

GEOCRES No. 52E-37DIST. 20 REGION W.P. No. CONT. No. W. O. No. 92-11011STR. SITE No. HWY. No. 659LOCATION 600 m N of Pelletier Bridge
Embankment InstabilityNo of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry
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Transportation

FILE

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WO 92-11011 DIST 20

HWY 659 STR SITE -

Embankment Instability
About 600 m North of
Pelletier Bridge on Hwy. 659

DISTRIBUTION

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FOUNDATION INVESTIGATION REPORT

For

Embankment Instability

W.O. 92-11011

Hwy. 659, District 20, Kenora

INTRODUCTION

The failure site on Hwy. 659 was inspected on 92 09 01 at the request of Mr. J. Coker, Kenora District, and Mr. P. Bound of the Geotechnical Section, Northwestern Region.

This report contains the results of a foundation investigation carried out at the above mentioned site on 92 09 02 & 03. The field work comprised of two sampled boreholes and Dynamic Cone Test adjacent to these holes.

The boreholes were located within the failed area and were advanced to a maximum depth of 5.4 m below the existing ground level. The elevations are referenced to the datum (assumed benchmark El: 100) established by the district office on the rock outcrop in the drainage ditch. The borehole locations are also referenced to the temporary stations (Culvert Centreline Sta. 10+000).

DESCRIPTION OF FAILURE

The failed area is located about 600 m north of Pelletier Bridge on Highway 659. The topography of the area around the failure location is highly undulating. The level of the adjacent Black Sturgeon Lake is at a lower elevation.

The road at this location runs almost parallel to the Black Sturgeon Lake and follows the contour. The rate of the current in the lake, with the exception of the bridge location is relatively slow (less than about 0.5 m to 0.6 m/sec).

The failed portion is displaced by approximately 0.8 m to 1.1 m vertically and 0.6 m to 1.0 m horizontally. Several cracks varying in width from a few millimetres to a maximum of about 1.0 m at the separation were observed. The details of the failure area are shown on Figure 1.

SUBSURFACE CONDITIONS

The underlying subsoil at this site consists of 3.3 m loose to compact sand fill and 2.1 m soft to firm clay. The sand fill and the clay layer are underlain by dense to very dense silty sand with varying proportions of gravel. For classification purposes, the soils encountered at this site can be divided into four different zones.

- a) Silty Sand, Some Gravel (Fill)
- b) Clayey Silt With Sand, Some Gravel
- c) Clay, Tr. of Sand, Tr. of Gravel
- d) Silty Sand with Gravel

The soils encountered during the course of the investigation, together with the field and laboratory test results, are shown on the Record of Borehole Sheets contained in the Appendix of this report. The location of the boreholes are shown on Figure 1. A stratigraphical section is shown on Figure 2. Description of the strata encountered are given below.

Silty Sand, Some Gravel (Fill)

This replacement fill which was placed recently after the failure on 92 07 03, consists of sand with varying proportions of silt and gravel. The thickness of this fill at the BH #1 location was 3.3 m. The Standard Penetration Test results indicate that this fill is in loose to compact state of denseness. However, it was observed to be very dense below 2.6 m depth.

Clayey Silt with Sand, Some Gravel

This deposit was encountered only in BH #1 immediately below the fill. The thickness of this layer is about 0.7 m and the consistency can be classified as stiff. The results of the Atterberg Limits Test are shown on Figure 3.

Clay, Trace of Sand, Trace of Gravel

This deposit was encountered only in BH #2 immediately below the ground level. The thickness of this deposit is about 2.1 m. The natural moisture content was observed to vary from 32% to 34%. The results of the Atterberg Limits Test are shown on Figure 4. The in-situ Vane Shear Test carried out in this clay indicate shear strength in the range of 30 kPa to 50 kPa (firm consistency) with sensitivity in the order of 10.

Silty Sand with Gravel

This sandy deposit was encountered in both boreholes immediately below the clayey layers. The results of Gradation Test carried out on a representative sample is shown on Figure 5. The Standard Penetration Test results vary from 29 blows/0.3 m to over 100 blows/0.3 m indicating dense to very dense state of denseness. The full extent of this deposit was not proven below El: 92.9.

Groundwater Conditions

The water level at the end of the drilling was observed near lake level (El: 95.1). The enquiries made at the site indicate that the lake water level does not vary appreciably.

DISCUSSION AND RECOMMENDATIONS

General

Instability of the embankment near the culvert was first observed by the district personnel around 92 06 08 and the road was graded to the required level by placing Granular "A" on top of the failed mass. Subsequent to this, the embankment failed and it was reported to the Foundation Design Section on 92 07 06. The site was inspected on 92 07 08 and recommended to remove only the fill overlying the natural ground, and backfill with acceptable fill material.

However, the information provided to us indicate that the soil to a maximum depth of 3.2 m was subexcavated with 2 horizontal to 1 vertical side slopes and backfilled with Granular "B". Subsequent to the restoration work, the embankment failed in the area where the fill height was maximum.

In our opinion, the failure is not deep seated and confined to the fill area. The reasons for the failure may be attributed to the presence of weak soil at the toe and increase in load at the top.

Restoration of Embankment

In order to stabilize the slope, it is recommended to subexcavate the clay at the toe and backfill with rock up to about 0.5 m above the lake water level (refer to Figure 6). In addition, the existing sand fill should be removed and compacted as per MTO Standard. As indicated on Figure 6, 300 mm thick crushed stones (20 mm to 25 mm) should be placed on top of the rock fill to avoid any loss of fines.

The subexcavation and placement of fill for the restoration of embankment should be carried out as follows:

- 1) Remove only the existing sand fill as indicated on Figure 7.

- 2) Subexcavate the clay to a depth of El: 94.0

The excavation should be carried out in 3m strips as shown on Figure 7 to avoid any failure of adjoining area.

- 3) Backfilling of the subexcavated portion should be carried out prior to the commencement of the subexcavation of a new strip

- 4) On completion of placing rock fill, remove any sand fill within the failure limit and compact as per MTO Standard

In order to ensure the integrity and the future performance of the embankment, pertinent MTO Specifications and Standards should be used.

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of M. Vasavithasan, Foundation Engineer. The equipment used was owned and operated by Kenora Soil Drilling. This report was prepared by M. Vasavithasan, reviewed by P. Payer, Sr. Foundation Engineer.



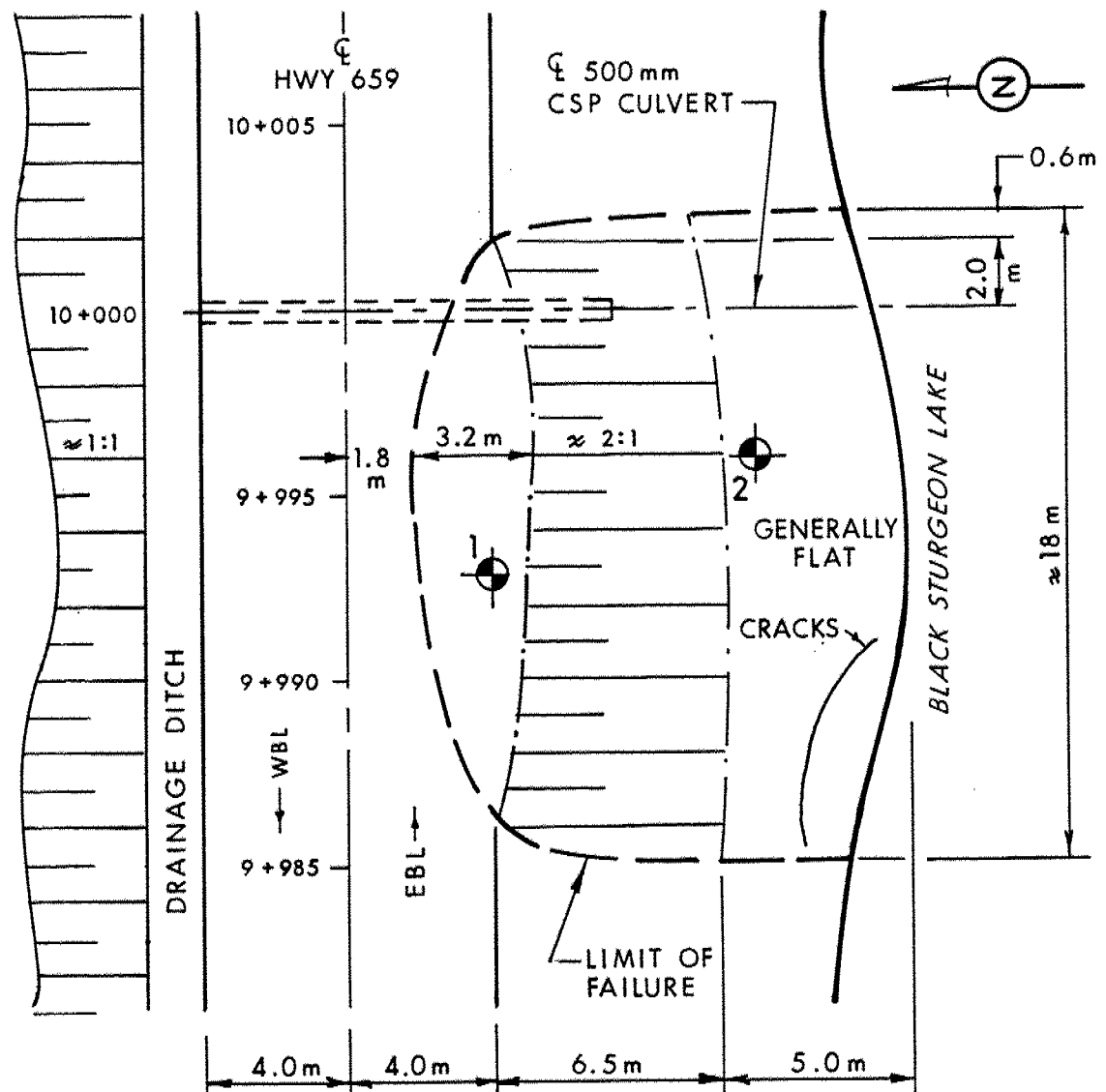
M. Vasavithasan

M. Vasavithasan, P. Eng.
Foundation Engineer

P. Payer

P. Payer, P. Eng.
Sr. Foundation Engineer

APPENDIX

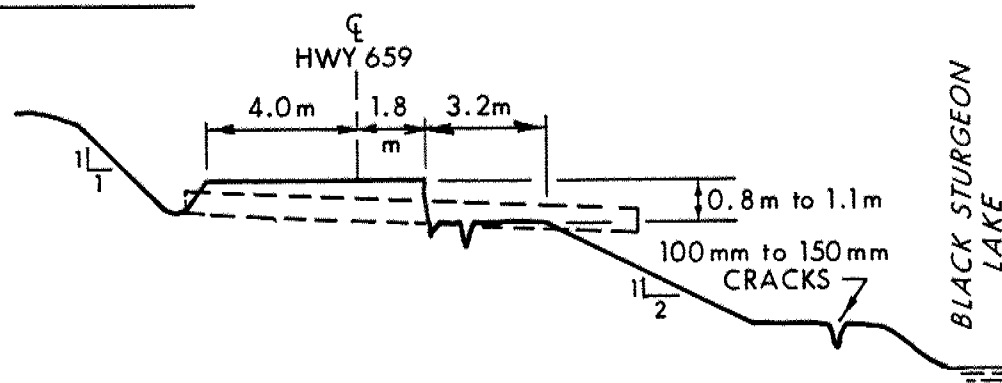


LEGEND

● BORE HOLE & CONE

PLAN

NOT TO SCALE



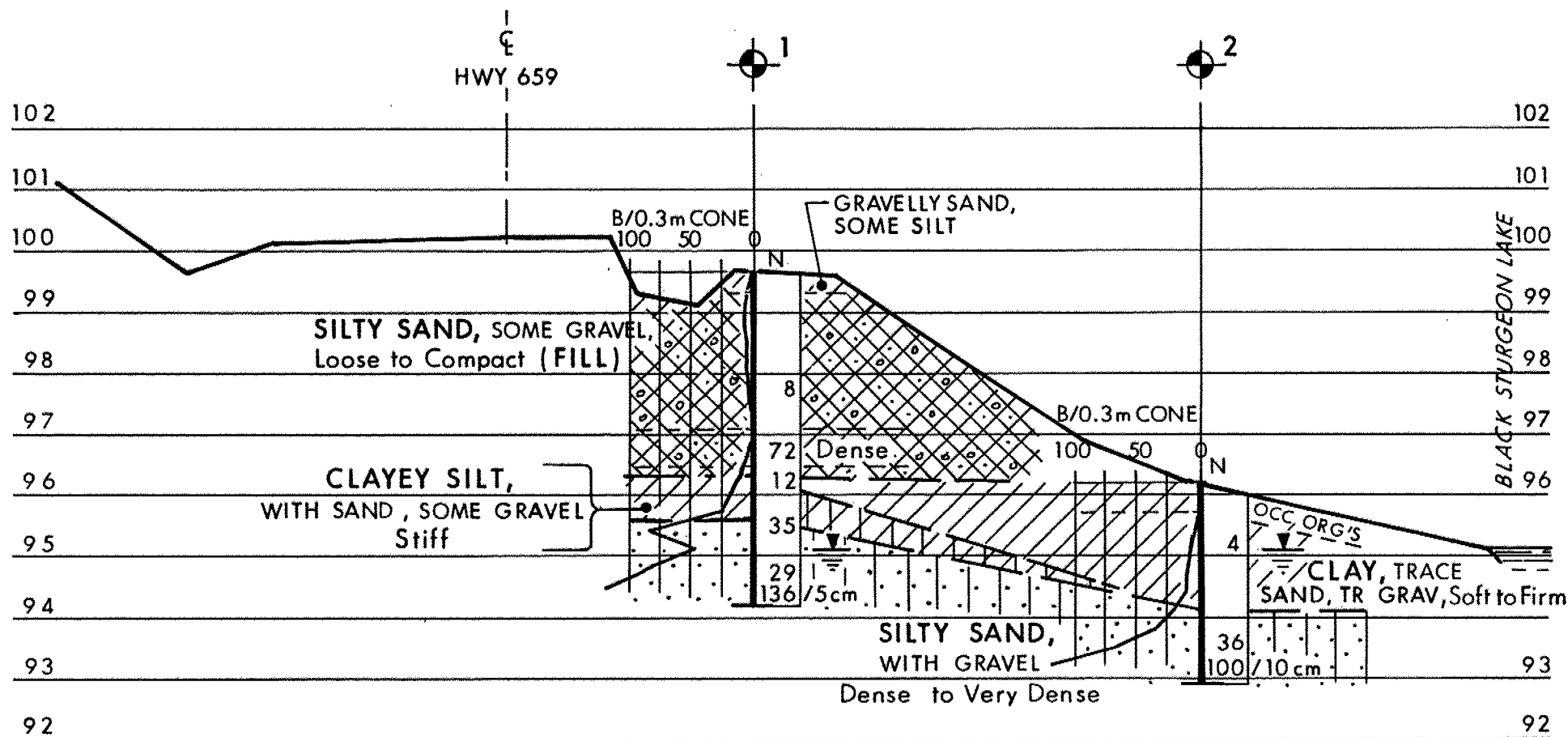
SECTION

EMBANKMENT INSTABILITY

(APPROXIMATE 600 m NORTH OF
PELLETIER BRIDGE, HWY 659)


Fig. 1

HWY 659, DIST. 20
WO 92-11011



SECTION AT STA. 9+896

LEGEND

 BORE HOLE & CONE

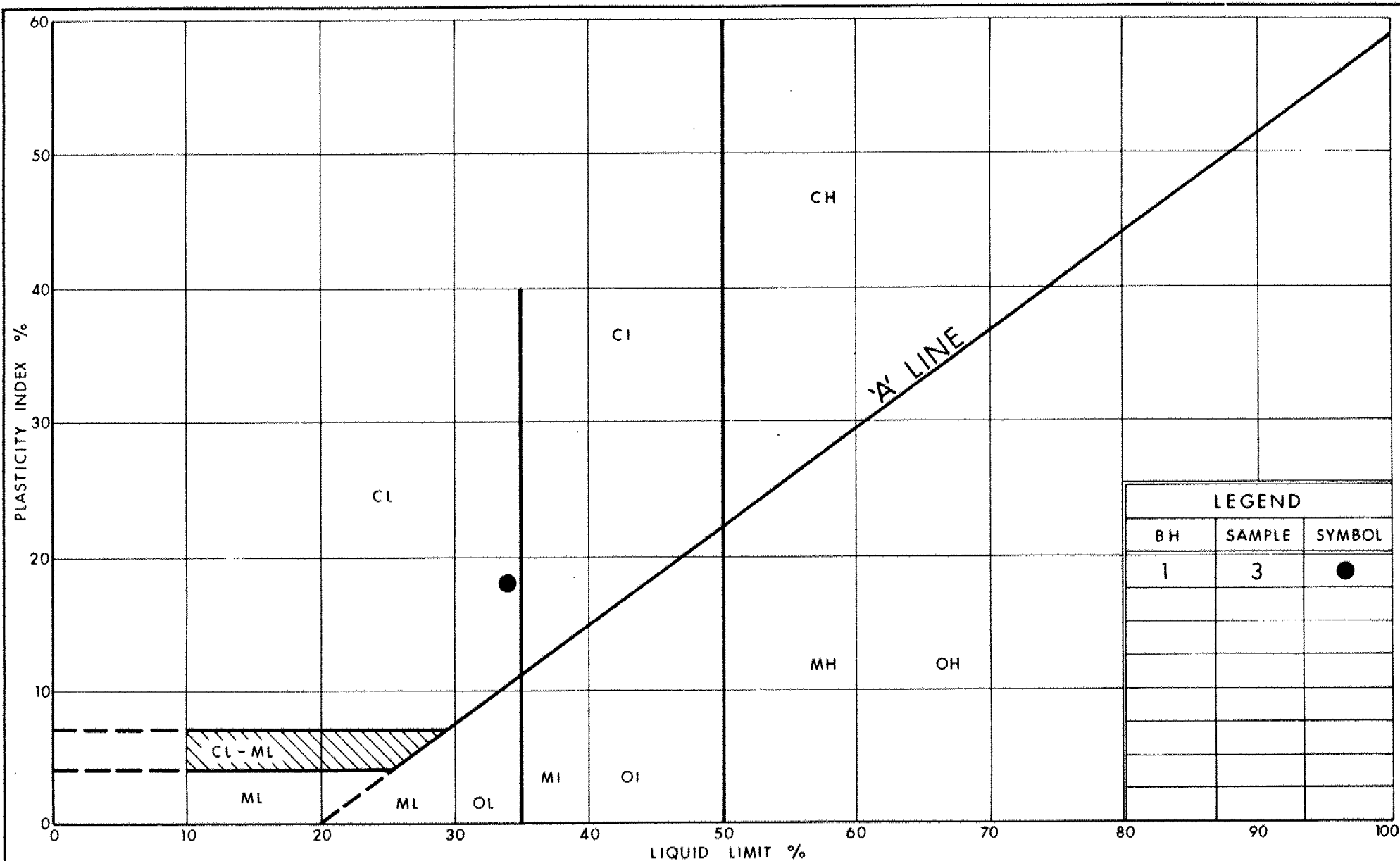
 WATER LEVEL

NOTE ELEVATIONS ARE REFERENCED TO ASSUMED DATUM.

Fig. 2

HWY 659, DIST. 20

WO 92-11011

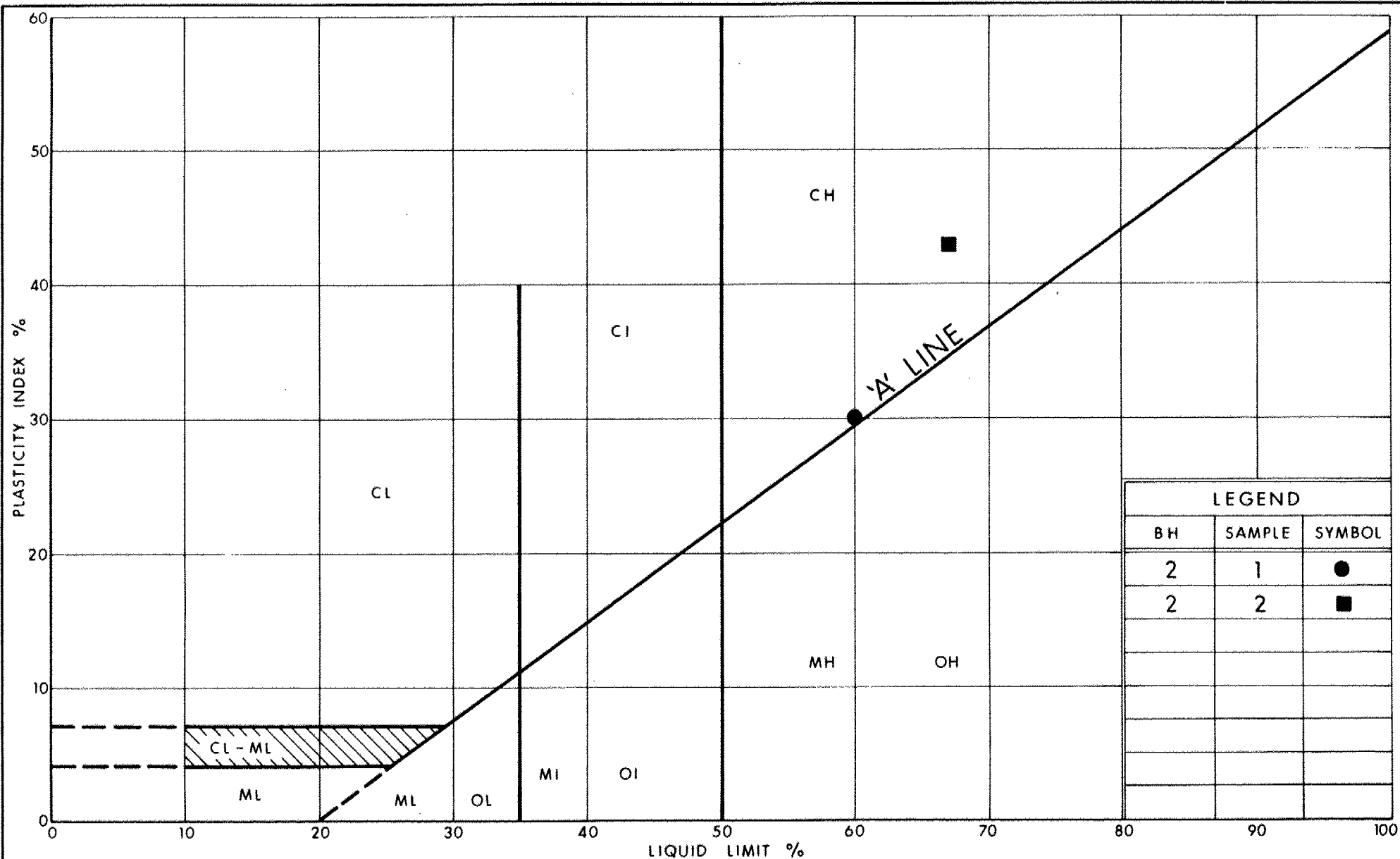


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PLASTICITY CHART CLAYEY SILT, WITH SAND, SOME GRAVEL

FIG No 3

WO 92-11011

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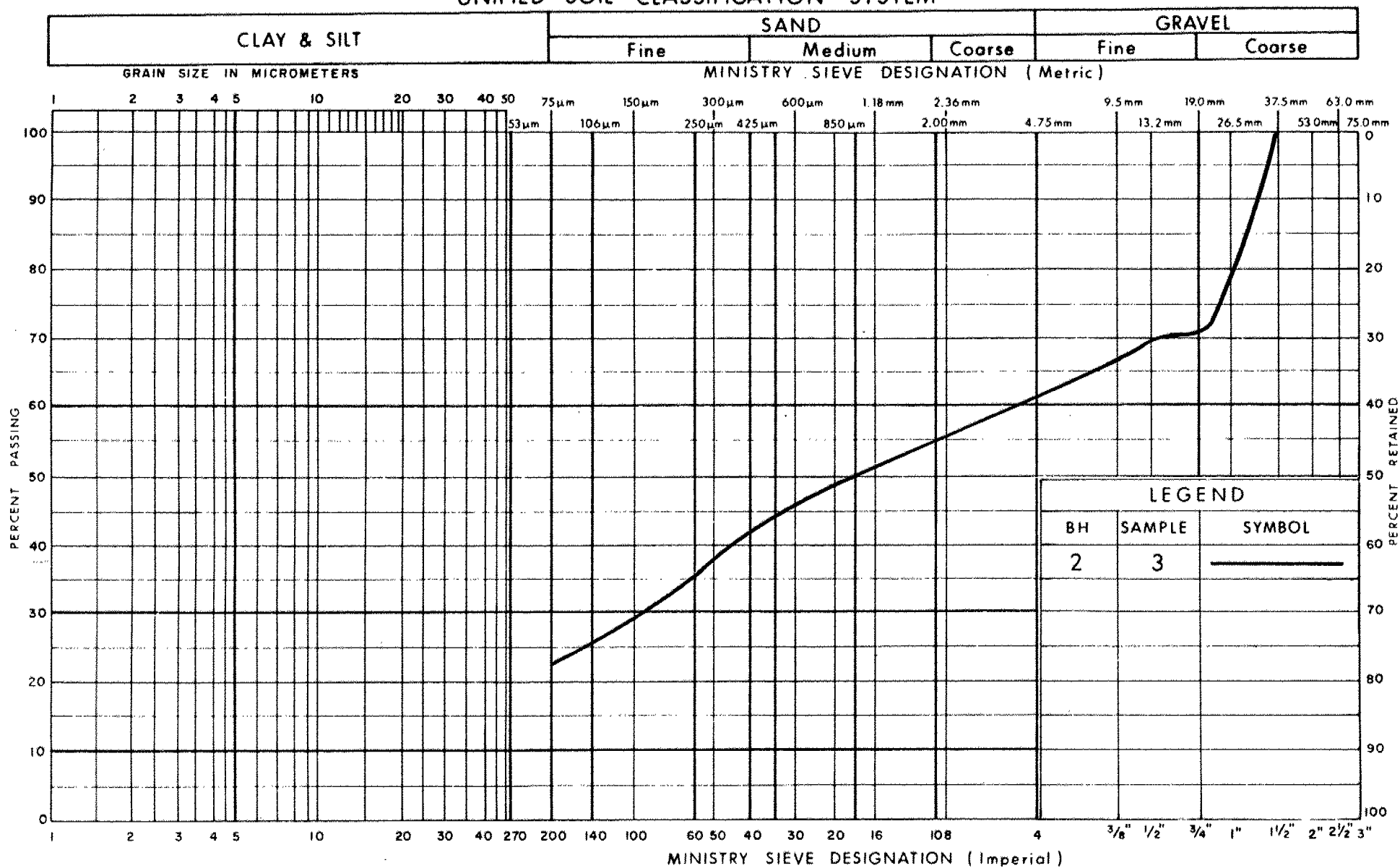
PLASTICITY CHART

CLAY, TRACE OF SAND, TRACE OF GRAVEL

FIG No 4

WO 92-11011

UNIFIED SOIL CLASSIFICATION SYSTEM

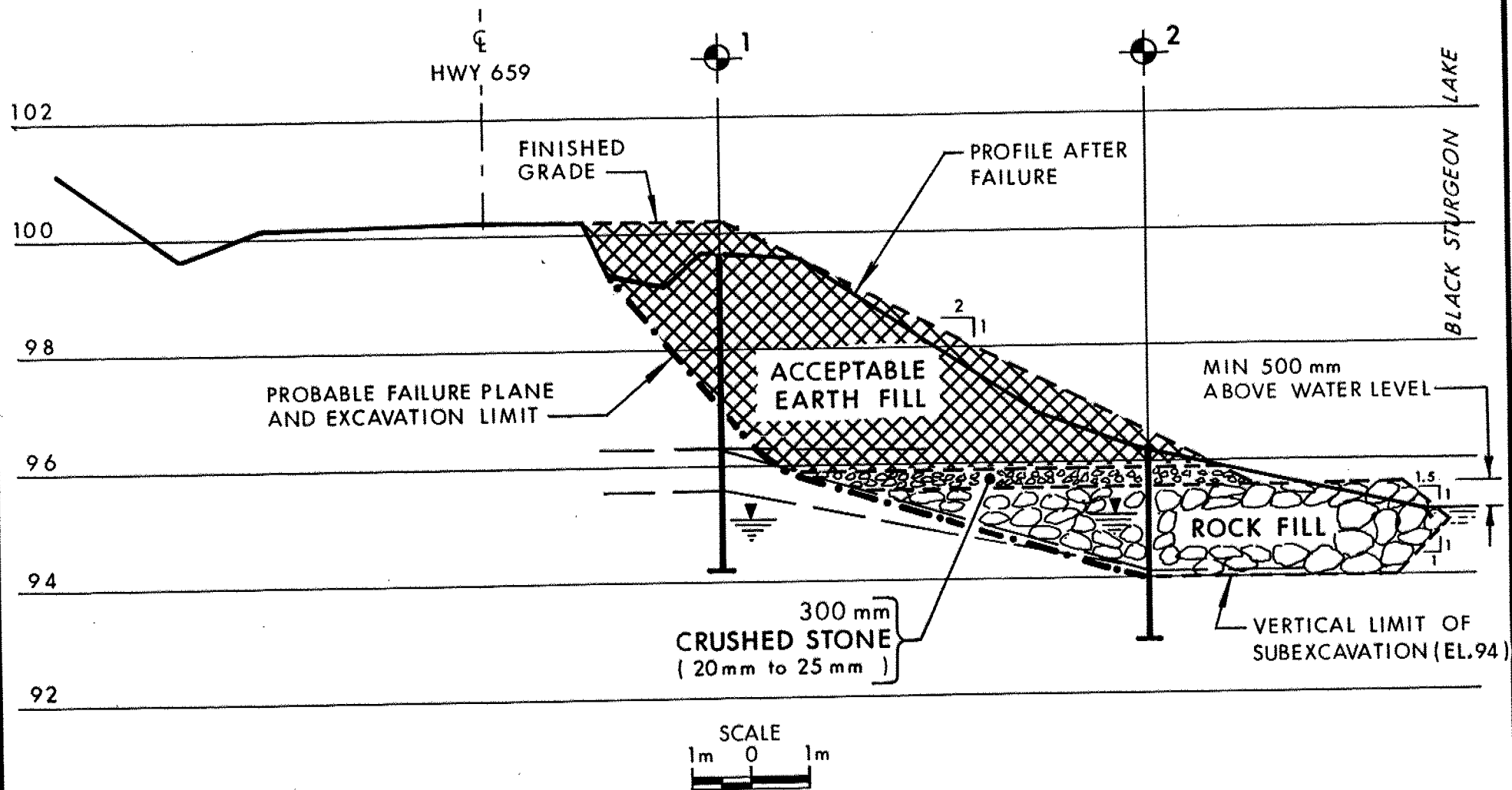


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GRAIN SIZE DISTRIBUTION
SILTY SAND, WITH GRAVEL

FIG No 5

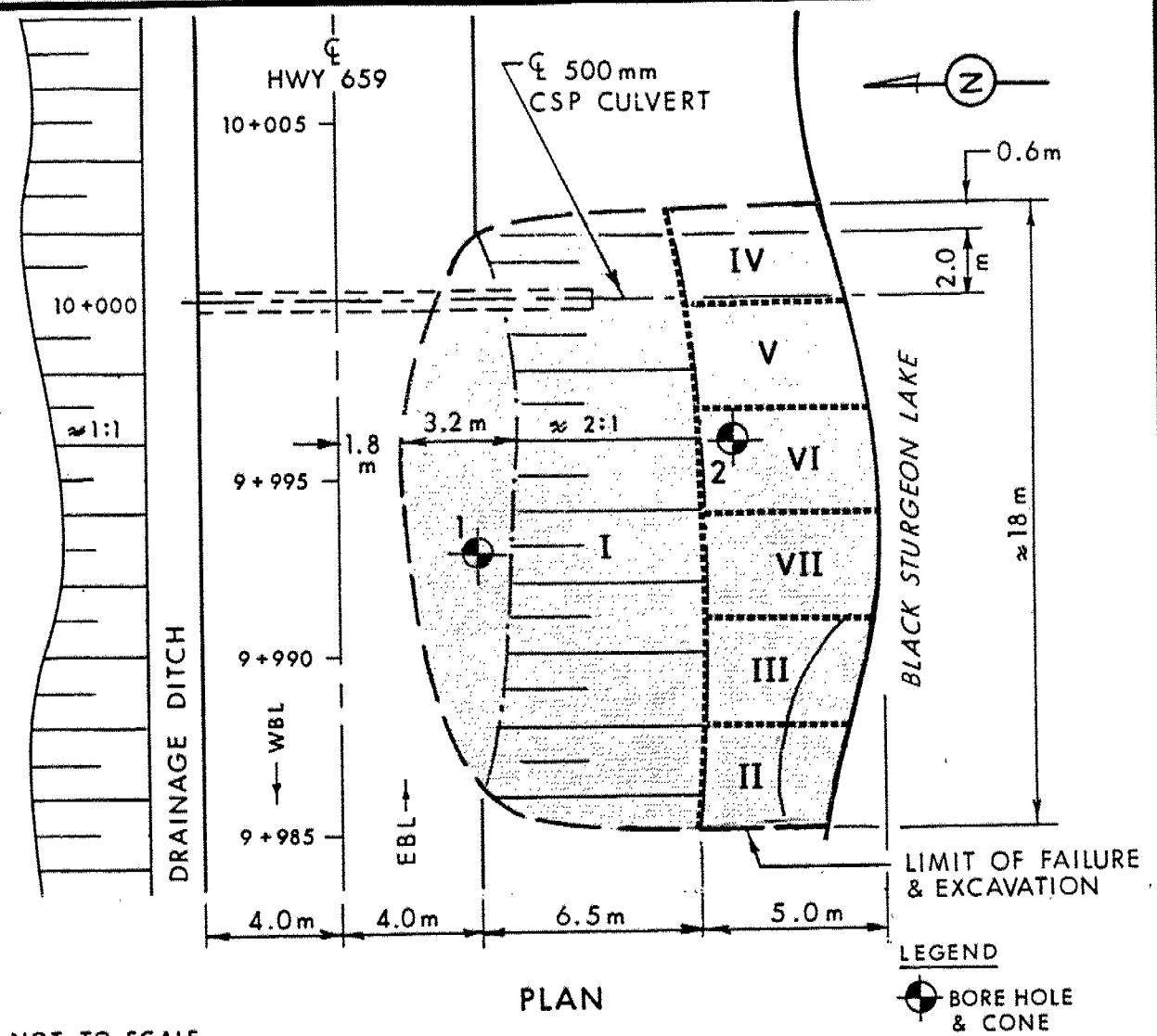
WO 92-11011



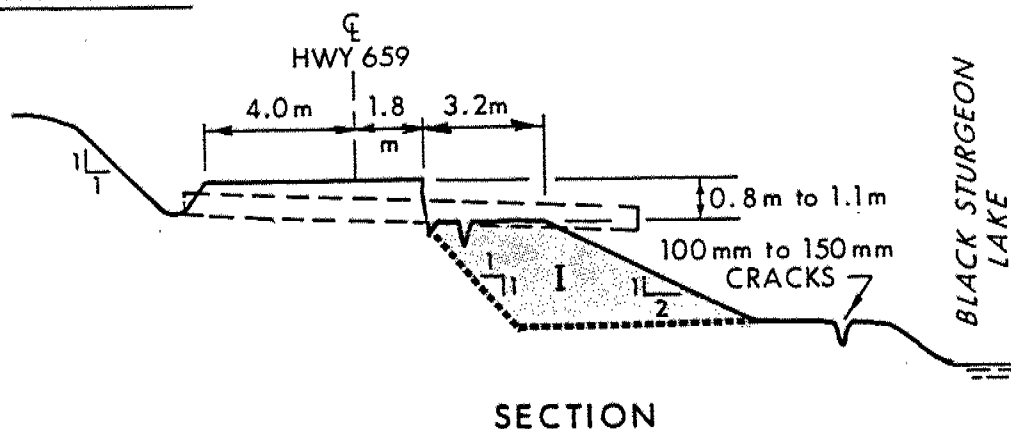
RESTORATION OF EMBANKMENT

Fig. 6

HWY 659, DIST. 20
WO 92-11011



NOT TO SCALE



NOTES:

- SEQUENCE OF EXCAVATION SHOULD BE IN THE ORDER OF I TO VII.
- IF ANY CLARIFICATION IS REQUIRED PLEASE CONTACT THE FOUNDATION DESIGN SECTION.

SEQUENCE OF EXCAVATION

Fig. 7

HWY 659, DIST 20
WO 92-11011

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

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	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
r_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	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.O. 92 - 11011 LOCATION Sta. 9+992.8; o/s 4.0 m Rt of E Hwy 659 ORIGINATED BY M.V.
 DIST 20 HWY 659 BOREHOLE TYPE NX CASING & CONE TEST COMPILED BY M.V.
 DATUM ASSUMED BENCH MARK DATE 92 09 02 & 03 CHECKED BY P.P.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
99.6	Hwy. 659 Shoulder												
0.0	Gravelly Sand, Some Silt												
	SILTY SAND, Some Gravel, Loose to Compact (Fill)		1	SS	8								
			2	SS	72								
96.3	Dense												
3.3	CLAYEY SILT, With Sand, Some Gravel, Stiff		3	SS	12								
95.6													
4.0	SILTY SAND, With Gravel, Dense to Very Dense		4	SS	35								
			5	SS	29								
94.2													
			6	SS	136	75cm							
5.4	End of Borehole												
	NOTE Borehole Location is Referenced to Temporary Station.												

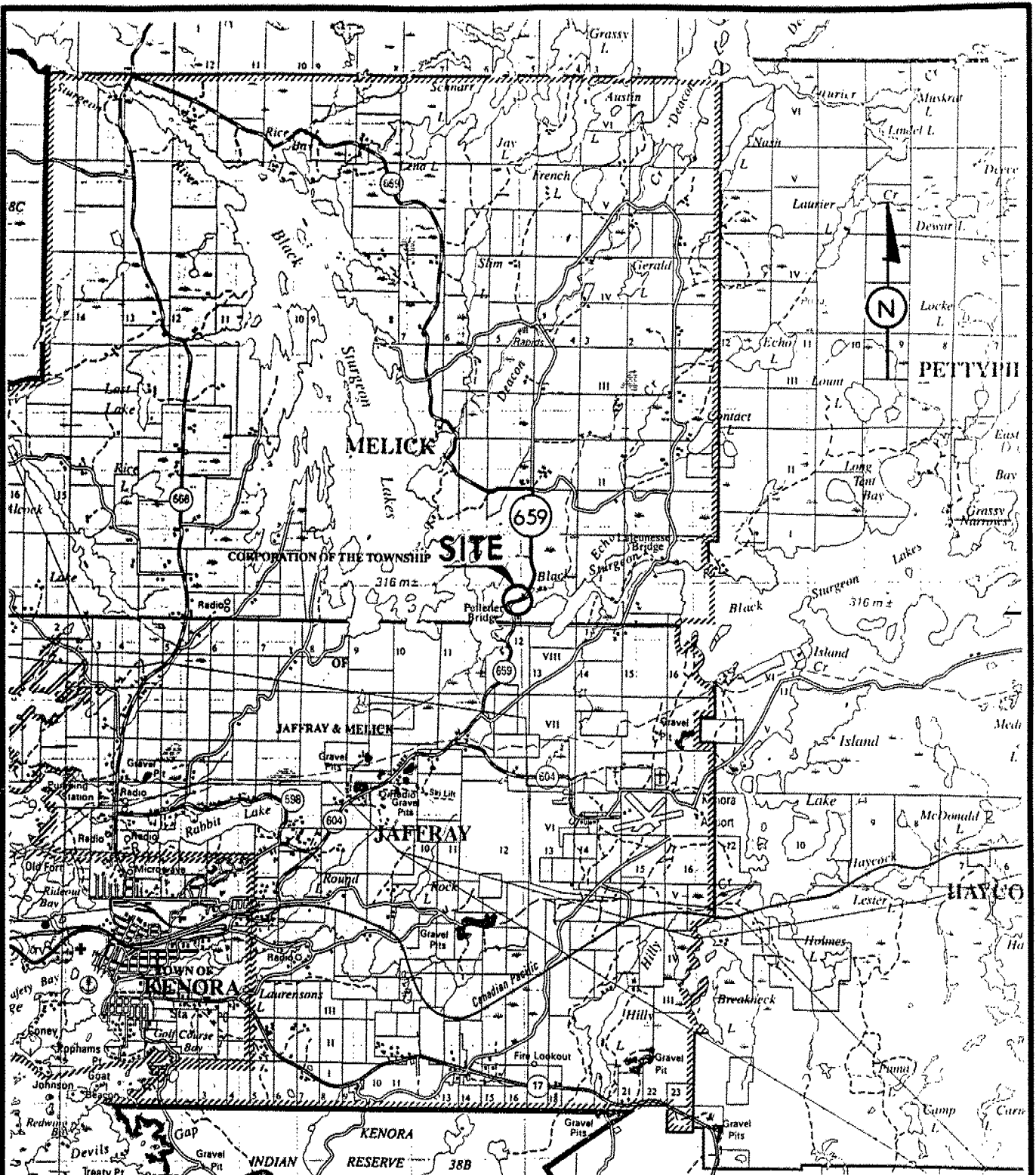
RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.O. 92 - 11011 LOCATION Sta.9+996.0 : o/s 11.3 m Rt of E Hwy 659 ORIGINATED BY M V
 DIST 20 HWY 659 BOREHOLE TYPE NX CASING & CONE TEST COMPILED BY M V
 DATUM ASSUMED BENCH MARK DATE 92 09 03 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
96.2	Ground Surface												
0.0	Occasional Organics												
	CLAY, Tr. of Sand, Tr. of Gravel, Soft to Firm		1	SS	4								
94.1			2	WS	-								
2.1	SILTY SAND, With Gravel, Dense to Very Dense		3	SS	36								38 39 (23)
92.9			4	SS	100	/10cm							
3.3	End of Borehole												
	Note: Borehole Location is Referenced to Temporary Station												



SITE LOCATION



GEOCRES No 52E -37

HWY 659, DIST. 20
WO 92-11011