Appendix 4 Geotechnical Investigation Report

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Eureka Civil Consulting Services

Geotechnical Report

C71130000 – Document No: C71130000-CI-REP-0001

10 January 2011

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PROJECT C71130000 - EUREKA CIVIL CONSULTING SERVICES

FILE LOC.: CALGARY

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	L. Martin	B. Smith	J. Quiroga	04-Oct-10		
B	Issued for client review	L. Martin	B. Smith	J. Quiroga	21-Oct-10		
0	Issued as final	L. Martin	B. Smith	J. Quiroga	10-Jan-11		

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EXECUTIVE SUMMARY

This report presents a geotechnical evaluation conducted in support of the Civil Consulting Study for Eureka, Nunavut, Canada. This evaluation includes an assessment of the existing runway, the proposed new fuel drum storage area, the proposed new sewage lagoon sites and existing water reservoir as well as a granular material borrow source investigation. This report is based on the results of a terrain and topographic mapping study, from an air photo review and field programs involving site reconnaissance and a test pit program.

The existing runway at Eureka consists of a thin layer (approx 150 mm) of granular material directly overlying native silty clay till. The entire site is underlain by permafrost which presumably extends to great depth. The seasonal thaw at the time of the site visit ranged from 1.0 to 1.4 metres below existing grade; in winter the entire soil profile will be frozen. The runway is poorly drained in some areas and placement of additional gravel fill is proposed to promote adequate drainage and improve the structural strength.

A new fuel drum storage area is proposed to the north of the Canadian Forces bulk fuel storage site at the airfield. This site was deemed unsuitable by the WorleyParsons field team due to its proximity to the Rose Rock Creek slope and an alternative location has been suggested. Soil conditions in the area consist of relatively undisturbed tundra (silty clay till) with permafrost located approximately 0.5 m below grade. The fuel drum storage area should be constructed on a thick gravel pad placed directly on the tundra. The pad should be placed in summer at the time of maximum thaw depth, to replicate worst-case conditions, and constructed to sufficient thickness to adequately support a loader even when the underlying till is in a partially thawed state.

Two new sewage lagoon locations have been proposed by others. Soil conditions in these locations consists of various depths of granular fill overlying silty clay colluvium with permafrost at a depth of approximately 1.0 m below grade. Based on the site topography, the southern location (Option 1) is deemed more suitable for construction of the lagoon.

The existing water reservoir is understood to be undersized for the potential station population. As well, during the site reconnaissance, signs of instability were noted in the existing reservoir berms. Several options were examined for upgrading or expanding the existing reservoir and for construction of a new reservoir. Any new reservoir should have a geosynthetic liner with an underdrain system to prevent uncontrolled seepage during the thaw season and influxes of contaminated and/or brackish groundwater. Any new reservoir should also have appropriately graded side slopes; slopes of 3H:1V for berms formed out of good quality granular fill and slopes of 4H:1V for berms formed out of the native fine grained soils.

Sources of suitable sand and gravel to serve as feedstock for a screening and crushing operation to procure good quality granular material were identified along the Station Creek, Blacktop Creek and Remus Creek watercourses. Of the three, Blacktop Creek was identified as the most practical location for a screening and crushing plant.

It should be noted that this report presents the results only of a site reconnaissance and shallow test pitting investigation conducted using the available equipment on site. Prior to the detailed design of the sewage lagoon or water reservoir, a detailed geotechnical investigation should be conducted using suitable drilling equipment.

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1. INTRODUCTION

1.1 General

WorleyParsons was retained by Public Works and Government Services Canada (PWGSC) to carry out a conceptual engineering study to assess potential upgrades to the water reservoir, sewage lagoon, airstrip and fuel storage facilities at Eureka, Nunavut.

The study included a preliminary geotechnical investigation to support the overall infrastructure study; this investigation comprised a site reconnaissance, a subsurface investigation at the existing airstrip and at the proposed sewage lagoon sites and a search for sources of granular construction materials.

1.2 Scope of Work

The proposed scope of work was outlined in WorleyParsons' Proposal No. CPR 10-039, dated July 21, 2010, and generally included:

a) a review of the available geotechnical and geological information for the Eureka area;

b) a geotechnical investigation, including site reconnaissance, test pitting and sampling of potential granular material borrow sources;

c) laboratory testing of selected soil samples recovered from the site; and

d) preparation of a geotechnical report, which summarizes the results of the study and provides suitable comments and recommendations.

1.3 Background Information

Eureka, Nunavut is a small outpost located on Slidre Fjord, midway up Ellesmere Island in the Canadian High Arctic (Figure 4.1). The site has been continuously occupied since 1946 and is the second most northerly permanently inhabited site on the globe. Mainly in use as part of Environment Canada's High Arctic Weather Station (HAWS) network, the site also currently supports ongoing atmospheric research as well as Canadian Forces activities. The primary facilities at the site include the main weather station complex, a water reservoir, sewage lagoon and an airstrip.

2. SITE DESCRIPTION

Eureka is located on the north shoreline of Slidre Fjord on the western coast of Ellesmere Island in the Qikiqtaalkuk Region of Nunavut. The area is in the high arctic and has an extreme climate with long, very cold winters and short cool summers. The average annual air temperature is -19.7 °C and the average annual precipitation is 75.5 mm (Environment Canada 2010). This temperature regime forms continuous permafrost across the region, with a thin active layer.

The station and airstrip are located in a low-lying plain between higher ridges to the west (Skull Point) and east (Black Top Ridge), and is roughly bound to the west by Station Creek, flowing north-south immediately east of the station and to the north by Rose Rock Creek, a west flowing tributary of Station Creek (Figure 4.2).

Photos 1 through 15, attached, were taken during the site reconnaissance and illustrate the prevalent conditions in and around Eureka.

2.1 Geological Setting

A surficial geological terrain mapping study was conducted by WorleyParsons using available satellite and air photo imagery for the station, as well as published geologic and surficial geologic maps of the region. The results of this mapping study are shown on Figures 4.3, 4.4, 4.5 and 4.6.

The study area was subject to recent glaciation, and the terrain is dominated by glacial, periglacial and mass wasting features. The terrain in the vicinity of the station consists of a glacial plain, incised by creek valleys. The predominant soil conditions in the area consist of silty clay glacial till overlying sedimentary bedrock. Creek channels, which are typically cut down into the glacial sediments and bedrock, comprise fluvial silts, sands and gravels and form deltas where they flow into the fjord. Exposed slopes immediately adjacent to the creek valleys and the shoreline typically consist of colluvial soil deposits left by mass wasting, thermokarst and soilfluction processes.

2.2 Permafrost

The site is located in the continuous permafrost region with 10-20% ground ice content (Natural Resources Canada 1995). Other than taliks that might be encountered underlying lakes and streams, permafrost is present throughout the entire region.

Three deep boreholes were drilled in or around the Eureka Area as part of a Canada wide permafrost survey (Taylor et al. 1982). These three (3) boreholes found that the base of the permafrost ranged from 300 to 500 meters below the ground surface (mbgs). Occasional thick ice layers (massive ice) were encountered in the boreholes; these may be relict ice bodies from glaciation.

3. GEOTECHNICAL SITE INVESTIGATION

3.1 Field Investigation

The geotechnical field investigation was conducted from August 15-17, 2010, consisting of 16 Test Pits (TP) that were excavated using a backhoe-loader. All test pits were excavated to practical bucket refusal on permafrost.

All test pit locations were selected in the field by WorleyParsons field personnel in locations which would not impede ongoing station work or airfield access. Following excavation, all test pit locations were established by high precision RTK GPS during the ongoing survey work.

Test Pits were excavated using a small rubber-tired Ford backhoe (Photo 1) and were supervised by WorleyParsons geotechnical field engineering staff, who logged in detail the soil and groundwater conditions encountered. Samples were obtained directly from the walls of the test pits or from the spoil pile. Detailed test pit logs are presented in Appendix 1.

In addition to the test pit program, five (5) bulk samples were recovered from several potential borrow sources using either the Ford backhoe (for vehicle accessible areas) or by hand.

3.2 Laboratory Testing

All soil samples recovered from test pits and borrow sources during the investigation were returned to the WorleyParsons Calgary office for review. Subsequently, samples were delivered for testing to EBA Engineering Ltd. laboratory in Calgary, AB.

The laboratory test program comprised the determination of:

- Natural Moisture Contents;
- Atterberg Limits;
- Grain Size Distributions;
- Standard Proctor Density;
- California Bearing Ratio;
- % Flat and Elongated Particles;
- Aggregate Soundness; and
- Petrographic Analysis.

The laboratory test results are discussed throughout the text of this report and can be found in Appendix 2.

3.3 Overall Subsurface Soil Conditions

Detailed descriptions of the subsurface conditions encountered in each test pit are presented on the Test Pit logs contained in Appendix 1. The soil descriptions provided in this report are based on accepted standard methods of classification and identification routinely used in current geotechnical state-of-practice. The stratigraphic boundaries shown on the test pit logs are inferred from non-continuous sampling and observations of excavation progress. These boundaries represent transitions between soil types rather than exact planes of geological change. Subsurface conditions may vary both with depth and laterally between individual borehole locations.

Based on the conditions encountered during the investigation, the subsurface soil stratigraphy at the site generally consists of granular fill materials overlying native silty clay till or colluvium. The till was encountered on the upland plateau by the airfield, while the native soils in and around the station appear to consist of colluvium.

Ground ice was encountered in all testpits and the thickness of surface thaw observed ranged from 0.6 mbgs to 1.9 mbgs, with an average depth of approximately 1.2 mbgs.

4. DISCUSSION AND RECOMMENDATIONS

4.1 Potential Granular Material Borrow Sources

It is our understanding that PWGSC would like to secure approximately 80,000 m^3 of good quality granular material, both for use in upgrading the runway, as well as for ongoing maintenance around Eureka.

The potential borrow sources investigated and discussed in this study were identified at the time of the site investigation by WorleyParsons' staff and in conversations with station personnel. They are considered representative of the potential sources that could be utilized for ongoing maintenance and construction purposes at the site. More detailed field investigations of the selected borrow sources should be undertaken prior to beginning quarry operations to ensure that the properties of the materials are suitable for specific project applications.

4.1.1 Existing Sandstone Pit

Currently, the station operates a gravel pit on an exposed sandstone outcrop located to the northwest of the main station (Figure 4.2). The rock in this area is a weakly cemented sandstone containing fossilized shells, light pinkish brown in colour. The sandstone is poorly cemented, friable and very weak (Photo 8).

The broken sandstone material is pushed up into low stockpiles using a bulldozer and then loaded into a tandem dump truck for use in and around the station; the bulldozer fragments the very weak sandstone into a useable size. The sandstone is removed by excavating in thin layers as the thaw front advances in July and August.

A bulk sample (Bulk 3) was retrieved from a low stockpile present in the quarry. As well, several large stockpiles of the broken sandstone were present at the barge landing site at the time of the investigation, and another bulk sample was also taken from these stockpiles (Bulk 2). Table A presents the laboratory determined properties:

Table A Broken Sandstone – Laboratory Properties

Sample	Gradation
Bulk 2 (Barge Landing)	2% Clay 4% Silt 33% Sand 61% Gravel
Bulk 3 (Existing Pit)	1% Clay 10% Silt 33% Sand 56% Gravel

Given that this material source is composed entirely of weak sandstone, this sandstone is not recommended for use as granular aggregate. Weathering of this material will result in ongoing and rapid breakdown of the larger particles to a fine sand.

4.1.2 Station Creek

Station Creek flows into Slidre Fjord to the west of the weather station. Surficial geologic features associated with Station Creek include the fluvial channel, a fluvial terrace and a delta at the mouth of the creek (Figure 4.3). Soil conditions in all of these terrain units consist of interbedded layers of silts, sands and fine gravel. Samples of these materials were not taken during the site reconnaissance.

It is apparent that these resources have been utilized for a gravel source in the past (Photo 9). A road is discernable, running up the creek channel to the fluvial terrace (s, g, F_t) identified on Figure 4.4, and several stockpiles are still present on the terrace (Photo 10). The material present in these stockpiles appears to be a silty sand and gravel, very similar to the material found in Blacktop and Remus Creeks, discussed below.

If deemed appropriate and necessary, either the Station Creek delta (s, g, F_d) or the terrace area (s, g, F_t) would likely be a favourable spot to develop a gravel pit. However, the supply of unprocessed material may be limited in the Station Creek delta. As well, based on visual observations of the stockpiles present in this area, the proportion of oversized cobbles and boulders, which are considered most suitable for crushing, is less than 5%.

4.1.3 Blacktop Creek

The mouth of Blacktop Creek is located approximately three km to the southeast of the airstrip (Figure 4.2). The surficial geologic features of Blacktop Creek include the fluvial channel, a fluvial plain (s, g, F_p) and a fluvial delta (c, g, F_d) (Figure 4.3). The soil conditions in these terrain units consist of interbedded layers of silts, sands and gravels.

The fluvial delta (c, g, F_d) associated with Blacktop Creek has been used as a gravel source in the past, and numerous shallow pits and low stockpiles were visible. A good quality, maintained road runs from the end of the runway down to Blacktop Creek. Based on conversations with the station staff, it is our understanding that the Canadian military has developed this gravel source. At the time of the investigation, there was a large stockpile of gravelly sand stockpiled on site (Photo 11). This stockpile was sampled using the backhoe (Bulk Sample 4); Table B presents the laboratory determined properties.

Table B Blacktop Creek Pit Run – Laboratory Properties

Gradation	Petrographic Number	Flat and Elongated Particles	Aggregate Soundness (ASTM C88)
1% Clay	80.7% Good	26.7 %	1.3% loss
5% Silt	11.7% Fair	(Poor)	(Good)
61% Sand	4.8% Poor		
33% Gravel	2.8% Deleterious		
	Overall Ranking = 172 (Poor)		

The pit run material in Blacktop Creek is not suitable for some applications, due to the high sand and fines content. However, by processing the material through a screening and crushing plant, good quality crushed aggregate could be produced. If required, Blacktop Creek can serve as a suitable source of water for washing operations. Based on visual observations taken of the existing stockpiles, as well as creek bank exposures, the pit run material appears to contain less than 5% cobbles and boulders.

The fluvial delta and plain at Blacktop Creek is approximately 1,000 m long by 500 m wide, and judging by the visible exposures (Photo 12), the granular materials are likely several metres thick. Based on these figures it has been estimated that at least 1 million cubic metres (m^3) of pit run material is present. Therefore, even considering losses during processing, several hundred thousand cubic metres of processed gravel may be available from this source.

4.1.4 Remus Creek

Remus Creek is located approximately 15 km east from the main station, on the coast of Slidre Fjord. The site is accessed by an existing trail, which continues on from Blacktop Creek, although there are no culverts or bridges along the route. At the time of the site investigation, Remus Creek was easily accessed along the road by an all-terrain vehicle. As with Station Creek and Blacktop Creek, the surficial terrain units of Remus Creek include a fluvial channel, a large fluvial delta and fluvial plain and several fluvial terraces. The soils associated with these terrain units consist of interbedded silts, sands and gravels.

A gravel sample was retrieved from an exposed face of a fluvial terrace (Photo 13) in Remus Creek by hand test pitting (Bulk 6); Table C presents the representative laboratory determined properties.

Table C Remus Creek Pit Run – Laboratory Properties

Gradation	Petrographic Number	Flat and Elongated Particles	Aggregate Soundness (ASTM C88)
0% Clay	71.6% Good	14.9%	1.4% loss
3% Silt	13.1% Fair	(Acceptable)	(Good)
38% Sand	12.1% Poor		
59% Gravel	3.2% Deleterious		
	Overall Ranking = 215 (Unsuitable)		

As with Blacktop Creek, the pit run material in the vicinity of Remus Creek would need to be processed for some applications. However, the Remus Creek delta is very large, on the order of 5 km^2. Therefore, assuming the depth of material is similar to Blacktop and Station Creeks, there is likely on the order of 10 million cubic metres of pit run material. Based on visual observations of bank exposures in Remus Creek, it is estimated that the pit run material from this area contains between 5 and 10% cobbles and boulders. This would provide a better feedstock of material for crushing operations, than Blacktop Creek.

4.1.5 Rock Outcrops

Multiple rock outcrops are visible along the road to Skull Point, as well as heading east to Remus Creek. These outcrops consist of siltstones and sandstones. Several outcrops were examined during the site reconnaissance, including the Awingak-Savik-Borden Island Formations approximately five (5) km west of the station (Photo 14) and along an exposed fault in the Heiberg Formation approximately two (2) km east of Blacktop Creek (Photo 15).

At both sites, the exposed rock was a poorly cemented sandstone which was fractured and friable. It is possible that these materials may be more suitable as a source of quarry rock than the sandstone outcrop currently being mined approximately two km west of the station. However, to properly characterize these formations it would be necessary to conduct geological mapping and obtain and test representative samples. Drilling would be a desirable supplement to confirm conditions at depth and to provide cores for test samples.

4.2 Airfield

4.2.1 General Information

The existing runway is located at the top of a plateau northeast of the main station (Figures 4.2 and 4.5). The plateau is relatively flat and is reasonably well drained, being bound on the east and west by dry gullies, to the north by the Rose Rock Creek valley, a tributary of Station Creek, and to the south by the slope down to the Fjord. Based on the conditions encountered in the test pits, it appears likely that the runway was constructed by filling in any localized low spots and grading the native colluvial silty clay to a level surface. A thin lift (50 to 200 mm) of imported granular material was then placed over the graded subgrade.

It is our understanding that the airport is currently serviced mainly by small to medium sized turboprop airplanes, such as the Twin Otter or Dornier 228. Heavier aircraft, such as the C-130 Hercules or Boeing 737-200, also make occasional use of the facility. Use of the facility by these heavier aircraft (heavier than 65,000 lbs) is typically not permitted during the thaw season (July and August) when the near surface soils are unfrozen (NavCanada 2010).

The runway and fueling apron appear reasonably well drained, although several localized poorly drained areas were visible during the site reconnaissance (Photo 2). While the area to the south of the runway is well drained, several low lying areas and tundra ponds are evident along the north side (Photo 3).

We understand that aircraft operations are negatively affected during the thaw season, particularly following rainy weather, due to the presence of the soft, wet areas. Therefore, PWGSC is currently proposing placing additional granular material over the existing runway surface to improve surface drainage.

4.2.2 Soil Conditions

Test Pits TP10-01 through TP10-06 were excavated along the south side of the existing runway (Drawing 18). These test pits revealed 50 to 200 mm of granular material directly overlying the native silty clay till, although TP10-02 encountered 0.7 m of clayey fill and granular fill overlying the native silty clay till. It is possible that this represents a low area that was filled in during runway construction.

The granular material encountered in the test pits generally consisted of a fine clayey gravel and sand. The source of the majority of the material appears to be the sandstone outcrop quarry located approximately 2 km northwest of the station. It is our understanding that the runway surface is currently being re-surfaced with this material. However, it is likely that the runway was originally constructed out of gravelly sand from the Black Top Creek delta, as similar granular material was encountered in TP10-02.

Silty clay till was encountered underlying the granular surfacing material or fill in all test pits. The till was generally firm to stiff, damp to moist and dark grey in colour with traces of sand and gravel. Ground ice was encountered in the underlying silty clay till in all of the test pits along the runway, with the depth of seasonal thaw ranging from 1.0 to 1.4 m below existing grade.

A seventh test pit was excavated by hand in the apron area to confirm the gravel apron structure (TP10-16). Similar soil conditions to those of the runway area were encountered in the apron area, with approximately 200 mm of granular material overlying the native silty clay till.

4.2.3 Resurfacing Recommendations

The runway should be resurfaced in two layers; a free draining granular base course layer and a granular wearing course, in accordance with the material properties recommended in the Canadian Standards and Recommended Practices for Airport Engineering ASG-06 (PWGSC 1996), as summarized in Table D. The wearing surface should be at least 150 mm thick, while the thickness of the base course will be dictated by the grading requirements.

Table D Granular Material Requirements

Property	Free-Draining Base Course	Wearing Surface
Gradation (% Passing)		
75 mm	100	
25 mm		100
19 mm		75 – 100
9.5 mm		50 – 75
4.75 mm		30 – 50
0.425 mm	0 – 30	10 – 30
0.075 mm	0 – 8	5 – 10
Plasticity Index (max.)	6	6
Required Density	98% Standard Proctor Maximum Dry Density	100% Standard Proctor Maximum Dry Density

If a sufficient thickness of base course gravel were placed over the existing runway the resulting increase in bearing capacity could allow for all-weather operations by C-130 aircraft. WorleyParsons would be pleased to determine the required thickness of base course required to meet this objective, if requested.

4.3 Fuel Drum Storage Area

4.3.1 General Information

A new fuel drum storage area is currently proposed for the north apron area at the airport (Figure 4.5 and Drawing 18). Sized to contain 2,000 drums, it is understood that the storage area will incorporate containment berms, a geosynthetic liner and a sump. The storage area should comply with Canadian Environmental Protection Act guidelines and should consider the severe weather at the site, as well as the methodology for using fuel drums on site.

Currently, pallets of fuel drums are stored in several locations around the airfield and at the main station. A front-end loader equipped with forks is used to pick up the pallets and move them around as needed. Typically, aircraft are refuelled using electric pumps directly from the drums. Following use, the drums are stockpiled at the drum crushing station where they are crushed and buried.

It should be noted that in observations of refuelling practices at the site, the chances of hydrocarbon contamination at the site appear greatest while planes are being refuelled from drums on the apron and at the drum burial site.

4.3.2 Soil Conditions

Test Pit TP10-07 was excavated in the centre of the proposed fuel drum storage area (Drawing 18). The area is relatively undisturbed tundra, comprised of very soft, moist, dark brownish grey silty clay till with some organics and rootlets at the surface and containing trace gravel, cobbles and boulders. Permafrost was encountered in the test pit at a depth of 0.6 m below grade.

4.3.3 Construction Recommendations

Although the ground conditions in the proposed storage area are suitable for construction of the drum storage area, the site is adjacent to the slope down to Rose Rock Creek. This slope appears to be unstable and undergoing mass soil wasting or soilfluction, with shallow soil slumps noticeable at the time of the site reconnaissance. It is probable that any ongoing climate warming may further destabilize this slope. We therefore recommend that the drum storage area be moved to the area east of the bulk fuel storage, on the east end of the north apron (Figure 4.5)

The storage area should be constructed on top of a pad of granular fill. The pad should be placed near the end of the thaw season when the annual depth of thaw is at a maximum. The gravel should be end dumped onto the undisturbed tundra off the edge of the existing apron. Heavy equipment should not operate directly on the tundra surface.

By placing the gravel pad at the end of the summer, the underlying soil conditions will be representative of the softest subgrade conditions expected annually. While a fill depth of about 1.0m should be adequate, the actual thickness of the pad will be dictated by field observations. Once the initial 1.0m lift has been placed and compacted, it should be proof-rolled using a loaded dump truck or other heavy equipment. If any signs of instability are noted, the thickness of gravel should be increased and the proof-rolling repeated. This process should continue until no signs of instability are noted in the gravel pad.

Ideally, the gravel should be placed and compacted in lifts no more than 300 mm thick. However, we recommend that the first lift of gravel be at least 500 mm thick to limit disturbance to the underlying soil. Care should be taken during compaction operations to avoid punching or rutting failures in the gravel surface.

Ideally, the compacted gravel pad should be left in place over a full winter season to stabilize. The following summer season, the pad can be re-graded as needed and the liner and liner cover material installed.

4.4 Sewage Lagoon

4.4.1 General Information

A single-cell sewage lagoon is currently located immediately adjacent to the fjord on the east side of the main station (Figure 4.6). Sewage is collected in storage tanks inside the weather station building and, once these tanks are filled, released to the sewage lagoon. Sewage collected in the lagoon over the winter freezes and then thaws during the first few weeks of the thaw season. In late August, the sewage is pumped into the Fjord in preparation for the following winter.

The existing lagoon is not considered adequate for the site. A study completed by Golder Associates (Golder 2009) investigated potential treatment options. One of the options was the construction of a new, two-cell lagoon and two potential sites were identified, located to the north and south of the main road between the station and the airstrip (Figure 4.6).

Eight (8) test pits were excavated along the proposed force main alignments and sewage lagoon locations east of the station (Drawing 25). Test Pits TP10-08 through TP10-11 were excavated in the southern alignment and lagoon location (Option 1), while TP10-12 through TP10-15 were excavated in the northern alignment and lagoon location (Option 2).

4.4.2 Option 1 Location – South of Main Road

Soil conditions in these test pits consisted of sand and gravel fill overlying native silty clay colluvium. The fill ranged in depth from 1.0 to 1.2 m below existing grade, and consisted of sand and gravel pitrun material. Underlying the sand and gravel fill, silty clay colluvium was encountered in all of the test pits. This colluvium was typically stiff, damp to moist and of low plasticity. Permafrost was encountered in all of the test pits at depths ranging from 1.0 to 1.2 m below existing grade. In several cases, the bottom of the active layer appeared to coincide with the top of the colluvium.

In TP10-10, excavated in the shoulder of the main station road to the airstrip, close to the main station building along the proposed force main alignment, solid ice was encountered at the base of the sand and gravel fill zone. The drainage in this area is poor and based on conversations with the station staff, ponding water is often encountered. It is likely that surface water infiltrating through the permeable sandy gravel is trapped on the surface of the relatively impermeable silty clay colluvium beneath and has frozen into a massive ice deposit.

From a geotechnical point of view, the new sewage lagoon could be constructed at this location. It may be possible to construct the lagoon by excavating below the existing ground surface and using the excavated material to construct the berms. The excavation could be undertaken (in the Spring) by blasting and then using the blasted material to form the reservoir berms. The berms and slopes of the reservoir would be graded as the material thaws during the subsequent thaw season. For conceptual design, it should be assumed that side slopes of 4H:1V will be required. If the subsurface materials are relatively impervious, it may not be necessary to line the reservoir with a membrane liner.

The feasibility of the foregoing method of construction will depend on the water (ice) content and the proportion of silt and clay in the material that underlies the site. If the ice content is high, then the material would be very soft and unstable when it thaws. Therefore, in order to assess the feasibility of this method of construction, it would be necessary to reappraise the soil conditions using a drill to advance a number of test holes.

Alternatively, the lagoon berms could be constructed with imported pit run gravel, placed over the existing ground surface. If the berms of the lagoon are constructed of gravel fill, then it will probably be necessary to install a membrane liner and subdrainage system, to prevent uncontrolled seepage losses during the thaw season.

It should be noted that the main power line from Eureka up to the airstrip currently runs through the proposed Option 1 footprint. The power line currently lies on the ground surface (Photo 4) and insufficient slack may exist in the line to reroute it around the lagoon envelope. It may therefore be necessary to disconnect the power line and splice in a new length of cable.

4.4.3 Option 2 Location – North of Main Road

Soil conditions in this area generally consisted of native clayey or sandy silt colluvium directly from the surface, although Test Pit TP10-12, excavated immediately to the east of the main weather station building encountered approximately 0.9 m of sandy gravel fill overlying the native colluvium. The native colluvium was generally firm to stiff, damp to moist and low plastic. Permafrost was typically encountered at a depth of approximately 1.0 m below grade in all of these test pits.

Development at this location is considered feasible from a geotechnical point of view. As at Site 1, it may be possible to construct the lagoon by excavating below the existing ground surface by blasting (in the Spring) and using the blasted material to construct the berms. The feasibility of using this method of construction on Lagoon Site 2 also depends on the properties of the underlying soils and therefore it would be necessary to explore the subsurface soils via test holes drilled to depths of three (3) to five (5) m.

The lagoon berms could be constructed with imported gravel, placed over the existing ground surface. In this case, it will probably be necessary to install a membrane liner and subdrainage system, to prevent uncontrolled losses from the lagoon during the thaw season.

One of the significant disadvantages of the Option 2 location is that it cuts off a natural drainage gully at the east end of the proposed site. This could cause significant ponding on the north (upslope) side of the reservoir. One option would be to shift the lagoon further west, so that will not affect the drainage. Alternatively, the drainage gully could be routed around the water reservoir; however, this could involve significant excavation and measures would be required to prevent silt from being carried into the fjord.

4.5 Water Reservoir

4.5.1 General Information

The water reservoir for the station is currently located in the Station Creek valley, immediately adjacent to Station Creek at an elevation approximately eight (8) m below the main station buildings, which are located on the colluvial slope above the Fjord (Figure 4.6 and Drawing 25). Water is pumped into the reservoir directly from the Creek using a small electric sump pump; periodically, water is then pumped from the reservoir into heated storage and treatment tanks for distribution within the station.

The reservoir appears to have been constructed by pushing up the fluvial silts, sands and gravels in the creek channel to form the berms. A fill channel was constructed on the north side of the reservoir (Figure 4.6), so that during the thaw season, water would flow by gravity from the creek into the water reservoir, through two culverts located on the north side of the reservoir. Several years ago, this practice was discontinued due to environmental concerns, and the entrance from the Creek into the fill channel was blocked off. However, the inlet culverts have not been blocked, so that there is still a hydraulic connection between the reservoir and the fill channel.

Seepage through the berms of the lagoon and the fill channel was noted at the time of the site reconnaissance (Photo 7). This is not unexpected, given that the berms are formed out of alluvial silts and sands. Signs of slumping and instability were also noticable in the reservoir berms at the time of the inspection and the lack of freeboard on the reservoir was also apparent (Photo 5). The berms at the north end of the fill channel are being actively eroded by the Creek (Photo 6).

It is our understanding that the water reservoir is currently undersized and an expansion is proposed (WorleyParsons 2010). Several options are being considered:

a) refurbishing the existing reservoir (Option 1);

b) raising the existing reservoir berms or deepening the existing reservoir (Option 2);

c) constructing a new reservoir north of the existing one (Option 3);

d) constructing a new, appropriately sized reservoir in a different location (Options 4 & 5); and

e) constructing above grade storage tanks (Option 6).

The design and construction issues for each option are discussed in more detail below.

4.5.2 Design Features

One constraint on reservoir design at Eureka is the amount of ice that forms on the reservoir every year. Ice formation on a body of water is a function of the winter temperatures, snow cover and water flow beneath the ice cover. Examining the Eureka climate record, the most severe winter in the past 30 years at the station was 1986/1987. Considering this winter season as the design-freezing index gives a value of 8,180ºC-days over a freezing season of 276 days. Using the modified Stefan Equation (USACE 2004) and considering the reservoir as a still body of water with snow cover, we get a design ice depth of 2.2 m. Therefore, any reservoir design must consider the loss of approximately 2.2 m of capacity due to ice.

Another constraint on any potential reservoir upgrades is that the reservoir is currently the only source of drinking water for the station. Additionally, the reservoir can only be filled during the limited period in the summer when Station Creek is flowing with a relatively low sediment load. Therefore, any construction program must include adequate considerations to ensure that the station has sufficient stored water for the winter season

The current reservoir is unlined and seepage through the existing berms was noticeable during the site reconnaissance (Photo 7). We therefore recommend that any new reservoir incorporate a geosynthetic liner to eliminate or significantly reduce seepage out of the reservoir. Such a liner would also require an underdrain system.

4.5.3 Construction Recommendations

Refurbishing the Existing Reservoir (Option 1)

Consideration has been given to upgrading the existing reservoir by placing fill to flatten the outside slopes of the reservoir to 4H:1V. In addition, the fill channel on the north side of the reservoir would be filled in and the inlet culverts on the north side of the reservoir would be removed (Drawing 26).

These upgrades would not increase the under-ice storage capacity of the reservoir; however, they may reduce seepage losses through the reservoir. In addition, the upgrades would reduce the risk of a slope failure on the outside slopes of the reservoir, which would prolong the useful life of the facility by several years.

The major advantage of this option is that it could be undertaken with the construction equipment currently available at the site, possibly over one (1) or two (2) thaw seasons, so that the cost would be minimal. In addition, the reservoir upgrades could be completed with no significant interruption in reservoir operations.

Consideration could also be given to flattening the inside slopes of the reservoir as part of such an upgrade program. However, this would reduce the under-ice capacity of the reservoir and require that the reservoir be taken out of service during construction.

Another option for increasing the depth of under ice storage on the existing reservoir would be to use an insulated floating cover, perhaps in combination with a bubbler unit.

Some thought was given to reducing seepage losses through the existing berms by injecting grout into the berms. It is unlikely that such a program would significantly reduce seepage. It would be impossible to inject grout into areas of the berms that are frozen and if any such ground ice present in ungrouted areas degrades in the future, seepage would immediately begin to occur. Any seepage, through even a small gap or crack in the ground ice, would immediately start a process of thermal erosion of the remaining frozen soil.

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Raising or Deepening the Existing Reservoir (Option 2)

Consideration has also been given to increasing the existing storage capacity by increasing the water depth inside the reservoir (Drawing 26). This could be accomplished by lowering the elevation of the floor of the reservoir or by increasing the height of the containment berms.

Lowering the floor of the reservoir is not recommended, as the floor is currently within 1 m of the high water mark in the Fjord. If the floor elevation is further reduced, there is a risk that unfrozen zones (taliks) will be encountered. Such taliks contain super-cooled brine, which may be hydraulically connected to the ocean and could contaminate the reservoir with sea water.

Alternatively, reservoir capacity could be increased by raising the reservoir berms by several metres. For conceptual design purposes, it should be assumed that the inside and outside slopes of the existing reservoir will need to be flattened to 4H:1V. Steeper side slopes may be possible (e.g. 3H:1V); however, this depends on the material properties of the existing berms.

A membrane liner should be installed over the inside slopes and floor of the reservoir. The liner is required to minimize seepage losses from the reservoir and to ensure that the outside slopes do not become unstable. Consideration will need to be given to protect the liner from ice action, either through a sacrificial second liner or by placing fill to serve as liner cover. A sub-drainage system will need to be installed below the membrane liner to prevent liner uplift from water pressure and air pockets that will collect below the liner.

The advantage of raising the containment berms is that it minimizes the volume of earthworks required to increase storage capacity. The primary disadvantage is that it requires that the reservoir be taken out of service during construction. The timing and schedule for the work would therefore become very critical.

The height to which the reservoir could be raised (and hence the available under-ice storage capacity) is limited by the presence of Station Creek to the west of the reservoir. If this option were selected, it may be necessary to shift the creek channel further west. In addition, it may also be necessary to move the existing bridge crossing further downstream, in order to provide an acceptable longitudinal profile for the east bridge approach.

Sheet piles could also potentially be used to increase the storage capacity of the reservoir by increasing the water height in the reservoir. However, it may be necessary to widen the crest of the existing containment berms to allow room for a piling rig to work. Potential concerns also exist due to the unknown permafrost conditions within and below the existing berms. A detailed geotechnical drilling investigation through the existing berms would be required prior to proceeding with sheet piling.

New Reservoir North of the Existing Reservoir (Option 3)

This option would involve construction of a new reservoir or new storage cell, north of the existing reservoir (Drawing 26).

The major advantage of this option is that the new reservoir could be constructed while maintaining operations in the existing reservoir. Unforeseen delays in constructing the new reservoir would therefore not affect the water supply to the weather station.

Construction at this location would use imported, manufactured granular material. For conceptual design, using these materials, the inside and outside reservoir slopes can be graded to 3H:1V. If unprocessed granular material is used, 4H:1V side slopes should be assumed.

The reservoir should be lined with a membrane liner to prevent seepage losses and to prevent instability of the outside slopes. A sub-drainage system will be required below the membrane liner to prevent uplift.

New Reservoir West of Station Creek (Option 4)

Consideration has been given to constructing a new reservoir on the west side of Station Creek (Drawing 26). The advantage of locating the reservoir in this area is that it may be possible to construct the reservoir by excavating below the existing ground surface and using the excavated material to construct the berms. As the soil in this area appears to consist largely of sands and gravels, this approach would reduce the requirement to import material from a borrow source.

The disadvantage of any site on the west side of Station Creek is that it would not be feasible to transfer water from the reservoir to the weather station using a pipeline. Due to the distance and the requirement to cross Station Creek, it would be necessary to haul water to the weather station by truck. Although this is a method which is commonly used in many northern communities, it may require additional station staff and/or equipment. If this option is selected, consideration should also be given to upgrading the existing bridge crossing at Station Creek.

The feasibility of constructing a reservoir at this location by excavating below existing grade and using the material to construct the berms, will depend primarily on the water (ice) content and the fines content of the underlying soils. If the water content were relatively low, it would then be feasible to excavate the reservoir by blasting (in the Spring) and using the blasted material to form the reservoir berms, prior to the thaw season. The sideslopes and berms could be graded and shaped as the material thaws during the thaw season. This was the method used to construct a large earthworks water reservoir in Pangnirtung (Smith et al. 1989).

However, if the excavated material has a high ice content and contains a significant proportion of silt and clay, then it will be very soft when it thaws and it will not be possible to operate construction equipment on it. Therefore, before the feasibility of this option can be evaluated, it would be necessary to drill a number of boreholes on the selected site in order to determine the gradation and water (ice) content of the underlying material.

New Reservoir NE of the Main Station Building (Option 5)

Consideration has also been given to constructing a new reservoir northwest of the weather station (Drawing 26). The advantage of this location is that it would be possible to provide a water pipeline from the reservoir to the station, avoiding truck hauling.

At this location, the water reservoir could be constructed by excavating below the existing ground surface by blasting and by using the blasted material to construct the berms. The feasibility of this method of construction will again depend on the water (ice) content and gradation of the soil that underlies the site. If this option is considered, we recommend further exploration at the site.

One disadvantage of this location is that it would require a relatively long fill line from Station Creek to the reservoir, a distance of 200 to 300 m. In addition, it might be necessary to construct an access road up Station Creek Valley to a filling point on Station Creek.

A second disadvantage of this site for the reservoir is that it would greatly inhibit further expansion of other facilities in the vicinity of the weather station buildings and would require relocation of the meteorological equipment compound.

The presence of the reservoir at this location may also cause significant snow drifting around the existing station and other buildings. If this site is preferred, we recommend that a snow drifting study be undertaken to assess this potential concern.

5. CLOSURE

We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

Report Prepared by
WorleyParsons

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NWT/NU

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6. REFERENCES

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7. IMPORTANT INFORMATION ON INTERPRETATION, USE AND LIABILITY OF THIS REPORT

This report has been prepared in accordance with a specific brief and scope of work. It should be read in its entirety.

The responsibility of WorleyParsons is solely to the Client. This report is not intended for, and should not be relied upon, by any third party. No liability is undertaken to any third party.

Ground conditions are subject to continuing natural and man-made processes. It can exhibit a variety of properties that vary from place to place, and can change with time.

Site investigation involves gathering and assimilating data by various means such as inspection, drilling, excavation, probing, sampling, and testing. The collected data is only directly relevant to the place where, and at the time when, the investigation was performed.

Environmental or biological assessment (e.g. mold, fungi, and bacteria) or identification or prevention of pollutants and hazardous materials or conditions are beyond the scope of this report. Other studies should be undertaken if the owner is concerned about the potential for such contamination or pollution.

Any interpretation or recommendation given in this report shall be understood to be based on judgment and experience, not on greater knowledge of facts other than those reported.

If different ground or site conditions are encountered during construction activities or subsequent to the investigation performed for this report, either due to natural variability of subsurface conditions or previous construction activities, WorleyParsons should be notified of the differences and provided with an opportunity to review the recommendations contained in this report.

If changes in the nature, design, or location of the project as outlined in this report, are considered, the conclusions and recommendations contained in this report shall not be considered valid. WorleyParsons geotechnical services should review the changes, and either verify or modify the conclusions of this report in writing.

Figures

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SOURCE:
CANADIAN GEOGRAPHIC

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NOT FOR CONSTRUCTION

DO NOT SCALE DRAWINGS

Project title/Titre du projet **CIVIL CONSULTING SERVICES** **EUREKA, NUNAVUT**	Drawing title/Titre du dessin **SITE LOCATION MAP**

Approved by/Approuve par **J.Q.**	PWGSC Project Manager/Administrateur de Projets TPSGC **J.D.**	Scale/Echelle **AS SHOWN**
Designed by/Concept par **L.M.**	PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'Ingénierie, TPSGC	Date/Date **2010-12-14**
Drawn by/Dessine par **L.P.**	Project No./No. du projet **R.015446.001**	Sheet/Feuille **Figure 4.1** — Revision/ Revision

PWGSC – ANSI A–P– 8.5 X 11

C71130000 siteloc

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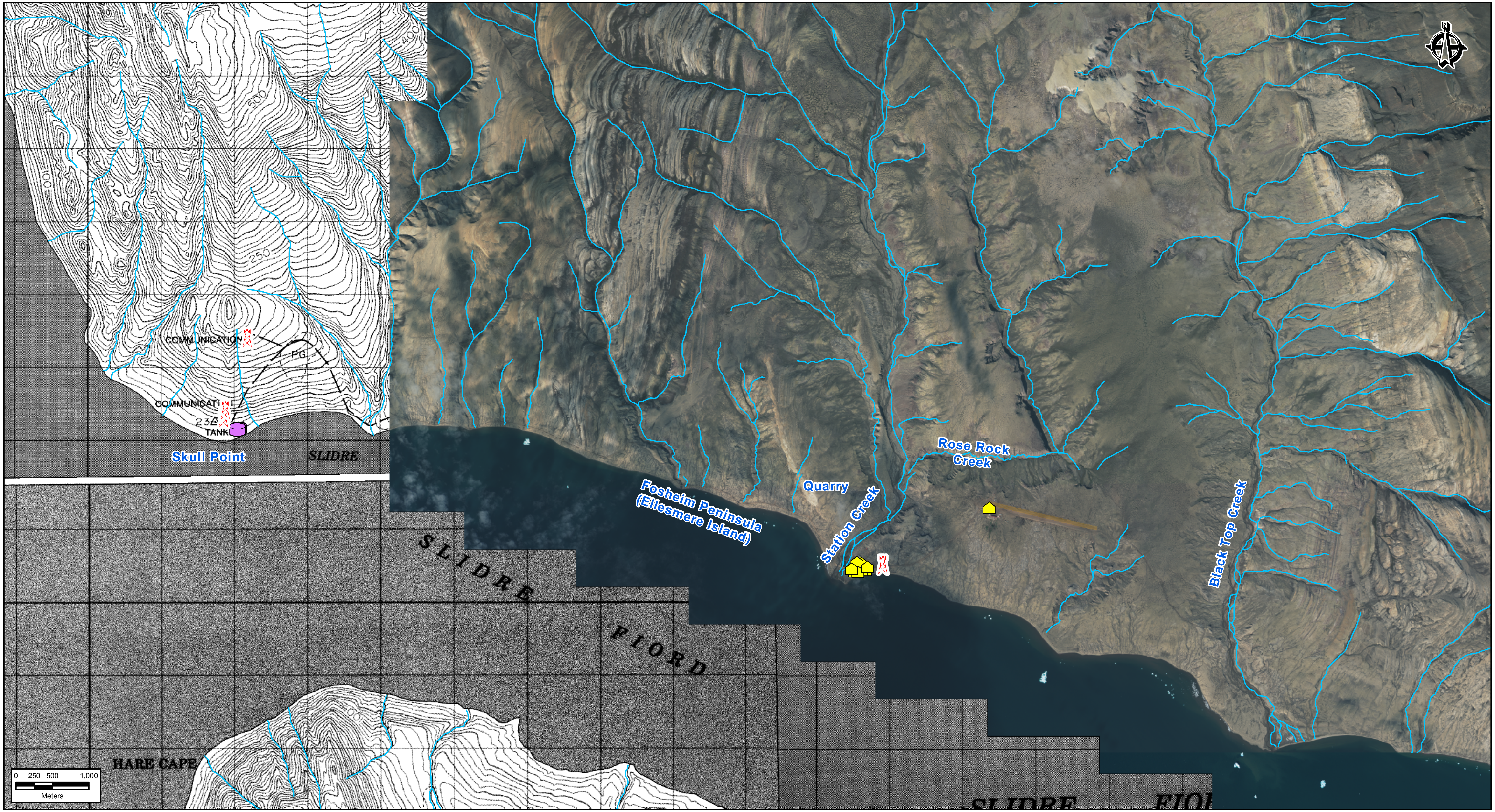

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Important Notes:

GeoEye-1 Satellite imagery shown acquired on August 2009, captured at 0.5m resolution. CanVec data courtesy of NRCan.

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Legend

- Building
- Communication Tower
- Tank
- Watercourse
- Runway

DRAWN YW
CHECK GVM
DESIGN YW
APPR. GVM

Eureka Study
Site Overview Map

DATE	MAP NUMBER	REV.	CONTRACTOR NAME
26 AUG 2010	Figure 4.2	D	WorleyParsons

WP NUMBER	SCALE	PROJECTION	DATUM	ORIG. PAGE SIZE
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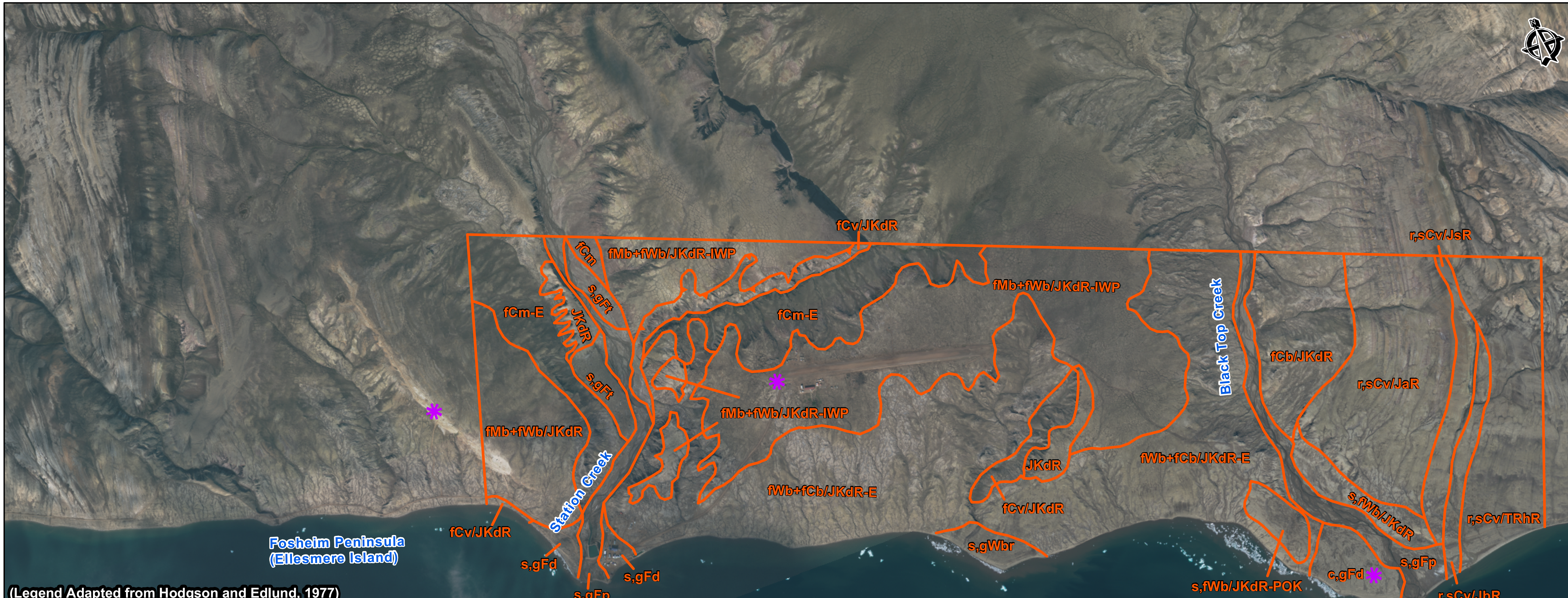

(Legend Adapted from Hodgson and Edlund, 1977)

Symbol	Terrain Unit	Texture	Thickness	Ice Content	Slope
Cv	Colluvial Veneer	Silt, Clay, Sand	< 1m	Variable	Moderate to Steep
Cb	Colluvial Blanket	Silt, Clay, Sand	1 to 3m	Variable	Moderate to Steep
Cm	Colluvial Mantle	Silt, Clay, Sand	> 3m	Variable	Moderate to Steep
Fp	Fluvial Plain	Sand, Gravel and Fines	> 3m	Low	Level
Ft	Fluvial Terrace	Sand, Gravel and Fines	> 3m	Moderate	Level
Fd	Fluvial Delta	Sand, Gravel and Fines	> 3m	Excess ice to 10%. Lenses and wedges	Level
Wb	Marine Blanket	Silt & Sand, Minor Gravel	1 to 3m+	Silt higher than sand & gravel	Level
Wbr	Marine Beach Ridges	Silt & Sand, Minor Gravel	> 3m	Moderate; Excess ice to 25%	Low ridges

Symbol	Terrain Unit	Texture	Thickness	Ice Content	Slope
Mb	Moraine Blanket	Silt & Clay, Some sand; Minor gravel (till)	1 to 3m+	High; Excess ice 5 to 95%; Ice wedge polygons	Level to Gentle
JKdR	Jurassic and Cretaceous Deer Bay Formation	Dark Grey Shale; Minor Siltstone, Mudstone & Sandstone	—	Excess ice in upper part of shale and in fine grained deposits	Level to Gentle
JaR	Jurassic Awingak Formation	Sandstone & Siltstone;Minor Shale	—	Excess ice only in thick colluvium	Gentle to Steep
JsR	Jurassic Savik Formation	Green Sandstone; Shale	—	Excess ice only in thick colluvium	Gentle to Steep
JbR	Jurassic Borden Island Formation	Sandstone	—	Excess ice only in thick colluvium	Gentle to Steep
TRhR	Triassic Heiberg Formation	Sandstone & Siltstone; Minor Shale	—	Excess ice only in thick colluvium	Gentle to Steep

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Symbols:

- Bedrock Escarpment
- IWP Ice Wedge Polygons
- POK Thermokarst
- -E Erosional Channels
- * BulkSampleLocation

Textures:

- c = Cobbles
- r = Rock Rubble
- g = Gravel
- s = Sand
- f = Clay, Silt, Fine Sand

Example:

fMb + fWb/JKdR
Fine grained moraine and marine deposits (with ice wedge polygons) that are 1 to 3+ m thick and overlie Jurassic shale of the Deer Bay Formation.

DRAWN	YW
CHECK	GVM
DESIGN	YW
APPR	LM

Eureka Study
Terrain Unit Mapping
Site Overview Map

DATE	MAP NUMBER	REV.	CONTRACTOR NAME
28 SEP 2010	Figure 4.3	C	WorleyParsons

WP NUMBER	SCALE	PROJECTION	DATUM	ORIG. PAGE SIZE
C71130000	1:30,000	UTM 16N	NAD 83	11 X 17

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(Legend Adapted from Hodgson and Edlund, 1977)

Map Symbol	Terrain Unit	Material	Thick-ness	Surface Drainage following Snowmelt	Ice Contents	Slope	Comments
Cv	Colluvial Veneer – Produced by Mass Wasting	Silt, Clay, Sand	<1 m	Well Drained	Variable ice contents. Lower on upper slopes in coarser material; Higher on lower slopes in fine grained material.	Moderate to Steep	Thin weathering and slope deposits developed on bedrock; Texture related to bedrock on which it is developed.
Cb	Colluvial Blanket – Produced by Mass Wasting	Silt, Clay, Sand	1 to 3 m	Moderately Well Drained; May be eroded and channeled where fine grained	Variable ice contents. Lower on upper slopes in coarser material; Higher on lower slopes in fine grained material.	Moderate to Steep	Moderately thick slope deposits overlying bedrock. Texture related to bedrock on which it is developed. May contain reworked till and marine deposits.
Cm	Colluvial Mantle – Produced by Mass Wasting	Silt, Clay, Sand	>3m	Moderately Well Drained; May be eroded and channeled where fine grained	Variable ice contents. Ice wedges in thicker fine grained deposits on lower slopes.	Moderate to Steep	Thicker slope deposits overlying bedrock. Texture related to bedrock on which it is developed. May contain reworked till and marine deposits.
Fp	Fluvial Plain – Actively forming along streams	Sand, Gravel and Fines	>3m	Poorly Drained	Low ice contents. Some lenses may be present. Pore ice in coarse sediments.	Level	Active Floodplain -May contain significant water during high water events. A source of sand and gravel along Station and Blacktop Creeks. Active pit in Station Creek floodplain.
Ft	Fluvial Terrace – Formed along streams in modern times	Sand, Gravel and Fines	>3m	Moderately Well Drained	Moderate Ice contents. Lenses and wedges may be present on inactive surfaces.	Level	Fluvial terraces above floodplains are source of sand and gravel, but ice contents are higher than in floodplain deposits. Some old terraces occur along Station Creek.
Fd	Fluvial Delta – Formed along streams in modern times.	Sand, Gravel and Fines	>3m	Well Drained	Excess ice to 10%. Lenses and wedges may be present.	Level	Old Fluvial deltas of Station and Blacktop Creeks may be sources of sand and gravel.
Wb	Marine Blanket – Formed during higher sea level in post-glacial time.	Silt & Sand, Minor Gravel	1 to 3m+	Moderately Well Drained to Poorly drained	Silt has higher ice contents than sand & gravel.	Level	Thermokarst occurs in marine blanket deposits near Blacktop Creek.
Wbr	Marine Beach Ridges - Formed during higher sea level in post-glacial time.	Silt & Sand, Minor Gravel	>3m	Moderately Well Drained	Moderate ice contents; Excess ice to 25%.	Low ridges	Could be a source of sand.
Mb	Moraine Blanket - Formed at base of glacier during glacial times.	Silt & Clay, Some sand; Minor gravel (till);	1 to 3m+	Moderately Well to Poorly Drained	High Ice contents; Excess ice 5 to 95%; Ice wedge polygons common. Reticulate and massive ice in fine grained sediments above 150 m elevation.	Level to Gentle	Often mixed with fine grained marine deposits below the marine limit.
JKdR	Jurassic and Cretac-eous Deer Bay Formation	Dark Grey Shale; Minor Siltstone, Mudstone & Sandstone	--	Poorly Drained	Excess ice in upper part of shale and in the colluvium, moraine and marine sediments that overlie it.	Level to Gentle	May be eroded and channeled on slopes. This unit has fairly thick moraine, marine and colluvial cover that exhibit ice wedge polygons. Shale could be used for fine grained material where it has lower ice contents (at depth).
JaR	Jurassic Awingak Formation	Sandstone & Siltstone;Minor Shale	--	Well Drained	Excess ice only in locations with thick colluvium	Gentle to Steep	Covered by sandstone rubble, sand and fine grained colluvium usually <1m thick
JsR	Jurassic Savik Formation	Green Sandstone; Shale	--	Well Drained	Excess ice only in locations with thick colluvium	Gentle to Steep	Covered by sandstone rubble, sand and fine grained colluvium usually <1m thick
JbR	Jurassic Borden Island Formation	Sandstone	--	Well Drained	Excess ice only in locations with thick colluvium	Gentle to Steep	Covered by sandstone rubble, sand and fine grained colluvium usually <1m thick
TRhR	Triassic Heiberg Formation	Sandstone & Siltstone; Minor Shale	--	Well Drained	Excess ice only in locations with thick colluvium	Gentle to Steep	Covered by sandstone rubble, sand and fine grained colluvium usually <1m thick

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Eureka Study
Terrain Unit Mapping Legend
1 of 1

DATE	MAP NUMBER	REV.	CONTRACTOR NAME
28 SEP 2010	Figure 4.4	C	WorleyParsons

WP NUMBER	SCALE	PROJECTION	DATUM	ORIG. PAGE SIZE
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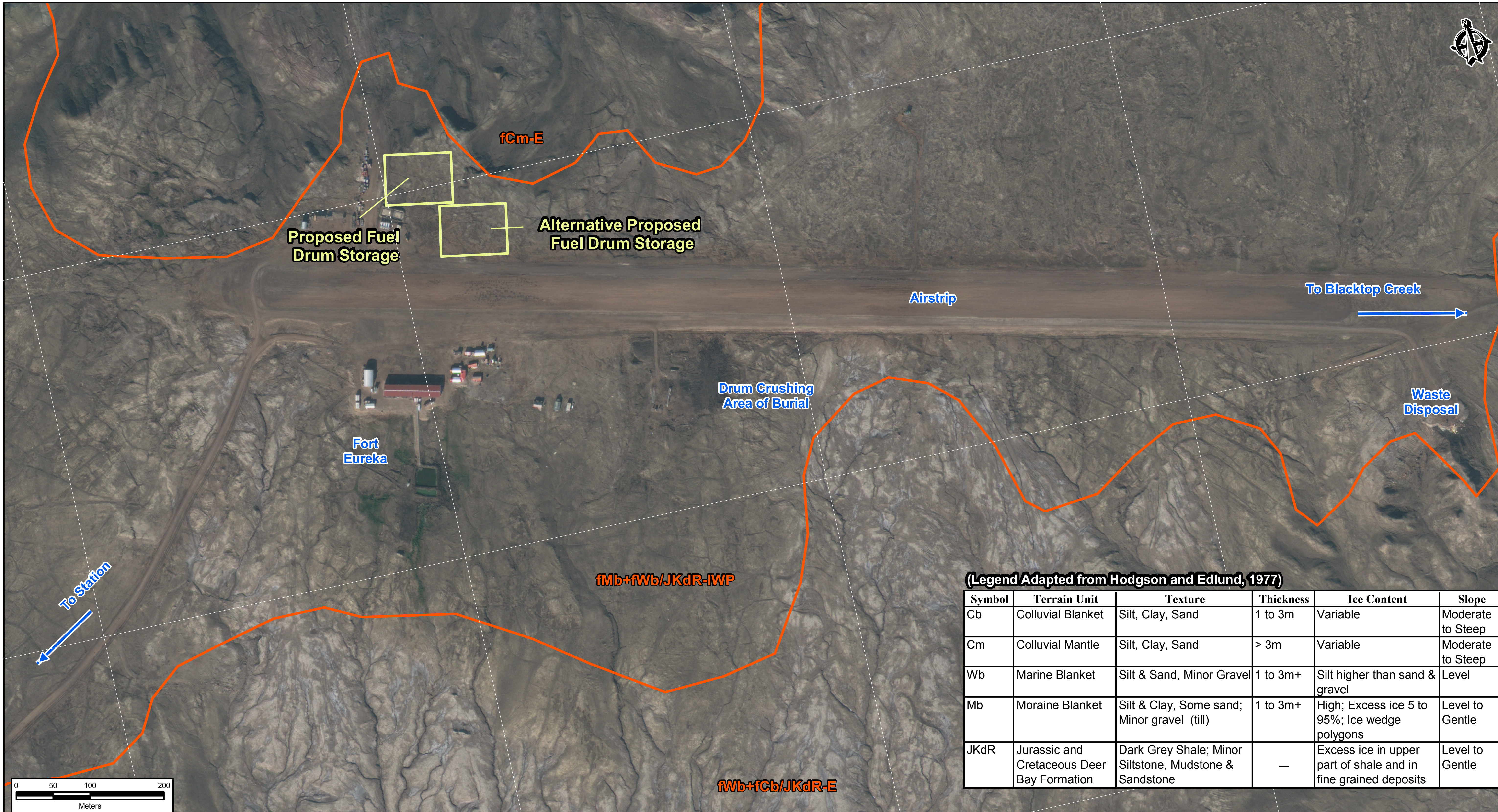

(Legend Adapted from Hodgson and Edlund, 1977)

Symbol	Terrain Unit	Texture	Thickness	Ice Content	Slope
Cb	Colluvial Blanket	Silt, Clay, Sand	1 to 3m	Variable	Moderate to Steep
Cm	Colluvial Mantle	Silt, Clay, Sand	> 3m	Variable	Moderate to Steep
Wb	Marine Blanket	Silt & Sand, Minor Gravel	1 to 3m+	Silt higher than sand & gravel	Level
Mb	Moraine Blanket	Silt & Clay, Some sand; Minor gravel (till)	1 to 3m+	High; Excess ice 5 to 95%; Ice wedge polygons	Level to Gentle
JKdR	Jurassic and Cretaceous Deer Bay Formation	Dark Grey Shale; Minor Siltstone, Mudstone & Sandstone	—	Excess ice in upper part of shale and in fine grained deposits	Level to Gentle

Eureka Civil Consulting Services

Public Works and Government Services Canada

Important Notes:

GeoEye-1 Satellite imagery shown acquired on August 2009, captured at 0.5m resolution.

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Symbols:

IWP Ice Wedge Polygons
-E Erosional Channels

Textures:

f = Clay, Silt, Fine Sand

Example:

fMb + fWb/JKdR
Fine grained moraine and marine deposits (with ice wedge polygons) that are 1 to 3+ m thick and overlie Jurassic shale of the Deer Bay Formation.

DRAWN YW
CHECK GVM
DESIGN YW
APPR. LM

Eureka Study
Terrain Unit Mapping
Airstrip Map

DATE	MAP NUMBER	REV.	CONTRACTOR NAME
28 SEP 2010	Figure 4.5	C	WorleyParsons

WP NUMBER	SCALE	PROJECTION	DATUM	ORIG. PAGE SIZE
C71130000	1:5,000	UTM 16N	NAD 83	11 X 17

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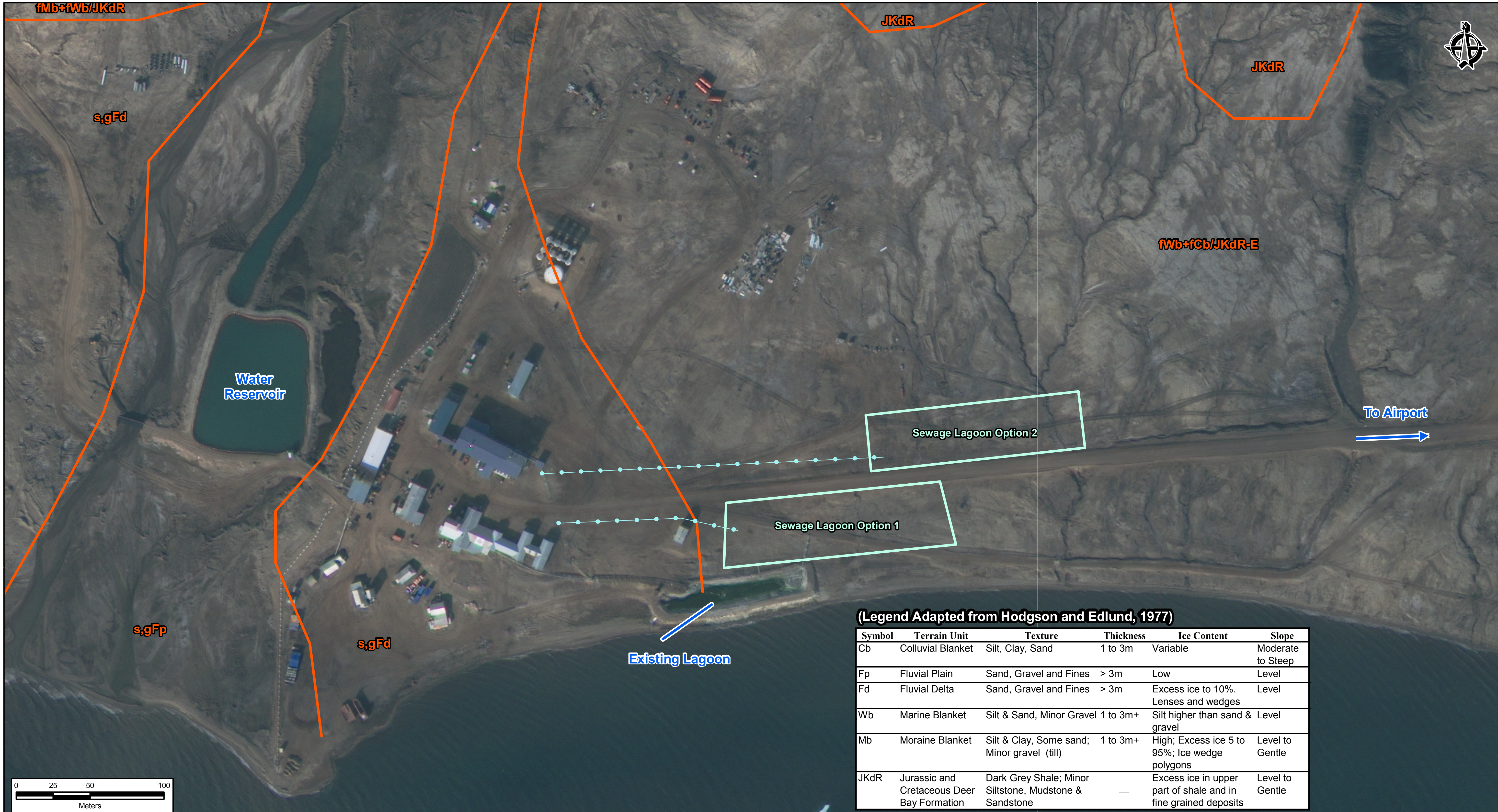

(Legend Adapted from Hodgson and Edlund, 1977)

Symbol	Terrain Unit	Texture	Thickness	Ice Content	Slope
Cb	Colluvial Blanket	Silt, Clay, Sand	1 to 3m	Variable	Moderate to Steep
Fp	Fluvial Plain	Sand, Gravel and Fines	> 3m	Low	Level
Fd	Fluvial Delta	Sand, Gravel and Fines	> 3m	Excess ice to 10%. Lenses and wedges	Level
Wb	Marine Blanket	Silt & Sand, Minor Gravel	1 to 3m+	Silt higher than sand & gravel	Level
Mb	Moraine Blanket	Silt & Clay, Some sand; Minor gravel (till)	1 to 3m+	High; Excess ice 5 to 95%; Ice wedge polygons	Level to Gentle
JKdR	Jurassic and Cretaceous Deer Bay Formation	Dark Grey Shale; Minor Siltstone, Mudstone & Sandstone	—	Excess ice in upper part of shale and in fine grained deposits	Level to Gentle

520,500 521,000

Eureka Civil Consulting Services

Public Works and Government Services Canada

Important Notes:

GeoEye-1 Satellite imagery shown acquired on August 2009, captured at 0.5m resolution.

Produced by WorleyParsons. The information used to create this product is based on the most current data available on the date of issue, and is considered reliable only at the scale at which the data was created and the scale at which the map was published. This drawing is prepared solely for the use of the contractual customer of WorleyParsons and WorleyParsons assumes no liability toany other party for any representations contained in these drawings.
This map must be printed at full scale (100%) in order for the scale to remain correct.

Symbols:

- Erosional Channels
- New Forcemain
- Cell

Textures:

g = Gravel
s = Sand
f = Clay, Silt, Fine Sand

Example:

fMb + fWb/JKdR
Fine grained moraine and marine deposits (with ice wedge polygons) that are 1 to 3+ m thick and overlie Jurassic shale of the Deer Bay Formation.

DRAWN	CHECK	DESIGN	APPR.
YW	GVM	YW	LM

Eureka Study
Terrain Unit Mapping
Wastewater Treatment Map

DATE	MAP NUMBER	REV.	CONTRACTOR NAME
28 SEP 2010	Figure 4.6	C	WorleyParsons

WP NUMBER	SCALE	PROJECTION	DATUM	ORIG. PAGE SIZE
C71130000	1:2,500	UTM 16N	NAD 83	11 X 17

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Z:\cgs\Projects\Eureka\07_ESRI_Projects\MXD\WORKING\09_GEOTECH\09-001-003.mxd

ANSIB-MAP-L VERSION: A

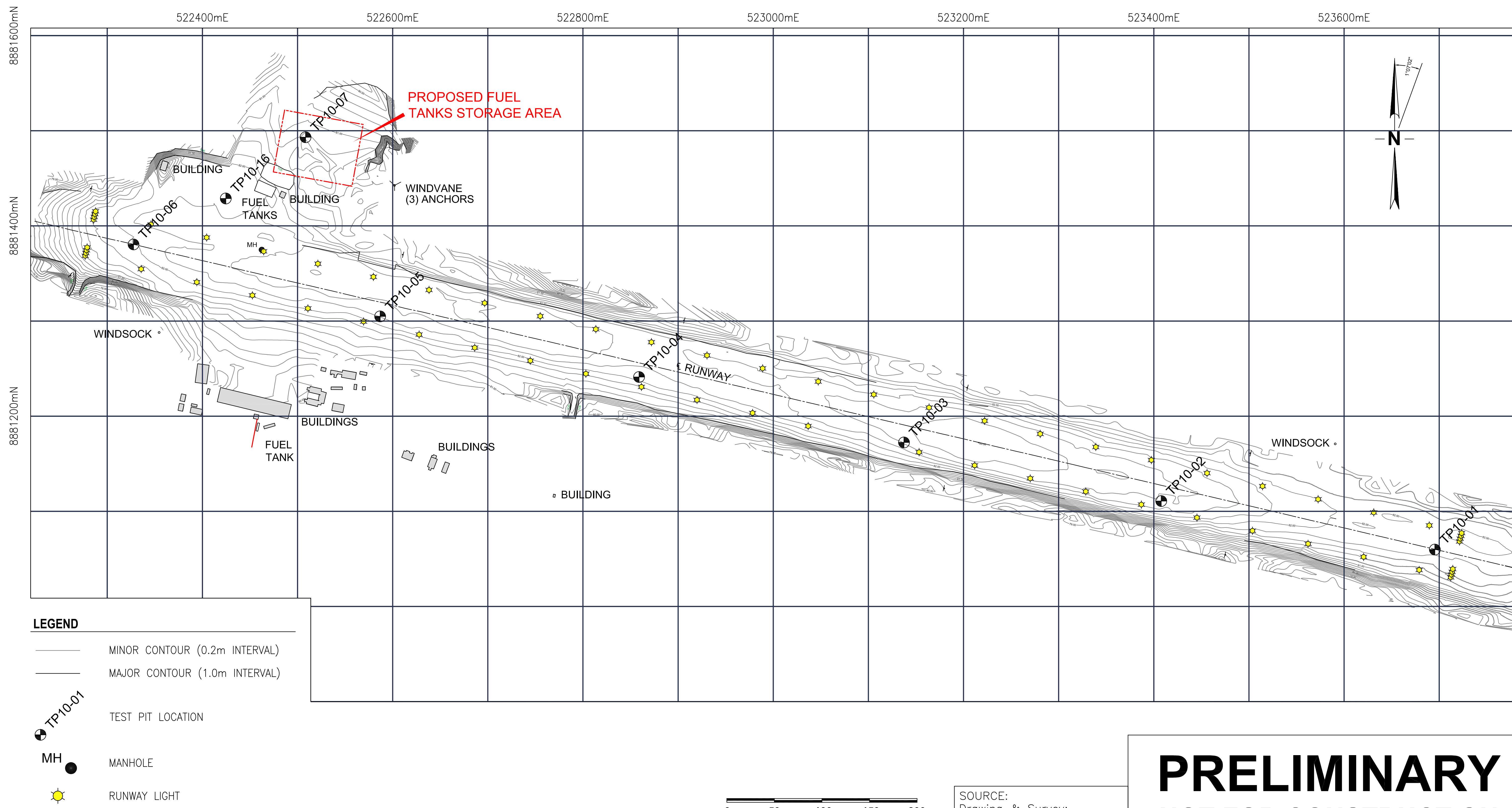
Drawings

Public Works and Government Services Canada

Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES / SERVICES IMMOBILIERS

Western Region / Région de l'ouest



0 50 100 150 200m

SCALE 1 : 4,000

SOURCE:
Drawing & Survey:
Challenger Geomatics,
Drawing File: 35062 SS.dwg

PRELIMINARY

NOT FOR CONSTRUCTION

DO NOT SCALE DRAWINGS

Client/client: PUBLIC WORKS & GOVERNMENT SERVICES CANADA (PWGSC) BOX 1408 100-167 LOMBARD AVE WINNEPEG, MANITOBA	Project title/Titre du projet: EUREKA, NUNAVUT CANADA CIVIL CONSULTING SERVICES	Drawing title/Titre du dessin: RUNWAY, APRON AND TAXIWAY	Approved by/Approuve par: J.Q.	PWGSC Project Manager/Administrateur de Projets TPSGC: J.D.	Project No./No. du projet: R.015446.001
			Designed by/Concept par: L.M.	PWGSC, Architectural and Engineering Resources Manager/Ressources Architectural et de Directeur d'Ingénierie, TPSGC	Sheet/Feuille: 18 OF 27 Revision/Revision
			Drawn by/Dessine par: L.P./D.R.H.	Date/Date: 2010-12-09	

A0 – PWGSC – ANSI B-L2 – 11X17

C71130000 base

Public Works and Government Services Canada

Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES / SERVICES IMMOBILIERS

Western Region / Région de l'ouest

N

LEGEND

MINOR CONTOUR (0.2m INTERVAL)

MAJOR CONTOUR (1.0m INTERVAL)

CULVERT LOCATION

TP10-09 TEST PIT LOCATION

0 25 50 75 100m

SCALE 1 : 2,500

SOURCE:
Drawing & Survey:
Challenger Geomatics,
Drawing File: 35062 SS.dwg

PRELIMINARY
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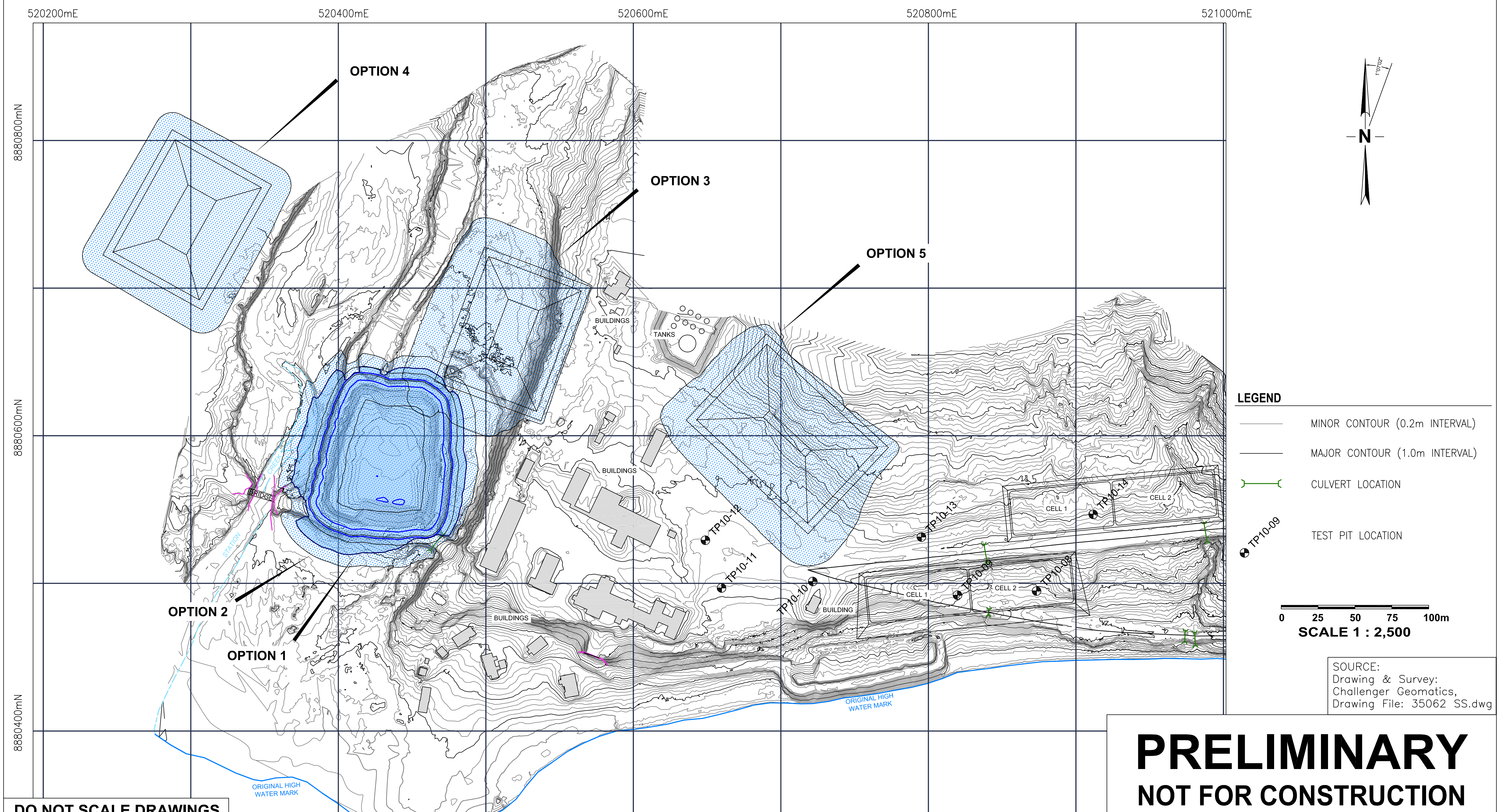
Client/client	Project title/Titre du projet	Drawing title/Titre du dessin	Approved by/Approuve par J.Q.	PWGSC Project Manager/Administrateur de Projets TPSGC J.D.	Project No./No. du projet R.015446.001
PUBLIC WORKS & GOVERNMENT SERVICES CANADA (PWGSC) BOX 1408 100-167 LOMBARD AVE WINNEPEG, MANITOBA	EUREKA, NUNAVUT CANADA CIVIL CONSULTING SERVICES	SITE PLAN	Designed by/Concept par L.M.	PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'Ingénierie, TPSGC	Sheet/Feuille 25 OF 27 · Revision/Révision
			Drawn by/Dessine par L.P./D.R.H.	Date/Date 2010-12-09	

A0 – PWGSC – ANSI B-L2 – 11X17

C71130000 base



SOURCE:
Drawing & Survey:
Challenger Geomatics,
Drawing File: 35062 SS.dwg

PRELIMINARY
NOT FOR CONSTRUCTION

DO NOT SCALE DRAWINGS

Client/client **PUBLIC WORKS & GOVERNMENT SERVICES CANADA (PWGSC)** BOX 1408 100-167 LOMBARD AVE WINNEPEG, MANITOBA	Project title/Titre du projet EUREKA, NUNAVUT CANADA CIVIL CONSULTING SERVICES	Drawing title/Titre du dessin OPTION 1-5 SITE PLAN	Approved by/Approuve par J.Q. Designed by/Concept par L.M. Drawn by/Dessine par L.P./D.R.H.	PWGSC Project Manager/Administrateur de Projets TPSGC J.D. PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'Ingénierie, TPSGC Date/Date 2010-12-09	Project No./No. du projet R.015446.001 Sheet/Feuille 26 OF 27 Revision/Révision

Photographs

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PHOTO 1: Test pit excavation in progress.

PHOTO 2: Low spots along existing runway.

PHOTO 3: Tundra pool on north side of runway.

PHOTO 4: Power line to Fort Eureka.

PHOTO 5: Existing reservoir berms showing instability and lack of freeboard.

PHOTO 6: Water reservoir - North Cell Bank.

PHOTO 7: Seepage through water reservoir berms.

WorleyParsons

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PHOTO 8: Existing quarry stone northwest of station.

PHOTO 9: Stockpiles in Station Creek delta.

PHOTO 10: Fluvial terrace above Station Creek.

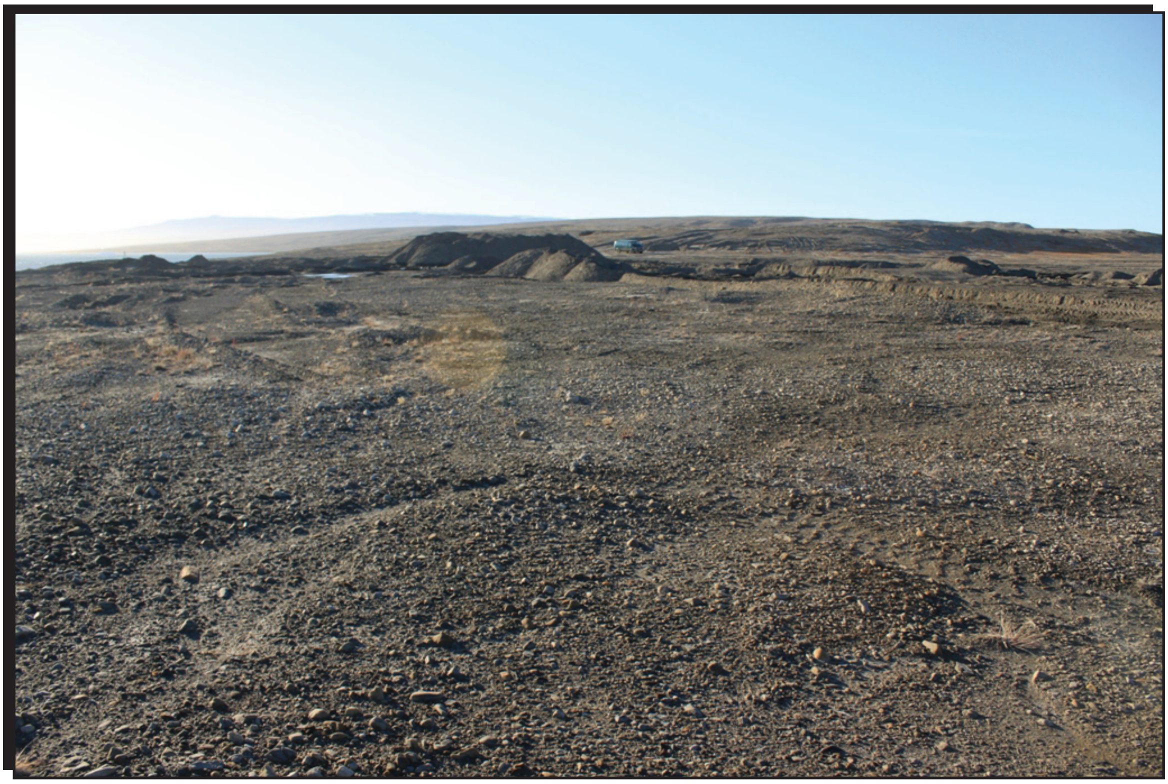

PHOTO 11: Existing stockpile at Blacktop Creek.

PHOTO 12: Stream bank exposure at Blacktop Creek.

PHOTO 13: Stream bank exposure at Remus Creek.

PHOTO 14: Awingak Formation exposure.

PHOTO 15: Heiberg Formation exposure.

Appendices

Appendix 4.1 Test Pit (TP) Logs

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-01**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,060.00 E 523,695.00	Method: Test Pitting	Elevation: 82.95 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0	GC	(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, clayey, reddish brown, approx. 50 mm thick.						
	CL-ML	(CL-ML) Silty Clay (Till) - Firm, moist, dark greyish brown	Grab	1-1		5.9		
0.5			Grab	1-2		18.5 PI=22	Clay = 26%, Silt = 66%, Sand = 8%, Gravel = 0%	82.5
1.0		- Visible ice						82.0
		End of Hole at a depth of 1.04 m Bucket refusal at 1.04 m in permafrost. Water Levels:						
1.5								81.5
								81.0

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.04 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	Page 1 of 1

WP STANDARD LOG EUREKA.GPJ WORLEY PARSONS LAB.GDT 10/12/10

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-02**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,111.00 E 523,408.00	Method: Test Pitting	Elevation: 82.55 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
		(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, clayey, reddish brown, approx. 100 mm thick.	Grab	2-1		4.1		82.5
		(CL-ML) Silty Clay (Fill) - Stiff, low plasticity, damp, dark grey in colour	Grab	2-2		16.5	Temp. 7.5°C	
0.5		(GW) Clayey Gravel (Fill) - Compact, damp, some cobbles and sand, meduim brown	Grab	2-3		16.1	Temp. 2.3°C	82.0
1.0		(ML) Sandy Silt - Firm, damp, some rootlets and organics, light brown in colour.					Temp. 0.2°C	81.5
		(CL-ML) Silty Clay (Till) - Stiff, damp, low plasticity, dark grey, ice poor.	Grab	2-4		25.3		
1.5		End of Hole at a depth of 1.40 m Bucket refusal at 1.40 m in permafrost. Water Levels:						81.0

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.40 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-03**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,172.00 E 523,137.00	Method: Test Pitting	Elevation: 82.65 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic – MC – Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0	GC	(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, clayey, reddish brown, approx. 150 mm thick.	Grab	3-1		5.9		
0.15	CL-ML	(CL-ML) Silty Clay (Till) - Firm to stiff, low plasticity, damp, dark grey, ice poor.						82.5
0.5							Temp. 3.7°C	
								82.0
			Grab	3-2		15.2, PI=10	Temp. 2.2°C Clay = 12%, Silt = 44%, Sand = 37%, Gravel = 7%	
1.0							Temp. 0.2°C	
								81.5
1.25		End of Hole at a depth of 1.25 m Bucket refusal at 1.25 m in permafrost. Water Levels:						
1.5								
								81.0

WorleyParsons resources & energy

Logged By: Lee Martin	Completion Depth: 1.25 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-04**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,241.00 E 522,859.00	Method: Test Pitting	Elevation: 82.10 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0–0.21	GC	(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, clayey, reddish brown, approx. 210 mm thick.	Grab Sample	4-1		3.9	Fines = 18.1%, Sand = 28.9%, Gravel = 53%	82.0
0.21–1.20	CL-ML	(CL-ML) Silty Clay (Till) - Firm, low plasticity, moist, dark grey, trace rootlets, ice poor	Grab Sample	4-2		22.2		
0.5		- Stiff, damp					Temp. 2.8°C	81.5
							Temp. 1.2°C	
1.0							Temp. <0°C	81.0
1.5								80.5

End of Hole at a depth of 1.20 m
Bucket refusal at 1.20 m in permafrost.

Water Levels:

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.20 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-05**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,305.00 E 522,587.00	Method: Test Pitting	Elevation: 82.21 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic MC Liquid (10 20 30 40)	Other Data	Elevation (m)
		(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, clayey, reddish brown, approx. 135 mm thick.	Grab	5-1		6.2		
		(CL-ML) Silty Clay (Till) - Stiff, low plasticity, damp, dark grey, ice poor						82.0
0.5			Grab	5-2		20.5 PI=14	Temp. 2.4°C	
							Temp. 0.9°C	81.5
1.0		End of Hole at a depth of 0.98 m Bucket refusal at 0.98 m in permafrost. Water Levels:						
								81.0
1.5								
								80.5

WorleyParsons resources & energy

Logged By: Lee Martin	Completion Depth: 0.98 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-06**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,381.00 E 522,328.00	Method: Test Pitting	Elevation: 81.95 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic MC Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0		(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, very clayey, reddish brown, approx. 50 mm thick.					Fines = 29.5%, Sand = 51.5%, Gravel = 19%	
		(CL-ML) Silty Clay (Till) - Stiff, low plasticity, damp, dark grey, sandy brown lenses noted throughout, ice poor - trace organics noted at top of colluvium layer	Grab	6-1		3.8		
0.5							Temp. 3.3°C	81.5
							Temp. 1.7°C	
1.0							Temp. <0°C	81.0
			Grab	6-2		16.2	Clay = 25%, Silt = 55%, Sand = 19%, Gravel = 1%	
1.5		End of Hole at a depth of 1.38 m Bucket refusal at 1.38 m in permafrost. Water Levels:						80.5
								80.0

WP STANDARD LOG EUREKA.GPJ WORLEY PARSONS LAB.GDT 10/12/10

WorleyParsons resources & energy

Logged By: Lee Martin	Completion Depth: 1.38 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-07**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,881,493.00 E 522,508.00	Method: Test Pitting	Elevation: 81.32 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic – MC – Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0		(CL-ML) Clayey Silt (Till) - very soft, moist, dark brownish grey, some organics and rootlets at surface, trace boulders and cobbles noted on surface and in test pit						
			Grab	7-1		29.4 PI=17	Temp. 1.0°C	81.0
							Temp. 0.4°C	
0.5							Temp. <0°C	
		- Ice poor permafrost	Grab	7-2		43.3		
								80.5
1.0		End of Hole at a depth of 1.00 m Bucket refusal at 1.00 m in permafrost. Water Levels:						
								80.0
1.5								
								79.5

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.00 m
Reviewed By:	Drilled on: 8/15/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-08**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,495.00 E 520,873.00	Method: Test Pitting	Elevation: 3.78 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic MC Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0		(SP) Gravelly Sand (Fill) - Loose, moist, some clay and silt, trace cobbles, buried cables and debris, trace organics, medium brown						
								3.5
0.5							Temp. 2.1°C	
							Temp. 0.7°C	3.0
			Grab	8-1		13.3		
1.0		(CL-ML) Silty Clay (colluvium) - Stiff, low plasticity, moist, trace gravel, sandy, dark grey, ice poor					Temp. <0°C	
								2.5
1.5							Clay = 28%, Silt = 70%, Sand = 2%, Gravel = 0%	
			Grab	8-2		32.1 PI=9		
								2.0

End of Hole at a depth of 1.90 m
Bucket refusal at 1.90 m in permafrost.

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.90 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-09**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,492.00 E 520,820.00	Method: Test Pitting	Elevation: 4.01 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0	(GP) Sandy Gravel (Fill) - Crushed sandstone, compact, damp, pinkish red						
0.33	(SP) Gravelly Sand (Fill) - Loose, moist to wet, some clay and silt, trace cobbles, medium brown						
0.5							3.5
		Grab	9-1		4.8		
1.0	- Ice poor permafrost						3.0
	- Seepage observed (thawing permafrost)						
1.2	(CL-ML) Silty Clay (Colluvium)- Stiff, low plasticity, damp, dark grey, ice poor						
		Grab	9-2		31.4, PI=11	Clay = 26%, Silt = 70%, Sand = 4%, Gravel = 0%	
1.4	End of Hole at a depth of 1.40 m Bucket refusal at 1.40 m in permafrost. Water Levels:						
1.5							2.5

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.40 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-10**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,501.00 E 520,722.00	Method: Test Pitting	Elevation: 7.68 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic – MC – Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0–1.0	GP	(GP) Sandy Gravel (Fill) - Compact, damp, trace cobbles, some silt and clay, medium brown	Grab Sample (0.5–0.65)	10-1		6.4		7.5, 7.0
1.0–1.1		- Water flowing into pit Solid Ice. Native colluvium may be present at 1.1m; however, difficult to ascertain due to presence of solid ice and flowing water.						

End of Hole at a depth of 1.10 m
Bucket refusal at 1.10 m in permafrost.

Water Levels:

Depth scale: 0.5, 1.0, 1.5. Elevation scale: 7.5, 7.0, 6.5, 6.0.

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.10 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-11**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,497.00 E 520,660.00	Method: Test Pitting	Elevation: 7.05 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0	GP	(GP) Sandy Gravel (Fill) - Compact, damp to moist, trace cobbles, some silt and clay, medium brown.						7.0
0.5			Grab Sample	11-1		4.7		6.5
0.9		- Water flowing into pit						
1.0								6.0
1.1	CL-ML	(CL-ML) Silty Clay (Colluvium) - Stiff, damp, low plasticity, dark grey, ice poor	Grab Sample	11-2		22.4		

End of Hole at a depth of 1.30 m
Bucket refusal at 1.30 m in permafrost.

Water Levels:

Depth scale: 0.5, 1.0, 1.5 — Elevation scale: 7.0, 6.5, 6.0, 5.5

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Logged By: Lee Martin	Completion Depth: 1.30 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-12**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,529.00 E 520,649.00	Method: Test Pitting	Elevation: 7.54 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic MC Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0		(GP) Sandy Gravel (Fill) - Compact, moist, some cobbles, some silt and clay, medium brown.						7.5
0.5								7.0
0.9		(CL-ML) Silty Clay (Colluvium) - Stiff, damp, low plasticity, dark grey, ice poor						
1.0		- water flowing in at 0.9m, testpit walls sloughing in						6.5
1.5								6.0

End of Hole at a depth of 1.10 m
Test pit terminated at 1.10 m because of large volumes of sloughing and water infiltration.

Water Levels:

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.10 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	Page 1 of 1

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-13**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,531.00 E 520,795.00	Method: Test Pitting	Elevation: 7.62 m

Sample Type: Shelby Tube | Core Sample | Spt Sample | Grab Sample | No Recovery | Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
		(ML) Clayey Silt (colluvium) - Firm, moist, light brown to dark grey, sandy, trace organics and rootlets.						7.5
0.5			Grab	13-1		21	Temp. 0.4°C	7.0
							Temp. <0°C	
		(CL-ML) Silty Clay (colluvium) - Stiff, low plasticity, damp, dark grey, ice poor						
1.0			Grab	13-2		30.5		6.5

End of Hole at a depth of 1.30 m
Bucket refusal at 1.30 m in permafrost.

Water Levels:

Depth (m)	Elevation (m)
1.5	6.0

WP STANDARD LOG EUREKA.GPJ WORLEY PARSONS LAB.GDT 10/12/10

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 1.30 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-14**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,547.00 E 520,912.00	Method: Test Pitting	Elevation: 7.85 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic – MC – Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0–0.98	ML	(ML) Sandy Silt (colluvium) - Firm, damp, medium brown, trace gravel, trace rootlets and organics - Ice poor permafrost	Grab Sample	14-1		11.4 PI=9	Temp. 1.8°C Clay = 11%, Silt = 26%, Sand = 33%, Gravel = 30% Temp. 0.4°C	7.5, 7.0
1.0		End of Hole at a depth of 0.98 m Bucket refusal at 0.98 m in permafrost. Water Levels:					Temp. <0°C	6.5, 6.0

Depth scale: 0.5, 1.0, 1.5

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 0.98 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	Page 1 of 1

WP STANDARD LOG EUREKA.GPJ WORLEY PARSONS LAB.GDT 10/12/10

Project: Eureka Geotechnical Investigation	Contractor: Environment Canada	Borehole Number: **TP10-15**
Client: Public Works and Government Services	Equipment: Ford Backhoe	Project Number: C71130000
Coordinates: N 8,880,561.00 E 521,014.00	Method: Test Pitting	Elevation: 9.13 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic / MC / Liquid (10 20 30 40)	Other Data	Elevation (m)
0.0		(CL-ML) Silty Clay (colluvium) - Firm, damp to moist, dark brownish grey, trace organics, some sand, trace gravel						9.0
0.5			Grab Sample	15-1		22.1 PI=10	Temp. <0°C	8.5
		- Ice poor permafrost with noticeable ice veins						
1.0							Clay = 21%, Silt = 77%, Sand = 2%, Gravel = 0%	
		End of Hole at a depth of 1.10 m Bucket refusal at 1.10 m in permafrost. Water Levels:						8.0
1.5								7.5

WorleyParsons resources & energy

Logged By: Lee Martin	Completion Depth: 1.10 m
Reviewed By:	Drilled on: 8/16/2010
Groundwater Depth:	

Project: Eureka Geotechnical Investigation	Contractor: Hand Excavation	Borehole Number: **TP10-16**
Client: Public Works and Government Services	Equipment: Hand Excavation	Project Number: C71130000
Coordinates: N 8,881,429.00 E 522,425.00	Method: Test Pitting	Elevation: 82.12 m

Sample Type: Shelby Tube, Core Sample, Spt Sample, Grab Sample, No Recovery, Bulk Sample

Depth (m)	Soil Symbol	SOIL DESCRIPTION	Sample Type	Sample Number	Blows/150 mm	Plastic MC Liquid (10 20 30 40)	Other Data	Elevation (m)
		(GC) Granular Surfacing Material - Fine gravel (crushed sandstone) and sand, firm, moist, clayey, reddish brown, approx. 200 mm thick.						82.0
		(CL-ML) Silty Clay (Till) - Firm, moist, low plasticity, dark greyish brown						
0.5		End of Hole at a depth of 0.50 m Test pit terminated at 0.5 metres in native clayey till. Water Levels:						81.5
1.0								81.0
1.5								80.5
2.0								80.0

WorleyParsons
resources & energy

Logged By: Lee Martin	Completion Depth: 0.50 m
Reviewed By:	Drilled on: 8/17/2010
Groundwater Depth:	

Appendix 4.2 Laboratory Testing

Table: 1

Summary of Petrographic Analysis of Coarse Aggregate Test Report

CSA 23.2-04 15A

Project:	Worley Parsons Materials Testing - 2010	Sample No.:	L-31(Bulk 4)
Client:	Worley Parsons Canada Services Ltd.	Date Received:	September 2, 2010
Project No.:	C12201471	Date Tested:	October 5, 2010
Source:	Eureka, NT	Petrographer:	MS
Description:	Gravel, sandy, trace silt	Office:	Calgary

Rock Type	Petrographic Multiplier	25 - 19 mm % in fraction	19 - 13 mm % in fraction	13 - 10 mm % in fraction	10 - 5 mm % in fraction	Weighted Average %
Good - High Strength						
QUARTZITE/SANDSTONE	1				28.3	28.3
CARBONATE	1				3.0	3.0
CHERT	1				4.1	4.1
MIGMATITE	1				26.1	26.1
GRANITE	1				19.2	19.2
Fair - Medium Strength						
QUARTZITE/SANDSTONE - weak	3				2.7	2.7
SHALE - weak	3				4.3	4.3
SILTSTONE	3				1.9	1.9
GRANITE - weathered	3				2.0	2.0
MIGMATITE - weathered	3				0.8	0.8
Poor - Low Strength						
SILTSTONE - weak	6				1.3	1.3
QUARTZITE/SANDSTONE - weak	6				1.9	1.9
SHALE - highly weathered	6				1.0	1.0
GRANITE - highly weathered	6				0.6	0.6
Deleterious						
IRONSTONE	10				2.8	2.8
SHALE-friable	10				0.0	0.0
Petrographic Number :		**Not Tested**	**Not Tested**	**Not Tested**	**172**	
Percent of Fraction in Sample:		4.0	8.0	4.0	13.0	

Weighted Average Petrographic Number: **172**

Weighted Average Chert Content: **4.1 %**

Weighted Average Ironstone Content: **2.8 %**

Petrographer: [signature]

EBA Engineering Consultants Ltd.

Table: 2

Summary of Petrographic Analysis of Coarse Aggregate Test Report

CSA 23.2-04 15A

Project:	Worley Parsons Materials Testing - 2010	Sample No.:	L-32(Bulk 6)
Client:	Worley Parsons Canada Services Ltd.	Date Received:	September 2, 2010
Project No.:	C12201471	Date Tested:	October 5, 2010
Source:	Eureka, NT	Petrographer:	WJ
Description:	Gravel, sandy, trace silt	Office:	Calgary

Rock Type	Petrographic Multiplier	25 - 19 mm % in fraction	19 - 13 mm % in fraction	13 - 10 mm % in fraction	10 - 5 mm % in fraction	Weighted Average %
Good - High Strength						
QUARTZITE/SANDSTONE	1				26.1	26.1
CARBONATE	1				7.1	7.1
CHERT	1				3.5	3.5
MIGMATITE	1				23.6	23.6
GRANITE	1				11.3	11.3
Fair - Medium Strength						
QUARTZITE/SANDSTONE - weak	3				3.4	3.4
SHALE - weak	3				5.7	5.7
SILTSTONE	3				1.5	1.5
GRANITE - weathered	3				2.0	2.0
MIGMATITE - weathered	3				0.5	0.5
Poor - Low Strength						
SILTSTONE - weak	6				0.9	0.9
QUARTZITE/SANDSTONE - weak	6				6.7	6.7
SHALE - highly weathered	6				3.3	3.3
GRANITE - highly weathered	6				1.2	1.2
Deleterious						
IRONSTONE	10				1.2	1.2
SHALE-friable	10				2.0	2.0
Petrographic Number :		**Not Tested**	**Not Tested**	**Not Tested**	**215**	
Percent of Fraction in Sample:		8.0	10.0	7.0	9.0	

Weighted Average Petrographic Number: **215**

Weighted Average Chert Content: **3.5 %**

Weighted Average Ironstone Content: **1.2 %**

Petrographer:

EBA Engineering Consultants Ltd.

MOISTURE CONTENT TEST RESULTS

Project:	Worley Parsons Materials Testing - 2010	Sample No.:	L-1 - L-22
Project No.:	C12201471	Date Tested:	9/15/2010
Client:	Worley Parsons Canada Services Ltd.	Tested By:	MS
Address:	Eureka, NT	Page:	1 of 2

B.H. Number	Sample Number	Depyh (m)	Tare Mass (g)	Mass of Wet Soil & tare (g)	Mass of Dry Soil & tare (g)	Moisture Content (%)	Visual Description of Soil EBA Work Method WM4400
1-1	L-1		249.3	1742.5	1659.0	5.9	GRAVEL, sandy, some silt, some clay
1-2	L-2	0.5	129.3	910.0	788.1	18.5	CLAY, silty, trace sand, brown, moist to wet
2-1	L-3		5.1	282.2	271.4	4.1	SAND and GRAVEL, silty, some clay, brown, moist
2-2	L-4	0.5	5.0	149.8	129.3	16.5	SAND and GRAVEL, silty, some clay, brown, moist
2-3	L-5	0.5	5.1	128.9	111.7	16.1	CLAY, silty, some sand, trace organics, dark brown, moist
2-4	L-6	1.3	5.1	117.5	94.8	25.3	CLAY, silty, trace sand, dark brown, moist to wet
3-1	L-7		5.1	232.6	219.9	5.9	SILT, sandy, some clay, some gravel, trace organics, brown
3-2	L-8	0.75	125.8	960.3	850.0	15.2	CLAY, silty, sandy, trace gravel, brown, moist
4-1	L-9	0	5.3	153.4	147.8	3.9	GRAVEL, sandy, some silt, some clay
4-2	L-10	0.4	5.2	218.6	179.8	22.2	CLAY, silty, same sand, trace organics, brown, moist to wet
5-1	L-11	0	11.8	340.8	321.6	6.2	SAND, silty, some gravel, brown, moist
5-2	L-12	0.5	11.9	339.9	284.2	20.5	CLAY, silty, trace sand, coal specs, brown, moist
6-1	L-13	0	5.1	240.8	232.1	3.8	SAND, some gravel, some silt, some clay brown, moist
6-2	L-14	1	127.6	961.9	845.4	16.2	CLAY, silty, some sand, trace gravel, black, moist (organic soil)
7-1	L-15	0.2	11.4	358.2	279.5	29.4	CLAY, silty,trace sand, some organics, dark bown, wet
7-2	L-16	0.6	11.6	206.4	147.5	43.3	CLAY, some silt, dark brown to grey, very wet
8-1	L-17	0.75	5.1	207.3	183.5	13.3	SAND, coarse, gravelly,some silt, dark brown, very wet
8-2	L-18	1.5	127.8	1118.5	877.5	32.1	CLAY, silty, trace sand, dark brown to grey, very wet
9-1	L-19	0.5	11.8	241.4	230.8	4.8	SAND, coarse, gravelly,some silt, brown to grey, wet
9-2	L-20		115.0	961.5	759.4	31.4	CLAY, silty, trace sand, dark brown to grey, very wet
10-1	L-21	0.5	11.8	296.0	279.0	6.4	SAND, gravelly, silty, some clay, dark brown to grey, moist
11-1	L-22	0.5	11.4	324.7	310.6	4.7	GRAVEL, coarse sand, trace silt, brown, moist

Tested in accordance with ASTM standard D2216, subject to review .
issued for internal use

EBA Engineering Consultants Ltd.

MOISTURE CONTENT TEST RESULTS

Project:	Worley Parsons Materials Testing - 2010	Sample No.:	L-23 - L-27
Project No.:	C12201471	Date Tested:	9/15/2010
Client:	Worley Parsons Canada Services Ltd.	Tested By:	MS
Address:	Eureka, NT	Page:	2 of 2

B.H. Number	Sample Number	Depth (m)	Tare Mass (g)	Mass of Wet Soil & tare (g)	Mass of Dry Soil & tare (g)	Moisture Content (%)	Visual Description of Soil EBA Work Method WM4400
11-2	L-23	1.1	5.0	232.6	191.0	22.4	SILT, clayey, trace sand, dark grey, very wet
13-1	L-24	0.5	5.2	193.6	160.9	21.0	SAND, silty, clayey, some boulders, brown, wet
13-2	L-25	1	5.3	178.0	137.6	30.5	CLAY silty, dark grey, very wet
14-1	L-26	0.5	247.3	1225.5	1125.7	11.4	CLAY, silty, some sand, trace gravel, dark brown, moist to wet
15-1	L-27	1	125.5	1365.8	1141.4	22.1	CLAY, silty, trace sand, dark brown, moist to wet

Tested in accordance with ASTM standard D2216, subject to review .
issued for internal use

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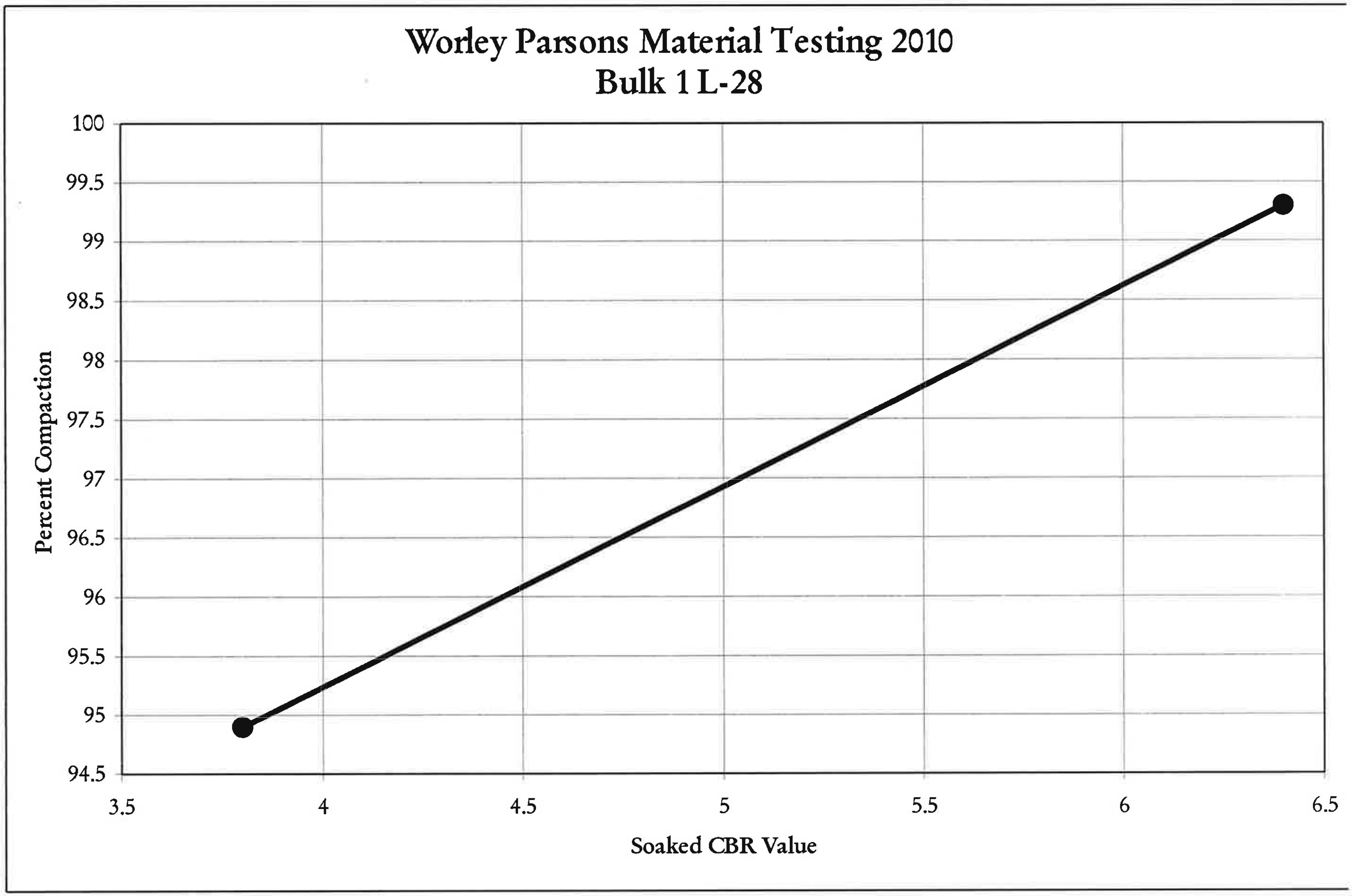


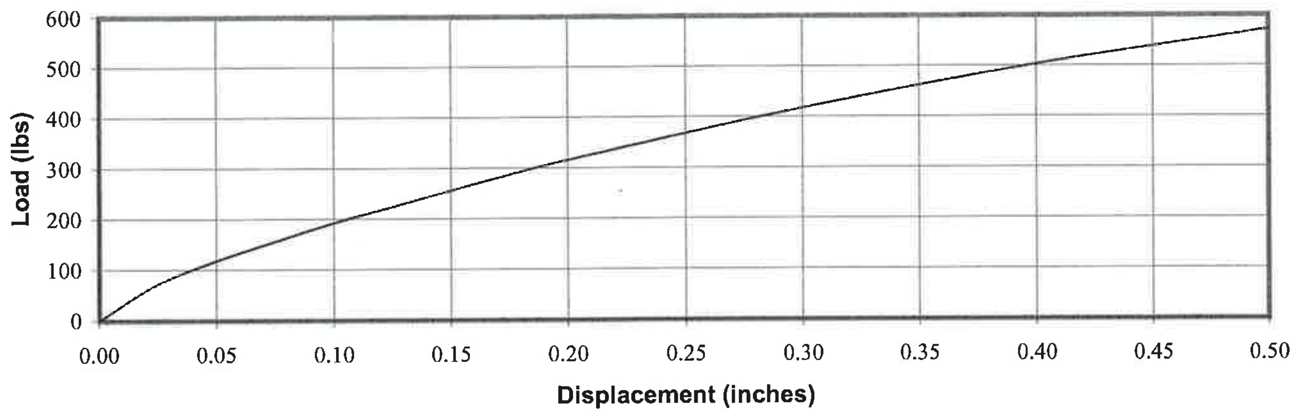
Worley Parsons Material Testing 2010
Bulk 1 L-28
Percent Compaction
100
99.5
99
98.5
98
97.5
97
96.5
96
95.5
95
94.5
3.5
4
4.5
5
5.5
6
6.5
Soaked CBR Value

CALIFORNIA BEARING RATIO (CBR) TEST REPORT

ASTM D1883

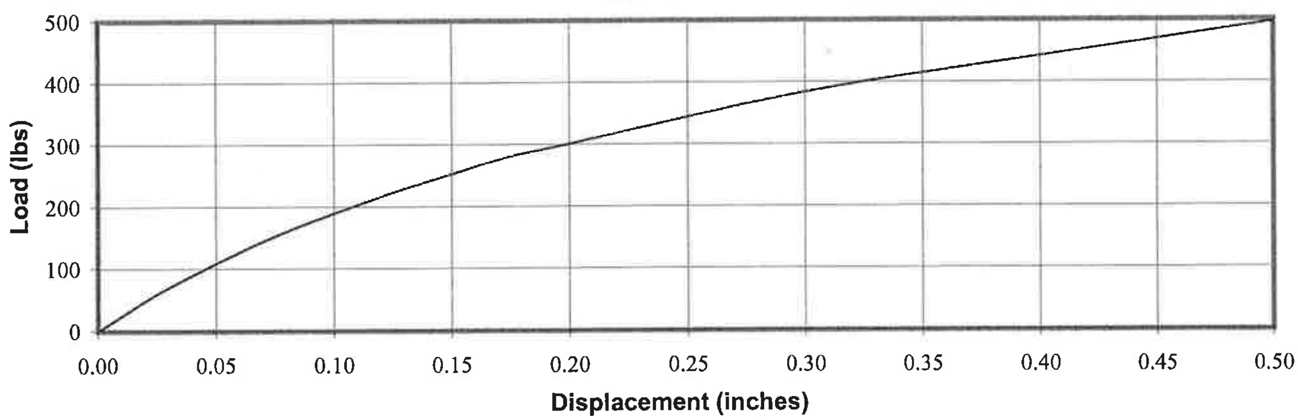
Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-28
Client:	Worley Parsons Canada Services Ltd.	Max. Dry Density by: ASTM D698	1800 kg/m³
Project No.:	C12201471	Optimum Moisture Content:	16.0 %
Test Date:	September 21, 2010	CBR Specimen Density:	1788 kg/m³
Soaking Time:	94.0 Hours	CBR Speciman Compaction	99.3 %
Description:	CLAY, silty, sandy	Surcharge Mass:	4.54 kg
Oversize 19mm:	0.0%	Total Swell (% of intial height):	0.20 %

CBR Before Soaking
Mold A



Bearing Ratio unsoaked % = **6.7** Moisture Content = **16.3 %**

CBR After Soaking
Mold A



Bearing Ratio soaked % = **6.4** Moisture Content = **16.2 %** M.C. @ 25.4mm = **19.3%**

Remarks:

Reviewed By: P.Eng.

Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA.The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

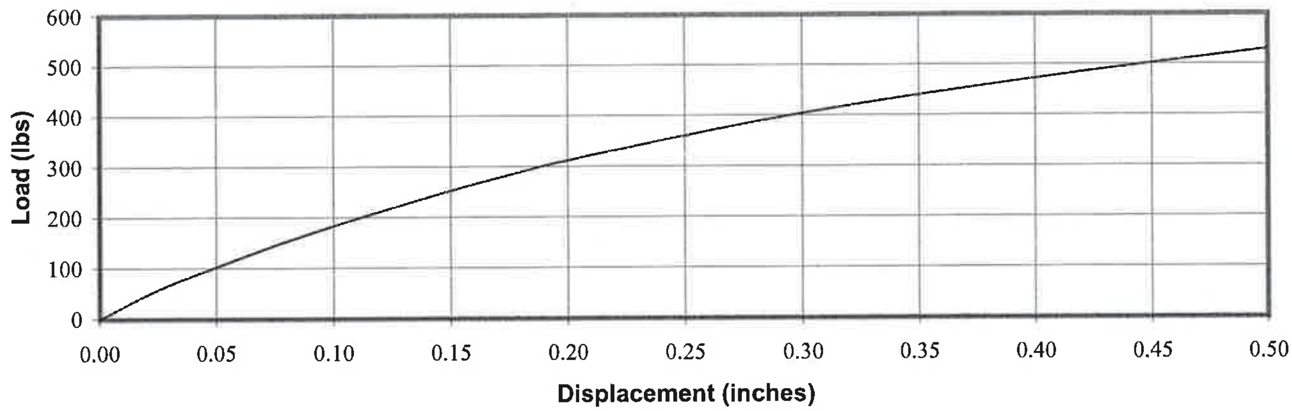
EBA Engineering Consultants Ltd.

CALIFORNIA BEARING RATIO (CBR) TEST REPORT

ASTM D1883

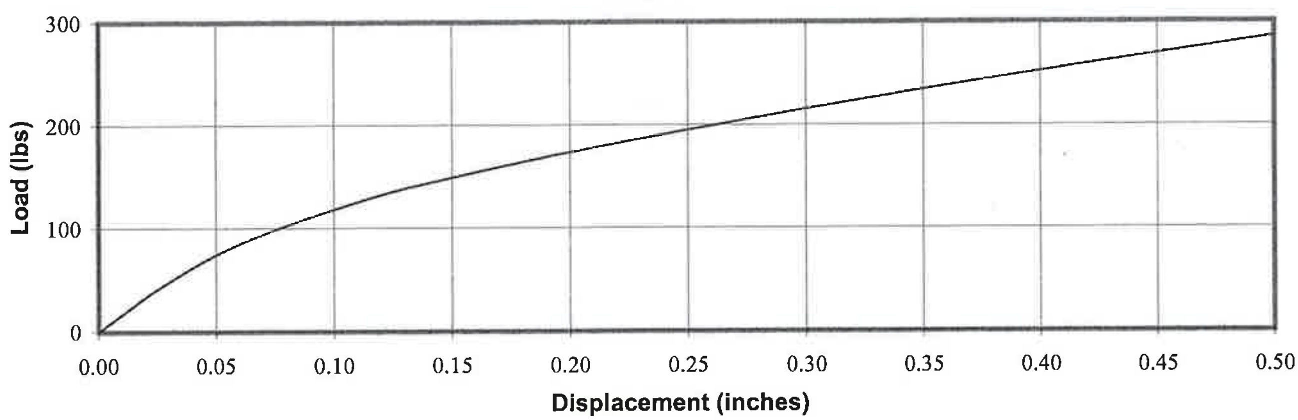
Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-28
Client:	Worley Parsons Canada Services Ltd.	Max. Dry Density by: ASTM D698	1800 kg/m³
Project No.:	C12201471	Optimum Moisture Content:	16.0 %
Test Date:	September 21, 2010	CBR Specimen Density:	1709 kg/m³
Soaking Time:	94.0 Hours	CBR Speciman Compaction	94.9 %
Description:	CLAY, silty, sandy	Surcharge Mass:	4.54 kg
Oversize 19mm:	0.0%	Total Swell (% of intial height):	0.15 %

CBR Before Soaking
Mold A



Bearing Ratio unsoaked % = **6.6** Moisture Content = **16.4 %**

CBR After Soaking
Mold A



Bearing Ratio soaked % = **3.8** Moisture Content = **16.7 %** M.C. @ 25.4mm = **18.7%**

Remarks:

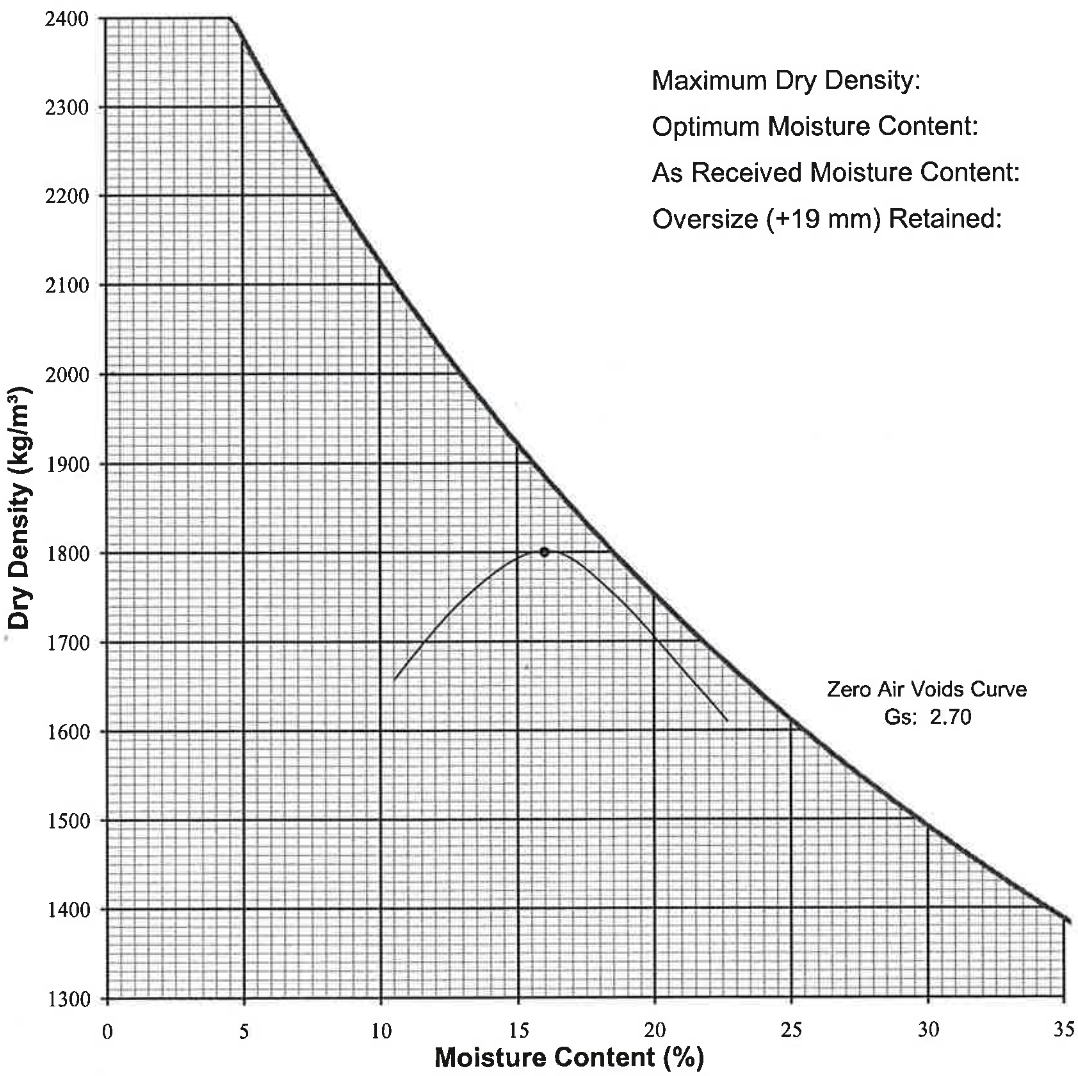
Reviewed By: P.Eng.

EBA Engineering Consultants Ltd.

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 (Standard Proctor)

Project:	Worley Parsons Materials Testing - 2010	Sample No.:	L-28
Project No.:	C12201471	Sampled By:	Client
Client:	Worley Parsons Canada Services Ltd.	Date Received:	2-Sep-10
Attention:	Lee Martin	Test Date:	16-Sep-10
E-mail:	Lee.Martin@WorleyParsons.com	Test Method:	Method A
Source:	Bulk 1	Compaction:	Manual
Sample Location:	Eureka, NT		
Sample Description:	CLAY, silty, sandy		



Maximum Dry Density:	**1800**	kg/m^3
Optimum Moisture Content:	**16.0**	%
As Received Moisture Content:	0.0	%
Oversize (+19 mm) Retained:	0.0	%

Remarks:

Reviewed By: C.Meagen P.Eng.

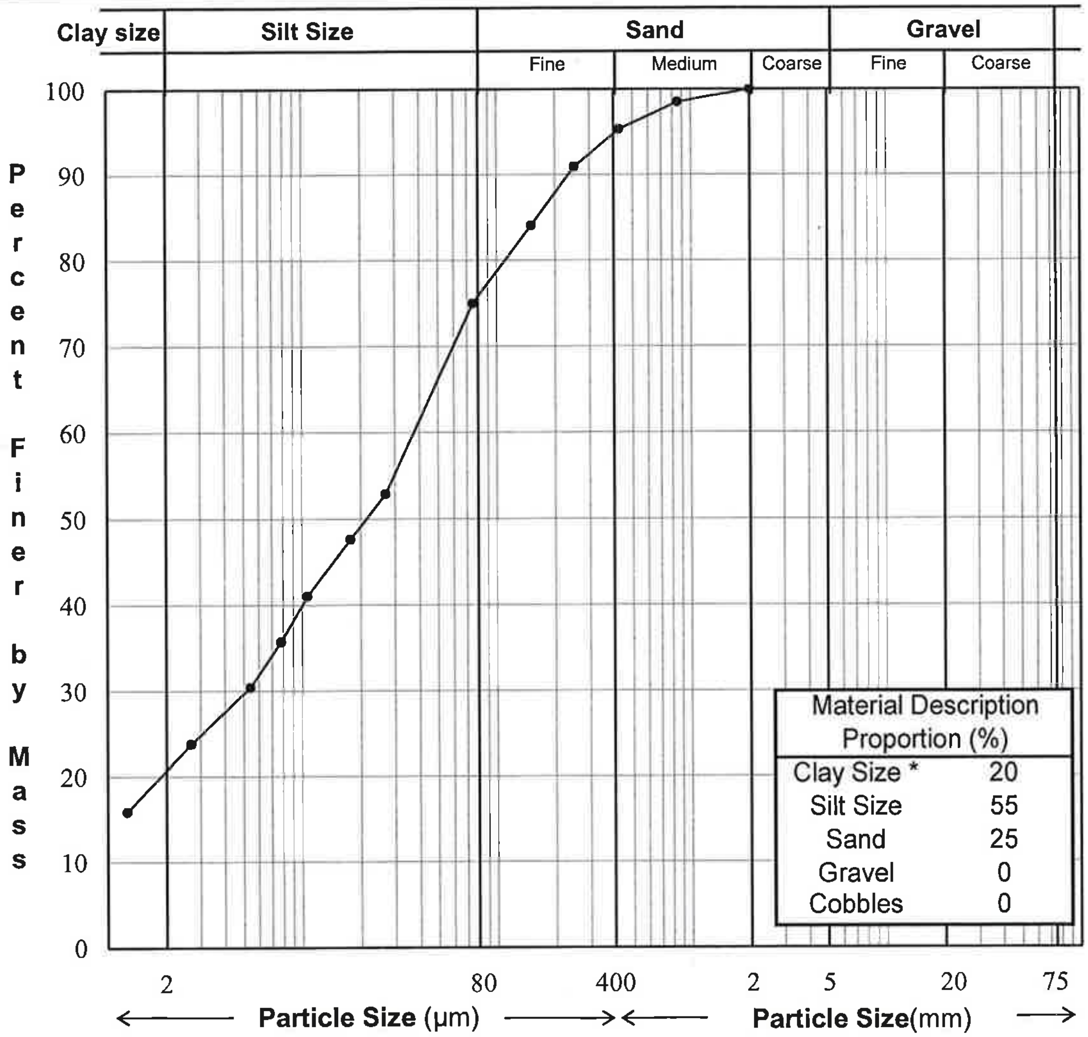
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-28
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	Bulk 1
Project No.:	C12201471	Depth:	Colluvium
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	CLAY, silty, sandy		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
850 μm	98
425 μm	95
250 μm	91
150 μm	84
75 μm	75
27 μm	53
18 μm	48
11 μm	41
8 μm	36
5 μm	30
3 μm	24
1 μm	16



Material Description	Proportion (%)
Clay Size *	20
Silt Size	55
Sand	25
Gravel	0
Cobbles	0

Remarks: * The upper clay size of 2 μm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: [signature] P.Eng.

EBA Engineering Consultants Ltd.

ATTERBERG LIMITS TEST FORM

ASTM D4318

Project: Worley Parsons Material Testing

Project Number: C12201471

Sample Description: CLAY, silty, trace sand

Sample Number: L-2

Borehole Number: 1-2

Source: 1-2

Date Sampled:

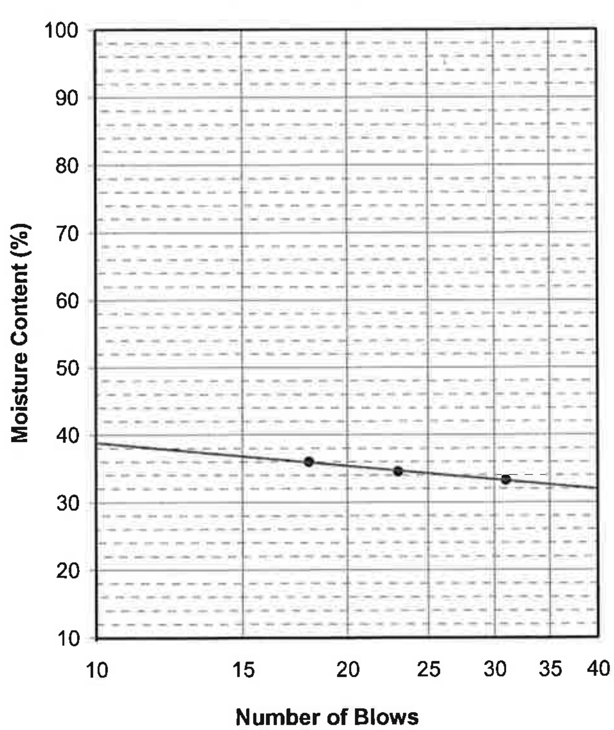
Sampled By:

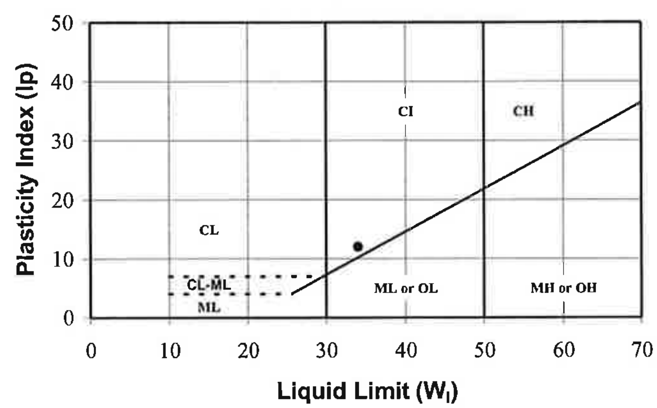
Date Tested: 28-Sep-10

Tested By: JB

Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	27.33	27.01	910
Mass Dry Soil + Tare	26.58	26.28	788.1
Mass of Tare	23.18	22.98	129.3
Mass of Water	0.75	0.73	121.9
Mass of Dry Soil	3.40	3.30	658.8
Moisture Content (%)	22.1	22.1	18.5

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	31	23	18
Tare Number	c	d	e
Mass Wet Soil + Tare	51.21	53.14	51.19
Mass Dry Soil + Tare	43.42	44.62	42.91
Mass of Tare	20.00	19.95	19.90
Mass of Water	7.79	8.52	8.28
Mass of Dry Soil	23.42	24.67	23.01
Moisture Content (%)	33.3	34.5	36.0





Natural Moisture (%)	18.5
Liquid Limit (%)	34
Plastic Limit (%)	22
PLASTICITY INDEX	**12**

Soil Description: Medium Plasticity

Mod.USCS Symbol: **CI**

Remarks:

reviewed by: CM

EBA Engineering Consultants Ltd.

eba

ATTERBERG LIMITS TEST FORM

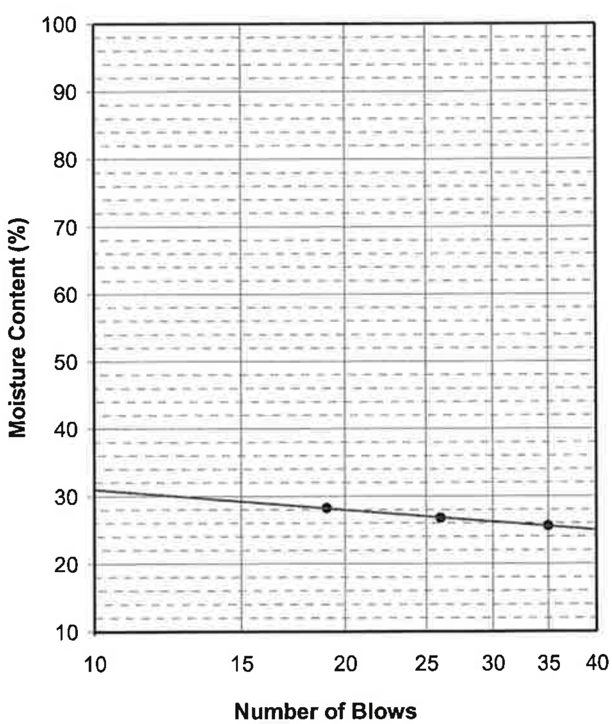
ASTM D4318

Project:	Worley Parsons Material Testing	Sample Number:	L-8
		Borehole Number:	3-2
Project Number:	C12201471	Source:	3-2
Sample Description:	CLAY, silty, sandy, trace gravel	Date Sampled:	
		Sampled By:	
		Date Tested:	28-Sep-10
		Tested By:	JB

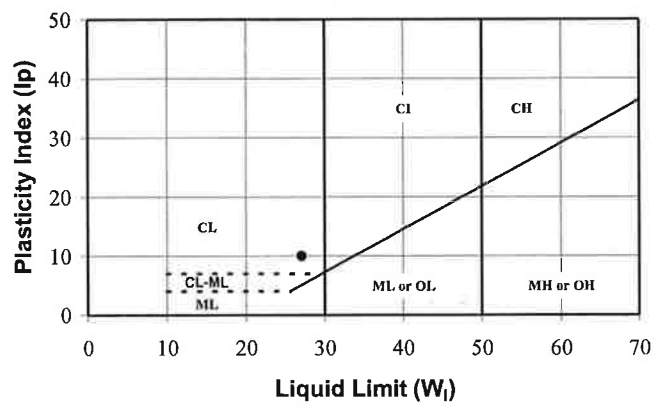
Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	20.87	20.24	960.3
Mass Dry Soil + Tare	20.29	19.72	850
Mass of Tare	16.94	16.74	125.8
Mass of Water	0.58	0.52	110.3
Mass of Dry Soil	3.35	2.98	724.2
Moisture Content (%)	17.3	17.4	15.2

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	35	26	19
Tare Number	c	d	e
Mass Wet Soil + Tare	46.78	49.11	51.20
Mass Dry Soil + Tare	40.66	42.26	43.59
Mass of Tare	16.73	16.67	16.63
Mass of Water	6.12	6.85	7.61
Mass of Dry Soil	23.93	25.59	26.96
Moisture Content (%)	25.6	26.8	28.2

Liquid Limit (W_l)



Plasticity Chart



Natural Moisture (%)	15.2
Liquid Limit (%)	27
Plastic Limit (%)	17
PLASTICITY INDEX	**10**

Soil Description: Low Plasticity

Mod.USCS Symbol: **CL**

Remarks:

reviewed by: CPM

EBA Engineering Consultants Ltd.

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ATTERBERG LIMITS TEST FORM

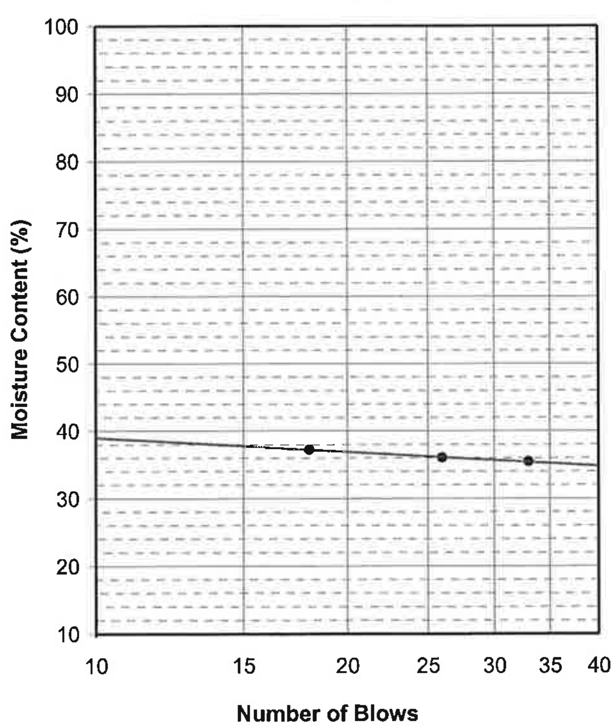
ASTM D4318

Project:	Worley Parsons Material Testing	Sample Number:	L-12
		Borehole Number:	5-2
Project Number:	C12201471	Source:	5-2
Sample Description:	CLAY, silty, trace sand trace coal specs	Date Sampled:	
		Sampled By:	
		Date Tested:	30-Sep-10
		Tested By:	JB

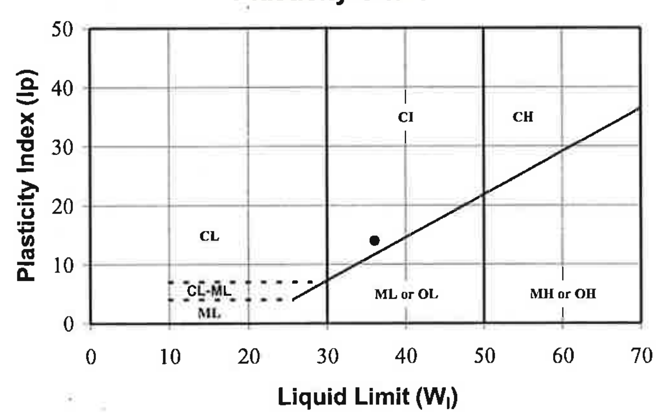
Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	20.68	20.20	339.9
Mass Dry Soil + Tare	19.94	19.55	284.2
Mass of Tare	16.56	16.55	11.9
Mass of Water	0.74	0.65	55.7
Mass of Dry Soil	3.38	3.00	272.3
Moisture Content (%)	21.9	21.7	20.5

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	33	26	18
Tare Number	c	d	e
Mass Wet Soil + Tare	51.32	47.20	56.54
Mass Dry Soil + Tare	42.29	39.15	45.65
Mass of Tare	16.82	16.82	16.43
Mass of Water	9.03	8.05	10.89
Mass of Dry Soil	25.47	22.33	29.22
Moisture Content (%)	35.5	36.1	37.3

Liquid Limit (W_l)



Plasticity Chart



Natural Moisture (%)	20.5
Liquid Limit (%)	36
Plastic Limit (%)	22
PLASTICITY INDEX	**14**

Soil Description: Medium Plasticity

Mod.USCS Symbol:

Remarks:

reviewed by: CM

EBA Engineering Consultants Ltd.

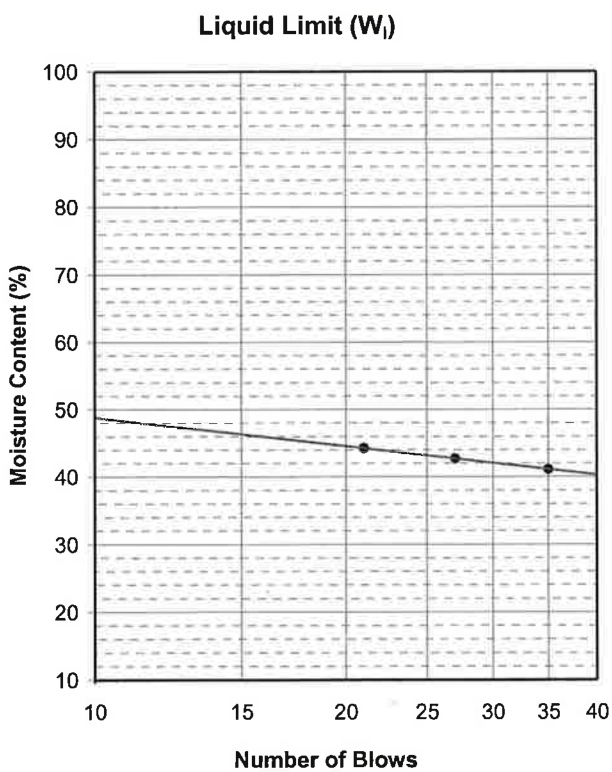
ATTERBERG LIMITS TEST FORM

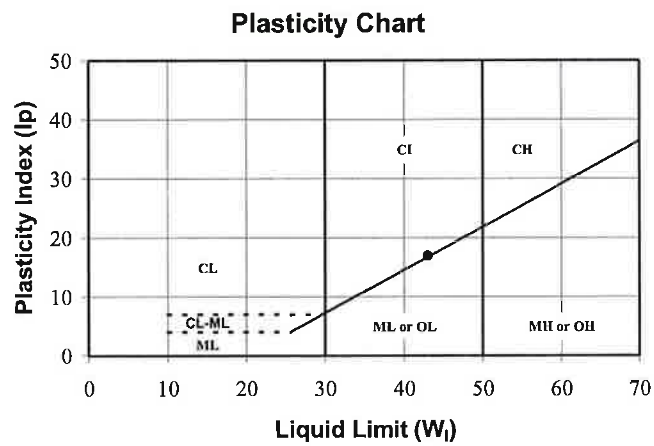
ASTM D4318

Project:	Worley Parsons Material Testing	Sample Number:	L-15
		Borehole Number:	7-1
Project Number:	C12201471	Source:	7-1
Sample Description:	CLAY, silty, trace sand some organics	Date Sampled:	
		Sampled By:	
		Date Tested:	28-Sep-10
		Tested By:	JB

Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	20.10	20.15	358.2
Mass Dry Soil + Tare	19.37	19.42	279.5
Mass of Tare	16.58	16.69	11.4
Mass of Water	0.73	0.73	78.7
Mass of Dry Soil	2.79	2.73	268.1
Moisture Content (%)	26.2	26.7	29.4

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	35	27	21
Tare Number	c	d	e
Mass Wet Soil + Tare	47.80	45.38	45.34
Mass Dry Soil + Tare	38.70	36.86	36.77
Mass of Tare	16.57	16.91	17.41
Mass of Water	9.10	8.52	8.57
Mass of Dry Soil	22.13	19.95	19.36
Moisture Content (%)	41.1	42.7	44.3





Natural Moisture (%)	29.4
Liquid Limit (%)	43
Plastic Limit (%)	26
PLASTICITY INDEX	**17**

Soil Description: Medium Plasticity

Mod.USCS Symbol: **CI**

Remarks:

reviewed by: CPM

EBA Engineering Consultants Ltd.

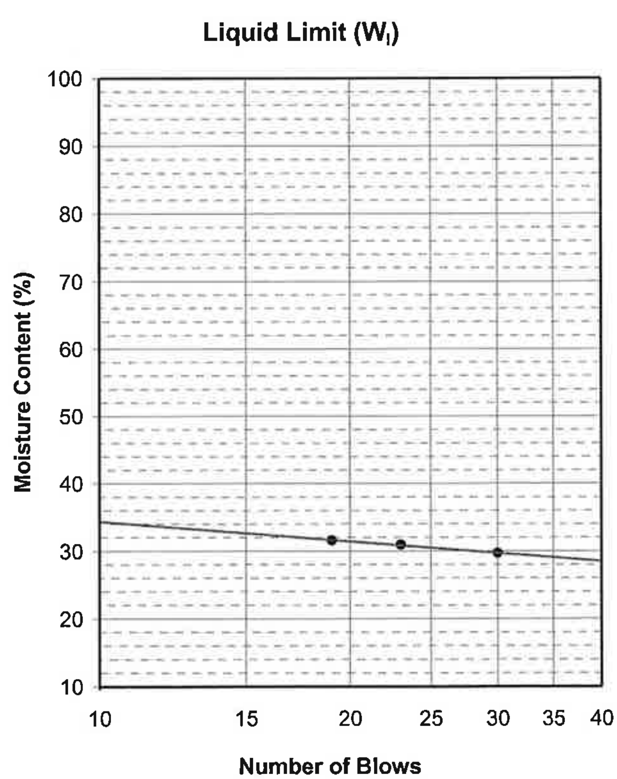
ATTERBERG LIMITS TEST FORM

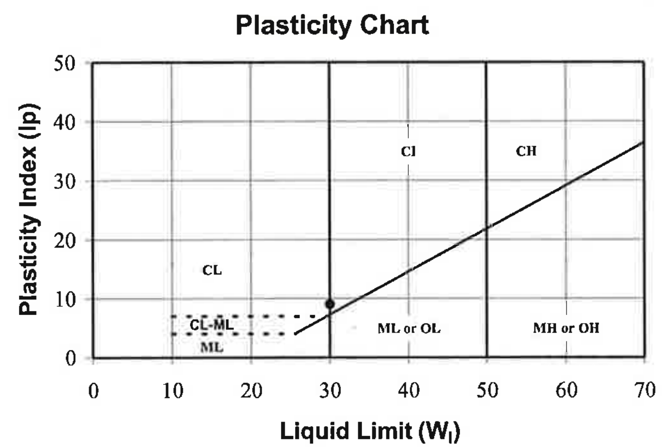
ASTM D4318

Project:	Worley Parsons Material Testing	Sample Number:	L-18
		Borehole Number:	8-2
Project Number:	C12201471	Source:	8-2
Sample Description:	CLAY, silty, trace sand	Date Sampled:	
		Sampled By:	
		Date Tested:	28-Sep-10
		Tested By:	JB

Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	19.79	19.21	1118.5
Mass Dry Soil + Tare	19.31	18.80	877.5
Mass of Tare	17.01	16.85	127.8
Mass of Water	0.48	0.41	241.0
Mass of Dry Soil	2.30	1.95	749.7
Moisture Content (%)	20.9	21.0	32.1

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	30	23	19
Tare Number	c	d	e
Mass Wet Soil + Tare	42.71	49.03	48.08
Mass Dry Soil + Tare	36.74	41.36	40.62
Mass of Tare	16.63	16.57	17.02
Mass of Water	5.97	7.67	7.46
Mass of Dry Soil	20.11	24.79	23.60
Moisture Content (%)	29.7	30.9	31.6





Natural Moisture (%)	32.1
Liquid Limit (%)	30
Plastic Limit (%)	21
PLASTICITY INDEX	**9**

Soil Description: Low to Medium Plasticity

Mod.USCS Symbol: **CL - CI**

Remarks:

reviewed by: CPM

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eba

ATTERBERG LIMITS TEST FORM

ASTM D4318

Project: Worley Parsons Material Testing

Project Number: C12201471

Sample Description: CLAY, silty, trace sand

Sample Number: L-20

Borehole Number: 9-2

Source: 9-2

Date Sampled:

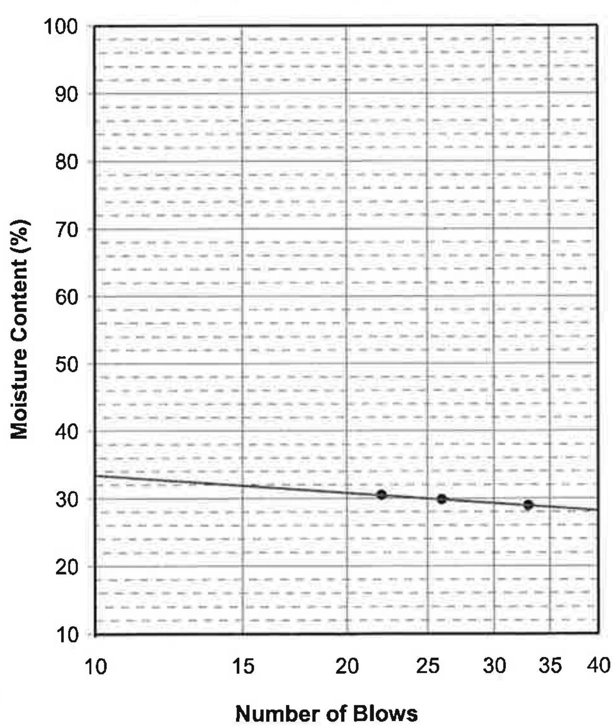
Sampled By:

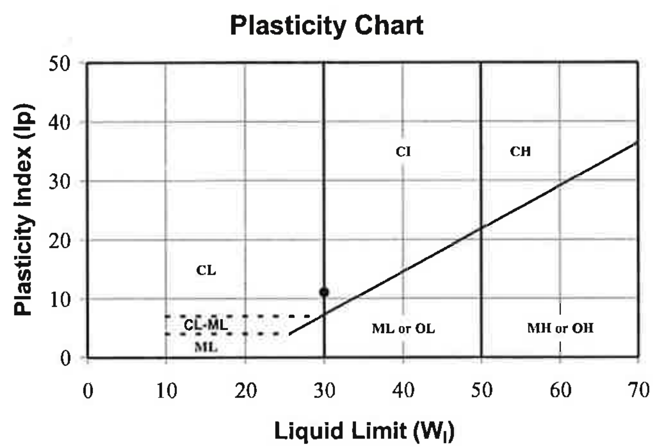
Date Tested: 28-Sep-10

Tested By: JB

Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	20.49	20.86	961.5
Mass Dry Soil + Tare	19.90	20.24	759.4
Mass of Tare	16.88	16.88	115
Mass of Water	0.59	0.62	202.1
Mass of Dry Soil	3.02	3.36	644.4
Moisture Content (%)	19.5	18.5	31.4

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	33	26	22
Tare Number	c	d	e
Mass Wet Soil + Tare	44.16	49.58	53.11
Mass Dry Soil + Tare	37.98	42.04	44.60
Mass of Tare	16.63	16.75	16.68
Mass of Water	6.18	7.54	8.51
Mass of Dry Soil	21.35	25.29	27.92
Moisture Content (%)	28.9	29.8	30.5





Natural Moisture (%)	31.4
Liquid Limit (%)	30
Plastic Limit (%)	19
PLASTICITY INDEX	**11**

Soil Description: Low to Medium Plasticity

Mod.USCS Symbol: **CL - CI**

Remarks:

reviewed by: CPM

EBA Engineering Consultants Ltd.

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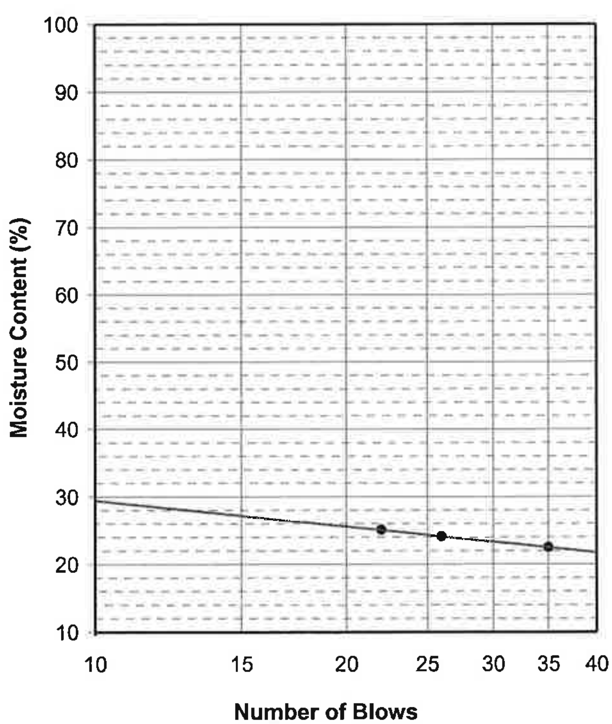
ATTERBERG LIMITS TEST FORM

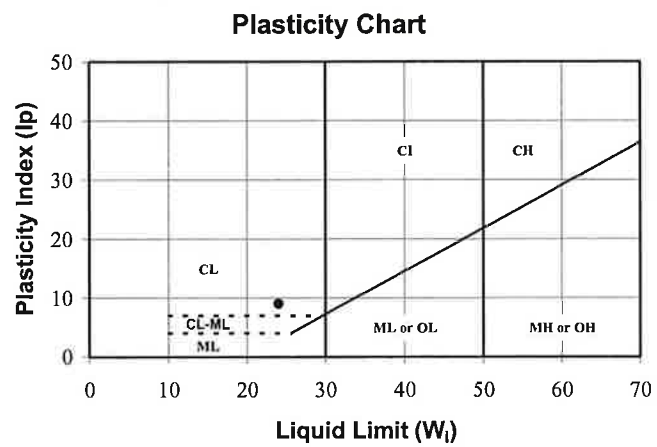
ASTM D4318

Project:	Worley Parsons Material Testing	Sample Number:	L-26
		Borehole Number:	14-1
Project Number:	C12201471	Source:	14-1
Sample Description:	CLAY, silty, sandy, gravelly	Date Sampled:	Sampled By:
		Date Tested: 30-Sep-10	Tested By: JB

Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	20.79	20.68	1225.5
Mass Dry Soil + Tare	20.27	20.14	1125.7
Mass of Tare	16.80	16.57	247.3
Mass of Water	0.52	0.54	99.8
Mass of Dry Soil	3.47	3.57	878.4
Moisture Content (%)	15.0	15.1	11.4

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	35	26	22
Tare Number	c	d	e
Mass Wet Soil + Tare	47.94	43.73	48.34
Mass Dry Soil + Tare	42.19	38.48	42.06
Mass of Tare	16.64	16.73	17.02
Mass of Water	5.75	5.25	6.28
Mass of Dry Soil	25.55	21.75	25.04
Moisture Content (%)	22.5	24.1	25.1





Natural Moisture (%)	11.4
Liquid Limit (%)	24
Plastic Limit (%)	15
PLASTICITY INDEX	**9**

Soil Description: Low Plasticity

Mod.USCS Symbol: **CL**

Remarks:

reviewed by: CPM

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ATTERBERG LIMITS TEST FORM

ASTM D4318

Project: Worley Parsons Material Testing

Project Number: C12201471

Sample Description: CLAY, silty, trace sand

Sample Number: L-27

Borehole Number: 15-1

Source: 15-1

Date Sampled:

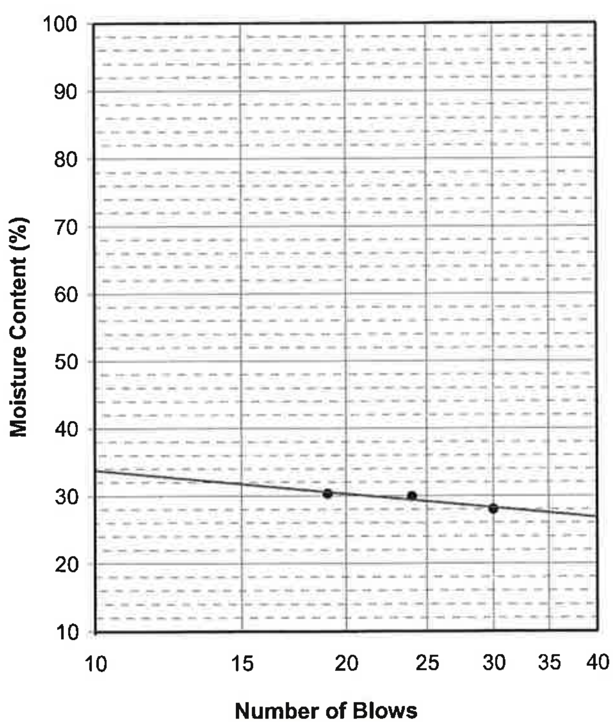
Sampled By:

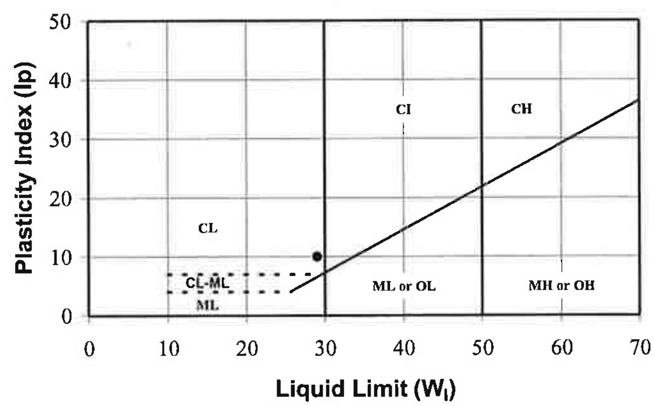
Date Tested: 30-Sep-10

Tested By: JB

Plastic Limit Test			Natural Moisture
Trial Number	1	2	
Tare Number	a	b	
Mass Wet Soil + Tare	19.95	20.00	1365.8
Mass Dry Soil + Tare	19.43	19.47	1141.4
Mass of Tare	16.72	16.79	125.5
Mass of Water	0.52	0.53	224.4
Mass of Dry Soil	2.71	2.68	1015.9
Moisture Content (%)	19.2	19.8	22.1

Liquid Limit Test			
Trial Number	1	2	3
No. of Blows	30	24	19
Tare Number	c	d	e
Mass Wet Soil + Tare	49.01	46.28	45.83
Mass Dry Soil + Tare	42.09	39.51	39.05
Mass of Tare	17.37	16.85	16.68
Mass of Water	6.92	6.77	6.78
Mass of Dry Soil	24.72	22.66	22.37
Moisture Content (%)	28.0	29.9	30.3





Natural Moisture (%)	22.1
Liquid Limit (%)	29
Plastic Limit (%)	19
PLASTICITY INDEX	**10**

Soil Description: Low to Medium Plasticity

Mod.USCS Symbol: **CL - CI**

Remarks:

reviewed by: CM

EBA Engineering Consultants Ltd.

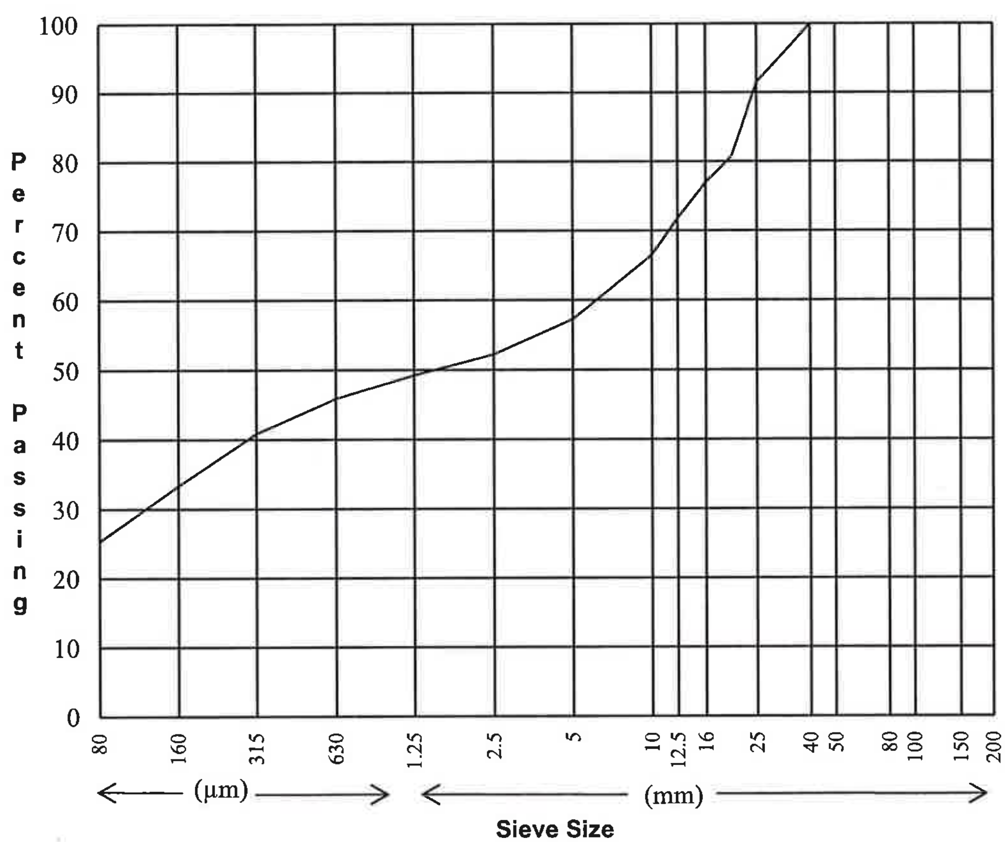
eba

AGGREGATE ANALYSIS TEST REPORT

ASTM C136, C117

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-1
Client:	Worley Parsons Canada Testing Ltd.	Date Sampled:	N/A
Project No.:	C12201471	Sampled By:	By Client
Attention:	Lee Martin	Date Tested:	August 17, 2010
Description:	GRAVEL, sandy, some silt, some clay	Tested By:	JB Lab: Calgary
Source:	1-2	No. Crushed Faces:	
Location:	Eureka, NT	Moisture Content:	5.9%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	
80 mm	
50 mm	
40 mm	100
25 mm	92
20 mm	81
16 mm	77
12.5 mm	72
10 mm	67
5.00 mm	57
2.5 mm	52
1.25 mm	49
630 µm	46
315 µm	41
160 µm	33
80 µm	25.4



Remarks:

Reviewed By: CMcagan P.Eng.

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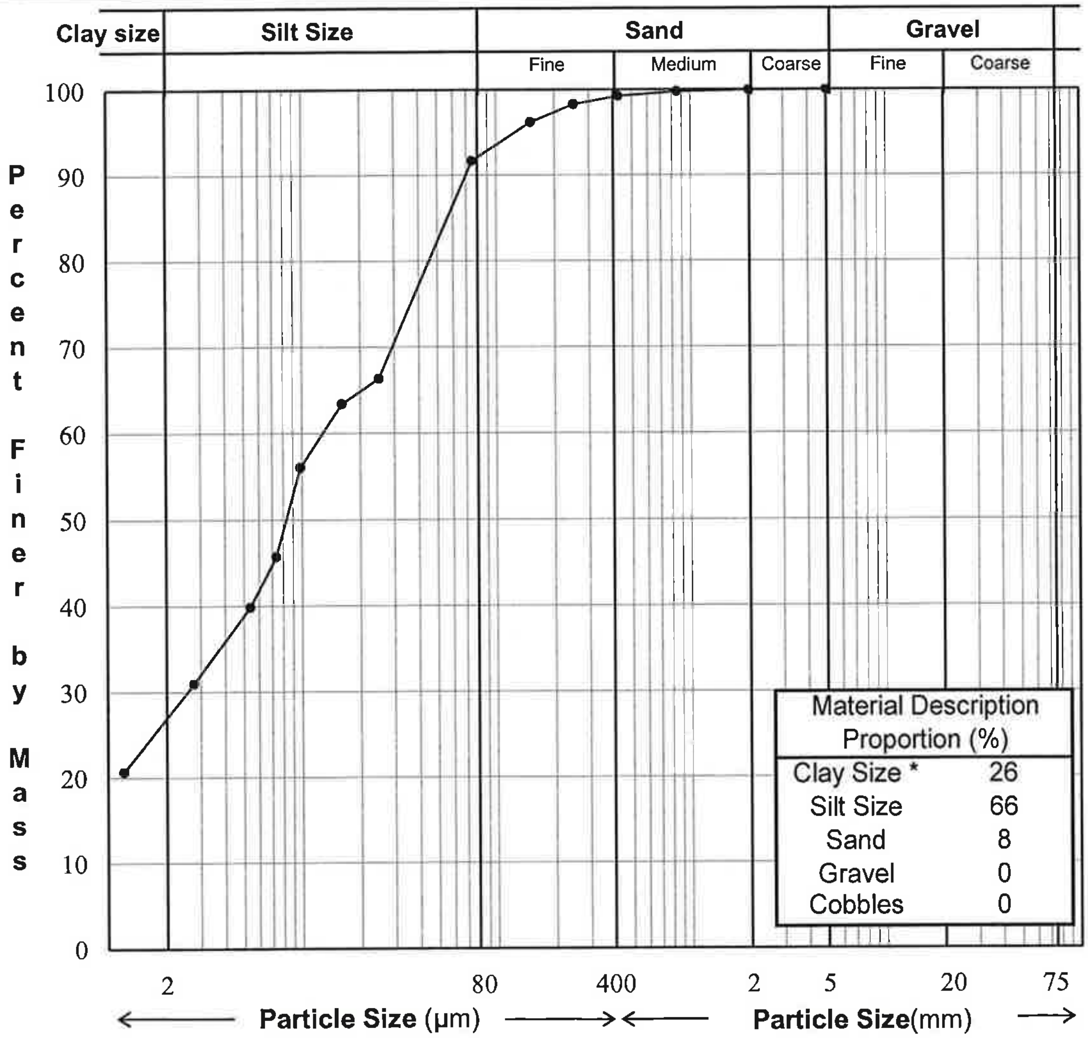
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-2
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	1 - 2
Project No.:	C12201471	Depth:	0.5 m
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	CLAY, silty, trace sand		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	100
2 mm	100
850 μm	100
425 μm	99
250 μm	98
150 μm	96
75 μm	92
25 μm	66
16 μm	63
10 μm	56
7 μm	46
5 μm	40
3 μm	31
1 μm	21



Material Description	Proportion (%)
Clay Size *	26
Silt Size	66
Sand	8
Gravel	0
Cobbles	0

Remarks: * The upper clay size of 2 μm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: ____________________ P.Eng.

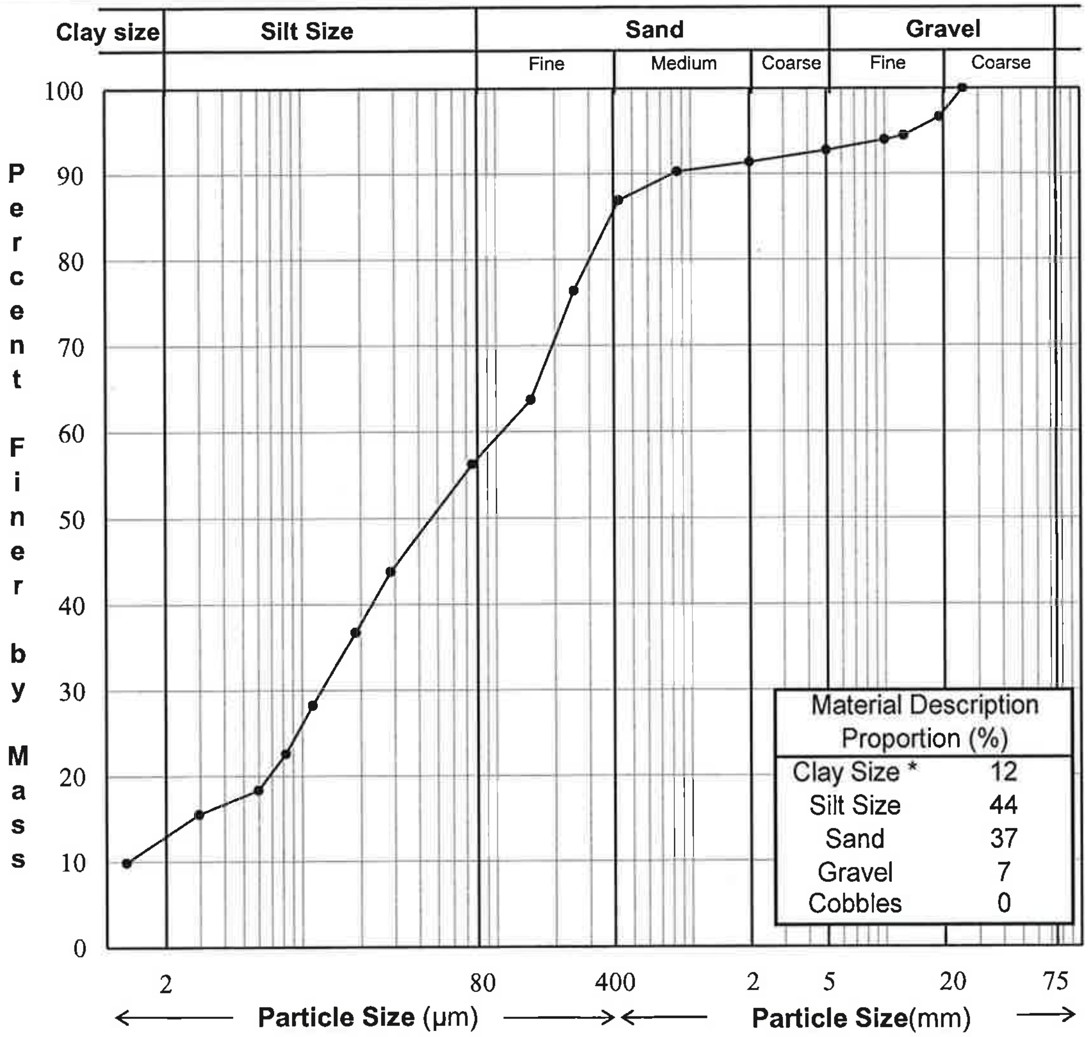
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-8
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	3-2
Project No.:	C12201471	Depth:	0.75 m
Location:	Eureka, NT	Date Tested	September 27, 2010
Description **:	CLAY, silty, sandy, trace gravel		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	100
19 mm	97
13 mm	94
10 mm	94
5 mm	93
2 mm	91
850 μm	90
425 μm	87
250 μm	76
150 μm	64
75 μm	56
29 μm	44
19 μm	37
11 μm	28
8 μm	23
6 μm	18
3 μm	16
1 μm	10



Material Description	Proportion (%)
Clay Size *	12
Silt Size	44
Sand	37
Gravel	7
Cobbles	0

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

Reviewed By: _______________ P.Eng.

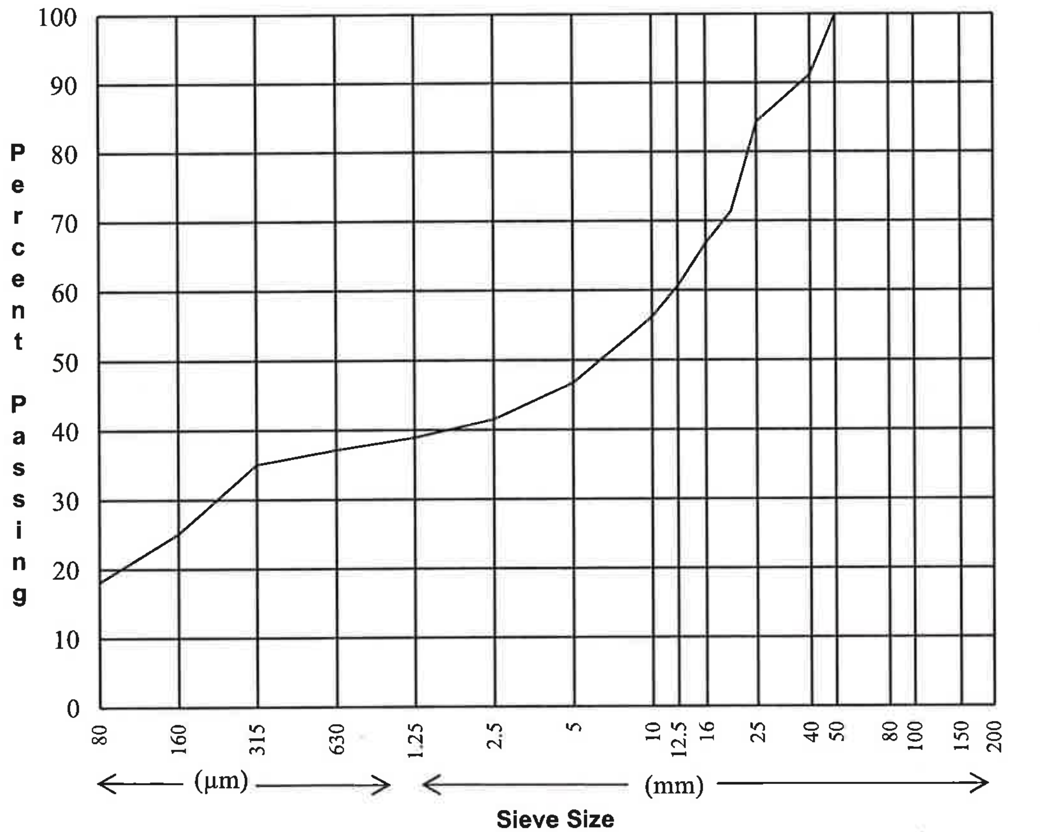
EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS TEST REPORT

ASTM C136, C117

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-9
Client:	Worley Parsons Canada Testing Ltd.	Date Sampled:	N/A
Project No.:	C12201471	Sampled By:	By Client
Attention:	Lee Martin	Date Tested:	September 27, 2010
Description:	GRAVEL, sandy, some silt, some clay	Tested By: JB	Lab: Calgary
Source:	4-1	No. Crushed Faces:	
Location:	Eureka, NT	Moisture Content:	3.9%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	
80 mm	
50 mm	100
40 mm	91
25 mm	84
20 mm	71
16 mm	67
12.5 mm	61
10 mm	56
5.00 mm	47
2.5 mm	42
1.25 mm	39
630 µm	37
315 µm	35
160 µm	25
80 µm	18.1



Remarks:

Reviewed By: CPMagan P.Eng.

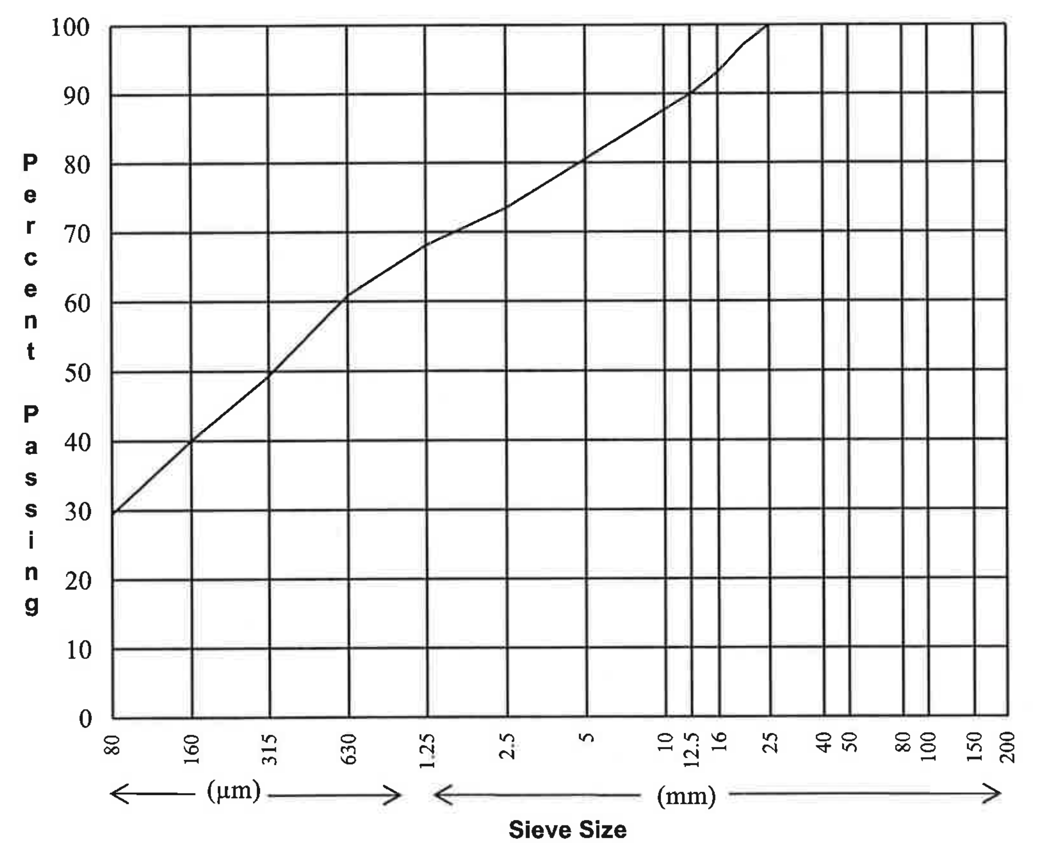
EBA Engineering Consultants Ltd.

AGGREGATE ANALYSIS TEST REPORT

ASTM C136, C117

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-13
Client:	Worley Parsons Canada Testing Ltd.	Date Sampled:	N/A
Project No.:	C12201471	Sampled By:	By Client
Attention:	Lee Martin	Date Tested:	September 27, 2010
Description:	SAND, some gravel, some silt, some clay	Tested By:	JB Lab: Calgary
Source:	6-1	No. Crushed Faces:	
Location:	Eureka, NT	Moisture Content:	3.8%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	
80 mm	
50 mm	
40 mm	
25 mm	100
20 mm	97
16 mm	93
12.5 mm	90
10 mm	88
5.00 mm	81
2.5 mm	73
1.25 mm	68
630 µm	61
315 µm	49
160 µm	40
80 µm	29.5



Remarks:

Reviewed By: [signature] P.Eng.

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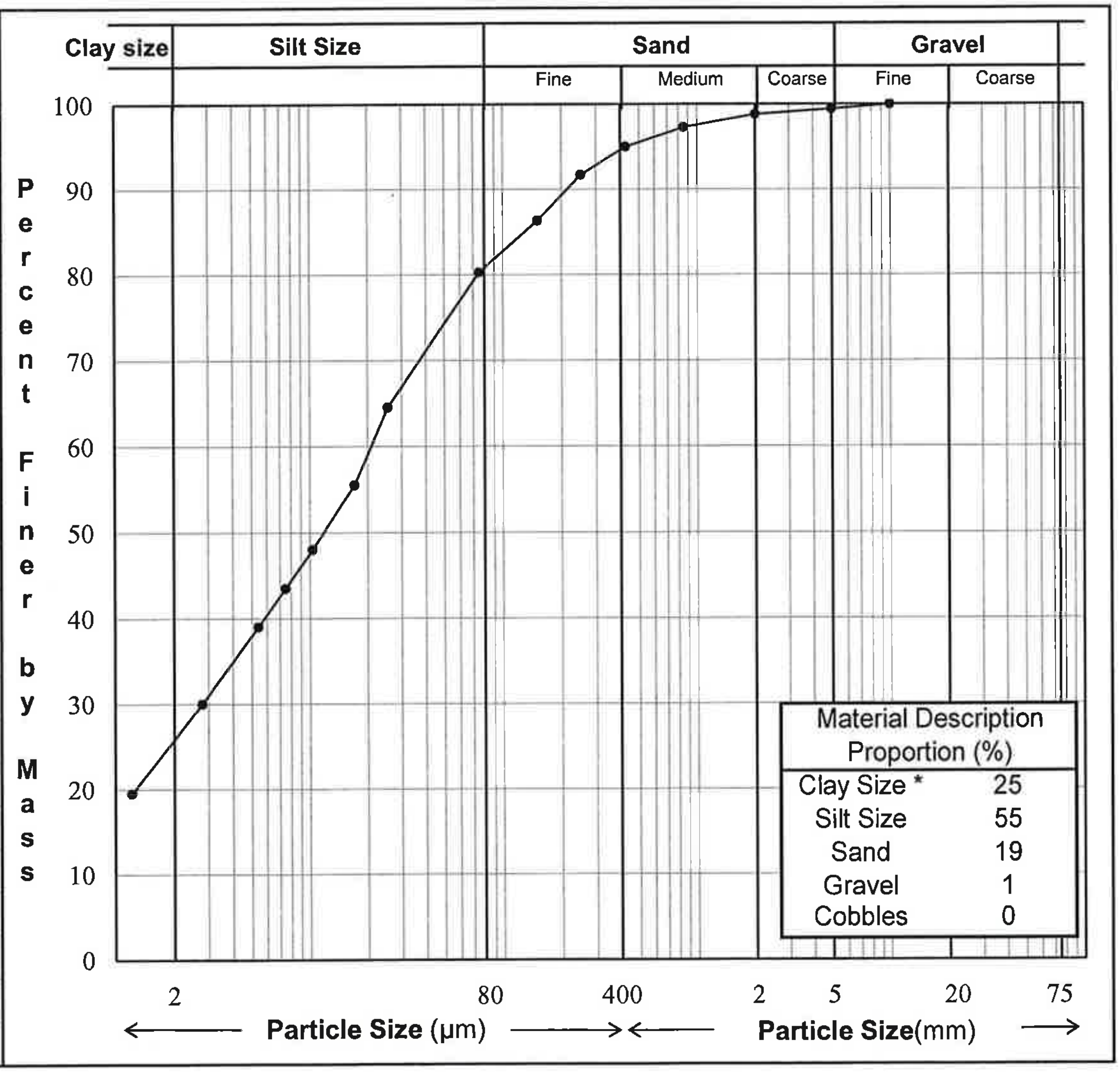
PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-14
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	6 - 2
Project No.:	C12201471	Depth:	1.0 m
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	CLAY, silty, some sand, trace gravel (organic soil)		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	100
5 mm	99
2 mm	99
850 µm	97
425 µm	95
250 µm	92
150 µm	86
75 µm	80
25 µm	65
17 µm	56
10 µm	48
7 µm	44
5 µm	39
3 µm	30
1 µm	20



Material Description	Proportion (%)
Clay Size *	25
Silt Size	55
Sand	19
Gravel	1
Cobbles	0

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

Reviewed By: ______________ P.Eng.

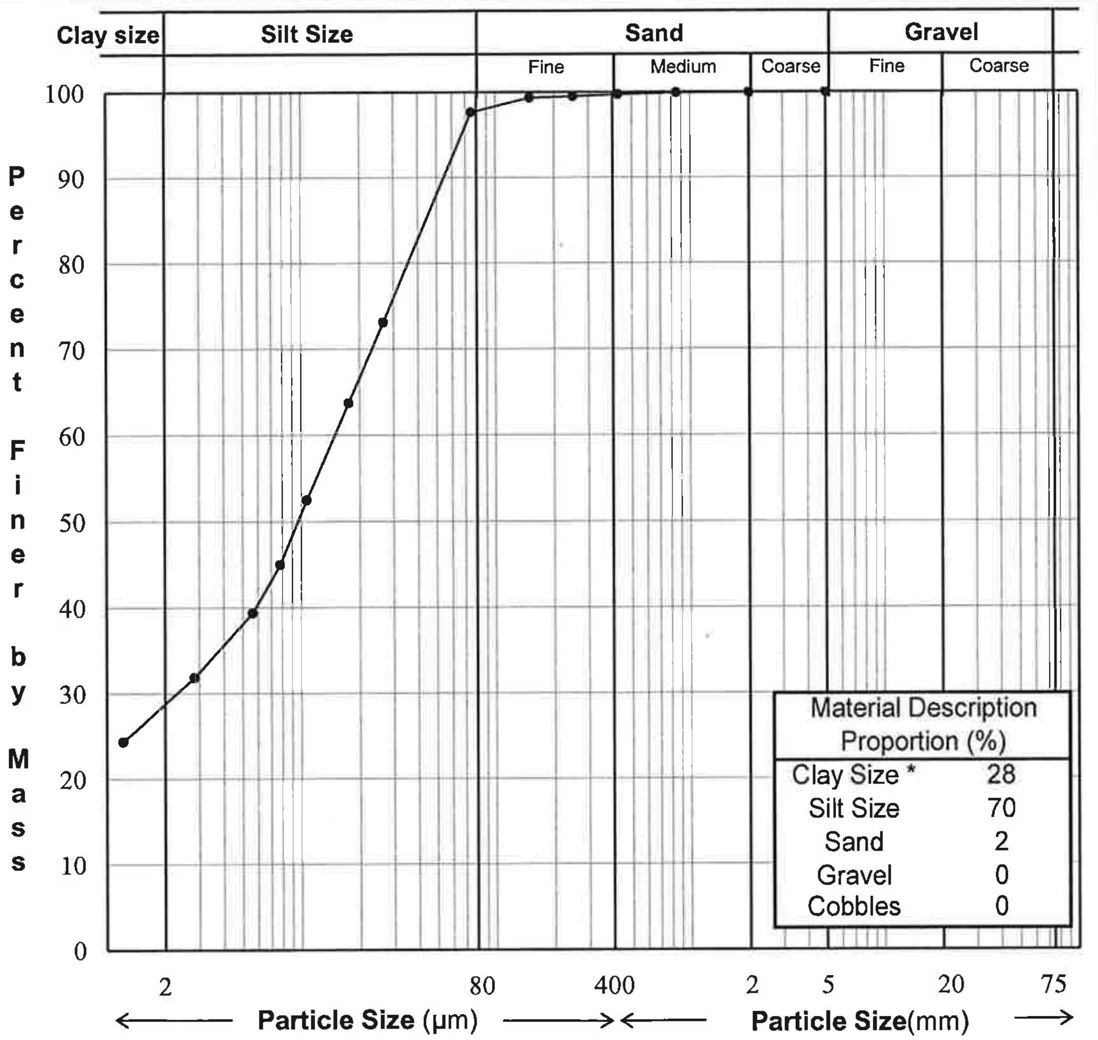
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-18
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	8-2
Project No.:	C12201471	Depth:	1.5 m
Location:	Eureka, NT	Date Tested	September 27, 2010
Description **:	CLAY, silty, trace sand		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	100
2 mm	100
850 μm	100
425 μm	100
250 μm	100
150 μm	99
75 μm	98
27 μm	73
18 μm	64
11 μm	52
8 μm	45
6 μm	39
3 μm	32
1 μm	24



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

Reviewed By: [signature] P.Eng.

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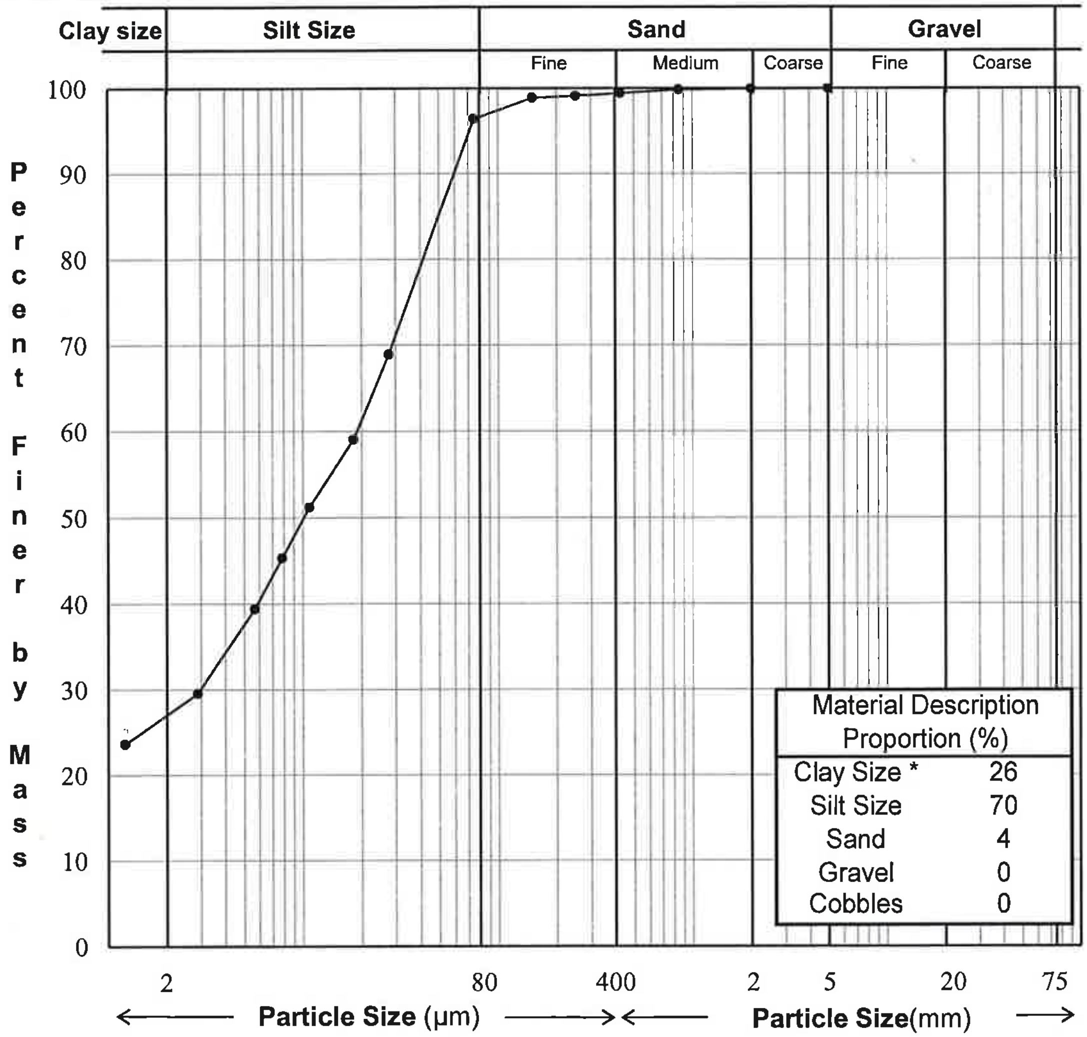
PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-20
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	9-2
Project No.:	C12201471	Depth:	
Location:	Eureka, NT	Date Tested	September 27, 2010
Description **:	CLAY, silty, trace sand		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	100
2 mm	100
850 μm	100
425 μm	99
250 μm	99
150 μm	99
75 μm	96
28 μm	69
18 μm	59
11 μm	51
8 μm	45
6 μm	39
3 μm	30
1 μm	24



Material Description	Proportion (%)
Clay Size *	26
Silt Size	70
Sand	4
Gravel	0
Cobbles	0

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

Reviewed By: ____________ P.Eng.

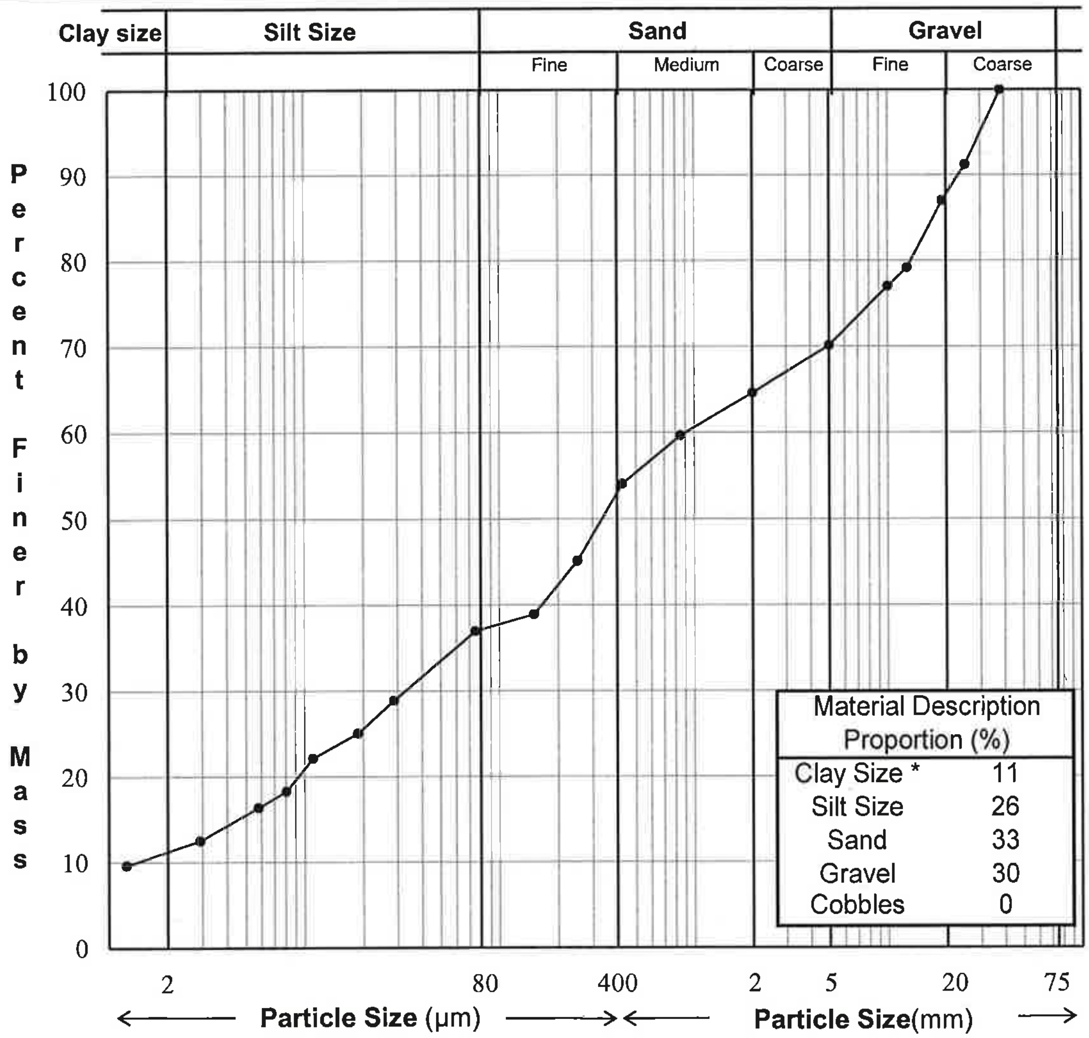
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-26
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	14 - 1
Project No.:	C12201471	Depth:	0.5 m
Location:	Eureka, NT	Date Tested	September 30, 2010
Description **:	CLAY, silty, sandy, gravelly		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	100
25 mm	91
19 mm	87
13 mm	79
10 mm	77
5 mm	70
2 mm	65
850 μm	60
425 μm	54
250 μm	45
150 μm	39
75 μm	37
29 μm	29
19 μm	25
11 μm	22
8 μm	18
6 μm	16
3 μm	13
1 μm	10



Material Description	Proportion (%)
Clay Size *	11
Silt Size	26
Sand	33
Gravel	30
Cobbles	0

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

Reviewed By: ______________ P.Eng.

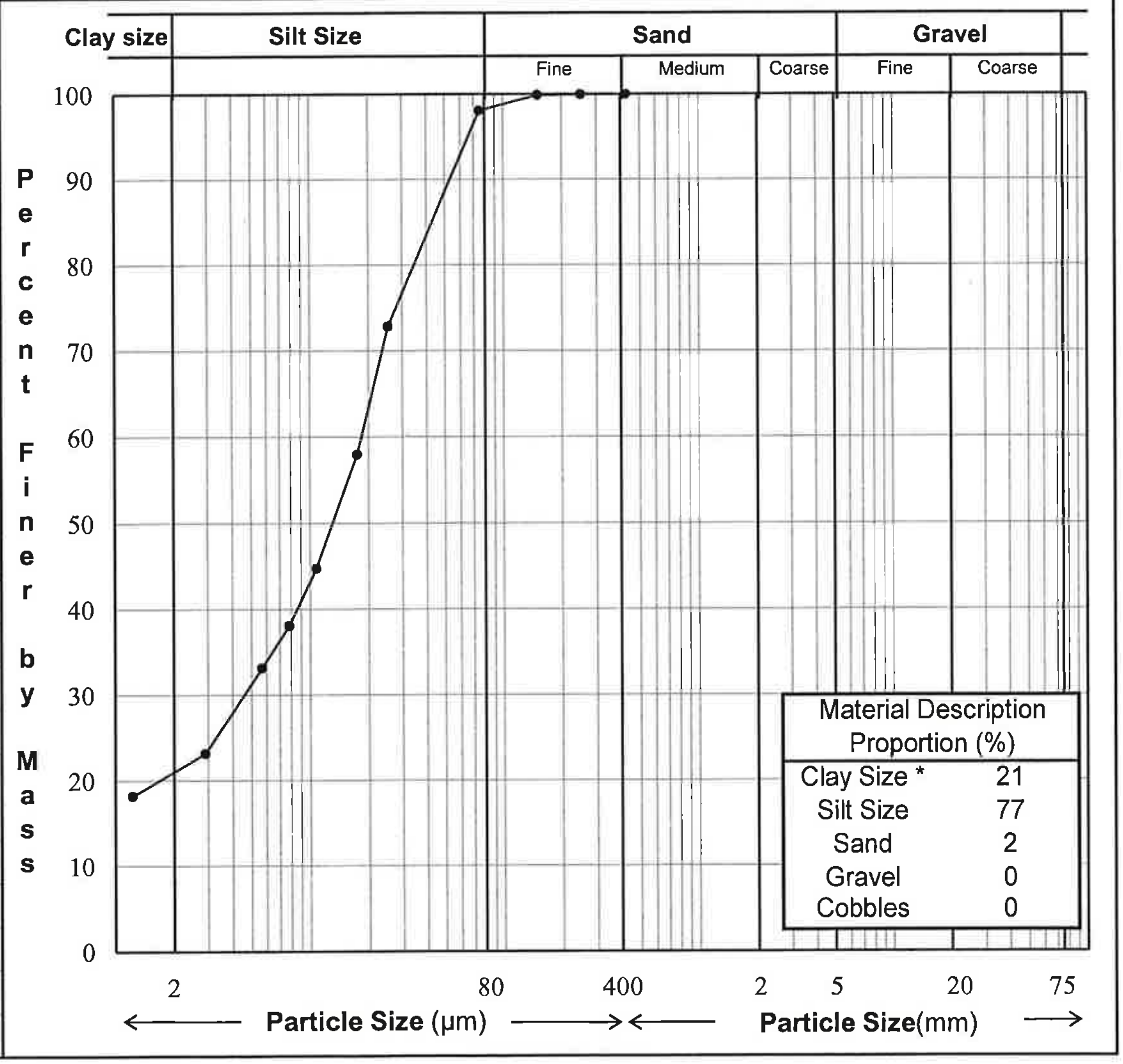
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-27
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	15 - 1
Project No.:	C12201471	Depth:	1.0 m
Location:	Eureka, NT	Date Tested	September 30, 2010
Description **:	CLAY, silty, trace sand		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	
850 μm	
425 μm	100
250 μm	100
150 μm	100
75 μm	98
25 μm	73
17 μm	58
11 μm	45
8 μm	38
6 μm	33
3 μm	23
1 μm	18



Material Description	Proportion (%)
Clay Size *	21
Silt Size	77
Sand	2
Gravel	0
Cobbles	0

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

Reviewed By: ______ P.Eng.

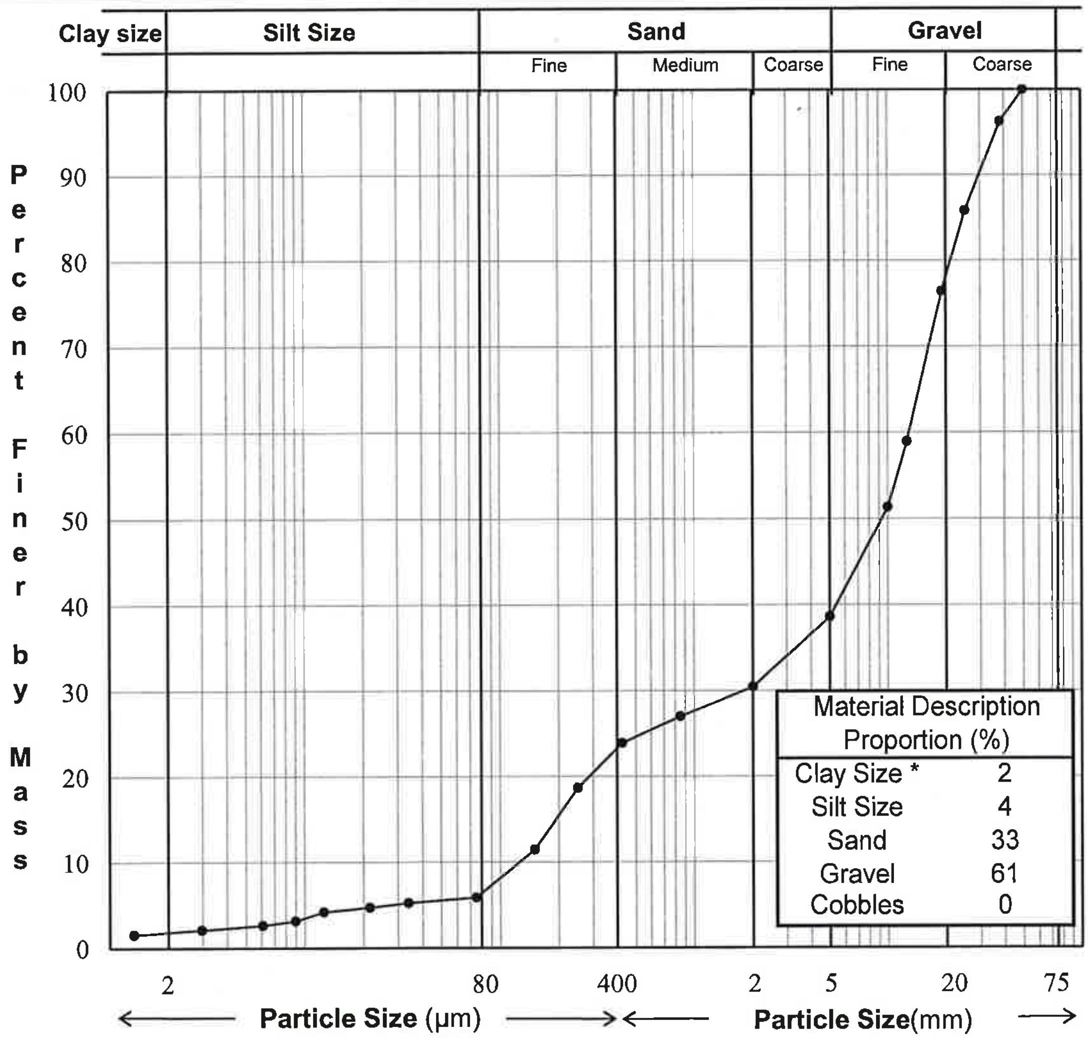
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-29
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	Bulk 2
Project No.:	C12201471	Depth:	Pier
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	Gravel, sandy, trace silt, trace clay		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	100
38 mm	96
25 mm	86
19 mm	76
13 mm	59
10 mm	51
5 mm	39
2 mm	30
850 µm	27
425 µm	24
250 µm	19
150 µm	11
75 µm	6
34 µm	5
22 µm	5
13 µm	4
9 µm	3
6 µm	3
3 µm	2
1 µm	2



Material Description	Proportion (%)
Clay Size *	2
Silt Size	4
Sand	33
Gravel	61
Cobbles	0

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

Reviewed By: ______________ P.Eng.

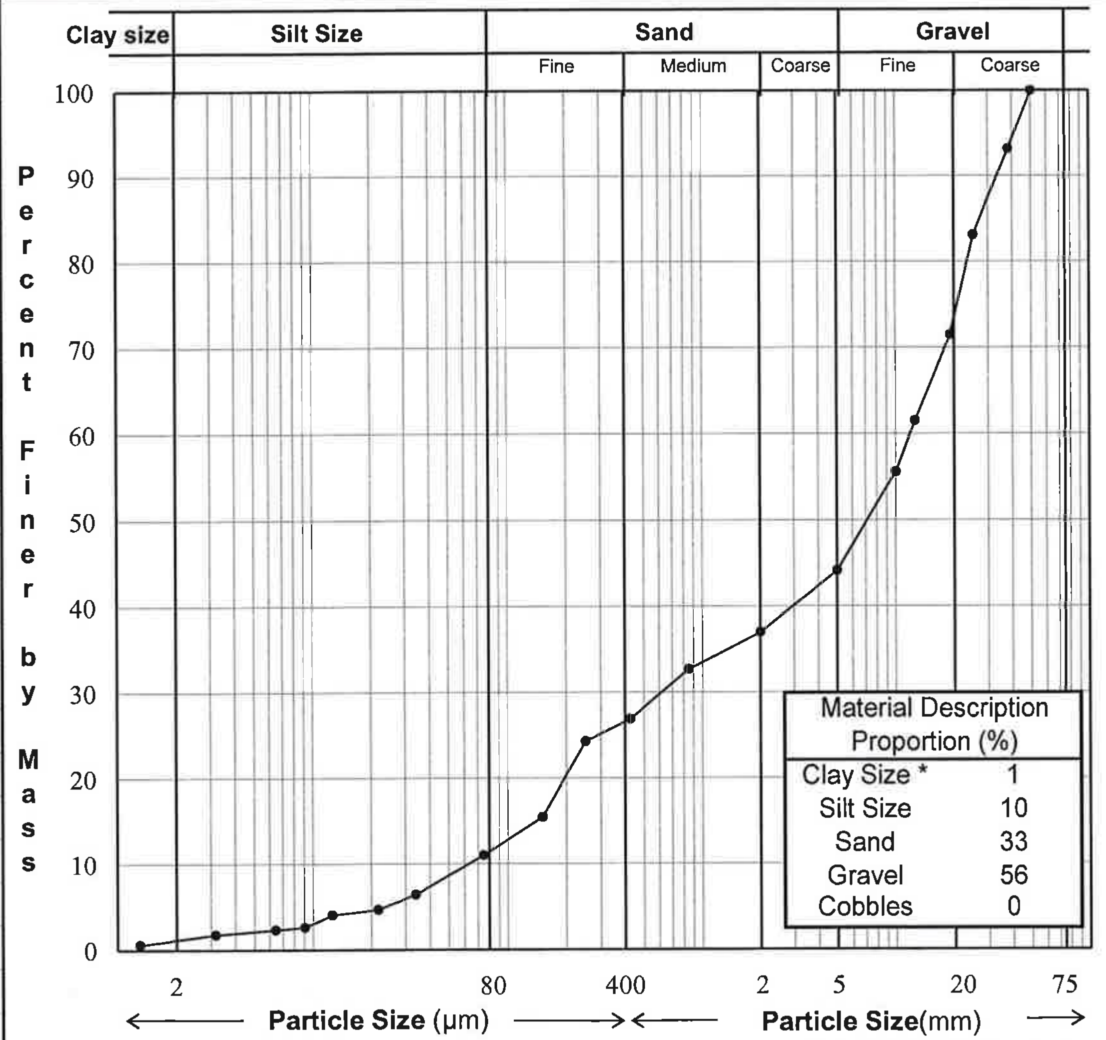
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-30
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	Bulk 3
Project No.:	C12201471	Depth:	Sandstone
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	Gravel, sandy, some silt, trace clay		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	100
38 mm	93
25 mm	83
19 mm	71
13 mm	62
10 mm	56
5 mm	44
2 mm	37
850 μm	33
425 μm	27
250 μm	24
150 μm	15
75 μm	11
34 μm	6
22 μm	5
13 μm	4
9 μm	3
6 μm	2
3 μm	2
1 μm	1



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

Reviewed By: ______________ P.Eng.

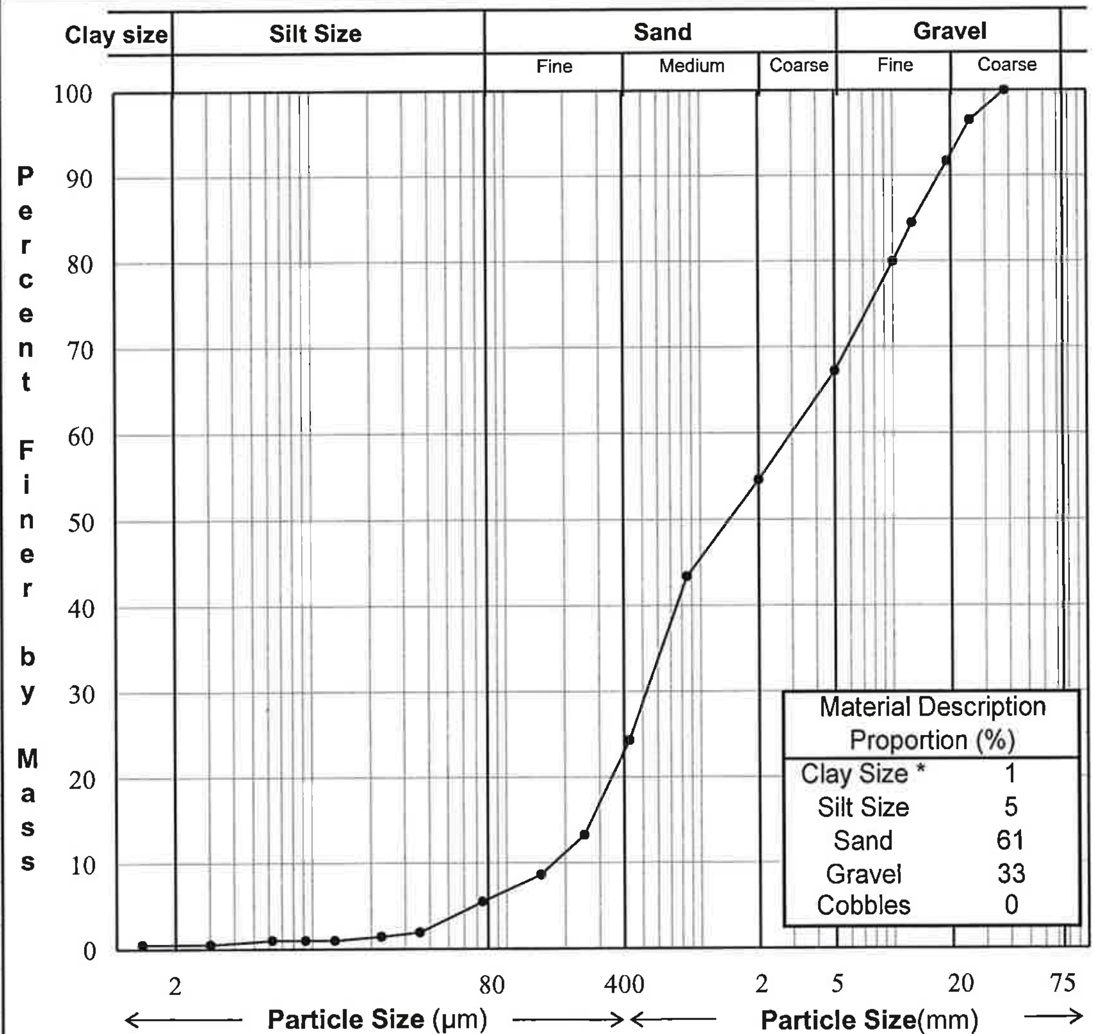
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-31
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	Bulk 4
Project No.:	C12201471	Depth:	Blacktop Cr.
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	SAND, gravelly, trace silt, trace clay		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	100
25 mm	96
19 mm	92
13 mm	84
10 mm	80
5 mm	67
2 mm	55
850 μm	43
425 μm	24
250 μm	13
150 μm	9
75 μm	5
36 μm	2
23 μm	1
13 μm	1
9 μm	1
6 μm	1
3 μm	0
1 μm	0



Material Description	Proportion (%)
Clay Size *	1
Silt Size	5
Sand	61
Gravel	33
Cobbles	0

Remarks: * The upper clay size of 2 μm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: _______________ P.Eng.

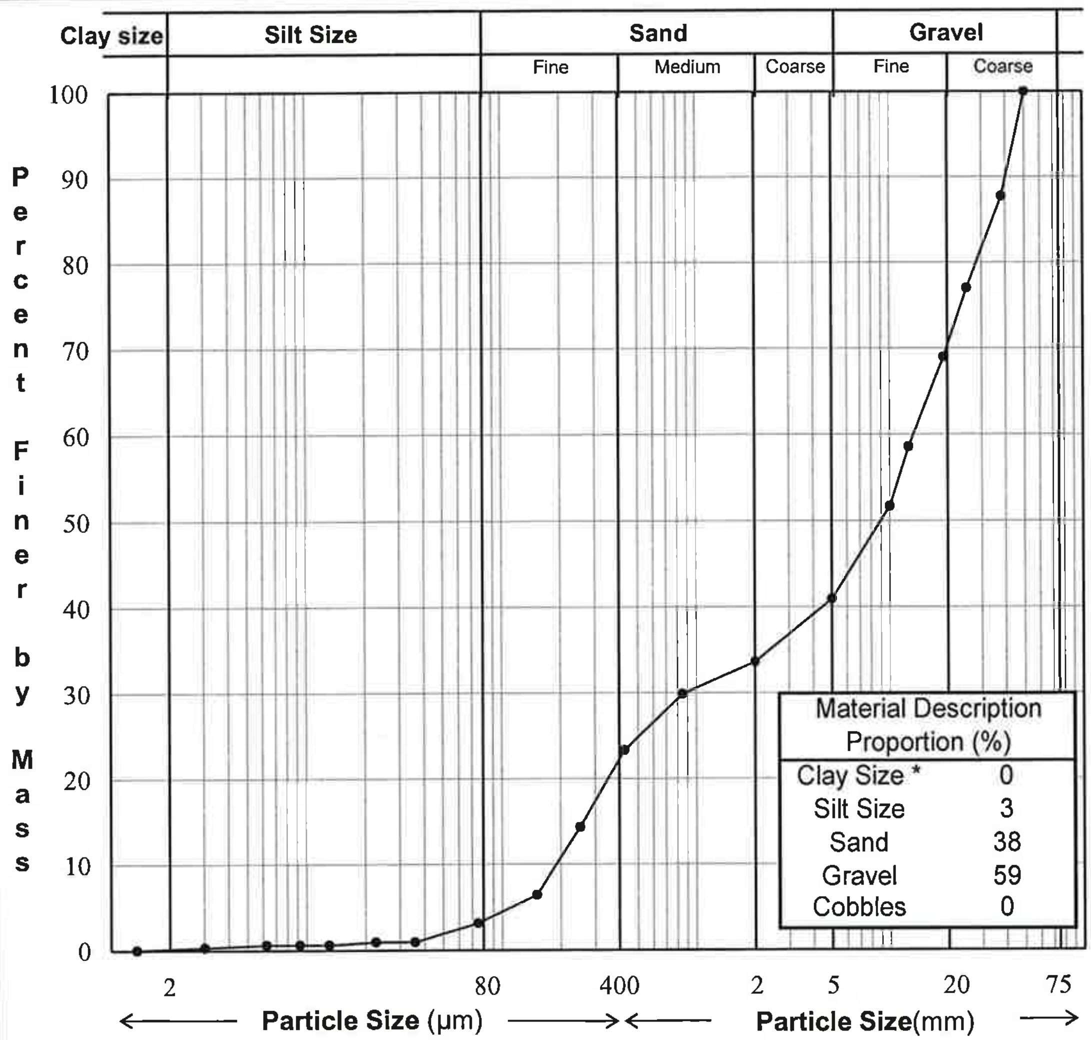
EBA Engineering Consultants Ltd.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Worley Parsons Material Testing - 2010	Sample No.:	L-32
Client:	Worley Parsons Canada Services Ltd.	Borehole/ TP:	Bulk 6
Project No.:	C12201471	Depth:	Remus Cr.
Location:	Eureka, NT	Date Tested	September 14, 2010
Description **:	GRAVEL, sandy, trace silt		

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	100
38 mm	88
25 mm	77
19 mm	69
13 mm	59
10 mm	52
5 mm	41
2 mm	34
850 μm	30
425 μm	23
250 μm	14
150 μm	6
75 μm	3
36 μm	1
23 μm	1
13 μm	1
9 μm	1
6 μm	1
3 μm	0
1 μm	0



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

Reviewed By: ______________ P.Eng.

EBA Engineering Consultants Ltd.

PERCENTAGE OF FLAT & ELONGATED PARTICLES

ASTM D 4791 - 05

Project No: C12201471 **Sample No.:** L-31
Project: Worley Parsons Material Testing - 2010 **Date Sampled:** N/A
Client: Worley Parsons Canada Ltd. **Sampled By:** Client
Date Tested: 22-Sep-10
Attention: Lee Martin **Fax:** **Tested By:** JB
Email: Lee.Martin@WorleyParsons.Com **Ph:** 403.247.5733 **Office:** Calgary

Description: SAND, gravelly, trace silt, trace clay
Source: Bulk 4
Sample Location: Eureka, NT
Supplier: Worley Parsons Canada Ltd.

Flat: Ratio of width to thickness greater than 4
Elongated: Ratio of length to width greater than 4

Sample No.	Size Fraction (mm)		Proportion of Sample in Size Fraction (%)	Percentage by mass of sample (%)			
				flat	elongated	flat and elongated	neither flat nor elongated
L-31	50.0	37.5	4.0				
	37.5	25.0	4.0				
	25.0	19.0	8.0	0.0	0.0	5.2	94.8
	19.0	12.5	4.0	5.2	0.0	23.9	70.9
	12.5	9.5	13.0	9.5	0.0	16.2	74.3
	9.5	4.75	12.0				

Weighted Average (9.5 mm retained)* **26.7%** **4:1 Ratio**

* Size fractions which have not been analysed are not included for the calculation

Remarks:

Reviewed By: _______________ P. Eng.

EBA Engineering Consultants Ltd.

PERCENTAGE OF FLAT & ELONGATED PARTICLES

ASTM D 4791 - 05

Project No: C12201471
Project: Worley Parsons Material Testing - 2010
Client: Worley Parsons Canada Ltd.

Attention: Lee Martin **Fax:**
Email: Lee.Martin@WorleyParsons.Com **Ph:** 403.247.5733

Sample No.: L-32
Date Sampled: N/A
Sampled By: Client
Date Tested: 22-Sep-10
Tested By: JB
Office: Calgary

Description: GRAVEL, sandy, trace silt
Source: Bulk 6
Sample Location: Eureka, NT
Supplier: Worley Parsons Canada Ltd.

Flat: Ratio of width to thickness greater than 4
Elongated: Ratio of length to width greater than 4

Sample No.	Size Fraction (mm)		Proportion of Sample in Size Fraction (%)	Percentage by mass of sample (%)			
				flat	elongated	flat and elongated	neither flat nor elongated
L-32	50.0	37.5	12.0				
	37.5	25.0	11.0	7.8	0.0	0.0	92.2
	25.0	19.0	8.0	17.7	0.0	4.4	78.0
	19.0	12.5	10.0	5.2	0.0	19.0	75.8
	12.5	9.5	7.0	11.9	0.0	16.7	71.4
	9.5	4.75	11.0				

Weighted Average (9.5 mm retained)* 14.9% **4:1 Ratio**

* Size fractions which have not been analysed are not included for the calculation

Remarks:

Reviewed By: CMa[signature] P. Eng.

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