ATTACHMENT 12.3

ORE DOCK FACTUAL GEOTECHNICAL REPORT

Report

Baffinland Iron Mines Corporation
Mary River Expansion Project

2017 Milne Port Ore Dock No. 2
Geotechnical Factual Data Report

				Warren R. Hoyle		
2017-10-03	0	Approved for Use	U Khan / A Boissonneault	W Hoyle	S Heiner	M Weaver
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
HATCH						**Client**

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This report contains the expression of the professional opinion of Hatch, based upon information available at the time of preparation. Hatch has conducted this investigation in accordance with the methodology outlined herein. It is important to note that the methods of evaluation employed, while aimed at minimizing the risk of unidentified problems, cannot guarantee their absence. The quality of the information, conclusions and estimates contained herein is consistent with the intended level of accuracy as set out in this report, as well as the circumstances and constraints under which this report was prepared.

Waiver, Release and Indemnification

To: Hatch Ltd. together with its affiliates, the “Consultant”

Re: 2017 Milne Ore Dock No. 2 Geotechnical Factual Data Report (and together with any subsequent revisions thereof, the “Report”) dated October 03, 2017 prepared by the Consultant for Baffinland Iron Mines Corporation (the “Client”), in respect of the drilling, soil sampling at the proposed Ore Dock 2 and laboratory testing of samples.

The undersigned hereby:

(a) acknowledges that it wishes to receive a copy of the Report from the Client and that a condition precedent to the provision of the Report to the undersigned is that it sign and deliver to the Consultant this Waiver, Release and Indemnification; and

(b) irrevocably and unconditionally:

(i) waives, releases and disclaims any and all suits, actions, proceedings, claims and any other rights (whether in tort, contract or otherwise and whether past, present or future) that it has or may have against or in relation to the Consultant in respect of or in connection with the Report;

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Dated: [insert current date]

[INSERT NAME OF REPORT RECIPIENT]

By:____

Name:

Title:

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1. Introduction

Baffinland Iron Mines LP (BIM) currently operates the Mary River iron ore mine in Nunavut, Canada. BIM plans to increase the mine production to 12 Mtpa, shipping the output through the Milne Port. This will be achieved by upgrading the mine fleet, constructing a 105 km long rail line from the mine site to the port, building a new crushing and screening facility at the port, construction of larger ore stockpiles and building a secondary dock for ship loading.

Hatch Ltd. (Hatch) was retained by BIM to conduct geotechnical investigations for an additional ore dock (Ore Dock No. 2) at the Milne Port Site.

This report presents (i) sonic borehole data at the proposed Ore Dock No. 2 location including the visual observations and laboratory test results for particle size distribution and soil behavior type and (ii) piezocone penetration test (CPTu) data. In addition, sample photographs are appended providing visual records of the soil cores.

1.1 Previous Investigations

Geotechnical investigation programs have previously been conducted at the Mary River mine site, Steensby Inlet port structure, and the Milne Inlet port site, the Tote Road, as well as offshore investigations for Ore Dock No. 1 at Milne Port.

These previous programs were conducted in 2006, 2007, and 2008 by Knight Piésold Consulting Ltd. (Knight Piésold), in 2010 by AMEC Earth and Environmental (AMEC) in 2011 by Thurber Engineering (Thurber), and in 2013 and 2014 by Hatch.

For the 2013-2014 investigation, offshore boreholes were drilled at the Milne Port for Ore Dock No. 1. The soil thermal resistivity was tested, and a geophysical survey consisting of seismic refraction, seismic resonance, and Multichannel Analysis of Surface Waves were conducted. Information from the 2013-2014 investigation undertaken by Hatch for the Milne Port has been used in this report when relevant.

1.2 Pre-Investigation Activities

1.2.1 Safety Management Plan

Safety management was a key consideration during the planning process for the geotechnical investigations. A safety management plan was prepared by Hatch and reviewed and approved by BIM and Boart Longyear Ltd. (Boart Longyear). As part of the execution plan for the Milne Port Offshore Investigation, a Job Hazard Analysis (JHA); appended as Appendix E; was developed by Hatch and BIM and reviewed by Boart Longyear. All site personnel reviewed and signed off on the JHA. This JHA was reviewed on a periodic basis and updated when there were changes to the conditions or the work activities.

1.2.2 Ice Thickness Assessment

As required by the JHA, an ice assessment plan was prepared to test the thickness of the ice sheet and assess it before mobilizing equipment on the ice, to ensure the ice was sufficiently strong to support the drill rig and associated equipment and personnel. The target thickness was more than 1.5 m of ice.

The ice thickness assessment consisted of auguring test holes through the ice on a grid pattern at the drilling location; 34 of the 46 planned auger holes were drilled to confirm the ice thickness. The 12 remaining holes were located mostly in an area of ground ice (full ice column to the seabed) and did not require detailed delineation as found during the ice augering program. The test holes were augured using a 20 cm (8 in) diameter gas-powered auger operated by two Boart-Longyear workers. Once the hole was augured, a Hatch field engineer measured the thickness of the sea ice, the depth of freeboard as well as the height of the snow cover on the ice. The completed ice assessment and UTM Coordinates of the test holes can be found in Appendix H.

2. Geotechnical Investigation

2.1 General

The drilling supervision, material logging and sampling was carried out by Hatch Boart Longyear was selected as the drilling contractor and ConeTec Inc. (ConeTec) was selected as the contractor to perform piezocone penetration tests, (piezocone soundings). The Hatch field personnel and the contractor mobilized to the site on March 7, 2017. The field investigations for the Milne Port Ore Dock No. 2 offshore program were completed between March 8, 2017 and April 7, 2017.

A total of six boreholes were developed ranging from a depth of 24.4 m to 42.7 m below the sea bed. In addition, eight piezocone soundings were performed with depths ranging from 20.5 to 39.5 m.

Soil samples were collected on site and shipped to the Hatch geotechnical laboratory in Niagara Falls for additional visual examination. Representative samples were selected for further laboratory testing (See Section 2.5 for more detail).

This report provides information for the proposed Milne Port Ore Dock No. 2 seabed area approximately 300 m from the shoreline. Land based drilling was completed for the Milne Port infrastructure and results are presented in the report entitled, “2016 Milne Port Geotechnical Investigation Factual Data Report (H353034-1000-229-230-0002, Rev. 2, October 03, 2017)”.

2.2 Sonic Borehole and CPTu Sounding Locations

The surveyed location of the sonic borehole and the borehole depths are provided in Table 2-1. The CPTu surveyed locations and total depths are summarized in Table 2-2. All coordinates are located within Zone 17 of the Universal Transverse Mercator (UTM) Grid. The horizontal datum for this project is the North American Datum 1983 (NAD 83).
The as-built borehole location plan is provided in Appendix A.

In the naming convention, the prefix BH represents Borehole and CPT represents Piezocone sounding, while 17 refers to 2017, the year of the investigation. The first letter following the dash symbol (-) categorizes the borehole location as the proposed Ore Dock No. 2 (D).

Table 2-1: Milne Port Borehole Locations and Depths

Borehole Number	Easting (m)	Northing (m)	Depth (m)
BH17-D001	503,644	7,976,666	27.4
BH17-D002	503,764	7,976,680	27.4
BH17-D003	503,608	7,976,710	30.5
BH17-D004	503,701	7,976,728	42.7
BH17-D005	503,786	7,976,738	31.1
BH17-D006	503,678	7,976,797	24.4

Table 2-2: Milne Port CPTu Locations and Depths

Borehole Number	Easting (m)	Northing (m)	Depth (m)
CPT17-D001	503,607	7,976,718	32.8
CPT17-D002	503,705	7,976,728	39.5
CPT17-D003	503,785	7,976,758	30.4
CPT17-D004	503,646	7,976,768	32.1
CPT17-D005	503,736	7,976,781	25.1
CPT17-D006	503,808	7,976,808	20.6
CPT17-D007	503,767	7,976,684	30.2
CPT17-D008	503,636	7,976,651	30.0

2.3 Drilling and Sampling Methodology for Boreholes

The geotechnical boreholes were drilled using a BL100 Mini Sonic Drilling rig owned and operated by Boart Longyear. The boreholes were advanced using vibration of the drill string at a high frequency in addition to rotary motion, and pressure by the drilling head.

A 178 mm (7 in.) casing was lowered to approximately 3 m above the seabed and suspended using a collar seated on the ice around the borehole. A 152 mm (6 in.) casing was then lowered to the seabed surface and an HQ rod (89 mm OD) was used for the sonic drilling with seawater. Figure 1 shows the offshore drilling setup including the drilling rig, drill shack, survival shack, drilling rods/casings rack and a light tower. Other major equipment included a tracked utility vehicle, skid steer, generator sets, frost fighters and pickup trucks.

Figure 1: 2017 Offshore Drilling Setup

In order to collect soil samples, a 3 m drilling rod was advanced 1.5 m into the seabed for each run. The bottom 1.5 m was collected into a 4 in. split PVC pipe, and the top 1.5 m was collected in a second 4 in. split PVC pipe. Both samples from the 3 m run were inspected by the field supervisor.

The Hatch field supervisor documented the materials encountered, and determined in situ testing and sampling requirements. Samples were typically taken at 2 m to 4 m spacing. The description of soils as detailed in the geotechnical borehole reports are based on field visual classification and confirmatory laboratory testing in accordance with the explanatory notes included with these reports.

The detailed geotechnical borehole drilling reports are contained in the attached Appendix B and should be referenced for a complete description of soil materials and the in situ testing and sampling performed. Appendix B also contains a set of explanatory notes detailing terminology used in the borehole reports. Additional observations such as testing and sampling procedures, percent recovery, water loss/gain, and mechanical heating of samples were recorded, along with time of observation. Photographs of samples collected during the drilling investigation are contained in Appendix C.

2.4 Methodology for Performing Piezocone Soundings

The piezocone soundings were completed by ConeTec using the Boart Longyear drilling rig, CPTu equipment and a ramset (Figure 2). The piezocone soundings were undertaken as per ASTM D5778. The ramset used the hydraulic system of the drilling rig to push an instrumented cone under the seabed. The drilling rig was secured in place using heavy duty steel chains and titanium ice studs to prevent it from lifting.

Figure 2: Ramset used for Pushing Cones through the Seabed

The cone was pushed through the soil at 2.5 cm/s and data was collected electronically in real time by an onsite data acquisition system as shown in Figure 3. Tip resistance, sleeve friction and pore-water pressure was recoded at 2.5 cm intervals. The Soil Behaviour Type (SBT) chart by Robertson and Campanella (1986) was used to characterize the soil type i.e., Sand, Silty Sand, etc.

Figure 3: Data Acquisition System for Piezocone Testing

A total of 8 piezocone soundings were completed for the offshore investigation. Piezocone testing characterizes the soil based on its behaviour type as opposed to the particle size distribution. Soil behavior is deduced based on the friction ratio.

$$Friction\ Ratio = \frac{Sleeve\ Friction}{Tip\ Resistance} \times 100$$

According to Robertson and Campanella's SBT chart, finer grained soils tend to have a high friction ratio (i.e., high sleeve friction, low tip resistance) while coarser grained soils tend to have a lower friction ratio (i.e., low sleeve friction, high tip resistance). Overburden stress and pore-water pressure data can be used to correct soil classifications acquired from piezocone testing.

See Appendix F for detailed information regarding the CPTu test results.

2.5 Laboratory Testing

All soil samples were shipped to the Hatch geotechnical laboratory in Niagara Falls, a Canadian Council of Independent Laboratories (CCIL) certified laboratory (see Appendix G for the certification document). Discussion of the lab results is included in Section 3 of this report, with full laboratory test results in Appendix D.

Table 2-3: Laboratory Testing Standards from 2017 Investigation

Name	Standard
Standard Test Methods for Particle-Size Distribution of Soils Using Sieve Analysis	ASTM D6913
Standard Test Method for Particle Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis	ASTM D7928
Direct Shear Tests of Soils Under Conolidated Drained Conditions	ASTM D3080

3. Results of Investigation

3.1 Milne Port Offshore Boreholes

A total of six (6) boreholes were drilled offshore at Milne Port to support design of the proposed Ore Dock No. 2 at Milne Port. The boreholes were arranged into three categories based on the depth to seabed; the shallow water (closest to shoreline), the mid-depth holes, and the deep water (farthest from shoreline). Fence diagrams of select borehole sections are presented in Appendix I.

The materials encountered during the investigation typically consisted of silt and sand, sand or gravelly sand. In the shallow and deep boreholes these layers were found inter layered without a consistent trend of coarsening or fining with depth, when all the boreholes are considered. In general, it was noted that there was a tendency for coarser deposits to have a brown to reddish brown colour whereas finer deposits tended to be coloured grey to dark grey, see Figure 4.

Figure 4: Transition from Gravelly Sand to Silt in BH17-D002

The recorded elevations for the boreholes were determined from the surveyed drilling position on the sea ice and the depth to the sea bed; the depths noted refer to depth below the sea bed. Total drilling depths were corrected for the tidal effects.

3.1.1.1 Silt and Sand

A soil comprising a mix of silt and sand was encountered at the surface, where there was recovery, in the mid-depth boreholes. Layers of silt and sand were also noted in the mid-depth boreholes beneath the surface layer of sand, and also at depth. The silt and sand was noted to occur in either grey to dark grey, generally comprised of fine sand, see Figure 5, or a reddish brown, which tended to have coarse sand.

Figure 5: Dark Grey Silt and Sand Encountered Below 4.6 m in BH17-D001

3.1.1.2 Sand

Sand was encountered at surface in the shallow and deep borehole locations. The sand was typically fine to coarse grained when encountered in the upper 10 m of the boreholes, and tended to be finer at depth. Sand was generally light grey to brown. Sand was intersected for the full depth of the deep borehole BH17-D006. Examples of the sand encountered in the investigation are presented in Figure 6 through Figure 8.

Figure 6: Fine Sand from BH17-D003

Figure 7: Grey Sand from the Sea Bed, BH17-D001

Figure 8: Reddish Brown Sand Encountered in BH17-D001

3.1.1.3 *Gravelly Sand*

The gravelly sand layer (also referred to as Sand with Gravel in the borehole logs) was encountered in both shallow and one mid-depth borehole. Typically the gravelly sand was well graded, and where described the gravel was noted to be rounded to subangular. The gravelly sand was brown to reddish brown in most cases, as seen in Figure 9.

Figure 9: Gravelly Sand from BH17-D005

3.1.2 *Shallow Water Boreholes*

The two boreholes drilled in shallow water are BH17-D001 and BH17-D002. The recorded elevations are -2.38 m and -3.25 respectively. The materials encountered in these boreholes are summarized in Table 3-1. Generally BH17-D001 intersected alternating sand and gravelly sand below 7.6 m, and BH17-D002 encountered gravelly sand below 8.5 m.

Table 3-1: Summary of Material Encountered in Shallow Boreholes

Borehole Number	Depth Material Encountered		
	Silt and Sand	Sand	Gravelly Sand
BH17-D001	4.3 – 7.6	0 – 4.3; 9.7 – 17.1; 18.3 – 21.9; 24.4 – 27.4*	17.1 – 18.3; 22.9 – 24.4
BH17-D002	4.6 – 8.5	0 – 3.0; 12.8 – 13.7	8.5 – 12.8; 13.7 – 27.4

* Denotes termination depth

3.1.3 *Mid-Depth Boreholes*

BH17-D003, BH17-D004 and BH17-D005 were drilled at an elevation of -15.3 m, -16.6 m and -19.5 m, respectively. The materials intersected in these boreholes is summarized in Table 3-2.

Table 3-2: Summary of Materials Encountered in Mid-Depth Boreholes

Borehole Number	Depth Material Encountered		
	Silt and Sand or Silty Sand	Sand	Gravelly Sand
BH17-D003	3.0 – 6.1; 21.3 – 21.9; 27.4 – 30.5*	1.5 – 3.0; 6.1 – 9.1; 10.7 – 11.3; 22.9 – 23.5; 24.4 – 25.0; 25.9 – 27.4*	15.2 – 15.8; 16.8 – 17.4; 18.3 – 18.9;
BH17-D004	0 – 1.5; 3.0 – 4.6; 25.9 – 33.5	4.6 – 18.3; 19.8 – 25.9; 33.5 – 42.7*	
BH17-D005	0 – 2.1; 6.7 – 9.1; 19.3 – 21.3	12.2 – 15.2; 16.5 – 19.3; 21.3 – 31.1*	

* Denotes termination depth

Gravelly sand was encountered in BH17-D003 between 15.2 m and 18.9 m, core loss during the investigation prevented full definition of this strata. While drilling, soil samples were retrieved using a core barrel with a flapper bit to ensure good sample recovery. In BH17-D003, the flapper drilling bit was lost at a depth of 9.1 m below the seabed. This resulted in poor sample recovery. A Standard Penetration Test (SPT) was carried out every 1.5 m to recover split spoon samples. A replacement drill bit was used for drilling between a depth of 29.9 m to the end of borehole.

3.1.4 *Deep Water Boreholes*

The sole deep water borehole, BH17-D006, was located on the sea bed with a collar elevation of -29.8 m. Unlike the other boreholes, neither silty material or gravelly material was intersected, see Table 3-3. An example of the sand from BH17-D006 is presented in Figure 10.

Table 3-3: Summary of Materials Encountered in Deep Borehole

Borehole Number	Depth Material Encountered		
	Silt and Sand or Silty Sand	Sand	Gravelly Sand
BH17-D006	Not Encountered	0 – 24.4*	Not Encountered

Figure 10: Sand from BH17-D006

3.1.5 *Influence of Drilling Methods on SPT N-Values*

Various drilling methods have been used at the Milne Port Site to investigate the seabed subsurface conditions. The rotary wash boring (rotary) method was primarily used with sea water as the drilling fluid during the 2013 investigations associated with the Ore Dock No. 1. There were difficulties encountered during the borehole advancement including sand binding around the rods and heaving into the drill rods. As a result of these difficulties, New Zam D mud was added to the sea water in order to mitigate these issues. This was only partly successful, while there was an improvement in production, some SPT values were considered to be invalid due to soil disturbance.

During the 2014 investigations, bentonite was added to the New Zam D mud mixture. This combination appeared to stabilize the borehole conditions resulting in a more consistent SPT blow count.

In order to maximize drilling production, a Mini Sonic Drilling rig was selected in 2017. However, the sonic drilling method involves advancement of the casing in conjunction with the core barrel, as well as the use of sea water as the drilling fluid and there was concern that this drilling technique might cause soil disturbance prior to conducting SPT. Disturbance of the in-situ conditions would likely result in a lower SPT N-value than would have been measured without the disturbance. Figures provided in Appendix J show a comparison of N-Values recorded in 2013, 2014 and 2017.

In contrast, piezocone sounding do not require advancement of drill casing and a core barrel past the surface layer of the seabed, reducing the chances of disturbance of the in-situ conditions. Accordingly, piezocone testing was undertaken as part of the 2017 investigation in order to provide the in-situ density data to supplement the material classification and sample collection undertaken in the boreholes. Down hole seismic profiling was carried out at two boreholes locations.

3.2 Piezocone Sounding Results

The piezocone data attached in Appendix F provides a general interpretation of the tip resistance, sleeve friction and pore water pressure during each sounding. The piezocone sounding plots, provided by Conetec, include inferred phi and SPT values as well as inferred soil types based on the soils Soil Behaviour Type (SBT) chart. Soil samples were collected using the sonic core barrel and SPT split spoon to supplement and confirm piezocone test results with field classification and laboratory testing.

The piezocone test data requires further review by a qualified geotechnical engineer for selection of the design parameters and safety factors. A summary of the inferred materials, based on the SBT, from each of the piezocone soundings is presented below.

3.2.1.1 CPT17-D001

CPT17-D001 was performed at the BH17-D003 location. The SBT indicates a silty sand in the upper 12 m, changing to sand with trace to some gravel below 12 m depth.

3.2.1.2 CPT17-D002

CPT17-D002 was performed at the same location at BH17-D004. The SBT indicates silt and sand for the top 6 m, alternating layers of sand and silty sand between 6 m and 16 m, and sand below 16 m from the seabed surface.

3.2.1.3 CPT17-D003

CPT17-D003 was performed slightly north of BH17-D005. Based on the SBT the soil type is silt and sand at the top 5m and 19 m to 21 m below the seabed. Alternating bands of sand and silty sand are indicated between 5 m and 11 m below seabed. The soil behaves like sand 11 m to 19 m and from 21 m to the end of the borehole.

3.2.1.4 CPT17-D004, CPT17-D005 and CPT17-D006

CPT17-D004, CPT17-D005 and CPT17-D006 were drilled along a line slightly south of BH17-D006. The SBT indicates alternating layers of sand and silty sand for the top 10 to 15 m below the seabed. The CPTu testing showed a 1 m thick layer of sandy silt at a depth of 17 m and 27 m, respectively, below the seabed.

3.2.1.5 CPT17-D007

CPT17-D007 was performed at the same location as BH17-D002. Based on the SBT, the soil behaves as silty sand in the upper 10 m below the seabed and indicates gravelly sand 15 m below seabed.

3.2.1.6 *CPT17-D008*

CPT17-D008 was performed close to borehole BH17-D001. Based on the SBT, the top 7 m of the test location is predominantly silty sand. Soil behaviour indicates sand from 7 m to 13 m, and alternating layers of sand and gravelly sand 13 m below the seabed.

3.3 Laboratory Test Results

Laboratory testing on select soil samples was undertaken to confirm the site classification of the material. The results of the classification tests are presented in Table 3-4 with full laboratory results presented in Appendix D. Results of the classification tests are also presented on the borehole reports in Appendix B.

Table 3-4: Summary of Particle Size Distribution Testing

Borehole ID	Depth (m)	Sample	Percent Gravel	Percent Sand	Percent Fines
BH17-D001	0.90	DS1	3	89	8
	7.00	DS4	3	41	57
	14.50	DS9	1	95	4
	17.70	DS11	60	39	1
BH17-D002	0.00	DS1	5	91	4
	5.20	DS3	2	46	52
	8.50	DS5	31	67	1
	15.70	DS9	28	68	3
	17.50	DS10	27	66	8
	25.90	DS13	32	66	2
BH17-D003	5.20	DS2	3	40	57
	15.20	AS6	35	63	1
	21.30	AS9	5	56	39
	30.20	DS14	1	78	23
BH17-D004	7.60	AS5	2	94	4
	18.00	DS10	1	96	3
	29.30	DS16	2	49	49
	38.70	DS20	8	91	1
	42.10	DS21	0	98	2
BH17-D005	0.00	DS1	8	54	38
	7.00	DS3	10	55	35
	12.80	DS5	5	92	3
	21.00	DS9	1	41	58
	25.30	DS12	1	80	20
	28.00	DS13	0	96	4

Borehole ID	Depth (m)	Sample	Percent Gravel	Percent Sand	Percent Fines
BH17-D006	0.00	AS1	3	79	18
	2.10	DS2	0	99	1
	11.60	DS8	3	95	2
	15.80	DS11	0	82	18

Representative samples were selected for direct shear testing. Samples were remolded and compacted to in situ conditions. The inferred values of peak and residual internal friction angles, based on the direct shear testing, are presented. The test reports should be reviewed by a qualified engineer to select the appropriate design values based on these results and in consideration with the other information gathered during the investigations. The results of the direct shear testing are summarized with the Laboratory Test Reports in Appendix D.

Table 3-5: Summary of Direct Shear Testing on Borehole Samples

Borehole ID	Depth (m)	Sample	Peak m	Residual m
BH17-D003	5.2 – 5.5	DS2	34.6°	32.3°
BH17-D004	18.0 – 18.3	DS10	42.9°	31.6°
BH17-D005	0.0 – 0.3	DS1	39.4°	36.7°
BH17-D005	12.8 – 13.1	DS5	37.8°	31.9°
BH17-D005	30.5 – 31.1	DS14	35.9°	33.3°

4. Summary of Geotechnical Findings

A summary of geotechnical findings for the 2017 Ore Dock No. 2 investigations is provided below:

- The most common soil intersected in the investigations was a sand, varying from fine grained with trace to some silt, to fine to coarse grained with trace gravel.
- Layers of silt and sand were intersected in the shallow and mid-depth boreholes; gravelly sand was encountered in both shallow boreholes and one mid-depth borehole.
- The soil primarily consists of sand with trace silt and gravel. Layers of silt and sand were observed at a depth of 0 m, 4.6 m, 21 m and 26 m. Layers of sand and some gravel were observed in the shallow boreholes at various depths between 8 m and 25 m below seabed.
- There is a linear increase with depth in the pore water pressure, as measured by the piezocone soundings, indicating clean sand. This notwithstanding, interbedded silt was noted with in the sand sequence in several locations and layers of silt and sand were encountered.

- Seismic data indicates an increase in shear velocity with depth.
- No bedrock was encountered during the 2017 Ore Dock No. 2 investigation.
- No permafrost or frozen soils were encountered during the 2017 offshore investigation.

5. References

Hatch Ltd. H337697-0000-15-124-0004.Geotechnical Data Report –Infrastructure. April 5, 2012.

Hatch Ltd. H349000-1000-15-122-0001. Geotechnical Design Criteria. Aug 08, 2013.

Hatch Ltd. H349000-2200-15-124-0002. Milne Ore Dock Geotechnical Investigation Factual Report. Feb 21, 2014.

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Robertson.P,K., Campanella, RG, Gillespie, D., and Greig, J., 1986. Use of Piezometer Cone data. In-Situ ’86 Use of In-situ testing in Geotechnical Engineering, GSP 6, ASCE, Reston, VA, Specialty Publication, pp 1263-1280.

ASTM D5778 Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.

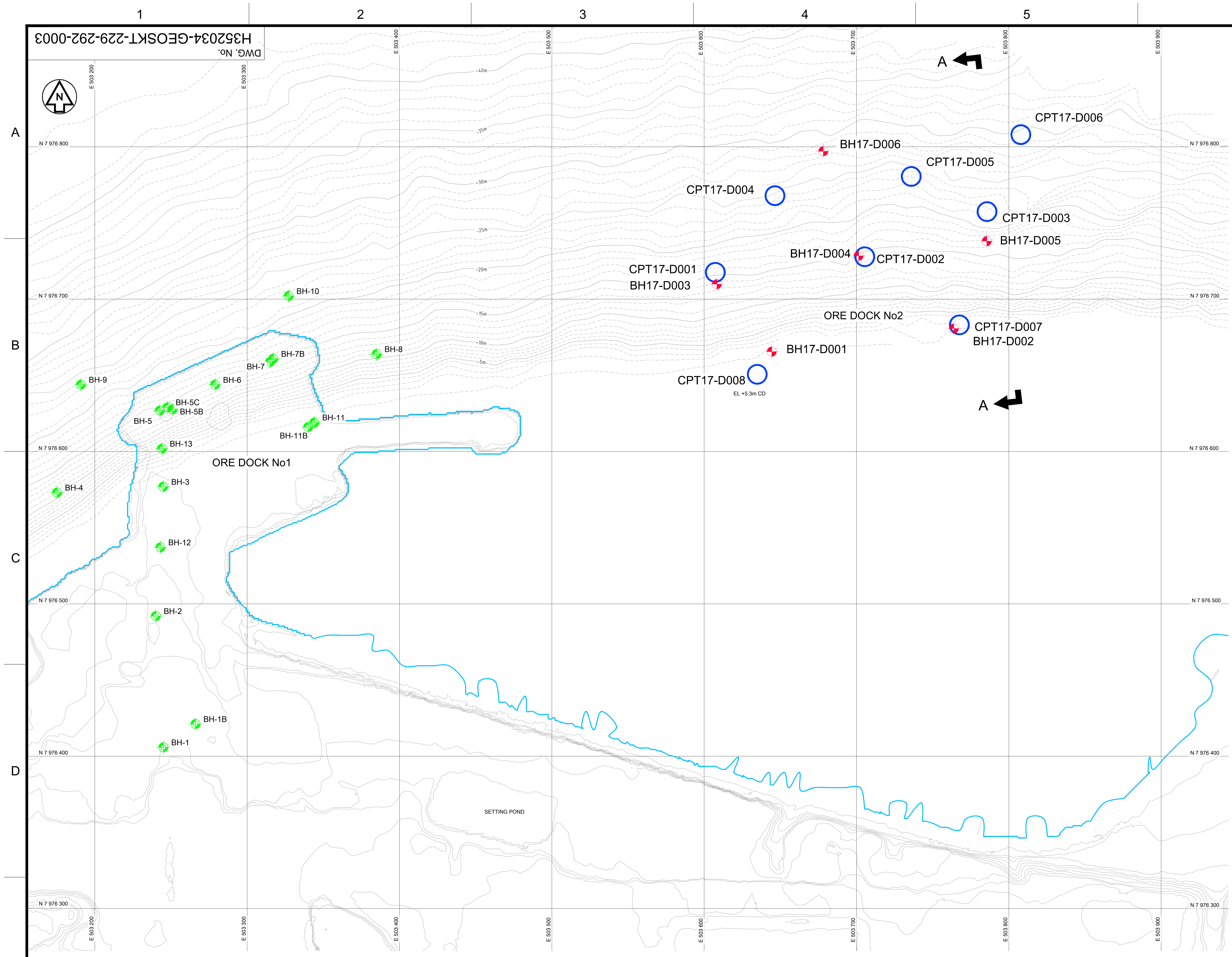
Hatch Ltd. H349000-2200-015-124-0002. 2014 Milne Ore Dock Geotechnical Investigation Factual Report.

Youd et al., 1998 Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluations of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, Salt Lake City, UT.

Appendix A

Borehole Location Plan

DWG. No.
H352034-GEOSKT-229-292-0003



PLAN

0 30 60 90 120 150 METRES

SCALE 1:1500

NOTES:

1. *COORDINATE GRID IS UTM, NAD 83, ZONE 17*
2. *INFORMATION FOR BATHAMETRY IS A COMBINATION OF LOGISTEC STEVEDORING INC. AND M&S.*
3. *THE CHART DATUM HAS BEEN ASSUMED TO BE 1.2 METRES BELOW CGVD 28 (0.0m CHART DATUM = -1.2m GEODETIC DATUM)*
4. *ELEVATIONS ARE BASED ON CHART DATUM*
5. *DIMENSIONS AND ELEVATIONS ARE SHOWN IN METERS*
6. *ELEVATIONS MEASURED AT THE TIME OF BOREHOLE COMPLETION (SEE BOREHOLE REPORTS) .*

LEGEND

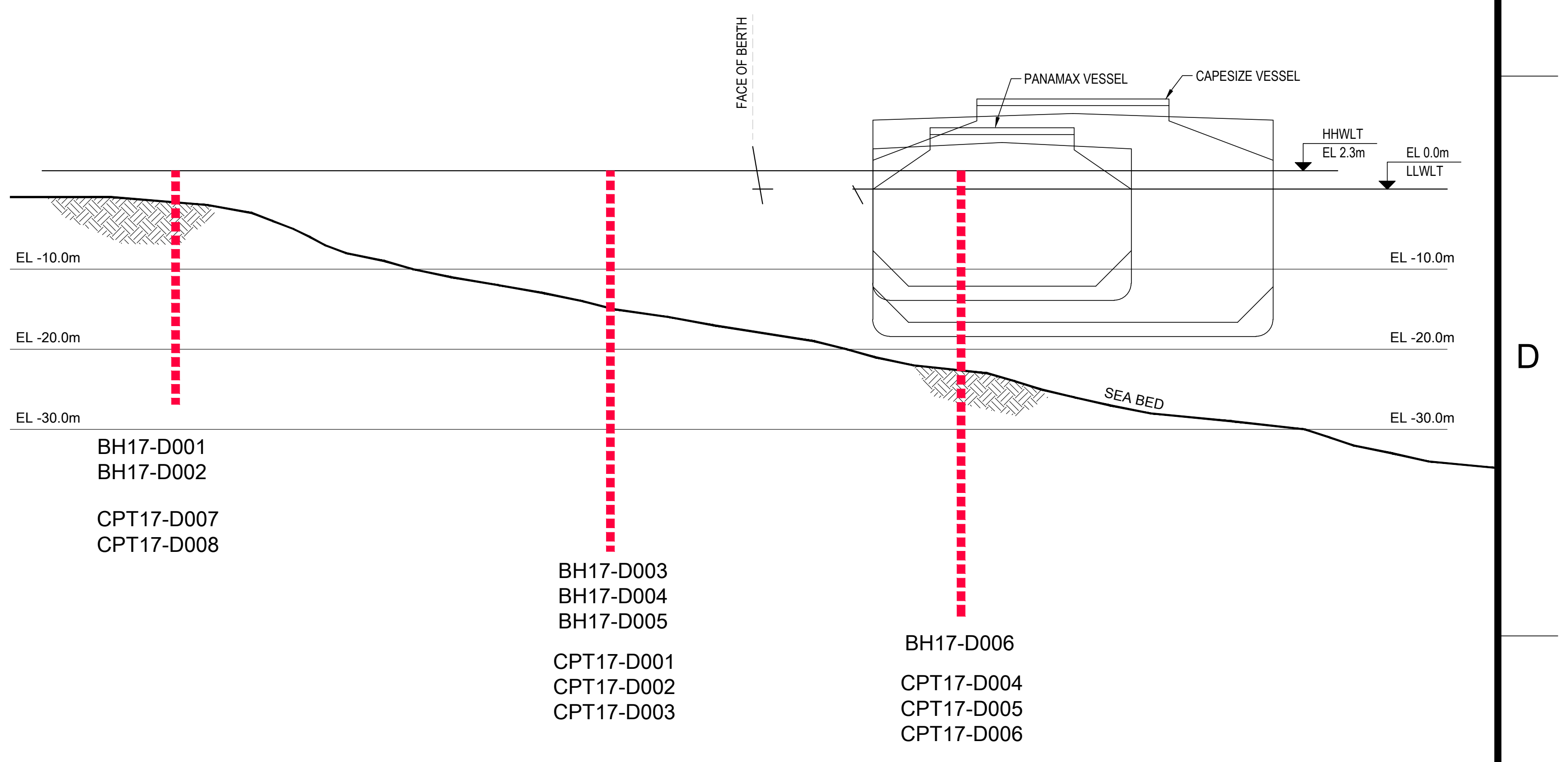
🟥	2017 GEOTECHNICAL INVESTIGATION SONIC BOREHOLE LOCATION
○	2017 GEOTECHNICAL INVESTIGATION PIEZOCONE PENETRATION TEST (CPTu) LOCATION
🟩	2013 GEOTECHNICAL INVESTIGATION BOREHOLE LOCATION

BH LOCATIONS (AS-BUILT)

POINT #	EASTING	NORTHING	DEPTH
BH17-D001	503644.4	7976665.6	27.4
BH17-D002	503763.9	7976680.7	27.4
BH17-D003	503608.4	7976709.9	30.5
BH17-D004	503701.4	7976728.5	42.2
BH17-D005	503785.6	7976738.1	31.1
BH17-D006	503678.2	7976797.1	24.4

CPT LOCATIONS (AS-BUILT)

POINT #	EASTING	NORTHING	DEPTH
CPT17-D001	503607.4	7976717.6	32.8
CPT17-D002	503705.3	7976728.1	39.5
CPT17-D003	503785.4	7976757.7	30.4
CPT17-D004	503646.4	7976768.1	32.1
CPT17-D005	503736.1	7976780.8	25.1
CPT17-D006	503807.6	7976808.4	20.5
CPT17-D007	503767.5	7976683.6	30.2
CPT17-D008	503635.0	7976650.8	30.0



SECTION A-A

0 15 30 45 60 75 METRES

SCALE 1:750

DESIGN SHOWN IS A HATCH CONCEPT DESIGN
CONTRACTOR TO PROVIDE HIS OWN DESIGN

DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

NAME

SIGNATURE

ENG REG NUMBER

REVISION DATE

ORIGINAL DATE

REGISTERED PROFESSIONAL

No.	DESCRIPTION	BY	CHK'D	DATE
C	AS BUILT BOREHOLE & CPTu	W.H.	S.H.	19/05/2017
B	NUMBER OF BH REVISED, CPT ADDED	W.H.	S.H.	27/01/2017
A	CLIENT REVIEW	W.H.	S.H.	20/01/2017

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	D PARKES	NR	20/01/2017
DESIGNER		NR	
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	S HEINER		

DRAWING APPROVAL STATUS: Record Document

Baffinland

BAFFINLAND EXPANSION 12 MTPA MINE OPTION
PRE FEASIBILITY STUDY

PORT SITE - ORE DOCK No. 2
2017 GEOTECHNICAL INVESTIGATIONS
BOREHOLE AND CPTu LOCATIONS

SCALE	DWG. No.	REV
1:50,000 OR AS NOTED	H352034-GEOSKT-229-292-0003	1

$USERNAME$ $DATE$ $FILE$ $TIME$

Appendix B

Borehole Reports

HATCH™

List of Abbreviations and Terms Used in the Borehole Reports

(Sheet 1)

General

Elevations
Elevations are referenced to datum indicated.

Depth
All depths are given in meters (feet) measured from the ground surface unless otherwise noted.

Sample Recovery
Indicates the length retained in millimeters (inches) in a split spoon sampler or percentage recovery of sample retained in the core barrel sampler.

Sample Number
Samples are numbered consecutively in the order in which they were obtained or attempted in the borehole.

Sample Type
The first letter describes the sampling method and the second, the shipping container.

Sampling Method
A – Split Tube
B – Thin Wall Tube
C – Piston Sampler
D – Core Barrel
E – Auger
F – Wash
G – Shovel Grab Sample
K – Slotted Sampler

Shipping Container
O – Tube
P – Water Content Tin
Q – Jar
S – Plastic Bag
U – Not Recovered
X – Plastic & PVC Sleeve (Sonic)
Y – Core Box
Z – Discarded

Abbreviations
N/A – Not applicable
N/E – Not encountered
N/O – Not observed

Soil

Soil Description, Label and Symbol
Soil description under the “Description” column conforms generally, but not rigorously, to the Unified Soils Classification System. For a given soil unit, defined by depth boundaries, the descriptive text constitutes the definitive soil unit description and takes precedence over both the brief label and the symbol used to graphically represent the soil unit.

Grain Size

Clay		<0.002 mm
Silt	0.002 –	0.075 mm
Sand	0.075 –	4.75 mm
Fine	0.075 –	0.42 mm
Medium	0.42 –	2.00 mm
Course	2.00 –	4.75 mm
Gravel	4.75 –	75 mm
Fine	4.75 –	19.00 mm
Coarse	19.00 –	75.00mm
Cobbles	75 –	300 mm
Boulder		>300 mm

Relative Quantities

Term	*Example*	*(%)*
Trace	Trace sand	1 – 10
Some	Some sand	10 – 20
With (adjective)	With Sand (Sandy)	20 – 35
And	And sand	>35
Noun	Sand	>50

Standard Penetration Test (SPT)
The test is carried out in accordance with ASTM D-1586 and the ‘N’ value corresponds to the sum of the number of blows required by a 63.5-kg (140-lb) hammer, dropped 760 mm (30 in.), to drive a 50-mm (2-in.) diameter split tube sampler the second and third 150 mm (6 in.) of penetration.

Density (Granular Soils)

	N(SPT)
Very loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very dense	>50

Consistency (Cohesive Soils)

	N(SPT)
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30
Hard	>30

Plasticity/Compressibility

		Liquid Limit (%)
Low plasticity clays	Low compressibility silts	<30
Medium plasticity clays	Medium compressibility silts	30 – 50
High plasticity clays	High compressibility silts	>50

Dilatancy
None - No visible change, during shaking or squeezing
Slow - Water appears slowly on surface of specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid - Water appears quickly on the surface of specimen during shaking and disappears quickly upon squeezing.

Sensitivity

Insensitive	<2
Low	2 – 4
Medium	4 – 8
High	8 – 16
Quick	>16

BASIS FOR SOIL DESCRIPTION

(Based on AS1726-1993 - Geotechnical Site Investigations, with modifications)

GRAPHIC SYMBOLS FOR SOILS

GRAVEL
- poorly graded - ▨
- well graded - ▨

SAND
- poorly graded - ▨
- well graded - ▨

SILT
- of low plasticity - ▥
- of high plasticity - ▥

CLAY
- of low plasticity - ▨
- of high plasticity - ▨

ICE - ■

COBBLES AND BOULDERS - ▨

ORGANIC/ PEATY SOIL - ▨

FILL/ MADE GROUND - ▩

Composite soil types are presented using combined symbols, eg. **Gravelly Sandy CLAY** ▨

GROUNDWATER OBSERVATIONS

- Permanent Water Level ▼
- Temporary Water Level ▽
- Inflow into Pit or Borehole ►
- Outflow/ Water Loss in Borehole ◄
- Slow Inflow/ Seepage into Pit or Borehole ≈

SAMPLE TYPES

- Disturbed bag sample ▧
- Bulk Disturbed (>20kg) ☒
- Hollow Stem Auger Core ▯
- Auger Flight Cuttings ▧
- Standard Penetration Test (SPT), with Disturbed Split-Spoon Sample ◪
- SPT (no recovery) ▱
- Thin walled "undisturbed" push tube sample eg. U60, U100 etc ■
- Sample attempted with no recovery ☒

HATCH

BOREHOLE REPORT

BH17-D001

Sheet 1 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/31/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT, trace GRAVEL: Grey, medium grained, poorly graded sand; fine gravel											
	-2.9	0.5															
									▨	DS1 taken from .90-1.20m.		3	89	8			
	-3.4	1.0															
	-3.9	1.5															
	-4.4	2.0															
	-4.9	2.5															
	-5.4	3.0						100%		AS2 taken from 3.00-3.60m. N= 7							
	-5.9	3.5															
	-6.4	4.0															
						SILT and SAND, trace GRAVEL: Reddish brown, coarse grained sand, well graded, rounded to subangular gravel											
	-6.9	4.5															
	-7.4	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D001

Sheet 2 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/31/2017
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SILT and SAND, trace GRAVEL: Reddish brown, coarse grained sand, well graded, rounded to subangular gravel *(Continued)*				DS3 taken from 5.20-5.50m.							
	-7.9	5.5															
	-8.4	6.0															
	-8.9	6.5															
	-9.4	7.0								DS4 taken from 7.00-7.30m.		3	41	57			
	-9.9	7.5															
						No core recovered											
	-10.4	8.0															
	-10.9	8.5															
	-11.4	9.0															
								0%		AS5 taken from 9.10-9.70m. N= 2							
	-11.9	9.5															
	-12.4	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D001

Sheet 3 of 6

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,644.4 m

Northing: 7,976,665.6 m

Surface Elevation: -2.38 m

Bottom Elevation: -29.78 m

Total Depth: 27.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/31/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace GRAVEL: Grey to light brown, fine to coarse grained sand; rounded to subrounded, well graded gravel *(Continued)*			▨	DS6 taken from 10.10-10.40m.							
	-12.9	10.5															
	-13.4	11.0															
									▨	DS7 taken from 11.30-11.60m.							
	-13.9	11.5															
	-14.4	12.0															
	-14.9	12.5							▨	DS8 taken from 12.50-12.80m.							
	-15.4	13.0															
	-15.9	13.5															
	-16.4	14.0															
						SAND, trace SILT, trace GRAVEL: Grey to light brown, fine to medium grained sand; rounded											
	-16.9	14.5							▨	DS9 taken from 14.50-14.90m.		1	95	4			
	-17.4	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D001

Sheet 4 of 6

Client:	Baffinland Iron Mines	**Project No.:**	H352034
Project:	Marry River Expansion Study Stage 2	**Datum:**	NAD83
Location:	Milne Port Ore Dock No.2	**Platform:**	Ice Surface
Contractor:	Boart Longyear	**Rig Type/ Mounting:**	MiniSonic Rig
Driller:	EB/SF	**Hole Diameter (mm):**	100
Date Logged:	3/31/2017	**Date Reviewed:**	5/18/2017

Easting:	503,644.4 m
Northing:	7,976,665.6 m
Surface Elevation:	-2.38 m
Bottom Elevation:	-29.78 m
Total Depth:	27.4 m
Logged By:	UK/AB
Reviewed By:	WH/CH

Elevation (m)	Depth (m)
-17.9	15.5
-18.4	16.0
-18.9	16.5
-19.4	17.0
-19.9	17.5
-20.4	18.0
-20.9	18.5
-21.4	19.0
-21.9	19.5
-22.4	20.0

Water	Method	Casing	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
			SAND, trace GRAVEL: Fine to coarse grained sand; fine, rounded, poorly graded gravel		75%		AS10 taken from 15.20-15.80m. N= 3							
			GRAVEL with SAND and trace SILT: Light brown to reddish brown; rounded well graded gravel; fine to coarse grained sand				DS11 taken from 17.70-18.30m.		60	39	1			
			SAND, trace GRAVEL: Light brown to reddish brown, fine to coarse grained sand; rounded to subrounded gravel				DS12 taken from 19.20-19.50m.							

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D001

Sheet 5 of 6

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,644.4 m

Northing: 7,976,665.6 m

Surface Elevation: -2.38 m

Bottom Elevation: -29.78 m

Total Depth: 27.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/31/2017

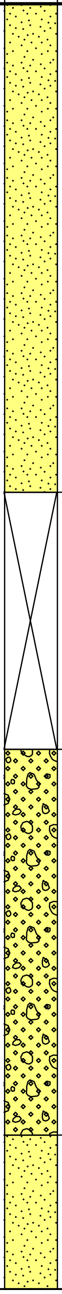
Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH



Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace GRAVEL: Brownish Grey, fine to coarse grained sand; rounded to subrounded gravel *(Continued)*											
									▨	DS13 taken from 20.40-20.70m.							
	-22.9	20.5															
	-23.4	21.0															
								100%	◣	AS14 taken from 21.30-21.90m. N= 9							
	-23.9	21.5															
						No core recovered											
	-24.4	22.0															
	-24.9	22.5															
						SAND, with GRAVEL: Grey to light brown, fine to coarse grained sand; rounded to subrounded, well graded gravel											
	-25.4	23.0															
	-25.9	23.5							▨	DS15 taken from 23.50-23.80m.							
	-26.4	24.0															
						SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand											
	-26.9	24.5															
	-27.4	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D001

Sheet 6 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2
Project No.: H352034
Datum: NAD83
Platform: Ice Surface
Easting: 503,644.4 m
Northing: 7,976,665.6 m
Surface Elevation: -2.38 m
Bottom Elevation: -29.78 m
Total Depth: 27.4 m
Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/31/2017
Logged By: UK/AB
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017
Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	-27.9 -28.4	25.5 26.0				SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand *(Continued)*				DS16 taken from 25.00-25.30m.							
	-28.9 -29.4	26.5 27.0				SAND, some SILT, trace GRAVEL: Light brown to dark grey, fine grained sand; rounded, poorly graded gravel				DS17 taken from 26.50-26.80m.							
	-29.9 -30.4 -30.9 -31.4 -31.9 -32.4	27.5 28.0 28.5 29.0 29.5 30.0				To Target Depth. **Drillhole BH17-D001 terminated at 27.4m.**											

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D002

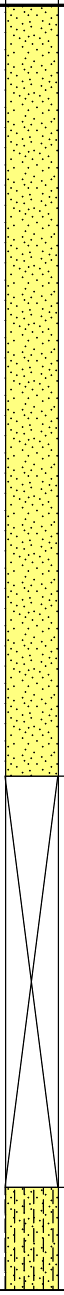
Sheet 1 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,763.9 m
Northing: 7,976,680.7 m
Surface Elevation: -3.25 m
Bottom Elevation: -30.65 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/21/2017
Date Reviewed: 5/18/2017



Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace GRAVEL, trace SILT: Grey, fine to coarse grained sand; poorly graded gravel			▨	DS1 taken from .00-.30m.		5	91	4			
	-3.8	0.5															
	-4.3	1.0															
	-4.8	1.5															
	-5.3	2.0							▨	DS2 taken from 2.00-2.20m.							
	-5.8	2.5															
	-6.3	3.0				No core recovered											
	-6.8	3.5															
	-7.3	4.0															
	-7.8	4.5															
						SILT and SAND, trace GRAVEL: Grey, fine grained sand; fine gravel											
	-8.3	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D002

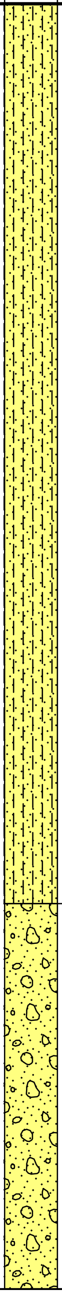
Sheet 2 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting:	503,763.9 m
Northing:	7,976,680.7 m
Surface Elevation:	-3.25 m
Bottom Elevation:	-30.65 m
Total Depth:	27.4 m
Logged By:	UK/AB
Reviewed By:	WH/CH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/21/2017
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017



Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SILT and SAND, trace GRAVEL: Grey, fine grained sand; fine gravel *(Continued)*				DS3 taken from 5.20-5.50m.		2	46	52			
	-8.8	5.5															
	-9.3	6.0						50%		AS4 taken from 6.10-6.70m. N= 8							
	-9.8	6.5															
	-10.3	7.0															
	-10.8	7.5															
	-11.3	8.0															
	-11.8	8.5				SAND, with GRAVEL: Brown, fine to coarse grained sand; fine to coarse gravel				DS5 taken from 8.50-8.80m.		31	67	1			
	-12.3	9.0															
	-12.8	9.5															
	-13.3	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:21

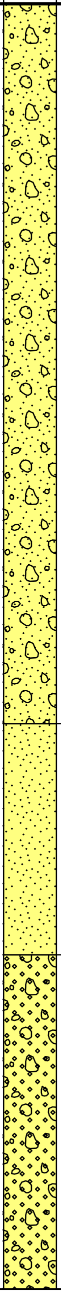
HATCH

BOREHOLE REPORT

BH17-D002

Sheet 3 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2
Project No.: H352034
Datum: NAD83
Platform: Ice Surface
Easting: 503,763.9 m
Northing: 7,976,680.7 m
Surface Elevation: -3.25 m
Bottom Elevation: -30.65 m
Total Depth: 27.4 m
Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/21/2017
Logged By: UK/AB
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017
Reviewed By: WH/CH



Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, with GRAVEL: Brown, fine to coarse grained sand; fine to coarse gravel *(Continued)*											
	-13.8	10.5															
								100%	◢	AS6 taken from 10.70-11.30m. N= 8							
	-14.3	11.0															
	-14.8	11.5															
									▨	DS7 taken from 11.90-12.20m.							
	-15.3	12.0															
	-15.8	12.5															
						SAND: Grey, fine grained, poorly graded											
	-16.3	13.0															
									▨	DS8 taken from 13.10-13.40m.							
	-16.8	13.5															
						SAND, with GRAVEL: Brown, fine to coarse grained, well graded sand; fine to coarse, well graded gravel											
	-17.3	14.0															
	-17.8	14.5															
	-18.3	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D002

Sheet 4 of 6

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,763.9 m

Northing: 7,976,680.7 m

Surface Elevation: -3.25 m

Bottom Elevation: -30.65 m

Total Depth: 27.4 m

Contractor: Boart Longyear

Driller: EB/SF

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100

Date Logged: 3/21/2017

Date Reviewed: 5/18/2017

Logged By: UK/AB

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, with GRAVEL: Brown, fine to coarse grained, well graded sand; fine to coarse, well graded gravel *(Continued)*											
	-18.8	15.5															
									▨	DS9 taken from 15.70-16.00m.		28	68	3			
						SAND with GRAVEL, trace SILT: Brown, fine to coarse grained, well graded sand; fine well graded gravel											
	-19.3	16.0															
	-19.8	16.5															
	-20.3	17.0															
	-20.8	17.5							▨	DS10 taken from 17.50-17.80m.		27	66	8			
	-21.3	18.0															
	-21.8	18.5															
	-22.3	19.0															
	-22.8	19.5															
	-23.3	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D002

Sheet 5 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,763.9 m
Northing: 7,976,680.7 m
Surface Elevation: -3.25 m
Bottom Elevation: -30.65 m
Total Depth: 27.4 m

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/21/2017
Logged By: UK/AB
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017
Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND with GRAVEL, trace SILT: Brown, fine to coarse grained, well graded sand; fine well graded gravel *(Continued)*											
	-23.8	20.5							▨	DS11 taken from 20.40-20.70m.							
	-24.3	21.0															
	-24.8	21.5															
	-25.3	22.0															
	-25.8	22.5															
	-26.3	23.0				SAND with GRAVEL, trace SILT: Light brown, fine to coarse grained sand, fine to coarse gravel											
	-26.8	23.5							▨	DS12 taken from 23.60-23.90m.							
	-27.3	24.0															
	-27.8	24.5															
	-28.3	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D002

Sheet 6 of 6

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,763.9 m
Northing: 7,976,680.7 m
Surface Elevation: -3.25 m
Bottom Elevation: -30.65 m
Total Depth: 27.4 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/21/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND with GRAVEL, trace SILT: Light brown, fine to coarse grained sand, fine to coarse gravel *(Continued)*											
	-28.8	25.5															
	-29.3	26.0				SAND with GRAVEL, trace SILT: Fine to coarse grained sand, rounded gravel, poorly graded			▨	DS13 taken from 25.90-26.70m.		32	66	2			
	-29.8	26.5															
	-30.3	27.0															
	-30.8	27.5				To Target Depth. **Drillhole BH17-D002 terminated at 27.4m.**											
	-31.3	28.0															
	-31.8	28.5															
	-32.3	29.0															
	-32.8	29.5															
	-33.3	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH BOREHOLE REPORT

BH17-D003

Sheet 1 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					☒	No Core Recovered											
	-15.8	0.5															
	-16.3	1.0															
	-16.8	1.5				SAND, trace Silt: Grey, fine to coarse grained sand, loose, poorly graded		100%		AS1 taken from 1.50-2.10m. N= 1							
	-17.3	2.0															
	-17.8	2.5															
	-18.3	3.0			☒	No core recovered											
	-18.8	3.5															
	-19.3	4.0															
	-19.8	4.5															
						SILT and SAND, trace GRAVEL: Dark grey, black mottling, organics; fine grained sand; fine angular gravel											
	-20.3	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D003

Sheet 2 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,608.4 m
Northing: 7,976,709.9 m
Surface Elevation: -15.34 m
Bottom Elevation: -45.84 m
Total Depth: 30.5 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/29/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SILT and SAND, trace GRAVEL: Dark grey, black mottling, organics; fine grained sand; fine angular gravel *(Continued)*				DS2 taken from 5.20-5.30m.		3	40	57			
	-20.8	5.5															
	-21.3	6.0															
						SAND, trace GRAVEL, trace COBBLES: Reddish brown, medium to coarse grained, poorly graded sand; angular gravel, and subroundded cobbles.											
	-21.8	6.5															
	-22.3	7.0								DS3 taken from 7.00-7.30m.							
	-22.8	7.5															
						SAND: Reddish brown, medium to coarse grained, poorly graded		0%		AS4 taken from 7.60-8.20m. N= 7							
	-23.3	8.0															
	-23.8	8.5															
	-24.3	9.0															
						No Core Recovered											
	-24.8	9.5															
	-25.3	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

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HATCH

BOREHOLE REPORT

BH17-D003

Sheet 3 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						No Core Recovered *(Continued)*											
	-25.8	10.5															
						SAND, trace Gravel: Grey, fine to medium grained sand, loose, poorly graded, subangular gravel		100%		AS5 taken from 10.70-11.30m. N= 9							
	-26.3	11.0															
						No Core Recovered											
	-26.8	11.5															
	-27.3	12.0															
								0%		taken from 12.20-12.80m. N= 8							
	-27.8	12.5															
	-28.3	13.0															
	-28.8	13.5															
								0%		taken from 13.70-14.30m. N= 4							
	-29.3	14.0															
	-29.8	14.5															
	-30.3	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D003

Sheet 4 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,608.4 m

Northing: 7,976,709.9 m

Surface Elevation: -15.34 m

Bottom Elevation: -45.84 m

Total Depth: 30.5 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/29/2017

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						No Core Recovered *(Continued)*											
	-30.8	15.5				Gravelly SAND, trace SILT: Reddish brown to grey, coarse to medium grained sand; rounded to subrounded gravel		50%		AS6 taken from 15.20-15.80m. N= 6		35	63	1			
	-31.3 -31.8	16.0 16.5				No core recovered											
	-32.3	17.0				SAND, with Gravel: Coarse grained sand; rounded to subangular coarse gravel, well graded		17%		AS7 taken from 16.80-17.40m. N= 10							
	-32.8 -33.3	17.5 18.0				No Core Recovered											
	-33.8	18.5				SAND, with Gravel: Coarse grained sand; coarse, rounded to subangular gravel		50%		AS8 taken from 18.30-18.90m. N= 9							
	-34.3 -34.8 -35.3	19.0 19.5 20.0				No Core Recovered		0%		taken from 19.80-20.40m. N= 5							

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D003

Sheet 5 of 7

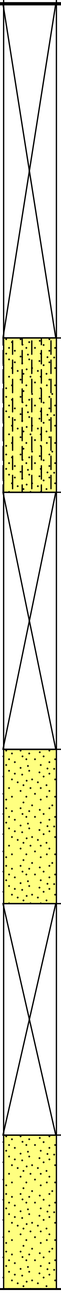
Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,608.4 m
Northing: 7,976,709.9 m
Surface Elevation: -15.34 m
Bottom Elevation: -45.84 m
Total Depth: 30.5 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/29/2017
Date Reviewed: 5/18/2017

Elevation (m)	Depth (m)
-35.8	20.5
-36.3	21.0
-36.8	21.5
-37.3	22.0
-37.8	22.5
-38.3	23.0
-38.8	23.5
-39.3	24.0
-39.8	24.5
-40.3	25.0



Water	Elevation (m)	Depth (m)	Method	Casing	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					No Core Recovered *(Continued)*											
					SILT and SAND, trace GRAVEL: Grey, medium to fine grained sand; fine grained, poorly graded gravel		50%		AS9 taken from 21.30-21.90m. N= 10		5	56	39			
					No Core Recovered											
					SAND, trace GRAVEL: Grey to light brown, fine grained sand; poorly graded, rounded to subangular gravel		100%		AS10 taken from 22.90-23.50m. N= 35							
					No Core Recovered											
					SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand, rounded to subrounded, poorly graded gravel		50%		AS11 taken from 24.40-25.00m. N= 26							

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH BOREHOLE REPORT

BH17-D003

Sheet 6 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,608.4 m
Northing: 7,976,709.9 m
Surface Elevation: -15.34 m
Bottom Elevation: -45.84 m
Total Depth: 30.5 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/29/2017
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					☒	No Core Recovered											
	-40.8	25.5															
					⠿	SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand; rounded, poorly graded gravel		50%	◢	AS12 taken from 25.90-26.50m. N= 23							
	-41.3	26.0															
	-41.8	26.5															
	-42.3	27.0															
					⠿	SAND with SILT, trace GRAVEL: Grey to light brown, fine grained sand; rounded, poorly graded gravel											
	-42.8	27.5															
	-43.3	28.0							▨	DS13 taken from 28.00-28.30m.							
	-43.8	28.5															
	-44.3	29.0															
	-44.8	29.5															
	-45.3	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D003

Sheet 7 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,608.4 m
Northing: 7,976,709.9 m
Surface Elevation: -15.34 m
Bottom Elevation: -45.84 m
Total Depth: 30.5 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/29/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					░	SAND with SILT, trace GRAVEL: Grey to light brown, fine grained sand; rounded, poorly graded gravel *(Continued)*			▨	DS14 taken from 30.20-30.50m.		1	76	23			
	-45.8	30.5				To Target Depth. **Drillhole BH17-D003 terminated at 30.5m.**											
	-46.3	31.0															
	-46.8	31.5															
	-47.3	32.0															
	-47.8	32.5															
	-48.3	33.0															
	-48.8	33.5															
	-49.3	34.0															
	-49.8	34.5															
	-50.3	35.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D004

Sheet 1 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					░	SAND and SILT: Dark grey to black, fine grained sand, trace of organics, black mottling											
	-17.1	0.5			░												
					░				▨	DS1 taken from .90-1.20m.							
	-17.6	1.0			░				▨								
	-18.1	1.5			⊠	No core recovered											
	-18.6	2.0			⊠												
	-19.1	2.5			⊠												
	-19.6	3.0			░	SAND and SILT, some GRAVEL: Dark grey, black mottling, fine grained sand; fine to coarse, rounded to subangular gravel											
					░				▨	DS2 taken from 3.20-3.40m.							
	-20.1	3.5			░												
	-20.6	4.0			░												
					░				▨	DS3 taken from 4.30-4.60m.							
	-21.1	4.5			░				▨								
					░	SAND, some SILT, some GRAVEL: Light brown, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded to subangular gravel			▨	DS4 taken from 4.70-5.00m.							
	-21.6	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D004

Sheet 2 of 9

Client:	Baffinland Iron Mines	**Project No.:**	H352034	**Easting:**	503,701.4 m
				Northing:	7,976,728.5 m
Project:	Marry River Expansion Study Stage 2	**Datum:**	NAD83	**Surface Elevation:**	-16.59 m
Location:	Milne Port Ore Dock No.2	**Platform:**	Ice Surface	**Bottom Elevation:**	-59.29 m
				Total Depth:	42.7 m
Contractor: Boart Longyear	**Rig Type/ Mounting:** MiniSonic Rig	**Date Logged:**	3/26/2017	**Logged By:**	UK/AB
Driller: EB/SF	**Hole Diameter (mm):** 100	**Date Reviewed:**	5/18/2017	**Reviewed By:**	WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, some SILT, some GRAVEL: Light brown, fine to coarse grained, well graded sand; multi-coloured, fine to coarse, rounded to subangular gravel *(Continued)*											
	-22.1	5.5															
	-22.6	6.0															
						SAND, trace GRAVEL, trace SILT: Brown, fine to coarse grained sand; multi-coloured, well graded, rounded to subrounded gravel											
	-23.1	6.5															
	-23.6	7.0															
	-24.1	7.5															
						SAND, trace SILT, trace GRAVEL: Brown, coarse grained, poorly graded sand; multi-coloured, angular gravel		100%	◣	AS5 taken from 7.60-8.20m. N= 6		2	94	4			
	-24.6	8.0															
	-25.1	8.5															
									▨	DS6 taken from 8.80-9.10m.							
	-25.6	9.0															
	-26.1	9.5															
	-26.6	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

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BOREHOLE REPORT

BH17-D004

Sheet 3 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT, trace GRAVEL: Brown, coarse grained, poorly graded sand; multi-coloured, angular gravel *(Continued)*											
	-27.1	10.5															
	-27.6	11.0								DS7 taken from 11.00-11.30m.							
	-28.1	11.5															
	-28.6	12.0															
	-29.1	12.5															
	-29.6	13.0															
	-30.1	13.5															
						SAND, trace GRAVEL, trace SILT: Reddish brown, medium to coarse grained sand; angular well graded gravel		100%		AS8 taken from 13.70-14.30m. N= 11							
	-30.6	14.0															
	-31.1	14.5															
	-31.6	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH BOREHOLE REPORT

BH17-D004

Sheet 4 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2
Project No.: H352034
Datum: NAD83
Platform: Ice Surface
Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 3/26/2017
Logged By: UK/AB
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017
Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace GRAVEL, trace SILT: Reddish brown, medium to coarse grained sand; angular well graded gravel *(Continued)*											
	-32.1	15.5								DS9 taken from 15.50-15.80m.							
	-32.6	16.0															
	-33.1	16.5															
	-33.6	17.0															
	-34.1	17.5															
	-34.6	18.0								DS10 taken from 18.00-18.30m.		1	96	3			
						No core recovered											
	-35.1	18.5															
	-35.6	19.0															
	-36.1	19.5															
								100%		AS11 taken from 19.80-20.40m. N= 35							
	-36.6	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D004

Sheet 5 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace Gravel: Reddish brown, medium to coarse grained sand; well graded, angular gravel *(Continued)*											
	-37.1	20.5															
	-37.6	21.0															
	-38.1	21.5															
	-38.6	22.0															
	-39.1	22.5															
						SAND, trace SILT: Grey, fine grained, poorly graded sand											
	-39.6	23.0															
	-40.1	23.5															
										DS12 taken from 23.80-24.10m.							
	-40.6	24.0															
	-41.1	24.5															
						24.70 m to 25.30 m: Some silt, mottled black, fine organics											
	-41.6	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D004

Sheet 6 of 9

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,701.4 m
Northing: 7,976,728.5 m
Surface Elevation: -16.59 m
Bottom Elevation: -59.29 m
Total Depth: 42.7 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/26/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT: Grey, fine grained, poorly graded sand *(Continued)*				DS13 taken from 25.00-25.30m.							
	-42.1	25.5															
	-42.6	26.0				SILT and SAND, trace GRAVEL: Brown, fine to medium grained, well graded sand		100%		AS14 taken from 25.90-26.50m. N= 9							
	-43.1	26.5															
	-43.6	27.0															
	-44.1	27.5															
	-44.6	28.0															
										DS15 taken from 28.30-28.60m.							
	-45.1	28.5															
	-45.6	29.0				SAND and SILT, trace GRAVEL: Brown, fine to coarse grained, well graded sand; multi-coloured, rounded gravel											
										DS16 taken from 29.30-29.60m.		2	49	49			
	-46.1	29.5															
	-46.6	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D004

Sheet 7 of 9

Client:	Baffinland Iron Mines	**Project No.:**	H352034
Project:	Marry River Expansion Study Stage 2	**Datum:**	NAD83
Location:	Milne Port Ore Dock No.2	**Platform:**	Ice Surface

Easting:	503,701.4 m
Northing:	7,976,728.5 m
Surface Elevation:	-16.59 m
Bottom Elevation:	-59.29 m
Total Depth:	42.7 m
Logged By:	UK/AB
Reviewed By:	WH/CH

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Date Logged:** 3/26/2017

Driller: EB/SF **Hole Diameter (mm):** 100 **Date Reviewed:** 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND and SILT, trace GRAVEL: Brown, fine to coarse grained, well graded sand; multi-coloured, rounded gravel *(Continued)*											
	-47.1	30.5															
	-47.6	31.0															
	-48.1	31.5															
	-48.6	32.0						100%		AS17 taken from 32.00-32.60m. N= 5							
	-49.1	32.5															
	-49.6	33.0															
	-50.1	33.5				SAND, some GRAVEL: Brown, coarse grained poorly graded sand; multi-coloured, rounded to subangular gravel											
	-50.6	34.0															
										DS18 taken from 34.40-34.70m.							
	-51.1	34.5															
	-51.6	35.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

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BOREHOLE REPORT

BH17-D004

Sheet 8 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/26/2017

Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace GRAVEL, trace SILT: Brown, coarse grained sand; poorly graded, fine, subangular gravel											
	-52.1	35.5															
	-52.6	36.0															
	-53.1	36.5															
						SAND, some SILT: Dark grey, fine grained, well graded sand											
	-53.6	37.0															
									▨	DS19 taken from 37.20-37.50m.							
	-54.1	37.5															
	-54.6	38.0															
						SAND, trace Gravel, trace SILT: Brown, coarse grained sand; fine, multi-coloured, rounded to subangular, well graded gravel											
	-55.1	38.5															
									▨	DS20 taken from 38.70-39.00m.		8	91	1			
	-55.6	39.0															
	-56.1	39.5															
	-56.6	40.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

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BOREHOLE REPORT

BH17-D004

Sheet 9 of 9

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,701.4 m

Northing: 7,976,728.5 m

Surface Elevation: -16.59 m

Bottom Elevation: -59.29 m

Total Depth: 42.7 m

Logged By: UK/AB

Reviewed By: WH/CH

Contractor: Boart Longyear

Driller: EB/SF

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100

Date Logged: 3/26/2017

Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	**Other Tests**
						SAND, trace Gravel, trace SILT: Brown, coarse grained sand; fine, multi-coloured, rounded to subangular, well graded gravel *(Continued)*											
	-57.1	40.5															
	-57.6	41.0															
						SAND, trace SILT: Brown, coarse grained sand; well graded, multi-coloured gravel											
	-58.1	41.5															
	-58.6	42.0															
									▨	DS21 taken from 42.10-42.40m.		0	98	2			
	-59.1	42.5															
						To Target Depth. **Drillhole BH17-D004 terminated at 42.7m.**											
	-59.6	43.0															
	-60.1	43.5															
	-60.6	44.0															
	-61.1	44.5															
	-61.6	45.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D005

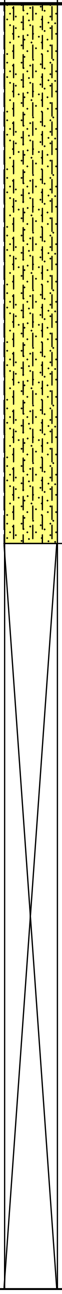
Sheet 1 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SILT and SAND, trace GRAVEL: Dark brown to black, fine to coarse grained sand; fine, poorly graded gravel			▨	DS1 taken from .00-.30m.		8	54	38			
	-20.0	0.5															
	-20.5	1.0															
	-21.0	1.5							▨	AS2 taken from 1.50-2.10m.							
	-21.5	2.0															
						No core recovered											
	-22.0	2.5															
	-22.5	3.0															
	-23.0	3.5															
	-23.5	4.0															
	-24.0	4.5															
	-24.5	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D005

Sheet 2 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					☒	No core recovered *(Continued)*											
	-25.0	5.5															
	-25.5	6.0															
	-26.0	6.5															
						SAND with SILT, trace GRAVEL: Brown, fine to coarse grained sand; well graded, rounded gravel											
	-26.5	7.0							▨	DS3 taken from 7.00-7.30m.		10	55	35			
	-27.0	7.5															
	-27.5	8.0															
	-28.0	8.5															
	-28.5	9.0															
					☒	No core recovered		100%		AS4 taken from 9.10-9.70m. N= 30							
	-29.0	9.5															
	-29.5	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D005

Sheet 3 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,785.6 m

Northing: 7,976,738.1 m

Surface Elevation: -19.50 m

Bottom Elevation: -50.60 m

Total Depth: 31.1 m

Contractor: Boart Longyear

Driller: EB/SF

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100

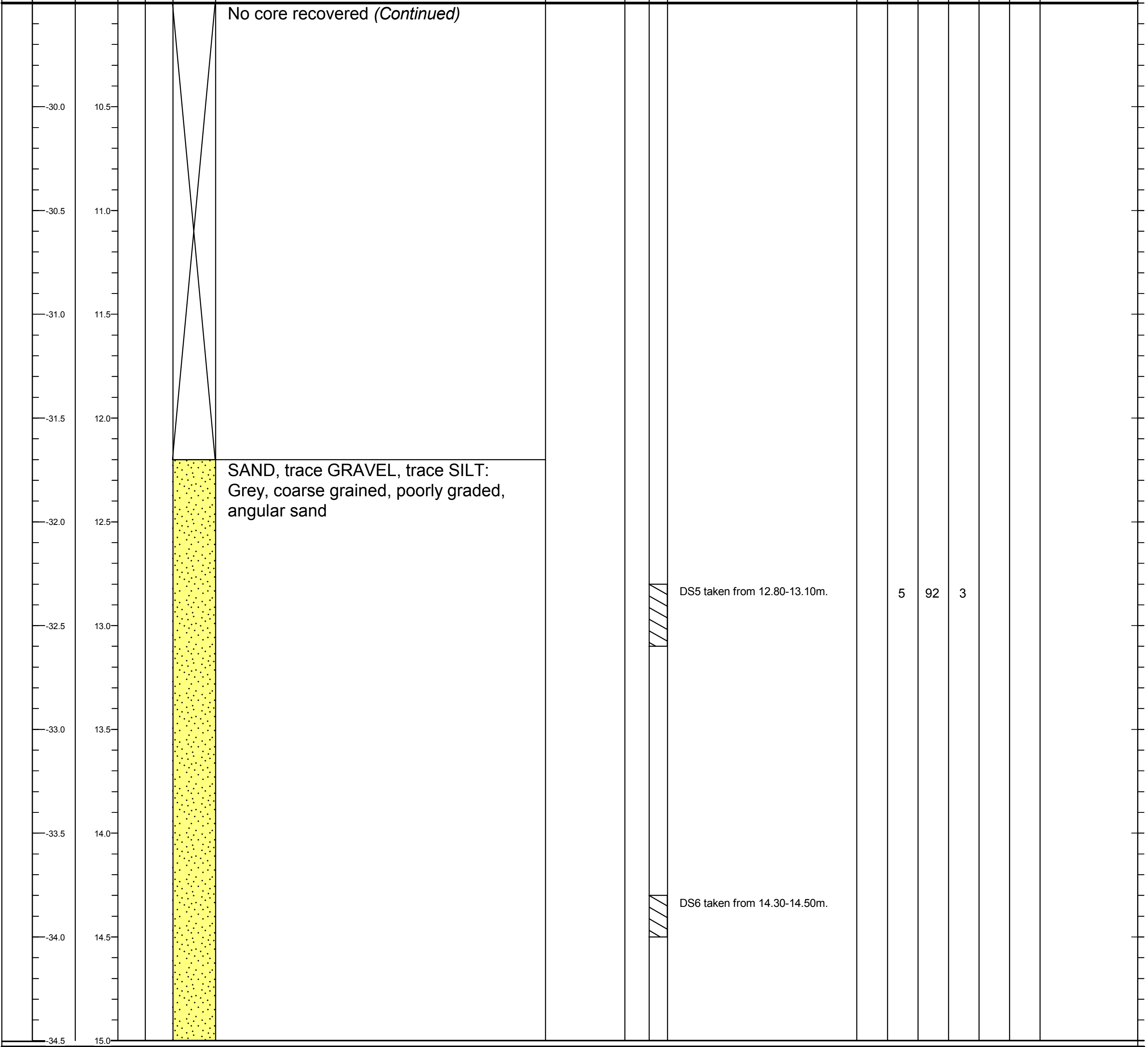
Date Logged: 3/24/2017

Date Reviewed: 5/18/2017

Logged By: UK/AB

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests



No core recovered *(Continued)*

SAND, trace GRAVEL, trace SILT: Grey, coarse grained, poorly graded, angular sand

DS5 taken from 12.80-13.10m. | 5 | 92 | 3

DS6 taken from 14.30-14.50m.

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D005

Sheet 4 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,785.6 m

Northing: 7,976,738.1 m

Surface Elevation: -19.50 m

Bottom Elevation: -50.60 m

Total Depth: 31.1 m

Contractor: Boart Longyear

Driller: EB/SF

Rig Type/ Mounting: MiniSonic Rig

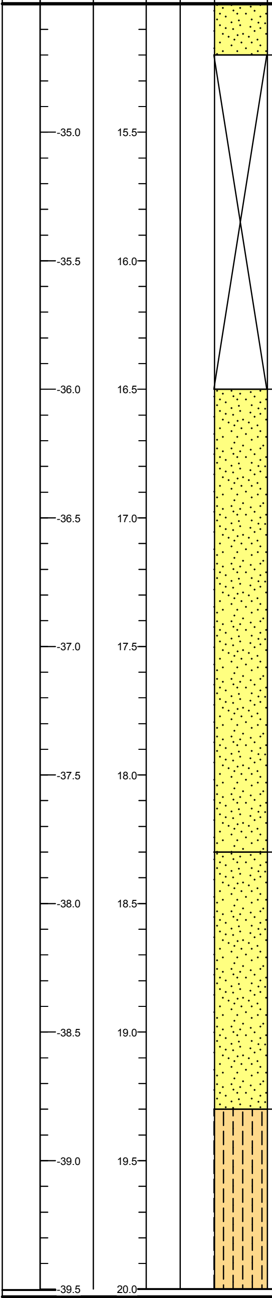
Hole Diameter (mm): 100

Date Logged: 3/24/2017

Date Reviewed: 5/18/2017

Logged By: UK/AB

Reviewed By: WH/CH



Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						No core recovered											
						SAND, some GRAVEL: Coarse grained sand; rounded to subangular coarse gravel			▨	DS7 taken from 16.50-16.80m.							
						SAND, some SILT: Brown, fine grained, poorly graded			▨	DS8 taken from 18.90-19.20m.							
						SILT and SAND, trace GRAVEL: Brown to Grey, medium to coarse grained, poorly graded sand; fine gravel											

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

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BOREHOLE REPORT

BH17-D005

Sheet 5 of 7

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,785.6 m

Northing: 7,976,738.1 m

Surface Elevation: -19.50 m

Bottom Elevation: -50.60 m

Total Depth: 31.1 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 3/24/2017

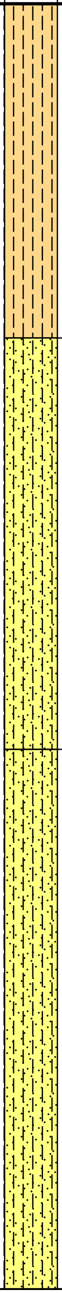
Logged By: UK/AB

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH



Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SILT and SAND, trace GRAVEL: Brown to Grey, medium to coarse grained, poorly graded sand; fine gravel *(Continued)*											
	-40.0	20.5															
	-40.5	21.0							▨	DS9 taken from 21.00-21.30m.		1	41	58			
						SAND, some SILT, trace GRAVEL: Light brown, fine to coarse grained sand, well graded, multi-coloured, rounded to subangular gravel											
	-41.0	21.5															
	-41.5	22.0							▨	DS10 taken from 21.90-22.30m.							
	-42.0	22.5															
	-42.5	23.0				SAND, some SILT: Light brown, well graded, medium to coarse grained sand											
	-43.0	23.5															
	-43.5	24.0				24.00 m to 24.40 m: Trace gravel, multi-coloured			▨	DS11 taken from 24.10-24.40m.							
	-44.0	24.5															
	-44.5	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D005

Sheet 6 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
					▨	SAND, some SILT: Light brown, well graded, medium to coarse grained sand *(Continued)*											
									▨	DS12 taken from 25.30-25.60m.		1	80	20			
	-45.0	25.5															
	-45.5	26.0															
	-46.0	26.5															
	-46.5	27.0															
					▨	SAND, trace SILT: Light brown, fine to coarse grained, well graded sand											
	-47.0	27.5															
	-47.5	28.0							▨	DS13 taken from 28.00-28.30m.		0	96	4			
	-48.0	28.5															
	-48.5	29.0															
	-49.0	29.5															
	-49.5	30.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D005

Sheet 7 of 7

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,785.6 m
Northing: 7,976,738.1 m
Surface Elevation: -19.50 m
Bottom Elevation: -50.60 m
Total Depth: 31.1 m
Logged By: UK/AB
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 3/24/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT: Light brown, fine to coarse grained, well graded sand *(Continued)*											
	-50.0	30.5						100%		AS14 taken from 30.50-31.10m. N= 2							
	-50.5	31.0															
						To Target Depth. **Drillhole BH17-D005 terminated at 31.1m.**											
	-51.0	31.5															
	-51.5	32.0															
	-52.0	32.5															
	-52.5	33.0															
	-53.0	33.5															
	-53.5	34.0															
	-54.0	34.5															
	-54.5	35.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D006

Sheet 1 of 5

Client: Baffinland Iron Mines

Project: Marry River Expansion Study Stage 2

Location: Milne Port Ore Dock No.2

Project No.: H352034

Datum: NAD83

Platform: Ice Surface

Easting: 503,678.2 m

Northing: 7,976,797.1 m

Surface Elevation: -29.84 m

Bottom Elevation: -54.24 m

Total Depth: 24.4 m

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 4/1/2017

Logged By: UK/MR

Driller: EB/SF

Hole Diameter (mm): 100

Date Reviewed: 5/18/2017

Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, some SILT, trace Gravel: Light brown to dark grey, fine grained sand; rounded gravel; organic silt		100%		AS1 taken from .00-.60m. N= 5		3	79	18			
	-30.3	0.5															
	-30.8	1.0															
	-31.3	1.5															
	-31.8	2.0															
						SAND, trace SILT: Grey to light brown, fine to coarse grained, well graded sand				DS2 taken from 2.10-2.40m.		0	99	1			
	-32.3	2.5															
	-32.8	3.0															
	-33.3	3.5															
										DS3 taken from 3.70-4.00m.							
	-33.8	4.0															
	-34.3	4.5															
	-34.8	5.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D006

Sheet 2 of 5

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2
Project No.: H352034
Datum: NAD83
Platform: Ice Surface
Easting: 503,678.2 m
Northing: 7,976,797.1 m
Surface Elevation: -29.84 m
Bottom Elevation: -54.24 m
Total Depth: 24.4 m
Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 4/1/2017
Logged By: UK/MR
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017
Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace SILT: Grey to light brown, fine to coarse grained, well graded sand *(Continued)*											
	-35.3	5.5								DS4 taken from 5.50-5.80m.							
	-35.8	6.0															
						SAND, trace GRAVEL: Grey to light brown, fine to medium grained sand; rounded, well graded gravel		100%		AS5 taken from 6.10-6.70m. N= 4							
	-36.3	6.5															
	-36.8	7.0															
	-37.3	7.5															
						SAND, trace GRAVEL, trace SILT: Grey to light brown, fine to medium grained sand; rounded, poorly graded gravel											
										DS6 taken from 7.90-8.20m.							
	-37.8	8.0															
	-38.3	8.5															
	-38.8	9.0															
	-39.3	9.5															
										DS7 taken from 9.80-10.10m.		3	95	2			
	-39.8	10.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCHCANADA2015 DRAFT.GLB Log ICE BOREHOLE MR EXPANSION STUDY STAGE 2 - REV A.GPJ <<DrawingFile>> 25/05/2017 14:22

HATCH

BOREHOLE REPORT

BH17-D006

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2
Project No.: H352034
Datum: NAD83
Platform: Ice Surface
Easting: 503,678.2 m
Northing: 7,976,797.1 m
Surface Elevation: -29.84 m
Bottom Elevation: -54.24 m
Total Depth: 24.4 m
Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 4/1/2017
Logged By: UK/MR
Driller: EB/SF
Hole Diameter (mm): 100
Date Reviewed: 5/18/2017
Reviewed By: WH/CH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, trace GRAVEL, trace SILT: Grey to light brown, fine to medium grained sand; rounded, poorly graded gravel *(Continued)*											
	-40.3	10.5															
						SAND, trace SILT, trace GRAVEL: Grey to light brown, fine to coarse grained sand, rounded to subrounded well graded gravel											
	-40.8	11.0															
	-41.3	11.5															
										DS8 taken from 11.60-11.90m.		3	95	2			
	-41.8	12.0															
								42%		AS9 taken from 12.20-12.80m. N= 4							
	-42.3	12.5															
	-42.8	13.0															
	-43.3	13.5															
	-43.8	14.0								DS10 taken from 14.00-14.30m.							
	-44.3	14.5															
	-44.8	15.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

BOREHOLE REPORT

BH17-D006

Sheet 4 of 5

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,678.2 m
Northing: 7,976,797.1 m
Surface Elevation: -29.84 m
Bottom Elevation: -54.24 m
Total Depth: 24.4 m
Logged By: UK/MR
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/1/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND, some SILT: Dark grey, fine to medium grained, poorly graded sand; organic silt											
	-45.3	15.5															
									▨	DS11 taken from 15.80-16.20m.		0	82	18			
	-45.8	16.0															
	-46.3	16.5															
	-46.8	17.0															
	-47.3	17.5															
									▨	DS12 taken from 17.70-18.00m.							
	-47.8	18.0															
						SAND: Light brown, fine to medium grained											
	-48.3	18.5															
									▨	DS13 taken from 18.90-19.20m.							
	-48.8	19.0															
	-49.3	19.5															
	-49.8	20.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

HATCH

BOREHOLE REPORT

BH17-D006

Sheet 5 of 5

Client: Baffinland Iron Mines
Project: Marry River Expansion Study Stage 2
Location: Milne Port Ore Dock No.2

Project No.: H352034
Datum: NAD83
Platform: Ice Surface

Easting: 503,678.2 m
Northing: 7,976,797.1 m
Surface Elevation: -29.84 m
Bottom Elevation: -54.24 m
Total Depth: 24.4 m
Logged By: UK/MR
Reviewed By: WH/CH

Contractor: Boart Longyear
Driller: EB/SF
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100
Date Logged: 4/1/2017
Date Reviewed: 5/18/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	**Soil Description** TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Consistency/ Density	Sample Type	Additional Observations	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						SAND: Light brown, fine to medium grained *(Continued)*											
	-50.3	20.5							▨	DS14 taken from 20.40-20.70m.							
	-50.8	21.0															
	-51.3	21.5															
	-51.8	22.0				Thin silt seams below 22.0m			▨	DS15 taken from 21.90-22.30m.							
	-52.3	22.5															
	-52.8	23.0															
	-53.3	23.5							▨	DS16 taken from 23.50-23.80m.							
	-53.8	24.0															
						To Target Depth. **Drillhole BH17-D006 terminated at 24.4m.**											
	-54.3	24.5															
	-54.8	25.0															

Notes: SPT blow counts lower than expected due to disturbed zone around sonic drill bit. Refer to piezocone test data for undisturbed in-situ testing.

Appendix C

Sample Photographs

Sample Photographs

Borehole Name:	BH17-D001	Mary River Expansion Study Stage 2
Location:	17 W 503644 7976665	2017 Geotechnical Investigation
Completion Date:	April 1, 2017	Baffinland Iron Mines

BH17-D001

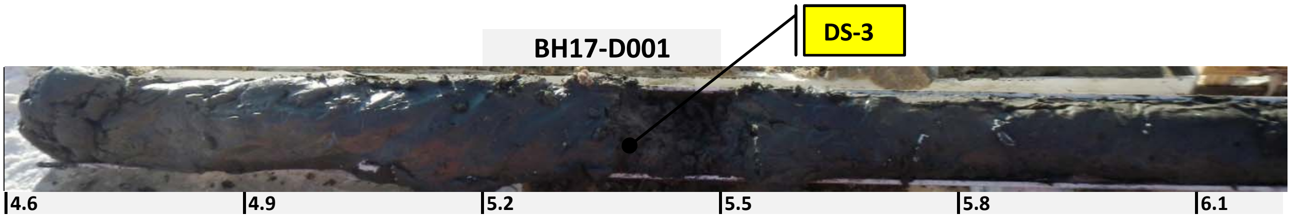
BH17-D001

SAMPLE PHOTO NOT TAKEN

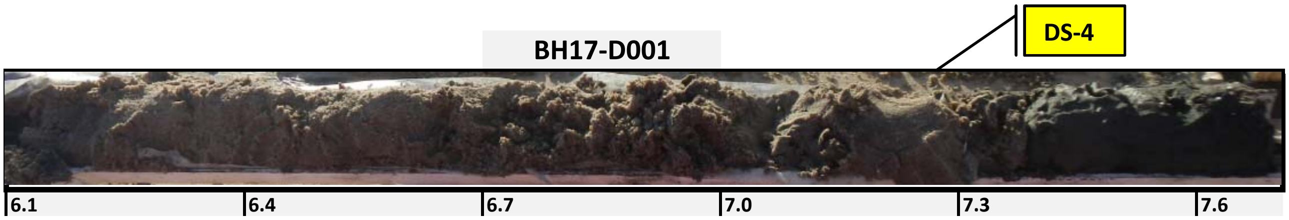
1.5 1.8 2.1 2.4 2.7 3.0

BH17-D001

BH17-D001



BH17-D001



BH17-D001

NO RECOVERY IN CORE BARREL

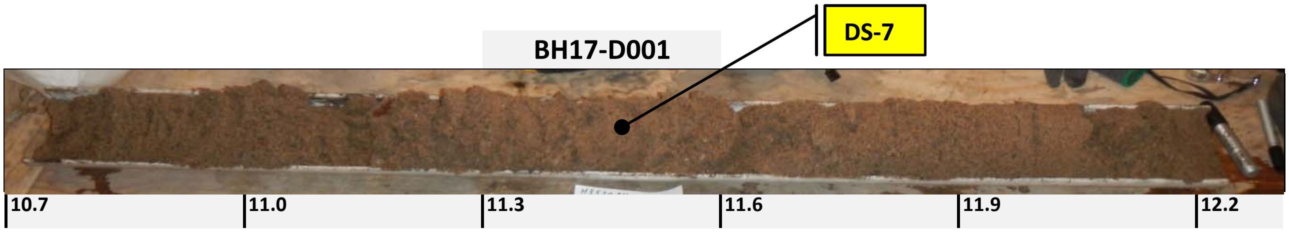
7.6 7.9 8.2 8.5 8.8 9.1

Sample Photographs

Borehole Name: BH17-D001
Location: 17 W 503644 7976665
Completion Date: April 1, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines



AS-10

BH17-D001

RECOVERED USING SPT SAMPLER

15.2	15.5	15.8	16.2	16.5	16.8

Sample Photographs

Borehole Name: BH17-D001
Location: 17 W 503644 7976665
Completion Date: April 1, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

DS-11

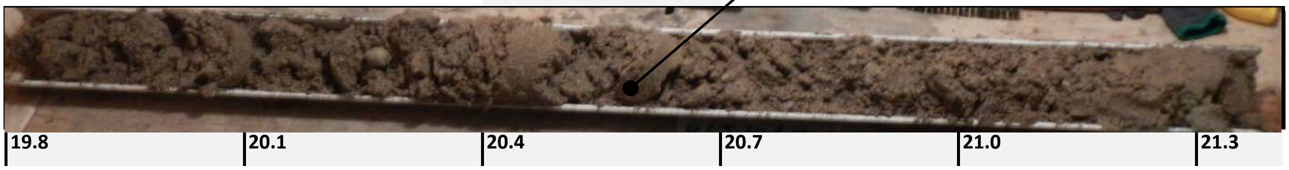
BH17-D001

DS-12

BH17-D001

DS-13

BH17-D001



AS-14

BH17-D001

RECOVERED USING SPT SAMPLER

21.3	21.6	21.9	22.3	22.6	22.9

DS-15

BH17-D001

Sample Photographs

Borehole Name:	BH17-D001	Mary River Expansion Study Stage 2
Location:	17 W 503644 7976665	
Completion Date:	April 1, 2017	Baffinland Iron Mines

DS-16

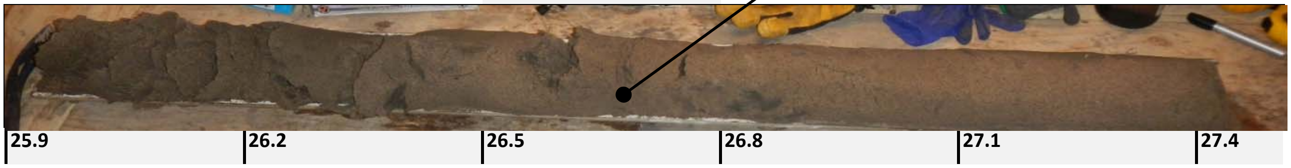
BH17-D001

SAMPLE PHOTO NOT TAKEN

24.4	24.7	25.0	25.3	25.6	25.9

DS-17

BH17-D001



25.9	26.2	26.5	26.8	27.1	27.4

Sample Photographs

Borehole Name:	BH17-D002	Mary River Expansion Study Stage 2
Location:	17 W 503764 7976681	
Completion Date:	March 24, 2017	Baffinland Iron Mines

BH17-D002

BH17-D002

BH17-D002

NO RECOVERY IN CORE BARREL

3.0 3.4 3.7 4.0 4.3 4.6

BH17-D002

BH17-D002

BH17-D002

Sample Photographs

Borehole Name: BH17-D002

Location: 17 W 503764 7976681

Completion Date: March 24, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

Sample Photographs

Borehole Name: BH17-D002
Location: 17 W 503764 7976681
Completion Date: March 24, 2017

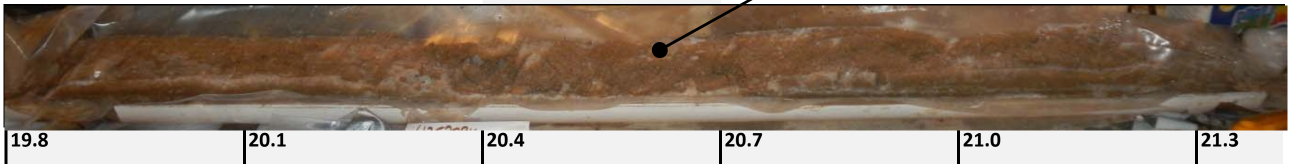
Mary River Expansion Study Stage 2

Baffinland Iron Mines

BH17-D002

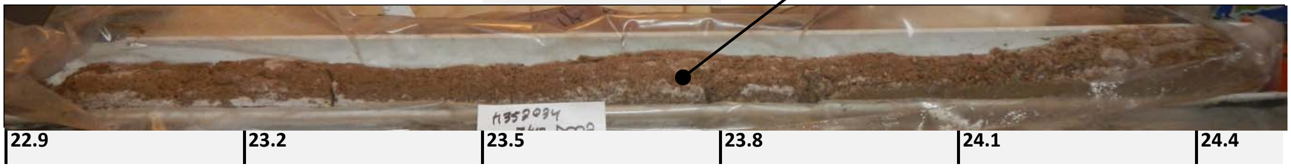
BH17-D002

BH17-D002



BH17-D002

BH17-D002



Sample Photographs

Borehole Name: BH17-D002
Location: 17 W 503764 7976681
Completion Date: March 24, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

BH17-D002

BH17-D002

Sample Photographs

Borehole Name:	BH17-D003	Mary River Expansion Study Stage 2
Location:	17 W 503608 7976710	2017 Geotechnical Investigation
Completion Date:	March 31, 2017	Baffinland Iron Mines

BH17-D003

NO RECOVERY IN CORE BARREL

0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5

AS-1

BH17-D003

RECOVERED USING SPT SAMPLER

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-D003

NO RECOVERY IN CORE BARREL

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH17-D003

BH17-D003

AS-4

BH17-D003

RECOVERED USING SPT SAMPLER

7.6 | 7.9 | 8.2 | 8.5 | 8.8 | 9.1

Sample Photographs

Borehole Name: BH17-D003

Location: 17 W 503608 7976710

Completion Date: March 31, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

BH17-D003

NO RECOVERY IN CORE BARREL

9.1	9.4	9.8	10.1	10.4	10.7

AS-5

BH17-D003

RECOVERED USING SPT SAMPLER

10.7	11.0	11.3	11.6	11.9	12.2

BH17-D003

NO RECOVERY IN CORE BARREL

12.2	12.5	12.8	13.1	13.4	13.7

BH17-D003

NO RECOVERY IN CORE BARREL

13.7	14.0	14.3	14.6	14.9	15.2

AS-6

BH17-D003

RECOVERED USING SPT SAMPLER

15.2	15.5	15.8	16.2	16.5	16.8

Sample Photographs

Borehole Name: BH17-D003
Location: 17 W 503608 7976710
Completion Date: March 31, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

AS-7

BH17-D003

RECOVERED USING SPT SAMPLER

16.8	17.1	17.4	17.7	18.0	18.3

AS-8

BH17-D003

RECOVERED USING SPT SAMPLER

18.3	18.6	18.9	19.2	19.5	19.8

BH17-D003

NO RECOVERY IN CORE BARREL

19.8	20.1	20.4	20.7	21.0	21.3

AS-9

BH17-D003

RECOVERED USING SPT SAMPLER

21.3	21.6	21.9	22.3	22.6	22.9

AS-10

BH17-D003

RECOVERED USING SPT SAMPLER

22.9	23.2	23.5	23.8	24.1	24.4

Sample Photographs

Borehole Name:	BH17-D003	Mary River Expansion Study Stage 2
Location:	17 W 503608 7976710	
Completion Date:	March 31, 2017	Baffinland Iron Mines

AS-11

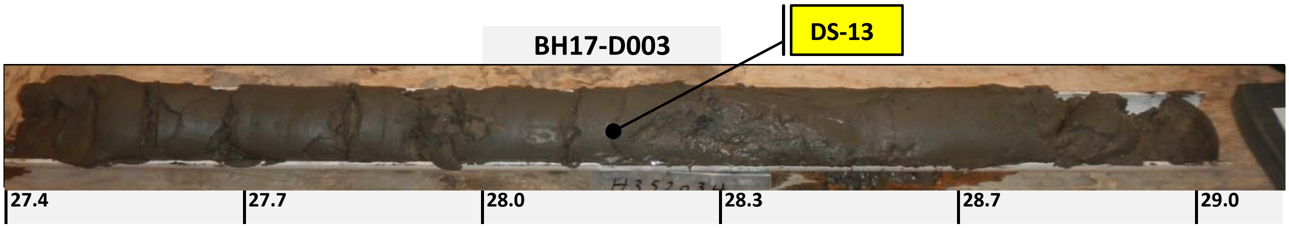
BH17-D003

RECOVERED USING SPT SAMPLER

24.4	24.7	25.0	25.3	25.6	25.9

BH17-D003

BH17-D003



BH17-D003

Sample Photographs

Borehole Name: BH17-D004
Location: 17 W 503701 7976728
Completion Date: March 28, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

BH17-D004

BH17-D004

NO RECOVERY IN CORE BARREL

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-D004

BH17-D004

BH17-D004

BH17-D004

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

BH17-D004

BH17-D004

BH17-D004

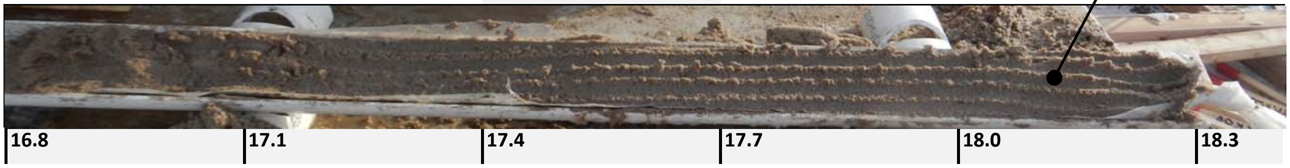
BH17-D004

BH17-D004

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

BH17-D004



BH17-D004

NO RECOVERY IN CORE BARREL

18.3 18.6 18.9 19.2 19.5 19.8

BH17-D004

BH17-D004

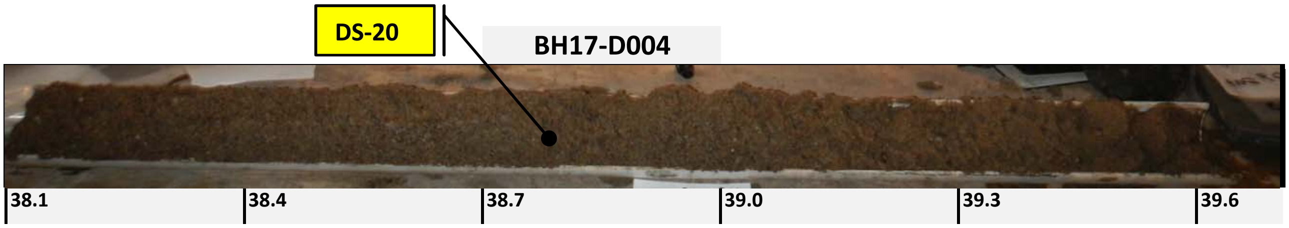
BH17-D004

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines



Sample Photographs

Borehole Name:	BH17-D004	Mary River Expansion Study Stage 2
Location:	17 W 503701 7976728	
Completion Date:	March 28, 2017	Baffinland Iron Mines

BH17-D004

BH17-D004

Sample Photographs

Borehole Name:	BH17-D005	Mary River Expansion Study Stage 2
Location:	17 W 503786 7976738	
Completion Date:	March 26, 2017	Baffinland Iron Mines

BH17-D005

AS-2

BH17-D005

RECOVERED USING SPT SAMPLER

1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0

BH17-D005

NO RECOVERY IN CORE BARREL

3.0 | 3.4 | 3.7 | 4.0 | 4.3 | 4.6

BH17-D005

NO RECOVERY IN CORE BARREL

4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1

BH17-D005

BH17-D005

Sample Photographs

Borehole Name: BH17-D005

Location: 17 W 503786 7976738

Completion Date: March 26, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

AS-4

BH17-D005

RECOVERED USING SPT SAMPLER

9.1 **9.4** **9.8** **10.1** **10.4** **10.7**

BH17-D005

NO RECOVERY IN CORE BARREL

10.7 **11.0** **11.3** **11.6** **11.9** **12.2**

BH17-D005

BH17-D005

BH17-D005

Sample Photographs

Borehole Name:	BH17-D005	Mary River Expansion Study Stage 2
Location:	17 W 503786 7976738	
Completion Date:	March 26, 2017	Baffinland Iron Mines

BH17-D005

BH17-D005

BH17-D005

BH17-D005

BH17-D005

HATCH

Sample Photographs

Borehole Name: BH17-D005

Location: 17 W 503786 7976738

Completion Date: March 26, 2017

Mary River Expansion Study Stage 2

Baffinland Iron Mines

BH17-D005

BH17-D005

BH17-D005

BH17-D005

AS-14

BH17-D005

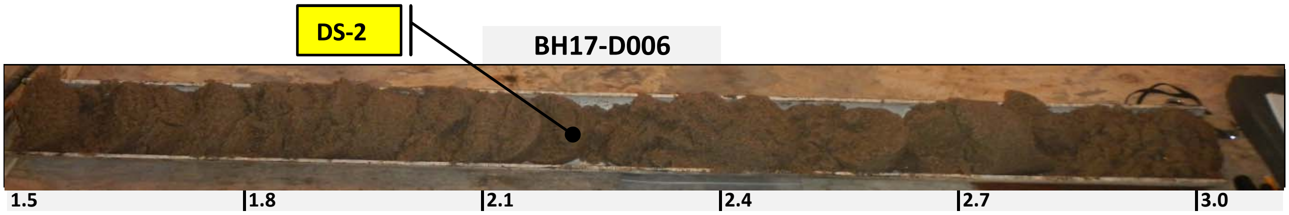
RECOVERED USING SPT SAMPLER

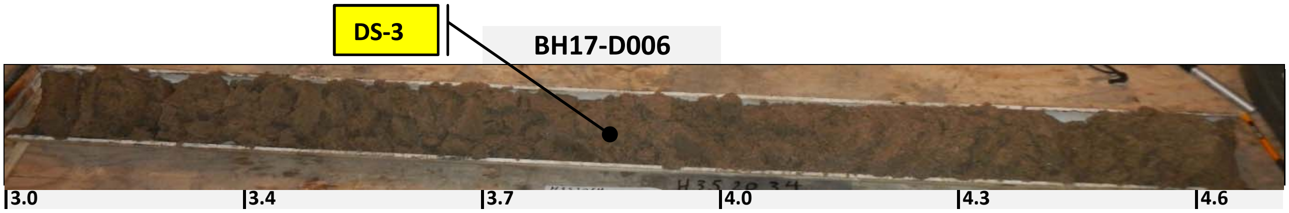
30.5 | 30.8 | 31.1 | 31.4 | 31.7 | 32.0

Sample Photographs

Borehole Name: BH17-D006
Location: 17 W 503678 7976797
Completion Date: April 2, 2017

Mary River Expansion Study Stage 2
2017 Geotechnical Investigation
Baffinland Iron Mines

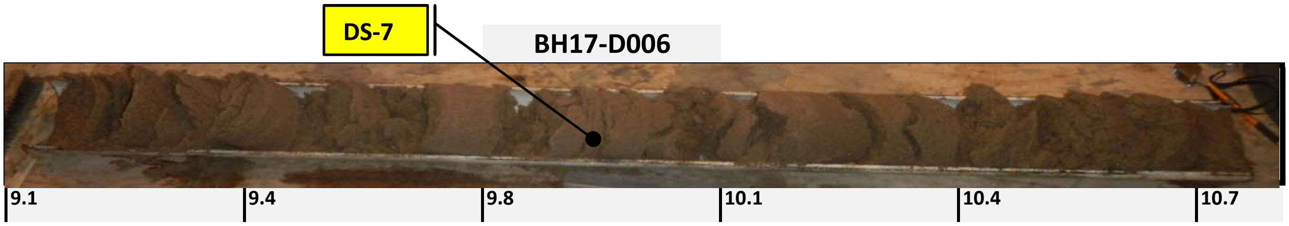




Sample Photographs

Borehole Name:	BH17-D006	Mary River Expansion Study Stage 2
Location:	17 W 503678 7976797	
Completion Date:	April 2, 2017	Baffinland Iron Mines

BH17-D006



BH17-D006

BH17-D006

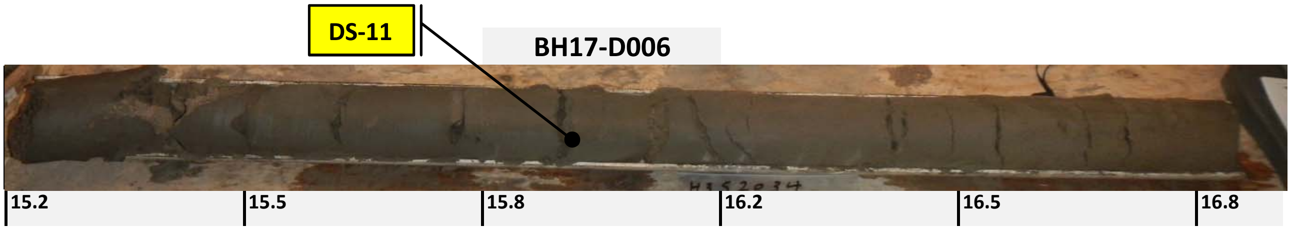
DS-10

BH17-D006

SAMPLE PHOTO NOT TAKEN

13.7	14.0	14.3	14.6	14.9	15.2

BH17-D006



Sample Photographs

Borehole Name: BH17-D006

Location: 17 W 503678 7976797

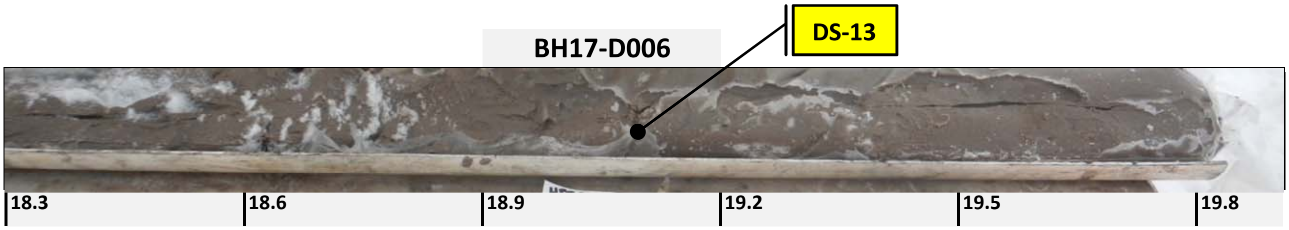
Completion Date: April 2, 2017

Mary River Expansion Study Stage 2

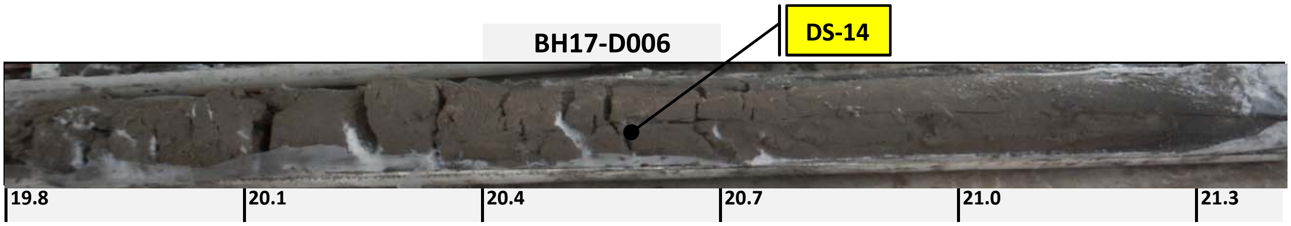
Baffinland Iron Mines

BH17-D006

BH17-D006

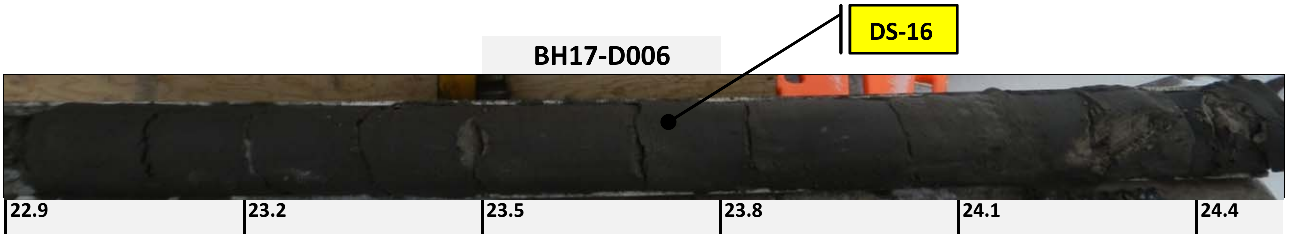


BH17-D006



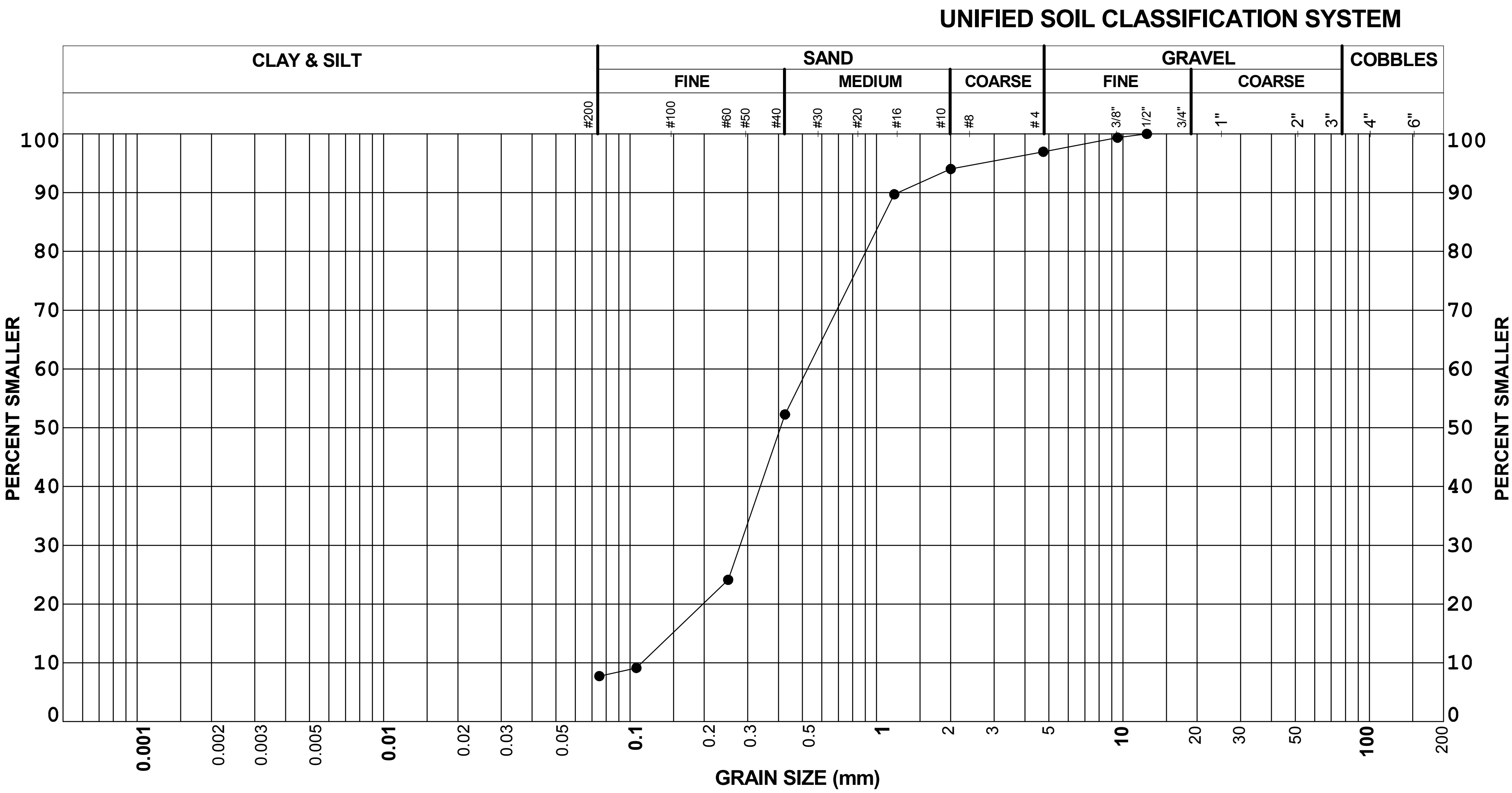
BH17-D006

BH17-D006



Appendix D

Laboratory Test Reports



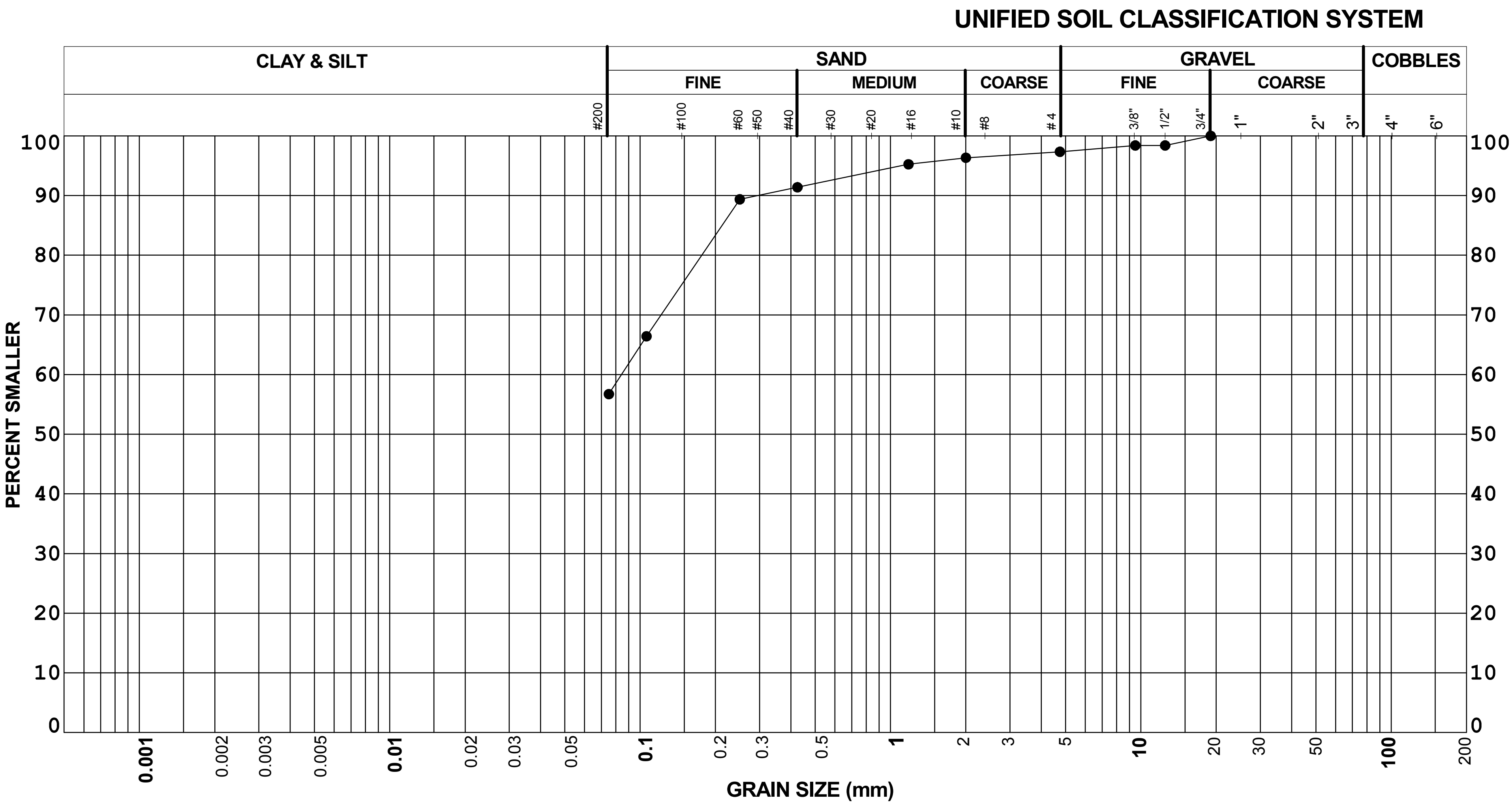
BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS1	0.90	3	89	8		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS4	7.00	3	41	57		

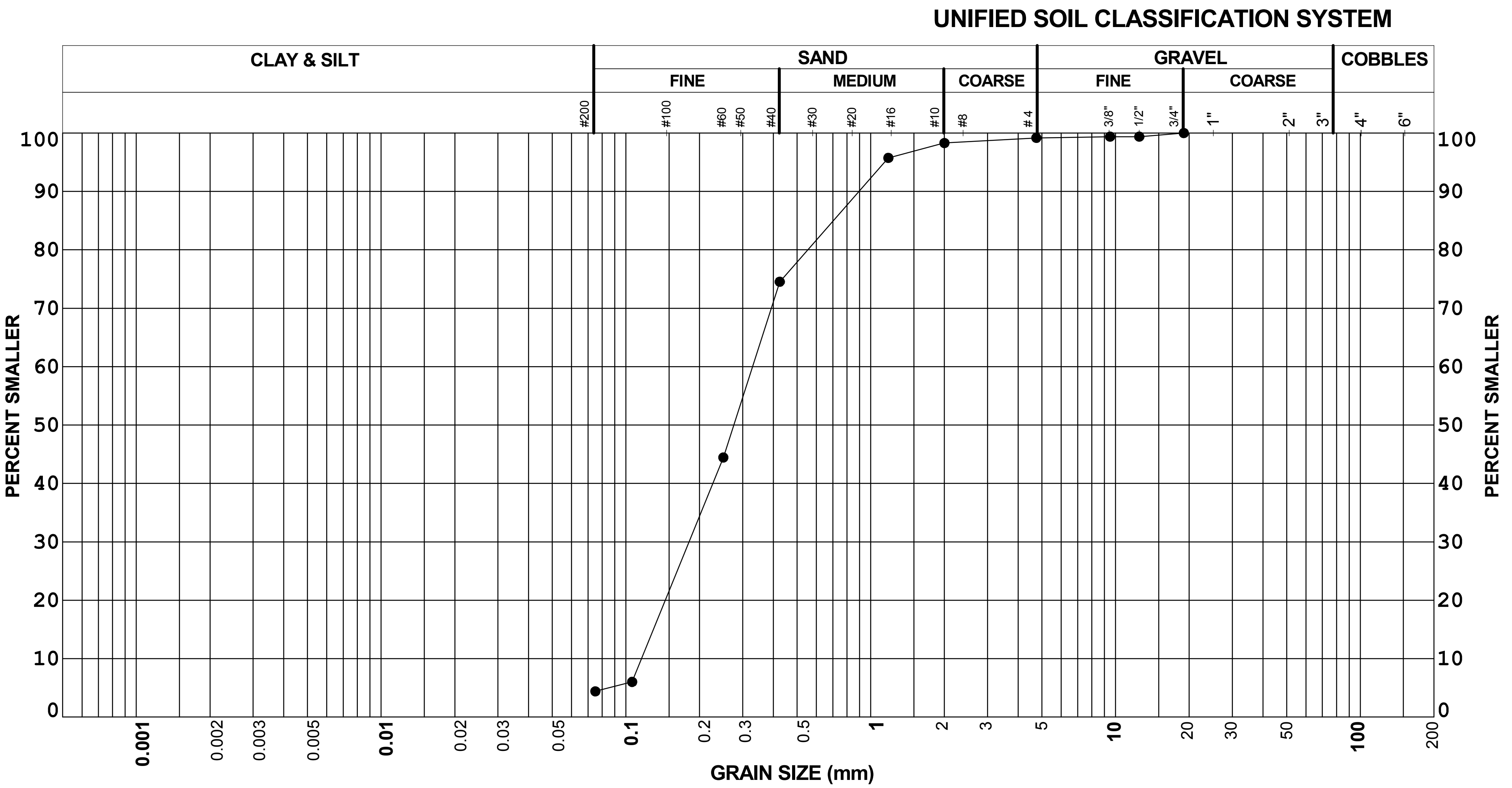
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS9	14.50	1	95	4		

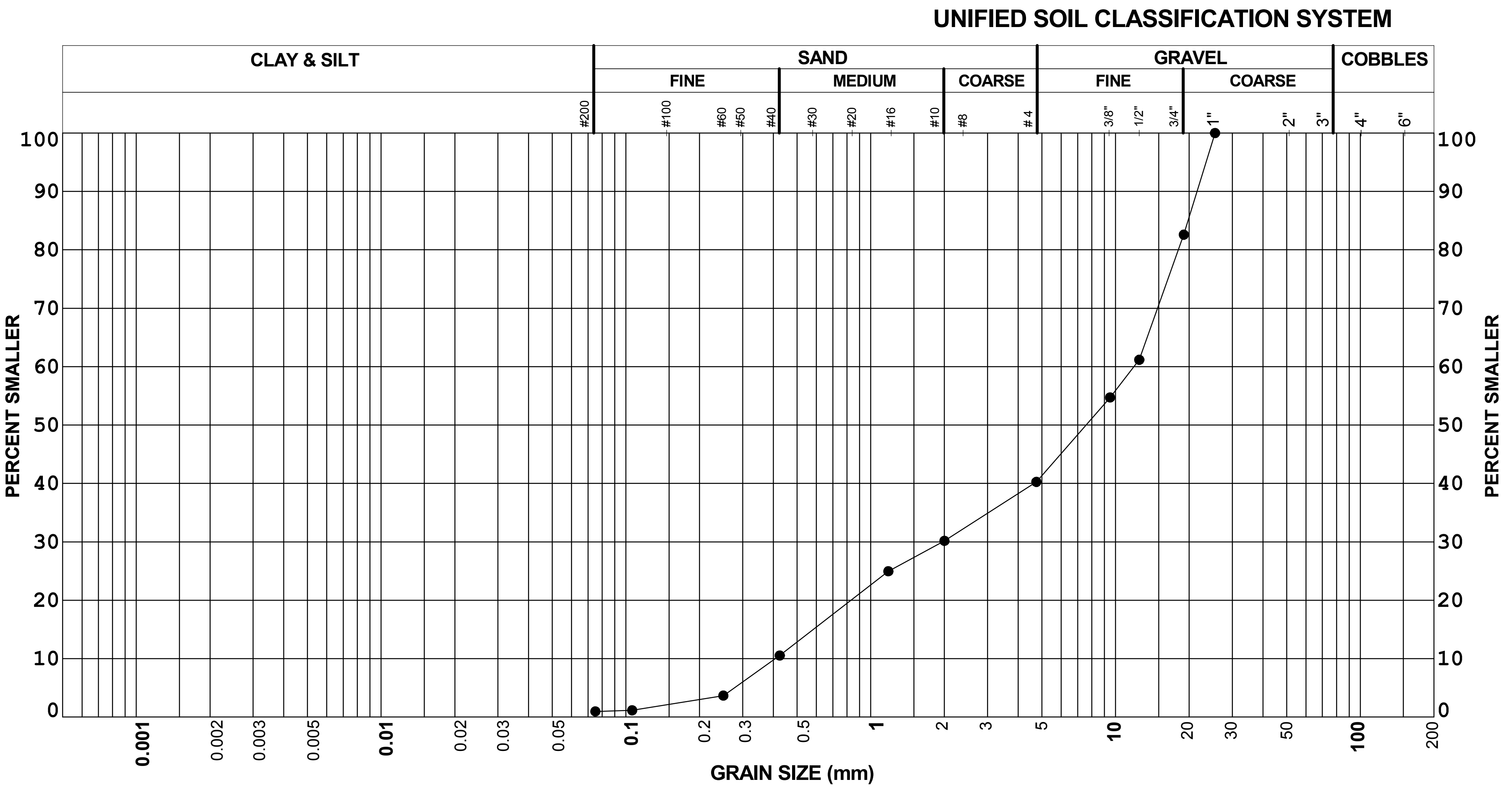
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D001	DS11	17.70	60	39	1		

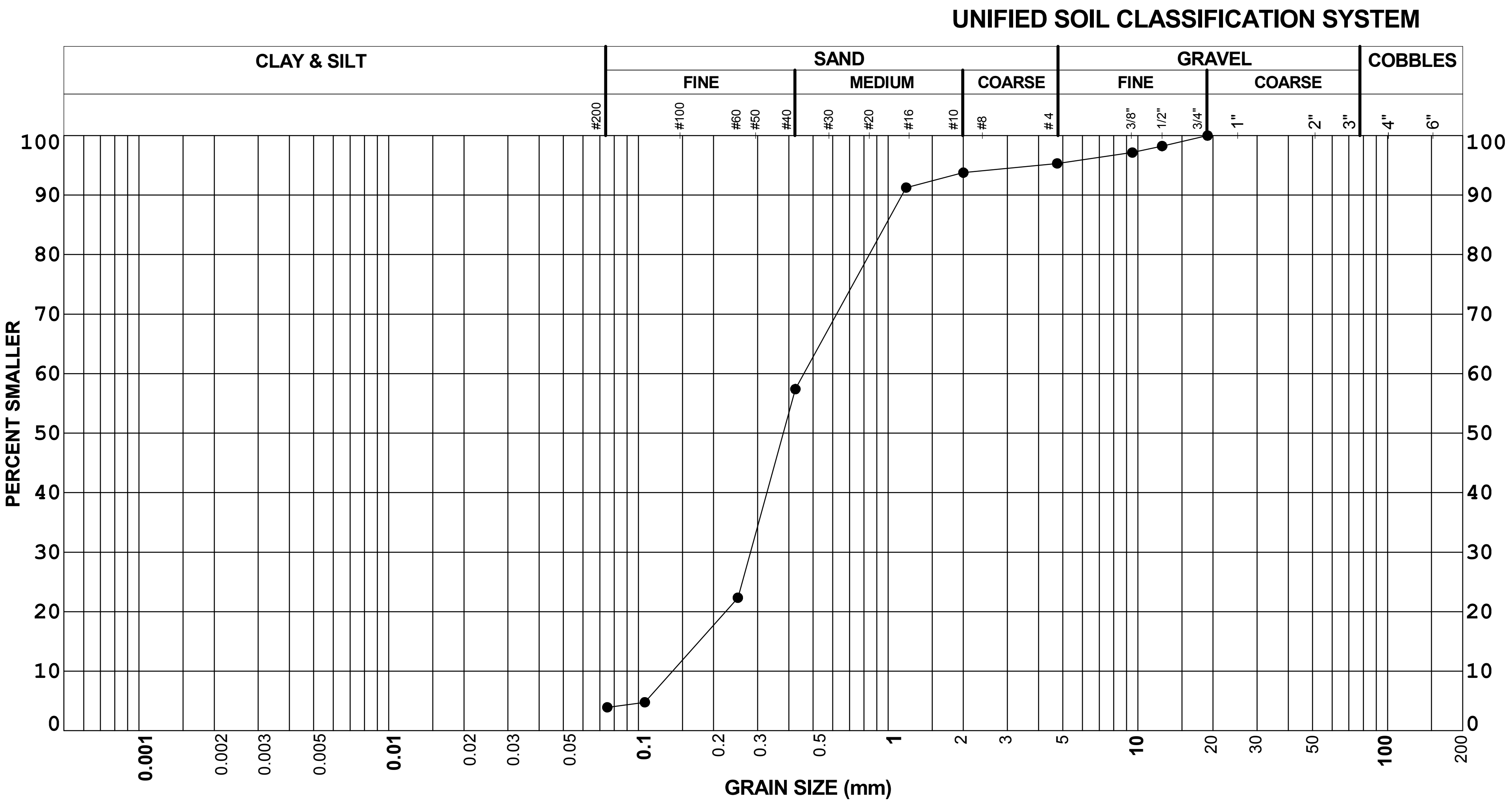
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D002	DS1	0.00	5	91	4		

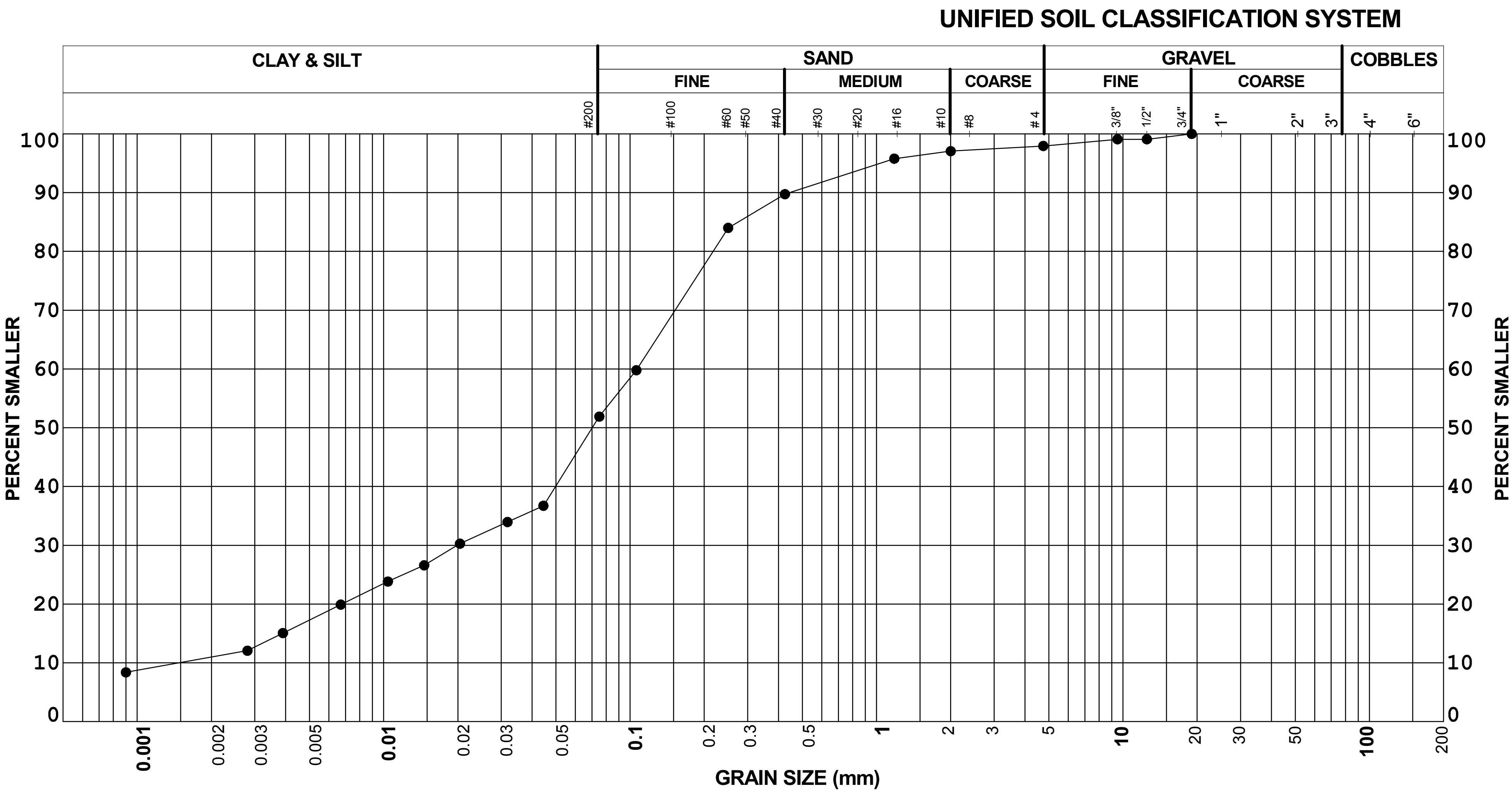
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS3	5.20	2	46	52		

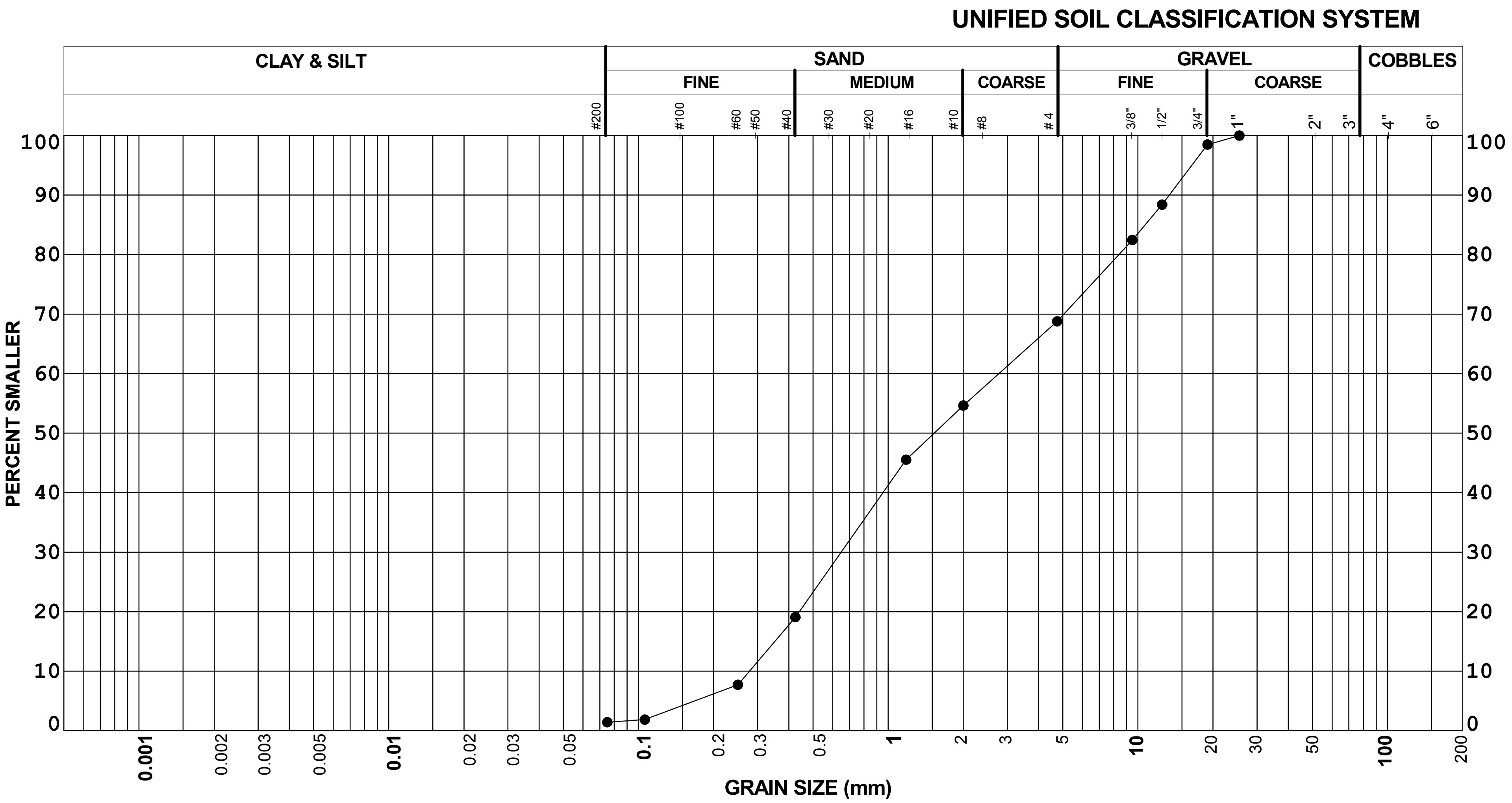
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



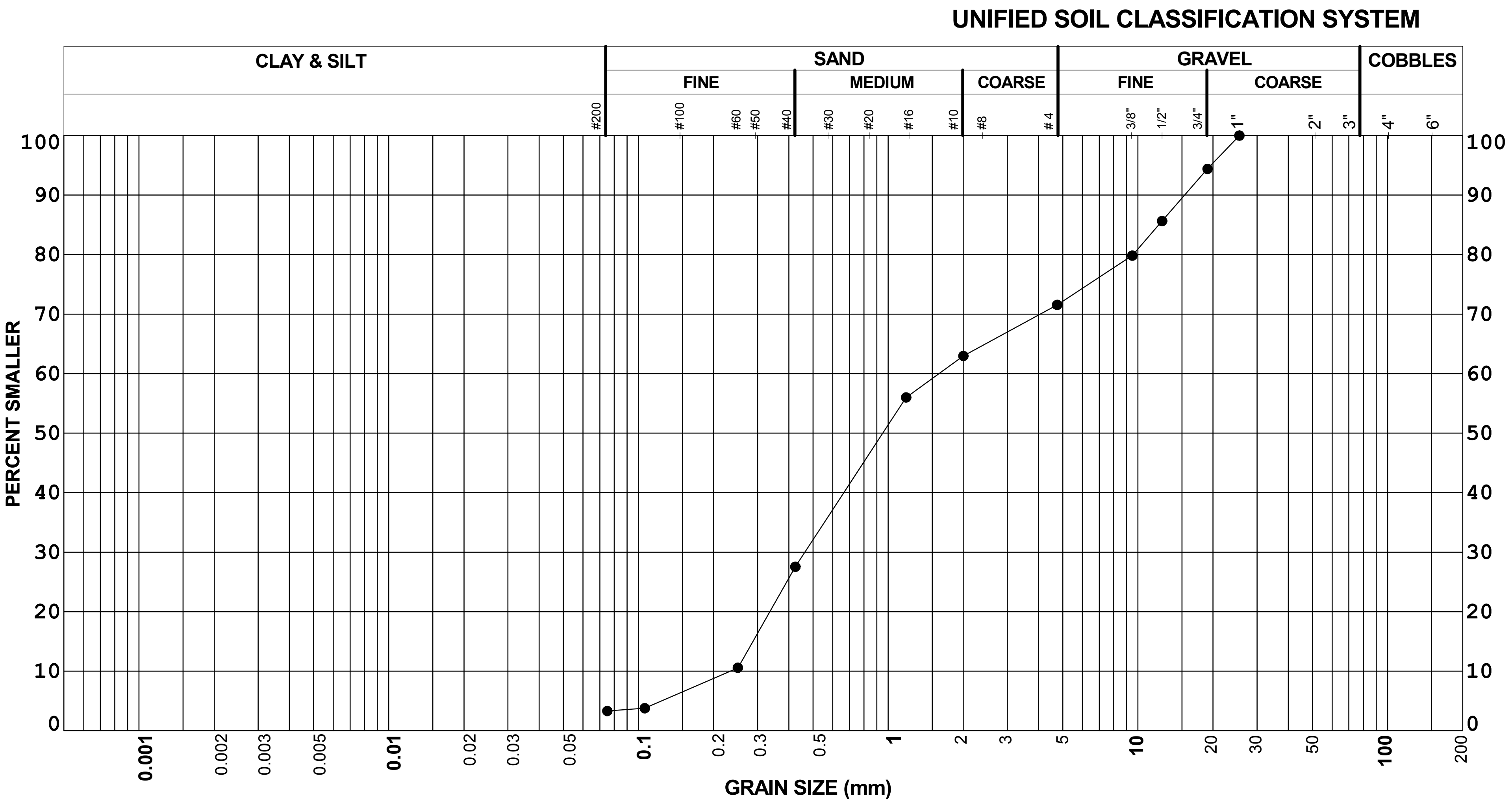
BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS5	8.50	31	67	1		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D002	DS9	15.70	28	68	3		

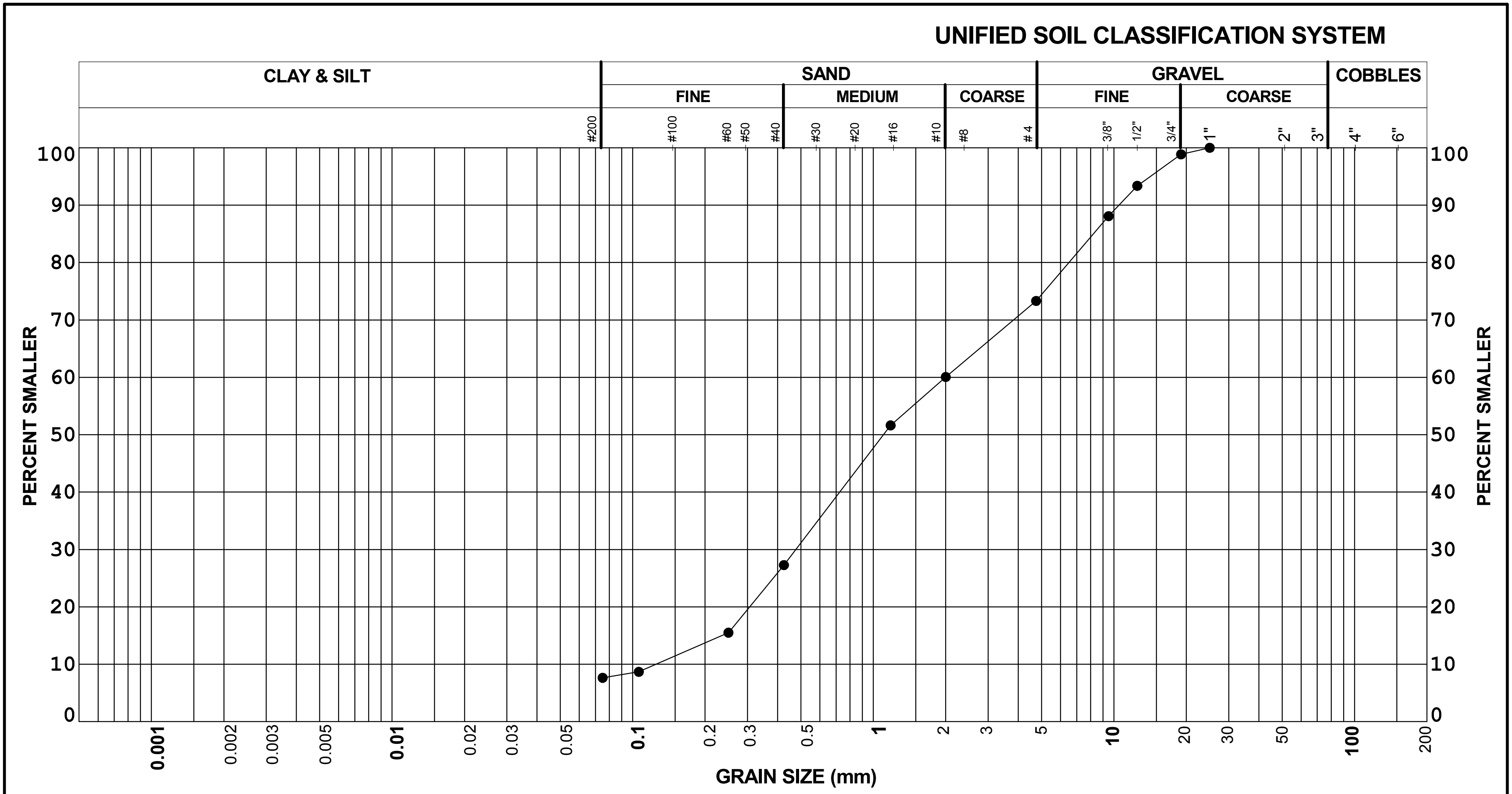
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D002	DS10	17.50	27	66	8		

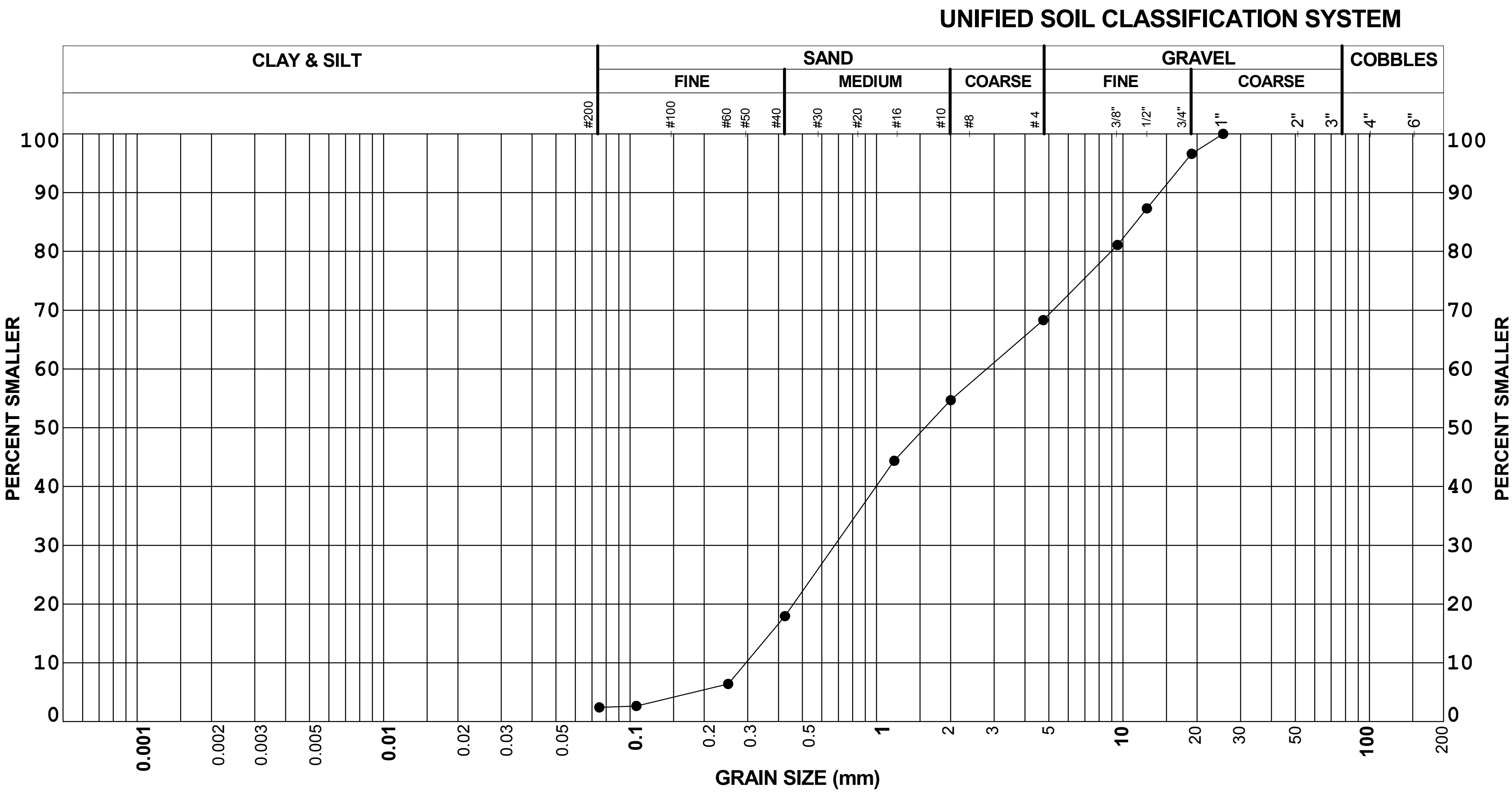
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D002	DS13	25.90	32	66	2		

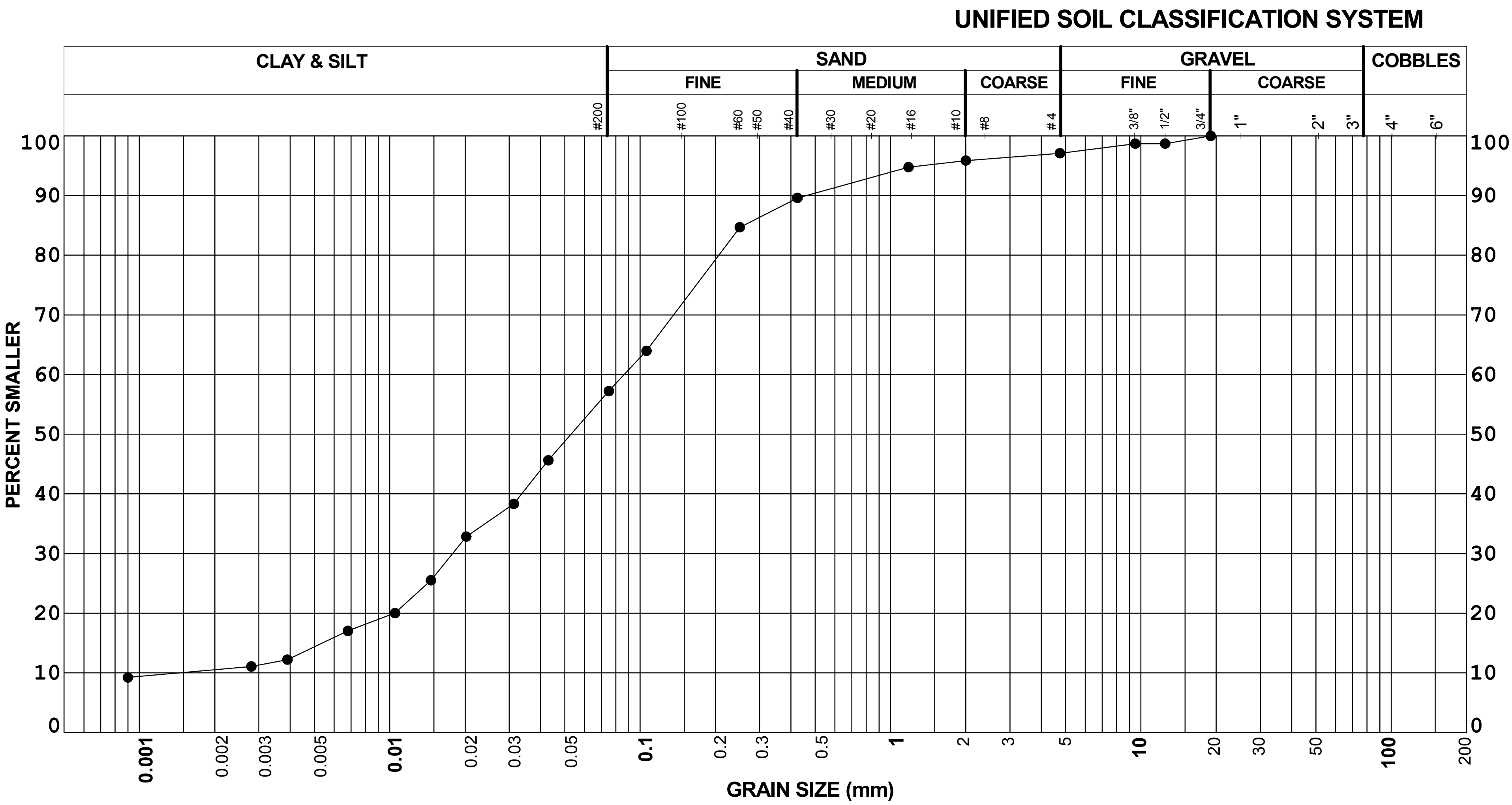
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D003	DS2	5.20	3	40	57		

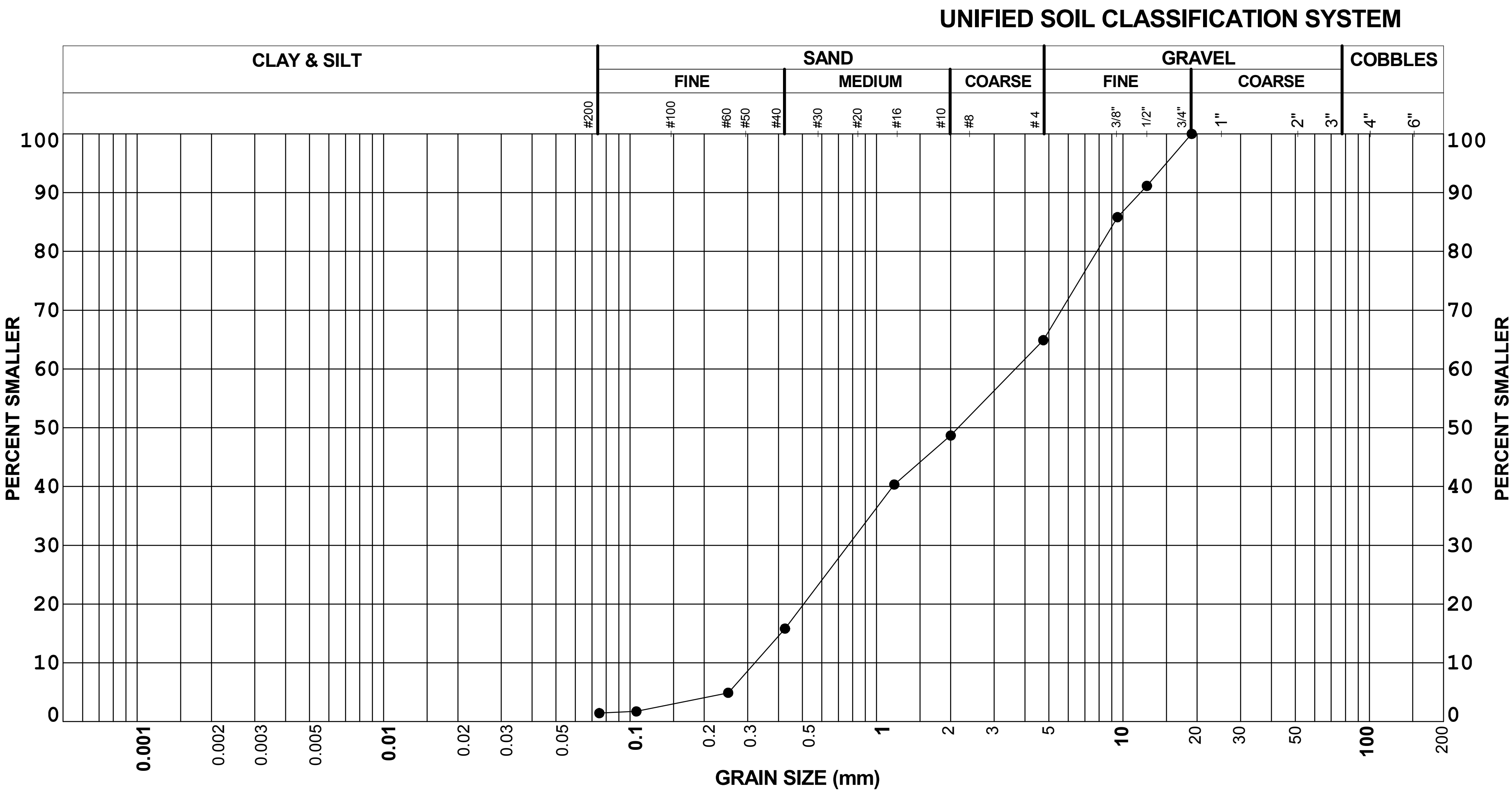
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D003	AS6	15.20	35	63	1		

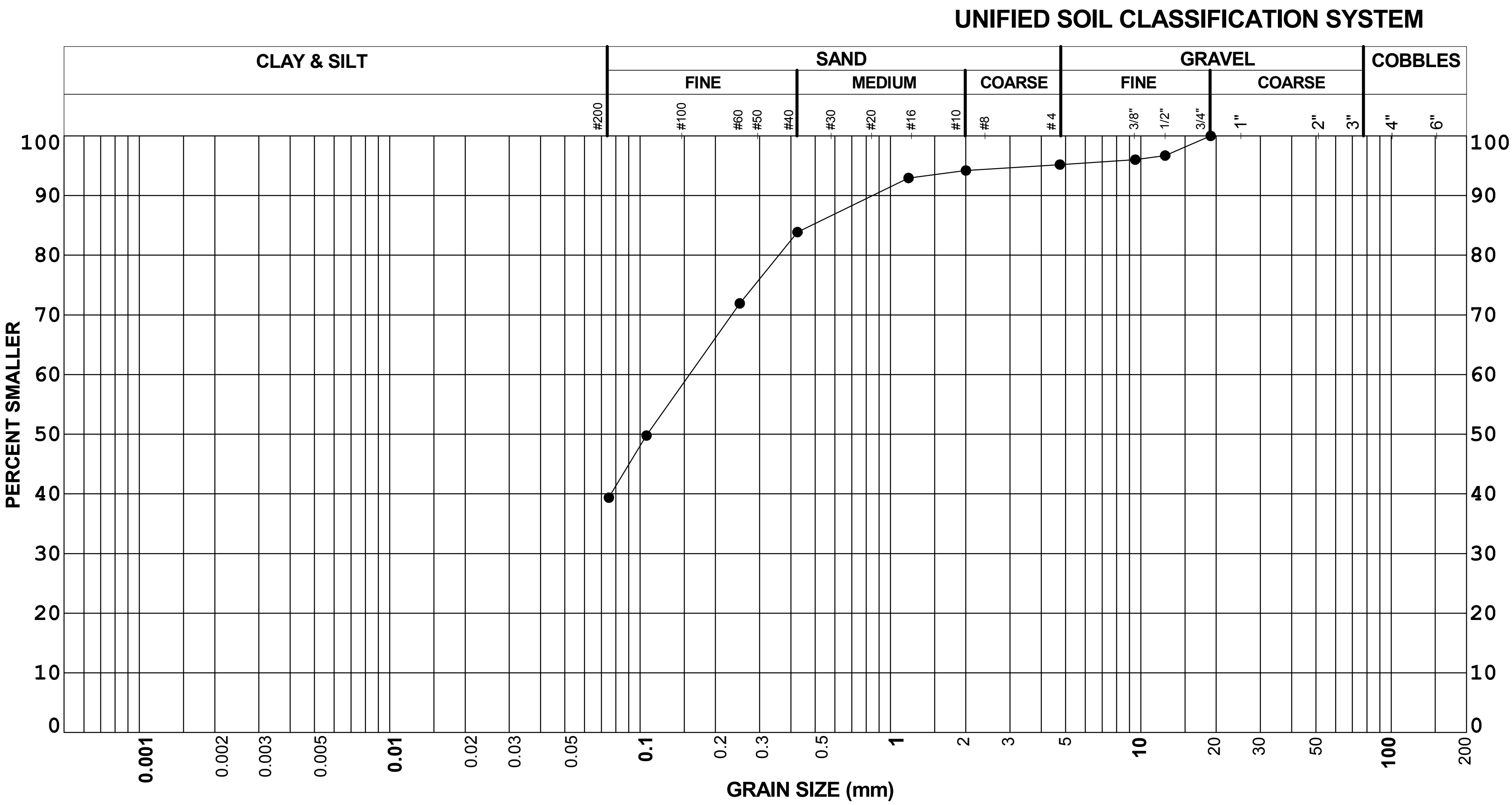
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D003	AS9	21.30	5	56	39		

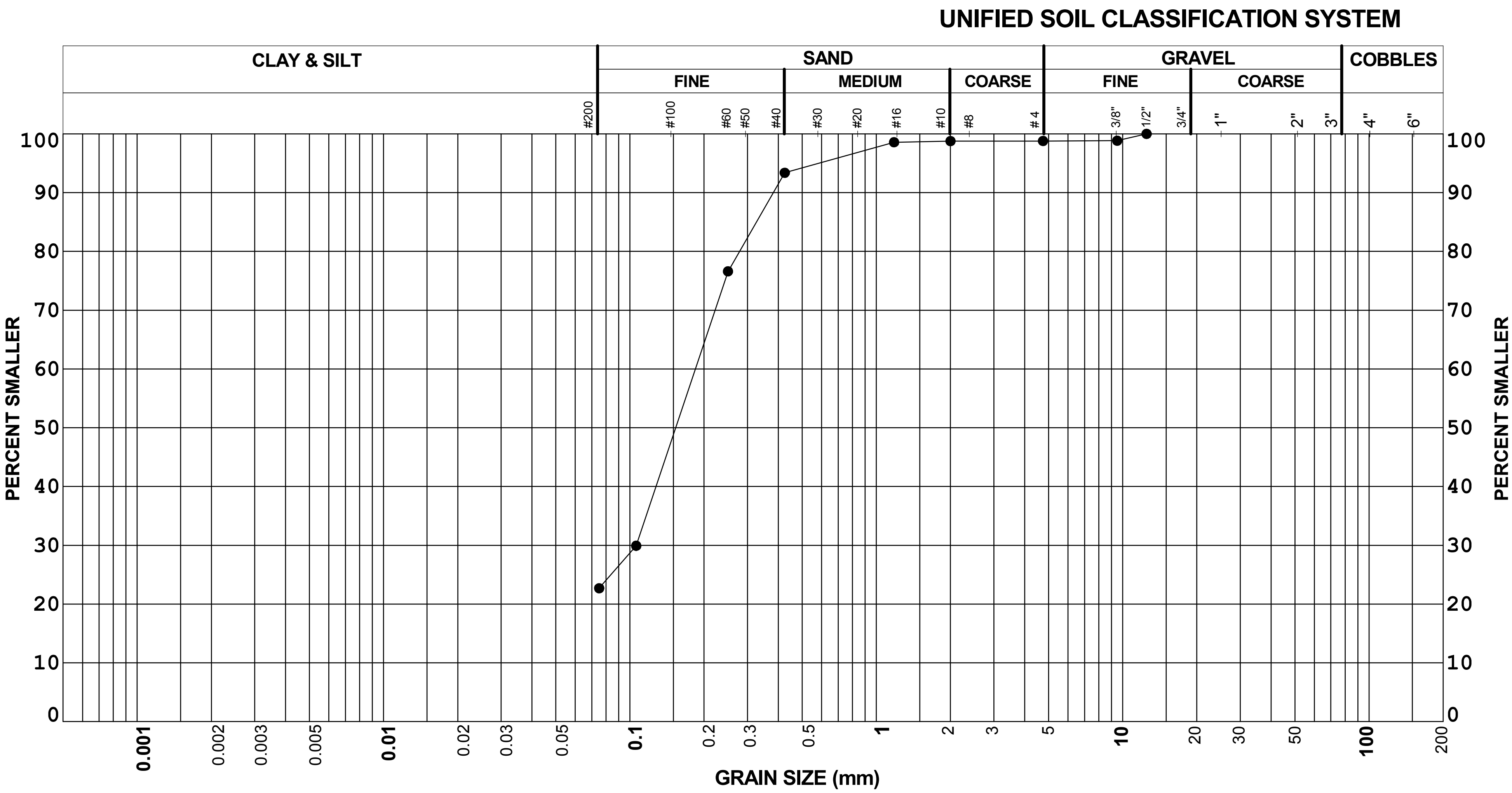
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D003	DS14	30.20	1	76	23		

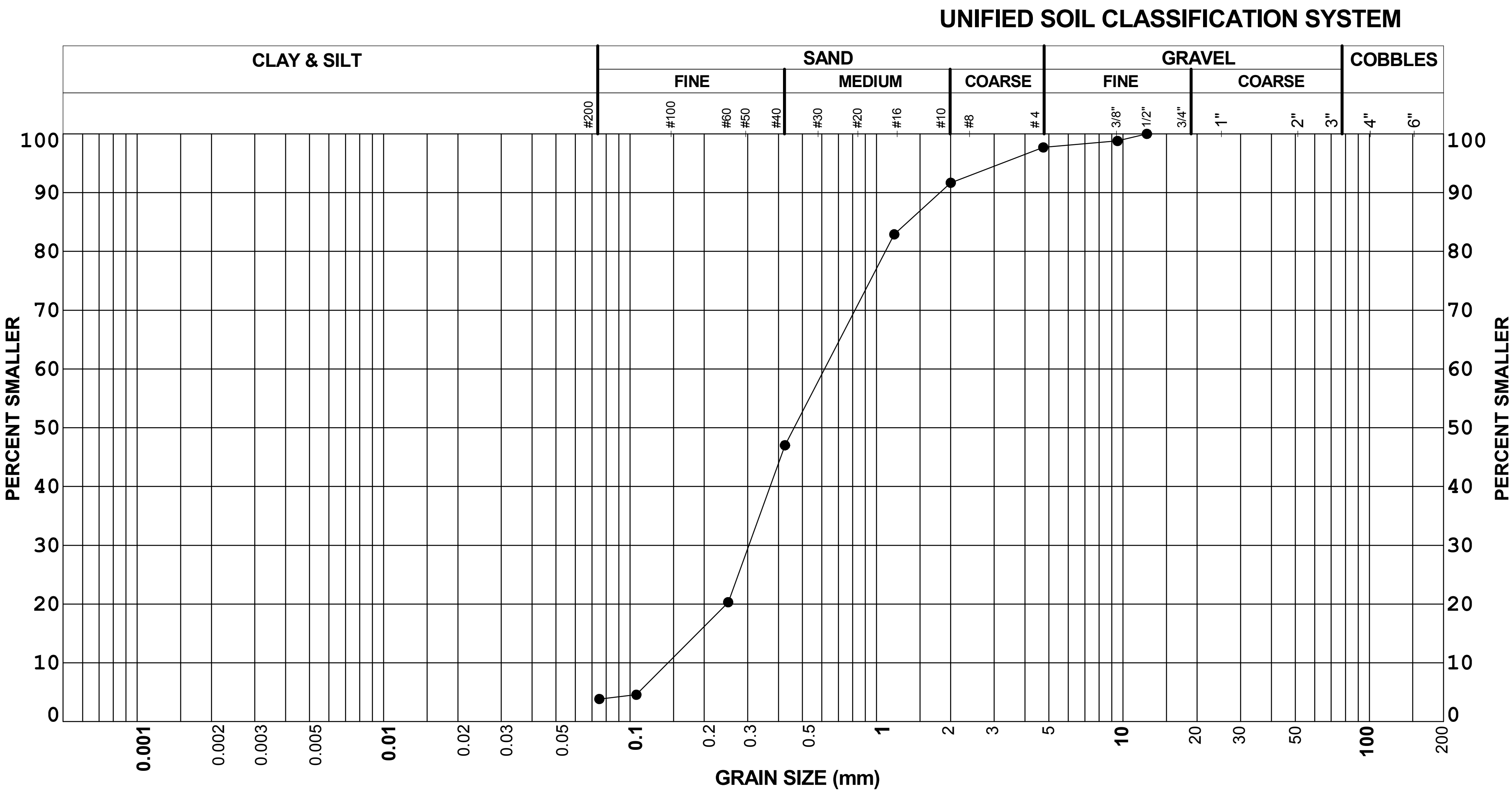
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	AS5	7.60	2	94	4		

REMARKS:

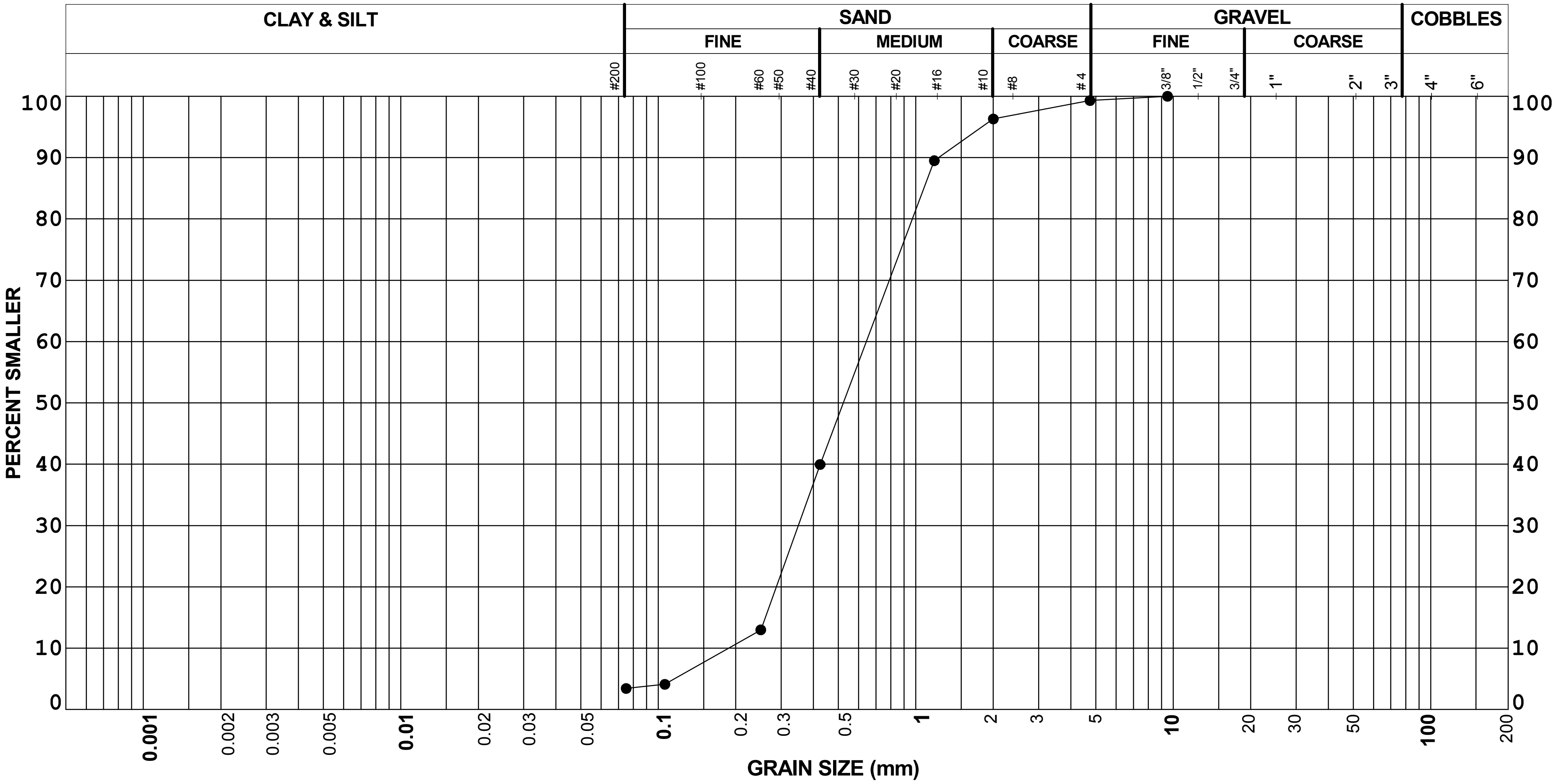
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D004	DS10	18.00	1	96	3		

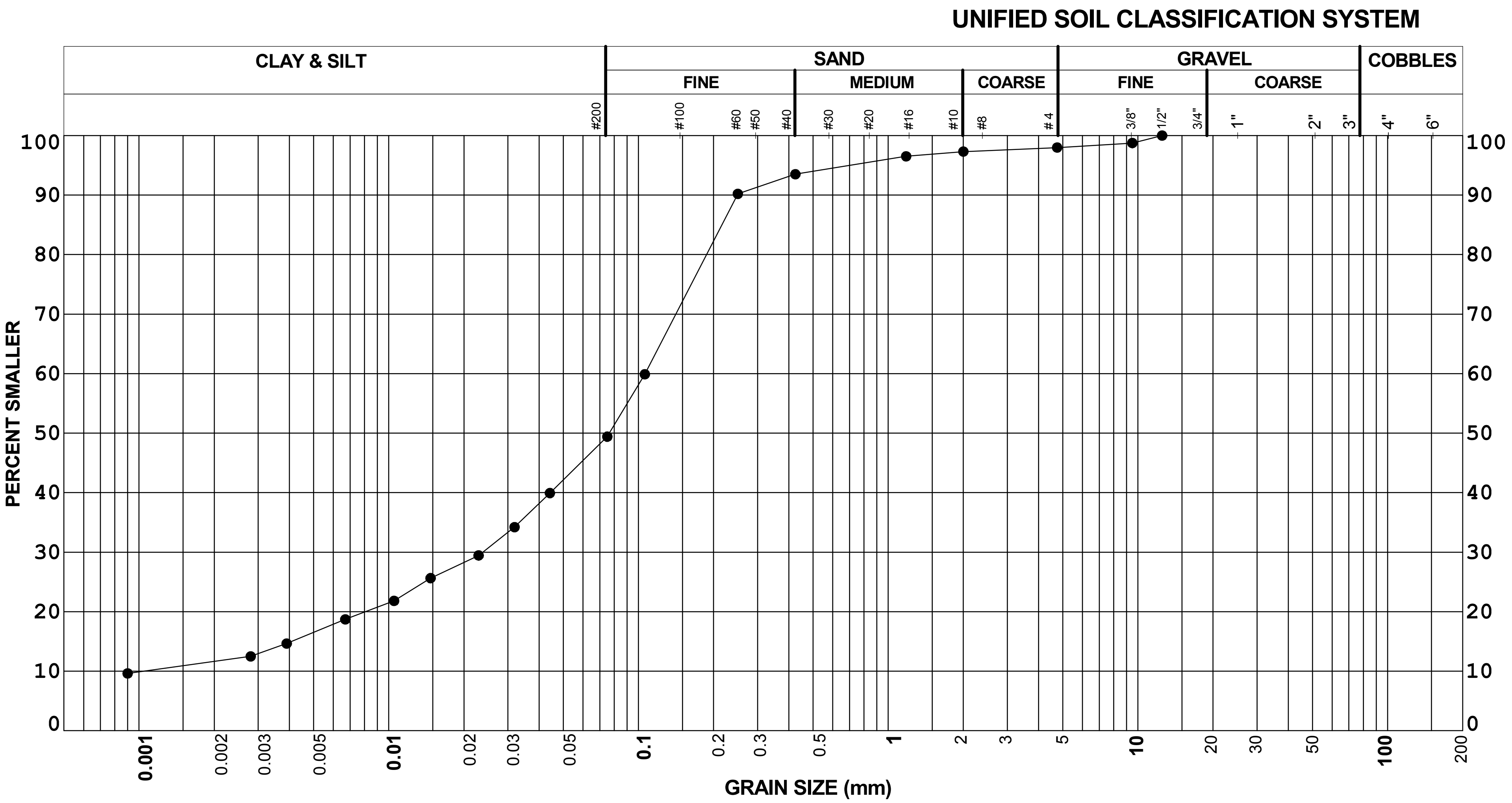
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	DS16	29.30	2	49	49		

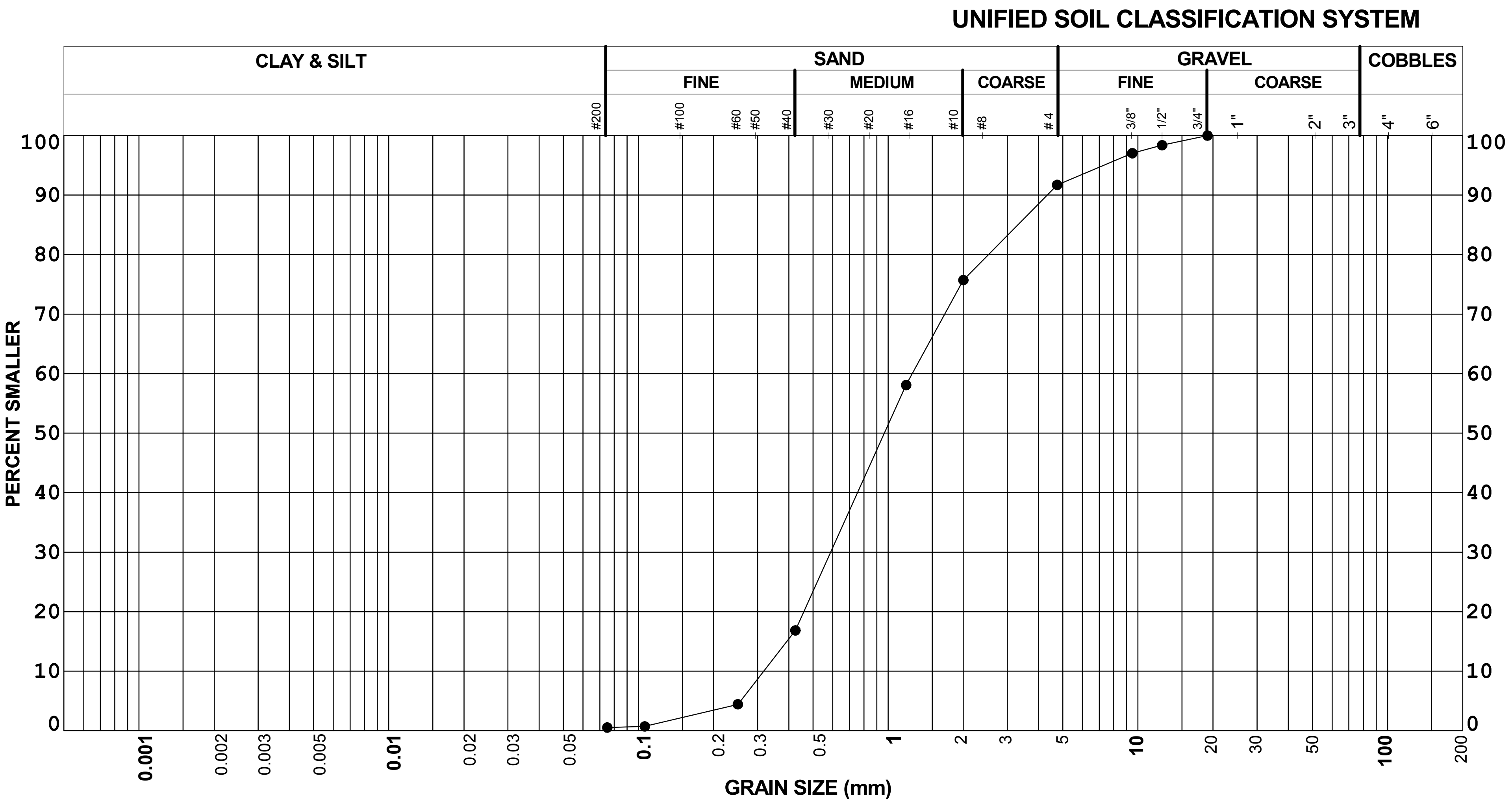
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D004	DS20	38.70	8	91	1		

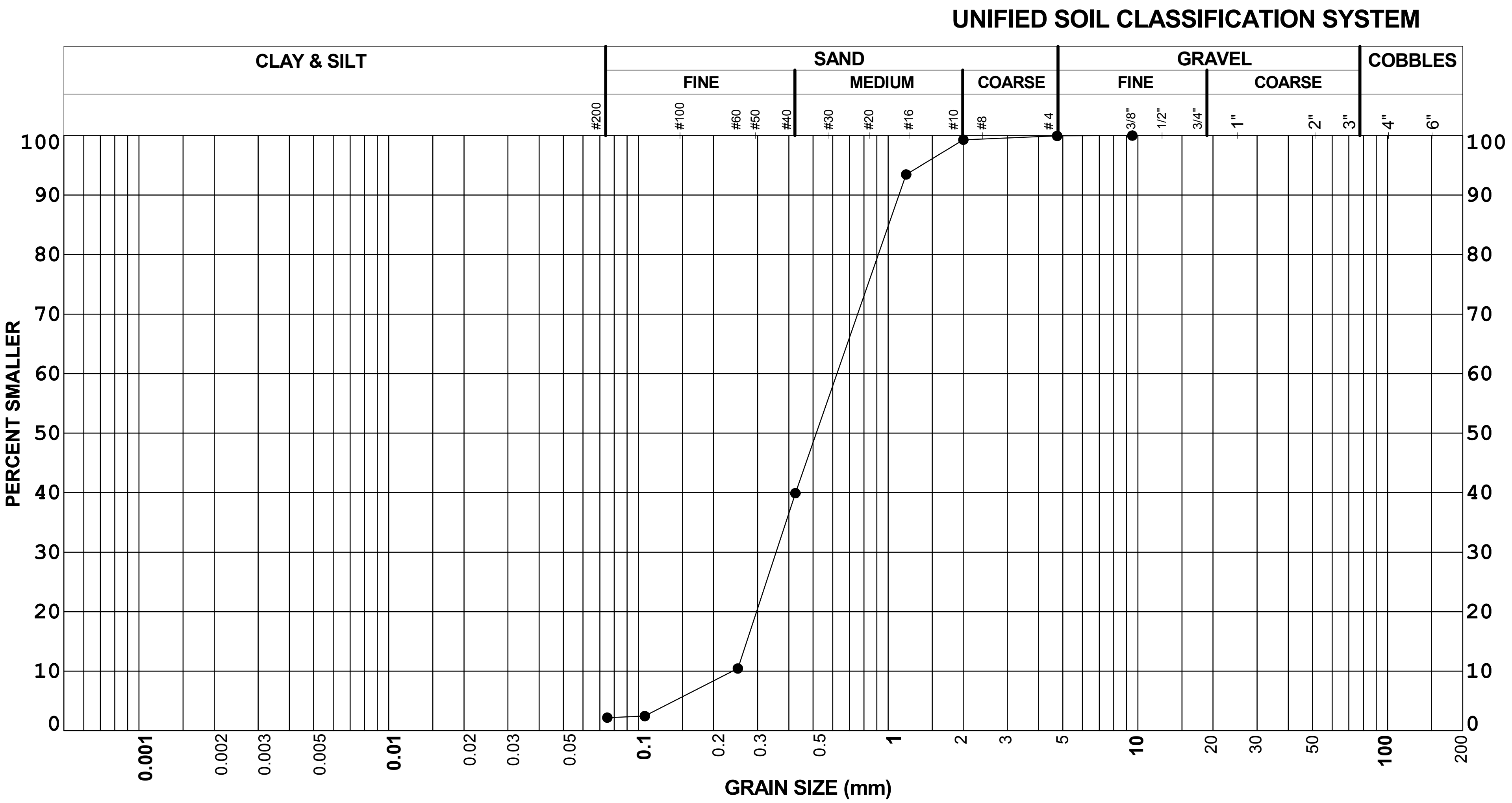
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D004	DS21	42.10	0	98	2		

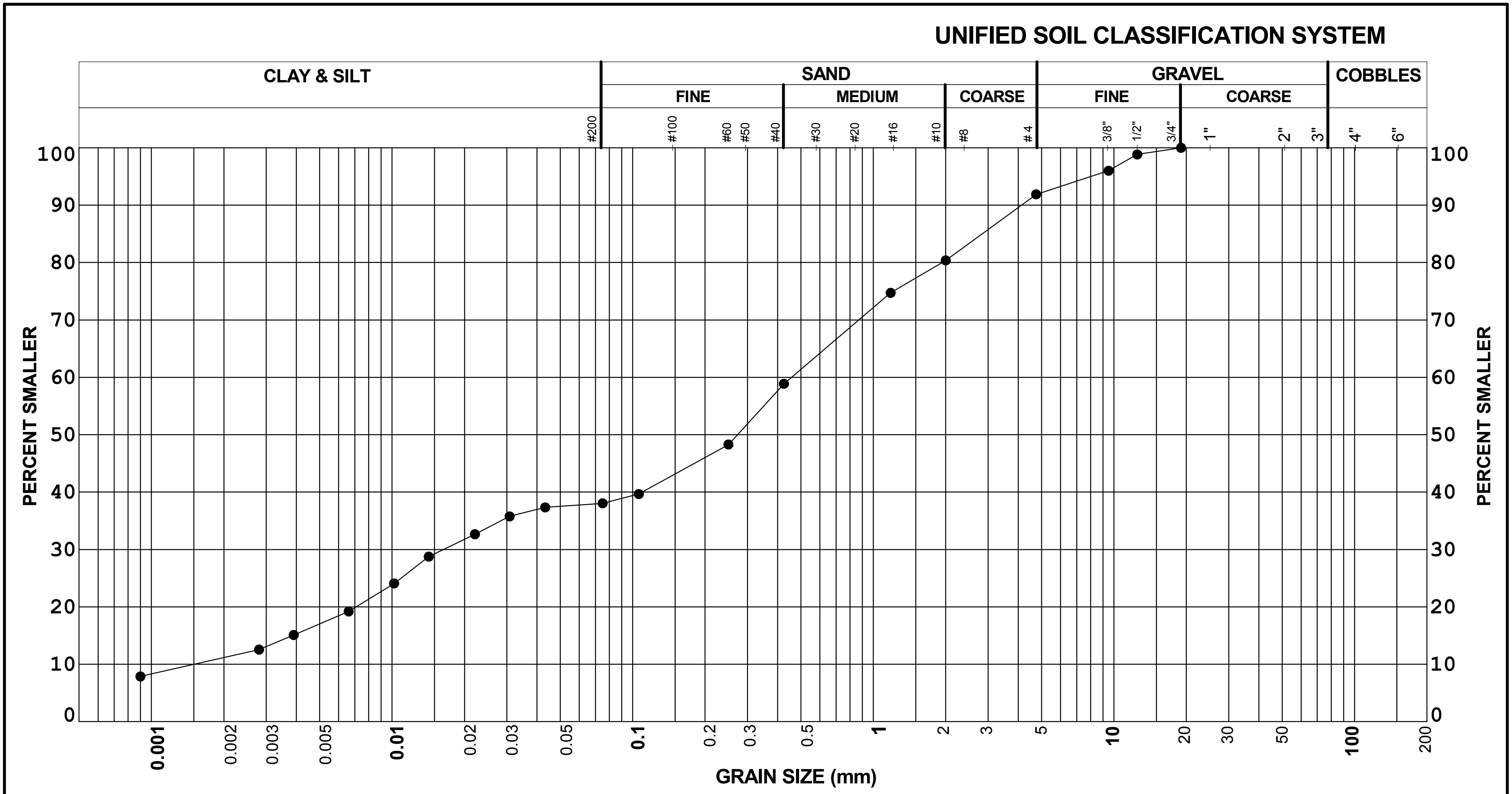
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS1	0.00	8	54	38		

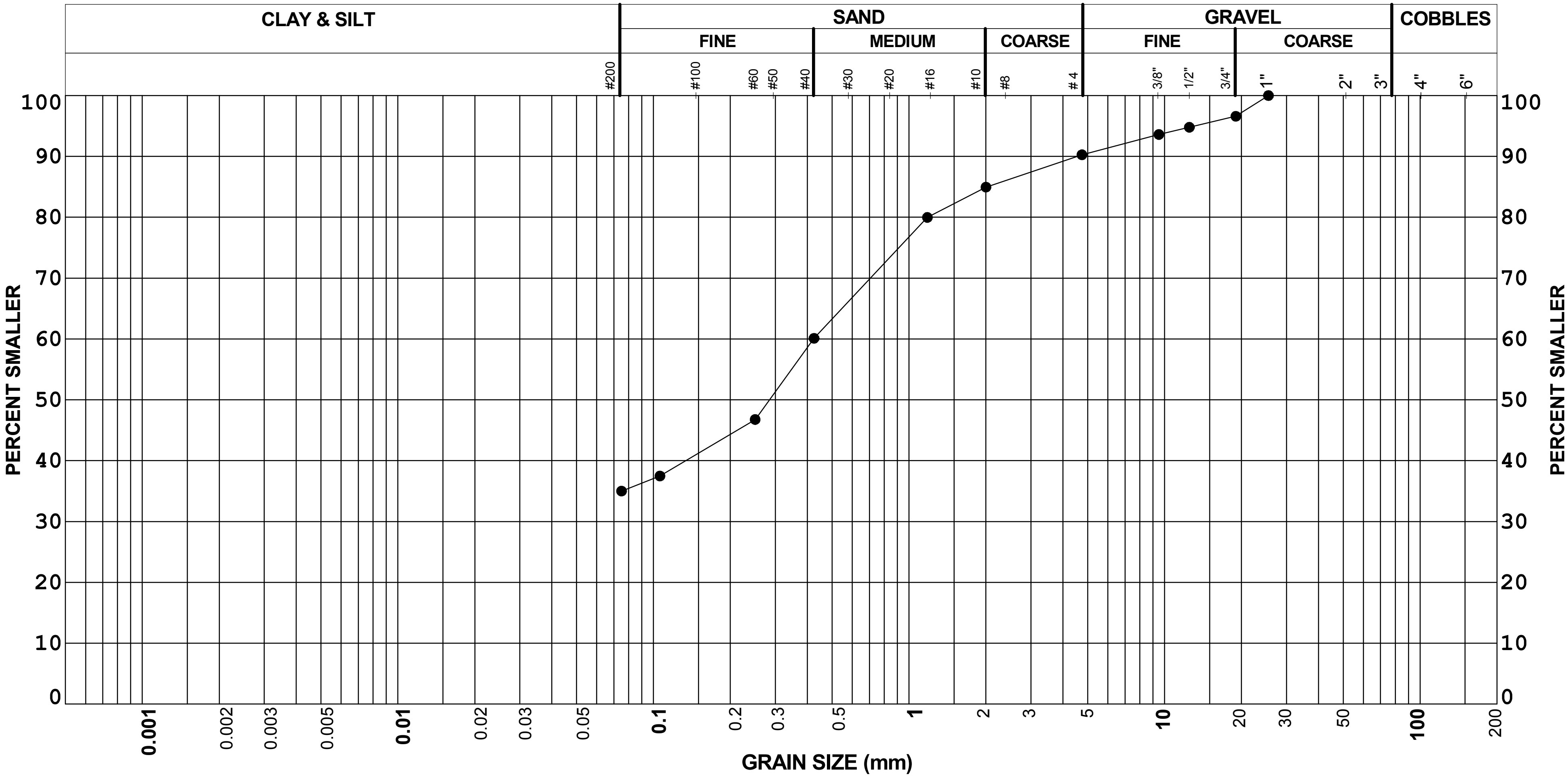
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS3	7.00	10	55	35		

REMARKS:

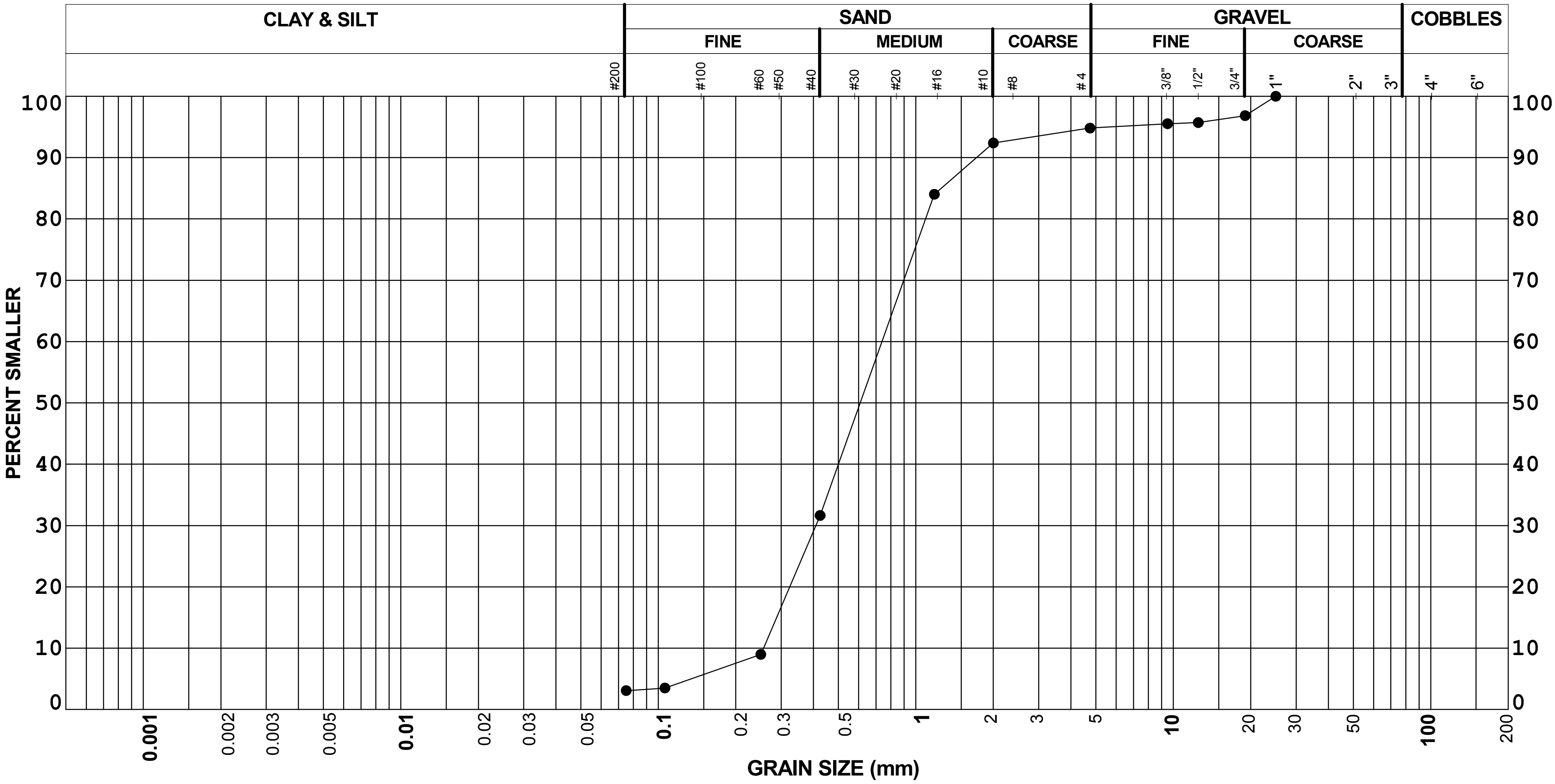
GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

UNIFIED SOIL CLASSIFICATION SYSTEM



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS5	12.80	5	92	3		

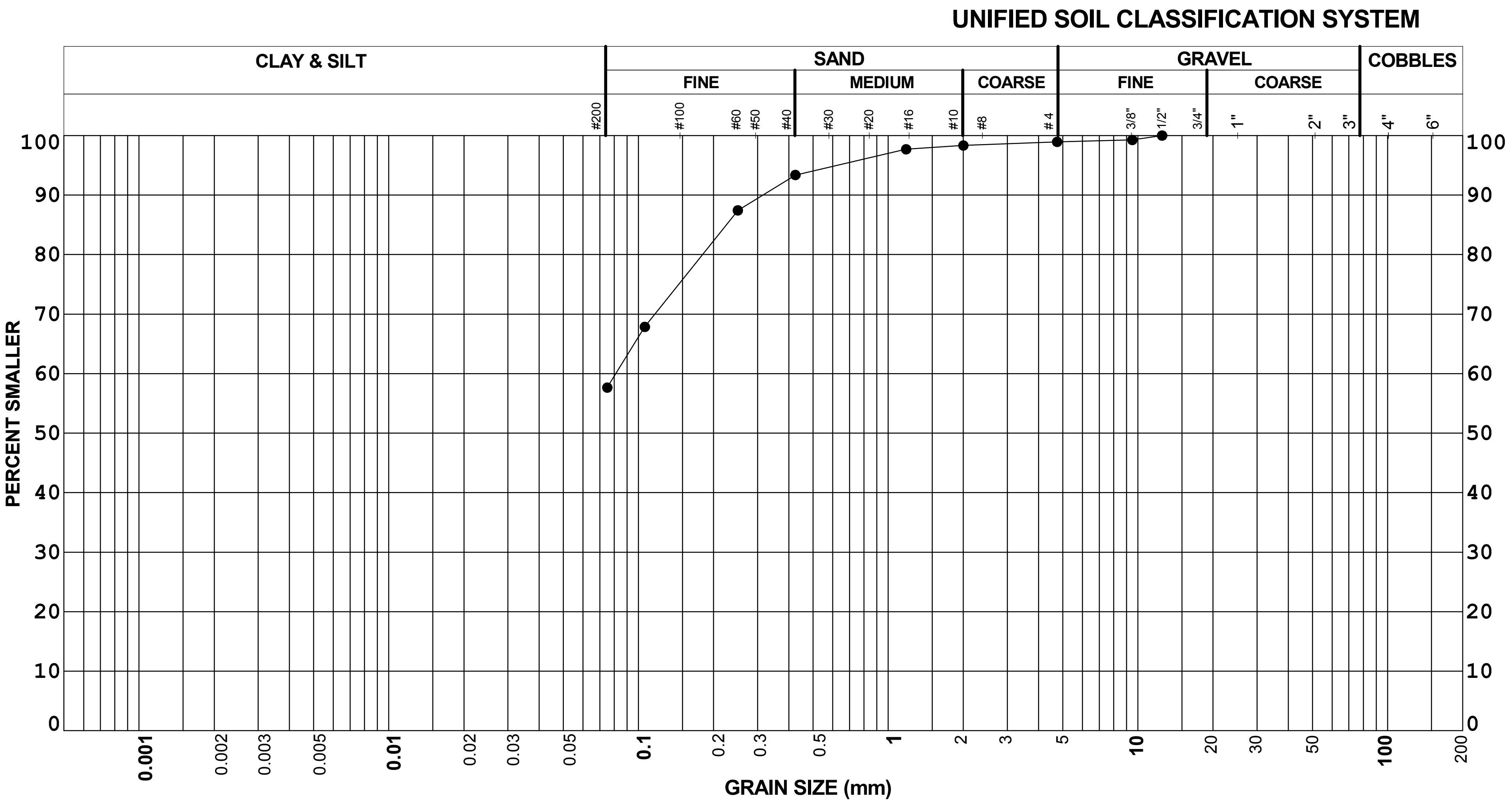
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D005	DS9	21.00	1	41	58		

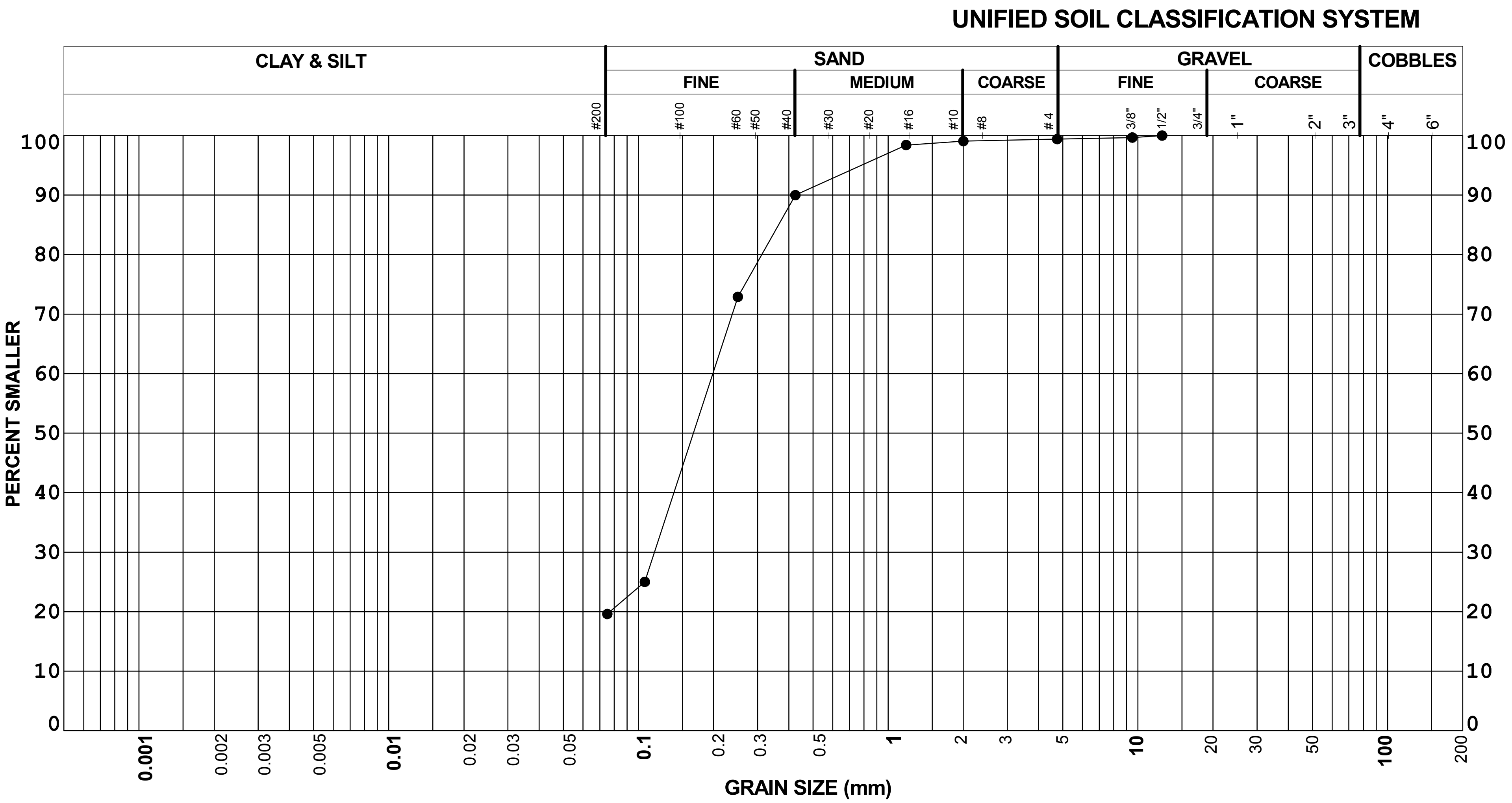
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D005	DS12	25.30	1	80	20		

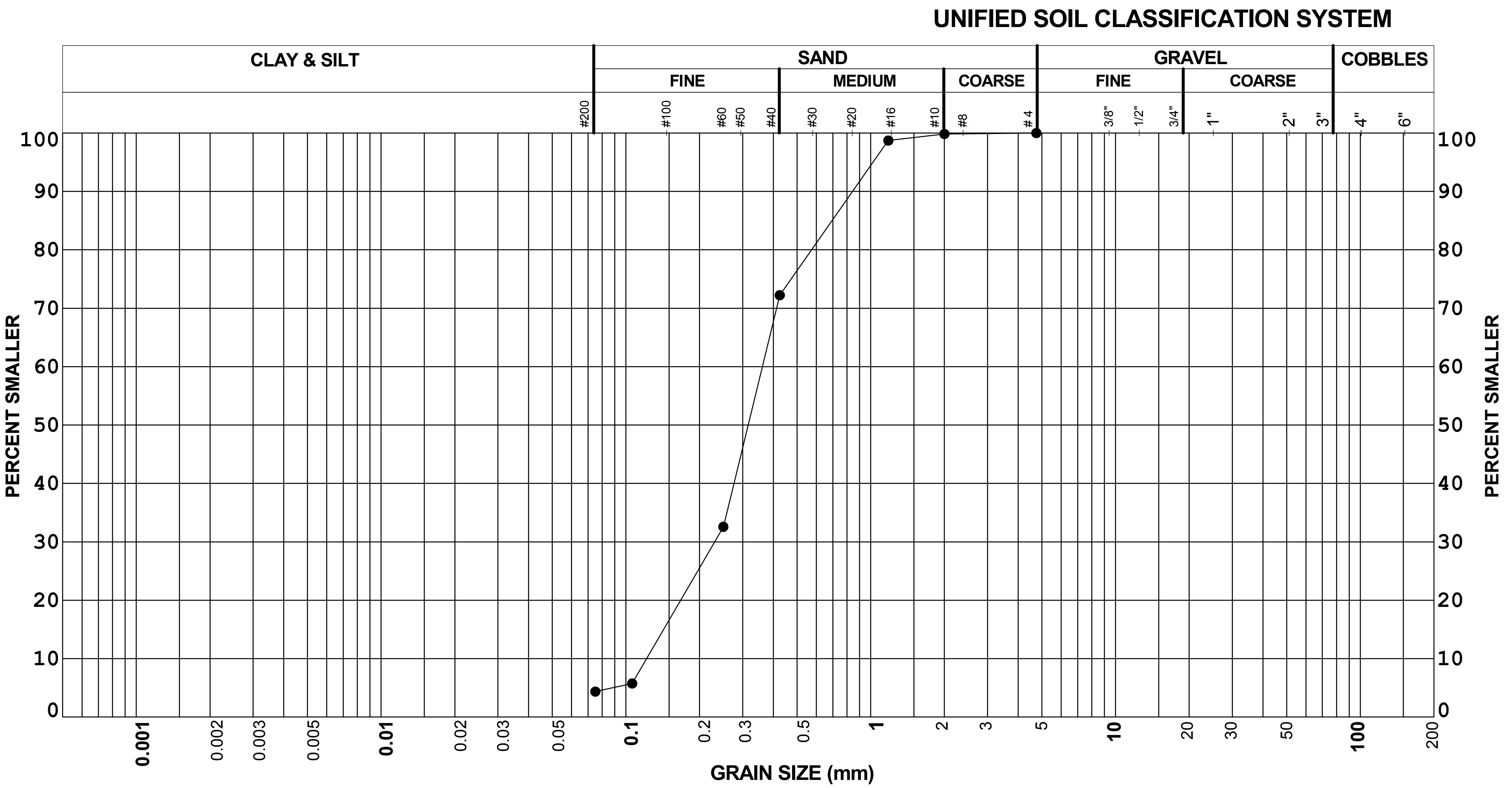
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D005	DS13	28.00	0	96	4		

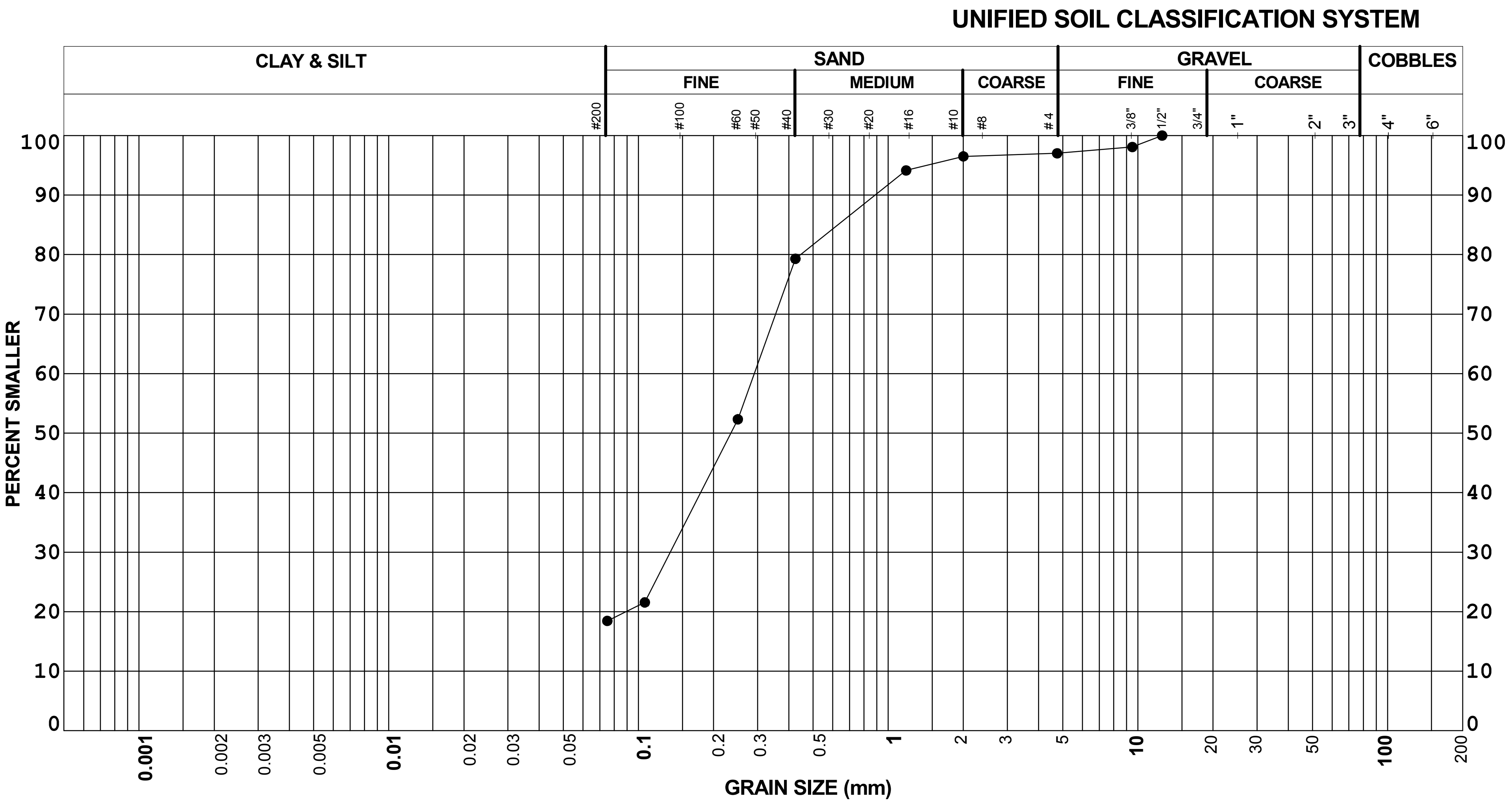
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



	BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
●	BH17-D006	AS1	0.00	3	79	18		

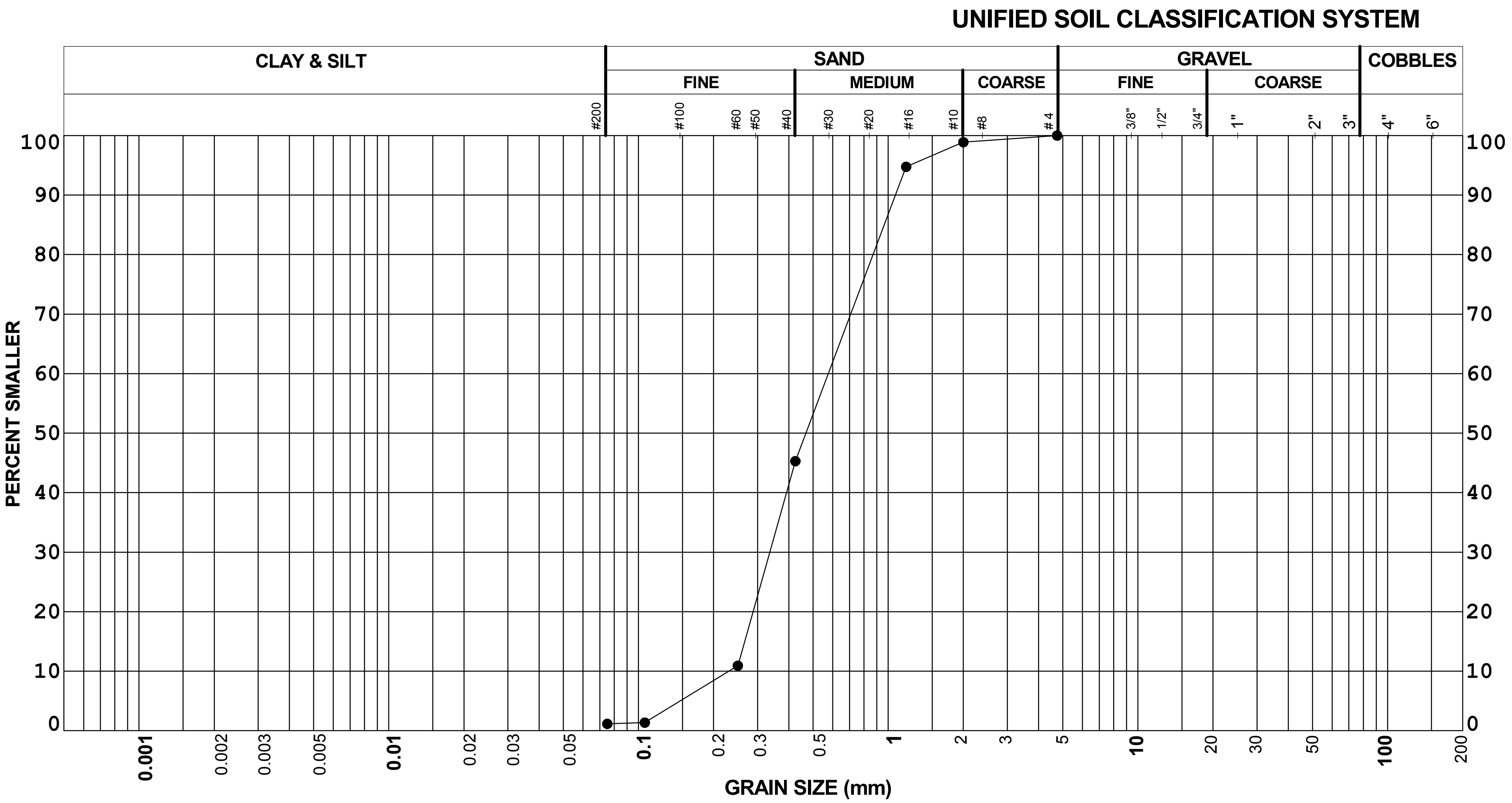
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



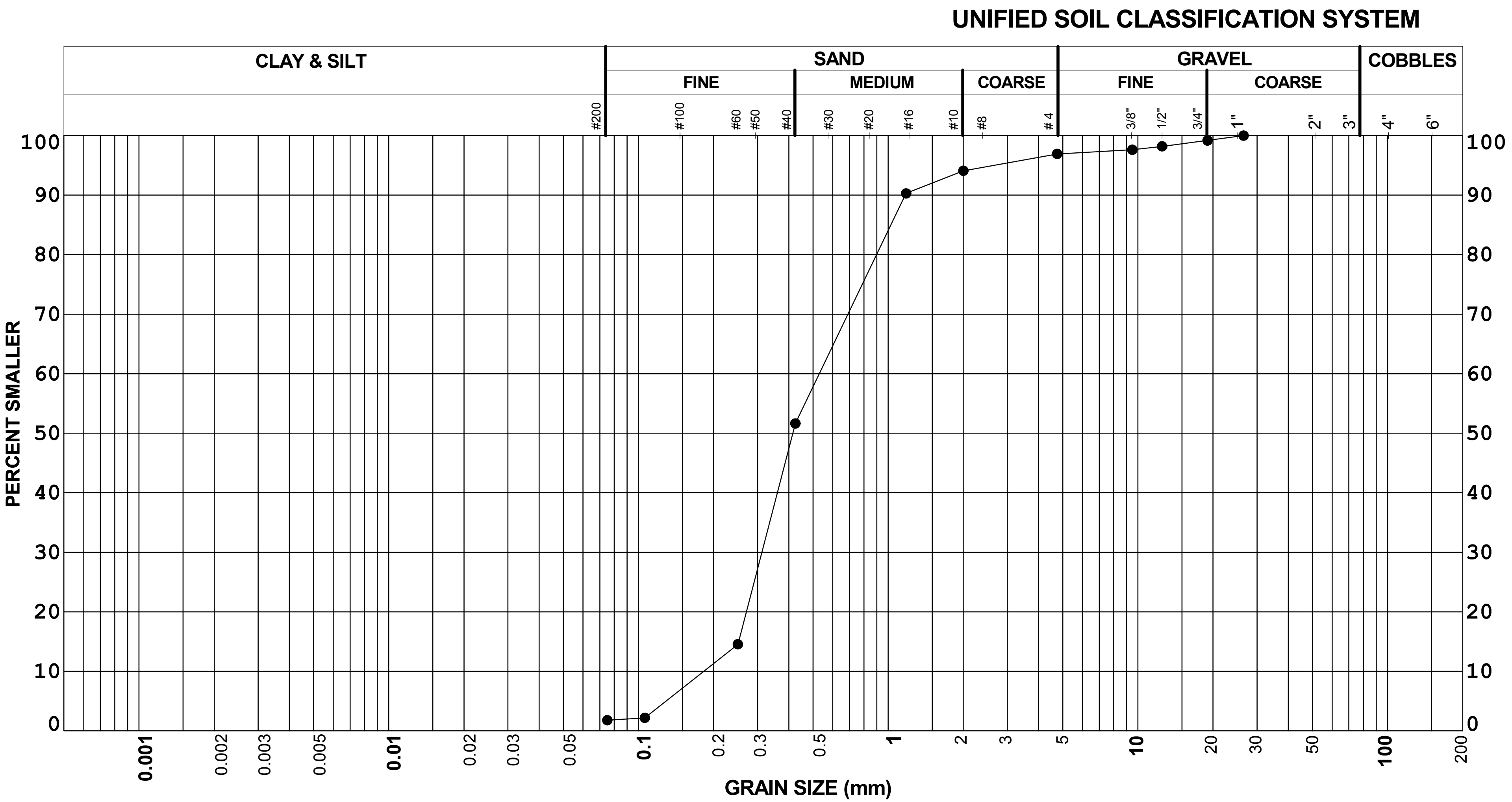
BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	DS2	2.10	0	99	1		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	DS8	11.60	3	95	2		

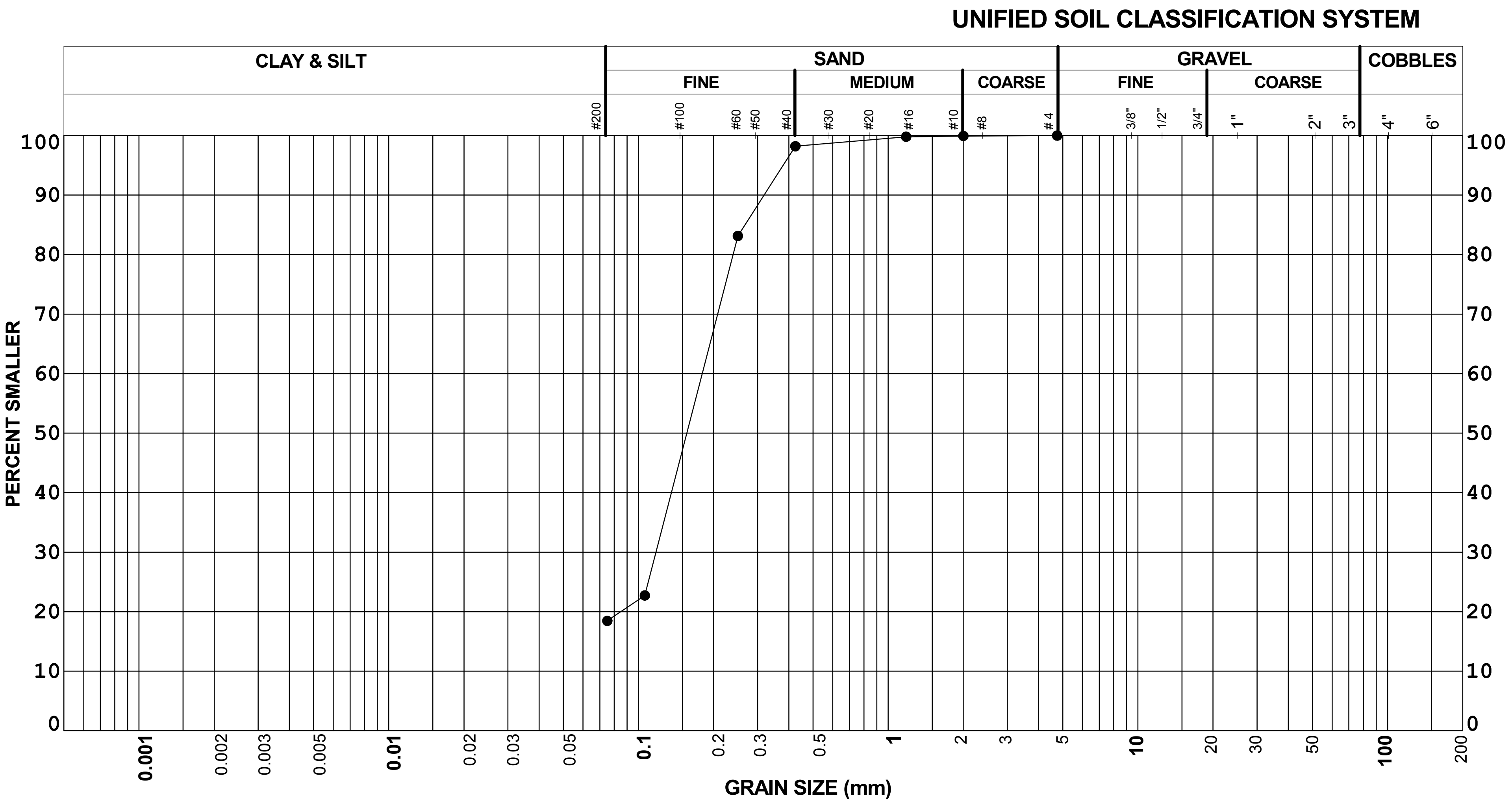
REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project



BOREHOLE	SAMPLE	DEPTH	GRAVEL (%)	SAND (%)	FINES (%)	LL (%)	PI (%)
● BH17-D006	DS11	15.80	0	82	18		

REMARKS:

GRAIN SIZE DISTRIBUTION

Baffinland Iron Mines

HATCH

Project

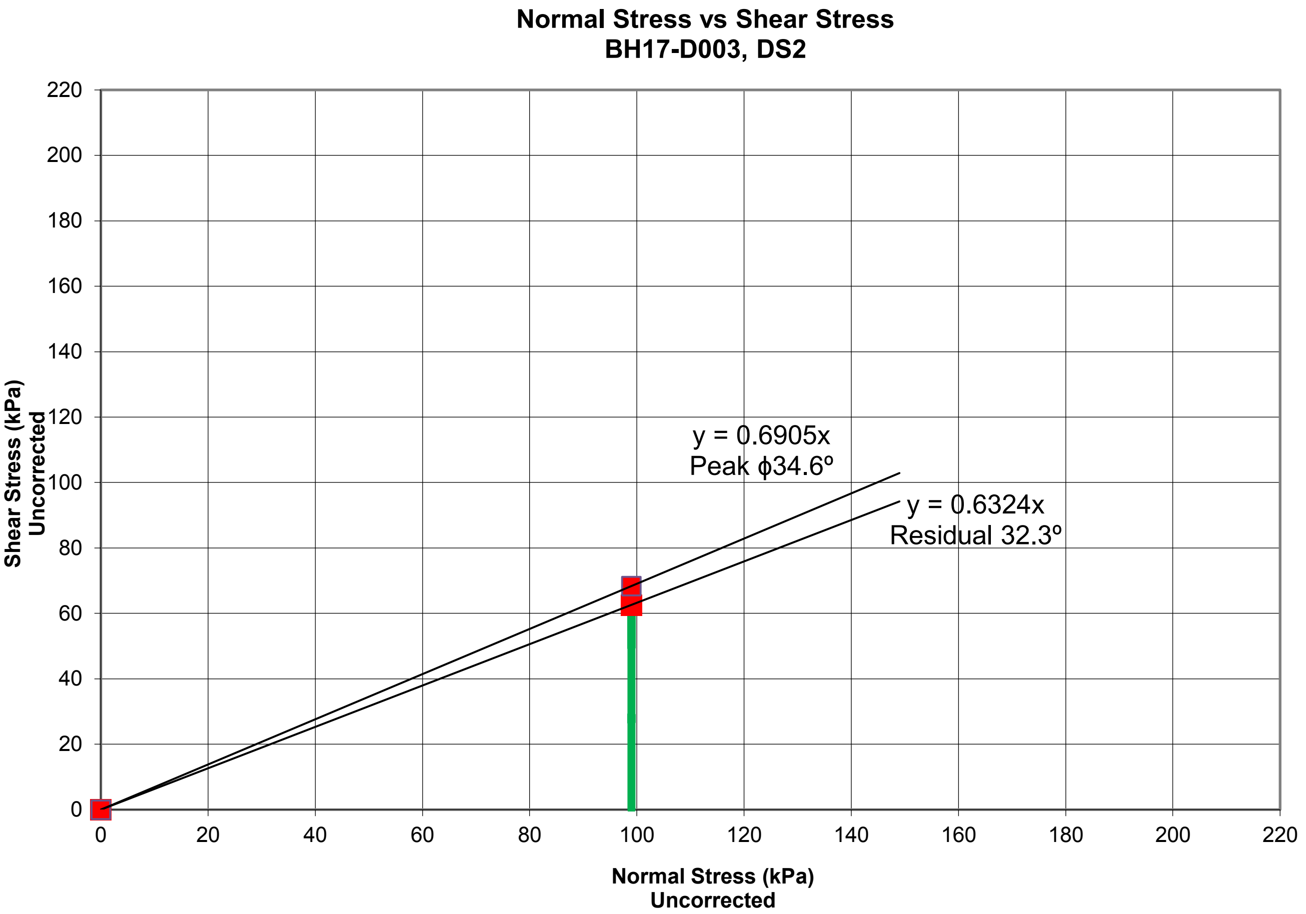
Direct Shear Test of Soils Under Consolidated Drained Conditions

ASTM D 3080/3080M- 11

HATCH
Geotechnical Laboratory

Date:	May 19, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study** **Stage 2**	**Attention: Matt Weaver**

Sample	**DS2 from 5.2 m to 5.5 m**
Source	**Milne Port Borehole BH17-D003**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

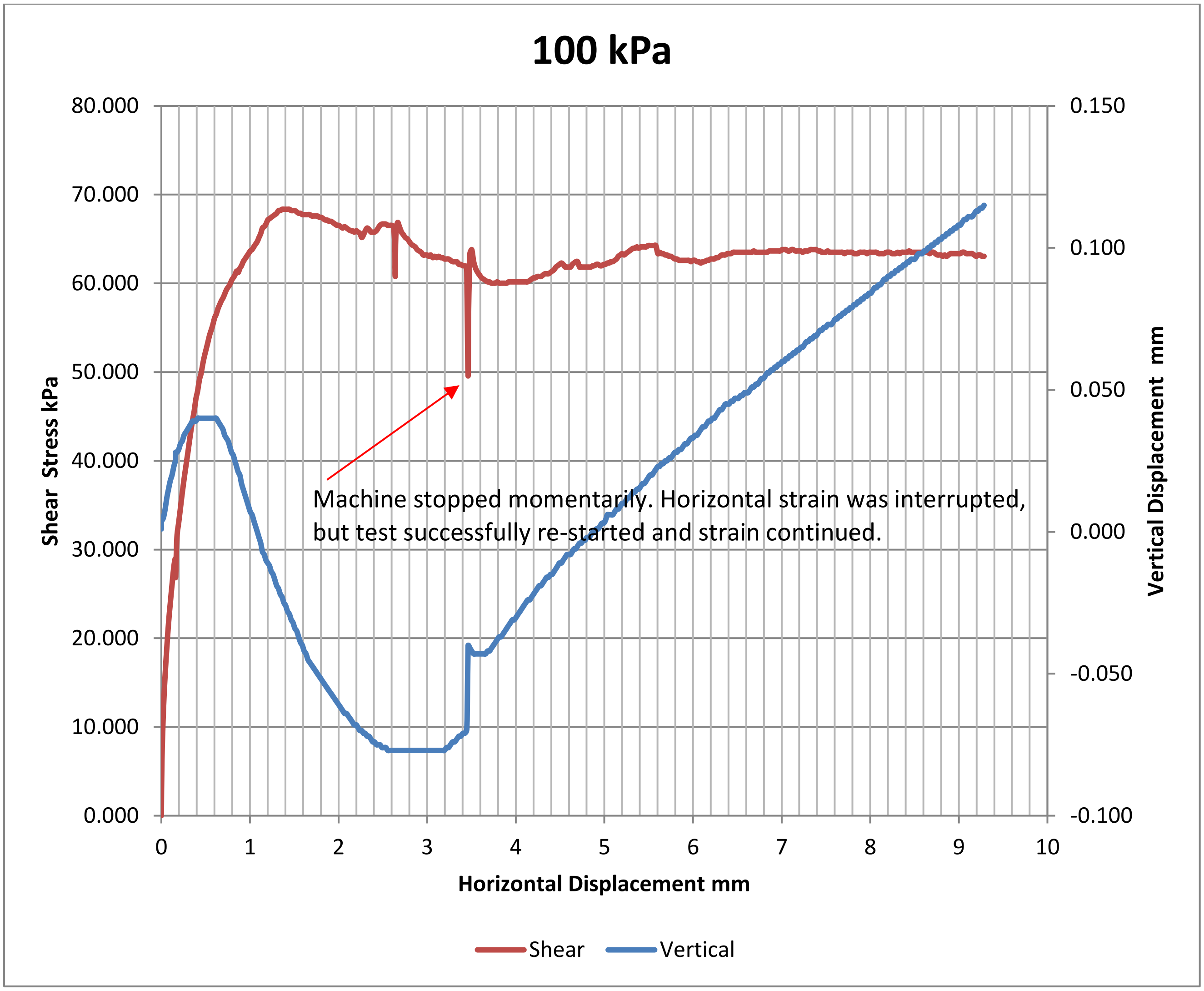
Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.988	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	107.067	********
Tare+Wet Samp. (gm)	2478.700	********	********
Tare (gm)	2247.300	********	********
Wet Weight (gm)	231.400	232.762	********
Water Content (%)	12.176	********	12.577
Tare	46.980	********	47.780
Tare+ Wet Soil	164.630	********	274.690
Tare+ Dry Soil	151.860	********	249.340
Dry Weight (gm)	206.283	********	********
Dry Density (kg/m3)	1951.500	********	********
Wet Density (kg/m3)	2189.112	2173.989	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	76.302	********	********
Void Ratio	1.385	********	********
Deg.of Saturation (%)	85.422	********	********
Height of Solids (cm)	2.13	********	********



Machine stopped momentarily. Horizontal strain was interrupted, but test successfully re-started and strain continued.

TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0043 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

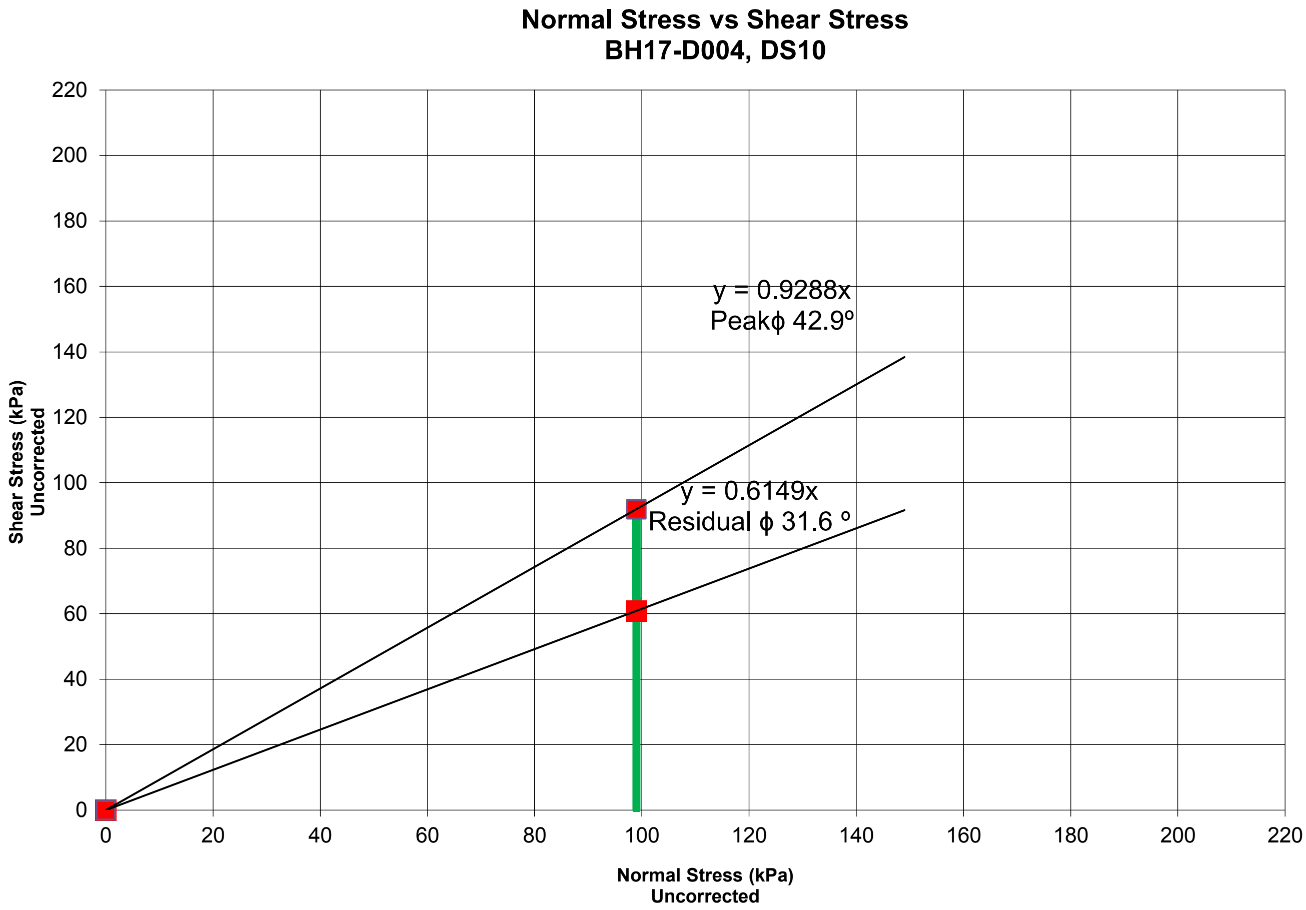
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH
Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	May 19, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS10 from 18.0 m to 18.3 m**
Source	**Milne Port Borehole BH17-D004**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

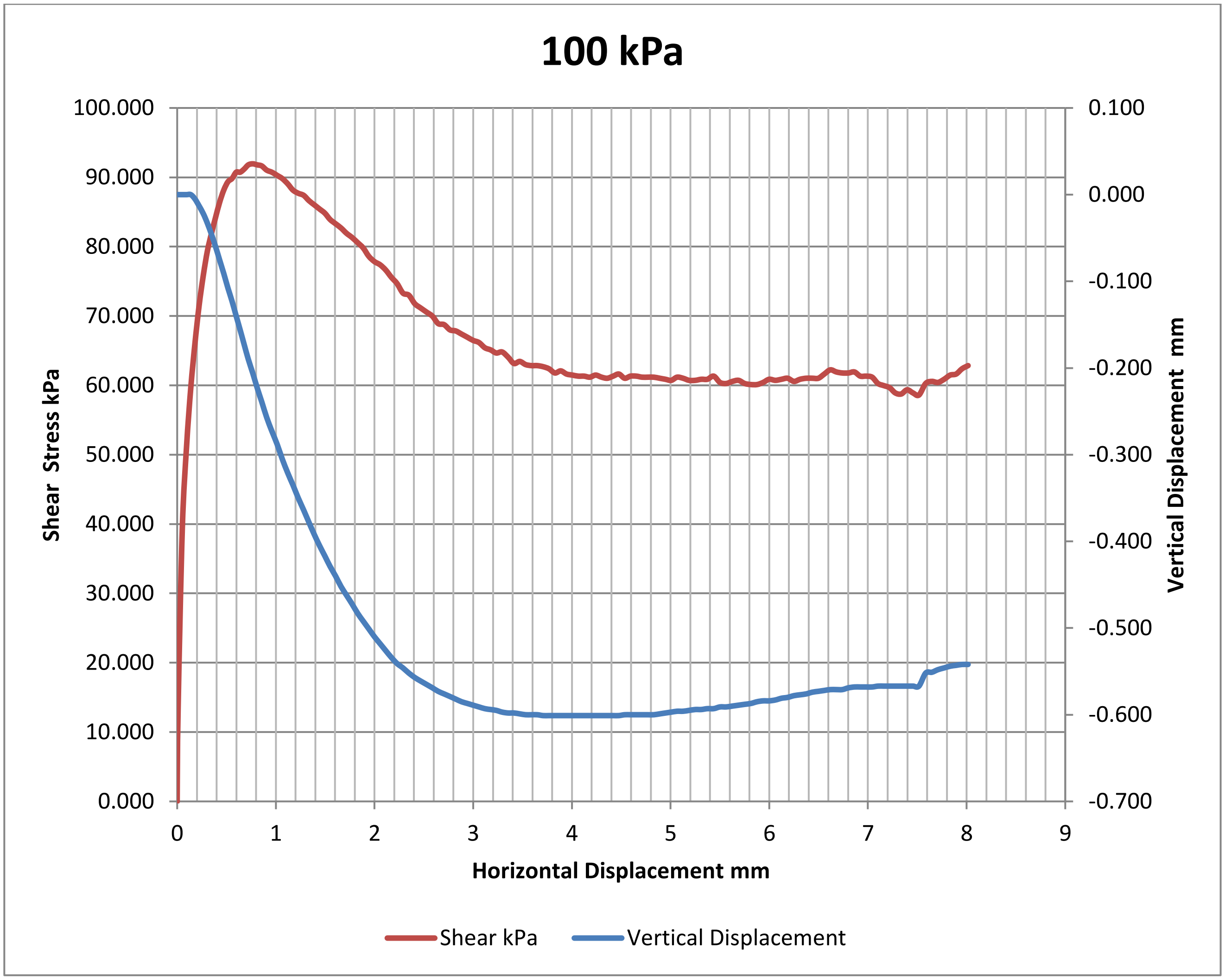
Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.988	2.988	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	107.067	107.067	********
Tare+Wet Samp. (gm)	2467.600	********	********
Tare (gm)	2243.100	********	********
Wet Weight (gm)	224.500	224.500	********
Water Content (%)	15.532	********	15.278
Tare	47.650	********	47.650
Tare+ Wet Soil	99.420	********	248.050
Tare+ Dry Soil	92.460	********	221.490
Dry Weight (gm)	194.318	********	********
Dry Density (kg/m3)	1814.927	********	********
Wet Density (kg/m3)	2096.826	2096.826	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	71.876	********	********
Void Ratio	1.490	********	********
Deg.of Saturation (%)	85.767	********	********
Height of Solids (cm)	2.01	********	********



TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0114 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

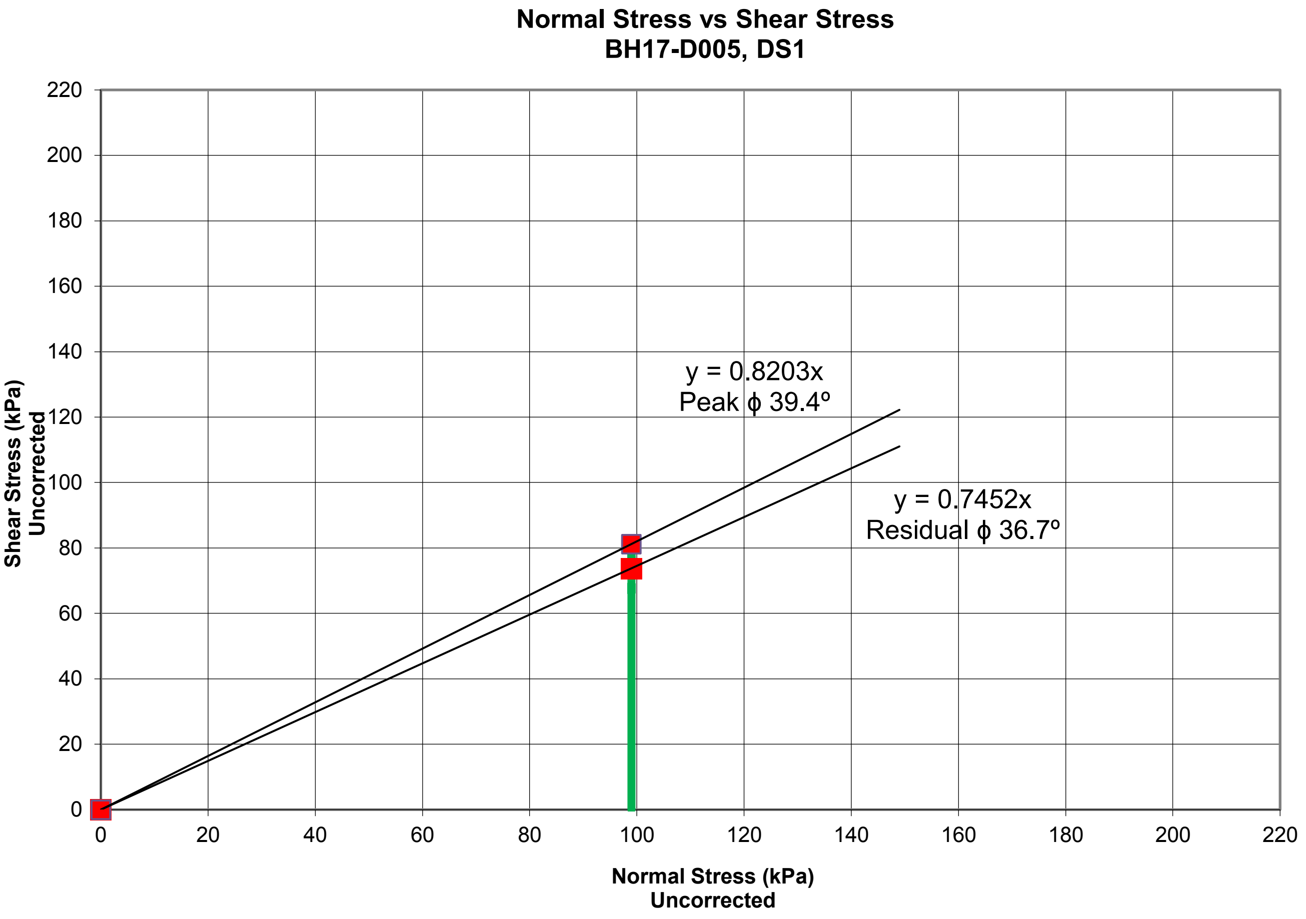
Direct Shear Test of Soils Under Consolidated Drained Conditions

HATCH
Geotechnical Laboratory

ASTM D 3080/3080M- 11

Date:	May 29, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS1 from 0.0 m to 0.3 m**
Source	**Milne Port Borehole BH17-D005**



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

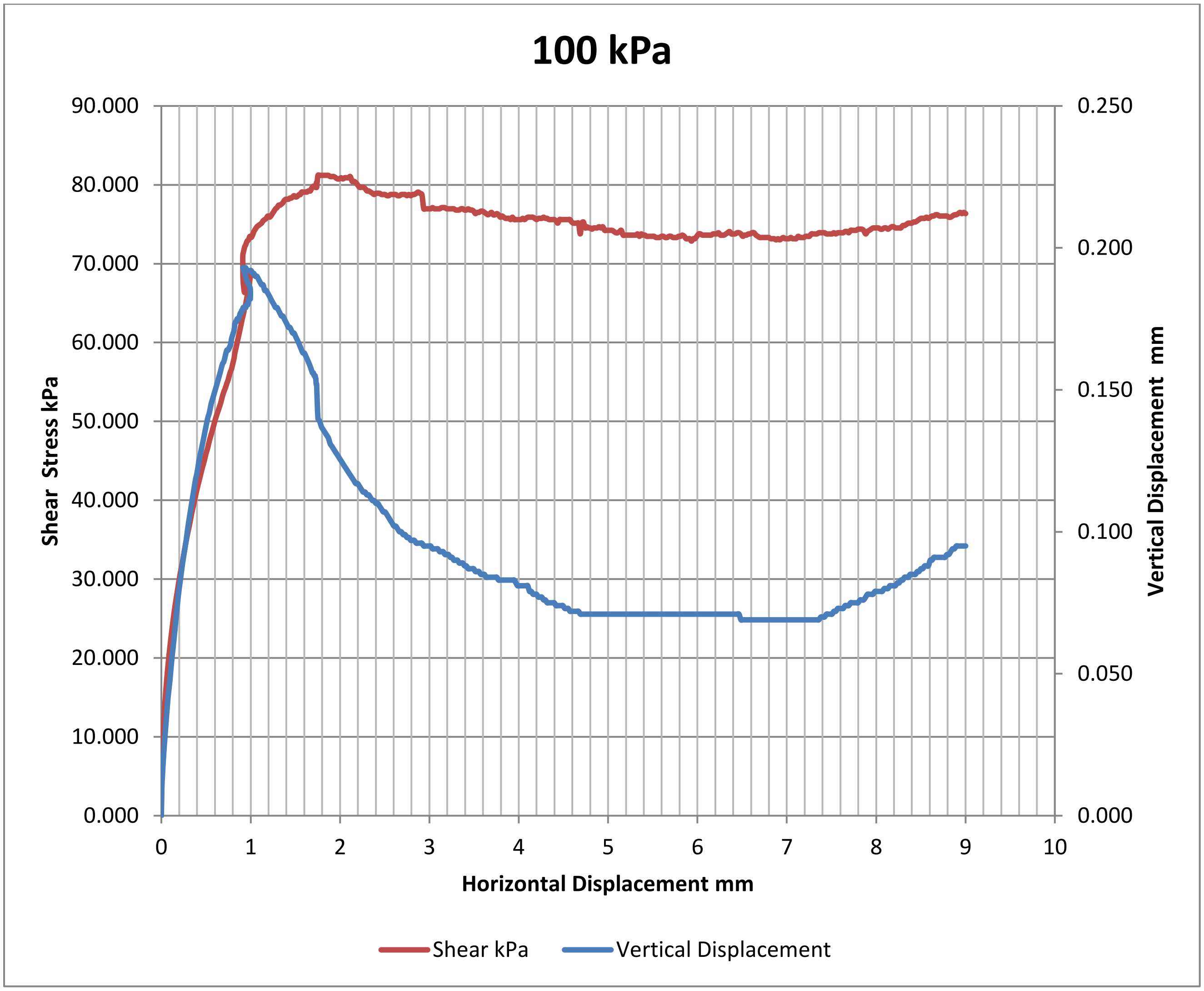
Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.796	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	100.183	********
Tare+Wet Samp. (gm)	2479.200	********	********
Tare (gm)	2246.000	********	********
Wet Weight (gm)	233.200	227.678	********
Water Content (%)	13.106	********	15.508
Tare	48.180	********	48.640
Tare+ Wet Soil	166.840	********	273.880
Tare+ Dry Soil	153.090	********	243.640
Dry Weight (gm)	206.177	********	********
Dry Density (kg/m3)	1950.499	********	********
Wet Density (kg/m3)	2206.140	2272.618	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	76.263	********	********
Void Ratio	1.386	********	********
Deg.of Saturation (%)	91.782	********	********
Height of Solids (cm)	2.13	********	********



TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0043 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

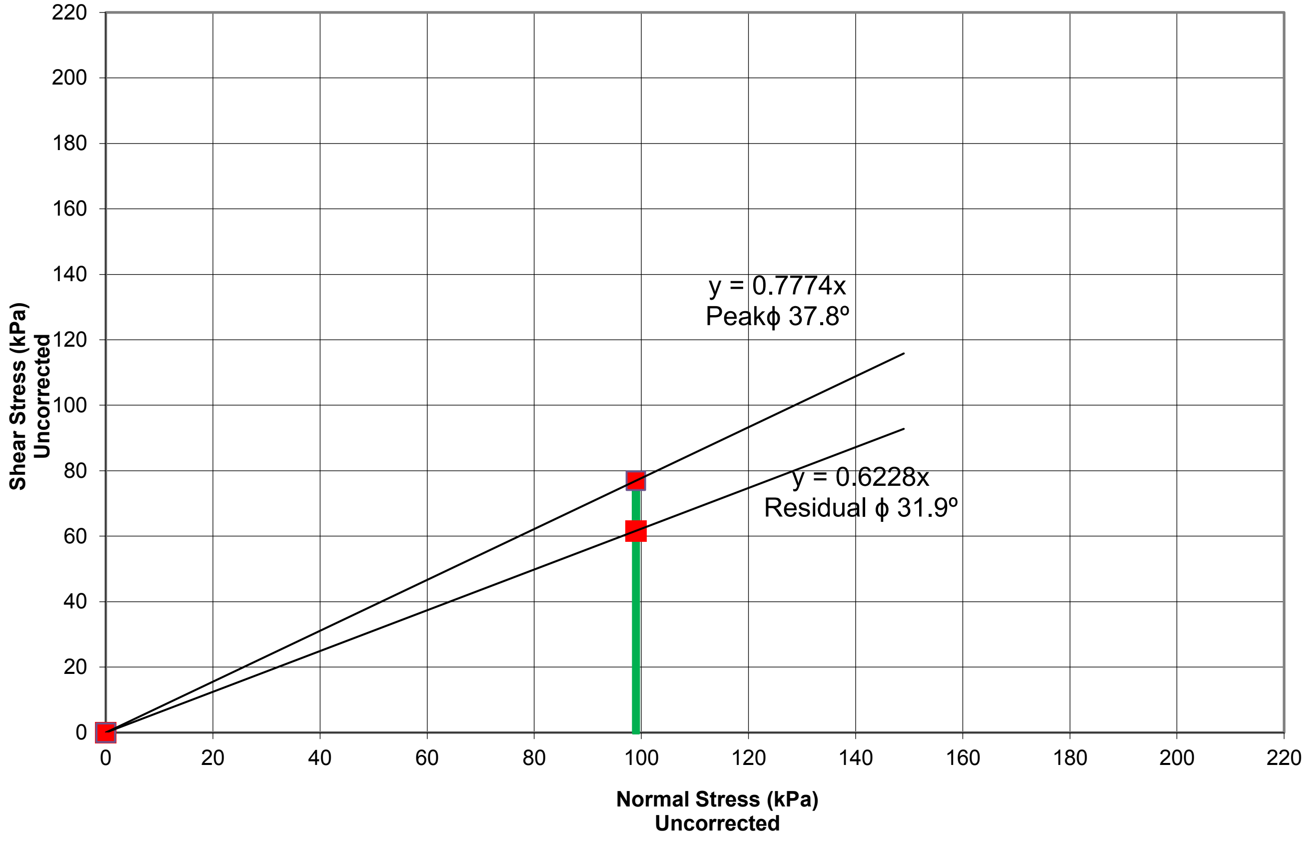
Direct Shear Test of Soils Under Consolidated Drained Conditions

ASTM D 3080/3080M- 11

Date:	June 1, 2017	Baffinland Iron Mines
Project Number:	H/352034	2275 Upper Middle Rd, Oakville Ont.
Project:	**Mary River Expansion Study Stage 2**	**Attention: Matt Weaver**

Sample	**DS5 from 12.8 m to 13.1 m**
Source	**Milne Port Borehole BH17-D005**

Normal Stress vs Shear Stress
BH17-D005, DS5



Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017

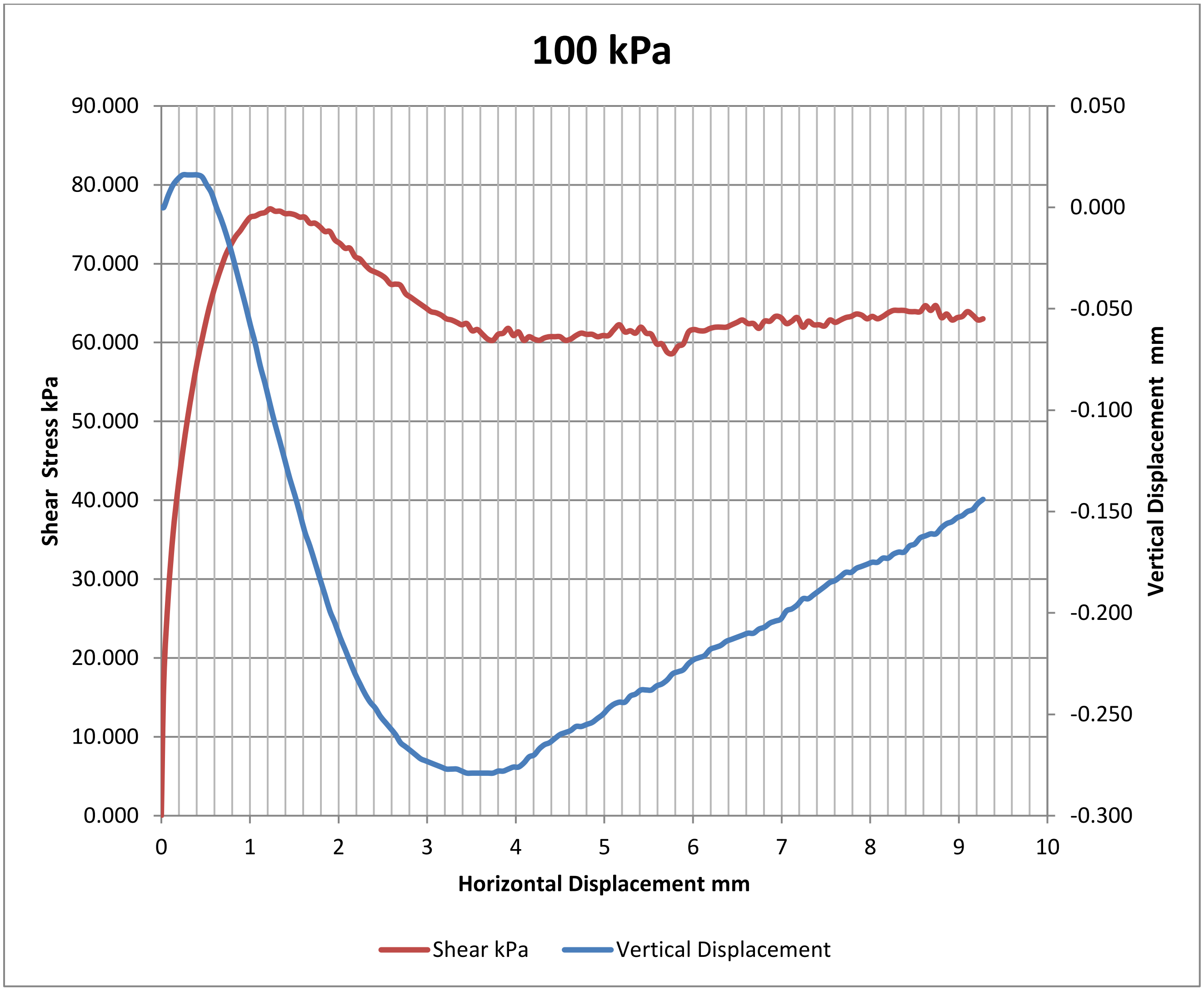
Name, Title, Date

Reviewed by: C. Hannon, May 2017

Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

100 kPa Test	Before Test	After Consolidation	After Test
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.887	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	103.448	********
Tare+Wet Samp. (gm)	2443.500	********	********
Tare (gm)	2247.200	********	********
Wet Weight (gm)	196.300	194.043	********
Water Content (%)	7.175	********	17.599
Tare	47.680	********	46.970
Tare+ Wet Soil	146.570	********	238.080
Tare+ Dry Soil	139.950	********	209.480
Dry Weight (gm)	183.159	********	********
Dry Density (kg/m3)	1732.738	********	********
Wet Density (kg/m3)	1857.055	1875.758	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	67.749	********	********
Void Ratio	1.560	********	********
Deg.of Saturation (%)	34.621	********	********
Height of Solids (cm)	1.89	********	********



TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0117 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

Direct Shear Test of Soils Under Consolidated Drained Conditions

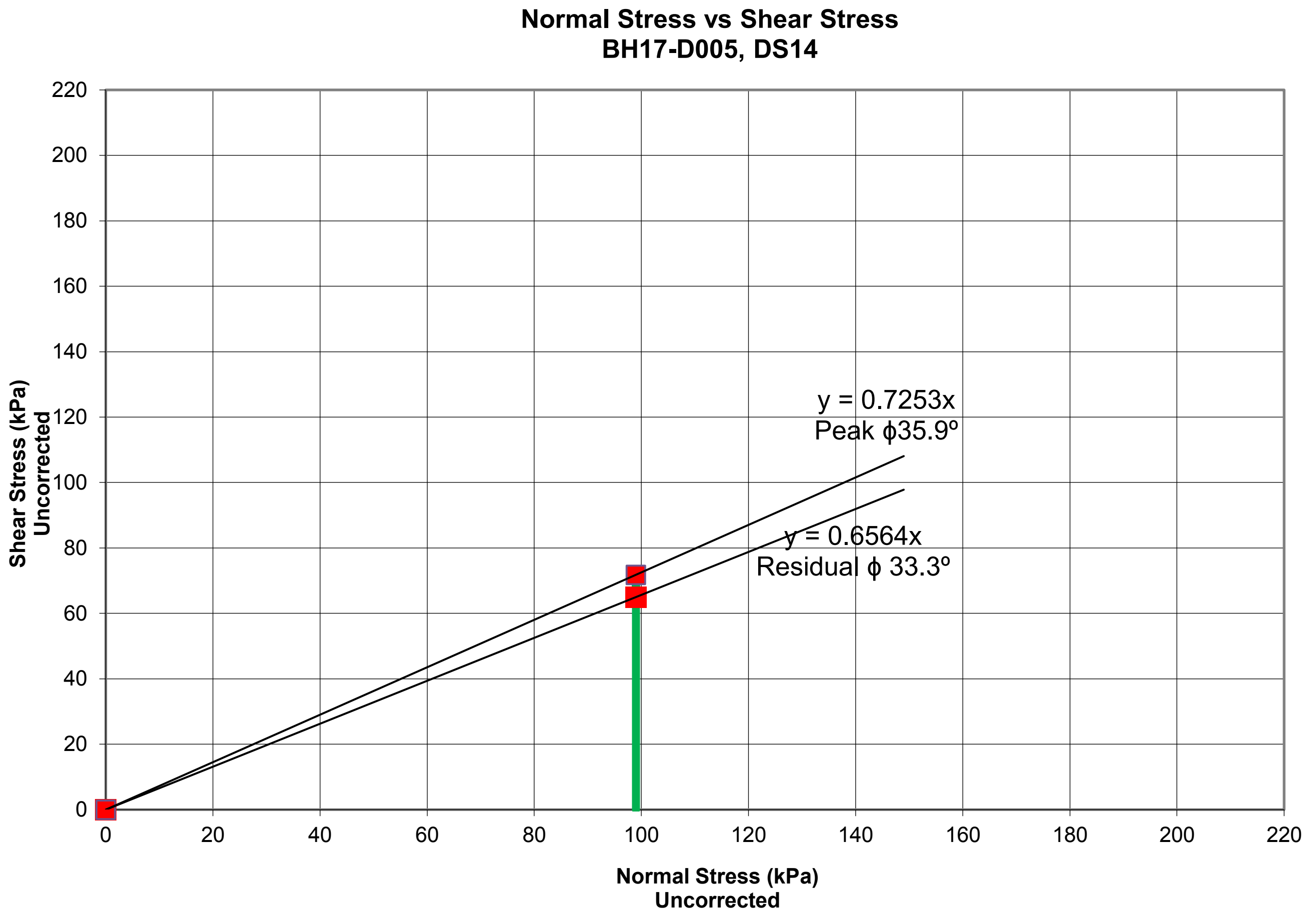
ASTM D 3080/3080M- 11

HATCH
Geotechnical Laboratory

Date: May 31, 2017
Project Number: H/352034
Project: **Mary River Expansion Study Stage 2**

Baffinland Iron Mines
2275 Upper Middle Rd, Oakville Ont.
Attention: Matt Weaver

Sample	**DS14 from 30.5 m to 31.1 m**
Source	**Milne Port Borehole BH17-D005**



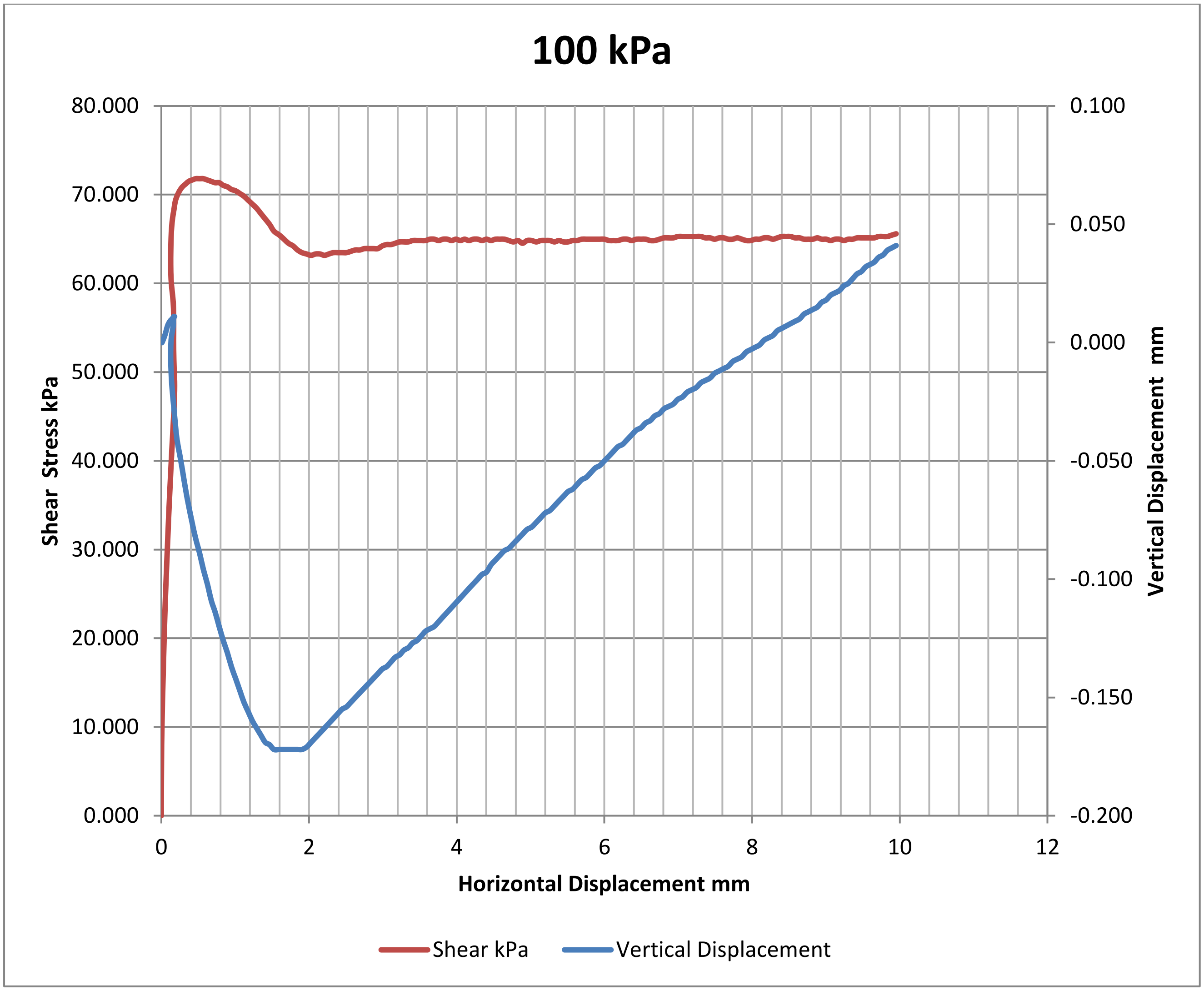
Comments:

Reported by: R.Serluca, Lab Tech, May 23, 2017
Name, Title, Date

Reviewed by: C. Hannon, May 2017
Name, Title, Date

Notice: the test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

100 kPa Test	**Before Test**	**After Consolidation**	**After Test**
Length and Width (cm)	5.986	********	5.986
Height (cm)	2.950	2.913	********
Area (cm2)	35.832	35.832	35.832
Volume (cm3)	105.705	104.368	********
Tare+Wet Samp. (gm)	2463.000	********	********
Tare (gm)	2246.700	********	********
Wet Weight (gm)	216.300	214.963	********
Water Content (%)	10.557	********	15.945
Tare	47.070	********	47.290
Tare+ Wet Soil	117.760	********	254.170
Tare+ Dry Soil	111.010	********	225.720
Dry Weight (gm)	195.646	********	********
Dry Density (kg/m3)	1850.869	********	********
Wet Density (kg/m3)	2046.261	2059.660	********
Specific Gravity (cm3)	2.700		********
Vol.of Solids (cm3)	72.367	********	********
Void Ratio	1.461	********	********
Deg.of Saturation (%)	61.954	********	********
Height of Solids (cm)	2.02	********	********



TEST NOTES.

1. Test carried out as per ASTM D3080 remolded and compacted.
2. Test specimen was split from total sample, portion passing 4.75 mm sieve.
3. Test carried out on Shear Machine #1.
4. Shear Rate 0.0116 cm per minute.
5. Value for Specific Gravity is assumed.
6. Peak PHI values are based on highest shear stress to normal stress ratio achieved during the test.
7. Residual PHI was taken at 6 mm train for all 5 samples in test suite.
8. Test data not corrected for area change during shearing as per ASTM.

Appendix E

Geotechnical Investigation Job Hazard Analysis

1. Introduction

A geotechnical field investigation is underway to gather subsurface data for the 12 Mtpa mine expansion prefeasibility study, which includes an offshore (on ice) investigation for the proposed Ore Dock No. 2. This job hazard analysis (JHA) presents an assessment of the hazards and control measures to reduce the likelihood or consequence of the hazards in order to carry out the offshore investigation program. There are a total of 10 proposed boreholes for the dock area including 5 sonic boreholes and 5 Piezocone (CPTu) test holes.

Job Hazard Analysis Form

PROJECT/TASK: ZG003 Geotechnical Marine Drilling Milne Inlet		**Department: Projects Boart Longyear**				**JOB No.:ZG003**			
SUPERVISOR: Emile Beauchamp		**LOCATION: Future Ore Dock Milne Inlet**				**DATE: March 12 ,2017**			
JOB STEP Break the job into steps. Listing work which may be hazardous.	**HAZARDS** List the hazard or type of harm identified with each step.	**Inherent**			**CONTROL MEASURE** List the necessary control measures to be followed to eliminate/reduce the identified hazards.	**Residual**			**ACTION** Person who will ensure this happens
		Consequence	**Likelihood**	**Risk Ranking**		**Consequence**	**Likelihood**	**Risk Ranking**	
1. Pre-job JHA Review.	Missing critical items on the JHA that can lead to an incident	3	2	5	Conduct a pre-job JHA review with Safety and critical team members All workers will have the opportunity to identify changes needed Any changes will be added to this document	1	1	2	Marlon Coakley/Warren Hoyle
2. Workers to complete FLRA card in the field at location prior to starting work.	Additional hazards in the area that may not have been identified on the JHA and daily changes that may pose additional danger to the health and safety of workers, the environment and property	3	3	6	Look at immediate work area for hazards that may exist, not identified on the JHA. Have other workers in the group sign off on the FLHA	1	1	2	All workers
3. Load Weights – The number and types of vehicles and equipment and their maximum gross weights	Not knowing load calculations will run the risk of breaking through the ice.	5	3	8	All equipment and material shall have posted GVW or gross equipment weight or maximum pull back loads available for use with load-ice thickness tables and shall follow the Ice Safety Plan. Refer to Attachment B for minimum ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety	4	2	6	Warren Hoyle

4. General Site	Ice Conditions – Slip falls Ice Conditions – Adequate load bearing capacity Inadequate lighting Interaction with a Polar Bear Cold Whiteout conditions Emergency Procedures	3	2	5	Construct a working platform for outside of drill shack to store drill steel and allow the use of salt Use of traction aids on work boots will be required for work on ice surfaces. Apply salt to drill shack decks Engineered Assessment of minimum ice thickness as referenced in Attachment B for ice thickness required for the drilling operations and Attachment C for further guidelines regarding Ice Safety Place delineators in the snow marking access from the drilling location to the shoreline Existing Baffinland procedure “Safely Working On Fresh And Salt Water Ice” shall be followed Polar Bear Monitor will be available at all times Employees will have appropriate PPE including clothing available for safely working in -40 C and windy conditions Worksite location is approximately 300 meters from the shoreline. No work will be conducted in whiteout conditions and a safety shelter will be available immediately adjacent to the work area Site emergency procedures will be provided and reviewed at site	2	1	3	All Crew

5. Working around water and sea ice	Water may appear to be completely frozen over, but not enough to support persons	5	1	6	Ice thickness to be assessed before walking on ice as per BIM Policy. Initial ice profiling will be conducted with an ice auger	2	1	3	Marlon Coakley/Warren Hoyle
	Falling in water	5	1	6	Floatation suit will be used for the initial ice profiling using an ice auger. Survival Bag (sleeping bag) will be available to reduce the risk of hyperthermia				
	Equipment breaking through ice	4	2	6	Follow the BIM Working On Ice Procedure (BAF-PH1-320-PRO-005, Rev 0, March 1, 2016)				
	Workers unaware of potential dangerous conditions	3	1	4	All workers will be required to complete the Alberta Working Safely on Ice Procedure online training				
6. Drill testing for ice thickness	Water may appear to be completely frozen over, but not enough to support persons. Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	4	7	Traction aids will be used for any ice work Ice thickness to be assessed before walking on ice Floatation suits will be worn by workers while ice auguring, the worker is to be tethered to a primary rescue worker at a distance of 30m Snow must be removed at the hole location so ice can be examined for quality as described in the Ice field guide. Hand shovelling may be necessary If crevices/ cracks greater than 50% of the ice thickness are present, repairs must be made if there is risk of falling through ice into deep water	2	2	4	Warren Hoyle / Marlon Coakley

				🟦	Ice thickness for a person to walk on must be a minimum 13 cm. **STOP** all work if this condition is not met and return to shore. Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger The ice auger hole spacing will be 20 m along the centreline access and the grid established in the designated work area. Secondary test holes will be augured at 10 m spacing within 250 m of the shoreline, if required based on the variable ice thickness Complete daily inspections of ice surfaces and record on ice log inspection sheet				
7. Access from Land to Sea Ice Snow removal equipment, drill rig and access vehicles are to be used for borehole access	Long distances to walk Exposure to cold White Out conditions Risk of falling under sea ice along the shoreline	4	1	5	Proper warm winter wear to be used Sat phones and digital radio use. Rig mats to be used to bridge over the fractured ice transition area if the transition between sea ice and shoreline needs leveling Buddy system is important to verify presence of frost bite or other cold related concerns **Vehicle operators and passengers are not to wear seat belts when working on ice**	1	1	2	All workers

8.	Refueling of equipment	Fuel spills Regulatory or social impacts Spills into water bodies	3	2	5	Use of duck ponds with any refueling Have sufficient spill cleanup supplies on hand to respond to potential spills Maximize space between refueling vehicle	3	1	4	All workers
9.	Extreme weather exposure when working outdoors or driving to and from the Borehole Location	Stranded work crew in white out conditions Cold emergencies or cold injuries Mechanical equipment failure	4	2	6	BIM has a procedure that is designed for white out conditions – it would be announced on the radio An emergency shelter to be used when in the Marine Drilling areas Emergency Shelter: Heated wooden shack (7' 8" by 7' 8") set on platform with skis Crews to radio from Hatch leads Buddy system to watch out for fellow workers who may not realize they are developing frost bite Workers to dress in arctic gear and layered clothing Proper PPE required Equipment check list Review Tidal charts on a daily basis Workers to take warm up breaks to stay warm and alert At toolbox review weather forecast with crew and prepare accordingly	2	1	3	All workers

10. Chemical handling- No unusual chemicals other than equipment needs are anticipated to be used.	Spills, leaks Chemical splash Chemical exposure	2	2	4	All products to be stored in secondary containment MSDS to supplied to BIM for review MSDS books to be accessible at the work front MSDS training and WHMIS training completed before arriving to site PPE will be followed as per MSDS recommendations as will first aid and environmental responses Spills response training and supplies to be kept with the equipment	1	1	2	Boart Longyear
11. Waste management and Wildlife Encounters	Risk of wildlife encounters due to improper waste controls Regulatory non compliance	3	2	5	Crews will collect waste daily and transport it back to camp Crews will follow BIM waste management guidelines No placing or storing of food in the back of pickup trucks Secure all small tools and PPE as foxes may carry away small articles from the site	2	2	4	All workers
12. Ecological and Cultural sensitive areas	Risk of causing damage to archeological areas Destroying vegetation Sensitive wildlife and marine life areas Regulatory and reputation damage	3	3	6	Crews have been instructed that there will be **NO** entry to the area east of the sealift ramp Crews are not to build or alter any inukshuk's or other rock formations on the tundra Permits will be required for the work	2	2	4	All personnel

13. Assemble Drill on skid platform skid and construct four walls and roofs	General hazards associated with drill assembly Inadequate communication between Boart Longyear and Site Services / mobile equipment operators	2	2	4	FLRA to be complete by Boart Longyear supervisor prior to executing work Boart Longyear Drilling operations SOPs to be followed including Boart Longyear Procedure 4001	1	1	2	Warren Hoyle / Marlon Coakley
14. Auguring holes in ice for sonic drilling and CPT work	Large ice cracks or crevices Falling in water Strains/Sprains Slipping on ice Drilling ice with power auger Changes in ice conditions	3	3	6	Wear traction aids for any ice work PFDs to be worn by workers while ice auguring during the sonic drilling and CPT operations Snow must be removed at the hole location so ice can be examined for quality. Hand shovelling may be necessary Be aware when using power ice auger that auger bit could bind or jam, have secure footing and grip on auger Complete daily inspections of ice surfaces and record on ice log inspection sheet All holes must be marked using an orange spray paint Any hole in ice over 30 cm in diameter must have a physical barrier around the hole	3	2	5	
15. Working around rotating equipment	Entanglement injuries	3	2	5	All equipment guards to be in place and in good working condition No loose clothing or drawstrings that can get pulled into rotating equipment Long hair must be contained to prevent entanglement into rotating equipment	2	1	3	All workers

					If any maintenance is required then energy isolation procedures to be followed				
16. Isolation of energy sources	Potential energy release that causes injury	3	2	5	All crews will follow the BIM Zero Energy State (ZES) procedure Crews to be given the BIM ZES training on site and fully understand the BIM requirements	1	1	2	Boart Longyear Crews BIM H&S
17. Working on equipment	Slip and trip hazards around railings, stairs and uneven ground.	2	2	4	Rails are installed around deck and to be properly maintained in good condition Stairs to be used on equipment A head cage will be used to reduce chance of contact with the rotating head Estops to be in good working order and easily accessible FLRA to be completed daily to review hazards All crews will follow the BIM Zero Energy State (ZES) procedure	1	1	2	Boart Longyear crew
18. Ice monitoring during drilling activities	Excessive deflection in ice	4	3	7	Hatch geotechs crew will monitor ice conditions during drilling including cracks around the work area, monitor freeboard in drilled holes for signs of ice deflection	2	2	4	All crew

19. Spotter activities	Equipment could come in contact with Spotter	4	2	6	Spotter to maintain eye contact with driver Spotter to review FLRA Agreed hand signals to be used with drivers in conjunction with BIM spotter procedure Agreed hand signals will be documented on the FLRA Drivers to immediately stop if the Spotter is out of eye contact	1	1	2	Boart Longyear crew
20. Manual lifting	Pinch point, back injuries, muscle and joint sprains and strains	2	3	5	Work in pairs, FLRA reviews Work with a buddy on heavy or awkward lifts Use proper lifting techniques 100 pound pipes to be handled by two workers	1	1	2	All crew
21. Working with pressure systems	Pressurized water and hydraulic fluids are used on drill and support equipment	3	2	5	Pre operational inspection Follow all safe work procedures. ZES when maintenance is required.	1	1	2	Boart Longyear crew
22. Falling objects	Potential exists for falling of drill rod and casing falling from overhead	3	2	5	Rigging and slinging training required when working with suspended loads and overhead hazards Perform FLRA	1	1	2	Boart Longyear Hatch Geotec EHS techs
23. High noise and vibration areas on the rigs	Hearing damage	2	2	4	Hearing protection is required by use of ear plugs or muffs.	2	1	3	Boart Longyear Hatch Geotec EHS techs

24. Housekeeping	Potential exists for poor housekeeping causing slip/trips and other hazards	3	2	5	Daily site assessments and toolbox meetings by drillers and site supervisors BIM EHS techs to perform daily inspections	2	2	4	All Crew
25. Fatigue	Potential exists for crew fatigue	2	2	4	Fit for duty confirmation required for all employees, daily FLRA reviews Micro breaks to stretch Proper rest during off shift period	1	1	2	All Crew
26. Working at night or 24 hour darkness	Higher risk of injury due to poor visibility	3	3	6	Hi-vis work gear to be used Use of flashlight and headlamp Workers to stay within 10 meters (30 feet) of the worksites at any time Use of wobble lights and light tower Emergency shelter	1	1	2	All Crew
27. Hot work - welding	Fire risk Burn injuries Welders Flash	2	2	4	Hot work training Use of hot work permits and JHA for any Hot Work Fire Watch required Proper PPE Welding training required	1	1	2	Boart Longyear crew

28. Rescue Plan	Rough terrain Further injuries to casualty during transit. Snow storm, white out conditions. Darkness	3	3	6	The track unit will be used to pull the survival shack (survival shack is 7’ 8” x 7’ 8” square) on platform with skis. When an incident has occurred, the Geotechnical Engineer must call a Code 1. Provide first aid treatment to the injured person until MRT arrives on site MRT will be dispatched to the location. MRT will transport the casualty. Visibility (whiteout conditions) will hinder rescue time, rescuers will have to wait out the storm, or until the whiteout conditions have subsided.	2	2	4	Marlon Coakley/ Warren Hoyle
29. Cleanup and Demob	Unfrozen open holes Complacency	3	3	6	All drill holes must be filled in with water and snow upon completion of drilling operations A Hatch site representative will confirm safe conditions upon demob All debris must be removed from ice surface and disposed off site per waste management plan BIM safety and environment representatives to attend a post project closeout inspection to document the completion of the clean-up	2	2	4	Boart Longyear

Comments:

Score	*CONSEQUENCE*		
	People	Plant	Environment
5 – Very High/ Catastrophic	Multiple Fatalities.	Greater than $10 Million Loss	Catastrophe, destruction of sensitive environment, worldwide attention. Likely EPA prosecution. More than 30 days delay.
4 – High/ Major	Fatality or Permanent Disabilities.	$1 Million to $10 Million Loss	Disaster, high levels of media attention, high cost of clean-up. Offsite environmental harm; more than 10 days delay.
3 – Moderate	Major Injuries – Incapacitations or requiring time of work.	$100 Thousand to $1 Million Loss	Major spills, onsite release, substantial environmental nuisance, more than 1day delay. (Leads to additional resources call out i.e. SES).
2 – Low/ Minor	Significant Injuries – Medical Treatments, non-permanent injury.	$10 Thousand to $100 Thousand Loss	Significant spills. (Leads to a call out of Site Emergency Response Group).
1 – Very Low/ Insignificant	Minor Injuries – First Aid Treatments (cuts/bruises).	Less than $10 Thousand Loss	Low environmental impact. Minor Spills less than 80 Litres.

Score	*LIKELIHOOD*
5 – Almost Certain	The event is expected to occur in most circumstances. Likely to occur frequently - More than 1 per year.
4 – Likely/ Probable	The event will probably occur in most circumstances. Likely to occur several times – 1 per year.
3 – Moderate/ Occasional	The event should occur at some time. Likely to occur at some time – 1 per 5 years.
2 – Remote/ Unlikely	The event could occur at some time. Unlikely but possible. 1 per 10 years.
1 – Rare/ Very Unlikely	The event may occur only in exceptional circumstances. Assumed it may not be experienced. 1 per 100 years.

Job Hazard Analysis Attendees: Darryl Finlay, Marlon Coakley, Warren Hoyle, Usman Khan, Alex Boissonneault

	Name	Signature	Date
Written by:	Marlon Coakley	Marlon Co	Mar 20/2017
Reviewed by:	Warren Hoyle (Hatch)	Warren Hoyle	March 30, 2017
	Darryl Finlay (BIM Safety Coordinator)		March 20, 2017

Risk Rating = Consequence + Likelihood

Consequence	Risk Rating				
5	6	7	8	9	10
4	5	6	7	8	9
3	4	5	6	7	8
2	3	4	5	6	7

Risk Rating - Definitions

Risk Rating	Definitions	*Action Required*
8 - 10	Intolerable	Task not to start till the risk is eliminated or reduced. Bring to the immediate attention of management. Formal assessment required. MUST reduce the risk as a matter of priority.
7	High	Bring to the immediate attention of management. Task not to start till the risk is eliminated or reduced. Further Assessment required. MUST reduce the risk as a matter of priority.
6	Significant Risk	Bring to the attention of supervision. Review risks and ensure that they are reduced to as low as reasonably practicable. To be dealt with as soon as possible, preferably before the task commences. Introduce some form of hardware to control risk.
5	Moderate Risk	Needs to be controlled but not necessarily immediately, an action plan to control the risk should be drawn up. Review effectiveness of controls. Ensure responsibilities for

			🟨	🟨	🟦
1	**2**	**3**	**4**	**5** 🟨	**6** 🟨
	1	**2**	**3**	**4**	**5**
	Likelihood				

		control are specified.
2-4	Low Risk	If practical reduce the risk. Ensure personnel are competent to do the task. Manage by routing procedure. Monitor for change

A JHA considers a variety of activities/tasks involved in a job scope and analyses the key hazards (sources of harm) and their consequences (types of harm) eg. Sources of harm – lifting a heavy pipe - manual handling. Types of harm – Back strain.

Main Points – On how to write a JHA.

1. Define the task – what is to be done.
2. Review previous JHA if any – have we done it before?
3. Identify the steps – what is to be done.
4. Identify the hazards of each step.
5. Identify who or what could be harmed.
6. Give the task a risk rating – Consequence + Frequency
7. Develop solutions to eliminate or control hazards in each step.
8. Review the risk rating after the control system has been implemented.
9. If risk rating unacceptable review the solutions till risk rating acceptable.
10. Agree who will implement the control system.
11. Document the JHA and discuss with the relevant personnel.

Hierarchy of Hazard Management – Control Measures

These steps outline what should be planned for when deciding what control measures are to be put in place. Whenever possible the highest step should be used first and then progress down the list.

1. Eliminate the hazard.
2. Substitution.
3. Reducing the frequency of a hazardous task.
4. Enclosing the hazard.
5. Additional procedures.
6. Additional supervision.
7. Additional training.
8. Instructions / information.
9. Some personal protective equipment.

Worker / Visitor review	Signature
Warren Hoyle	Warren Hoyle March 19 / 2017.
Marlon Coakley	March 19/2017
Usman Khan	
Alex Boissonneault	March 19, 2017
Emile Beauchamp	March 19/2017
Samuel Flynn	March 19/2017
Ruben Gross	MARCH 19/2017
Justin Gross	Justin Gross March 19/2017
Chris Entz	Chris Entz March 19/2017
Doug Roach	
Robbie Jordan	

Enclosed:

Attachment A – BIM Working on Ice Procedure
Attachment B – On Ice Platform for Geotechnical Drilling
Attachment C – Best Practice for Building and Working Safely on Ice Covers in Alberta
Attachment D – Ice Thickness Assessment
Attachment E – Ice Assessment Drawing

Attachment A – BIM Working on Ice Procedure

Baffinland Iron Mines Corporation

Working on Ice Procedure

BAF-PH1-320-PRO-0055

Rev 0

Prepared By: Shawn Parry
Department: Road Maintenance
Title: Manager
Date: February 9, 2017
Signature:

Approved By: Sylvain Proulx
Title: Chief Operating Officer
Date: February 9, 2017
Signature:

DOCUMENT REVISION RECORD

Issue Date MM/DD/YY	Revision	Prepared By	Approved By	Issue Purpose
01/19/17	1	S.P.	R.G.	use

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1 PURPOSE AND SCOPE

Baffinland Iron Mines Corporation is committed to taking the necessary steps to ensure that work performed on ice of lakes, rivers, streams or the ocean is conducted in a safe, efficient and environmentally compliant manner.

This procedure is not intended to provide instructions for large scale ice operations such as ice road construction and operation. For large scale ice operations, refer to "Best Practice for Building and Working Safely on Ice Covers in Alberta (Work Safe Alberta)".

2 DEFINITIONS

2.1 BAFFINLAND CLASSIFICATIONS FOR WORKING ON ICE

Class A Job – The ice is between 15 centimetres and 38 centimetres thick and the load weight, including people on the ice will be 4,536 kilograms or less.

Class B Job – The ice is more than 38 centimetres thick and the load weight, including people, is greater than 4,536 kilograms but less than 63,000 kilograms.

Class C Job – The job requirements cannot be met by either Class A or B guidelines.

See section 4, Protocols for a discussion of Class A, B and C requirements.

3 RESPONSIBILITIES

The following roles have specific accountabilities that must be met to ensure that any work on ice is conducted in a safe and environmentally responsible manner.

3.1 CHIEF OPERATING OFFICER OR GENERAL MANAGER, OPERATIONS

The Chief Operating Officer or General Manager, Operations must review and approve any Class C job for working on ice.

3.2 DEPARTMENT MANAGER/SUPERINTENDENT

The Department Manager and Superintendent are responsible to ensure their department supervisors are aware of and comply with this procedure. The manager and superintendent are also responsible to validate the terms and conditions of the JHA are implemented.

3.3 DEPARTMENT SUPERVISOR

The Supervisor is responsible for supervising the work/tasks in accordance with this procedure and the terms and conditions of the JHA. Specifically, the supervisor is responsible for:

- Notify the department manager and superintendent of the requirement to work on ice and send each a copy of the completed JHA.
- Ensure a geographically specific JHA is completed and implemented, prior to starting work.
- Notify the MRT Trainer and have them participate in the JHA.
- Ensuring that workers have reviewed and understand the JHA, prior to starting work.
- Supervise the work and act as the main point of contact for workers working on ice.

3.4 WORKER

The worker, is responsible for the following:

- Review, sign and comply with the terms and conditions of the JHA.
- Promptly reporting to their supervisor, any safety concerns or incidents that occur while working on ice.

3.5 SAFETY SUPERINTENDENT OR COORDINATOR

The Safety Superintendent or Coordinator will facilitate the working on ice JHA process.

3.6 MINE RESCUE TEAM TRAINER OR DELEGATE

The Mine Rescue Team Trainer or delegate is responsible to work with the supervisor to develop the rescue plan component of the JHA.

4 PROTOCOL

4.1 CLASS A JOB

The following table provides requirements for performing work on ice under Class A conditions. The JHA must meet the following conditions;

Equipment Example	Weight (kilograms)	Minimum Ice Thickness (centimetres)	Ice Integrity
1 or 2 people and their tools and equipment	Up to 272	15	Solid ice that is free of cracks, water and slush
Snowmobile and rider	Up to 363	20	Solid ice that is free of cracks, water and slush
2 snowmobiles and riders	Up to 726	25	Solid ice that is free of cracks, water and slush
Pickup truck or other mobile equipment, cargo and driver/passengers	Up to 4536	38	Solid ice that is free of cracks, water and slush

4.2 CLASS B JOB

The ice is greater than 38 centimetres thick and the load weight, including people, is greater than 4536 kilograms but less than 63, 000 kilograms.

Ice Thickness Calculation	Weight and Ice Thickness	Ice Integrity
The Golds formula found in Section 5 must be applied to calculate the safe ice thickness. The calculation, including safe ice thickness must be documented in or attached to the working on ice JHA.	The combined weight of the load, including equipment and people is greater than 4536 kilograms but less than 63, 000 kilograms and the ice is 38 centimetres thick or greater	Solid ice that is free of cracks, water and slush

4.3 CLASS C JOB

The job requirements cannot be met by either Class A or B guidelines. The assistance of a professional engineer recognized as an authority on ice covers, must be consulted and their guidance documented in or attached to, the JHA.

5 GOLDS ICE WEIGHT BEARING CAPACITY FORMULA

GOLD'S FORMULA
All guidelines currently in use in Canada are based on a technical paper published by Dr. Lorne Gold in 1971 entitled "Use of Ice Covers for Transportation". Gold's Formula is;

$P = A \times h^2$
Where:

- P is the allowable load in kilograms
- A is a parameter that depends on the strength of the ice
- h is the effective thickness of good quality ice (cm)

Gold suggested a range of A-values for lake ice that corresponds to a range of safe ice thicknesses for a given load or a range of acceptable loads for a given ice thickness. Baffinland has adopted Golds "Tolerable Risk" value for ice quality, therefore the A value in Golds formula will be four (4) when calculating ice thickness for a Baffinland Class B job.

Gold's formula **A** value of 4 is most commonly used for normal operations with moving vehicles. When equipment will be working in the same spot (stationary) for more than 2 hours, the value for **A** in Golds formula, must be reduced to two (2).

Two examples using the Golds Formula for a Class B job:

What is the weight capacity of good quality ice that is 60 cm thick?
Capacity (in Kgs) = A x h^2
Capacity (in Kgs) = 4 x (60x60)
Capacity (in Kgs) = 4 x 3600
Capacity = 14400 Kgs

The weight bearing capacity of good quality ice that is 60 cm thick is up to 14400 kilograms.

What is the weight bearing capacity of good quality ice that is 60 cm thick and the load will be stationary for 2 hours or more?
Capacity (in Kgs) = A x h^2
Capacity (in Kgs) = 2 x (60x60)
Capacity (in Kgs) = 2 x 3600
Capacity = 7200 Kgs

7, 200 kgs is the weight bearing capacity of good quality ice that is 60 cm thick and the load will be stationary for 2 hours or more.

5.1 WORKING ON ICE FROZEN TO THE BOTTOM (RIVER, LAKE – ETC.)

When Ice thickness measurements determine the ice has frozen to the bottom in the area of travel and work, the ice may be considered as safe provided the ice quality is routinely monitored and remains solid and free of slush and water.

6 WORKING ON ICE JHA AND WORK PLANNING MEETING

Working on ice may be divided into two parts;

1. initial measurement of ice thickness
2. working on the ice

Both parts require a JHA.

A work planning meeting must be held prior to any work on ice. This meeting will be based on review of the completed JHA. All individuals participating in the work must present and review their work instructions, roles and responsibilities. The following points will be covered in the JHA and will be covered as part of the topics of discussion during the "planning meeting":

- A description of the work to be done – with sufficient detail for individuals to understand their role
- Potential hazards associated with the work
- Personal safety equipment
- Specific safety procedures for working on ice
- Rescue procedures and necessary equipment
- Individual job tasks
- Communications and hand signals to be used
- Load (i.e. equipment, personnel) weight and distribution on ice during work
- Ice assessment – thickness and condition

JHA safety and emergency response considerations;

- Measuring ice thickness should always be a two person operation.
- Initial ice measurement must be done with a PFD and the lead tester on a tether to the second person who is a safe distance behind.
- Self-recovery is not the primary means of rescue, it's the second person and the tether.
- The MRT will provide a backup rescue plan.

7 MEASURING AND RECORDING ICE THICKNESS

The task of ice thickness measurements may be the subject of a separate JHA or may be included in the working on ice JHA.

Ice thickness is the primary measurement required to determine the safe working load that can be put on the ice (allowable load bearing capacity). Manual measurements are made by cutting a hole in the ice cover with an auger, a saw or an ice chisel and then directly measuring the ice thickness. Measurements are made in a prescribed spacing or pattern to provide sufficient coverage and verify the thickness of the ice cover.

It must be mentioned that in all cases of manual ice thickness measurements it is the absolute minimum thickness measured in all holes that must be used. Not an average or any other measurement.

It is imperative that a systematic procedure be implemented to document all ice thickness measurements. Measurement locations should be taken either with a Global Positioning System (GPS) receiver or marked with stakes, or other reliable system so that these locations can be tracked in future measurements or identified for repairs. This information is a key element in the monitoring control plan.

These records are vital to reconcile any ice failures that may occur. These records must be maintained in a log that is specific to recording ice thickness. See Appendix #1 - Ice Thickness Measurement Log

Suitable equipment and personal protective equipment (PPE) must be prescribed for the work. Initial testing should be conducted by at least two trained crew members travelling separately over the ice. The work could be carried out by travelling:

- On foot, by snowmobile or by amphibious vehicle.
- While testing, the crew should also be checking the ice for cracks and noting the snow load.
- If vehicles are used, two separate vehicles must be used at all times and must be separated at safe distance unless ice conditions are known.

7.1 TEST HOLE SPACING

Rivers

If GPR is used, test holes are only required for calibration and for mapping of thin areas. Recommend 30 meters between test holes along alternate edges. Look for thin areas caused by river current.

Lakes

If GPR is used, test holes are only required for calibration. If within 250 metres of shore: 30 meters between test holes along centre line. If more than 250 metres from shore: 250 metres between test holes along centre line

Note – these recommendations indicate normal test hole spacing. Good judgement based on field experience must be used when varying from these recommendations. In thin ice areas the suggested spacing should be reduced to determine their extent and severity.

8 REFERENCES AND RECORDS

- Baffinland Job Hazard Analysis Procedure BAF-PH1-810-PRO-0016r1
- Baffinland Iron Mines Corporation– Emergency Response Plan (BAF-PH1-830-P16-0007)
- Best Practice for Building and Working Safely on Ice Covers in Alberta (Work Safe Alberta)
- NWT Transportations Guide to Ice Road Construction

Appendix #1
Ice Thickness Measurement Log

Date:	Location:
Completed by:	Signature:
Weather Conditions, including temperature:	

Test Hole #	Ice Thickness	Notes on test hole – clear solid ice cracking, water – etc.
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Names of other participants	Signature of other participants

Attachment B – On Ice Platform for Geotechnical Drilling

Safe Work Procedure

Baffinland Iron Mines Corporation: Mary River Project ERP
H349000

On-Ice Platforms for Geotechnical Drilling
HS-SWP-165

On-Ice Platforms for Geotechnical Drilling at Steensby Island

2013-04-09	0	Approved for Use	V. Tatone	D. Wolek	S. Perry	D. Matthews
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**

Table of Contents

List of Appendices

1. Purpose

1.1 This Procedure identifies minimum safe work practices for the set-up and maintenance of on-ice platforms to be used to support geotechnical drill rigs for near shore work at Steensby Island.

NOTE: This Procedure does not replace safe work procedures for working on ice.

2. Scope

2.1 This Procedure applies to all locations where on-ice platforms are required for near shore work at Steensby Island.

3. Roles and Responsibilities

3.1 Construction Manager

3.1.1 The Construction Manager shall be accountable for ensuring full implementation and compliance with the requirements of this Procedure.

3.2 Contractor's Line Managers

3.2.1 Contractor's Line Managers shall have the following accountabilities:

- Conduct risk assessments for tasks associated with this Procedure and ensure the implementation of controls
- Ensure equipment is used and processes are applied in accordance with this Procedure

3.3 Site Health and Safety Manager

3.3.1 The Site Health and Safety Manager shall have the following accountabilities:

- Audit and monitor compliance with this Procedure
- Identify remedial corrective actions required to meet this Procedure

3.4 Supervisors

3.4.1 Supervisors shall have the following accountabilities:

- Ensure the application of this Procedure
- Responsibility for details of construction of the platforms
- Ensure that a JHA/FLRA is developed for tasks associated with this Procedure

- Ensure that employees review and sign the JHA/FLRA prior to task commencement
- Responsibility for removal of the ice platforms

3.5 Employees

3.5.1 All employees shall have the following accountabilities:

- Ensure they follow this Procedure
- Ensure that JHA/FLRA developed for tasks associated with this Procedure are followed

4. Definitions

4.1 Solid Ice

4.1.1 Stable sheet of solid ice, thickness adequate to safely support the operation. The solid ice may be subject to movement due to tides.

4.2 Sea Ice

4.2.1 Sea ice is any form of ice that is found at sea and has originated from the freezing of sea water.

4.3 Rafted Ice or Raft Ice

4.3.1 Ice in cakes or sheets overlapping or piled on one another. This is a body of near shore ice segments fused together and formed during fall freeze-up. The surface of suitable rafted ice should be reasonably flat and elevation at or near high tide. This rafted ice is a stable entity. Rafted ice that moves with the tides shall be regarded as unstable.

4.4 Ice Platform

4.4.1 A platform constructed on the rafted ice by flooding with salt water and including embedded rig mats.

4.5 Rig Mat

4.5.1 A portable platform used to support equipment used in construction and resource based activity including drill rigs.

4.6 Drill Rig

4.6.1 A track mounted drill rig used for geotechnical investigations.

5. Procedure

5.1 Specific Requirements for Ice Platforms

5.1.1 The rafted ice must be stable and fused to act as a homogeneous mass. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.2 Do not attempt to construct an ice platform in locations where sea ice is pushed up onto the rafted ice to a height exceeding 2 m.

5.1.3 The solid ice adjacent to the ice platform must be stable during tidal influence and capable of safely supporting the gravity loads imposed by the operation, including at the edge of the ice sheet. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.4 The zone of discontinuity between the solid and rafted ice must not be open water at any time and must be sufficiently narrow so that the rig mats will safely support the movement of equipment and personnel across this zone. No work is to be performed over this zone of discontinuity. Appropriate ice profiling and/or direct measurement of ice thickness is required.

5.1.5 The ice platform shall be constructed by alternate overlapping layers of rig mats and flooding with salt water until a suitable work space is created over the rafted ice. Profile the ice with an ice profiler or measure ice thickness using a mechanical ice auger prior to any flooding.

5.1.6 The rig mats shall be constructed of steel frames and timber cross beams. The rig mats shall be strong enough to bridge across the zone of discontinuity. Note that the attached sketch is conceptual only. The number of rig mats must be determined on site. It is anticipated that the number of available rig mats will not be more than six.

5.1.7 The rig mats shall be adequately connected by mechanical means to be determined at site.

5.1.8 The platform must be sufficiently long and wide to permit a clearance of at least two metres on each side of the equipment and supplies.

5.1.9 The platforms must be removed by means established by the supervisor.

6. References

Nunavut General Safety Regulations, R.R.N.W.T. 1990.

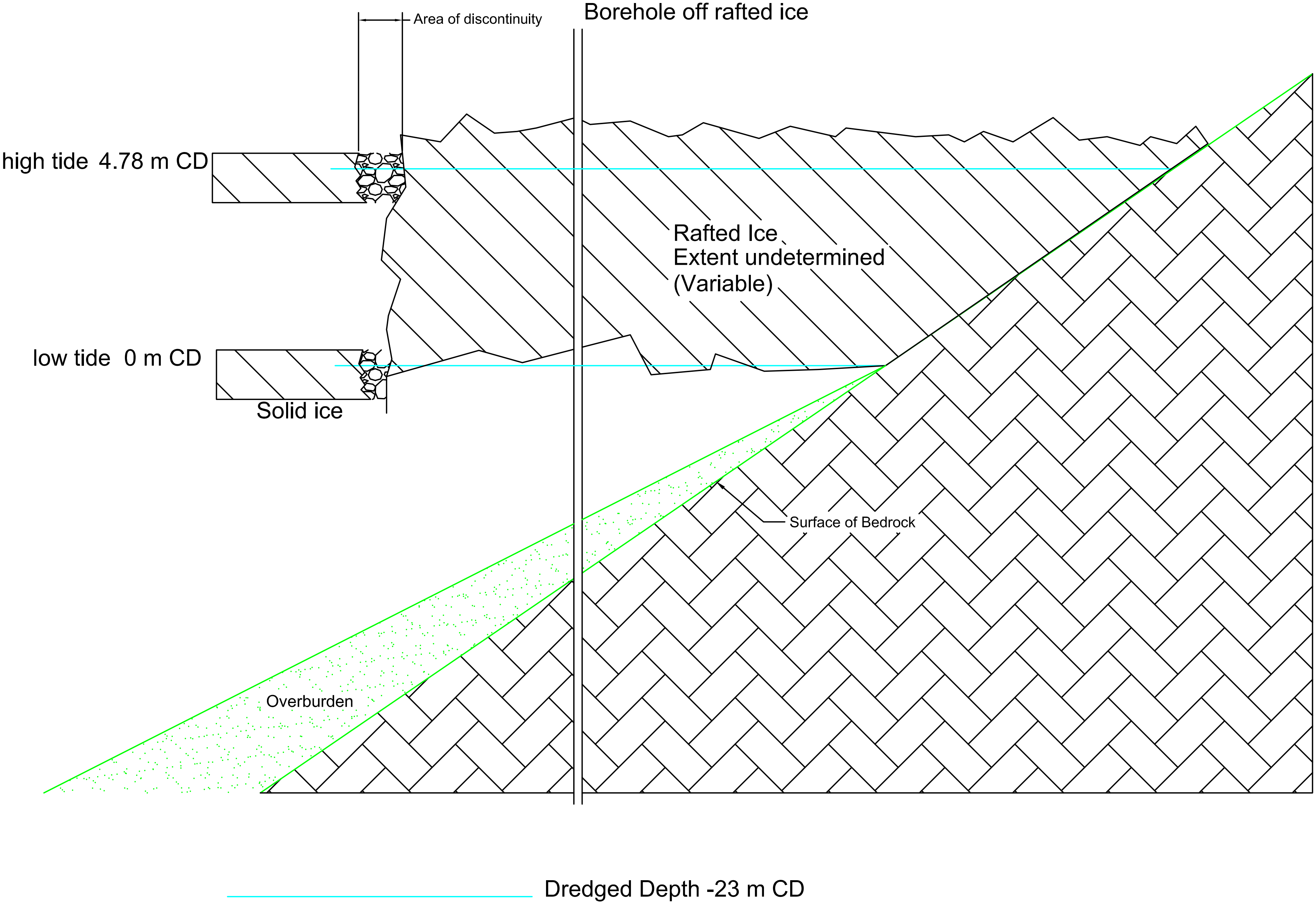
Nunavut Mine Health and Safety Regulations, R-125-95.

Safe Work Procedure – Working on Ice (HS-SWP-092).

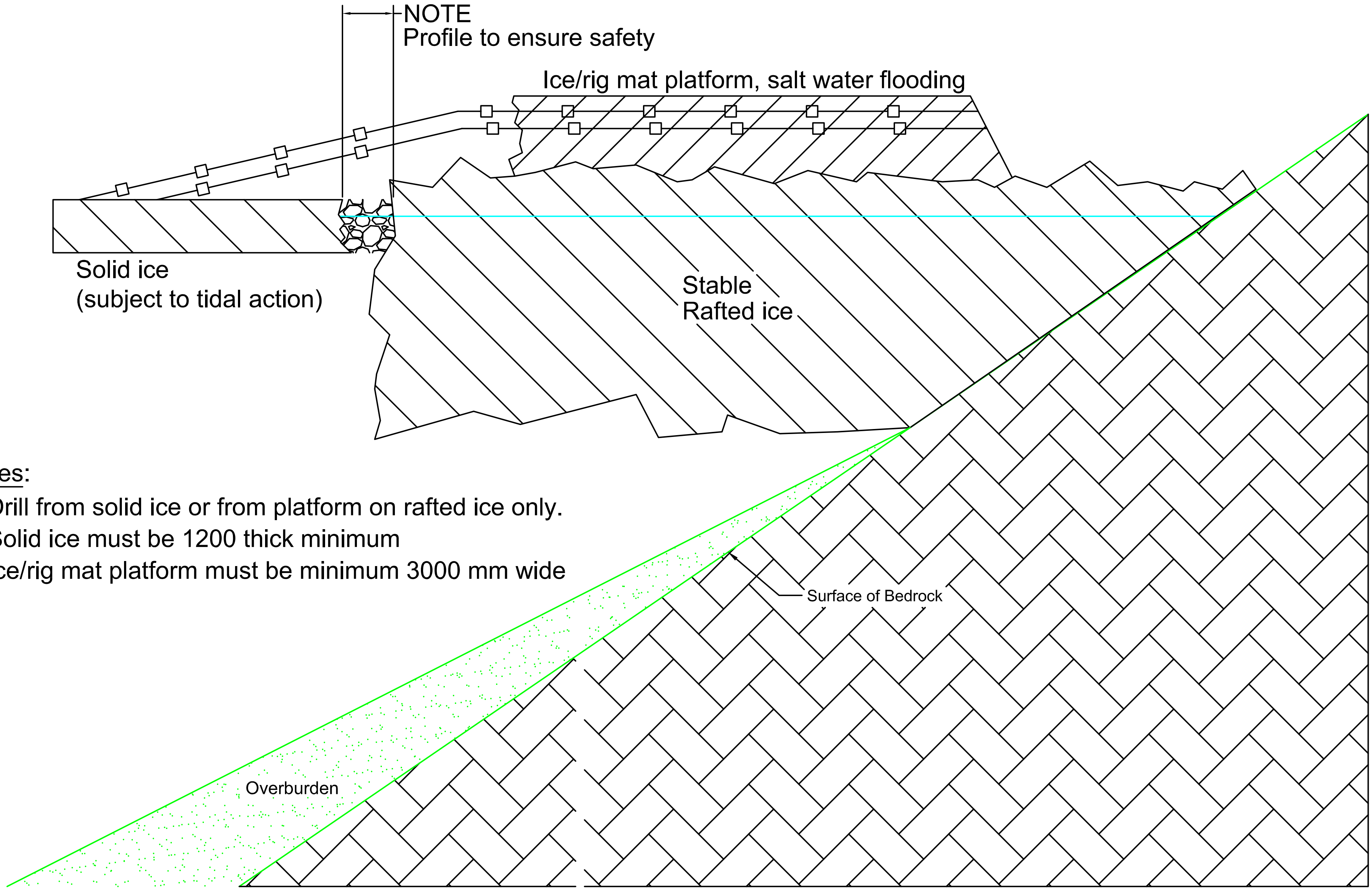
END OF SECTION

Appendix A

Illustrations



ORE DOCK
NEARSHORE CROSS SECTION



Notes:

1. Drill from solid ice or from platform on rafted ice only.
2. Solid ice must be 1200 thick minimum
3. Ice/rig mat platform must be minimum 3000 mm wide

ORE DOCK
ICE PLATFORM CONCEPT

Appendix B

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

Project Memo

December 14, 2011

TO: K. Skebo FROM: B. Gill

cc: S. Hinchberger
R. MacCrimmon

Baffinland Iron Mines Corporation
Mary River Project

Consideration of Bearing Capacity of Ice for Geotechnical Drilling Program

1. Introduction

The purpose of this note is to consider the ice features that may affect the execution of a planned geotechnical drilling program in a safe and effective manner. The program will be conducted during April and May in the proposed mine and marine facilities areas of the Baffinland project on northern Baffin Island. This note addresses primarily the bearing capacity of the ice cover for supporting the drilling program vehicles and equipment.

1.1 Air Temperatures and Ice Thickness

The air temperatures over the period from 1971 to 2000 for Hall Beach to the southwest and Pond Inlet to the northeast for April and May are as follows:

Table 1-1: Air Temperatures

	Hall Beach		Pond Inlet	
	April	**May**	**April**	**May**
Daily Average	-20.4	-9.0	-22.1	-9.9
Daily Maximum	-15.2	-4.8	-17.7	-5.8
Daily Minimum	-25.6	-13.2	-26.5	-13.9

Thus it is seen that the air temperature is well below freezing for the period and ice will continue to grow. Ice thickness data for Hall Beach show that in most years, the thickness reaches to 2 m or greater by May. The minimum thickness for May over 50 years is approximately 1.5 m. This is a significant thickness that is capable of supporting very heavy loads.

1.2 The Bearing Capacity of Ice

The guidelines in Canada for determining safe working loads for operations on ice are based on work by Dr. L. Gold of the National Research Council (see for example, "A Field Guide to Ice Construction Safety" by NWT Department of Transportation, November, 2007 and "Best Practice for Building and Working Safely on Ice Covers in Alberta by Work Safe Alberta, Government of Alberta, October, 2009). Dr. Gold published his paper "Use of Ice Covers for Transportation" in 1971. His formula, which says that the safe working load is a function of the ice thickness squared, is $P = Ah^2$ where A is a parameter that is related to the ice strength and h is the ice thickness. The value of A may vary depending on the degree of risk one is willing to take and the offsetting precautionary and response measures that are implemented in a given case. For the current case in which the ice thickness is large, the ice is static, and the equipment loads are relatively modest in relation to the ice bearing capacity, one could assume a low risk factor, and the subsequent calculated minimum ice thickness for the planned equipment weight would be relatively high, but still well below the thickness in April and May. In the Alberta and NWT documents referred to above, the former document uses a range of values for 'A' from 3.5 to 7 and suggests hazard control measures appropriate to each level, whereas the latter document uses a single value of 4 for 'A'. Both of these documents are concerned with freshwater lake and river ice.

Using a value of 4 for 'A' and an ice thickness of 200 cm results in an allowable load of 160 tonnes or more than 12 times the weight of a Cat 950 loader. The ratio would be presumably even greater in the case of a drill rig. In the same manner, the minimum (freshwater) ice thickness that a stationary or slowly moving 950 loader weighing about 13,000 kg would require is 57 cm.

The allowable load in the case of sea ice would be less than that for an equivalent thickness of freshwater ice because of the lower strength (under the same temperature conditions) that results from brine inclusions in the sea ice. A reasonable understanding of this derating can be obtained by comparing the flexural strengths of the two types of ice. For a salinity of 8 ppt (parts per thousand) for arctic sea ice at an average ice temperature of -20 deg C, the resulting flexural strength is about 65 percent of the strength of freshwater ice at the same temperature. The minimum sea ice thickness for a 950 loader would then be about 70 cm. This is 35 percent of the expected ice thickness at the project site during the drilling period.

The rate of movement of the equipment is not expected to be a significant factor, unlike in the case of transport vehicles moving at speed on ice covers over relatively shallow water. The speeds in the present case will not be sufficient to cause any dynamic effects that could lead to a magnification in deflection of the ice cover. According to field studies reported in the above-referenced Alberta Government document, a vehicle would have to travel at 50 km/h over ice 1 m thick in 15 m of water to cause such effects.

1.3 Potential Hazard Control

As noted, the large ice thickness in relation to the minimums required to safely carry the loads and the static nature of the ice cover in the present case mean that this is a low-risk operation in terms of potential ice bearing problems. An appropriate hazard control procedure would entail prior ice measurements to confirm the anticipated thickness in the working areas, measurements thereafter if any uncertainties exist with respect to ice thickness, monitoring the ice quality (e.g. cracks, effects of warming, water on the ice, etc), and checking for deflection of the ice cover as time of equipment in one location increases (this can be done by observing the water level in boreholes).

An overall ice safety plan should be implemented, including orientation and instruction for employees and contractors and routine daily observations to ensure rules of working on an ice cover are followed.

BG:vl

Internal Memo

H352034

March 18, 2017

To: Warren Hoyle

From: Usman Khan

cc: Marlon Coakley
Alex Boissonneault
Sean Hinchberger
Tyler Bruce
Sven Heiner

Baffinland Iron Mines
Mary River Expansion Study Stage 2

Minimum Ice Thickness for Offshore Drilling at Milne Port 2017

1. Introduction

Hatch Ltd. (Hatch) was retained by Baffinland Iron Mines to conduct an offshore, on-ice, geotechnical drilling investigation at the Milne Port Site. This investigation is scheduled for the period of mid to late March 2017. In order to mitigate risk relating to ice breakthrough, the investigation team reviewed ice strength evaluation completed for a similar offshore investigation at the Steensby site in 2011.

2. Allowable Ice Loading

2.1 Moving Loads

The 2011 evaluation of ice thickness utilized Gold's formula to calculate the allowable weight for a variable ice thickness. Gold's formula is based on literature that utilizes data collected from ice breakthroughs and forms an empirical relationship to predict the allowable bearing capacity of ice.

$$P = Ah^2$$

P = Allowable load in kilograms

A = Constant which depends on the quality of the ice, the geometry of the load and the factor of safety appropriate

h = Effective thickness of the ice in centimeters

Further literature review suggests using a value of 4 as a conservative estimate for freshwater ice. Government of Alberta and Northwest territories both recommend using a factor of 4.

It is noted that a factor of 4 is used for freshwater ice and does not account for the reduction of flexural strength in sea ice due to the presence of brine. A reduction factor of 0.65 is applied per Hatch project memo entitled, “On-Ice Platforms for Geotechnical Drilling at Steensby Island” (Document # H349000-HS-SWP-165).

Table 2-1: Maximum Allowable Load On Sea Ice

Ice Thickness (cm)	Load (kg)	Load (lb)		Ice Thickness (cm)	Load (kg)	Load (lb)
5	60	150		105	28,660	63,200
10	260	580		110	31,460	69,360
15	580	1,290		115	34,380	75,810
20	1,040	2,300		120	37,440	82,550
25	1,620	3,590		125	40,620	89,570
30	2,340	5,160		130	43,940	96,880
35	3,180	7,030		135	47,380	104,470
40	4,160	9,180		140	50,960	112,350
45	5,260	11,610		145	54,660	120,520
50	6,500	14,340		150	58,500	128,980
55	7,860	17,340		155	62,460	137,720
60	9,360	20,640		160	66,560	146,740
65	10,980	24,220		165	70,780	156,060
70	12,740	28,090		170	75,140	165,660
75	14,620	32,250		175	79,620	175,550
80	16,640	36,690		180	84,240	185,720
85	18,780	41,420		185	88,980	196,180
90	21,060	46,430		190	93,860	206,930
95	23,460	51,740		195	98,860	217,970
100	26,000	57,330		200	104,000	229,290

2.2 Static Loads

Gold's formula is adequate for calculating the allowable bearing capacity for moving loads on ice but it does not propose a relationship between allowable loads and ice thickness for static loads. To ensure ice safety for a static load operation, a literature review was completed. It was concluded that the deflection in ice must be monitored throughout the drilling operation and loading must be removed in case of excessive deflections. Ice cover should not exceed the freeboard elevation to ensure safety of the drilling crew.

3. Monitoring During Drilling Activities

A hole will be augured through ice within 5 m of the point of maximum load. The depth of water in the hole will be monitored throughout the duration of the drilling investigation at each borehole location. Drilling will be terminated if sea water is observed flowing through the top of the augured hole. Ref 3 provides further details regarding the bearing capacity of ice covers under static loads.

4. References

1. W, Gold. L. (n.d.). Field study on the load bearing capacity of ice covers. National Research Council Canada, 61(5), 3-7. Retrieved March 18, 2017, from http://nparc.cisti-icist.nrc-cnrc.gc.ca/eng/view/object/?id=e7d278d9-808a-4959-b9f7-27320d757afd
2. KINGERYW, . D., KLICKD, . W., DYKINSJ., E. Sea ice engineering summary report-Project ICEWAY. U.S. Naval Civ. Eng. Lab.Port Hueneme, Calif., Tech. Rep. R-189.
3. Frederking, R. M. W., and L. W. Gold. "The Bearing Capacity of Ice Covers under Static Loads." Canadian Journal of Civil Engineering 3.2 (1976): 288-93. Web Accessed March 18, 2017.

UK:UK
Attachment(s)/Enclosure

Appendix F

ConeTec Report

PRESENTATION OF SITE INVESTIGATION RESULTS

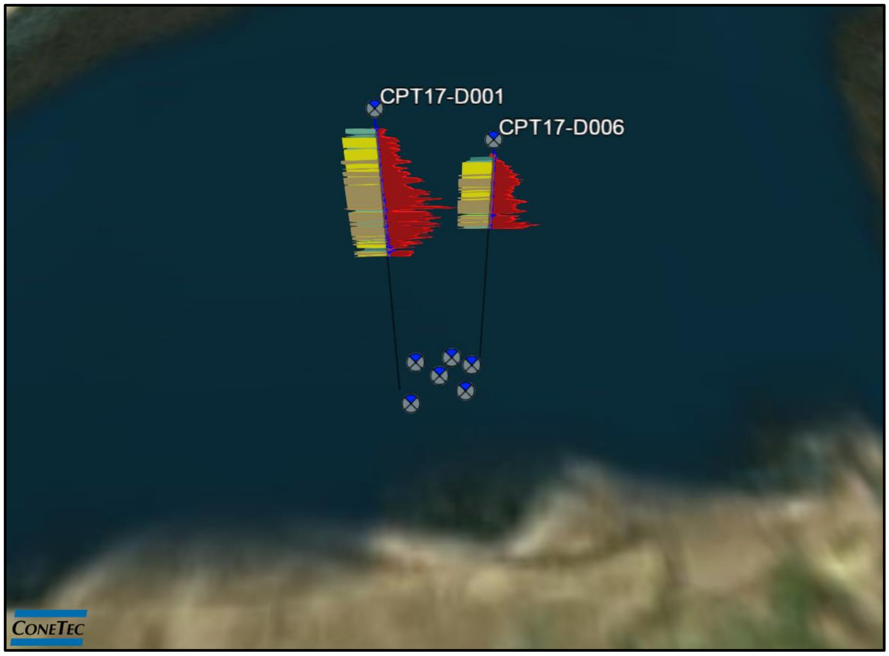
Milne Port Expansion

Prepared for:

Baffinland Iron Mines Corporation

ConeTec Job No: 17-05010

Project Start Date: 22-Mar-2017
Project End Date: 09-Apr-2017
Report Date: 13-Apr-2017
Revised Date: 21-Apr-2017



Prepared by:

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Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Investigations Ltd. for Baffinland Iron Mines Corporation at Milne Inlet, Baffin Island, Nunavut. The program consisted of six cone penetration tests (CPT) and two seismic cone penetration tests (SCPT) carried out under the direction of Hatch Ltd.

Project Information

Project	
Client	Baffinland Iron Mines Corporation
Project	Milne Port Expansion
ConeTec project number	17-05010

A map from Google earth including the CPT and SCPT test locations is presented below.

Rig Description	Deployment System	Test Type
Boart LS100	Portable	CPT, SCPT

Coordinates		
Test Type	Collection Method	EPSG Number
CPT, SCPT	ConeTec Trimble Survey (RTK)	26917

Cone Penetration Test (CPT)	
Depth reference	Depths are referenced to the existing mudline at the time of each test.
Tip and sleeve data offset	0.1 meter This has been accounted for in the CPT data files.
Additional plots	Advanced CPT plots with Ic, Phi, and N1(60) and SCPT plots have been included.

Cone Penetrometers Used for this Project						
Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
338:T1500F15U500	338	15	225	1500	15	500
374:T1500F15U500	374	15	225	1500	15	500
The CPT summary indicates which cone was used for each sounding.						

Interpretation Tables	
Additional information	The Soil Behaviour Type (SBT) classification chart (Robertson et al., 1986 presented by Lunne, Robertson and Powell, 1997) was used to classify the soil for this project. A detailed set of calculated CPT parameters were generated and are provided in Excel format files in the release folder. The calculated CPT parameters are based on values of corrected tip (q_t), sleeve friction (f_s) and pore pressure (u_2). Soils were classified as either drained or undrained based on the Soil Behaviour Type (SBT) classification chart (Robertson et al., 1986 presented by Lunne, Robertson and Powell, 1997). Calculations for both drained and undrained parameters were included for materials that classified as silt (zone 6).

Survey	
Tidal Fluctuations	As requested by Hatch Ltd., a survey grid was setup to monitor ice movement due to tidal fluctuation throughout the drill program. The grid was laid out around the proposed drilling area using six survey points in a 200m by 100m grid. ½ inch steel pins was installed at each point by drilling out a section of ice and freezing the rod in place. The pins were surveyed repeatedly throughout a 12-hour period to determine if the ebb and flow of the tide was moving the ice laterally. After installation they were then surveyed every couple of days.
Surveying Methodology	Due to the lack of compatibility with the onsite base station, a second base station broadcasting in the 450MHz band had to be setup to support the drill program surveying. An observed control point was surveyed in by the BIM

	surveyor onsite in datum NAD83 using an ellipsoid model. Our base station was permanently setup over the surveyed point with a vertical offset of 1.32m to the bottom of the R8 base. An existing control point, KM002, was surveyed for quality control. A second control point, PRJCNTRL, was surveyed in to allow for easy quality control when restarting the base station.
Depth Control	Significant tidal fluctuations between two and seven feet were observed on the ice throughout the drill program. Constant monitoring of the elevation of the ice was required while conducting the cone penetration tests (CPTs) to ensure the depth was correct throughout the sounding. At the beginning of the CPT, the Northing, Easting, and Elevation of the sounding was recorded along with a dip tape measurement to the sea floor. The dip tape measurement was subtracted from the ice elevation to get the sea floor elevation. Throughout the CPT, the elevation of ice was monitored and compared to the initial measurement to get an accurate depth at the end of every meter.
Ice Cracks and Survey Grid	There were large cracks in the ice near the drilling pad. They appeared to open and close as the tide went up and down. The Northing and Easting coordinates of the grid were surveyed using a continuous topo. The survey grid coordinates are not presented as part of this report.

Limitations

This report has been prepared for the exclusive use of Baffinland Iron Mines Corporation (Client) and Hatch Ltd. for the project titled “Milne Port Expansion”. The report’s contents may not be relied upon by any other party without the express written permission of ConeTec Investigations Ltd. (ConeTec). ConeTec has provided site investigation services, prepared the factual data reporting, and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client and Hatch Ltd. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

The cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd. of Richmond, British Columbia, Canada.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table presented in the first Appendix. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meets or exceeds those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

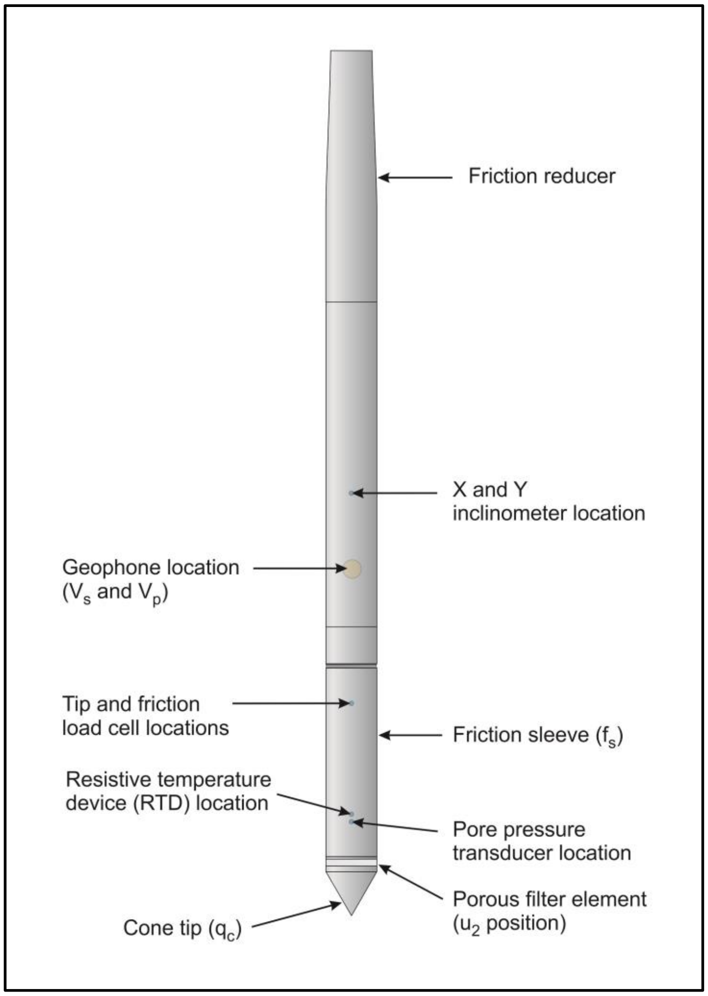

Figure CPTu. Piezocone Penetrometer (15 cm^2)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording intervals are either 2.5 cm or 5.0 cm depending on project requirements; custom recording intervals are possible. The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerine or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil or glycerine under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson (1990) and Robertson (2009). It should be noted that it is not always possible to accurately identify a soil type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behaviour type.

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al, 1986:

$$q_t = q_c + (1\text{-}a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of interpretation files were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the interpretation methods used is also included in the data release folder.

For additional information on CPTu interpretations, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

Shear wave velocity testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave (Vp) velocity is also determined.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that triggers the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

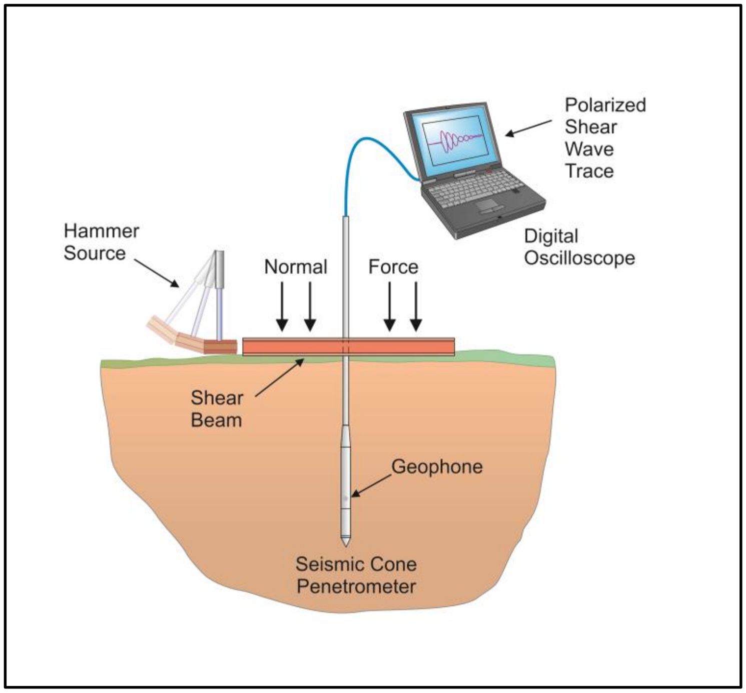

Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Multiple wave traces are recorded for quality control purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et.al. (1986).

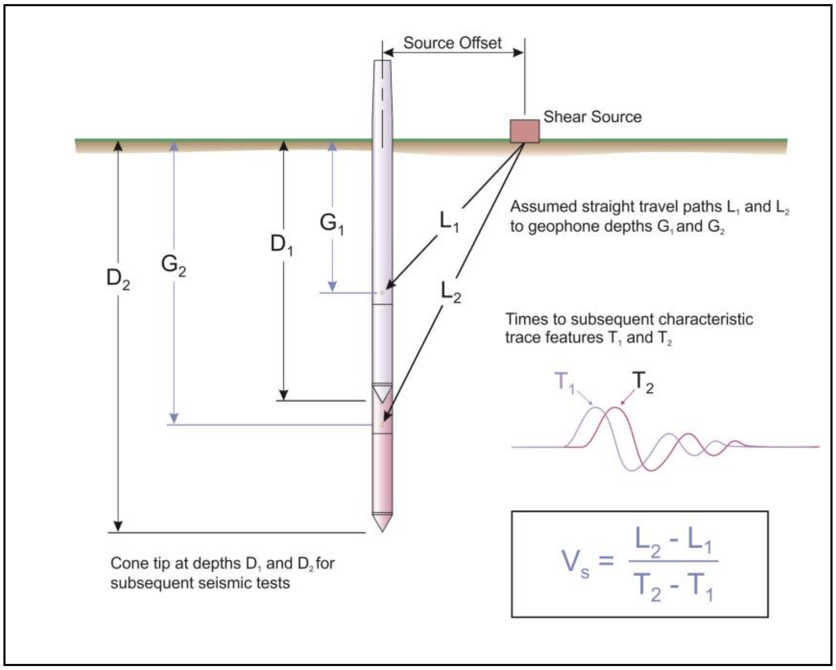

Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 30 meters (V_{s30}) has been calculated and provided for all applicable soundings using an equation presented in Crow et al., 2012.

$$V_{s30} = \frac{total\ thickness\ of\ all\ layers\ (30m)}{\sum(layer\ traveltimes)}$$

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

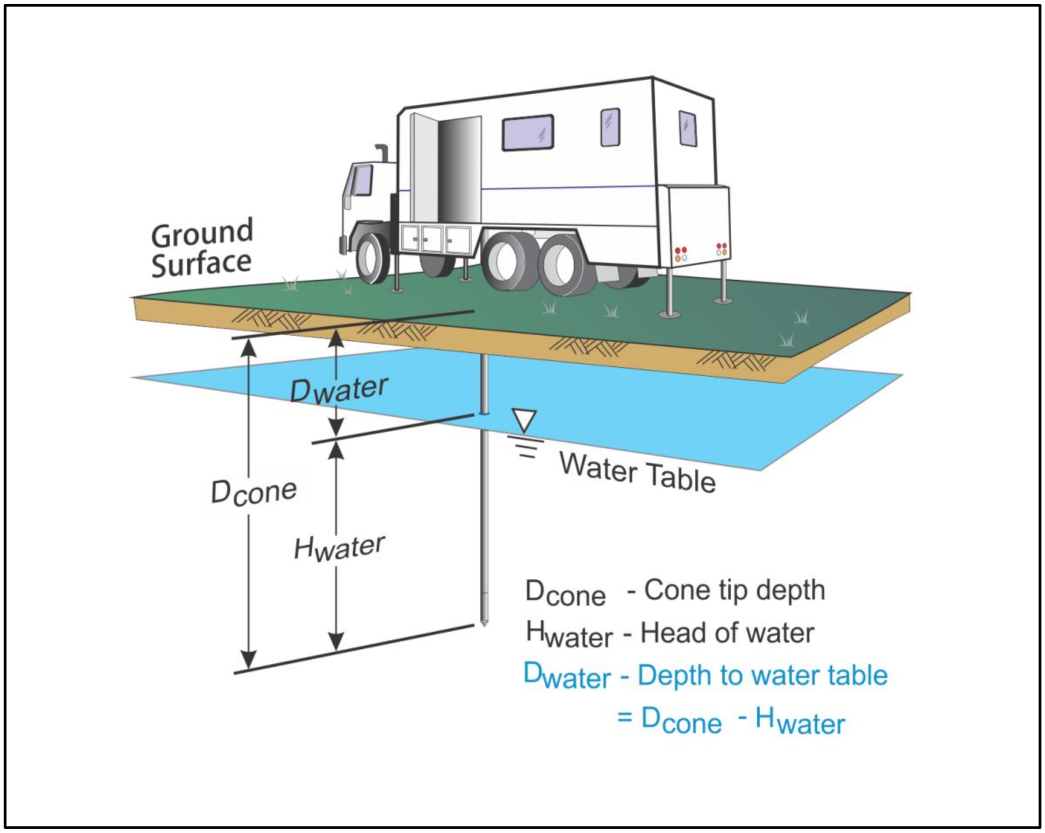

Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behaviour.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

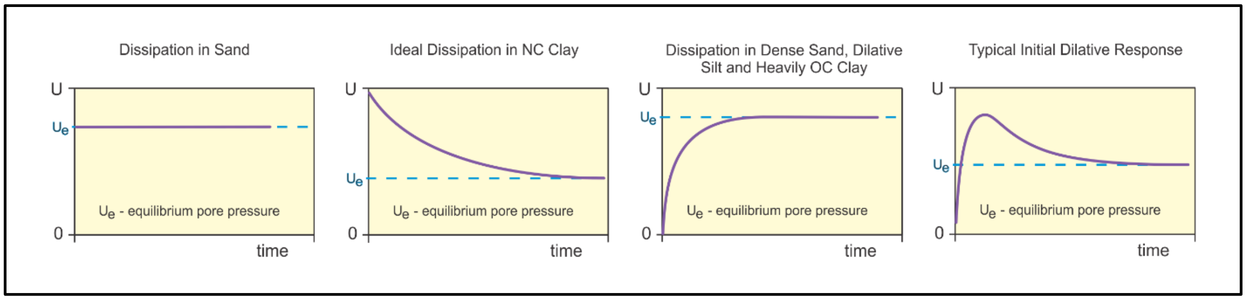

Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve of Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as t_{100}. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to t_{100}. A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation (c_h) at various degrees of dissipation resulting in the expression for c_h shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T*	is the dimensionless time factor (Table Time Factor)
a	is the radius of the cone
I_r	is the rigidity index
t	is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

Degree of Dissipation (%)	20	30	40	50	60	70	80
T* (u_2)	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time (t_{50}) corresponding to a degree of dissipation of 50% (u_{50}). In order to determine t_{50}, dissipation tests must be taken to a pressure less than u_{50}. The u_{50} value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as u_{100}. To estimate u_{50}, both the initial maximum pore pressure and u_{100} must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at t_{100}) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly (u_{100}), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of c_h (Teh and Houlsby, 1991), t_{50} values are estimated from the corresponding pore pressure dissipation curve and a rigidity index (I_r) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining t_{50}. In cases where the time to peak is excessive, t_{50} values are not calculated.

Due to possible inherent uncertainties in estimating I_r, the equilibrium pore pressure and the effect of an initial dilatory response on calculating t_{50}, other methods should be applied to confirm the results for c_h.

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

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Crow, H.L., Hunter, J.A., Bobrowsky, P.T., 2012, “National shear wave measurement guidelines for Canadian seismic site assessment”, GeoManitoba 2012, Sept 30 to Oct 2, Winnipeg, Manitoba.

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Robertson, P.K., Sully, J.P., Woeller, D.J., Lunne, T., Powell, J.J.M. and Gillespie, D.G., 1992, “Estimating coefficient of consolidation from piezocone tests”, Canadian Geotechnical Journal, 29(4): 551-557.

Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, “An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils”, Canadian Geotechnical Journal, 36(2): 369-381.

Teh, C.I., and Houlsby, G.T., 1991, “An analytical study of the cone penetration test in clay”, Geotechnique, 41(1): 17-34.

APPENDICES

The following appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Advanced Cone Penetration Test Plots with Ic, Phi, and N1(60)
- Seismic Cone Penetration Test Tabular Results
- Seismic Cone Penetration Test Plots
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

Cone Penetration Test Summary and Standard Cone Penetration Test Plots

CONETEC

CONETEC

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Start Date: 03-Apr-2017
End Date: 07-Apr-2017

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (m)	Final Depth[2] (m)	Northing[3] (m)	Easting (m)	Elevation (m)	Refer to Notation Number
CPT17-D001	17-05010_CPD001	05-Apr-2017	338:T1500F15U500	-17.6	32.750	7976717.62	503607.38	-16.97	
SCPT17-D002	17-05010_SPD002	05-Apr-2017	338:T1500F15U500	-16.9	39.475	7976728.05	503705.30	-16.12	
CPT17-D003	17-05010_CPD003	06-Apr-2017	338:T1500F15U500	-23.2	30.425	7976757.71	503785.39	-22.68	
SCPT17-D004	17-05010_SPD004	04-Apr-2017	338:T1500F15U500	-27.3	32.050	7976768.10	503646.44	-26.59	
CPT17-D005	17-05010_CPD005	03-Apr-2017	338:T1500F15U500	-26.0	25.125	7976780.84	503736.09	-24.98	
CPT17-D006	17-05010_CPD006	06-Apr-2017	374:T1500F15U500	-32.0	20.575	7976808.43	503807.55	-31.32	
CPT17-D007	17-05010_CPD007	07-Apr-2017	374:T1500F15U501	-4.7	30.200	7976683.63	503767.46	-4.23	
CPT17-D008	17-05010_CPD008	07-Apr-2017	374:T1500F15U502	-1.4	30.000	7976650.76	503635.99	-1.80	

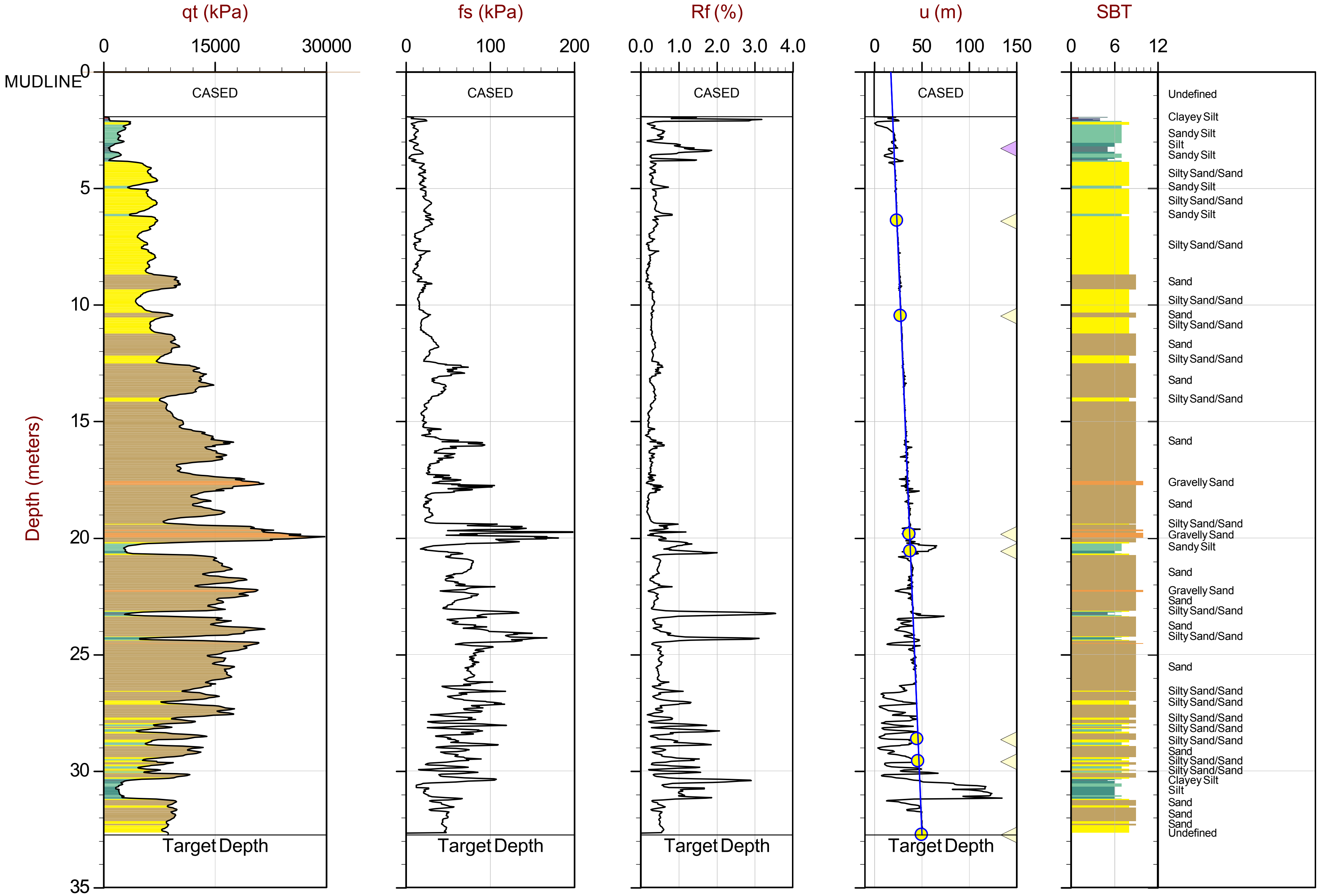
1. The assumed phreatic surface was based on pore pressure dissipation tests. Hydrostatic conditions were assumed for the interpretation tables.
2. Depth is referenced from the mudline at the time of testing.
3. Coordinates and elevations were acquired using ConeTec Trimble Survey in datum NAD 83 / UTM Zone 17 North. Elevation is of the mudline at the time of testing.

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500



Max Depth: 32.750 m / 107.45 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD001.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976717.62m E: 503607.38m Elev: -16.97m

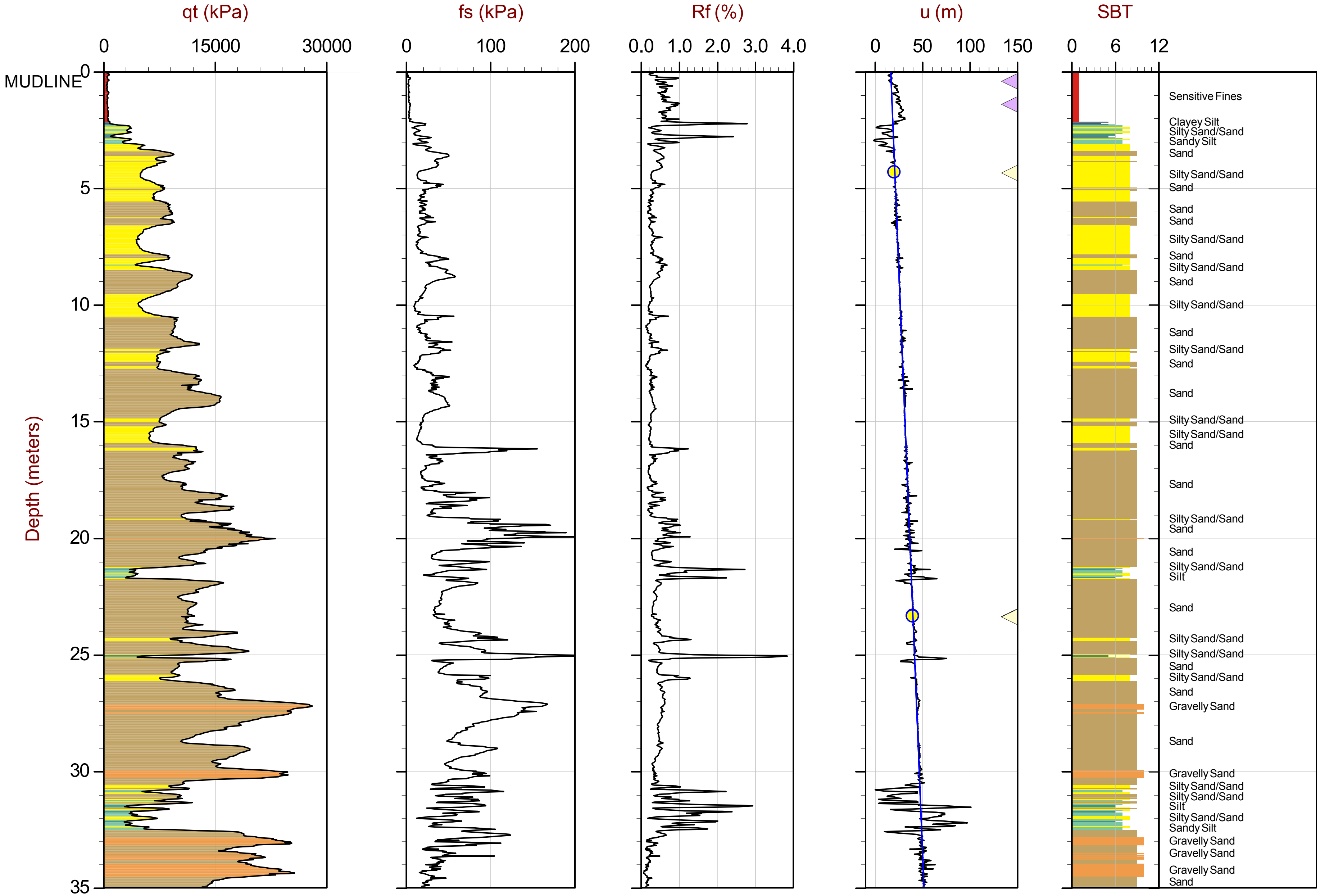
● Equilibrium Pore Pressure (Ueq) ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq achieved — Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

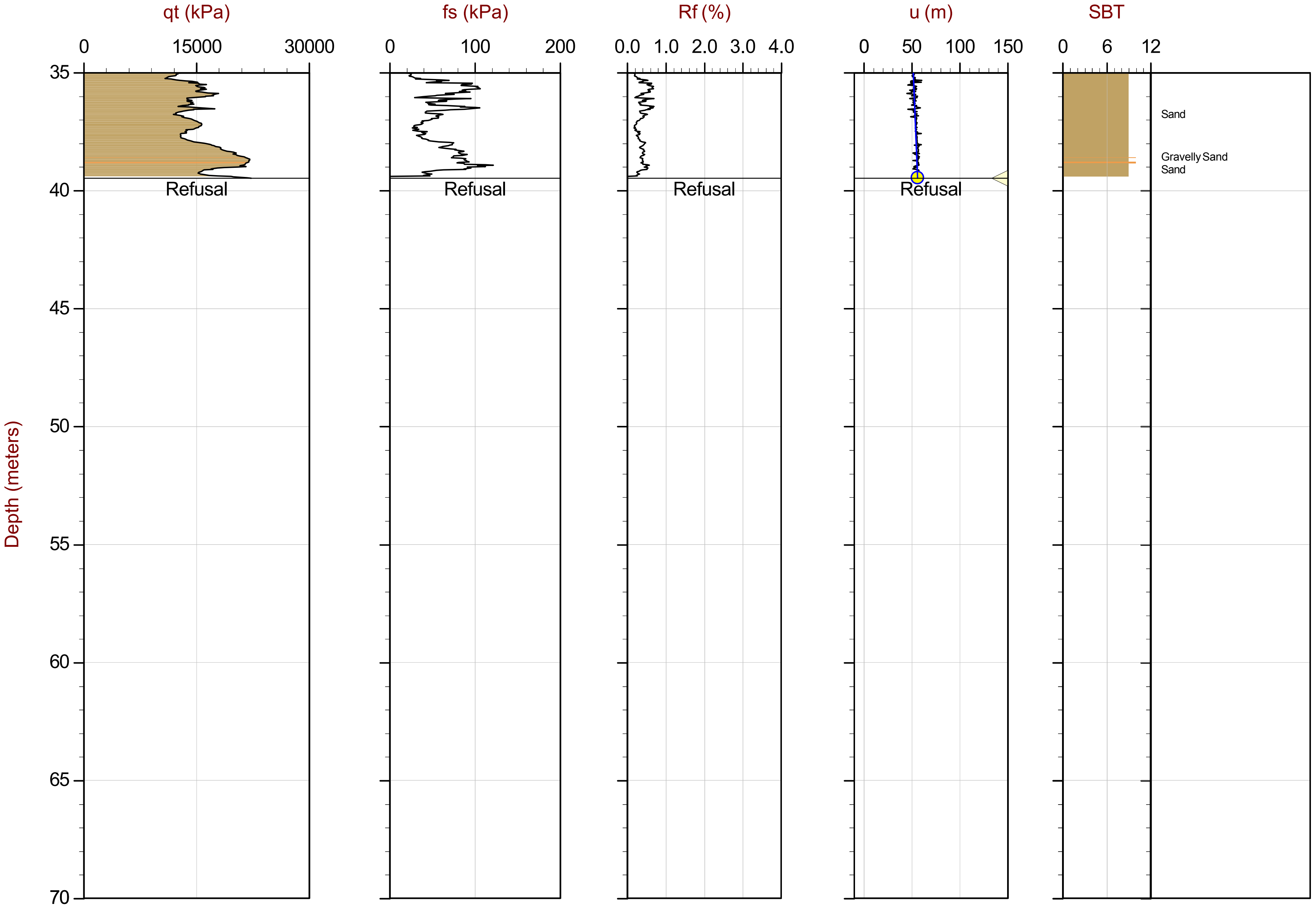
● Equilibrium Pore Pressure (Ueq)   ◁ Dissipation, Ueq not achieved   ◁ Dissipation, Ueq achieved   — Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

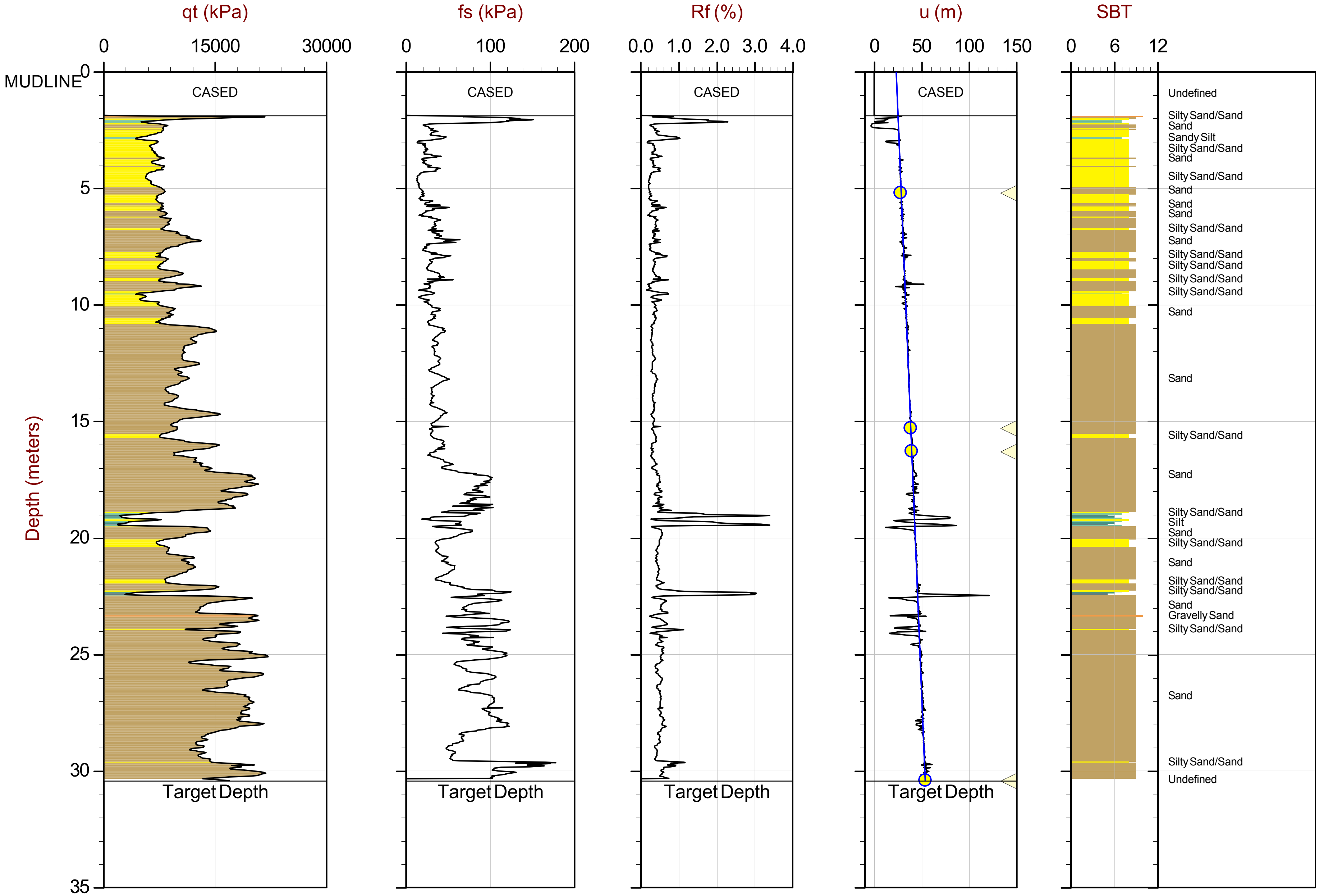
● Equilibrium Pore Pressure (Ueq) ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq achieved — Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500



Max Depth: 30.425 m / 99.82 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD003.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N:7976757.71m E:503785.39m Elev:-22.68m

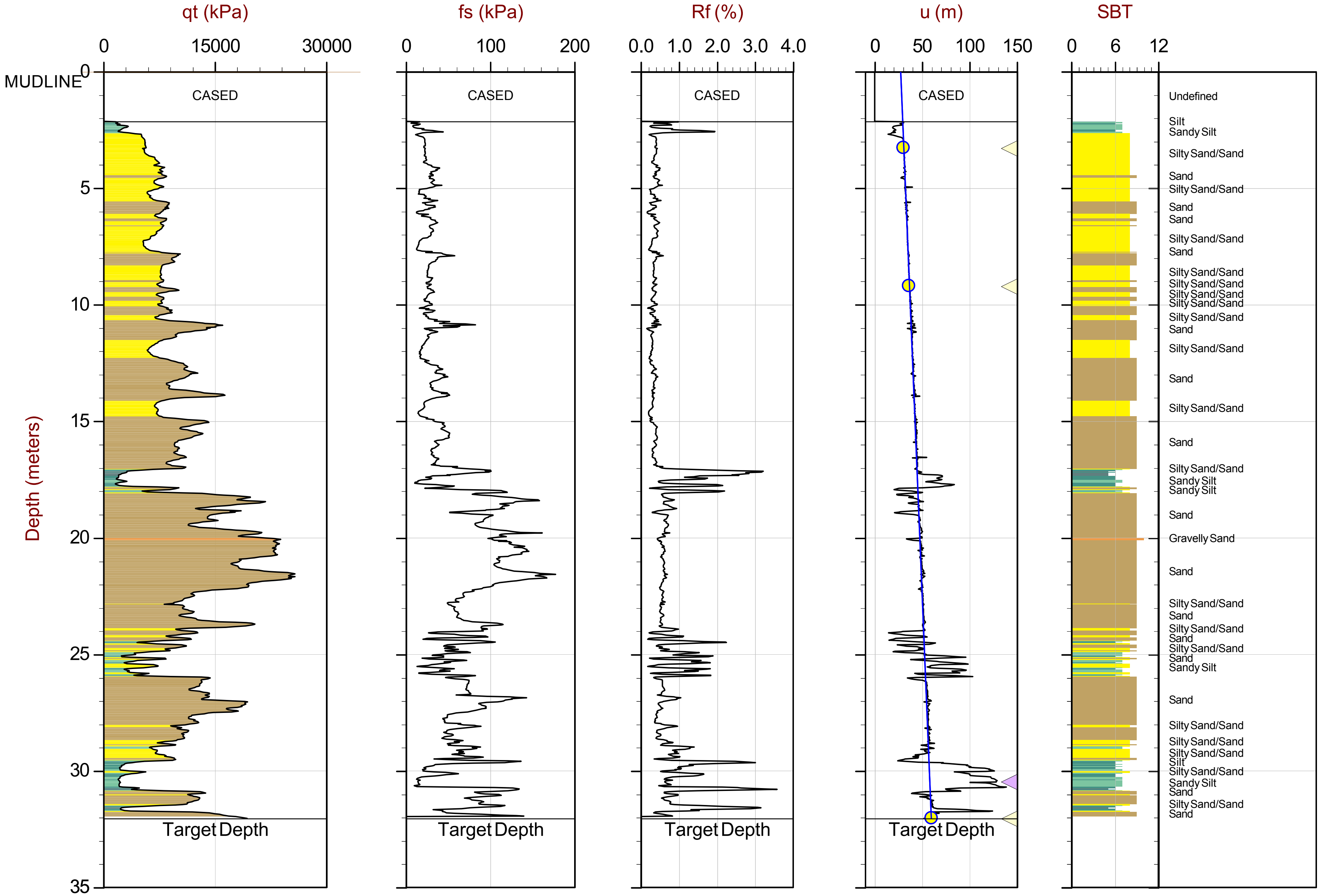
● Equilibrium Pore Pressure (Ueq) ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq achieved — Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-04 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500



Max Depth: 32.050 m / 105.15 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD004.COR
Unit Wt: SBT (R&C1986)

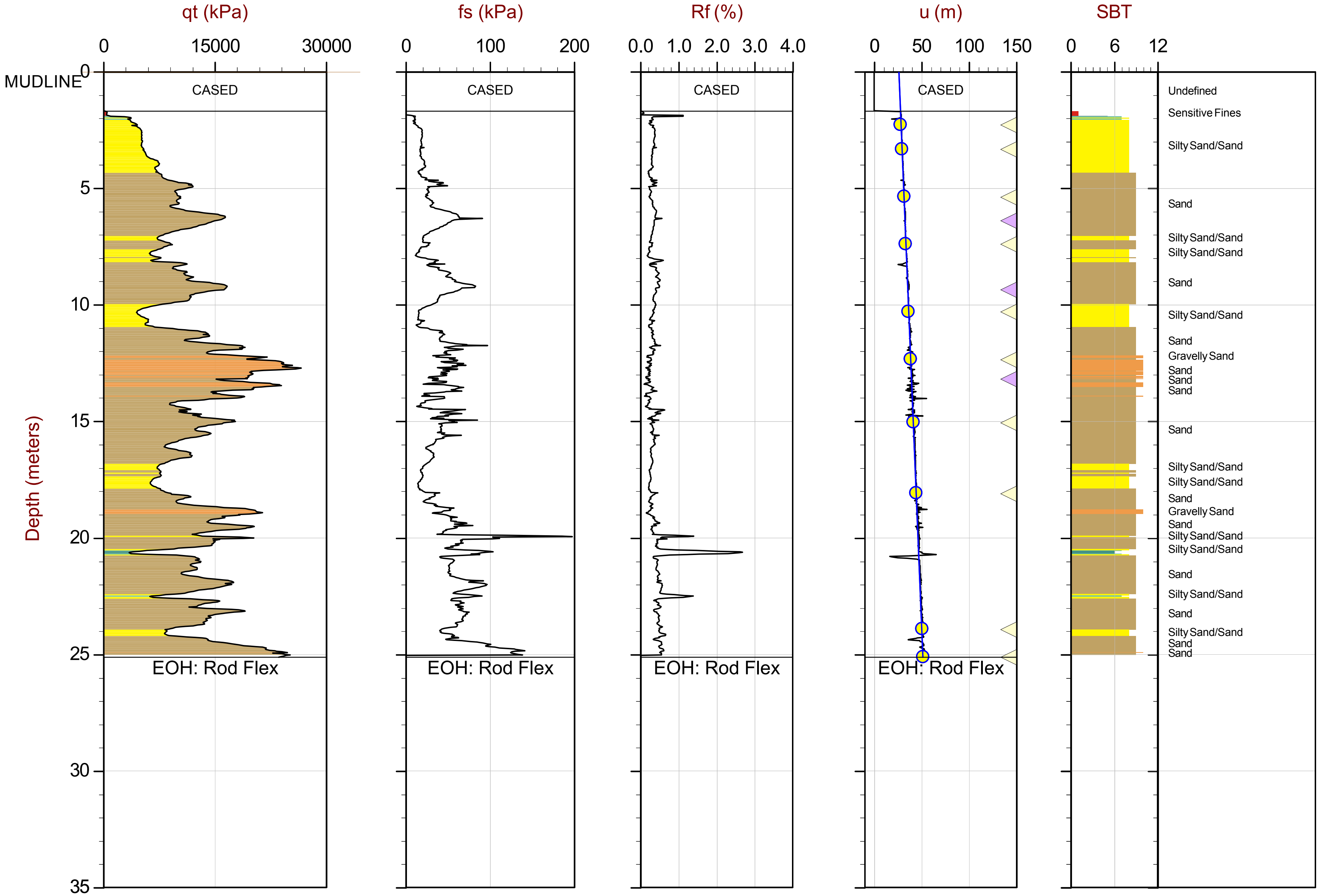
SBT: Robertson and Campanella, 1986
Coords: UTM17N N:7976768.10m E:503646.44m Elev:-26.59m

● Equilibrium Pore Pressure (Ueq) ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq achieved — Hydrostatic Line

Baffinland

Job No: 17-05010
Date: 2017-04-03 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500



Max Depth: 25.125 m / 82.43 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD005.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976780.84m E: 503736.09m Elev: -24.98m

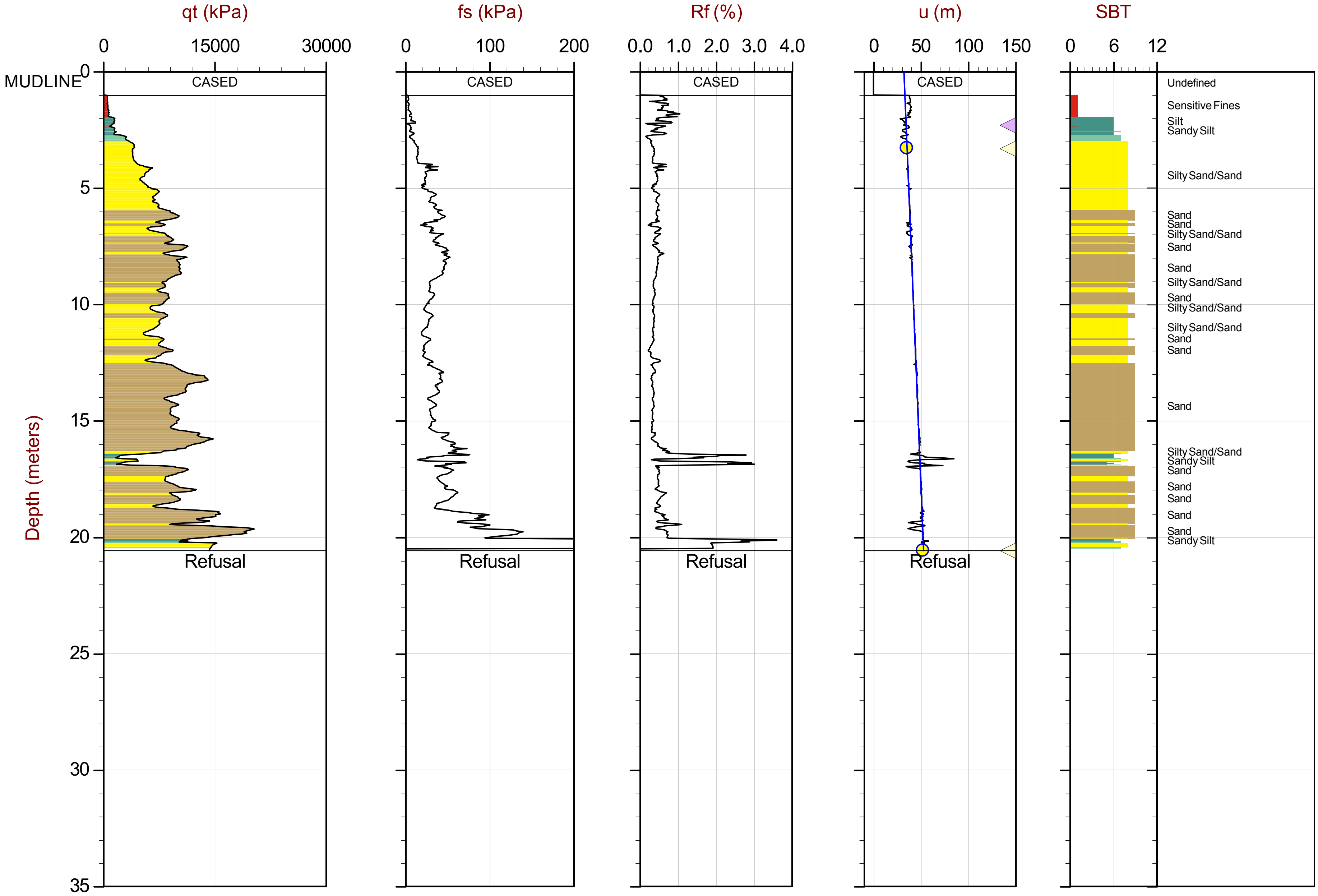
● Equilibrium Pore Pressure (Ueq)
◁ Dissipation, Ueq not achieved
◁ Dissipation, Ueq achieved
— Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500



Max Depth: 20.575 m / 67.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD006.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976808.43m E: 503807.55m Elev: -31.32m

● Equilibrium Pore Pressure (Ueq)　◁ Dissipation, Ueq not achieved　◁ Dissipation, Ueq achieved　— Hydrostatic Line

ConeTec

Baffinland

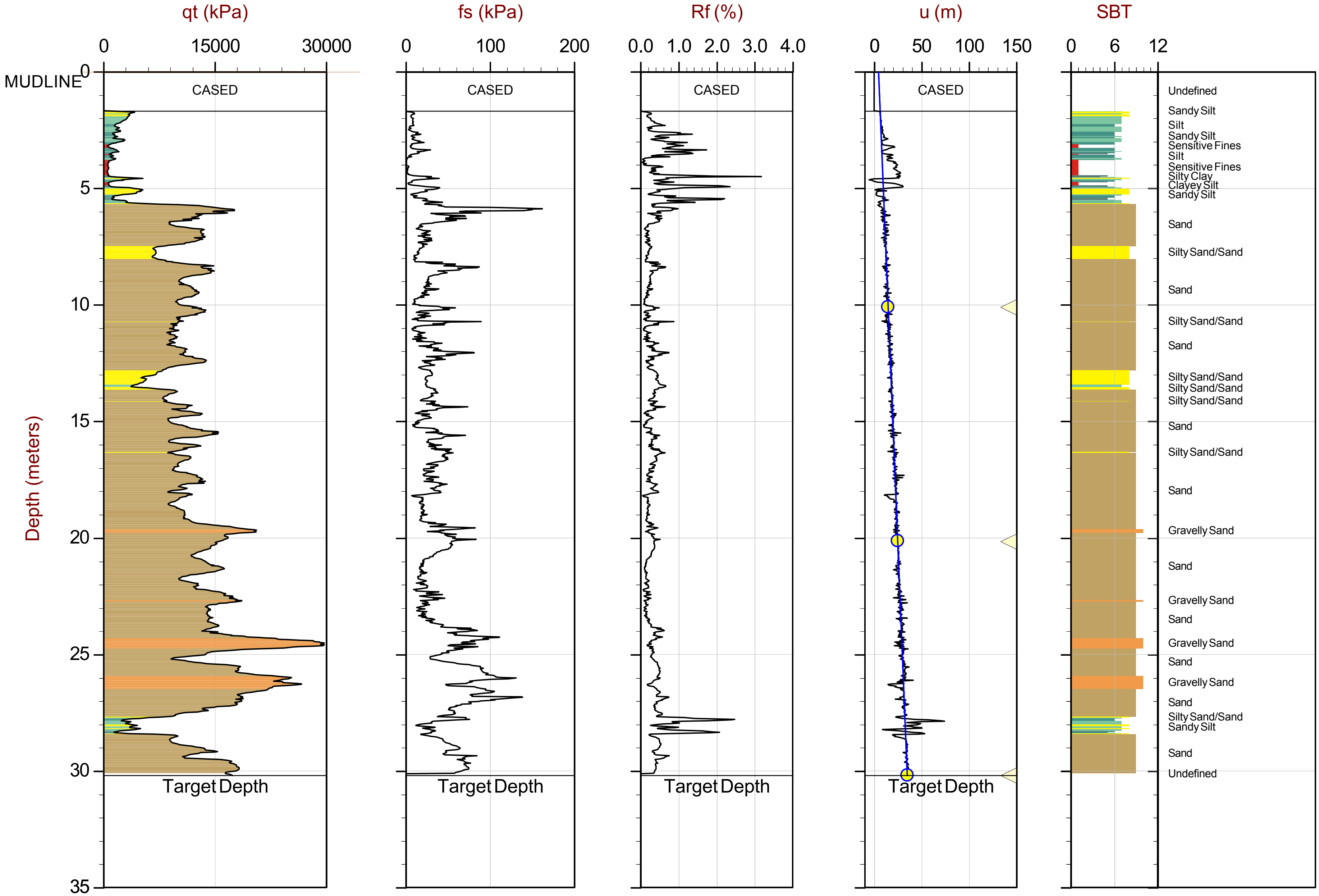
Job No: 17-05010

Date: 2017-04-07 11:27

Site: Milne Port Expansion

Sounding: CPT17-D007

Cone: 374:T1500F15U500



Max Depth: 30.200 m / 99.08 ft

Depth Inc: 0.025 m / 0.082 ft

Avg Int: Every Point

File: 17-05010_CPD007.COR

Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986

Coords: UTM17N N: 7976683.63m E: 503767.46m Elev: -4.23m

● Equilibrium Pore Pressure (Ueq)

◁ Dissipation, Ueq not achieved

◁ Dissipation, Ueq achieved

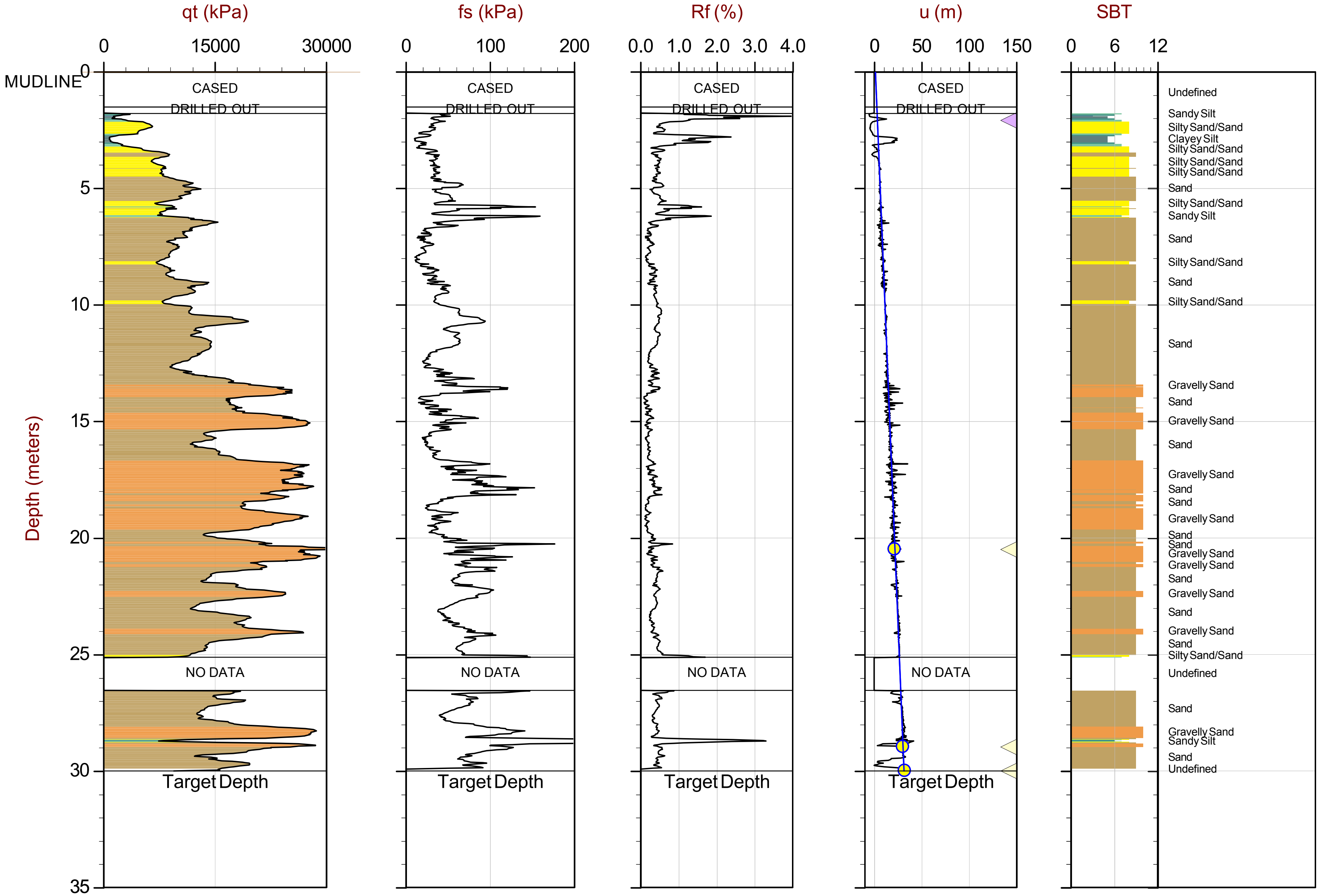
— Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-07 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD008.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976650.76m E: 503635.99m Elev: -1.80m

● Equilibrium Pore Pressure (Ueq) ◁ Dissipation, Ueq not achieved ◁ Dissipation, Ueq achieved — Hydrostatic Line

Advanced Cone Penetration Test Plots with Ic, Phi, and N1(60)

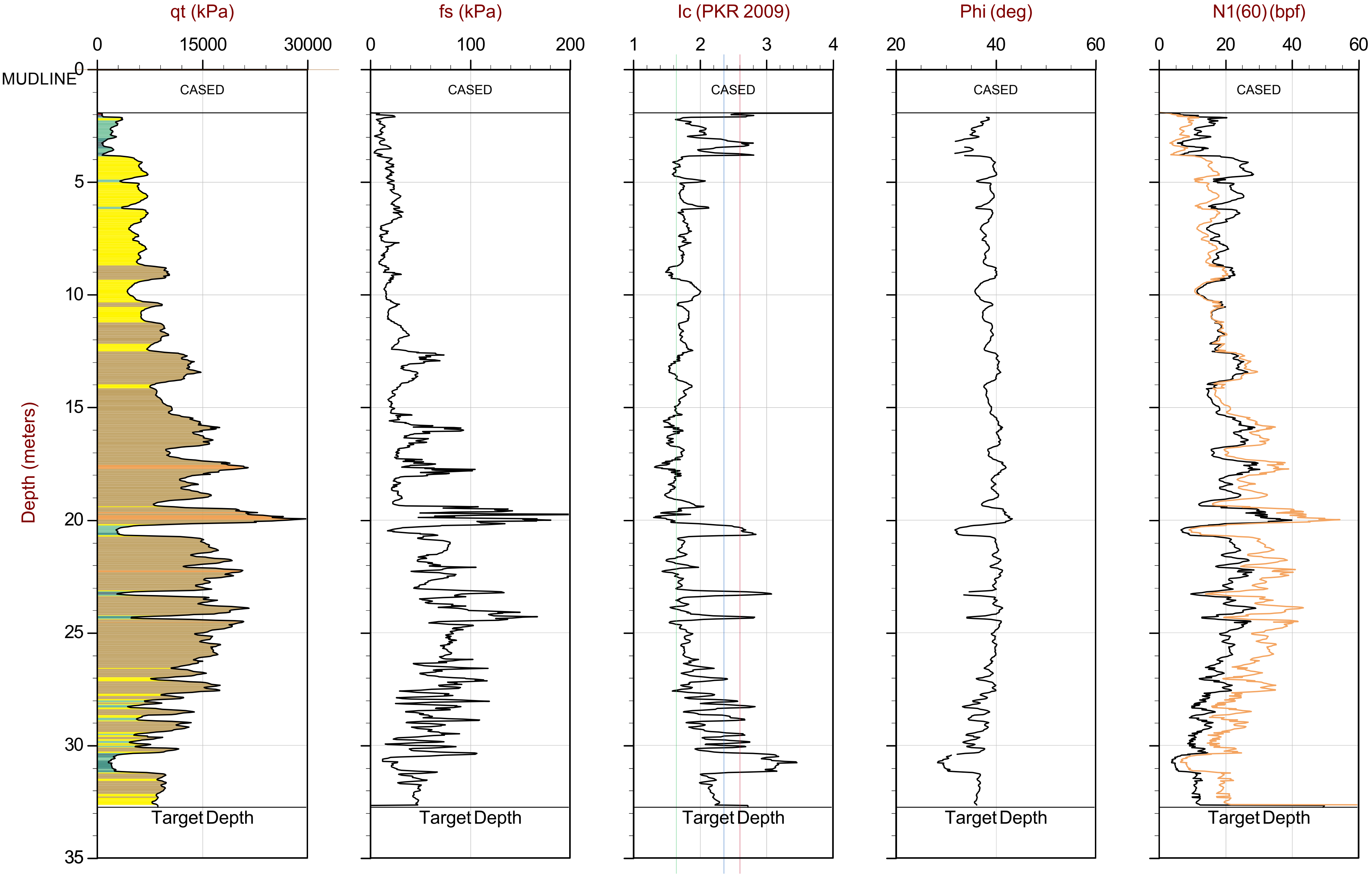
ConeTec

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500



Max Depth: 32.750 m / 107.45 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD001.COR
Unit Wt: SBT (R&C1986)

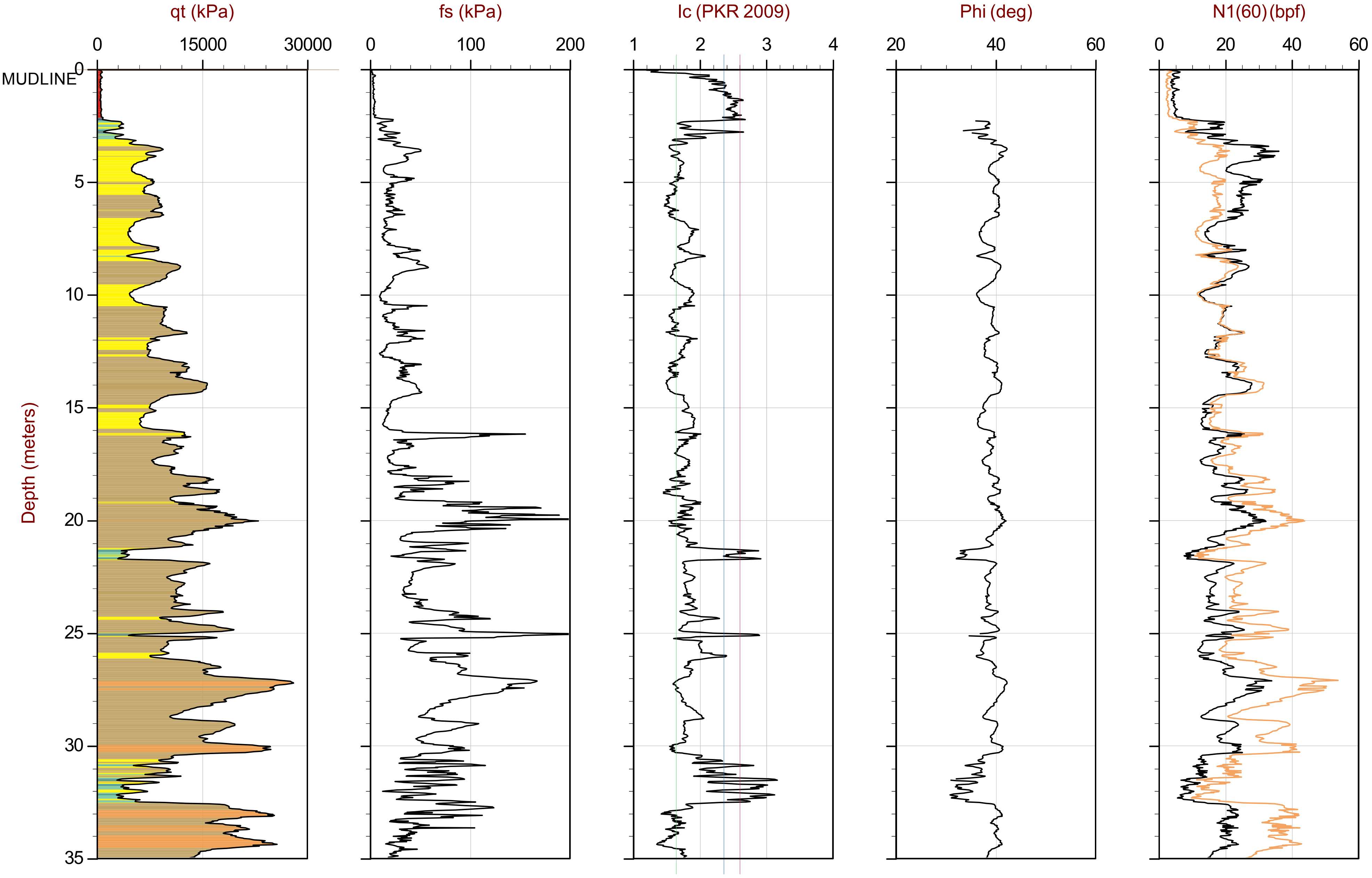
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976717.62m E: 503607.38m Elev: -16.97m

N(60) (bpf)

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

N(60) (bpf)

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

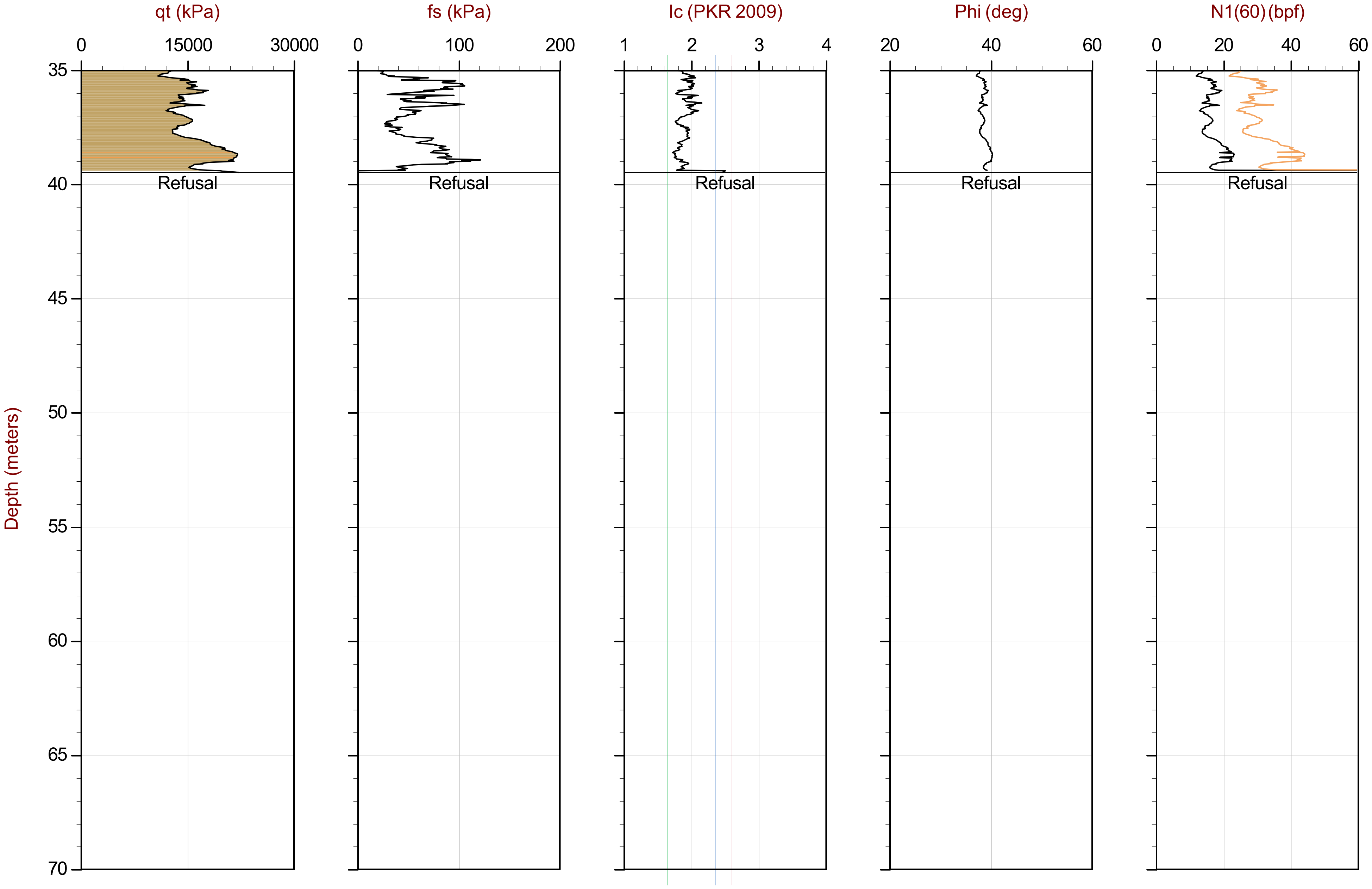
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

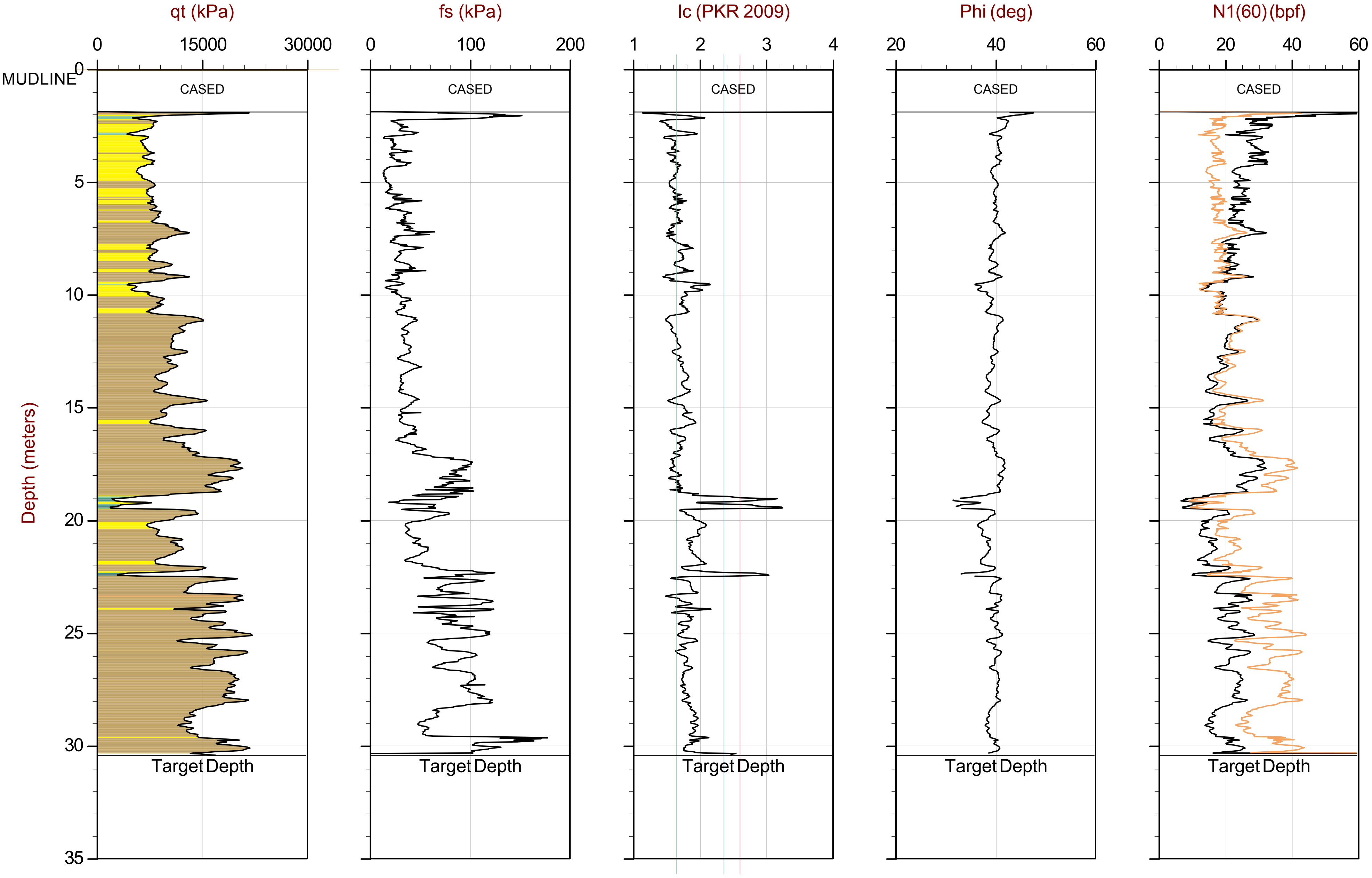
File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

Baffinland

Job No: 17-05010
Date: 2017-04-06 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500



Max Depth: 30.425 m / 99.82 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_CPD003.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N:7976757.71m E:503785.39m Elev:-22.68m

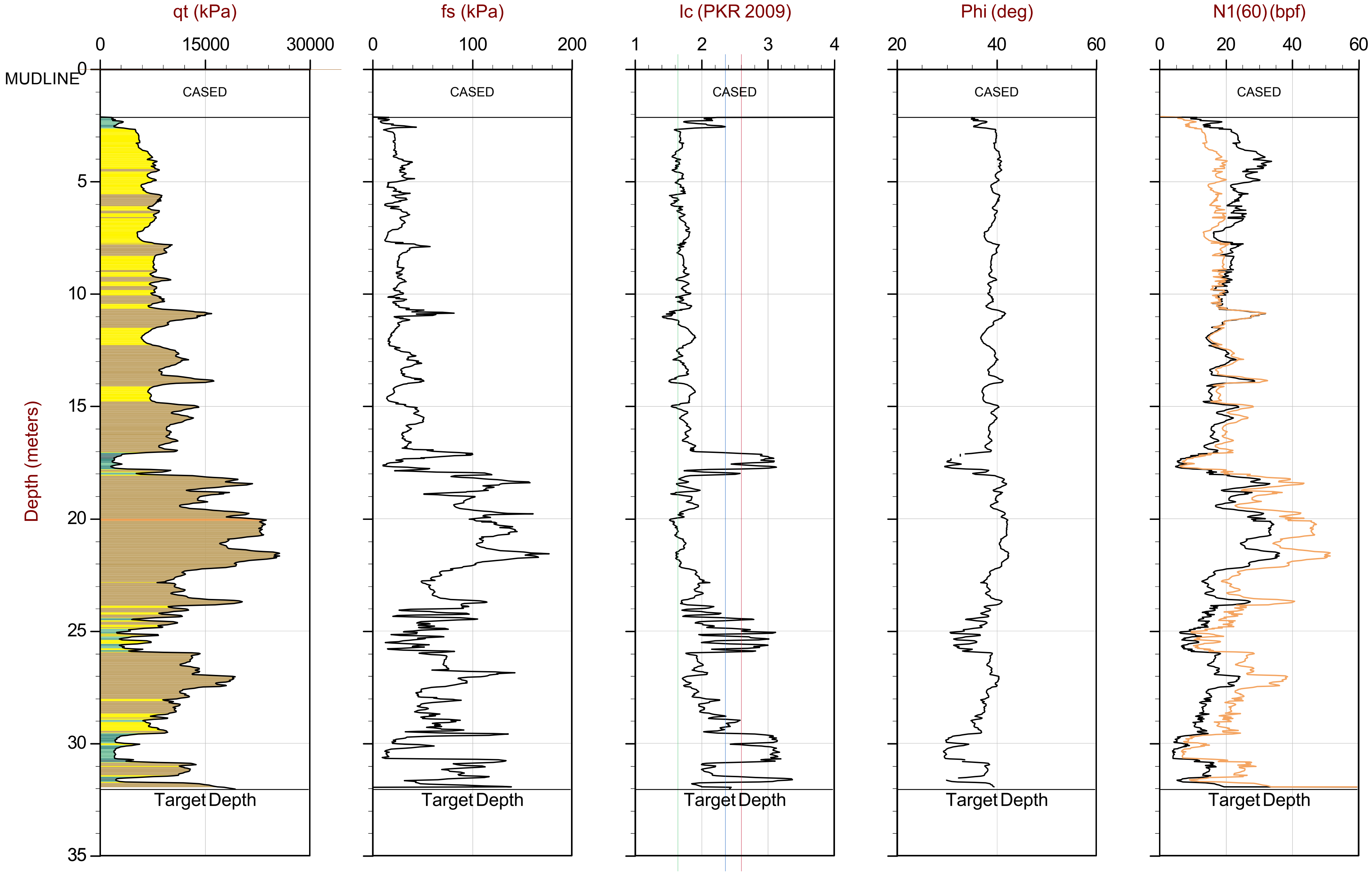
N(60) (bpf)

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-04 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500



Max Depth: 32.050 m / 105.15 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

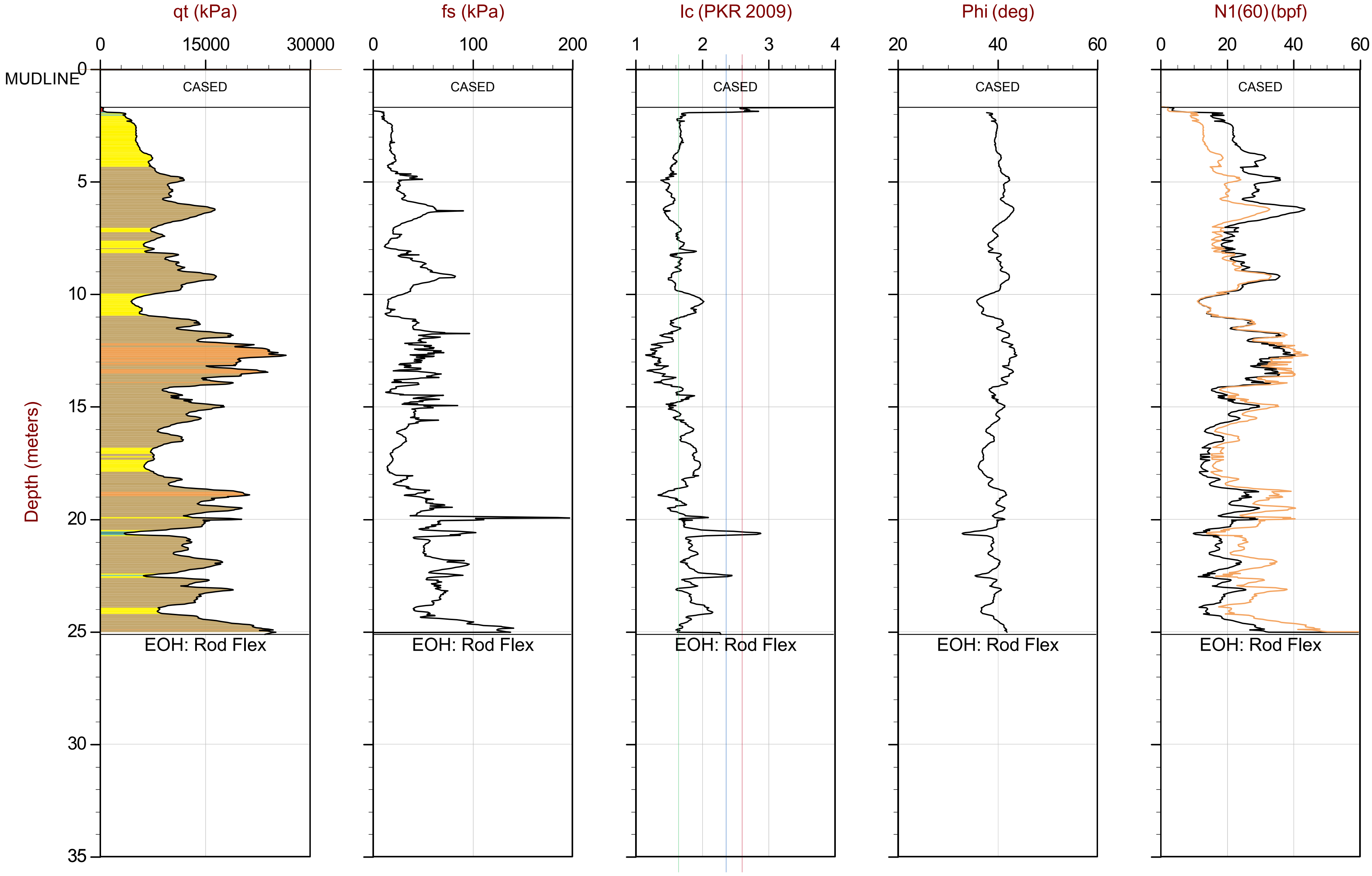
File: 17-05010_SPD004.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976768.10m E: 503646.44m Elev: -26.59m

Baffinland

Job No: 17-05010
Date: 2017-04-03 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500



Max Depth: 25.125 m / 82.43 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD005.COR
Unit Wt: SBT (R&C1986)

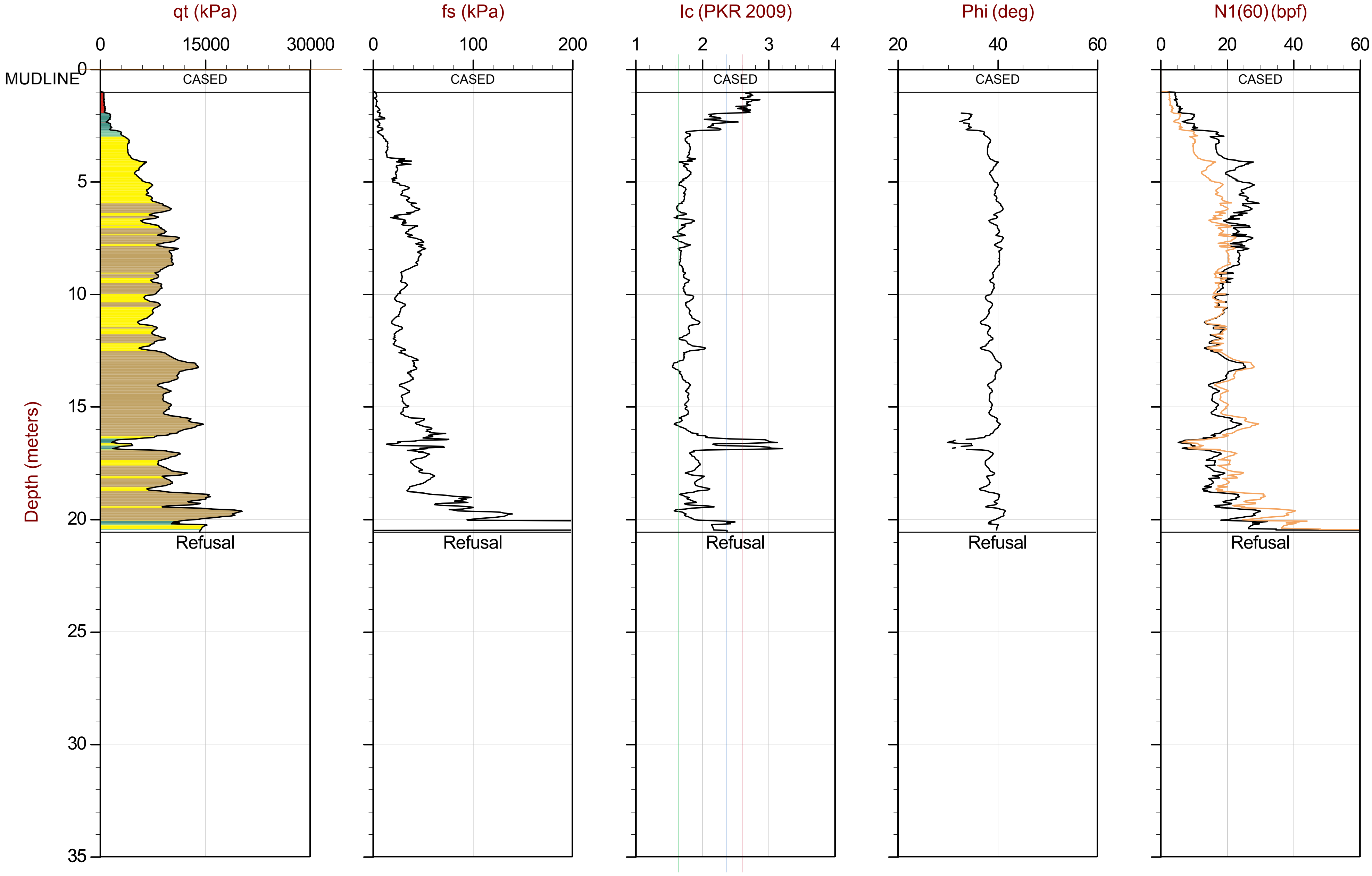
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976780.84m E: 503736.09m Elev: -24.98m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-06 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500



Max Depth: 20.575 m / 67.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

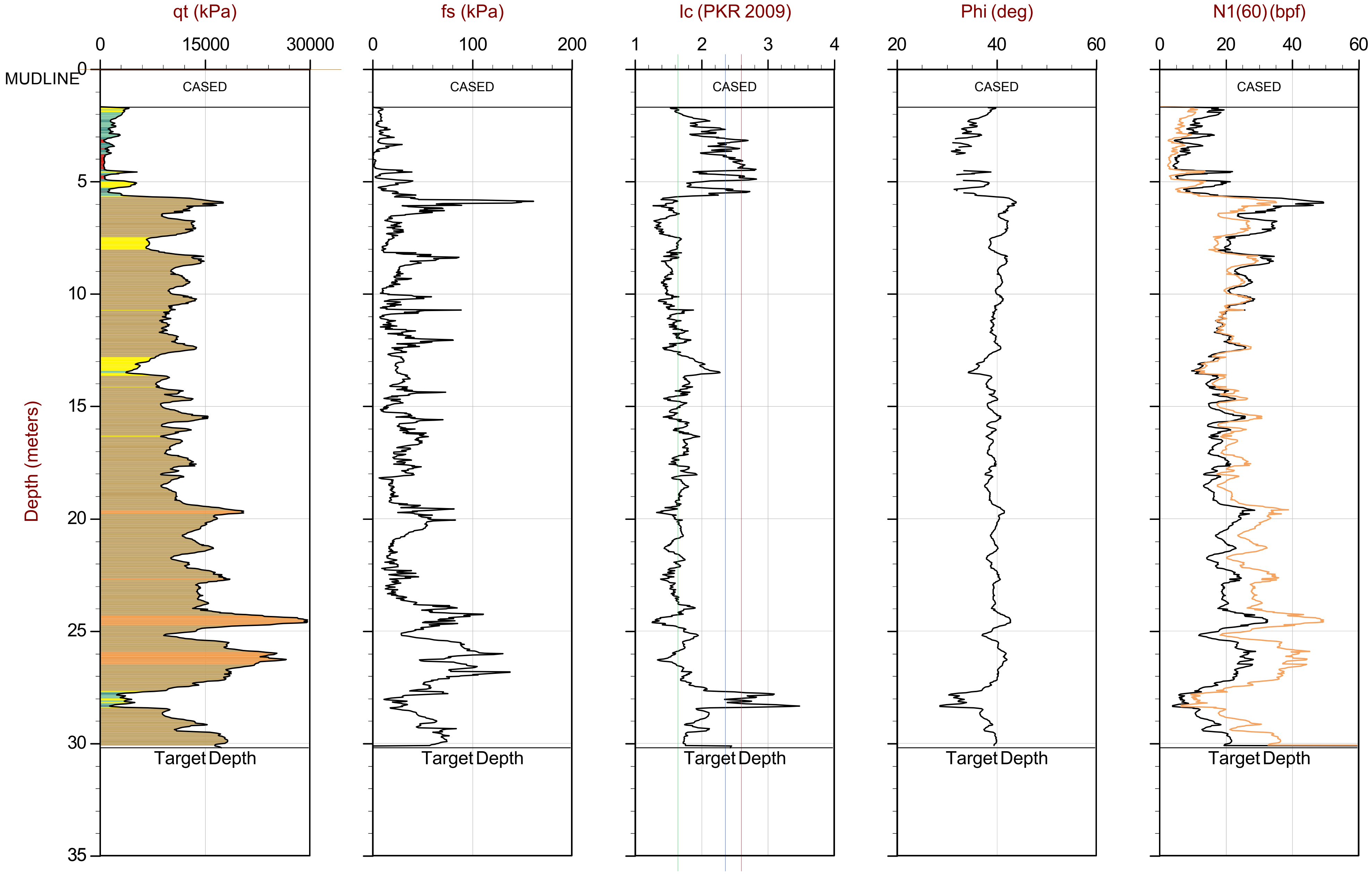
File: 17-05010_CPD006.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976808.43m E: 503807.55m Elev: -31.32m

Baffinland

Job No: 17-05010
Date: 2017-04-07 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500



Max Depth: 30.200 m / 99.08 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD007.COR
Unit Wt: SBT (R&C1986)

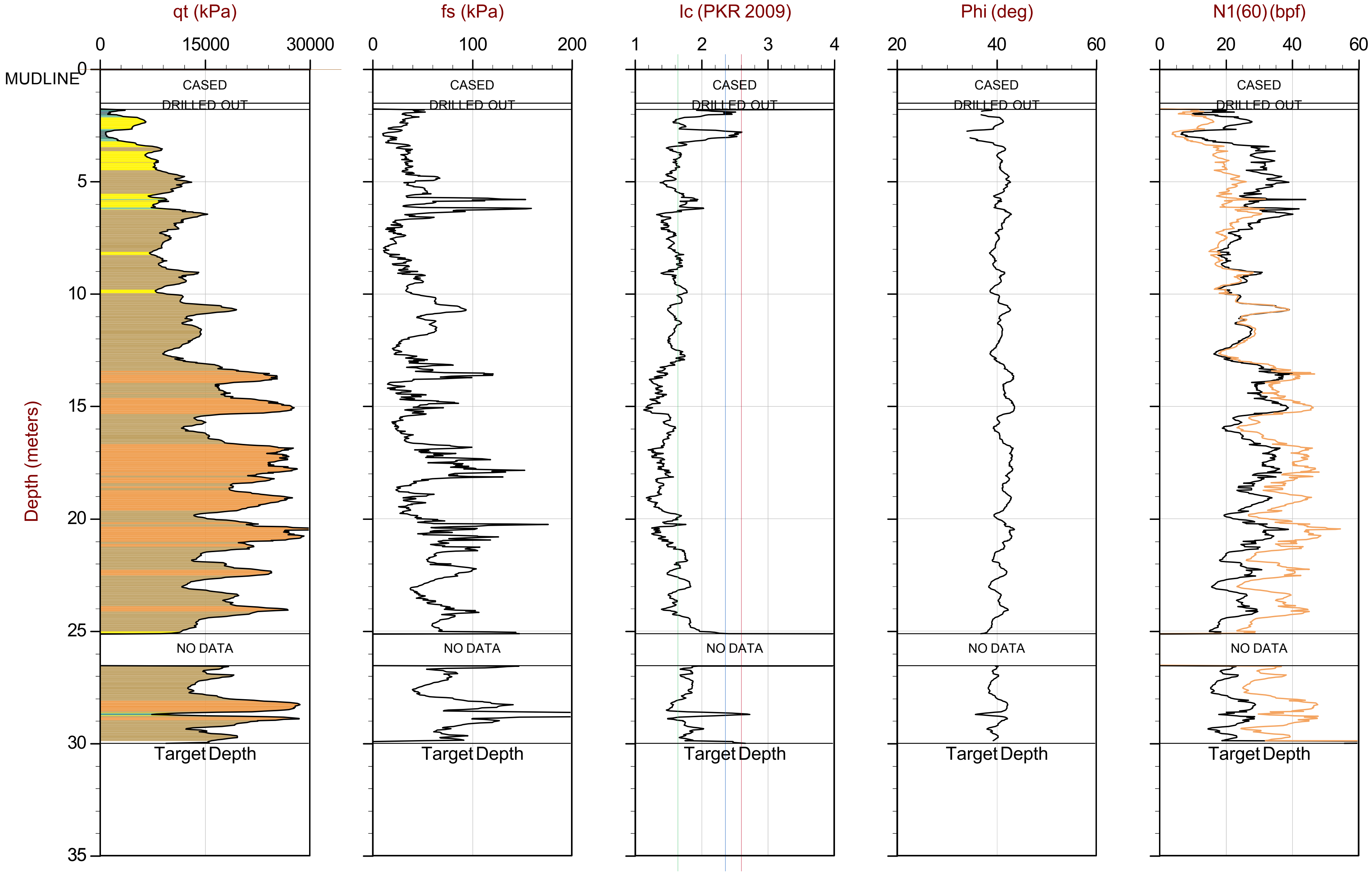
SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976683.63m E: 503767.46m Elev: -4.23m

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-07 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point
N(60) (bpf)

File: 17-05010_CPD008.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976650.76m E: 503635.99m Elev: -1.80m

Seismic Cone Penetration Test Tabular Results

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Sounding ID: SCPT17-D002
Date: 05-Apr-2017

Seismic Source: Auto-seismic
Source Offset (m): 4.30
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
3.38	3.18	5.35			
5.38	5.18	6.73	1.38	8.94	155
6.35	6.15	7.50	0.77	4.62	167
7.40	7.20	8.39	0.88	5.00	177
8.38	8.18	9.24	0.86	4.38	195
9.40	9.20	10.16	0.91	5.21	175
10.38	10.18	11.05	0.90	4.78	187
11.38	11.18	11.98	0.93	5.35	173
12.40	12.20	12.94	0.96	4.82	198
13.43	13.23	13.91	0.98	4.81	203
14.43	14.23	14.87	0.95	4.70	203
15.43	15.23	15.83	0.96	4.39	219
16.43	16.23	16.79	0.96	4.40	219
17.40	17.20	17.73	0.94	4.13	228
18.45	18.25	18.75	1.02	4.54	225
19.40	19.20	19.68	0.93	3.87	239
20.35	20.15	20.60	0.93	3.91	238
21.35	21.15	21.58	0.98	4.50	217
22.35	22.15	22.56	0.98	4.44	221
23.35	23.15	23.55	0.98	4.67	210
24.27	24.07	24.45	0.91	4.13	219
25.30	25.10	25.47	1.01	4.00	254
26.27	26.07	26.42	0.96	3.80	252

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Sounding ID: SCPT17-D002
Date: 05-Apr-2017

Seismic Source: Auto-seismic
Source Offset (m): 4.30
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
27.32	27.12	27.46	1.04	4.08	254
28.38	28.18	28.51	1.05	3.93	267
29.43	29.23	29.54	1.04	4.08	254
30.40	30.20	30.50	0.96	3.54	271
31.40	31.20	31.49	0.99	3.55	279
32.38	32.18	32.47	0.97	3.59	270
33.38	33.18	33.46	0.99	3.56	279
34.40	34.20	34.47	1.01	3.63	279
35.40	35.20	35.46	0.99	3.60	276
36.40	36.20	36.45	0.99	3.75	265
37.40	37.20	37.45	0.99	3.87	257
38.40	38.20	38.44	0.99	3.81	261
39.40	39.20	39.44	0.99	3.81	261

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Sounding ID: SCPT17-D004
Date: 04-Apr-2017

Seismic Source: Auto-seismic
Source Offset (m): 3.40
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
4.30	4.10	5.33			
5.30	5.10	6.13	0.80	4.48	179
6.20	6.00	6.90	0.77	3.86	198
7.20	7.00	7.78	0.89	3.86	229
8.20	8.00	8.69	0.91	4.17	218
9.20	9.00	9.62	0.93	4.33	214
10.95	10.75	11.27	1.65	7.11	233
11.93	11.73	12.21	0.94	3.87	243
12.93	12.73	13.18	0.96	4.33	223
13.95	13.75	14.16	0.99	4.10	241
14.88	14.68	15.07	0.90	3.75	241
15.88	15.68	16.04	0.98	4.50	217
16.88	16.68	17.02	0.98	4.05	242
17.85	17.65	17.97	0.95	4.80	198
18.85	18.65	18.96	0.98	3.75	262
19.88	19.68	19.97	1.01	4.21	241
20.90	20.70	20.98	1.01	3.94	255
21.82	21.62	21.89	0.91	3.18	286
22.82	22.62	22.87	0.99	3.63	272
23.85	23.65	23.89	1.02	4.39	232
24.80	24.60	24.83	0.94	3.63	259
25.80	25.60	25.82	0.99	4.09	242
26.80	26.60	26.82	0.99	3.63	273

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Sounding ID: SCPT17-D004
Date: 04-Apr-2017

Seismic Source: Auto-seismic
Source Offset (m): 3.40
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

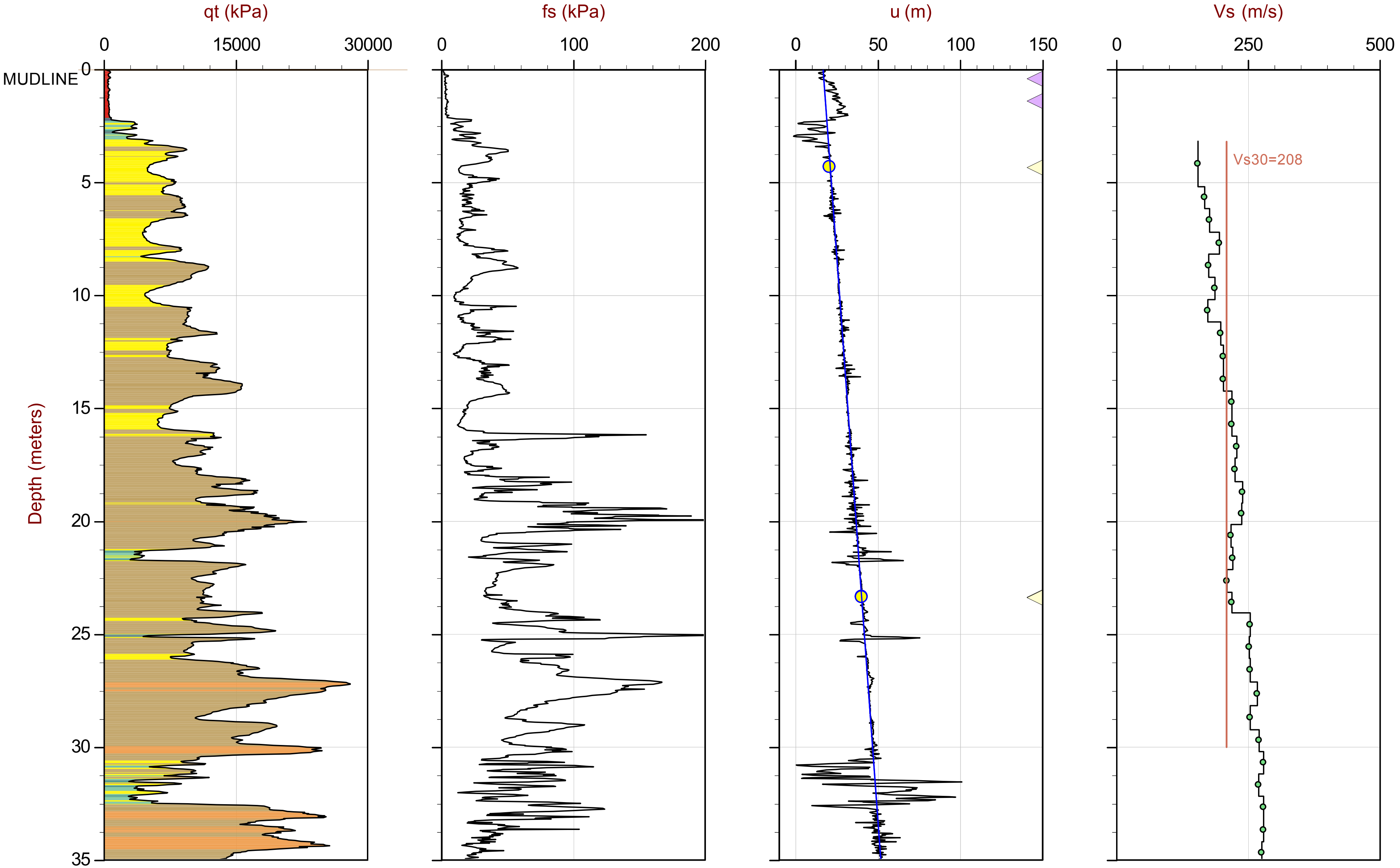
Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
27.82	27.62	27.83	1.01	3.63	278
28.82	28.62	28.82	0.99	3.94	252
29.82	29.62	29.81	0.99	3.79	262
30.77	30.57	30.76	0.94	3.48	271
31.80	31.60	31.78	1.02	3.79	270
32.05	31.85	32.03	0.25	0.91	274

Seismic Cone Penetration Test Plots

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

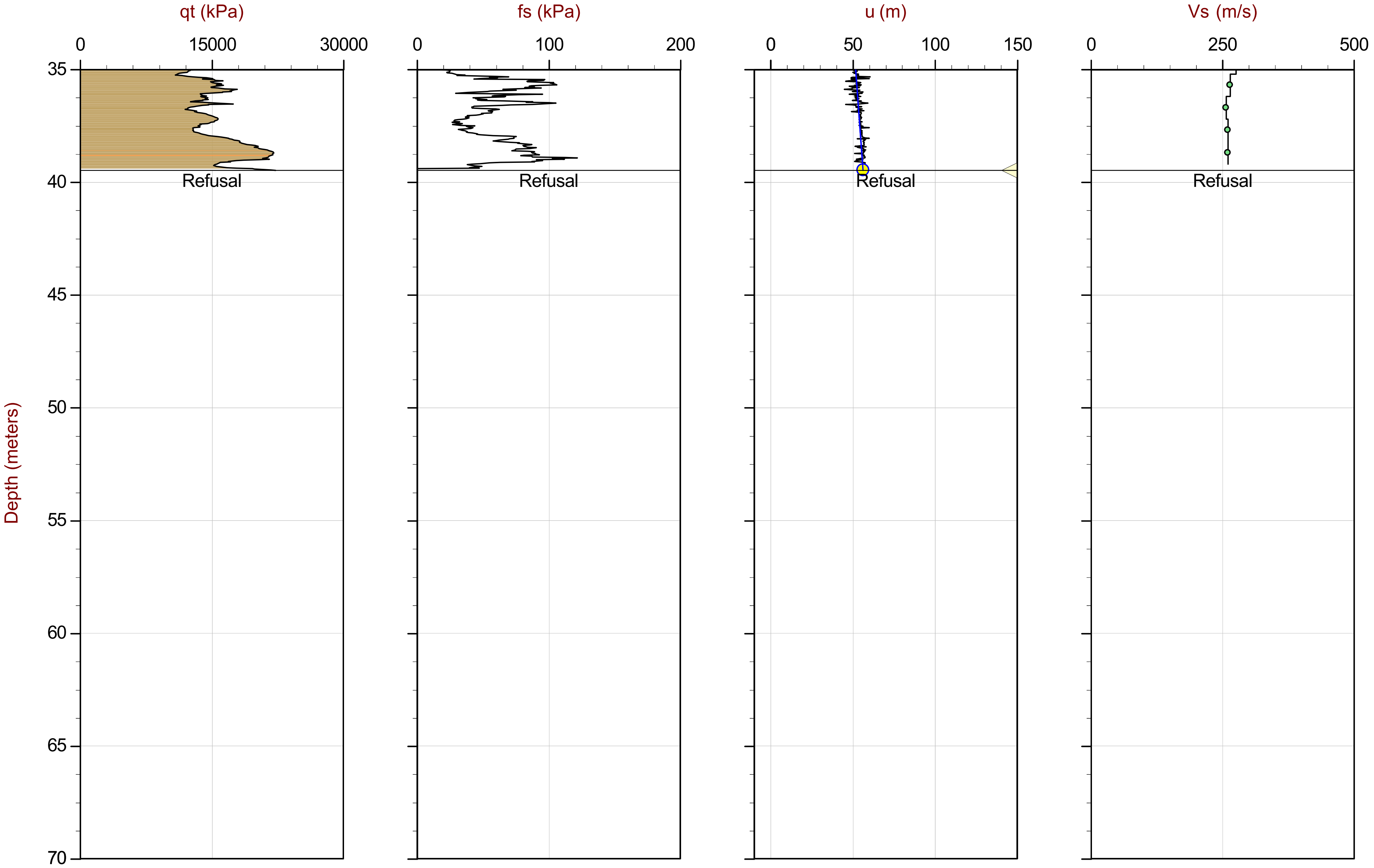
● Equilibrium Pore Pressure (Ueq)
◁ Dissipation, Ueq not achieved
◁ Dissipation, Ueq achieved
— Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-05 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500



Max Depth: 39.475 m / 129.51 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD002.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976728.05m E: 503705.30m Elev: -16.12m

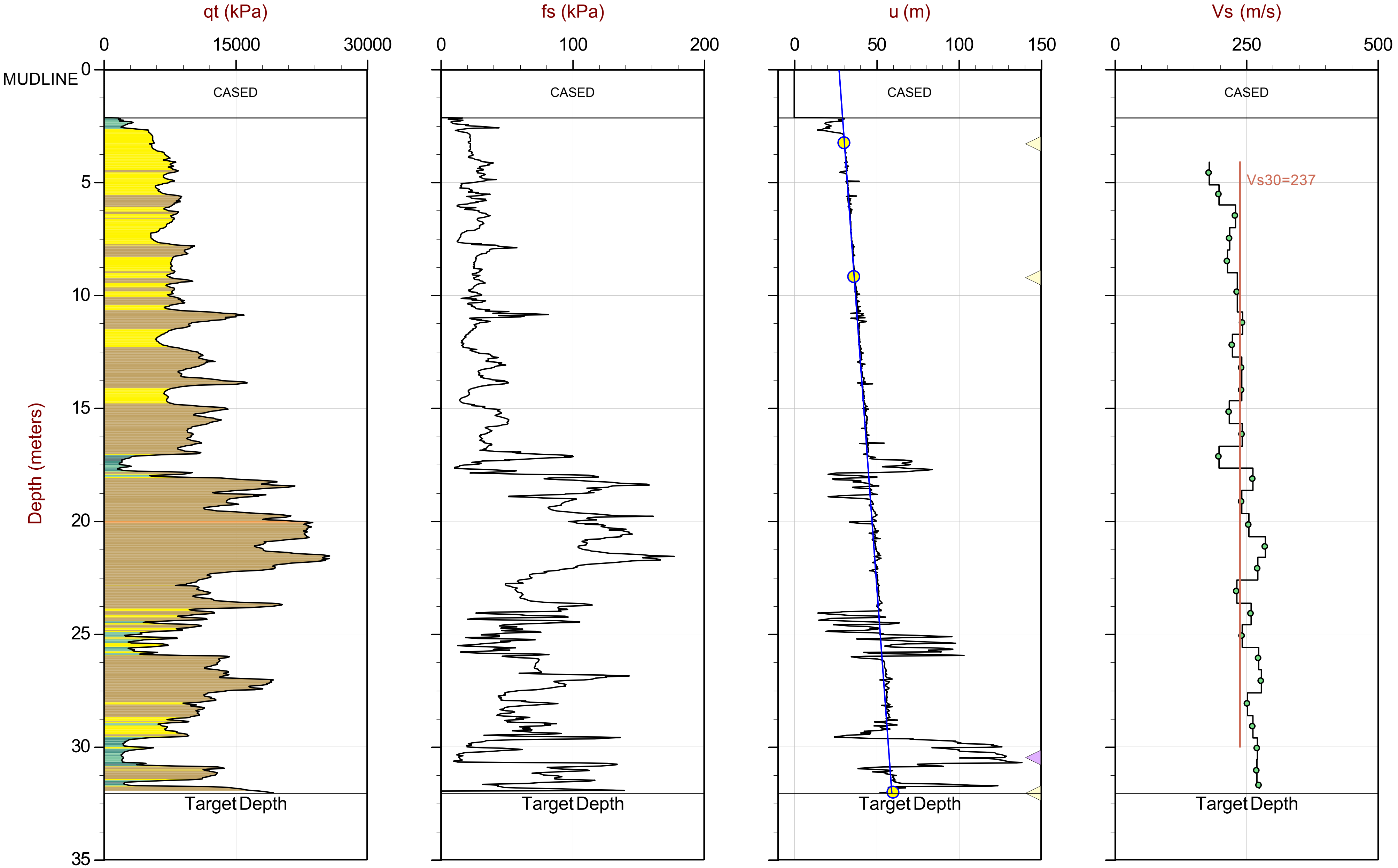
● Equilibrium Pore Pressure (Ueq)
◁ Dissipation, Ueq not achieved
◁ Dissipation, Ueq achieved
— Hydrostatic Line

CONETEC

Baffinland

Job No: 17-05010
Date: 2017-04-04 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500



Max Depth: 32.050 m / 105.15 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05010_SPD004.COR
Unit Wt: SBT (R&C1986)

SBT: Robertson and Campanella, 1986
Coords: UTM17N N: 7976768.10m E: 503646.44m Elev: -26.59m

● Equilibrium Pore Pressure (Ueq)
◀ Dissipation, Ueq not achieved
◁ Dissipation, Ueq achieved
— Hydrostatic Line

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

ConeTec

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Start Date: 03-Apr-2017
End Date: 07-Apr-2017

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Calculated Phreatic Surface (m)
CPT17-D001	17-05010_CPD001	15	260	3.275	Not Achieved	
CPT17-D001	17-05010_CPD001	15	95	6.400	24.0	-17.6
CPT17-D001	17-05010_CPD001	15	300	10.475	28.1	-17.6
CPT17-D001	17-05010_CPD001	15	100	19.850	37.5	-17.6
CPT17-D001	17-05010_CPD001	15	400	20.575	38.5	-17.9
CPT17-D001	17-05010_CPD001	15	95	28.650	45.6	-16.9
CPT17-D001	17-05010_CPD001	15	150	29.600	46.7	-17.1
CPT17-D001	17-05010_CPD001	15	400	32.750	50.4	-17.7
SCPT17-D002	17-05010_SPD002	15	105	0.400	Not Achieved	
SCPT17-D002	17-05010_SPD002	15	110	1.375	Not Achieved	
SCPT17-D002	17-05010_SPD002	15	150	4.325	20.7	-16.4
SCPT17-D002	17-05010_SPD002	15	600	23.350	40.2	-16.9
SCPT17-D002	17-05010_SPD002	15	275	23.375	40.4	-17.0
SCPT17-D002	17-05010_SPD002	15	200	39.475	56.6	-17.1
CPT17-D003	17-05010_CPD003	15	110	5.200	28.2	-23.0
CPT17-D003	17-05010_CPD003	15	400	15.300	38.5	-23.2
CPT17-D003	17-05010_CPD003	15	105	16.300	39.6	-23.3
CPT17-D003	17-05010_CPD003	15	1200	30.425	54.1	-23.7
SCPT17-D004	17-05010_SPD004	15	95	3.275	30.4	-27.1
SCPT17-D004	17-05010_SPD004	15	300	9.200	36.5	-27.3
SCPT17-D004	17-05010_SPD004	15	600	30.475	Not Achieved	
SCPT17-D004	17-05010_SPD004	15	300	32.050	60.3	-28.2
CPT17-D005	17-05010_CPD005	15	1340	2.275	28.3	-26.0
CPT17-D005	17-05010_CPD005	15	110	3.325	29.5	-26.2
CPT17-D005	17-05010_CPD005	15	95	5.375	31.8	-26.4
CPT17-D005	17-05010_CPD005	15	145	6.375	Not Achieved	
CPT17-D005	17-05010_CPD005	15	110	7.400	33.5	-26.1
CPT17-D005	17-05010_CPD005	15	125	9.350	Not Achieved	
CPT17-D005	17-05010_CPD005	15	300	10.300	36.5	-26.2

CONETEC

Job No: 17-05010
Client: Baffinland Iron Mines Corporation
Project: Milne Port Expansion
Start Date: 03-Apr-2017
End Date: 07-Apr-2017

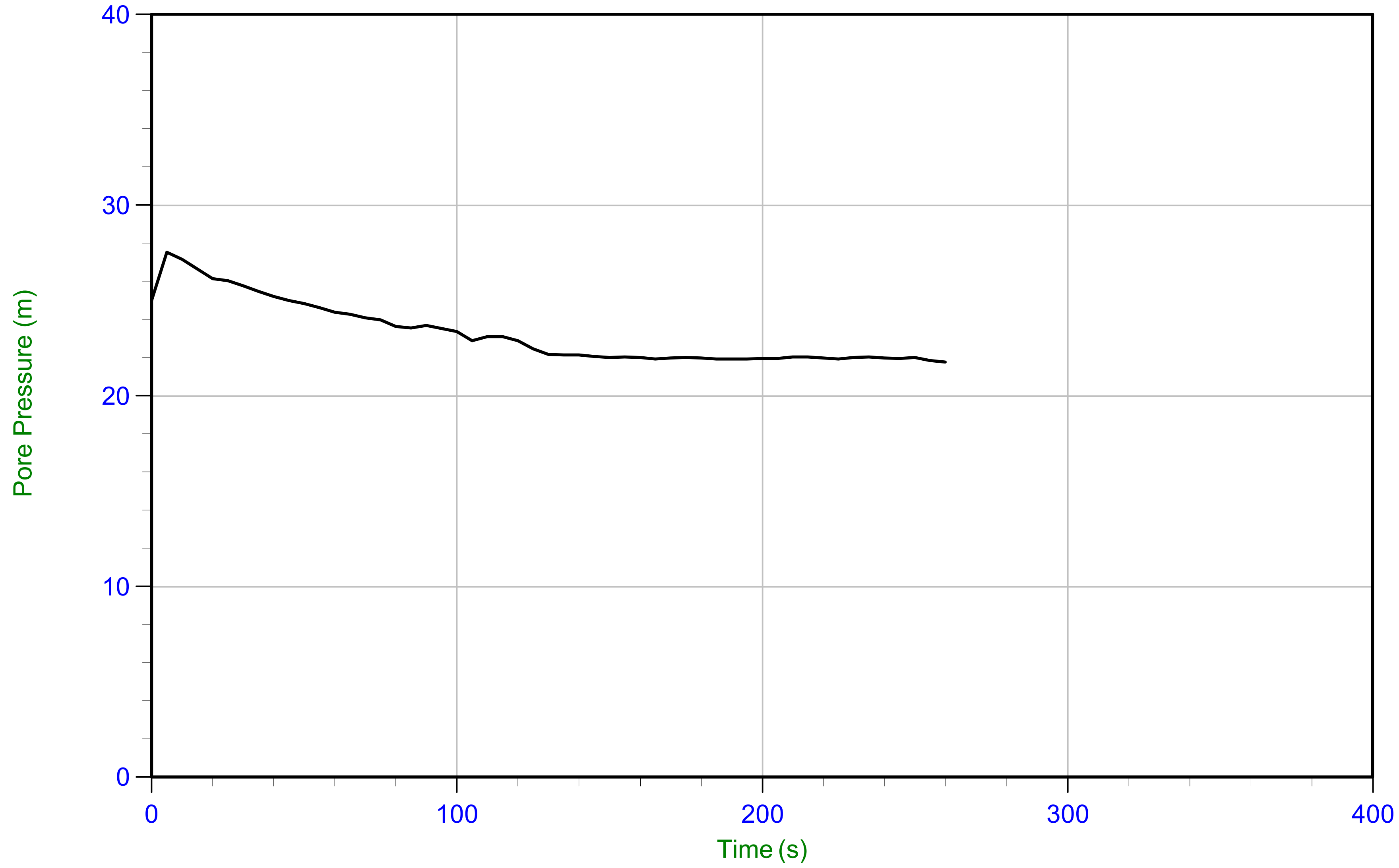
CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Calculated Phreatic Surface (m)
CPT17-D005	17-05010_CPD005	15	1460	12.350	38.8	-26.4
CPT17-D005	17-05010_CPD005	15	275	13.175	Not Achieved	
CPT17-D005	17-05010_CPD005	15	305	15.050	41.7	-26.6
CPT17-D005	17-05010_CPD005	15	165	18.100	44.7	-26.6
CPT17-D005	17-05010_CPD005	15	130	23.925	50.7	-26.8
CPT17-D005	17-05010_CPD005	15	300	25.125	51.9	-26.8
CPT17-D006	17-05010_CPD006	15	105	2.300	Not Achieved	
CPT17-D006	17-05010_CPD006	15	2100	3.300	35.3	-32.0
CPT17-D006	17-05010_CPD006	15	300	20.575	52.4	-31.8
CPT17-D007	17-05010_CPD007	15	200	10.100	14.8	-4.7
CPT17-D007	17-05010_CPD007	15	200	20.150	25.1	-5.0
CPT17-D007	17-05010_CPD007	15	200	30.200	35.5	-5.3
CPT17-D008	17-05010_CPD008	15	180	2.075	Not Achieved	
CPT17-D008	17-05010_CPD008	15	200	20.500	21.9	-1.4
CPT17-D008	17-05010_CPD008	15	120	28.975	30.4	-1.4
CPT17-D008	17-05010_CPD008	15	405	30.000	32.2	-2.2

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 3.275 m / 10.745 ft
Duration: 260.0 s

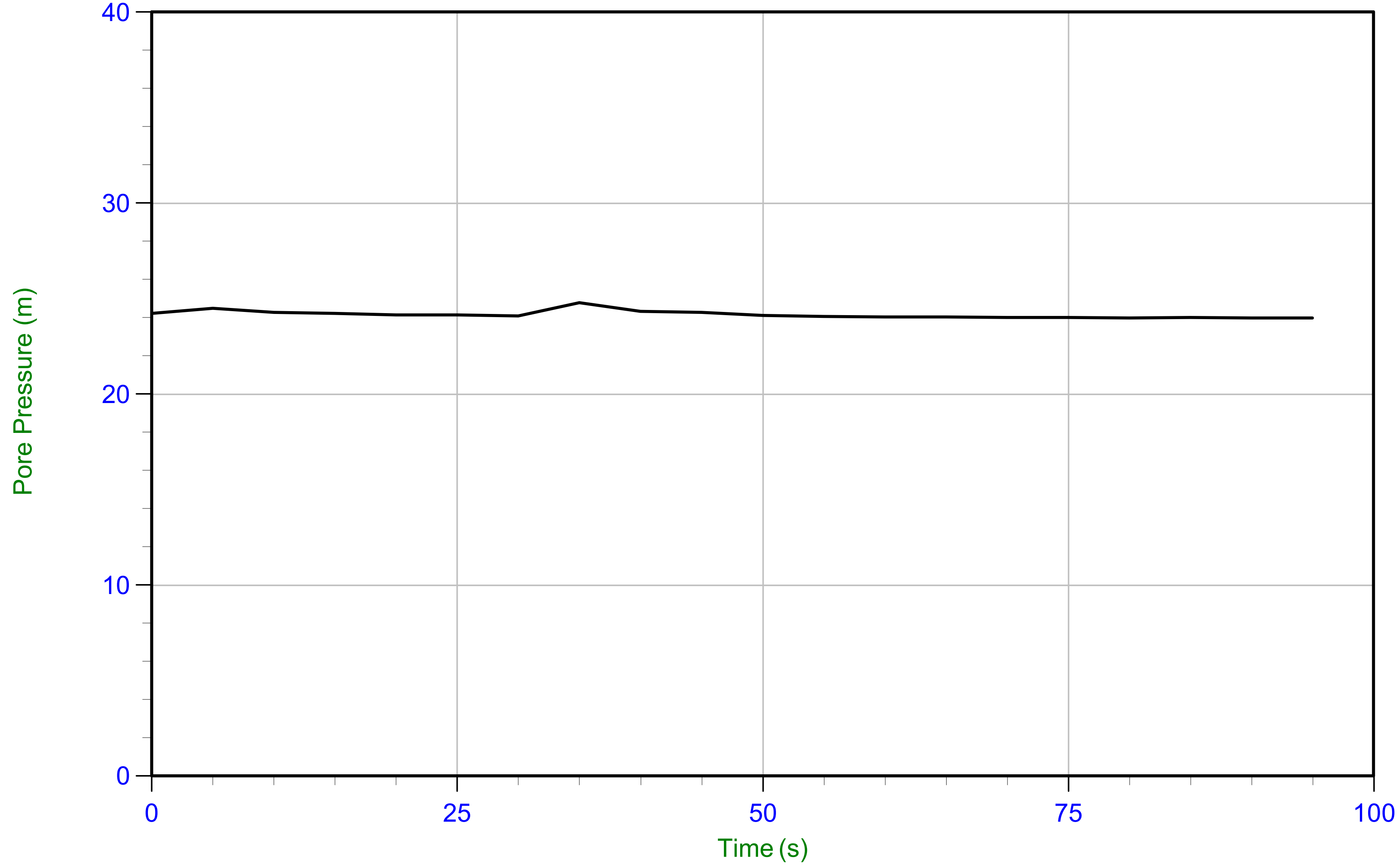
U Min: 21.8 m
U Max: 27.5 m

ConeTec

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²

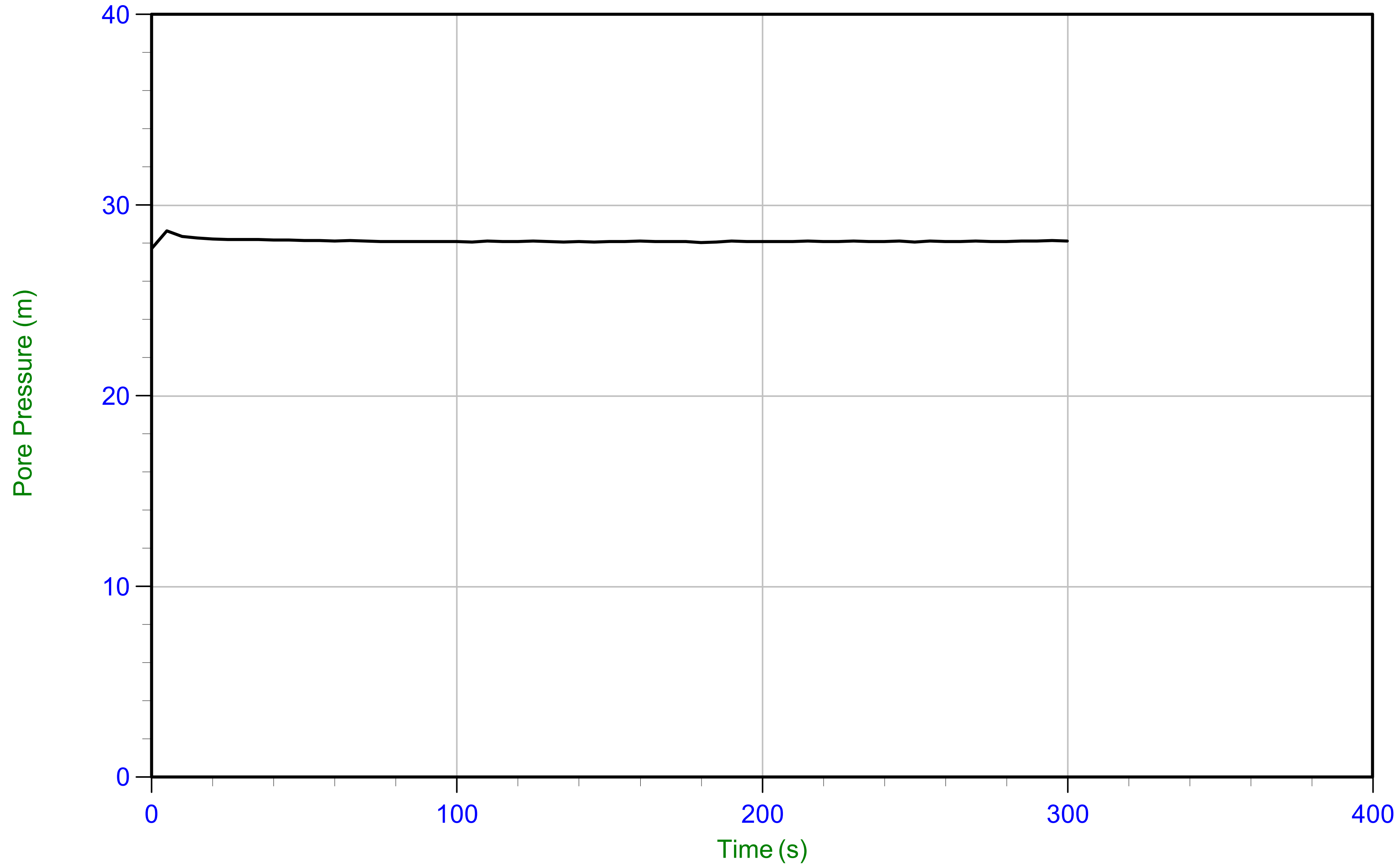


Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 6.400 m / 20.997 ft
Duration: 95.0 s

U Min: 24.0 m
U Max: 24.8 m

WT: -17.600 m / -57.742 ft
Ueq: 24.0 m



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 10.475 m / 34.366 ft
Duration: 300.0 s

U Min: 27.7 m
U Max: 28.6 m

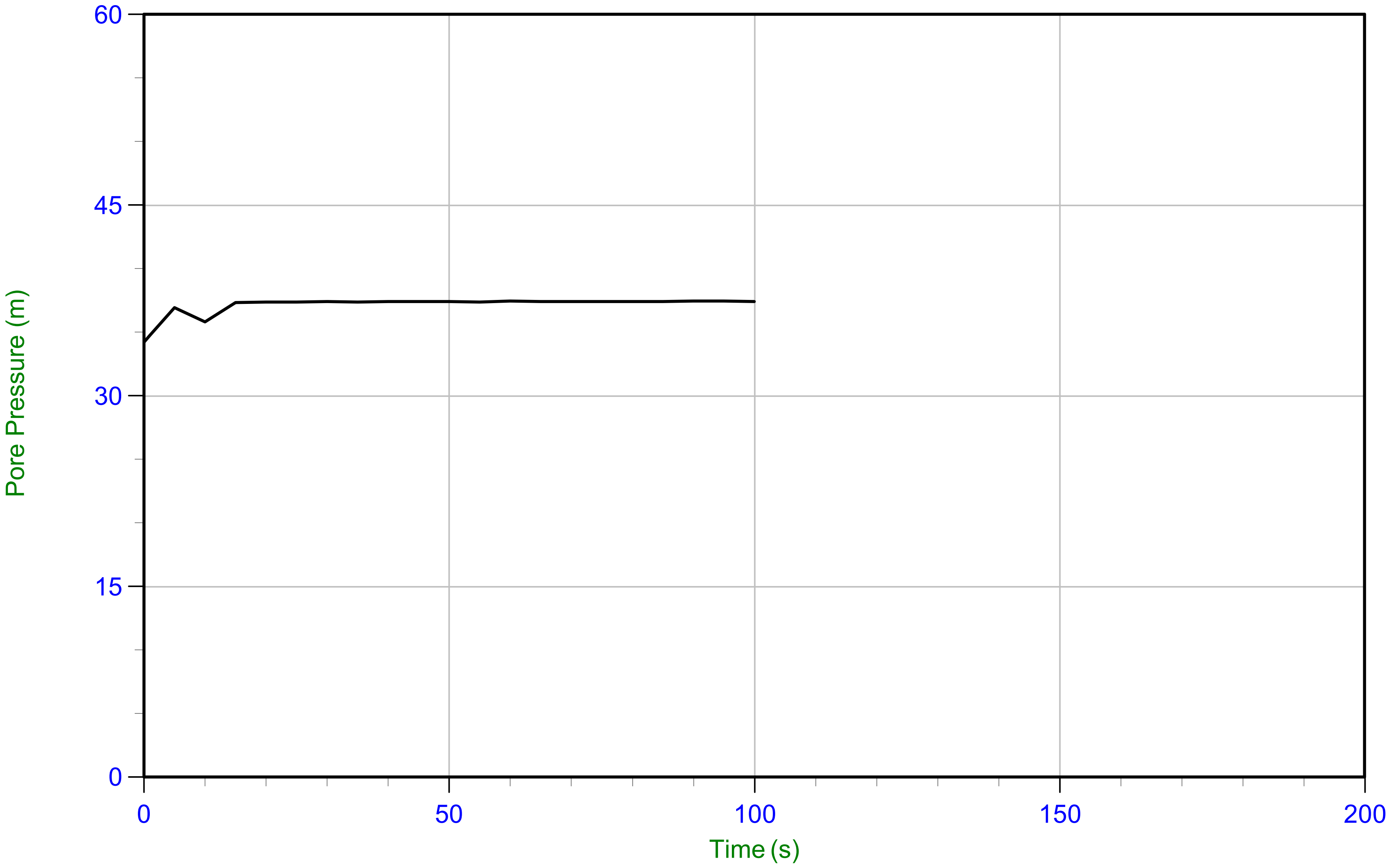
WT: -17.646 m / -57.893 ft
Ueq: 28.1 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 19.850 m / 65.124 ft
Duration: 100.0 s

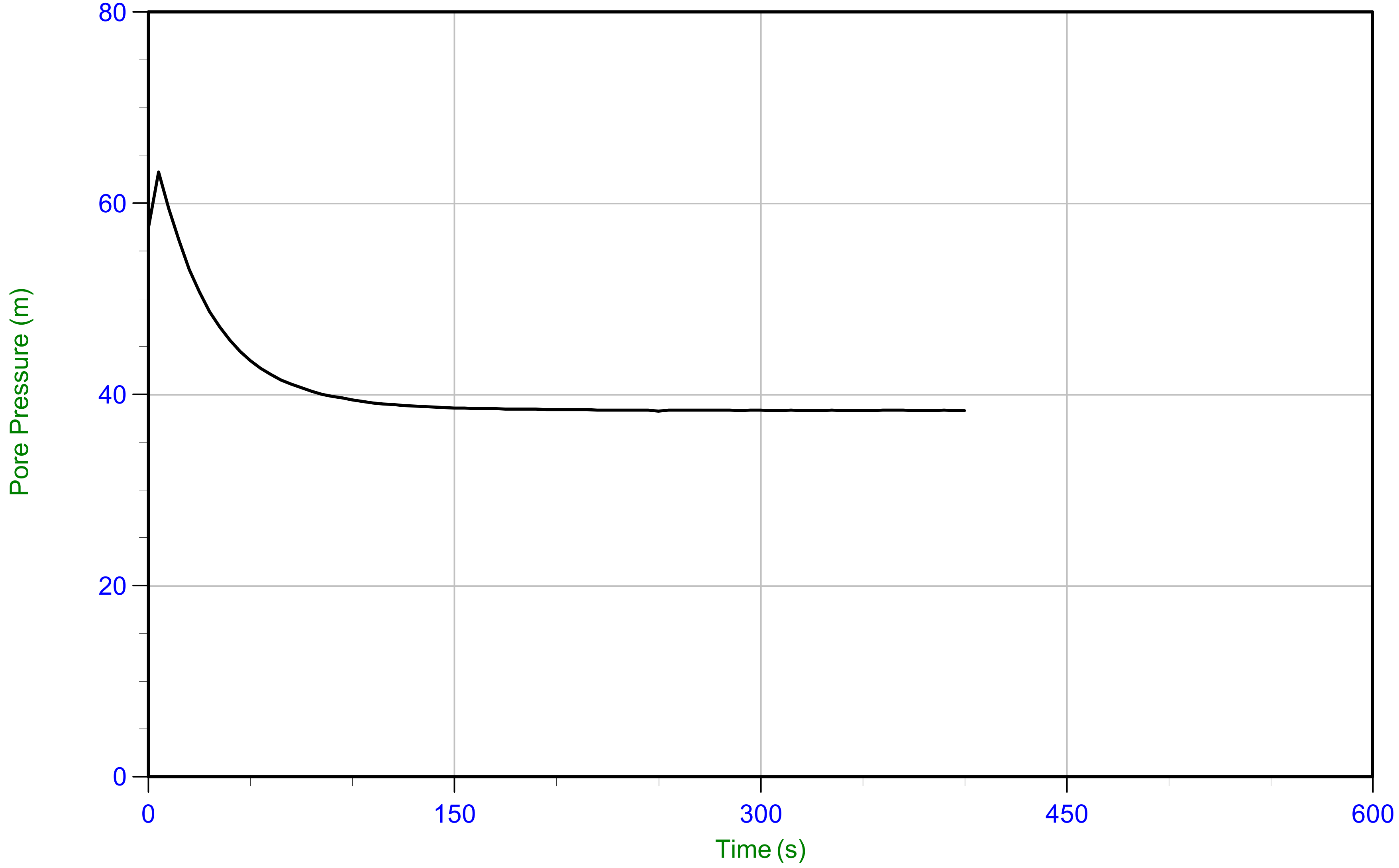
U Min: 34.2 m
U Max: 37.5 m

WT: -17.605 m / -57.758 ft
Ueq: 37.5 m

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 20.575 m / 67.502 ft
Duration: 400.0 s

U Min: 38.3 m
U Max: 63.3 m

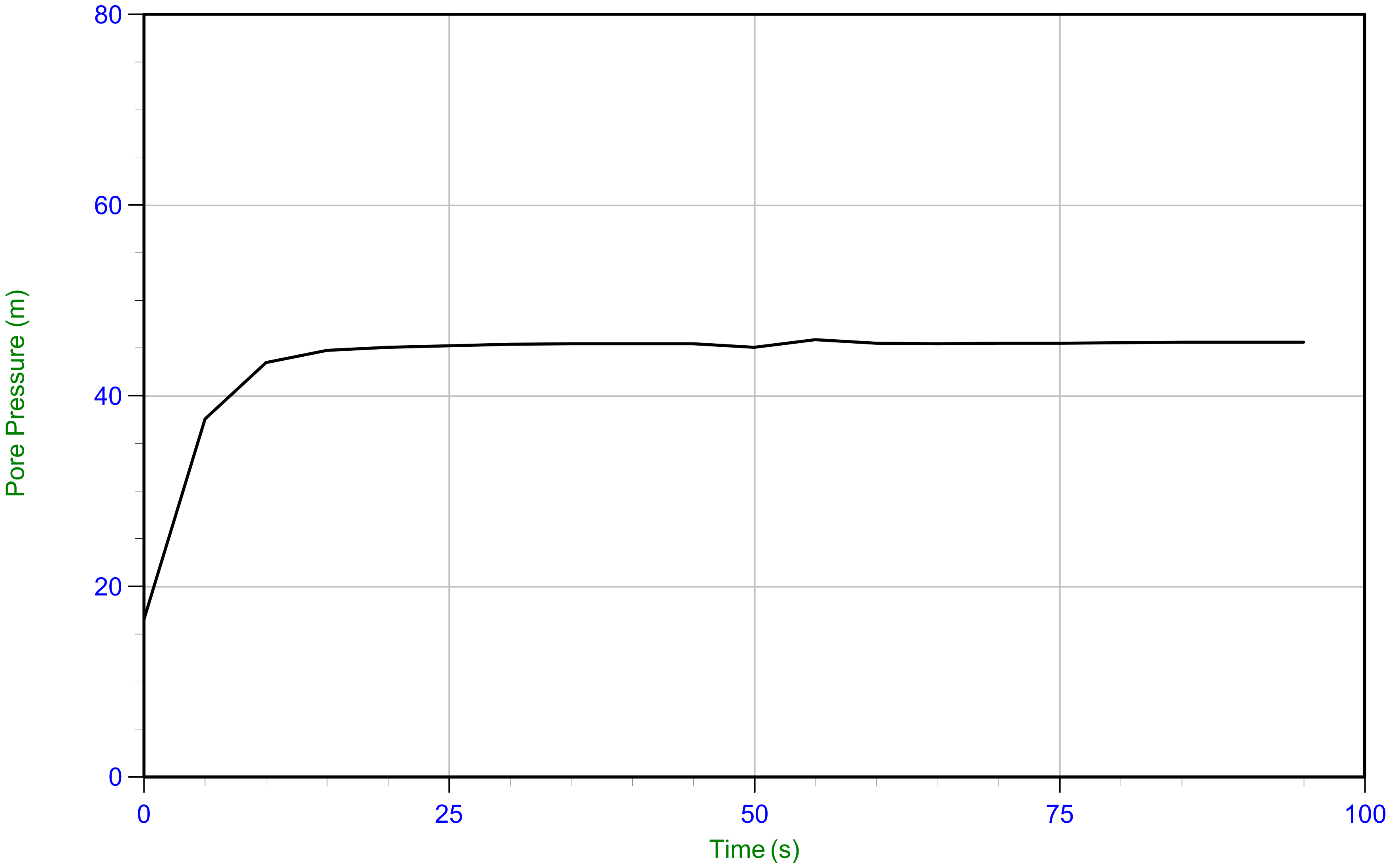
WT: -17.890 m / -58.694 ft
Ueq: 38.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 28.650 m / 93.995 ft
Duration: 95.0 s

U Min: 16.6 m
U Max: 45.9 m

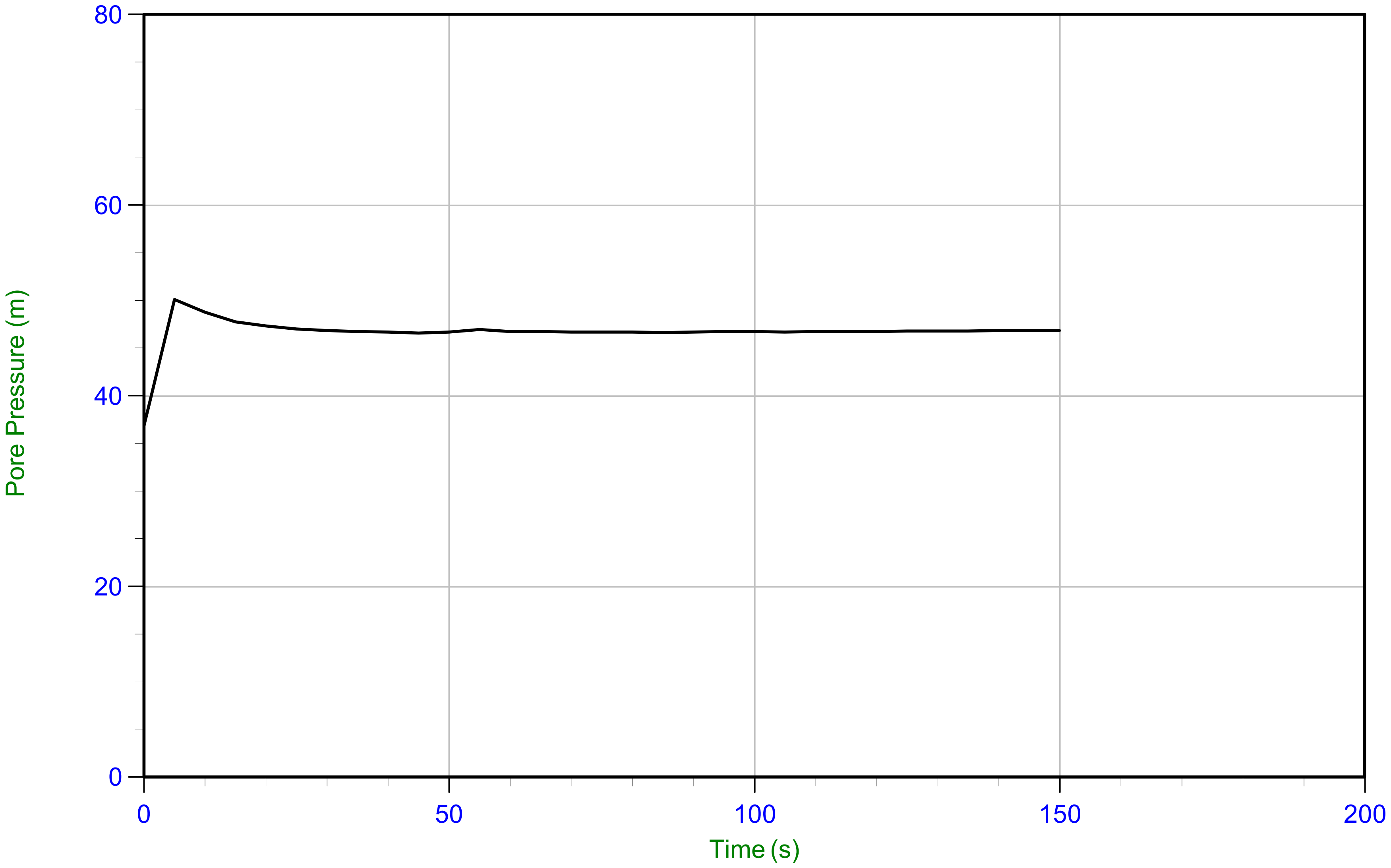
WT: -16.926 m / -55.531 ft
Ueq: 45.6 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 09:17
Site: Milne Port Expansion

Sounding: CPT17-D001
Cone: 338:T1500F15U500 Area=15 cm²

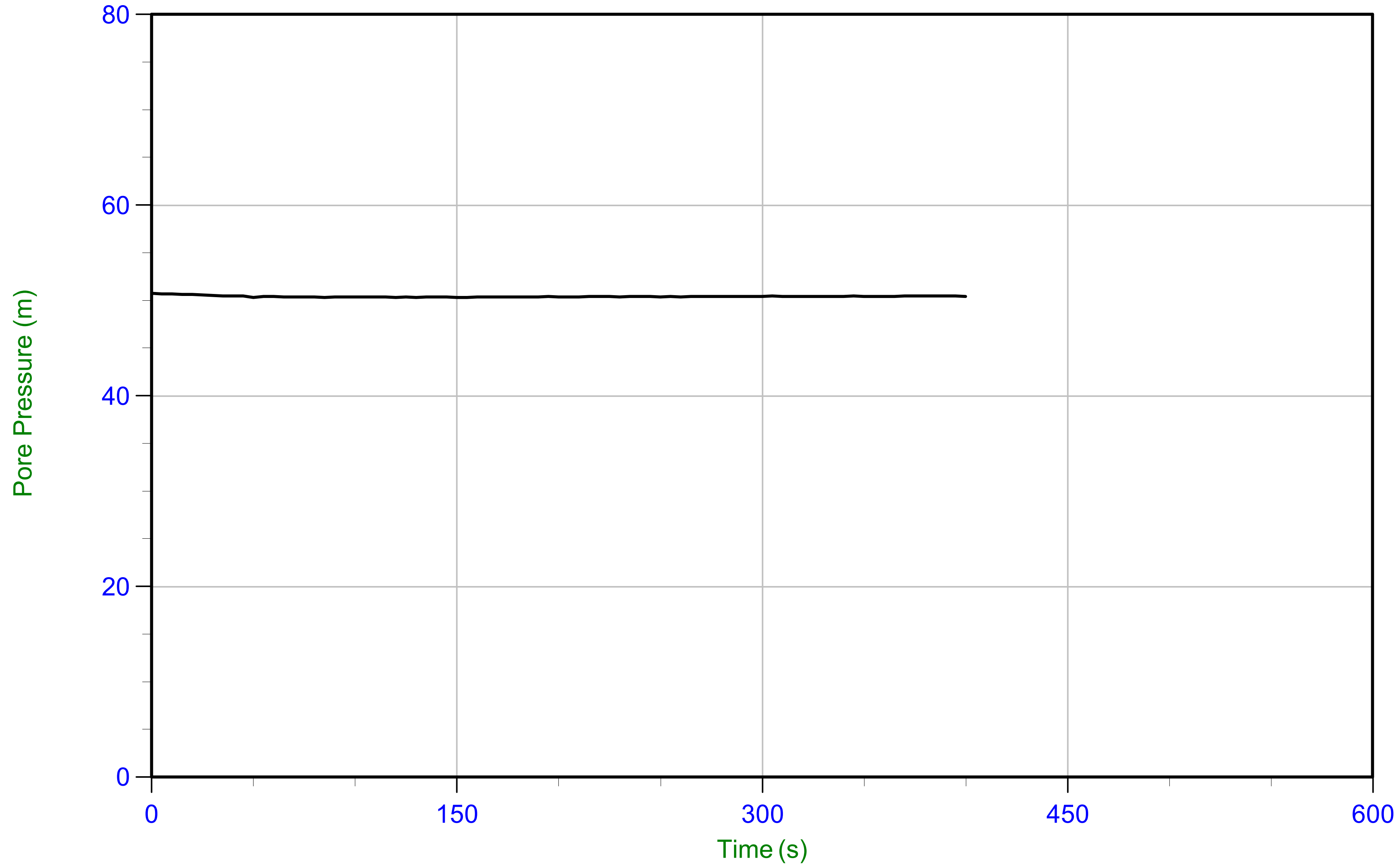


Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 29.600 m / 97.112 ft
Duration: 150.0 s

U Min: 36.9 m
U Max: 50.1 m

WT: -17.107 m / -56.125 ft
Ueq: 46.7 m



Trace Summary:

Filename: 17-05010_CPD001.PPF
Depth: 32.750 m / 107.446 ft
Duration: 400.0 s

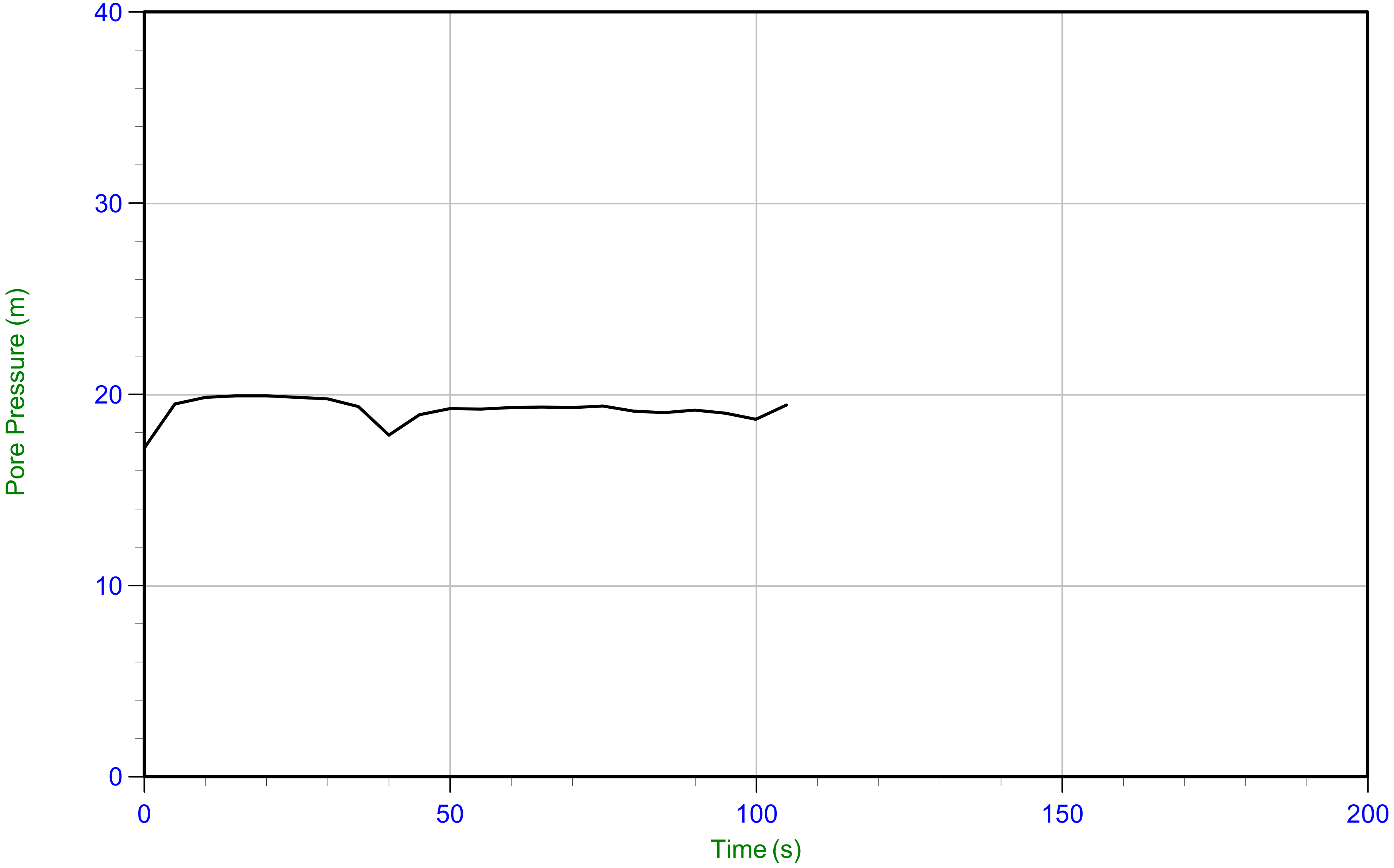
U Min: 50.3 m
U Max: 50.7 m

WT: -17.674 m / -57.985 ft
Ueq: 50.4 m

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

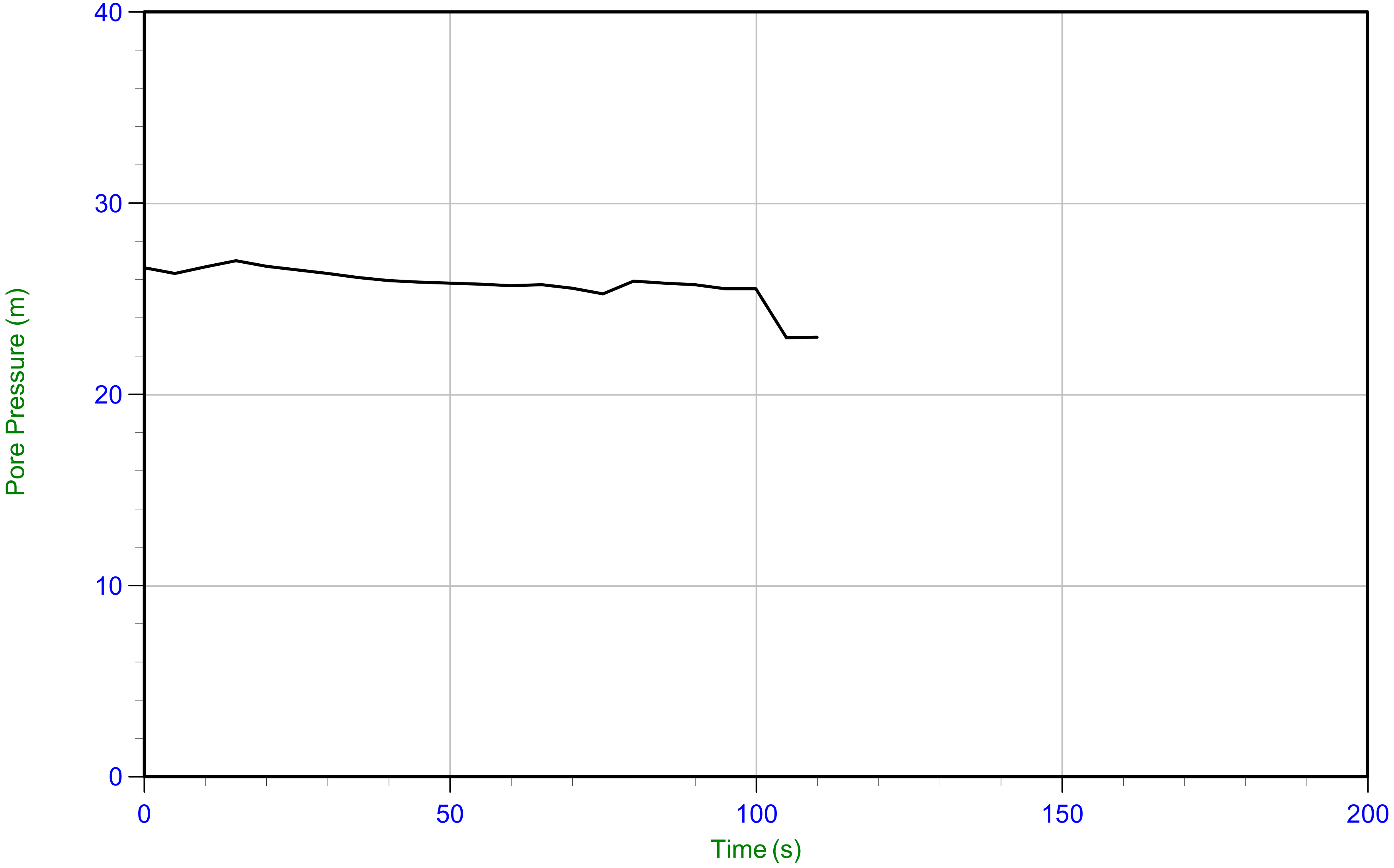
Filename: 17-05010_SPD002.PPF
Depth: 0.400 m / 1.312 ft
Duration: 105.0 s

U Min: 17.2 m
U Max: 19.9 m

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

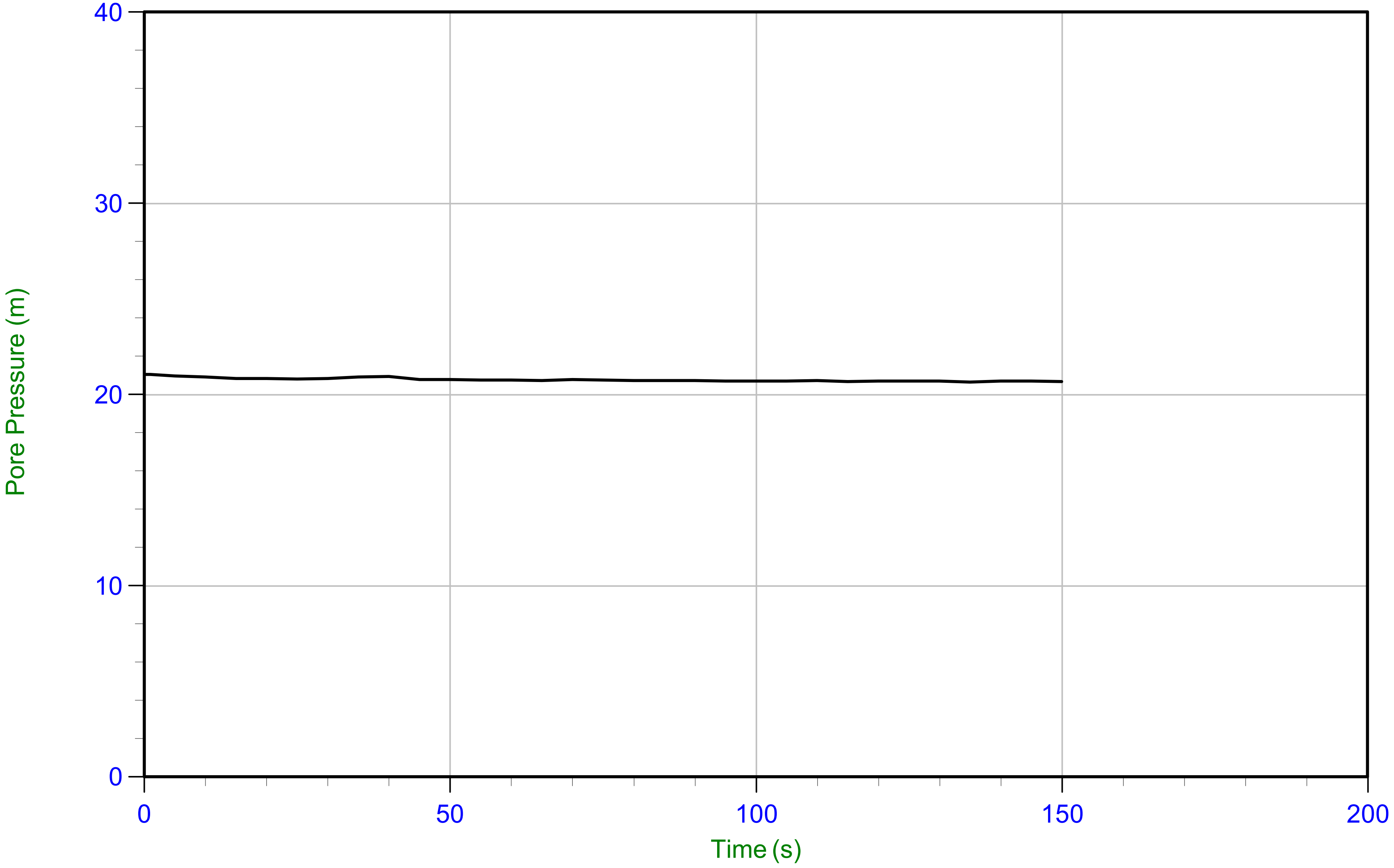
Filename: 17-05010_SPD002.PPF
Depth: 1.375 m / 4.511 ft
Duration: 110.0 s

U Min: 23.0 m
U Max: 27.0 m

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²

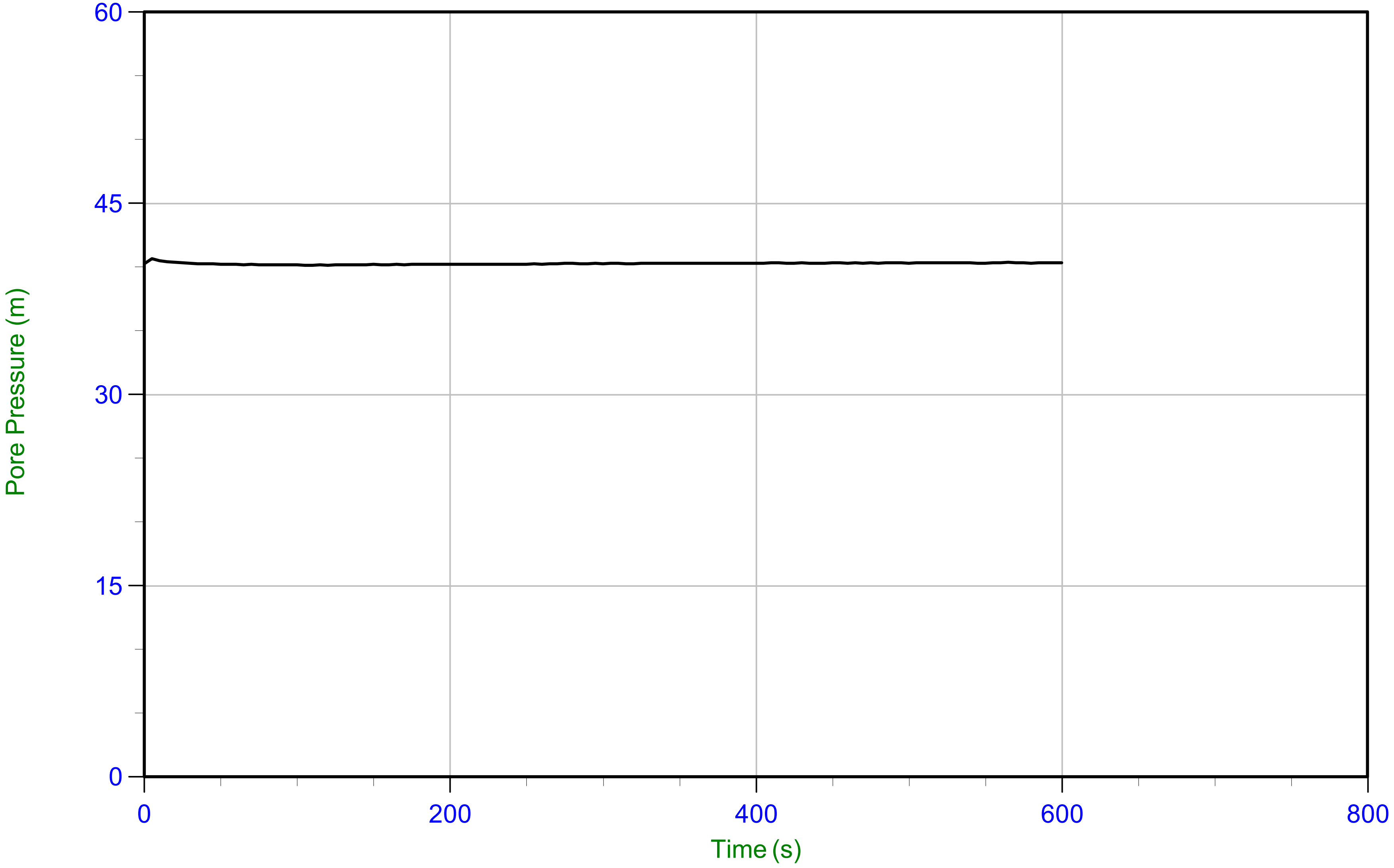


Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 4.325 m / 14.189 ft
Duration: 150.0 s

U Min: 20.7 m
U Max: 21.1 m

WT: -16.362 m / -53.680 ft
Ueq: 20.7 m



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 23.350 m / 76.607 ft
Duration: 600.0 s

U Min: 40.1 m
U Max: 40.6 m

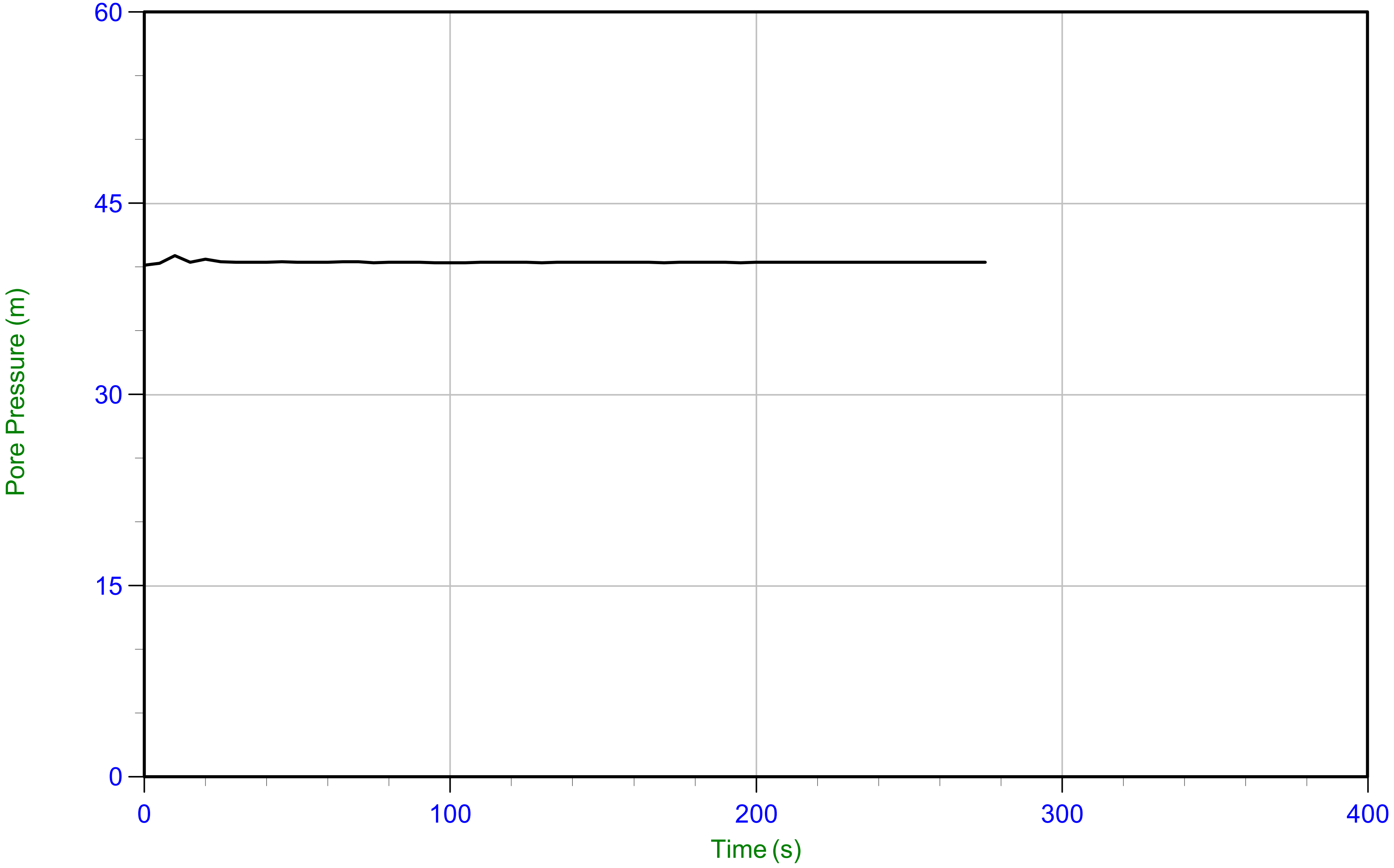
WT: -16.892 m / -55.419 ft
Ueq: 40.2 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 23.375 m / 76.689 ft
Duration: 275.0 s

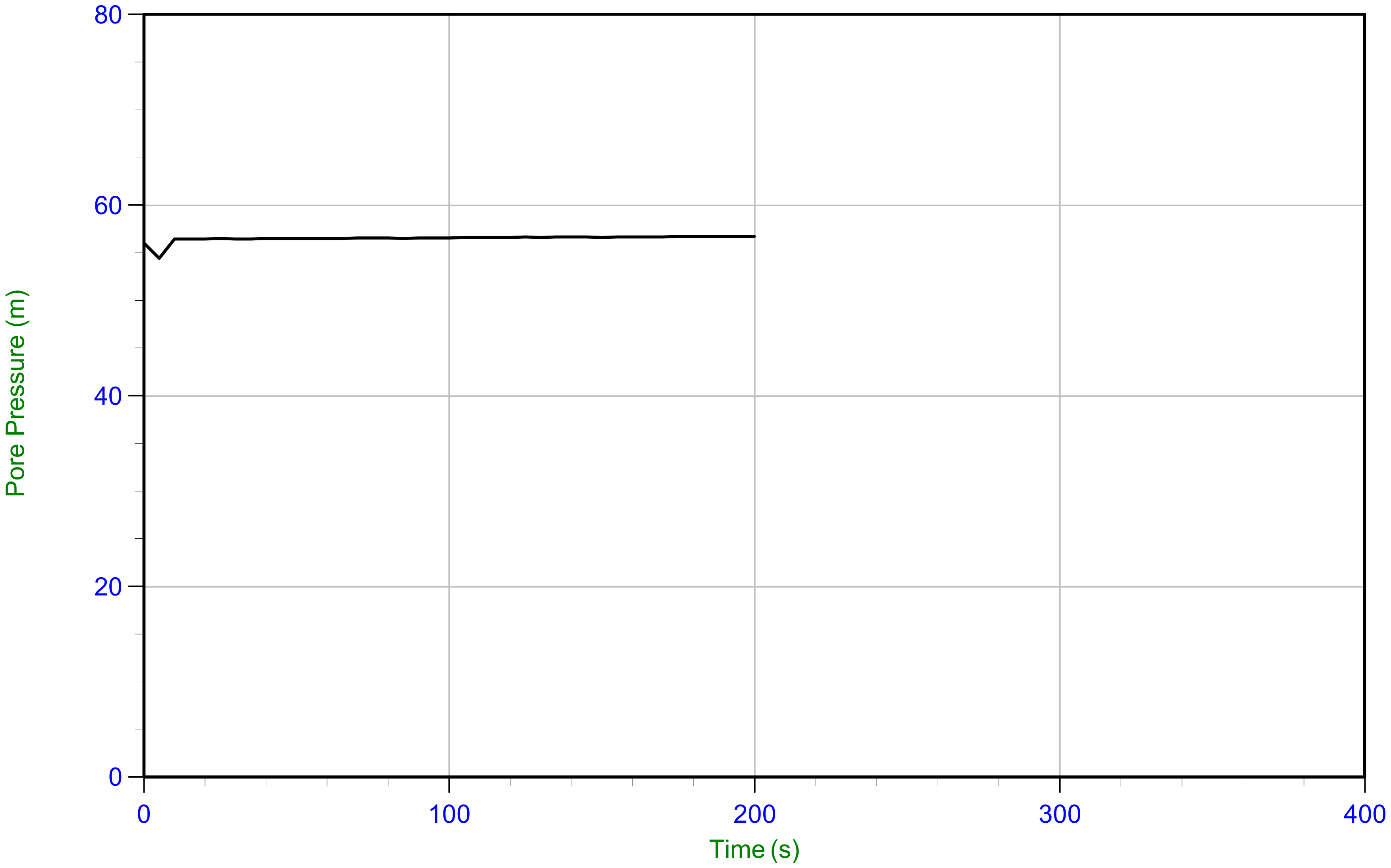
U Min: 40.2 m
U Max: 40.9 m

WT: -16.989 m / -55.738 ft
Ueq: 40.4 m

Baffinland

Job No: 17-05010
Date: 04/05/2017 20:44
Site: Milne Port Expansion

Sounding: SCPT17-D002
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD002.PPF
Depth: 39.475 m / 129.510 ft
Duration: 200.0 s

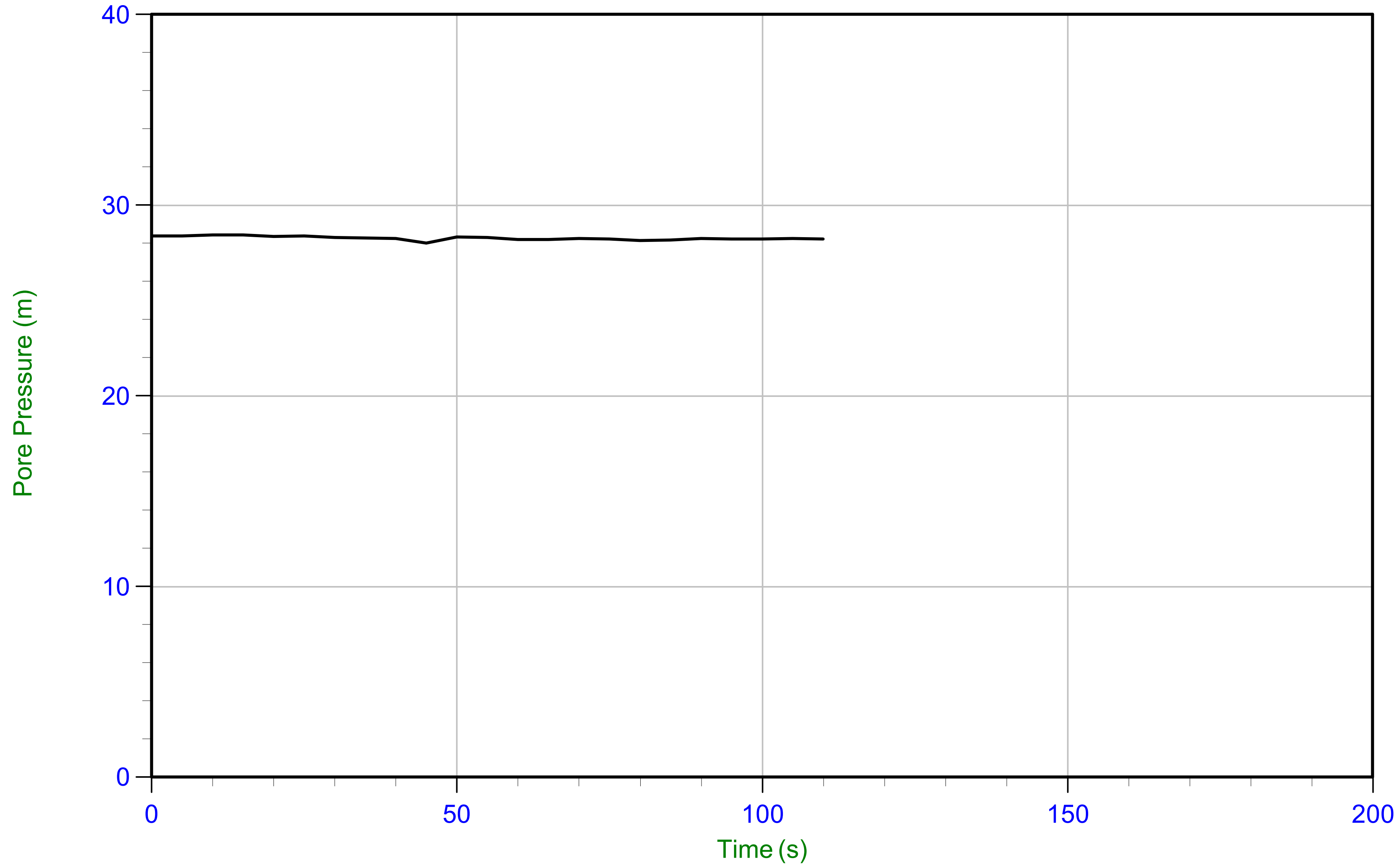
U Min: 54.4 m
U Max: 56.7 m

WT: -17.091 m / -56.072 ft
Ueq: 56.6 m

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 5.200 m / 17.060 ft
Duration: 110.0 s

U Min: 28.0 m
U Max: 28.4 m

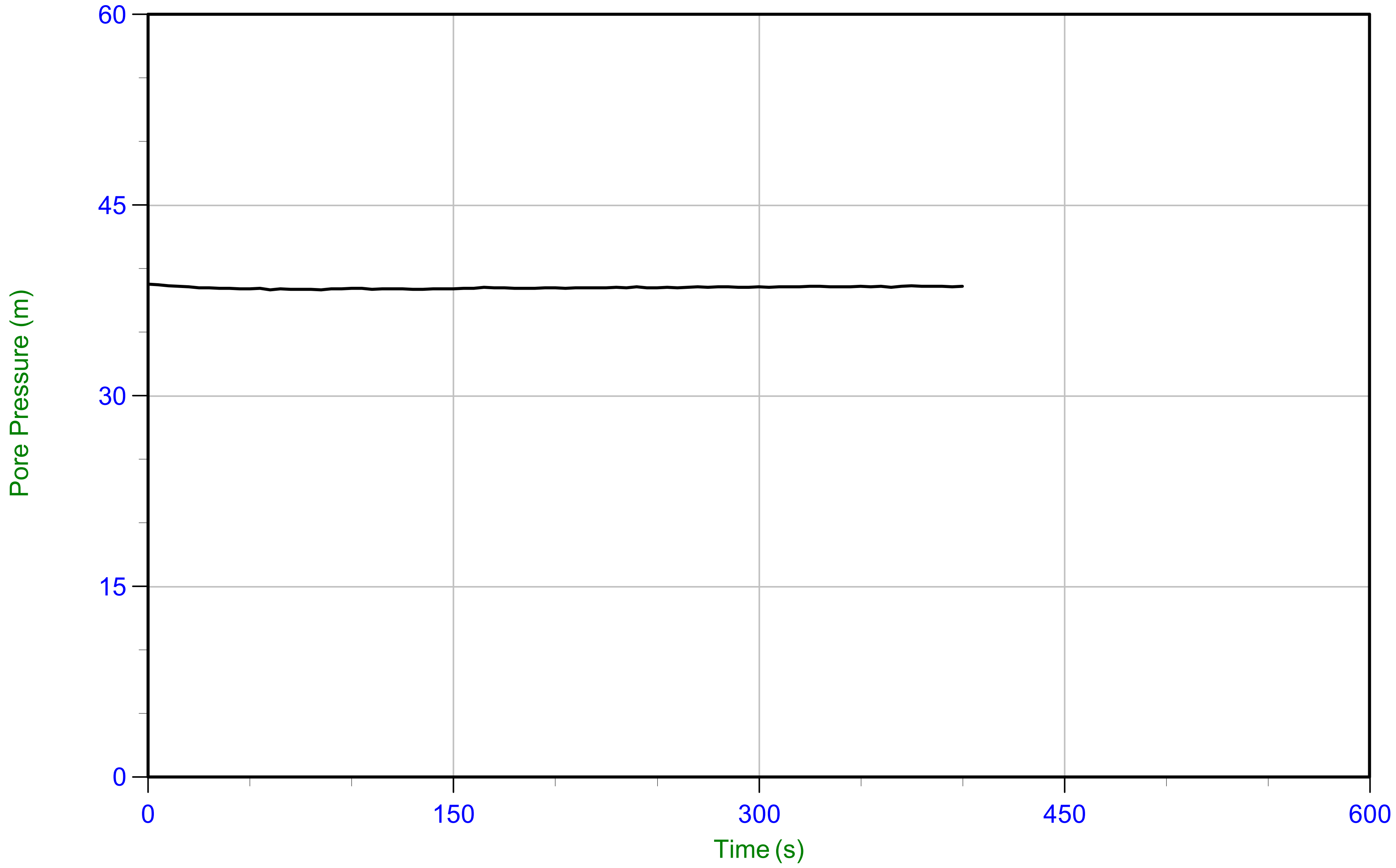
WT: -23.002 m / -75.465 ft
Ueq: 28.2 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 15.300 m / 50.196 ft
Duration: 400.0 s

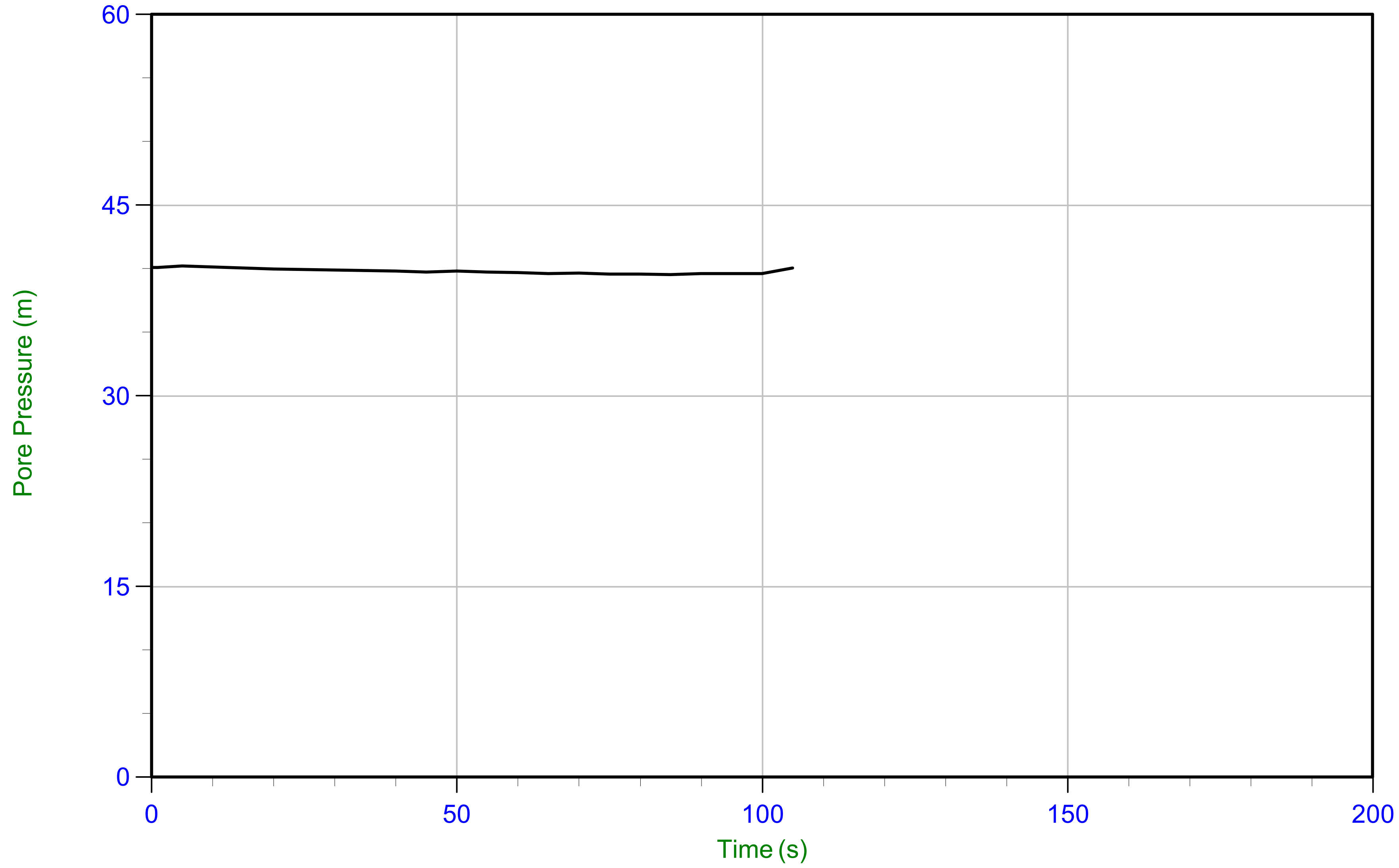
U Min: 38.3 m
U Max: 38.8 m

WT: -23.245 m / -76.262 ft
Ueq: 38.5 m

Baffinland

Job No: 17-05010
Date: 04/06/2017 13:34
Site: Milne Port Expansion

Sounding: CPT17-D003
Cone: 338:T1500F15U500 Area=15 cm²

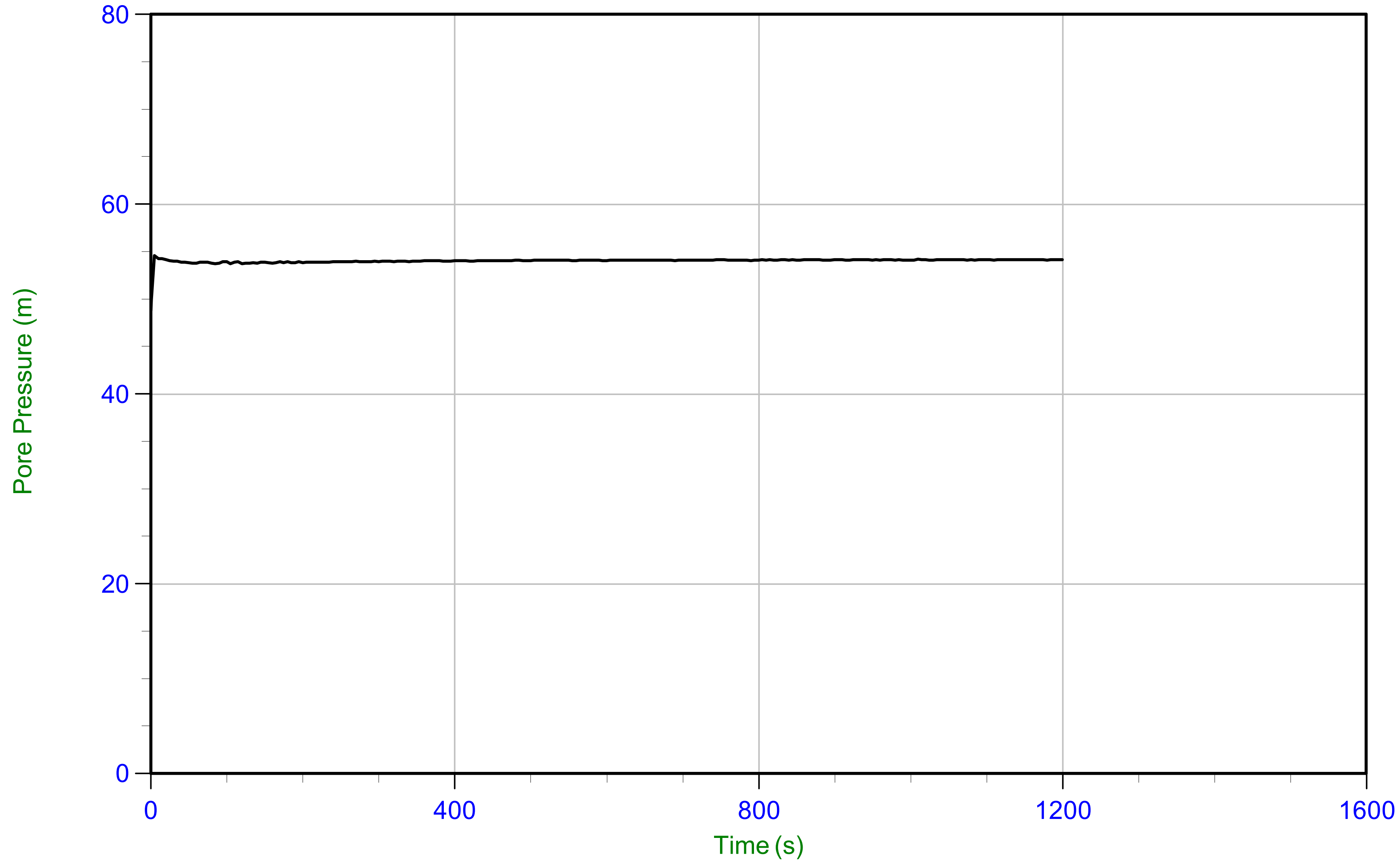


Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 16.300 m / 53.477 ft
Duration: 105.0 s

U Min: 39.5 m
U Max: 40.2 m

WT: -23.336 m / -76.561 ft
Ueq: 39.6 m



Trace Summary:

Filename: 17-05010_CPD003.PPF
Depth: 30.425 m / 99.818 ft
Duration: 1200.0 s

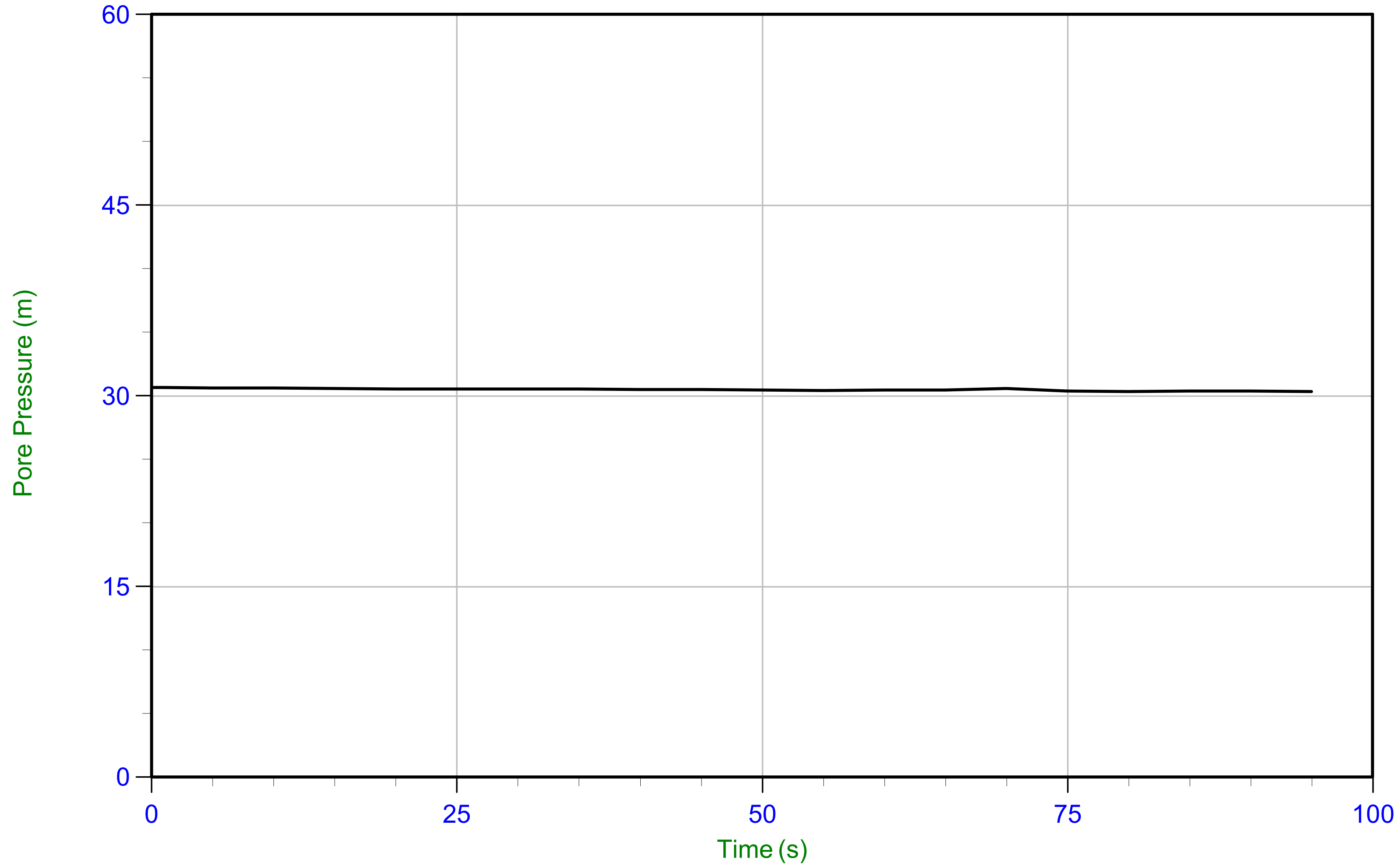
U Min: 48.8 m
U Max: 54.6 m

WT: -23.716 m / -77.807 ft
Ueq: 54.1 m

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



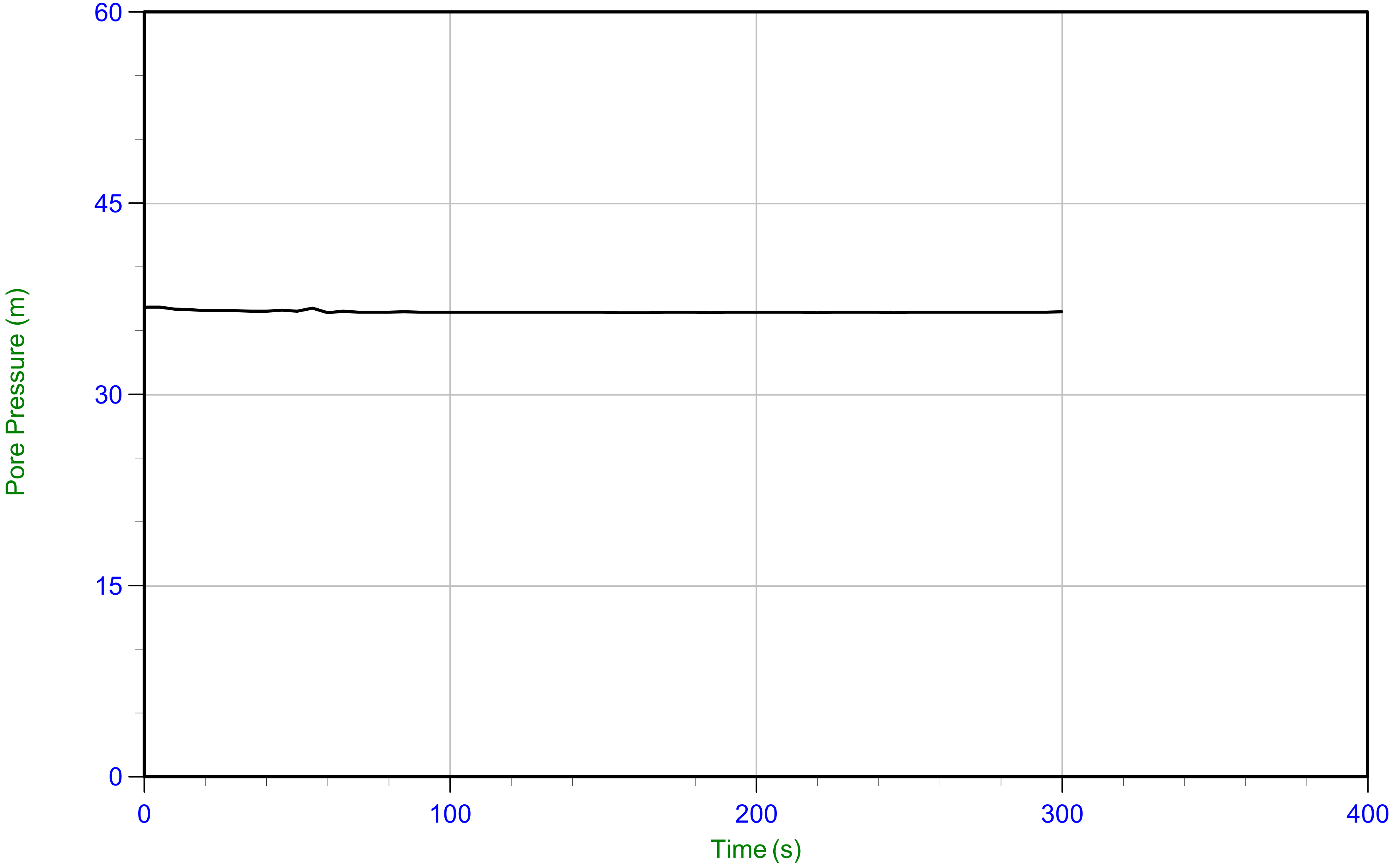
Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 3.275 m / 10.745 ft
Duration: 95.0 s

U Min: 30.3 m
U Max: 30.7 m

WT: -27.149 m / -89.070 ft
Ueq: 30.4 m

Baffinland	Job No: 17-05010 Date: 04/04/2017 16:44 Site: Milne Port Expansion	Sounding: SCPT17-D004 Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 9.200 m / 30.183 ft
Duration: 300.0 s

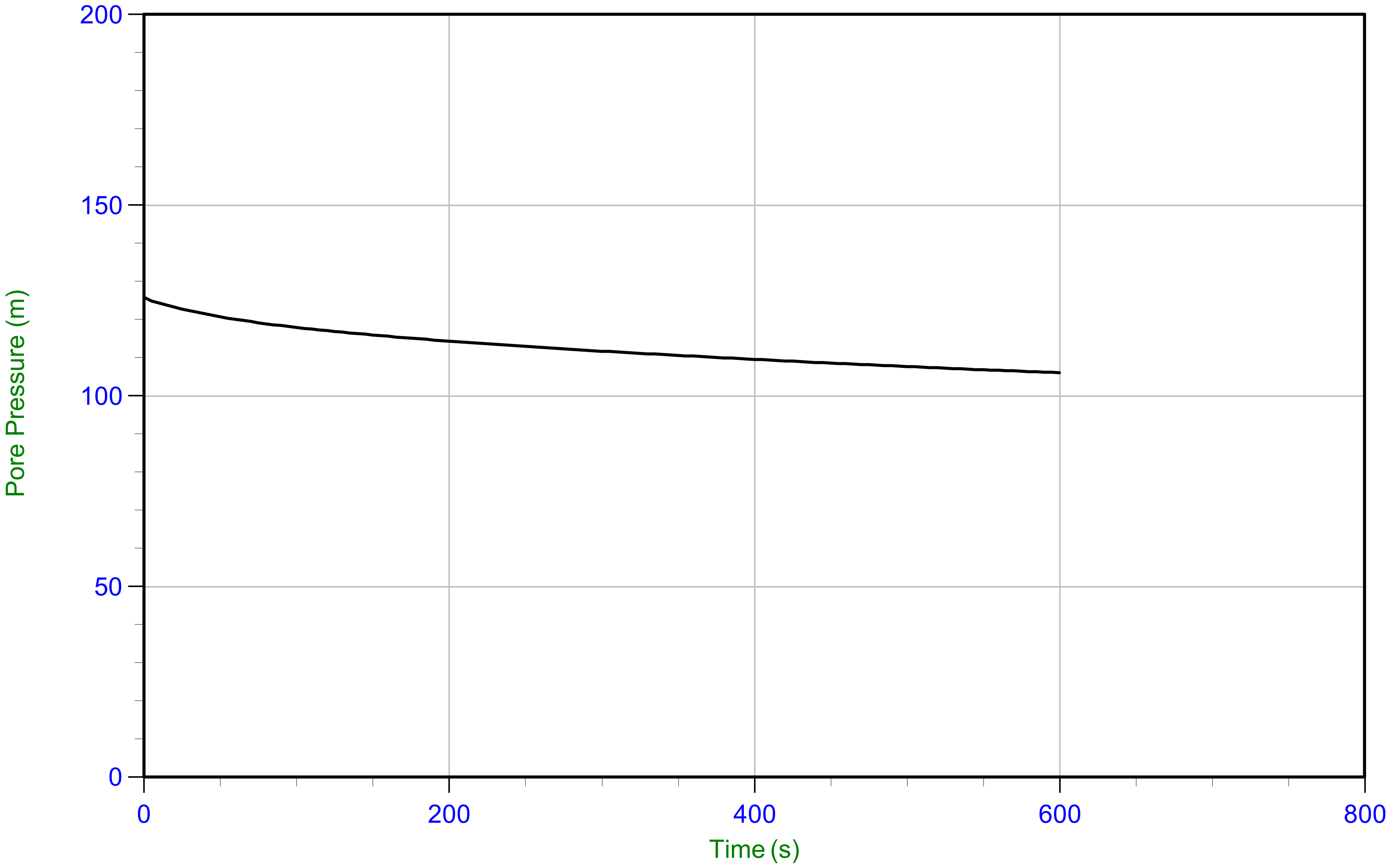
U Min: 36.4 m
U Max: 36.9 m

WT: -27.285 m / -89.517 ft
Ueq: 36.5 m

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 30.475 m / 99.982 ft
Duration: 600.0 s

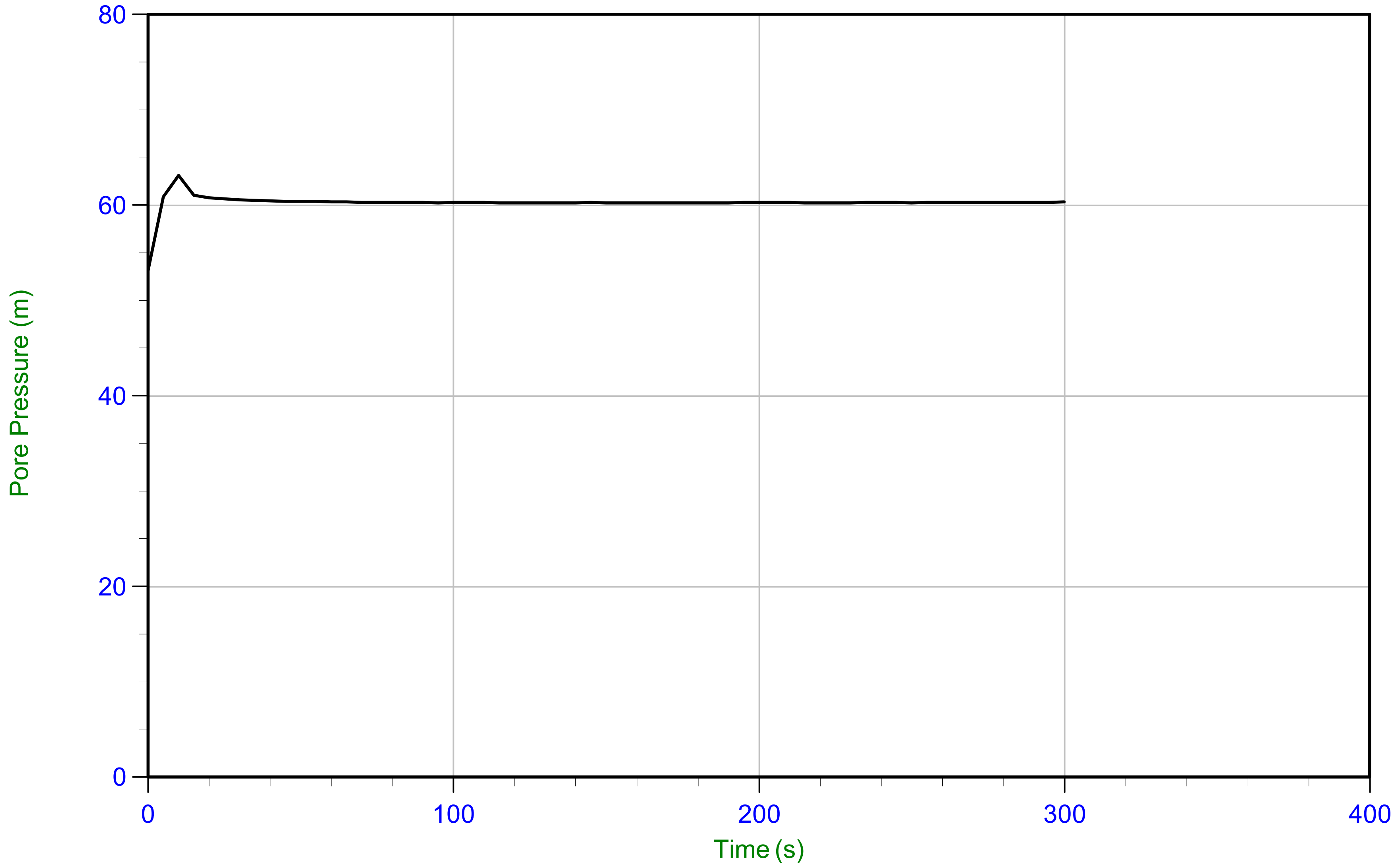
U Min: 106.1 m
U Max: 125.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/04/2017 16:44
Site: Milne Port Expansion

Sounding: SCPT17-D004
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_SPD004.PPF
Depth: 32.050 m / 105.150 ft
Duration: 300.0 s

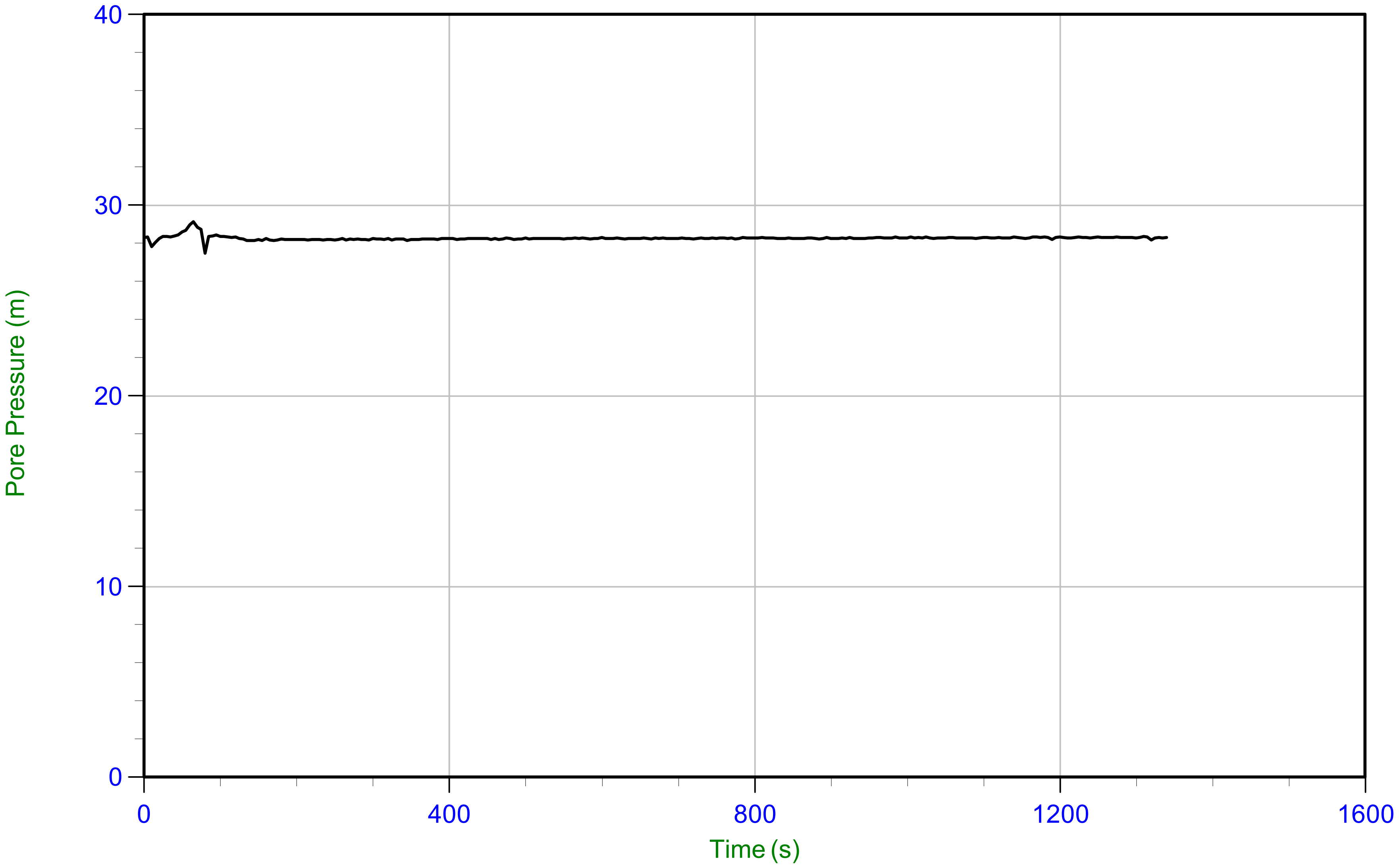
U Min: 53.2 m
U Max: 63.1 m

WT: -28.233 m / -92.627 ft
Ueq: 60.3 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 2.275 m / 7.464 ft
Duration: 1340.0 s

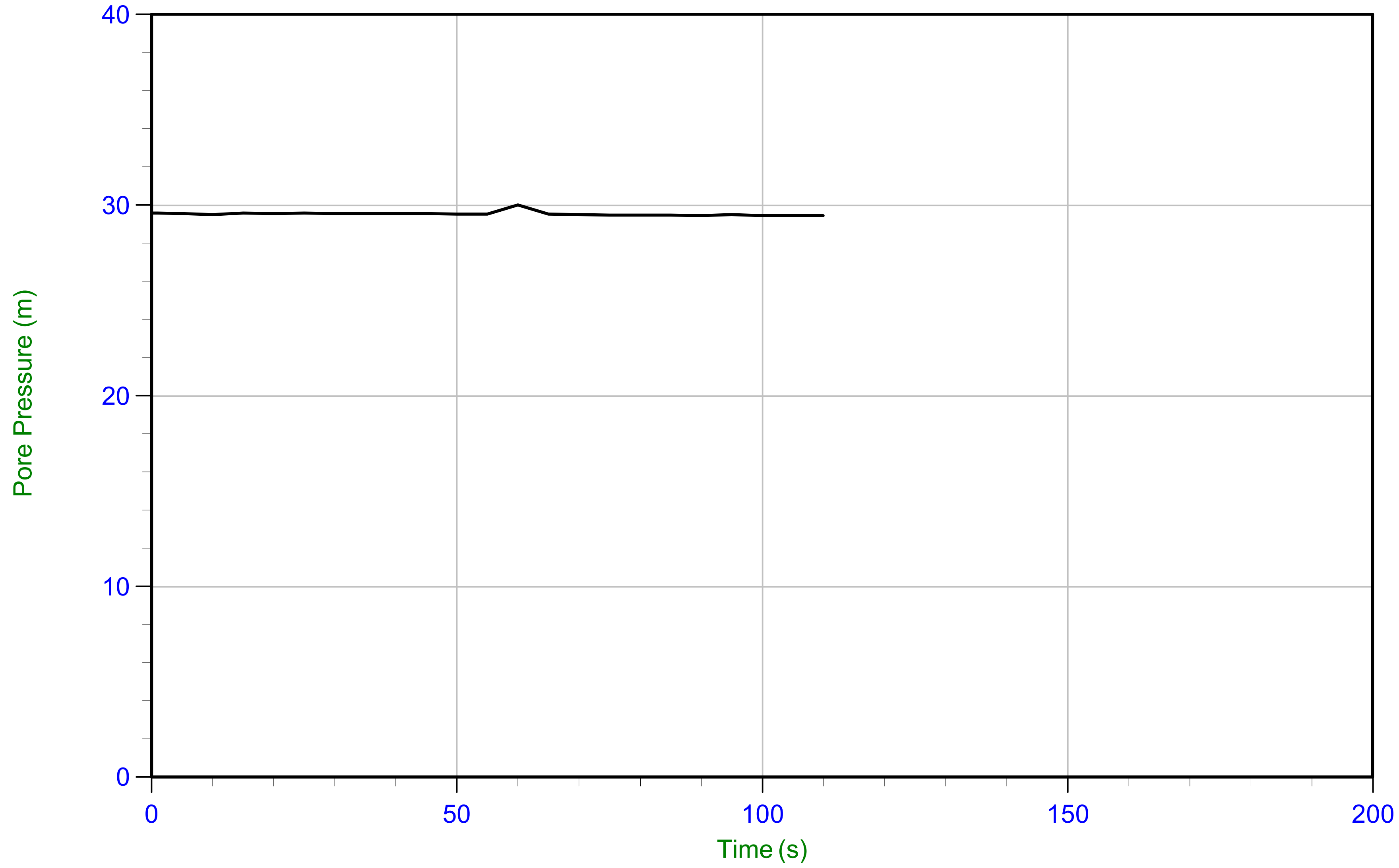
U Min: 27.5 m
U Max: 29.1 m

WT: -26.008 m / -85.327 ft
Ueq: 28.3 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 3.325 m / 10.909 ft
Duration: 110.0 s

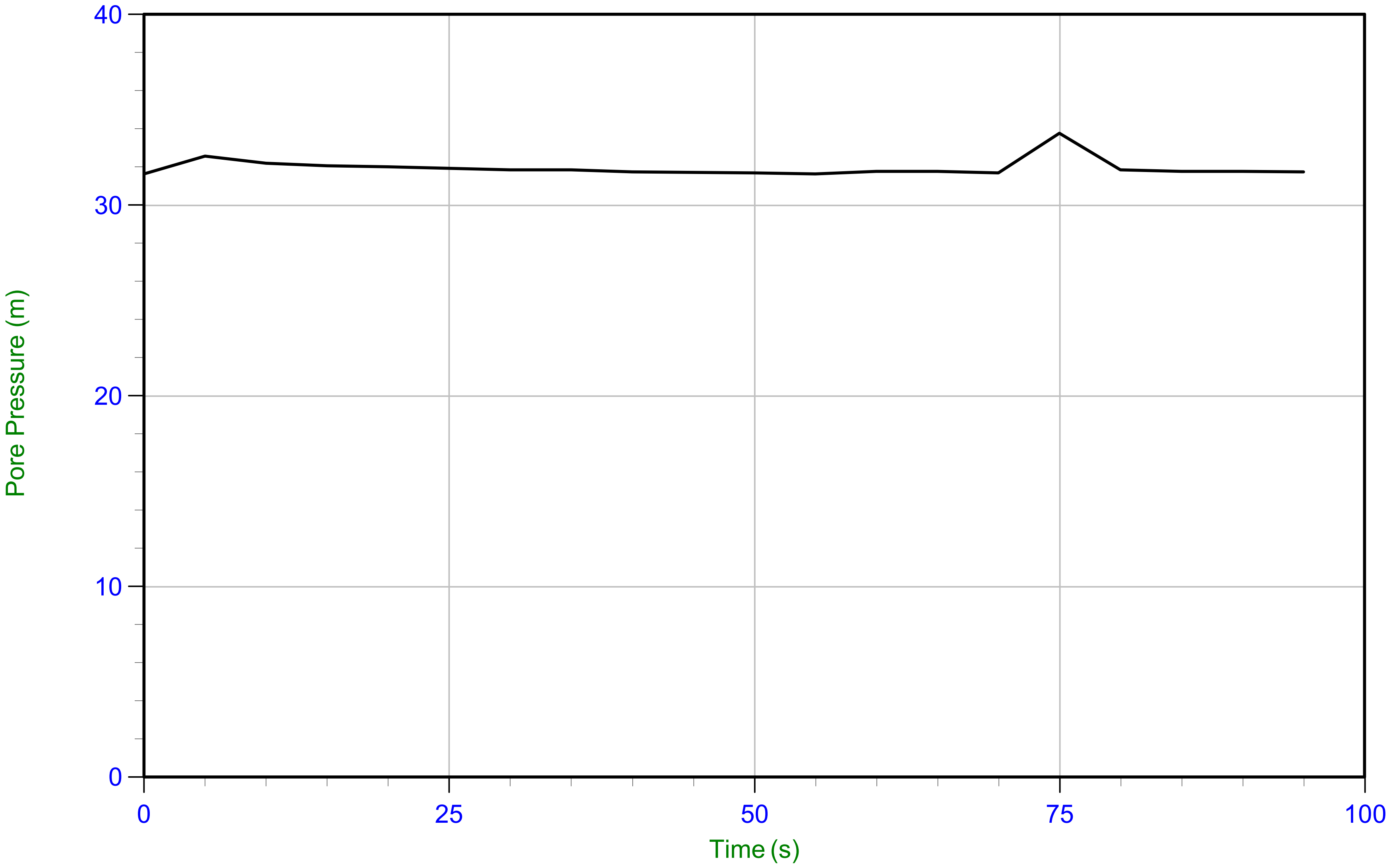
U Min: 29.4 m
U Max: 30.0 m

WT: -26.170 m / -85.859 ft
Ueq: 29.5 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 5.375 m / 17.634 ft
Duration: 95.0 s

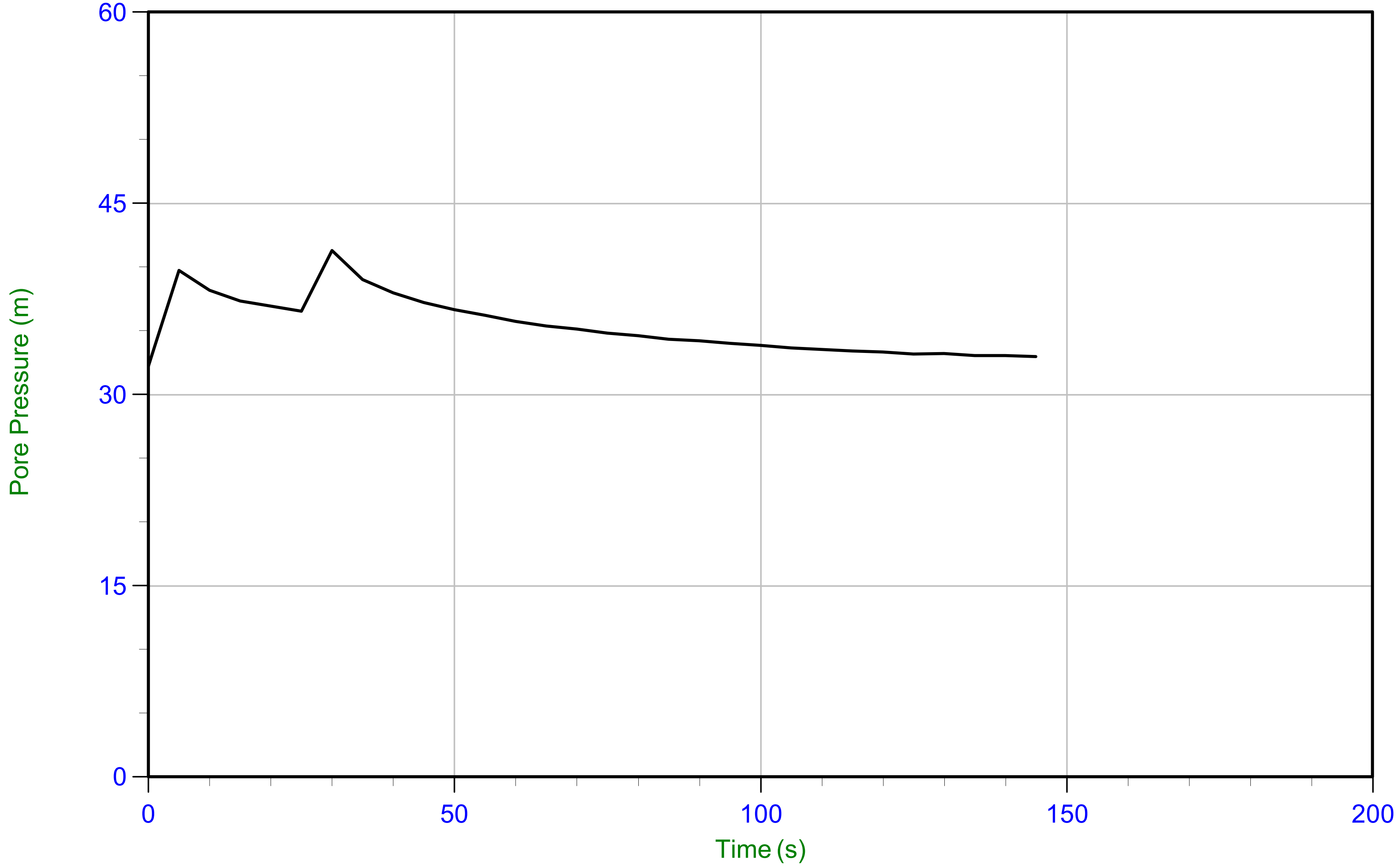
U Min: 31.6 m
U Max: 33.8 m

WT: -26.383 m / -86.557 ft
Ueq: 31.8 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

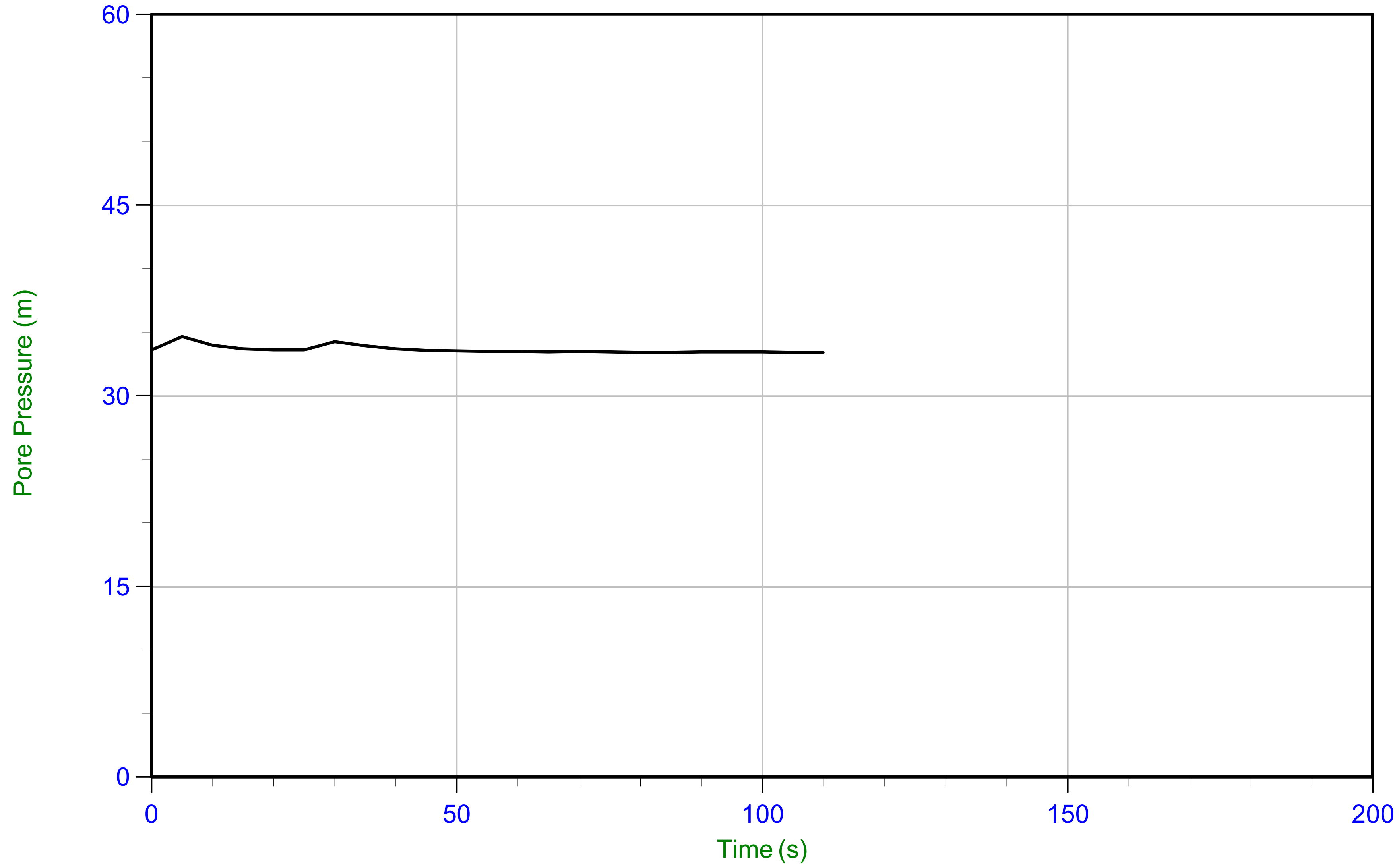
Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 6.375 m / 20.915 ft
Duration: 145.0 s

U Min: 32.2 m
U Max: 41.3 m



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 7.400 m / 24.278 ft
Duration: 110.0 s

U Min: 33.4 m
U Max: 34.6 m

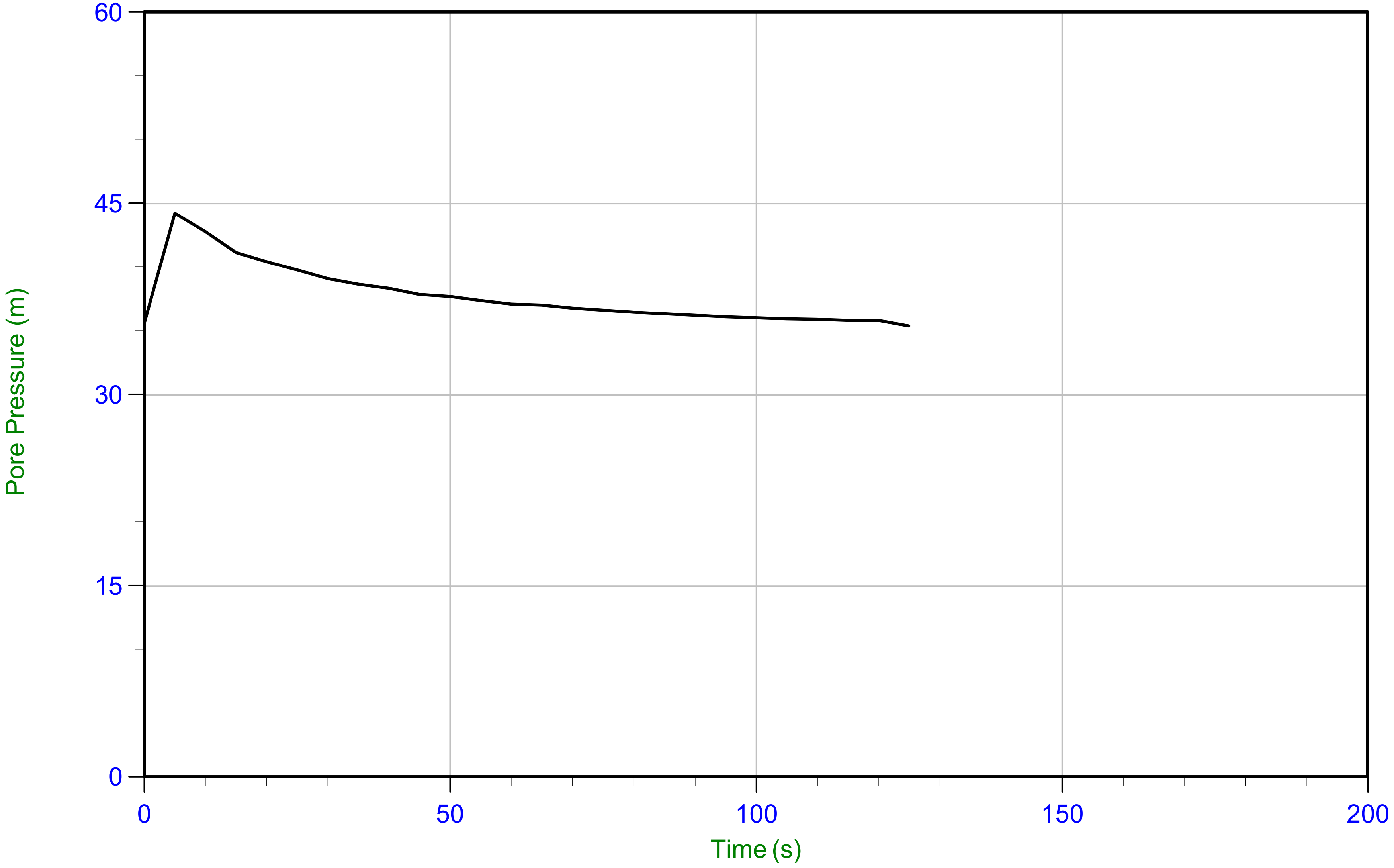
WT: -26.055 m / -85.481 ft
Ueq: 33.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

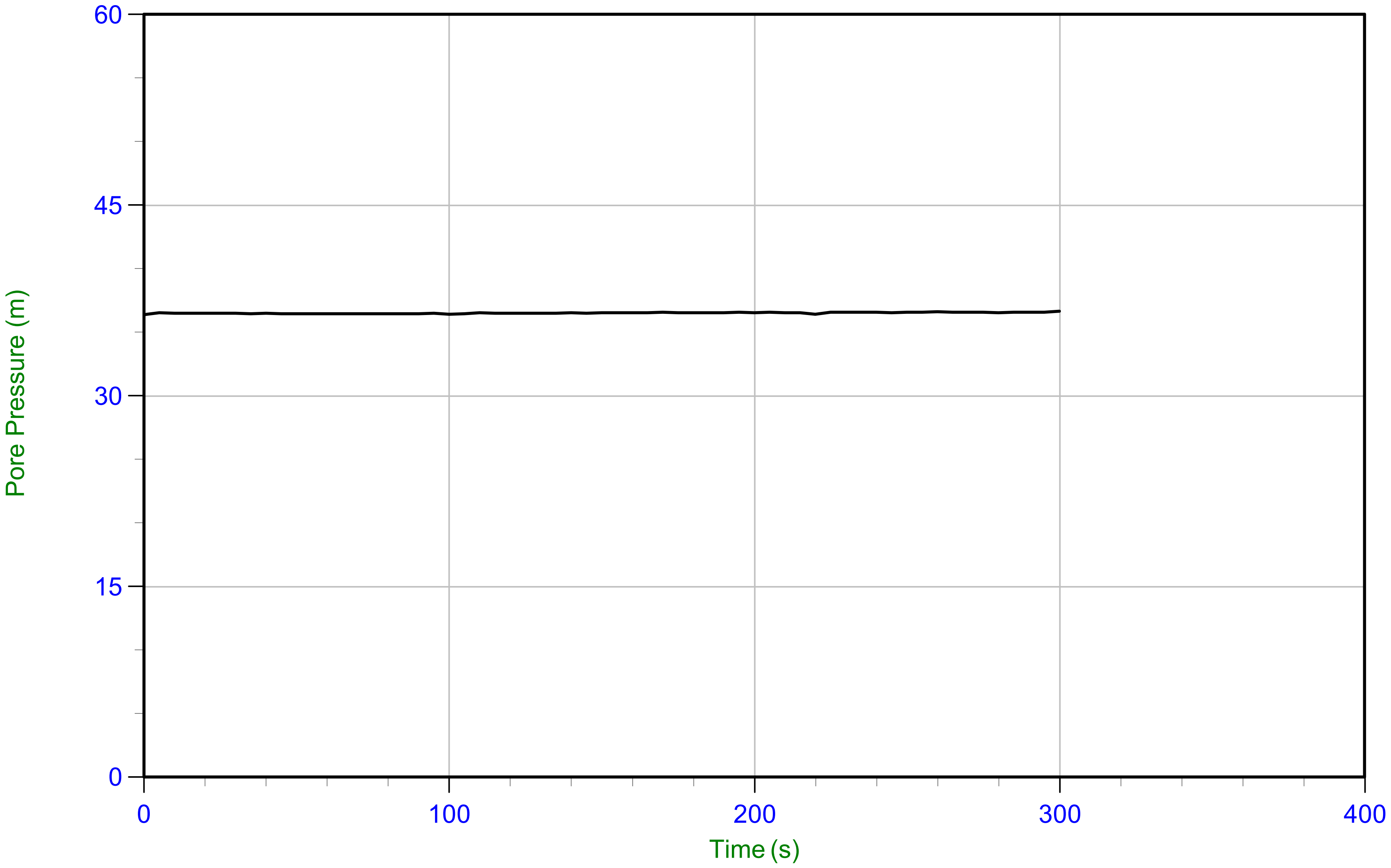
Filename: 17-05010_CPD005.PPF
Depth: 9.350 m / 30.675 ft
Duration: 125.0 s

U Min: 35.4 m
U Max: 44.2 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²

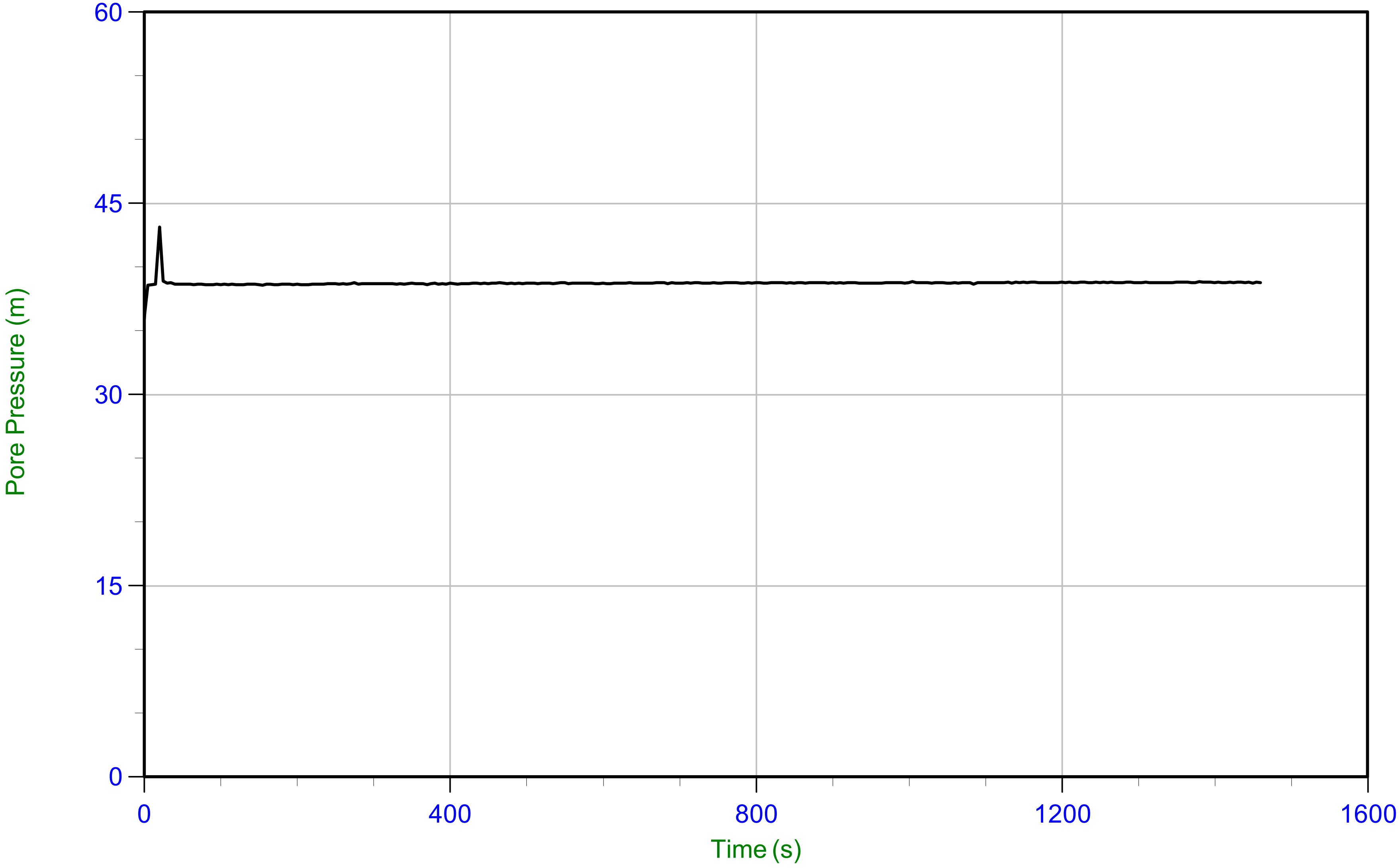


Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 10.300 m / 33.792 ft
Duration: 300.0 s

U Min: 36.4 m
U Max: 36.6 m

WT: -26.185 m / -85.908 ft
Ueq: 36.5 m



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 12.350 m / 40.518 ft
Duration: 1460.0 s

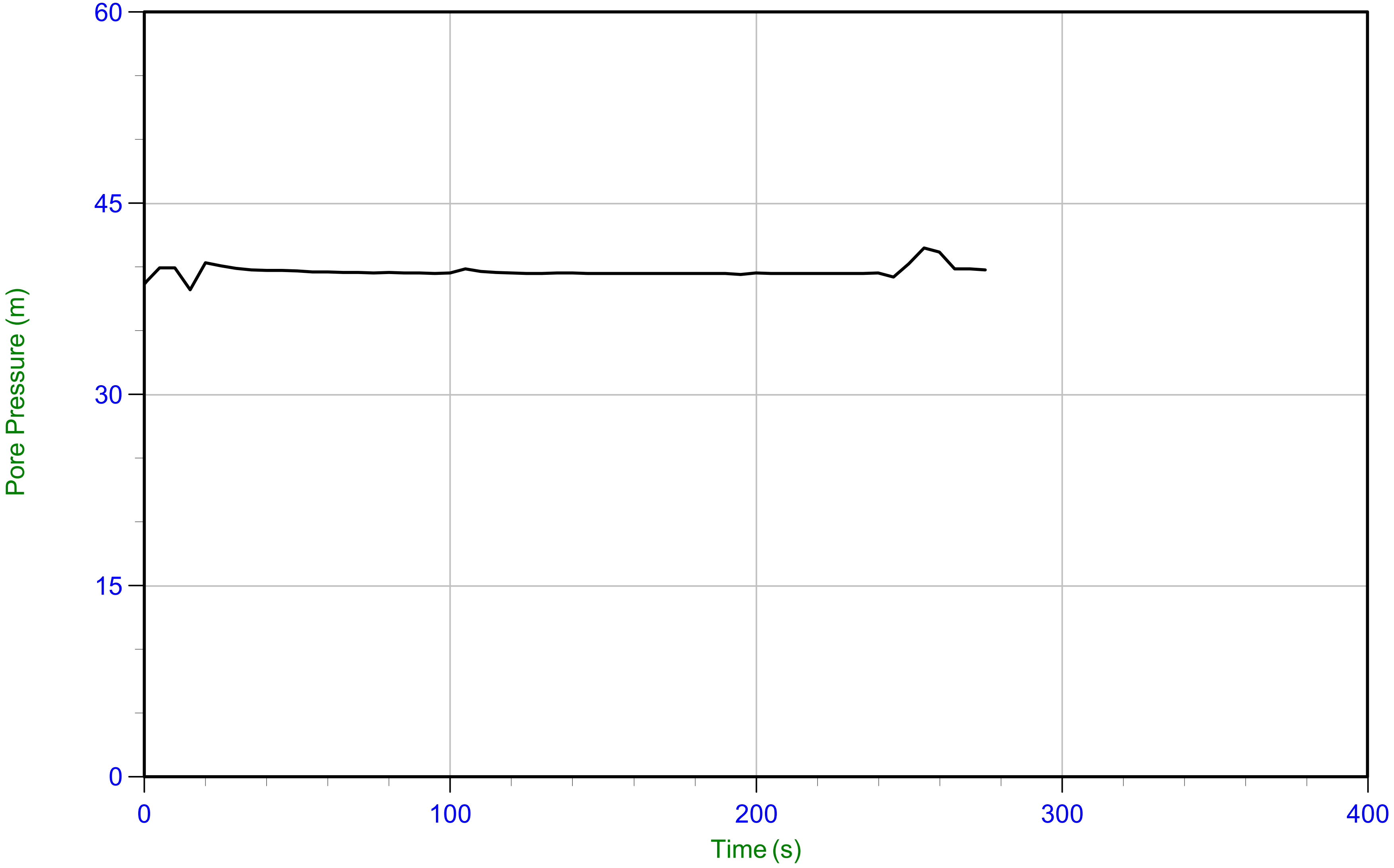
U Min: 35.9 m
U Max: 43.1 m

WT: -26.438 m / -86.738 ft
Ueq: 38.8 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

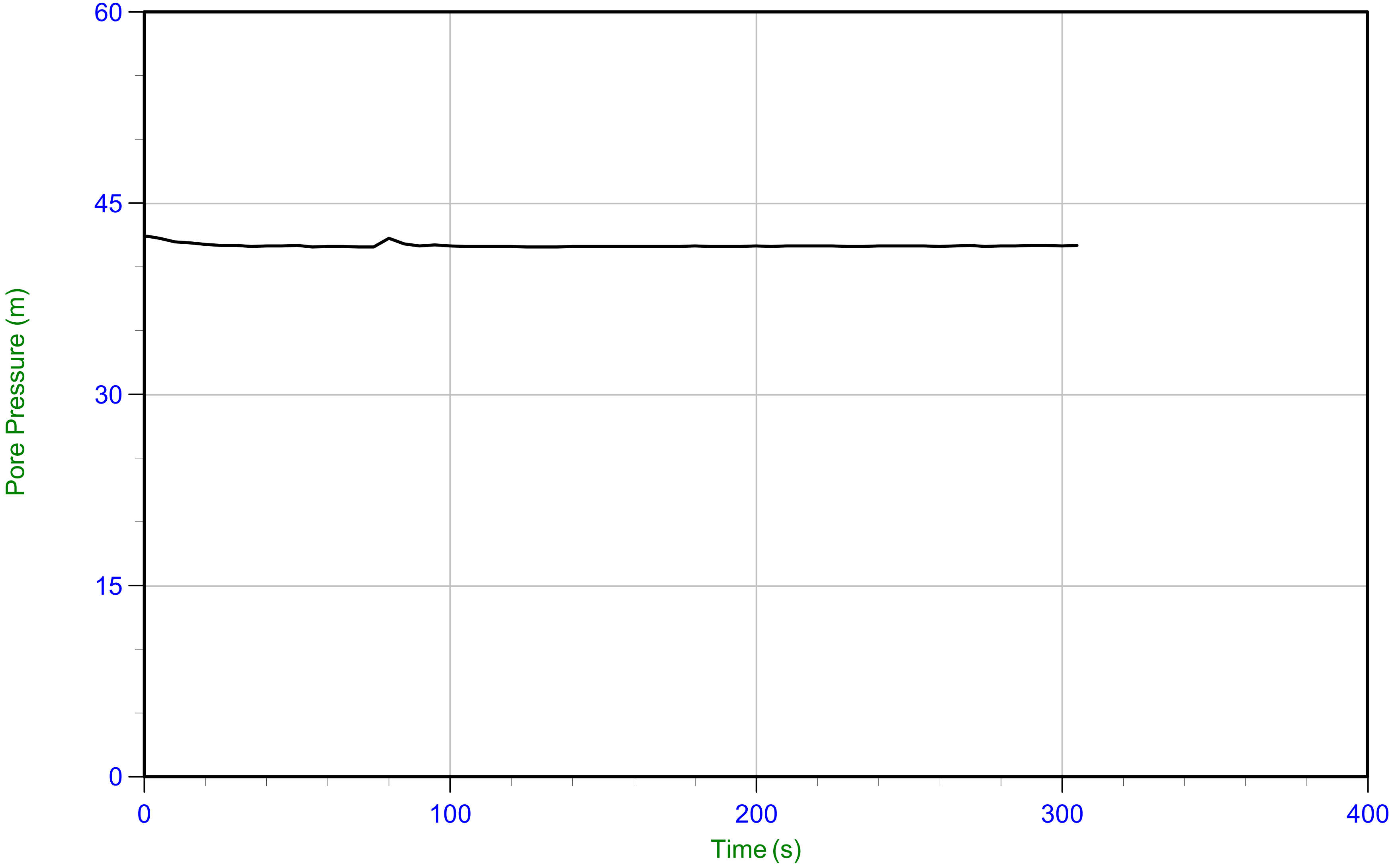
Filename: 17-05010_CPD005.PPF
Depth: 13.175 m / 43.225 ft
Duration: 275.0 s

U Min: 38.2 m
U Max: 41.5 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 15.050 m / 49.376 ft
Duration: 305.0 s

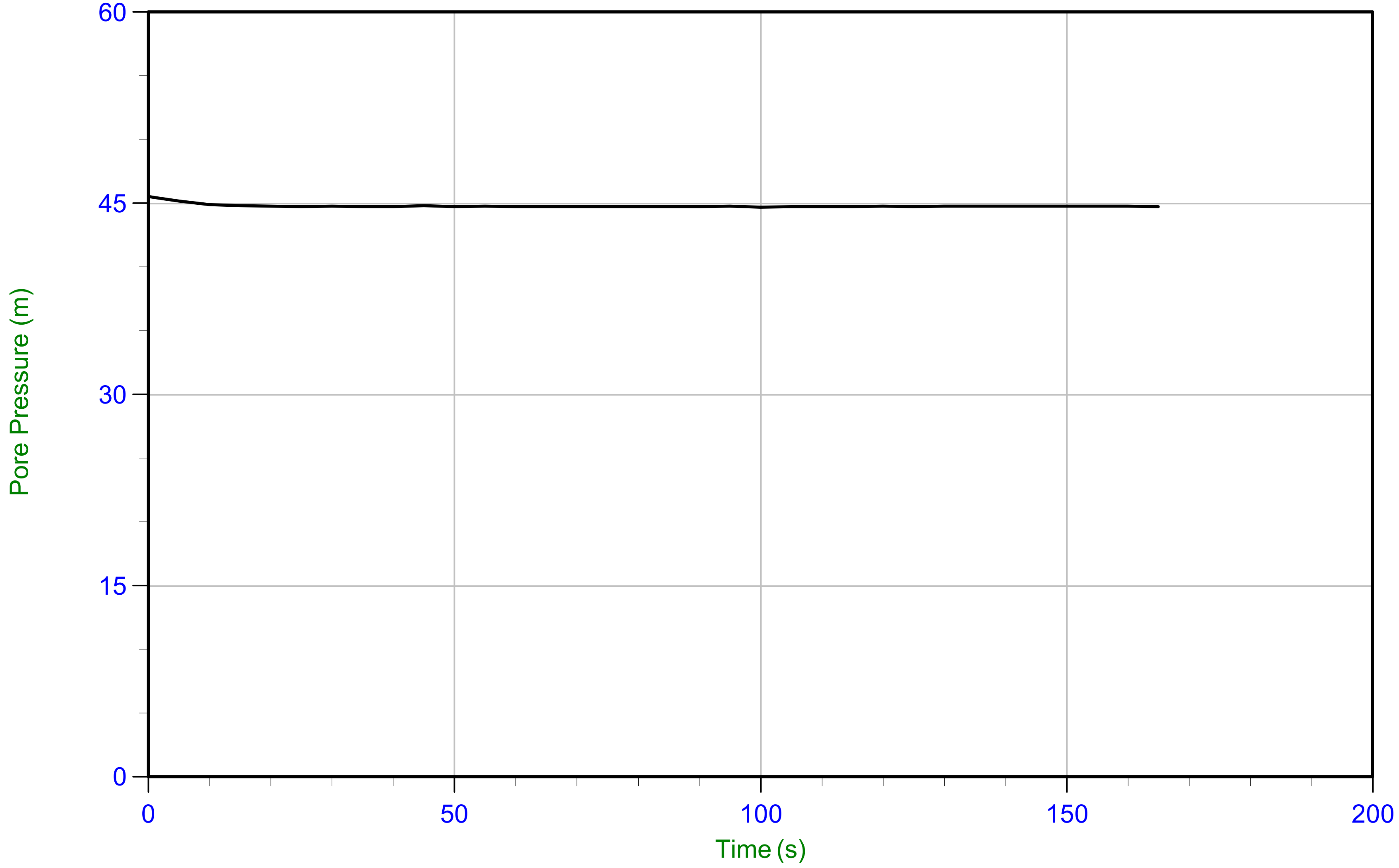
U Min: 41.6 m
U Max: 42.4 m

WT: -26.647 m / -87.423 ft
Ueq: 41.7 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 18.100 m / 59.382 ft
Duration: 165.0 s

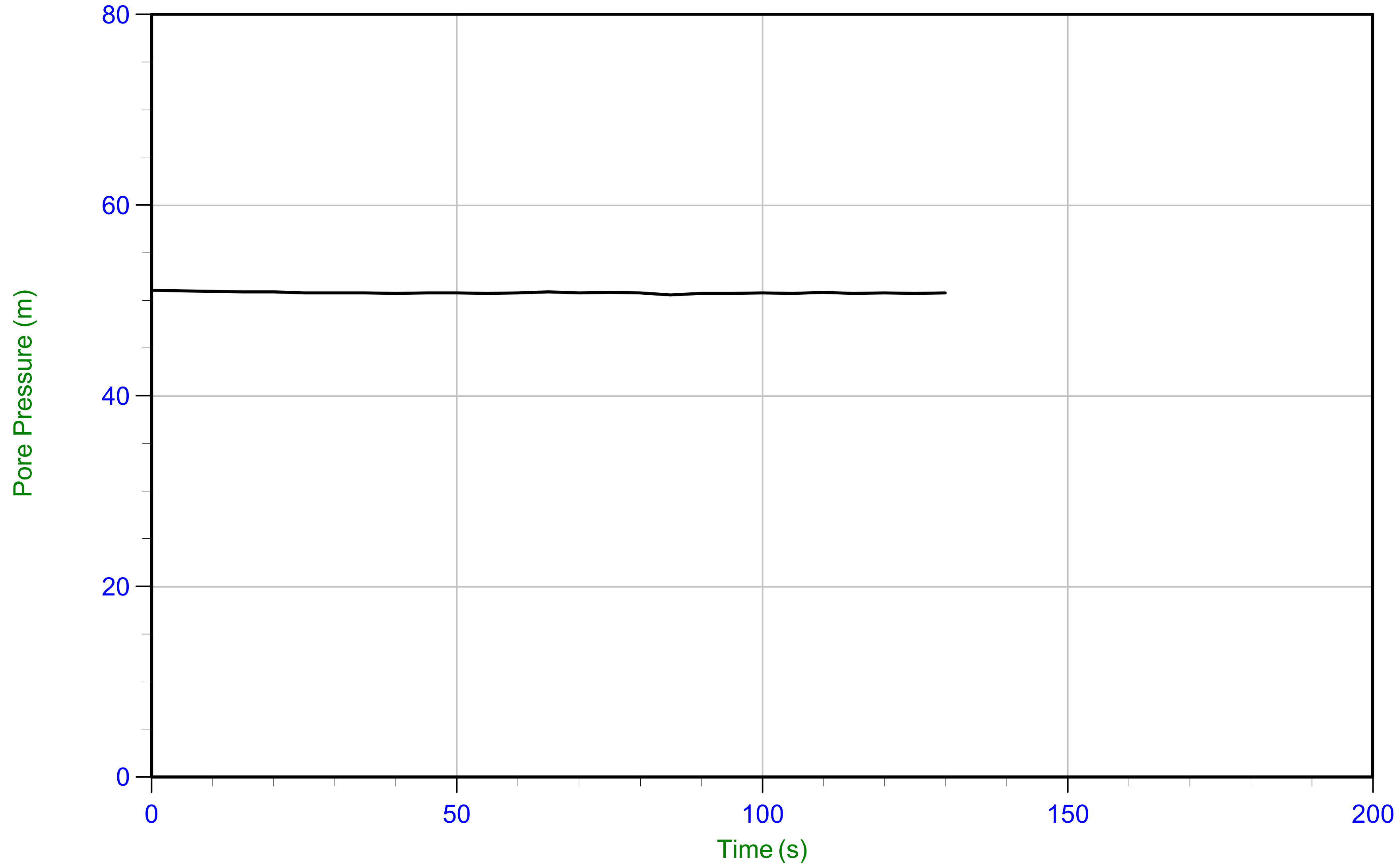
U Min: 44.7 m
U Max: 45.5 m

WT: -26.627 m / -87.358 ft
Ueq: 44.7 m

Baffinland

Job No: 17-05010
Date: 04/03/2017 02:19
Site: Milne Port Expansion

Sounding: CPT17-D005
Cone: 338:T1500F15U500 Area=15 cm²



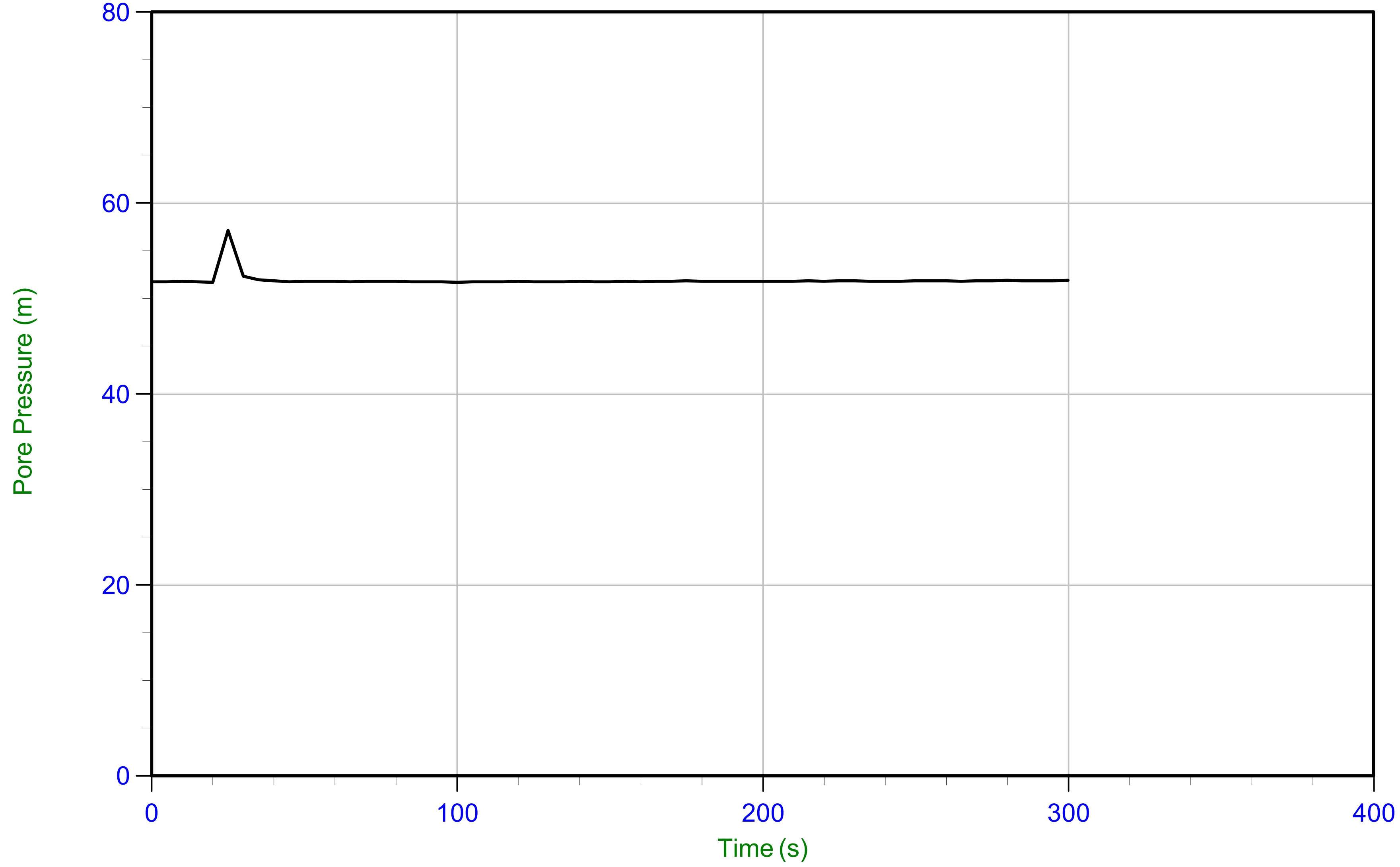
Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 23.925 m / 78.493 ft
Duration: 130.0 s

U Min: 50.6 m
U Max: 51.1 m

WT: -26.822 m / -87.998 ft
Ueq: 50.7 m

Baffinland	Job No: 17-05010	Sounding: CPT17-D005
	Date: 04/03/2017 02:19	Cone: 338:T1500F15U500 Area=15 cm²
	Site: Milne Port Expansion	



Trace Summary:

Filename: 17-05010_CPD005.PPF
Depth: 25.125 m / 82.430 ft
Duration: 300.0 s

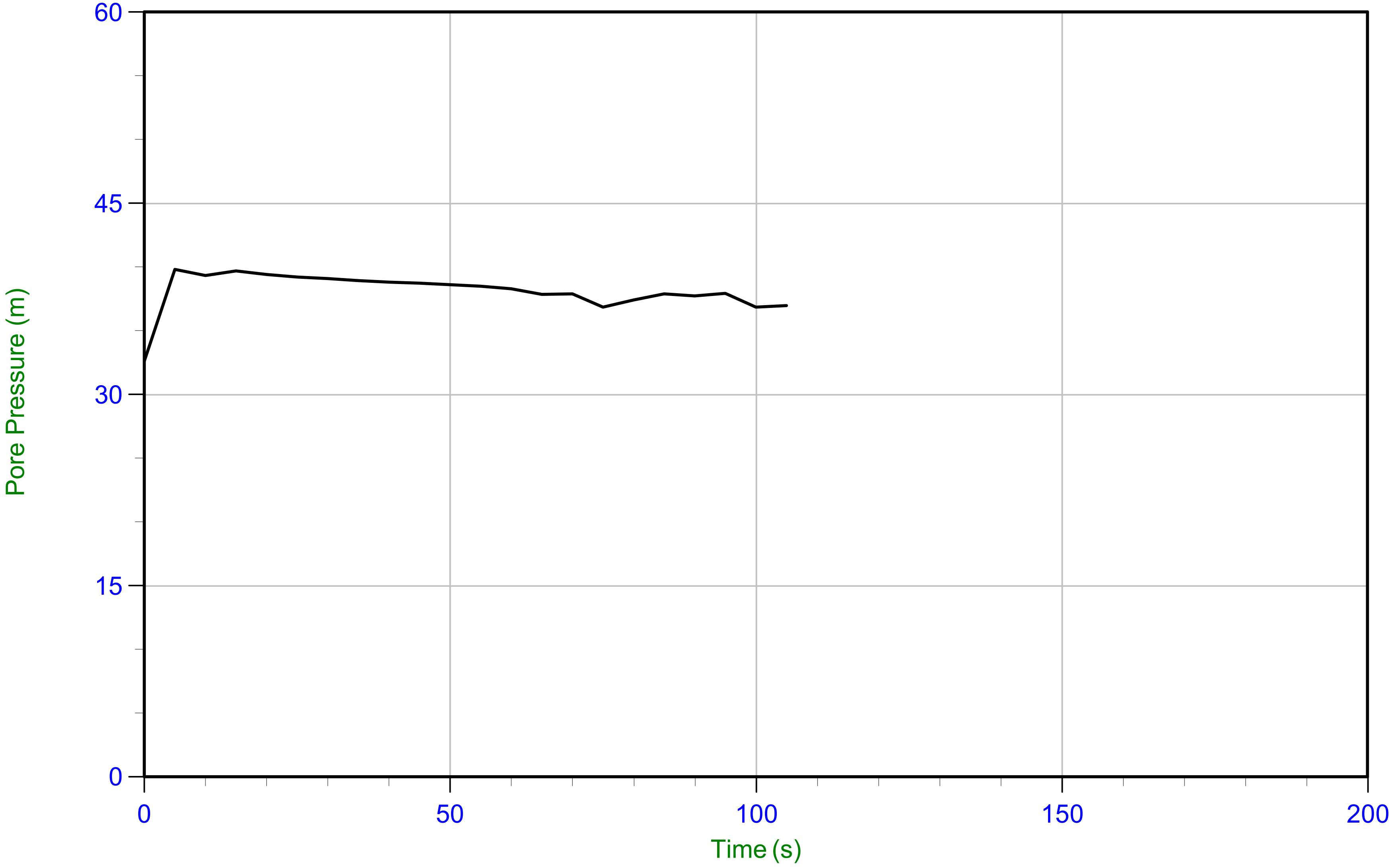
U Min: 51.7 m
U Max: 57.2 m

WT: -26.754 m / -87.775 ft
Ueq: 51.9 m

Baffinland

Job No: 17-05010
Date: 04/06/2017 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD006.PPF
Depth: 2.300 m / 7.546 ft
Duration: 105.0 s

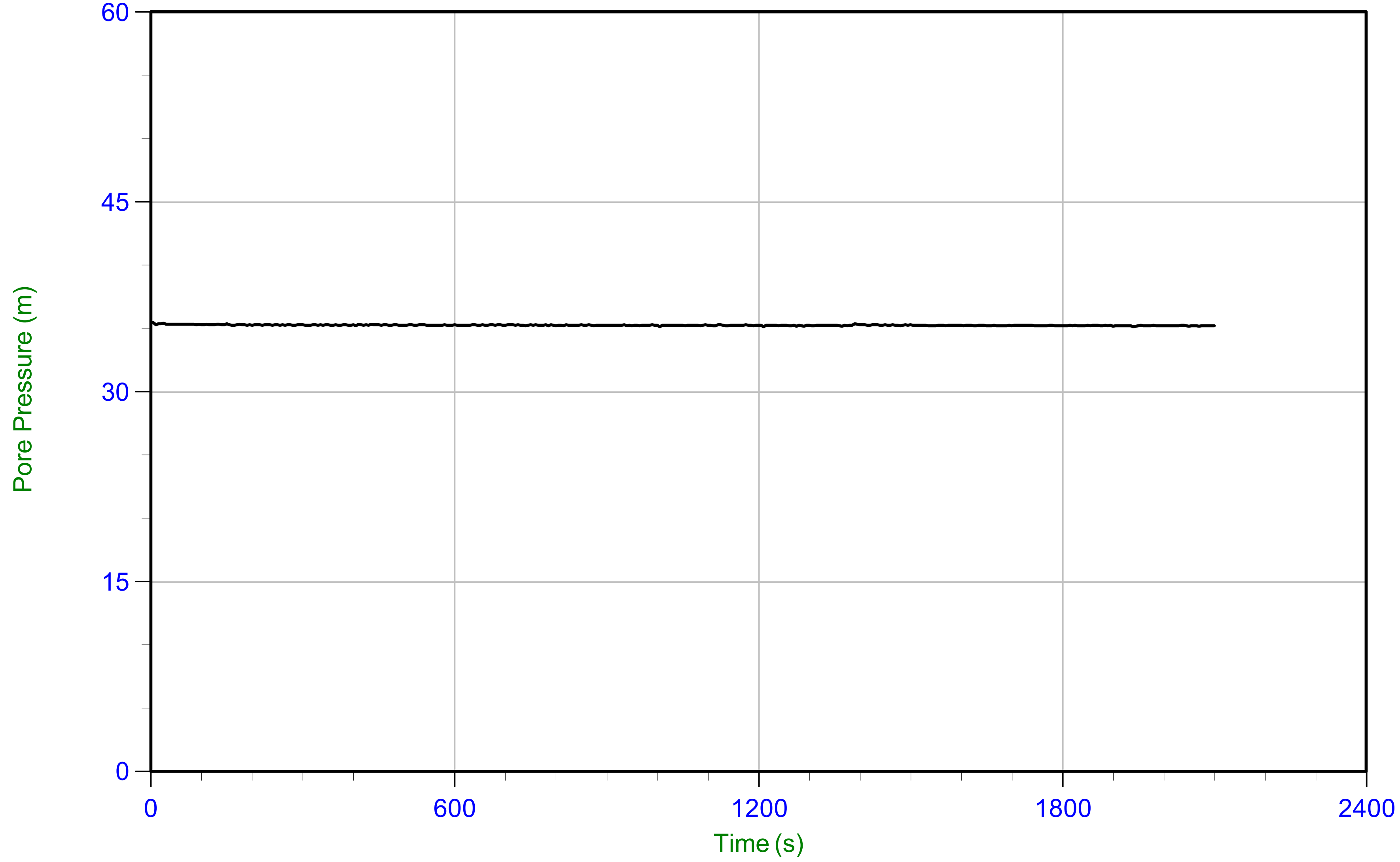
U Min: 32.6 m
U Max: 39.8 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/06/2017 23:59
Site: Milne Port Expansion

Sounding: CPT17-D006
Cone: 374:T1500F15U500 Area=15 cm²

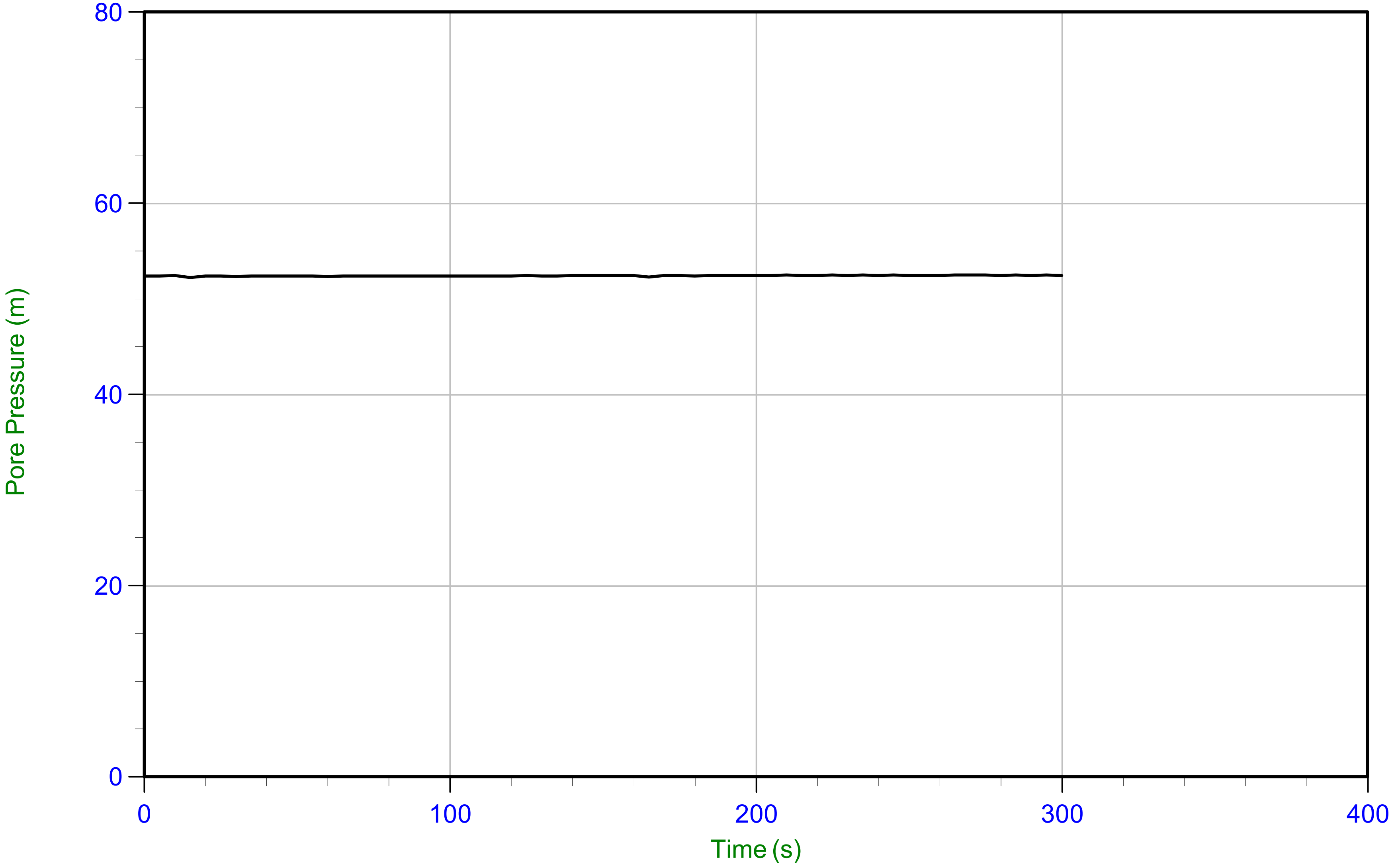


Trace Summary:

Filename: 17-05010_CPD006.PPF
Depth: 3.300 m / 10.827 ft
Duration: 2100.0 s

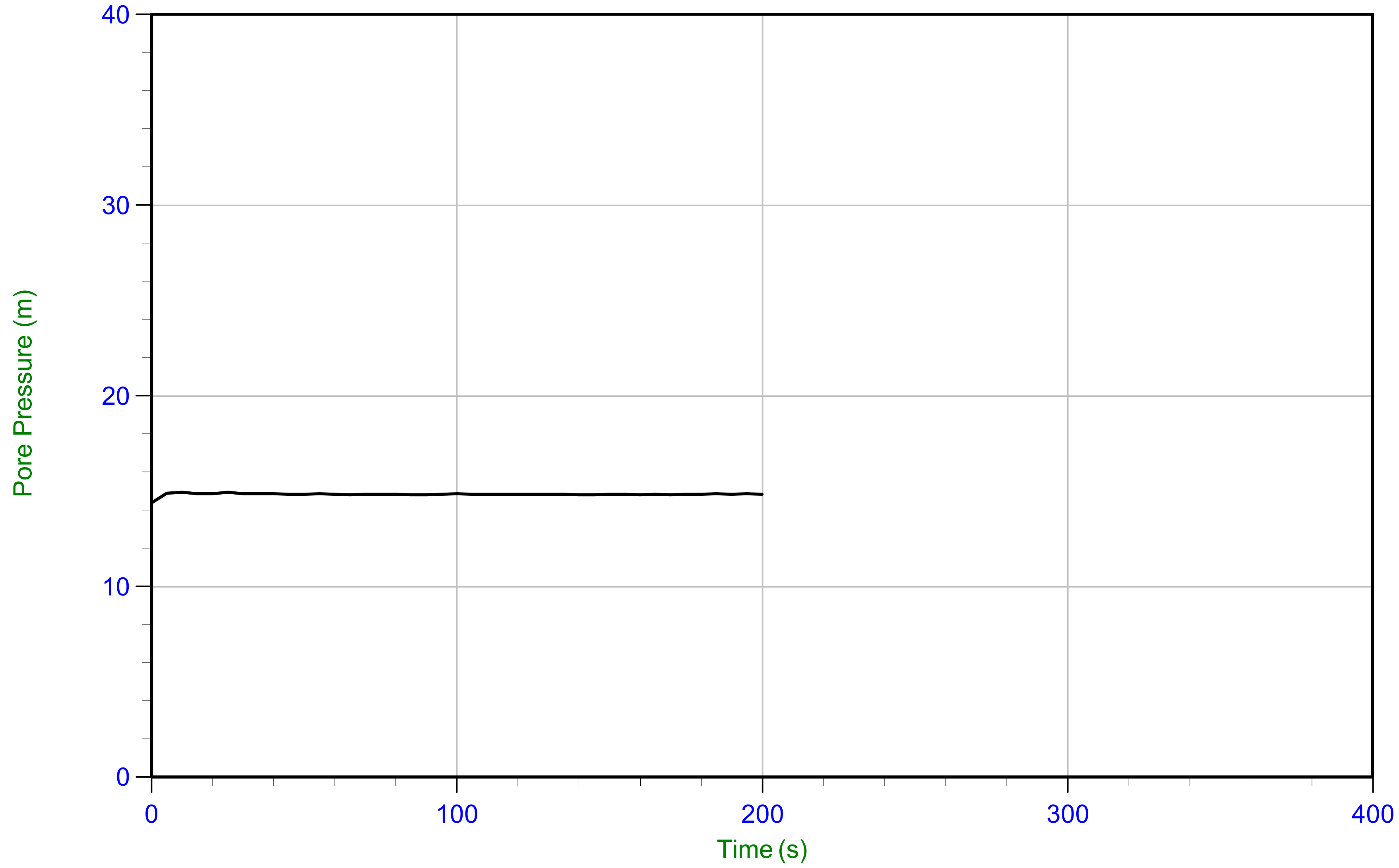
U Min: 35.1 m
U Max: 35.4 m

WT: -31.973 m / -104.897 ft
Ueq: 35.3 m



Trace Summary:

Filename: 17-05010_CPD006.PPF	U Min: 52.2 m	WT: -31.789 m / -104.293 ft
Depth: 20.575 m / 67.502 ft	U Max: 52.5 m	Ueq: 52.4 m
Duration: 300.0 s		



Trace Summary:

Filename: 17-05010_CPD007.PPF
Depth: 10.100 m / 33.136 ft
Duration: 200.0 s

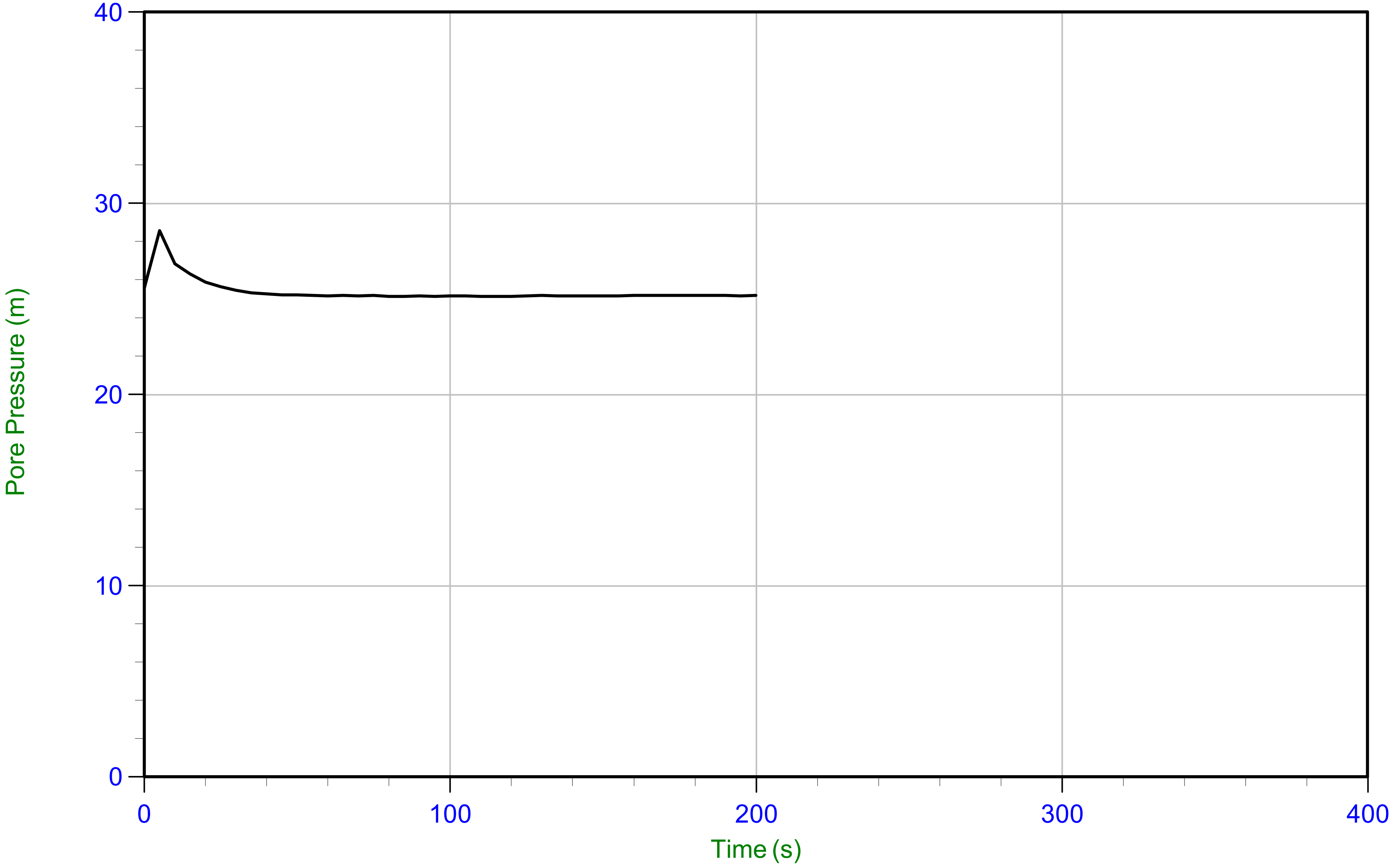
U Min: 14.4 m
U Max: 15.0 m

WT: -4.688 m / -15.380 ft
Ueq: 14.8 m

Baffinland

Job No: 17-05010
Date: 04/07/2017 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD007.PPF
Depth: 20.150 m / 66.108 ft
Duration: 200.0 s

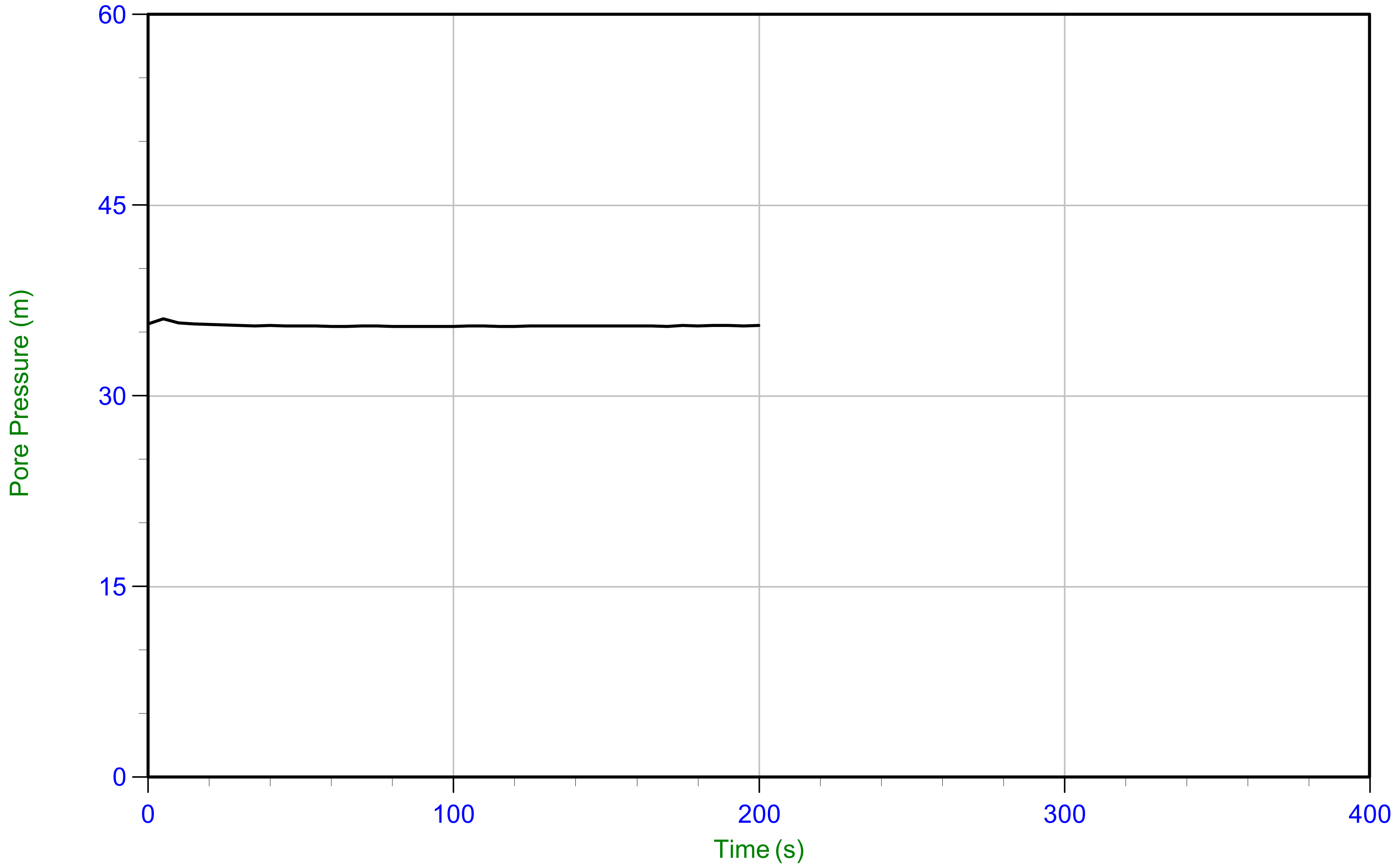
U Min: 25.1 m
U Max: 28.6 m

WT: -4.981 m / -16.342 ft
Ueq: 25.1 m

Baffinland

Job No: 17-05010
Date: 04/07/2017 11:27
Site: Milne Port Expansion

Sounding: CPT17-D007
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD007.PPF
Depth: 30.200 m / 99.080 ft
Duration: 200.0 s

U Min: 35.5 m
U Max: 36.0 m

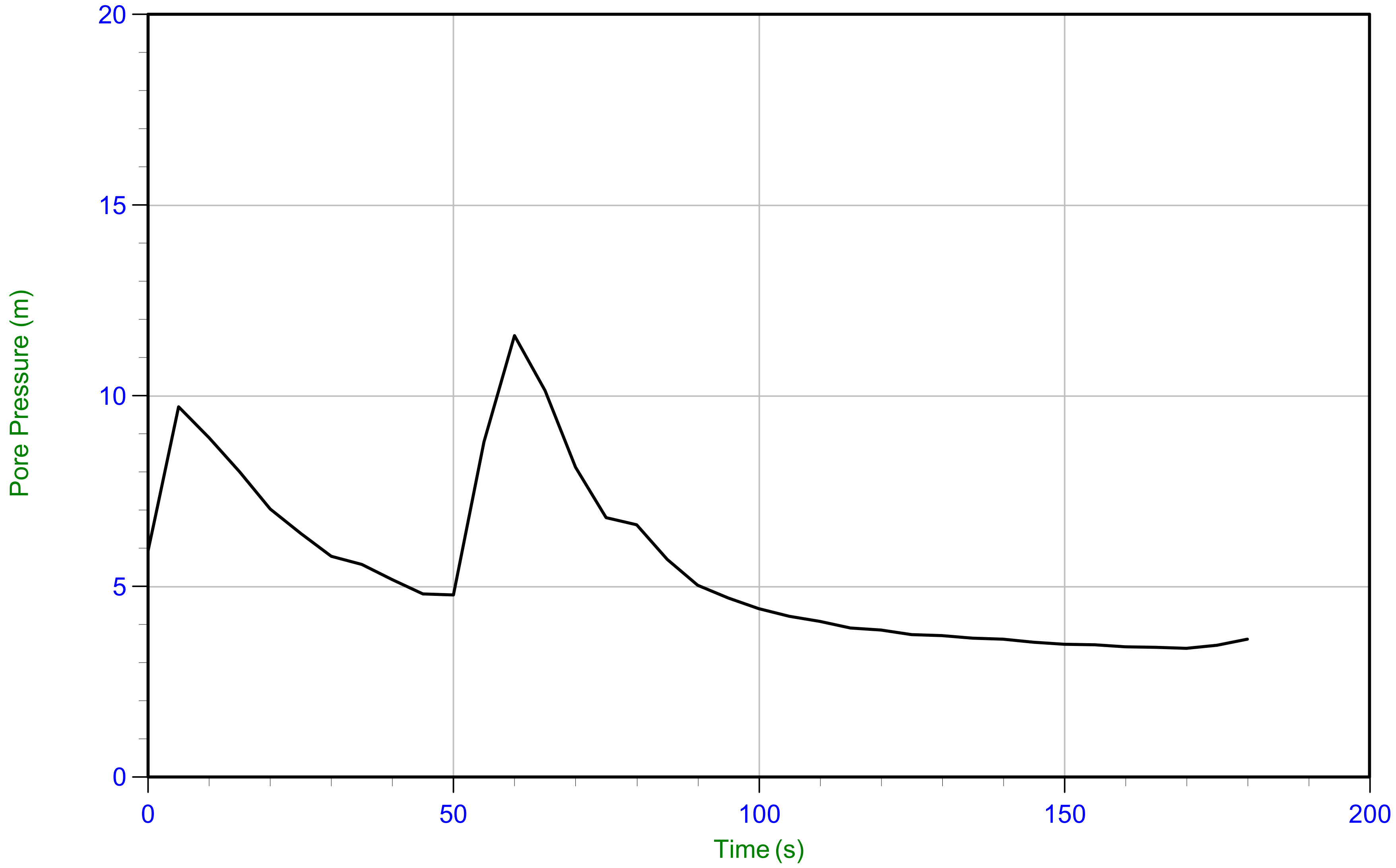
WT: -5.315 m / -17.437 ft
Ueq: 35.5 m

CONETEC

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

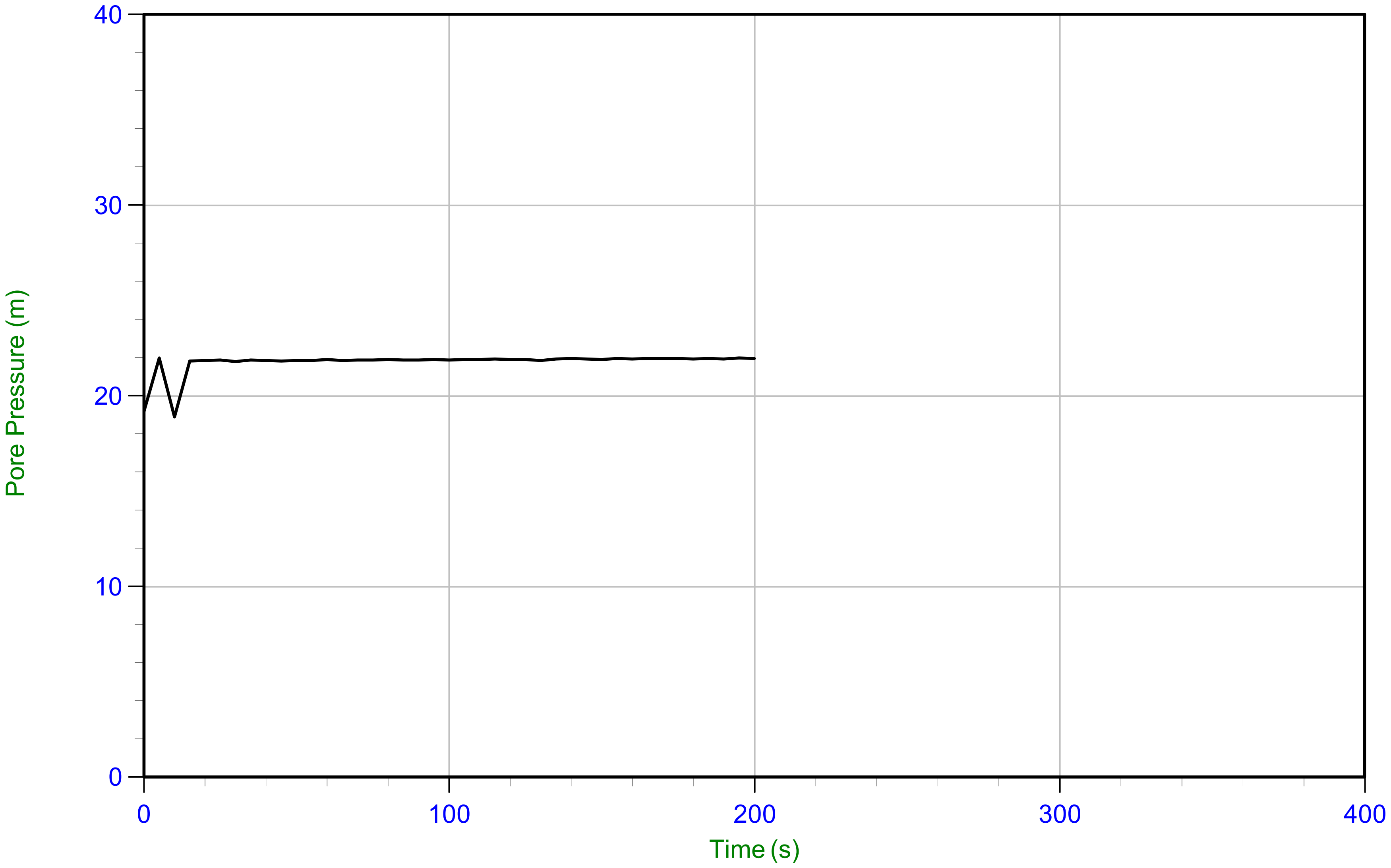
Filename: 17-05010_CPD008.PPF
Depth: 2.075 m / 6.808 ft
Duration: 180.0 s

U Min: 3.4 m
U Max: 11.6 m

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 20.500 m / 67.256 ft
Duration: 200.0 s

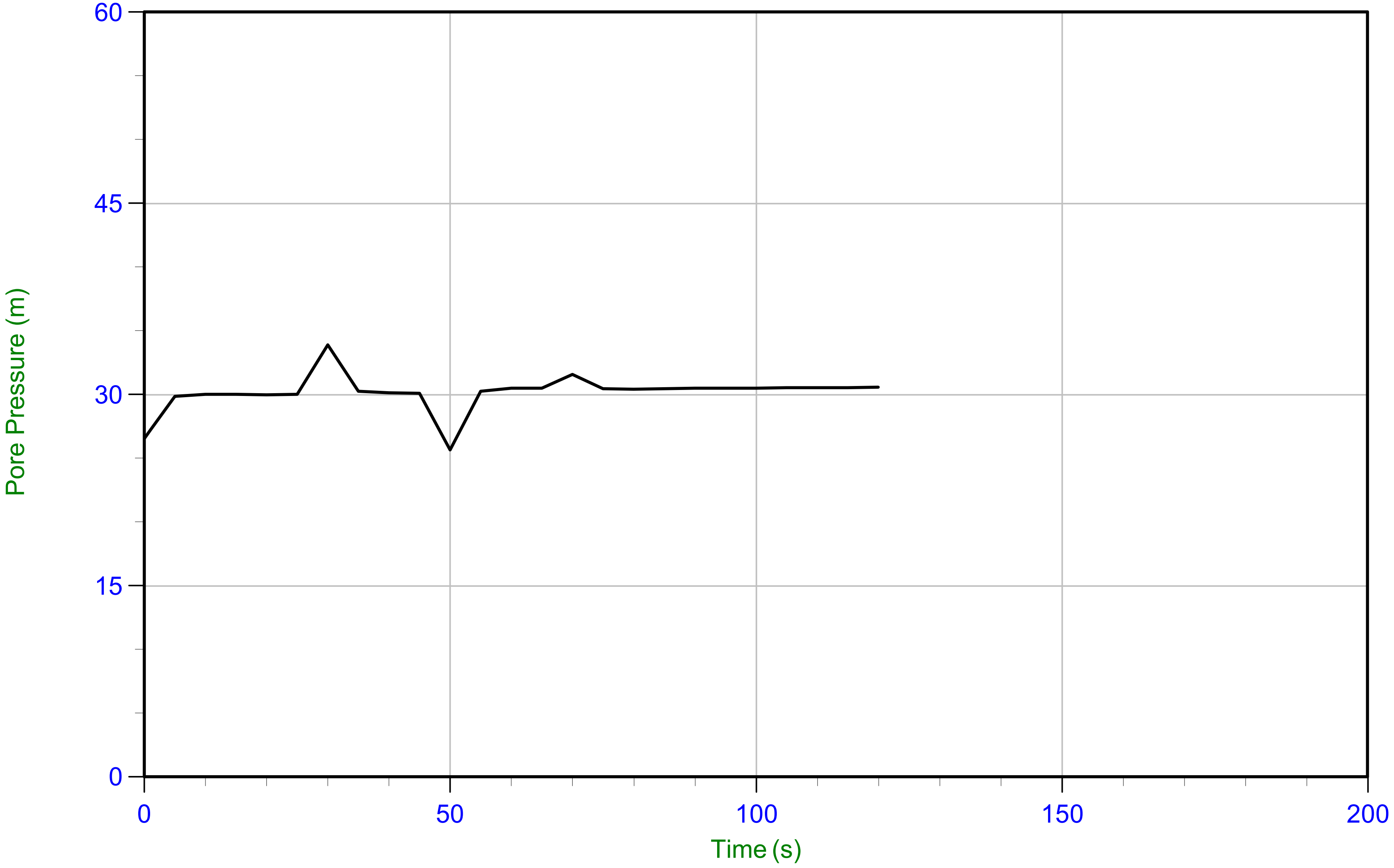
U Min: 18.9 m
U Max: 22.0 m

WT: -1.399 m / -4.590 ft
Ueq: 21.9 m

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 28.975 m / 95.061 ft
Duration: 120.0 s

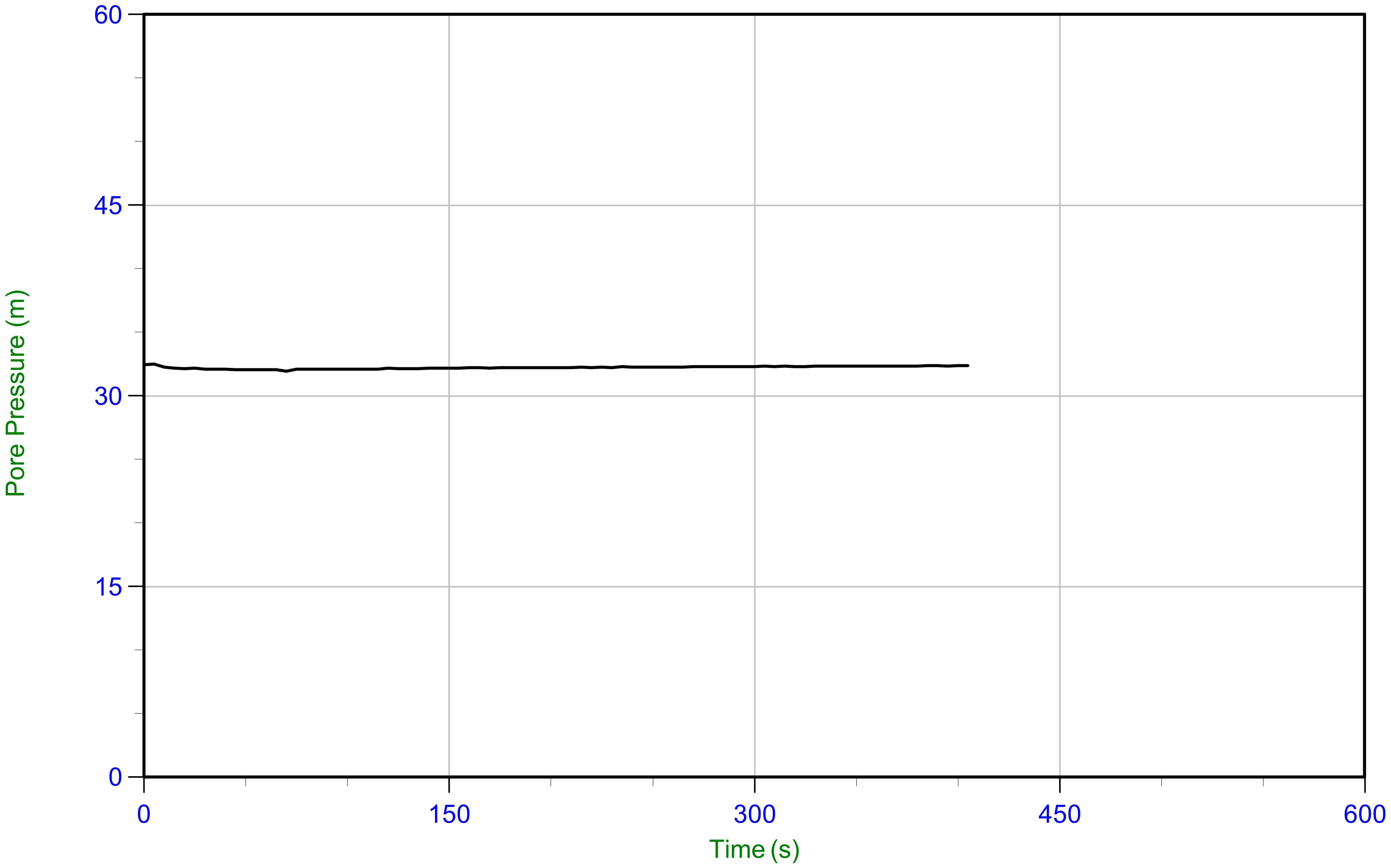
U Min: 25.6 m
U Max: 33.9 m

WT: -1.449 m / -4.754 ft
Ueq: 30.4 m

Baffinland

Job No: 17-05010
Date: 04/07/2017 16:47
Site: Milne Port Expansion

Sounding: CPT17-D008
Cone: 374:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05010_CPD008.PPF
Depth: 30.000 m / 98.424 ft
Duration: 405.0 s

U Min: 32.0 m
U Max: 32.5 m

WT: -2.242 m / -7.356 ft
Ueq: 32.2 m

Appendix G

Laboratory Certificate

CCIL

Canadian Council of Independent Laboratories

CERTIFICATE OF CONFORMANCE

AGGREGATE LABORATORY CERTIFICATION

This is to certify that

Hatch

Located at:

Niagara Falls ON

Has met the Standardization and Interlaboratory Testing Requirements of the CCIL/OSSGA AGGREGATE LABORATORY CERTIFICATION PROGRAM and has qualified under the following categories and test methods:

AGGREGATE QUALITY CONTROL LABORATORY (TYPE C)

LS-600/C-702; LS-601/C-117; LS-602/C-136; LS-607; LS-608; LS-621

AGGREGATE PHYSICAL PROPERTY LABORATORY (TYPE D)

LS-623/D698; LS-702/D422; LS-703,704/D4318; LS-705/D854; LS-709/D2434

Gib McIntee

GIB MCINTEE, P. ENG.
CHAIRMAN, CERTIFICATION PROGRAM ADMINISTRATION COMMITTEE

May 1, 2016 - April 30, 2017

Date

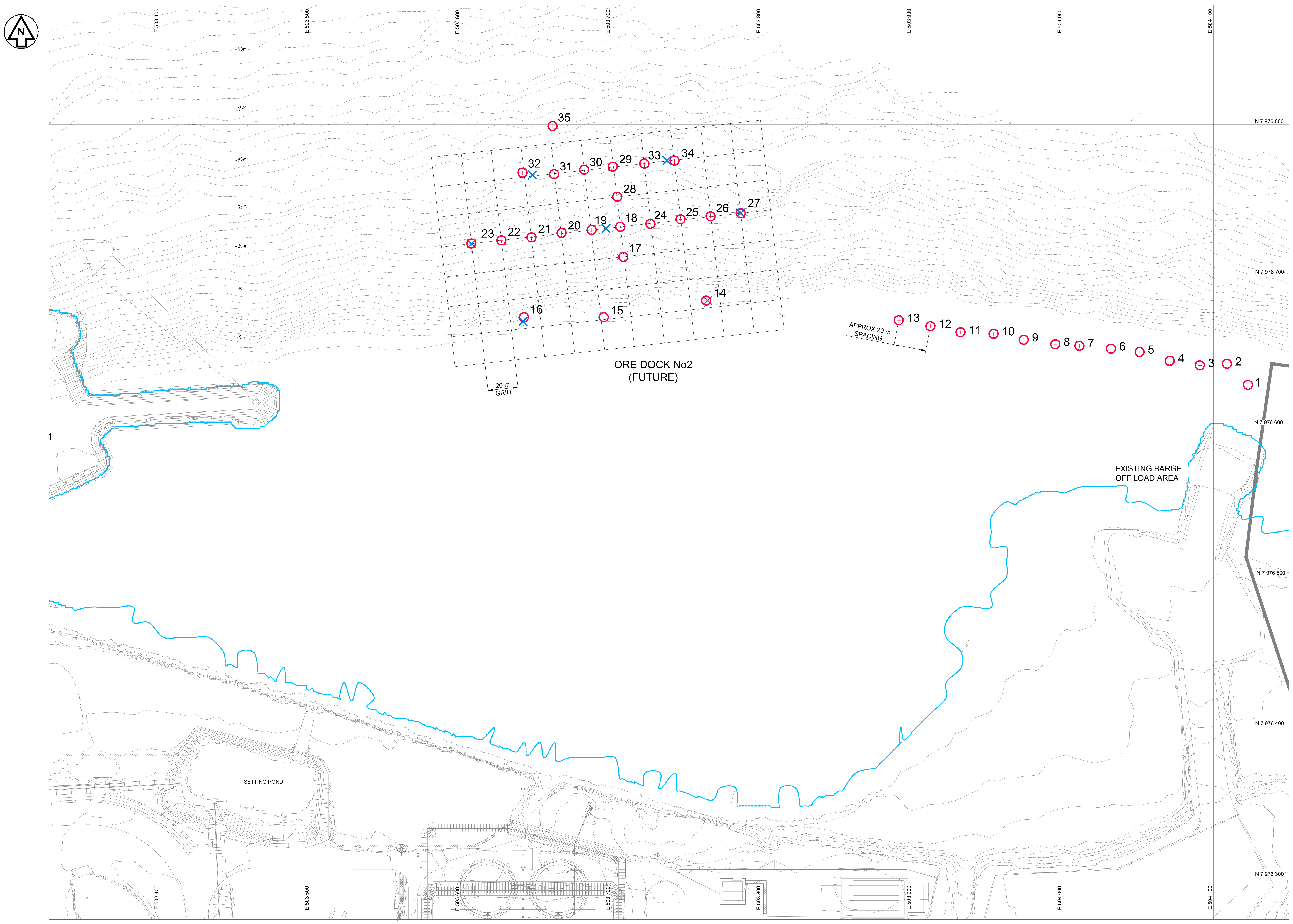
Gordon H Leaman

GORDON H. LEAMAN, P. ENG.
PRESIDENT

Appendix H

Ice Thickness Assessment

DWG. No. H352034-GEOSKT-229-292-0007



PLAN

0 30 60 90 120 150 METRES

SCALE 1:1500

NOTES:

1. *COORDINATE GRID IS UTM, NAD 83, ZONE 17*
2. *INFORMATION FOR BATHAMETRY IS A COMBINATION OF LOGISTEC STEVEDORING INC. AND M&S.*
3. *THE CHART DATUM HAS BEEN ASSUMED TO BE 1.2 METRES BELOW CGVD 28 (0.0m CHART DATUM = -1.2m GEODETIC DATUM)*
4. *ELEVATIONS ARE BASED ON CHART DATUM*
5. *DIMENSIONS AND ELEVATIONS ARE SHOWN IN METERS*

LEGEND

✕	GEOTECHNICAL INVESTIGATION LOCATION
⊕	AUGER HOLE LOCATION FOR OFFSHORE ICE ASSESSMENT (20 METERS SPACING, MAXIMUM)

DESIGN SHOWN IS A HATCH CONCEPT DESIGN
CONTRACTOR TO PROVIDE HIS OWN DESIGN

DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

NAME

SIGNATURE

ENG REG NUMBER

REVISION DATE

ORIGINAL DATE

REGISTERED PROFESSIONAL

No.	DESCRIPTION	BY	CHK'D	DATE
-	-	-	-	-

REVISIONS

HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	D PARKES	NR	16/03/2017
DESIGNER		NR	
CHECKER			
DESIGN COORD.	W HOYLE		
RESP. ENG.			
LEAD DISC. ENG.	S HINCHBERGER		
ENG. MANAGER			
PROJ. MANAGER	S HEINER		

DRAWING APPROVAL STATUS: CLIENT REVIEW

Baffinland

BAFFINLAND EXPANSION 12 MTPA MINE OPTION
PRE FEASIBILITY STUDY

PORT SITE - ORE DOCK No. 2
OFF SHORE ICE ASSESSMENT
AUGER HOLE LOCATIONS

SCALE 1:50,000 OR AS NOTED

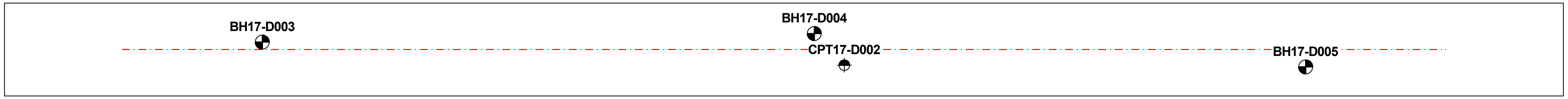
DWG. No. H352034-GEOSKT-229-292-0007

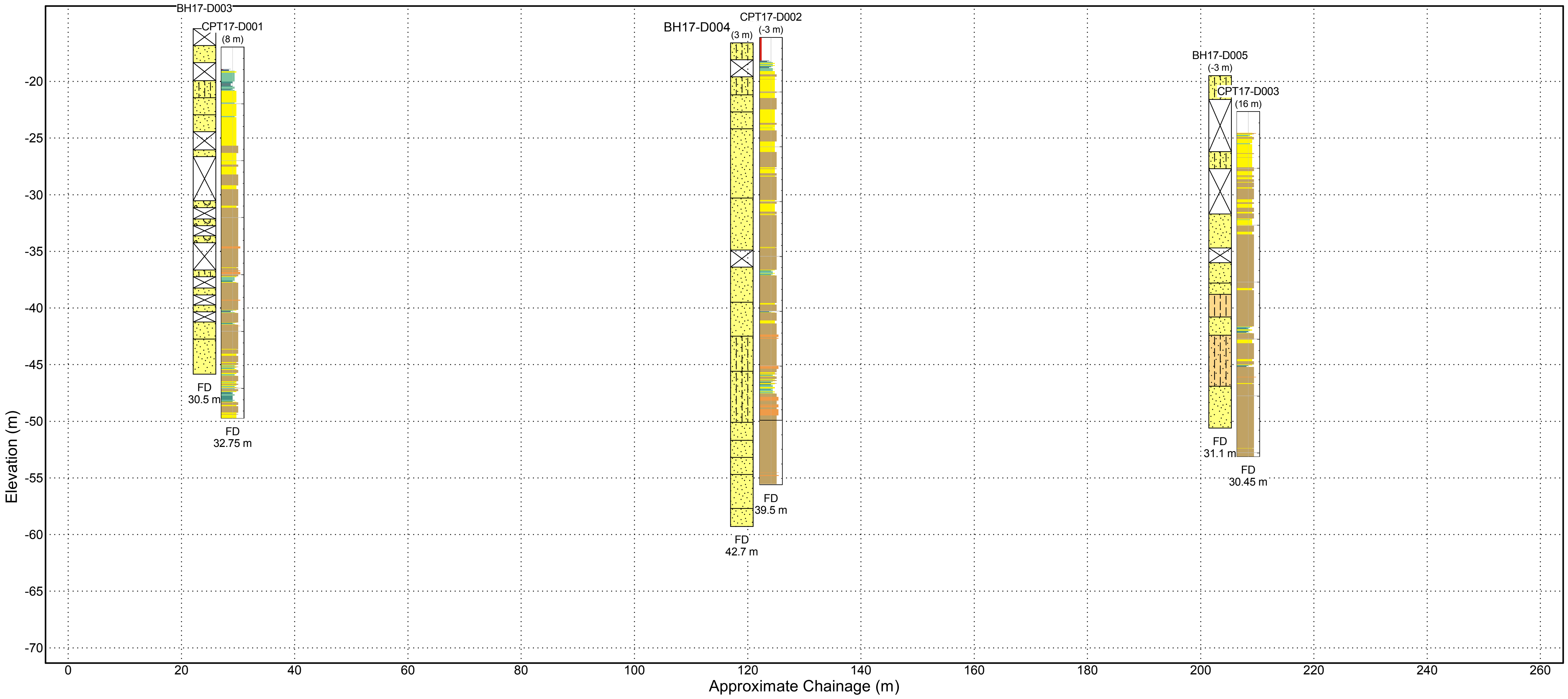
REV B

$USERNAME$
$DATE$
$FILE$
$TIME$

Appendix I

Fence Diagrams





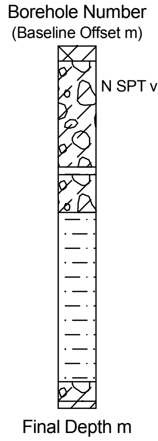
MAP KEY

● BH03 INVESTIGATION ON SECTION

◐ TP03 INVESTIGATION OFF SECTION

▲ ▲ SECTION LINES

POST LEGEND



STRATAGRAPHIC BOUNDARIES

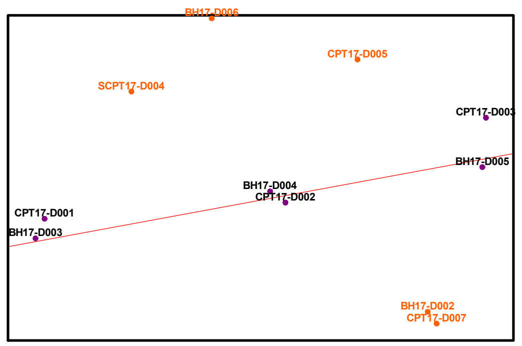
MATERIAL GRAPHICS

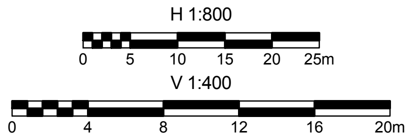
☒ Core Loss
▨ Sandy SILT
▨ Poorly-graded SAND
▨ Silty SAND
▨ Poorly-graded Gravelly SAND
▨ SILT

SBT GRAPHICS

▨ SAND
🟨 Silty SAND
🟧 Gravelly SAND
🟩 Sandy SILT
▨ SILT

SITE MAP





Coord.System: GDA94 Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines

PROJECT Marry River Expansion Study Stage 2

DRAWN JCH
DATE 4/28/2017

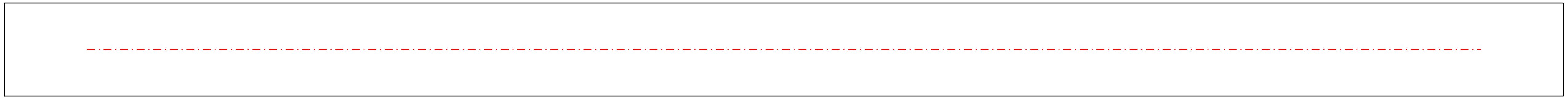
CHECKED WH
DATE 5/18/2017

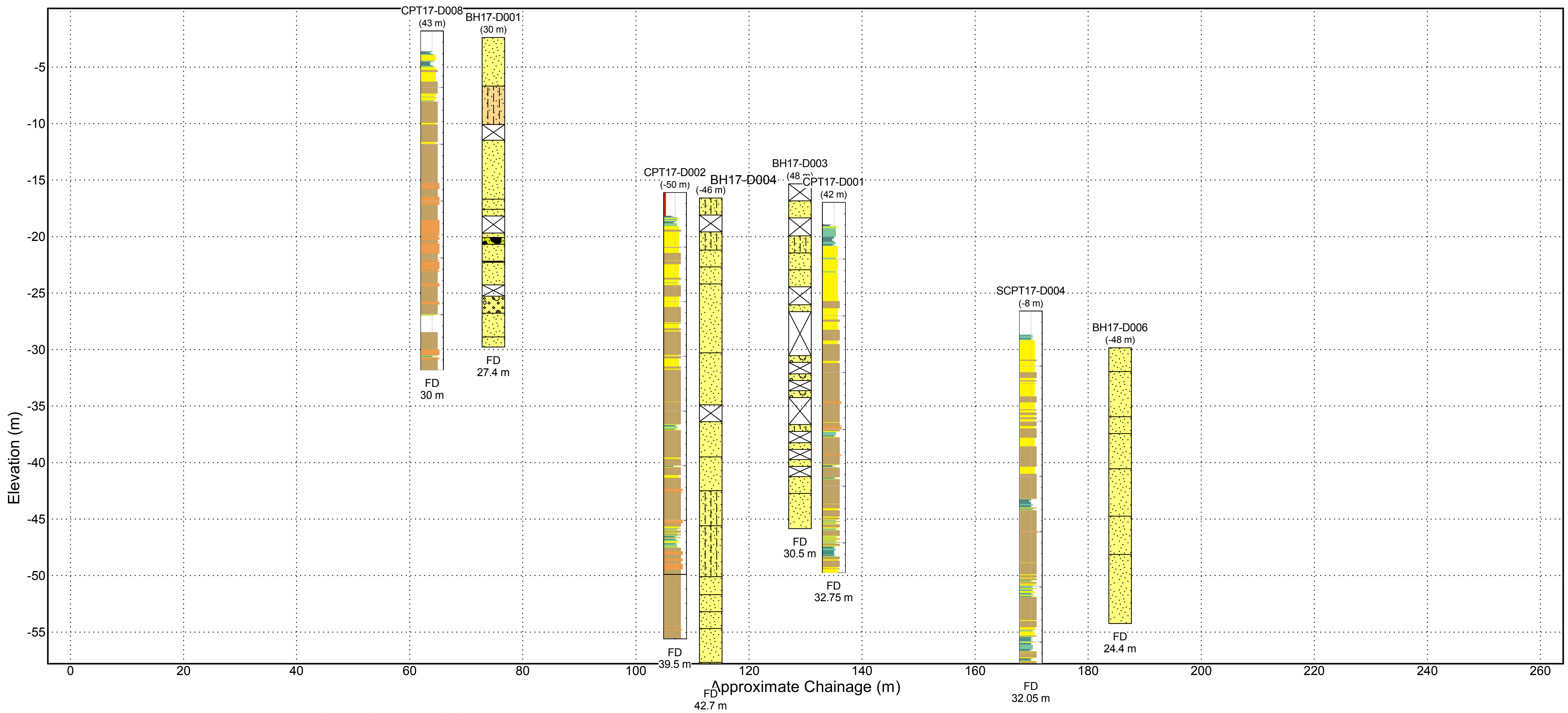
TITLE Ore Dock No. 2 Area West-East Section

SCALE H 1:800 V 1:400 VE=2X

PROJECT No H352034

FIGURE No I.1





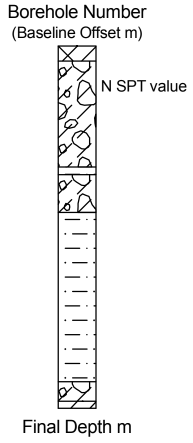
MAP KEY

◕ BH03 INVESTIGATION ON SECTION

◕ TP03 INVESTIGATION OFF SECTION

▲ ▲ SECTION LINES

POST LEGEND



STRATAGRAPHIC BOUNDARIES

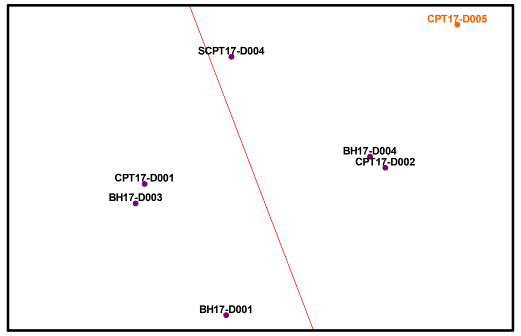
MATERIAL GRAPHICS

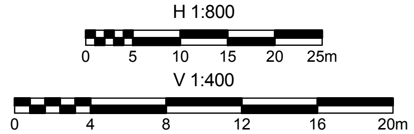
- ▨ Poorly-graded SAND
- ▨ Silty SAND
- ▨ Sandy SILT
- ▨ Poorly-graded Gravelly SAND
- ☒ Core Loss
- ▨ Well-graded Sandy GRAVEL
- ▨ Well-graded Gravelly SAND

SBT GRAPHICS

- 🟫 SAND
- 🟨 Silty SAND
- 🟧 Gravelly SAND
- 🟩 Sandy SILT
- 🟩 SILT

SITE MAP





Coord.System: GDA94 Zone 17 Height Datum: NAD83

HATCH

CLIENT Baffinland Iron Mines

PROJECT Marry River Expansion Study Stage 2

DRAWN JCH DATE 4/28/2017

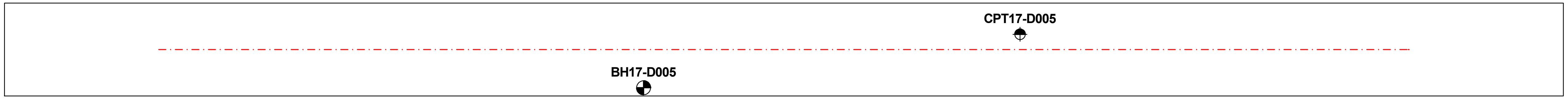
CHECKED WH DATE 5/18/2017

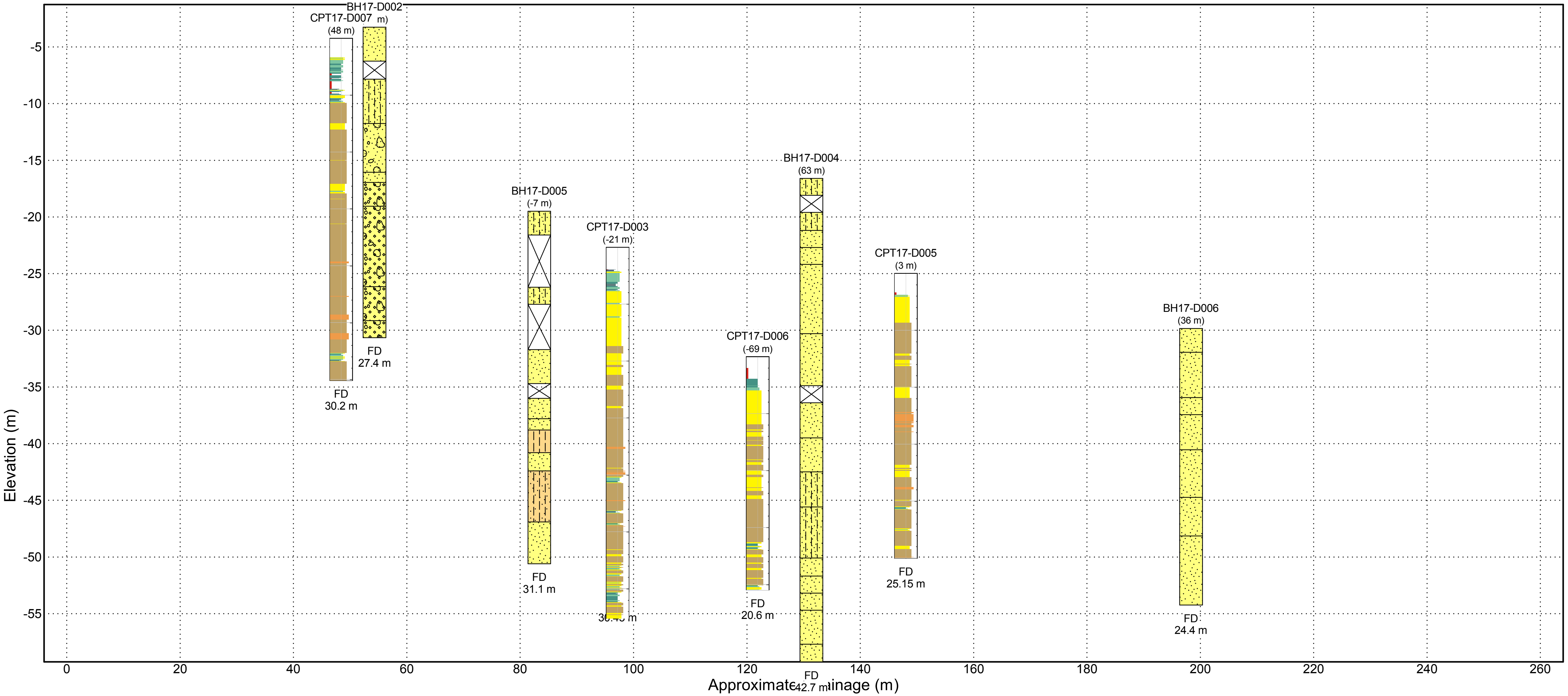
TITLE Ore Dock No. 2 Area South-North Section (West Side)

SCALE H 1:800 V 1:400 VE=2X

PROJECT No H352034

FIGURE No I.2

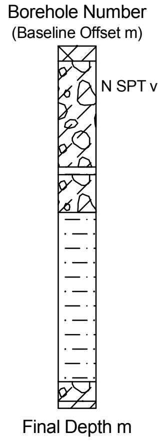




MAP KEY

●	BH03	INVESTIGATION ON SECTION
◐	TP03	INVESTIGATION OFF SECTION
▲ ▲		SECTION LINES

POST LEGEND



STRATAGRAPHIC BOUNDARIES

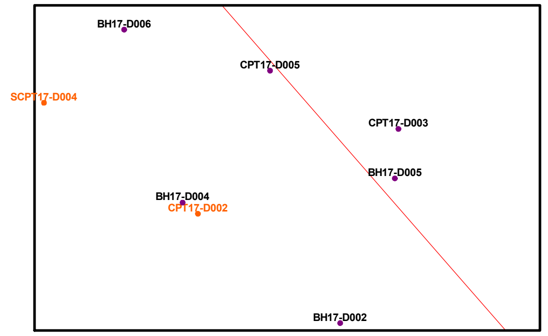
MATERIAL GRAPHICS

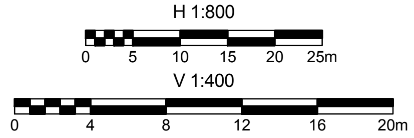
▨	Poorly-graded SAND	▨	SILT
☒	Core Loss	▨	Sandy SILT
▨	Silty SAND		
▨	Poorly-graded Gravelly SAND		
▨	Well-graded Gravelly SAND		

SBT GRAPHICS

🟫	SAND
🟨	Silty SAND
🟧	Gravelly SAND
🟩	Sandy SILT
🟩	SILT

SITE MAP





Coord.System: GDA94 Zone 17 Height Datum: NAD83

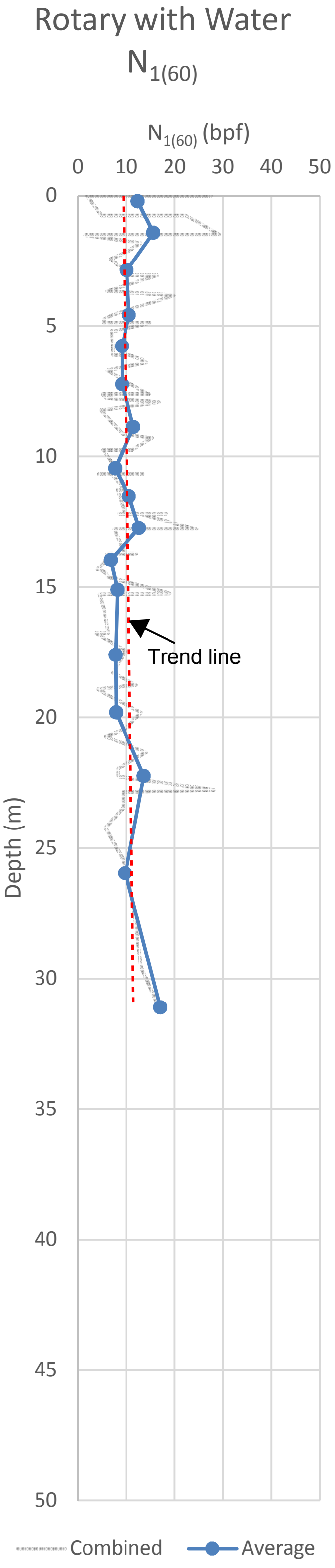
HATCH

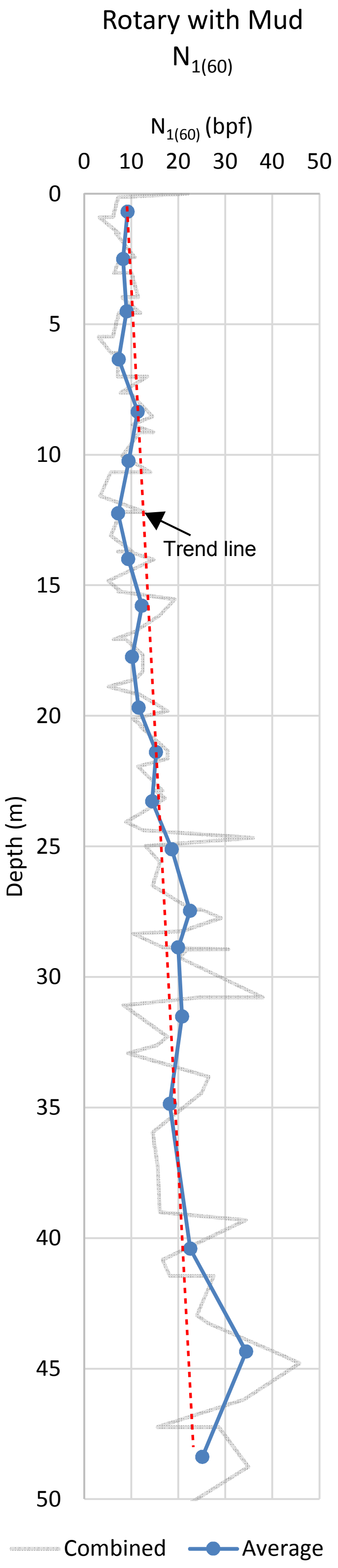
CLIENT Baffinland Iron Mines		PROJECT Marry River Expansion Study Stage 2	
DRAWN JCH	DATE 4/28/2017	TITLE Ore Dock No. 2 Area South-North Section (East Side)	
CHECKED WH	DATE 5/18/2017		
SCALE H 1:800 V 1:400 VE=2X		PROJECT No H352034	FIGURE No I.3

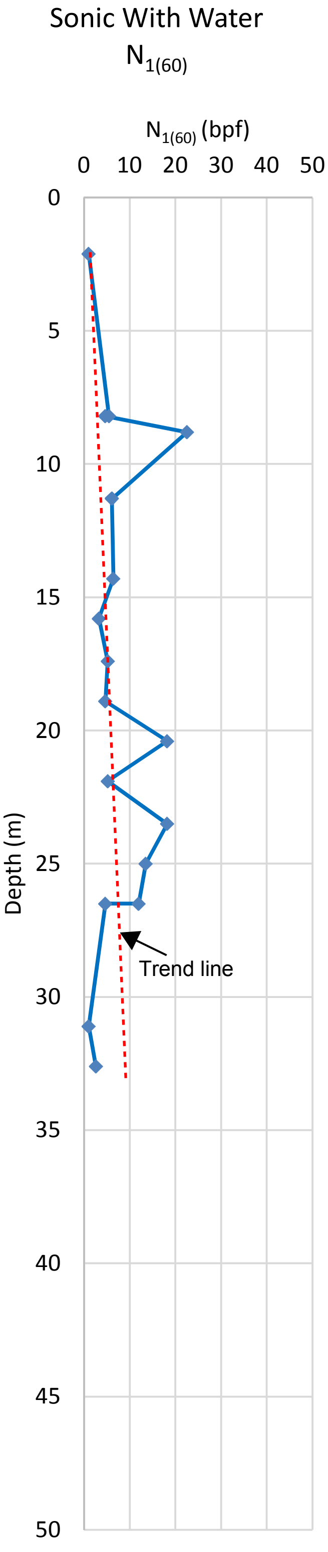
Appendix J

Influence of Drilling Method on Standard Penetration Testing

Mary River Expansion Study Stage 2
Geotechnical Investigation 2017
Influence of Drilling Methods on SPT $N_{1(60)}$ values


Rotary with Water
$N_{1(60)}$

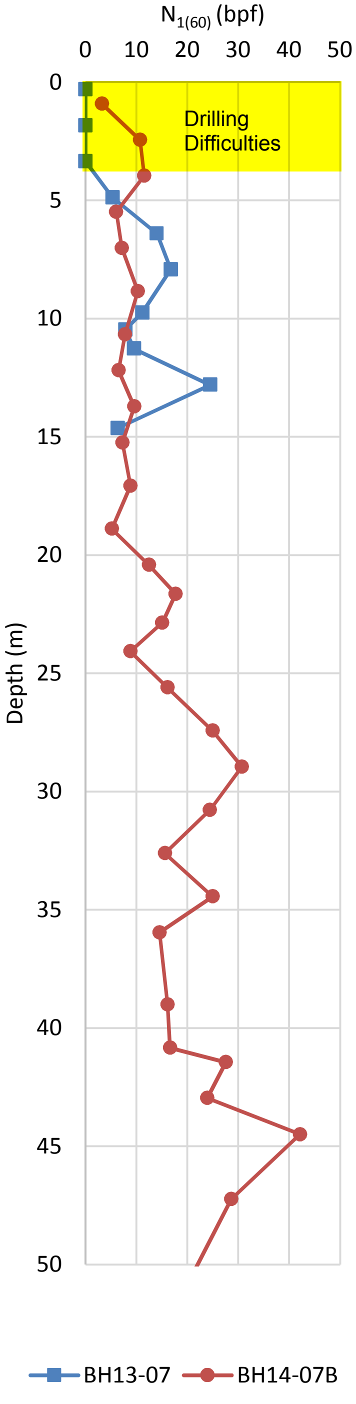

Rotary with Mud
$N_{1(60)}$


Sonic With Water
$N_{1(60)}$

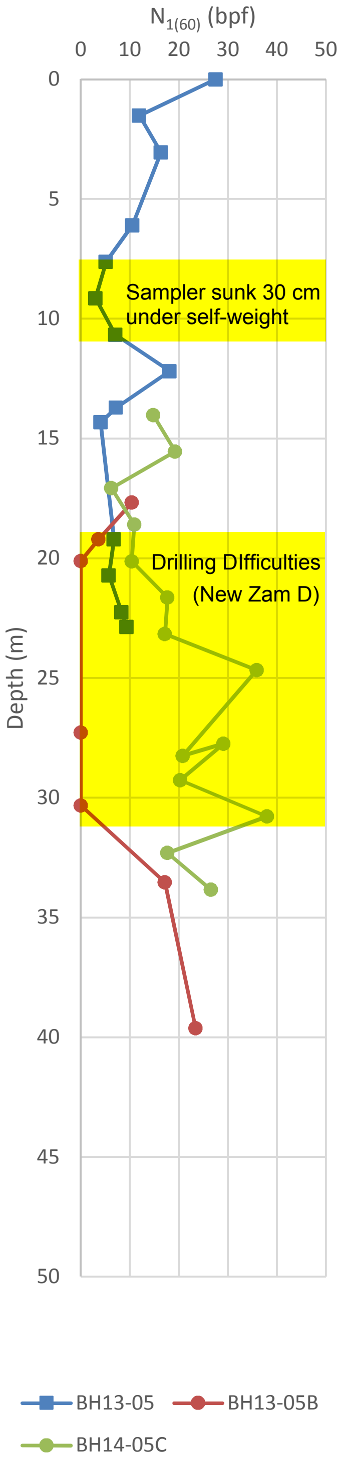
Not sufficient data for averaging $N_{1(60)}$ values

Notes:
Diamond Rotary with water includes data from BH13-03, BH13-05, BH13-07, BH13-08, BH13-09 and BH13-011
Diamond Rotary with Mud includes data from BH14-05C, BH14-06, BH14-07B, BH14-12 and BH14-13
Sonic with Water includes data from BH17-D001, BH17-D002, BH17-D003, BH17-D004, BH17-D005 and BH17-D006.

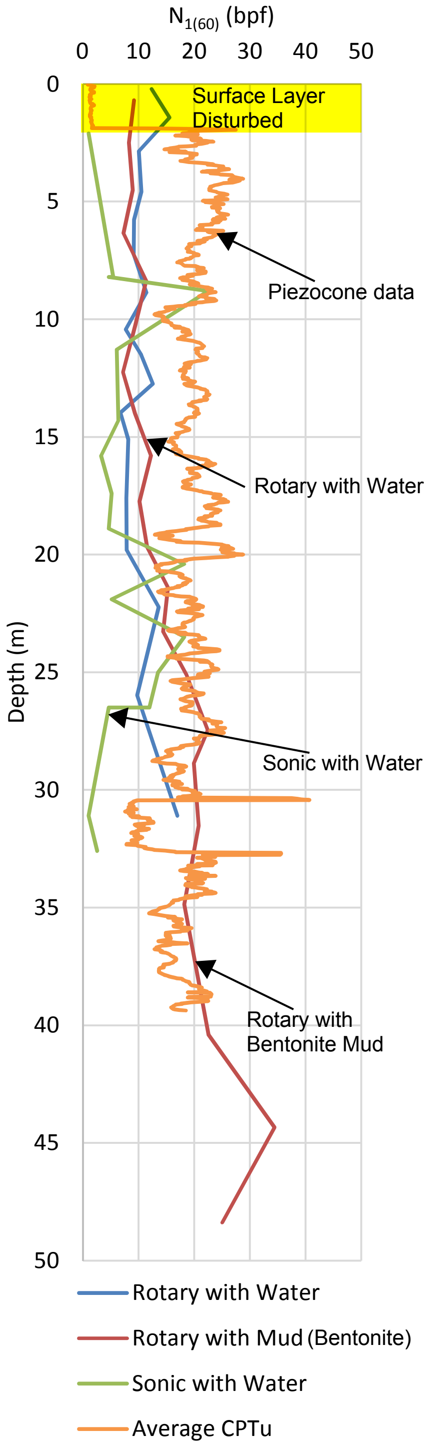
BH13-07
Water vs. Mud
$N_{1(60)}$ Comparison



BH13-05
Water vs. Mud
$N_{1(60)}$ Comparison



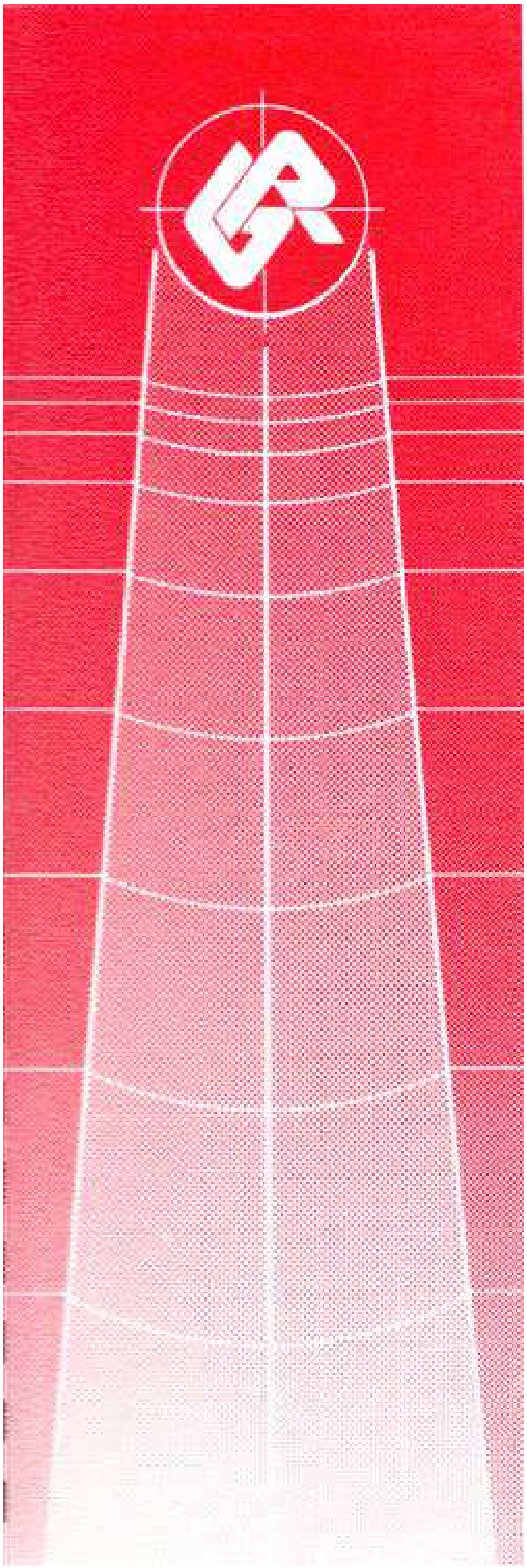
$N_{1(60)}$ Comparison
Drilling Methods



Notes:
BH13-05B was drilled with New Zam D Mud Only
BH14-05C and BH14-07B were drilled with New Zam D Mud and Bentonite
CPTu was averaged using data from CPT-D001, CPT-D002 and CPT-D003

ATTACHMENT 12.4

ORE DOCK GEOPHYSICS REPORT



GEOPHYSICAL SEISMIC SURVEY FOR A PROPOSED FIXED DOCK, MARY RIVER PROJECT, MILNE INLET, NUNAVUT

Presented to:
Baffinland Iron Mines Corporation
2275 Upper Middle Road East, Suite 300,
Oakville, Ontario
L6H 0C3

Presented by:
Geophysics GPR International Inc.
6741 Columbus Road. Unit 14
Mississauga, Ontario
L5T 2G9

February 2014 T13615

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1. Introduction

Geophysics GPR International Inc. was requested by Baffinland Iron Mines Corporation to carry out a geophysical survey to aid in projection and planning of a proposed fixed dock for the Mary River Project, Milne Inlet, Nunavut. The aim of the investigation was to map the depth to bedrock and provide details of the overburden material.

Seismic profiles were collected approximately parallel with the shoreline as well as lines going from land perpendicularly out to sea (Figure 1). The start and end of line coordinates are outlined in Table 1.

Table 1: Profile Line UTM Coordinates and Chainage

Profile	UTM Start		UTM End		Chainage Start	Chainage End
A-A'	503251E	7976390N	503238E	7976742N	0+000	0+352.5
B-B'	503325E	7976422N	503312E	7976774N	0+000	0+352.5
C-C'	503091E	7976600N	503415E	7976740N	0+000	0+352.5
D-D'	503105E	7976568N	503430E	7976707N	0+000	0+352.5
E-E'	503114E	7976547N	503439E	7976686N	0+000	0+352.5

Geophysics GPR field personnel involved in this project and the dates that they were on-site are outlined in Table 2.

Employee	Title	Dates On-Site
Cameron Coatsworth	Field Supervisor	Nov. 26 to Dec. 5, 2013
Benoit Maille	Senior Tech	Nov. 26 to Dec. 5, 2013
Nicolas Beaulieu	Geophysicist	Nov. 26 to Dec. 5, 2013

Table 2: Geophysics GPR Field Personnel

The seismic reflection, refraction, TISAR and shear-wave velocity analysis methods were applied to collect the data along the alignments shown in Figure 1. Approximately 1.76 km of profiled data were collected.

The following report describes the survey design, the principles of the seismic methods, the methodology for interpreting the data and finally a culmination of the results in the form of interpreted bedrock profiles.

Figure 1: Approximate seismic profile orientations, Milne Inlet, Nunavut

2. Methodology

2.1. Positioning, Topography and Units of Measurement

The locations of the seismic profiles were oriented to encompass the area and to align with the design of the proposed fixed dock location.

The positioning data (northing and easting) were collected by Monteith & Sutherland Limited at the start and end of each line as well as every 15 m along the lines.

The GPS coordinates and field observations were then converted to project chainage based on site plans provided by Baffinland and Hatch.

The geophones were installed on the ice surface. The elevation of the geophones varied with the tides. Ice elevation data provided by Monteith & Sutherland Limited from December 2nd and 3rd indicate a range of approximate 0.9 m to -1.1 m over the course of the survey day. An average elevation of the geophones on the ice has been assumed to be 0 m.

The topography for the land portions of the Line A and B has been estimated using field observations and borehole elevation data.

All geophysical measurements were collected in SI units.

2.2. Seismic Methods

Seismic methods for geologic mapping involve measuring/recording the response of vibration sensors. Multiple techniques and methodologies are available for analysis of the data depending on the ultimate goal of the investigation. The profiles were collected using a standard stationary geophone arrangement. Several different seismic sources were applied including; propelled elastic generator (PEG) hammer, buffalo gun and explosives. After initial testing, it was determined that the buffalo gun and explosives were the most suitable sources for this particular site.

Several essentially independent techniques were used to analysis the resulting data; namely, seismic reflection, seismic refraction, TISAR and surface wave analysis.

Each of the seismic techniques has strengths and weaknesses primarily related to the depth of interest and local geology. After initial testing, it was determined that the seismic reflection method was likely going to be the primary methodology supplemented with seismic refraction and TISAR and surface wave analysis.

2.2.1. Seismic Reflection

Basic Theory

The seismic reflection method relies on measuring the transit time of an acoustic energy wave that travels from the energy source location to a reflective event (i.e. change in acoustic impedance) and back to a receiver (geophone). The fastest seismic waves are the compressional (P) or acoustic waves. Figure 2 is a basic geometric layout for reflection ray paths.

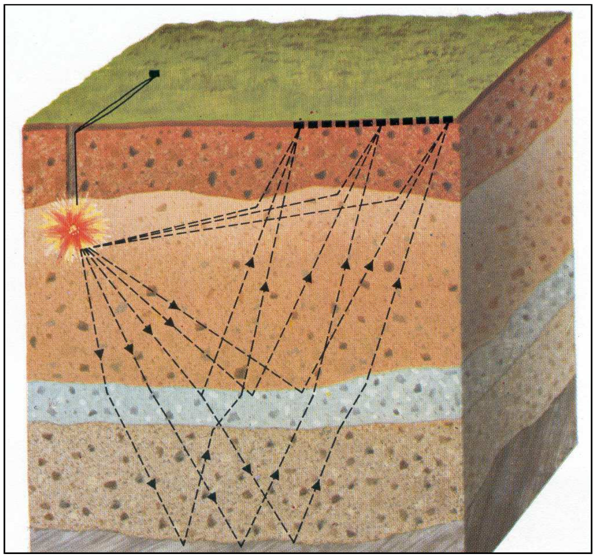


Figure 2: Simple Geometry of reflected pulse ray paths

Survey Design

A seismic spread consisted of 48 vibration monitoring devices (geophones) connected in line (spread) to a seismograph (ABEM Terraloc Pro) by connector cables. A seismic pulse (shot) is generated at a known location relative to the spread with a trigger system linked with the seismograph to begin the recording of the time-arrivals of the various seismic waves (shot record).

This investigation used 48 – 4.5 Hz geophones with a spacing between geophones of 7.5 m for a total individual profile length of 352.5 m.

The spacing between shots was 15 m with the shot inline with the seismic spread. Typically single shots were taken for each shot record, stacking was not needed to improve the signal to noise ratio.

The combination of geophone spacing and shot interval used for this investigation results in a varied-fold data set. Where fold refers to the multiplicity of the common-midpoint data. The highest fold was in the middle of the spread and decreased toward the ends.

The fold may be less for some shot gathers depending on geometry and individual geophone trace quality.

The seismic sources selected for this survey were devices called a “buffalo gun” and a “propelled elastic generator” (PEG). The “buffalo gun” was designed to fire a 12-gauge shotgun shell into a 5 cm diameter hole drilled through the ice. The PEG is a weight drop accelerated by elastic bands. The PEG was determined to be inadequate. It could not generate enough energy to transmit to the depths required of the geology. The “buffalo gun” source was determined to be the best option due to the prohibited use of explosives for the marine portion of this site.

Processing of Reflection Data

There are some common processing steps for every reflection data-set. These are purely mathematical or systematic steps that account for site conditions. There are also processing steps that serve to enhance the appearance of reflectors. Some of the more common steps include the removal of traces that are unusually noisy (trace kills) or correction of topography (statics corrections). In the processing sequence used for this project, there is flexibility in the order and the settings used in some optional processing steps.

It is important to note that there is no one correct processing sequence, as the processing steps and sequence are dependent on the geology and method of data collection. The following is a list of the processing steps and the order in which they were applied for this project.

1) Input seg2 data
2) time cut to 600 ms
3) trace editing (remove noisy traces)
4) Interpolation of removed traces
5) Gain correction
6) Filtering (bandpass and frequency-wave number)
7) Velocity Analysis
8) Normal move-out corrections
9) Common mid-point (CMP) Stacking
10) Time to depth conversion
11) Visual gain adjustments, horizontal filtering and contouring

Interpretation Method and Accuracy of Results

The reflection profile is essentially an image which must be interpreted. Without corroborating data, the true source or nature of a reflector can only be assumed. Interpretation of the data involves identifying reflectors and assigning a geologic context to them.

The two main sources of uncertainty in the results of a seismic reflection survey are in the velocity analysis and the assigning of reflectors to given geologic units.

2.2.2. Seismic Refraction

Basic Theory

The seismic refraction method relies on measuring the transit time of the wave that takes the shortest time to travel from the shot-point to each geophone. The fastest seismic waves are the compressional (P) or acoustic waves, where displaced particles oscillate in the direction of wave propagation. The energy that follows this first arrival, such as reflected waves, transverse (S) waves and resonance, is not considered under routine seismic refraction interpretation. Figure 3 illustrates the basic operating principle for refraction surveys.

Survey Design

The seismic spread setup utilized for seismic reflection was also used for seismic refraction. The seismic source was mainly buffalo gun. Explosives were used for the end and far shots on the land portion of the Line A and Line B.

This investigation used 48 – 4.5 Hz geophones with a spacing between geophones of 7.5 m for a total individual profile length of 352.5 m.

Typically, seven or more shots are executed per seismic spread; three to five shots within the profile to obtain the lateral velocity variation in the overburden and two shots on either side of the spread to provide the true velocity of the bedrock surface. The spacing between shots was generally every 45 m with the shot inline with the seismic spread. Typically single shots were taken for each shot record, stacking was not needed to improve the signal to noise ratio.

Interpretation Method and Accuracy of Results

Interpretation of the seismic data was primarily done using the critical distance method. Ideally, the Hawkins’ method is the preferred method as it allows the computation of the rock depth to every geophone, information on the thickness of the various overburden layers, depth to bedrock and rock quality. At this particular site, the depth of the rock was greater than expected, performing a full Hawkins' interpretation would have required the use of explosives in the water which was not permissible. Accordingly the critical distance and partial Hawkins' method were employed.

A full description of the strengths and limitations of the refraction seismic method is presented in Appendix A.

The seismic refraction method typically allows the determination of the bedrock profile with a precision of 10% or better for depths greater than 10 m and a precision of 1 m for depths less than 10 m. The precision in the determination of rock velocities is plus or minus 3%.

The two most significant problem areas for refraction mapping are the “hidden” layer and effect of velocity inversions.

A “hidden” layer or “blind zone” is a stratigraphic layer that is not possible to discern from the arrival time data due to insufficient velocity variation or thickness. The unknown presence of a hidden layer has the effect of making the interpreted bedrock depth too shallow. The presence of a “hidden” layer is typically revealed through borehole or test-pit data and calculations can be made to compensate for the presence of such a layer.

Velocity inversions occur when the velocity does not increase with depth. The velocity inversion can result from the presence of a low or high velocity layer. Refractions from low-velocity layers cannot be determined from the arrival time data. The unknown presence of a low velocity layer has the effect of making the interpreted depths deeper than actual depths.

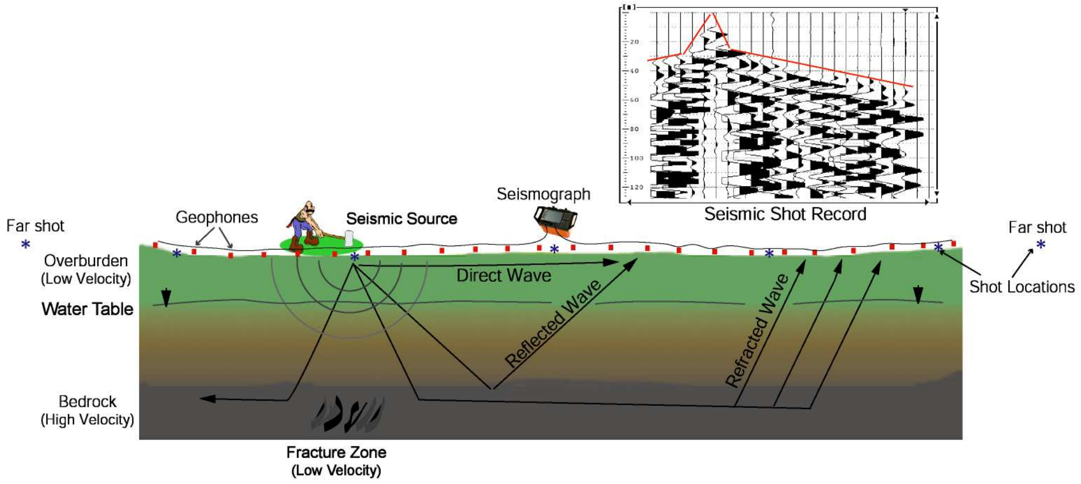


Figure 3: Seismic Refraction Operating Principle

2.2.3. Seismic Resonance (TISAR)

Basic Theory

The seismic resonance, or *TISAR (Testing & Imaging using Seismic Acoustic Resonance),* method is based on the frequency analysis of seismic records. It considers the seismic resonance within the signal. The method was originally developed for geological sub-surface profiling (1 to 15 m deep); however it has been shown to be effective for ranges smaller than 0.1 m for testing of concrete/asphalt structures, as well as for deep (100 m) geological investigations. Figure 4 is a combination figure showing applications for the method and a small sample of an output that is interpreted for geologic contacts.

The method uses the information from an induced seismic signal in the frequency domain instead of the direct time domain as with classic seismic reflection. For both methods, however, the principal physical parameter involved remains the acoustic impedance contrast, which is the product of the seismic velocity and the volumetric mass of the investigated materials. At the interface between two materials with different acoustic impedance, the seismic signal is partially reflected back to the surface. Under specific conditions, the repetition of such reflections leads to the build-up of a resonance signal, whose frequency is related to the depth of the interface and the seismic velocity of the upper material. The resonance frequency is inversely proportional to the reflection time. The first advantage of the use of frequencies instead of reflection times is the amplitude and the repetitive signal, which is less sensitive to the ambient noise and produces a resolution that increases with shallow depths. The second advantage of using resonance frequencies is the ability to resolve very thin layers (contrary to standard reflection).

Survey Design

The seismic spread setup utilized for seismic reflection and seismic refraction was also used for TISAR. A buffalo gun was used as the primary energy source. The buffalo gun was a good energy source for the resonance survey. The TISAR data was primarily used to supplement the reflection data in the shallow on-land portions.

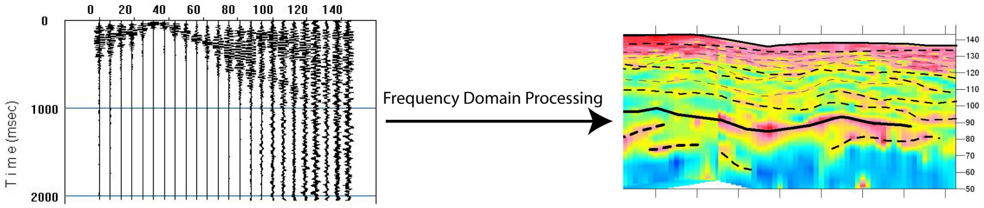
Interpretation Method and Accuracy of Results

The seismic resonance method requires adequate geological models and seismic velocities. These parameters are typically derived from seismic refraction measurements. The accuracy of the depths of TISAR reflectors is related to the accuracy of the layer velocities and thicknesses of the geological model. It may be possible that velocities vary by approximately 10% or more resulting in a similar variation in depth to a given reflector. Layer thicknesses estimated in the model could vary by a few metres resulting in variations of 20 to 30% in the resonance reflector depth. Resonance has the advantage of a vertical resolution that cannot be obtained from conventional seismic methods.

TISAR resonators can occur from geologic contacts, fractures and/or voids. As with seismic reflection and ground penetrating radar, the true nature/source of the resonators cannot be certain. Interpretation involves identifying trends in the relative amplitude of resonators.

The use of the word "relative" is the operative word. The vibration response of each geophone is normalized to itself and then a gain curve is applied to the entire geophone spread to compensate for the decrease in signal amplitude with depth (this is similar to ground radar). The gain curves are kept similar between profiles; however, changes in near surface geology and the resulting geophone coupling and hammer signal amplitude and frequency requires individual adjustment of the gain curves for each profile. Accordingly, discretion must be used when comparing the relative amplitudes of the resonators between profiles and depths.

The same colour palette (blue through violet) has been applied in all the data sets presented in this report. The TISAR values are unitless. The blue has "relatively" little or no acoustic impedance contrast when compared to the red within an entire data set. A geologic contact such as a fracture should appear in yellow to red unless there is a stronger contact such as a larger void within the data set in which case a subtle stratigraphic contact may not be visible.



Example Shot Record

Interpreted Results

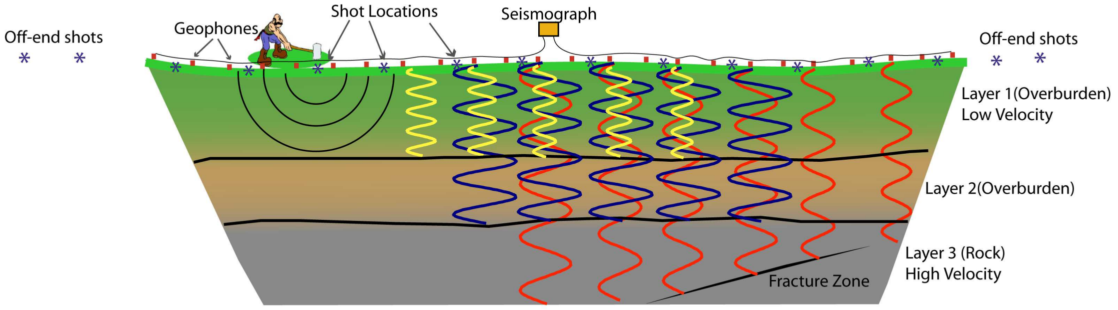


Figure 4: TISAR operating principle.

2.2.4. Multichannel Analysis of Surface Waves (MASW)

Basic Theory

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves ("ground roll"). The dispersion properties are measured as a change in phase velocity with frequency. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. Inversion of the Rayleigh wave dispersion curve yields a shear-wave (V_s) velocity depth profile (sounding). Figure 5 outlines the basic operating procedure for the MASW method. Figure 6 is an example image of a typical MASW record and resulting 1D V_s model. A more detailed description of the method can be found in the paper *Multi-channel Analysis of Surface Waves,* Park, C.B., Miller, R.D. and Xia, J. Geophysics, Vol. 64, No. 3 (May-June 1999); P. 800–808.

Survey Design

The geometry of an MASW survey is similar to that of a seismic refraction investigation (i.e. 12 or more geophones in a linear array). The fundamental principle involves intentionally generating an acoustic wave at the surface and digitally recording the surface waves from the moment of source impact with a linear series of geophones on the surface. This is referred to as an “active source” method. Unlike the reflection method, which produces a data point beneath each geophone, the shear-wave depth profile is the average of the bulk area within the entirety of the geophone spread.

Interpretation Method and Accuracy of Results

The main processing sequence involves plotting, picking, and 1-D inversion of the MASW shot records using the SeisimagerSW™ software package. The results of the inversion process are inherently non-unique and the final model must be judged geologically realistic. The inversion modelling also assumes that all layering is flat/horizontal and laterally uniform.

Typically the accuracy of the shear-wave velocities modelled from the MASW method is on the order of +/- 10 to 15% for overburden material. The estimated error is typically higher for shear-wave velocities within rock formations.

At this particular site, the geology was not ideal for MASW soundings. The permafrost, ice and water layers will complicate the dispersion images. The method also assumes that the geology is laterally homogenous. The most suitable profile for MASW analysis was SL-E as the water depth was relatively shallow and uniform; however, analysis of the dispersion images for SL-D and SL-C appear to yield reasonable results. Ideally for marine MASW surveys, the geophones/hydrophones are placed on or as close as possible to the sea-floor.

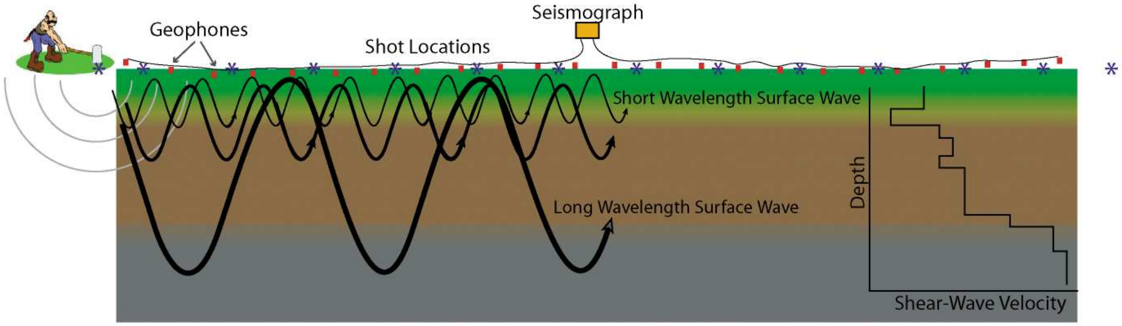
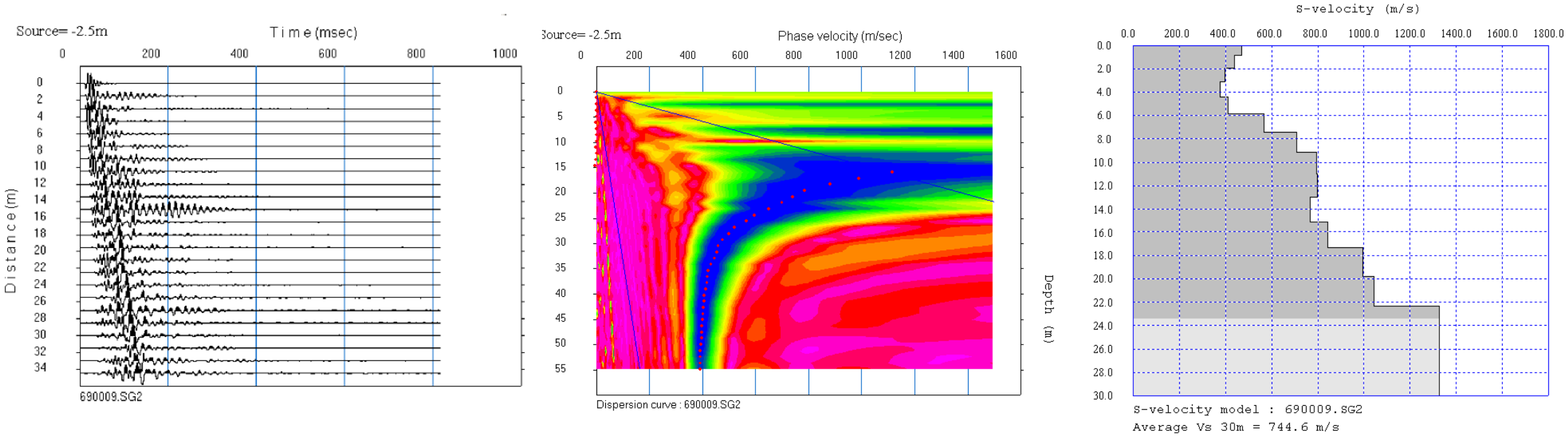


Figure 5: MASW Operating Principle



Raw Seismic Shot Record

Phase Velocity-Frequency Transformation indicating Dispersion Curve

1D Shear-Wave Velocity Profile from Inversion of Dispersion Curve

Figure 6: Example of a typical MASW shot record, phase velocity/frequency curve and resulting 1D shear-wave velocity model.

3. Results

The combined results of the seismic reflection, refraction, TISAR and MASW interpretations are presented in Appendix C in the form of interpreted cross-sections (Drawing T13615_A1). The interpreted contacts are based on the combined results of the shear-wave modelling, reflection images, critical distance calculations and borehole data.

The overall quality of the seismic records was very good.

Initial testing indicated that the seismic reflection method was most suitable to this particular site.

The primary objective of the survey was to identify the top of rock. It has been represented by a thick red line from the reflection interpretation and a magenta line based on the refraction analysis. Additional overburden contacts interpreted from the reflection and TISAR images are indicated by blue and grey lines respectively.

S-wave velocities can be used as an indicator of overburden types and bedrock competence. Appendix A contains a table of soil and rock classification based on S-wave velocities. MASW shear-wave data were analyzed for SL-C, SL-D and SL-E. The shear-wave models have been overlain on the cross-sections of drawing T13615_A1. As discussed above, the conditions for MASW analysis were not ideal at this particular site. The S-wave velocities determined through the MASW method are modelled velocities as opposed to true velocities measured using standard in-situ measuring methodology. The modelled velocities are typically within +/-10 to 15% of the true velocities of the overburden material; however, the added complications of the ice/water layers and multiple dispersion modes likely increase this error for this particular survey.

The seismic reflection and resonance (TISAR) data are primarily imaging tools. Alone, the methods do not provide indications of the material type. In addition, a velocity must be applied to convert the vertical scale of the images to a depth scale. The velocity can be estimated by correlation with borehole data. Interpretation of the data involves visually identifying reflector trends and corroborating with borehole data.

Interpretation of the seismic reflection data has identified 6 layers based on relatively stronger reflectors. These 6 layers have very good correlation at the intersection points of the seismic lines. The identification of the layers does not necessarily indicate uniform material within the layer. Gradual changes or thin layers may not generate a clear detectable reflection.

Relatively weaker reflectors have also been identified. The correlation of the weaker reflectors between the seismic profiles has not been systemically analyzed.

Comparison with the borehole logs suggest the following summaries for the defined overburden layers:

Layer 1: Layer 1 the upper most layer and represents materials from the sea floor to an elevation of approximately -10 m (onshore) to -32 m (offshore at SL-C). Offshore, in the vicinity of Line C, and based on borehole BH-13-09, this layer is interpreted as loose silty sand. Towards the shore there appears to be an increase in coarser grained materials; however the layer remains loose (BH-13-05 and MASW data). At the shoreline, boreholes indicate that this layer is fully (BH-13-01) to partially frozen (BH-13-02).

MASW S-wave velocities were modelled to be between 175 to 250 m/s for this layer.

Layer 2: Layer 2 is defined by a strong upper reflector. Borehole 13-09, along SL-C, suggests that this layer is characterized by compact silt and sand. Boreholes along SL-D indicate the layer is dominated by relatively uniform compact sand. Boreholes along SL-E indicate predominately compact sand (BH-13-08) with some silt and gravel layers (BH-14-13 and BH-13-11).

MASW S-wave velocities were modelled to be between 175 to 275 m/s for this layer.

Layer 3: The top of Layer 3 is best defined along SL-D.

BH-14-07b indicates primarily sand with some gravel and silt layers. The SPT N-Values are higher than the overlying layers.

BH-14-06 indicates more silt content than BH-14-07b.

BH-14-05C indicates primarily dense to very dense sand with some silt layers. As with BH-14-07b, the SPT N-Values are higher than the overlying layers.

BH-13-05b indicates very loose sand. This conflicts with the nearby BH-14-05C.

BH-13-09 intersects with the top of Layer 3 on SL-C. There is no sample logging; however, the DCPT indicates an increase (followed by a decrease) in blows near the top of Layer 3.

BH-14-13 along SL-E extends into the top of this layer and indicates sand and gravel for the upper 7 m.

No boreholes on-shore extend to this layer.

MASW S-wave velocities were modelled to be between 250 to 375 m/s for this layer.

Layer 4: The top of layer 4 is well defined along SL-C; however there are no boreholes that extend to it along the line nor along SL-E. Along SL-D BH-13-05B, BH-14-05C, BH-14-06 and BH-14-07B extend into this interpreted layer at an elevation of approximately -53 m. The boreholes indicate primarily dense to very dense sand.

MASW S-wave velocities were modelled to be between 400 to 460 m/s for this layer.

No on-shore boreholes extended into this interpreted layer.

Layer 5: A single borehole (BH-14-07b) extends to the top of Layer 5 at an elevation of -66 m. The borehole indicates dense sand with trace silt, less dense than the material immediately overlying it.

MASW S-wave velocities were modelled to be between 460 to 600 m/s for this layer.

Layer 6: MASW S-wave velocities were modelled to be between 525 to 760 m/s for this layer indicating the potential for dense sediments.

No boreholes extend to layer 6.

4. Conclusions & Recommendations

A total of approximately 1.76 km of seismic data were collected along five profiles in the vicinity of the proposed fixed dock, Mary River Project, Milne Inlet, Nunavut (Figure 1).

The data are presented in the form of cross-sectional figures in drawing T13615_A1.

Bedrock depths have been interpreted from a combination of seismic reflection and refraction data. The interpreted bedrock elevation ranged from approximately 90 to 140 m below sea-level. There was no borehole data available to corroborate the bedrock depth. P-wave velocities in the order of 3900 to 5100 m/s suggest the bedrock is competent.

Interpretation of the reflection data identifies 6 overburden layers overlying the bedrock based on relatively stronger, continuous reflectors. Borehole data for 16 boreholes were provided by Hatch Ltd. to aid in the interpretation of the seismic data. Brief descriptions of the bulk layer properties based on borehole data have been provided above. The reader is referred to the geotechnical report by Hatch Ltd. for the analysis of borehole and geotechnical data.

Interpretation of the TISAR data identifies a number of resonators that could represent geologic overburden contacts. In general the TISAR method provides a higher resolution than the seismic reflection method. The TISAR contacts are interpreted to represent the various sand/gravel contacts identified in the borehole logs. As mentioned above, the TISAR data requires an accurate velocity model. At this particular site, due to the permafrost, assumptions had to be made regarding the velocity model. Variations in the thickness or seismic velocity of the permafrost layers will have a large effective in the overall accuracy of the interpreted results.

The velocity model, and thus interpreted images, for the on-shore portions are likely less accurate than the off-shore profiles. This is due to the irregularly/discontinuous frozen soil as indicated in BH-13-01/b, BH-13-02 and BH-14-12. The combined TISAR and reflection images for SL-A and SL-B do suggest however, that the geologic layers interpreted off-shore, can be interpreted continuing on-shore.

Line SL-E was the most suitable data set for MASW processing due to the shallow water and unfrozen sediments. The frozen ground on/near the shore created a large velocity inversion and contrast at surface, which does not allow adequate frequency dispersion. The water was shallow for SL-E and the sediments unfrozen. Lines SL-C and SL-D had deep water and unfrozen sediments. The overall accuracy of the shear-wave velocity measurements is not certain due to water depths and ice.

Shear strength data can be more reliably measured in marine conditions using data collected with hydrophones on or near the water bottom and a seismic source such as an air gun. On-shore, intrusive, e.g. downhole, methods can accurately measure the shear-wave velocity beneath the permafrost.

Processing and interpretation of the seismic data was performed by Ben McClement, P.Eng. and Olivier Létourneau. This report has been written by Milan Situm, P.Geo. and reviewed by Ben McClement, P.Eng.

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APPENDIX A

SEISMIC EQUIPMENT AND METHODOLOGY FACT SHEETS

TERRALOC PRO FEATURES

Terraloc Pro - Your guarantee for high-quality fieldwork

A STAND-ALONE SEISMOGRAPH, RUGGED FOR DEMANDING ENVIRONMENTS:
A self-contained instrument, designed to cope with rough field conditions.

VERSATILE & FUTURE-PROOF: You don't know what your next job will demand, with the Terraloc Pro you are equipped to successfully take on a wide range of seismic surveys.

SAVES VALUABLE FIELD TIME: Terraloc Pro offers built-in diagnostics and remote management as well as vendor assisted support over the net.

HIGH QUALITY DATA: Don't compromise, return from the field with superior data, Terraloc Pro delivers top class performance.

SECURE INVESTMENT: Terraloc Pro is a product for the future, it allows for add-on of new functionality and seamless expansion.

The ABEM Terraloc line of seismographs has a long and well-known reputation for ease of use and reliability under the toughest field conditions. With this brand new Terraloc Pro instrument, ABEM has stretched the specification and incorporated several new features. Well working software functionality has been inherited from its predecessor in order to save time and effort for the user. All together, this new instrument is a high quality product, designed to meet demanding field requirements.

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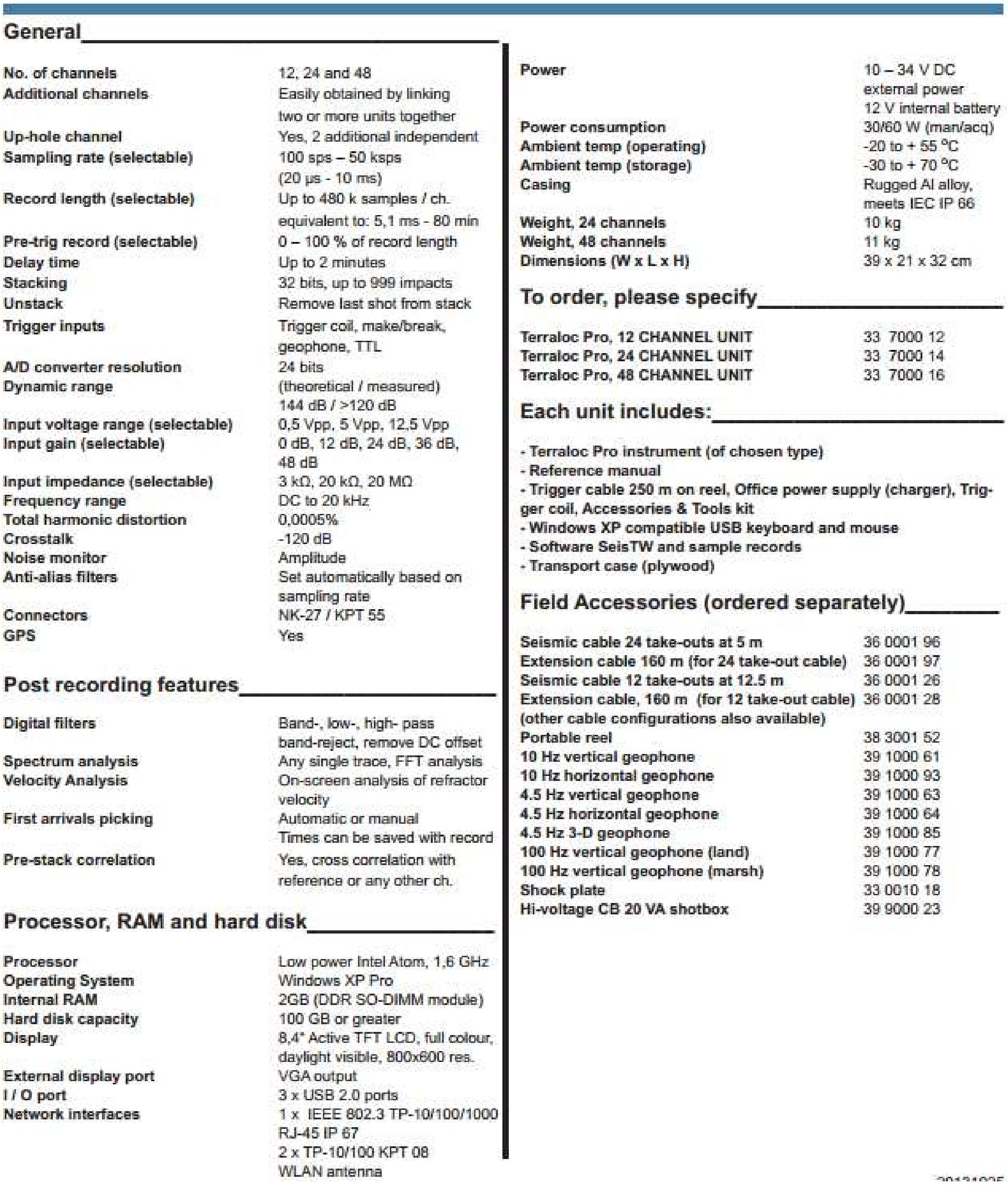


General

No. of channels	12, 24 and 48
Additional channels	Easily obtained by linking two or more units together
Up-hole channel	Yes, 2 additional independent
Sampling rate (selectable)	100 sps – 50 ksps (20 µs - 10 ms)
Record length (selectable)	Up to 480 k samples / ch. equivalent to: 5,1 ms - 80 min
Pre-trig record (selectable)	0 – 100 % of record length
Delay time	Up to 2 minutes
Stacking	32 bits, up to 999 impacts
Unstack	Remove last shot from stack
Trigger inputs	Trigger coil, make/break, geophone, TTL
A/D converter resolution	24 bits
Dynamic range	(theoretical / measured) 144 dB / >120 dB
Input voltage range (selectable)	0,5 Vpp, 5 Vpp, 12,5 Vpp
Input gain (selectable)	0 dB, 12 dB, 24 dB, 36 dB, 48 dB
Input impedance (selectable)	3 kΩ, 20 kΩ, 20 MΩ
Frequency range	DC to 20 kHz
Total harmonic distortion	0,0005%
Crosstalk	-120 dB
Noise monitor	Amplitude
Anti-alias filters	Set automatically based on sampling rate
Connectors	NK-27 / KPT 55
GPS	Yes

Post recording features

Digital filters	Band-, low-, high- pass band-reject, remove DC offset
Spectrum analysis	Any single trace, FFT analysis
Velocity Analysis	On-screen analysis of refractor velocity
First arrivals picking	Automatic or manual Times can be saved with record
Pre-stack correlation	Yes, cross correlation with reference or any other ch.

Processor, RAM and hard disk

Processor	Low power Intel Atom, 1,6 GHz
Operating System	Windows XP Pro
Internal RAM	2GB (DDR SO-DIMM module)
Hard disk capacity	100 GB or greater
Display	8,4" Active TFT LCD, full colour, daylight visible, 800x600 res.
External display port	VGA output
I / O port	3 x USB 2.0 ports
Network interfaces	1 x IEEE 802.3 TP-10/100/1000 RJ-45 IP 67 2 x TP-10/100 KPT 08 WLAN antenna

Power	10 – 34 V DC external power 12 V internal battery
Power consumption	30/60 W (man/acq)
Ambient temp (operating)	-20 to + 55 °C
Ambient temp (storage)	-30 to + 70 °C
Casing	Rugged Al alloy, meets IEC IP 66
Weight, 24 channels	10 kg
Weight, 48 channels	11 kg
Dimensions (W x L x H)	39 x 21 x 32 cm

To order, please specify

Terraloc Pro, 12 CHANNEL UNIT	33 7000 12
Terraloc Pro, 24 CHANNEL UNIT	33 7000 14
Terraloc Pro, 48 CHANNEL UNIT	33 7000 16

Each unit includes:

- **Terraloc Pro instrument (of chosen type)**
- **Reference manual**
- **Trigger cable 250 m on reel, Office power supply (charger), Trigger coil, Accessories & Tools kit**
- **Windows XP compatible USB keyboard and mouse**
- **Software SeisTW and sample records**
- **Transport case (plywood)**

Field Accessories (ordered separately)

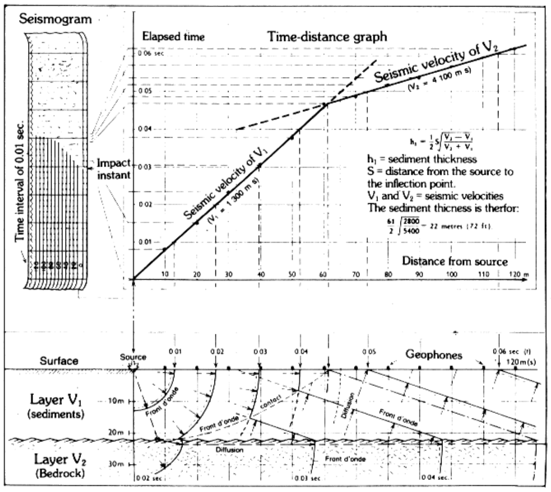
Seismic cable 24 take-outs at 5 m	36 0001 96
Extension cable 160 m (for 24 take-out cable)	36 0001 97
Seismic cable 12 take-outs at 12.5 m	36 0001 26
Extension cable, 160 m (for 12 take-out cable)	36 0001 28
(other cable configurations also available)	
Portable reel	38 3001 52
10 Hz vertical geophone	39 1000 61
10 Hz horizontal geophone	39 1000 93
4.5 Hz vertical geophone	39 1000 63
4.5 Hz horizontal geophone	39 1000 64
4.5 Hz 3-D geophone	39 1000 85
100 Hz vertical geophone (land)	39 1000 77
100 Hz vertical geophone (marsh)	39 1000 78
Shock plate	33 0010 18
Hi-voltage CB 20 VA shotbox	39 9000 23

GEOPHYSICS G P R INTERNATIONAL INC.

SEISMIC REFRACTION

Seismic refraction consists of recording the length of time taken for an artificially provoked surface vibration to propagate through the earth. By processing the data, the seismic velocities and depths of the underlying rock layers can be determined. These velocities are characteristic of the nature and quality of the bedrock; a fissured, fractured or sheared rock will be characterized by reduced seismic velocities.

The method is generally used to obtain a better geological analysis of the sub-surface and to determine the following characteristics: the quality, profile and depth of bedrock, its nature, degree of alteration and any other physical contrasts. Seismic refraction ensures that maximum information may be gained from geological field work, and that direct investment costs (drilling, excavation), will be reduced.



PRINCIPLE OF SEISMIC REFRACTION

FEATURES

- Precise determination of soil thickness .
- Precise determination of the seismic velocities (rock type and quality).
- Localization and identification of geological units.
- Detailed analysis of soil.
- Year-round use.
- Sea and land surveys (above and below ground).
- Great accessibility possible to rough terrain and remote regions.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

- Identification of faults, fractures, shear zones.
- Detection of rock differences (veins, dykes, cavities, etc.).
- Determination of rock topography.
- Evaluation of volume of soil present or to be excavated.
- Excellent complement to geological mapping.
- Recognition of geophysical anomalies such as VLF, gravimetry, etc.
- Drill site selection, better target identification.
- Evaluation of the size, thickness and condition of surface shafts (mining exploitation).
- Mass Rock Quality Determination (MRQD).
- Detection of rock irregularities and breaks.
- Hydrogeology (detection of water tables, veins, reservoirs).
- Excellent complement to any geological analysis.

AREAS OF APPLICATION

Civil Engineering/Mining Exploration - Exploitation/Petroleum and Gas Sectors/ Geotechnology/Geology/ Hydrology.

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- Detection of rock irregularities and breaks.
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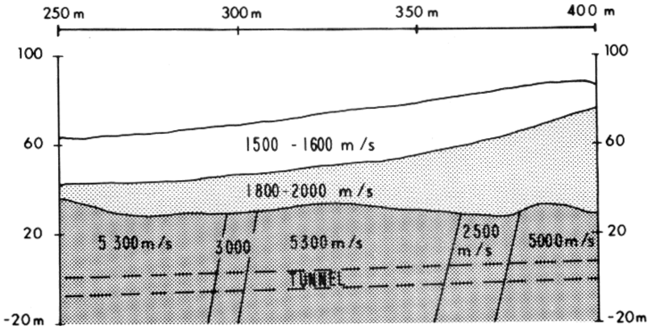
- Excellent complement to any geological analysis.

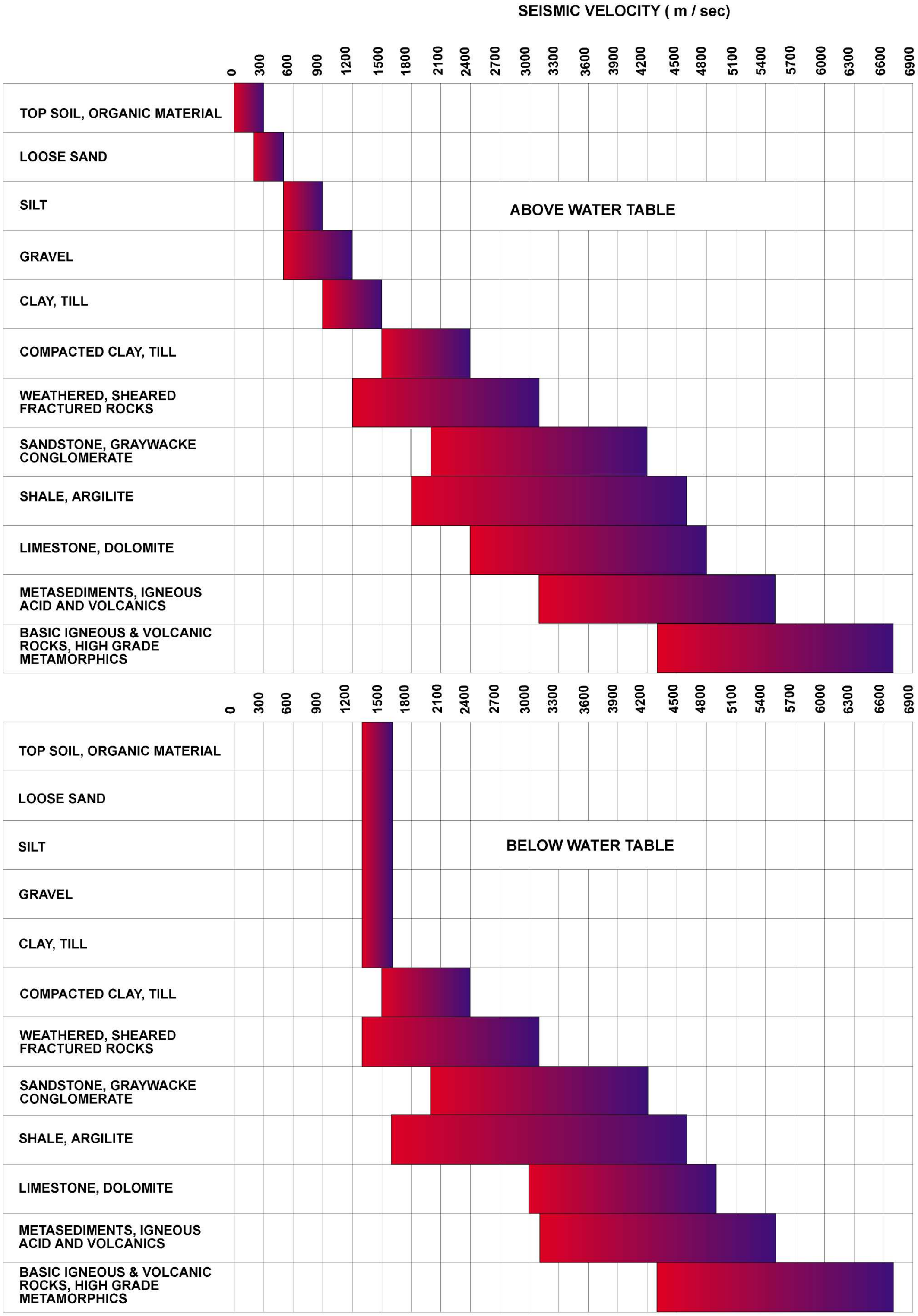


Interpretation results of a seismic profile

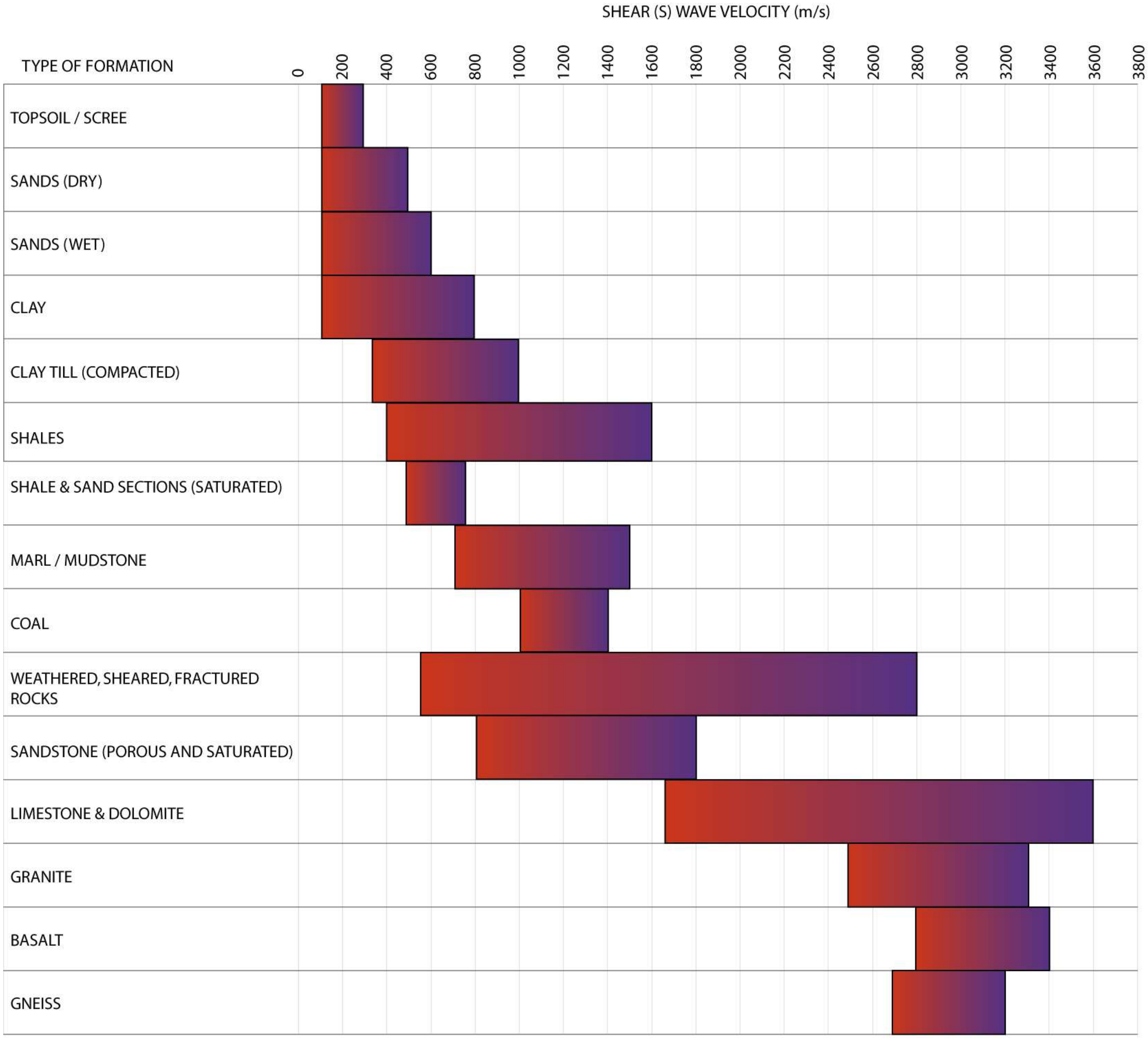
ADDITIONAL REMARKS

Geophysics GPR International Inc. has been recognized for the past fifteen years as a leader in both the application and the development of seismic methods. Seismic refraction is currently used in both civil and mining engineering; the use of lighter high-performance equipment and better tomographical interpretation of the results have contributed to its growing popularity.

GEOPHYSICS G P R INTERNATIONAL INC.



SOIL AND ROCK CLASSIFICATION
BASED ON SEISMIC VELOCITIES



Typical rock velocities, Based on Bourbie, Coussy and Zinszner, Acoustics of Porous Media, 1987
with modifications by Geophysics GPR. Rev A.1 July 2011

APPENDIX B

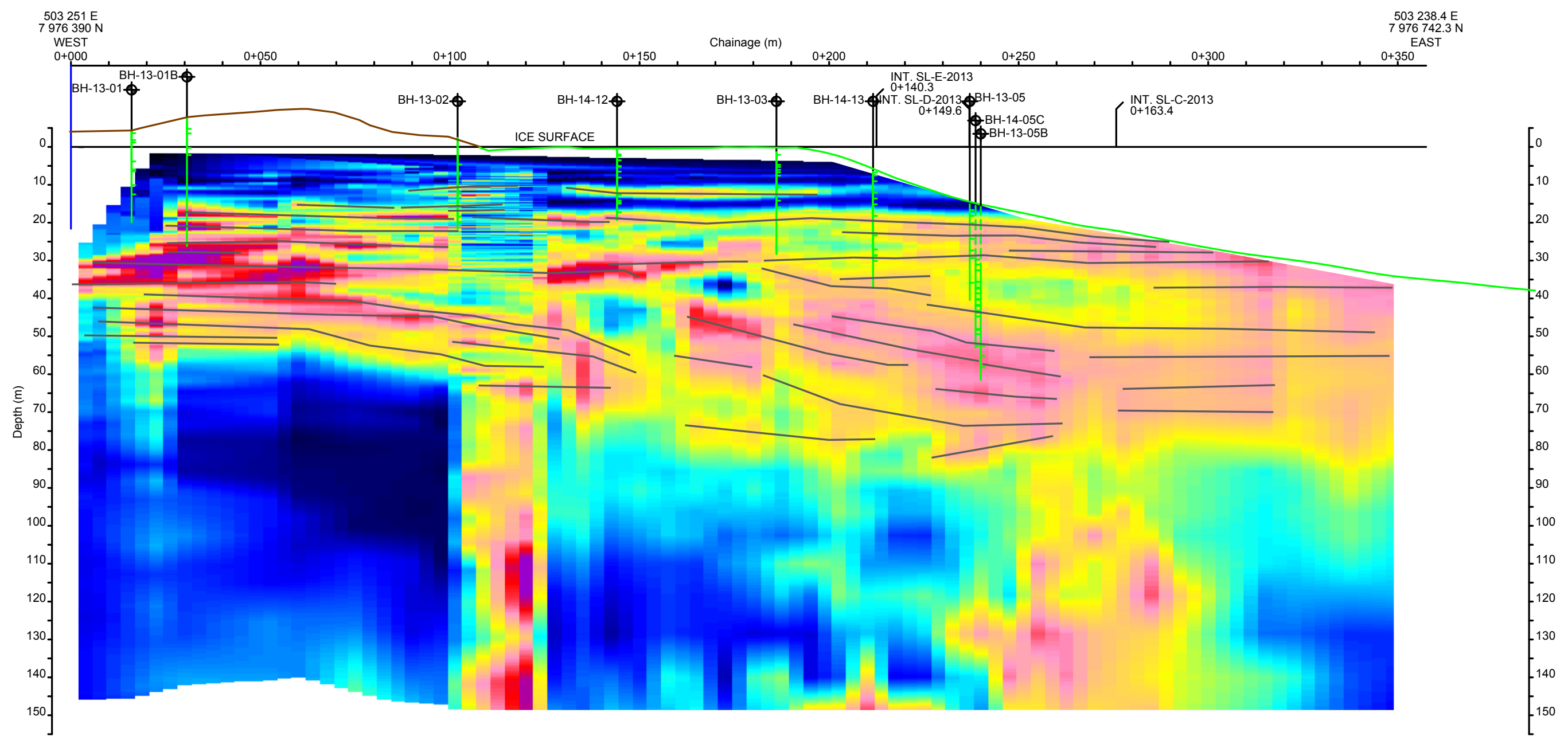
SITE PHOTOS

Photo 1: Seismic line setup with buffalo gun

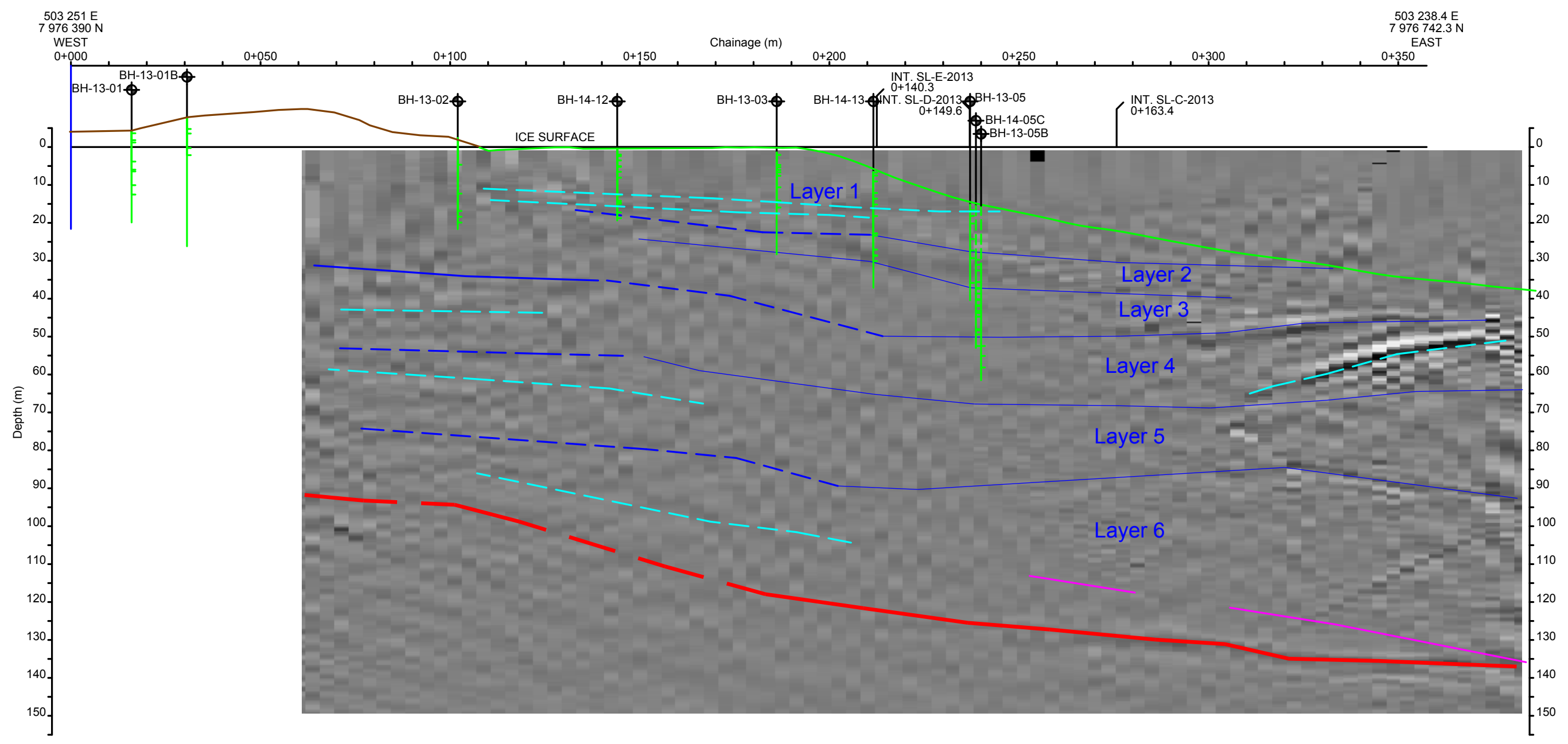
Photo 2: Seismic line setup, with seismograph shelter

APPENDIX C

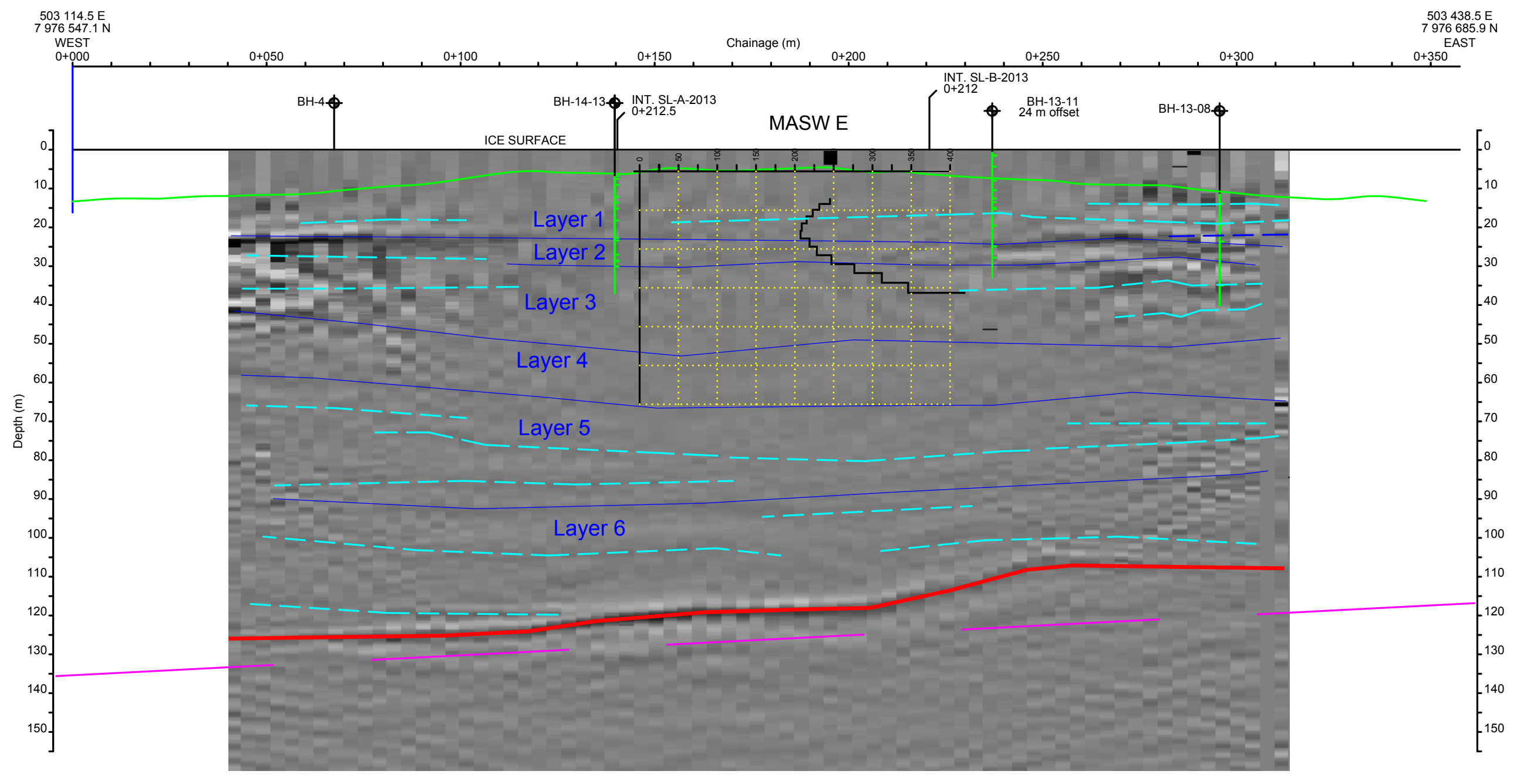
DRAWING T13615_A1



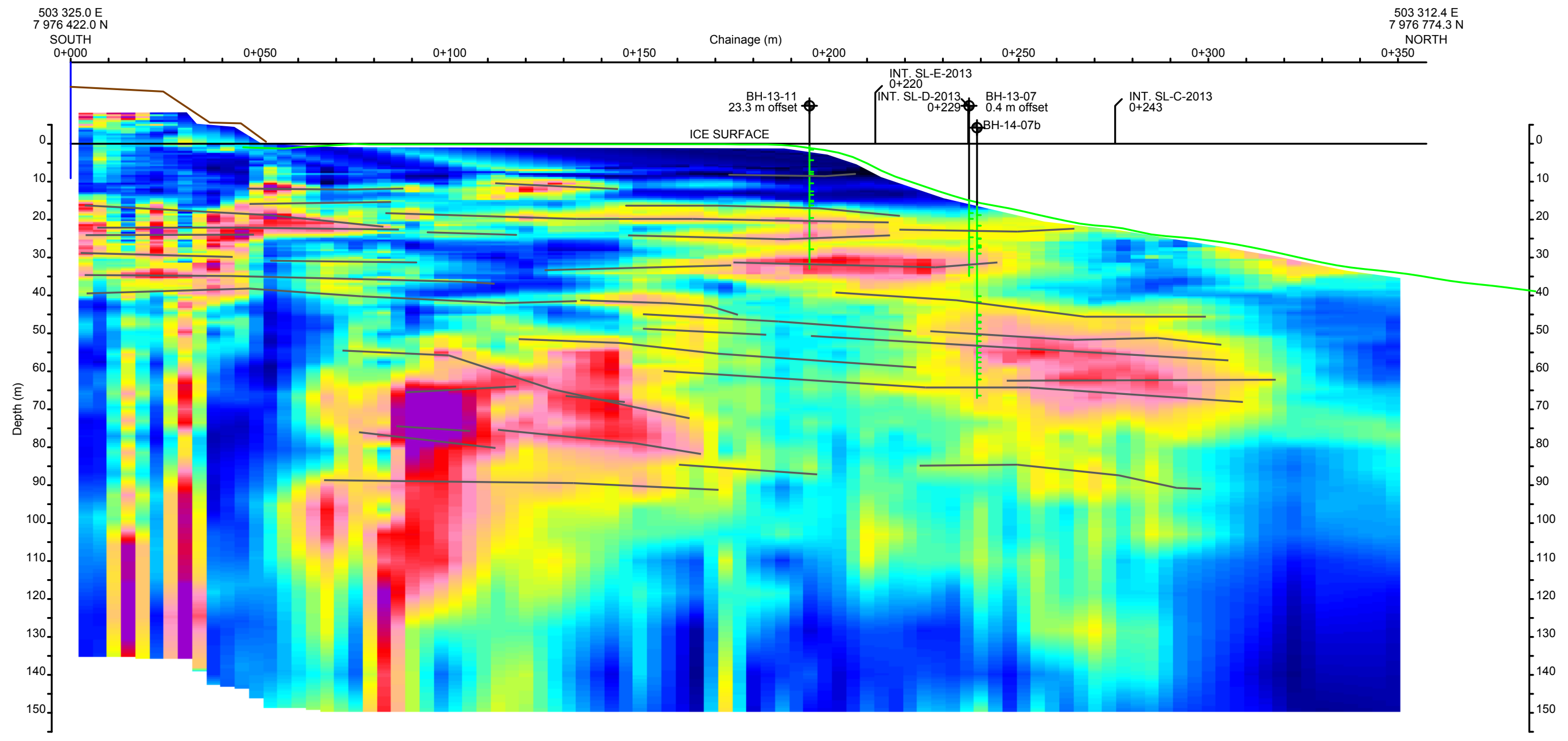
SL-A-2013
(TISAR)



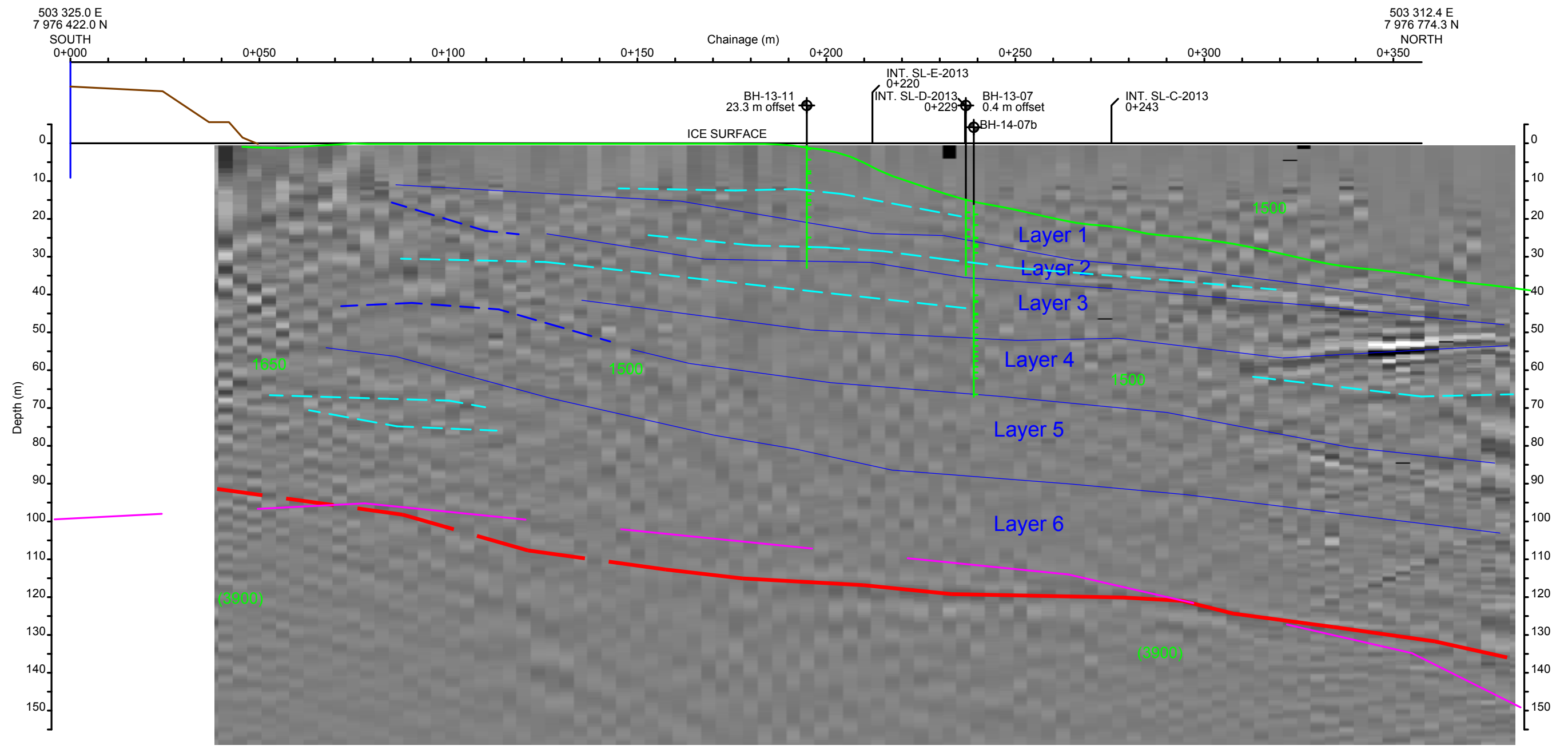
SL-A-2013
(Reflection and Refraction)



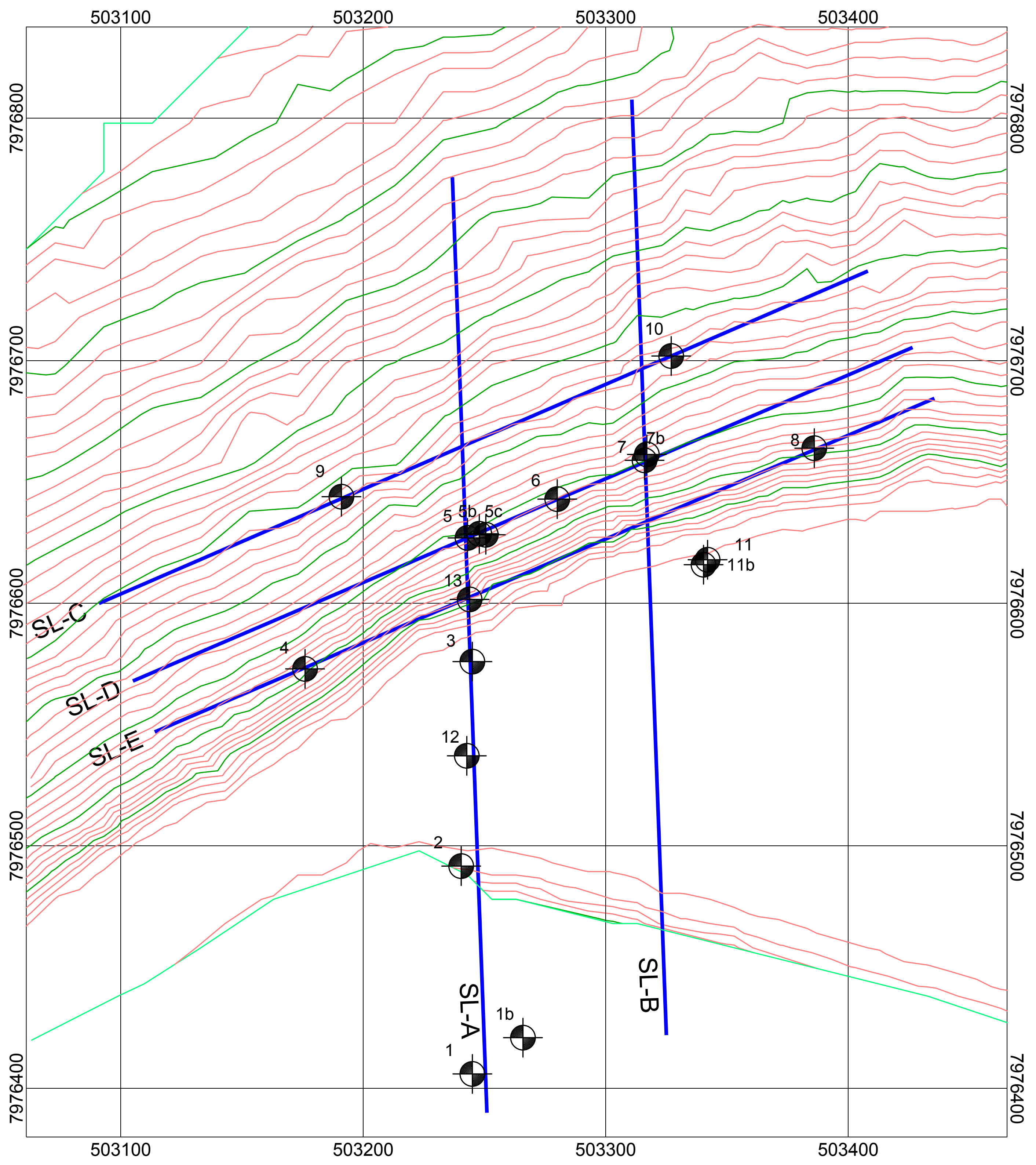
SL-E-2013
(Reflection and Refraction)



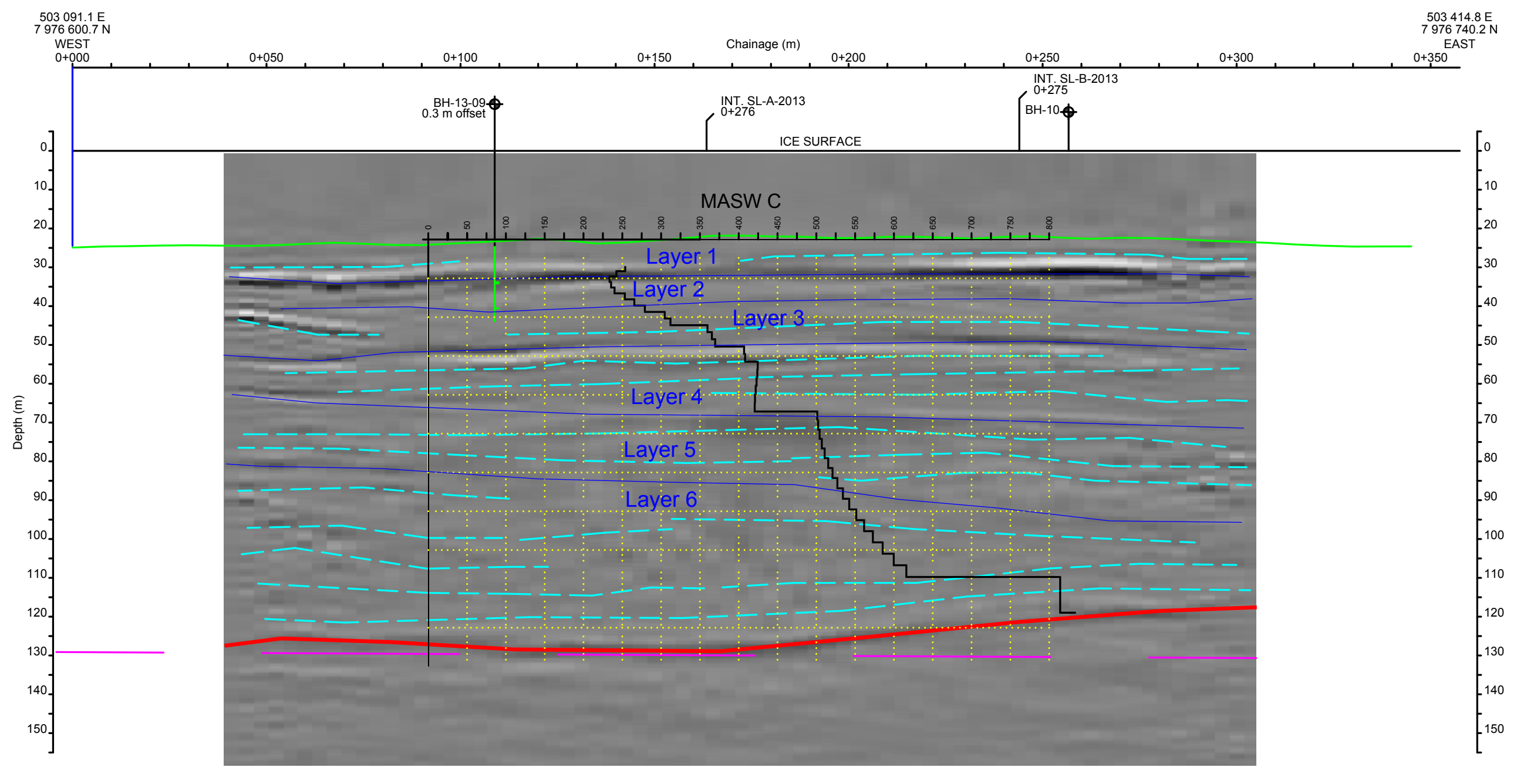
SL-B-2013
(TISAR)



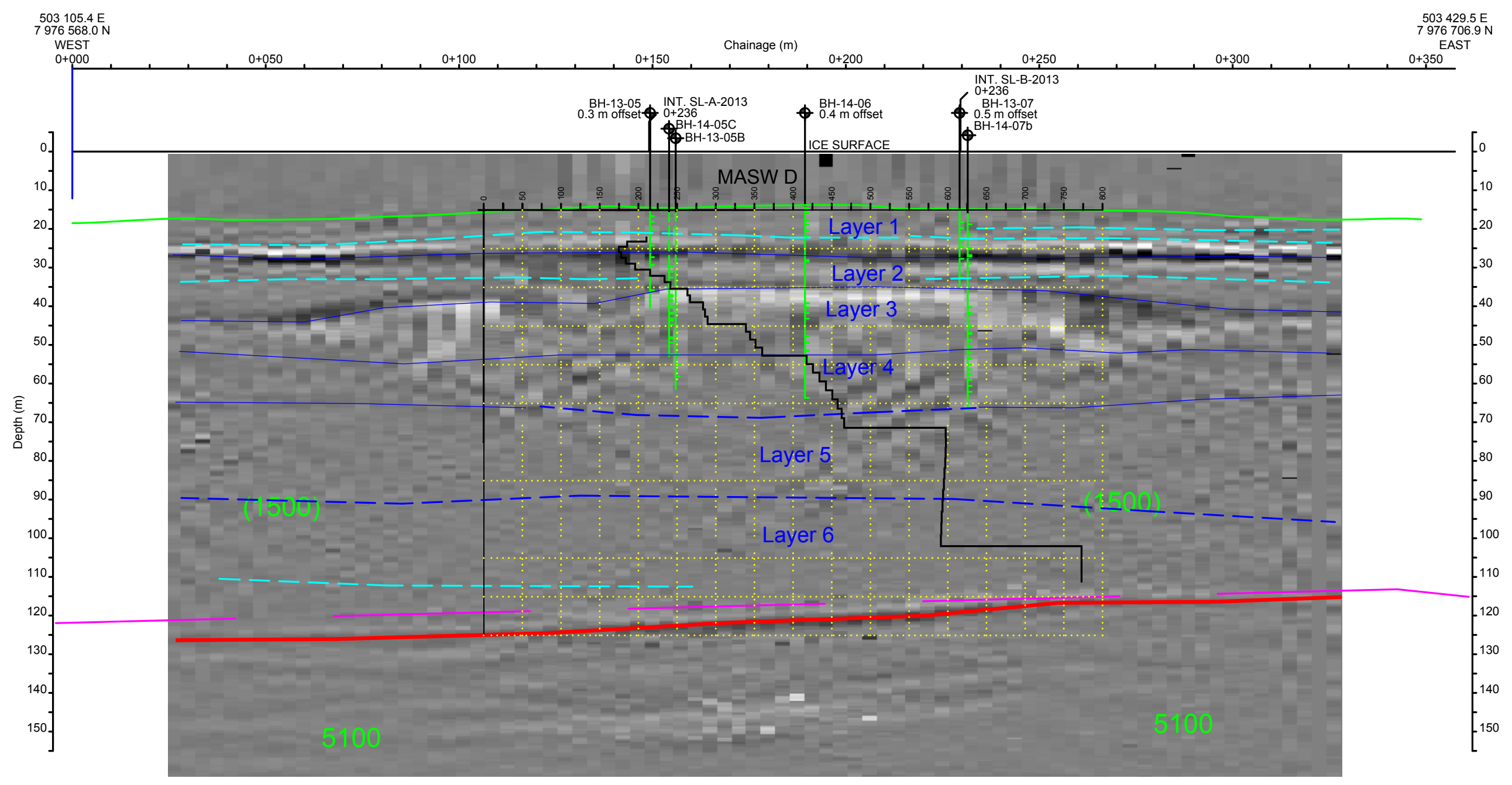
SL-B-2013
(Reflection and Refraction)



PLAN VIEW MAP WITH BATHYMETRY CONTOURS



SL-C-2013
(Reflection and Refraction)



SL-D-2013
(Reflection and Refraction)

LEGEND

🟥	Interpreted Bedrock from Reflection data
	Interpreted Bedrock from Refraction data
—	Interpreted Overburden Reflector (stronger)
— — —	Interpreted Overburden Reflector (weaker)
(1500)	Seismic Refraction Velocity
—	Interpreted Overburden Resonator (TISAR)
—	Bathymetry Profile
—	Topography Profile
⊕	Geotechnical Borehole (Hatch)

No	NOTES
1	THE GEOPHYSICAL SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. DECEMBER, 2013
2	COORDINATE SYSTEM: NAD83 UTM ZONE 17N
3	BATHYMETRY DATA, AND BOREHOLE DATA PROVIDED BY HATCH LTD.
4	REFER TO THE FULL REPORT FOR A DISCUSSION OF METHODLOGY, RESULTS, ACCURICIES AND LIMITATIONS
5	
6	

No	DATE	MODIFICATIONS	GPR	APP.
1	Feb 10, 2014	Minor adjustments to layer interpretation at intersection points of lines Added interpretation for weaker seismic reflectors and MASW S-wave Profiles		
2	Feb 28, 2014	Minor formating/labeling changes		

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR DRAWN BY	RBM
VERIFIÉ PAR CHECKED BY	B.McClement, P. Eng.
APPROUVÉ PAR APPROVED BY	M. Situm, P. Geo.
# CONTRAT CONTRACT #	T-13615
DATE	February 28, 2014
ÉCHELLE SCALE	AS SHOWN
# DESSIN DRAWING #	T13615_A1

CLIENT CLIENT

BAFFINLAND IRON MINES CORP.

PROJET PROJECT

MARY RIVER PROJECT
MILNE INLET, NUNAVUT

TITRE TITLE

GEOPHYSICAL SEISMIC INVESTIGATION
INTERPRETED SEISMIC PROFILES