

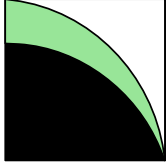
APPENDIX B - Geotechnical Reports

B1) Preliminary Geotechnical Investigation, Proposed BIO Buoy Maintenance Laydown Area, Dartmouth, NS. TerrAtlantic Engineering Limited, File No. 444.57, October 17, 2012.

B2) Geotechnical Investigation, Proposed BIO Buoy Storage and Maintenance Area, Dartmouth, Nova Scotia. TerrAtlantic Engineering Limited, File No. 444.57, February 22, 2013.

B3) Additional Geotechnical Investigation - Rock Quality, Proposed BIO Buoy Maintenance Laydown Area, Dartmouth, NS. TerrAtlantic Engineering Limited, File No. 444.57, August 9, 2013.

B4) Rock Excavation at the Proposed Buoy Laydown Area, Dartmouth - Nova Scotia. CBCL / Graham Daws Associates Ltd., File No. CBCL 121032.011, 30 August 2013.



TerrAtlantic

Engineering Limited

34 Trider Crescent
Dartmouth, Nova Scotia, B3B 1R6

tel: (902) 481-0008 fax: (902) 481-0012

October 17, 2012

File: 444.57

Chris Kingsland, P.Eng
CBCL Limited
PO Box 606
1489 Hollis Street
Halifax, NS B3J 2R7

Dear Chris,

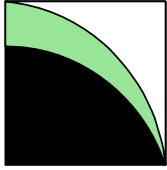
**RE: PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED BIO BUOY MAINTENANCE LAYDOWN AREA, DARTMOUTH, NS**

Please find enclosed our report for the preliminary geotechnical investigation conducted for the proposed BIO Buoy Maintenance Area project, located in Dartmouth, NS.

We trust that this report is adequate for your purposes. Please contact the undersigned if we can clarify its content or if we can otherwise be of further assistance.

Sincerely,

SCOTT MUNRO, M.SC.E., P. ENG
TERRATLANTIC ENGINEERING LIMITED
GEOTECHNICAL ENGINEER



TerrAtlantic

Engineering Limited

34 Trider Crescent
Dartmouth, Nova Scotia, B3B 1R6

tel: (902) 481-0008 fax: (902) 481-0012

October 17, 2012

File #444.57

Chris Kingsland, P.Eng
CBCL Limited
PO Box 606
1489 Hollis Street
Halifax, NS B3J 2R7

Dear Chris:

**RE: PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED BIO BUOY MAINTENANCE LAYDOWN AREA, DARTMOUTH, NS**

Introduction

TerrAtlantic Engineering Limited was retained by CBCL Limited to carry out a preliminary geotechnical investigation for the proposed Bedford Institute of Oceanography (BIO) Maintenance Laydown Area, to be constructed adjacent to the existing BIO building, in Dartmouth, NS. The purpose of the investigation was to obtain information on the subsurface conditions at the proposed site in order to help establish site grading and pavement structure requirements as well as to assist with the layout of the proposed infrastructure within the laydown area. The following letter report presents all findings from the field and laboratory work, along with some general recommendations to assist with the design and construction.

Site Description

The site is located on the northern section of the BIO property, located in Dartmouth, Nova Scotia. The site is bordered by DND property (Canadian Forces Ammunition Depot) to the north, a gravel parking area to the east, Discovery Drive to the south and the Canadian Coast Guard Building to the west.

The site is currently being used as a laydown area for small water craft, sea cans, trailers, etc. The presence of several debris piles on the southern end of the site suggest that this portion of the site has historically been used as a debris stockpile area. The site grade slopes downwards from east to west. A steep slope is located on the eastern (up-hill) side, and a boulder wall on the west (down-hill) side of the property. Site drainage occurs via a french drain at the toe of the eastern slope and through a east-west trending cross culvert beneath the centre of the property.

Geology and Surficial Geology

The geological mapping indicates that bedrock in the area comprises quartzite from the Goldenville Formation. The Goldenville Formation forms the lower part of the Meguma Group and is made up of Cambrian age rock, predominantly sandstone turbidites and minor slate with some schist and gneiss.

The Surficial Geology Map of Nova Scotia indicates that the principal native overburden in the area consists of a thin discontinuous veneer of glacial till above bedrock with glacially scoured basins and knobs. The glacial till is generally a compact material, derived from both local and distant sources and is typically comprised of dense silty sand and gravel.

Methodology

The field investigation was conducted on September 25, 2012 and consisted of the excavation of eleven (11) test pits in the area of the proposed laydown. Each test pit was excavated by a track mounted excavator, to depths ranging from 1.8 to 4.9 m. The observed subsurface conditions were recorded and representative soil samples were recovered and sent to our geotechnical laboratory for final visual assessment, testing and classification. Detailed test pit logs are provided in Appendix A and the results from laboratory testing are presented in Appendix B.

Detailed surveying of test pit locations (Geodetic) and ground elevations was conducted by others. The location of each test pit, TP1 to TP11 are presented in Figure 1.

Subsurface Conditions

The subsurface conditions encountered at this site vary from hole to the next. Table 1 and the paragraphs below summarize the soil, bedrock and groundwater conditions encountered.

Table 1. Summary of subsurface layer thicknesses at each test pit location

Test Pit	Ground Elevation (m)	Gravel (m)	Fill (m)	Boulder & Peat (m)	Organics, Grubbings (m)	Silty Sand (m)	Elevation of Till surface (m)	Elevation of Bedrock surface (m)	Water Seepage (m)
TP1	12.2	0.3	1.8	1.4	-	-	8.8	<8.7	1.7 and 2.6
TP2	12.2	0.3	1.4	0.8	-	-	9.8	9.4	2.0
TP3	11.8	-	0.3	-	-	-	11.5	<9.0	2.0
TP4	12.2	-	2.2	-	-	-	10.0	8.9	-
TP5	11.0	-	2.2	-	>2.4	-	<6.4	<6.4	4.0
TP6	11.3	0.3	>4.6	-	-	-	<6.4	<6.4	2.7
TP7	11.5	0.4	2.1	-	0.2	0.5	8.4	<7.9	1.5
TP8	11.9	0.4	0.8	-	-	-	10.6	9.1	-
TP9	11.8	0.4	1.6	-	-	0.3	9.5	<8.8	-
TP10	11.5	0.2	3.2	-	>1.5	-	<6.6	<6.6	-
TP11	11.8	-	0.3	-	-	-	11.5	9.9	1.5

Gravel

Gravel was encountered in test pits TP1, TP2 and TP6 to TP10. The thickness of this layer ranged from 0.2 m to 0.4 m. One grain size analysis was conducted on this material. It comprised 71% gravel, 22% sand and 7 silt/clay sized particles. Based on the gradation, this material is consistent with the properties of NSTIR Type 2 gravel. One moisture content test was performed on a sample of gravel and showed a moisture content of 3.9%.

Fill

Fill was encountered in all eleven test pits. The fill consisted of brown to grey-brown silty sand with gravel, to silty gravel with sand. Cobbles and boulders were encountered frequently in the fill. Two grain size analyses were conducted on fill samples. The result of these tests were remarkably consistent. Each sample comprised 49% gravel, 33% sand, and 19% silt/clay size particles. Moisture contents conducted on the fill ranged between 8 and 20%.

Boulders and Peat

A layer of boulders intermixed within a peat/organic matrix was encountered beneath the fill in test pit TP1 and TP2, at the eastern edge of the site. This layer was observed at a depth ranging from depths of 1.6 to 2.0 m and ranged in thickness from 0.8 to 1.4 m.

Organics and Grubbings

A thick organic/grubbings layer was encountered in test pits TP5 and TP10, towards the south west section of the site. This layer was observed at a depth ranging from depths of 2.2 to 3.4 m and was observed to be more than 2.4 metres thick at TP5 and more than 1.5 metres thick TP10.

Silty Sand and Till

Native, undisturbed till was encountered in all test pits with the exception of TP5, TP6 and TP10. The till comprised grey to grey-brown silty sand with gravel to sandy silty (trace gravel) and was encountered at depths ranging from 0.3 m to 3.4 m. In TP7 and TP9, a layer of rust-brown coloured silty sand with gravel with a thickness ranging from 0.3 to 0.4 m was observed just above the till layer.

One grain size analysis was conducted on the till. This sample comprised 6% gravel, 35% sand, and 59% silt/clay size particles. Moisture contents of the till ranged from 8 to 12%.

Bedrock

Bedrock was inferred in test pits TP2, TP4, TP8 and TP11 at depths ranging from 1.5 to 2.8 m. The bedrock is described as slightly weathered, grey quartzite.

Groundwater

Groundwater seepage was observed in seven of the eleven test pits. The depth of seepage ranged from 1.5 to 4.0 m below the ground surface. Seepage observations within test pits provide a useful indication of the presence of groundwater but should not be relied upon for accurate groundwater elevations. Groundwater levels will vary from one season to the next, and may be higher than those indicated, especially during wetter periods.

Discussion and Recommendations

It is understood that the site is to be utilized for various proposed facilities. These include:

- a buoy laydown area,
- a storage building,
- a concrete pad to serve as a chain inspection area,
- a fork lift loading area, and
- a buoy washdown area.

It is further understood that the buoy laydown area will encompass the majority of the site and that the location of the other facilities will be chosen to as to ensure the most effective use of the space.

General

The soil conditions at this site generally comprise an extensive layer of fill which has been placed above loose peat, organics. These soils should not be considered as a suitable subgrade for building foundations, concrete pads or asphaltic or concrete pavement. Where these types of structures are envisaged, all fill material, peat and organic layers should be removed down to undisturbed till and should be replaced with engineered fill. In some areas (for example near TP3) very little sub-excavation may be required. However, in other areas, between 2.5 m and more than 5 m of excavation may be required.

The suitability of the existing fill, peat and organic soil layers to remain beneath proposed, unpaved laydown facilities will depend largely on the magnitude of settlement which is deemed acceptable by the design team. It is likely that the fill, organics and peat layers are currently undergoing primary consolidation and creep settlement. This settlement is likely to continue and would be exacerbated by the addition of material or other sources of additional load. However, if the laydown areas are to remain unpaved, then presumable surface settlement in these areas may not be considered a major concern. The added maintenance cost associated with this settlement (routine grading etc.) would likely be very small when compared to the cost of sub-excavation and replacement of the poor quality material.

Soil Improvement

Several ground improvement techniques are available for the densification and/or reinforcement of poor foundation soil conditions such as these. These methods might include:

- dynamic compaction,
- jet grouting,
- vacuum consolidation,
- vibrocompaction,
- soil mixing, and
- compaction grouting.

The cost of these techniques is generally high, but may be economically feasible when compared to the cost of removal and replacement of a large quantity of soil. However, as noted above, the cost of additional maintenance in unpaved laydown areas undergoing settlement would likely be much less than either removal and replacement or soil improvement techniques.

Geosynthetic Reinforcement

Settlement in unpaved laydown areas may be reduced, perhaps significantly, with the inclusion of a suitably selected geotextile or geogrid layer placed at the proper depth. However, even with the addition of geosynthetic reinforcing layer, some settlement is likely to occur, especially in areas of thick fill and organic deposits. It can often take significant tensile strain to mobilize tensile resistance in geosynthetics and quite often, the magnitude of vertical settlement required to mobilize this strength exceeds serviceability limits. For this reason, geosynthetics are not recommended as a replacement option for removal and replacement of soil beneath foundation or pavement structures.

Site Grading

As discussed above, some significant settlement may be expected to occur over much of the site. As a result, we recommend that all travel surfaces and laydown areas be left as gravel surfaces and that routine maintenance including grading and granular material placement be anticipated. It is

recommended that a granular surface course comprising of 200 to 300 mm of NSTIR TYPE 1 be placed in all travel and laydown areas, in addition to the existing granular layer (200 to 300 mm thick) located at the surface.

In areas where the grades are to be increased, engineered fill shall consist of 6" minus rockfill or other approved material. All materials shall be approved by the geotechnical consultant prior to being brought to site. Engineered fill should be placed in lifts of 300 mm (un-compacted thickness) and compacted, with a large vibratory roller, to the following maximum Standard Proctor Dry Densities:

Subgrade	95%
Subbase	100%
Base	100%

Engineered fill should be placed under the full time supervision of qualified geotechnical personnel to ensure that the required compaction criteria are met.

Further Investigation

A steep fill slope is located on the eastern side of the site. A gravel parking area is located at the top of the slope. It is understood that the proposed laydown area is to be located at the toe of this slope. It is recommended that a slope stability assessment of this embankment be conducted to determine the factor of safety of the existing slope, and to provide recommendations on rehabilitation, if required. This study would consist of drilling 2 to 3 boreholes, advanced laboratory testing to establish soil strength parameters, limit equilibrium analyses of the slope cross section, and the preparation of a report.

In addition to a slope stability assessment, some additional test pits should be considered once final building locations have been laid out in order to accurately delineate the extent of the organic layers and to identify a suitable bearing stratum.

Closure

A soils investigation is a limited sampling of a site. This report presents the soil and bedrock conditions encountered at the time of the investigation, and at the specific test locations. Should any conditions be encountered that differ from those presented in this report, we ask that we be immediately notified in order to permit reassessment of our recommendations.

This report was prepared Scott Munro, M.Sc.E., P.Eng. and reviewed by Simon Dickinson, Ph.D., P.Eng. We trust that the information contained in this report is adequate for your present purposes. If you have any questions about the contents of the report or if we can be of any other assistance please contact us at your convenience.

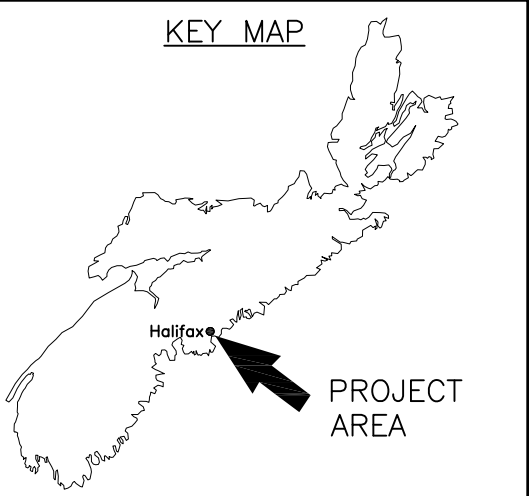
Yours very truly,

A handwritten signature in black ink, appearing to read 'Scott Munro', with a long horizontal flourish extending to the right.

SCOTT MUNRO, M.SC.E., P.ENG.
GEOTECHNICAL ENGINEER



TEST PITS	ELEVATION	NORTHING	EASTING
TP1	12.21	4949902.76	5570429.13
TP2	12.20	4949880.73	5570431.98
TP3	11.76	4949844.43	5570423.52
TP4	12.21	4949828.64	5570397.33
TP5	10.93	4949835.28	5570365.30
TP6	11.27	4949872.28	5570360.64
TP7	11.51	4949901.59	5570363.11
TP8	11.86	4949948.06	5570363.22
TP9	11.76	4949900.53	5570385.81
TP10	11.47	4949863.74	5570391.13
TP11	11.75	4949922.41	5570402.39



NOTES

- 1. ALL UNITS ARE IN METERS
- 2. ELEVATIONS ARE BASED ON CANADIAN GEODETIC VERTICAL DATUM AND REFER TO NS COORDINATE MONUMENT No. 5542: ELEV. 30.227 METERS
- 3. TEST PITS WERE COMPLETED ON SEPTEMBER 25, 2012

LEGEND

- TEST PIT LOCATION
- FENCE
- BUILDINGS
- GRAVEL
- PILES OF DEBRIS

FIGURE 1
GENERAL SITE PLAN

TEST PIT LOCATIONS FOR
BIO BUOY MAINTENANCE AREA

SCALE: 1:750	DRAWN BY: DO
DATE: OCT 10, 2012	CHECKED BY: SM
DWG. NO. 4445701	PROJECT NO. 444.57



APPENDIX A



TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP1





CLIENT:	PROJECT NO.:	DATE EXCAVATED:
CBCL LIMITED	444.57	September 25, 2012

PROJECT:	POCKET PENETROMETER kg/cm ²
BIO BUOY MAINTENANCE AREA	<input type="checkbox"/>

LOCATION:	EASTING:	NORTHING:	WATER CONTENT, %
DARTMOUTH, NS	5570429.13	4949902.76	<input checked="" type="checkbox"/>

GROUND ELEVATION:	GW. SEEPAGE ELEVATION:	EXCAVATOR	LOGGED BY:	ATTEBERG LIMITS	PLASTIC LIMITS	LIQUID LIMITS
12.21 m	2.59	CAT 320	SM			

HYDRAULIC CONDUCTIVITY log K	<input checked="" type="checkbox"/>
------------------------------	-------------------------------------

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K											ELEVATION metres									
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1												
0	1	G	3.9		0.25m Gravel with silt and sand (NSTIR Type 2)																				12.21	
					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered																				11.96	
	2	G	10.9																							
1																										
2	3	G	25.5		2.03m Boulders intermixed within a peat matrix (thickness varies from 0.8 m to 1.4 m within test hole)																				10.18	
					3.4m 3.48m Grey silty sand with gravel: TILL - Occasional cobbles																				9.62	
																									8.81	
					END OF HOLE 3.48m																				8.73	
4					-Seepage observed at depths of 1.7 m and 2.6 m. -Seepage at 1.7 m is likely a result of adjacent french drain located at the toe of slope.																					
5																										
6																										



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP2

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570431.98

NORTHING:

4949880.73

GROUND ELEVATION:

12.20 m

GW. SEEPAGE ELEVATION:

2.01

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐


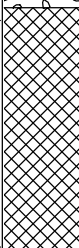


WATER CONTENT, % ☒

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K											ELEVATION metres									
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1												
0					0.25m Gravel with silt and sand (NSTIR Type 2)																				12.20	
	1	G	19.8		Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered																				11.95	
1																										
	3	G	10.5																							
					1.62m Boulders intermixed within a peat matrix																					10.58
2																										10.19
					2.44m Grey silty sand with gravel to sandy silt, trace gravel: TILL																					9.76
	2	G	7.9		2.84m - Occasional cobbles																					9.36
3					END OF HOLE 2.84m																					
					-Inferred bedrock ridge on south side of test pit, at a depth of 1.4 m (GS3) - Seepage observed at 2.0 m depth																					
4																										
5																										
6																										


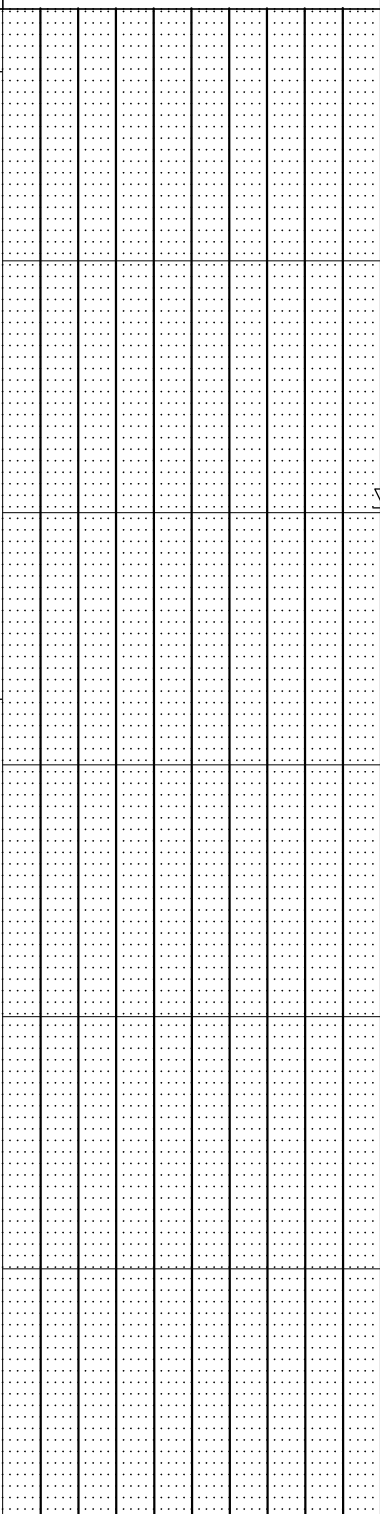


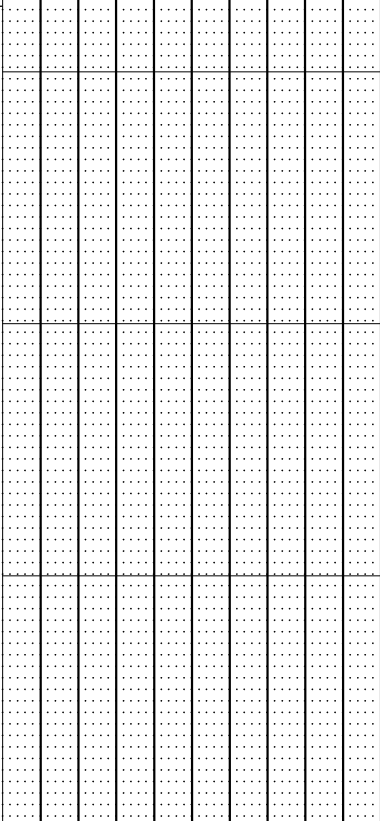


TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP3
PROJECT NO.:	DATE EXCAVATED:
444.57	September 25, 2012

CLIENT: CBCL LIMITED			
PROJECT: BIO BUOY MAINTENANCE AREA			
LOCATION: DARTMOUTH, NS	EASTING: 5570423.52	NORTHING: 4949844.43	
GROUND ELEVATION: 11.76 m	GW. SEEPAGE ELEVATION: 1.98	EXCAVATOR: CAT 320	LOGGED BY: SM

POCKET PENETROMETER kg/cm ²	<input type="checkbox"/>
WATER CONTENT, %	<input checked="" type="checkbox"/>
ATTERBERG LIMITS	PLASTIC LIMITS <input type="checkbox"/> LIQUID LIMITS <input type="checkbox"/>
HYDRAULIC CONDUCTIVITY log K	<input checked="" type="checkbox"/>

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K										ELEVATION metres
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1		
0					Brown to grey brown silty sand with gravel: FILL		11.76									
				0.25m				Grey brown silty sand with gravel: TILL - Occasional cobbles and boulders	11.51							
1																
	1	G	8.3													
2					2.74m		9.78									
								END OF HOLE 2.74m	- Seepage observed at 2.0 m	9.02						
3																
4																
5																
6																



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP4

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570397.33

NORTHING:

4949828.64

GROUND ELEVATION:

12.21 m

GW. SEEPAGE ELEVATION:

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐

WATER CONTENT, % ☒

ATTERBERG LIMITS


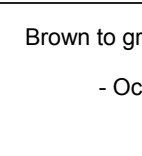
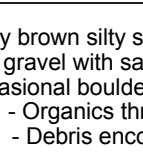
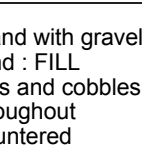
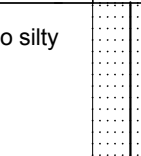
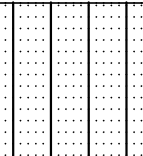
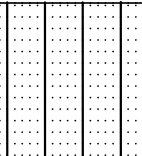
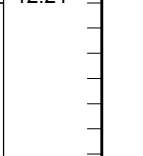





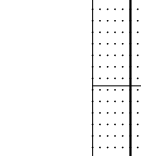
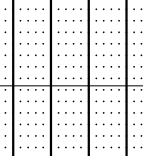
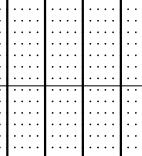
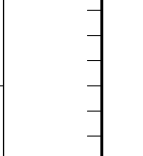





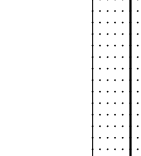
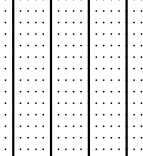
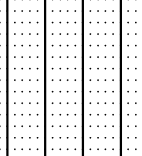
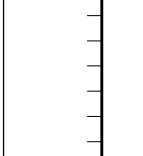

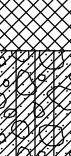
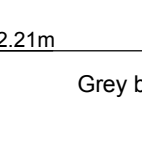
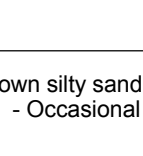
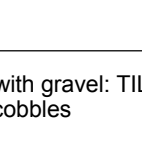
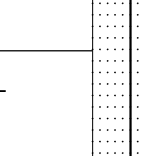
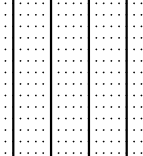
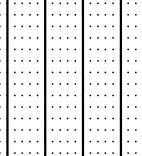
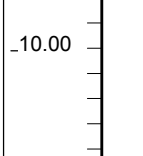

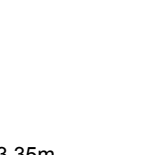


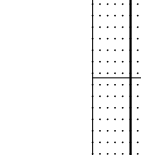
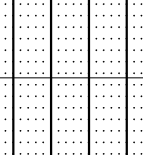
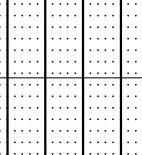
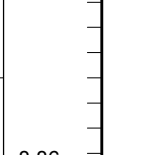

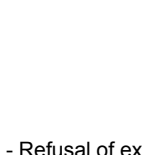
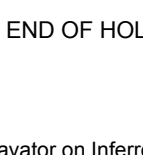
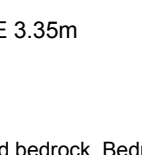
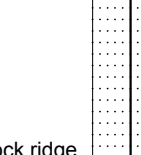
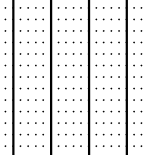
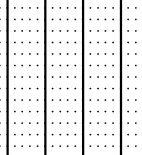
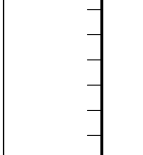

PLASTIC

LIQUID

LIMITS

LIMITS

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K										ELEVATION metres
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1		
0					Brown to grey brown silty sand with gravel to silty gravel with sand : FILL - Occasional boulders and cobbles - Organics throughout - Debris encountered										12.21	
	1	G	7.9													
1																
	2	G	14.6													
2																
					2.21m										10.00	
3																
	3	G	12.3		3.35m										8.86	
4																
					END OF HOLE 3.35m											
5																
					- Refusal of excavator on Inferred bedrock. Bedrock ridge encountered at 2.8 m within test pit. - No seepage observed											
6																

TEST PIT LOG REV3 44457TP.GPJ WELL LOGS.GDT 10/15/12



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP5

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570365.30

NORTHING:

4949835.28

GROUND ELEVATION:

10.93 m

GW. SEEPAGE ELEVATION:

3.96

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐

WATER CONTENT, % ☒

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K										ELEVATION metres
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1		
0					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Frequent large boulders encountered											10.93
1																
2																
2.21m																
2.21m					ORGANICS (roots, stumps, grubblings)											8.72
3																
4																
4.57m																
4.57m					END OF HOLE 4.57m											6.36
5					- Seepage observed at 4.0 m depth											
6																

TEST PIT LOG

STATION:

EXPLORATORY HOLE NO.:

OFFSET:

TP6

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm²

WATER CONTENT, %
100
90
80
70
60
50
40
30
20
10
0

X

ATTERBERG LIMITS

PLASTIC LIMITS — LIQUID LIMITS

LIMITS

LIMITS

HYDRAULIC CONDUCTIVITY log K

LOCATION:

DARTMOUTH, NS

EASTING:

5570360.64

NORTHING:

4949872.28

GROUND ELEVATION:

11.27 m

GW. SEEPAGE ELEVATION:

2.67

EXCAVATOR

CAT 320

LOGGED BY:

SM

[illegible]



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP7

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570363.11

NORTHING:

4949901.59

GROUND ELEVATION:

11.51 m

GW. SEEPAGE ELEVATION:

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐





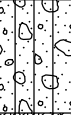
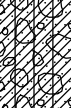
WATER CONTENT, % ☒

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K											ELEVATION metres									
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1												
0					Gravel with silt and sand (NSTIR Type 2)																				11.51	
					0.41m																					11.10
					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered																					
1	1	G	13																							
																										
2	2	G	13.6																							
					2.54m																					
					2.69m																					
					ORGANICS																					
					Rust brown silty SAND with gravel																					
3					3.14m																					
					Grey brown silty sand with gravel: TILL - Occasional cobbles																					
	3	G	9.5																							
					3.66m																					
					END OF HOLE 3.66m																					
4					- No seepage observed																					
5																										
6																										



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP8

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570363.22

NORTHING:

4949948.06

GROUND ELEVATION:

11.86 m

GW. SEEPAGE ELEVATION:

1.52

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐


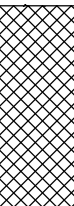

WATER CONTENT, % ☒

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K										ELEVATION metres	
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1			
0					Gravel with silt and sand (NSTIR Type 2)												11.86
					0.4m												11.46
					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered												10.64
1					1.22m												10.34
					Grey brown silty sand with gravel: TILL - Occasional cobbles												9.12
2					2.74m												
					END OF HOLE 2.74m												
3					- Refusal of excavator on inferred Bedrock (bedrock depth varies from 2.1 to 2.7 m within test hole) - Seepage observed at 1.5 m depth												
4																	
5																	
6																	



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP9

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570385.81

NORTHING:

4949900.53

GROUND ELEVATION:

11.76 m

GW. SEEPAGE ELEVATION:

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐


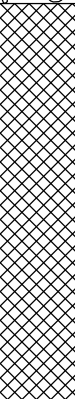


WATER CONTENT, % ☒

ATTERBERG LIMITS

PLASTIC

LIQUID

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K										ELEVATION metres		
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1				
0					Gravel with silt and sand (NSTIR Type 2) 0.36m													11.76
					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Frequent cobbles and boulders (large boulders from 1.8 m to 2.7 m) - Organics throughout - Debris encountered													11.40
1																		
					2m													
2					Rust brown silty SAND with gravel 2.31m													9.76
					Grey brown silty sand with gravel: TILL - Occasional cobbles													9.45
					2.95m													
3					END OF HOLE 2.95m - No seepage observed													8.81
4																		
5																		
6																		



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP10

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570391.13

NORTHING:

4949863.74

GROUND ELEVATION:

11.47 m

GW. SEEPAGE ELEVATION:

3.35

EXCAVATOR

CAT 320

LOGGED BY:

SM

POCKET PENETROMETER kg/cm² ☐

WATER CONTENT, % ☒

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

HYDRAULIC CONDUCTIVITY log K ☒

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION	log K											ELEVATION metres
	NO.	TYPE	WC %			-9	-8	-7	-6	-5	-4	-3	-2	-1			
0					0.2m Gravel with silt and sand (NSTIR Type 2)												11.47
	1	G	10.3		Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered												11.27
1																	
2	2	G	11.9														
3																	
					3.4m												8.12
4					ORGANICS (roots, stumps, grubbings)												8.07
					4.88m												6.59
5					END OF HOLE 4.88m												
					-Refusal of excavator within grubbings due to maximum reach. -Seepage observed at 4.88 m												
6																	

TEST PIT LOG

STATION:

EXPLORATORY HOLE NO.:

OFFSET:

TP11

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

September 25, 2012

PROJECT:

BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm^2 

WATER CONTENT, %
100
90
80
70
60
50
40
30
20
10
0

X

ATTERBERG LIMITS

PLASTIC LIMITS _____ LIQUID LIMITS

LIMITS

LIMITS

HYDRAULIC CONDUCTIVITY log K

LOCATION:

DARTMOUTH, NS

EASTING:

5570402.39

NORTHING:

4949922.41

GROUND ELEVATION:

11.75 m

GW. SEEPAGE ELEVATION:

1.52

EXCAVATOR	
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CAT 320

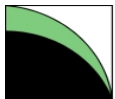
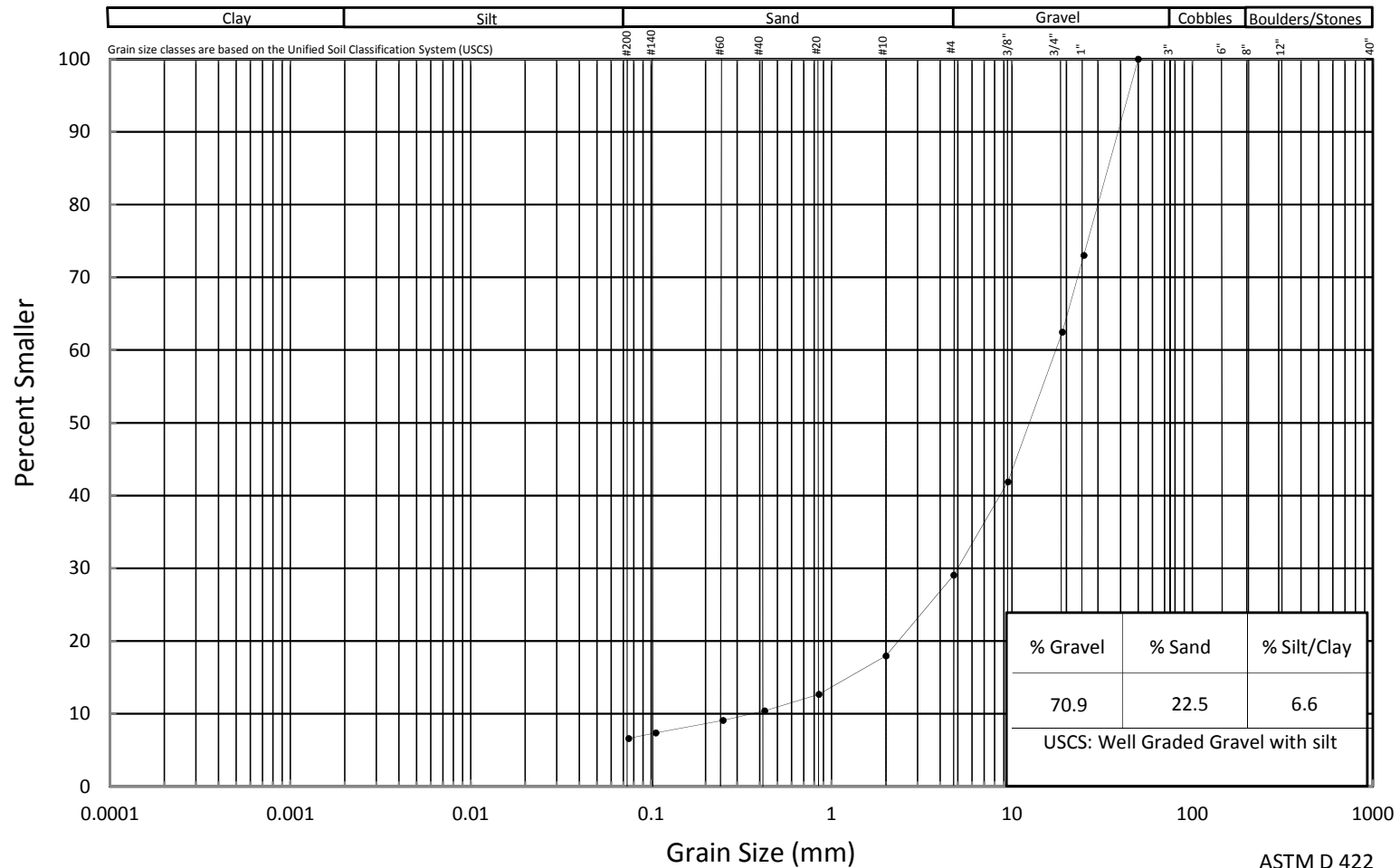
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SM

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APPENDIX B

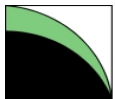
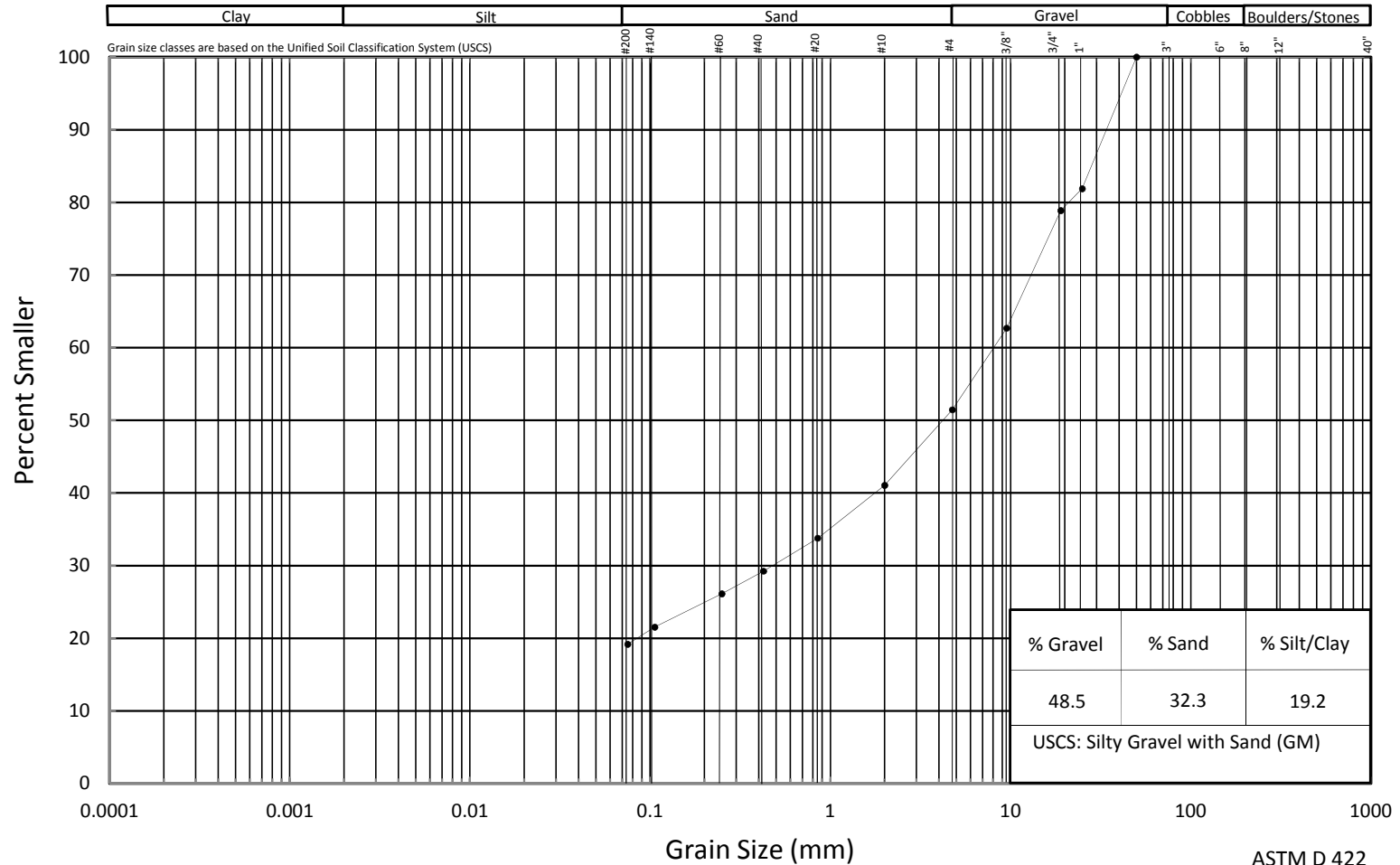
Grain Size Analysis - TP1, GS1 (0.30 m depth)



TerrAtlantic
Engineering Limited

ASTM D 422
Grain Size Analyses
444.57 October 15, 2012
BIO Buoy Maintenance Area

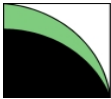
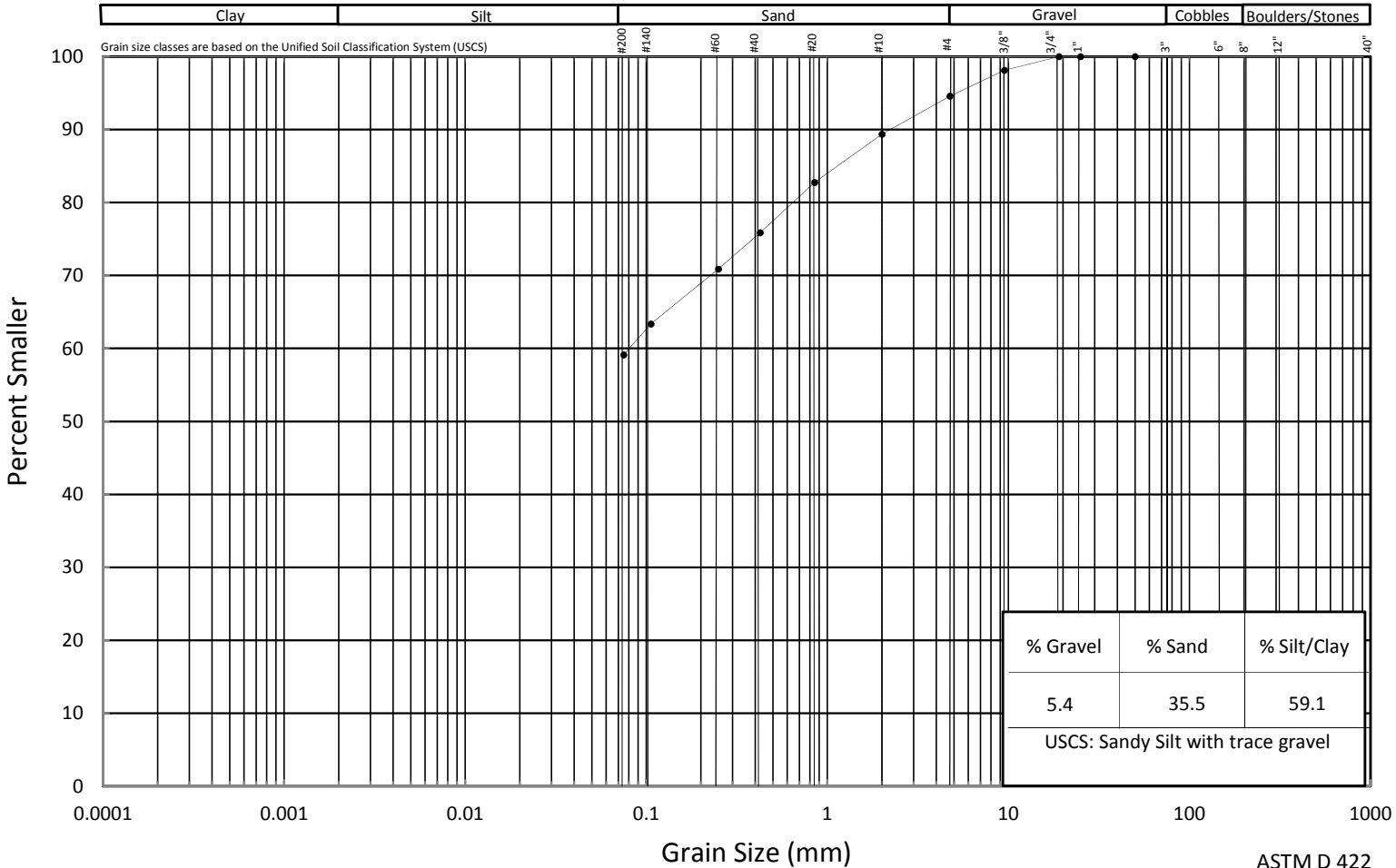
Grain Size Analysis on TP1, GS2 (0.60 to 0.90 m depth)



TerrAtlantic
Engineering Limited

ASTM D 422
Grain Size Analyses
444.57 October 15, 2012
BIO Buoy Maintenance Area

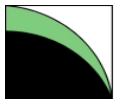
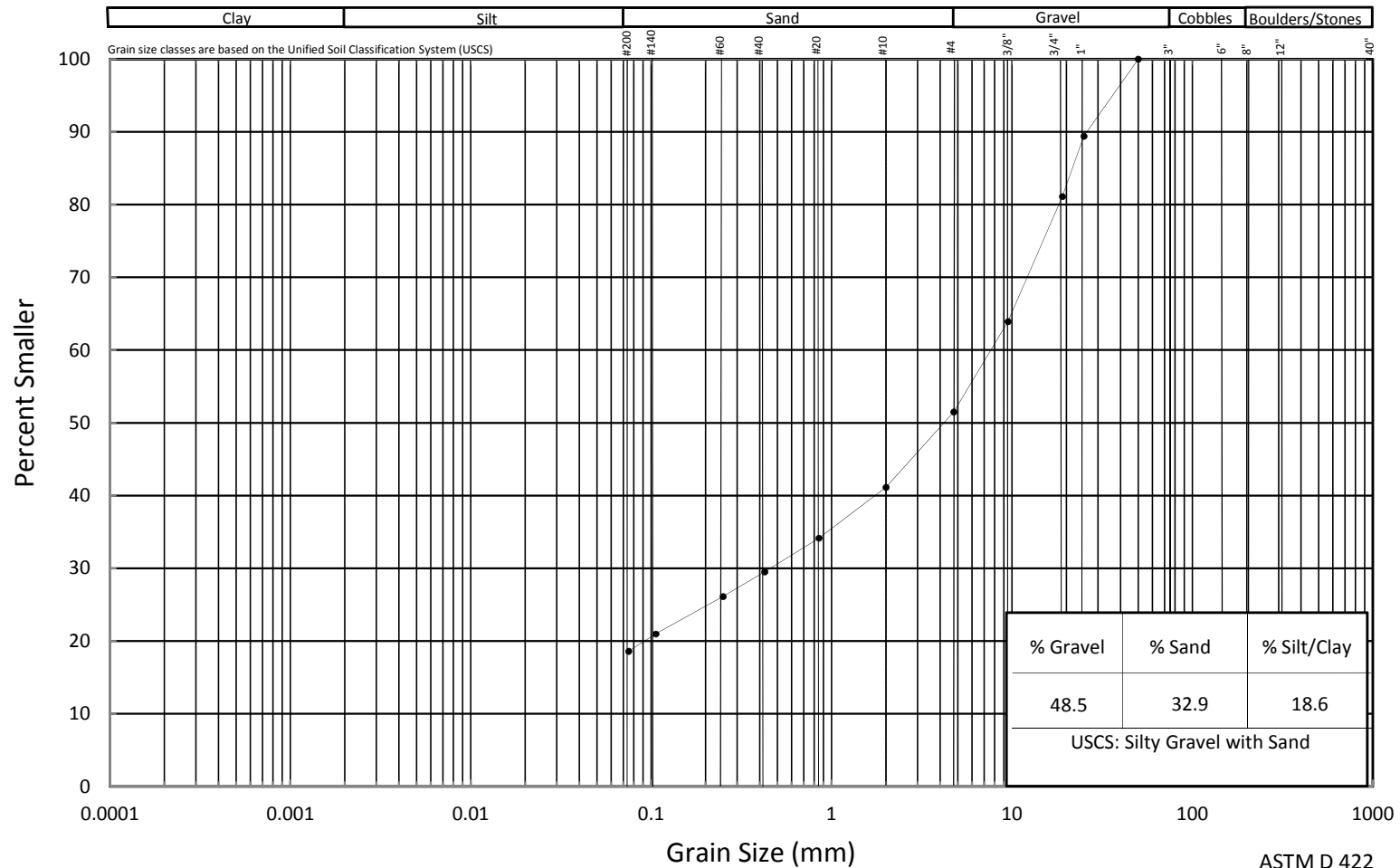
Grain Size Analysis - TP2, GS2 (2.4 to 2.7 m depth)



TerrAtlantic
Engineering Limited

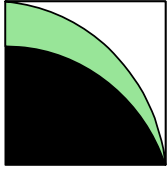
ASTM D 422
Grain Size Analyses
444.57 October 15, 2012
BIO Buoy Maintenance Area

Grain Size Analysis - TP4, GS1 (0.6 to 0.9 m depth)



TerrAtlantic
Engineering Limited

ASTM D 422
Grain Size Analyses
444.57 October 15, 2012
BIO Buoy Maintenance Area



TerrAtlantic

Engineering Limited

34 Trider Crescent
Dartmouth, Nova Scotia, B3B 1R6

tel: (902) 481-0008 fax: (902) 481-0012

February 22, 2013

File: 444.57

Chris Kingsland, P. Eng.
CBCL Limited
1489 Hollis Street
PO Box 606
Halifax, NS B3J 2R7

Dear Chris,

**RE: GEOTECHNICAL INVESTIGATION
PROPOSED BIO BUOY STORAGE AND MAINTENANCE AREA
DARTMOUTH, NOVA SCOTIA**

We have enclosed a copy of our report on the geotechnical investigation for the proposed Buoy Maintenance Area located at the Bedford Institute of Oceanography (BIO).

Please contact the undersigned for any clarification of the report or if we can otherwise be of further assistance.

Sincerely,

SCOTT M. MUNRO, M.SC.E., P. ENG
MANAGER, NS OPERATIONS
GEOTECHNICAL ENGINEER

***GEOTECHNICAL INVESTIGATION
PROPOSED BIO BUOY STORAGE
AND MAINTENANCE AREA
DARTMOUTH, NOVA SCOTIA***

A report prepared for

CBCL Limited

by

TerrAtlantic Engineering Limited



TerrAtlantic
Engineering Limited

File: 444.57
Date: February 22, 2013

GEOTECHNICAL INVESTIGATION, PROPOSED BIO BUOY STORAGE
AND MAINTENANCE AREA, DARTMOUTH, NOVA SCOTIA

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GEOTECHNICAL INVESTIGATION, PROPOSED BIO BUOY STORAGE
AND MAINTENANCE AREA, DARTMOUTH, NOVA SCOTIA

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GEOTECHNICAL INVESTIGATION, PROPOSED BIO BUOY STORAGE AND MAINTENANCE AREA, DARTMOUTH, NOVA SCOTIA

1.0 INTRODUCTION

TerrAtlantic Engineering Limited was retained by CBCL Limited to carry out a geotechnical investigation for the proposed BIO Buoy Storage and Maintenance Area located at the Bedford Institute of Oceanography (BIO), in Dartmouth, Nova Scotia. The purpose of the investigation was to characterize the subsurface soil, bedrock and groundwater conditions at the site and to provide recommendations for the design and construction of a laydown area, access road and related infrastructure. The results from a preliminary test pit investigation were presented in a TerrAtlantic report dated October 17, 2012. The findings of the preliminary investigation as well as those from the present expanded study have been included in the present report.

2.0 SITE DESCRIPTION

2.1 Site location, topography and drainage

The BIO property is located in Dartmouth, Nova Scotia, approximately 300 metres northwest of the northern abutment of the A. Murray MacKay Bridge. The approximately 70 m by 130 m investigated area is located at the northern end of the BIO facility and is accessed by Baffin Blvd. The site is bordered by DND property (Canadian Forces Ammunition Depot) to the north, a gravel parking area to the east, Discovery Drive to the south and a Canadian Coast Guard building to the west. An approximately 10-m-high embankment slopes upwards from the eastern site boundary providing separation between the investigated area and the gravel parking area. A 3-m-high boulder wall is located between the investigated area and the Canadian Coast Guard building to the west.

The site is currently being used as a laydown area for small water craft, sea cans, trailers, etc. The presence of several debris piles in the southern portion of the site suggest that this area has historically been used for the stockpiling of debris. The site grade slopes downwards from east to west with drainage primarily via an east-west trending cross culvert beneath the middle of the site.

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Runoff from the eastern slope is collected by means of a french drain at the base of the slope.

2.2 *Surficial geology*

The Surficial Geology Map of Nova Scotia describes the overburden in the area as "Stony Till Plain (ground moraine)", consisting of a "stony, sandy matrix, material derived from local bedrock sources".¹ This till unit is described as a basal till unit, being deposited from the base of an ice sheet by melting.

2.3 *Bedrock geology*

The geological mapping indicates that bedrock in the area comprises quartzite from the Goldenville Formation. The Goldenville Formation forms the lower part of the Meguma Group and is made up of Cambrian age rock, predominantly sandstone turbidites and minor slate with some schist and gneiss. The mapping describes the unit as "sandstone turbidites and slate: continental rise prism (in places metamorphosed to schist and gneiss)".²

3.0 METHODOLOGY

3.1 *Field Investigations*

As discussed in Section 1.0, a preliminary test pit investigation was conducted on September 25th, 2012, the results of which were reported on October 17, 2012. Additional test pitting and drilling investigation were conducted on February 2nd, 3rd and 6th, 2013. In total, the field work included the excavation of twenty four (24) test pits, the drilling of two (2) rock probes and one (1) borehole.

¹ Surficial Geology Map of the Province of Nova Scotia. R. R. Stea, H. Conley and Y. Brown, 1992. NSDNR Map ME 1992-3. Scale 1:500 000. Digital Geoscience Data Product DP ME 36, Version 2, 2006.

² Geological Map of the Province of Nova Scotia. J. D. Keppie, 2000. NSDNR Map ME 2000-1. Scale 1:500 000. Digital Geoscience Data Product DP ME 43, Version 2, 2006.

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The location of each exploratory hole is shown in Figure 1.

3.1.1 Test Pits

A total of twenty four (24) test pits were excavated at the site. Each test pit was excavated by means of a tracked excavator (CAT 320) to a maximum depth of 4.9 m (or refusal on inferred bedrock) under the supervision of TerrAtlantic personnel. The subsurface conditions were recorded and representative soil samples were taken of the various strata encountered. Upon completion, the test pits were backfilled with the excavated material and lightly compacted.

3.1.2 Rock Probes

Two (2) rock probes were drilled adjacent, and to the north of the existing Canadian Coast Guard (CCG) building. Rock probes were drilled using a conventional geotechnical drill rig, under the supervision of TerrAtlantic personnel. The rock probes were drilled for the purposes of estimating bedrock depth in the area. Each of the rock probes was advanced to refusal using flight augers. The depth of the rock probes RP1 and RP2 was 1.7 and 3.8 m, respectively.

3.1.3 Boreholes

One (1) borehole was drilled at the top of the fill slope in the eastern parking area in order to observe the type and nature of the fill slope material, embankment subgrade and groundwater situation. This information was later used to assess the current stability of the slope. Drilling services were provided by Logan Geotech under the supervision of TerrAtlantic professional staff.

The borehole was advanced to a depth of 10.4 metres using 100 mm diameter solid-stem augers. Where possible, soil samples were taken by means of a 50 mm diameter split-spoon sampler while performing Standard Penetration Tests (SPT). The SPT or N-Value is the number of blows required to drive the split-spoon sampler 300 mm into the soil using a standard fall-height and weight.

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N-values provide an indication of relative density, and can also be used to estimate other soil parameters.

In general, the fill material was too coarse for split spoon sampling and coring (NQ size - 47.6 mm diameter) was required to advance the borehole.

Following completion of the borehole, a plastic standpipe was installed to estimate the groundwater level at this location.

3.2 *Surveying*

Exploratory holes were laid out in the field by TerrAtlantic Engineering Limited with the use of a handheld GPS unit (Garmin model GPSMAP 62s). Final (as built) borehole, test pit and rock probe locations were provided by CBCL Limited, interpolated from an existing topographic survey.

3.3 *Laboratory Testing*

Soil samples recovered from drilling operations were taken back to TerrAtlantic's Dartmouth laboratory for further analysis and classification. Soils were classified based on ASTM 2487-00 - *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System (USCS))*. Conventional laboratory tests were conducted in accordance with the latest editions of applicable American Society for Testing and Materials (ASTM) standards and recognized good practice. These tests included: moisture content determinations and sieve analyses. Selected bedrock samples were also submitted to Dal Minerals Engineering Centre for total sulphur content analysis.

4.0 SOIL, ROCK AND GROUNDWATER CONDITIONS

The subsurface soil, bedrock and groundwater conditions are quite variable over this site. There

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exist deep fills overlying organics, till and bedrock and thin fills overlying, till and shallow bedrock. For more details on the subsurface soil, bedrock and groundwater conditions encountered, refer to the following paragraphs, test pit and borehole logs presented in Appendix B.

TABLE 1 - SUMMARY OF SOIL, BEDROCK AND GROUNDWATER CONDITIONS, TEST PITS

Test Pit	Ground Elevation (m)	Gravel Thick. (m)	Fill Thick. (m)	Boulder & Peat Thick. (m)	Organics, Grubbings Thick. (m)	Silty Sand Thick. (m)	Elevation of Till surface (m)	Elevation of Bedrock surface (m)	Water Seepage Depth (m)
TP1	12.21	0.25	1.78	1.37	-	-	8.81	<8.73	1.7 and 2.6
TP2	12.20	0.25	1.37	0.82	-	-	9.76	<9.36	2.0
TP3	11.76	-	0.25	-	-	-	11.51	<9.02	2.0
TP4	12.21	-	2.21	-	-	-	10.00	8.86	-
TP5	10.93	-	2.21	-	>2.36	-	<6.36	<6.36	4.0
TP6	11.27	0.30	>4.58	-	-	-	<6.39	<6.39	2.7
TP7	11.51	0.41	2.13	-	0.15	0.45	8.37	<7.85	-
TP8	11.86	0.40	0.82	-	-	-	10.64	9.12	-
TP9	11.76	0.36	1.64	-	-	0.31	9.45	<8.81	-
TP10	11.47	0.20	3.20	-	>1.48	-	<6.59	<6.59	-
TP11	11.75	-	0.30	-	-	-	11.45	9.92	1.5
TP12	22.27	0.10	>2.95	-	-	-	<19.22	<19.22	-
TP13	21.85	-	3.56	-	-	0.10	<18.19	<18.19	-
TP14	21.77	0.08	2.97	-	-	-	<18.72	<18.72	-
TP15	21.46	0.05	3.00	-	-	-	<18.41	<18.41	-
TP16	18.98	0.40	0.51	-	-	-	18.07	17.78	-
TP17	15.63	0.45	-	-	-	0.20	14.98	14.73	2.8
TP18	13.30	0.20	-	-	-	-	13.10	12.74	-
TP19	11.87	0.28	-	-	-	-	11.59	10.65	1.0
TP20	9.02	0.10	0.71	-	-	-	-	8.21	1.1

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TP21	5.72	0.05	-	-	-	-	5.67	4.53	-
TP22	11.20	0.30	3.36	-	-	-	-	7.54	2.44
TP23	11.28	-	2.29	-	-	0.31	8.68	<8.23	-
TP24	11.91	0.41	1.92	-	-	-	9.58	<9.17	-

TABLE 2 - SUMMARY OF SOIL, BEDROCK AND GROUNDWATER CONDITIONS, BH1, RP1 AND RP2

Rock Probe/ Borehole	Ground Elevation (m)	Fill Thick. (m)	Elevation of Till surface (m)	Depth to Bedrock (m)	Inferred Bedrock Elevation (m)	Water Depth (m)	Comments
BH1	21.44	5.94	15.50	>10.36	<11.08	>5.2	Standpipe blocked at 5.2 m depth. No water encountered
RP1	5.16			1.67	3.49	0.80	Refusal on inferred bedrock or large boulder at 1.67 m
RP2	5.52			>3.81	<1.71	1.02	Bedrock not encountered to 3.81 m depth

4.1 Soil Conditions

4.1.1 Gravel [Fill]

Grey gravel fill, typically ranging in thickness from 50 to 450 mm was encountered in approximately 75 percent of the exploratory holes. The gravel generally comprised well graded gravel with silt and sand. The moisture content of two samples of the gravel fill were evaluated and ranged from 3.6 to 3.9%.

One grain size analysis was conducted on a sample of the gravel fill. That sample comprised 71%

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gravel, 22% sand and 7 silt/clay sized particles. Based on the gradation, the majority of the gravel fill likely originated as NSTIR Type 2 fill. A visual assessment of samples of the thin gravel layer encountered in TP12, TP14 and TP15 suggest that this material is likely representative of NSTIR Type 1 fill.

4.1.2 Re-worked Till [Fill]

Grey-brown, re-worked till fill was encountered in approximately 80 percent of the exploratory holes. Gradationally speaking this material appears to be representative of the native till in the area and very likely originated from a nearby source.

The gradations of five (5) samples of re-worked till were assessed (Appendix C). The gradation ranges were 20 to 49 percent gravel, 32 to 42 percent sand and 18 to 37 percent silt/clay size particles. The fines proved to be non-plastic suggesting that the fine grained portions of these samples were primarily of silt size as opposed to clay. Frequent cobbles and boulders were also encountered within this material. Based on the Unified Soil Classification System (USCS), the re-worked till is described as silty gravel with sand to silty sand with gravel. The moisture content of the re-worked till ranged from 8 to 21 percent.

4.1.3 Boulders and Peat

A layer of boulders intermixed within a peat/organic matrix was encountered beneath the fill in test pits, TP1 and TP2, at the eastern edge of the laydown area. This layer was observed at a depth ranging from 1.6 to 2.0 m and ranged in thickness from 0.8 to 1.4 m.

4.1.4 Organics and Grubbings

A thick organic/grubbings layer was encountered in test pits TP5 and TP10, towards the southwestern portion of the site. This layer was observed at a depth ranging from 2.2 to 3.4 m and

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was found to be more than 1.5 metres thick in TP10 and more than 2.4 metres thick in TP5. Three additional test pits (TP22, TP23 and TP24) were excavated in this area in order to better delineate the extent of the organics. No organics were encountered in these test pits.

4.1.5 Glacial Till

Grey-brown, silty gravel with sand to sandy silt with gravel till was encountered in approximately 60 percent of the exploratory holes at depths ranging from 0.2 to 3.4 metres. Occasional to frequent cobbles and boulders were also observed within this unit.

Gradation analyses of two (2) samples were performed (Appendix C). The gradation ranges of these samples were 5 to 42 percent gravel, 35 to 39 percent sand and 18 to 59 percent silt/clay size particles. The fines were found to be non-plastic. The moisture content of this material generally ranged from 7.9 to 12.3 percent. Based on visual observation during test pitting and on limited borehole SPT data, the relative density of the till appeared to range from compact to very dense. This suggests that the till is of lodgement origin having been consolidated under the weight of glacial ice.

In approximately 20% of the exploratory holes, the upper 0.1 to 0.45 metres of the till was significantly looser than the underlying till and had significantly higher natural moisture content in the range of 19 to 21%. This, orange-brown surficial layer is believed to represent natural weathering of the underlying lodgement till, possibly the results of frost action. The gradation of one sample of this weathered till was evaluated and comprised 20% gravel, 70% sand and 10% silt/clay sized particles.

4.2 Bedrock

Bedrock was inferred in approximately 40 percent of the exploratory holes. Where encountered, the depth to bedrock ranged from 0.6 m to 3.7 m. The bedrock generally comprised slightly

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weathered, good to excellent quality quartzite which was consistent with the available geological mapping (refer to Section 2.3). The bedrock depth appeared to be highly variable throughout the site, even within many of the test pits (e.g. TP8, TP11, TP16 and TP17). Exposed bedrock outcrops were frequently observed throughout the BIO property.

Two samples of quartzite bedrock were submitted for Total Sulphur analyses. The results of these tests are presented in Table 3 below.

TABLE 3 - TOTAL SULPHUR CONTENT ON SELECT SAMPLES OF QUARTZITE BEDROCK

Test Pit No.	Depth of Sample (m)	Total Sulphur (%)
TP18 G1	0.6	0.015
TP20 G1	0.8 to 1.1	0.016

4.3 Groundwater conditions

Groundwater seepage was observed in approximately 40 percent of the test pits. The depth of seepage ranged from 1.0 to 4.0 m below the ground surface. Seepage observations within test pits provide a useful indication of the presence of groundwater but should not be relied upon for accurate groundwater elevations. Groundwater levels will vary from one season to the next, and may be higher than those indicated, especially during wetter periods.

5.0 GEOTECHNICAL DESIGN AND CONSTRUCTION RECOMMENDATIONS

For the purposes of this discussion, the geotechnical scope of work has been subdivided into four separate tasks:: 1) access road; 2) laydown area; 3) slope stability; and 4) utility trenches. Each are discussed in turn below.

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5.1 Access Road

The proposed access road into the laydown area starts at the intersection of Discovery Drive and Hudsons Way and trends northwards for a distance of approximately 140 metres. It then turns sharply to the west and trends downwards over a distance of approximately 240 metres towards the laydown area. It is understood that the access road is to be designed to accommodate “lowboy” trailers and semi-trailers.

5.1.1 Site Grading and Subgrade Preparation

The gravel, grass, rootmat and fill should be removed down to the desired subgrade elevation. Following removal, the subgrade should be proof-rolled with a loaded tandem truck under the supervision of qualified geotechnical personnel. Any soft areas, or poor subgrade conditions encountered should be over-excavated and replaced with a suitable thickness of engineered fill (150 mm minus or other approved material). Due to the frequency of boulders encountered over much of the site it is recommended that a geotextile be placed above the subgrade to prevent the migration of fines into underlying layers.

Engineered fill, compacted and placed to 98 % of maximum Standard Proctor dry density, should be used to raise grades where required. Engineered fill may consist of site fill or imported fill, and shall be approved by the geotechnical consultant prior to utilization. All fill materials should be free of deleterious substances (organics, debris, soft soils), and boulders larger than 200 mm.

Subbase and base materials should consist of NSTIR (Nova Scotia Transportation and Infrastructure Renewal) Type 1 and Type 2 material. The physical properties of the Type 1 and Type 2 gravels should be in accordance with NSTIR Standard Specifications. The gravels should be compacted to at least 100% of the maximum Standard Proctor dry density.

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5.1.2 Rock Excavation

It is understood that a series of road profiles are being considered for the access road with envisaged maximum cuts ranging between 1.0 m and 3.0 m (deeper excavations may be required for utility trenches). Some excavation of bedrock will almost certainly be required in order to achieve the final design grades.

Small quantities of the quartzite bedrock may be removed with an excavator mounted rock breaker. This approach may not be practical for deeper cuts where blasting would likely be required.

Water seepage was observed in three of the test pits excavated along the proposed access road, those being TP17 (at 2.8 m), TP19 (at 1.0 m) and TP20 (at 1.1 m). Depending on the depths of the proposed cuts, it is anticipated that some dewatering may be required. Diversion of water away from work areas via drainage swales or french drains is recommended. Pumping from sump pits excavated below the work areas may also be required.

5.2 Buoy Laydown Area - Storage, Chain Inspection, Loading/Unloading, Washdown

The proposed 70 m by 130 m laydown area is understood to consist of a chain inspection area, a forklift loading/unloading area, a buoy washdown area and storage for approximately 80 buoys. The soil conditions encountered at the existing laydown area generally comprise an extensive layer of fill placed above till, and bedrock. In some areas (e.g. TP1, TP2, TP5 and TP10), the fill is underlain by a very loose layer of peat and boulders.

5.2.1 Poor Subsoils

The organic soils encountered in TP1, TP2, TP5 and TP10 should not be considered as a suitable subgrade for building foundations, concrete pads or asphaltic or concrete pavement. Where these types of structures are envisaged, all fill material, peat and organic layers should be removed down

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to undisturbed till and should be replaced with engineered fill. In some areas, very little sub-excavation may be required. However, in other areas, between 2.5 m and more than 5 m of excavation may be required.

The suitability of the existing fill, peat and organic soil layers to remain beneath proposed, unpaved laydown facilities will depend largely on the magnitude of settlement which is deemed acceptable by the design team. It is likely that the fill, organics and peat layers are currently undergoing primary consolidation and creep settlement. This settlement is likely to continue and would be exacerbated by the addition of material or other sources of additional load. However, if the laydown areas are to remain unpaved, then presumably surface settlement in these areas may not be considered a major concern. The added maintenance cost associated with this settlement (routine grading etc.) would likely be very small when compared to the cost of sub-excavation and replacement of the poor quality material.

5.2.2 Subgrade Preparation

It is understood that two options are being considered for grading of the laydown area. The first option would be to place an approximately 0.5-metre-thick layer of fill over the entire site. This layer would be as thick as 2.0 metres on the west side and would taper off towards the eastern side of the site. The second option would consist of re-grading the existing surface to promote drainage to specific areas of the site. This option would promote the use of existing grades (where possible) and would require the raising or lowering of site grades by up to 1.0 m in places.

Prior to conducting grading operations, the granular material encountered at the surface of the laydown area (identified as NSTIR Type 2) should be stripped and stockpiled for later re-use as engineered fill. The debris piles located on the south side and northeastern corner of the site as well as any other deleterious materials (organics, large boulders, etc.) should be removed and discarded as waste. Once completed, the surface of the laydown area can be graded to the desired levels (i.e. subgrade), either by sub-excavation or through placement of engineered fill.

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Engineered fill may consist of existing stockpiled site fill (gravel or silty gravel with sand) or imported material capable of achieving the required compaction criteria (98% of Standard Proctor dry density). If site material is to be used as engineered fill, all boulders larger than 200 mm should be removed prior to placement. In some areas, the natural moisture content of the fill is exceedingly high and as a result the material would need to be dried out to achieve the desired compaction criteria. In that case, it may be more practical to waste the material depending on the weather at the time of construction. All materials should be approved by the geotechnical consultant prior to their use.

Subbase and base materials should consist of NSTIR (Nova Scotia Transportation and Infrastructure Renewal) Type 1 and Type 2 gravel. The physical properties of the Type 1 and Type 2 gravels should be in accordance with NSTIR Standard Specifications. The gravels should be compacted to at least 100% of the maximum Standard Proctor dry density.

5.3 Slope Stability

A slope stability analysis was carried out on a representative cross section of the eastern slope, extending from borehole BH1 at the top of the slope to the area between TP1 and TP2 at the base of the slope. The stratigraphy in this area comprised coarse granular re-worked till fill above dense lodgement till. A layer of peat and boulders was encountered at the base of the slope. No groundwater was encountered within the fill layer and, for the analyses, it was assumed that the static groundwater level was at the surface of the till.

The cross section of the slope was analyzed firstly under existing conditions (Figure D1) and secondly after the slope had been cut back to 1V to 2.5H (Figure D2). The existing slope fill appeared to have been placed in a loose fashion, perhaps having been “tail-dumped” from the parking area above. If so, it may be reasonable to assume that this material currently rests at its

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natural angle of repose, the Factor of Safety being unity³. Given the slope geometry and subsurface stratigraphy at this location, the shear strength parameters of the fill corresponding to a Factor of Safety $F=1$ would be Φ' (angle of internal shearing resistance) = 32° and c' (cohesive intercept) = 0⁴. These values are believed to be very reasonable for this type of re-worked, stony till.

Based on these analyses, were the slope were to be cut back to 1V to 2.5H, the Factor of Safety would increase from $F=1$ to $F=1.55$ (Figure D2). Typically a Factor of Safety of $F>1.5$ is acceptable for the long term stability of an embankment slope. The extent of the organic layer encountered in test pits TP2 and TP3 is unknown. Based on the overall site topography, it is thought to be unlikely that it would extend further into the slope than as shown in Figures D1 and D2. If that were the case, the presence of the organics do not appear to effect the stability of the slope.

Because the critical failure surface appears to be localized to the re-worked fill material, and assuming that this material derives its strength entirely from interparticle friction (i.e. $c'=0$), the Factor of Safety can be calculated from the following equation:

$$F = \tan\Phi' / \tan\alpha$$

where α is the angle of the slope.

For example, for $\Phi'=32^\circ$ and $\tan\alpha = 0.4$ (i.e. 1V to 2.5H), the Factor of Safety $F=0.62/0.4 = 1.55$. For a slope of 1V to 2H, the corresponding Factor of Safety $F=1.24$.

It should be noted that the analyses presented herein do not account for additional loading to the top of the slope. The impact of such loading would need to be assessed if, for example, additional load from vehicular traffic or the addition of fill near the top of the slope were to be anticipated.

³ $F = \Sigma \text{resisting forces} / \Sigma \text{driving forces}$

⁴ $c'=0$ is typical for granular soils such as these

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Due to the amount of erosion observed on the existing slope, it is recommended that the finished surfaces of the newly constructed slope be protected from erosion. This might include (but is not limited) to the following: 1) topsoil and hydro-seed/sod, 2) rip-rap or granular fabric, 2) geotextile reinforced slope in combination with topsoil and sod.

5.4 *Utility Trenches*

All trenches should conform to the requirements of the Nova Scotia Occupational Health and Safety Act and Regulations (Part 14 - Excavations and Trenches, section 166 to 173). Trenches should be backfilled in accordance with applicable standards (i.e. Halifax Regional Municipality Standard Specifications). For deep excavations cut into the overburden, trenches deeper than 1.2 m shall be supported by some means of shoring/bracing or sloped such that a person can safely enter the trench. Temporary side slopes within the overburden should be cut back to slopes of 1.5 horizontal to 1 vertical. If wet conditions are encountered within the slopes/side walls of the excavation, shallower slopes will be required.

It is possible that drainage pipes will be cut into bedrock. The stability of rock slopes is dependant on the fracture orientation, the orientation of the excavation, the type of rock and on the height of the groundwater table. If the walls or crests of a trench are cut into rock, rock bolts, wire mesh, or other means of protection will be required. At the interface between the overburden and bedrock, a 1.5 m bench is recommended to prevent loose debris/material from falling into the trench. A geological engineer should be consulted at the onset of construction, once bedrock has been exposed, in order to better assess the structural nature of the bedrock jointing/fracture system.

The material surrounding the pipe should be placed in lifts not exceeding 150 mm and compacted to 95% of the maximum Standard Proctor dry density in accordance with ASTM D698. This material should not be placed in trenches having soft, unstable bottom conditions. If soft, unstable conditions exist at the bottom of the trench, soft material should be removed and replaced with an appropriate thickness of compacted rock fill (150 mm minus) to stabilize the base.

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Placement of material surrounding the pipe should be carried out such that the pipe is backfilled equally on both sides at the same time. General fill may be placed above the pipe zone material up to the defined subgrade in lifts not exceeding 200 mm and compacted to 95% of the maximum Standard Proctor dry density. Compaction equipment for pipe bedding should be sized so as not to cause damage to the pipe (e.g. plate tamper).

6.0 CLOSURE

The data presented here reflect the findings determined at the specific exploratory hole locations. Should conditions encountered during construction materially differ from those described here, we request the opportunity to examine such conditions and review the findings presented in this report.

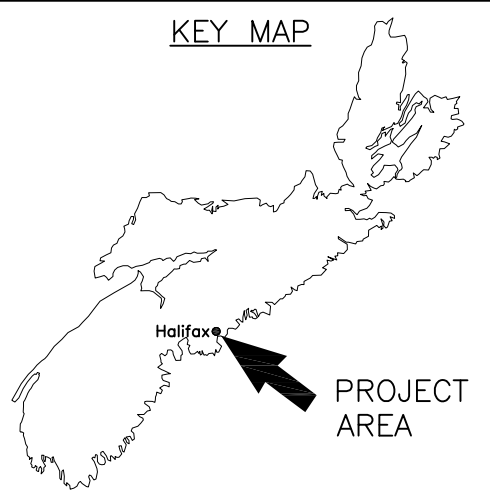
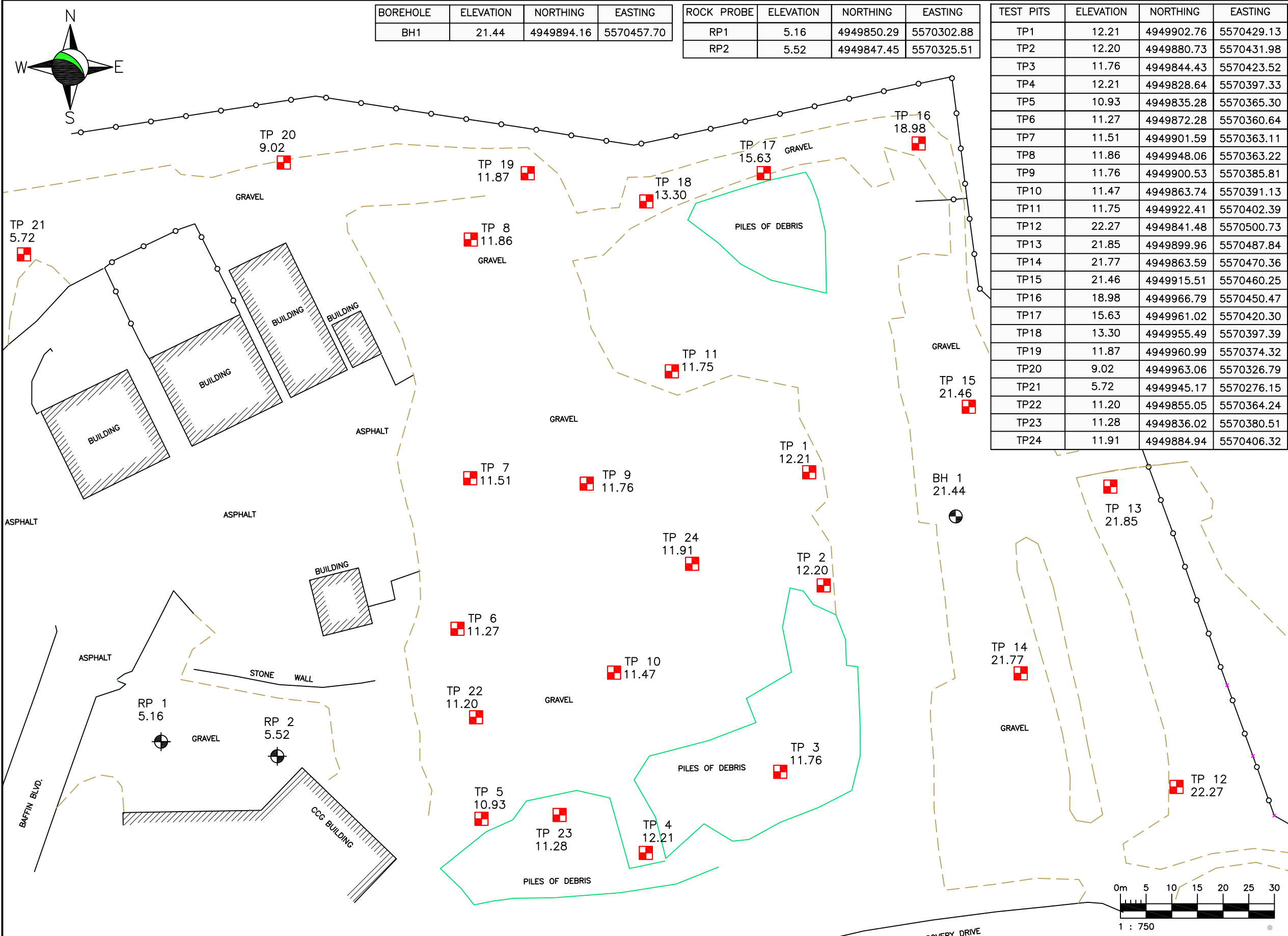
This report was prepared by Scott Munro, M.Sc.E., P.Eng., and reviewed by Simon Dickinson, Ph.D., P.Eng.



SCOTT M. MUNRO, M.SC.E., P. ENG
MANAGER, NS OPERATIONS
GEOTECHNICAL ENGINEER

APPENDIX A

FIGURE 1 - TEST PIT, BOREHOLE AND ROCK PROBE LOCATION PLAN



- NOTES**
- ALL UNITS ARE IN METERS
 - ELEVATIONS ARE BASED ON CANADIAN GEODETIC VERTICAL DATUM AND REFER TO NS COORDINATE MONUMENT No. 5542: ELEV. 30.227 METERS
 - TEST PITS, BOREHOLE AND ROCK PROBES WERE COMPLETED ON SEPTEMBER 25, 2012, FEBRUARY 2 and 3, 2013

- LEGEND**
- TEST PIT
 - BOREHOLE
 - ROCK PROBE
 - FENCE
 - BUILDINGS
 - GRAVEL
 - PILES OF DEBRIS

FIGURE 1
GENERAL SITE PLAN

TEST PIT, BOREHOLE AND ROCK PROBE LOCATIONS – BIO BUOY MAINTENANCE AREA

SCALE: 1:750	DRAWN BY: DO
DATE: FEB 13, 2013	CHECKED BY: SM
DWG. NO. 4445701	PROJECT NO. 444.57



APPENDIX B

TEST PIT AND BOREHOLE LOGS



TEST PIT LOG






STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP1

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2012 September 25
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
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LOCATION: DARTMOUTH, NS	EASTING:	NORTHING:	WATER CONTENT, % ×
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GROUND ELEVATION: 12.21	GW. SEEPAGE: 2.59	EXCAVATOR CAT 320	LOGGED BY: SM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0	1	G	3.9		0.25m Gravel with silt and sand (NSTIR Type 2)	X											12.21
																	11.96
	2	G	10.9			X											
1					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered												
2	3	G	25.5		2.03m			X									10.18
					Boulders intermixed within a peat matrix (thickness varies from 0.8 m to 1.4 m within test hole)												9.62
3																	
					3.4m 3.48m Grey silty sand with gravel: TILL - Occasional cobbles												8.81 8.73
					END OF HOLE												
4					-Seepage observed at depths of 1.7 m and 2.6 m. -Seepage at 1.7 m is likely a result of adjacent french drain located at the toe of slope.												
5																	
6																	



TEST PIT LOG

CLIENT:
CBCL LIMITED

PROJECT NO.:
444.57

DATE EXCAVATED:
2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm² **■**

LOCATION:
DARTMOUTH, NS

EASTING: _____

NORTHING: _____

WATER CONTENT, % **×**

GROUND ELEVATION:
12.2


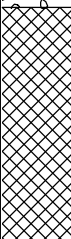


GW. SEEPAGE:
2.01

EXCAVATOR
CAT 320

LOGGED BY:
SM

ATTERBERG LIMITS

PLASTIC LIMITS **—** LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					0.25m Gravel with silt and sand (NSTIR Type 2)												12.20
					11.95												
	1	G	19.8		Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered												
1																	
	3	G	10.5														
					1.62m												10.58
					Boulders intermixed within a peat matrix												
2																	10.19
					2.44m												9.76
	2	G	7.9		Grey silty sand with gravel to sandy silt, trace gravel: TILL - Occasional cobbles												
					2.84m												9.36
3					END OF HOLE - Inferred bedrock ridge on south side of test pit, at a depth of 1.4 m (GS3) - Seepage observed at 2.0 m depth												
4																	
5																	
6																	

TEST PIT LOG

STATION:

EXPLORATORY HOLE NO.:

OFFSET:

TP3

Page 1 of 1

CLIENT:
CBCL LIMITED

PROJECT NO.:

DATE EXCAVATED:

444.57

2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm²

LOCATION:
DARTMOUTH, NS

EASTING:

NORTHING:

WATER CONTENT, %	
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X

GROUND ELEVATION:
11.76

GW. SEEPAGE:	1.98
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EXCAVATOR
CAT 320

LOGGED BY:	SM
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ATTERBERG LIMITS

PLASTIC LIMITS — LIQUID LIMITS

[illegible]



TEST PIT LOG

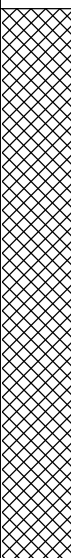
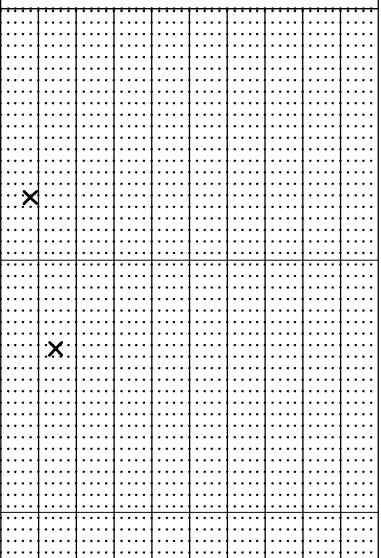
STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP4

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2012 September 25
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PROJECT:
BIO BUOY MAINTENANCE AREA

LOCATION: DARTMOUTH, NS	EASTING:	NORTHING:	POCKET PENETROMETER kg/cm ² ■
GROUND ELEVATION: 12.21	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SM

WATER CONTENT, % ×
ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
0					Brown to grey brown silty sand with gravel to silty gravel with sand : FILL - Occasional boulders and cobbles - Organics throughout - Debris encountered																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					



TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP5

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2012 September 25
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
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LOCATION: DARTMOUTH, NS	EASTING:	NORTHING:	WATER CONTENT, % ×
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GROUND ELEVATION: 10.93	GW. SEEPAGE: 3.96	EXCAVATOR CAT 320	LOGGED BY: SM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0																	10.93
1					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Frequent large boulders encountered												
2					2.21m												8.72
3					ORGANICS (roots, stumps, grubblings)												
4					4.57m												6.97
5					END OF HOLE - Seepage observed at 4.0 m depth												6.36
6																	



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP6

Page 1 of 1

CLIENT:
CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm²

■

LOCATION:
DARTMOUTH, NS

EASTING:

NORTHING:

WATER CONTENT, %

×

GROUND ELEVATION:

11.27

GW. SEEPAGE:

2.67

EXCAVATOR

CAT 320



LOGGED BY:

SM

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					Gravel with silt and sand (NSTIR Type 2)												11.27
				0.3m													10.97
1					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered												
2																	
3																	
4																	
5				4.88m	END OF HOLE												6.39
					- Pocket of organics from 2.4 to 3.1 m depth - Large boulder at 2.7 to 3.4 m depth - Refusal of excavator within fill, due to maximum reach of excavator - Seepage observed at 2.7 m												
6																	



TEST PIT LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

TP7

Page 1 of 1

CLIENT:
CBCL LIMITED

PROJECT NO.:

444.57

DATE EXCAVATED:

2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm²

■

LOCATION:
DARTMOUTH, NS

EASTING:

NORTHING:

WATER CONTENT, %

×

GROUND ELEVATION:
11.51

GW. SEEPAGE:


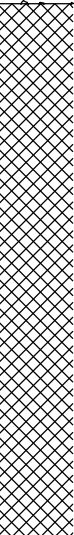

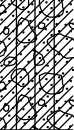
EXCAVATOR
CAT 320

LOGGED BY:
SM

ATTERBERG LIMITS

PLASTIC
LIMITS

LIQUID
LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres			
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90					
0					Gravel with silt and sand (NSTIR Type 2) 0.41m												11.51		
1	1	G	13		Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered 2.54m												8.97		
2	2	G	13.6																8.82
							ORGANICS												
3					Rust brown silty SAND with gravel 3.14m												8.37		
	3	G	9.5		Grey brown silty sand with gravel: TILL - Occasional cobbles 3.66m												7.85		
4					END OF HOLE - No seepage observed														
5																			
6																			



TEST PIT LOG

CLIENT:
CBCL LIMITED

PROJECT NO.:
444.57

DATE EXCAVATED:
2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm² **■**

LOCATION:
DARTMOUTH, NS

EASTING: _____

NORTHING: _____

WATER CONTENT, % **×**

GROUND ELEVATION:
11.86


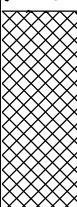
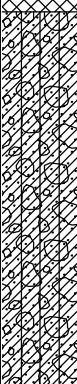
GW. SEEPAGE:
1.52

EXCAVATOR
CAT 320

LOGGED BY:
SM

ATTERBERG LIMITS

PLASTIC LIMITS **—** LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					Gravel with silt and sand (NSTIR Type 2)												11.86
					0.4m Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Occasional boulders - Organics throughout - Debris encountered												11.46
1					1.22m Grey brown silty sand with gravel: TILL - Occasional cobbles												10.64
2					2.74m END OF HOLE - Refusal of excavator on inferred Bedrock (bedrock depth varies from 2.1 to 2.7 m within test hole) - Seepage observed at 1.5 m depth												10.34
3																	
4																	
5																	
6																	9.12



TEST PIT LOG


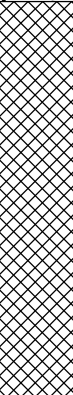


STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP9

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2012 September 25
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
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LOCATION: DARTMOUTH, NS	EASTING:	NORTHING:	WATER CONTENT, % ×
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GROUND ELEVATION: 11.76	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					Gravel with silt and sand (NSTIR Type 2) 0.36m												11.76
					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL - Frequent cobbles and boulders (large boulders from 1.8 m to 2.7 m) - Organics throughout - Debris encountered 2m												11.40
1																	
					Rust brown silty SAND with gravel 2.31m												9.76
2					Grey brown silty sand with gravel: TILL - Occasional cobbles 2.95m												9.45
					END OF HOLE - No seepage observed												8.81
3																	
4																	
5																	
6																	

CLIENT:
CBCL LIMITED

PROJECT NO.:

DATE EXCAVATED:	
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444.57

2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm²

LOCATION:
DARTMOUTH, NS

EASTING:

NORTHING:	
-----------	--

WATER CONTENT, %	STRENGTH, MPa
10	1.5
15	1.8
20	2.2
25	2.5
30	2.8
35	3.0
40	3.2
45	3.5
50	3.8
55	4.0
60	4.2
65	4.5
70	4.8
75	5.0
80	5.2
85	5.5
90	5.8
95	6.0
100	6.2

x

GROUND ELEVATION: 11.47

GW. SEEPAGE:	3.35
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EXCAVATOR
CAT 320

LOGGED BY:	SM
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ATTERBERG LIMITS

PLASTIC LIMITS — LIQUID LIMITS

[illegible]



TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP11

CLIENT:
CBCL LIMITED

PROJECT NO.:
444.57

DATE EXCAVATED:
2012 September 25

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm² **■**

LOCATION:
DARTMOUTH, NS

EASTING:

NORTHING:

WATER CONTENT, % **×**

GROUND ELEVATION:
11.75

GW. SEEPAGE:
1.52

EXCAVATOR
CAT 320

LOGGED BY:
SM

ATTERBERG LIMITS

PLASTIC LIMITS **—** LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					Brown to grey brown silty sand with gravel to silty gravel with sand: FILL												11.75
					0.3m												11.45
1					Grey brown silty sand with gravel: TILL - Occasional cobbles												10.23
					1.83m												9.92
2					END OF HOLE - Refusal of excavator on inferred Bedrock (bedrock ridge encountered at 1.5 m within test hole)												
3																	
4																	
5																	
6																	



TEST PIT LOG

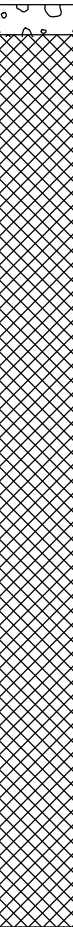
STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP12

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570500.73	NORTHING: 4949841.48	WATER CONTENT, % ×
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GROUND ELEVATION: 22.268	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90		
0					0.1m	Type 1 GRAVEL										22.27
																22.17
1																
2																
3					3.05m	END OF HOLE										19.22
4																
5																

TEST PIT LOG REV1 44457TP12-24.GPJ WELL LOGS.GDT 13/2/22



TEST PIT LOG

CLIENT:
CBCL LIMITED

PROJECT NO.:
444.57

DATE EXCAVATED:
2013 February 2

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm² **■**

LOCATION:
DARTMOUTH, NS

EASTING:
5570487.84

NORTHING:
4949899.96

WATER CONTENT, % **×**

GROUND ELEVATION:
21.848



GW. SEEPAGE:

EXCAVATOR
CAT 320

LOGGED BY:
SMM

ATTERBERG LIMITS

PLASTIC LIMITS **—** LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres			
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90					
0					0.1m GRASS / ROOTMAT												21.85 21.75		
	1	GS	21		Brown, silty SAND with gravel to silty gravel with sand - FILL - 75 mm gravel layer at 0.6 m depth - Frequent cobbles and boulders														
1																			
	2	GS	7.4																
2																			
3																			



TEST PIT LOG

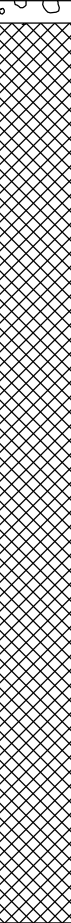
STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP14

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
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LOCATION: DARTMOUTH, NS	EASTING: 5570470.36	NORTHING: 4949863.59	WATER CONTENT, % ×
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GROUND ELEVATION: 21.769	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					0.075m Type 1 GRAVEL												21.77 21.69
	1	GS	7.7				×										
1							×										
	2	GS	6														
						Brown to grey-brown silty GRAVEL with sand to silty SAND with gravel - FILL - Frequent cobbles and boulders - Minor debris (rebar) - Large boulders at 1.2 m depth (approx 0.6m x 0.6m x 1.2m)											
2																	
	3	GS	11.6				×										
3					3.05m END OF HOLE												18.72
					- No seepage observed - Frost depth approx 0.9 m												
4																	
5																	



TEST PIT LOG

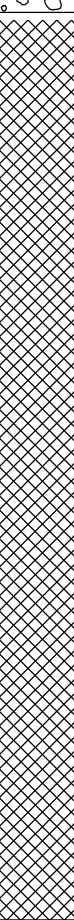
STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP15

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
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LOCATION: DARTMOUTH, NS	EASTING: 5570460.25	NORTHING: 4949915.51	WATER CONTENT, % ×
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GROUND ELEVATION: 21.463	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres		
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90				
0					0.05m Type 1 GRAVEL												21.46 21.41	
	1	GS	8.6		Brown to grey-brown silty GRAVEL with sand to silty SAND with gravel - FILL - Frequent cobbles and boulders - Minor debris (concrete)	x												
1																		
	2	GS	7.4			x												
2																		
	3	GS	8			x												
3					3.05m END OF HOLE												18.41	
					- No seepage observed													
4																		
5																		



TEST PIT LOG

CLIENT:
CBCL LIMITED

PROJECT NO.:
444.57

DATE EXCAVATED:
2013 February 2

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm² **■**

LOCATION:
DARTMOUTH, NS

EASTING:
5570450.47

NORTHING:
4949966.79

WATER CONTENT, % **×**

GROUND ELEVATION:
18.976








GW. SEEPAGE:

EXCAVATOR
CAT 320

LOGGED BY:
SMM

ATTERBERG LIMITS

PLASTIC LIMITS **—** LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres		
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90				
0					GRAVEL with silt and sand (NSTIR Type 2)													18.98
					0.405m													18.57
	1	GS	19.2		Orange-brown SAND with silt and gravel to silty SAND with gravel - occasional cobbles and boulders - trace roots			X										18.07
1	2	GS	8.2		Brown to grey-brown, silty GRAVEL with sand to silty SAND with gravel - TILL	X												17.78
					1.2m													
2					Grey, good to excellent quality, QUARTZITE: BEDROCK - Bedrock ridge encountered at 1.2 m depth - Bedrock drops off on west side of test pit down to 3.05m													
3					3.05m													15.93
					END OF HOLE													
					- Refusal of excavator at 3.05m on inferred bedrock. - No seepage observed													
4																		
5																		

TEST PIT LOG

STATION:

EXPLORATORY HOLE NO.:

OFFSET:

TP17

Page 1 of 1

CLIENT:
CBCL LIMITED

PROJECT NO.:

DATE EXCAVATED:

444.57

2013 February 2

PROJECT:
BIO BUOY MAINTENANCE AREA

POCKET PENETROMETER kg/cm^2

LOCATION:
DARTMOUTH, NS

EASTING:	5570420.30
----------	------------

NORTHING:	4949961.02
-----------	------------

WATER CONTENT, %

x

GROUND ELEVATION:	15.626
-------------------	--------

GW. SEEPAGE:	2.75
--------------	------

EXCAVATOR
CAT 320

LOGGED BY:	SMM
------------	-----

ATTERBERG LIMITS

PLASTIC LIMITS LIQUID LIMITS

[illegible]



TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP18

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570397.39	NORTHING: 4949955.49	WATER CONTENT, % ×
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GROUND ELEVATION: 13.301	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
------------------------------------	--------------	-----------------------------	--------------------------	--

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0	1	GS	3.6		0.2m GRAVEL with silt and sand (NSTIR Type 2)	✕											13.30
					Brown to grey-brown, silty GRAVEL with sand to silty SAND with gravel - TILL												13.10
	2	GS	8.2		0.56m - Frequent cobbles and boulders	✕											12.74
					END OF HOLE												
					- No seepage observed												
					- Refusal of excavator on inferred bedrock												
1																	
					</												



TEST PIT LOG


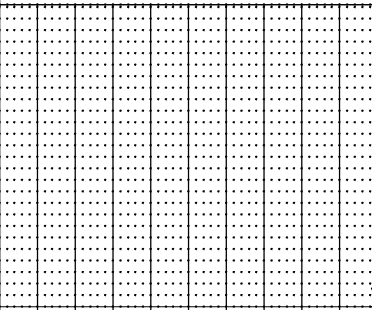

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP19

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570374.32	NORTHING: 4949960.99	WATER CONTENT, % ×
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GROUND ELEVATION: 11.867	GW. SEEPAGE: 1	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
------------------------------------	--------------------------	-----------------------------	--------------------------	--

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres		
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90				
0					GRAVEL with silt and sand (NSTIR Type 2)												11.87	
				0.28m													Brown to grey-brown, silty GRAVEL with sand to silty SAND with gravel - TILL - Frequent cobbles and boulders	11.59
1																		10.87
				1.22m														10.65
			END OF HOLE															
					- Seepage observed at 1.0m - Refusal of excavator at 1.22m on inferred bedrock													
2																		
3																		
4																		
5																		



TEST PIT LOG



STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP20

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
--------------------------------	-------------------------------	---

PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570326.79	NORTHING: 4949963.06	WATER CONTENT, % ×
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GROUND ELEVATION: 9.019	GW. SEEPAGE: 1.12	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
-----------------------------------	-----------------------------	-----------------------------	--------------------------	--

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					0.1m GRAVEL with silt and sand												9.02
					Brown, silty SAND with gravel to silty GRAVEL with sand - FILL - Frequent cobbles and boulders												8.92
					0.81m												8.21
1	1	GS			Inferred BEDROCK												7.900
					1.12m	END OF HOLE - Seepage observed at 1.12m - Refusal of excavator at 0.81 and 1.12m. Depth to bedrock varies.											
2																	
3																	
4																	
5																	



TEST PIT LOG

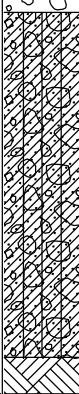
STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP21

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
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PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570276.15	NORTHING: 4949945	WATER CONTENT, % ×
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GROUND ELEVATION: 5.719	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
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DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90		
0					0.05m	GRAVEL										5.72
																5.67
1																
					1.19m											4.53
					1.31m	Refusal on inferred BEDROCK										4.41
					END OF HOLE											
					- No seepage observed											
2																
3																
4																
</																



TEST PIT LOG


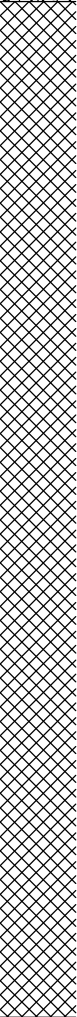
STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP22

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2013 February 2
--------------------------------	-------------------------------	---

PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570364.24	NORTHING: 4949855.05	WATER CONTENT, % ×
-----------------------------------	-------------------------------	--------------------------------	------------------------------

GROUND ELEVATION: 11.203	GW. SEEPAGE: 2.44	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS PLASTIC LIMITS LIQUID LIMITS
------------------------------------	-----------------------------	-----------------------------	--------------------------	--

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0					GRAVEL with silt and sand (NSTIR Type 2)												11.20
					0.3m												10.90
1																	
2					Brown to grey-brown, silty GRAVEL with sand to silty SAND with gravel - FILL - Frequent cobbles and boulders - Minor debris (roots, wood, etc)												
3																	8.76
					3.66m												7.54
4					END OF HOLE - Refusal of excavator on inferred bedrock or large boulder - Seepage observed at 2.44 m												
5																	



TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP23

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2012 February 3
--------------------------------	-------------------------------	---

PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570380.51	NORTHING: 4949836.02	WATER CONTENT, % ×
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GROUND ELEVATION: 11.283	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS	PLASTIC LIMITS	LIQUID LIMITS
------------------------------------	--------------	-----------------------------	--------------------------	------------------	----------------	---------------

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90			
0																	11.28
1																	
2																	
					2.29m												8.99
					Orange-brown, silty SAND with gravel - Occasional cobbles - Trace roots												
					2.6m												8.68
					Brown to grey-brown, silty GRAVEL with sand to silty SAND with gravel - TILL - Frequent cobbles and boulders												
3					3.05m												8.23
					END OF HOLE												
					- No seepage observed												
4																	
5																	



TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP24


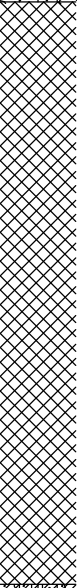
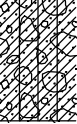
Page 1 of 1

CLIENT: CBCL LIMITED	PROJECT NO.: 444.57	DATE EXCAVATED: 2012 February 3
--------------------------------	-------------------------------	---

PROJECT: BIO BUOY MAINTENANCE AREA	POCKET PENETROMETER kg/cm ² ■
--	--

LOCATION: DARTMOUTH, NS	EASTING: 5570406.32	NORTHING: 4949884.94	WATER CONTENT, % ×
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GROUND ELEVATION: 11.914	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM	ATTERBERG LIMITS	PLASTIC LIMITS	LIQUID LIMITS
------------------------------------	--------------	-----------------------------	--------------------------	------------------	----------------	---------------

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres		
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90				
0					GRAVEL with silt and sand (NSTIR Type 2)													11.91
					0.405m													11.51
1					Brown to grey-brown, silty SAND with gravel to silty GRAVEL with sand - FILL - Frequent cobbles and boulders - Minor debris													
2					2.33m													9.58
					Brown to grey-brown, silty SAND with gravel - TILL - Frequent cobbles and boulders													9.17
					2.74m													
3					END OF HOLE - No seepage observed													
4																		
5																		



BOREHOLE LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

BH1

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570457.70

NORTHING:

4949894.16

GROUND ELEVATION:

21.44 m

TOP OF CASING ELEVATION:

NA

DRILL:

LOGGED BY:

JW

PROJECT NO.:

444.57

DATE DRILLED:

2013 February 6

UNDRAINED SHEAR STRENGTH, kPa

■

WATER CONTENT, %

×

ATTERBERG LIMITS

PLASTIC LIMITS

LIQUID LIMITS

N, BLOWS PER 300mm

●

J, BLOWS PER 150mm

•

ELEVATION

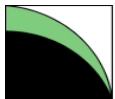
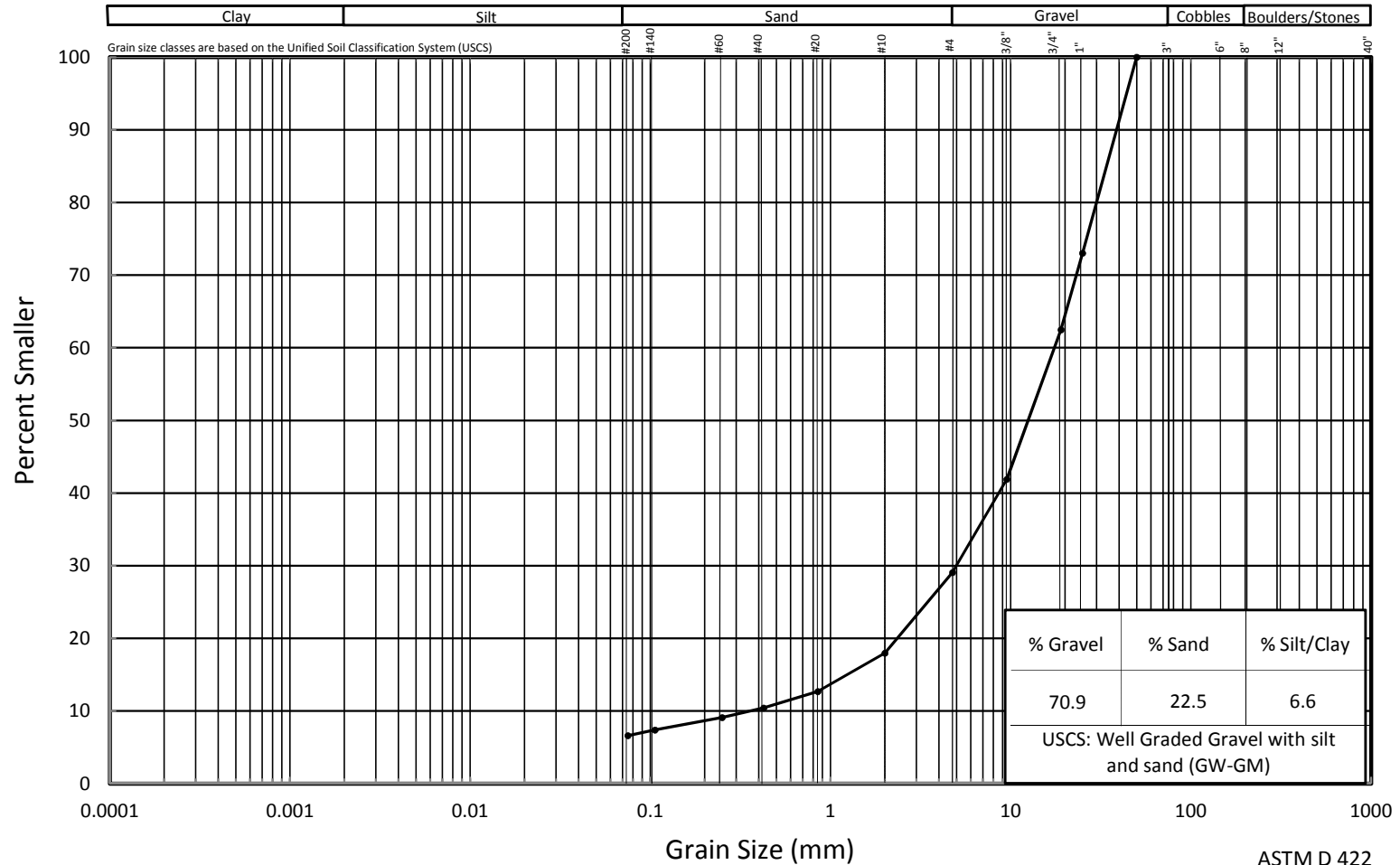
metres

DEPTH Metres	SAMPLE					SOIL/ ROCK	SOIL/ROCK DESCRIPTION	J, BLOWS PER 150mm										ELEVATION metres		
	NO.	TYPE	REC cm or %	BLOWS /300 mm RQD%	WC %			10	20	30	40	50	60	70	80	90				
0		AU					COBBLES AND BOULDERS with silt, sand and gravel intermixed - FILL												21.44	
		SS																		
1	2	NQ	74%	48%	8.3				X											
	3	G			13.3			X												
2	4	NQ	67%	45%																
3							3.05m											18.39		
4	5	NQ	27%	0%			Brown to grey-brown silty GRAVEL with sand to silty SAND with gravel - FILL													
		AU																		
5	6	SS	28.0	19	11.6					X	●									
	7	SS	30.5	18	16.7		5.94m			X	●							15.5		
6	8	SS	15.2	80	9.0		Brown silty SAND with gravel to silty GRAVEL with sand - TILL - occasional cobbles			X							●			
	9	SS	25.4	39	12.4					X				●						
7	10	SS	20.3	28	11.3					X				●						
8	11	NQ	0%	0%																
9							10.36m													
10																				
																			11.08	
11							END OF HOLE 10.36m - dry to 5.2 m - standpipe installed, blocked/pinched at 5.2 m													
12																				

BOREHOLE LOG5 BH1.GPJ WELL LOGS.GDT 13/2/22

APPENDIX C
LABORATORY TESTING

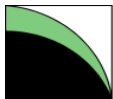
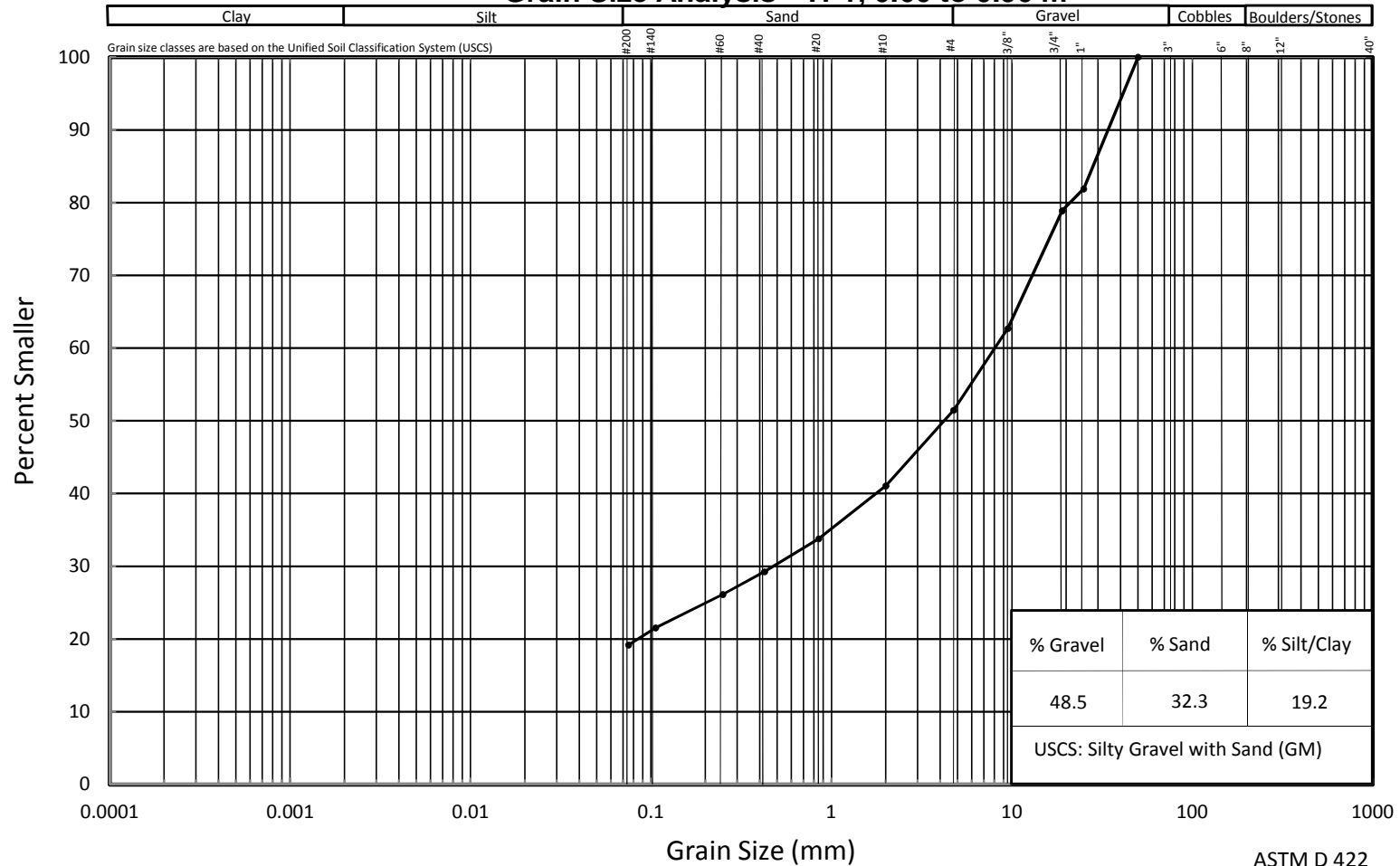
Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP1, 0 - 0.25 m



TerrAtlantic
Engineering Limited

ASTM D 422
Grain Size Analyses
444.57 October 15, 2012
BIO Buoy Maintenance Area

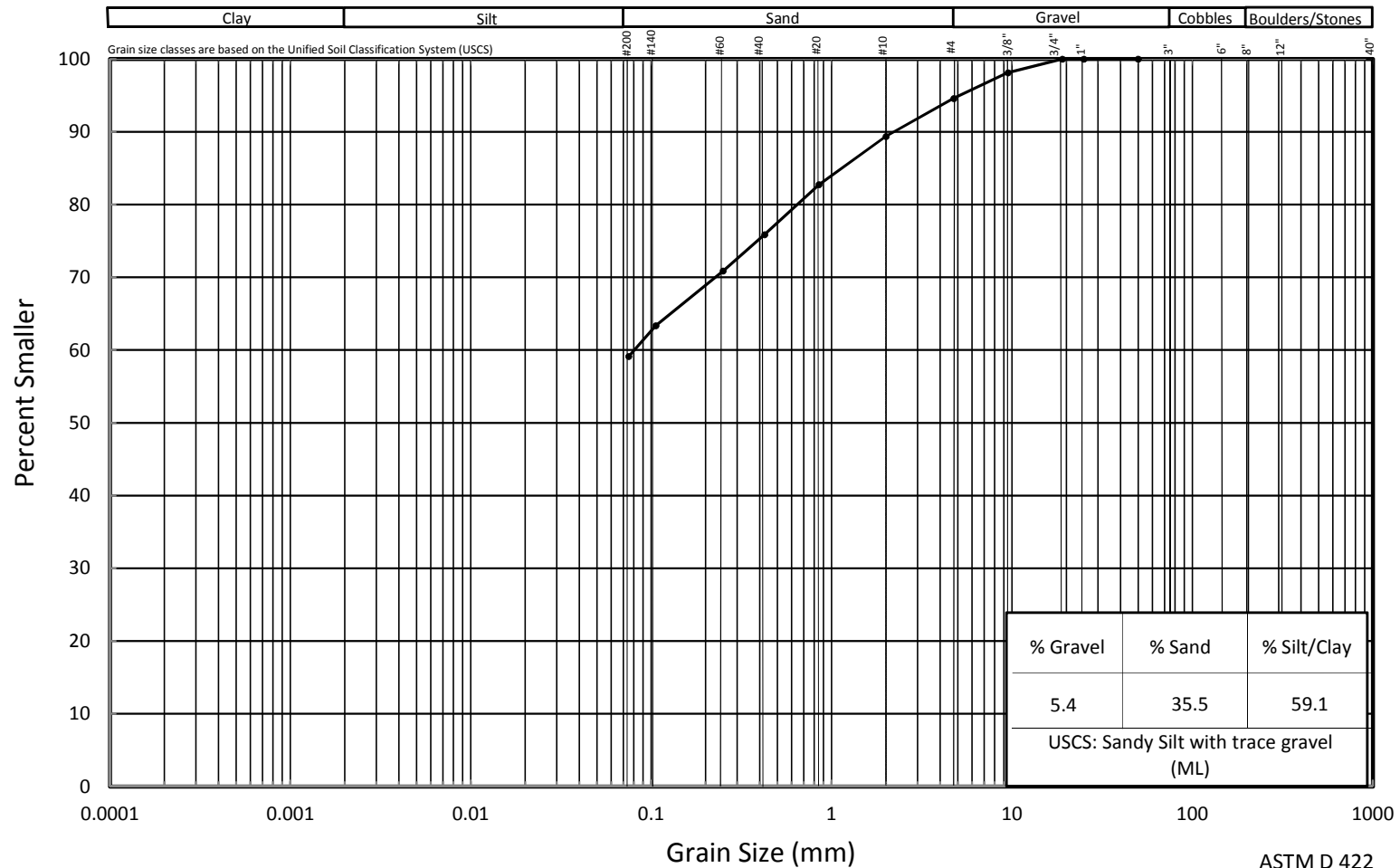
Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP1, 0.60 to 0.90 m



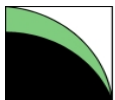
TerrAtlantic
Engineering Limited

ASTM D 422
Grain Size Analyses
444.57 October 15, 2012
BIO Buoy Maintenance Area

Geotechnical Investigation - BIO Buoy Laydown Area **Grain Size Analysis - TP2, 2.4 to 2.7 m**

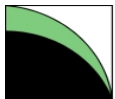
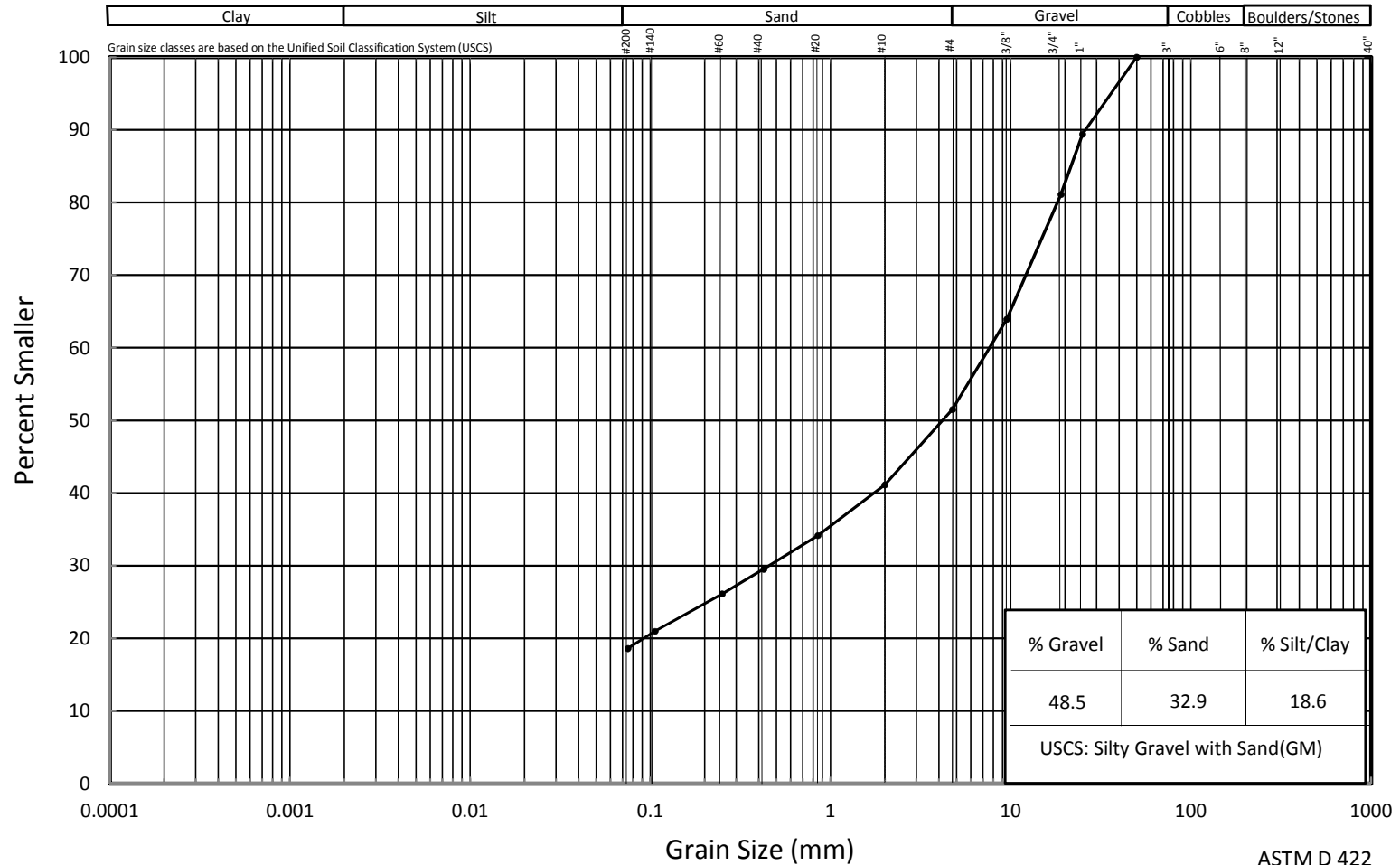


ASTM D 422
 Grain Size Analyses
 444.57 October 15, 2012
 BIO Buoy Maintenance Area



TerrAtlantic
 Engineering Limited

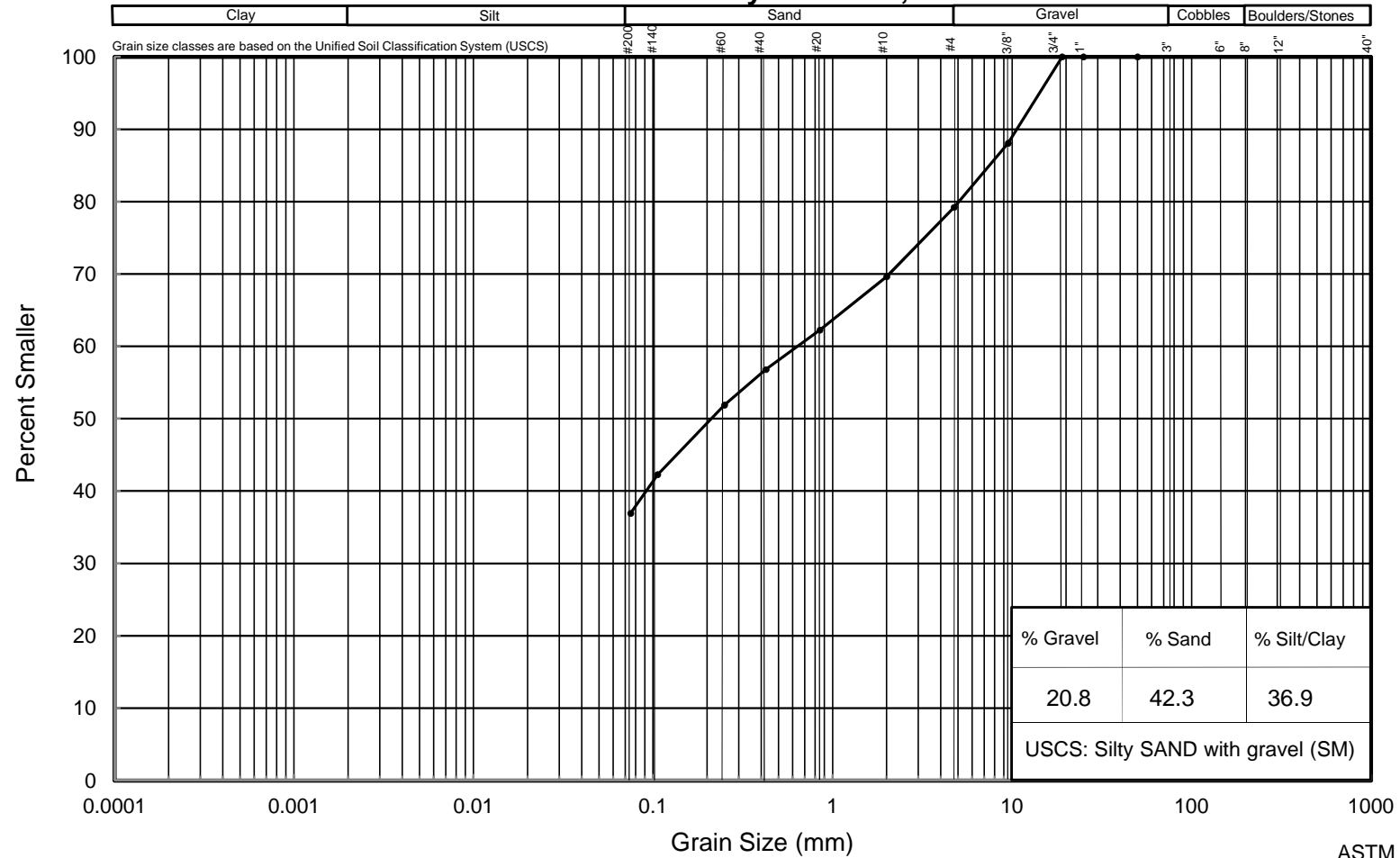
Geotechnical Investigation - BIO Buoy Laydown Area **Grain Size Analysis - TP4, 0.6 to 0.9 m**



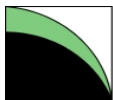
TerrAtlantic
Engineering Limited

ASTM D 422
 Grain Size Analyses
 444.57 October 15, 2012
 BIO Buoy Maintenance Area

Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP13, 0.6-0.9 m

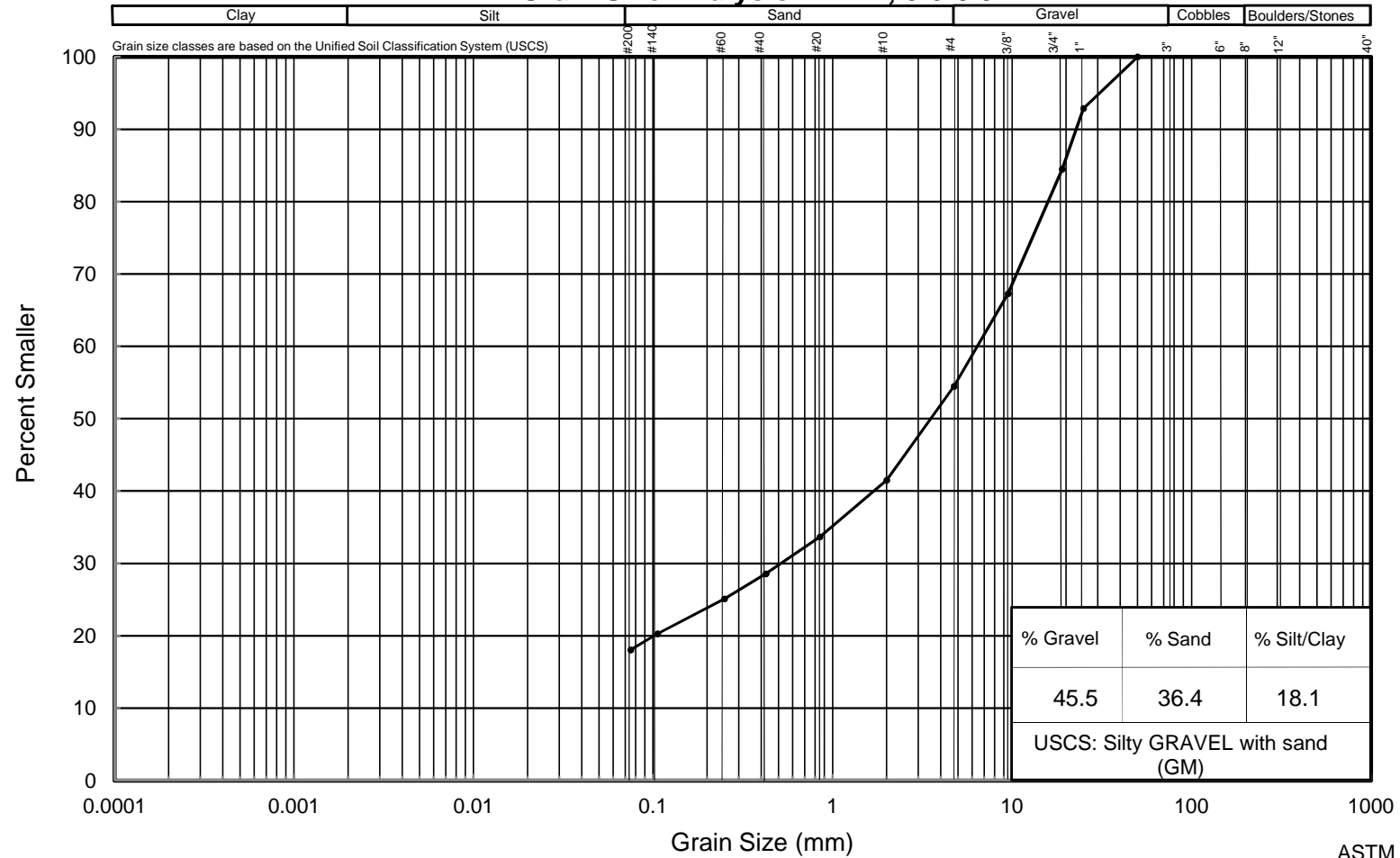


ASTM D 422
Grain Size Analyses
444.57, Feb 12/13
Dartmouth, NS

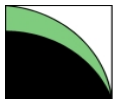


TerrAtlantic
Engineering Limited

Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP14, 0.6-0.9 m

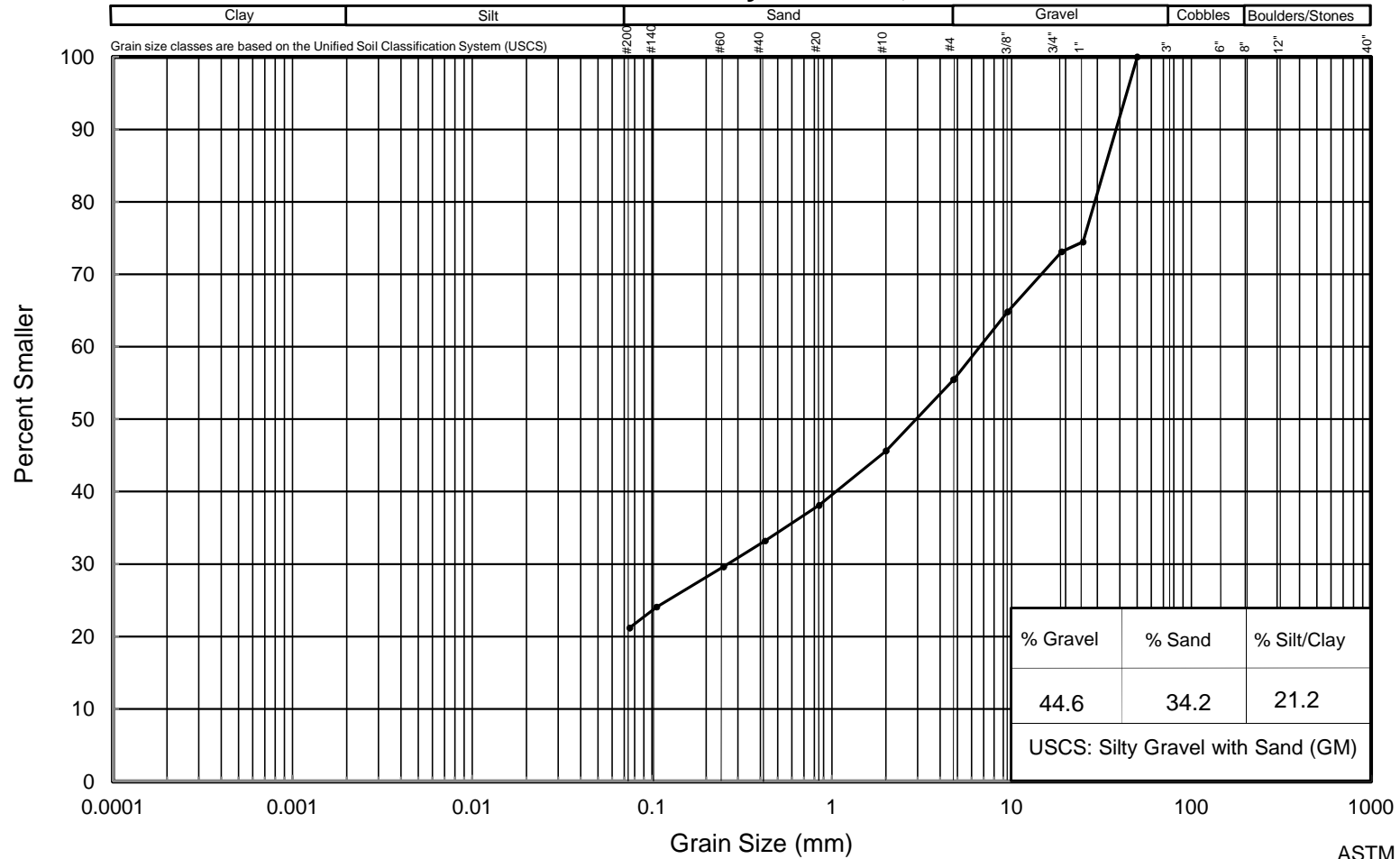


ASTM D 422
Grain Size Analyses
444.57, Feb 12/13
Dartmouth, NS

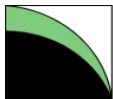


TerrAtlantic
Engineering Limited

Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP15, 0.6-0.9 m

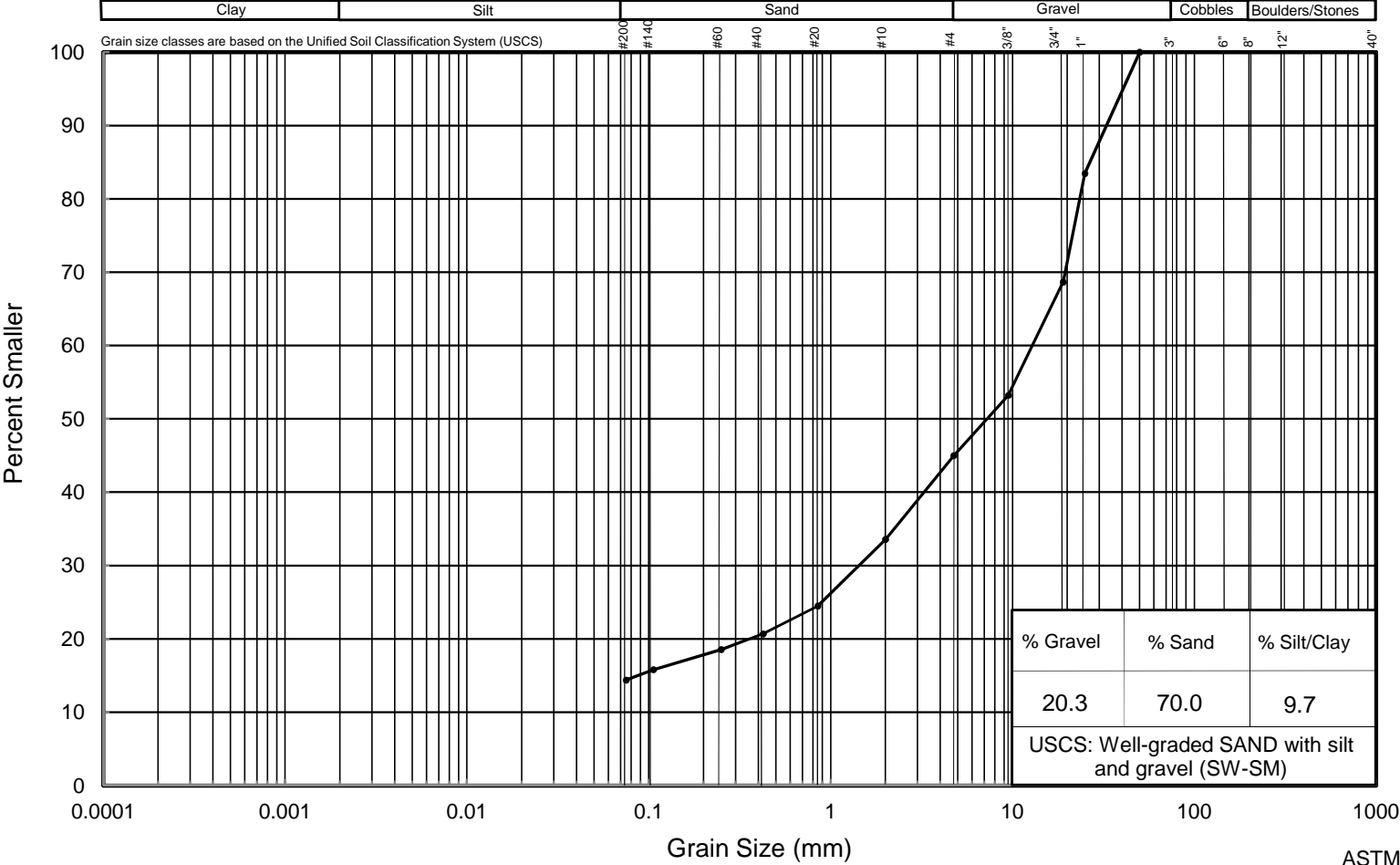


ASTM D 422
Grain Size Analyses
444.57, Feb 12/13
Dartmouth, NS



TerrAtlantic
Engineering Limited

Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP16, 0.6-0.9 m

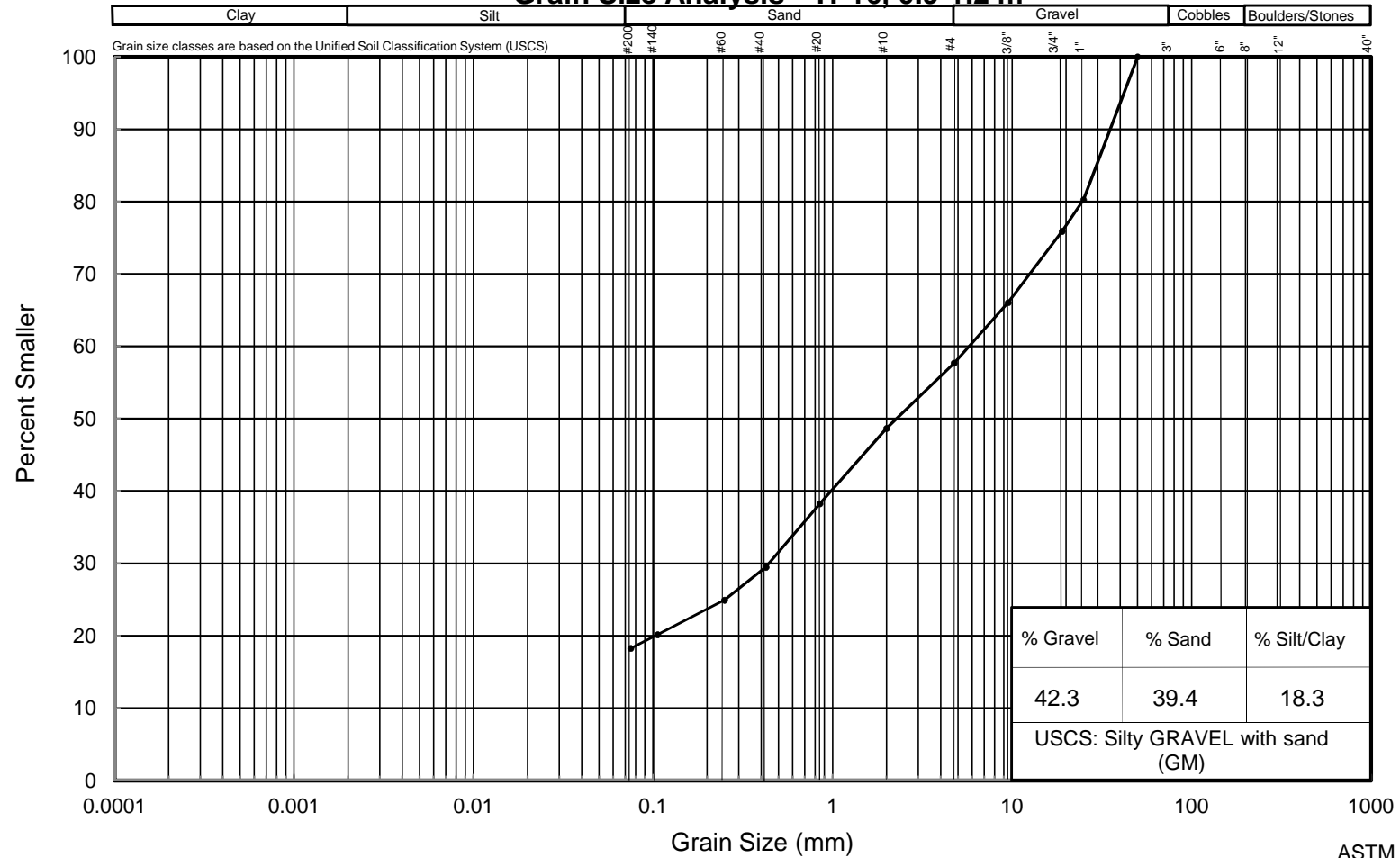


ASTM D 422
 Grain Size Analyses
 444.57, Feb 12/13
 Dartmouth, NS

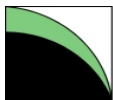


TerrAtlantic
 Engineering Limited

Geotechnical Investigation - BIO Buoy Laydown Area Grain Size Analysis - TP16, 0.9-1.2 m



ASTM D 422
Grain Size Analyses
444.57, Feb 12/13
Dartmouth, NS

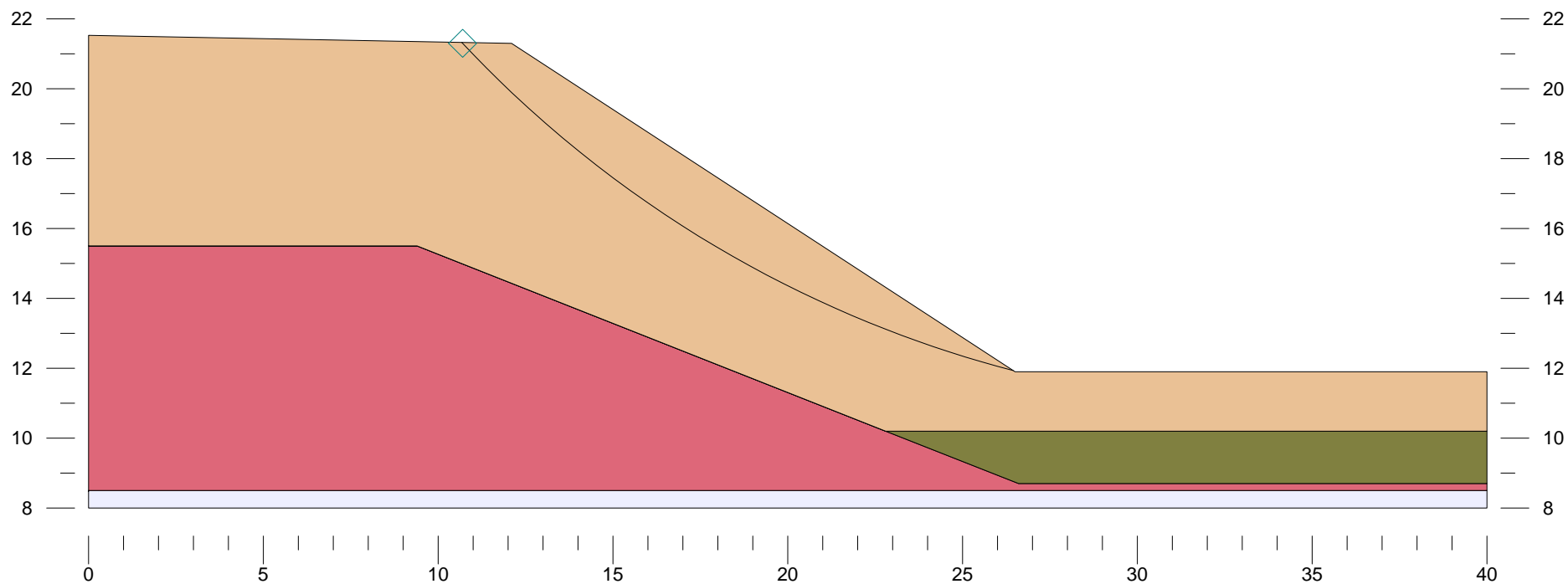
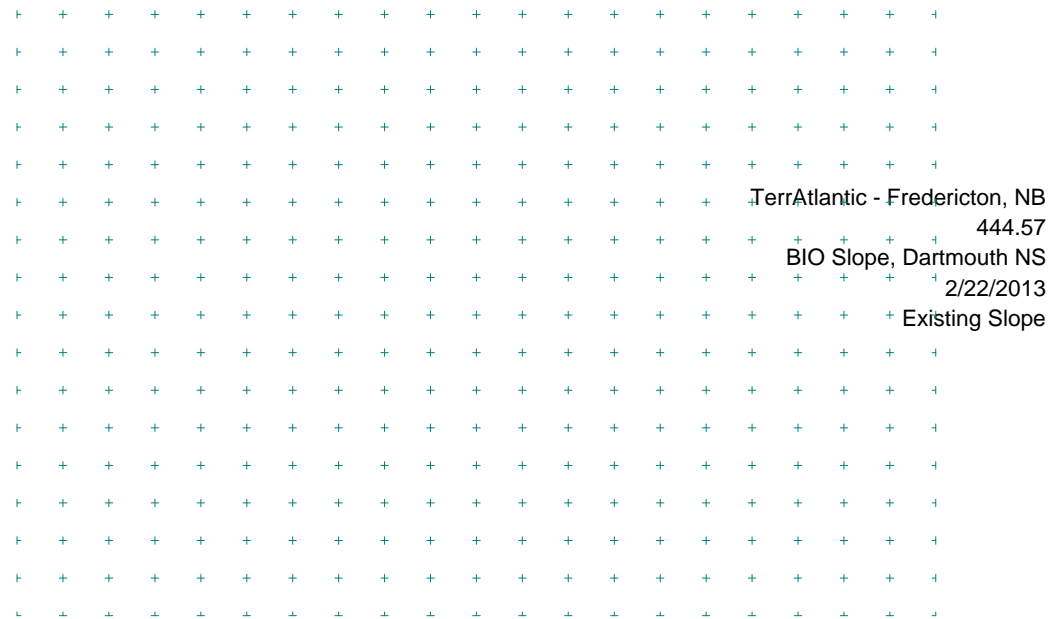


TerrAtlantic
Engineering Limited

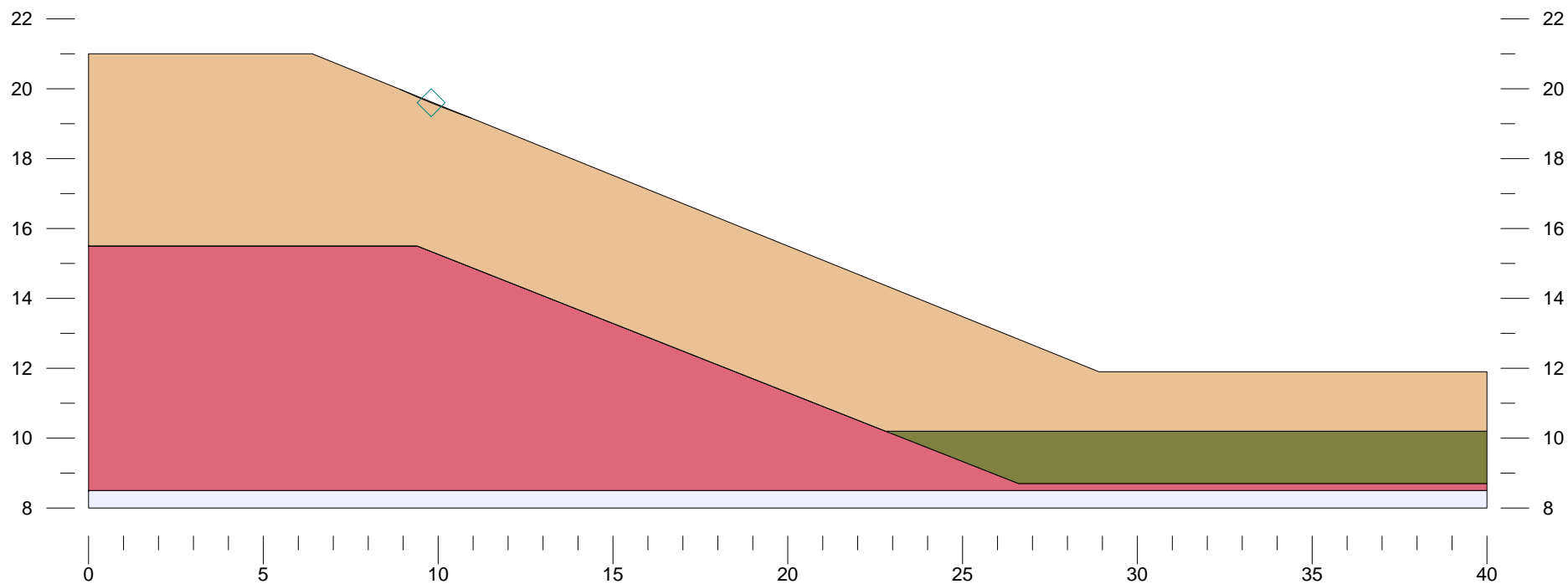
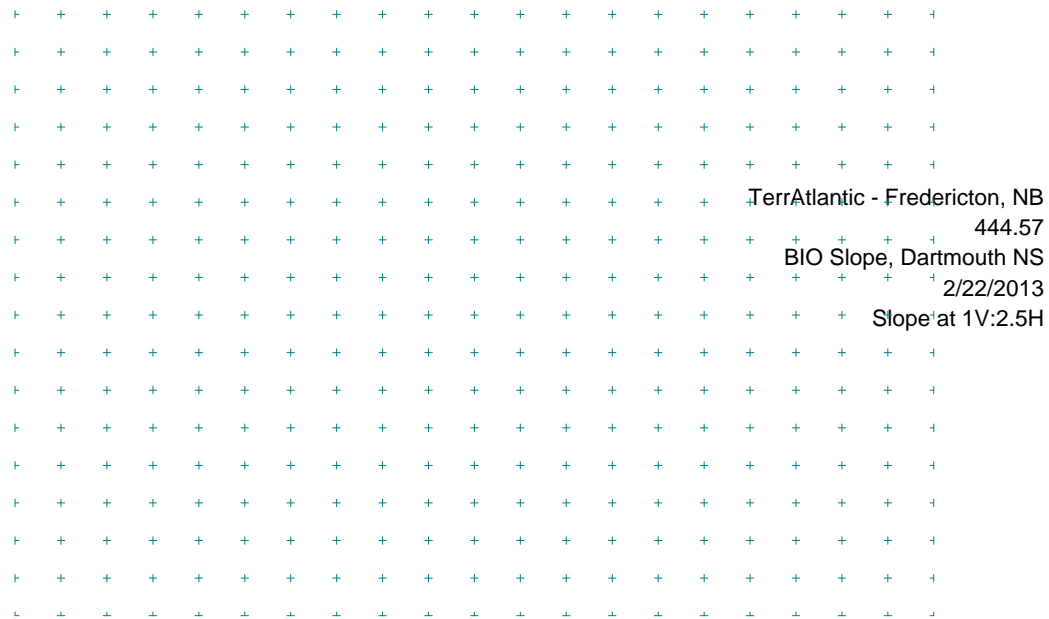
APPENDIX D

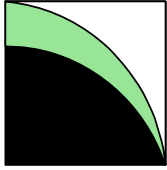
SLOPE STABILITY FIGURES D1 AND D2

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Fill	20	0	32	0
Peat	12	10	0	0
Till	20	0	34	0
Bedrock	(Infinitely Strong)			



	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Fill	20	0	32	0
Peat	12	10	0	0
Till	20	0	34	0
Bedrock	(Infinitely Strong)			





August 9, 2013

File #444.57

Chris Kingsland, P.Eng.
CBCL Limited
PO Box 606
1489 Hollis Street
Halifax, NS B3J 2R7

Dear Chris:

RE: *ADDITIONAL GEOTECHNICAL INVESTIGATION - ROCK QUALITY*
PROPOSED BIO BUOY MAINTENANCE LAYDOWN AREA, DARTMOUTH, NS

Introduction

TerrAtlantic Engineering Limited was retained by CBCL Limited (on behalf of PWGSC) to carry out additional geotechnical investigation for the proposed Bedford Institute of Oceanography (BIO) Maintenance Laydown Area, Dartmouth, NS. The purpose of this work is to provide additional information about the quartzite bedrock located along the northern access road. This work included additional field investigation to obtain rock core samples and conducting a series of laboratory tests to quantify the properties of the quartzite bedrock (strength, frequency of fractures, etc.).

The following letter report presents all findings from the field and laboratory work. Previous geotechnical investigations at this site were conducted by TerrAtlantic¹.

Field Investigation

Three (3) boreholes were drilled and two (2) test pits were excavated as part of this additional work. The boreholes were drilled on July 23, 2013 and test pits were excavated on the following day. All field work was supervised by TerrAtlantic personnel. The location of each exploratory hole is

¹ 1) Geotechnical Investigation - Proposed Buoy Storage and Maintenance Area, February 22, 2013. and 2) Preliminary Geotechnical Investigation - Proposed BIO Buoy Maintenance Laydown Area, October 17, 2012).

shown in Figure 1 of Appendix A with borehole and test pit logs provided in Appendix B.

Boreholes were drilled by conventional means, to depths ranging from 6.0 to 8.8 m. All drilling services were provided by Logan Geotech. Split-spoon samples and Standard Penetration Tests (SPT) were performed until refusal was met. Once refusal was achieved, boreholes were advanced using NQ² size core. The rock from each borehole was logged for the following: Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and Fracture Index (FI) per 300 mm (number of fractures per 300 mm core run). Borehole logs and colored photographs of rock core are provided in Appendix B and Appendix C respectively. Fracture Index data are provided in Appendix D.

Test pits were excavated by means of a tracked excavator to depths of 0.7 and 2.2 m in TP25 and TP26 respectively. Excavation services were provided by Falkenham Construction. The subsurface conditions were recorded and representative soil samples were taken of the various strata encountered. Upon completion, the test pits were backfilled with the excavated material and lightly compacted.

Surveying was conducted by Allnorth Consulting Limited personnel upon completion of field work. Elevations are referenced to a Geodetic Datum (NSCM #228268) with locations referenced to coordinate system Modified Traverse Mercator (MTM) Zone 5.

Laboratory Testing

A total of seven (7) samples were tested for Unconfined Compressive Strength (UCS) and twenty nine (29) samples were subjected to point load testing.

Of the seven (7) UCS tests, five (5) samples were tested to failure using an Accutek 250 Digital Compression Machine (TerrAtlantic Engineering Limited), and two (2) samples were tested to failure using a servo-controlled compression frame (Queen's University). All testing was performed using the latest editions of applicable American Society for Testing and Materials (ASTM) standards and recognized good practice. The following ASTM Standards were utilized:

- *ASTM D7012 - Standard Test Method for Compressive Strength and Elastic Moduli of Intact*

² NQ size core has an inside diameter of 47.6 mm. The hole diameter is 75.8 mm.

Rock Core Specimens under Varying States of Stress and Temperatures

- *ASTM 4543 - Standard Practices for Preparing Rock Core Specimens and Determining Dimensional and Shape Tolerances*

All samples were prepared and measured in accordance with ASTM D4543 for straightness, flatness, parallelism and perpendicularity. The following general procedure was used:

- diamond sawing to prepare cylindrical samples having nearly parallel end faces;
- end surface grinding to prepare samples to within the applicable tolerances; and
- testing to failure in compression frame (at a stress rate of 0.5 MPa/s).

In addition to UCS testing, thirty one (31) point load tests were performed. Twenty two (22) samples were tested axially and nine (9) samples were tested diametrically. All samples were tested in accordance with *ASTM D5731 - Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications*. Photos of each test break are provided in Appendix C.

Findings

Shallow bedrock was encountered in all three boreholes (BH2, BH3, and BH4) at depths ranging from 0.2 to 1.2 m beneath the existing ground surface. Bedrock was also inferred in both test pits at depths of 0.7 (TP25) and 2.2 m (TP26).

The bedrock encountered consists of very poor to excellent quality, grey quartzite. Slight weathering is present along fracture planes, and discontinuities/fractures were at a close to moderate spacing (0.06 m to 0.6 m).

The bedrock is more fractured nearer the surface (upper 2.6 to 4.2 m) as indicated by both RQD values and the number of fractures per 300 mm (see Appendix D for Fracture Index). The Rock Quality Designation (RQD) values were generally low in this area, ranging from 11% to 50%. Below this upper fractured zone, the rock quality increases with depth, with RQD values ranging from 50% to 90%.

A summary of the UCS test results and point load test results are presented in Tables 1 and 2 below. The unconfined compressive strength (from UCS tests) ranges from 84 to 243 MPa and

would be described as Strong to Very Strong (Marino and Hoek, 2001). The average Young's Modulus of the two samples tested was approximately 21 GPa and the Poisson's ratio of these samples was 0.10 to 0.11. Point load pressures ranged from 450 psi to 2500 psi, corresponding to calculated unconfined compressive strengths of 55 to 292 MPa (strong to extremely strong).

TABLE 1. SUMMARY OF UNCONFINED COMPRESSIVE (UCS) STRENGTH TESTS

Borehole Sample	Depth (m)	Density (g/m ³)	UCS (MPa)	Young's Modulus (GPa)	Poisson's Ratio	Strength Classification
BH2 NQ3	0.8 - 1.1	2.73	109.9	21.3	0.10	Very Strong
BH2 NQ4	2.0 - 2.2	2.69	177.5	-	-	Very Strong
BH3 NQ5	2.7 - 3.0	2.70	84.1	20.9	0.11	Strong
BH3 NQ6	3.8 - 4.1	2.80	200.5	-	-	Very Strong
BH4 NQ4	2.2 - 2.4	2.85	203.3	-	-	Very Strong
BH4 NQ7	4.9 - 5.3	2.68	168.9	-	-	Very Strong
BH4 NQ7	5.4	2.68	243.0	-	-	Very Strong

TABLE 2. POINT LOAD TESTS CONDUCTED ON SELECTED SAMPLES OF QUARTZITE

Borehole Sample	Depth (m)	Point Load Pressure (psi)	Calculated UCS (MPa)	Strength Classification
BH2 NQ2	0.2 - 0.76	700 - 1500	92-182	Strong/Very Strong
BH2 NQ3	0.76 - 1.78	650 - 700	97 - 116	Strong/Very Strong
BH2 NQ4	1.78 - 3.34	450 - 1800	55 - 235	Strong/Very Strong
BH3 NQ2	0.43 - 0.81	1500 - 2000	196 - 236	Very Strong
BH3 NQ3	0.81 - 1.52	1150 - 1250	146 - 161	Very Strong
BH3 NQ6	3.2 - 4.72	1400 - 1900	182 - 224	Very Strong
BH4 NQ3	1.22 - 1.83	1450 - 2500	189 - 292	Very Strong/Extremely Strong
BH4 NQ4	1.83 - 3.35	1700 - 2000	223 - 262	Very Strong/Extremely Strong

Standpipes were installed in each of the three boreholes. Water levels were measured on

August 7, 2013 at which time water depths were 0.53 m (BH2), 0.47 m (BH3) and 4.7 m (BH4). It should be noted that water levels will fluctuate seasonally in response to precipitation events and to daily tidal fluctuations.

Discussion

It is anticipated that in order to construct the access road along the northern section of the site, cuts of between 1.0 m and 4.0 m will be required (deeper cuts may be required for utility trenches). Based on these details and on the subsurface conditions encountered, some excavation of the quartzite bedrock will therefore be required. The quartzite bedrock nearer the surface (2.6 to 4.0 m) is somewhat fractured and is described as very poor to fair quality. Fractures are less frequent with depth, and the quality of bedrock improves (fair to excellent quality). The strength of the quartzite bedrock is in the strong to extremely strong range with UCS values in the range of 50 to 300 MPa.

It is understood that due to the proximity of the MacKay bridge (approximately 500 m away), the preferred method of rock removal is with the use of rock breaking equipment. Whilst it is possible that small portions of the upper fractured zone of the bedrock can be excavated by rock breaker (the ability to remove rock by this means will depend on the size and nature of the equipment used and on the experience of the operator), the rock has a high unconfined compressive strength which will make this process increasingly difficult, time-consuming and costly as excavation depths increase. Rock removal by blasting is in our view the more practical alternative, but any blasting would need to be conducted in a controlled manner so as not to result in damage to nearby structures. This could be accomplished by proper blast design - limiting the charge weight per delay so as to keep the peak particle velocities at nearby structures within an acceptable range. Pre-blast surveying and blast monitoring should be conducted.

Groundwater in BH2 and BH3 was encountered at a depth of approximately 0.5 m. As such, some dewatering will be required in order to construct the access road and utility trenches.

Closure

A geotechnical investigation is a limited sampling of a site. This report presents the subsurface conditions encountered at the time of the investigation, and at the specific test locations. Should any conditions be encountered that differ from those presented in this report, we ask that we be

immediately notified in order to permit reassessment of our recommendations.

This report was prepared Scott Munro, M.Sc.E., P.Eng. and reviewed by Geoff Dickinson, M.Eng., P.Eng. We trust that this submission is adequate for your present purposes. If you have any questions about the contents of the report or if we can be of any other assistance please contact us at your convenience.

Yours very truly,

A handwritten signature in black ink, appearing to read 'Scott Munro', written in a cursive style.

SCOTT MUNRO, M.SC.E., P.ENG.
GEOTECHNICAL ENGINEER

APPENDIX A

APPENDIX B



BOREHOLE LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

BH2

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570302.6

NORTHING:

4949958.52

GROUND ELEVATION:

7.46 m

TOP OF CASING ELEVATION:

NA

DRILL:

CME55

LOGGED BY:

JW

PROJECT NO.:

444.57

DATE DRILLED:

2013 July 23

TOTAL CORE RECOVERY (TCR)

SOLID CORE RECOVERY (SCR)

ROCK QUALITY DESIGNATION (RQD), % **X**

N, BLOWS PER 300mm **●**

DEPTH Metres	SAMPLE					SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	REC cm or TCR%	BLOWS /300 mm SCR%	RQD %			10	20	30	40	50	60	70	80	90			
0	1	SS	102	50			0.2m Grey GRAVEL, some sand FILL												7.46
	2	NQ	100%	59%	39%														7.26
1	3	NQ	100%	60%	28%		Grey, poor to fair quality, QUARTZITE BEDROCK - slight weathering along fractures - close to moderately spaced discontinuities												6.93
2	4	NQ	73%	42%	33%		2.69m												4.77
3							Grey, good to excellent quality, QUARTZITE BEDROCK - slight weathering - moderately spaced discontinuities												1.44
4	5	NQ	97%	79%	76%														1.44
5	6	NQ	83%	75%	83%														1.44
6							6.02m												1.44
7							END OF HOLE 6.02m												1.44
8																			1.44
9																			1.44
10																			1.44

BH5 BIO BH2-4.GPJ WELL LOGS.GDT 13/8/8



BOREHOLE LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

BH3

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT NO.:

444.57

DATE DRILLED:

2013 July 23

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570351.04

NORTHING:

4949964.15

GROUND ELEVATION:

10.81 m

TOP OF CASING ELEVATION:

NA

DRILL:

CME55

LOGGED BY:

JW

TOTAL CORE RECOVERY (TCR)

SOLID CORE RECOVERY (SCR)

ROCK QUALITY DESIGNATION (RQD), % **X**

N, BLOWS PER 300mm **●**

DEPTH Metres	SAMPLE					SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres	
	NO.	TYPE	REC cm or TCR%	BLOWS /300 mm SCR%	RQD %			10	20	30	40	50	60	70	80	90			
0	1	SS	25	30			0.43m Grey GRAVEL, some sand FILL			●									10.81
	2	NQ	100%	50%	37%						X								
1	3	NQ	100%	18%	22%		Grey, very poor to poor quality QUARTZITE BEDROCK - Slight weathering along fractures - Close to moderately spaced discontinuities		X										
	4	NQ	94%	39%	22%					X									
2	5	NQ	60%	49%	50%		2.6m					X							8.209
3																			
4	6	NQ	100%	84%	90%		Grey, fair to excellent quality QUARTZITE BEDROCK - Slight weathering - Moderately spaced discontinuities										X		
5	7	NQ	95%	51%	50%														
6							6.25m												4.559
								END OF HOLE 6.25m											
7																			
8																			
9																			
10																			

BH5 BIO BH2-4 GPJ WELL LOGS GDT 13/8/8



BOREHOLE LOG

STATION:

OFFSET:

EXPLORATORY HOLE NO.:

BH4

Page 1 of 1

CLIENT:

CBCL LIMITED

PROJECT:

BIO BUOY MAINTENANCE AREA

LOCATION:

DARTMOUTH, NS

EASTING:

5570435.27

NORTHING:

4949966.30

GROUND ELEVATION:

17.55 m

TOP OF CASING ELEVATION:

NA

DRILL:

CME55

LOGGED BY:

JW

PROJECT NO.:

444.57

DATE DRILLED:

2013 July 23

TOTAL CORE RECOVERY (TCR)

SOLID CORE RECOVERY (SCR)

ROCK QUALITY DESIGNATION (RQD), %

X

N, BLOWS PER 300mm

●

DEPTH Metres	SAMPLE					SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres
	NO.	TYPE	REC cm or TCR%	BLOWS 300 mm SCR%	RQD %			10	20	30	40	50	60	70	80	90		
0		A					0.3m Grey GRAVEL, some sand FILL											17.55
	1	SS	38	33			Brown, silty SAND with gravel FILL											17.254
1	2	SS	46	50														
	3	NQ	88%	56%	38%		Grey, very poor to poor quality QUARTZITE BEDROCK - Slight weathering along fractures - Close to moderately spaced discontinuities											16.334
2	4	NQ	72%	43%	45%													
3	5	NQ	56%	11%	11%													
4	6	NQ	100%	75%	75%													13.284
5	7	NQ	93%	78%	76%													
6	8	NQ	100%	88%	85%		Grey, fair to good quality QUARTZITE BEDROCK - Slight weathering - Moderately spaced discontinuities											
7	9	NQ	95%	78%	72%													
8							8.84m											8.714
9							END OF HOLE 8.84m											
10																		

BH5 BIO BH2-4.GPJ WELL LOGS.GDT 13/8/8


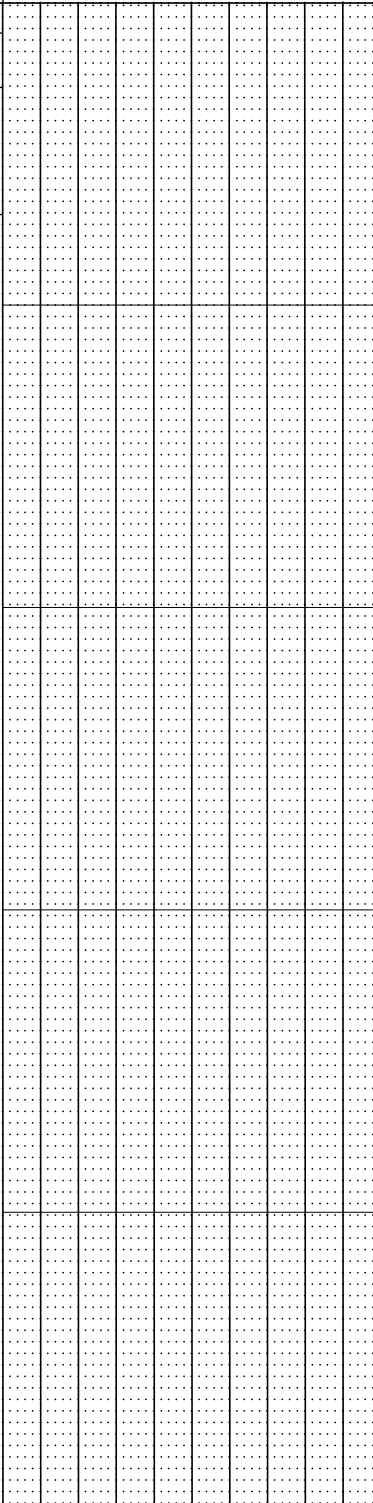
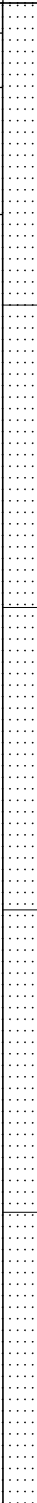
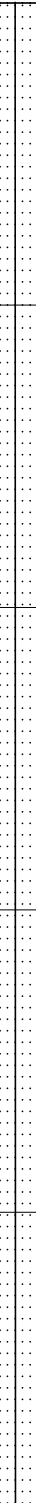
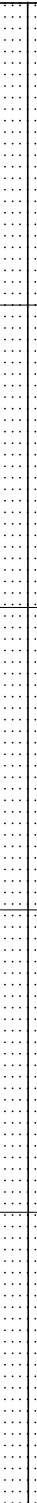
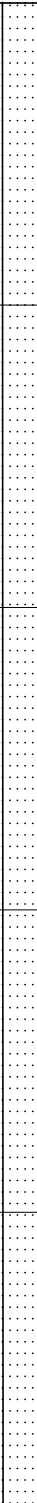
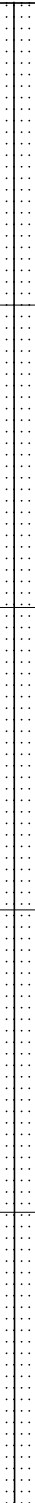
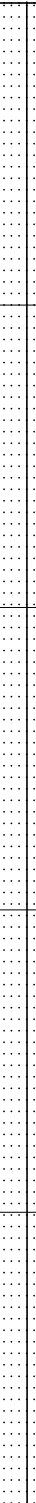


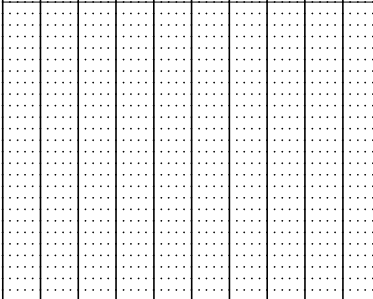
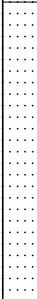
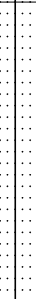
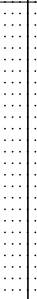
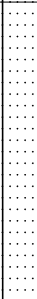
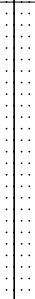
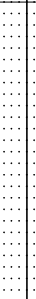


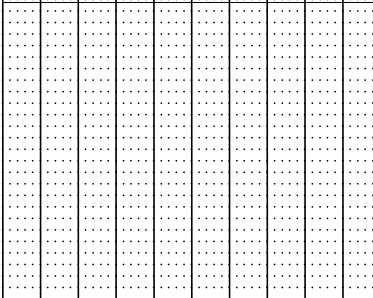
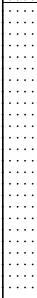
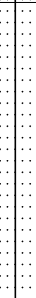
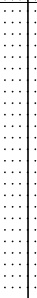
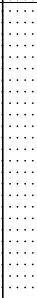
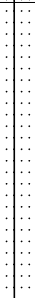
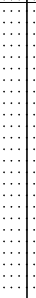


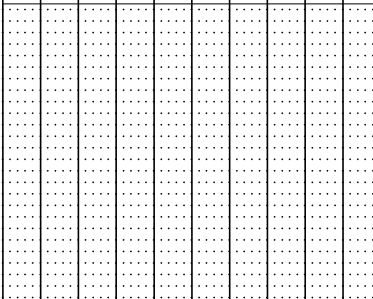
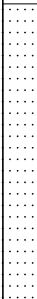

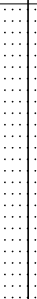
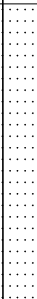
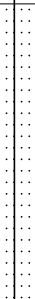
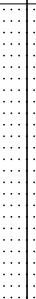


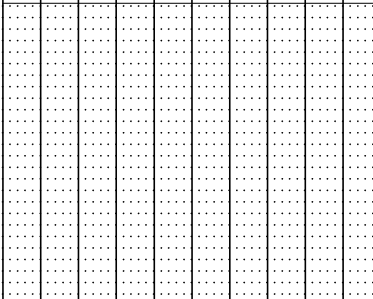


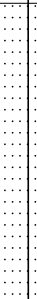

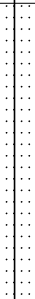
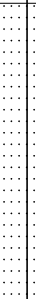












TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP25
PROJECT NO.:	Page 1 of 1
444.57	DATE EXCAVATED:
	2013 July 24

CLIENT: CBCL LIMITED			
PROJECT: BIO BUOY MAINTENANCE AREA			
LOCATION: DARTMOUTH, NS	EASTING: 5570473.07	NORTHING: 4949950.48	
GROUND ELEVATION: 18.719	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM

POCKET PENETROMETER kg/cm ²	■
WATER CONTENT, %	×
ATTERBERG LIMITS	PLASTIC LIMITS — LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90		
0					0.1m ROOTMAT									18.72		
				Brown to orange brown silty SAND with gravel, frequent cobbles and boulders	18.62											
				0.28m Grey brown silty SAND with gravel TILL	18.44											
				- frequent cobbles and boulders												
				0.7m	18.02											
1					- Refusal of excavator on inferred bedrock or large boulder - Test pit excavated to toe of fill slope - No Seepage observed END OF HOLE 0.7m											
2																
3																
4																
5																


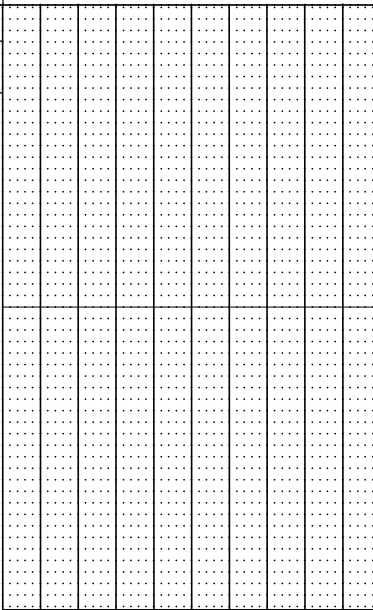

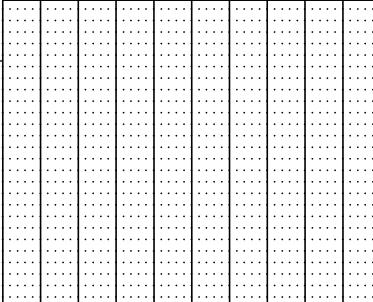

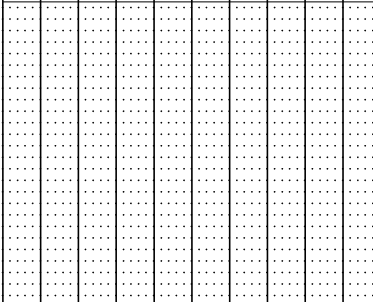
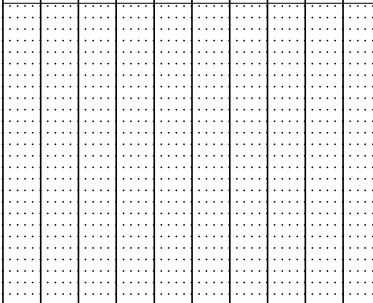
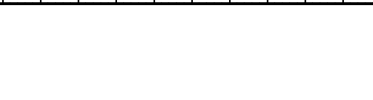


TEST PIT LOG

STATION:	EXPLORARY HOLE NO.:
OFFSET:	TP26
PROJECT NO.:	Page 1 of 1
444.57	DATE EXCAVATED:
	2013 July 24

CLIENT: CBCL LIMITED			
PROJECT: BIO BUOY MAINTENANCE AREA			
LOCATION: DARTMOUTH, NS		EASTING: 5570469.02	NORTHING: 4949975.47
GROUND ELEVATION: 20.319	GW. SEEPAGE:	EXCAVATOR CAT 320	LOGGED BY: SMM

POCKET PENETROMETER kg/cm ²	■
WATER CONTENT, %	×
ATTERBERG LIMITS	PLASTIC LIMITS — LIQUID LIMITS

DEPTH Metres	SAMPLE			SOIL/ ROCK	SOIL/ROCK DESCRIPTION											ELEVATION metres
	NO.	TYPE	WC %			10	20	30	40	50	60	70	80	90		
0					0.12m ROOTMAT		20.32									
				Brown to orange brown silty SAND with gravel, frequent cobbles and boulders at surface	20.20											
				0.29m Dense grey brown silty GRAVEL with sand TILL				20.03								
				- frequent cobbles and boulders - Large boulder encountered (or bedrock) from 0.6m - 2.2m												
1																
2					2.2m		18.12									
					- Refusal of excavator on inferred bedrock or large boulder											
					- No Seepage observed											
					END OF HOLE 2.2m											
3																
4																
5																

APPENDIX C

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA



Photo 1 – Borehole, BH2 – 0.20 to 6.02 m



Photo 2 – Borehole, BH2 - Left side



Photo 3 – Borehole, BH2 - Middle



Photo 4 – Borehole, BH2 – Right side



Photo 5 – Borehole, BH3 – 0.43 – 6.25 m



Photo 6 – Borehole, BH3 – Left side

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA



Photo 7 – Borehole, BH3 - Middle



Photo 8 – Borehole, BH3 – Right side



Photo 9 – Borehole, BH4 – 1.22 to 8.84 m



Photo 10 – Borehole, BH4 – Left side



Photo 11 – Borehole, BH4 - Middle



Photo 12 – Borehole, BH4 – Right side

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA

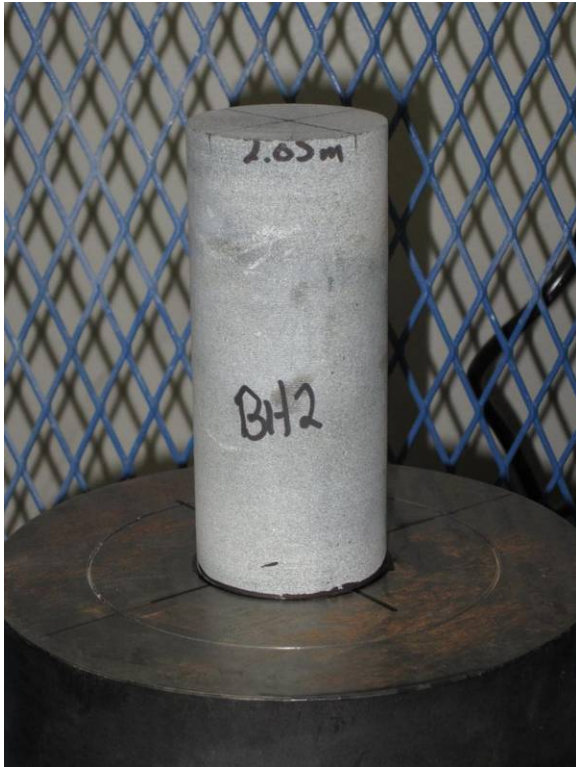


Photo 13 – UCS, BH2 – 2.05 to 2.2 m, before



Photo 14 – UCS, BH2 – 2.05 to 2.2 m, after



Photo 15 – UCS, BH4 – 5.35 m, before



Photo 16 – UCS, BH4 – 5.35 m, after

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA



Photo 17 – UCS, BH4 – 4.9 to 5.12 m, before



Photo 18– UCS, BH4 – 4.9 to 5.12 m, after



Photo 19– UCS, BH3 – 3.8 to 4.05 m, before



Photo 20 – UCS, BH3 – 3.8 to 4.05 m, after

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA



Photo 21 – UCS, BH4 – 2.09 to 2.2 m, before



Photo 22– UCS, BH4 – 2.09 to 2.2 m, after

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA



Photo 23 – UCS, BH2 (0.8 m) and BH3 (2.7 m) before



Photo 24 - UCS, BH2 (0.8 m) and BH3 (2.7 m) after



Photo 25 – Point load testing – BH2 NQ2, 0.2 to 0.76 m



Photo 26 – Point load testing – BH2 NQ3, 0.76 to 1.78 m

APPENDIX C – PHOTOGRAPHS

ADDITIONAL GEOTECHNICAL INVESTIGATION, BIO BUOY MAINTENANCE AREA



Photo 27 – Point load testing – BH2 NQ4, 1.78 to 3.30 m



Photo 28 – Point load testing – BH3 NQ2, 0.43 to 0.81 m



Photo 29 – Point load testing – BH3 NQ3, 0.81 to 1.52 m



Photo 30 – Point load testing – BH3 NQ5, 3.2 to 4.72 m



Photo 31 – Point load testing – BH4 NQ3, 1.22 to 1.83 m



Photo 32 – Point load testing – BH4 NQ4, 1.83 to 3.35 m

APPENDIX D

APPENDIX D - FRACTURE INDEX DATA
ADDITIONAL GEOTECHNICAL INVESTIGATION BIO BUOY MAINTENANCE AREA

NUMBER OF FRACTURES PER 300 MM - BOREHOLES BH2, BH3 AND BH4

DEPTH BELOW BEDROCK SURFACE mm	BOREHOLE		
	BH2	BH3	BH4
	DEPTH TO BEDROCK, m		
	0.20	0.43	1.22
0 - 300	3	4	5
300 - 600	2	3	3
600 - 900	2	NI	3
900 - 1200	4	NI	4
1200 - 1500	NI	NI	2
1500 - 1800	5	3	NI
1800 - 2100	NI	NI	2
2100 - 2400	5	2	NI
2400 -2700	2	1	NI
2700 - 3000	0	1	NI
3000 - 3300	3	1	1
3300 - 3600	NI	1	0
3600 - 3900	0	1	0
3900 - 4200	0	2	1
4200 - 4500	1	3	0
4500 - 4800	1	1	0
4800 - 5100	1	4	3
5100 - 5400	2	6	NI
5400 - 5700	2	2	2
5700 - 6000	1	3	1

NOTES:

1. NI = NON-INTACT

2. Length of lowest length increment may be slightly more or less than 300 mm to match actual hole depth below bedrock surface.

ROCK EXCAVATION AT THE PROPOSED
BOUY LAYDOWN AREA
DARTMOUTH - NOVA SCOTIA

30th August 2013



CBCL LIMITED

Consulting Engineers

File No. CBCL 121032.011



ROCK EXCAVATION AT THE PROPOSED BOUY LAYDOWN AREA
DARTMOUTH - NOVA SCOTIA

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ROCK EXCAVATION AT THE PROPOSED BOUY LAYDOWN AREA
DARTMOUTH - NOVA SCOTIA

1. INTRODUCTION

Graham Daws Associates Ltd (GDA) were commissioned by CBCL Ltd to review geotechnical information gained for the construction of the proposed Bouy Laydown Area in close proximity to MacKay Bridge and give an opinion regarding excavation techniques for construction works on site.

In particular a review was required regarding whether or not blasting would be required as part of the excavation process. If blasting was required then an assessment of the impact on MacKay Bridge was required.

This report addresses these issues.

2. REVIEW OF GEOTECHNICAL INFORMATION

GDA were provided with three reports from TerrAtlantic Engineering Ltd (TA) and these were as follows:

- i) “Preliminary Geotechnical Investigations” dated 17th October 2012
- ii) “Geotechnical Investigations” dated 22nd February 2013
- iii) “Additional Geotechnical Investigations – Rock Quality dated” 9th August 2013

GDA has reviewed these documents and extracted data in order to assess rock properties. We have taken the assessment from TA concerning the depth of fracturing etc at face value. In particular determination of Rock Mass Rating (RMR) [1] was carried out to aid consideration of excavation methods.

Apart from superficial deposits etc the main bedrock appears to comprise an upper fractured zone underlain by a very competent intact rock. All bedrock was noted by TA as being grey Quartzite.

From the information given in the reports referenced above RMR was determined for the fractured zone and the intact rock. These are given as follows.

Fractured Rock

Parameter	Value	Rating
Unconfined Compressive Strength (UCS)	Max 80 MPa	5
RQD	11 – 50 %	8
Fracture Spacing	60 - 300mm	8
Fracture Condition	Slight weathering	25
Water	Wet	7
RMR		53 (Fair Rock)

Intact Rock

Parameter	Value	Rating
Unconfined Compressive Strength (UCS)	Up to 243 MPa	12
RQD	50 - 90 %	17
Fracture Spacing	60 - 600mm	10
Fracture Condition	Slight weathering	25
Water	Wet	7
RMR		71 (Good Rock)

3. EXCAVATION OF ROCK

An initial assessment on the techniques required to excavate the rock was made using the methodology proposed by Abdullatif and Crudden [2]. Fig. 1 shows the graph of RMR and excavation techniques. This shows that the fractured rock should be capable of excavation using equipment sized for heavy impact ripping operations but the bedrock falls in the blasting category.

3.1 Blasting and its impact on MacKay Bridge

The most sensitive structure adjacent to the proposed site is the MacKay Bridge and it is understood that the closest element of the bridge to the proposed site is 450m. Consequently this figure has been taken when assessing blast vibration effects.

Pal Roy [3] has analysed the vibration due to blasting in detail for various rock types. Consequently this approach has been adopted to assess the impact of blasting on MacKay Bridge.

The following expressions have been used.

Peak Particle Velocity (ppv) = H (SD)^{-B}

Where H and B are constants depending on rock type etc
 SD = Scaled Distance

SD = D / √W

Where D = Distance from blast (m)
 W = Max Instantaneous Charge Weight (kg)

Pal Roy [3] has published the values of the constants H and B for various rock types. There are no values for Quartzite but values for Granite and Basalt are available. Consequently these values have been used and are given as follows.

Rock Type	H	B
Granite	574.188	1.53311
Basalt	895.644	2.152

For a maximum instantaneous charge weight of 45 kg then the ppv at 450m would be between 0.105 and 0.91 mm/sec.

These levels of ppv would be barely perceivable and would not create any structural damage. They are significantly lower than the limits set out in the Halifax Regional Municipality By Law B-600 Respecting Blasting. In the UK, GDA have extensive experience of the effects of open pit blasting on ancient structures. In such instances we normally set a limit of 5 mm/sec at the structure and to date no structural damage has been experienced at any of the sites.

Using the above approach and setting a limit of 1 mm/sec at 450m then a maximum instantaneous charge weight of 50.9 kg could be used.

In addition to seismic waves, air blast overpressure will occur. This is a compressional wave generated in air as a result of a blast detonation. Noise is that part of the air blast which falls in the audible range of frequencies (approx. 20 to 20,000 Hz). Air blast with a frequency of less than 20 Hz is termed concussion.

Even though a mathematical relationship exists, it is difficult to predict the noise level from a particular blast as the intensity of the noise is governed by the speed of sound in air. This, in turn, depends on air temperature and wind speed. Table 1 gives some examples of noise and blast effects.

TABLE 1 - NOISE AND BLAST EFFECTS

Noise level (dbL)	Peak Overpressure (psi)	Effect Example
180	3	Severe structural damage
170	1	Most windows break
150	0.1	Some windows break
140	0.03	Large plate glass windows may break
120	0.003	Jet aircraft
90	0.0001	Passing train
70	0.00001	Loud radio

Damage to hearing usually occurs above about the 140 dbL level. Atmospheric conditions which are unfavourable for blasting are as follows:

- i) Foggy, hazy or smoky days with little, or no, wind.
- ii) Cloudy days with a low ceiling.
- iii) During periods of the day when the surface temperature is falling.
- iv) During strong winds accompanying the passage of a cold front.

The effects of air blast overpressure will be negligible at 450m.

Naturally, all blasting shall comply with Halifax Regional Municipality By Law B-600 Respecting Blasting.

4. **PRE BLAST SURVEYS AND VIBRATION MONITORING**

Although the blasting is not predicted to have any influence on the MacKay Bridge it is recommended that a pre blast survey of the piers etc be carried out as required in By Law B-600. This is particularly important as we believe there has been much recent concern about the possible effects of blasting at the Nova Centre on adjacent structures. The pre blast survey should be in the form of a detailed examination and photographic records. Detailed high quality video evidence of the pre blast state of structures would also be useful. Drawings should also be produced showing any minor imperfections, shrinkage cracking etc., as this could be the subject of much debate later.

Vibration monitoring seismographs should be mounted on the closest structures to the proposed blast sites to confirm that the proposed levels of ppv have not been exceeded. It would be prudent to carry out a trial blast prior to production blasting in order to confirm that ppv has not exceeded the threshold limit. If any

blast produces a ppv of greater than the threshold limit then all blasting should be suspended and a re assessment of blast design carried out incorporating a further trial blast with reduced maximum instantaneous charge weight.

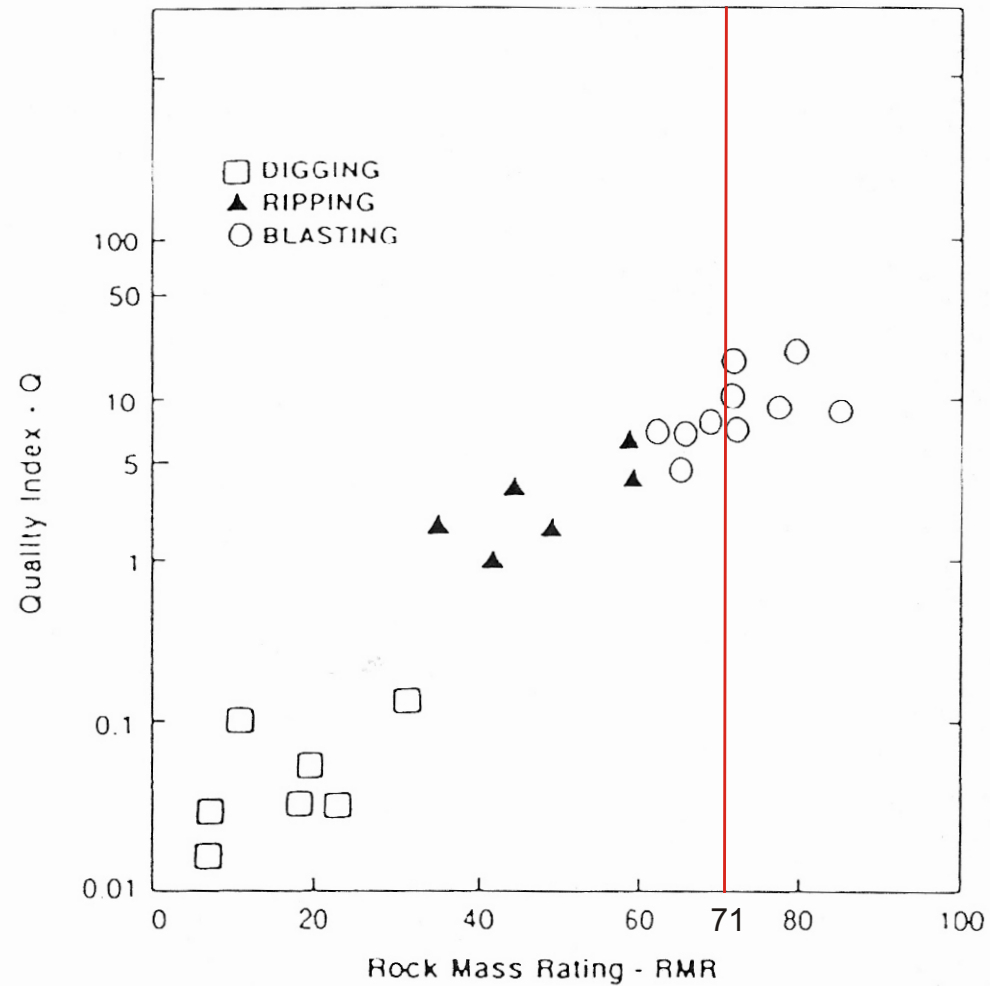
5. REFERENCES

- 1 Bieniawski, Z T “Engineering Rock Mass Classification” John Wiley and Sons, 1989, pp 51 – 73
- 2 Abdullatif, O M “The Relationship between Rock Mass Quality and Ease of Excavation” Bull Int Assoc Eng Geologists No 28, 1983 pp183 – 187
- 3 Pal Roy, P “Prediction and Control of Ground Vibration due to Blasting” Colliery Guardian Nov 1991 pp215 – 219




Eur. Ing. G. Daws BSc (Hons), PhD, C. Eng, FIMMM, FGS
30th August 2013

FIGURES



Excavation Guide

RMR	Excavation Method
0 – 30	Duggable
30 – 45	Rippable
45 – 69	Impact Braking
+60	Blasting

Client CBCL Ltd			Drawing Title ROCK EXCAVATION CHART	
Project BOUY LAYDOWN AREA				
Drg No Fig, 1	Scale NTS	Date Aug 13		
Drawn by GD	Checked by	Approved by		
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