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LABEC CENTURY IRON ORE INC.

Joyce Lake and Area DSO Project Geotechnical Engineering Feasibility Study – Open Pit Design

Final Report

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LVM, a division of EnGlobe Corp.

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1 INTRODUCTION

1.1 MANDATE AND SCHEDULE OF WORK

In September 2014, Labec century Iron Ore inc. (LCIO) granted the mandate to WESA, a division of BluMetric, (WESA) and LVM inc., a Division of Englobe Corporation inc. (LVM) to respectively perform Hydrogeological and Geotechnical Feasibility Studies for the Joyce Lake and Area Direct Shipping Ore (Joyce Lake DSO) Project.

The mandate included site work consisting of drilling boreholes, logging cores and in situ testing for both the Hydrogeological and Geotechnical aspects. The site investigation work was followed by laboratory testing and a series of three study reports cover the site investigation. WESA is responsible for the Hydrogeology feasibility Study and LVM is responsible for the Geotechnical Feasibility Study. The geotechnical Feasibility Study is two folds: one part concerns the pit slope analysis and design and, the other one concern the mine infrastructures of the surrounding areas. This report presents the results of the pit slope analysis and design.

The three stand-alone reports are:

- Joyce Lake and Area DSO Project Hydrogeological Study;
- Joyce Lake and Area DSO Project Geotechnical Engineering Feasibility Study Open Pit Design (Current Report);
- ► Joyce Lake and Area DSO Project Geotechnical Feasibility Study Surrounding Areas.

The site investigation work, the study and the reporting have been completed during Fall 2014.

1.2 **PROJECT DESCRIPTION**

The Joyce Lake property is located in the western part of the Labrador Trough iron range and about 1,200 km northeast of Montreal and 20 km north east of the town of Schefferville (see Appendix 1). The Joyce Lake DSO project mainly consists of an Open Pit Mining, Beneficiation Plant, Access roads, Workers Camp, Haul road leading to a railway loop and loading station. The ore is extracted from the pit, sent to a dry plant to be processed, loaded on trucks, hauled to the loading railway loop and loaded on train for shipment to the Pointe Noire Harbour facility near Setp-Îles, Québec. The general layout of the installations is shown on Appendix 1.

1.3 **REPORT ORGANIZATION**

The report is composed of 10 chapters. The current chapter introduces the scope and schedule of the project and the structure of the report. The general site characteristics and geological settings are presented in chapter 2. The field investigation work is described in chapter 3. The geotechnical characteristic of the lithology, of the intact rock and the rock mass are presented in chapter 4. Chapters 6 and 7 address the pit slope design and stability issues. Finally, chapters 8 and 9 present the recommendations and conclusion of the report. While chapter 10 presents the list of references.



2 SITE PHYSICAL SETTING

Most of the background and geological information was obtained from previous studies and reports, conducted for the Joyce Lake project. This includes reports prepared by CIMA+ (*Preliminary Economic Assessment (PEA) Study Report for the Joyce Lake DSO Project*), SRK (*Independent Technical Report, Attikamagen Iron Project, Schefferville Area, Québec*) and SGS (*Mineral Resource Update Joyce Lake DSO Iron Project Newfoundland & Labrador / NI 43-101 Technical Report Joyce Lake DSO Iron Project NewfoundLand & Labrador*). Some excerpts from these reports are presented in this chapter.

2.1 LOCATION

The Joyce lake property is located on a peninsula, bordered by the Attikamagan Lake. The peninsula is about 3.5 km wide where Joyce Lake is located. The lake itself is oblong and oriented approximately N300 with roughly a length of 1360 m and a width of 340 m. The proposed open pit mine is located north-west of Joyce Lake and intercepts the lake in its West part.

The South part of the Attikamagan Lake, named Iron Arm range, separates the Joyce Lake peninsula from the South shore of Attikamagan Lake.

There is no access road connecting the Joyce Lake property to western Labrador or elsewhere in Quebec. There is a gravel road connecting Schefferville to Iron Arm South shore. Some locals have seasonal cabins along the Iron Arm range south shore.

There are presently no roads connecting the Iron Arm Camp South shore to Joyce Lake property on its North Shore. Helicopter or floatplane can access Joyce Lake at Summer time or skidoos can be used to cross Iron Arm range during winter time.

Figure 1 shows the location of the project.





2.2 REGIONAL GEOLOGY

Figure 2 shows regional geology and major geological structures (faults, foliation and bedding) around Joyce Lake.





Figure 2: Regional geology around Joyce Lake (after Geology of the South-Central Labrodor Trough, Map 82-5, Government of Canada)

2.2.1 Lithology

The Labrador Trough, that is also called the Labrador-Quebec Fold Belt, extends North-South for more than 1,000 km along the eastern margin of the Superior craton from Ungava Bay to Lake Pletipi, Quebec. The belt is about 100 km wide in its central part and becomes narrower at the north and south.



The Labrador Trough is a sequence of Proterozoic sedimentary rocks including iron formation, volcanic rocks and mafic intrusions forming the Kaniapiskau Supergroup. The Kaniapiskau Supergroup is comprised of the Knob Lake Group in the western part and the Doublet Group which is primarily volcanic in the eastern part. To the west of Schefferville, rocks of the Knob Lake Group lie unconformably on Archean gneisses and, to the east; they pass into the eugeosynclinal facies of the Labrador Trough. The Kaniapiskau Supergroup has been intruded by numerous diabase dikes known as the Montagnais Intrusive Suite. These dikes along with the Nimish volcanic rocks are the only rock types representing igneous activity in the western part of the central Labrador Trough.

The Knob Lake Group includes the Sokoman Formation which is the main exploration target of the Joyce Lake Iron Project.

2.2.2 Deposit Geology

The iron formations of the Sokoman Formation are classified as Lake Superior type. They consist of a banded sedimentary unit composed principally of bands of magnetite and hematite within chert-rich rocks and variable amounts of silicate-carbonate-sulphide. Such iron formations have been the principal sources of iron throughout the world. Superior-type iron formations with low iron tenor can be locally brought to "ore grade" through the process of enrichment by leaching and deep weathering processes due to seepage of meteoric and syn-orogenic fluids. Hydrothermal and meteoric fluids circulating through the banded iron formation during the Hudsonian orogenesis recrystallized iron minerals to hematite, and leached silica and carbonate gangue. The result is a residually enriched iron formation that may be further enriched, whereby iron oxides (goethite, limonite), hematite and manganese are redistributed into the openings left by the primary leaching phase, and/or deposited along fracture/cleavage surfaces and in veinlets. Almost all the iron deposits near surface in the Labrador Trough are enriched to some degree by these processes. The minimum iron content required to be considered as economic at a given market price is generally greater than thirty percent iron. Iron oxides must also be amenable to concentration (beneficiation) and the concentrates produced must be low in manganese, aluminum, phosphorus, sulphur and alkalis. Beneficiation involves segregating the silicate and carbonate gangue and other rock types inter-bedded within the iron formation from the iron-rich oxides.

The iron formation occurring on the Joyce Lake Iron Project consists mostly of subunits of the Sokoman Formation characterized by recrystallized chert and jasper with bands and disseminations of magnetite, hematite and martite; a type of hematite pseudomorph after magnetite and specularite. Other gangue minerals are a series of iron silicates comprised of minnesotaite, pyrolusite and stilpnomelane and iron carbonate, mainly siderite.



2.2.3 Major Structures

Three major structural zones have been identified in the area of Joyce Lake:

- Western marginal zone (Howells River area);
- Zone of close spaced folds and thrust faults (Schefferville Mining District);
- Eastern zone of more widely spaced folds and faults.

The Iron Arm - Attikamagen Lake area is within the Eastern Zone and lies on the eastern limb of the Petitsikapau Synclinorium, a major structural feature in the central part of this zone.

The Eastern Zone lies to the northeast of the Knob Lake thrust fault and extends to the Iron Arm - Attikamagen Lake area (Harrison et al., 1972). It is believed to be underlain by strata of the Attikamagen, Denault, Dolly, Wishart, Ruth, Sokoman and Menihek Formations. Apart from the Knob Lake fault, only one other major thrust fault was defined by Harrison et al. (1972) in this area. This fault lies about 3.2 km east of the Knob Lake fault and brings strata of the Denault against the Sokoman Formation.

As shown on figure 2, the structural picture is a confused one around Joyce Lake. At least three episodes of deformation have identified on previous field exploration.

2.3 CLIMATE AND PHYSIOGRAPHY

The Schefferville area has a subarctic continental taiga climate with very harsh winters. Daily average temperatures exceed 0 °C for only five months a year. Daily mean temperatures for Schefferville average - 24.1 °C and -22.6 °C in January and February respectively. Mean daily average temperatures in July and August are 12.4 °C and 11.2 °C, respectively. Snowfall in November, December and January generally exceeds 50 cm per month and the wettest summer month is July with an average rainfall of 106.8 mm.

The Joyce Lake Property is located within a relatively rugged physiography with rolling hills and valleys reflecting the structure of the underlying bedrock. Elevation in the Project Area can vary from 472 m on the shores of Iron Arm up to 583 m at the high point. Joyce Lake surface is about 502 m in elevation. The natural overburden material in the area is mainly composed of till and glacial deposits are present throughout the area, except on the ridgelines.

2.4 PERMAFROST

Permafrost in the area of Schefferville is described as Sporadic. Usually, permafrost is found in high grounds where snow cover is minimized by winds and is not generally present near and under wetlands and lakes. Visual observations at the open pit site have shown that the overburden thickness is not important and that rock outcrops are well present.



3 GEOTECHNICAL SITE INVESTIGATION

3.1 PLANNED OPEN PIT MINE

An optimized open pit shell was developed by others based on the block model of the resource for Joyce Lake project. The optimised open pit constitutes the minimal excavation required for access to the iron ore, meeting the DSO mining criteria. The optimized open pit layout as of September 22nd 2014 is shown in Appendix 1. The proposed open pit reaches a depth of about 150 m and it extends approximately 700 m in East-West and 600 m in North-South direction.

3.2 SITE INVESTIGATION PROGRAM

The geotechnical site investigation for the feasibility study of the open pit consisted of four inclined boreholes (BH-P-01 to BH-P-04), driven to a vertical depth of 150m. The field work campaign took place from September 22nd to October 13th, 2014. This investigation included:

- Drilling of four inclined HQ-3 size diamond coring geotechnical holes with core orientation;
- Geotechnical core logging including description and orientation of discontinuities;
- Core photographs; and
- Collection of rock samples for laboratory testing.

A total of 653 m core was drilled. The geotechnical boreholes were oriented against the pit wall slopes. The locations of the four boreholes are shown in Appendix 1 along with the locations of the four vertical boreholes performed by WESA within the scope of the hydrogeological feasibility study. Rock description of the WESA boreholes were taken into consideration within this study.

In order to respect the schedule and to meet the high quality requirement of the project, three senior geologists of LVM were mobilized on the site. The drilling work was undertaken 24 hours a day under the supervision of two senior geologists (day and night shifts). A first logging was performed by one of these senior geologists at the drill shack as drilling proceeds. A second logging and verification was done by a third senior geologist, after transporting the core boxes by helicopter to Schefferville at the LCIO core shack.

3.3 BOREHOLE DRILLING

The boreholes were drilled using a Boart-Longyear LF-70 drill rig. The LF-70 modular design consists of seven sections that can be moved by helicopter for reaching remote locations. The drilling core size was HQ-3 (triple core barrel) and occasionally HQ size was used in highly crushed rock zones. The diameter of the rock cores are 61.1 and 63.5 mm, respectively.

Core orientation is considered an essential piece of data in order to assess the main orientation of discontinuities and estimate geomechanical properties of rock masses. It allows identifying precisely the original orientation of a core sample prior to its extraction from the ground. The CorientR device developed by Fordia inc. in Canada was used to identify the bottom of the core in order to determine its original orientation in the rock mass. Based on the



orientation data collected from these holes, stereographic projections were prepared and are presented in chapter 4.

3.4 BOREHOLES SURVEY

Initials boreholes ground survey was performed using a hand held GPS and by measuring the elevation of the surface ground on the LIDAR 3D topographic model available for the project. The drilling sites were flat and horizontal. The precision of the location and elevation using this method is satisfactory in view of the open pit size and depth.

Final survey was performed by LCIO at the end of site investigation work using high precision differential GPS (DGPS).

3.5 DOWNHOLE SURVEY

Deviation of the inclined holes during drilling advancement is sometimes significant, especially with long boreholes and small drilling sizes. A Ranger Borehole Survey System was used to monitor the plunge angle and azimuth deviations along the full boreholes lengths. The instrument is inserted in the borehole after completion.

Deviations from the hole alignment were measured and represent less than 2% of the angles which is considered acceptable.

3.6 GEO-MECHANICAL CORE LOGGING

The core logging was performed in two steps. A first core logging was performed by a senior geologist at the drill rig, as drilling proceeds. It consisted in documenting the rock cores and nature of the rock formation, the run length and the depth of the beginning and the end of the run. The following parameters were recorded and measured at this stage:

- Rock Type and Geological Description.
- TCR: Total Core Recovery (%) is the total length of the core recovered, including broken zones, divided by the total length of the core drilled.
- RQD: Rock Quality Designation- is determined from the following expression proposed by Deere et al. (1969): RQD (%) =100 times the sum of the lengths of core in pieces equal to or longer than 10 cm divided by the length of core run.
- Fracture frequency is the number of natural fractures which occur over the length of core examined or per unit length (Mechanical breaks and fractures with length of persistence less than the core diameter is not included in this calculation).

Once these parameters were included in the borehole log, the rock cores were photographed to document the state of the cores prior to shipment to the core shack located in Schefferville. The Core boxes were transported by helicopter directly from the drill rig to the core shack.

A second geologist, in Schefferville, completed the core logging by assessing the strength of intact rock and its weathering and/or alteration indices as well as measuring the structural properties of discontinuities of the cores.



The hardness scale shown in Table 1, based on the International Society of Rock Mechanics (ISRM, 1981), was employed for field estimation of intact rock strength.

The ISRM strength classification is based on simple mechanical tests, which can be easily performed in the field. Wherever possible, the full range of tests was performed to determine hardness, including hitting the core with a rock hammer, scraping or peeling with a knife and scratching with the thumbnail, as per the procedures described in the table.

GRADE	DESCRIPTION	FIELD IDENTIFICATION	APPROXIMATIVE RANGE OF UNIAXIAL COMPRESSIVE STRENGTH (MPa)
R0	Extremely weak rock	Indented by thumbnail	0.25 – 1.0
R1	Very weak rock	Crumbles underfirm blows with point of geological hammer, can de peely by a pocket knife	1.0 – 5.0
R2	Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5.0 – 25
R3	Medium strong rock Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow or geological hammer		25 – 50
R4	Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50 – 100
R5	Very strong rock	Specimen requires many blows of geological hammer to fracture it	100 – 250
R6	Extremely strong rock	Specimen can only be chipped with geological hammer	> 250

Table 1: Strength Index description (after ISRM, 1981)

The degree of weathering and/or alteration was recorded on a per run basis during the geotechnical core logging. The weathering process describes the breakdown of rock by physical processes, while the hydrothermal and/or supergene alteration processes cause the alteration and breakdown of the intact rock by chemical processes. The degree of weathering or alteration tends to cause a reduction in the rock strength and competency. Table 2 was used to describe the degree of weathering as defined by the ISRM (1981).

TERM / SYMBOL	DESCRIPTION	DISCOLORATION EXTENT	FRACTURE CONDITION / SURFACE CHARACTERISTICS
Fresh / W1	No visible sign of rock material weathering.	None	Closed or Discolored / Unchanged
Slightly weathered / W2	Discoloration indicates weathering of rock material on discontinuity surfaces. Less than 5% of rock mass altered.	< 20 % of fracture spacing on both sides of fracture	Discolored, may contain thin filling / Partial discoloration
Moderately weathered / W3	Less than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	> 20 % of fracture spacing on both sides of fracture	Discolored, may contain thin filling / Partial to complete discoloration, not friable except poorly cemented rocks
Highly weathered / W4	More than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	Throughout	Filled with alteration minerals / Friable and possibly pitted
Completely weathered / W5	100% of the rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	Throughout	Filled with alteration minerals / Resembles soil
Residual soil / W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	Throughout	Non available / Resembles soil

Table 2: Weathering Index determination (after ISRM, 1981)

All intercepted natural discontinuities were described and when possible oriented. The following fracture types will be used to identify each discontinuity measured in the core interval:

- Fracture (FR): A discontinuity of uncertain origin (e.g., possible mechanical break).
- **Joint (JN):** A discontinuity with no infilling and no evidence of previous movement.
- Fault (FLT): A discontinuity across which there has been substantial movement. Infill will be relatively thick.
- Shear (SHR): A discontinuity across which there has been limited movement. Infill will be relatively thin, generally associated with polished or slicken sided surfaces.
- Bedding (BD): A discontinuity associated with sedimentary processes (e.g. mud seam in sandstone).

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- Foliation (FO): A preferential direction of structural weakness in the rock due to alignment of weak minerals, caused by metamorphism.
- Vein (VN): A discontinuity infilled or healed by another mineral (e.g. quartz). Veins are generally of limited interest unless material is particularly weak or broken.
- Contact (CO): A discontinuity that represents a change between two geological bedrock units.

The orientation of discontinuities measured when it was possible. The discontinuities angles were measured using a cylindrical Ezi-logger core goniometer. The measured angles are defined as follow, (see Figure 3):

- The dip angle (alpha) is measured for each natural discontinuity observed in the core. This angle is measured relative to the core axis, where 0° = parallel to core axis and 90° = perpendicular to core axis.
- The dip direction (beta) angle is measured for each natural discontinuity observed in the core. This angle is measured clockwise to the reference line looking down the core axis in the direction of drilling.

Figure 3: Measurement of angles Alpha and Beta



The discontinuities conditions were measured for each natural discontinuity observed and is based on the joint shape and roughness which describe the joint surface irregularity. The shape of the discontinuity is described using the following terms: Planar (PL), Curved (CU), Undulating (UN), Stepped (ST) and Irregular (IR). The surface roughness of the fracture is described using the following terms: Polished (PO), Slickensided (K), Smooth (SM), Rough (RO, Very Rough (VR) and Closed (C).



The discontinuities infill material is described as the material contained within the discontinuities: Broken rock; minerals such as biotite, chlorite, calcite, hematite, quartz, sulfide, iron, epidote; Gravel, sand, clay; Gouge, intrusive material such as chert.

Finally, Fault Gouge & Breccia intervals and intervals of broken core are also noted on the log.



4 ENGINEERING GEOLOGY MODEL

The aim of the site investigations was to gather geotechnical rock mass characteristics for the preparation of a preliminary Engineering Geology Model. Pit slope design parameters will be engineered based on the information and conclusions presented in the geotechnical model. The following sections present the main results of the site investigation that address the various aspects of the preliminary engineering model.

4.1 SUMMARY OF STRATIGRAPHY

The stratigraphic conditions encountered within boreholes consist typically of a downward sequence of overburden or highly weathered bedrock followed by bedrock.

Table 3 illustrates the stratigraphy encountered at each borehole location in terms of depths and elevations. Detailed descriptions of materials encountered in boreholes may be consulted on individual borehole reports in Appendix 2.

	LENGTH GEODESIC ELEVATION (m)					
BOREHOLE ELEVATION (m)	OVERBURDEN OR HIGHLY WEATHERED BEDROCK *	IRON FORMATION	SHALE	SANDSTONE		
BH-P-01 [527.85]	0.00 – 7.00 [527,85 – 520,85]	7.00 – 118.90 [520,85 – 416.12]	118.90 – 134.10 [416,12 – 401,84]	134.10 - ≥160.00 [401.84 - ≤377,50]		
BH-P-02 [522,18]	0.00 – 3.00 [522,18 – 519,18]	3.00 – ≥173.00 [519,18 – ≤372.36]				
BH-P-03 [526,33]	0.00 – 9.00 [526,33 – 517,87]	9.00 – 78.00 [517,87 – 453.03]	78.00 – 108.50 [453,03 – 424,37]	108.50 - ≥160.70 [424.37 - ≤375,32]		
BH-P-04 [519,26]	0.00 – 1.50 [519,26 – 517,85]	1.50 – ≥160.00 [517,85 – ≤368.91]				
* Thickness of overburden may be lower than indicated						

Table 3: Subsoil stratigraphy observed in boreholes

4.2 OVERBURDEN

From 3 to 9 meters thick of either overburden or highly weathered rock was found at the surface within boreholes BH-P-01 to BH-P-04.

It should be noted that in all boreholes location, visual observations showed that overburden seems to be thin and that rock outcrops are frequent. No recovery was possible down to a certain depth when initiating the boreholes. It is therefore impossible to assess if the first runs are in highly weathered bedrock or in overburden.



4.2.1 Bedrock

4.2.1.1 Iron Formation (rock type A and B and group I)

Iron Formation consists of iron oxide with white and red chert, fine to medium grained, dark grey, with centimetric bands of white to reddish medium grained chert and millimetric bands of fine grained red chert. We note the presence of nodules of white chert and pockets of iron oxide.

This formation is highly fractured with limonite in most fracture. Mostly non-magnetic with few weakly magnetic zone were observed.

This formation is also highly weathered as illustrated in histograms presented in Appendix 3 with very low RQD values were measured.

Two mains lithology have been identified within Iron Formation:

- Massive, weakly to highly hydroxidized (limonite, goethite) Iron Oxide (Hematite) with chert (white, gray or red) - rock type A;
- Mainly massive, weakly to highly hydroxidized (limonite, goethite) Iron Oxide (Hematite) rock type B.

No thickness of more than 5 meters has been identified for rock type A and B From a geomechanical point of view, these 2 lithology were grouped (group I).

In the Preliminary Economic Assessment (PEA), 3 members of units have been identified within the Iron Formation for a geological point of view. From a geomechanical point of view, all these members were grouped in one lithology (Group I).

4.2.1.2 Shale (rock type C and group II) from Ruth Formation

This rock unit was only intercepted in BH-P-01 and BH-P-03. The shale unit consists generally of black shale with zone of interbedded siltstone. This formation is not weathered as illustrated in histograms presented in Appendix 3 and medium to high RQD values were measured.

4.2.1.3 Sandstone (rock type D and group III) from Wishart Formation

As mentioned in the PEA document, the lithology was described as a sedimentary quartzite (metamorphic sandstone) and arkose, a quartz and feldspar clastic deposit. For the purpose of this study, this unit was described as grey sandstone from on-site geologists since no petrographic analysis has been performed on sample.

Similar to Shale rock unit, the Sandstone was only intercepted by BH-P-01 and BH-P-03. Grey Sandstone, fine to medium grain centimetric interdedded with black shale. This formation is not weathered as illustrated in histograms in Appendix 3 and high RQD values were measured.

4.2.2 Classification of Rock units

Arising from the previous section, three (3) principals lithology have been identified in the Pit area:

Banded Iron Formation (Group I);



- Shale (Group II);
- Sandstone (Group III).

4.3 INTACT ROCK LABORATORY TEST

4.3.1 Introduction

An essential part of a rock mass characterization program is the evaluation of intact rock strength for the various geological units. Laboratory testing of selected rock samples was carried out to measure the intact rock properties. This section presents the laboratory rock test results, carried out at Rock Mechanics Laboratory of Laval University, Quebec City, and at LVM's rock and soil laboratory at Boucherville using the core samples obtained from the geotechnical holes including: BH-P-01, BH-P-02, BH-P-03 and BH-P-04. The geotechnical drilling program was performed during the fall 2014. The results of the tests are presented in this section.

4.3.2 Rock Strength Testing

Rock laboratory testing was performed on the selected samples obtained from Iron oxide (Group I), Shale (Group II) and Sandstone (Group III) rock units of the site under investigation in the Joyce Lake project. The samples were selected to cover all major rock units at the site. The samples were sent to the Rock Mechanics Laboratory of Laval University in three different shipments. The first batch of samples was sent on October 14th 2014, the second batch was sent on October 22th 2014 and finally the third batch was sent on October 28th 2014. From the three batches of rock samples sent to the Rock Mechanics Laboratory of Laval University, overall 66 samples were strength tested. In addition to the samples that were tested at Laval University, one batch of rock samples was sent to the LVM's rock and soil laboratory at Boucherville. Among the total samples that were sent to Boucherville 31 samples were subjected to strength tests.

Of the 66 tested rock samples at Laval University (including the first, the second and the third batch of samples), 27 rock samples were tested for uniaxial compressive strength (UCS), 33 samples for Brazilian Indirect Tensile Strength and 6 samples for triaxial compressive strength. The results of the strength tests are summarized in Tables 4 and 5. In addition, the reports of Laval University testing program results for the current geotechnical investigation are included in Appendix 4. The report includes the picture of samples before and after testing.

Of 31 tested samples at Boucherville laboratory, 3 rock samples were tested for uniaxial compressive strength (UCS), 9 samples for Brazilian Indirect Tensile Strength and 19 samples for point load test. Table 5 summarizes the results of the strength tests performed at Boucherville laboratory.

The core samples collected from the geotechnical drilling program are of the HQ-3 and HQ size (61.1 mm and 63.5 mm of diameter). These core sizes are larger than the NQ (50 mm) size recommended by the International Society for Rock Mechanics (ISRM), as a standard size for compressive strength tests, Ulusay and Hudson (2007). Consequently, a specimen size



correction factor proposed by Hoek and Brown (1980) was used to correct the strength results recorded for the larger samples. This correction was mainly done for the UCS tests, while for the triaxial strength tests the samples had to be trimmed to the NX size in order to be fitted in the pressure cell. Therefore, no size effect correction was performed for these results.

SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	DENSITY (kN/m³)	σ₁ (MPa)	σ₃ (MPa)	TENSILE STRENGTH σ⊤ (MPa)	TEST VALIDITY
PLT-07-A	А	76.60 -76.90	UCS	31.5	105.1	0	-	Yes
PLT-07-B	А	76.60 -76.90	TRX	32.7	256.7	8.2	-	Yes
PLT-03	А	61.50-61.75	UCS	28.9	20.1*	0		No
RS-41	А	69.65-69.90	TRX	27.0	112.4	4.9	-	Yes

Table 4: Summary of UCS, Triaxial, and Brazilian Laboratory Tests performed at Laval University

Table 4: Summary of UCS, Triaxial, and Brazilian Laboratory Tests performed at Laval University (suite)

SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	DENSITY (kN/m³)	σ₁ (MPa)	σ₃ (MPa)	TENSILE STRENGTH στ (MPa)	TEST VALIDITY
RS-39	А	63.50-63.85	BRZ	29.1	-	-	5.371*	No
RS-51-A	А	149.0-149.27	TRX	30.9	5.4*	91.2*	-	No
RS-51-B	А	149.0-149.27	BRZ	33.2	-	-	7.17	Yes
RS-03	А	170.40-170.60	BRZ	30.3	-	-	6.7	Yes
RS-08	А	142.65-142.85	BRZ	31.2	-	-	9.72	Yes
RS-13A	А	133.25-133.6	UCS	31.1	106.74	0	-	Yes
RS-13B	А	133.25-133.6	BRZ	27.9	-	-	9.00	Yes
RS-16A	А	114.65-115.15	UCS	34.3	98.34	0	-	Yes
RS-16B	А	114.65-115.15	BRZ	33.4	-	-	7.20	Yes
RS-17	А	87.60-87.80	UCS	30.1	96.09	0	-	Yes
RS-19	А	87.45-87.65	BRZ	28.9	-	-	2.70	No
RS-01A	В	161.02-161.33	BRZ	28.8	-	-	5.20	Yes
RS-01B	В	161.02-161.33	BRZ	34.8	-	-	10.40	Yes
RS-02	В	164.47-164.76	BRZ	44.3	-	-	16.30	Yes
RS-09	В	139.65-139.85	BRZ	37.9	-	-	6.10	Yes
RS-11	В	143.75-144.0	UCS	34.7	120.28*	0	-	No
RS-14	В	139.25-139.42	BRZ	41.3	-	-	7.80	Yes
RS-15A	В	119.80-120.20	BRZ	35.4	-	-	23.20	Yes
RS-15B	В	119.80-120.20	BRZ	47.2	-	-	28.10	Yes
RS-18	В	60.65-60.84	BRZ	28.7	-	-	4.80	Yes

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SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	DENSITY (kN/m³)	σ ₁ (MPa)	σ₃ (MPa)	TENSILE STRENGTH στ (MPa)	TEST VALIDITY
RS-04A	В	148.10-148.33	UCS	26.3	30.62	0	-	Yes
RS-04B	В	148.10-148.33	BRZ	26.2	-	-	2.97	Yes
RS-05	В	148.55-148.71	BRZ	26.7	-	-	2.90	Yes
RS-06A	В	157.12-157.39	UCS	28.3	39.25*	0	-	No
RS-06B	В	157.12-157.39	BRZ	29.5	-	-	2.33*	No
RS-07	В	157.50-157.67	UCS	28.4	51.35	0	-	Yes
RS-10A	В	137.80-138.10	UCS	23.9	15.84	0	-	Yes
RS-10B	В	137.80-138.10	BRZ	30.1	-	-	10.32	Yes
RS-12A	В	135.05-135.30	UCS	24.6	25.63	0	-	Yes
RS-12B	В	135.05-135.30	BRZ	27.5	-	-	3.25	Yes
PLT-11A	В	161.40-161.70	UCS	26.8	24.32	0	-	Yes
PLT-11B	В	161.40-161.70	BRZ	27.6	-	-	1.62	Yes
PLT-12A	В	161.70-161.95	UCS	32.9	39.49*	0	-	No
PLT-12B	В	161.70-161.95	BRZ	28.5	-	-	4.52	Yes

Table 4: Summary of UCS, Triaxial, and Brazilian Laboratory Tests performed at Laval University (suite)

SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	DENSITY (kN/m³)	σ₁ (MPa)	σ₃ (MPa)	TENSILE STRENGTH στ (MPa)	TEST VALIDITY
PLT-16A	В	123.85-124.10	UCS	30	51.26	0	-	Yes
PLT-16B	В	123.85-124.10	BRZ	48.8	-	-	13.69	Yes
PLT-16C	В	123.85-124.10	BRZ	46.9	-	-	11.09	Yes
PLT-17A	В	138.20-138.50	BRZ	37.3	-	-	3.47	Yes
PLT-17B	В	138.20-138.50	TRX	37.9	58.4	8.1	-	Yes
RS-50	В	123.10-123.27	TRX	38.3	39.3	3.4	-	Yes
RS-46	В	123.0-123.23	UCS	38.2	29.29	0	-	Yes
RS-52	В	157.80-158	UCS	40.5	88.39	0	-	Yes
RS-45	В	121.70-121.87	TRX	41.4	71.4	5.7	-	Yes
RS-54A	С	81.0-81.26	UCS	27.2	44.86	0	-	Yes
RS-54B	С	81.0-81.26	BRZ	27.5	-	-	19.99	Yes
RS-58A	С	89.60-89.96	UCS	27.7	68.21	0	-	Yes
RS-58B	С	89.60-89.96	UCS	29	137.67	0	-	Yes
RS-58C	С	89.60-89.96	BRZ	30.6	-	-	4.11	Yes
RS-57A	С	87.0-87.20	UCS	30.2	114.36	0	-	Yes
RS-57B	С	87.0-87.20	BRZ	30.7	-	-	10.41	Yes

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SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	DENSITY (kN/m³)	σ₁ (MPa)	σ₃ (MPa)	TENSILE STRENGTH στ (MPa)	TEST VALIDITY
RS-27	С	125.25-125.50	UCS	26.7	138.18	0	-	Yes
RS-28	С	125.70-125.90	UCS	26.3	134.53	0	-	Yes
RS-29A	С	126.25-126.55	UCS	26.1	137.15	0	-	Yes
RS-29B	С	126.25-126.55	BRZ	26.0	-	-	12.05	Yes
RS-30	С	128.05-128.2	BRZ	25.9	-	-	16.97	Yes
RS-32A	D	135-135.35	UCS	26.2	228.63	0	-	Yes
RS-32B	D	135-135.35	BRZ	25.3	-	-	12.06	Yes
RS-33	D	148.04-148.46	BRZ	26.2	-	-	19.19	Yes
RS-34	D	148.26-148.50	UCS	26.4	237.40	0	-	Yes
RS-37A	D	154.83-155.20	UCS	26.7	340.19	0	-	Yes
RS-37B	D	154.83-155.20	BRZ	26.6	-	-	28.51	Yes
RS-38	D	159.43-159.60	UCS	27.7	256.84	0	-	Yes

¹ The size corrected test results are presented for the UCS tests in the Table.

Rock Types: A= Hematite with White Chert; B= Mainly Iron Oxide (massive or with limonite alteration); C= Shale; D= Sandstone

Test Types: UCS: Unconfined Compressive Strength Test; BRZ: Indirect Tensile Brazilian Test; TRX: Triaxial Compressive Strength Test; PLT: Point Load Test

* Invalid test (broke along foliation or bedding)

SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	σ ₁ (MPa)	Is ₅₀	σ _c (MPa)	TENSILE STRENGTH (MPa)
21	А	60.82	PLT	-	1.93	46.32	-
22	А	61.00	PLT	-	6.88	165.12	-
23	А	70.00	PLT	-	4.89	117.36	-
24	А	69.05	PLT	-	0.60	14.40	-
25	А	81.50	PLT	-	1.60	38.40	-
26	А	82.40	PLT	-	0.65	15.60	-
27A	А	90.30	PLT	-	1.82	43.68	-
27B	А	90.30	BRZ	-	-	-	8.60
30	А	74.10	PLT	-	4.28	102.72	-
28A	В	67.95	PLT	-	0.13	3.12	-
28B	В	67.95	BRZ	-	-	-	7.00
29A	В	68.70	PLT	-	0.55	13.20	-
29B	В	68.70	BRZ	-	-	-	1.40
31A	В	77.35	PLT	-	0.90	21.60	-

Table 5: Summar	v of UCS. Po	oint Load. a	nd Brazilian L	aboratory .	Tests I	performed	at LVM's	Boucherville	lab
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SAMPLE	ROCK TYPE	DEPTH (m)	TEST TYPE ¹	σ ₁ (MPa)	IS 50	σ _c (MPa)	TENSILE STRENGTH (MPa)
31B	В	77.35	BRZ	-	-	-	3.30
32A	В	99.30	PLT	-	0.15	3.60	-
32B	В	99.30	BRZ	-	-	-	5.40
33A	В	101.80	PLT	-	0.09	2.16	-
33B	В	101.80	BRZ	-	-	-	1.70
39A	С	131.54	PLT	-	3.16	75.84	-
39A	С	131.54	UCS	22.55	-	-	-
34A	С	119.1	PLT	-	0.7	16.80	-
34B	С	119.1	BRZ	-	-	-	4.90
35A	С	122.45	PLT	-	1.84	44.16	-
35B	С	122.45	UCS	88.43	-	-	-
36A	С	124.03	PLT	-	2.78	66.72	-
36B	С	124.03	UCS	44.06	-	-	-
37A	С	126.85	PLT	-	2.84	68.16	-
37B	С	126.85	BRZ	-	-	-	2.50
38A	С	128.15	PLT	-	3.31	79.44	-
38A	С	128.15	BRZ	-	-	-	12.10

¹ The size corrected test results are presented for the UCS tests in the Table.

Rock Types: A= Hematite with White Chert; B= Mainly Iron Oxide (massive or with limonite alteration); C= Shale; D= Sandstone **Test Types**: UCS: Unconfined Compressive Strength Test; BRZ: Indirect Tensile Brazilian Test; TRX: Triaxial Compressive Strength Test; PLT: Point Load Test

Due to the banding nature of the iron formation, in some of the collected iron oxide samples it was observed that the banding angle varies importantly. This can be associated with the dip angle of the drilled boreholes with respect to the banding iron formation. Most of the iron oxide samples with dominant banding structure, used for the compressive strength tests, were either totally or partially failed along a plane parallel to the banding (See Figure 4 for sample RS-11). This has resulted in low intact strength values particularly when the angle between the core axis and the banding planes is ranging between 30 and 45 degree. It was further observed that presence of white or red chert in iron oxide samples could change the behavior of rock samples under the compressive loading conditions and reduce the influence of bandings on the intact rock strength.



Figure 4: Rock sample RS-11 (iron oxide-massive) failed along a surface parallel to the banding structures



Determination of compressive strengths of anisotropic rocks that include weakness planes has its particular difficulties. Hoek (2006) suggested that the uniaxial compressive strength of anisotropic rock units can vary by a factor of five depending on the direction of loading with respect to the plane of weakness. The maximum compressive strength is generally recorded when the loading direction is perpendicular to the weakness plane. On the other hand, the lowest strength occurs when the angle of weakness plane with respect to loading direction varies from 30 to 45 degree, Figure 5. Therefore, it can be argued that most of the compressive strength values obtained for the samples of iron oxide, with well-developed banding structures, represent the minimum strength values.

LVM



Figure 5: Effect of plane of weakness on intact rock strength (after, Hoek (1983))

4.3.2.1 UCS Test Results

A total of 30 samples were subjected to UCS testing. Four tests out of the 30 tests were considered invalid as the samples were failed along a pre-existing joint. The invalid test results were not taken into consideration. A summary of the UCS results by rock type is shown in Table 6. The table shows the minimum, maximum, mean, standard deviation, coefficient of variance and the number of tests for each rock unit. The iron oxide rock unit samples with white or red chert (Rock type A) were treated separately from the other iron oxide samples such as massive hematite, hematite with hydroxide or hematite with limonite (Rock type B). The Shale rock unit samples collected from the BH-P-01 and BH-P-03 were grouped together, same as the sandstone samples.

ROCK GROUP	ROCK TYPE	NUMBER OF TESTS	AVERAGE UCS (MPa)	STANDARD DEVIATION (MPa)	COEFFICIENT OF VARIATION (%)	MAXIMUM UCS (MPa)	MINIMUM UCS (MPa)
	А	4	101.5	5.1	5.0	106.7	96.1
I	В	8	23.4	23.4	59.1	88.4	15.8
II	С	10	93.0	45.3	48.7	138.1	22.5
III	D	4	265.7	51.0	19.1	340.2	228.6

Table 6: Summary of UCS tests by Rock Type

Rock Types: A= Hematite with White Chert; B= Mainly Iron Oxide (massive or with limonite alteration); C= Shale; D= Sandstone

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The results of UCS tests show that:

- For rock type A, presence of white and red cherts in the iron oxide samples generally improves the strength of the intact rock samples. The samples of this rock unit show a very low variation in strength (CoV = 5.0%).
- For rock type B, presence of limonite alterations in iron oxide samples has highly degraded the compressive resistance of samples and consequently the ultimate strength of the samples with higher percentage of limonite are lower.
- For rock type B, the relatively low strength values for the iron oxide rock unit is also attributed to the pre-existing banding structures in the rock samples, which have resulted in failure of samples parallel to these weakness planes.
- For rock type B, Mainly iron oxide, a very high coefficient of variation was recorded (CoV = 59.1%). This implies the complex mineralogical composition and alteration of the rock samples collected for this rock unit.
- The highest average UCS was recorded for the Sandstone (rock type D), while the lowest average UCS was obtained for the mainly iron oxide samples (rock type B).

4.3.2.2 Brazilian Test Results

A total of 42 samples were selected for Brazilian tensile strength testing. Three tests out of the 42 Brazilian tests were considered invalid. The invalid test results were discarded. A summary of the Brazilian testing by rock type is shown in Table 7. This includes 6 samples of the iron oxide with cherts rock unit (rock type A), 22 samples of the mainly iron oxide rock unit (rock type B), 8 samples of the Shale rock unit and 3 samples of the Sandstone rock unit. The table 7 shows the mean, standard deviation, coefficient of variance, the number of tests and the range of tensile strength for each rock unit.

ROCK GROUP	ROCK TYPE	NUMBER OF TESTS	AVERAGE TENSILE STRENGTH (MPa)	STANDARD DEVIATION (MPa)	COEFFICIENT OF VARIATION (%)	RANGE OF TENSILE STRENGTH (MPa)
1	А	6	8.0	1.2	15	6.7 - 9.7
I	В	22	7.9	7.0	88.6	1.4 - 28.1
II	С	8	10.3	6.2	60.1	2.5 – 19.9
III	D	3	19.9	8.2	41.4	12.1 - 28.5

Table 7: Summary of Brazillian tests by rock type

Rock Types: A= Hematite with White Chert; B= Mainly Iron Oxide (massive or with limonite alteration); C= Shale; D= Sandstone



The results of Brazilian indirect tensile strength tests show that:

- The average indirect tensile strength of both the hematite with chert (rock type A) and mainly iron oxide (rock type B) are almost the same. However, the variation of the values measured for the mainly iron oxide (rock type B) is significant with a CoV= 88.6%.
- The highest average indirect tensile strength was recorded for the Sandstone (rock type D), following by Shale (rock type C).

4.3.2.3 Triaxial Test Results

A summary of the triaxial testing by rock type is shown in Table 8. A total of 6 samples were selected from the geotechnical investigation boreholes for triaxial testing. Only 5 test results were considered valid. This includes 2 samples from the rock unit A (Hematite with white Chert) and 3 samples from the rock unit B (Mainly Iron Oxide (massive or with limonite alteration)). The confining pressures for the triaxial testing were between 3.4 and 8.2 MPa. No triaxial test was carried out on the Shale and Sandstone samples.

ROCK GROUP	ROCK TYPE	σ₃ (MPa)	NUMBER OF TESTS	σ₁ (MPa)				
	۸	8.2	1	256.7				
	A	4.9	1	112.4				
I		8.1	1	58.4				
	В	3.4	1	39.2				
		5.7	1	71.4				
Rock Types: A= Hematite with White Chert; B= Mainly Iron Oxide (massive or with limonite alteration)								

Table 8: Summary of Triaxial tests by rock type

The results of triaxial strength tests show that:

- For rock type A, by increasing the confining stresses, the ultimate strength of rock samples increase.
- For rock type B, the results do not clearly show an increase of ultimate strength with increasing of confining stresses. This can be attributed to the heterogeneous mineralogical composition of the samples taken from rock type B.

4.3.2.4 Point Load Test Results

A summary of the point load testing by rock type is shown in Table 9. Point load index test was carried out on 19 samples at Boucherville laboratory on the rock samples collected from the four geotechnical drill holes. The number of tests for each rock type, and average index test results are presented in Table 9. The compressive strength of rock samples were estimated based on the I_{50} values based on the correlation proposed by Bieniawski (1975), $\sigma_c = 24 \times I_{50}$.



ROCK GROUP	ROCK TYPE	NUMBER OF TESTS	AVERAGE Is50	AVERAGE σc (MPa)	RANGE OF σc (MPa)
	А	8	2.83	67.9	14.4 – 165.1
I	В	5	0.36	8.7	2.1 – 21.6
II	С	6	2.43	58.5	16.8 – 79.4
Rock Type: Sandstone	s : A= Hemati	te with White Chert; B=	Mainly Iron Oxide (mas	sive or with limonite alte	ration); C= Shale; D=

Table 9: Summary of Point Load tests by rock type

The results of Point Load tests show that:

- The average sig-c values obtained for the three rock types (A, B, and C) are lower than the average values of UCS test results presented in Table 6. This can be attributed to the limited number of point load tests performed for each rock type which statistically not enough to draw an appropriate conclusion from the results. In addition, index to strength conversion factors are site-specific and the common factor used in this case may not be representative for the site under investigation.
- Due to the inconsistency of the point load test results and the UCS results, the results of point load index tests were discarded at this stage for estimating UCS average value. These results could be used with more confidence once statistically enough samples were tested for each rock type.

4.3.2.5 Tilt test

Because the length of intact rock samples was short, no direct shear test were performed on rock core samples to evaluate friction angle. In order to preserve a larger number of samples for triaxial and uniaxial compressive tests, tilt test (non-destructive) were performed on Iron Formation cores at Rock Mechanics Laboratory at Laval University. Table 10 summarizes the results of the tilt tests.



SEGMENT		DEPT	⁻ H (m)	with	ΦBASE
SEGMENT	BUREHULE	FROM	то	CORE SEGMENT	(DEGREE)
RS-01	BH-02	161,02	161,33	RS-02	35
RS-01	BH-02	161,02	161,33	RS-15	36
RS-01	BH-02	161,02	161,33	RS-09	36
RS-12	BH-02	135,05	135,30	RS-04	37
RS-12	BH-02	135,05	135,30	RS-06	37
RS-12	BH-02	135,05	135,30	RS-07	39
RS-12	BH-02	135,05	135,30	RS-10	37
RS-13	BH-02	133,25	133,60	RS-03	31
RS-13	BH-02	133,25	133,60	RS-08	30
RS-13	BH-02	133,25	133,60	RS-11	30
RS-13	BH-02	133,25	133,60	RS-16	29
RS-17	BH-02	87,60	87,80	RS-18	24
RS-17	BH-02	87,60	87,80	RS-19	29

Table 10: Summary of Tilt test results

The results of tilt tests indicate that the basic friction angle for Iron Oxide rock units is varying between 24 and 39 degree.

4.3.3 Intact Rock Strength Material Properties

The UCS, triaxial and Brazilian testing data for rock type A and B (Hematite with White Chert and Mainly Iron Oxide) were used to develop the strength envelops for the iron oxide rock units. The laboratory test results were entered into RocData® (distributed by Rocscience Inc.) for defining appropriate Hoek-Brown rock strength envelope parameters (Hoek et al., 2002).

Investigation by the four geotechnical drillholes indicates that, at present stage of the project, it is not possible to clearly delineate the spatial distribution of rock types A and B. The iron oxide with cherts (rock type A) is randomly intercepted along the geotechnical boreholes similar as the iron oxide with limonite alteration or hematite with hydroxide (rock type B); resulting in an extremely heterogeneous rock mass. This complexity needs to be addressed in the future geotechnical investigations. Due to the lack of information regarding the approximate distribution of the rock type A and B in the iron oxide zone, for this study, it was decided to combine the laboratory strength results for the rock types A and B and to deal with a broader range of rock matrix properties. In is recognized that the average values obtained by combining the test results for the rock type A and B would be more influenced by the results of rock type B, due to the greater number of tests available for this rock type.

Table 11 summarizes the lab testing results for the main rock units in the pit area.

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PROPERTIES		LITHOLOGY		
PARAMETER	VALUE	IRON FORMATION	SHALE	SANDSTONE
Unconfined Compressive Strength, σ _{ci} (MPa)	Mean	60	96	195
	Min	25	44	104
	Max	105	138	256
Brazilian Test, σ ⊤ (MPa)	Mean	7	10	14
	Min	3	4	10
	Max	14	17	19
Unit Weight, γ (kN/m ³⁾	Mean	32,5	27,6	26,4
	Min	23,9	25,9	25,3
	Max	48,8	30,7	27,7
mi		8	9	14

Table 11: Intact rock strength material properties

The m_i values obtained for the Shale and Sandstone rock units (Rock type C and D) were found to be characteristic when compared to typical values usually encountered for similar rock types. Typical m_i values reported for the Shale and Sandstone rock units range between 4-8 and 13-21, respectively, (Brady and Brown 2004). The derived m_i value for the iron oxide rock unit (rock type A+B) is relatively in the range of the m_i values typically reported for fine to very fine grain sedimentary rocks.

4.3.4 Highlights

- The evaluation of the intact strength of anisotropic rocks is more complex than that of isotropic rocks and requires testing of rock samples at different orientations with respect to the weakness planes. At this stage of the project, it was not practical to collect samples at orientations other than the one selected, and drilling perpendicular to the banding structures was not possible. It is recognized that the UCS results from this drilling campaign more likely represent the lowest values for the "mainly iron oxide" rock type (rock type B).
- The value of σ_{ci} obtained from the combination of all testing results for iron oxide samples (combination of rock type A and B), including UCS, triaxial and Brazilian test data, is slightly lower than the corresponding average UCS value of all tested samples. Therefore, at this stage, the average UCS value of all tested samples for rock types A and B (~ 60 MPa), was used to represent the intact rock strength of the iron oxide rock unit in the geomechanical pit design procedure.
- In the next geomechanical investigation program and during the open pit progress, there will be opportunities to collect more samples of iron oxide at different orientations to the banding structures and to conduct a more in depth strength testing and analysis campaign.

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If during the future geological or geomechanical campaign, the spatial distribution of iron oxide with white chert (rock type A) could be identified, it is recommended to separately consider the strength test results for rock type A and B.

4.4 ROCK MASS CHARACTERISTICS

4.4.1 Lithology

As mentioned previously, three principals lithology have been identified in the Pit area, a Banded **Iron Formation** (Sokoman Formation) overlying **Shale** and **Sandstone** from the Ruth Formation.

The Iron Formation is interbeded bands of red and grey to white chert. Many zones, regardless of the depth, present strong ferric alteration. Hydroxides (limonite and goethite) are presents throughout the Iron Formation in variable quantity.

4.4.2 Structural Analysis

Structural description of discontinuities was performed on oriented rock core. These descriptions can be found in Appendix 2. It is important to note that the majority of the described oriented joints were done in Shale and Sandstone units. As mentioned earlier, the iron oxide rock mass in the pit area has been subjected to many deformation phases and at least two series of folding. Consequently, the iron oxide rock unit is highly fractured and altered. From the 530 meters core drilled in the Iron Formation, overall, only 10 meters of core were described. Therefore, the majority of the structural data comes from the Shale and Sandstone rock types.

All of the measured discontinuity data were analyzed statistically using the software DIPS, distributed by RocScience, and the discontinuity sets were selected from contour plot stereographic projections. Figure 6 shows the stereographic projections of the oriented core data for all lithologies, presented based on the type of discontinuities. As can be seen only two types of discontinuities have been observed including joints (JN) and bedding (BD). Two (2) to Five (5) joint sets can potentially be present as indicated in Figures 6 and 7. Figure 7 presents the same discontinuity data as a function of drillholes (borehole BH-P-01 to BH-P-04). Table 12 summarizes the dip and dip direction of the potential five joint sets. Three sub-horizontal and two sub-vertical joint sets could be seen.

POTENTIAL DISCONTINUITY/DEFECT SET MEAN PLANE	DIP DIRECTION (°)	DIP (°)
J1	189	28
J2	25	86
J3	302	18
J4	118	35
J5	57	75

Figure 6: Stereonet of potential joint sets for all lithology based on discontinuity types







Figure 7: Stereonet of potential joint sets based on boreholes (borehole BH-P-01 to BH-02

From figure 7, it is noted that joint sets J2 and J5 are only present in borehole BH-P-02.

The structural data analysis indicates that:

- Due to the limited number of discontinuity measurement for the iron oxide rock type in the structural database, the developed stereographic projects cannot fully describe the entire structural complexity of the Iron Formation. Because of multiphase deformation of the iron oxide rock mass in the pit area, joint sets orientation measured for shale and sandstone cannot be representative of the upper Iron Formation.
- The number of structural data representing the Iron Formation is not sufficient to draw a comprehensive understanding of the Iron Formation rock mass structure.

4.4.3 Summary of Rock Mass Classification

Rock mass classification systems are frequently used for rock engineering projects. The rock mass classification systems provide a quantitative index of rock mass quality based on measurements and observations of rock mass parameters. An assessment of the overall quality of the rock masses that comprise the Joyce Lake project area has been prepared using the Geological Strength Index (GSI), Hoek et al. (1995 and 2013).

During the geotechnical site investigation, the Rock Quality Designation (RQD) values were estimated per each drilling run along the four geotechnical drillholes. The statistical analysis of the RQD data indicates that:


- The RQD values of iron oxide rock type ranges from 0 to 100 with an average value of 37 and a standard deviation of 32. This implies that the iron oxide rock mass is highly fractured with a significant structural heterogeneity. The histograms of the RQD values for the Iron Oxide rock type is presented in Appendix 3.
- The RQD values of Shale and Sandstone rock units are much higher than the iron oxide rock mass with a mean RQD value of 74 and a standard deviation of 24. The histograms of the RQD values for the Shale and Sandstone rock type is presented in Appendix 3.

During the geotechnical site investigation, characteristics of the discontinuities were collected in the field. In general, for the iron oxide rock unit, discontinuities were characterized as planar and closed and planar and rough, while for the Shale and Sandstone rock types, discontinuities were characterized as planar and smooth. The histograms associated with the characteristics of the discontinuities are presented in Appendix 3. The joint surfaces in iron oxide rock are mainly coated or infilled with white chert while the joint surfaces in Shale and Sandstone are mainly coated with iron oxide.

Based on field assessment of the rock hardness in the geotechnical drillholes, the rock units are on average strong to very strong, with a mean rock hardness value of about R4 and R5 for iron oxide rock type (group I) and Shale and Sandstone (group II and III), respectively.

The results of weathering index indicate that the iron oxide rock has a weathering index mostly between W3 and W4, (moderately to highly weathered), while the Shale and Sandstone rock types have a mean weathering index of W2, (slightly weathered).

The Geological Strength Index (GSI) for the iron oxide rock mass was estimated based on two different approaches:

- Descriptive estimation based on RQD and Rock Joint Conditions (J_{cond}) (Hoek, Carter and Diederichs, 2013)
- Qualitative estimation based on overall observation and consensus of experts using general Guidelines for estimating GSI factor on the basis of Structure and joint conditions.

Although, there weren't enough information to apply the descriptive method (i.e. limited number of Joint Condition J_{cond89} values are available for the iron oxide), the result of both descriptive and qualitative methods showed a good coherent and agreement to evaluate the GSI between 25 and 45 for the iron oxide rock mass. The estimated range of GSI is presented on the figure 8.



Figure 8: Evaluated range of GSI based on both descriptive and qualitative method (after Hoek et al., 1995)





4.4.4 Rock Mass Strength

The rock mass strength is estimated using the Hoek-Brown failure criterion, which is expressed by:

$$\sigma_1 = \sigma_3 + \sigma_{ci} \left(m_b \frac{\sigma_3}{\sigma_{ci}} + s \right)^a$$

Where:

- m_b is the value of the constant *m* for the rock mass;
- *s* and *a* are constants which depend upon the characteristics of the rock mass;
- σ_{ci} is the uniaxial compressive strength (UCS) of the intact rock; and
- σ_1 and σ_3 are the axial and confining principal stresses, respectively.

With aid of the RocData software, intact rock properties were downgraded to get rock mass properties. For the purpose of the calculation, disturbance factor D=0.7 was assumed, corresponding to good quality blasting for the final pit walls.

Table 13 presents the Hoek-Brown parameters obtained for the different rock masses at the project area. The same Table shows the equivalent Mohr-Coulomb cohesion and friction angle for the same rock masses.

It should be noted that the influence of blast damage on the near surface rock mass properties has been taken into account using D factor, which depends upon the degree of disturbance due to blast induced damage and stress relaxation. Based on the evaluation of excavation method, this factor is considered equal to 0.7.

Hoek Brown Failure Envelopes for iron oxide rock mass are presented in figure 9. This figure shows a rock mass strength of 3.468 MPa. The rounded value of 3.5MPa is retained.



Table 13: Summary of Inferred Rock Mass Strength Parameters

PROPERTY	VALUE	COMMENTS											
Intact Rock Properties –Iron Formation													
Unit Weight (kN/m ³)		32,5	Average Lab Test										
Intact Uniaxial Compressive Strength, σ_c (I	MPa)	60	Average Lab Test										
mi		8	Calculated										
Rock Mass Properties –Iron Formation													
Geological Strength Index (GSI)		35	Evaluated Based on Observation										
Disturbance factor D		0,7	Mechanical Excavation ¹										
	а	0,516											
Generalised Hoek-Brown failure criterion	m₀	0,225	Estimated with RocData										
	S	1,00E-04											
Mala On Lond	c, (MPa)	0,347	Estimated title Deepete										
Monr-Coulomb	φ (°)	30,28	Estimated with RocData										
In	tact Rock Prope	erties – Shale											
Unit Weight (kN/m ³)		27,6	Average Lab Test										
Intact Uniaxial Compressive Strength, σ_c (N	/Pa)	96	Average Lab Test										
mi		9	Calculated										
R	ock Mass Prope	erties – Shale											
Geological Strength Index (GSI)		50	Evaluated Based on Observation										
Disturbance factor D		0	No effect										
	а	0,506											
Generalized Hoek-Brown failure criterion	m₀	1,509	Estimated with RocData										
	S	0,0039											
Mahr Caulamh	c, (MPa)	1,453	Estimated with DeeDate										
	φ (°)	45,62	Estimated with RocData										
¹ See figure 10 and 11 for justification of mechai	¹ See figure 10 and 11 for justification of mechanical excavation												





4.4.4.1 *Mechanical excavation*

The final geometry of benches shall be obtained by mechanical excavation. According to Abdullatif and Cruden (1983) and more recently Tsiambaos and Saroglou (2010), the highly fractured rock mass can be excavated by digging and/or ripping. Figures 10 and 11 show respectively the study results of the first and second publications.



Figure 10 : Average rock mass strength (3.5 MPa) –vs- average GSI (35)

Figure 11 shows typical areas in term of GSI for Point load index smaller than 3 MPa. All Point Load Index measured on the Iron Formation are smaller than 3.0 MPa. The figure 11 shows that for an average GSI of 35 and extreme values of 25 to 45, the Iron Formation can be dug and/or ripped.

Figure 11 : Excavation methods in term of GSI for Point load index smaller than 3 MPa



4.4.5 **Hydrogeology**

For detail hydrogeological site condition, the reader can refer to Hydrogeological Report mentioned in section 1.1.



5 PIT SLOPE CONCEPTS AND ACCEPTABILITY CRITERIA

5.1 PIT SLOPE GEOMETRIES

Pit walls consist of many slope elements, which require separate design decisions. The basic unit of the pit design is the bench, formed by a single cut or lift.

The bench configuration, controlled by the bench face angle, bench height and bench width, defines the inter-ramp angle. The overall slope angle consists of inter-ramp sections separated by wide ramps.

Bench configurations, recommended by LVM, are given based on a bench height of 9 meters, as set by the block model for optimized open pit mine.

Benches widths should be sufficient to provide effective protection against rockfall. The following modified Ritchie criteria (Ryan and Pryor, 2000) is commonly used for initial estimates of design of bench width:

Bench Width (m) = (0.2 * Bench Height) + 4.5 m

In the present case, this will yield 6.3 m bench width.

5.2 DESIGN CRITERIA

Slope stability analyses are generally performed using the Limit Equilibrium Method, where the safety factor is represented by the ratio of resisting forces to the acting forces. A general guidance to pit slope design acceptance criteria is summarized in Table 14 (after Read and Stacey, 2009) and suggested factor of safety and probability of failures are highlighted.

	CONSEQUENCES	AC	CEPTANCE CRITERI	A
SLOPE SCALE	OF FAILURE	FOS (min) (Static)	FOS (min) (Dynamic)	POF (max) P[FOS≤1]
Bench	Low to High	1.1	N/A	25%-50%
	Low	1.15-1.2	1.0	25%
Inter-ramp	Medium	1.2	1.0	20%
	High	1.2-1.3	1.1	10%
	Low	1.2-1.3	1.0	15%-20%
Overall	Medium	1.3	1.05	5%-10%
	High	1.3-1.5	1.1	≤5%

Table 14: Acceptance	criteria for the pit slo	ope design (after	Read and Stacy, 2009)
			· · · · · · · · · · · · · · · · · · ·



The slope angles were determined based on the acceptance criteria for probability of failure (PoF), to ensure that the design slope angles were optimal based on a quantitative evaluation of alternative designs. The PoF value incorporates the variations associated with the input parameters data set. In the present study the available data set is quite small and variable. A probabilistic analysis has been conducted to assess this feature.



6 OPEN PIT ROCK SLOPE STABILITY ASSESSMENT

6.1 POTENTIAL MODES OF FAILURE

6.1.1 Kinematic Analysis

Kinematic failure modes in rock slopes typically include planar, wedge and toppling failures. These failure modes can be identified by using stereographic analysis of peak pole concentrations of the discontinuity data. These failure modes will occur if the discontinuities are continuous over the bench scale or more, if weak infilling is present along the measured discontinuities or the geometry of the discontinuities is conducive to failure. A brief description of each mode of failure is provided below:

6.1.1.1 Wedge Failure Analysis

Wedge sliding is defined as a translation of a tetrahedral-shaped failure mass on either of the two lower bounding geologic structures, or on both, along the line of their intersection. The rock wedge is bounded by the slope face, the essentially flat upper surface and two geologic structures, each oriented obliquely to the slope face.

6.1.1.2 *Planar Failure Analysis*

Planar sliding is defined as a translation (sliding) of a failure mass on a single geologic structure, oriented approximately parallel with the slope being modeled.

6.1.1.3 **Toppling**

Flexural Toppling is defined as a mode of failure, involving the bending of interacting rock columns formed by a single set of steeply dipping discontinuities, such as regular bedding planes, foliation, or joints. In such cases, the rock columns bend forward under their own weight and transfer load to the underlying columns, thus giving rise to tensile and compressive bending stresses. Failure is initiated when the tensile (bending) stress in the toe column exceeds the tensile strength of the rock.

Direct Toppling is defined as the forward rotation out of the slope of mass of soil or rock about a point or axis below the centre of gravity of the displaced mass. Toppling is sometimes driven by gravity exerted by material upslope of the displaced mass and sometimes by water or ice in cracks in the mass.

6.1.2 Rock Mass Stability Analysis

The maximum overall rock slope angle of large open pit mines is usually determined by rock mass strength. The rock mass strength parameters were derived using the Hoek-Brown failure criterion (Hoek, et. al., 2002). This criterion utilizes the characteristics of the rock mass to downgrade the measured intact rock properties to rock mass scale values. The mechanical characteristics of the rock mass are set by lithology, intact rock strength and rock mass quality. Rock mass disturbance is of importance. It is typically caused by blast damage, vertical unloading and strain resulting from stress changes and rotation in the pit walls rock mass.



6.2 FACTOR AFFECTING PIT SLOPE DESIGN

6.2.1 Ground water

Open pit slope drainage and depressurization is a key factor in presence of highly fractured rock masses. Water pressure in discontinuities diminishes the overall resistance of the rock mass.

6.2.2 **Ice formation**

Deep depressurisation of rock slope, especially in cold climate where frost penetration can reach decametric order of magnitude, is important in order to avoid rock mass disturbance due to ice formation and water pressure build up behind the iced zone.

6.2.3 Blasting

Hoek et al, 2002 recommends that the rock mass strengths be downgraded to disturbed values to account for rock mass disturbance associated with heavy production blasting and vertical stress relief and stress rotation. Hoek indicates that, in deep open pits, a disturbance factor of 0.7 would be appropriate for a mechanical excavation where no blasting damage is expected. Experience indicates that a disturbance factor approaching the value of 0.7 may be achievable for moderate height slopes with the application of excellent controlled blasting practices. A disturbance factor of 1.0 is assumed for conventional production blasting.

In the present case, mechanical excavation is foreseen and if blasting proves to be necessary, precautions must be used. The blasting strategy should keep blast holes a certain distance from the bench slope surfaces. It should consider excavating with mechanical means the zone in between the blast holes and the bench faces. The intensive presence of discontinuities in the rock mass will quite obviously absorb the blasting energy rapidly thus limiting the range of damages penetration to the rock slope. With this procedure, it is expected that the disturbance factor should be minimized.

6.3 METHODOLOGY FOR PIT SLOPE STABILITY ASSESSMENT

Based on the preliminary Engineering Geological Model developed for the rock masses encountered in the Joyce Lake pit area and presented in chapter 4, the iron oxide rock mass quality is considered as "weak". Consequently, the potential instability mode in the pit slopes is likely to be controlled by rock mass strength rather than structure, even at bench scale. For this reason, the slope design process was started with analyses of the overall and inter-ramp slope angles, to determine a slope angle that meets the stability acceptance criteria presented in Table 14.

Conventional Limit Equilibrium Analyses (LEA) are often conducted to evaluate the maximum overall slope angle for pit walls with an acceptable factor of safety. LVM performed a slope stability assessment using limited equilibrium analysis software Slide 6.0, developed by Rocscience. This software was used to generate Factors of Safety according to the Morgenstern-Price solution for circular slip surfaces.



The inputs for the LEA analysis are listed below:

- Slope configuration, defined by the slope height and inter-ramp slope angle.
- Material properties, assigned to entire slope based on the dominant rock type (weighted density, cohesion and friction angle, obtained from the rock mass properties).
- Water Table, coinciding with the surface of the pit, to simulate the worst-case scenario.
- Seismic loading, simulated by an application of static forces, that represent seismic inertial forces resulting from potential ground accelerations caused by an earthquake (pseudo-static method).

The seismic loading requires the input of seismic parameters such as peak ground acceleration (PGA) and the seismic coefficient (k).

The PGA value was determined from Natural Resources Canada – Earthquakes Canada, 2013. Based on the interpolation using the Shepard's method from a 10km spaced grid of points. The value of PGA in the area of the proposed pit is 0.036 g, determined for a 2% in 50 years (0.000404) probability of exceedance according to Canadian National Building Code 2010.



7 PIT WALL STABILITY ANALYSES

7.1 RATIONALE AND INPUT DATA FOR STABILITY ANALYSES

One of the input parameters for the slope stability assessment using LEA is the material properties. Figure 12 shows the flow chart for estimation of rock mass parameters required for stability analysis using GSI and Hoek-Brown method.

Figure 12: Data flow for using Hoek-Brown and GSI system for estimation rock mass properties



In order to use this criterion for estimating the strength of jointed rock masses, three following 'properties' of the rock have to be estimated:

- Uniaxial compressive strength σ_{ci} of the intact rock pieces;
- Value of the Hoek-Brown constant m_i;
- Value of the Geological Strength Index GSI for the rock mass (Hoek (1994) and Hoek, Kaiser and Bawden (1995)) for estimating the reduction in rock mass strength for different geological conditions.

These parameters, σ_{ci} , m_i and GSI, were estimated and discussed in the section 4.



7.2 LIMIT EQUILIBRIUM STABILITY ANALYSIS

7.2.1 General

The limit equilibrium analyses were conducted to evaluate the maximum achievable overall slope angle for each design section with an acceptable factor of safety of 1.3.

7.2.2 Geotechnical Model

As stated in section 6, the Iron Formation rock mass quality is such that LEA represents the mode of slope failure independently of the pit slope dip orientation. A generic open pit mine slope of 150 m high for which the Iron Formation compose essentially the slope material and where the shale formation is more deeply imbedded has been considered as the base case. This corresponds to a bottom of pit at an elevation of roughly 380m. Also, the base case considers that Joyce Lake will be emptied completely from water, exception made of a water pond used to pump collected runoff. The analyses were conducted in both static and seismic loading conditions.

These analyses are used to assess the Inter Ramp Angle (IRA) meeting the required 1.3 safety factor. Figure 13 shows the geometry of the base case model.



Figure 13: Geometry of the generic pit slope model

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The evaluated GSI values were used to estimate the parameters for generalized Hoek-Brown failure criterion. The parameters used in the rock mass stability analysis for pit slopes are summarized in Table 13.

7.2.3 Analyses Results

7.2.3.1 Static Analysis

A stability sensitivity analysis has first been performed to assess the impact of the presence of the water pond collecting runoff for pumping in the Joyce lake bed. It was assumed that the groundwater can seep through the pit slope wall with different H_W/H values depending on the distance from the pit slope edge and the water pond. The groundwater profile has been determined using finite element seepage analysis to determine the seepage surface extent on the pit slope. The results of multiple analyses are presented in figure 14 where safety factors are plotted for different distances and different IRA slope angles.

Figure 14: Safety Factor Vs Inter-Ramp Angle depending on distance (50, 100 and 150m) from water pond



Based on the appreciation of these results and considering field logistic operation, a distance of 100 m between the crest and the water pond was selected.

A second sensitivity composed of multiple analyses was conducted to assess the influence of the underground water table position in regard with the pit slope surface. A distance of 15 meters was set as a minimum distance to avoid frost penetration to mitigate icing damages in the rock mass and also to avoid water pressure buildup in the slope wall due to icing restriction

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to seepage flow. At the present stage of the hydrogeological study, a peripheral system of deep wells is considered for the underground water table control. Therefore, respecting a distance of 25 meters between the slope and the water table was considered feasible and was retained for the base case. Figure 15 presents the plotted curves where safety factors are plotted for 15 m and 25 m distances and different IRA slope angles.



Figure 15: Safety Factor Vs Inter-Ramp Angle depending on distance (15m and 25m) between slope and water table

It can be seen that for the last case, an IRA of 47⁰ is acceptable. The IRA does not take into account the presence of the Hauling Ramp.

Based on the assumptions of using good controlled production blasting practices and trimming and forming of the final benches with mechanical excavation (D=0.7), the minimum safety factors obtained from the analyses is found to meet the required minimum safety factor based on common engineering practice for static loading conditions. Figure 16 shows the results of static analysis based on the mean values of rock mass properties.



Figure 16: Minimum safety factor of static analysis (deterministic approach)

7.2.3.2 Pseudo-Static Analysis

The seismic stability of the base case slope was analyzed using the pseudo-static method. Seismic data was taken from the 2010 National Building Code Seismic Hazard Calculation data base which is reproduces in Appendix 5. A seismicity event with 2500 years return period was selected for the seismic analysis, which is considered appropriate for the open pit. The analyses were performed using a peak ground acceleration value (PGA) of 0.036 g which yields the pseudo-static parameter $k = 0.5 \times PGA = 0.018$.

As shown on figure 17, the minimum safety factor obtained from the analyses is much greater than the required minimum factors of safety for pseudo-static slope stability analyses are selected based on common engineering practice as 1.1 for high consequences as presented in table 14.



Figure 17: Minimum safety factor of pseudo-static analysis (deterministic approach)

7.2.3.3 Probabilistic Analysis

Since the rock mass strength parameters are variable and a high degree of uncertainty is always predictable, a probabilistic approach to the analysis of slope stability can be useful to assess the risk of failure. Assigning a normal distribution to the rock mass parameters allows to simulate the degree of uncertainty in these values. The Monte-Carlo technique is used to randomly generate input data samples, based on the normal distribution. Therefore, for a given slip surface which is calculated based on the mean values, variable safety factor values can be generated. This results in a distribution of safety factors, from which a Probability of Failure for the slope can be calculated. This is an essential parameter in risk assessment.

The probabilistic slope stability analysis is performed using the variation of geo-mechanical parameters of Iron Formation summarized in table 15. Based on the design criteria explained in section 5.2, the probability of failure (P [FOS≤1]) obtained from the probabilistic analyses is found to be less than the required criteria of 5%.



ROCK MASS AND INTACT ROCK PARAMETERS	MIN	MEAN	MAX	COMMENTS
GSI	25	35	45	Evaluated by - Figure 8
Unit Weight, (kN/m ³)	23,9	32,5	48,8	Laboratory Test
UCS, (MPa)	15	60	106	Laboratory Test

Table 15: Variation of Geo-mechanical Parameters of Iron Formation

Figure 18 shows the results of the probabilistic analysis. Also, cumulative probability plot of factor of safety is presented in Figure 19. As it can be seen, the probability of factor of safety less than 1.0, 1.2 and 1.3 are <3%, <24% and <47% respectively. This means that the existing database on the Iron Formation presents variations for which in 47% of the cases, the real Safety Factor doesn't meet the safety requirements. It also means that there is a 3% risk of slope failure. Further information on rock mass quality and increasing the number of tests on the rock could diminish the standard deviation. This would reduce the probability not to meet the required Safety Factor value.





LVM





7.2.3.4 Sensitivity Analysis

For this study a sensitivity analysis has been performed to determine which geo-mechanical parameters of Iron Formation have the greatest effect on safety factor. To do so, individual input parameters are varied between the minimum and maximum values presented in table 15 which results in a plot of safety factor versus the geo-mechanical parameter value shown on figure 20. The three parameters shown have the most significant influence on the safety factor. Consequently, efforts should be put on collecting more data on these parameters.





Figure 20: Plot factor of safety versus the variation of geo-mechanical parameters of Iron Formation (see table 15)

7.2.3.5 Benches Static Stability Analysis

For this study a sensitivity analysis has been performed to determine minimum factor of safety on a local bench (H) when water table (Hw) vary using static stability analysis. To do so, the (Hw/H) ratio is varied between 0 and 1 to measure the influence on factor of safety.

The minimum safety factors obtained from the analyses met the required minimum F.S. based on common engineering practice for static loading conditions as presented in table 14.

Figure 21 shows the results of static analysis on local bench based on the mean values of rock mass properties.



Figure 21: Minimum safety factor of static analysis varying water table on a local bench

7.3 STRUCTURAL STABILITY CONSIDERATIONS AND KINEMATICS ANALYSIS

During the geo-mechanical field investigation, some rock discontinuity data including joint orientation, joint roughness, joint planarity, joint alteration and joint infill were collected. These data were recorded from the cores as part of core logging process and are presented on the borehole logs in Appendix 2. The joint orientation data collected as alpha (α) and beta (β) angles were analyzed using Dips Version 6, developed by RocScience to infer the potential mean joint/fracture planes that may trigger unstable structural failure during mine excavations. Stereographic plot of the data is presented in Figures 6 and 7. Disregarding the geological units and based on available orientation data from 4 inclined boreholes drilled on the pit wall, five (5) discrete joint sets were potentially identified as summarized in Table 12 in section 4.4.2.

The failure mode of this highly fractured rock mass should primarily be governed by rock mass strength properties applied to the overall slope. Kinematic failure modes could also be an issue but the number and location of structural data representing the Iron Formation is not sufficient to carry out the kinematic analysis. Kinematic analysis generally addresses the potential of local structural instability in the scale of one or several benches. In the present case the local stability has been checked using LEA.



8 **RECOMMENDATIONS**

8.1 PIT WATER MANAGEMENT

8.1.1 Joyce Lake Pumping facility

The base case concerning the infringement of the mining open pit within the footprint of Joyce Lake is to temporarily empty the lake during the pit operation. To maintain the lake empty through time, runoff from the lake watershed will need to be pumped out on an ongoing manner. Pumping facilities will have to include a water ponding basin for pumps operations. This basin should be kept away from the open pit slope crest in order to avoid feeding unfavorably the underground water table. A preliminary sensitivity analysis (see chapter 7) has shown that a minimum distance of 100m between the water ponding and the crest of the pit slope would be reasonable.

8.1.2 Surface diversion ditches

Diversion ditches along the pit crest are required to divert the surface runoff away from the pit during operations.

8.1.3 Pit slope depressurization

Stability analyses of the rock mass for optimization of the pit slope have shown that the safety factor is very sensitive to the position of the water table. Also, deep frost penetration in exposed pit slope surface is to be considered. This consideration shall enforce that the water table be maintain as far as possible from the slope surface in order to avoid ice formation in joints that will diminish the rock mass permeability and promote the rise of the water table around the pit. This would result in pressurization of the pit slope and would be very detrimental to the slope stability. A minimum perpendicular distance of 25 meters from the inter ramp angle line measured between the toes of benches faces and the water was considered for stability analyses and is recommended to be always maintained during mine operation.

8.1.3.1 Vertical Pumping Wells

The installation of pumping wells will be of great importance to control and depressurize the rock mass. The water table lowering can be achieved either by the installation of staged peripheral medium depth wells or by peripheral deep wells system installed at ground surface level. The later might prove to be more cost effective. It can progressively lower the water table as excavation proceeds without possibly delaying production as would the implementation of the former system might do. Indeed, the stage wells system would have to be installed on the slope benches as excavation proceeds. This might interfere with operations. Also, with a stage wells system, upper stages can become obsolete as the water table is drawn down while the deep wells system remains always functional. Finally one further advantage for peripheral deep well system is that additional wells can be added at any time at ground surface if unpredicted water seepage condition develops in the pit walls.



One of the advantages of well pumping compared to bottom of pit pumping is the potential superior water quality of wells outflow compared to surface water. The later will definitively require water treatment before release in the environment while the former might very likely be adequate for direct release in the environment.

8.1.3.2 *Horizontal drains*

Horizontal drains are not, in the present project, the favoured solution for open pit slope depressurization and drainage. This is due mainly to the following different considerations:

- Due to the deep frost penetration in exposed rock mass, they should be drilled with an upward slope to insure free gravity flow without water remaining inside the drains and they shall be long enough to reach unfrozen rock mass.
- They would increase potentially the frost penetration depth in the rock mass by intrusion of cold air.
- Due to the highly fractured rock mass, they need to be lined with slotted piles to avoid local collapse or plugging by falling pieces of rock within the hole.
- The water released by a horizontal drain system will runoff on benches (if not connected directly to header pipes) and will quite probably pick up suspended iron oxide particles. Therefore, it will have to be pumped to a treatment facility before release in the environment. Also the permanent water runoff will promote benches saturation and increase their instability.

Horizontal drains should be used only locally and in exceptional cases where no other solution is available.

8.2 SLOPE GEOMETRY

8.2.1 Benches and IRA

Benches height has been set at 9m by the main engineering consultant when optimizing the pit profile in regard of the actual block model. Stability analyses have shown that the maximum IRA is to be 45° if the water table is drawn down sufficiently to insure a distance of 15 m between the slope face and the water table. The IRA can be increased to 47° if this distance is increased to 25 m. Drawing down the water table to this level is possible but additional pumping effort will imply a trade off with the economy on the stripping ratio at a later phase in the project. Meanwhile, the IRA of 47° is recommended at this phase of the project. Benches face angles varying between 65° and 75° are recommended and can be adapted to the local rock mass characteristics observed during excavation. For bench faces of 75° , bench width is 6.0m which is 5% less than 6.3 m required bench width mentioned in section 5.1. At this stage of the study, bench width 6.0m was considered acceptable.



8.2.2 Rockfall Protection

The rock mass being highly fractured, the possibility of loose blocks falling down the 9 m high benches faces is to be foreseen.

For benches width smaller than 6.0m, catch fences installed on the benches should be considered every two to four benches depending on local rock mass quality and as benches width gets narrower, safety berms meeting this dimension should be inserted at regular benches intervals. Also, wire mesh protection could provide an alternative solution for Rockfall.

8.3 OPERATIONAL CONSIDERATIONS

8.3.1 Excavation and slope protection

Most of excavation will be done by ripping and/or digging.

Any blasting if required should be kept at as minimum distance of 50m from benches faces. Some of the rock mass material could locally be erodible by runoff water. Local protection using membranes to intercept runoff might prove to be necessary. Proper management of runoff water is to be implemented to avoid surface erosion of benches and saturation of the rock mass in the benches.

Regular inspection and cleaning of water diversion systems (surface diversion ditches, collection ditches and sumps, etc.) have to be implemented on a regular basis.

8.3.2 Slope depressurization

Slope depressurization is a key element for the open pit slope stability. The system shall be robust and some redundancy of wells has to be integrated to the system to insure its effectiveness in case of partial shutdowns. Also, backup of key elements of the system related to energy delivery, piping, pumps and electrical equipment should be envisaged.

8.3.3 Geotechnical monitoring

The rock mass of the iron formation is very heterogeneous in terms of intact rock and in term of rock mass mechanical properties. Monitoring of local slope movements and of water table position is of prime interest.

Slope movements can be monitored on continuous basis using one or several slope stability radar units aiming at the critical sectors of the open pit. The radar system is mainly used for operational safety because it's rapid response and wide area coverage. Radar data is transmitted to central computers that can analyse the response and be programmed to trigger alarms if pre-specified levels are reached. Radar technology has to be used along with precise periodical land survey of monitoring monuments to complement the radar data by defining the direction of displacements and covering larger areas than the radar.

During excavation operations, some local slope areas could prove to be critical and might need special monitoring such as installation of inclinometers installed at certain benches levels.



Extensive water table monitoring is to be considered. Multi-level piezometers will have to be installed in numerous places and monitored on a regular basis. The minimum number of piezometers shall be at least equal to the number of dewatering wells and they should be staggered with the peripheral wells and located downstream of the wells line. Also, continuous records of wells discharge rates have to be implemented.

Temperature monitoring is also a concern to assess frost penetration in the exposed rock mass. The installation of thermistors is to be considered.

8.4 NEXT PHASE STUDY REQUIREMENTS

Out of 529 m of drilling length in the Iron Formation only 110 meters of runs showed an RQD larger than 50% and only 10 meters of core were presenting lengths sufficiently long to be tested in laboratory. This yields a database of rock joints orientation which proves to be variable and limited in number.

The next phase study shall aim at defining more accurately the joints database and the overall geometry of the contact between competent shale and sandstone formations with the Iron Formation. In order to achieve this, additional boreholes will be needed and additional methods of investigation should be deployed.

Geophysical methods such as seismic reflexion coupled with seismic refraction should be promising and relatively cheap to execute. Four parallel 1km long lines oriented North-East / South-West and two perpendicular lines of the same length should yield needed information of the Iron Formation to shale interface position. Also, a geophysical study of blasting energy absorption by the Iron Formation could at the same time be executed. It would help to assess the minimum distance between blasting holes and the future faces of the pit slope, in order to protect the rock mass if blasting is deemed to be used.

To adequately enhance the knowledge of the joint orientation data base, the execution of acoustic and optical geo-camera surveys in additional boreholes should permit to measure joints orientations and the in-situ joints geometry and bedding characteristics. Such a survey is, on the other hand, perilous due to the risk of losing the cameras if pieces of rock fall down the hole behind the camera. Innovative methods of providing shelter to the camera against fallouts might have to be experimented.

A minimum of 6 additional HQ3 size vertical geotechnical boreholes phase with acoustic and optical camera survey should be envisaged for detail engineering. Vertical holes will quite probably yield better recovery than incline holes.

8.4.1 Laboratory tests for next phase study

Rigorous statistical procedures exist to determine the number of specimen to test in order to build a database sufficiently robust to meet requirement for detail engineering design.

Gill et al. (2004) proposed an algorithm based on small – sampling theory to determine the minimal number of specimen to achieve the required precision index (figure 22) with respect to



a given target confidence interval. The precision index is defined as the ratio of upper and lower bounds of the number of mean interval as estimated from a group of samples. For permanent mining works and civil engineering applications, it is suggested to insure that $P \le 1.35$.

The minimal number of specimens then is determined using this algorithm which relates the required precision index and the coefficient of variation (100 × average value / standard deviation) obtained after testing.

Based on the number of laboratory tests done for Iron Formation (chapter 4), the coefficient of variation of 60 % and 78 % are evaluated for uniaxial compression strength and tension strength respectively. With respect to the confidence interval of 95 %, the minimal number of samples for laboratory testing using small-sampling theory for two different precision indexes of 1.35 and 1.5, are determined and presented in table 16. Table 17 presents the current amount of data obtained during this campaign.

For permanent mine opening, a precision index 1.35 is desirable, which means that a total of about 109 UCS test and 66 Brazilian tests should be required to build a robust database.



Figure 22: The precision index and maximum relative error suggested for different application

Table 16: Minimal number of laboratory testing for different Precision index

PRECISION INDEX	NUMBER OF SPECIMENS FOR UCS TEST	NUMBER OF SPECIMENS FOR BRAZILIAN TEST
P ≤ 1.3	66	109
P ≤ 1.5	38	62

Table 17: Current Database

NUMBER OF UCS TEST PERFORMED	NUMBER OF BRAZILIAN TEST PERFORMED
26	39
Note : These numbers exclude tests that were considered inva	lid

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9 CONCLUSION

The primary considerations for the design of the open pit slopes are related to maximum interramp and overall slope angles. These angles will affect the stripping ratio and the amount of ore that can be economically removed from the mineralized zone. The basis incorporated for the design of the open pit slopes is consistent with typical practices for open pit mines. Overall inter-ramp slope stability analyses have been conducted to ensure a minimum factor of safety of at least 1.3. The slope angles have been set based on overall rock mass characteristic which take into consideration the highly fractured Iron Formation and its intact rock physical and mechanical properties. The overall rock mass characteristics showed that essentially the primary mode of failure would be an overall circular slope failure similar to a soil failure.

The highly fractures rock mass of the Iron Formation greatly limited the possibility of orienting intact core recovery and therefore limited the possibility to identify with confidence families of discontinuities. Therefore the small data set of discontinuity characteristics which was collected limits the possibility of kinematic analyses for the assessment of local failure modes in the benches.

The overall stability analyses suggest the recommended pit slope angles are reasonable and appropriate. However, this design has a number of operational constraints including keeping water ponding away from the slope, careful mechanical excavation, slope surface water runoff control and effective slope depressurization. It also requires extensive monitoring and on-going commitments to data collection throughout the operational life of the mine.

As optimization of the open pit outline progresses the final bottom depth of the open pit is to be increased by 66m. An update of the safety factor for this additional depth will be included in this report at a later stage. This will diminish the safety factor of the slope. The minimum acceptance criteria of 1.2 for the safety factor is actually well met with the 1.3 present value. It is believed that the update will show that the minimum acceptance criteria will still be met.



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Appendix 1 Installations layout and benches details





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Appendix 2

Boreholes logs, photos and structural description



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			494.02 36.00	millimetric bands of red c	hert	-36																			
				bands of white chert.			1.0	50			R4	W4													
				oxyde]"/b"		-37	0.5	100			R4	W4													
= 1 : 10						-38		_																	
al Scale							1.3	50			H4	W4													
Vertica						-39																			
							1.6	19																	
			489.89 40.40	Iron oxyde interbeded wi		40																			Bedding N/A
			-10.10	millimetric bands of red c	hert	41	16	25	10		BA	WA													Joints at 40 to 75°
				bands of white chert.			1.0		15		114	***													
						42																			
						-43	1.5	0	0																
			105			-44	1.5	66	13.5		R4	W4													
			486.04	· · · · · · · · · · · · · · · · · · ·		E																			
	Joi Wa Pla Pla Pla Joi Fa	int R avy a avy a anar/ anar/ pe: int: ult:	oughnes and Rou and Smo and Rou Smooth Slickens	ss, Jr: gh 3.0 yoth 2.0 Jgh 1.5 Fill 1.0 sided 0.5 JN Bedding: BD FLT Foliation: FO		hint Al nfilled aled aining ightly lty/sa ay co	teratio Fractu g only altere ndy co pating	n, Ja: ıres d wall ating	0.7 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: Clay < Clay < Clay < L Clay > Clay > Clay >	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm 5mm	ck 1 1 1 1 1	4 6 8 12 10 15 20	Joint Mass One Two Two Three Three Four	Numb set plus ra sets sets pl sets pl sets sets or more bed root	er, Jn: ndom us ran plus ra e sets	dom ndom		0.5 2 3 4 6 9 12 15 20			IOLE	#:
.03.200	Sn Ve Co	ear: in: injug	ate:	VN Orthogonal: OR CJ Cleavage: CL	PI	ape: anar: urved	P :C	LUn USte	dulatin epped:	g: L	JN Im ST CI	egular: osed:	: IR C							I				-	
2-09-Ge-66A R.1 04	Ro Po Slie	lishe	ness: ed: P(sided: K	O Smooth: SM Very Rough: Rough: Ro Closed:	VR Bi C Bi Cl Fr	filling: oken otite: ay: nlorite esh:	Rock:	Br Bt Ca Cl Ep Ch Iro Fr Clo	lcite: iclote: n: osed:	Go Ca Gr Ep He Fe Qu C	ouge: avel: matite iartz:	Go Gr : He Qz	Sand: Sericil Silt: Sulphi	Sa e: Se Si de: Su	3									B	H-P-01

-17 15h	RE	ECO	ORD (OF ROCK CORE DRILLI	NG AN	ND 1	rest	ING	- BC	REH	IOLE	N°:						Bł	1-P-(01		I	Page		4 of11
2014-11	Fil	le n	°:	B-0010504-3	Projec	ct N	ame:								Joy	ce La	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed:
inted : 2	Nc	orth	ing:	6086486.969	Refer	enc	e Poi	nt:									Pre	ecisio	on GF	PS	Logge	ed by	/:		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658114.121	Datun	n:									Ν	IAD8	3 UT	M ZC	ONE	19	Drillin	g Co	ontrac	tor:	Downing
e_Lake	Ele	eva	tion:	527.85	Azimu	ut:										_		3	303.7	<u>0°</u>	Drille	rs:			
N_Joyc	Inc	clina	ation:	70°	Bit typ	be: _	r				Flu	sh:				Fee	d:				Drill F	{ig:			LF-70
LVM_A	Ĵ.			ROCK TYPE			INTE	RVAL	REC. I		STRENG	TH DATA			DI	sco	NTIN	UIT	/ DA	ТА					
otec_80Log_Forage_1 B-0010504-3	Casing&Core Diameter/Depth	Water Notes	:LEV./ Length(m)	DESCRIPTION		Depth (m)	ertval No. & Dept (from-to)(m)	TCR (%)	RQD (%)	ractures per_1_n	Strength Index	Veathering Index	Depth (m)	ype & Number (#	Orien	ETA (°)	Shape	Surface escription ssauu n bn	Infill	Jr	Ja	Jn	tt Breccia/ Gouge	ken Core	ES/COMMENTS PRINT DEPTH/ FILL TYPE & THICKNESS
og_Gec			ш				Ĕ			Ē		>		£.	AL	В		Ro					Fau (Bro	
√\Log\L			485.47	Highly weathered zone		45	0.5	00	100	10	D 2	10/4													Bedding at 65°
Y:\Style_L VI			485.10 45.50	inclusion oxyde interbeded with millimetric bands of red ch and millimetric to centimet bands of white chert	hert / tric /	46	0.5	00	100	10		VV4	-												Joints at 65 to 80°
				Highly weathered zone	/	47	2.5	40	0		R2	W5													
B.T.						48							-												
						49	1.5	0	0		R2	W5													
			481.24 49.60	[Weathered massive Iron oxyde]"/b"		50	1.5	13	0																
						51																			
: 100						52	1.5	33	10																
ical Scale = 1						53	1.5	13																	
Ver			476.92 54.20 476.64 54.50	Highly weathered zone Iron oxyde interbeded wit millimetric bands of red ch	 h nert	54 55	1.5	13																	
				bands of white chert.	unc	56	0.7	42			R4	W3	-												
						57	0.8	19																	
						58	1.5	0	0																
			471.85			59	1.3	15																	
9-Ge-66А R.1 04.03.2009	Joi Wa Pla Pla Pla Joi Fat Sh Co Roo Slid	int R avy a anar anar/ pe: int: ult: ear: in: njug ughr lishe ckins	ate: ate: ate: bided: K	ss, Jr: gh 3.0 ooth 2.0 gh 1.5 //ill 1.0 sided 0.5 JN Bedding: BD FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL D Smooth: SM Very Rough: V Rough: Ro Closed: C		int Al filled aled alinin; ghtly ghtly ghtly sa ay co anar: nrved illing: oken obtite: ay: alorite	teration Fractu g only alteren ndy co ating P : C Rock:	n, Ja: res d wall ating L Und U Ste Br Bt Cal Cl Epi Ch Iror Ch Iror	0.7 2 3 4 dulatin pped: cite: clote: : : : : : : : : : : : : :	g: L Go Ca Gr: Ep He Fe Qu	Filled Sand Stiff (Soft (Swell Stiff (Stiff (Soft (Swell Stiff (Stiff (Soft (Stiff (Soft (Swell Stiff (Stiff (Soft (Soft (Swell Stiff (Stiff (Soft (Soft (Soft (Stiff (Soft	: /Crush Clay < Clay > Clay > Clay > Clay > Clay > Clay > Go Gr Gr Gr Gr Qz	ned Ro 5mm 5mm 5mm 5mm 5mm 5mm 25mm 25mm 25mm	ck 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	4 6 8 12 10 15 20	Joint Mass One s One s Two s Two s Three Three Four Crust	Numb ive set blus ra sets sets pl e sets e sets or mor ned roo	er, Jn: ndom us ran plus ra e sets x	dom		0.5 2 3 4 6 9 12 15 20		F	IOLE	#: H-P-01

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-17 15h	R	ECO	ORD	OF ROCK CORE DRILLING	AND	TE	EST	ING	- BC	REF	IOLE	E N°:						B	H-P-(01		l	Page	: _!	5 of1	<u> </u>
2014-11	Fi	le n	ı°:	B-0010504-3 Pr	oject l	Na	me:								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & l	_ogge	ed:	_
rinted :.	No	orth	ing:	6086486.969 Re	eferen	ce	Poi	nt:									Pr	ecisio	on Gl	PS	Logg	ed by	/:		Al <u>ain Lemond</u>	е
e.sty- P	Ea	astir	ng:	658114.121 Da	atum:										Ν	IAD8	3 UT	MZ	ONE	19	Drillir	ng Co	ontrad	ctor:	Downin	g
e_Lake	El	eva	ition:	527.85 Az	zimut:											_		:	303.7	<u>′0°</u>	Drille	rs:				_
N_Joyc	In	clin	ation:	70° Bi	t type:	_					+1ı	ish:				⊦ee	ed:				Drill	Rig:			LF-/	0
LVM_A	_ E			ROCK TYPE		11		RVAL	REC. I		STRENE	ITH DATA		<u></u>	DI	SCO		ידוטו	Y DA	TA		1				
orage504-3	& Core	otes	gth(m)		Ű		a a a a a a a a a a a a a a a a a a a	(9		er_1_n	ndex	Index	Ê	ber (#	Orien	tation	D	Surface escripti	e on	Jr	Ja	Jn			ENTS TH/ S	
.og_Geotec_80Log_F B-00105	Casing Diameter/I	Water N	ELEV./ Len	DESCRIPTION	Dent		Inertval No. 8 (from-to)	TCR (%	RQD (%	Fractures pe	Strength I	Weathering	Depth (r	Type & Num	ALPHA (°)	BETA (°)	Shape	Roughness	Infil				Fault Breccia/ Gouge	Broken Core	NOTES/COMMI /IMPRINT DEF INFILL TYPE THICKNES!	
MILOGIL			59.60 471.47	Highly weathered zone		0																				
yle_LV			470.91	millimetric bands of red chert	í É		1.2	75	8.3		R4	W4														
Y:ISI			470.81 60.70	bands of white chert.	/i F6 - ',' F	1	0.5	60			R4	W3														
				Iron oxyde interbeded with	-' [0.5	20	0		R4	WЗ														
н.				millimetric bands of red chert and millimetric to centimetric	F	-	1.0	60	12		R4	W3														
				bands of white chert.	6	3 –	_																		Bedding at 70°	
					Ē		1.0	70	50	16	R4	WЗ													Joints at 45,70 and 85°	
					6	4																				
						_	1.5	66	47	24	R4	WЗ														
					Ē	•																			Bedding at 65° Joints at 65	
			466.02 65.80 465.83	Highly weathered zone	· ~ - 6	6	0.3	100			R4 R0	W3 W5													(10 75	
00			66.00	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	6	,	1.5	20																		
9 = 1 : 1			67.50 464.00	>50% of white chert.	·																				Bedding at 70° Joints at 70	
Vertical Scale			67.95 463.30 68.70	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric		5	1.5	83	44	19	R4	W5													\ <u>to 90°</u>	
			68.90 462.83	Highly weathered zone	- // E																				Bedding at 70° Joints at 70	
			69.20 462.36 69.70 462.07	h millimetric bands of red chert	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	D	1.8	89	31	20	R5	W3													to 90° Bedding at 70° Joints at 70 to 90°	
			461.60 70.50 461.32 70.80	4 centimetric bands of earthy material.	-7. -7. -7.	1	1.2	100	63	9	R5	W5													Bedding at 60°	
			46 <u>1.2</u> 3 70.90	millimetric bands of red chert and millimetric to centimetric bands of white chert		2 -	1.0	85	65		R5	W3													Joints at 70 to 85°	
				Highly weathered zone		3	0.2	100			-															
				millimetric bands of red chert and millimetric to centimetric bands of white chert.		4	1.6	94	60	13	R5	WЗ													Bedding at 60 to 70° Joints at 60 to 70°	
	Jo	int R	oughne	ss, Jr:	Joint	Alte	ratior	n, Ja:		•	Filler	•	•			Joint	Numb	er, Jn:		·	0.5	·				
		avy a avy a anar anar/ anar/ pe: int:	and Smo and Ro /Smooth /Slicken:	gri 2.0 ugh 2.0 JFill 1.5 sided 0.5 JN Bedding: BD	Heale Staini Slight Silty/s Clay o	id Fi ing c ily a sanc coat	ractu only Iterec dy coa ting	res 1 wall ating	0.7 1 2 3 4	5	Sance Stiff Soft Swel Stiff Soft Soft	i. Clay < Clay < Clay < I. Clay Clay > Clay > I. Clay	ed Ro 5mm 5mm 5mm 5mm 5mm > 5mr	n r	4 6 8 12 10 15 20	One One Two Two Three Three Four	set plus ra sets sets pl e sets e sets or mol	indom lus ran plus ra re sets	dom Indom		2 3 4 6 9 12 15				/ M	7
4.03.2009	Sh Ve Co	ear: ein: onjug	jate:	SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL	Shap Plana Curve	e: r: ed:	PI C	L Un U Ste	dulatin pped:	g: l	JN Irr ST C	egular losed:	: IR C			Crus	hed ro	ck			20			~		
:Q-09-Ge-66A R.1 0	Ro Po Sli	lishe ckins	ness: ed: P sided: K	O Smooth: SM Very Rough: VR Rough: Ro Closed: C	Infillin Broke Biotite Clay: Chlor Fresh	g: en R a: ite: :	lock: E E (Br Bt Ca CI Epi Ch Iror Fr Clo	lcite: iclote: n: osed:	Go Ca Gr Ep He Fe Qu C	ouge: avel: ematite uartz:	Go Gr : He Qz	Sand: Serici Silt: Sulph	Sa te: Sa Si ide: Si	1 9 9									В	п-۲-01	

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Vertical Scale = 1 : 100

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	Fil	le n	ı°:	B-0010504-3 Pro	oject N	lame	:							Joy	ce L	ake	- Op	en P	'it	Date	drille	⊮d & L	₋ogge	əd:
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	. (E			ROCK TYPE			RVAL	REC. I		STRENG	TH DATA	_		DI	SCO	NTIN	ΙΟΙΤΥ	<u>1 DA1 /</u>	ΓA	Т	<u>т</u>			
504-3	&Core Depth	otes	gth(m)	l	E E	& Dept	; ;	(9	er_1_n	ndex	Index	Ê	iber (#	Orient	tation	De	Surface escription	on	Jr	Ja	Jn			S TH/ S
Ug Gener_outug_	Casing Diameter/I	Water N	ELEV./ Leng	DESCRIPTION	Dept	Inertval No. { (from-to)	, TCR (%	RQD (%	Fractures pe	Strength I	Weathering	Depth (r	Type & Num	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INFILL TYPE THICKNES!
MILUYI		\square	74.60 457.56	Highly weathered zone	- / 75	F	\square	\square	\square	\square	\square							\square			\square			
			74.80 456.62 75.80	 millimetric bands of red chert and millimetric to centimetric bands of white chert. 		1.0	100	10		R4	W3													
			455.50 77.00	50% of white chert. Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric		1.7	67	88	48	R5														Bedding at 60 to 70° Joints at 60°
ġ			454.32	30 to 40% of white chert. Iron oxvde interbeded with	-' - 78	0.8	100	13		R5														Bedding N/A Joints at 80°
			78.25 453.99 78.60 453.15	¹ millimetric bands of red chert ¹ and millimetric to centimetric ¹ bands of white chert. ¹ 30% of white chert.	/ 179	1.8	86	5		R5	W5													Bedding at 5 to 40° Joints at 10 and 60 to 70°
			79.50 452.68 80.00	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	- 80 	1.0	80	30	10	R5	WЗ													Bedding at 20° Joints at 20 to 45° and 80°
			450.80 82.00 450.23	Highly weathered zone Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	- 82	1.6	50	28	16	R5	W3													Bedding at 80° Joints at 45 to 80°
Vertical ocare = 1			82.60	40 to 50% of white chert. Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	83	1.4	100	24	19	R5	W3	-												Bedding at 80 °
					85	1.5	100	27	30	R5	W3	_												Bedding N/A
			446.95	Highly weathered zone	86	1.5	100	20	18	R1	W4													Joints at 60 to 70° Bedding N/A Joints at 45,60
			86.20	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric	87	1.5	100	61		R3	W4													and 85°
			444.60	bands of white chert.	-88	1.6	94	25	35	R5	WЗ													Joints at 70°
			88.60	Iron enriched dark grey zone.		1.1	73	9		R5	W2								L					
	Joi Wa	int R avy ३	oughnes	ss, Jr: gh 3.0	Joint A Unfiller	Iteratio	on, Ja:			Filled	:				Joint Mass	Numb	er, Jn:			0.5	1			
	Wa Pla Pla Pla Ty Jo	avy a inar inar/ inar/ inar/ pe: int:	and Smo and Rou Smooth/ /Slickens	oth 2.0 igh 1.5 Fill 1.0 sided 0.5	Healed Stainin Slightly Silty/sa Clay cr	Fractor g only altere andy ca bating	ures d wall pating	0.75 1 2 3 4	5	Sand, Stiff (Soft (Swell Stiff (Soft (/Crush Clay < Clay < I. Clay Clay > Clay >	ied Ro 5mm 5mm 5mm 5mm 5mm	n	4 6 8 12 10 15	One s One p Two s Two s Three Three	set plus ra sets sets pl e sets e sets	Indom lus ran plus ra	dom		2 3 4 6 9 12				
3.2009	Fa Sh Ve	ult: ear: ear:		FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR	Shape: Planar		PL Un	dulatin	ig: ţ		egular	: IR			Crush	hed ro	ck		_	20			IULE	
Q-09-Ge-66A R.1 U4.u	RoPosi	ughr lishe ckins	ness: pd: PC sided: K	Smooth: SM Very Rough: VR Rough: Ro Closed: C	Infilling: Broken Biotite: Clay: Chlorite Fresh:	: Rock: e:	Br Bt Ca Cl Epi Chiror Fr Ck	Icite: iclote: n: psed:	Go CaGr Ep He Fe Qu C	Juge: avel: matite Jartz:	Go Gr : He Qz	Sand: Sericil Silt: Sulphi	Sa te: Sa Si ide: Si	a e i U									B	H-P-01

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Vertical Scale = 1 : 100

1-17 15h	R	ECO	ord o	OF ROCK CORE DRILLING	AND	TES	TING	- BC	DRE	IOLE	N°:						BI	H-P-	01		I	Page	:	7 of11
2014-1	Fil	le n	•	B-0010504-3 P	roject N	lame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed:
rinted :	No	orth	ing:	6086486.969 R	eferenc	e Po	int:									Pr	ecisio	on Gl	<u>PS</u>	Logg	əd by	<i>'</i> :		Al <u>ain Lemonde</u>
e.sty- P	Ea	astir	ng:	<u>658114.121</u> D	atum:									Ν	IAD8	IS UT	MZ	ONE	19	Drillir	ig Co	ontrac	ctor:	Downing
ce_Lak	El	eva	tion:	527.85 A	zimut:					Elu	unde:				For	d.		303.7	<u>′0°</u>	Drille	íS: Diai			
NVoV	Inc		ation:	70° B	i type.	1					1511.				ree					DIIIII	1ig.			LF-70
- TVM_	e E		2	ROCK TYPE		INTE 5		REC.		STRENG	TH DATA		æ	DI	SCO		Surface	Y DA						
Forage_ 504-3	Dept	lotes	gth(m) (E) L	& Dep (m)	(%	(%	er_1_	Index	g Inde	Ê	nber (;	Orien	itation	D	escripti	on	Jr	Ja	Jn			ENTS PTH/ S
Log_Geotec_80Log_ B-0010	Casing	Water N	ELEV./ Len	DESCRIPTION	Dept	Inertval No. (from-to	TCR (°	RQD (°	Fractures p	Strength	Weathering	Depth (Type & Nun	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMM /IMPRINT DEI INFILL TYPI THICKNES
Style_L VM\Log			443.37 89.90 443.19 90.10 442.95	Iron oxyde interbeded with millimetric bands of red chert		1.0	100	100	23	R5	wз	-												Bedding at 80° Joints at 70 to 80°
<i>λ</i> :/			90.35 442.81 90.50 442.72 90.60	bands of white chert. 80% of white chert.	<mark> </mark>	1.0	0	0	-															
B.T.			442.34 91.00 441.68 91.70	A minimetric barlds of red chert and millimetric to centimetric bands of white chert. Highly weathered zone	/ 92	1.3	31	0				_												
			439.52 <mark>94.00</mark> 439.33	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.		1.5	80	66	15	R5	W3													Bedding N/A Joints at 20,45, 60 and 85°
			94.20	iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric	- 	1.2	60	20	18			_												Bedding N/A Joints at 10,30,
0				Highly weathered zone Iron oxyde interbeded with millimetric bands of red chert	/ <mark>- 96</mark> _/	1.3	76	15		R5	WЗ													\55 and 70°
al Scale = 1 : 10				and millimetric to centimetric bands of white chert.	-98	0.3	50 24																	
Vertic					99	0.8	100			R5	WЗ	-												
					-10	0 1.2	100	46	-			-												
					10	1.0	60	23																
					10	1.5 3	51			R5	W3													
					-10	4 1.5	20																	
	Jo	int R	oughnes	ss, Jr:	Joint A	Iteratio	n, Ja:					•	•		Joint	Numb	er, Jn:		·					
	Wa	avy a avy a anar	and Smo and Smo	ooth 2.0 Jigh 1.5	Healed	u. I Fracti Ig onlv	ures	0.7	5	Sand Stiff (/Crush Clav <	ned Ro 5mm	ck	4 6	One One	set plus ra	Indom			23				
	Pla Pla	anar/ anar/	Smooth Slickens	/Fill 1.0 sided 0.5	Slightl Silty/si	y altere andy co	d wall bating	2		Soft (Swel	Clay < I. Clay	5mm < 5mm	n r	8	Two Two	sets sets p	us ran	dom		4				
	Ty Joi	pe: int:		JN Bedding: BD	Clay c	oating		4		Stiff C Soft C	Clay > Clay >	5mm 5mm > 5mn		10 15 20	Thre	e sets e sets or mo	plus ra	andom		9 12 15		[F		# ·
2009	Fa Sh Ve	uit: iear: ein:		SHR Contact: CO VN Orthogonal: OR	Shape	: : F	PL Un	dulatin	ng: I	JN IIm	egular	: IR		_	Crus	hed ro	ck			20				
1 04.03	Co Ro	onjug oughr	ate: ness:	CJ Cleavage: CL	Curve Infilling	d: (:	CU Ste	epped:		ST C	osed:	С											В	H-P-01
2-09-Ge-66A R.	Po Sli	lishe ckins	ed: P(sided: K	D Smooth: SM Very Rough: VR Rough: Ro Closed: C	Broker Biotite Clay: Chlorit Fresh:	e:	Br Bt Ca CI Ep Ch Iron Fr Clo	lcite: iclote: n: osed:	Ga Ca Gr Ep He Fe Qr C	ouge: avel: ematite uartz:	Go Gr : He Qz	Sand: Sericil Silt: Sulph	Sa e: Se Si de: Su	1 e E										

Y:IStyle_LVMILogLog_Geotec_80Log_Forage_LVM_AN_Joyce_Lake.sty- Printed : 2014-11-17 15h

Vertical Scale = 1 : 100

-17 15h	R	ECC	ORD (OF ROCK CORE DRILLIN	IG AN	ID 1	TEST	ING	- BC	REF	IOLE	N°:						B		01		I	Page	:	8 of1
2014-11	Fil	le n	°:	B-0010504-3	Projec	ct Na	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	_ogge	ed:
inted : 2	No	orthi	ing:	6086486.969	Refere	ence	e Poi	nt:									Pr	ecisio	on GF	<u>PS</u>	Logg	ed by	<i>ı</i> :		Alain Lemonde
.sty- Pr	Ea	astir	ng:	<u>658114.121</u>	Datun	n:									Ν	IAD8	3 UT	M ZQ	ONE	19	Drillir	ig Co	ontrac	ctor:	Downing
e_Lake	Ele	eva	tion:	527.85	Azimu	ıt:										_		:	303.7	<u>0°</u>	Drille	rs:			
N_Joyc	Inc	clina	ation:	<u>70°</u>	Bit typ	be: _					Flu	ish:				⊦ee	ed:				Drill F	Rig:		T	LF-70
LVM_A	(m)			ROCK TYPE			INTE 윤	RVAL	REC. I		STRENG	TH DATA			DI	sco		ידוטו	/ DA	ТА					
orage504-3	& Core Depth	otes	gth(m)			(m)	a Dep a	((9	sr_1_n	ndex	Index	Ê	ber (#	Orien	tation	D	Surface escripti	e on	Jr	Ja	Jn			S ATH/S
_Geotec_80Log_F B-00105	Casing Diameter/I	Water N	ELEV./ Lenç	DESCRIPTION		Depth	Inertval No. 8 (from-to)	тск (%	RQD (%	Fractures pe	Strength I	Weathering	Depth (r	Type & Num	(°) ALPHA (BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	IOTES/COMMI /IMPRINT DEF INFILL TYPE THICKNES
W\Tog\Log																									-
yle_LV						-105																			
Y:IS						106	1.3	100	0		R5	W3													
Ë.						-107	1.7	20																	
						108																			
						109	1.5	33	17		R4	WЗ													
			424.96 109.50 424.67 109.80	Altered black mineralized material	 /	-110	1.0	100	60		R0	W5													
			424.02 110.50 423.78	interbeded with millimetric	1		0.5	100	50		R2	W4													
100			110.75	bands of very crieft and millimetric to centimetric bands of white chert. Iron oxyde interbeded with	'i	-111	1.7	60	19		R0	W5													
cal Scale = 1 :			422.23 112.40	i millimetric bands of red che and millimetric to centimetri bands of white chert. Altered black mineralized	rt ; c ; ';	113	1.0	100	100			WE													
Verti			420.73 114.00	Weathered Iron oxyde interbeded with millimetric	' '	-114	1.5	100				vv3													
			419.51 115.30	millimetric to centimetric bands of white chert.	' ' ,-	-115	1.5	80	40																
			419.04 115.80	Altered black mineralized material & Iron oxyde interbeded with millimetric	' 	116	1.7	88	88	15	R4	W5													
				bands of red chert and millimetric to centimetric	-	-117	0.5	80																	
				bands of white chert. Iron oxyde blackish interbeded with millimetric	'	-118	1.0	80	80	12	R4	W5													Bedding N/A Joints at 10,45 and 70°
			416.12 118.90	bands of red chert and millimetric to centimetric	_	-119	0.5	100	80	5															
	Joi	int Re	oughne	ss, Jr:		int Al	teratio	n, Ja:	•	•	Filled		•	•		Joint	Numb	er, Jn:			0.5				
	Wa Pla Pla Pla Ty Joi	avy a anar a anar/a anar/ pe: int:	and Smo and Ro Smooth Slicken	yri 3.0 yoth 2.0 ugh 1.5 /Fill 1.0 sided 0.5 JN Bedding: BD	He Sta Sli Cla	aled aining ghtly ty/sai ay co	Fractu g only altere ndy co ating	ires d wall ating	0.7 1 2 3 4	5	Sand Stiff (Soft (Swel Stiff (Soft (Soft (Clay < Clay < Clay < I. Clay Clay > Clay >	ed Ro 5mm 5mm 5mm 5mm 5mm	ck	4 6 8 2 0 5	One One Two Two Three Three	set plus ra sets sets pl e sets e sets	indom us ran plus ra	dom		2 3 4 6 9 12				
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२-09-Ge-66A R.1 04.03 .	Co Ro Po Sii	njug ughr lishe ckins	ate: ness: d: P sided: K	CJ Cleavage: CL O Smooth: SM Very Rough: VF Rough: Ro Closed: C	Cu Cu Brc Bid Cla Ch Fre	illing: oken otite: ay: lorite osh:	Rock:	Br Bt Cal Cl Epi Ch Iror Fr Clo	cite: clote: 1: sed:	Go Ca Gr Ep He Fe Qu C	ST CI ouge: avel: matite iartz:	Go Gr : He Qz	C Sand: Sericit Silt: Sulph	Sa e: Sa Si de: Su)))									В	H-P-01

LVM AN JO BOL C V-IStule I VMU o

Vertical Scale = 1 : 100

-17 15h	RE	ECO	ORD	OF ROCK CORE DRILLING	g and	TES	TING	- BC	REF	IOLE	N°:						B	H-P-(<u>)1</u>		I	Page	: _ !	9 of <u>11</u>
2014-11	Fil	le n	۱°:	B-0010504-3 P	roject N	lame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed:
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e.sty- P	Ea	astii	ng: 	<u>658114.121</u> D	atum:									Ν	IAD8	3 UT	M ZQ		<u>19</u>	Drillin	ig Co	ontrac	tor:	Downing
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e_LVM	ore th (m)		Ê			epth			E	×	ex		(#)	Orien	itation		Surface	, ,						w _
Geotec_80Log_Forag B-0010504-3	Casing&Co Diameter/Dep	Water Note	ELEV./ Length(DESCRIPTION	Depth (m	Inertval No. & De (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1	Strength Inde	Weathering Ind	Depth (m)	Type & Number	ALPHA (°)	BETA (°)	Shape	scripti	Infill	JI	Ja	511	ault Breccia/ Gouge	roken Core	DTES/COMMENT MPRINT DEPTH INFILL TYPE & THICKNESS
og\Log_(\ bands of white chert.	_/ E												-					ш Т	•	Bedding N/A
				Black Shale	-12	0.8	100	80	21															and 70° Bedding N/A
Y:\Style					-12	1.5	100	90	15	R4	W2													Joints at 10,45 and 70° Bedding N/A
<u>ر</u> ،					12	_																		and 70°
B .7						1.5	100	67	13															Joints at 10,45 and 70°
					-12	1.5 4	100	59	19	R4	W2													Bedding N/A Joints at 10,45 and 70°
					-12	5 1.5	100	93	6	R4	W2													Bedding N/A Joints at 10,45 and 70°
= 1 : 100			408.09		-12	1.5 7	100	87	8	R4	W2													Bedding N/A Joints at 15,45 and 70°
Vertical Scale			127.45 408.04 127.50	Bed of Siltstone	-/	8 1.5	100	100	4	R4	W2													Bedding at 75° Joints at 15,45 and 70°
			129.00	Interbedded Grey Siltstone / Blackshale		9																		Bedding at 80° Joints N/A
					-13	1.5 0	100	93	14	R4	W2													Bedding at 75° Joints at 10,45, 60 and 85°
					-13	1 1.5	100	90	15	R4	W2													
					-13	2																		Bedding at 75° Joints at 10,45,
					-13	1.5 3	93	51	10	R4	W2													\65 and 85°
											-													
	Joi	int R	401.84 Coughne	ess, Jr:	F-13	4 Viterati	on, Ja:								Joint	Numb	er, Jn:							
	Wa Pla Pla Pla Joi Fa	avy a avy a anar anar/ anar/ pe: int: ult:	and Rou and Smo and Ro /Smooth /Slicken	igh 3.0 ooth 2.0 ugh 1.5 VFiil 1.0 sided 0.5	Unfille Healed Stainir Slighti Silty/s Clay c	d: I Fract Ing only y altern andy c oating	ures ed wall oating	0.7 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: Clay < Clay < Clay < Clay > Clay > Clay >	ed Ro 5mm 5mm 5mm 5mm 5mm > 5mn	ck n 1 1 n 2	4 6 8 12 10 15 20	Mass One : One : Two : Two : Three Three Four Crust	ive set sets sets pl sets pl sets sets or mor hed roo	ndom us ran plus ra e sets	dom Indom		0.5 2 3 4 6 9 12 15 20			IOLE	#:
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Q-09-Ge-66A R.1 04	Ro Po Slie	lishe ckins	ness: ed: P sided: K	O Smooth: SM Very Rough: VR Rough: Ro Closed: C	Infilling Broker Biotite Clay: Chlorit Fresh:	j: n Rock : :e:	:Br Bt Ca CI Ep Chlroi Fr Clo	lcite: iclote: n: osed:	Go Ca Gr Ep He Fe Qu C	ouge: avel: matite iartz:	Go Gr : He Qz	Sand: Sericit Silt: Sulphi	Sa e: Se Si de: Su	1 9 9									В	H-P-01

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2014-11-	Fi	le n	ı°:	B-0010504-3	Project	Na	ame:								Joy	ce L	ake	- Op	oen F	Pit	Date	drille	d & L	logge	ed:
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og_Geotec_80Log_Fc B-00105	Casing8 Diameter/D	Water No	ELEV./ Leng	DESCRIPTION		Depth	Inertval No. & (from-to)(TCR (%	RQD (%	Fractures pe	Strength Ir	Weathering	Depth (n	Type & Numb	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INFILL TYPE THICKNESS
N/Log\L			134.10	Grey Sandstone, fine to medium grain			1.5	97	80	6	R4	W2													Bedding N/A Joints at 5 to 15,45,
yle_LVI					E1	35							-												60 and 85°
Y:\S						36	1.5	100	90	5	R4	W2													Bedding N/A Joints at 5 to 15,45,
B.T.					1	37	1.5	100	53	10	R4	W2													60 and 85°
					-1	139	1.5	80	10	12	R4	W2													Bedding N/A Joints at 5 to 15,45,
					1	40	1.5	100	95	5															60 and 85°
00					1	41	1.5	100	40	17	R4	W2	-												
cal Scale = 1 : 1					1	142							-												Fine Bedding at 90° Joints at 5 to 10,20, 60 to 70°
Verti					1	144	1.5	100	73	7			-												
			391.13	- Crov Sandatana fina ta		45	1.5	100	13	93	R4	W2	-												
			140.00	medium grain centimetric interdedded with black shal	e.	146	1.5	100	93	8															Well marked Beddings at 60 to 90° Joints at 20,40, 60 and 80°
					1	48	1.5	100	73	11	R4	W2	147.60 147.69 147.80 147.82 147.94	JN JN JN JN JN	58 78 70 73 73	315 280 290 310 310	PL UN PL PL PL PL	SM SM SM SM SM	QZ QZ FR FR FR						Orientation test
	-		<u> </u>		<u>F</u>								147.98	JN	64 73	310	PL	SM	FR						
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 | BETA (°) | Shape | Roughness
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Gouge | Broken Core | NOTES/COMI
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| | | 384.74
152.30 | Grey Sandstone | -152 | 1.5 | 100 | 93 | 5 | R4 | W2

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Bedding
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 | 151.40
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295 | PL | PO
 | FR | | | | | | to 75° |
| | | | | -154 | 0.6 | 100 | 100 | 4 | R4 | W2

 | 154.10 | JN
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| | | | | -155 | 0.9 | 100 | 100 | 3 | R4 | W2

 | 154.28
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| | | | | | 0.8 | 100 | 100 | 4 | R4 | W2

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| | | | | -156 | 1.0 | 100 | 80 | 7 | R4 | W2

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| | | 377.50 | End of borobolo at a longth of | -159 | 1.0 | 100 | 100 | 6 | R4 | W2

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Northing: Easting:	<u>6086486.969</u> 658114.121	Reference Point: Datum:		Precision GPS NAD83 UTM ZONE 19	<u>S</u> 9	Logged by: Drilling Contractor:	<u>Alain Lemonde</u> Downing
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Northing:	6086486.969	Reference Point:			Logged by:	Alain Lemonde
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Elevation: 527.85 Azimut: 303.70°	Drillers:	Downing
Inclination: 70° Bit type: Flush: Feed:	Drill Rig:	LF-70
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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	DGRAPHY - BOREHOLE N°: B-0010504-3 6086486.969 658114.121 527.85 70°	BH-P-01 Project Name: Reference Point: Datum: Azimut: Bit type:	 Flush:	Joyce Lake - Open P Precision GP NAD83 UTM ZONE 1 303.70 Feed:	t 6 9 -	Page: <u>12</u> Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	of <u>12</u> Alain Lemonde Downing LF-70
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DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run					Discontinuity					
Dept	th (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
7,50	8,00	100	0								
8,00	9,00	25	0								
9,00	10,50	27	0								
10,50	11,50	85	0								
11,50	12,00	100	20								
12,00	13,20	65	50								
13,20	14,10	100	20								
14,10	15,00	100	33								
15,00	18,00	13	0								
18,00	21,00	27	0								
	24,00	3	0								
	27,00	8	0								
	29,20	36	0								
	30,00	4	0								
	31,50	10	0								
	33,00	16	0								
	34,70	80	28								
	36,00	100	23								
	37,00	50	0								
	37,50	100	0								
	38,80	50	0								
	40,40	19	0								
	42,00	25	19								
Ту	/pe						Roughnes	S		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	K	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	jht:	VR	Gouge		GO
Foliation:	FO						01		Biotite:	-	ы
Contact:	CO	<u> </u>				Diaman	Snape		Calcite	<u>.</u>	
						Planar:			Uniorite	e:	
									liron:	+o.	
						Chammard	ig:		nemati	ie:	
						Stepped:		10	Quartz		
						irregular:		μк	LIMONI	te:	LI



F

DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run			Discontinuity							
Dept	h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
	43,50	0	0								
	45,00	66	14								
	45,50	80	0								
	48,00	40	0								
	49,50	0	0								
	51,00	13	0								
	52,50	33	10								
	54,00	13	0								
	55,50	13	0								
	56,20	42	0								
	57,00	19	0								
	58,50	0	0								
	59,80	15	0								
	61,00	75	8								
	61,50	60	0								
	62,00	20	0								
	63,00	60	12								
	64,00	70	50								
	65,50	66	47								
	66.00	100	0								
	67.50	20	0								
	69.00	83	44								
	70.80	89	31								
Τv	De	00	01				l Rouahnes	s		Infilli	na
Joint:	JN					Polished:	y	PO	Broken	rock:	BŘ
Fault:	FLT					Slickinsid	led:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:	-	RO	Clay:		CL
Bedding:	BD					Very roug	jht:	VR	Gouge		GO
Foliation:	FO								Biotite:		BT
Contact:	CO					Diama	Shape		Calcite		
						Planar:			Chiorite	9:	
						Curved:	<u></u>		liron:		
						Stormark	ig:		nemati	ie:	
						Stepped:		31 ID			
					Irregular: IR Limonite: LI						



F

DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run					Discontinuity					
Dept	th (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	l ype & number	α angle	β angle	Shape	Roughness	Infill
	72,00	100	63								
	73,00	85	65								
	73,20	100	0								
	74,80	94	60								
	75,80	100	10								
	77,50	67	88								
	78,25	100	13								
78,25	80,00	86	5								
80,00	81,00	80	30								
81,00	82,60	50	28								
82,60	84,00	100	24								
84,00	85,50	100	27								
85,50	87,00	94	25								
87,00	88,60	94	25								
88,60	89,70	73	9								
89,70	90,70	100	100								
90,70	91,70	0	0								
91,70	93,00	31	0								
93,00	94,50	80	66								
94,50	95,70	60	20								
95,70	97,00	76	15								
97,00	97,30	50	0								
97,30	99,00	24	0								
Ту	/pe						Roughnes	S		Infilli	ing
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA
Snear Voin:						Smooth:		BO	Clay:		
Redding:						Verv roug	ht	VB	Goure		GO
Foliation	FO		1		L	Trony roug		1	Biotite	1	BT
Contact:	co						Shape		Calcite	:	CA
	1				L	Planar:		PL	Chlorit	e:	СН
						Curved:		CU	Iron:		FE
						Undulatin	g:	UN	Hémati	te:	HE
						Stepped:		ST	Quartz	•	QZ
						Irregular:		IR	Limoni	te:	



DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run				Discontinuity						
Dept	h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
99,00	99,80	100	0								
99,80	101,00	100	16								
101,00	102,00	60	23								
102,00	103,50	51	0								
103,50	105,00	20	0								
105,00	106,30	100	0								
106,30	108,00	20	0								
108,00	109,50	33	17								
109,50	110,50	100	60								
110,50	111,00	100	50								
111,00	112,70	60	19								
112,70	114,00	100	100								
114.00	115,50	80	40								
115,5	117,2	88	88								
117,2	117,7	80	0								
117,7	118,7	80	80								
118,7	119,2	100	80								
119,2	120	100	80								
120	121,5	100	90								
121,5	123	100	67								
123	124,5	59	19								
124,5	126	93	6								
126	127,5	100	87								
Ту	ре						Roughnes	S		Infilli	ing
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	iht:	VR	Gouge		GO
Foliation:	FO		1				0		Biotite:		RI
Contact:	CO					Diaman	Shape		Calcite		
						Planar:			Chiorite	9:	
						Curvea:	A -		liron:		
						Ondulatin	ig:		nemati	le:	
						Stepped:		121	Quartz		
						irregular:		μк	LIMONI	le:	



E

DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run						Disco	ontinuity			
Dept	h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
127,50	129,00	100	100								
129,00	130,00	100	93								
130,00	130,50										
130,50	132,00	100	90								
132,00	133,50	93	51								
133,50	135,00	97	80								
135,00	136,50	100	90								
136,50	138,00	100	53								
138,00	139,50	80	100								
139,50	141,00	100	95								
141,00	142,50	100	40								
142,50	144,00	100	73								
144,00	145,50	100	13								
145,50	147,00	100	93								
147,00	148,50	100	73								
				147,60	148,50	BD	60	305-360	PL		QZ
					147,60	1 JN	56	315	PL	SM	QZ
					147,69	1 JN	78	280	UN	SM	QZ
					147,80	1 JN	70	290	PL	SM	
					147,82	1 JN	73	310	PL	SM	
					147,94	1 JN	73	310	PL	SM	
					147,98	1 JN	64	310	PL	SM	
					148,06	1 JN	73	310	PL	SM	
Ту	ре						Roughnes	S		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	K	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:						Hought:	ht.		Ciay:		
Beading:	BD EO					Ivery roug	jiit.	١٧Ħ	Biotito:		BT
Contact:							Shane		Calcite:		CA
Sonact.	itact: CO		1			Planar:	onupo	PL	Chlorite	a:	СН
						Curved:		CU	Iron:		FE
						Undulatin	g:	UN	Hémati	te:	HE
						Stepped:	~	ST	Quartz:		QZ
						Irregular:		IR	Limoni	ie:	LI



DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Rur	ו					Disco	ontinuity			
Dep	th (m)			Dep	th (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
					148,28	1 JN	64	340	PL	SM	
					148,50	1 JN	75	30	PL	SM	
148,50	150,00	100	100								
					149,05	1 JN	70	330	PL	SN	QZ
				149,10	149,25	BD	70-76	10	PL	PO	QZ
					149,54	1JN	63	285	PL	PO	СН
					150,00	1 JN	42	325	IR	RO	
150,00	151,50	100	100								
					150,08	1 JN	87	290	PL	SM	FE
				150,08	150,27	BD	83	90	UN		
					150,27	1 JN	78	165	IR	SM	QZ
				150,40	151,07	BD	37-63	60	UN		
					150,46	1 JN	67	70	CU	SM	FE
					150,58	1 JN	65	67	CU	SM	QZ
					150,83	1 JN	56	80	PL	PO	
					150,86	1 JN	50	85	PL	PO	
					151,01	1 JN	36	85	UN	1	
					151,07	1 JN	61	100	CU	PO	
					151,08	1 JN	40	100	PL	PO	
					151,14	1 JN	71	95	PL	RO	FE
					151,40	1 JN	77	315	IR	SM	EP
					151,50	1 JN	73	295	PL	PO	
151,50	153,00	100	93							1	
Ту	/pe						Roughnes	ŝS		Infilli	ing
Joint:	JN					Polished:	· ·	PO	Broker	rock:	BR
Fault:	FLT					Slickinsic	led:	K	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:	-	RO	Clay:		CL
Bedding:	BD					Very roug	jht:	VR	Gouge	:	GO
Foliation:	FO		-				01	Biotite: Calcite:			BI
Contact:		1				Dianari	Snape		Calcite	:	
						Curved:			lrop	е.	
						Undulatin	nu.		Hámeti	ito:	HE
						Stenned	·y.	ST	Quartz		07
						Irregular.		IR	Limoni	te:	<u> </u>
								1			1



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DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

1

	Run						Disco	ontinuity			
Dept	th (m)			Dept	th (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
153,00	153,20	100	100								
153,20	153,70	80	80								
153,70	154,30	100	100								
154,30	155,20	100	100								
					154,10	1 JN	76	50	CU	SM	
					154,28	2 JN	10	215	PL	SM	
					154,65	1 JN	81	70	PL	RO	QZ
					154,83	1 JN	70	195	PL	RO	QZ
					155,20	1 JN	78	65	PL	RO	FE
155,20	156,00	100	100								
156,00	157,00	100	80								
157,00	157,50	100	100								
157,50	159,00	100	100								
159,00	160.00	100	100								
	End of h	ole									
Ту	(ne						Roughnes	<u> </u>		Infilli	ing
Joint:	JN					Polished:	noughnes	PO	Broken	rock:	BR
Fault:	FLT					Slickinsic	led:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	jht:	VR	Gouge		GO
Foliation:	FO								Biotite :		BT
Contact:	tact: CO						Shape		Calcite		CA
						Planar:		PL	Chlorit	e:	СН
						Curved:		CU	Iron:		FE
						Undulatin	ig:	UN	Hémati	te:	HE
						Stepped:		ST	Quartz		QZ
					Irregular:		IR	Limoni	te:	LI	

-17 15h	R	ECO	ORD C	F ROCK CORE DRILLING	AND .	TEST	ING	- BO	REH	IOLE	N°:						Bł	I-P-0	2		l	Page	:	1 of12_	_
2014-11-	Fil	le n	•:	B-0010504-3 Pro	oject N	ame								Joy	ce L	ake	- Op	en P	it [Date	drille	ed & L	ogge	ed: 2014-09-25	-
inted : 2	No	orth	ing:	6086299.006 Re	ferenc	e Poi	nt:									Pre	ecisio	n GP	<u>s</u> l	_ogge	ed by	/ :		Al <u>ain Lemonde</u>	•
.sty- Pr	Ea	astir	ng:	658177.634 Da	tum:									Ν	IAD8	3 UT	M ZC	ONE 1	9 [Drillin	g Co	ontrac	ctor:	Downing	ļ
e_Lake	Ele	eva	tion:	522.18 Azi	mut:										_		1	97.4	<u>°</u>	Drille	s:				-
N_Joyc	Inc	clina	ation:	60° Bit	type:					Flu	sh:				⊦ee	ed:			_ [Jrill F	lg:			LF-70	
LVM_A	(m)			ROCK TYPE		INTE	RVAL	REC. I		STRENG	TH DATA		(;	DI	sco	NTIN	UIT	DAT	Ά						
Geotec_80Log_Forage_ B-0010504-3	Casing&Core Diameter/Depth	Water Notes	ELEV./ Length(m	DESCRIPTION	Depth (m)	Inertval No. & Dep (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_r	Strength Index	Weathering Index	Depth (m)	Type & Number (#	Orien (_) ALPHA (_)	tation (_) BETA	Shape	scription Surface	III	Jr	Ja	Jn	ault Breccia/ Gouge	Broken Core	OTES/COMMENTS (IMPRINT DEPTH/ INFILL TYPE & THICKNESS	
bo'l po			522.18 0.00	Casing	-																	u.	_	ź	
Vertical Scale = 1 : 100 B.T. Y:ISI/Ie_LVML			<u>519.58</u> 3.00	Iron oxyde with white and red chert, fine to medium grained, dark grey, with centimetric bands of white to reddish medium grained chert and millimetric bands of fine grained red chert. Presence of nodules of white chert and pockets of iron oxyde. Fractured rock with limonite in most fracture. Mostly non magnetic with few weakly magnetic zone.	1 2 3 4 6 7 8 9 10 11 12 13	3.0 1.5 0.9 0.6 0.5 0.5 0.5 1.5 1.2 0.3 1.0 0.7 2.0	70 60 60 100 60 177 29 57 0 21 35	0 10 17 20 40 0 0 0 0 0 0 0 0 0	10	R5 R5 R5 R5 R5 R5 R5 R5 R5 R5 R5	W2 W2 W2 W2 W2 W2 W2 W2 W2 W2 W2 W2 W2													Bedding at 15° Joint at 20° Bedding at 30° Joint at 30° Bedding at 0° Joint at 20° Bedding at 40 to 50° Joint at 5 to 50° No recuperation from 8.0 to 9.0m	
2-09-Ge-66A R.1 04.03.2009	Joi Wa Plaa Pla Joi Fa Sh Co Ro Sii	int R avy a avy a anar anar/ pe: int: ult: ear: in: njug ughr lishe ckins	oughnes and Roug and Smo and Rou Slickens Sickens ate: ness: d: PC sided: K	is, Jr: jh 3.0 oth 2.0 gh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL D Smooth: SM Very Rough: VR Rough: Ro Closed: C	Joint A Unfillec Healed Stainin Slightly Slightly Slightly Slightly Clay cc Planar: Curved Infilling Broken Biotite: Clay: Clay: Clay: Clay: Clay: Curved Clay: Clay: Clay: Clay: Curved Clay: Clay: Clay: Clay: Clay: Clay: Curved Clay: Clay: Clay: Clay: Clay: Curved Clay: Clay: Clay: Clay: Clay: Curved Clay: Clay	teratio Fractu altere ndy cc ating P C Rock:	n, Ja: Ires d wall ating L Uni CU Stee Br Et Ca Et Ca Fr Chiror Fr Cic	0.75 1 2 3 4 dulatin pped: cite: clote: clote: 1: ssed:	Googe Que Contraction of the second s	Filled: Sand/ Soft C Soft C So	Crush Clay < Clay > Clay > Clay > Clay Sed: Go Go Gr He Qz	ed Roo 5mm 5mm 5mm 5mm 5mm 2 5mr 1R C Sand: Saricit: Sulphi	ck 4 1 1 1 1 1 2 See e: See Side: Si	4 66 88 12 00 15 5 200	Joint Mass One o Two Two Three Four Crust	Numb ive set olus ra sets plus a sets a sets a sets or mor ned roo	er, Jn: ndom us ran plus ra plus ra sets sk	dom		0.5 2 3 4 6 9 12 12 15 20		F	HOLE	#: H-P-02	

Y:\Style LVM\LoaLoa Geotec 80Loa Forage LVM AN Joyce Lake.sty- Printed : 2014-11-17 15h

4-11-17 15h	RE	ECO	ORD O 。.	F ROCK CORE DRILLI	NG A	ND .	TES	ING	- BC	REF	IOLE	N°:					ako	Bl	<u>H-P-(</u>	0 <u>2</u> Dit	Data	drille	Page	: _2	2 of <u>12</u>
1:201			•	<u>D-0010304-3</u>											UUy			- <u> </u>		<u>"</u>				Jogge	
Printeo		orth	ing:	6086299.006	Refe	renc	e Po	int:									Pro Pro			<u>-S</u>	Logg	ed by	/:		Alain Lemonde
ce.sty-	Ea	istir	ng:	658177.634	Datu	m:									N	IAD8	3 01	MZC		<u>19</u>	Drillir	ig Co	ontrac	ctor:	Downing
ce_Lak	Ele	eva	tion:	522.18															197.4	. <u>0</u> °		rs:			
vor_N	Inc		ation:	60°	ысту	pe.	r					1511.				гее	u.					nıg.	1		LF-70
-VM_A) E			ROCK TYPE		1	INTE	RVAL	REC. I		STRENG	TH DATA			DI	SCO		UIT	Y DA	TA	1				
g_Geotec_80Log_Forage_1 B-0010504-3	Casing&Core Diameter/Depth	Water Notes	ELEV./ Length(m)	DESCRIPTION		Depth (m)	Inertval No. & Dept (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Depth (m)	Type & Number (#	Orien (₀) WHA (₀)	BETA (°)	Shape	Surface escripti sseuu uu Bono Buno Buno Buno Buno Buno Buno	on	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
-og/Lo						F	0.3	83	47		R5	<u>W2</u>													Joints at 0°
TNM/T						Ē	0.2	100		16	R5 R5	W2 W2													Joints at 5 to 20°
Style						-16	0.8	81	71		R5	W2													
÷:				Banded (3) white chert at		Ē	0.5	60	0		R5	W2													
				59.44° and 34°		17	14	57	31		B5	W2													Bedding at 3 to 60°
н				White obort and homotite		Ē																			Joints at 30 to 40°
				nodules.		-18																			
				20 to 20.1m and 60° red cl from 20.1 to 20.2m.	n hert	-19	1.7	0	0																
			504.86			20	0.4	100	65	5	R5	W2													Bedding at 65°
			20.00	Gradual contact		Ē	0.3	83 100/	73		R5 R5	W2 W2													
						21	0.5	89	33		R5	W2													Joints at 30°
						22	0.9	100 100	0		R5 R5	W2 W2													Bedding at 30°
90			502.69 22.50	Iron oxyde with much more	e	ŧ	0.9	94	30		R5	W2													
				red chert, few white chert,	fine	-23	0.3	100	0		85	W2													
al Scale				to reddish, centimetric (1 t	D	Ē	0.6	45	0		R0	W45													
Vertica				5cm) bands of granulated white chert.		-24	0.7	26	0		D5	W0													Smalls zones B1
				Presence of nodules and		Ē	0.7	100	0		B5	W2 W2													and W4 at 24.6 and 25.2m
				sman veins of white chert		-25	0.5	40	0		R5	W2													
				Highly weathered zone fro 25.4 to 25.5m.	m	Ē	0.6	55	0		R1	W4													
				2 white chert bands at ±30	۰.	26	0.4	100	29 0		R5	W2													
						-27	1.3	65	27		R5	WЗ													Joints at 10 to 35°
			498.10 27.80	27.5 to 27.8m.	m /	-28																			
			497.32	(millimetric to centimetric)	of	Ē	0.9	100	46	15	R5	W2													loints at 30° few at
			28.70	hematite white chert and received the chert at ±30°.	ed	- 29	0.7	86	33		R2	W3													65°
ŀ	Joi	nt R	oughnes	s, Jr:	լ	r oint A	l Iteratio	n, Ja:		ı	·	·	<u> </u>			Joint	Numb	er, Jn:		·		·			
	Wa Pla Pla Pla Joi Fa	avy a avy a inar inar/ pe: nt:	and Roug and Smoo and Roug Smooth/I Slickensi	h 3.0 5th 2.0 gh 1.5 Fill 1.0 ided 0.5 Bedding: BD Full Enliation: 50		Infillec lealed itainin lightly ilty/sa clay co	l: Fractu g only altere ndy co pating	ures d wall pating	0.7 1 2 3 4	5	Filled Sand Stiff (Soft (Swel Stiff (Soft (Soft (Swel	: Clay < Clay < Clay < I. Clay Clay > Clay > I. Clay	ed Ro 5mm 5mm 5mm 5mm 5mm > 5mn	n 1 n 1	4 6 8 12 10 15 20	Mass One s One s Two s Two s Three Three Four	ive set plus ra sets sets pl sets sets sets or moi	indom lus ran plus ra re sets	dom Indom		0.5 2 3 4 6 9 12 15			HOLE	/ M
2009	Sh	ear: in:		SHR Contact: CO VN Orthogonal: OR	S	hape: lanar:	F	PL Un	dulatin	g: l	JN [Irr	egular	IR			Crust	hed ro	ck			20				
Q-09-Ge-66A R.1 04.03.	Co Ro Pol Slia	njug ughr lishe ckins	ate: (ness: id: PC sided: K	CJ Cleavage: CL Smooth: SM Very Rough: V Rough: Ro Closed: C		Curved filling roken iotite: Clay: Chlorite resh:	: C Rock:	Br Bt Ca Cl Epi Ch Iror Fr Clc	lcite: iclote: n: osed:	Ca Gr Ep He Fe Qu C	ST Cl ouge: avel: ematite uartz:	Go Gr : He Qz	C Sand: Sericil Silt: Sulphi	Sa te: Se Si ide: Su	1 5 3									В	H-P-02

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-17 15h	RE	ECC	ORD C	OF ROCK CORE DRILLING	AND	TES	ГING	- BC	REF	IOLE	E N°:						Bl	<u>-1-P-(</u>)2		ľ	Page	:(3 of <u>12</u>
2014-11	Fil	le n	•:	B-0010504-3 Pro	oject N	lame	:							Joy	ce L	ake	- Op	en F	<u>'it</u>	Date	drille	:d & L	₋ogg∈	ed: 2014-09-25
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e_Lake	Ele	eva	tion:	522.18 Az	imut:													197.4	<u>0°</u>	Drille	rs:			
V_Joyce	Inc	clina	ation:	<u>60°</u> Bit	type:					Flu	ish:				Fee	;d:			_	Drill F	≀ig:			LF-70
VM_AI	<u>(</u>			ROCK TYPE			RVAL	REC. I		STRENG	ITH DATA	-		DI	SCO		IUITY	<u>/ DA</u>	ΓA					
orage_L 04-3	Core	otes	th(m)		Ē	Dept			- - -	dex	Index	e	oer (#)	Orien	ntation	D	Surface escripti) on	Jr	Ja	Jn			NTS ™TH S
.og_Geotec_80Log_Fc B-001050	Casing8 Diameter/D	Water No	ELEV./ Leng	DESCRIPTION	Depth	Inertval No. & (from-to)(TCR (%)	RQD (%	Fractures pe	Strength In	Weathering	Depth (m	Type & Numb	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INFILL TYPE THICKNESS
NM/Tod/				29.6 to 29.9m: weathered band.	-30	1.9	95	42	26	R0	W2								1					
Style_L1		ĺ		band.	-31							30.70 30.90	JN JN	30 23	265 80	PL PL	SM SM	FE QZ	1					
SI:Y				chert with hermatite as a	Ē							30.90 31.08	JN JN	0 28	15 45	PL ST	RO SM	QZ-FE QZ-FE	1					Bedding of Iron
		ĺ		secondary component	-32							32.10	BD	30	85	PL	с	с	1					Oxyde and red Chert
Н.					Ē	2.1	100	32		R1	W3	32.80		20	85	ы	SM	ED	1					
B		ĺ			-33							52.00	JIN	30	85		GIVI		1					
					-34	1.0	100	13		R1	W3								1					Joints at 20 to 40°
						0.2	100			R2 R5	W3 W2								1					
					-35	1.2	100	70		R5	W2								1					Bedding at 30° Joints at 30 to 45° some at 5 to 10°
					-36	0.4	86	0											1					
				Weakly magnetic around 36.5 and 37.8m.	-37	1.2	82	41	20										1					Bedding at 25° Joints at 25 and 45°
- 1 : 100						0.2	100 100	50 90	20 22										1					Beddings at 20° Joint at 20°
Scale =						1.2	01	41	17										1					Fine Bedding at 5° Joints at 5°
Vertical				39.0 to 39.3m: weathered band.	-39														1					Joints at 5° and 50 to 90°
				40.0 to 41.0m; weathered	40	1.2	52	10											1					Bedding at 5° Joint at 5°
		ĺ		band.		0.4	62	0											1					
				Weakly magnetic around 41.0 and 41.2m.	-41	1.5	100	27											1					Bedding at 10° Joints at 10 and 30°
					-42	0.3	100	0											1					
					43	1.2	54	13											1					Bedding at 5° Joint at 5°
					-44	1.6	12	0											1					Bedding at 45° Joint at 30,45 and 90°
-09-Ge-66A R.1 04.03.2009	Joi Wa Pia Pia Joi Joi Seco Ro Poii	int R avy a avy a anar/ anar/ pe: int: ult: pear: bin: bin: binshe ickins	L oughnes ind Roug and Smo and Rou Smooth/ Slickens ate: ness: rd: PC sided: K	is, Jr: 3.0 gh 3.0 obth 2.0 igh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL D <smooth:< td=""> SM Very Rough: VR Rough: Ro Closed: C</smooth:<>	L Joint A Unfiller Healec Stainin Slightly Silty/sc Clay of Shape Planar Curver Broker Biotite Clay: Chlorit Fresh:	I Fractu I Fractu I Fractu I Gonly y altere andy cc Dating 	I In, Ja: Ires d wall xating V U Ste Br Cl Ep Chiro Fr Cic	dulatin pped: licite: iciclote: n: osed:	5 5 GC Ca Ep He Fe QL C	Filled Sand Stiff (Soft (Swell Stiff (Swell JN Im ST CI Swell JN Im ST CI Swell Suge: avel: avel: artz:	: //Crush Clay < Clay > I. Clay > Clay > I. Clay > I. Clay Clay > Clay > Clay > Clay > Clay > Clay > Clay > Clay = Clay =	I 5mm 5mm 5mm 5mm 5mm 5mm 5mm 5mm 5mm 5m	ck n 1 n 2 se: Se Si de: Su	4 6 8 12 10 15 20	Joint Mass One Two Two Three Three Four Crus	Numb ive set plus ra sets sets pl e sets e sets or mon hed ro	Indom us ran plus ra e sets ck	dom		0.5 2 3 4 6 9 12 15 20			HOLE B	#: H-P-02

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e_Lake	El	eva	tion:	522.18 Azi	imut:										_		1	197.4	.0°	Drille	rs:			
N_Joyc	In	clina	ation:	<u>60°</u> Bit	type:					Flu	ish:				Fee	ed:				Drill F	Rig:			LF-70
LVM_A	Ē			ROCK TYPE		INTE	RVAL	REC.		STRENG	TH DATA			DI	sco	NTIN	UIT	/ DA	TA	1				
3eotec_80Log_Forage_ B-0010504-3	Casing&Core Diameter/Depth	Water Notes	ELEV./ Length(m)	DESCRIPTION	Depth (m)	Inertval No. & Dep (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_n	Strength Index	Weathering Index	Depth (m)	Type & Number (#	Orien	tation (.) BETA (.)	Shape	Surface scriptions scriptions	Infill	Jr	Ja	Jn	ault Breccia/ Gouge	roken Core	DTES/COMMENTS MPRINT DEPTH/ INFILL TYPE & THICKNESS
1/Fog/Fog_(-45																	Ľ.	•	Bedding at 45° Joint at 30,45
r:\Style_LVN					-46	1.7	15	0	-	B5	W3													<u>and 90°</u>
<u>^</u>					-47	0.3	100	0	-	B5	W3													
ж. т .						0.3	100	58	7	R5	W2													Joints at 60 and 5°
H					-48	1.0	100	62	80	R5	W2													Joints at 40,60 and 20°
				49.0 to 49.8m: weathered band.	-49 	0.8	31	0		R1	W4													
					-50	1.2	43	0		R2	WЗ													
				51.05 to 51.10m: weathered band.	51	1.2	67	43	5	R2	W4													Joints at 30 and 60°
: 100				52.0 to 52.2m: weathered band.	52	0.2	75	0		<u>R4</u> R4	<u>W2</u> W2													
ical Scale = 1					53	1.2	8	0																
Vert					54	1.0	100	22	-	R3	W3													Joints at 10,20
					55	0.5	50	0		R4	W3													
					-56	0.6	50	0		R1	W3													
				and 56.9 to 57.0m: weathered band.	57	0.9	100	0		R1	W4													
						0.4	100	38	12	R4	W2													
				58.3 to 59.0m: weathered	58	1.6	58	30		R3	W2													Joints at 0 and 45°
				band.	- 59	0.7	70	0	-	R5	W3													
-66A R.1 04.03.2009	Jo Wi Wi P P P P J F S W C R P S S Wi S S S S S S S S S S S S S S S S	int R avy a avy a anar/ anar/ pe: int: ult: ult: iear: onjug oughr lishe ckins	oughne and Rou and Smooth Slicken ate: ness: ed: P sided: K	ISS, JT: Igh 3.0 Soth 2.0 ugh 1.5 VFill 1.0 Sided 0.5 JN Bedding: BD FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL O Smooth: SM Very Rough: VR Rough: Ro Closed: C	Joint A Unfillec Healed Stainin Slightly Silty/se Clay cc Planar: Curvec Infilling Broken Biotite: Clay:	Iteratic I: Fractu g only altere ndy co bating F I: Rock:	n, Ja: ures d wall pating PL Un CU Ste Br Bt Ca CI En	0.73 1 2 3 4 dulatin epped: lcite: iclote:	5 Ig: U S CaGr Fp He	Filled Sand Stiff (Soft (Swel Stiff (Swel Swel JN Im ST Cl Duge: avel:	: /Crush Clay < Clay < I. Clay > Clay > Clay > I. Clay > I. Clay egular: osed: Go Gr	ed Ro 5mm 5mm 5mm 5mm 5mm > 5mn 5mm Sand: Sericit Sait	ck n 1 1 n 2 See: See Si	4 6 8 12 10 15 20	Joint Mass One s One s Two s Two s Three Four Crush	Numb ive set sets sets pl sets sets or mor ned roo	er, Jn: ndom us ran plus ra e sets x	dom		0.5 2 3 4 6 9 12 15 20		F	HOLE	#: H-P-02
EQ-09-Ge-66/	51	CKINS	siaed: K	jrkougn: ko (Ciosed: C	Clay: Clay: Chlorite Fresh:	ə:	ET Ca CI Epi Chiroi Fr Cic	icite: iclote: n: osed:	Ca Gr Ep He Fe Qu C	avei: ematite iartz:	Gr : He Qz	Sericit Silt: Sulphi	e: Se Si de: Su	÷										

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Vertical Scale = 1 : 100

-66A R.1 04.03.2009

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	Fi	le n	•:	B-0010504-3 Pr	oject	Na	me:								Joy	ce L	ake	- Op	en l	Pit	Date	drille	d & L	logge	ed: 2014-09-25
	No	orth	ing:	6086299.006 Re	eferen	ice	Poi	nt:									Pr	ecisio	on Gl	PS	Logge	əd by	/:		Al <u>ain Lemonde</u>
	Ea	astir	ng:	658177.634 Da	atum:										Ν	NAD8	3 UT	MZC	ONE	19	Drillin	ıg Co	ontrac	tor:	Downing
	El	eva	tion:	522.18 Az	zimut:											_			197.4	10°	Drille	rs:			
	In	clina	ation:	60° Bit	t type	:					Flu	ish:				Fee	ed:				Drill F	lig:			LF-70
	Ē			ROCK TYPE		1		RVAL	REC.		STRENG	TH DAT <i>i</i>	4		DI	ISCO		ידוטו	/ DA	TA	1				
04-3	& Core Depth	otes	jth(m)		1	Ē	k Dept (m)	•	-	r_1_	xabr	Index	Ê	ber (#	Orier	ntation	D	Surface escripti	e on	Jr	Ja	Jn			۲H/ ۲H/
B-00105	Casing Diameter/D	Water No	ELEV./ Leng	DESCRIPTION	1110	neptu	Inertval No. 8 (from-to)(тсв (%	RQD (%	Fractures pe	Strength Ir	Weathering	Depth (n	Type & Num	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INFILL TYPE THICKNESS
					6	0	0.7	11	0		R3	WЗ													No core between 59.70 and 60.10m
				Thinly bedded (Iron oxyde and mostly red and some		-	0.6	100	83	13	R3	W3													Bedding at 50° Joints at 45
				white chert) from 60.40 to 65.57m.	6	1	0.6	100	48	33	R3	W3													to 60° Bedding at 5 to 10° Joints at 5 to 10°
					6	2																			\and 30, 70°
¦ L					-6	3	1.6	100	6		R3	W3													Bedding at 30°
							1.0	100	47	20	R5	W3													Bedding at 30° Joints at 30,45 and 55°
				64.3 to 64.4m: weathered band.	-6	4	0.9	100	30		R3	WЗ													Bedding at 40° Joint at 40°
				64.8 to 64.9m: band of white chert.	6	5	0.5	100	0		R3	W3	-												
					6	6																			
							1.5	40	0		R5	W2													
					6	7	0.1 /	100/			R5 /	W2													
				68.0 to 74.0m: centimetric (2 to 5cm) bands of white chert.	6	8	2.1	100	67	16	R5	W2													Bedding at 30° Joints at 10 and 45°
				About 5 per meter.	6	9							68.63 68.64 68.78	JN JN	30 45 43	345 90 95	PL PL PL	SM SM	FR FR FR						From 69.64 to 70.24m: fine
							0.8	53	37		R5	W2	68.88 68.95	JN JN JN	40 40 90	295 55 42	IR IR	ST SM	FR						\bedding Bedding at 45° Vein at 0°
				70.5 to 75.5m; fine bedding of	f F	0	0.8	100	64	20	R5	W2	69.11 69.19 69.21	JN JN JN JN	40 33 52 42	40 20	IR PL PL	RO RO RO	FR FR FR						Bedding at 40° Joints at 30° and 50 to 6°
				chert and iron oxyde.	7	1	0.8	100	41		R5	W2													Bedding at 35 to 45°
					Ē,	2	0.2	_50_	0		R5	W2													and 5°
					ľ	2	1.0	100	31	41	R5	W2													Bedding at 25 to 35° Joints at 40
					7	3	0.8	44	0		R5	W3													to 60°
					7	4	1.0	100	56	11	R5	W2													Bedding at 35° Joints at 60°
	Jo	int Re	oughnes	ss, Jr:	Joint Unfill	Alte	eratio	n, Ja:		•	Filled					Joint	Numb	er, Jn:			0.5				
	Wi Pli Pli Pli Pli Pli Jo	avy a anar anar/ anar/ pe: int:	nd Smo and Rou Smooth Slickens	soth 2.0 igh 1.5 Fill 1.0 sided 0.5	Heale Stain Sligh Silty/ Clay	ed F ing o tly a sand coat	ractu only Itered dy co ting	res d wall ating	0.7 1 2 3 4	5	Sand Stiff (Soft Swel Stiff (Soft (Clay < Clay < Clay < I. Clay Clay > Clay >	ned Ro 5mm 5mm 5mm 5mm 5mm	n r	4 6 8 12 10 15	One One Two Two Thre Thre	set plus ra sets sets p e sets e sets	indom lus ran plus ra	dom		2 3 4 6 9 12		L		/ M
	Fa Sh	ult: lear:		FLT Foliation: FO SHR Contact: CO	Shap	e: ar:	P		dulatin		Swel	. Clay	> 5mn	n 2	20	Four Crus	or mo hed ro	re sets ck			15 20		ŀ	IOLE	#:
	Co Ro Po Sii	onjug oughr lishe ckins	ate: ness: d: P(sided: K	VIX Orthogonal. OR CJ Cleavage: CL D Smooth: SM Very Rough: VR Rough: Ro Closed: C	Curve Infillir Broke Biotiti Clay:	ed: ng: en R e:	C Rock:	U Ste Br Bt Ca CI Epi	lcite:	Go Ca Gr Ep He	ST Cl ST Cl ouge: avel: ematite	Go Gr Gr He	Sand: Sericit	Sa le: Se Si	3									В	H-P-02
					Chlor Fresh	rite: 1:		Chilror Fr Clo	n: osed:	Fe Qu C	uartz:	Qz	Sulph	ide: Si	L L										

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Vertical Scale = 1 : 100

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2014-11-	Fil	le n	•	B-0010504-3	Project	Na	ame:								Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed: 2014-09-25
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sty- Pr	Ea	astir	ng:	658177.634	Datum:										Ν	IAD8	3 UT	MZC	ONE	19	Drillin	ig Co	ontrac	ctor:	Downing
∋_Lake	El	eva	tion:	522.18 <i>F</i>	Azimut:													1	197.4	0°	Drille	rs:			
V_Joyc	Ind	clina	ation:	60° E	Bit type): 					Flu	ish:				Fee	ed:				Drill F	Rig:			LF-70
VM_AI) آ		Ī	ROCK TYPE			INTE _	RVAL	REC. I		STRENG	TH DATA			DI	sco	NTIN	Ιυιτι	DA'	ТА	1				
orage_l 04-3	& Core Depth	otes	lth(m)			Ē	m) Dept		(r_1_m	xabr	Index	ĉ	ber (#)	Orien	ntation	De	Surface scription	on	Jr	Ja	Jn			RNTS & %
Log_Geotec_80Log_Fc B-00105	Casing8 Diameter/D	Water No	ELEV./ Leng	DESCRIPTION		Depth	Inertval No. & (from-to)(TCR (%	%) UDB	Fractures pe	Strength Ir	Weathering	Depth (n	Type & Num!	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INFILL TYPE THICKNESS
ie_L VM\Log				Presence of centimetrics beds of iron, black and fissil	le.	75	1.0	100	36	20	R5	WЗ													Bedding at 25 to 30°
Y:\St				Mineralisation from 75.0 to 75.5m. Presence of beds of yellow limonite.	- 17 	76	1.3	100	100	20	R2	W2													Bedding at 30° Joints at 30,45 and 60°
B.T.					7	77	1.1	60	18	18	R1	W4													Bedding at 30° Joint at 30°
					7	78	1.0	02		10	D1	W/4													Bedding at 30 to 35° Joints at 25 to 45°
					7	79	1.0	03	32	10		VV4													
					-	30 31 -	1.2	100	28	18	R1	W4													Bedding at 30 to 35° Joints at 30 to 35°
100						32	1.4	100	34		R2	W4													Bedding at 30° Joint at 30°
cal Scale = 1 :						33	1.6	96	25	30	R1	W4													Bedding at 30 to
Vert						34	1.3	100	10		R1	W4													and 45°
						35																			Bedding and Joints
					•	36																			at 30 to 60°
				From 87.3 to 97.1, the white chert represente 30° to 50° rock. It is oriented randomly	of	37	1.7	88	34	8	R1	W2													Bedding at 4° Joint at 25,50 and 70°
						39	0.4	100 _100_	30 _70		R1 	W4 													Joints at 40 to 70°
	Joi Wa Pla Pla Fla Joi Fa	int Ra avy a anar anar/ pe: int: ult	oughnes ind Roug ind Smo and Rou Smooth/ Slickens	ss, Jr: gh 3.0 oth 2.0 igh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD EIT Foliation: FO	Joint Unfill Heal Stair Sligh Silty/ Clay	t Alt led: ed I ning ntly a /san	eratio Fractu only altered ady co ating	n, Ja: ires d wall ating	0.75 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: Clay < Clay < Clay < L Clay > Clay > Clay >	ed Ro 5mm 5mm < 5mm 5mm 5mm > 5mn	n 1 n 1	4 6 8 12 10 15 20	Joint Mass One s One s Two s Two s Three Three Four	Numb ive set plus ra sets sets pl sets sets sets or mor	er, Jn: ndom us ran plus ra e sets	dom ndom		0.5 2 3 4 6 9 12 15			HOLE	/ M
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2-09-Ge-66A R.1	Po	ckins	d: PC ided: K	D Smooth: SM Very Rough: VF Rough: Ro Closed: C	R Brok Biotit Clay Chlo Fres	te: rite: h:	Rock:	Br Bt Ca Cl Epi Ch Iror Fr Clc	lcite: clote: n: ised:	Go Ca Gr Ep He Fe Qu C	ouge: avel: ematite uartz:	Go Gr : He Qz	Sand: Sericit Silt: Sulphi	Sa le: Se Si ide: Su	1 9 9 3										

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2014-11	Fi	le n	°:	B-0010504-3 P	roject N	ame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed: 2014-09-25
inted : 2	No	orth	ing:	6086299.006 R	eferenc	e Po	int:									Pre	ecisio	on Gl	PS	Logg	ed by	/ :		Al <u>ain Lemonde</u>
.sty- Pr	Ea	astir	ng:	658177.634 D	atum:									Ν	IAD8	3 UT	M ZC	ONE	19	Drillir	ig Co	ontrac	ctor:	Downing
e_Lake	EI	eva	tion:	522.18 A:	zimut:												-	197.4	0°	Drille	rs:			
N_Joyo	In	clina	ation:	<u>60°</u> Bi	t type:	,				Flu	ish:				Fee	ed:				Drill F	Rig:			LF-70
-VM_AI	Ĵ.			ROCK TYPE			RVAL	REC.		STRENG	TH DATA			DI	sco	NTIN	UIT	/ DA	TA	-				
eotec_80Log_Forage_ B-0010504-3	Casing&Core Diameter/Depth	Water Notes	ELEV./ Length(m)	DESCRIPTION	Depth (m)	nertval No. & Depi (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_n	Strength Index	Weathering Index	Depth (m)	Type & Number (#	Orien (°) AHA (tation (°) AT38	Shape	Surface scriptions scriptions	Iliju	Jr	Ja	Jn	ult Breccia/ Gouge	oken Core	TES/COMMENTS APRINT DEPTH/ NFILL TYPE & THICKNESS
g'Log_G						-	100	62	15	D/	W/2		-	'			æ					Fa	B	N € _
NMITO					- 90	0.0					**2													
Y:\Style_L				Concentration of yellowish		1.2	100	45	17	R4	W2													Joints at 25 to 35°
~				limonite from 90.6 to 91.1.	-91	11	100	0	14	R4	W2													Joints at 5,20, 40 and
3. <i>T</i> .					92																			
-					-93	0.7	100	38	-	R2	W3													Bedding at 20 to 35°
						1.0	85	14		R4	WЗ													Joints at 20 to 35°
					9 4	1.2	100	36	15	R3	WЗ													Bedding at 30° Joints at 15 to 20, 30 and 45°
					-95																			
					- 96	1.7	88	0		R3	W2													Joints at 15 to 45 Vein at 5°
100					-9 7	0.2	100	0		R2	_W2_													
cal Scale = 1 :					98	1.4	100	68	19	R2	WЗ													Bedding at 30° Vein at 20° Joints at 20,30 and 45°
Verti				From 98.7 the white chert represents 50% of the mass.	99	1.7	100	41	12	R2	W3													Bedding at 30 and 45°
					-100																			and 45°
					-101	0.8	100	50	14	R2	WЗ													Joints at 25 to 35 and 70°
						0.7	100	50	14	R3	WЗ													Joint at 20°
					-102	1.6	100	36	25	R4	W3													Bedding at 30° Joints at 30 and 85°
					-104	1.2	100	21	32	R4	W5													
	Jo W	int R avy a	oughne Ind Rou	uss, Jr:3.0	Joint Al Unfilled	teratio	n, Ja:			Filled	:				Joint Mass	Numb ive	er, Jn:			0.5				
	Wi Pia Pia Pia Ty Jo Fa	avy a anar anar/ anar/ pe: int: ult:	nd Smo and Ro Smooth Slicken	Ooth 2.0 ugh 1.5 /Fill 1.0 sided 0.5 JN Bedding: BD FLT Foliation: FO	Healed Staining Slightly Silty/sa Clay co	Fractu g only altere ndy co pating	ures d wall bating	0.7 1 2 3 4	5	Sand Stiff (Soft (Swel Stiff (Soft (Swel	/Crush Clay < Clay < I. Clay Clay > Clay > I. Clay	ed Ro 5mm 5mm 5mm 5mm 5mm > 5mn	ck 1 1 1	4 6 8 12 10 15 20	One s One j Two s Two s Three Three Four	set plus ra sets sets pl e sets e sets or mor	ndom us ran plus ra e sets	dom ndom		2 3 4 6 9 12 15 20		F	HOLE	#:
.03.2009	Ve Co	iear: ein: onjug	ate:	SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL	Shape: Planar: Curved	F : C	PL Un CU Ste	dulatin apped:	ig: l	JN Irr ST CI	egular <u>ose</u> d:	IR C			Unusi	.50 100	-			20			-	
:Q-09-Ge-66A R.1 04.	Ro Po Sli	ughr lishe ckins	ness: d: P iided: K	O Smooth: SM Very Rough: VR Rough: Ro Closed: C	Infilling: Broken Biotite: Clay: Chlorite Fresh:	Rock:	Br Bt Ca Cl Epi Ch Iroi Fr Clo	lcite: iclote: n: osed:	Go Ca Gr Ep He Fe Qu C	ouge: avel: ematite Jartz:	Go Gr : He Qz	Sand: Sericil Silt: Sulphi	Sa e: Se Si de: Si	1 5 7									В	H-P-02

Vertical Scale = 1 : 100

-17 15h	R	ECC	ORD (OF ROCK CORE DRILL	ING A	ND .	TEST	ING	- BO	REF	IOLE	N°:						BI	H-P-(02		I	Page	: _8	3 of2
2014-11	Fil	le n	•:	B-0010504-3	Proje	ect N	ame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed: 2014-09-25
rinted :	No	orthi	ing:	6086299.006	Refe	renc	e Po	int:									Pr	ecisio	on GF	PS	Logge	ed by	/:		Al <u>ain Lemonde</u>
e.sty- P	Ea	astir	ng:	658177.634	Datu	m:									Ν	VAD8	3 UT	MZ	ONE	19	Drillin	ig Co	ontrac	ctor:	Downing
se_Lak	Ele	eva	tion:	522.18	Azim	ut:						ah.				Fac	. d.		197.4	.0°	Drille	rs:			
N_Joy	Inc		ation:	60°	ыцу	pe						ISH.				Fee						ng.	1		LF-70
TVM 7	e (m)		-	ROCK TYPE			INTE		REC. I	Ε	STRENG	TH DATA		(f	D	ISCO				TA					
Log_Geotec_80Log_Forage B-0010504-3	Casing&Cor Diameter/Depth	Water Notes	ELEV./ Length(m	DESCRIPTION		Depth (m)	Inertval No. & Dep (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_	Strength Index	Weathering Inde	Depth (m)	Type & Number (Orier (°) AHAJA	BETA (°)	Shape	Bondhness	on	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
NM/Fog/						105	0.5	100	60		R3	W5													
Y:\Style_L				From 106.0m, the white of is pratically absent and the reak is alward.	chert ie	100	1.6	90	25	27	R3	WЗ													Bedding at 25° Joints at 20 and 45°
B.T.				rock is allered.		107	1.4	27	8		R3	W3	-												
						-109	1.7	39	0		R1	W5	-												
						-110	1.3	69	0	12	R2	W5													Joints at 20 and 50°
0							0.8	67	0		R2	W4	-												
= 1 : 10						E-112	1.0	50	30		R2	W4													Dedding at 05 %
al Scale						-113	0.1	100	90_/		R2_/	<u>W4</u>													Joints at 25°
Vertic						-114	1.1	100	90	12	R4	W4	-												
						-115	1.3	100	73		R2	W2	114.40 114.43 114.51 114.57 114.63	JN BD BD BD+JN JN	19 25 25 21 32	75 53 35 35 35	IR UN UN PL PL	VR C RO C	QZ QZ QZ QZ QZ						Orientation test.
							0.1	<u>100</u> / 100/	100/ 100/		<u>R4</u> R4	<u>W2</u> W2	114.66 114.68 114.76	BD BD BD	36 36 36	55 50 65	PL PL PL	CCCC	QZ QZ QZ						Bedding at 30° Joint at 30 and 70°
							1.4	64	43		R4	W2	114.81 114.89 114.91 114.99	BD JN BD BD	25 19 58 27 40	50 70 35 80	PL PL IR PL	00000	QZ FE QZ						
						-117	0.9	100	89	18	R4	W2	115.13 115.14 115.16 115.19 115.30	JN BD BD JN	40 48 40 60 32	70 118 118 285	IR PL PL IR	RO C C RO	FE QZ QZ QZ-FE						Bedding at 45° Joints at 45 and 60°
						-118	0.7	86	0		R3	WЗ													
						-119																			
	Joi Wa Pla Pla Pla Ty Joi	nt Re avy a anar a anar/s anar/s anar/s	oughnes ind Rou and Smo and Rou Smooth Slickens	ss, Jr: gh 3.0 poth 2.0 ugh 1.5 /Fill 1.0 sided 0.5 JN Bedding: BD Fill Foliation:		oint Al Infilled Iealed Itaining Ilightly Ility/sa Ilay co	teratio Fractu g only altere ndy co pating	n, Ja: ures d wall bating	0.75 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: /Crush Clay < Clay < L Clay Clay > Clay >	ned Ro 5mm 5mm 5mm 5mm 5mm 5mm 5mm		4 6 8 12 10 15 20	Joint Mass One One Two Two Thre Thre Four	Numb sive set plus ra sets sets p e sets e sets or mo	indom us ran plus rafs	dom		0.5 2 3 4 6 9 12 15				/ M
03.2009	Sh Ve	ear: in: niuc	ate:	SHR Contact: CO VN Orthogonal: OR	SPC	hape: lanar:	. F	PL Un	dulatin	g: L		egular	: IR			Crus	hed ro	ck			20				
2-09-Ge-66A R.1 04.	Ro Po Slie	ughr lishe ckins	ided: K	O Smooth: SM Very Rough: Rough: Ro Closed:		filling: roken iotite: lay: chlorite resh:	Rock:	Br Bt Ca CI Epi Ch Iroi Fr Clo	lcite: iclote: 1: osed:	Gc Ca Gr Ep He Fe Qu C	ouge: avel: matite iartz:	Go Gr : He Qz	Sand: Sericit Silt: Sulphi	Sa e: Sa Si de: Su	3									В	H-P-02
-17 15h	RI	ECC	ORD (OF ROCK CORE DRILL	ING AN	ND 1	TES1	ING	- BC	REH	IOLE	N°:						BI	H-P-()2		I	Page	:	9 of <u>12</u>
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2014-11-	Fil	le n	•:	B-0010504-3	Projec	ct Na	ame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed: 2014-09-25
inted : 2	No	orthi	ng:	6086299.006	Refer	ence	e Poi	nt:									Pr	ecisio	on GF	PS	Logge	ed by	<i>ı</i> :		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658177.634	Datun	n:									Ν	NAD8	3 UT	MZ	ONE	19	Drillin	ig Co	ontrac	tor:	Downing
e_Lake	El	eva	tion:	522.18	Azimu	ut:													197.4	<u>0°</u>	Drille	rs:			
N_Joyc	Inc	clina	ation:	60°	Bit typ	be: _					Flu	sh:				Fee	ed:				Drill F	{ig:			LF-70
LVM_A	Ĵ.			ROCK TYPE			INTE 윤	RVAL	REC. I		STRENG	TH DATA	·		D	ISCO		UIT	Y DA	ГА					
orage	& Core Depth	otes	gth(m)			(m)	a Depi		(9	sr_1_n	ndex	Index	(F	ber (#	Orier	ntation	D	Surface escripti	e on	Jr	Ja	Jn			NTH STH STH S
30Log_F B-00105	asing: neter/l	ater N	./ Len	DESCRIPTION		Depth	I No. ¿ om-to)	CR (%	ROD (%	Ires pe	ngth I	hering	epth (r	& Num	V (°)	(。)	Q	less					eccia/ Je	Core	COMMI TYPE KNES
eotec_8	Diar	>	ELEV				nertva (fro		ш	Fractu	Stre	Weat	Δ	Type	VLPH/	BETA	Shap	Ingho	Infil				ult Br Goug	roken	TES/C MPRIN NFILL THIC
ILOG_G						_	-					14/0						<u>۳</u>					Fa	ā	Q ₹ _
NM/Tog							1.6	100	38		R3	W3	119.60 119.67	JN BD	38 33	45 45	PL PL	RO C	FE-QZ QZ						Orientation test.
Style_L						-120							119.75 119.75 119.80	JN BD JN	33 33 73	60 40-45 55	PL PL PL	C RO	FE FE+QZ FQ						
Y:I						-121	1.3	23	0		R5	W2	119.91 119.91 120.11	JN BD JN	39 40 24	57 57 55-60	PL PL PL	C C C C	C QZ C						
													120.20	вD				C	FE-QZ						
B.T.						-122	1.6	88	75	17	R5	W2													Bedding at 35 to 45°
						100																			between 25 to 40°
						123	0.5	100	72	17	R5	W2													some at 60°
						-124	12	100	17		R4	W2													
						-125	1 2	100	100	10	DA	W/2													
						-126	1.5	100	100	10	114	vv3													Bedding at 25 and 35°
																									Joints at 30,45, 60 and 70°
1:100						-127	1.6	100	69	10	R4	W3													
Scale =							0.3	100	33		B1	W5													
/ertical S						-128		100	50	40															Fourvisible
-						129	1.1	100	50	18	п	005													Bedding at 35°
																									Joints at 35 to 50 and 75 to 85°
						-130	1.4	100	1/	18	R1	W5													
						-131	1.5	100	20		R2	W4													
						-132																			
				50% white chert			1.6	100	60	11	22	W/2	132.35 132.37 132.42	JN JN BD	74 47 33	345 125 165	PL IR IB	RO RO C	LI FE OZ						
						133	1.0	100	09		n3	vv3	132.43 132.53 132.56	JN BD BD	33 30-51 33	180 140 140	IR IR PI	0000	C QZ+FE QZ						Orientation test.
						124							132.62 132.63 132.71	JN BD JN	43 33 40	60 140 85	PL IR IR	C C BO	C QZ FF+QZ						
	Jo	int Re	oughne	ess, Jr:		int Al	teratio	n, Ja:					1	•		Joint	Numb	er, Jn:			0.5				
	Wa Wa	avy a avy a anar a	nd Rou nd Smo and Ro	ooth 2.0 ugh 1.5	He	aled	: Fractu a only	ires	0.7	5	Sand Stiff (: /Crusł Clav <	ned Ro 5mm	ck	4	One	sive set plus ra	Indom			23				
	Pla Pla	anar/s	Smooth Slicken	n/Fill 1.0 Isided 0.5	Sli	ghtly ty/sai	altere ndy co	d wall ating	23		Soft (Swel	Clay < . Clay	5mm < 5mn	1	8 12	Two Two	sets sets p	lus ran	dom		4				
	Ty Joi	pe: int:		JN Bedding: BD		ay co	ating		4		Stiff C Soft C	Clay > Clay >	5mm 5mm > 5mn	,	10 15 20	Thre	e sets e sets	plus ra	Indom		9 12 15		F		: <i>#</i> ·
2009	Fa Sh Ve	uit: ear: in:		FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR	Sh	ape: anar:	P	L Un	dulatin	g: L	JN Im	egular	: IR			Crus	hed ro	ck			20		'		. π.
1 04.03.	Co	njuga ughr	ate: iess:	CJ Cleavage: CL	Ci	irved: illing:	: C	CU Ste	pped:		ST CI	osed:	C											В	H-P-02
-66A R.:	Po Sli	lishe ckins	d: P ided: K	O Smooth: SM Very Rough: Rough: Ro Closed:	VR Bri C Bid	oken otite:	Rock:	Br Bt Ca	cite:	Go Ca Gr	ouge: avel: matito	Go Gr	Sand: Sericit	e: Se	a Ə										
Q-09-Ge					Ch	lorite esh:	:	Chiroi Fr Cic	n: ised:	Fe Qu C	iartz:	Qz	Sulphi	de: Si	u										

-17 15h	RE	ECC	ORD C	OF ROCK CORE DRILLING	AND	TES	TING	- BC	REH	IOLE	N°:						В	H-P-()2		I	Page	: _1	0 of <u>12</u>
2014-11-	Fil	le n	•	B-0010504-3 Pro	oject N	lame	:							Joy	ce L	ake	- Op	oen F	Pit	Date	drille	d & L	logge	ed: 2014-09-25
inted : 2	No	orthi	ng:	6086299.006 Re	eferenc	e Po	int:									Pr	ecisi	on GF	<u>PS</u>	Logge	ed by	/:		Al <u>ain Lemonde</u>
.sty-Pr	Ea	astir	ıg:	658177.634 Da	tum:									Ν	AD8	3 UT	MZ	ONE	19	Drillin	ig Co	ontrac	ctor:	Downing
te_Lake	Ele	eva	tion:	522.18 Az	imut:										-			197.4	<u>0°</u>	Drille	rs:			
N_Joyc	Inc	clina	ation:	<u>60°</u> Bit	type:	1				FIU	isn:				Fee	ed:				Drill F	kig:		1	LF-70
TVM	e (m)		~	ROCK TYPE		INTE	RVAL	REC. I	Ε	STRENG	TH DAT/	4	Ŧ		SCO			Y DA	ΓΑ					
Forage_ 504-3	j&Cor Depth	lotes	gth(m		ш ц	& Dep (m)	(%	(%	er_1_1	Index	g Inde:	Ê	nber (i	Orien	tation	D	escripti	on	Jr	Ja	Jn			ENTS PTH/ E &
	Casing	Vater I	V./ Ler	DESCRIPTION	Dept	al No. rom-to	TCR (RQD (tures p	ength	therin	Depth	& Nur	(°) AI	۹ (°)	be	ness	II				reccia	n Core	COMIN NT DE LL TYPI CKNES
Geotec	Di		ELE			Inert [,]			Frac	St	Wea		Type	ALP	BET	Sha	Roug	<u>In</u>				ault B Got	Broke	
oglLog						1.4	100	71	11	R3	W4	132.78 132.94	BD JN	40	145 120	PL PI	C BO	QZ FF+07				<u> </u>	_	Z ~
					-13							132.94 134.08 134.12	BD JN JN	36 33 31	120 210 10	PL PL UN	C RO RO	QZ+FE FE QZ						Chemation test.
Y:\Style				Bands of limonite.								134.17 134.22 134.25	BD BD BD	31 36 36	15 15 15	IR PL PL	C C C	QZ QZ QZ						
					-13	1.6	94	83	11	R3	W4	134.26 134.33 134.37	JN BD BD	33 33 32	20 0 0	PL PL PL	SM C C	FE QZ QZ						
Ŀ.					Ē							134.41 134.47 134.54	BD JN JN	30 55 26	0 220 245	PL IR IR	C RO SM	QZ FE+QZ FE+QZ						
8					E	1.4	100	57		R3	W4	134.74 134.80 134.88	BD JN	41-43 34 38	15 0 5	PL PL IR	C C RO	PE+QZ QZ LI						
				138.0m to 139.0m, black,	-13	-						134.92 134.96 135.00	BD JN	42 38 45	5 5 5	PL PL IR	C RO	FE LI+QZ						
				very altered.		1.6	94	34	1	R5														
					-13	9																		
				139.0m to 146.2m, 20 to 30% of white chert.	-14	D																		
						1.4	100	50	12	R4	W3	140.45 140.59	JN BD	39 36-41	0 0	c c	c c	c c						
					-14	1						140.68 140.72 141.22	JN BD BD	40 40-43 38-40	0 0 0	C C C	C C C	с с с						
: 100					-14	1.5	100	57	12	R5	W2	141.22 141.31 141.33	JN BD JN	39 39 38	0 0 0	C C C	C C C	000						Orientation test.
cale = 1				146.2m to 149.3m mostly limonite	Ē							141.40 141.64 141.70	BD BD BD	39 36-39 43	0		0000	0000						
ertical Se					-14	1.5	93	40	12	R5	W2	141.88 142.03 142.20 142.45	BD JN	43 40 35 31	0		0000	0000						Bedding at 35 to 40°
>												142.45	BD	49	Ő	č	č	č						Joints at 35 to 40°
					Ē																			Bedding at 40° Joint at 40°
					-14	1.5	67	33		R3	W3													
					Ē																			
					-14	1.5	100	37		R3	WЗ													
					-14							146.79	JN JN	48 51	250 50	PL PL	SM SM	LI LI						Orientation test.
					Ē	1.5	100	63	14	B3	W2	146.93 147.00 147.00	JN JN JN	34 36 38	135 40 250	PL PL PL	SM SM SM							
					-14	8						147.74 147.78 147.82	BD JN	41 44 42 47	165 340 175	PL IR IR	C RO BO	FE+QZ FE FE						Orientation test.
												147.83 147.86	BD JN	50 56	0 180	PL PL	C SM	QZ FE						
	Joi Wa	int Ro avy a	nd Rou	ss, Jr: gh 3.0	Joint A Unfilled	lteratio 1:	on, Ja:		- 1	Filled	:		-1-1		Joint Mass	Numb Numb	er, Jn:			0.5				/ N.A
	Pla Pla	avy a anar a anar/3	nd Smo and Rou Smooth	otn 2.0 Igh 1.5 Fill 1.0	Stainin	g only altere	ures ed wall	0.73	>	Sand Stiff (Soft (/Crusi Clay < Clay <	5mm 5mm	CK	4 6 8	One One Two	set plus ra sets	andom			2 3 4		L		
	Pla Ty	anar/: pe:	Slickens	ided 0.5	Silty/sa Clay co	andy co bating	oating	3		Swell Stiff (l. Clay Clay >	< 5mm	n	12 10	Two Three	sets p e sets	lus ran	dom		6 9		_	1	
60	Joi Fa Sh	int: ult: ear:		JN Bedding: BD FLT Foliation: FO SHR Contact: CO	Shape					Swel	l. Clay	> 5mr	n	20	Four Crus	or mo hed ro	re sets ck			15 20		F	IOLE	#:
4.03.200	Ve Co	in: njuga	ate:	VN Orthogonal: OR CJ Cleavage: CL	Planar Curveo	: F 1: (PL Un CU Ste	dulatin epped:	g: L S	JN Im ST CI	egular osed:	: IR C											Р	
A R.1 0	Ro Po Slie	lishe ckins	iess: d: PC	D Smooth: SM Very Rough: VR Rough: Ro Closed: C	Infilling Broker Biotite	Rock	Br Bt Ca	lcite:	Go Ca Gr	ouge: avel:	Go Gr	Sand:	S	a									В	п-Р-02
9-Ge-66.		JAN 15	u. n		Clay: Chlorit	D:	CI Ep Chlro	iclote: n:	Ep He Fe Qu	matite artz:	: He Qz	Silt: Sulphi	ide: S	i u										
0-0					⊢resh:		⊢r Clo	osed:	C															

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-17 15h	R	ECO	ORD C	OF ROCK CORE DRILLING	g an	ND 1	TEST	ING	- BC	REF	IOLE	N°:						В	H-P-()2		I	Page	_1	1 of
2014-11	Fil	le n	•:	B-0010504-3 P	rojec	ct N	ame:								Joy	ce L	ake	- Op	oen F	Pit	Date	drille	ed & L	ogge	ed: 2014-09-25
inted :.	No	orth	ing:	6086299.006 R	efere	ence	e Poi	nt:									Pr	ecisi	on GF	<u>'S</u>	Logge	ed by	/:		Al <u>ain Lemonde</u>
e.sty- PI	Ea	astir	ng:	658177.634 D	atun	n:									Ν	IAD8	3 UT	MZ	ONE	19	Drillin	ig Co	ontrac	tor:	Downing
se_Lake	El	eva 	tion:	522.18 A	zimu	ut:										F			197.4	<u>0°</u>	Drille	rs:			
N_Joyc	Ind	clina	ation:	<u> 60°</u> B	it typ	be: _					Flu	isn:	1			Fee	ed:				Drill F	kig:			LF-/0
LVM_A	ູຍ		<u> </u>	ROCK TYPE			INTE ₽	RVAL	REC. I		STRENG	TH DAT/	1	ŧ	DI	SCO			Y DA	ΓΑ					
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ie_L VM\Log\						-150	1.5	100	93		R3	W2	148.08 148.33 148.43 148.50 148.51	JN JN BD JN	37 58 65 38 63	180 200 210 20-25 210	IR PL PL PL PL	RO RO SM C SM							Joints at 30 and 60°
Y:\Sty				Presence of limonite.		151	1.5	60	11		R3	W2													
B.T.				Iron oxyde with few bands of white chert up to 155,0m.		152	1.0	50	0		R4	W2	-												
							0.5	100	100		R4	W2	152.45 152.54 152.64	JN JN JN	39 49 44	15 20 145	IR IR IR	RO RO RO	QZ FE FR						Orientation test.
						-153	1.5	93	0	12	R4	W2	152.65 152.75 152.79 152.86 152.94	JN JN BD JN+BC JN	36 41 43 42 32 50	5 20 20 25 210	PL PL PL PL PL	SM SM C RO RO	FE FE QZ QZ FR						Bedding at 35°
													155.24	JIN	50	200		Vn	, re						Joints at 35 and 60°
						-155	0.5	80	40		R4	W4	-												
				Iron oxyde with 5 to 10% of white chert and 50% of limonite.		-156	1.0	50	12		R4	W4	_												
: 100						-157	1.0	100	16		R3	W4	157.00		40										
icale = 1							0.5	90	80		R3	W3	157.06	JN JN	40 56 56	310 320	PL PL PL	SM SM							Orientation test.
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						-159	0.5	100	50	12	R3	W3	157.88 157.90	JN BD	16 36-41	10 125	PL PL	C SM	FE+QZ FE+LI						40 and 60°
						-160	1.0	100	70	9	R3	WЗ	-												Bedding at 40° Joint at 30 to 40°
						-161	1.5	80	77	9	R3	W3	160.93 160.95 161.01 161.33 161.36 161.39	JN JN JN BD BD	43 42 45 36 41 41	180 180 305 180 180 180	PL PL IR PL PL PL	C C RO SM C C	C C FR FE+LI FE QZ						Orientation test.
							0.3	100	50	8	R4	W3	161.48 161.64 161.82	JN JN BD	45 54 39	180 305 180	PL IR PL	C BR C	FE FE+LI FE+LI						Bedding at 35 to
						-163	2.7	100	92	8	R4	WЗ	161.95 162.00	JN JN	57 57	25 25	PL PL	SM SM	FE+LI FE+LI						45° Joint at 35 to 45, 60 and 90°
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2014-11-	Fil	le n	•	B-0010504-3	Projec	ct Na	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed: 2014-09-25
inted : 2	No	orth	ing:	6086299.006	Refere	ence	e Poi	nt:									Pre	ecisio	n GF	<u>PS</u>	Logge	ed by	/:		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658177.634	Datun	n:									Ν	IAD8	3 UT	MZC	ONE [·]	19	Drillin	ig Co	ontrac	tor:	Downing
e_Lake	El	eva	tion:	522.18	Azimu	ıt:										_		1	97.4	<u>0°</u>	Drille	rs:			
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e_L VM\Log				Iron oxyde with less then 5 of white chert and few ban	i% ds																				Bedding at 35 to 45° Joint at 35 to 45,
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				166,6m.		166	1.5	100	70		113	W3													
B.T.						-167	1.0	85	70	10	R3	W3													
				Iron oxyde with 30 to 50%	of	168	0.5	80	80	10	R4	W3													Bedding at 40 to 45° Joints at 30,45
						169	1.5	93	67	10	R4	W3													and 60°
						-170	0.6	50	33		R3	W3													
				Highly weathered zone fro 170,70 to 171,0m.	m		0.3	67	0		R3	W3													
00						171	1.6	81	53	9	R3	W3													
Scale = 1 : 1						172	1.0	100	40		R3	W3													
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CORF PHOT	OGRAPHY - BORFHOLE N°:	BH-P-02		Page:	1 of 17
File n°:	B-0010504-3	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	<u>197.40°</u>	Drillers:	
Inclination:	<u>60°</u>	Bit type: Flush.	reeu.	Drill Rig:	LF-70_
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2	8-	Borehole : BH-C		V A CANA	
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					HOLE #:
					BH-D-02
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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N°: B-0010504-3 6086299.006 658177.634 522.18 60°	BH- Project Name: Reference Point: Datum: Azimut: Bit type:	P-02	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 197.40° Feed:	Page:2 Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	of17 2014-09-25
- 30- 31- 32- Leugth 32- 33- 33-						
34- 35- 36-		Proje	ect : JOYCE LAKE rehole : BH-02	Box FROM TO 09 28,70 31,30 10 31,30 33,40 11 33,40 34,40 12 34.40 36,00		DLE #: BH-P-02

B.T.

Vertical Scale = 1 : 0

CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	DGRAPHY - BOREHOLE N°: B-0010504-3 6086299.006 658177.634 522.18 60°	BH-P-02 Project Name: Reference Point: Datum: Azimut: Bit type:Flus	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 197.40° sh: Feed:	Page:3of17Date drilled & Logged:2014-09-25Logged by:Alain LemondeDrilling Contractor:DowningDrillers:Drill Rig:LF-70
44- 45- 46- 47-		Project : JO Borehole	DYCE LAKE Box from to 13 36,00 38.00 14 38.00 40.30 15 40.30 42.20 16 42,20 47,30	Image: big

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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N B-0010504-3 6086299.006 658177.634 522.18 60°	Project Name: Reference Point: Datum: Azimut: Bit type:	Joyce Lake - Open Precision O NAD83 UTM ZONE 197. Flush: Feed:	Pit Date aPS Logg 19 Drilli 40° Drilli Drilli	Page: 4 of 17 e drilled & Logged: 2014-09-25 ged by: Alain Lemonde ing Contractor: Downing ers: Rig: LF-70
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CORE PHOTOG	JRAPHY - BOREHULE N°:		-P-02	lavas Laka Onan Dit	Page: <u>6</u>	of <u>17</u>
File n°:	B-0010504-3	Project Name:		Precision GPS	Date drilled & Logged:	2014-09-25
Northing:	658177 634	Reference Point:			Logged by:	Alain Lemonde
Easting.	522 18	Azimut:		<u>197.40°</u>	Drillers	Downing
Inclination:	<u> </u>	Bit type:	Flush:	Feed:	Drill Rig:	LF-70
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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N B-0010504-3 6086299.006 658177.634 522.18 60°	N°: Project Name: Reference Point: Datum: Azimut: Bit type:	BH-P-02	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 197.40° Feed:	Page:7of17Date drilled & Logged:2014-09-25Logged by:Alain LemondeDrilling Contractor:DowningDrillers:Drill Rig:LF-70
-77 78- 79- 80-			THE SALES		Action of the second of the
ש 1- 82- 83- 84-			Project : JOYCE LAKE Borehole : BH-02	Box from to 29 7558 78.00 30 78.00 80.40 31 80.40 82.45 32 82.45 84.80	BH-02_75.58-84.8.JPG Type: Image JPEG Taille: 6,68 Mo

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CORE PHOT	OGRAPHY - BORFHOLE N°	BH-P-02		Page:	8 of 17
File n°: Northing: Easting: Elevation: Inclination:	B-0010504-3 6086299.006 658177.634 522.18 60°	Project Name: Reference Point: Datum: Azimut: Bit type:F	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 197.40° lush: Feed:	Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	
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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N°: B-0010504-3 6086299.006 658177.634 522.18 60°	BH- Project Name: Reference Point: Datum: Azimut: Bit type:	P-02	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 197.40° Feed:	Page: 9 Date drilled & Logged:	of <u>17</u> 2014-09-25 Nain Lemonde Downing LF-70
93- 94- 95- (E) 150- 96- 97- 98-						
99- 100- 101-		Pro	oject : JOYCE LAKE orehole : BH-02	Box from to 37 92.30 94.65 38 94.65 26.90 39 96.90 98.70 40 98.70 101.30	BH-02_92.3-101.3.JPG Type : Image JPEG Taile : 7,29 Mo Dimension : 4896 × 3672 pix HOLE # BH LVMM	#: 1-P-02



CORE PHOTOC	GRAPHY - BOREHOLE N°:	BH-P-02		Page: 11 of 17
File n°:	B-0010504-3	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged: 2014-09-25_
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by: <u>Alain Lemonde</u>
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor: Downing
Elevation:	<u>522.18</u>	Azimut: Bit type: Flus	h: Feed:	Drill Big: LF-70
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CORE PHOTO	DGRAPHY - BOREHOLE N°:	BH-P-02			Page:14	of <u>17</u>
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:		<u>197.40°</u>	Drillers:	
Inclination:	60°_	Bit type: F	Flush:	Feed:	Drill Rig:	LF-70







HOLE #:

BH-P-02

CORE PHOTO	OGRAPHY - BOREHOLE N°:	B	H-P-02		Page: _	15 of
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:		<u>197.40°</u>	Drillers:	
Inclination:	60°	Bit type:	Flush:	Feed:	Drill Rig:	LF-70_



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HOLE #:



BH-P-02

CORE PHOTOGRAPHY - BOREHOLE N°:	BH-P-02	-	Page: <u>16</u>	of <u>17</u>
File n°: B-0010504-3	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing: <u>6086299.006</u>	Reference Point:		Logged by:	Alain Lemonde
Easting: <u>636177.634</u> Elevation: 522.18	Azimut:	197.40°	Drillers:	Downing
Inclination: 60°	Bit type: Flush:	Feed:	Drill Rig:	LF-70
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CORE PHOTOGRAPHY - BORCHTOLE NY: BTH-*UZ Point - UZ						_	
File n° Bediologies Project Name: Joyne Lake - Open Pit Diado dilició di Logono di Degio Alain Lanzoda Bediori 0PS S082590005 Reference Point: Internation 0PS Picialina 0PS Diagono di Degio Alain Lanzoda Bediori 0PS S2218. Adminut: INADES UTM2004 Diagono di Degio Alain Lanzoda Doming Bediori 0PS S2218. Adminut: Picialina 0PS Diagono di Degio Degio Doming Doming </td <td>CORE PHOTO</td> <td>GRAPHY - BOREHOLE N°:</td> <td>BH-F</td> <td>-02</td> <td></td> <td>Page:</td> <td><u>17</u> of <u>17</u></td>	CORE PHOTO	GRAPHY - BOREHOLE N°:	BH-F	-02		Page:	<u>17</u> of <u>17</u>
Notking: Beschafter Beference Print: NABB UTM 200 F: 10 Logged by: Abin Lénomés Doming Elevatio: 527.85 Bitype: Fuelt NCBB UTM 200 F: 10 Difference Print:	File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Easting:	Northing:	6086299.006	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Elevation: 90° Bitype Flught: Peet: Drilling: LF-YIL 100 Bitype Flught: Peet: Drilling: LF-YIL 100 G Image:	Easting:	658177.634	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Incluration: 6.0° Bit type: Fluth: Fletd: Drill Hg: LF.20. 16- 16- 16- 16- 16- 16- 16- 16- 16- 16-	Elevation:	522.18	Azimut:		<u>197.40°</u>	Drillers:	
Image: Sector	Inclination:	60°	Bit type:	Flush:	Feed:	Drill Rig:	LF-70
	163- 164- 165- (E) 166- 167- 167- 168- 169- 170-					<image/>	HOLE #: BH-P-02



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run						Disco	ntinuity			
Dep	th (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
3,00	4,50	97	0								
4,50	5,40	60	10								
5,40	6,00	66	17								
6,00	6,50	70	20								
6,50	7,00	80	20								
7,00	7,50	100	40								
7,50	8,00	60	0								
8,00	9,50	17	0								
9,50	10,70	29	0								
10,70	11,00	57	0								
11,00	12,00	0	0								
12,00	12,70	21	0								
12,70	14,70	35	10								
14,70	15,00	83	47								
15,00	15,20	100	0								
15,20	15,30	100	0								
15,30	16,10	81	71								
16,10	16,60	60	0								
16,60	18,00	57	31								
18,00	19,70	0	0								
19,70	20,10	100	65								
20,10	20,40	83	73								
20,40	20,55	100	0								
Ту	/pe						Roughnes	S		Infilli	ing
Joint:						Polished:	lod:	PO K	Broken Sand:	rock:	RK RK
Shear	SHR					Smooth:	ieu.	SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	ht:	VR	Gouge		GO
Foliation: FO					· · · ·			Biotite :		BT	
Contact: CO						Shape		Calcite		CA	
· · · · ·					Planar:		PL	Chlorit	e:	CH	
					Curved:		CU	Iron:		FE	
						Undulating: UN			Hemati	te:	HE
					Stepped:		51 ID				
						irregular:		ILL	LIMOUL	ເອເ	LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

	Run						Disco	ntinuity			255 Infill 2					
Dept	th (m)			Dept	h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
20,55	21,00	89	33													
21,00	21,90	100	0													
21,90	22,20	100	0													
22,20	23,10	94	30													
23,10	23,40	100	0													
23,40	24,00	45	0													
24,00	24,70	36	0													
24,70	24,90	100	0													
24,90	25,40	40	0													
25,40	25,95	55	0													
25,95	26,30	100	29													
26.30	26.50	75	0													
26.50	27.80	65	27													
27.80	28 70	100	46													
28.70	29.40	86	33													
20,70	21,40	95	42													
23,40	22.40	100	42													
22.40	24.40	100	10							┨────┤						
33,40	34,40	100	13													
34,40	34,60	100	0													
34,60	34,80	100	0													
34,80	36,00	100	70													
36,00	36,35	86	0													
36,35 -	37,50	82	41													
l y						Polichod	Rougnnes	S	Brokon		ing Ipp					
Joint: Fault:						Slickinsid	ed.	K	Sand	IUCK.	SV SV					
Shear	SHR					Smooth		SM	Silt		SI					
Vein:	VN					Rought:		RO	Clav:		CL					
Beddina:	BD					Very roug	ht:	VR	Gouae		GO					
Foliation:	FO					, ,3			Biotite:		BT					
Contact: CO				Shape		Calcite		CA								
					Planar:		PL	Chlorite	e:	СН						
					Curved:		CU	Iron:		FE						
				Undulatin	g:	UN	Hématite:		HE							
						Stepped:		ST	Quartz		QZ					
						Irregular:		IK	Limoni	te:	LI					



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

	Run						Disco	ntinuity			ss Infill					
Dept	th (m)			Dept	h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
37,50	37,70	100	50													
37,70	38,00	100	90													
38,00	39,15	91	41													
39,15	40,30	52	10													
40,30	40,70	62	0													
40,70	42,20	100	27													
42,20	42,50	100	0													
42,50	43,70	54	13													
43,70	45,30	12	0													
45,30	47,00	15	0													
47,00	47,30	100	0													
47.30	48.00	100	58													
48.00	49.00	100	62													
49.00	49.80	31	0													
49.80	51.00	43	0													
51.00	52 20	67	43													
52 20	52,20	75														
52,20	52,40	62	0							┨────┤						
52,40	52,00	03	0													
52,80	54,00	8	0													
54,00	55,00	100	22													
55,00	55,50	50	0													
55,50	56,00	50	0													
56,00	57,00	100	0				Doughnoo			Infill						
loint:	ире					Polished	Rougnnes		Broken		Ing BB					
Fault:						Slickinsid	led:	K	Sand	TOCK.	SA					
Shear	SHR					Smooth:		SM	Silt:		SI					
Vein:	VN					Rought:		RO	Clay:		CL					
Beddina:	BD	1			h	Very roug	ht:	VR	Gouge		GO					
Foliation:	FO		•		·	<u> </u>		•	Biotite:		BT					
Contact: CO						Shape		Calcite		CA						
					Planar:		PL	Chlorite	e:	CH						
					Curved:		CU	Iron:		FE						
				Undulatin	g:	UN	Hématite:		HE							
					Stepped:		ST	Quartz		QZ						
						Irregular:		IK	Limoni	te:	LI					



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

Run				Depth (m) Type & Type & angle β angle Shape Roughness Infill from to Infill β angle Shape Roughness Infill Image Image								
Dep	th (m)			Dept	h (m)							
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill	
57,00	57,40	100	38									
57,40	59,00	58	30									
59,00	59,70	70	0									
59,70	60,40	11	0									
60,40	61,00	100	83					1				
61,00	61,63	100	48									
61,63	63,20	100	6									
63,20	64,70	100	47									
64,70	65,10	100	30							1		
65,10	65,57	100	0							1		
65,57	67.04	40	0									
67.04	67.74	100	0									
67.74	69.24	100	57									
				68 64	69 24	BD	30	345	PI		Fine bedding	
				00,04	68.64	1 IN	45	90	PI	SM	The bedding	
					69.79	1 11	40	90		SIM		
					00,70		43	95	FL DI			
					00,70		40	295		510		
					68,88	1 JN	40	55	IR	51		
					68,95	1 JN	90		IR	SM		
					69,04	1 JN	46	42	IR	RO		
				69,05	69,11	4 JN	33	38	IR	RO		
					69,19	1 JN	52	40	PL	RO		
				69,19	69,24	4 JN	42 Downhaa	20	PL	RO		
loint:	/ре Ци					Polished	Roughnes		Broker		BB	
Fault:	FIT					Slickinsid	led:	ĸ	Sand:	TOOK.	SA	
Shear	SHR					Smooth:		SM	Silt:		SI	
Vein:	VN					Rought:		RO	Clay:		CL	
Beddina:	BD					Very roug	ht:	VR	Gouge		GO	
Foliation: FO							-	•	Biotite		BT	
Contact:	CO						Shape		Calcite		CA	
Planar:							PL	Chlorit	e:	CH		
ס					Curved:		CU	Iron:		FE		
Ur				Undulatin	ig:	UN	Hémati	te:	HE			
<u></u>				Stepped: ST		Quartz		QZ				
Irregular: IR							Limoni	te:	LI			



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

	Run	l					Disco	ntinuity			
Dep	th (m)			Dept	th (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
69,24	70,00	53	37								
70,00	70,78	100	64								
70,78	71,58	100	41								
71,58	71,78	50	0								
71,78	72,78	100	31								
72,78	73,58	44	0								
73,58	74,58	100	56								
74,58	75,58	100	36								
75,58	76,90	100	100								
76,90	78,00	60	18								
78,00	79,80	83	32								
79,80	81,00	100	28								
81,00	82,40	100	34								
82,40	84,00	96	25								
84.00	85.30	100	10								
85.30	86.80	100	20								
86.80	88.50	88	34								
88.50	88.90	100	30								
88.90	89.10	100	70								
89.10	90.00	100	63								
90.00	91,20	100	45								
91,20	92.30	100	0								
92.30	93.00	100	38								
Ту	/pe						Roughnes	S		Infill	ing
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	K	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein: Boddings						Kought:	ht.		Clay:		
Eduaring:	FO					veryroug	111.	٧n	Biotite		BT
Contact:	Foliation: FO					Shape		Calcite	:	CA	
Jonuoti		<u>I</u>	<u> </u>		<u> </u>	Planar:		PL	Chlorit	e:	СН
						Curved:		CU	Iron:		FE
						Undulatin	g:	UN	Hémati	te:	HE
						Stepped:		ST	Quartz		QZ
						Irregular:		IR	Limoni	te:	LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run						Disco	ntinuity			
Dept	:h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
93,00	94,00	85	14								
94,00	95,60	100	36								
95,60	96,90	88									
96,90	97,10	100	0								
97,10	98,50	100	68								
98,50	100,20	100	41								
100,20	101,70	100	40								
101,70	103,30	100	36								
103,30	104,50	100	21								
104,50	105,00	100	60								
105,00	106,60	90	25								
106,60	107,90	27	8								
107,90	109,70	39	0								
109,70	111,00	69	0								
111,00	111,76	67	0								
111,76	112,80	50	30								
112,80	112,92	100	90								
112,92	114,00	100	90								
114,00	115,30	100	73								
					114,40	1JN	19	75	IR	VR	QZ
					114,43	1BD	25	53	UN		QZ
					114,51	1BD	25	35	UN		QZ
					114,57	1BD+1JN	21	35	PL	RO	QZ
Ту	ре					I	Roughnes	S		Infill	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA
Shear	SHR					Smooth:		SM			
Vein:						Rought:	h+.	KU VD	Clay:		
Bedding: BD							Ivn	Biotite	•	BT	
Contact: CO						Shape		Calcite	•	CA	
Sonact.		Į		Planar: PL Chlorite:				CH			
						Curved: CU Iron:					FE
					Undulating: UN Hématite: H				HE		
						Stepped:	•	ST	Quartz		QZ
						Irregular:		IR	Limoni	te:	LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run	1		Discontinuity												
Dep	th (m)			Dept	h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
					114,63	1JN	32	35	PL		QZ					
					114,66	1BD	36	55	PL		QZ					
					114,68	1BD	36	50	PL		QZ					
					114,76	1BD	36	65	PL		QZ					
					114,81	1BD	25	50	PL		QZ					
					114,89	1BD	19	70	PL	1	QZ					
					114,91	1JN	58	35	IR		FE					
					114.99	1BD	27	80	PL	+	QZ					
					115.13	1BD	40	118	PL		QZ					
					115,14	1JN	48	70	IR	RO	FE					
					115,16	1BD	40	118	PL		QZ					
					115,19	1BD	60	118	PL		QZ					
					115,30	1JN	32	285	IR	RO	QZ+FE					
115,30	115,40	100	100													
115.40	115.60	100	100							-						
115.60	117.00	64	43							+						
117.00	117.90	100	89							+						
117.90	118.60	86	0													
118.60	120.20	100	38													
110,00	120,20	100	50		110.60	1 IN	20	45	DI		EE . OZ					
					110.67		30	45								
					119,07		33	45								
				110.07	110,00		33			5101	FE					
Т	(ne			119,67	119.83	> 20 BD	33 Boughnes	40 10 45	PL	Infill						
Joint	I.IN					Polished:	louginics	PO	Broken	rock:	IBR					
Fault:	FIT					Slickinsid	ed:	ĸ	Sand:		SA					
Shear	SHR					Smooth:		SM	Silt:		SI					
Vein:	VN					Rought:		RO	Clav:		CL					
Beddina:	Bedding: BD					Very roug	ht:	VR	Gouge		GO					
Foliation:	FO							1	Biotite		BT					
Contact:	CO						Shape		Calcite	:	CA					
	-		!			Planar:		PL	Chlorit	e:	СН					
					Curved:		CU	Iron:		FE						
						Undulatin	g:	UN	Hémati	te:	HE					
						Stepped:	-	ST	Quartz		QZ					
						Irregular:		IR	Limoni	te:	LI					
									•							



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run				Discontinuity											
Dept	th (m)			Dept	h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
					119,80	1JN	73	55	PL	RO	FE					
					119,91	1JN	39	57	PL							
					119,91	1BD	40	57	PL		QZ					
				120,10	120,20	> 20 BD	24	55 TO 60	PL		FE+QZ					
					120,11	1JN	30	60	PL							
120,20	121,50	23	0													
121,50	123,10	88	75													
123,10	123,60	100	72													
123,60	124,80	100	17													
124,80	126,10	100	100													
126,10	127,70	100	69													
127,70	128,00	100	33													
128,00	129,10	100	50													
129,10	130,50	100	17													
130,50	132,00	100	20													
132,00	133,60	100	69							<u> </u>						
					132,35	1JN	74	345 P		RO	LI					
					132,42	1BD	33	165	IR		QZ					
					132,43	1JN	33	180	IR							
					132,56	1BD	33	140	PL		QZ					
					132,62	1JN	43	60	PL							
					132,63	1BD	33	140	IR		QZ					
					132,71	1JN	40	85	IR	RO	FE+QZ					
Ту	ре						Roughnes	S		Infilli	ing					
Joint:	JN					Polished:		PO	Broken	rock:	BR					
Fault:	FLT					Slickinsid	led:	К	Sand:		SA					
Shear	SHR					Smooth:		SM	Silt:		SI					
Vein:	VN					Rought:	-	RO	Clay:		CL					
Bedding:	g: BD					Very roug	ht:	VR	Gouge	<u> </u>	GO					
Foliation:	FO						0		Biotite	-	ы					
Contact:	CO	<u> </u>				Dianarr	Snape		Calcite	:						
						Planar:			Uniorit	e:						
						Curvea:	<u>a</u> .		liron:	to						
						Stoppod	y:			ເ ປ ີ.						
						Irrogular:			Limoni	to:						
						megular:		חין	LIIIOUI	ι ς .	LI					



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

	Run	l		Discontinuity											
Dept	th (m)			Dept	h (m)										
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill				
					132,78	1BD	40	145	PL		QZ				
				132,91	132,94	4JN	36	120	PL	RO	FE+QZ				
				132,91	132,94	4BD	36	120	PL		QZ+FE				
					132,37	1JN	47	125	IR	RO	FE				
				132,47	132,53	9BD	30 to 51	140	IR	<u> </u>	QZ+FE				
133.6	135,00	100	71												
					134,08	1JN	33	210	PL	RO	FE				
					134,12	1JN	31	10	UN	RO	QZ				
					134,17	1BD 31		15	IR		QZ				
					134,22	1BD	1BD 36		PL		QZ				
					134,25	1BD	36	15	PL	1	QZ				
					134,26	1JN	33	20	PL	SM	FE				
					134,33	1BD	33	0	PL		QZ				
					134,37	1BD	32	0	PL		QZ				
					134,41	1BD	30	0	PL	1	QZ				
					134,47	1JN	55	220	IR	RO	FE+QZ+LI				
					134,54	1JN	26	245	IR	SM	FE+QZ+LI				
				134,58	134,74	15BD	41 to 43	15	PL	1	FE+QZ				
					134,80	1BD	34	0	PL		QZ				
					134,88	1JN	38	5	IR	RO	LI				
					134,92	1BD	42	5	PL		FE				
					134,96	1BD	38	5	PL		FE				
					135,00	1JN	45	5	IR	RO	LI+QZ				
Ту	vpe						Roughnes	S		Infilli	ing				
Joint:	JN					Polished:		PO	Broken	rock:	BR				
Fault:	FLT					Slickinsid	led:	K	Sand:		SA				
Shear	SHR					Smooth:		SM							
Vein: Roddingu						Norv roug	ht		Gouge						
Eoliation	FO					veryroug	, ,,,, ,	VII	Biotite		BT				
Contact.	co	1					Shape		Calcite		CA				
		<u>.</u>	Į			Planar:		PL	Chlorit	e:	СН				
						Curved:		CU	Iron:		FE				
					Undulating:			UN	Hématite:		HE				
				Stepped:				ST	QZ						
						Irregular:		IR	Limoni	te:	LI				



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

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	Run			Discontinuity											
Dept	h (m)			Dept	h (m)										
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill				
135,00	136,60	94	83												
136,60	138,00	100	57												
138,00	139,60	94	34												
139,60	141,00	100	50												
					140,45	1JN	39								
				140.45	140.59	15BD	36 to 41								
				-, -	140.59	1JN	41								
				140.59	140.72	9BD	40 to 43								
					140.68	1.JN	40								
					140 72	1JN 40									
				140 72	141.09	Broken rock									
				141.00	141.00		28 to 40								
				141,09	141,22	1 IN	20								
				141.00	141,22	1600	39								
				141,22	141,40		39								
					141,33	1 JIN	38								
					141,40	1JN	34								
				141,40	141,64	17BD	36 to 39								
					141,64	1JN	39								
					141,70	1BD	43								
					141,88	1BD	43								
					142,03	1BD	40								
					142,20	1JN	35								
					142,45	1JN	31								
Ту	ре						Roughnes	S		Infilli	ing				
Joint:	JN					Polished:	. d.	PO	Broken	rock:	BK				
Fault:						Slickinsid	ea:	n SM	Sand:		SA				
Voin	VN					Bought.		BO	Clav.						
Bedding.	BD					Very rough	ht:	VR	Goude		GO				
Foliation:	FO							1	Biotite	-	BT				
Contact:	co	1					Shape		Calcite	:	СА				
	-		•		-	Planar:		PL	Chlorit	e:	СН				
						Curved:		CU	Iron:		FE				
						Undulating:		UN	Hémati	te:	HE				
				Stepped:		ST	Quartz		QZ						
						Irregular:		IR	Limoni	te:	LI				



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

	Run			Discontinuity												
Dept	th (m)			Dept	h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
					142,45	2BD	49									
141,00	142,50	100	87													
142,50	144,00	93	40													
144,00	145,50	67	33													
145,50	147,00	100	37													
					146,79	1JN	48	250	PL	SM	LI					
					146,85	1JN	51	50	PL	SM	LI					
					146,93	1JN	34	135	PL	SM	LI					
					147,00	1JN	36	40	PL	SM	LI					
					147,00	1JN	38	250	PL	SM	LI					
147,00	148,50	100	63													
					147,66	1JN	41	175	IR	RO	QZ					
				147,66	147,74	8BD	44	165	PL		FE+QZ					
					147,78	1JN	42	340	IR	RO	FE					
					147,82	1JN	47	175	IR	RO	FE					
					147,83	1BD	50	0	PL		QZ					
					147,86	1JN	56	180	PL	SM	FE					
					148,08	1JN	37	18O	IR	RO	LI					
				148,10	148,50	>20 BD	38	20 to 25	PL		LI					
					148,33	1JN	58	200	PL	RO	LI					
					148,43	1JN	65	210	PL	SM	LI					
					148,51	1JN	63	210	PL	SM	LI					
148,50	150,00	100	93													
Ту	/pe						Roughnes	S		Infilli	ing					
Joint:	JN					Polished:		PO	Broken	rock:	BR					
Fault:	FLT					Slickinsid	led:	К	Sand:		SA					
Shear	SHR					Smooth:		SM	Silt:		SI					
Vein:	VN					Rought:		RO	Clay:		CL					
Bedding:	BD					Very roug	int:	VK	Gouge		GO					
Foliation:	FU		1			1	Chana		BIOTITE:	-	ы					
Contact:	CO					Dianari	Snape		Calcite	:						
	Planar:						Uniorit	e:								
	Curved:				<u>a</u> .		Iron: Hématite									
						Stenned	9.	ST	Quartz		07					
						Irregular		IR	limoni	te:	11					
						in egular.		1								



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run	1		Discontinuity											
Dept	:h (m)			Dept	th (m)										
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill				
150,00	151,50	60	11												
151,50	152,50	50	0												
152,50	153,00	100	100												
					152,45	1JN	39	15	IR	RO	QZ				
					152,54	1JN	49	20	IR	RO	FE				
					152,64	1JN	44	145	IR	RO					
					152,65	1JN	36	5	PL	SM	FE				
					152,75	1JN	41	20	PL	SM	FE				
					152,79	1BD	43	20	PL		QZ				
					152,86	1JN+1BD	42	25	PL	RO	QZ				
					152,94	1JN	32	210	PL	RO					
					153,24	1JN	50	200	IR	VR	FE				
153,00	154,50	93	85												
154,50	155,00	80	40												
155,00	156,00	50	12												
156,00	157,00	100	16												
					157,06	1BD	40	60	PL		LI				
					157,12	1JN	56	310	PL	SM	LI				
					157,39	1JN	56	320	PL	SM	LI				
				157,50	157,61	> 20 BD	36	125	PL		FE+LI				
					157,50	1JN	54	280	PL	SM	LI				
				157,64	157,90	> 20 BD	36 at 41	125	PL		FE+LI				
					157,64	1JN	61	310	IR	RO	LI				
Ту	pe						Roughnes	S		Infilli	ing				
Joint:	JN					Polished:		PO	Broken	rock:	BR				
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA				
Shear	SHR					Smooth:		SM	Silt:		SI				
Vein:	VN					Rought:	b 4.	KO	Clay:						
Beading:	BD BD					very roug	nt:	١٧Ħ	Biotito		BT				
Contact:							Shane		Calcite						
		ļ			1	Planar:	Unape	PL	Chlorit	e:	CH				
						Curved:		CU	Iron:		FE				
						Undulatin	UN Hématite:			HE					
						Stepped:	-	ST	Quartz		QZ				
					Irregular:		IR	te:	LI						



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run			Discontinuity												
Dept	th (m)			Dept	:h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
					157,79	1JN	33	150	IR	RO	LI					
					157,81	1JN	13	10	PL	SM	FE+LI					
					157,85	1JN	46	180	IR	RO						
					157,88	1JN	16	10	PL	SM	FE+QZ					
					157,90	1JN	35	150	PL	SM	FE+LI					
157,00	157,50	90	80													
157,50	159,00	90	56													
159,00	159,50	100	50													
159,50	160,50	100	70							<u> </u>						
160,50	162,00	80	77													
				160.80	161,33	> 20 BD	38 to 42	180	PL		FE + QZ					
					160.93	1JN	43	180	PL							
					160.95	1JN	42	180	PL							
					161.01	1.IN	45	305	IB	BO						
					161.33	1.IN	36	180	PI	SM						
					161,00	1BD	41	180	PI		FE					
					161 39	180	41	180	PI		07					
					161.48	1 IN	45	180	PI		FE					
					161.64	1 IN	54	305	IR	VB	FE ± 11					
				161.64	162.00	> 20 RD	20	190	DI	VII						
				101,04	161.05	> 20 DD	53	25		SM						
					162.00	1 101	57	25		SIM						
100.00	100.00	100	50		162,00	IJIN	57	25	ГЦ	3101						
162,00 T v	162,30	100	50				Boughnes	<u> </u>		Infill	ing					
Joint [.]	.IN					Polished:	nouginics	IPO	Broken	rock:	BR					
Fault:	FIT					Slickinsid	led:	K	Sand:		SA					
Shear	SHB					Smooth:		SM	Silt:		SI					
Vein:	VN	1				Rought:		RO	Clav:		CL					
Beddina:	BD	1				Very roug	ht:	VR	Gouge		GO					
Foliation:	FO								Biotite		BT					
Contact:	CO						Shape		Calcite	:	СА					
		-			-	Planar:		PL	Chlorit	e:	СН					
						Curved:		CU	Iron:		FE					
						Undulatin	g:	UN Hématite:			HE					
						Stepped:		ST	Quartz	:	QZ					
						Irregular:		IR	Limoni	te:	LI					



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-02

	Run			Discontinuity											
Dept	h (m)			Dept	h (m)										
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill				
162,30	165,00	100	92												
165,00	166,50	100	70												
166,50	167,50	85	70												
167,50	168,00	80	80												
168,00	169,50	93	67												
169,50	170,10	50	33												
170.10	170.40	67	0												
170.40	172.00	81	53												
172.00	173.00	100	40												
172,00	173,00 100		40												
Ту	ре						Roughnes	S		Infill	ing				
Joint:	JN					Polished:		PO	Broken	rock:	BR				
Fault:	FLT					Slickinsid	led:	К	Sand:		SA				
Shear	SHR					Smooth:		SM	Silt:		SI				
Vein:	VN					Rought:	-	RO	Clay:		CL				
Bedding:	BD					Very roug	ht:	VR	Gouge		GO				
Foliation:	FO					, ,			Biotite:		BT				
Contact:	CO					5	Shape	101	Calcite		CA				
						Planar:			Chlorite:						
						Curved:			iron:						
						Ondulatin	g:		nemati	ie:					
						Stepped:		51	Quartz						
				irregular:		IK	Limoni	te:	LI						

-20 11h	RE	ECO	ORD (OF ROCK CORE DRILLING	ID TESTING - BOREHOLE N°:								BH-P-03)3	Page			:	1 of1			
2014-11-	Fil	le n	°:	B-0010504-3 P	roject I	ject Name: Jo						Joy	oyce Lake - Open Pit				Pit	Logge				ed:	_		
inted : 2	No	orth	ing:	6086562.697 R	eferen	e Po	int:									Pre	ecisio	on GF	PS	Logged by:				Al <u>ain Lemonde</u>	<u>,</u>
.sty- Pr	Ea	astir	ng:	658422.620 D	atum:									Ν	NAD83 UTM ZONE 19				19	Drillir	ig Co	ontrac	tor:	Downing	Į
e_Lake	Ele	eva	tion:	<u> </u>	zimut:										45.00			<u>0°</u>	° Drillers:					-	
V_Joyc	Inc	clina	ation:	<u> </u>	t type:					Flu	sh:				Feed:				Drill F	Rig:			LF-70	-	
-VM_A	(m			ROCK TYPE			RVAL	REC. I		STRENG	TH DATA			DI	sco	NTIN	IUITY	' DA'	ГА						
ec_80Log_Forage_ B-0010504-3	Casing&Core Diameter/Depth	Water Notes	.EV./ Length(m)	DESCRIPTION	Depth (m)	tval No. & Depi (from-to)(m)	TCR (%)	RQD (%)	ictures per_1_n	trength Index	eathering Index	Depth (m)	pe & Number (#	Orien	(°) AT	hape	Surface escriptions ssoup b	n	Jr	Ja	Jn	Breccia/ ouge	en Core	S/COMMENTS RINT DEPTH/ ILL TYPE & ICKNESS	
g_Geot	-		Ш			Inel			Fra	0	Ň		Ţ	ALF	BE	S	Rou	-				Fault	Brok		
rog/Log			526.33 0.00	Casing			-																	-	_
Vertical Scale = 1 : 100 B.T. Y:IStyle_LVM			<u>517.87</u> 9.00	Completely weathered grey t reddish Iron Oxyde with milimetric and centimetrics bands of red and white chert.	-1 -2 -3 -4 -5 	2.0	22040	20		R0	W5														
Q-09-Ge-66A R.1 04.03.2009	Joi Wa Pla Pla Pla Joi Fa Sh Ve Co Ro Poi	int R avy a anar anar/ anar/ pe: int: ult: ear: in: ughr lishe ckins	oughne and Rou and Smooth Slickens ate: ness: d: P sided: K	iss, Jr:	Joint / Unfille Heale Stainin Slight/s Clay c Shape Plana Curve Infilling Broke Biottle Clay: Chlori Fresh	1.5 Neteratid d: J Fracti g only y alter andy c ooating : : : : 1 d: () : : : : : : : : : : : : : : : : :	A 40 on, Ja: ures ed wall bating PL Un CU Ste Br Cl Ep Ch Iron Fr Clo	0 0.7 1 2 4 dulatin epped: iclote: iclote: n: ssed:	g: L g: L g: Ca Gro Ep He Fe Qu C	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell JN Im ST CI uge: avel: matite artz:	W5 /Crush Clay < Clay < Clay > Clay > Clay > Clay > Clay > Clay > Clay = Clay > Clay = Clay =	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm 5mm 5mm 5mm 5m	ck 1 1 1 1 1 See: See Side: Su	4 6 8 2 0 0 5 20	Joint Mass One s One s Two : Three Four Crust	Numb ive set plus ra sets a sets pl a sets a sets or mor hed roo	ndom us ran plus ra sets ck	dom		0.5 2 3 4 6 9 12 15 20		F	ROLE	#: H-P-03	
-20 11h	R	ECO	ORD	OF ROCK CORE DRILL	ING AN	ID 1	TEST	ING	- BC	REF	IOLE	N°:						B	I-P-	03		I	Page	:	2 of11
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2014-11	Fi	ile n	•:	B-0010504-3	Projec	t Na	ame:								Joy	ce L	ake	- Op	en I	Pit	Date	drille	ed & L	logge	ed:
rinted ::	N	orth	ing:	6086562.697	Refere	ence	e Poi	nt:									Pre	ecisio	on Gl	PS	Logg	ed by	/:		Al <u>ain Lemonde</u>
e.sty- P	Ea	astir	ng:	658422.620	Datum	า:									Ν	IAD8	3 UT	M ZC	ONE	<u>19</u>	Drillir	ng Co	ontrac	ctor:	Downing
/ce_Lak	El	leva clin	tion: ation:	<u> </u>	Azımu Bit typ	it: be:					Flu	sh:				Fee	d:		45.0	<u>00°</u>	Drille Drill F	rs: Ria:			I F-70
lob_AN_		T			Bittyp	··· _	INTE	RVAI	BEC I	ΠΔΤΔ	STRENG	тн пата			וח	500		II II T \	/ ם /	та		<u>.</u> .			
e_LVM	bre th (m)		Ê			(epth			ε	×	ex		(#)	Orien	tation		Surface							۵.
.og_Geotec_80Log_Forag B-0010504-3	Casing&Co Diameter/Dep	Water Notes	ELEV./ Length(DESCRIPTION		Depth (m	Inertval No. & De (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1	Strength Inde	Weathering Ind	Depth (m)	Type & Number	ALPHA (°)	BETA (°)	Shape	Boughness	on Iliju	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENT /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
Y:\Style_LVM\Log\L						16	1.5	47	0		R0	W5													
Ŀ.						17	1.3	92	70		R0	W5													Bedding at 50°
8						-18	1.3	100	50	-	R0	W5													Joints at 60 to 80°
							0.2	_50_	0		R0	_W5_													
						20	1.5	6	0																
						21 22	1.5	13	0																
cale = 1 : 100						23	1.5	33	0	-	R0	W5													
Vertical So						24	1.0	100		17		ME													Bedding at 60°
						25	0.2	100	00	17		WE													Joints at 55 to 65°
						26	1.5	47	0	-	R0	W5													
						27				-															
			499.74 28.30	Grey to blackish massive		28	1.5	13	0	-															
				Medium grain.		29	1.5	33	0		R3	W4													
1.2009	Jo W P P P P P P S F S F S F S F	pint R avy a anar anar/ anar/ pint: ault: ault: ault: ault: ault:	oughne and Rou and Sm and Rc Smootl Slicken	ess, Jr: ugh 3.0 iooth 2.0 Jugh 1.5 h/Fill 1.0 isided 0.5 JN Bedding: BD FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR	Joi Uni Hea Sta Slic Silt Cla Slit Silt Cla Pla	int Al filled aled aining ghtly ghtly ay co ape: anar:	teratio Fractu g only alterendy co ating	n, Ja: Ires d wall ating L Un	0.78 1 2 3 4 4 dulatin	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: /Crush Clay < Clay < Clay > Clay > Clay > . Clay egular:	ned Ro 5mm 5mm 5mm 5mm 5mm > 5mn		4 6 8 12 10 15 20	Joint Mass One Two Two Three Three Four Crust	Numb ive set plus ra sets sets pl sets sets or moi ned ro	er, Jn: Indom us ran plus ra e sets ck	dom Indom		0.5 2 3 4 6 9 12 15 20		F	HOLE	/M
2-09-Ge-66A R.1 04.0℃	CORPOSI	onjug oughi olishe ickins	ate: ness: ed: F sided: K	CJ Cleavage: CL O Smooth: SM Very Rough: Rough: Ro Closed:	Cu Infii VR Brc C Bio Cla Ch Fre	rved: lling: oken otite: ay: lorite esh:	: C Rock:	Br Br Bt Ca Cl Epi Ch Iroi Fr Clc	lcite: iclote: n: osed:	Ga Ca Gr Ep He Fe Qu C	ST Cl ouge: avel: amatite uartz:	Go Gr He Qz	C Sand: Sericit Silt: Sulphi	Sa e: Se Si de: Su	1 5 3									В	H-P-03

Vertical Scale = 1 : 100

-20 11h	R	ECC	ORD C	F ROCK CORE DRILLIN	IG AN	ID 1	TEST	ING	- BC	REF	IOLE	N°:						Bł	1-P-(03		I	Page	: _:	3 of1
2014-11	Fil	le n	•:	B-0010504-3	Projec	ct Na	ame:								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed:
rinted ::	No	orthi	ing:	6086562.697	Refere	ence	e Poi	nt:									Pre	ecisio	on Gl	PS	Logg	ed by	<i>י</i> :		Al <u>ain Lemonde</u>
e.sty- P.	Ea	astir	ng:	658422.620	Datun	n:									Ν	IAD8	3 UT	M ZC	DNE	19	Drillir	ig Co	ontrac	tor:	Downing
ce_Lake	Ele	eva	tion:	526.33	Azimu	ıt:													45.0	<u>0°</u>	Drille	rs:			
N_Joy	Inc		ation:	/ <u>//</u>	ы тур							ISN.				гее						ng.			LF-70
TVM	e. 1 (m)		(r	ROCK TYPE			INTE 5	RVAL	REC.	E.	STRENG	TH DATA		(#	DI	sco	NIIN	Surface							
g_Geotec_80Log_Forage B-0010504-3	Casıng&Cor Diameter/Deptl	Water Notes	ELEV./ Length(m	DESCRIPTION		Depth (m)	Inertval No. & Der (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_	Strength Index	Weathering Inde	Depth (m)	Type & Number (Orien (。) ALPHA (。)	tation (_) BETA (_)	Shape	Boundersscription	on	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
/rog/Lo						30																			
Y:\Style_LVM			497.20 31.00 497.01 31.20	Highly weathered zone	' '	31	1.5	33	0		R3	W4													
B.T.			496.82 31.40 496.73 31.50	A Iron Oxyde, weathered. Medium grain. Highly weathered zone Grey to blackish massive Iron Oxyde, weathered	'' ''	32 33	1.5	20	0																
				Medium grain.			0.8	100	37		R3	W4													
						34	0.7	71	0		R3	W4													
			493.44 35.00	Iron Oxyde interbeded with		35	0.8	75	0		R3	W4													
				milimetrics band of red cher and milimetrics to	t	36	0.7	43	0		R3	W4													
				centimetrics band of white chert.			1.0	15	0																
8						37	0.5	40	0		R3	W4													
rtical Scale = 1 : 1						38	1.5	53	0		R3	W4													
Ve						-40	1.5	33	0		R3	W4													
						41	1.5	13	0																
			486.21 42.70 485.64 43.30	Completely weathered [Iron Oxyde]"/b" interbeded with milimetrics band of red cher	 t	42	1.5	100	0		R3	W4													Bedding at 75° Joints at 75°
			484.80 44.20 484.70	and milimetrics to centimetrics band of white	'/-	44	1.5	100	0		R5	W5													
	Joi Wa	int Re avy a	oughnes and Roug	s, Jr: gh 3.0 oth 2.0	Joi Un	int Al filled	teratio	n, Ja:	07	5	Filled	: Cruck	ad Po	ck	4	Joint Mass	Numb ive	er, Jn:			0.5				/ NA
	Pla Pla Pla Ty Joi	anar anar/anar/ anar/ pe: int:	and Rou Smooth/ Slickens	Un 2.0 Fill 1.5 Fill 1.0 ided 0.5 JN Bedding: BD		aining ghtly ty/sai ay co	altere altere ndy co ating	d wall ating	0.73 1 2 3 4		Sand Stiff (Soft (Swell Stiff (Soft (Clay < Clay < Clay < I. Clay Clay > Clay >	5mm 5mm < 5mm 5mm 5mm		6 8 2 0 5	One Two Two Three Three	set plus ra sets sets pl e sets e sets e sets	ndom us ran plus ra	dom Indom		2 3 4 6 9 12				
2009	Fa Sh Ve	ult: ear: in:		FLT Foliation: FO SHR Contact: CO VN Orthogonal: OP	Sh	ape: anar:	P	L Un	dulatin	ig: l	JN Im	egular	: IR	1 2		Crust	ned ro	e seis ck			20			IULE	#.
2-09-Ge-66A R.1 04.03.	Co Ro Po Si	njug ughr lishe ckins	ate: ness: d: PC sided: K	CJ Cleavage: CL Smooth: SM Very Rough: VF Rough: Ro Closed: C	Cu Infi Brc Bic Ch Fre	illing: oken otite: ay: llorite esh:	Rock:	Br Bt Ca Cl Epi Ch Iroi Fr Clc	lcite: iclote: n: osed:	GC Ca Gr Ep He Fe Qu C	ST CI ouge: avel: ematite uartz:	Go Gr Gr Qz	C Sand: Sericit Silt: Sulphi	Sa e: Sa Si de: Su	1									В	H-P-03

V:\Style_LVM\Log\Log_Geotec_80Log_Forage_LVM_AN_Joyce_Lake.sty- Printed : 2014-11-20 11h

Vertical Scale = 1 : 100

-20 11h	R	ECO	ORD	OF ROCK CORE DRILLI	NG A	ND .	TESI	ING	- BO	REF	IOLE	N°:						Bł	H-P-(03		I	Page	:	1 of1	1
2014-11	Fil	le n	°:	B-0010504-3	Proje	ect N	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	d:	_
inted : 2	No	orth	ing:	6086562.697	Refe	renc	e Poi	nt:									Pr	ecisio	on GF	PS	Logg	ed by	<i>ı</i> :		Alain Lemond	<u>le</u>
esty- Pr	Ea	astir	ng:	658422.620	Datu	m:									Ν	IAD8	3 UT	MZ	ONE	19	Drillir	ig Co	ontrac	tor:	Downin	١g
e_Lake	El	eva	tion:	526.33	Azim	ut:										_			45.0	0°	Drille	rs:				
N_Joyc	Ind	clina	ation:	70°	Bit ty	pe:					Flu	sh:				Fee	ed:				Drill F	Rig:			LF-7	<u>′0</u>
LVM_A	Ĵ.			ROCK TYPE		T	INTE	RVAL	REC. I		STRENG	TH DATA			DI	sco		UIT	Y DA	TA						
orage_504-3	& Core Depth	otes	gth(m)			Ē	& Depi (m)		()	er_1_n	ndex	Index	(L	ber (#	Orien	tation	D	Surface escripti	e on	Jr	Ja	Jn			ENTS TH/ S	
og_Geotec_80Log_F B-00105	Casing Diameter/I	Water N	ELEV./ Lenç	DESCRIPTION		Depth	Inertval No. { (from-to)	TCR (%	RQD (%	Fractures pe	Strength I	Weathering	Depth (r	Type & Num	(°) ALPHA (BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INFILL TYPE THICKNES\$	
Y:\Style_LVM\Log\L			484.42 44.60 483.86 45.20	Altered Iron Oxyde interbeded with milimetric: band of red Chert and milimetrics to centimetrics band of white Chert.	6	45	1.5	17	0																	
B.T.				Highly weathered zone Quartz vein Iron Oxyde interbeded wi milimetrics band of red Ch and milimetrics to	'i 'i th iert	47	1.5	23	0		R4	W4														
				centimetrics band of white Chert. Interbeded with 5 to cm earth zones bands.	e o 10	49	1.5	100	12	18	R4	W4													Bedding at 70° Joints at 5,30 and 70°	
						50	1.5	80	0		R4	W4													Podding at 70%	
100						52	1.5	20	0	17	R4	W4													Joints at 70°	/
/ertical Scale = 1 :						53	1.5	50	16		R4	W4													De della e et 70 te	
-			475.02 54.60 474.65 55.00	Fron Oxyde with 70% of w	/hite	-55	1.0	90	30	10	R4	W4													Joints at 10,50 and 70°	
			473.71 56.00 473.52 56.20	and milimetrics band of red Ch and milimetrics band of white centimetrics band of white Chart Interbeded with 5 tr	ert	56	1.7	100	30		R4	W4														
				i cm earth zones bands. I Iron Oxyde with 70% of w Chert. Altered Iron Oxyde	hite	57	1.1	55	0		R4	W4														
				interbeded with milimetrics	3		0.7	100	21	17	R4	W4													Bedding at 70° Joints at 10,30	
				milimetrics to centimetrics		-59	0.8	100	25		R4	W4													and 70	
		int R	oughne				0.7	100	0		R4	W4					Numh	or In			<u> </u>				1	
	Wa Pla Pla Pla Ty Joi	avy a avy a anar anar/ anar/ pe: int: ult:	and Rou and Smooth Smooth	JN Bedding: BD JN Bedding: FO		nfilled taining lightly ilty/sa	Fractu g only altere ndy co pating	d wall ating	0.78 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: Clay < Clay < Clay < Clay > Clay > Clay >	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm 5mm	ck 1 1 1 1 1	4 6 8 2 0 5 20	Mass One Two Two Three Four	sets sets sets sets pl sets pl sets pl sets sets sets or mol	indom lus ran plus ra	dom Indom		0.5 2 3 4 6 9 12 15 20			IOLE	/ M	
:Q-09-Ge-66A R.1 04.03.2009	Sh Ve Co Ro Polii	ear: in: njug ughr lishe ckins	ate: ness: d: P sided: K	SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL O Smooth: SM Very Rough: O Smooth: Rough: Closed:		hape: lanar: urved filling roken iotite: lay: hlorite resh:	P : C : Rock:	L Un U Ste Br Bt Ca Cl Epi Ch Iror Fr Clo	dulatin pped: lcite: iclote: n: psed:	g: L Gc Ca Gr Ep He Fe Qu C	JN Im ST CI avel: matite lartz:	egular: osed: Go Gr He Qz	IR C Sand: Sericit Silt: Sulphi	Sa e: Sa Si de: Su	1 1	Urus	<u>neu ro</u>	<u>UK</u>			20			В	H-P-03	

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-20 11h	R	ECC	ORD C	OF ROCK CORE DRILLIN	NG A	ND 1	TEST	ING	- BC	REF	IOLE	E N°:						BI	H-P-(03		I	Page	: _!	5 of1
2014-11	Fil	le n	°:	B-0010504-3	Proje	ct N	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed:
inted ::	No	orthi	ing:	6086562.697	Refe	renc	e Poi	nt:									Pr	ecisio	on Gl	<u>PS</u>	Logg	ed by	<i>'</i> :		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658422.620	Datu	m:									Ν	IAD8	3 UT	MZ	ONE	19	Drillir	ig Co	ontrac	tor:	Downing
ce_Lake	Ele	eva	tion:	526.33	Azim	ut:										-			45.0	0°	Drille	rs:			
N_Joy	Inc		ation:	<u>70°</u>	ысту	pe						ISH.				ree						ng.			LF-70
- MVJ	e (m)		-	ROCK TYPE			INTE 5	RVAL	REC.	Ε	STRENG	TH DATA		ŧ	DI	SCO		Surface							
Forage 504-3	g&Cor /Depth	Votes	ngth(m			(m) H	& Der (m)	(%	(%	er_1_	Index	g Inde	Ē	nber (Orien	itation	D	escripti	on	Jr	Ja	Jn			IENTS PTH/ E & SS
80Log	Casing	Vater I	v./ Ler	DESCRIPTION		Dept	al No.	TCR (RQD (ures p	ength	therin	Depth	& Nur	A (°)	۹ (°)	e	ness	=				reccia ge	I Core	COMIN NT DE L TYP SKNES
Geotec	Dia	-	ELE				Inertv (f			Fract	Str	Wea	-	Type	ALPH	BET	Sha	Rough	l T				ault B Gou	Sroker	OTES/ IMPRI INFIL THIC
						F	0.7	100	0		B4	W4											ш.		ž
T VM/LG						60	0.2	100	0		R4	W4													
':\Style						61	1.3	30	0		R4	W4													
^																									
						62	15	100	30	26	R4	W4													Bedding at 20 to 30°
B.T.																									Joints at 20, 30 and 45°
						- <mark>63</mark>	0.6	83	0		R4	W4													
						64																			
							1.5	100	0		R4	W4													
						65	0.3	100	67		R4	W4													Bedding at 60 to
							0.6			20	R4	W4													70° Joints at 10, 60
																									\and 75°
			463.14			67	1.5	53	23		R4	W4													
= 1 : 100			67.25 462.90	Hematite red and white																					
l Scale -			462.15	Grey massive Iron Oxyde with few fine beddings of		68	0.8	100	88		R5	W2													Bedding at 65 to 70° Joints at 5 10
Vertica			461.68 68.80	white Chert.	';	- <u>69</u>	0.7	100	50	22	R5	W2													and 65, 70°
			461.30 69.20 461.02	milimetrics band of red Che	ert i	Ē																			
			69.50	centimetrics band of white	1	70	1.5	53	40		R3	W4													
				white Chert.																					
				milimetrics band of red Che	n ¦ ərt ¦	71	1.2	58	0		R3	W4													
			458.95 71.70 458.67	i and milimetrics to	- 5	72	0.3				R0	W5													
			72.00	Left Chert, Limonite.	¦∦		4.5	47	•																
			457 36	i milimetrics band of red Che and milimetrics to	ərt	73	1.5	47	0		R3	W4													
			73.40	Chert. More then 50% of	j,	Ē	0.0	70	50	10		10/4													Rodding at 65°
			456.42	white Chert.		-74	0.9	/8	90	12	R2	VV4													Joints at 40 and 65
	Joi Wa	int Re avy a	oughnes ind Rou	ss, Jr: gh 3.0	J	oint Al	teratio	n, Ja:			Filled					Joint Mass	Numb sive	er, Jn:			0.5				
	Pla	avy a anar : anar/	and Smo and Rou Smooth	oth 2.0 igh 1.5 Fill 1.0	S	ealed taining lightly	Fractu g only altere	ires d wall	0.7	5	Sand Stiff (/Crush Clay < Clay <	ned Ro 5mm 5mm	ck	4 6 8	One One Two	set plus ra sets	andom			2 3 4				
	Pla	nar/	Slickens	ided 0.5	Š	lity/sa lay co	ndy co ating	ating	3		Swel Stiff (l. Clay Clay >	< 5mn 5mm	n 1	12 10	Two Thre	sets p e sets	lus ran	dom		6 9			1	
	Joi Fa	nt: ult:		JN Bedding: BD FLT Foliation: FO		hanai					Soft	Clay > I. Clay	5mm > 5mn	n 2	15 20	Four Four	e sets or mo hed ro	plus ra re sets ck	Indom		12 15 20		F	IOLE	#:
.03.200	Ve Co	in: njug	ate:	VN Orthogonal: OR CJ Cleavage: CL	P	anar: urved	P :C	L Un U Ste	dulatin pped:	g: L §	JN Irr ST CI	egular: osed:	IR C											_	
A R.1 04	Ro Po	ughr lishe	ness: d: P(D Smooth: SM Very Rough: V	R B	filling: roken	Rock:	Br	- 11	Go	ouge:	Go	Sand:	Sa										В	H-P-03
Ge-66A	Sli	ckins	aded: K	Rough: Ro Closed: C	BCC	otite: lay: hlorite	e:	Bt Ca CI Epi Ch Iror	icite: clote: n:	Ca Gr Ep He Fe O	avel: matite lartz:	Gr : He Qz	Sericit Silt: Sulnhi	e: Se Si de: Si) 										
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2014-11	Fil	le n	•:	B-0010504-3 P	roject l	Nar	me:								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed:
inted : 2	Nc	orth	ing:	6086562.697 R	eferen	се	Poi	nt:									Pr	ecisio	on GF	PS	Logg	ed by	<i>ı</i> :		Al <u>ain Lemonde</u>
9.sty- P.	Ea	astir	ng:	658422.620 D	atum:										Ν	IAD8	3 UT	M ZC	ONE	19	Drillir	ig Co	ontrac	tor:	Downing
ce_Lak	Ele	eva	tion:	526.33 A	zimut:							ab.				For	d.		45.0	0°	Drille	rs:			
VOL_NF	Inc		ation:	70* B	it type.							1511.				ree						nıg.			LF-70
TVM_	e (m)		(ROCK TYPE		n ¥		RVAL	REC. I	E.	STRENG	ITH DATA		(#	DI	SCO		Surface							
Forage 504-3	g&Cor /Depth	Votes	igth(m		(m) 4		a E	(%	(%	er_1_	Index	g Inde	Ê	nber (Orien	itation	D	escripti	on	Jr	Ja	Jn			IENTS PTH/ E & SS
og_Geotec_80Log_ B-0010	Casin Diameter	Water I	ELEV./ Ler	DESCRIPTION		Inertical No	from-to	TCR (RQD (Fractures p	Strength	Weatherin	Depth	Type & Nur	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia Gouge	Broken Core	NOTES/COMM /IMPRINT DE INFILL TYP THICKNES
N/Log'L			455.85	Weathered Iron Oxyde		5	0.6	100	33		R3	W5													Bedding at 65° Joints at 40 and 65
Style_L VI			75.00	band of red Chert and milimetrics to centimetrics			1.5	80	10		R3	W5													
7.				Highly weathered zone	- 11 - 7 - 11 - - 11 - - 11 -	5	0.3	67	0		R3	W5	-												
				band of red Chert and		7	0.7				R3	W5													
ю.			453.03	i milimetrics to centimetrics	, E,	(0.5				R3	W5													
			78.00	5cm Earthy zones. Completely weathered, iron Oxyde, interbeded with milimetrics band of red Chert		9	1.5	100	93	7	R6	W3													Bedding at 70° Joints at 5, 20, 45 and 70°
			451.25 79.90 450.68 80.50	centimetrics to centimetrics band of white Chert. weathered zone at cludepth of 74.0m.	- 111 - 111		1.5	100	77	11	R6	W2													Bedding at 65 to 70° Joints at 20 and 70
: 100			140.00	 Chert, ±Limonite. Weathered black Shale with bands of Iron Oxyde interbeded with milimetrics band of red Chert and 		2	1.5	100	75	9	R6	W2													Bedding at 70° Joints at 5, 45 and 70°
Vertical Scale = 1			448.62 82.70	I milimetrics to centimetrics J J band of white Chert. Black Shale with milimetrics J beds of white Chert. Black Shale with more then	- 4/ - 4/ - 4/ - 4/ - 4/ - 4/ - 4/ - 4/	3	1.5	100	75	10	R6	W2													Bedding at 70° Joints at 30 and 70
			445.89	50% of white Chert. Black Shale with milimetrics beds of white Chert. Black Shale with more then		5	1.5	100	73	12	R6	W2													Bedding at 70 to 75° Joints at 5, 30 and 70, 75°
			85.60	Black Shale with milimetrics beds of white Chert.	8	6 7	1.5	100	56	10	R6	W2													Bedding at 65 to 70° Joints at 5, 20 and 65, 70°
					-81	B	1.5	100	67	13	R6	W2													Bedding at 70° Joints at 5, 30 and 70°
					8	•	1.5	87	80	3	R6	W2													Bedding at 70 to 75° Joints at 20 and 70
	Joi We	int R	oughne	ss, Jr: ah 30	Joint	Alter	ratior	n, Ja:		ı	Filled	•				Joint	Numb	er, Jn:			0.5	 			
	Wa Pla Pla Pla Tyj	avy a avy a anar anar/ anar/ pe: nt:	and Smo and Rou Smooth Slickens	gin 3.0 opth 2.0 ugh 1.5 /Fill 1.0 sided 0.5	Heale Staini Slight Silty/s Clay o	d Fr ng c ly al and coati	ractu only terec ly coa ing	res 1 wall ating	0.78 1 2 3 4	5	Sand Stiff (Soft (Swel Stiff (Soft (Soft (I. Clay < Clay < Clay < I. Clay Clay > Clay >	ned Ro 5mm 5mm 5mm 5mm 5mm	n 1	4 6 8 12 10 15	One One Two Two Three Three	set plus ra sets sets pl e sets e sets	indom us ran plus ra	dom		0.5 2 3 4 6 9 12				/ M
2009	Fai Sh Ve	uit: ear: in:		FLI Foliation: FO SHR Contact: CO VN Orthogonal: OR	Shap Plana	e: r:	P	L Un	dulatin	g: l	JN IIm	egular	: IR	4		Crus	hed ro	ck			20			.015	<i>u</i> .
:Q-09-Ge-66A R.1 04.03	Co Ro Pol Slid	njug ughr lishe ckins	ate: ness: d: P sided: K	CJ Cleavage: CL O Smooth: SM Very Rough: VR Rough: Ro Closed: C	Curve Infillin Broke Biotite Clay: Chlor Fresh	ed: g: en Ro a: ite: :	C ock: I (U Ste Br Bt Ca Cl Epi Ch Iror Fr Clc	cite: clote: n: used:	Go Ca Gr Ep He Fe Qu C	ST Cl puge: avel: matite lartz:	Go Gr : He Qz	C Sand: Sericit Silt: Sulphi	Sa te: Sa Si ide: Su	3									В	H-P-03

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2014-11	Fi	le n	۱°:	B-0010504-3 P	roject N	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed:
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4N_Joy	In		allon.		i type	r					511.					;u.					יו ט .		1	
TVM	e.		2	RUCK TYPE		Ę		REC.	E.	STRENG			(#		500		Surface							
og_Geotec_80Log_Forage B-0010504-3	Casing&Cor Diameter/DeptI	Water Notes	ELEV./ Length(n	DESCRIPTION	Depth (m)	Inertval No. & De (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_	Strength Index	Weathering Inde	Depth (m)	Type & Number (Orien (°) ALPHA (°)	tation (°) AT38	Shape	Bondhness	on	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
MILogILi																								Bedding at 70 to 75°
Y:\Style_LVI					-90	1.5	100	67	12	R6	W2													Bedding at 70 to 75° Joints at 15, 30
					92																			and 70°
B.T.					-93	1.5	100	40	11	R6	W2													Dadding at 70.9
			438.47 93.50	Black Shale with motre then		0.5	100	31	16	R6	W2													Joints at 30 and 70°
			438.19 ⁻ 93.80	50% of white chert. Crushed rock Black Shale with milimetrics	, 94 _'	1.0	100	31	17	R6	W2													Bedding at 70° Joints at 30 and 70°
			436.16	beds of white Chert.	95	1.5	97	54	10	R6	W2													Bedding at 70° Joints at 20, 30 and 70°
1:100			95.96 436.12 96.00 435.93 196.20 435.79 96.35	Quartz/felspath vein. Black Shale with milimetrics beds of white Chert. Quartz/felspath vein. Massive black shale	- / 1 - / 1 - / 1 - / 97 - /	1.5	100	40	10	R6	W2													Joints at 30 and 70 °
Vertical Scale =			434.71 97.50	Black Shale with milimetrics beds of white Chert.	-98	1.5	100	50	10	R6	W2													Bedding at 75° Joints at 40 and 70°
					-100	1.5	100	63	6	R6	W2													Bedding at 70°
					-101	1.5	100	59	18	R6	W2													Joints at 70°
					102																			Joints at 5, 30
					-103	1.6	100	69	12	R6	W2													Bedding at 70° Joints at 5, 10 and 30, 70°
	-		428.46			1.4	100	27		R6	W2	<u> </u>												
		int R avy a anar anar/ anar/ pe: int: iult:	toughnes and Roug and Smo and Rou /Smooth/ /Slickens	is, Jr: jh 3.0 oth 2.0 igh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD FLT Foliation: FO	Joint Al Unfilled Healed Staining Slightly Silty/sa Clay co	Iteratio Fractu g only altere ndy co pating	n, Ja: ures d wall bating	0.7 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: Clay < Clay < Clay < Clay > Clay > Clay > Clay >	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm 5mm		4 6 8 12 10 15 20	Joint Mass One Two Two Three Four	Numb set plus ra sets sets pl sets pl sets sets or moi	er, Jn: Indom us ran plus ra re sets	dom		0.5 2 3 4 6 9 12 15 20				/M
1.03.200	Ve	iear: ein: onjug	jate:	SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL	Shape: Planar: Curved	F : C	PL Un CU Ste	dulatin pped:	g: L	JN Im ST CI	egular: osed:	IR C			10100				1				-	
CQ-09-Ge-66A R.1 04	Ro Po Sli	bughi blishe ickins	ness: ed: PC sided: K	Smooth: SM Very Rough: VR Rough: Ro Closed: C	Infilling: Broken Biotite: Clay: Chlorite Fresh:	: Rock: e:	Br Bt Ca Cl Epi Ch Iror Fr Clc	lcite: clote: n: ised:	Go Ca Gr Ep He Fe Qu C	ouge: avel: matite iartz:	Go Gr He Qz	Sand: Sericil Silt: Sulphi	Sa e: Se Si de: Su	1 9									B	н-р-03

Vertical Scale = 1 : 100

-20 11h	R	ECO	ORD C	OF ROCK CORE DRILLING	g and	TES	TING	- BC	REF	IOLE	N°:						Bł	1-P-()3		F	Page	:	8 of11
2014-11	Fi	le n	ı°:	B-0010504-3 P	roject N	lame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	logge	ed:
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N_Joy	Inc		ation:	70° B	it type.	1					SII.				гее						iig.		1	LF-70
-TVM_	e E		-	ROCK TYPE		INTE 5		REC.	Ε	STRENG	TH DATA		()	DI	SCO				IA					
3eotec_80Log_Forage_ B-0010504-3	Casing&Cor Diameter/Depth	Water Notes	ELEV./ Length(m	DESCRIPTION	Depth (m)	Inertval No. & Dep (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_r	Strength Index	Weathering Index	Depth (m)	Type & Number (‡	Orien	BETA (°)	Shape	scripti	n	Jr	Ja	Jn	ault Breccia/ Gouge	roken Core	TTHCKNES
\rod\rod_C				Black Shale interbedded with	n E	1.4	100	27		R6	W2						ш.					<u>в</u>	8	
e_LVM\			427.47	grey sandstone.		5																		Bedding at 70°
Y:\Styl			103.20	beds of white Chert.	-10	1.5	100	93	11	R6	W2													Joints at 5, 45, 60 and 70°
B.T.					10	1.5	83	83	5	R6	W2													Bedding at 70° Joints at 30 and 70°
			424.37 108.50	Gray Sandstone , fine to medium grain.	-10	1.5	100	70	13	R6	W2													Bedding at 70° Joints at 5, 10 and 30, 70°
					-11	1.5	100	100	4	R6	W2													Joints at 10, 15 and 30°
1:100					-11:	1.5	100	80	5	R6	W2													Joints at 5 and 30°
Vertical Scale =			419.67 113.50	Grey to yellow to brown,		1.5	87	35	10	R6	W2													Joints at 5,10 and 60, 80°
			419.02 114.20	sandstone.	_/	0.7	100	29	20	R6	W2													Joints at 5,10 and 60, 70, 80°
				Grey Sandstone, fine to medium grain.	-11	0.8	100	30	11	R6	W2													Joints at 30,60 and 70°
					-11	1.5	93	73	10	R6	W2													Joints at 10, 20 and 70°
					- E.	0.3	100	100	10	R6	W2													
			415.26 118.20 414.98 118.50	Grey Sandstone, fine to medium grain interbedded		1.2	100 93	100 87	10 9	R6 R6	W2 W2													Bedding at 75° Joints at 20 and 70°
		int D		with black shale.	/ [-11!	Itorotic	00 n lo:	0,	Ű	110				<u> </u>		Numb	or In:							
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2014-11-	Fil	le n	ı°:	B-0010504-3	Proje	ct N	ame:								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	.ogge	ed:	
nted ::	Nc	orth	ing:	6086562.697	Refer	enc	e Poi	nt:									Pre	ecisio	on GF	PS	Logg	ed by	/:		Al <u>ain Le</u> i	monde
sty- Pr	Ea	astir	ng:	658422.620	Datur	n:									Ν	AD8	3 UT	MZC	ONE	19	Drillir	ıg Cc	ontrac	tor:	Do	owning
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_og_Geotec_80Log_Fo B-001050	Casing& Diameter/D	Water No	ELEV./ Lengt	DESCRIPTION		Depth	Inertval No. & (from-to)(r	TCR (%)	RQD (%)	Fractures per	Strength In	Weathering I	Depth (m	Type & Numb	(°) AHPA (BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMMEI /IMPRINT DEP1	INFILL TYPE & THICKNESS
NM/F0 <i>ð</i> /			414.04 119.50	Grey Sandstone , fine to			1.5	93	87	9	R6	W2													Bedding a 75° Joints at 5	t 50 to
T. Y:\Style_L			413.38 120.20 412.63 121.00 412.16 121.50	Interbedded with black sh Grey Sandstone , fine to medium grain. Interbedded with black sh Grey Sandstone , fine to medium grain.	iale. iale. 	120	1.5	100	80	10	R6 R6	W2 W2													And 50,70 Bedding a 75° Joints at 1 and 50,70	° t 60 to 5, 30
•			411.31 122.40 411.03	Interbedded with black sh	iale.		0.4	100	62		B6	W2														
			122.70	medium grain.		-123	1.5	100	100	8	R6	W2													Bedding a 75° Joints at 5 and 60°	t 60 to , 30
						-125	1.0	100 100	100 100	7	R6 R6	W2 W2													Bedding a Joints at 3 and 70°	t 70° 0, 45
= 1 : 100			406.52			-126	1.5	100	77	11	R6	W2													Bedding a Joints at 2 and 70°	t 75° 0, 25
Vertical Scale			127.50	Grey Sandstone , coarse grain altered.		-128	1.5	93	100	12	R6	W2													Joints at 2 and 70°	0, 60
			404.55 129.60	Siltstone		-130	1.5	100	89	8	R4	W3													Joints at 5	0 and 70°
						-131	1.5	93	75	4	R4	W3													Joints at 3	0 and 90°
						133	1.5	100	50	17	R6	W2													Joints at 1 and 60, 65	0,40 ;°
						- 134																				
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-20 11h	RE	ECC	ORD C		ING A	ND 1	TEST	ING	- BC	REF	IOLE	N°:						B	I-P-(03		I	Page	: _1	0 of <u>11</u>
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_og_Geotec_80Log_Forage_ B-0010504-3	Casing&Cor Diameter/Depth	Water Notes	ELEV./ Length(m	DESCRIPTION		Depth (m)	Inertval No. & Dep (from-to)(m)	TCR (%)	(%) UOU	Fractures per_1_r	Strength Index	Weathering Inde	Depth (m)	Type & Number (#	Orien (。) VHA'TV	BETA (°)	Shape	Surface	on	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
F VM\Log\						-135	1.5	100	91	7	R6	W2													Bedding at 75° Joints at 20, 45 and 70°
Y:\Style						-136	1.5	100	80	15	R6	W2													Bedding at 70° Joints at 15, 50 and 70°
B.T.						-137 -138	1.5	100	59	11	R6	W2													
						-139	1.5	100	55	7	R6	W2													Joints at 10 an 65°
			394.77 140.00	Siltstone interbedded with black shale.	 1	140	1.5	100	80	9	R6	W2													Joints at 40,50 and 70°
le = 1 : 100			392.89 142.00	Siltstone.		142	1.5	100	87	7	R6	W2													Bedding at 60 to 70° Joints at 30 and 60, 70°
Vertical Sca						-143	1.5	100	40	3	R6	W2													Bedding at 65 to 70° Joints at 5 and 60, 70°
						-145	1.5	100	93	10	R6	W2													Joints at 40 60 and 70°
						-146	1.5	100	56	5	R6	W2													Bedding at 75° Joints at 20, 30 and 70°
						-148	1.5	100	0	9	R6	W2													Bedding at 75° Joints at 15, 25 and 65, 70°
						Ē	1.2	100	88	3	R6	W2													Joints at 65°
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2014-11-	Fil	le n	ı°:	B-0010504-3 Pro	ect N	ame	:							Joy	ce La	ake	- Op	en F	Pit	Date	drille	ed & L	logge	ed:
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og_Geotec_80Log_Forag B-0010504-5	Casing&Co Diameter/Dep	Water Note	ELEV./ Length(DESCRIPTION	Depth (m	Inertval No. & D((from-to)(m)	TCR (%)	RQD (%)	Fractures per_1	Strength Inde	Weathering Ind	Depth (m)	Type & Number	(°) ALPHA (°)	BETA (°)	Shape	Boughness	Infill	51	Ja	511	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENT /IMPRINT DEPTH INFILL TYPE & THICKNESS
			386.03 149.30	Siltstone interbedded with black shale.	-	1.2	100	88	3	R6	W2													Joints at 65°
Y:\Style					-150	1.7	100	82	7	R6	W2													Bedding at 70° Joints at 15, 45 and 65, 75°
3. T.					-152																			Joints at 45 and 65, 75°
-			382.56	Silitano		1.6	100	100	7	R6	W2													
			381.15		-154	1.5	100	93	5	R6	W2													Joints at 15, 45 and 60, 65°
			154.50	Siltstone interbedded with black shale.	-155	1.5	88	88	5	R6	W2													Bedding at 60 to 65° Joints at 60 and 70°
0			379.27 1 56.50	Siltstone				70																Bedding at 70° Joints at 5 \and 60, 70°
Scale = 1 : 10					-157	1.5	100	70	14	R6	W2													Joints at 50, 60 and 70°
Vertical					-158	1.5	97	88	6	R6	W2													Joints at 30, 50 and 70, 75°
					-159	1.7	88	65	8	R6	W2													Joints at 30, 40 and 65, 75°
			375.32 160.70	End of borehole at a length of 160.7m.	-161																			
					-162																			
					-163	3																		
Q-09-Ge-66A R.1 04.03.2009	Joi Wa Pla Pla Pla Joi Fa Sh Co Ro Po Sli	int R avy a avy a anar/ anar/ pe: int: ult: ear: int: ult: lishe ckins	and Roughest and Roughest and Smo and Smo (Smooth) (Slickens) (Sli	iss, Jr:	L Joint Al Unfilled Healed Staining Slightly Slightly Slightly Sal Clay co Clay co Shape: Planar: Curved Infilling: Broken Biotite: Clay: Chlorite Fresh:	Iteratic Fracti g only alterendy co pating F : () Rock:	L ures d wall pating PL Un CU Ste Br CI Epi Ch Irou Fr Clc	dulatin pped: clote: clote: ssed:	g: L GC Ca Gr Ep He Fe Qu C	Filled Sand Stiff (Swell Swell Soft (Swell Soft (Swell Soft (Swell Stiff (Soft (Soft (Swell Stiff (Soft (Swell Stiff (Soft (Soft (Swell Stiff (Soft (Soft (Soft (Swell Stiff (Soft (: /Crush Dlay < Clay < . Clay Dlay > . Clay egular: osed: Go Gr : He Qz	smm 5mm 5mm 5mm > 5mm > 5mm > 5mm Smm Smm Smm Smm Smm Smm Smm Smm Smm	ck childe: Sa	4 6 8 2 0 5 20	Joint Mass One : One : Two : Two : Two : Three Four Crust	Numbo ive set blus ra sets sets pl sets pl sets sets pl sets pl sets pl sets pl sets pl sets pl	ndom us ran plus ra e sets x	dom		0.5 2 3 4 6 9 12 15 20			HOLE	/M #: H-P-03

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Vertical Scale = 1 : 100

CORE PHOT File n°: Northing: Easting: Elevation: Inclination:	OGRAPHY - BOREHOLE N°: B-0010504-3 6086562.697 658422.620 526.33 70°	BH-P-03 Project Name: Reference Point: Datum: Azimut: Bit type: Flush:	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 45.00° Feed:	Page: <u>1</u> Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	of <u>13</u>
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1 2 2 2 2 2 2		Project : JOYCE LA Borehole : BH-P-	AKE Box from to 01 9.00 13.50 03 02 13.50 03 02 13.50 03 02 13.50 03 02 13.50 03 02 13.50 03 02 13.50 03 0.2 13.50 03 0.4 19.30 0.4 19.30 $25,20$		IOLE #: BH-P-03

CORE PHOTOGRAPHY - BOREHOLE N°:	BH-P-03		Page:2	of <u>13</u>
File n°: B-0010504-3	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing: 6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting: 658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation: <u>526.33</u>	Azimut:	45.00°	Drillers:	
Inclination: <u>70°</u>	Bit type: Flush	: Feed:	Drill Rig:	LF-70_
26- 27- 28- 29- 30- 31- 32- 33- 34- 35- 36- 37- 38- 39- 40- 41- 42-	line traiting the second secon	Box from to 05 25.20 30.00 04 30.00 33.80 07 33.80 37.60 08 37.60 42.70	<image/> <image/> <image/>	LE #: BH-P-03

Vertical Scale = 1 : 0

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CORE PHOTOC File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N°: B-0010504-3 6086562.697 658422.620 526.33 70°	BH- Project Name: Reference Point: Datum: Azimut: Bit type:	- P-03	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 45.00° Feed:	Page: Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	5 of <u>13</u> Alain Lemonde Downing LF-70
(E) (C) (C) (C) (C) (C) (C) (C) (C) (C) (C			Project : JOYCE LAKE Borehole : BH-P-03	Box from to 17 65.40 68.30 18 68.30 71.70 19 71.70 74.40 20 74.40 76.80		HOLE #: BH-P-03

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File II ⁻ .	<u>B-0010504-3</u>	Project Name.		Precision GPS	Date drilled & Logged.	
Northing:	658422.620	Reference Point:			Logged by:	Alain Lemonde
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CORE PHOTO	OGRAPHY - BOREHOLE N°:	BH-F	·-03		Page:7_	of <u>13</u>
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:		45.00°	Drillers:	
Inclination:	<u>70°</u>	Bit type:	Flush:	Feed:	Drill Rig:	LF-70_
88 90 91 (m) 92 93 94 95 96			roject : JOYCE LAKE Borehole : BH-P-03	Box from to 25 87.20 89.60 26 89.60 92.07 27 92.07 94.50 28 94.50 96.70	<image/> <image/>	DLE #: BH-P-03

Vertical Scale = 1 : 0

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CORE PHOTO	GRAPHY - BOREHOLE N°:	BH-P-0)3		Pa	age: <u>8</u> of <u>13</u>
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Lo	gged:
Northing:	6086562.697	Reference Point:			Logged by:	Alain Lemonde
Easting:	<u> </u>	Datum:		<u>NAD83 UTM ZONE 19</u> 45.00°	Drilling Contracto	or: <u>Downing</u>
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						HOLE #:
					1 1	BH-P-03

Vertical Scale = 1 : 0

		BH	1_D_U3		Page 0	~f 12
		Distant Namo	1-F-UJ	Javas Laka - Onan Dit	Fdyt. <u>v</u>	
File II ⁻ .	D-UU I UJUH-J	Project marrie.		Precision GPS	Date united a Logged.	Alain Lomando
Northing.	6584222 620	Reference Form.		NAD83 LITM ZONE 19	Loggea by. Drilling Contractor:	Alain Lemonue
Easting. Flevation:	526.33	Azimut:		45.00°	Drillers:	Downing
Inclination:	<u>70°</u>	Bit type:	Flush:	Feed:	Drill Rig:	LF-70
107 108 109 110 110 111 (E) 411 112 113 114 115 116 117			Project : JOYCE LAKU Borehole : BH-P-03	Box from to 33 (06.50 (09.50) 34 (09.50) (12.50) 35 (12.50) (14.70) 36 (14.70) (17.30)		DLE #:
						BH-P-03

CORE PHOTOGRAPHY - BOREHOLE N°: File n°: B-0010504-3 Northing: 6086562.697 Easting: 658422.620 Elevation: 526.33 Inclination: 70°	BH-P-03 Project Name:	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 45.00° Feed:	Page: 10 of 13 Date drilled & Logged:
118- 119- 120-			
121- 122- (L) tb 123- 124-			
- 125- - 126- - 127-	Project : JOYCE LAK	E Box from to <u>37</u> 117,30 120,00 <u>38</u> 120,00 122,60	
128-	borenoie . bh-r-o.	<u>39 122.60 125.50</u> <u>40 125.50 128.40</u>	HOLE #: BH-P-03

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CORE PHOTO	GRAPHY - BOREHOLE N°:	BH-F-0	J		Page:1	<u>1</u> Of <u>13</u>
File n°:	<u>B-0010504-3</u>	Project Name:		Joyce Lake - Open Plt	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	<u>526.33</u>	Azimut:	Fluch:	45.00°		
Inclination:	80	Вії туре.	1 10311.	1 660.	Dhii Rig.	LF-70
129 130 131 132 (m) 133 134 135 136 136 137 138			oject : JOYCE LAKE	Box from to 41 128.40 130.80 42 130.80 133.50 43 (33.50 136.30 44 (36.30 138.60		
					ł	HOLE #:
						BH-P-03

CORE PHOTO File n°:	GRAPHY - BOREHOLE N°: B-0010504-3	BH-P-03 Project Name:	3	Jovce Lake - Open Pit	Page: <u>12</u> Date drilled & Logged:	of <u></u>
Northing:	6086562.697	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting: Elevation:	<u> </u>	Datum: Azimut:		<u>NAD83 UTM ZONE 19</u> 45.00°	Drilling Contractor: Drillers:	Downing
Inclination:	70°	Bit type:	Flush:	Feed:	Drill Rig:	LF-70
140- 141- 142- (E) HDD 144- 145- 146- 147- 148-			Project : JOYCE LAKE Borehole : BH-P-03	Box from to 45 138,40 (41,45 46 (41,45 (44,00) 47 (44,00) (46,30) 48 (46,30) (48,85	<image/>	
						BH-P-03

CORE PHOTO	GRAPHY - BOREHOLE N°:	B	H-P-03			Page: 13	of <u>13</u>
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Da	te drilled & Logged:	
Northing:	6086562.697	Reference Point:		Precision GPS	Log	gged by:	Alain Lemonde
Easting:	658422.620	Datum:		NAD83 UTM ZONE 19	Dri	lling Contractor:	Downing
Elevation:	<u>526.33</u>	Azimut:	Flush:	45.00° Feed:	Dri	llers:	
inclination.	70	ыі туре.	1 10311.	1000.	DII	ії піў	LF-70
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150-	8	14		The second second stands	a High Mais in	I al and I many of	
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151-	-15				Supported to the second	100 million (100 million)	
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152-		ANT TO AN A TO AN	The state of the state	and and	and the state of the state of the		
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152-	1 Prototo to the design	derter to Better to Are	and a second party of	Barren Barren Barren Harren Barren Barr		A. Y. de Falle failed and	
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150-	A State of the second	my know facility	KYEK Z	10-1-	he and the local	5.6	
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157-		Part in the second	-	Box from to			
		F	Project : JOYCE LAKE	49 148 85 15/80			
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		A REAL PROPERTY OF	Borehole : BH-P-03	<u> 20 137,80 154,30</u>			
				51 154,50 157,00			
1 59 -				52 157,00 159,70			
						HOL	-E #:
					_		BH-P-03
						VM	
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EQ-09-Ge-66A R.1 04.03.2009



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°:	B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

	Run				Discontinuity							
Dept	th (m)			Dept	h (m)							
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill	
0,00	9,00	Casing										
9,00	11,00	20										
11,00	12,00	20	40									
12,00	13,50	40										
13,50	15,00	40										
15,00	16,50	47										
16,50	16,70	100										
16,70	18,00	92	70									
18,00	19,30	100	50									
19,30	19,50	50										
19,50	21,00	6										
21,00	22,50	13										
22,50	24,00	33										
24,00	25,20	100	80									
25,20	25,50											
25,50	27,00	47										
27,00	28,50	13										
28,50	30,00	33										
30,00	31,50	33										
31,50	33,00	20										
33,00	33,80	100	37									
33,80	34,50	71										
34,50	35,30	75										
Ту	/pe						Roughnes	S		Infilli	ng	
Joint:	JN					Polished:		PO	Broken	rock:	BR	
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA	
Shear	SHR					Smooth:		SM	Silt:		SI	
Vein:	VN					Rought:		RO	Clay:		CL	
Bedding:	BD					Very roug	ht:	VR	Gouge:		GO	
Foliation:	FO								Biotite:		BT	
Contact:	CO						Shape		Calcite		CA	
						Planar:		PL	Chlorite	e:	СН	
					Curved: CU Iron: FE					FE		
					Undulating: UN Hématite: HE						HE	
						Stepped:		ST	Quartz:		QZ	
						Irregular:		IR	Limoni	te:	LI	



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°:	B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

	Run						Disco	ontinuity			
Dept	th (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
35,30	36,00	43									
36,00	37,00	15									
37,00	37,50	40									
37,50	39,00	53									
39,00	40,50	33									
40,50	42,00	13									
42,00	43,50	100									
43,50	45,00	100							<u> </u>	ł – – –	
45,00	46,50	17									
46,50	48,00	23							<u> </u>		
48,00	49,50	100	12						<u> </u>		
49,50	51,00	80							<u> </u>		
51,00	52,50	20									
52,50	54,00	50	16								
54,00	55,00	90	30								
55,00	56,70	100	30								
56,70	57,80	55									
57,80	58,50	100	21								
58,50	59,30	100	25								
59,30	60,00	100									
60,00	60,20	100									
60,20	61,50	30									
61,50	63,00	100	30								
Ту	ре						Roughnes	S		Infilli	ing
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	jht:	VR	Gouge:	:	GO
Foliation:	FO		-						Biotite:		BT
Contact:	CO						Shape		Calcite		CA
						Planar:		PL	Chlorite	e:	СН
						Curved: CU Iron: FE					FE
					Undulating: UN Hématite: HE					HE	
						Stepped:		ST	Quartz:		QZ
						Irregular:		IR	Limoni	te:	LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°:	B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

	Run			Discontinuity								
Dept	th (m)			Dept	h (m)							
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill	
63,00	63,60	83										
63,60	65,10	100										
65,10	65,40	100	67									
65,40	66,00	NA	NA									
66,00	67,50	53	23									
67,50	68,30	100	88									
68,30	69,00	100	88									
69,00	70,50	53	40									
70,50	71,70	58										
71,70	72,00	N A	N A									
72,00	73,50	47										
73,50	74,40	56										
74,40	75,00	100	33									
75,00	76,50	80	10									
76,50	76,80	67										
76,80	77,50	100										
77,50	78,00	100										
78,00	81,00	100	93									
81,00	82,50	100	75									
82,50	84,00	100	75									
84,00	85,50	100	73									
85,50	87,00	100	56									
87,00	88,50	100	67									
Ту	vpe						Roughnes	S		Infilli	ing	
Joint:	JN					Polished:		PO	Broken	rock:	BR	
Fault:	FLT					Slickinsid	led:	K	Sand:		SA	
Shear	SHR					Smooth:		SM	Silt:		SI	
Vein:	VN					Rought:		RO	Clay:		CL	
Bedding:	BD					Very roug	ht:	VR	Gouge		GO	
Foliation:	FO								Biotite:		ВТ	
Contact:	CO			Shape Calcite: CA					CA			
				Planar: PL Chlorite: CH						СН		
				Curved: CU Iron: FE					FE			
				Undulating: UN Hématite: HE					HE			
						Stepped:		ST	Quartz		QZ	
						Irregular:		IB	Limoni	te:		



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FIL	ΕI	N٥	:	

BH-P-03

B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

	Rur	ı –		Discontinuity								
Dep	th (m)			Dep	th (m)							
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill	
88,50	90,00	87	80									
90,00	91,50	100	67									
91,50	93,00	100	56									
Corient	Test			92.55	93.00	BD	68		PL		WC	
					92.55	1 JN	30		PL	SM		
					92.65	1 JN	70		PL	SM		
					92.71	1 JN	68		PL	SM	FE	
					92.85	1 JN	69		PL	SM	WC - FE	
					93.00	1 JN	68		PL	SM	FE	
93.00	94.50	100	31									
94.50	96.00	97	54									
96.00	97.50	100	40									
97.50	99.00	100	50							<u> </u>		
99.00	100 50	100	63							-		
Corient	Test	100	00	99.85	100 50	10 BD	79-77	55-80	PI		WC	
Concint	1031			00.00	99.85	1 IN	76	35	PI	SM	FE	
					99.00	1 111	70			5101	TE WC	
					91.00		20	90		CM		
					100.04	I JIN	71	08	PL	510	FE	
					100.50	1 JN	73	100	PL	RO	FE	
L												
100.50	102.00	100	59									
102.00	103.60	100	69									
103.60	105.00	100	27				Deverbage					
loint:	уре ПNI					Polished	Rougnnes		Broker		ing IBB	
Fault:						Slickinsic	led:	K	Sand	TOCK.	SA	
Shear	SHB					Smooth:		SM	Silt:		SI	
Vein:	VN					Rought:		RO	Clav:		CL	
Beddina:	BD					Verv rought: VR				:	GO	
Foliation:	FO					Biotite:					BT	
Contact:	CO					Shape Calcite:					СА	
						Planar:		PL	Chlorit	e:	СН	
					Curved: CU Iron: FE						FE	
					Undulating: UN Hématite: HE					HE		
						Stepped:		ST	Quartz	:	QZ	
						Irregular:		IR	Limoni	te:	LI	



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DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°:	

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

BH-P-03

B-0010504-3

	Run			Discontinuity							
Dept	:h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
105.00	106.50	100	93								
106.50	108.00	83	83								
108.00	109.50	100	70								
109.50	111.00	100	100								
111.00	112.50	100	80								
112.50	114.00	87	35								
114,00	114.70	100	29								
114.70	115.50	100	87								
115.5	117.00	93	73								
117.00	117.30	100	100								
117.30	118.50	100	100								
118.50	120,00	93	87								
				120.45	121.50	Corient Test					
					120.45	1 JN	71	0	PL	SM	WC-FE
					120.60	1 JN	13	300	UN	VR	WC-FE
					121.02	1 JN	37	120	IR	RO	FE
				121.06	121.50	BD	65-69	120-140			
					121.10	1 JN	56	120	PL	SM	FE
					121.14	1 JN	74	115	PL	SM	FE
					121.22	1 JN	47	150	ON	SM	FE
					121.29	1 JN	53	125	PL	SM	FE
					121.52	1 JN	66	130	ON	SM	FE
120.00	121.50	100	80								
Ту	ре					F	Roughnes	S		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	ht:	VR	Gouge	:	GO
Foliation:	FO				Biotite:						BT
Contact:	CO				Shape Calcite: CA						CA
				Planar: PL Chlorite: CH							CH
						Curved:			Iron:		FE
						Undulatin	g:		Hemati	le:	HE
						Stepped:		51	Quartz		QZ
						irregular:			Limoni	le:	LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: _____ B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-03

	Run	1		Discontinuity								
Dept	h (m)			Dept	th (m)							
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill	
121.50	122.60	100	100									
122.60	123.00	100	62									
123.00	124.50	100	100									
124.50	125.50	100	100									
				125.50	127.39	Corient Test						
					125.50	1 JN	49	85	PL	SM		
					125.78	1 JN	51	50	PL	RO	FE	
					126.03	1 JN	83	50	PL	RO	FE	
					126.10	1 JN	66	30	PL	SM	CL	
					126.13	1 JN	67	40	PL	RO	FE	
					126.15	1 JN	69	45	PL	RO	FE	
					126.27	1 JN	70	140	PL	SM	FE	
					126.30	1 JN	69	165	PL	SM	FE	
					126.34	1 JN	69	170	PL	RO	WC-FE	
					126.37	1 JN	66	172	ON	SM	FE	
					126.40	1 JN	64	180	PL	SM		
					126.55	1 JN	29	50	ON	RO	FE	
					126.86	1 JN	26	220	PL	RO	FE	
					127.02	1 JN	69	125	PL	RO	WC-FE	
					127.13	1 JN	67	140	IR	RO	FE	
					127.14	1 JN	56	140	PL	RO	FE	
					127.15	1 JN	68	140	PL	RO	FE	
					127.27	1 JN	67	110	PL	SM	FE	
Ту	pe					F	Roughnes	S		Infilli	ing	
Joint:	JN					Polished:		PO	Broken	rock:	BR	
Fault:	FLT					Slickinsided: K		Sand:		SA		
Shear	SHR					Smooth: SM			Silt:		SI	
Vein:	VN					Rought: RO			Clay:			
Bedding:	BD BD					Very rought: VR G				<u>. </u>	GU	
Contact:			1		1	Bi Shana C				•		
Contact:		1	1			Planar:	Shape	PI	Chlorit	e.	СН	
						Curved			Iron		FE	
						Undulatin	a:	UN	Hémati	te:	HE	
Si				Stepped: ST		ST	Quartz:		QZ			
Irregular:						IR	Limoni	te:	LI			



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DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE	N°	:	

B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

Run				Discontinuity							
Dept	:h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
					127.31	1 JN	66	120	ON	SM	FE
					127.39	1 JN	67	180	PL	SM	FE
125.50	126.00	100	100								
126.00	127.50	100	77								
127.50	129.00	73	100								
129.00	130.50	100	89								
				129.00	130.67	Corient Test					
					129.00	1 JN	73	320	PL	SM	WC
					129.05	1 JN	77	250	PL	RO	WC-FE
					129.13	1 JN	66	290	PL	RO	FE
					129.15	1 JN	90	175	IR	RO	FE
					129.18	1 JN	50	270	PL		FE
					129.35	1 JN	69	300	IR	RO	FE
					129.44	1 JN	67	250	PL	RO	FE
					129.56	BD	65	290	PL		
					129.58	1 JN	68	285	IR	VR	FE
					129.84	1 JN	75	300	IR	VR	FE
					130.26	1 JN	69	305	IR	RO	FE
					130.45	1 JN	86	330	IR	RO	FE
					130.48	1 JN	81	NA	PL	RO	FE
					130.67	1 JN	88	NA	PL	RO	FE
130.50	132.00	93	75								
132.00	133.50	100	50								
Ту	ре					F	Roughnes	S		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA
Shear	SHR					Smooth: SM					
vein: Reddings							ht.		Gourse		
Ecliption:	FO							Ivn	Biotite	•	BT
Contact:	0						Shape		Calcite		
Sontaot.						Planar:	Sinapo	PL	Chlorit	e:	СН
						Curved:		CU	Iron:		FE
						Undulatin	q:	UN	Hémati	te:	HE
						Stepped:	~	ST	Quartz		QZ
						Irregular:		IR	Limoni	te:	LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE	N°	:	

BH-P-03

B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

DI1-1 -00

	Run						Disco	ontinuity					
Dept	th (m)			Dept	h (m)								
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill		
133.50	135.00	100	91										
				133.75	135.00	Corient Test							
					133.75	1 J	69	175	PL	SM	CL		
					133.98	1 J	73	200	PL	SM	FE		
					134.10	1 J	80	240	UN	SM	FE		
					134.30	1 J	50	10	UN	RO			
					134.98	1 J	73	180	PL	SM	WC		
					135.00	1 J	67	180	PL	BO	WC		
135.00	136 50	100	80										
136.50	138.00	100	59										
138.00	139.50	100	55										
120.50	141.00	100	80							<u> </u>			
141.00	140.50	100	00							┨─────			
141.00	142.50	100	87		1 40 50	0 · · · ·				<u> </u>			
				141.80	142.50	Corient Test				───			
					141.86	BD	76	300	PL	<u> </u>	WC		
					141.84	1 J	21	180	UN	RO	WC-FE		
					141.86	1J	73	330	PL	RO	WC-FE		
142.50	144.00	100	40										
				143.50	143.80	BD	65	320	UN		WC		
					143.50	1 JN	70	320	PL	SM	WC		
					144.	1 JN	69	280	IR	RO	FE		
144.00	145.50	100	73										
				145.20	145.50	Corient Test							
Ту	/pe					ŀ	Roughnes	S		Infilli	ing		
Joint:	JN					Polished:		PO	Broken	rock:	BR		
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA		
Shear						Smooth:					51		
Vein: Reddingu						Norv roug	ht.		Gougo				
Bedaing: BD						very loug		٧n	Biotite	: <u> </u>	BT		
Contact:			1				Shape		Calcite		CA		
Jontuoti						Planar:		PL	Chlorit	e:			
						Curved:		CU	Iron:		FE		
						Undulatin	g:	UN	Hémati	te:	HE		
						Stepped:		ST	Quartz		QZ		
						Irregular:		IR	Limoni	te:	LI		



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE	ΞN°	:

BH-P-03

B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

	Run	l		Discontinuity													
Dep	th (m)			Dept	th (m)												
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill						
					145.20	1 JN	65	5	PL	RO	WC						
					145.50	1 JN	67	295	PL	RO	FE						
145.50	147.00	100	56														
147.00	148.50	100	0														
148.50	149.70	100	88														
				149.35	149.70	Corient Test											
				149.35	149.70	BD	74-84	10	UN		SI						
					149.35	1 JN	68	305	PL	SM	WC						
					149.70	1 JN	84	235	UN	SM	FE						
149.70	151.00	100	82														
151.40	153.00	100	100														
				151.80	153.00	Corient Test											
					151.80	1 JN	69	270	UN	SM	WC						
					152.10	1 JN	60	295	UN	BO	WC						
					152.12	1 JN	60	295	UN	BO	WC						
				152 12	152.85	BD	48-64	255			WC						
				102.12	152.00	1 IN	36	80		PO	CH						
					152.22	1 IN	47	0		PO							
					152.47	1 101	47 56	245		PO	BO						
					152.60	1 JN	50	345			RO						
150.00	154.50	100	00		152.64	I JIN	63	350	IR	RU	RU						
153.00	154.50	100	93														
154.50	156.00	88	88														
156.00 T	157.50	100	70				Roughnes			Infilli	ing						
Joint:	JN					Polished:	lougines	PO	Broken	rock:	BR						
Fault:	FLT					Slickinsid	ed:	К	Sand:		SA						
Shear	SHR					Smooth:		SM	Silt:		SI						
Vein:	VN					Rought:		RO	Clay:		CL						
Bedding:	BD					Very roug	ht:	VR	Gouge		GO						
Foliation:	FO					•			Biotite		BT						
Contact:	CO						Shape		Calcite	:	CA						
						Planar:			Chlorit	e:							
						Curved:	A		Iron:	10.							
						Changed	g:		Hemati	ເe:							
						Stepped:		51 ID	Quartz	:							
						irregular:		חון	LINON	ie:							



PROJECT : Geotechnical Feasibility Study – Open Pit Design

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°:

	Run			Discontinuity												
Dept	h (m)			Dept	h (m)											
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill					
157.50	159.00	97	88													
159.00	160.70	88	65													
EOH																
Τv	pe						Rouahnes	S		Infilli	ina					
Joint:	JN					Polished:		PO	Broken	rock:	BR					
Fault:	FIT					Slickinsid	ed:	ĸ	Sand:		SA					
Shear	SHR					Smooth:		SM	Silt:		SI					
Vein	VN				L	Bought:		BO	Clay.		CL					
Redding:	RD					Very roug	ht	VB	Goure		60					
Eolistion	50		1			1 tory roug		1	Biotite		RT					
Contact:						I	Shana		Calaita	•						
Contact:						Bloner	Shape	Ы	Chlorit							
						Planar:			Uniorit	e:						
						Curved:			iron:							
						Undulatin	g:		Hemati	te:	HE					
						Stepped:		ST	Quartz		QZ					
						Ilrregular:		IIR	Limoni	te:	111					

-17 15h	R	ECO	ORD C	F ROCK CORE DRILLING	- BC	OREHOLE N°:						BH-P-04						F	Page	:	1 of	11			
2014-11-	Fi	le n	•	B-0010504-3 Pro	oject N	ame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & l	Logged: 2014-10-10		
inted :.	No	orth	ing:	6086397.562 Re	ferenc	e Po	int:									Pre	ecisio	on GF	PS	Logge	ed by	/:		Alain Lem	onde
e.sty- Pi	Ea	astir	ng:	658603.194 Da	tum:									Ν	IAD8	3 UT	MZC	ONE	19	Drillin	ıg Co	ontrad	ctor:	Dow	vning
e_Lake	El	eva	tion:	519.26 Azi	mut:							135.00°						<u>0°</u>	Drille	rs:					
N_Joyc	Inc	clin	ation:	70° Bit	type:	,				Flu	sh:	Feed:							Drill F	Rig:			L	_F-70	
-VM_AI	Ē		<u> </u>	ROCK TYPE		INTE 	RVAL	REC.		STRENG	TH DATA		-	DI	sco		IUITY	/ DA	ГА		<u> </u>				
orage_L 04-3	& Core	otes	th(m)		Ē	m) Dept			- - -	dex	Index	(ber (#)	Orien	tation	De	Surface escription	on	Jr	Ja	Jn			NTS TH∕S	5
Geotec_80Log_Fc B-00105	Casing8 Diameter/D	Water No	ELEV./ Leng	DESCRIPTION	Depth	Inertval No. & (from-to)(TCR (%	RQD (%	Fractures pe	Strength Ir	Weathering	Depth (n	Type & Numb	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	IOTES/COMME /IMPRINT DEP INFILL TYPE	THICKNESS
oglLog			519.26 0.00	Casing	-																-	<u> </u>		2	
Style_L VM\L					1	1.5																			
7:14			517.85 1.50	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.	2	1.5	26	13	-	R5	W2														
B.T.					3	1.1	73	0	-	R5	W2														
					4	0.4	100	10		R5	W2														
					5	1.2	17	0		R5	W2														
					6	0.8	27	10			W2														
					7	0.7	71	50	-	R4	W2														
: 100			512.02 7.70	Highly weathered zone		0.7	100	31	_	R4	W2														
cale = 1			8.10	Dark grey Iron Oxyde with millimetric to centimetric beds		0.4	100	0	-	RU	W6														
Vertical S				of red an white chert.	9	1.3	14	38	-	R5	W3														
					-10	0.2	100	0		B5	W3														
			508.83		-11			<u> </u>	1																
			11.10 508.55 11.40	Highly weathered zone Dark grey Iron Oxyde with millimetric to centimetric beds of rod an white chort		1.5	100	8	-	R5	W3														
			507.28 12.75 5 <u>06.95</u> -	Highly weathered zone	 13	1.2	100	21		R5	W3														
			13.10	millimetric to centimetric beds		0.8	100	50		R5	W3														
				or red arr write chert.	-14	0.4	100	0		R5	W3														
					Ē	0.6	100	10		R5	W3														
	Joi Wa	int R avy a	oughnes and Roug	s, Jr: jh 3.0	Joint A Unfilled	Iteratio I: Erect	n, Ja:	0.7	E	Filled	: /Cruck	ad Do	ak		Joint Mass	Numb	er, Jn:			0.5					A
	Pla Pla Pla Ty	avy a anar anar/ anar/ pe:	and Rou Smooth/ Slickens	bin 2.0 gh 1.5 Fill 1.0 ided 0.5	Stainin Slightly Silty/sa Clay co	g only altere indy co pating	d wall bating	0.73 1 2 3 4	5	Sand Stiff (Soft (Swell Stiff (Clay < Clay < Clay < . Clay Clay >	5mm 5mm 5mm 5mm 5mm	1 1	4 6 8 12 10	One Two Two Three	set plus ra sets sets pl e sets	ndom us ran	dom		2 3 4 6 9					
6	Jo Fa Sh	int: ult: ear:	i	JN Bedding: BD FLT Foliation: FO SHR Contact: CO	Shape					Swell	. Clay	> 5mn	1 2	20	Four	or mor hed roo	e sets ck	nuom		15 20		H	HOLE	: #:	
1 04.03.200	Ve Co Ro	onjug oughr	ate: (VN Orthogonal: OR CJ Cleavage: CL	Planar: Curved	F I: C	PL Un CU Ste	dulatin epped:	ng: L	JN Im ST CI	egular: osed:	C IR											в	H-P-04	ł
Q-09-Ge-66A R.	Po Sli	lishe ckins	d: PC sided: K	Smooth: SM Very Rough: VR Rough: Ro Closed: C	Br Bt Ca Cl Epi Ch Iror Fr Clo	lcite: iclote: n: osed:	Gouge: Go Sand: Sa e: Ca Gravel: Gr Sericite: Se ste: Ep Hematite: He Silt: Si Fe Quartz: Qz Sulphide: Su ed: C																		

AN 108 I VAAN

Vertical Scale = 1 : 100

-17 15h	RE	ECO	ord C	F ROCK CORE DRILLIN		ND 1	TEST	ING	- BC	REF	IOLE	N°:						Bł	1-P-(04		l	Page	:	2 of11
2014-11	Fil	le n	•:	B-0010504-3	Projec	ct N	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed: 2014-10-10		
inted : 2	Nc	orth	ing:	6086397.562	Refer	enc	e Poi	nt:									Pre	ecisio	on GF	PS	Logge	ed by	/:		Al <u>ain Lemonde</u>
.sty- Pr	Ea	astir	ng:	658603.194	Datun	n:								NAD83 UTM ZONE 19					19	Drillin	ig Co	Downing			
e_Lake	Ele	eva	tion:	519.26	Azimu	ut:								135.00°					<u>0°</u>	Drille	rs:				
N_Joyc	Inc	clina	ation:	<u> </u>	Bit typ	be: _				Flush:						Fee	ed:			_	Drill F	{ig:		LF-/0	
LVM_A	_ ٤			ROCK TYPE			INTE	RVAL	REC. I		STRENG	TH DATA		(;	DI	sco		IUITY	(DA	ТА					
orage 504-3	& Core	otes	gth(m			٦ E	& Dep (m)	()	(%	er_1_r	ndex	(apul	Ê	hber (#	Orien	tation	De	Surface	on	Jr	Ja	Jn			ENTS PTH/ S
otec_80Log_H B-0010	Casing Diameter/	Water N	ELEV./ Len	DESCRIPTION		Deptl	ertval No. (from-to)	TCR (%	RQD (9	ractures p	Strength I	Veathering	Depth (ype & Num	(°) AHA (8ETA (°)	Shape	nghness	Infill				lt Breccia/ Gouge	oken Core	ES/COMM PRINT DEF IFILL TYPE THICKNES
Log_G€			_				<u>-</u>							F	۷	ш		Rc					Fau	Bre	
T VM\Log\							1.3	75	10		R5	W3													
Style			504.13 16.10	Highly weathered zone		16																			
~			503.76 16.50	Dark grey Iron Oxyde with	·		0.2	100			R0	<u>W6</u>													
				of red an white chert.	as	-17	1.3	100	77	21	R5	WЗ													
B.1						-18	0.5	51	0		R5	W3													
							0.3	100	0		R5	W3													
						-19	1.2	100	17		R5	WЗ													
			500.56 19.90 500.47 20.00	Highly weathered zone Dark grey Iron Oxyde with millimetric to centimetric be	 ' ds	20	1.2	90	0		R5	WЗ													
				of red an white chert.	uu	21																			
0						22	1.5	68	0	10	85	W2													
= 1 : 10			107 27			23	0.2	100	_60_	_18_	<u>H5</u>	<u>_w2</u>													Joints at 15 to 30°
al Scale			23.30	White Chert			1.3	100	54	22	R5	W2													Bedding N/A Joints at 15 to 30°
Vertic			24.00	Dark grey Iron Oxyde with		-24	0.5	100	0		R5	W3													
			496.05 24.70 495.77	 of red an white chert. 	/	-25	0.5	100	0		R0	W6													
			25.00	Dark grey Iron Oxyde with millimetric to centimetric be	/ ds	26	1.5	30	0		R0	W6													
			494.55 26.30 494.26	Highly weathered zone	·		0.5	100	0			W2													
			26.60	millimetric to centimetric be of red an white chert.	ds	27	1.0	70	60	11		w3													
						-28	1.0	100	50			W3													Bedding N/A Joints at 5 to 20° and 45 to 60°
						29	0.5	100	00																
			491.45				0.5	100	0		R0	W3 W6													
	Joi Wa	int R avy a	oughnes and Roug	s, Jr: jh 3.0	Jo	int Al Ifilled	teratio	n, Ja:			Filled	:				Joint Mass	Numb ive	er, Jn:			0.5				
	Wa Pla Pla	avy a anar anar/ anar/	and Smo and Rou Smooth/ Slickens	2.0 gh 1.5 Fill 1.0 ided 0.5	He Sta Sii	aled aining ghtly ty/sa	Fractu g only altere ndy co	ires d wall ating	0.7	5	Sand Stiff (Soft (Swell	/Crush Clay < Clay < I. Clay	ed Ro 5mm 5mm < 5mn 5mm	ck 4	4 6 8 2	One One Two Two	set plus ra sets sets pl sets pl	ndom us ran	dom		2 3 4 6				
6	Joi Fai Sh	pe: int: ult: ear	ĺ	JN Bedding: BD FLT Foliation: FO SHR Contact: CO		ane.	aung				Soft (Swel	Clay > Clay >	5mm > 5mn	ן 1 1 2	5 20	Three Four Crus	e sets or moi hed ro	plus ra e sets ck	ndom		12 15 20		F	IOLE	#:
4.03.200	Ve Co	in: njug	ate:	VN Orthogonal: OR CJ Cleavage: CL	Pla	anar: irved	P : C	L Un U Ste	dulatin pped:	g: l	JN Im St Ci	egular osed:	C IR											P	
09-Ge-66A R.1 0	Roughness: Polished: PO Smooth: SM Very Rough: VF Slickinsided: K Rough: Ro Closed: C						Rock:	Br Bt Ca Cl Epi Ch Iror Fr Clo	lcite: clote: 1:	Go Ca Gr Ep He Fe Qu C	ouge: avel: ematite iartz:	Go Gr : He Qz	Sand: Sericif Silt: Sulphi	Sa e: Se Si de: Su	1 1						BH				Π-٣-ህ4

-17 15h	RI	ECO	ord (OF ROCK CORE DRILLING	AND	TES	TING	- BC	REH	IOLE	E N°:						Bł	H-P-(04		I	Page	: _:	3 of	11
2014-11	Fi	le n	•	B-0010504-3 Pr	oject N	lame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed: 2014-	10-10
inted ::	No	orth	ing:	6086397.562 Re	eferenc	e Po	int:									Pr	ecisio	on GF	PS	Logge	ed by	/:		Al <u>ain Lem</u>	nonde
e.sty- Pi	Ea	astir	ng:	658603.194 Da	atum:				1							3 UT	MZC	ONE	19	Drillin	ig Co	ontrac	tor:	Dov	wning
e_Lake	El	eva	tion:	519.26 Az	zimut:										135.00°					Drille	rs:				
N_Joyc	In	clina	ation:	70° Bi	t type:					Flu	sh:				reed.					Drill F	Rig:				LF-70
LVM_A	Ē			ROCK TYPE		INTE	RVAL	REC. I		STRENG	TH DATA			DI	sco		IUITY	Y DA	ТА						
orage 504-3	& Core Depth	otes	gth(m)		Ē	g Depi			er_1_n	ndex	Index	Ê	ber (#	Orien	tation	D	Surface escription	e on	Jr	Ja	Jn			ENTS TH/	× ۵
.og_Geotec_80Log_F 	Casing Diameter/I	Water N	ELEV./ Lenç	DESCRIPTION	Depth	Inertval No. 8 (from-to)	TCR (%	RQD (%	Fractures pe	Strength I	Weathering	Depth (r	Type & Num	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMME /IMPRINT DEP INEILL TVDE	
4/Fog/F			491.07 30.00	Highly weathered zone	= 30	0.5	100			R0	_W6														
Y:\Style_LVA			490.88 30.20	millimetric to centimetric beds of red an white chert. Highly weathered zone	_/ _31	1.5	40	0		R0	W6														
3. <i>T</i> .			489.28 31.90 488.34	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.	32	1.5	67	0		R4	WЗ														
"			32.90 488.25 33.00	Highly weathered zone Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.	- 33 - 34	1.4	86	0		R4	W3														
			400.40		Ē	0.2	100			R4	_W2													N/A	
			34.90 486.28	Highly weathered zone		0.9	89	0		R3	W6														
			35.10	millimetric to centimetric beds	;	0.5	100	0		R5	W2														
					-37	1.5	27	0		R5	W2														
ale = 1 : 100					-38	1.0		0		R5	W2														
Vertical Sc					-39	0.5	30	0		R5	W2														
			481.25		-40	1.5	27	0		R5	W2														
			40.45 480.92 40.80	Highly weathered zone Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.	-41	1.5	75	0		R0	W6														
					42																				
					43	1.5	60	0		R5	W2														
					44	0.5	60	0		R5	W2														
						1.0	50	0		R5	W2														
	Jo Wa	int R avy a	oughne and Rou	ss, Jr: gh3.0	Joint A Unfilled	Iteratio	on, Ja:			Filled				\exists	Joint Mass	Numb	er, Jn:			0.5					
	Vi Pla Pla Pla Pla Jo Fa	avy a anar anar/ anar/ pe: int: ult:	and Smo and Roi Smooth Slickens	Soft 2.0 Jgh 1.5 /Fill 1.0 sided 0.5 JN Bedding: BD FLT Foliation: FO	Healed Stainin Slightly Silty/sa Clay co	Fractu g only altere indy co pating	ures ed wall pating	0.75 1 2 3 4	5	Sand Stiff (Soft (Swell Stiff (Soft (Swell	/Crush Clay < Clay < . Clay Clay > Clay > . Clay	ed Ro 5mm 5mm 5mm 5mm 5mm > 5mn	ck n 1 1 n 2	4 6 8 12 10 15 20	One s One s Two s Two s Three Three Four	set plus ra sets sets pl e sets e sets or mol	ndom us ran plus ra re sets	dom Indom		2 3 4 6 9 12 15 20			IOLE	#:	1
03.2005	Sh Ve Co	iear: ein: eniua	ate:	SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CI	Shape Planar Curveo	F : (PL Un CU St∉	dulatin	g: L	JN Im ST CI	egular osed:	: IR C			Unual		~			20					
Q-09-Ge-66A R.1 04.	Ro Po Sii	lishe	ness: id: Pi sided: K	O Smooth: SM Very Rough: VR Rough: Ro Closed: C	Curved: CU Stepped: Infilling: Broken Rock: Br Broken Rock: Br Clay: Cl Clay: Cl Epiclote: Epiclote: Chlorite: Ch Fron: Fe Fresh: Fr Closed: C					SI [Closed: C Gouge: Go Sand: Sa Ca Gravel: Gr Sericite: Se Ep Hematite: He Silt: Si Fe Quartz: Qz Sulphide: Su C			1 9 9	J - - - -					BI			H-P-04	1		

Y:\Style_LVM\LogLog_Geotec_80Log_Forage_LVM_AN_Joyce_Lake.sty- Printed : 2014-11-17 15h

Vertical Scale = 1 : 100
-17 15h	R	ECO	ORD (OF ROCK CORE DRILLING	AND	TES	TING	- BC	DREF	IOLE	N°:						Bł	H-P-(04		I	Page	:	4 of1
2014-11-	Fil	le n	°:	B-0010504-3 Pr	oject I	Name	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed: 2014-10-10
inted : 2	No	orth	ing:	6086397.562 Re	feren	ce Po	int:									Pre	ecisio	on Gl	<u>PS</u>	Logg	ed by	<i>ı</i> :		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658603.194 Da	itum:									Ν	IAD8	3 UT	MZ	ONE	19	Drillin	ig Co	ontrac	ctor:	Downing
ce_Lake	Ele	eva	tion:	519.26 Az	imut:													135.0	0°	Drille	rs:			
N_Joya	Inc		ation:	/0° Bit	type:						sn:	1			Fee	20:					tig:			LF-70
TVM_	e (m)		Ê	ROCK TYPE		INTE E		REC.		STRENG	TH DATA		(#		SCO		Surface							
Forage 5504-3	g&Cor /Depti	Notes	ngth(n		(m)	% Det	(%	(%	er_1_	Index	g Inde	(E	nber (Orien	itation	De	escripti	on	Jr	Ja	Jn	,		IENTS PTH/ E & SS
80Log B-001	Casin	Vater	V./ Lei	DESCRIPTION	Dep	al No.	TCR (RQD (tures p	ength	therin	Depth	& Nui	(°) AI	۹ (°)	be	ness					reccia Ige	Core	COMIN DE LE TYP
Geotec	Dia	-	ELE			Inertv	-		Fract	Str	Wea		Type	ALPF	BET	She	Rougł					ault B Gou	Brokei	OTES/ IMPRI INFIL THIC
oglLog					Eas																	ш.	-	Ž
T VM/L																								
Y:\Style_					46	1.5	26	0																
			475.00			0.4	100	0	-	R5														
			475.09 474.81/	Grey Massive Iron Oxyde,	- - 47 / E	1.1	100	81	16	B5	W4													Bedding N/A
B.7			47.30 474.53 47.60	Dark grey Iron Oxyde with																				Joints at 30°
			474.06 48.10 473.87	, of red an white chert.	1	1.5	59	17		D 2	We													
			473.68	Grey Massive for Oxyde, fine grain. Deals arous lice Oxyde with	/i=49	1.5					**0													
			40.00	millimetric to centimetric beds																				
				Highly weathered zone		1.5	38	0		R3	W4													
			471.34 51.00	millimetric to centimetric beds	/ = 51		-			<u> </u>														
			471.15 <mark>51.20</mark>	Grey Massive Iron Oxyde,		1.5	72	20		R3	W4													
00			470.30 52.10	_ ∖ fine grain. \ Dark grey Iron Oxyde with	; 52	2																		
e = 1 : 1			469.74 52.70	 millimetric to centimetric beds of red an white chert. 	_;/ _	0.4	100	0		R0	W6													
cal Scal				Units Highly weathered zone Dark grey Iron Oxyde with	;' E	1.1	60	20		R3	W4													
Verti				millimetric to centimetric beds of red an white chert.	54	0.2	100	100		R3	W4													
			467 48		Ē	15	87	23	10	B5	W3													
			55.10 467.29	White Chert Band Dark grey Iron Oxyde with																				Bedding at 30° \Joints at 30°
			466.92 55.70	millimetric to centimetric beds		5																		Bedding at 40°
			466.64 56.00 466.36	White Chert Band	-', T	1.5	87	37	21	R5	W3													Joints at 45 to 50° and 80°
			56.30 465.79 56.90	ii millimetric to centimetric beds	1/ 57	·																		Dedding at 5 to 100
				White Chert >50%	-' 58	1.0	100	75	9	R5	W3													Joints at 25,40 and 60°
				millimetric to centimetric beds	Ē	0.4	100	0		R5	W3													
				or red an white chert.	-59	1.3	100	0		R5	W3													
	Joi	int R	oughne	ss, Jr:	Joint /	Alteratio	n, Ja:								Joint	l Numb	er, Jn:							
	Wa Wa Pla	avy a avy a anar	and Rou and Smo and Rou	gh 3.0 poth 2.0 Jah 1.5	Unfille Heale Staini	d: d Fract ng only	ures	0.7	5	Filled Sand Stiff (: /Crush Clav <	ned Ro 5mm	ck	4 6	Mass One s	ive set olus ra	Indom			0.5 2 3				/ M
	Pla Pla	anar/ anar/	Smooth Slickens	/Fill 1.0 sided 0.5	Slight Silty/s	y altere andy c	ed wall bating	2		Soft (Swel	Clay < . Clay	5mm < 5mn	n 1	8	Two : Two :	sets sets pl	us ran	dom		4				
	Ty Joi Fa	pe: int: ulf:		JN Bedding: BD		oating		4		Soft (Swel	Clay > Clay > . Clay	5mm 5mm > 5mn	1 1 1 2	15 20	Three	e sets e sets or moi	plus ra re sets	Indom		9 12 15		F	IOLE	#:
3.2009	Sh Ve	ear:	-1-	SHR Contact: CO VN Orthogonal: OR	Shape Plana		PL Un	dulatir	ng: l	JN Im	egular	: IR			Crus	hed ro	ck			20			_	
1.1 04.0	Ro	njug ughr	ate: ness: id: Di	CJ (Cleavage: CL		d: (g: p. Rock	CU Ste	epped:			OSEC:	C Sand	64										В	H-P-04
e-66A R	Sli	ckins	sided: K	Rough: Ro Closed: C	Biotite Clay:	II ROCK	Bt Ca CI Ep	lcite: iclote:	Ca Gr Ep He	avel: ematite	Gr Gr He	Sano: Sericit Silt:	e: Se Si	2 9										
EQ-09-G					Chlori Fresh	te:	Chiro Fr Clo	n: osed:	Fe Qu C	uartz:	Qz	Sulphi	de: Su	1										

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-17 15h	R	ECO	ORD (OF ROCK CORE DRILLING	G AND '	TES	TING	- BO	REH	IOLE	N°:						Bł	1-P-()4			Page	: _{	5 of <u>11</u>
2014-11	Fi	le n	°:	B-0010504-3 P	roject N	ame								Joy	ce L	ake	- Op	en P	Pit	Date	drille	ed & L	ogge	d: 2014-10-10
rinted :	No	orth	ing:	6086397.562 R	eferenc	e Po	int:									Pre	ecisio	on GF	<u>s</u>	Logge	ed by	/:		Al <u>ain Lemonde</u>
e.sty- F	Ea	astir	ng: 	658603.194 D	atum:									N	IAD8	3 UT	MZC	DNE ·	19	Drillin	ig Co	ontrac	ctor:	Downing
'ce_Lak	El	eva	tion:	519.26 A	zimut:					Flu	ch.				For	d.	1	35.0	0°	Drillei Drill F	rs: Ria:			I E_70
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TVM	h (m		Ê	ROCK TIPE		E E		REC. I	Ε.	STRENG			(#)		500		Surface		A					<i>(</i> 0
Forage 0504-3	g&Co r/Dept	Notes	ngth(n	DECODIDITION	th (m)	8 De (m)	(%)	(%)	per_1_	Index	g Inde	(m)	mber (Orien	tation	De	escriptio	on	Jr	Ja	Jn	/		AENTS EPTH/ PE & SS
Log_Geotec_80Log_ B-001	Casin Diameter	Water	ELEV./ Lei	DESCRIPTION	Dep	Inertval No. (from-to	TCR (RQD (Fractures p	Strength	Weatherin	Depth	Type & Nu	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia Gouge	Broken Core	NOTES/COMA /IMPRINT DE INFILL TYP THICKNE%
Y:\Style_LVM\Log			462.78 60.10 462.64 60.25 462.31 60.60 461.66	White Chert Band Dark grey Iron Oxyde with millimetric to centimetric beda of red an white chert.	60 S / _ 61	1.6	100	88	12	R5	W3													Beddings at 5 and 10° Joints at 45,60 and 75°
			61.30	2 White Chert Bands Dark grey Iron Oxyde with		0.5	100	0		R5	W3													
B.T.				millimetric to centimetric beds of red an white chert.	S	1.0	100	50	17	R5	W3													Bedding at 1° Joints at 0
					63	1.0	100	80	11	R5	W3													Land 45° Bedding at 20° Joints at 5,20
					64	0.5	100	70	4	R5	W3													Bedding at 30°
					65																			Joints at 30°
			457.05		- 66	1.4	100	35		D5	W3													
			457.05 66.20	White Chert >50%		1.5	100	57	7	R5	W3													Bedding at 25° Joints at 25 and 30°
1:100						1.0	100	57	,	- 110														Bedding at 20°
Scale =					68	0.2	100 100	_6 70	_ <u>16</u> 6	R5 R5	W3 W3													And 50 to 75°
Vertical					-69	0.6	67	40		R5	W3													Joints at 15 to 20°
					-70	1.5	100	60	11	R5	W3													Bedding at 20° Joints at 20,30 and 45°
			453.01 70.50	Dark grey Iron Oxyde with millimetric to centimetric bed of red an white chert.	s -71	1.2	100	15	10	R5	W3													Bedding N/A Joints at 20,30 and 45°
					-72	1.8	85	56	6	R5	W3													Bedding at 20° Joints at 20 and 50°
			450.19 73.50 449.72 74.00	White Chert Band Dark grey Iron Oxyde with	- 74	1.1	100	82	10	R5	W3													Bedding at 20° Joints at 30 and 50°
	Joi Wa	int R	oughnes	ss, Jr:	Joint A	Iteratio	n, Ja:			Filled					Joint Mass	Numb ive	er, Jn:			0.5				
	Wa Pla Pla Pla Fa Jo Fa	avy a anar anar/ anar/ pe: int: ult:	and Smc and Rou Smooth Slickens	Ji 5.5 oth 2.0 igh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD FLT Foliation: FO	Healed Stainin Slightly Silty/sa Clay co	g only altere ndy co pating	ires d wall pating	0.78 1 2 3 4	5	Sand Stiff C Soft C Swell Stiff C Soft C Swell	Clay < Clay < . Clay Clay > Clay > . Clay	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm	ck 1 1 1 1 1	4 6 8 2 0 5 20	One One Two Two Three Four	set plus ra sets sets pl sets sets sets or mor	ndom us ran plus ra e sets	dom ndom		2 3 4 6 9 12 15			HOLE	#:
04.03.2009	Sh Ve Co	ear: in: injug	ate:	SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL	Shape: Planar: Curved	F I: C	PL Uno CU Ste	dulatin pped:	g: L S	JN m ST C	egular: osed:	IR C			Crus	ned roo	CK			20			R	H-P-04
:Q-09-Ge-66A R.1 (Po	lishe ckins	iess: id: P(sided: K	D Smooth: SM Very Rough: VR Rough: Ro Closed: C	Broken Biotite: Clay: Chlorite Fresh:	Rock: e:	Br Bt Cal Cl Epi Chlror Fr Clo	lcite: clote: n: ised:	Go Ca Gri Ep He Fe Qu C	ouge: avel: matite iartz:	Go Gr He Qz	Sand: Sericit Silt: Sulphi	Sa e: Se Si de: Su											···· 207

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	REC	OF	rd o	F ROCK CORE DRILLING	AND	TES	ING	- BC	REF	IOLE	N°:						Bl	H-P-(04	_		Page	: _6	6 of11
	File	n°:	-	B-0010504-3 Pr	oject N	ame								Joy	ce L	ake	- Op	en F	<u>Pit</u>	Date	drille	ed & L	ogge	d: 2014-10-10
	Nort	hin	g: _	6086397.562 Re	eferenc	e Po	int:									Pr	ecisio	on GF	<u>PS</u>	Logg	ed by	/:		Al <u>ain Lemonde</u>
	East	ting): _	658603.194 Da	atum:									Ν	IAD8	3 UT	MZ	DNE	<u>19</u>	Drillir	ng Co	ontrac	ctor:	Downing
	Elev	atic	on:	519.26 Az	imut:										F			135.0	<u>0°</u>	Drille	rs:			
	Inclu	nati	ion:	<u></u>	t type: _					FIU	isn:				Fee	ea:				Drill F	Rig:			LF-/0
	(E			ROCK TYPE		INTE ع	RVAL	REC. I		STRENG	TH DATA		_	DI	sco	NTIN	ידוטו	/ DA	TA					
Core	epth	8	th(m)		Ē	Dept			E 	dex	ndex	-	er (#)	Orien	itation	D	Surface escripti	e on	Jr	Ja	Jn			R H S
B-001050 Casing&	Diameter/D Water No		ELEV./ Leng	DESCRIPTION	Depth	Inertval No. & (from-to)(r	TCR (%)	RQD (%)	Fractures per	Strength In	Weathering I	Depth (m	Type & Numb	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMMEI /IMPRINT DEP1 INFILL TYPE & THICKNESS
		7. 44 7.	4.60 18.97 4.80	millimetric to centimetric beds	// 75	1.5	100	20	14	DE	wa													
		44 7 44	18.78 5.00 18.03 5.80	Dark grey Iron Oxyde with millimetric to centimetric beds	-'; <u>-</u> 76	1.5	100	30	14	HO DO	W3													Bedding N/A Joints at 20,30 and 60°
		변4 7	47. <u>8</u> 4 6.00	White Chert Hematite and White Chert	_'i 	0.3	67	0		R3	VV4													Destation of 400
		44	15.96	>50% Dark grey Iron Oxyde with millimetric to centimetric beds	79	1.6	85	45	13	R3	W4													Joints at 20,30 and 60°
		74 44 71	8.00 45.59 8.40	of red an white chert. White Chert Grey Iron Oxyde with Quartz and white Chert.	79	1.5	100	18	11	R5	W2													Bedding at 25° Joints at 30 and 40°
					80	1.5	16	0		R5	W2													
					82	1.6	68	38	6	R5	W2													Bedding at 30° Joints at 10 and 30°
		44	41.17		-83	0.5	80	0		R5	W2													Joints at 15°
L		<mark>8</mark> 44	3.10 40.80	White Chert 30 to 50%		0.4	100	0		R5	W3													
		8	3.50	millimetric to centimetric beds of red an white chert.	84	0.4	100	50		R5	W3													Bedding at 80° Joints at 45
		43	38.92		85	1.6	100	80	22	R5	W3													and 50 to 60°
		8	5.50	White Chert 30 to 50%	86	1.6	100	50	17	R5	WЗ													Beddings at 5 to 20° Joints at 20
					87	0.5	100	0		R5	W3													10 00
		43 8	36.47 8.10	Dark grey Iron Oxyde with millimetric to centimetric beds		1.1	91	32		R5	WЗ	88.40 88.50	JN JN			PL PL	SM RO	FE FE						Bedding at 5°
				of red an white chert.	89	1.4	86	79	7	R5	W3	88.60	JN			PL	С	С						Joints at 5 to 20° and 35 to 50°
	Joint Wavy Plana Plana Plana Type: Joint: Fault:	Rou and and and an an an Sli	ghness d Roug d Smoo d Roug nooth/I ickensi	s, Jr: h 3.0 th 2.0 jh 1.5 iil 1.0 ded 0.5 N Bedding: BD LT Foliation: FO	Joint A Unfillec Healed Stainin Slightly Silty/sa Clay co	Iteratio I: Fractu g only altere indy co pating	n, Ja: ıres d wall bating	0.7 1 2 3 4	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: /Crush Clay < Clay > Clay > Clay > L Clay	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm 25mn	ck 1 1 1 1	4 6 8 2 0 5 20	Joint Mass One One Two Two Three Three Four	Numb sive set plus ra sets sets p e sets e sets or mol hed ro	er, Jn: andom lus ran plus ra re sets	dom Indom		0.5 2 3 4 6 9 12 15 20			IOLE	/M
	Shea Vein: Conju Roug Polist Slicki	r: Igate hnes ned: nside	e: (ss: PO ed: K	Contact: CO /N Orthogonal: OR CJ Cleavage: CL Smooth: SM Very Rough: VR Rough: Ro Closed: C	Shape: Planar: Curved Infilling Broken Biotite: Clay: Chlorite Fresh:	F I: C Rock:	PL Un CU Ste Br Bt Ca CI Epi Ch Iroi Fr Clc	dulatin pped: lcite: iclote: n: psed:	g: L Go Ca Gr Ep He Fe Qu C	JN Im ST CI ouge: avel: ematite iartz:	egular osed: Go Gr : He Qz	: IR C Sand: Sericil Silt: Sulphi	Sa e: Se Si de: Su)))		10010	<u>vn</u>			20			В	H-P-04

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Vertical Scale = 1 : 100

-17 15h	R	ECO	ORD C	OF ROCK CORE DRILLING	AND .	TES	TING	- BC	REF	IOLE	N°:						BI	I-P-(04		I	Page	:	7 of11
2014-11-	Fil	le n	•:	B-0010504-3 Pro	oject N	ame	:							Joy	ce L	.ake	- Op	en F	Pit	Date	drille	d & L	ogge	ed: 2014-10-10
inted ::	No	orth	ing:	6086397.562 Re	ferenc	e Po	int:									Pr	ecisio	on Gl	<u>PS</u>	Logg	ed by	<i>'</i> :		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658603.194 Da	tum:									Ν	IAD8	33 UT	MZ	ONE	19	Drillir	ig Co	ontrac	ctor:	Downing
e_Lake	El	eva	tion:	519.26 Azi	mut:										_			135.0	0°	Drille	rs:			
N_Joyc	Ind	clin	ation:	<u>70°</u> Bit	type:						isn:				Fee	ed:			_	Drill F	Rig:	T		LF-70
LVM_A	ູ່ຍ			ROCK TYPE	—	INTE ₽	RVAL	REC.		STRENG	TH DAT/		ŧ)	DI	SCO			(DA	TA					
orage_504-3	& Core	otes	gth(m		E E	& Dep	()	(9	er_1_r	ndex	Inde	Ê	iber (#	Orien	ntation	D	Surface escripti	e on	Jr	Ja	Jn			ENTS PTH/ S
Log_Geotec_80Log_F B-0010	Casing Diameter/	Water N	ELEV./ Len	DESCRIPTION	Dept	Inertval No. 8 (from-to)	TCR (%	RQD (%	Fractures pe	Strength I	Weathering	Depth (Type & Num	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMMI /IMPRINT DEF INFILL TYPE THICKNES:
.VM\Log					-90							_												° and 35 to 50°
Style_L					Ē																			Bedding at 0 to 20° Joints at 20
``			100.10		-9 1	1.5	100	13	12	H5	W3													
			433.18 91.60	White Chert 30 to 50%		0.5	100	25	8	R5	W3	-												Bedding at 0 to 20° Joints at 10 to 45°
B.T.						0.5	100	0		R5	W3													
					93	0.4	100	100	-	R5	W3													
					Ē	1.3	92	92		R5	WЗ													
					-94	0.2	100	0	-	B5	W3													Bedding at 20 to
					-95																			35° Joints at 20,35 and 45°
					Ē	1.5	100	80	11	R5	W3													
					<mark>-96</mark>	0.5	100	100		R5	W3	-												
_					97																			
= 1 : 10						1.5	100	67		R5	W3													Bedding at 30 to
al Scale					-98	0.6	100	100	10		W/2	97.80 97.85 98.00	BD JN BD	41 41 9	70 70 265	PL PL UN	C RO C	QZ QZ QZ						Joints at 20,40 and 50°
Vertica					Ē	0.6	100	100	20	R5	W3 W3													Bedding at 30°
					-99																			Joints at 30°
					-100	1.5	100	60	8	R5	WЗ													Bedding at 15 to 40° Joints at 30 and 45°
			423 98		101	1.5	100	53		R5	W3													
			101.40	Dark grey Iron Oxyde with millimetric to centimetric beds	- +						-													
				of red an white chert.	-102	1.5	100	0		R5	W3													
					-104	1.2	100	0		R5	WЗ	-												
	Jo	int R	oughnes	ss, Jr:	L Joint A	Iteratio	l n, Ja:								Joint	l Numb	er, Jn:				L			
	Wa Wa Pla	avy a avy a anar	and Roug and Smo and Rou	gh 3.0 oth 2.0 igh 1.5	Unfilled Healed Stainin	l: Fractu g only	ires	0.7	5	Sand Stiff (: /Crusł Clay <	ned Ro 5mm	ck	4 6	Mass One One	sive set plus ra	Indom			0.5 2 3				/M
	Pla	anar/ anar/	Smooth/ Slickens	1.0 sided 0.5	Slightly Silty/sa	altere ndy co ating	d wall bating	234		Soft Swel	Clay < I. Clay Clay >	5mm < 5mm	1	8 12 10	Two Two Thre	sets sets p e sets	us ran	dom		4 6 9				
	Joi Fa	pe: int: ult:		JN Bedding: BD FLT Foliation: FO		Jating				Soft Swel	Clay > I. Clay	5mm > 5mn	1 1	15 20	Thre Four	e sets or mo	plus ra re sets	Indom		12 15		ŀ	IOLE	#:
3.2009	Sh Ve	ear: in:	-1	SHR Contact: CO VN Orthogonal: OR	Shape: Planar:	F	PL Un	dulatin	ig: l	JN Irr	egular	: IR			Crus	hed ro	ck			20				
3.1 04.0	Ropo	ugh: lishe	ness:	CJ Cleavage: CL	Infilling	. (Rock:	JU ISTE	shbea;	<u>ارد</u>		Go	Sand	ç,										В	H-P-04
EQ-09-Ge-66A F	Sli	ckins	sided: K	Rough: Ro Closed: C	Biotite: Clay: Chlorite Fresh:):	Bt Ca CI Ep Chiro Fr Ck	lcite: iclote: n: osed:	Ca Gr Ep He Fe Qu C	avel: matite uartz:	Gr : He Qz	Sericit Silt: Sulph	e: Se Si de: Si	1										

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-17 15h	R	ECC	ORD C	OF ROCK CORE DRILLI	NG AN	DT	EST	ING	- BC	REF	IOLE	N°:						B	1-P-(04		l	Page	:	8 of <u>11</u>
2014-11	Fi	le n	•	B-0010504-3	Project	t Na	ame:								Joy	ce L	ake	- Op	en F	Pit	Date	drille	d & L	logge	ed: 2014-10-10
rinted :.	No	orthi	ing:	6086397.562	Refere	nce	e Poi	nt:									Pre	ecisio	on Gl	PS	Logg	ed by	/:		Al <u>ain Lemonde</u>
e.sty- F	Ea	astir	ng: 	658603.194	Datum	:									Ν	JAD8	3 UT	M ZC		<u>19</u>	Drillin	ng Co	ontrac	tor:	Downing
'ce_Lak	El	eva	tion:	519.26	Azimut Bit type	:: 					Flu	ch.				For	d.		135.0	<u>00°</u>	Drille	rs: ⊇ia:			I E-70
AN_JO					Dirtyp	יי <u>-</u> ר	INTER				PTOENO	ти пата				500			/ ¬^	т.		ug.	T		
WA1_e	th (m)		Ê	HOCKTIFE		_	pth			ε		ă e		(#)	Orion	totion		Surface			Τ.				S
Log_Geotec_80Log_Forage B-0010504-3	Casing&Co Diameter/Dept	Water Notes	ELEV./ Length(r	DESCRIPTION		Depth (m)	Inertval No. & De (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1	Strength Index	Weathering Ind	Depth (m)	Type & Number	ALPHA (°)	BETA (°)	Shape	scripti	III	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENT: /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
/le_L VM\Log\						105	1.2	96	3	11	R5	W3													Bedding at 30 to 35°
Y:ISt						106																			Joints at 30 \and 35°
B.T.						107	2.1	71	0		R5	W3													
			417.77 108.00	White Chert > 50%		108																			
			416.08			109	1.5	100	13	8	R4	W3													Bedding at 0 to 20° Joints at 0 to 20°
			109.80 415.10	Dark grey Iron Oxyde wit millimetric to centimetric b of red an white chert.	ih – – – – – peds –	110	1.5	100	0	15	R4	W4													Bedding at 20° Joints at 20 and 40°
1:100			110.85 414.95 111.00	Limonite band White Chert > 50%	'	111	1.5	50	0		R4	W3													
Vertical Scale =						113	1.5	0	0																
						114	1.5	13	0																
			410.07 116.20	Completely weathered		116	1.5	100	30	12	R3	W5													
						117	1.5	100	0		R0	W5													Joints at 30 and 60°
						119	1.5	100	23	11	R0	W5													
ае-66А R.1 04.03.2009	Joi Wa Pla Pla Pla Pla Fa Sh Co Ro Po Sii	int Re avy a anar a anar/: pe: int: ult: ear: in: njugar lishe ckins	ate: dided: K	is, Jr: gh 3.0 oth 2.0 igh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD FLT Foliation: FO SHR Contact: CO VN Orthogonal: OR CJ Cleavage: CL Smooth: SM Very Rough: 1 Rough: Ro Closed: 0	Claver Cl	it Alt illed: iled ining htly //sar y cor ing: ing: ing: iing: ite: y:	P C Rock:	n, Ja: res d wall ating L Und Cl Ste Br Bt Cal Cl Epi Cl Epi	0.7 1 2 3 4 dulatin pped: cite: clote:	g: L Gc Ca Gr Ep He	Filled Sand Stiff (Soft (Swell Stiff (Swell ST CI Duge: avel: matter	: /Crush Clay < Clay > Clay > Clay > Clay > Clay > Clay = Clay = Clay = Clay = Clay =	ed Ro 5mm 5mm 5mm 5mm 5mm 5mm 25mn 25mn 25mn	ck n 1 n 1 n 2 se: Se si de: Se	4 6 8 12 10 15 20	Joint Mass One Two Two Three Three Four Crus	Numb sive set plus ra sets sets pl e sets e sets or mol hed ro	er, Jn: ndom us ran plus ra e sets ck	dom		0.5 2 3 4 6 9 12 15 20			iole	/ M #: H-P-04

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-17 15h	R	ECO	ORD C	OF ROCK CORE DRILLI	NG AN	ID 1	TEST	ING	- BC	REF	IOLE	N°:						B	H-P-	04		l	Page	:	9 of11
2014-11	Fil	le n	•:	B-0010504-3	Projec	t N	ame	:							Joy	ce L	ake	- Op	en I	Pit	Date	drille	ed & L	logge	ed: 2014-10-10
inted : 2	No	orth	ing:	6086397.562	Refere	ence	e Po	int:									Pre	ecisio	on Gl	PS	Logg	ed by	/ :		Al <u>ain Lemonde</u>
e.sty- Pi	Ea	astir	ng:	658603.194	Datum	1:									Ν	IAD8	3 UT	MZ	ONE	19	Drillir	ig Co	ontrac	ctor:	Downing
ce_Lake	El	eva	tion:	519.26	Azimu	t:						ah.							135.0	<u>0°</u>	Drille	rs:			
N_Joy	Inc		ation:	<u>70°</u>	ыстур	e						sn.				ree						ng.		1	LF-70
-TVM_	e u		Ê	ROCK TYPE			INTE		REC. I	ДАТА Е.	STRENG	TH DATA		(SCO		Surface							
Forage 504-3	g&Cor /Depti	Votes	ngth(m			(m) H	& Der (m)	(%	(%	er_1_	Index	g Inde	E)	nber (Orien	itation	De	escripti	on	Jr	Ja	Jn			IENTS PTH/ SS
Geotec_80Log_ B-001	Casin Diameter	Water	ELEV./ Lei	DESCRIPTION		Depi	Inertval No. (from-to	TCR (RQD (Fractures p	Strength	Weatherin	Depth	Type & Nu	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				ault Breccia Gouge	Broken Core	DTES/COMA IMPRINT DE INFILL TYP THICKNES
VM\Tog\Tog_			406.68																					-	Ž Bedding at 50° Joints at 40 to 50° and 80°
Style_L			406.12	vein]"/b" well crystalized.		-120																			Joints at 15 to 60°
Y::K			405.09	Completely weathered reddish Iron Oxyde		-121	1.5	100	33	6	R5	W5													
B.T.			121.50	Dark grey Massive Iron Oxyde with red Chert veinl	ets.	-122	1.5	100	32	2	R6	W4													Bedding N/A Joints at 50 to 60°
						-123	1.1	100	100		R6	W2													
						124	0.4	100	50		R6	W2													
						-125	1.3	83	83		R6	W2													Bedding N/A
00						-126	1.3	100	58	3	R6	W2													Joints at 40 to 55°
e = 1 : 1						121	0.3	100	100		R6	W2													
Vertical Scal						-128	1.3	100	0		R6	W2													
						-129	1.1	82	45	5	R6	W2													Bedding N/A Joints at 5,20
						130	0.3 0.4	100 100	0 80	12	R6 R6	W2 W2													And 60° Bedding at 20° Joints at 30
						121	0.1	100/			R6_/	<u>W2</u>													to 60°
						-132	1.4	100	100	2	R6	W2													Bedding N/A Joints at 30 to 60°
							0.8	0	0			**2													Loss of water
			394.28 133.00	Dark grey Massive Iron		-133	0.4	100	50		R2	W2													
				Chert veinlets concentratio	n	-134	1.6	100	59	12	R6	W4													Joints at 30,60 and 130°
	Jo	int R	oughnes	ss, Jr:		nt Al	teratio	n, Ja:			Filled					Joint	Numb	er, Jn:		·	0.5				
	Via Pla Pla Pla Ty	avy a anar anar/ anar/ pe:	and Smo and Rou Smooth/ Slickens	oth 2.0 igh 1.5 Fill 1.0 ided 0.5	Hea Sta Slig Cla	aled iining ghtly y/sa iy co	Fractu g only altere ndy co ating	ures d wall bating	0.7 1 2 3 4	5	Sand Stiff (Soft (Swell Stiff (Clay < Clay < . Clay < . Clay >	ed Ro 5mm 5mm 5mm 5mm 5mm	n r	4 6 8 12 10	One One Two Two Three	set plus ra sets sets pl e sets	indom lus ran	dom		2 3 4 6 9				M
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Q-09-Ge-66A R.1	Po	lishe	ed: PC sided: K) Smooth: SM Very Rough: V Rough: Ro Closed: C	R Bro Bio Cla Chl Fre	oken itite: iy: lorite ish:	Rock:	Br Bt Ca Cl Epi Ch Iroi Fr Clo	lcite: iclote: n: ised:	Go Ca Gr Ep He Fe Qu C	ouge: avel: ematite iartz:	Go Gr : He Qz	Sand: Sericii Silt: Sulphi	Sa te: Se Si ide: Si	1 9 9										

-17 15h	RI	ECO	ORD C	OF ROCK CORE DRILLING	AND 1	TEST	ING	- BO	REF	IOLE	N°:						Bł	1-P-(04		I	Page	: _1	0 of11
2014-11	Fi	le n	ı°:	B-0010504-3 Pro	oject N	ame								Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & L	ogge	ed: 2014-10-10
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e_Lake	E	eva	ition:	519.26 Azi	imut:										_			135.0	0°	Drille	rs:			
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LVM_A	ູີຍ			ROCK TYPE		INTE ₽	RVAL	REC. I		STRENG	TH DATA		ŧ	DI	sco			/ DA	TA 					
Forage504-3	J&Cor	lotes	gth(m		(m)	& Dep (m)	(%	(%	er_1_r	ndex	g Inde	Ê	ther (#	Orien	tation	De	scripti	e on	Jr	Ja	Jn			ENTS PTH/ S
og_Geotec_80Log_ B-0010	Casing Diameter/	Water N	ELEV./ Len	DESCRIPTION	Dept	Inertval No. (from-to	TCR (9	ROD (°	Fractures p	Strength	Weathering	Depth (Type & Nun	ALPHA (°)	BETA (°)	Shape	Roughness	Infill				Fault Breccia/ Gouge	Broken Core	NOTES/COMM /IMPRINT DEI INFILL TYPE THICKNES
1/Fog/F				and more alteration.	Ē																			Joints at 15,30,45
vle_LVN					135																			and 60°
Y:\St					-136	1.5	100	0		R6	W4													
B.T.					-137	1.5	100	31		R6	W4													
					-138	0.6	100	100	5	R5	W3													Joints at 30°
			388.64 139.00	Highly weathered zones, 5 to	139	1.0	100	35	9	R4	W4													Bedding at 35° Joints at 30°
			139.60	Alternance of slightly altered massive Iron Oxyde with extremely weathered Iron	[-140	1.0	50	10		R5	W4													
				Oxyde.	-141	0.4	100	0	4	R4 R5	W4 W4													Poddingo at 25, 1
ale = 1 : 100					-142																			to 5° and 25 to 30°
ertical Se					-143	1.2	100	50		R4	W4													
>			384.23 143.70	Massive Iron Oxyde with		0.3	100	100		R5	W3													
				white Chert.	-145	1.3	100	92	3	R5	W3													Bedding at 20 to 30° Joints at 20 to 35°
			382 30			0.5	100	60		R5	W3													
			145.75 882.16 145.90	Highly weathered zone Massive Iron Oxyde with white Chert.		1.5	100	65	6	R5	W6													Bedding at 20 to 30° Joints at 30°
					-147	1.5	16	0		R5	W3													
	Jo	int R	oughnes	ss, Jr:	Joint Al	teratio	n, Ja:								Joint	Numb	er, Jn:							
	Wa Wa Pla	avy a avy a anar	and Roug and Smo and Rou	an 3.0 oth 2.0 ah 1.5	Healed	: Fractu a only	ires	0.78	5	Sand Stiff (: /Crush Clav <	ed Ro 5mm	ck	4 6	Mass One s One	sive set plus ra	ndom			0.5 2 3				/ M
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-17 15h	R	ECO	ORD O	F ROCK CORE DRILLING	AND	TEST	ring	- BC	DREF	IOLE	N°:						BI	1-P-(04			Page	: _1	1 of1
2014-11	Fil	le n	۱°:	B-0010504-3 Pro	oject N	lame	:							Joy	ce L	ake	- Op	en F	Pit	Date	drille	ed & l	_ogge	ed: 2014-10-10
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e.sty- P	Ea	astir	ng:	658603.194 Da	tum:									Ν	IAD8	3 UT	M Z	ONE	19	Drillir	ng Co	ontra	ctor:	Downing
ce_Lak	Ele	eva	ation:	519.26 Az	mut:					Flu	ch.				Foo	d.		135.0	<u>00°</u>	Drille	rs: Rig:			I E_70
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Forage 0504-3	g&Col r/Dept	Notes	ngth(n	DECODIDITION	th (m)	8 De	(%)	(%)	per_1_	Index	ig Inde	(E	mber (Orien	tation	De	escripti	on I	Jr	Ja	Jn	7		AENTS EPTH/ PE & SS
og_Geotec_80Log	Casin Diametei	Water	ELEV./ Lei	DESCRIPTION	Dep	Inertval No. (from-to	TCR (RQD (Fractures	Strength	Weatherin	Depth	Type & Nu	(°) AHPLA (BETA (°)	Shape	Roughness	Infill				Fault Breccia Gouge	Broken Core	NOTES/COMM /IMPRINT DE INFILL TYP THICKNES
T VM\LogV						1.5	100	80	7	R5	W3													Bedding at 25° Joints at 25 and 70°
Y:\Style			378.02 150.30 376.90	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.		1.5	100	70	20	R5	W3													Bedding at 20° Joints at 20°
B.T.			151.50	N/A	-15:	2 1.5	0	0																
			374.08 154.50	Dark grey Iron Oxyde with millimetric to centimetric beds		1.5																		
			372.67	of red an white chert. Presence of a few centimetric Massive Iron Oxyde bands.	-15	1.5	87	55	14	R5	W4													Bedding at 20° Joints at 30 and 60°
: 100			156.00 371.73	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.		1.5	100	20	7	R5	W6													Bedding N/A
cale = .			157.00 871.45 157.30	Highly weathered zone Dark grey Iron Oxyde with																				\Joints at 40°
Vertical S			371_16 157.60	 millimetric to centimetric beds of red an white chert. Grey Massive Iron Oxyde, no alteration. 	/ 15	1.5	100	33	5	R6	W2													Bedding N/A Joints at 35 and 45°
			159.10 368.91	Highly weathered zone		1.0	100	0		R0	W6													
			160.00	End of borehole at a length of 160.0m.	16	1																		
					-16:	3																		
6	Joi Wa Pla Pla Pla Pla Joi Fai Soi	int R avy a avy a anar anar/ anar/ pe: int: ult:	Roughnes and Roug and Smoo and Rou /Smooth/ /Slickensi	s, Jr: jh 3.0 oth 2.0 gh 1.5 Fill 1.0 ided 0.5 JN Bedding: BD FLT Foliation: FO SUB Contact: CO	Joint A Unfilled Healed Stainin Slightly Silty/sa Clay co	Iteratio J: I Fractu g only altere andy co pating	n, Ja: ures d wall pating	0.7	5	Filled Sand Stiff (Soft (Swell Stiff (Soft (Swell	: /Crush Clay < Clay < Clay > Clay > . Clay	ed Ro 5mm 5mm 5mm 5mm 25mm > 5mn	ck n 1 1 1 1	4 6 8 2 0 5 20	Joint Mass One One Two Two Three Three Four Crusi	Numb set plus ra sets sets pl e sets e sets or mon hed ro	er, Jn: Indom us ran plus ra re sets ck	dom Indom		0.5 2 3 4 6 9 12 15 20		ŀ	HOLE	/M
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CORE PHOTO	GRAPHY - BORFHOLE Nº.	BH-P	-04		Page:	2 of 16
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	<u>519.26</u>	Azimut: Bit type:	Flush:	135.00° Feed	Drillers:	L E-20
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CORE PHOTOC File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N°: B-0010504-3 6086397.562 658603.194 519.26 70°	BH-P-04 Project Name: Reference Point: Datum: Azimut: Bit type:Flu	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 135.00° sh: Feed:	Page:3of16Date drilled & Logged:2014-10-10Logged by:Alain LemondeDrilling Contractor:DowningDrillers:Drill Rig:LF-70
– 21– 22– 23– 23– 24– 24– 25– 26– 26–				
- 28- - 29-		Project : JOYCE Borehole : BH	ELAKE Box from to 0.9 19.80 22.70 10 22.70 24.50 11 24.50 27.00 12 27.00 29.50	HOLE #: BH-P-04



CORE PHOTOGRAPHY - BOREHOLE N°: File n°: B-0010504-3 Northing: 6086397.562 Easting: 658603.194 Elevation: 519.26 Inclination: 70°	BH-P-04 Project Name: Reference Point: Datum: Azimut: Bit type:Flush:	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 135.00° Feed:	Page: _ Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	<u>5</u> of <u>16</u> <u>2014-10-10</u> <u>Alain Lemonde</u> <u>Downing</u> <u>LF-70</u>
	erehole : BH-P-	$KE = \begin{array}{c} Box & from & to \\ 17 & 39.00 & 43.50 \\ 18 & 43.50 & 46.90 \\ 19 & 46.90 & 49.50 \\ 20 & 49.50 & 52.90 \end{array}$		HOLE #: BH-P-04

CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	DGRAPHY - BOREHOLE N°: B-0010504-3 6086397.562 658603.194 519.26 70°	BH Project Name: Reference Point: Datum: Azimut: Bit type:	- P-04	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 135.00° Feed:	Page: Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	6 of <u>16</u> 2014-10-10 <u>Alain Lemonde</u> Downing <u>LF-70</u>
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Length 25				JEAZ		
60		30 P	Project : JOYCE LAKE Borehole : BH-P-04	Box from to 21 52.90 55.70 22 55.70 58.20 23 58.20 59.90 24 59.90 62.00	BH-04_52.9-62.JP Type : Image JPE0 Taille : 7,02 Mo Dispatcher J 4906 N	G 1
02	£					HOLE #: BH-P-04

CORF PHOTO	GRAPHY - BORFHOLF N°:	BH-P-04	4		Page: 8	of 16
File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:		135.00°	Drillers:	
Inclination:	<u>70 °</u>	Bit type:	Flush:	Feed:	Drill Rig:	LF-70_
71- 72- 73- 74- (u) 410 75- 76- 76- 78- 78- 79-			ict : JOYCE LAKE arehole : BH-P-04	Box from to 29 70.30 72.80 30 72.80 74.80 31 74.80 77.00 32 77.00 79.50		DLE #: BH-P-04

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Vertical Scale = 1 : 0

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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	DGRAPHY - BOREHOLE N°: B-0010504-3 6086397.562 658603.194 519.26 70°	BH-P Project Name: Reference Point: Datum: Azimut: Bit type:	-04	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 135.00° Feed:	Page: Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	9 of <u>16</u> 2014-10-10 <u>Alain Lemonde</u> Downing <u>LF-70</u>
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CORF PHOTOGRAPHY - BOREHO	F Nº. BH-P-()4		Page: 10	of 16
File n°: B-0010504-3	Project Name:	Jo	yce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing: 6086397.562	Reference Point:		Precision GPS	Logged by:	Alain Lemonde
Easting: 658603.194	Datum:		NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation: 519.26	Azimut:		<u>135.00°</u>	Drillers:	
Inclination: <u>70</u>	Bit type:	Flush:	Feed:	Drill Rig:	LF-70_
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Vertical Scale = 1 : 0

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	BH-P-04		Page: 11	of 16
File n ^{on} B-0010504-3	Project Name:		Date drilled & Logged:	2014-10-10
Northing: 6086397.562	Beference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting: 658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation: 519.26	Azimut:	135.00°	Drillers:	
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CORE PHOTO File n°: Northing: Easting: Elevation: Inclination:	GRAPHY - BOREHOLE N°: B-0010504-3 6086397.562 658603.194 519.26 70°	BH-P-04 Project Name: Reference Point: Datum: Azimut: Bit type:	J	loyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 135.00° Feed:	Page: <u>12</u> Date drilled & Logged: Logged by: Drilling Contractor: Drillers: Drill Rig:	_ of <u>16</u> <u>2014-10-10</u> <u>Alain Lemonde</u> <u>Downing</u> <u>LF-70</u>
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ິພູ 113- + tibu- 114- 115- 116-						
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Vertical Scale = 1 : 0

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		BH-P-04		Page: 14 of 16
File n°: Northing: Easting: Elevation: Inclination:	B-0010504-3 6086397.562 658603.194 519.26 70°	Project Name: Reference Point: Datum: Azimut: Bit type: Flush:	Joyce Lake - Open Pit Precision GPS NAD83 UTM ZONE 19 135.00° Feed:	Date drilled & Logged: 2014-10-10 Logged by: Alain Lemonde Drilling Contractor: Downing Drillers:
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BH-P-04

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File n°:	B-0010504-3	Project Name:		Joyce Lake - Open Pit	Date drilled & Logged:	<u>2014-10-10</u>
Northing: Easting:	<u>6086397.562</u> 658603.194	Reference Point: Datum:		NAD83 UTM ZONE 19	Logged by: Drilling Contractor:	<u>Alain Lemonde</u> Downing
Elevation:	519.26	Azimut:	Fluch	135.00°	Drillers:	
Inclination:	/U*	Bit type:			Drill Kig:	<u>LF-/U</u>
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	-	and the state of	Project : JOYCE LAKE	Box from to	and the second s	
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HOLE #:

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(L) 154 41 L L E L E L E L E L E L E L E L E L E	-				
157	-	Project : JOYCE LAKE	Box from to 61 148.90 151.25		
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Vertical Scale = 1 : 0

B.T.



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-04

Run							Disco	ontinuity			
Dept	th (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
Casing	1,50										
1,50	3,00	26	13								
3,00	4,10	73									
4,10	4,50	100	10								
4,50	5,70	17									
5,70	6,50	27	10								
6,50	7,20	71	50								
7.20	7.90	100	31								
7.90	8.30	100									
8.30	9.00	14									
9.00	10.30	100	38								
10.30	10.50	100	00								
10,50	12.00	100	0								
10,50	12,00	100	0								
12,00	13,20	100	21								
13,20	14,00	100	50								
14,00	14,40	100									
14,40	15,00	100	10								
15,00	16,30	100									
16,30	16,50	100									
16,50	17,80	100	77								
17,80	18,30	51									
18,30	18,60	100									
18,60	19,80	100	17								
Ту	vpe						Roughnes	s		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA
Shear	SHR					Smooth:		5M			51
Vein:	VN					Rought:	b	KU VD	Clay:		
Beading:	BD BD					very roug	nt:	١٧n	Biotite		BT
Contraction:						I	Shana		Calaita		
Contact:						Dianar	Shape	DI	Chlorit		
						Curved:			Iron		FF
						Undulatin	a.		Hémati	te:	HF
						Stepped	3	ST	Quartz		QZ
						Irregular		IR	Limoni	te:	LI
								I			



F

DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-04

	Run	l				Discontinuity					
Dept	th (m)			Dept	th (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
19,80	21,00	90									
21,00	22,50	68									
22,50	22,70	100	60								
22,70	24,00	100	54								
24,00	24,50	100									
24,50	25,00	100									
25,00	26,50	100	33								
26,50	27,00	100									
27,00	28,00	70	60								
28,00	29,00	100	50								
29,00	29,50	100	80								
29,50	30,00	100									
30,00	31,50	40									
31,50	33,00	67									
33,00	34,40	88									
34,40	34,60	100									
34,60	35,50	90	89								
35,50	36,00	100									
36,00	37,50	27									
37,50	38,50										
38,50	39,00	30									
39,00	40,50	2									
40,50	42,00	75									
Ту	/pe						Roughnes	s		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	K	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		KO	Clay:		
Bedding:	RD RD					very roug	int:	VK	Gouge:		GU DT
Contact:							Shane		Caloito		
Contact:		1				Planar	Shape	PI	Chlorit		СН
						Curved			Iron		FE
						Undulatin	ia:	UN	Hémati	te:	HE
						Stepped:	3.	ST	Quartz		QZ
						Irregular:		IR	Limoni	te:	LI
											•



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°:

B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-04

Discontinuity Run Depth (m) Depth (m) Type & RQD (%) TCR (%) α angle β angle Shape Roughness Infill number from to from to 42,00 43,50 60 43,50 44,00 60 44,00 45,00 50 45,00 46,50 26 46,50 46,90 100 46.90 48.00 100 81 48,00 49,50 58 17 38 49,50 51,00 72 51,00 52,50 20 52,50 52,90 100 52,90 54,00 60 20 54,00 54,20 100 100 55,70 87 54,20 23 55,70 57,20 87 37 75 57,20 58,20 100 58,20 58,60 100 58,60 59,90 100 61,50 100 59,90 88 62.00 100 61,50 62,00 63,00 100 50 63,00 64,00 100 80 64,00 64,50 100 70 64,50 65,90 100 35 Type Roughness Infilling Joint: JN Polished: PO Broken rock: BR Slickinsided: Κ SA FLT Sand: Fault: Silt: SI Shear SHR Smooth: SM Rought: RO CL Vein: VN Clay: VR Bedding: BD Very rought: Gouge: GO **Biotite:** BT Foliation: FO Shape CA Calcite: Contact: CO Planar: PL Chlorite: CH CU Curved: Iron: FE

Undulating:

Stepped:

Irregular:

UN

ST

IR

Hématite:

Limonite:

Quartz:

HE

QZ

LI



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-04

	Run				Discontinuity						
Dept	th (m)			Dep	th (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
65,90	66,20	30	100								
66,20	67,70	100	57								
67,70	67,90	100	70						1		
67,90	68,40	67	40								
68,40	69,00	67	40								
69,00	70,50	100	60								
70,50	71,70	100	15								
71,70	73,50	85	56								
73,50	74,60	85	56								
74,60	76,00	100	30								
76,00	76,40	67									
76,40	78,00	85	45								
78,00	79,50	100	18								
79,5	81	n-a	n-a								
81	82.6	68	38								
82.6	83.1	80									
83.1	83.5	100									
83.5	83.9	100	50								
83.9	85.5	100	80								
85.5	87.1	100	50								
87.1	87.6	100	50								
97.6	99.7	01	22								
07,0	00,7	31	52	99.40	99.70	coriont	tost				
Т	/pe			00,40	00,70	conent	Boughnes	S		Infilli	na
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	jht:	VR	Gouge		GO
Foliation:	FO								Biotite:		BT
Contact:	CO						Shape		Calcite		CA
						Planar:		PL	Chlorit	e:	CH
						Curved:			Iron:		FE
						Undulatin	ig:		Hemati	te:	HE
						Stepped:		51	Quartz		
						urregular:		μκ	Limoni	te:	LI



F

DISCONTINUITY DATA

PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-04

	Rur	1					Disc	Discontinuity				
Dep	th (m)			Dep	th (m)							
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill	
					88,40	1 JN	17	280	PL	SM	FE	
					88,50	1 JN	45	215	PL	Roughness	FE	
					88,60	1 JN	29	345	PL			
					88,60	1 BD	9	265	UN		QZ	
88,70	90,10	100	13									
90,10	91,60	100	13									
91,60	92,10	100	25									
92,10	92,60	100	100									
92.60	93.00	100	100									
93,00	94,30	92	92									
94.30	94.50	100										
94.50	96.00	100	80									
96.00	96.50	100	100									
96.50	98.00	100	67									
00,00	00,00	100	07	97 80	98.00	corient	test					
				07,00	98.00	1 BD	41	70	PI		07	
					97.80	1 IN	41	70	PI	Boughness	07	
					07.95	1 IN	20	70		Poughnoss	07	
08.00	09.60	100	100		97,05	T JIN		70	L L	nougriness	QZ	
98,00	98,60	100	100									
98,60	99,00	100	100									
99,00	100,50	100	60									
100,50	102,00	100	53									
102,00 T	103,50	100					Poughno			Infilli		
loint:	ли					Polished	nougime		Broker		IBR	
Fault:	FIT					Slickinsic	led:	K	Sand:		SA	
Shear	SHR					Smooth:		SM	Silt:		SI	
Vein:	VN					Rought:		RO	Clav:		CL	
Beddina:	BD					Verv roud	iht:	VR	Gouge	:	GO	
Foliation:	FO						, -		Biotite		BT	
Contact:	CO						Shape		Calcite	:	СА	
						Planar:		PL	Chlorit	e:	СН	
						Curved:		CU	Iron:		FE	
						Undulatir	ig:	UN	Hémati	ite:	HE	
						Stepped:	-	ST	Quartz	:	QZ	
						Irregular:		IR	Limoni	te:	LI	
						· · · ·					•	



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

BH-P-04

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREH	OLE N	°:

	Run				Discontinuity						
Dept	h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
103,50	104,70	100									
104,70	105,90	96	3								
105,90	108,00	71									
108,00	109,50	100	13								
109,50	111,00	100									
111,00	112,50	50									
112,50	114,00	N-A	N-A								
114,00	115,50	13									
115,50	117,00	100	30								
117,00	118,50	100									
118,50	120,00	100	23								
120,00	121,50	100	33								
121,50	123,00	100	32								
123,00	124,10	100	100								
124,10	124,50	100	50								
124,50	125,80	83	83								
125,80	127,10	100	58								
127,10	127,40	100	100								
127,40	128,70	100									
128,70	129,80	82	45								
129,80	130,00	100									
130,00	130,50	100	80								
130,50	130,60	100									
Ту	ре						Roughnes	s		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	led:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	ht:	VR	Gouge:		GO
Foliation:	FO							•	Biotite:		BT
Contact	00						Shape		Calcite		СА
Sontaot.		I	I		1	Planar	Chape	PI	Chlorit		СН
						Curved.			Iron		
							~		Hómet		
						Undulatin	g:		riemati	le:	
						Stepped:		SI	Quartz:		QZ
						Irregular:		lir 🗌	Limoni	te:	



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE

FILE N°: B-0010504-3

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

BOREHOLE N°: BH-P-04

	Run					Discontinuity					
Dept	th (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
130,60	132,00	100	100								
132,00	133,00	20	10								
133,00	133,40	100	50								
133,40	135,00	100	59								
135,00	136,50	100									
136,50	138,00	100	31								
138,00	138,60	100	100							1	
138,60	139,60	100	35								
139,60	140,60	50	10								
140,60	141,00	100									
141,00	142,20	100	54								
142,20	143,70	100	50							1	
143,70	145,00	100	92								
145,50	147,00	100	65								
				146,50	147,00	BD	25-29	235	PL		WC
					146,50	1 JN	30	230	IR	Roughness	FE
					146,80	1 JN	39	255	PL	SM	FE
				151,38	151,50	Test Corient				1	
					151,44	1 BD	22	280	UN	1	FE
147,00	148,50	16								1	
148,50	150,00	100	80							1	
150,00	151,50	100	70								
Ту	/pe						Roughnes	S		Infilli	ng
Joint:	JN					Polished:		PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	K	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	nt:	VK	Gouge	<u> </u>	GO
Foliation:	FO		1			1			Biotite		RI
Contact:	CO						Shape		Calcite	:	CA
						Planar:			Chlorit	e:	
						Curved:			iron:	4	
						Chammer	g:		Hemati	<u>te:</u>	
						Stepped:		31	Quartz	<u>.</u>	
						prregular:		μκ	Limoni	le:	



PROJECT : Geotechnical Feasibility Study – Open Pit Design

FILE N°: B-0010504-3

BOREHOLE N°: _____BH-P-04

LOCATION : Joyce Lake, 20 km from Schefferville, (Québec)

	Run						Disco	ontinuity			
Dept	h (m)			Dept	h (m)						
from	to	TCR (%)	RQD (%)	from	to	Type & number	α angle	β angle	Shape	Roughness	Infill
151,50	153,00	20									
153,00	154,50	N A	N A								
154,50	156,00	87	55								
156,00	157,50	100	20								
157,50	159,00	100	33								
159,00	100,00										
EOH											
Τv	pe						Roughnes	S		Infilli	na
Joint:	JN	İ				Polished:	V	PO	Broken	rock:	BR
Fault:	FLT					Slickinsid	ed:	К	Sand:		SA
Shear	SHR					Smooth:		SM	Silt:		SI
Vein:	VN					Rought:		RO	Clay:		CL
Bedding:	BD					Very roug	ht:	VR	Gouge:		GO
Foliation:	FO								Biotite:		BT
Contact:	CO						Shape		Calcite		CA
						Planar:		PL	Chlorite	9:	СН
						Curved:		CU	Iron:		FE
						Undulatin	g:	UN	Hémati	te:	HE
						Stepped:		ST	Quartz:		QZ
						Irregular:		IR	Limoni	te:	LI

Appendix 3

Rock joints characteristics histograms





Vertical Scale = 1 : 1175



Vertical Scale = 1 : 1175




Vertical Scale = 1 : 1175

EQ-09-Ge-66A R.1 04.03.2009



ROCK JOINTS CHARACTERISTICS

IRON FORMATION



mean=37.344 s.d.=32.0443 min=0 max=100

Quantitative Chart of RQD



Qualitative Chart of ROUGHNESS

Client :	Labec Century Iron Ore Inc.	Scale:	Pas à l'échelle
Project :	Joyce Lake and Area DSO Project – Geotechnical Feasability Study – Open Pit Design	Ref. :	025-B-0010504-3-GE-0001-0A
		Prepared by	<i>ı</i> :G. Joyal
Histograms :	RQD, Roughness,	Date :	2014-11-19

Roug	hness
Polished:	PO
Slickinsided:	K
Smooth:	SM
Rought:	RO
Very rought:	VR
Closed	С





Qualitative Chart of WI



Qualitative Chart of SHAPE

Client : Labec Century Iron Ore Inc. Scale: Pas à l'échelle	
Project : Joyce Lake and Area DSO Project – Geotechnical Feasability Study – Open Pit Design Ref. : 025-B-0010504-3-GE-0001-0A	
Prepared by :G. Joyal	
Histograms : Shape, Weathering Index Date : 2014-11-19	

Shap	e
Planar:	PL
Curved:	CU
Undulating:	UN
Stepped:	ST
Irregular:	IR

Appendix 4 Université Laval Rock Mechanics Laboratory Report



Essais de laboratoire

Résistance en compression uniaxiale Résistance en tension indirecte (brésilien) Résistance en compression triaxiale

À l'attention de PASCAL GARAND, Ing. M.Sc. A Directeur Expertise Géotechnique

LVM, une division d'EnGlobe Corp. 1200, boul. Saint-Martin ouest, bureau 300 Laval, QC, Canada, H7S 2E4





Faculté des sciences et de génie Département de génie des mines, de la métallurgie et des matériaux

Québec, le 17 novembre 2014

PASCAL GARAND, Ing. M.Sc. A Directeur Expertise Géotechnique

LVM, une division d'EnGlobe Corp. 1200, boul. Saint-Martin ouest, bureau 300 Laval, QC, Canada, H7S 2E4

Objet : Essais de laboratoire - propriétés mécaniques

Monsieur,

Nous avons réalisé, à votre demande, une série d'essais mécaniques sur des échantillons de roc intact.

Les échantillons ont été préparés et testés selon les recommandations établies par la SIMR (Société internationale de mécanique des roches). Vous trouverez les détails relatifs aux résultats des tests dans ce rapport.

Pour de plus amples renseignements, n'hésitez pas à nous contacter.

Veuillez recevoir, monsieur, nos meilleures salutations.

Martin Grenon, professeur, ing., Ph.D. Tél.: 418 656-7478 Télec.: 418 656-5343 Courriel: <u>martin.grenon@gmn.ulaval.ca</u>

Essais réalisés :

- 27 essais en compression uniaxiale
- 34 essais brésiliens
- 6 essais triaxiaux

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Résumé

Des échantillons des trous BH-01, BH-02, BH-03 et BH-04 ont été envoyés au Laboratoire de mécanique des roches (LMR) de l'Université Laval par LVM (Laval) pour déterminer :

- La résistance en compression uniaxiale (UCS);
- La résistance en tension (σ_t);
- La résistance en compression triaxiale (σ₁, σ₃).

Des segments de carottes de forage, provenant de 7 lithologies différentes, ont été reçus au LMR le 14, le 22 et le 28 octobre 2014. Par la suite, ces carottes ont servi à la préparation de :

- 27 échantillons pour des essais en compression uniaxiale;
- 34 échantillons pour des essais en tension indirecte (brésiliens);
- 6 échantillons pour des essais en compression triaxiale.

Les échantillons ont été préparés et testés suivant, dans la mesure du possible, les recommandations prescrites par la Société internationale de mécanique des roches (SIMR) :

Brown, E.T., Suggested Methods: Rock Characterization, Testing and Monitoring, International Society for Rock Mechanics, E. Brown, Éd., London: Pergamon Press, 1981, p. 211.

Il est important de noter que même si les recommandations de la SIMR ont été suivies, l'état des échantillons n'a pas permis d'atteindre les standards quant à la planéité et à la rugosité des surfaces des échantillons. Aussi, l'échantillonnage étant restreint, le nombre d'essais par lithologie et par type d'essais est insuffisant.

Tous les essais ont été effectués à l'aide d'une presse SATEC 400RD PRISM.

La résistance en compression a été évaluée et les résultats sont présentés pour chacune des lithologies. Le même traitement a été fait pour la résistance en tension.

Description des échantillons

Le Laboratoire de mécanique des roches (LMR) de l'Université Laval a reçu des segments de carottes de forage le 14, le 22 et le 28 octobre 2014. Ces segments, provenant des trous BH-01, BH-02, BH-03 et BH-04, ont servi à la préparation d'échantillons pour la réalisation d'essais sur le roc intact. Au total, le LMR a effectué 27 essais de résistance en compression uniaxiale, 34 essais de résistance en tension indirecte (brésiliens) et 6 essais triaxiaux.

Les échantillons proviennent de carottes de forages (diamètre HQ) sondées dans 7 lithologies différentes :

- LITHO1: *Mainly Iron Oxyde*;
- LITHO2: Iron Oxyde with White Chert;
- LITHO3: Iron Oxyde with Limonite;
- LITHO4: Iron Oxyde (Hematite) Massive;
- LITHO5: *Mix of Shale and White Chert*;
- LITHO6: Shale;
- LITHO7: Sandstone.

Les tableaux 1,2 et 3 répertorient les échantillons qui ont été préparés avec la lithologie, le numéro qui leur a été attribué, le numéro du forage duquel ils proviennent, leur profondeur, leurs dimensions et leur masse.

	Numéro de	Numéro du	Profond	leur (m)				
Lithologie	l'échantillon	forage	De	À	D (mm)	L (mm)	L/D	Masse (g)
Mainly Iron Oxyde	RS-11	BH-02	143,75	144,00	47,0	111,8	2,4	672,6
	RS-13	BH-02	133,25	133,60	63,6	135,7	2,1	1341,6
Iron Oxyde	RS-16	BH-02	114,65	115,15	63,7	139,8	2,2	1526,8
with White	RS-17	BH-02	87,60	87,80	61,4	137,9	2,2	1228,8
Chert	PLT-07	BH-02	76,60	76,90	61,33	126,34	2,1	1177,2
	PLT-03	BH-02	61,50	61,75	59,92	138,53	2,3	1129,2
lron Oxyde with Limonite	RS-04	BH-02	148,10	148,33	63,2	134,4	2,1	1110,2
	RS-06	BH-02	157,12	157,39	63,5	140,2	2,2	1254,2
	RS-07	BH-02	157,50	157,67	47,5	111,8	2,4	563,0
	RS-10	BH-02	137,80	138,10	47,0	103,1	2,2	428,3
	RS-12	BH-02	135,05	135,30	63,4	129,7	2,0	1006,6
	PLT-11	BH-02	161,40	161,70	63,32	135,3	2,1	1142,5
	PLT-12	BH-02	161,70	161,95	63,18	136,47	2,2	1406,2
Iron Oxyde	PLT-16	BH-04	123,85	124,10	60,92	135,15	2,2	1715,2
(Hematite)-	RS-46	BH-04	123,00	123,23	60,72	131,75	2,2	1458,1
Massive	RS-52	BH-04	157,80	158,00	47,37	99,64	2,1	711,4
	RS-54	BH-03	81,00	81,26	63,55	136,84	2,2	1181,4
Mix of Shale	RS-58A	BH-03	89,60	89,96	63,48	129,48	2,0	1135,2
Chert	RS-58B	BH-03	89,60	89,96	63,40	132,62	2,1	1213,0
Chert	RS-57	BH-03	87,00	87,20	63,51	134,90	2,1	1289,1
	RS-27	BH-01	125,25	125,50	63,47	135,77	2,1	1147,0
Shale	RS-28	BH-01	125,70	125,90	63,49	135,52	2,1	1128,8
	RS-29	BH-01	126,25	126,55	63,47	133,79	2,1	1105,4
	RS-32	BH-01	135,00	135,35	63,49	132,85	2,1	1103,3
Sandstone	RS-34	BH-01	148,26	148,50	63,53	140,9	2,2	1178,5
Sanastone	RS-37	BH-01	154,83	155,20	63,36	136,86	2,2	1150,6
	RS-38	BH-01	159,43	159,60	63,25	136,33	2,2	1188,5

TABLEAU 1 : ÉCHANTILLONS POUR LES ESSAIS DE RÉSISTANCE EN COMPRESSION

* Notez que le diamètre de certains échantillons varie car il était initialement prévu de faire des essais triaxiaux sur ceux-ci.

Laboratoire de mécanique des roches de l'Université Laval

Approche

Préparation des échantillons

La préparation des échantillons s'est faite suivant les recommandations prescrites par la Société internationale de mécanique des roches (SIMR), (Brown, E.T., 1981). Chaque échantillon fourni a été coupé puis rectifié. La planéité des surfaces, leur parallélisme et leur perpendicularité ont été vérifiés. Il est important de noter que même si les recommandations de la SIMR ont été suivies, l'état des échantillons n'a pas permis d'atteindre les standards quant à la planéité et à la rugosité des surfaces des échantillons.

Les échantillons ont été préparés pour qu'ils aient un ratio L/D : compris entre 2,0 et 2,5 pour les essais en compression uniaxiale, de 0,5 pour les essais brésiliens et de 2,0 pour les essais triaxiaux. Pour ces derniers, le diamètre des échantillons NQ (47,6 mm) est imposé par l'équipement utilisé pour assurer le confinement.

Même si le diamètre des segments reçus était du HQ (63,5 mm), le diamètre de certains échantillons préparés pour les essais en compression et en tension indirecte diffère des autres. Quelques échantillons avaient été sélectionnés pour des essais triaxiaux alors qu'ils ont plutôt été testés autrement. Aussi les échantillons sélectionnés pour les essais triaxiaux ont été rectifiés pour en réduire le diamètre, passant ainsi du HQ au NQ.

Un fois préparés, les échantillons ont été photographiés avant que les tests ne soient effectués. Leurs photos, ainsi que leurs dimensions sont disponibles sur les feuilles de résultats présentées en annexe.

Méthodologie des essais

Les tests ont été effectués en suivant les recommandations présentées dans l'ouvrage "Suggested Methods: Rock Characterization, Testing and Monitoring", (Brown, E.T., 1981):

- Suggested Methods for Determining the Uniaxial Compressive Strength and Deformability of Rock Materials.
- Suggested Methods for Determining Tensile Strength of Rock Materials.
- Suggested Methods for Determining the Strength of Rock Materials in Triaxial Compression.

Les essais en compression uniaxiale, en tension indirecte et triaxiaux ont été réalisés à l'aide d'une presse SATEC 400RD PRISM servo contrôlée.

Les valeurs de résistance au moment de la rupture ont été enregistrées.

Il est important de noter que le nombre d'essais en compression uniaxiale, en tension indirecte et en compression triaxiale réalisés sont insuffisants selon les recommandations mises de l'avant par la SIMR. Pour les essais en compression uniaxiale, un seul essai pour la lithologie *Mainly Iron Oxyde*, 3 essais pour la lithologie *Iron Oxyde (Hematite)-Massive*, 4 essais pour la lithologie *Mix of Shale and White Chert*, 3 essais pour la lithologie *Shale* et seulement 3 essais ont été réalisés pour la lithologie *Sandstone* alors que la norme prévoit 5 essais pour la lithologie *Iron Oxyde (Hematite)-Massive*, 3 essais pour la lithologie *Iron Oxyde with Limonite*, 3 essais pour la lithologie *Iron Oxyde with Limonite*, 3 essais pour la lithologie *Iron Oxyde with Limonite*, 3 essais pour la lithologie *Iron Oxyde (Hematite)-Massive*, 3 essais pour la lithologie *Mix of Shale and White Chert*, 3 essais pour la lithologie *Iron Oxyde with Limonite*, 3 essais pour la lithologie *Iron Oxyde (Hematite)-Massive*, 3 essais pour la lithologie *Mix of Shale and White Chert*, 3 essais pour la lithologie *Shale* et seulement 3 essais ont été réalisés pour la lithologie *Iron Oxyde with Limonite*, 3 essais pour la lithologie *Shale* et seulement 3 essais ont été réalisés pour la lithologie *Sandstone* alors que la norme prévoit 10 essais valides par lithologie. Pour les essais en compression triaxiale, 3 essais pour la lithologie *Iron Oxyde with White Chert* alors que la norme prévoit 5 essais valides par lithologie.

Validité des essais de résistance en compression uniaxiale

Au total, six (6) échantillons (RS-11, PLT-03, RS-06, PLT-12, RS-54 et RS-58A) ont été qualifiés de non valides lors des essais en compression uniaxiale. La rupture s'est faite suivant les plans de sédimentation ou un plan pré-identifié.

Sommaire des valeurs de résistance en compression uniaxiale - essais valides

17

Un sommaire des résultats, pour les essais valides uniquement, est présenté au tableau 5. La résistance en compression uniaxiale de *Iron Oxyde with White Chert* est de 97,6 MPa avec un écart type de 4,9 MPa; celle de *Iron Oxyde with Limonite* est de 29,0 MPa avec un écart type de 13,6 MPa; celle de *Iron Oxyde (Hematite)-Massive* est de 55,7 MPa avec un écart type de 31,0 MPa; celle de *Mix of Shale and White Chert* est de 120,7 MPa avec un écart type de 15,8 MPa; celle de *Shale* est de 130,9 MPa avec un écart type de 1,8 MPa et celle de *Sandstone* est de 254,6 MPa avec un écart type de 48,8 MPa. Aucun résultat n'a été obtenu pour la lithologie *Mainly Iron Oxyde* car l'unique essai effectué a été non valide.

	Nombre	Coefficient de				
Lithologie	d'essai	Moyenne	Écart type	Min	Max	variation (%)
Mainly Iron Oxyde	0	-	-	-	-	-
Iron Oxyde with White Chert	4	97,6	4,9	92,6	102,2	5,0
Iron Oxyde with Limonite	5	29,0	13,6	16,0	51,8	46,9
Iron Oxyde (Hematite)-Massive	3	55,7	31,0	28,3	89,3	55,6
Mix of Shale and White Chert	2	120,7	15,8	109,5	131,9	13,1
Shale	3	130,9	1,8	128,9	132,4	1,4
Sandstone	4	254,6	48,8	219,0	325,9	19,2
		_				

TABLEAU 5 : SOMMAIRE DES RÉSISTANCES EN COMPRESSION UNIAXIALE (σ_{ci}) – ESSAIS VALIDES

Le coefficient de variation est utilisé afin d'évaluer la variabilité des données et il est défini comme le rapport entre l'écart-type (σ) et la moyenne(μ).

$$C_{v} = \frac{\sigma}{\mu}$$

En géotechnique minière, un coefficient de variation de moins de 10 % est considéré comme faible alors qu'un coefficient de variation supérieur à 30 % est considéré comme élevé (Read, J., Stacey, P., 2009).

Pour les essais de compression uniaxiale réalisés, *Iron Oxyde with White Chert* présente un coefficient de variation de 5,0 %, *Iron Oxyde with Limonite* présente un coefficient de variation de 46,9 %, *Iron Oxyde (Hematite)-Massive* présente un coefficient de variation de 55,6 %, *Mix of Shale and White Chert* présente un coefficient de variation de 13,1 %, *Shale* présente un coefficient de variation de 1,4 % et *Sandstone* présente un coefficient de variation de 19,2 %. Selon les résultats de résistance en compression obtenus, les lithologies *Iron Oxyde with Limonite, Iron Oxyde (Hematite)-Massive (Hematite)-Massive* présentent un coefficient de variation de 19,2 %.

Total

Sommaire des valeurs de résistance en tension indirecte

Un sommaire des résultats est présenté au tableau 7 en considérant uniquement les essais valides. La moyenne de la résistance en tension indirecte de *Mainly Iron Oxyde* est de 12,7 MPa avec un écart type de 8,9 MPa; celle de *Iron Oxyde with White Chert* est de 7,9 MPa avec un écart type de 1,3 MPa; celle de *Iron Oxyde with Limonite* est de 4,3 MPa avec un écart type de 3,1 MPa; celle de *Iron Oxyde (Hematite)-Massive* est de 9,4 MPa avec un écart type de 5,3 MPa; celle de *Mix of Shale and White Chert* est de 11,5 MPa avec un écart type de 8,0 MPa; celle de *Shale* est de 14,6 MPa avec un écart type de 2,5 MPa et celle de *Sandstone* est de 19,9 MPa avec un écart type de 8,2 MPa. Les coefficients de variations valent respectivement 69,8 %, 16,8 %, 73,1 %, 56,4 %, 69,5 %, 16,9 % et 8,2 %. Selon les résultats de résistance en tension obtenus, les lithologies *Mainly Iron Oxyde, Iron Oxyde with Limonite, Iron Oxyde (Hematite)-Massive et Mix of Shale and White Chert* présentent un coefficient de variation de plus de 30 %.

Lithologia	Nombre		Coefficient de			
Litrologie	d'essai	Moyenne	Écart type	Min	Max	variation (%)
Mainly Iron Oxyde	8	12,7	8,9	4,8	28,1	69,8
Iron Oxyde with White Chert	5	7,9	1,3	6,7	9,7	16,8
Iron Oxyde with Limonite	6	4,3	3,1	1,6	10,3	73,1
Iron Oxyde (Hematite)-Massive	3	9,4	5,3	3,5	13,7	56,4
Mix of Shale and White Chert	3	11,5	8,0	4,1	20,0	69,5
Shale	3	14,6	2,5	12,0	17,0	16,9
Sandstone	3	19,9	8,2	12,1	28,5	8,2

TABLEAU 7: SOMMAIRE DES RÉSISTANCES EN TENSION INDIRECTE (σ_{τ}) – ESSAIS VALIDES

Total	31
-------	----

Résistance en compression triaxiale

Au total 6 valeurs de résistance en compression triaxiale ont été évaluées à partir des essais effectués sur des échantillons reçus. Pour chacun des essais réalisés, une feuille synthèse avec les photos, les caractéristiques de l'échantillon et les résultats de l'essai est présentée à l'annexe 3.

Validité des essais triaxiaux

Au total, deux essais ont été qualifiés de non valide (PLT-17 et RS-51).

Sommaire des valeurs de résistance en compression triaxiale

Un sommaire des résultats est présenté au tableau 8.

Lithologie	Numéro de	Numéro du	Profon	deur (m)	σ. (MPa)	σ. (MPa)	Commentaire	
Litilologie	l'échant	forage	De	À	03 (IVIF d)	0 ₁ (IVIP d)		
Iron Oxyde	PLT-17	BH-04	138,20	138,50	8,1	58,4	Essai non valide	
(Hematite)- Massive	RS-50	BH-04	123,10	123,27	3,4	39,3	Mixte	
	RS-45	BH-04	121,70	121,87	5,7	71,4	Mixte	
have Quarks with	PLT-07	BH-03	76,60	76,90	8,2	256,7	Mixte	
Iron Oxyde with	RS-41	BH-03	69,65	69,90	4,9	112,5	Diagonale	
white chert	RS-51	BH-04	149,00	149,27	5,4	91,2	Essai non valide	

TABLEAU 8 : RÉSISTANCE EN COMPRESSION TRIAXIALE (σ_1, σ_3)

Annexe 1 -Résistance en compression uniaxiale : Feuilles-synthèses

[17]

Laboratoin Département Québec (Québec	Laboratoire de mécanique des roches UNIVERSITÉ Département de génie des mines, de la métallurgie et des matériaux UNIVERSITÉ Québec (Québec) Canada G1K 7P4 Faculté des sciences et de génie									
Essai en	compres	ssion	uniaxiale		-	_				
- D - L	Echantil	lon	Essai		ŀ	-orage	Profondeur (m)	Ор	érateur	Date
	RS-1 1	1	UCS-00	5	BH-02		143,75@144,00		J-JKM	23/10/2014
	Ca	ractéris	stiques de l'é	chantil	llon		Ré	sultat	du test	
D (mm)	L (mm)	L/D	Aire (mm	²) Ma	asse (g)	État	Force - rupture (kl	V)	σ	_{ci} (MPa)
46,96	111,79	2,4	1731,9	9 6	672,6	SEC	210,7		1	21,65
Type de roche :			Mair	ly Iror	n Oxyde		Durée (min) :		2	2,7090
Note :							Validit	é :		NON
	Cellule de	e charg	e : SATEC 4	00K			Taux : 0.75	6 MPa	/sec	
Remarque	e sur la rup	oture :	Plan de rupt	ire à e	environ 4	0° par rapport	à l'axe de la carot	te.		
Type de ru	upture :	А		DIAGON		CONIQ		E 🗌		
Rupture s pré identif	selon un p ié :	olan				PARTIELLEME	NT 🗌 PARALLÈL	.E 🗌	SUIVANT	LE CLIVAGE 🔀
Nombre d	e fragments	6: 4	- de 3 🗌	-	de 3 🔀	ROCHE BROY	ÉE			



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	Échantill	lon	Ess	sai		Forage	Profondeur (m)	Op	pérateur	Date
D	RS-16	6	UCS	·008		BH-02	114,65@115,65	С	J-JKM	23/10/2014
	Car	ractéris	stiques de	l'échar	ntillon		F	ésulta	t du test	
D (mm)	L (mm)	L/C) Aire (mm²)	Masse (g)	État	Force - rupture (kN)	σ	_{ci} (MPa)
63,66	139,80	2,2	2 318	2,90	1526,8	SEC	299,7		9	94,16
Type de roche :			Iron O	xyde w	vith white c	hert	Duré (min)	e :	2	2,106
Note :							Valid	té :		OUI
	Cellule de	charg	je : SATEC	C 400K			Taux : 0.7	5 MPa	/sec	
			RE							
Pomorau		15-0.98								
Remarque	e sur la rup	oture :						_		
Type de ru	upture :	A		DIAG		CONIQ		RE 🗌		MIXTE 🔀
Rupture s pré identif	selon un p ié :	blan	ουι 🗌			PARTIELLEME			SUIVANT	LE CLIVAGE
Nombre d	e fragments	s: -	+ DE 3 🔀		- de 3 🗌	ROCHE BROY	ÉE 🗌			



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	Échanti	llon	Essa	ai		Forage	Profonde	eur (m)	Ор	érateur	Date
	PLT-0)7	UCS-0)22		BH-02	76,60@	76,90	C	J-JKM	11/11/2014
	Ca	ractéri	stiques de l	'échanti	illon			Ré	sultat	du test	
D (mm)	L (mm)	L/[D Aire (r	nm²) M	lasse (g)	État	Force - r	upture (kN)	σ	_{si} (MPa)
61,33	126,34	2,	1 2954	1,2 1	1177,2	SEC	29	99,2		1	01,28
Type de roche :			Iron ox	yde with	n white cl	nert.		Durée (min) :		2	2,263
Note :	Fo	liation	à 35 degré	s par ra	pport à l'	axe de la carot	tte.	Validité	e:		OUI
	Cellule de	e charg	ge : SATEC	400K			Ται	ux : 0.75	MPa	/sec	
							se se se se se se se se se se se se se s				
Remarque	e sur la ru	pture :									
Type de ru	upture :	1	AXIALE 🔀	DIAGO	NALE 🗌	CONIQ	UE 🗌	AUTRE			
Rupture s pré identifi	selon un lé :	plan				PARTIELLEME	NT 🛛 🛛 F	PARALLÈLI	E 🗌	SUIVANT	LE CLIVAGE
Nombre de	e fragment	s:	+ de 3 🖂	-	de 3 🗌	ROCHE BROY	ÉE				



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	Échantil	lon	E	ssai		Forage	Profonde	ur (m)	Ор	érateur	Date
	RS-04	4	UC	S-001		BH-02	148,10@ ⁻	148,33	C.	J-JKM	23/10/2014
	Ca	ractéri	stiques o	de l'écha	antillon			Ré	sultat	du test	
D (mm)	L (mm)	L/E	D Ai	re (mm²)	Masse (g)	État	Force - r	upture (kN)	σ	_{ci} (MPa)
63,20	134,44	2,	1 3 ⁻	137,07	1110,2	SEC	9	2,1			29,36
Type de roche :			Irc	on oxyde	with limon	ite		Durée (min) :		0	,6570
Note :		Foliat	ion à 30	° par rap	port à l'axe	e de la carotte.		Validité):		OUI
	Cellule de	e charg	ge : SAT	EC 400k	<		Ται	ıx : 0.75	MPa	/sec	
		RS 5-0 105-0									
Remarque	e sur la rup	oture :	Rupture	e à 30° s	uivant part	iellement la foli	iation.				
Type de ru	upture :	1	AXIALE 🛛	DIA	GONALE 🔀	CONIQ		AUTRE			
Rupture s pré identifi	selon un p ié :	olan]		PARTIELLEME	NT 🛛 P	ARALLÈLI		SUIVANT	LE CLIVAGE 🔀
Nombre de	e fragments	s: ·	+ DE 3 🖂]	- de 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantill	on	Ess	sai		Forage	Profondeur (m)	Op	pérateur	Date		
D	RS-07	,	UCS	-003		BH-02	157,50@157,6	' C	J-JKM	23/10/2014		
	Car	actéris	tiques de	l'échai	ntillon		ŀ	Résulta	t du test			
D (mm)	L (mm)	L/D	Aire	(mm²)	Masse (g)	État	Force - rupture	kN)	σ	_{ci} (MPa)		
47,49	111,84	2,4	177	1,31	563,0	SEC	91,8		4	51,83		
Type de roche :			Iron	oxyde	with limon	ite	Duré (min	e :		1,17		
Note :							Valio	ité :		OUI		
	Cellule de	charge	e : SATEC	C 400K			Taux : 0.	75 MPa	a/sec			
		RS-o	7									
		5.00					The second second second second second second second second second second second second second second second se	1.40				
Remarque	e sur la rup	ture :	Rupture s	uivant	partiellem	ent le clivage.						
Type de ru	ipture :	A	XIALE 🔀	DIAG		CONIQ		RE 🗌				
Rupture s pré identifi	selon un p é :	olan	oui 🗌			PARTIELLEMENT 🛛 🛛 PARALLÈLE 🗌 SUIVANT LE CLIVAGE 🖂						
Nombre de	e fragments	: +	- de 3 🖂		- de 3 🗌	ROCHE BROY	ÉE 🗌					



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	Échantil	lon	E	issai		Forage	Profondeu	ır (m)	Ор	érateur	Date
	RS-12	2	UC	S-006		BH-02	135,05@1	5@135,30 CJ-JKM 23/10/20			23/10/2014
	Ca	ractéris	stiques o	de l'écha	antillon			Ré	sultat	du test	
D (mm)	L (mm)	L/C	D Aii	re (mm²)	Masse (g)	État	Force - ru	pture (kN)	σ	_{ci} (MPa)
63,35	129,67	2,0) 3 [,]	151,98	1006,6	SEC	77	' ,4		4	24,56
Type de roche :			Irc	on oxyde	e with limon	ite		Durée (min) :		(),559
Note :	Foliation à	1 35° pa	ar rappo	rt à l'axe	e de la caro	otte.		Validité	:		OUI
	Cellule de	e charg	je : SAT	EC 400ł	≺		Taux	x : 0.75	MPa	/sec	
Pemerau		RSucs	S-12								
Remarque	e sur la rup	oture :	Rupture	e suivant	t partiellem	ent le clivage					
Type de ru	upture :	A	Δ XIALE	DIA	GONALE 🔀	CONIC		AUTRE			
Rupture s pré identif	selon un p ié :	olan	OUI 🗌]		PARTIELLEME	ENT 🛛 PA	RALLÈLE		SUIVANT	LE CLIVAGE 🔀
Nombre d	e fragments	s: -	+ DE 3 🛛		- de 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantill	on		Essai		F	Forage	Profonde	ur (m)	Ор	érateur	Date
D	PLT-1	2	ι	JCS-011			BH-02	161,70@	161,95	C.	J-JKM	06/11/2014
	Car	actéria	stique	s de l'écha	antillor	n			Ré	sultat	du test	
D (mm)	L (mm)	L/E	D	Aire (mm ²)	Mass	se (g)	État	Force - r	upture (kN)	σ	_{ci} (MPa)
63,18	136,47	2,2	2	3135,1	140	6,2	SEC	11	18,7			37,86
Type de roche :				Iron oxyde	e with I	limoni	ite		Durée (min) :		(),849
Note :	Ru	ubanei	ment	à 30 ° par	rappor	rt à l'a	ixe de la caroti	ie.	Validité	:	l	NON
	Cellule de	charg	ge : SA	ATEC 400	K			Tau	лх : 0.75	MPa	/sec	
		PLT- UCS	12 000									
Domension		(Interaction	Durat			10.00			P september	- I	· ·	
Tuncate	e sur la rup	oture :	Rupt				a environ 30°.					
Rupture	apture : selon un p	/ olan	AXIALE		GONAL					- -		
pré identifi Nombre de	é : e fragments	s: •	+ DE 3		- DE	3	ROCHE BROY	ÉE	AKALLELI	= 📖	SUIVANT	



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	Échantil	lon		Essai		Forage	Profonde	ur (m)	Ор	érateur	Date
D	RS-46	RS-46 UCS-013				BH-04	123,00@ <i>*</i>	123,23	С	J-JKM	06/11/2014
	Ca	ractéri	stiques	de l'écha	antillon			Ré	sultat	t du test	
D (mm)	L (mm)	L/E	D A	ire (mm ²)	Masse (g)	État	Force - r	upture (kN	l)	σ	₀ (MPa)
60,72	131,75	2,2	2	2895,7	1458,1	SEC	8	1,9			28,28
Type de roche :			Iron	oxide (He	ematite)-Ma	assive		Durée (min) :		(),653
Note :	Échantillor visibles av	n très vant l'e	s poreu ssai.	x, s'effr	ite facilem	nent. Plusieurs	s fissures	Validité	:		OUI
	Cellule de	e charg	ge : SAT	EC 400	≺		Ται	ıx : 0.75	MPa	/sec	
		RS- UCS-	76 015								
Remarque	e sur la rup	oture :									
Type de ri	inture :	/				CONIO			:		
Rupture	selon un p	olan				PARTIELLEME	:NT Р	ARALLÈL		SUIVANT	
Nombre d	ie : e fragments	6: ·	+ DE 3 [_	- DE 3 🔀	ROCHE BROY	ÉE 🗌				



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	Échantil	lon	E	ssai		Forage	Profonde	eur (m)	Ор	érateur	Date
D	RS-54 UCS-024					BH-03	81,00@	81,26	C.	J-JKM	11/11/2014
	Ca	ractéri	stiques d	e l'écha	Intillon			Ré	sultat	du test	
D (mm)	L (mm)	L/E	D Aire	e (mm²)	Masse (g)	État	Force - I	rupture (kN)	σ	_{si} (MPa)
63,55	136,84	2,2	2 3	71,9	1181,40	SEC	1	36,3		2	12,97
Type de roche :			Mix o	f shale a	and white o	chert.		Durée (min) :		C),963
Note :	Foliation	n à 75	degrés p vi	ar rappo sibles a	ort à l'axe d vant l'essa	de la carotte. F i.	issures	Validité):		NON
	Cellule de	e charg	ge : SATE	C 400k	κ		Ta	ux : 0.75	MPa	/sec	
		RS-5 Acs-	54				A R R R R R R R R R R R R R R R R R R R				
Remarque			24				N. S. K. K. K. K. M.				
Remarque	e sur la rup	sture :									
Type de ru	ipture :	/	AXIALE 🔀	DIAC	GONALE 🗌	CONIQ		AUTRE			
pré identifi	é:	bian	oui 🛛			PARTIELLEME		PARALLÈLI		SUIVANT	LE CLIVAGE
Nombre de	e fragments	s: ·	+ DE 3 🖂		- de 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantil	lon	Ess	ai		Forage	Profonde	eur (m)	Ор	érateur	Date
	RS-58	в	UCS-	027		BH-03	89,60@	39,60@89,96 C			11/11/2014
	Ca	ractéris	stiques de	l'échant	illon			Ré	sultat	du test	
D (mm)	L (mm)	L/D) Aire (mm²) N	/lasse (g)	État	Force - r	upture (kN)	σ	₀i (MPa)
63,40	132,62	2,1	315	57,0 ⁻	1213,0	SEC	4	16,3		1	31,87
Type de roche :			Mix of	shale an	d white c	hert.		Durée (min) :			2,939
Note :	Fo	liation a	à 75 degré	ès par ra	pport à l'	axe de la caro	tte.	Validité	÷:		OUI
	Cellule de	e charg	e : SATEC	C 400K			Tau	ux : 0.75	MPa	/sec	
		15-58 c5-0	827								
	R. R. R. R. M. R. M. M. M. M. M.			a la serie			AINLESS STEEL		- AND - AND		
Remarque	e sur la rup	oture :									
Type de ru	upture :	A		DIAGO		CONIQ		AUTRE			MIXTE 🛛
Rupture s pré identifi	selon un p ié :	plan	OUI 🗌			PARTIELLEME	NT 🗌 🛛 F	PARALLÈLI	E 🗌	SUIVANT	LE CLIVAGE
Nombre de	e fragments	s: +	+ DE 3 🔀	-	• DE 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantillon Essa			ssai	i Forage		Profonde	eur (m)	Ор	érateur	Date
	RS-27	7	UC	S-015		BH-01	125,25@	125,50	C	J-JKM	11/11/2014
	Ca	ractéri	stiques o	de l'écha	Intillon			Ré	sultat	du test	
D (mm)	L (mm)	L/E	D Aiı	re (mm²)	Masse (g)	État	Force -	rupture (kN)	σ	₀ (MPa)
63,47	135,77	2,	1 3	163,9	1147,0	SEC	4	18,8		1	32,37
Type de roche :				SI	hale.			Durée (min) :		2	2,949
Note :								Validité):		OUI
	Cellule de	e charg	ge : SAT	EC 400k	<		Та	ux : 0.75	MPa	/sec	
	2 5 5 8 8 8 8 8 8 8 8 9 8 9 8 8 8 8 8 8 8	RS-2 cs- (7,15								
Pomorqui											
kemarque	e sur la rup	sture :	N	7							
Type de ru	upture :	/	AXIALE 🔀	DIA0	GONALE 🗌	CONIC		AUTRE			MIXTE 🖂
pré identifi	ié :	pian	OUI 🗌]		PARTIELLEME		PARALLÈLE		SUIVANT	LE CLIVAGE
Nombre de	e fragments	s: ·	+ de 3 🖂]	- de 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantillon Essai				Forage BH-01		Profonde	ur (m)	Ор	érateur	Date
	RS-29	•	UCS	-015		BH-01	126,25@	126,55	C	J-JKM	11/11/2014
	Ca	ractéris	stiques de	l'échant	tillon			Ré	sultat	du test	
D (mm)	L (mm)	L/C) Aire	(mm²) M	Masse (g)	État	Force - r	upture (kN	l)	σ	_{ci} (MPa)
63,47	133,79	2,1	1 316	63,9	1105,4	SEC	4	15,7		1	31,39
Type de roche :				Sha	ale.			Durée (min) :			2,933
Note :								Validité	é:		OUI
	Cellule de	e charg	je : SATEC	C 400K			Tai	JX : 0.75	MPa	/sec	
		RS-2 ucs-1	9017				S. S. H. K. K. K. K. K. K. A. M. A. M. M. A.				
Remarque	e sur la rup	oture :									
Type de ru	upture :	A		DIAGO		CONIQ		AUTRE			MIXTE 🖂
Rupture s pré identifi	selon un p ié :	olan	oui 🗌			PARTIELLEME	NT 🗌 🛛 F	PARALLÈLI	E	SUIVANT	LE CLIVAGE
Nombre de	e fragments	s: -	+ DE 3 🖂		- DE 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantil	llon	Ess	ai		Forage	Profonde	eur (m)	Ор	érateur	Date
	RS-34	S-34 UCS-019				BH-01	148,26@	148,50	C	J-JKM	11/11/2014
	Ca	ractéris	stiques de	'échan	tillon			Ré	sultat	du test	
D (mm)	L (mm)	L/C	D Aire (r	mm²) M	Masse (g)	État	Force - r	upture (kN)	σ	"(MPa)
63,53	140,90	2,2	2 316	9,9	1178,5	SEC	72	20,8		2	27,39
Type de roche :				Sands	stone.			Durée (min) :		5	5,076
Note :	Craquem	ient ve	rs 3 min. 3	5 sec. I de la c	Foliation arotte.	à 60° par rappo	ort à l'axe	Validité			OUI
	Cellule de	e charg	ge : SATEC	400K			Tau	лх : 0.75	MPa	/sec	
		A						×	1	Y	
Remarque	e sur la ru	oture :				1					
Type de ru	upture :	A		DIAGO		CONIQ		AUTRE			
Rupture s	selon un j ié [.]	plan				PARTIELLEME	NT 🗌 🛛 F	PARALLÈLI	E 🗌	SUIVANT	LE CLIVAGE
Nombre de	e fragments	s: •	+ DE 3 🔀		- de 3 🗌	ROCHE BROY	ÉE 🗌				



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	Échantil	lon	E	Essai		Forage	orage Profondeur (m) Opérateur Da					
	RS-38 UCS-021 B		BH-01	159,43@159	9,60	C.	J-JKM	11/11/2014				
	Ca	ractéri	stiques	de l'écha	Intillon		Résulta			at du test		
D (mm)	L (mm)	L/[D A	ire (mm ²)	Masse (g)	État	Force - rupture (kN)			σ _{ci} (MPa)		
63,25	136,33	2,2	2 3	3142,0	1188,5	SEC	773,	,0		246,02		
Type de roche :			·	San	dstone.		D (r	Durée min) :			5,48	
Note :							V	/alidité	:		OUI	
	Cellule de	e charg	ge : SAT	EC 400k	<		Taux	: 0.75	MPa/	/sec		
	S. K. K. K. K. K. K. K. K. K. A. A. A. A. A. A. A. A.	RS-: ucs-	38									
Remarque												
Tunt	e sur la rup	sture :		7							 _	
Rupture	apture : selon un r	, olan	AXIALE [∕			CONIQ		AUTRE				
pré identifi	lé :					PARTIELLEME	ENT 🔄 🛛 PAR	RALLÈLE		SUIVANT		
	e nagments	.	+ DE 3 [2	L L	- DE 3 🗌	ROCHE BROY						

Annexe 2 -Résistance en tension indirecte (brésilien) : Feuilles-synthèse

[47]

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$\uparrow \bigcirc \bigcirc$	Échantillon		No. Essai Forage		Forage	F	Profondeur (m)	Opéra	iteur	Date			
u	RS-01A		BRE-007		BH-02	1	61,02@161,33	CJ-JI	KM	24/10/2014			
	Caracté	eristiques of	de l'échantillon			J	R	ésultat d	du test				
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)			
63,23	28,75	0,5	260,6		SEC		14,8	5,18					
Type de roche :		N	lainly Iron Oxyd	e			Durée (min) :			1,26			
Note :				OUI									
Cell	ule de char	ge : SATE	C 400K				Taux : 20	00 N/sec					
	RE-007 BRE-												
	A١	/ANT		APRÈS									

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$\uparrow \bigcirc \bigcirc$	Échantillon RS-02		No. Essai	F	orage	Pro	fondeur (m)	Opéra	Opérateur Date		
L↓			BRE-012	E	3H-02	164,	,47@164,76	CJ-Jł	٢M	24/10/2014	
	Caracté	ristiques	de l'échantillon				R	ésultat d	at du test		
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)	
63,40	29,11	0,5	406,8		SEC 47,3				16,32		
Type de roche :		Ν	Mainly Iron Oxyd	e		D	Ourée (min) :			3,96	
Note :						V	/alidité :			OUI	
Cell	ule de char	ge : SATE	EC 400K								
	A۱	/ANT			APRÈS						

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$\uparrow \bigcirc \bigcirc$	Échant	illon	No. Essai Forage		orage	F	Profondeur (m)	Opéra	iteur	Date	
L↓	RS-1	RS-14 BRE-014 BH-02 139,2		39,25@139,42	CJ-J	KM	24/10/2014				
D	Caracté	eristiques c	de l'échantillon				R	ésultat d	du test		
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)	
46,95	20,59	0,4	147,6		SEC		11,8		7,77		
Type de roche :		N	lainly Iron Oxyd	e		Durée (min) :				0,99	
Note :							Validité :			OUI	
Cell	ule de char	ge : SATE	C 400K				Taux : 20	00 N/sec			
4 5	6 7	AFPS 2	e 10 11	4	5			10			
	A۱	/ANT		APRÈS							

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$\uparrow \bigcirc \bigcirc$	Échantillon RS-15B		No. Essai	F	orage	Profo	ndeur (m)	Opéra	teur	Date	
L↓			BRE-015	E	3H-02	119,80	0@120,20	CJ-JKM		24/10/2014	
	Caracté	ristiques	de l'échantillon				R	ésultat d	lu test		
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture (kN)			σ _t (MPa)	
63,43	29,53	0,5	439,5		SEC 82,7				28,11		
Type de roche :		Ν	Mainly Iron Oxyd	e		Dur	rée (min) :			6,89	
Note :						Val	lidité :			OUI	
Cell	ule de char	ge : SATE	EC 400K								
	RS BRE		9 10 11 12	13						11 12 13	
		RS- 158				5 6 7					
	A۱	ANT		APRÈS							

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$\uparrow \bigcirc \bigcirc$	Échantillon		No. Essai	ł	Forage	Profondeur (m)	Opéra	iteur	Date		
	RS-0	03	BRE-017		BH-02	170,40@170,60	CJ-JI	KM	28/10/2014		
	Caracté	éristiques	de l'échantillon			R	tésultat du test				
D (mm)	L (mm)	L/D	Masse (g)		État	Force - rupture	e (kN)		σ _t (MPa)		
63,05	28,43	0,5	268,9		SEC	SEC 18,8			6,68		
Type de roche :		Iron (Oxyde with white	chert		Durée (min) :			1,59		
Note :				Validité :			OUI				
Cell	lule de char	ge : SATI	EC 400K			Taux : 20	00 N/sec	l			
		8				12 13					
	A۱	/ANT		APRÈS							

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$\uparrow \bigcirc \bigcirc$	Échantillon		No. Essai	F	Forage	Profondeur (m)	Opéra	ateur	Date			
u↓	RS-13		BRE-006	-006 BH-02		133,25@133,60	CJ-J	KM	23/10/2014			
D	Caracté	éristiques	de l'échantillon			F	Résultat o	du test				
D (mm)	L (mm)	L/D	Masse (g)		État	Force - rupture	e (kN)		σ _t (MPa)			
63,44	29,45	0,5	259,40		SEC	26,4			8,99			
Type de roche :		Iron	Oxyde with white	chert		Durée (min) :		2,21				
Note :			OUI									
Cell	lule de char	ge : SAT	EC 400K			Taux : 20	00 N/sec					
. 10 3			9 10 11									
	A۱	/AN I			APRÈS							

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\uparrow	Échantillon RS-19		No. Essai Fo		orage	Pro	ofondeur (m)	Opérateur		Date
ų			BRE-016	E	3H-02	87	7,45@87,65	CJ-JI	KM	24/10/2014
D D	Caracté	eristiques o	de l'échantillon				R	lésultat c	du test	
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)
61,33	27,65	0,5	236,6		SEC			2,74		
Type de roche :		Iron C	Dxyde with white	chert		C	Durée (min) :			0,63
Note :				/alidité :			NON			
Cell	ule de char	ge : SATE	EC 400K				Taux : 20	0 N/sec	I	
	5 8 7			3					10	
	AV	/ANT	APRÈ					2ÈS	10	11 12 13

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$\uparrow \bigcirc \bigcirc$	Échant	tillon	No. Essai	F	orage	Pro	ofondeur (m)	Opéra	teur	Date			
u↓	RS-51		BRE-031	BRE-031 BH-04		14	149,0@149,27		KM	11/11/2014			
	Caracté	éristiques	de l'échantillon				R	ésultat d	du test				
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)			
61,21	30,45 0,5 297,7				SEC 21,0				7,17				
Type de roche :		Iron o	oxide with white o	chert.		[Durée (min) :			1,76			
Note :						\	Validité :			OUI			
Cell	lule de char	ge : SATE	EC 400K				Taux : 20	0 N/sec					
	RE-031 BRE-031 4 5 6 7 8 9 10 11 12												
AVANT APRÈS													
	A						AFK	LU					
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$\uparrow \bigcirc \bigcirc$	Échant	tillon	No. Essai		Forage	P	rofondeur (m)	Opéra	teur	Date
	RS-0	05	BRE-013		BH-02	14	48,55@148,71	CJ-JI	KM	24/10/2014
D	Caracté	éristiques	de l'échantillon				R	ésultat c	du test	I
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ_t (MPa)
47,13	22,22	0,5	103,4		SEC		4,7			2,86
Type de roche :		Iror	n Oxyde with limc	onite			Durée (min) :			0,42
Note :							Validité :			OUI
Cell	ule de char	ge : SAT	EC 400K				Taux : 20	0 N/sec		
4 5	Rs-os Rs-os BRE-013 BRE-013 6 7 8 9 10 11								13	
	5 6	7	8 9 10		3	4				
	A١	/ANT				APRÈS				

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\uparrow	Échant	tillon	No. Essai	F	orage	Profondeur (m)	Opéra	ateur	Date
ų	RS-1	10	BRE-004	ŀ	BH-02	137,80@138,10	CJ-J	KM	23/10/2014
	Caracté	éristiques	de l'échantillon				Résultat o	du test	
D (mm)	L (mm)	L/D	Masse (g)		État	Force - ruptu	re (kN)		σ _t (MPa)
47,00	23,09	0,5	120,70		SEC	17,6			10,32
Type de roche:		Iror	n Oxyde with limc	onite		Durée (min) :			1,52
Note :						Validité :			OUI
Cell	ule de char	ge : SAT	EC 400K			Taux : 2	200 N/sec	;	
3 4		7 8	s 10	11	3		7 8		
3 4	5 6		9 10	11					
	A۱	/ANT			AP	RÈS			

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	Échant	tillon	No. Essai	F	orage	Pi	rofondeur (m)	Opéra	teur	Date
u	PLT-	11	BRE-019	ŀ	BH-02	16	61,40@161,70	CJ-Jł	٢M	06/11/2014
	Caracté	éristiques	de l'échantillon				R	ésultat d	lu test	
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)
63,30	29,72	0,5	258,0		SEC		4,80			1,62
Type de roche :		Iror	Oxyde with limonite				Durée (min) :			0,58
Note :							Validité :			OUI
Cell	ule de char	ge : SATI	EC 400K				Taux : 20	0 N/sec		
3 4	PL BRE			13						1 12 13
	6 7 1									12 13
	AVANT						APR	ÈS		

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$\uparrow \bigcirc \bigcirc$	Échant	illon	No. Essai		Forage	Profond	deur (m)	Opéra	teur	Date
L↓	PLT-1	6A	BRE-021		BH-04	123,85	@124,1	CJ-Jł	٢M	06/11/2014
	Caracté	eristiques	de l'échantillon				R	ésultat d	lu test	
D (mm)	L (mm)	L/D	Masse (g)		État	Fo	rce - rupture	(kN)		σ _t (MPa)
60,89	29,24	0,5	415,3		SEC		38,30			13,69
Type de roche :		Iron ox	kide (Hematite)-M	lassive	e	Duré	e (min) :			3,22
Note :						Valid	ité :			OUI
Cell	ule de char	ge : SATI	EC 400K				Taux : 20	0 N/sec		
	S S S	-02	9 10 11 12			4 5	6 Z B			12 13
	13						12 13 14			
AVANT							APR	ÈS		

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$\uparrow \bigcirc \bigcirc$	Échant	illon	No. Essai		Forage	Profondeur (m)	Opéra	teur	Date
	PLT-	17	BRE-023		BH-04	138,2@138,5	CJ-JI	KM	06/11/2014
	Caracté	ristiques	de l'échantillon	I		R	tésultat c	du test	<u> </u>
D (mm)	L (mm)	L/D	Masse (g)		État	Force - rupture	e (kN)		σ _t (MPa)
60,96	28,56	0,5	311,30		SEC	9,50			3,47
Type de roche :	Iror	n oxide (H	lematite)-Massive	/with ł	hydroxie	Durée (min) :			1,12
Note :						Validité :			OUI
Cell	ule de char	ge : SAT	EC 400K			Taux : 20	00 N/sec	L	
	BRE		9 10 11 12			A 5 6 7		3	
			10 11 12						
	A۱	/ANT				APR	RÈS		

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$\uparrow \bigcirc \bigcirc$	Échant	tillon	No. Essai	F	orage	Profondeur (m)	Opéra	teur	Date
L↓	RS-	58	BRE-034		BH-03	89,6@89,96	CJ-JI	KM	11/11/2014
	Caracté	éristiques	de l'échantillon			R	lésultat c	lu test	
D (mm)	L (mm)	L/D	Masse (g)		État	Force - rupture	e (kN)		σ _t (MPa)
63,37	29,85	0,5	264,8		SEC	1282			4,106
Type de roche :		Mix of	shale and white	e cher	t.	Durée (min) :			1,04
Note :						Validité :			OUI
Cell	lule de char	rge : SATI	EC 400K			Taux : 20	00 N/sec		
	BR	£ • 0	BY 9 10 11	22 1		ASE - O BRE-O BRE-O BRE-O	8 9		
			9 10 11 12	. 13				×	
	A	VANT			APR	25			

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$\uparrow \bigcirc \bigcirc$	Échant	tillon	No. Essai		Forage	F	Profondeur (m)	Opéra	iteur	Date
L↓	RS-3	31	BRE-026		BH-01	1	28,30@128,60	CJ-JI	KM	11/11/2014
D -	Caracté	éristiques	de l'échantillon			I	R	ésultat c	du test	
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)
63,47	29,71	0,5	257,7		SEC		43,5			14,69
Type de roche :			Shale.				Durée (min) :			3,61
Note :							Validité :			OUI
Cell	ule de char	ge : SATI	EC 400K				Taux : 20	0 N/sec	1	
	AS BRE	-31 -02	9 10 11	12	3 4		BNE-		· · · ·	12 13 14
				2 1	3 4				11	12 13 14
AVANT						APR	E9			

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$\uparrow \bigcirc \bigcirc$	Échant	tillon	No. Essai	F	orage	F	Profondeur (m)	Opéra	ateur	Date
L↓	RS-:	30	BRE-025	E	3H-01	1	28,05@128,2	CJ-J	KM	11/11/2014
	Caracté	éristiques	de l'échantillon			I	R	ésultat o	du test	<u> </u>
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)
63,41	29,75	0,5	242,9		SEC		50,3			16,97
Type de roche :		·	Shale.				Durée (min) :			4,21
Note :							Validité :			OUI
Cell	ule de char	rge : SATI	EC 400K				Taux : 20	0 N/sec		
	RS BRE		9 10 11 12	4	S 6 7 8		5	12 13 14		
		85-30				4		Ès	10 11	12 13 14
				APK	L0					

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\uparrow	Échant	illon	No. Essai	F	orage	P	Profondeur (m)	Opéra	teur	Date
	RS-3	33	BRE-028	E	BH-01	14	48,04@148,46	CJ-J	KM	11/11/2014
	Caracté	ristiques	de l'échantillon			I	R	ésultat d	du test	
D (mm)	L (mm)	L/D	Masse (g)		État		Force - rupture	(kN)		σ _t (MPa)
63,46	30,48	0,5	252,3		SEC		58,3			19,19
Type de roche :			Sandstone				Durée (min) :			4,86
Note :							Validité :			OUI
Cell	ule de char	ge : SATE	EC 400K				Taux : 20	0 N/sec	1	
	RSBRE	-33	2.8	1.2.1		The second secon	BRC BRC	302	8	
				APR	ÈS					

Annexe 3 -Résistance en compression triaxiale : Feuilles-synthèse

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Essai en compression triaxiale

	Échanti	llon	No. D'ess	sai F	orage		Pr	ofondeur ((m)	Opérateur	Date
D	PLT-1	7	TX-001		BH-04		13	8,20@138	3,50	CJ-JKM	06/11/2014
	Cara	actérist	iques de l'é	chantillon				F	Résult	at du test	
D (mm)	L (mm)	L/D	Aire (m	m ²) Masse (g)	État	σ (MF	¹ Pa)	σ ₃ (MPa)		Force de (kN	rupture)
47,10	97,51	2,1	1742	2,3 644,4	SEC	58,	43	8,08		101	,8
Roc :	Iron o	xide (H	lematite)-M	assive with hyd	roxide.	Dure	ée (n	nin) :		4,12	68
Note :		É	chantillon t	rès fissuré.		Valio	dité :			NO	N
	Cellu	le de cl	harge : 400	К				Taux : 0.7	75	MPa/sec	
	and a state of the	PL: North States	21-1 2001					A A A A A A A A A A A A A A A A A A A			
Remarqu	Remarque sur la rupture : Rupture suivant la foliation à :					jrés pa	ar ra	pport à l'a	xe de	a carotte	
l ype de r Selon u	upture : n plan	A pré									
identifié : Nombre d	ROCHE B	ROYÉE			LLE						

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Essai en compression triaxiale

$\bigcirc \top$	Échanti	llon	No. D'€	essai	F	orage		Pr	ofondeur	(m)	Opérateur	Date
- D - L	RS-4	5	ТХ-0	03	E	BH-04 121,70@121,87 CJ-JKM 06/11/2						06/11/2014
	Cara	actérist	iques de	l'échai	ntillon				F	Résult	at du test	
D (mm)	L (mm)	L/D	Aire	(mm²)	Masse (g)	État	σ (MF	¹ Pa)	σ ₃ (MPa)		Force de l (kN	rupture)
46,56	95,80	2,1	17	02,6	675,8	SEC	71,	36	5,65		121	,5
Roc :	Iron o	kide (H	ematite)-	Massiv	e with hyd	roxide.	Dure	ée (n	nin) :		3,59	02
Note :							Valio	dité :			OU	I
	Cellu	le de c	harge : 4	00K					Taux : 0.7	75 I	MPa/sec	
R5-45 TX-003								A Conversion of the state of th				
Remarqu	e sur la ru	pture	:									
Type de r	upture :	A		DIA	GONALE 🛄	CC	NIQUE		AU	TRE		MIXTE 🔀
Selon u identifié :	n plan	pré				PARTIELL	EMENT	-	PARALI	LÈLE [SUIVAN	T LE CLIVAGE 🗌
Nombre d	e fragmen	ts: +	- de 3 🔀		- de 3 🗌	ROCHE BI	ROYÉE					

Laboratoire de mécanique des roches

Département de génie des mines. de la métallurgie et des matériaux Québec (Québec) Canada G1K 7P4



Faculté des sciences et de génie

Essai en compression triaxiale

	Échanti	llon	No. D'essai	F	orage		Pr	ofondeur ((m)	Opérateur	Date
	RS-4	1	TX-005	E	3H-04		69	9,65@69,9	90	CJ-JKM	12/11/2014
	Cara	actérist	iques de l'écha	ntillon				F	Résult	at du test	
D (mm)	L (mm)	L/D	Aire (mm ²)	Masse (g)	État	σ (MF	¹ Pa)	σ ₃ (MPa)		Force de r (kN)	upture)
46,37	98,57	2,1	1688,7	449,9	SEC	112	,45	4,88		189,9	ЭО
Roc :		Iror	n oxide with whi	te chert.		Dure	ée (n	nin) :		3,880)2
Note :	Foliation	à 20 de	egrés. Fissures	visibles ava	ant l'essai.	Valio	dité :			OU	Ι
	Cellu	le de cl	harge : 400K					Taux : 0.7	75 I	MPa/sec	
		R5-4 172-					01151151151151151151161151151				
Remarqu	e sur la ru	ipture	Échantillon c	oincé dans l	a membrar	ne ap	rès e	essai.			
Selon u identifié :	upture : n plan	A pré		GONALE 🔀	CO PARTIELLI	INIQUE		AU PARALI			
Nombre c	Nombre de fragments : + DE 3 A - DE 3 ROCHE BROYÉE										

Appendix 5 2010 National Building Code Seismic Hazard Calculation



2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836 Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , Site Coordinates: 54.896 North 66.525 West User File Reference:

National Building Code ground motions:

2% probability of exceedance in 50 years (0.000404 per annum)Sa(0.2)Sa(0.5)Sa(1.0)Sa(2.0)PGA (g)0.0950.0570.0360.0140.036

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. *These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.*

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.011	0.035	0.055
Sa(0.5)	0.008	0.023	0.035
Sa(1.0)	0.006	0.015	0.024
Sa(2.0)	0.003	0.007	0.010
PGA	0.003	0.011	0.019

References

National Building Code of Canada 2010 NRCC

no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3

Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation) Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



November 25, 2014