• Fisheries and Oceans Canada

Geotechnical Investigation

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Project Number
KCH-00215059-GE

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November, 2013

Fisheries and Oceans Canada

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Date Submitted:
November, 2013

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1 Introduction and Background

Exp Services Inc. (**exp**) was retained by Fisheries and Oceans Canada to conduct a Geotechnical Investigation at the Port Elgin Harbour in Port Elgin, Ontario, hereinafter referred to as the 'site'. Authorization for **exp** to proceed with the Geotechnical Investigation was given by Mr. Mike Macdiarmid, P. Eng., of Fisheries and Oceans Canada.

Based on an interpretation of the factual test hole data and a review of subsurface information from test holes advanced at the site, **exp** has provided geotechnical engineering comments.

1.1 Terms of Reference

The geotechnical investigation was generally done in accordance with Terms of Reference.

The purpose of the investigation was to determine subsurface conditions at specific locations of the harbour. Based on an interpretation of the factual test hole data, and a review of soil and groundwater information from test holes advanced at the site, **exp** has provided geotechnical engineering comments.

This report is provided on the basis of the terms of reference presented above and on the assumption that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning geotechnical aspects of the codes and standards, this office should be contacted to review the design.

The information in this report in no way reflects on the environmental aspects of the soil. Should specific information in this regard be needed, additional testing may be required.

2 Methodology

The fieldwork for this investigation was carried out on October 24 and 25, 2013. During this time, two (2) sampled boreholes were advanced at the approximate locations shown on the attached Borehole Location Plan (Drawing. 1).

The boreholes were advanced to depths of about 10.0 m below ground surface/harbour bottom using a locally sub-contracted, portable drill-rig mounted on a barge, which was secured to the adjacent pier. The boreholes were advanced using tri-coning and coring equipment and overburden samples were recovered using split spoon sampling techniques.

Within the boreholes, Standard Penetration Tests (SPTs) were performed to assess the compactness of the underlying soils and to obtain representative samples. In cohesive soils, pocket penetrometer readings were taken to assess the undrained shear strength. During the drilling, the stratigraphy in the boreholes was examined and logged in the field by exp geotechnical personnel. Short-term groundwater level observations within the open boreholes and the natural moisture contents of recovered soil samples were recorded on the borehole logs.

The fieldwork was supervised by a member of the **exp** technical staff who directed the drilling and sampling operations, and logged the samples. All samples recovered were transported to **exp**'s London laboratory for detailed examination and selective testing. Laboratory testing for this investigation consisted of routine moisture content determinations, with results presented on the attached Borehole Logs. Unit weight determinations and a grain size analysis were also conducted on selected soil samples.

Samples remaining after the classification testing will be stored for a period of three months following the date of sampling (i.e., until January, 2014). After this time, they will be discarded unless prior arrangements have been made for longer storage.

The locations of the boreholes were established in the field by exp. The ground surface/harbour bottom elevations of the boreholes were referenced to geodetic survey data provided by the Canadian Hydrographic Service on the Fisheries and Oceans website.

3 Site and Subsurface Conditions

3.1 Site Description

A review of available surficial geology maps indicates that beneath any fill, the predominant native deposits in the vicinity of the harbour consist of lacustrine and glaciolacustrine deposits underlain by a hard sandy silt till known as the Elma Till. The overburden is underlain by cherty limestone of the Bois Blanc Formation. Based on a review of the bedrock topography, bedrock is located about 30 m below the surface of the harbour bottom (reference Tiverton – Port Elgin Sheet, Bedrock Topography Series, Preliminary Map P.124, Ontario Department of Mines, 1962).

3.2 Soil Stratigraphy

The detailed stratigraphy encountered in the boreholes is detailed in the borehole logs found in Appendix B. The stratigraphy is summarized in the following paragraphs. It must be noted that boundaries of soil indicated in the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for the purposes of geotechnical design and should not be interpreted as exact planes of geological change.

3.2.1 Fill - Sand

At Borehole 2, sand fill was encountered at surface/harbour bottom, to a depth of about 3.0 m, Elevation 171.89 m. The sand fill was noted to be grey, fine-grained and contained some organic odours. The compactness condition of the sand fill very loose to compact, based on SPT N-values of 2 to 21 blows per 300 mm penetration of the spoon. The *in situ* moisture content of the sand fill is 24 to 30 percent, indicating wet/saturated conditions.

For design purposes, the soil parameters of the sand fill are:

$\emptyset = 30°$

$K_a = 0.33$

$K_p = 3.03$

3.2.2 Fill – Clayey Silt

At Borehole 1, clayey silt fill was encountered at surface/harbour bottom, to a depth of about 3.6 m, Elevation 169.19 m. At Borehole 2, clayey silt fill was encountered beneath the sand fill, to an approximate Elevation of 171.89 m. The fill was generally noted to be grey and contain traces of gravel and sand. The result of the grain size analysis indicates that the till typically consists of 9% Gravel, 13% Sand, 53% Silt, and 25% Clay. A copy of the grain size analysis is included as Drawing 2.

Based on the pocket penetrometer readings of undrained shear strength, the consistency of the clayey silt fill is firm to very stiff. The unit weight of the clayey fill is in the order of 21.7 kN/m^3 and the *in situ* moisture content is 13 to 21 percent.

For design purposes, the soil parameters of the clayey silt fill are:

Ø = 25°

K_a = 0.40

K_p = 2.5

γ = 21.5 kN/m^3

c = 5 kPa

3.2.3 Fill – Cobbles and Boulders

Fill, consisting of cobbles and boulders was encountered beneath the clayey silt fill at BH1 and BH2. The thickness of this fill layer was noted to range from about 0.6 to 4.0 m and is expected to contain silt and sand within the voids. This layer could required rock coring techniques to advance the borehole.

3.2.4 Gravel/Sand

Beneath the cobbles and boulders, a layer ranging in composition from fine gravel to medium-grained sand was encountered to termination depths (~Elevation 162.84 to 164.89 m). This layer was noted to be grey and wet. The compactness condition of the medium-grained sand and fine gravel is compact to dense based on SPT N-values of 20 to greater than 50 blows per 300 mm penetration of the spoon. The *in situ* moisture content of the sand and gravel is 17 to 21 percent, indicating wet/saturated conditions.

For design purposes, the soil parameters of the sand and gravel are:

Ø = 40°

K_a = 0.22

K_p = 4.54

3.3 Groundwater Conditions

Details of the groundwater conditions observed within the boreholes are provided on the attached Borehole Logs. Moisture contents of all retained samples are also recorded on the attached Borehole Logs. Upon completion of drilling and removing the augers and casing, free water was at surface, consistent with underwater drilling.

4 General Limitations

The information presented in this report is based on a limited investigation designed to provide information regarding the current conditions within the subject property. The conclusions and recommendations presented in this report reflect site conditions existing at the time of the investigation. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent. Should this occur, exp Services Inc. should be contacted to assess the situation, and the need for additional testing and reporting. **Exp** has qualified personnel to provide assistance in regards to any future geotechnical and environmental issues related to this property.

Our undertaking at exp, therefore, is to perform our work within limits prescribed by our clients, with the usual thoroughness and competence of the engineering profession. It is intended that the outcome of this investigation assist in reducing the client's risk associated with environmental impairment. Our work should not be considered 'risk mitigation'. No other warranty or representation, either expressed or implied, is included or intended in this report.

The comments given in this report are intended only for the guidance of design engineers. The number of test holes required to determine the localized underground conditions between test holes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

Exp Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not afforded the privilege of making this review, **exp** Services Inc. will assume no responsibility for interpretation of the recommendations in this report

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We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Appendix A – Drawings

BOREHOLE LOCATION PLAN

1:2000

LEGEND

BH — APPROXIMATE BOREHOLE LOCATION

NOTES

1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT TEST HOLE LOCATIONS. BETWEEN TEST HOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

2. SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR 3 MONTHS AND THEN DESTROYED UNLESS CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.

3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE TEST HOLE LOCATIONS.

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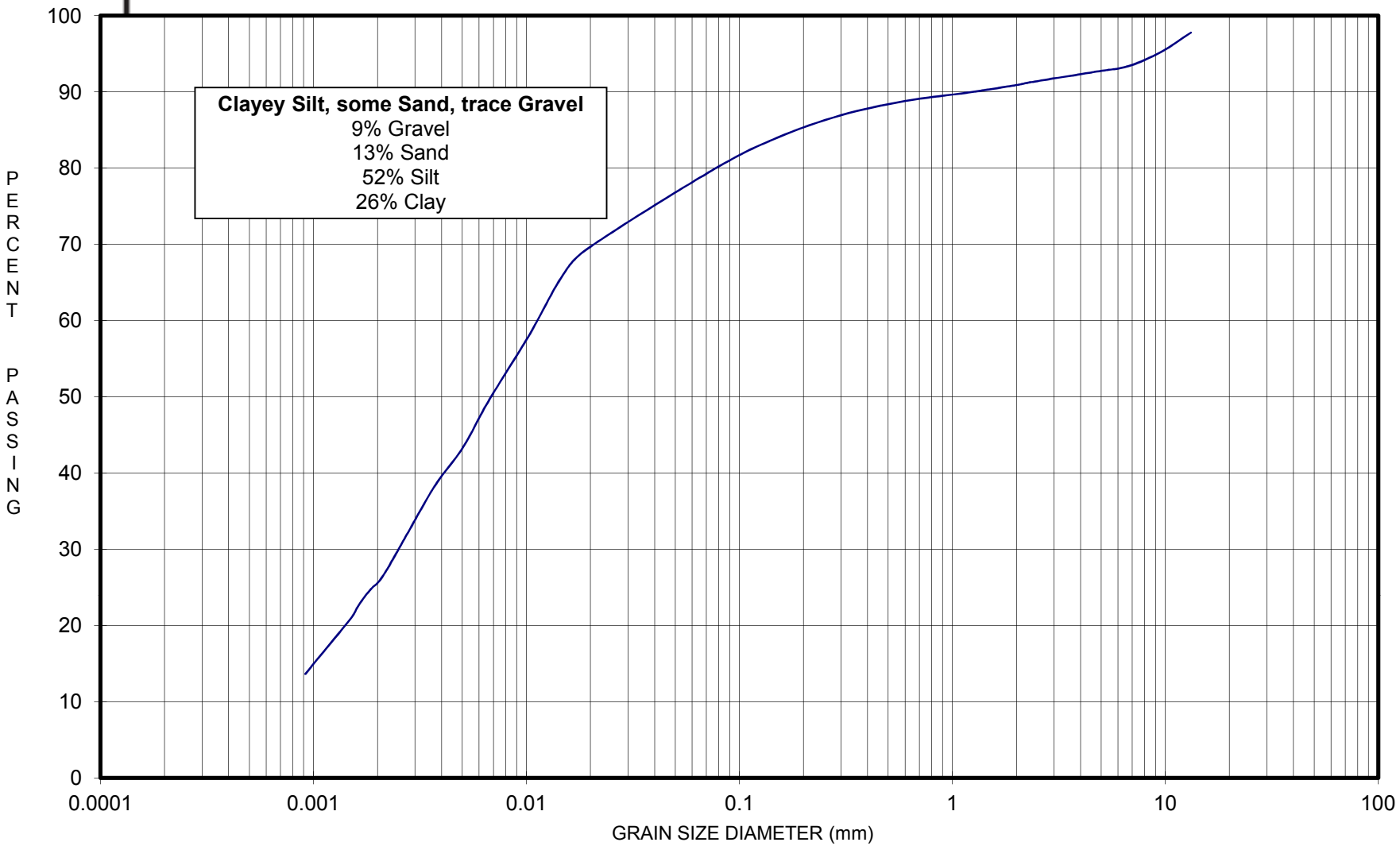
DRAWING TITLE: BOREHOLE LOCATION PLAN, GEOTECHNICAL INVESTIGATION PORT ELGIN HARBOUR,ONTARIO	JOB #: KCH-00215059-GE	DWN.: MD
	SCALE: 1:2000	CHKD.: GF
	DATE: OCTOBER, 2013	DWG. No.: 1

MECHANICAL GRAIN SIZE ANALYSIS



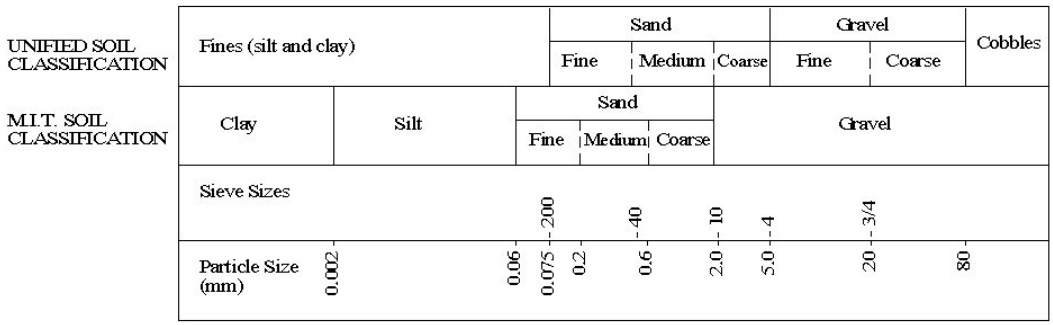
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	
	SILT			SAND			GRAVEL			

MODIFIED M.I.T. CLASSIFICATION	**Sample Description:** **Borehole 1 Sample 3**	**Port Elgin Harbour** **Project: KCH-00215059-GE**	**Drawing 2**

Appendix B – Borehole Logs

NOTES ON SAMPLE DESCRIPTIONS

1. All descriptions included in this report follow the 'modified' Massachusetts Institute of Technology (M.I.T.) soil classification system. The laboratory grain-size analysis also follows this classification system. Others may designate the Unified Classification System as their source; a comparison of the two is shown for your information. Please note that, with the exception of those samples where the grain size analysis has been carried out, all samples are classified visually and the accuracy of the visual examination is not sufficient to differentiate between the classification systems or exact grain sizing. The M.I.T. system has been modified and the **exp** classification includes a designation for cobbles above the 75 mm size and boulders above the 200 mm size.



2. **Fill**: Where fill is designated on the borehole log, it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description therefore, may not be applicable as a general description of the site fill material. All fills should be expected to contain obstructions such as large concrete pieces or subsurface basements, floors, tanks, even though none of these obstructions may have been encountered in the borehole. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact and correct composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. The fill at this site has been monitored for the presence of methane gas and the results are recorded on the borehole logs. The monitoring process neither indicates the volume of gas that can be potentially generated or pinpoints the source of the gas. These readings are to advise of a potential or existing problem (if they exist) and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic waste that renders the material unacceptable for deposition in any but designated land fill sites; unless specifically stated, the fill on the site has not been tested for contaminants that may be considered hazardous. This testing and a potential hazard study can be carried out if you so request. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common, but not detectable using conventional geotechnical procedures.

3. **Glacial Till**: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process, the till must be considered heterogeneous in composition and as such, may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm in diameter) or boulders (greater than 200 mm diameter) and therefore, contractors may encounter them during excavation, even if they are not indicated on the borehole logs. It should be appreciated that normal sampling equipment can not differentiate the size or type of obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited area; therefore, caution is essential when dealing with sensitive excavations or dewatering programs in till material.

BOREHOLE LOG

BH1
Sheet 1 of 1

PROJECT **Port Elgin Harbour** PROJECT NO. **KCH-00215059-GE**
CLIENT **Fisheries and Oceans Canada** DATUM **Geodetic**
DRILL TYPE/METHOD **Tri-Cone & Coring** DATES: Boring **October 24, 2013** Water Level **Oct 24, 2013**

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) or (%)	SAMPLES N VALUE (blows) or RQD (%)	PENETROMETER (kPa)
0	172.84	**FILL:** Clayey silt, grey, traces of gravel, firm		▼		S1	370	4	25
1									
2		-unit weight = 21.7 kN/m3				S2	325	12	25
3						S3	325	8	25
	169.19								
4		**FILL:** Cobbles and boulders							
5						S4	900		
6									
7									
	165.24								
8		**SAND:** Grey, medium-grained, wet, very dense				S5	370	50	
9									
						S6	325	50	
10	162.84					S7	275		
		End of Borehole at 10.0 m depth.							
11									
12									

SHEAR STRENGTH
✚ S Field Vane Test (#=Sensitivity)
▲ Penetrometer ■ Torvane
100 200 kPa
Atterberg Limits and Moisture
W_P W W_L
● SPT N Value × Dynamic Cone
10 20 30 40

NOTES

1) Borehole interpretation requires assistance by exp before use by others. Borehole Log must be read in conjunction with exp report KCH-00215059-GE. For definition of terms used on log, see sheets prior to log.

2) After removing augers, borehole open to 8.5 m.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
▥ Rock Core (eg. BQ, NQ, etc.) ▣ VN Vane Sample

OTHER TESTS
G Specific Gravity
H Hydrometer
S Sieve Analysis
γ Unit Weight
P Field Permeability
K Lab Permeability
C Consolidation
CD Consolidated Drained Triaxial
CU Consolidated Undrained Triaxial
UU Unconsolidated Undrained Triaxial
UC Unconfined Compression
DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)

BOREHOLE LOG

BH2
Sheet 1 of 1

PROJECT **Port Elgin Harbour** PROJECT NO. **KCH-00215059-GE**
CLIENT **Fisheries and Oceans Canada** DATUM **Geodetic**
DRILL TYPE/METHOD **Tri-Cone & Coring** DATES: Boring **October 25, 2013** Water Level **Oct 25, 2013**

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WELL LOG	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) or (%)	SAMPLES N VALUE (blows) or RQD (%)	PENETROMETER (kPa)
0	174.89	**FILL:** Sand, grey, fine-grained, some organic odour, very loose to compact		▼		S1	370	2	
1									
2						S2	320	21	
3	171.89								
		FILL: Clayey silt, grey, firm to very stiff -unit weight= 21.3 kN/M3				S3	320	10	
4									
5						S4	370	26	120
6									
	168.19	-unit weight= 21.4 kN/M3				S5	370	48	25
7	167.59	**FILL:** Cobbles and boulders							
		GRAVEL: Grey, small gravel, some coarse-grained sand, wet, compact to dense				S6	370	46	170
8									
9						S7	320	20	
10	164.89					S8	400		
		End of Borehole at 10.0 m depth.							
11									
12									

SHEAR STRENGTH
✚ S Field Vane Test (#=Sensitivity)
▲ Penetrometer ■ Torvane
100 200 kPa
Atterberg Limits and Moisture
W_P W W_L
● SPT N Value × Dynamic Cone
10 20 30 40

NOTES

1) Borehole interpretation requires assistance by exp before use by others. Borehole Log must be read in conjunction with exp report KCH-00215059-GE. For definition of terms used on log, see sheets prior to log.

2) After removing augers, borehole open to 7.3 m, and water at surface.

SAMPLE LEGEND
☒ AS Auger Sample ▨ SS Split Spoon ■ ST Shelby Tube
▥ Rock Core (eg. BQ, NQ, etc.) ▥ VN Vane Sample

OTHER TESTS

G Specific Gravity	C Consolidation
H Hydrometer	CD Consolidated Drained Triaxial
S Sieve Analysis	CU Consolidated Undrained Triaxial
γ Unit Weight	UU Unconsolidated Undrained Triaxial
P Field Permeability	UC Unconfined Compression
K Lab Permeability	DS Direct Shear

WATER LEVELS
▽ Apparent ▼ Measured ▲ Artesian (see Notes)