Public Works Canada

Travaux Publics Canada

Western Region

Region de l'Ouest

VOLUME I - REPORT

GEOTECHNICAL INVESTIGATION

MILE 347 TO MILE 690 MACKENZIE HIGHWAY

WINTER - 1975

DEPARTMENT OF PUBLIC WORKS

WESTERN REGION

REPORT ON

GEOTECHNICAL INVESTIGATION

MILE 347 TO MILE 690

MACKENZIE HIGHWAY

VOLUME I

GEOTECHNICAL ANALYSIS

Submitted by R.D. Cook, P.Eng.
Materials Engineer
February 1, 1976

I INTRODUCTION

1.1 General

1.1.1 This report documents field and laboratory work carried out in the course of a geotechnical investigation along the portion of the Mackenzie Highway between Camsell Bend (Mile 347) and Ft. Good Hope (Mile 725). Field work was carried out during the winter of 1975, commencing January 20, and with completion on April 10. The testing programme was undertaken by staff of the Special Services and Highways sections of the Design and Construction Branch, D.P.W., Western Region. Camp and drilling equipment were provided by D.P.W.; caterpillar support and catering were provided on a contract basis.

1.2 Engineering Objectives

1.2.1 The entire length of the Mackenzie Highway between Camsell Bend and Ft. Good Hope had been investigated by consultants during the winter of 1972-73, and this current programme was directed toward three main objectives:

1) to investigate and evaluate subsoil and permafrost conditions along route revisions not drilled previously, and to investigate potential problem areas on the existing route;
2) to locate, investigate and evaluate potential sources of embankment borrow along revisions, and in areas where proven borrow material was limited;

... 2

3) to investigate, evaluate and make design recommendations for design of structures at revised crossings over major streams, and to augment available information at some major crossings previously test drilled.

1.3 Scope of Work

1.3.1 Field operations were carried out from a mobile camp and commenced at Ft. Simpson (Mile 300) in January and proceeded north toward Ft. Good Hope (Mile 725). Due to access problems and time restraints, actual field work was limited to the section of highway between approximately Mile 370 and Mile 690. During the course of the work a total of 1490 holes were drilled, logged and sampled. Of these, approximately 600 holes were drilled on revisions or at bridge sites, and the remainder were drilled in search of embankment borrow. A total of 130 potential borrow areas were investigated. Approximately 8500 samples were taken and moisture contents and visual classifications were obtained on all samples in the Departmental laboratory in Edmonton. Selected representative samples were subjected to more extensive classification testing and some special testing, where required.

1.4 Report Organization

1.4.1 The report encompasses V volumes. The text of the report is confined to this volume (Volume I), and is a summarization of

pertinent data with recommendations regarding borrow sources and some aspects of highway design.

1.4.2 Volumes II through V contain the borehole log sheets, which include all field and laboratory data, and 1"= 1,000' airphoto mosaics, showing the route and the location of drill holes. The borehole data has been sub-divided into volumes by mileage as follows:

Volume II	-	Mile 347 to Mile 440
Volume III	-	Mile 440 to Mile 510
Volume IV	-	Mile 510 to Mile 583 (Ft. Norman)
Volume V	-	Mile 583 to Mile 691 (Donnelly River)

1.4.3 Investigations at major stream crossings have not been included in this report, and will be reported separately.

... 4

2. GENERAL FIELD OPERATION

2.1 Field Procedures

2.1.1 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. A technician accompanied each drill rig and was responsible for logging boreholes, visual identification of soil and ice constituents, sampling, packaging and labelling of all samples.

2.1.2 Major equipment included the camp, two track mounted drilling rigs, two D-7 dozers, and vehicles for personnel transport. Daily operations were normally limited to single 10-hour shifts.

2.1.3 As much of the test drilling was to augment available information, drilling sites were frequently widely spaced and daily camp moves were the norm. Thus one dozer was assigned to camp moves with the second dozer utilized for clearing of drill sites.

2.1.4 Many of the highway revisions, especially north of Ft. Norman (Mile 583), had not previously been cleared and a single dozer width was opened along centerline to permit drill access.

2.2 Air-Photo Analysis and Terrain Evaluation

2.2.1 Prior to the commencement of field work, and throughout the course of the work, aerial photographs were examined and

... 5

analyzed in conjunction with available subsoil data along the route, to evaluate the terrain and to pre-select potential borrow sites. Borehole data was available along the route from previous drilling by consultants (1972-73), from previous drilling by D.P.W. (1974), and from Canadian Gas Arctic (CAGSL) pipeline investigations.

2.2.2 Generally, borrow areas pre-selected for investigation were located within 1/2 mile of the highway, and there were very few occasions when more distant areas were drilled. As a general rule sufficient borehole data was available along the route to permit good terrain analysis from airphotos, and thereby limit the need for investigation of features distant from the route.

2.3 Selecting Drill Sites

2.3.1 Test hole locations on revisions were based on a maximum interval of roughly 1000 feet with a minimum of 5 test holes per mile, in accordance with instructions from the Environmental Working Group. The governing criteria for the test hole locations, in addition to the above guidelines, were representation of the terrain and advance information for borrow pit investigations. Generally centerline holes were spotted on highs and lows, at creek crossings, or on any unusual feature, whether geologic or vegetative. Locations were normally selected from air photo interpretation with some modifications made on the basis of observations on the ground during flagging. Hole

... 6

locations were marked on air photo mosaics in the field at the time of flagging.

2.3.2 Selecting drill hole locations and clearing access in potential borrow areas was much more time consuming than centerline hole layout. 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 at least 250' off centerline.
4) Holes were not located within 300' of centerline, nor within 300' 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.

2.4 Drilling and Sampling

2.4.1 Two drilling rigs were used during this programme - a Failing 1250 rotary rig using compressed air as a drilling fluid, and a Mobile B-50 auger rig using either 6" solid stem, or 8" hollow-stem flight augers.

2.4.2 Centerline drilling on revisions was normally completed in advance of borrow investigations to provide additional subsoil information. Holes were generally drilled to a depth of 15' on centerline. Disturbed 'grab' samples were taken at depths of 2', 5', 8', 11' and 15'.

2.4.3 Borrow pit holes were usually advanced to a depth of 20-30'. Sampling was similar to centerline holes except that 'grab' samples were taken at 5' intervals below a depth of 15'.

2.4.4 All samples were returned to the Departmental laboratory in Edmonton, and were visually identified, assessed as to relative thawed moisture content, and tested for natural moisture content. Additional testing was carried out on selected samples for borrow pits - 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.

... 8

3. NUMBERING AND CLASSIFICATION SYSTEMS

3.1 Borehole Numbering

3.1.1 Boreholes on centerline were prefixed with the mile in which it was located, identified by the letter C to indicate centerline, and then progressively numbered within each mile. Thus hole No. 355-C-4 is the fourth hole drilled on centerline between Mile 355 and Mile 356.

3.1.2 Borrow areas were numbered consecutively from Mile 347 north, and holes for borrow investigations were prefixed by the pit number. Subsequently, the mileage in which the borrow area is located was added to the number--i.e., #412-B49-10 indicates the 10th hole drilled in pit B49 which is located between Mile 412 and 413.

3.2 Soils Classification

3.2.1 Soils were classified according to the Unified Classification System which is outlined in Appendix A, Volume I, at the rear of this volume.

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

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

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

3.3 Ice Description

3.3.1 The ice classification system used is a modification of that outlined in the National Research Council Technical Memorandum No. 73 "A Guide to a Field Description of Permafrost"--see Appendix A, Volume I.

3.3.2 The NRC system requires relatively large undisturbed samples in order to establish if the ground ice is stratified, random, in individual crystals, or occurs as coating on larger soil particles. With the air circulation rig used on this project, the sample cutting sizes returned to the surface ranged from chips of 3/4" maximum dimension, to powder. Large ice lenses (1/2" or more) could be detected by close observation of drill cuttings, and ice crystals or ice coatings could be determined from the soil chips, however accurate classification of the intervening excess ice formations was impossible. During past testing programmes in the N.W.T., technicians have had the opportunity to compare drill cuttings with drill cores and have developed a 'feel' for ground ice through visual observation of disturbed cuttings. Therefore, the classification of the ground ice that is recorded on the borehole logs, using the NRC symbols, is at least partially inferred or estimated.

... 10

3.3.3 In addition to the NRC classification system, the logging technicians also used a series of relative terms to indicate the amount of visual ground ice. These terms and the approximate relationship 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 (½"+) ice lenses
'very high'	- continuous large ice lenses
'ice'	- ice with some soil, or clear ice

... 11

4. GEOTECHNICAL EVALUATION

4.1.1 The following pages outline, summarize, and comment on the geotechnical information obtained from approximately Mile 395 (Willowlake River) to Mile 690 (Donnelly River). The portion of the route south of Willowlake River is currently under construction and subsoil data obtained on that section has previously been submitted to highway designers. Borehole logs and locations are included in Volume II however no comments on that section are included herein.

4.1.2 Borehole data is summarized in accordance with increasing mileage. Sketches of borrow pits which are suitable for use are included, with recommended areas for development shown where applicable. All test holes have been shown on the mosaics which precede the borehole logs in Volumes II to V of the report.

4.1.3 For ease of reference the following summary and comments have been subdivided into 50 mile sections commencing at Mile 400. Borrow pits #49 to #156 were investigated north of Mile 400.

... 12

GEOTECHNICAL EVALUATION

MILE 400 TO MILE 450

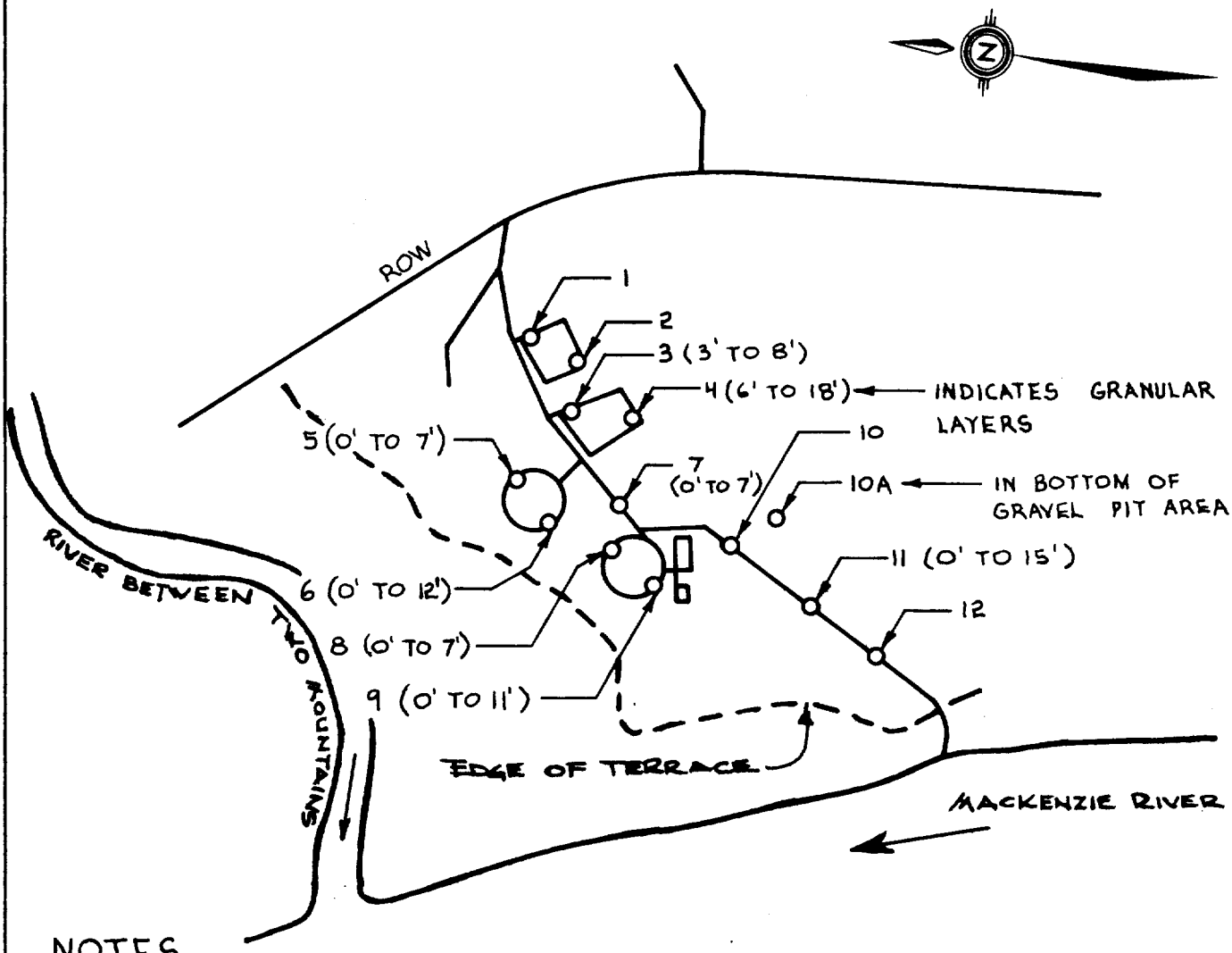
MACKENZIE HIGHWAY

MILE 411.0 - BORROW PIT NO. 58

- 1,000 to 2,500 feet left of centerline.

The area test drilled here is the former D.P.W. camp-site at River Between Two Mountains, and is located on a terrace of the Mackenzie River. Small amounts of sandy gravel borrow were apparently obtained here when the camp was occupied. Twelve test holes were drilled over an area measuring 1000 feet x 3000 feet. Subsoil varies from silty sandy clays to silty sandy gravels. Granular materials are, for the most part, in relatively shallow layers and large areas would have to be developed to obtain substantial volumes. Permafrost is sporadic, however, most of the granular materials appear permafrost free. This area was drilled primarily as a granular borrow source and the depths of granular material are shown on the site plan in each hole. Much of the material contains an excess of sand sizes and is short on gravel sizes, however, there is some good granular borrow available here. One drill hole (10A) was advanced in the bottom of a small open pit on the southside of the camp-site where some gravel has been obtained. Silts and clays were encountered and there is no usable granular material below the level of the present pit.

MILE 411.0 - 1000' TO 3000' LT. OF ℄



NOTES

- AREA DRILLED IS ON TERRACE OF MACKENZIE RIVER
- SUBSOIL SANDY CLAYS TO SANDY GRAVELS
- NO GRANULAR MATERIALS IN HOLES * 1, 2, 10, 10A, OR 12
- PERMAFROST SPORADIC
- MOST NON-GRANULAR SOILS ARE WET ON THAWING

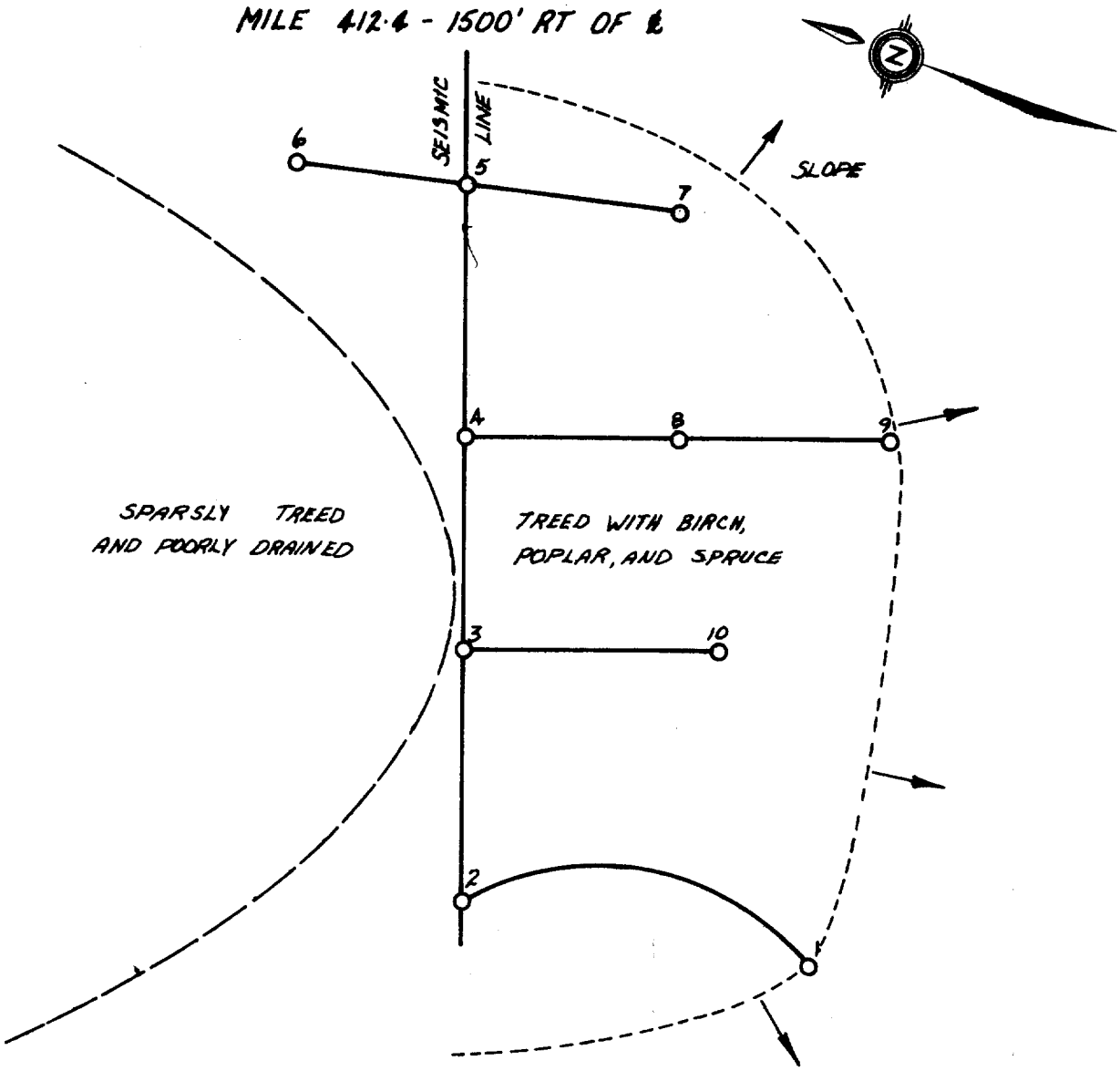
Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 58	designed by / conçur par — date
	scale / échelle: 1" ≃ 1000'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 412.4 - BORROW PIT NO. 49

- 1,500 feet right of centerline.

This pit is located on a bluff of high land defined on the east and south by the valley of River Between Two Mountains, and on the west by the valley of the Mackenzie River. There is heavy forest cover consisting of poplar, birch and spruce on the slopes of the bluff and extending inland approximately 500 feet from the top of the slope. Behind the treed area the terrain is flat-lying and boggy, and the borrow area is confined to the better drained tree area. Ten test holes in this area revealed medium plastic silty clay to depths of at least 30 feet; frozen and with low to moderate ice. Plastic limit of the clay is roughly 20% and moisture contents range from 20 to roughly 28%, with occasional higher values in the upper 3 to 4 feet. This area is considered to be a borderline borrow source as at least 3 to 4 feet of stripping will be required and moisture contents upon thawing will probably average 3 or 4% above optimum.



NOTES

- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- PERMAFROST PRESENT WITH MODERATE ICE CONTENT
- STRIPPING ESTIMATED @ 3-4'
- MOISTURE CONTENT UPON THAWING ESTIMATED AT 3-4% ABOVE OPTIMUM

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 49	designed by / conçur par — date
	scale / échelle: 1" = 200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region	revisions — date	project number / no. de entreprise — drawing no / no du dessin
region	revisions	

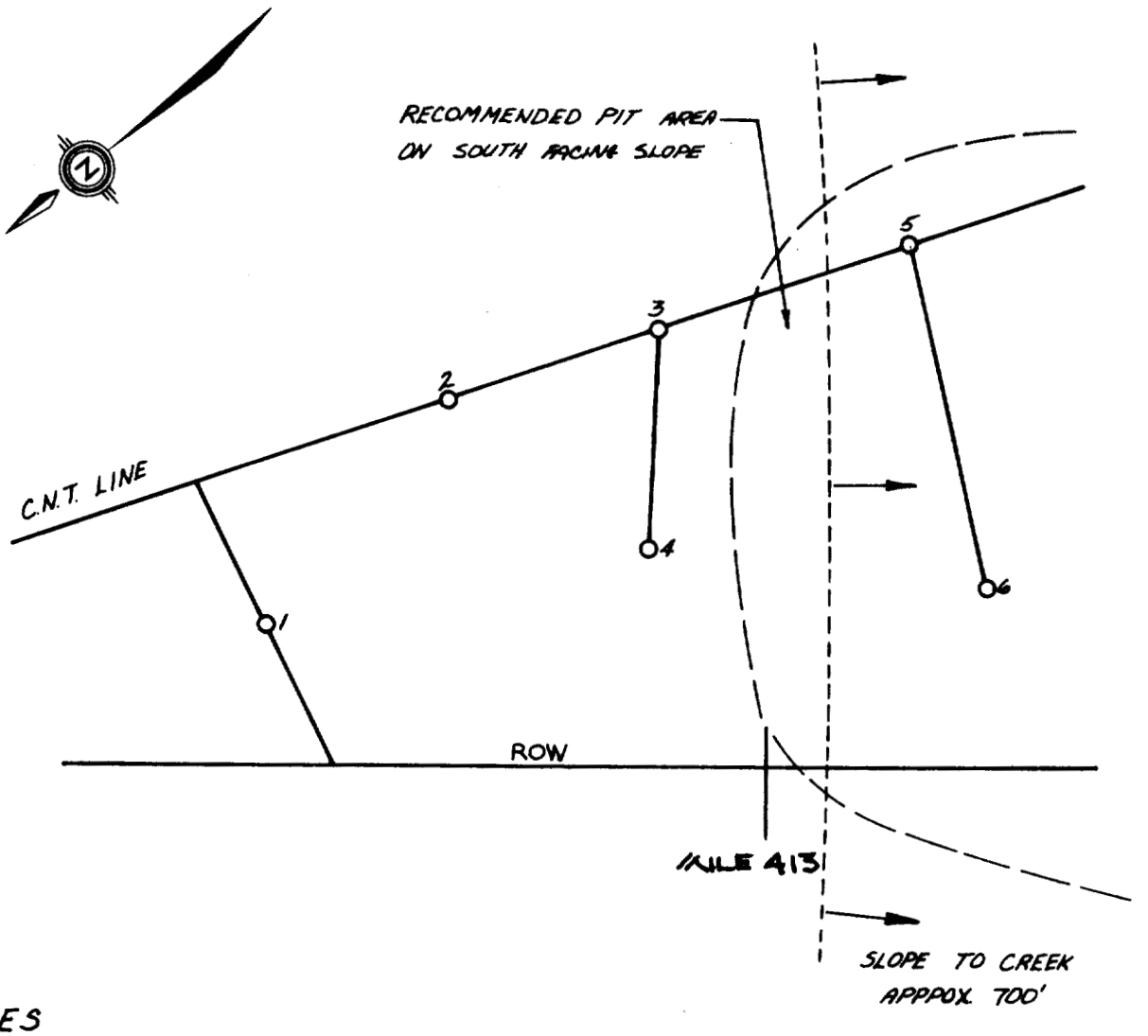
D.P.W. 700 A

MILE 413.0 - BORROW PIT NO. 50

- 400 feet right of centerline.

The area investigated here is on the top of the valley wall and is defined on the west by the slope of the Mackenzie River Valley, and on the south by the slope of a small tributary creek valley. Tree cover varies from small poplar on the south facing slope to small spruce on the level terrain above the slope. As in Borrow Pit #49, the subsoil is glacial lake sediments consisting of medium plastic, silty clay. Permafrost is present throughout and ice contens are moderate. Moisture contents are slightly higher than in pit #49 with the exception of the south facing slope where test holes No. 5 and No. 6 are located. Should this area be developed, it is recommended the pit be confined to the poplar treed area on the south facing slope (see site plan).

MILE 413·0 - 400' RT OF ℄



NOTES

- RECOMMENDED PIT AREA DENOTED BY DASHED LINES
- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- PERMAFROST THROUGHOUT
- STRIPPING 1-2'
- MOISTURE CONTENT UPON THAWING NEAR OPTIMUM

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 50 scale / échelle 1" = 200'	designed by / conçu par — date drawn by / dessiné par — date reviewed by / examiné par — date approved by / approuvé par — date
region region	revisions — date revisions	project number no. de entreprise drawing no no du dessin

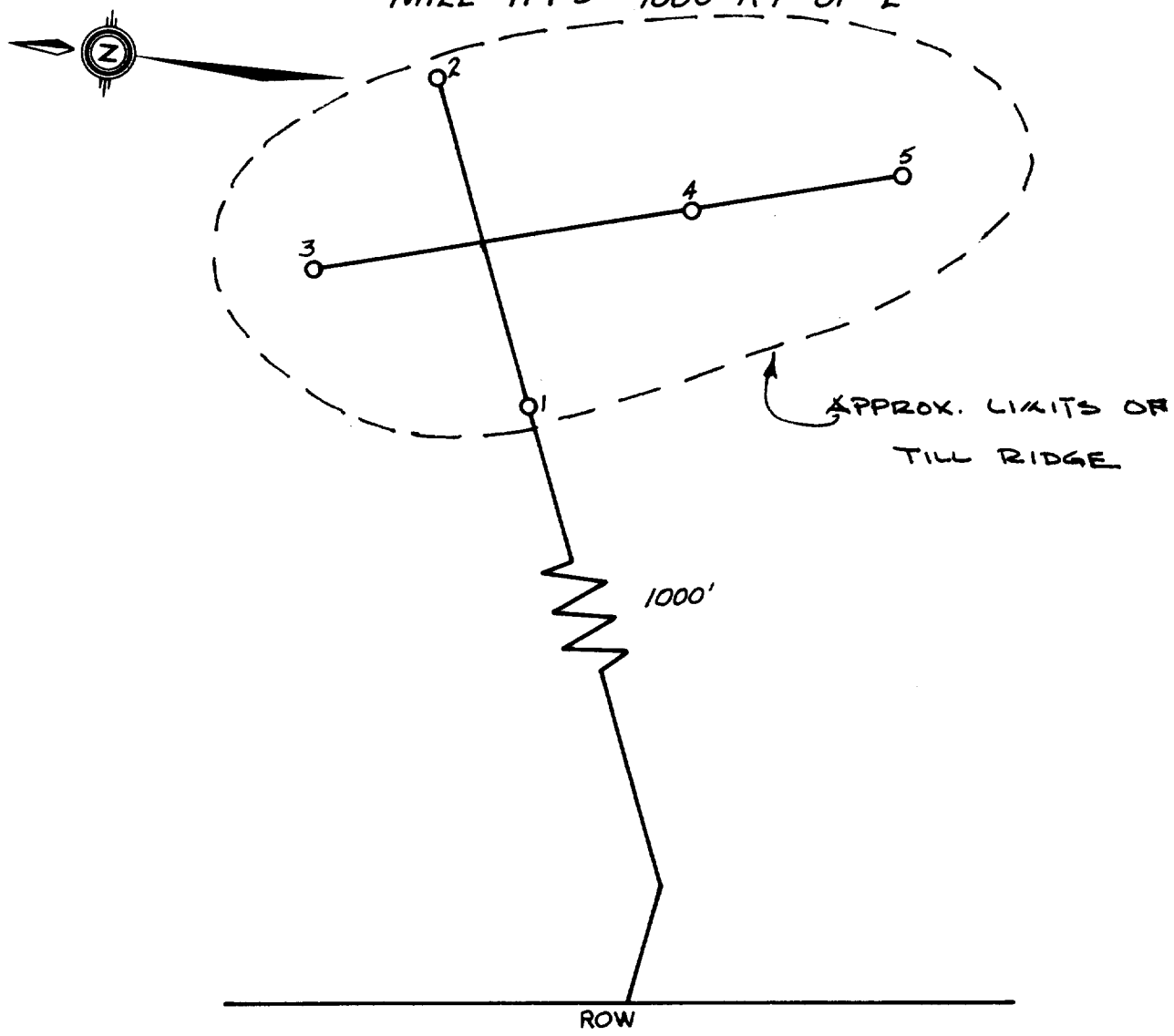
D.P.W. 700 A

MILE 414.5 - BORROW PIT NO. 51

- 1,000 feet right of centerline.

This area is located on a small elongate till ridge which is devoid of the surficial slopewash or glacial lake sediments common to the area. Tree cover is moderate to heavy with 6-8" diameter spruce. A total of 5 test holes in an area measuring roughly 400 x 700 feet encountered unfrozen low moisture content, gravelly till with some very granular zones. Moisture contents throughout are near the 10% level. This area is an excellent borrow source.

... 19



NOTES

- SUBSOIL UNFROZEN, GRAVELLY CLAY (TILL)
- LOW MOISTURE CONTENT (< 10%)
- EXCELLENT BORROW SOURCE

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 51	designed by / conçur par — date
	scale / échelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

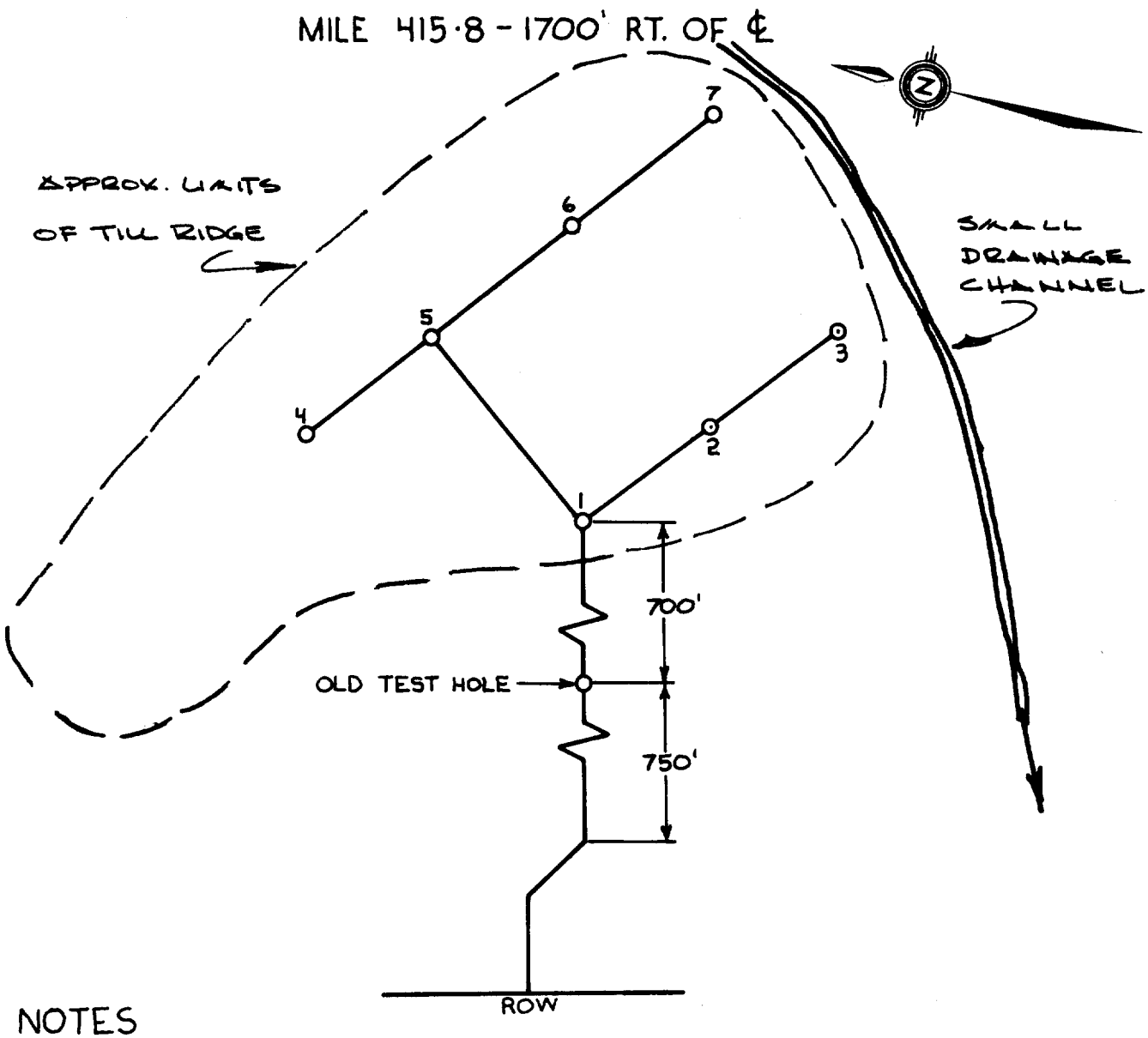
D.P.W. 700 A

MILE 415.8 - BORROW PIT NO. 52

- 1,700 feet right of centerline.

The area investigated here is located on a till ridge similar to that on which Borrow Pit No. 51 is located. It is heavily treed with 5-6" diameter spruce and with good drainage to the west. The area investigated measures roughly 800' x 600' and 7 holes revealed granular clay subsoil to depths of at least 25 feet. Moisture contents are low throughout and no permafrost was encountered. Occasional cobbles and/or boulders are present throughout. This is an excellent borrow source.

... 21



NOTES

- SUBSOIL LOW PLASTIC, UNFROZEN GRAVELLY CLAY WITH OCCASIONAL COBBLES AND BOULDERS
- UNFROZEN
- MOISTURE CONTENTS LESS THAN 10%
- EXCELLENT BORROW SOURCE

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 52	designed by / conçur par — date
	scale / echelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 415.9 - TEST HOLE 415-C-1 - ON CENTERLINE

This hole is located on a small mound which is a remnant of a sandy outwash delta. Subsoil is sandy clay or clay sand with no permafrost. The mound is some 5 to 10 feet above the level of the surrounding terrain and any cut should be limited to 6 to 7 feet as the subsoil becomes wet with depth below that level.

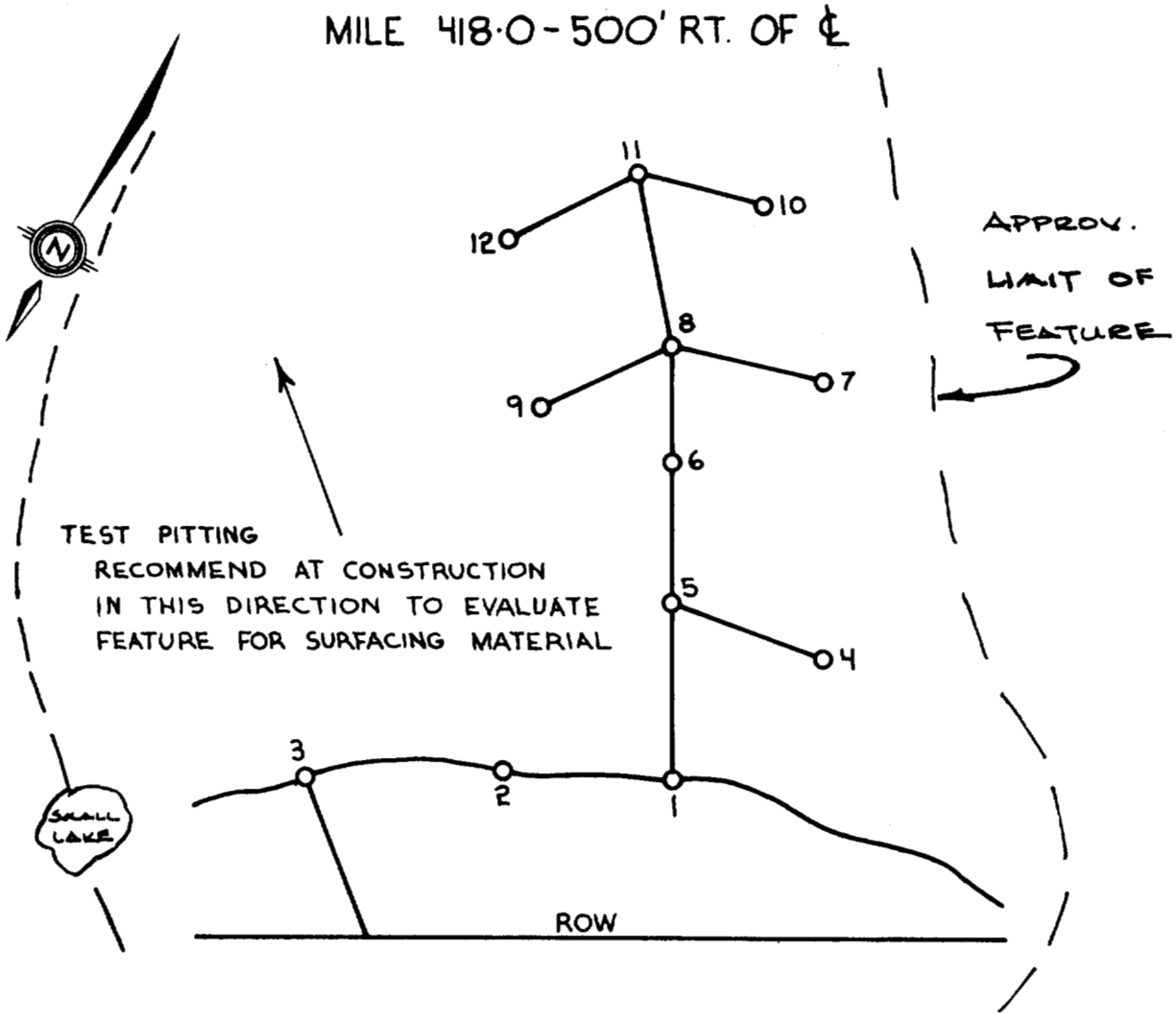
MILE 416.5 TO 416.8 - TEST HOLES 416-C-1 TO 416-C-5 - ON CENTERLINE

These holes are on a narrow elongate ridge which is a continuation of the feature on which Borrow Pit 52 is located. The highway route crosses and approximately parallels the ridge, and a cut section varying up to 25 feet in depth is proposed over a distance of some 1800 feet. The subsoil is low plastic, sandy silty clay till. There was no permafrost noted and moisture contents, for the most part, are less than 10%. This cut will provide an excellent source of borrow and no construction or maintenance problems are anticipated.

MILE 418.2 - BORROW PIT NO. 53

- 500 feet right of centerline.

The feature investigated here is a large glaciofluvial outwash deposit measuring 2000 x 4000 feet. The feature is heavily treed with jackpine and occasional poplar stands. Test drilling for Borrow Pit No. 53 consisted of a dozen holes spaced over an area measuring 700 x 1200 feet. All holes encountered cohesionless gravelly sand with occasional sandy gravel zones. Hole depths were limited to 10 or 11 feet. Moisture contents are low throughout and the majority of the material is unfrozen. This area is considered an excellent source of embankment borrow and may be a source of surfacing material although there appears to be a shortage of plus No. 4 material and an excess of sands. Test pitting over a larger area is recommended at construction to determine the availability of surfacing materials.



NOTES

- PIT AREA IN A LARGE FLUVIAL DEPOSIT
- SUBSOIL GRAVELLY SAND WITH SOME SANDY GRAVEL ZONES
- LOW MOISTURE CONTENTS
- TEST HOLES TERMINATED AT 10-11' DUE TO HOLES CAVING
- EXCELLENT BORROW SOURCE
- MAY BE A SOURCE OF SURFACING MATERIAL
- TEST PITTING RECOMMENDED AT CONSTRUCTION

	drawing title / titre du dessin: BORROW PIT 53	designed by / conçur par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle: 1"=300'	approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

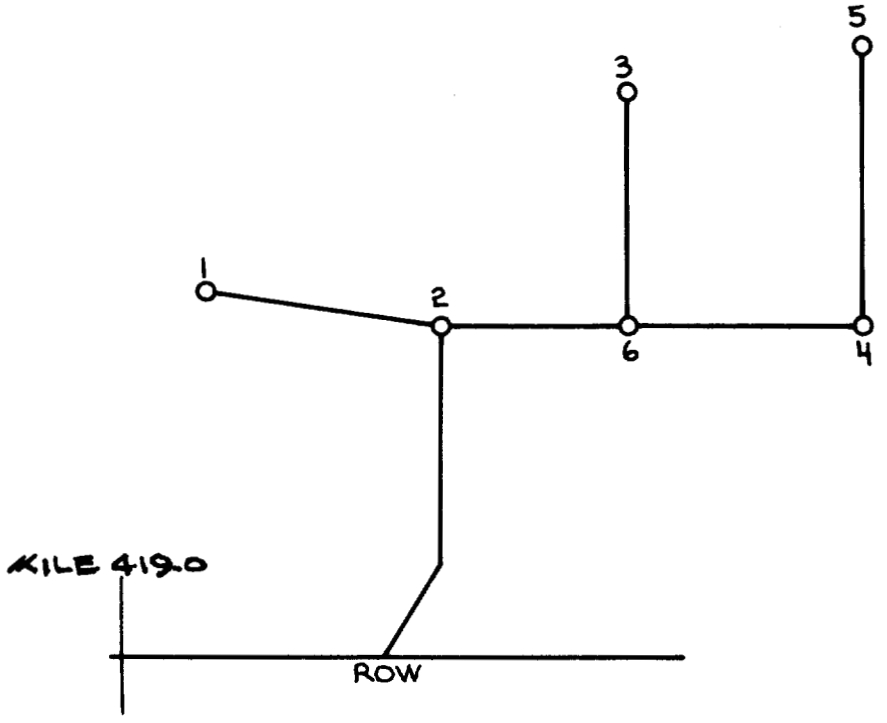
MILE 418.9 - BORROW PIT NO. 54

- 500 feet right of centerline.

Pit area No. 54 is on a portion of the glaciofluvial deposit in which Pit No. 53 is located but in an area of subdued relief. It is heavily treed with spruce, jackpine and poplar. Subsoil consists of silty sands, with occasional gravelly sand zones. Moisture contents are low throughout and the area is largely unfrozen. Recommended as an embankment borrow source if required, but holds little promise as a source of surfacing materials.

... 26

MILE 418·9 - 500' RT. OF ℄



NOTES

- SUBSOIL SILTY SAND AND GRAVELLY SAND
- LOW MOISTURE CONTENTS
- LITTLE OR NO PERMAFROST
- EXCELLENT BORROW SOURCE
- AREA HEAVILY TREED WITH SPRUCE AND JACKPINE
- LITTLE OR NO RELIEF

Public Works Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 54

scale / echelle 1"= 200'

designed by / conçur par date

drawn by / dessiné par date

reviewed by / examiné par date

approved by / approuvé par date

region

region

revisions date

revisions

project number

no. de entreprise

drawing no

no du dessin

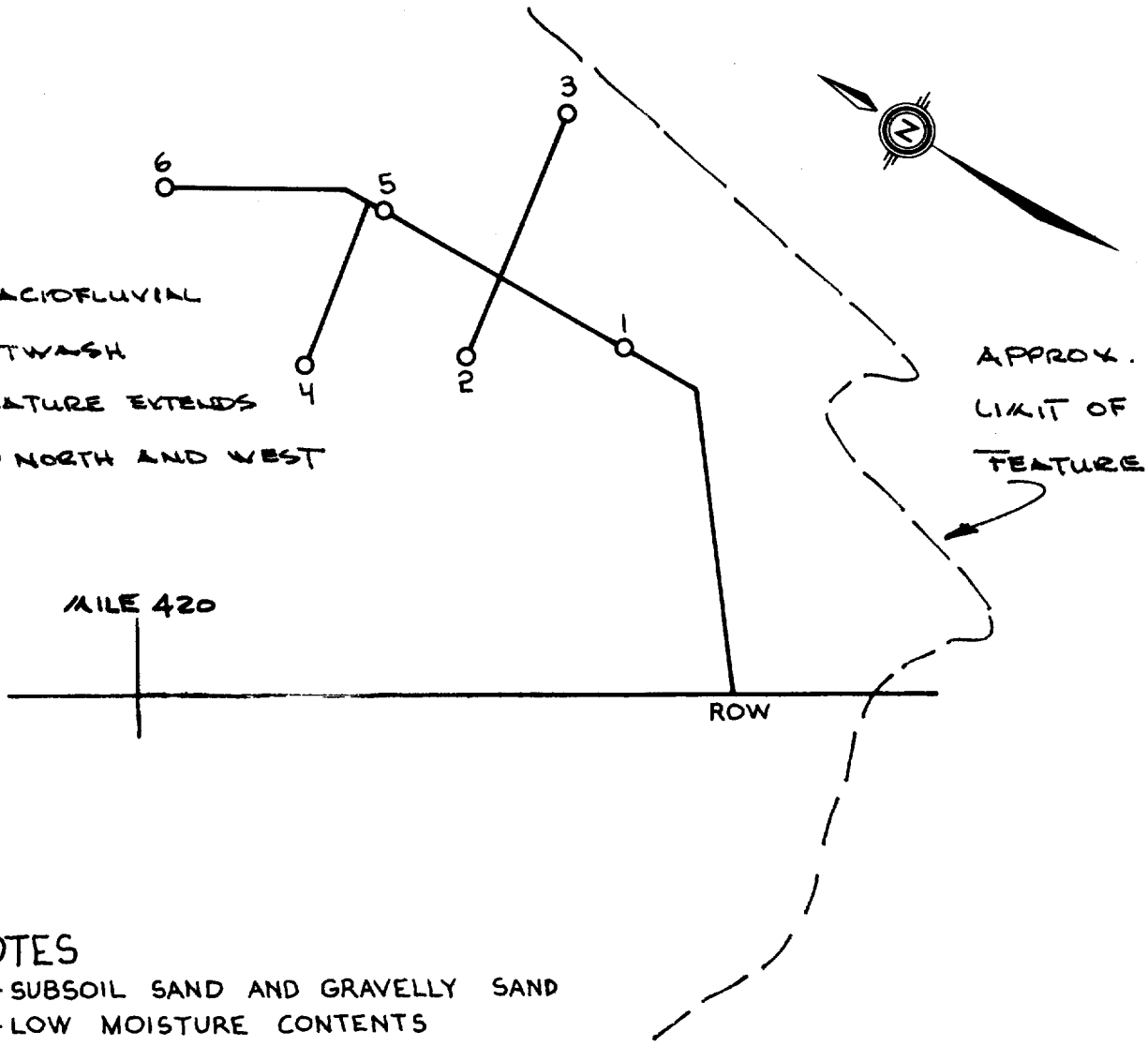
D.P.W. 700 A

MILE 419.8 - BORROW PIT NO. 55

- 500 feet right of centerline.

This pit is near the edge of a large glaciofluvial outwash plain and is similar to Pits 53 and 54. Subsoil is primarily sand with some gravelly zones. Moisture contents are low throughout and there is little or no permafrost. Maximum hole penetration was to 12' due to caving of the cohesionless subsoil. Area is heavily treed with spruce and jackpine. Recommended for embankment borrow but unsuitable as a source of surfacing materials.

... 28



NOTES

- SUBSOIL SAND AND GRAVELLY SAND
- LOW MOISTURE CONTENTS
- LITTLE OR NO PERMAFROST.
- EXCELLENT BORROW SOURCE
- AREA HEAVILY TREED WITH SPRUCE AND JACKPINE

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 55

scale / échelle 1"= 200'

designed by / conçur par date

drawn by / dessiné par date

reviewed by / examiné par date

approved by / approuvé par date

region

région

revisions date

révisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 420.0 TO 425.1 - REVISION

This revision, for the most part, is located on a large glacio-fluvial outwash plain. The plain is dissected at Mile 422.7 and at Mile 424.3 by small creek valleys. A total of 34 test holes were drilled along centerline on the five mile revision. The material in the outwash plain consists of medium to coarse grained sands and gravelly sands from Mile 420 to 423, with an increase in silt content and a decrease in gravel sizes north of Mile 423. Permafrost is generally absent along the revision, with the exception of the area north of Mile 424 where the subsoil is higher in silt content. Moisture contents are generally low throughout, again the exception being north of Mile 424.5 where sporadic ice-rich zones are wet on thawing. A balanced grade line is proposed throughout the revision and no problems with cuts are anticipated with the possible exception of the cut north of Mile 424.3 from Station 1549 to 1569. There is permafrost along much of this cut and the sandy subsoil to the depth of cut is wet on thawing and generally unsuitable for borrow. Consideration should be given to raising the grade line within this cut section.

A major culvert is proposed in the creek at Mile 422.7 and a test hole at the culvert location (422-C-5) revealed unfrozen sand and gravelly sand to the depth of 8' where water was encountered forcing the hole to be abandoned. Subsoil data from the single hole

... 30

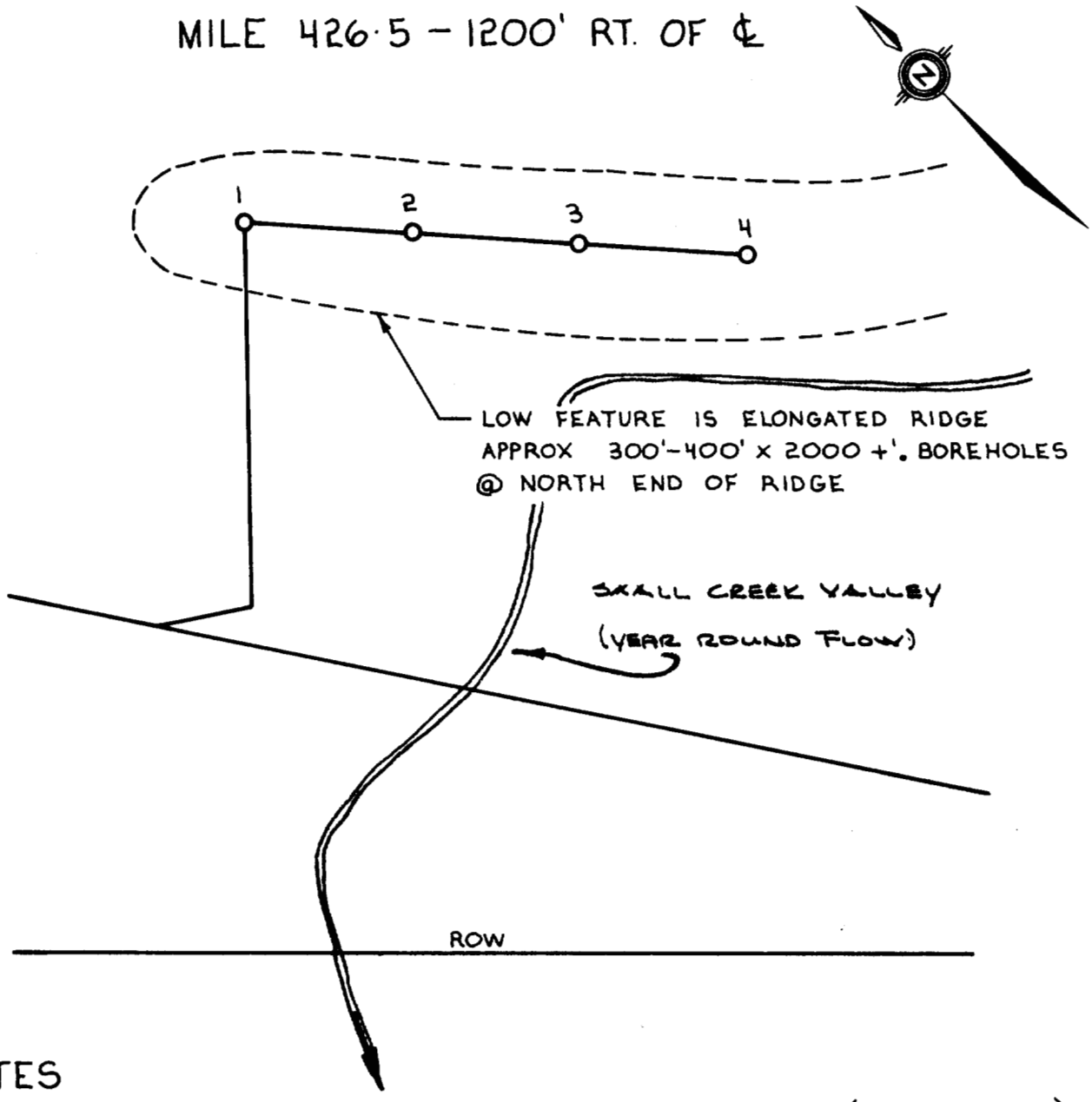
is inconclusive, however, based upon the surficial geology of the area, it is considered likely that a good base will be available for the culvert installation.

MILE 426.0 TO 426.6 - BORROW PITS 56, 56A AND 56B

- Both right and left of centerline.

These three areas were drilled on what is thought to be thin glacial lake sediments over glacial till. Of the three areas, Borrow Pit 56B located 1200 feet right of centerline at Mile 426.5 is the preferred area. The feature here is an elongate ridge some 300 to 400 feet wide and 2000 to 2500 feet in length. It is treed with large spruce to 2 feet in diameter. Subsoil is low plastic sandy silty clay with pebbles (glacial till). Moisture contents, for the most part, are below 10% and no permafrost was reported. This is considered to be an excellent borrow source.

MILE 426·5 – 1200' RT. OF ℄



NOTES

- SUBSOIL LOW PLASTIC SANDY SILTY, CLAY WITH PEBBLES (GLACIAL TILL)
- NO PERMAFROST REPORTED
- MOISTURE CONTENTS GENERALLY ≤ 10%
- GOOD BORROW SOURCE

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 56B	designed by / conçur par — date
	scale / echelle: 1"= 300'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region	revisions — date	project number / no. de entreprise
region	revisions	drawing no / no du dessin

D.P.W. 700 A

MILE 426.7 - TEST HOLE #426-C-2 - ON CENTERLINE

This hole was drilled on the north side of a small creek valley at approximately Station 1673. A cut section is proposed here from Station 1668 to approximately 1677 and reaching a maximum depth of 10 feet. The area is on a deltaic sand plain and subsoil to the depth of drilling at 15 feet is silty, clay-sand. Permafrost is present below 6-7' and moisture (ice) contents below the depth of 4-5' are in excess of 15% and the subsoil is wet or saturated in the thawed state. The bottom of the cut and the lower portion of the back slopes will be saturated upon thawing however, as the cut is shallow, very little back slope slough will occur and, as ice contents are low, little or no subsidence is expected. The roadway should be sub-excavated at least to ditch line and back filled.

MILE 427.4 - TEST HOLES 427-C-1 AND C-2 - ON CENTERLINE

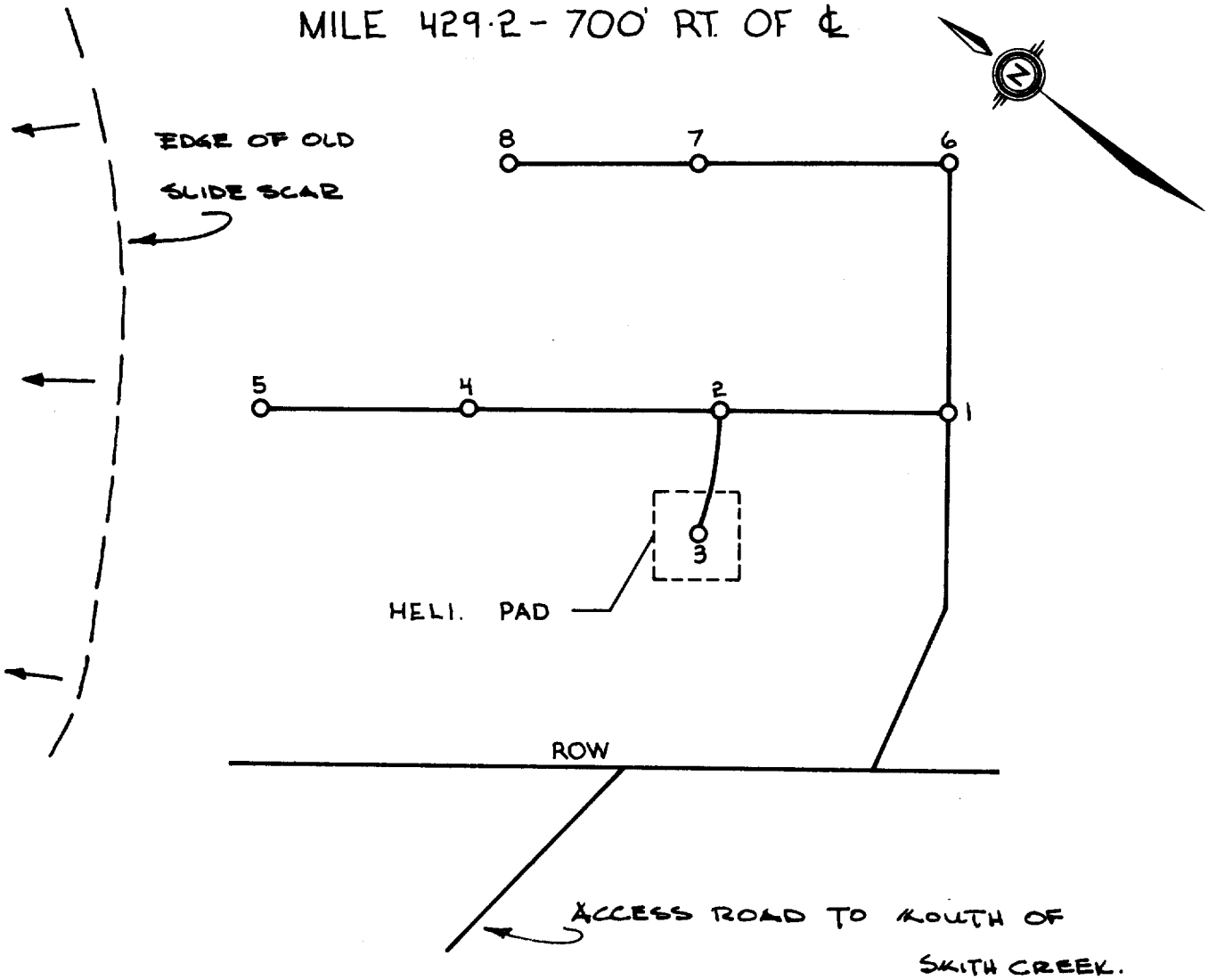
These holes are located in a proposed cut on the south side of a small stream valley near Mile 427.5. The proposed cut will extend from Station 1705 to Station 1715 and will reach a maximum of 20 feet at Station 1709. Subsoil is low plastic silty, clay-sand. Permafrost is present below a depth of 6-7' and moisture contents on thawing below that depth are in excess of 20%, and the sand is wet or saturated in the thawed state. The subsoil below the permafrost level is unsuitable for embankment construction and sub-excavation will be required to ditch line. Minor

sloughing may occur in the lower part of back slopes, however, it is not expected to be significant enough to warrant blanketing of slopes. The grade line here approaches 5% slope and, as the sandy subsoil is easily erodable, ditch checks should be provided.

MILE 429.2 - BORROW PIT NO. 57

- 700 feet right of centerline.

The area test drilled here is thought to be part of an abandoned terrace of the Mackenzie River. It is located immediately above an old slide area on the south side of Smith Creek and is some 3500 feet south of the Smith Creek crossing. The area is heavily treed with spruce and poplar. Subsoil varies from gravelly sands to sandy gravels and many holes were stopped short of 10 feet due to caving of the cohesionless deposits. Permafrost is at least partially present, although the surficial deposits penetrated in the drill holes were generally unfrozen with moisture contents less than 5%. This should be an excellent source of embankment borrow, and possibly a good source of granular material for culvert backfill.



NOTES

- SUBSOIL GRAVELLY SAND - SOME SANDY GRAVEL
- DRY TO AT LEAST 10'
- EXCELLENT BORROW SOURCE
- PERMAFROST SPORADIC BUT GENERALLY ABSENT TO AT LEAST 10'

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 57	designed by / conçur par — date
	scale / echelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 429.3 TO 430.0 - SMITH CREEK SLIDE AREA

The area of interest here is an old slide scar on the south side of the Smith Creek Valley. The area measures some 3000' x 4000' and the proposed highway route descends directly across the slide scar to the crossing of Smith Creek. The proposed grade-line rolls over the ground contours with fill section throughout.

Test holes were drilled for two purposes:

First, to investigate the feasibility of a cut section in the upper portion of the slide area where the route begins its descent to Smith Creek, and second, to determine the stability of the old slide area. Eight test holes (429-C-1,-2,-3,-3A, -3B,-4,-4A-4B) were drilled in the area of possible cut at the top of slope. These holes revealed low plastic silty sandy clay at depth with a thin overlay of silty sand. Permafrost is present throughout and ice contents are low to moderate. A deep cut is not recommended here, however, near surface soils are not especially wet on thawing and, as a shallow cut would appear to reduce qualities significantly across the slide area, it is recommended that the grade-line in this area be reviewed with consideration being given to introduction of a shallow cut at the top of slope.

The stabilized slide is in an area of old glacial lake-bed sediments. Subsoil encountered in all test holes consisted of low to medium plastic sandy silty clays. Permafrost is present throughout and

... 36

ice contents vary from moderate to high. The slide area should be disturbed as little as possible by construction, however, as permafrost is present throughout, renewal of slide movement will not occur.

MILE 430.05 - TEST HOLE 430-C-1 - ON CENTERLINE

On the north side of Smith Creek is an extensive terrace of the Mackenzie River composed of stratified, fluvial and/or outwash sands and gravels. A cut to a maximum depth of approximately 40 feet is proposed in the steep exposed face of the terrace. A single test hole here was terminated at a depth of 8' due to caving of cohesionless sands and gravels, however, inspection of the exposed face suggests no problems will be encountered in cuts in the granular terrace.

MILE 433.5 TO MILE 439.5 - WRIGLEY REVISION

This revision is a by-pass around the settlement of Wrigley and includes a crossing of Hodgson Creek. A total of 46 test holes were drilled along the revision and along the Wrigley access road. In addition five borrow areas were investigated (Borrow Pit 59 to Borrow Pit 63).

The proposed by-pass re-routes the highway off of a granular terrace along the Mackenzie River and onto glacial lake sediments.

From Mile 434 to approximately Mile 435 the route crosses a flat, poorly drained terrain with peat filled depressions and ice-rich silty clay subsoil. At Mile 435 the route turns parallel to the valley wall of the Mackenzie River, and to Mile 436.5 alternately crosses low shoulders and erosional channels near the base of the valley slope. Much of the material along this section is ice-rich silty clay, however, the better drained shoulders contain dry material and will be suitable for shallow cuts and borrow.

Since the time of drilling, the location of the by-pass from Mile 436 to approximately Mile 439.5 has been changed and the route test-drilled will not be used, hence no further comments will be made here on the test borings on that section, although the location of the test holes and the test hole logs are included in Volume II. A revised crossing over Hodgson Creek near Mile 437 is included in the relocation. Two borrow areas were investigated on the lower valley slope to Mile 436, Borrow Pit 59 at Mile 434.9 and Borrow Pit 60 at Mile 435.9. Both areas are good sources of embankment borrow, and are discussed below.

MILE 434.8 (WRIGLEY BY-PASS) - BORROW PIT NO. 59

- 500 feet right of centerline.

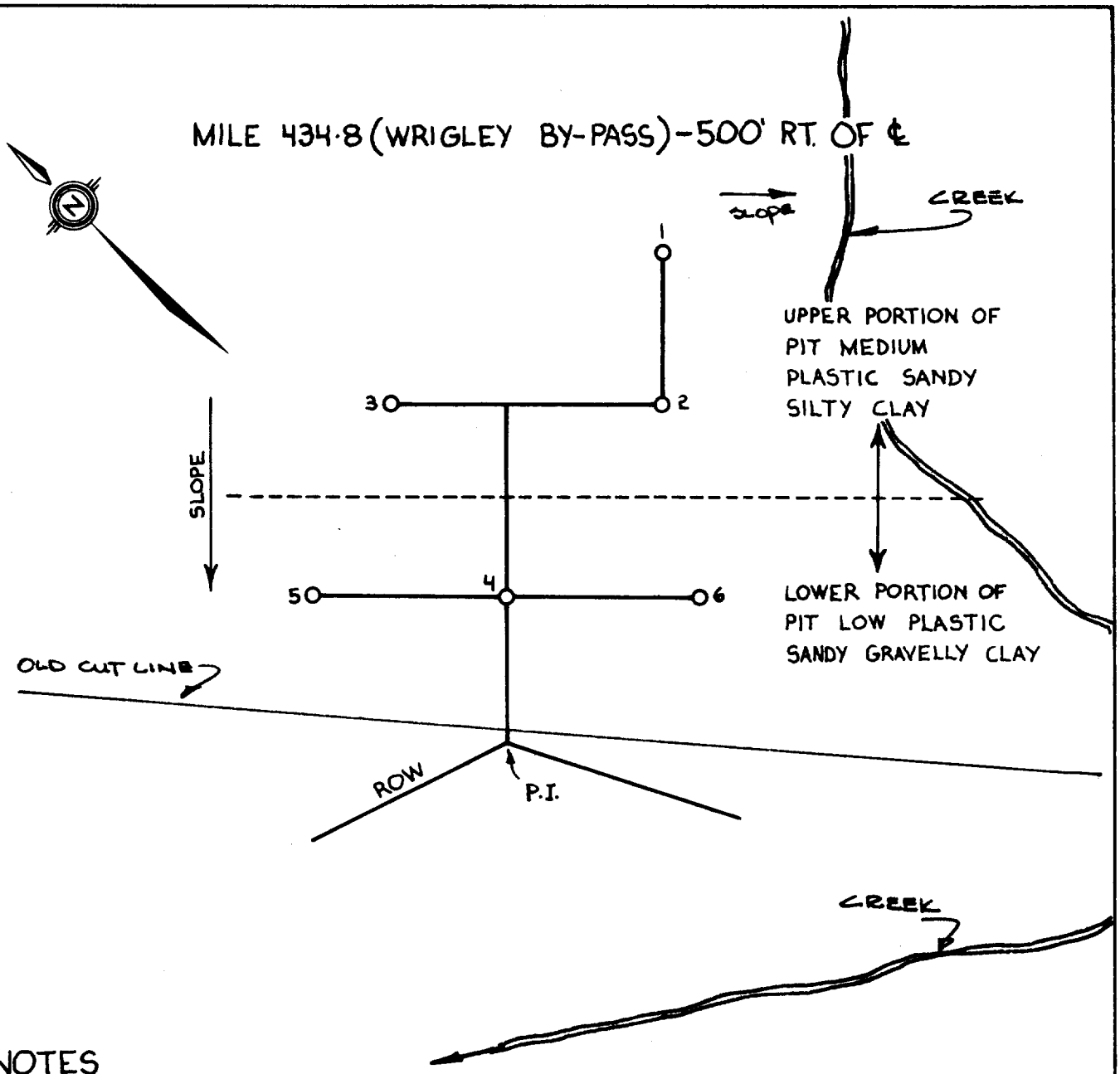
This pit is located in a heavy stand of poplar near the base of the valley slope and is bordered on the south by a small creek.

The area is well drained and appears to be permafrost free. Two soil types were encountered:- in the south-eastern portion (test holes 1, 2, and 3), the subsoil is a medium plastic, silty clay with moisture contents between 15 and 20% and near the plastic limit of the material; in the north-western portion of the pit, which is at a low elevation, the subsoil is a gravelly, sandy clay, very low plastic and with moisture contents generally less than 10%. Both material types are suitable for borrow. Little stripping will be required.

MILE 435.9 (WRIGLEY BY-PASS) - BORROW PIT NO. 60

- 500 feet right of centerline.

Area test drilled is near the base of the south facing valley slope. It is heavily treed with poplar and no permafrost was noted. Subsoil is medium plastic silty clay. Moisture contents are near 20% and slightly below the plastic limit. Stripping will be 1 to 2 feet. An excellent borrow source.

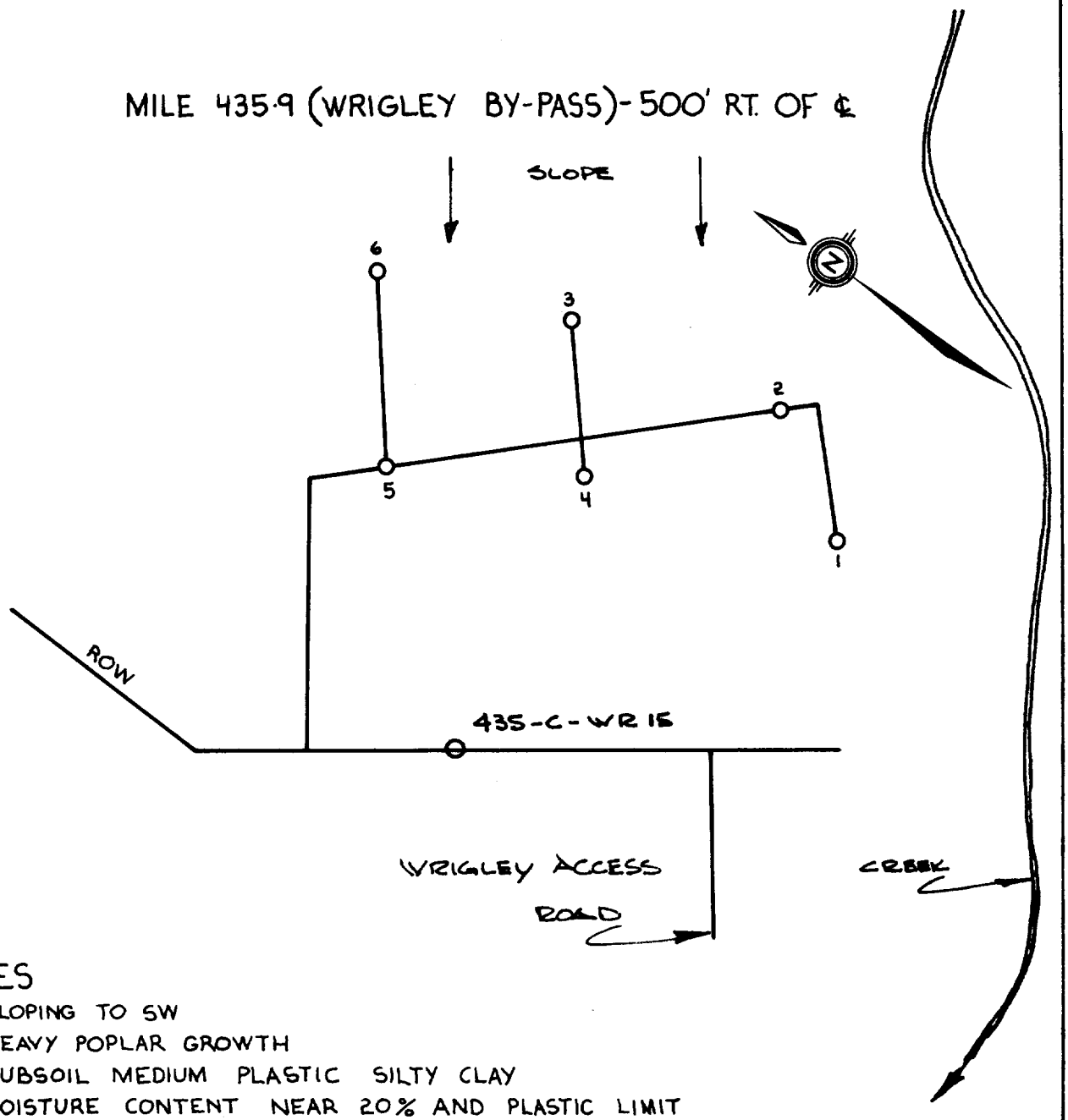


NOTES

- AREA HEAVILY TREED WITH POPLAR
- NO PERMAFROST EVIDENT
- EXCELLENT BORROW SOURCE

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 59	designed by / conçu par — date
	scale / échelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A



NOTES

- SLOPING TO SW
- HEAVY POPLAR GROWTH
- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- MOISTURE CONTENT NEAR 20% AND PLASTIC LIMIT
- NO PERMAFROST
- EXCELLENT BORROW SOURCE

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 60

scale / échelle 1"= 200'

designed by / conçu par date

drawn by / dessiné par date

reviewed by / examiné par date

approved by / approuvé par date

region

region

revisions date

revisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 438.1 (WRIGLEY BY-PASS) - BORROW PIT NO. 61

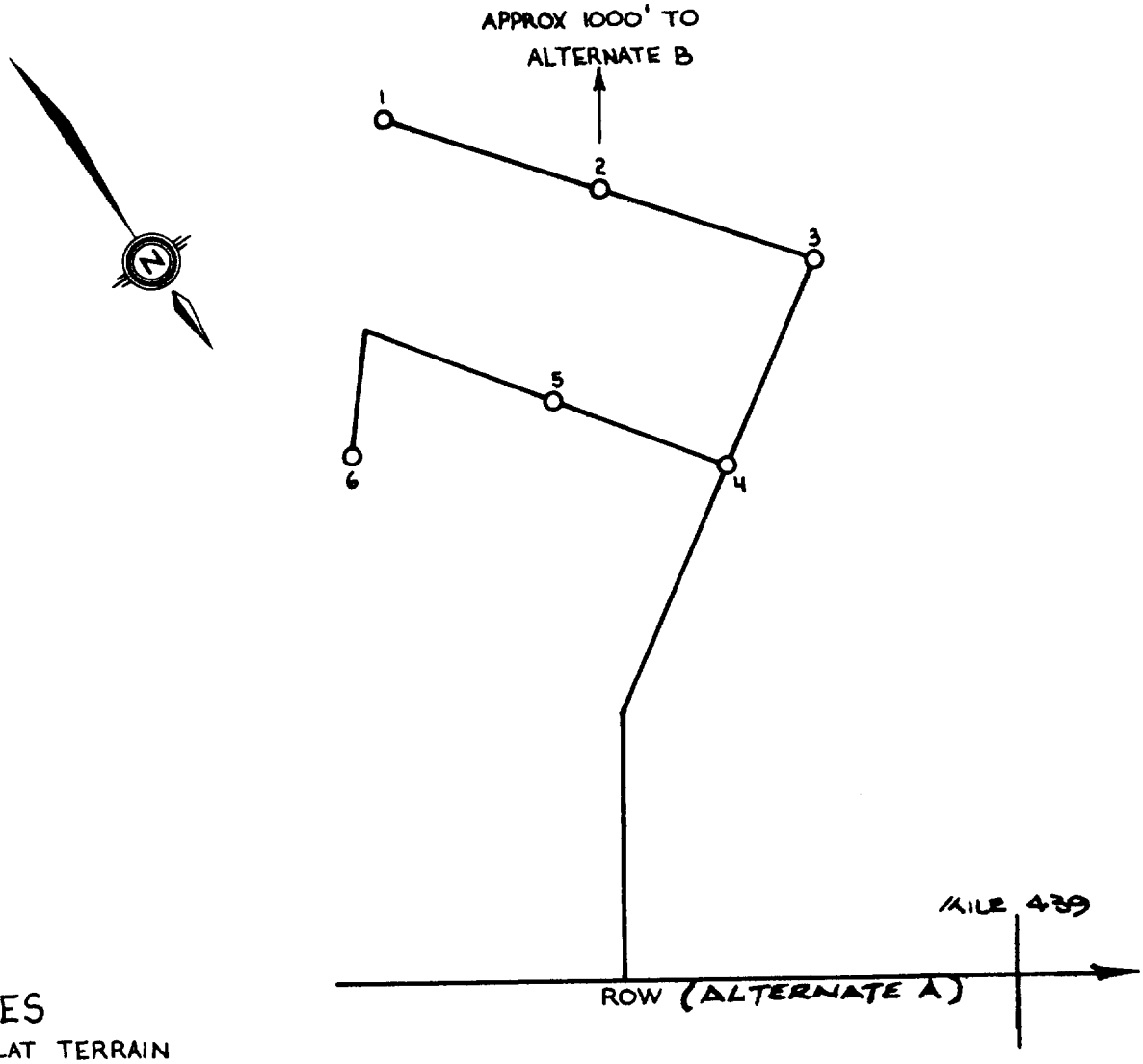
This pit was near the original Wrigley By-Pass (Alternate A - see mosaic in Volume II). A subsequent revision here (Alternate B) will place Borrow Pit 61 approximately 4000 feet from the right-of-way. Consequently, it is not recommended as a borrow source.

MILE 439.0 (WRIGLEY BY-PASS) - BORROW PIT NO. 62

- 1,000 feet right of centerline - Alternate B

Area test drilled is on flat poorly drained glaciolacustrine plain in a heavy stand of spruce and poplar. Subsoil is medium plastic silty clay. Permafrost is sporadic but the majority of the area is frozen. Moisture (ice) contents average slightly below 20% and near the plastic limit. Stripping depths are estimated at 2 to 3 feet. Considered to be a usable borrow source in an area of generally poor borrow.

APPROX MILE 439 (WRIGLEY BY-PASS)



NOTES

- FLAT TERRAIN
- HEAVY SPRUCE AND POPULAR GROWTH
- SUBSOIL MEDIUM - HIGHLY PLASTIC SILTY CLAY
- PERMAFROST SPORADIC
- MOISTURE (ICE) CONTENT NEAR 20% AND PLASTIC LIMIT
- 2-3' OF STRIPPING
- ACCEPTABLE BORROW SOURCE

	drawing title / titre du dessin: BORROW PIT 62	designed by / conçu par — date	
		drawn by / dessiné par — date	
		reviewed by / examiné par — date	
	scale / échelle 1" = 200'	approved by / approuvé par — date	
region / region	revisions / revisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

MILE 439.3 (WRIGLEY BY-PASS) - BORROW PIT NO. 63

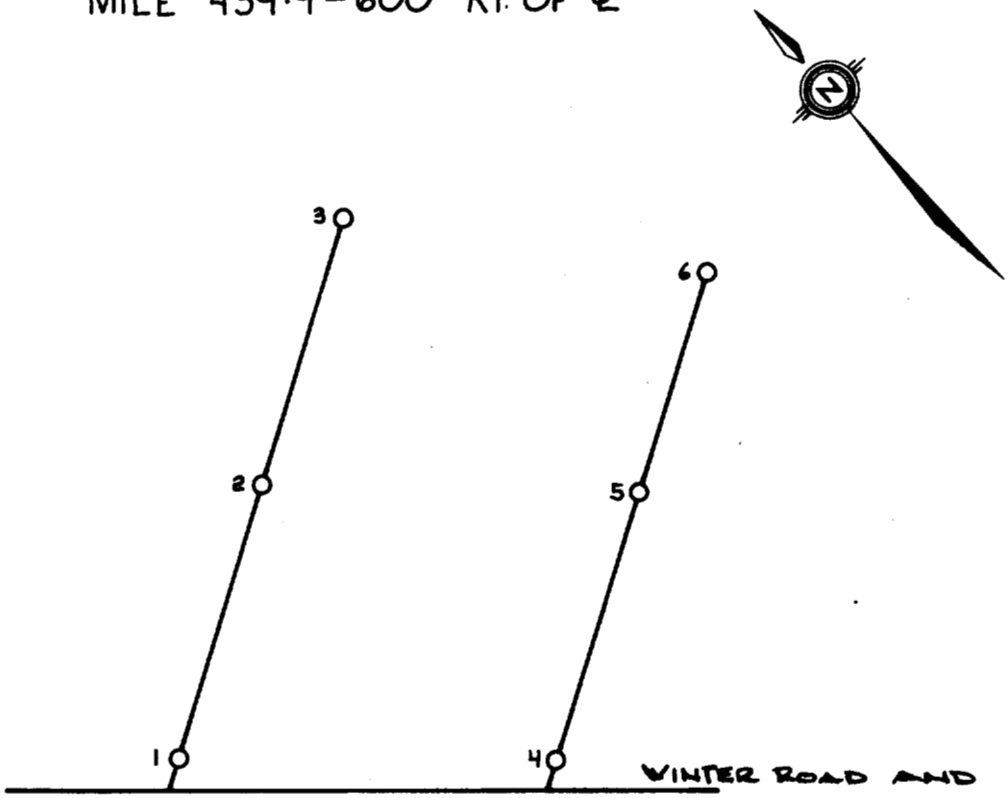
Centerline of Alternate B (Wrigley By-Pass) passes directly through the centre of the area test-drilled here. In addition, Borrow area 63 is within approximately 1500 feet of Borrow Pit 62, consequently it is not recommended as a borrow source.

MILE 439.9 - BORROW PIT NO. 64

- 600 feet right of centerline.

The terrain here is a very flat, poorly drained glaciolacustrine plain which exhibits thermokarst lakes, ponds and muskeg bogs. Area test drilled is in a stand of 3 to 4" diameter spruce with some birch. Subsoil is medium plastic silty clay. Permafrost is continuous and ice contents are low. Upon thawing, moisture contents are in the 20 to 25% range and at, or slightly above, the plastic limit. Stripping depths vary from 2 to possibly 5 feet. Considered to be a borderline source of borrow, however, there is no better quality material available within 2 or 3 miles.

MILE 439·9 – 600' RT. OF ℄



NOTES

TERRAIN FLAT LYING WITH POOR DRAINAGE
PIT AREA IN STAND OF SPRUCE AND BIRCH
SUBSOIL MEDIUM PLASTIC SILTY CLAY
PERMAFROST THROUGH-OUT WITH LOW VISIBLE ICE CONTENT
MOISTURE (ICE) CONTENT 20-25% AND SIGHTLY ABOVE PLASTIC LIMIT

	drawing title / titre du dessin BORROW PIT 64 scale / echelle 1" = 200'	designed by / conçur par date drawn by / dessiné par date reviewed by / examiné par date approved by / approuvé par date
region region	revisions date revisions	project number no. de entreprise drawing no no du dessin

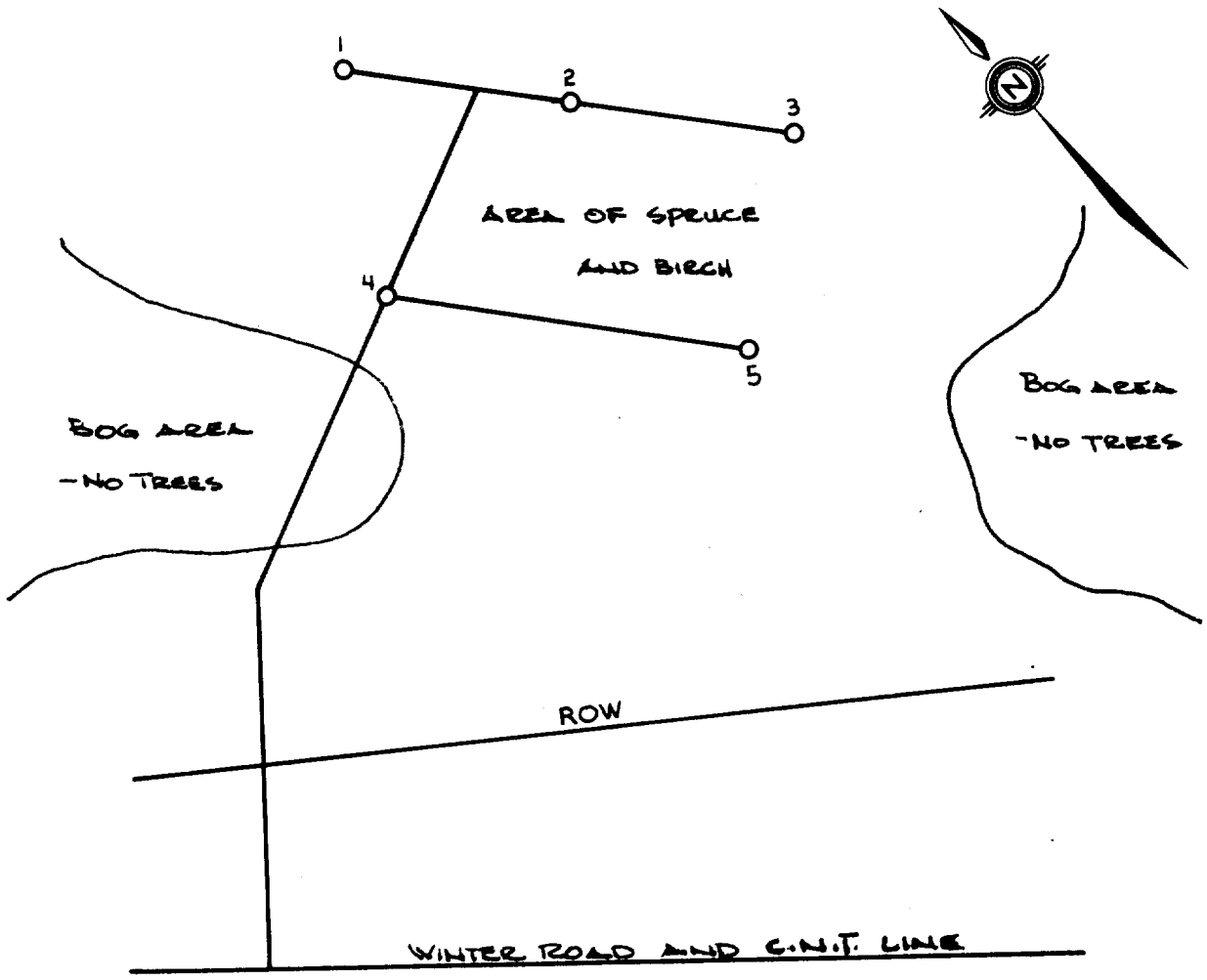
D.P.W. 700 A

MILE 440.6 - BORROW PIT NO. 65

- 800 feet right of centerline.

Area drilled here is a heavy stand of spruce and birch in an otherwise sparsely treed, flat, poorly drained terrain which is part of an extensive glaciolacustrine plain. Subsoil is medium plastic silty clay. Permafrost is present throughout and ice contents are low. Moisture contents on thawing range between 20 and 25% and slightly above the plastic limit. Stripping depths vary from 2-4'. Material is similar in quality and moisture content to Borrow Pit 64 and as the two are in close proximity (approximately 2/3 of a mile) it is recommended that only one area be developed.

MILE 440·6 - 800' RT. OF ℄



NOTES

SUBSOIL MEDIUM PLASTIC SILTY CLAY
PERMAFROST THROUGH OUT
MOISTURE (ICE) CONTENT 20-25% SLIGHTLY ABOVE PLASTIC LIMIT
WITHIN 4000' OF BP-64
ACCEPTABLE BORROW SOURCE

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 65	designed by / conçur par — date	
	scale / echelle: 1"=200'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / region	revisions / revisions — date	project number / no. de entreprise	drawing no / no du dessin

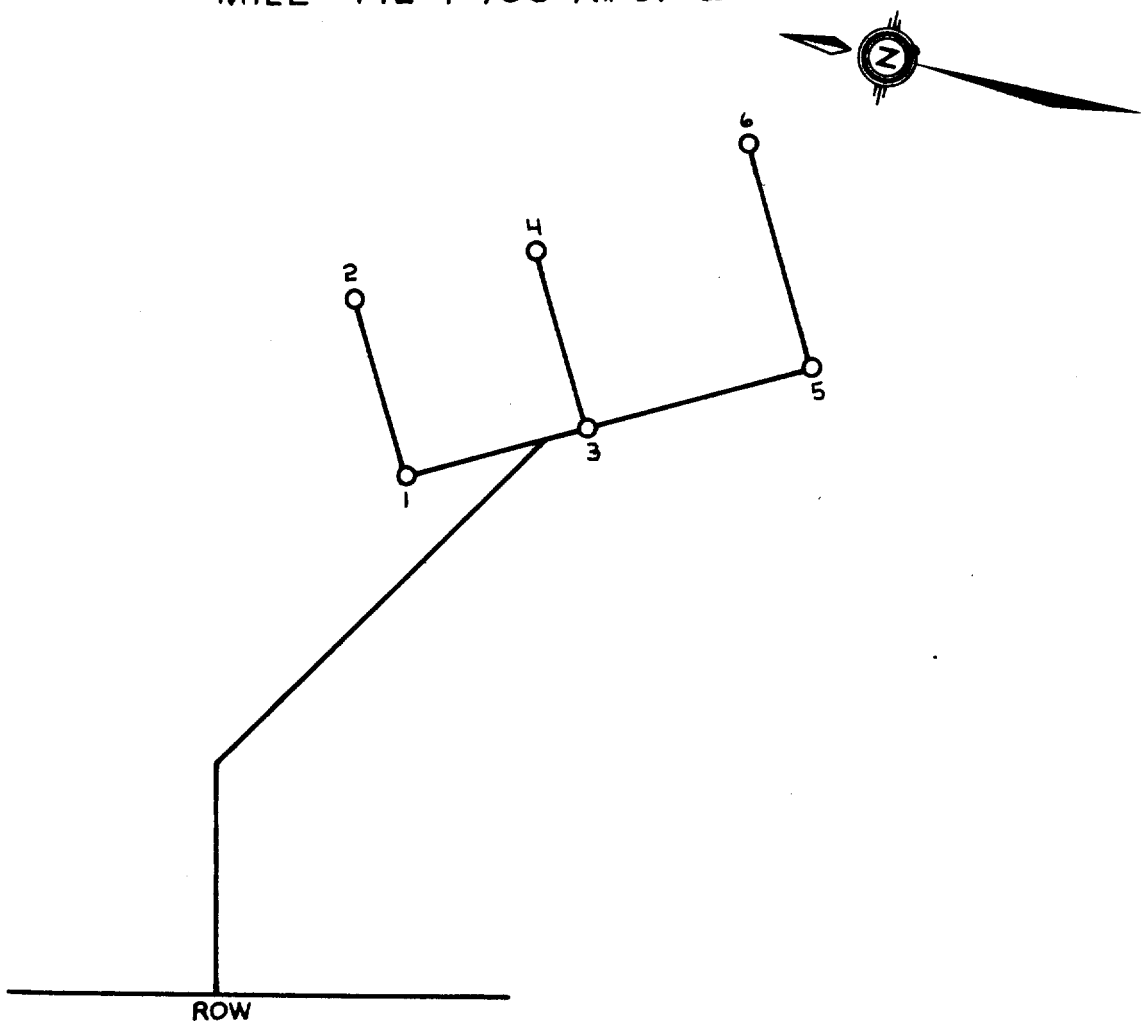
D.P.W. 700 A

MILE 442.4 - BORROW PIT NO. 66

- 700 feet right of centerline.

The terrain here is a continuation of the flat sparsely treed, poorly drained, lake sediments which are marked by numerous small lakes and pot holes. Area test drilled is an isolated stand of heavy spruce and poplar. Six test holes over an area measuring 400' x 600' encountered medium plastic silty clay. Permafrost is continuous and moisture (ice) contents range up to 20% and are generally at or slightly below the plastic limit. Stripping depths are estimated at 2-3'. Considered to be an acceptable borrow source in an area of extremely poor material.

MILE 442·4-700' RT. OF ℄



NOTES

SUBSOIL MEDIUM PLASTIC SILTY CLAY
FROZEN WITH MOISTURE (ICE) CONTENT BELOW 20% AND AT OR BELOW PLASTIC LIMIT
ACCEPTABLE BORROW SOURCE

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 66	designed by / conçur par — date	
		drawn by / dessiné par — date	
		reviewed by / examiné par — date	
	scale / échelle: 1"=200'	approved by / approuvé par — date	
region / region	revisions / révisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

MILE 443.5 - TEST HOLES 443-C-1 TO 443-C-4 - PROPOSED CUT SECTION

A cut to a maximum depth of approximately 10 feet is proposed here over a distance of some 1200 feet. The test holes revealed low to medium plastic silty clay to depths well below the ditch line. Permafrost is present, however, ice contents are generally low and moisture contents on thawing are near the plastic limit. The subsoil here will be suitable for embankment borrow and no construction or maintainence problems are anticipated in the cut.

MILE 444 TO 445 - BORROW PITS 67, 68, AND 69

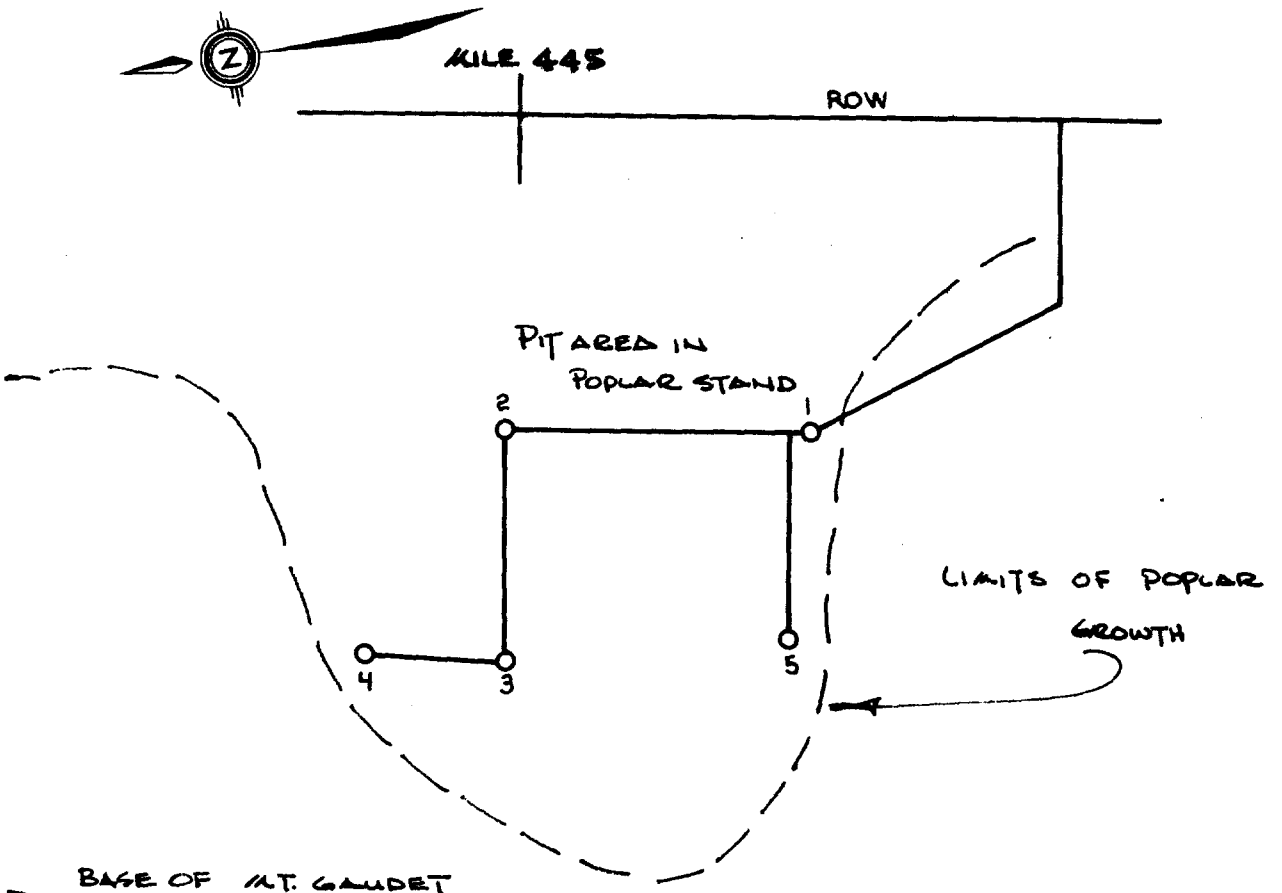
From Mile 444 to 445 the right-of-way crosses flat, poorly drained, sparsely treed, glaciolacustrine sediments near the base of Mount Gaudet. Three potential borrow areas were investigated: At Mile 444.1 (Borrow Pit 67); at Mile 444.7 (Borrow Pit 68); and at 444.9 (Borrow Pit 69). The subsoil in all areas consisted of medium plastic silty clay. Permafrost is continuous throughout and moisture (ice) contents are erratic. It is unlikely a borrow pit could be developed in any of the areas drilled without encountering some ice-rich material. Of the three, Borrow Pit 69 is preferred although the area of suitable material is relatively small, measuring only approximately 300' x 400'. There is a stand of poplar located near Mile 444.5 which probably contains good borrow but which was not drilled as it is some 2000 feet off the right-of-way. It is suggested that the material for construction between Mile 444

... 50

to 445 be obtained by expanding the cuts at Mile 443.5 and at Mile 445.4 and, if necessary, by developing Borrow Pit 69. Borrow Pit 67 and 68 are not recommended. Stripping in Borrow Pit 69 will probably average 2-3'.

... 51

MILE 444·9 - 400' LT. OF ℄



NOTES

- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- FROZEN WITH MOISTURE (ICE) CONTENT NEAR 20% AND SLIGHTLY ABOVE THE PLASTIC LIMIT
- PREFERRED BORROW SOURCE IN AN AREA OF POOR MATERIAL

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 69	designed by / conçur par — date
	scale / échelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 445.4 - TEST HOLES 445-C-1 TO 445-C-5 - PROPOSED CUT SECTION

A shallow cut to a maximum depth of approximately 10 feet and extending over a distance of 1500 feet is proposed near Mile 445.4. The test holes here revealed medium to highly plastic silty clay to depths well in excess of the ditch line. The holes were drilled on the CNT line and, although permafrost was not continuous throughout the depth of the holes, it is expected that permafrost will be continuous adjacent to the cleared CNT line. Moisture contents, for the most part, are between 20 and 25% and at or slightly above the plastic limit of the material. Material from the cut can be used for embankment borrow and no construction or maintainence problems are anticipated in the cut.

MILE 446.6 - TEST HOLES 446-C-1 TO 446-C-6 - POTENTIAL CUT SECTION

Near Mile 446.6 the right-of-way crosses a long low ridge some 15 to 20 feet above the surrounding terrain. The grade line presently rolls over this ridge entirely in fill section, and the test holes were drilled here to investigate the possibility of a shallow cut. The subsoil throughout is medium to highly plastic silty clay. Permafrost is continuous with the possible exception of the CNT right-of-way and the moisture contents on thawing vary around 25% and slightly above the plastic limit. The material is described as damp or moist in the thawed state and a cut to roughly 10 feet would appear to be feasible here with the excavated material suitable for embankment construction.

... 53

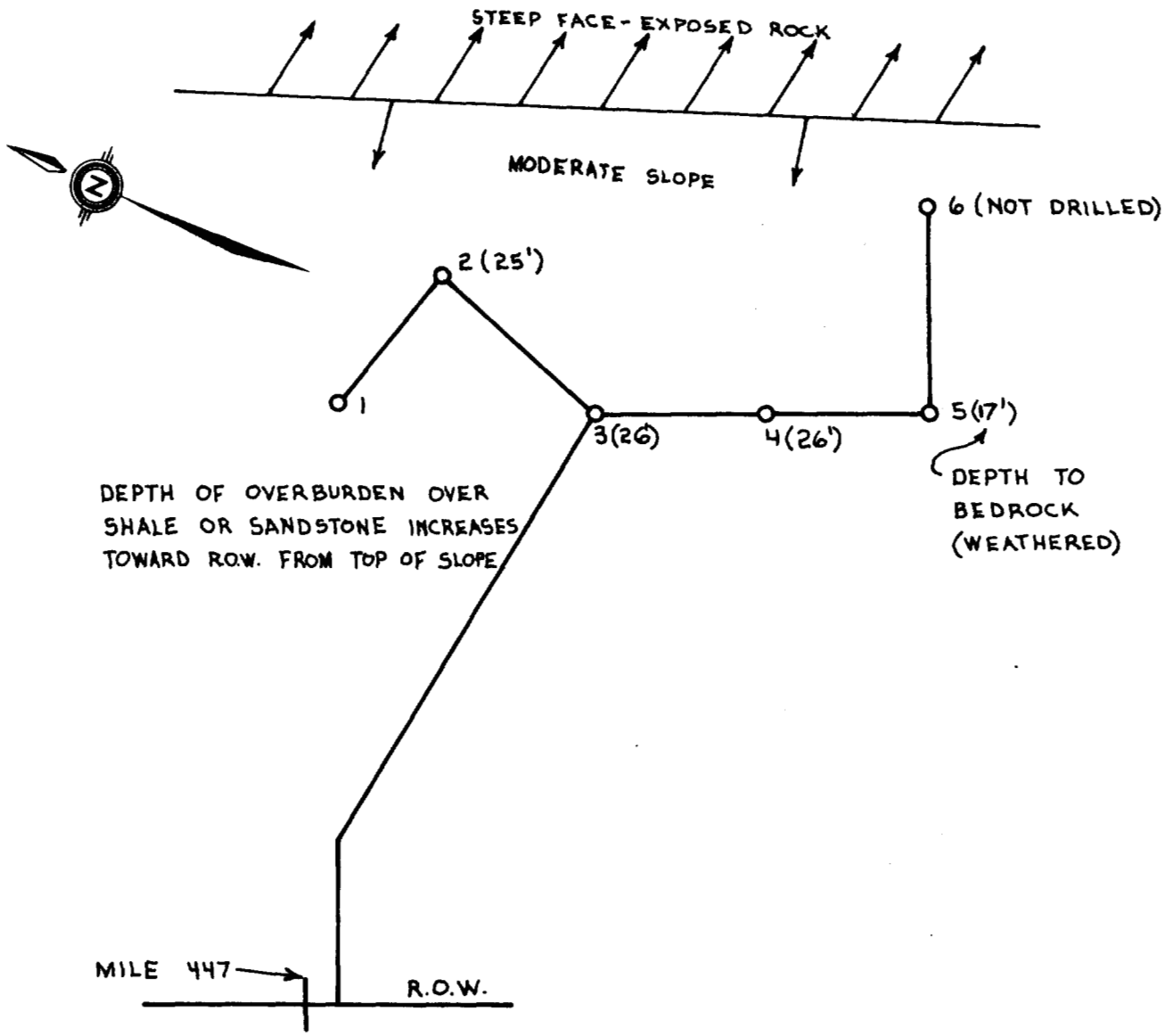
MILE 447.0 - BORROW PIT NO. 70

- 800 feet right of centerline.

This pit is located on the flank of a ridge that is a continuation of Mount Gaudet. The area test drilled is near the top of the ridge in heavy spruce cover. Material is primarily medium plastic silty clay over shale or sandstone bedrock at depths generally in excess of 20'. Moisture contents are near 20% and vary around the plastic limit. Permafrost may be present. Stripping will vary from probably 3-5'. This area is considered suitable as a borrow source. There are bedrock exposures on the eastern face of the ridge and the depths to bedrock are shown on the site plan for each hole.

... 54

MILE 447·0 - 800' RT. OF ℄



NOTES

- PIT ON RIDGE THAT IS CONTINUATION OF MT. GAUDET
- SUBSOIL SILTY CLAY OVER SHALE OR SANDSTONE
- PERMAFROST PARTALLY PRESENT - MOISTURE CONTENTS NEAR 20%
- STRIPPING PROBABLY 3'-5'
- SUITABLE BORROW SOURCE

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 70

scale / échelle 1"=200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

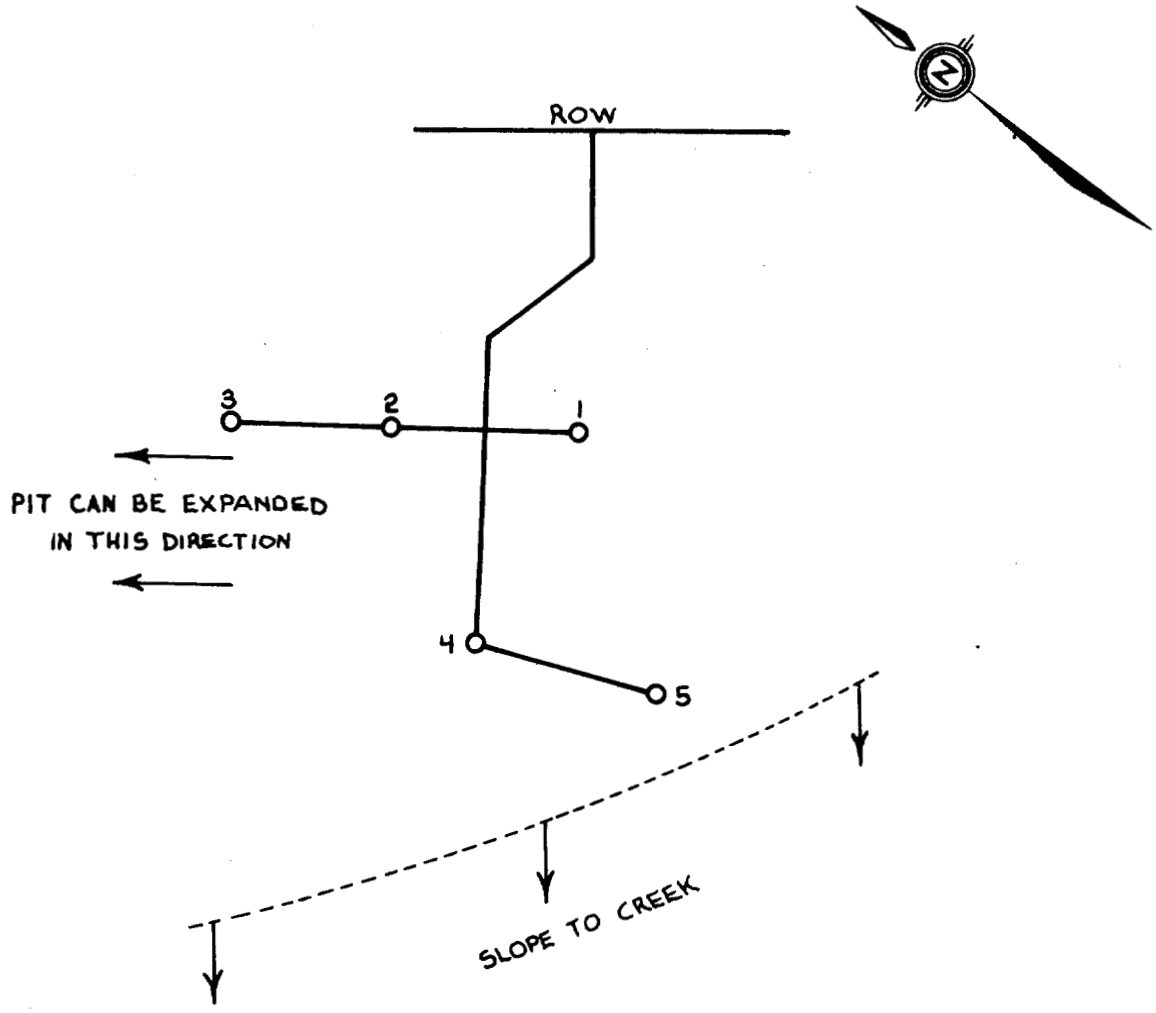
D.P.W. 700 A

MILE 448.7 - BORROW PIT NO. 71

- 500 feet left of centerline.

Pit No. 71 is located in a stand of dense birch between the right-of-way and a small creek valley which parallels the route. Subsoil is medium plastic silty clay with moisture (ice) contents averaging near 20% and at the plastic limit. Permafrost is continuous. Stripping depths vary from 1 to probably 3'. This area is suitable for borrow and although the area drilled is limited, the pit can be expanded parallel to the creek valley in a north-westerly direction.

MILE 448·7 – 500' LT. OF ℄



NOTES

- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- FROZEN WITH MOISTURE (ICE) CONTENTS NEAR 20% AND THE PLASTIC LIMIT
- 1–3' OF STRIPPING
- ACCEPTABLE BORROW SOURCE

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 71	designed by / conçu par — date
	scale / échelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 448.8 - TEST HOLES 448-C-1 AND 448-C-2 - CUT SECTION

Much of the route between Mile 448 and 449 is in cut sections that have been extensively drilled. The two holes that were drilled during this program are in an area of shallow cut that was not drilled previously. Subsoil is frozen, medium plastic silty clay with moisture contents on thawing generally between 20 and 25% and slightly above the plastic limit. No problems should occur in the shallow cut proposed here.

GEOTECHNICAL EVALUATION

MILE 450 TO MILE 500

MACKENZIE HIGHWAY

MILE 451.1 - TEST HOLES 450-C-1 AND 451-C-1 TO 451-C-4 - POTENTIAL CUT SECTION

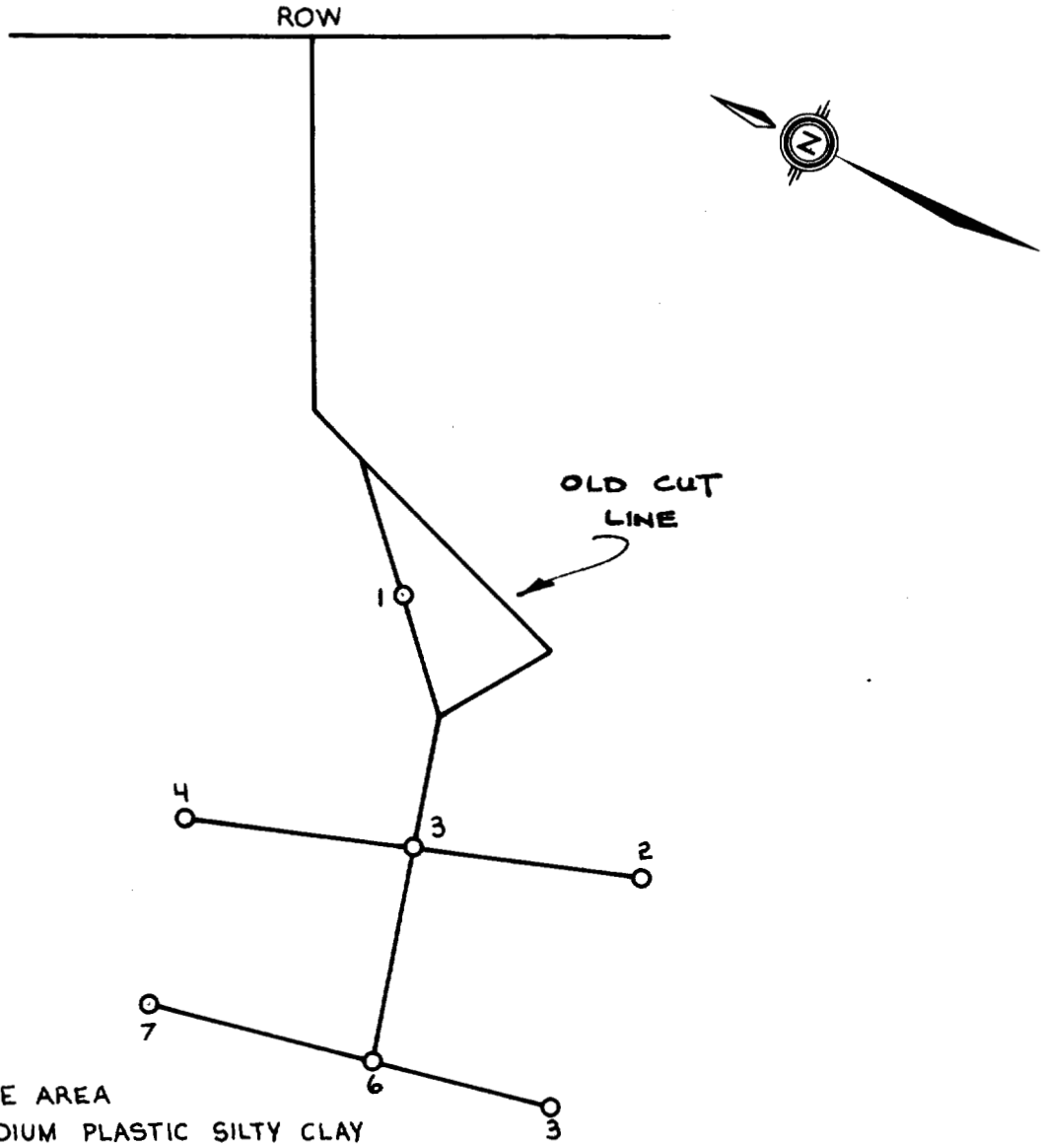
The route crosses a long low rise near Mile 451 with the grade line entirely in fill section. Five test holes were drilled along the rise to determine feasibility of introducing a shallow cut to reduce haul costs. The subsoil is low to medium plastic silty clay. Permafrost is present throughout and moisture contents on thawing average around 25% and slightly above the plastic limit. Much of the material in the upper 2-3' here is wet on thawing and would be unsuitable as embankment material without drying, hence there would appear to be little advantage to a cut in this area.

MILE 451.3 - BORROW PIT NO. 72

- 800 feet left of centerline.

Area test drilled is in a stand of poplar in what is generally flat, poorly drained terrain. Permafrost is expected over the majority of the pit area. Subsoil is medium plastic silty clay and moisture contents average around 20%+ and near the plastic limit. Stripping is estimated at 1-2'. This area considered to be a usable borrow source in an area of generally poor borrow.

MILE 451.3 - 800' LT. OF ℄



NOTES

- POPLAR TREE AREA
- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- PERMAFROST SPORADIC BUT EXPECTED OVER MAJORITY OF PIT AREA
- MOISTURE (ICE) CONTENTS NEAR 20% AND PLASTIC LIMIT
- 1-2' OF STRIPPING
- USEABLE BORROW SOURCE

Public Works Travaux Publics Canada Canada

drawing title / titre du dessin

BORROW PIT 72

scale / échelle 1"=200'

designed by / conçur par date

drawn by / dessiné par date

reviewed by / examiné par date

approved by / approuvé par date

region

region

revisions date

revisions

project number

no. de entreprise

drawing no

no du dessin

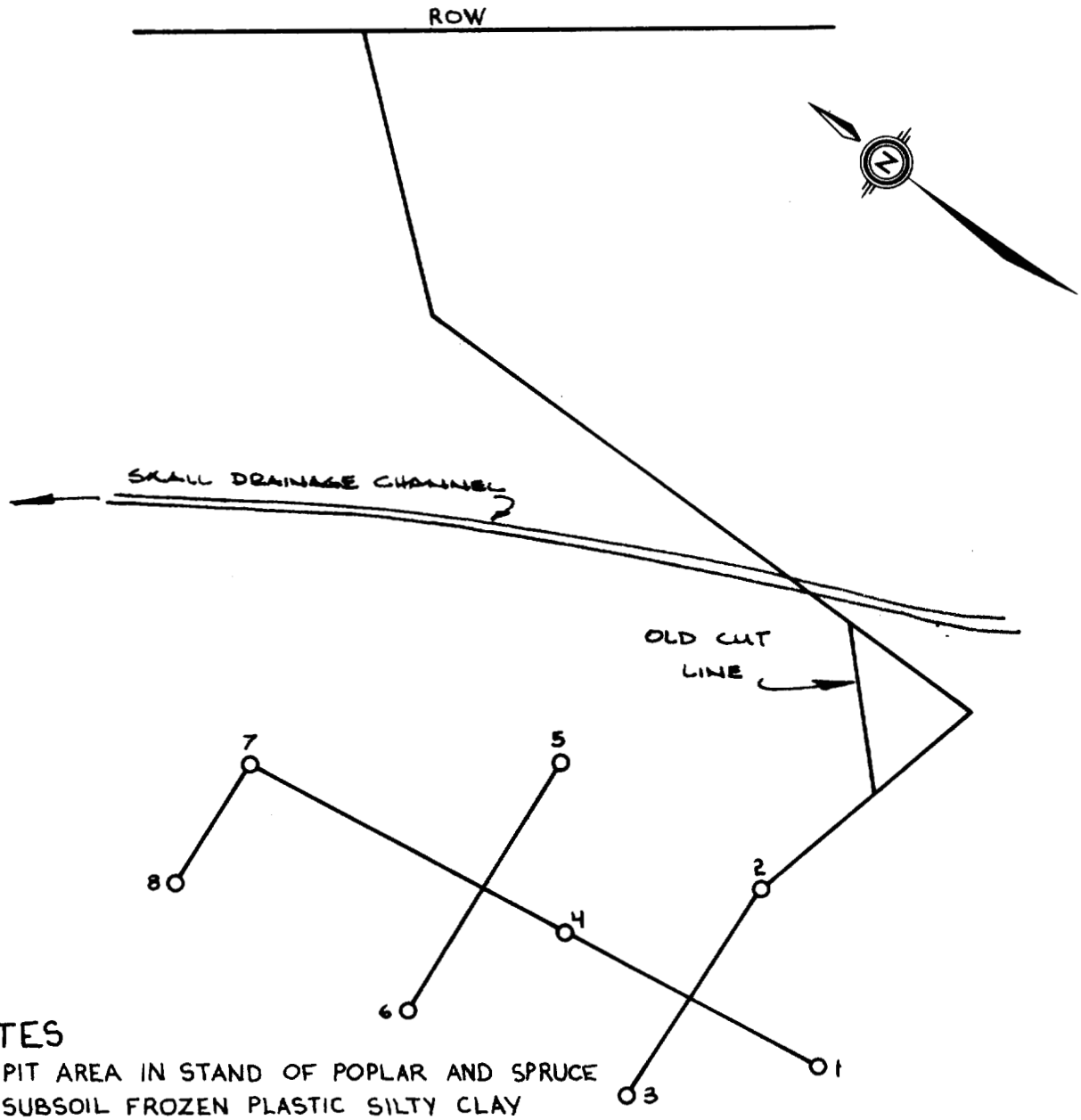
D.P.W. 700 A

MILE 452.4 - BORROW PIT NO. 73

- 1100 feet left of centerline.

Test area is a heavy stand of poplar and some spruce in an otherwise sparsely treed, flat, poorly drained, terrain. Medium plastic, silty clay was encountered in all eight test holes. Permafrost is present and moisture (ice) contents average around 20% and approximately at the plastic limit. Stripping depths are expected to be less than 2 feet. Considered to be acceptable borrow source in a terrain of extremely poor materials.

MILE 452·4 – 1100' LT. OF ℄



NOTES

- PIT AREA IN STAND OF POPLAR AND SPRUCE
- SUBSOIL FROZEN PLASTIC SILTY CLAY
  WITH MOISTURE (ICE) CONTENT NEAR 20% AND THE PLASTIC LIMIT
- STRIPPING < 2'
- ACCEPTABLE BORROW SOURCE

Public Works Travaux publics Canada Canada

drawing title / titre du dessin

BORROW PIT 73

scale / échelle 1"=200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

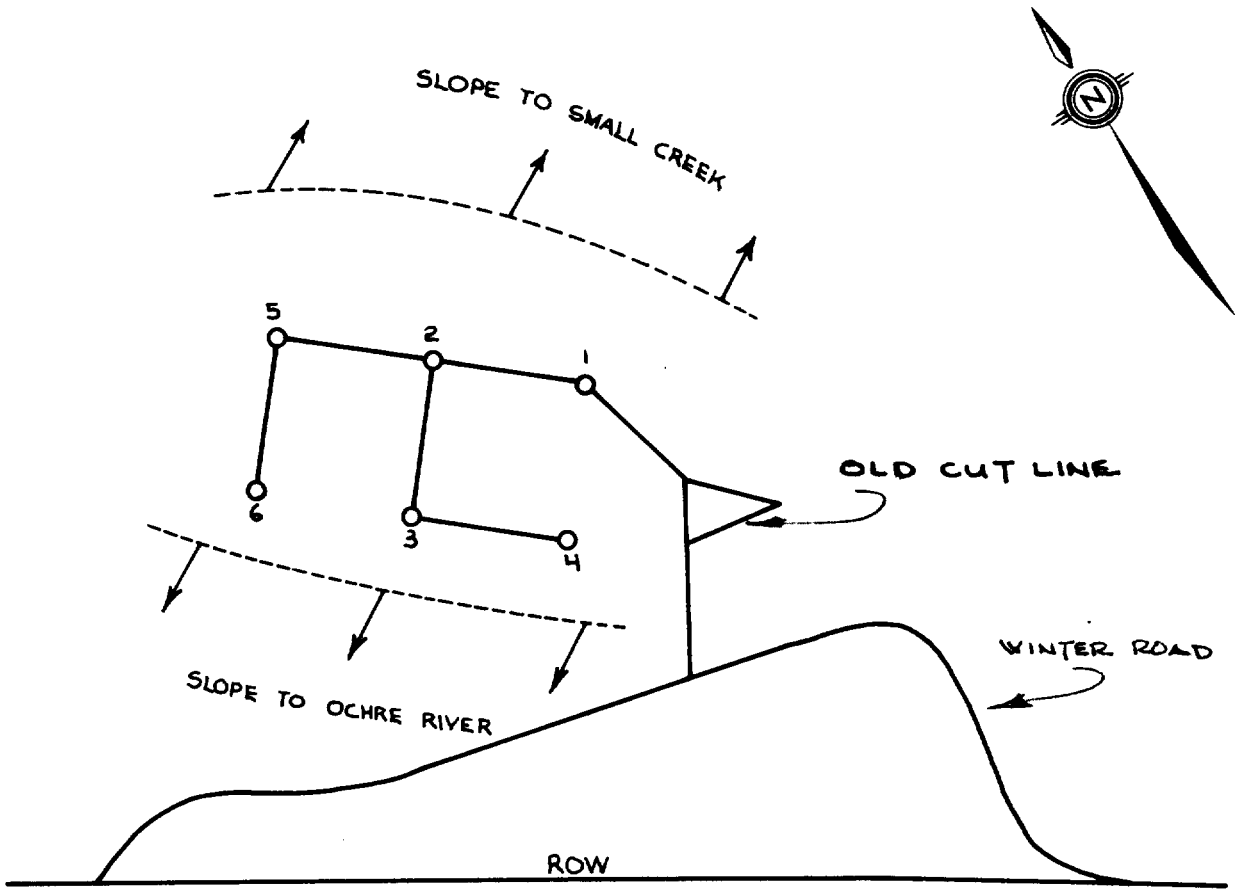
D.P.W. 700 A

MILE 453.7 - BORROW PIT NO. 74

- 800 feet right of centerline.

Pit No. 74 is on a segment of high ground defined on the west by the valley slope to the Ochre River and on the north and east by the valley slope of a small tributary creek. The area is well drained with dense poplar growth. Subsoil is medium plastic silty clay with moisture contents generally below 20% and slightly below the plastic limit. Permafrost is present although visible ice contents are low. Considered to be a good borrow source. There is ample area available on the high ground for a large pit as the area drilled measures approximately 1000' x 500'.

MILE 453·7 – 800' RT OF ℄



NOTES

- HEAVY POPLAR GROWTH
- SUBSOIL FROZEN MEDIUM PLASTIC SILTY CLAY WITH MOISTURE (ICE) CONTENTS GENERALLY BELOW 20% AND THE PLASTIC LIMIT
- STRIPPING < 2'
- GOOD BORROW SOURCE

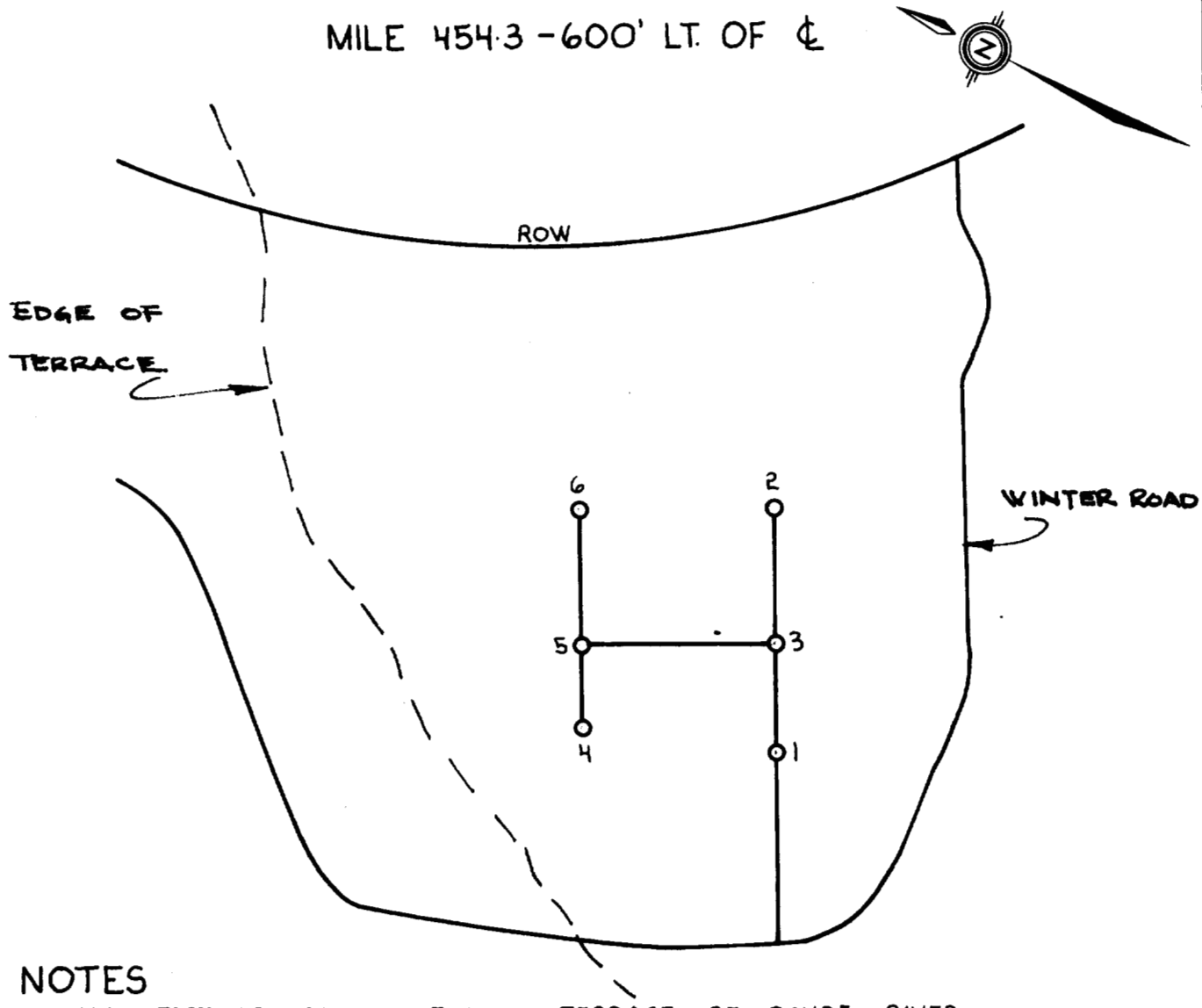
Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 74	designed by / conçu par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle: 1" = 300'	approved by / approuvé par — date
region	revisions — date	project number / no. de entreprise; drawing no / no du dessin
region	revisions	

D.P.W. 700 A

MILE 454.3 - BORROW PIT NO. 75

- 600 feet left of centerline.

Area test drilled is on a fluvial terrace approximately 1500 feet south of the present channel of the Ochre River. Deposits here consist of sands and gravels with a 3 to 5' overlay of silts and clays. Maximum depth of drilling was 15' with many holes terminated near 10 feet due to caving of cohesionless deposits. Stripping depths here will be variable up to a maximum of roughly 4 feet. There is usable borrow in this area although some of the cohesionless materials will be very wet upon thawing but should drain quickly. The more granular materials at depth may be suitable for culvert backfill after thawing and draining.



NOTES

- AREA TEST DRILLED ON FLUVIAL TERRACE OF OCHRE RIVER
- SUBSOIL 2-5' OF SILT AND CLAY OVER SANDS AND GRAVELS
- PERMAFROST SPORADIC
- SOME GRANULAR DEPOSITS WILL BE WET ON THAWING BUT SHOULD DRAIN QUICKLY
- USEABLE BORROW SOURCE

	drawing title / titre du dessin: BORROW PIT 75	designed by / conçur par — date
	scale / échelle: 1" = 300'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 456.9 - TEST HOLES 456-C-1 TO 456-C-3 - POTENTIAL CUT AREA

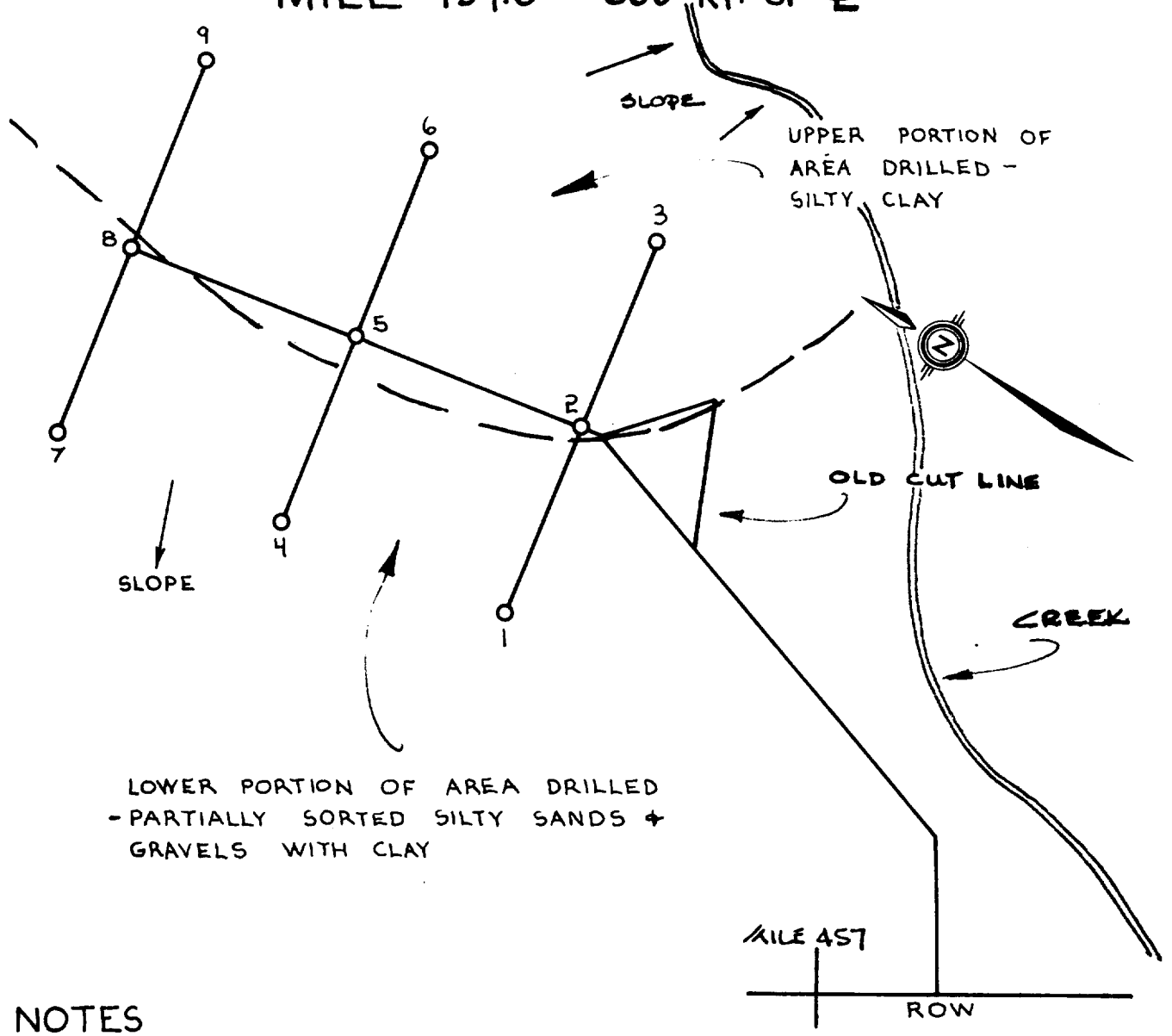
The grade line rolls over a short rise immediately south of Mile 457 and four test holes were drilled here to investigate the possibility of introducing a cut. Subsoil is frozen silty clay, high in organics and wet upon thawing. This area is unsuitable for cut.

MILE 457.1 - BORROW PIT NO. 76

- 600 feet right of centerline.

The area test drilled here is an alluvial fan produced by deposition from a small creek on the flood plain of the Mackenzie River near the base of the valley slope. The area is well treed with poplar, spruce and birch. Permafrost is continuous although ice contents are low. Materials are variable over the area drilled. Test holes at the highest elevations are on the valley slope and encountered silty clay. The lower test holes are on the alluvial fan and encountered partially sorted silty sands with gravel and clay. Moisture contents are low throughout and stripping depths should be less than 2'. This is considered a good borrow source.

MILE 457.0 - 600' Rt. of ℄



NOTES

- AREA DRILLED PARTIALLY ON ALLUVIAL FAN AND PARTIALLY ON VALLEY SLOPE
- UPPER PORTION (VALLEY SLOPE) IS MEDIUM PLASTIC SILTY CLAY
- LOWER PORTION SAND & GRAVELS WITH CLAY
- PERMAFROST THROUGHOUT BUT ICE CONTENTS LOW
- GOOD BORROW SOURCE

Public Works Travaux publics Canada Canada

drawing title / titre du dessin

BORROW PIT 76

scale / échelle 1" = 200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

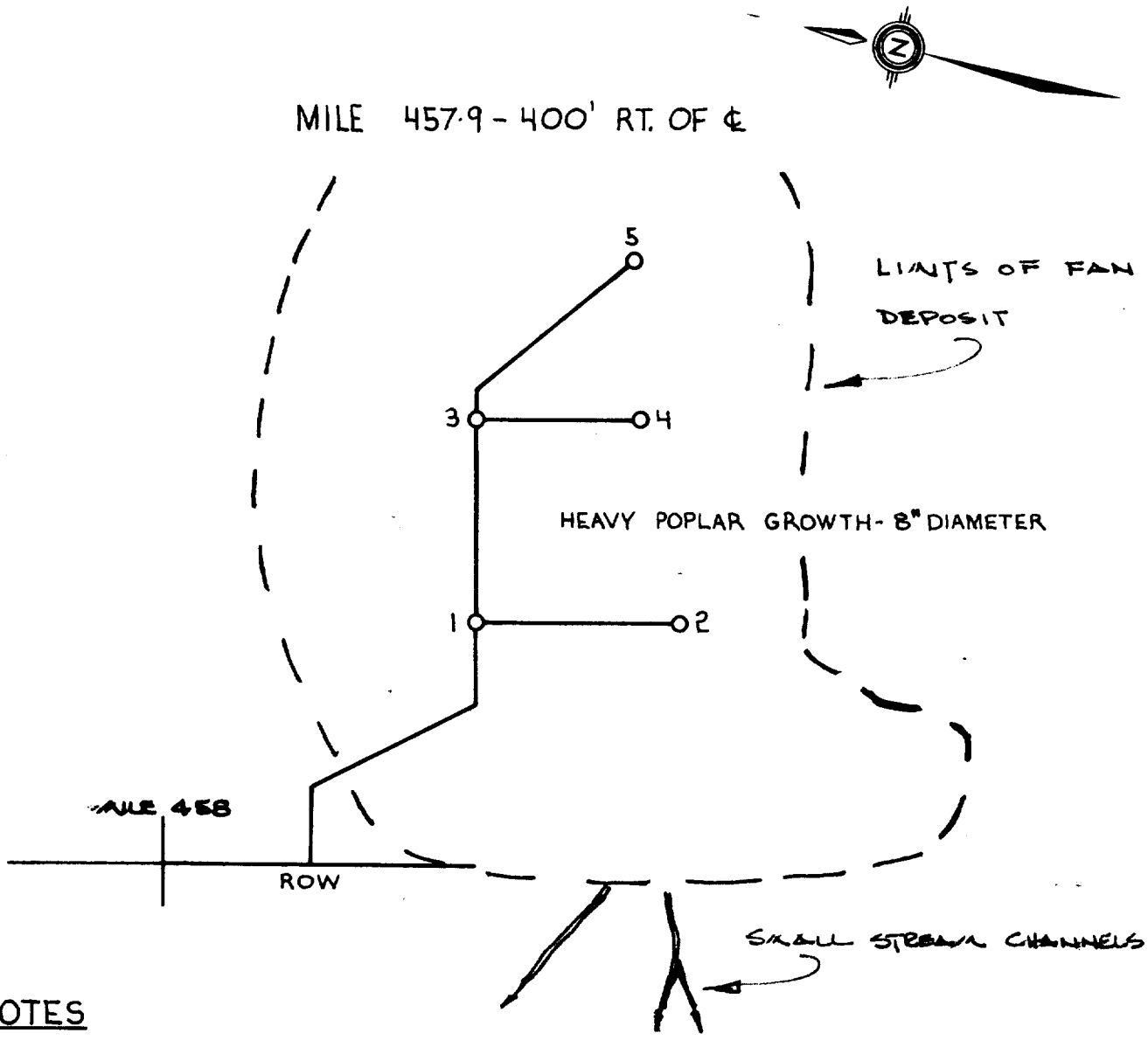
D.P.W. 700 A

MILE 458 - BORROW PITS 77 AND 78

- right side of centerline.

These two potential borrow sources were investigated in similar terrain near Mile 458. Both are near the base of the valley slopes partially on poorly sorted alluvial fan and alluvial terrace deposits,and partially upon the unsorted glacial lake sediments in the valley wall. Borrow Pit 77 at Mile 457.9 is 300-400' right of centerline. The area test drilled is largely unfrozen and moisture contents are low. Subsoil varies from sandy silty clay to silty gravelly sand. This is an excellent borrow source.

Borrow Pit 78 is at Mile 458.5 approximately 700-800' right of centerline. Deposits here are primarily medium plastic silty clay with some poorly sorted silty sands in lower portions of the pit area. Permafrost is continuous although moisture contents, upon thawing, are low. Pit 77 is considered superior and is recommended for development.

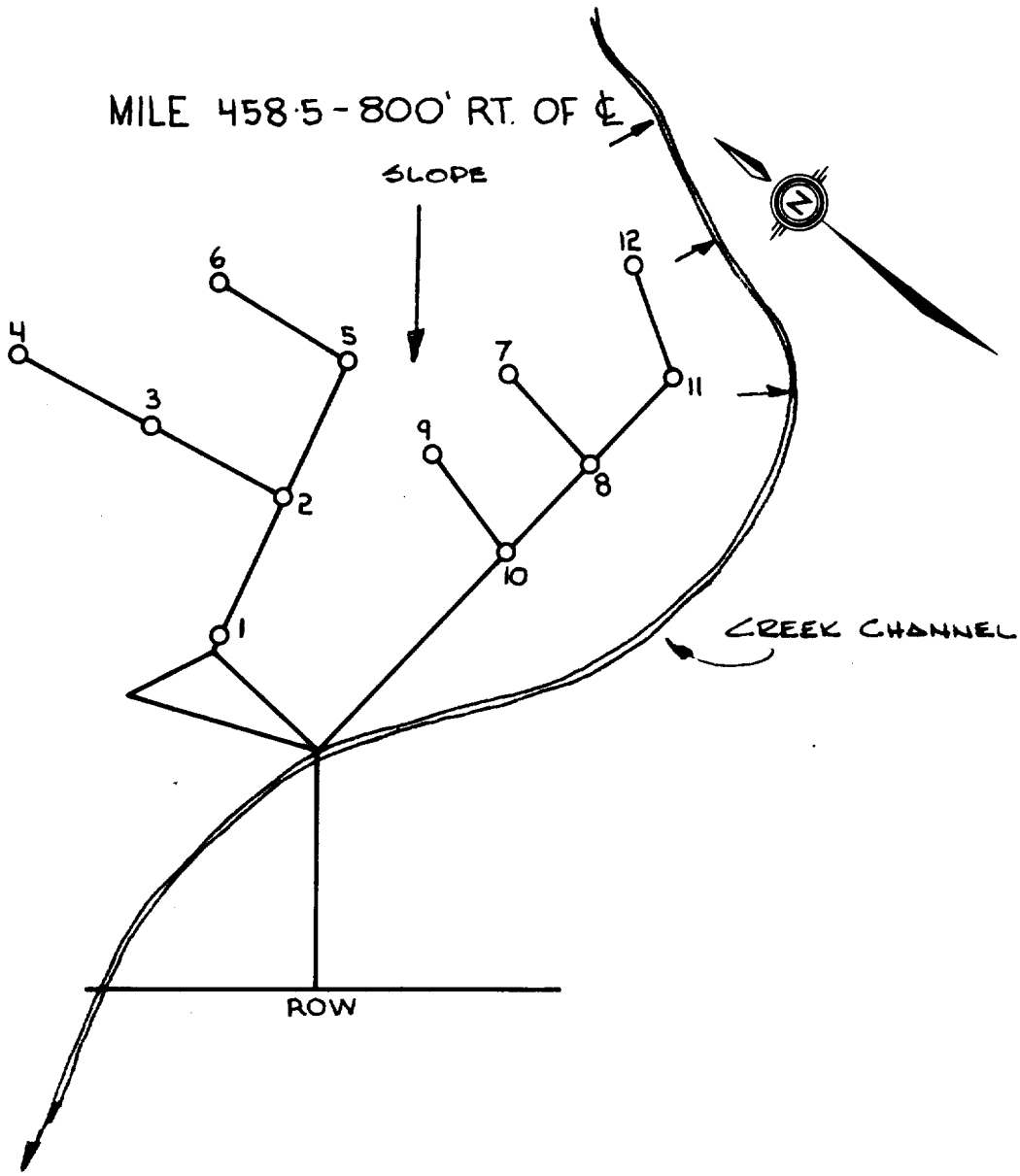


NOTES

- PIT AREA LARGELY UPON FAN DEPOSITS
- SUBSOIL UNFROZEN, SILTY CLAYS OR PARTIALLY SORTED SILT-SANDS WITH GRAVEL AND CLAY
- LOW MOISTURE CONTENTS
- GOOD BORROW SOURCE - RECOMMEND FOR DEVELOPMENT
- 1-2' OF STRIPPING

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 77	designed by / conçur par — date
	scale / echelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A



NOTES

- -SUBSOIL PRIMARILY SILTY CLAY WITH SOME SORTED ALLUVIAL FAN DEPOSITS NEAR BASE OF SLOPE
- -FROZEN BUT LOW MOISTURE (ICE) CONTENTS
- -O.K. FOR BORROW BUT NOT RECOMMENDED DUE TO CLOSE PROXIMITY (1/2 MILE) TO BP-77

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 78	designed by / concur par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle 1"=300'	approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise — drawing no / no du dessin

D.P.W. 700 A

MILE 459.5 - APPROACH CUT ON SOUTHSIDE OF WHITESAND CREEK VALLEY

Test hole 459-C-1 was drilled here where a cut to 40 feet is proposed in an alluvial river terrace as the route descends to the Whitesand Creek crossing. Subsoil is gravelly sand and sandy gravel with moisture contents generally less than 5%. No problems with the cut should occur.

459.7 (WHITESAND CREEK) TO MILE 462.0 - REVISION

This revision parallels the western edge of an alluvial river terrace of the Mackenzie River but for the most part is below the level of the terrace. The revision is entirely in fill section with the exception of a cut on the north side of an unnamed creek valley at Mile 461.7. This cut to a maximum depth of 15 feet extends over a distance of 1500 feet into sands and silts that are wet or saturated upon thawing. Some minor slough may be expected at the bottom of back slopes here, however, as no ice concentrations were encountered, the back slopes should stabilize and not be a maintainence problem.

Three borrow areas were investigated along this revision. One on the north side of Whitesand Creek on the alluvial terrace and two others near the edge of the alluvial terrace on the lower valley slopes.

Test Holes 429-C-2 to 429-C-6 were drilled on the alluvial terrace adjacent to Whitesand Creek. The subsoil here is silty gravelly sands and/or sandy gravels at low moisture (ice) contents and is an excellent source of borrow. Some borrow will be obtained in cuts on both sides of Whitesand Creek, however, it may be worthwhile developing a pit on the north side of Whitesand Creek for embankment construction to the north, as borrow areas investigated to approximately Mile 463 are borderline in quality. The two additional borrow areas drilled along the revision are designated as Borrow Pit 79 and 79A and are discussed below.

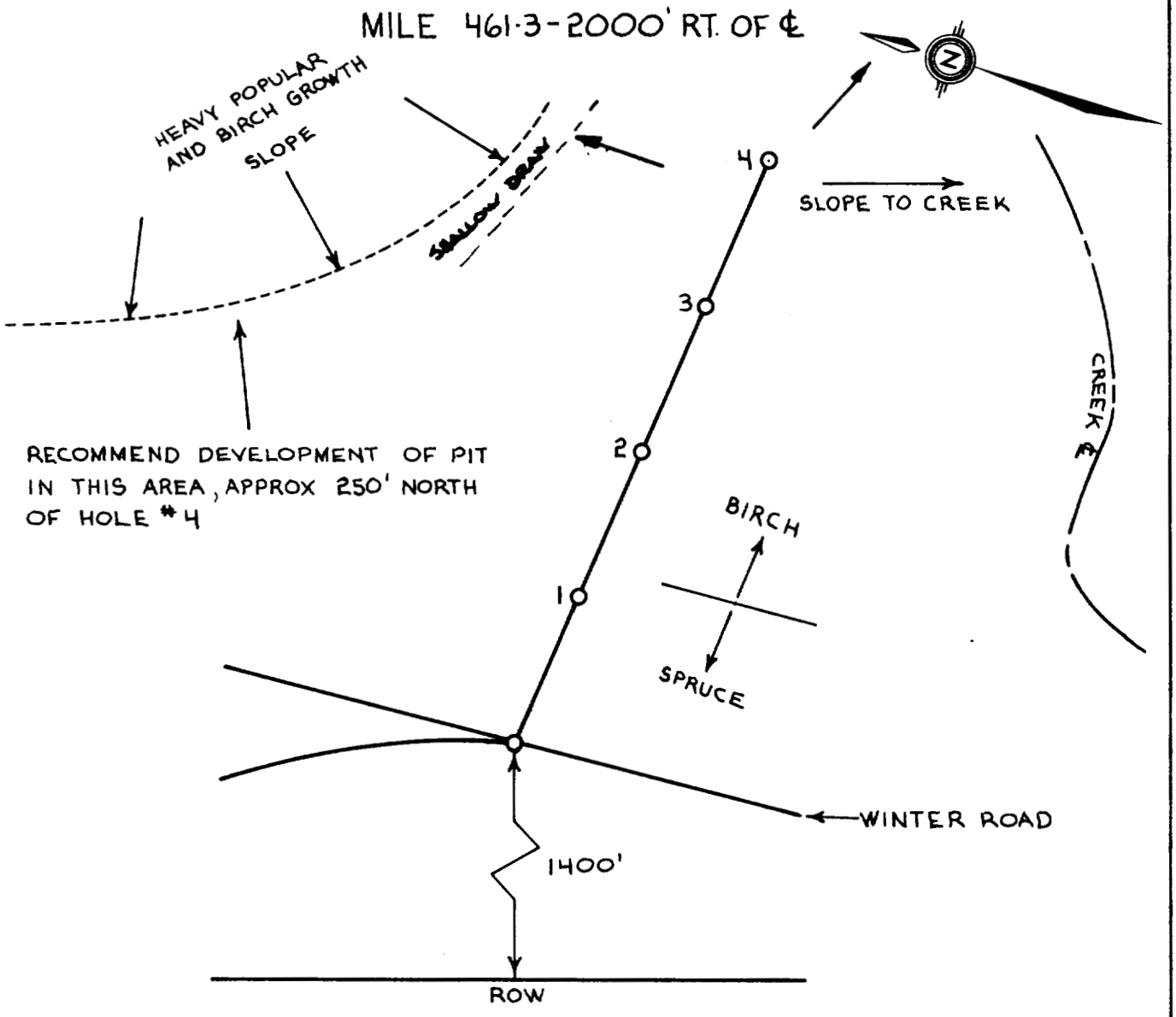
MILE 461.0 - BORROW PIT 79 AND 79A

- Approximately 2000 feet right of centerline.

Borrow Pit #79 was drilled on the lower valley slopes slightly above an alluvial terrace of the Mackenzie River, in an area of variable spruce and poplar cover. The subsoil is medium plastic silty clay and permafrost is continuous. Moisture (ice) contents are irregular and although one or two holes indicate good quality material, it is believed the moisture conditions are too variable for development of a pit. This area is not recommended.

Test drilling in Borrow Pit 79A consisted of a series of five test holes at progressively higher elevations along an alluvial fan and up the valley slope. Tree cover varies from spruce at lower elevations to birch at the highest level. Only the upper portion of the pit area drilled contains suitable borrow material consisting of medium plastic silty clay, frozen but with moisture (ice) contents below 20%. The proven area of good material is very small, although it appears from the tree cover that continuation of the good material can be expected in a northerly direction. Thus it is recommended that Pit 79A be developed if required with expansion in a northerly direction as shown on the site plan. However the area of good material is some 2000' from the R.O.W. and improved economics may be obtained by hauling better material from the north side of Whitesand Creek Valley.

... 74



NOTES

SUBSOIL MEDIUM PLASTIC SILTY CLAY
PERMAFROST THROUGHOUT
GOOD, USEABLE MATERIAL IN HOLE #4
RECOMMENDED DEVELOPMENT OF PIT NORTH OF HOLE #4 AS INDICATED

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 79A	designed by / concu par — date	
	scale / echelle: 1"=200'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / region	revisions / revisions — date	project number / no. de entreprise	drawing no / no du dessin

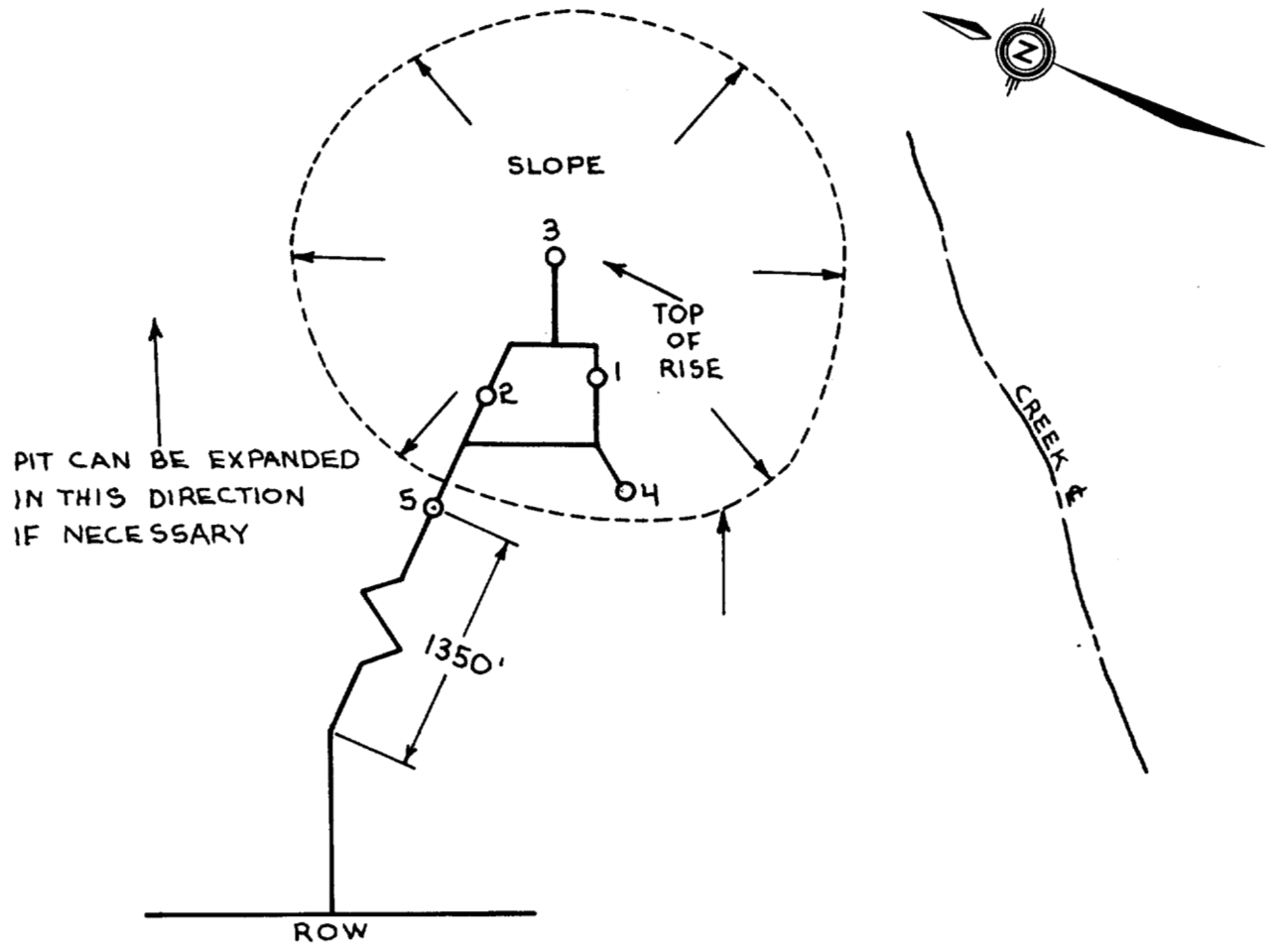
D.P.W. 700 A

MILE 462.9 - BORROW PIT NO. 80

- 2,000 feet right of centerline.

Borrow Pit #80 is on the lower slopes of the valley wall in a dense stand of poplar. Subsoil is medium plastic silty clay and permafrost is thought to be continuous throughout although ice contents are very low and moisture contents upon thawing are below 20% and below the plastic limit. Stripping depths are less than 2'. This is a good source of borrow and is recommended for development. The proven area is relatively small measuring only 400' x approximately 200', however, if necessary the pit can be expanded in a northerly direction into similar terrain - (See site plan).

MILE 462·9-2000' RT. OF ℄



NOTES

SUBSOIL MEDIUM PLASTIC SILTY CLAY
FROZEN
MOISTURE (ICE) CONTENTS < 20% AND BELOW PLASTIC LIMIT
GOOD BORROW SOURCE
PIT CAN BE DEVELOPED IN NORTHERNLY DIRECTION IF REQ'D

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 80	designed by / conçur par — date
	scale / echelle: 1"=300'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise
		drawing no / no du dessin

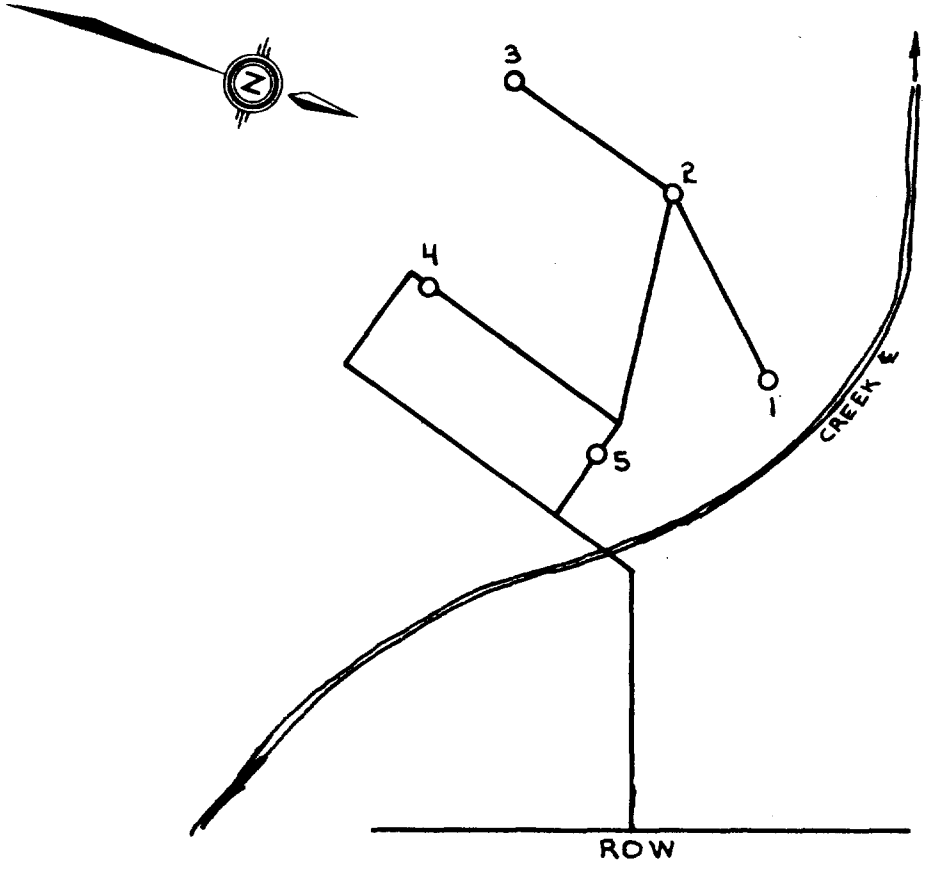
D.P.W. 700 A

MILE 463.9 - BORROW PIT NO. 81

- 500 feet left of centerline.

The area test drilled is on a low alluvial terrace of the Mackenzie River and is adjacent to a small tributary creek. Materials here are thought to be river deposits at depth with overlying alluvium of the tributary creek valley. Five test holes reveal sandy clay silts to depths of 10-13' overlying sands and gravels. Permafrost was not reported. Moisture contents tend to be variable with wet zones especially in the upper silty deposits. This area is considered borderline as a borrow source, however, it is recommended for development as there is a shortage of borrow along this stretch of highway.

MILE 463·9 – 500' LT. OF ℄



NOTES

- TREE COVER BIRCH, SPRUCE AND POPLAR
- SUBSOIL SANDY-CLAY-SILTS TO 10'-13', OVER SAND AND GRAVELS
- NO PERMAFROST REPORTED
- WET ZONES IN UPPER SILTY MATERIALS
- BORDER-LINE AS BORROW SOURCE, HOWEVER RECOMMENDED FOR DEVELOPMENT DUE TO LACK OF BETTER MATERIAL ALONG HIGHWAY

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 81	designed by / conçur par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle: 1"=200'	approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise — drawing no / no du dessin

D.P.W. 700 A

PROPOSED CUT MILE 465.3 - TEST HOLES 465-C-1 AND 465-C-2

A short shallow cut to 8' is proposed here in an alluvial fan deposited at the mouth of a tributary creek valley. Subsoil is silty sand with pebbles and the cut should not present problems. Borrow Pit #82 is located to the right of centerline here, partially on the fan deposits, and partially upon the lower portion of the valley wall. This area is discussed below.

MILE 465.4 - BORROW PIT NO. 82

- 600 feet right of centerline.

Previous drilling had been carried out here over a very small area by consultants, and usable material was indicated, resulting in this area being selected as a borrow source. This current program was carried out over a larger area extending both onto the alluvial fans sediments and onto the valley slope. Permafrost is continuous throughout and ice contents are moderate to high, resulting in frequent wet zones on thawing. It is considered that ice rich zones are too frequent and erratic here to permit development of a good borrow source, consequently this area is not recommended.

MILE 466.6 - BORROW PIT NO. 83

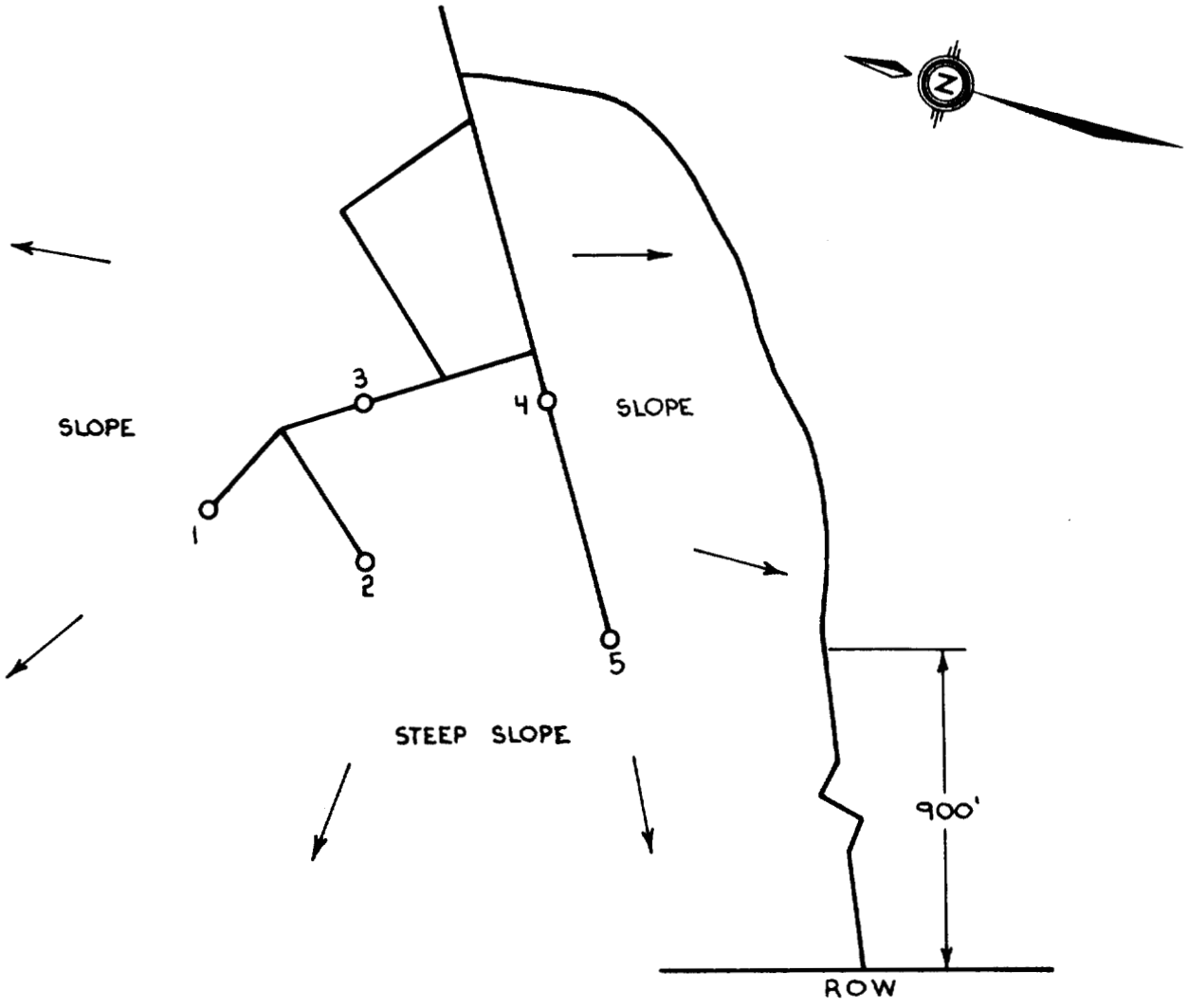
- 1,200 feet right of centerline.

The area test drilled here is on the top of the valley slope, well above the alluvial terrace of the Mackenzie River on which the

... 80

highway is located. Direct access up the face of the slope was not possible, however an old seismic cut line which gained access to the top of slope along a small draw was conveniently located nearby. Test holes were sited as close to the edge of slope as possible in relatively dense poplar and spruce. Subsoil here is frozen, low to medium plastic silty clay. Moisture contents on thawing are variable and range from 15% to over 30%. This area is considered borderline as a borrow source as it is expected there will be considerable volumes of material at moisture contents of 3 to 5% above optimum. A much better source of borrow is available in Borrow Pit 84 approximately 4500 feet farther north, and, in view of the access problems, questionable material, and haul distance for Borrow Pit 83, it is recommended that this pit not be developed.

MILE 466·5 - 1200' RT. OF ℄



NOTES

- -SUBSOIL LOW TO MED. PLASTIC SILTY CLAY
- -FROZEN WITH MOISTURE (ICE) CONTENTS RANGING FROM 15-33%, SOME PORTIONS WELL ABOVE OPTIMUM
- -CAN BE DEVELOPED AS PIT HOWEVER BETTER MATERIAL IS AVAILABLE 4500' NORTH IN PIT B-84

	drawing title / titre du dessin: BORROW PIT 83	designed by / concur par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle: 1"=200'	approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

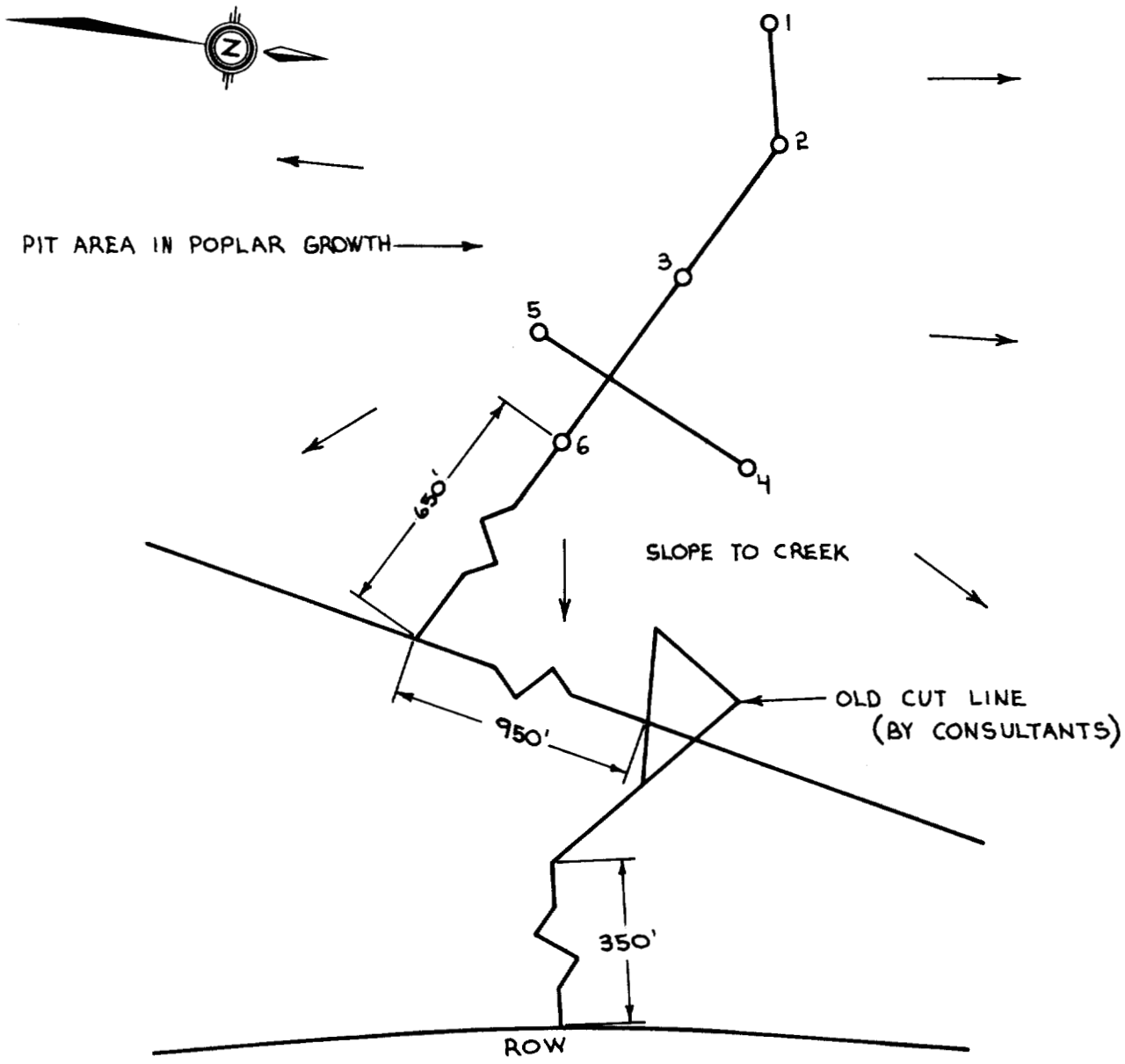
D.P.W. 700 A

MILE 467.4 - BORROW PIT NO. 84

- 1,400 feet right of centerline.

Borrow Pit #84 is on the top of the valley slope, similar to Borrow Pit #83, well above the level of the right-of-way. There is a relatively large tributary creek valley on the south side of the area test-drilled and there is good drainage to both the west and south. Access directly up the west face was not possible and a circuitous route up a small draw was necessary. The pit area is well treed with poplar and spruce. Subsoil is medium to highly plastic silty clay. Permafrost is continuous, however, moisture contents upon thawing are at or below the plastic limit. This is considered a good borrow source and is recommended for development.

MILE 467·4 - 1400' RT. OF ℄



NOTES

SUBSOIL FROZEN, MEDIUM TO HIGHLY PLASTIC SILTY CLAY
MOISTURE (ICE) CONTENTS AT OR BELOW THE PLASTIC LIMIT
GOOD BORROW SOURCE - RECOMMENDED FOR DEVELOPMENT

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 84	designed by / conçu par — date
	scale / échelle: 1"= 200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 469.1 - TEST HOLES 469-C-1 TO 469-C-6 - PROPOSED CUT SECTION AND BORROW AREA

A cut section to a maximum depth of 25 feet and extending over a distance of 1100 feet is proposed on the north side of an unnamed creek valley at Mile 469.1, and a borrow area is designated here on the left side of centerline, also on the north side of the unnamed creek valley.

The route is located on an longitudinal alluvial river terrace and is very close to the adjacent valley wall. Test holes 469-C-1 and 469-C-2 were drilled in the potential cut area. These holes reveal frozen ice-rich slope-wash deposits to depths of 11 to 15 feet,over sandy alluvial terrace deposits. It is expected the lower portions of the back slopes will be stable here, but some slough may occur in the ice-rich material in the upper 6-8'.

Previous drilling in the designated borrow pit indicated sandy gravels, however test holes 469-C-4 to 469-C-6 in the borrow area revealed sandy deposits that are less granular than expected, although moisture contents are relatively low and the area should be a suitable source of borrow.

MILE 470 TO MILE 470.2 - PROPOSED CUT AREA

Near Mile 470 the route is located on an alluvial terrace with deep unnamed creek valleys at Mile 470.0 and Mile 470.2. A shallow cut is proposed between Mile 470 to 470.2 and borings were carried out here to determine the feasibility of lowering the grade

... 85

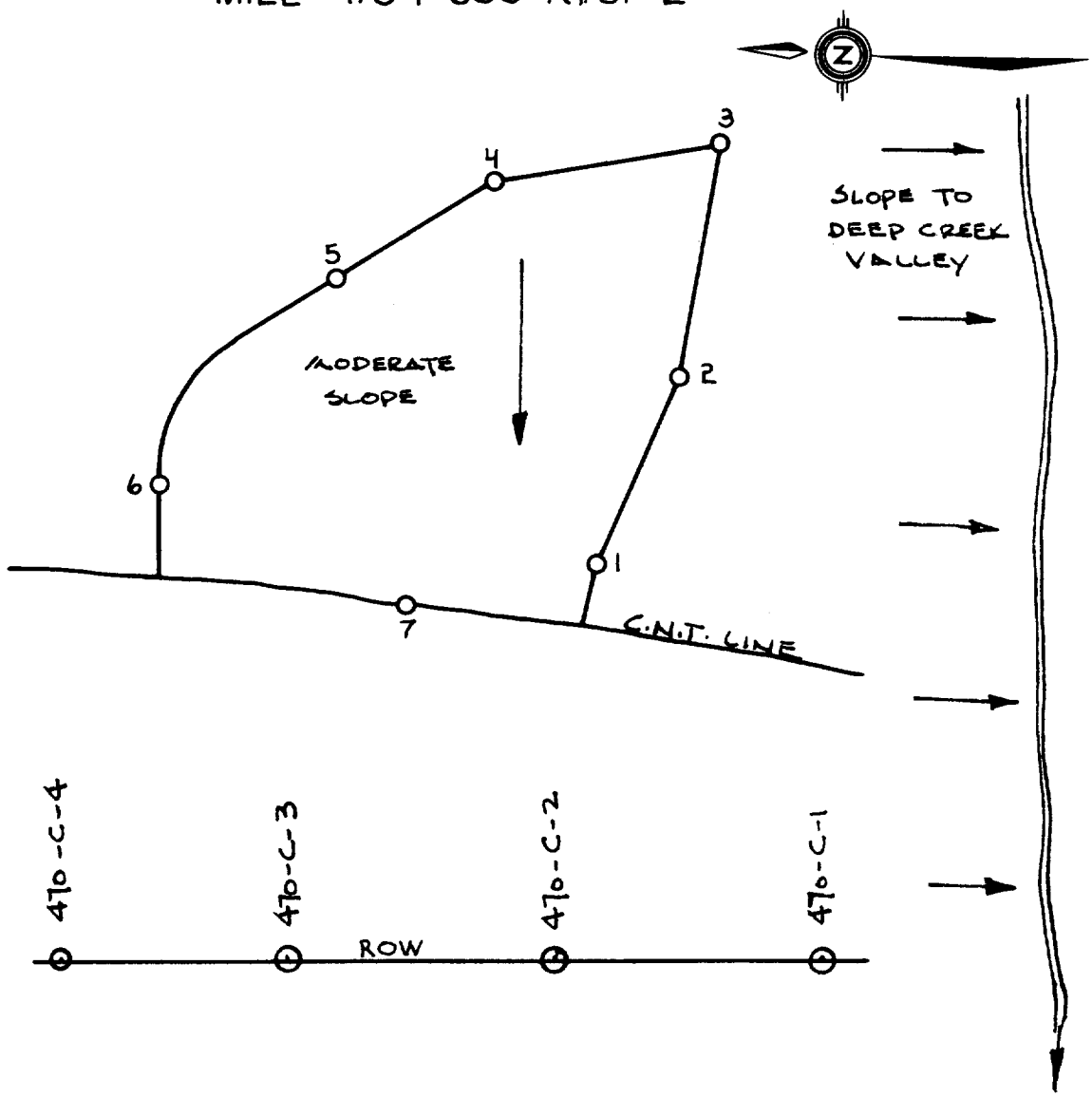
line and increasing the depth of cut between the two creek valleys. Six test holes here (469-C-7 and C-8, and 470-C-1 to 470-C-4) indicate the materials are generally unsuitable for excavation and no change in grade line is recommended. Borrow Pit #85 is located adjacent to the right-of-way at Mile 470.1 but is above the alluvial terrace and on the valley slope where the subsoil is dryer. Borrow area #85 is discussed below.

MILE 470.1 - BORROW PIT NO. 85

- 600 feet right of centerline.

This area is located on the west facing valley slope in dense poplar and spruce cover. Access directly up the slope was possible and pit development should not be a problem. Subsoil is medium to highly plastic silty clay. Permafrost is present, however, moisture contents on thawing are low and below the plastic limit. This is an excellent borrow source.

MILE 470·1-600' RT. OF ℄



NOTES

SUBSOIL MEDIUM TO HIGHLY PLASTIC SILTY CLAY
FROZEN WITH MOISTURE (ICE) CONTENTS BELOW PLASTIC LIMIT
GOOD BORROW SOURCE

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 85	designed by / conçu par — date	
	scale / echelle: 1" = 200'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / region	revisions / revisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

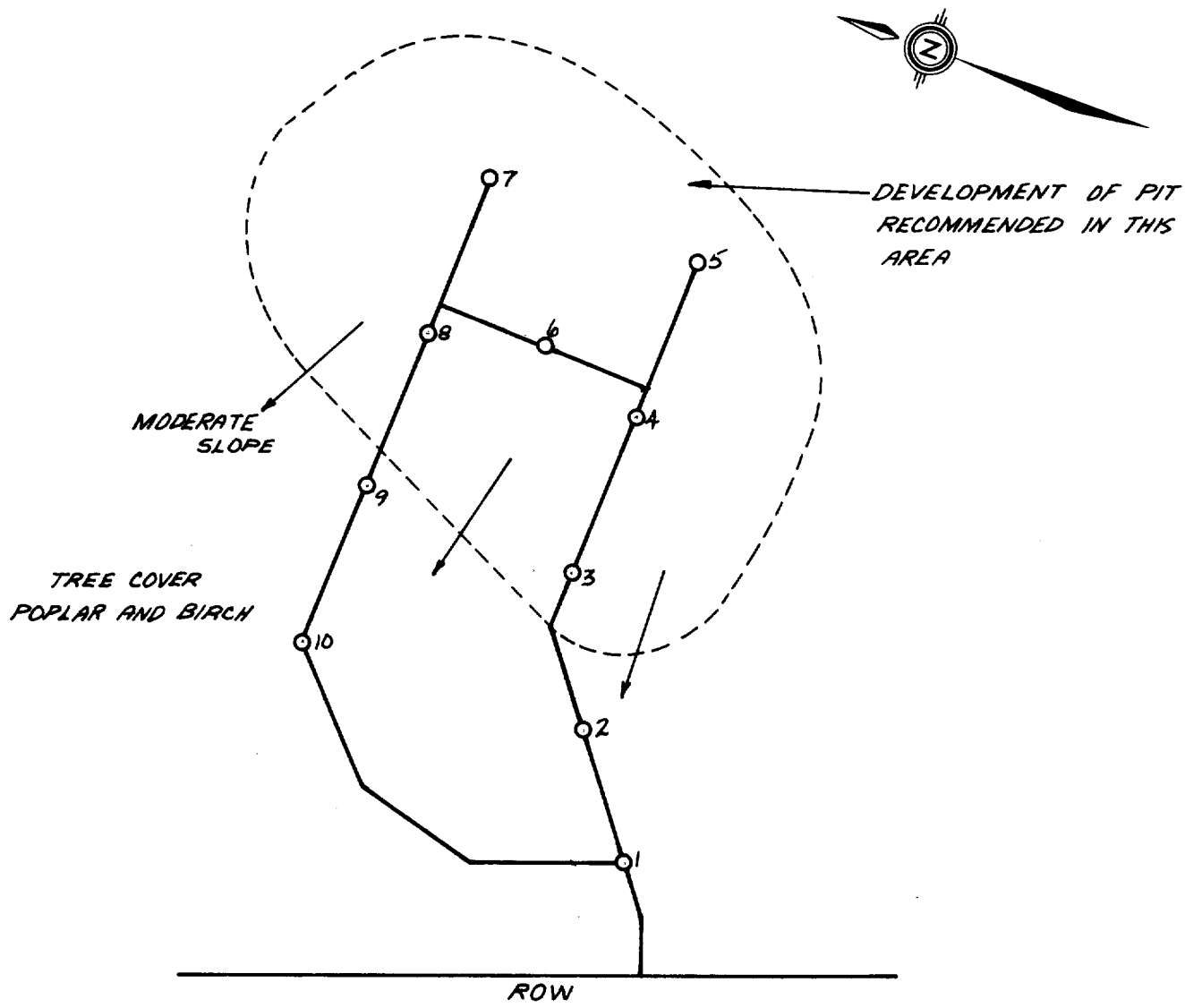
MILE 470.9 - BORROW PIT NO. 86

- 1,000 feet right of centerline.

The area test drilled here extends over 1000 feet from the alluvial terrace where the right-of-way is located, to the top of the west facing valley slope. Tree cover consists largely of poplar and birch. Subsoil is medium to highly plastic silty clay. Permafrost is present on the lower portions of the slope but was difficult to detect near the top of slope due to very low ice contents. Moisture contents in the lower slope generally range between 25 and 30%. Near the top of slope, material is much dryer with moisture contents below 25%. Development of the pit area is recommended on the higher terrain (see site plan).

... 88

MILE 470·9 - 1000' RT OF ℄



NOTES

- SUBSOIL MEDIUM TO HIGHLY PLASTIC SILTY CLAY
- PERMAFROST PRESENT IN LOWER SLOPES - MAY NOT BE PRESENT AT TOP OF SLOPE
- MOISTURE CONTENTS ∠ 20% AND BELOW PLASTIC LIMIT NEAR TOP OF SLOPE - PIT DEVELOPMENT RECOMMENDED HERE

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 86	designed by / conçu par — date
	scale / echelle 1" = 300'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 471.2 - BORROW PIT NO. 86A

- 500 feet right of centerline.

Pit #86A is located on an alluvial terrace of the Mackenzie River near the mouth of Rainbow Creek. The area drilled is some 200 or 300 feet from Rainbow Creek and roughly 800' from the Mackenzie River. Deposits here at depth are sands and gravelly sands, with from 3-6' of slope-wash consisting of clays and silts. Permafrost is present over at least a portion of the site, however, moisture contents at depth are relatively low. Stripping is estimated at 2-3'. There is usable borrow here, however, because of the close proximity to Rainbow Creek, development of this pit is considered unlikely.

MILE 473.0 - BORROW PIT NO. 87

- 800 feet right of centerline.

The area test drilled here is at the top of the very steep valley slope, well above the alluvial terrace of the Mackenzie River and the highway right-of-way. Direct access up the face of this slope was impossible and the top of the bench was reached by a circuitous route up a nearby tributary creek valley and an assault from the rear. The subsoil is frozen highly plastic silty clay with moisture contents varying from 20 to over 30%. The material is usable, however, there is a better source of borrow approximately 3500 feet farther north (Borrow Pit No. 88) on the same bench but with easier access. Pit 87 would also have to be developed at the edge of the bench where it would be visible from the highway and, as the two

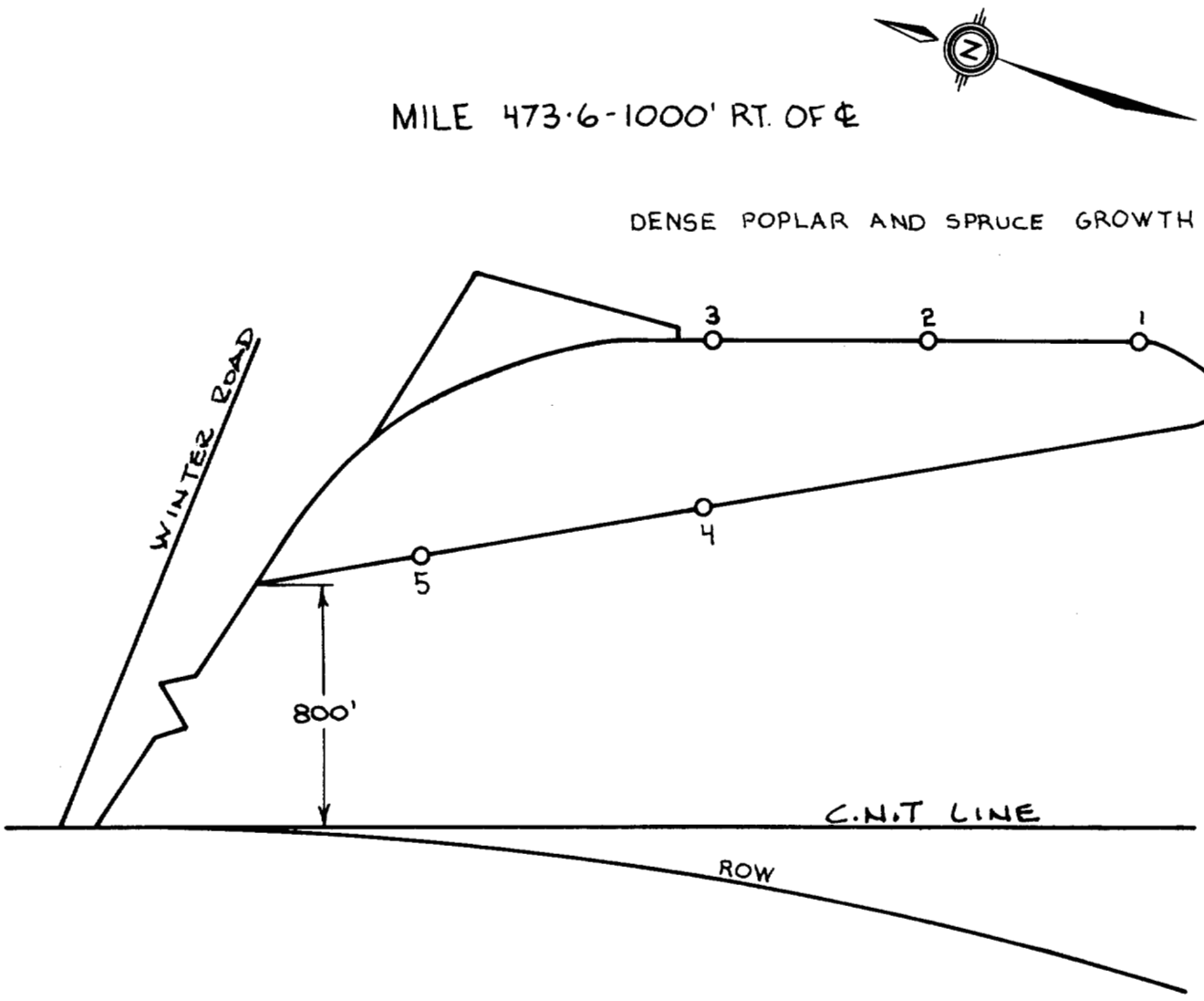
... 90

pit areas are in close proximity, it is recommended that only Pit #88 be developed.

MILE 473.6 - BORROW PIT NO. 88

- 1,000 feet right of centerline.

Borrow Pit #88 is located in heavy poplar and spruce on flat terrain well back from the edge of the bench on which it is located. Subsoil is frozen highly plastic silty clay with moisture contents near 20% and below the plastic limit. This is an excellent borrow source and is recommended for development. Stripping should be less than 2'.



NOTES

- -SUBSOIL HIGHLY PLASTIC SILTY CLAY
- -FROZEN WITH MOISTURE (ICE) CONTENTS NEAR 20% AND BELOW THE PLASTIC LIMIT
- -STRIPPING < 2'
- -GOOD BORROW SOURCE

Public Works Travaux publics Canada / Canada	drawing title / titre du dessin: BORROW PIT 88	designed by / conçu par — date	
		drawn by / dessiné par — date	
		reviewed by / examiné par — date	
	scale / échelle 1"=200'	approved by / approuvé par — date	
region / région	revisions — date / revisions	project number / no. de entreprise	drawing no / no du dessin

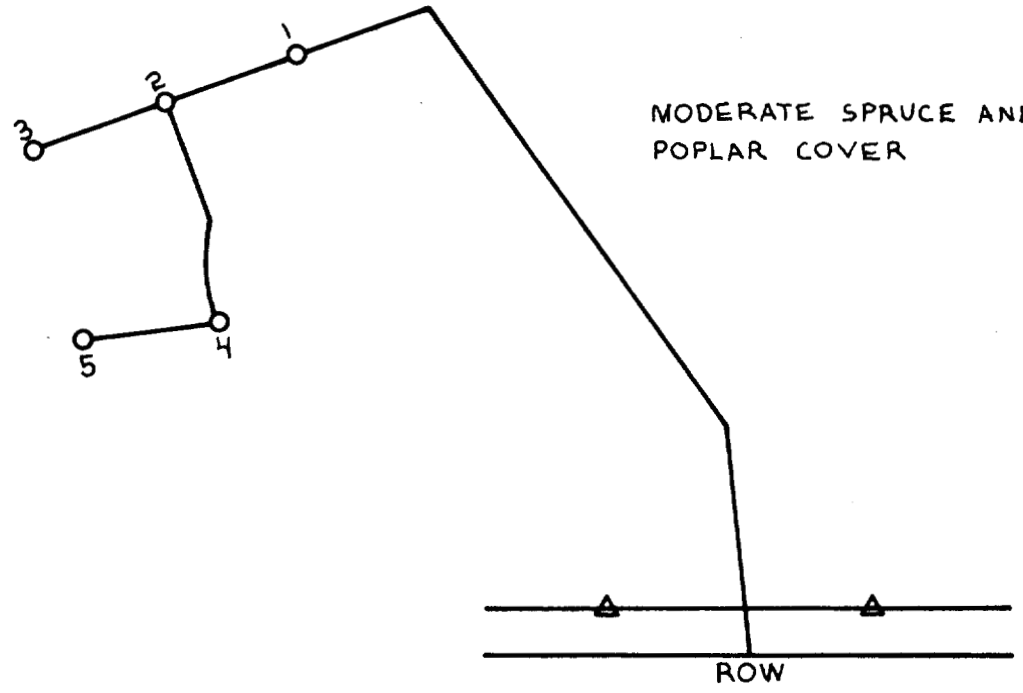
D.P.W. 700 A

MILE 475.3 - BORROW PIT NO. 89

- 400 feet right of centerline.

The area test drilled here is in a moderate stand of poplar and spruce in an otherwise sparsely treed, flat, poorly drained, glaciolacustrine plain. Subsoil is highly plastic silty clay. Permafrost is present throughout and ice contents are low to moderate. Moisture contents average in the low 20's and near the plastic limit with occasional values as high as 30%. Stripping depths are estimated at 2-3'. This area contains usable material in an area with generally poor borrow and is recommended for development.

MILE 475·3 - 400' RT. OF ℄



NOTES

- SUBSOIL HIGHLY PLASTIC SILTY CLAY
- PERMAFROST THROUGHOUT WITH LOW TO MODERATE VISIBLE ICE
- MOISTURE CONTENTS ON THAWING ≈ PLASTIC LIMIT WITH RANDOM WETTER ZONES
- 2-3' OF STRIPPING
- USEABLE BORROW SOURCE IN AN AREA OF GENERALLY POOR MATERIAL

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 89	designed by / conçur par — date
	scale / echelle: 1"= 200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 477.5 TO 479.0 - REVISION

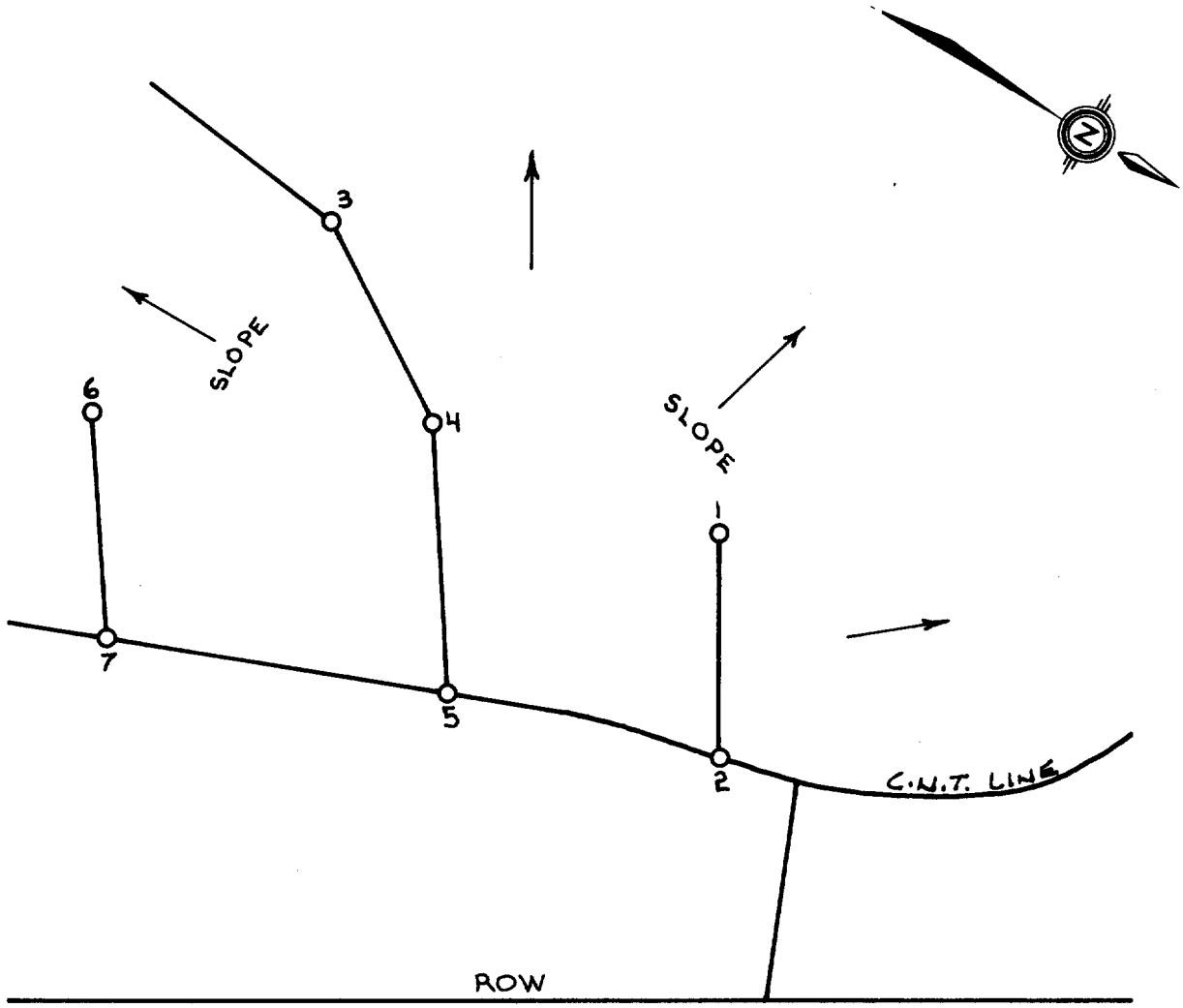
This revision encompasses the descent to the Dam Creek valley and includes two relatively long but shallow cuts. A total of ten test holes along the revision revealed glaciolacustrine sediments consisting of medium to highly plastic silty clays. Permafrost is continuous, however, moisture contents on thawing generally range between 20 and 25% and near the plastic limit of the material. No problems with construction or maintainence of the cut sections are anticipated.

MILE 478.2 - BORROW PIT NO. 90

- 600 feet left of centerline.

Borrow Pit #90 is located at the top of the valley slope adjacent to the right-of-way where the route begins descent to the crossing of Dam Creek. The pit area is well drained with slopes to the south, west and north and is treed with birch, spruce and poplar. Subsoil is highly plastic silty clay, frozen with low visible ice contents. Moisture contents on thawing average near 20% and are roughly at the plastic limit. There are occasional wet zones, however, these should not be a serious detriment in the high plastic material. Stripping depths are estimated at 2-3'. This borrow area is recommended for development.

MILE 478·2-600' LT. OF ℄



NOTES

- SUBSOIL HIGHLY PLASTIC SILTY CLAY
- FROZEN WITH LOW VISIBLE ICE AND MOISTURE CONTENTS ≃ 20% AND THE PLASTIC LIMIT
- OCCASIONAL WET ZONES
- 2-3' OF STRIPPING
- CONSIDERED TO BE USEABLE BORROW

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 90	designed by / concur par — date	
	scale / échelle: 1"=200'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / region	revisions / révisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

MILE 479.1 - TEST HOLE 479-C-1 - DAM CREEK CROSSING

A large multiplate culvert is proposed at Dam Creek and will be located on an artificial cut-off across a short meander loop. Frozen silty clay with low ice contents was encountered in the location of the cut-off with moisture contents on thawing near the plastic limit. The lack of ice concentrations here indicates post-construction culvert settlements should not be a problem.

MILE 479.5 - BORROW PIT NO. 91

- 700 feet left of centerline.

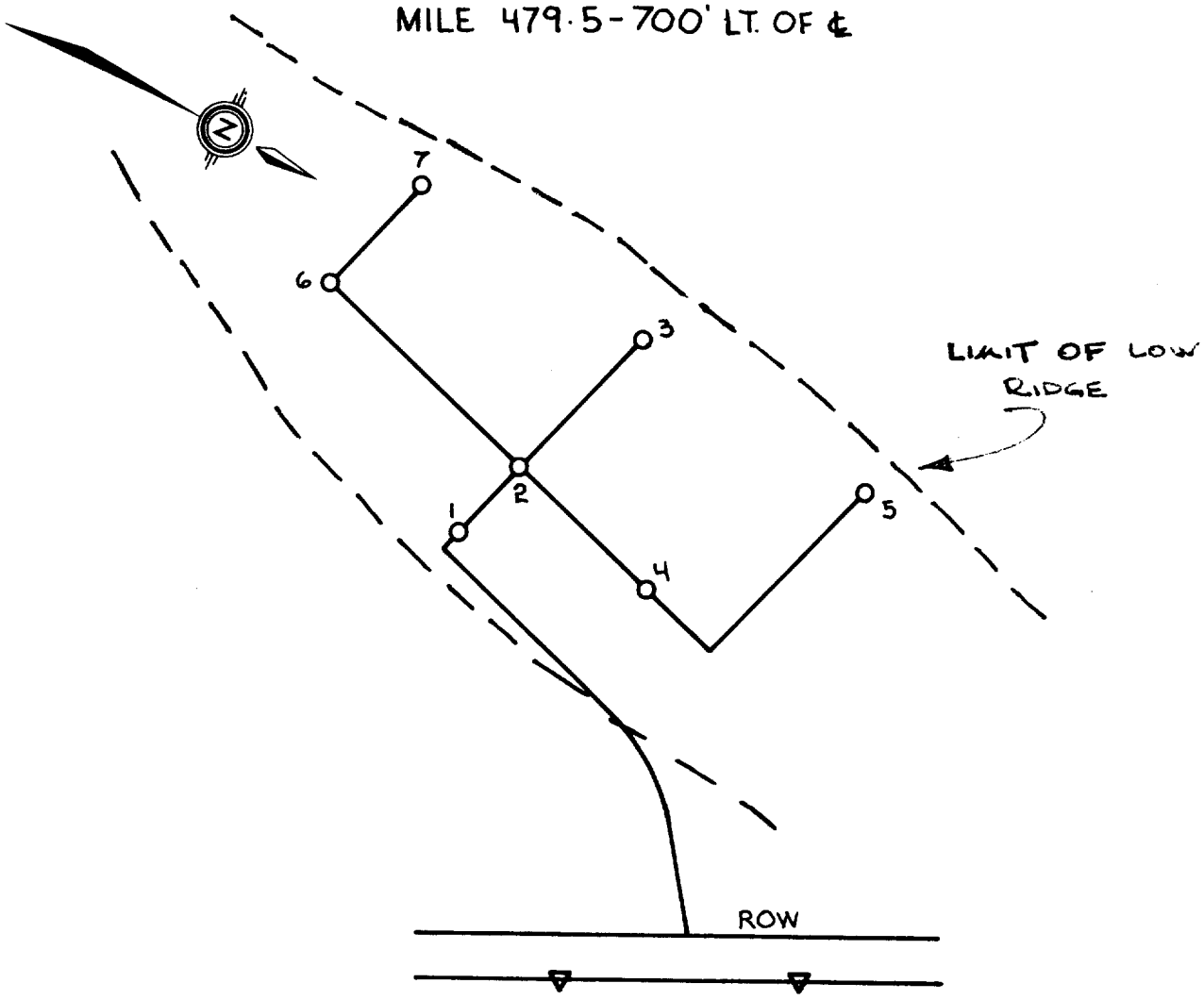
The area test drilled here is a low alluvial terrace of the Mackenzie River on the north side of Dam Creek. The subsoil is primarily silty sand with some gravel and clay. Permafrost is continuous with very low ice contents. Moisture contents for the most part are less than 10%. This is considered to be a good borrow source. Stripping depths should be less than 2'.

MILE 479.0 - BORROW PIT NO. 91A

- 700 feet left of centerline.

The area test drilled is a portion of the alluvial terrace on which Borrow Pit #91 is located but is on the south side of Dam Creek. Deposits are sandy but poorly sorted and frozen and are not as suitable as in Borrow Pit #91 some 2500 feet to the north, hence 91A is not recommended for development.

... 97



NOTES

- PIT AREA IS ON A LOW RIDGE OF FLUVIAL DEPOSITS
- SUBSOIL SILTY SANDS WITH SOME GRAVEL
- FROZEN WITH LOW ICE CONTENTS
- RECOMMENDED AS A BORROW SOURCE

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 91	designed by / concur par — date
	scale / echelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 481.3 - BORROW PIT NO. 92

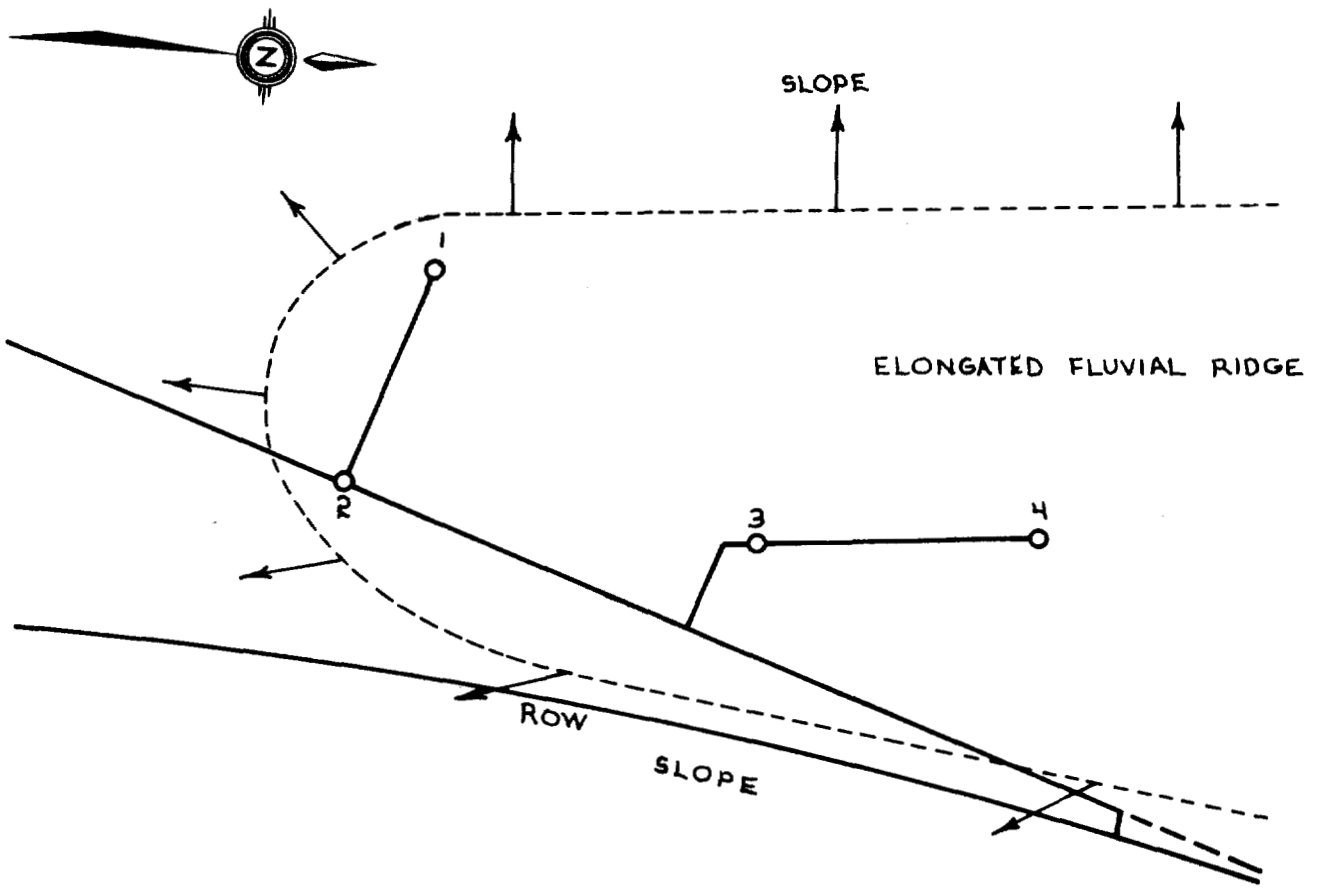
- 400 feet left of centerline.

Between Mile 481 and 482, the highway is within 1000 to 2000 feet of the Mackenzie River and is separated from the river by an elongate alluvial terrace. Borrow Pit #92 is located on the southern end of this ridge. Deposits are poorly sorted and vary from sandy silty gravels to gravelly sandy clays. Permafrost is at least partly present, however, ice contents are extremely low and moisture contents on thawing average less than 10%. This is considered to be an excellent borrow source.

... 99

MACKENZIE RIVER →

MILE 481·3 - 400' LT. OF ℄



NOTES

- SUBSOIL IS POORLY SORTED AND VARIES FROM SANDY SILTY GRAVEL TO GRAVELLY CLAY
- PARTIALLY FROZEN BUT VERY LOW ICE AND MOISTURE CONTENTS LESS THAN 10%
- EXCELLENT BORROW SOURCE

	drawing title / titre du dessin: BORROW PIT 92	designed by / concur par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle 1"=200'	approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 482.2 - TEST HOLES 482-C-1 AND C-2 - PROPOSED CUT SECTION

A cut to maximum depths of 25 feet is proposed over a distance of some 1200 feet in the steep face of an alluvial terrace which encompasses the highway between Mile 482 and 483. The two test holes here were terminated at depths of less than 10 feet due to caving of cohesionless sands and gravels. It is expected that the granular materials extend at least to the depth of cut and no construction or maintainence problems should occur.

MILE 486 (NORTH-END OF BLACKWATER AIR STRIP) - PROPOSED CUT

A cut to a maximum depth of 15 feet and extending over 2500 feet is proposed in a portion of an alluvial terrace at the north-end of the Blackwater Air Strip. Four holes here (485-C-1, -2, -3 and 486-C-1) indicate low moisture content, gravelly sands, sandy gravels, or gravelly sandy clays which are suitable for cut section and will provide excellent embankment material. A large multiplate culvert is proposed at the end of the cut near Mile 486.2 and Test Hole 486-C-1 on the south bank of the present creek channel encountered similar sand and gravel deposits with low visible ice, indicating a good base for the culvert and no post-construction settlement problems.

MILE 493 TO 494 - POTENTIAL CUT AREA

Between Mile 493 and 494 the highway route leaves the flood plains and alluvial terraces of the Mackenzie River and climbs some 270

... 101

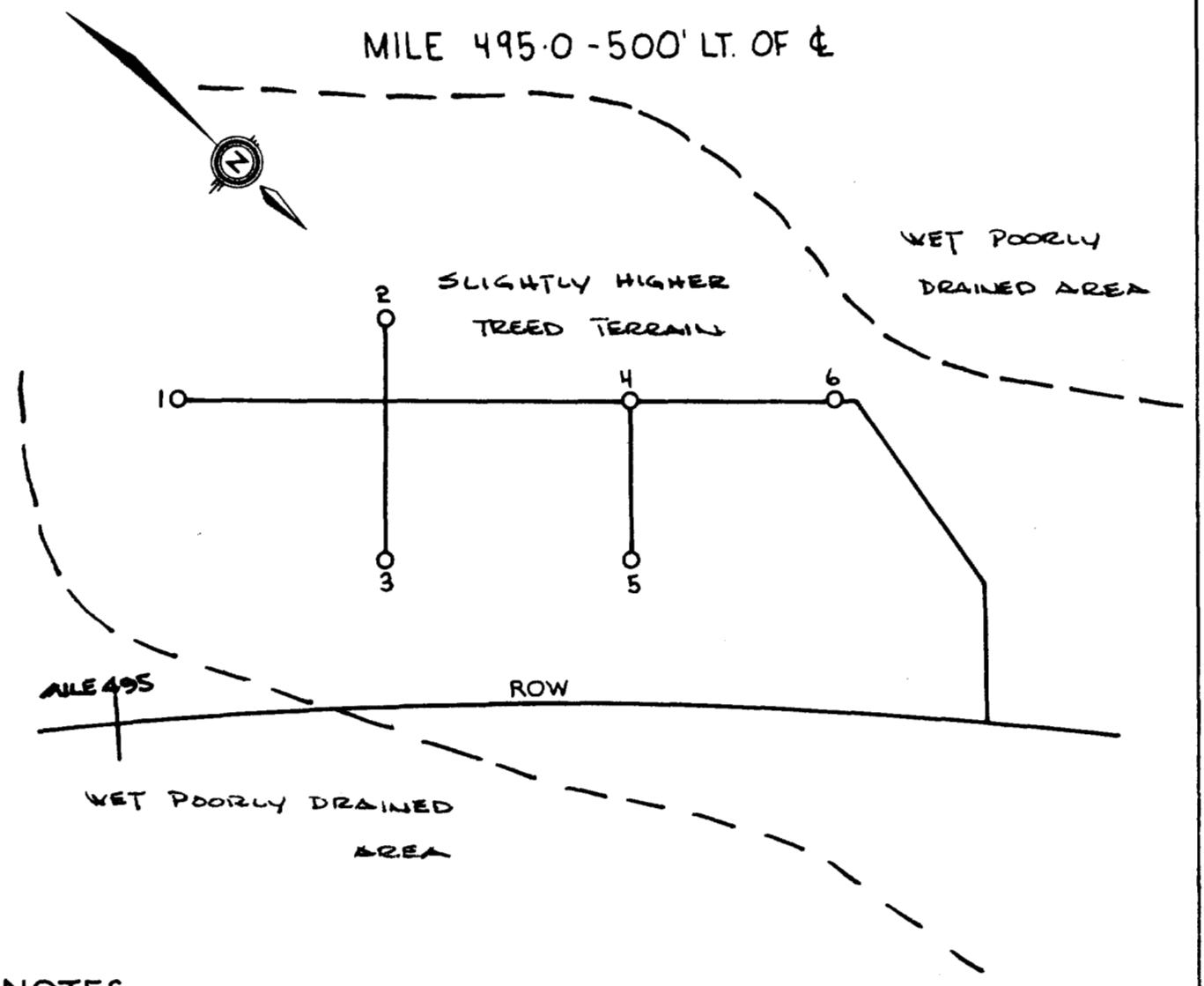
feet onto an extensive glaciolacustrine plain. Eight test holes (493-C-1 to C-8) were drilled in the valley slopes in the potential cut area. All holes revealed low to medium plastic silty clay. Permafrost was sporadic, however, as most holes were drilled on existing cut lines near the edge of the valley slope, it is expected that a massive cut would largely encounter frozen subsoil especially on the right-hand or up-slope side of centerline. Visible ice contents in all holes were low to moderate and moisture contents on thawing consistently range between 20 and 25% and roughly at the plastic limit of the clay. These drill holes indicate that an extensive cut would be feasible here, that the excavated material would be suitable for embankment construction, and that post-construction back-slope stability problems would be limited to localized sloughs where ice concentrations were encountered.

MILE 495.0 - BORROW PIT NO. 93

- 500 feet left of centerline.

The terrain north of Mile 494 to approximately Mile 500 is a very flat glaciolacustrine plain, sparsely treed and poorly drained with numerous small lakes and potholes. Borrow area 93 is in a stand of willow, spruce and birch. Soil is medium to highly plastic silty clay and although permafrost is continuous, ice contents are low. Moisture contents upon thawing average near 20% and are at or slightly below the plastic limit. Stripping depths are estimated at 2-3'. Pit 93 is considered to be usable material in a terrain of generally poor borrow.

... 102



NOTES

- TREE COVER SPRUCE, BIRCH AND WILLOW
- SUBSOIL HIGHLY PLASTIC SILTY CLAY
- PERMAFROST THROUGHOUT - LOW ICE CONTENT
- MOISTURE CONTENTS ON THAWING ≃ 20% ≈ PLASTIC LIMIT
- USEABLE BORROW SOURCE

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 93	designed by / conçur par — date
	scale / échelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

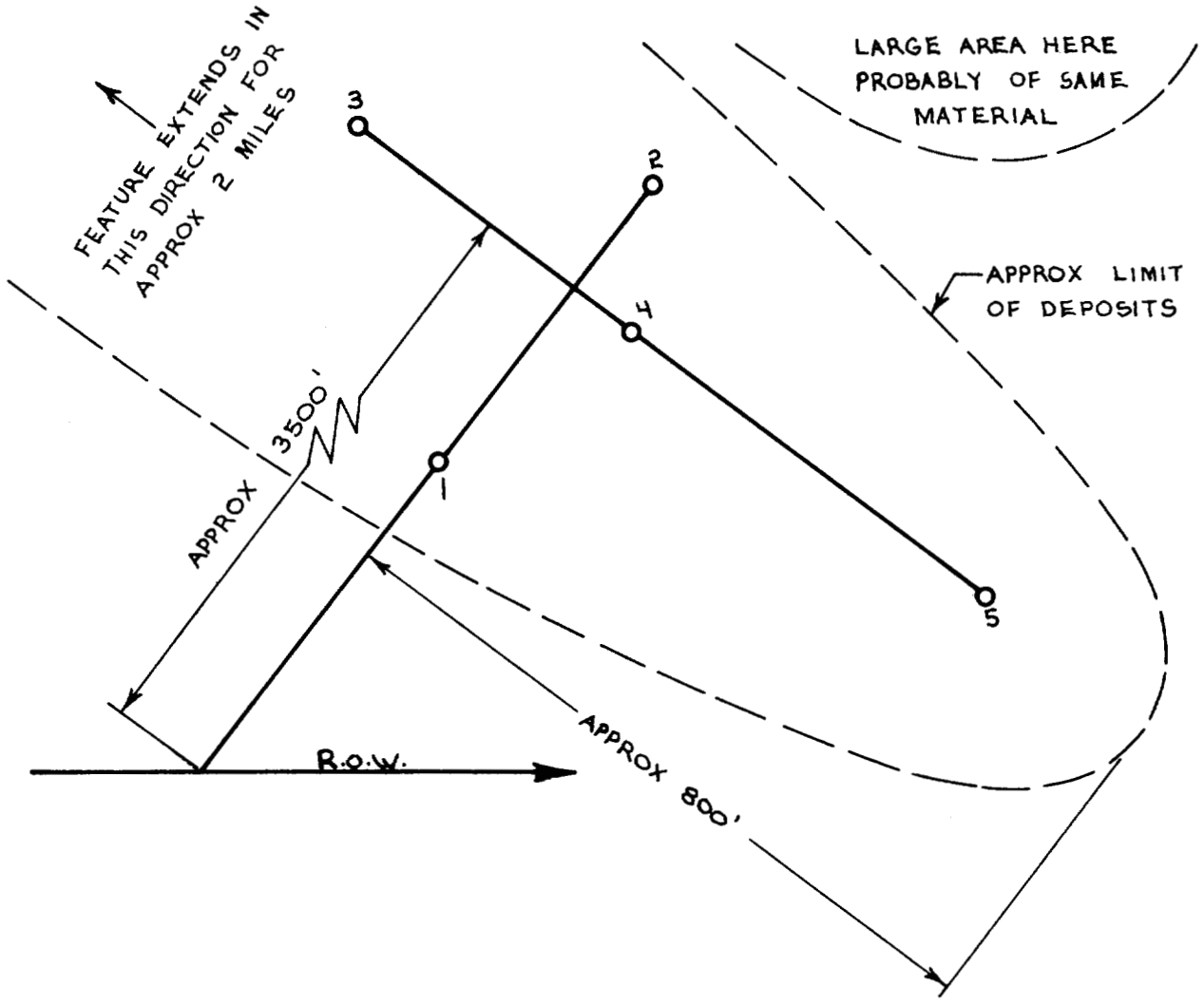
MILE 497.7 - BORROW PIT NO. 94

- 3500 feet left of centerline.

Borrow Pit 94 is on the tip of a large longitudinal segment of a glaciofluvial plain. Deposits in the area drilled vary from silty sands to gravelly sands to sandy gravels. Tree cover on the granular materials is primarily jackpine with some spruce. Permafrost is largely absent and moisture contents are very low, the majority being less than 5%. This area is an excellent borrow source. The feature on which Pit 94 is located ranges from 1000 to 2500 feet in width and is approximately 2 1/2 miles in length. This area will likely be a good source of granular surfacing materials.

... 104

MILE 497·7 - 3500' LT. OF ℄



NOTES

- TREE COVER JACKPINE AND SPRUCE
- FLUVIAL DEPOSITS VARYING FROM SILTY SANDS TO GRAVELLY SANDS TO SANDY GRAVELS
- LITTLE OR NO PERMAFROST
- VERY LOW MOISTURE < 5%
- EXCELLENT BORROW SOURCE
- PROBABLE SOURCE OF SURFACING MATERIALS WEST & NORTH OF AREA DRILLED

Public Works Travaux publics Canada Canada

drawing title / titre du dessin

BORROW PIT 94

scale / échelle 1"=200'

designed by / conçu par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 495 TO 497 - BORROW PITS NO. 95, 96 AND 97

- 2,500 to 4,000 feet right of centerline.

These three areas were drilled in terrain similar to Borrow Pit 93 and subsoil, permafrost and moisture conditions are practically identical to those encountered in Pit 93. Material in these areas is considered usable, however because of the distance from the right-of-way and the availability of material in Pits 93 and 94, development of Pits No. 95, 96 and 97 will likely prove to be uneconomical.

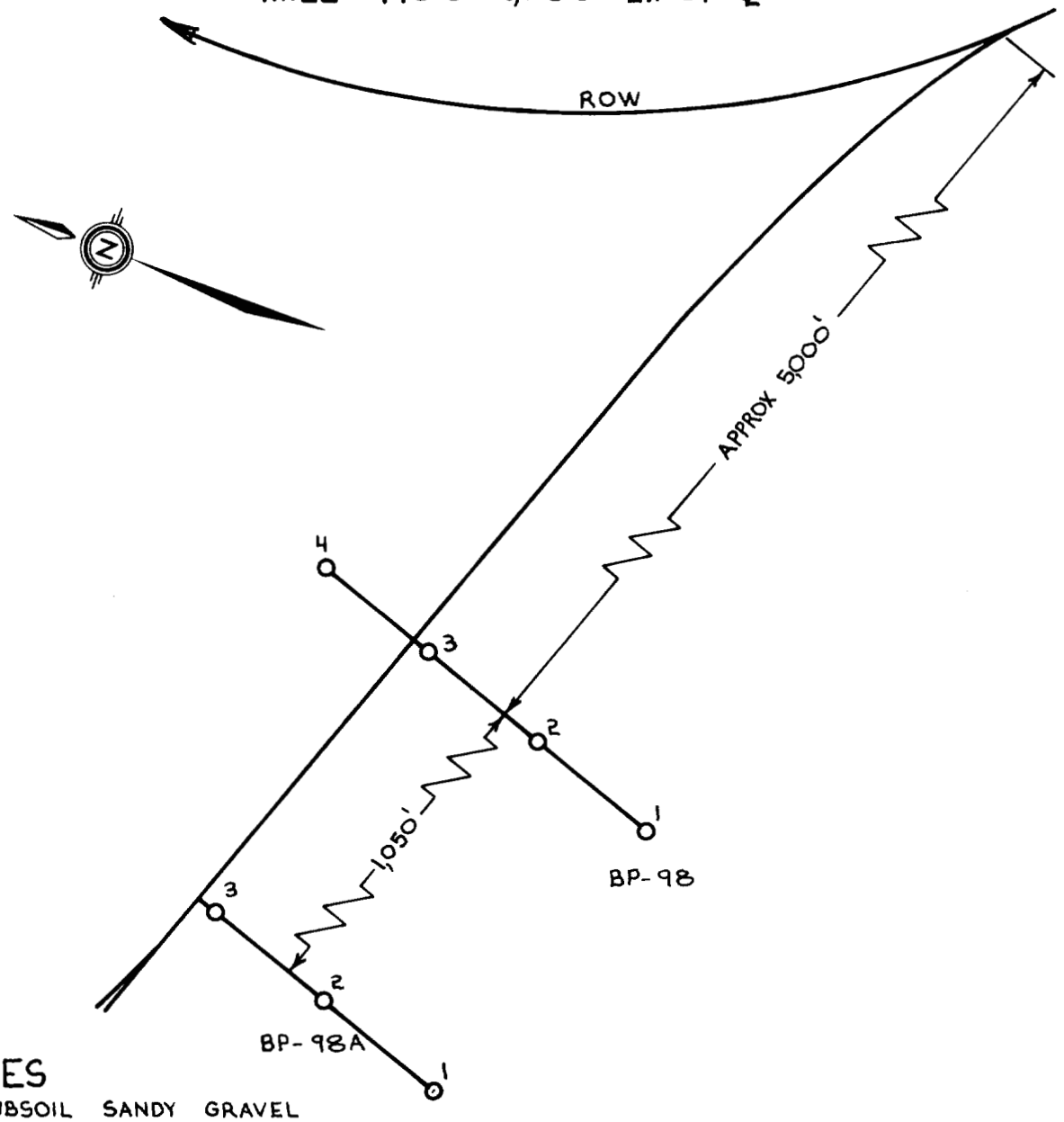
MILE 498.0 (APPROXIMATE) - BORROW PITS NO. 98 AND 98A

- 5,000 feet left of centerline.

These two areas were drilled on another large longitudinal segment of the glaciofluvial plain on which Borrow Pit 94 is located. Deposits encountered during this drilling program and during previous drilling by others (Granular Materials Inventory - PEMCAN SERVICES '72) were gravelly sands and sandy gravels. This segment of the glaciofluvial plain encompasses an area of approximately 3 1/2 miles in length and averages 1/4 mile in width. Volumes have been estimated by Pemcan '72 at 10 million cubic yards. Permafrost was not encountered in the test holes and moisture contents to roughly the 15' level are low. Below 15 feet some free water was noted and the deposits are generally wet. This area would appear to be an excellent source of granular borrow.

... 106

MILE 498·0 - 5,000' LT. OF ℄



NOTES

- -SUBSOIL SANDY GRAVEL
- -NO PERMAFROST
- -WET BELOW 15'
- -EXCELLENT SOURCE OF GRANULAR BORROW
- -VOLUME ESTIMATED BY 'PEMCAN 72' @ 10,000,000 YDS^3

Public Works Travaux publics Canada Canada

drawing title / titre du dessin

BORROW PIT 98 & 98A

scale / echelle 1" = 300'

designed by / concur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

révisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 498.0 TO MILE 500.8 - REVISION

This revision is on glaciolacustrine plain sediments from Mile 498 to approximately Mile 499.8, and eleven test holes within this section (498-C-1 to C-5, and 499-C-1 to 499-C-6) reveal frozen, medium to highly plastic, silty clay throughout. From Mile 499.8 to approximately Mile 500.7 the route crosses a poorly drained, infilled, melt water channel marked by numerous lakes and muskeg bog areas. There is a narrow band of granular glaciofluvial deposits at the mid-point of the outwash channel, and one hole (500-C-2) revealed sandy gravels to a depth of at least 15 feet here. On either side of this granular deposit the melt water channel contains peat and ice-rich organic silts and clays, and an embankment will be subject to significant subsidence if subgrade thaw should occur. Thus minimum fill heights of 6-7' are recommended across the melt water channel.

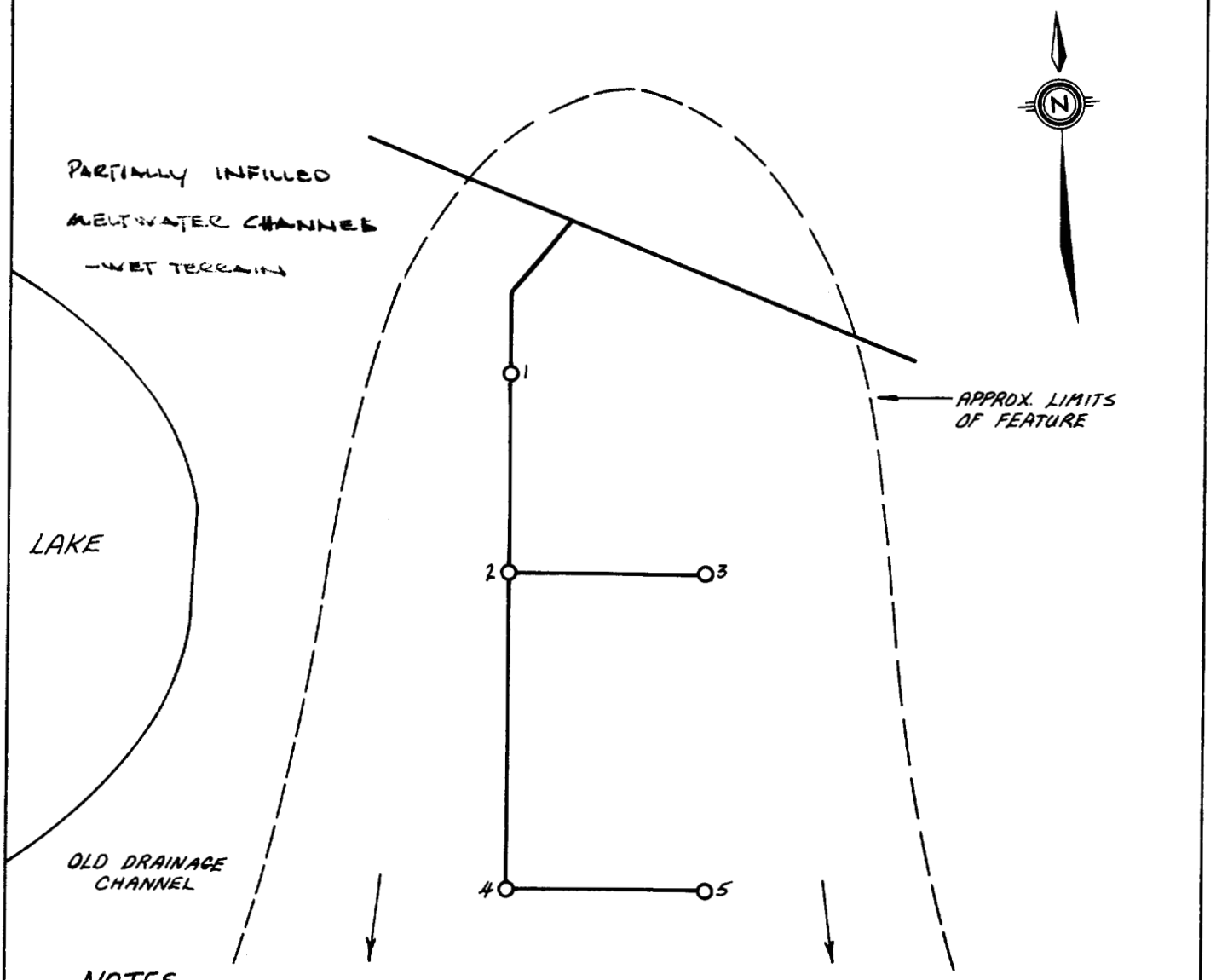
MILE 500.2 - BORROW PIT NO. 99

- 500 feet left of centerline.

Pit No. 99 is adjacent to test hole 500-C-2 and is on the tip of the longitudinal segment of the glaciofluvial plain on which Borrow Pit 98 and 98A are located. Deposits in the area drilled are sandy gravel. Permafrost was not encountered and moisture contents are low to a depth of 13-15' where water was noted. Tree cover is primarily jackpine. This is an excellent source of granular borrow.

... 108

MILE 500·2 - 500' LT OF ℄



NOTES

- SUBSOIL SANDY GRAVEL.
- EXCELLENT GRANULAR BORROW.
- NO PERMAFROST.
- DRY TO APPROX 13'-15' WET BELOW.
- SAME FEATURE AS B98 AND B98A ARE LOCATED ON.

FEATURE EXTENDS IN THIS DIRECTION SOME 3½ MILES. INCLUDES PIT AREAS B98 AND B98A.

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 99

scale / échelle 1" = 200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

GEOTECHNICAL EVALUATION

MILE 500 TO MILE 550

MACKENZIE HIGHWAY

MILE 505.0 - TEST HOLES 504-C-1 AND 504-C-2 - CREEK CROSSING

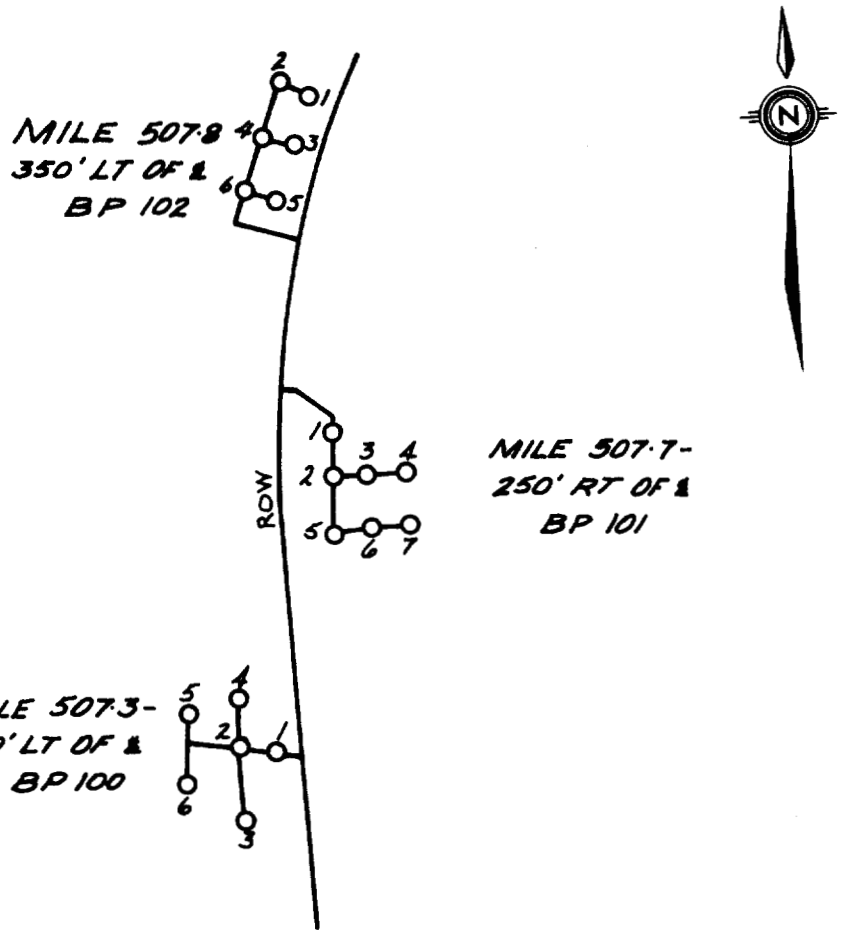
The test holes here reveal organic and ice-rich subsoil to a depth of approximately 4-5', below which are silty gravelly sands to approximately 20 feet, which in turn overlie sandy silty clay till. The sandy deposits below the depth of 5-6' should provide a good base for the proposed culverts and sub-excavation and backfill to that level is recommended.

MILE 507 TO 508 - BORROW PITS NO. 100, 101 AND 102

- 500 to 600 feet both right and left of centerline.

These three areas are located on a portion of a glaciolacustrine plain that is dissimilar from the adjacent terrain in that there is an absence of small ponds and peat filled depressions. Tree cover is small spruce. Subsoil deposits are somewhat variable but generally consist of low plastic sandy silty clays with pebbles to approximately 15-20', overlying partially sorted sandy deposits. Permafrost is common to the area and visible ice is generally low with occasional moderate ice zones. Moisture contents on thawing are generally below 15%. Where the subsoil contains significant amounts of clay, the material is damp to moist on thawing. Where the subsoil is primarily silt or sand the material is wet on thawing. Stripping depths will probably range from 2-4'. There is little to choose between the three areas. All contain what is considered to be usable borrow in a stretch of poor quality subsoil, and it is recommended that the location which provides the best haul economics be selected as a borrow source.

... 110



NOTES

- SUBSOIL SANDY SILTY CLAY WITH PEBBLES TO APPROX 20' OVER POORLY SORTED SANDY DEPOSITS
- PERMAFROST THROUGHOUT
- SUBSOIL DAMP TO MOIST ON THAWING WHERE CLAY CONTENT IS SUBSTANTIAL- WHERE CLAY CONTENT IS LOW MATERIAL MOIST TO WET
- USEABLE BORROW WITH PROBABLY 2-4' OF STRIPPING
- SUGGEST SELECT AREA WHICH WILL PROVIDE BEST HAUL ECONOMICS

Public Works Travaux publics
Canada

drawing title 'titre du dessin
BORROW PITS
100, 101 & 102

scale / échelle

designed by / conçur par — date
drawn by /dessiné par — date
reviewed by / examiné par — date
approved by / approuvé par — date

region
region

revisions — date
revisions

project number
no. de entreprise

drawing no
no du dessin

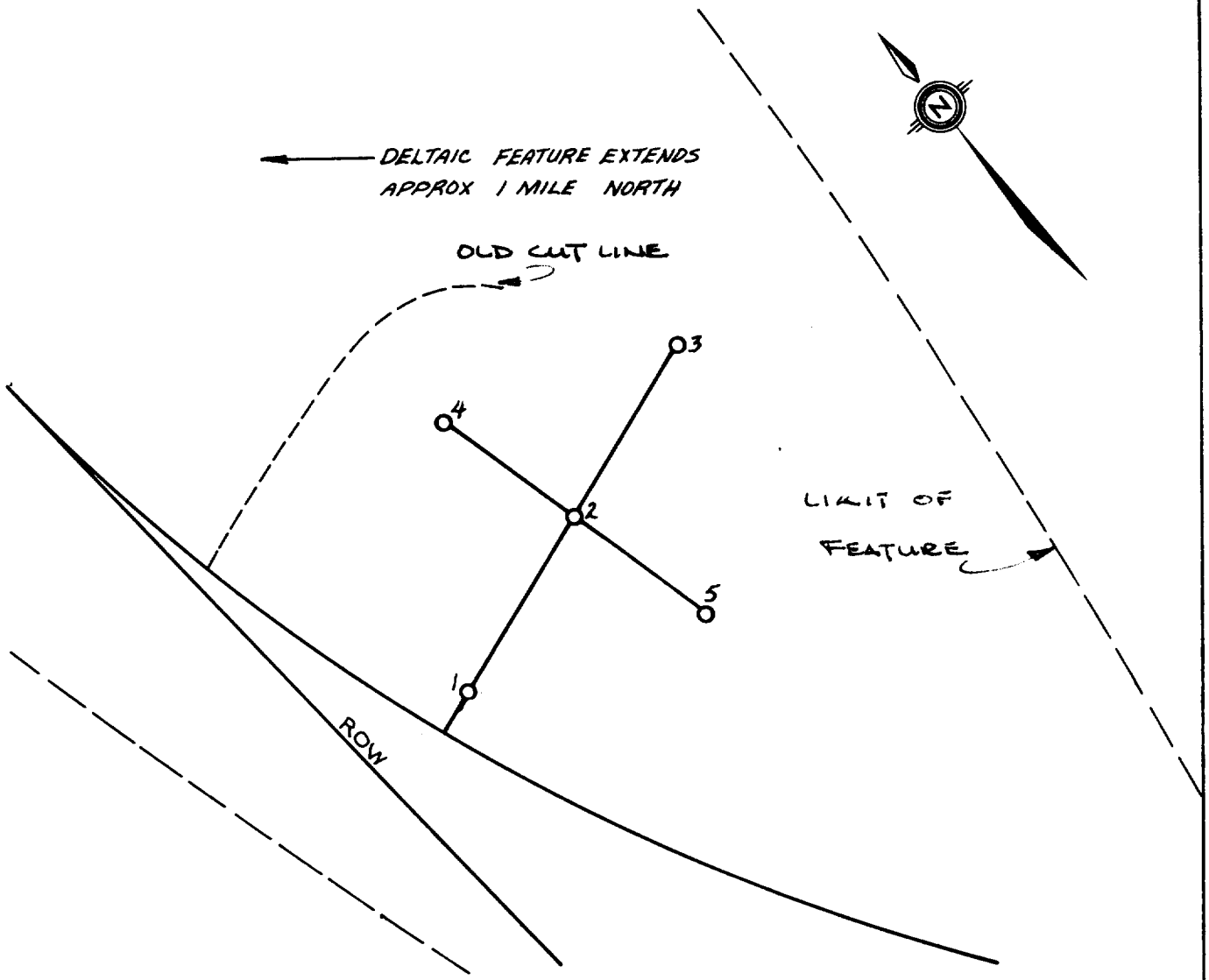
D.P.W. 700 A

MILE 508.8 - BORROW PIT NO. 103

- 600 feet right of centerline.

The area test drilled here is part of a deltaic sand deposit within a glaciolacustrine plain. The deltaic feature rises slightly above the adjacent flat plain and covers an area of approximately one mile in length and one-half mile in width. Pit No. 103 is near the south-end of the feature. Deposits consist of fine to coarse gravelly sand to the depth of 11 or 12 feet, overlying low plastic sandy silty clay with pebbles. Permafrost is expected to be absent from the site. Moisture contents are generally 10 to 12% or lower, however, there is sufficient moisture that the sandy material is wet. The right-of-way traverses the deltaic deposit to approximately Mile 509.7 and it is anticipated that similar material will be encountered anywhere along that section, thus a borrow pit can be developed wherever it is most favorable for haul economics. The material is considered to be usable borrow despite the wet zones. Stripping will likely be less than 2 feet.

... 112



NOTES

- FEATURE IS DELTAIC DEPOSIT - SANDS TO 11-12' OVER SILTY CLAY
- LITTLE OR NO PERMAFROST
- MOISTURE CONTENTS ∠ 15% BUT SANDS TEND TO BE WET
- CONSIDERED TO BE USEABLE MATERIAL
- PIT CAN LIKELY BE LOCATED ANYWHERE BETWEEN MILE 508·8 AND 509.7 FOR BEST HAUL ECONOMICS - MATERIAL SHOULD BE SIMILIAR.

Public Works Travaux publics Canada Canada

drawing title / titre du dessin

BORROW PIT 103

scale / echelle

designed by / concur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 510.8 - TEST HOLE 510-C-1 - PROPOSED CUT

A cut to 45 feet is proposed here where the route descends roughly 170 feet from a glaciolacustrine plain to the flood plain of the Mackenzie River and the crossing of Steep Creek. Previous drilling (by consultants) in this cut section had indicated unfrozen poorly graded gravels or gravelly clays. The single test hole during this program, however, encountered sandy silts over silty sandy clay. Only surface frost was encountered and despite what appears to be variable subsoil conditions, the area should be suitable for cut. A wet layer was noted near 10 feet at the intersection of the silty sand and clay layers and it is likely that some seepage will be noted in the backslopes at this level following construction.

MILE 512.7 - TEST HOLES 512-C-1 TO 512-C-6 - PROPOSED CUT

From Mile 512 to Mile 513 the route climbs some 200 feet from the flood plain of the Mackenzie River to the top of the adjacent glaciolacustrine plain, following the crossing of Steep Creek. The proposed cut here is near the upper edge of the plain, and extends over approximately 1000 feet reaching depths of about 15 feet. The subsoil in the cut consists of variable depths of sand-silt over low plastic sandy silty clay. The face of the slope appears to be permafrost free, however, permafrost was encountered near the surface of the plain, hence at least a

... 114

portion of the cut will be in permafrost. Moisture contents throughout the cut section generally do not exceed 20%, however, some of the sand-silt material is wet or saturated in the thawed state at moisture contents of 20%. These silty materials may tend to flow upon thawing and some localized slough will likely occur on backslopes following construction. The underlying clay would appear to be a glacial till and will perform well in cuts even though frozen.

MILE 514 - TEST HOLES 513-C-1 TO 513-C-4, AND 514-C-1 TO 514-C-3 - PROPOSED CUT SECTIONS

Near Mile 514 the route crosses a deep unnamed stream valley on the glaciolacustrine plain and major cut sections are proposed on either side of the depression. Medium plastic silty clay was encountered throughout both cut sections and although permafrost is present, visible ice contents are low and moisture contents on thawing generally are at or slightly below the plastic limit. Occasional isolated ice-rich zones may be encountered in these cuts, however, in general, the material should perform well in cut section and should be acceptable for embankment construction.

MILE 515 TO 518 - BORROW PITS NO. 104 TO 107

Between Mile 515 and 518 the highway route crosses a glacio-lacustrine plain. A borrow pit has been selected from previous drilling near Mile 516.3 (left of centerline), however, the material in the designated pit is borderline as fill material, consisting of medium plastic silty clay with low to moderate ice contents. Borrow Pits No. 104 to 107 were drilled in an attempt to improve on the quality of material in the designated pit. Subsoil in all 4 areas is medium plastic sandy silty clay. Permafrost is continuous and moisture contents upon thawing average between 25 and 30% and are above the plastic limit of the material and probably average 3 to 5% above optimum. Stripping depths are estimated at 3 to 5 feet. None of the 4 areas are considered an improvement over the designated pit and no changes are recommended.

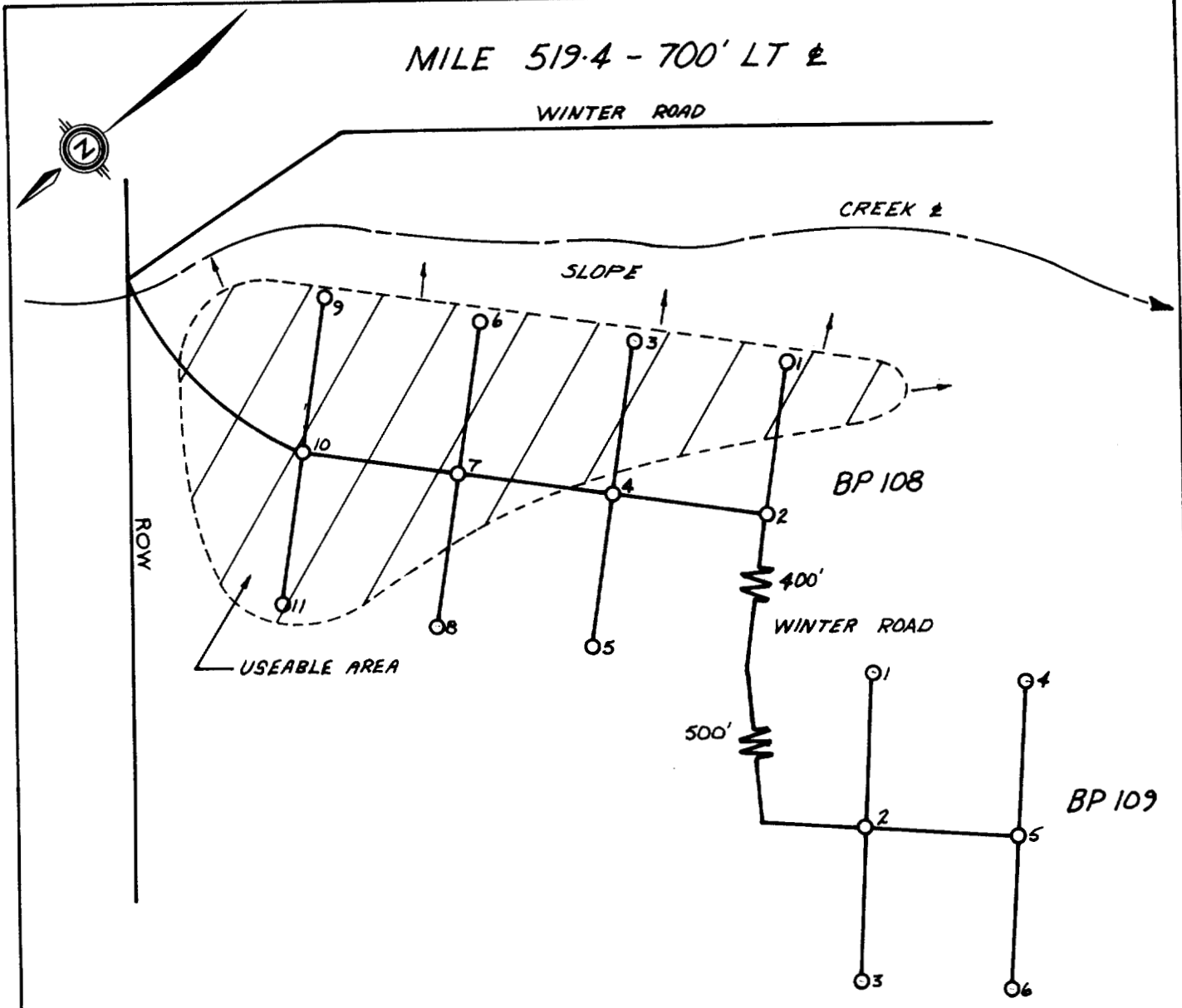
MILE 519 TO 521 - BORROW PITS NO. 108, 109, 110 AND 111

Between an unnamed creek at Mile 519 and the Saline River at Mile 521.5, the route crosses near the western edge of a large glaciofluvial plain. Four areas were test drilled here, all on the western side of the right-of-way and off the glaciofluvial plain. Areas 108, 109, and 110 are located along the banks of the unnamed creek from Mile 519 to 520. Subsoil is medium plastic silty clay and usable material is available only along the slopes of the creek valley. Area 108 is preferred here and although permafrost is present, significant volumes of borrow can be obtained (see site plan). Moisture contents on thawing are below 20% and at, or slightly below,the plastic limit. Pit 108 is at Mile 519.5 - 700 feet left of centerline.

Borrow Pit 111 is located at Mile 520.9 approximately 1000 feet left of centerline. The feature drilled here is probably a narrow band of glaciofluvial deposits. The subsoil consists of variable thicknesses of partially sorted deposits primarily silty sands and/or gravelly sands, over sandy silty clay. Permafrost is continuous throughout and moisture contents are erratic. There is some usable borrow here, however, conditions are highly variable and it will be difficult to develop a pit of any size. A small area of usable material, in which 3 holes were drilled, has been shown on the site plan and further drilling is recommended here at construction to define the borrow limits. As an alternate, Pemcan '72 encountered what appears to be usable sands and gravels on the glaciofluvial plain approximately 2000 to 2500 feet due north of Mile 520.

... 118

MILE 519·4 - 700' LT ℄



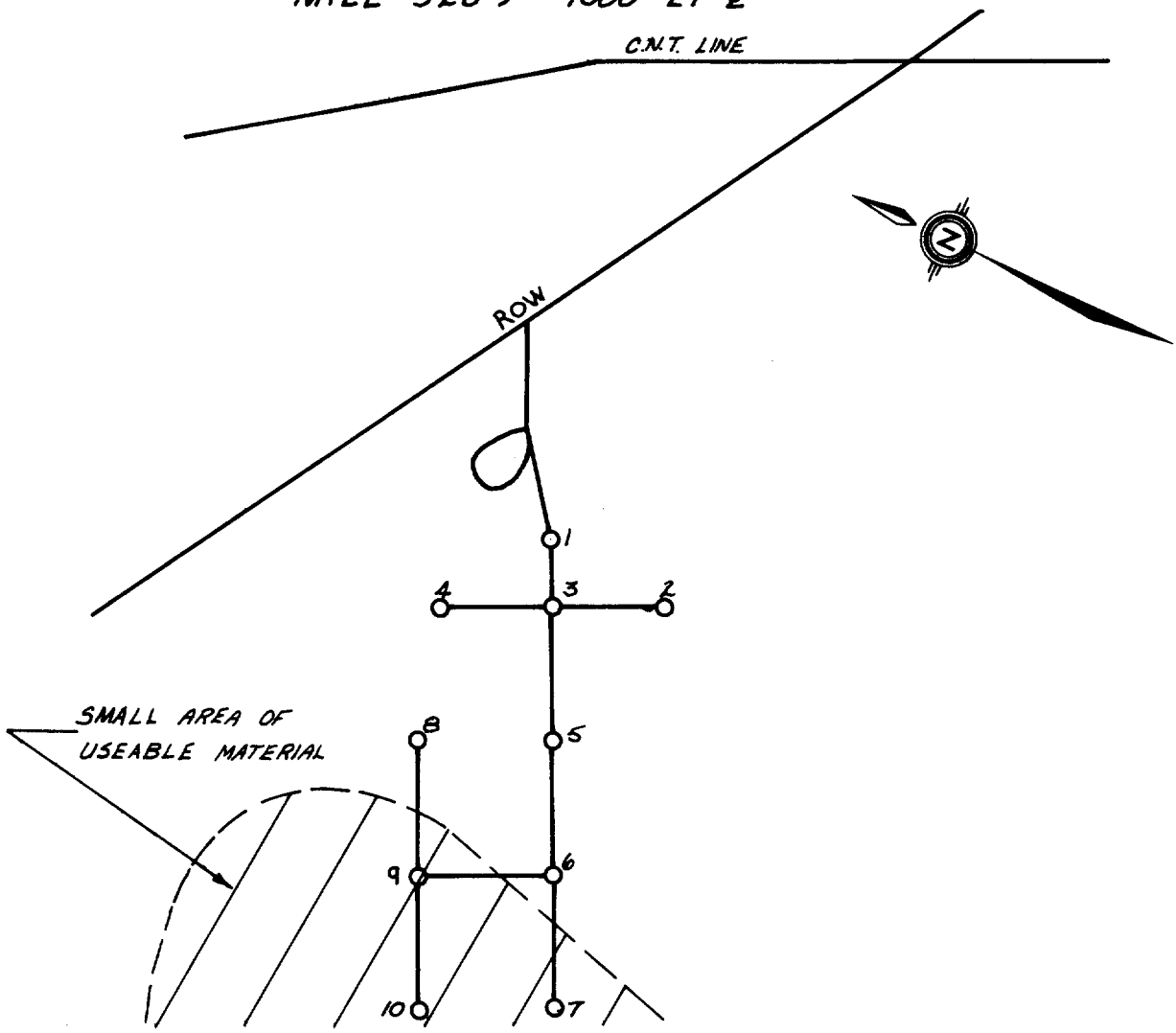
NOTES

- SUBSOIL MEDIUM PLASTIC SILTY CLAY
- PERMAFROST THROUGHOUT
- MOISTURE CONTENTS ∠ 20% ∠ PLASTIC LIMIT
- PREFERRED AREA IS ALONG EDGE OF SMALL CREEK VALLEY
- STRIPPING IN HATCHED AREA ESTIMATED @ 2'

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PITS 108 & 109	designed by / conçur par — date
	scale / échelle: 1"= 300'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 520·9 - 1000 LT ℄



NOTES

- SUBSOIL SILTYSANDS AND SOME SAND-GRAVELS OVER SANDY SILTY CLAY
- PERMAFROST THROUGHOUT AND MOISTURE (ICE) CONTENTS VARIABLE AND ERRATIC
- SOME USEABLE MATERIAL IN HATCHED AREA WITH 2·3' OF STRIPPING
- FURTHER DRILLING RECOMMENDED AT CONSTRUCTION.

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT III scale / échelle: 1"= 400'	designed by / conçur par — date drawn by / dessiné par — date reviewed by / examiné par — date approved by / approuvé par — date
region region	revisions — date revisions	project number no. de entreprise drawing no no du dessin

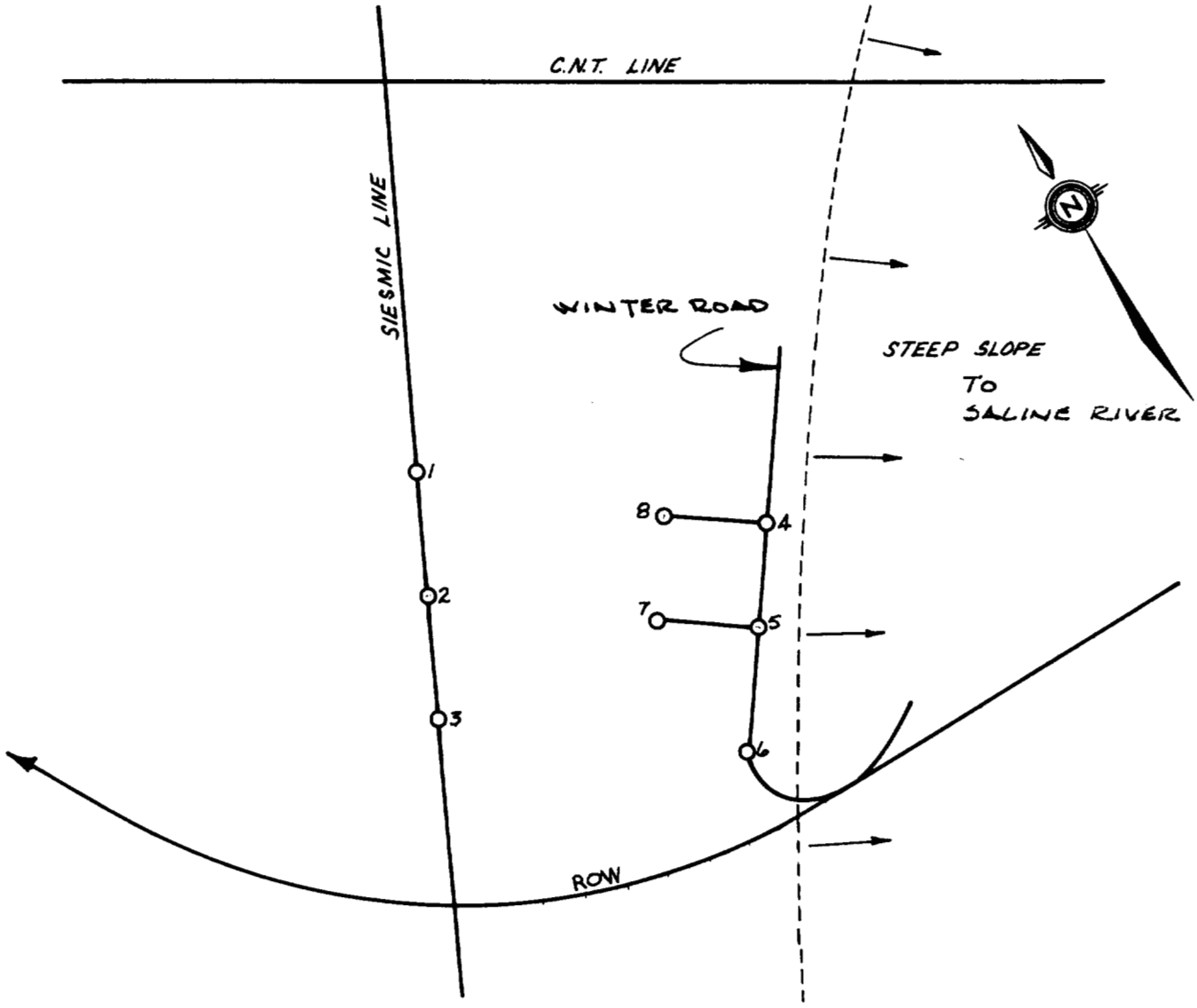
D.P.W. 700 A

MILE 521.8 - BORROW PIT NO. 112

- 700 feet right of centerline.

The area test drilled here is on flat terrain above the northwestern valley slope of the Saline River. The tree cover is willow and sparse birch. Subsoil is low to medium plastic sandy silty clay with pebbles - probably glacial till. Permafrost is continuous, however, visible ice is low and moisture contents on thawing are in the 15 to 18% range and near the plastic limit. Stripping should be less than 2 to 3 feet. This is considered to be a usable borrow source.

MILE 521·8 - 700' RT ℄



NOTES

- SUBSOIL LOW TO MEDIUM PLASTIC SANDY SILTY CLAY WITH PEBBLES (TILL)
- FROZEN WITH MOISTURE (ICE) CONTENTS ≃ PLASTIC LIMIT @ 15 to 18%
- USEABLE BORROW
- WILLOW AND BIRCH TREE COVER
- STRIPPING ESTIMATED @ ∠ 2·3'

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 112	designed by / conçur par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / échelle 1"= 400'	approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 522.9 - BORROW PIT NO. 113

- 400 feet left of centerline.

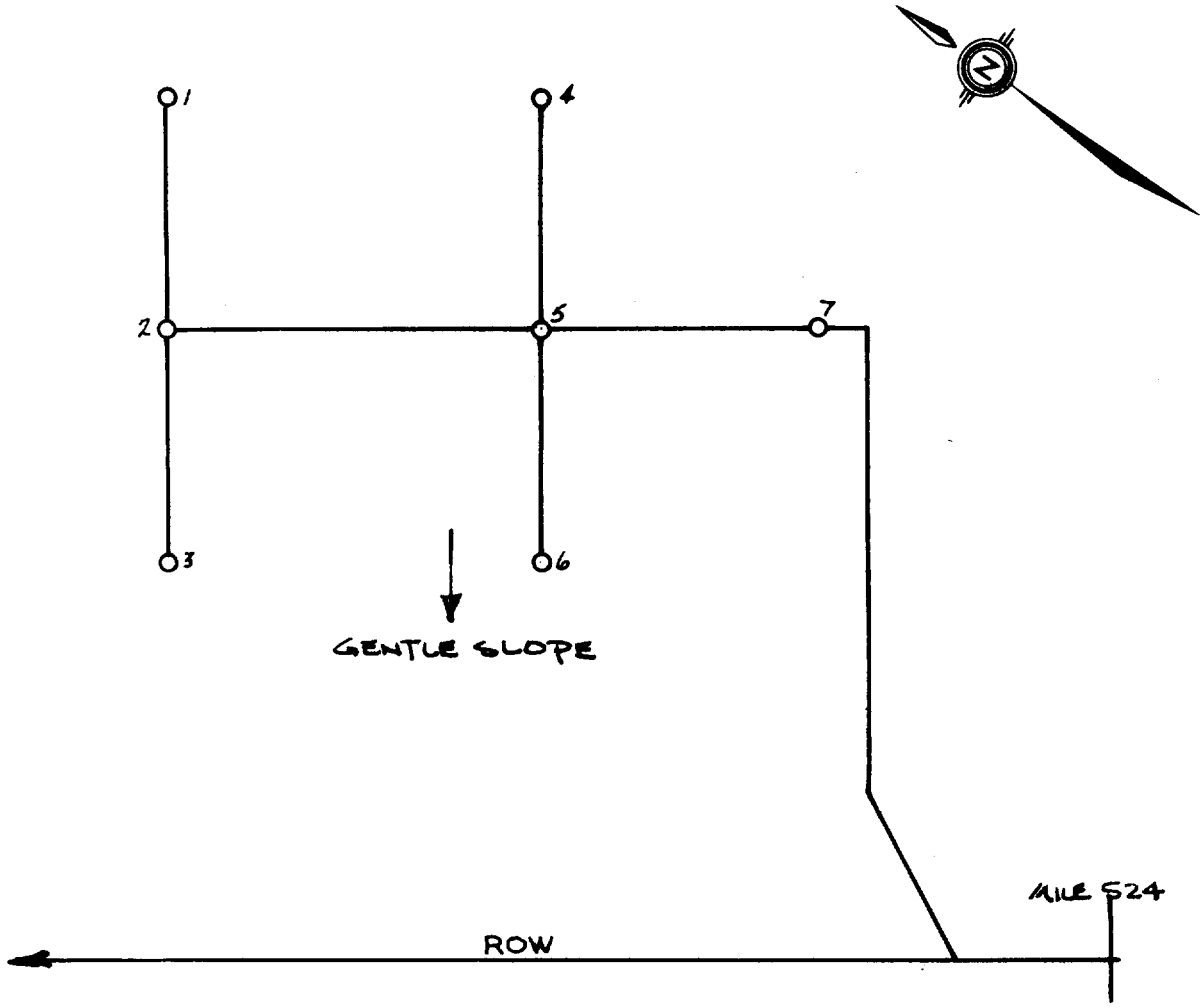
Subsoil here is frozen, low to medium plastic sandy silty clay (till). Ice contents are variable and stripping depths are estimated at 2 to 5 feet. Not recommended as a borrow source.

MILE 524.1 - BORROW PIT NO. 114

- 600 feet right of centerline.

This pit was selected on the basis of a previous drilling program and the current drilling was for the purpose of expanding and confirming the borrow area. The feature drilled is a low till ridge. Subsoil is low to medium plastic sandy silty clay with pebbles (till). The ridge appears to be unfrozen and moisture contents vary around 10 to 12% and below the plastic limit. This is an excellent borrow source.

MILE 524·1 - 600' RT OF ℄



NOTES

- FEATURE IS A LOW TILL RIDGE
- SUBSOIL UNFROZEN, LOW TO MEDIUM PLASTIC, SANDY SILT CLAY WITH PEBBLES
- MOISTURE CONTENTS - 10 - 12%
- STRIPPING ∠ 2'
- EXCELLENT BORROW SOURCE

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 114

scale / échelle

designed by / conçu par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

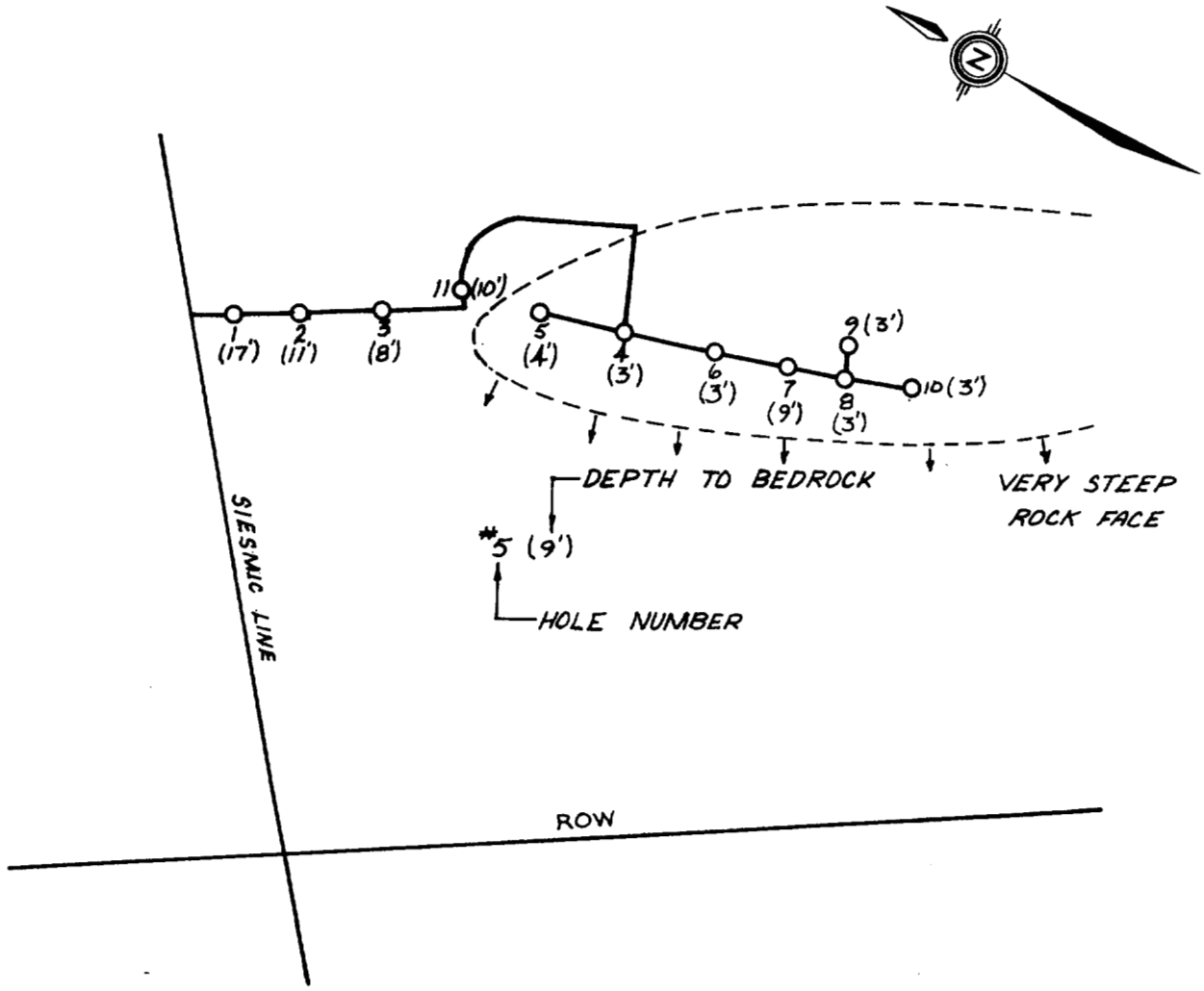
D.P.W. 700 A

MILE 526.0 - BORROW PIT NO. 115

- 3,000 feet right of centerline.

The feature drilled here is a narrow, elongate bedrock ridge which roughly parallels the right-of-way. The ridge is sharply defined on the west with steep exposed rock faces, and access was gained on the more rounded slopes to the east. Bedrock is shales and dolomite with variable cover consisting of sandy silty clay till. The overburden till is at low moisture contents and is usable borrow. The underlying bedrock was categorized as soft by the field crews, however, it is anticipated that blasting of bedrock will be required for borrow. Depths to bedrock are shown for each hole on the site plan.

MILE 526 - 3000' RT OF ℄



NOTES

- SUBSOIL CLAY TILL OVER SHALE AND/OR DOLMITE
- CLAY TILL IS USEABLE WITH LITTLE STRIPPING ∠ 2'
- BEDROCK IS CATEGORIZED AS SOFT BUT BLASTING IS ANTICIPATED FOR BORROW

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 115	designed by / conçu par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / echelle: 1"= 1000'	approved by / approuvé par — date
region	revisions — date	project number / no. de entreprise; drawing no / no du dessin
region	revisions	

D.P.W. 700 A

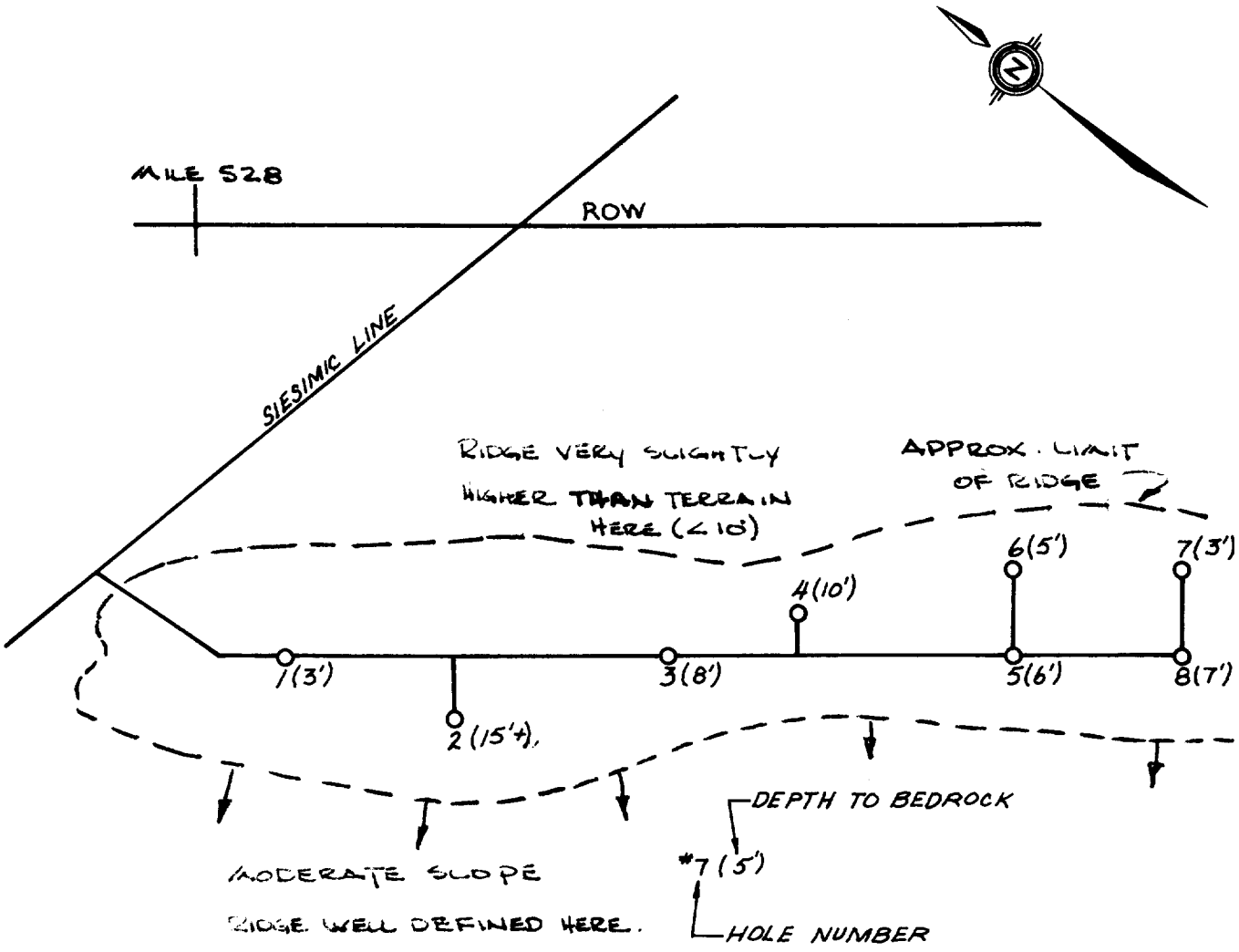
MILE 527.7 - BORROW PIT NO. 116

1,000 feet left of centerline.

This feature is an elongate ridge similar to Borrow Pit No. 115 but smaller and with less relief. The western edge of the ridge is defined by a moderately steep slope, whereas on the east, the level of the ridge is only slightly above the surrounding terrain. Bedrock is shales and sandstones with overburden consisting of variable thicknesses of sandy silty clay till and decomposed bedrock. The overburden is at a low moisture content and can be used with very little stripping. The bedrock is rather unusual as it appears there are relatively soft clay-like seams within the layers of shale and sandstone. It is considered quite possible that the bedrock can be ripped and blasting may not be required here. Depths to bedrock are shown for each hole on the site plan.

... 127

MILE 527·7 - 1000' LT OF ℄



NOTES

- GLACIAL TILL OVER SHALES AND SANDSTONES WITH CLAY SEAMS
- TILL IS USEABLE WITH LITTLE STRIPPING ∠ 2'
- BEDROCK WAS CATEGORIZED AS SOFT AND RIPPING MAY BE POSSIBLE

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 116	designed by / conçur par — date
	scale / echelle: 1"=400'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / revisions — date	project number / no. de entreprise — drawing no / no du dessin

D.P.W. 700 A

MILE 529.0 - TEST HOLES 528-C-1 AND 529-C-1 - PROPOSED CUT

A major cut to a depth of 35 feet is proposed on the descent into an unnamed creek valley near Mile 529 and two holes were drilled to confirm the suitability of material as indicated from previous drilling. Both holes encountered silty clays over variable deposits of sandy clay, sandy silt and silty sand which is in accordance with previous drilling data. Permafrost appears to be sporadic and at least part of the cut will be in frozen ground. Materials to the depth of 6-8' will be somewhat wet upon thawing, however, in general, the area should be suitable for cut.

MILE 533.7 - TEST HOLES 533-C-1 TO 533-C-3 - PROPOSED CUT

This cut is in the south slope of the Little Smith Creek valley where the route descends to the crossing of Little Smith Creek. The valley wall is near the edge of a large glaciofluvial outwash plain and the materials in the wall consist of up to 8-10' of sands and gravels over clays and silts. Permafrost is present throughout at depth and while the upper portions of the backslopes will be in stable materials, the lower portions will be in clays and silts that will contain pockets of wet or saturated material on thawing. The ice-rich zones will be near the bottom of the backslopes hence any slough that occurs should be very minor, and ditch erosion will be controlled by the coarse granular ditch lining proposed on the design drawings.

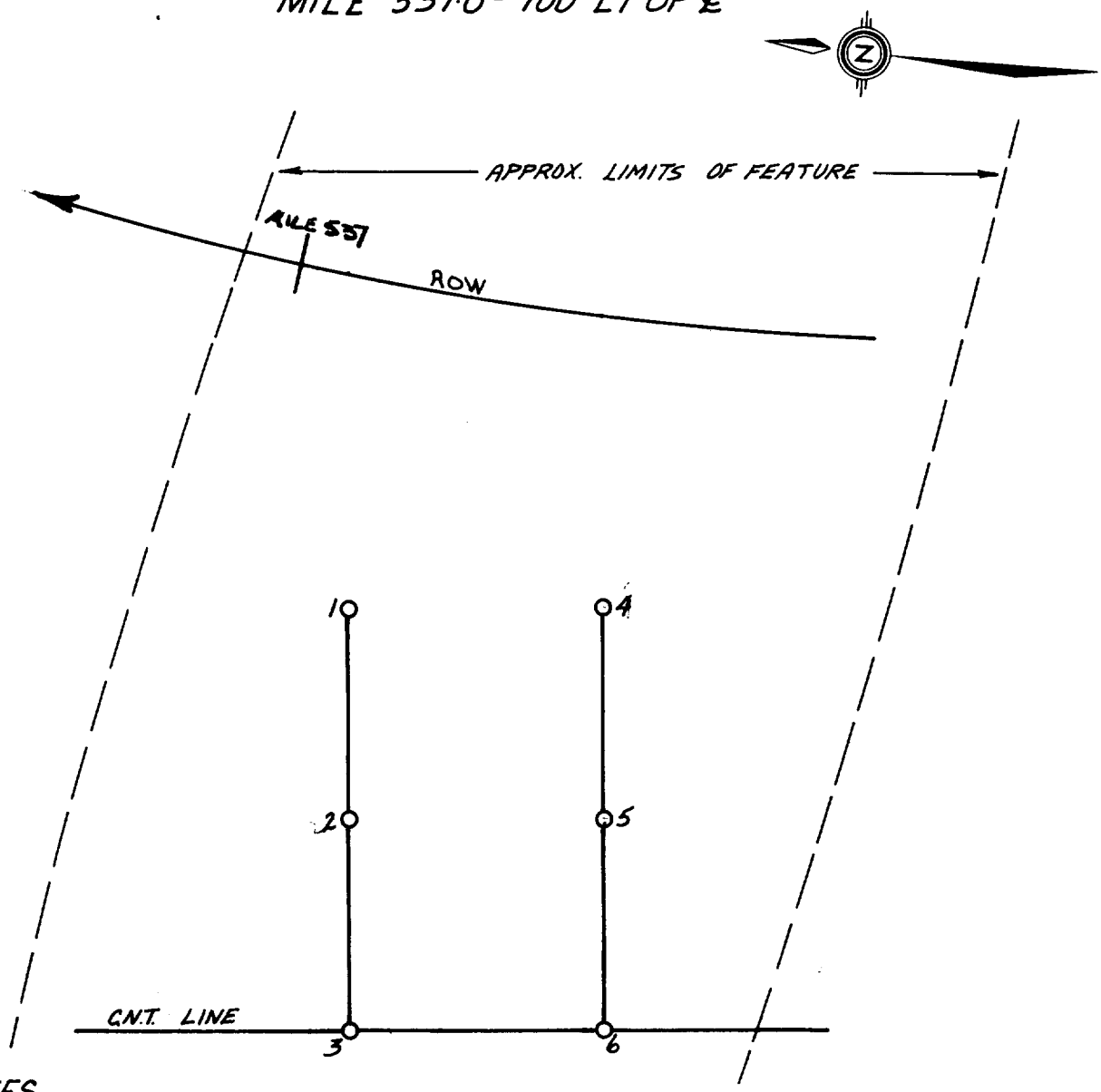
... 129

MILE 537.0 - BORROW PIT NO. 117

- 700 feet left of centerline.

Borrow Pit No. 117 is located on a small fluvial deposit - probably a glacial outwash feature. This area was selected as a borrow source from previous drilling and the current drilling was carried out to confirm and expand the indicated borrow area. The feature is only slightly higher than the surrounding flat, poorly drained, terrain, but is differentiated by a more luxuriant growth of spruce and poplar to 1' diameter. Subsoil is silty and gravelly sand. Permafrost is absent and moisture contents are generally less than 5% to the depth of 15 or 20 feet. Below this level the material becomes wet and limits the depth of usable material. Stripping is estimated at 1 to 2 feet.

MILE 537.0 - 700' LT OF ℄



NOTES

- FLUVIAL DEPOSIT OF SILTY SANDS AND GRAVELLY SANDS
- NO PREMAFROST
- MOISTURE CONTENTS ∠ 5% TO 15.20' - WET BELOW
- LOWER LIMIT OF USEABLE MATERIAL @ 15.20'
- MODERATELY HEAVY SPRUCE AND POPLAR COVER

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 117	designed by / conçu par — date
	scale / echelle: 1"= 200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

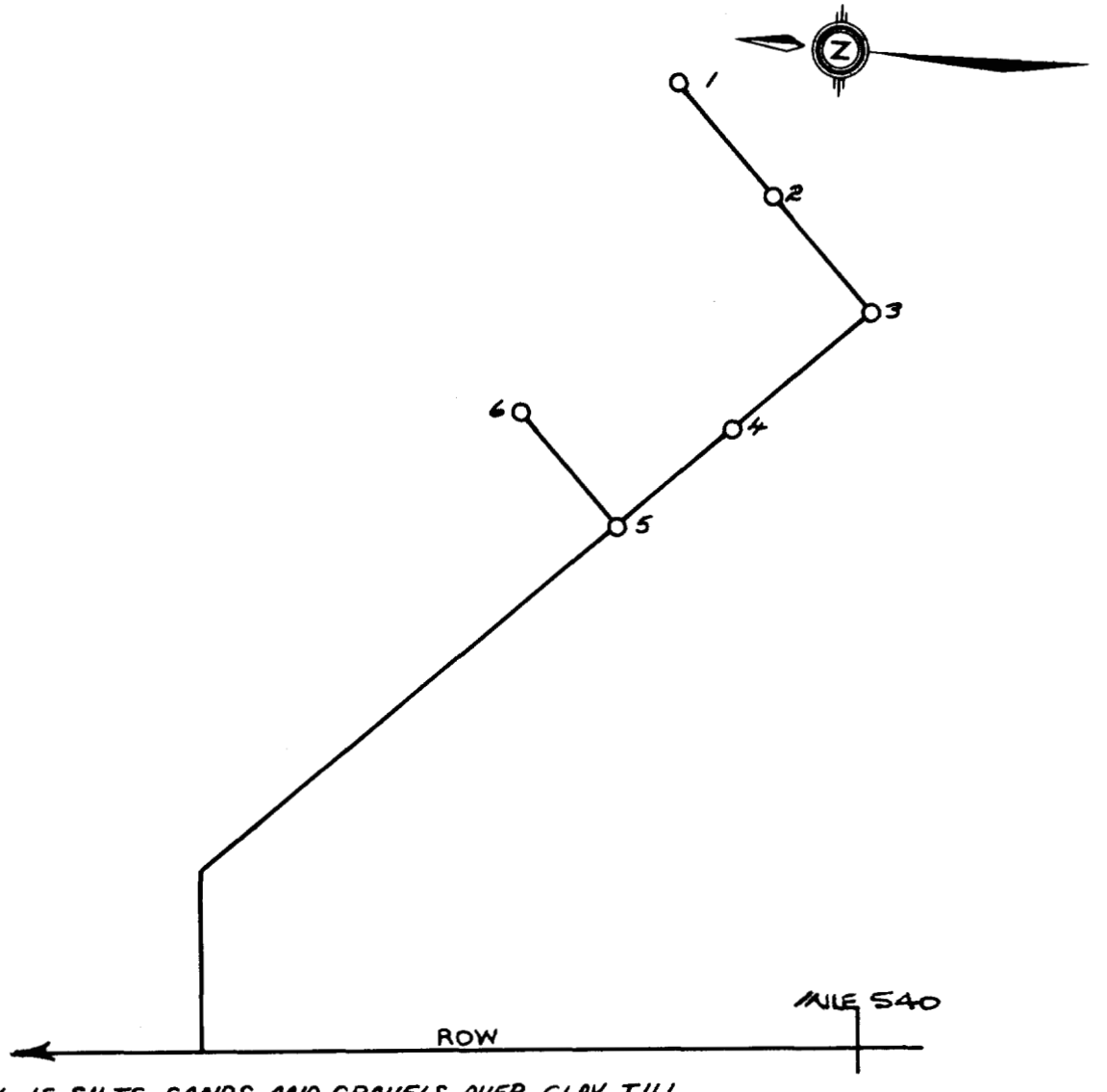
MILE 539 TO 540.2 - BORROW PITS NO. 118 AND 119

The terrain in this area is very flat, and consists of slope wash, over glacial lakebed sediments, over glacial till at depth. The areas test drilled are generally undistinguished from the surrounding terrain in terms of either relief or vegetation. In Borrow area 118 at Mile 539.1, the subsoil consists of variable depths of low plastic sandy silts over medium plastic sandy silty clays. The upper silts tend to be wet and stripping depths are estimated up to 5 feet. Moisture contents at depth are lower but are generally above the plastic limit and average above 20%. Permafrost is at least partially present in the area drilled. The material here is borderline as usable borrow and this area is not recommended for development.

In Borrow area 119 at Mile 540.1 the subsoil consists of variable thicknesses of silts, sands, and sandy gravels, over sandy silty clay till. The low plastic surface deposits tend to be wet upon thawing and stripping depths here could vary up to 5 feet. Materials below the stripping is generally usable although some high ice zones were encountered. This area is considered to contain usable borrow at depths and is probably superior to Pit No. 118 however, the stripping costs may negate against development.

... 132

MILE 5401 - 1000' RT OF ℄



NOTES

- SUBSOIL IS SILTS, SANDS, AND GRAVELS OVER CLAY TILL AT VARIOUS DEPTHS
- PERMAFROST PRESENT
- STRIPPING DEPTHS TO ≈ 5'
- USABLE BORROW AT DEPTH
- DEVELOPMENT DEPENDENT ON HAUL ECONOMICS.

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 119	designed by / conçur par — date
	scale / échelle: 1" = 300'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / revisions — date	project number / no. de entreprise — drawing no / no du dessin

D.P.W. 700 A

MILE 541.2 - BORROW PIT NO. 120

- 500 feet right of centerline.

The previous drilling programs have established bedrock at shallow depths near Mile 541.9, and Pit area No. 120 was drilled as a check for shallow bedrock farther south near the right-of-way. Bedrock was encountered at depths varying from 7 to 17 feet in the area drilled,versus 4 to 5 feet in the designated pit near Mile 541.9. Overburden in Pit No. 120 is sandy silty clay till and stripping depths would vary from 2 to possibly 4 feet. The underlying bedrock is hard and could not be penetrated with the auger rig. A quarry operation would be required here regardless of the pit area. There would be no advantage of changing from the designated pit at Mile 541.9 hence area No. 120 is not recommended.

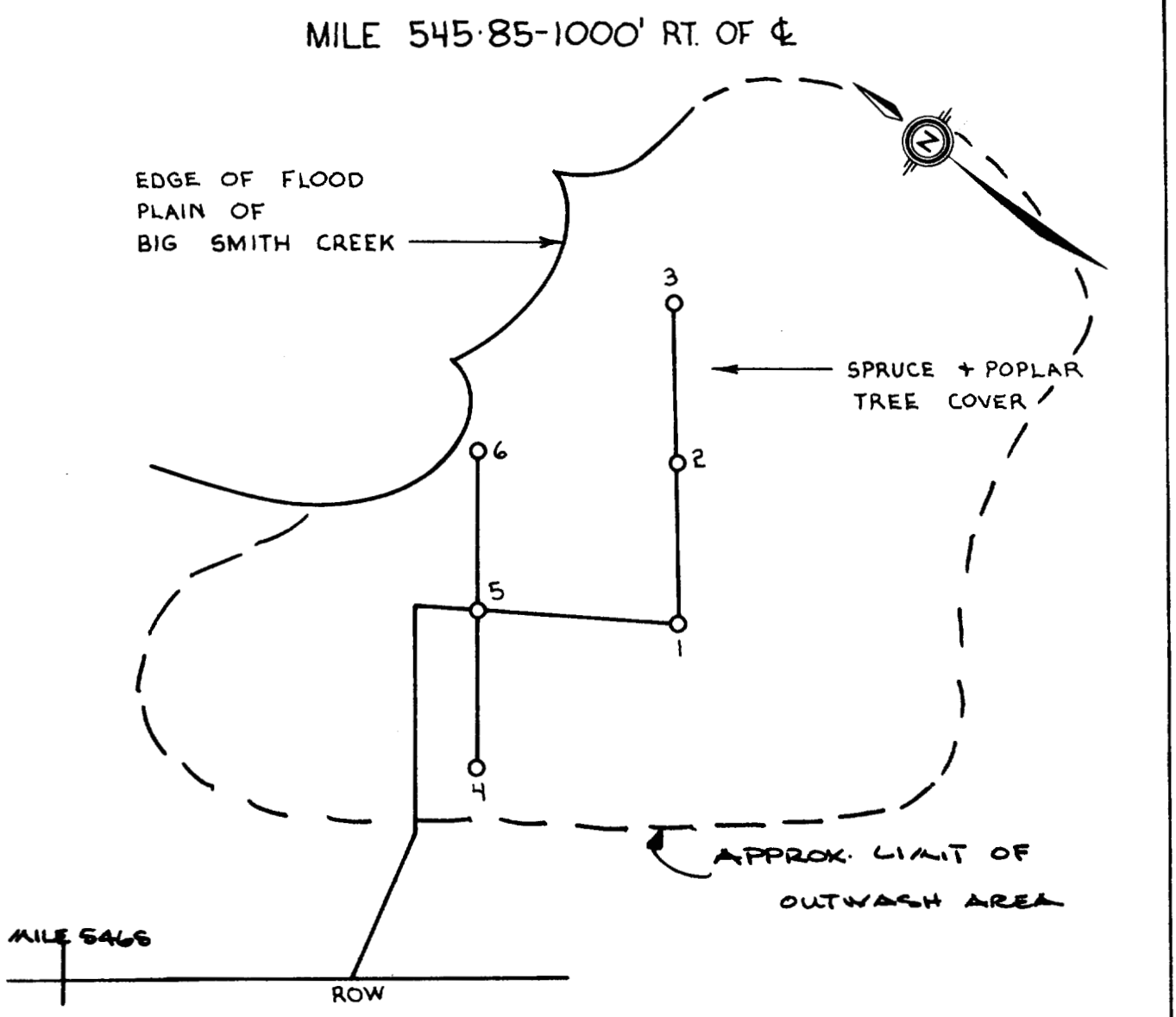
... 134

MILE 545.8S - BORROW PIT NO. 126

- 1,000 feet right of centerline.

The area test drilled here was designated as a borrow area from a previous drilling program and the current program was for the purpose of expanding and confirming the borrow source. The feature in which the pit is located is thought to be an outwash delta which rises slightly above the adjacent, flat, glaciolacustrine plain. Subsoil varies from fine to coarse sand, to gravelly sand, to sandy gravel. The area would appear to be unfrozen and moisture contents are less than 10% and average around 5%. This area should provide large volumes of good borrow material as the available area should be in excess of 1000 feet x 1000 feet.

... 136



NOTES

SUBSOIL SANDS, GRAVELLY SANDS + SANDY GRAVELS
APPEARS TO BE PERMAFROST FREE
MOISTURE CONTENTS < 10% – AVERAGE 5%
GOOD BORROW SOURCE

Public Works Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 126	designed by / conçu par — date	
	scale / échelle: 1"= 200'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / region	revisions / révisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

MILE 546.8S - BORROW PIT NO. 127

- 700 feet left of centerline.

Pit No. 127 was drilled immediately north of Big Smith Creek near the right-of-way in hopes of encountering the bedrock formation which is exposed slightly downstream along the creek. Subsoil is fine to medium sand and silty sand and bedrock was not encountered within depths of 15 feet. Borrow material in Pit No. 126 immediately south of the Big Smith Creek is superior to that in Pit No. 127, hence it is not recommended for development.

MILE 547S (BIG SMITH CREEK) TO MILE 553 - BORROW PITS NO. 121 TO 125 INCLUSIVE AND BORROW PITS NO. 128 TO 129

From Big Smith Creek to Mile 553 the right-of-way crosses a deltaic sand plain with advanced thermokarst development. The terrain is marked by frequent lakes, bogs and peat filled depressions. Subsoil is silty to clean, fine to medium, sands with lacustrine silty clays at depths. The upper sands are frequently ice-rich and are wet upon thawing. Areas test drilled within this section are summarized below:

Borrow Pit 121, Mile 545.3 - 600 feet right of centerline.
Borrow Pit 122, Mile 547.1N- 800 feet right of centerline.
Borrow Pit 123, Mile 548.3 - 3000 feet left of centerline.
Borrow Pit 124, Mile 550.0 - 400 feet left of centerline.
Borrow Pit 125, Mile 555.1 - 600 feet left of centerline.
Borrow Pit 128, Mile 549.1 - 800 feet left of centerline.
Borrow Pit 129, Mile 552.5 - 500 feet left of centerline.

... 138

None of the above areas are considered good borrow sources. All contain frozen ice-rich silty sands which are categorized as either wet, saturated, or containing free water upon thawing. Use of any of the above pits would require that the material be placed in a frozen state and allowed to thaw and consolidate before being capped with a trafficable material. Thus selection of any pits in this area will depend upon the construction economics of delay to allow thaw, versus haul costs for better quality materials.

MILE 546N - CREEK CROSSING

At Mile 546N the highway route crosses a partially infilled melt water channel on a glacial lake-bed. The old channel is marked by numerous lakes and peat deposits and some flow is still carried in a small creek. Three holes were drilled here: 546-C-1 was drilled in the existing creek, and 546(N)-C-1 and -C-2, were drilled on a narrow neck of lake sediments that extends into the old channel. Approximately 10 feet of peat and organic silt was encountered in the existing channel and this material should be removed before culvert installation. The subsoil in the narrow neck of lake sediments is frozen and contains moderate ice contents, however, will provide embankment support.

MILE 548 - PROPOSED REVISION

A one mile revision was proposed near Mile 548 to avoid a potential icing problem at Robb Creek at Mile 548.4 on the existing line. Subsequent to drilling the revision was abandoned, however, the test hole logs on the revision have been included in Volume IV and the drill locations are shown on the mosaics.

GEOTECHNICAL EVALUATION

MILE 550 TO MILE 600

MACKENZIE HIGHWAY

MILE 553 TO 554 - TEST HOLES 553-C-1 TO 553-C-7 - POTENTIAL CUT SECTIONS

There are three major ridges of deltaic sands between Mile 553 and 554 where cut sections are proposed. These deposits are relatively dry to the depth of annual thaw which seems to vary between 8 and 10 feet. Below this level the moisture (ice) contents average near 15% which, in most cases, is sufficient to produce a wet or saturated material upon thawing. However, it is expected the sands at depth will drain rather than slough or flow and cut sections should be feasible. The sands will be unsuitable as a traffic material and will require topping, and backslopes will likely be subject to wind erosion.

MILE 553 TO 554.5 - BORROW PITS NO. 130, 131 AND 132

Beginning near Mile 553 the right-of-way enters into a better drained area of deltaic sands and near Mile 554 into a large sand dune complex. Borrow Pit No. 130 at Mile 553.5 contains deltaic silty sands which are relatively dry to the depth of annual thaw (approximately 8 to 10 feet) below which they are wet or saturated upon thawing. This area is not recommended for borrow.

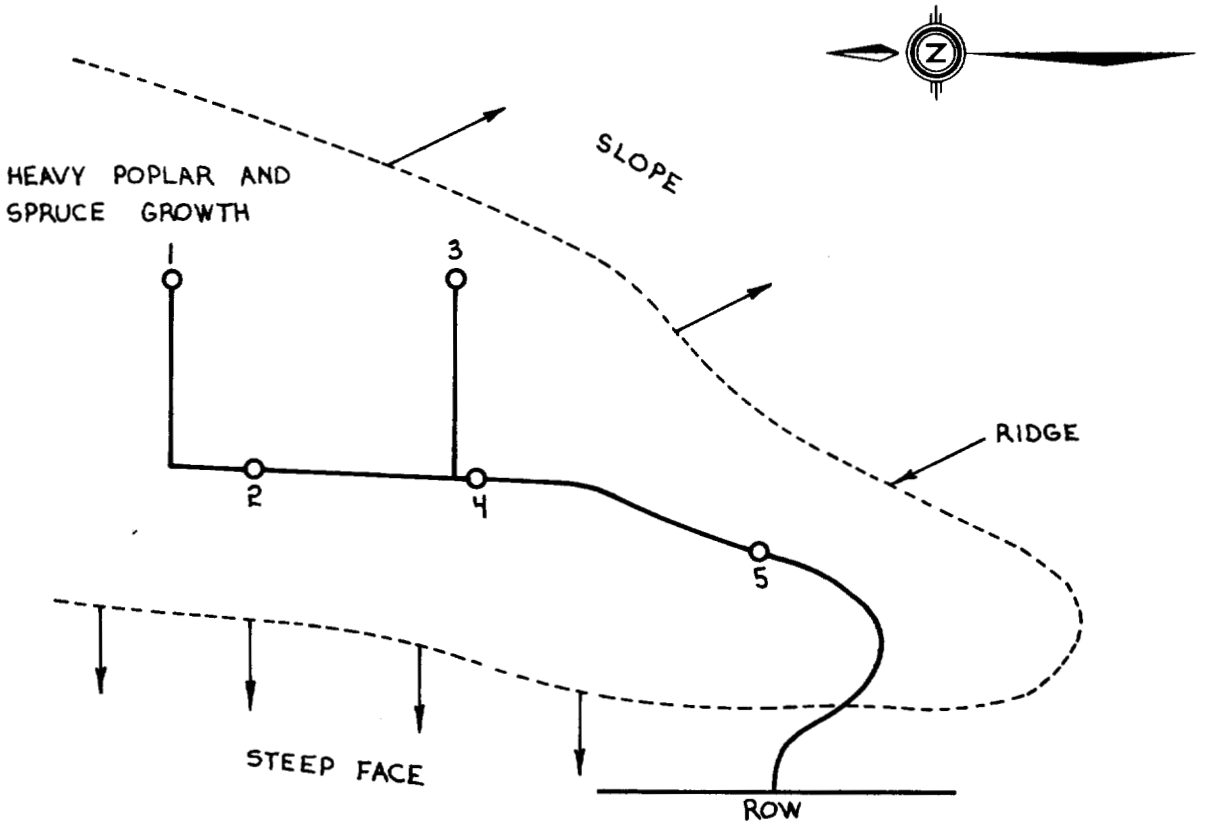
Borrow Pits 131 at Mile 553.9 and 132 at Mile 554.4 are on a portion of the deltaic deposits that have been reworked by wind action. Subsoil is fine,poorly graded eolian sand, generally at moisture contents near 5% but with occasional wet zones at depth.

... 141

Permafrost appears to be sporadic in Pit 131 and generally absent in Pit 132. Pit area 132 is preferred here although several large cuts in the right-of-way will likely permit a balanced design and eliminate the need for additional borrow.

... 142

MILE 554·4 - 600' RT. OF ℄



NOTES

- FEATURE IS IN A LARGE STABILIZED SAND DUNE
- SUBSOIL FINE, POORLY GRADED SAND
- GENERALLY UNFROZEN - MOISTURE CONTENTS NEAR 5%
- USEABLE BORROW
- RECOMMENDED IF ADDITIONAL BORROW REQUIRED IN THIS AREA

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 132	designed by / conçu par — date
	scale / échelle: 1" = 200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 554 TO 558 - REVISION

This revision is across a terrain consisting of sand dunes or deltaic sand deposits on an old glacial lake-bed. A total of 21 holes on centerline were drilled through this section.

From Mile 554 to 555 the route crosses a sand dune complex with low relief and a balanced grade line will be possible. From Mile 555 to 556 relief is more pronounced as a result of two deep stream channels and the subsoil, although sandy, contains more silt and clay and is frozen throughout with moderate ice contents. The majority of the subsoil between Mile 555 and 556 is wet or saturated upon thawing and any cuts proposed should not exceed 8 to 10 feet. There is a major culvert at Mile 555.3 and one test hole here (555-C-2), although not on the centerline of the culvert, indicates organic subsoil below the base of the culvert which will require sub-excavation and backfill at construction.

From Mile 556.0 to 556.7 the route is on glacial lake-bed sediments consisting of silty clays with organic inclusions that are extremely ice-rich. Two small culverts at 556.1 will require some excavation and backfill in ice-rich organic clay. Near Mile 556.7 the route encounters a major sand dune that rises some 70 to 80 feet above the glacial lake-bed and a cut of 10 to 15 feet is proposed in the face of the dune. Only the lower portion of this cut will be below the depth of annual thaw

... 144

where the subsoil is wet or saturated on thawing, and it is expected these materials will drain rather than slough and flow. Granular ditch linings are proposed on design drawings which should inhibit ditch erosion.

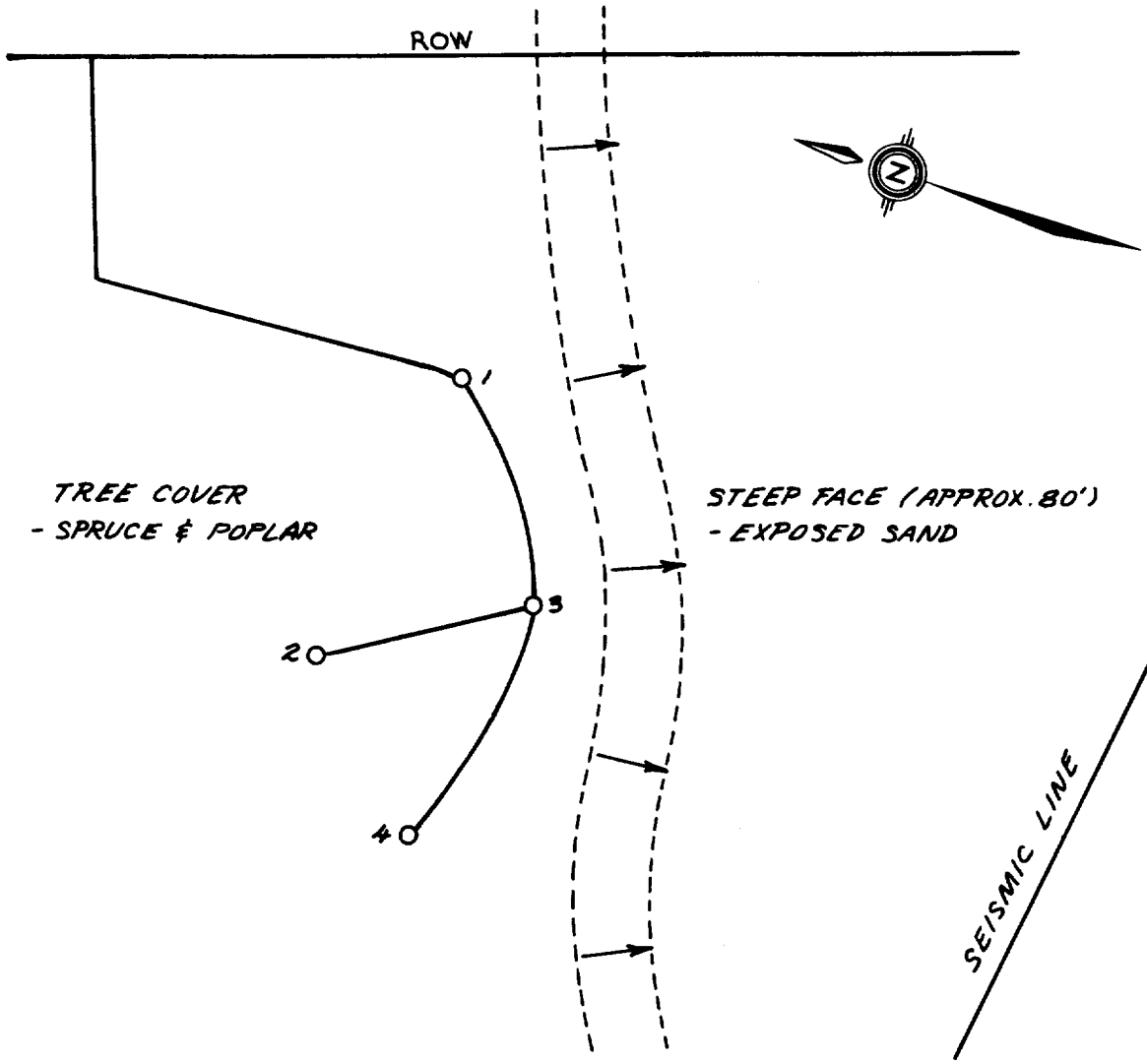
Borrow Pit 133 is located on the south facing slope of this sand dune to the left of centerline and is discussed below.

MILE 556.8 - BORROW PIT NO. 133

- 350 feet left of centerline.

The area test drilled here is part of a major sand dune complex located on an ancient glacial lake-bed. There is a steep face of some 80' on the south of this feature while on the north the dune has a flat profile and is coincident with the surrounding terrain. This area was previously drilled by consultants and the current program was for the purpose of confirming and expanding the area. The sand is fine, poorly graded and slightly silty. The material near the exposed face tends to be permafrost free and relatively dry, whereas back from the face, permafrost is continuous and moisture contents on thawing vary from 5% to as high as 20%. Moisture contents tend to increase with depth below the level of the active thaw zone which appears to vary from roughly 6 feet to 12 feet nearer the face. There is usable borrow here with the preferred development area along the exposed south facing slope.

MILE 556·8 - APPROX. 350' LT ℄



NOTES

- SUBSOIL IS FINE, POORLY GRADED SAND
- DRY TO LEVEL OF ACTIVE THAW ZONE
- WET BELOW ON THAWING
- DEPTH OF THAW DECREASES BACK FROM THE FACE
- PREFERRED DEVELOPMENT AREA ALONG EXPOSED FACE

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 133	designed by / conçu par — date
		drawn by / dessiné par — date
		reviewed by / examiné par — date
	scale / echelle: 1"=200'	approved by / approuvé par — date
region / region	revisions / révisions — date	project number / no. de entreprise; drawing no / no du dessin

D.P.W. 700 A

MILE 558 TO 559 - TEST HOLES 558-C-1 TO 558-C-2 - PROPOSED CUTS

Between Mile 558 and 559 the route is located on a large longitudinal sand dune. Both test holes here confirm the suitability of shallow cut sections in the fine silty sandy subsoil.

MILE 559 TO 560.4 - REVISION

This revision was for the purpose of locating the route over a large longitudinal sand dune which previous drilling by consultants had indicated to be suitable for cut and borrow. This current drilling program, however, indicates that the sand is dry only to the depths of annual thaw, hence the proposed cut should not exceed a depth of 6 to 8 feet.

Near Mile 560 the terrain is very low lying and three small lakes are immediately adjacent to the right-of-way. The subsoil is ice-rich here with extensive peat overlays. In a small drainage channel at approximately Mile 560.05, 7 feet of peat was encountered and sub-excavation and backfill will be required here for culvert installation.

MILE 560.7 - TEST HOLES 560-C-2 AND 560-C-3 - PROPOSED CUT

A shallow cut is proposed in a low sand dune near Mile 560.7. Both test holes here confirm the suitability of this cut in the fine silty sand subsoil.

... 147

MILE 564.7 - BORROW PIT NO. 134

- 500 feet right of centerline.

Borrow Pit No. 134 is located on a small sand dune on an ancient glacial lake-bed. The dune is approximately 4000 feet in length and averages 200 feet in width. Maximum relief is in the order of 25 feet above the adjacent flat, poorly drained terrain. Subsoil is fine, silty, poorly graded sand. Permafrost is continuous at depths and only the material in the upper few feet to the depth of active thaw is considered usable. Below the active thaw level moisture (ice) contents average near 20% and material is wet and saturated upon thawing. Near the high point of the dune, some 2000 feet from the right-of-way, the depth of the usable material is approximately 12', however, overall volumes are small and this area is not recommended for development.

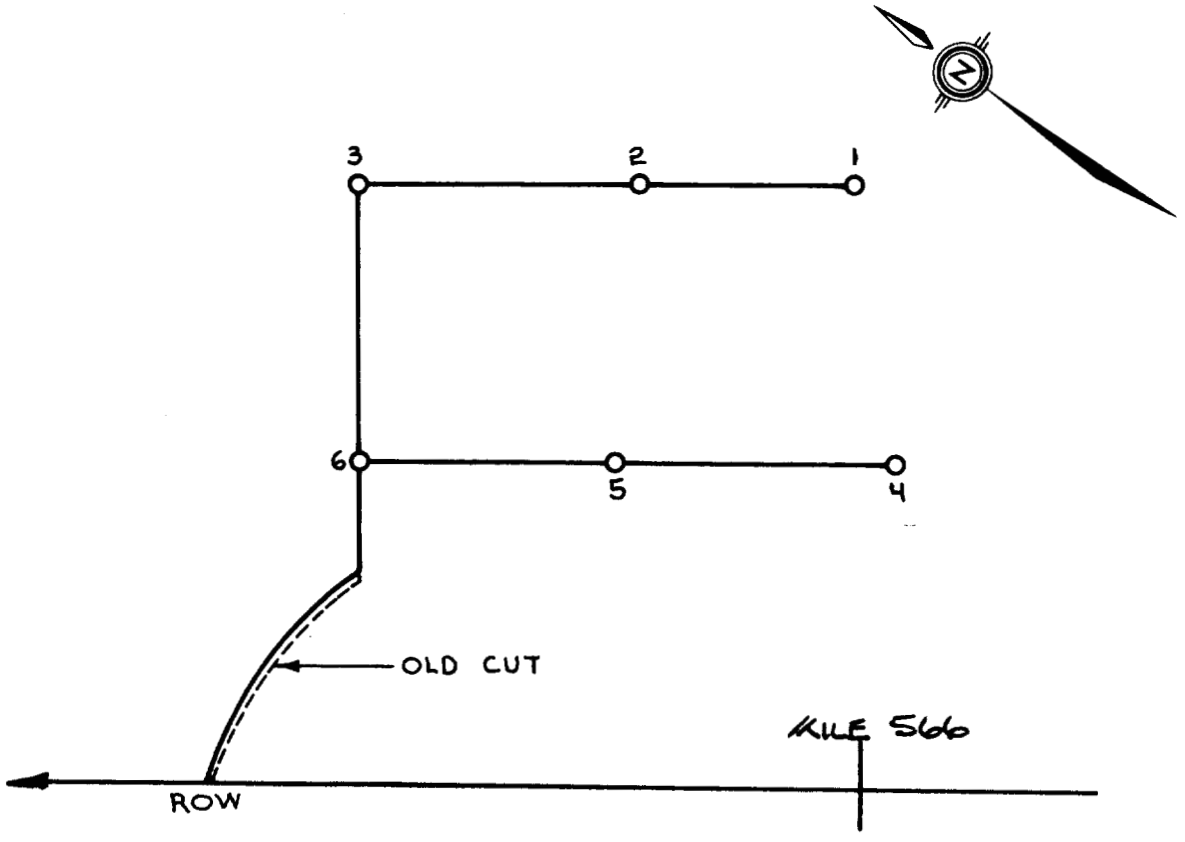
MILE 566.1 - BORROW PIT NO. 135

- 500 feet right of centerline.

Pit No. 135 is located on a better drained portion of a flat, poorly drained, deltaic sand plain. Tree cover is moderately dense spruce and poplar to 6" diameter. The subsoil is silty fine sand. Permafrost is continuous and moisture contents upon thawing generally range between 10 to 20% and the sand is wet or saturated when thawed. Use of this pit would require that the material be placed in a frozen condition and allowed to thaw and consolidate before capping with a trafficable material.

... 148

MILE 566·1-500' RT. OF ℄



NOTES

- SUBSOIL FROZEN, FINE, SILTY SAND
- MOISTURE CONTENTS ON THAWING 10 TO 20%
- SAND IS WET OR SATURATED WHEN THAWED
- USE OF THIS PIT WILL REQUIRE MATERIAL BE PLACED IN FROZEN STATE AND ALLOWED TO THAW AND CONSOLIDATE BEFORE CAPPING

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 135

scale / échelle 1"=200'

designed by / conçu par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

région

revisions — date

révisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 567 TO 569.7 - REVISION

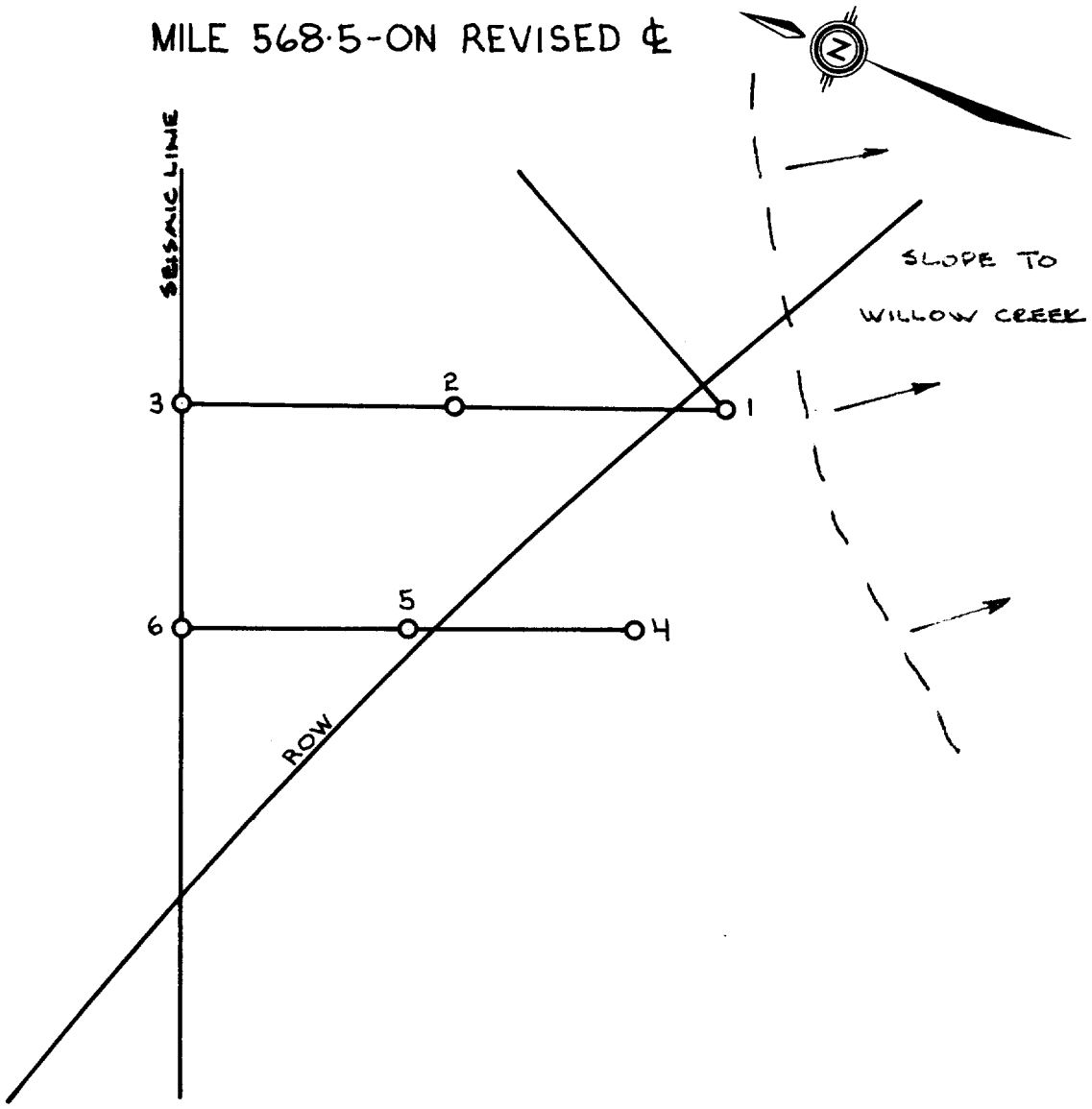
Since the time of this field investigation, the route location through this section has been changed and the test borings carried out are of no value on the revised location. However, the logs have been included in Volume IV and the hole locations are shown on the mosaics. As a result of the re-location, the highway route now passes directly through Borrow Pit No. 136 which is discussed below.

MILE 568.5 - BORROW PIT NO. 136

- on revised centerline.

Borrow Pit No. 136 is located above the north valley slope of the small Willow Creek Valley. Subsoil here consists of silty sands and sandy silts. Permafrost is sporadic but present over the majority of the area and most of the materials on thawing are in a wet or saturated state. There is some usable material here along the top of the valley slope, however, for the most part, the use of this pit will require that the material be placed in a frozen state and allowed to thaw and consolidate before being capped with a trafficable material.

MILE 568·5-ON REVISED ℄



NOTES

- SUBSOIL SILTY SAND & SANDY SILTY
- PERMAFROST PRESENT OVER MAJORITY OF SITE
- MATERIAL WET OR SATURATED UPON THAWING
- SOME USEABLE MATERIAL ALONG TOP OF VALLEY SLOPE

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 136	designed by / conçu par — date	
	scale / échelle: 1"=200'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / région	revisions / révisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

MILE 570 TO 583 (FORT NORMAN) - BORROW PITS NO. 137 TO 147

Beginning near approximately Mile 570, the highway route emerges from the deltaic sand plain to the south, onto ancient glacial lake-bed sediments which continue to Fort Norman at Mile 583. The glacial lake-bed is relatively flat and poorly drained with numerous lakes and potholes. Permafrost is continuous throughout and deposits tend to be ice-rich especially in the upper 10 to 15 feet. Subsoil on the lake-bed is primarily medium plastic silty clay. The following borrow areas were test drilled within this section:

Borrow Pit 137 - Mile 571.4 - 2000 feet left of centerline.
Borrow Pit 138 - Mile 572.3 - 1500 feet left of centerline.
Borrow Pit 139 - Mile 572.4 - 700 feet right of centerline.
Borrow Pit 140 - Mile 573.6 - 500 feet left of centerline.
Borrow Pit 141 - Mile 574.3 - 500 feet left of centerline.
Borrow Pit 142 - Mile 576.4 - 500 feet left of centerline.
Borrow Pit 143 - Mile 578.2 - 600 feet left of centerline.
Borrow Pit 144 - Mile 579.1 - 300 feet left of centerline.
Borrow Pit 145 - Mile 579.5 - 500 feet left of centerline.
Borrow Pit 146 - Mile 581.4 - 700 feet left of centerline.
Borrow Pit 147 - Mile 581.2 - 2500 feet left of centerline.

Without exception, the material in the above pits consists of low to medium plastic silty clay, frozen with moderate to high ice contents, and with moisture contents on thawing generally not less than 20%. In a thawed state much of the material, especially in the upper 6-8', is described as wet or saturated with the moisture content near the liquid limit. Below the upper ice-rich zone moisture contents are generally well above the plastic limit and

... 152

above the optimum moisture content. None of the above areas are considered to be good borrow sources, however, because of the lack of any alternate sources in the area, construction economics may dictate the use of this poor quality borrow. These materials will have to be placed in a frozen state and allowed to thaw, drain and consolidate before being shaped and brought up to grade. The upper few feet of very ice-rich material should be wasted from any pit used and pit selection should be based upon the construction economics of stripping versus haul costs. There is little to choose between any of the above pits in terms of quality of material or depth of stripping.

MILE 579.3 TO 580.2 - TEST HOLES 579-C-1 TO 579-C-7 - REVISION

This revision encompasses the crossing of Four Mile Creek. Subsoil along the revision is primarily low to medium plastic, sandy clays and sandy silts. Permafrost is present throughout with low to moderate ice contents and much of the subsoil is wet on thawing. Cuts are not recommended on this revision.

MILE 590.0 - TEST HOLES 590-C-1 TO 590-C-4 - PROPOSED CUT

This cut section is in a bedrock controlled ridge. Test borings reveal sandy silty clay till, over shale and sandstone bedrock at depths varying from 1 to 8 feet. The bedrock is relatively hard and it is unlikely that it can be ripped.

... 153

MILE 591 - TEST HOLES 491-C-1 TO 491-C-4 - CUT SECTIONS

There are two cut sections near Mile 591, both in bedrock controlled ridges with variable thicknesses of overburden. The bedrock is relatively hard shales and sandstones, which likely cannot be ripped.

MILE 596 TO MILE 600.5 - JUNGLE RIDGE REVISION

This revision re-locates the route from the crest of Jungle Ridge onto the sloping flanks of the ridge to the south-west. Jungle Ridge is bedrock controlled and is covered with a layer of glacial till which increases in depth toward the south-west and the revised route location. A total of 30 holes along the revision encountered glacial till at depth with a variable overlying peat mat. There is permafrost throughout and moisture (ice) contents are relatively high in the upper 5 to 6 feet. The proposed gradeline along the revision will be entirely in fill section.

GEOTECHNICAL EVALUATION

MILE 600 TO MILE 650

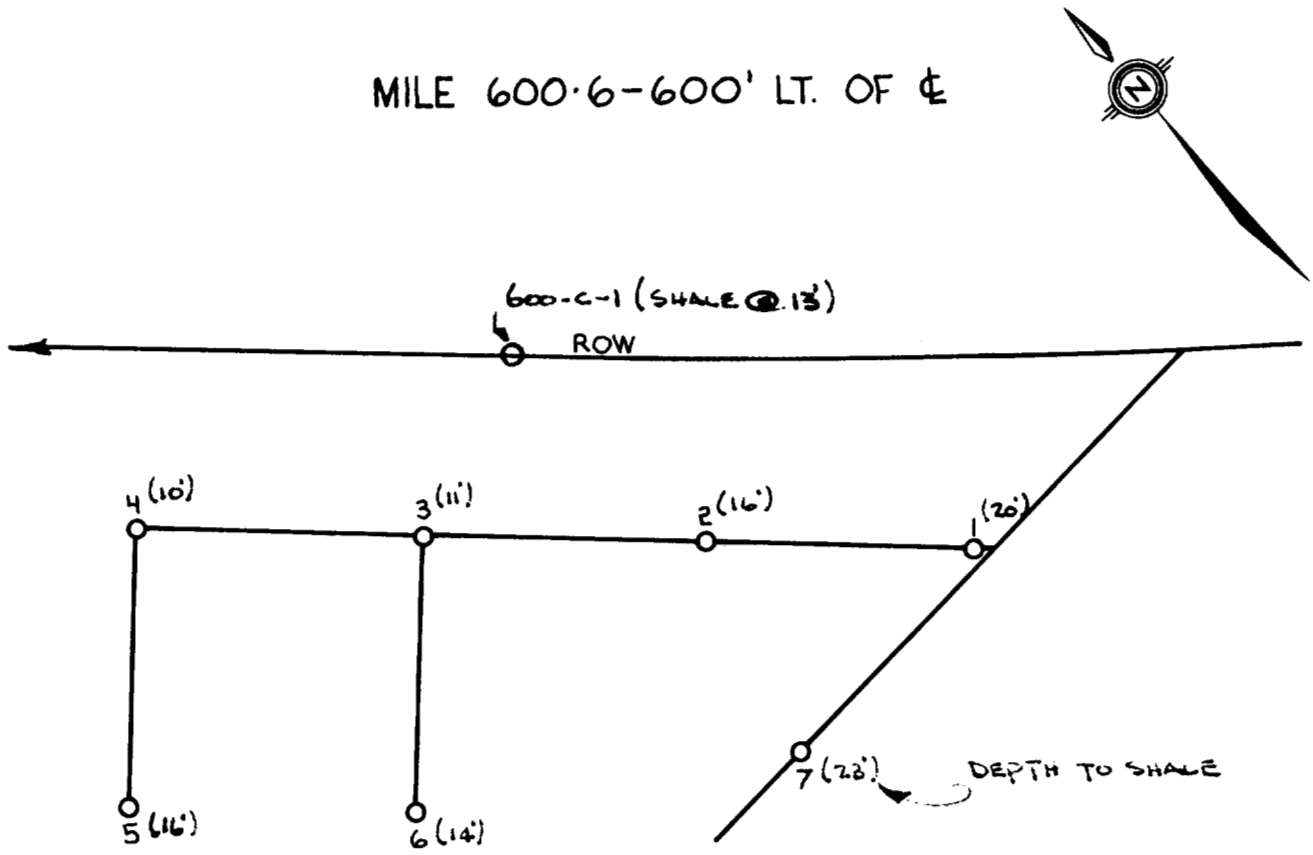
MACKENZIE HIGHWAY

MILE 600.6 - BORROW PIT NO. 148

- 600 feet left of centerline.

Borrow Pit No. 148 was drilled at the north-end of Jungle Ridge on a flat glacial till plain. This area was drilled when a garbage disposal hole at the camp site on the adjacent centerline encountered shale at relatively shallow depths. Subsoil consists of low to medium plastic sandy silty clay till overlying shale bedrock at depths varying from 10 to roughly 20 feet. The overburden till is frozen, however, with the exception of the upper 3 to 4 feet, moisture contents are near 15% and slightly below the plastic limit. The shale was categorized as soft by the drilling crews and could possibly be ripped with heavy construction equipment. Stripping depths are estimated at approximately 4', a large percentage of which will be peat and organic soils.

Based upon previous drilling by consultants in this area, a borrow pit had been selected at Mile 600.3 on the right side of centerline or within approximately 1/4 mile of Borrow Pit No. 148. Subsoil in the designated pit was the same medium plastic clay till encountered in 148, however, bedrock was not encountered to a depth of 30 feet. Stripping depths between the two areas would appear to be comparable and Borrow Pit No. 148 can be considered a good alternate to the designated pit, providing there is a need or desire for shale as a construction material.



NOTES

- SUBSOIL CLAY TILL OVER SHALE BEDROCK
- FROZEN - WET ON THAWING TO APPROX. 4' DAMP BELOW
- STRIPPING TO APPROX 4', 1-3' OF WHICH IS PEAT
- GOOD BORROW SOURCE

Public Works Travaux publics Canada Canada

drawing title / titre du dessin

BORROW PIT 148

scale / échelle 1" = 200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

révisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 602.0 - BORROW PIT NO. 149

- 1,000 feet left of centerline.

The area in which Borrow Pit No. 149 is located is beyond the till deposits of Jungle Ridge and Borrow Pit 148, and is on a glacial lake-bed. As a result the subsoil consists of silty clays and clay silts with moderate to high ice contents. Moisture contents on thawing are variable and generally high, and this area is not recommended for borrow.

MILE 602.9 - BORROW PIT NO. 150

- 400 feet both right and left of centerline.

Pit area No. 150 was drilled in an attempt to locate shallow bedrock near the right-of-way. The terrain here is a very flat glacial lake-bed. Subsoil is silty clays and clay silts, frozen with moderate to high ice contents. Bedrock was not encountered to depths of 15'. On thawing the subsoil is wet or saturated in the upper 8 to 10' and this area is not recommended for borrow.

... 157

MILE 603.1 TO 606.5 - REVISION

This revision encompasses revised crossings over both Nota Creek and Vermilion Creek.

The terrain is partially rolling ground moraine, but is primarily glacial lake sediments over shallow shale bedrock. To Mile 604, shale is at depths of less than 15 feet with overburden consisting of sandy silty clay till, with peat overlays of up to 3 feet. Permafrost is continuous and ice contents are high in the upper 5 to 7 feet. From Mile 604 to 606.5 the route is on glacial lake-bed clays with the exception of the two creek crossings. Permafrost is continuous throughout and peat overlays are unusually high and vary from roughly 3 feet to 6 or 7 feet. Materials are ice-rich in the upper 4 to 8 feet. Shallow cut sections are proposed on either side of Vermilion Creek. Both cuts will bottom out below the level of peat and ice-rich material, however the back slopes will be entirely in ice-rich material and will slough and flow upon thawing. Because of the thicknesses of peat in this area, consideration should be given to using vertical back slopes and allowing the slopes to heal themselves following construction.

Two large multiplate culverts are proposed at Nota Creek. Test holes on either side of the Nota Creek channel encountered shale

... 158

at depths of 8 to 13 feet which is only 3 to 4 feet below the bottom of the stream channel, thus there is a good base for the culvert installations.

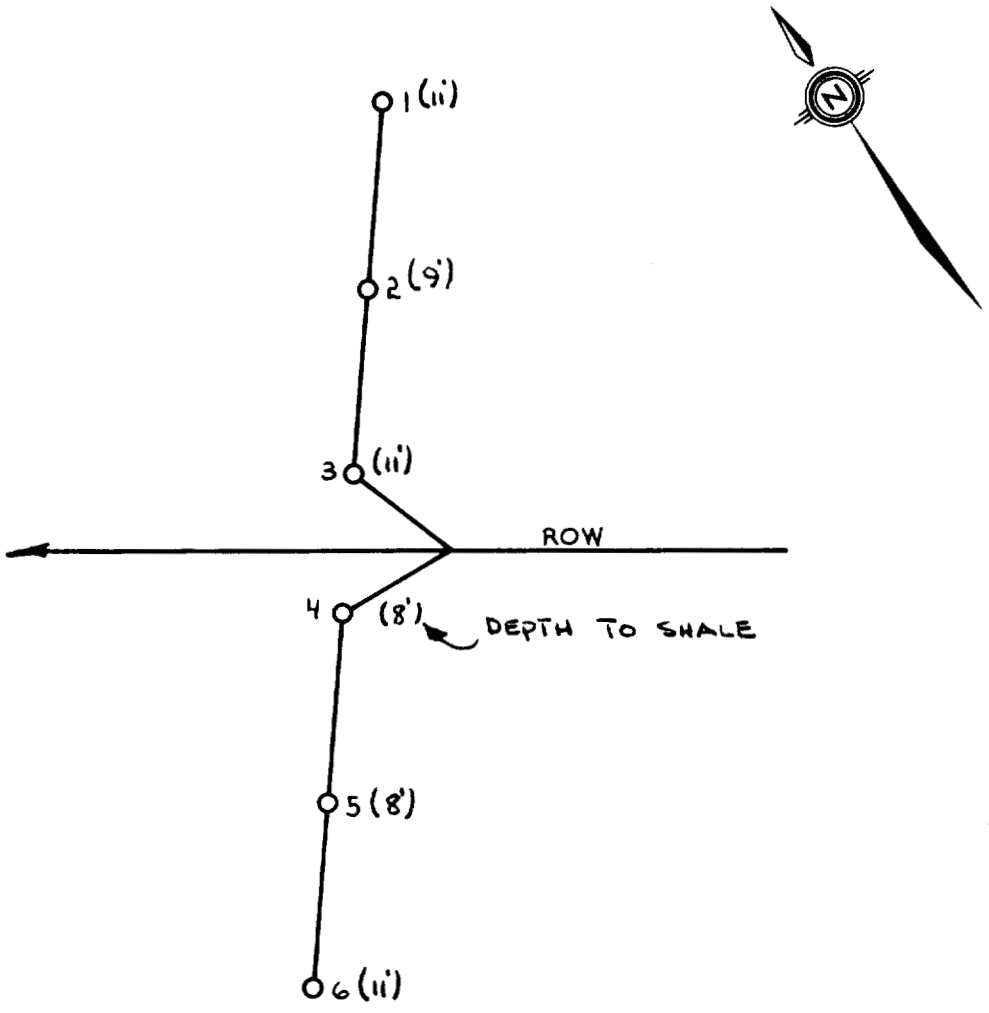
A bridge is proposed at the Vermilion Creek crossing and test drilling carried out for the footings will be reported separately.

MILE 607 TO 608 - BORROW PITS NO. 151 AND 152

- left and right of centerline.

These two areas were drilled in an attempt to locate shallow bedrock near the right-of-way. Subsoil is low to medium plastic sandy silty clay till over shale bedrock. Borrow Pit No. 151 at Mile 606.9 encountered shale at depths varying from 9 to 16 feet. The overburden till is usable below depths of 3 to 4 feet and much of the stripping is peat and organic soil. Borrow Pit No. 152 at 607.9 encountered shale at depths between 9 to 11 feet and the overburden till would appear to be usable below depths of 2 to 3 feet. Again much of the stripping would be peat and organic soils. Of the two areas, Borrow Pit No. 152 is preferred because of less stripping and development of Pit 152 is recommended if shale is preferred as a construction material over the clay till which is abundant in the area. The shale is described as soft by the field crews and possibly could be ripped with heavy construction equipment.

MILE 607.9 - RT. & LT. OF ℄



NOTES

- SUBSOIL FROZEN CLAY TILL OVER SHALE
- STRIPPING ESTIMATED @ 2-3' MUCH OF WHICH IS PEAT & ORGANIC SOILS
- GOOD BORROW SOURCE

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 152

scale / échelle 1" = 200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region / région

revisions / révisions — date

project number / no. de entreprise

drawing no / no du dessin

D.P.W. 700 A

MILE 609 TO 611 - BEDROCK SEARCH

Test holes were drilled on three seismic lines between Mile 609 and 611 in an attempt to locate shallow bedrock near the right-of-way. Five test holes left of centerline near Mile 609.1 encountered shale under sandy silty clay till at depths varying from 9 to 12 feet. The till is frozen and stripping depths would vary from 3 to 5 feet.

Two holes left of centerline at Mile 610.1 encountered shale at depths of 10 to 12 feet again under sandy silty clay till with stripping depths of 3 to 5 feet.

Five holes near Mile 611, left of centerline, encountered shale at depths of 9 feet. Overburden soils are primarily silty clay till with stripping depths estimated at 2 to 5 feet.

Development of any of these areas will depend upon the stripping costs versus haul economics of alternate sources and the desirability of using shale for embankment construction. The shale in all three areas is described as soft by the field crews and could possibly be ripped with heavy construction equipment.

... 161

MILE 611.7 TO 613.2 - REVISION

This revision consists of a very slight re-alignment to improve the approach to Prohibition Creek which is incised some 60 to 100 feet below the level of the surrounding terrain. Extensive cut sections are proposed in both valley walls. Six test holes (611-C-6 and 612-C-1 to 612-C-5) reveal shale bedrock at depths of less than 10 to 12 feet in both cut areas. The overburden consists of sandy silty clay till with very little ice-rich material. A bridge is proposed for the Prohibition Creek crossing and test borings carried out for the footings will be reported separately.

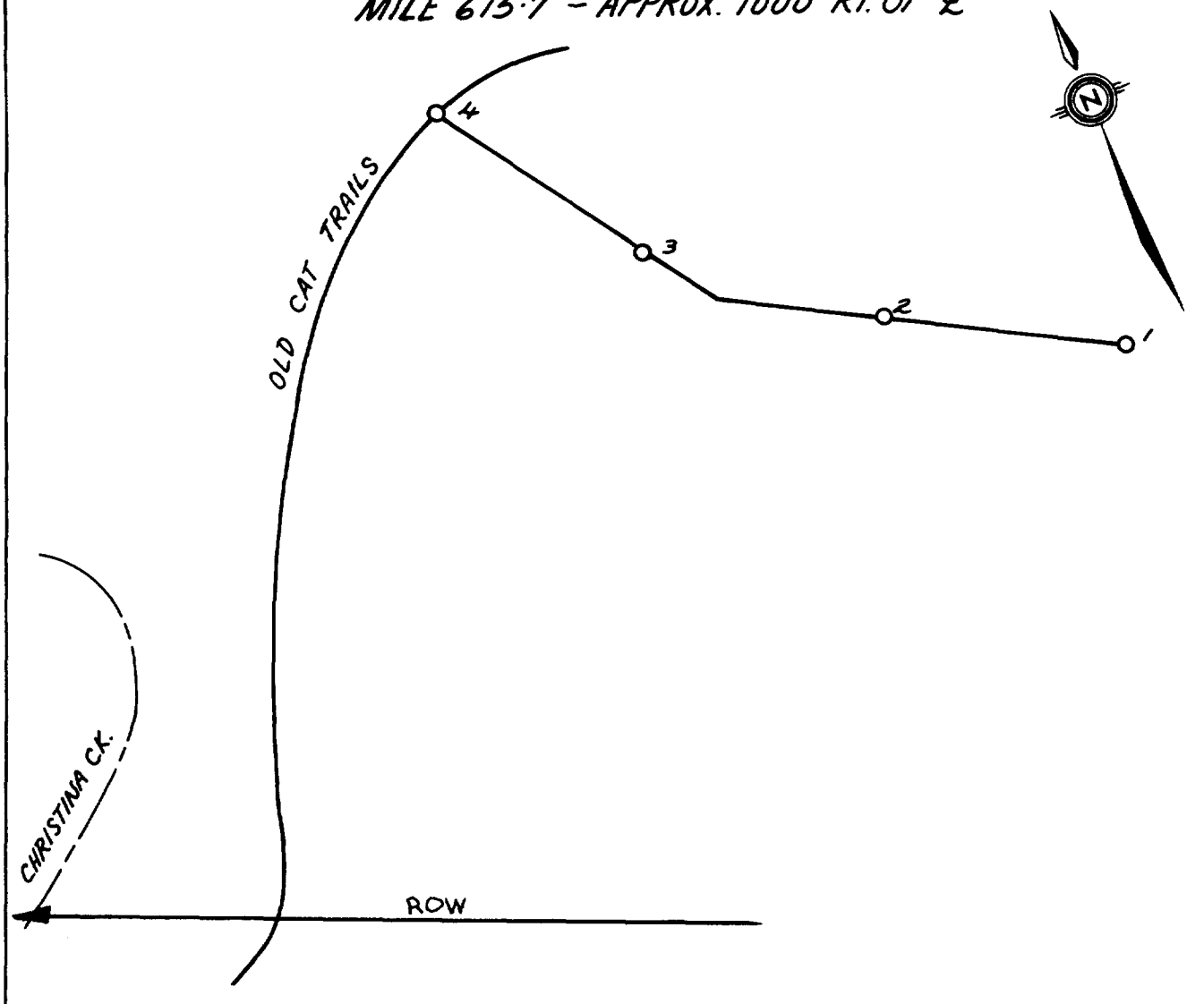
MILE 615.7 - BORROW PIT NO. 153

- 1,000 feet right of centerline

The area test drilled here is a low beach ridge immediately south of Christina Creek. Subsoil consists of a very shallow surface layer of poorly sorted silt, sand and gravel,over low plastic sandy silty clay till. Drilling indicates permafrost is absent and moisture contents for the most part are less than 15% and slightly below the plastic limit. Stripping would appear to vary around 1 to 2 feet and although occasional wetter zones may be encountered in the upper 6 feet, it is anticipated this material could be incorporated in a fill. This area is considered to be a usable borrow source.

... 162

MILE 615·7 - APPROX. 1000' RT. OF ℄



NOTES

- SUBSOIL IS SANDY, SILTY CLAY TILL
- PERMAFROST APPEARS TO BE ABSENT
- STRIPPING ESTIMATED AT 1'-2'
- USABLE TILL BELOW AT MOISTURE CONTENTS & PLASTIC LIMIT
- GOOD BORROW SOURCE

Public Works Canada / Travaux publics Canada

drawing title / titre du dessin

BORROW PIT 153

scale / échelle 1"=200'

designed by / conçur par — date

drawn by / dessiné par — date

reviewed by / examiné par — date

approved by / approuvé par — date

region

region

revisions — date

revisions

project number

no. de entreprise

drawing no

no du dessin

D.P.W. 700 A

MILE 616.0 TO 616.7 - REVISION

This is a very short re-alignment to a revised crossing over Hellava Creek, and includes a very shallow cut in a small fluvial fan on the south side of Hellava Creek. Four holes were drilled on the revision (616-C-1 to 616-C-4) and one hole was drilled in the bottom of Hellava Creek. Subsoil in the proposed cut area is sands and gravelly sands and although frozen and slightly wet on thawing, should drain and provide good fill material.

Two multiplate culverts are proposed at Hellava Creek and a test hole to the depth of 15 feet in the creek bed encountered sandy gravels which should provide an excellent base for the culvert installations.

MILE 620 TO 621 - CANYON CREEK REVISION

Several test holes were drilled on a tentative re-alignment at Canyon Creek which would shift the crossing approximately 1000 feet downstream from the original line. This revision was abandoned subsequent to drilling, however, the test hole logs have been included in Volume V and the locations are shown on the mosaics. Several holes were drilled at the proposed Canyon Creek bridge site on the original line and these will be reported separately.

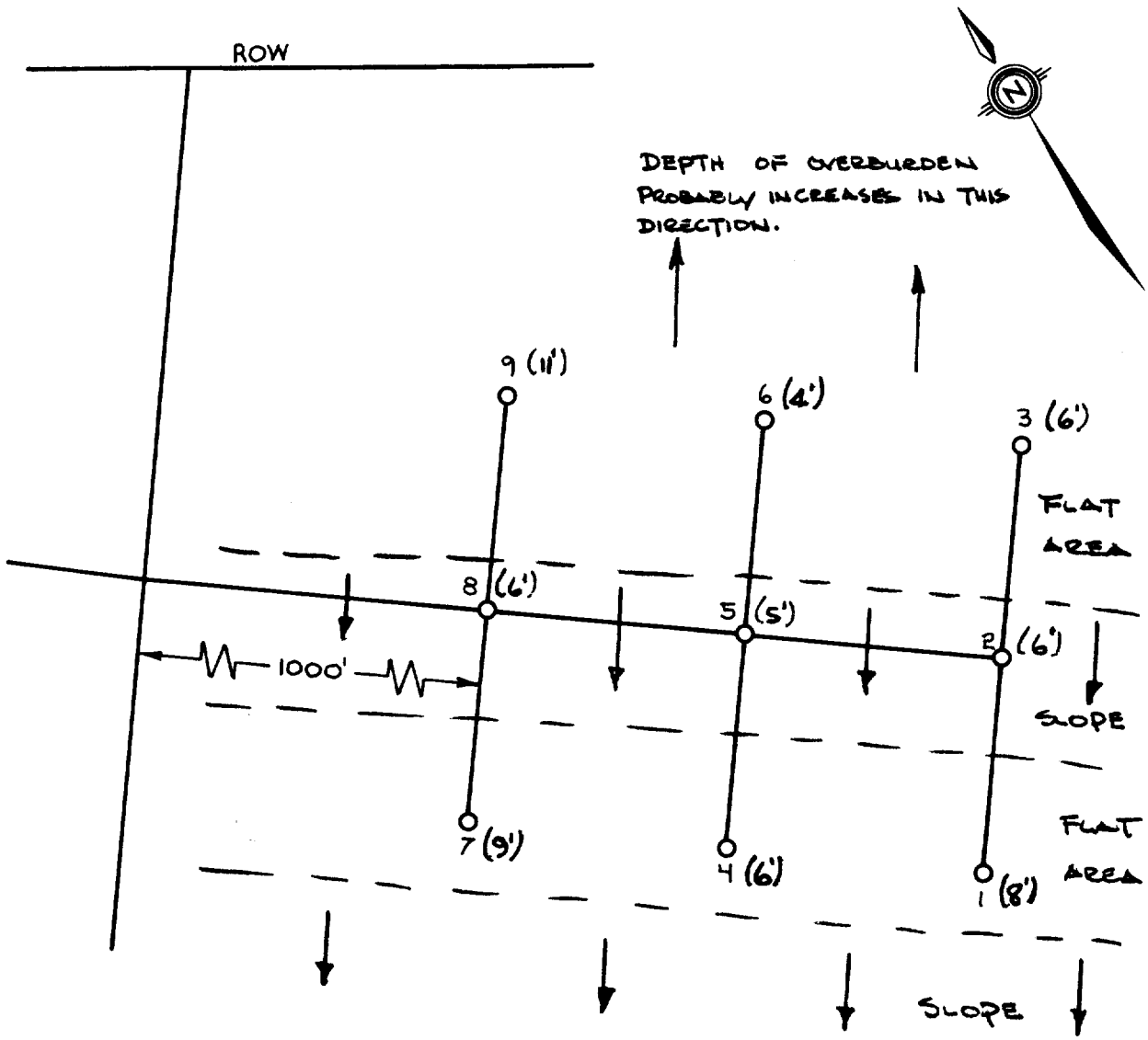
... 164

MILE 624.7 - BORROW PIT NO. 154

- 700 feet left of centerline.

Test drilling here was to expand and confirm a pit that was selected on the basis of previous drilling by consultants. The feature is a bedrock controlled ridge with shallow till overburden. The ridge is elongate in the north-west south-east direction. It has a long moderate slope in the south-west direction however behind the ridge toward the right-of-way, there has been in-filling with slope wash and little relief is evident. Bedrock consisting of sandstones, shales, and possibly limestone was encountered at variable depths. Overburdened is primarily low plastic sandy silty clay till with some areas of sandy silt. Stripping depths could vary from 2 to possibly 5 feet. The bedrock is generally hard and a quarry operation will be required. Depths to bedrock in the area drilled could vary from 4 to 11 feet and average around 6 feet (see site plan).

MILE 624.7 - 700' LT. OF ℄



NOTES

- BEDROCK SHALES, SANDSTONES AND LIMESTONE
- OVERBURDEN PRIMARILY CLAY TILL - FROZEN
- STRIPPING ESTIMATED @ 1-2'
- QUARRY OPERATION REQUIRED

Public Works Travaux publics Canada Canada	drawing title / titre du dessin: BORROW PIT 154	designed by / conçur par — date
	scale / échelle: 1"=200'	drawn by / dessiné par — date
		reviewed by / examiné par — date
		approved by / approuvé par — date
region / région	revisions / révisions — date	project number / no. de entreprise
		drawing no / no du dessin

D.P.W. 700 A

MILE 626 TO MILE 631N - REVISION

This revision is some 7 miles in length and relocates the highway to the north-east around Norman Wells and onto higher, better drained, bedrock controlled terrain (Key Escarpment). Bedrock was initially encountered in test holes at depths of less than 15 feet beginning near Mile 627, and is under variable but generally shallow overburden to approximately Mile 632S. The overburden soils are partially silty clay till and, possibly, badly fractured and weathered bedrock. The bedrock is shale and limestone.

The proposed grade line is largely in fill section with occasional isolated shallow cuts on high points, and two or three relatively long cuts between Mile 629 and 631S. These longer cuts are shallow and with very minor exceptions should not extend below the depth of overburden soils or badly decomposed bedrock that can be ripped with construction equipment.

MILE 647.3 TO 648.6 - REVISION

This short revision is partially on a deltaic sand plain and partially on glaciolacustrine sediments. The terrain is poorly drained and exhibits thermokarst features characterized by numerous lakes, ponds and muskeg bogs. The revision is in fill section with the exception of two cuts near Mile 648, one of

which extends over a distance of roughly 1000 feet. This cut is primarily in a sand ridge and for the most part will not extend below the annual depth of thaw, hence any slough that may occur near the ditch line would be incidental.

Two multiplate culverts are proposed in a stream at Mile 648.5. A test hole in the creek bottom was inconclusive because of contamination with creek water, however Test Hole 648-C-3 drilled within 500 feet of the creek in similar swampy terrain suggests that several feet of organic silts and clays may be encountered below the stream channel and extensive sub-excavation and backfill will probably be required for culvert installations.

MILE 649.2 - BORROW PIT NO. 155

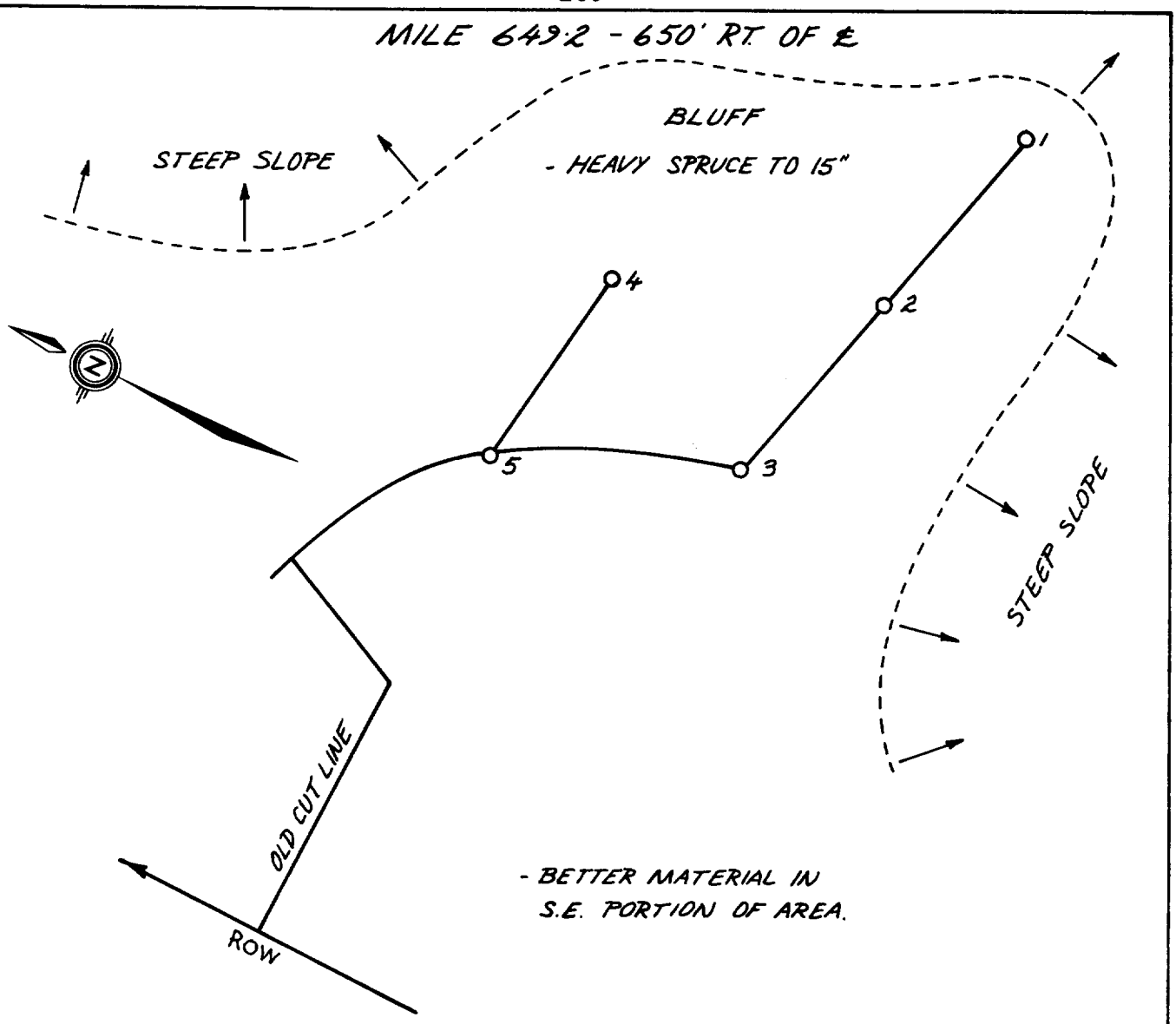
- 650 feet right of centerline.

Borrow Pit No. 155 is located immediately adjacent to the north bank of Oscar Creek on what is thought to be a remnant of an old glaciofluvial delta. Oscar Creek is entrenched at present in the delta and the flood plain of the Creek is well below the level of the Borrow Pit. Deposits are poorly sorted silty sands, gravelly sands and sandy gravels with some clay content. Better quality materials are located in the south-east portion of the area drilled. Permafrost would appear to be sporadic and moisture contents on thawing are variable.

... 168

Much of the material is in a wet state upon thawing, however, because of the lack of cohesion it is believed the materials will drain well and can be used for borrow. This is considered to be a usable borrow source although thawing, draining and stabilizing of the material will be required after placement.

... 169



NOTES

- SUBSOIL IS SANDS, GRAVELLY SANDS, & SANDY GRAVELLS
- SPORADIC PERMAFROST
- MATERIALS DRY TO WET ON THAWING
- USABLE BORROW; SOME THAWING & DRAINING REQUIRED

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 155	designed by / conçur par — date	
		drawn by / dessiné par — date	
		reviewed by / examiné par — date	
	scale / echelle: 1"=200'	approved by / approuvé par — date	
region	revisions — date	project number	drawing no
region	revisions	no. de entreprise	no du dessin

D.P.W. 700 A

MILE 649.5 TO MILE 651.5 - REVISION

The change in alignment here is relatively minor and was introduced primarily to gain an improving crossing site over an unnamed creek near Mile 651.1. The terrain throughout the revision is a poorly drained glaciolacustrine plain. Permafrost is continuous and moisture (ice) contents are moderate to high in the upper 6 to 8 feet. The grade line is in fill section with the exception of approach cuts in the stream valley at Mile 651.1. These cuts extend to depths of 10 to 15 feet in silts and clays that are very ice-rich in the upper 6 to 8 feet and backslope slough can be expected at least to that level. A large multiplate culvert was proposed in the creek channel and one test hole (651-C-3) on the north bank of the stream encountered a layer of sands and gravels near 7 feet which should provide a good base for the culvert installation.

MILE 653.2 - BORROW PIT NO. 156

- 1,000 feet right of centerline.

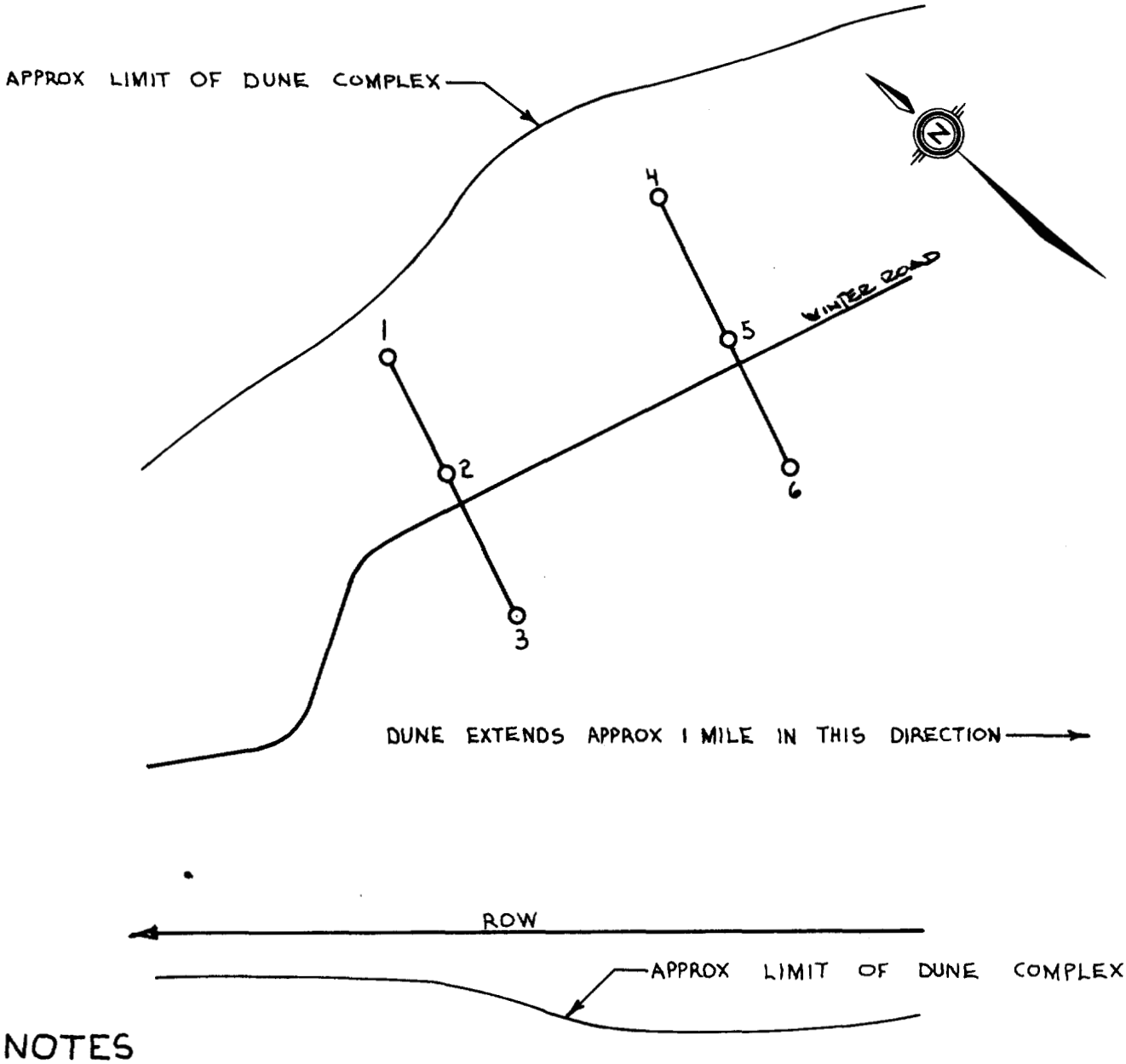
Borrow Pit No. 156 is located on a portion of a large sand dune complex approximately 1 1/2 miles in length, about 1/4 mile in width, and some 30 to 50 feet above the adjacent, flat, glaciolacustrine plain. The highway right-of-way traverses the western edge of the sand dune complex for a distance of approximately 1 mile. The sand dune contains fine grain, poorly graded, eolian

... 171

sands with varying amounts of silt. Permafrost is generally absent and moisture contents for the most part, are less than 5%. Stripping is minimal. This is a good source of sub-grade borrow material and it is likely that a borrow pit can be developed anywhere in the sand dune between Mile 652 and 653.2.

... 172

MILE 653·2-1000' RT. OF ℄



NOTES

- -SUBSOIL DUNE SAND
- -DRY WITH LITTLE OR NO PERMAFROST
- -GOOD SOURCE OF BORROW

Public Works Canada / Travaux publics Canada	drawing title / titre du dessin: BORROW PIT 156	designed by / conçur par — date	
	scale / échelle: 1" = 300'	drawn by / dessiné par — date	
		reviewed by / examiné par — date	
		approved by / approuvé par — date	
region / région	revisions / révisions — date	project number / no. de entreprise	drawing no / no du dessin

D.P.W. 700 A

MILE 657 to MILE 659 - REVISION

Near Mile 657.2 the original highway location crosses an old melt water channel on a glaciolacustrine plain. The old channel is partially infilled and is marked by numerous lakes and peat bogs and carries a year round flow in a small stream channel. Three test holes (657-C-1 to 657-C-3) were drilled on a narrow neck of lake where the route crosses the old channel. At the time of drilling (April, 1975) the thickness of ice was only 8" and an odor of sulphur was noted when the D-7 broke through. Permafrost was absent in all three holes. The subsoil is very soft clay silt sediments, high in organic content, and it is anticipated that the embankment across this lake will undergo significant long term settlements.

A tentative revision which would parallel the old channel for approximately 1 1/2 miles from Mile 657 to approximately Mile 658.5 was test drilled. This revision would cross the old channel at the end of a long lake but would not cross any existing ponds. Deposits along the revision are ice-rich sands, silts and clays, however, the peat and organic subsoil in the old channel appear to be much less extensive on the revision than on the original alignment. In addition, permafrost appears to be continuous across the old channel on the revision which would permit excavation of the peat and organic deposits that are present. The test drilling suggests that the revision may be the preferred location along this section.

... 174

MILE 666.9 TO 674.1 - REVISION

This section of highway primarily crosses a wet muskeg terrain with thermokarst features and numerous small lakes and muskeg bogs which indicate a highly thermally sensitive ground condition. The route roughly parallels Broken-Off-Mountain through this section and at Mile 668 crosses a sharply defined bedrock ridge. The revision is generally less than 2000 feet from the original alignment and the main purposes for the change were to improve the vertical alignment over the bedrock ridge at Mile 668 and to shift the location nearer the base of Broken-Off-Mountain between Mile 670 to 674, and onto less thermally sensitive terrain. The grade line is in fill section throughout with the exception of a major cut in the bedrock ridge at Mile 668 and some very shallow cuts between Mile 673 and 674. Surfical deposits along much of the revision are ice-rich silts and clays with variable peat overlays up to 4 and 5 feet.

Near Mile 669 the route crosses a small lake and muskeg bog in a old partially infilled channel. Hole 660-C-7 on the edge of this bog encountered 4 feet of peat and it is expected that several feet of organic soils will be encountered below the lake bottom which may not be frozen, hence significant long-term embankment settlements could occur here.

The revision crosses the Hanna River at Mile 669.7 at the same location as the original alignment. Two holes were drilled here at the location of the proposed abutments and these holes will be reported separately.

At approximately Mile 672.5 the route crosses a small creek issuing from Broken-Off-Mountain which was unfrozen at the time of drilling (April, 1975). As the terrain in the general area of the creek tends to be high in organics in the upper few feet and,as there is likely to be a fairly large thaw bulb under the open creek, culvert and embankment settlement may occur here unless significant sub-excavation and backfill is carried out.

The cut sections between Mile 673 and 674 are in subsoil that is considered poor for cut, however, as all cuts are shallow (less than 5') any problems that occur should be minor.

Near Mile 674.5 is a muskeg area some 1200 to 1300 feet in length. This area was not test drilled, however the D-7 became stuck here and it is expected that there are extensive deposits of peat and organic soils with little or no permafrost. Embankment settlements through this section could be significant and long-term.

MILE 675.3 TO 676.5 - REVISION

This is a very minor revision resulting in a lateral line shift of less than 500 feet. The grade line is in fill section with the exception of two shallow cuts in sharply defined ridges near Mile 675.1. Test Hole 675-C-1 in one cut section revealed sandy clay silts with moisture contents near the liquid limit upon thawing. This material is considered unsuitable for cut, however, as there is only a 200 foot section where the depth of cut exceeds 6 to 7 feet, any backslope problems that do occur should be minor.

MILE 686.2 TO 690.8 - REVISION

This is a major revision and results in relocation of the route away from the edge of Chip Lake onto higher, better drained terrain to the south-west that is at least partially bedrock controlled. Included also is a revised crossing over the Donnelly River.

The subsoil along the revision consists of variable slope-wash and reworked glacial till, overlying glacial drift and/or bedrock. Permafrost is continuous and most of the surfical deposits are ice-rich to the depth of 6 or 8 feet. The revision crosses a bedrock ridge near Mile 687.5 (Test Hole 687-C-3 to

687-C-5) and only this area is considered suitable for cut. Bedrock was also encountered in a deep creek valley near Mile 687 (Test Hole 686-C-5) at a depth of 5 feet. Excellent bearing would be available here for a culvert installation.

Two test holes were drilled in a potential borrow area on the north side of the Donnelly River (689-C-5 and 689-C-6). These holes encountered medium to highly plastic silty clays over shale at a depth of 16 to 17 feet. The overlying clays are frozen but could probably be used as borrow below a depth of 3 to 4 feet where moisture contents are less than 30%.

Test holes were drilled for bridge foundations at the Donnelly River, both on the revision and on the original alignment. Shale was encountered at relatively shallow depths at both sites, however, these results will be reported separately.

APPENDIX A

DEFINITION AND EXPLANATION OF TERMS

GLOSSARY OF TERMS

Active Layer	The layer of soil above the permafrost table (in the area of this study, the active layer usually freezes completely during the winter.)
Alluvium	Stream deposits of comparatively recent time, does not include subaqueous deposits of seas and lakes.
Anhydrite	A mineral, anhydrous calcium sulfate, $CaSO_4$. Orthorhombic, commonly massive in evaporite beds.
Annuals	A plant that lives only one year or season.
Autoclave Expansion	Laboratory test procedure as designated by ASTM-C151-63 for determination of expansive qualities for all types of Portland Cement and aggregate reactions.
Berm	A horizontal portion of an earth embankment to ensure greater stability of a long slope.
Biotic	Of or pertaining to life or mode of living.
Boreal	Pertaining to the North.
Boulder	A rock fragment larger than 8" in diameter.
Cartographic	Pertaining to a map. In geology a cartographic unit is a rock or group of rocks that is shown on a geologic map by a single color or pattern.
Clay	Soil particles smaller than 0.002 mm. in diameter.
Cobble	A rock fragment between 3" and 8" in diameter.
Colluvium	A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.

Conglomerate	Rounded water-worn fragments of rocks or pebbles, cemented together by another mineral substance which may be of a siliceous or argillaceous nature.
Continuous Zone	That zone where permafrost occurs everywhere beneath the ground surface including large lakes and rivers.
Cretaceous	The third and latest of the periods included in the Mesozoic era; also the system of strata deposited in the Cretaceous period.
Crystalline	Of or pertaining to the nature of a crystal; having regular molecular structure.
Delta Deposits	An alluvial deposit, usually triangular, at the mouth of a river.
Devonian	In the ordinarily accepted classification, the fourth in order of age of periods, comprised in the Paleozoic era, following the Silurian and succeeded by the Mississippian. Also the system of strata deposited at that time.
Discontinuous Zone	That zone where permafrost occurs everywhere beneath the ground surface except beneath large lakes or wide rivers.
Dolomite	A mineral, $CaMg(CO_3)_2$, commonly with some iron replacing magnesium; a common rock-forming mineral.
Drunken Forest	An area characterized by the appearance of many trees leaning in differing directions without any apparent pattern to the direction of inclination. This phenomenon is caused by differential thawing of ground ice.
Ecology	The study of the mutual relationships between organisms and their environments.
Eolian	Deposits which are due to the transporting action of the wind.
Escarpment	The steep face of a ridge of high land.

Esker	A narrow ridge of gravelly or sandy drift, deposited by a stream in association with glacier ice.
Excess Ice	Ice in excess of the fraction that would be retained as water in the soil voids upon thawing.
Fauna	The animals collectively of any given age or region.
Flood Plain	That portion of a river valley, adjacent to the river channel, which is built of sediments during the present regime of the stream and which is covered with water when the river overflows its banks at flood stages.
Flora	The plants collectively of any given formation, age or region.
Fossiliferous	Containing organic remains.
Geomorphology	The study of landscape and of the geologic forces that produce it. It is the dynamic geology of the face of the earth. It concerns that branch of physical geography dealing with the origin and development of the earth's surface; features (landforms) and the history of geologic changes through the interpretation of topographic forms.
Geothermal Gradient	Change in temperature of the earth with depth, either in degrees per unit depth or in units of depth per degree.
Glacial Till	Non sorted, non stratified sediment carried or deposited by a glacier.
Glaciofluvial	Fluvioglacial. Pertaining to streams flowing from glaciers or to the deposits made by such streams.
Glaciolacustrine	Pertaining to glacial-lake conditions, as in glaciolacustrine deposits.
Gravel	Soil particles smaller than 3" in diameter and larger than 2.0 mm in diameter.

Ground Ice	Bodies of more or less clear ice in permanently frozen ground.
Ground Moraine	A moraine with low relief, devoid of transverse linear elements.
Gypsum	Alabaster. Selenite. Satin Spar. A mineral, $CaSO_4$, $2H_2O$. Monoclinic. A common mineral of evaporites.
Heterogeneous	Differing in kind; having unlike qualities; possessed of different characteristics; opposed to homogeneous.
Hummock	A mound or knoll.
Icing	Mass of surface ice formed during winter by successive freezing of sheets of water seeping from the ground, a river or spring.
Kames	A mound composed chiefly of gravel or sand, whose form is the result of original deposition modified by settling during the melting of glacier ice against or upon which the sediment is accumulated.
Karst	A limestone plateau marked by sinkholes and underlain by cavernous carbonate rocks having subterranean drainage channelways that largely follow solution-widened joints, faults, and bedding planes.
Lacustrine	Produced or belonging to lakes.
Lichen	Any of a group of low growing plant formations composed of a certain fungi growing close together with certain algae.
Massif	A French term adopted in geology and physical geography for a mountainous mass or group of connected heights, whether isolated or forming a part of a larger mountain system.

Meandering	Condition of river that follows a winding path owing to natural physical causes not imposed by external restraint. Characterized by alternating shoals and bank erosion.
Moraine	Drift, deposited chiefly by direct glacial action, and having constructional topography independent of control by the surface on which the drift lies.
Morphological	The scientific study of form. Used in various connections, e.g. landforms (geomorphology).
Muskeg	The term designating organic terrain, the physical condition of which is governed by the structure of peat it contains and its related mineral sublayer, considered in relation to topographic features and the surface vegetation with which the peat co-exists.
Ordovician	The second of the periods comprised in the Paleozoic era, in the geological classification now generally used. Also the system of strata deposited during that period.
Organic Soil	Soil material which contains a significant proportion of organic material. Where the organic nature of the soil is its dominent characteristics, the soil is referred to as a peat.
Perennial	Lasting through the year.
Permafrost	The thermal condition under which earth materials are at a temperature below $32^{o}F$ continuously for a number of years.
Permafrost Degradation	The lowering of the permafrost table due to thawing.
Permafrost Table	A more or less irregular surface which represents the upper limit of permafrost.
Petrography	The branch of science treating of the systematic description and classification of rocks.
Proglacial	Pertaining to features of glacial origin beyond the limits of the glacier itself, as...streams,...deposits,...sand.

Sand	Soil particles smaller than 2.0mm. in diameter and larger than 0.06mm. in diameter.
Screes	A heap of rock waste at the base of a cliff or a sheet of coarse debris mantling a mountain slope.
Seasonal Frost	Freezing of the ground during the winter. The term implies that the frost so formed will thaw during the following spring or summer.
Silurian	The third in order of age of the geologic periods comprised in the Paleozoic era, in the nomenclature in general use. Also the system of strata deposited during that period.
Sinuous	Winding or curving in and out.
Slope Wash	Soil and rock material that is being or has moved down a slope predominantly by the action of gravity assisted by running water that is not concentrated into channels.
Sporadic Zone	That zone where permafrost occurs only in isolated patches (usually beneath peat bogs)
Subgrade	The original ground upon which an embankment is placed.
Surface Degradation	The lowering of the ground surface due to thawing of underlying ground ice.
Taiga	A Russian word applied to the old, swampy, forested region of the north...that region between the Tundra in the north and the Boreal in the south.
Talus	Coarse angular fragments of rock and subordinate soil material dislodged by weathering (temperature and moisture changes) and collected at the foot of cliffs and other steep slopes and moved downslope primarily by the pull of gravity.

Terrace	A relatively flat elongate stairstepped surface bounded by a steeper ascending slope on one side and a steep descending slope on the other.
Tertiary	The earlier of the two geologic periods comprised in the Cenozoic era, in the classification generally used. Also the system of strata deposited during that period.
Thaw Settlement	Settlement of a soil mass due to thawing of ground ice.
Thermal Conductivity	The amount of heat passing through a unit cross-section in unit time under the influence of unit heat gradient.
Thermal Erosion	Erosion due to the melting of ground ice rather than the removal of soil
Thermal Regime	The temperature conditions in the ground at a given point in time.
Thermal Regression	The thawing of frozen ground due to surface disturbance, increasing temperature, etc.
Thermokarst	Uneven land subsidence caused by the melting of ground ice. The resulting ground surface resembles the karst topography found in limestone areas.
Thermokarst Lake	(Cave-in Lake), lakes which occupy depressions resulting from subsidence caused by thawing of ground ice.
Tundra	Any of the vast, nearly level, treeless plains of the Arctic Regions.
Turbid	Having the sediment stirred up hence muddy, impure.

NATIONAL RESEARCH COUNCIL PERMAFROST CLASSIFICATION SYSTEM

Permafrost ground ice occurs in three basic conditions including non-visible, visible (less than one inch 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 1" 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 1" thick)

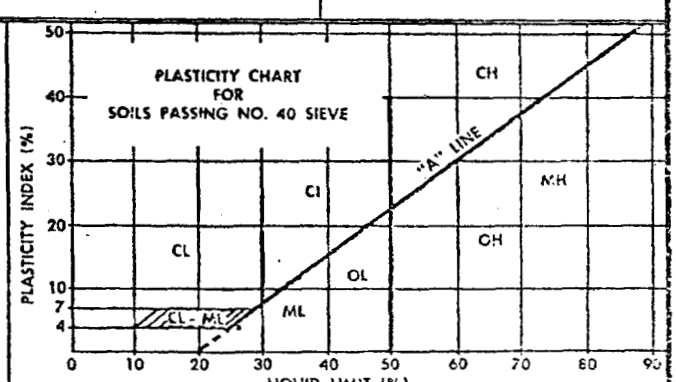
Ice - ice with soil inclusions

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	$C_U = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			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 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	$C_U = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			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, 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%.

APPENDIX B

PROJECT OPERATIONS AND COSTS

I PROJECT OPERATIONS

This section provides an outline of field operations and costs, to assist in planning of similar investigations in the future.

1.1 Background

1.1.1 The geotechnical investigation carried out on Section D of the Mackenzie Highway (Mile 725 to Mile 936) in the winter of 1973-74 provided a good basis for planning the 1975 programme. This previous investigation generated useful information on equipment requirements and the suitability and limitations of various items; drilling rates in cold weather; problems, and rates of movement for the camp; preferred mode of field operations, etc. The sled mounted camp facilities were available from that programme and were transported from Ft. Good Hope to Ft. Simpson by barge during the summer of 1974.

1.1.2 The 1975 programme differed from the previous work in that the number of boreholes required were considerably less (1500 versus roughly 3300 in 1973-74) and were on randomly located sections of the route extending over a distance of roughly 400 miles (versus roughly 200 in 1973-74). Thus camp mobility was a major factor in planning and an

average progress rate of 5 miles per day was considered necessary to complete the project within the limited time frame available.

1.1.3 Two drilling rigs mounted on Nodwell tracked vehicles were available within the Department for this project. Since drilling sites were randomly spaced along the route it was anticipated these two rigs working daily 10 hour shifts could keep pace with camp movement.

1.2 Work Schedule

1.2.1 Start up of field work was governed by the availability of an ice bridge over the Mackenzie River at Ft. Simpson. This had been estimated for the first part of January, however, the early part of winter was unusually warm, and the ice-bridge was not suitable for crossing until January 22nd.

1.2.2 Due to staff limitations, complete crew rotation was not possible and past operations had proven a continuous work period of 4 weeks in relative isolation to be the maximum for crew morale and efficiency. Thus two short work breaks had been included in the initial work schedule. The delay due to the ice-bridge, and equipment breakdowns, forced a change in the initial schedule and only one work

break was taken, with partial staff rotation in lieu of a second break. The actual work program was as follows:

January 22 to February 13	-	operating	- 24 days
February 14 to February 18	-	shutdown	-
February 19 to April 11	-	operating	- 52 days
		total field operations	- 76 days

1.2.3 Field work was terminated on April 11 slightly short of the objective (Mile 690 versus Ft. Good Hope at Mile 725) as spring breakup was rapidly approaching and highway location and access were unsettled in the vicinity of the settlement of Fort Good Hope. The camp was returned to Norman Wells (Mile 630) and demobilized at that point.

1.3 Camp and Equipment

1.3.1 The camp was entirely sleigh mounted and consisted of the following:

(a) 1 - kitchen/diner - suitable for 15-18 men
(b) 1 combined washroom, laundry room, office, and 3-4 man bunk unit
(c) 1 - 8-10 man sleeping trailer
(d) 1 - 3 man sleeping trailer (owned by dozer contractor)
(e) 1 power house (c/w 2 - 300 gallon fuel tanks 2 - 20 KVA generators)
(f) 1 fuel sleigh 8' x 30' c/w 2500 gallon tanks
(g) 1 1000 gallon water tank on 6' x 16' sloop

1.3.2 Two D-7 dozers were contracted for the project from Karl Mueller Construction Ltd. Auxiliary equipment supplied by the Contractor included a fuel sled with 2000 gallon capacity, welding unit, and generator for welding unit.

1.3.3 The Departmental drill rigs were both mounted on Nodwell 110 tracked vehicles and consisted of: 1 Failing Model 1250 rotary rig powered by the Nodwell diesel motor and equipped with a 500 c.f.m. compressor, and; 1 Mobile B50 auger rig with a gasoline motor power unit.

1.3.4 Support equipment included two FN-10 Nodwell tracked personnel carriers, and two 4-wheel drive crew cab vehicles (3 for part of the project). All of these units were available within the Department.

1.4 Staff

1.4.1 The operational crew consisted of the following:

1	field engineer (part-time)
1	camp supervisor
1	location technician
2	drilling technicians
2	drillers
2	driller's helpers
1	camp maintenance person
3	dozer operators
2	cooks
Total 15	

1.4.2 The cooks were hired on a contract basis from Bull Catering Ltd. Food supplies were provided by the Department through field offices in Ft. Simpson and Norman Wells.

1.5 Fuel Supply

1.5.1 Fuel requirements were estimated at 250 gallons of diesel per day and 60 gallons of gasoline per day, but only reached that consumption in periods of extreme cold weather and longer than normal work days. Supply of fuel was available by truck haul along the winter road from either Ft. Simpson or Norman Wells.

1.6 Radio

1.6.1 Two radio-telephones were provided for external communications (one unit in the camp and one unit in a truck) through the C.N.T. Communications System. Both units worked consistently well and provided excellent contact with N.W.T. settlements as well as Edmonton.

1.7 Production

1.7.1 Test borings were carried out between roughly Mile 370 and Mile 690 and the actual operating period for this section

was 70 days. Thus a progress rate of slightly more than 4.5 miles per day was achieved. In all some 1485 holes were drilled, and, with 2 drilling shifts per day, production rate of 10-11 holes per shift was obtained. By comparison the 1973-74 programme averaged 8 holes per shift.

1.7.2 The winter road which closely follows the proposed highway route to Ft. Good Hope was a definite asset to operations. Vehicle and camp movements benefited greatly from the road and resulted in fewer breakdowns, more rapid camp movement, and more ease of movement for drilling crews and supervisory staff (as compared to the 1973-74 programme when the majority of movement was along the cleared highway centerline). In addition fuel and camp supply by truck was possible, and in several instances water supply by truck from settlements and Hire North camps was possible. The winter road was opened primarily for the geotechnical operations (at least for that portion north of Wrigley (Mile 435), and without the winter road it is doubtful if progress would have reached Ft. Norman (Mile 580) before spring breakup.

1.7.3 Drilling production did not suffer significantly from rig breakdown, although the hydraulic system on the Mobile B-50 auger rig was a constant problem in cold weather and

breakdowns on this unit did occur. Fortunately it was possible to double shift the Failing drill rig during breakdowns and little production was lost.

1.7.4 The FN-10 tracked vehicles again proved to be unreliable. Heating systems were a constant problem on these units and problems with the motors and drive trains occurred from time to time. The 4 x 4 crew cabs performed well and were definitely superior to the tracked vehicles despite constant usage and rough terrain.

1.8 Delivery of Supplies and Personnel

1.8.1 Deliveries of supplies, repairs and personnel was by truck along the winter road from Ft. Simpson and Norman Wells, and by plane to airstrips at Wrigley (Mile 435), Blackwater River (Mile 490), Little Smith Creek (Hire North camp - Mile 534) and Ft. Norman (Mile 580). Helicopter usage was very limited.

1.9 Land Use Regulations

1.9.1 Land use regulations did not slow or hinder the operations once underway. There were occasional inspections by personnel based in Ft. Simpson and Norman Wells, however no serious complaints were lodged.

1.10 Cost of Project

1.10.1 The following table summarizes costs which can be attributed directly to this project, and does not include such items as laboratory and office overhead (Edmonton), and expediting services by D.P.W. offices at Ft. Simpson and Norman Wells. A portion of costs for opening the winter road have been included. A total of $5,000 has been allowed for camp repair and maintenance and a project charge of $25,000 has been included for depreciation and post-project overhaul and repair of Departmental vehicles and drilling rigs assigned to the operations. Staff costs are payroll costs (i.e. salary and administrative overhead).

Costs

Dozers - contract - Mueller Contracting	$67,000
Hired Driller - contract - Mobile Augers	12,400
Cooks - contract - Bull Catering	8,300
Drill Bits - contract - Walker-McDonald Bit Co.	24,000
Food Supply - various	13,000
Fuel Costs - various	12,000
Air Fares & Travel Costs - scheduled service	9,100
Chartered Air Service - various	9,700
Minor rentals - truck, heaters, radio, etc.	3,500
Shipping costs - including barging costs for camp Ft. Good Hope to Ft. Simpson	20,000
Camp maintenance and repair	5,000
Depreciation, overhaul and repair costs on Departmental vehicles after job completion	25,000
Staff Payroll Costs - including field operations, overtime, lab. testing and reporting (to and including soils engineer level)	80,000
Minor field supplies, repairs, miscellaneous (estimated)	10,000
Report preparation, telephone charges, etc.	3,000
Portion of D.P.W. costs for preparation of winter road (estimated)	80,000
Total	$382,000

Cost Per Hole = $255/hole

Cost Per Mile (use 320 miles) = $1,200/mile

1.10.2 It is of interest to compare the 1973-74 programme with the 1975 programme in terms of cost, and comparisons are outlined below:

1973/74	1975
Section D = 200 Miles	Sections B & C = 320 Miles
field staff = 26	field staff = 15
operating days = 95	operating days = 70
boreholes = 3300	boreholes = 1500
samples = 19,000	samples = 8500
Total Cost = $680,000	Total Cost $380,000
Total Cost/Mile = $3,400	Total Cost/Mile = $1,200
Total Cost/Hole = $ 205	Total Cost/Hole = $ 255
Total Cost/Sample = $ 36	Total Cost/Sample = $ 45
Catering Costs = $13.50/man/day	Cost of food supply + cooks salary = $19.00/man/day
D.P.W. Payroll Costs per hole including drilling, testing and reporting= $58/hole	D.P.W. Payroll Costs per hole including drilling, testing and reporting =$54/hole
Contracted Costs = $118/hole	Contracted Costs = $134/hole
Travel Costs including charter and schedule flights = $17/hole	Travel Costs including charter and schedule flights = $12/hole

NOTE - Equipment rental in the 1973/74 programme included both dozers (2) and drill rigs (2). The 1975 programme included only dozer rental (2), plus an $80,000 allowance for costs of clearing the winter road.