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Geotechnical Evaluation
Proposed McGowan Subdivision
& Cowley Creek Crossing
Whitehorse, Yukon - 2013



Prepared For: **Yukon Government**
Energy, Mines & Resources
Lands Management Branch

Date : **September 3, 2013**

File No: **200-003-13**

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1.0 INTRODUCTION

Chilkoot Geological Engineers Ltd. was retained by the *Yukon Government (YG), Energy, Mines & Resources (EMR), Lands Management Branch* to conduct a geotechnical evaluation at a newly proposed residential subdivision which is to be located in Whitehorse, Yukon. The proposed subdivision, which is to be known as McGowan Subdivision, spans an area of ~175 ha and is located west of Klondike Highway # 2 (approximately km 151 LHS of the South Klondike Highway), as noted in Figure 1.

Our geotechnical evaluation was separated into two phases in order to first assess the overall suitability of the intended site for rural residential purposes and once deemed feasible, to secondarily assess options to upgrade an existing culvert crossing of Cowley Creek as well as explore other points of geotechnical interest. The first phase of the evaluation was completed through test pit methodologies in the fall of 2012. The December 11, 2012 findings, which should be considered an integral part of this report, verified that proposed region was suitable for subdivision development.

The findings of the second phase of work, which were completed through primarily drilling methodologies in the spring of 2013, have been presented herein. Authorization to proceed with the evaluation was granted by Mr.R.Gorczyca, Manager – Lands Availability, of *YG – EMR* on September 28, 2012.

The drilling component of the field work was conducted between April 11th and April 16th, 2013, in accordance with our June 29th, 2012, proposal, in order to take advantage of low seasonal water elevations. A supplementary test pit program was conducted on June 4th, 2013, in order to obtain additional geotechnical information. A detailed description of the methodologies we employed during the work has been provided below.

2.0 METHODOLOGY

The methodology was comprised of a literature review, field and laboratory work programs as described below.

2.1 Literature Review

A literature review was conducted during each of the two phases of our geotechnical evaluation. The initial review, which was conducted during Phase I of our evaluation, was comprised of reviewing a technical feasibility study, topographical, surficial and bedrock geology maps as well as aerial reconnaissance photos of the study area.

Our literature review during this phase of the evaluation, focused upon assessing preliminary (December 4th, 2012) road alignments proposed by the YG retained planning consultant, *Inukshuk Planning and Development Ltd.* The purpose of assessing the alignments was to target readily accessible geotechnical points of interest within the proposed alignment prior to implementing the field work program. As each of the proposed alignments were similar to one another in the regions of the proposed crossing and primary (north-south) access route to higher elevations within the development area, we have for simplicity attached a single copy of Concept 1 as Figure 2, for ease of reference. Our boreholes (and test pit) which were advanced during this phase of our evaluation have been super-imposed on the conceptual plan for reference purposes.

In addition to reviewing the proposed alignments air photo analysis of the crossing location was conducted to better evaluate the crossing area. In brief, the analysis revealed that Cowley Creek meanders within the confines of a local floodplain and that abandoned channels were present within the crossing area.

In addition to the above noted information, the drawings and specifications for Cowley Creek Phase II Country Residential Subdivision – Roadway Construction (dated April, 1995), were also reviewed.

Cowley Creek Phase II Subdivision – Drawings & Specifications

The specifications were prepared by *Lorimer & Associates* of Whitehorse, Yukon for the *Government of Yukon, Department of Community and Transportation Services Engineering and Development Branch* (*C&TS*). As Phase II of the project crossed Cowley Creek along Salmon Trail, the specifications included details regarding the installation of an *Armtec 69A18* multiplate.

> In brief, the specifications called for founding the structure on 0.9 meter wide concrete footings placed upon a (nominal) 1.0 meter thick by 3 meter wide granular base. The thickness of the footing varied between 0.6 meters and 0.3 meters. The span of the multiplate was in the order of 7 meters.

While the geotechnical report (upon which the specifications would have been based), was not available, the *Technical Feasibility Study* (discussed below), suggests that soil conditions in the region may be similar to the ones encountered during our evaluation of the proposed Cowley Creek crossing/upgrade.

Technical Feasibility Study - Inukshuk Planning and Development Ltd.

The feasibility study was entitled McGowan Lands Rural Residential Subdivision Technical Feasibility Study (March 2010) and was prepared by *Inukshuk Planning and Development Ltd*. in association with *EBA Engineering* and *Neils A Jacobsen – Civil Engineering Consultant* for *Government of Yukon – EMR – Lands Branch and Community Services*.

> In brief, the information within the study verified that the proposed area appeared suitable for development and that a sub-surface investigation was required to verify the soil conditions and other geotechnical parameters. The study also discussed various design considerations that must be overcome in

order to allow for access at the proposed (km 7.3 Carcross Road) location. Specifically, the study indicated that geometric design challenges will have to be met at the confluence of the proposed sub-division road and the South Klondike Highway, particularly given the approximately 10 meter difference in elevations between the crossing region and the Klondike Highway. These aspects would need to be assessed in greater detail during the design of the intersection and embankment regions.

The study noted that a pre-existing culvert had failed in the region of the existing CSP culvert during the Spring of 2009. While the size of the culvert that was involved in the failure was not discussed, the study indicated that the roadway (which now crosses the floodplain area) was built up several feet following the failure.

Discussions with local residents during the spring drilling program indicated that the existing culvert location has been prone to periodic overflow events in the spring.

Surficial Geology Map - Geoscience Map # 2005-6, Geology of MacRae

Our evaluation revealed that there were (morainal) glacial till deposits located within the glaciofluvial terrain identified on the surficial geology map - *Geoscience Map # 2005-6, Geology of MacRae* (compiled by J.D.Bond, S.R.Morrison and K.McKenna). A portion of the surficial geology map has been attached as Figure 3 for reference purposes.

Water Resources Data

Flow rates, water levels and similar types of information useful for evaluation and design purposes were not available for Cowley Creek (or its tributaries). However, following discussions with *Yukon Government – Department of Environment – Water Resources Branch*, technical information regarding Wolf Creek, of which Cowley

Creek is a tributary, were located. The information, which summarized mean daily flow rates may provide an approximation of the regional freshet period.

Topographical Maps (1:50,000 & 1:250,000 Scale)

As water resource data regarding Cowley Creek does not exist, an evaluation of the regional setting from a qualitative perspective allows for some insight into the magnitude of water flow at the location of the proposed crossing.

A portion of the 1:50,000 scale topographical map has been attached as Figure 4 for reference purposes.

South Klondike Highway Tributaries

Based upon the 1:50,000 scale topographical map, there appears to be three tributaries which feed into Cowley Creek from the east. Two of these tributaries are located downstream of the proposed crossing. The third tributary feeds into Cowley Creek approximately 800 meters upstream of the proposed crossing area. Based upon the map, the tributaries are shown to cross the South Klondike Highway at approximately km 149.7, km 152.0 (Kookatsoon Lake) and km 155.1, as noted on Figure 4.

A July 14, 2013 site inspection of the three tributaries revealed that only the Kookatsoon Lake (km 152.0) location had water flowing within the tributary. A 600 mm Ø CSP culvert was utilized at this location to allow for the water to flow beneath the Klondike Highway. There was no indication of flowing water or culverts at the two other locations (km 149.7 and km 155.1). Based upon our observations, it appeared that the tributary flow at these two locations is seasonal and that the water crosses the highway by permeating through the base of the highway embankment in the form of groundwater seepage.

2.2 Field Work Program

The field work program was comprised of the following phases of work;

2.2.1 Site Reconnaissance

A site reconnaissance of the culvert crossing was conducted by the undersigned in the fall of 2012 as well as in April and June of 2013. The purpose of the reconnaissance was to note site specific geological features to assess the terrain within the region of the crossing as well as other areas of the site.

The existing crossing, which measures in the order of 150 meters in length (between the floodplain embankments), is comprised of a ~ 3 meter wide gravel roadway. The creek, which regionally flows to the north, parallels the southern edge of the roadway and crosses the roadway through a 6 meter long, 1.5 meter diameter CSP culvert. The culvert is located approximately 40 meters from the eastern side of the floodplain embankment.

Our April observations noted the presence of snow and winter conditions. The existing access road appeared to be maintained by the local property owners as snow had been cleared from the roadway. The creek was noted to be frozen and no water flow through the culvert was noted. The level of the (frozen) water surface was noted to be ~ 0.8 meters below the top of the culvert.

Our observations in the fall of 2012 and in June of 2013, noted the presence of local isolated terraces which were ~ 2 meters higher in elevation than the surrounding marsh areas and Cowley Creek. These regions were noted to be well treed with stands of mature spruce. The occasional tree located within the isolated terraces and floodplain embankment areas, exhibited ‘drunken’ (i.e. leaning) type of characteristics. This characteristic typically suggests the presence of permafrost. Local pockets of standing water were also encountered within the terrain features and

the floodplain embankment areas. A local schematic, which illustrates the existing roadways location relative to the isolated terraces and floodplain embankments, has been attached as Figure 5.

Existing Access Road Crossing - Culvert Inlet (facing west)



April 16, 2013

Note drill @ BH3-13 (right side of photo)



June 1, 2013

Access Road

2.2.2 Subsurface Utilities

Our previous assessment of subsurface utilities, which was conducted during the Phase I test pit program, revealed that there were no subsurface utilities located with the study area or region of the crossing. However, there appears to be both surface and subsurface utilities located within/nearby the South Klondike Highway right-of-way.

2.2.3 Drilling Program

The drilling program was conducted under *Chilkoot* supervision between April 11th & 16th, 2013 by *Donjek Services* utilizing a CME-750 drill mounted on an FN-60 Nodwell.

The program was comprised of advancing eight (8) boreholes (BH 1-13 to BH 8-13) in order to obtain soil samples and characterize the subsurface conditions. The boreholes were advanced at the approximate locations noted on Figure 6.

The boreholes were advanced utilizing either 150 mm Ø solid-stem or 200 mm Ø hollow-stem continuous flight augers. Specifically, boreholes BH 1-13 to 3-13 were advanced utilizing hollow-stem drilling methodologies in order to allow for installation of groundwater monitoring wells. The remainder of the boreholes were advanced utilizing solid-stem augers. Borehole BH 3-13, utilized solid-stem augers to initiate the drilling process given the presence of frozen fine grained soils at this location.

The average depth the boreholes were advanced was 5.81 meters below the existing grade (but varied between 3.05 meters (BH 5-13) and 9.15 meters (BH 8-13).

The use of the hollow-stem augers in BH 1-13 through BH 3-13, allowed for the retention of relatively undisturbed soil samples through standard penetration test (SPT) methodologies to depths of approximately 6.25 meters below the existing grades.

The SPT's allowed for an assessment of the relative density of sub-surface soils by measuring the number of blows (N-value) required to drive a 50 mm. diameter uncased sampler tube a distance of 300 mm utilizing a 63.5 kg hammer dropped from a height of 760 mm. These 'N' values allowed for correlation of the noted resistance relative to the materials density/consistency where thawed materials were encountered. The correlation has been presented on the '*Notes on Soil Classification'* which has been enclosed in *Appendix A* with the Soil Logs. In brief, the N-values indicated that the density of the soils varied between very soft to very dense materials.

Monitoring Well Installation

2" diameter ABS monitoring wells were installed in BH 1-13 to BH 3-13 to depths of approximately 5.65 meters below the existing ground surface. Details regarding installation and groundwater elevations have been attached as Table I – Groundwater Observations.

The lower 3.05 meters of the wells were slotted and a silt sock was utilized to minimize the influx of fines and extend the life of the well. The annular space was backfilled with the native materials. The exception to this was between 0.5-0.8 meter depth where a bentonite plug was installed to seal the annular space in accordance with good installation practices. Access to the wells was restricted through the installation of lockable steel casings which were concreted into the existing ground surface. The casings were painted red for visibility purposes.

2.2.4 Test Pit Program

A test pit program was conducted on June 4th, 2013, to better assess the sub-surface conditions in the region of the Cowley Creek crossing. The program involved excavating a single test pit at the location noted on Figure 6. The test pit was excavated to a depth of ~ 2.7 meters below the existing ground surface. This equates to an elevation of ~ 732.44 meters.

The test pit was excavated utilizing a *Bobcat E35* rubber tracked mini-excavator equipped with a digging bucket. The excavator was supplied and operated by *Yellow Truck Excavating Inc.* of Whitehorse, Yukon. As the test pit was excavated near the existing access road, clearing was not required.

2.2.5 Soil Logs

During the borehole drilling and test pit excavation, field soil logs were maintained by the undersigned to record the stratigraphy of the soils that were encountered. This information was utilized to compile the Soil Logs which have been enclosed in *Appendix A* along with an outline of the soil classification systems that were utilized

The soil logs were compiled utilizing a combination of field notes, visual observations and results of laboratory analysis. These observations were supplemented by utilizing a *Humboldt Manufacturing Ltd*. pocket penetrometer

which was utilized on cohesive (fine-grained) soils to provide relative estimates (in kg/cm^2) of the materials unconfined compressive strength. A digital thermo-coupler thermometer was also utilized on the soils to verify the presence of frozen soil conditions. The pocket penetrometer results and digital thermometer readings have been noted on the soil logs.

2.2.6 Sampling Program

During the drilling and test pit programs, soil samples were retained at regular intervals, to allow for subsequent laboratory analysis.

> Samples obtained during the solid-stem drilling were retrieved as grab samples directly from the auger flighting. Samples obtained during the hollow-stem SPT drilling were retained from a split-spoon sampler at a frequency of ~ 1 sample per 1.5 meters, in order to obtain relatively undisturbed soil samples.

Once the soil samples were retained, they were described on the field soil logs by the undersigned. The samples were subsequently sealed in air-tight plastic bags and numbered consecutively in order to allow for subsequent laboratory analysis.

In all, a total of seventy-three (73) samples were obtained. This included sixty-five 65 samples which were obtained during the drilling program and eight (8) samples which were obtained during the test pit program.

Upon completion of the daily field work, the retained samples were transported to our Whitehorse laboratory facilities to allow for more detailed examination and analysis as described in Section 2.3, below.

2.2.7 Borehole & Test Pit Locations

The boreholes and test pit were situated adjacent to existing trails and gravel roadways as noted in Figure 6.

Boreholes BH 1-13 through BH 5-13 and Test Pits TP 1-13, were advanced to characterize soils in the region of the proposed Cowley Creek crossing.

Boreholes BH 4-13 & 6-13 were advanced near the regions of the proposed road alignment(s) as these areas were readily accessible through the use of existing trails.

Boreholes 7-13 and 8-13 were advanced to better characterize soil conditions in regions of higher elevations and in the case of BH 7-13, to assess a potential granular borrow source.

2.2.8 Borehole & Test Pit Survey/Elevations

Following drilling, the borehole and test pit locations were surveyed utilizing a hand-held GPS. This allowed for their approximate locations to be plotted on Figure 6.

The elevations of boreholes BH 4-13 and BH 6-13 through BH 8-13 were collated relative to a site specific (1:5000 scale) topographical map. The remainder of the boreholes were surveyed relative to BH 4-13 utilizing a laser level. The test pit and other local elevations in the region of the crossing were surveyed relative to BH 1-13.

It should be reiterated that while elevations have been presented for discussion purposes, a qualified surveyor should verify our assumptions if the elevation data is be utilized for design purposes. Furthermore, as the individual wells have moved (~0.2 meters) due to frost action and soil volume fluctuations, the noted groundwater elevations may vary and so this should also be considered when viewing the data.

2.2.9 Borehole & Test Pit Termination

The depth of borehole termination varied as noted on the individual borehole soil logs and the summary of soil stratigraphy enclosed as Table II.

In brief, the hollow-stem boreholes (BH 1-13 through 3-13) were terminated at a depth of 6.25 meters. Borehole BH 4A-13 encountered refusal at a depth of 3.05 meters. The borehole was relocated 2 meters to the south and was subsequently advanced to 6.1 meters as BH 4B-13. Borehole BH 8-13 was advanced to a depth of 9.15 meters. TP 1-13 was terminated at a depth of 2.7 meters below the existing ground surface due to the presence of very dense permafrost (which was encountered at a depth of ~ 2.3 meters).

The solid-stem boreholes were left open for approximately 10 minutes following excavation in order to assess the sidewall stability over the course of time. In addition, this time allowed for observations regarding groundwater seepage. The depth to which the boreholes collapsed was recorded and marked on the Soil Logs as '*Caved To'*. Although BH 4B-13 and BH 5-13 each appeared to encounter the groundwater interface, there was no observable amount of groundwater seepage into either of the boreholes following the elapsed time frame.

The '*Caved To*' depths noted on the hollow-stem boreholes refers to the depth of fines influx following removal of the centerline A-stem immediately prior to SPT sampling. This influx of fines is primarily due to groundwater pressures and soil composition.

Following our observations, the boreholes and test pit were backfilled with the auger cuttings and excavation spoils, respectively. Following this, the test locations were marked utilizing wooden survey lathe to allow for subsequent field location.

2.2.10 Well Monitoring Program

The groundwater monitoring wells were measured on April 21st and July 1st, 2013 to determine the approximate elevations of the groundwater in the region of the proposed crossing. Our observations have been attached as Table I.

Of note, our observations noted frozen well conditions during each of the two episodes in different wells. This suggests the presence of a complex

groundwater and thermal regime. In addition, the July 1st episode noted that the monitoring wells may have heaved in the order of 200 mm relative to the adjacent ground surface and so the noted elevations may in fact vary to some degree.

2.2.11 Photographs

Photographs of the field work, soil samples and site conditions were maintained during the course of the evaluation to document the work.

A selection of these photos has been provided in *Appendix E – Selection of Photos*.

2.3 Laboratory Work Program

Both physical and chemical laboratory work programs were conducted on the retained samples to better characterize the soils that were encountered.

2.3.1 Physical Laboratory Analysis

The physical laboratory analysis was conducted at our Whitehorse laboratory facilities between April 14th and June 6th, 2013 in order to characterize the index properties and conditions of the retained soil samples.

The laboratory analysis was comprised of;

Moisture Content Determination	ASTM D 2216-92	73 Samples
Grain Size Distribution Analysis	ASTM D 422-633	28 Samples
Atterberg Limit Analysis	ASTM D 4318-10	2 samples

An additional 7 (TP 1-13) samples were washed in accordance with ASTM D 442-633, to determine the samples fines, sand and gravel content.

The results of the moisture analysis have been denoted as 'MC' (⦿ - Symbol) on the Soil Logs enclosed in *Appendix A.*

The Grain Size Distribution Analysis was conducted in order to assist in soil classification utilizing the *Unified Soils Classification System*. The results of the analysis have been summarized on the Soil Logs with the percent composition of fines (silt & clay), sand and gravel denoted with the symbols - ▲, ● & ■ , respectively. The results of the Atterberg Limit analysis was also utilized to classify fine grained soils. The results of the analysis have been presented on the Soil Logs as ' | ', which represent the values of their plastic and liquid limits, respectively.

The results of the laboratory analysis, which graphically illustrate the gradational distribution of the respective samples, have been attached in *Appendix B – Grain Size Distribution Analysis.*

2.3.2 Chemical Laboratory Analysis

The chemical laboratory analysis was conducted by our sub-consultant *Levelton Consultants Ltd.* at their Surrey, B.C., laboratory facilities on June 18th, 2013. The purpose of the analysis was to assess the resistivity and pH of soil and water samples which were retained from the region of the newly proposed crossing. Specifically, the soil sample was a split portion of Sample No.4 retained from Test Pit TP 1-13 at a depth of ~ 2.0 meters. These soils would coincide with the approximate location and depth of the newly proposed culvert. The water sample was retained from flowing creek water located ~ 5 meters upstream of the existing culvert inlet.

The samples were tested in accordance with ASTM Standard G57 and Standard G51 to determine the samples resistivity and ph, respectively. These parameters should allow for the civil design consultant to determine culvert specifications relative to the aggressiveness of the soil and water.

In brief, the analysis revealed the following levels;

SAMPLE	Resistivity (ohm-cm)	pH
Cowley Creek - Soil	1326	7.03
Cowley Creek – Water	3911	6.85

The *Levelton Consultants Ltd.* report has been attached in Appendix C.

3.0 SITE CONDITIONS

3.1 Physiographic Setting

While the proposed subdivision is located in a region surrounding the southern half of a prominent hill (situated approximately 1 kilometer west of Cowley Creek), this phase of the evaluation focused upon the conditions near the proposed Cowley Creek crossing, east of the subdivision. At this location, km 7.3 of Carcross Road (~km 150.8 LHS of South Klondike Highway #2), a gravel road is utilized to access private residences located near the study area. The access road traverses a glacial till deposit (from South Klondike Highway elevations ~746 m) cross-slope, until lower elevations (~736 m) are attained near the floodplain embankment. The access road then crosses a 6.1 meter long, 1.5 meter diameter, CSP culvert installed in Cowley Creek at a road elevation near ~735.3 m. The elevation gain on either side of the creek crossing (floodplain) in this region was noted to be approximately 2 to 3 meters.

The elevation gain from the crossing area (~735 m) to the upper regions of the primary subdivision area (~805 m) is in the order of 70 meters.

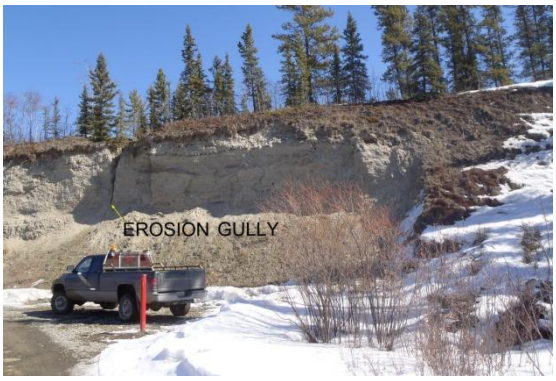
The condition of the till slope in the region of the existing access road appears to be unstable as fresh slough was noted at some locations in the spring. Portions of the slope formed what could be described as a head-scarp, as the slope aspects were noted to be near vertical. An erosion gully was noted within the head-scarp feature.

North Klondike Highway Headscarp



Existing access road facing south
(parallel to the Klondike Highway)

Note slough



Glacial till headscarp facing east
(towards the Klondike Highway)

Note erosion gully (center left) &
BH 1-13 foreground

Regionally, the area is vegetated with a mature forest comprised of deciduous poplar, pine and spruce trees. The presence and density of the understory shrubbery (willow and brush) varied. A number of trees with the Cowley Creek crossing area exhibited 'drunken' characteristics which are indicative of the potential permafrost.

While the existing crossing should be evaluated based upon the local site conditions and geomorphological factors, it is important to also examine other regions where crossings of Cowley Creek have been undertaken. Specifically, there are two other locations where roadways have been constructed across Cowley Creek. These crossings are comprised of the Alaska Highway and Salmon Trail (located in the Cowley Creek subdivision) and have been noted on Figure 4.

Alaska Highway #1 – km 1406.7

At this location, Cowley Creek is routed through dual 1.5 meter diameter CSP culverts, which appear to measure in the order of 50 meters in length. The culverts appeared to be deformed as the outlet sides of the culverts could not be seen when viewed from the inlet.

An inspection of the site conditions on April 19, 2013 noted frozen conditions. The level of the frozen water surface at the inlets was noted to be ~ 1.0 meters below the top of the culverts. A subsequent inspection of the inlet side on June 1, 2013 revealed flowing water which measured ~ 1.1 meters below the top of the culverts (as measured from the top of the culvert to the water interface at the side of the culvert).

Alaska Highway Crossing



April 19, 2013



June 1, 2013

Salmon Trail – Cowley Creek Country Residential Subdivision

A 9 meter wide road surface crosses Cowley Creek along Salmon Trail in Phase II of the Cowley Creek Subdivision. At this location, Cowley Creek is routed through a low profile arch (*Armtec 69A18*) culvert which spans ~ 7.0 meters and measures ~ 13 meters in length. The culvert is founded upon continuous footings which measure approximately 1.0 meters wide. The scaled drawings suggest that the top of the culvert is located ~1.9 meters above the top of the footing.

An inspection of the site conditions on April 19, 2013 noted frozen conditions. The level of the frozen water surface at the time of the inspection was noted to be within ~ 0.3 meters of the top of the culvert. A subsequent inspection of the culvert on June 1st, 2013 revealed flowing water which measured ~ 0.4 meters below the top of the culvert.

Salmon Trail Crossing



April 19, 2013



June 1, 2013

3.2 Geomorphic Setting

While the McGowan study area is located in a region comprised of predominately glacial (till) deposits which were channeled by glacial meltwater, the depositional history is complex. Glaciofluvial, fluvial and till deposits lie to the east, in the region where this phase of the evaluation took place (and where future site access to the subdivision will be developed).

Specifically, within the region of Cowley Creek, our evaluation noted that the terrain within the floodplain was comprised of fluvial deposits consisting of local isolated terraces and low lying fluvial (marsh and creek) areas. The isolated terraces (which measured ~ 2 meters higher than Cowley Creek and surrounding marsh areas), were comprised of predominately sandy silt which were noted to be permanently frozen at a depth of ~ 2.3 meters (elevation 732.84 meters in TP 1-13) below the existing ground surface. This elevation is approximately 0.5 meters below the elevation of Cowley Creek (which was noted to be ~ 733.35 meters) in this region. The low lying marsh and creek areas were comprised of organic rich soils which overlay silty sandy clays and clayey sandy silts which overlay more coarse grained silty gravelly sands at an elevation of ~ 730.7 meters.

The composition of the embankments which lay on either side of the floodplain varied. The eastern embankment was comprised of glacial till which overlay glaciofluvial deposits. The western embankment was comprised of glaciofluvial deposits.

A portion of the surficial geology map (*Geoscience Map # 2005-6, Geology of MacRae* compiled by J.D.Bond, S.R.Morrison and K.McKenna) which denotes the approximate spatial distribution of the various soil types located in the study area, has been attached as Figure 3 for illustration purposes.

3.3 Subsurface Conditions

Details of the subsurface conditions encountered at each of the borehole and test pit locations have been provided in the Soil Logs attached in Appendix A. In brief, the soil types and conditions varied between each of the boreholes and test pit locations.

A table summarizing the stratigraphic conditions encountered during the evaluation has been attached in Table II. The boreholes and test pit within the table have been arranged relative to their distance from the Klondike Highway for presentation purposes.

3.3.1 Soil Stratigraphy

In general, the subsurface soils were comprised of fill, glacial till, glaciofluvial and fluvial deposits or combinations thereof. These deposits were generally covered by a thin veneer of surficial organics at the ground surface.

Surficial Organics

As the majority of the boreholes were advanced adjacent to existing trails and roadways, surficial organics were generally not encountered. The exception to this was in BH 3-13 and TP 1-13 which were advanced within the Cowley Creek

floodplain. At these locations, the organic mat was noted to measure 0.20 and 0.08 meters thick respectively.

Fill

A 0.9 meter thick layer of fill, comprised of predominately glacial till materials, was encountered in BH 1-13 near the ground surface. The fill material was likely placed at this location during construction of existing access road. BH 8-13 also encountered fill comprised of 150 mm of granular road base.

Glacial Till Deposits

Glacial till deposits were encountered in boreholes BH 1-13, BH 4-13, BH 7-13 and BH 8-13. The till deposits in boreholes BH 1-13, BH 4-13 and BH 7-13 all overlay glaciofluvial deposits. The thickness of the till deposits at these locations were noted to be 1.08, 3.25 and 3.67 meters respectively. Borehole BH 8-13, which was advanced in a region of higher elevations (~ 786.5 m) near the proposed development area, encountered glacial till near the ground surface (0.15 m) to its depth of termination (9.15 m).

In general, the glacial till deposits were comprised of damp, loose to dense, poorly graded silty sands which contained varying amounts of gravel and clay. At some locations, sandy silts were also encountered. The soil unit contained dark rock inclusions which measured on average 2 to 3 mm in size. Cobbles and potentially boulder sized materials were encountered in boreholes BH 4-13 and BH 8-13.

Additional information regarding the glacial till deposit can be found in our December 12, 2012 Geotechnical Evaluation.

Glaciofluvial Deposits

The glaciofluvial deposits were encountered in boreholes BH 1-13, BH 2-13 and BH 4-13 through BH 7-13. Boreholes BH 2-13, BH 5-13 and BH 6-13 all encountered

glaciofluvial deposit at the ground surface to the depth of borehole termination (which averaged 5.1 meters). The glaciofluvial deposits in boreholes BH 1-13, BH 4-13 and BH 7-13 were all overlain by glacial till deposits which averaged 2.67 meters thick (but varied between 1.08 meters (BH 1-13) and 3.67 meters (BH 7-13)). Borehole BH 7-13 was unique in that glaciofluvial deposits were encountered near the ground surface (above), and at depth (below), a glacial till deposit. The near surface deposit which overlay the glacial till was comprised of a thin veneer of sandy gravel (trace silt) which measured 0.8 meters thick.

The glaciofluvial deposits were comprised of predominately sands and gravelly sands and (based upon the results of fourteen (14) grain size distribution analysis) contained on average 10.2 % silt. The deposit was intermittently noted to contain cobbles and possibly boulder sized materials.

The soil unit was noted to be compact to very dense. As the majority of this soil unit was encountered below the groundwater table, the material was noted to be wet with an average moisture content of 9.2 %.

Fluvial Deposits

Fluvial deposits were encountered in BH 3-13, BH 6-13 and TP 1-13. The deposits in BH 3-13 and TP 1-13 were situated within the Cowley Creek floodplain and were encountered immediately below a veneer of surficial organics and extended to the depth of termination at each test location. Each location encountered seasonally frozen materials. TP 1-13 encountered permanently frozen (permafrost), as described in Section 3.3.4, below.

The stratigraphy noted at BH 3-13 was comprised of approximately 1 meter of organic rich silts (OL) which overlay low plasticity silty sandy clays (CL) and clayey sandy silts (CL-ML). As the SPT within the silty sandy clays penetrated through the base of the frozen materials, the underlying soils were noted to be very soft with an

SPT value of N = 2. The results of Atterberg Limit analysis revealed that the silty sandy clay (moisture content = 31.4%) was above its liquid limit (of ~25.9%).

The consistency of the underlying clayey sandy silts were noted to be stiff (SPT N = 10). The moisture content of these soils was noted to be (18.8 %) just above their plastic limit (~18.4%).

Borehole BH 3-13, which was advanced to depths of 6.25 meters, noted a coarsening downwards trend as compact silty gravelly sands were encountered at SPT sampling depths of 4.27 meters and 5.79 meters.

Borehole BH 6-13 was unique as it was located in a region of higher elevations and encountered the fluvial deposit at a depth of approximately 5.49 meters (Elevation = 747.01 meters) below glaciofluvial soils. The fluvial deposits at this location were noted to be comprised of clayey silt which had a moisture content of 24.0%.

3.3.2 Cobbles and Boulders

Rounded cobbles and possibly boulder sized materials were encountered within the till deposits (BH 4A-13 and BH 8-13) as was originally identified in our initial evaluation conducted in the fall of 2012.

Cobbles were also encountered within the glaciofluvial deposits within BH 1-13, BH 5-13 and BH 7-13. Possible boulders were also encountered within these deposits in BH 7-13 (as identified by auger action), at a depth of 5.1 meters.

Regionally, surficial boulders (in size to 3 meters) were noted within the floodplain in the region of the crossing and throughout the proposed McGowan Subdivision.

3.3.3 Seasonal Frost

Seasonal frost was encountered in each of the boreholes and the test pit. The average depth of frost penetration in the boreholes (which were advanced between April 11th-16th) was noted to be 1.25 meters but varied between 0.7 meters (BH 6-13) and 1.6 meters (BH 8-13). Test Pit TP 1-13 (which was excavated on June 4th) encountered seasonal frost between a depth of 0.3 and 0.9 meters below the existing ground surface.

In general, the frozen soils encountered in the boreholes were classified as '*segregated ice not visible by eye – well bonded with no excess ice* – Nbn', in accordance with the *National Research Council* (*NRC*) soil classification for frozen soils. The near surface frozen soils in BH 3-13, which was advanced within the floodplain, were predominately classified as Nbn as well as *'well bonded with excess ice'* - Nbe. A zone of granulated ice was also encountered in BH 3-13 at a depth of ~ 0.5 meters. The thickness of this ice lens was estimated to be ~ 100 mm.

3.3.4 Permafrost

There were two locations were permafrost was encountered, namely TP 1-13 and BH 1-13. Test Pit TP 1-13 was excavated in a region of the flood plain where conditions were similar to those encountered in the isolated terraces. Borehole BH 1-13 was advanced in a heavily shaded region near the steep escarpment located on the east side of the proposed crossing area. Based upon our observations, it is likely that permafrost will be more prevalent in heavily shaded regions (predominately the eastern floodplain embankment) within the crossing area as well as within the regions of the isolated terraces.

Test Pit TP 1-13

Test Pit TP 1-13 encountered permafrost at a depth of 2.3 meters (Elevation 732.84 meters) within the fluvial soils. These soils were predominately comprised of well bonded silty sand and sandy silt which were classified as Nbn (*well bonded with no*

excess ice). These soils measured ~ 0.2 meters thick. Below these soils, a well bonded sandy silt with some clay was encountered. This material was classified as Nbe (*well bonded with excess ice*). The Nbn and Nbe soils all contained a trace of organics and rootlets.

Borehole BH 1-13

While an inspection of Sample No.2 (retained from BH 1-13 at a depth of 1.22 meters), did not suggest the presence of frozen soils, the frozen groundwater conditions encountered July 1, 2013 in the installed monitoring well and the high SPT values (38 blows and 5" of penetration) at this depth suggests that the till deposits in this region may in fact be permanently frozen. It is possible that the energy dissipated during the SPT sampling thawed the retained sample.

3.3.5 Groundwater

As a portion of the evaluation focused upon crossing Cowley Creek, groundwater was encountered during the drilling. Specifically, boreholes BH 1-13 through BH 5-13 each encountered groundwater at an average elevation of 734.32 meters (standard deviation ~ 0.26 meters).

Groundwater wells were installed in Boreholes BH 1-13 through BH 3-13 in order to allow for monitoring of local groundwater levels. Groundwater levels were measured immediately following installation, as well as on April 21st and July 1st, 2013. A summary of our observations have been attached as Table I – Groundwater Elevations.

> Of note, the groundwater within BH 3-13 was noted to be frozen at an elevation of 734.40 meters during the April monitoring episode. The groundwater within BH 1-13 was noted to be frozen at an elevation of 734.84 meters during the July monitoring episode.

Based upon the readings obtained from the three monitoring wells, the average groundwater elevation was noted to be 734.60 meters and 734.78 meters during the April 21st and July 1st monitoring episodes, respectively. By comparison, the water elevation noted at the inlet to the existing culvert was noted to be 734.28 (frozen condition) and 734.18 meters, respectively. As the groundwater regime is complex the noted elevations would be affected by seasonal fluctuations and variations in the flow regime.

3.3.6 Bedrock

There was no indication of bedrock in any of the boreholes or test pits that were excavated during this phase of our evaluation. While borehole BH 4A-13 encountered refusal at a depth of 3.05 meters, the nearby (~ 2 meters) advancement of BH 4B-13 to depths of 6.1 meters suggests that refusal was likely due to the presence of a large boulder.

TP 3-12 and TP 12-12 excavated during Phase I (fall of 2012), each encountered a single piece of rock in size to 200 mm within the till deposits at depths of 2.0 meters and 3.0 meters, respectively. The presence of the rocks may be indicative of potential regional bedrock located at shallower depths. As the underlying bedrock is known to be comprised of Laberge Group sedimentary rocks, the presence of these rocks may be indicative of potential bedrock located at shallow depths near these two locations.

4.0 DISCUSSIONS

The soils encountered during our evaluation suggest that crossing of Cowley Creek and overall road development at the site will be feasible. However, the subsurface conditions will be challenging in the region of the crossing as the local geomorphology suggests that there may be regions where channel infilling has occurred. These regions may be comprised of (or contain) organics, boulders, trees, ice lenses and other deleterious materials. In addition, the presence of permafrost as well as fine grained and organic soils in the crossing region will require additional consideration, further to standard design and construction practices. Specifically, the use of four differing types of road structures will be required in order to construct a rural residential roadway through the access and proposed development areas. Three of these road structures will be required in the region of the creek crossing in order to accommodate the differing soils compositions and proposed culvert installation. A forth (standard) road profile, should allow for road construction throughout the remainder of the proposed subdivision. While a schematic which illustrates the four types of road structures has been attached as Figure 7, the actual configuration will need to be verified by the civil design consultant and will depend upon the field conditions encountered at the time of construction.

A proposed horizontal alignment for the crossing region has been presented in Figure 5 for discussion purposes. In brief, the proposed road crossing was aligned with the intent to maximize the use of locally higher elevation terrain features (isolated terraces) within the floodplain and where possible, utilize the existing access road as a toe-berm for the upstream side of the newly constructed embankment.

A summary of local elevations has been presented in Table III for discussion purposes. While these elevations were obtained at different intervals during the course of the evaluation, the noted elevations provide some insight as to general design parameters and local constraints.

4.1 Road Structures

A description of each of the differing road structures has been provided, as follows;

4.1.1 Low Lying Fluvial Deposits

The regions of the low lying fluvial deposits harbor regions of highly compressible organics which are underlain by fine grained organic rich silt and clayey soils. These soils inherently have a poor bearing capacity. As such, where these deposits are encountered, as a minimum, the organic silt should be removed to practical depths and the satisfaction of the geotechnical consultant.

> While the minimum depths of removal have been estimated to be approximately 1 meter, the actually depths in the field will vary and may be influenced due to the presence/influx of groundwater and fine grained materials. Specifically, as fine grained soils (which were near or beyond their liquid limits) were encountered additional efforts will be required to prevent their influx as these materials will behave as a liquid. The contractor should be prepared to retain these materials at the excavation limits through the combined use of sheet piles, gabion baskets and filter fabric or similar types of retaining systems. Staged excavation/backfill operations may be required.

Following (staged) excavation, the prepared regions should be overlain with geotextile fabric and subsequently backfilled utilizing a well graded course granular material which contains a high percentage of cobbles. The initial lift of the backfill should be robust (measuring in the order of 0.8 meters thick) and static rolled, in order to bridge the poor bearing nature of the underlying soils. Subsequent lifts should be placed in 300 mm thick lifts and keyed into the adjacent isolated terraces and floodplain embankments. Geotextile fabric and geogrid should be systematically incorporated into the road structure as illustrated in Figure 7.

The course grained granular sub-grade should be established to elevations which parallel the top of the adjacent isolated terraces and floodplain embankments (~736 m) such that the roadway can be established in accordance with Section 4.1.4.

4.1.2 Isolated Terraces and Floodplain Embankments

While the isolated terraces and floodplain embankments had an increased resistance to soil erosion (due to their relatively coarse grained composition, frozen nature and fluvial related factors), they will be prone to thermal disturbance as they harbor regions of permafrost. As such, the proposed road structure in these regions has been envisioned with the intent to minimize disturbance to the thermal regime. Specifically, following clearing operations, grubbing operations should be limited to removing tree stumps and large roots. All other organics should be left in-place such that they serve as a natural layer of insulation following backfill operations.

Alternately, the organic materials could be removed and replaced with a thermal equivalent (~100 mm) of High Density SM Styrofoam in order to eliminate the total amount of settlement that would occur due to the compressible nature of the remnant organics. The insulation should be encased within a sand buffer to prevent damage to the Styrofoam during embankment construction. The joints of the individual pieces should be taped and the joints of successive layers of insulation should be overlapped to improve thermal performance.

The use of Styrofoam would however increase the construction costs so their use should be carefully considered. The degree to which these potential measures may reduce the effects of long-term settlement and thaw-degradation would be difficult to assess due to the complexity of the thermal and groundwater regimes.

Following clearing and (limited) grubbing operations, a leveling course comprised of a clean, well graded sand and gravel mixture should be placed and compacted directly

upon the grubbing (to elevation ~736 m) to allow for placement of a geotextile fabric. The purpose of the leveling course would be to prevent remnant rootlets and branches from puncturing the geotextile fabric.

In regions where the isolated terraces transition to fluvial or other regions, the sides of the terraces should be keyed (at an approximate step of 3:1 horizontal to vertical) to allow for placement of geotextile fabric, geo-grid and adjacent granular courses.

Following placement of the geotextile fabric, the remainder of the roadway should be established in accordance with Section 4.1.4.

4.1.3 Cowley Creek Culvert

From a design (and construction) standpoint, often simple designs are the most effective in minimizing the detrimental impacts of thaw-degradation and poor founding conditions which are typically encountered in permafrost regions. As such, given the anticipated low flow rates of Cowley Creek at this location and the presence of discontinuous permafrost, upgrading of the existing crossing should be accomplished through the use of dual (~1.5 m Ø) culverts or else a mid-sized (full base) multi-plate.

> The use of arch type multi-plates, which require the installation of footings, should not be considered given the frozen nature of the soil conditions encountered in the region of the anticipated crossing. The installation of large sized multi-plates may not be feasible without exploring deep foundation options.

Based upon the envisioned road structures, the elevation of the newly constructed road at the location of the culvert will be ~737.7 meters.

> This elevation is ~ 2.5 meters higher than the elevation of the existing road at the location of the existing culvert and ~ 3.5 meters higher than the observed creek elevation (~ 734.2 meters) at the location of the existing culvert inlet.

As the rise from the crossing to the South Klondike Highway would be in the order of 8.3 meters, the anticipated road grades in this region would be in the order of 10%.

Based upon the envisioned elevations, the road centerline should be offset (~ 0.75 meters) to the south relative to the mid-point of the proposed culvert. This should help accommodate the difference in elevation between the inlet and outlet sides of the culvert relative to the proposed road surface (and hence difference in embankment thicknesses).

The envisioned elevations would require the length of the newly proposed culvert to measure in the order of 36 meters.

The design should incorporate provisions to allow for periods of high water events. As a minimum, this should include provisions to allow for moderately sized overflow culverts (downchain, and/or upchain) and potentially overflow embankment areas.

The capacity of the culverts/multi-plate should be over-sized in anticipation that their capacity will be reduced over time due to the influx of sediment, pipe deformation and/or potentially long-term settlement and thaw-degradation.

Following culvert installation and backfill (to an elevation of ~736 m) the roadway should be established in accordance with Section 4.1.4.

The culvert should be installed in accordance with the recommendations provided in Section 5.0, below.

4.1.4 Road Construction in the Crossing Region

Once a uniform surface has been prepared (to elevation ~736 m) in the region of the fluvial deposits, isolated terraces / floodplain embankment and culvert locations, a

geo-grid should be placed upon the prepared surface and extend (in the order of 10 meters) into regions which lie beyond the floodplain embankments.

The geogrid should be continuous throughout the placement area between the two sides of the floodplain. If construction breaks are required, the geo-grid should be overlapped and conjoined in accordance with the manufacturer's recommendations. In regions of the isolated terraces, the geo-grid can be placed directly upon the geotextile fabric.

Following geo-grid placement, the roadway can be constructed in accordance with the Recommendations provided in Section 5.0.

4.1.5 Regions of Standard Road Construction

The roadways within the remainder of the study area (beyond the region of the crossing) can be constructed utilizing standard road construction practices as described in the Recommendations provided in Section 5.0.

4.2 Permafrost

From a geotechnical standpoint, road and creek crossing construction in regions of permafrost generally disturb the thermal regime regardless of the thaw-preventative measures employed and so higher construction, maintenance (and potentially rehabilitation) costs should be anticipated. The effectiveness of the employed design/construction to reduce the impacts of thaw degradation will vary.

4.3 Organic Rich Soils

As organic rich and other fine grained compressible soils were encountered in the region of the crossing, additional consideration may be required when estimating the volumes of imported fills that will be required in these regions. Typically,

construction volumes will be higher than those anticipated in the design due to the soils compressible nature and potential for lateral displacement during embankment construction and so this should also be taken into account from a project management and design perspective.

4.4 Bedrock Potential

While most boreholes were advanced to depths of 6 meters (or more), the presence of bedrock cannot be refuted or confirmed within all regions of the proposed horizontal alignment(s) as access to regions where potentially large cuts were envisioned was restricted and so this should be considered.

4.5 Borrow Source

As the surficial geology mapping indicated that glaciofluvial deposits were noted on the eastern portions of the property, borehole BH 7-13 was advanced to better characterize potential granular reserves located within the study area. In brief, the stratigraphy noted within BH 7-13 suggests that clean, coarse grained glaciofluvial deposits (classified as gravelly sand with some silt) are located at a depth of ~ 4.6 meters (elev. = 766.9 meters). While the (3.67 m) thickness and composition of the overlying till deposits may prohibit their use as a borrow source at the borehole location, further investigation should be conducted near elevation 767 meters (immediately west of the clearing and east of the borehole) as the granular materials may daylight along the slope. These coarser deposits may however be limited in thickness (to perhaps elevation 762 meters) as predominately sand soils were noted within the prominently cleared area.

Regionally, a granular borrow source is located on the South Klondike Highway immediately east of the study area. Available quantities of the granular reserve would need to be verified.

5.0 RECOMMENDATIONS

Technical components of the discussions provided in Section 4.0, above, should be considered an integral part of the recommendations provided herein.

5.1 Cowley Creek Culvert Installation

5.1.1 General

The crossing of Cowley Creek should be facilitated through the use of dual (1.5 m Ø) CSP (or potentially HDPE) culverts (or else a mid-sized multi-plate), founded upon an approved granular bed constructed in accordance with the recommendations provided below.

The culvert should be installed from the outlet location and advanced towards the inlet in accordance with good installation practices.

5.1.2 Excavations

Excavations should be conducted utilizing a tracked excavator equipped with a smooth lip (clean-up) bucket in order to minimize disturbance to the sub-grade materials. If a suitable founding surface cannot be prepared through mechanical means, then hand cleaning may be necessary.

Loose, disturbed, remolded or slough materials should not be allowed to remain in excavations.

Excavations should be protected from surface and groundwater. Water should not be allowed to pool in the base of prepared excavations at any time. If surface and/or groundwater infiltrate the excavations, the water and saturated materials should be removed. The surrounding surfaces should be graded so as to direct water away from any excavation. As groundwater was encountered during our investigation, the

Contractor should be prepared to undertake construction dewatering to ensure a dry working area.

The Contractor should be prepared to adjust their construction methodology and excavation profiles as soil and site conditions dictate.

5.1.3 Excavation Limits

The excavation limits will be governed by the proposed culvert invert elevation and dimensions. In general however, the base of the excavation should measure approximately three (3) times the width of the culvert diameter.

5.1.4 Deleterious Materials

The existing surficial organics, organic silt and frozen soils are considered deleterious and should be removed from within the excavation limits of the culvert/multi-plate locations.

Seasonally frozen soils encountered during the course of the work will likewise, not be suitable for use during construction and so they should be removed from the site and relocated to a designated waste area.

5.1.5 Sub-grade Preparation

Assuming the construction of a 0.5 meter thick granular base below the (1.5 m Ø) pipe inverts, the elevation for the base of the culvert bedding would vary between 732.56 and 733.20 meters (given a 1.75% culvert gradient). As such, based upon the stratigraphy encountered in Test Pit TP 1-13, the sub-grade materials will likely be comprised of sandy silt which may or may not be permanently frozen.

If frozen soils are encountered at the sub-grade depth, additional consideration will be required as some of these soils may not be thaw stable. This may require sub-excavation in order to allow for the establishment an increased thickness of granular

bedding as determined by the retained Geotechnical Consultant. Regardless, the bedding should be of uniform thickness throughout its entire length.

The prepared undisturbed sub-grade surface should be approved by the retained Geotechnical Consultant.

5.1.6 Bedding

The granular base established below the culvert (or multi-plate) should be comprised of;

UNIT	THICKNESS	COMPACTION [A]	COMPOSITION
Base	200 mm	95 %	Bedding Sand, overlying
Sub-base	300 mm [B]	95 %	80 mm minus sub-base course aggregate, overlying
Sub-grade	[C, D, E, F]	95 %	approved native sub-grade materials

Notes: -

[A] – maximum proctor dry density at (or near, ± 2%) its optimum moisture content. All base course and sub-base materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction.

[B] – Sub-base thickness to be increased if permafrost is encountered at the sub-grade depth.

[C] – Sub-grade to be approved by retained geotechnical consultant.

[D] – the base and sides of the excavation should be lined with geotextile fabric such that the bedding materials are separated from the adjacent soils.

[E] - A geo-grid should be utilized at the interface with underlying sub-grade materials.

[F] - If poor conditions are encountered at the sub-grade depth, sub-excavation may be required as recommended by the onsite geotechnical consultant.

The use of a thin veneer of fractured clear stone in size to 80 mm fully encased in geotextile fabric should be considered in lieu of granular bedding sub-base and potentially base materials.

The imported fill should be comprised of an approved, clean, inorganic, well graded sand and gravel mixture. A recommended grain size distribution for the specified fills has been provided in *Appendix D – Imported Fill Specifications.*

The width of the culvert bedding should measure approximately three (3) times the width of the culvert diameter.

The granular base should extend beyond the inlet/outlet such that (if incorporated) cutoff and headwall structures are founded upon a constructed granular base.

5.1.7 Backfill

Backfill around culvert components should be brought up evenly so as not to induce any intolerable lateral loads. There should be no more than 150 mm difference in elevation between either side of the culvert backfill during successive lifts.

The material should be placed in 150 mm lifts (as measured following compaction) and compacted to 95% of the materials maximum proctor dry density at (or near ± 2%) the materials optimum moisture content.

The placement and compaction of backfill should be conducted perpendicular to the axis of the culvert/multi-plate once the backfill height attains ¾ of the pipe diameter or multi-plate height.

5.1.8 Cover

The amount of cover over the culvert/multiplate should be considered so as to minimize bearing loads. The height of cover should be limited so as not to exceed

maximum allowable limits as specified by the manufacturer and dictated by the site conditions.

Heavy equipment should not be allowed to cross above the culvert/multi-plate until a minimum of 1.0 meters of cover has been established above the top of the pipe. Coarse grained granular materials should not be placed above the pipe until a minimum of 0.3 meters of bedding material has been established above the pipe.

5.1.9 Allowable Bearing Pressure

The net allowable bearing pressure should not be greater than 160 kilopascals for culverts (or multi-plate) constructed upon the envisioned 0.5 meter thick granular base (described herein) and founded upon the fluvial deposits described in Section 5.1.5. This figure includes the total of all live and dead loads.

The retained Geotechnical Consultant should verify that the allowable bearing capacity at the time of construction.

5.1.10 Cutoff & Headwall Construction

The use of a cutoff and headwall should be carefully considered given the long-term movements that are anticipated due to thaw-degradation and seasonal fluctuations. The use of concrete structures should be avoided.

As a minimum, the design should incorporate (a 1.0 meter thick) low permeability soil cap which is fully encased in geotextile fabric at the location of the inlet. The cap should extend up the embankment to an elevation approximately 1.0 meters above the anticipated high water mark. The seal should be protected by a sand buffer such that rip-rap placement can be facilitated on the upstream side of the embankment without damaging the geotextile fabric.

The cut-off wall should not incorporate any such low permeability layer (such that undesirable embankment pore pressures are not induced).

5.1.11 Decommissioning of Existing Culvert and Channel

Following removal of the existing culvert, the void (and decommissioned channel area) should be backfilled with general purpose fill encased within geotextile fabric. While this material should be predominately course grained in nature, it should also contain a high percentage (15-20%) of fines such that it serves as an impermeable plug. The material should be placed and compacted in accordance with Section 5.2.4 (granular sub-grade).

5.1.12 Construction Schedule

As permafrost may be encountered during construction of the crossing, the work should be conducted during the fall when cooler temperatures prevail. It is critical that once initiated, construction of the crossing be conducted in a timely manner so as to minimize potential exposure of the permafrost to thawing temperatures. The use of insulated tarps should be considered in the region of the culvert crossing where permafrost may be exposed for a short term basis to reduce the overall quantities of waste materials that may result from permafrost degradation.

If the road in the region of the crossing is to be surfaced utilizing BST, the application should be delayed for several years to allow for long-term settlement and potential stabilization of the crossing region.

The omission of BST in the region of the crossing should also be considered. This will allow for an ease of maintenance of the graveled roadway surface and allow for larger magnitudes of surface movements (in the permafrost regions) to be accommodated. If BST is applied in the region of the crossing, it may require rehabilitation (and potentially repeated applications) if long-term movements are encountered.

5.2 Road Construction

5.2.1 Site Development

Caution should be exercised in order to minimize disturbance to the permafrost sub-grade materials which were encountered in the Cowley Creek crossing. The sub-grade materials in this region are subject to a loss of strength if they thaw and/or are disturbed and as such, equipment should not be allowed to operate directly on the sub-grade surfaces. Specialized low ground pressure earth moving equipment should be utilized during construction operations in the region of Cowley Creek where poor bearing conditions are anticipated (ie low lying fluvial regions). The permafrost is likewise susceptible to thaw-degradation if the thermal regime is adversely disturbed and so precautionary measures should be employed to minimize the impact of construction operations.

The contractor should be prepared to adjust their construction methodology as soil and site conditions dictate.

5.2.2 Deleterious Materials

In regions outside of the Cowley Creek crossing, the existing surficial organics, organic silts and frozen soils are considered deleterious and should be removed from within the loading envelope of the roadway. Where possible, the surficial organics should be windrowed separately such that they can be reshaped along the embankments following road construction to promote embankment re-vegetation/stabilization.

In regions within the Cowley Creek crossing where permafrost was not encountered (ie low lying fluvial deposits), the existing surficial organics, organic silt, saturated and fine grained fluvial soils (which are near or beyond their liquid limits) are considered deleterious and should be removed from within the load envelope of the roadway to practical depths. Any frozen soils encountered within the proposed

excavation footprint should also be removed if these soils are considered thaw-unstable or are seasonally frozen.

In regions within the Cowley Creek crossing where permafrost was encountered (ie isolated terraces), contrary to standard construction practices, the surficial organic cover and organic mat should be left in-place during construction of embankment fills such that disturbance to the underlying permafrost regime is minimized. Following clearing of the proposed road right-of-way large stumps within the region should be grubbed while leaving the remainder of rootlets and organic mat in-place (to serve as a natural insulator).

The above noted deleterious materials will not be suitable for use as construction fill and so should be removed from the region and placed (and graded) in a designated waste area. The exception to this would be the surficial organics which should be utilized for embankment rehabilitation purposes.

5.2.3 Gravel Sub-grade

Following placement of the geogrid, a base layer of course grained well graded granular pit run should be placed and compacted to 95% of the materials standard proctor maximum dry density at (or near ± 2%) the materials optimum moisture content. The pit run should contain a high percentage of cobble sized materials and should be placed in uniform, level lifts which measure in the order of 300 mm thick.

The base layers should be robust and extend a minimum of 2 meters beyond the limits of the roadway sub-base embankment. Where possible, the layer should extend and tie-in to the existing access road located upstream of the crossing location. The existing access road should be left in-place so as to minimize disturbance to the creek on the upstream side.

In regions where fluvial deposits are encountered, the base layers of pit run should be placed in successive lifts to attain an elevation approximately one meter higher than the prevailing elevation of the isolated terraces.

5.2.4 Road Structure & Construction

The road structure should be comprised of;

UNIT	THICKNESS	COMPACTION [A]	COMPOSITION
Base	Varies 150 mm or 200 mm [B]	98 %	20 mm minus crushed granular aggregate, overlying
Sub-base	Varies 300 mm or 600 mm[C]	98 %	80 mm minus sub-base course aggregate, overlying
Gravel Sub-grade	Varies [D] minimum 1 meter	95%	300 mm minus well graded clean granular pit run, overlying
Native Sub-grade	E, F, G, H	95 %	approved native sub-grade materials

Notes: -

[A] – maximum proctor dry density at (or near, ± 2%) its optimum moisture content. All base course and sub-base materials should be placed in uniform, level lifts that do not exceed 150 mm thick, as measured following compaction.

[B] - The thicker base course should be utilized in regions of the crossing.

[C] –The thicker sub-base should be utilized in regions of the crossing and steep roadway grades.

[D] – Not required in areas 10 meters beyond the crossing region. The initial lift(s)

within the fluvial deposits of the Cowley Creek crossing should be static rolled so as to minimize disturbance to the subgrade. Lift thickness should not exceed 300 mm following placement of the initial lift.

[E] – Thawed Sub-grade to be approved by retained geotechnical consultant.

[F] - If predominately fine grained soils are encountered at the sub-grade depth, sub-excavation may be required as recommended by the onsite geotechnical consultant. The use of a geotextile fabric would be required at the interface with underlying fine grained soils.

[G] - If additional fill is required to meet the anticipated sub-grade design elevations, the fill can be comprised of approved glacial till or else a clean, well graded 'pit run' material. The maximum particle size of any of these materials should be < 150 mm. These soils can be placed and compacted in 300 mm thick lifts so long as adequate compaction is attained.

[H] - If the sub-grade becomes saturated and does not dry during the course of the work, sub-excavation and subsequent backfill utilizing approved granular fills underlain within geotextile fabric would be required.

The imported fill should be comprised of an approved, clean, inorganic, well graded sand and gravel mixture. A recommended grain size distribution for the specified fills has been provided in *Appendix D – Imported Fill Specifications.*

The imported granular fill in roadway areas should extend outwards from any load footprint at a minimum slope of 2:1 (horizontal:vertical) until a suitable approved sub-grade as been attained.

The surfaces of the base, sub-base and sub-grade should be shaped with a 2% crown to promote drainage.

5.2.5 Geotextile Fabric and Geo-grid

While the anticipated road design will incorporate geotextile fabric and geo-grids in the region of Cowley Creek crossing, additional quantities of these materials should be available for use in other regions where soft, compressible or frozen soils are encountered at the discretion of the retained geotechnical consultant.

5.2.6 Culvert Installations

Standard sized culverts (up to 600 mm Ø) should be placed upon a minimum of 300 mm of clean bedding sand. A minimum of 300 mm of bedding material should encompass the culvert sides and cover. A minimum of 500 mm of granular material should be placed above the culvert before traffic is allowed to cross the culvert.

Culvert bedding and backfill should be placed in 150 mm thick lifts which are compacted to 95% of the materials maximum proctor dry density at (or near ± 2%) of the materials optimum moisture content.

The culvert inlet and outlet areas should be covered with protective rip-rap in accordance with standard design/construction practices.

5.2.7 Lot Accesses

The construction of the individual lot accesses should be regulated such that their construction (by individual home-owners) does not impact the regional drainage or design intent. Minimum culvert sizes should be specified prior to the time of sale.

5.2.8 Common Fill

The glacial till and glaciofluvial deposits can be utilized as common fill during road construction so long as the material is placed in 300 mm thick lifts and are compacted to 95% of the materials maximum proctor dry density at (or near ± 2%) of the materials optimum moisture content. Oversized cobbles and boulders should be removed from the material prior to (or during) placement.

5.2.9 Surface and Groundwater

Excavations should be protected from surface and groundwater at all times. The surrounding areas should be graded so as to direct water away from any excavations or construction areas. Water should not be allowed to pool in the base of prepared excavations at any time. If water infiltrates the excavation(s), it should be removed.

As groundwater was encountered during our evaluation, the Contractor should be prepared to undertake construction dewatering to ensure a dry working area.

The saturated and fine grained fluvial soils encountered during our evaluation are not free draining and so dewatering these soils will not be possible.

If poor weather conditions are anticipated during the construction, then local sumps should be incorporated into the excavations/works such that they can be utilized as pump out areas and minimize the impact that water may have upon the sub-grade and placed backfill materials.

5.2.10 Temporary Stockpiles

Stockpiled materials that may be utilized during construction should be protected from segregation and the ingress of snow, rain and surface waters.

5.2.11 Inclement Weather

The fluvial materials are susceptible to a loss in strength if they become wet and/or are disturbed. The till materials are also moisture sensitive. As such, the sub-grade and construction materials should be protected from drying, freezing, snow and the ingress of surface/groundwater at all times. Construction operations during inclement weather may need to be curtailed or halted if the site conditions become unfavorable.

5.2.12 Guardrails

Guardrails and other protective barriers should be incorporated into the design in regions where traffic traverses steep embankment areas or where there is the potential for other hazards.

5.2.13 Erosion Control

Silt fencing should be established in select regions as the sub-grade and the native materials are prone to erosion in the event of precipitation and/or groundwater flow.

Efforts to protect the works may be required through construction of interception ditches and by maintaining positive drainage during the work.

In regions where steep gradients are encountered, baffles should be established within the ditches to decrease down-slope flow velocities of surface waters.

Provisions for hydro-seeding should be included within the design/construction to promote re-vegetation, particularly in regions where steep or large embankments are encountered/constructed.

5.2.14 Rip-Rap

The use of rip-rap reinforcement should be heavily incorporated into the design to decrease the amount of soil erosion that may occur following the realignment of the creek and in other locations which may be subject to high flow volumes or rates. Rip-rap should be comprised of a hard, angular, durable rock which is free of fractures and other defects. The rip-rap should be placed in a well graded mass with a minimum amount of voids and placed upon a shaped surfaced covered with geotextile fabric.

5.2.15 Ditches

Standard rural residential roadway ditches should be incorporated into the roadway design.

Additional design consideration will be required in regions where gullies are encountered. The use of rip-rap/deflection berms and culverts should be considered if the gullies intersect the road locations.

The ditches should be reinforced with rip-rap in regions which may be subject to high flow volumes or rates.

5.2.16 Side Slopes

The recommended angle of repose for the embankment side slopes should be confirmed by the retained Geotechnical Consultant at the time of embankment construction/excavation.

In general, side slopes should be cut at 3:1 (or shallower) in regions where fine grained soils are encountered. Side slopes can be cut at 2:1 in regions where glacial till or granular glaciofluvial materials are encountered.

If large cut slopes are required (or if fine grained deposits are encountered), then additional consideration may be required by qualified geotechnical personnel to minimize the degree of soil erosion and the potential for slope movements. The design should consider incorporating cross-slope interception ditches to better control drainage in these areas, particularly in large embankment regions.

5.2.17 Construction Schedule

Road construction should be conducted when thawed conditions prevail. As the sub-grade materials are moisture sensitive, construction operations during times of inclement weather may need to be curtailed or may not be possible.

If BST surfacing of the subdivision roadways is required, then as a minimum, delayed application (in the order of several years) should be considered. This will not only allow for construction related and seasonal settlement of the roadway, but will also allow time for home owners to install local accesses to their properties. This will minimize disturbance to any applied BST surface during the construction of the private lot accesses.

5.2.18 Maintenance Program

If the application of BST is delayed (to allow for road stabilization), the gravel road will need to be maintained in order to allow for public access. This will include grading the road on a regular basis to eliminate surface disturbances, applying sanding aggregate during the winter months and other similar types of maintenance. The application of additional surfacing aggregate may be required over time dependent upon the road usage and conditions.

As the native soils are predominately frost susceptible, some disturbance to the roadway can be expected during the fall and spring due to soil volume fluctuations. This may result in surface disturbances such as cracks in the BST surface which should be sealed during regular maintenance operations.

If silt fencing and ditch baffles are incorporated into the design, then the maintenance program will also need include provisions to clear out materials trapped within these zones until such time that the roadway and ditches stabilize following construction.

Rip-rapped regions should be closely monitored for signs of erosion and if required, reinforced on an as need basis.

5.2.19 Geotechnical Confirmation

Once the right-of-way has been cleared, we recommend that drilling methodologies be employed to verify the feasibility of the proposed vertical alignment. This work should be concentrated in regions where the road traverses the eastern portions of the site as these regions may require moderate degrees of cut to attain the desired sub-grade and ditch profiles. The investigation should focus upon identifying the presence of bedrock and/or fine grained soils which may affect the construction. The sub-grade conditions should also be verified at the location of the crossing during this time. As a minimum, a heavy excavator should be utilized to excavate exploratory test pits adjacent to the culvert inlet, mid-point and outlet locations, prior to culvert installation. The purpose of excavating the test pits would be to better assess the soils that may be encountered such that the final design can be evaluated and if required, modified to better suit the anticipated soil conditions.

The above noted confirmatory work should be overseen by the retained Geotechnical Consultant.

5.3 Worker Safety

Worker safety is paramount.

Temporary excavations should comply with current regulations under the *Yukon Workers Compensation Board - Occupational Health & Safety Act*.

Excavation sidewall and slope stability will be dependent upon the material characteristics, configuration of the excavation/slope and length of exposure.

Slope stability will be poor if wet/saturated materials, fills or fine-grained materials are encountered and more gradual cut slopes will be required in these areas to minimize the potential for slope failure.

Cobbles and boulders should be removed from the excavation sidewalls and slopes such that they do not pose a hazard for workers.

Excavation sidewalls and embankment slopes should be monitored by qualified geotechnical personnel for signs of movement.

5.4 Construction Review, Monitoring and Inspection

A Geotechnical Consultant should be retained to review the design/drawings and the intended methods of construction prior to and during the work, in order to verify conformance with the geotechnical restrictions and assumptions. During construction, qualified geotechnical personnel should provide monitoring and inspection services to inspect and test the sub-grade, common and imported fills to verify that the materials conform to the required specifications and anticipated conditions.

The monitoring and inspection should be provided on a continuous basis throughout the course of construction.

6.0 CONCLUSIONS

The horizontal rural road alignments proposed by *Inukshuk Planning & Development Ltd.* appear to be feasible. However, additional evaluation would be required through drilling methodologies to verify the feasibility of any proposed vertical alignments following final design.

The upgrading of Cowley Creek crossing can be facilitated through the installation of dual (~1.5 m Ø) culverts (or else a mid-sized multi-plate) constructed by means of conventional cut/fill methodologies. If larger structures are required, then either deep foundation options or else the use of a permafrost cooling system would need to be considered.

The glacial till deposits which were encountered throughout the majority of the study area will be suitable for development of the proposed subdivision and construction of the access roads. Some work will however be required in order to remove near surface deleterious materials and prepare the site for rural road construction.

The presence of fine grained fluvial deposits and discontinuous permafrost within the region of the crossing will require additional consideration further to standard design and construction practices in order to allow for culvert installation and access road realignment. In addition, the presence of these soils and permafrost conditions will affect the long term performance of the culvert and roadway within the region of the crossing and so this should also be considered from a maintenance and design-life standpoint.

While there did not appear to be commercial quantities of locally available granular borrow sources located within the study area, adequate granular reserves would be located on the South Klondike Highway, across from the study area and/or towards the Alaska Highway.

7.0 LIMITATIONS

This report is intended for the sole use of the *Government of Yukon*. No portion of this report may be used as a separate entity; it is intended to be read in its entirety. Any use of this report by a third party is the responsibility of such third party.

The recommendations provided herein are based upon the subsurface conditions encountered at the time of our evaluation, current construction techniques and generally accepted engineering practices. The report content reflects our best judgment in light of the information available at the time of its preparation. It is important to emphasize that a geotechnical evaluation involves random sampling and that our comments are based upon the results obtained at the sample locations. Due to the geomorphological nature of the deposits encountered, interpolations of subsurface conditions between the test locations have not been made or implied other than for discussion purposes. The anticipated construction conditions have been discussed, but only to the extent that they may influence design decisions. Any references to construction methods contained herein expresses our opinion and are not intended to direct contractors on how to carry out construction. Prospective contractors should be aware that our interpretation of the data may not be sufficient to assess all factors that may have an effect upon construction and so this should be considered.

Our report is limited in that a detailed thermal assessment of the region was not conducted. Our recommendations have been provided without considering the affects of deep and long-term thaw of local (or regional) permafrost which may result from global warming, the proposed construction or other causes.

Should unexpected subsurface soils or conditions be encountered during construction, our firm should be notified immediately in order to confirm the suitability of our recommendations. If required, our firm may alter or modify our recommendations at such time.

8.0 CLOSURE

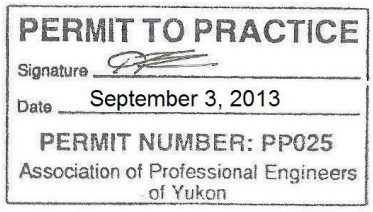
Thank you for providing *Chilkoot Geological Engineers Ltd.* with the opportunity to conduct the above noted geotechnical evaluation.

We trust that the information we have provided will be suitable for your purposes, however, if you should have any questions or concerns, please feel free to contact the undersigned at your convenience.

Respectfully Submitted,

CHILKOOT GEOLOGICAL ENGINEERS LTD.



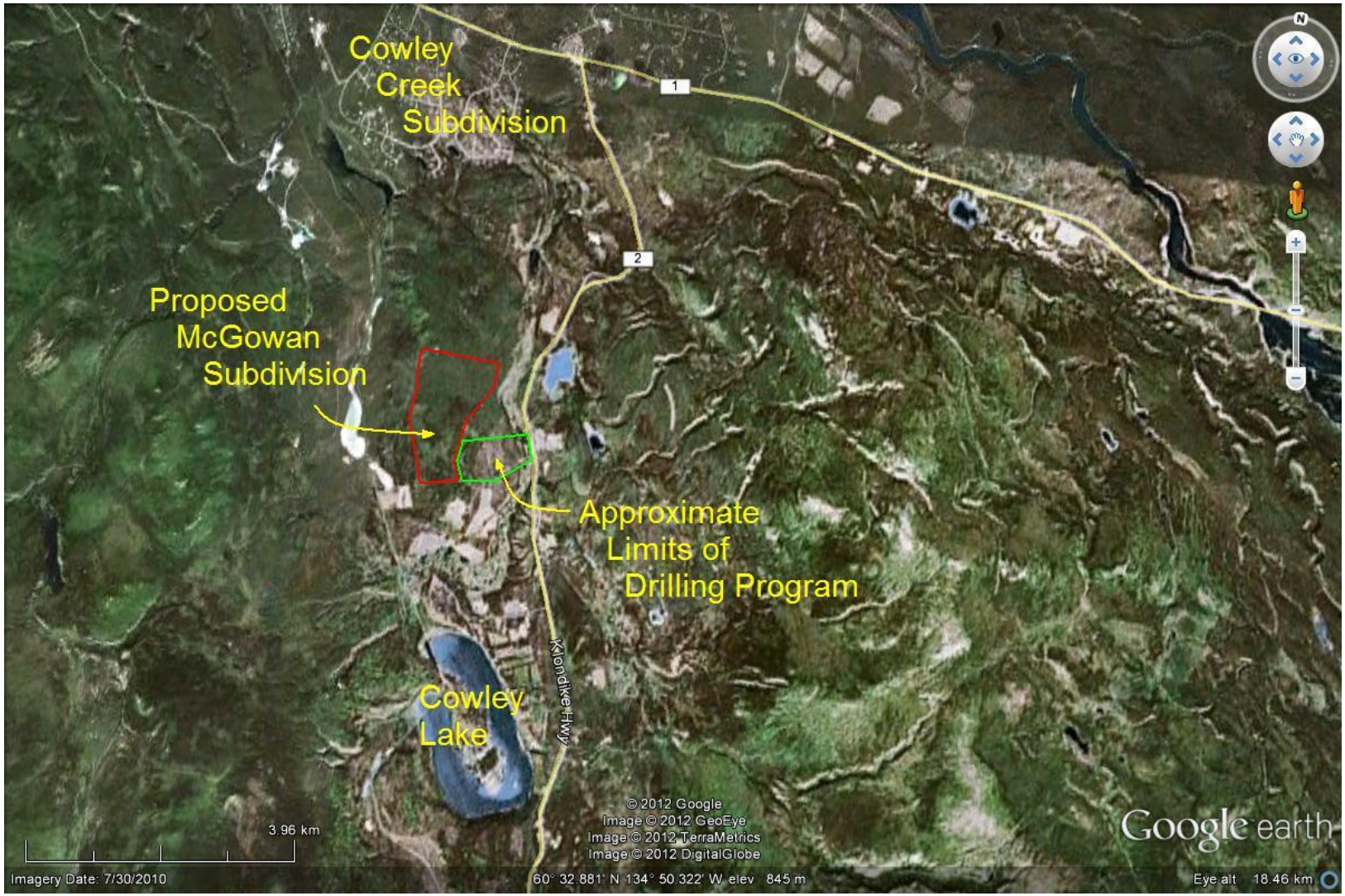


Tares Dhara, P.Eng.
Principal

TD/td

Geotechnical Evaluation - Proposed McGowan Subdivision, Whitehorse, Yukon – 2013

FIGURE 1 – Location of Study Area

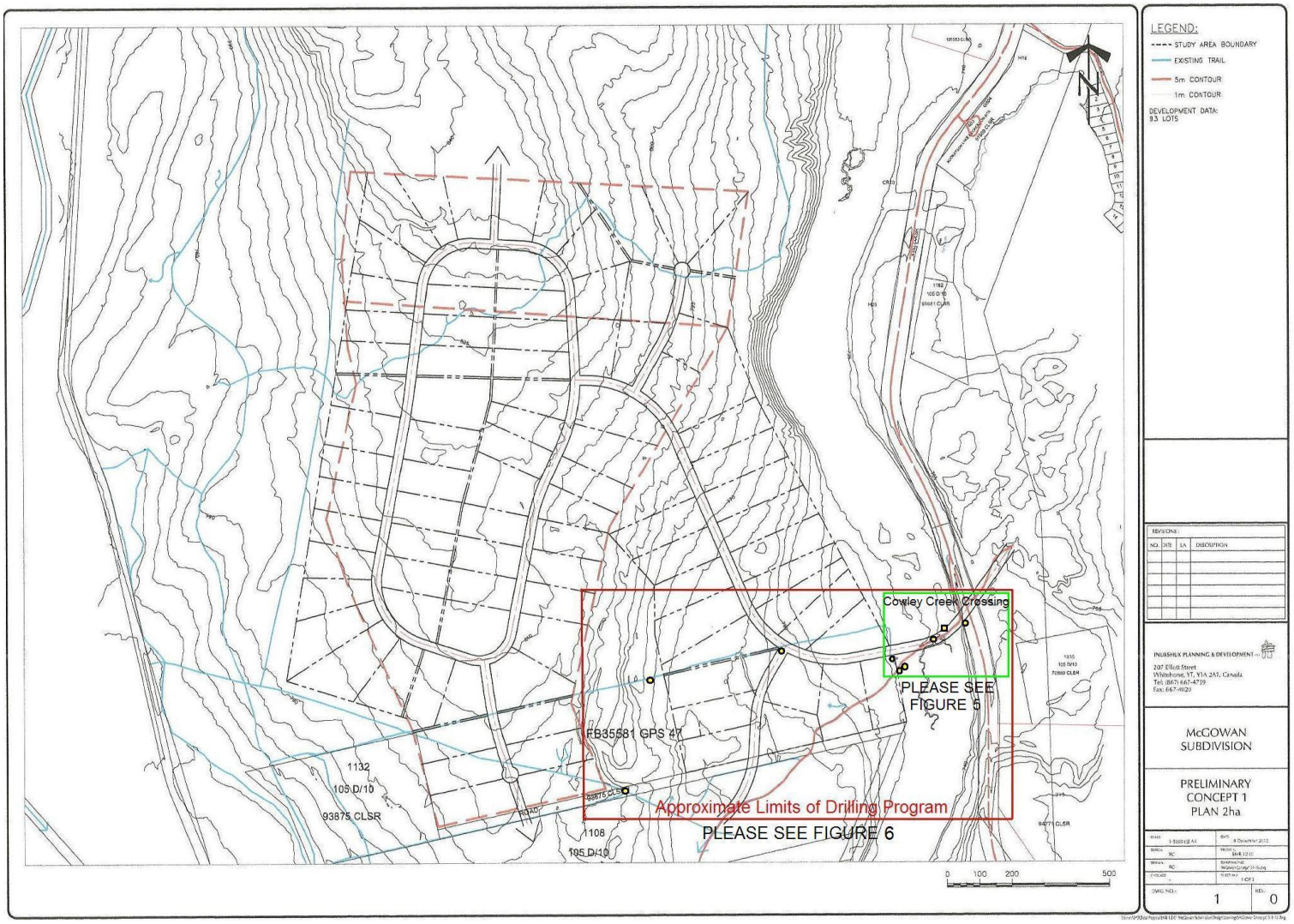


Based map modified from Google Earth

Compiled June 18, 2012 by T.Dhara

Geotechnical Evaluation - Proposed McGowan Subdivision, Whitehorse, Yukon – 2013

FIGURE 2 – Conceptual Road Alignment & Limits of Drilling Program



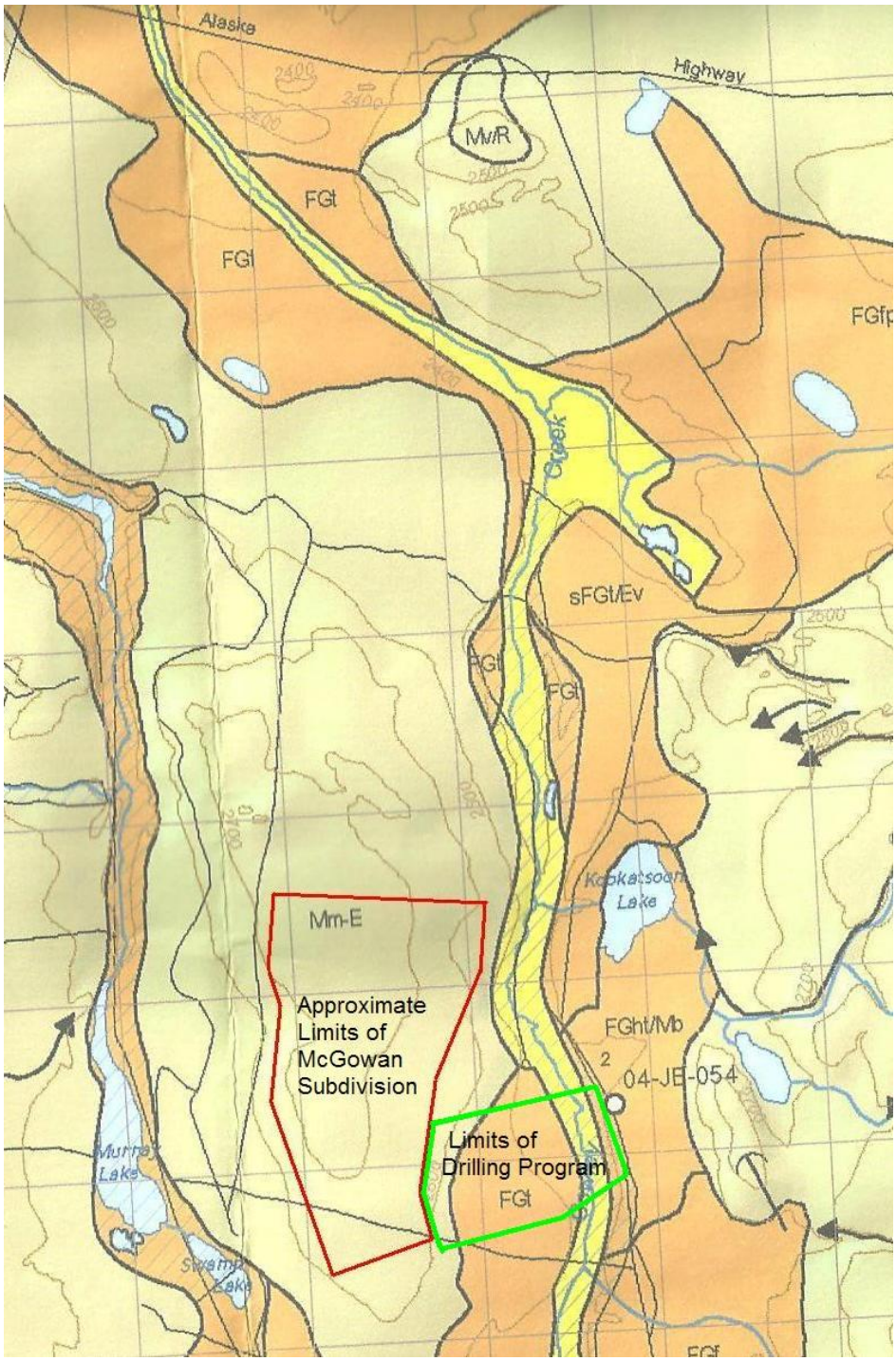
Based map modified from Inukshuk Planning & Development Ltd.

Compiled June 30, 2013 by T.Dhara

Geotechnical Evaluation

Proposed McGowan Subdivision, Whitehorse, Yukon – 2013

FIGURE 3 – Surficial Geology

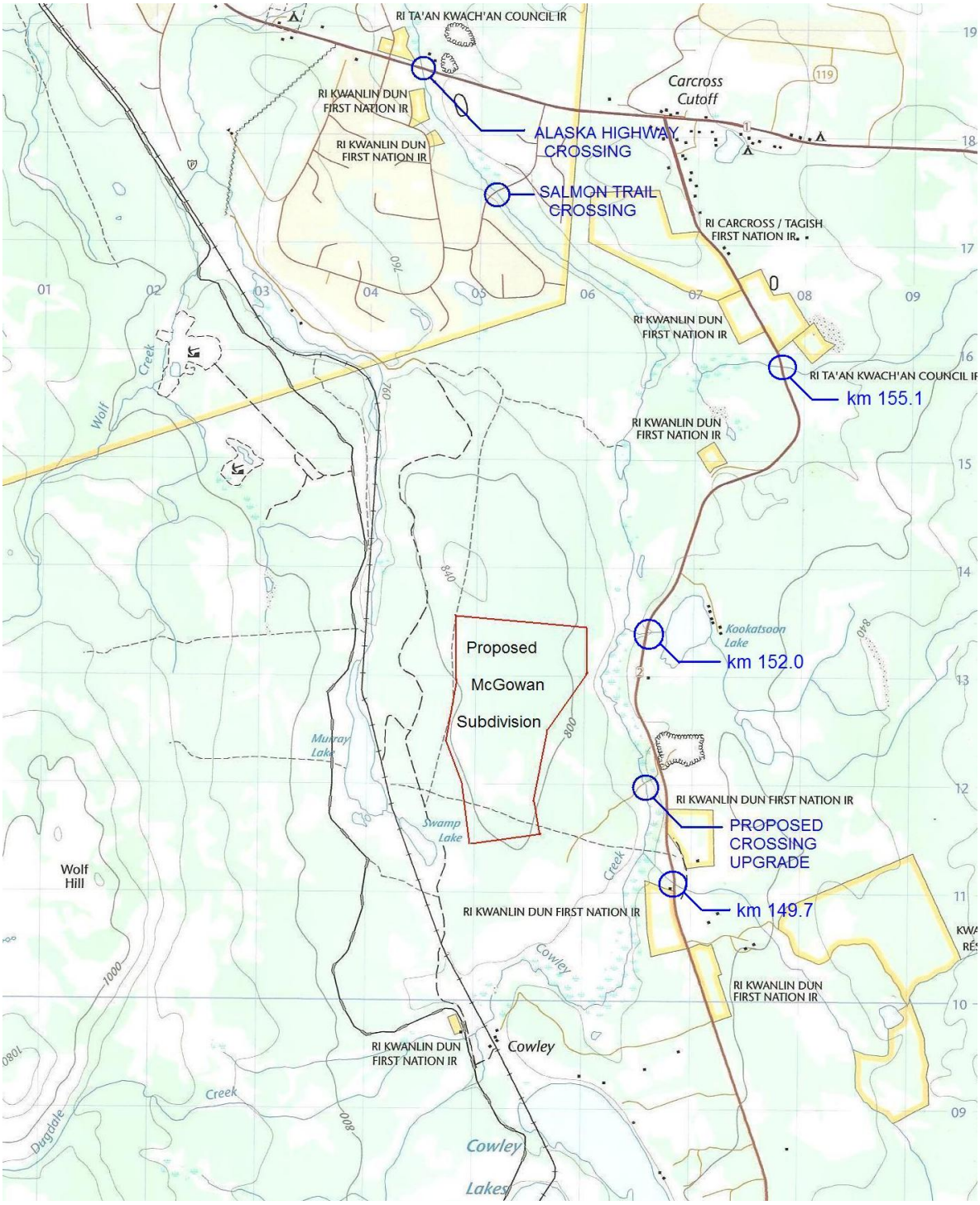


Based map modified from Geoscience Map # 2005-6 Compiled Aug.14, 2013 by T.Dhara

Geotechnical Evaluation

Proposed McGowan Subdivision, Whitehorse, Yukon – 2013

FIGURE 4 – 1:50,000 Scale Topographical Map & Cowley Creek Crossing Locations

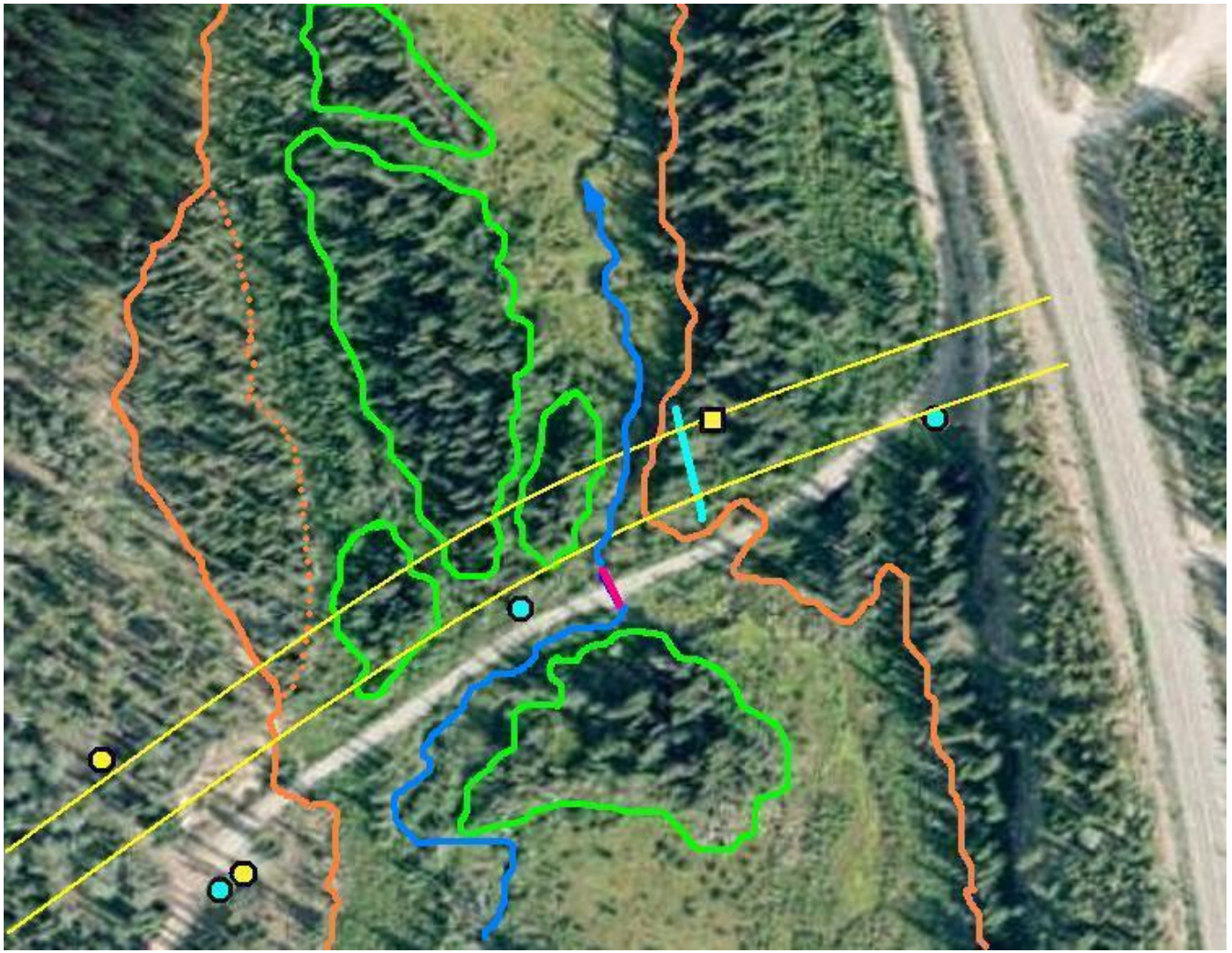


Based map modified from1:50:000 Scale Topographical Map

Compiled July 4, 2013 by T.Dhara

Geotechnical Evaluation - Proposed McGowan Subdivision, Whitehorse, Yukon – 2013

FIGURE 5 – Cowley Creek Crossing



LEGEND

- Proposed Road
- Test Pit
- Borehole (BH)
- BH w/ Well
- Existing Culvert
- Proposed Dual Culvert
- Embankment Transition
- 'Floodplain' Embankment
- Isolated Terraces
- Cowley Creek (location may vary)

N

NOT TO SCALE

Based map modified from YG Water Placer Atlas

Compiled July 4, 2013 by T.Dhara

FIGURE 6 – Borehole & Test Pit Locations



1-13 to 3-13 – Hollow-Stem Boreholes (Well Installations)

4-13 to 8-13 – Solid Stem Boreholes

TP1-13 – Test Pit Location

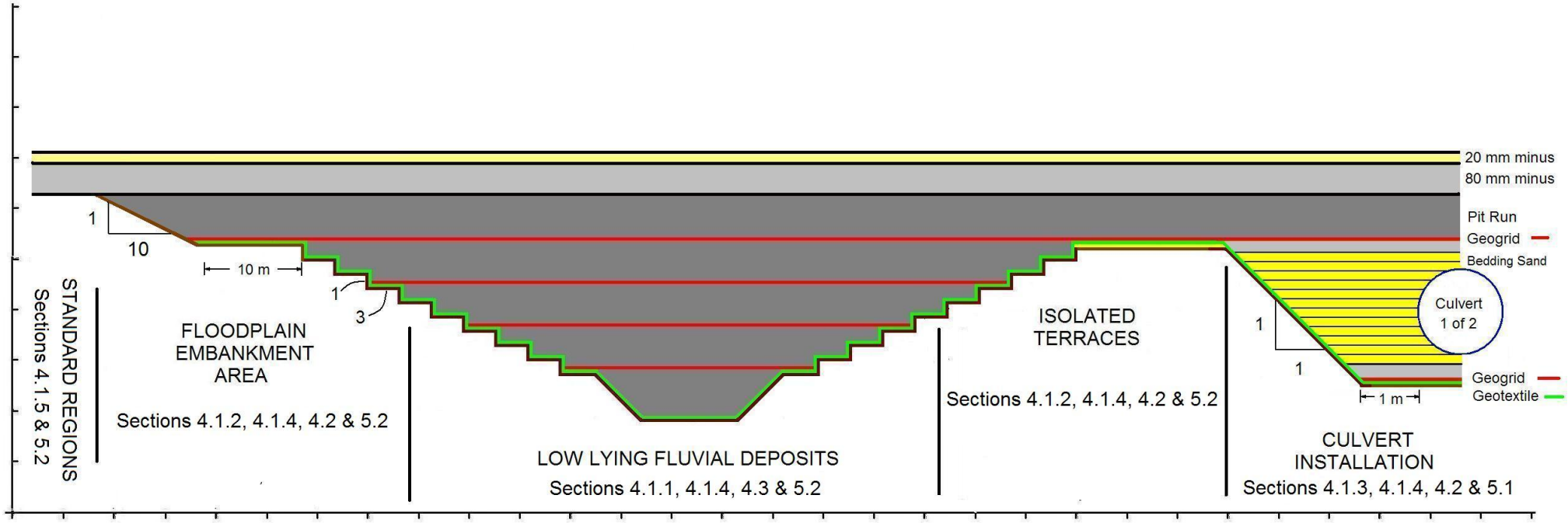
Base Plan obtained from YG Water Placer Atlas

Drawn by TD – June 30, 2013

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GEOTECHNICAL EVALUATION
PROPOSED McGOWAN SUBDIVISION
COWLEY CREEK CROSSING

FIGURE 7 - ROAD STRUCTURE PROFILE



Drawn by TD
August 15, 2013
Not to Scale
Not all pertinent sections have been referenced
For discussion purposes only
Not intended for construction

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5b Bennett Road, Whitehorse, YT

Geotechnical Evaluation - Proposed McGowan Subdivision

Table I - Groundwater Observations

	1-13	Culvert	Road	3-13	2-13	4-13	5-13
Elevation - Top of Standpipe/Culvert (@ Inlet)	737.28	735.08	NA	735.50	739.01	NA	NA
Existing Ground Surface	736.08	735.08	735.26	734.40	737.89	739.50	736.98
Groundwater at time of drilling	734.41	734.28	NA	733.87	734.45	734.32	734.54
Groundwater (April 19, 2013)	734.62	734.28	NA	734.40	734.79	NA	NA
Groundwater (July 1, 2013)	734.84	734.18	NA	734.53	734.96	NA	NA
Elevation - Base of Standpipe	730.78	NA	NA	728.68	731.98	NA	NA

Notes -

- Indicates frozen conditions

Values denoted approximate elevation in meters

Compiled by T.Dhara, P.Eng . - July 1, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5b Bennett Road, Whitehorse, Yukon

Geotechnical Evaluation - Proposed McGowan Subdivision

Table II - Stratigraphic Summary

Region	Cowley Creek Crossing					
	Eastern Embankment	Terraces	Floodplain	Western Embankment		
Borehole/Test Pit	BH 1-13	TP 1-13	BH 3-13	BH 2-13	BH 5-13	BH 4-13
Soil Unit	Fill - 0.9 m	Organics - 0.08 m	Organics - 0.2 m	Glaciofluvial > 6.25 m	Glaciofluvial > 3.05	Organics - 0.1 m
Soil Unit	Organics - 0.15 m	Fluvial - > 2.42 m	Organics Silts - 0.8 m			Till - 3.25 m
Soil Unit	Till - 1.08 m	Permafrost @ 2.3 m	Fluvial - > 5.25 m			Glaciofluvial > 3.25 m
Soil Unit	Glaciofluvial > 4.1					
Depth of Termination (m)	6.25	2.70	6.25	6.25	3.05	6.10

Region	Roadway	Higher Elevations	
Borehole/Test Pit	BH 6-13	BH 7-13	BH 8-13
Soil Unit	Organics - 0.02 m	Organics - 0.1 m	Fill - 0.15 m
Soil Unit	Glaciofluvial - 5.47 m	Glaciofluvial - 0.8 m	Till - > 9.0
Soil Unit		Till - 3.67 m	
Soil Unit	Fluvial > 0.6 m	Glaciofluvial > 1.53 m	
Depth of Termination (m)	6.10	6.10	9.15

Compiled by T.Dhara, P.Eng. - June 19, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.
5b Bennett Road, Whitehorse, Yukon

Geotechnical Evaluation - Proposed McGowan Subdivision

Table III - Summary of Local Elevations

GRADIENT OF WATER IN EXISTING CULVERT (%)	
Water Elevation - Existing Culvert Inlet (meters)	734.28
Water Elevation - Existing Culvert Outlet (meters)	733.96
Drop in water elevation between Inlet & Outlet of Existing Culvert	0.320
Length of Culvert (meters)	6.1
Gradient of Water in Existing Culvert (%)	**5.2**

GRADIENT OF EXISTING CULVERT (%)	
Elevation - Invert of Existing Culvert Inlet (meters)	733.58
Elevation - Invert of Existing Culvert Outlet (meters)	732.99
Drop in elevation between inlet and outlet at invert	0.59
Length of Culvert (meters)	6.1
Gradient of Existing Culvert (%)	**9.7**

GRADIENT OF CREEK ON OUTLET SIDE (%)	
Water Elevation - Existing Culvert Outlet (meters)	733.96
Water Elevation - At Creek near TP 1-13 (meters)	733.75
Drop in elevation between outlet and creek at TP 1-13 (meters)	0.21
Approximate distance from existing outlet to creek near TP 1-13 (meters)	30
Gradient of Creek on outlet side (%)	**0.70**

GRADIENT OF WATER WITHIN PROPOSED CULVERT (%)	
Distance (on north-south axis) between existing and proposed culvert inlets	11
Gradient of Creek on outlet side (%)	0.70
Drop in water elevation from existing inlet to proposed inlet (meters)	0.08
Water Elevation - Existing Culvert Inlet (meters)	734.28
Water Elevation - Proposed Culvert Inlet (meters)	734.20
Water Elevation - Proposed Culvert Outlet (meters)	733.70
Drop in water elevation between inlet and outlet	0.50
Length of Culvert (meters)	36.6
Gradient of Water within Proposed Culvert (%)	**1.37**

All elevations and distances are approximate/estimates

Compiled by T.Dhara, P.Eng. - July 25, 2013

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5b Bennett Road, Whitehorse, Yukon

Geotechnical Evaluation - Proposed McGowan Subdivision

Table III - Summary of Local Elevations

GRADIENT OF PROPOSED CULVERT (%)	
Elevation - Invert of Proposed Culvert Inlet - (meters)	733.70
Elevation - Invert of Proposed Culvert Outlet (meters)	733.06
Drop in elevation between inlet and outlet at invert	0.64
Length of Culvert (meters)	36.6
Gradient of Proposed Culvert (%)	**1.75**

GRADIENT OF PROPOSED ROAD FROM HIGHWAY TO PROPOSED CULVERT (%)	
Elevation of Ridge of Isolated Terrace (Eastern Embankment near TP 1-13)	735.94
Water Elevation - At Creek near TP 1-13 (meters)	733.75
Typical Height of Terrace (meters)	2.19
Height of Base Layer above Terrace (meters)	1.0
Thickness of proposed road structure - sub-base and base course (meters)	0.8
Elevation of top of proposed Culvert at mid-point (meters)	734.88
Proposed Road elevation at proposed Culvert mid-point (meters)	737.74
Road elevation at existing Culvert mid-point (meters)	735.26
Height of Proposed Road Surface above proposed inlet water elevation (meters)	3.54
Height of Proposed Road Surface above top of proposed culvert @ mid-point (meters)	2.86
Height of Proposed Road Surface above existing road surface (meters)	2.48
Elevation - Klondike Highway (meters)	746.0
Difference in elevation between Klondike Highway and proposed culvert road surface	8.26
Approximate distance from Klondike Highway to Proposed Culvert (meters)	85
Estimated grade from Klondike Highway to Proposed Culvert (%)	**9.7**

APPROXIMATE LENGTH OF PROPOSED CULVERT (%)	
Estimated length - cneterline to inlet side - assuming 5 meter wide road lanes (meters)	17.6
Estimated length - centerline to outlet side (meters)	19
Total Estimated Culvert Length	36.6

All elevations noted are relative to a local benchmark which was given an arbitrary elevation.

APPENDIX A

Soil Logs

NOTES ON SOIL LOGS

Soil Description

The soil is named after its principal component and modified by other components as follows;

Percent of Component	Modifier
> 15 %	XXX - ey
11% to 15%	some XXX
5% to 10%	trace XXX

Examples;

SILT	SAND	GRAVEL	Description
6	32	62	Sandy Gravel trace Silt
55	6	39	Gravelly Silt trace Sand
43	36	21	Silty Gravelly Sand

Note: In the cases where the coarse fraction (sand & gravel) comprise > 50% of the sample, then the larger component of the coarse fraction becomes the principal component.

Undrained Shear Strength of Cohesive Soils

Consistency	Undrained Shear Strength	
	p.s.f	kN/m^2
Very Soft	< 375	<20
Soft	375-750	20-40
Firm	750-1500	40-75
Stiff	1500-3000	75-150
Very Stiff	3000-6000	150-300
Hard	>6000	<300

Relative Density (Qualitative Classification)

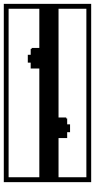
Cohesive Soils

Very Soft	- Exudes between fingers when squeezed by hand
Soft	- Moulded by light finger pressure
Firm	- Moulded by strong finger pressure
Stiff	- Cannot be moulded by fingers – Can be indented by thumb
Very Stiff	- Can only be indented by thumbnail
Hard	- Cannot be indented by thumbnail

Granular Soils

Very Loose	- Considerable sidewall sloughage noted
Loose	- Some sidewall sloughage noted – Easy digging
Compact/ Medium-Dense	- Unimpeded excavation – little to no sidewall sloughage
Dense	- Considerable effort required during excavation – Stable vertical sidewalls
Very Dense	- Extreme difficulty in excavation

Soil Log - Sample Type

Symbol	Test Pitting	Drilling
	**Grab Sample** Retained from excavation sidewall or base	**Auger Sample** Retained from Auger flighting
	**Bucket Sample** Retained from leading edge of excavator bucket	**Split-Spoon Sample** Retained from Split-Spoon Sampler tube



Relative Moisture

Described as - *dry, damp, moist, wet* or *saturated* - relative to the principal soil matrix.

> For example, a moisture content of 10 percent may be classified as '*moist*' for a coarse grained soil (sand or gravel) but '*damp*' for a fine grained (silt) soil.

The moisture content is recorded as a percentage (%) of the weight of water within the soil sample relative to the dry weight of the sample.

Recovery

Refers to the (linear) amount of sample retained after driving the Split Spoon (SPT) sampler tube 18 inches.

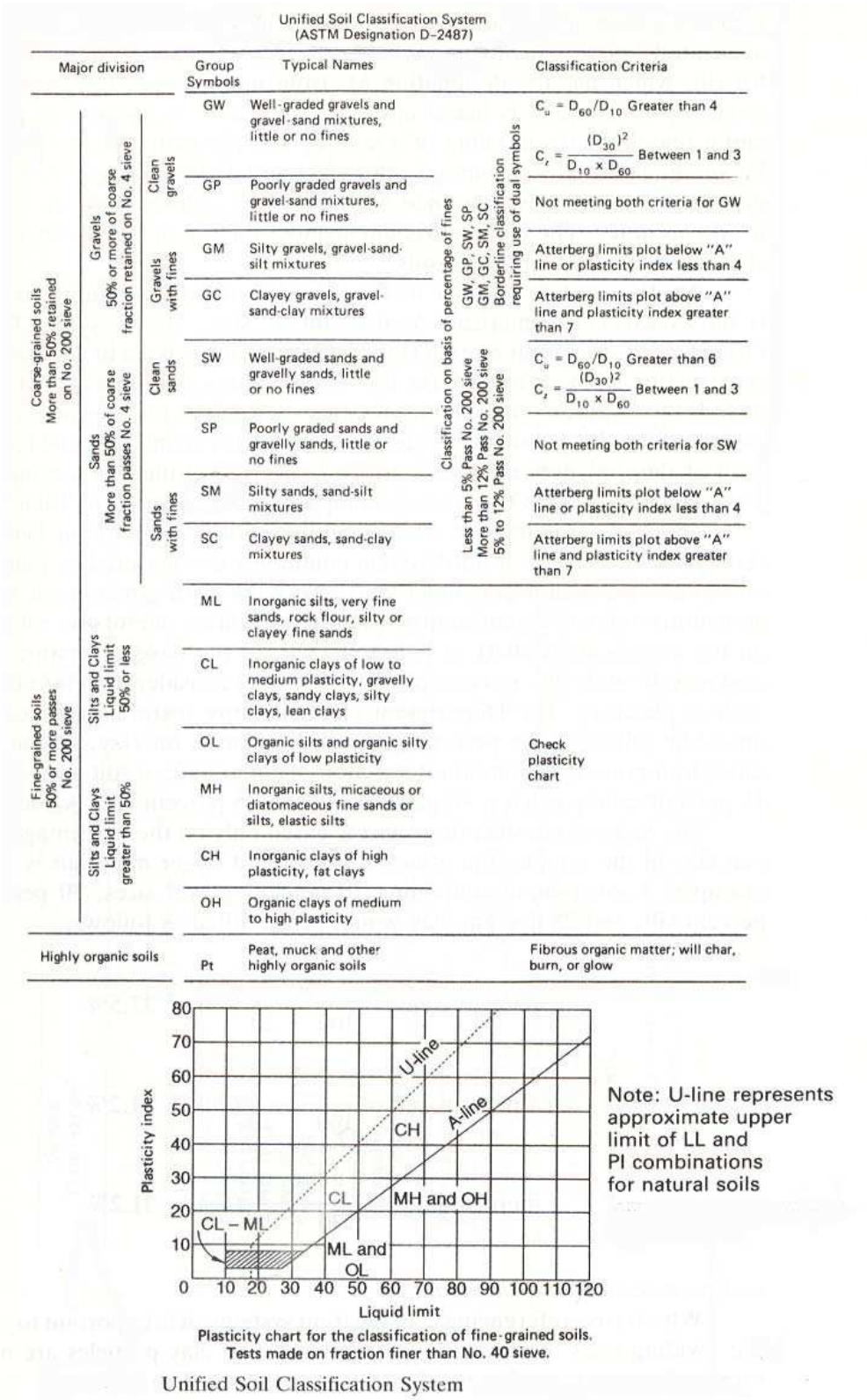
Recorded as a percentage (i.e. 12 inch sample/18 drive = 66 %)

N-Value

Refers to the total number of blows required to drive the Split Spoon sampler tube the final 12 inches of the 18 inch drive.

Relative Density based upon SPT 'N' Value

Non-cohesive (Granular) Soil		**Cohesive (Clayey) Soils**	
Relative Density	**Blows per Foot (N-value)**	**Consistency**	**Blows per Foot (N-value)**
Very Loose	< 5	*Very Soft*	0 to 2
Loose	5 to 9	*Soft*	3 to 4
Compact	10 to 29	*Firm*	5 to 8
Dense	30 to 50	*Stiff*	9 to 15
Very Dense	> 50	*Very Stiff*	16 to 30
		Hard	> 30



Unified Soil Classification System
(ASTM Designation D-2487)

Major division			Group Symbols	Typical Names	Classification Criteria
Coarse-grained soils More than 50% retained on No. 200 sieve	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	$C_u = D_{60}/D_{10}$ Greater than 4; $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits plot below "A" line or plasticity index less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits plot above "A" line and plasticity index greater than 7
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines	$C_u = D_{60}/D_{10}$ Greater than 6; $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines	Not meeting both criteria for SW
		Sands with fines	SM	Silty sands, sand-silt mixtures	Atterberg limits plot below "A" line or plasticity index less than 4
			SC	Clayey sands, sand-clay mixtures	Atterberg limits plot above "A" line and plasticity index greater than 7
Fine-grained soils 50% or more passes No. 200 sieve	Silts and Clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	Check plasticity chart
	Silts and Clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity	
Highly organic soils			Pt	Peat, muck and other highly organic soils	Fibrous organic matter; will char, burn, or glow

Classification on basis of percentage of fines
Less than 5% Pass No. 200 sieve: GW, GP, SW, SP
More than 12% Pass No. 200 sieve: GM, GC, SM, SC
5% to 12% Pass No. 200 sieve: Borderline classification requiring use of dual symbols

Note: U-line represents approximate upper limit of LL and PI combinations for natural soils

Plasticity chart for the classification of fine-grained soils.
Tests made on fraction finer than No. 40 sieve.

Unified Soil Classification System

Figure 18. UNIFIED SOIL CLASSIFICATION SYSTEM

Table 1.2 Description and classification of frozen soils (adapted from Linnell and Kaplar, 1966)

I: Description of soil phase (independent of frozen state)	Classify soil phase by the unified soil classification system						Classify soil phase by the unified soil classification system		
	Major group		Subgroup				Field identification	Pertinent properties of frozen materials which can be measured by physical tests to supplement field identification	Thaw characteristics
	Description	Designation	Description		Designation				
II: Description of frozen soil	Segregated ice not visible by eye	N	Poorly bonded or friable		Nf		Identify by visual examination; to determine presence of excess ice, use procedure under note (3) and hand magnifying lens as necessary; for soils not fully saturated estimate degree of ice saturation (medium, low); note presence of crystals or of ice coatings around larger particles	In-place temperature Density and void ratio *a.* In frozen state *b.* After thawing in place Water content (total H_2O, including ice) *a.* Average *b.* Distribution Strength *a.* Compressive *b.* Tensile *c.* Shear *d.* Adfreeze Elastic properties Plastic properties Thermal properties Ice crystal structure (using optical instruments) *a.* Orientation of axes *b.* Crystal size *c.* Crystal shape *d.* Pattern of arrangement	Usually thaw-stable
			Well bonded	No excess ice	Nb	a			
				Excess ice		c			
	Segregated ice visible by eye (ice 25 mm or less thick)	V	Individual ice crystals or inclusions		Vx		For ice phase, record the following as applicable Location, Size, Orientation, Shape, Thickness, Pattern of arrangement, Length, Spacing, Hardness, Structure, Color } per part III below Estimate volume of visible segregated ice present as percent of total sample volume		Usually thaw-unstable
			Ice coatings on particles		Vc				
			Random or irregularly oriented ice formations		Vr				
			Stratified or distinctly oriented ice formations		Vs				
III: Description of substantial ice strata	Ice greater than 25 mm thick	ICE	Ice with soil inclusions		ICE + soil type		Designate material as ice and use descriptive terms as follows, usually one item from each group, as applicable: Hardness: hard, soft (of mass, not of individual crystals) Structure: clear, cloudy, porous, candled, granular, stratified Color: colorless, gray, blue Admixtures: contains few thin silt inclusions	Same as part II above, as applicable, with special emphasis on ice crystal structure	
			Ice without soil inclusions		ICE				

(see notes on p. 32)

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

TEST PIT SOIL LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-12

Date Excavated: June 4, 2013
Elevation : 735.14 meters
Depth of TP: 2.7 meters
Instrumentation: NA

TEST PIT

1-13

Sheet 1 of 1

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery (%)	Penetrometer (kg/cm2)	PID	Laboratory Results (%)
735.0		0.05	SURFICIAL ORGANICS (80 mm) - Labrador Tea Cover, moss, organic silt and rootlets, black-brown	soft	moist							
		0.20		loose	moist							
	1.0			compact	moist	X	1	NA	NA	NA	NA	31.7
				frozen								
		0.5	SANDY SILT some Rootlets - fine grained, non-plastic, light-brown/tan			X	2	-0.4	NA	NA	NA	19.7
734.5	2.0											
	3.0		- as above - dark brown with Organic inclusions in size to 75 mm and decreasing rootlets	firm	moist	X	3	0.2	NA	0.75-1.0	NA	21.0
734.0	4.0											
		1.0	Seasonally Frozen 0.3 m to 0.9 m - brown									
	5.0											
733.5		1.5	- as above but thawed - decreasing sand content									
	6.0											
		2.0	- as above but increasing sand content				4	0.2	NA	NA	NA	20.1
733.0	7.0											
		2.30										
		2.40	SILTY SAND trace Rootlets & Organics - fine to medium grained, poorly graded, zones of orange oxidation in size to 30 mm, grey - Frozen - well bonded no excess ice	frozen	moist		5	-0.3	NA	NA	NA	22.7
	8.0	2.50		frozen	moist		6	-0.3	NA	NA	NA	24.4
		2.5		frozen	wet		7	-0.2	NA	NA	NA	19.3
732.5		2.70					8	-0.2	NA	NA	NA	37.9
			SANDY SILT trace Rootlets & Organics - grey - Frozen - well bonded - no excess ice									27.0
			SANDY SILT some CLAY trace Rootlets & Organics - slightly plastic - blue/grey-brown - well bonded with excess ice									32.0
732.0												
			End of Test Pit @ 2.7 meters - No groundwater, seepage zones or slough encountered									
731.5												
731.0												
730.5												

USCS/NRC	Depth (m)	Symbol	Elev. (m)
ORG			735.14
ML			735.09
			735.0
			734.84
	1.0		734.5
ML			734.24
	2.0		734.0
			733.5
			733.14
			733.0
			732.84
Nbn (SM)			732.74
Nbn (ML)			732.64
Nbe (CL-ML)			732.5
			732.44
			732.0
			731.5
			731.0
			730.5

Contractor: Yellow Truck Excavating Inc. Excavator: Bobcat E35 Mini-Excavator Bucket Type: Digging Bucket

Water Level(s)
- During Excavation
- At End of Excavation
- 30 min after Exavation

Logged By : G.Keitel
Date : June 4, 2013

Data Entry By : T.Dhara, P.Eng.
Date : June 5, 2013

Reviewed By:
Date : June 12, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 11, 2013
Elevation : 736.08 meters
Depth of BH: 6.25 meters
Instrumentation: Monitoring Well

BOREHOLE **1-13**
Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
736.0		0.15	ROAD BASE - SANDY GRAVEL - poorly graded, gravel in size to 50 mm, grey-brown - Seasonally Frozen	Frozen	Moist								FILL		736.08
	1.0			Frozen	Moist										736.0
		0.5													735.93
735.5	2.0		SILTY SAND some GRAVEL (TILL FILL) - poorly graded, fine to medium grained, gravel in size to 20 mm, fragments of black rock inclusions in size to 3 mm, light brown - Seasonally Frozen to 1.07 meters												735.5
		0.90				X	1	NA	NA	NA	NA		FILL		
	3.0	1.05		Soft	Moist										735.32
735.0		1.22													735.18
	4.0			Dense	Moist								ORG		735.03
		1.37													735.0
		1.5													734.86
734.5	5.0		- as above but grey-brown										SM		734.71
			ORGANICS - rootlets and organic silt, black												734.62
	6.0		SILTY SAND (TILL) - poorly graded, fine grained, odd fractured gravel in size to 12 mm, fragments of black rock inclusions in size to 2 mm, trace oxidation, grey-brown												734.5
		2.0											2.0		
734.0	7.0	2.13													734.08
	8.0														
		2.5													
733.5		2.74													733.5
	9.0		- possible groundwater interface @ 1.46 m	Compact	Wet										733.34
		2.90		Compact	Wet								SP		733.18
		3.0	- easier drilling @ 2.13 m - possible glacio-fluvial deposit				3	NA	100	NA	19		SP SM		733.0
733.0	10.0	3.20													732.88
			SAND - poorly graded, fine grained, brown												
	11.0	3.5													732.5
732.5			GRAVELLY SAND trace SILT - poorly graded, medium to coarse grained, washed, brown												
	12.0														
		4.0											4.0		
732.0	13.0														732.0
		4.27													731.81
	14.0		GRAVELLY SAND trace SILT - poorly graded, medium to coarse grained, brown - cobble (Refusal during SPT)	Dense	Wet		4	NA	83	NA	45		SP		
		4.5													731.51
731.5		4.37													731.43
	15.0	4.65													
	16.0														731.43
		5.0											5.0		

Laboratory Results (%): ▲ - FINES ● - SAND ■ - GRAVEL; PL, MC, LL; 20 40 60 80

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 200 mm Hollow Stem | Bit Type : Carbide-Button

Water Level(s)
▽ During Drilling ▽ After Drilling ▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 11, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 11, 2013
Elevation : 736.08 meters
Depth of BH: 6.25 meters
Instrumentation: Monitoring Well

BOREHOLE

1-13

Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
731.0												▲ - FINES ● - SAND ■ - GRAVEL; MC; PL; LL; 20 40 60 80			(continued) 731.0
	17.0														
	18.0	5.5													
730.5															730.5
		5.79													Caved 730.29
	19.0		Compact SAND some GRAVEL - poorly graded, medium to coarse grained, brown		Wet										5.54
		6.0					5	NA	100	NA	17	4.9 ▲ 13.9 ■ 13.1		SP	
730.0	20.0											82.0 ●			730.0
		6.25	Borehole terminated at 6.25 m. below the existing ground surface.												729.83
729.5															729.5
729.0															729.0
728.5															728.5
728.0															728.0
727.5															727.5
727.0															727.0
726.5															726.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 200 mm Hollow Stem | Bit Type : Carbide-Button

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 11, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 12, 2013
Elevation : 737.88 meters
Depth of BH: 6.25 meters
Instrumentation: Monitoring Well

BOREHOLE 2-13
Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
												▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80			
		0.30	GRAVELLY SILTY SAND - poorly graded, fine grained, gravel in size to 30 mm, brown - Seasonally Frozen to 0.9 meters	Frozen	Moist								SM		737.88
737.5	1.0			Frozen	Moist										737.58
	0.5												SM		737.5
	2.0	0.76	SILTY SAND trace GRAVEL - poorly graded, fine grained, gravel in size to 10 mm, light brown				6	NA	NA	NA	NA	6.9			737.12
737.0	3.0	1.0										6.0 18.4 75.5	1.0		737.0
		1.22										8.6			736.66
	4.0	1.25	GRAVELLY SILTY SAND - poorly graded, fine grained, light brown	Dense	Moist		7	NA	100	NA	41		SM		736.63
736.5				Dense	Damp							3.5	SP-SM		736.5
	5.0	1.5					8	NA	100	NA	41	0.2 7.8 91.9			736.2
		1.68	SAND trace SILT - poorly graded, fine to medium grained, light brown												
736.0	6.0	2.0													736.0
	7.0														
735.5	8.0	2.5													735.5
		2.74													735.14
	9.0		SAND trace SILT - poorly graded, fine to medium grained, light brown - possible groundwater interface	Dense	Wet		9	NA	100	NA	44	6.5 18.6 89.4	SP-SM		735.0
735.0	10.0	3.0													734.68
		3.20													
734.5	11.0	3.5													734.5
	12.0														
734.0	13.0	4.0											4.0		734.0
		4.27													733.61
	14.0		GRAVELLY SAND trace SILT - well graded, medium to coarse grained, gravel in size to 20 mm, brown	V.Dense	Wet		10	NA	100	NA	63	8.2 8.1 35.8 56.0	SW-SM		733.5
733.5	15.0	4.5													733.16
		4.72													
733.0	16.0	5.0											5.0		733.0
															733.16

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 200 mm Hollow Stem | Bit Type : Carbide-Button

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 12, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 12, 2013
Elevation : 737.88 meters
Depth of BH: 6.25 meters
Instrumentation: Monitoring Well

BOREHOLE
2-13
Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
												▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80			(continued)
732.5	17.0														732.5
	18.0	5.5												Caved	
		5.79													732.09
732.0	19.0		SANDY GRAVEL trace SILT - well graded, medium to coarse grained, gravel in size to 35 mm, brown	V.Dense	Wet		11	NA	100	NA	82	6.2 / 8.0 / 38.8 / 53.1	GW-GW 0.0		732.0
	20.0	6.0													
		6.25	Borehole terminated at 6.25 m. below the existing ground surface.												731.63
731.5															731.5
731.0															731.0
730.5															730.5
730.0															730.0
729.5															729.5
729.0															729.0
728.5															728.5
728.0															728.0

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 200 mm Hollow Stem | Bit Type : Carbide-Button

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 12, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 13, 2013
Elevation : 734.39 meters
Depth of BH: 6.25 meters
Instrumentation: Monitoring Well

BOREHOLE

3-13

Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	USCS/NRC	Depth (m)	Symbol	Elev. (m)
734.0		0.20	ORGANIC MAT - Rootlets and Organic Silt, black	Frozen	Wet							ORG			734.39
	1.0	0.50		Frozen	Wet										734.19
	0.5	0.60	ORGANIC SILT & ORGANICS trace fine SAND odd GRAVEL - low plasticity, gravel in size to 10 mm, black - visible granulated ice lens up to 100 mm thick	Frozen	Wet							Nbn (OL)			734.0
	2.0			Frozen	Wet	X	12	-0.1	NA	NA	NA				733.89
733.5	3.0	1.00										ICE			733.79
		1.0		Frozen	Wet							Nbn (OL)			733.54
	4.0		ORGANIC SILT - Frozen												733.5
		1.37													733.39
733.0			SILTY SANDY CLAY - low plasticity, odd rootlet, grey & brown - Frozen	Very Soft	Wet		13	NA	66	0.25	2	Nbn (CL)	1.0		
	5.0	1.5													733.02
		1.68													733.0
	6.0		SILTY SANDY CLAY - low plasticity, fine grained sand, odd rootlets up to 1 mm diameter and 5 mm in length, grey & brown with mottled streaks of oxidation - Frozen to 1.52 meters									CL			732.87
732.5		2.0													732.71
	7.0														732.5
													2.0		
732.0	8.0	2.5													732.0
		2.74													731.65
	9.0		CLAYEY SANDY SILT - low plasticity, fine grained sand, grey with mottled streaks of oxidation	Stiff	Wet							CL-ML			731.5
731.5		3.0					14	NA	78	1.5 2.25	10		3.0		731.29
	10.0	3.10													
731.0	11.0														731.0
		3.5													
	12.0														
730.5															730.5
	13.0	4.0											4.0		
		4.27													730.12
	14.0		SILTY GRAVELLY SAND - poorly graded, gravel in size to 35 mm, grey	Compact	Wet		15	NA	56	NA	18	SM			730.0
730.0		4.52													729.87
	15.0														
729.5															729.5
	16.0	5.0											5.0		729.87

Laboratory Results (%): ▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 200 mm Hollow Stem | Bit Type : Carbide-Button

Water Level(s): During Drilling; After Drilling; At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 13, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 13, 2013
Elevation : 734.39 meters
Depth of BH: 6.25 meters
Instrumentation: Monitoring Well

BOREHOLE **3-13** Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
729.0	17.0	5.5										▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80			(continued)
	18.0														729.0
		5.79												Caved	
728.5	19.0		Compact GRAVELLY SAND some SILT - (influx)		Wet		16	NA	100	NA	20	11.1 1.8 19.5		o	5.49 728.6
		6.05											SP-SM 6.0		728.5 728.34
	20.0		Compact SILTY GRAVELLY SAND - poorly graded, fine grained, grey		Wet		17		100			15.6 36.5 47.8 68.7	SM		728.14
728.0		6.25	Borehole terminated at 6.25 m. below the existing ground surface.												728.0
727.5															727.5
727.0															727.0
726.5															726.5
726.0															726.0
725.5															725.5
725.0															725.0
724.5															724.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 200 mm Hollow Stem | Bit Type : Carbide-Button

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 13, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 15, 2013
Elevation : 739.5 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE **4-13**
Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Panetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
		0.10	ORGANICS some SILT, fine SAND and rootlets, odd GRAVEL - black - Seasonally Frozen	frozen	moist		18	NA	NA	NA	NA		ORG		739.5 739.4
739.0	1.0	0.5	SILTY GRAVELLY SAND (TILL) - poorly graded, fine to medium grained, gravel in size to 30 mm, brown - Seasonally Frozen to 1.2 meters	frozen	damp		19	NA	NA	NA	NA	6.4			739.0
738.5	3.0	1.0											1.0		738.5
	4.0			compact	damp							3.0			738.3
738.0	5.0	1.5	GRAVELLY SILTY SAND (TILL) - poorly graded, fine to medium grained, gravel in size to 30 mm, brown				20	NA	NA	NA	NA				738.0
	6.0											3.8	SM		737.6
737.5		2.0	- as above				21	NA	NA	NA	NA	20.5 22.0 50.5	2.0		737.5
	7.0			dense	damp										737.37
	8.0		- odd cobble in size to 150 mm												737.06
737.0		2.5	- hard grindy drilling - possible boulders	v.dense	damp										737.0
	9.0											3.1			736.65
736.5		3.0	- as above				22	NA	NA	NA	NA		3.0		736.5
	10.0		- refusal in BH 4-13 @ 3.05 m - Borehole (4B-13) relocated 2 meters south												736.45
	11.0	3.35	GRAVELLY SAND some SILT (Possible Glaciofluvial Deposit) - poorly graded, fine to medium grained, gravel in size to 50 mm, brown	compact	moist							7.4			736.15
736.0		3.5					23	NA	NA	NA	NA				736.0
	12.0														
735.5	13.0	4.0										9.8	SM		735.3
	14.0		- as above				24	NA	NA	NA	NA	14.6 24.8 60.7	4.0		735.0
735.0	15.0	4.5													734.7
	16.0		- as above				25	NA	NA	NA	NA	8.9	5.0		736.15 734.5
734.5		5.0													

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
During Drilling | After Drilling | At End of Drilling

Logged By : T.Dhara. P.Eng.
Date : April 15. 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 15, 2013
Elevation : 739.5 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE **4-13**
Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
				compact (continued)	moist (continued)							▲-FINES ●-SAND ■-GRAVEL; MC; PL; LL; 20 40 60 80			(continued)
	17.0		GRAVELLY SAND some SILT (Possible Glaciofluvial Deposit) - poorly graded, fine to medium grained, gravel in size to 50 mm, brown - possible groundwater	compact	wet							⊙ 7.1			734.32
734.0	18.0	5.5					26	NA	NA	NA	NA		SM		Caved to 5.18
	19.0		- as above				27	NA	NA	NA	NA	⊙ 10.4	6.0		734.0
733.5		6.0													733.6
	20.0	6.10	Borehole terminated at 6.10 m. below the existing ground surface.												733.5
															733.4
733.0															733.0
732.5															732.5
732.0															732.0
731.5															731.5
731.0															731.0
730.5															730.5
730.0															730.0
729.5															729.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 15, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 15, 2013
Elevation : 736.98 meters
Depth of BH: 3.05 meters
Instrumentation: NA

BOREHOLE

5-13

Sheet 1 of 1

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
736.5	1.0	0.5	GRAVELLY SAND - poorly graded, fine to medium grained, brown - Seasonally Frozen to 0.9 m	Frozen	Damp	X	28	NA	NA	NA	NA	5.9	SP		736.98
	3.0	0.91													736.5
736.0	4.0	1.0	SAND - poorly graded, medium to coarse grained, brown	Compact	Damp	X	29	NA	NA	NA	NA	3.7	1.0		736.07
735.5	5.0	1.5													736.0
	6.0	2.0	- possible cobble												735.5
735.0	7.0	2.29													735.15
	8.0	2.5	SAND some SILT - poorly graded, fine grained, brown - possible groundwater - as above	Compact / Loose	Moist / Wet	X	30	NA	NA	NA	NA	0.0 / 11.0 / 18.7 / 20.4	2.0		735.0
734.5	9.0					X	31	NA	NA	NA	NA	89.0			734.69
734.0	10.0	3.05	Borehole terminated at 3.05 m. below the existing ground surface.										3.0		734.54 Caved 734.5 to 734.33
733.5															734.0
733.0															733.5
732.5															733.0
732.0															732.5
															732.0

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
▽ During Drilling ▽ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 15, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
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BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 15, 2013
Elevation : 752.5 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE **6-13**
Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
		0.02	ROOTLETS & ORGANICS - brown-black - Seasonally Frozen	Frozen	Moist								ORG		752.5
	1.0			Frozen	Dry-Damp										752.48
752.0		0.5	SILTY SAND odd GRAVEL - poorly graded, fine grained, gravel in size to 10 mm, orange-brown - Seasonally Frozen to 0.7 m				32	NA	NA	NA	NA	5.5 / 0.0 / 18.1 / 81.9	SM		752.0
	2.0	0.70		Compact	Dry-Damp										751.8
	3.0	1.0	SAND some SILT odd GRAVEL - poorly graded, fine grained, gravel in size to 10 mm, brown				33	NA	NA	NA	NA	3.5	1.0		751.5
	4.0						34	NA	NA	NA	NA	3.5			751.28
751.0	5.0	1.5	- as above but no gravel												751.0
	6.0						35	NA	NA	NA	NA	3.1 / 0.0 / 10.4 / 89.6			750.55
750.5		2.0	- as above										SP-SM		750.5
	7.0														750
750.0	8.0	2.5	- as above				36	NA	NA	NA	NA	4.3	2.0		750.0
	9.0														
749.5	10.0	3.0											3.0		749.5
	11.0														749
749.0		3.50	SANDY SILT - slight-plasticity, grey	Compact	Moist		37	NA	NA	NA	NA	12.6 / 6.0 / 15.5 / 84.5			749.0
	12.0												ML		
	13.0	4.00	SANDY SILT - non-plastic, light brown	Compact	Damp										748.5
748.5	14.0		- as above				38	NA	NA	NA	NA	7.4 / 8.1	4.0		748.25
748.0	15.0	4.5	- as above				39	NA	NA	NA	NA		ML		748.0
	16.0														747.8
747.5		5.0											5.0		748.5 747.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
During Drilling | After Drilling | At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 15, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By: D
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 15, 2013
Elevation : 752.5 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE
6-13
Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
	17.0		SANDY SILT - non-plastic, light brown	Compact (continued)	Damp (continued)							▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80; 9.1			(continued)
							40	NA	NA	NA	NA		ML		Caved 747.01
747.0	18.0	5.49 5.5													747.0
			CLAYEY SILT - low plasticity, grey	Soft	Wet							24.0			14.4
	19.0						41	NA	NA	NA	NA		CL-ML		
746.5		6.0											6.0		746.5
	20.0	6.10	Borehole terminated at 6.10 m. below the existing ground surface.												746.4
746.0															746.0
745.5															745.5
745.0															745.0
744.5															744.5
744.0															744.0
743.5															743.5
743.0															743.0
742.5															742.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
▽ During Drilling ▽ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 15, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 16, 2013
Elevation : 771.5 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE **7-13**
Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
771.5	0.10		ORGANIC SILT & ORGANICS some SAND and GRAVEL - gravel in size to 30 mm, black - Seasonally Frozen	Frozen / Frozen	Moist / Damp	X	42	NA	NA	NA	NA	13.9	ORG		771.5 / 771.4
771.0	1.0 / 0.5		SANDY GRAVEL trace SILT - poorly graded, fine to medium grained, brown - Seasonally Frozen to 0.9	Dense	Damp	X	43	NA	NA	NA	NA	2.9 / 8.4 / 28.9 / 62.7	GP-GM		771.0 / 770.6
770.5	3.0 / 1.0		SILTY SAND trace GRAVEL (TILL) - poorly graded, fine grained, odd black rock fragment in size to 1 mm, gravel in size to 30 mm, light brown			X	44	NA	NA	NAN	NA	5.2	SM		770.5 / 770.0
770.0	5.0 / 1.5														
769.5	6.0 / 2.0		- as above			X	45	NA	NA	NA	NA	4.7			769.5 / 769.3
769.0	8.0 / 2.44			Dense	Moist										769.06
	2.5		SANDY SILT (TILL) - non-plastic, light brown												769.0
768.5	9.0		- as above			X	46	NA	NA	NA	NA	0.0 / 11.9 / 18.9 / 81.0			768.65
	10.0 / 3.0		- as above but some GRAVEL												768.45
768.0	11.0 / 3.5		- as above			X	47	NA	NA	NA	NA	10.0	ML		768.1 / 768.0
767.5	12.0 / 13.0 / 4.0														767.5
	4.11		GRAVELLY SANDY SILT (TILL) - non-plastic, light brown	Dense	Damp	X	48	NA	NA	NA	NA	7.0			767.39
767.0	14.0 / 4.5														
	4.57		GRAVELLY SAND some SILT (glaciofluvial)	V.Dense	Damp	X	49	NA	NA	NA	NA	4.2 / 11.4 / 38.1 / 50.6	ML / SP-SM		767.0 / 766.93
766.5	15.0 / 16.0 / 5.0														766.49 / 766.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
During Drilling | After Drilling | At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 16, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 16, 2013
Elevation : 771.5 meters
Depth of BH: 6.1 meters
Instrumentation: NA

BOREHOLE
7-13
Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
766.4															766.4
	17.0		GRAVELLY SAND some SILT (glaciofluvial) - poorly graded, medium to coarse grained, gravel in size to 30 mm, brown	V.Dense	Damp							▲-FINES ●-SAND ■-GRAVEL PL MC LL 20 40 60 80			
766.0	18.0	5.5	- grindy drilling - possible cobbles and boulders @ 5.1 meters				50	NA	NA	NA	NA	4.0	SP-SM		766.0
	19.0											6.3			
765.5		6.0					51	NA	NA	NA	NA		6.0		765.5
	20.0		Borehole terminated at 6.10 m. below the existing ground surface.												765.4
765.0															765.0
764.5															764.5
764.0															764.0
763.5															763.5
763.0															763.0
762.5															762.5
762.0															762.0
761.5															761.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 16, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
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BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 16, 2013
Elevation : 786.5 meters
Depth of BH: 9.15 meters
Instrumentation: NA

BOREHOLE **8-13**
Sheet 1 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degrees C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
786.5												▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80			786.5
		0.15		Frozen	Wet								FILL		786.35
	1.0		SILTY GRAVELLY SAND - poorly graded, fine to medium grained, brown - Seasonally Frozen	Frozen	Moist										
786.0		0.5					52	NA	NA	NA	NA	8.8			786.0
	2.0		SILTY SAND trace GRAVEL (TILL) - poorly graded, fine to medium grained, gravel in size to 10 mm, brown												
							53	NA	NA	NA	NA	8.1			
785.5	3.0	1.0											SM 1.0		785.5
	4.0											8.1			
							54	NAN	NA	NA	NA	5.2			785.1
785.0	5.0	1.5	- Seasonally frozen to 1.6 meters												785.0
		1.60													784.9
	6.0		SILTY SAND odd GRAVEL (TILL) - poorly graded, fine to medium grained, gravel in size to 10 mm, brown	Compact	Dry-Damp										
784.5		2.0					55	NA	NA	NA	NA	6.4	2.0		784.5
	7.0														
784.0	8.0	2.5											SM		784.0
	9.0											6.2			
			- as above				56	NA	NA	NA	NA	3.3			783.65
783.5	10.0	3.0											3.0		783.5
		3.20													783.3
	11.0		SILTY SAND trace GRAVEL (TILL) - poorly graded, fine to medium grained, brown	Compact	Dry-Damp										
783.0		3.5					57	NA	NA	NA	NA	6.3			783.0
	12.0											8.0			
	13.0	4.0											4.0 SM		782.5
782.5			- as above												782.3
	14.0						58	NA	NA	NA	NA	6.8			
782.0		4.5													782.0
	15.0		- as above but light brown		Damp										781.85
	16.0														
781.5		5.0											5.0		781.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 16, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

BOREHOLE LOG

Client : Yukon Government - EMR Lands Branch
Location : Whitehorse, Yukon
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Chilkoot Project No. : 200-003-13

Date Drilled: April 16, 2013
Elevation : 786.5 meters
Depth of BH: 9.15 meters
Instrumentation: NA

BOREHOLE **8-13**
Sheet 2 of 2

Elev. (m)	Depth ft	Depth m	Stratigraphic Description	Relative Density	Relative Moisture	Field Sample Type	Number	Temperature (degree C)	Recovery % / PID ppm	Penetrometer (kg/cm2)	SPT 'N'	Laboratory Results (%)	USCS/NRC Depth (m)	Symbol	Elev. (m)
												▲ - FINES ● - SAND ■ - GRAVEL; PL MC LL; 20 40 60 80			(continued)
	17.0		SILTY SAND trace GRAVEL (TILL) - poorly graded, fine to medium grained, brown	Compact (continued)	Dry-Damp (continued)	X	59	NA	NA	NA	NA	7.6			781.0
781.0	18.0	5.5	- grindy drilling - possible cobbles/boulders @ 5.5 meters										SM		
	19.0		- as above			X	60	NA	NA	NA	NA	6.6	6.0		780.6
780.5	20.0	6.0													780.5
		6.25													780.25
	21.0		GRAVELLY SILTY SAND (TILL) - poorly graded, fine to medium grained, brown	Dense	Dry-Damp	X	61	NA	NA	NA	NA	4.1			
780.0	22.0	6.5													780.0
	23.0	7.0	- as above			X	62	NA	NA	NA	NA	5.7	7.0		779.5
															779.4
779.0	24.0	7.5													779.0
	25.0		- as above			X	63	NA	NA	NA	NA	4.8			778.8
	26.0	8.0											SM 8.0		778.5
778.5															778.27
	27.0		- grindy drilling - possible increasing gravel content and possible cobbles/boulders at 8.23 meters			X	64	NA	NA	NA	NA	4.3			
778.0	28.0	8.5													778.0
	29.0		- as above			X	65	NA	NA	NA	NA	3.9			777.65
777.5	30.0	9.0											9.0		777.5
		9.15	Borehole terminated at 9.15 m. below the existing ground surface.												777.35
777.0															777.0
776.5															776.5

Drilled By : Donjek Services | Drill Type : CME 750 (FN60) | Drill Method : 150 mm Solid Stem | Bit Type : Fish Tail

Water Level(s)
▽ During Drilling ▼ After Drilling
▼ At End of Drilling

Logged By : T.Dhara, P.Eng.
Date : April 16, 2013

Data Entry By : T.Dhara, P.Eng.
Date : April 20-29, 2013

Reviewed By:
Date : April 30, 2013

APPENDIX B

Grain Size Distribution Analysis

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 1-13
Elevation :735.47 m
Depth : 0.61 m
Sampling Method : Grab

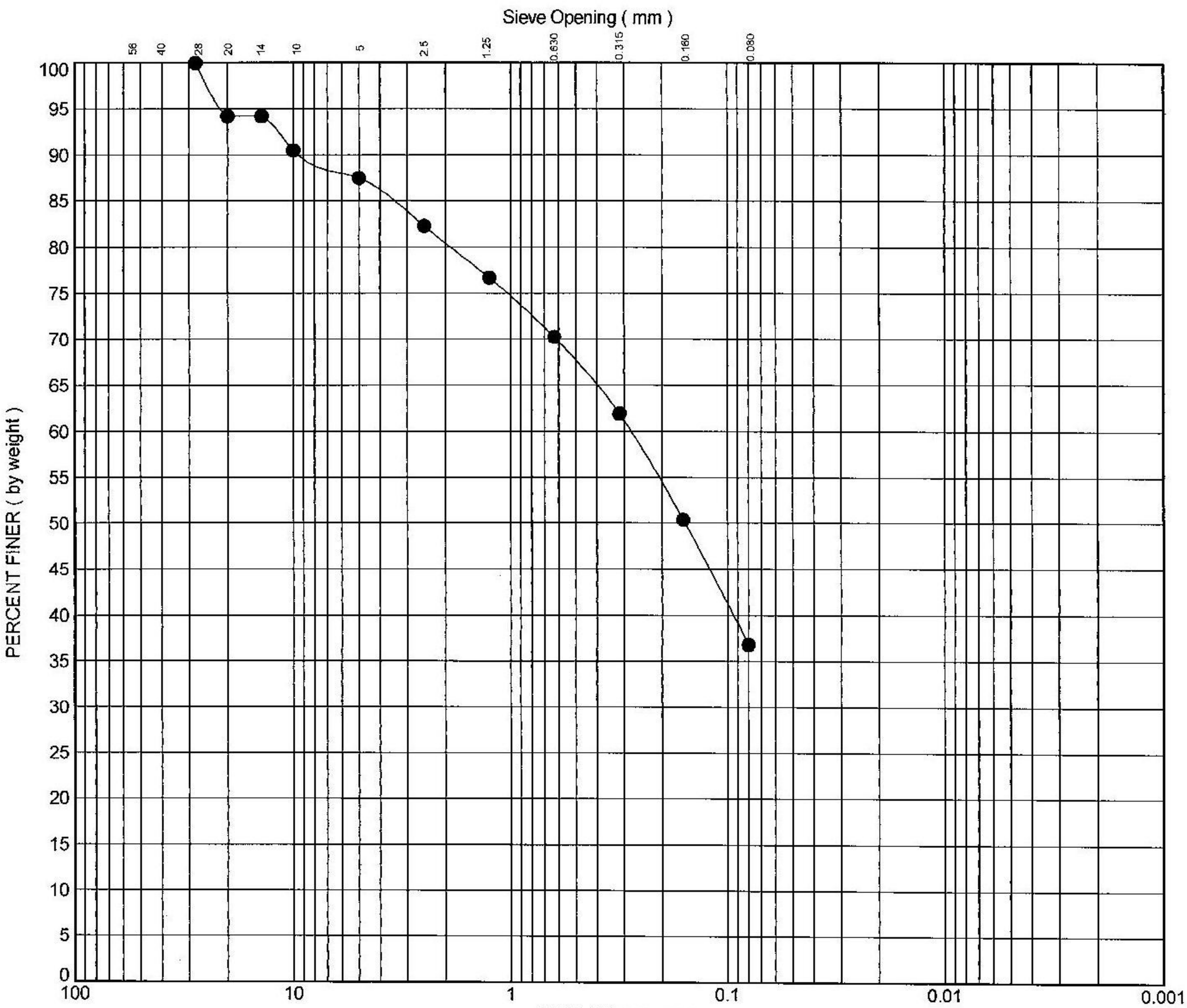
SAMPLE NUMBER

1

Material Description : Silty Sand some Gravel

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
12.5	50.7	36.8		15.0	28	0.282				



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 11, 2013

Received By : Chilkoot - T.Dhara
Date : April 11, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 1-13
Elevation :734.86 m
Depth : 1.22 m
Sampling Method : Split Spoon

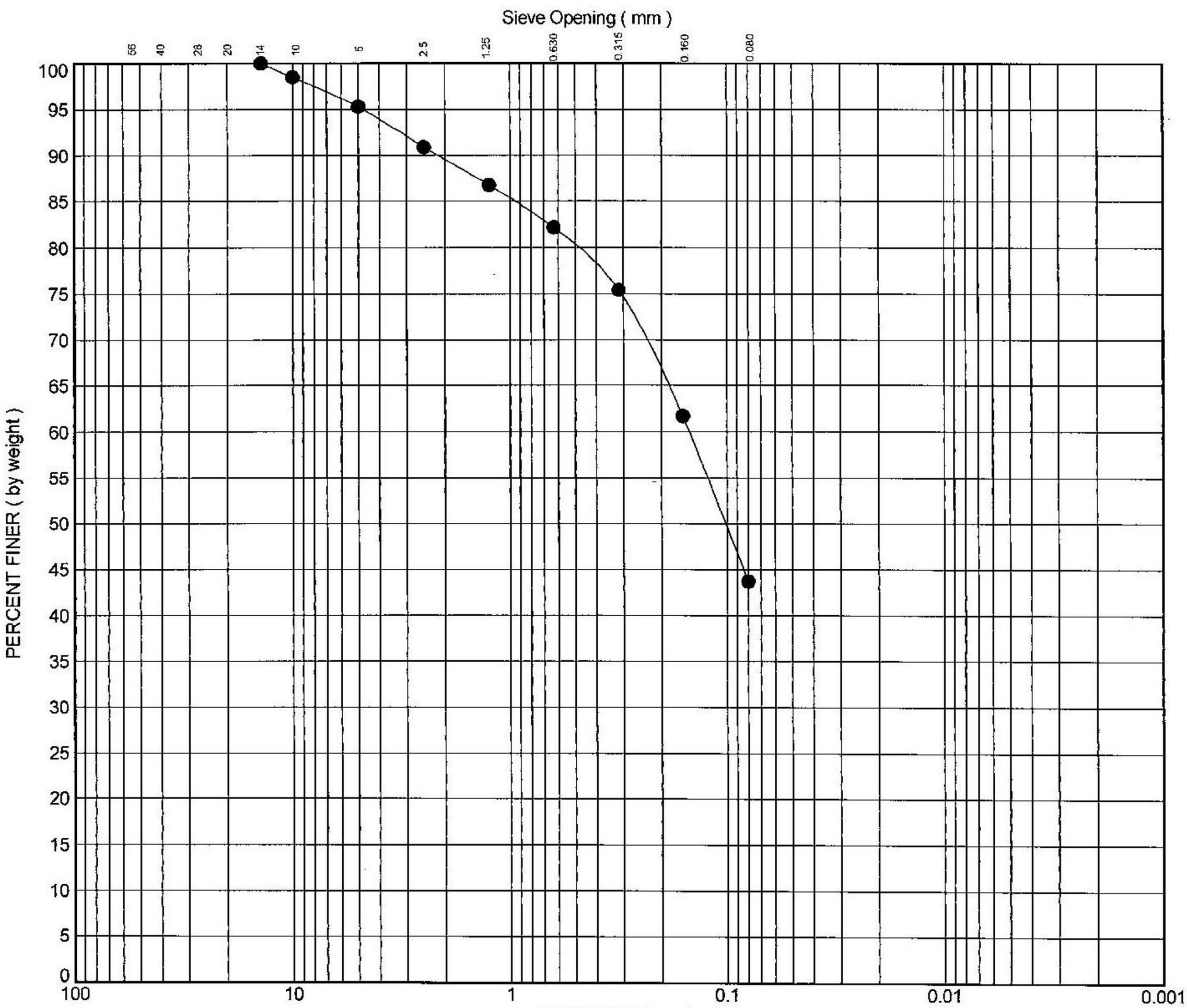
SAMPLE NUMBER

2

Material Description : Silty Sand

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
4.7	51.6	43.7		13.3	14	0.15				



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 11, 2013

Received By : Chilkoot - T.Dhara
Date : April 11, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 1-13
Elevation :733.34 m
Depth : 2.74 m
Sampling Method : Split Spoon

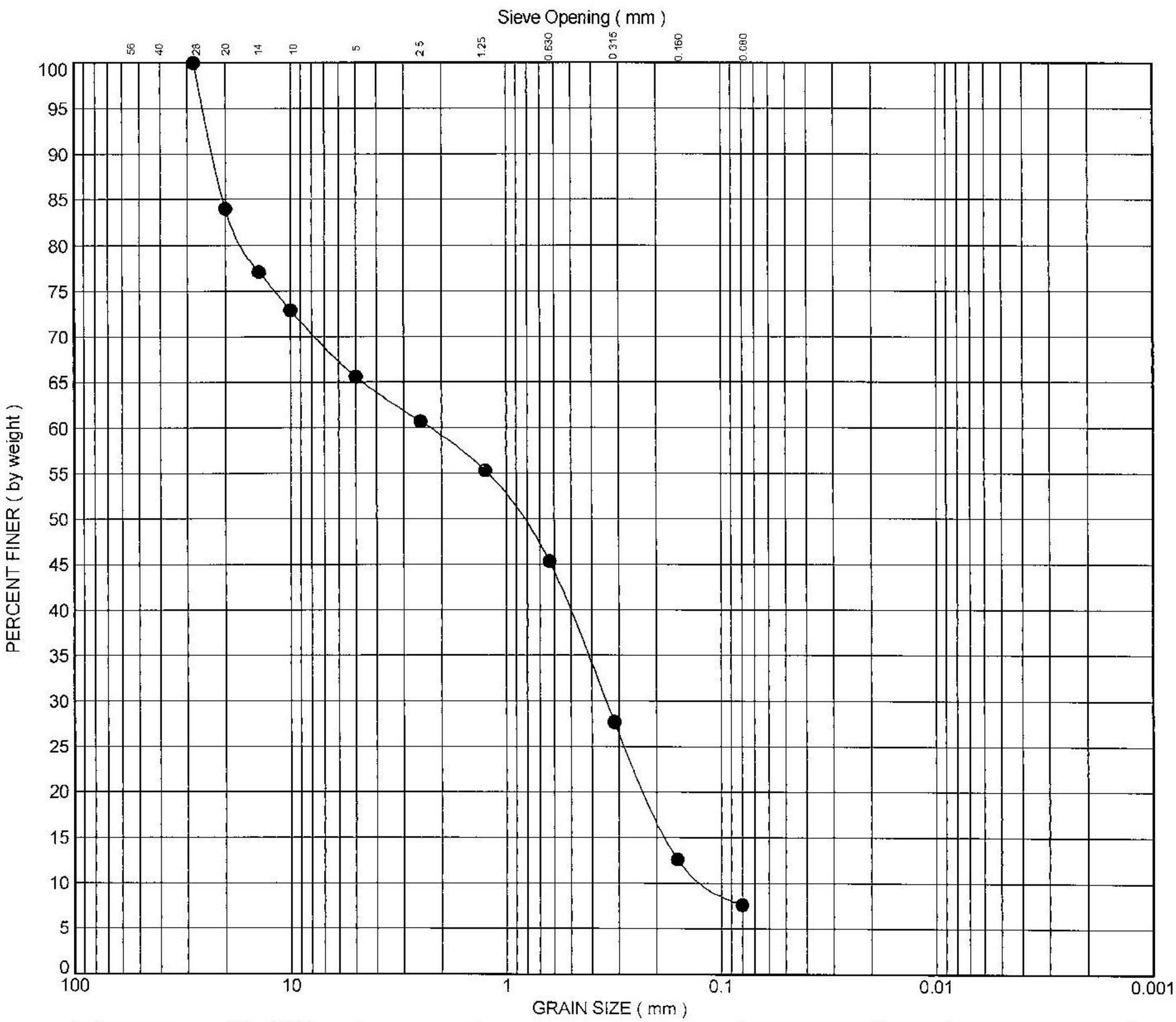
SAMPLE NUMBER

3

Material Description : Gravelly Sand trace Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
34.4	57.9	7.6		11.7	28	2.285	0.345	0.112	0.47	20.48



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 11, 2013

Received By : Chilkoot - T.Dhara
Date : April 11, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 1-13
Elevation :731.81 m
Depth : 4.27 m
Sampling Method : Split Spoon

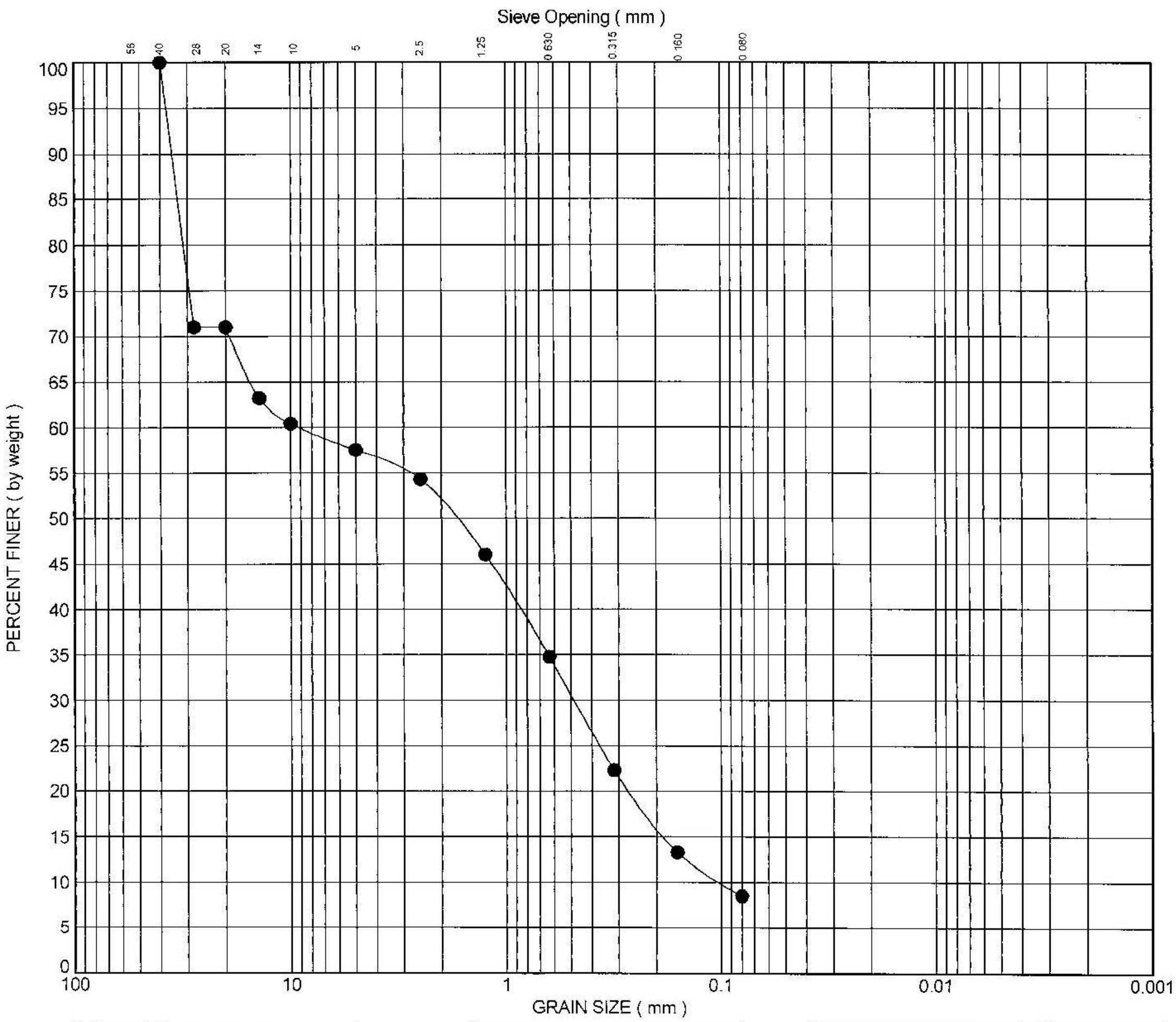
SAMPLE NUMBER

4

Material Description : Gravelly Sand trace Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
42.5	48.9	8.5		13.6	40	9.088	0.483	0.099	0.26	91.48



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 11, 2013

Received By : Chilkoot - T.Dhara
Date : April 11, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

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(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 1-13
Elevation :730.29 m
Depth : 5.79 m
Sampling Method : Split Spoon

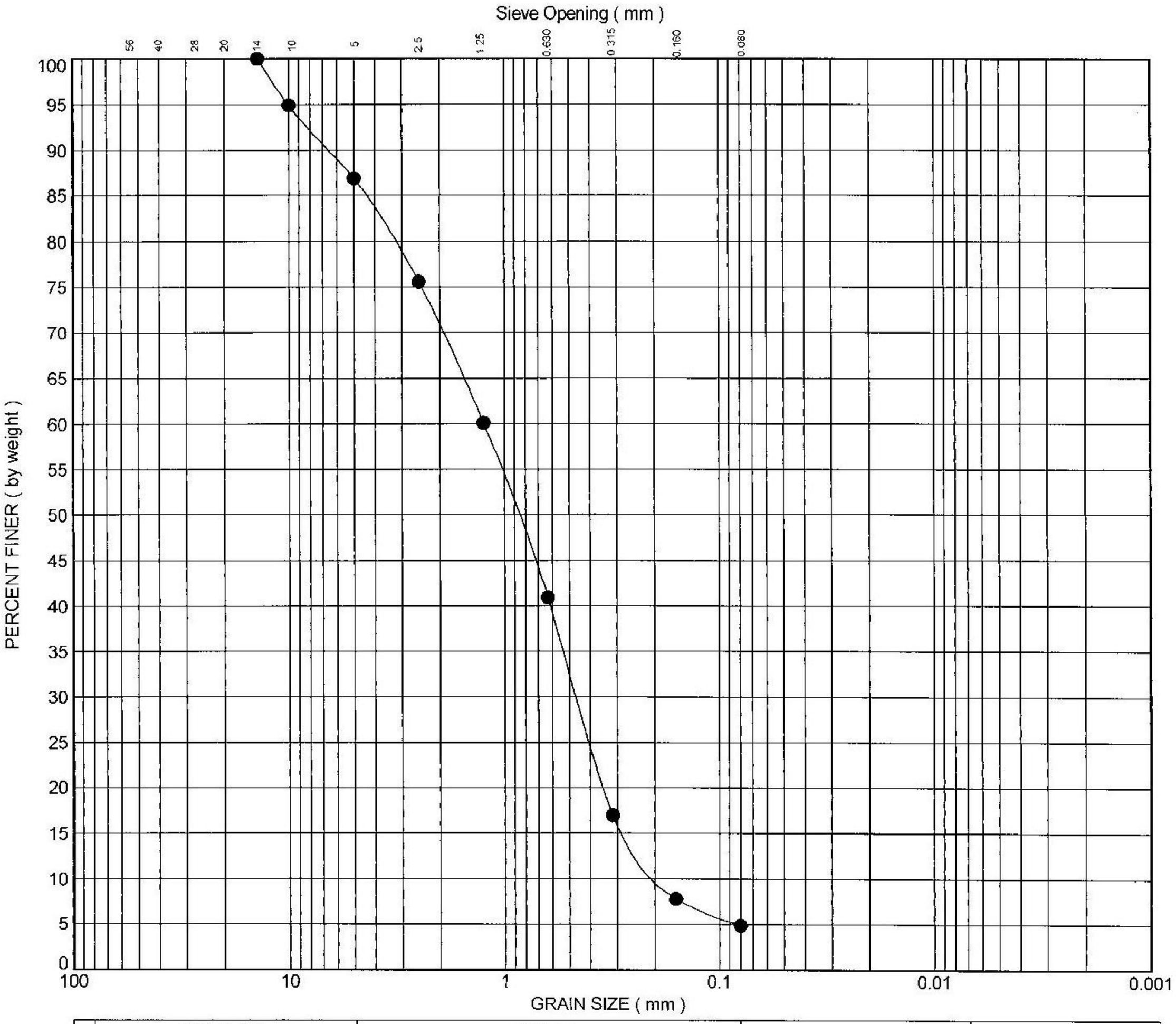
SAMPLE NUMBER

5

Material Description : Sand some Gravel

USCS Classification : SP

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
13.1	82.0	4.9		13.9	14	1.246	0.459	0.188	0.90	6.62



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 11, 2013

Received By : Chilkoot - T.Dhara
Date : April 11, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 2-13
Elevation :737.27 m
Depth : 0.61 m
Sampling Method : Grab

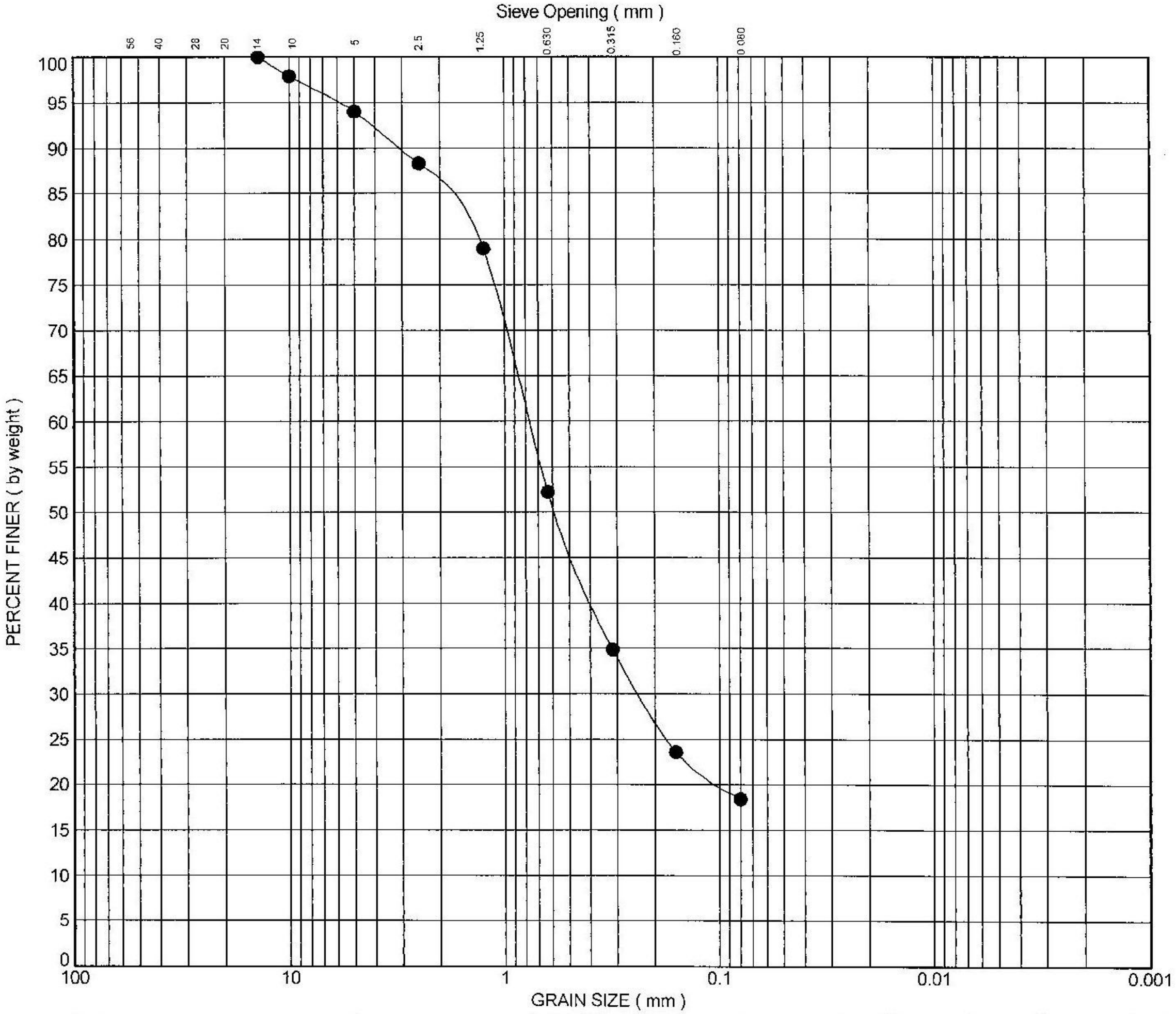
SAMPLE NUMBER

6

Material Description : Silty Sand trace Gravel

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
6.0	75.5	18.4		6.9	14	0.769	0.235			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 12, 2013

Received By : Chilkoot - T.Dhara
Date : April 12, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 2-13
Elevation :736.64 m
Depth : 1.24 m
Sampling Method : Split Spoon

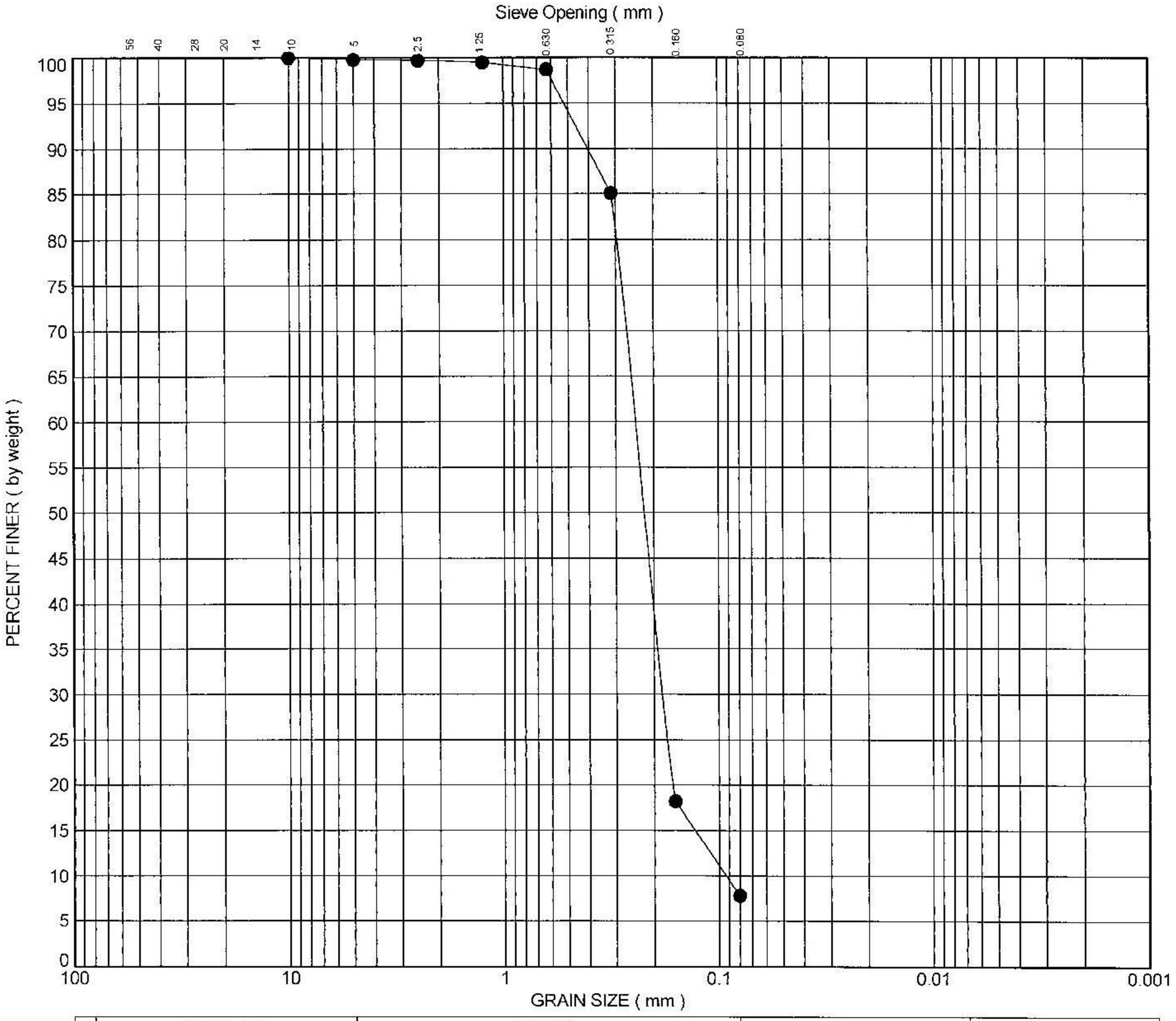
SAMPLE NUMBER

8

Material Description : Sand trace Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.2	91.9	7.8		3.5	10	0.244	0.18	0.093	1.44	2.64



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 12, 2013

Received By : Chilkoot - T.Dhara
Date : April 12, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

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(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 2-13
Elevation :735.14 m
Depth : 2.74 m
Sampling Method : Split Spoon

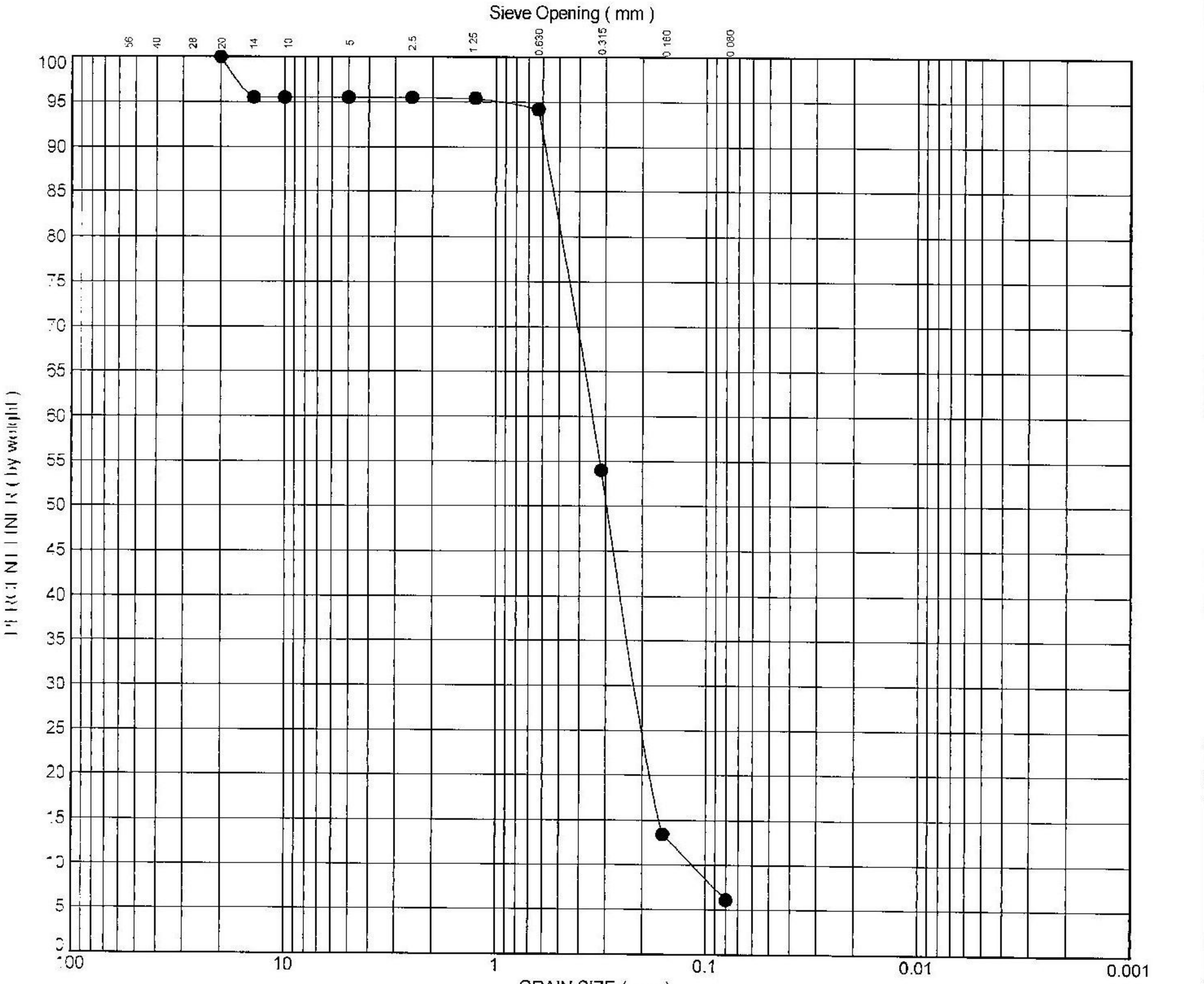
SAMPLE NUMBER

9

Material Description : Sand trace Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
4.5	89.4	6.1		18.6	20	0.349	0.211	0.116	1.10	3.02



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 12, 2013

Received By : Chilkoot - T.Dhara
Date : April 12, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

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(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 2-13
Elevation :733.61 m
Depth : 4.27 m
Sampling Method : Split Spoon

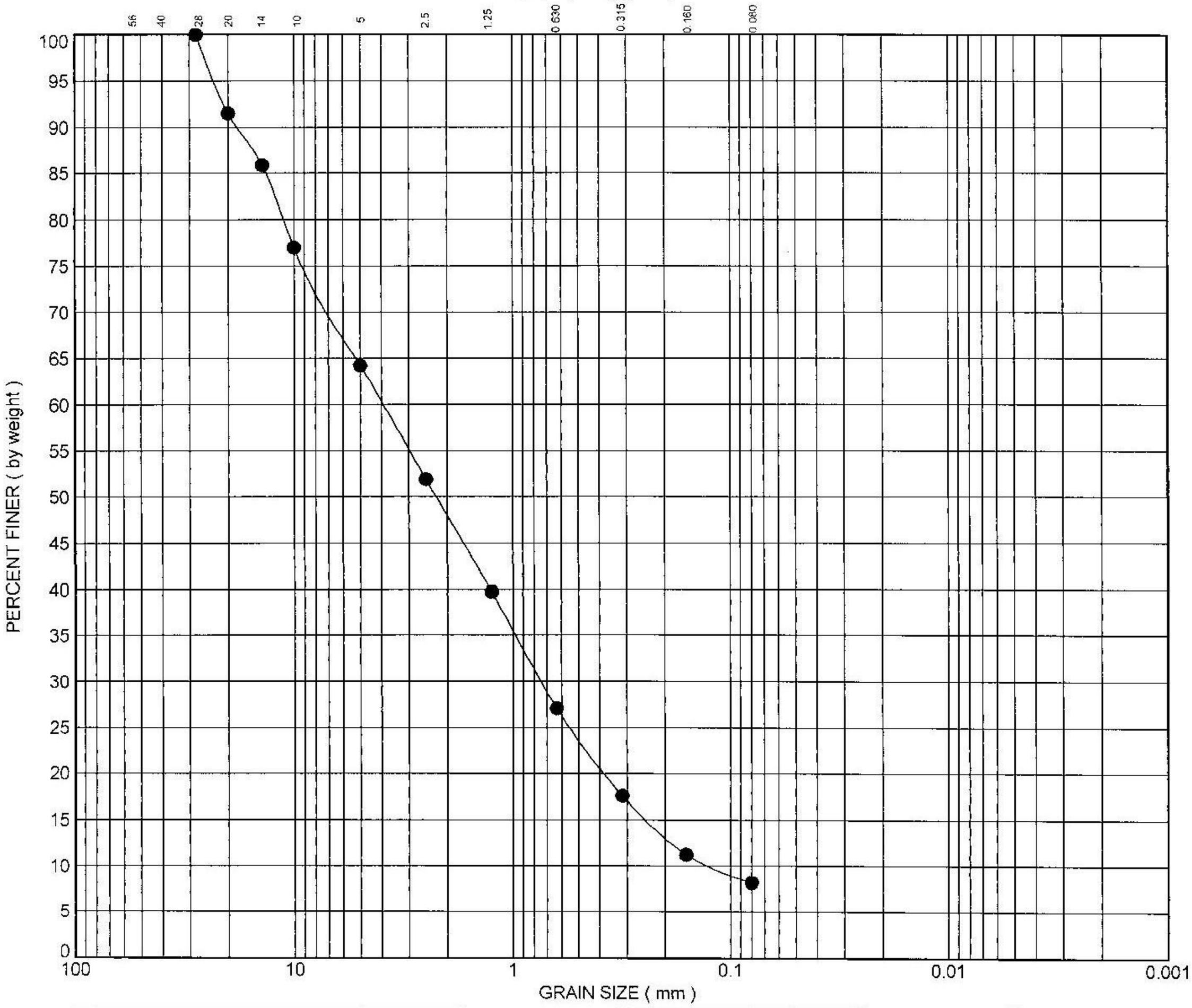
SAMPLE NUMBER

10

Material Description : Gravelly Sand trace Silt

USCS Classification : SW-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
35.8	56.0	8.2		8.1	28	3.946	0.738	0.121	1.14	32.54



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 12, 2013

Received By : Chilkoot - T.Dhara
Date : April 12, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

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(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 2-13
Elevation :732.09 m
Depth : 5.79 m
Sampling Method : Split Spoon

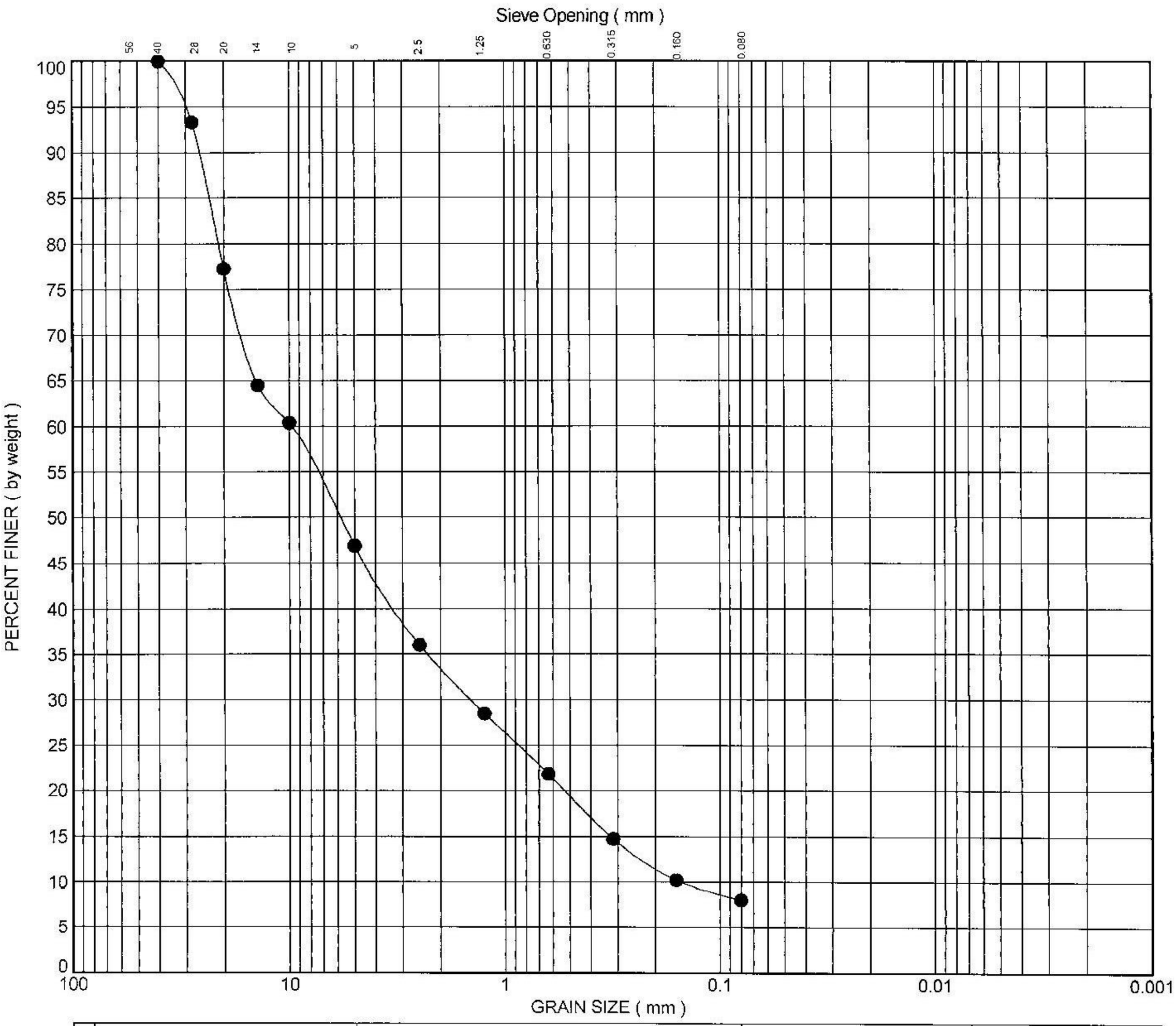
SAMPLE NUMBER

11

Material Description : Sandy Gravel trace Silt

USCS Classification : GW-GM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
53.1	38.8	8.0		6.2	40	9.797	1.436	0.15	1.40	65.21



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 12, 2013

Received By : Chilkoot - T.Dhara
Date : April 12, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 3-13
Elevation :733.02 m
Depth : 1.37 m
Sampling Method : Split Spoon

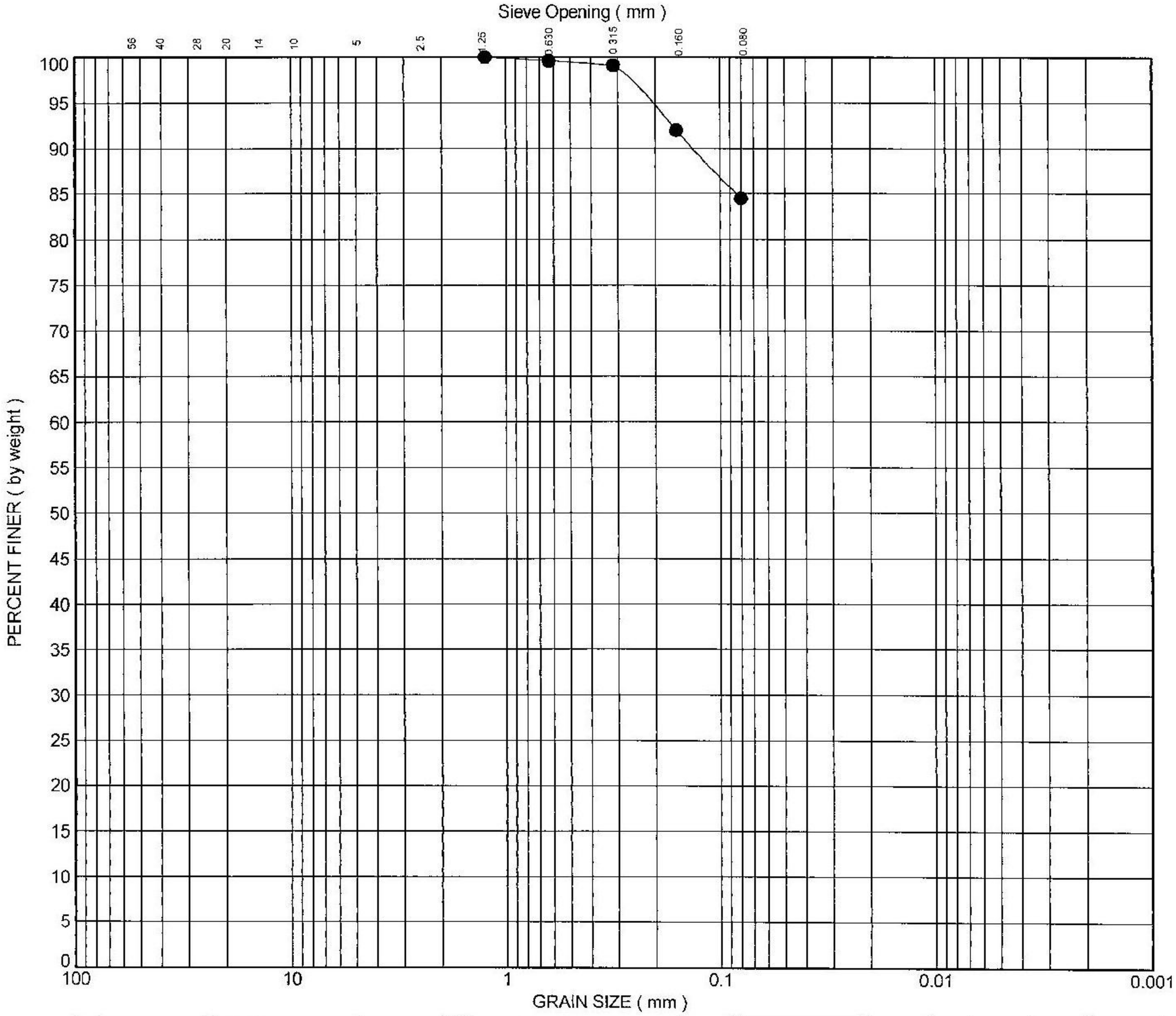
SAMPLE NUMBER

13

Material Description : Silty Sandy Clay

USCS Classification : CL

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	15.5	84.5		31.4	1.25					



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 13, 2013

Received By : Chilkoot - T.Dhara
Date : April 13, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 20, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 3-13
Elevation :731.65 m
Depth : 2.74 m
Sampling Method : Split Spoon

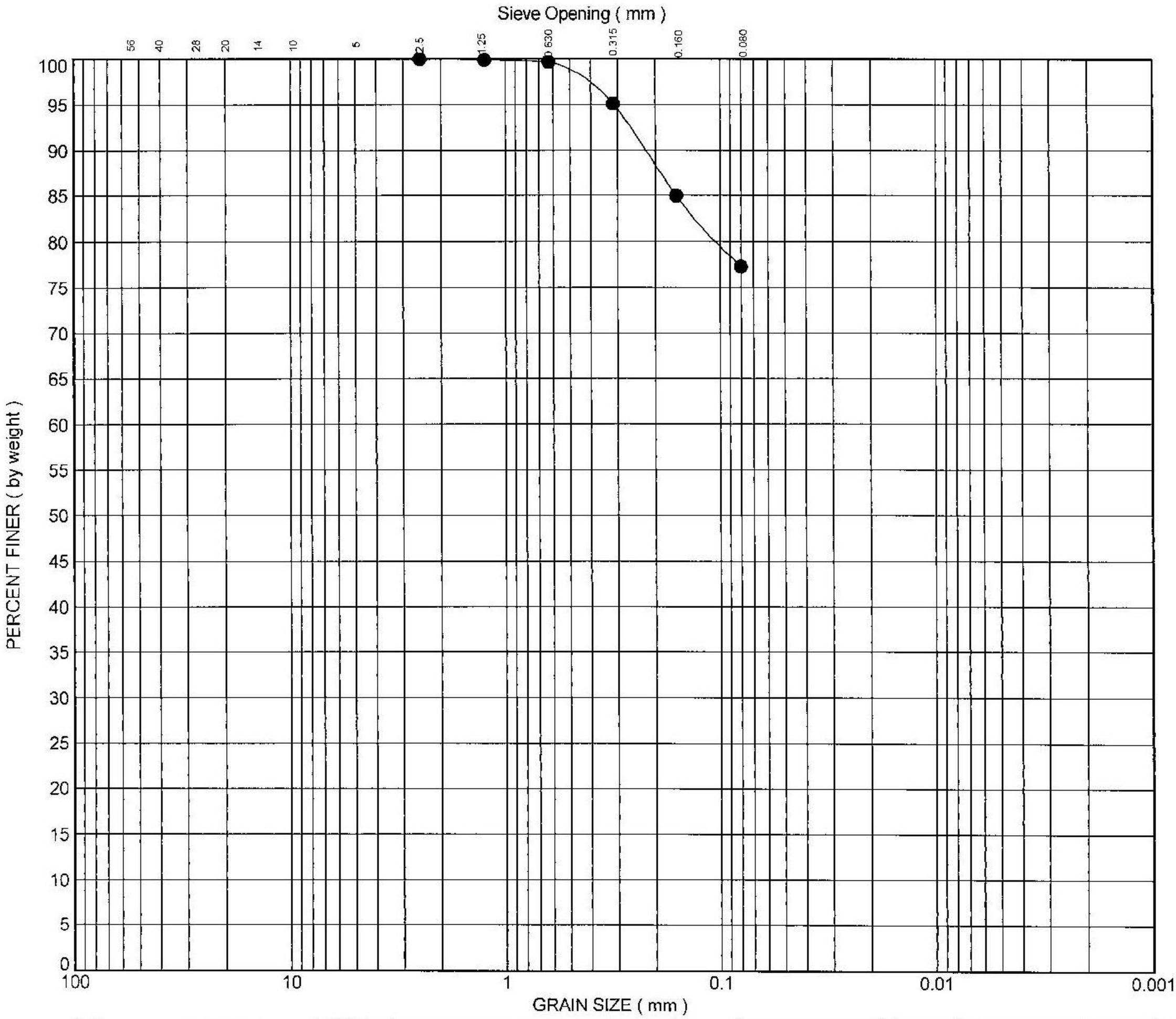
SAMPLE NUMBER

14

Material Description : Clayey Sandy Silt

USCS Classification : CL-ML

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	22.7	77.3		18.8	2.5					



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 13, 2013

Received By : Chilkoot - T.Dhara
Date : April 13, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 20, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 3-13
Elevation :730.12 m
Depth : 4.27 m
Sampling Method : Split Spoon

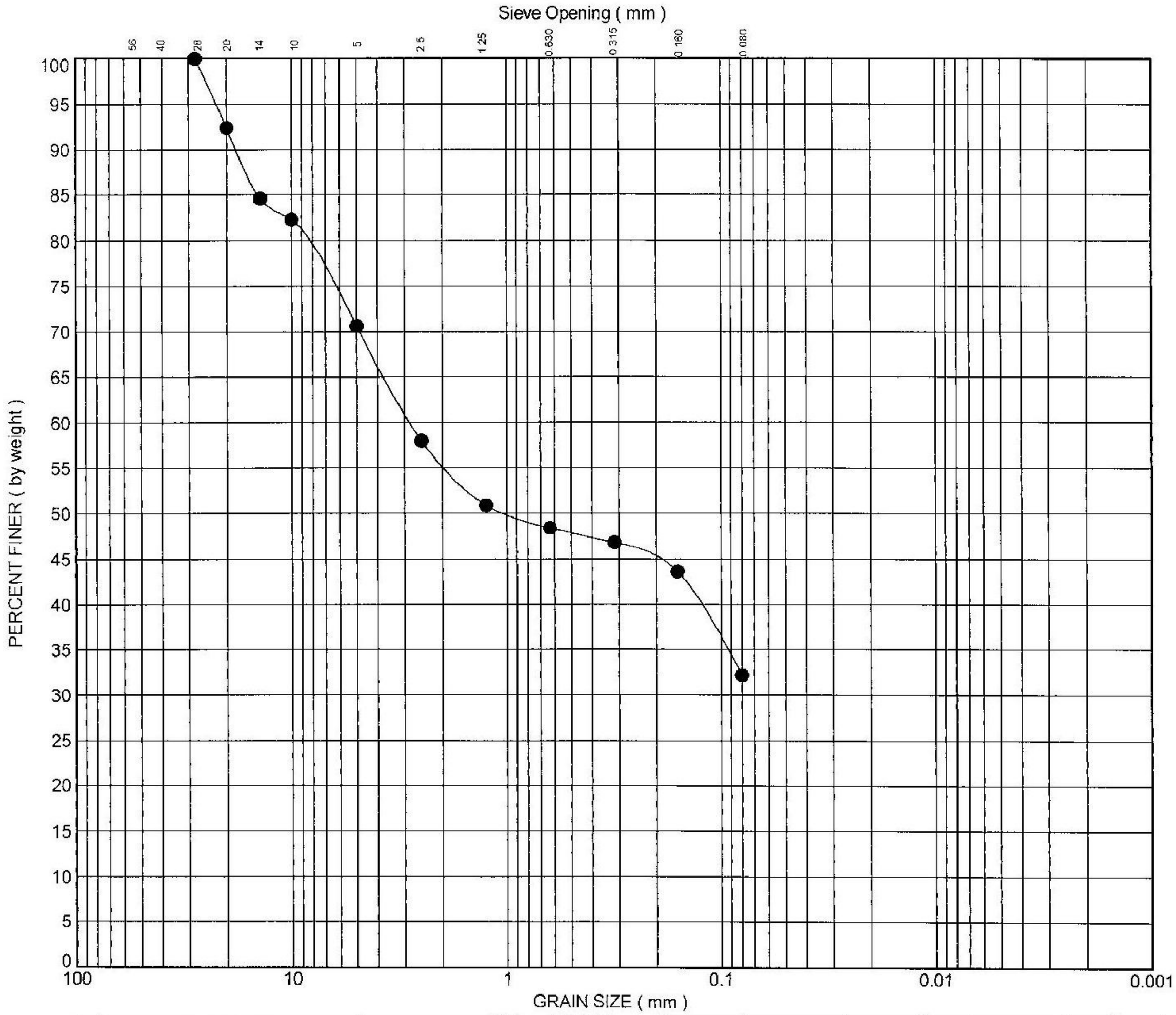
SAMPLE NUMBER

15

Material Description : Silty Gravelly Sand

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
29.4	38.4	32.2		11.5	28	2.791				



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 13, 2013

Received By : Chilkoot - T.Dhara
Date : April 13, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 3-13
Elevation :728.6 m
Depth : 5.79 m
Sampling Method : Split Spoon

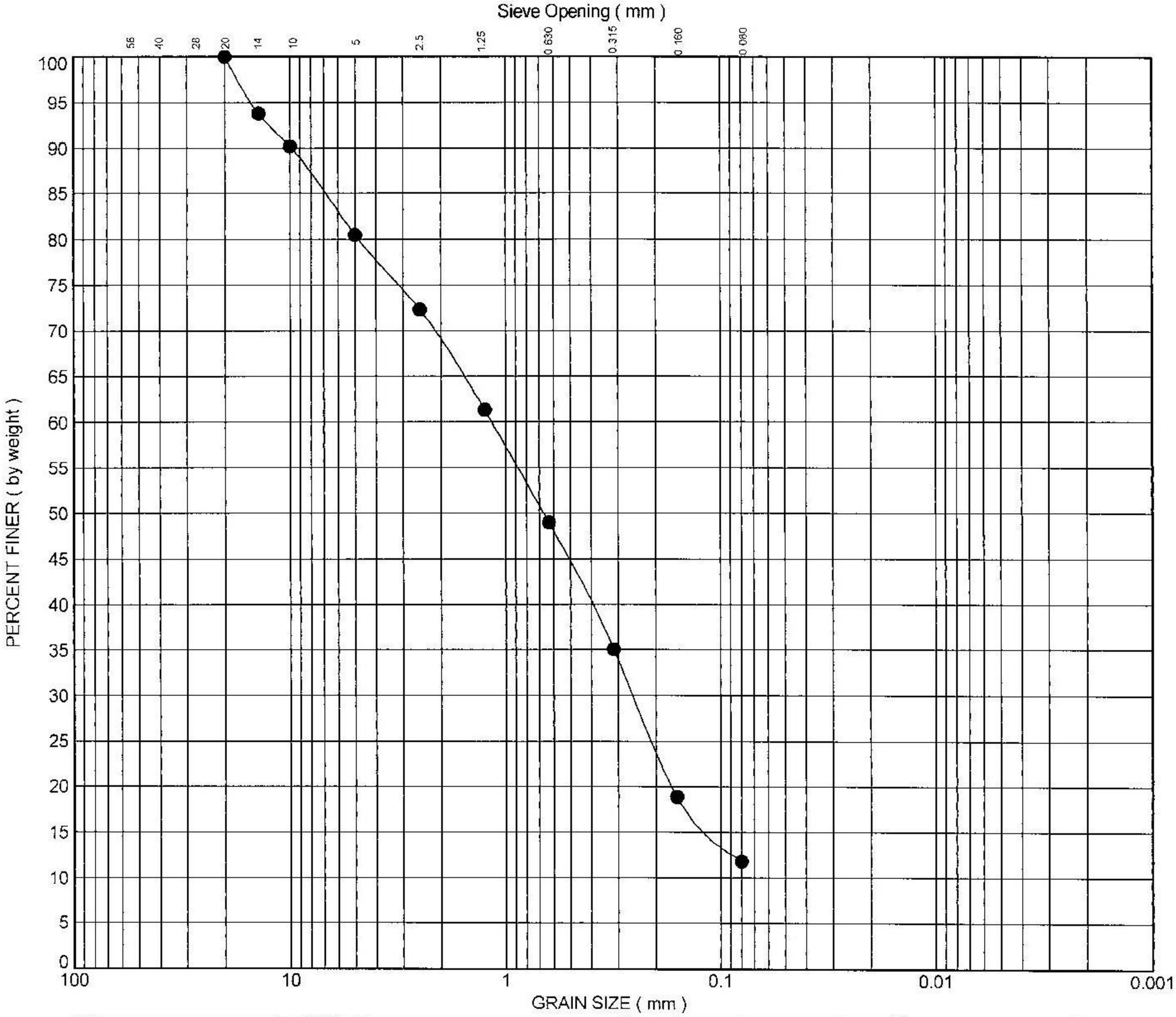
SAMPLE NUMBER

16

Material Description : Gravelly Sand some Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
19.5	68.7	11.8		11.1	20	1.163	0.255			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 13, 2013

Received By : Chilkoot - T.Dhara
Date : April 13, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 3-13
Elevation :728.34 m
Depth : 6.05 m
Sampling Method : Split Spoon

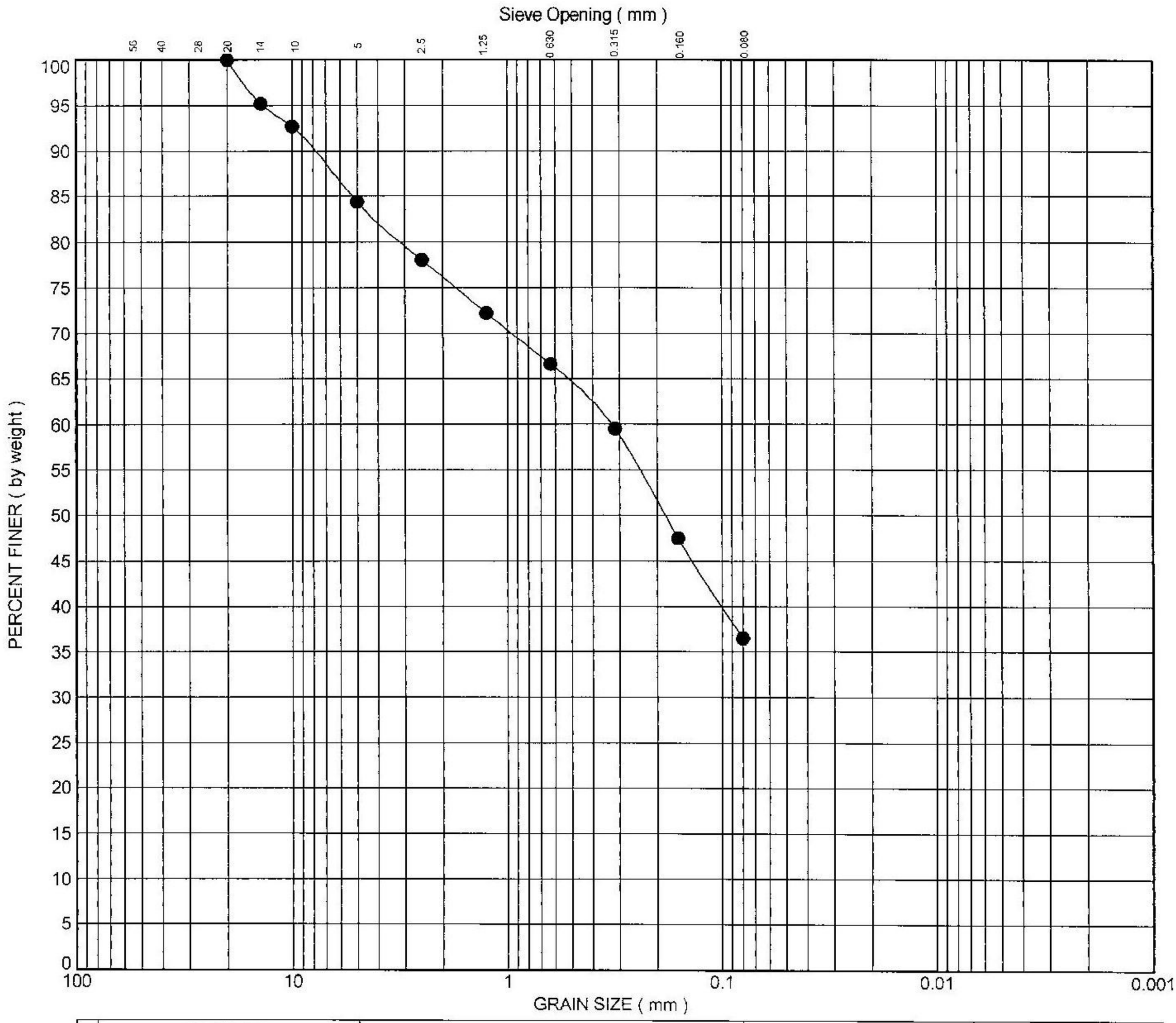
SAMPLE NUMBER

17

Material Description : Silty Gravelly Sand

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
15.8	47.8	36.5		9.4	20	0.331				



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 13, 2013

Received By : Chilkoot - T.Dhara
Date : April 13, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 14-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 4-13
Elevation :737.67 m
Depth : 1.83 m
Sampling Method : Grab

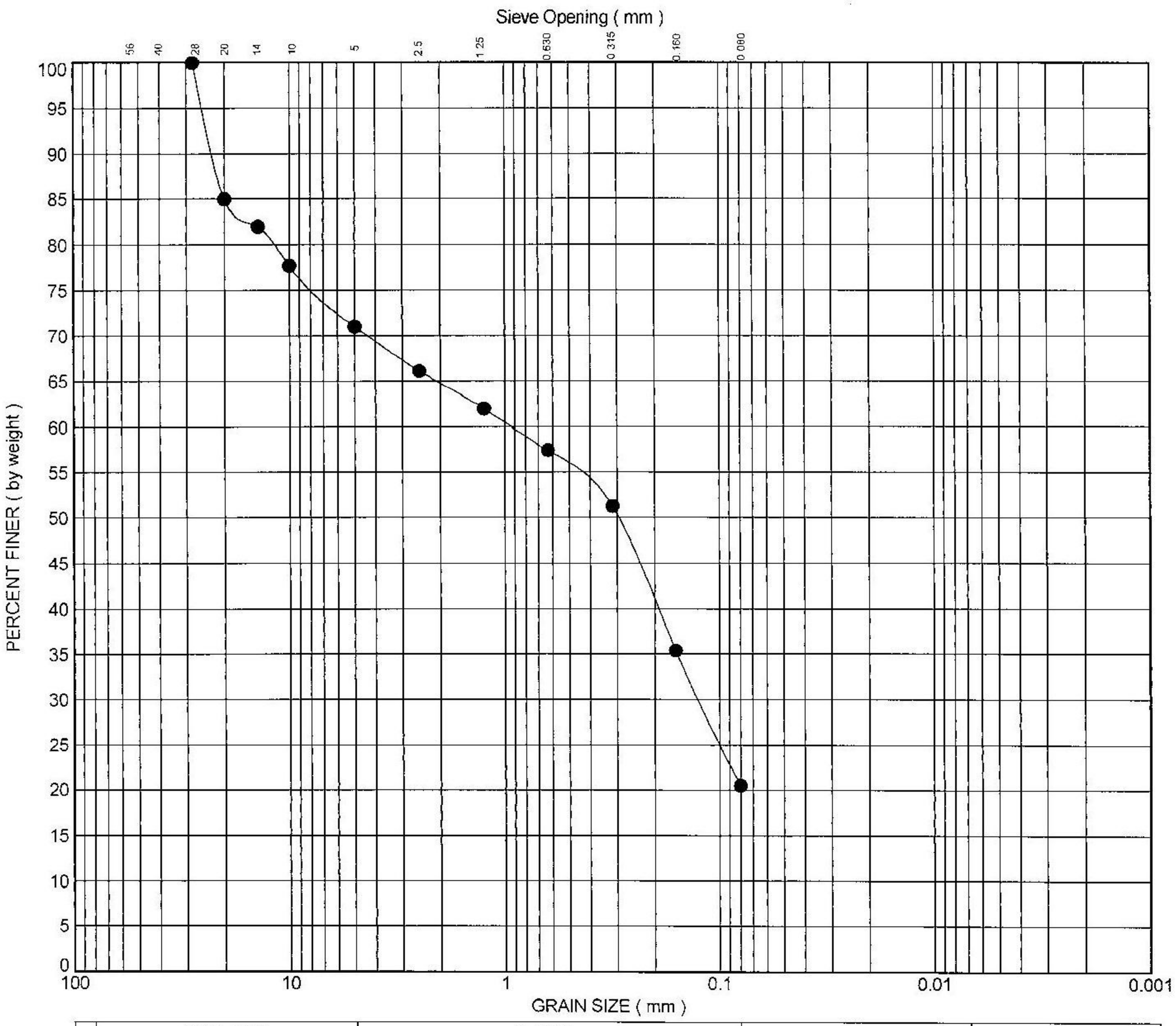
SAMPLE NUMBER

21

Material Description : Gravelly Silty Sand

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
29.0	50.5	20.5		3.8	28	0.928	0.124			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 15, 2013

Received By : Chilkoot - T.Dhara
Date : April 15, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 4-13
Elevation :735.39 m
Depth : 4.11 m
Sampling Method : Grab

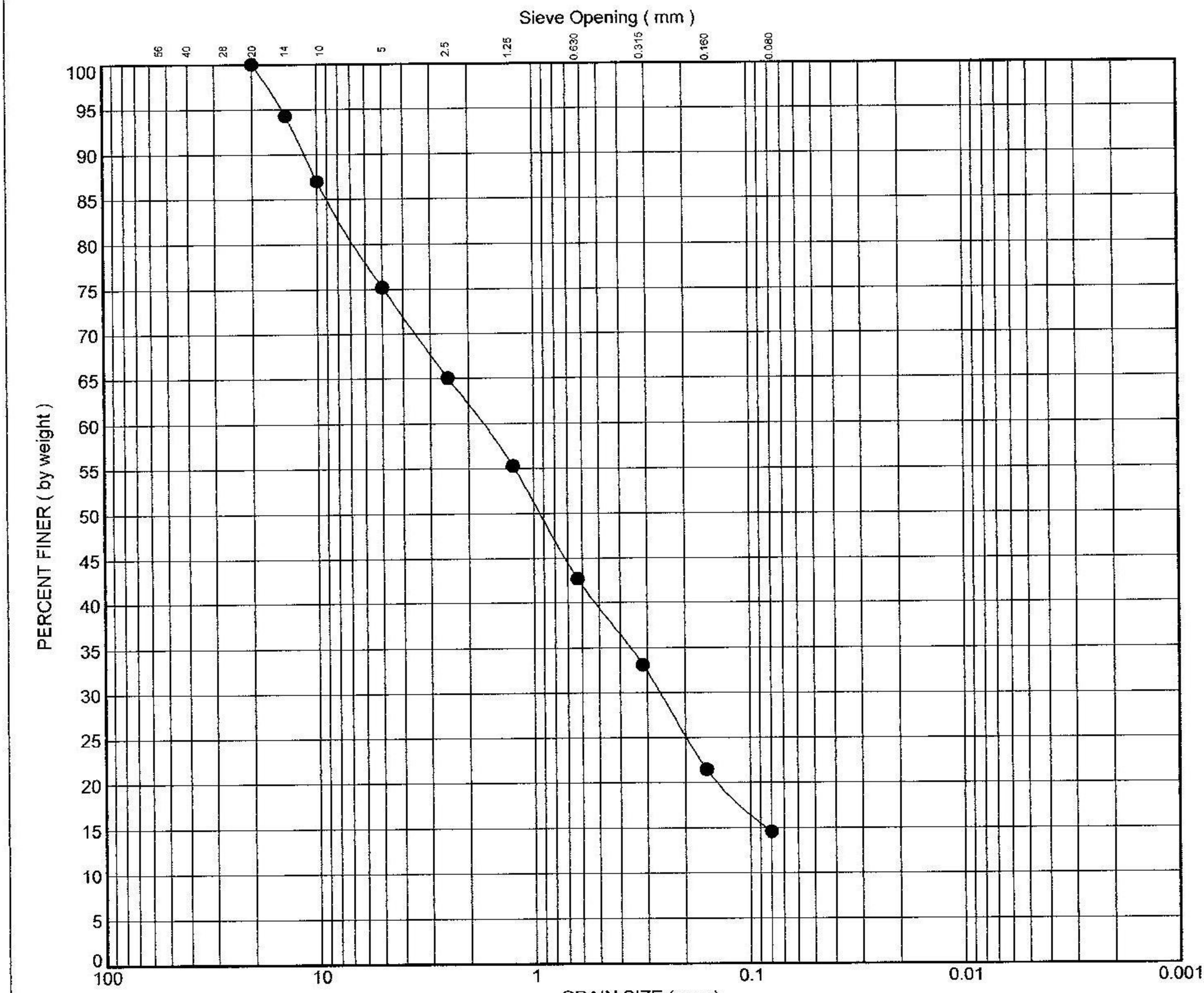
SAMPLE NUMBER

24

Material Description : Gravelly Sand some Silt

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
24.8	60.7	14.6		9.8	20	1.743	0.263			



Sampled By : Chilkoot - T.Dhara
Date : April 15, 2013

Received By : Chilkoot - T.Dhara
Date : April 15, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 5-13
Elevation :734.69 m
Depth : 2.29 m
Sampling Method : Grab

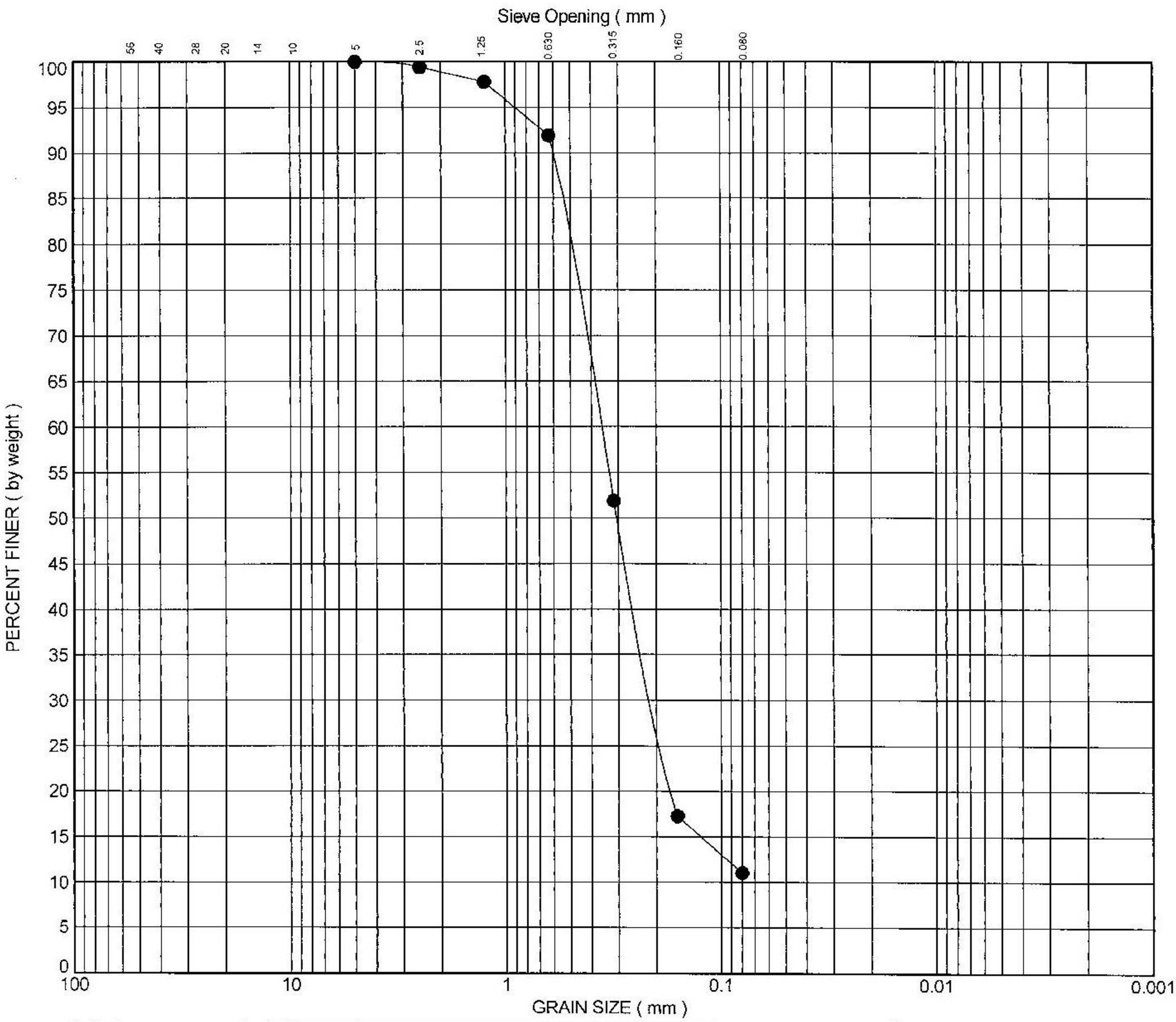
SAMPLE NUMBER

30

Material Description : Sand some Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	89.0	11.0		18.7	5	0.362	0.205			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 15, 2013

Received By : Chilkoot - T.Dhara
Date : April 15, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 6-13
Elevation :752.2 m
Depth : 0.3 m
Sampling Method : Grab

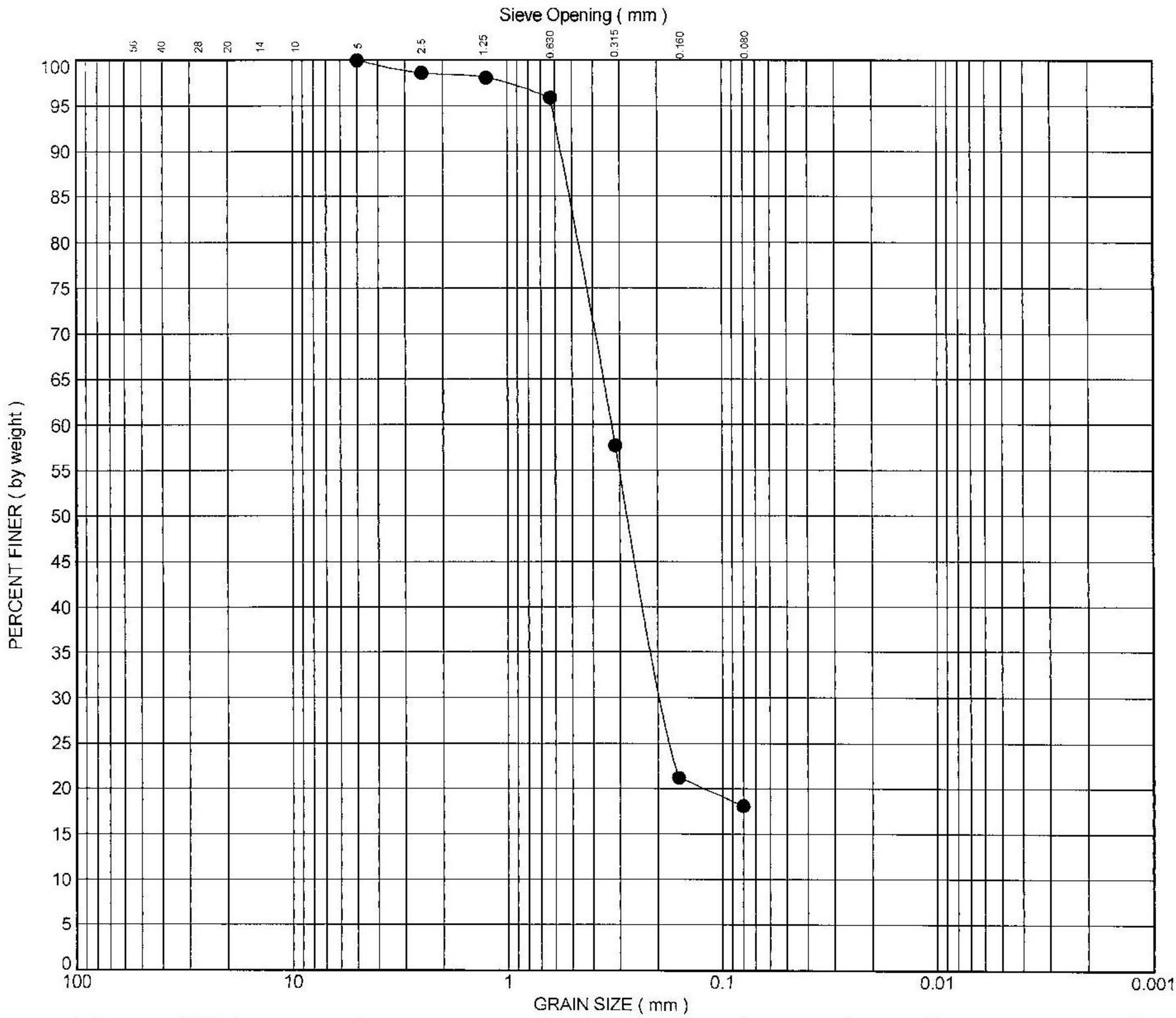
SAMPLE NUMBER

32

Material Description : Silty Sand

USCS Classification : SM

Grave	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	81.9	18.1		5.5	5	0.328	0.188			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 15, 2013

Received By : Chilkoot - T.Dhara
Date : April 15, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 6-13
Elevation :750.67 m
Depth : 1.83 m
Sampling Method : Grab

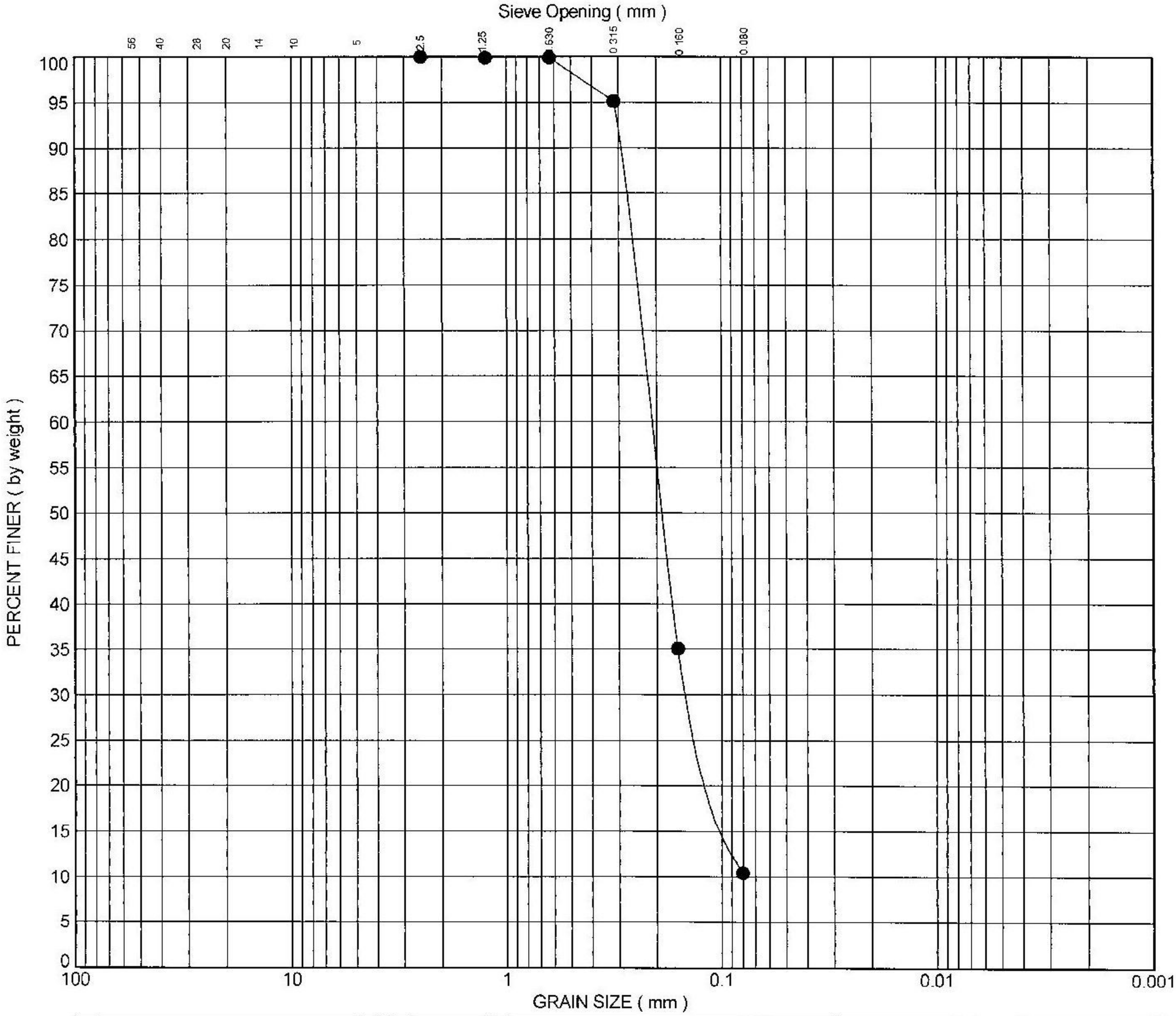
SAMPLE NUMBER

35

Material Description : Sand some Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	89.6	10.4		3.1	2.5	0.212	0.139			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 15, 2013

Received By : Chilkoot - T.Dhara
Date : April 15, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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5B Bennett Road, Whitehorse, Yukon
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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 6-13
Elevation :748.84 m
Depth : 3.66 m
Sampling Method : Grab

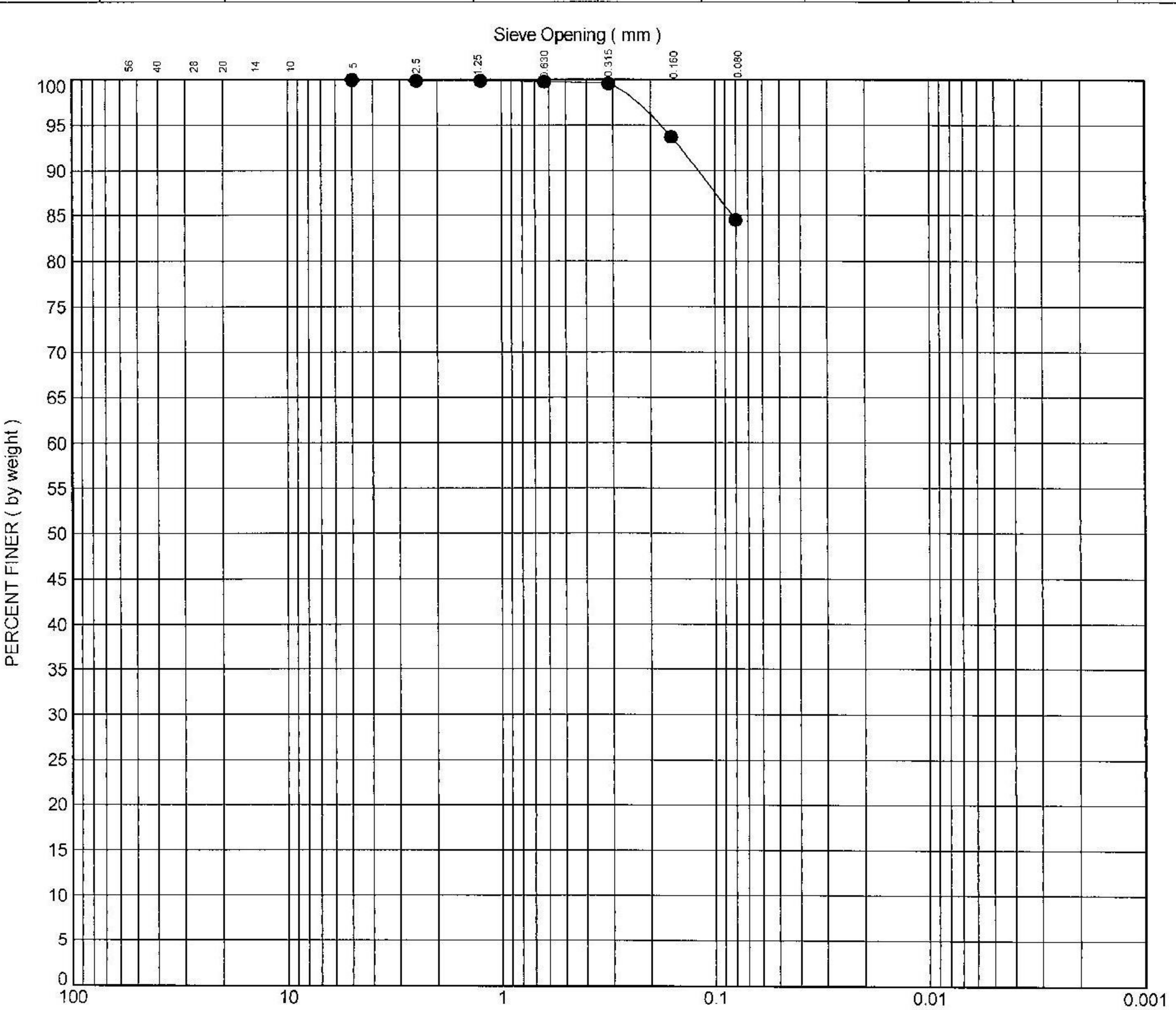
SAMPLE NUMBER

37

Material Description : Sandy Silt

USCS Classification : ML

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	15.5	84.5		12.6	5					



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 15, 2013

Received By : Chilkoot - T.Dhara
Date : April 15, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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5B Bennett Road, Whitehorse, Yukon
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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 7-13
Elevation :770.89 m
Depth : 0.61 m
Sampling Method : Grab

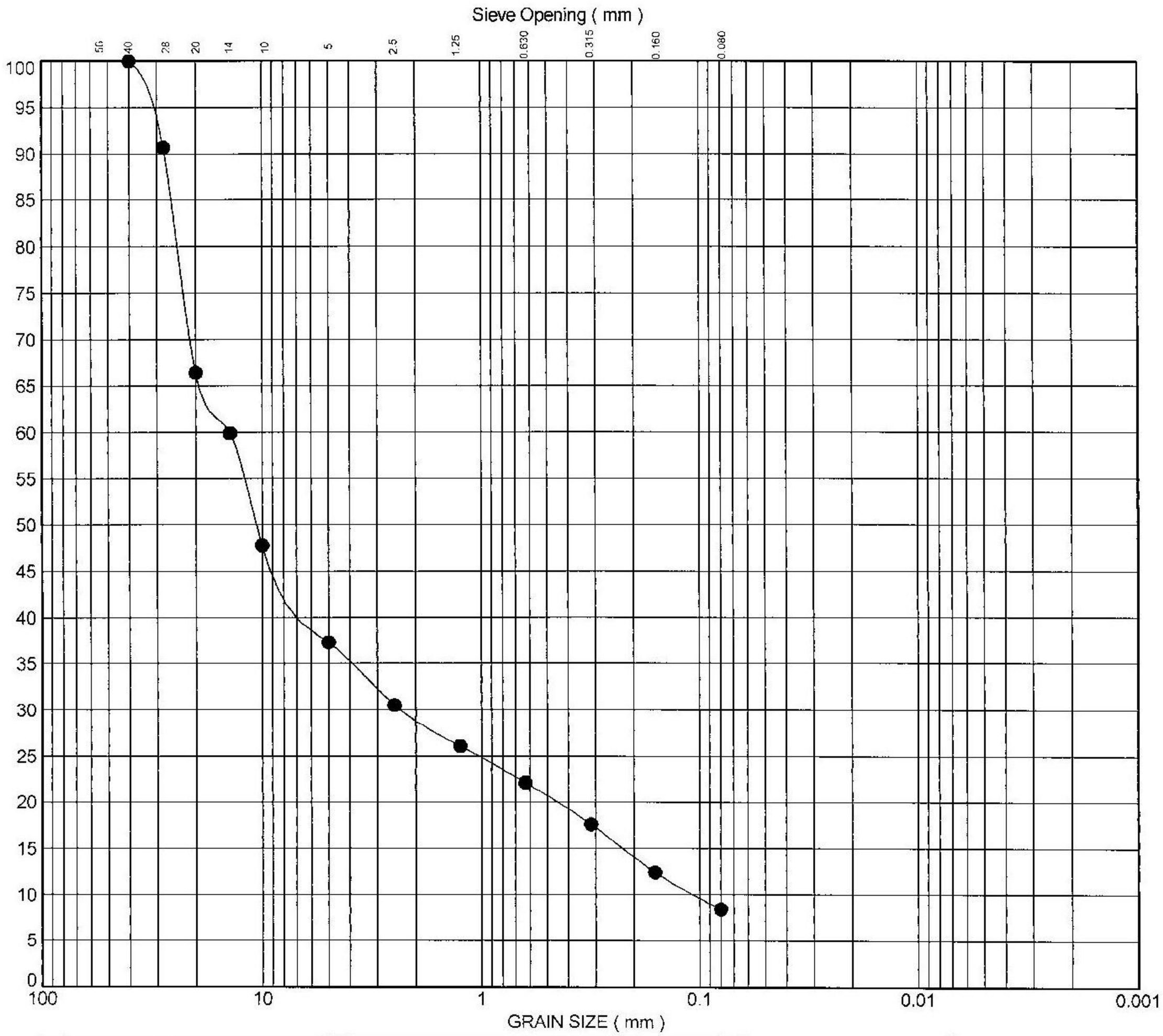
SAMPLE NUMBER

43

Material Description : Sandy Gravel trace Silt

USCS Classification : GP-GM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
62.7	28.9	8.4		2.9	40	14.077	2.311	0.106	3.59	133.35



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 7-13
Elevation :768.76 m
Depth : 2.74 m
Sampling Method : Grab

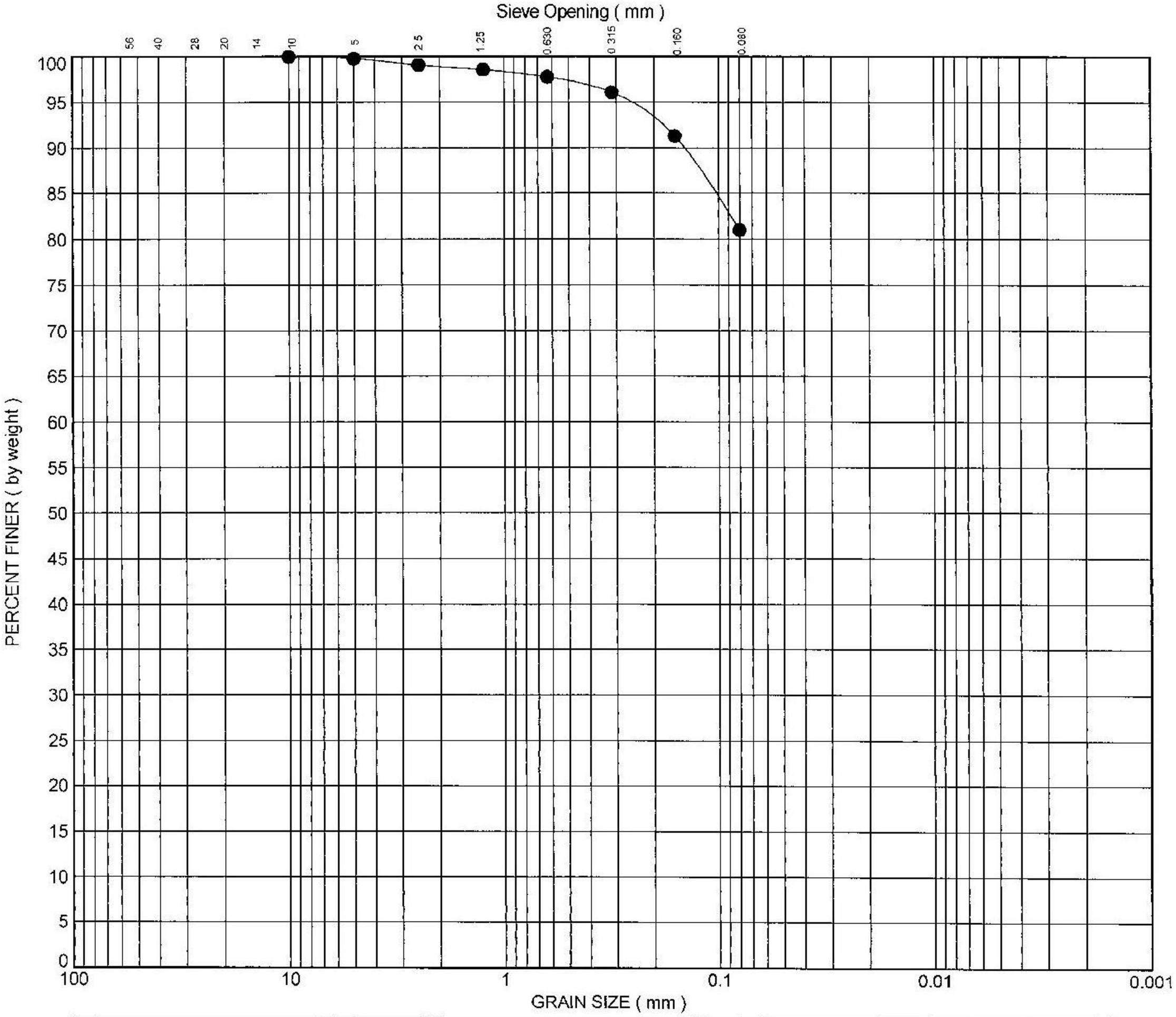
SAMPLE NUMBER

46

Material Description : Sandy Silt

USCS Classification : ML

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
0.0	18.9	81.0		11.9	10					



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 7-13
Elevation :766.93 m
Depth : 4.57 m
Sampling Method : Grab

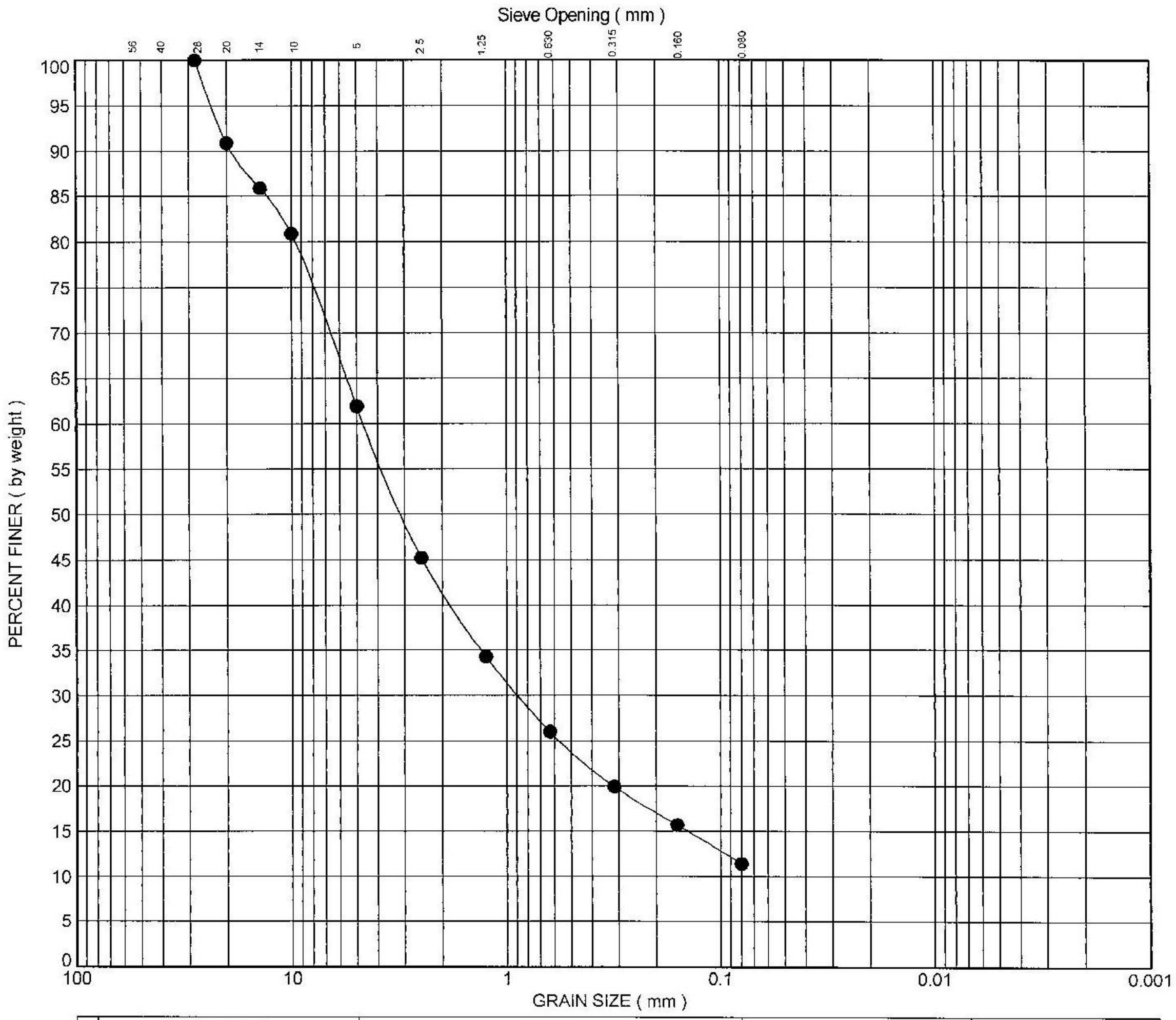
SAMPLE NUMBER

49

Material Description : Gravelly Sand some Silt

USCS Classification : SP-SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
38.1	50.5	11.4		4.2	28	4.621	0.876			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 8-13
Elevation :785.28 m
Depth : 1.22 m
Sampling Method : Grab

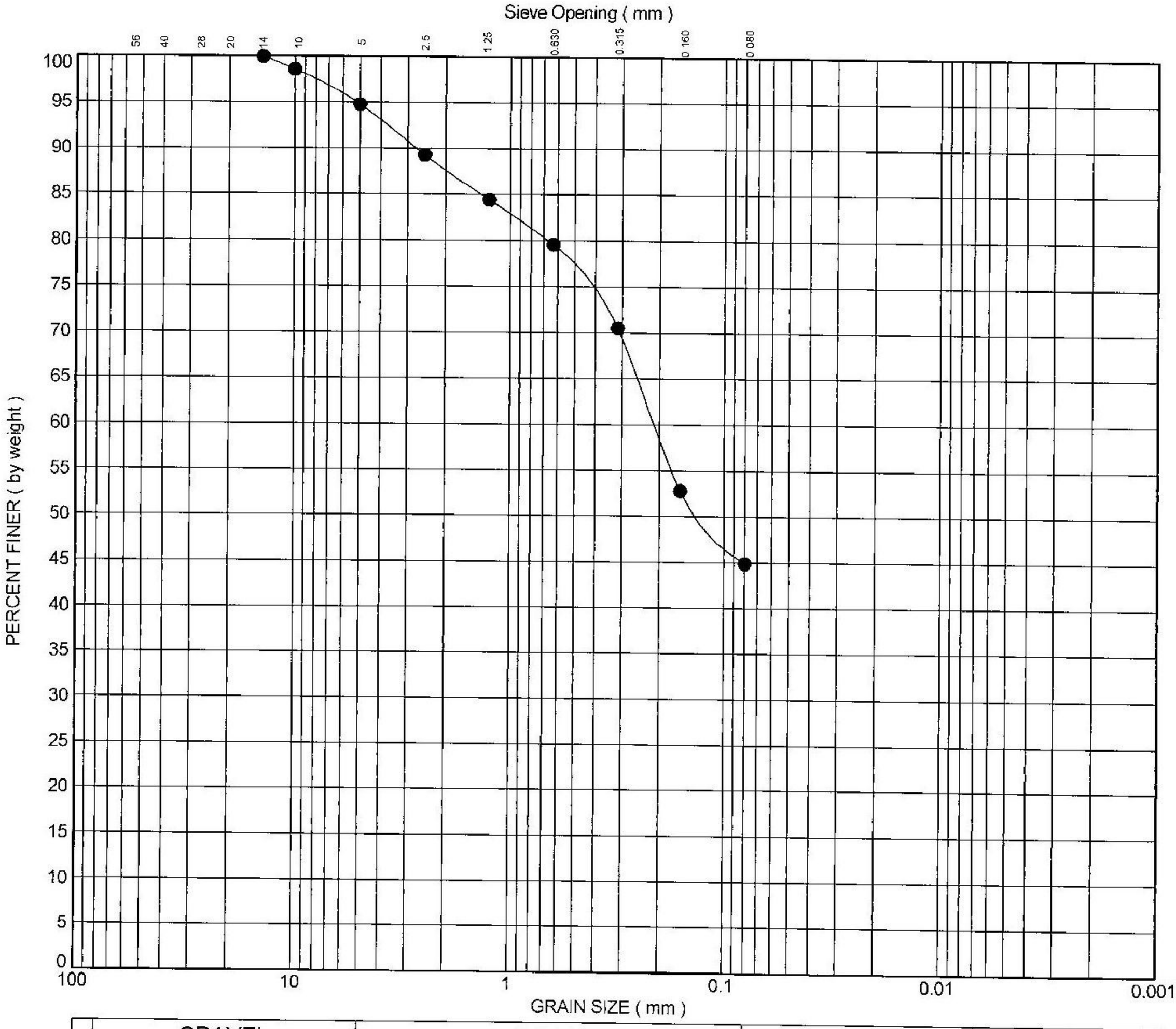
SAMPLE NUMBER

54

Material Description : Silty Sand trace Gravel

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
5.2	49.9	44.9		8.1	14	0.211				



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 8-13
Elevation :783.76 m
Depth : 2.74 m
Sampling Method : Grab

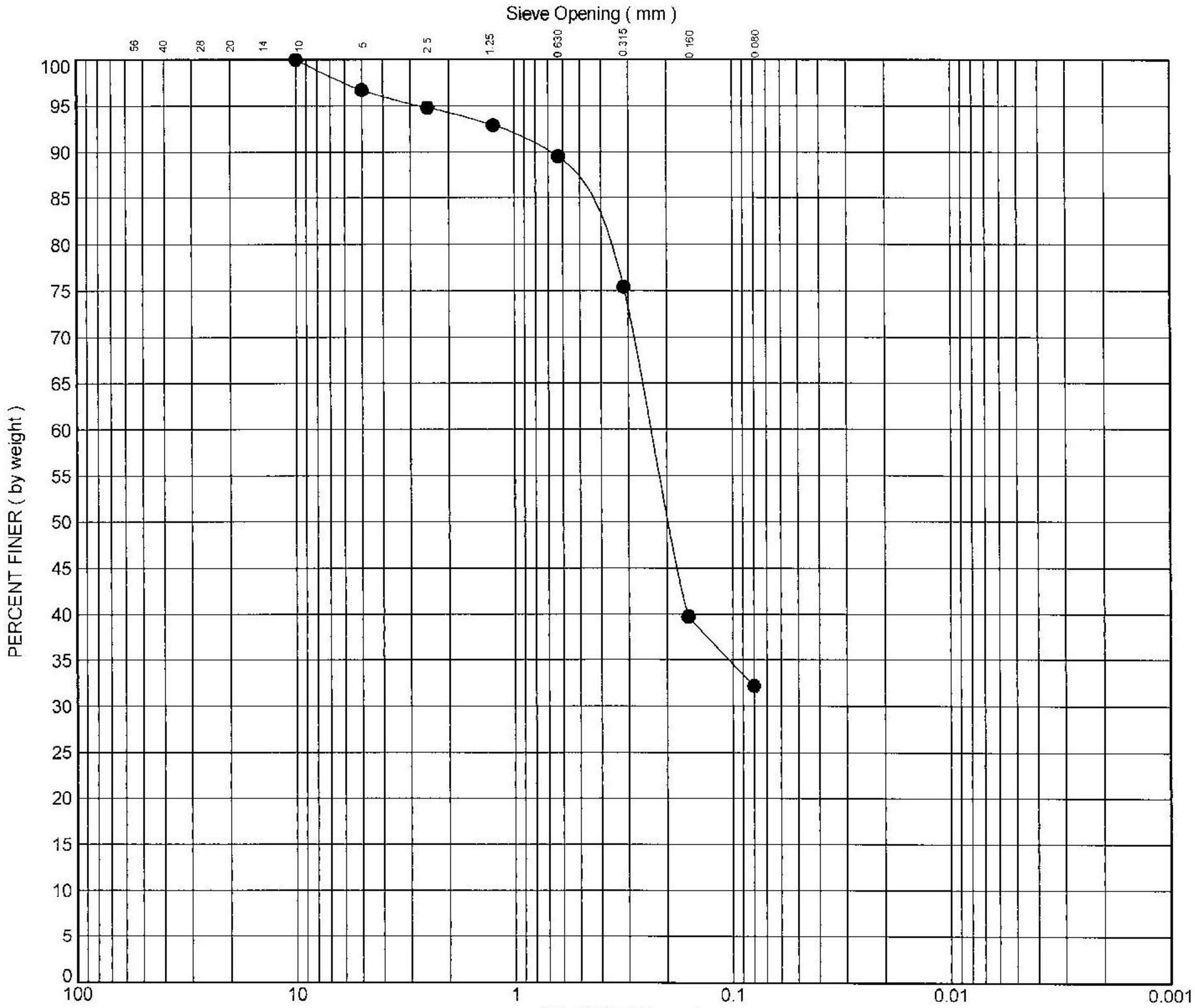
SAMPLE NUMBER

56

Material Description : Silty Sand

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
3.3	64.5	32.2		6.2	10	0.235				



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

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GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 8-13
Elevation :783.15 m
Depth : 3.35 m
Sampling Method : Grab

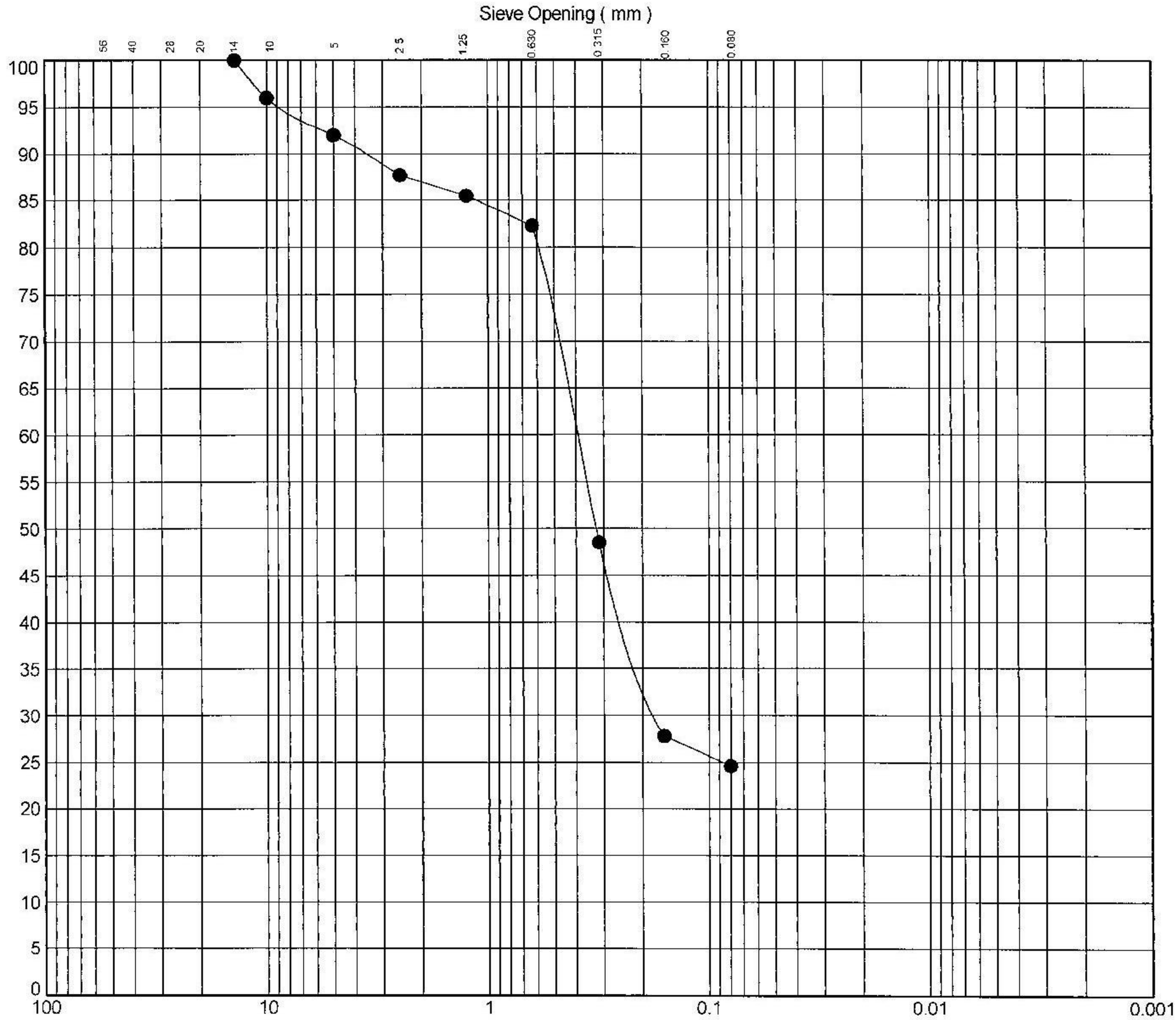
SAMPLE NUMBER

57

Material Description : Silty Sand trace Gravel

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
8.0	67.4	24.6		6.3	14	0.399	0.172			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

CHILKOOT GEOLOGICAL ENGINEERS LTD.

5B Bennett Road, Whitehorse, Yukon
(867) 667-6671 chilkoot@northwestel.net

GRAIN SIZE ANALYSIS - ASTM D422-633

Client : Yukon Government - EMR Lands Branch
Project : Geotechnical Evaluation - Proposed McGowan Subdivision
Location : Whitehorse, Yukon
Chilkoot Project No. : 200-003-13

Borehole : 8-13
Elevation :778.27 m
Depth : 8.23 m
Sampling Method : Grab

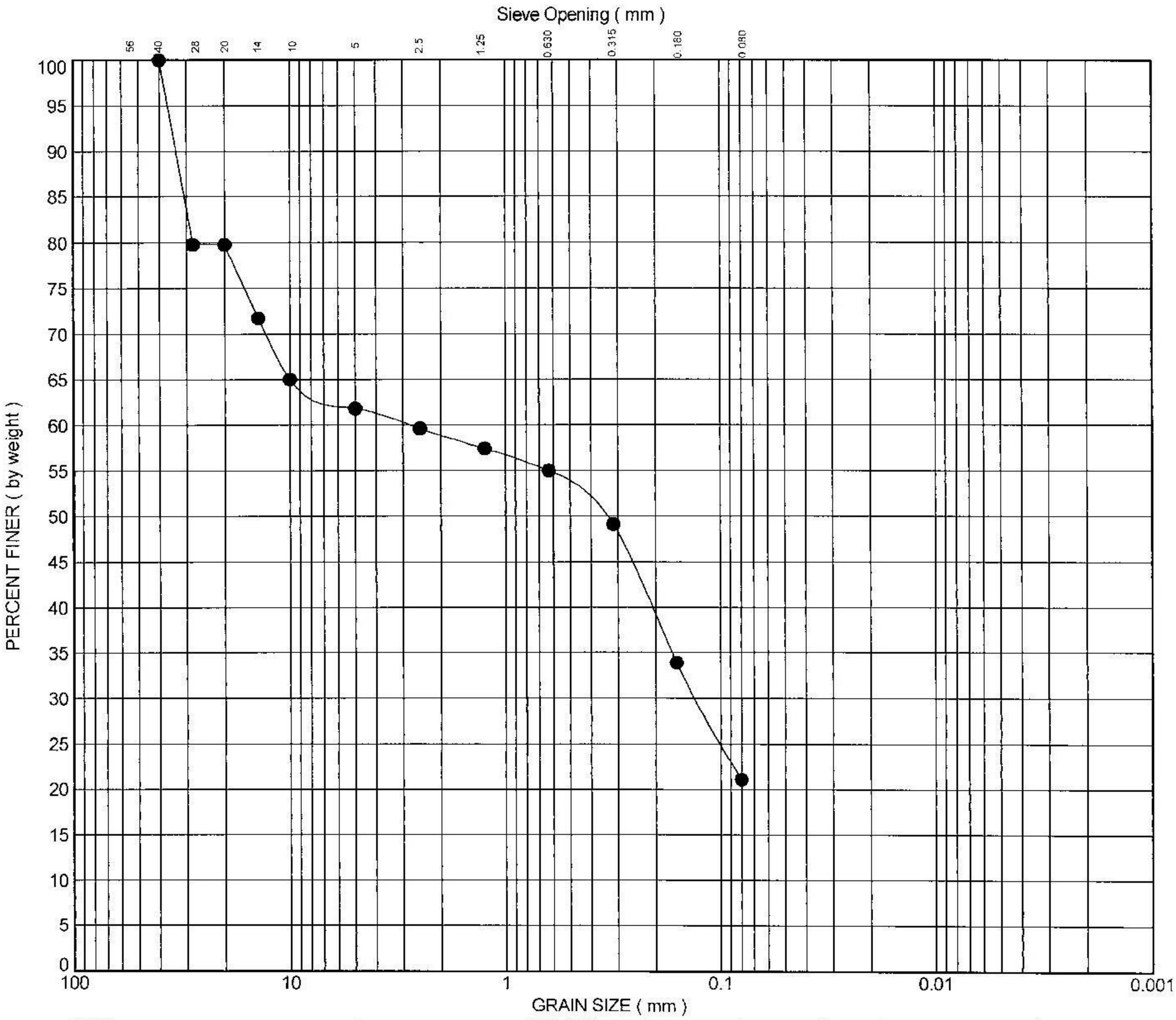
SAMPLE NUMBER

64

Material Description : Gravelly Silty Sand

USCS Classification : SM

Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	D100	D60	D30	D10	Cc	Cu
39.2	40.8	21.1		4.3	40	2.836	0.13			



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

Sampled By : Chilkoot - T.Dhara
Date : April 16, 2013

Received By : Chilkoot - T.Dhara
Date : April 16, 2013

Analyzed By : Chilkoot - T.Dhara
Date : April 16-19, 2013

Reviewed By:
Date : April 30, 2013

APPENDIX C

Levelton Consultants Ltd

pH & Resistivity Analysis

Levelton Consultants Ltd.

BC Mainland Region

150-12791 Clarke Place
Richmond, BC V6V 2H9
Canada

Tel: 604 278-1411
Fax: 604 278-1042
E-Mail: surrey@levelton.com

301 – 19292 60th Avenue
Surrey, BC V3S 3M2
Canada

Tel: 604 533-2992
Fax: 604 533-0768
E-Mail: surrey@levelton.com

110 - 34077 Gladys Avenue
Abbotsford, BC V2S 2E8
Canada

Tel: 604 855-0206
Fax: 604 853-1186
E-Mail: abbotsford@levelton.com

108 – 3677 Highway 97N
Kelowna, BC V1X 5C3
Canada

Tel: 250-491-9778
Fax: 250-491-9729
Email: kelowna@levelton.com

Construction Materials
Building Science
Geotechnical
Corrosion Prevention
Metallurgy
Environmental
Physical Testing

June 18, 2013

File: R813-1132-00

Chilkoot Geological Engineers Ltd.
5 Bennett Road
Whitehorse, YT
Y1A 5Z4

Attention: Mr. Tares Dhara, P.Eng.

Dear Mr. Chiu:

Re: ASTM G57 Soil Resistivity Test

Levelton Consultants Ltd. conducted electrical resistivity and pH tests on one sample of soil and one sample of water from Cowley Creek, for the McGowan Subdivision in Whitehorse, Yukon.

The soil samples were tested as per ASTM Standard G57 (resistivity) and ASTM Standard G51 (pH). The test results are as follows:

Table 1

Sample ID	Resistivity (ohm-cm)	pH
Cowley Creek - Soil	1326	7.03
Cowley Creek - Water	3911	6.85

Apparatus:

- MC Miller Co. plexiglass soil box having dimensions of 22.23cm long by 3.97cm wide and 3.19cm high.
- Nillson Soil Resistivity Meter (SN 20-1651)
- Oakton Waterproof Double Junction pHTestr 20

Should you have any questions, please contact this office.

Yours sincerely,

LEVELTON CONSULTANTS LTD.

Per: Earl Mayuga, EIT
NACE Certified CP Tester No. 22052

CHILKOOT GEOLOGICAL ENGINEERS LTD.

APPENDIX D

Recommended Grain Size Distribution for Import Fills

Gran E Pit Run	
Sieve Size (mm)	% Passing By Wt
200	100
80	75-100
25	55-100
12.5	42-84
5	26-65
1.25	11-47
0.315	3-30
0.08	2-15
LA Abrasion 35 % Max Loss	

80 mm minus Sub-base	
Sieve Size (mm)	% Passing By Wt
80	100
25	60-100
12.5	40-90
5	20-65
1.25	9-35
0.315	3-15
0.08	0-8
LA Abrasion 35 % Max Loss	

Clear Stone	
Sieve Size (mm)	% Passing By Wt
28	100
20	70-100
12.5	55-100
10	30-80
5	0-40
2	0-10
NA	NA
LA Abrasion 35 % Max Loss	

Bedding Sand	
Sieve Size (mm)	% Passing By Wt
10	100
5	80-100
2	55-100
0.63	25-65
0.25	10-40
0.08	2-10

20 mm minus Base Course	
Sieve Size (mm)	% Passing By Wt
20	100
12.5	64-100
5	36-72
1.25	12-42
0.315	4-22
0.08	3-6

Class I Rip-Rap	
Sieve Size (mm)	% Passing By Wt
450	100
350	80
300	50
200	20

Class II Rip-Rap	
Sieve Size (mm)	% Passing By Wt
800	100
600	80
500	50
300	20

Class III Rip-Rap	
Sieve Size (mm)	% Passing By Wt
1200	100
900	80
800	50
500	20

APPENDIX E

Selection of Photos



Photo # 1 – Cowley Creek crossing
BH 1-13 in foreground

April 21, 2013



Photo # 2 – BH3-13 Location (background right)
Access road facing west

April 13, 2013

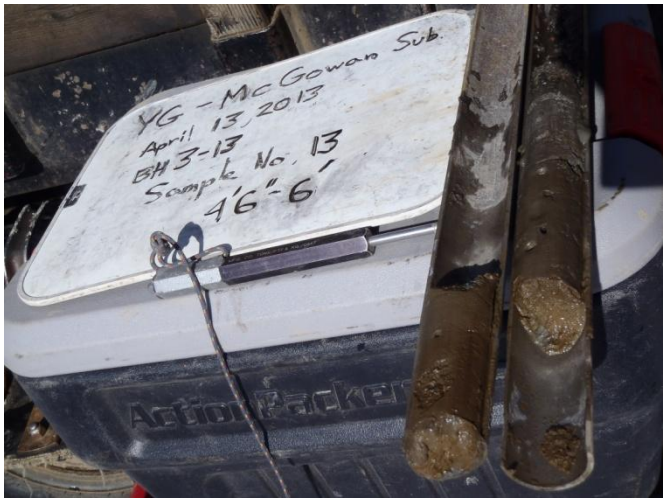


Photo # 3 – BH3-13 – Sample No.13

April 13, 2013

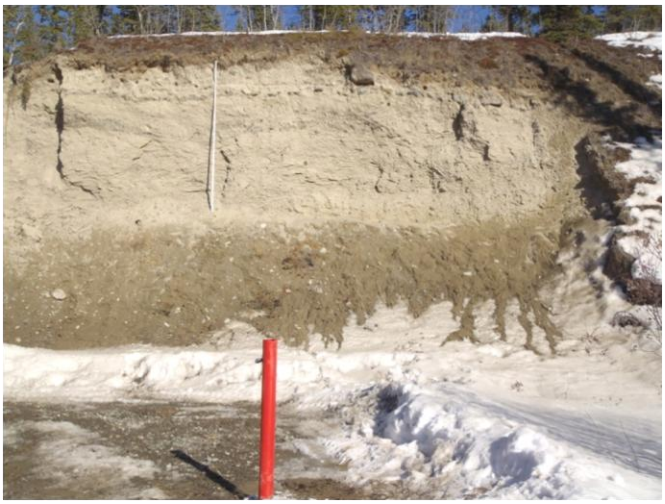


Photo # 4 – Embankment adjacent to highway
Note - 5 meter survey rod center left

April 13, 2013



Photo # 5 – TP1-13 Site Conditions.

June 4, 2013



Photo # 6 – TP1-13 Conditions & Spoils

June 4, 2013