

Geocres No:
41H-30

Ministry of Transportation

Northern Region
North Bay, Ontario

Britt Patrol Yard
Geocres No. 41H-30

Foundation Investigation and Design Report Sand/Salt Storage Structure

FINAL

April 16, 2001



Acres International
Oakville, Ontario, Canada

Table of Contents

List of Tables

List of Figures

Part 1	Foundation Investigations	1
1	Introduction	1
2	Site Description	1
3	Investigation Procedures	2
3.1	Field Investigations	2
3.2	Field Survey	2
3.3	Laboratory Testing	2
4	Subsurface Conditions	3
4.1	Fill (SW)	3
4.2	Sand and Silt to Clayey Sand and Silt (SM - ML)	4
4.3	Silty Clay (CI - CH)	4
4.4	Sandy Silt (ML)	4
5	Groundwater Conditions	5
Part 2	Foundation Design	6
6	Engineering Discussion and Recommendations	6
6.1	Summary of Geotechnical Site Conditions	6
6.2	Sand/Salt Storage Structure	7
6.2.1	Alternative Foundations	8
7	Foundations for Sand/Salt Stockpiles	12
8	Chemical Analysis of Groundwater	12

Tables

Figures

Appendix A	Record of Boreholes
Appendix B	Chemical Test Results
Appendix C	Explanation of Terms Used in Report

List of Tables

No.	Title
1	Summary of Borehole Data
2	Summary of Laboratory Test Results

List of Figures

No.	Title
1	Location of Boreholes
2	Soil Stratigraphy
3	Grain Size Distribution, Sand (SW) with Trace Gravel
4	Grain Size Distribution, Silty Sand with Trace Clay
5	Grain Size Distribution, Silty Clay (CH)
6	Grain Size Distribution, Sandy Silt (ML)
7	Plasticity Chart, Silty Clay and Clay
8	Consolidation Testing, Borehole BH 1

Part 1 Foundation Investigations

1 Introduction

Acres International (Acres) was retained by the Ministry of Transportation Ontario (MTO) to undertake foundation investigations and testing, and preparation of geotechnical reports for Highway (Hwy) 510 swamp and Hwy 607A swamp and three sand/salt storage structures located in the Northern Region. The work was authorized by MTO Agreement PO5005A000167 dated June 2000. The Terms of Reference also included the evaluation of potential impact of the storage of deicing salts on the quality of shallow water in the ground at the site.

This report presents the results of foundation investigations at one of the proposed sand/salt storage structures located at the MTO Patrol Yard in Britt, Northern Ontario.

2 Site Description

The Britt Patrol Yard is located adjacent to Hwy 526 about 15 km north of Parry Sound and about 600 m west of the intersection of Hwy 526 and Hwy 69 as shown in Figure 1. The yard is about 100 m to the north of the Magnetawan River.

The topography and physiography, including the presence of bedrock outcrop highs both to the north and south of the river suggests that the area is a filled in bedrock valley within which the course of the river is controlled.

The site of the storage structure is situated in an MTO operating maintenance patrol yard. It is fully fenced and accessed from Hwy 526. The yard contains an existing 30-m dia sand/salt structure, a 5-bay garage and storage shed, Figure 1. Access roads to these facilities are all paved with asphalt.

The new sand/salt structure is proposed to be located at the southeast corner of the site and the topography in this area is generally low and level.

3 Investigation Procedures

3.1 Field Investigations

The site investigations were carried out on August 31, 2000. A total of four boreholes, numbered BH-1 to BH-4, were drilled at the locations shown in Figure 1. The boreholes were advanced to depths ranging from 5.2 to 19.3 m using a truck-mounted continuous flight hollow-stem augering equipment owned and operated by Boart Longyear Inc. (Boart) of Maple, Ontario. Soil samples were obtained at approximately 0.75- and 1.5-m intervals using a split-spoon sampler in conjunction with Standard Penetration Test (SPT), performed in accordance with ASTM D1586 Designation. SPT N-values were recorded and used to provide an estimate of the relative denseness of the cohesionless soils and consistency of cohesive soils.

A representative of Acres was present throughout the drilling period to monitor and inspect drilling and sampling operations. All soil samples were identified and described in the field, and subsequently transported to Acres Geotechnical Laboratory in Niagara Falls for further detailed examination and laboratory testing.

A summary of borehole data is given in Table 1. Detailed information on the boreholes is presented in the Record of Boreholes in Appendix A.

As per MTO guidelines and OHBDC standards, soil samples were classified according to Unified Soil Classification Systems. The clay content reported as per MTO format in Record of Boreholes forms is based on grain size less than 0.002 mm.

3.2 Field Survey

Survey of location and ground surface elevation of the boreholes was carried out by Acres. The elevation was referenced to an MTO monument located at the east corner of the sand/salt storage building with a known elevation of 180.740 m.

3.3 Laboratory Testing

Selected samples of the overburden obtained from the boreholes were tested in accordance with applicable ASTM standards, as follows:

- moisture content
- Atterberg index limits
- grain size distribution
- natural unit weight
- consolidation.

Testing was carried out at Acres Geotechnical Laboratory in Niagara Falls and the results are shown in Table 2, and also included in the Record of Boreholes in Appendix A. The results of grain size distribution are presented graphically in Figures 3 to 6 and the plasticity chart is shown in Figure 7. Consolidation test results are given in Figure 8.

Chemical analyses of the groundwater sample collected from the piezometer installation in Borehole BH-4 was carried out to assess the potential impact of storage of deicing salt at the site. Testing was carried out by Maxxam Analytics Inc. of Mississauga, Ontario, and the results are included in Appendix B.

4 Subsurface Conditions

The soil stratigraphy, shown in Figure 2, comprised granular fill overlying fine sand and silt to clayey sand and silt (SM - ML) underlain by silty clay (CI - CH) and a deposit of sandy silt with some clay (ML).

Details of the various soils encountered at the borehole locations, together with the summary of SPT N-values and the results of laboratory test results, are summarized in the Record of Boreholes in Appendix A. It should be noted that the soil boundaries indicated in the Record of Boreholes are inferred from non-continuous sampling and observations during drilling.

A brief description of the soils encountered at the site in the order of depth is given below.

4.1 Fill (SW)

Fill materials were encountered in all boreholes. The fill comprised a well graded clean grayish brown sand with gravel, generally moist. Grain size distribution of a typical sample is presented in Figure 3. The granular fill is about 0.6 m thick.

4.2 Sand and Silt to Clayey Sand and Silt (SM - ML)

This soil deposit, varying from light grey fine sand and silt to clayey sand and silt (SM-ML), was encountered in all the four boreholes. The top elevation of this deposit varies from el. 179.82m in Borehole 2 to el. 178.66m at Borehole 3. The thickness varies from 1.8m to 3 m. SPT N-values ranged between 1 and 12 indicating that the material is very loose to compact, but mostly very loose to loose. The material is generally wet with moisture content ranged between 16% and 30% depending on clay content. Grain size distribution results are given in Figure 4 indicating silt and clay fractions of 30% and 10%, respectively. The sand fraction of this natural soil layer is fine grained.

4.3 Silty Clay (CI - CH)

Silty clay (CI - CH) was encountered below the fine sand and silt to clayey sand and silt (SM-ML). The top of this deposit varies from el. 177.98m at Borehole 2 to el. 176.07m at Borehole 4. Cone penetration test results for Borehole 1 and auger refusal at Borehole 3 indicate the soft silty clay deposit varies in thickness from 4.3 m to 7 m, respectively. This deposit is moist, generally very soft to soft light grey silty clay with SPT N-values ranging between 0 to 12. The plasticity index varies between 25 and 55 and the moisture content was at or exceeding the liquid limit, varying from 40% to 80%, Figure 7. The moist unit weight of the material was about 15 kN/m³. Grain size distribution results are given in Figure 5 indicating the following distribution.

- gravel: 0%
- sand: 1%
- silt: 28 % to 32%
- clay (<0.002 mm): 67% to 72%

Field vane shear test results gave undrained shear strength of 12 to 20 kPa. A laboratory consolidation test was conducted on a sample from Borehole BH-1 at 5.8 m depth (about el 174.5 m) and the results suggest that the material is normally-consolidated with $C_c = 1.1$, Figure 8.

4.4 Sandy Silt (ML)

Underlying the soft silty clay, a deposit of light grey wet sandy silt (ML) with trace to some clay was penetrated below el. 169.36 m at Borehole 1 and el. 172.26 m at

Borehole 3. The SPT N-values were very low indicating that the material is very loose to loose. The moisture content ranged between 20% and 30%. The results of one grain size distribution test is shown in Figure 6 indicating sand, silt and clay fractions of about 23%, 65% and 12% respectively. The cone penetration test results suggest that this sandy silt unit ranges in thickness from 2 to 9 m, increasing toward the south.

In Borehole BH-1, the bottom was sounded by driving a cone to refusal at 19.4 m depth or el 160.6 m. In Borehole BH-3, auger refusal was encountered at 10.8 m depth, from which the top of assumed refusal elevation was inferred at el 169.4 m.

5 Groundwater Conditions

The piezometer installed 2 m south and 2 m west of Borehole BH-4 indicated water level after completion of drilling at a depth of about 1.33 m equivalent to el 178.39 m.

At the request of the MTO Northern Region, Acres' staff collected a groundwater sample from the standpipe piezometer which was installed near Borehole BH-4. This sample was submitted for chemical analysis in order to provide a preliminary evaluation of the potential for impact on groundwater quality at the site as a result of the past use and/or storage of deicing salts at the site. Chemical testing results are attached as Appendix B.

Part 2 Foundation Design

6 Engineering Discussion and Recommendations

The overriding finding emerging from the geotechnical investigations is a site underlain by weak and compressible fine-grained soils with a total thickness of about 18 m. Even for relatively light loadings, these soils present challenging conditions in terms of bearing and support, large and potentially uneven settlement, detailed design and construction practice.

The proposed location of the storage structure is shown on Figure 1. A number of foundation alternatives have been considered for the Britt Yard site. The alternatives include cast-in-place shallow ring or strip foundations, a mat or raft foundation, pre-loading and driven piles. Based on the foundation investigations, a strip/ring foundation is not recommended for the structure due to the high potential for large and variable settlement. A rigid mat foundation may be feasible depending on design loads; however, this option has restrictive ULS and SLS bearing capacities. Pile foundations are feasible but the relative cost of this option is high and possibly unwarranted.

Generally, the proposed location for the storage structure is uneconomic and an alternative location for the structure should be considered. Referring to Figure 1, Foundation conditions may be more favorable adjacent to the existing salt storage dome. The existing dome is situated near a bedrock outcrop encountered at the east edge of the Britt Yard. In the absence of a more suitable location, a mat foundation is recommended for consideration at the new site. As noted above, however, the bearing values provided in this report are restrictive. As a last resort, a pile foundation option may be required.

6.1 Summary of Geotechnical Site Conditions

The soils encountered in the subsurface are as follows:

Thickness (m)	Type
0.6	Granular fill (SW)
2.0 - 3.0	Grey fine sand and silt to clayey silt and sand (SM -ML)
4.0 - 8.0	Brown grey silty clay, very stiff (CI - CH)
>8.0	Sandy silt, loose to compact (ML)

The depth of frost penetration is estimated to be about 2 m. Therefore foundation elements should be placed at a minimum depth of 2.0 m below finished grade elevation to provide adequate protection against frost action. ?

6.2 Sand/Salt Storage Structure

The MTO Terms of Reference offer no specific dimensions or required floor elevation of the proposed storage structure at the Britt Patrol Yard. Based on the examination of the topography shown in Figure 1 and details of site conditions presented earlier, the following recommendations and comments are provided for the design of the proposed storage structure at the Britt Patrol Yard. ?

- maximum size of the storage structure which can be accommodated at the proposed site is about 30 m diameter.
- considering drainage, the floor elevation of the proposed storage structure should be higher than the surrounding finished ground surface, if possible. The area around the storage structure must be graded away from the structure at a minimum slope of 2% within at least 5 m of the structure.
- the foundation preparation consists of the following:
 - first stage excavation down to foundation level.
 - proof roll the foundation material at the excavation grade to achieve a compaction of at least 98% of the Standard Proctor Maximum Dry Density (SPMDD) as obtained from the Standard Proctor Compaction Tests.
 - any soft or unsuitable material at the excavation grade to be removed and filled with Granular 'A' material and compacted to 98% SPMDD
 - if slab on grade construction is considered, provide a bedding layer of Granular 'A' a minimum of 0.3 m for the support of floor slab inside the storage structure

- spread fill materials, when required in continuous and approximately uniform layers not exceeding 150 mm before compaction and compact to 98% SPMDD for granular and impervious fills
- for shallow excavations for footings, there may be perched water that may seep out during construction. It is expected that such seepage will be minimal and can be controlled using conventional construction techniques such as pumping from sumps or perimeter ditches. However deep excavation may run into weak soils with excess water.
- in view of the fine grained nature of the soils at the site, perimeter drains around the paved areas and around access ways, parking lot and loading areas are recommended.

The general ground surface in the investigated area is about el 180.0 m.

6.2.1 Foundations Alternatives

(a) Ring or Strip Foundation

It is understood that this type of structure is typically founded on a ring or strip footing founded on or within a compacted granular pad. Given the very loose and very soft state of foundation soils at the Britt Yard, strip and/or spread cast-in-place footings constructed on overburden soil are not recommended. Although the proposed salt dome is a lightly loaded structure, the pressure applied to the foundation soils by salt and sand stored within the dome will cause significant total and differential settlements impacting on the dome foundation. Furthermore, the addition of 2 m of fill at the dome location will cause about 300 mm of long term consolidation settlement.

Also, some excavation may be necessary in the upper weak soils to provide foundation for the footings. Such excavations require special care so as to cause minimal further weakening and disturbance in soils likely to behave in a sensitive manner.

(b) Mat Foundation

Given the high potential for significant total and differential settlements at the site, engineering precedent would dictate consideration of a mat foundation. Special provisions will be required in the design, however, to accommodate settlement. The following table summarizes ultimate and serviceability limit state bearing values for a mat foundation:

Bearing Capacity	Elevation - Bottom of Mat		
	180 m	179 m	178 m
Factored Ultimate Limit State (ULS)	50 kPa	65 kPa	80 kPa
Serviceability Limit State (SLS)	30 kPa	50 kPa	70 kPa
Settlement at SLS	100 - 125 mm	100 - 125 mm	100 - 125 mm

The ultimate limit state (ULS) bearing pressure for the mat foundation is governed by the shear strength of the soft silty clay deposit encountered at el 177 m \pm . Appropriate mat elevations and bearing values used for the site will depend on considerations such as site drainage.

The recommended bearing values at the Serviceability Limit State (SLS) account for off-loading which will occur as the mat elevation is reduced below existing ground level. Settlements at SLS have been estimated between 100 mm and 125 mm for the structure irrespective of mat level. The time required for 50% and 90% of the settlement is estimated at 3 yrs and 10 yrs, respectively.

A mat foundation of suitable rigidity will promote even distribution of settlements over the entire structure; however, provisions must be incorporated in the dome design to accommodate settlement without introducing serviceability problems associated with drainage and dome access. A modulus of sub-grade reaction equal to 500 kN/m³ is recommended for design of the raft foundation. It is recommended that the net change in pressure, applied to the underlying very soft silty clay deposit be limited to less than 30 kPa.

In terms of foundation preparation, all near surface foundation soils at the site are susceptible to disturbance during construction. For foundation levels below the existing ground surface, excavations must be properly drained by perimeter ditching and pumping from sumps. The foundation surface should be prepared using an excavator equipped with a scrapping bucket to remove all loose material and debris. After excavation to foundation level, the foundation soil should be covered with 300 mm of Granular "A" fill placed using a light dozer (such as a Cat D3 or equivalent) and compacted using a smooth drum roller without vibration or a vibrating plate tamper provided the foundation soils can tolerate vibration. Construction equipment, including excavator, should not be permitted on the foundation soil until a proper sub-base granular pad has been spread and compacted. The Granular "A" granular pad should be compacted to a minimum 98% Standard Proctor Maximum Dry Density (SPMDD).

(c) Pre-Loading, or Partial Excavation

Pre-loading and excavation of the soft clay layer has been considered for the Britt Yard site. Based on the results of oedometer consolidation tests conducted on samples obtained from boreholes, pre-loading is not considered feasible given the significant time (about 3 years) required to achieve 50% consolidation. Also, full and partial excavation of the soft material at the site is not considered practical since excavated slopes will need to be very flat to provide adequate factor of safety against failure. ?

(d) Pile Foundation

Driven piles may be considered for the salt dome structure and associated floor slab. Deep foundations for the storage structure would limit settlements to less than 10-20 mm; however, the relative cost is probably high and unwarranted for such a lightly loaded utility structure. The following axial loads are recommended for HP-310x79 piles, and round timber piles driven to end bear on bedrock or to a resistant level. 7

Load Condition	HP310x79	Round Timber Pile (200 mm minimum tip dia.)
Factored Axial Load at Ultimate Limit State, ULS	1050 kN	400 kN
Axial Load at Serviceability Limit State, SLS	800 kN	350 kN
Downdrag Load (unfactored)	125 kN	100 kN

On the basis of cone penetration tests results, an end-bearing or resistant stratum is located 19.3 m and 10.8 m below original ground at the location of Boreholes BH-1 and BH-3 respectively. In the event that timber piles are considered, the piles should be treated to protect against decay. The pile cap (structural slab) should be protected against frost heave.

In relation to pile installation, the bedrock surface in Northern Ontario is highly irregular even over short distances. Due to bedrock surface irregularities, it is essential to ensure satisfactory tip seating. All piles should be equipped with suitable driving shoes to protect against pile damage and to facilitate seating on bedrock. Upon initial contact with rock, the pile driving energy should be reduced then gradually increased to facilitate seating and to minimize out of tolerance piles. In addition to seating difficulties, driving of piles at this site will likely cause adjacent piles to heave upward possibly losing contact with the rock. A sequence of driving and re-striking piles will be required during construction to ensure adequate end-bearing. Generally, out of tolerance piles should be expected at the site and incorporated in the design.

In the event that piles should reach refusal in dense resistant soil stratum above rock, a Pile Driving Analyzer (PDA) or the Hiley formula may be used to assess capacity.

The bedrock on the site was not confirmed by coring. It is further recognized that a pile foundation is likely unprecedented in such light

structures. In the event that pile foundations are chosen for the structure, however, consideration should be given to coring bedrock prior to construction, or as part of a construction control.

7 Foundations for Sand/Salt Stockpiles

The exact location of the sand/salt stockpiles is not known. Assuming locations in the proximity of the storage structure, consideration should be given to limiting height of stockpiles to about 5 m for the initial several years. To ensure stability against base failure in the foundation, slopes at 2.5 H to 1.0 V are recommended. No excavation is necessary and the backfill, if required may be compacted Granular 'B', Type I. The material at the elevation grade should be proof-rolled to achieve a compaction of at least 98% of the maximum dry density as obtained from SPMDD. Considering a functional design life of 10 to 15 years, the following pavement structure is recommended under the sand/salt stockpiles:

Pavement Layer	Compaction Requirements	Thickness
Asphaltic concrete	97% Marshall density	- 40 mm OPSS HL-4 surface course - 50 mm OPSS HL-4 binder course
Granular 'A'	98% SPMDD	- 150 mm
Granular 'B' Type I	98% SPMDD	- 350 mm

Subdrains should be provided to intercept excess moisture and to prevent subgrade softening. The finished pavement surface should be free of depressions and sloped at a minimum grade of 2% to provide effective surface drainage toward catch basins or open ditches.

8 Chemical Analysis of Groundwater

At the request of the MTO Northern Region, Acres' staff collected a groundwater sample from a standpipe piezometer which was installed near

Borehole BH-4. This sample was tested for chemical analysis for preliminary evaluation.

The test results indicate that groundwater sample exhibited a significant level of sodium and chloride concentration. This level is consistent with long term storage of deicing salts at this site and is evidenced by the extremely high chloride concentration (13500 mg/L) and sodium concentration (7550 mg/L). These concentrations are substantially higher than the Ontario Drinking Water Standard of 250 mg/L for chloride and 200 mg/L for sodium. The high concentrations of each of chloride and sodium indicate that deicing salt contaminated runoff is infiltrating the ground. Since the standpipe piezometer was screened within the upper fine sand and silt with some clay, the high salt concentrations in this upper unit are not surprising, given the presence of the lower-permeability soft silty clay unit which would tend to restrict downward vertical movement of a salt-contaminated groundwater.

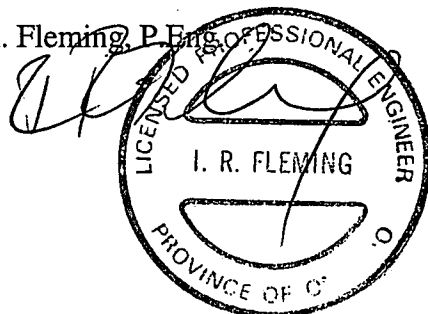
As well, it would be prudent to retain the standpipe piezometer in order that samples may be taken in future for comparison with the present results.

Design and Construction

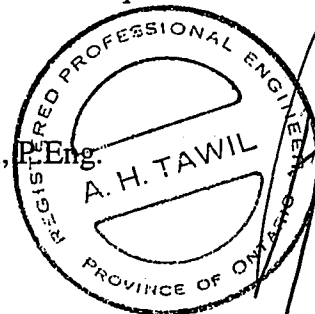
Information in this report is intended to provide general characterization of ground conditions. Variations in the subsurface should be expected and provided for in detailed engineering and construction practices.

Supervision of excavations and backfill should be performed and approved by experienced geotechnical engineers familiar with the requirements of design.

I. R. Fleming, P. Eng.



A. H. Tawil, P. Eng.



Tables

Table 1

Summary of Borehole Data

Borehole	Ground Surface Elevation (m)	Bottom of Borehole (m)	
		Depth	Elevation
BH-1	179.96	19.35	160.61
BH-2	180.42	7.31	173.11
BH-3	180.18	10.82	169.36
BH-4	179.72	5.18	174.54

Table 2

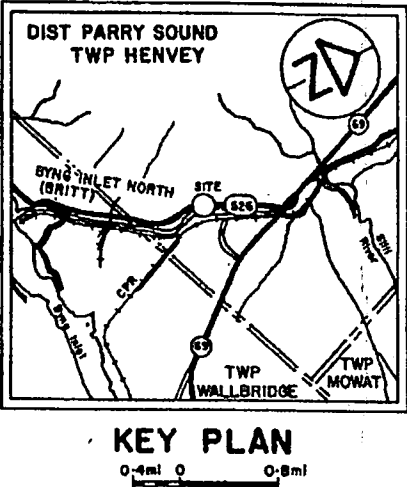
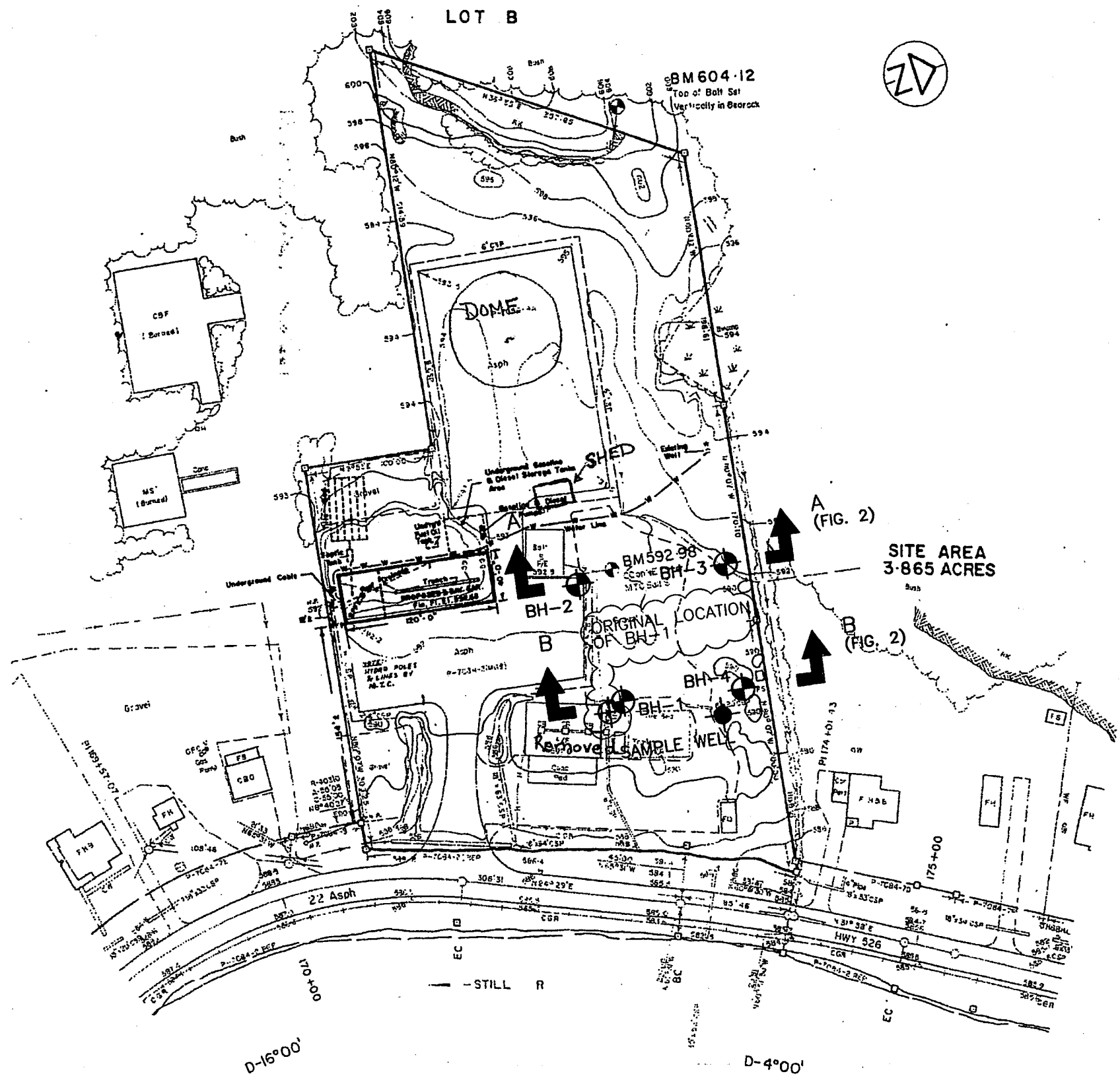
Summary of Laboratory Test Results

Borehole	Depth From-To (m)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Unit Weight (kN/m3)
BH-1	0.76 - 1.37	18.8	41	18	23	15.27
	1.52 - 2.13	16.8				
	2.29 - 2.90	23.9				
	3.05 - 3.66	29.9				
	3.81 - 4.42	53.2				
	4.57 - 5.18	66.9	79	27	52	
	5.33 - 5.94	78.5				
	6.10 - 6.71	76.0				
	7.62 - 8.23	85.6				
	10.67 - 11.28	28.2				
BH-3	0.76 - 1.37	39.5	76	26	50	
	2.29 - 2.90	23.0				
	3.05 - 3.66	36.8				
	3.81 - 4.42	39.3				
	4.57 - 5.18	61.4				
	6.10 - 6.71	72.0				
	9.14 - 9.75	20.9				

Figures



DIST PARRY SOUND
TWP HENVEY

CON A
LOT B



NOTES

LEGEND

- BH-3  BOREHOLE
 SAMPLE WELL

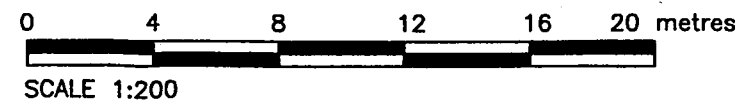
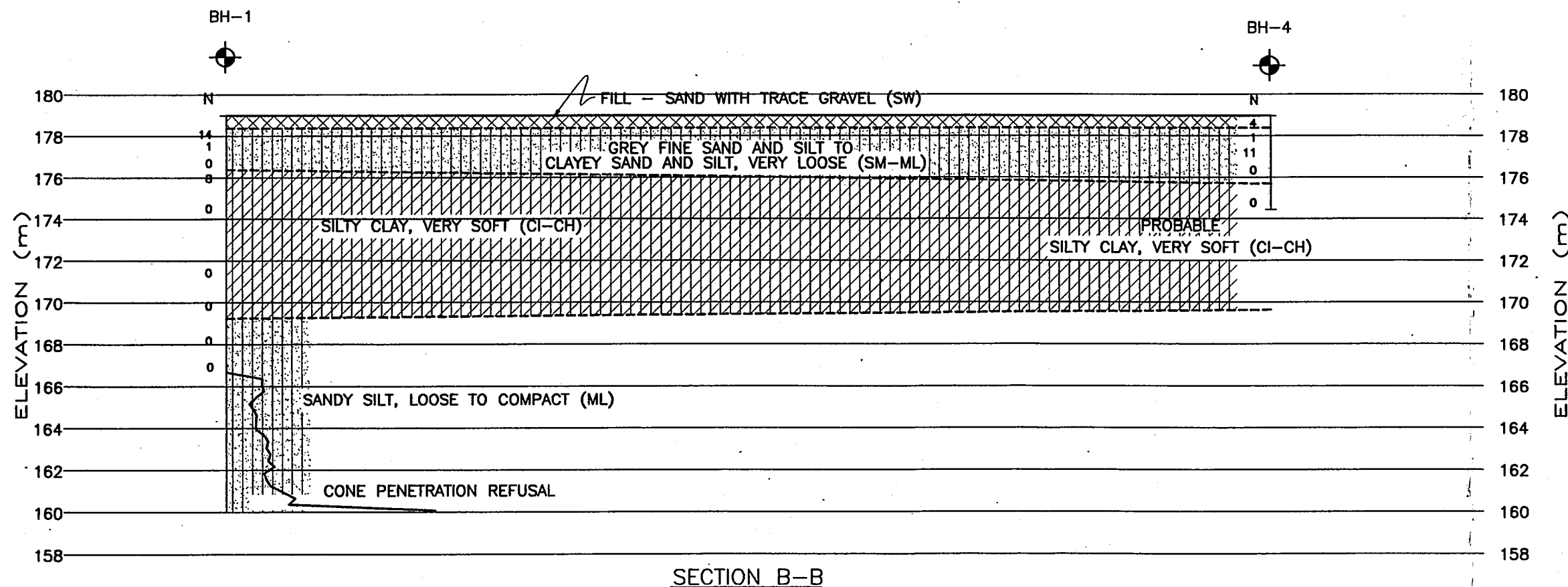
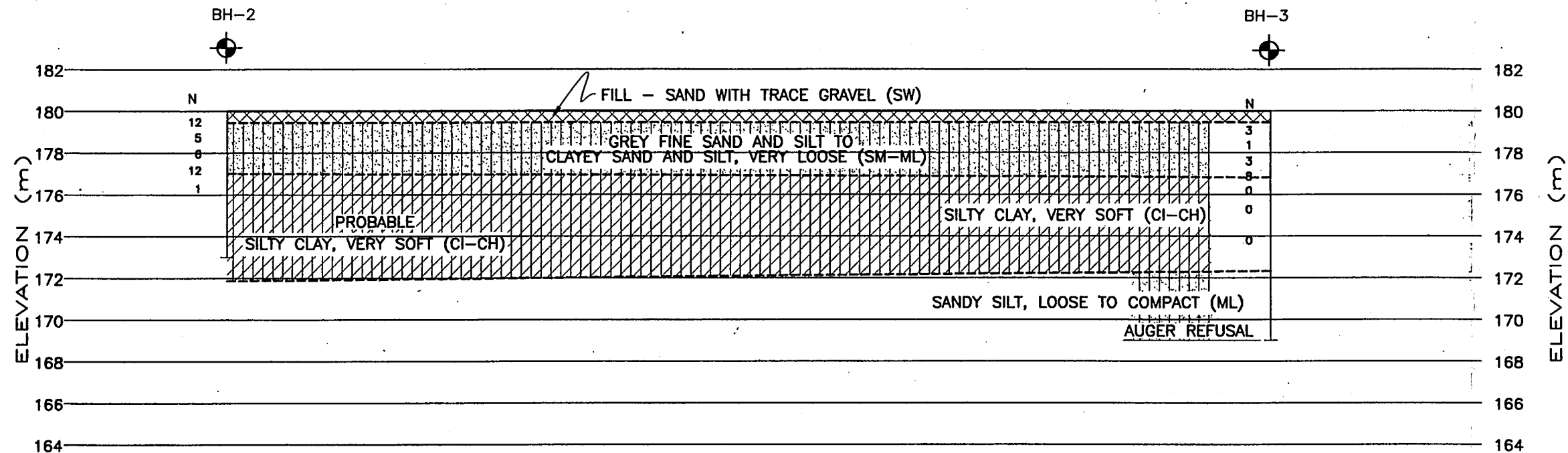
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ACRES INTERNATIONAL

STAMP

Ministry of Transportation
Ontario

DISTRICT	LOT	B
PARRY SOUND	CON.	A
	TWP	HENVEY
PROJECT TITLE	DRAWING DESCRIPTION/TITLE	
BRITT PATROL YARD SALT/SAND STORAGE STRUCTURE	FIGURE 1 BOREHOLE LOCATION PLAN	
GEOCRES NO. 41H-30	DATE	AS NOTED
	FEBRUARY 2001	
DRAWN BY	T.DANIEL	DWG. No.
DESIGNED BY		PROJ. No.
CHECKED BY	L.R.F.	FILE No.
APPROVED BY		



NOTES

LEGEND

BH11
BOREHOLE

REFUSAL

STANDARD PENETRATION
N VALUE BLOWS/300mm

CONE PENETRATION TEST
N VALUES BLOWS/300mm

REV. BY	REV. No.	DESCRIPTION OF REVISION	APPROVED BY	DATE

ACRES INTERNATIONAL

Ministry of Transportation
Ontario

DISTRICT	LOT
PARRY SOUND	B

CON.	TYP.
A	HERVEY

PROJECT TITLE
BRITT PATROL YARD
SAND/SALT STORAGE STRUCTURE

DRAWING DEScript./TITLE
FIGURE 2
SOIL STRATIGRAPHY

DATE	SCALE
FEBRUARY 2001	AS NOTED

DRAWN BY	ENG. No.
T.DANIEL	of

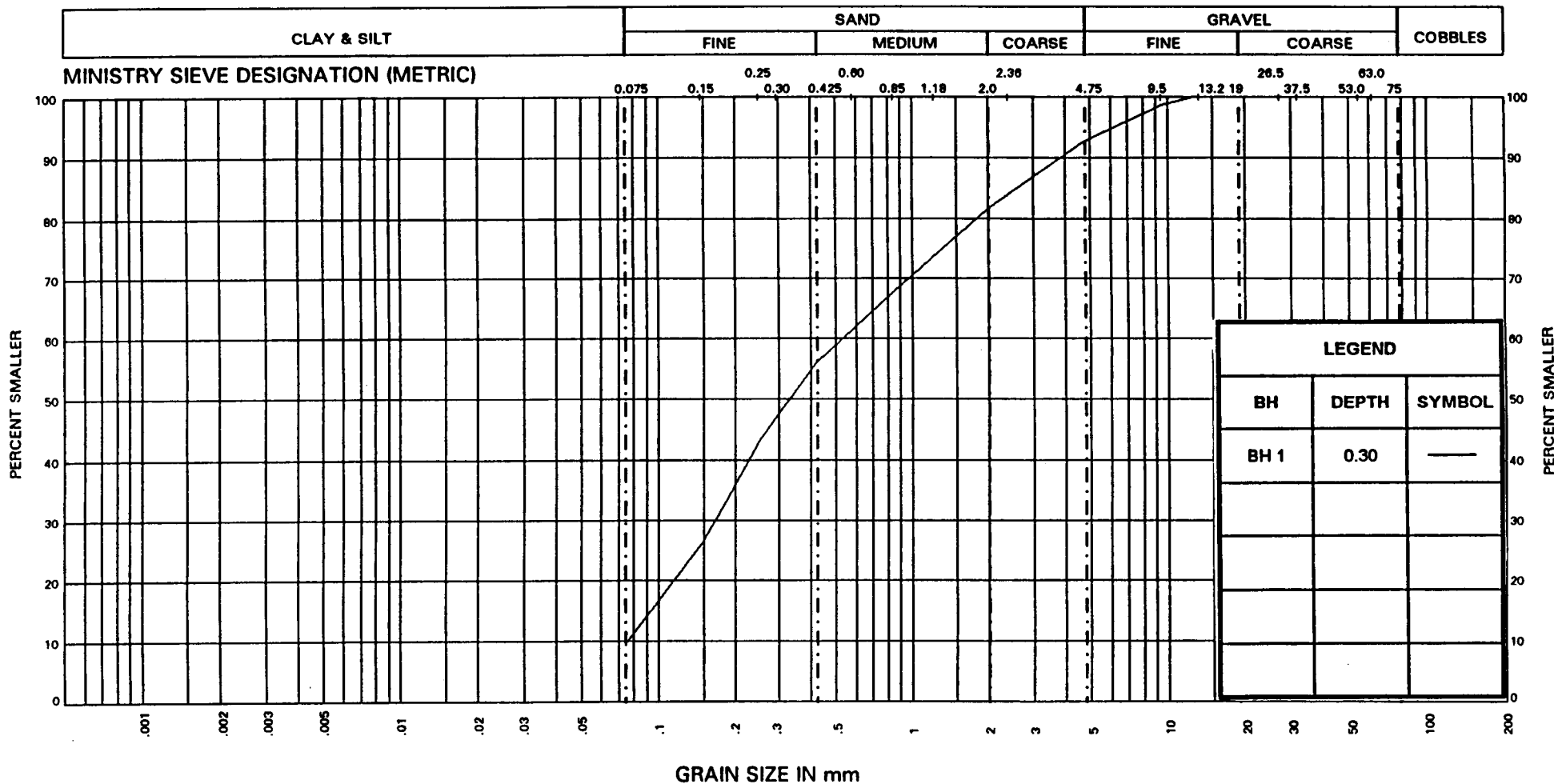
DESIGNED BY	PROJ. No.
L.R.F.	P1349800

CHECKED BY	FILE No.
L.R.F.	

APPROVED BY
A.H.T.

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UNIFIED SOIL CLASSIFICATION SYSTEM



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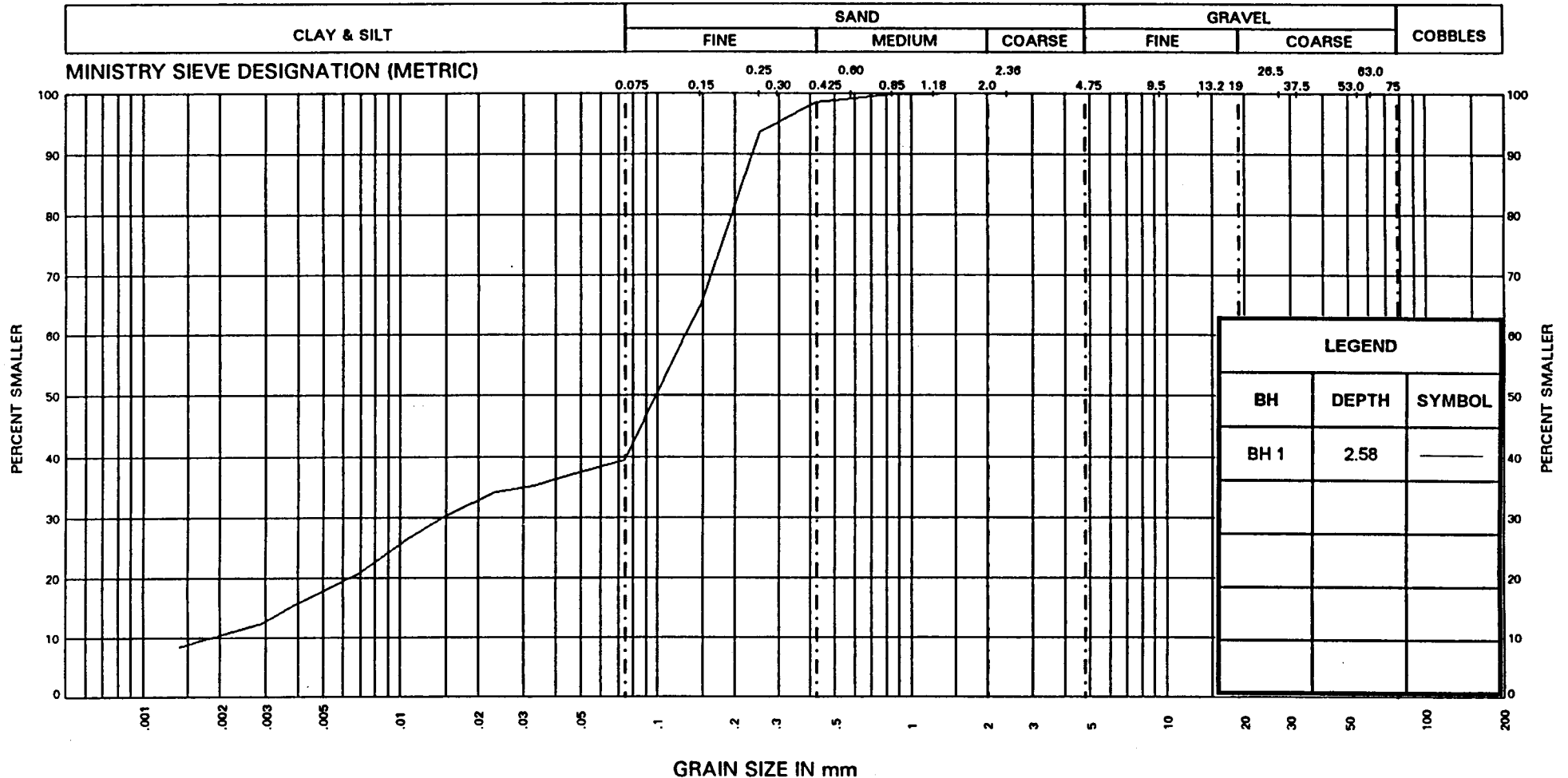
GRAIN SIZE DISTRIBUTION SAND (SW) WITH TRACE GRAVEL

FIGURE 3

W.P. 3 Sand/Salt Structures

BRITT PATROL YARD

UNIFIED SOIL CLASSIFICATION SYSTEM



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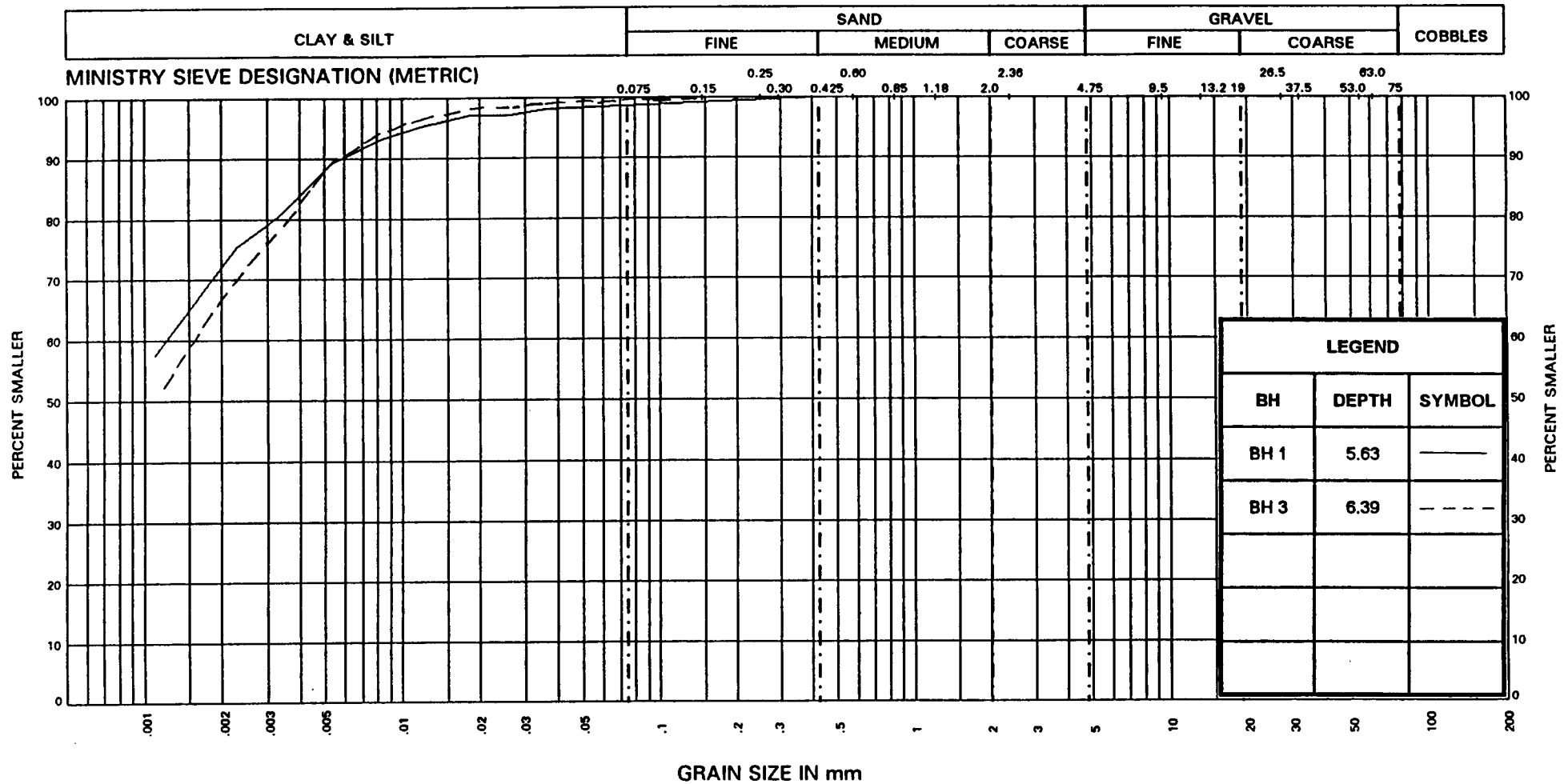
GRAIN SIZE DISTRIBUTION SILTY SAND WITH TRACE CLAY

FIGURE 4

W.P. 3 Sand/Salt Structures

BRITT PATROL YARD

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GRAIN SIZE DISTRIBUTION SILTY CLAY (CH)

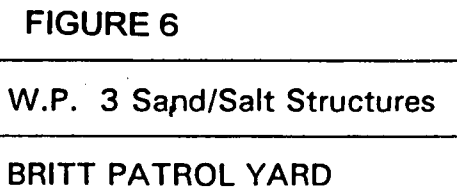
FIGURE 5

W.P. 3 Sand/Salt Structures

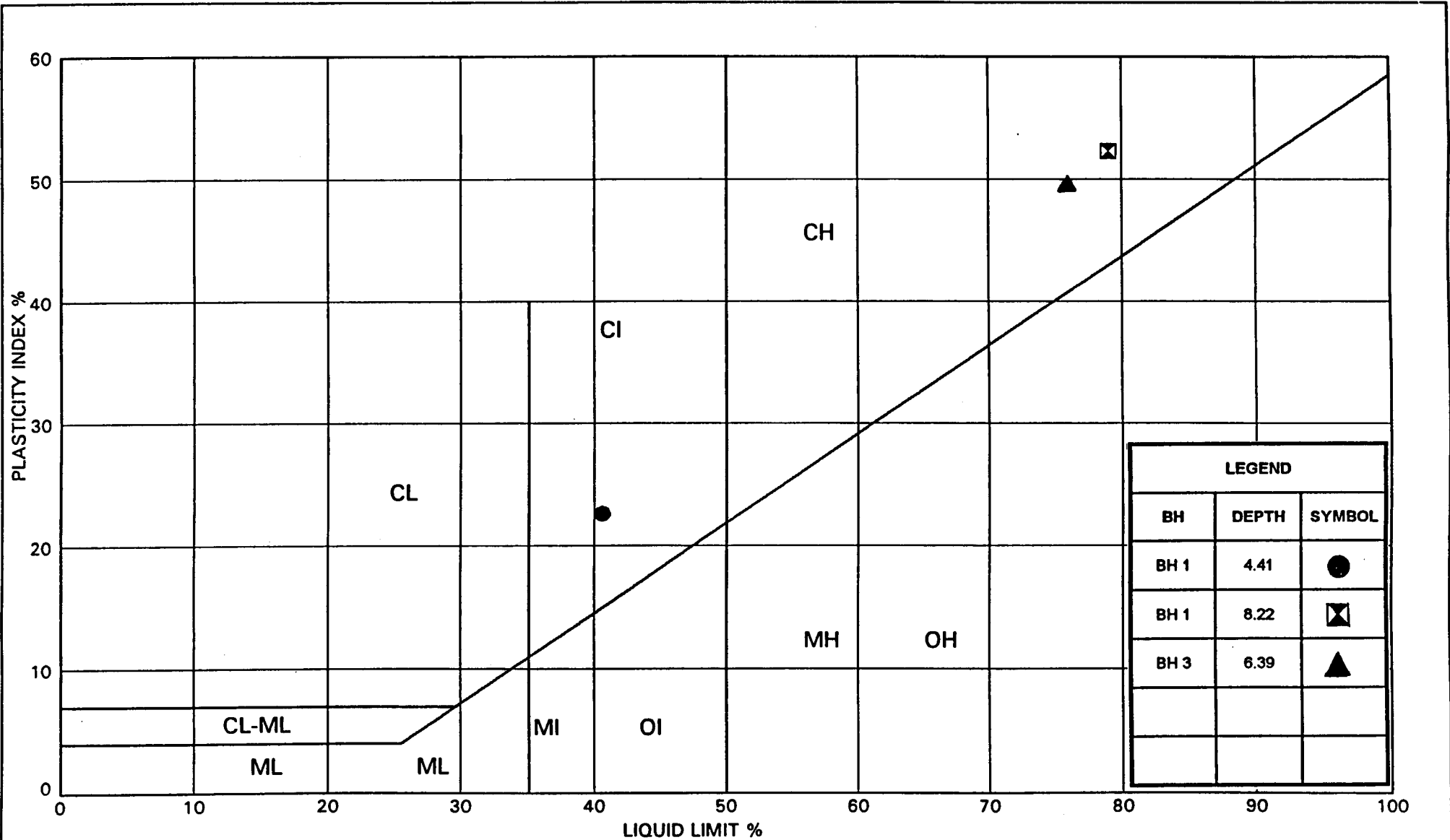
BRITT PATROL YARD

GRAIN SIZE DISTRIBUTION

SANDY SILT (ML)



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Ontario

PLASTICITY CHART

SILTY CLAY AND CLAY

FIGURE 7

W.P. 3 Sapd/Salt Structures

BRITT PATROL YARD

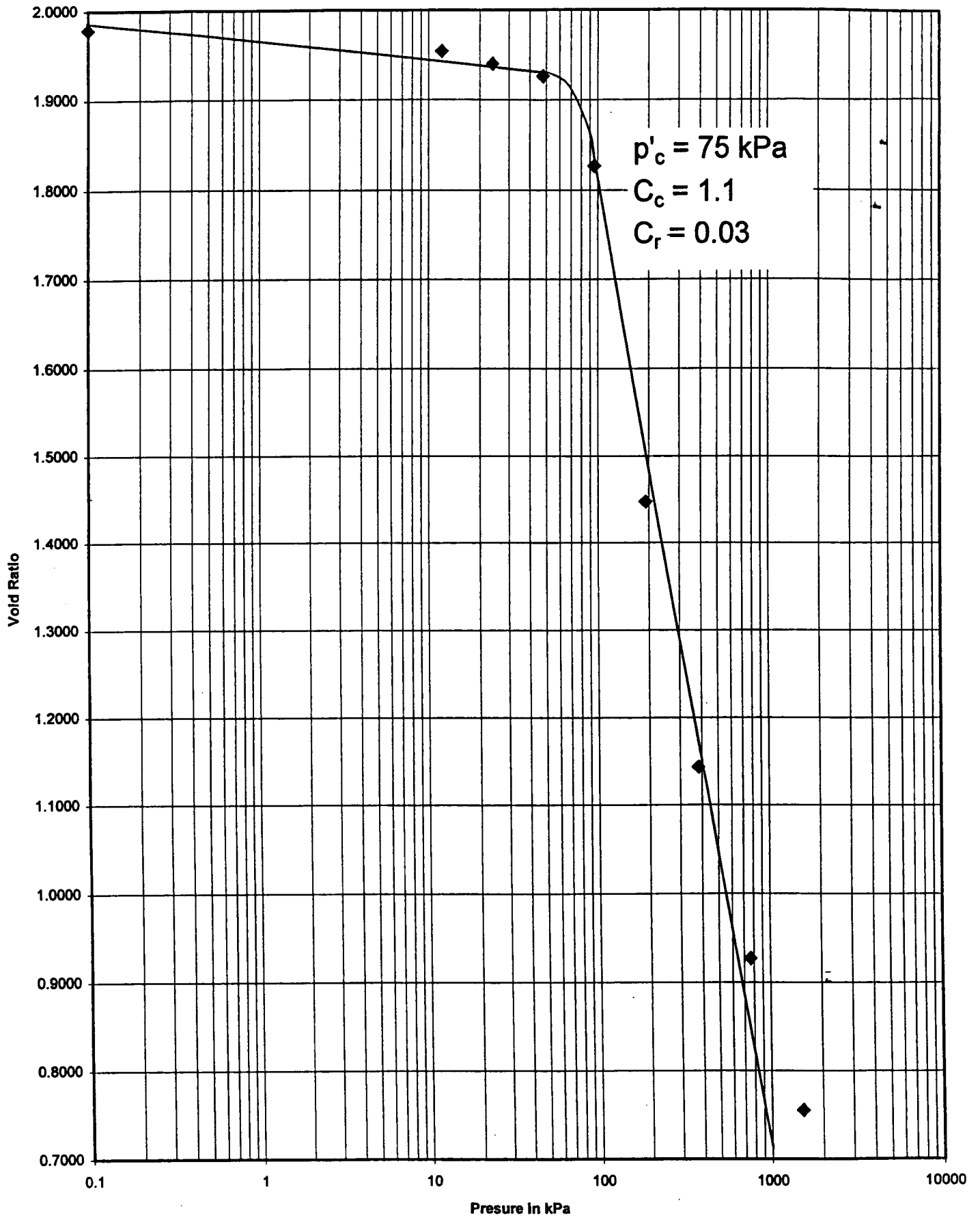


FIGURE 8

Appendix A

Record of Boreholes

RECORD OF BOREHOLE 1

METRIC

W.P: 3 Sand / Salt Structures

LOCATION Britt Patrol Yard

ORIGINATED BY R.S

DIST Northern Region HWY 526

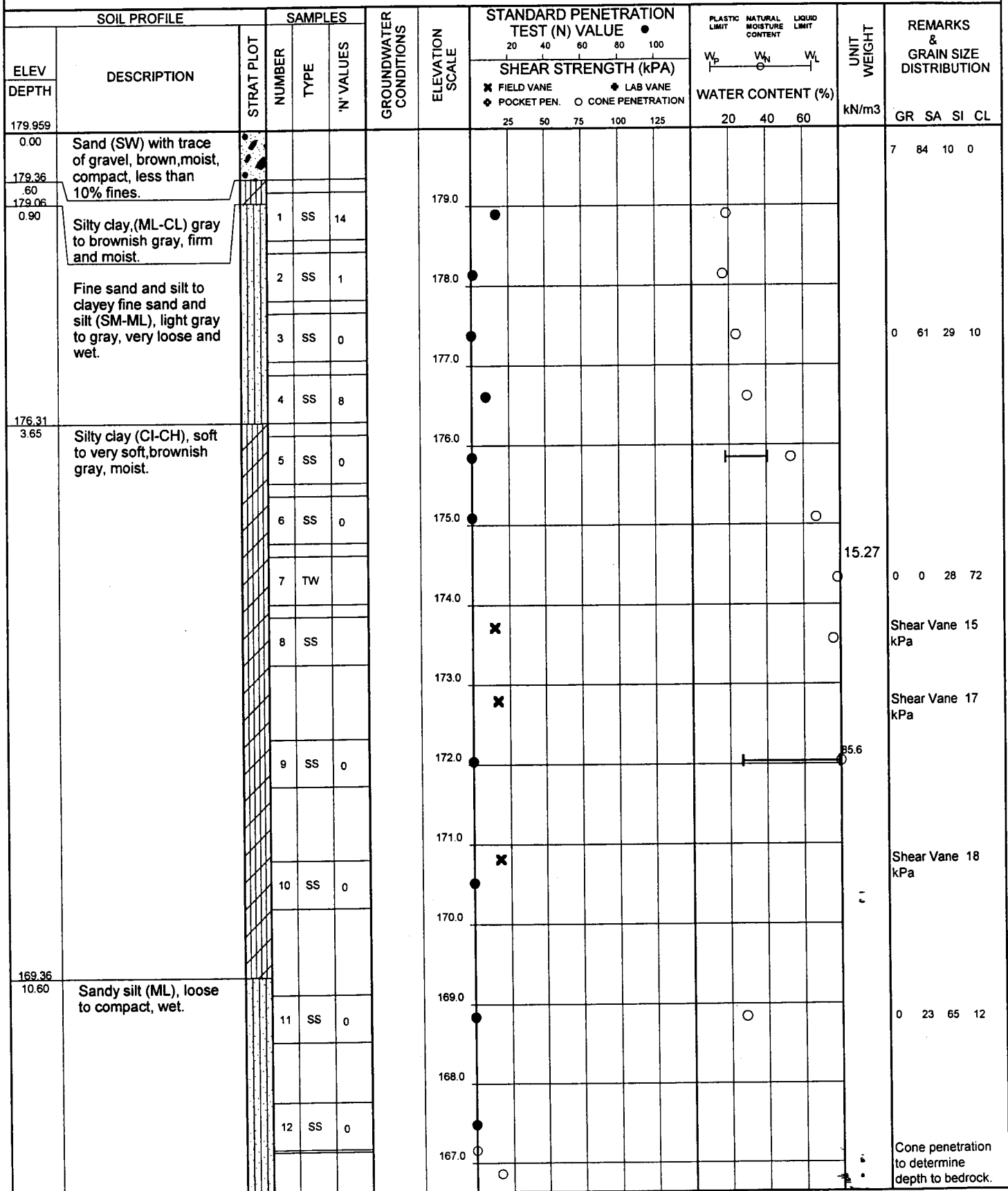
BOREHOLE TYPE Hollow Stem Augers

COMPILED BY R.S

DATUM Geodetic

DATE Sept. 20 2000

CHECKED BY I.F



RECORD OF BOREHOLE 1

METRIC

W.P: 3 Sand / Salt Structures

LOCATION Britt Patrol Yard

ORIGINATED BY R.S

DIST Northern Region HWY 526

BOREHOLE TYPE Hollow Stem Augers

COMPILED BY R.S

DATUM Geodetic

DATE Sept. 20 2000

CHECKED BY I.F

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)				
								25	50	75	100	125	20	40	60		
166.0																Values shown are not corrected.	
165.0																	
164.0																	
163.0																	
162.0																	
161.0																	
160.61 19.35	Water levels measured during and after drilling are not recorded as they are not representative of actual field conditions						END OF BOREHOLE								Refusal to cone penetration test, 100 blows for 0.25m.		

METRIC

ORIGINATED BY R.S

COMPILED BY R.S

CHECKED BY I.F

[illegible]

RECORD OF BOREHOLE 3

METRIC

W.P: 3 Sand / Salt Structures

LOCATION Britt Patrol Yard

ORIGINATED BY R.S

DIST Northern Region HWY 526

BOREHOLE TYPE Hollow Stem Augers

COMPILED BY R.S

DATUM Geodetic

DATE Sept. 20 2000

CHECKED BY I.F

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH (kPA)		WATER CONTENT (%)				
							20 40 60 80 100		W _p W _N W _L					
180.180 0.00	Sand (SW) with trace of gravel, brown, moist, compact, less than 10% fines.													
179.58 .60			1	SS	3									
178.66 1.52	Silty clay, (ML-CL) gray to brownish gray, firm and moist.		2	SS	1									
	Fine sand and silt to clayey fine sand and silt (SM-ML), light gray to gray, very loose and wet.		3	SS	3									
			4	SS	8									
176.53 3.65	Silty clay (CI-CH), soft to very soft, brownish gray, moist.		5	SS	0									
			6	SS	0									
			7	SS	0									
172.26 7.92	Sandy silt (ML), loose to compact, wet.		9	TW										
169.36 10.82	Water levels not recorded as they are not representative of actual field conditions													
END OF BOREHOLE														
														Refusal to augers, cannot penetrate past 10.82m.

METRIC

ORIGINATED BY R.S

COMPILED BY R.S

CHECKED BY I.F

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	STANDARD PENETRATION TEST (N) VALUE		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION	
ELEV	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH (kPA)		WATER CONTENT (%)					
DEPTH								✕ FIELD VANE ◆ POCKET PEN.	◆ LAB VANE ○ CONE PENETRATION	W _p	W _N	W _L			
179.720														GR SA SI CL	
0.00	Sand (SW) with trace of gravel, brown, moist, compact, less than 10% fines. Fine sand and silt to clayey fine sand and silt (SM-ML), light gray to gray, very loose and wet.						179.0								
179.12			1	SS	4		178.0								
.60			2	SS	1		177.0								
			3	SS	11		176.0								
			4	SS	0		175.0								
176.07	Silty clay (CI-CH), very soft, brownish gray, moist.													Shear Vane 17 kPa	
3.65															
174.54			5	SS	0										
5.18															
END OF BOREHOLE															
* Water level measured in a stand pipe piezometer installed 2m south and 2m east of borehole BH-4. The piezometer was installed in a 3.05m deep borehole drilled for the purpose of obtaining a water sample for chemical analysis.															

Appendix B

Chemical Test Results

Acres & Associates
525-21 Four Seasons Pl
Etobicoke, ON
M9B 6J8

Attention: Louise Pearce

Report Date: 2000/10/06

Your Project #: MTO WELL 005A32

ANALYTICAL REPORT

MAXXAM JOB #: A018512

Received: 2000/09/20, 13:21

Sample Matrix: LIQUID

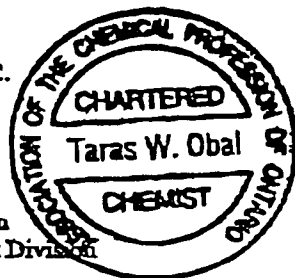
Samples Received: 3

<u>Analyses</u>	<u>Number of Tests</u>	<u>Date</u>	<u>Date</u>	<u>Laboratory Method</u>	<u>Method</u>
ALKALINITY	3	N/A	2000/09/28	APHA 2320 B	ANALYTICAL METHOD
ANIONS	3	N/A	2000/09/29	EPA 300.0	TITRATION
AQUA-PAK - CALCULATION (mg/L)	3	N/A	2000/10/04		Ion Chromatography
AQUA-PAK - CALCULATION (mg/L)	3	N/A	2000/10/04		
AQUA-PAK - CALCULATION (%)	3	N/A	2000/10/04		
AQUA-PAK - CALCULATION	3	N/A	2000/10/04		
AQUA-PAK - CALCULATION (umho/cm)	3	N/A	2000/10/04		
COLOUR	3	N/A	2000/10/02	APHA 2120	COLOURIMETRIC
CONDUCTIVITY	3	N/A	2000/09/21	APHA 2510	CONDUCTIVITY METER
GRAPHITE FURNACE METALS	3	2000/10/03	2000/10/03		GRAPHITE FURNACE
ICP METALS (SELECTED)	3	2000/10/02	2000/10/02	EPA 6010	ICP
SOLUBLE ICP METALS (SELECTED)	3	2000/09/22	2000/09/22	EPA 6010	ICP
AMMONIA-N	3	N/A	2000/09/28	APHA 4500	COLOURIMETRIC
NITRITE-N - COLOUR	3	N/A	2000/09/28	APHA 4500	COLOURIMETRIC
PH	3	N/A	2000/09/21	APHA 4500H	PH METER
ORTHOPHOSPHATE-P	3	N/A	2000/09/21	APHA 4500 PE	COLOURIMETRIC
TOC	3	N/A	2000/09/27	EPA 9060	UV/PEROX/FID
TURBIDITY	3	N/A	2000/09/21	APHA 2150	TURBIDITY METER

MAXXAM ANALYTICS INC.

T. W. Obal

TERRY OBAL, Ph.D., C. Chem
General Manager, Environment Division



Total pages: 1



REPORT DATE: 2000/10/06

PROJECT #: MTO WELL 005A32
MAXXAM JOB #: A018512

RESULTS OF CHEMICAL ANALYSES OF LIQUID

Maxxam ID		448189		448191		448192		
COC Number		107867		107867		107867		
Sampling Date		2000/09/19		2000/09/19		2000/09/19		
Parameter	Units	BRITT	MDL	FIELD	POWASSAN	MDL	SPIKED BLANK %REC	
Alkalinity (Total as CaCO ₃)	mg/L	187	1	202	110	1	N/A	
Nitrate (N)	mg/L	<1	1	0.2	<0.1	0.1	N/A	
Bromide (Br ⁻)	mg/L	<0.35	0.35	<0.35	<0.35	0.35	N/A	
Fluoride (F ⁻)	mg/L	2	1	1.3	1.6	0.1	N/A	
Chloride (Cl ⁻)	mg/L	13500	0.15	626	4.97	0.15	N/A	
Sulfates (SO ₄)	mg/L	191	0.5	62.6	11.3	0.5	N/A	
Hardness (CaCO ₃)	mg/L	1020	1	609	96.1	1	N/A	
Carbonate (CaCO ₃)	mg/L	<1	1	<1	<1	1	N/A	
Bicarbonate (CaCO ₃)	mg/L	187	0.05	202	109	0.05	N/A	
Calculated TDS	mg/L	21800	1	1290	135	1	N/A	
Cation Sum	me/L	350	N/A	23.2	2.65	N/A	N/A	
Anion Sum	me/L	388	N/A	23.0	2.58	N/A	N/A	
% Difference	%	5.25	N/A	0.454	0.507	N/A	N/A	
Ion Ratio	N/A	0.900	N/A	1.01	0.990	N/A	N/A	
Saturation pH @ 4C	N/A	6.90	N/A	7.20	8.19	N/A	N/A	
Langelier Index @ 4C	N/A	0.158	N/A	0.0770	-0.457	N/A	N/A	
Calculated Conductivity	umho/cm	48600	N/A	2770	251	N/A	N/A	
Colour	TCU	83.7	1	12.1	3	1	99	
Conductivity	umho/cm	31800	0.01	2570	260	0.01	N/A	
Lead (Pb)	mg/L	<0.002	0.002	<0.002	<0.002	0.002	103	
Aluminum (Al)	mg/L	38.7	0.025	0.082	<0.025	0.025	101	
Copper (Cu)	mg/L	0.108	0.003	<0.003	<0.003	0.003	123	
Iron (Fe)	mg/L	42.1	0.005	0.500	0.012	0.005	108	
Manganese (Mn)	mg/L	2.36	0.001	0.512	0.014	0.001	102	
Zinc (Zn)	mg/L	1.14	0.003	0.035	0.031	0.003	105	
Magnesium (Mg)	mg/L	32.7	0.003	43.5	8.61	0.003	N/A	
Potassium (K)	mg/L	27.8	1	8	<1	1	N/A	
Silicon (Si)	mg/L	5.40	0.015	3.26	5.45	0.015	N/A	
Sodium (Na)	mg/L	7550	0.6	247	13.8	0.08	N/A	
Calcium (Ca)	mg/L	353	0.04	172	24.8	0.04	N/A	
Ammonia-N	mg/L	1.83	0.05	0.53	<0.05	0.05	N/A	
Nitrite (N)	mg/L	<0.1	0.1	<0.1	<0.1	0.1	101	
pH	pH	7.08	0.01	7.28	7.73	0.01	N/A	
Orthophosphate (P)	mg/L	0.010	0.005	0.012	0.009	0.005	N/A	
Total Organic Carbon	mg/L	14.9	0.1	6.2	0.4	0.1	94	
Turbidity	NTU	1060	0.1	5.5	0.2	0.1	N/A	

N/A = Not Applicable

MDL = METHOD DETECTION LIMIT



REPORT DATE: 2000/10/08

PROJECT #: MTO WELL 005A32

MAXXAM JOB #: A018512

RESULTS OF CHEMICAL ANALYSES OF LIQUID

Maxxam ID					
COC Number					
Sampling Date					

Parameter	Units	METHOD BLANK	MDL	MATRIX SPIKE %REC	QC %REC
Alkalinity (Total as CaCO ₃)	mg/L	<1	1	N/A	103
Nitrate (N)	mg/L	<0.1	0.1	94	98
Bromide (Br)	mg/L	<0.35	0.35	98	98
Fluoride (F)	mg/L	<0.1	0.1	95	99
Chloride (Cl)	mg/L	<0.15	0.15	89	99
Sulfates (SO ₄)	mg/L	<0.5	0.5	100	102
Hardness (CaCO ₃)	mg/L	N/A	N/A	N/A	N/A
Carbonate (CaCO ₃)	mg/L	N/A	N/A	N/A	N/A
Bicarbonate (CaCO ₃)	mg/L	N/A	N/A	N/A	N/A
Calculated TDS	mg/L	N/A	N/A	N/A	N/A
Cation Sum	me/L	N/A	N/A	N/A	N/A
Anion Sum	me/L	N/A	N/A	N/A	N/A
% Difference	%	N/A	N/A	N/A	N/A
Ion Ratio	N/A	N/A	N/A	N/A	N/A
Saturation pH @ 4C	N/A	N/A	N/A	N/A	N/A
Langelier Index @ 4C	N/A	N/A	N/A	N/A	N/A
Calculated Conductivity	umho/cm	N/A	N/A	N/A	N/A
Colour	TCU	<1	1	98	101
Conductivity	umho/cm	1.80	0.01	N/A	100
Lead (Pb)	mg/L	<0.002	0.002	99	110
Aluminum (Al)	mg/L	<0.025	0.025	100	99
Copper (Cu)	mg/L	<0.003	0.003	110	98
Iron (Fe)	mg/L	<0.005	0.005	117	102
Manganese (Mn)	mg/L	<0.001	0.001	111	99
Zinc (Zn)	mg/L	0.003	0.003	114	98
Magnesium (Mg)	mg/L	<0.003	0.003	N/A	102
Potassium (K)	mg/L	<1	1	N/A	103
Boron (Si)	mg/L	<0.015	0.015	N/A	98
Sodium (Na)	mg/L	<0.06	0.06	N/A	99
Calcium (Ca)	mg/L	<0.04	0.04	N/A	100
Ammonia-N	mg/L	<0.05	0.05	100	102
Nitrite (N)	mg/L	<0.1	0.1	100	102
pH	pH	N/A	N/A	N/A	100
Orthophosphate (P)	mg/L	<0.005	0.005	102	104
Total Organic Carbon	mg/L	<0.1	0.1	99	100
Turbidity	NTU	N/A	N/A	N/A	103

N/A = Not Applicable

MDL = METHOD DETECTION LIMIT

QC = QC Standard

Appendix C

Explanation of Terms Used in Report

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND /OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL			$w - w_p$	i	1	HYDRAULIC GRADIENT