BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CONSTANTINE NORTH INC.

PALMER VMS PROJECT

SEDIMENTATION PONDS AND LAND APPLICATION AREA SITE INVESTIGATION

FINAL

PROJECT NO.: 1790-002 DATE: March 2, 2018

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March 2, 2018
Project No.: 1790002

Darwin Green
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Dear Darwin,

Re: Palmer Sedimentation Ponds and Land Application Area Site Investigation – FINAL

Please find enclosed a copy of our above-referenced final report dated March 2, 2018. Should you have any questions, please contact the undersigned at the number listed above or by email at dcook@bgcengineering.ca.

Yours sincerely,

BGC ENGINEERING INC.
per:

Diana Cook, Ph.D., PE
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EXECUTIVE SUMMARY

A field investigation was undertaken by BGC Engineering Inc. (BGC) on behalf of Constantine North Inc. (Constantine) at the Palmer VMS Project (the Project), located 56 km (35 miles) northwest of Haines, Alaska. The purpose of the field investigation was to collect hydrogeologic and geotechnical data to support conceptual design and permitting discussions for a series of sedimentation ponds, and to determine a suitable area for a land application disposal (LAD).

Three areas were investigated at the Project site. These have been designated as the Waterfall Creek area, the Terminus area, and the Mahogany area (also known as Hangover). The sedimentation ponds were planned for the Terminus area. The potential planned discharge areas were the Terminus area, below the sedimentation ponds, the Waterfall Creek area, and the Mahogany area. A total of eight exploratory test pits were completed to characterize the shallow subsurface conditions, gather information on the engineering properties of the soils encountered, and collect grab samples for laboratory index and hydraulic conductivity testing. To determine a suitable location for a LAD, a total of four infiltration tests were performed in test pits completed in the Waterfall Creek and Mahogany Project areas.

The key findings from the field investigation program are summarized as follows:

- The general stratigraphic profile encountered from test pit excavations is summarized by Project Area as follows:
  - Terminus area soils consisted of, from ground surface to depth, a thin (<0.5 m [1.6 ft]) topsoil horizon followed by a silty clay to sandy gravel glacial till to at least 4.5 m (14.8 ft) depth.
  - Waterfall Creek area soils consisted of, from ground surface to depth, a thin horizon of cobbly topsoil at surface, and a sandy gravel alluvial or fluvial unit with cobbles to at least 3.6 m (11.8 ft) depth.
  - Mahogany area soils consisted of, from ground surface to depth, a thin layer of topsoil, a sand and gravel unit (likely of alluvial origin) to approximately 1.0 m (3.3 ft) depth, and a sandy, cobbly gravel (also interpreted to be alluvial) to at least 4.5 m (14.8 ft) depth.
- The water table depth in the Waterfall Creek area corresponded closely to the creek level.
- Infiltration testing was completed in the Waterfall Creek and Mahogany area test pits.
  - Infiltration testing indicated a hydraulic connection from the upper Waterfall Creek test pit to the lower test pit over a distance of about 100 m (328 ft), as evidenced by seepage observed in the lower test pit during the infiltration test in the upper test pit.
  - Based on preliminary infiltration rates observed during testing, only Mahogany Area test pits were selected for detailed analysis. The measured infiltration rate for Mahogany area soils during infiltration testing was 3.2×10^{-4} m/s (45 in/hr) at a water depth of 2.7 m. The results were consistent at both test pits.
- Laboratory testing on Waterfall Creek area samples indicated a geometric mean hydraulic conductivity value of 2.9×10^{-6} m/s.

Based on the space available for the proposed facilities, the field investigations, and the laboratory testing program conducted by BGC, the Mahogany area is the recommended option for the proposed LAD in the Project area. The Terminus area is the recommended option for the proposed sedimentation ponds.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

LIST OF DRAWINGS

LIMITATIONS

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1.0 INTRODUCTION

BGC Engineering Inc. (BGC) was retained by Constantine North Inc. (Constantine) to conduct a field investigation to support conceptual design of an exploration water management system at the Palmer Volcanogenic Massive Sulphide (VMS) Project (the Project), located approximately 56 km (35 miles) northwest of Haines, Alaska (Drawing 01).

Palmer is a high-grade VMS project that is currently in a multi-year exploration phase to evaluate the scale of potential development. With plans for advancing an exploration ramp, Constantine is proposing to collect intercepted groundwater and potentially impacted surface water from the immediate mine portal area into a series of sedimentation ponds that will be located downgradient of the portal. Water collected in the sedimentation ponds will be discharged to the subsurface using a land application disposal (LAD) method, provided a suitable area is identified.

This report outlines the field investigation methodology, summarizes the field program findings, and presents the current understanding of near-surface hydrogeology downgradient of the mine portal. It is anticipated that results from the field program will be used to support conceptual design for the sedimentation ponds and LAD area for management of exploration groundwater and potentially impacted surface water.

1.1. Background

Previous hydrogeological testing by Tundra Consulting LLC (Tundra 2017a) indicated that “large quantities of water may be discharged from… [the proposed] adit” at the Project site. In a plan developed to manage the anticipated adit water, a series of sedimentation ponds (two) were proposed, followed by discharge to surface using a LAD. To determine a suitable location for a LAD, a total of nine in-situ small-scale pilot infiltration tests (PITs) were performed within three different project areas, the Terminus, Waterfall and Mahogany (also known as Hangover) areas (Drawing 01; Tundra 2017b) between June 25 and July 15, 2017. Results of the investigation were used by Tundra to form the following conclusions:

- The Terminus area, composed primarily of glacial till, had minimal to no capacity for infiltration, making the area unsuitable for a LAD.
- The Waterfall area, composed of a mix of glacial outwash and debris flow material, had large infiltration rates (at least 25 m/hr [980 in/hr], based on two test locations), but was subject to water disposal design constraints (e.g., Alaska Pollutant Discharge Elimination System [APDES] permit likely required due to proximity to Waterfall Creek).
- The Mahogany area, composed of alluvial and debris flow material, had an average infiltration rate of 0.5 m/hr (21 in/hr, based on three tests), varying from 0.2 to 0.7 m/hr (8 to 30 in/hr) and presented the best potential zone for a LAD.

Based on these results, additional in-situ large-scale PITs were recommended near the Mahogany and Waterfall Creek Areas, prior to proceeding with final LAD siting and conceptual design.

In a proposal submitted September 21, 2017, BGC provided recommendations for an area expected to be adequately sized for the proposed sedimentation ponds (e.g., Terminus area), and two alternate areas for the LAD (BGC 2017). The first proposed alternate location for the LAD was in the Mahogany area on the alluvial deposit east of Waterfall Creek, as shown in Drawing 01, and the other was within the Terminus area between Waterfall Creek and the proposed Avalanche Berm. The lower portion of the Terminus area (below El. 570 m) was expected to be a groundwater discharge area based on prior infiltration testing (Tundra 2017b), and was therefore not expected to provide an appropriate location for the LAD.

Two sediment ponds were proposed to each provide a minimum of approximately 1,900 cubic meters (m^3) of water storage (500,000 US gallons or 1.5 acre-feet), which is equivalent to a retention time of about 17 hours (each), assuming an average discharge flow of 32 liters per second (L/s) or 500 gallons per minute (gpm) (J. DiMarchi, personal communication, July 2017). Water from the lower sedimentation pond would flow to the LAD, which would conceptually consist of a series of perforated pipes or infiltration trenches, to discharge water into the local groundwater system. In addition to the LAD, a planned optional diffuser discharge to Waterfall Creek would conceptually consist of a perforated pipe buried near Waterfall Creek, designed to limit additional sediment load to Waterfall Creek. The above-described water collection system would be anticipated to operate actively for the period of exploration only, or approximately three years, with additional passive operation possible, depending on ongoing Project needs.

1.2. Project Objective and Scope of Work

The objective of the field investigation was to provide sufficient hydrogeologic and geotechnical data to support conceptual design of the sedimentation ponds and LAD.

BGC's scope of work for the field investigation program consisted of the following tasks:

- Excavation of eight test pits in the sedimentation pond and LAD areas.
- Collection of overburden samples from test pits and performance of laboratory testing for grain size distribution and moisture content and selected hydraulic conductivity tests (LAD area samples).
- Performance of in-situ large-scale PITs in each potential LAD area and at the pond locations (four total), with analysis as required.
- Characterization of subsurface materials based on the collected subsurface data and laboratory test results.

This report summarizes the findings of the field investigation; conceptual design of the LAD, diffuser system and sedimentation ponds is in progress for presentation in a separate report (BGC 2018).

1.3. Project Setting

The proposed location for the two adjacent sedimentation ponds is directly below the planned portal site on a sloping till deposit between two glacial outwash valleys (Glacier Creek and Waterfall Creek in Drawing 01) and below a slope break, referred to as the Terminus area. The

proposed LAD location is on an alluvial fan comprised of poorly sorted sandy gravel, on the west side of the site between Waterfall Creek and another glacial outwash valley, Hangover Creek (Drawing 01); this area has been referred to as the Mahogany area (also known as Hangover). The alluvial deposits and colluvial material are mainly derived from glacial till and have been deposited in a relatively high energy environment. The Mahogany area is characterized by poorly sorted and poorly stratified mixtures of silt, sand, gravel, cobbles and boulders. With frequent and episodic events (floods, debris flows and avalanches) creating the surface deposits, the fan is generally interlayered with finer material (lower permeability) and coarser material (higher permeability) up to boulder sizes.

The Terminus area is a recessional moraine with clay-rich till typically found 0.3 m (1.0 ft) below ground surface (bgs) (Tundra 2017b). Tundra (2017b) interpreted the upper portion of the Terminus area (estimated by BGC as above El. 570) to be a hydrologic recharge zone, collecting and transmitting groundwater and infiltrating surface flows to lower portions of the fan. Tundra (2017b) interpreted the lower portion of the Terminus area (estimated by BGC as below El. 570) to be a groundwater discharge area, with the phreatic level at the surface and numerous springs and seeps feeding the downgradient streams.

2.0 METHODOLOGY

Drawing 01 shows the Project site, including the locations of test pits excavated during both the June/July field investigation conducted by Tundra (2017b) and the October 2017 field investigation conducted by BGC. Large-scale in-situ PITs were performed in the potential LAD area encompassing Waterfall Creek and the Mahogany Area.

2.1. Test Pit Excavations

A total of eight exploratory test pits were completed at the sedimentation pond and LAD sites between October 11 and 14, 2017 (Drawing 01). A Caterpillar 320D LRR track-mounted hydraulic excavator, provided by Constantine, was used to excavate the test pits to the maximum reach of the excavator or until refusal (approximately 3 to 5 m depth, or 9.8 to 16.4 ft). The soil was logged at each site and disturbed grab samples were collected for laboratory testing. Samples were collected either from the excavator bucket or from the soil piles. The logging included depth, lithology and other pertinent descriptions. After logging and infiltration testing were completed for select test pits (Section 2.2), the holes were backfilled using the excavated material, tamped in-place with the excavator bucket, then marked with flagging tape and surveyed with a Trimble Geo 7X Rangefinder, H-Star handheld GPS. Test pit ITP-29 (Proposed BGC TP02) was backfilled with a conduit in place for subsequent installation of a thermistor[1] string by Tundra on October 16, 2017.

The soil samples collected in the field were shipped to BGC's Fredericton, New Brunswick, Canada laboratory for moisture content determination (ASTM D2216-10), grain size analysis (ASTM D-6913 Method A), and hydraulic conductivity testing (ASTM D5856-15; Method B). The latter two tests were only completed on select samples from test pits in the Waterfall Creek and Mahogany areas since previous work by Tundra (2017b) and field observations of high silt content in the Terminus area test pits at the time of the excavations (Section 3.2.1) indicated infiltration in this area would be limited.

2.2. Infiltration Testing

The infiltration testing conducted for this field program is a non-standard test designed by BGC to replicate a small-scale version of the LAD, such that the results can be scaled up directly to represent LAD behavior. With logistical support from Constantine and Tundra, BGC completed one infiltration test in each of the following four test pits: ITP-27 (TP06A), ITP-28 (TP06), ITP-33 (TP07), and ITP-34 (TP08), for a total of four infiltration tests. A known flowrate of water was discharged into the excavation until the depth of water stabilized for each infiltration test. Flow into the excavation was measured in gallons using a Recordall Badger Meter flowmeter and

[1] The thermistor was not installed during the field program because the datalogger was missing a configuration file. Details on thermistor design and installation are outside the scope of this report.

recorded manually. Each test was conducted in series and took approximately half a day to complete. Infiltration test equipment was provided by Constantine and included:

- A pump, a generator and a flowmeter capable of 6.3 L/s (100 gpm)
- Waterline, 50.8 mm (2-inch) in diameter, and couplings of sufficient length to link each target test location to Waterfall Creek, and connectors to link with the pump and flowmeter
- 50.8 mm (2-inch) discharge hose and energy diffuser
- 20 L (5-gallon) bucket to measure flow rates independent of flowmeter
- Ball valves and tees to control and divert flow as needed
- Spare parts and tools necessary to assemble/disassemble test equipment
- Flagging tape to mark test locations and access
- Pickup truck, excavator and ATV to transport equipment.

Constantine support staff were on site to transport equipment, lay hose, make and break couplings and provide additional support, as needed.

3.0 RESULTS

3.1. Test Pit Excavations

The location of the test pits is shown in Drawing 01 and summarized in Table 3-1, including the depths of collected grab samples. The test pit logs and photographs[2] are provided in Appendix A.

Table 3-1. Test pit and sampling summary.

Constantine Test Pit Name	BGC Test Pit Name	Northing (m)	Easting (m)	Elevation (m asl)	Depth of Hole (m)	Sample ID
ITP-27	TP06A	6583679	421792	591.5	3.4	TP06A 0-2.0 M
						TP06A 3.3 M
ITP-28	TP06	6583762	421864	571.0	3.6	TP06 2.0 M
						TP06 3.6 M
ITP-29	TP02	6583862	421814	560.2	4.5	TP02 2.0 M
						TP02 3.5 M
ITP-30	TP01	6583861	421775	560.5	4.2	TP01 2.0 M
						TP01 4.2 M
ITP-31	TP04	6583804	421722	576.2	4.5	TP04 2.0 M
						TP04 4.5 M
ITP-32	TP03	6583786	421771	580.4	4.0	TP03 1.0 M
						TP03 3.0 M
ITP-33	TP07	6583937	422080	561.7	4.5	TP07 0-1 COMP
						TP07 3-4.5 COMP
ITP-34	TP08	6583943	422022	549.4	4.2	TP08 0-1 COMP
						TP08 2-2.7 COMP
						TP08 4.0-4.2 COMP

Note: Coordinates collected by Constantine using a Trimble Geo 7X Rangefinder, H-Star GPS; projection is NAD 83 UTM Zone 8N.

3.2. General Stratigraphy

This section provides a stratigraphic summary of the thickness of each of the geologic units encountered at the test pit locations, as well as observed depths of groundwater seepage in the Terminus area (Section 3.2.1), Waterfall Creek area (Section 3.2.2) and Mahogany area (Section 3.2.3).

[2] No photographs available for ITP-30.

3.2.1. Terminus Area

The four Terminus area test pits (ITP-29 [TP02], ITP-30 [TP01], ITP-31 [TP04] and ITP-32 [TP03]) presented a similar stratigraphic profile, with thin horizons of topsoil (0.1 to 0.5 m [0.3 to 1.6 ft]) at surface and glacial till to 4.0 and 4.5 m (13.1 and 14.8 ft) depth in ITP-32 (TP03) and ITP-31 (TP04), respectively. In ITP-31 (TP04), the glacial till was generally described as a well graded, sandy, cobbly gravel with some fines, and silt observed from 0.1 to 1.4 m (0.3 to 4.6 ft) depth. In ITP-32 (TP03), the glacial till was described as a sandy gravel, with some clay and some silt to 3.0 m (9.8 ft) depth and a gravelly silty sand to 4.0 m (13.1 ft) depth; a 0.2 m (0.7 ft) lens of clayey, sandy gravel was observed at 2.7 m (8.9 ft) bgs. In ITP-29 [TP02], a lens of organic material containing woody debris was found at 2.3 m (7.5 ft) depth. No visible water (i.e., groundwater) was encountered during the excavations in this area.

3.2.2. Waterfall Creek Area

The typical stratigraphy encountered in the two test pits completed in the Waterfall Creek area (ITP-27 [TP-06A] and ITP-28 [TP06]) comprised thin horizons of cobbly topsoil (<0.2 m [0.7 ft]) at surface, and sandy, cobbly gravel alluvial or fluvial material to 3.4 and 3.6 m (11.2 and 11.8 ft) depth at ITP-27 (TP06A) and ITP-28 (TP06), respectively. Natural groundwater seepage was observed during test pit excavation of ITP-28, at a depth of between 1.5 m and 2.5 m (4.9 and 8.2 ft) below ground surface (bgs); the flowrate was estimated at 0.06 to 0.1 L/s (1 to 2 gpm). The soil moisture condition observed in ITP-27 (TP06A) was moist to wet. Bedrock was not encountered to the depth of the excavations.

3.2.3. Mahogany Area

The general stratigraphic profile encountered in test pits completed in the Mahogany area (ITP-33 [TP07] and ITP-34 [TP08]) comprised, from ground surface to depth, a thin layer of topsoil (<0.5 m [1.6 ft], ITP-33 only), followed by silty sand and gravel with some cobbles to approximately 1.0 m to 4.2 m (3.3 to 13.8 ft) depth in ITP-33 and ITP-34, respectively. In ITP-33, the silty sand and gravel graded into a cobbly, sandy gravel with some fines to refusal at 4.5 m (14.8 ft). The soil moisture condition observed in both test pits was moist, and no visible water was encountered during the excavations. Bedrock was not encountered to the depth of the excavations.

3.3. Infiltration Testing

Infiltration testing was completed in Waterfall Creek area test pits (ITP-27 [TP06A], ITP-28 [TP06]) and Mahogany area test pits (ITP-33 [TP07] and ITP-34 [TP08]). Based on field observations of high fines content in the Terminus area test pits at the time of the excavations, infiltration testing was not conducted in the proposed sedimentation pond locations. Furthermore, based on the shallow observed groundwater table in the Waterfall Creek test pits and observed groundwater seepage into the lower Waterfall Creek test pit (ITP 28) during the upper Waterfall Creek test pit (ITP 27) infiltration test, only Mahogany area test pits were selected for analysis (ITP-33 [TP07] and ITP-34 [TP08]). For both tests, the infiltration rate (or hydraulic conductivity; K) was calculated

for a point in time using a modified form of Darcy's Law to account for one-dimensional spherical flow:

$$K = \frac{qA}{4\pi rh}$$

Where:

q = flow to formation (m/s)

A = wetted area of test pit

r = spherical radius of infiltration, calculated as the cube root of the volume of water in test pit

h = depth of water in test pit.

Using this equation, the average infiltration rate from both tests was 3 x 10^{-5} m/s. A summary of infiltration testing parameters and results is provided in Table 3-2; infiltration test data for the two tests analyzed is provided in Appendix B.

Table 3-2. Summary of Mahogany infiltration testing parameters and results.

Constantine Test Pit Name	BGC Test Pit Name	Test Pit Dimensions (m)		Steady State Infiltration Rate (m^3/s)	Steady State Infiltration Rate (m/s)	Area (m^2)	Infiltration (Wetted) Area	Hydraulic Conductivity (m/s)
		Length	Width					
ITP-33	TP07	4.0	2.2	2.8 x 10^{-3}	3.2 x 10^{-4}	8.8	41.9	3.1 x 10^{-5}
ITP-34	TP08	5.3	2.2	3.8 x 10^{-3}	3.3 x 10^{-4}	11.7	51.4	3.0 x 10^{-5}

Notes:
1. Test pit dimensions, area and infiltration area values reflect location of the water table in pit during which flow to the test pit equated infiltration to formation.
2. Steady state infiltration rate reflects conditions of constant flow and steady water level at end of flow portion of testing. The corresponding water depth was 2.7 m.

3.4. Laboratory Testing

Laboratory results from testing completed on select soil grab samples are summarized in Table 3-3. Laboratory reports are provided in Appendix C.

3.4.1. Index Testing

A total of seventeen samples were collected from the test pits. Fourteen of these samples were submitted for gravimetric water content determination and sieve analysis; eight in the Terminus area, three in the Waterfall Creek area, and three in the Mahogany area. In the Terminus area, test pit samples had an arithmetic average gravimetric water content of 9%, and average composition of 52% gravel, 30% sand, 19% fines. In the Waterfall Creek area, test pit samples had an arithmetic average gravimetric water content of 8%, and average composition of 57% gravel, 30% sand, 13% fines. In the Mahogany area, test pit samples had an arithmetic average

gravimetric water content of 8%, and average composition of 54% gravel, 34% sand, 12% fines. The fines are defined as passing the minus 200 mesh, or 0.075 mm in diameter, and could be either silt or clay. The laboratory-measured fines contents confirmed the field interpretation that the fines contents in the Mahogany area are typically lower than the fines contents in the Terminus area. Terminus area fines contents were uncorrelated with depth.

3.4.2. Hydraulic Conductivity Testing

Five samples, two from Waterfall Creek area test pits and three from Mahogany area test pits were submitted for hydraulic conductivity (K) testing. Results for the Waterfall Creek area and Mahogany area samples indicated a geometric mean average K value of 2.9×10^{-6} m/s and 3.4×10^{-6} m/s, respectively. Individual results are summarized in Table 3-3 and include grain size distributions from sieve analyses.

Table 3-3. Laboratory results.

Constantine Test Pit Name	BGC Test Pit Name	General Area	Sample ID	Sample Depth (m)	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	Hydraulic Conductivity[1] (m/s)	Dry Density[1] g/cm^3
ITP-27	TP06A	Waterfall Creek	TP06A 0-2.0 M	2.0	-	-	-	-	-	-
			TP06A 3.3 M	3.3	6.0	61	29	10	4.3×10^{-6}	1.99
ITP-28	TP06	Waterfall Creek	TP06 2.0 M	2.0	7.0	59	30	11	-	-
			TP06 3.6 M	3.6	10.2	50	32	17	4.5×10^{-6}	1.85
ITP-29	TP02	Terminus	TP02 2.0 M	2.0	7.8	49	32	18	-	-
			TP02 3.5 M	3.5	9.0	55	28	17	-	-
ITP-30	TP01	Terminus	TP01 2.0 M	2.0	6.9	57	31	13	-	-
			TP01 4.2 M	4.2	8.6	52	29	18	-	-
ITP-31	TP04	Terminus	TP04 2.0 M	2.0	9.4	48	33	19	-	-
			TP04 4.5 M	4.5	10.0	66	16	19	-	-
ITP-32	TP03	Terminus	TP03 1.0 M	1.0	7.9	42	34	25	-	-
			TP03 3.0 M	3.0	9.8	46	35	19	-	-
ITP-33	TP07	Mahogany	TP07 0-1.2 COMP	0-1.2	-	-	-	-	-	-
			TP07 3-4.5 COMP	3-4.5	8.1	50	36	14	1.1×10^{-6}	1.80
ITP-34	TP08	Mahogany	TP08 0-1 COMP	0-1	-	-	-	-	-	-
			TP08 2-2.7 COMP	2-2.7	6.6	61	30	9	1.7×10^{-5}	1.81
			TP08 4.0-4.2 COMP	4.0-4.2	8.6	52	35	13	1.3×10^{-6}	1.78

Notes:

1. For hydraulic conductivity testing, samples were not remolded to a specified dry density, but instead loosely packed prior to testing. The dry density of each sample following this compaction is specified here and in Appendix C.
2. "-" indicates sample was not tested.

4.0 CONCLUSIONS

The purpose of the field investigation was to provide hydrogeologic and geotechnical data to support conceptual designs of the sedimentation ponds and LAD. Objectives of the test pit program were to characterize the shallow subsurface conditions, gather information on the engineering properties of the soils encountered, and collect grab samples for laboratory index and laboratory hydraulic conductivity testing.

The key findings from the field investigation program are summarized as follows:

- The general stratigraphic profile varied based on test pit location: Terminus, Waterfall Creek, and Mahogany areas.
    - Terminus area soils consisted of, from ground surface to depth, a thin (<0.5 m [1.6 ft]) topsoil horizon followed by a sandy gravel glacial till to a depth of at least 4.5 m (14.8 ft).
    - Waterfall Creek area soils consisted of, from ground surface to depth, a thin horizon of cobbly topsoil at surface, and a sandy gravel alluvial or fluvial unit with cobbles to at least 3.6 m (11.8 ft) depth.
    - Mahogany area soils consisted of, from ground surface to depth, a thin layer of topsoil, a sand and gravel unit (likely of alluvial origin) to approximately 1.0 m (3.3 ft) depth, and a sandy, cobbly gravel (also interpreted to be alluvial) to at least 4.5 m (14.8 ft) depth.
- Natural groundwater seepage was observed during test pit excavation of ITP-28 (TP06) in the Waterfall Creek area, between 1.5 m and 2.5 m (4.9 and 8.2 ft) bgs; the flowrate was estimated as 0.06 to 0.1 L/s (1 to 2 gpm). No visible water (i.e., groundwater) was encountered during the other seven test pit excavations.
- Infiltration testing was completed in Waterfall Creek area test pits ITP-27 (TP06A) and ITP-28 (TP06), and Mahogany Area test pits ITP-33 (TP07) and ITP-34 (TP08). The shallow groundwater table conditions and groundwater seeps observed at the Waterfall Creek area during infiltration testing precluded infiltration test analyses at Waterfall Creek. Therefore, only Mahogany area test pits were selected for infiltration test analysis (ITP-33 [TP07] and ITP-34 [TP08]). The average infiltration rate for Mahogany Area soils based on infiltration testing at ITP-33 (TP07) and ITP-34 (TP08) was 3.2×10^{-4} m/s (45 in/hr) at a water depth of 2.7 m.
- Laboratory K testing competed on Mahogany area sandy gravel soils had a geometric mean of three tests of 3.4×10^{-6} m/s (0.4 in/hr).
- Laboratory K testing on Waterfall Creek area samples indicated a geometric mean average K value of 2.9×10^{-6} m/s.

Overall, results confirm previous field investigations, with the Mahogany area presenting the best option for the proposed LAD in the Project area. The site investigation results will be used to support the ongoing conceptual design for sediment ponds and discharge system.

5.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

Brent Mooder, M.Sc., P.Eng.
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Michael Henderson, Ph.D., P.E., P.Eng.
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Reviewed by:

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DC/TR/hwn/mm

REFERENCES

BGC Engineering Inc. 2017. Field Investigation Proposal – Palmer Sedimentation Ponds and Land Application Area. *Prepared for* Constantine North Inc., September 21, 2017.

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APPENDIX A
TEST PIT LOGS

SYMBOLS AND TERMS
FOR SOIL DESCRIPTIONS ON DRILL HOLE LOGS

Project: Palmer VMS Project—Sedimentation Ponds and LAD SI

Project Number: 1790-002

CLASSIFICATION BY PARTICLE SIZE [a]

NAME	SIZE RANGE		
	(mm)	US STANDARD SIEVE SIZE	
		Retained	Passing
Boulders	> 300	12 inch	-
Cobbles	75 - 300	3 inch	12 inch
Gravel: Coarse Fine	19 - 75 4.75 - 19	0.75 inch No. 4	3 inch 0.75 inch
Sand: Coarse Medium Fine	2 - 4.75 0.43 - 2 0.075 - 0.43	No. 10 No. 40 No. 200	No. 4 No. 10 No. 40
Fines (Silt or Clay) [d]	< 0.075	-	No. 200

PROPORTION OF MINOR COMPONENTS BY WEIGHT [b]

And	> 35%
y/ey	20% to 35%
Some	10% to 20%
Trace	> 0% to 10%

PARTICLE SHAPE [c]

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and Elongated	Particles that meet both criteria for flat and elongated
Equidimensional	Equal extents

GRADATION [e]

Well Graded	Range of particle sizes
Gap Graded	Range of particle sizes with some absent
Uniformly Graded	Uniform size of particles

ANGULARITY [c]

Angular	Particles have sharp edges and relatively planar sides with unpolished surfaces
Subangular	Particles are similar to angular description but have some rounded edges
Subrounded	Particles have nearly planar sides but have well rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

CEMENTATION [c]

Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

DENSITY OF GRANULAR SOILS [b, f]

DESCRIPTION	SPT N	FIELD IDENTIFICATION
Very Loose	0 - 4	Easily penetrated with a 12 mm rod pushed by hand
Loose	4 - 10	
Compact	10 - 30	Penetrated 300 mm with 12 mm rod driven by a 2.3 kg hammer
Dense	30 - 50	
Very Dense	> 50	Penetrated 25 to 50 mm with 12 mm rod driven by a 2.3 kg hammer

NATURAL MOISTURE CONDITION [c]

Dry	Absence of moisture
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

STRUCTURE [c]

Stratified	Alternating layers of varying material or colour with layers at least 6 mm thick
Laminated	Alternating layers of varying material or colour with the layers less than 6 mm thick
Fissured	Breaks along definite planes or fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps
Lensed	Inclusion of small pockets of different soils
Homogeneous	Same colour and appearance throughout
Heterogeneous	Colour and appearance vary throughout

SYMBOLS AND TERMS
FOR SOIL DESCRIPTIONS ON DRILL HOLE LOGS

Project: Palmer VMS Project—Sedimentation Ponds and LAD SI | Project Number: 1790-002

PLASTICITY OF COHESIVE SOILS [e]		
DESCRIPTION	**LIQUID LIMIT (LL) [a]**	**FIELD CRITERIA [c]**
High Plasticity	> 50%	It takes considerable time rolling and kneading to reach the plastic limit — a 3 mm thread can be rerolled several times after reaching the plastic limit — the lump can be formed without crumbling when drier than the plastic limit
Low Plasticity	< 50%	A 3 mm thread can be rolled (with some difficultly or ease) but cannot be rerolled after reaching the plastic limit — a lump cannot be formed, or crumbles when drier than the plastic limit
Non Plastic	-	A 3 mm thread cannot be rolled at any water content

CONSISTENCY OF COHESIVE SOILS [b, f, g]			
DESCRIPTION	**SPT N**	**UNDRAINED SHEAR STRENGTH - s_u (kPa)**	**FIELD IDENTIFICATION**
Very soft	< 2	< 12	Easily penetrated several centimeters by the fist
Soft	2 - 4	12 - 25	Easily penetrated several centimeters by the thumb
Firm	4 - 8	25 - 50	Can be penetrated several centimeters by the thumb with moderate effort
Stiff	8 - 15	50 - 100	Readily indented by the thumb but penetrated only with great effort
Very Stiff	15 - 30	100 - 200	Readily indented by the thumbnail
Hard	> 30	> 200	Indented with difficulty by the thumbnail

MOISTURE CONDITION OF PLASTIC COHESIVE SOILS	
Drier than the Plastic Limit (DTPL)	A thread rolled at the natural water content is greater than 3 mm in diameter
Near the Plastic Limit (NPL)	A thread rolled at the natural water content is approximately 3 mm in diameter
Wetter than the Plastic Limit (WTPL)	A thread rolled at the natural water content is greater than 3 mm in diameter

SENSITIVITY [b, f]	
St	**Sensitivity**
St < 2	Low Sensitivity
2 < St < 4	Medium Sensitivity
4 < St < 8	Sensitive
8 < St < 16	Extra Sensitive
St > 16	Quick Clay
St = Ratio of intact to remoulded strength	

DRY STRENGTH [c]	
None	The dry specimen crumbles into powder upon applying pressure or handling
Low	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very High	The dry specimen cannot be broken between the thumb and a hard surface

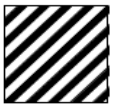
DILATANCY [c]	
None	No visible change in the specimen during shaking or squeezing
Slow	Water appears slowly on the surface of the specimen during shaking and disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

SYMBOLS AND TERMS
FOR SOIL DESCRIPTIONS ON DRILL HOLE LOGS

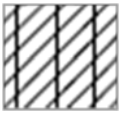
Project: Palmer VMS Project—Sedimentation Ponds and LAD SI

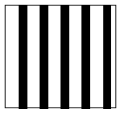
Project Number: 1790-002

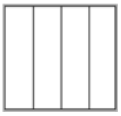
SOIL LITHOLOGICAL GRAPHIC LOG LEGEND

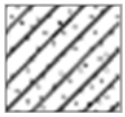

High Plasticity Clay


Low Plasticity Clay

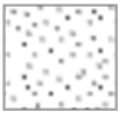

Silt / Clay

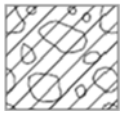

High Plasticity Silt


Low Plasticity Silt


Clay / Sand

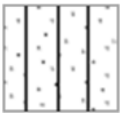

Well Graded Sand

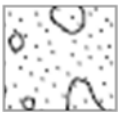

Poorly Graded Sand

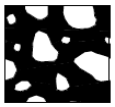

Clay / Gravel


Well Graded Gravel

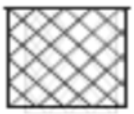

Poorly Graded Gravel

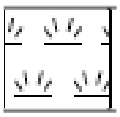

Silt / Sand


Sand / Gravel


Boulders and Cobbles


Silt / Gravel


Fill


Peat / Topsoil

SITU AND LABORATORY TESTING SYMBOLS

○ Moisture Content	⇿ Plasticity Index	★ % Fines
△ Pocket Penetrometer (PP) Result (Expressed as PP/2 in kPa)		

SAMPLE SYMBOLS

 Grab Sample	 SPT / LPT Samples	 Lexan Sample

LIST OF ACRONYMS

MPS	Maximum Particle Size Observed in Core
VWP	Vibrating Wire Piezometer
m bgs	Metre Below Ground Surface
m asl	Metre Above Sea Level
m bTOP	Metre Below Top of Pipe
m ags	Metre Above Ground Surface
Wp	Plastic Limit
Wl	Liquid Limit
S/N	Serial Number

SYMBOLS AND TERMS
FOR SOIL AND ROCK DESCRIPTIONS ON DRILL HOLE LOGS

Project: Suncor DPL | Project Number: 0292-086

NOTES AND REFERENCES

NOTES

Soil:

a. After ASTM Standard D2487-11, Unified Soil Classification System (USCS).
b. After Canadian Geotechnical Society, 2006.
c. After ASTM Standard D2488-09a.
d. Fines are classified as silt or clay on the basis of plasticity and Atterberg limits (refer to plasticity chart).
e. Gradation and plasticity descriptions on logs are a judgment based combination of field visual-manual identification and laboratory index testing where available.
f. Terzaghi, Peck and Mesri, 1996
g. Undrained shear strength can be estimated by shear vane (gives S_u), pocket penetrometer (gives unconfined compressive strength, qu = 2 * S_u), or unconfined compression test (gives qu = 2 * S_u).

General:

- Log depths are rounded to the nearest 10 cm.
- Genesis classifications are given where possible in square brackets and are interpretations subject to change.

REFERENCES

American Society for Testing and Materials. Standard D2487-11: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). West Conshohocken, PA.

American Society for Testing and Materials. Standard D2488-09a: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). West Conshohocken, PA.

Bieniawski, Z. T. 1976. Rock mass classification in rock engineering. In: Proceedings of the Symposium on Exploration for Rock Engineering. Johannesburg; pg: 92 - 106

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual 4th Edition. pp. 488.

International Society of Rock Mechanics (ISRM). 1978. Suggested methods for the quantitative descriptions of discontinuities in rock masses. International Journal of Rock Mechanics and Mining Sciences. 15(6), 319-368.

Methods for the Quantitative Description of Discontinuities in Rock Masses. Committee on Field Tests, Document No. 4, pp. 319-368.

Terzaghi, K., Ralph B. Peck, and Gholamreza Mesri. 1996, Soil Mechanics in Engineering Practice, John Wiley and Sons, New York.

Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-27

Co-ordinates (m): 421,792E; 6,583,679N
Ground Elevation (m): 591.5
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Waterfall Creek
Excavator: Caterpillar 320D LRR
Operator: Constantine

Start Date: 11 Oct 2017
Finish Date: 11 Oct 2017
Final Depth Of Pit (m): 3.4
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				TOPSOIL - 0 m to 0.2 m		
				GRAVEL and SAND - 0.2 m to 2.0 m some cobbles, some silt, trace boulders, trace clay, well graded, subangular to angular, grey, moist, heterogeneous. [ALLUVIAL or FLUVIAL]		
1		TP06A 0-2.0 M				
2				GRAVEL - 2.0 m to 3.4 m Cobbly, sandy, silty, trace boulders, trace clay, well graded, subangular, grey, moist to wet, heterogeneous, MPS = 610 mm. [ALLUVIAL or FLUVIAL]		
3				At 3.0 m - Boulder, > 900 mm in diameter.		
		TP06A 3.3 M		END OF TEST PIT at 3.4 m NOTES: 1. Test pit terminated at extent of excavator reach. 2. No visible water encountered in test pit.	Sample TP06A 3.3 M (3.3 m): Sieve analysis - Gravel 61%, Sand 29%, Fines 10%.	○
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Client: Constantine North Inc.

CONSTANTINENORTH (TESTPIT) CONSTANTINENORTH.GDL BGC.GDT 2/20/18

Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-28

Co-ordinates (m): 421,864E; 6,583,762N
Ground Elevation (m): 571
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Waterfall Creek
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 11 Oct 2017
Finish Date: 11 Oct 2017
Final Depth Of Pit (m): 3.6
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				TOPSOIL - 0 m to 0.1 m		
				GRAVEL - 0.1 m to 3.6 m Cobbly, sandy, trace boulders, trace silt, well graded, dense, subangular to angular, grey, moist to wet, heterogeneous. [ALLUVIAL or FLUVIAL]		
1						
					1.5 m to 2.5 m - Seepage, flowrate approximately 0.06 to 0.1 L/s (1 to 2 gpm).	
2		TP06 2.0 M			Sample TP06 2.0 M (2.0 m): Sieve analysis - Gravel 59%, Sand 30%, Fines 11%.	○
3						
		TP06 3.6 M		END OF TEST PIT at 3.6 m NOTES: 1. Test pit terminated at extent of excavator reach.	Sample TP06 3.6 M (3.6 m): Sieve analysis - Gravel 50%, Sand 32%, Fines 17%.	○
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Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-29

Co-ordinates (m): 421,814E; 6,583,862N
Ground Elevation (m): 560.2
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Terminus
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 11 Oct 2017
Finish Date: 11 Oct 2017
Final Depth Of Pit (m): 4.5
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				TOPSOIL - 0 m to 0.2 m		
				CLAY - 0.2 m to 2.0 m Sandy, silty, some gravel, some cobbles, trace boulders, firm to stiff, brownish grey; coarse fraction is well graded, dense, angular to subangular, grey, moist, heterogeneous. [GLACIAL TILL]		
1						
2				GRAVEL - 2.0 m to 4.5 m Sandy, some fines, well graded, angular to subangular, brownish grey, moist, heterogeneous. [GLACIAL TILL]		
		TP02 2.0 M			Sample TP02 2.0 M (2.0 m): Sieve analysis - Gravel 49%, Sand 32%, Fines 18%.	○
3				At 2.3 m - Bluish grey, lens of organic material with woody debris.		
		TP02 3.5 M		At 3.5 m - Trace iron oxide staining.	Sample TP02 3.5 M (3.5 m): Sieve analysis - Gravel 55%, Sand 28%, Fines 17%.	○
4						
5				END OF TEST PIT at 4.5 m NOTES: 1. Test pit terminated at extent of excavator reach. 2. No visible water encountered in test pit.		
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Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-30

Co-ordinates (m): 421,775E; 6,583,861N
Ground Elevation (m): 560.5
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Terminus
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 11 Oct 2017
Finish Date: 11 Oct 2017
Final Depth Of Pit (m): 4.2
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				TOPSOIL - 0 m to 0.2 m		
				CLAY - 0.2 m to 2.0 m Cobbly, silty, some sand, some gravel, trace boulder, firm to stiff; coarse fraction is dense, angular to subangular, moist. [GLACIAL TILL]		
2		TP01 2.0 M		GRAVEL - 2.0 m to 4.2 m Sandy, some fines, well graded, compact to dense, angular to subangular, moist. [GLACIAL TILL]	Sample TP01 2.0 M (2.0 m): Sieve analysis - Gravel 57%, Sand 31%, Fines 13%.	○
4		TP01 4.2 M		END OF TEST PIT at 4.2 m NOTES: 1. Test pit terminated at extent of excavator reach. 2. No visible water encountered in test pit.	Sample TP01 4.2 M (4.2 m): Sieve analysis - Gravel 52%, Sand 29%, Fines 18%.	○

Moisture Content W% scale: 20, 40, 60, 80

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Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-31

Co-ordinates (m): 421,722E; 6,583,804N
Ground Elevation (m): 576.2
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Terminus
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 12 Oct 2017
Finish Date: 12 Oct 2017
Final Depth Of Pit (m): 4.5
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				TOPSOIL - 0 m to 0.1 m		
				SILT - 0.1 m to 1.4 m Some cobbles, some gravel, trace sand, trace clay, low plasticity, soft to firm, brownish grey; coarse fraction is well graded, subangular to angular, grey, moist, heterogeneous. [GLACIAL TILL] 0 m to 0.5 m - Some roots, 5 mm diameter. At 0.8 m - Wet.		
2		TP04 2.0 M		GRAVEL - 1.4 m to 4.5 m Some cobbles to cobbly, some sand to sandy, some fines, trace to some boulders, well graded, subrounded to angular, brownish grey, moist, heterogeneous. [GLACIAL TILL]	Sample TP04 2.0 M (2.0 m): Sieve analysis - Gravel 48%, Sand 33%, Fines 19%.	○
3				3.0 m to 4.5 m - Wet.		
4				3.5 m to 4.5 m - Some clay.		
5		TP04 4.5 M		END OF TEST PIT at 4.5 m NOTES: 1. Test pit terminated at extent of excavator reach. 2. No visible water encountered in test pit.	Sample TP04 4.5 M (4.5 m): Sieve analysis - Gravel 66%, Sand 16%, Fines 19%.	○
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Client: Constantine North Inc.

CONSTANTINENORTH (TESTPIT) CONSTANTINENORTH.GDL BGC.GDT 2/20/18

Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-32

Co-ordinates (m): 421,771E; 6,583,786N
Ground Elevation (m): 580.4
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Terminus
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 12 Oct 2017
Finish Date: 12 Oct 2017
Final Depth Of Pit (m): 4.0
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				TOPSOIL - 0 m to 0.5 m		
1				GRAVEL - 0.5 m to 3.0 m Sandy, some silt, some clay, trace boulders, well graded, subrounded to subangular, grey, moist, heterogeneous; fines are low plasticity. [GLACIAL TILL]		
				0 m to 0.5 m - Roots, 5 mm in diameter.		
1		TP03 1.0 M			Sample TP03 1.0 M (1.0 m): Sieve analysis - Gravel 42%, Sand 34%, Fines 25%.	○
2						
				2.7 m to 2.9 m - Clayey, soft to firm, bluish grey, lensed.		
3				2.9 m to 3.0 m - Sand, silty, some gravel, trace clay, well graded, subrounded to subangular, brown, wet, heterogeneous.		
3		TP03 3.0 M			Sample TP03 3.0 M (3.0 m): Sieve analysis - Gravel 46%, Sand 35%, Fines 19%.	○
4				SAND - 3.0 m to 4.0 m Fine, gravelly to and gravel, silty to some silt, some cobbles, trace boulders, trace clay, well graded, dense, subrounded to subangular, brownish grey, moist, heterogeneous. [GLACIAL TILL]		
5				END OF TEST PIT at 4.0 m NOTES: 1. Test pit terminated extent of excavator reach. 2. No visible water encountered in test pit.		
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Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-33

Co-ordinates (m): 422,080E; 6,583,937N
Ground Elevation (m): 561.7
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Mahogany
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 13 Oct 2017
Finish Date: 13 Oct 2017
Final Depth Of Pit (m): 4.5
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines / Moisture Content W% (W_P% × — — — — — ○ — — — — — × W_L%)
0				0 m to 0.5 m - Topsoil, reddish brown, roots, 8 mm diameter, trace woody debris.		
1		TP07 0-1.2 COMP		SAND and GRAVEL - 0.5 m to 1.2 m Silty, some cobbles, trace clay, well graded, compact, subangular, brownish grey, moist, heterogeneous.		
2				GRAVEL - 1.2 m to 4.5 m Cobbly, sandy, trace to some silt, trace boulders, trace clay, well graded, compact to loose, subrounded to angular, grey, moist, stratified, trace reddish brown oxidation, MPS = 800 mm.		
3						
4		TP07 3-4.5 COMP			Sample TP07 3-4.5 COMP (3.0 m to 4.5 m): Sieve analysis - Gravel 50%, Sand 36%, Fines 14%.	○
5				END OF TEST PIT at 4.5 m NOTES: 1. Test pit terminated at extent of excavator reach. 2. No visible water encountered in test pit.		
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CONSTANTINENORTH (TESTPIT) CONSTANTINENORTH.GDL BGC.GDT 2/21/18

Project: Palmer Sedimentation Ponds and LAD SI

Project No.: 1790-002

TEST PIT # ITP-34

Co-ordinates (m): 422,022E; 6,583,943N
Ground Elevation (m): 549.4
Survey Method: Handheld GPS
Datum: NAD 83, Zone 8N

Location: Mahogany
Excavator: Caterpillar 320D
Operator: Constantine

Start Date: 13 Oct 2017
Finish Date: 13 Feb 2018
Final Depth Of Pit (m): 4.2
Logged by: BM
Reviewed by: DC

Depth (m)	Sample Type	Sample No.	Symbol	Lithologic Description	Lab Tests and Comments	★ % Fines; W_P% Moisture Content W% W_L% (20 / 40 / 60 / 80)
0				SAND and GRAVEL - 0 m to 4.2 m Silty, some cobbles, trace boulders, well graded, subrounded to angular, grey to brownish grey, moist, heterogeneous to stratified; alternating stratifications of sand, clayey, some gravel, 40 mm thick, with gravel, 40 mm thick, MPS = 500 mm.		
1		TP08 0-1 COMP		1.2 m to 2.7 m - Stratified sand, silty, 80 mm thick.		
2		TP08 2-2.7 COMP			Sample TP08 2-2.7 COMP (2.0 m to 2.7 m): Sieve analysis - Gravel 61%, Sand 30%, Fines 9%.	○
3				2.7 m to 3.2 m - Clay, sandy, some gravel, some cobbles, brown.		
4		TP08 4.0-4.2 COMP		4.0 m to 4.2 m - Wet. END OF TEST PIT at 4.2 m NOTES: 1. Test pit terminated at extent of excavator reach. 2. No visible water encountered in test pit.	Sample TP08 4.0-4.2 COMP (4.0 m to 4.2 m): Sieve analysis - Gravel 52%, Sand 35%, Fines 13%.	○
5						
6						
7						
8						
9						
10						

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Client: Constantine North Inc.

CONSTANTINENORTH (TESTPIT) CONSTANTINENORTH.GDL BGC.GDT 2/20/18

Photo 1. Soil profile of ITP-27 (TP06A).

Photo 2. View from ITP-27 (TP06A).

Photo 3. Infiltration Testing at ITP-27 (TP06A)

Photo 4. Recordall® Badger Meter.

Photo 5. Material at bottom of ITP-27 (TP06A) prior to testing.

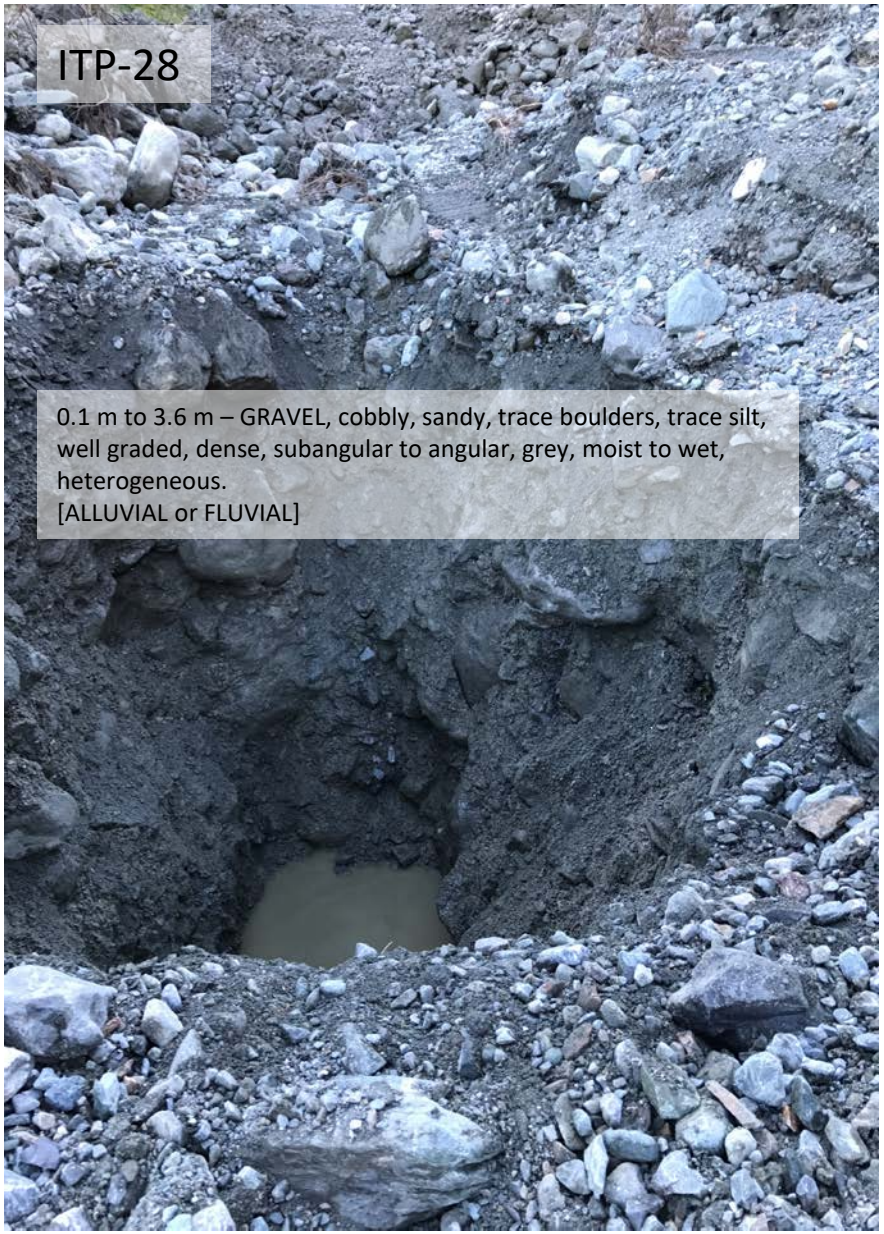


Photo 6. Soil profile of ITP-28 (TP06).

Photo 7. Natural seepage from formation to ITP-28 (TP06).

Photo 8. Infiltration Testing at ITP-28 (TP06)

Photo 9. Recordall® Badger Meter.

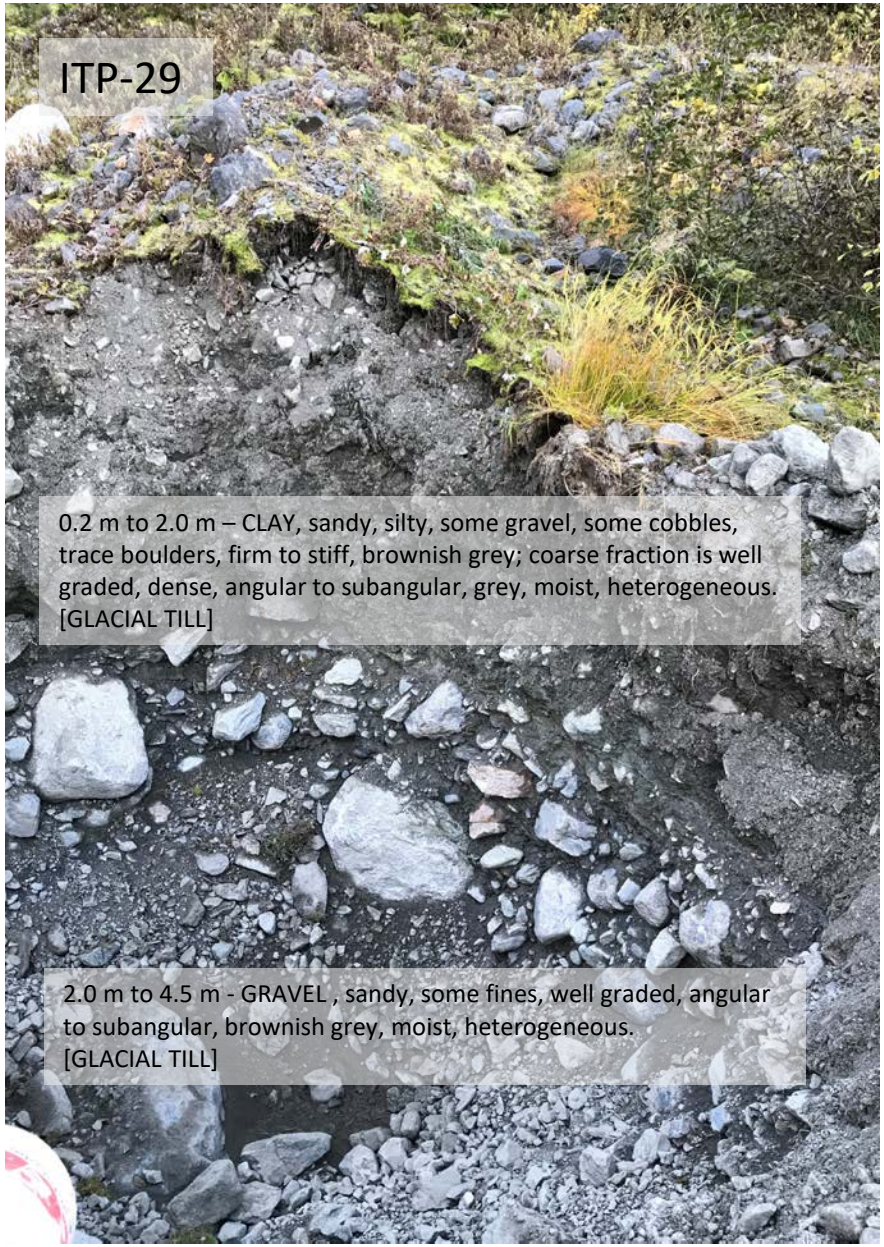


Photo 10. Soil profile of ITP-29 (TP02).

Photo 11. Material near top of ITP-29 (TP02)

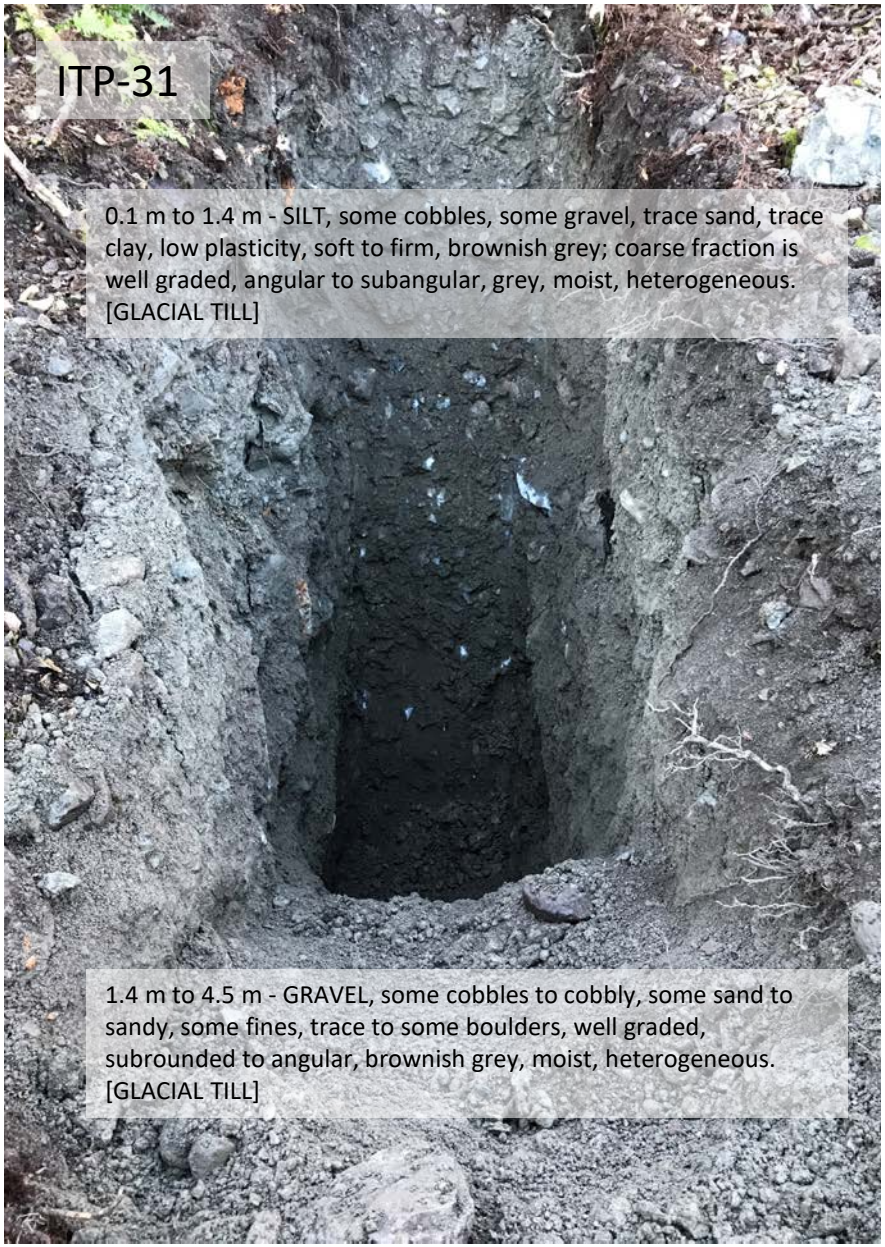


Photo 12. Soil profile of ITP-31 (TP04).

Photo 13. View from ITP-31 (TP04).

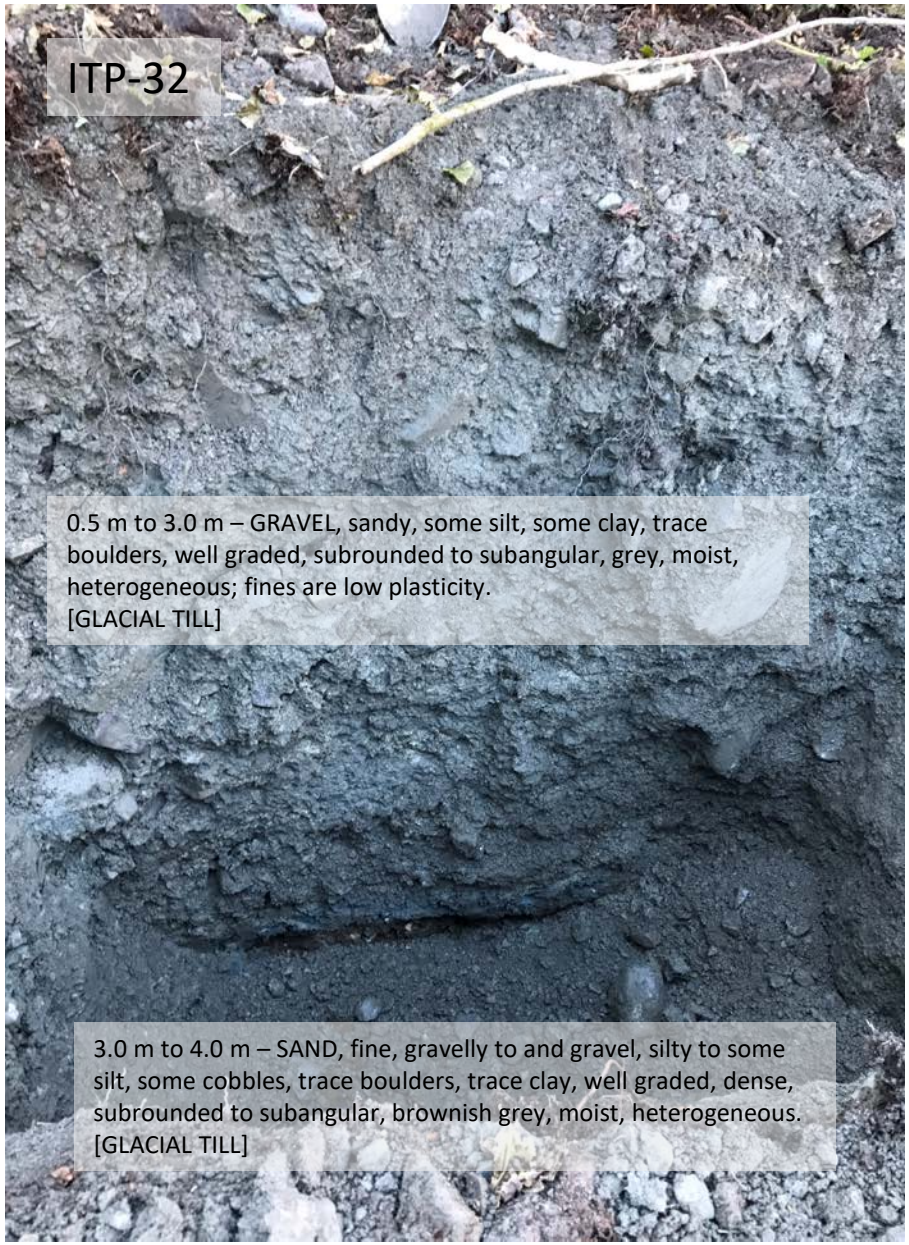


Photo 14. Soil profile of ITP-32 (TP03).

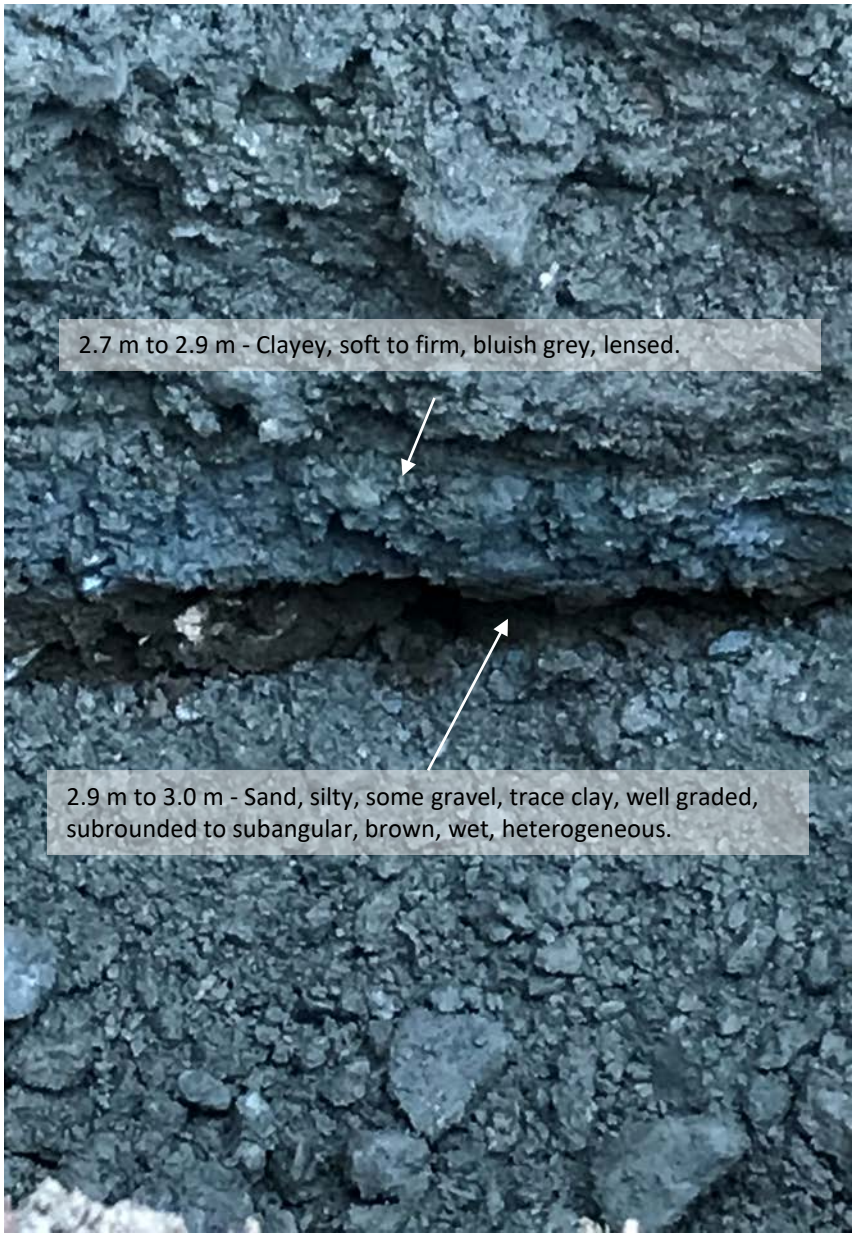


Photo 15. Detail in ITP-32 (TP03).

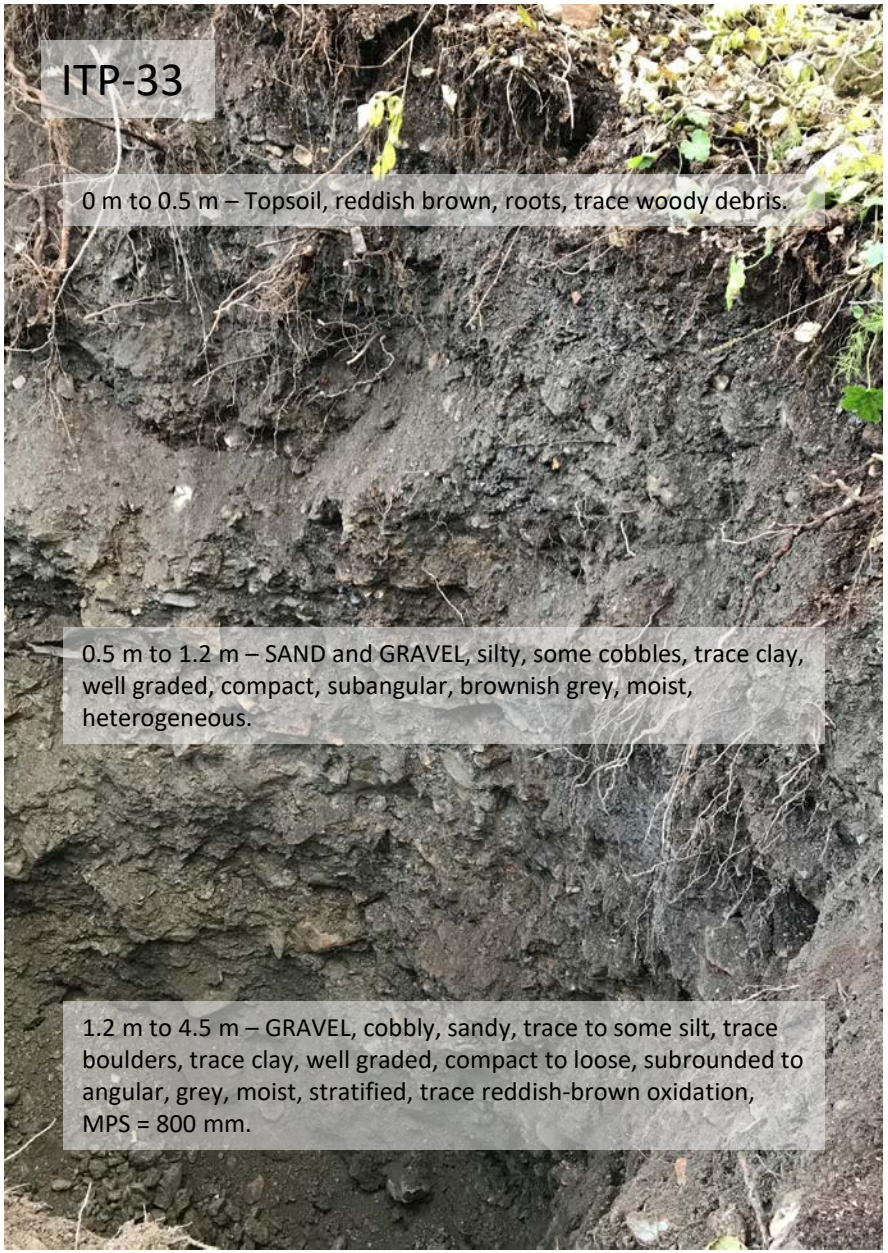


Photo 16. Soil profile of ITP-33 (TP07).

Photo 17. ITP-33 (TP07).

Photo 18. Infiltration Testing at ITP-33 (TP07).

Photo 19. Pumping water from Waterfall Creek.

Photo 20. View from ITP-33 (TP07).

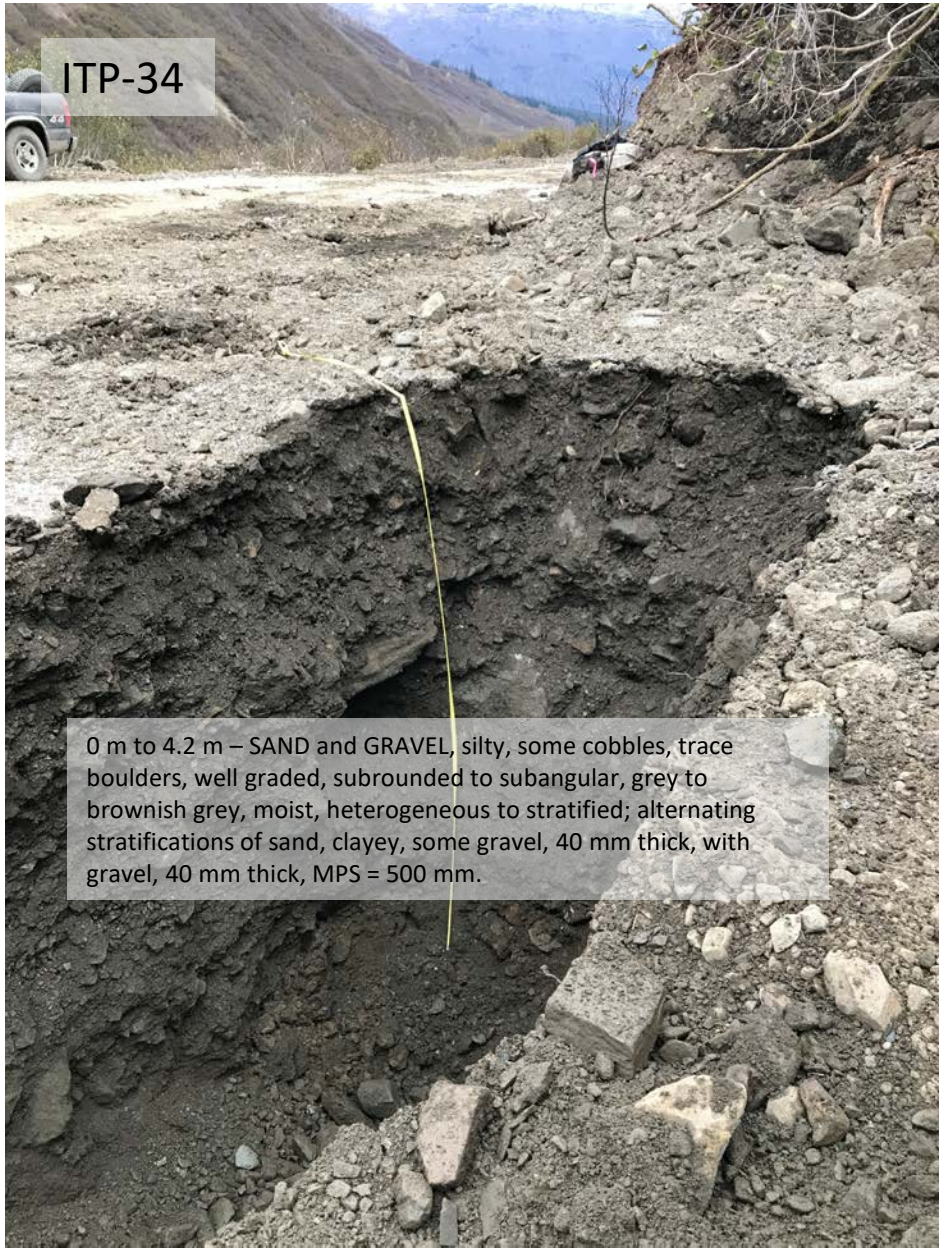


Photo 21. Soil profile of ITP-34 (TP08).

Photo 22. View from ITP-34 (TP08).

Photo 23. Material near top of ITP-34 (TP08).

Photo 24. Infiltration Testing at ITP-34 (TP08).

Photo 25. View of ITP-34 (TP08).

Photo 26. Water line, flowmeter and flow manifold.

APPENDIX B
INFILTRATION TEST DATA

Table B-1. Infiltation test data from ITP-33 (TP07).

Elapsed Time	Depth of Water	Pit Dimensions Relative to Water Table			Wetted Area	Flow Rate	Flow Rate per Wetted Area	Excess flow	Flow to Formation	Radius	K - spherical flow
		Length	Width	Horizontal Area							
(h:mm)	(m)	(m)	(m)	(m^2)	(m^2)	(m^3/s)	(m/s)	(m/s)	(m/s)	(unit)	(m/s)
0	0.00	4.4	1.6	7.0	7.0	5.36E-03	7.62E-04	-	-	-	-
0:10	0.90	4.4	1.9	8.2	19.4	5.36E-03	6.56E-04	1.50E-03	-8.4E-04	1.9	-3.1E-04
0:20	1.50	4.3	2.2	9.3	28.7	5.36E-03	5.77E-04	1.00E-03	-4.2E-04	2.4	-8.7E-05
0:30	1.70	4.3	2.3	9.7	32.1	5.36E-03	5.51E-04	3.33E-04	2.2E-04	2.5	3.9E-05
0:40	1.90	4.3	2.3	9.9	34.9	5.36E-03	5.44E-04	3.33E-04	2.1E-04	2.7	3.3E-05
0:50	2.15	4.3	2.3	9.9	38.3	5.36E-03	5.42E-04	4.17E-04	1.3E-04	2.8	1.7E-05
1:00	2.30	4.3	2.3	9.9	40.3	4.16E-03	4.21E-04	2.50E-04	1.7E-04	2.8	2.1E-05
1:10	2.40	4.3	2.3	9.9	41.6	4.16E-03	4.21E-04	1.67E-04	2.5E-04	2.9	2.9E-05
1:20	2.48	4.3	2.3	9.9	42.6	3.85E-03	3.89E-04	1.33E-04	2.6E-04	2.9	2.8E-05
1:30	2.50	4.3	2.3	9.9	42.9	3.60E-03	3.64E-04	3.33E-05	3.3E-04	2.9	3.6E-05
1:40	2.51	4.3	2.3	9.9	43.0	3.60E-03	3.64E-04	1.67E-05	3.5E-04	2.9	3.7E-05
1:50	2.59	4.3	2.3	9.9	44.1	3.60E-03	3.64E-04	1.33E-04	2.3E-04	2.9	2.4E-05
2:00	2.59	4.3	2.3	9.9	44.1	3.22E-03	3.25E-04	0.00E+00	3.3E-04	2.9	3.4E-05
2:10	2.61	4.0	2.2	8.8	41.2	3.22E-03	3.66E-04	3.33E-05	3.3E-04	2.8	3.1E-05
2:20	2.63	4.0	2.2	8.8	41.4	3.22E-03	3.66E-04	3.33E-05	3.3E-04	2.8	3.1E-05
2:30	2.65	4.0	2.2	8.8	41.7	3.22E-03	3.66E-04	3.33E-05	3.3E-04	2.9	3.1E-05
2:40	2.67	4.0	2.2	8.8	41.9	3.22E-03	3.66E-04	3.33E-05	3.3E-04	2.9	3.0E-05
2:50	2.67	4.0	2.2	8.8	41.9	2.84E-03	3.23E-04	0.00E+00	3.2E-04	2.9	3.0E-05
3:00	2.67	4.0	2.2	8.8	41.9	2.84E-03	3.23E-04	0.00E+00	3.2E-04	2.9	3.0E-05
3:10	2.67	4.0	2.2	8.8	41.9	2.84E-03	3.23E-04	0.00E+00	3.2E-04	2.9	3.0E-05
3:15	2.53	4.0	2.2	8.8	40.2	0.00E+00	0.00E+00	-4.67E-04	4.7E-04	2.8	4.6E-05
3:20	2.44	4.0	2.2	8.8	39.1	0.00E+00	0.00E+00	-3.00E-04	3.0E-04	2.8	3.1E-05
3:30	2.27	4.0	2.2	8.8	36.9	0.00E+00	0.00E+00	-2.83E-04	2.8E-04	2.7	3.2E-05
3:40	2.12	4.0	2.2	8.8	35.1	0.00E+00	0.00E+00	-2.50E-04	2.5E-04	2.7	3.1E-05
3:50	2.00	4.0	2.2	8.8	33.6	0.00E+00	0.00E+00	-2.00E-04	2.0E-04	2.6	2.7E-05
4:00	1.89	4.0	2.2	8.8	32.2	0.00E+00	0.00E+00	-1.83E-04	1.8E-04	2.6	2.7E-05
4:10	1.77	4.0	2.2	8.8	30.7	0.00E+00	0.00E+00	-2.00E-04	2.0E-04	2.5	3.2E-05
4:20	1.69	4.0	2.2	8.8	29.8	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.5	2.2E-05
4:30	1.59	4.0	2.2	8.8	28.5	0.00E+00	0.00E+00	-1.67E-04	1.7E-04	2.4	3.0E-05
4:40	1.49	4.0	2.2	8.8	27.3	0.00E+00	0.00E+00	-1.67E-04	1.7E-04	2.4	3.3E-05
4:50	1.41	4.0	2.2	8.8	26.3	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.3	2.9E-05
5:00	1.31	4.0	2.2	8.8	25.0	0.00E+00	0.00E+00	-1.67E-04	1.7E-04	2.3	3.9E-05
5:10	1.23	4.0	2.2	8.8	24.1	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.2	3.4E-05

Table B-2. Infiltation test data from ITP-34 (TP08).

Elapsed Time	Depth of Water	Inflow Rate to Pit	Pit Dimensions Relative to Water Table			Wetted Area	Flow Rate	Flow Rate per Wetted Area	Excess flow	Flow to Formation	Radius	K - spherical flow
			Length	Width	Horizontal Area							
(h:mm)	(m)	(gpm)	(m)	(m)	(m^2)	(m^2)	(m^3/s)	(m/s)	(m/s)	(m/s)	(unit)	(m/s)
0:16	1.17	110	3.8	1.2	4.6	16.3	6.94E-03	1.52E-03				
0:25	1.50	110	4.2	1.3	5.0	21.6	6.94E-03	1.39E-03	6.11E-04	7.8E-04	2.0	1.0E-04
0:26	1.52	110	4.2	1.4	6.0	22.9	6.94E-03	1.16E-03	3.33E-04	8.2E-04	2.1	1.3E-04
0:50	1.93	78	4.7	1.5	7.0	31.1	4.92E-03	7.03E-04	2.85E-04	4.2E-04	2.4	5.0E-05
1:00	2.00	78	4.8	1.6	8.0	33.4	4.92E-03	6.15E-04	1.17E-04	5.0E-04	2.5	6.4E-05
1:13	2.06	78	4.8	1.6	8.0	34.5	4.92E-03	6.15E-04	7.69E-05	5.4E-04	2.5	6.6E-05
1:38	2.16	78	5.0	1.6	8.0	36.5	4.92E-03	6.15E-04	6.67E-05	5.5E-04	2.6	6.2E-05
1:45	2.19	78	5.0	1.7	8.0	37.1	4.92E-03	6.15E-04	7.14E-05	5.4E-04	2.6	6.0E-05
2:00	2.28	78	5.1	1.7	8.7	39.7	4.92E-03	5.68E-04	1.00E-04	4.7E-04	2.7	5.2E-05
2:15	2.35	78	5.2	1.8	9.0	41.7	4.92E-03	5.47E-04	7.78E-05	4.7E-04	2.8	5.1E-05
2:30	2.40	78	5.2	1.8	9.0	42.9	4.92E-03	5.47E-04	5.56E-05	4.9E-04	2.8	5.2E-05
2:45	2.43	71	5.3	1.9	10.0	44.7	4.48E-03	4.48E-04	3.33E-05	4.1E-04	2.9	4.7E-05
3:00	2.46	71	5.3	1.9	10.1	45.5	4.48E-03	4.45E-04	3.33E-05	4.1E-04	2.9	4.6E-05
3:15	2.56	71	5.3	2.2	11.7	50.1	4.48E-03	3.84E-04	1.11E-04	2.7E-04	3.1	3.2E-05
3:30	2.63	71	5.3	2.2	11.7	51.1	4.48E-03	3.84E-04	7.78E-05	3.1E-04	3.1	3.5E-05
3:45	2.62	61	5.3	2.2	11.7	51.0	3.85E-03	3.30E-04	-1.11E-05	3.4E-04	3.1	3.9E-05
4:00	2.65	61	5.3	2.2	11.7	51.4	3.85E-03	3.30E-04	3.33E-05	3.0E-04	3.1	3.3E-05
4:15	2.65	61	5.3	2.2	11.7	51.4	3.85E-03	3.30E-04	0.00E+00	3.3E-04	3.1	3.7E-05
4:30	2.64	61	5.3	2.2	11.7	51.3	3.85E-03	3.30E-04	-1.11E-05	3.4E-04	3.1	3.8E-05
4:35	2.52	0	5.3	2.2	11.7	49.5	0.00E+00	0.00E+00	-4.00E-04	4.0E-04	3.1	4.8E-05
4:40	2.45	0	5.3	2.2	11.7	48.4	0.00E+00	0.00E+00	-2.33E-04	2.3E-04	3.1	2.9E-05
4:45	2.38	0	5.3	2.2	11.7	47.4	0.00E+00	0.00E+00	-2.33E-04	2.3E-04	3.0	3.0E-05
4:50	2.28	0	5.3	2.2	11.7	45.9	0.00E+00	0.00E+00	-3.33E-04	3.3E-04	3.0	4.5E-05
4:55	2.23	0	5.3	2.2	11.7	45.1	0.00E+00	0.00E+00	-1.67E-04	1.7E-04	3.0	2.3E-05
5:00	2.15	0	5.3	2.2	11.7	43.9	0.00E+00	0.00E+00	-2.67E-04	2.7E-04	2.9	3.9E-05
5:05	2.07	0	5.1	2.1	10.7	40.5	0.00E+00	0.00E+00	-2.67E-04	2.7E-04	2.8	3.9E-05
5:10	2.00	0	5.0	2.0	9.8	37.6	0.00E+00	0.00E+00	-2.33E-04	2.3E-04	2.7	3.4E-05
5:15	1.94	0	4.9	1.9	9.1	35.3	0.00E+00	0.00E+00	-2.00E-04	2.0E-04	2.6	2.9E-05
5:20	1.90	0	4.8	1.8	8.6	33.7	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.5	1.9E-05
5:25	1.86	0	4.7	1.8	8.4	32.7	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.5	1.9E-05
5:30	1.81	0	4.7	1.7	8.1	31.3	0.00E+00	0.00E+00	-1.67E-04	1.7E-04	2.5	2.4E-05
6:00	1.57	0	4.3	1.6	6.9	25.4	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.2	2.1E-05
6:10	1.49	0	4.2	1.7	7.0	24.5	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.2	2.3E-05
6:15	1.46	0	4.1	1.7	7.1	24.1	0.00E+00	0.00E+00	-1.00E-04	1.0E-04	2.2	1.8E-05
6:20	1.42	0	4.1	1.8	7.2	23.7	0.00E+00	0.00E+00	-1.33E-04	1.3E-04	2.2	2.5E-05
6:25	1.39	0	4.0	1.8	7.2	23.3	0.00E+00	0.00E+00	-1.00E-04	1.0E-04	2.2	1.9E-05
6:30	1.36	0	4.0	1.8	7.2	23.0	0.00E+00	0.00E+00	-1.00E-04	1.0E-04	2.1	2.0E-05
6:40	1.30	0	4.0	1.8	7.2	22.3	0.00E+00	0.00E+00	-1.00E-04	1.0E-04	2.1	2.1E-05
6:50	1.25	0	4.0	1.8	7.2	21.7	0.00E+00	0.00E+00	-8.33E-05	8.3E-05	2.1	1.8E-05
7:00	1.19	0	4.0	1.8	7.2	21.0	0.00E+00	0.00E+00	-1.00E-04	1.0E-04	2.0	2.4E-05

APPENDIX C
LABORATORY TESTING

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP01
Sample #:	TP01 2.0 M
Depth:	2.0m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-22
Report Date:	2017-11-24

Preparation Method: Oven Dry [x] Air Dry [ ]

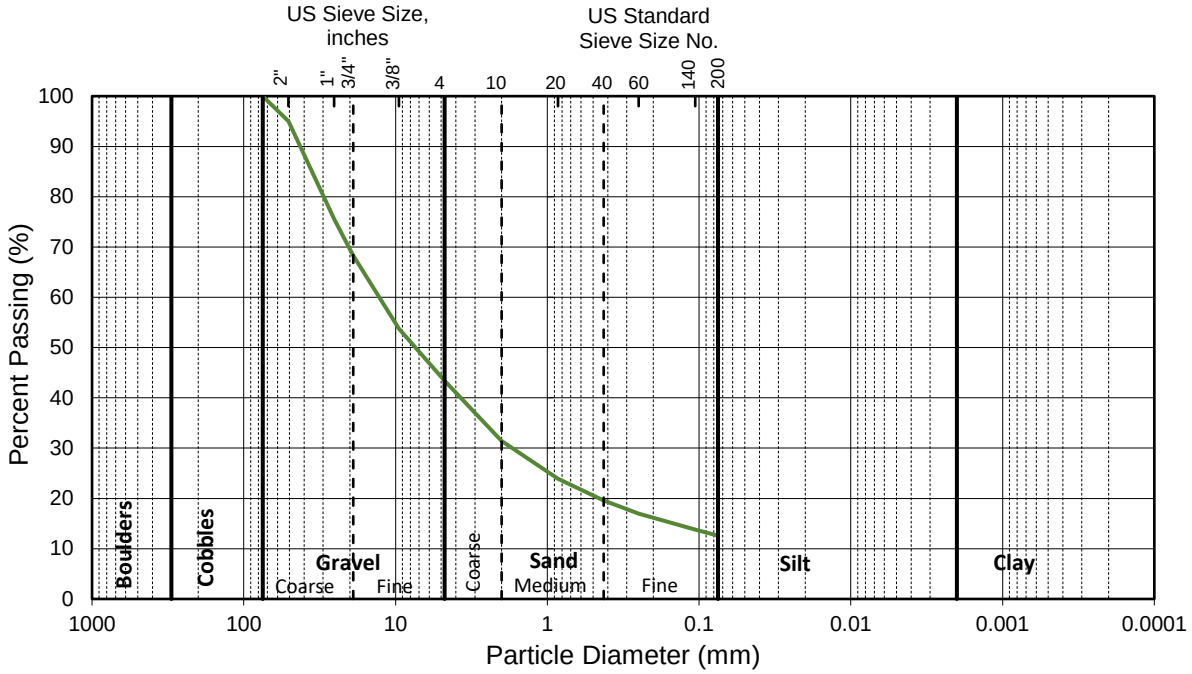
Laboratory Comments/Observations

Gradation Summary

Gravel%	57
Sand%	31
Fines%	13
D60, mm:	12.79
D30, mm:	1.70
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	17.0
50.800	95.01	0.106	13.8
25.400	75.56	0.075	12.6
19.000	68.31		
9.500	53.77		
4.750	43.40		
2.000	31.44		
0.850	23.91		
0.425	19.56		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP01
Sample #:	TP01 4.2 M
Depth:	4.2m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-22
Report Date:	2017-11-24

Preparation Method: Oven Dry [x] Air Dry [ ]

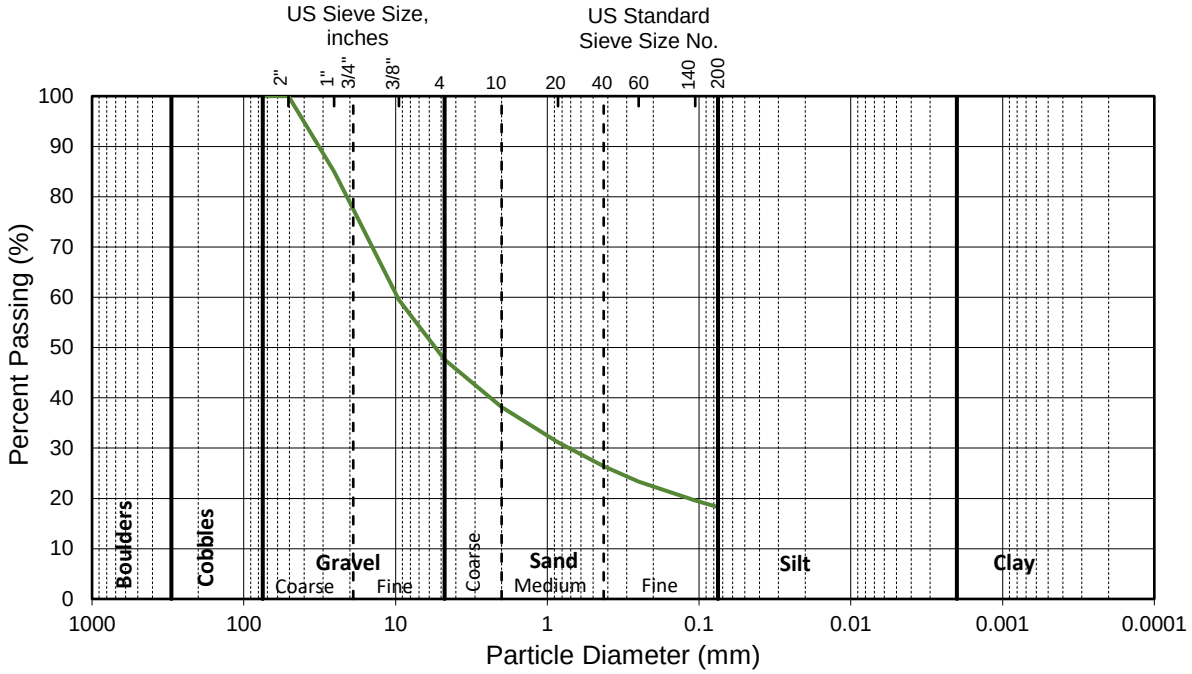
Laboratory Comments/Observations

Gradation Summary

Gravel%	52
Sand%	29
Fines%	18
D60, mm:	9.69
D30, mm:	0.72
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	23.3
50.800	100.00	0.106	19.6
25.400	84.92	0.075	18.3
19.000	77.57		
9.500	59.48		
4.750	47.57		
2.000	38.18		
0.850	31.15		
0.425	26.37		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP02
Sample #:	TP02 2.0 M
Depth:	2.0m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-22
Report Date:	2017-11-24

Preparation Method: Oven Dry [x] Air Dry [ ]

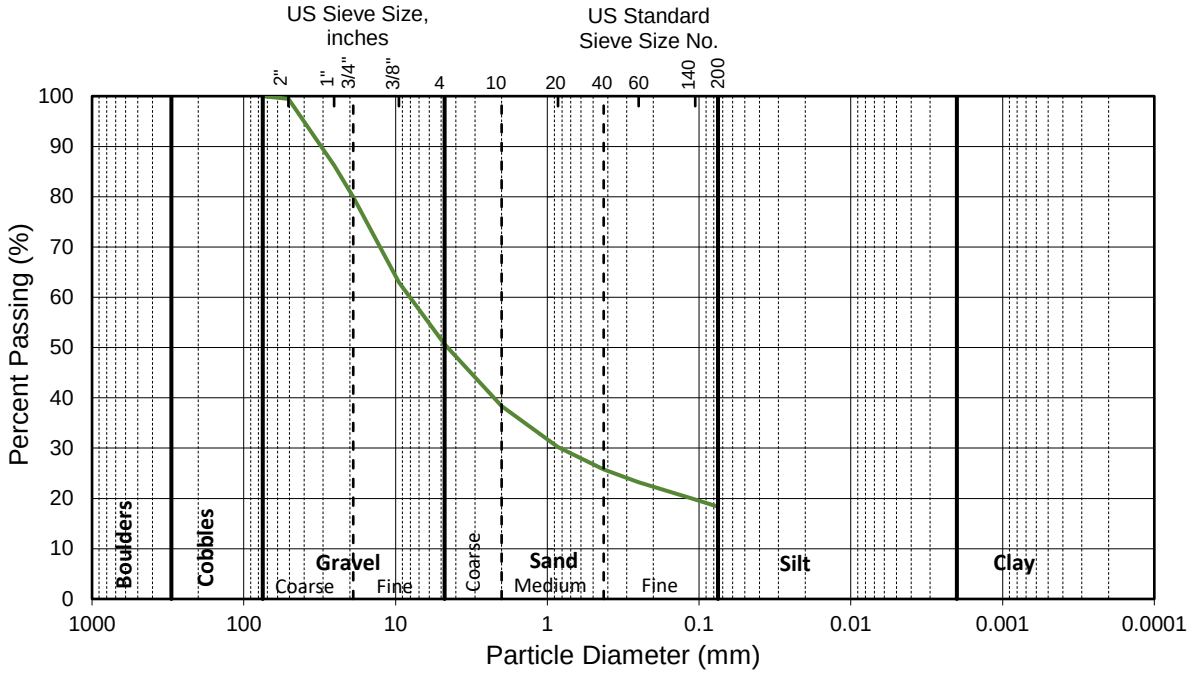
Laboratory Comments/Observations

Gradation Summary

Gravel%	49
Sand%	32
Fines%	18
D60, mm:	8.04
D30, mm:	0.83
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	23.2
50.800	99.44	0.106	19.8
25.400	86.20	0.075	18.3
19.000	79.99		
9.500	62.97		
4.750	50.63		
2.000	38.39		
0.850	30.19		
0.425	25.73		

Soil Classification as per USCS (ASTM D2487)



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AN APPLIED EARTH SCIENCES COMPANY

PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP02
Sample #:	TP02 3.5 M
Depth:	3.5m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-24
Report Date:	2017-11-28

Preparation Method: Oven Dry [x] Air Dry [ ]

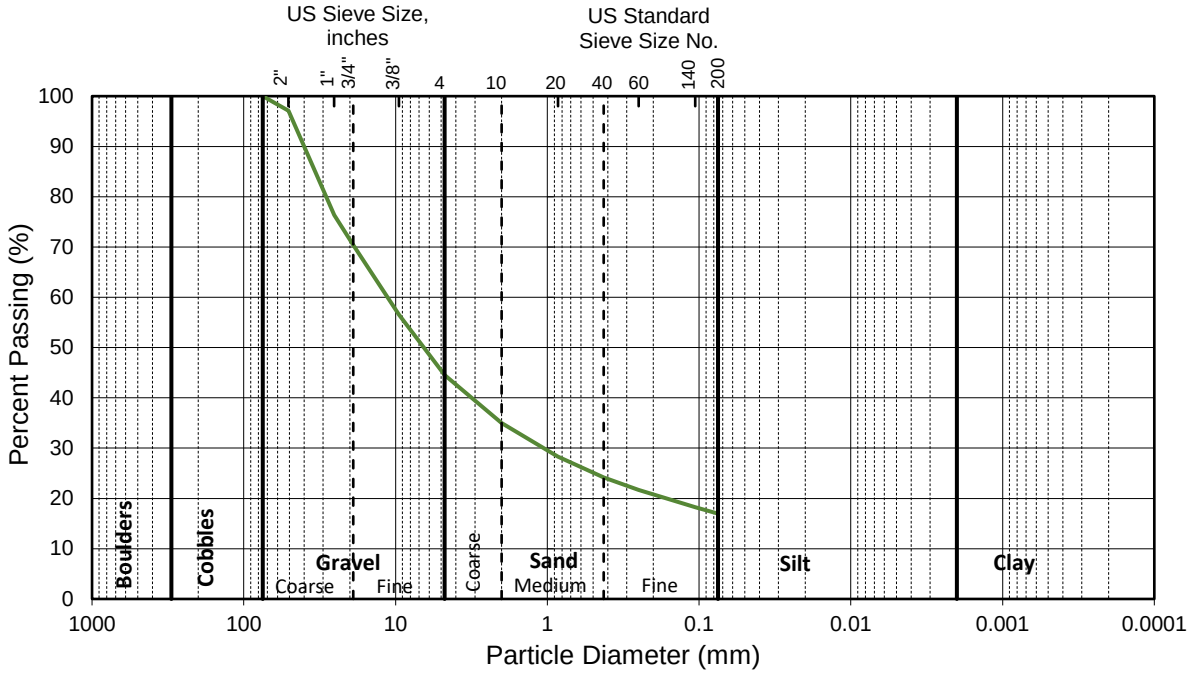
Laboratory Comments/Observations

Gradation Summary

Gravel%	55
Sand%	28
Fines%	17
D60, mm:	11.27
D30, mm:	1.05
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	21.7
50.800	97.14	0.106	18.3
25.400	76.37	0.075	17.0
19.000	70.44		
9.500	56.57		
4.750	44.51		
2.000	34.99		
0.850	28.33		
0.425	24.16		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP03
Sample #:	TP03 1.0 M
Depth:	1.0m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-24
Report Date:	2017-11-28

Preparation Method: Oven Dry [x] Air Dry [ ]

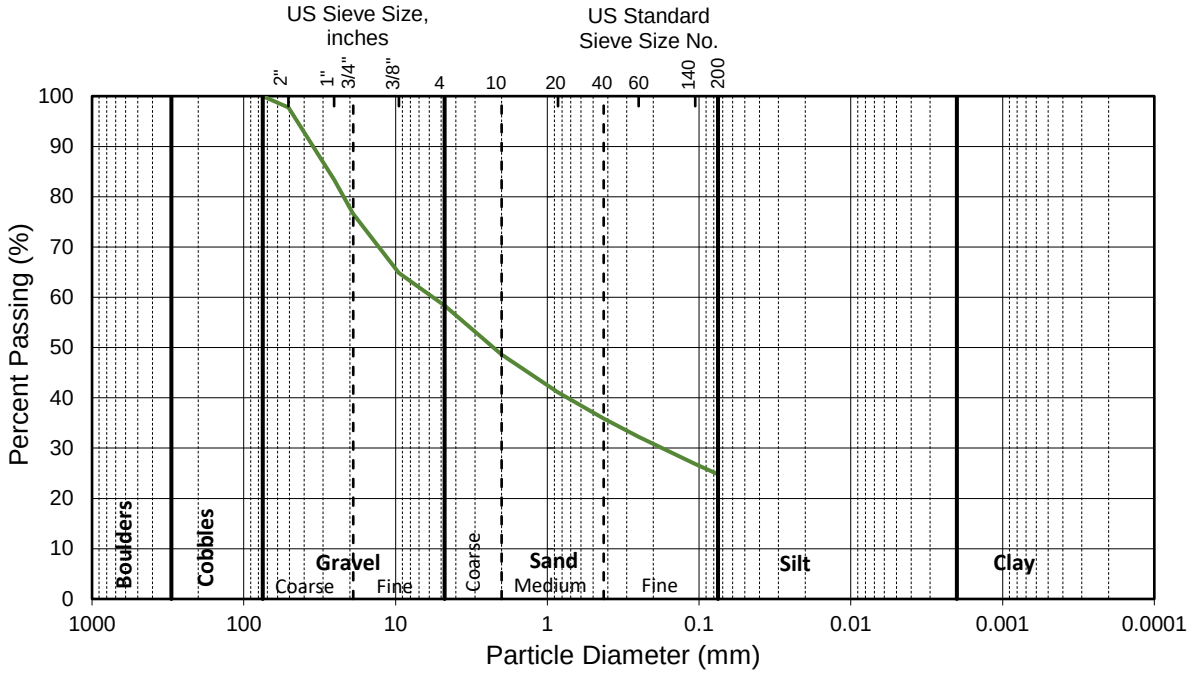
Laboratory Comments/Observations

Gradation Summary

Gravel%	42
Sand%	34
Fines%	25
D60, mm:	5.67
D30, mm:	0.17
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	32.3
50.800	97.74	0.106	26.9
25.400	83.35	0.075	24.8
19.000	76.60		
9.500	64.82		
4.750	58.35		
2.000	48.59		
0.850	41.09		
0.425	35.88		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP03
Sample #:	TP03 3.0 M
Depth:	3.0m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-24
Report Date:	2017-11-28

Preparation Method: Oven Dry [x] Air Dry [ ]

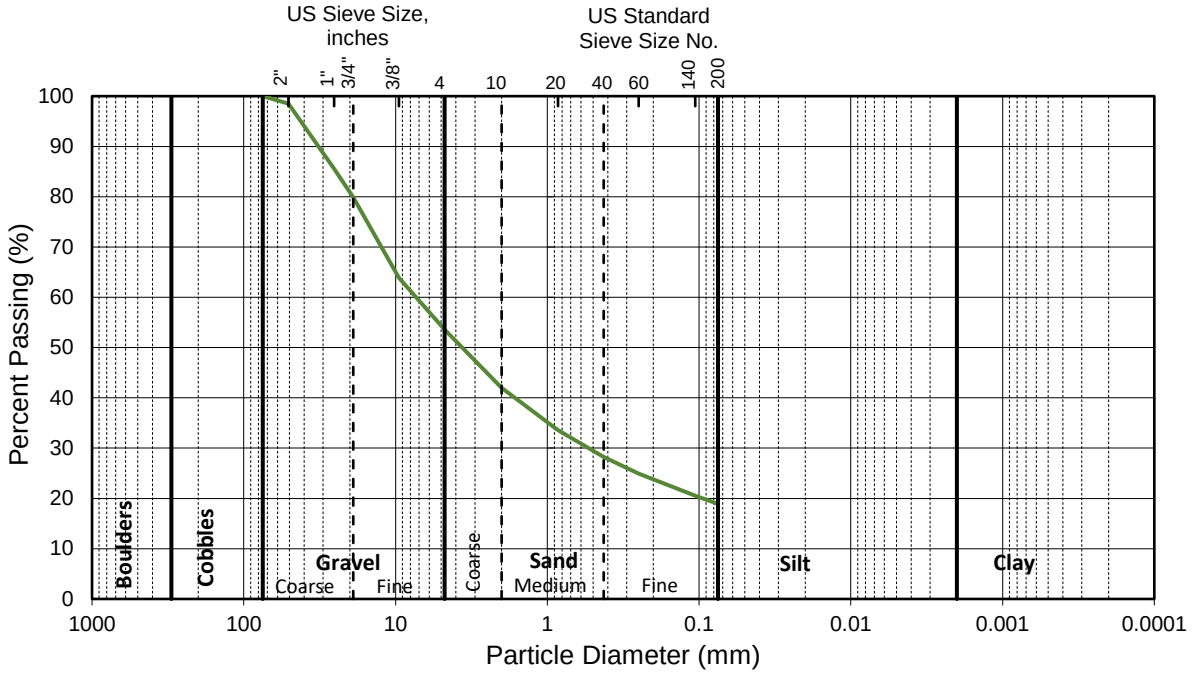
Laboratory Comments/Observations

Gradation Summary

Gravel%	46
Sand%	35
Fines%	19
D60, mm:	7.32
D30, mm:	0.53
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	25.0
50.800	98.48	0.106	20.6
25.400	85.55	0.075	18.9
19.000	79.94		
9.500	63.89		
4.750	53.55		
2.000	42.00		
0.850	33.59		
0.425	28.26		

Soil Classification as per USCS (ASTM D2487)



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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP04
Sample #:	TP04 2.0 M
Depth:	2.0m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-24
Report Date:	2017-11-28

Preparation Method: Oven Dry [x] Air Dry [ ]

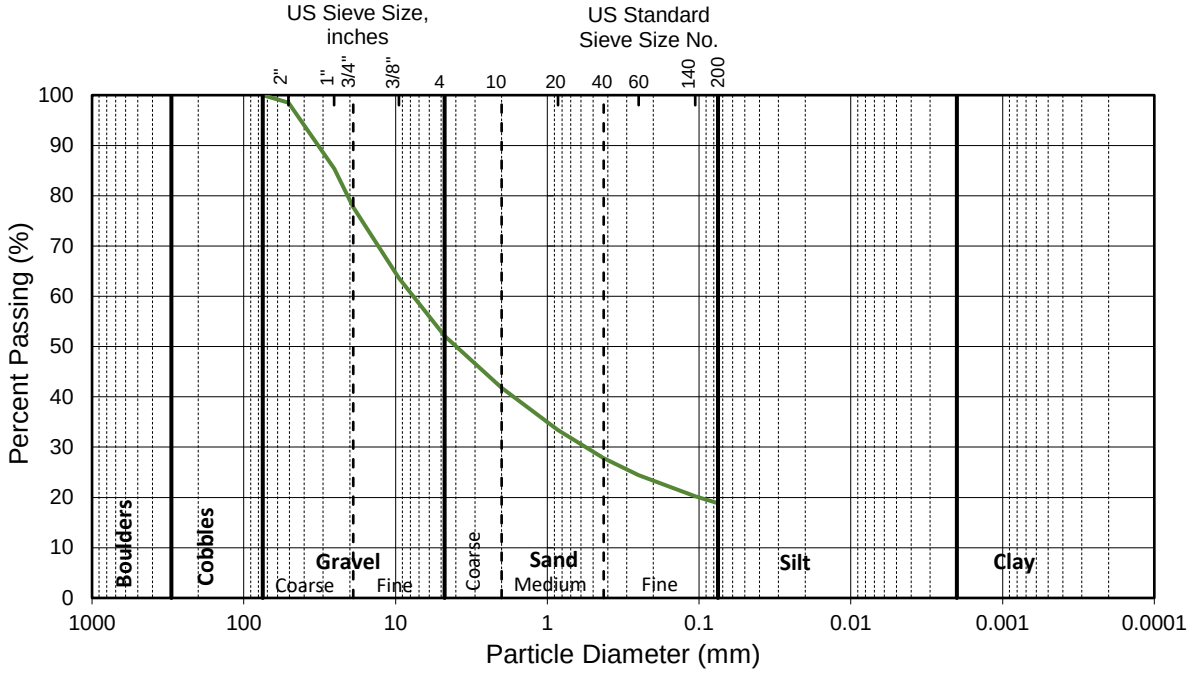
Laboratory Comments/Observations

Gradation Summary

Gravel%	48
Sand%	33
Fines%	19
D60, mm:	7.64
D30, mm:	0.56
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	24.4
50.800	98.49	0.106	20.2
25.400	85.39	0.075	18.8
19.000	77.75		
9.500	63.61		
4.750	52.13		
2.000	41.77		
0.850	33.42		
0.425	27.83		

Soil Classification as per USCS (ASTM D2487)



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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP04
Sample #:	TP04 4.5 M
Depth:	4.5m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-24
Report Date:	2017-11-28

Preparation Method: Oven Dry [x] Air Dry [ ]

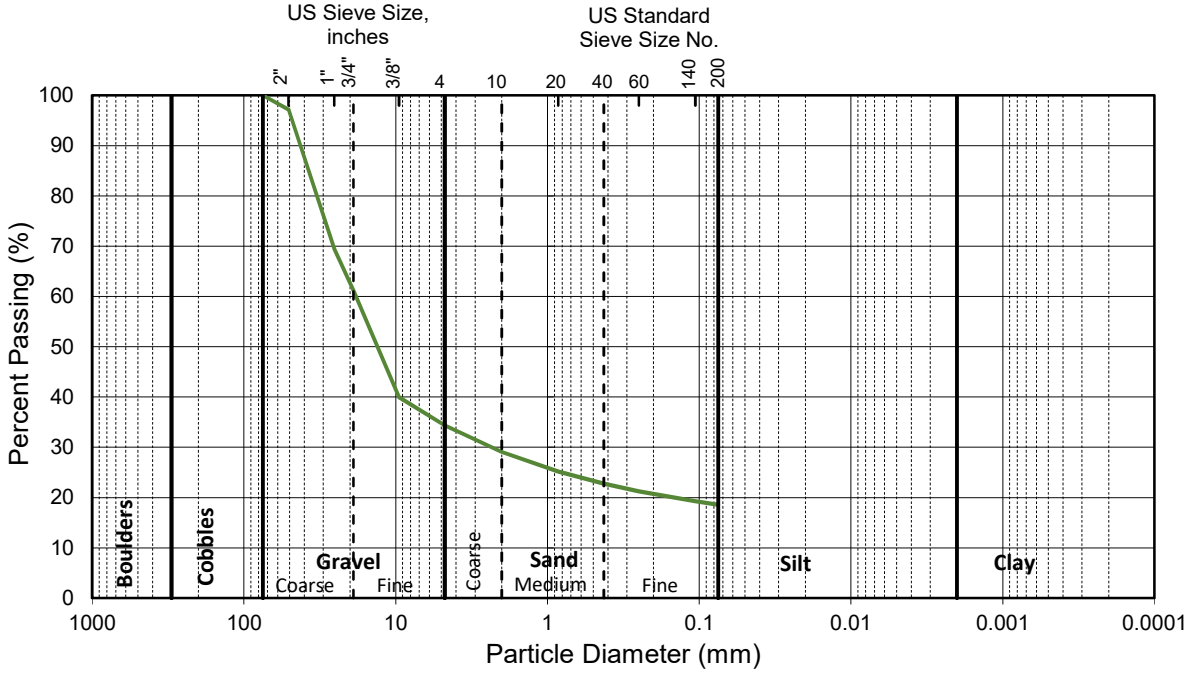
Laboratory Comments/Observations

Gradation Summary

Gravel%	66
Sand%	16
Fines%	19
D60, mm:	18.24
D30, mm:	2.33
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	21.3
50.800	97.19	0.106	19.3
25.400	69.42	0.075	18.6
19.000	61.25		
9.500	39.98		
4.750	34.37		
2.000	29.05		
0.850	25.17		
0.425	22.77		

Soil Classification as per USCS (ASTM D2487)



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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP06
Sample #:	TP06 2.0 M
Depth:	2.0m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-24
Report Date:	2017-11-28

Preparation Method: Oven Dry [x] Air Dry [ ]

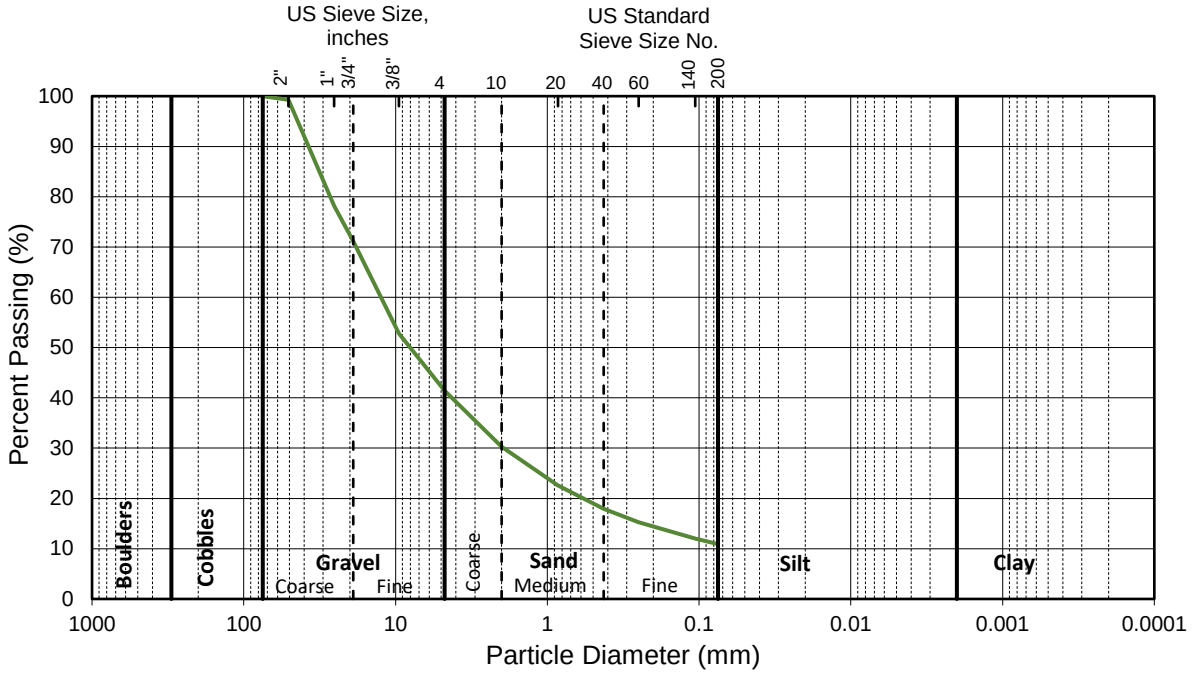
Laboratory Comments/Observations

Gradation Summary

Gravel%	59
Sand%	30
Fines%	11
D60, mm:	12.45
D30, mm:	1.94
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	15.3
50.800	99.26	0.106	12.0
25.400	78.12	0.075	10.9
19.000	71.21		
9.500	52.83		
4.750	41.39		
2.000	30.28		
0.850	22.58		
0.425	17.94		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP06
Sample #:	TP06 3.6 M
Depth:	3.6m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-29
Report Date:	2017-12-01

Preparation Method: Oven Dry [x] Air Dry [ ]

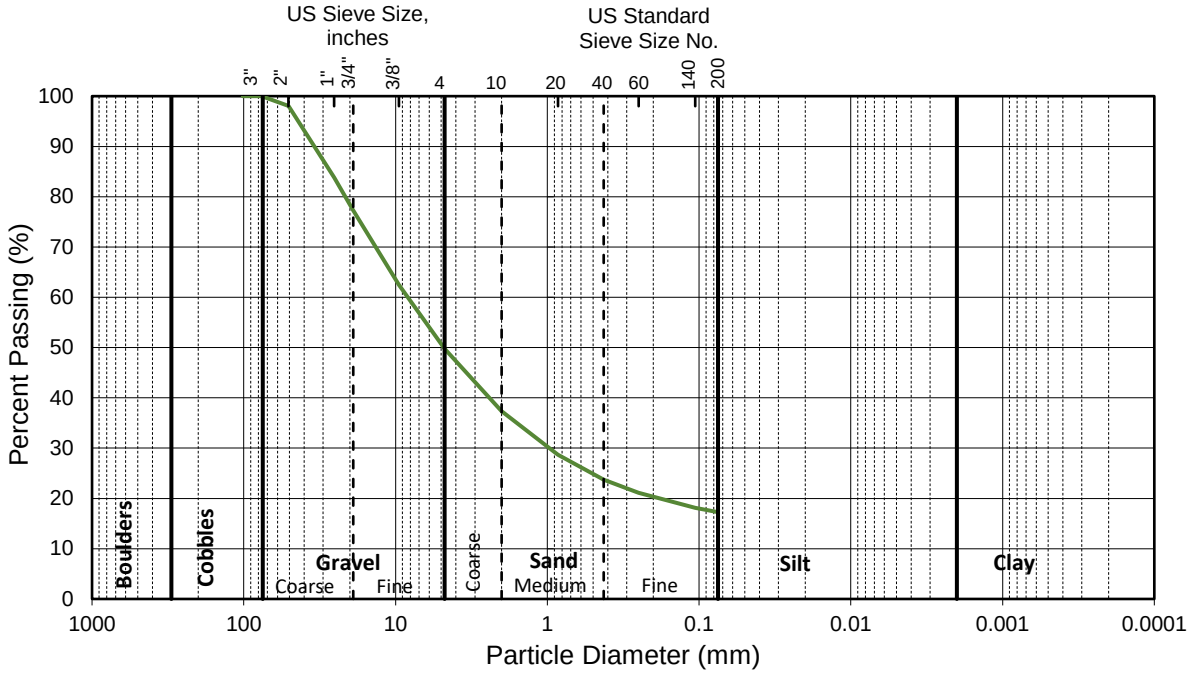
Laboratory Comments/Observations

Gradation Summary

Gravel%	50
Sand%	32
Fines%	17
D60, mm:	8.30
D30, mm:	0.97
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
101.600	100.00	0.425	23.7
76.200	100.00	0.250	21.1
50.800	98.08	0.106	18.1
25.400	83.83	0.075	17.3
19.000	77.29		
9.500	62.49		
4.750	49.73		
2.000	37.37		
0.850	28.70		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP06A
Sample #:	TP06 3.3 M
Depth:	3.3m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-28
Report Date:	2017-11-30

Preparation Method: Oven Dry [x] Air Dry [ ]

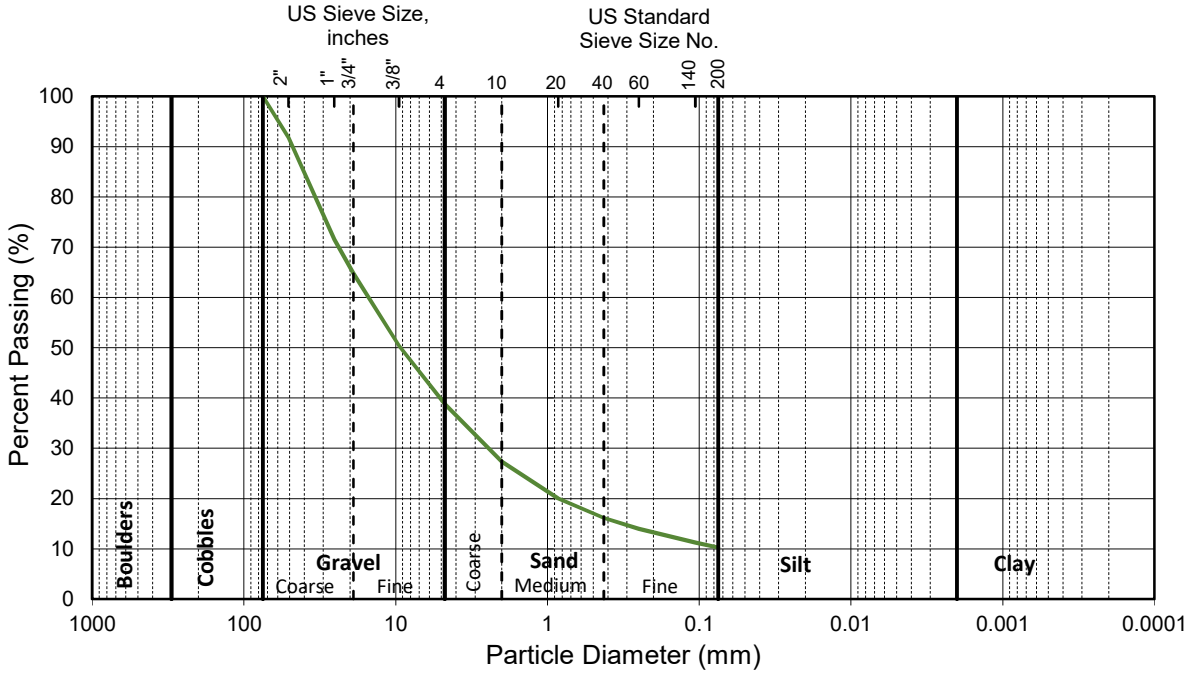
Laboratory Comments/Observations

Gradation Summary

Gravel%	61
Sand%	29
Fines%	10
D60, mm:	15.08
D30, mm:	2.44
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
75.000	100.00	0.250	14.0
50.800	91.73	0.106	11.2
25.400	71.49	0.075	10.3
19.000	64.81		
9.500	50.40		
4.750	38.83		
2.000	27.34		
0.850	20.06		
0.425	16.16		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP07
Sample #:	TP07 3.0-4.5 Comp
Depth:	3.0m to 4.5m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-29
Report Date:	2017-12-01

Preparation Method: Oven Dry [x] Air Dry [ ]

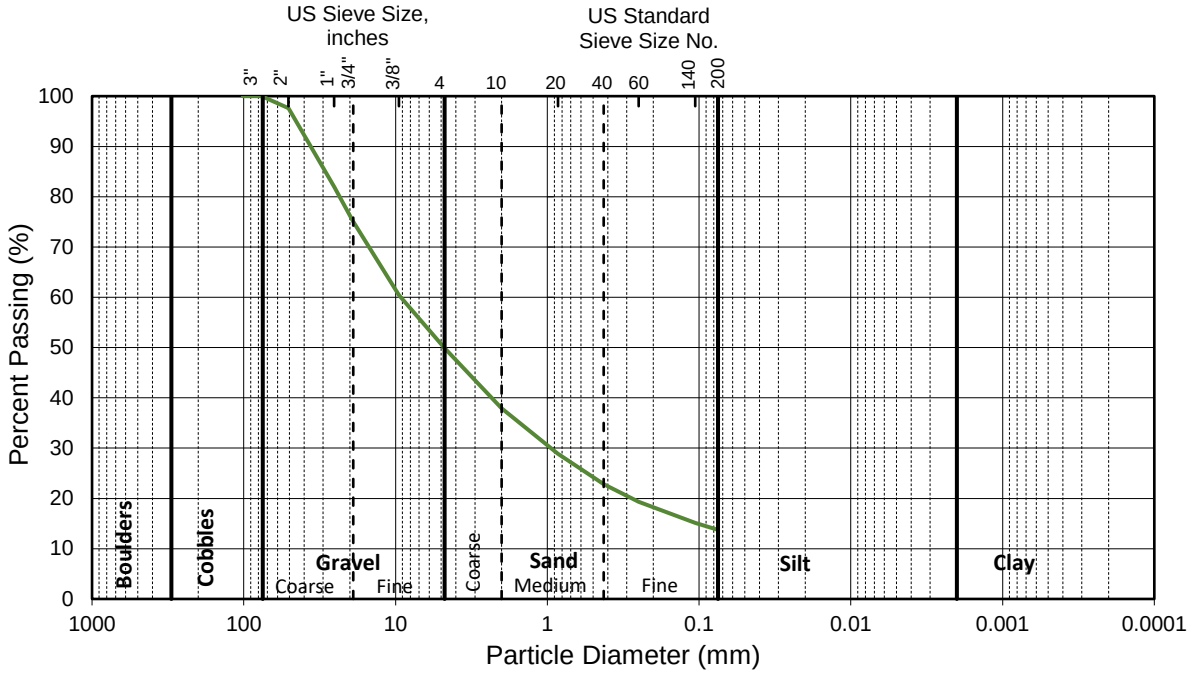
Laboratory Comments/Observations

Gradation Summary

Gravel%	50
Sand%	36
Fines%	14
D60, mm:	9.22
D30, mm:	0.94
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
101.600	100.00	0.425	22.8
76.200	100.00	0.250	19.3
50.800	97.59	0.106	15.1
25.400	81.94	0.075	13.7
19.000	75.10		
9.500	60.45		
4.750	49.91		
2.000	37.91		
0.850	28.89		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP08
Sample #:	TP08 2.0-2.7 Comp
Depth:	2.0m to 2.7m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-28
Report Date:	2017-11-30

Preparation Method: Oven Dry [x] Air Dry [ ]

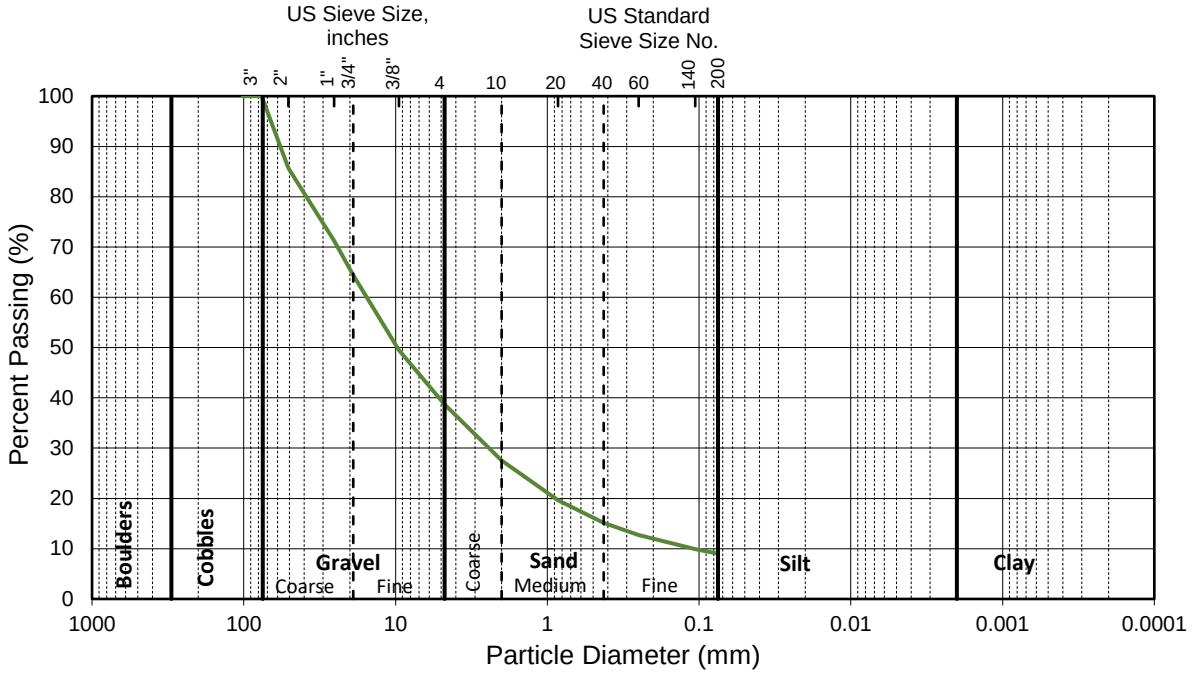
Laboratory Comments/Observations

Gradation Summary

Gravel%	61
Sand%	30
Fines%	9
D60, mm:	15.45
D30, mm:	2.43
D10, mm:	0.11
Cc:	3.5
Cu:	143.0

(mm)	% Pass	(mm)	% Pass
101.600	100.00	0.425	15.1
76.200	100.00	0.250	12.7
50.800	85.63	0.106	9.9
25.400	71.22	0.075	9.0
19.000	64.46		
9.500	49.50		
4.750	38.65		
2.000	27.52		
0.850	19.66		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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PARTICLE SIZE ANALYSIS
ASTM D-6913 Method A

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Sample Information

Borehole/Test Pit:	TP08
Sample #:	TP08 4.0-4.2 Comp
Depth:	4.0m to 4.2m
Sample type:	Grab
Sampled by:	BGC

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S.Dickinson
Test Date:	2017-11-28
Report Date:	2017-11-29

Preparation Method: Oven Dry [x] Air Dry [ ]

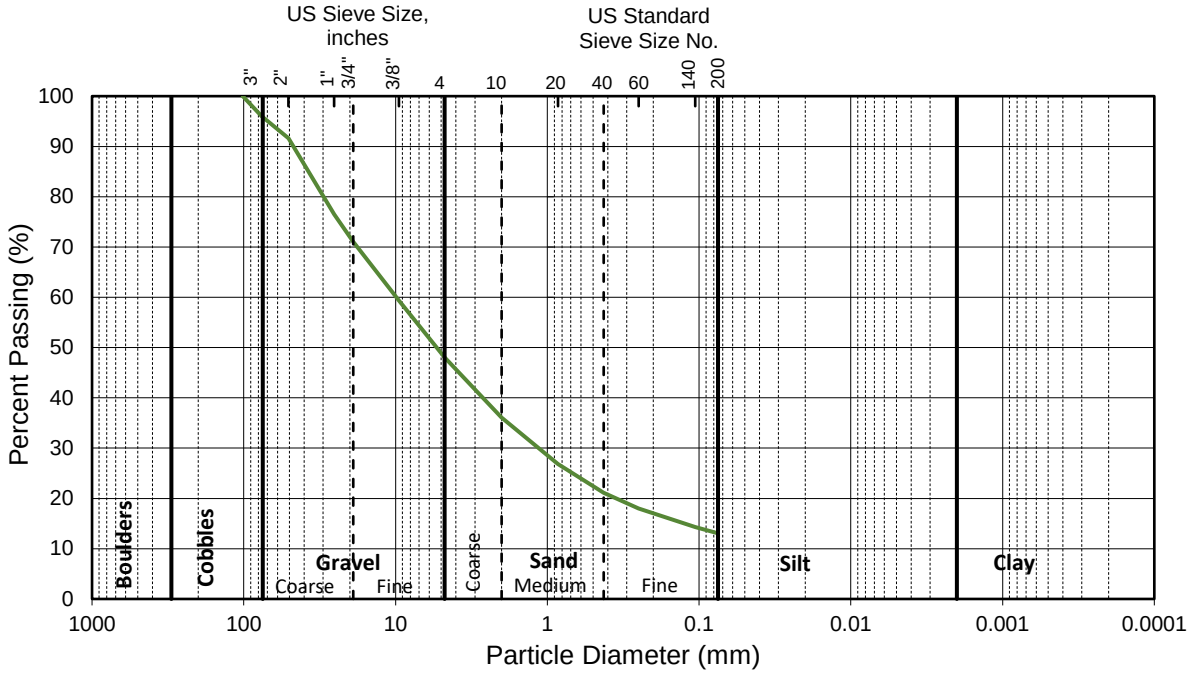
Laboratory Comments/Observations

Gradation Summary

Gravel and larger%	52
Sand%	35
Fines%	13
D60, mm:	9.87
D30, mm:	1.14
D10, mm:	-
Cc:	-
Cu:	-

(mm)	% Pass	(mm)	% Pass
101.600	100.00	0.425	21.1
76.200	96.02	0.250	18.0
50.800	91.65	0.106	14.3
25.400	76.47	0.075	13.1
19.000	71.05		
9.500	59.35		
4.750	48.06		
2.000	36.06		
0.850	26.83		

Soil Classification as per USCS (ASTM D2487)



BGC ENGINEERING INC.
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MOISTURE CONTENT OF SOIL

ASTM D-2216-10

Project Information

Project Name:	Palmer Project
Project Number:	1790-002
Client Name:	Constantine Metal Resources Ltd.

Laboratory Information

Lab Name:	BGC Fredericton
Tested By:	D.Oldford
Checked By:	M.Billings
Approved By:	S. Dickinson
Test Date:	2017-11-22
Report Date:	2017-12-01

Sample Information

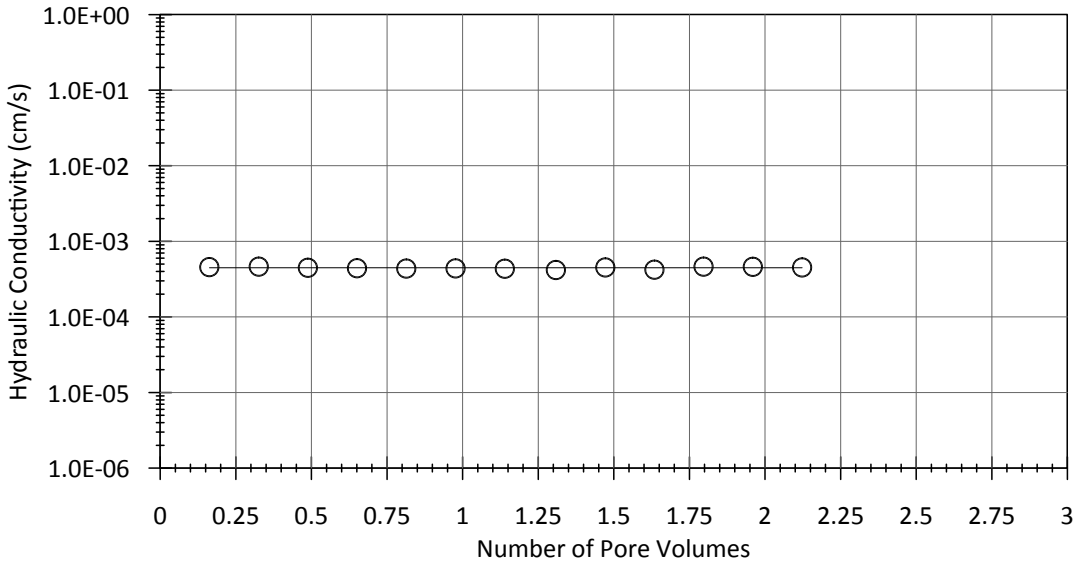
Borehole / Test Pit	Sample #	Depth (m)	Sample Type	Sampled By	Pan ID	Mass of Moist Soil + Pan (g)	Mass of Dry Soil + Pan (g)	Mass of Pan (g)	Mass of Dry Soil (g)	Water Content (%)
TP01	TP01 2.0 M	2.0	Grab	BGC	KJ1	29460.20	27670.00	1578.70	26091.30	6.9
TP01	TP01 4.2 M	4.2	Grab	BGC	K31	29730.60	27498.40	1568.40	25930.00	8.6
TP02	TP02 2.0 M	2.0	Grab	BGC	BT3	31170.60	29043.40	1703.80	27339.60	7.8
TP02	TP02 3.5 M	3.5	Grab	BGC	K6	32350.00	29811.70	1705.80	28105.90	9.0
TP03	TP03 1.0 M	1.0	Grab	BGC	R1	29765.90	27700.90	1698.50	26002.40	7.9
TP03	TP03 3.0 M	3.0	Grab	BGC	WT	30182.10	27621.20	1573.00	26048.20	9.8
TP04	TP04 2.0 M	2.0	Grab	BGC	BT3	25181.60	23155.00	1565.50	21589.50	9.4
TP04	TP04 4.5 M	4.5	Grab	BGC	K21	32279.90	29501.80	1716.60	27785.20	10.0
TP06	TP06 2.0 M	2.0	Grab	BGC	BT41	38501.00	36075.00	1570.90	34504.10	7.0
TP06	TP06 3.6 M	3.6	Grab	BGC	DM	39677.30	36154.60	1693.80	34460.80	10.2
TP06A	TP06A 3.3 M	3.3	Grab	BGC	DT	32506.90	30771.90	1721.20	29050.70	6.0
TP07	TP07 3-4.5 COMP	3.0 to 4.5	Grab	BGC	B3	29021.50	26981.40	1710.90	25270.50	8.1
TP08	TP08 2-2.7 COMP	2.0 to 2.7	Grab	BGC	BT19	31269.70	29418.30	1567.00	27851.30	6.6
TP08	TP08 4.0-4.2 COMP	4.0 to 4.2	Grab	BGC	E41	33885.80	31328.50	1551.40	29777.10	8.6

PROJECT INFORMATION		SAMPLE INFORMATION	
Number	1790-002	Borehole/Test Pit	TP06
Name	Palmer Project	ID	TP06 3.6 m
Location	Haines, Alaska	Depth	3.6 m
Client	Constantine Metal Resources Ltd.	Type	Reconstituted

TEST INFORMATION	
Compaction	Loosely Packed
Permeant	De-aired water
Screened on Sieve	9.5 mm (3/8")
Test Method	Method B - Falling head test with constant tailwater

SAMPLE PROPERTIES (INITIAL)	
Diameter (cm)	10.1
Height (cm)	11.7
Bulk Density (g/cm^3)	1.86
Dry Density (g/cm^3)	1.85
Water Content (%)	0.18
Void ratio	0.46
Specific Gravity (assumed)	2.70

TEST RESULTS	
Hydraulic Conductivity (cm/s)	4.5E-04



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Fredericton, NB Canada E3B 1X6
T 506.460.8660 | F 506.460.8679

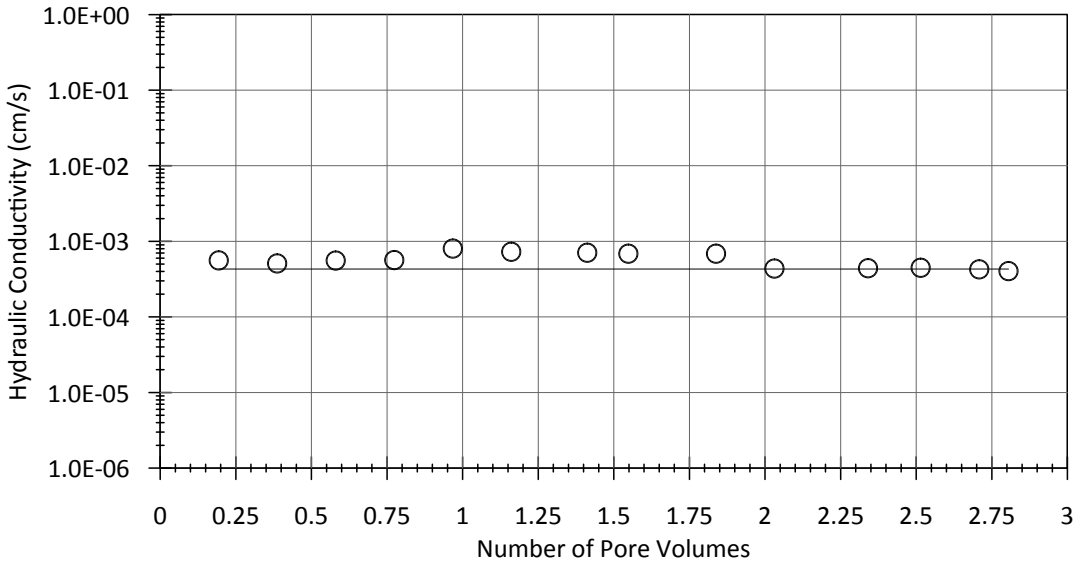
Tested by D. Oldford (12/4/2017)
Reviewed by M. Billings (12/19/2017)
Approved by S. Dickinson (12/22/2017)

PROJECT INFORMATION		SAMPLE INFORMATION	
Number	1790-002	Borehole/Test Pit	TP06A
Name	Palmer Project	ID	TP06A 3.3 m
Location	Haines, Alaska	Depth	3.3 m
Client	Constantine Metal Resources Ltd.	Type	Reconstituted

TEST INFORMATION	
Compaction	Loosely Packed
Permeant	De-aired water
Screened on Sieve	9.5 mm (3/8")
Test Method	Method B - Falling head test with constant tailwater

SAMPLE PROPERTIES (INITIAL)	
Diameter (cm)	10.1
Height (cm)	11.7
Bulk Density (g/cm^3)	1.99
Dry Density (g/cm^3)	1.99
Water Content (%)	0.16
Void ratio	0.36
Specific Gravity (assumed)	2.70

TEST RESULTS	
Hydraulic Conductivity (cm/s)	4.3E-04



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Reviewed by M. Billings (12/19/2017)
Approved by S. Dickinson (12/22/2017)

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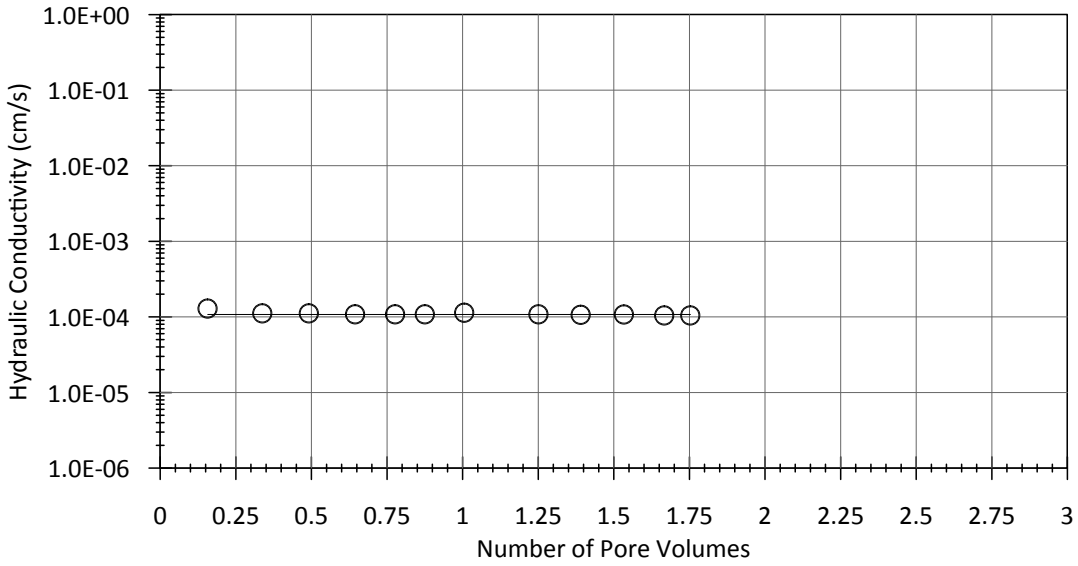
PROJECT INFORMATION		SAMPLE INFORMATION	
Number	1790-002	Borehole/Test Pit	TP07
Name	Palmer Project	ID	TP07 3-4.5 COMP
Location	Haines, Alaska	Depth	3.0m to 4.5m
Client	Constantine Metal Resources Ltd.	Type	Reconstituted

TEST INFORMATION	
Compaction	Loosely Packed
Permeant	De-aired water
Screened on Sieve	9.5 mm (3/8")
Test Method	Method B - Falling head test with constant tailwater

SAMPLE PROPERTIES (INITIAL)	
Diameter (cm)	10.1
Height (cm)	11.7
Bulk Density (g/cm^3)	1.81
Dry Density (g/cm^3)	1.80
Water Content (%)	0.27
Void ratio	0.50
Specific Gravity (assumed)	2.70

TEST RESULTS	
Hydraulic Conductivity (cm/s)	1.1E-04



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Reviewed by M. Billings (12/19/2017)
Approved by S. Dickinson (12/22/2017)

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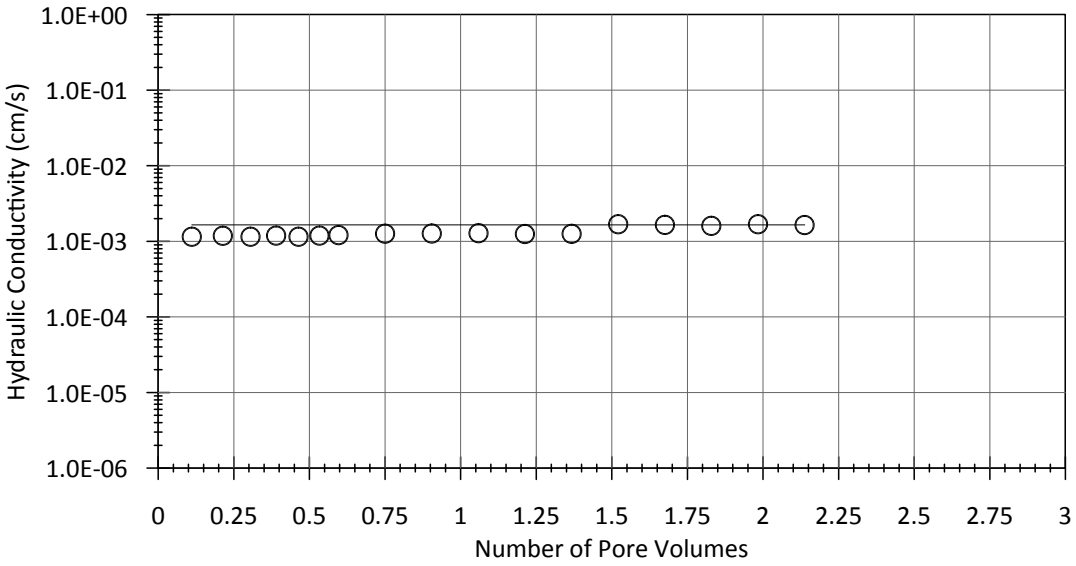
PROJECT INFORMATION		SAMPLE INFORMATION	
Number	1790-002	Borehole/Test Pit	TP08
Name	Palmer Project	ID	TP08 2.0-2.7 COMP
Location	Haines, Alaska	Depth	2.0 m to 2.7 m
Client	Constantine Metal Resources Ltd.	Type	Reconstituted

TEST INFORMATION	
Compaction	Loosely Packed
Permeant	De-aired water
Screened on Sieve	9.5 mm (3/8")
Test Method	Method B - Falling head test with constant tailwater

SAMPLE PROPERTIES (INITIAL)	
Diameter (cm)	10.1
Height (cm)	11.7
Bulk Density (g/cm^3)	1.81
Dry Density (g/cm^3)	1.81
Water Content (%)	0.20
Void ratio	0.49
Specific Gravity (assumed)	2.70

TEST RESULTS	
Hydraulic Conductivity (cm/s)	1.7E-03



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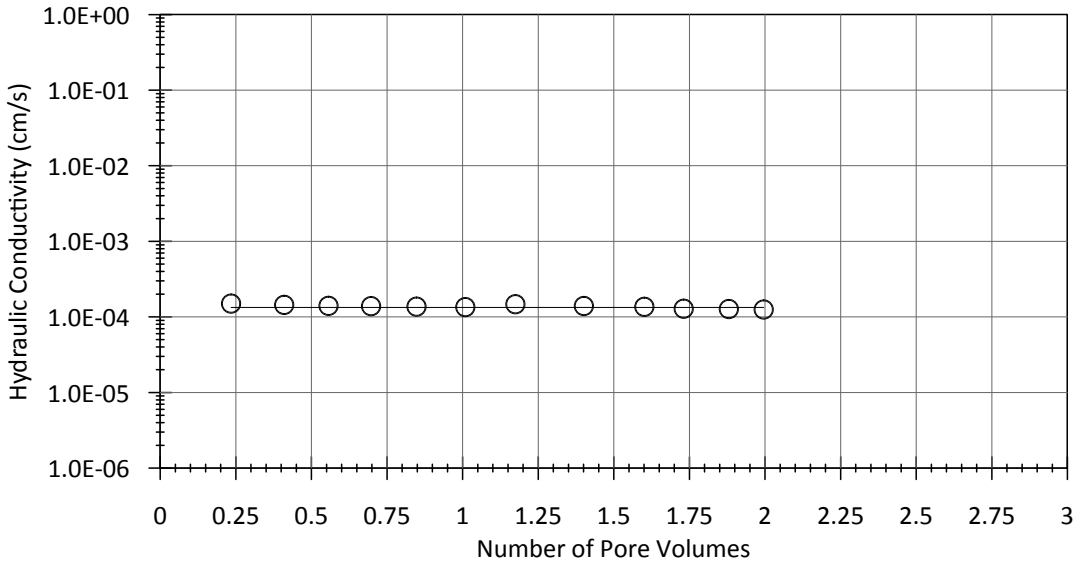
Reviewed by M. Billings (12/19/2017)
Approved by S. Dickinson (12/22/2017)

PROJECT INFORMATION		SAMPLE INFORMATION	
Number	1790-002	Borehole/Test Pit	TP08
Name	Palmer Project	ID	TP08 4.0-4.2 COMP
Location	Haines, Alaska	Depth	4.0 m to 4.2 m
Client	Constantine Metal Resources Ltd.	Type	Reconstituted

TEST INFORMATION	
Compaction	Loosely Packed
Permeant	De-aired water
Screened on Sieve	9.5 mm (3/8")
Test Method	Method B - Falling head test with constant tailwater

SAMPLE PROPERTIES (INITIAL)	
Diameter (cm)	10.1
Height (cm)	11.7
Bulk Density (g/cm^3)	1.78
Dry Density (g/cm^3)	1.78
Water Content (%)	0.28
Void ratio	0.52
Specific Gravity (assumed)	2.70

TEST RESULTS	
Hydraulic Conductivity (cm/s)	1.3E-04



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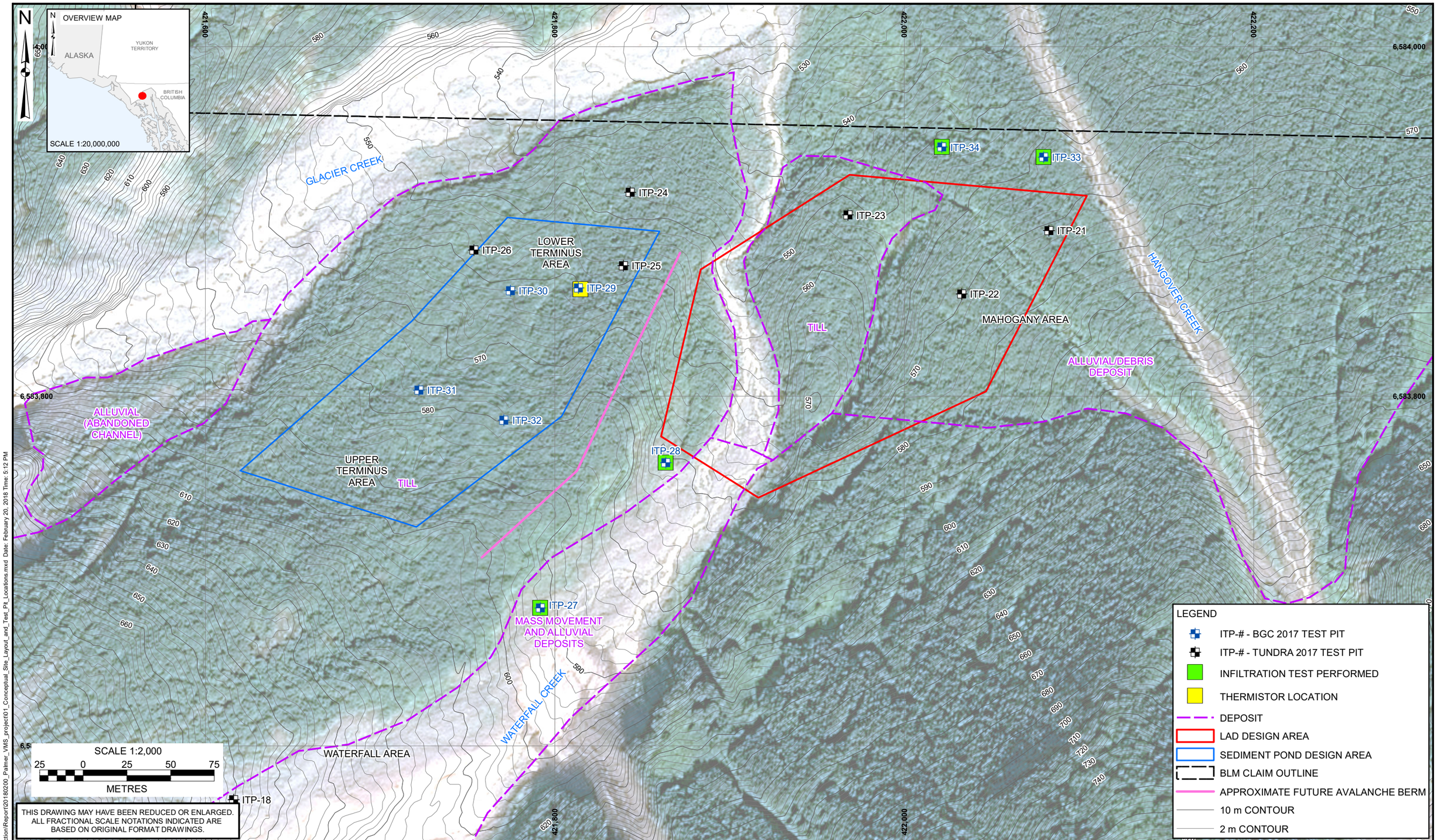
DRAWINGS



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NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S LETTER TITLED "CONCEPTUAL DESIGN FOR LAD, DIFFUSER SYSTEM, AND SEDIMENT PONDS", AND DATED NOVEMBER 2017.
3. TUNDRA 2017 TEST PIT COORDINATES FROM TUNDRA CONSULTING, LLC, RECEIVED OCTOBER 2017. BGC 2017 TEST PIT COORDINATES PROVIDED BY TUNDRA CONSULTING, LLC, EXCAVATED UNDER THE DIRECT SUPERVISION OF BGC.
4. BLM CLAIM OUTLINE FROM CORE GEOSCIENCE SERVICES INC., RECEIVED SEPTEMBER 2017.
5. TERRAIN FEATURES INTERPRETED BY OTHERS, PROVIDED BY TUNDRA CONSULTING, LLC.
6. BASE TOPOGRAPHIC DATA BASED ON LiDAR PROVIDED BY CONSTANTINE NORTH INC., RECEIVED AUGUST 2017. CONTOUR INTERVAL IS 2 m.
7. PROJECTION IS NAD 83 UTM ZONE 8N.
8. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

DRAFT

SCALE:	1:2,000
DATE:	FEB 2018
DRAWN:	LL
CHECKED:	JW
APPROVED:	BM

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: CONSTANTINE NORTH INC.

PROJECT: SEDIMENTATION PONDS AND LAND APPLICATION AREA SITE INVESTIGATION

TITLE: CONCEPTUAL SITE LAYOUT AND TEST PIT LOCATIONS

PROJECT No.:	DWG No.:
1790-002	01