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Geophysical and borehole investigation of aggregate resources in the Whitehorse area, Yukon

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Cover photo: Sonic drilling for aggregate exploration in the city of Whitehorse.

INTRODUCTION

Aggregate is an integral resource for the development of Whitehorse. The City of Whitehorse receives much of its gravel from private quarries located within city limits; this benefits the city by reducing the transportation costs associated with hauling aggregate from outside of the city. Anticipated growth and development places an increased demand on locally sourced aggregate required for construction. While new quarries are vital for growth, it is important that resource extraction be maximized near existing quarries in order to take advantage of existing infrastructure. The goal of this project is to gain a better estimate of the quality and quantity of aggregate at four sites in the vicinity of Whitehorse.

Field investigations were conducted in the summer of 2013 by Kryotek Arctic Innovation and the Yukon Geological Survey to better delineate existing and potential sources of aggregate near Whitehorse (Fig. 1). This project was also implemented to further investigate the geophysical results presented by Golder and Associates (2015). Techniques employed for this investigation include electrical resistivity tomography (ERT), induced polarization tomography (IP); sonic borehole drilling; grain size analysis; and ground penetrating radar (GPR).

STUDY SITES

Four locations (Fig. 1) in the Whitehorse area were investigated for their aggregate potential: 1) McLean Lake, 60°38'20.62"N 135°04'06.75"W; 2) Km 196 North Klondike Highway (Takhini Bridge); 3) Haekle Hill/ Alaska Highway (60°48'17".77N 135°13'36.95"W, 761 m asl); and 4) Long Lake (road site 60°45'26.19"N 135°02'34.42"W, 723 m asl).

GEOPHYSICAL METHODS

DC Electrical Resistivity Tomography

Resistivity was selected for this area as the electrical properties of silt, gravel and granite bedrock are distinct and easily definable. A Lippmann 4-point Resistivity System was used. This system allows up to 40 m of depth penetration. Data were collected and inverted using AGI Earth Imager 2D software. Noisy data points and electrodes with poor contact resistance were removed and data were filtered for spikes or depressions in resistivity. The software produced two-dimensional tomograms using smoothed, least squares damped and robust inversion parameters. Preliminary interpretations were conducted on the processed data.

This technique injects a direct electrical current into the ground surface, and then measures the voltage that remains at a number of distances from the injection point. As different soils have different resistances to electrical current, a tomogram (subsurface diagram) of resistivities can be produced. This technique is useful for displaying the high-resistance regions of bedrock and ground-ice.

Induced Polarization Tomography

This technique is conducted simultaneously with the DC electrical resistivity. As the electrical current is injected into the ground, a charge is retained in soil and rock materials, and then decays as a function of time. Decay rates differ according to the electrical properties of the ground materials and can be useful in differentiating subsurface material types and boundaries.

Earth Imager 2D software, by Advanced Geosciences Inc., was used to invert and process the geophysics data. Two-dimensional tomograms of resistivity data are produced. The images were processed using both smoothed and robust inversion parameters in order to clarify transitions between material types as well as resistivity properties of those materials.

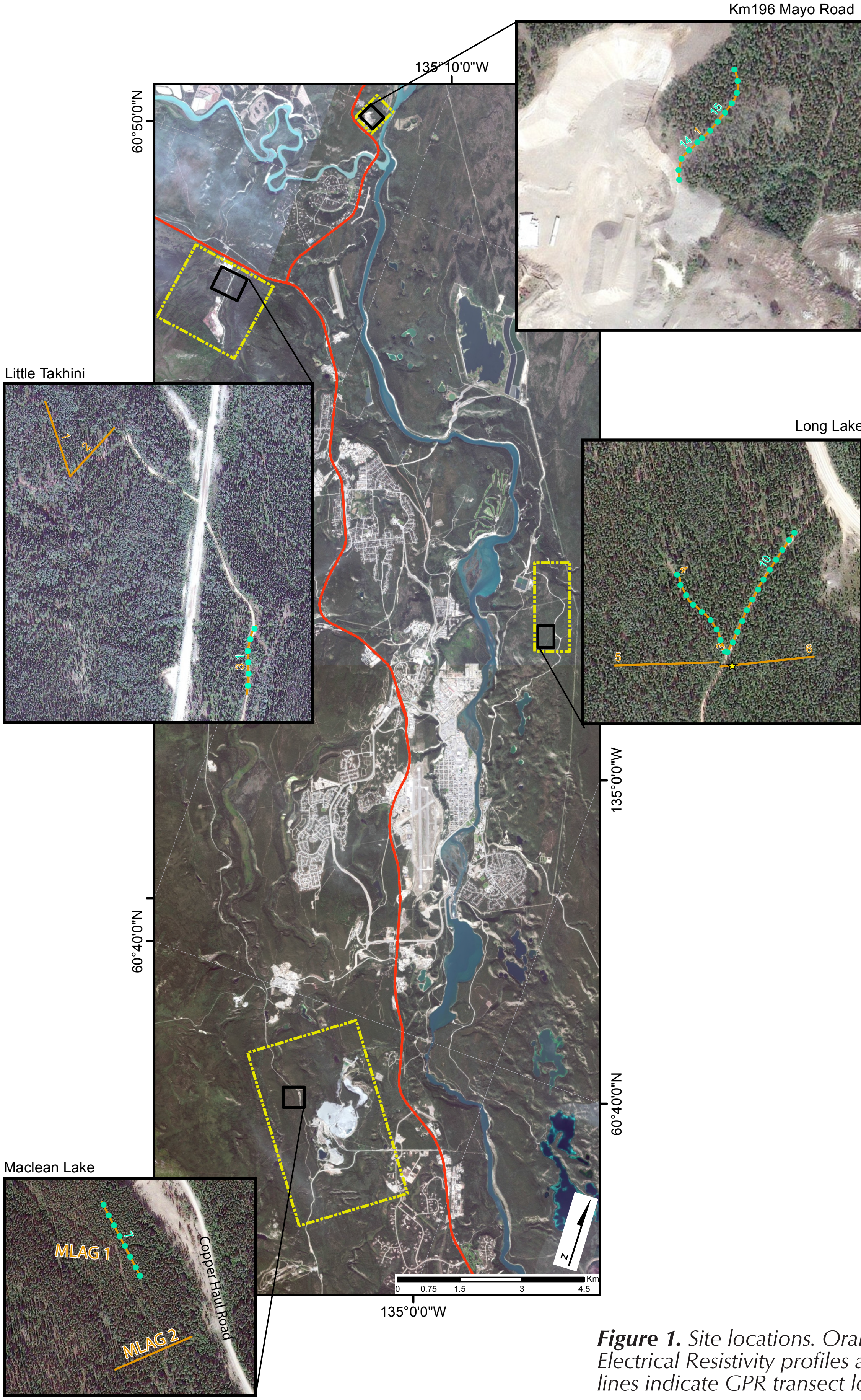


Figure 1. *Site locations. Orange lines demark Electrical Resistivity profiles and dotted green lines indicate GPR transect locations.*

Interpretations are subjective and highly dependent on the experience of the interpreter.

General principles and assumptions in the interpretation are:

1. Fine-grained materials more than 600 Ohm/m are generally frozen;
2. Dry gravel has high resistivity, from 2000-8000 Ohm/m;
3. In the Whitehorse area, regions of higher resistivity (4000-8000 Ohm/m) appear to indicate the presence of cobbles and boulders;
4. Increasing water content and increasing fines content lower resistivity;
5. Frozen gravel and ice-rich materials have much higher resistivity (from 10 000 up to 100 000 Ohm/m);
6. Low resistivity can indicate thawed and saturated areas;
7. Contrasts in resistivity readings indicate transitions between materials and are more important than absolute values; and
8. Resistivity is the primary tool. IP sections are only included when they provide data useful for interpreting the resistivity. As a result, only resistivity images will be labeled with supplementary information on the IP sections where relevant. IP is most useful when a large contrast in IP values matches a contrast in resistivity and indicates the top of bedrock below overburden.

Limitations

The DC electrical resistivity and induced polarization method provides an estimate of subsurface conditions only at the specific locations where lines were injected and only to the depths penetrated, and within the accuracy of the method. Data gathered represents a hemispherical cross-section extending downwards from the surface. Results are more accurate closer to the surface and become more general with increasing depths. The presence of permafrost is a major complicating factor and can cause changes in resistivity of up to several orders of magnitude.

Resistivity and IP data are indirect and the interpreted features subjective in nature; identified anomalies are based on a visual assessment of the characteristic signatures in the data coupled with information from nearby boreholes and test pits. Interpretation is largely based on the experience of the operator with the specific equipment and terrain types. Certain material types can be very similar in resistivity, resulting in ambiguous results.

Ground penetrating radar

Ground penetrating radar was used to gain a two dimensional image below ground surface. A TerraSIRch Subsurface Interface Radar (SIR) System 3000® with a shielded 100-MHz monostatic antenna (Geophysical Survey Systems, Inc. (GSSI)) was employed for the field investigation. Post collection processing was conducted using RADAN™ (Version 7, GSSI) software.

GPR data processing included the correction of the initial pulse to time-zero to ensure that the first reflection is from the ground surface and the subsequent reflections are from deeper below the ground surface; FIR boxcar filter to remove background horizontal noise; and range gain adjustments to recover lower-amplitude waves from reflections deeper in the ground (Conyers, 2004; Doolittle and Nelson, 2009). The objectives of the processing procedures were to reduce signal attenuation with depth, and improve the continuity of stratigraphic reflections and the signal-to-noise ratio. The data records were not corrected to account for changes in surface topography.

Sonic Drilling

A Sonic Drill Corporation SDC150 track-mounted sonic drill was used to collect subsurface samples. This drill used high-frequency vibrations to advance a 100 mm core tube into the soil. This tube was then withdrawn and the core extracted on the surface. The drill can penetrate most types of overburden, however it requires water to advance a casing in very dry, sloughing soils. Water was not available at any of the sites; dry, sandy gravel was encountered at 3 to 4 m in most boreholes. This depth is sufficient to confirm the presence of aggregate.

Grain Size Analysis

Grain size analysis was conducted as per American Society for Testing and Materials (ASTM) standards using a standard sieve stack and shaker.

RESULTS

Long Lake

Of the four sites examined, the Long Lake site appeared to be the most promising aggregate source. While there is not a quarry at this location, there is existing road infrastructure to the site, and it is situated within city limits. Results from the EM31 electromagnetic ground resistivity survey completed by Golder and Associates (2015) indicate potential aggregate source areas at this location. Based on these results from Golder and Associates, a combination of techniques consisting of geophysics and borehole drilling with sediment recovery were employed to further investigate the aggregate potential at this location. Geophysics data were collected along lines extended from a central point. Drilling was completed along a linear transect (start of transect ERT4 UTM 0497675E, 6735795N; end 0497614E, 6735861N) through the area with boreholes situated on the same transects as the lines used for geophysics; information collected from drilling was used to aid the interpretation of geophysical results. The extent of gravel was determined by drilling four holes to an average depth of 4.0 m; sand and gravel are encountered throughout (Appendix A). Dry cobble and gravel material prevented further drilling without the use of water to place a casing.

The geophysical data show good agreement, a 2-4 m thick layer of lower resistance sand and gravel (2000-3000 Ohm/m) overlying coarse, dry gravel (4000-6000 Ohm/m), which extend 10-15 m in depth. There is then a distinct boundary with another lower resistivity (1000-2000 Ohm/m) geological unit, which may be bedrock, the top of the water table, or silty sand (Fig. 2). The contact between the lowermost layers appears consistent with fluvial erosion and deposition, and may indicate an outwash channel. Yellow lines on the GPR image for transect 009 at Long Lake demark paleochannel bed surfaces (Fig. 2). These surfaces are similar to the subsurface features visible in the resistivity images.

Data from the geophysical survey indicate the deposit is at least 200 m wide by 200 m long, and 10 m deep, for a minimum gravel volume of 400 000 cubic metres.

Grain sizes show a good distribution of fine and coarse gravel extending 10-15 m below the ground surface. The gravel is extremely dry and is overlain by a very thin (5-10 cm) layer of loess and organics. Particle size analyses for the Long Lake samples exhibited some consistency with the average size range equalling 70% gravel, 28% sand, and 2% silt/clay (Appendix B).

McLean Lake

The McLean Lake site consists of a thin gravel and boulder deposit 5 to 10 m thick, 60 to 70 m wide, and more than 200 m long. This deposit has been partially excavated, providing a ten-metre high exposure (Fig. 3). Geophysical survey line MLAG 1 (McLean Lake 1; transect start UTM 0495705E, 6723404N; end 0495755E, 6723316N) was run along the crest of the exposure and the resistivity values can be directly correlated to the material in the exposure (Fig. 1).

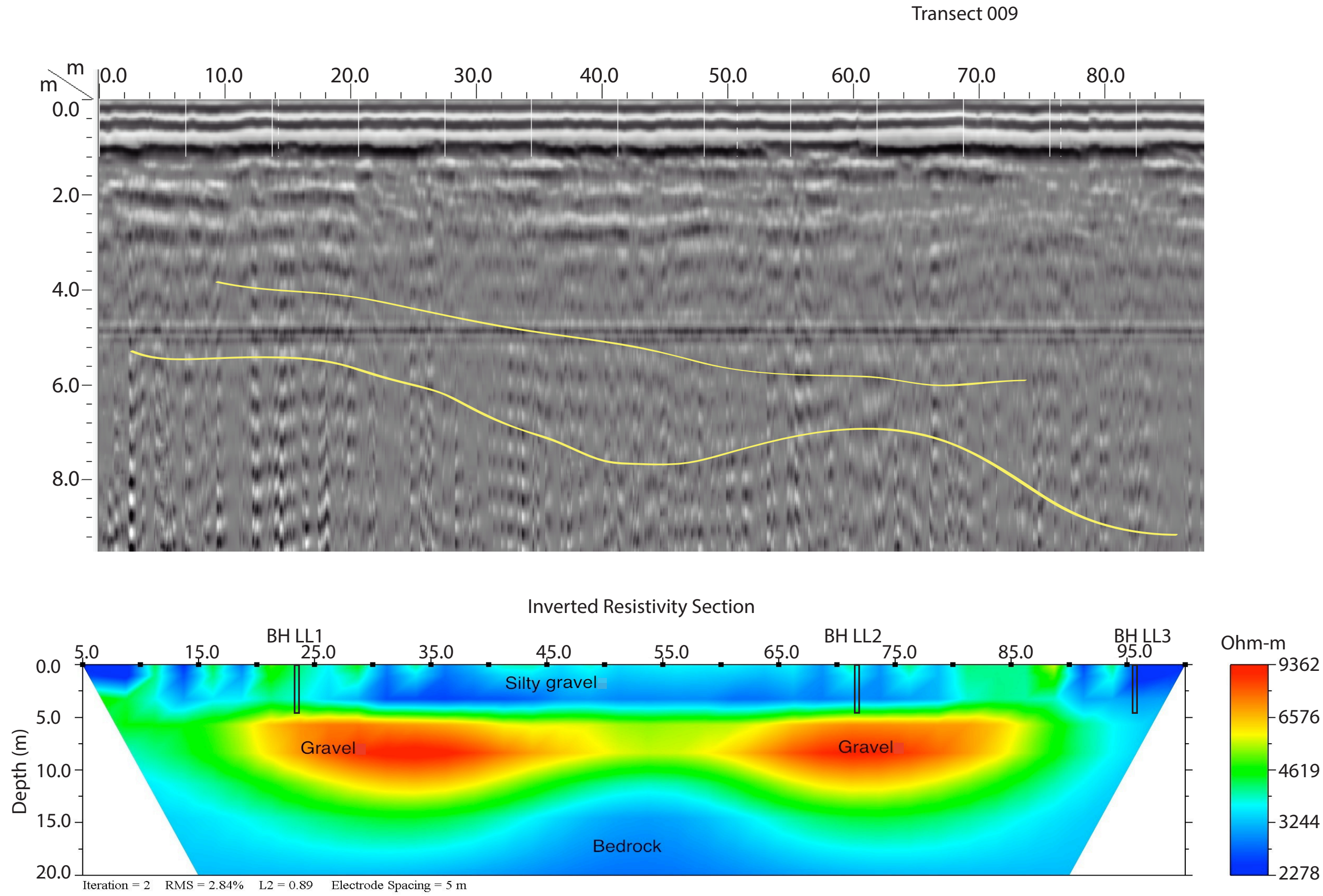


Figure 2. *Long Lake results; ERT 4 and GPR 009. Yellow lines demark paleochannel beds.*

Sandy gravel from 1000 to 3000 Ohm/m is found in the upper 2-3 m of the section. This is underlain by a layer of cobbles and small boulders 3 m thick with much higher resistivity (greater than 4000 Ohm/m) than the sandy gravel above. This higher resistivity may be due to both the boulders as well as the larger air spaces between the boulders and cobbles. Below the cobbles is another layer of sandy gravel with 1000 to 2000 Ohm/m resistivity. Well-defined basalt bedrock, with low resistivities of 300-800 Ohm/m, is visible at the base of the image. Columnar basalt is visible in surface outcrops in the area adjacent to the geophysical survey lines (Fig. 4).

Ground penetrating radar transect 007 (Fig. 4) shows the boundaries between the sandy gravel and cobbles and small boulders at a depth of approximately 3 m and the sandy gravel above and below. This contact is outlined by the yellow line in Figure 4, and corresponds well with the data from the resistivity survey.

MLAG1 (McLean Lake 1) was inaccessible for drilling. Given the excellent exposure in the pit wall drilling was relocated to just beyond the end of MLAG2 (McLean Lake 2), where bedrock was encountered at depths between 1.4 and 3.0 m beneath sandy gravel (Fig. 1). Drilling was also conducted on the east side of the Copper Haul Road to determine the gravel extent. One borehole was drilled to bedrock, a depth of 4.0 m.

This area is 70-m-wide and more than 100-m-long, with depths of 5 to 10 m. Fifty thousand cubic metres of gravel is likely located in this deposit; however, there is a large quantity of boulder material which would complicate excavation and processing of the aggregate. Results from particle size analyses for McLean Lake yield an average size range of 63% gravel, 35% sand, and 3% silt/clay (Appendix B).

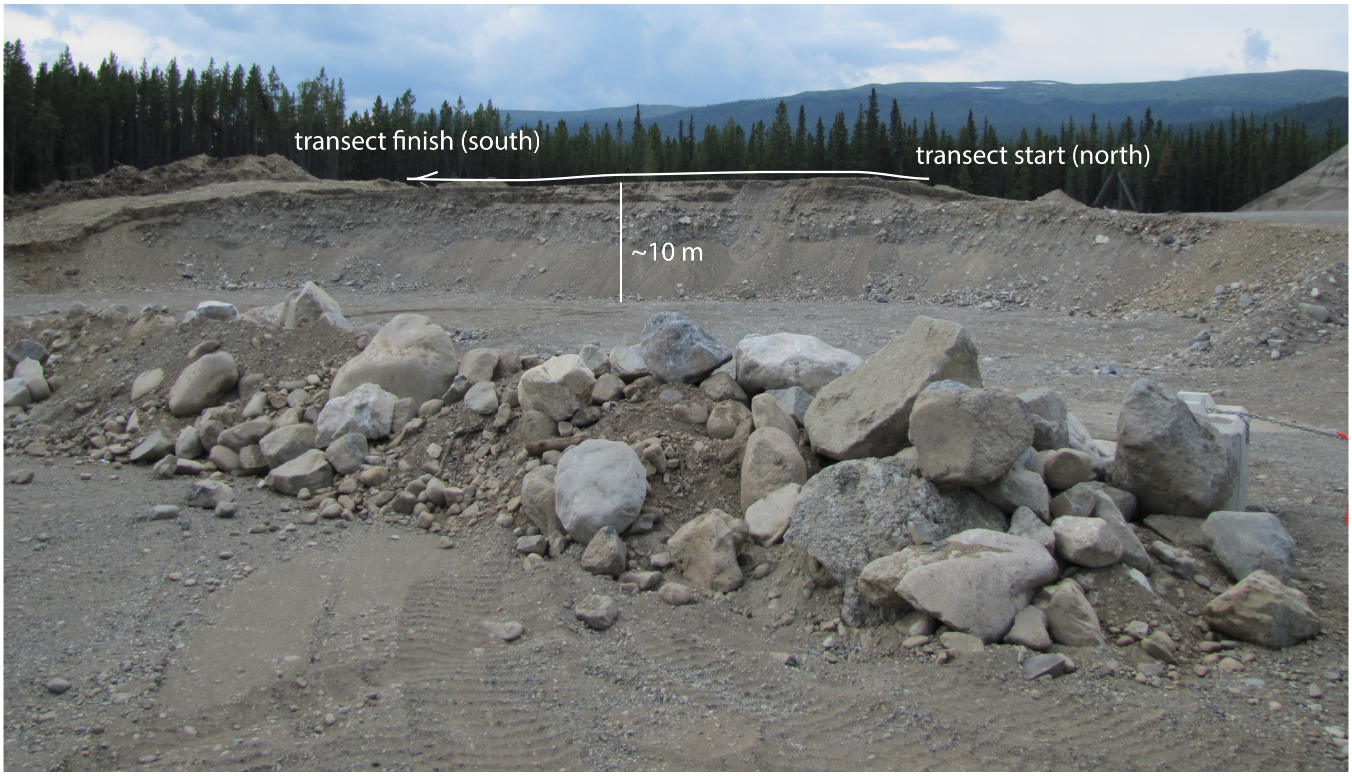


Figure 3. *McLean Lake sediment exposure and transect location.*

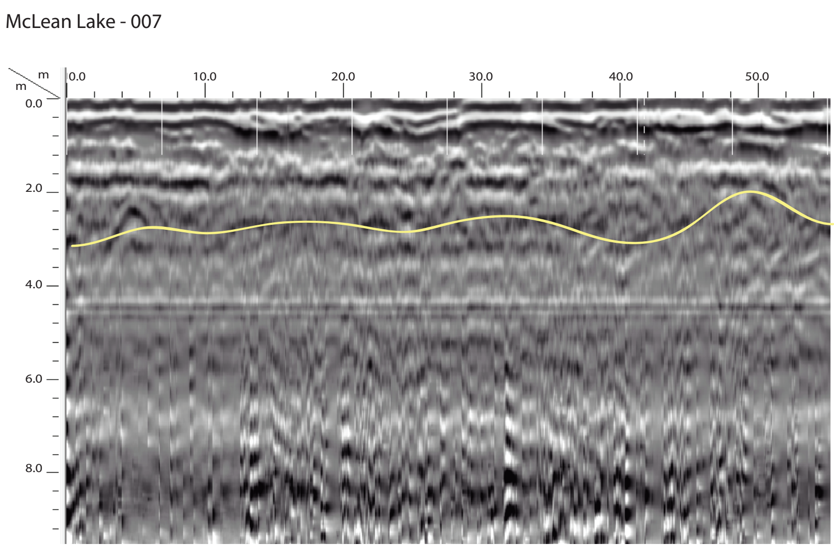
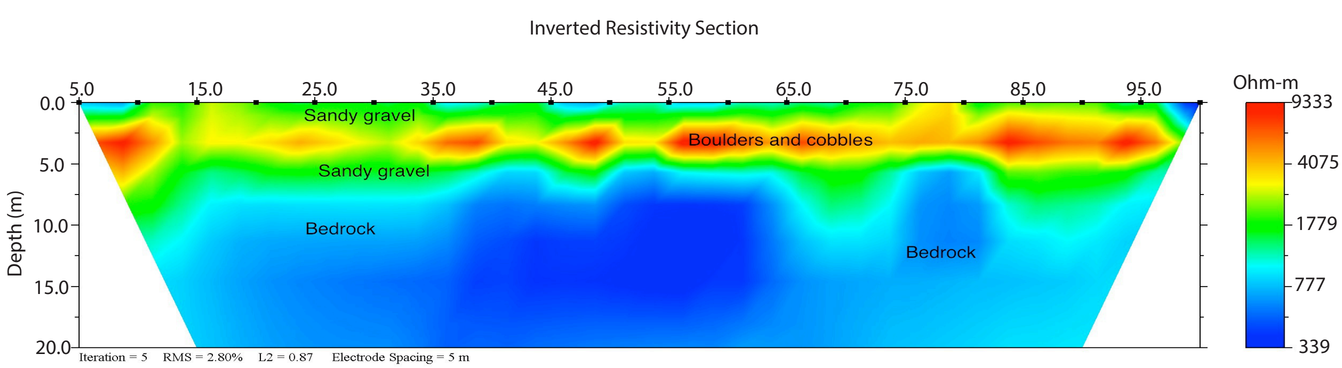


Figure 4. *McLean Lake results; MLAG 1 and GPR 007. The yellow line indicates the boundary between the sandy gravel and the cobbles and small boulders.*



Little Takhini

The Little Takhini site is located adjacent to an existing gravel quarrying operation, located on a glaciofluvial terrace. An electromagnetic ground resistivity survey run by Golder and Associates (2015) yielded a large area of interpreted distribution of aggregate in their Little Takhini study region. To further quantify the results outlined in the Golder and Associates (2015) report, three geophysical survey lines and three boreholes were completed on ridge tops in hummocky terrain (Fig. 5) to the north of the existing operation. Geophysics results were much less homogenous than those at Mclean Lake and Long Lake and showed considerable variation with depth and linearly. High resistivity areas may be gravel, but may also be permafrost. Boreholes encountered cobbles and silt with relatively low resistivity (300-1000 Ohm/m), interspersed with higher resistivity material (2000-5000 Ohm/m).

DC resistivity image LT3 (Fig. 6; transect start UTM 0487651E, 6741076N; end 0487642E, 6740982N) shows a large extremely high resistivity region (20 000-100 000 Ohm/m). This is likely permafrost extending from 5 to 12 m below surface. The extremely high resistivity region, interpreted as permafrost at LT3, could be composed of gravel and is a potential aggregate supply, but could also just be frozen silt. Additional drilling or excavation would be required to determine the type of material causing the extremely high resistivity visible on LT3, as it lays below the maximum depth of borehole BHLT3. The presence of permafrost complicates interpretation for gravel as high resistivities in fine-grained permafrost can be similar to that in gravel. However, in this area the resistivities are so high (greater than 10 000 Ohm/m) that it is almost certainly permafrost. The boreholes encountered silt, cobbles, and some gravel before refusal on large cobbles at 4.0 m depths.

The contact between the linear feature and the high resistivity visible silty gravel and possible permafrost in the DC resistivity image LT3 is also apparent in the GPR output data. A yellow line outlines this upper contact in GPR profile 006 and the lower yellow line most likely indicates where the top of the permafrost is located (Fig. 6).

Figure 5. *Little Takhini transect location.*

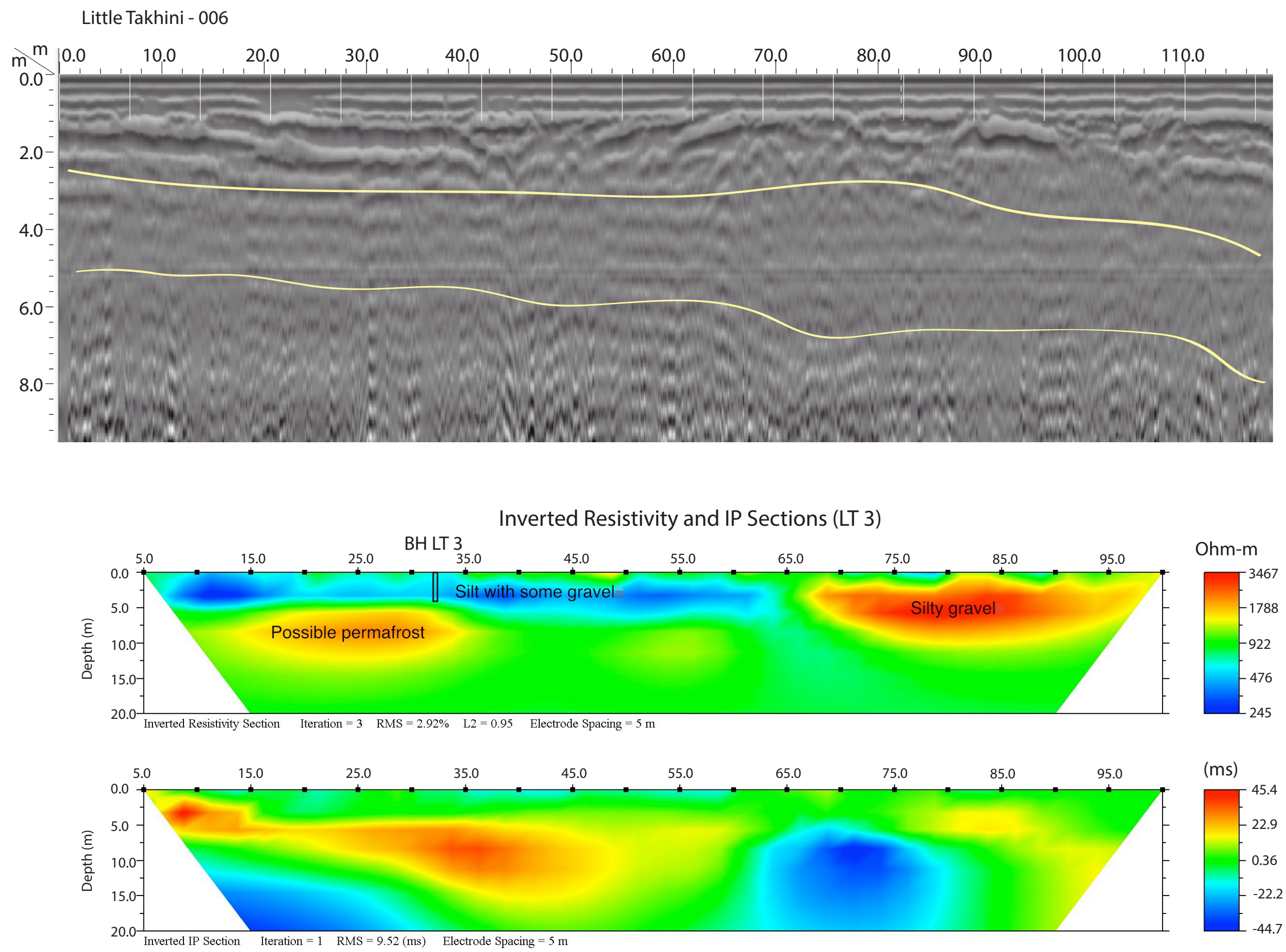


***Figure 6**. Little Takhini results; LT 3 and GPR 006. Yellow lines demark paleochannel beds.*

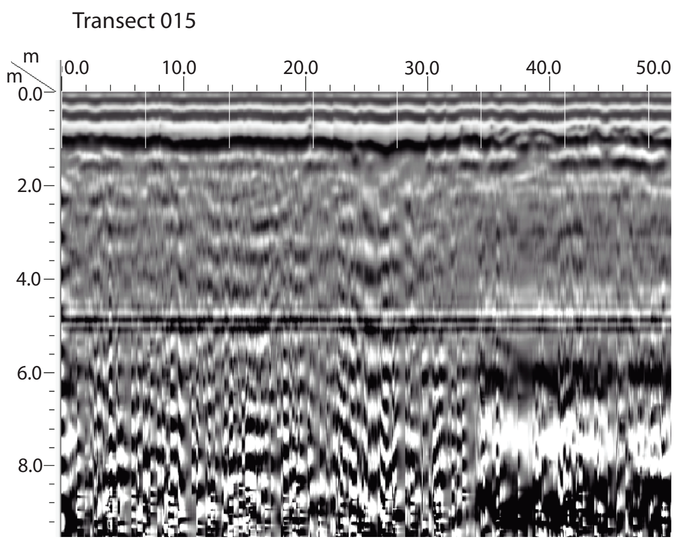
Based on our sampling results, this area does not have high potential for gravel and almost certainly contains discontinuous permafrost, which would create problems for any future gravel quarrying. However, only a small portion of the Little Takhini area was sampled for this study and further investigation, including trenching, borehole drilling, and geophysical surveys, is recommended. Particle size analyses for the Little Takhini samples resulted in an average size range of 43% gravel, 57% sand, and 1% silt/clay (Appendix B).

Km 196 Mayo Rd. Site

Resistivity surveys were conducted along two lines at Km 196. Due to poor electrode contact resistance and noisy data only one line was useful. The site is a large existing gravel quarry with poor access to nearby areas around the quarry. For safety reasons the drill was not able to be used at this site; the drill cannot traverse the steep slopes surrounding the quarry.

Geophysical surveys were conducted along the top of a cut bank that exposed a 4 m section of sand and gravel (Fig. 7; transect start UTM 0489381E, 6746128N; end 0489416E, 6746211N). The resistivity image shows a large high resistivity area (greater than 3000 Ohm/m) in the centre of the line, which corresponds to dry sand and gravel with some cobbles in the adjacent cut bank (Fig. 8). This is surrounded by lower resistivity (1000-2500 Ohm/m) which corresponds to sandier gravel with fewer cobbles. Low resistivity areas (25-600 Ohm/m) near the surface and towards the right-hand side of the image are moist organics and silts that have been disturbed by a bulldozer (Fig. 8). Ground penetrating radar results indicate that

Figure 7*. KM 196 sedimentary exposure below transects.*



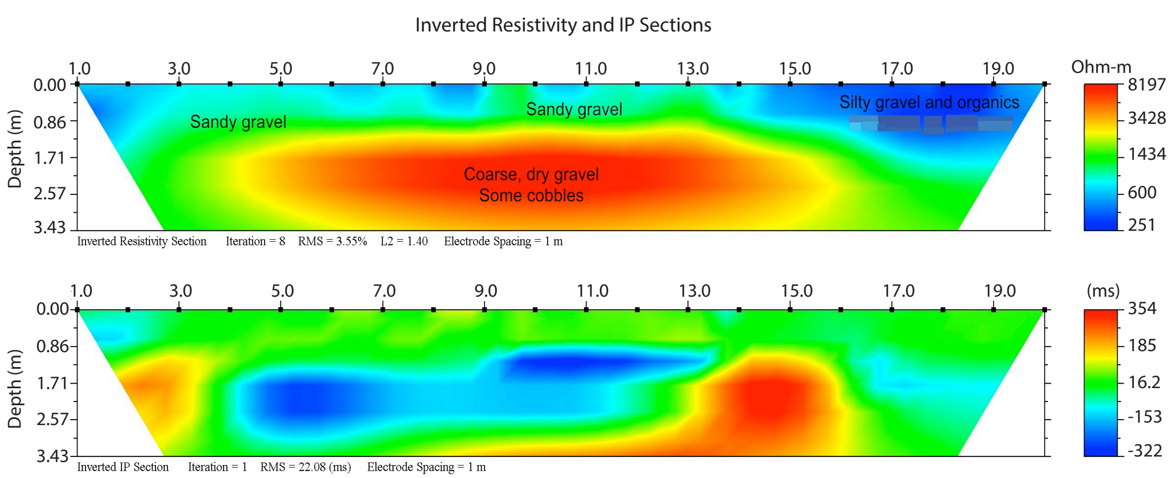


Figure 8. *Km 196 results; Electrical Resistivity and GPR 015.*

there is a mixture of grain sizes and uneven bedding at a depth of approximately 1 m; this is consistent with what is viewed at the section of the cut bank where there is a contact between the silt and cobble layer approximately 1 m below the ground surface (Fig. 7).

CORRELATION OF DRILLING WITH GEOPHYSICS

Laboratory geophysical testing of samples was unable to determine a reliable resistivity value comparable with *in situ* measurements. Samples collected by the Sonic Drilling were extremely dry, leading to very high contact resistance between the material and electrodes. When attempting to test samples, the contact resistance prevented the appropriate amount of electricity from being transmitted to the sample which is required to produce a reliable reading. For this reason, resistivity values taken *in situ* are considered to be more reliable. Planned downhole resistivity geophysics was not conducted. The extremely dry condition of the soil caused the borehole to collapse as the drill casing was withdrawn. This prevented the resistivity probe from being lowered into the borehole.

SUMMARY

Geophysical and borehole investigations reveal that the Long Lake site has the best potential for aggregate development. It is estimated that the resource for this deposit is at least 200 m wide by 200 m long, and 10 m deep, for a minimum gravel volume of 400 000 cubic metres.

The McLean Lake site also displayed good potential. The area is 70 m wide and more than 100 m long, with depths of 5 to 10 m. Fifty thousand cubic metres of gravel is likely located in this deposit; however, there is a large quantity of boulder material which would complicate excavation and processing of the aggregate.

Based on the interpretation of the DC electrical resistivity results, the Little Takhini site has limited potential for gravel and almost certainly contains discontinuous permafrost, which would create problems for any future gravel quarrying.

There is an existing quarry at the Km 196 Mayo Rd site. Results from geophysics run adjacent to the existing quarry indicate that there is material available for the immediate future; however, further trenching or drilling is recommended to get a better estimate of the long term potential of the site, as the main deposit may be exhausted in the near future.

Recommendations for further investigation to delineate the aggregate resources at the Long Lake and McLean Lake sites, the two sites with the best potential, include targeted trenching and deeper drilling in the undisturbed ground. Trenching could be beneficial adjacent to the current aggregate pit at Km 196 to assess the remaining resource potential at that site.

ACKNOWLEDGEMENTS

Thanks to Samantha Darling for her cheerful assistance with GPR field surveys and figures.

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Golder Associates, 2015. Geophysical and Geological Exploration for Aggregate in the City of Whitehorse Area. Yukon Geological Survey, Miscellaneous Report MR-12, 68 p.

APPENDIX A

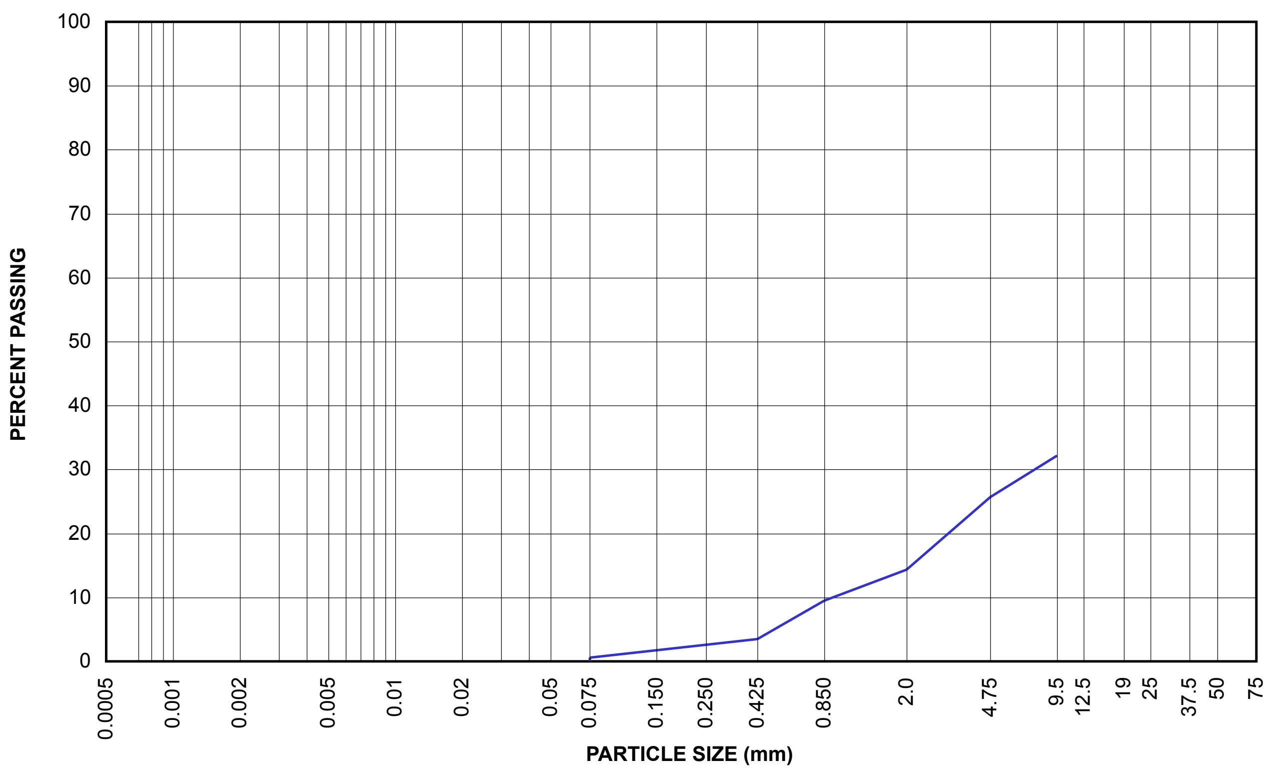
Borehole	Drill Type	UTM	0.0 - 1.5 m	1.5 - 3.0 m	3.0 - 4.5 m	4.5 m	Total Meterage	Comments
LL AG01	Sonic	8 V 497657 6735813	Sandy gravel, trace silt (dry)	Sandy gravel, trace silt (dry)	End of hole at 4.0 m		4	Grain size done 0.5-1.5m, 1.5-3.0m
LL AG02	Sonic	8 V 497630 6735840	Sandy gravel, trace silt (dry)	Gravelly sand, trace silt	End of hole at 4.0 m		4	Grain size done 0.5-1.5m, 1.5-3.0m
LL AG03	Sonic	8 V 497620 6735859	Sandy gravel, trace silt (dry)	Sandy gravel, trace silt (dry)	End of hole at 4.0		4	Grain size done 0.0-1.5m
LL AG04	Sonic	8 V 497684 6735797	Sandy gravel, trace silt (dry)	Sandy gravel, trace silt (dry)	Sandy gravel, trace silt (dry)	End of hole at 4.5 m	4.5	Grain size done 1.5-3.0m, 3.0-4.0m
LT AG01	Sonic	8 V 487402 6741298	Sand, some gravel	Sand and gravel (dry)	Sand and gravel (dry)	End of hole at 4.5 m	4.5	Grain size done 0.0-1.5m 1.5-3.0m, 3.0-4.5m
LT AG02	Sonic	8 V 487454 6741309	Sand, some gravel	Sand and gravel (dry)	Sand and gravel (dry)	End of hole at 4.5 m	4.5	Grain size not done
LT AG03	Sonic	8 V 487656 6741043	Sand, some gravel	Sand and gravel (dry)	Sand and gravel (dry)	End of hole at 4.5 m	4.5	Grain size not done
ML AG01	Sonic	8 V 495535 6723541	Sandy gravel, trace silt, some cobbles	End of hole at 3.0 m (refusal)			3	Grain size not done
ML AG02	Sonic	8 V 495577 6723506	Sandy gravel (dry)	Sand and gravel (dry)	Sandy gravel, trace silt (dry)	End of hole at 4.2 m (bedrock)	4.2	Grain size done 0.0-1.5m, 1.5-3.0m, 3.0-4.2m
ML AG03	Sonic	8 V 495522 6723635	Sandy gravel, trace silt (dry)	End of hole at 1.4 m (bedrock)			1.4	Grain size done 0.0-1.5m
							Total Drilled 38.6 m	14 Grain Size Analysis Completed

PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate
SITE: LL1
Long Lake
PROJECT NO: Aggregate
CLIENT: YGS
SAMPLE NO: 2 (0.5 m to 1.5 m)
DATE TESTED: Sep 25/13 BY: AG
USC CLASSIFICATION: G (Inferred)
NATURAL MOISTURE CONTENT: 0.0%
REMARKS: Grab Core Sample
%Gravel = 74 %Sand = 25 %Silt/Clay = 1

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

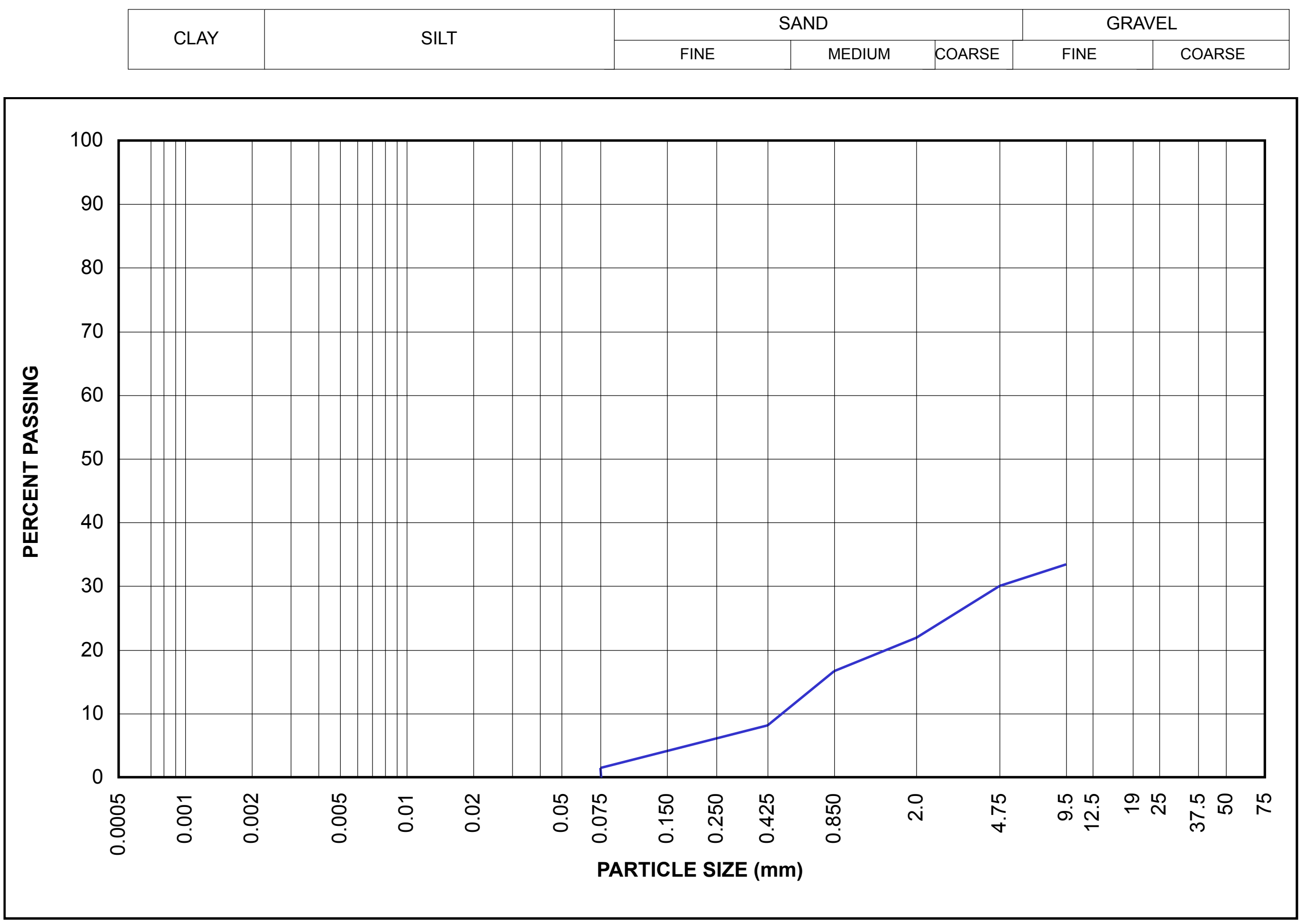
CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate
SITE: LL1
Long Lake
PROJECT NO: Aggregate
CLIENT: YGS
SAMPLE NO: 2 (1.5 m to 3.0 m)
DATE TESTED: Sep 25/13 BY: AG
USC CLASSIFICATION: G (Inferred)
NATURAL MOISTURE CONTENT: 0.0%
REMARKS: Grab Core Sample
%Gravel = 70 %Sand = 29 %Silt/Clay = 1

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

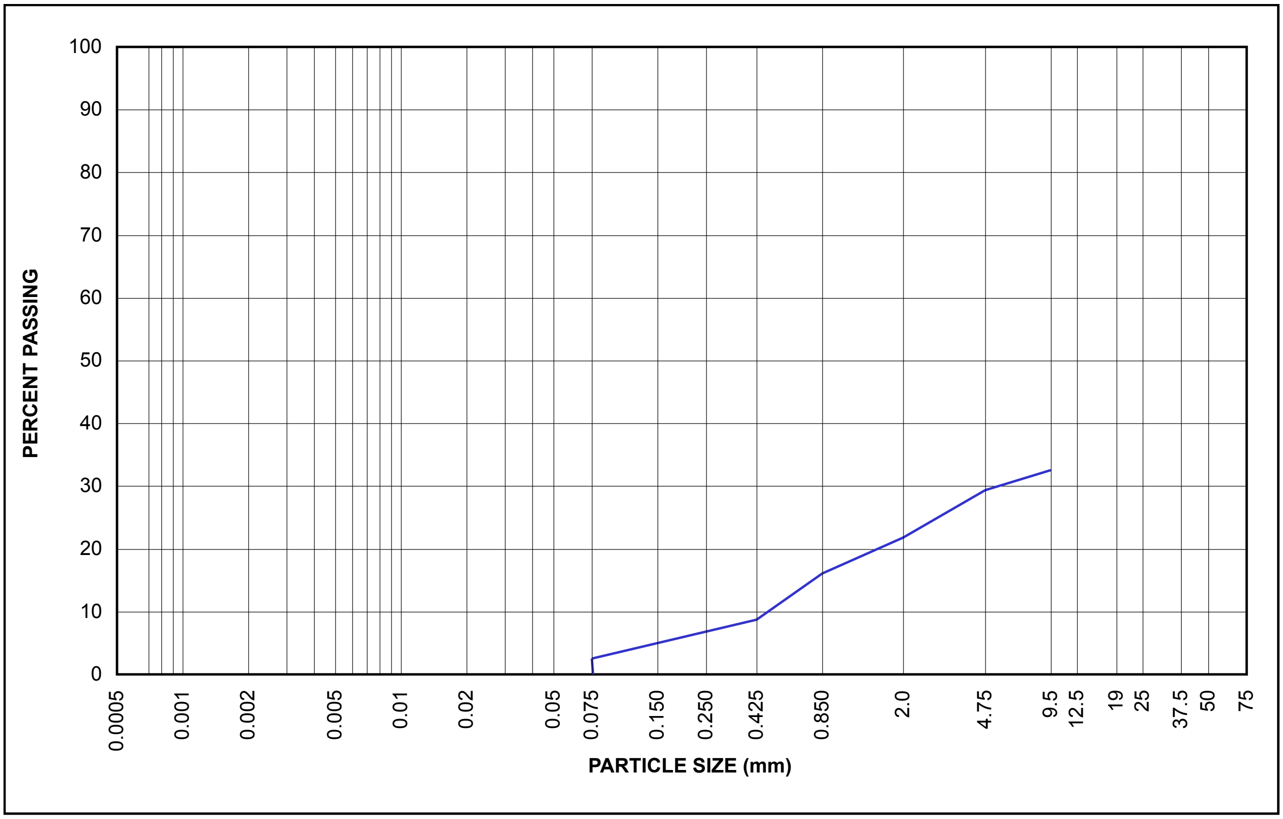


PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate
SITE: LL2
Long Lake
PROJECT NO: Aggregate
CLIENT: YGS
SAMPLE NO: 4 (0.5 m to 1.5 m)
DATE TESTED: Sep 25/13 **BY:** AG
USC CLASSIFICATION: G (Inferred)
NATURAL MOISTURE CONTENT: 0.0%
REMARKS: Grab Core Sample
%Gravel = 71 %Sand = 26 %Silt/Clay = 3

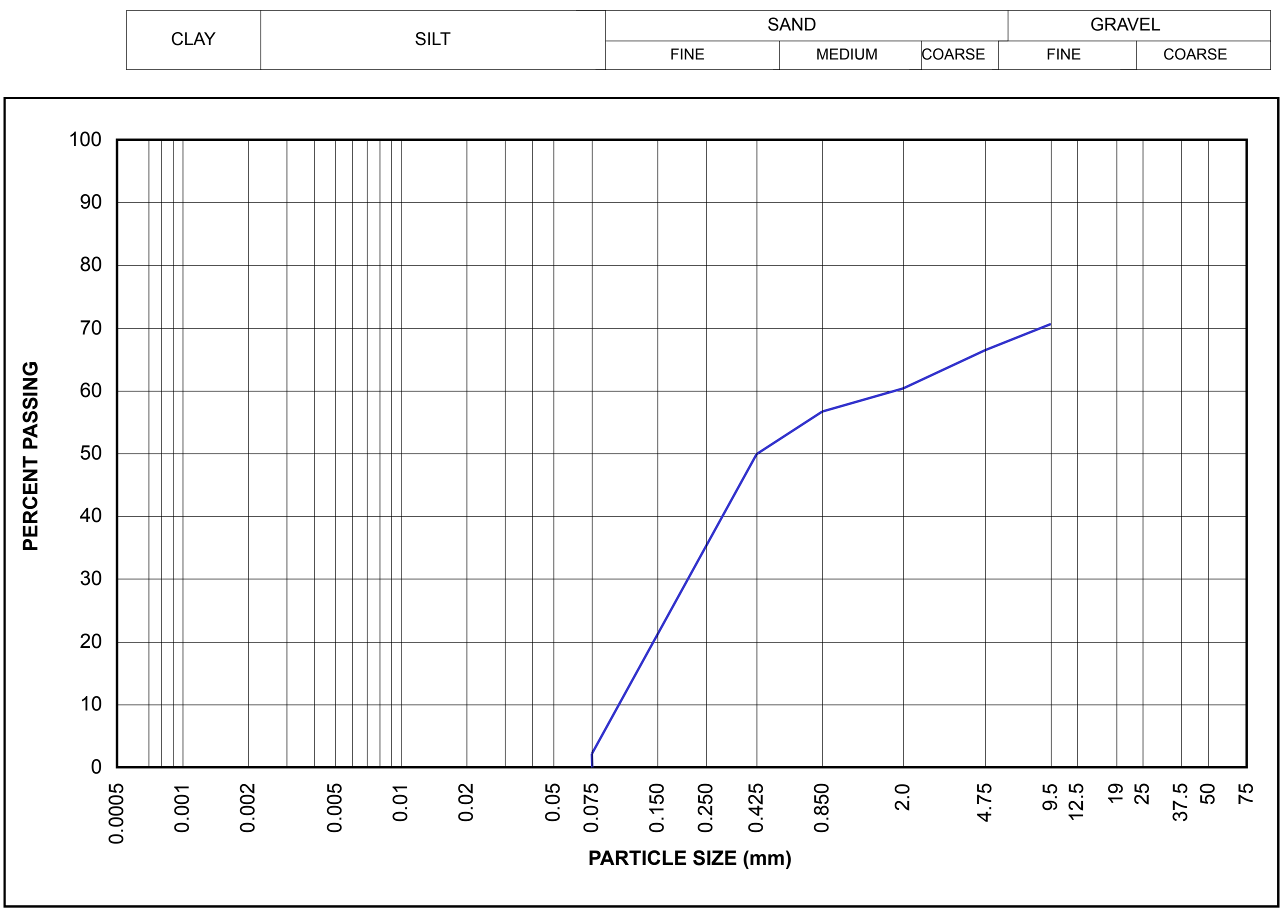
PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



PARTICLE SIZE ANALYSIS REPORT

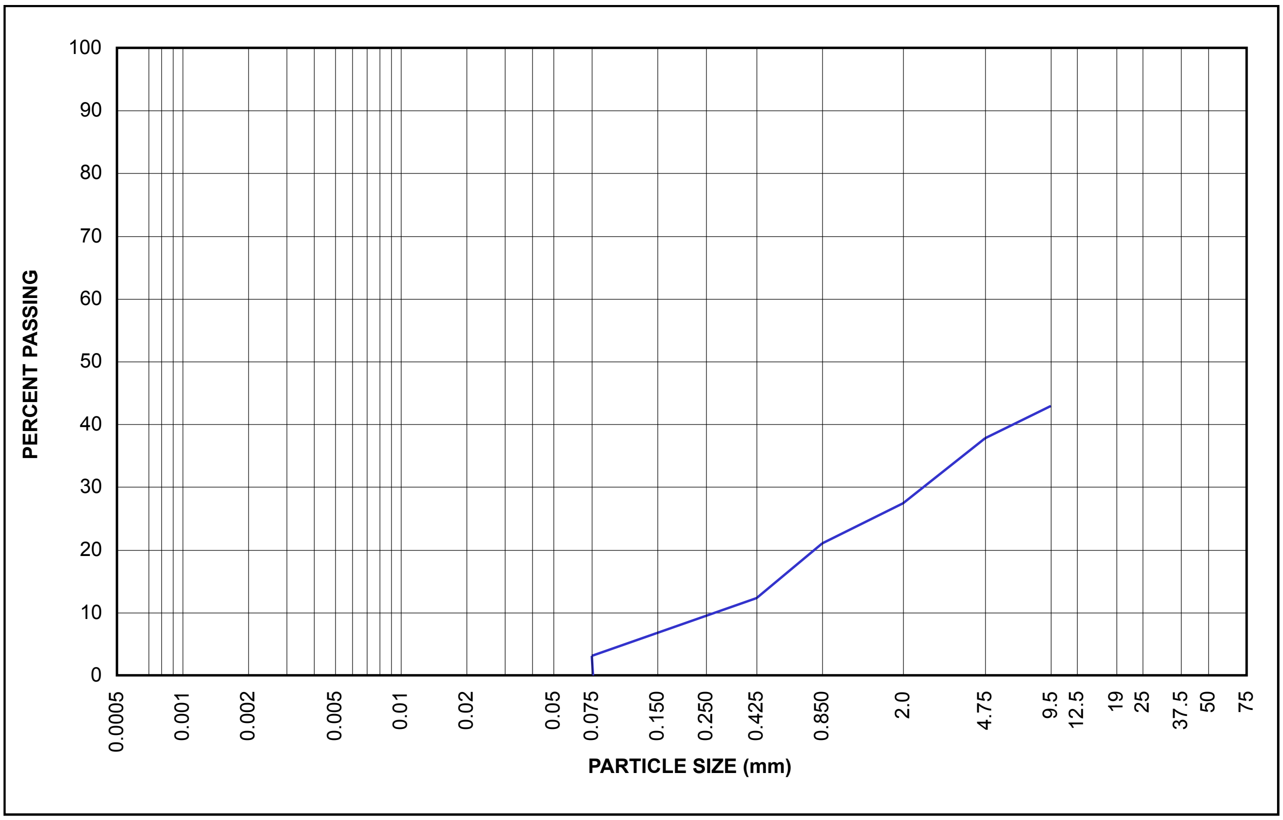
		PARTICLE SIZE
PROJECT:	YGS Aggregate	
SITE:	LL2	
	Long Lake	
PROJECT NO:	Aggregate	
CLIENT:	YGS	
SAMPLE NO:	4 (1.5 m to 3.0 m)	
DATE TESTED:	Sep 25/13 BY: AG	
USC CLASSIFICATION:	S (Inferred)	9.5
NATURAL MOISTURE CONTENT:	0.0%	4.75
REMARKS:	Grab Core Sample	2.0
%Gravel = 34	%Sand = 64 %Silt/Clay = 2	0.850
		0.425
		0.075



PARTICLE SIZE ANALYSIS REPORT

		PARTICLE SIZE
PROJECT:	YGS Aggregate	
SITE:	LL3	
	Long Lake	
PROJECT NO:	Aggregate	
CLIENT:	YGS	
SAMPLE NO:	6 (0.0 m to 1.5 m)	
DATE TESTED:	Sep 25/13 **BY:** AG	
USC CLASSIFICATION:	G (Inferred)	9.5
NATURAL MOISTURE CONTENT:	0.0%	4.75
REMARKS:	Grab Core Sample	2.0
%Gravel = 62	%Sand = 35 %Silt/Clay = 3	0.850
		0.425
		0.075

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

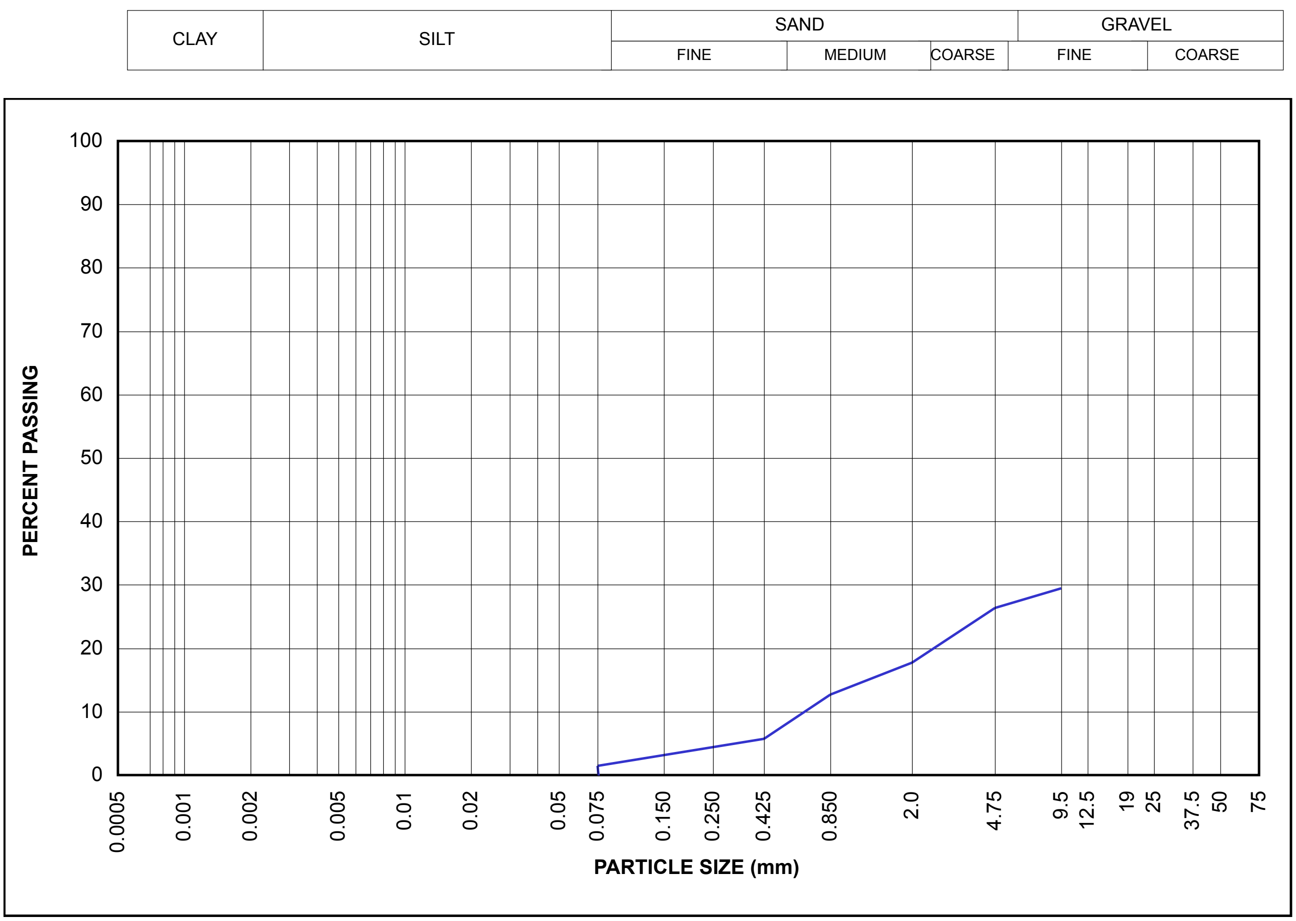


PARTICLE SIZE ANALYSIS REPORT

PROJECT:	YGS Aggregate	
SITE:	LL4	
	Long Lake	
PROJECT NO:	Aggregate	
CLIENT:	YGS	
SAMPLE NO:	8 (3.0 m to 4.0 m)	
DATE TESTED:	Sep 25/13	BY: AG
USC CLASSIFICATION:	G (Inferred)	
NATURAL MOISTURE CONTENT:	0.0%	
REMARKS:	Grab Core Sample	

%Gravel = 74 %Sand = 25 %Silt/Clay = 1

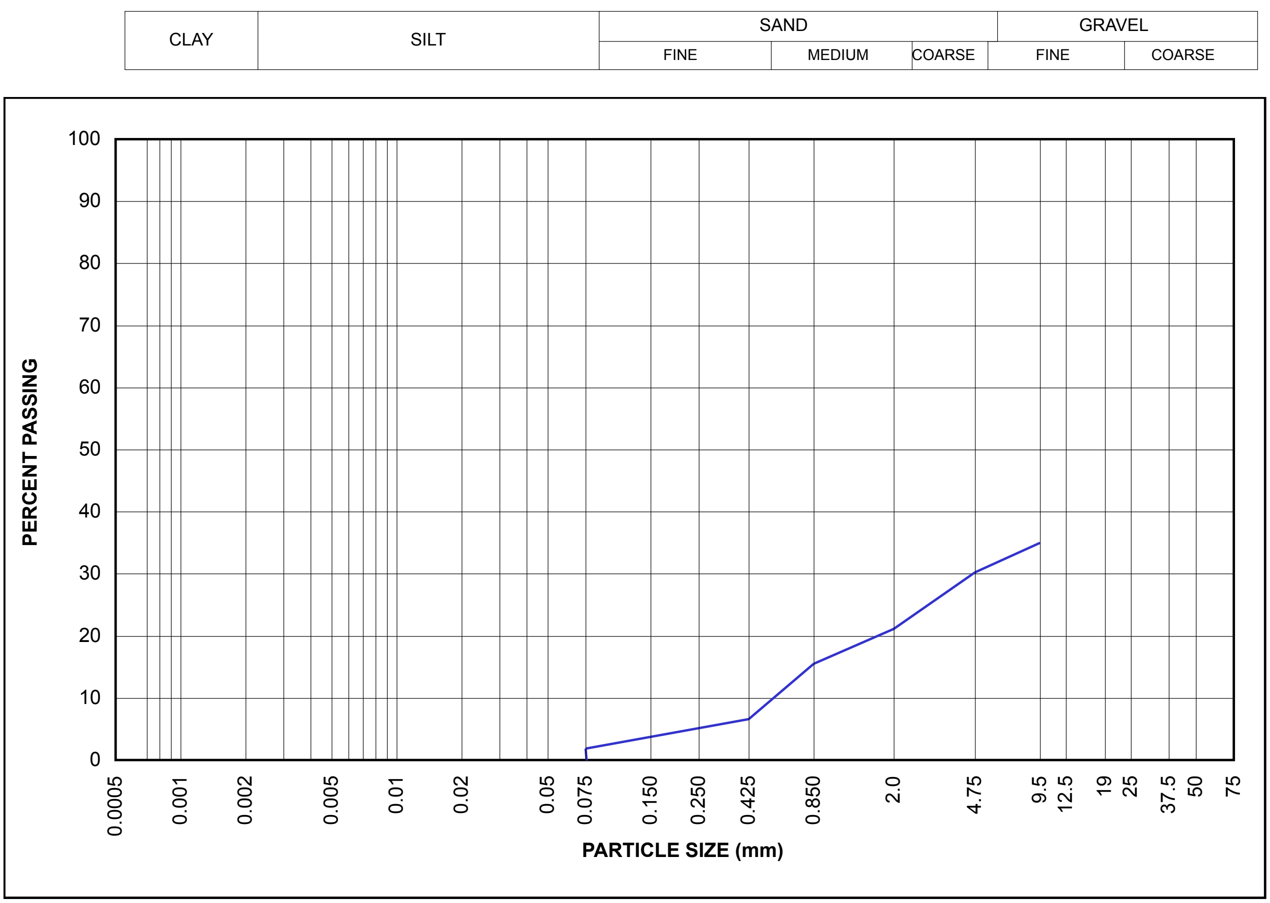
PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075



PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate
SITE: LL4
Long Lake
PROJECT NO: Aggregate
CLIENT: YGS
SAMPLE NO: 9 (1.5 m to 3.0 m)
DATE TESTED: Sep 25/13 **BY:** AG
USC CLASSIFICATION: G (Inferred)
NATURAL MOISTURE CONTENT: 0.0%
REMARKS: Grab Core Sample
%Gravel = 70 %Sand = 28 %Silt/Clay = 2

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

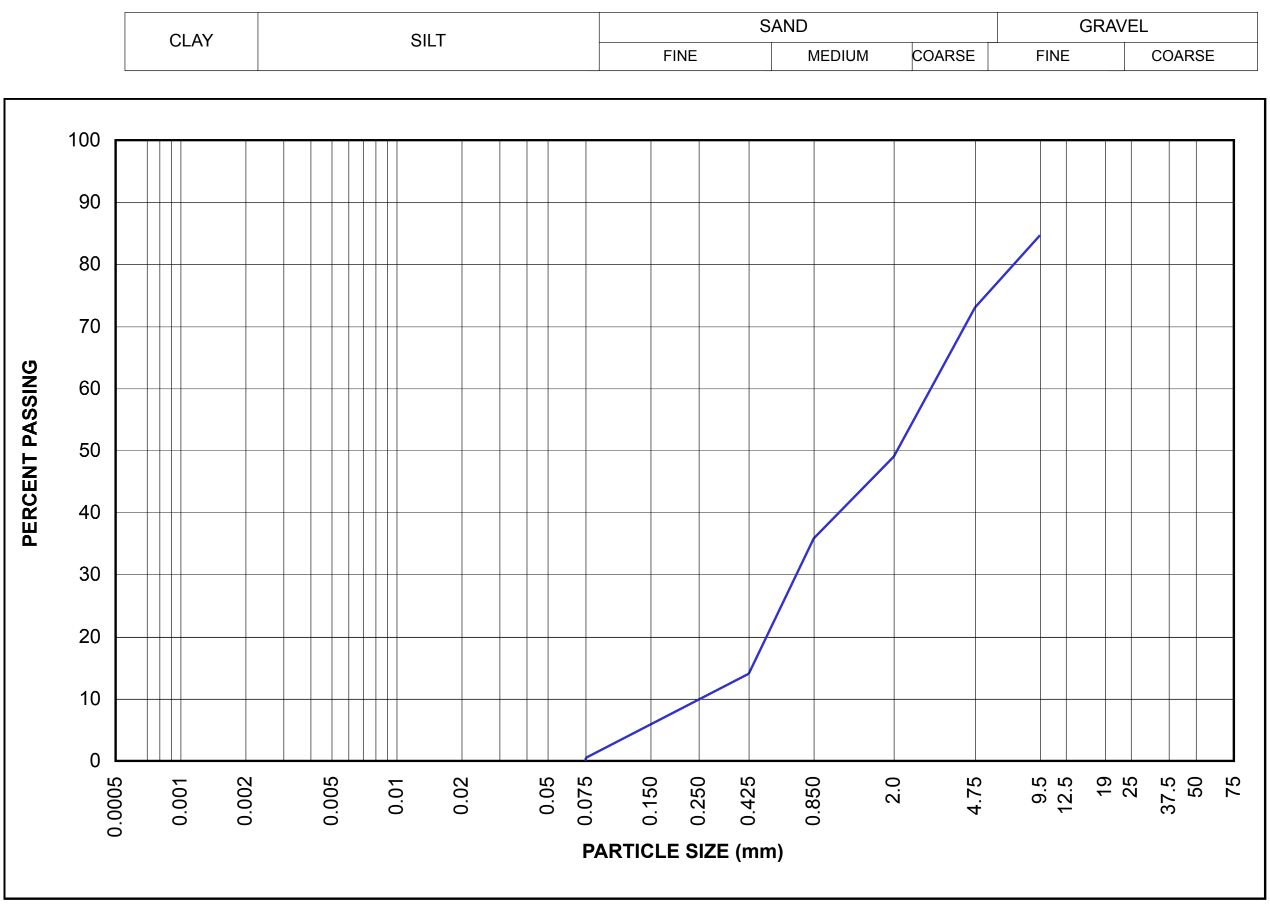


PARTICLE SIZE ANALYSIS REPORT

PROJECT:	YGS Aggregate
SITE:	LT
	Little Takhini
PROJECT NO:	Aggregate
CLIENT:	YGS
SAMPLE NO:	AG01 (0.0 m to 1.5 m)
DATE TESTED:	Sep 25/13 BY: AG
USC CLASSIFICATION:	S (Inferred)
NATURAL MOISTURE CONTENT:	0.0%
REMARKS:	Grab Core Sample

%Gravel = 27 %Sand = 73 %Silt/Clay = 0

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

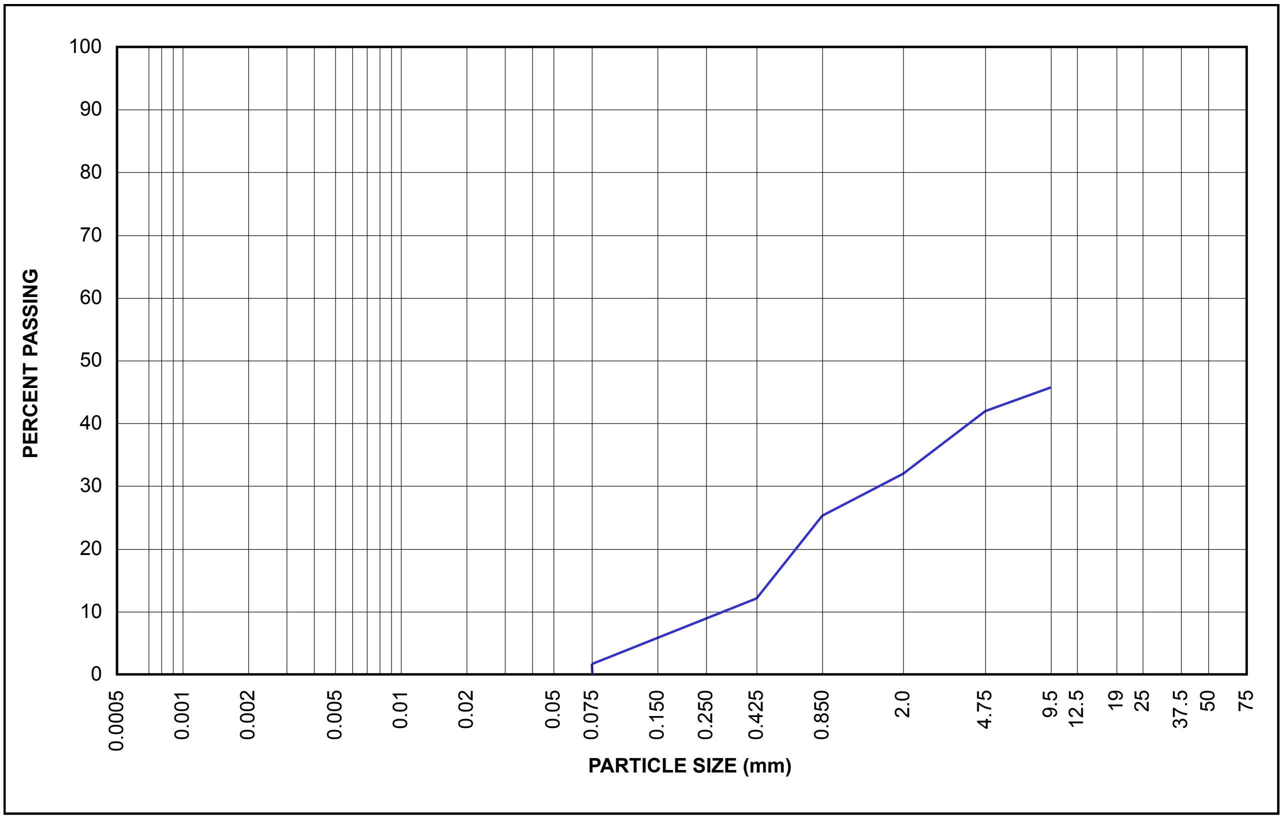


PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate
SITE: LT
Little Takhini
PROJECT NO: Aggregate
CLIENT: YGS
SAMPLE NO: AG01 (3.0 m to 4.5 m)
DATE TESTED: Sep 25/13 **BY:** AG
USC CLASSIFICATION: G (Inferred)
NATURAL MOISTURE CONTENT: 0.0%
REMARKS: Grab Core Sample
%Gravel = 58 %Sand = 40 %Silt/Clay = 2

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

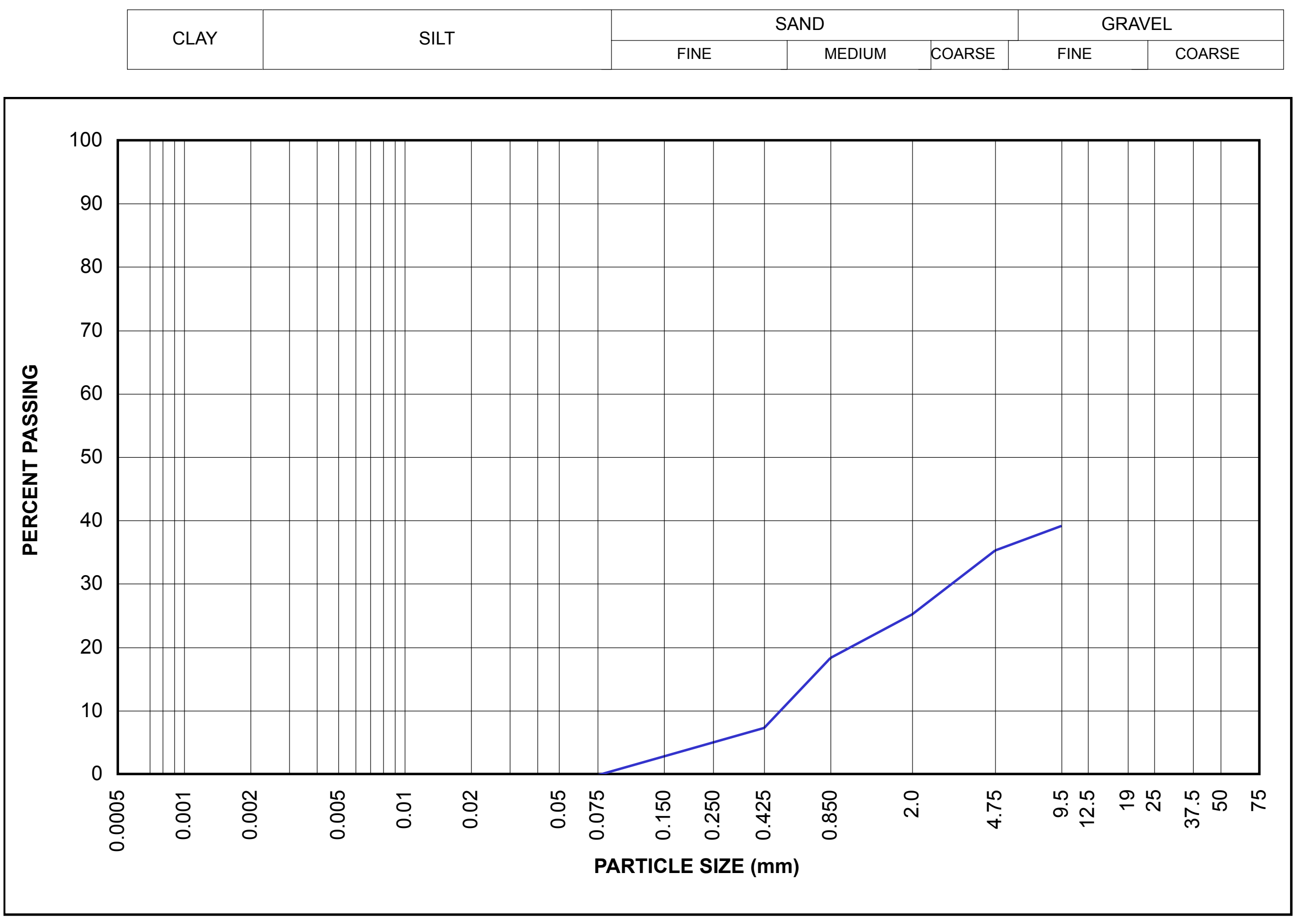
CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate
SITE: ML
MacLean Lake
PROJECT NO: Aggregate
CLIENT: YGS
SAMPLE NO: AG02 (0.0 m to 1.5 m)
DATE TESTED: Sep 25/13 **BY:** AG
USC CLASSIFICATION: G (Inferred)
NATURAL MOISTURE CONTENT: 0.0%
REMARKS: Grab Core Sample
%Gravel = 65 %Sand = 35 %Silt/Clay = 0

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075



PARTICLE SIZE ANALYSIS REPORT

PROJECT: YGS Aggregate

SITE: ML

MacLean Lake

PROJECT NO: Aggregate

CLIENT: YGS

SAMPLE NO: AG02 (1.5 m to 3.0 m)

DATE TESTED: Sep 25/13 **BY:** AG

USC CLASSIFICATION: G (Inferred)

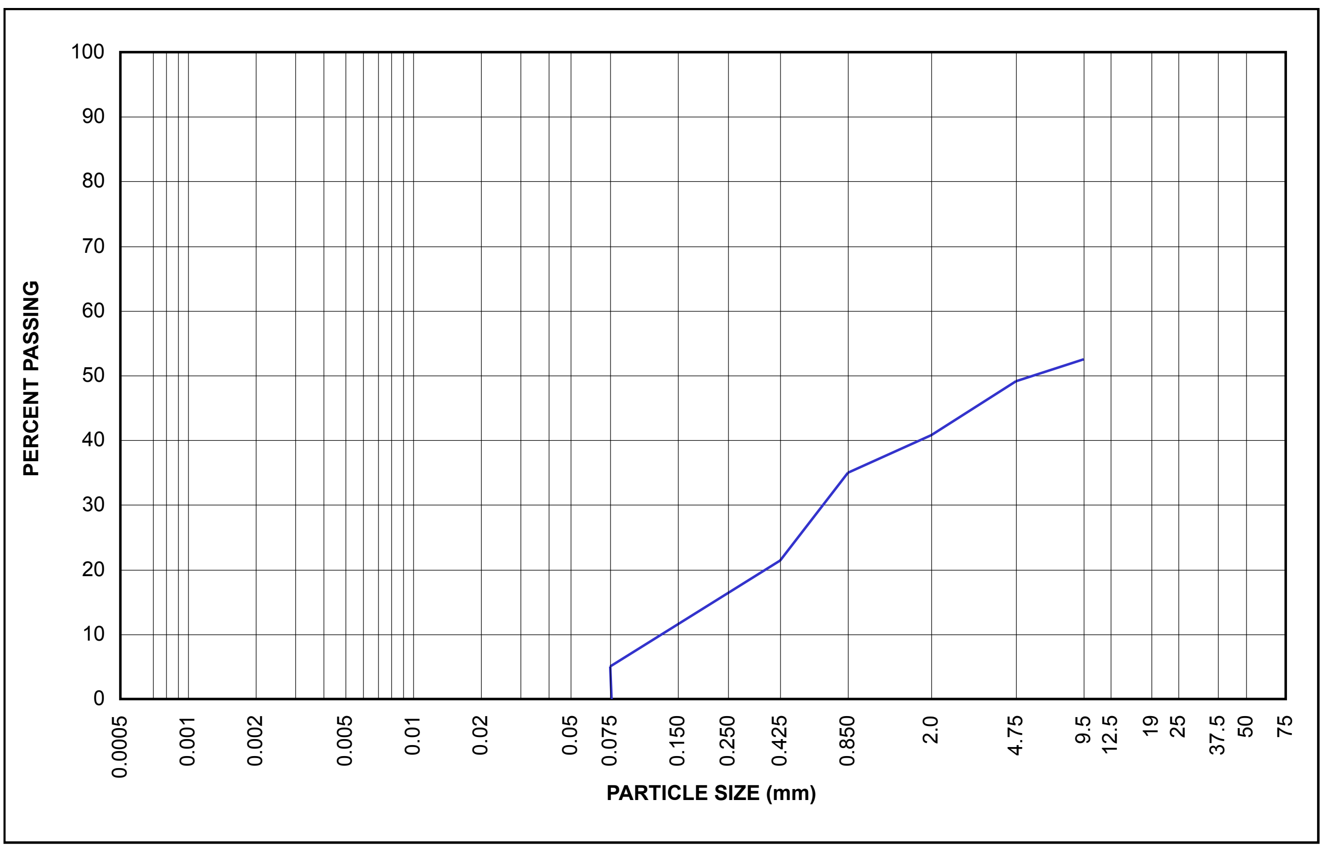
NATURAL MOISTURE CONTENT: 0.0%

REMARKS: Grab Core Sample

%Gravel = 51 %Sand = 44 %Silt/Clay = 5

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

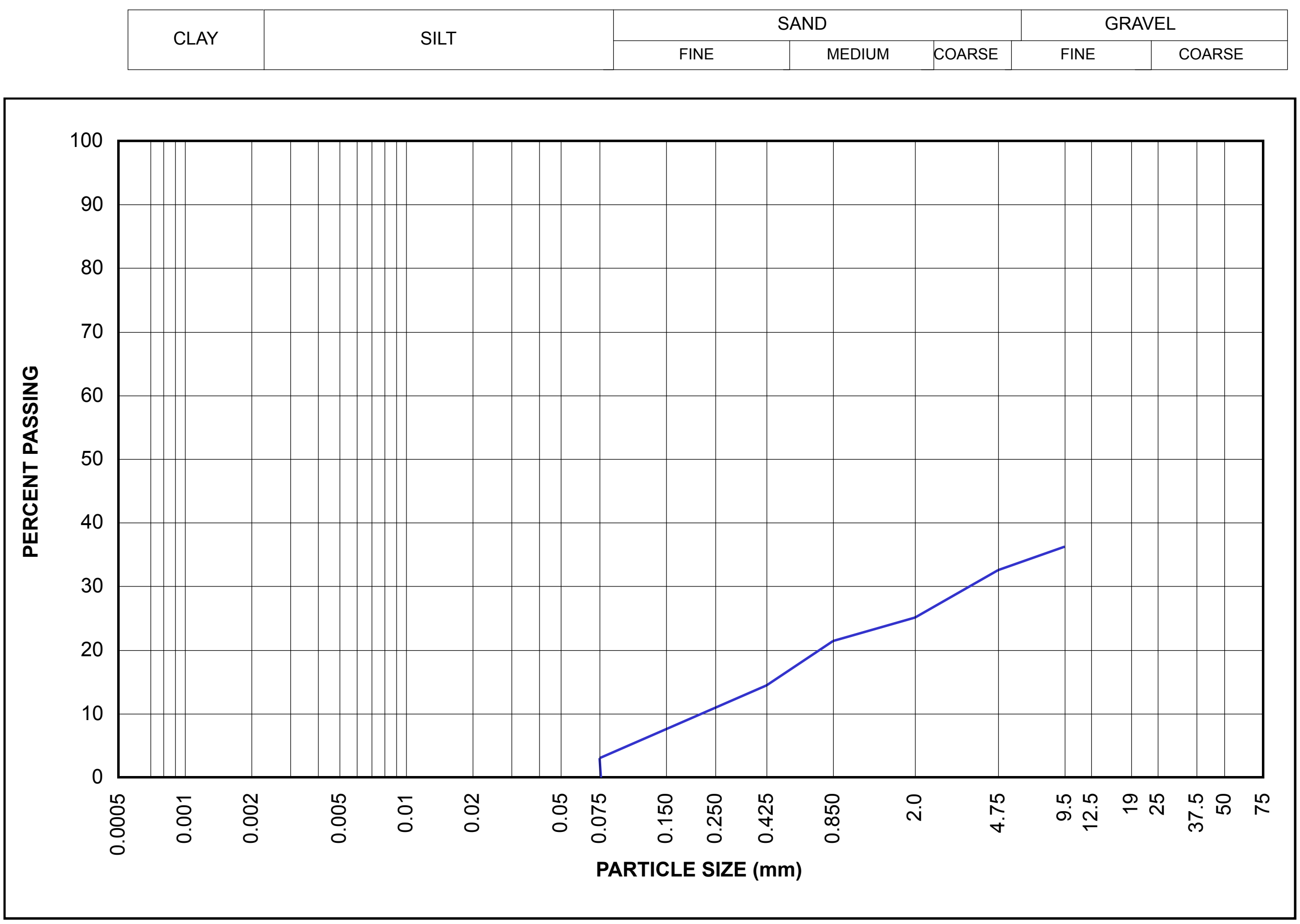


PARTICLE SIZE ANALYSIS REPORT

PROJECT:	YGS Aggregate
SITE:	ML
	MacLean Lake
PROJECT NO:	Aggregate
CLIENT:	YGS
SAMPLE NO:	AG02 (3.0 m to 4.2 m)
DATE TESTED:	Sep 25/13 BY: AG
USC CLASSIFICATION:	G (Inferred)
NATURAL MOISTURE CONTENT:	0.0%
REMARKS:	Grab Core Sample

%Gravel = 67 %Sand = 30 %Silt/Clay = 3

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075



PARTICLE SIZE ANALYSIS REPORT

PROJECT:	YGS Aggregate
SITE:	ML
	MacLean Lake
PROJECT NO:	Aggregate
CLIENT:	YGS
SAMPLE NO:	AG03 (0.0 m to 1.0 m)
DATE TESTED:	Sep 25/13 BY: AG
USC CLASSIFICATION:	G (Inferred)
NATURAL MOISTURE CONTENT:	0.0%
REMARKS:	Grab Core Sample

%Gravel = 67 %Sand = 30 %Silt/Clay = 3

PARTICLE SIZE
9.5
4.75
2.0
0.850
0.425
0.075