Specification

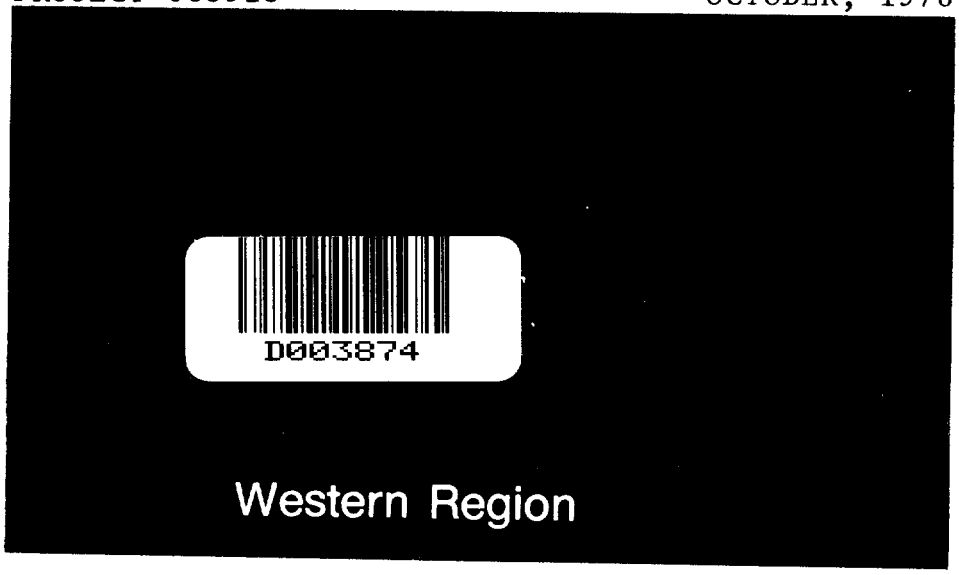
2 ✓

LIARD HIGHWAY

MILE 54.0 TO MILE 67.1

CLEARING AND INTERCEPTOR/OFFTAKE DITCHING

PROJECT 085913 OCTOBER, 1978



DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

NORTHERN OPERATIONS BRANCH

LAND USE PERMIT

PERMIT - Class A NUMBER N78E778

SUBJECT TO THE TERRITORIAL LAND USE REGULATIONS AND THE TERMS AND CONDITIONS IN THIS PERMIT, AUTHORITY IS HEREBY GRANTED TO:

PUBLIC WORKS CANADA
PERMITTEE

TO PROCEED WITH THE LAND USE OPERATION DESCRIBED IN THE APPLICATION OF:

FEBRUARY 1, 1978	F.F. KIMBALL
DATE	SIGNED BY
RIGHT-OF-WAY CLEARING MILE 21 - 66.5, LIARD HIGHWAY	LIARD HIGHWAY
TYPE OF LAND USE OPERATION	LOCATION

THIS PERMIT MAY BE ASSIGNED, EXTENDED, DISCONTINUED, SUSPENDED OR CANCELLED PURSUANT TO THE TERRITORIAL LAND USE REGULATIONS.

DATED AT YELLOWKNIFE, N.W.T.

THIS 3RD DAY OF MARCH, 1978

D Long
ENGINEER

MARCH 6, 1978	MARCH 6, 1980
COMMENCEMENT DATE	EXPIRY DATE

NOTE: THE GRANTING OF THIS PERMIT DOES NOT RELIEVE THE PERMITTEE FROM OBSERVING AND COMPLYING WITH ANY OTHER APPLICABLE ACTS, REGULATIONS, ORDINANCES, BY-LAWS OR ORDERS.

OPERATING CONDITIONS - PART I

The Operator DEPARTMENT OF PUBLIC WORKS - CANADA shall conduct the RIGHT-OF-WAY CLEARING MILE 21-66.5, LIARD HIGHWAY

Land Use Operation authorized by this Land Use Permit in accordance with the following operating conditions:

GENERAL CONDITIONS

1. THE OPERATOR SHALL ADHERE TO ALL APPLICABLE CONDITIONS STATED IN PART I (GENERAL) OF THE TERRITORIAL LAND USE REGULATIONS.

2. THE OPERATOR'S FIELD SUPERVISOR SHALL CONTACT THE FORT SIMPSON DISTRICT OFFICE OF THE NORTHWEST LANDS AND FOREST SERVICE PHONE NUMBER 695-2231 FORTY EIGHT HOURS PRIOR TO THE COMMENCEMENT OF THIS LAND USE OPERATION.

3. THE OPERATOR IS RESPONSIBLE FOR UNDERTAKING FOREST FIRE PREVENTION AND SUPPRESSION MEASURES, AS DIRECTED BY THE NORTHWEST LANDS AND FOREST SERVICE.

4. PRIOR APPROVAL SHALL BE OBTAINED THROUGH THE LAND USE INSPECTOR FOR PROPOSED CHANGES IN THE APPROVED PLAN OF OPERATIONS, CAMP LOCATIONS AND OTHER ASSOCIATED FACILITIES.

5. THE LAND USE PERMIT AND ANNEXED OPERATING CONDITIONS SHALL BE POSTED AT THE SITE OF OPERATIONS AND ALL PERSONNEL MADE FAMILIAR WITH THE CONTENTS AND INTENT.

6. INSTALLATION OF EROSION CONTROLS AND CLEANUP OF WASTE WILL BE CONTINUOUS AND KEEP PACE WITH PROJECT ACTIVITY.

7. NOTWITHSTANDING THE TERMINATION OF THE PERMIT, THE OBLIGATION OF THE OPERATOR WITH RESPECT TO CLEANUP AND RESTORATION DOES NOT CEASE UNTIL HE IS IN POSSESSION OF A LETTER OF CLEARANCE FROM THE HEAD, LAND USE SECTION, DIAND, YELLOWKNIFE, N.W.T.

FUEL STORAGE

8. PRIOR TO THE INSTALLATION OF FUEL STORAGE FACILITIES EXCEEDING 5,000 GALLONS THE OPERATOR WILL REQUIRE WRITTEN APPROVAL FROM THE HEAD, LAND USE SECTION, DIAND, YELLOWKNIFE, N.W.T.

9. FOR FUEL STORAGE FACILITIES OF 5,000 GALLONS OR LESS THE OPERATOR SHALL LOCATE AND PLACE FUEL STORAGE CONTAINERS SO THAT ANY SPILLED OR LEAKED FUEL WILL BE TOTALLY CONTAINED.

10. FUEL OUTLETS EXCEPTING THE OUTLET CURRENTLY IN USE SHALL BE SEALED TO PREVENT LEAKAGE.

11. THE LAND USE INSPECTOR WILL BE INFORMED OF THE LOCATION OF ALL FUEL CACHES.

12. ALL STATIONARY FUEL STORAGE FACILITIES SHALL BE CLEARLY MARKED WITH FLAGS OR POSTS SO THEY ARE PLAINLY VISIBLE, REGARDLESS OF SNOW COVER, WEATHER OR DAYLIGHT CONDITIONS.

WILDLIFE

13. THE OPERATOR SHALL NOT USE MACHINERY OR OTHERWISE CONDUCT THE OPERATION SO AS TO HARASS OR UNNECESSARILY DISTURB WILDLIFE OR DAMAGE WILDLIFE HABITAT.

14. THE OPERATOR SHALL COOPERATE AT ALL TIMES WITH GAME OFFICIALS TO PROTECT WILDLIFE AND WILDLIFE HABITAT.

15. (A) ALL FIREARMS SHALL BE UNDER THE CONTROL OF SUPERVISORS AND BE USED ONLY FOR PROTECTION.

(B) THE PRESENCE OF A WILD ANIMAL THAT MAY CREATE A HAZARD IS TO BE REPORTED IMMEDIATELY TO THE NEAREST GAME MANAGEMENT OFFICER OR R.C.M.P. DETACHMENT.

(C) THE FEEDING OF WILDLIFE IS PROHIBITED.

16. FOOD AND CAMP KITCHEN WASTE WILL BE HANDLED IN A MANNER TO AVOID ATTRACTING WILDLIFE.

17. HUNTING IS PROHIBITED FOR PERSONS EMPLOYED BY THE OPERATOR OR CONTRACTOR AND RESIDENT IN A PERMITTEE OR CONTRACTOR OPERATED CAMP (I.E. CAMPS WILL NOT BE USED AS A BASE FOR HUNTING).

VEHICLE TRAVEL

18. WINTER COMMENCEMENT AND SPRING SHUTDOWN DATES FOR OVERLAND VEHICLE MOVEMENT WILL BE DETERMINED BY THE HEAD, LAND USE SECTION, BASED ON LOCAL TERRAIN CONDITIONS.

19. WINTER ACCESS ROADS SHALL BE OF PACKED SNOW CONSTRUCTION.

20. IN ORDER TO MINIMIZE SURFACE DISTURBANCE, BULLDOZER BLADES WHEN USED OUTSIDE THE AREA OF CONSTRUCTION ACTIVITY SHALL BE ELEVATED A MINIMUM OF SIX INCHES ABOVE THE GROUND BY MUSHROOM-TYPE SHOES OR A SIMILAR DEVICE. REMOVAL MAY BE AUTHORIZED BY THE LAND USE INSPECTOR FOR SPECIAL PURPOSES.

21. THE OPERATOR SHALL PRESCOUT PROPOSED ROUTES AND LINES AND SHALL INDICATE WITH GROUND MARKERS THE MOST FAVORABLE LOCATIONS FOR CROSSING STREAMS OR AVOIDING TERRAIN OBSTACLES PRIOR TO MOVEMENT OF CRAWLER TRACTORS OR OTHER HEAVY VEHICLES.

22. SHOULD EXCESSIVE TERRAIN DAMAGE RESULT FROM VEHICLES, THEIR USE WILL BE LIMITED OR STOPPED BY THE LAND USE INSPECTOR.

ARCHAEOLOGICAL

23. (A) ARCHAEOLOGICAL FINDS MUST BE MADE KNOWN TO THE LAND USE INSPECTOR.

(B) IDENTIFIED ARCHAEOLOGICAL SITES MUST BE PROTECTED FROM DAMAGE OR INTERFERENCE.

ROW CLEARANCE AND CONSTRUCTION - PART II

CAMPSITES AND STAGING AREAS

24. IN ORDER TO MINIMIZE SURFACE DISTURBANCE OR SOIL SUBSIDENCE THE OPERATOR SHALL PREPARE THE GROUND SURFACE BENEATH ALL FACILITIES AND STRUCTURES ASSOCIATED WITH THIS LAND USE OPERATION.

25. PORTABLE RAMPS WILL BE USED FOR BARGE LOADING AND UNLOADING: PUSH-OUTS WILL NOT BE USED UNLESS AUTHORIZED BY THE LAND USE INSPECTOR.

26. AN AREA CLEARLY SIGNED SALVAGE SHALL BE MARKED OUT, AND USED FOR THE STORAGE OF ALL SURPLUS STORES AND EQUIPMENT AND SALVAGEABLE MATERIAL.

27. THE DISPOSAL OF NONSALVAGEABLE EQUIPMENT AND PARTS SHALL BE BY COMPACTION AND BURIAL AT A SITE APPROVED BY THE LAND USE INSPECTOR.

28. KITCHENS AND WASH CARS SHOULD INCORPORATE WATER SAVING AND WASTE SEPARATION FEATURES.

29. ALL COMBUSTIBLE GARBAGE AND DEBRIS SHALL BE INCINERATED IN A FUEL-FIRED, FORCED-AIR INCINERATOR AT LEAST DAILY, AND THE RESIDUE AND ALL OTHER NONCOMBUSTIBLE GARBAGE AND DEBRIS SHALL BE DISPOSED OF IN A MANNER ACCEPTABLE TO THE LAND USE INSPECTOR.

30. ALL WASTE PETROLEUM PRODUCTS SHALL BE DISPOSED OF DAILY BY INCINERATION.

31. THE TAKING OF WATER AND DISPOSAL OF WATERBORNE WASTE SHALL BE IN ACCORDANCE WITH THE NORTHERN INLAND WATERS ACT.

TIMBER CLEARING AND DISPOSAL

32. DISPOSAL OF TIMBER AND BRUSH FROM THE RIGHT-OF-WAY AND ASSOCIATED FACILITIES WILL BE DONE BY ONE OF THE FOLLOWING METHODS:

    (A) CLEARING AND PLACING TIMBER AND BRUSH WITHIN THE RIGHT-OF-WAY FOR INCORPORATION INTO THE GRADE.

    (B) REMOVAL TO A BORROW SITE OR SIMILAR SUITABLE LOCATION FOR BURNING AND/OR BURIAL.

    (C) BURNING SMALL PILES.

33. WHEN CLEARING AND BRUSHING WITHIN THE RIGHT-OF-WAY IS DONE BY HAND CREWS, STUMPS WILL BE CUT AS CLOSE TO THE GROUND AS POSSIBLE. BRUSH LESS THAN 2 FEET HIGH MAY BE LEFT STANDING.

34. PROCEDURES FOR ADVANCED CLEARING STREAM BANKS OR STEEP SLOPES REQUIRE PRIOR APPROVAL OF THE LAND USE INSPECTOR.

35. ON AREAS ADJACENT TO BORROW PITS AND DESIGNATED AS SPOIL AREAS, TIMBER AND BRUSH MATERIALS WILL BE WALKED DOWN PRIOR TO THE PLACEMENT OF SPOIL MATERIALS.

36. LEANERS AND DEBRIS SHALL NOT BE LEFT IN STANDING TIMBER.

GRUBBING (OR STRIPPING)

37. AREAS TO BE GRUBBED SHALL BE DEFINED BY THE OPERATOR TO THE LAND USE INSPECTOR PRIOR TO COMMENCEMENT.

38. GRUBBING SHALL BE CONFINED TO MINIMUM AREAS FOR PURPOSES OF CUTS, DITCHING AND BORROW PITS.

39. MOVEMENT OF GRUBBING EQUIPMENT SHALL BE CONFINED TO AREAS TO BE GRUBBED AND RIGHT-OF-WAY.

40. DISPOSAL OF GRUBBED MATERIAL WILL BE BY BURNING OR BURIAL.

ACCESS ROADS

41. ACCESS ROUTES REQUIRE PRIOR APPROVAL BY THE LAND USE INSPECTOR.

42. ACCESS TO BORROW PITS SHALL BE LIMITED TO:

(A) A SINGLE ROUTE OF A MINIMUM WIDTH NECESSARY FOR TWO-WAY PASSAGE OF VEHICLES: OR

(B) TWO ROUTES OF A MINIMUM WIDTH NECESSARY FOR ONE-WAY PASSAGE OF VEHICLES.

43. DOGLEG APPROACHES ARE REQUIRED ON ALL BORROW PIT ACCESS ROADS.

44. TOTAL DISPOSAL OF TIMBER ON ACCESS ROADS SHALL BE CARRIED OUT TO THE LIMIT OF VISIBILITY FROM THE FINISHED ROADWAY.

BORROW PITS AND WASTE PILES

45. ADDITIONAL DEVELOPMENT AND RESTORATION PROPOSALS FOR BORROW PITS, CUTS AND WASTING AREAS SHALL BE APPROVED BY THE LAND USE INSPECTOR PRIOR TO THE COMMENCEMENT OF CLEARING.

46. IN TIMBERED AREAS A RESIDUAL TIMBER STAND OF 300 FEET SHALL BE MAINTAINED BETWEEN THE HIGHWAY AND BORROW OR WASTE AREAS, UNLESS OTHERWISE AUTHORIZED BY THE LAND USE INSPECTOR.

47. STRIPPED MATERIAL SHALL BE REMOVED IN SUCH A MANNER AND PLACED IN SUCH A LOCATION AT THE EDGE OF THE BORROW AREA AS TO FACILITATE RESTORATION ON COMPLETION OF THE OPERATION.

48. BACKSLOPES IN BORROW AREAS SHALL BE MAINTAINED AT A SLOPE OF TWO HORIZONTAL TO ONE VERTICAL FOR COMMON EXCAVATION, OR OTHERWISE TO THE SATISFACTION OF THE LAND USE INSPECTOR.

49. WASTE PILES WILL HAVE A LOW PROFILE FOR STABILITY.

50. LEVELLING AND SHAPING OF WASTE PILES WILL BE PROGRESSIVE WITH OPERATIONS.

DRAINAGE AND STREAM CROSSINGS

51. THE OPERATOR SHALL MAKE TEMPORARY CROSSINGS OF STREAMS IN SUCH A MANNER AS TO AVOID EXCAVATING OR OTHERWISE UNDULY DISTURBING APPROACHES, SHORES, BANKS AND STREAMBEDS AND, NOTWITHSTANDING THE FOREGOING, NO EXCAVATIONS SHALL BE MADE WITHOUT THE PRIOR APPROVAL OF THE LAND USE INSPECTOR. NO DEBRIS WILL BE DEPOSITED IN ANY STREAM DURING THE OPERATIONS.

52. APPROVAL FOR ALL PERMANENT CROSSINGS MUST BE AUTHORIZED UNDER THE NORTHERN INLAND WATERS ACT.

53. THE PLACEMENT OF CULVERTS WILL BE PROGRESSIVE WITH GRADE CONSTRUCTION IN ORDER TO PREVENT OBSTRUCTION TO NORMAL DRAINAGE.

54. DRAINAGE WILL BE PROVIDED FOR WHEN ESTABLISHING ACCESS ROADS.

55. EXCAVATED MATERIAL NOT SUITABLE FOR PROJECT USE MUST BE DISPOSED OF IN A LOCATION AND MANNER SATISFACTORY TO THE LAND USE INSPECTOR.

56. ANY OBSTRUCTION TO NATURAL DRAINAGE OCCURRING DURING THE LAND USE OPERATION SHALL BE REMOVED AND CONDITIONS RESTORED TO THE ORIGINAL STATE AS QUICKLY AS POSSIBLE.

DEPARTMENT OF PUBLIC WORKS

WESTERN REGION

REPORT ON

GEOTECHNICAL INVESTIGATION

KILOMETER 207 TO KILOMETER 254

FT. LIARD HIGHWAY

Submitted by R.D. Cook, P.Eng.
Geotechnical Engineer
August 10, 1978

TABLE OF CONTENTS

I INTRODUCTION

1.1 General

This report presents the results of a centerline soil survey and assessment of potential borrow sources along the Ft. Liard highway route between the Muskeg River (km 207) and the British Columbia border (km 254.5). The objectives of this geotechnical programme were to identify and classify the subgrade soils along the route; to evaluate their suitability for conventional "cut and fill" embankment construction; to locate and evaluate sources of embankment borrow as required; and to evaluate all potential sources of granular surfacing materials within a reasonable haul distance of the right-of-way.

Field work on this section of the highway was carried out during the course of a field investigation over the entire non-completed length of the Ft. Liard Highway in the N.W.T., i.e. from km 35 to km 254.5. This overall programme, as described below, commenced in mid January, 1978 and was completed near the end of March.

1.2 Scope of Field Programme

Field operations were carried out from a mobile camp and commenced near Ft. Simpson and proceeded toward the B.C. border. Drilling equipment was supplied by P.W.C. and camp and caterpillar support were provided on a

contract basis. The field crew averaged 15 throughout the work, consisting of eight (8) to nine (9) P.W.C. staff, and six (6) to seven (7) contractor employees.

During the course of the field programme approximately 1500 holes were drilled, logged and sampled. A total of 129 potential borrow areas were investigated. Approximately 8000 samples were taken and moisture contents and visual classifications were obtained on all samples in the Departmental Laboratory in Edmonton. Selected representative samples, primarily from major highway cut sections and from borrow sources, were subjected to more extensive classification testing.

1.3 Field Procedures

Field work was under the direction of a geotechnical engineer with the assistance of a senior technician, responsible for field location and clearing of borrow sites, and flagging test holes. Technicians assigned to each drill crew were responsible for logging boreholes, field identification of soil, sampling, packaging and labelling of all samples.

Prior to the commencement of field work, and throughout the course of the work, aerial photograph analysis was employed to evaluate the terrain and select potential borrow sites. Centerline drill hole locations were determined primarily from a tentative gradeline along

the centerline profile, with some modifications made on the basis of terrain observations during flagging. The extent of borrow search along any portion of the route was modified daily on the basis of suitability of the right-of-way subsoils for cut and borrow. Drill hole locations were marked on centerline profiles, or, in the case of borrow search, on air photos or air photo mosaics.

The following criteria, based on both construction and environmental considerations, generally were observed in hole layout for borrow:

1) Seismic lines and trails were used for access whenever possible;
2) An attempt was made to locate access lines so they could be used for future haul roads;
3) In order to screen future borrow activity from the highway, all access lines were 'dog-legged' at a distance of approximately 75 m (250 feet) off centerline;
4) Holes were not located within 90 m (300 feet) of centerline, nor within 90 m (300 feet) of lakes or streams, as environmental restrictions dictated against obtaining borrow within these limits;
5) Wherever possible a portion of a potential borrow source was selected for investigation in such a

manner that the pit, if developed, would not be visible from the highway and would have good drainage;

6) Access lines were cleared with a minimum cutting of trees and disturbance to the organic cover, and all lines were 'cleaned up' with all 'leaners' knocked down and brush cover piled on one side of the lines.

A track mounted Mobile B-50 auger rig using 15 cm (six inch) solid stem flight augers was used for the majority of the work. This rig was double shifted until the last three (3) weeks of the programme when a truck mounted auger rig was brought in via Ft. Nelson and Ft. Liard as a supplement.

Centerline test holes were generally drilled to a depth of 3 to 3.3 m (10 to 11 feet) or, in major cut sections, below the tentative gradeline elevation. Disturbed 'grab' samples were obtained off the augers at depths of 0.5 m (1.5'), 0.9 m (3'), 1.5 m (5'), 2.4 m (8'), 3.3 m (11'), 4.6 m (15'), 6 m (20'), 7.6 m (25'), etc.

Borrow area test holes were usually advanced to depths of 6 m to 9 m (20 to 30 feet) with identical sampling methods and depths.

All samples were returned to the Departmental laboratory

in Edmonton, and were visually identified, assessed as to relative moisture content, and tested for natural moisture content. Additional testing was carried out on selected samples from borrow pits and major cut sections - usually both grain size analysis and Atterberg Limits were performed. Final borehole logs were then prepared with both field and laboratory data included, for evaluation and reporting.

1.4 Numbering and Classification Systems

A. Borehole Numbering

Boreholes on centerline were prefixed with the kilometre in which it was located, identified by the letter C to indicate centerline, and then progressively numbered within each kilometre. Thus hole No. 102-C-4 is the fourth hole drilled on centerline between km 102 and km 103.

Borrow areas were numbered consecutively from km 35 south, and holes for borrow investigations were prefixed by the pit number. Subsequently, the kilometre in which the borrow area is located was added to the number, i.e. #242-128B-3 indicates the 3rd hole drilled in borrow area 128 which is located between kilometre 242 and 243.

B. Soils Classification

Soils were classified according to the Unified Classification System which is outlined at the rear

of this text.

Soil samples were also categorized in the laboratory using a series of terms to indicate the relative moisture content of the soil. The terms and their approximate relationship to the Atterberg Limits are summarized below:

Relative Moisture Content	Atterberg Limits
'dry'	
'humid'	
'damp'	plastic limit
'moist'	
'wet'	liquid limit
'saturated'	
'free water'	

The above information is included on the borehole log sheets for all samples.

1.5 Permafrost Ice Description

Very little permafrost is present along the highway location; that which was encountered occurs as random pockets often overlain by muskeg. The ice classification system used was the National Research Council system which follows this text. In addition to the N.R.C. classification, the logging technicians also employed a series of relative terms to indicate the amount of visual ground ice. These terms and their approximate relation-

ship to ground ice are outlined below:

Relative Term	Visual Ground Ice
'nil'	- frozen, but little or no ice in any form - usually confined to dry surface gravels or bedrock.
'low'	- ice coatings, ice crystals and, possibly, occasional very small lenses.
'moderate'	- numerous small ice lenses.
'high'	- continuous small ice lenses with a significant amount of large (1.3 cm +) (½" +) ice lenses.
'very high'	- continuous large ice lenses.
'ice'	- ice with some soil, or clear ice.

II SUMMARY OF RESULTS

Muskeg River to B.C. Boundary

Test drilling along this section of the Highway consisted of 280 centerline holes plus 115 holes in 30 potential borrow areas. All hole locations are shown on the 1:10,000 airphoto mosaics included with the design package. Borehole logs are included in Appendix A.

2.1 General Geology

The highway route covered by this report begins at the

crossing of the Muskeg River (km 207.7), parallels the Liard River valley to the Ft. Liard access road (km 217), then turns S.E. and parallels the Petitot River to the B.C. boundary (km 254.5).

The dominant surficial feature within this section is the Maxhamish Escarpment - a long ridge of exposed sedimentary bedrock projecting some 125 to 150 m above the surrounding terrain. The route intersects and crosses the lower end of this ridge at about km 250.

The Maxhamish escarpment is an anticline exposing limestones, quartzose sandstone, and sandy shale. Between this ridge and the Liard River to the west the underlying bedrock is sedimentary sandstones, siltstones, and shales. Topographically this area is generally flat with the Petitot River flowing in a narrow valley cut down some 150 m below the relatively flat upland.

The upland is covered with glacial till, much of it highly sculptured by advancing ice into prominent flutings and till drumlins. These till ridges are oriented in a general North-South direction hence the route from Ft. Liard to the border crosses these features at right angles. Depressions between the till ridges tend to carry shallow or surface muskeg with occasional deep muskeg (infilled lakes) and occasional shallow ponds.

There is a conspicuous lack of granular ice deposits on the till upland. All sorted granular deposits within this section are fluvial deposits along and at the mouth of the Petitot River.

The following describes this portion of the route and the test boring results in detail.

2.2 Kilometre by Kilometre Comments

Kilometre 207 to 208.7

This is the crossing of the Muskeg River and the present valley floor of the Muskeg River valley.

The present Muskeg River valley is probably located in a much larger old, pre-glacial channel that was eroded through glacial till and bedrock. During the last deglaciation period this valley was infilled with alluvial silts, sands and some gravels, much of which have been scoured and eroded out by the river to the present floodplain. There remain remnants of these former deposits on both sides of the valley extending well above the present valley floor.

Deposits below the present floodplain along the right-of-way consist of surficial silts and sands with a shallow stratum (2 - 3 m) of sandy gravel at depth. At the crossing and on the North side of the river the alluvial deposits are at least 25 - 30 m deep. On the south side near the valley wall the alluvial

deposits are underlain by glacial till at about 5 - 7 m.

At about km 208.7 the route crosses an abandoned infilled meander bend. This old channel contains roughly 5 m of organic clays over glacial till. The highway will be in a major fill section here and significant short and long term settlements can be expected over this channel. Precautions such as flat (3:1) embankment side slopes and/or berms will be required here to safeguard against a shear failure.

Embankment settlements or shear failure will not be a problem on the valley floor with the exception of the infilled channel outlined above.

B.P. 99 located roughly 0.6 m downstream of the crossing encountered approximately 4 - 5 m of clean sandy gravel under about 1.5 m of overburden silts and sands. These are floodplain deposits of the river and extend over an estimated area of roughly 60,000 m^2 and are considered to be a good source of surfacing aggregates despite a high stripping/borrow ratio.

Km 208.8 to 209.2

The route climbs up the south bank of the Muskeg River valley from about elevation 208 to about elevation 255. It is largely in cut section here with cuts of up to 12 m.

The subsoil in the valley wall is alluvial clays over

silty sands. The upper clays are well above optimum; the lower sands are moist with moisture contents near 10%. Near the top of the valley wall free water was noted in the upper 5 - 6 m.

Backslopes should remain stable through this cut with minor short term seepage; material from the cut although above optimum may be used at the base of the large fills on the valley floor.

Km 209.2 to 211.0

The route continues to climb above the Muskeg River valley onto the adjacent upland but at a gradual slope. Subsoil here is glacial till at depths of 2-3 m with a silty overlay. Deposits above the till are generally wet as the till restricts downward drainage. The till is slightly above optimum.

Borrow pit #101 is located left of and above the right-of-way at km 210. It is on a relatively well drained rise and contains useable glacial till which is slightly above optimum.

Km 211.0 to 213

This area is flat lying and poorly drained. Till is shallow (2 - 4 m) with overlays of wet silt, clay, and peat. Free water is common and moisture contents average 25 - 30%. There is higher ground to the left of ℄ with abundant glacial till, however, investigation

for borrow here revealed moisture contents well above optimum.

Km 213 to 218

The route continues across the till upland which is slightly rolling, and intersects several small cross-drainage channels. Glacial till is shallow throughout with thin 1 - 4 m overlays of silts, clays and sand-silts. These surficial deposits are generally wet and although there are small rises (notably at km 214.4 and 215.1) and a deep stream channel at km 217.0, where cuts would enhance the gradeline and borrow requirements, the materials are unsuitable for any significant cut.

Although glacial till is plentiful here it is generally well above optimum and unsuitable for borrow. Best bet for borrow is borrow area #104 to the right of ℄ near km 215.1 where moisture contents are variable around 20% and on the average are not significantly above optimum.

Km 218 to km 225

Beginning near km 218 the route turns south-easterly and parallels the Petitot River. The upland gradually rises from elevation 330 near km 218 to elevation 460 near km 225. Glacial till is shallow throughout this area and the surface is marked by small ridges of till without distinct orientation to about km 222, and then

by larger distinct flutings to km 225. Beginning near km 119.5 the glacial till becomes drier with moisture contents consistently near 15% with depth. The upper 0.5 to 1 m is occasionally wet through this area as the underlying impermeable till does not promote good drainage, however, cuts are feasible on most ridges.

Borrow is abundant through this section. Five (5) borrow sources are available - at km 119.1, 221.2, 222.0, 223.2, and 224.8 - all of which contain glacial clay till near optimum moisture content.

There are some shallow muskegs or peat areas (1 - 2 m deep) within this area, notably between km 224 and 225 where the flutings are more pronounced and intervening depressions poorly drained.

Km 225 to 227.0

The route descends from elevation 460 to elevation 404 across an undifferentiated, heavily treed surface. Glacial till is shallow throughout with some shallow surficial sand and sandy gravel ridges near small streams. The glacial till is near optimum throughout. Borrow if required is available to the right of ℄ at km 226.

Km 227 to 231

This is an area of very old burn with some small second growth spruce, and jackpine in drier areas. From km 227

to about 229 the terrain is relatively flat and poorly drained. Glacial clay till is within about 1 m of the surface, however, the upper 1 - 2 m tends to be wet of optimum.

At km 229 the route crosses a broad drainage channel (400 m) with two (2) small streams. Muskeg to about 2 m can be expected in this drainage channel and should be wasted. From 229.4 to 231 the route gradually climbs on poorly drained terrain. Glacial clay till is shallow throughout but is wet in the upper 1 - 2 m.

Borrow is readily available through this section as the clay till is shallow throughout and is an excellent construction material. Four areas were checked for borrow - a till ridge at km 227.1, and three (3) areas of jackpine that indicate drier surface materials at km 228.5, 228.9 and 230.5. All areas are suitable for use - the latter three (3) areas contain some near surface zones that are slightly above optimum.

Km 231 - 235

This area is a glacial till plain covered with a series of parallel, narrow, low, till ridges produced by advancing glacier ice. The long narrow depressions between the low ridges are not well drained and shallow peat deposits are common. Vegetation on the ridges is largely small poplar and jackpine - in the depressions it is small spruce. The route crosses these ridges

roughly at right angles.

Glacial till is shallow throughout. On the ridges it is dry and cuts are practical. In the flatter areas it tends to be wet in the upper 0.5 to 1.0 m. In depressions there is commonly about 1 m of peat which ideally should be wasted before embankment construction. A balanced gradeline should be possible through this area - if not, borrow is readily available in any ridge - three ridges at 232.2, 233.2 and 234.6 were confirmed as borrow sources.

Km 235 to 238

The route continues across the fluted till plain described above except that the relief is greater, i.e. the ridges are broader and higher and the depressions deeper and wider. There is much more opportunity for major cuts in the till ridges in this section and a balanced grade line would seem assured. Major depressions occur at km 235 (400 m wide - 1 to 2 m of peat), km 235.4 (150 m wide - 0.5 to 1.0 m of peat), km 237.5 (200 m wide - up to 2 m of peat), and km 237.9 (about 150 m wide - up to 1.25 m of peat). Removal of peat in these and occasional smaller depressions is recommended before embankment construction.

A borrow area test-drilled in a stand of jackpine in a depression at km 237.8 revealed highly plastic silty clay over soft shale, indicating the mantling till layer

is relatively thin above bedrock in depressions.

Km 238 to km 240

This is a large till ridge that is neither fluted nor drumlinized. The route climbs from elevation 396 to about elevation 420 then returns to elevation 396 at km 240. Glacial till is very shallow throughout and there is opportunity for a major cut at the higher elevation to produce a balanced gradeline. In some areas the upper 0.5 to 1 m of till is wet of optimum, and an extremely dense sand was encountered at depth (2 to 4 m) near the top of the rise. Auger refusal was encountered a few metres into this sand and it is recommended that cuts be limited to a depth of about 4 m here to avoid significant penetration into this hard sandy stratum.

Km 240 to 245.8

The route crosses a large heavily forested rise that is neither fluted nor drumlinized but is mantled with glacial till. It rises from elevation 400 to about 475 then drops back to elevation 445 near km 246. Glacial till is near the surface throughout - there is little micro relief (i.e. small ridges or depressions) hence cut sections will be relatively shallow, however, a balanced gradeline should be possible with some ditch borrow. The near surface till is generally near optimum where the terrain is sloping and reasonably well drained; on flatter poorly drained areas the upper 0.5 to 1.0 m

of subsoil is wet and well above optimum. There are few depressions within this section that contain peat.

Additional borrow, if required, is available at km 241.1, 242.6 and 245.6.

Km 245.8 to 247.1

This is a wide valley in which there are two drainage depressions separated by a low till mound. The first depression at km 246 is some 300 - 350 m in width and peat deposits are shallow, probably less than 0.5 to 1.0 m. The second depression near km 247 is about 400 m wide and peat deposits of up to 2 m can be expected. Removal of the peat before embackment construction is recommended.

The intervening till mound is suitable for cut and will provide fill for both depressions.

Km 247.1 to 250

The route climbs toward and parallels the Maxhamish Escarpment here, reaching a maximum elevation of 534 at km 249.7. For the most part the R.O.W. is on a cross slope through this section and the many ridges which will be in cut section will have high backslopes on the north and/or east. A balanced gradeline is possible with the majority of cut sections in glacial till near optimum moisture content.

Two cut areas may encounter bedrock: At km 249 is a ridge of 200 m that is composed largely of very hard or dense sand that may be a soft sandstone. Auger refusal was reached after very hard drilling in this ridge at depths of 3 to 6 meters. The ridge is strewn with huge boulders 1 - 2 + meters in diameter.

Near km 249.7 is a second major ridge of 400 m where auger refusal was reached abruptly at depths of 3 to 5 meters. Hard bedrock is anticipated in this ridge and proposed cuts should not be extended below the depths of auger refusal shown on the borehole logs.

Km 250 to 253

The route skirts the end of the Maxhamish Escarpment and decends the eastern side to elevation 420 at km 253. This is an area of significant relief - i.e., ridges - most of which are composed of glacial till and there will be several major cuts and fills. Boulders are prevalent in the till near the excarpment, however bedrock was not encountered. A balanced gradeline can easily be attained here.

Km 253 to 254.5. (B.C. Border)

This area is relatively flat and some parts have poor drainage, however glacial till is near the surface and there are some low till ridges where cuts are possible. Some shallow peat overlays may be encountered near km

254, however the depth of peat should not exceed 0.5 to 1.0 m. Additional borrow can be obtained here by widening cuts in the low till ridges or by developing adjacent borrow pits in the ridges. The glacial clay till is an excellent construction material and is near optimum throughout, with the exception of the upper 0.5 m in poorly drained areas.

2.3 Ft. Liard Access Road. (Km 216.8 to Ft. Liard) - 4.0 km

From the intersection with the highway, the access road desends on a gently sloping till upland roughly 1.7 km to the valley of the Liard River, then drops into the valley from elevation 294 to elevation 214 by km 2.5, and then crosses Liard River floodplain deposits to Ft. Liard.

On the upland the subsoil is glacial till with overlays of silts, clays, and silt-sands which increase in thickness from about 1 m near the junction to in excess of 8 m near the valley wall. This upland is poorly drained and the upper soils are generally wet of optimum. A deep (8 m) stream channel crosses the alignment at 0.8 m, and a shallow cut to about 2.5 m will be possible here in silt-sand that is wet at the surface (to 0.5 m).

A major cut will be required through the valley wall of the Liard River - from about km 1.4 to km 2.2. The subsoil here is primarily alluvial silt-sand with glacial

till at depth and will be useable embankment material. The silt-sand is relatively dry with some seepage noted along the sand-till interface. Cuts terminating in the silt-sand will result in severe erosion in the ditches and will require frequent ditch checks; cuts extending through the silt-sand into the underlying clay till will likely encounter seepage at the sand-till interface. Backslope stability should not be a problem.

From km 2.2 to Ft. Liard the route is on alluvial floodplain deposits of the Liard River, which consists of stratified clays, silts and sands. There was little granular material encountered on the floodplain and materials tend to be very wet at shallow depths. The route crosses a small abandoned infilled channel near km 2.4 and shallow organics (1 to 1.5 m) may be encountered here and should be removed before embankment construction. Some long term settlement will occur near km 2.4, however a shear failure is unlikely under the relatively high fill. Exploratory holes at several locations on the Liard floodplain along the roadway near Ft. Liard failed to encounter any granular deposits.

2.4 Granular Borrow Source at Ft. Liard

The present source of gravel for the settlement of Ft. Liard is a high terrace along the east side of the Liard River valley at the confluence of the Petitot River valley. These deposits are believed to be old glacial

channel deposits that have been partially eroded by both the Liard and Petitot Rivers in post-glacial time. The present development of the source by the settlement is at the base of the terrace on a single small face. As the top of the terrace in inaccessible with equipment from the settlement, a route to the area partially utilizing existing seismic lines was cleared, beginning near km 219 on the highway. This route is some 5 km in length. The granular area was designated Borrow Area #113 and 17 test holes were drilled.

There is good quality granular aggregates here in quantity. The lower part of the terrace nearest the settlement (test holes #1 to #6) is apparently reserved for use by settlement of Ft. Liard. Of the remaining area test drilled, the best quality granular material was encountered in the vicinity of holes #13, #14 and #15. These holes were terminated in gravel at depths of 9 to 11 m with 2 - 3 m of overburden, and were spaced at intervals of about 100 m indicating a substantial volume of material. The holes were located parallel to and within about 80 m of the Petitot, hence the area is limited by the river on the south but is open to the north. The volume of material available is estimated to be in excess of 400,000 cubic meters, however additional drilling should be carried out to define the deposit.

There is one additional feature that is considered, from air photo analysis, to have some potential as an aggregate source. This is a high terrace along the Petitot River located due south of the highway at kilometer 230. Test drilling was not attempted due to a steep slope on the valley wall leading to the terrace. Test pitting by hand is recommended here to assess the area as an aggregate source.

NATIONAL RESEARCH COUNCIL PERMAFROST

CLASSIFICATION SYSTEM

Permafrost ground ice occurs in three basic conditions including non-visible, visible (less than 25 mm in thickness) and clear ice.

A. Non-visible - N

N_f - poorly bonded or friable frozen soil

N_{bn} - well bonded soil, no excess ice

N_{be} - well bonded soil, excess ice

B. Visible - V (less than 25mm thick)

V_x - individual ice crystals or inclusions

V_c - ice coatings on particles

V_r - random or irregularly oriented ice formations

V_s - stratified or oriented ice formations

C. Visible Ice - (greater than 25mm thick)

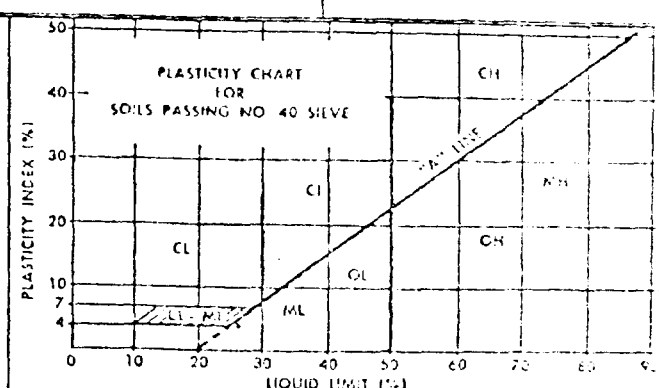
Ice - ice with soil inclusions

Ice + soil - ice without soil inclusions

A more complete description of this system is included in NRC publication TM 79.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS (MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		RED	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP		RED	POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS (MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)	SW		RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP		RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC		YELLOW	CLAYEY SANDS, SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)	
		$W_L > 50\%$	MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS		
		$30\% < W_L < 50\%$	CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE ON CHART	$W_L < 50\%$	OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER F (E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	



1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD AS IN A.S.T.M. E.11.
2. BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.

GEOTECHNICAL NOTES ON LIARD HIGHWAY MILE 40-67, KM 205-254,

MILE 34 BORROW PIT AND FORT LIARD ACCESS ROAD.

Mile 34 Pit run gravel: The pit is outlined on the basis of two holes only while the access road merits 5 holes although for winter use only. This represents an imbalance in data collection. Additional holes at the proposed pit extremeties would be prudent. The plan for pit development appears acceptable providing that additional drilling confirms the presence of suitable material throughout the proposed area.

General - Obtaining data on clays and silts as fines is economically sound but there may be some circumstances where the separation would be prudent for both engineering and environmental assessment. These circumstances would be primarily where the material being proposed for use is predominantly sand or gravel but a fines component of 10-25% is present.

The geotechnical report by R.D. Cook has a minor inconsistency which should be noted in case it should translate into excavation; on p. 3 it is noted that drilling was not undertaken within 90m of lakes or streams and yet on p.21 "holes were located parallel to and within about 80m of the Pettitot"...

Access Road

Culvert - Access Rd. 4.020 shows from going both ways.

KM.3 - Campsite area is not completely on the mosaic nor is there any indication of drilling to determine the suitability of the substrata. The reader is left to assume that the site has been checked out as being suitable.

What arrangements for water supply and disposal are anticipated?

Mile 40-65 - No grain size data 40-1 to 4 incl.

No grain size data 41

Mile 43. Cut at C5 and C6 - no grain size at C5 - materials may be in permafrost as stream at the base appears to be beaded suggesting thawing of ground ice lenses.

Hole 44-5 - No data recorded except depth of hole.

Hole 47-4 and 6 in generally "high fines" terrain and at location of two minor cuts but no grain size data.

Holes 48-5-6-7 in area of cut and highly variable materials (70-30 to 23-77) but no grain size from hole 6. Slope could contain permafrost pocket.

Stream at 48.2583 appears to be beaded suggesting permafrost with ice lenses in vicinity.

Mile 49-C-9 - main part of cut and yet no grain size data.

Mile 50-C-6 - as above.

Mile 50-C-8 - Located within cut and saturated layer at 8' but no grain size data. Both C-7 and C-9 have substantial fines.

Culvert intake at 51-2733 is shown 1.5 ft. above current ground level.

Mile 51-C-6 - Material from cut is medium plastic - may not be suitable foraadjacent fill.

Mile 52-C-12 - Material at level of cut is medium plastic and above plastic limit - may pose stability or maintenance problems as on one of the steeper grades, unless additional precautions are taken.

Mile 53-2840 - Centreline shown of the cleared ROW.

Mile 54 - Culvert at 2858 shown with intake 5 ft. above current stream bed. A ponding problem?

Mile 55 - Culvert at 2915 shown with intake 8.5 ft. above current stream bed. Another ponding problem?

Mile 55 2943 - Major 40 ft. depression with no provision for cross drainage.

Mile 58 at 3114.5 - Culvert shown buried with repsect to ground level - why?

Mile 59 3130 - Cut surface just in a low plastic interval at 59-C-4.

Mile 62 3294 - 36" culvert inset 24" below ground surface - too deep?

Mile 62 3317 - 30" culbert inset 18" below ground surface - too deep?

Hole 47-4 and 6 in generally "high fines" terrain and at location of two minor cus

Mile 65 Cut at 3462: proposed cut surface is in a plastic clay silt which may go over the plastic limit when wet.
Mile 65 C-10 and C-11 low to medium plastic materials may not be suitable for fill. No grain size data for these two holes.
Mile 66 Holes 1 and 2 do not penetrate sufficiently below projected grade. This is particularly important as the materials are plastic and no grain size data are given.
Mile 66 - Approach cut to Blackstone River. No grain size data despite identifying a plastic interval in each of the three holes. The variability of the material could also cause additional problems due to differences in permeability.
Holes 10 and 11 yield less penetration of the proposed cut surface than is desirable for assessing stability and erosion potential.

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Oct. 6/78