of transfer areas along the Billy Diamond Highway and Grevet-Chapais line corridors, specifically the area at kilometre post (hereafter, KP) 257;
- Upgrade and paving of the Route du Nord, and;
- Construction of a secondary access road to the Cree Nation of Mistissini.

The location of the infrastructures listed above is shown on Figure 1.

Limitations associated with this report and its contents are provided in the Statement of General Conditions included in Appendix A.



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**Figure 1 La Grande Alliance – Phase I Feasibility Study Area Overview**



## **1.2 Scope of Work**

One of the objectives of the Eeyou Istchee's feasibility study of Phase I was to evaluate the availability of borrow materials (i.e. granular borrow sources and bedrock quarries) able to supply structural fill for the construction and/or upgrade of the different infrastructures.

Subsequently, Cree Development Corporation (CDC) mandated Stantec to conduct a geotechnical investigation which includes the exploration of quarry sites previously identified within the feasibility study. This report presents the results of the desktop borrow sources and quarry sites' assessment and the results of the geotechnical investigations of the targeted sites along the Waskaganish Access Road.

The main tasks performed regarding the identification and exploration of potential borrow sources and quarry sites consisted of the:

- Selection and acquisition of aerial photos covering the study area;
- Compilation and review of data related to the geology and the surficial deposits;
- Photo interpretation and delineation of sectors showing potential for material extraction (granular material and bedrock);
- Proposal of a field investigation program and identification of field targets for the conduction of boreholes
- Acquisition of the necessary environmental permits and authorization to carry out the geotechnical investigation
- Execution of the geotechnical field program which includes the:
  - o coordination with subcontractors and tallymen;
  - o forest clearing; and
  - o realization of boreholes.
- Laboratory testing to characterize the materials (bedrock) to determine the suitability for the study needs
- Preparation of a summary report presenting the main characteristics of the potential borrow sources and quarry sites, including an estimate of the potentially extractable volumes.



### **1.3 Material Requirements**

Preliminary estimates of borrow materials required for the upgrade and paving of the Waskaganish Access Road are presented in Table 1. Note that these estimates consist of compacted volumes and exclude quantities generated from the excavation of road cuts.

**Table 1 Summary of the Material Requirements for the upgrade of the Waskaganish Access Road**

<b>Type of Material</b>	<b>Volume (compacted) (m<sup>3</sup>)</b>
MG 112	225 500
MG 20	307 130
Pavement (ESG-10 and ESG-14)	74 875

According to the NQ-2560-114 standards (BNQ, 2014) used by the ministère des Transports et de la Mobilité durable for aggregates used in civil engineering works, several requirements must be met for aggregates to be used as a granular material for foundations.

Regarding the intrinsic characteristics, the aggregate must be at most category 5 meaning that the Micro-Deval test result must be lower than 35%, the Los Angeles test result must be lower than 50%, and the sum of the two results must be lower than 80%. In the case of manufacturing characteristics, they must be classified no more than as a category e, i.e., with a percentage of fragmentation greater than or equal to 50%.



## **2.0 Study Area and Background Review**

The Waskaganish Access Road extends for 103.8 km from the Cree community of the same name on James Bay shore to the Billy Diamond Highway.

The study area has a maximum width of 10 km and consists of an offset of 5 km on each side of the Waskaganish roadbed. Once all problematic areas (environmental and access constraints) are removed, the final study surface is considerably reduced. Potential sites that would require the construction of new access roads crossing major watercourses, waterbodies, and/or wetlands were also avoided when possible. Generally, the 5 km offset was reached when existing access roads were present and the sites easily reachable, otherwise the accessibility constraint was considered too high for the site to be a possible option.

Regional bedrock geology mapping (SIGEOM, 2023) shows that the study area is underlain by Archean bedrock belonging to the Superior Province. The bedrock encountered along the Waskaganish Access Road mostly consists of diatexite et metatexite derived from paragneiss of the Complexe de Rupert.

During the Late Wisconsin Glaciation (24 000 to 8 000 years before present (BP)), the James Bay region was covered by the Laurentide ice sheet. During this glaciation, large amounts of materials were transported and subsequently deposited as till (morainal deposits) across the landscape. Following the ice melt, the marine transgression of the Tyrrell Sea occurred around 7,900 BP (Hardy 1977). Glaciomarine silt and clay accumulated on the low-lying areas and coarser deposits accumulated along the former Tyrrell Sea shorelines. Peat bogs and fens have accumulated over the glacial and non-glacial deposits, especially over poorly drained glaciomarine and morainal (till) deposits.

Locally, since the Waskaganish community and their access road are located within the altitudinal limit of the Tyrrell Sea, the area was mostly covered by glaciomarine clay in the lower sectors. These poorly drained fine-grained sediments have led to the accumulation of thick organic deposits. Furthermore, as the altitude rises toward the Billy Diamond Highway, some littoral and till deposits of variable thickness, and bedrock exposure occupy the higher terrain.



### **3.0 Methodology**

#### **3.1 Photo Interpretation and Identification of Potential Borrow Sources and Quarry Sites**

Photo interpretation allows the geomorphologists to assess the study area in three-dimensions in order to identify landforms that are likely to contain granular materials. Spatial delineation of potential borrow sources is based on the geomorphologist’ knowledge of Quaternary deposits and on their ability to identify landforms that could potentially provide suitable granular borrow materials. Within the study area, landforms expected to be favorable for borrow material extraction include littoral deposits from the postglacial Tyrell Sea.

In addition to granular deposits, potential quarry sites were selected by identifying favorable bedrock hills – generally about ten (10) meters above the surrounding terrain – and by delineating areas that could provide significant volumes.

The photo interpretation exercise was completed using a mirror stereoscope for the visualization of black and white 1:15 000 to 1:60 000 scale aerial photos. The aerial photos used for the assessment were acquired from Natural Resources Canada (NRCAN, 2023) - National Air Photo Library (NAPL) and are listed in Table 2.

The potential sites were selected based on their distance from the Waskaganish Access Road or other existing accesses in order to limit the costs associated with the construction and/or maintenance of access roads. Special attention was given to avoid apparent environmental constraints such as the proximity of the potential sites to watercourses or waterbody, and wetlands.

The potential borrow sources and quarry sites were identified and drawn directly onto the aerial photographs. These were subsequently scanned and georeferenced, and the delineated landforms were digitized using ArcMap© software. The sites are identified by the prefixes GD (Granular Deposit) or Q (Quarry) followed by the KP of their location (i.e., GD-40 or Q-28.8).

**Table 2 Aerial Photos Used for the Identification of Potential Borrow Sources and Quarry Sites**

<b>Year</b>	<b>Roll number</b>	<b>No. of aerial photo</b>	<b>Scale</b>
1955	A14973	3 to 16	1: 60 000
1955	A14975	15 to 19	1: 60 000
1955	A14976	13 to 16	1: 60 000
1986	A31452	82 to 121	1: 15 000
1986	A31452	138 to 144	1: 15 000



## **3.2 ENVIRONMENTAL PERMITTING**

Before proceeding with the geotechnical investigations, Vision Eeyou Istchee obtained the necessary authorizations and permits for the execution of the work:

- Land use (obtained from the ministère des Ressources naturelles et des Forêts du Québec);
- Tree cutting (obtained from the ministère des Forêts, de la Faune et des Parcs du Québec); and
- Declaration of compliance (submitted to the ministère de l'Environnement, de la Lutte contre les changements climatiques du Québec).

All activities conducted on the territory (land occupancy, land clearing, exploration trenches and drilling) were carried out in compliance with the current laws and regulations.

## **3.3 Geotechnical Field Investigation**

A total of six (6) potentially favorable sites, including three (3) potential granular borrow sources (GD-40, GD-50, and GD-52) and three (3) potential quarry sites (Q-28.8, Q-48, and Q-69.3). At the current state of the feasibility study, the geotechnical investigation was limited to the exploration of the potential sites (Q-48 and Q-69.3).

The fieldwork for the potential quarry site assessment was carried out from August 4 to August 6, 2022 and consisted in drilling four (4) boreholes (Q-48-BH22-01, Q-48-BH22-02, Q-63.9-BH22-01, Q-63.9-BH22-02), two in each potential quarry site. The boreholes were drilled using a track-mounted CME-55 drill rig to a depth of about 10 m. The subsurface stratigraphy encountered was recorded by Stantec field personnel. Rock coring was carried out in all boreholes using a NQ-size core barrel (with inner diameter of 47.6 mm) to confirm the type and characteristics of the bedrock. When encountered, overburden samples were recovered at regular intervals using a B or N size split-spoon sampler. Bedrock samples collected during the fieldwork investigation were sent to Stantec's laboratory for detailed classification and additional testing.

## **3.4 Laboratory Testing**

All rock samples that were brought back to Stantec's laboratory were subjected to detailed visual examination and additional classification by a geologist. Laboratory testing conducted on rock cores consisted of two (2) Micro-Deval tests (LC 21-070) and Los Angeles tests (LC 21-400) for each borehole.

## **3.5 Volume Calculation**

The volume estimates were calculated by multiplying the potential borrow source or quarry site's area by the estimated average thickness of suitable materials or exploitable bedrock. Photo interpretation and Canadian Digital Surface Models derived from radar data (NRCan, 2000) were used to determine the potential exploitable thickness of granular material or bedrock. However, a conservative approach was used while estimating the potential volumes to avoid overestimating the material availability.



### **3.6 Site Potential Classification**

The site potential classification consists of a qualitative assessment of the site based on the accessibility, material quality (Granulometry, Los Angeles and Micro-Deval results), potential volumes available, and the efforts required to develop the site.

The classification uses four different categories which are defined as:

**High** – Clean, well-graded sand with variable proportions of gravel, or bedrock suitable to use as high-quality aggregates with minimum processing. Presence of significant volumes and easy to access with minimum efforts required for site development.

**Good** – Good quality material generally consisting of well-graded sand with variable proportions of gravel and limited quantities of silt, or good quality bedrock which could provide good quality aggregates with minimal processing efforts. Presence of significant volumes and relatively easy to access with limited efforts required for site development.

**Fair** - Fair quality material consisting generally of poorly graded sand and variable proportions of gravel with or without substantial silt content or fair quality bedrock. Available material volumes are less significant and/or are relatively difficult to access (absence, existing access or requiring significant rehabilitation efforts). Materials may require treatment to meet the standards (granulometric specification).

**Poor (not suitable)** - Poor quality material generally consisting of silty, poorly graded, fine-grained sand with minor gravel, poor-quality bedrock or presence of major extraction constraints (shallow water table, thick overburden, etc.).

The site potential classification is provided only for the site for which a geotechnical field investigation was conducted as part of this mandate (in this case two quarry sites – Q-48 and Q-69.3) since no site-specific data are available for the other sites.



## **4.0 Results**

Using aerial photo interpretation three (3) potential granular borrow sources and three (3) quarry sites were identified as being more likely to contain suitable materials along the Waskaganish Access. The potential borrow source consist of littoral deposits, while the potential quarry sites consist of a small bedrock hill with an approximate height of 8-10 m. A specific attention was paid to avoid as much as possible the sites where environmental constraints (proximity to watercourses, waterbodies, or wetlands) were present. The main characteristics of the identified granular borrow sources and quarry sites are listed in Table 3, while their specific description is presented below.

The location of the identified potential quarry sites and drilled boreholes is shown on the location maps in Appendix B. Detailed borehole descriptions are provided within the borehole records in Appendix C. Laboratory test results are shown in Appendix D while a photographic album of the bedrock cores is provided in Appendix E.



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**Table 3 Potential Quarry Sites Identified Along the Waskaganish Access Road**

Site ID	Status	Centroid Coordinates (NAD 83 CSRS MTM 9)		No. SMS (lease expiration date) <sup>1</sup>	Claim (expiration date) <sup>1</sup>	Material Type	Area (ha)
		Easting (m)	Northing (m)				
GD-40	New	179 775	5 688 635	32M08-4 (2023/03/31)	Partially (expired)	Sand and gravel	14.5
GD-50	New	188 620	5 688 408	-	Yes (expired)	Sand and gravel	24.6
GD-52	New	191 320	5 688 005	32M08-10 (expired)	Partially (expired)	Sand and gravel	14.5
Q-28.8	Existing	377 130	5 688 185	32M08-11 (2027/06/01)	Yes (2027/06/01)	Bedrock (Paragneiss) <sup>2</sup>	2.2
Q-48	Existing	397 410	5 691 215	32M08-16 (expired)	Yes (expired)	Bedrock (Granite)	12.2
Q-69.3	Existing	417 120	5 685 140	32N05-11 (expired)	Partially (expired)	Bedrock (Granite)	2.9

<sup>1</sup> Source: Gestim Plus, 2023

<sup>2</sup> Bedrock lithology source: SIGÉOM, 2023

## **4.1 Potential Borrow Sources (Granular Material)**

The following sections (4.1.1 and 4.1.3) present the potential borrow sources identified along the Waskaganish Access Road. The Figure B1 (Appendix B) shows an overview map of the potential borrow source locations along the Waskaganish Access Road while Figure B2 to B5 (Appendix B) shows site-specific maps of each site. Along this access road, the opened pits were generally completely exploited and many sites that were not exploited were previously explored. The sites suggested in the following sections are those appearing the most favorable for granular materials extraction.

### **4.1.1 Potential Borrow Source GD-40**

**Landform type:** Littoral deposit

**Material:** Sand and gravel

**Estimated average material thickness:** 2 m

**Estimated volume:** 50 000 m<sup>3</sup>



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## Site description:

The potential borrow source GD-40 is located about 475 m south of the KP 40 of the Waskaganish Access Road. The site consists of littoral deposits arranged in a southwest to northeast orientation. The site is about 990 m long, 120 to 280 m wide, and has an area of 14.5 ha. A camp with only one cabin is present within the site boundaries. It has never been exploited and has a sparse vegetation cover. The material thickness is expected to be approximately 2 m.

As for environmental constraints, two peatlands are located on the northwest and the south boundaries of the site from which a 30 m buffer distance would to be respect.

## Site access:

The site can be accessed using a 490 m trail from the Waskaganish Access Road, although this trail would need improving to allow the exploitation of the materials.

## 4.1.2 Potential Borrow Source GD-50

**Landform type:** Littoral deposit

**Material:** Sand and gravel

**Estimated average material thickness:** 2.5 m

**Estimated volume:** 250 000 m<sup>3</sup>

## Site description:

The potential borrow source GD-50 is located about 75 m north of the KP 49 of the Waskaganish Access Road. The site consists of a succession of beach ridges arranged in a west to east orientation, parallel to the Waskaganish Access Road. The delineated deposit has a length of 1560 m, a width of 85 to 250 m, and an area of 24.6 ha. The site has never been exploited and is sparsely forested. Small peatlands are located to the north of the site in its central part. Their presence should not affect significantly the potential exploitable volume. However, a buffer of 30 m would need to be respected between the limits of the site and the wetlands.

## Site Access:

This site can be reached from the Waskaganish Access Road using a small trail of approximately 80 m although it would need to be improved to allow the exploitation of the materials.



### **4.1.3 Potential Borrow Source GD-52**

**Landform type:** Littoral deposit

**Material:** Sand and gravel

**Estimated average material thickness:** 2.5 m

**Estimated volume:** 300 000 m<sup>3</sup>

**Site description:**

The potential borrow source GD-52 is located 125 m north of the KP 52 of the Waskaganish Access Road. The site consists of a succession of crests arranged in a west northwest to east northeast orientation. The site was previously exploited on the easternmost face of the site, and it is mostly forested except for a ~3.8 ha area that was cleared. The site has a maximum length of 1960 m, a maximum width of 435 m, and an area of 29.7 ha. Sand and gravel are expected to be found within the first 3.5 m deep of the landform, on average. A large peatland is located approximately 30 m north of the eastern section of the site which should not impact the potentially exploitable volume of this site. Otherwise, no other environmental constraints were observed in the vicinity of this site.

**Site access:**

The site can be reached using the access road leading to the existing borrow pit or by two (2) existing trails, one in the central portion of the site and the other at its westernmost extremity. These two (2) trails would require upgrading works to allow the exploitation of the site.

## **4.2 Potential Quarry Sites**

The following section (4.2.1 to 4.2.3) present the potential quarry sites identified along the Waskaganish Access Road. The Figure B1 (Appendix B) show an overview map while Figures B5 to B7 (Appendix B) show site-specific maps of each site.

### **4.2.1 Potential quarry site Q-28.8**

**Landform type:** Elongated rocky hill

**Material:** Bedrock (paragneiss)

**Estimated average material thickness:** 8 - 10 m

**Estimated volume:** 250 000 m<sup>3</sup> (287 500 m<sup>3</sup> including a swell ratio of 1.15 once compacted)



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### Site description:

The potential quarry site Q-28.8 is located about 1.7 km south of the PK 28.8 of the Waskaganish Access Road. The site consists of an elongated rocky hill that was previously exploited on the easternmost side of the landform. The site has a length of 760 m, a width of 130 to 200 m and an approximate area of 11.9 ha. The bedrock is mostly exposed or covered by a thin overburden layer. No environmental constraints were identified in the surrounding of the site.

### Site access:

The site is easily accessible from an access road that is already in place from the Waskaganish Access Road, therefore no additional construction works would be required to allow the exploitation of this site.



**Figure 2 Rocky Hill at Potential Site Q-48**

### Field investigation program and laboratory testing:

Two (2) boreholes (Q-48-BH22-01, Q-48-BH22-02) were drilled on site on August 4th and 5th, 2022. The first borehole reached a depth of 10.19 m while the second one reached a depth of 10.67 m. Following the description of the bedrock cores by a geologist, representative samples of rock were selected to perform two (2) Micro-Deval tests (LC 21-070), and two (2) Los Angeles tests (LC 21-400) for each borehole.



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**Subsurface conditions:**

The encountered bedrock in boreholes Q-48-BH22-01 and Q-48-BH22-02 consists of grey granite from the ground surface to depths of 10.19 m and 10.67 m, respectively.

The laboratory test results for the selected samples showed that the Micro-Deval results varied from 10 to 13 %, while the Los Angeles results ranged from 18 to 24 %, indicating that the bedrock should be suitable to produce various types of aggregates.

The subsurface conditions observed in the two boreholes are summarized in Table 4 and the laboratory test results are provided in Table 5.

**Site potential:**

**High** – The site seems to be composed of a significant volume of suitable bedrock to produce crushed stone and an access is already available.

**Table 4 Summary of Observed Stratigraphy for Potential Quarry Site Q-48**

Borehole ID	Total depth (m)	Stratigraphy (depth-m)
		Granite
Q-48-BH22-01	10.19	0.00 – 10.19
Q-48-BH22-02	10.67	0.00 – 10.67

**Table 5 Laboratory results for potential quarry site Q-48**

Borehole ID	Sample	Depth (m)	Geotechnical laboratory test results	
			Micro-Deval (%) (LC 21-070)	Los Angeles (%) (LC 21-400)
Q-48-BH22-01	DC-01 to DC-04	0.13 – 5.21	13	24
Q-48-BH22-01	DC-04 to DC-07	5.21 – 9.60	10	19
Q-48-BH22-02	DC-01 to DC-03	0.00 – 4.80	10	18
Q-48-BH22-02	DC-04 to DC-07	4.80 – 10.67	10	19



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**4.2.2 Potential Quarry Site Q-69.3**

**Landform type:** Residual rocky hill

**Material:** Bedrock (grey and white Granite)

**Potentially exploitable thickness:** 5 m

**Estimated volume:** 100 000 m<sup>3</sup> (115 000 including a swell ratio of 1.15 once compacted)

**Site description:**

The potential quarry site Q-69.3 is located about 120 m to the north of KP 69.3 of the Waskaganish Access Road. The site consists of a residual rocky hill that was previously exploited (Figure 3). It has a length of about 330 m, a width of about 90 to 140 m, and an area of 2.9 ha. The site is sparsely vegetated, and the bedrock is mostly exposed. An open peatland is located north of the site. Thus, a 30 m buffer should be respected with the exploitation area. No other constraints were identified in the vicinity of the site.

**Site access:**

The site is easily accessible using the access road of the existing quarry.



**Figure 3 Picture of the Open Face of the Site Q-69.3**



**LA GRANDE ALLIANCE FEASIBILITY STUDY – PHASE I  
POTENTIAL BORROW SOURCES AND QUARRY SITES ASSESSMENT – WASKAGANISH ACCESS  
ROAD**

**Field investigation program and laboratory testing:**

Two boreholes (Q-69.3-BH22-01, Q-69.3-BH22-02) were drilled on site on August 5 and 6, 2022, reaching maximum depths of 10.64 m and 10.87 m, respectively. Following the description of the bedrock cores by a geologist, representative samples of rock were selected to perform two (2) Micro-Deval tests (LC 21-070), and two (2) Los Angeles tests (LC 21-400) for each borehole.

**Subsurface conditions:**

The two boreholes contained grey (Q-69.3-BH22-01) and grey and white (Q-69.3-BH22-02) granite up to the base of the boreholes.

The laboratory test results for the selected samples from the boreholes show that Micro-Deval values range from 9 to 13 %, while the Los Angeles results range from 21 to 25 % indicating that the bedrock should be suitable to produce various types of aggregates.

The subsurface conditions observed in the two boreholes are summarized in Table 6 and the laboratory test results are provided in Table 7.

**Site potential:**

**High** – The site appears to contain significant volume of suitable bedrock for aggregate material production and is easily accessible.

**Table 6 Summary of Observed Stratigraphy for Potential Quarry Site Q-69.3**

Borehole ID	Total depth (m)	Stratigraphy (depth-m)
		Granite
Q-69.3-BH22-01	10.64	0.00 – 10.64
Q-69.3-BH22-02	10.87	0.00 – 10.87

**Table 7 Laboratory Results for Potential Quarry Site Q-69.3**

Borehole ID	Sample	Depth (m)	Geotechnical laboratory test results	
			Micro-Deval (%) (LC 21-070)	Los Angeles (%) (LC 21-400)
Q-69.3-BH22-01	DC-01 to DC-03	0.00 – 4.78	9	21
Q-69.3-BH22-01	DC-04 to DC-07	4.78 – 10.64	11	22
Q-69.3-BH22-02	DC-01 to DC-04	0.23 – 4.92	11	25
Q-69.3-BH22-02	DC-04 to DC-07	4.92 – 10.87	13	23



## **5.0 Discussion and Conclusion**

The assessment undertaken to identify potential borrow sources and quarry sites was conducted to comply with the material needs for the upgrade and paving of the Waskaganish Access Road. Using aerial photo interpretation, three (3) potential granular borrow sources and three (3) potential quarry sites were identified. Two (2) of the quarry sites (Q-48 and Q-69.3) were selected for further geotechnical investigations. Two (2) boreholes were performed within each of the potential sites to describe their bedrock and to conduct laboratory tests (Micro-Deval, and Los Angeles tests). Based on the available information, the quality and quantity of the potentially suitable material were characterized. The table 8 summarizes the potential exploitable volumes identified along the Waskaganish Access Road.

**Table 8 Summary of the Potentially Exploitable Volumes Identified Along the Waskaganish Access Road**

<b>Site ID</b>	<b>Material Type</b>	<b>Estimated average material thickness (m)</b>	<b>Potential volume with respect to environmental constraints (m<sup>3</sup>)</b>	<b>Potential bedrock volume considering a swell ratio of 1.15 (once compacted)</b>
GD-40	Sand and gravel	2	50 000	N/A
GD-50	Sand and gravel	2.5	250 000	
GD-52	Sand and gravel	2.5	300 000	
Q-28.8	Bedrock	8-10	250 000	287 500
Q-48	Bedrock	5	150 000	172 500
Q-69.3	Bedrock	5	100 000	115 000
Total - Granular materials	600 000 m <sup>3</sup> considering environmental constraints			
Total - Bedrock	575 000 m <sup>3</sup> (including a swell ratio of 1.15 once compacted)			

The sites GD-40, GD-50, and GD-52 show good potential granular borrow source site development since they seem to contain a significant amount of material and would require minimum efforts for the construction of access roads. As for the potential site Q-28.8, it consists of an already open quarry with a significant amount of material that remain available to use. The potential sites Q-48 and Q-69.3 were selected for further geotechnical investigations. The laboratory results showed that the encountered bedrock in both sites was granite that would be suitable to provide the materials needed for the upgrade of the Waskaganish Access Road.



## **LA GRANDE ALLIANCE FEASIBILITY STUDY – PHASE I POTENTIAL BORROW SOURCES AND QUARRY SITES ASSESSMENT – WASKAGANISH ACCESS ROAD**

Based on the actual material requirements, the volumes contained within the delineated potential granular borrow sources and quarry sites would be sufficient to meet the needs for the upgrade and paving of the road.

However, an update of the potential borrow sources and quarry materials available should be conducted at later stages of the program as materials may have been used for other purposes in the meantime. Based on this update, a geotechnical investigation campaign should be conducted to confirm the quality and quantity (volumes) of available materials as well as the overburden thickness and the groundwater conditions at sites that were not part of this geotechnical investigation. Also, an assessment of the access road conditions should be carried out at the appropriate time to evaluate the extent of the rehabilitation work needed.

Finally, it must be noted that the location and the exploitation of borrow pits and quarries are submitted to the Regulation respecting sand pits and quarries (Chapter Q-2, r 7.1) of the Environment Quality Act (Gouvernement du Québec, 2022). The final selection and delineation of the sites should be done according to the applicable regulations in effect at the time of their exploitation.



## 6.0 References

Bureau de normalisation du Québec, 2014. Norme BNQ-2560-114/2014, Travaux de génie civil – Granulats. 69 pages.

Gestim Plus, 2023. Gestion des titres miniers. Interactive map. [https://gestim.mines.gouv.qc.ca/MRN\\_GestimP\\_Presentation/ODM02201\\_menu\\_base.aspx](https://gestim.mines.gouv.qc.ca/MRN_GestimP_Presentation/ODM02201_menu_base.aspx)

Gouvernement du Québec, Environment Quality Act, Regulation respecting sand pits and quarries (updated to 1 August 2022). <https://www.legisquebec.gouv.qc.ca/en/document/cr/Q-2,%20r.%207.1>

Hardy, L., 1977. Deglaciation, and Lacustrine and Marine Episodes on the Québec Portion of the James Bay Lowlands. Géographie Physique et Quaternaire, 31(3-4), 261-273. <https://doi.org/10.7202/1000277ar>

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Système d'information géominière du Québec (SIGÉOM), 2023. Interactive map. [https://sigeom.mines.gouv.qc.ca/signet/classes/l1108\\_afchCarteIntr](https://sigeom.mines.gouv.qc.ca/signet/classes/l1108_afchCarteIntr)



# **APPENDICES**

## **Appendix A Statement of General Conditions**



## STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Experts-conseils and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Experts-conseils present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Experts-conseils is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

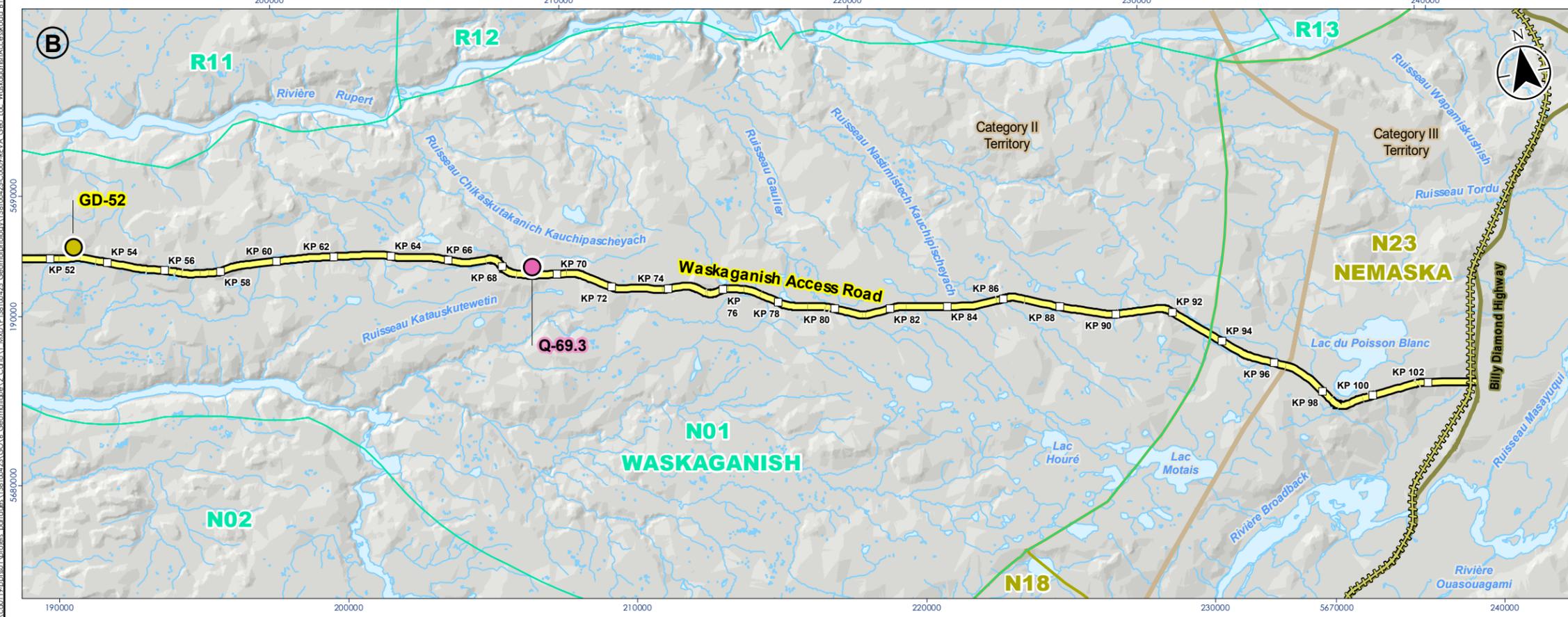
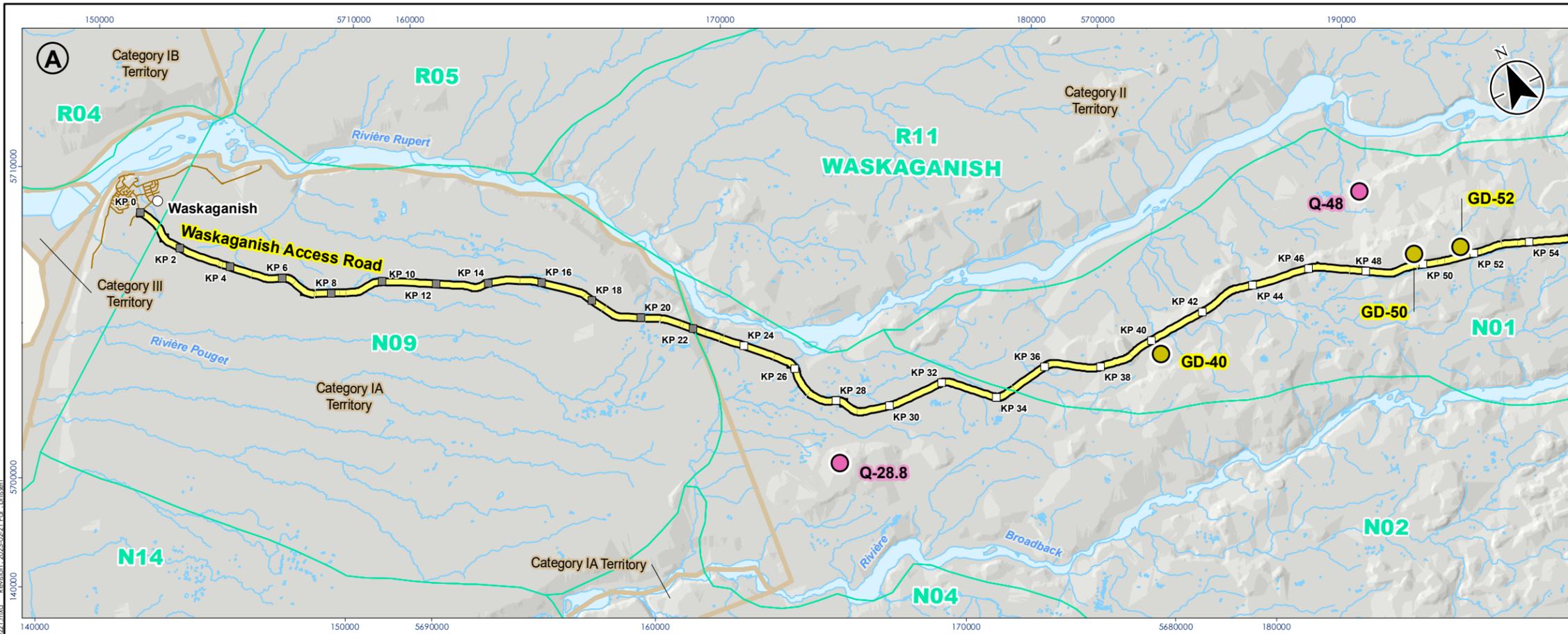
INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Experts-conseils at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Experts-conseils must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Experts-conseils will not be responsible to any party for damages incurred as a result of failing to notify Stantec Experts-conseils that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Experts-conseils, sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Experts-conseils cannot be responsible for site work carried out without being present.

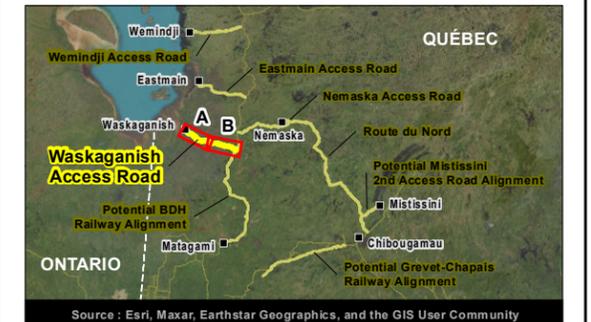
## Appendix B Figures





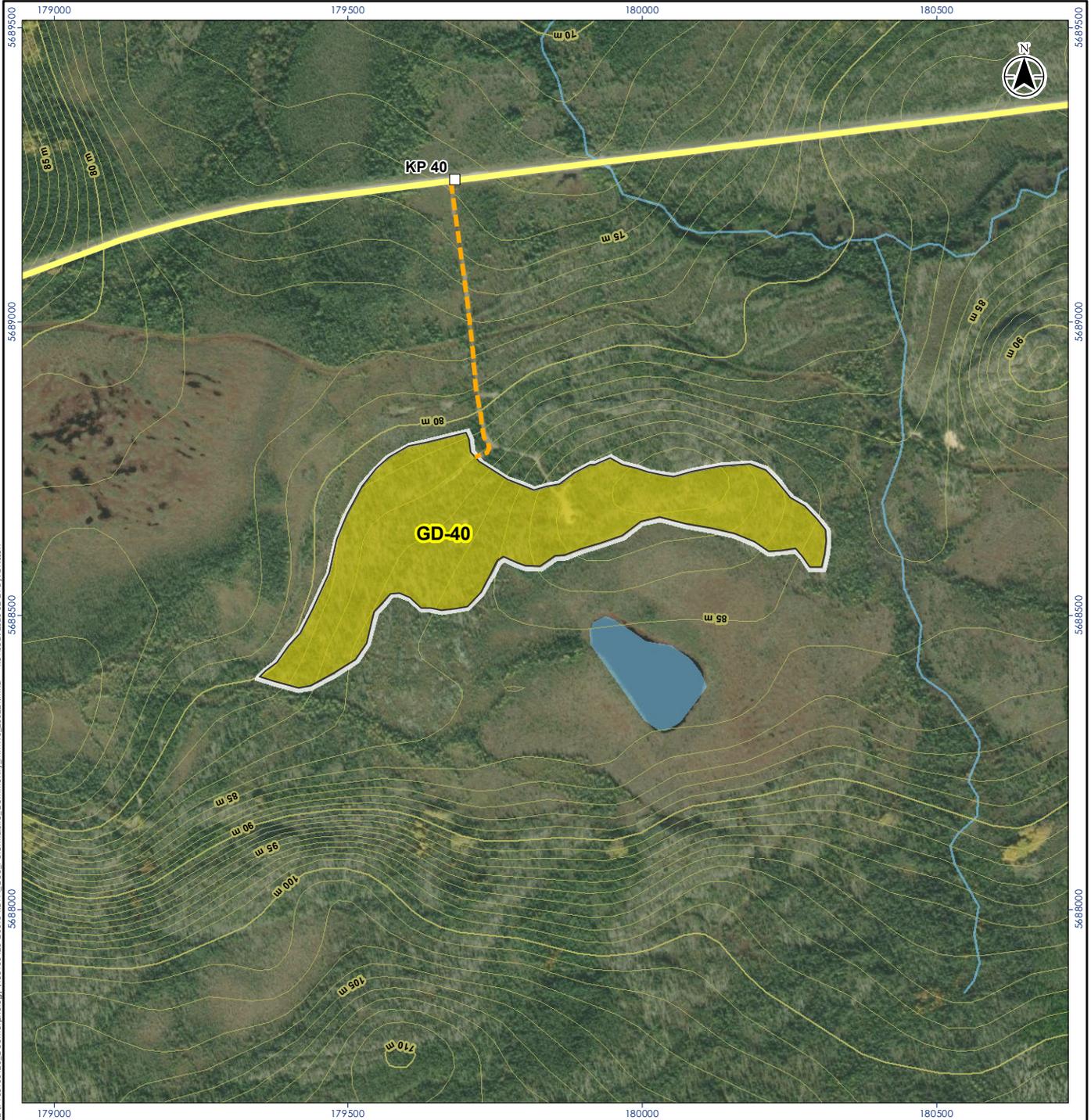
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 Client/Project Cree Development Corporation  
 La Grande Alliance – Feasibility Study  
 Phase 1  
 Project Location 158100425-C0001 REVA  
 Eeyou Itchee, Québec Prepared by Julie Brunette on 2023-02-21  
 Verified by E. Ferland on 2023-02-21  
 Independent Review by F. Vinet on 2023-02-21

- Human Environment Component**
- Cree Village
  - ▭ Category I, II or III Territory
- Study Components**
- Waskaganish Access Road
- Projected Component**
- Potential BDH Railway Alignment
- Potential Material Source**
- Potential Quarry Site (Q)
  - Potential Borrow Source (GD)
- Trapline Limit and Community Name**
- ▭ Nemaska
  - ▭ Waskaganish
- Hydrography**
- ▭ Body of water
  - - - Intermittent Watercourse
  - Permanent Watercourse
- Road Network**
- Kilometric Point (MTQ, 2021)
  - Kilometric Point (Created by Stantec)
- Road Classification**
- Local



- Notes**
1. Coordinate System: NAD 1983 CSRS MTM 8
  2. Geotechnical Investigation: Stantec, 2023
  3. Road Network: Adresses Québec, 2021
  4. Hydrography: GRHQ, 2017
  5. Orthoimagery: ESRI-World Imagery, 2017





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- Study Component**
- Waskaganish Access Road
- Projected Component**
- Proposed Access Road
- Potential Material Source**
- Potential Borrow Source (GD)

- Road Network**
- Kilometric Point (MTQ, 2021)
- Hydrography**
- Body of Water
  - Watercourse
- Topography**
- Contour line (1 m)
    - Primary
    - Secondary



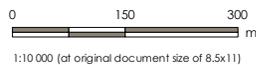
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 Prepared by J. Brunette on 2023-02-21  
 Eeyou Itchee, Québec  
 Technical Review by E. Ferland on 2023-02-21  
 Independent Review by F. Vinet on 2023-02-21

Client/Project  
 Cree Development Corporation  
 La Grande Alliance – Feasibility Study  
 Phase 1

Map No.  
**B2**

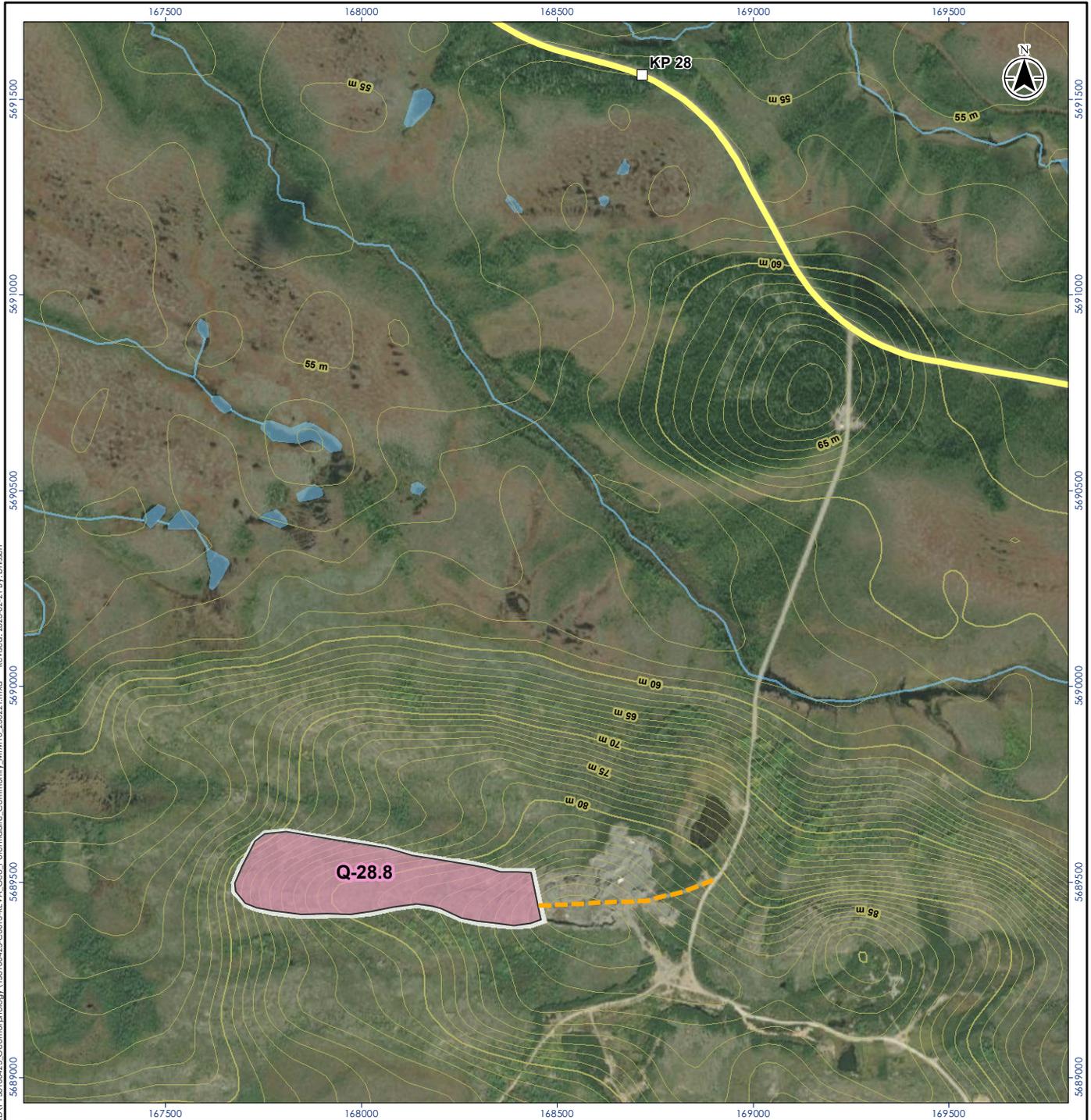
**Potential Borrow Source GD-40**

- Notes**
- Coordinate System: NAD 1983 UTM Zone 18N
  - Geotechnical Investigation: Stantec, 2023
  - Road Network: Adresses Québec, 2021
  - Hydrography: GRHQ, 2017
  - Topography: Forêt Ouverte, 2023
  - Orthoimagery: ESRI-World Imagery, 2017









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- Study Component**
- Waskaganish Access Road
- Projected Component**
- Proposed Access Road
- Potential Material Source**
- Potential Quarry Site (Q)

- Road Network**
- Kilometric Point (MTQ, 2021)
- Hydrography**
- Body of Water
  - Watercourse
- Topography**
- Primary
  - Secondary



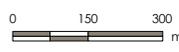
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 Prepared by J. Brunette on 2023-02-21  
 Technical Review by E. Ferland on 2023-02-21  
 Independent Review by F. Vinet on 2023-02-21

Client/Project: Cree Development Corporation  
 La Grande Alliance – Feasibility Study  
 Phase 1

Map No.: **B5**

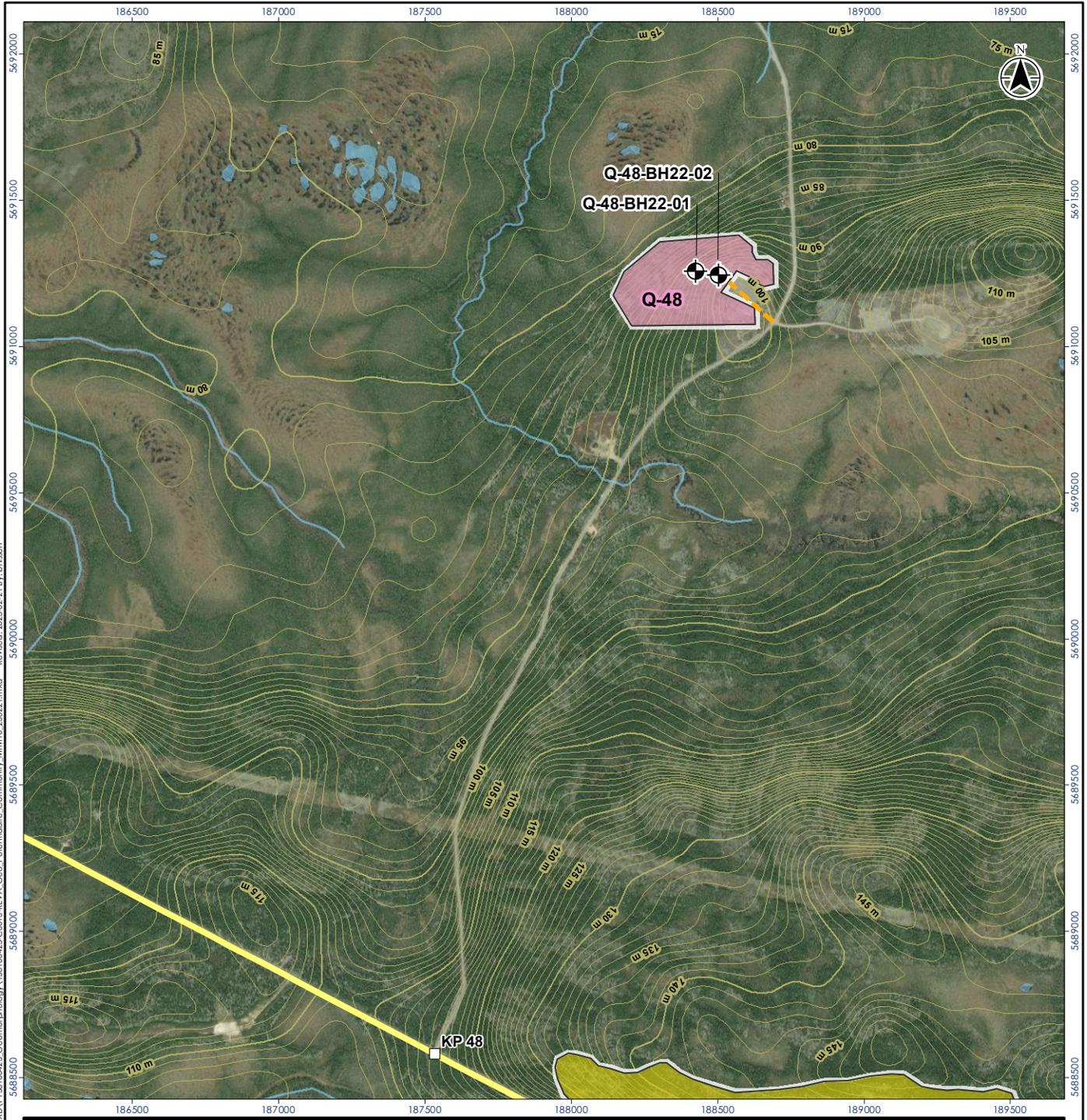
Title: **Potential Quarry Site Q-28.8**

- Notes**
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  2. Geotechnical Investigation: Stantec, 2023
  3. Road Network: Adresses Québec, 2021
  4. Hydrography: GRHQ, 2017
  5. Topography: Forêt Ouverte, 2023
  6. Orthoimagery: ESRI-World Imagery, 2017



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 Revised: 2023-02-21 By: brisen



- Study Component**
- Waskaganish Access Road
- Projected Component**
- Proposed Access Road
- Potential Material Source**
- Potential Borrow Source (GD)
  - Potential Quarry Site (Q)
- Geotechnical Investigation**
- Borehole

- Road Network**
- Kilometric Point (MTQ, 2021)
- Hydrography**
- Body of Water
  - Watercourse
- Topography**
- Contour line (1 m)
  - Primary
  - Secondary

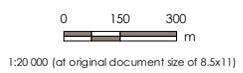


Project Location: 158100425-C0013 REV A  
 Prepared by J. Brunette on 2023-02-21  
 Technical Review by E. Ferland on 2023-02-21  
 Independent Review by F. Vinet on 2023-02-21

Client/Project: Cree Development Corporation  
 La Grande Alliance – Feasibility Study  
 Phase 1

Map No.: **B6**

Title: **Potential Quarry Site Q-48**



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## Appendix C Borehole Reports



Project: <b>La Grande Alliance - Feasibility Study - Phase I</b>	Coordinate : <b>Geo. System : MTM-NAD83 Zone: 10</b> X : <b>397 425</b> Y : <b>5 690 771</b>	Borehole : <b>Q-48.0-BH22-01</b> Page : <b>1 of 2</b> Start date : <b>2022-08-05</b> Inspector : <b>H. Desrochers, CPI</b> Depth : <b>10,19 m</b>
Project No.: <b>158100425.500.710.2</b>	Type of borehole : <b>Diamond Core</b>	
Client: <b>Cree Development Corporation</b>	Equipment : <b>CME</b>	
Site: <b>Waskaganish Access Road</b>	Sampling type : <b>NQ</b>	Figure :

SAMPLE TYPE	QUALITATIVE TERMINOLOGY	QUANTITATIVE TERMINOLOGY	SYMBOLS	GROUNDWATER						
SS Split spoon CS Continuous sampling DC Diamond rock core AS Auger TW Thin wall sampler ST Shelby tube MA Manual sample	Clay < 0.002 mm Silt 0.002 - 0.08 mm Sand 0.08 - 5 mm Gravel 5 - 80 mm Cobbles 80 - 200 mm Boulders > 200 mm	Traces < 10 % Some 10 - 20 % Adjective (...y) 20 - 35 % and (ex: and gravel) > 35 % Main word Dominant fraction	N Standard penetration value (ASTM D 1586) Nc Dynamic cone penetration value (BNQ 2501-145) RQD Rock Quality Designation (%)	<table border="1"> <tr><th>Date</th><th>Depth</th></tr> <tr><td>Reading 1</td><td>m</td></tr> <tr><td>Reading 2</td><td>m</td></tr> </table>	Date	Depth	Reading 1	m	Reading 2	m
Date	Depth									
Reading 1	m									
Reading 2	m									

SAMPLE STATE	MECHANIC CHARACTERISTICS OF SOILS	ROCK QUALITY DESIGNATION	JOINTS SPACING
Remoulded Intact (thin wall sampler) Lost Core (diamond rock core)	COMPACTION INDEX "N" Very loose 0 - 4 Loose 4 - 10 Compact 10 - 30 Dense 30 - 50 Very dense > 50	CONSISTENCY Very soft < 12 Soft 12 - 25 Firm 25 - 50 Stiff 50 - 100 Very stiff 100 - 200 Hard > 200	QUALIFICATIVE RQD Very poor < 25 % Poor 25 - 50 % Fair 50 - 75 % Good 75 - 90 % Excellent 90 - 100 %

STRATIGRAPHY			SAMPLES					TESTS		REMARKS				
DEPTH (m)	DEPTH (ft)	DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	CALIBER	RECOVERY (%)		N - RQD	Standard penetration test BLOWS/150mm	WATER LEVEL / WATER INFLOW	GA : grain size analysis H : hydrometer test C : consolidation W : water content W <sub>l</sub> : liquid limit W <sub>p</sub> : plastic limit Dr : specific gravity k : permeability f <sub>c</sub> : compressive str. OM: organic matter CA : chemical analyses
		0.00	Destructive drilling with casing.											
		0.13	Bedrock : Grey GRANITE, of excellent quality.	+										
1				+		DC-01		NQ	100	95				
5				+		DC-02		NQ	98	93				
2				+		DC-03		NQ	100	97				
3		10		+										
4				+										
		15		+										

General remarks:	Verified by : B. Cyr, géo. Date : 2023-01-23
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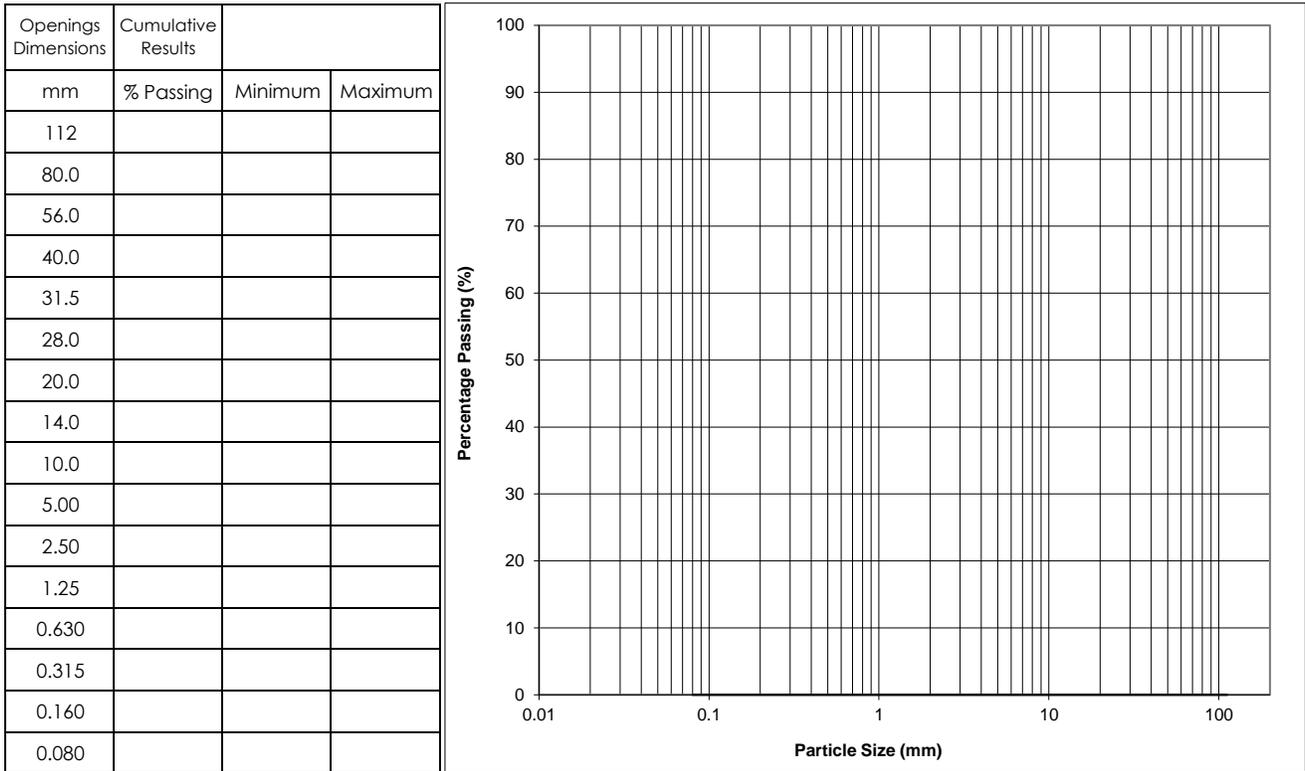


## **Appendix D Laboratory Test Results**



Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 05, 2022
Sample No : Q-48-BH22-01 DC-01 to DC-04	
Depth : 0,13 - 5,21m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



Soils Classification		Modified Proctor (BNQ 2501-255)	
% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

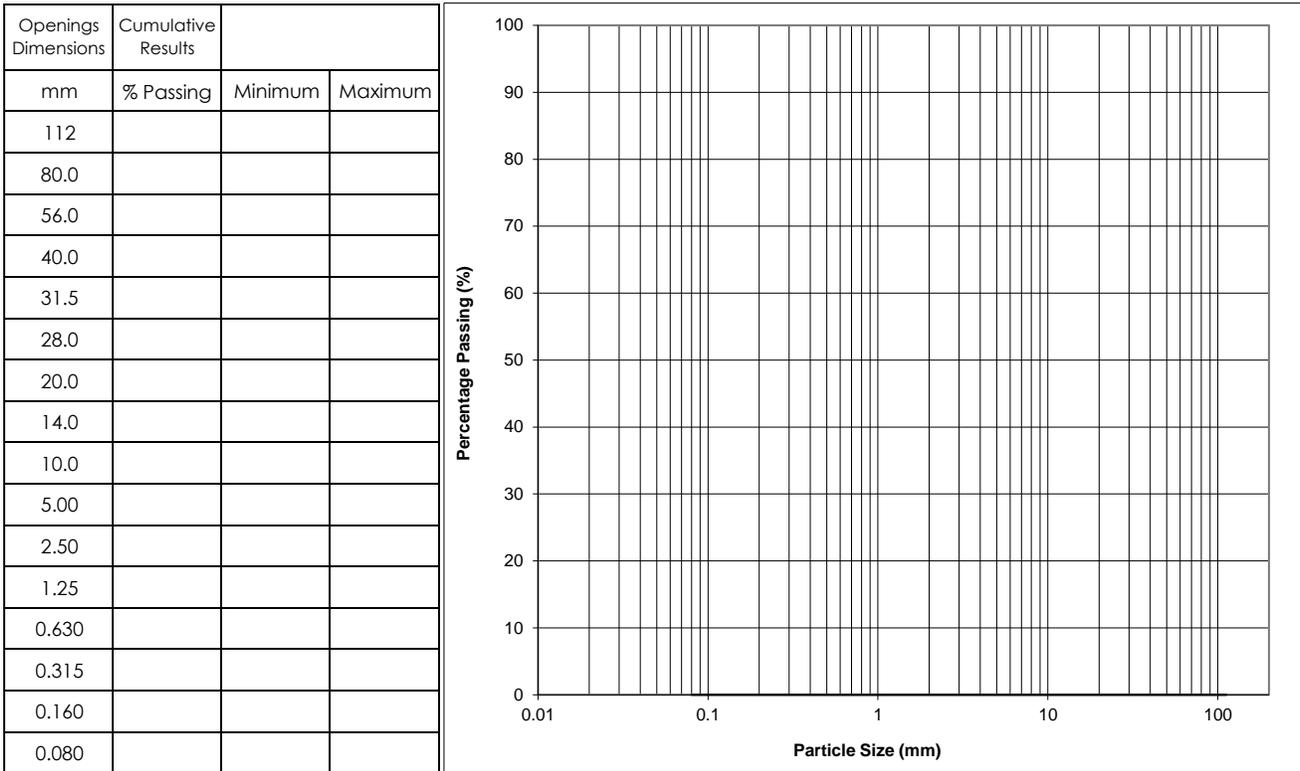
Other Tests							
Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading A) (LC 21-400) (%)	24						
Micro Deval (grading F) (LC 21-070) (%)	13						

Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .Geo #786 \_\_\_\_\_ Date: January 27, 2023

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.	Sampling Date : August 05, 2022
Sample No : Q-48-BH22-01 DC-04 to DC-07	
Depth : 5,21 - 9,60m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



**Soils Classification**

**Modified Proctor (BNQ 2501-255)**

% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

**Other Tests**

Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading A) (LC 21-400) (%)	19						
Micro Deval (grading F) (LC 21-070) (%)	10						

Remarks :

\_\_\_\_\_

Prepared By:

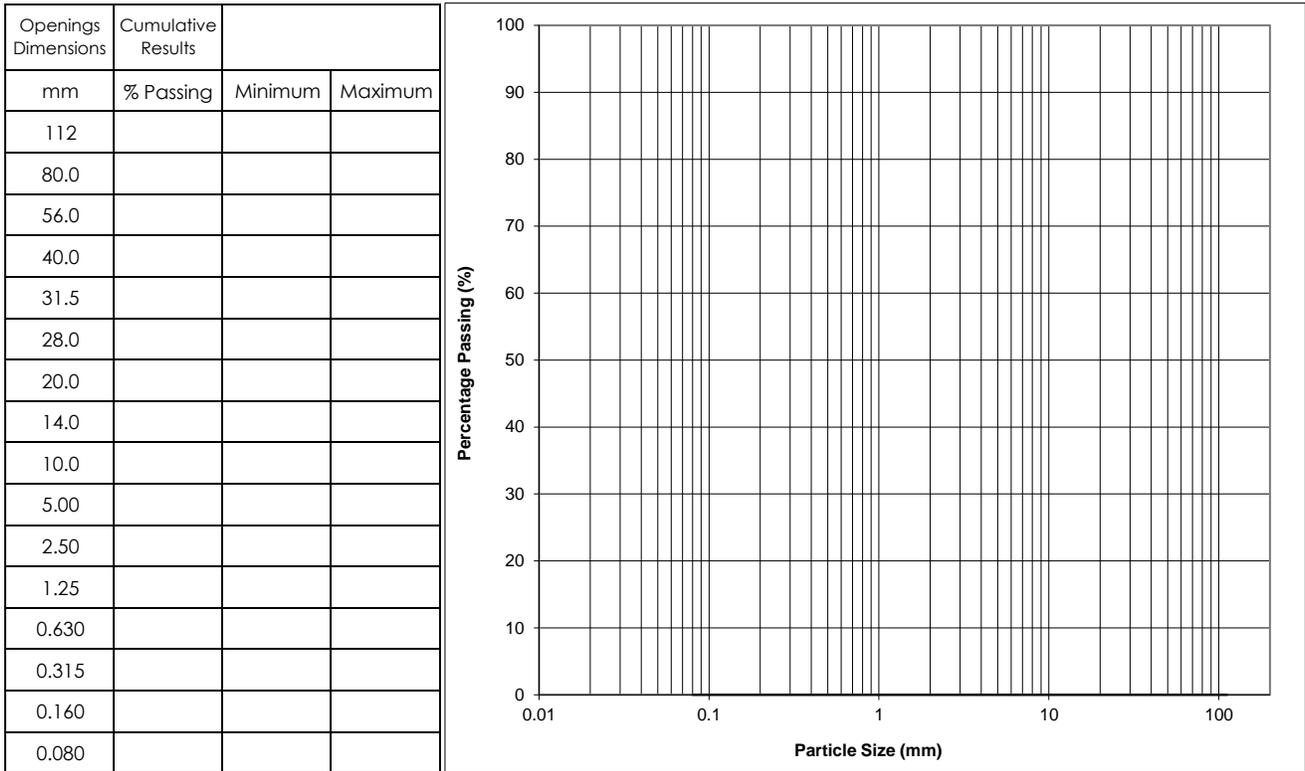
Benoit Cyr, Geo. *BJ* .Geo  
#186

Date: January 27, 2023

\_\_\_\_\_

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 04, 2022
Sample No : Q-48-BH22-02 DC-01 to DC-03	
Depth : 0,00 - 4,80m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



Soils Classification		Modified Proctor (BNQ 2501-255)	
% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

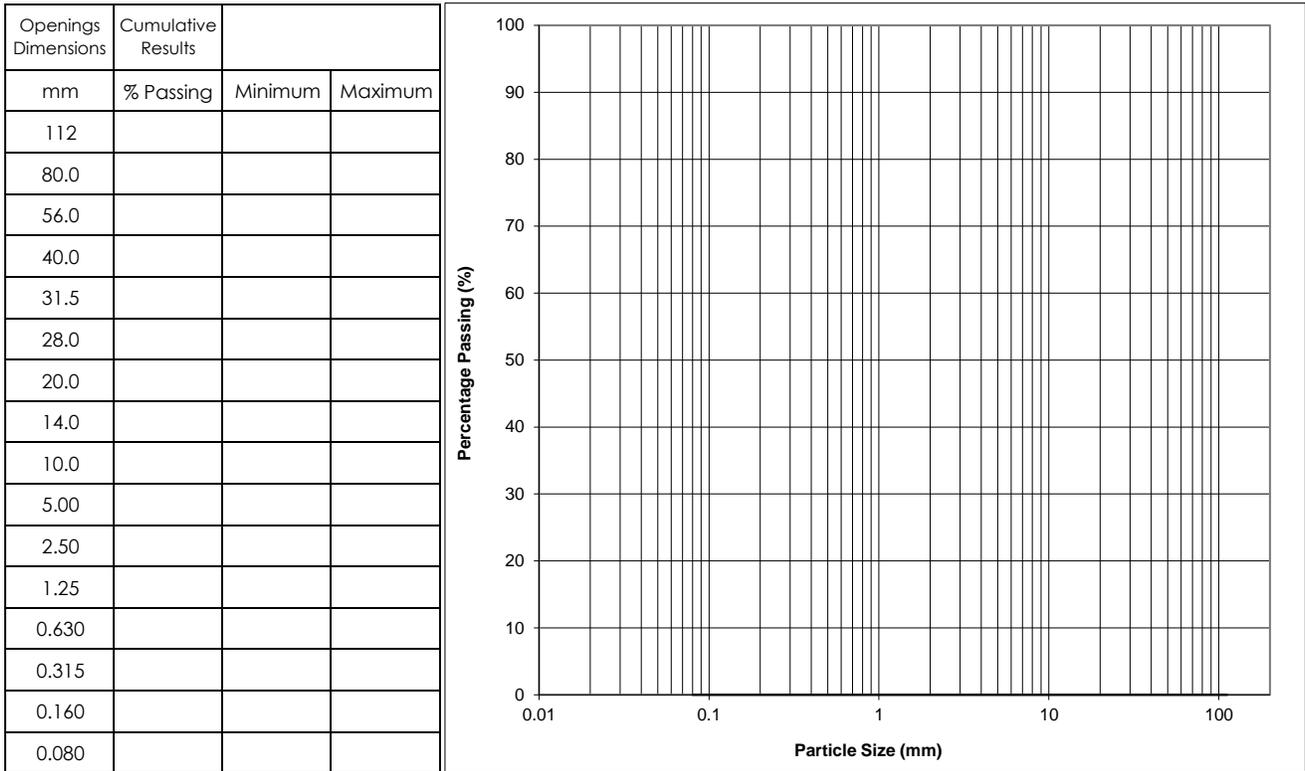
Other Tests							
Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading A) (LC 21-400) (%)	18						
Micro Deval (grading F) (LC 21-070) (%)	10						

Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .Geo #786 \_\_\_\_\_ Date: January 27, 2023 \_\_\_\_\_

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 04, 2022
Sample No : Q-48-BH22-02 DC-04 to DC-07	
Depth : 4,80 - 10,67	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



Soils Classification		Modified Proctor (BNQ 2501-255)	
% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

Other Tests							
Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading B) (LC 21-400) (%)	19						
Micro Deval (grading F) (LC 21-070) (%)	10						

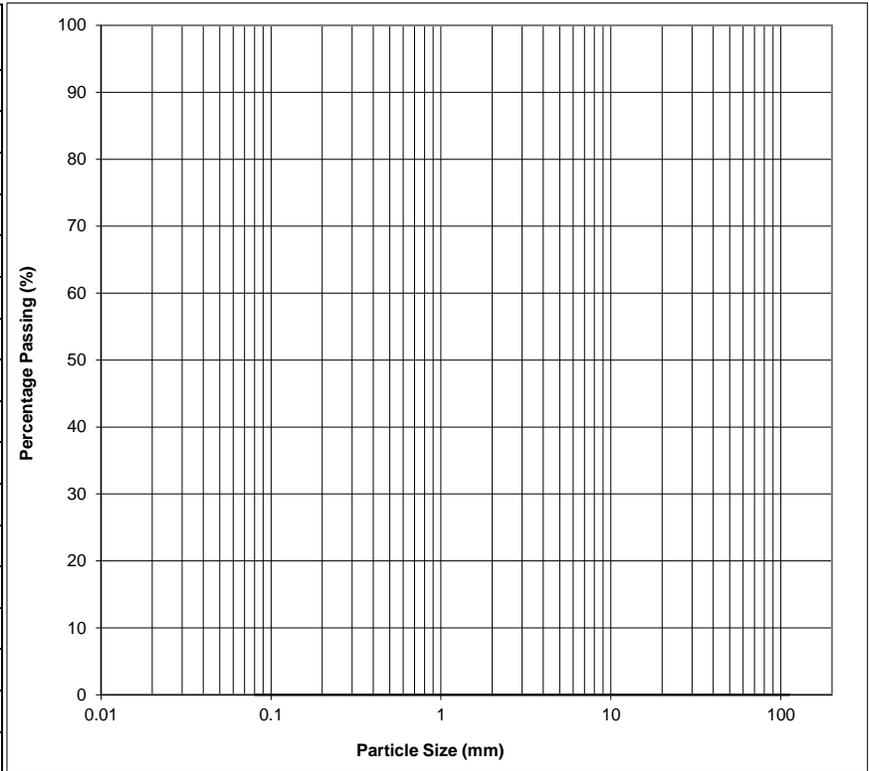
Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .Geo #786 Date: January 27, 2023

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 05, 2022
Sample No : Q-69.3-BH22-01 DC-01 to DC-03	
Depth : 0,00 - 4,78m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**

Openings Dimensions	Cumulative Results		
mm	% Passing	Minimum	Maximum
112			
80.0			
56.0			
40.0			
31.5			
28.0			
20.0			
14.0			
10.0			
5.00			
2.50			
1.25			
0.630			
0.315			
0.160			
0.080			



Soils Classification		Modified Proctor (BNQ 2501-255)	
% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

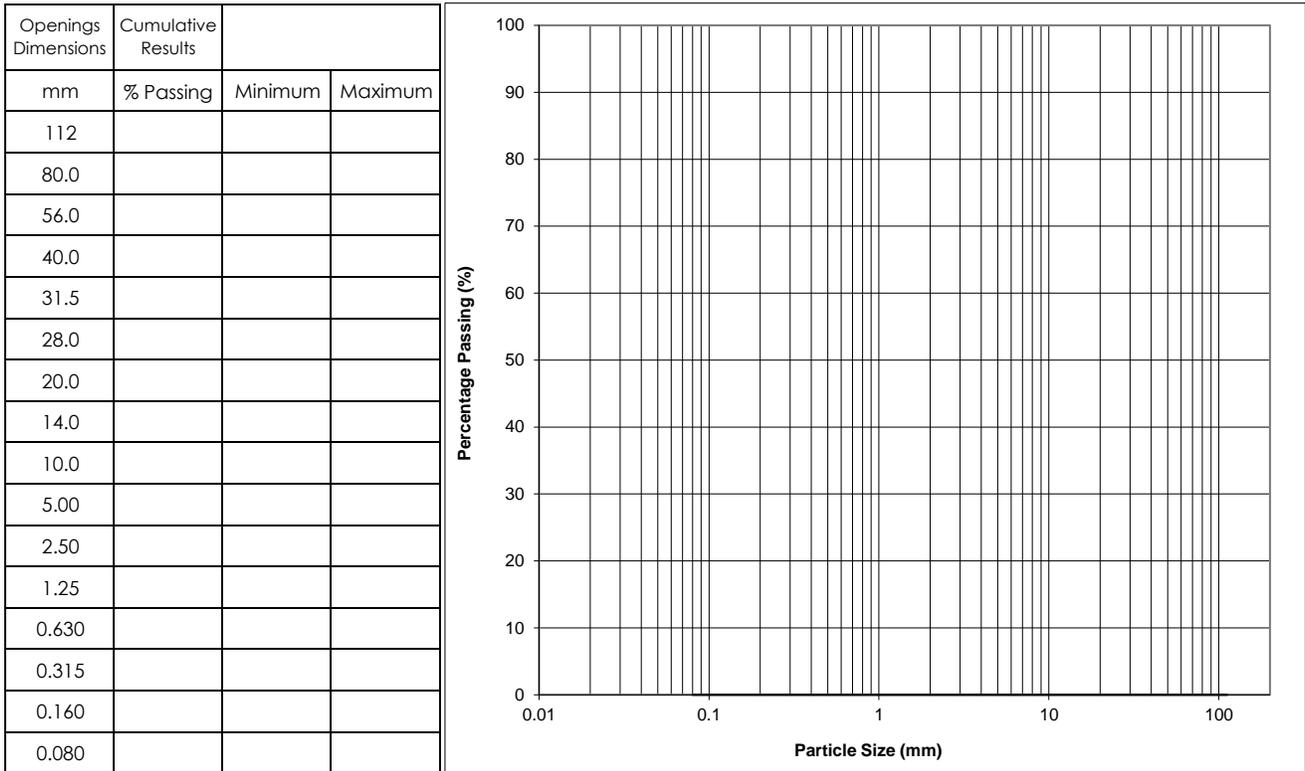
Other Tests							
Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading B) (LC 21-400) (%)	21						
Micro Deval (grading F) (LC 21-070) (%)	9						

Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .Geo #786      Date: January 27, 2023

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 05, 2022
Sample No : Q-69.3-BH22-01 DC-04 to DC-07	
Depth : 4,78 - 10,64m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



Soils Classification		Modified Proctor (BNQ 2501-255)	
% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

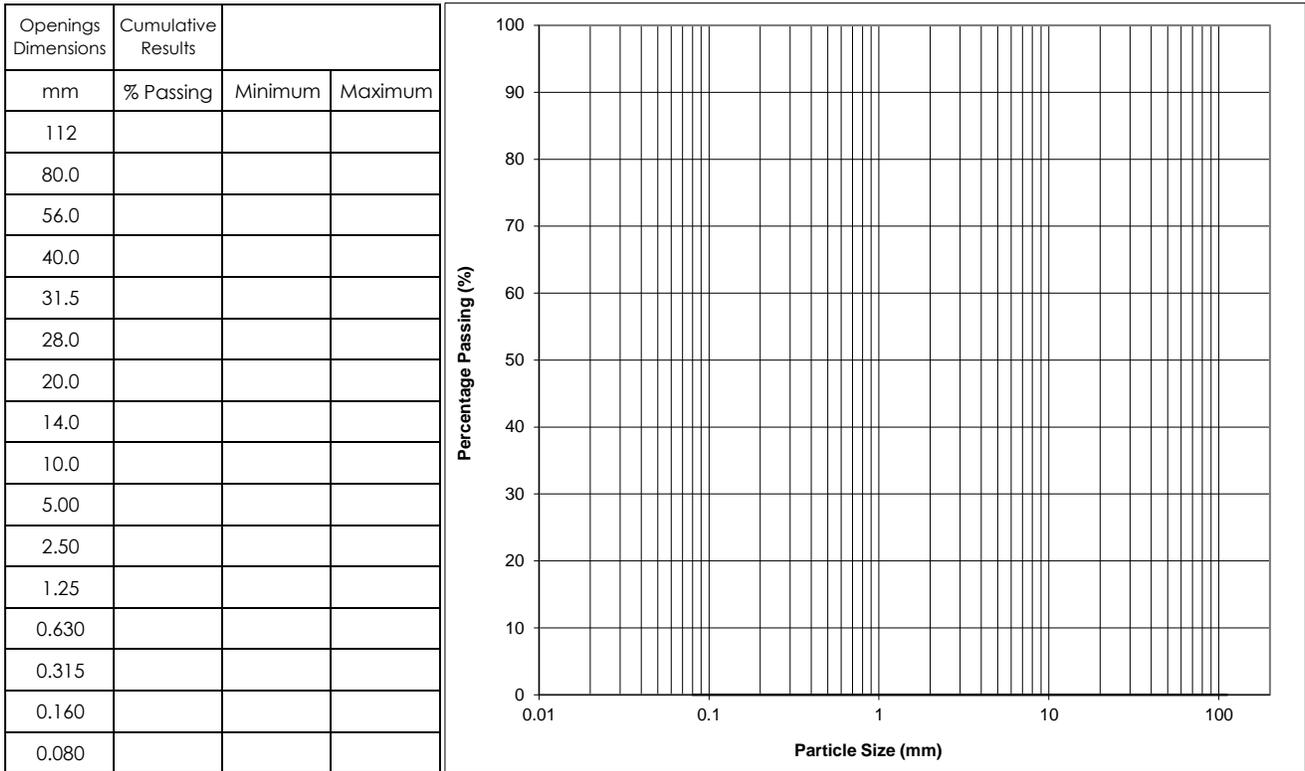
Other Tests							
Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading B) (LC 21-400) (%)	22						
Micro Deval (grading F) (LC 21-070) (%)	11						

Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .Geo #786 Date: January 27, 2023

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 06, 2022
Sample No : Q-69.3-BH22-02 DC-01 to DC-04	
Depth : 0,23 - 4,92m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



Soils Classification		Modified Proctor (BNQ 2501-255)	
% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

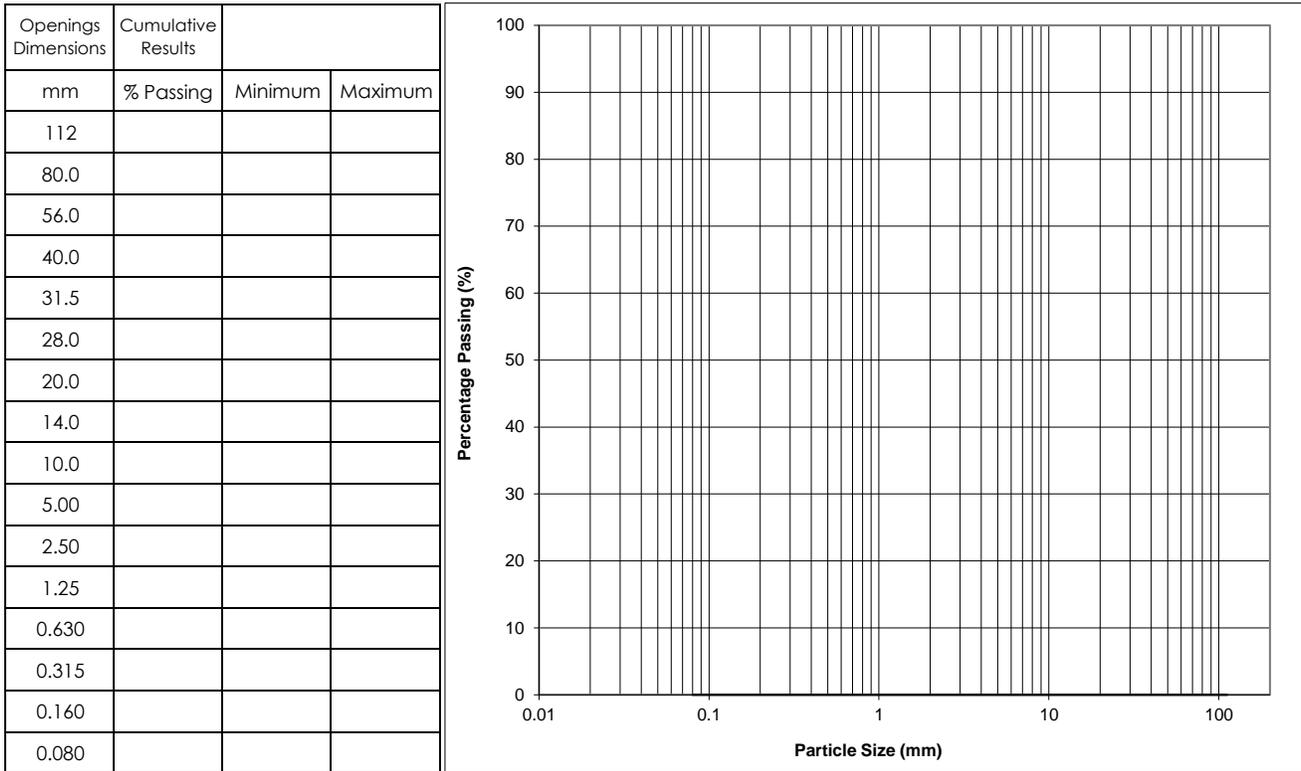
Other Tests							
Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading B) (LC 21-400) (%)	25						
Micro Deval (grading F) (LC 21-070) (%)	11						

Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .Geo #786      Date: January 27, 2023

Client : Cree Development Corporation	Type of material : Crushed rock cores
Project : La Grande Alliance - Feasibility Study - Phase I Waskaganish Access Road	Sampled by : Khaled Haiek
Project No : 158100425.500.710.2	Sampling Date : August 06, 2022
Sample No : Q-69.3-BH22-02 DC-04 to DC-07	
Depth : 4,92 - 10,87m	

**Sieve Analysis (LC 21-040 / BNQ 2501-025 )**



**Soils Classification**

**Modified Proctor (BNQ 2501-255)**

% Gravel		Testing Method used	
% Sand		Maximum Dry Unit Weight (kg/m <sup>3</sup> )	
% Fine Particles		Optimum Moisture Content (%)	

**Other Tests**

Test / Standard	Results	Requirements		Test / Standard	Results	Requirements	
		Min	Max			Min	Max
Los Angeles (grading B) (LC 21-400) (%)	23						
Micro Deval (grading F) (LC 21-070) (%)	13						

Remarks : \_\_\_\_\_

Prepared By: Benoit Cyr, Geo. *BJ* .GEO #786

Date: January 27, 2023

## **Appendix E Photographic Album**





Photo 1: Q-48-BH22-01 (Wet)



Photo 2: Q-48-BH22-01 (Dry)



Photo 3: Q-48-BH22-02 (Wet)



Photo 4: Q-48-BH22-02 (Dry)



Photo 1: Q-69.3-BH22-01 (Wet)



Photo 2: Q-69.3-BH22-01 (Dry)



Photo 3: Q-69.3-BH22-02 (Wet)



Photo 4: Q-69.3-BH22-02 (Dry)