

December 4, 2007

EBA File: W14101102

Inukshuk Planning & Development
207 Elliott Street
Whitehorse, Yukon
Y1A 2A1

Attention: Mr. Ian Robertson, MCIP

Subject: **Predesign Geotechnical Evaluation**
Arkell Residential Expansion – Whitehorse, Yukon

At the request of Mr. Ian Robertson of Inukshuk Planning & Development, EBA has completed a conceptual/pre-design level geotechnical evaluation of the above captioned study area. The evaluation is based primarily on site specific geotechnical data, along with site reconnaissance and terrain analysis information.

The 13 hectare parcel was originally proposed for residential development. However, since it was a potential land claim selection in 1989, the area became a part of the greenbelt area between the Logan and McIntyre Subdivisions.

1.0 EXISTING INFORMATION

Information collected and reviewed for this evaluation includes:

- Terrain mapping from the Southern Lakes series terrain maps and Agricultural Branch surficial terrain map for the Whitehorse area
- Numerous geotechnical and construction projects have been completed by EBA in the Grainger/Copper Ridge Subdivisions and EBA staff have a good working knowledge of the area.

2.0 TESTPITTING PROGRAM & SITE RECONNAISSANCE

A site reconnaissance of the area was completed during the proposal stage of this project to ensure access by small tracked excavator and to note terrain features which may require closer scrutiny.

On November 8, 2007, a testpitting program was completed. A total of four testpits were excavated throughout the site with a Kubota KX121-3 tracked excavator subcontracted from Arctic Backhoe Services of Whitehorse, Yukon.

All testpits were excavated to a depth of 3.0 m. At each testpit location, detailed testpit logs were prepared describing the geotechnical conditions encountered; representative soil samples were collected at regular intervals; UTM coordinate locations were recorded utilizing a hand held GPS unit and upon completion, all testpits were backfilled to grade.

The soil samples collected during the testpitting program were returned to the EBA Whitehorse facility. The laboratory testing program included natural moisture content determination for all samples collected and particle size distribution testing on select samples for classification purposes and assessing the frost susceptibility of the soils underlying the site.

Geotechnical conditions are described in the following section. Testpit locations are presented on Figure 1 and detailed testpit logs and associated laboratory testing report forms are presented following Figure 1.

3.0 GEOTECHNICAL CONDITIONS

The study area is a triangular shaped parcel located between McIntyre Subdivision (to the north and east) and Logan/Arkell (to the south and west). Access into the site was gained through the well established trail network throughout the site. Generally, the site slopes gently (slopes less than 10%), in an easterly direction with steep slopes defining the north-west corner of the site. The site has moderately dense mature tree cover (Fire Smart program has completed work in the area).

Soil conditions are consistent throughout the site and include a thin veneer of organic soil overlying coarse sand and gravel till soils, which extend to an undetermined depth. Numerous cobbles and boulders were noted on the surface of the area and were encountered at depth during the testpitting program. Neither groundwater, bedrock nor permafrost were encountered during the shallow testpitting program (they were not anticipated in this area).

4.0 TERRAIN ISSUES

No serious terrain issues will effect subdivision development in this area. However, the 30 m high bank defining the northwest corner of the site may experience some erosion if the area along the crest is not protected.

A contour map of the site was utilized to plot a slope profile upon which a worst case geometric analysis of slope stability was completed. The steepest portion of the slope (far north-west corner of the site) has an existing slope angle of approximately 25°. Based on a geometric setback distance calculation, and conditions noted during site reconnaissance, a setback distance of 10 m is recommended.

5.0 SITE SUITABILITY & DEVELOPMENT CONSTRAINTS

The terrain and geotechnical conditions noted during this evaluation suggest that the site is suitable for serviced residential subdivision development. However, groundwater seepage zones have been encountered throughout the Grainger/Copper Ridge areas (as close as the Elijah Smith Elementary School), so care must be taken to ensure that residential units are not constructed in groundwater discharge areas. If groundwater is encountered during initial construction, the location and proposed foundation system of adjacent residential units must be examined in greater detail.

6.0 SUBDIVISION CONSTRUCTION CONSIDERATIONS

Aspects of construction addressed in the following sections include roadway structure design and construction; underground utilities installation, including thermal analysis considerations; excavation and material reuse.

6.1 Roadway Design

Throughout the entire subdivision, coarse sand and gravel till subgrade soils will be encountered beneath a thin veneer of organic soil during roadway construction. This is typical of subgrade soil conditions throughout most of the Grainger/Copper Ridge area.

The till soils are considered to be somewhat frost susceptible due to silt contents of greater than 10% (ranged from 14% to 35% in the samples tested). However, the natural moisture content profiles from the samples collected during this evaluation suggest that the soils throughout the area are damp and therefore, minimal potential for frost heave damage exists as long as roadway design and construction ensures control of surface water.

Typically, the roadway structure used throughout this area of Whitehorse has included the construction of 150 mm of 50 mm crushed sub-base gravel; 150 mm of 20 mm crushed basecourse gravel; and 75 mm of asphalt. It is EBA's recommendation to remain consistent with this construction practice. Roadway design and construction should ensure compliance to the City of Whitehorse – Servicing Standards Manual including:

- A prepared non-frost susceptible sub-base course (50 mm crushed sub-base gravel – 150 mm in compacted thickness), is to be placed, moisture conditioned to facilitate the compaction process, and compacted to at least 98% of maximum dry density using standard effort (ASTM D698).
- Basecourse (20 mm crushed gravel – 150 mm in compacted thickness) is to be placed, moisture conditioned and also compacted to at least 98% of maximum dry density using standard effort (ASTM D698).
- Asphalt traffic course must be at least 75 mm thick and compacted to 98% of Marshall density.

All imported granular materials to be used must comply with the gradation specifications presented in the City Servicing Standards Manual.

If alternate materials are being considered, EBA will conduct particle size analysis testing and provide an opinion regarding acceptability for use in specific applications.

6.2 Underground Utilities Installation

Underground utilities installation, including water & sewer lines, as well as services to individual lots or structures, storm sewer system construction and shallow electrical utilities (power and communications lines) can all be constructed using conventional construction methods (tracked excavator equipped with a clean-up bucket is recommended).

Excavation of utility trenches must conform to the Yukon Occupational Health & Safety Regulations. The predominant soil profile will be dry to damp sand and gravel till with significant oversize particles that could present a safety risk if allowed to roll back into the utility trench excavations.

It is recommended that a Class "B" pipe bedding configuration (as presented in the Whitehorse City Servicing Standards Manual) be specified for this site. This insures proper protection of the buried utility lines during backfill. Bedding may be imported bedding sand or bedding stone; however, it is understood that it has become common practice to utilize bedding stone throughout the Grainger/Copper Ridge area. The bedding sand and stone should conform to the gradation specifications presented in Table 6.2 and should be at least 150 mm thick below the pipe and 300 mm thick above the pipe.

TABLE 6.2 RECOMMENDED PIPE BEDDING MATERIALS SPECIFICATIONS			
BEDDING SAND		25 mm BEDDING STONE	
SIEVE SIZE (mm)	% PASSING BY MASS	SIEVE SIZE (mm)	% PASSING BY MASS
10.000	100	25.000	100
5.000	80 - 100	20.000	70 - 100
2.000	55 - 100	12.500	55 - 100
0.630	25 - 65	10.000	30 - 80
0.250	10 - 40	5.000	0 - 40
0.080	2 - 15	2.000	0 - 10

If alternate materials are being considered, EBA will conduct particle size analysis testing and provide an opinion regarding acceptability for use in specific applications.

Material excavated from the trenches is considered acceptable for use as trench backfill, as long as no cobbles and boulders are allowed close to the pipes or on the subgrade surface.

6.3 Geothermal Analyses

The EBA "Geothermal Design Manual - 1998" presents ground temperature data in typical soils from the Grainger/Copper Ridge area. Results presented suggest the following seasonal frost penetration depths:

- 2.6 m - 3.0 m under snow covered areas (lawns, boulevards, etc.)
- 3.6 m under paved roadways
- 5.0 m for the 1:50 year design under paved roadways

Again, current construction practice in this area of Whitehorse, along with frost protection devices installed on each residential structure appear to be adequate.

7.0 FOUNDATIONS

Generally, the construction of conventional foundation systems, (strip & spread footings or monolithic thickened slab-on-grade foundations) is considered acceptable for use throughout the study area. Shallow foundations throughout the study area should consider the potential for frost heave. The use of perimeter insulation may be required, but most importantly, the control of roof runoff and surface water must be considered.

8.0 CLOSURE

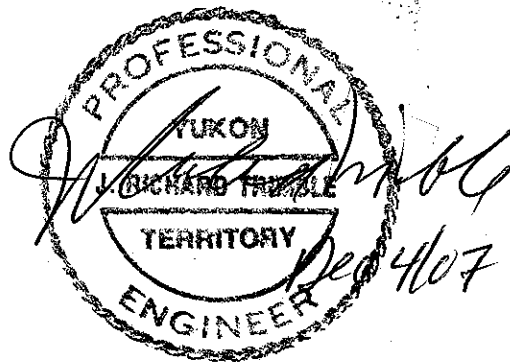
This report and the recommendations contained in it are intended for the sole use of the team working on this project. EBA does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than that specified above for any project other than that described in this report. Any such unauthorized use of this report is at the sole risk of the user. Additional information regarding the use of this report is presented in the attached General Conditions, which form a part of this report.

Please contact the undersigned if additional information or clarification of any item in this report is required.

Yours truly,
EBA Engineering Consultants Ltd.



Myles C. Plaunt, C.E.T.
Engineering Technologist
(Direct Line: 867-668-2071 Ext. 227)
(Email: mplaunt@eba.ca)



J. Richard Trimble, M.Sc. (Eng.), P.Eng.
Project Director, Yukon Region
(Direct Line: 867-668-2071 Ext. 222)
(Email: rtrimble@eba.ca)

PERMIT TO PRACTICE	
EBA ENGINEERING CONSULTANTS LTD.	
SIGNATURE	<i>J. Richard Trimble</i>
Date	<i>Dec 4/07</i>
PERMIT NUMBER PP003	
Association of Professional Engineers of Yukon	

GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

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2.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

3.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

4.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

5.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

6.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

7.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

8.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

9.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

10.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

11.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

12.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

13.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

14.0 ENVIRONMENTAL AND REGULATORY ISSUES

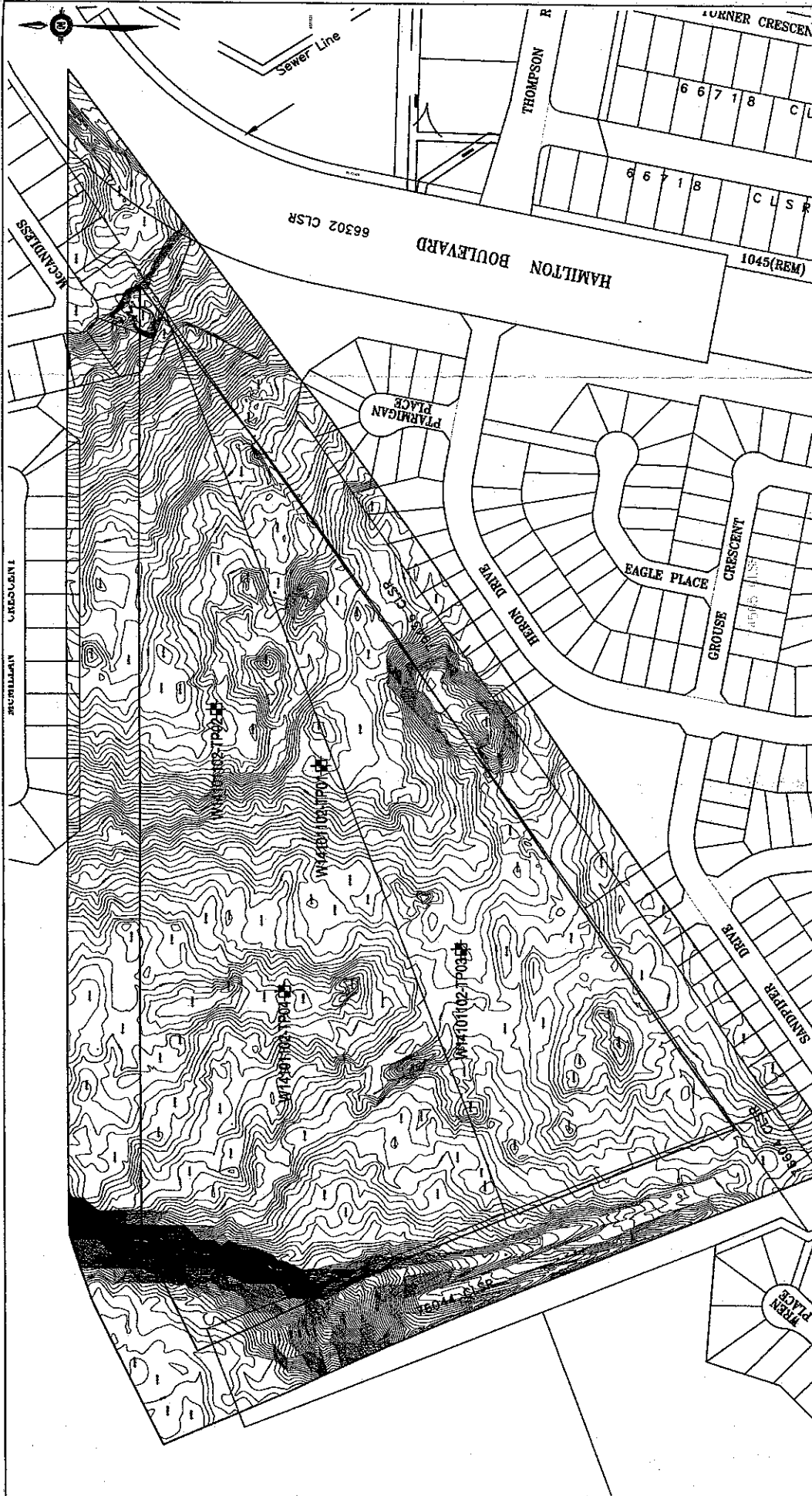
Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

15.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.



ARKELL RESIDENTIAL EXPANSION
WHITEHORSE, YUKON

INUKSHUK
PLANNING &
DEVELOPMENT

EBA Engineering
Consultants Ltd.

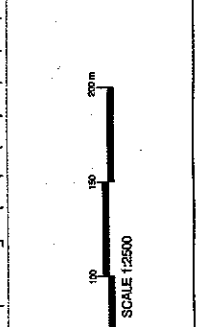
PROJECT: W1410112
DATE: EBA-WHSE

DATE: JSS
DATE: MCD
DATE: 0

REV: 0

November 19, 2007

Figure 1



TESTPIT	ZONE	NORTHING	EASTING
TP01	8	6730680	493287
TP02	8	6730752	493365
TP03	8	6730585	493741
TP04	8	6730706	493712

LEGEND

✚ TESTPITS (JULY 2008)

NOTES:

1. THIS DRAWING HAS BEEN PRODUCED IN COLOR. ANY REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL.

Arkell Residential Expansion	CLIENT: Inukshuk Planning and Development	TESTPIT NO: W14101102-TP01
Arkell Subdivision Area	EXCAVATOR: Kubota Tracked	PROJECT NO: W14101102
Whitehorse, YT	6730680N; 493897E; Zone 8	

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BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input checked="" type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	MOISTURE CONTENT	PLASTIC M.C. LIQUID	UNCONFINED (kPa)	POCKET PEN. (kPa)	Depth (ft)
				PLASTIC M.C. LIQUID ────┬───┬───┬─── 20 40 60 80	◆ UNCONFINED (kPa) ◆ 50 100 150 200	▲ POCKET PEN. (kPa) ▲ 100 200 300 400	
0	ORGANIC ROOT MAT - seasonally frozen, black						0
	SAND AND GRAVEL (TILL) - some silt, trace of clay, cobbles throughout, damp, compact, brown becoming olive grey below 0.6 m	6.8	●				
1	- occasional boulders below 2.0 m up to 400 mm, subrounded	2.3	●				5
2		2.4	●				
3	END OF TESTPIT 3.0 m	2.7	●				10
4							15
5							16

EBA Engineering Consultants Ltd.	LOGGED BY: MCP	COMPLETION DEPTH: 3m
	REVIEWED BY: JRT	COMPLETE: 11/8/2007
	DRAWING NO:	Page 1 of 1

PARTICLE SIZE DISTRIBUTION

ASTM C136 & D422

Project: Arkeil Residential Expansion

Project Number: W14101102

Date Tested: 11/13/2007

Borehole Number: Testpit W14101102-TP01

Depth: 2.0 m to 2.2 m

Soil Description: GRAVEL AND SAND TILL - some silt, trace of clay

Cu: N/A

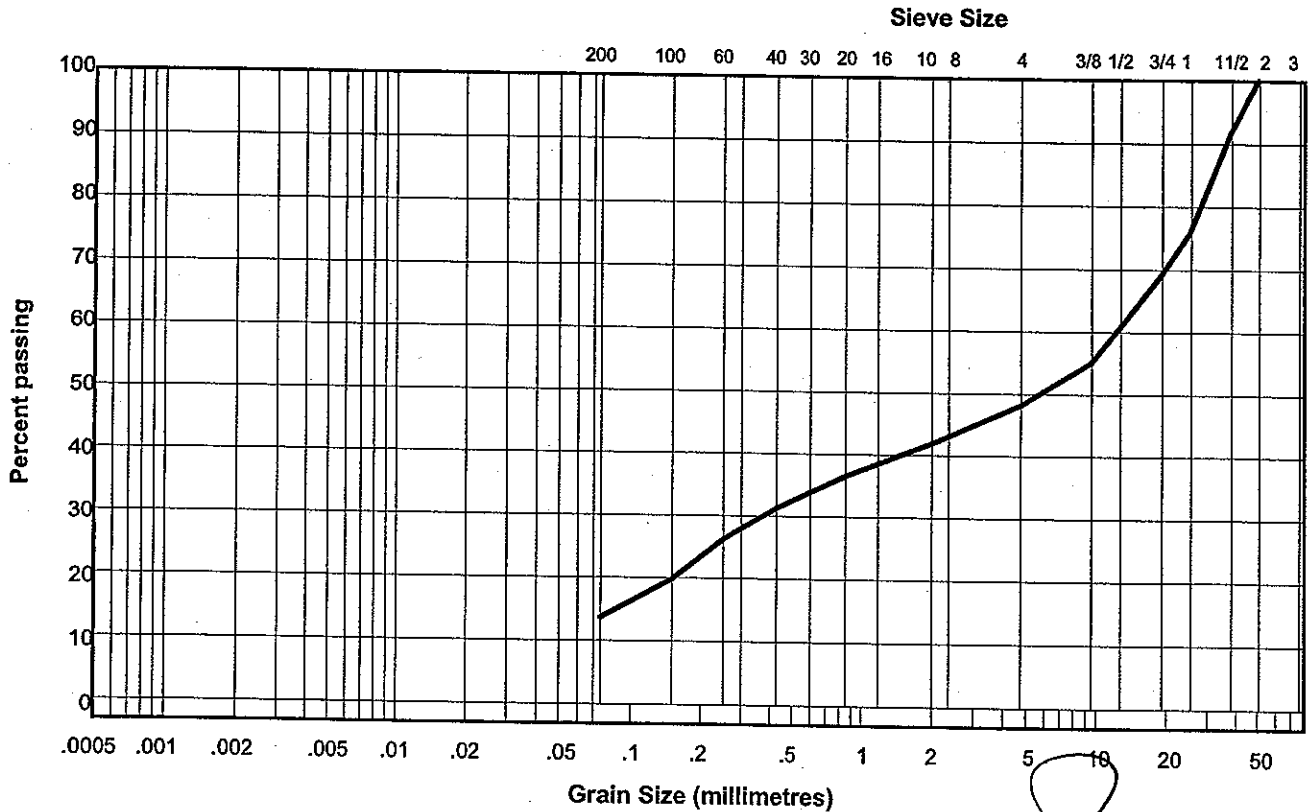
Cc: N/A

Natural Moisture Content: 2.4%

Remarks: N/A

Sieve Size	Percent Passing
50.000	100
37.500	92
25.000	76
19.000	69
12.500	61
9.500	55
4.750	48
2.000	42
0.850	37
0.425	31
0.250	26
0.150	20
0.075	13.7

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: *[Signature]*

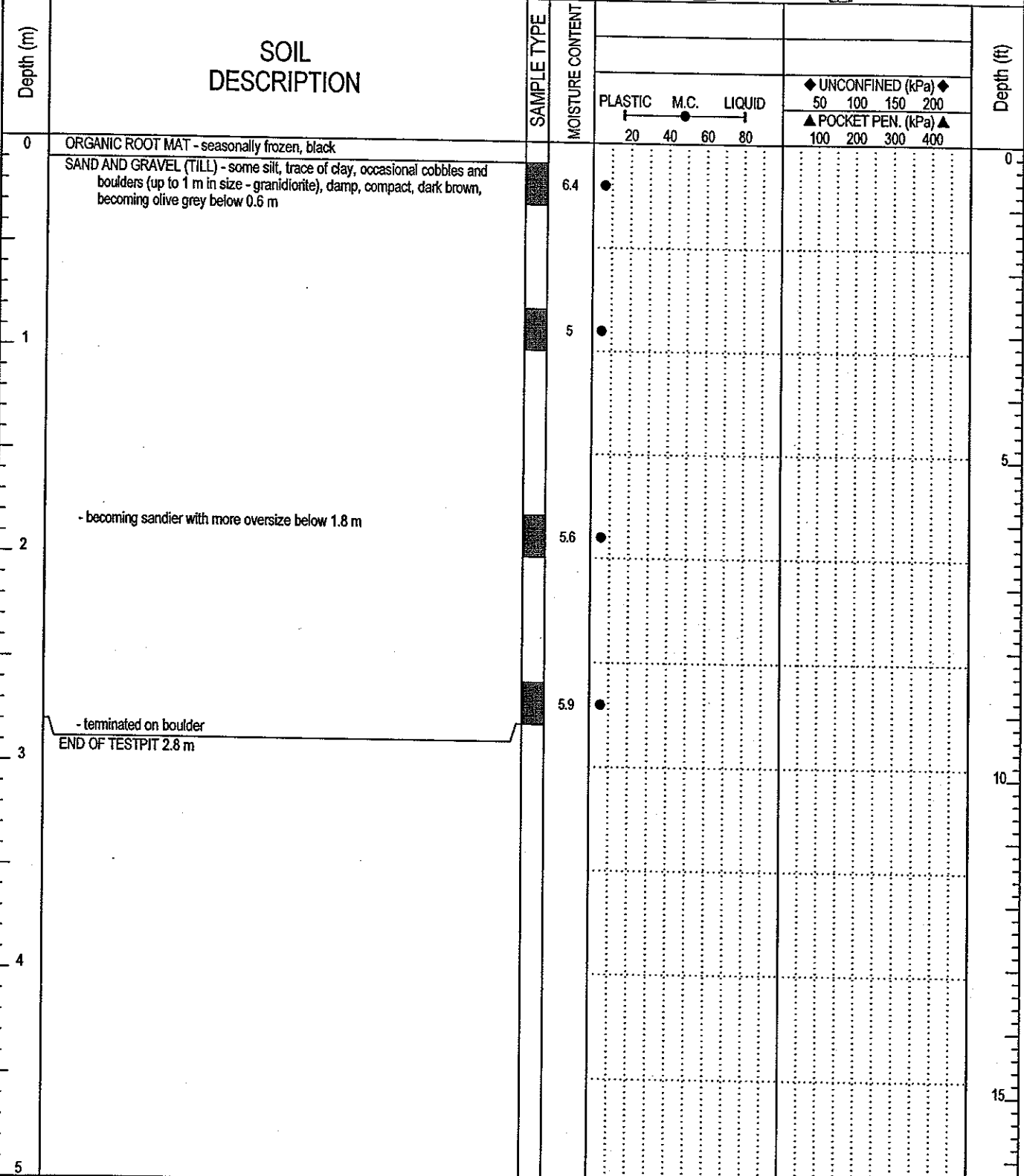
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Arkell Residential Expansion	CLIENT: Inukshuk Planning and Development	TESTPIT NO: W14101102-TP02
Arkell Subdivision Area	EXCAVATOR: Kubota Kx 121-3	PROJECT NO: W14101102
Whitehorse, YT	6730752N; 593905E; Zone 8	

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BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND



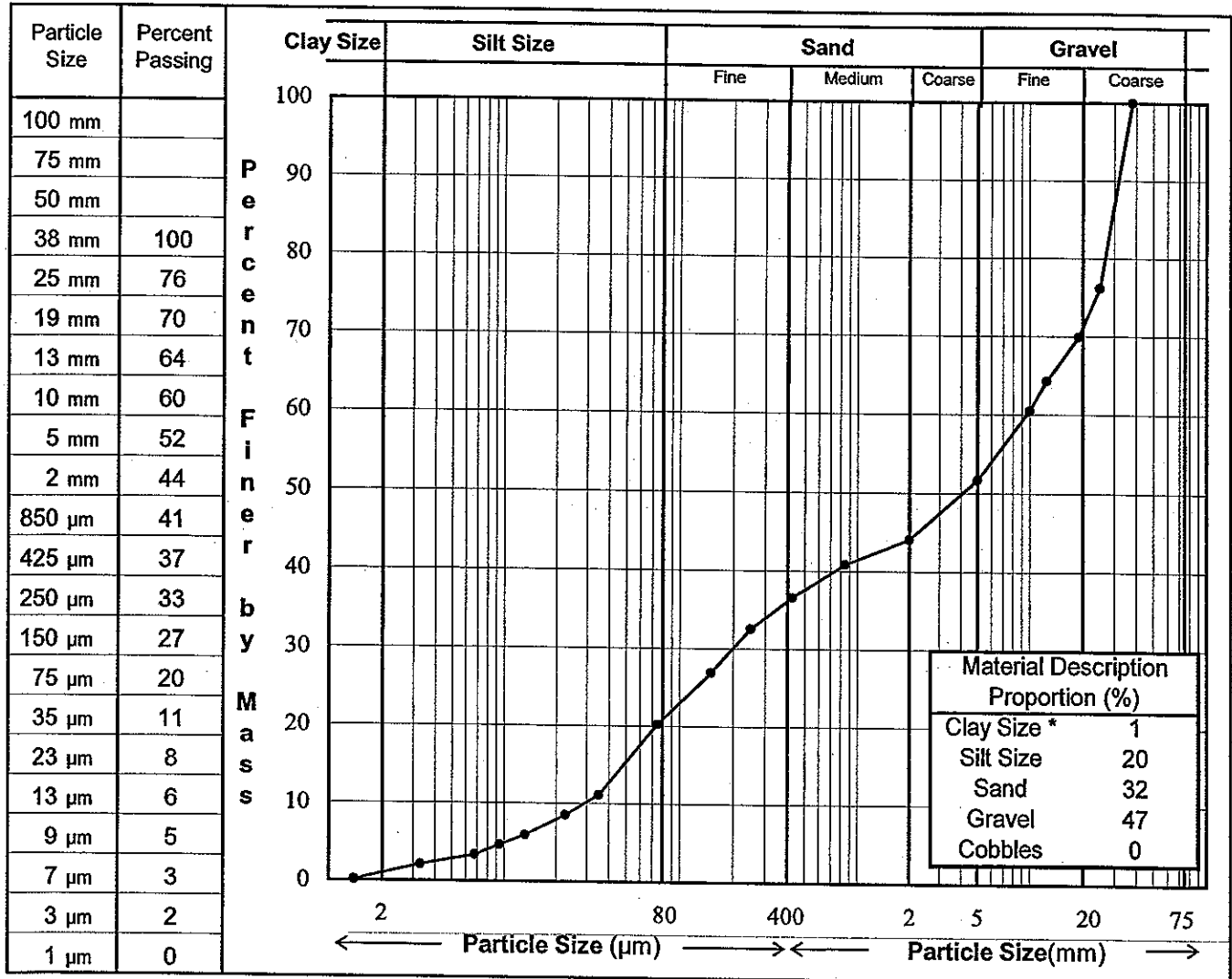
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	REVIEWED BY: JRT	COMPLETE: 11/8/2007
	DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **Arkell Residential Expansion**
 Client: **Inukshuk Planning & Development**
 Project No.: **W14101102**
 Location: **Testpit W14101102-TP02**
 Sample No.: **SA-02**
 Depth: **0.8 m to 1.0 m**
 Description**: **GRAVEL AND SAND TILL - some silt, trace of clay**

Date Tested: **2007/10/11**



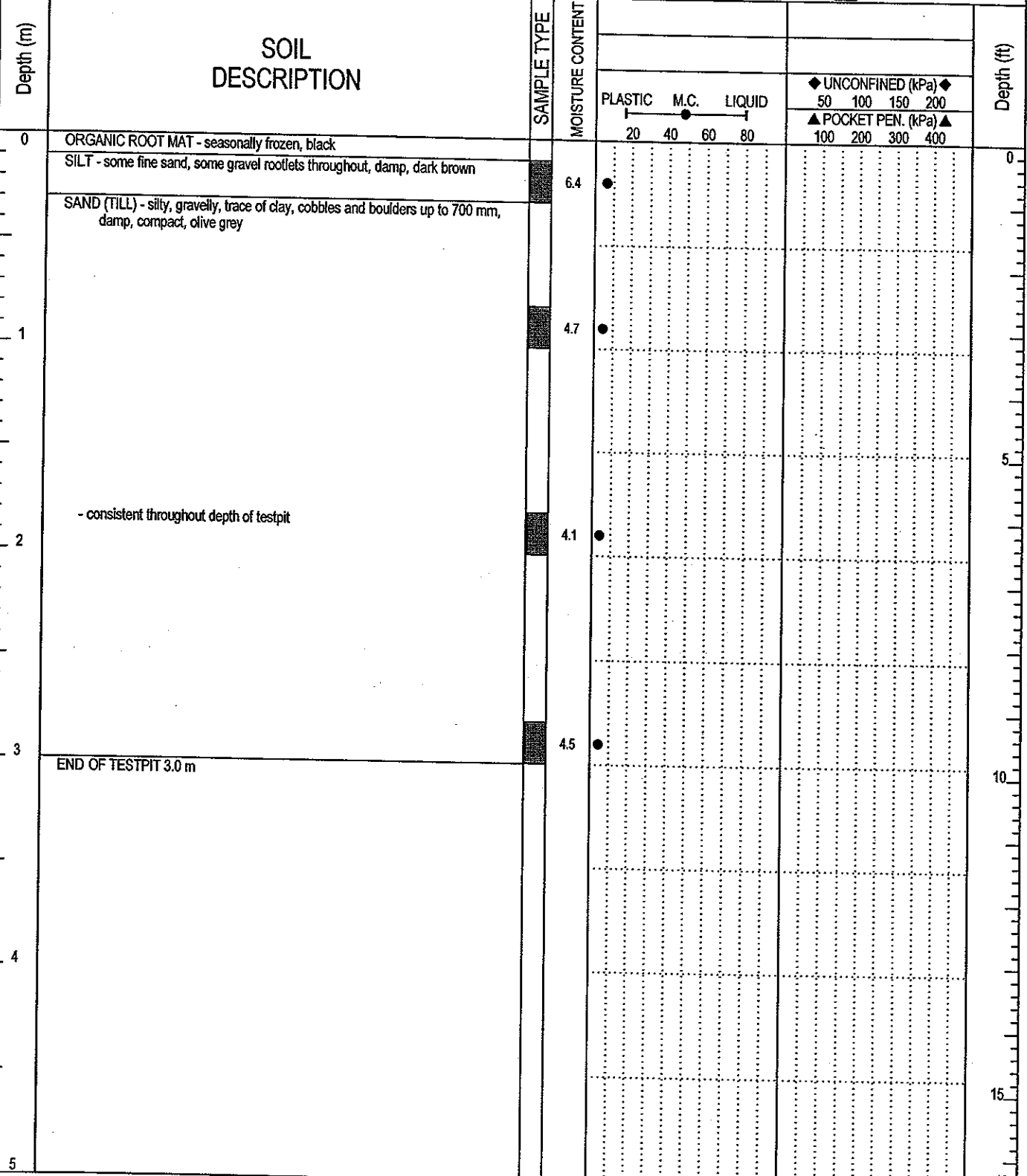
Remarks: * The upper clay size of 2 µm, per the Canadian Foundation Engineering Manual.
 ** The description is visually based & subject to EBA description protocols.

Reviewed By: _____

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Arkell Residential Expansion	CLIENT: Inukshuk Planning and Development	TESTPIT NO: W14101102-TP03
Arkell Subdivision Area	EXCAVATOR: Kubota Kx 121-3	PROJECT NO: W14101102
Whitehorse, YT	6730585N; 493741E; Zone 8	

SAMPLE TYPE	<input checked="" type="checkbox"/> DISTURBED	<input checked="" type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> SPT	<input type="checkbox"/> A-CASING	<input type="checkbox"/> SHELBY TUBE	<input type="checkbox"/> CORE
BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND



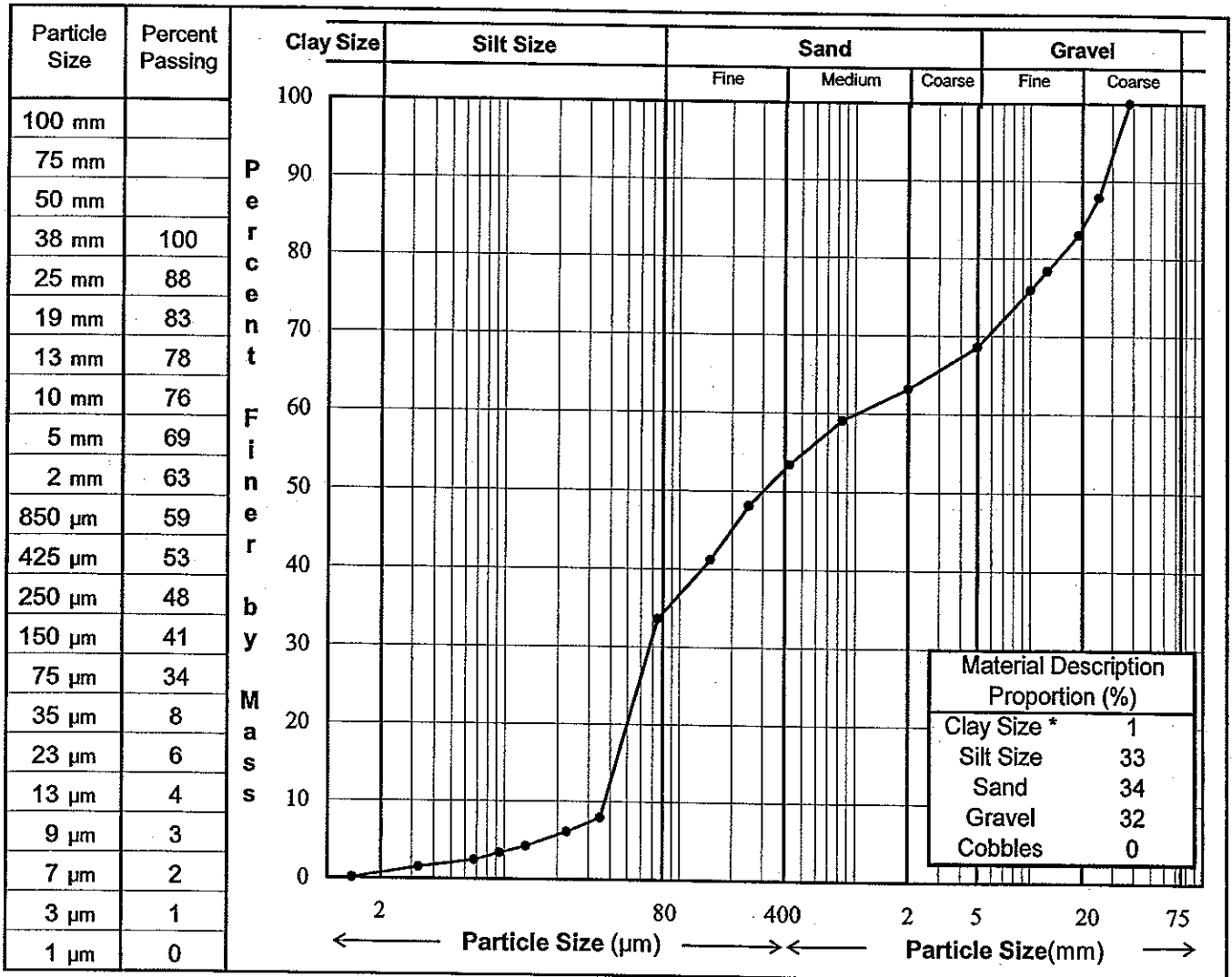
 EBA Engineering Consultants Ltd.	LOGGED BY: MCP	COMPLETION DEPTH: 3m
	REVIEWED BY: JRT	COMPLETE: 11/8/2007
	DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: Arkell Residential Expansion
Client: Inukshuk Planning & Development
Project No.: W14101102
Location: Testpit W14101102-TP03
Sample No.: SA-03
Depth: 0.1 m to 0.3 m
Description:** SAND, SILT & GRAVEL TILL - trace of clay

Date Tested: 2007/11/13



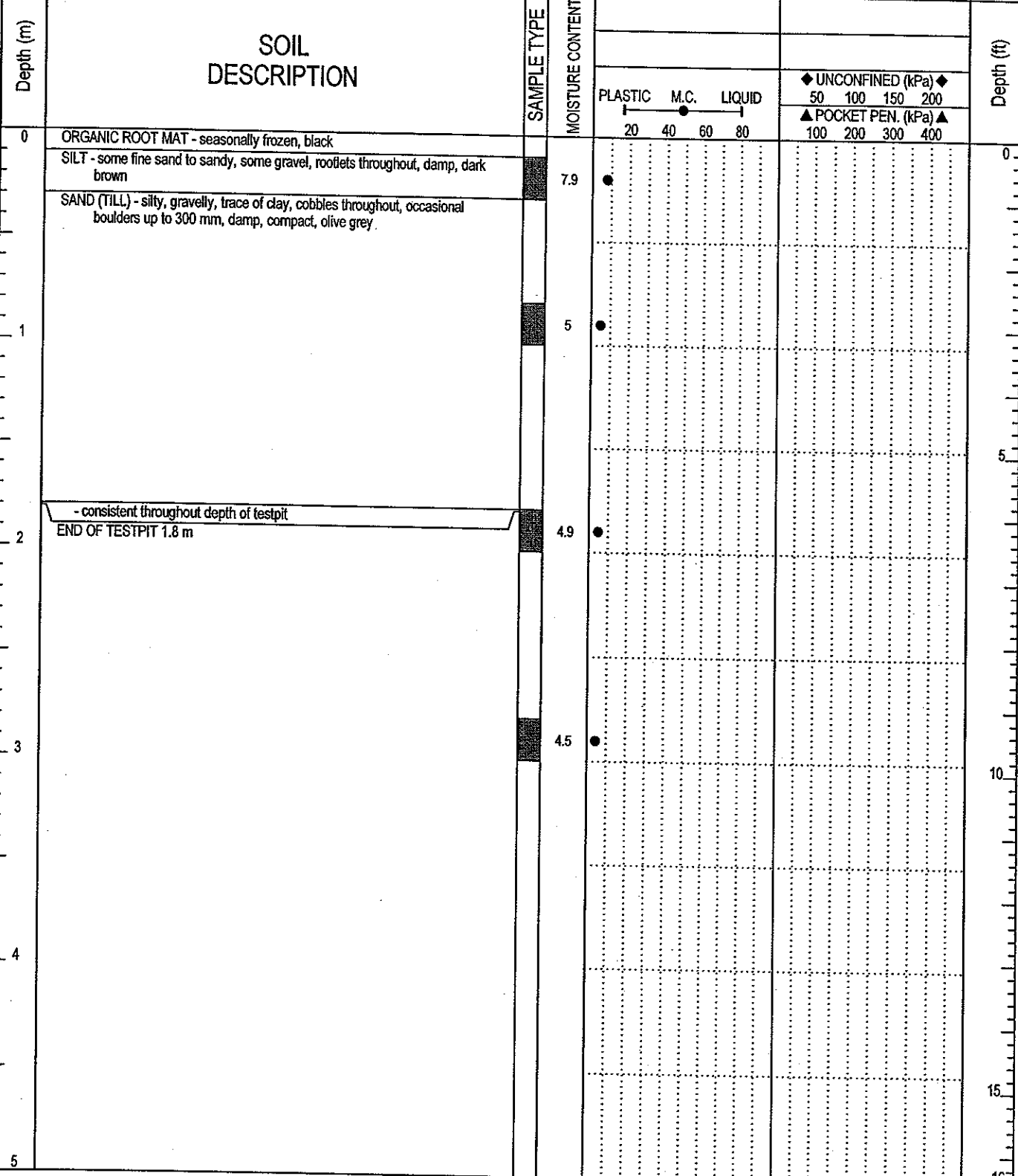
Remarks: * The upper clay size of 2 μm, per the Canadian Foundation Engineering Manual.
 ** The description is visually based & subject to EBA description protocols.

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Arkell Residential Expansion	CLIENT: Inukshuk Planning and Development	TESTPIT NO: W14101102-TP04
Arkell Subdivision Area	EXCAVATOR: Kubota Kx 121-3	PROJECT NO: W14101102
Whitehorse, YT	6730706N; 493712E; Zone 8	

SAMPLE TYPE	<input checked="" type="checkbox"/> DISTURBED	<input checked="" type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> SPT	<input type="checkbox"/> A-CASING	<input type="checkbox"/> SHELBY TUBE	<input type="checkbox"/> CORE
BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND



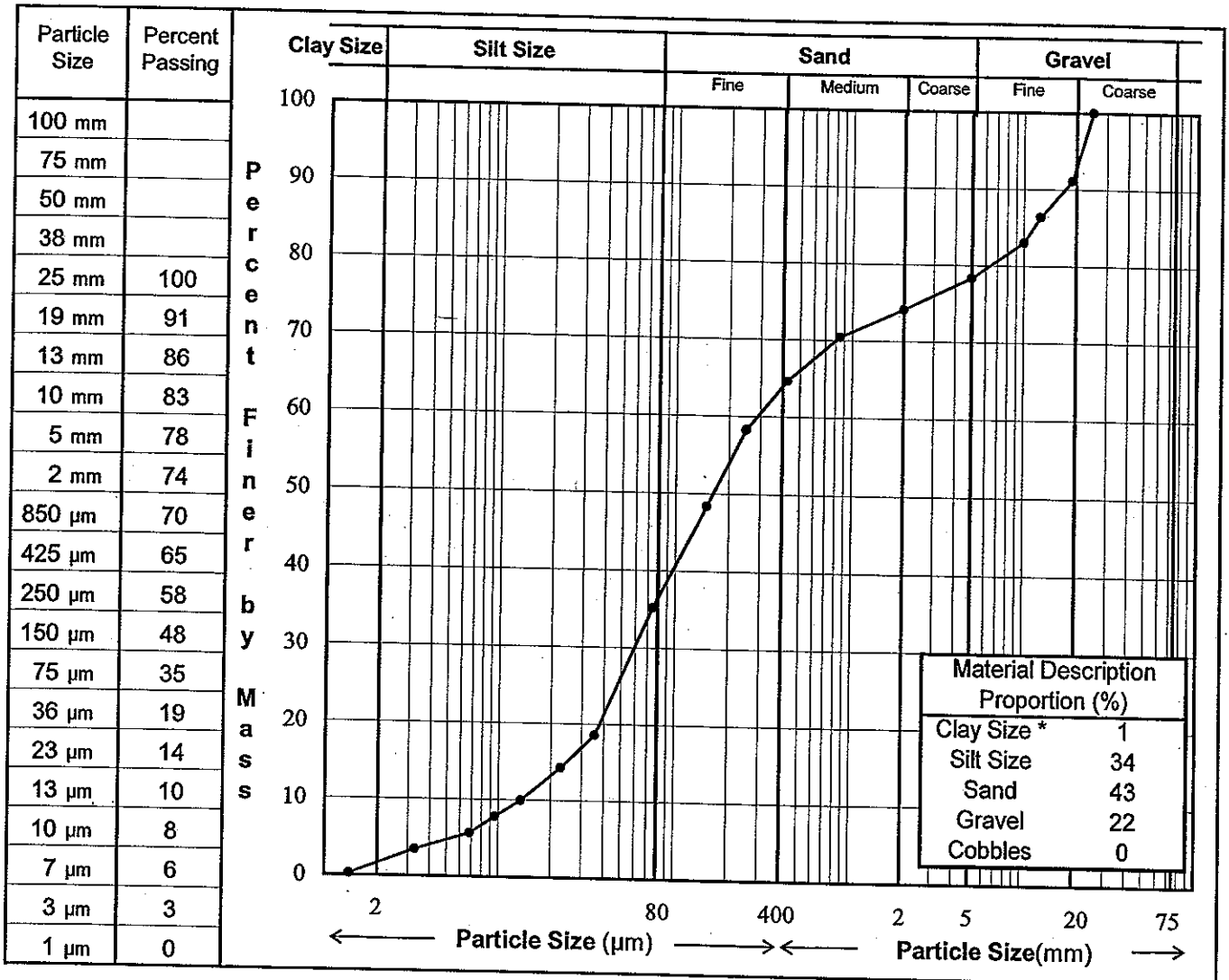
	LOGGED BY: MCP	COMPLETION DEPTH: 1.8m
	REVIEWED BY: JRT	COMPLETE: 11/8/2007
	DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **Arkell Residential Expansion**
 Client: **Inukshuk Planning & Development**
 Project No.: **W14101102**
 Location: **Whitehorse, Yukon**
 Sample No.: **Testpit W14101102-TP04**
 Depth: **0.8 m to 1.0 m**
 Description**: **SAND TILL - silty, gravelly, trace of clay**

Date Tested: **2007/11/13**



Remarks: * The upper clay size of 2 μm, per the Canadian Foundation Engineering Manual.
 ** The description is visually based & subject to EBA description protocols.

Reviewed By: _____

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