

G.I.F-30 SEPT. 1976

GEOCRES No. 40I14-104DIST. 2 REGION W.P. No. 40-66-03CONT. No. 80-77W. O. No. STR. SITE No. 19-534HWY. No. 402LOCATION Hwy 81 Mudpass
0.5 mi W of Hwy 2No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

MEMORANDUM

40114-104

GEOCRE No.

TO: A.P. Watt (2)
Regional Structural Planning Engineer
Southwestern Region, London

FROM: Soil Mechanics Section
Geotechnical Office
West Bldg.

ATTENTION:

DATE: April 8, 1976

OUR FILE REF.

IN REPLY TO

APR 13 1976

SUBJECT:

FOUNDATION INVESTIGATION REPORT

For

W.P. 40-66-03
Hwy 402 District 2 London
Hwy 81 Underpass
0.5 Miles West of Hwy 2

Attached we are forwarding to you our detailed Foundation Investigation Report on the subsoil conditions existing at the above mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your requirements. Should additional information be required, please do not hesitate to contact our Office.

K.G. Selby

K.G. Selby
Supervising Engineer

KGS/bp

cc: R.S. Pillar
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FOUNDATION INVESTIGATION REPORT

For

402 W.P. 40-66-03
Hwy 81 District 2 London
Hwy 81 Underpass
0.5 Miles West of Hwy 2

1. INTRODUCTION

This report contains the results of a foundation investigation carried out at the following site:

Hwy 81 Underpass

W.P. 40-66-03, Site: 0.7 miles west of jct.
of Hwy 2 and Hwy 81
Hwy 402 District 2, London, Ont.

The report contains factual and interpreted subsurface data and recommendations pertaining to the design and construction of the proposed structure and roadway cut.

2. SITE DESCRIPTION

The proposed underpass structure is located at the crossing of the existing Hwy 81 and future Hwy 402 on Lot 22, Conc. 1, and Lot 22, Range 1, Township of Caradoc, County of Middlesex.

In terms of topography, the immediate area of the site is flat and gently sloping towards the valley of the meandering Thames River which is located about 1200 ft. east northeast and about 1.2 miles in the southwestern direction from the proposed Jct. of Hwy 81 and 402. The river water level was found to be at elev. 665 ± in the month of May 1975. The land, in most part, is used for agricultural purposes. Some residential buildings are located along Hwy 81. These houses are supplied with adequate and good quality ground-water from dug wells or from deep wells.

Physiographically, the site is situated in the region referred to as the Caradoc Sand Plains. Irregularly placed beds or zones of clays, silts

and fine sands were deposited by a succession of glacial spillways and inter-glacial lakes.

3. FIELD AND LABORATORY INVESTIGATION

A total of four boreholes, three accompanied by dynamic cone penetration test, were carried out during the course of the field investigation. (Dec. 1 - 12, 1975). In addition, four shallow holes, to depths of 5, 10, 15 and 20 ft. were drilled for groundwater level observation.

The borings were advanced by means of a truck mounted continuous flight auger machine. When advancement in a borehole was prevented due to 'cave-in', the hole was cased with BX size casings and washboring methods were employed.

'Disturbed' samples were obtained in 2" O.D. split-spoon samplers, which were hammered into the soil in accordance with the specifications for the Standard Penetration Test. The same energy was used to carry out the dynamic cone penetration tests. 'Undisturbed' samples were recovered using 2" I.D. Shelby Tubes, which were pushed into the soil hydraulically.

The groundwater conditions across the site were determined by recording the water level in the open holes during the course of the field investigation.

The locations and elevations of all borings were surveyed by personnel from the Southwestern Region Engineering Surveys and are shown on Drawing 406603-A.

The samples were subjected to visual examination in the field and subsequently in the laboratory.

Laboratory tests were performed on selected samples to determine the physical properties of the various soil types, namely:

- Natural Moisture Content
- Grain-size Distributions
- Atterberg Limits (cohesive soils only)
- Undrained Shear Strength (unconfined)
- Bulk Density

The results of the field and laboratory tests are plotted on the Record of Borehole Sheets contained in the Appendix of this report.

4. SUBSURFACE CONDITIONS

4.1 Soil Conditions

The subsoil at the site was found to vary in both horizontal and vertical directions. Below a shallow (up to 10 ft. thick) surficial deposit of sand with some silt and traces of clay, zones or layers of cohesive and non-cohesive materials were encountered in the boreholes.

The cohesive portion of the subsoil consists mainly of clayey silt with irregular layers, seams and pockets of sand and silt. Most of these sand and silt layers were found to be water bearing. The consistency ranges from stiff to hard.

The non-cohesive deposits were found to consist of sands and silts in with varied percentage combinations. Layers, seams and pockets of clayey silt material were found interbedded within the main stratum in random occurrence. Traces of gravel were also encountered. The relative density is estimated to range from compact to dense.

Two boreholes (1 and 8) were advanced over 100 ft. in depth. These borings penetrated into a hard heterogeneous mixture of gravel sand, silt and clay (glacial till) stratum at elev. 645 \pm ft. and elev. 650 \pm respectively.

References should be made to the Record of Borehole Sheets and Drawing 406603-A for physical properties and boundaries of the different deposits at each boring location.

It is pointed out that the subsoil conditions have been established only at the borehole locations and were found to differ from borehole to borehole.

A Geotechnical Report by Hydrology Consultants Ltd., indicates that the bedrock surface is located some 225 ft. (elev. 535 \pm) below ground level in this area.

4.2 Groundwater Conditions

The following groundwater levels were observed during the field investigation:

B.H. #1	Elev. 757.0
#2	757.0
#3	756.0
#4	756.1

B.H. #5	Elev. 756.8
#6	756.7
#7	757.2
#8	756.1

The average natural ground surface is at elev. 761 \pm in the vicinity of the site.

It is pointed out that the water level observations were carried out during a relatively dry period and that higher levels will probably prevail in a wet period such as spring time.

It was observed that the non-cohesive layers (seams) interbedded within the cohesive deposits, are water bearing. Seepage from these layers are anticipated.

A 'hydrogeological study in the vicinity of the proposed highway 402 route through Lot 22, Concession 1 and Lot 22, Range 1 north Township of Caradoc' was carried out upon the request of MTC's southwestern region by Hydrology Consultants Limited (Mississauga).

5. DISCUSSION AND RECOMMENDATIONS

5.1 General

It is proposed to build a two-span underpass structure either with 163.4 - 163.4 ft. long, or 188.4 - 183.4 ft. long spans at this location. (Ref. Dwg. 406603-A)

The profile grade of future Hwy 402 (WBL and EBL) will be at elev. 740 \pm , which is about 22 ft. lower than the profile grade of Hwy 81.

The encountered subsoil, as described previously was found to be rather complex as far as the type, consistency (Denseness) and extent (vertical and horizontal) is concerned.

The observed groundwater level varied between elev. 756 \pm and 757 \pm which is 4 to 5 ft. below existing ground level.

5.2 Foundations

Two types of foundations are being considered for the proposed structure support: Spread footings and piles.

5.2.1 Spread Footings

5.2.1.1 Abutments

Assuming that the foundation level will be at elev. 748 ± a safe design load of 2.5 t.s.f. may be used for design purposes.

The subsoil at this elevation consists of stiff cohesive (clayey silt) material interbedded with sands and silts. The undrained shear strength of the cohesive portion ranges from 2000 to 4000 p.s.f. However, the base of the footing excavations could contain water bearing sand and silt layers which are sensitive to disturbance. In addition to decrease in bearing capacity, dewatering might present a problem.

In view of these facts it is recommended that before excavation is carried out interlocking sheet piles be driven to a distance equal to the hydrostatic head existing above the footing excavation base at the time of the construction.

The underside of the footing should be placed within the cohesive portion of the subsoil. Consequently all non-cohesive material should be removed from the excavation base.

The front face of the abutment footing (measured in the plane of the underside of footing) should not be placed closer than 10 ft. from the forward slope surface.

For computation of sliding resistance, an adhesion value of 3000 p.s.f. or a coefficient of 0.35, whichever results in the lesser resisting force, assumed to apply between bases of footings and the underlying soil at the foundation level.

5.2.1.2 Pier

The subsurface conditions were found to be somewhat similar to those existing at the abutments locations. The recommendations of 5.2.1.1 (with a few exceptions) are applicable to the pier design and construction.

The exceptions are as follows:

- a) Safe Design Load: 2.0 t.s.f. at elev. 734 ±.
- b) Adhesion value : 2000 p.s.f. or a coefficient of 0.35

5.2.2 Pile Support

The entire structure may be supported on one of the following pile

types:

a) Timber Piles

For #14 treated timber piles driven about 45 ft. into the original ground, a design load of 25 tons per pile is recommended.

b) 'H' Piles

End-bearing steel 'H' piles would have to be driven beyond elev. 640 in order to achieve the maximum allowable load for the respective pile section selected.

The pile driving during construction should be controlled by employing the Hiley Dynamic Pile Driving Formula. (MTC Standard SS3-10 and 11).

5.2.3 Frost Protection

The base of spread footings and the pile caps should be protected against frost action with a minimum of 4 ft. of earth cover.

5.2.4 Settlement

Total settlements under the footings should not be more than 1 inch. Differential settlements between piers and abutments should be less than 1 inch.

5.3 Roadway Cut

The proposed new Hwy 402 will be located in an approx. 22 ft. deep cut at this site. The observed groundwater level is about 16-17 ft. above the proposed profile grade of Hwy 402. The subsoil in which the roadway cut will be carried out consists of randomly varied zones or layers of stratified cohesive and non-cohesive deposits. The non-cohesive layers and seams interbedded within the cohesive zones are water-bearing. Since these pervious sand and silt layers are confined within the relatively impervious cohesive deposit, they would act as small reservoirs thus softening the surrounding soil. The trapped water would freeze during the winter period.

Upon thawing in the spring, the stored water could create large seepage forces on the face of the slope, which tend to cause surficial

instability. To ensure the longterm stability of the cut slopes the following treatment should be carried out:

- a) Perforated subdrains should be constructed at the toe of the slope. The depth of the drain should be governed by the depth of frost penetration which is about 4 ft. in this area. An adequate drainage outlet should be provided for the system.
- b) An 18 inch thick granular 'A' blanket should be provided over the slope surface as shown on Fig. 1.

This treatment should be carried out on both sides of the proposed cuts.

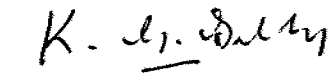
The slopes should be protected against erosion as per current MTC practices. 2:1 slopes are recommended.

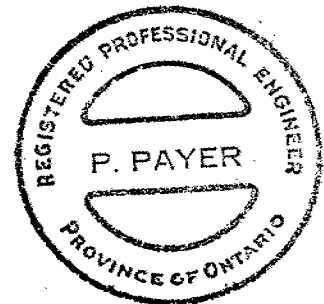
5.4 Construction Considerations

To minimize construction problems which may occur due to the observed high groundwater level, the following construction scheme is suggested:

- a) Excavate for roadway
- b) Construct subdrains and place granular 'A' blanket on slopes
- c) Construct structure


P. Payer, P. Eng.
Senior Engineer


K.G. Selby, P. Eng.
Supervising Engineer



April, 1976

APPENDIX

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

WP 40-66-03 LOCATION Co-ords. 15,590,243 N; 1,283,723 E. ORIGINATED BY PP
 DIST 2 HWY 402 BORING DATE December 3 to 5, 1975 COMPILED BY GP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger, Washbore & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_P WATER CONTENT — w			UNIT WEIGHT γ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		25	50	75	100	125	w_p	w	w_L		
759.5	Ground Level															
0.0	Sand, traces of silt and clay.		1	SS	9											
	Loose to Compact		2	SS	28											0 93 (7)
751.4			3	SS	34											
8.1	Clayey silt, pockets & seams of sand. Hard		4	SS	47	750										0 7 68 25
745.0			5	SS	31											5 92 (3)
14.5	Silty sand, traces of gravel		6	SS	15											
			7	SS	17											
			8	SS	26	740										0 25 45 30
			9	SS	21											
			10	SS	18											
	irregular layers, seams and pockets of clayey silt.		11	SS	16											
			12	SS	25	730										0 44 38 18
			13	SS	30											
			14	SS	31											
	Compact to Dense		15	SS	41	720										
			16	SS	11											
			17	SS	35											
711.0						710										
48.5	Clayey silt		18	SS	16											
	irregular layers, seams & pockets of sand and silt.		19	SS	22	700										
			20	SS	32	690										
	Very Stiff to Hard															
			21	SS	28	680										
			22	SS	39	670										
			23	SS	45	660										
655.5																
104.0																

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1 Continued

WP 40-66-03 LOCATION Co-ords. 15,590,243 N; 1,283,723 E. ORIGINATED BY PP
 DIST 2 HWY 402 BORING DATE December 3 to 5, 1975 COMPILED BY GP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger, Washbore & Cone Test CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ PCF	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		25	50	75	100	125	W_P	W	W_L		
655.5	continued															
104.0	Clayey silt, irregular layers, seams & pockets of sand and silt.															
	Very Stiff to Hard		24	SS	94	650										
644.5																
115.0	Het. mix. of gravel, sand, silt & clay															
	Glacial Till															
638.0	Hard		25	SS	36	640										
121.5	End of Borehole															

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 3

WP 40-66-03 LOCATION Co-ords. 15,590,188 N 1,283,772 E. ORIGINATED BY MK
 DIST 2 HWY 402 BORING DATE December 1, 1975 COMPILED BY GP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		25	50	75	100	125	w_p	w	w_L		
760.0	Ground Level															
0.0	Sand, some silt, traces of clay.		1	SS	6											0 67 28 5
	Very Loose to Compact		2	SS	3											0 68 25 7
751.5			3	SS	16											4 76 (20)
8.5	Clayey silt, seams & pockets of sand.		4	SS	46	750										0 1 79 20
745.0	Hard		5	SS	38											
15.0	Silt, Compact to Dense trace of sand and clay seams.		6	SS	44											0 8 81 11
740.5			7	SS	26	740										
19.5	Clayey silt, occasional seams & pockets of sand.		8	SS	14											
			9	SS	16											
733.0	Stiff to Very Stiff		10	SS	23											
27.0	Silty sand to sandy silt, seams & pockets of clay.		11	SS	18	730										0 32 48 20
			12	SS	34											
			13	SS	40											
	Compact to Dense		14	SS	10	720										
713.5			15	SS	22											0 59 35 6
46.5	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 7

WP 40-66-03 LOCATION Co-ords. 15,590,205 N; 1,283,533 E. ORIGINATED BY RVV/PP
DIST 2 HWY 402 BORING DATE December 10 to 12, 1975 COMPILED BY GP
DATUM Geodetic BOREHOLE TYPE Washbore - BX Casing and Cone Test CHECKED BY

SOIL PROFILE		STRAT. PLOT	SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ PCF	REMARKS			
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	N' VALUES		25	50	75	100	125	w_p	w	w_L		GR	SA	SI	CL
761.1	Ground Level																		
0.0	Sand, some silt, traces of clay.		1	SS	7	760													
			2	SS	24														
			3	SS	111														
			4	SS	71														
751.1	Loose to Very Dense		5	SS	46														
10.0	Clayey Silt		6	SS	27	750													
			7	SS	39														
			8	TW	PH														
			9	SS	35														
	irregular layers, seams & pockets of sand and silt.		10	SS	22														
			11	TW	PH														
			12	TW	PH														
			13	TW	PH														
			14	TW	PH														
			15	TW	PH														
			16	TW	PH														
			17	SS	24														
			18	SS	26														
	Stiff to Hard		19	SS	29														
			20	SS	18														
719.6			21	SS	14	720													
41.5	End of Borehole																		

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 8

WP 40-66-03 LOCATION Co-ord. 15,590,161 N; 1,283,407 E. ORIGINATED BY MK/BYY
 DIST 2 HWY 402 BORING DATE December 8 to 10, 1975 COMPILED BY GP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger, Washbore & Cone Test CHECKED BY

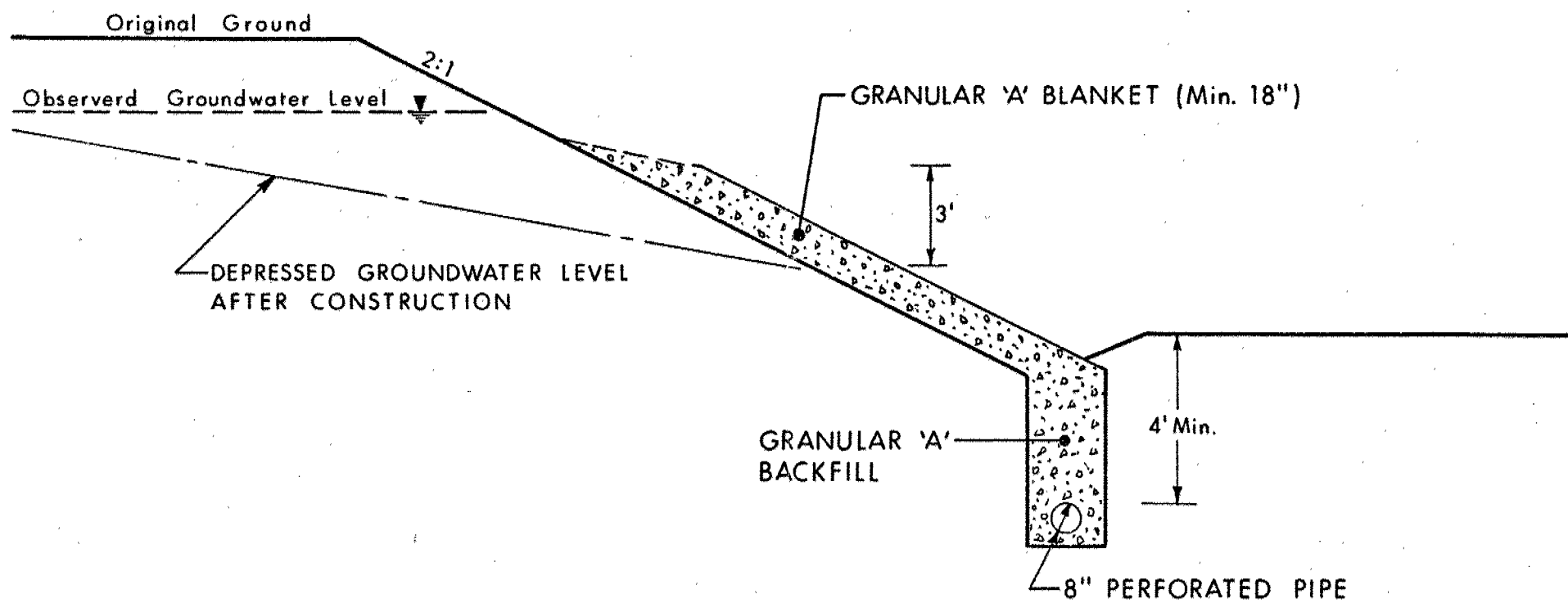
SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			UNIT WEIGHT γ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		25	50	75	100	125	W _P	W	W _L		
762.2	Ground Level															
0.0	Sand, traces of silt and clay.		1	SS	11	760										0 87 (13)
	Compact		2	SS	19											0 86 (14)
752.7	gravel		3	SS	41											21 73 (6)
9.5	Clayey silt irregular layers, seams & pockets of sand and silt		4	SS	31											0 11 55 34
			5	SS	34											0 12 58 30
			6	SS	41											
			7	SS	28											
			8	SS	23											
	Stiff to Hard		9	SS	15											
			10	SS	23											0 4 70 26
			11	SS	29											
730.2			12	SS	21											
32.0	Silty sand to sandy silt, some clay		13	SS	30											0 47 32 21
			14	SS	23											
722.7	Compact to Dense		15	SS	32											0 18 65 17
39.5	Clayey silt layered		16	SS	15											
716.2	Very Stiff		17	SS	71											
46.0	Silt, trace of sand, irregular layers of clayey silt		18	SS	22											0 7 72 21
			19	SS	22											
	Compact to Dense		20	SS	32											0 9 66 25
696.2																
66.0	Clayey silt irregular layers, seams and pockets of sand and silt		21	SS	31											
			22	SS	81											
			23	SS	87											0 0 63 37
	Very Stiff to Hard		24	SS	29											
658.2																
104.0																

RECORD OF BOREHOLE No 8 Continued

WP 40-66-03 LOCATION Co-ords. 15,590,161 N; 1,283,407 E. ORIGINATED BY MK/BVV
 DIST 2 HWY 402 BORING DATE December 8 to 10, 1975 COMPILED BY GP
 DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger, Washbore & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		25	50	75	100	125	w_p	w	w_L		
658.2	continued															
104.0	clayey silt, irregular layers, seams & pockets of sand and silt.															
650.2	Very Stiff to Hard		25	SS	49	650										
112.0	Glacial Till															
645.2	Hard		26	SS	167											
117.0	End of Borehole															

RECOMMENDED CUT SLOPE TREATMENT



N.T.S.

FIG. 1

W.P. 40-66-03

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' = STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10 % , SOME 10-25 % , WITH 25-40 % , > 40 % SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
w_S	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_f	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

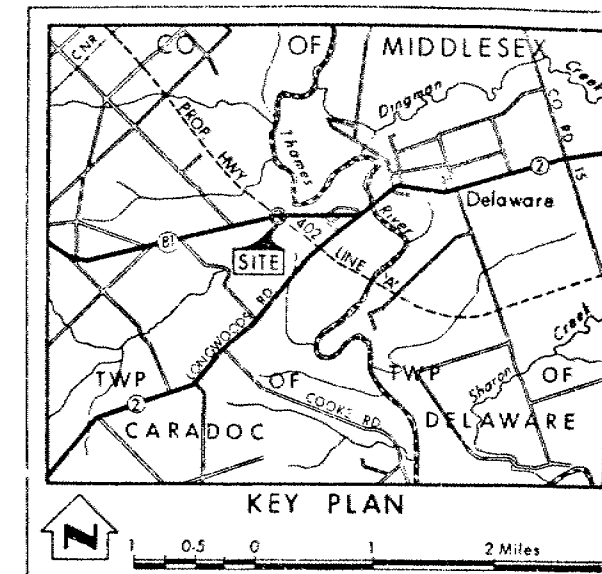
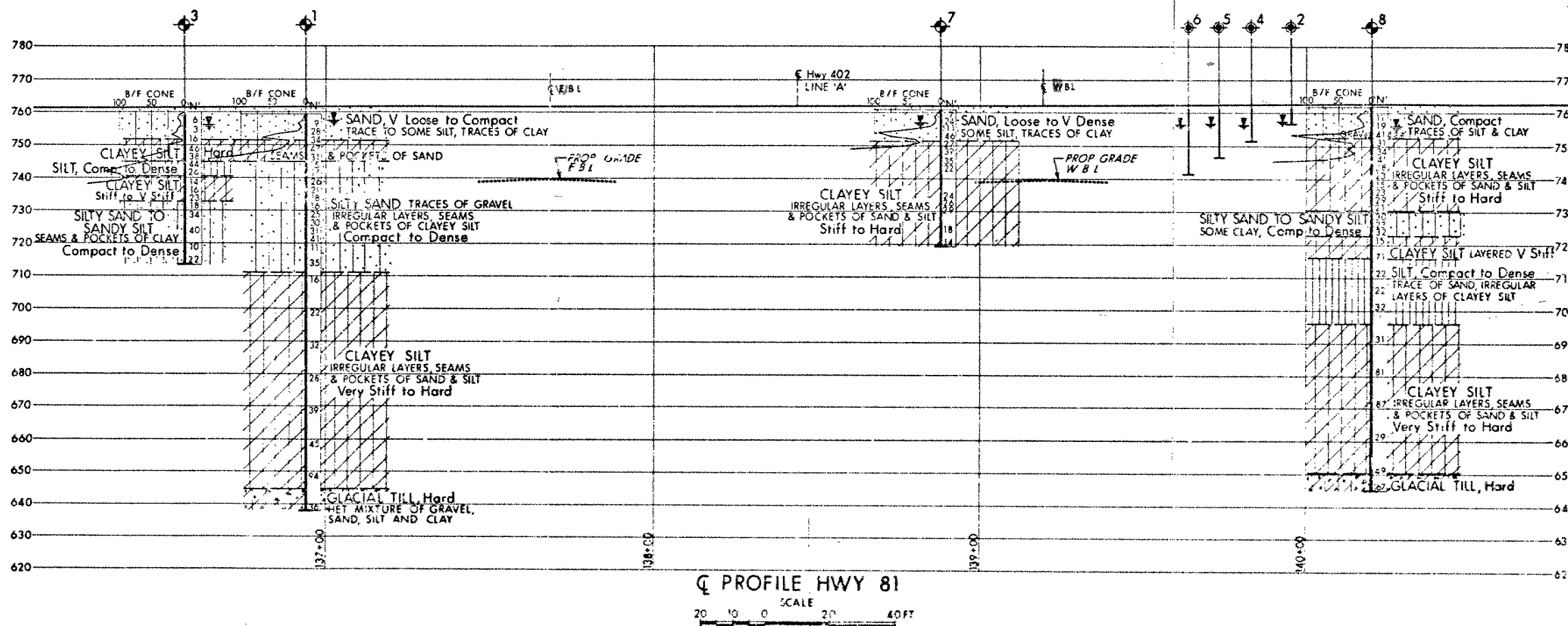
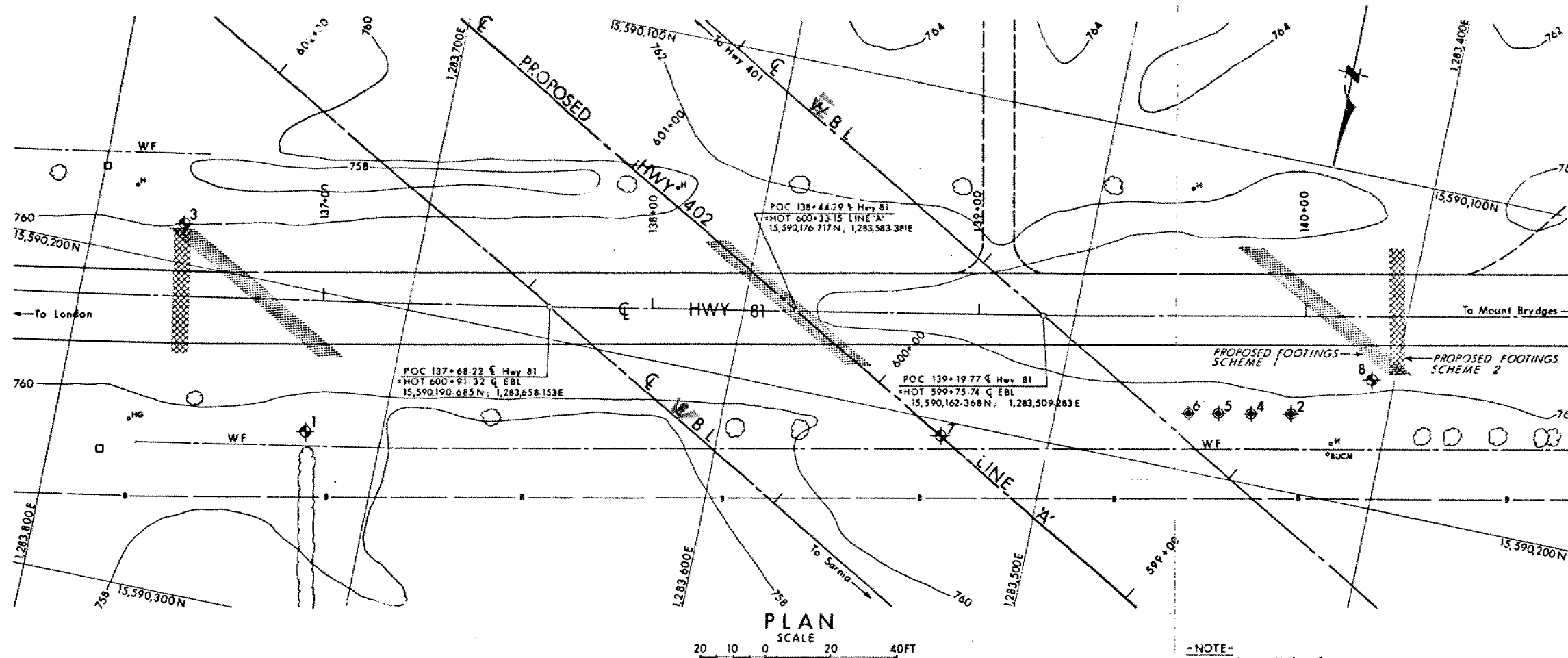
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



LEGEND			
	Bore Hole		
	Dynamic Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, Dec 1975		
	Auger Hole		
NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	759.5	15,590,243	1,283,723
2	761.5	15,590,176	1,283,429
3	760.0	15,590,188	1,283,772
4	761.5	15,590,179	1,283,441
5	761.5	15,590,181	1,283,451
6	761.5	15,590,183	1,283,460
7	761.1	15,590,205	1,283,533
8	762.2	15,590,161	1,283,407

NOTE: The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE—SOIL MECHANICS SECTION

HIGHWAY 81
(0.5 Mile West of Hwy 2)

HIGHWAY NO. Prop. 402 LINE 'A' DIST NO. 2
CO. MIDDLESEX
TWP. CARADOC LOT 22 RANGE 1N1R

BORE HOLE LOCATIONS & SOIL STRATA

SUBMITTAL CHECKED BY: [] DRAWING NO. 406603-A
DRAWN BY: [] CHECKED BY: []
DATE: April 6, 1976 SITE NO. 19-534 BRIDGE DRAWING NO.
APPROVED: [] CONT. NO.