

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 41P-17

DIST. 14 REGION

W.P. No. 195-88-02

CONT. No. 90-454

W. O. No.

STR. SITE No. 47-40

HWY. No. 560

LOCATION Hwy 560 & Wapus Creek

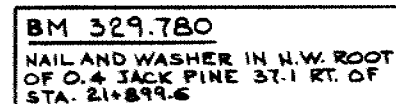
No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL DATA
3. FOUNDATION LAYOUT AND DETAILS
4. WEST ABUTMENT DETAILS
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13. BARRIER WALL
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16. STANDARD DETAILS

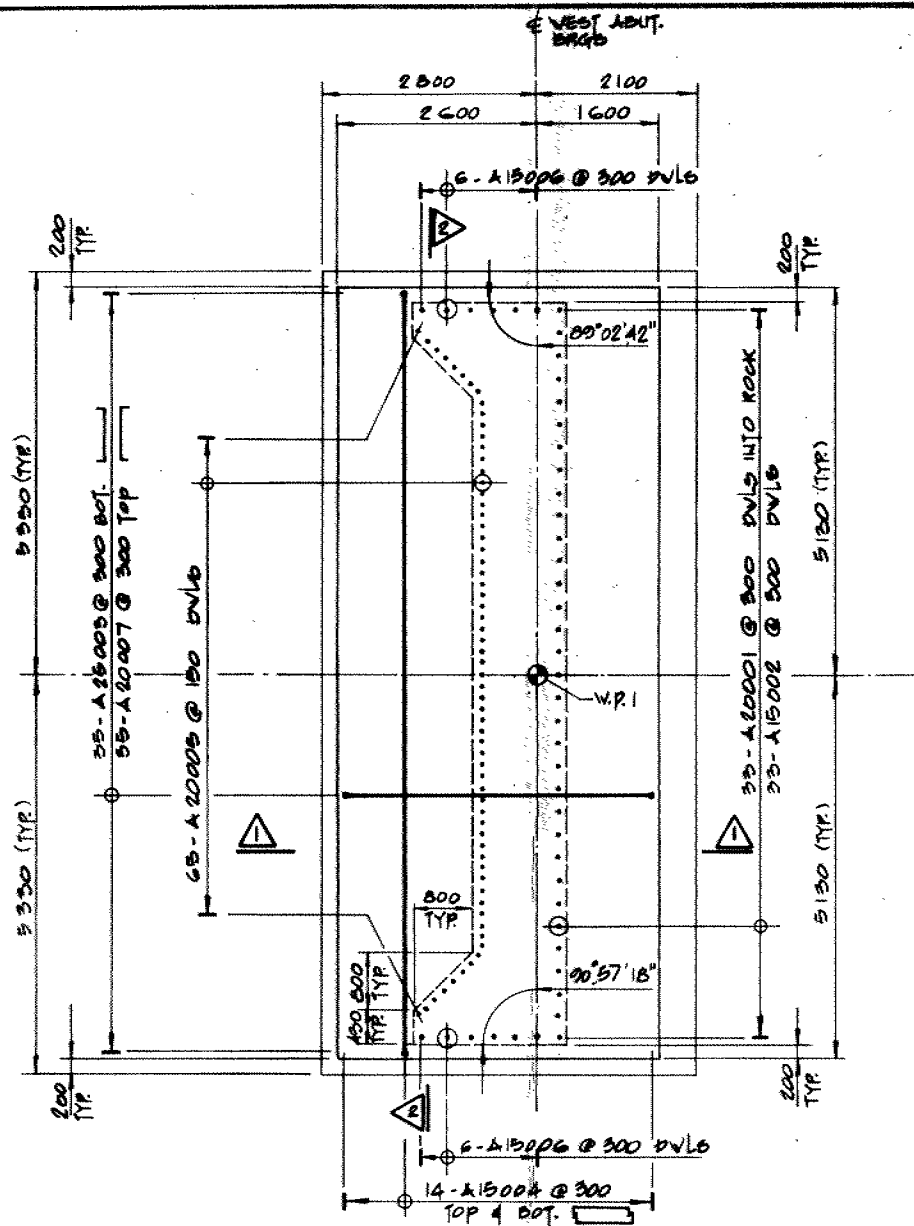


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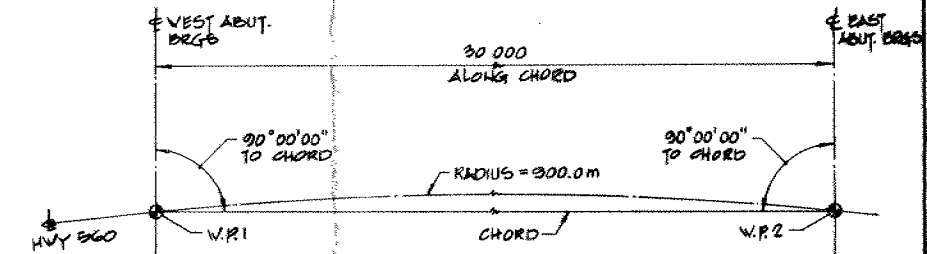
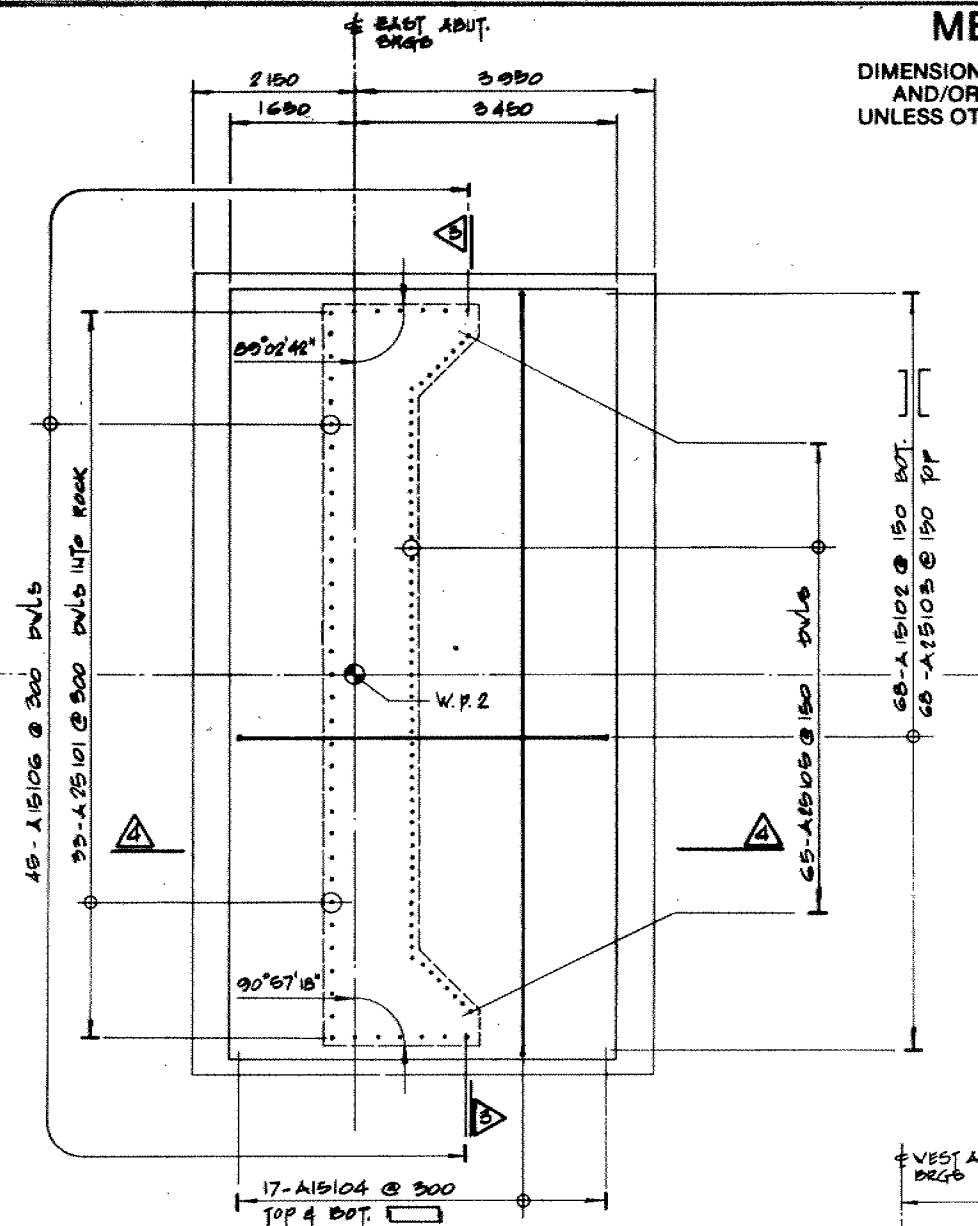
REVISIONS						
	DATE	BY		DESCRIPTION		
	DESIGN P.S.	CHECK BRB	LOADING	CHADC-BBA	DATE APR 8	
	DRAWING V.Z.	CHECK BRB	SITE No	47-1025-40	DWG 1	

NOTES:

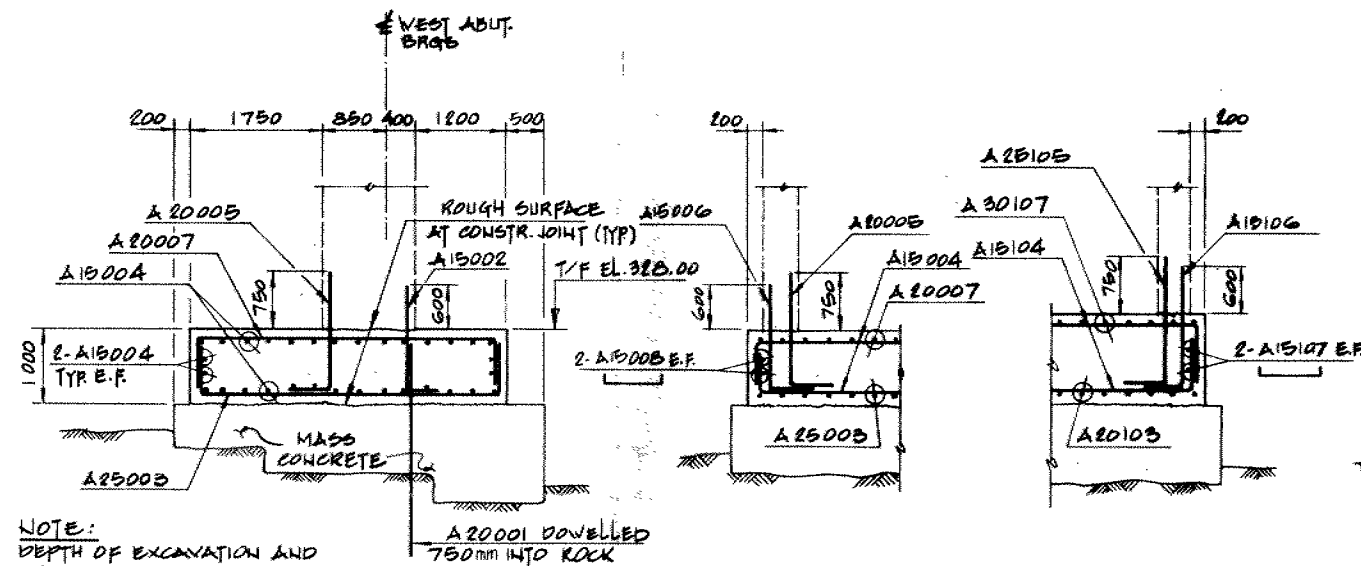
- FOR LOCATION OF WORKING POINTS SEE GENERAL ARRANGEMENT DWG NO 1.
- E.F. DENOTES EACH FACE.



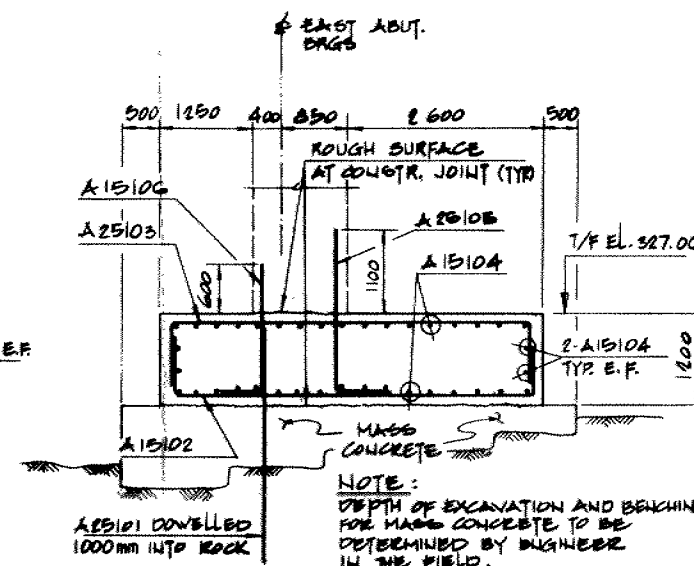
PLAN
1:50



FOUNDATION LAYOUT
N.T.S.



NOTE:
DEPTH OF EXCAVATION AND
BENCHING FOR MASS CONCRETE
TO BE DETERMINED BY ENGINEER
IN THE FIELD.



NOTE:
DEPTH OF EXCAVATION AND BENCHING
FOR MASS CONCRETE TO BE
DETERMINED BY ENGINEER
IN THE FIELD.



DRAWING NOT TO BE SCALED
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REVISIONS								
DATE		BY		DESCRIPTION				
DESIGN BRB	CHK EPB	CODE OHBDC-83		LOAD CLASS A		DATE	SEP.89	
DRAWN AP	CHK BRB	SITE 47-1025-40		STRUCT		SCHEME	DWG. 3	

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 90-454



Ministry of
Transportation and
Communications

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<u>Page No.</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations and Symbols
	Foundation Investigation Report for
3 - 21	Wapus Creek W.P. 195-88-02, Site 47-40 Hwy. 560, Dist. 14, New Liskeard

Note: For purposes of the contract, this report supercedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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_a	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						

1 - INTRODUCTION

Acres International Limited (Acres) was retained by the Ministry of Transportation of Ontario (MTO) to undertake a foundation investigation for a proposed bridge structure at the crossing of Wapus Creek and Highway 560, District #14 New Liskeard, W.P. 195-88-02, Site 47-40. The work was authorized by Agreement 4238-9088-237 dated November 14, 1988.

The location, site plan and section of the proposed bridge are shown on MTO Plan E-1025-560-1.

Drilling and sampling operations were performed by Longyear Canada Inc. under the full-time supervision and direction of Mr. Philip C. Miles, an Acres geotechnical engineer. Fieldwork commenced on January 28, 1989 and was completed February 5, 1989. A plan of the site, showing the borehole locations and stratigraphic profiles, is shown on Drawing No. 2018802-A. *

All soil samples and bedrock core were returned to Acres geotechnical laboratory in Niagara Falls for detailed examination, logging and testing.

The results of the field and laboratory investigations are presented in this report, together with an interpretation of the data obtained and recommendations concerning the geotechnical aspects of the design and construction of the proposed bridge.

* Dwg No 2 of the Contract Dwg's

2 - EXPLORATORY WORK

The exploratory work at Wapus Creek consisted of 8 boreholes drilled to depths ranging from 3.2 m to 10.5 m in both overburden and bedrock, and located as shown on Drawing No. 2018802-A*. A total of 10.0 m of overburden and 38.1 m of bedrock were drilled. Drilling was performed using a track-mounted CME75 drill equipped with hollow stem augers and an NQ wireline core barrel.

Access to all boreholes from existing Highway 560 was provided by a small bulldozer owned and operated by Gunter Contracting Ltd. Borehole sites were leveled which effectively removed the snow cover, surface boulders and some of the organic rich topsoil layer. The site was covered with up to 0.7 m of snow prior to clearing by the bulldozer. Temperatures ranged from approximately 0°C to -40°C during the investigations.

Boreholes 1 to 6 were drilled to determine subsurface conditions at the proposed bridge abutment locations. Three boreholes were located on each side of Wapus Creek. Boreholes 7 and 8, at the top of and partway down the rock ridge immediately to the east of Wapus Creek were drilled to determine the overburden and bedrock conditions along the proposed approach rock cut. The holes were advanced through overburden using hollow stem augers and attempts were made to sample it at intervals of 0.6 m or less, using a 51-mm O.D. split barrel sampler in accordance with the Standard Penetration Test procedure. Coring of bedrock, using an NQ double tube wireline core barrel, was carried out through the hollow stem augers or NW casing drilled and seated into bedrock.

Borehole locations (chainages, offsets and ground surface elevations) were surveyed by the MTO. Table 1 summarizes the physical data for each borehole.

* Dwg No 2 of the Contract Dwg's

TABLE 1SUMMARY OF BOREHOLE PHYSICAL DATA

<u>Borehole Number</u>	Ground	<u>Centerline Chainage</u> (m)	<u>Offset</u> *	<u>Overburden/Bedrock Contact</u>		<u>Bottom of Borehole</u>	
	<u>Surface Elevation</u> (m)			<u>Depth</u> (m)	<u>Elevation</u> (m)	<u>Depth</u> (m)	<u>Elevation</u> (m)
1	327.05	21+728	4.8R	2.13	324.92	7.16	319.89
2	327.23	21+726	0	1.52	325.71	6.38	320.85
3	327.34	21+728	4.8L	1.93	325.41	6.10	321.24
4	328.44	21+696.3	4.4L	1.30	327.14	4.88	323.56
5	328.78	21+696.2	5.2R	0.56	328.22	4.08	324.69
6	328.37	21+700	1.0L	1.83	326.54	5.74	322.63
7	341.92	21+754	0.5R	0.48	341.44	10.5	331.42
8	337.98	21+782.4	2.0R	0.20	337.78	<u>3.22</u>	334.76
Total Depth Drilled						48.07	

* R = right

L = left

All soil and rock samples were returned to Acres geotechnical laboratory for more detailed logging and testing. Due to its granular nature, only grain size analyses were performed on four selected overburden samples. The results of these tests are shown in Figure 1.

Piezometers were not installed in any of the boreholes. However, observations of water levels in boreholes were made on completion and up to 2 days after the drilling of each hole.

Records for each of the boreholes, summarizing all the field and laboratory data, are presented following the report text.

3 - SITE CONDITIONS

3.1 - General

The proposed Highway 560 realignment at Wapus Creek is located approximately 35 m north of the existing highway and runs roughly parallel to it in an east-west direction. The location of the proposed bridge site is shown on the key plan on Drawing No. 2018802-A.*

Wapus Creek flows in a northerly direction through hilly terrain controlled by ridges of Precambrian bedrock. Topographic relief in the immediate area of the site is in the order of 20 m. Bedrock is exposed in rock cuts along the existing road alignment at Wapus Creek and also outcrops a short distance to the east and west of the creek, along the proposed realignment. A high bedrock ridge exists almost immediately to the east of the creek. Topographic lows are generally wet with numerous lakes and swamps present in the area.

3.2 - Soil Conditions

Overburden, in the form of talus, alluvium and completely weathered bedrock, is present on both sides of the creek in the area of the site investigations. The maximum depth to bedrock on the east side of the creek was found to be approximately 2.1 m in BH-1, and on the west side 1.8 m in BH-6.

On the east side of the river, the overburden is generally a sand and gravel with varying amounts of silt, cobbles and boulders and some sand layers. A reliable estimate of the density of these materials, using the Standard Penetration Test, was not possible due to the presence of numerous large particles.

In BH-1 and BH-2, the upper zone, is a collection of relatively loose, brown to black, silty sand, gravel and cobbles extending to depths of

* Dwg No 2 of the Contract Dwg's

0.91 m and 0.3 m, respectively. Organics are present in the upper 0.3 m, however, some of this material, up to about 0.2 m, may have been removed during the site preparation and leveling operations. In BH-1 this material is underlain by moist to wet, relatively dense gravel and cobbles with a trace of silt varying in color from grayish brown at the top to reddish brown at the bedrock surface, at a depth of approximately 2.1 m. The bedrock surface at BH-1 is completely weathered becoming less weathered with depth. Small granular samples were recovered with the split spoon down to a depth of 4.0 m. Many fragments from overburden sample SS3, just above the bedrock surface, consisted of completely weathered bedrock and could be easily crushed between the fingers.

In BH-2, the upper zone is underlain by a 1-m thick layer of moist, loose to compact silty sand with some gravel which grades in color from brown to reddish brown. This overlies a 0.15-m thick layer of a wet, dense, brown, sandy gravel on the bedrock surface at a depth of 1.52 m.

At BH-3, the overburden appears to contain more boulders and cobbles in a brown to black silt, sand, gravel and organic matrix down to bedrock at a depth of 1.93 m.

Overburden conditions on the west side of the river are similar to those on the east. In BH-4 and BH-5 the material consists of a brown to reddish-brown sand (fine sand in BH-5) with varying amounts of silt, gravel, cobbles and organics. Bedrock in BH-4 and BH-5 was encountered at depths of 1.30 and 0.56 m, respectively.

In BH-6, the upper 0.7 m of overburden is a brown to reddish-brown, loose, fine sand with some gravel to silty, gravelly sand. Beneath this, however, is a 1.1-m thick zone of cobbles and boulders in a matrix believed to consist of silt, sand and gravel. This extends to bedrock at a depth of 1.83 m.

In general, the gravel, cobbles and boulders which were encountered were angular in shape and of the same lithology as the dioritic bedrock. Some andesite and quartzitic cobbles were also encountered during drilling in the overburden.

At BH-7 and BH-8, the overburden consisted of a thin mantle of brown silt, sand, gravel, cobbles and organics with a thickness up to approximately 0.5 m. A portion of the overburden in BH-7 was cohesive. The thickness of 0.5 m is believed to be representative of the depth to bedrock, along the proposed centerline on the eastern slope of the bedrock ridge, immediately east of Wapus Creek.

3.3 - Bedrock Conditions

Bedrock at the site consists of an overall grayish, coarse-grained altered diorite which was observed to grade into a darker gabbro or a fine-grained andesite on rare occasions. Rock strength, based on its reaction to drilling and observation of core samples, was judged to range from weak to strong. It was found to be highly to moderately weathered. A predominant feature of the bedrock is the presence of frequent planar to irregular, weakly cemented, healed fractures. These fractures, when broken, often show evidence of shear displacement or slickensiding, very thin chlorite or discontinuous carbonate coatings and, on occasion, silty, clayey coatings or fillings. These healed fractures frequently were steeply dipping to subvertical in orientation, although a wide variety of orientations were observed.

Bedrock encountered in Boreholes 1 to 6 was found to be of poorer quality than the rock drilled in BH-7 and BH-8 on top of the ridge to the east of the creek. In BH-1 the rock was penetrated with a split spoon sampler for short distances to approximately 2 m below its surface. The Rock Quality Designation (RQD) values for the rock core can be used to assess the quality of the rock mass. In this rock the RQD is most sensitive to the degree of weathering which has occurred in and around the numerous healed fractures which have been observed. The

term 'sound' rock has been used to describe rock where the RQD values are consistently greater than 75%.

In BH-1, BH-2 and BH-3, on the east side of the creek, RQD values indicate the rock quality ranges from very poor to excellent. Generally, however, the rock is very poor quality. RQD values of 0% were common in the rock down to depths of 4.0 to 5.5 m. Such very low RQD values were usually manifested in completely fragmented core with the rock fragment surfaces being black, chloritic, with some signs of slickensiding and frequently with a brown staining or a thin, brown, silty, clayey coating. Only in BH-2 was sound rock encountered where the quality of the rock improved to good to excellent, and this occurred below the depth of 4.5 m. Low RQD values were often associated with reduced core recovery and frequent blockage in the core barrel during drilling.

In BH-4, BH-5 and BH-6, on the west side of the creek, the rock was also found to be of very poor to fair quality. Again, RQD's as low as 0% were common. Apart from the single core run in BH-5, where the RQD rose to the good quality range, the rock core gives no significant indication that bedrock quality improves with depth down to about 5.75 m.

In BH-7, the rock was of fair to excellent quality. Based on the RQD values, sound rock was encountered at the depth of 6.25 m. Sound rock was not penetrated in BH-8 as RQD values were consistently below 69% indicating the rock to be very poor to fair quality. BH-8 was limited to a depth of 3.22 m.

Natural open jointing in the rock core was often difficult to distinguish from fractures caused by the action of the core barrel during drilling. Numerous weakly-cemented, healed fractures were observed in the more solid pieces of core. Many of the healed fractures may have been broken during the drilling process. Fracture orientation ranged from subhorizontal to subvertical with all fractures having similar characteristics. Typically, they are smooth to rough and planar, with

fracture surfaces being black to dark green, and sometimes brown stained. Very thin fracture coatings (<1 mm) of chlorite, discontinuous carbonate or a brown silty clay were frequently observed. Fractures with a dip greater than approximately 35° frequently displayed signs of shear displacement or slickensiding, and occasionally contained a filling of brown silty clay, up to approximately 5 mm thick.

An examination of the more solid core pieces of BH-6, BH-7 and BH-8 indicates that joint spacing is variable, ranging from very close in BH-6 to close to moderately close in BH-8, and moderately close in BH-7 (for explanation of terms refer to sheet prefacing the Record of Boreholes).

Rock cuts, along the existing road at Wapus Creek, were, for the most part, snow covered at the time of the investigation. However, where exposed, they appeared to be controlled by jointing in the rock mass and no remnant blast hole traces could be observed. Two subvertical joint sets were observed, one striking northwest-southeast, and the other striking northeast-southwest. Other joint sets, particularly a subhorizontal set, are also likely to be present in the rock mass but were not observed because of the limited rock face exposures.

Rock core from BH-1 to BH-6 was noticeably more broken and fragmented than core from BH-7 and BH-8. This may indicate that the rock in the valley, through which the Wapus Creek flows, has been weakened by shear deformation (faulting) sometime during its geologic history.

3.4 - Groundwater Conditions

The water level in Wapus Creek, at the time of the investigation, was not determined by survey; however, it is believed to have been close to the 325.5-m elevation recorded on September 27, 1988 by the MTO.

Water levels were observed in all boreholes, following and up to 2 days after completion of their drilling, except for BH-6 where no water level could be seen. Borehole piezometers were not installed.

In BH-1, BH-2 and BH-3, on the east side of the creek, water levels were within the overburden and in the order of 0.9 m above the creek water level.

In BH-5, on the west side of the creek, the water level was found to be below the bedrock surface and approximately 1 m above the creek water level. The water level remained high in BH-4 (0.3 m below ground surface) following drilling.

In BH-7 and BH-8, in the rock ridge to the east of Wapus Creek, water levels following drilling were found to be 1.2 m and 0.4 m below ground surface, respectively.

These water levels can be considered as approximate only as the duration of observation was relatively short and drill water may not have had sufficient time to stabilize with the natural groundwater level.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Acres International Limited (Acres), (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.

RECORD OF BOREHOLE No 1

METRIC

W P 195-88-02

LOCATION Sta. 21 + 728 o/s 4.8 m Rt. & Hwy. 560 Line 'A'

ORIGINATED BY PCM

DIST 14 HWY 560

BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core

COMPILED BY PCM

DATUM Geodetic

DATE January 28, 1989

CHECKED BY JPB

OFFICE REPORT ON SOIL EXPLORATION

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	* VALUES			20	40	60	80	100					
327.05	Ground Surface						327										
0.0	Silty sand, gravel, cobbles, organics, moist																
326.14	Loose, brown to black sand, gravel and cobbles, trace silt, moist to wat.		2	SS	87**		326										50 45 (5)
324.92	Dense, Brown chlorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some nickensided features, some chlorite and dis- continuous carbonate fracture coatings, some clayey fracture fillings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to ver- tical fracture.		3	SS	170/239mm		325										
			4	SS	100/200mm		324										
			5	SS	100/50mm		323										
			6	SS	100/16mm		322										
			7	SS	100/50mm		321										
			8	RC	REC												RQD=0Z
			9	RC	REC	45%											RQD=0Z
			10	RC	REC	79%											RQD=0Z
			11	RC	REC	100%											RQD=71Z
			12	RC	REC	100%											RQD=61Z
319.89	End of Borehole						320										



Fragmented Core

* For RC samples
numbers represent
Core Recovery in %

** SPT likely
influenced by
cobble

* 3, * 5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2										METRIC				
W P 195-88-02		LOCATION Sta. 21 + 726		S. Hwy. 560 Line 'A'		ORIGINATED BY PCM								
DIST 14 HWY 560		BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core				COMPILED BY PCM								
DATUM Geodetic		DATE January 29, 1989				CHECKED BY JAP								
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES*			20	40					
327.23	Ground Surface													
0.0	Silty sand, gravel, cobbles, organics, moist													
0.30	loose, brown to black silty sand, some gravel, moist		1	SS	9									
325.86	loose to compact, brown sandy gravel, some silt		2	SS	26									14 58 (28)
1.52	wet, dense Brown Diorite bedrock (minor andesite), gray, highly to moderately weathered weak to moderately strong, some slicken-sided fractures, some chlorite and carbonate fracture coatings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures.		3	RC NQ	REC 25%									RQD=11%
			4	RC NO	57%									RQD=0%
			5	RC NQ	92%									RQD=1%
			6	RC NO	100%									RQD=64%
			7	RC NO	100%									RQD=86%
			8	RC NQ	REC 100%									RQD=94%
320.85	Sound													
6.38	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



Fragmented Core
 Very Closely Broken and Fragmented Core

* For RC samples numbers represent Core Recovery in %

+3, x⁵: Numbers refer to Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3										METRIC			
W P 195-88-02		LOCATION Sta 21 + 728 o/s 4.8 m Lt. E. Hwy. 360 Line 'A'				ORIGINATED BY PCM							
DIST 14 HWY 360		BOREHOLE TYPE Hollow Stem Auger, NQ Rock Cover				COMPILED BY PCM							
DATUM Geodetic		DATE January 29, 30, 1989				CHECKED BY JAB							
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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20					
327.34	Ground Surface												
0.0	Boulders, cobbles, some sand, gravel, silt and organics, moist to wet												
325.41	Brown to black												
1.93	Diorite bedrock, (minor gabbro), gray, highly to moderately weathered, weak to moderately strong, some slicken-sided fractures, some chlorite and carbonate fracture coatings, numerous healed fractures. Fracture orientations range from sub-horizontal to vertical with a higher frequency of steeply dipping to vertical fractures		1	RC		REC							RQD=0%
			2	RC									RQD=0%
			3	NQ									RQD=0%
			4	NQ									RQD=0%
			5	NQ									RQD=0%
			6	NQ									RQD=0%
			7	RC									RQD=56%
			8	NQ									RQD=0%
			9	RC									RQD=0%
			10	NQ									RQD=40%
			11	NQ									RQD=16%
321.24	End of Borehole												
6.10													

 Fragmented Core
 Very Closely Broken and Fragmented Core
 * For RC samples numbers represent Core Recovery in %

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 195-88-02 LOCATION Sta. 21 + 696.3 o/s 4.4 m Lt. S Hwy. 560 Line 'A' ORIGINATED BY PCN
DIST 14 HWY 560 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY PCN
DATUM Geodetic DATE January 30, 1989 CHECKED BY JAB

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES *			20	40	60	80					
328.44	Ground Surface														
0.0	Sand, gravel, cobbles, some silt and organics, thin interlayers of fine sand, moist														
327.14	Loose to dense Brown	1	SS	114/254mm											
1.30	Diorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided fractures, some chlorite, silty and clayey fracture coatings, some clayey fracture fillings, numerous healed fractures. Fracture orientations range from sub-horizontal to vertical with a higher frequency of steeply dipping to vertical fractures	2	RC	REC											
		3	NQ	75%											
		4	NQ	100%											
		5	NQ	67%											
		6	RC	100%											
		7	RC	100%											
		8	RC	100%											
		9	RC	100%											
		10	RC	100%											
323.56		11	RC	100%											
4.88	End of Borehole														

Fragmented Core

Very Closely Broken and Fragmented Core

* For RC samples numbers represent Core Recovery in %



RECORD OF BOREHOLE No 5										METRIC			
W P 195-88-02		LOCATION Sta. 21 + 696.2 o/m 5.2 m Rt. & Hwy. 560 Line 'A'				ORIGINATED BY PCM							
DIST 14 HWY 560		BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core				COMPILED BY PCM							
DATUM Geodetic		DATE January 31, 1989				CHECKED BY JLB							
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			VALUES ²	20					
328.78	Ground Surface		1	SS	10								1 56 (43)
0.0	Fine sand, silt and organics, trace gravel, occasional cobbles, moist to wet.		2	SS	700%								
329.22			3	RC	92%								RQD=0%
0.56	Loose to compact Brown Diorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided fractures, some chertic, silty and clayey fracture coatings, some clayey fracture fillings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures		4	RC	100%								RQD=0%
			5	RC	100%								RQD=79%
			6	RC	100%								RQD=0%
			7	RC	100%								RQD=15%
			8	RC	100%								RQD=50%
324.69													
4.09	End of Borehole												

Fragmented Core

*For RC samples numbers represent Core Recovery in %

RECORD OF BOREHOLE No 6										METRIC		
W P 195-88-05		LOCATION Sta. 21 + 700 o/s 1.0 m Lt. G Hwy. 560 Line 'A'						ORIGINATED BY PCW				
DIST 14 HWY 560		BOREHOLE TYPE RQ Rock Core						COMPILED BY PCW				
DATUM Geodetic		DATE February 2, 1989						CHECKED BY JAB				
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	* VALUES					
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%)				
328.37	Ground Surface											
0.0	Fine sand, some gravel and organics, moist to wet		1	SS	7							29 49 (22)
0.48	Silty, gravelly sand		2	SS	138/254mm							RQD=0%
0.72	Cobbles and boulders, sand, gravel and fines		3	RC	REC							RQD=0%
			4	NQ	47%							RQD=0%
			4	NQ	57%							RQD=0%
326.54	Diorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided fractures, some chlorite fracture coatings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures.		5	RC	REC							RQD=0%
			6	NQ	100%							RQD=0%
			7	RC	REC							RQD=0%
			7	NQ	72%							RQD=0%
			8	RC	REC							RQD=0%
			8	NQ	48%							RQD=0%
			9	RC	REC							RQD=0%
			9	NQ	91%							RQD=0%
			10	RC	REC							RQD=45%
			10	NQ	100%							RQD=0%
			11	RC	REC							RQD=0%
			11	NQ	100%							RQD=0%
	Very closely to closely jointed		12	RC	REC							RQD=0%
			12	NQ	100%							RQD=0%
322.61	End of Borehole											
5.74												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 195-88-02 LOCATION Sta. 21 + 754 o/s 0.5 m Rt. 6 Hwy. 560 Line 'A' ORIGINATED BY PCM
DIST 14 HWY 560 BOREHOLE TYPE NQ Rock Core COMPILED BY PCM
DATUM Geodetic DATE February 4, 1989 CHECKED BY VCE

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
341.92	Ground Surface															
0.0	Silt, some clay, trace sand and gravel, organics, wet, brown		1	CS												
341.44																
0.46																
	Diorite bedrock, gray, highly to moderately weathered, moderately weak to strong, some slickensided fractures, some chlorite, carbonate and silty clay fracture coatings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures, moderately closely jointed.		2	RC NQ	REC 100%	5/2/89	341									RQD=74%
			3	RC NQ	REC 100%		340									RQD=100%
			4	RC NQ	REC 100%		339									RQD=56%
			5	RC NQ	REC 100%		338									RQD=100%
			6	RC NQ	REC 100%		337									RQD=57%
			7	RC NQ	REC 100%		336									RQD=90%
	Sound		8	RC NQ	REC 100%		335									RQD=100%
			9	RC NQ	REC 100%		334									RQD=95%
			10	RC NQ	REC 100%		333									RQD=85%
			11	RC NQ	REC 100%		332									RQD=100%
331.42			12	RC NQ	REC 100%											
10.5	End of Borehole															

Fragmented Core

* For RC samples numbers represent Core Recovery in %

+3, x5: Numbers refer to Sensitivity

20
15 - 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 195-88-02 LOCATION Sta. 21 + 782.4 o/s 2.0 m Rt. 8 Hwy. 560 Line 'A' ORIGINATED BY PCM
 DIST 14 HWY 560 BOREHOLE TYPE NO Rock Core COMPILED BY PCM
 DATUM Geodetic DATE February 5, 1989 CHECKED BY JAS

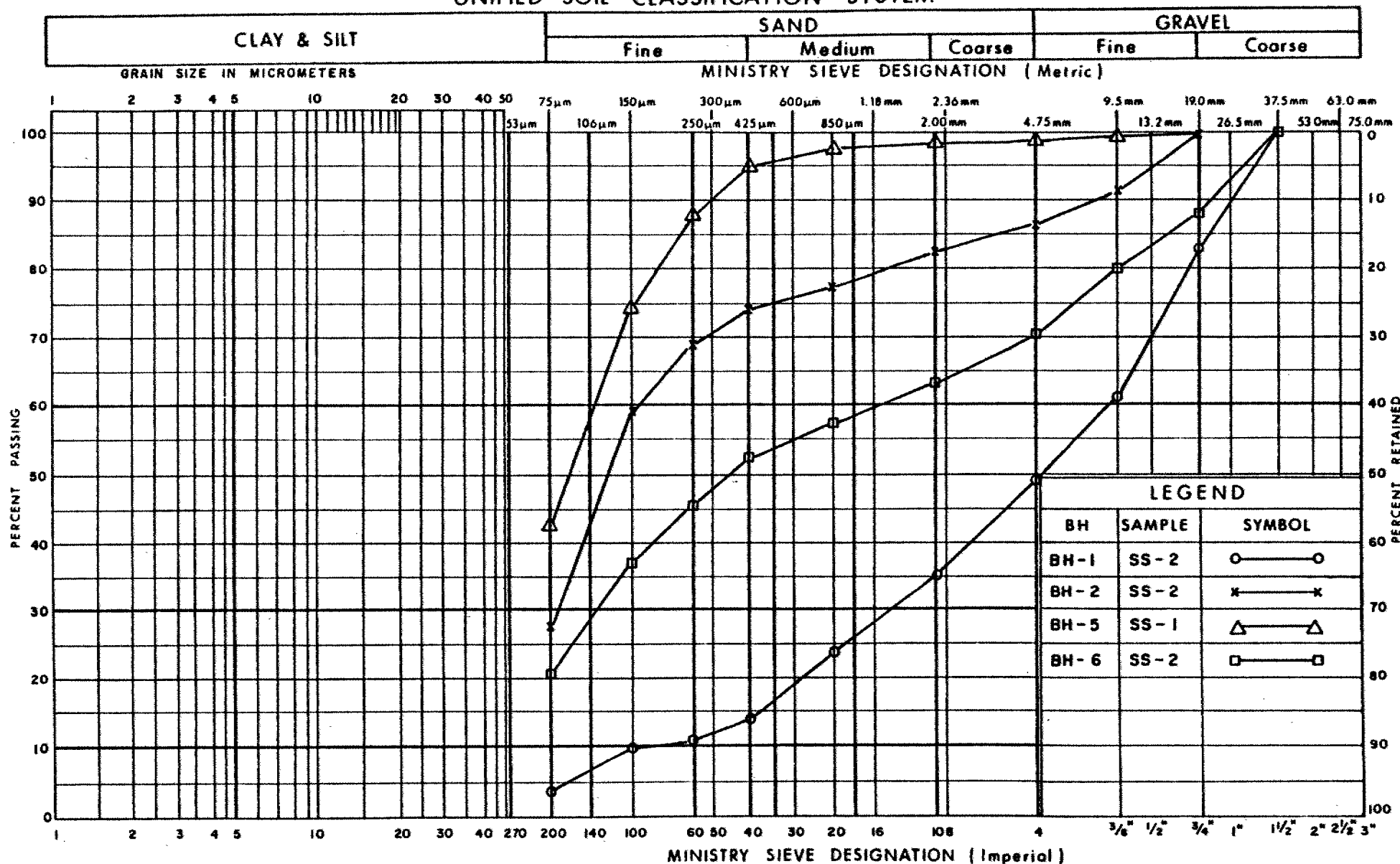
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES*		20	40	60	80	100					
037.98	Ground Surface															GR SA SI CL
037.78 0.20	Organics, silt, sand, gravel, cobbles					5/2/89										
	Black to brown Diorite bedrock, gray, highly to moderately weathered, moderately weak to moderately strong, some organic and clay filled frac- tures, some chloritic and clayey fracture coatings, minor carbo- nate fracture coatings, numerous healed frac- tures.		1	RC NQ	REC 86%											RQD=0%
			2	RC NQ	REC 100%	337										RQD=15%
			3	RC NQ	REC 94%	336										RQD=58%
	closely jointed closely to moderately closely jointed		4	RC NQ	REC 83%	335										RQD=69%
034.76 3.22	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

Fragmented Core

*For RC samples
numbers represent
Core Recovery in %

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

**GRAIN SIZE DISTRIBUTION
MATRIX SAMPLES FROM THE MIXTURE OF
SAND, GRAVEL, COBBLES, BOULDERS AND SILT**

FIG No I

W P 195-88-02

MINISTRY OF TRANSPORTATION
PROVINCE OF ONTARIO

FOUNDATION INVESTIGATION
FOR BRIDGE STRUCTURE

WAPUS CREEK AND HWY 560
DISTRICT #14 NEW LISKEARD
W.P. 201-88-02, SITE 47-40
195-88-02

CONT 90-454

March 1989

GEOCRES # 4IP-17

Acres International Limited
Niagara Falls, Ontario

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FIGURE

EXPLANATION OF TERMS USED IN REPORT

RECORD OF BOREHOLES

DRAWING NO. 2018802-A

LIST OF FIGURES

<u>Number</u>	<u>Title</u>
1	Grain Size Distribution - Matrix Samples from the Mixture of Sand, Gravel, Cobbles, Boulders and Silt

1 - INTRODUCTION

Acres International Limited (Acres) was retained by the Ministry of Transportation of Ontario (MTO) to undertake a foundation investigation for a proposed bridge structure at the crossing of Wapus Creek and Highway 560, District #14 New Liskeard, W.P. 201-88-02, Site 47-40. The work was authorized by Agreement 4238-9088-237 dated November 14, 1988.

The location, site plan and section of the proposed bridge are shown on MTO Plan E-1025-560-1.

Drilling and sampling operations were performed by Longyear Canada Inc. under the full-time supervision and direction of Mr. Philip C. Miles, an Acres geotechnical engineer. Fieldwork commenced on January 28, 1989 and was completed February 5, 1989. A plan of the site, showing the borehole locations and stratigraphic profiles, is shown on Drawing No. 2018802-A.

All soil samples and bedrock core were returned to Acres geotechnical laboratory in Niagara Falls for detailed examination, logging and testing.

The results of the field and laboratory investigations are presented in this report, together with an interpretation of the data obtained and recommendations concerning the geotechnical aspects of the design and construction of the proposed bridge.

2 - EXPLORATORY WORK

The exploratory work at Wapus Creek consisted of 8 boreholes drilled to depths ranging from 3.2 m to 10.5 m in both overburden and bedrock, and located as shown on Drawing No. 2018802-A. A total of 10.0 m of overburden and 38.1 m of bedrock were drilled. Drilling was performed using a track-mounted CME75 drill equipped with hollow stem augers and an NQ wireline core barrel.

Access to all boreholes from existing Highway 560 was provided by a small bulldozer owned and operated by Gunter Contracting Ltd. Borehole sites were leveled which effectively removed the snow cover, surface boulders and some of the organic rich topsoil layer. The site was covered with up to 0.7 m of snow prior to clearing by the bulldozer. Temperatures ranged from approximately 0°C to -40°C during the investigations.

Boreholes 1 to 6 were drilled to determine subsurface conditions at the proposed bridge abutment locations. Three boreholes were located on each side of Wapus Creek. Boreholes 7 and 8, at the top of and partway down the rock ridge immediately to the east of Wapus Creek were drilled to determine the overburden and bedrock conditions along the proposed approach rock cut. The holes were advanced through overburden using hollow stem augers and attempts were made to sample it at intervals of 0.6 m or less, using a 51-mm O.D. split barrel sampler in accordance with the Standard Penetration Test procedure. Coring of bedrock, using an NQ double tube wireline core barrel, was carried out through the hollow stem augers or NW casing drilled and seated into bedrock.

Borehole locations (chainages, offsets and ground surface elevations) were surveyed by the MTO. Table 1 summarizes the physical data for each borehole.

TABLE 1SUMMARY OF BOREHOLE PHYSICAL DATA

<u>Borehole Number</u>	<u>Ground</u>		<u>Offset</u> [*] (m)	<u>Overburden/Bedrock Contact</u>		<u>Bottom of Borehole</u>	
	<u>Surface Elevation</u> (m)	<u>Centerline Chainage</u> (m)		<u>Depth</u> (m)	<u>Elevation</u> (m)	<u>Depth</u> (m)	<u>Elevation</u> (m)
1	327.05	21+728	4.8R	2.13	324.92	7.16	319.89
2	327.23	21+726	0	1.52	325.71	6.38	320.85
3	327.34	21+728	4.8L	1.93	325.41	6.10	321.24
4	328.44	21+696.3	4.4L	1.30	327.14	4.88	323.56
5	328.78	21+696.2	5.2R	0.56	328.22	4.09	324.69
6	328.37	21+700	1.0L	1.83	326.54	5.74	322.63
7	341.92	21+754	0.5R	0.48	341.44	10.5	331.42
8	337.98	21+782.4	2.0R	0.20	337.78	<u>3.22</u>	334.76
Total Depth Drilled						48.07	

*R = right

L = left

All soil and rock samples were returned to Acres geotechnical laboratory for more detailed logging and testing. Due to its granular nature, only grain size analyses were performed on four selected overburden samples. The results of these tests are shown in Figure 1.

Piezometers were not installed in any of the boreholes. However, observations of water levels in boreholes were made on completion and up to 2 days after the drilling of each hole.

Records for each of the boreholes, summarizing all the field and laboratory data, are presented following the report text.

3 - SITE CONDITIONS

3.1 - General

The proposed Highway 560 realignment at Wapus Creek is located approximately 35 m north of the existing highway and runs roughly parallel to it in an east-west direction. The location of the proposed bridge site is shown on the key plan on Drawing No. 2018802-A.

Wapus Creek flows in a northerly direction through hilly terrain controlled by ridges of Precambrian bedrock. Topographic relief in the immediate area of the site is in the order of 20 m. Bedrock is exposed in rock cuts along the existing road alignment at Wapus Creek and also outcrops a short distance to the east and west of the creek, along the proposed realignment. A high bedrock ridge exists almost immediately to the east of the creek. Topographic lows are generally wet with numerous lakes and swamps present in the area.

3.2 - Soil Conditions

Overburden, in the form of talus, alluvium and completely weathered bedrock, is present on both sides of the creek in the area of the site investigations. The maximum depth to bedrock on the east side of the creek was found to be approximately 2.1 m in BH-1, and on the west side 1.8 m in BH-6.

On the east side of the river, the overburden is generally a sand and gravel with varying amounts of silt, cobbles and boulders and some sand layers. A reliable estimate of the density of these materials, using the Standard Penetration Test, was not possible due to the presence of numerous large particles.

In BH-1 and BH-2, the upper zone, is a collection of relatively loose, brown to black, silty sand, gravel and cobbles extending to depths of

0.91 m and 0.3 m, respectively. Organics are present in the upper 0.3 m, however, some of this material, up to about 0.2 m, may have been removed during the site preparation and leveling operations. In BH-1 this material is underlain by moist to wet, relatively dense gravel and cobbles with a trace of silt varying in color from grayish brown at the top to reddish brown at the bedrock surface, at a depth of approximately 2.1 m. The bedrock surface at BH-1 is completely weathered becoming less weathered with depth. Small granular samples were recovered with the split spoon down to a depth of 4.0 m. Many fragments from overburden sample SS3, just above the bedrock surface, consisted of completely weathered bedrock and could be easily crushed between the fingers.

In BH-2, the upper zone is underlain by a 1-m thick layer of moist, loose to compact silty sand with some gravel which grades in color from brown to reddish brown. This overlies a 0.15-m thick layer of a wet, dense, brown, sandy gravel on the bedrock surface at a depth of 1.52 m.

At BH-3, the overburden appears to contain more boulders and cobbles in a brown to black silt, sand, gravel and organic matrix down to bedrock at a depth of 1.93 m.

Overburden conditions on the west side of the river are similar to those on the east. In BH-4 and BH-5 the material consists of a brown to reddish-brown sand (fine sand in BH-5) with varying amounts of silt, gravel, cobbles and organics. Bedrock in BH-4 and BH-5 was encountered at depths of 1.30 and 0.56 m, respectively.

In BH-6, the upper 0.7 m of overburden is a brown to reddish-brown, loose, fine sand with some gravel to silty, gravelly sand. Beneath this, however, is a 1.1-m thick zone of cobbles and boulders in a matrix believed to consist of silt, sand and gravel. This extends to bedrock at a depth of 1.83 m.

In general, the gravel, cobbles and boulders which were encountered were angular in shape and of the same lithology as the dioritic bedrock. Some andesite and quartzitic cobbles were also encountered during drilling in the overburden.

At BH-7 and BH-8, the overburden consisted of a thin mantle of brown silt, sand, gravel, cobbles and organics with a thickness up to approximately 0.5 m. A portion of the overburden in BH-7 was cohesive. The thickness of 0.5 m is believed to be representative of the depth to bedrock, along the proposed centerline on the eastern slope of the bedrock ridge, immediately east of Wapus Creek.

3.3 - Bedrock Conditions

Bedrock at the site consists of an overall grayish, coarse-grained altered diorite which was observed to grade into a darker gabbro or a fine-grained andesite on rare occasions. Rock strength, based on its reaction to drilling and observation of core samples, was judged to range from weak to strong. It was found to be highly to moderately weathered. A predominant feature of the bedrock is the presence of frequent planar to irregular, weakly cemented, healed fractures. These fractures, when broken, often show evidence of shear displacement or slickensiding, very thin chlorite or discontinuous carbonate coatings and, on occasion, silty, clayey coatings or fillings. These healed fractures frequently were steeply dipping to subvertical in orientation, although a wide variety of orientations were observed.

Bedrock encountered in Boreholes 1 to 6 was found to be of poorer quality than the rock drilled in BH-7 and BH-8 on top of the ridge to the east of the creek. In BH-1 the rock was penetrated with a split spoon sampler for short distances to approximately 2 m below its surface. The Rock Quality Designation (RQD) values for the rock core can be used to assess the quality of the rock mass. In this rock the RQD is most sensitive to the degree of weathering which has occurred in and around the numerous healed fractures which have been observed. The

term 'sound' rock has been used to describe rock where the RQD values are consistently greater than 75%.

In BH-1, BH-2 and BH-3, on the east side of the creek, RQD values indicate the rock quality ranges from very poor to excellent. Generally, however, the rock is very poor quality. RQD values of 0% were common in the rock down to depths of 4.0 to 5.5 m. Such very low RQD values were usually manifested in completely fragmented core with the rock fragment surfaces being black, chloritic, with some signs of slickensiding and frequently with a brown staining or a thin, brown, silty, clayey coating. Only in BH-2 was sound rock encountered where the quality of the rock improved to good to excellent, and this occurred below the depth of 4.5 m. Low RQD values were often associated with reduced core recovery and frequent blockage in the core barrel during drilling.

In BH-4, BH-5 and BH-6, on the west side of the creek, the rock was also found to be of very poor to fair quality. Again, RQD's as low as 0% were common. Apart from the single core run in BH-5, where the RQD rose to the good quality range, the rock core gives no significant indication that bedrock quality improves with depth down to about 5.75 m.

In BH-7, the rock was of fair to excellent quality. Based on the RQD values, sound rock was encountered at the depth of 6.25 m. Sound rock was not penetrated in BH-8 as RQD values were consistently below 69% indicating the rock to be very poor to fair quality. BH-8 was limited to a depth of 3.22 m.

Natural open jointing in the rock core was often difficult to distinguish from fractures caused by the action of the core barrel during drilling. Numerous weakly-cemented, healed fractures were observed in the more solid pieces of core. Many of the healed fractures may have been broken during the drilling process. Fracture orientation ranged from subhorizontal to subvertical with all fractures having similar characteristics. Typically, they are smooth to rough and planar, with

fracture surfaces being black to dark green, and sometimes brown stained. Very thin fracture coatings (<1 mm) of chlorite, discontinuous carbonate or a brown silty clay were frequently observed. Fractures with a dip greater than approximately 35° frequently displayed signs of shear displacement or slickensiding, and occasionally contained a filling of brown silty clay, up to approximately 5 mm thick.

An examination of the more solid core pieces of BH-6, BH-7 and BH-8 indicates that joint spacing is variable, ranging from very close in BH-6 to close to moderately close in BH-8, and moderately close in BH-7 (for explanation of terms refer to sheet prefacing the Record of Boreholes).

Rock cuts, along the existing road at Wapus Creek, were, for the most part, snow covered at the time of the investigation. However, where exposed, they appeared to be controlled by jointing in the rock mass and no remnant blast hole traces could be observed. Two subvertical joint sets were observed, one striking northwest-southeast, and the other striking northeast-southwest. Other joint sets, particularly a subhorizontal set, are also likely to be present in the rock mass but were not observed because of the limited rock face exposures.

Rock core from BH-1 to BH-6 was noticeably more broken and fragmented than core from BH-7 and BH-8. This may indicate that the rock in the valley, through which the Wapus Creek flows, has been weakened by shear deformation (faulting) sometime during its geologic history.

3.4 - Groundwater Conditions

The water level in Wapus Creek, at the time of the investigation, was not determined by survey; however, it is believed to have been close to the 325.5-m elevation recorded on September 27, 1988 by the MTO.

Water levels were observed in all boreholes, following and up to 2 days after completion of their drilling, except for BH-6 where no water level could be seen. Borehole piezometers were not installed.

In BH-1, BH-2 and BH-3, on the east side of the creek, water levels were within the overburden and in the order of 0.9 m above the creek water level.

In BH-5, on the west side of the creek, the water level was found to be below the bedrock surface and approximately 1 m above the creek water level. The water level remained high in BH-4 (0.3 m below ground surface) following drilling.

In BH-7 and BH-8, in the rock ridge to the east of Wapus Creek, water levels following drilling were found to be 1.2 m and 0.4 m below ground surface, respectively.

These water levels can be considered as approximate only as the duration of observation was relatively short and drill water may not have had sufficient time to stabilize with the natural groundwater level.

4 - GEOTECHNICAL DESIGN AND CONSTRUCTION CONSIDERATIONS

4.1 - General

In summary, the foundation conditions in the vicinity of the proposed bridge abutments consist of approximately 1 to 2 m of essentially granular materials, ranging from boulders down to silt sizes overlying bedrock. The bedrock is a weathered diorite containing frequent, weakly-cemented, healed fractures. Within the significant depth of the bridge abutments, the quality of the rock, as defined by the RQD, would be classified as very poor to fair, with the major portion being in the very poor category.

Groundwater levels measured during the investigation period were within the overburden materials and about 0.5 to 1.0 m above the bedrock surface and the creek in the east abutment area. At the west abutment, the water level in two of the holes was within the bedrock while in the other hole (BH-4) it was relatively high and within the overburden.

4.2 - Bridge Abutments

4.2.1 - General

The proposed road grade is set at el 332.5 m and the span of the bridge, as proposed, is about 29 m. Water level observations by MTO in September 1988 indicated that the creek water level was at approximately el 325.5 m with the water depth being about 0.5 m.

The granular overburden, in general, at the proposed location of both abutments is a maximum of about 2 m deep. These granular materials are not considered to be a suitable foundation layer because of their variability in composition and density and potential erodibility.

It is, therefore, recommended that all granular overburden in the area of the abutments be removed and the proposed bridge abutments be founded on bedrock or over an improved subgrade. The bedrock is at about el 327 at the west abutment and approximately 2 m lower (el 325) at the east abutment.

4.2.2 - West Abutment

The foundation preparation at the west abutment is expected to be minimal. The bottom of the foundation can be set at el 327 m. This will involve excavation of all overburden in the abutment area and some minor rock excavation in the south-west portion. To provide a level bearing surface for setting up the formwork and rebar, some fill concrete will be required in the north-east area. Groundwater levels at the west abutment are probably above the creek level and, therefore, any groundwater seepage or flow can be drained by opening trenches directed towards the creek.

For the design of the base of the abutment, a factored bearing capacity of 1000 kPa at Ultimate Limit State is recommended. The bearing capacity at Serviceability Limit State will not govern the design since the anticipated settlements under the design pressures will be minimal, that is, less than 25 mm.

4.2.3 - East Abutment

In order to set the footings on bedrock at the east abutment, a number of options were considered. These options, in the order of preference, are as follows.

- Foundation on a fill concrete block.
- Foundation directly on bedrock.
- Foundation on an engineered fill.

All options involve the removal of the overburden in the area of the abutment and exposing the bedrock. The overburden should

also be removed behind the proposed abutment and the bedrock exposed up to the proposed deck level at about el 332.5 m. When excavating below creek level, some dewatering measures will be necessary to control flow into the excavations by creek water and any seepage from the high rock ridge. The dewatering will be simpler if the construction can be scheduled for a low flow period. Blanketing the creek bed and the east bank in the area of the abutment with relatively impervious materials, possibly from the nearby swamps, will reduce the flow of creek water into the excavations. In addition, provisions will be required for ditching, sumping and pumping to keep the excavation free from water.

Regardless of the option selected, the abutment foundations must be placed sufficiently deep below the finished ground surface or creek bank to protect against frost action. On the basis of a Freezing Index of 1750°C-days, the frost can penetrate in the range of 2.5 to 3.0 m depending on soil type. Since the material which will be placed around the abutments will be primarily granular, it is recommended that a frost penetration depth of 3.0 m be assumed in designing the protective cover.

4.2.3.1 - Foundation on a Fill Concrete Block

The abutment base can be set at el 327.0 by founding it on a fill concrete block placed on the bedrock surface at about el 325 m. The base of the abutment should be anchored to the fill concrete block by dowels and keys, as required, to prevent sliding along the interface. Using this option, the height of the abutment including the base can be made the same as the west abutment, approximately 5.5 m, thereby simplifying formwork and reinforcing.

A factored bearing capacity of 1000 kPa at Ultimate Limit State is recommended for the design of the base of the abutment and sizing of fill concrete block. The bearing capacity at Service-

ability Limit State will not govern the design, since the anticipated settlements under the design pressures will be minimal, less than 25 mm.

4.2.3.2 - Foundation Directly on Bedrock

Setting the abutment base directly on bedrock can be achieved in two ways. It can be set on the bedrock at approximately el 325 m centered about 15 m east of the creek centerline or it can be moved further east until the bedrock is encountered at the desired founding level.

Constructing the foundation at the former location, at about el 325 m, increases the height of the retaining wall to about 7.5 m. The abutment will be subjected to additional backfill pressures due to increased height.

In setting the foundation at the same level as the west abutment, el 327, it will be necessary to relocate the footing in the order to 7 to 8 m to the east. Such a change will correspondingly increase the bridge span and the associated cost of the superstructure. The dewatering requirement for this option will be minimal as outlined for the west abutment since the excavation grade will be above the creek bed.

Both the above options are technically feasible and the choice between them would probably be governed by economics and scheduling of work.

For the design of the footings on bedrock, a factored bearing capacity of 1000 kPa at Ultimate Limit State is recommended. The bearing capacity at Serviceability Limit State will not govern the design since the anticipated settlements under the design pressures are expected to be small, that is, less than 25 mm.

4.2.3.3 - Foundation on an Engineered Fill

This option is similar to the foundation on the fill concrete block, except that the fill concrete block is replaced with a compacted granular fill which must be considered as part of the foundation. Extreme care must be exercised in its placement. The fill material would be MTO Granular A which would be spread and compacted in continuous, horizontal layers. Each layer would have a loose thickness not greater than 150 mm before compaction and would be compacted by repeated passes of a smooth, steel drum, vibratory roller having sufficient weight to compact the full layer thickness. The number of passes would be such as to achieve a minimum dry density of at least 95% of the maximum dry density as determined by ASTM Test Designation D1557.

Excavation to el 325 will be required to expose the bedrock and effective dewatering measures will be necessary throughout the period of fill placement. The engineered fill must be protected against possible erosion from flow in the creek and the roadside ditches. The surface of the compacted fill zone should extend at least 1.5 m beyond the concrete abutment base at the concrete level and extend down to bedrock within the zone defined by a line sloping down at an angle of 45° from the crest of the granular berm.

As mentioned in subsection 4.2.3, this granular fill pad must be covered by about 3.0 m of fill to prevent frost penetrating into the foundation area.

There is a potential for differential settlement between the two abutments where one is founded directly on bedrock and the other on fill; however, its magnitude should be very small.

The capacity of the foundation is governed by the density of the fill and the level to which the fill will be submerged under maximum flood conditions.

A factored bearing capacity of 500 kPa at the Ultimate Limit State is recommended for the design of the abutment base over an engineered fill. The capacity at the Serviceability Limit State should be assumed as 250 kPa.

While this option is technically feasible, its satisfactory long-term performance is dependent on careful control of the fill placement operation and the design of proper filters and erosion protection layers. Adoption of this arrangement can only be recommended if the above design and construction details can be assured.

4.2.4 - Lateral Earth Pressures

For all options considered, with the exception of the foundation on an engineered fill, the abutment walls should be designed to support the at-rest earth pressure, since the bedrock foundation is considered to be unyielding.

For the foundation on an engineered fill, the abutment can be designed for the active earth pressure on the condition that the abutment is free to rotate or deflect at the top, a distance equal to 0.2% of the of the abutment height.

Free-draining, granular material conforming to MTO Granular A should be used for backfill behind the abutment. The following properties may be used for design.

- Unit weight - 22 kN/m^3 .
- Angle of internal friction - 35° .

The extent of the Granular A backfill behind the abutment should be at least equivalent to the triangular wedge defined by a line rising from the toe of the base of the abutment at an angle of 45° .

4.2.5 - Sliding Stability

With regard to the sliding stability of the abutments, it is recommended that a sliding friction angle of 25° be assumed for the contact between rock and concrete or granular fill and concrete. This angle represents the ultimate sliding resistance and must, therefore, be factored to provide an adequate margin of safety.

4.3 - Approach Cuts and Fills

4.3.1 - East Approach Cut

A rock cut, up to approximately 10 m deep, will be required to bring the highway alignment through the rock ridge to the east of the proposed bridge location. Boreholes 7 and 8 indicate the cut will be in a highly to moderately weathered, weak to moderately strong, medium- to coarse-grained diorite with numerous variably oriented healed fractures. A predominance of steeply dipping to subvertical fractures was noted. An upper weakened zone, with RQD values ranging from very poor to excellent, was observed to exist in BH-7 and BH-8 down to a depth of 6.3 m. Below this depth the rock in BH-7 was found to be of excellent quality. BH-8 was limited to a depth of only 3.2 m. In the upper weakened zone, blasted rock cuts will show significant overbreak.

Exposed faces of relatively shallow rock cuts existing along Highway 560 at Wapus Creek are controlled by jointing in the rock mass and this is also expected to be the case for the cuts on the new alignment. Joint spacing, as observed in the drill core, ranged from close to moderately close in BH-8 to moderately close in BH-7, indicating that the rock is less jointed at depth. Therefore, below the upper weakened zone, jointing is expected to exercise less control over the blasted rock surface.

As outlined in Section 3.3, two subvertical joint sets were observed in the largely snow covered rock cuts along the existing highway. One set had a strike northeast-southwest and the other northwest-southeast. Based on observations of the drill core, other less prominent sets, including subvertical to subhorizontal sets, are also likely to be present.

The highway alignment at Wapus Creek trends generally east-west which is oblique to the subvertical joint sets noted above. The presence of these sets in a blasted rock cut will likely result in a somewhat saw-toothed face. Regarding the design of the rock cuts, vertical slopes would be suitable, realizing that the 'as-built' slope will be flattened in the upper weakened zone, as all loose and unstable blocks are removed, and that only the bottom several meters will remain vertical or near vertical. As is normal practice, all loose rock should be scaled from the rock face as part of the initial construction and a ditch, sufficiently wide to retain all rock fragments which may fall from the slope over the long term, should be constructed.

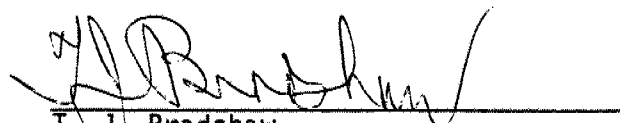
4.3.2 - Fill on West Approach

The west approach area is covered by trees and organic topsoil, the latter being approximately 0.3 m thick. It is anticipated that the granular surficial deposits encountered in the abutment area extend to the west towards a low bedrock ridge which traverses the road centerline approximately 30 m to the west.

In preparation for the embankment fill placement, the topsoil should be removed and the tree stumps grubbed. The stability of the embankment fill should present no problems with side slopes as steep as 1.5H:1V in rockfill and 2.0H:1V for random granular fill. A portion of the rock blasted from the cut on the east approach should provide suitable fill for the bulk of the west approach embankment.

Immediately adjacent to the abutment, a zone of Granular A material, as outlined in Section 4.2.4, should be placed and compacted in layers in accordance with MTO standard practice. A transition zone of fill should be placed between the random rockfill in the embankment and the Granular A to ensure the latter material does not migrate into the rockfill. A similar zone may also be required below the road surfacing and rockfill.




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Geotechnical Department

FIGURE

FIG No 1



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 473 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	P S	FOIL SAMPLE

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

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_f	kPa	REMOULDED SHEAR STRENGTH
S_f	1	SENSITIVITY = $\frac{c_u}{\tau_f}$

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 = $\frac{w - w_p}{I_p}$	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						

Explanation of Terms Used in Report - 2

Rock Weathering

- Fresh - No discoloration or loss of strength.
- Slightly Weathered - Some discoloration on discontinuities, no loss of strength.
- Moderately Weathered - Rock is discolored, discontinuities may be open, alteration starting to penetrate, rock is weaker than the fresh rock.
- Highly Weathered - Rock is discolored, discontinuities may be open, alteration penetrates deeply, loss of strength.
- Completely Weathered - Rock is discolored, completely altered but original fabric is preserved. A few core stones may be present. Properties still partly dependent on parent rock.
- Residual Soil - Rock is completely changed to a soil in which original fabric is absent. There is a large change in volume.

Rock Strength

	<u>Unconfined Compressive Strength</u>	
	<u>MPa</u>	<u>lb/in.</u>
Extremely strong	>200	>29000
Very strong	100 - 200	14500 - 29000
Strong	50 - 100	7750 - 14500
Moderately strong	12.5 - 50	1800 - 7750
Moderately weak	5 - 12.5	725 - 1800
Weak	1.25 - 5	180 - 725
Very weak	<1.25	<180

Fragmented Core - Fractured core where the average fracture spacing is less than 25 mm and the core pieces are less than full core diameter.

Very Closely Broken Core - Fracture core where the average fracture spacing is less than or equal to 50 mm and the core pieces are full core diameter.

Rock Soundness - The term 'sound rock' has been applied where RQD values are consistently greater than 75%.

RECORD OF BOREHOLES

RECORD OF BOREHOLE No 1

METRIC

W P 201-88-02 LOCATION Sta. 21 + 728 o/s 4.8 m Rt. & Hwy. 560 Line 'A' ORIGINATED BY PCM
 DIST 14 HWY 560 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY PCM
 DATUM Geodetic DATE January 28, 1989 CHECKED BY NHB

OFFICE REPORT ON SOIL EXPLORATION

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	* 'N' VALUES			20	40	60	80	100					
327.05	Ground Surface																
0.0	Silty sand, gravel, cobbles, organics, moist						327										
326.14	Loose Brown to black						326										
0.9	Sand, gravel and cobbles, trace silt. moist to wet.		2	SS	87**												50 45 (5)
324.92	Dense Brown		3	SS	170/239mm		325										
2.13	Marlstone bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided features, some chlorite and discontinuous carbonate fracture coatings, some clayey fracture fillings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fracture.		4	SS	100/80mm												
			5	SS	100/50mm		324										
			6	SS	100/60mm												
			7	SS	100/50mm		323										
			8	RC	REC												RQD=0%
			9	RC	REC		322										RQD=0%
			10	RC	REC												RQD=0%
			11	RC	REC		321										RQD=71%
			12	RC	REC												RQD=61%
319.89	End of Borehole						320										



Fragmented Core
 * For RC samples numbers represent Core Recovery in %
 ** SPT likely influenced by cobble

RECORD OF BOREHOLE No 2

METRIC

W P 201-88-02 LOCATION Sta. 21 + 726 6 Hwy. 560 Line 'A' ORIGINATED BY PCM
 DIST 14 HWY 560 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY PCM
 DATUM Geodetic DATE January 29, 1989 CHECKED BY JAP

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			20	40	60	80	100					
327.23	Ground Surface																
0.0	Silty sand, gravel, cobbles, organics, moist																
0.30	loose, brown to black silty sand, some gravel, moist		1	SS	9												
325.86	loose to compact Brown		2	SS	26												14 58 (28)
1.3	Sandy gravel, some silt																
1.52	wet, dense Brown																
	Diorite bedrock (minor andesite), gray, highly to moderately weathered, weak to moderately strong, some slicken-sided fractures, some chlorite and carbonate fracture coatings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures.		3	RC NQ	REC 25%												RQD=11%
			4	RC NQ	57%												RQD=0%
			5	RC NQ	92%												RQD=0%
			6	RC NQ	100%												RQD=64%
			7	RC NQ	100%												RQD=86%
	Sound		8	RC NQ	REC 100%												RQD=94%
320.85																	
6.38	End of Borehole																

 Fragmented Core
 Very Closely Broken and Fragmented Core

* For RC samples numbers represent Core Recovery in %

RECORD OF BOREHOLE No 3

METRIC

W P 201-88-02 LOCATION Sta 21 + 728 o/s 4.8 m Lt. & Hwy. 560 Line 'A' ORIGINATED BY PCM
DIST 14 HWY 560 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Cover COMPILED BY PCM
DATUM Geodetic DATE January 29, 30, 1989 CHECKED BY JAB

OFFICE REPORT ON SOIL EXPLORATION

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	* VALUES			20	40	60	80	100				
327.34	Ground Surface															GR SA SI CL
0.0	Boulders, cobbles, some sand, gravel, silt and organics, moist to wet															
					REC											RQD=0%
			1	RC	0%											RQD=0%
			2	RC	35%											RQD=0%
325.41	Brown to black		3	RC	6%											RQD=0%
1.93	Diorite bedrock, (minor gabbro), gray, highly to moderately weathered, weak to moderately strong, some slicken-sided fractures, some chlorite and carbonate fracture coatings, numerous healed fractures. Fracture orientations range from sub-horizontal to vertical with a higher frequency of steeply dipping to vertical fractures		4	RC	69%											RQD=0%
			5	WS												RQD=0%
			6	RC	100%											RQD=0%
			7	RC	100%											RQD=56%
			8	RC	100%											RQD=0%
			9	RC	100%											RQD=0%
			10	RC	100%											RQD=40%
			11	RC	100%											RQD=16%
321.24	End of Borehole															
6.10																

Fragmented Core

Very Closely
Broken and
Fragmented Core

* For RC samples
numbers represent
Core Recovery in %

RECORD OF BOREHOLE No 4

METRIC

W P 201-88-02 LOCATION Sta. 21 + 696.3 o/s 4.4 m Lt. & Hwy. 560 Line 'A' ORIGINATED BY PCM
 DIST 14 HWY 560 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY PCM
 DATUM Geodetic DATE January 30, 1989 CHECKED BY JLB

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	* VALUES			20	40	60	80	100					
328.44	Ground Surface																GR SA SI CL
0.0	Sand, gravel, cobbles, some silt and organics, thin interlayers of fine sand, moist						328										
327.14	Loose to dense Brown		1	SS	114/254mm												
1.30	Diorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided fractures, some chlorite, silty and clayey fracture coatings, some clayey fracture fillings, numerous healed fractures. Fracture orientations range from sub-horizontal to vertical with a higher frequency of steeply dipping to vertical fractures		2	RC NQ	REC. 75%		327										RQD=0%
			3	RC NQ	51%												RQD=0%
			5	RC NQ	67%												RQD=0%
			6	RC NQ	100%		326										RQD=0%
			7	RC NQ	100%												RQD=22%
			8	RC NQ	100%		325										RQD=50%
			9	RC NQ	100%												RQD=0%
			10	RC NQ	100%		324										RQD=64%
323.56			11	RC NQ	100%												RQD=0%
4.88	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

Fragmented Core
 Very Closely
 Broken and
 Fragmented Core

* For RC samples
 numbers represent
 Core Recovery in %

+3, x5: Numbers refer to
 Sensitivity

20
 15
 10
 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 201-88-02 LOCATION Sta. 21 + 696.2 o/s 5.2 m Rt. & Hwy. 560 Line 'A' ORIGINATED BY PCM
 DIST 14 HWY 560 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY PCM
 DATUM Geodetic DATE January 31, 1989 CHECKED BY JLB

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	* VALUES			20	40	60	80	100					
328.78	Ground Surface																GR SA SI CL
0.0	Fine sand, silt and organics, trace gravel, occasional cobble, moist to wet.		1	SS	10												1 56 (43)
328.22	Loose to compact Brown		2	SS	7000												RQD=0%
0.56	Diorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided fractures, some chertic, silty and clayey fracture coatings, some clayey fracture fillings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures		3	RC	REC 92%		328										RQD=0%
			4	RC	REC 100%												RQD=0%
			5	RC	REC 100%		327										RQD=79%
			6	RC	REC 100%												RQD=0%
			7	RC	REC 100%		326										RQD=15%
			8	RC	REC 100%		325										RQD=50%
324.69	End of Borehole																
4.09																	

OFFICE REPORT ON SOIL EXPLORATION



Fragmented Core

*For RC samples numbers represent Core Recovery in %

RECORD OF BOREHOLE No 6

METRIC

W P 201-88-02 LOCATION Sta. 21 + 700 o/s 1.0 m Lt. G Hwy. 560 Line 'A' ORIGINATED BY PCW
 DIST 14 HWY 560 BOREHOLE TYPE RQ Rock Core COMPILED BY PCW
 DATUM Geodetic DATE February 2, 1989 CHECKED BY JLB

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		20	40	60	80	100					
328.37	Ground Surface														GR SA SI CL
0.0	Fine sand, some gravel and organics, moist to wet		1	SS	7										
327.89	Loose Brown		2	SS	138/254mm										29 49 (22)
0.48	Silty, gravelly sand		3	RC	REC										RQD=0%
0.72	Compact Brown		4	NQ	47%										RQD=0%
	Cobbles and boulders, sand, gravel and fines		5	RC	REC										RQD=0%
326.54			6	NQ	57%										RQD=0%
1.83	Diorite bedrock, gray, highly to moderately weathered, weak to moderately strong, some slickensided fractures, some chlorite fracture coatings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures.		7	RC	REC										RQD=0%
			8	NQ	29%										RQD=0%
			9	RC	REC										RQD=0%
			10	NQ	72%										RQD=0%
			11	RC	REC										RQD=45%
			12	NQ	48%										RQD=0%
322.63	Very closely to closely jointed														RQD=0%
5.74	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

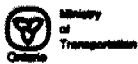
Fragmented Core

Very closely broken and fragmented core

* For RC samples numbers represent Core Recovery in %

+³, x⁵: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 7

METRIC

W P 201-88-02 LOCATION Sta. 21 + 754 o/s 0.5 m Rt. C Hwy. 560 Line 'A' ORIGINATED BY PCM
DIST 14 HWY 560 BOREHOLE TYPE NQ Rock Core COMPILED BY PCM
DATUM Geodetic DATE February 4, 1989 CHECKED BY VLR

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
341.92	Ground Surface													GR SA SI CL	
0.0	Silt, some clay, trace sand and gravel, organics wet, brown		1	CS											
341.44			2	RC NQ	REC 100%	5/2/89	341							RQD=74%	
0.48	Diorite bedrock, gray, highly to moderately weathered, moderately weak to strong, some slickensided fractures, some chlorite, carbonate and silty clay fracture coatings, numerous healed fractures. Fracture orientations range from subhorizontal to vertical with a higher frequency of steeply dipping to vertical fractures, moderately closely jointed.		3	RC NQ	REC 100%		340							RQD=100%	
			4	RC NQ	REC 100%		339							RQD=56%	
			5	RC NQ	REC 100%		338							RQD=100%	
			6	RC NQ	REC 100%		337							RQD=57%	
			7	RC NQ	REC 100%		336							RQD=90%	
	Sound		8	RC NQ	REC 100%		335							RQD=100%	
			9	RC NQ	REC 100%		334							RQD=95%	
			10	RC NQ	REC 100%		333							RQD=85%	
			11	RC NQ	REC 100%		332							RQD=100%	
331.42			12	RC NQ	REC 100%										
10.5	End of Borehole														

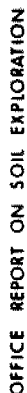
Fragmented Core

* For RC samples numbers represent Core Recovery in %

3, x 5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

**METRIC**

ORIGINATED BY PCM

COMPILED BY PCM

CHECKED BY WAS

+3, x5 : Numbers refer to Sensitivity

20
✦
10

DRAWING NO. 2018802-A

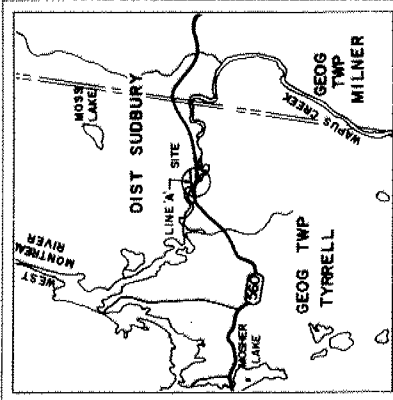
CONT No
WP No 201-88-02

WAPUS CREEK

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

ACRES INTERNATIONAL LIMITED



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation Jan, Feb. 1989
- 327.0 Contour defined by MTO
- 340.0 Contour interpreted by Acres based on MTO survey data

No	ELEVATION	CENTERLINE CHAINAGE	OFFSET
1	327.05	21+728	4.8 Rt
2	327.23	21+726	0
3	327.34	21+728	4.8 Lt
4	328.44	21+696.3	4.4 Lt
5	328.78	21+696.2	5.2 Rt
6	328.37	21+700	1.0 Lt
7	341.92	21+754	0.5 Rt
8	337.98	21+782.4	2.0 Rt

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specific to the project and is not to be used for any other project without the written consent of Acres International Limited.

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memorandum



To: P. Furst
Head, Structural Section
Northern Region
North Bay

Date: 1990 02 05

Attn: P. Stuart

From: Foundation Design Office
Room 315, Central Bldg.
Downsview

Re: Wapus Creek Structure
W.P. 195-88-02, Site: 47-1025-40
Hwy. 560, District 14, New Liskeard

We have reviewed Drawings #1 and #3 for the above project and no comments are offered.

A handwritten signature in dark ink, appearing to read "P. Payer", with a checkmark at the end.

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

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/jb

memorandum



Mr. G. Todd
To: Head, Planning & Design Section
Northern Region

Date: 90 01 03

Phone 1-705-472-7900
Ext. 286, 7

Attention: J. Hueston

FROM: Geotechnical Section
Northern Region

Addendum to Soils Design Report

WP 195-88-01
Hwy 560, From 16.1 km West
of Gowganda E'ly 8.1 km
District # 14, New Liskeard

Mr. R. Dufort informed us that some of the fills that are to be constructed with rock may be greater than 10 m in height. In the Preliminary Soils Recommendations, issued on 89 04 06, it was noted that rock fills greater than 10.0 m in height require a berm to provide stability.

If rock fills are constructed on this project to a height of 10.0 m or higher provide a 3.5 m wide berm constructed with rock fill material to one-half the height of the fill.

In some areas rock fill may be placed on top of SSM. If the fill material is changed from SSM on the lower part of the fill to rock on the upper part of the fill ensure that the top of the SSM fill is one (1) metre wider than the bottom of the rock fill material on both the left and the right.

Typical Drawings are attached to this memo to illustrate these recommendations.

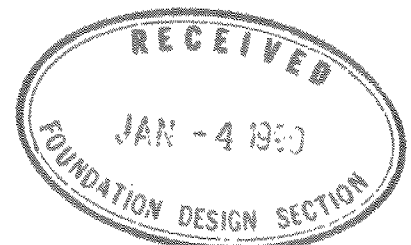
A handwritten signature in dark ink, appearing to read "E. V. Clinch".

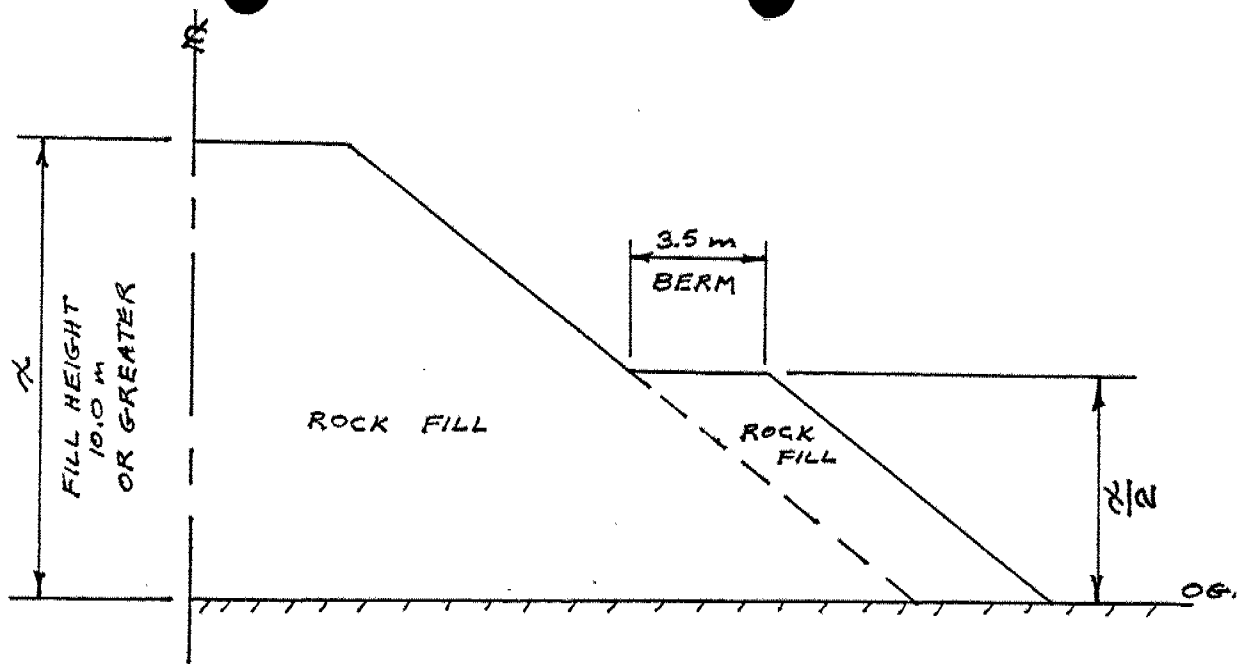
E. V. Clinch
Pavement Design &
Evaluation Officer

EVC/ap

Attach:

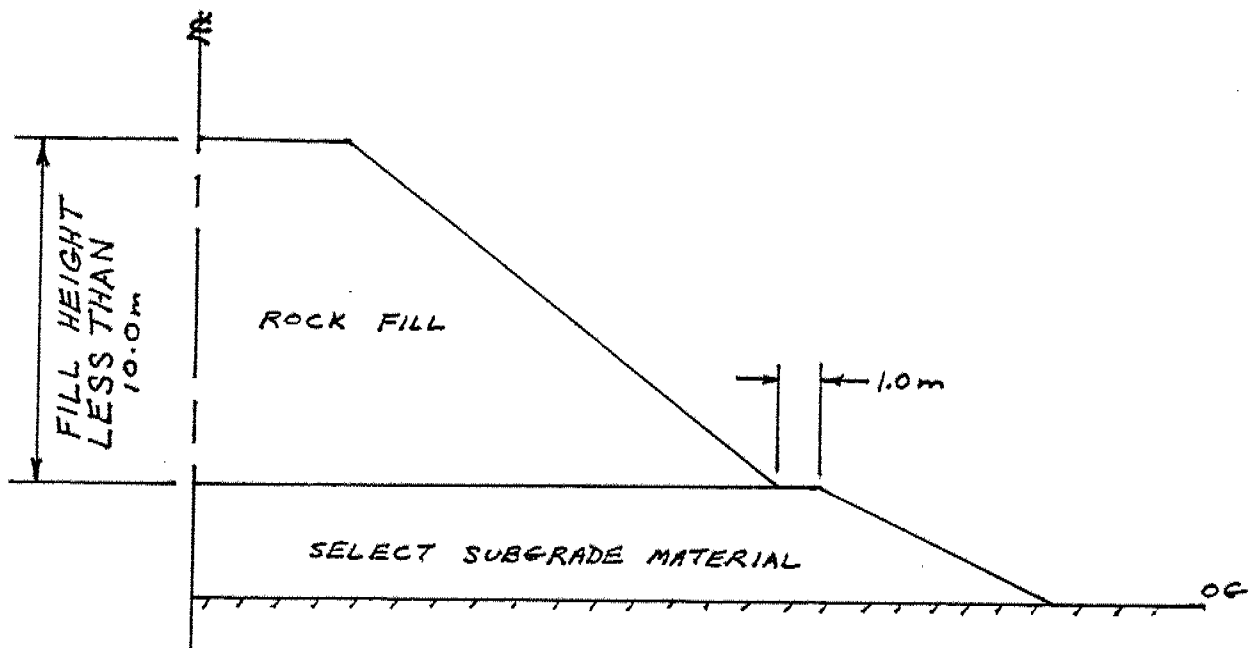
cc: B. Roberts
S. G. Wilson
J. Robertson
J. Curtis
R. S. Pillar
C. R. Watson
T. Kazmierowski
M. S. Devata
File (2)





BERM ON HIGH ROCK FILLS

(N.T.S.)



ROCK FILL PLACED ON SSM FILL

(N.T.S.)

memorandum



To: P. Stuart
Senior Structural Engineer
Structural Section
Northern Region
North Bay

Date: 1989 07 04

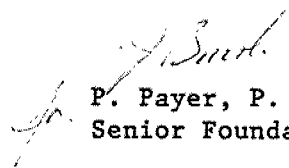
From: Foundation Design Section
Room 315, Central Bldg.
Downsview

RE: Review of General Arrangement Plan
Wapus Creek Bridge
W.P. 201-88-02, Site 47-1025-40
Hwy. 560, District 14 (New Liskeard)

We have reviewed Drawing No: P1 for the above structure and our comments are as follows:

- 1) The base of the footings should be anchored.
- 2) The topsoil should be removed and the tree stumps grubbed at the west approach location.

PP/jb


P. Payer, P. Eng.
Senior Foundation Engineer

memorandum



To: Mr. B. Farago,
Design Engineer,
DESIGN SECTION,
STRUCTURAL OFFICE,
3501 Dufferin St.,
DOWNSVIEW

Date: 89 05 15

STRUCTURAL SECTION,
NORTHERN REGION

WAPUS CREEK BRIDGE
W.P. 201-85-02.
SITE 47-1025-40
HIGHWAY 560
DISTRICT #14. NEW LISKEARD

Attached are 14 Prints of the General Arrangement Drawing 47-40-P1 for presentation to the preliminary review group.

The estimated cost of the proposed structure is \$430,000, which includes tender, materials, engineering and sundry construction.

Detailed design will be carried out by Giffels Associates Ltd.

A structure with an exposed concrete check was chosen for two reasons. First, Highway 560 will be left in a snow packed condition with only sand used to improve traction. Second, the reconstructed highway will be primed and surface treated. The only hot mix on the contract would be the asphalt on the bridge deck. A long haul over bad roads would therefore be required to bring asphalt to this isolated site. This would result in poor quality asphalt at a high price.

Vince Zebala
for P. Stuart,
Sr. Structural Engineer,
STRUCTURAL SECTION,
NORTHERN REGION
PS/fjMc

c.c. *L. Barton*
K. Bucci
B. Richardson
L. Reel
M. Halowka
G. Al-Bay
B. Farago
H. Jagasia
S. Aspinwall
P. Farago

