
**Geotechnical Evaluation
Proposed Secondary Sewage Treatment Facility
Carmacks, Yukon**

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TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	SCOPE OF WORK	1
2.1	PROJECT DESCRIPTION	2
3.0	GEOTECHNICAL DATA	3
3.1	EXISTING GEOTECHNICAL DATA	3
3.2	SITE INVESTIGATION	3
4.0	SITE CONDITIONS	4
4.1	SITE DESCRIPTION	4
4.2	SOILS	5
4.2.1	<i>Cross section A-A': Plant Site to Outfall Location</i>	<i>5</i>
4.2.2	<i>Cross section B-B': Sewer Extension Route</i>	<i>6</i>
4.2.3	<i>Existing Information for Lot 32</i>	<i>7</i>
4.3	GROUNDWATER	8
4.4	SEASONAL FROST PENETRATION	8
4.5	PERMAFROST	9
5.0	SITE INFRASTRUCTURE RECOMMENDATIONS	9
5.1	ROADWAYS & PARKING	9
5.1.1	<i>Site Preparation and Construction</i>	<i>10</i>
5.2	SEWER LINE	11
5.2.1	<i>Frost Protection</i>	<i>11</i>
5.2.2	<i>Construction</i>	<i>11</i>
5.2.3	<i>Dewatering</i>	<i>13</i>
5.2.4	<i>Additional Recommendations for the Lift Station</i>	<i>14</i>
6.0	BUILDING FOUNDATIONS	15
6.1	GENERAL	15
6.2	FOUNDATIONS	15
6.2.1	<i>Site Preparation & Excavations</i>	<i>15</i>
6.2.2	<i>Dewatering</i>	<i>16</i>
6.2.3	<i>Foundations</i>	<i>16</i>

6.2.4	<i>Frost Protection</i>	17
6.2.5	<i>Slab-On-Grade</i>	17
6.2.6	<i>Backfill and Compaction</i>	18
6.2.7	<i>Lateral Earth Pressures</i>	18
6.3	GEOTECHNICAL SEISMIC DESIGN PARAMETERS.....	19
6.4	SITE DRAINAGE.....	20
6.5	CONCRETE.....	20
7.0	ADDITIONAL INFORMATION REQUIRED	21
8.0	REVIEW OF DESIGN AND CONSTRUCTION SPECIFICATIONS	22
9.0	LIMITATIONS	22
	CLOSURE	23

TABLES

Table 1:	Generalized Stratigraphic Soil Profile: Plant Site to Lift Station	Page 6
Table 2:	Generalized Stratigraphic Soil Profile: Outfall Line	Page 6
Table 3:	Generalized Stratigraphic Soil Profile: Sewer Line Extension	Page 7
Table 4:	Generalized Stratigraphic Soil Profile: Existing Information	Page 7
Table 5:	Monitoring Well Water Elevations	Page 8
Table 6:	Granular Material Gradation Specifications	Page 10
Table 7:	Bedding Material Gradation Specifications	Page 18
Table 8:	Concrete Properties for Exposure Class S-2	Page 21

FIGURES

- Figure 1: General Site Plan of WWTP Facility
 Figure 2: Site Plan Showing Borehole Locations
 Figure 3: Cross Sections A-A' and B-B'

APPENDICES

- Appendix A: General Conditions
 Appendix B: Existing Borehole Information
 Appendix C: Borehole Logs

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was retained by G.J. Bull & Associates Inc. (G.J. Bull) to evaluate the subsurface soil conditions for the proposed Wastewater Treatment Plant (WWTP) in Carmacks, Yukon. The evaluation encompasses both geotechnical and geophysical assessments; however, only the geotechnical findings and recommendations arising for this evaluation are contained in the following report. The geophysical data and findings are presented in a separate report entitled “Geophysical Site Investigation Waste Water Treatment Plant, Carmacks, Yukon” dated September 2003.

This report has been prepared in accordance with generally accepted geotechnical practice and engineering judgment has been used in the development of recommendations. For additional information regarding the use of this report, please refer to the General Conditions included as Appendix A that forms a part of this report.

It is noted that during the preparation of this report, the nature of foundation loads for the main plant and lift station structures are unknown. Review of the foundation recommendations presented in this report is necessary after foundation loads are known, to ensure the foundation system would be appropriate for each given structure. Furthermore, should the location of the WWTP change from that presented in this report, all recommendations and conclusions must be reviewed to ensure their validity for the new location. This includes relocating the WWTP at another location on Lot 32.

Authorization to proceed with this evaluation was provided by Mr. Greg Bull, P. Eng., of G.J. Bull of May 30, 2002.

2.0 SCOPE OF WORK

The scope of work for this project was defined in the Predesign Study Work Plan for the Mechanical Wastewater Treatment Plant and Yukon River Outfall submitted to the Village of

Carmacks on March 22, 2002. EBA's geotechnical and geophysical assessments only form a portion of the Predesign Study Work Plan as EBA is a member of a multi-disciplinary team of specialists evaluating the above-mentioned project. Task 5.2 of the work plan outlines the proposed geotechnical site characterization in the specific areas of the main WWTP site, the outfall location, and the sewer extension route. Upon completion of the proposed geotechnical site characterization, a predesign geotechnical evaluation report was to be submitted to G.J. Bull covering the following aspects:

- A description of field and laboratory work completed;
- Geotechnical and construction recommendations for the facility structures, outfall structures, and sewer extension route would be addressed;
- Dewatering options for the facility structures, outfall structures, access routes, lift station, and forcemains would be addressed;
- General recommendations for the construction of access roads and routes would be provided.

2.1 Project Description

The Village of Carmacks has evaluated several wastewater treatment and disposal options since 1999 and, after considerable public consultation and preliminary investigations, have opted for a mechanical treatment plant and outfall system to the Yukon River. Presently, it has been proposed to locate the WWTP on Lot 32 in the Village of Carmacks and construct an outfall line from Lot 32 into the Yukon River. A multi-disciplinary team of specialists, of which EBA is a member, was assembled by G. J. Bull and are evaluating this proposed treatment and disposal option.

It is understood that development of the WWTP will include the construction of the main treatment plant, a sewer line from the existing treatment site to the proposed treatment plant (including one lift station), and an outfall line from the treatment plant into the Yukon River. The tentative location of the proposed new WWTP, lift station and sewer line was provided to EBA by Yukon Engineering Services in December 2002, and is presented on Figure 1.

It is our understanding that the WWTP will be approximately 185 m² in area and consist of three tanks located from 4 m to 6 m below grade. These tanks will be approximately 4 m in diameter to 4 m to 6 m in height. The lift station's foundation could be up to 12 m in depth. Specifics of the foundation loads for these structures are unknown at the time of this report.

3.0 GEOTECHNICAL DATA

3.1 Existing Geotechnical Data

In addition to the site-specific work completed by EBA for this project, EBA has also reviewed internal files relating to this site and adjacent sites, as well as external information available along the River Road alignment. Where applicable, borehole logs showing detailed soil conditions and laboratory test results, along with individual laboratory test data, are presented in Appendix B.

3.2 Site Investigation

A geotechnical site investigation (drilling) program was conducted by EBA between February 25 and 27, 2003, and consisted of advancing 8 auger boreholes (1200014-BH01 to 1200014-BH08) throughout the proposed development. The scheduling of the drilling program was controlled by the requirement to thicken the ice on the Yukon River, so that it would support the drilling equipment. This work was approved by the Village of Carmacks, and completed by Midnight Sun Drilling Company Ltd. between February 21 and 25, 2003. Boreholes 1200014-BH01 to BH03 were located along the sewer extension route, 1200014-BH04 was located at the proposed lift station while 1200014-BH08 was located at the proposed treatment plant site. Boreholes 1200014-BH05 to BH07 were located along the outfall line alignment, drilled through the ice on the Yukon River. The approximate borehole locations are shown on Figure 2.

The boreholes, which ranged in depth from 6.5 m to 16.5 m, were advanced using a Nodwell-mounted CME 75 drill contracted from Midnight Sun Drilling Company Ltd. of Whitehorse,

Yukon. Both solid shaft and hollow stem augers were utilized in the drilling program. Boreholes 1200014-BH01 to BH03, located along the sewer extension, were advanced to 7.5 m depth while Borehole 1200014-BH04, located at the proposed lift station was advanced to 12.5 m. From ice elevation, 1200014-BH05 was advanced to 6.5 m and 1200014-BH06 and BH07 to 8.0 m. Excluding the ice and water depths, drilling resulted in 5.2 m, 5.0 m, 4.8 m of soil stratigraphy for 1200014-BH05, BH06 and BH07, respectively. Borehole 1200014-BH08 was advanced to 10.5 m using hollow stem augers, at which time a dynamic cone penetration test (DCPT) was conducted to 16.5 m.

Both standard penetration test (SPT) split-spoon samples and grab samples from the auger flights were collected from each borehole. Generally, the standard penetration testing and sampling was completed at 1.5 m intervals throughout the depth of each borehole. Blow counts for the completed SPT and DCPT tests were recorded and are presented on the borehole logs accompanying this report. Disturbed grab samples were collected at select depths to augment the penetration test samples as deemed appropriate by the EBA representative at the site.

All drilling was directed, observed, and logged by a senior technician from EBA's Whitehorse office. All soil samples were returned to EBA's Whitehorse laboratory for natural moisture content determination. Grain size testing was completed on a select number of samples to assist in soil characterization.

Borehole logs, showing detailed soil conditions and presenting laboratory results, are presented in Appendix C of this report. Where applicable, the results of individual laboratory tests are reported separately following the relevant borehole log in Appendix C.

4.0 SITE CONDITIONS

4.1 Site Description

The proposed location for the wastewater treatment plant is on Lot 32, which is situated off the River Road approximately 630 m northwest of the existing wastewater treatment facility. The

sewer extension is to be extended from the existing facility northwest along the south side of River Road to Lot 32. It will then travel perpendicular from the road to a lift station and then up to an upper bench located on the lot where the plant is to be located. The outfall line is to be constructed from the plant across River Road and into the thalweg of the Yukon River. A general site plan of the sewer extension, main site and outfall line is presented in Figure 1.

The elevated bench located on Lot 32 is situated in the west portion of the lot and rises up from the River Road. The area is covered with natural spruce and poplars excluding the presence of several trails.

The east portion of the lot has low-lying wet areas complete with thick moss ground cover and sparse, dwarf black spruce tree cover. The type of terrain is typical of permafrost areas in the Yukon – it is understood that no development will occur in this area.

4.2 Soils

Data from the borehole logs obtained from the site characterization program has been summarized to produce two cross sections (A-A' and B-B'), which illustrate the soil stratigraphy from the plant site to the outfall location and along the sewer extension from the existing plant to the lift station location. Cross-sections A-A' and B-B', as located on Figure 2, are presented in Figure 3. Existing boreholes located on Lot 32 have also been reviewed and are discussed in the following section 4.2.3.

Detailed descriptions of all existing and newly explored soils are contained on the borehole logs presented in Appendices B and C, as previously noted.

4.2.1 Cross section A-A': Plant Site to Outfall Location

Review of the borehole logs from along the plant site to the outfall location indicate a relatively consistent soil profile of SAND AND SILT overlying GRAVEL AND SAND which in turn is underlain by SAND AND SILT. Boreholes located in the Yukon River did not have the upper SAND AND SILT layer and commenced with SAND AND GRAVEL. The profile is

generalized in Table 1 for the plant site to the lift station location and Table 2 for the outfall line in the Yukon River.

**Table 1
GENERALIZED STRATIGRAPHIC SOIL PROFILE:
PLANT SITE TO LIFT STATION**

Soil Unit	Thickness (m)	Average Thickness (m)	Average Profile (m)
ORGANICS	0.1 – 0.7	0.30	0.30
SAND AND/OR SILT- fine grained	1.0 – 4.0	2.50	2.80
GRAVEL- sandy, silty to some silt	0.0 – 2.8	1.40	4.20
GRAVEL AND SAND- trace to some silt	4.5 – 5.4	4.95	9.15
SAND AND SILT- gravelly	0.0 – 2.3	1.15	10.30
SAND AND SILT- fine grained	>1.0 – 1.3 ⁽¹⁾	>1.15 ⁽¹⁾	11.45 ⁽²⁾

Note: ⁽¹⁾ Boreholes terminated in this layer.

⁽²⁾ The average depth of the two boreholes advanced was 11.50 m.

**Table 2
GENERALIZED STRATIGRAPHIC SOIL PROFILE: OUTFALL LINE**

Soil Unit	Thickness (m)	Average Thickness (m)	Average Profile (m)
WATER	1.3 – 3.2	2.50	2.50
GRAVEL AND SAND- trace to some silt	1.6 – 3.8	2.37	4.87
SAND AND SILT- fine grained	>1.4 – 3.4 ⁽¹⁾	>2.63 ⁽¹⁾	7.50 ⁽²⁾

Note: ⁽¹⁾ Boreholes terminated in this layer.

⁽²⁾ The average depth of the three boreholes advanced was 7.50 m.

4.2.2 Cross section B-B': Sewer Extension Route

Review of the borehole logs from the sewer extension route indicate a relatively consistent soil profile of SAND AND SILT which becomes gravelly with depth overlying SAND AND GRAVEL. This profile is generalized in Table 3.

Table 3
GENERALIZED STRATIGRAPHIC SOIL PROFILE: SEWER LINE EXTENSION

Soil Unit	Thickness (m)	Average Thickness (m)	Average Profile (m)
ORGANICS OR FILL	0.1 – 0.9	0.45	0.45
SAND AND/OR SILT- fine grained	1.1 – 4.0	2.15	2.60
SAND AND SILT- gravelly	0.0 – 2.1 ⁽¹⁾	0.53 ⁽¹⁾	3.13
SAND AND GRAVEL- trace to some silt	>3.4 – 4.5 ⁽²⁾	3.78 ⁽²⁾	6.91
SAND AND SILT- gravelly	2.3 ⁽³⁾		
SAND AND SILT- fine grained	>1.0 ⁽⁴⁾		

Note: ⁽¹⁾ Only encountered in one of the four boreholes in this cross section.

⁽²⁾ Three of the four boreholes terminated in this layer.

⁽³⁾ Only encountered in one of the four boreholes in this cross section.

⁽⁴⁾ One of the four boreholes terminated in this layer.

4.2.3 Existing Information for Lot 32

Existing information for Lot 32 was reviewed to provide a greater understanding of soil stratigraphy information for the proposed site. A testpitting program was completed by EBA on February 6, 1995 that involved several lots in Carmacks including Lot 32. Review of the borehole logs (11730-04 to 06) indicate a consistent soil profile with those of this characterization with some fine sand SILT overlying GRAVEL AND SAND – trace silt underlain by SAND AND SILT – fine grained. Testpits 11730-04 and -05 terminated in the GRAVEL AND SAND layer. A silty layer of GRAVEL AND SAND was present between the upper SILT layer and the GRAVEL layer in 11730-05. The soil profile for these three boreholes is generalized in Table 4.

Table 4
GENERALIZED STRATIGRAPHIC SOIL PROFILE: EXISTING INFORMATION

Soil Unit	Thickness (m)	Average Thickness (m)	Average Profile (m)
ORGANICS	0.1	0.10	0.10
SILT- fine grained	0.2 – 1.2	0.70	0.80
GRAVEL AND SAND- silty	0.0 – 2.3 ⁽¹⁾	0.77 ⁽¹⁾	1.57
GRAVEL AND SAND- trace silt	0.9 – 2.7 ⁽²⁾	1.57 ⁽²⁾	3.14
SAND AND SILT- fine grained	>3.0 ⁽³⁾		

Note: ⁽¹⁾ Only encountered in one of the three boreholes.

⁽²⁾ Two of the three boreholes terminated in this layer.

⁽³⁾ One of the three boreholes terminated in this layer.

4.3 Groundwater

Groundwater was encountered in all land boreholes advanced for this project. A monitoring well was installed at each of the borehole locations for future monitoring of the groundwater table. Installation records are presented on the borehole logs presented in Appendix C. The groundwater level was recorded at the time of drilling and has been recorded twice since the well installations. Findings are presented in Table 5.

Table 5
MONITORING WELL WATER ELEVATIONS

Monitoring Well	Ground Elevation (m)	February 25 – 27, 2003 Water Elevations	June 6 2003 Water Elevation	August 6, 2003 Water Elevation
1200014 – BH01	519.1	517.1	517.5	517.5
1200014 – BH02	521.1	517.0	517.3	517.5
1200014 – BH03	521.1	516.6	517.2	517.2
1200014 – BH04	520.7	517.3	517.5	517.6
1200014 – BH08	522.9	517.1	517.1	517.5

Groundwater was not observed in the 1995 Testpits 11730-04 or 11730-05, which were excavated to 4.0 m and 4.2 m, respectively. However, groundwater was present in 11730-06 at a depth of 3.3 m. No monitoring well was installed during this testpitting program.

4.4 Seasonal Frost Penetration

At the time of the site characterization work, seasonally frozen soils were encountered. Although measured seasonal frost depths were only up to 1.3 m, it is expected that maximum seasonal frost penetration would extend to at least 3.0 m under cleared areas (roads, etc.) and 2.0 m elsewhere.

4.5 Permafrost

Permafrost was not encountered during the site characterization work, nor was it observed in 11730-04 or 11730-06. Testpit 11730-05 indicates the gravel and sand layer (0.8 m to ~1.5 m) as frozen and possibly permafrost, but judging from the moisture contents, it is more likely seasonal frost.

5.0 SITE INFRASTRUCTURE RECOMMENDATIONS

Development of the proposed WWTP at Lot 32 will require new access routes and parking areas as well as the installation of new buried utilities (sewer line). Recommendations for the design and construction of these infrastructure elements are presented in Sections 5.1 and 5.2.

5.1 Roadways & Parking

It is recommended that all access roads and parking on site be constructed of at least 500 mm of imported granular materials. This would consist of 400 mm of 80 mm Subbase and 100 mm of 20 mm Base Course. In excessively wet areas, a non-woven geotextile may be required beneath the gravel and on top of the natural subgrade. All organics must be stripped and wasted prior to placing any geotextile or road fill. All road fill materials must be placed in maximum lift thicknesses of 250 mm and compacted to at least 98 percent of Standard Proctor maximum dry density (SPMDD) (per ASTM D698), using a large vibratory drum roller.

Gradation specifications for the above materials recommended in are presented in Table 6.

Table 6
GRANULAR MATERIALS GRADATION SPECIFICATIONS

80 mm Subbase		20 mm Base Course	
Sieve Size (mm)	% Passing By Mass	Sieve Size (mm)	% Passing By Mass
80.000	100		
25.000	60 - 100		
20.000		20.000	100
12.500	40 - 90	12.500	64 - 100
5.000	20 - 65	5.000	36 - 72
1.250	9 - 35	1.250	12 - 42
0.315	5 - 23	0.315	4 - 22
0.080	2 - 10	0.080	3 - 6

5.1.1 Site Preparation and Construction

Preparation of the roadways and parking areas will require excavation and removal of all organic or organic contaminated soils. The borehole information from the site indicates that up to 0.7 m of stripping may be required. Upon stripping of the surface organics, the exposed subgrade must be recompacted to at least 98 percent of SPMDD for an effective depth of at least 300 mm. During recompaction, the subgrade must be moisture conditioned to $\pm 2\%$ of its optimum moisture content as determined by a Standard Proctor moisture-density test (ASTM D698).

After recompaction, proof rolling of the area should be conducted using equipment suitable to the Engineer. If proof rolling identifies areas of excessive deflection, the Engineer may direct the Contractor to subcut this area to greater depth and rebuild it with a thickness of subbase aggregate. All subcut areas would be placed and compacted as per the subgrade and subbase requirements specified above.

After acceptance of the prepared subgrade, the subbase aggregate may be placed and compacted in thicknesses as previously stated. The subbase should be moisture conditioned to $\pm 2\%$ of its optimum moisture content and compacted to at least 98% of SPMDD.

After acceptance of the subbase, the base course can be placed and compacted. The base course must be compacted to at least 98% of SPMDD and must be moisture conditioned to $\pm 2\%$ of its optimum moisture content.

5.2 Sewer Line

5.2.1 Frost Protection

Due to the expense of replacing buried utilities that are damaged by freezing or frost action, a higher standard for frost protection is generally recommended, as opposed to that required for surface works that are more easily repaired. EBA's Geothermal Design Manual suggests that for a 50-year design winter in similar soils in the Whitehorse area, frost protection should be provided to the lesser of 3.6 m or to a nominal depth below the yearly low groundwater table. The use of heat tracing, insulation, re-circulation, and other preventative techniques may also be necessary as determined by a qualified Municipal Engineer. Once detailed design of subsurface works is completed, EBA could provide a design temperature profile with depth, if desired.

5.2.2 Construction

The use of tracked excavators for trench excavation during underground utilities construction should not encounter any problems during sewer line construction, depending upon the depth of excavation. Sideslopes for trenches should not exceed 1.5:1 (horizontal:vertical) for any trenches deeper than 1.2 m. Deeper cuts will encounter groundwater seepage, and the contractor must be prepared to pump water from the excavations. Below the groundwater table, flatter slopes will be required, and, depending upon the depth, shoring may also be necessary.

It is recommended that a Class "B" pipe bedding configuration (as presented in the Whitehorse City Servicing Standards Manual) be specified for this project. This insures proper protection of the buried utility lines during backfill. Bedding sand is recommended for use in dry areas while bedding stone is to be used in wet conditions. The bedding sand and stone should conform to the gradation specifications presented in Table 7 and should be at least 150 mm thick below the pipe and 300 mm thick above the pipe. Compaction levels of the sand bedding should be at

least 95% of Standard Proctor maximum dry density unless bedding stone is utilized, in which case manually rodding of the stone below the spring line of the pipe should be satisfactory prior to placing subsequent lifts.

Table 7
BEDDING MATERIALS GRADATION SPECIFICATIONS

Bedding Sand		Bedding Stone	
Sieve Size (mm)	% Passing By Mass	Sieve Size (mm)	% Passing By Mass
		25.000	100
		20.000	70 - 100
		12.500	55 - 100
10.000	100	10.000	30 - 80
5.000	80 - 100	5.000	0 - 40
2.000	55 - 100	2.000	0 - 10
0.630	25 - 65		
0.250	10 - 40		
0.080	2 - 15		

The excavated soils along the sewer extension route and throughout the site will likely be either sand and silt, or gravel and sand, depending on depth of excavation. In areas where frost heave is not a concern, existing soils should be suitable for reuse as trench backfill; however, the fine grained soils closer to the ground surface are susceptible to frost heave and are expected to be unsuitable for re-use in some circumstances and should be wasted from the site. In addition, fine-grained soils will be difficult to spread and compact in wet conditions.

The trenches should be backfilled in lifts not exceeding 250 mm in thickness and compacted to at least 95% of Standard Proctor maximum dry density to within one metre of design elevations. If the trench will pass underneath a roadway or parking area, the final metre should then be compacted to at least 98% of SPMDD. Otherwise, the compaction level (for undeveloped areas) within 1 m of finished grade can be maintained to at least 95% of SPMDD.

All backfill, including sand bedding, placed in utility trenches should be moisture conditioned during compaction to $\pm 2\%$ of the optimum moisture content of the backfill material.

5.2.3 *Dewatering*

As presented in Table 5, groundwater along the sewer line was recorded between the elevations of 517.2 and 517.6 (August 6, 2003). Preliminary sewer line invert elevations provided by YES in January 2003, indicate elevations of 517.5 to 515.5 m along River Road and 515.5 to 515.2 m from River Road to the wastewater plant. The base of the lift station is at 515.2.

Although the sewer line inverts along River Road are up to 2 m below the groundwater table (in August, 2003), cross section B-B indicates that the majority of the excavated depth will be along the Sand and Silt and Sand and Gravel interface. Given the properties of the Silt and Sand, it is believed, a traditional sloped excavation utilizing sumps and pumps could be successful. In areas where the base of the excavation is located in the Sand and Gravel layer, as in the sewer line between River Road and the wastewater plant along with the lift station, groundwater will be more of a concern. The deeper the excavation extends in the Sand and Gravel layer below the water table, the less likely it will be that pumping from sumps would be successful. Other options include shored excavations, slurry supported excavations, and the use of sheet piles.

Dewatering could be difficult in the Sand and Gravel layer. It is EBA's opinion that this depth is approaching the limit of a conventional excavation and pump type of operation wherein sump pumps are able to maintain a dry work area within an oversized excavation. If such an operation is envisioned, EBA would recommend that a trial excavation be conducted at final design and then again during the tendering process so that designers or contractors can witness firsthand the volume of water that would be entering the excavation.

The use of well points for dewatering deep excavations in granular soils is another option for construction. However, well points are best suited to sites with sandy soils and would likely require a staged dewatering plan using at least two rows of well points. Moreover, to EBA's knowledge there is no local contractor with well point experience. For these reasons EBA does not consider well points to be a feasible choice for this site.

Another option to facilitate the dewatering operations would be sheet piling. Sheet piles could be driven into the underlying sand and silt below the gravel to provide both a stable excavation

and to reduce (but not eliminate) groundwater seepage into the excavation. A well-designed sheet pile wall would reduce seepage to levels that could be handled by conventional pumping.

A final option for dewatering is to not completely dewater the excavation but to construct the lift station in the 'wet'. Several viable techniques could be considered by contractors to prefabricate a well and place it into a prepared wet excavation. Issues for such an operation include the proper preparation of the base of the excavation and stabilization of the excavation walls.

For any of the dewatering scenarios considered for this project, the issue of obtaining approval to discharge water from the excavation needs to be included. The Water Licence requirements should be reviewed to determine how much water of what quality can be discharged. Depending on the depth of the lift station and the contractor's plans, it may be necessary to obtain a Water License for construction. It is understood that other members of the design team will be responsible for this requirement.

In any case, EBA recommends that the excavation and dewatering methods be selected by the contractor, who should retain an expert to assist in the construction plan. It is our recommendation that a trial excavation, to a typical design depth below the groundwater table, be completed during the tendering process. This test excavation would eliminate uncertainty for the contractors and allow them to select the most cost effective method to advance the excavation and dewater the site.

It should also be noted that any shoring systems used will require the approval of a qualified Professional Engineer registered in the Yukon Territory.

5.2.4 Additional Recommendations for the Lift Station

The base of the lift station should be founded upon a compacted engineered fill pad. A base of 20 mm base course is recommended for use in dry areas while bedding stone is to be used in wet conditions. The 20 mm base course or bedding stone should conform to the gradation specifications presented in Table 6 or 7 and should be at least 300 mm thick. Compaction levels

of the 20 mm material should be at least 98% of Standard Proctor maximum dry density unless bedding stone is utilized, in which case manually rodding of the stone to ensure “rock on rock contact” should be satisfactory prior to placing subsequent lifts.

6.0 BUILDING FOUNDATIONS

6.1 General

Subsurface soil conditions at the site are considered to be generally suitable to support the proposed construction; however, the near-surface soils are frost-susceptible, and measures to control these potential seasonal frost movements will need to be included in the design of foundations on site.

6.2 Foundations

Standard concrete footings bearing on the in-situ soils, or on engineered fill, are an acceptable foundation type for the proposed site development. This includes separate footings and slabs, or the use of a thickened slab foundation. Details of the recommended foundation systems are presented in the following sections.

6.2.1 Site Preparation & Excavations

Preparation of the building site for foundation construction/subgrade preparation will require the removal, from the building footprint, of all topsoil and organic contaminated soils to reveal the native subgrade. The footprint includes the building plan area plus at least 1 m beyond the building area on all sides.

Footing or other excavations below the stripping depth may be continued using a sloped excavation with slopes no steeper than 1:1 (horizontal:vertical). Excavated materials removed from the development areas may be wasted as directed by the Owner or stockpiled for later use as (non-structural) landscaping fill around the site.

Following the completion of all excavations and stripping, the exposed subgrade will require recompaction to at least 98% of SPMDD within the complete area of the building footprint.

6.2.2 Dewatering

As presented in Table 5, groundwater at the building site (1200014-BH08) was recorded to be at an elevation of 517.5 m or a corresponding depth of 5.4 m (August 6, 2003). The plant is expected to have three tanks 4 m to 6 m below floor elevation.

At this time, it is unknown if the base of the tanks below the building will be within groundwater. It is believed that a traditional sloped excavation utilizing pumps could be successful; however, as previously discussed, the deeper the excavation extends into the Sand and Gravel layer below the groundwater table, the less likely it will be that such a system would be successful. Other options include shored excavations, slurry supported excavations, and the use of sheet piles.

6.2.3 Foundations

Building loads for the WWTP will be carried by conventional strip and spread footings or by a thickened slab foundation. Footing and/or slab thickenings should be constructed on recompacted native gravel or on properly compacted structural fill. Footings should be proportioned using a maximum allowable static bearing pressure of 120 kPa (2500 psf) for either recompacted native gravel or compacted structural fill. Both the native gravel and structural fill, if used, should be compacted to at least 98% of the SPMDD in order to develop the allowable bearing pressure specified in this report.

The maximum allowable static bearing pressure assumes concentric loading and a minimum footing depth of 0.6 m. The allowable bearing pressure also assumes that a minimum of 0.9 m of native gravel underlies all bearing surfaces.

Regardless of the allowable bearing pressure, all thickened areas and/or strip footings carrying line loads should have a minimum width of 0.5 m. For point load areas/pad footings the minimum width should be 1.0 m.

The native sand and gravel soils at the site may be susceptible to loosening due to construction traffic or through desiccation. Any loosened soil must be recompacted prior to pouring concrete. Given the nature of this material, it is recommended that a 100 mm thick levelling course of well-graded sand and gravel with a maximum aggregate size of 20 mm (structural fill) be placed underneath all footings. This material would reduce problems associated with drying and disturbance of the native sand and gravel within footing areas. Compaction of the levelling course to at least 98% of SPMDD would be required.

Settlement of the structure erected over the properly prepared foundation is expected to be minimal and should result primarily from elastic compression of the underlying soils. Total settlements should be less than 20 mm and differential settlements should be less than 15 mm.

6.2.4 Frost Protection

As indicated above, the potential for frost heave action must be accounted for in the design of the building. Wherever frost action is a possible concern in the Carmacks region, a minimum un-insulated footing depth of 2.4 m is typically recommended for all exterior footings around a heated structure. For this specific site, the depth to the Silt and Sand layer is 0.9 m while the Gravel – silty to some silt extends to a depth of 3.7 m. The use of horizontal perimeter insulation can be used to provide additional frost protection for the exterior building foundations.

For exterior footings founded at a depth of 1.0 m, 50 mm of perimeter insulation would be recommended. The 50 mm thick horizontal insulation would have to be placed for a width of 1.2 m around the building perimeter. The horizontal insulation should extend at least 1.2 m beyond any corner of the building and should be increased to a thickness of 100 mm within 1.2 m of any corner. Details for a suitable insulation plan are shown on Figure 4.

6.2.5 Slab-On-Grade

The use of a concrete floor slab for conventional loaded floors (up to 4.8 kPa), either as part of a thickened slab foundation or as a structural element separate from the foundations is considered feasible for the proposed buildings. The slab should be cast upon a 200 mm thick levelling

course of 20 mm crushed gravel and sand placed over the recompacted native sand. The levelling course should be compacted to at least 98% of SPMDD. A moisture barrier, such as polyethylene sheeting, should be placed immediately beneath the floor slab to enhance concrete hydration and to act as a vapour barrier.

6.2.6 Backfill and Compaction

Fill placed underneath footings and slabs is considered to be structural fill. Structural fill shall be placed in lifts with a loose thickness no greater than 250 mm and compacted to at least 98% of SPMDD. Fill placed on the exterior side of footings and foundation walls is exterior backfill and will only require compaction to at least 95% of SPMDD. Suitable structural fill should be non-frost susceptible sand and gravel mixture meeting the gradation limits presented in Table 6 of Section 5.1. Exterior fill can be native sand or imported general fill that meets the gradation limits of Table 8, below.

**Table 7
IMPORTED GENERAL FILL GRADATION SPECIFICATIONS**

Sieve Size (mm)	Weight Passing (%)
200.000	100
80.000	75 – 100
25.000	55 – 100
12.500	42 – 84
5.000	26 – 65
1.250	11 – 47
0.315	3 – 30
0.080	0 – 8

Both structural and exterior fill will require moisture conditioning during placement to achieve a moisture content $\pm 2\%$ of the optimum moisture content as determined by the moisture-density relationship (Standard Proctor test) for that material.

6.2.7 Lateral Earth Pressures

Subsequent to footing and foundation wall construction, backfill along the inside and outside of the foundation walls should be completed concurrently. The excavated granular materials will be satisfactory for backfill along foundation walls. If construction is to be completed in cold

weather conditions, the contractor must be prepared to heat and hoard areas where backfill is being placed. The backfill should be placed in 200 mm lifts, moisture conditioned, and compacted to at least 98% of SPMDD along the inside of the foundation wall (to properly support a slab-on-grade floor system). Along the outside of the foundation wall, the backfill should be compacted to at least 98% of SPMDD in the areas requiring structural support, and 95% SPMDD in landscaped areas. The final backfill elevation should ensure proper drainage away from the structure.

Foundation wall and buried tank design should consider the lateral earth pressures in the at-rest condition, and may be designed using the following expression, which assumes a triangular pressure distribution:

$P_o = k_o(\gamma_b H + Q)$ where:

P_o = lateral earth pressure at rest, and no movement of wall occurs at the given depth (kPa)

k_o = coefficient of earth pressure at rest condition, use 0.45 for granular backfill

γ_b = bulk unit weight of backfill soil; use 22.5 kN/m³

H = depth below final grade (m)

Q = any surcharge pressure at ground surface (kPa)

The above expression assumes that backfill will remain unsaturated and will be placed using conventional techniques in an open excavation. Should an alternative construction technique be considered, the impacts on the lateral pressures will have to be evaluated.

The wall pressure distribution provided is for the static case. For earthquake loading (see Section 6.3) it will be necessary to add 19 kPa as a constant pressure distribution with depth, the same as for any surface surcharge pressure.

6.3 Geotechnical Seismic Design Parameters

Carmacks is not listed in the National Building Code of Canada (1995) (NBCC) for seismic design parameters, so the next closest location will be used: Aishihik, YT. Aishihik lies within Seismic Acceleration Zone 3 and Seismic Velocity Zone 5 with a zonal velocity ratio of 0.3 (NBCC 1995, Appendix C).

6.4 Site Drainage

As a further means to mitigate possible frost action, all buildings at this site must have suitable surface drainage measures. It is recommended that the finished grade be at least 0.3 m about the surrounding original ground elevations, as measured from the highest side of the respective building areas.

Landscaping of the completed building areas should include a cover of at least 300 mm of excavated native silt soils and/or topsoil over all exposed fill slopes and exterior surfaces. This cover soil will help to reduce the amount of runoff that percolates into the soil underneath the buildings. The cover soil should be nominally compacted to at least 90% of SPMDD to avoid erosion due to runoff. Seeding of the cover soil is recommended to enhance runoff over the soil.

The contouring of the finished development area should further ensure that runoff does not drain towards or pond around the buildings. If required, shallow swales should be installed to direct flow away from the development area. Runoff from buildings should also be collected onto splash pads and directed away from the buildings.

6.5 Concrete

It is recommended that all concrete be designed, mixed, and placed in accordance with the Canadian Standards Association standard CAN/CSA-A23.1-M00. According to this standard concrete should be designed to at least satisfy minimum environmental durability requirements as defined by its exposure class.

The exposure class of the concrete is dependent upon the presence or lack of chlorides, sulphates, freezing and thawing conditions, and saturated conditions. Foundation concrete at this site may be exposed to freezing and thawing cycles be potentially saturated, but will not be exposed to chlorides. Although not specifically tested at this site, EBA's experience indicates that water-soluble sulphate concentrations are likely negligible. Therefore, the governing exposure class for concrete at this site should be S-2. Exposure class S-2 requires the use of concrete with the properties indicated in Table 8, below.

Table 8
Concrete Properties for Exposure Class S-2

Minimum Compressive Strength	32 MPa
Maximum Water/Cement Ratio	0.45
Entrained Air Content Range	4% - 7% ⁽¹⁾
Cement Type	Type 10 (Normal)

Note: ⁽¹⁾ Assumes 20 mm maximum aggregate size

Note that the assumption that the presence of water-soluble sulphates is negligible is based on testing from similar sites. It is recommended that this be confirmed through site specific testing, should that be desired.

In addition to the above requirements, CAN/CSA-A23.1-M00 also provides recommendations for cold weather concrete placement. These include protecting freshly placed concrete from freezing temperatures.

7.0 ADDITIONAL INFORMATION REQUIRED

During final design, it is recommended that the following information be gathered:

- Chemical Analysis of Foundation Soil: Soluble Sulphate Test – this will determine whether the type of cement recommended is satisfactory for this given site or whether Sulphate Resistant cement is required.
- Site Specific Soil Stratigraphy – Should the location of the sewer extension, lift station, outfall, and/or the WWTP change from that presented in Figure 1, additional soil stratigraphy may be required to verify that the recommendations presented in this report are still valid.
- Dewatering Test Pit Program – Once the final location of the lift station and wastewater plant is located, a test pit program should be conducted to evaluate the volume of water flowing into an open excavation. Ideally, this program should be completed at the same time of year as that proposed for trenching and excavation during construction.

8.0 REVIEW OF DESIGN AND CONSTRUCTION SPECIFICATIONS

It is recommended that EBA be given the opportunity to review details of the final design and specifications, related to the geotechnical aspects of this project, prior to tendering. Past experience has shown that this action may prevent inconsistencies, poor performance and/or increased costs that may lead to disputes.

Furthermore, it is recommended that engineering field services such as observation of the bearing surfaces, pile monitoring, and testing of the fill placement be completed to ensure that the requirements of this report are followed.

9.0 LIMITATIONS

The recommendations prepared and presented in this report are based on the geotechnical data gathered by EBA during this project and from other projects as identified in this report. The provided data, in the form of geotechnical borehole and associated laboratory index property test results, has been supplemented by EBA's direct observations of the site. In order to develop recommendations from this information, it was necessary to make some assumptions concerning conditions other than at the specific locations of boreholes advanced for this project. Moreover, the recommendations required the completion of evaluations that use input soil parameters derived from the borehole logs and/or index properties of the soils, as well as, from correlations to published data on similar soils.

It should be recognized that geological conditions are innately variable and are seldom spatially uniform; therefore, there is always some unavoidable level of risk in preparing assumptions based on the determined geotechnical data. The conditions reported and assumptions made for this project are believed to be reasonable and representative of the site and the development. Nevertheless, adequate monitoring should be provided during construction to check these assumptions. Should monitoring identify different conditions than those identified and/or assumed in this report, it is requested that EBA be notified so that our recommendations can be re-evaluated accordingly.

This report and the recommendations contained in it are intended for the sole use of the G.J. Bull & Associates and its agents. 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 the G.J. Bull & Associates, or its agents, 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.

CLOSURE

EBA trusts that this report meets with your approval. Please do not hesitate to contact the undersigned should you have any questions or comments.

Respectfully submitted,
EBA Engineering Consultants Ltd.

Reviewed by:

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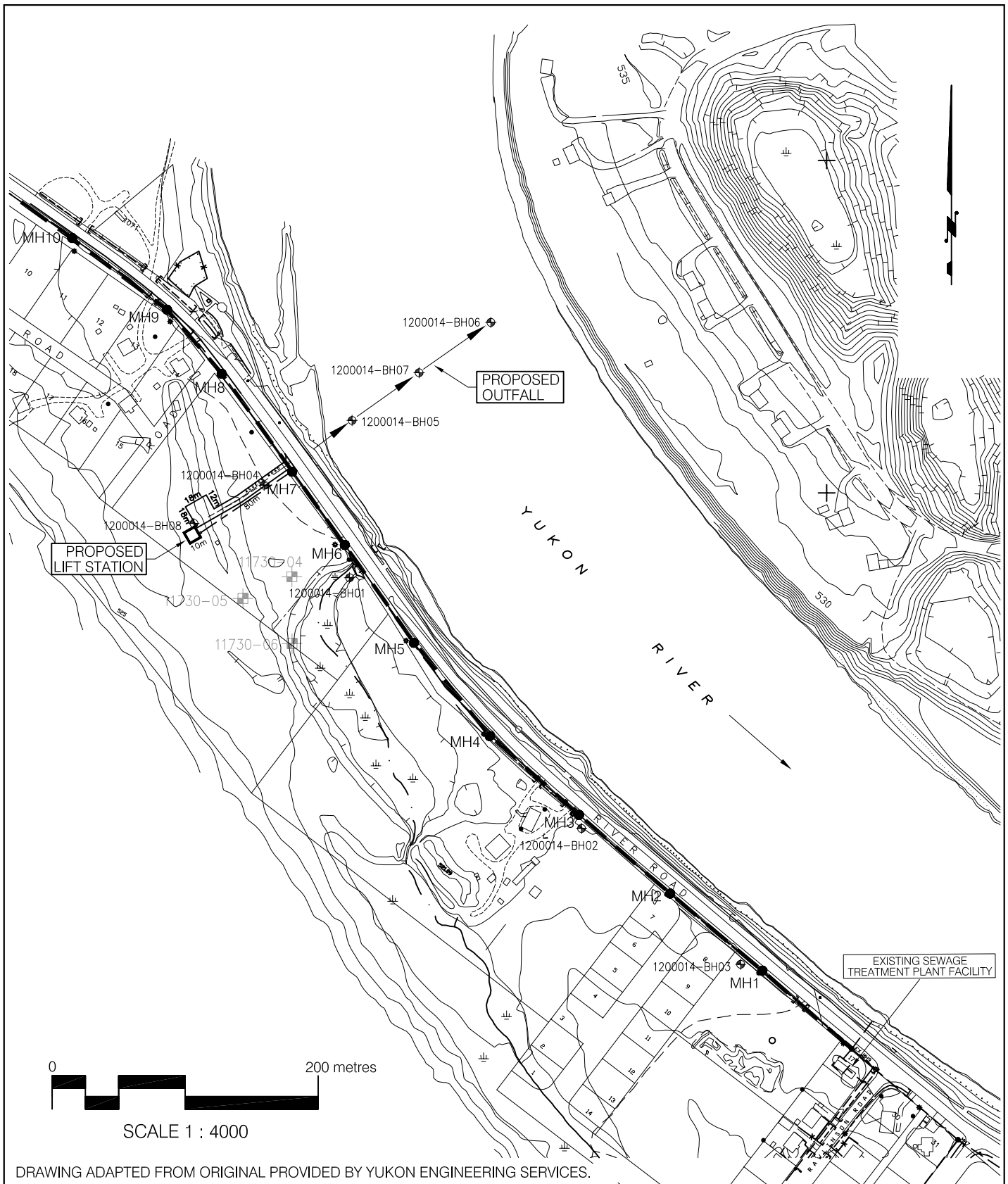
R01-1200014 geotech.doc

REFERENCES


EBA Engineering Consultants Ltd., December 1998. Geothermal Design Manual for the City of Whitehorse. Prepared for the City of Whitehorse Engineering Department. EBA File: 0201-97-13049.

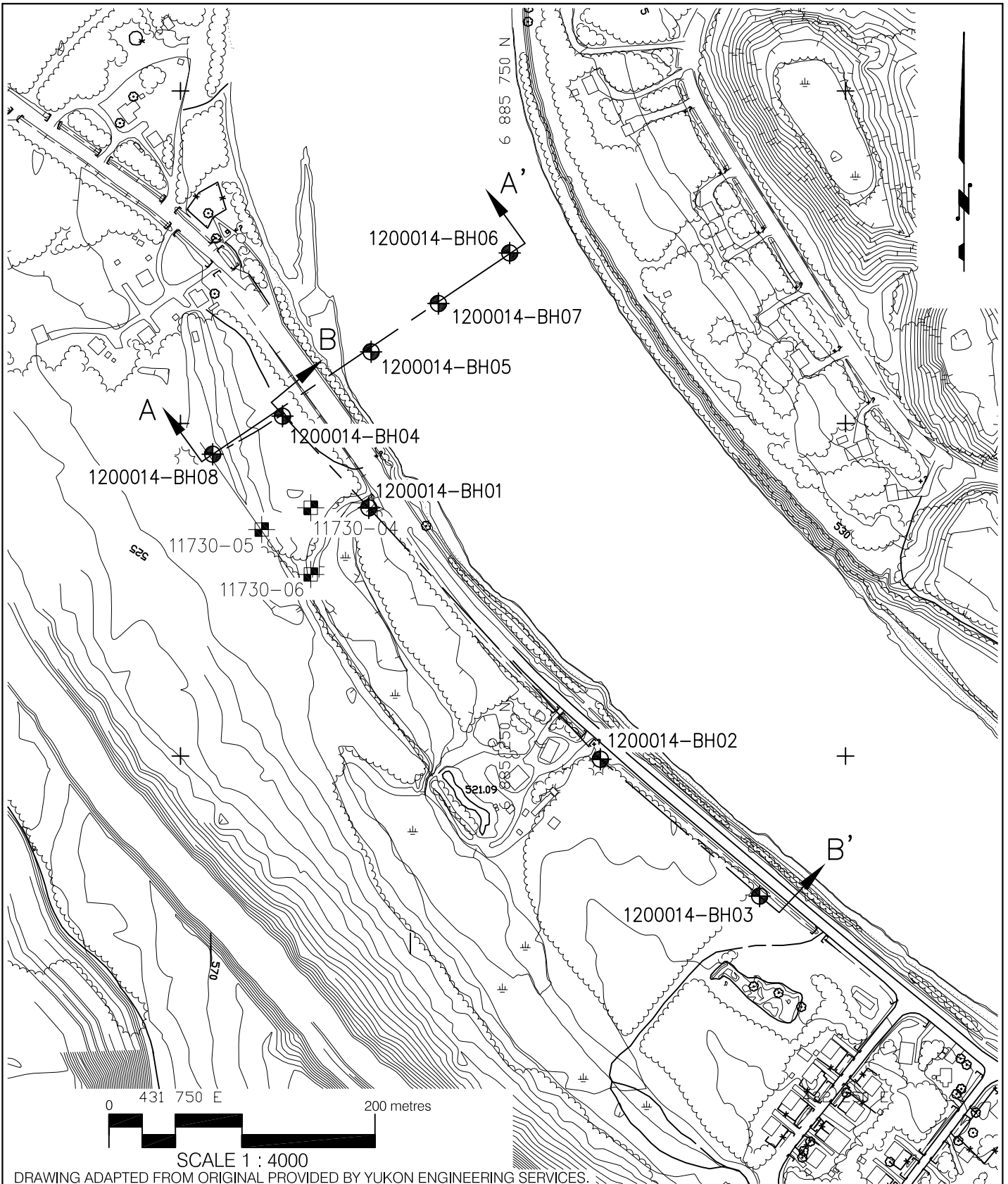
EBA Engineering Consultants Ltd., February 1995. Residential Expansion, Carmacks, Yukon. Prepared for the Government of Yukon. EBA File: 0201-11730.

FIGURES




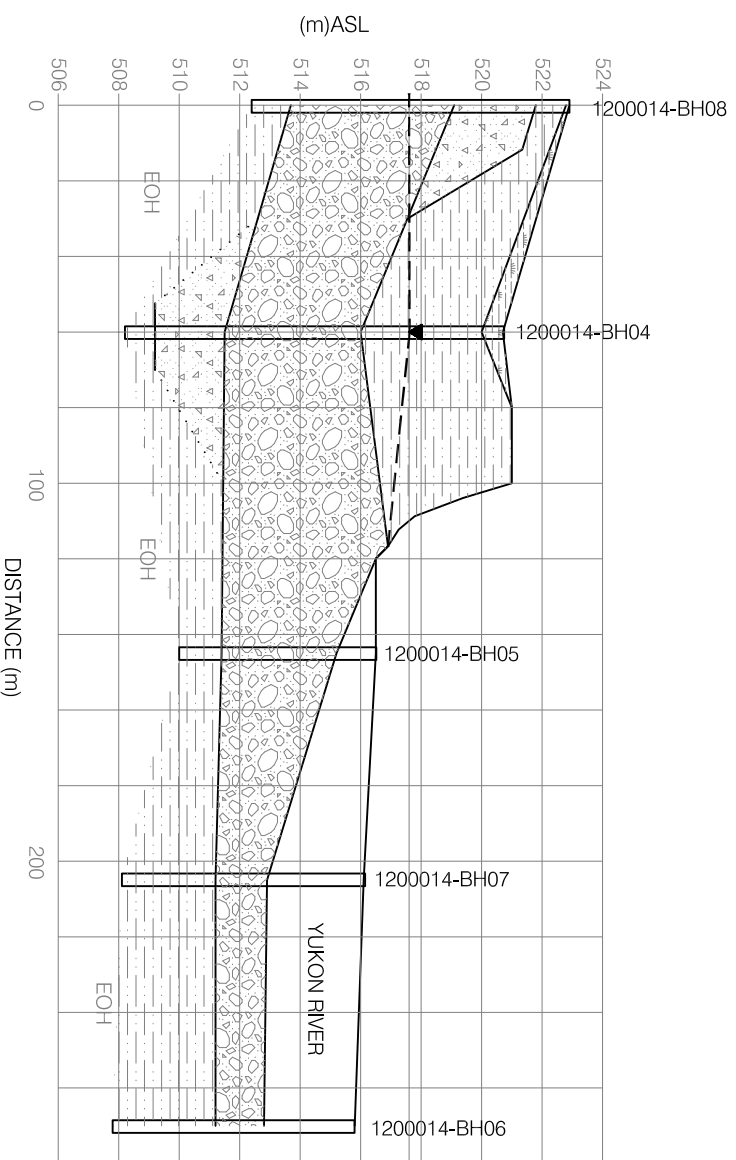
DRAWING ADAPTED FROM ORIGINAL PROVIDED BY YUKON ENGINEERING SERVICES.

 EBA Engineering Consultants Ltd.				PROJECT WASTE WATER TREATMENT PLANT CARMACKS, YUKON	
CLIENT G.J. BULL & ASSOCIATES				TITLE SITE PLAN SHOWING LOCATION OF BOREHOLES, LIFT STATION, SEWER LINE EXTENSION & OUTFALL	
DATE	MARCH 2003	DWN.	JPB/JSB	CHKD.	JRT
FILE NO.	0201-1200014	DRWG.	FIGURE 1		



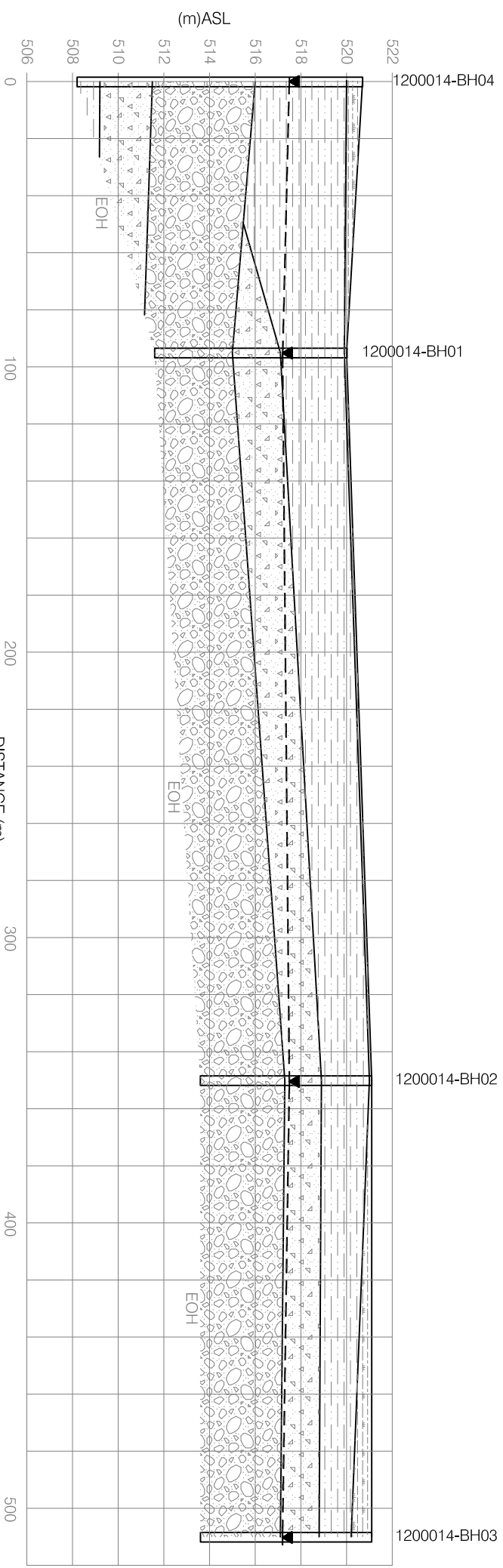
DRAWING ADAPTED FROM ORIGINAL PROVIDED BY YUKON ENGINEERING SERVICES.

 EBA Engineering Consultants Ltd.	PROJECT WASTE WATER TREATMENT PLANT CARMACKS, YUKON		
CLIENT G.J. BULL & ASSOCIATES	TITLE SITE PLAN SHOWING LOCATION OF BOREHOLES & CROSS-SECTIONS		
DATE MARCH 2003	DWN. JPB/JSB	CHKD. JRT	FILE NO. 1200014 DRWG. FIGURE 2



CROSS SECTION A - A'
SCALE: 1:200 HORIZONTAL
1:250 VERTICAL

NOTE:
BOREHOLE INFORMATION GENERALIZED TO PRODUCE THESE CROSS SECTIONS.
FOR SPECIFIC FINDINGS CONSULT BOREHOLE LOGS IN APPENDIX C.
WATER DEPTHS OBTAINED IN BOREHOLES ON AUGUST 6, 2003.

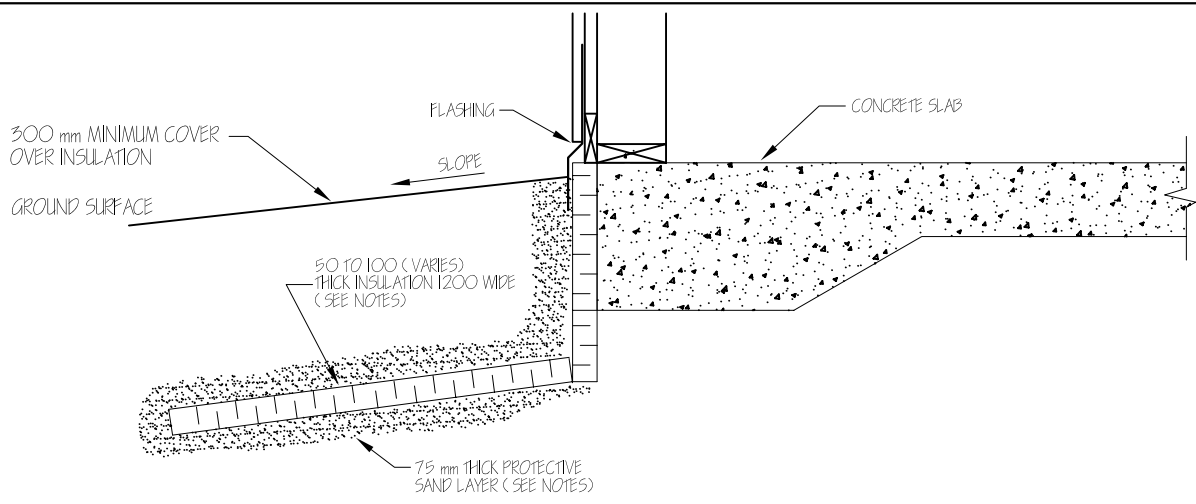


CROSS SECTION B - B'
SCALE: 1:200 HORIZONTAL
1:250 VERTICAL

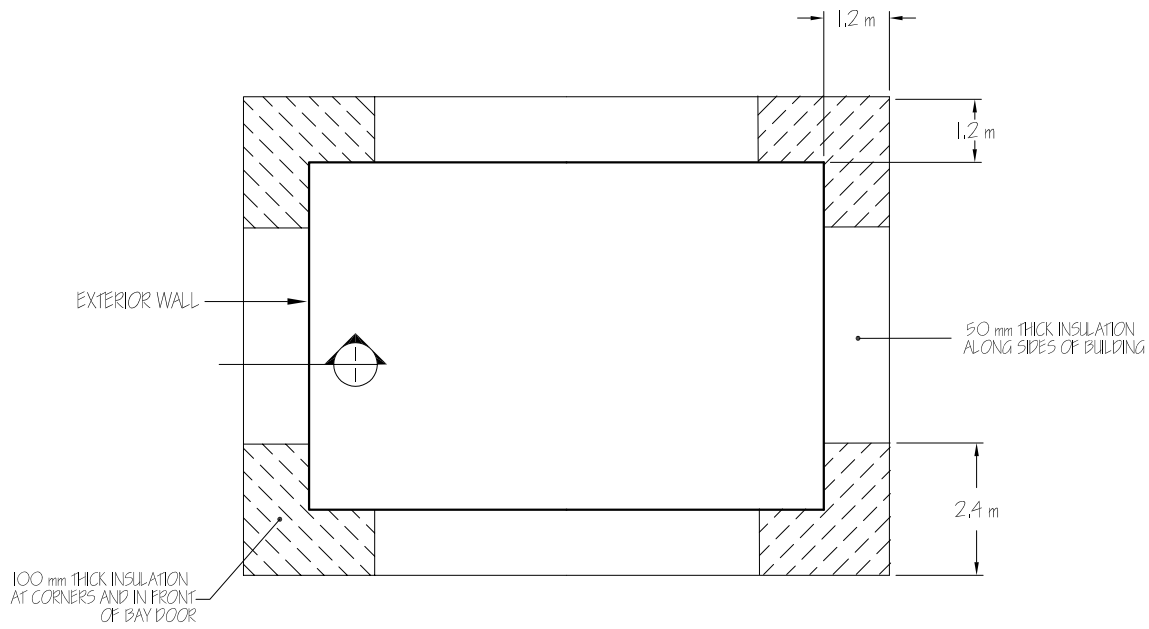
LEGEND

- ORGANICS AND/OR FILL
- SAND AND/OR SILT - FINE GRAINED
- GRAVEL - SANDY, SILTY TO SILT AND SAND - GRAVELLY
- SAND AND GRAVEL - TRACE TO SOME SILT
- EOH
- END OF BOREHOLE
- WATER TABLE BASED ON AUG. 2003 READINGS

				PROJECT WASTE WATER TREATMENT PLANT CARMACKS, YUKON	
CLIENT G. J. BULL & ASSOCIATES INC.				TITLE CROSS SECTIONS A - A' & B - B'	
DATE	OCT. 2003	DWN.	JPB/JSB	CHKD.	JRT
FILE NO.	1200014	DRWG.	FIGURE 3		



SECTION
MONOLITHIC SLAB
N.T.S.



PLAN
N.T.S.

NOTES: THE INSULATION SHOULD BE MOISTURE RESISTANT AND SUITABLE FOR BURIAL (i.e. DOW CHEMICAL HI OR SM SERIES STYROFOAM OR POLYURETHANE).
A MINIMUM BEDDING THICKNESS OF 75 mm OF FINE TO MEDIUM SAND SHOULD BE PLACED ABOVE AND BELOW THE INSULATION FOR PROTECTION.
DIMENSIONS IN MILLIMETRES, UNLESS OTHERWISE NOTED.



EBA Engineering Consultants Ltd.

PROJECT	WASTE WATER TREATMENT PLANT CARMACKS, YUKON		
TITLE	THICKENED SLAB FOUNDATION INSULATION DETAILS		
DATE	OCT. 2003	DWN.	JSB
CHKD.	JRT	FILE NO.	1200014
		DRWG.	FIGURE 4

CLIENT	G.J. BULL & ASSOCIATES		
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APPENDIX A
GENERAL CONDITIONS

EBA Engineering Consultants Ltd. (EBA)
GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these “General Conditions”.

A.1 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.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

A.2 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.

A.3 LOGS OF TEST HOLES

The test hole 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 that requires precise definition of

soil or rock zone transition elevations may require further investigation and review.

A.4 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.

A.5 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.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance that 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.

A.7 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.

EBA Engineering Consultants Ltd. (EBA)
GEOTECHNICAL REPORT – GENERAL CONDITIONS

A.8 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.

A.9 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.

A.10 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems that 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.

A.11 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.

A.12 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.

A.13 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.

A.14 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.

A.15 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.

APPENDIX B

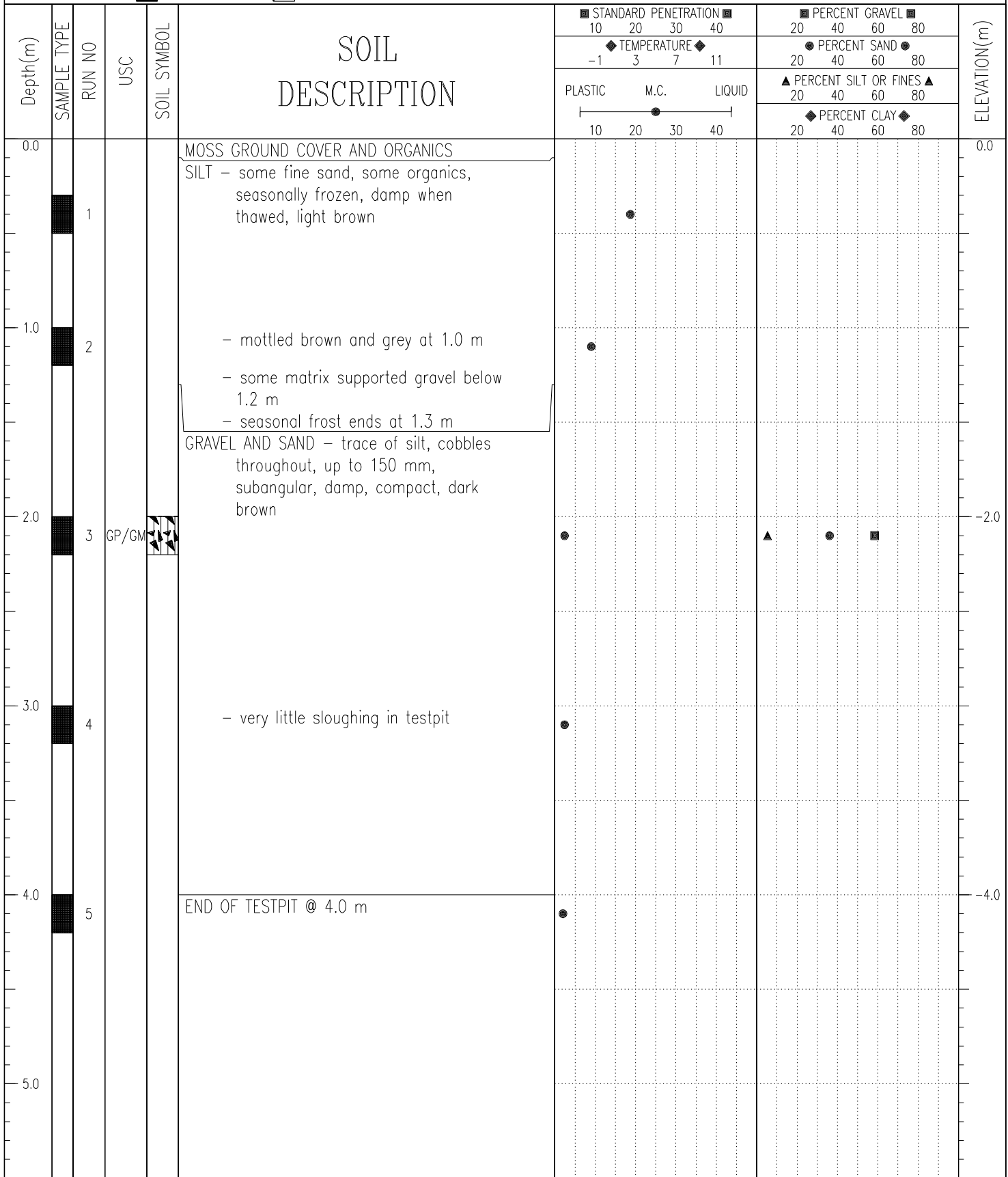
EXISTING BOREHOLE INFORMATION



CLIENT EBA Engineering Consultants Ltd. GOVERNMENT OF YUKON ENGINEERING AND DEVELOPMENT				PROJECT RESIDENTIAL EXPANSION - CARMACKS, YUKON			
TITLE SITE PLAN SHOWING TESTPIT LOCATIONS				DWG NO. 11730-A-01			
DATE 95-02-23	DWN MCP	CHKD MCP	DWG NO. 11730-A-01	DATE 95-02-23	DWN MCP	CHKD MCP	0201-11730

GEOTECHNICAL EVALUATION	CLIENT: YTG – ENGINEERING & DEVELOPMENT	TEST PIT NO: 11730-04
RESIDENTIAL INFILL	EXCAVATOR: CAT 225	PROJECT NO: 0201-11730
CARMACKS, YUKON	UTM ZONE: 8 N6885160 E433950	ELEVATION:

SAMPLE TYPE GRAB NO RECOVERY

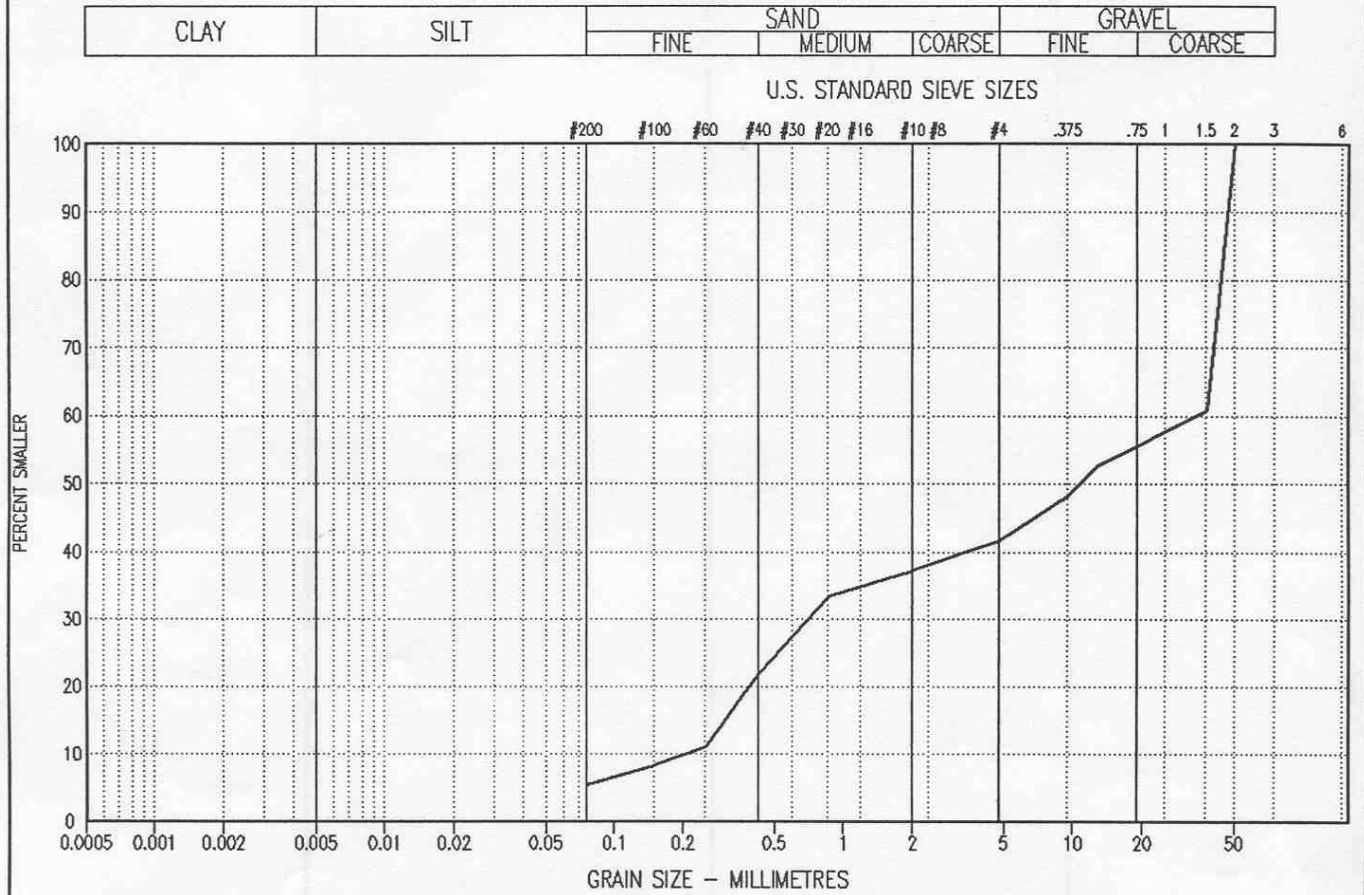


EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP
REVIEWED BY: MCP

COMPLETION DEPTH: 4 m
COMPLETE: 06/02/95

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
	11730-04	2.00 - 2.20	5.4	36.1	58.5	165.1	0.1	GP-GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

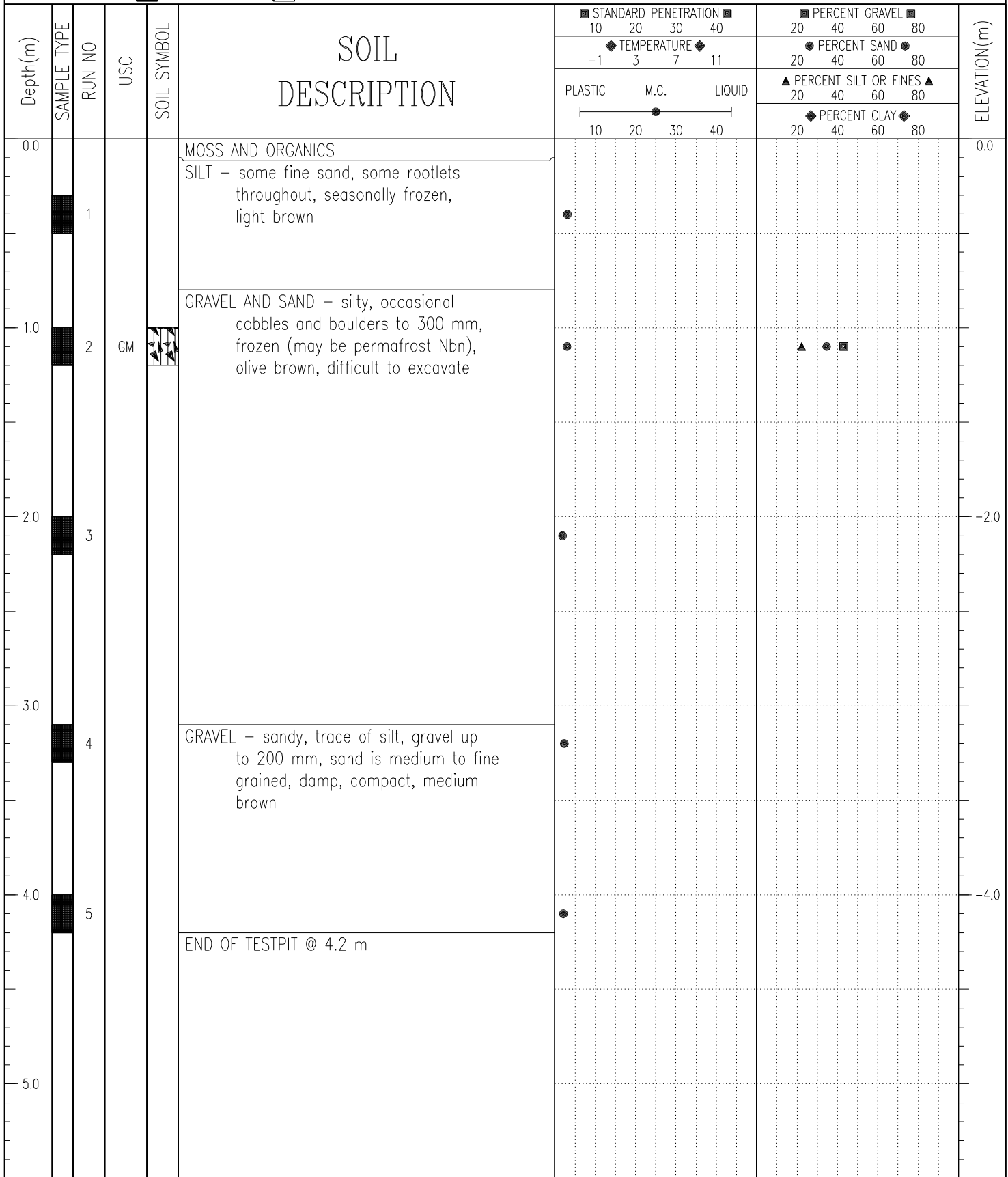
Tested in accordance with ASTM D422 unless otherwise noted.

Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use or misuse of this data by any

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not

GEOTECHNICAL EVALUATION	CLIENT: YTG - ENGINEERING & DEVELOPMENT	TEST PIT NO: 11730-05
RESIDENTIAL INFILL	EXCAVATOR: CAT 225	PROJECT NO: 0201-11730
CARMACKS, YUKON	UTM ZONE: 8 N6885140 E432850	ELEVATION:

SAMPLE TYPE GRAB NO RECOVERY

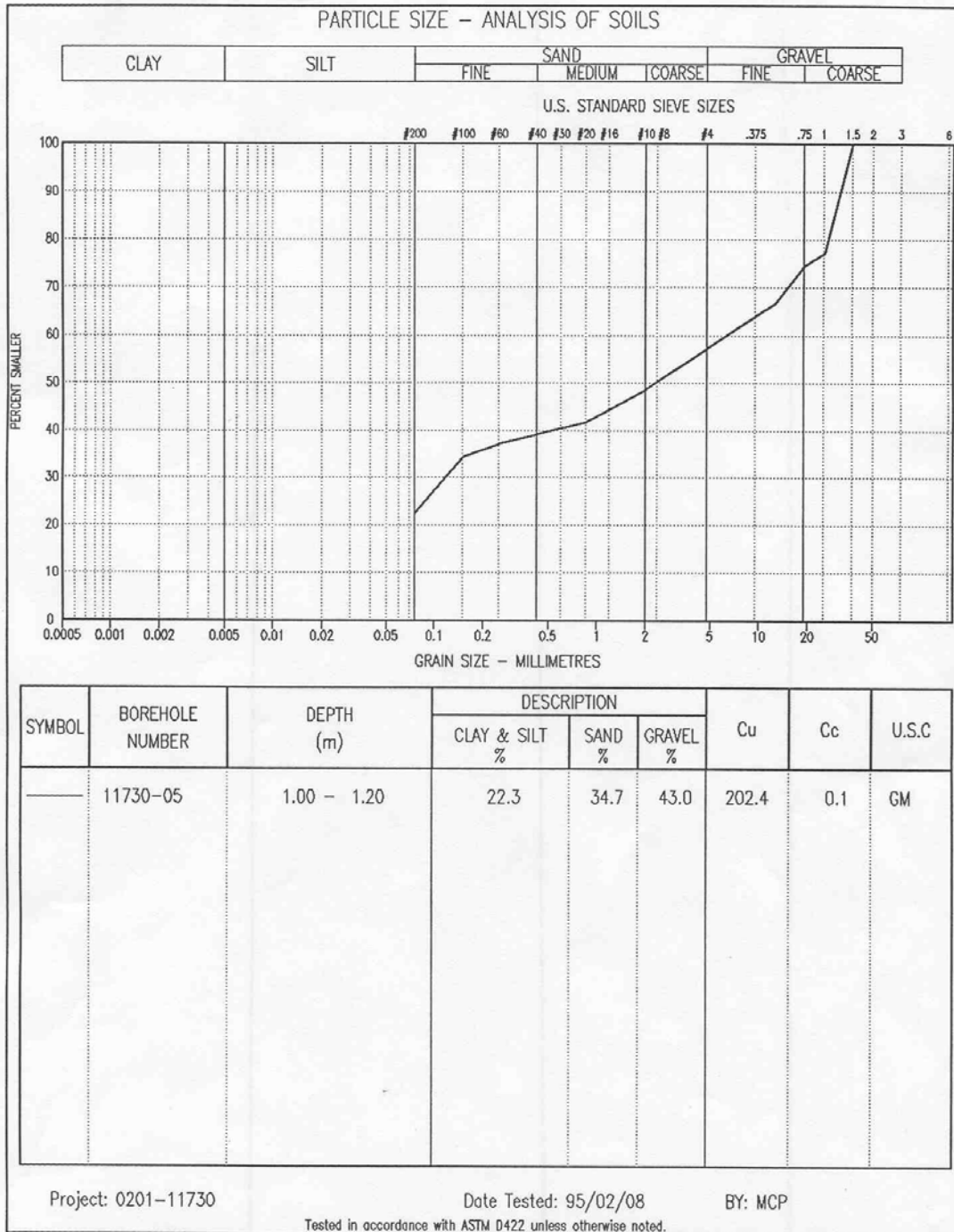


EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP
REVIEWED BY: MCP

COMPLETION DEPTH: 4.2 m
COMPLETE: 06/02/95

EBA Engineering



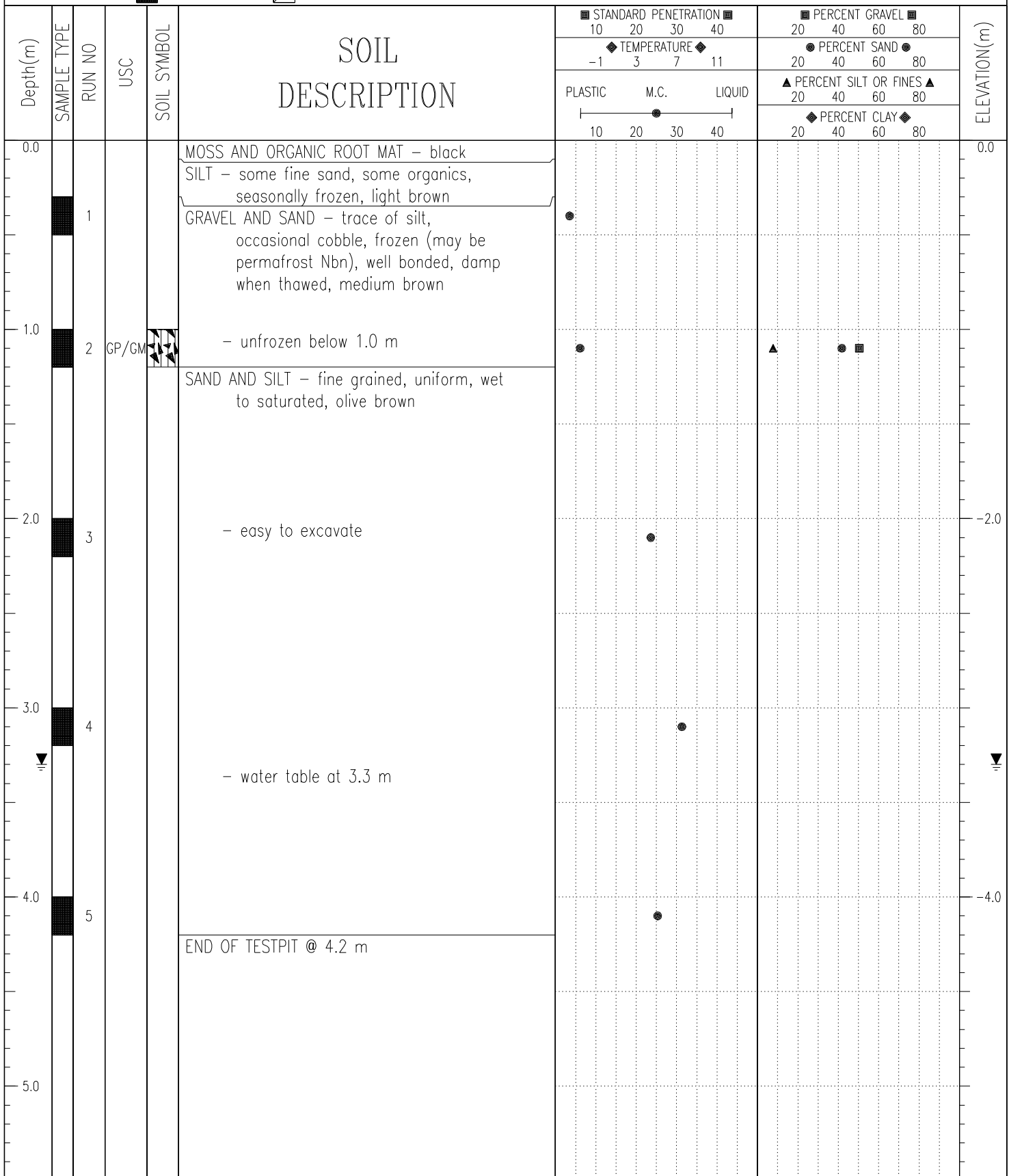
Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA

Tested in accordance with ASTM D422 unless otherwise noted. The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.



GEOTECHNICAL EVALUATION	CLIENT: YTG – ENGINEERING & DEVELOPMENT	TEST PIT NO: 11730-06
RESIDENTIAL INFILL	EXCAVATOR: CAT 225	PROJECT NO: 0201-11730
CARMACKS, YUKON	UTM ZONE: 8 N6885040 E432850	ELEVATION:

SAMPLE TYPE GRAB NO RECOVERY



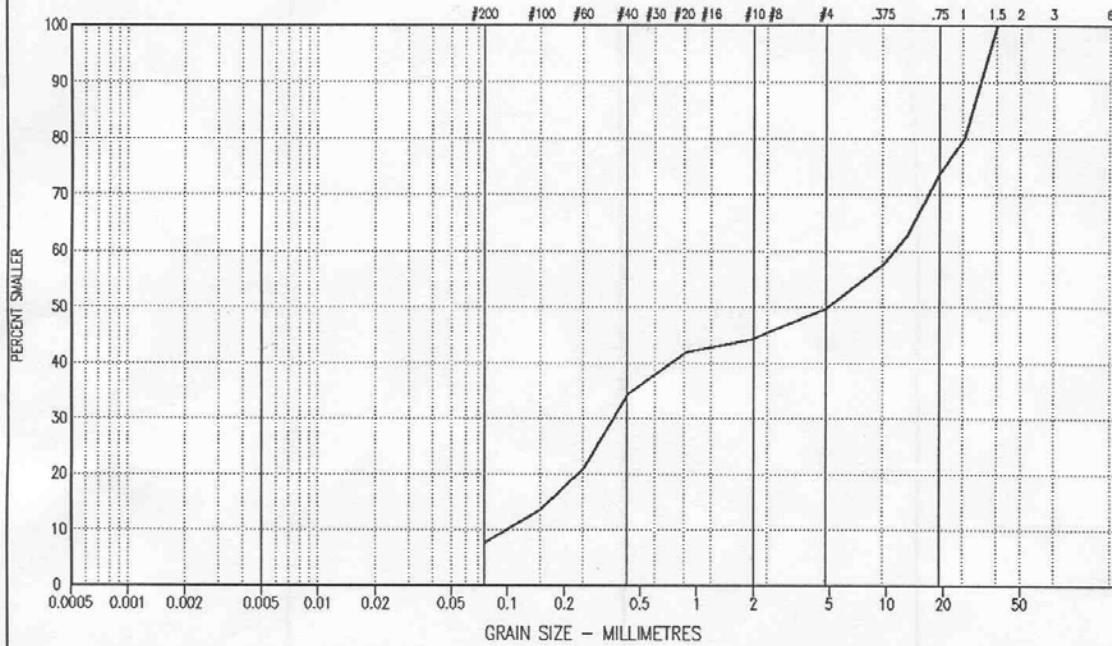
EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 4.2 m
REVIEWED BY: MCP	COMPLETE: 06/02/95
	Page 1 of 1

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
	11730-06	1.00 - 1.20	7.7	41.8	50.5	106.6	0.1	GP-GM

Project: 0201-11730

Date Tested: 95/02/08

BY: MCP

Tested in accordance with ASTM D422 unless otherwise noted.

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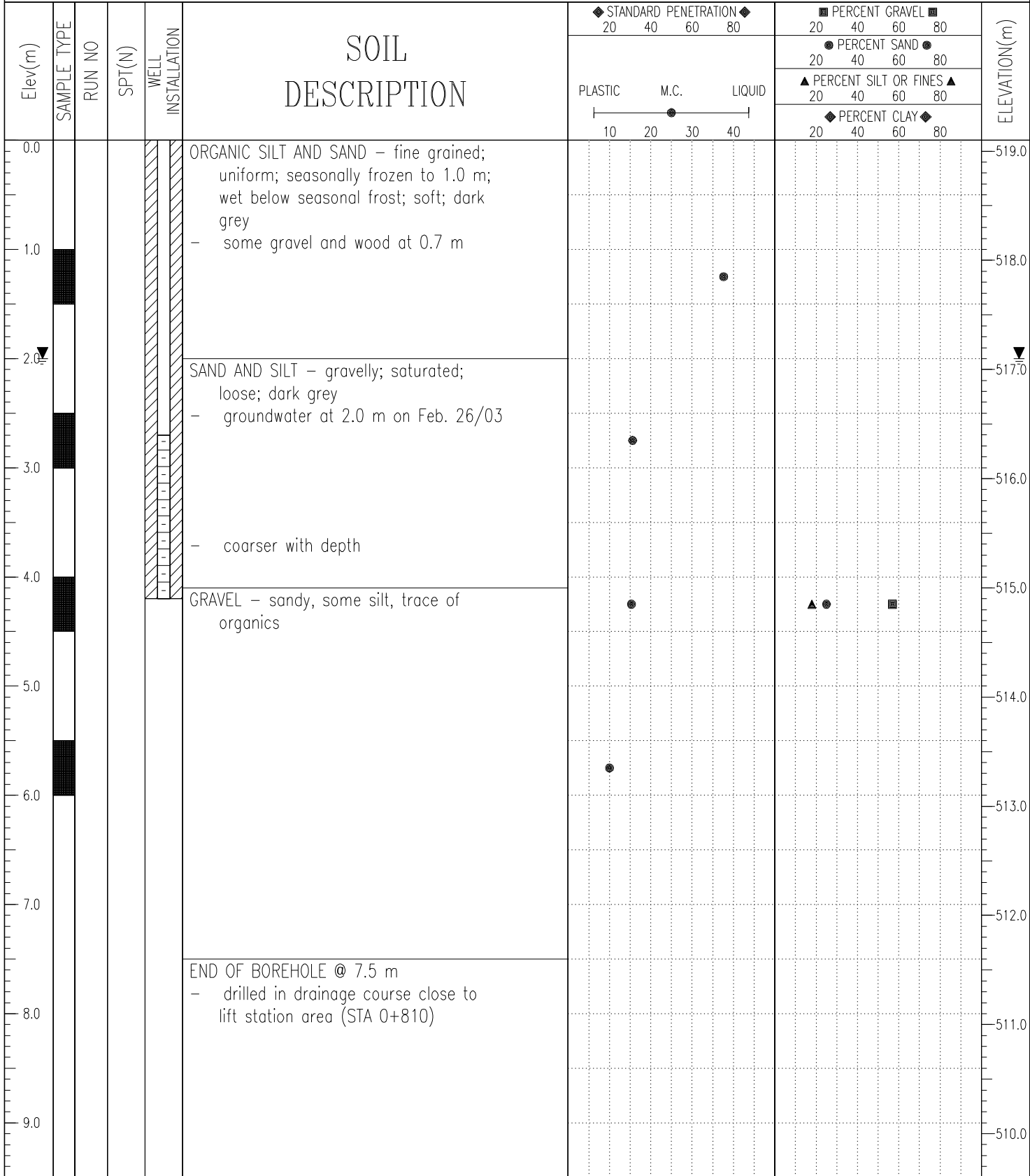
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APPENDIX C
BOREHOLE LOGS

Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH01
Sewer Line Extension	DRILL: CME 750 c/w Solid Flight Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885437 E431892	ELEVATION: 519.1 m

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPOON	<input type="checkbox"/> CRREL BARREL	
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



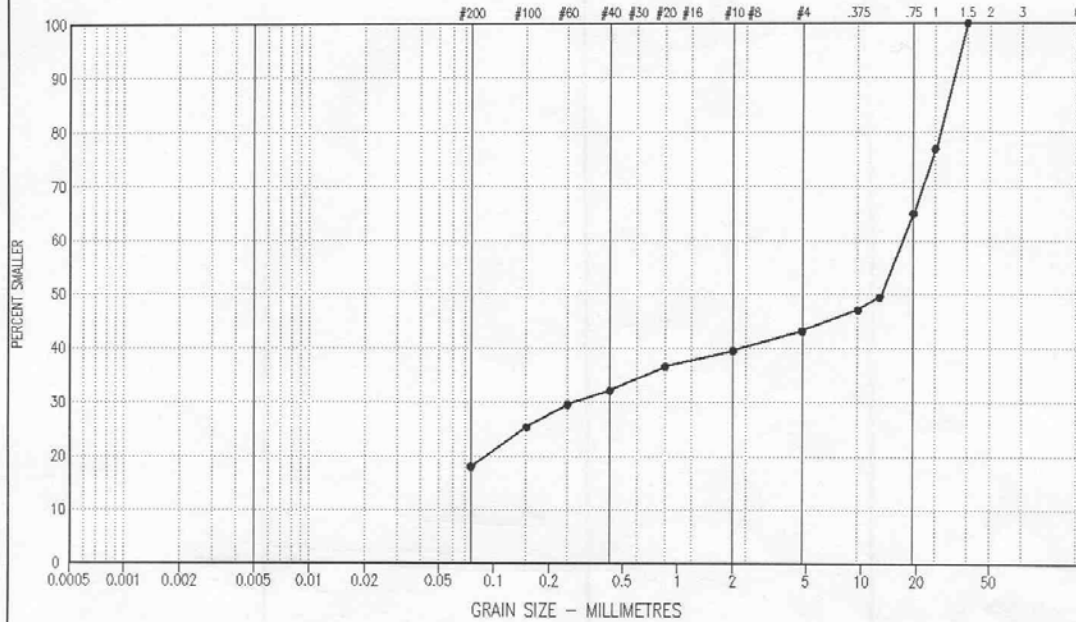
EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 7.5 m
	REVIEWED BY: JRT	COMPLETE: 25/02/03

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PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

U.S. STANDARD SIEVE SIZES



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C.
			CLAY & SILT %	SAND %	GRAVEL %			
●—	1200014-BH01	4.00 - 4.50	18	25	57	-	-	

Project: 0201-1200014

Date Tested: 07/03/03

BY: MCP

Tested in accordance with ASTM D422 unless otherwise noted.

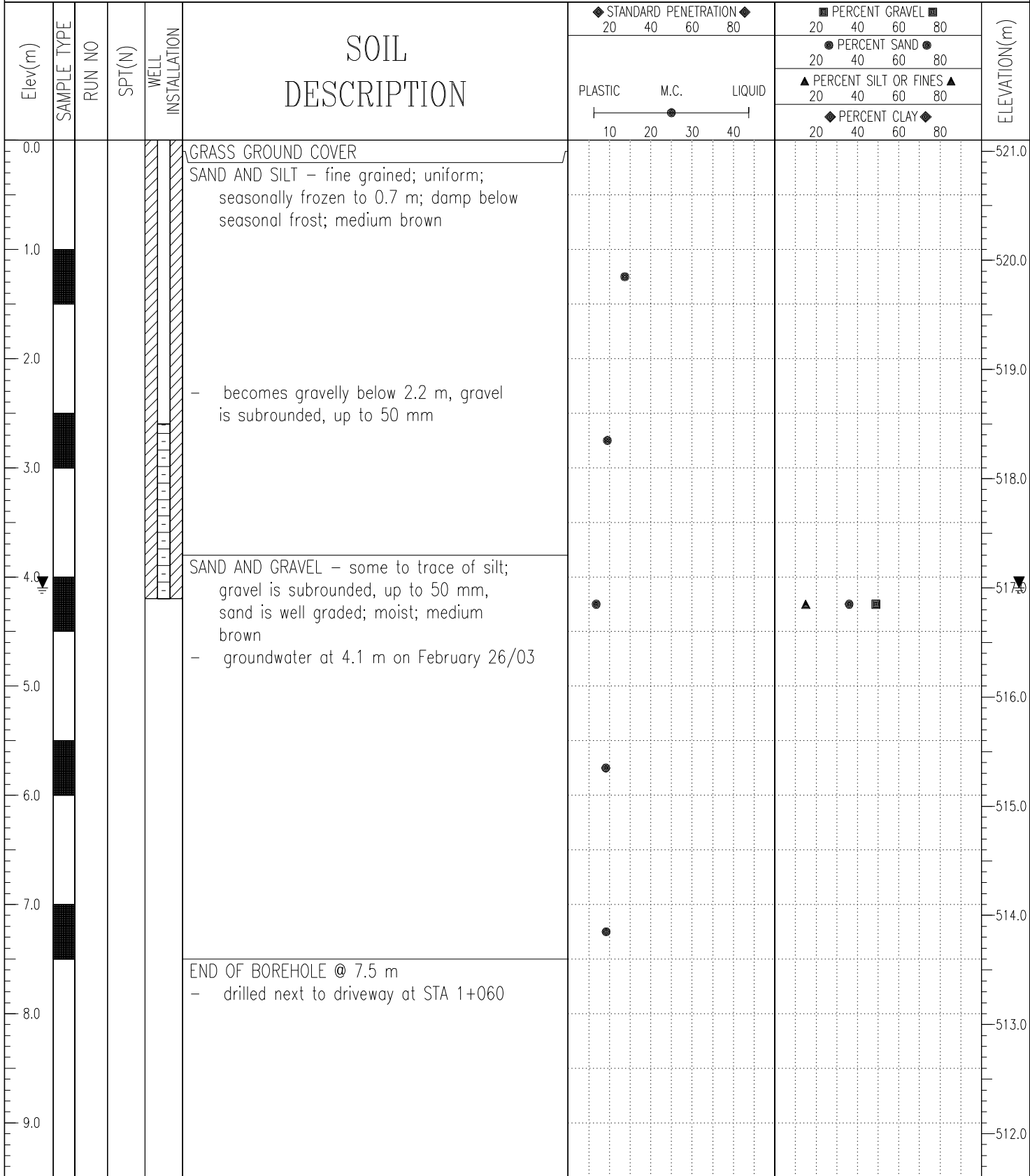
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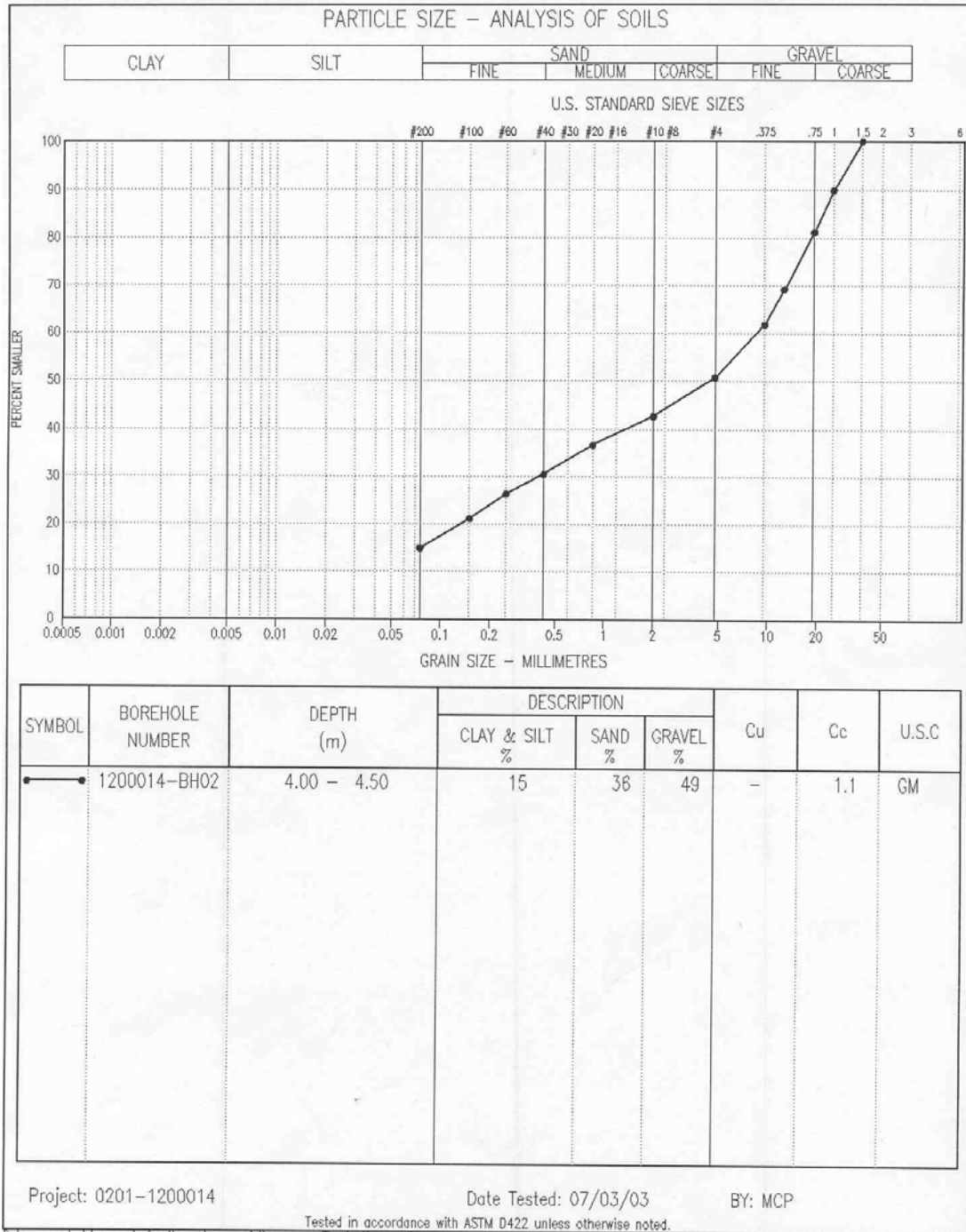
Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH02
Sewer Line Extension	DRILL: CME 750 c/w Solid Flight Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885248 E432066	ELEVATION: 521.1 m

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPOON	<input type="checkbox"/> CRREL BARREL	
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. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 7.5 m
	REVIEWED BY: JRT	COMPLETE: 25/02/03

EBA Engineering



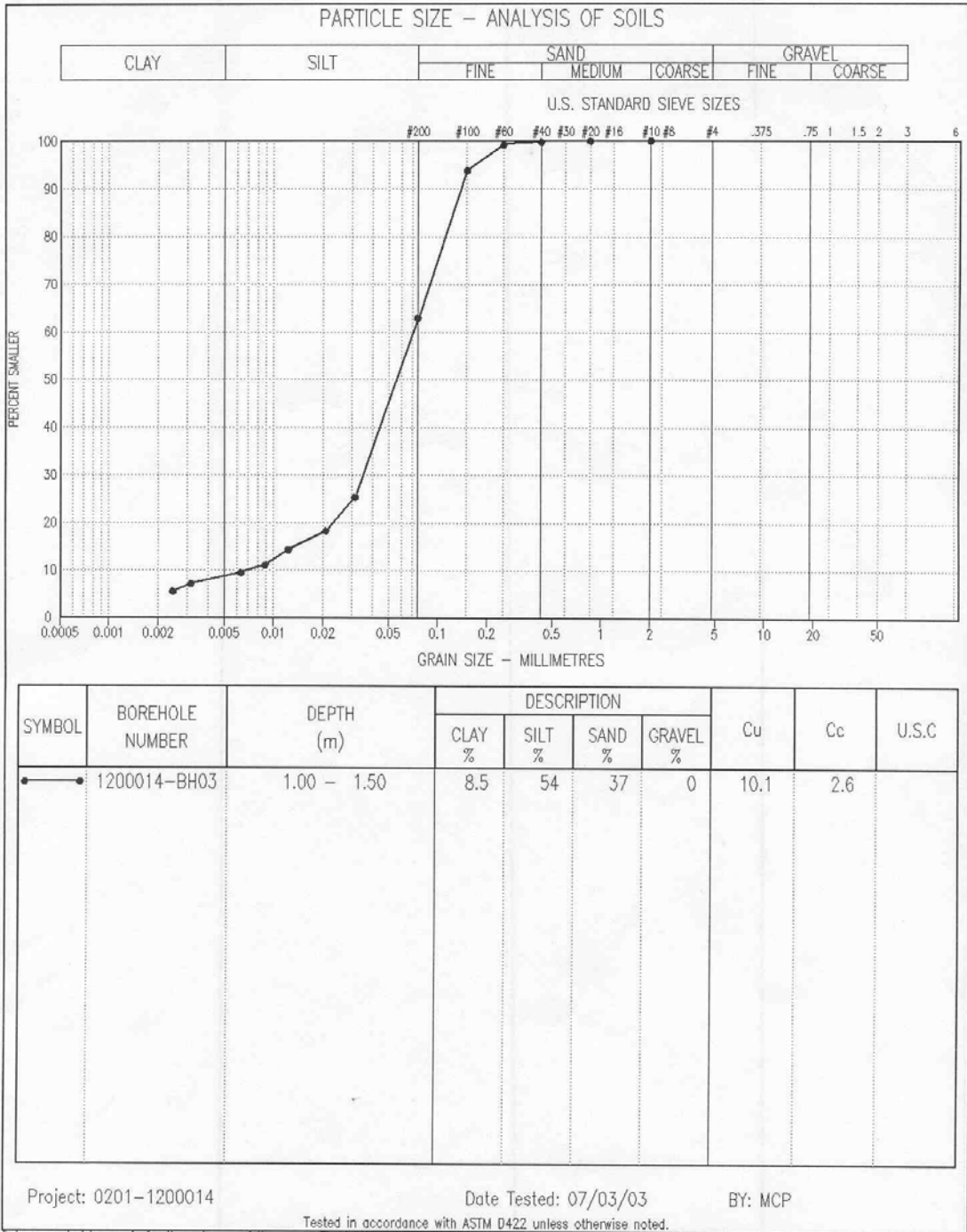
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Waste Water Treatment Plant			CLIENT: GJ Bull & Associates			BOREHOLE NO: 1200014-BH03											
Sewer Line Extension			DRILL: CME 750 c/w Solid Flight Augers			PROJECT NO: 0201-1200014											
Carmacks, YT			UTM ZONE: 8 N6885145 E432185			ELEVATION: 521.1 m											
SAMPLE TYPE			<input checked="" type="checkbox"/> GRAB SAMPLE	<input type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPOON	<input type="checkbox"/> CRREL BARREL										
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									
Elev(m)	SAMPLE TYPE	RUN NO	SPT(N)	WELL INSTALLATION	SOIL DESCRIPTION	STANDARD PENETRATION		PERCENT GRAVEL		PERCENT SAND		PERCENT SILT OR FINES		PERCENT CLAY		ELEVATION(m)	
						20	40	60	80	20	40	60	80	20	40		60
0.0					GRASS GROUND COVER AND ORGANIC ROOTMAT												521.0
					SAND AND GRAVEL (FILL) – some silt to silty; seasonally frozen; medium brown ORGANICS – seasonally frozen; black												
1.0					SAND AND SILT – trace of clay; fine grained; uniform; damp to moist below seasonal frost (1.0 m)												520.0
2.0					– becomes gravelly below 2.3 m												519.0
3.0																	518.0
4.0					SAND AND GRAVEL – some silt to trace of silt; moist to wet; loose; sloughing badly; brown												517.0
					– groundwater at 4.5 m on Feb. 28/03												516.0
5.0																	515.0
6.0					– slightly finer below 5.5 m, drilling becomes smoother												514.0
7.0																	513.0
8.0					END OF BOREHOLE @ 7.5 m Note: hole redrilled to 4.6 m with Hollow Augers on Feb. 28/03												512.0
9.0					– drilled at edge of clearing at STA 1+220												
EBA Engineering Consultants Ltd. Whitehorse, Yukon						LOGGED BY: MCP REVIEWED BY: JRT			COMPLETION DEPTH: 7.5 m COMPLETE: 26/02/03								

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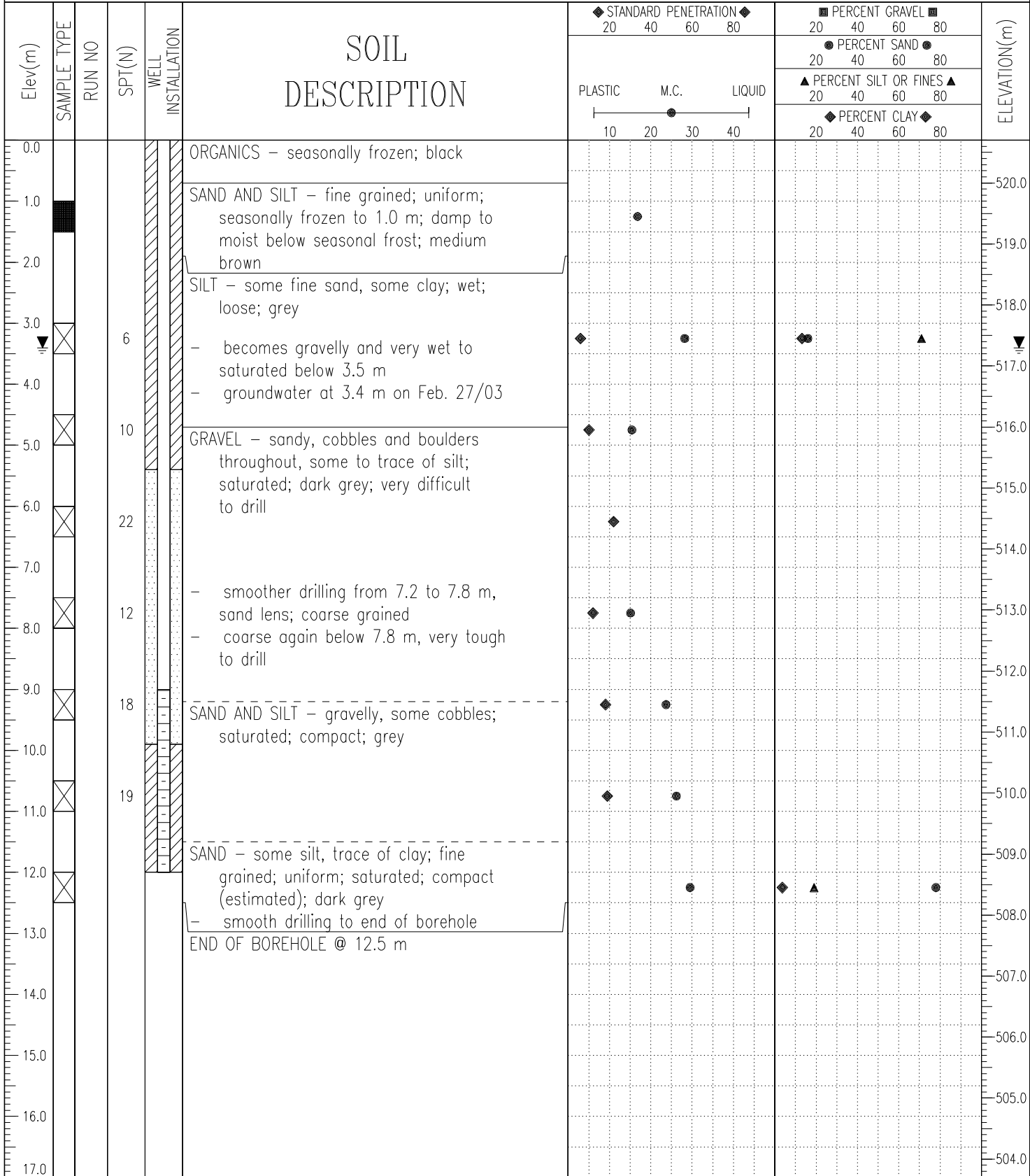
Tested in accordance with ASTM D422 unless otherwise noted.

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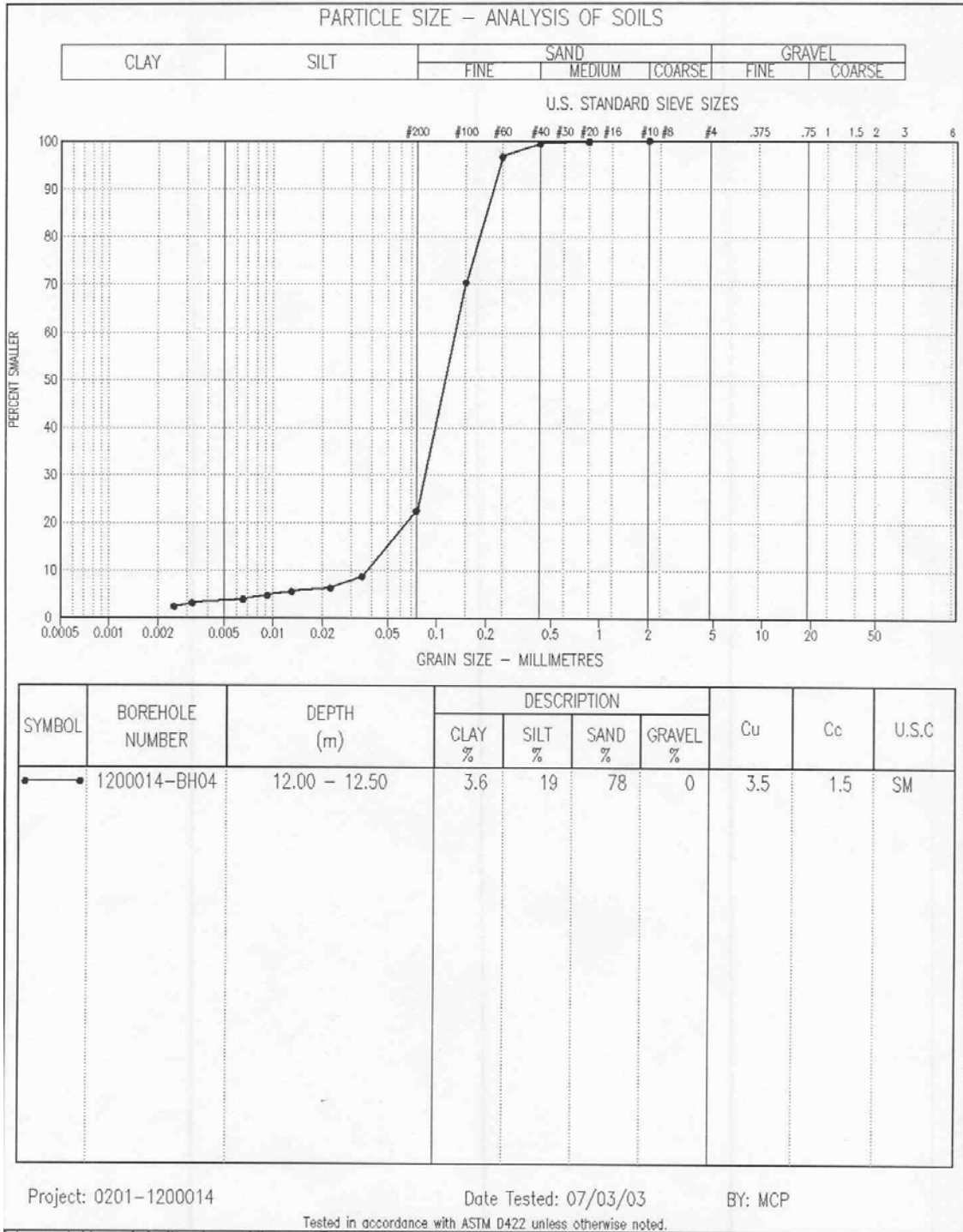
Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH04
Possible Lift Station	DRILL: CME 750 c/w Hollow Stem Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885505 E431827	ELEVATION: 520.7 m

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPOON	<input type="checkbox"/> CRREL BARREL	
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. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 12.5 m
	REVIEWED BY: JRT	COMPLETE: 26/02/03

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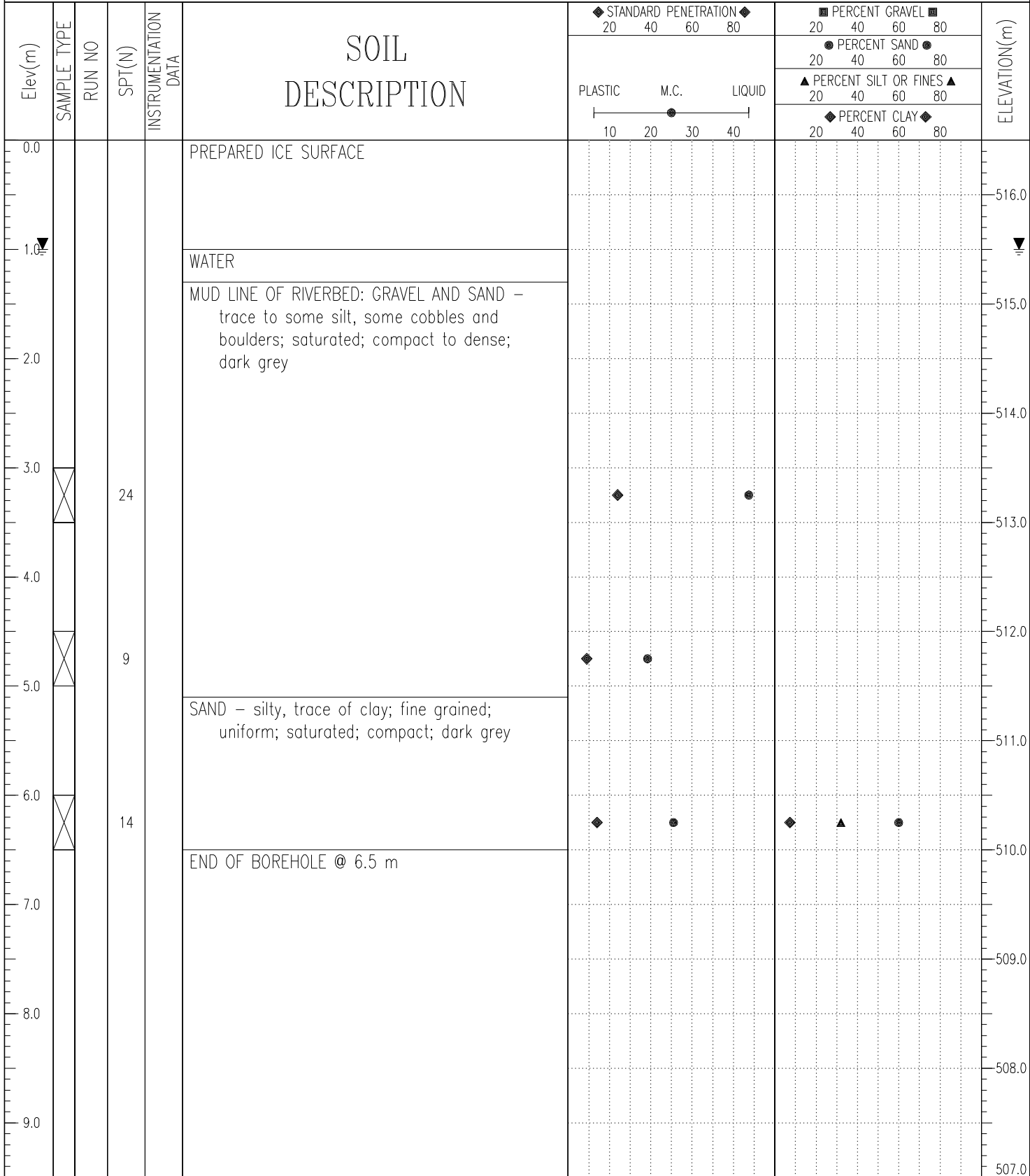
Tested in accordance with ASTM D422 unless otherwise noted.

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Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH05
Outfall Line on River	DRILL: CME 750 c/w Hollow Stem Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885554 E431893	ELEVATION: 516.5 m

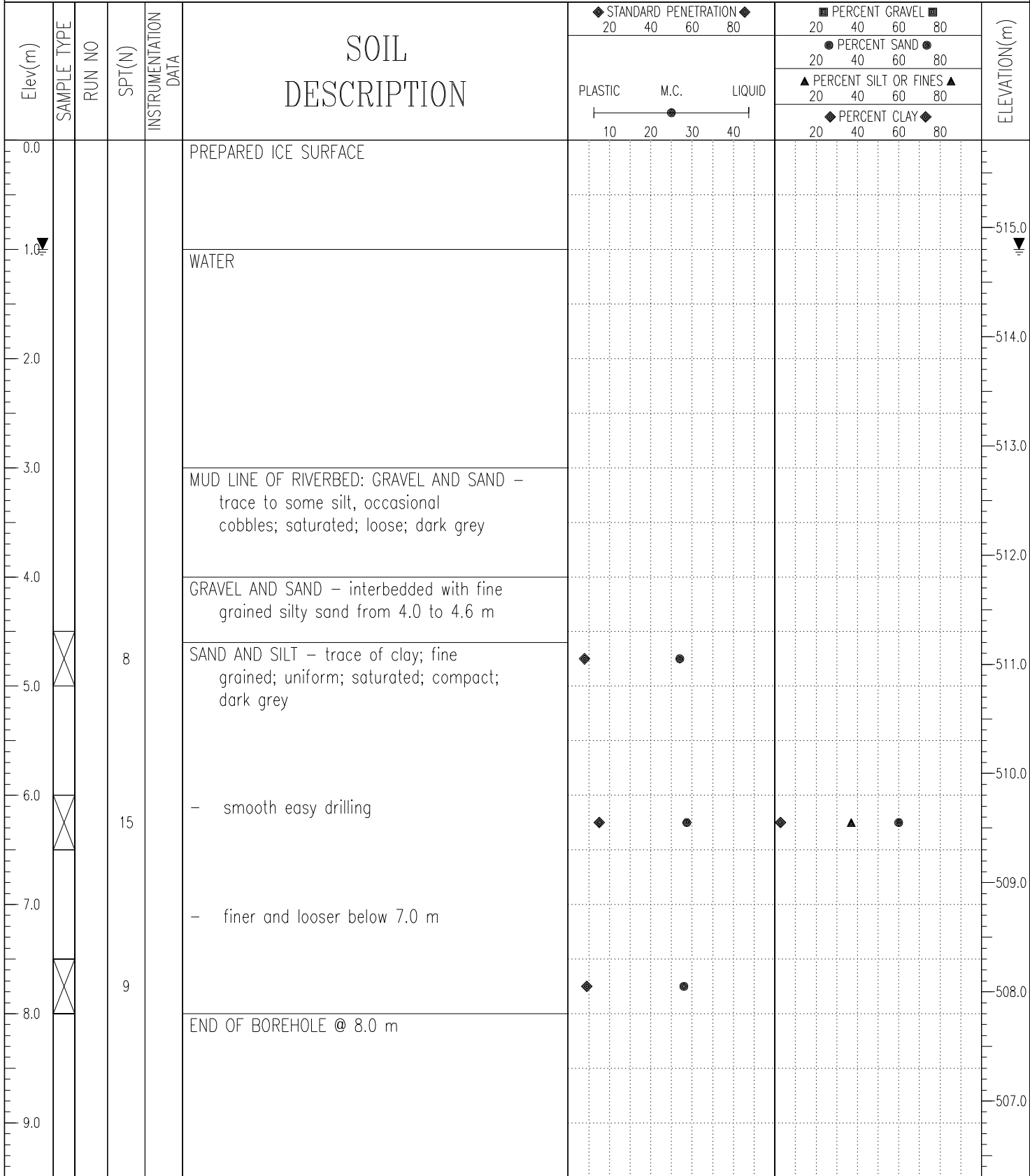
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BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 6.5 m
	REVIEWED BY: JRT	COMPLETE: 26/02/03

Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH06
Outfall Line on River	DRILL: CME 750 c/w Hollow Stem Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885628 E431997	ELEVATION: 515.8 m

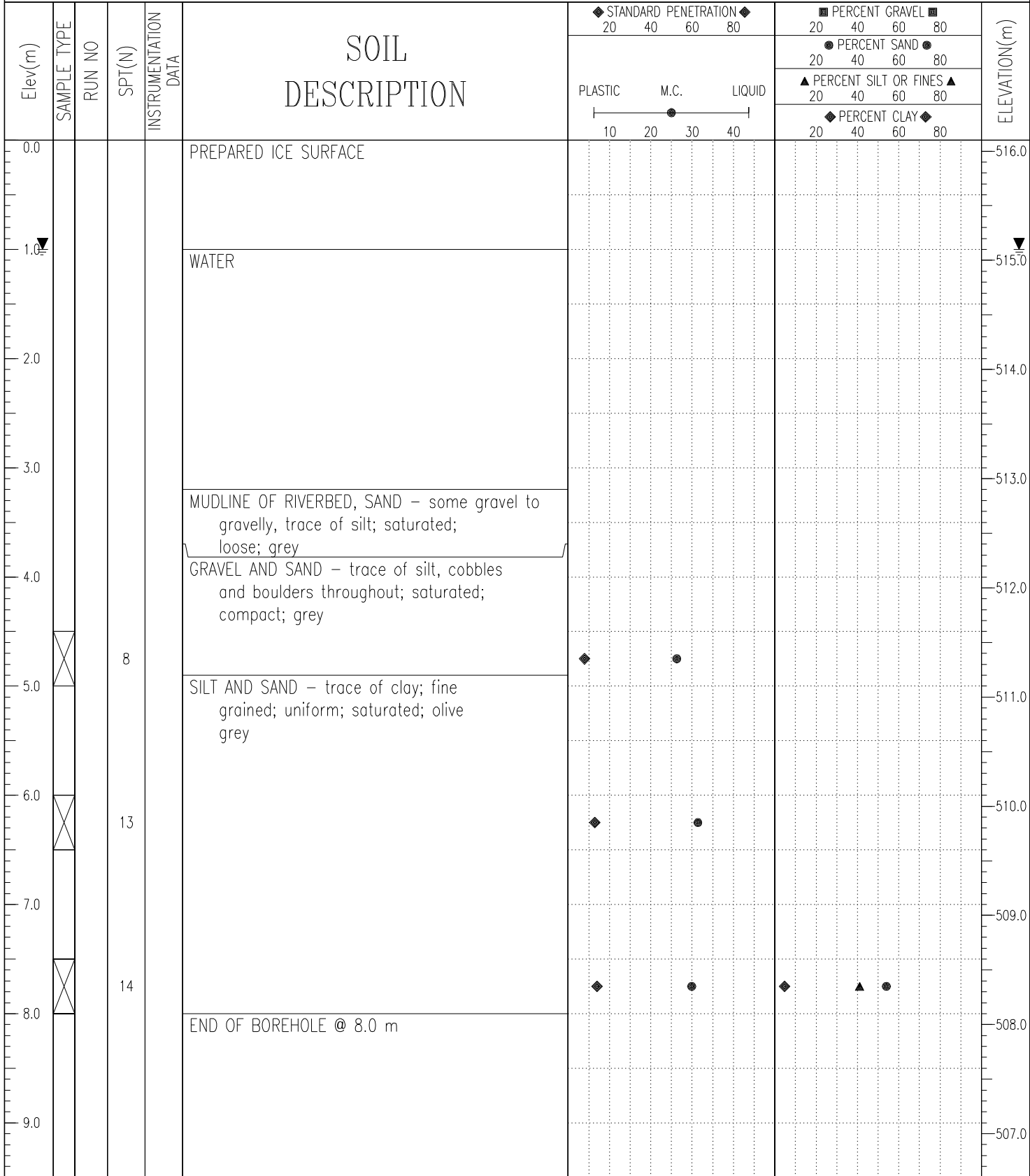
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BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 8 m
	REVIEWED BY: JRT	COMPLETE: 27/02/03

Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH07
Outfall Line on River	DRILL: CME 750 c/w Hollow Stem Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885590 E431944	ELEVATION: 516.1 m

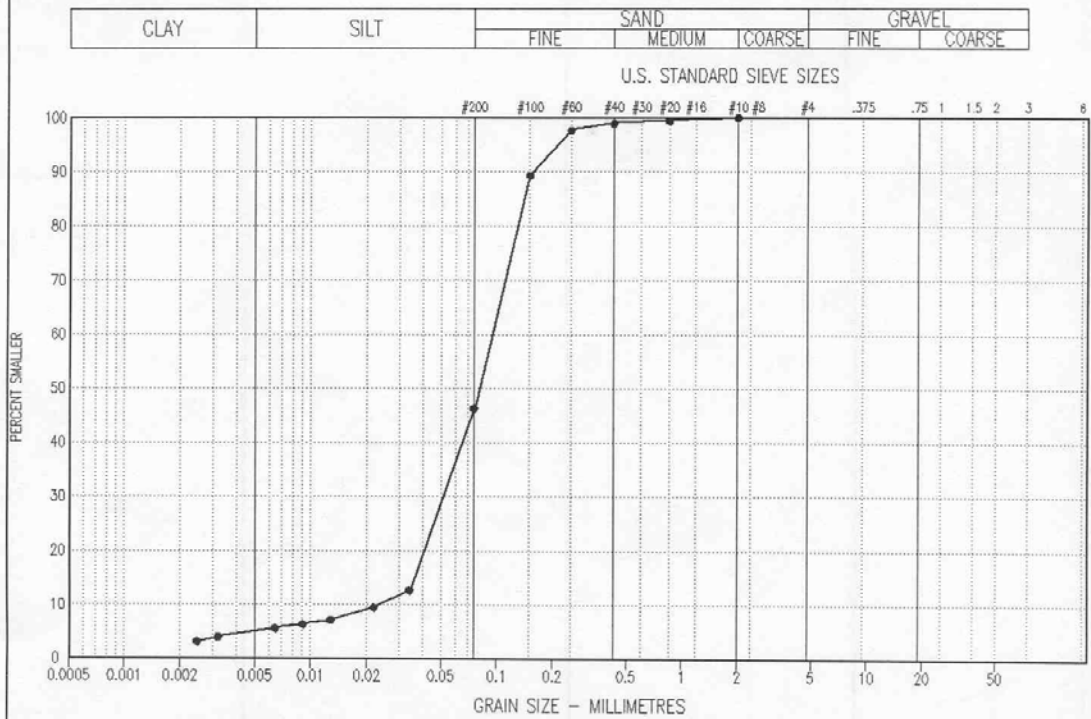
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BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE	<input type="checkbox"/> PEA GRAVEL	<input type="checkbox"/> SLOUGH	<input type="checkbox"/> GROUT	<input type="checkbox"/> DRILL CUTTINGS	<input type="checkbox"/> SAND



<p>EBA Engineering Consultants Ltd. Whitehorse, Yukon</p>	<p>LOGGED BY: MCP REVIEWED BY: JRT</p>	<p>COMPLETION DEPTH: 8 m COMPLETE: 27/02/03</p>
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EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
●—●	1200014-BH07	7.50 - 8.00	4.8	41	54	0	4.2	1.3	SM

Project: 0201-1200014

Date Tested: 07/03/03

BY: MCP

Tested in accordance with ASTM D422 unless otherwise noted.

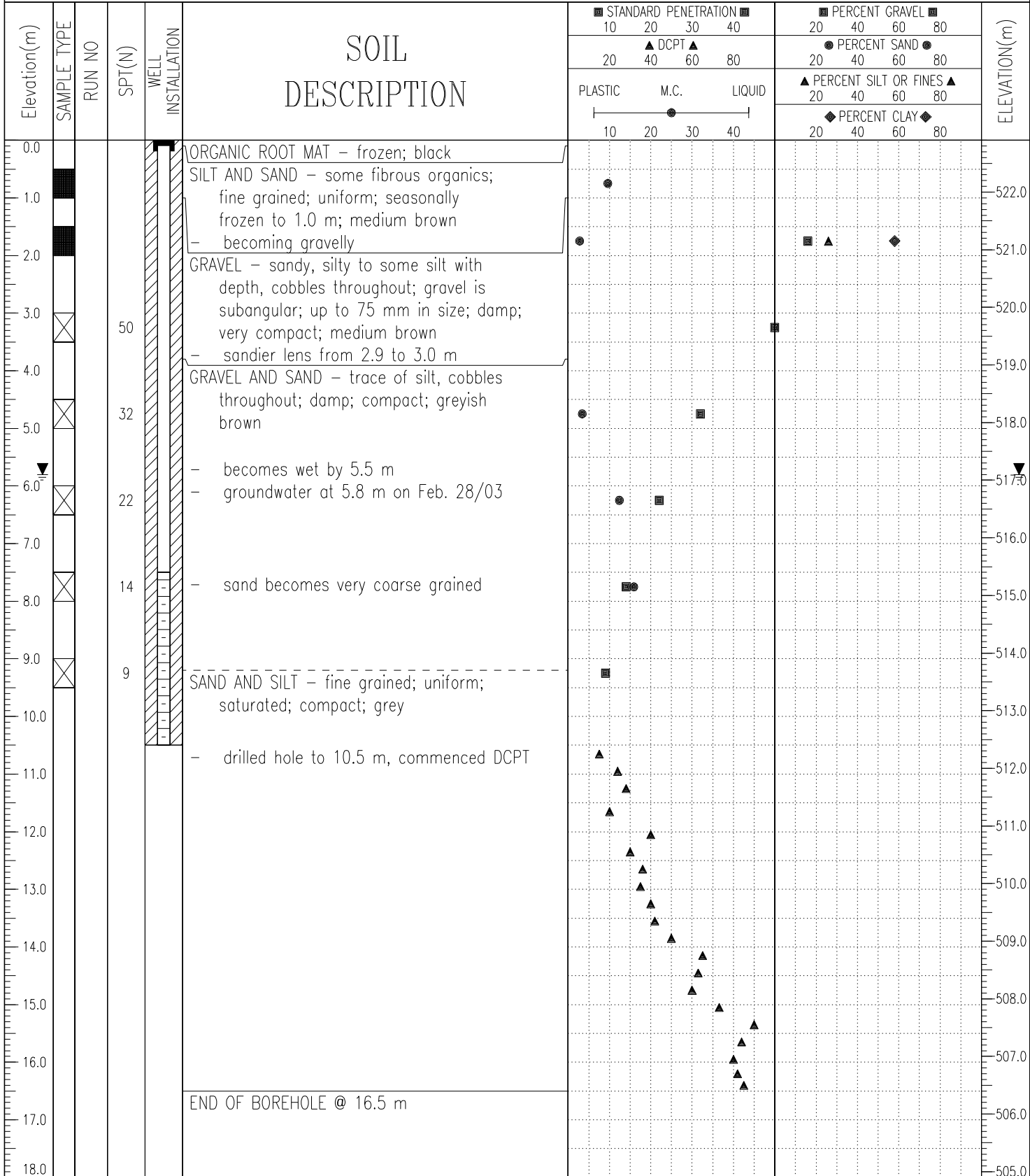
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Waste Water Treatment Plant	CLIENT: GJ Bull & Associates	BOREHOLE NO: 1200014-BH08
Treatment Plant/Lift Station	DRILL: CME 750 c/w Hollow Stem Augers	PROJECT NO: 0201-1200014
Carmacks, YT	UTM ZONE: 8 N6885477 E431774	ELEVATION: 522.9 m

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPLIT SP.	<input type="checkbox"/> CRREL BARREL	<input type="checkbox"/> NW 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. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 16.5 m
	REVIEWED BY: JRT	COMPLETE: 27/02/03

