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Geotechnical Investigation

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FINAL VERSION



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1 Introduction

Englobe Corp., at your request, has carried out a geotechnical investigation at the site of a proposed development at the Bedford Institute of Oceanography (BIO) in Dartmouth, Nova Scotia. The purpose of the work was to identify the subsurface soil and bedrock conditions at the site and make geotechnical recommendations regarding earthworks and foundation design.

This report presents our observations and preliminary engineering recommendations associated with the geotechnical investigation of the site. Included herein are the factual results of the field investigation including discussion of field procedures, subsurface conditions, laboratory analysis and recommendations for site development.

2 Site and Project Description

It is understood that the existing Fish Lab building at the BIO in Dartmouth, Nova Scotia will be renovated and/or expanded. Detailed design of the structure has not been undertaken to date, however, preliminary indication is that the structure(s)/renovations will be of conventional design and supported by a shallow foundation system or driven piles to bedrock. Founded conditions for current Fish Lab are currently unknown.

3 Investigation Procedure

Fieldwork for the current investigation was carried out from October 19 to 22, 2020, when four (4) boreholes were drilled at the locations shown on the enclosed Figure 1. The borehole investigation was carried out using a truck mounted drill rig supplied by Nova Drilling from Mount Uniacke, NS.

The investigation was carried out by qualified field engineering personnel who logged the subsurface conditions. The boreholes were advanced using continuous flight augers and casing with field sampling and testing performed in the open boreholes. Standard Penetration Tests (SPT) were carried out at regular intervals in select boreholes to obtain soil blow counts (i.e. N-values) using a 50-mm O.D. split spoon sampler. Disturbed soil samples were obtained from the boreholes using conventional techniques. Bedrock was drilled and sampled in select boreholes using HQ-sized (i.e. 63.5 mm dia.) coring equipment.

Following field sampling and visual description, overburden samples were placed in sample jars and rock cores placed in core boxes and transported to our Dartmouth laboratory for further examination and scheduling for geotechnical index testing.

Please note that the interior borehole was not completed due to space restrictions for drilling equipment and coarse nature of the insitu soils.

4 Subsurface Conditions

An explanation of terms and symbols used in the report is provided in Appendix A. A summary of the encountered geologic conditions is provided in the Borehole Logs in Appendix B.

It should be noted that the stratigraphic boundaries on the Borehole Logs typically represent a transition of one soil type to another and do not necessarily indicate an exact plane of geologic change. Subsurface conditions may vary between and beyond the borehole locations.

Due to coarse nature (i.e. boulder/cobble content) of the fill deposits and glacial till, split spoon sample recovery was consistently low. Given the low soil recovery, the transition depth from fill deposits to native till was difficult to identify.

In summary, asphalt pavement was encountered overlying fill materials, undisturbed glacial till and quartzite/greywacke bedrock. The following table (Table 1) summarizes the subsurface conditions.

Table 1: Summary of Subsurface Conditions

LOCATION	DEPTH TO GROUNDWATER (METRES)	DEPTH TO TILL (METRES)	DEPTH TO BEDROCK (METRES)
BH 1	-- 1.	3.0	4.7
BH 2	-- 1.	5.8	10.5
BH 3	-- 1.	3.7	6.7
BH 4	-- 1.	3.0	7.0

1. Groundwater depth not observed due to water injection for coring process

4.1 Asphalt Pavement

A layer of asphalt pavement was encountered at the surface of all borehole locations. The asphalt pavement was approximately 75 mm in thickness on average.

4.2 Fill

Fill was encountered in all boreholes beneath the asphalt pavement. The fill generally varied from gravels, gravelly sand some silt to sand and gravel, some silt. The fill contained occasional to some cobbles and boulders. Observations of the in situ deposits indicated that the material was grey to brown in colour and its moisture content was described as moist to saturated. Representative standard penetration N values recorded for the fill material ranged from 15 to greater than 50 blows per 300 mm, indicating a compact to loose material. The higher N-values recorded are due mainly to cobble and boulder content in the fill interfering with the test and not necessarily representative of *insitu* relative density. The fill was proven to a total depth of 5.8 metres at borehole BH 2.

Laboratory gradation testing was completed on a select fill sample, and indicated a material with 39 percent gravel, 42 percent sand, and a fines (i.e. silt and clay sizes) content of 19 percent. Moisture content testing provided values ranging from 4.3 to 8.2 percent.

4.3 Sand

A site-native sand deposit was encountered below the fill deposits at borehole BH 1. These soils are described as sand, trace to some silt, and trace gravel. Representative standard penetration N values recorded for the sand material were in excess of 50 blows per 300 mm, indicating a very dense material. Observations of the in situ deposits indicated that the material was brown to grey in colour and its moisture content was described as saturated. The sand deposit was proven to a total depth of 3.0 metres at borehole BH 1.

4.4 Glacial Till

Site-native glacial till deposits were encountered below the fill and sand deposits at all boreholes. These typically compact soils are described in the Borehole Logs in Appendix B as gravelly sand, some silt, trace clay to sand and gravel, some silt. The till contained occasional to some cobbles and boulders. Observations of the in situ deposits indicated that the material was light brown to grey in colour and its moisture content was described as wet to saturated. Representative standard penetration N values recorded for the till material were in excess of 50 blows per 300 mm, indicating a very dense material. The higher N-values recorded are due mainly to cobble and boulder content in the fill interfering with the test and not necessarily representative of insitu relative density. The till was proven to a total depth of 10.5 metres below the existing ground surface at borehole BH 2.

Laboratory gradation testing was completed on a select till sample, and indicated a material with 36 percent gravel, 39 percent sand, and a fines (i.e. silt and clay sizes) content of 25 percent. Moisture content testing provided values of 9.2 and 10.3 percent.

4.5 Bedrock

Bedrock geology mapping of the area indicates that the site is underlain by the Meguma Group of metasediments. Specifically, the Goldenville Formation which consists of greywacke, quartzite, slate, schist and gneiss underlies the area.

Bedrock was encountered in all boreholes. Examination of bedrock core samples obtained indicates that the site is underlain by quartzite/greywacke. The bedrock has been observed to be highly fractured and weathered and grey in colour. The Rock Quality Designation (RQD) values of core samples ranged from 0% to 54%, indicating a very poor to fair quality rock.

4.6 Groundwater

Groundwater observations were made during the field investigation through open-hole measurement at the test locations. A summary of the accumulated groundwater information is provided on the Borehole Logs in Appendix B.

During the current site investigation, groundwater was not observed during the drilling process in the boreholes due to water injection for the coring process. Perched groundwater should be expected during construction. Seasonal variations in groundwater levels can be expected. Moderate to deep excavations at the site will likely be influenced by tidal influence.

5 Discussion and Recommendations for Design

5.1 Site Development - General

In the following paragraphs, a discussion of site development is presented in light of the observed subsurface conditions. The recommendations outlined in the following sections assume that the structure(s) and renovations will be located generally in the area(s) investigated, as shown in Figure 1. Currently, it is understood that the new structure(s) will be of conventional design and will be carried by a foundation system of spread and strip footings or driven steel piles to bedrock. Current recommendations are based on preliminary information currently available for the project. Once final design drawings are available for the site, a review of our report should be conducted.

The subsurface conditions encountered throughout the development area are relatively uniform and consist of either asphalt pavement or gravels overlying fill deposits, “undisturbed” glacial soils and bedrock.

5.2 Site Preparation, Excavation and Earthworks – Shallow Foundations

To prepare the immediate building areas to receive foundations/slabs, it will be necessary to remove all fill materials, wet/loose soils and organics from beneath foundation and slab bearing areas. This material should be subexcavated to the level of competent soil (i.e. material noted on the Borehole Logs as Bedrock or Glacial Till).

Following this initial subexcavation, geotechnical evaluation of the exposed subgrade is recommended to identify any loose or soft areas. Any such areas identified should be subexcavated and replaced with an approved structural fill.

Contingent upon final design grades, a filling program to reach desired floor and foundation subgrade levels may be necessary. This would likely include reuse of select on-site fill materials. Processing of site materials to remove organics and oversized particles will be

required to create a suitable product for reuse as structural fill. Depending on final design grades, filling may require importation of an approved structural fill to compensate for deficient quantities. The reuse of on-site materials will be contingent to a large extent on the condition of the materials after excavation, handling and stockpiling. Re-use of the on-site soils would be subject to their condition at time of earthworks.

Imported structural fill should consist of well-graded sand and gravel, or rockfill with a maximum particle size of 200 mm diameter. The fill is to be free of organics, debris, and slate and should have a fines (i.e. silt and clay sized) content not greater than 15 percent. Structural fill should be placed in lifts not exceeding 300 mm in thickness compacted to 100 percent of the material's standard Proctor maximum dry density or equivalent for rockfill. Water and loose/soft soils should be removed from excavations, and bearing stratum approved prior to fill placement. Quality control inspection and testing of engineered fill is recommended.

Please note that excavations below tidal levels will likely be difficult to maintain a dry excavation due to the coarse nature of the site soils and proximity of the adjacent harbour.

Temporary excavations in soil extending in depth greater than 1.2 m should be sloped at a minimum one horizontal to one vertical (1H:1V). Flatter side slopes may be required for stability of the excavation due to surface or groundwater infiltration, or soil condition.

5.3 Re-use of On-site Materials and Backfilling

Select portions of the fill deposits and glacial till would be considered suitable for reuse at the site as common material or, in some applications, as engineered fill. The reuse of on-site materials will be contingent on the condition of the materials after excavation, handling and stockpiling. Organic soils and wet soils are not suitable for structural fill; these soils should only be used in non-settlement sensitive areas of the site.

To qualify as engineered backfill, all boulders, debris and deleterious inclusions should be removed. Backfill should be placed in lifts and compacted using appropriate compaction equipment. Lift thickness should be limited to 400 mm using large vibratory rollers, and 250 mm using hand equipment (e.g. diesel plate tampers). The maximum particle size should be limited to 2/3 of the lift thickness.

Backfill against structures should be compacted to 95% of Standard Proctor Density.

5.4 Shallow Foundation Design

For design of foundations by Limit States Design, the factored bearing resistance (using a bearing resistance factor of 0.5) of strip footings with a minimum width of 0.6 metres and spread footings with a minimum width of 1.2 metres are as follows:

Table 2: Limit States Design Parameters

LIMIT STATES DESIGN PARAMETER	GLACIAL TILL / STRUCTURAL FILL	FRACTURED BEDROCK
Factored Geotechnical Resistance at Ultimate Limit States (ULS)	300 kPa	500 kPa
Geotechnical Resistance at Serviceability Limit States (SLS)	200 kPa	

The effect of site conditions on seismic response should be considered in the design of foundations. Based on the subsurface soil conditions encountered in the test locations, the site may be considered as Class C for seismic site response (NBCC 2015 Table 4.1.8.4.A).

5.5 Deep Foundation Design

Piled foundations may be considered as a foundation design for support of the new development. Driven steel piles may consist of 'H' type piles. These piles may be driven to practical refusal within the bedrock encountered at depths of between 4.7 and 10.5 metres below existing grade at the borehole locations.

Piles may be designed using a factored ULS geotechnical axial compressive resistance of 60 MPa based on the cross-sectional area of the steel pile. This includes a resistance factor of 0.4. Settlement of piles driven to refusal within bedrock are expected to be negligible.

Load carrying capacity for typical 'H' type steel piles for typical end bearing piles in bedrock are given below. The pile type and size chosen for design will be influenced by several factors such as the structural loads carried by the foundation, the availability of the pile type/size and the pile driving equipment.

The pile capacities given below are based on the proposed pile size and anticipated site conditions. Final pile capacities are a function of pile size, penetration depth, resistance criteria, site grading requirements, etc. For preliminary design of piles driven to a suitable depth end-bearing in the bedrock, the calculated ULS load capacity (with applied resistance factor of 0.4) are as follows:

<u>Pile Type</u>	<u>Factored ULS Capacity (compression)</u>
HP 310 x 110 'H' Pile	846 kN
HP 360 x 152 'H' Pile	1164 kN

Steel piles should have a minimum wall thickness of 12 mm and the tip protected with a driving shoe. For steel piles, a pile driving hammer capable of delivering energy of 252 Joules/cm² to 315 Joules/cm² of steel cross-section is recommended. The pile hammer shall deliver a rated energy of not less than 33,895 kN-m.

Quality control inspection during piling operations is recommended to ensure proper seating of piles and that driving criteria has been met. A quality assurance-testing program for piles is recommended and should include Pile Driving Analyzer (PDA) monitoring to confirm load capacities during initial driving and subsequent re-strikes.

At a minimum, PDA testing should be conducted at the end of initial driving and during re-striking on a least two piles per abutment. Re-striking should be conducted a minimum of 24 hours following initial driving.

Piles should be driven to practical refusal (i.e. pile set) within the site bedrock. At a minimum, 15 blows per 25 mm for two consecutive sets should be achieved. Pile set criteria should be confirmed through PDA testing during initial pile driving and modified as required. Piles should be re-tapped no sooner than 24 hours after achieving the refusal criteria and sufficiently driven to re-establish the refusal criteria. Additional subsequent re-taps should be conducted as necessary.

Piles should be spaced no closer than 3 times the pile diameter (measured centre-to-centre). Strict control of pile location and verticality should be exercised to ensure accurate pile spacing and prevent eccentric and non-vertical loading of piles and groups.

Driving records should be kept throughout the pile installation period. Information to be recorded should include, pile dimensions, hammer type, rated energy, ram weight, anvil weight and driving resistance.

5.6 Interpreted Soil and Bedrock Design Parameters

Bedrock and soil parameters recommended for use in design are outlined in the following table. The parameters indicated have been summarized from known empirical correlations. The values indicated are provided as a guide and their specific use in design should be confirmed with the geotechnical engineer.

Table 3: Interpreted Soil and Bedrock Design Parameters

PARAMETER	GLACIAL TILL	IMPORTED STRUCTURAL FILL (I.E. CRUSHED GRAVEL OR ROCKFILL)	BEDROCK
Total Unit Weight, kN/m ³	21	21.5	26
Effective Unit Weight, kN/m ³	11	11.5	16
Effective Angle of Internal Friction	32°	36°	40°
Active Earth Pressure Coeff.(K _a)	0.31	0.26	--
Passive Earth Pressure Coeff.(K _p)	3.3	3.85	--

5.7 Floor Slabs

Slab-on-grade floors for the proposed structure should be cast on a free-draining granular material (Nova Scotia Transportation and Infrastructure Renewal (NSTIR) Type 1 Gravel or equivalent) with a minimum thickness of 200 mm and compacted to 100 percent of the material's standard Proctor maximum dry density.

In heavily loaded areas (i.e. equipment storage, vehicle bay, etc.), the minimum thickness should be increased to 300 mm and may require the placement of rockfill to provide adequate subgrade strength.

To reach the level of the underslab base course, earthworks should be carried out in accordance with previous recommendations for foundation and subgrade preparation.

5.8 De-Watering and Foundation Drainage

During earthworks, water may be expected to enter excavations during precipitation events, as surface runoff or as seepage from within the soil and rock strata. The rate of infiltration into shallow excavations is expected to be minor to moderate and can be controlled by conventional dewatering techniques consisting of 50 to 75 mm diameter portable pumps and grading of excavations to sump locations. Moderate to heavy inflow can be expected for excavations taken to levels below tidal levels and may require larger pumps (i.e. 150 mm diameter)

Water pumped from excavations is expected to contain fines and will require care in disposal. Provision for proper site drainage in accordance with applicable municipal, provincial, and federal environmental requirements should be made at the construction stage. Consideration should be given to the environmental implications related to pumping and disposal of potentially environmentally impacted groundwater.

5.9 Erosion and Sediment Control Guidelines

Nova Scotia Environment has published a set of guidelines dealing with environmental protection, specifically, erosion and sedimentation control. The document is of a general nature, however, presents proven methods for lessening the impact of soil erosion on downstream receptors. The Guidelines should be adopted for construction.

5.10 Flexible Pavement Design

Reinstatement of asphalt paved areas will likely be required following building construction. It is expected that vehicle traffic will generally be large trucks, construction equipment, etc. A flexible pavement design recommended for the site is as follows:

Table 4: Flexible Pavement Design

ITEM	HEAVY DUTY PAVEMENT
Asphalt Top Course – C mix *	40 mm
Asphalt Base Course – B mix *	50 mm
NSTIR Type 1 Gravel **	150 mm
NSTIR Type 2 Gravel **	350 mm

* Minimum compaction (asphalt pavement) – 92 % Theoretical Maximum Density (ASTM D2041)

** Minimum compaction (granular(s)) – 100 % Standard Proctor Maximum Dry Density

The above pavement designs assume a prepared subgrade levelled and compacted to 98 percent standard Proctor maximum dry density. An assessment of the prepared subgrade at time of construction may warrant re-evaluation of design gravel thickness.

Grading of parking and access areas should ensure positive drainage away from active site areas (i.e. to perimeter/adjacent ditches, catch basins, sheet flow off-site, etc.). At or near the proposed structure(s) a minimum of 2 percent positive grade should be maintained.

6 Comments on Construction

The following comments on specific construction aspects of the project are provided for the guidance of designers. The contractor undertaking the work should make their own interpretation of the factual information provided in this report as it affects their construction procedures and scheduling.

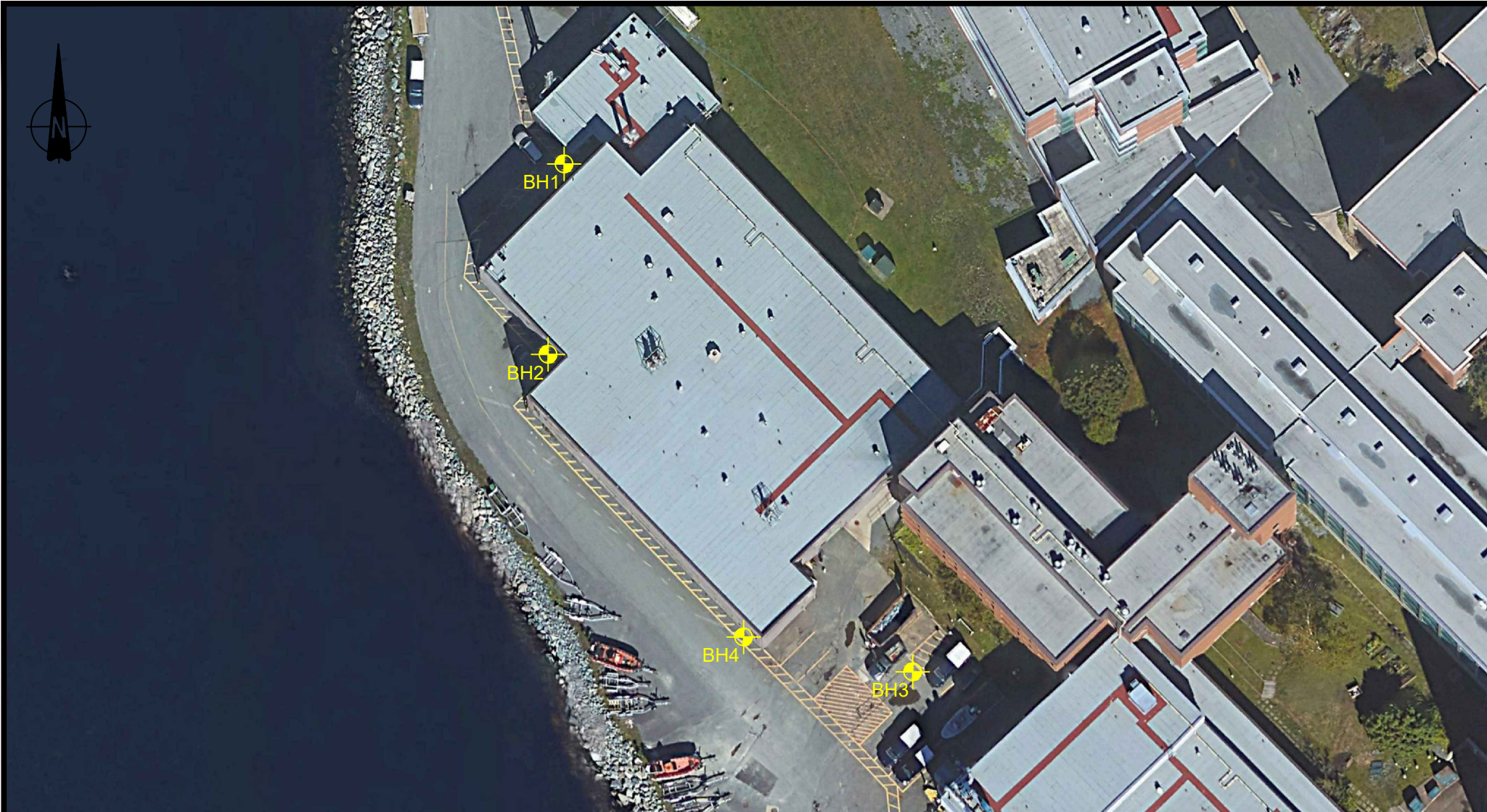
Portions of the in-situ soils are subject to loosening and softening in the presence of water. Construction methods and scheduling should reflect this. If construction takes place in the winter months care must be taken not to allow freezing of subsoil. Any fill or native soil that freezes must be sub excavated and replaced.

In periods of inclement weather or during extended work delays, foundation excavations within the site native soils should be protected by a granular pad (NSTIR Type 1 Gravel or equivalent), or working mat of lean concrete placed over the bearing soil immediately following excavation and preparation of the foundation contact area. It may be also necessary to insulate the founding strata during periods of sub-zero temperatures.

Geotechnical inspection and testing by qualified personnel is recommended during earthworks construction.

7 Closure

The geotechnical investigation undertaken has involved random sampling of site conditions. Should any conditions be encountered during constructions that are contrary to those reported herein, we request immediate notification so that reassessment can be undertaken.



LEGEND



- Approximate Borehole Location

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Client

Public Services & Procurement Canada

Projet

Geotechnical Investigation Fish Lab Renovations

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Titre

Borehole Location Plan



Englobe Corp.

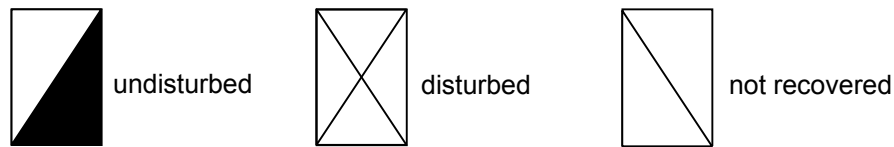
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Appendix A Terms and Symbols

SOIL SAMPLES

CONDITION – This column graphically indicates the depth and condition of the sample:



TYPE – The type of sample is indicated in this column as follows:

- A auger sample
- B block sample
- C rock core, or frozen soil core
- D drive sample
- G grab sample
- SS split spoon
- P Pitcher tube sample
- U tube sample (usually thin-walled)
- W wash or air return sample
- O other (see report text)

PENETRATION RESISTANCE – Unless otherwise noted this column refers to the number of blows (N) of a 140 pound (63.5 kg) hammer freely dropping 30 inches (0.76 m) required to drive a 2 inch (50.8 mm) O.D. open-end sampler 0.5 feet (0.15 m) to 1.5 feet (0.45 m) into the soil, or until 100 blows have been applied, in which case, the penetration is stated. This is the standard penetration test referred to in ASTM D 1586.

OTHER TESTS

In this column are tabulated results of other laboratory tests as indicated by the following symbols:

*C	Consolidation test
Fines	Percentage by weight smaller than #200 sieve
D _R	Relative density (formerly specific gravity)
k	Permeability coefficient
*MA	Mechanical grain size analysis and hydrometer test (if appropriate)
pp	Pocket penetrometer strength
*q	Triaxial compression test
q _U	Unconfined compressive strength
*SB	Shearbox test
SO ₄	Concentration of water-soluble sulphate
*ST	Swelling test
TV	Torvane shear strength
VS	Vane Shear Strength (undisturbed-remolded)
ε _f	Unit strain at failure
γ	Unit weight of soil or rock
γ _d	Dry unit weight of soil or rock
ρ	Density of soil or rock
ρ _d	Dry density of soil or rock

* The results of these tests usually are reported separately

SYMBOLS AND TERMS USED ON THE BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Behavioural properties (i.e. plasticity, permeability) take precedence over particle gradation in describing soils.

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidation of clay minerals, shrinkage cracks etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating layers of different soil types, e.g. silt and sand or silt and clay
Well Graded	- having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Uniformly Graded	- predominantly of one grain size.

Terminology used for describing soil strata based upon the proportion of individual particle size present:

Trace, or occasional	Less than 10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. silt and sand)	35-50%

The standard terminology to describe cohesionless soils includes the relative density, as determined by laboratory test or by the Standard Penetration Test 'N' - value: the number of blows of 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil.

Relative Density	'N' Value	Relative Density %
Very loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression test, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength		'N' Value
	Kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25-0.5	12.5-25	2-4
Firm	0.5-1.0	25-50	4-8
Stiff	1.0-2.0	50-100	8-15
Very Stiff	2.0-4.0	100-200	15-30
Hard	>4.0	>200	>30

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

MAJOR DIVISION			GROUP SYMBOL	GRAPHIC SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS MORE THAN HALF COARSE FRACTION LARGER THAN NO.4 SIEVE SIZE	CLEAN GRAVELS	GW		RED	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		RED	POORLY-GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, <5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS	
		DIRTY GRAVELS	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW 'A' LINE OR $I_p < 4$	
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE 'A' LINE OR $I_p > 7$	
	SANDS MORE THAN HALF COARSE FRACTION SMALLER THAN NO.4 SIEVE SIZE	CLEAN SANDS	SW		RED	WELL-GRADED SANDS, GRAVELLY SANDS, <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		RED	POORLY-GRADED SANDS, OR GRAVELLY SANDS, <5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS	
		DIRTY SANDS	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW 'A' LINE OR $I_p < 4$	
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE 'A' LINE OR $I_p > 7$	
	FINE - GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO.200 SIEVE SIZE)	SILTS		ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$
		BELOW 'A' LINE ON PLASTICITY CHART; NEGLECTIBLE ORGANIC CONTENT		MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$
CLAYS		CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$		
ABOVE 'A' LINE ON PLASTICITY CHART; NEGLECTIBLE ORGANIC CONTENT		CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY SILTY CLAYS	$W_L > 30, < 50$		
		CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$		
ORGANIC SILTS & ORGANIC CLAYS		OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$		
BELOW 'A' LINE ON PLASTICITY CHART		OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$		
							SEE CHART BELOW	



FILL



TILL

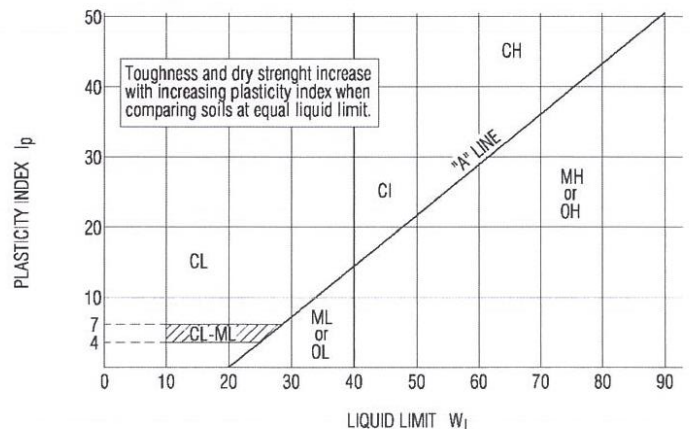


BEDROCK

- All sieve sizes mentioned on this chart are U.S. Standard, ASTM E11.
- Boundary classifications possessing characteristics of two groups are given combined group symbols eg GW-GC is a well-graded gravel-sand mixture with clay binder between 5% and 12%.
- Soil fractions and limiting textural boundaries are in accordance with the Unified Soil Classification System, except that an inorganic clay of medium plasticity (CI) is recognized.
- The following adjectives may be employed to define percentage ranges by weight of minor components:

and	50 - 36%
gravelly, sandy, silty, clayey, ect.	35 - 21%
some	20 - 11%
trace	10 - 1%

PLASTICITY CHART



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Appendix B Borehole Logs



BOREHOLE LOG

PROJECT

Geotechnical Investigation - Fish Lab
BIO, Dartmouth, Nova Scotia

LOGGED/DWN. NMD		CKD. RH		DATE OF INVEST. 20-10-19		JOB NO. 2004260.000		HOLE NO. BH 1	
CASING RESISTANCE blows/300mm ▲		DEPTH	ELEVATION	SOIL SYMBOL	SOIL DESCRIPTION		SOIL SAMPLE		DRILL TYPE
<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><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PROJECT

Geotechnical Investigation - Fish Lab
BIO, Dartmouth, Nova Scotia

LOGGED/DWN. NMD						CKD. RH		DATE OF INVEST. 20-10-19		JOB NO. 2004260.000		HOLE NO. BH 2				
CASING RESISTANCE blows/300mm ▲						DEPTH		ELEVATION	SOIL SYMBOL	SOIL DESCRIPTION		SOIL SAMPLE			DRILL TYPE	
										DATUM Existing Ground Surface		COND.	TYPE	N-VALUE RQD/ RECOVERY	Excavator	
WC % wp-┤ w-● wl-┤ 10 20 30 40 50						ft m				SURFACE ELEVATION						
										Asphalt					TCR - Total Core Recovered RQD - Rock Quality Designation UCS - Unconfined Compressive Strength	
										Gravel		X	SS	N=39		
						-2	1			FILL: gravelly sand, some silt, occasional to some cobbles and boulders, compact to loose, moist to wet, grey to brown.		X	SS	N=26		
						-4						X	SS			
						-6		2					X	SS		
						-8										
						-10	3				≡	SS	50/25			
						-12										
						-14		4								
						-16				X	SS	50/100				
						-18										
						-20	6			TILL: sand and gravel, some silt, trace clay, occasional to some cobbles and boulders, dense to very dense, wet to saturated, greyish brown.		X	SS	N=106		
						-22				X	SS	50/75				
						-24		7								
						-26				X	SS	50/125				
						-28	8									
						-30				≡	SS	50/25				
						-32		9								
						-34										
						-36	10									
						-38										



Englobe

BOREHOLE LOG

PROJECT

Geotechnical Investigation - Fish Lab
BIO, Dartmouth, Nova Scotia

LOGGED/DWN. NMD	CKD. RH	DATE OF INVEST. 20-10-19	JOB NO. 2004260.000	HOLE NO. BH 2		
<div>CASING RESISTANCE blows/300mm ▲</div> <div>WC % wp- w- wl- 10 20 30 40 50</div>	DEPTH ft m	ELEVATION	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE	DRILL TYPE
				DATUM Existing Ground Surface	COND. TYPE N-VALUE ROD/RECOVERY	Excavator
				SURFACE ELEVATION		OTHER TESTS
	36 11			BEDROCK: quartzite/greywacke, highly fractured and weathered, grey.		TCR= 95% RQD= 18%
	38					
	12			End of Borehole at 11.9 metres in Bedrock.		
	40					
	42			Groundwater depth not determined due to water injection for coring process.		
	13					
	44					
	46					
	14					
	48					
	15					
	50					
	52					
	16					
	54					
	56					
	17					
	58					
	18					
	60					
	62					
	19					
	64					
	20					
	66					



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BOREHOLE LOG

PROJECT

Geotechnical Investigation - Fish Lab
BIO, Dartmouth, Nova Scotia

LOGGED/DWN. NMD		CKD. RH		DATE OF INVEST. 20-10-21		JOB NO. 2004260.000		HOLE NO. BH 3														
CASING RESISTANCE blows/300mm ▲		DEPTH ft m	ELEVATION	SOIL SYMBOL	SOIL DESCRIPTION		SOIL SAMPLE		DRILL TYPE													
WC % wp- ┤ w- ● wl- ┤					DATUM Existing Ground Surface		COND.	TYPE	N-VALUE ROD/ RECOVERY	Excavator												
10 20 30 40 50					SURFACE ELEVATION																	
		2			Asphalt			SS	N=46	TCR - Total Core Recovered												
			Gravel			SS					50/50	RQD - Rock Quality Designation										
		4	FILL: sand and gravel, some silt, occasional to some cobbles and boulders, compact to loose, moist to wet, grey to brown.											SS	70/125	UCS - Unconfined Compressive Strength						
		6																				
		8																				
		10																SS	50/25			
		12																				
		14																				
		16																			SS	50/50
		18	TILL: gravelly sand, some silt, trace clay, occasional to some cobbles and boulders, dense to very dense, wet to saturated, greyish brown.																			
		20																				
		22																				
		24	BEDROCK: quartzite/greywacke, highly fractured and weathered, grey.			RC	TCR= 80% RQD= 0%															
		26																				
		28																				
		30						RC	TCR= 98% RQD= 10%													
		32																				
		10	-75 mm quartz seam at 9.1 metres End of Borehole at 9.3 metres in Bedrock.																			
			Groundwater depth not determined due to water injection for coring process.																			






















Englobe

BOREHOLE LOG

PROJECT

Geotechnical Investigation - Fish Lab
BIO, Dartmouth, Nova Scotia

LOGGED/DWN. NMD		CKD. RH		DATE OF INVEST. 20-10-22		JOB NO. 2004260.000		HOLE NO. BH 4			
CASING RESISTANCE blows/300mm ▲		DEPTH	ELEVATION	SOIL SYMBOL	SOIL DESCRIPTION		SOIL SAMPLE		DRILL TYPE		
<div><div></div><div></div><div></div><div></div><div></div></div>					DATUM Existing Ground Surface	COND.	TYPE	N-VALUE ROD/ RECOVERY	Excavator		
<div><div>WC %</div><div>wp- w- ● wl- </div><div>10 20 30 40 50</div></div>		ft m			SURFACE ELEVATION				OTHER TESTS		
		2			Asphalt				TCR - Total Core Recovered		
					Gravel			SS		50/25	
		4	1		FILL: gravelly sand, some some silt, occasional to some cobbles and boulders, compact to loose, moist to wet, grey to brown.			SS	N=50	RQD - Rock Quality Designation	
		6	2			SS	N=26	UCS - Unconfined Compressive Strength			
		8				SS	N=16				
		10	3			SS	50/125				
		12	4			TILL: gravelly sand, some silt, trace clay, occasional to some cobbles and boulders, dense to very dense, wet to saturated, greyish brown.				SS	50/125
		14					SS		50/75		
		16	5				SS	50/125			
		18				SS	50/75	TCR= 90% RQD= 26%			
		20	6				SS		50/75		
		22	7			BEDROCK: quartzite/greywacke, highly fractured and weathered, grey.			RC	TCR= 85% RQD= 54%	
		24	8			RC					
		26					RC				
		28	9		End of Borehole at 9.1 metres in Bedrock.						
		30			Groundwater depth not determined due to water injection for coring process.						
		32	10								

Appendix C Laboratory Test Results

TABLE C-1: SUMMARY OF LABORATORY DATA
Geotechnical Investigation
Fish Lab Renovations, BIO, Dartmouth, NS
Project No. 2004260

Borehole No.	Sample No.	Depth (metres)	Description	Moisture Content (%)	Particle Size Distribution		
					Gravel (%)	Sand (%)	Fines (silts and clays) (%)
BH 2	2	0.9 - 1.5	FILL	7.6			
	3	1.5 - 2.1	FILL	7.1			
	6	5.8 - 6.4	TILL: sand and gravel, some silt, trace clay	9.2	36	39	25
	8	7.6 - 8.2	TILL	10.3			
BH 3	1	0.3 - 0.9	FILL: sand and gravel, some silt, trace clay	8.2	39	42	19
	3	1.8 - 2.4	FILL	7.7			
BH 4	2	0.6 - 1.2	FILL	4.3			
	5	3.0 - 3.6	TILL	9.9			
	7	6.4 - 7.0	TILL	9.4			

97 TROOP AVE., DARTMOUTH, N.S. B3B 2A7 - TEL (902) 468-6486 FAX 468-4919

Client:

Public Works Government Services Canada
P.O. Box 2247
Bedford Row, Halifax, N.S.
B3J 3C9

Our Project No:

02004260.000.0001.0001

Client Contract No.:
Client PO.:
CC:

Attn: Ian Sceles

PHONE (902) 999-9999

FAX:

Project: Fish Lab Renovations and MCI Heavy Equip

Source: BH 2

Sample No: 6

Date Sampled: 19-Oct-20

Sampled by: NMD

Date Received: 28-Oct-20

Location: 5.8 - 6.4 m

Date Tested: 29-Oct-20

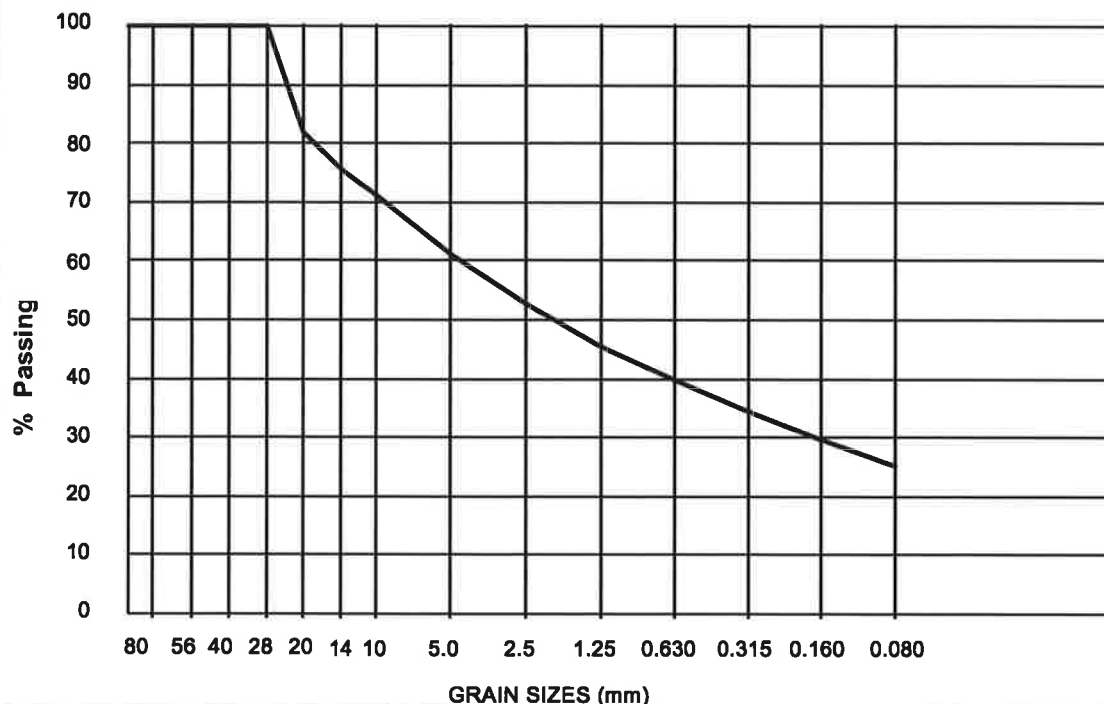
PHYSICAL PROPERTY TESTS

Soil Type	Till	Liquid Limit	Flat and Elongated Particles, %
Gravel, %	39	Plastic Limit	Coarse Spec. Gravity
Sand, %	36	Plasticity Index	Fractured Faces, %
Silt and Clay, %	25	Coarse Absorption, %	Petrographic No.
Moisture Cont., %	9.2	Fine Absorption, %	Max. Dry Density, (kg/m3)
Abrasion Loss, %		Micro Deval Loss, %	Optimum Moisture, %

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56		
40		
28	100	
20	82	
14	75	
10	71	
5.0	61	
2.5	53	
1.25	45	
0.630	40	
0.315	34	
0.160	30	
0.080	25.3	

GRAIN SIZE CURVE

Spec Band
NO SPEC



Comments:

Record No: 12357

Englobe Tech:

PER



CERTIFIED LABORATORY
FOR TESTING CONCRETE

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of test results is provided only on request.

project manager: Scott Simms

97 TROOP AVE., DARTMOUTH, N.S. B3B 2A7 - TEL (902) 468-6486 FAX 468-4919

Client:

Public Works Government Services Canada
P.O. Box 2247
Bedford Row, Halifax, N.S.
B3J 3C9

Our Project No:

02004260.000.0001.0001

Client Contract No.:
Client PO.:
CC:

Attn: Ian Sceles

PHONE (902) 999-9999

FAX:

Project: Fish Lab Renovations and MCI Heavy Equip

Source: BH 3

Sample No: 1

Date Sampled: 19-Oct-20

Location: 0.3 - 0.9 m

Sampled by: NMD

Date Received: 28-Oct-20

Date Tested: 29-Oct-20

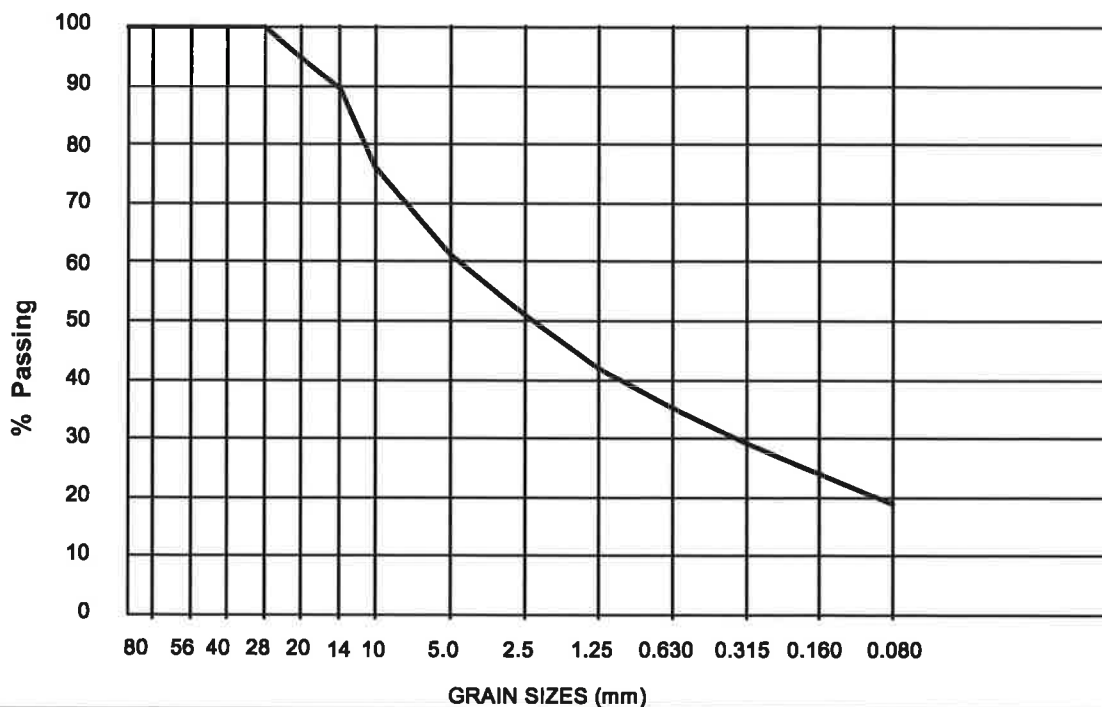
PHYSICAL PROPERTY TESTS

Soil Type	Fill	Liquid Limit		Flat and Elongated Particles, %	
Gravel, %	39	Plastic Limit		Coarse Spec. Gravity	
Sand, %	42	Plasticity Index		Fractured Faces, %	
Silt and Clay, %	19	Coarse Absorption, %		Petrographic No.	
Moisture Cont., %	8.2	Fine Absorption, %		Max. Dry Density, (kg/m3)	
Abrasion Loss, %		Micro Deval Loss, %		Optimum Moisture, %	

Sieve Size (mm)	Percent Passing	Spec. Band
112		
80		
56		
40		
28	100	
20	95	
14	89	
10	76	
5.0	61	
2.5	51	
1.25	42	
0.630	35	
0.315	29	
0.160	24	
0.080	19.0	

GRAIN SIZE CURVE

Spec Band
NO SPEC



Comments:

Record No: 12358

Englobe Tech:

PER



CERTIFIED LABORATORY
FOR TESTING CONCRETE

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project manager: Scott Simms