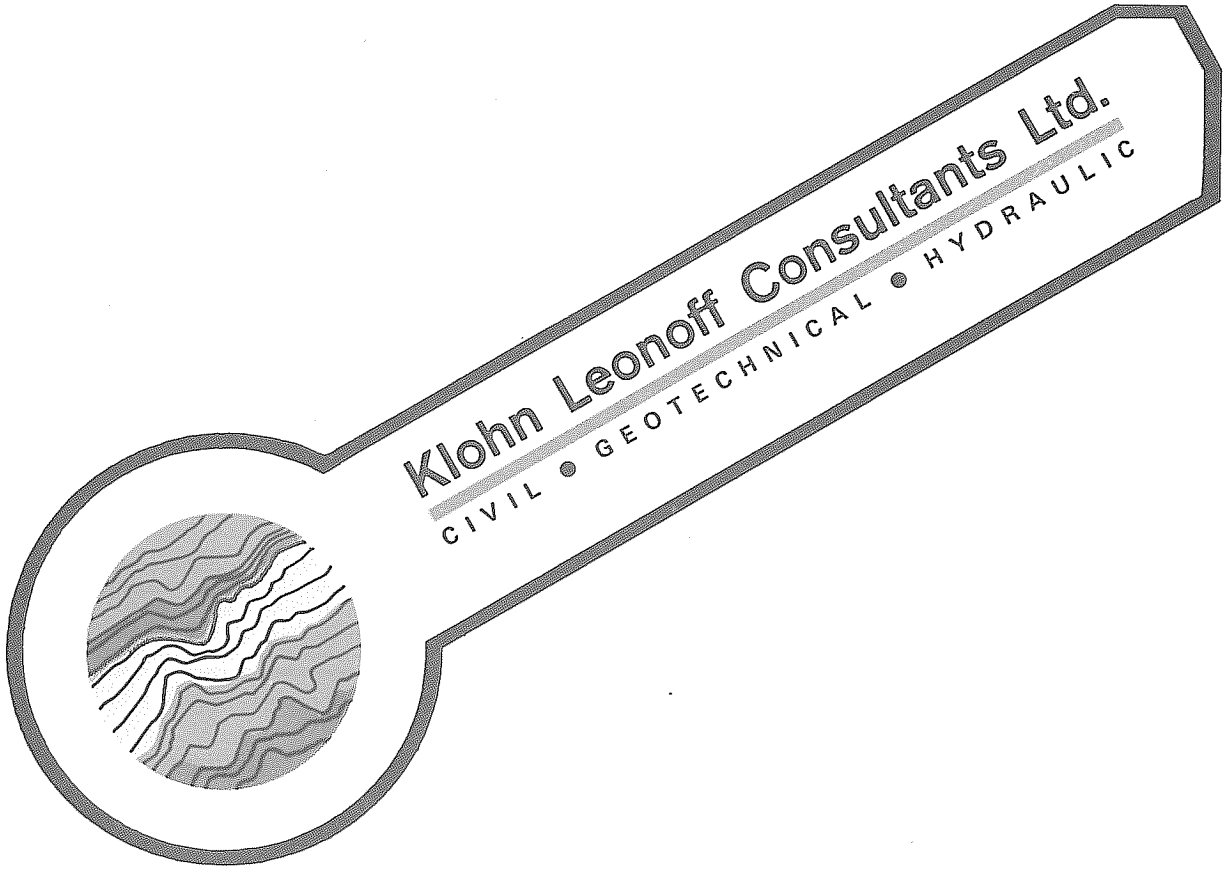
REPORT



FINAL REPORT

FROST HEAVE TEST DRILLING PROGRAM (MP 0 To 40)

FOOTHILLS PIPE LINES CO. LTD.

AL0890

DECEMBER 22, 1977

19771222-2

APPENDIX "B" to ALASKA HIGHWAY PIPELINE PROJECT FROST HEAVE PROGRAM, JANUARY, 1978, FOOTHILLS PIPE LINES (YUKON) LTD. AND NORTHWEST PIPELINE CORP.

KLOHN LEONOFF CONSULTANTS LTD.
Civil · Geotechnical · Hydraulic

December 22, 1977

OUR FILE NO.: AL0890

Foothills Pipe Lines Company Ltd.
1600 Bow Valley Square #2,
205 - 5th Avenue S.W.,
Calgary, Alberta
T2P 2V7

Attention: Dr. F. Yip, P. Eng.

Dear Sir:

RE: Final Report
Frost Heave Test Drilling Program

This report presents the results of the test drilling program carried from MP 0 at the Alaskan Border to MP 40 at the White River, between September 19 and November 5, 1977. The purpose of the program was to locate a potential frost heave test site along this segment of the pipeline where gas may be chilled.

The written introductory section of the report describes the scope of the frost heave test drilling program and provides a general overview of the soil and permafrost conditions along the 40 mile segment of the route. A summarized assessment of the soil and permafrost conditions as applicable to the potential frost heave sites, is also presented.

The field and laboratory data for each of the ten sites drilled during the program are attached in the Appendices 1 to 10 inclusive. The data contained in each appendix are as follows:

1. A written summary describing both the terrain at each drill site and the underlying soil and permafrost conditions.
2. General site location plan.
3. Photo mosaic showing test hole locations.
4. Site photograph.
5. Test hole logs - following each test hole log is the laboratory test data including grain size curves and frozen bulk densities.

19771222-2

A legend describing the terrain classification terms used on the enclosed airphotographs is provided in Appendix A. A description of both the symbols and terms and the soil classification system used on the test hole logs is given in Appendix B.

Please contact the writer or Mr. Don Davison of this office should you have any questions concerning this report.

Yours very truly,

KLOHN LEONOFF CONSULTANTS LTD.

A. L. Edgeworth, P. Eng.

ALE/clt

cc: Mr. R. Lazerte

Halliday

NORTHWEST ALASKAN PIPELINE COMPANY

Memorandum

To: Members of EPB Technical Subcommittee-Permafrost Date: August 1, 1978

From: Edwin (Al) Kuhn, Director, Government and Environmental Affairs

Subject: Distribution of Appendices to January 1978 Frost-Heave Program

By letter dated July 25, 1978, Dan Friedman provided members of the Permafrost Subcommittee with a copy of the NEB staff "Reply to Foothills (Yukon) Frost-Heave Program Proposal."

The NEB comments pertain to a report entitled "Alaska Highway Pipeline Project, Frost-Heave Program," submitted to the NEB of Canada in January 1978 by Foothills and Northwest Alaska Pipeline companies. In order to fully evaluate the NEB staff comments on this report it is necessary to have in hand all of the appendices to our January 1978 report.

Attached hereto are copies of Appendices A.1 through A.5 and Appendix C. Appendix B is a bulky document prepared by Klohn Leonoff Consultants, Ltd., which is being forwarded to your directly from that firm.

Al Kuhn

EAK/fes

Attachments

cc: Dan Friedman
Jack Cannon

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July 25, 1978

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1.0 INTRODUCTION

1.1 Scope

The scope of this project as outlined by Foothills Pipe Lines Ltd. was to locate a potential frost heave test site within the first 40 miles of the proposed pipeline route between the Alaska border and the White River. Initially, the drilling was confined to an area along the proposed pipeline right-of-way, although this was modified during the program to include a two mile corridor on either side of the proposed line. The requirements for the proposed test site location as outlined to us, were to comprise the following conditions:

a) a considerable area underlain by a thick sequence of fine grained, frost susceptible soils (in the order of 20 feet).
b) essentially unfrozen subsoils
c) a high water table or a nearby water source.

Prior to commencing the field drilling program, Klohn Leonoff Consultants undertook a thorough examination of relevant geological data pertaining to the 40 mile segment along the right-of-way. The office study entailed a detailed review of the following data:

a) thirty-five test hole logs drilled in the area by Klohn Leonoff Consultants during the 1976 drilling program.
b) reconnaissance notes acquired during the 1976 examination of the route.
c) thermistor instrumentation data from installations made during the 1976 drilling program.
d) airphoto interpretation and terrain classification data describing the geomorphological features and landforms in the area.
e) D.P.W. drill logs and G.S.C. publications
f) 1" to 2000' air photography available along the pipeline corridor.

Subsequent to the office study, a total of 10 potential frost heave test sites were selected. From 3 to 5 test holes for each potential site were laid out in the field and drill pads were cleared. At the outset of the program it was understood the proposed test facility would be in the order of 1 mile in length. Thus, the test holes were laid out about

200 to 400 m. apart within each potential site. During the latter part of the field program we were informed that the proposed test facility was reduced considerably in size for economic reasons. However, this change in criteria did not affect the investigation in progress.

At the time the test holes at the potential frost heave test sites were being located in the field, the writer undertook a detailed examination of soil exposures and terrain conditions along and adjacent to the 40 miles of pipeline right-of-way. This examination included a considerable number of helicopter spot checks and ground truthing along the old Haines-Fairbanks pipeline right-of-way. Subsequent to this detailed field reconnaissance, several adjustments in drill hole locations were made in the field as the program progressed. In total, 52 test holes were drilled during the time period from September 19th to November 5, 1977.

1.2 Glacial History

A brief overview of the glacial history is beneficial to explain the general soil conditions along the 40 mile segment of the pipeline right-of-way. In this area, the Quaternary geology is complex and most of the underlying subsoils have a glacial origin. The southern portion of the area was inundated by at least two recent advances of the Cordilleran ice sheet, namely the Mirror Creek and Macauley glaciations. The Mirror Creek glaciation, according to the G.S.C., is early Wisconsin or Illinoian in age, whereas the Macauley glaciation is the equivalent of the "classical" Wisconsin.

The ice sheet of the older Mirror Creek glacial stage advanced northerly to about MP 15 of the pipeline route, immediately south of Beaver Creek, where hummocky morraines were deposited. During glacial recession to the south, a large outwash plain was deposited beyond the limit of the glacial advance, in the area between MP 5 and 15.

The ice sheet during the younger Macauley glaciation advanced northerly to about MP 25 of the pipeline route in the vicinity of the present day Enger Lakes. In this area, especially near the glacial limit, extensive

areas of undulating, disintegration moraines were deposited. During deglacation, vast amounts of meltwaters issuing from the glaciers carved out meltwater channels along Dry Creek, Enger Creek and other glacial scoured depressions. At the same time, water transported silts infilled many of the depressions in the Mirror Creek moraines and outwashes. Locally, small ice dammed lakes were also formed, and deposited fine grained glaciolacustrine sediments above the glacial outwash and till.

Post glacial processes have subsequently eroded or masked the glacial deposits, especially in low lying areas. A thin veneer of volcanic ash was deposited in the southwestern Yukon by two large volcanic eruptions in the St. Elias Mountains during the past 2,000 years.

2.0 SUMMARY - SUBSOIL & PERMAFROST CONDITIONS (MP 0 to 40)

The test hole data from both the 1976 and 1977 drilling programs along the 40 mile segment of the pipeline route, generally confirmed the glacial history and airphoto terrain analysis of the area. In general, the subsoils are quite granular, and permafrost is widespread except in areas of considerable ponded water, adjacent to streams, and occasionally in hummocky glacial terrain. The following paragraphs describe the general subsoil and permafrost conditions on a macro-scale, based on the test drilling along the 40 mile segment. (The reader should refer to Appendices 1 to 10 inclusive for test hole logs, laboratory data, and a detailed description of each of the ten potential sites). Variations of the described conditions will certainly occur locally. The conditions at the ten potential frost heave sites drilled during the past two months are also summarized in the following paragraphs.

The pipeline route from MP 0 to 5 crosses a series of hills separated by narrow well defined valleys. Eight and six test holes respectively were drilled in this section during the 1976 and 1977 drilling programs. Thirteen of the test holes drilled in the valleys encountered frozen, interlayered fine grained soils consisting of organic silt and clayey silt up to depths exceeding 25 meters. The upper 8 m. are high ice

content with extensive organic laminations and inclusions. Based on one test hole and extensive field observations, the hills are comprised of bedrock masked by low ice content colluvium. On the lower valley flanks, the colluvium may be ice rich and exceed 9 m. in thickness. Potential frost heave sites 1 and 2 were drilled in the valleys at MP 1 and 2.5 respectively. There is no area between MP 0 and 5 suitable for a frost heave test site, as no unfrozen soil conditions could be located.

The pipeline route from MP 5 to 9 crosses a flat to very gently rolling, featureless area between Mirror and Snag Creeks. The area is poorly drained. In low lying areas the ground surface is soft and swampy, with ponded water to more than 1 m. deep. Four and eleven test holes respectively were drilled in this section during the 1976 and 1977 drilling programs. The subsoils consist of a thin organic veneer, overlying glaciolacustrine, non-to-slightly plastic silts and sands, all of which overlie a very dense stratum of gravel and sand. The upper fine grained soils vary from 1 to 7 m. thick, and average 3 to 4 m. thick. The permafrost conditions are variable. Permafrost is generally present except in broad open areas with considerable ponded water. In areas adjacent to Snag Creek and Mirror Creek and its tributaries, permafrost generally occurs as a "talik" from 3 to 5 m. thick. Potential frost heave sites 3 and 4 were drilled between MP 5.5 to 6.5 and MP 8 to 9. The only substantial areas of unfrozen ground between MP 5 and 9 occur where water is ponded to depths exceeding about 1 m.. Therefore, the potential for a frost heave test site along this segment of the route is poor.

The pipeline route from MP 9 to 15 crosses the flat featureless outwash plain which was deposited beyond the limit of the Mirror Creek glacier. The post glacial alluvial flood plain of Beaver Creek occurs at MP 15. Five test holes were drilled in this section during the 1976 drilling program. Considerable excavation and test pit data are also available within the community of Beaver Creek. The subsoils in this area are quite uniform, consisting of dense interlayered sandy gravels below a depth of 1 to 2 m.. Permafrost is widespread but generally has a low ice content. This area is not considered suitable for a frost heave

test site due to widespread permafrost and shallow gravel deposits.

The pipeline route from MP 15 to 23 climbs onto the undulating moraine and outwash terrain which denotes the maximum ice advance during Mirror Creek glaciation. The area is gently rolling, with numerous small drainage courses flowing into Enger Creek. Three test holes were drilled in this section during the 1976 drilling program. The three test holes encountered 3 to 5 m. of peat and glaciolacustrine silts overlying a dense granular stratum. Observations during ground truthing along Enger Creek indicates the creek bed is essentially gravel. Permafrost was encountered in all three test holes and considerable probing along the old Haines-Fairbanks pipeline indicates permafrost is virtually continuous. Based on the test drilling and considerable field observations, there is no location in this area which is considered suitable for a frost heave test site, due to widespread permafrost and the shallow granular strata.

The pipeline route from MP 24 to 31 crosses a variety of terrains which mark the maximum ice advance during the Macauley glaciation. The area is rolling and noticeably hummocky. Three and eleven test holes respectively were drilled in this section during the 1976 and 1977 drilling programs. The subsoil and permafrost conditions in this region are variable. The rolling upland terrain consists of a thin upper stratum of silt, clay, and sand overlying a variable and often till-like gravel, sand and silt. Permafrost is variable, but the test drilling indicated areas of unfrozen ground. In the lower lying flatter areas, the terrain is underlain by interlayered peat, silt, sand, and clay up to 10 m. thick. All test holes drilled in the low lying flat areas encountered permafrost to the maximum depths drilled. Potential frost heave site 6 was drilled between MP 26.5 and 27.5. In general, the areas of unfrozen rolling terrain from MP 24 to 31, have shallow gravel and sand or till-like strata, whereas the low lying areas which are underlain by fine grained soils are permafrost affected. Therefore, a frost heave test site could not be located in this area.

The pipeline route from MP 31 to 31.5 crosses a narrow, well defined

meltwater channel valley which is drained by Dry Creek. Fifteen test holes were drilled in the valley adjacent to the creek at potential frost heave site 7. In general, the subsoil conditions at Site 7 consist of a narrow band of unfrozen soils along the west side of Dry Creek. The subsoil conditions are variable, grading from clays and silts to sands and gravels. The depth of fine-grained material varies from more than 8 m. in confined zones in the north central portion of the site, to less than 2 m. in the north and south ends of the site.This site is described and assessed in detail in Section 3.0 of this report as well as Appendix 3.

Six additional test holes were drilled at potential frost heave sites 9 and 10 in the Dry Creek valley. These two sites are located up-stream from Site 7 along the Dry Creek valley. All six test holes drilled at sites 9 and 10 encountered permafrost to depth up to 11 m.. Therefore, there is no potential for locating a frost heave test site at sites 9 and 10 due to a lack of unfrozen soil conditions.

The pipeline route from MP 31 to 40.5 crosses a series of rolling hummocky moraines and outwash deposits. Seven test holes were drilled during the 1976 drilling program. The subsoils consist of interlayered peat, organic silt and sand to a depth of 4 m., overlying interlayered granular strata. Permafrost is widespread and six of the seven test holes encountered permafrost to the maximum drilled depths. Therefore, a frost heave test site could not be found between MP 31 and 40.5 due to widespread permafrost and shallow granular strata.

The pipeline route from MP 40.5 to 42 descends into a meltwater channel valley and proceeds across gently sloping coalescing alluvial fan terrain. Two and three test holes respectively were drilled in this section during the 1976 and 1977 drilling programs. Based on the two test holes drilled in the meltwater channel valley, the subsoils consist of 1.5 to 3 m. of laminated silts overlying a dense gravel and sand stratum. No permafrost was encountered in either of these test holes. The three test holes drilled to the south in the coalescing alluvial fan terrain encountered widespread permafrost. The subsoils consist

of 3 to 5.5 m. of interlayered sand and silts, overlying a granular substrata. A frost heave test site could not be located in this area due to widespread permafrost and shallow granular strata in areas of unfrozen ground.

3.0 ASSESSMENT AND CONCLUSIONS

As discussed during previous meetings and in preliminary reports, we have carried out a detailed appraisal of the soil and permafrost conditions along the first 40 miles of the proposed Alaska Highway pipeline south of the Alaskan Border. A total of 87 test holes were drilled in this region during the past two years. The test drilling results indicate that both permafrost and granular soils are widespread along the 40 mile pipeline segment. Permafrost was encountered to the maximum depths drilled at many of the drill sites. However, in some areas the permafrost consists of an upper frozen "talik" overlying unfrozen and often saturated gravel strata. Local areas of unfrozen soil were encountered immediately adjacent to creeks, in areas with considerable ponded water, or occasionally in rolling hummocky terrain.

Based on an assessment of the data for the 40 mile segment of the pipeline route, we were unable to locate a site which met all the specified requirements as laid out in the scope of this report. The conditions at Site 7, although variable, meet many of specified requirements. A summary of the conditions at Site 7 are summarized in the following:

1. The thickest sequence of unfrozen, fine grained soils along the 40 mile segment of the route were encountered in some of the test holes drilled at Site 7.
2. Due to the complex glacial and post-glacial history of deposition, the subsoil conditions at the site are variable. The most unifrom conditions occur in a confined area in the vicinity of test holes 1, 5, and 6.
3. The unfrozen soils at Site 7 are confined to a narrow zone along the west side of Dry Creek. Portions of this zone are underlain by "taliks" of permafrost in the order of 2 to 4 m. thick.

4. The site has several relatively abrupt transition areas from ice-rich permafrost to unfrozen frost susceptible soils.
5. The site is bisected by a creek which has a bed load of fine grained silts. The unfrozen ground near the creek has high water table generally within 2 to 4 m. of ground surface.
6. The site is easily accessible due to its close proximity (within 100 m.) to the Alaska Highway.

Site 7 is representative of difficult soil and permafrost conditions which will occur along the 40 mile segment of the pipeline route. The variability of both the soil and permafrost conditions provide a representative situation where differential frost heave is a concern for a chilled gas pipeline. However, after detailed discussions with Foothills staff and their various consultants, it was decided that the soil stratigraphy is too variable to permit testing of various modes of frost heave mitigation. In particular, to permit comparisons of tests, the three test sections and one control section of pipe must be located in a uniform (ideally homogeneous) soil profile. Also, the depth of fine-grained material is insufficient at the Dry Creek crossing (due to the required depth of burial), to provide a serious frost heave problem.

In conclusion while Site 7 is representative of the worst frost heave conditions likely to be encountered in the chilled section of pipeline (milepost 0 to 40), it does not provide suffiently serious conditions to be used as a full scale test facility, nor does it provide the uniformity of soil and permafrost required for testing modes of frost heave mitigation. Unfrozen soils with a thickness similar to those at Site 7 were also encountered in the area between MP 5 and 9 near the potential frost heave sites 3 and 4. However, these areas of unfrozen soils were found to occur only in broad open areas with ponded water or immediately adjacent to creeks. In addition, unfrozen soils were also encountered locally in the hummocky moraines at the potential frost heave site 6. This hummocky terrain is widespread between MP 24 and 31. However, the unfrozen ground is generally comprised of gravel and sand

or granular till-like materials at shallow depths.

4.0 COMMENTS & RECOMMENDATIONS

Based on the detailed frost heave drilling program along the first 40 mile segment of the pipeline, it was decided that if a test facility is to be located in the Yukon, the area of search must be extended beyond MP 40. A review of the surficial geology and airphotos between MP 40 and Whitehorse indicates several areas of potential deep fine grained glaciolacustrine soils. These areas are located near present day lakes which were much larger during glaciation, and in areas occuppied by former glacial lakes. Several areas have been discussed with Dr. F. Yip and Mr. R. Lazerte during meetings in mid December, as outlined in the following:

Site 11 - located in the Dezadeash River valley south of MP 207. This valley was occuppied by Glacial Lake Champagne and is underlain with thick sequences of fine grained glacial lake basin sediments. The potential site is located about 0.5 mile south of the pipeline route and 0.5 mile north of the Dezadeash River, in the central part of the valley where the fine grained subsoils should be the thickest.

Sites 12 & 13

- located in the Dezadeash River valley about 2 to 3 miles east of the abandoned community of Champagne. The potential sites are located about 0.5 miles north and south of the Alaska Highway respectively, at distances of about 0.5 and 1.5 miles south of the pipeline right-of-way. This area was the centre of Glacial Lake Champagne and is underlain by thick sequences of fine grained glacial lake basin sediments. The potential sites are located in the central part of the valley where the fine grained subsoils should be thickest.

Sites 14, 15, & 16

- located north of Whitehorse at the south end of Lake Laberge. There are several potential sites in this area located on both sides of the Yukon River. This area was occuppied by Glacial Lake Laberge which was much larger than the present day lake, and is therefore underlain by fine grained glacial lake basin sediments. Preliminary drilling in this area indicates a high water table and up to 20 m. of clayey silts and silt & clay soils with generally 80 to 90% passing the #200 sieve. Sand dunes and a topstratum of sand occur locally.

We expect that at least one of the above six sites will conform to the following test heave site criteria:

a) a broad area of unfrozen, relatively homogenous fine grained soils in excess of 8 m. thick.

b) a groundwater table within 3.5 m. below ground surface.

An evaluation of the above sites is required to determine their suitability as potential frost heave test sites. The recommended schedule for selecting the location of a new site is provided in the following table.

DESCRIPTION OF WORK	TIME IN WEEKS							
	1	2	3	4	5	6	7	8
Site Reconnaissance & Land-Use Review	——							
Approval to Start Work	•							
Geophysical Examination		——						
Test Drilling				——	——	——	——	
Decision Made for New Site							•	
Approval Obtained for New Site								—?

SITE 1 (MP 0.5 - 1.0)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 0.5 and 1.0 along the proposed pipeline right-of-way which parallels the Haines Fairbanks pipeline. The Alaska Highway is located 2,000 meters east of the site. The reader should refer to the attached location plan on Plate A-0890-1-1 as well as the aerial and site photographs on Plate A-0890-1-2 & 3.

2.0 SUMMARY

The site is located in glaciolacustrine basin terrain (GLB-1) in an east-west trending valley approximately 1,000 m. wide. The hills bounding the north and south margins of the valley are terrain-typed as mountain valley colluvium overlying bedrock (MTV/B).

The north central portion of the valley bottom has flat to gentle slopes (1/2% - 2%), with considerable ponded water. The ground surface is vegetated with grass, peat tussocks, willows, and a light growth of spruce to 10 m.. The valley bottom is drained by a small creek and a number of poorly defined drainage courses which flow to the east at a gradient of less than 1%. The creek flows through a series of thermokarst lakes in the north, into Scottie Creek near the Alaska-Yukon border, and eventually into the Chisana River in Alaska.

Three test holes were drilled at this site. Two holes were located in the valley - one adjacent to the creek on the north side and the other in the central part of the valley. The third hole was located near the toe of the ridge bounding the southern side of the site. Based on the three test holes, as well as four holes drilled during the 1976 drilling program, the subsoils are frozen, interlayered fine lake sediments. These sediments consist of organic silt and non-plastic silt up to depths exceeding 30 m.. The upper 5 m. consists of

organic silt, interlayered with peat and wood. Below this depth the soil is a grey, laminated, non-plastic silt. In test hole 77-1-3 drilled on the flanks of the ridge along the south side of the site, the soils consist of interlayered gravelly and sandy silt overlying shale and siltstone bedrock at a depth of 9 m..

The entire site is underlain by permafrost beneath a shallow active layer. Permafrost was found in all test holes located in the valley, up to the maximum drilled depth of 30 m.. In the upper 5 m., the soils have a high ice content, with many thin random and horizontal ice lenses 1 to 5 mm. thick. In test hole 77-1-3, a 2.5 m. thick ice layer overlies bedrock from the 6.5 to 9.0 m. depth. In general, the subsoils below the upper 5 m. are low ice content, with mostly well bonded non-visible ice.

3.0 SITE DESCRIPTION

Test hole 77-1-1 is located at the northern end of the site, 15 m. east of the H-F pipeline right-of-way and 20 m. south of a small creek. The ground surface slopes gently at 1/2% to the southwest. The ground surface is soft, grass covered, poorly drained with ponded water between extensive peat tussocks. The site is sparsely vegetated with stunted spruce to 5 m..

Test hole 77-1-2 lies about 400 m. south of 77-1-1 and 30 m. east of the H-F pipeline. The terrain between these two holes is gently undulating with a series of very shallow east-west trending depressions. Slopes vary between 1/2 and 2% in a north south direction, with an overall gradient of 1% to the east. Drainage is to the east along a number of poorly defined drainage courses. The ground surface at 77-1-2 is soft with ponded water between extensive peat tussocks. The site is sparsely vegetated with grass and spindly spruce to 10 m..

Test hole 77-1-3 is located about 350 m. south of 77-1-2 and 100 m. east of the H-F pipeline on the lower northern flanks of a ridge. Along the H-F pipeline between test holes 77-1-2 and 77-1-3, the terrain is moderately well drained with gradients in a northerly direction increasing

to 10% at 77-1-3. The ground surface at test hole 77-1-3 is firm and moss covered, with a moderately dense growth of spruce to 15 m..

4.0 SOIL AND PERMAFROST CONDITIONS

4.1 Test Hole 77-1-1

Drilling test hole 77-1-1 incorporated dry augering to 0.5 m., coring of frozen sediments from 0.5 to 5.08 m. followed by rotary drilling with mud from 5.08 to a completion depth of 30.0 m.. The topsoil is composed mainly of peat having a high moisture content (542%).

Beneath the peat topstratum the upper soils to a depth of 4.77 m. consist of laminated organic silt and peat, with high moisture contents varying from about 110 to 340%. From a depth of 4.77 m. to the maximum depth drilled (30 m.), the soils consist of glaciolacustrine, grey silts which are non to slightly plastic. The silts are faintly laminated and have moisture contents decreasing from 50 to 35% below a depth of 9 m..

Permafrost occurs from a depth of 0.45 to 30.0 m.. From a depth of 0 to 4.77 m. the soils have a high excess ice content ranging from about 5 to 30% by volume. Below a depth of 4.77 m., the excess ice content if very low with sparse thin ice lenses from 1/4 to 1/2 mm. thick.

4.2 Test Hole 77-1-2

This test hole was drilled to a total depth of 10.1 m. by dry augering to 0.5 m., coring from 0.5 to 4.52 m., and rotary drilling with mud from 4.52 to 10.1 m.. Peat and organic silt form the topstratum to a depth of 0.38 m.. The moisture content in the topstratum material is 148%. Beneath the peat topstratum to a depth of 4.12 m., the soils consist of an organic silt with extensive black organic laminations and traces of sand and clay. The organic silt has a high moisture content, ranging from 100 to 300%, due to both a high organic and excess ice content. From a depth of 4.12 m. to the maximum drilled depth of 10.1 m., the soils consist of glaciolacustrine, grey silts

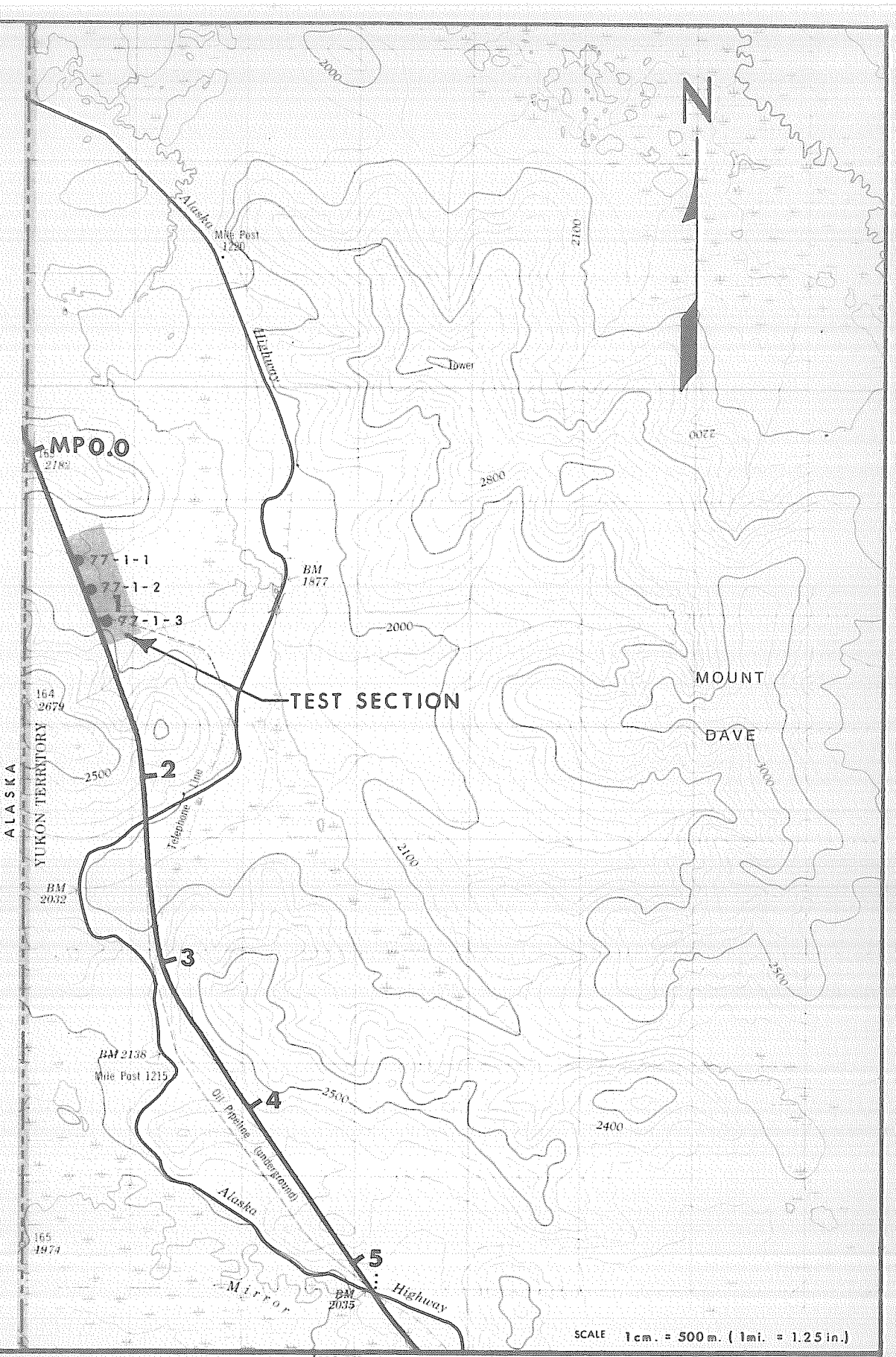
which are non to slightly plastic. The silts are faintly laminated and have moisture contents averaging 35 to 45%.

Permafrost occurs from a depth of 0.5 to 10.1 m.. The upper soils to a depth of 4.12 m. have high excess ice contents ranging up to 90% by volume between depths of 1.38 and 2.4 m.. Below a depth of 4.5 m. the excess ice content is generally less than 2% by volume. Ice occurs as randomly spaced thin lenses from 1/4 to 1/2 mm. thick.

4.3 Test Hole 77-1-3

Test hole 77-1-3 was drilled to a depth of 11.5 m. by dry augering to 1.2 m., coring from 1.2 to 3.83 m., then, rotary drilling with mud. Beneath a 0.2 m. thick moss cover, the soils to a depth of 6.5 m. consist of interlayered silts and gravelly sands. Thick soil and ice layers occur between depths of 3.0 to 3.83 m. and 6.5 to 9.0 m.. Shale and siltstone bedrock underlies the upper soil and ice strata below a depth of 9.0 m..

Permafrost occurs from a depth of 0.6 to 11.5 m.. The ice contents of the subsoils in this test hole are variable. Moisture contents vary from 45 to 95% in soil layers and from 100 to 700% in ice rich layers. Excess ice content in the interlayered gravelly and sandy silt strata varies from about 2 to 30% by volume. The ice content in the shale and siltstone bedrock below 9.0 m. was not ascertained during drilling, but is believed to be negligible at depth.



KLOHN LEONOFF CONSULTANTS LTD.
CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

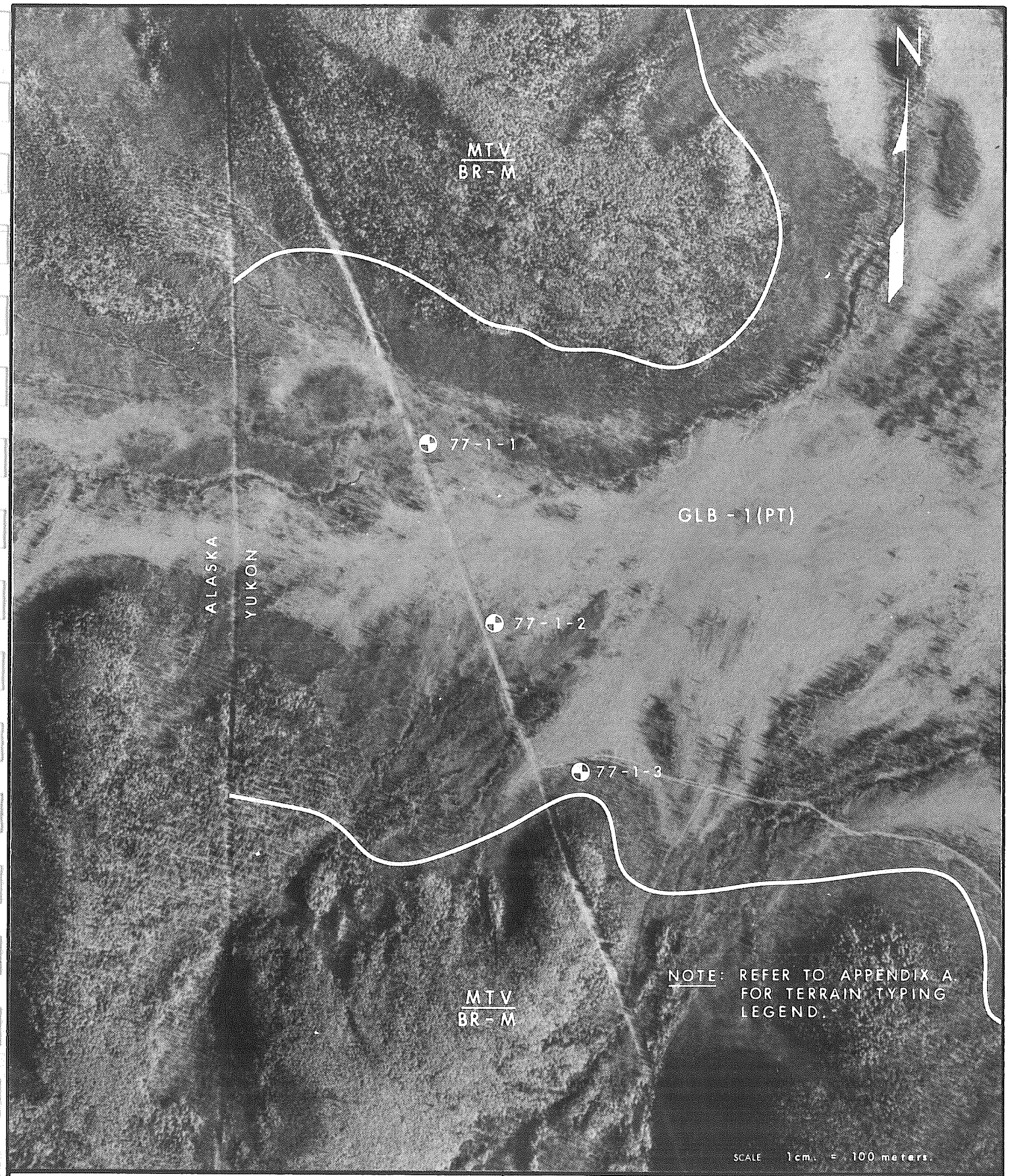
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 1

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-1-1	

APPROVED A. Ridgeworth.



KLOHN LEONOFF CONSULTANTS LTD.
CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

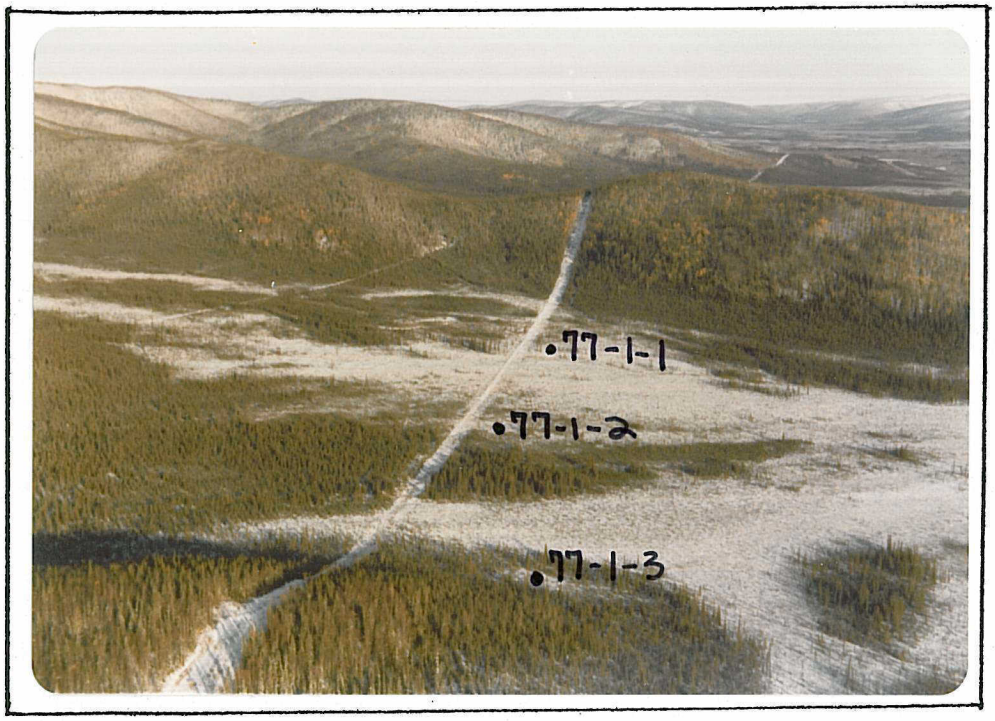
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No. 1

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-1-2	

APPROVED A. L. Edgeworth.



SITE 1

View looking northwesterly at Site 1 along the Haines-Fairbanks pipeline right-of-way. The site is located in an east-west trending valley which drains to the east. The Alaska-Yukon border is visible in the upper left of the photograph.

TEST HOLE LOG

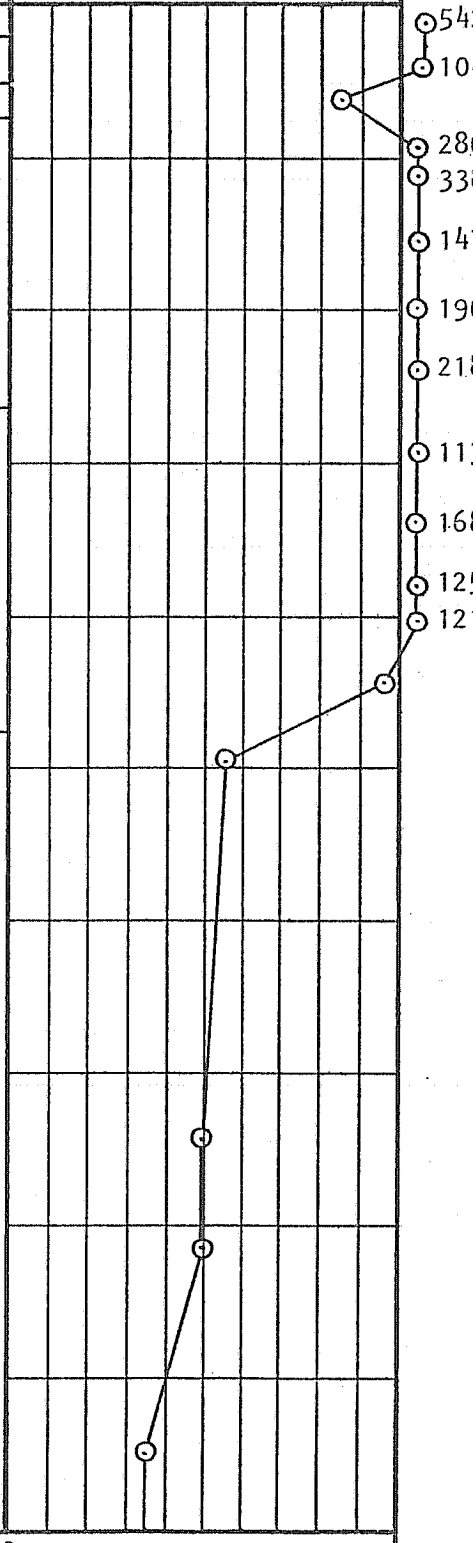
HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B					NF .45	0.2m PEAT
	B		1				0.5m ORGANIC SILT
	C		2		Vr, Vx		0.68m SILT - trace sand
1	C		3		Vr, Vs Vx		ORGANIC SILT - peat layers, wood pieces - trace sand - non to slight plasticity - brown to grey ice lenses to 7 mm. ice lenses ½-1mm spaces @ 1-3 mm.
	C		4				
	C		5		Vr		
2	C		6				
	C		7		Vr, Vs, Vx		2.58m
3	C		8				ORGANIC SILT - trace sand, wood pieces, trace clay - laminated with organics - brown to grey ice lenses 1-5mm spaced @ 5-10 mm. ice lenses ¼mm spaced @ 1-3mm ice lenses ½mm spaced @ ½ - 1 mm.
	C		9				
4	C		10		Vr, Vs		
	C		11				
	C		12				4.77 m
5	C		13		Nbn		SILT - trace sand, trace clay - sparse wood pieces - non to slight plasticity - grey
6							
7							
	SPT	79 157	14		Vr		
8							
	SPT	84 156	15		Vx, Vr Nbn		
9							
	SPT	94 145	16		Vr, Vx		ice lenses ½mm spaced @ 5-30mm.
10							(Continued)

LOCATION See Plate A-0890-1-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 0.5 to 1.0
HOLE No.	77-1-1
DATE	Sept.30/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.
11			
12	SPT	90 / 230	17
13			
14			
15	SPT	110 / 212	18
16			
17			
18	SPT	121 / 240	19
19			
20			

SYMBOLS

PERMAFROST

LOCATION

ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▨ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — — 0 — — — — — — X
10 30 50 70 90%

N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
		(As above)
		SILT - trace clay - occasional layer of fine sand - non to slight plasticity - grey
Nbn Vs		
Nbn Vs		← ice lenses to ¼mm spaced @ 35mm
Nbn		← extensive organic fibres
		(Continued)

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 0.5 to 1.0
HOLE No.	77-1-1 Continued
DATE	Oct. 1/77. PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
							(As above)
21							
22							
23							
24							SILT - trace to little fine sand, trace clay - organic specks - non to slight plasticity - grey
25	B		20		Nbn		
26							Notes: 1. Hole located 15 m east of H-F P/L and 20 m south of small drainage course. Terrain slopes ½-1% to south & east.
27							2. Peat tussocks on ground surface. Site is vegetated with sparse spruce to 5 m.
28							3. Hole cored from 0.5-5.08 m. Drilling mud used from 5.08 to 30m.
29	B		21				4. Thermistors installed at 0.5, 1.5, 3.0 and 4.5 m. Standpipe piezometer installed.
30							30.0m END OF HOLE @ 30.0 m

LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

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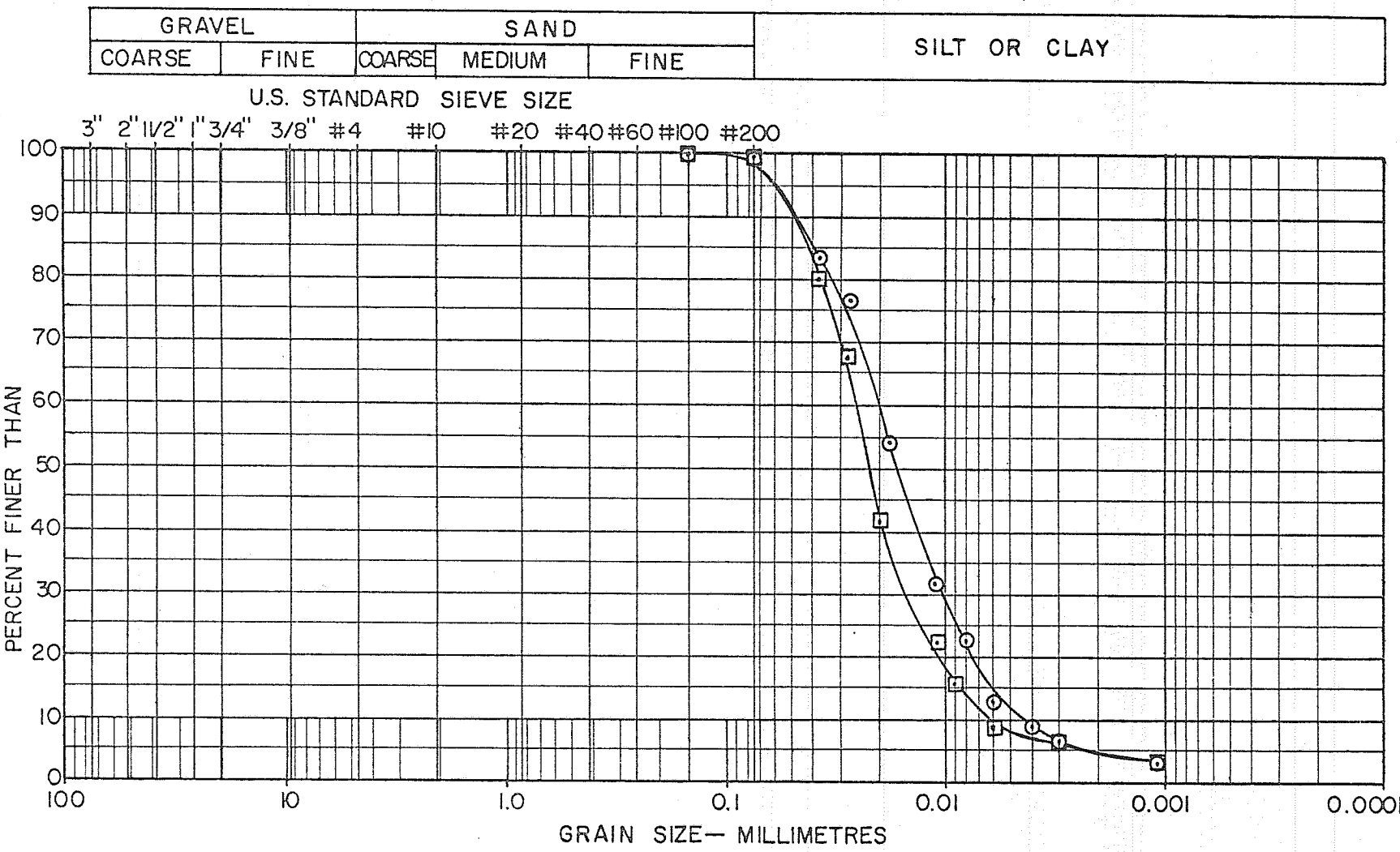
JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 0.5 to 1.0
HOLE No. 77-1-1 Continued
DATE Oct. 1/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa. # 8 (2.58-3.13m) Organic silt - trace sand, trace clay

⊡——⊡ Sa. #13 (4.77-5.08m) Silt - trace sand, trace clay

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 1
HOLE No.	77-1-1 DEPTH
DATE	Oct. 24/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 1-1

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.50-0.68	1,700	101.0
3	0.68-0.98	1,040	61.8
4	0.98-1.28	1,160	68.9
5	1.28-1.73	1,220	72.5
6	1.73-2.18	1,120	66.5
7	2.18-2.58	1,310	77.8
8	2.58-3.13	1,150	68.31
10	3.58-3.88	1,340	79.6
11	3.88-4.15	1,210	71.8
12	4.15-4.77	1,380	82.0
13	4.77-5.08	1,400	83.2

TEST HOLE LOG

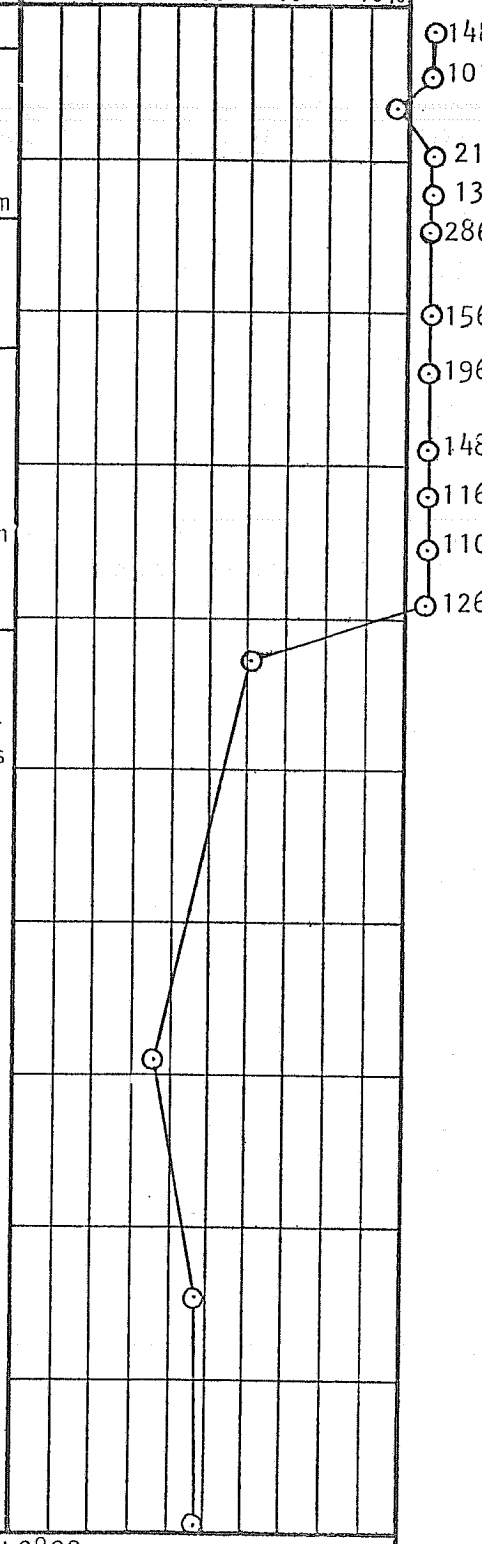
HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW / 15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
						NF	0.38m PEAT & ORGANIC SILT
	C		1			0.3	
	C		2		Vr,		ORGANIC SILT
1	C		3		Vs		- extensive black organic layers
	C		4				- tr. sand, tr. clay
	C		5				1.38 ice lenses 1-5 spaced @ 3-5 mm
	C				Ice		ICE AND SOIL
2					and		- soil mostly peat and organic silt
	C		6		Soil		2.40 m
	C		7		Vr,		ORGANIC SILT
3					Vx,		- laminated with organic layers
	C		8		Vs		- tr. sand, tr. clay
	C		9				- dark grey-brown
	C		10				ice lenses to 15mm spaced @ 15mm
4							ice lenses 1-2mm spaced 2-5mm
	C		11		Vr,		4.12 m
	C		12		Vx, Vs		SILT
5							- trace fine sand
							- trace clay
							- sparse organic layers
							- non plastic
							- grey
6							extensive pieces of wood
							ice lenses $\frac{1}{4}$-$\frac{1}{2}$mm spaced @ 2-5mm
7	SPT	103					
		285	13		Nbn		
8							
9	SPT	151					
		450	14		Nbn Vs		ice lenses $\frac{1}{4}$mm spaced @ 5mm
10	SPT	154					
		376	15		Nbn Vr		(Continued)

LOCATION See Plate A-0390-1-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — 0 — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 0.5 to 1.0
HOLE No.	77-1-2
DATE	Oct. 1/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▨ UNCONF.
PLASTIC LIMIT X — WATER CONTENT 0 — LIQUID LIMIT X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

11

END OF HOLE @ 10.1 m.

Notes:

1. Test hole located 30 m east of H-F P/L. Terrain slopes gently 1% to east.
2. Peat tussocks on ground surface. Sparse spruce growth to 10 m.
3. Hole augered to 0.5 m., cored from 0.5 to 4.52 m., & drilled with water from 4.52 to 10.0 m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 0.5 to 1.0
HOLE No.	77-1-2 continued
DATE	Oct. 1/77 PLATE

K.L.C. - METRIC

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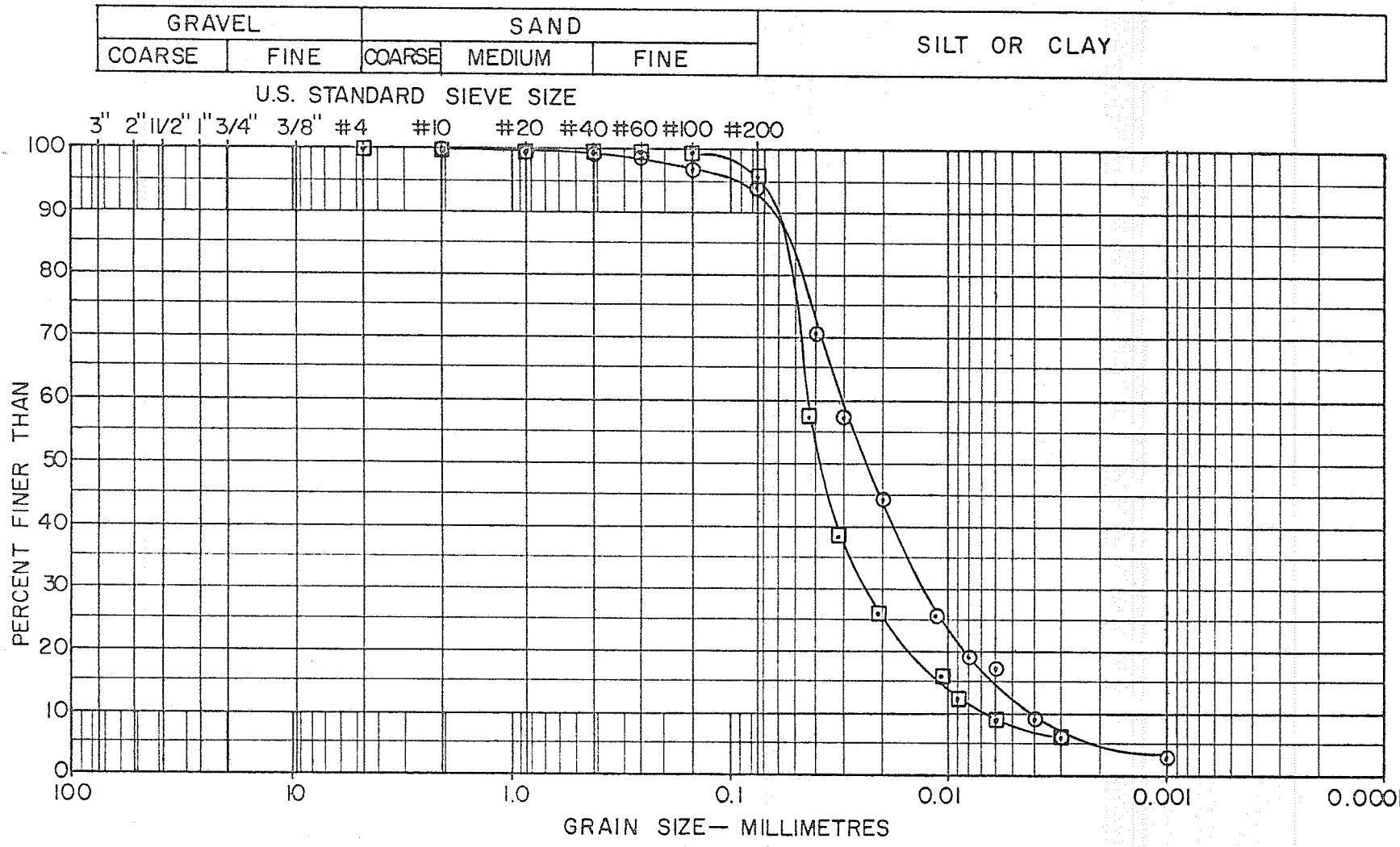
GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa. # 4 (1.1-1.38m) Organic silt - trace sand, trace clay

⊡——⊡ Sa. #13 (6.8-7.1m) Silt - trace sand, trace clay

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 1
HOLE No. 77-1-2 DEPTH
DATE Oct. 24/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 1-2

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.50-0.85	1,410	83.8
3	0.85-1.10	1,300	77.2
5	1.40-1.65	880	52.3*
7	2.25-2.70	1,170	69.5
8	2.80-3.10	1,200	71.3
9	3.10-3.40	1,230	73.1
10	3.40-3.77	1,030	61.2
12	4.12-4.50	1,120	66.5**

* low value due to thick ice lenses combined with peat & wood pieces.

** value is low due to extensive ice lenses & organic soil with wood. The frozen bulk density value is not representative of the grey silt in this stratum.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B					NF	0.2m MOSS - organic cover
	B		1			0.6	SILT - some sand - little gravel - shale & siltstone - trace clay - light brown
1	B		2		Vr, Vs		
			3				1.48m
	C						SILT - some sand & gravel - pieces of siltstone - dark brown organics
	C		4		Vr, Vs, Vx, Vc		
2	C		5				2.1m
	C		6				SILT - and sand & gravel - pieces of siltstone - organic layers
	C		7				fine gravel layer @ 2.85 m
3	C		8				3.0m
	C		9				ICE AND SOIL - soil is a mixture of gravel, sand & silt - rusty layers
	C		10		Ice and Soil		
	C		11				3.83m
4							4.13 GRAVEL-shale&siltstone 3cm. Ø
							SILT - some gravel - trace sand - grey
5					Vr, Vs		
							5.3m
	SPT	87 292	12				SILT - and sand (fine to very fine) - organic specks - grey ice lense ¼ mm @ ½ - 1 mm
6							6.5m
7		37 118	13		ICE		ICE - layered with silt and sand - hard, candled, cloudy
8							
		149 243	14				
9							9.0m
			15		Nbn, Vs		SHALE AND SILTSTONE - interbedded black shale & rusty siltstone layers (Bedrock)
10							Cont'd.

LOCATION See Plate A-0890-1-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

108
690

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 0.5 to 1.0
HOLE No.	77-1-3
DATE	Oct. 2/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
11							(As Above) SHALE AND SILTSTONE (Bedrock) 11.5 m
12							END OF HOLE AT 11.5 m

LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

Notes:

1. Test hole located 100 m east of H-F P/L on lower north flanks of a ridge.
2. Terrain slopes 10% north-easterly. Ground surface is firm and moss covered with a moderate spruce growth to 15 m.
3. Hole augered to 1.2 m, cored from 1.2 to 3.83 m, and drilled with water from 3.83 to 11.5 m.

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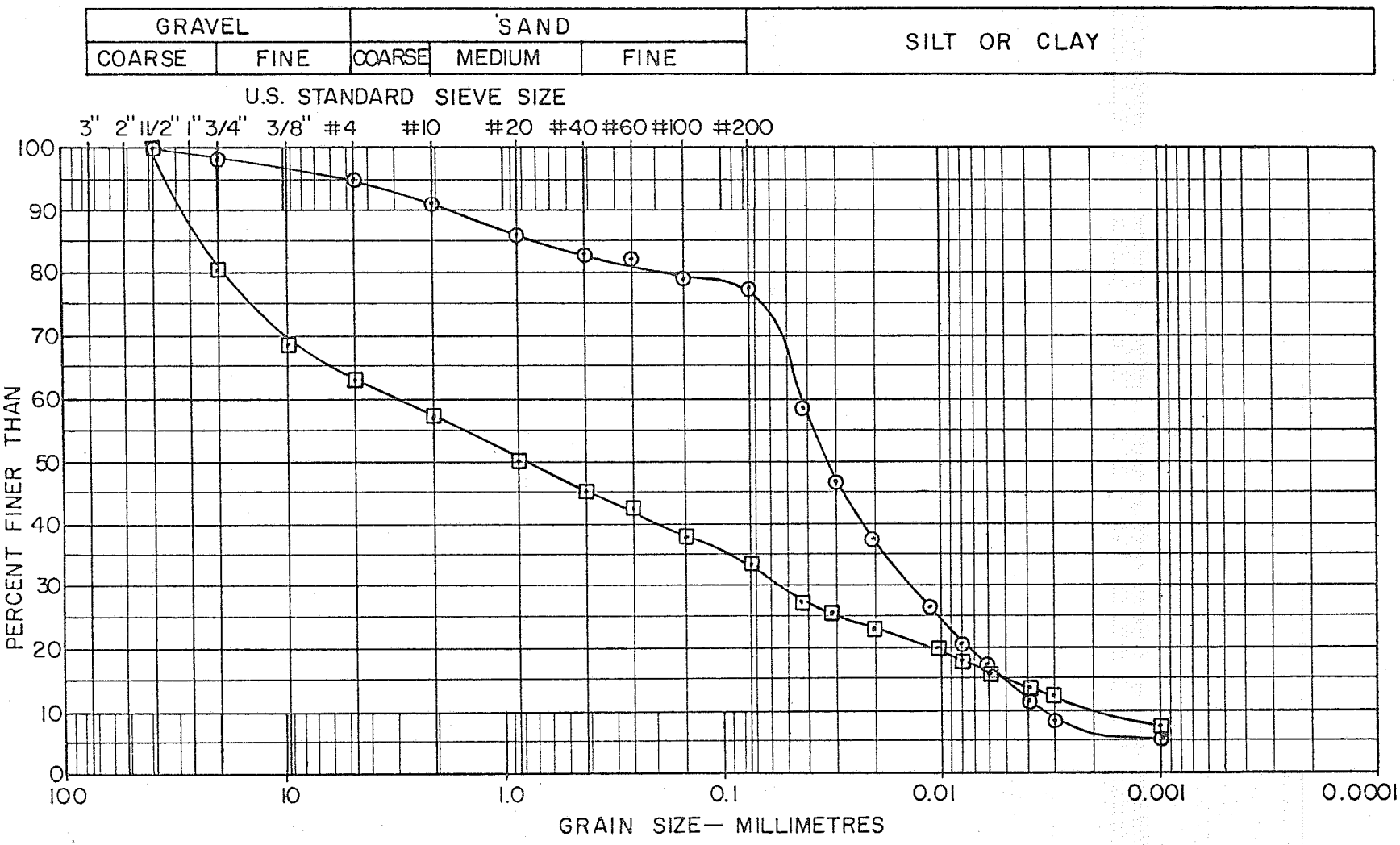
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 0.5 to 1.0
HOLE No.	77-1-3 continued
DATE	Oct. 2/77 PLATE

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 1
HOLE No. 77-1-3 DEPTH
DATE Oct. 24/77

GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sa. # 4 (1.55-1.85m) Silt - some sand, trace gravel, trace clay

⊡—⊡ Sa. # 9 (3.0-3.3m) Gravel, Sand, Silt

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 1-3

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.20-1.55	1,370	81.4
4	1.55-1.85	1,480	87.9
5	1.85-2.10	1,490	88.5
6	2.10-2.42	1,590	94.4
7	2.42-2.71	1,560	92.7
8	2.71-3.00	2,350	139.6
9	3.00-3.30	1,390	82.6

SITE 2 (MP 2.5 - 3.0)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 2.5 and 3.0 along the proposed pipeline right-of-way which parallels the Haines-Fairbanks pipeline. The Alaska Highway is in close proximity to the pipeline on the north and south sides of the valley, and 600 meters to the west of the pipeline in the valley bottom. The reader should refer to the attached location plan on Plate A-0890-2-1 as well as the aerial and site photographs on Plates A-0890-2-2 & 3.

2.0 SUMMARY

The site is located in glaciolacustrine basin terrain (GLB-1) in an east-west trending valley approximately 300 m. wide. The upper valley slopes are classified as mountain valley colluvium overlying bedrock (MTV/BR-M).

The valley bottom is drained by a small creek which has a gradient of 1% to the east. The creek drains into a larger creek located one mile east of the site in a north-south trending valley. This creek flows through a series of thermokarst lakes into Scottie Creek near the Alaska-Yukon border, and eventually into the Chisana River in Alaska.

Although the valley bottom has considerable ponded water in flat grassed areas, the flanks of the valley are fairly well drained. The lower valley flanks vary between slopes of 1 and 8%, increasing to more than 25% in the upper portions.

Three test holes were drilled at this site. Two were located in the valley and the third on the slopes of the ridge bounding the southern side of the site. Based on two drill holes in the valley bottom, as well as two previous holes drilled during the 1976 program,

the soil conditions are relatively consistent. The subsoils are frozen, interlayered fine lake sediments consisting of non-plastic organic silt and non to slightly plastic silt up to depths exceeding 25 m.. The upper 8 m. consists of interlayered organic silt and peat with extensive wood chunks and other organic inclusions. Below this depth the soil is grey, non-plastic silt with thinly interbedded gravel and sand seams. Considerable organic material was encountered from the 18.45 to 20.0 m. depth in test hole 77-2-2. Test hole 77-2-3 drilled on the side slopes of the ridge on the south side of the site encountered 1.7 m. of silt and clay overlying interbedded shale and siltstone bedrock.

The entire site is underlain by permafrost beneath a shallow active layer. Permafrost occurs in both test holes drilled in the valley up to depths exceeding 25 m.. The upper 8 m. are high ice content, with ice layers up to 1.5 m. thick. Ice layers in excess of 5 m. thick were encountered within the upper 8 m. of some test holes drilled during the 1976 test drilling program. In test hole 77-2-3, permafrost occurs from 0.75 m. to the maximum drilled depth of 3.0 m.. The colluvium and bedrock in this test hole are low ice content with sparse random ice lenses to 5 mm. thick.

3.0 SITE DESCTIPTION

Test hole 77-2-1 is located at the northerly end of the site in a small drainage course at the bottom of an east-west trending valley. The H-F pipeline lies about 50 m. to the west. The hole was drilled adjacent to the creek bed about 0.1 m. above water level. At the time of drilling the creek has an estimated flow of 0.1 to 0.2 cms. The creek drains to the east and essentially follows an old fire break along which the organic layer has been disturbed and subsidence has occurred as a result of permafrost degradation. Considerable thaw slumps are evident along the creek and probing in the creek bed encountered permafrost at 0.8 m.. Massive ground ice is exposed about 500 m. downstream where the creek has eroded a gulley some 3 to 4 m. deep. Vegetation along the creek consists of dense willows to about 2 m. high with sparse spruce to 10 m. high in the surrounding terrain. A denser growth of spruce exists in the valley bottom

northwest of the test hole.

Test hole 77-2-2 lies 300 m. south of 77-2-1 and is situated 40 m. west of the H-F pipeline. The terrain between these test holes slopes northerly and ascends from 2 to 5% towards 77-2-2. The terrain is relatively open with grass and peat tussocks on the ground surface. At test hole 77-2-2 the ground is firm and fairly well drained. Vegetation consists of a light spruce growth to 5 m. high.

Test hole 77-2-3 is located about 500 m. south of 77-2-2 along the H-F pipeline, on the north flank of the ridge bounding the east-west trending valley to the north. The terrain between these test holes ascends to a maximum slope of about 18% before decreasing near the ridge crest. Test hole 77-2-3 was drilled about 10 m. west of the H-F pipeline and 40 m. east of the Alaska Highway. The terrain at the hole slopes about 5% to the north and drops off to about 12% in the west towards the highway. The ground surface at the site is firm and well drained. Vegetation consists of a healthy forest cover of spruce, poplar and birch to 20 m. high.

4.0 SOIL & PERMAFROST CONDITIONS

4.1 Test hole 77-2-1

Test hole 77-2-1 was drilled to a depth of 26.3 m.. The hole was augered to 1.0 m., cored from 1.0 to 9.65 m., and rotary drilled with mud from 9.63 to 26.3 m.. The upper soils to a depth of 6.77 m. consist of organic silt with fine sand and clay laminations. Due to the high ice content and extensive organic material, the soils have a moisture content varying from 50 to 550%, and averaging more than 100%. From 6.77 to 23 m., the subsoils consist of non to slightly plastic, grey silt with a little sand and trace of clay in laminations. The moisture content of the soil varies from 45 to 145% between 6.77 and 10.5 m., and averages 30 to 35% from 10.5 to 23.0 m.. A coarse gravel and sand layer underlies the upper glaciolacustrine silt strata from a depth of 23 to 26.2 m.. A hard siltstone material, believed to be bedrock, was encountered at 26.2 m.. However, the hard consolidated nature of the

siltstone prevented penetration to confirm bedrock.

Permafrost occurs below a shallow unfrozen active layer (0.7 m. thick) to the maximum depth drilled (26.3 m.). The upper subsoils to a depth of 6.77 have a high excess ice content. Between a depth of 1.0 and 2.44 m. the excess ice content is greater than 75% by volume. The excess ice content decreases with depth to less than 25% by volume between 6.77 and 10.5 m.. Below a depth of 10.5 m. the excess ice content is low, and ice occurs only as random 1/4 to 1/2 mm. lenses.

4.2 Test Hole 77-2-2

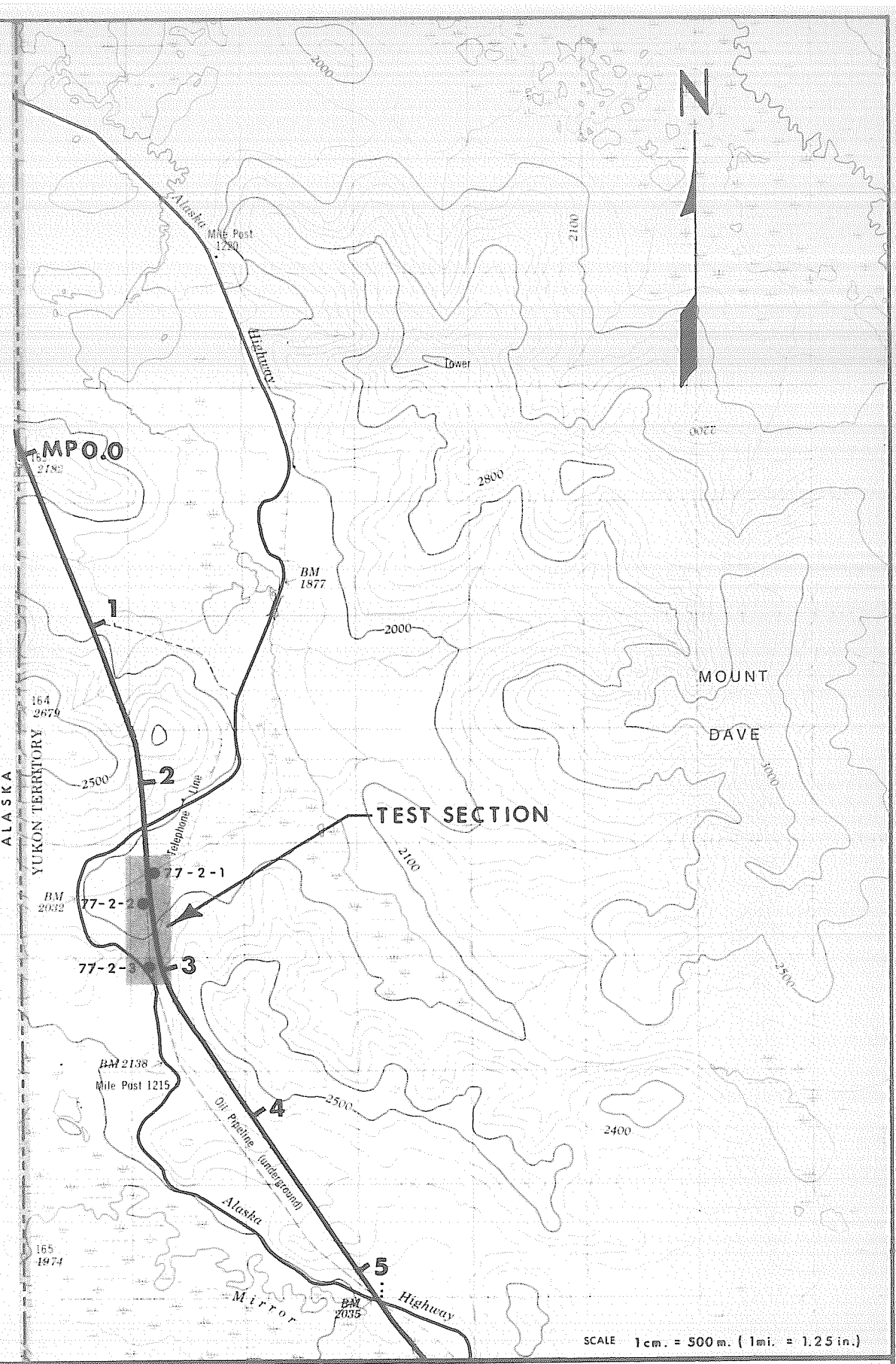
Test hole 77-2-2 was drilled to a depth of 26.3 m.. The method of drilling involved augering to 0.55 m., coring from 0.55 to 10.65 m., and rotary drilling with mud from 10.65 to 20.0 m.. The soils essentially consist of interlayered glaciolacustrine silts with minor sand and gravel seams at depth. The upper 8 m. consists of highly organic silt with extensive pieces of wood and organic laminations. The moisture content of the frozen organic silt is high and generally varies from about 80 to 200%. From 8 to 17.35 m. the organic silt is underlain by non to slightly plastic silt interlayered with gravel and sand seams. The interbedded gravel and sand seams are up to 0.5 m. thick, and occur only below a depth of 12 m.. The moisture content of the silt varies from 32 to 109%, averaging about 50%. A layer of organic silt and ice underlies the silt soils from 17.45 m. to maximum depth drilled (20.0 m.).

Permafrost occurs below a shallow 0.5 m. thick unfrozen active layer to the maximum depth drilled. The upper 8 m. of organic silt has a high excess ice content ranging from an estimated 10 to 30% by volume. The ice generally occurs as closely spaced horizontal lenses from 1/4 to 5 mm. thick. The excess ice content of the soils from 8 to 17.45 m. is low and generally much less than 10% by volume. Although the ice content of the subsoils in this area generally decreases with depth, a high ice content layer occurs at the bottom of this test hole from 17.45 to 20.0 m.. The organic silt at this depth has an estimated excess ice content of 25 to 50% by volume.

4.3 Test Hole 77-2-3

Test hole 77-2-3 was drilled to a depth of 3.0 m.. The hole was augered to 1.2 m. and cored from 1.2 to 3.0 m.. The subsoil profile consists of a thin 0.1 m. veneer of topsoil underlain by silt, with minor pockets and layers of gravel, sand and shale to a depth of 1.7 m.. The moisture content of this material averages about 20%. The upper silt stratum is underalin by shale and siltstone bedrock from 1.7 m. to the maximum depth drilled. The bedrock is friable and dark grey with orange weathering along joint surfaces.

Permafrost occurs below a shallow unfrozen active layer (0.75 m. thick at the time of drilling), to the maximum depth drilled (3.0 m.). The estimated excess ice content of the frozen silt soils above bedrock is less than 10% by volume, and of the bedrock is less than 5% by volume. It is expected that the excess ice content of the bedrock below the upper weathered zone is negligible.



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VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 2

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-2-1	

APPROVED A. Volgenweth

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VANCOUVER - CALGARY - WINNIPEG, CANADA

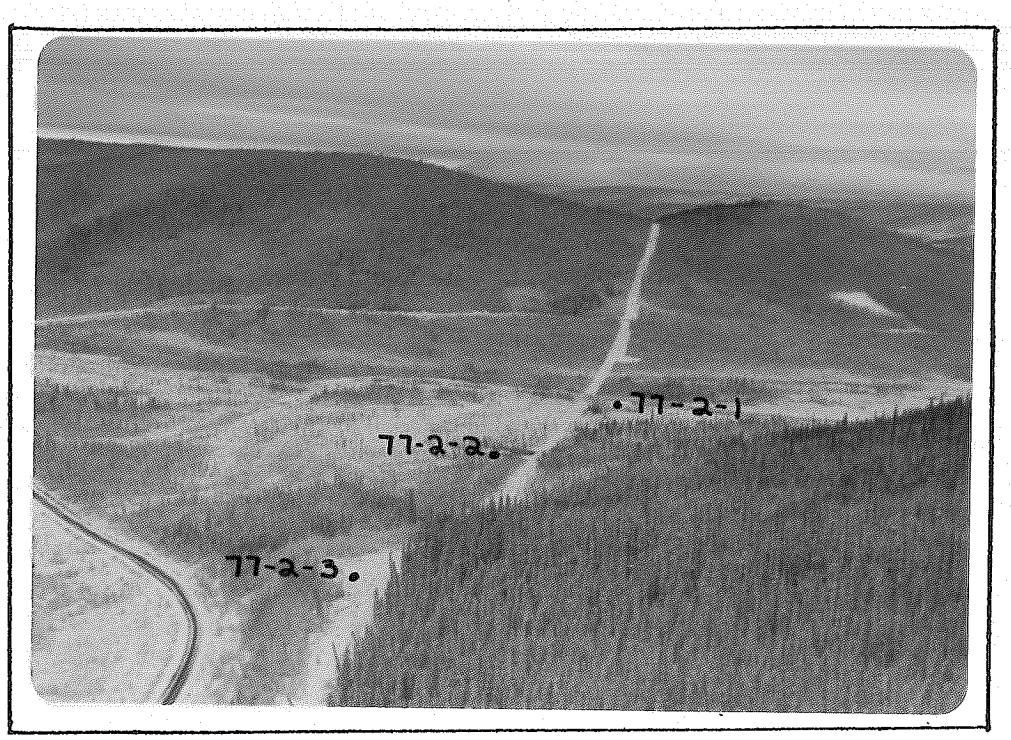
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No. 2

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT./77.	AL0890	A-0890-2-2	

APPROVED A. L. Edgworth.



SITE 2

View looking northerly at Site 2 along the Haines-Fairbanks pipeline right-of-way. The site is located in an east-west trending valley which drains to the east. The Alaska Highway is visible on the left and upper part of the photograph.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

LOCATION See Plate A-0890-2-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ▦ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL	
1	B		1			N.F	ORGANIC SILT - slightly plastic - rootlets - dark brown	
							1.0m.	
	C		2				ICE & SOIL INCLUSIONS - soil is organic - silt, some fine sand, trace clay	545
	C		3					126
2	C		4		ICE			126
	C		5					435
	C		6				2.44m.	550
	C		7		Vr Vs		SILT - some sand, trace clay - peat layers - organic specks - non to slight plasticity	136
3	C				Vx,Nbr			
	C		8		ICE		(ice lenses 3 cm. spaced @ 1-2 mm.)	
	C		9		Vr			
4	C		10		Vs		3.87m.	
	C		11		Vx,Nbr		(ice lenses 1/4 - 1 mm. spaced @ 1-2 mm.)	196
	C		12		Vx Vr		(ice lenses 1/4-1mm. spaced @ 1-5mm.)	
5	C		13		Vs			128
	C		14				ORGANIC SILT - wood specks to 2 cm. - root fibres - little sand - brown & grey	
	C		15					
6	C		16		Vr			104
	C		17				(ice lenses 9mm. thick)	126
	C		18		Vs		6.77m. (ice lenses ¼mm. spaces @ ¼mm.)	
7							SILT - little sand - brown wood specks - laminated - non to slight plasticity - brown & grey	
	C		19					
	C		20					
8	C		21		Vx			
	C		22		Vr		(ice lenses 1/4-1mm. spaced @ 1cm.)	
							(ice lenses 15mm. thick)	
9	C		23		Vs			
	C		24		Vr,Vs		(ice lenses 6-15mm. spaced @ 20 mm.)	145
10					Nbn		- extensive wood specks	

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 2.5
HOLE No.	77-2-1
DATE	Sept. 28/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
PERMAFROST
LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

SAMPLE DATA				SYMBOL	N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
DEPTH	TYPE	BLOW / 15 cm.	No.				
					Vr, Vs Nbn		10.5m (AS ABOVE)
11							
12	SPT	96 147 150	25		Nbn		SILT - little sand in laminations - trace organic specks - non to slight plasticity - grey with brown
13							
14							
15	SPT	117 157 181	26				- sand laminations (1/4-1/2mm)
16							
17							
18	SPT	100 205 270	27		Nbn		
19							
20							

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 2.5
HOLE No.	77-2-1
DATE	Sept. 28/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

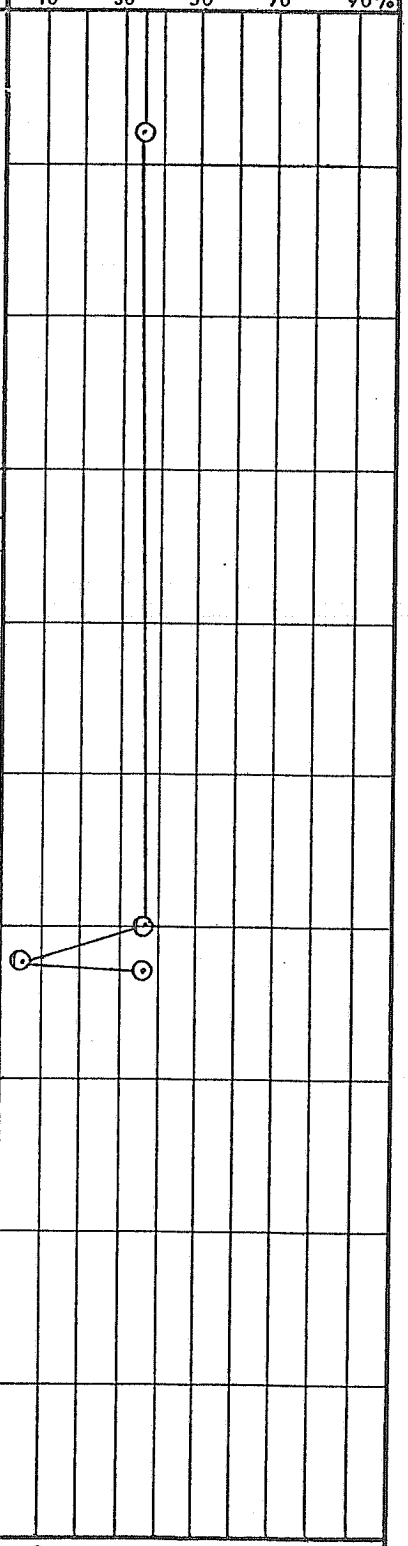
HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
21	SPT	135 180	28		Nbn		AS ABOVE
22							
23							23.0m.
							23.3m. GRAVEL - coarse
							23.5m. SAND - coarse
24					Nbn		GRAVEL - coarse
25							25.5m.
26	SPT						25.85m. SAND - coarse
	SPT		29		Nbn		26.2m. SAND - medium to coarse and gravel
	SPT	174			Vx		26.3m. SILTSTONE (bedrock?)
27							END OF HOLE @ 26.3m.
28							NOTES:
29							1. Hole located in small drainage course in the bottom of a broad east-west trending valley. Terrain slopes 1/2% easterly.
30							2. Low willows along creek and sparse spruce to 10m. in surrounding terrain.
							3. Test hole cored from 1m. to 9.63m.. Drilling mud used from 9.63m. to 26.3m.
							4. Water level at ground surface during drilling.

LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 2.5
HOLE No. 77-2-1
DATE Sept. 29/77 PLATE

K.L.C. - METRIC

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GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S. STANDARD SIEVE SIZE

3" 2" 1 1/2" 1" 3/4" 3/8" #4 #10 #20 #40 #60 #100 #200

PERCENT FINER THAN

100 90 80 70 60 50 40 30 20 10 0

100 10 1.0 0.1 0.01 0.001 0.0001

GRAIN SIZE— MILLIMETRES

GRAIN SIZE CURVE

REMARKS: ⊙——⊙ Sa. #5 (2.0 - 2.32) Ice & soil consisting of silt, some fine sand

△——△ Sa. #16 (5.67-5.97) Silt - little fine sand

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION M. P. 2.5

HOLE No. 77-2-1

DATE Oct. 17/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 2-1

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
18	6.27-6.77	1,183	70.3
19	6.77-7.27	1,252	74.4
20	7.27-7.72	1,495	88.8
21	7.72-8.17	1,566	93.0
22	8.17-8.57	1,403	83.3
23	8.72-9.12	1,495	88.8
24	9.25-9.63	1,437	85.4

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
	C		1
1	C		2
	C		3
	C		4
	C		5
2	C		6
	C		7
	C		8
3	C		9
	C		10
	C		11
4	C		12
	C		13
	C		14
5	C		15
	C		16
6	C		17
	C		18
	C		19
	C		20
7	C		21
8	C		22
9	C		23
	C		24
10	C		25

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF
Vs	
Vr	
Nbn	
Vs	
Vr	
Vx	
Vs	
Vr	
Vx, Nbn	
Vs, Vr	
Nbn	
Vs	
Vr	
Vs	
Vr	

LOCATION See Plate: A-0890-2-2
ELEVATION

DESCRIPTION OF MATERIAL

0.15m. PEAT & ORGANIC SILT

SILT - Organic Pockets
- Little sand in lenses

0.7m.

SILT
- little sand
- light brown

1.57m.

ORGANIC SILT
- trace sand in lenses
- wood specks, trace clay
- peat layers
- roots
- laminated, dark brown

extensive 1/4-1/2 mm. ice lenses spaced @ 1-5 mm.

rusty sand lenses

(Ice lenses 1/2-2mm. spaced @1-2mm.)

5.53m.

SILT
- trace sand, trace clay
- organic laminations
- slight plasticity

6.3 m.

SILT
- trace fine sand
- organic laminations
- root fibres
- non to slight plasticity
- brown & grey

(ice lenses 2-3mm. spaced @ 7mm.)

(ice lenses 2-5mm. spaced @ 5mm.)

ice lenses to 2mm.

(ice lenses 1/4 mm. spaced @ 1-5 mm.)

9.6 m.

SILT - trace clay

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ▦ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

133 108 106 132 197 151 161 157 136 134 109

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 2.5
HOLE No. 77-2-2
DATE Sept. 21/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW / 15 cm.	No.	SYMBOL	N.R.C. CLASS	N.F. or F.
			26		Vr, Vs	
		76	27		Nbn	
11	SPT	137				
		137	28			
					Vr	
12						
13						
14	SPT	86				
		220	29		Nbn	
		x				
15						
					Vx	
16						
17						
		98				
		150	30		Vs	
		x				
18	SPT					
					Vr	
19						
		91				
		129	31			
20	SPT	x				

PERMAFROST
LOCATION
ELEVATION

DESCRIPTION OF MATERIAL

SILT
- little fine sand, tr. clay
- trace organic specks
- slight plasticity
- grey with brown

10.65m.

SILT
- little sand
- root fibres
- grey & brown

12.08m.

GRAVEL
- med. to coarse
- based on drill action

12.6m.

SILT
- little sand
- trace of gravel inlayers
- root fibres
- rusty silt pockets

14.0m.

14.15m. GRAVEL
- based on drill action

SILT
- little sand
- interlayered with thin gravel layers

17.35m.

17.45m. SAND
- fine, white, uniform

ORGANIC SILT & ICE
- extensive organic
- fibre & peat
- easy drilling with extensive ice chips in mud return

(ice lenses 2-10mm. spaced @ 5-15m)

20.0m. END OF HOLE

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

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JOB No. AL0890
PROJECT Frost Heave Test Site
LOCATION M.P. 2.5
HOLE No. 77-2-2 cont'd.
DATE Sept. 21/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm. 0.2 0.6 1.0 1.4 1.8 FIELD VANE LAB VANE UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
10 30 50 70 90%

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located 40 m. west of old Haines - Fairbanks line on terrain sloping 5% to north.
2. Ground is firm, with a light growth of spruce to 5m.
3. Hole cored from 0.55 to 10.65m. Drilling mud used from 10.65m. to 20.0 m..
4. Thermistors installed at 0.5, 1.5, 3.0, and 4.5 m. depths. Standpipe piezometer installed

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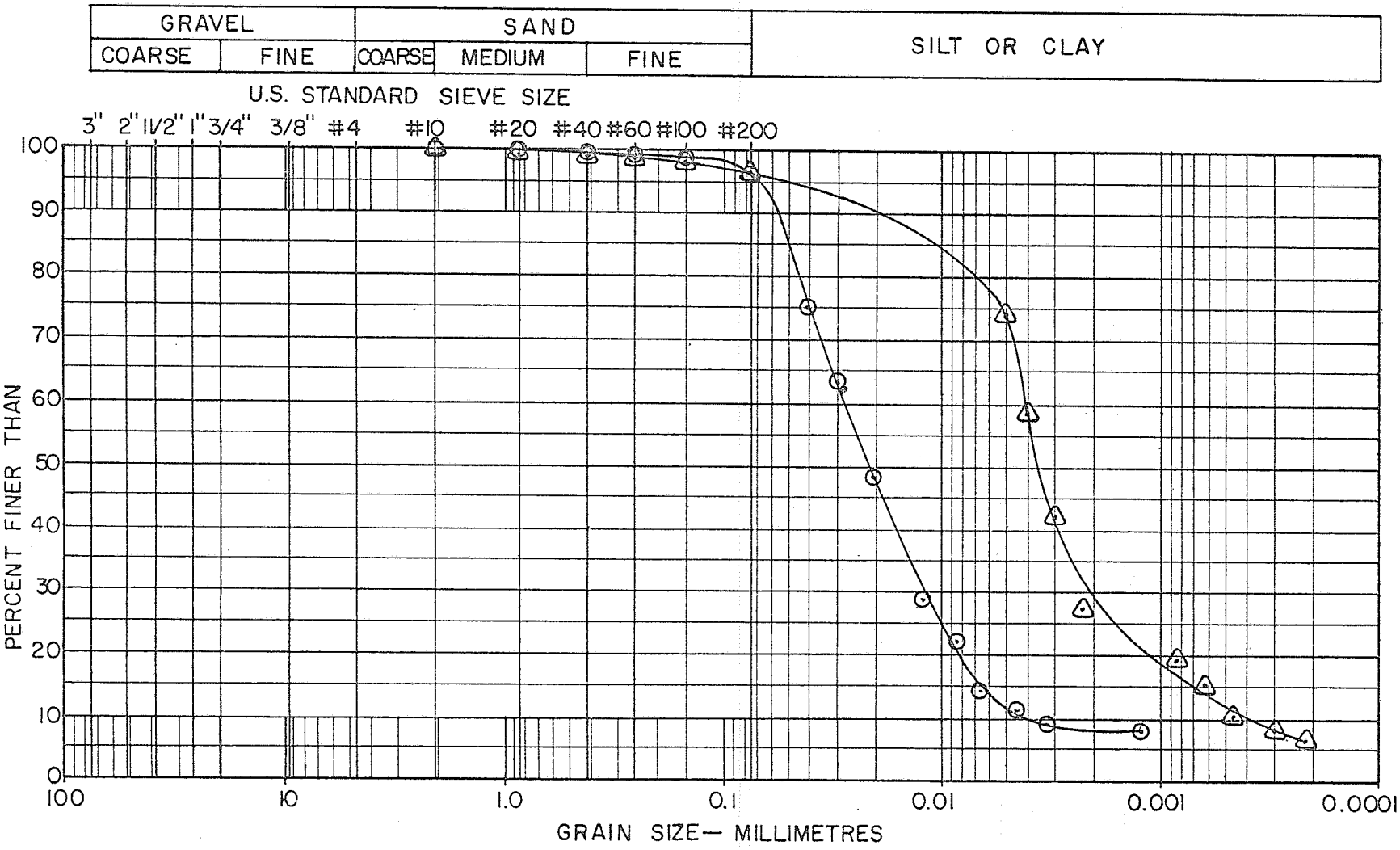
JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 2.5
HOLE No. 77-2-2 cont'd.
DATE Sept. 29/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

Sa. #5 (1.57 - 1.8 m) Silt - trace fine sand

Sa. #18 (5.87 - 6.0 m.) Silt - trace fine sand, trace clay, slight plasticity

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION M.P. 2.5

HOLE No. 77-2-2

DATE Oct. 21/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 2-2

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
1	0.55-0.70	1,240	73.6
2	0.70-1.00	1,250	74.3
3	1.00-1.27	1,440	85.5
4	1.27-1.57	1,420	84.3
5	1.57-1.80	1,400	83.2
6	1.80-2.12	1,290	76.6
7	2.12-2.47	1,600	95.0
11	3.42-3.72	1,240	73.6
12	3.72-4.02	1,230	73.0
14	4.27-4.59	1,220	72.5
15	4.59-4.89	1,290	76.6
16	4.89-5.21	1,340	79.6
17	5.21-5.86	1,280	76.0
18	5.86-6.07	1,530	90.9
19	6.07-6.29	1,310	77.8
20	6.29-6.64	1,410	83.8
21	6.79-7.14	1,440	85.5
22	7.59-7.97	1,510	89.7
23	8.47-8.87	1,430	84.9
24	9.12-9.60	1,590	94.4
25	9.60-9.90	1,680	99.8
26	9.90-10.15	1,620	96.2
27	10.15-10.6	1,620	96.2

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW / 15 cm.	No.
	B		1
1	B		2
	C		3
2	C		4
3	C		5
4			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF
Nf Vx Vr	
Vr	
Vs	

LOCATION See Plate: A-0890-2-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

0.1m. ORGANIC SILT
- roots, dark brown
- trace volcanic ash

0.75m. SILT AND CLAY
- organic pockets, roots
- trace shale & siltstone gravel, little sand
- slight to low plastic
- dark brown

1.70m. SILT
- little sand, trace clay
- trace to little gravel
- pieces of shale
- slightly plastic
- dark grey

3.0m. SILTSTONE & SHALE
- fragile, orange weathering
- black
- (ice lenses 1-5mm. spaced @ 1-3mm.)

(BEDROCK)

END OF HOLE

NOTES:
1. Test hole located adjacent to the old Haines-Fairbanks pipeline on the north slope of a ridge. Terrain is well drained, sloping 10% northwesterly.
2. Dense spruce and poplar 15 to 20 m.
3. Hole dry augered to 1.2 m. & cored from 1.2 to 3.0 m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 2.5
HOLE No.	77-2-3
DATE	Sept. 29/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 2-3

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.2-1.7	1,570	93.3
4	1.7-1.3	1,880	111.7

SITE 3 (MP 5.5 - 6.5)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 5.5 and 6.5 along the proposed pipeline right-of-way. The H-F pipeline right-of-way parallels the site and the Alaska Highway passes within 200 meters of the southern part of the site. Refer to the location plan attached on Plate A-0890-3-1, as well as the photographs of the site on Plates A-0890-3-2 & 3.

2.0 SUMMARY

The site is located adjacent to a small creek which flows northwesterly into Mirror Creek. The Mirror Creek drainage flows northerly and westerly, draining into the Chisana River in Alaska. The terrain consists of a glaciolacustrine plain underlain by outwash, and is generally flat to very gently rolling and featureless. In the flat, lower lying, open areas the ground is soft and swampy, with water to 1.0 m. deep ponded on the ground surface. In slightly higher terrain and in gently sloping areas, the ground is firm, moss covered and vegetated with a light to moderate spruce growth.

Based on the five test holes drilled across the site, the soil profile is relatively consistent. The subsoils consist of a thin organic veneer, overlying glaciolacustrine non to low plastic silts and sands, all of which overlie a very dense stratum of gravel and sand. The upper sequence of fine grained soils varies from 3.4 to 3.55 m. thick in test holes 77-3-2 to 5 inclusive. In test hole 77-3-1 the fine grained soils extend to 5.0 m.. In general, the fine grained soils grade from slight to low plastic silts, to fine silts and sands, to coarser sands at depth. The very dense gravel and sand stratum which underlies the upper fine grained strata is well graded and relatively clean, with a trace of silt. All five test holes were drilled to the 8.5 m. depth.

The permafrost conditions at the site are variable. Test holes 77-3-2 and 77-3-3 which were drilled in open grassed areas with considerable ponded water, are entirely unfrozen. Test holes 77-3-1 and 77-3-4 were both drilled within 7 m. of the tributary creek to Mirror Creek. These holes have a shallow unfrozen active layer above permafrost which extends to the 5.0 and 3.2 m. depths respectively. Beneath the upper permafrost zone the gravel and sand is unfrozen to a depth of 8.5 m.. Test hole 77-3-5 encountered permafrost to a depth of 8.5 m. beneath a shallow 0.5 m. active layer. Ice in the permafrost affected soils is variable but occurs essentially as lenses and random layers in the fine grained soils and as inclusions and coatings in the gravel and sand stratum. Excess ice contents up to 50% by volume occur from 0.5 to 3 m. in test holes 77-3-4 & 77-3-5.

3.0 SITE DESCTIPTION

Test hole 77-3-1 is located at the north end of the site, 40 m. southwest of the H-F pipeline and 7 m. east of the tributary to Mirror Creek. The ground elevation at the test hole is about 0.7 m. above creek level and the terrain slopes gently 2-3% to the west and north towards the creek. The ground surface is firm, moss covered, with a tree cover consisting mainly of spindly spruce to 7 m. high. The creek adjacent to the test hole is about 3 m. wide, 0.7 - 1.3 m. deep, with an estimated flow of 1 c.m.s.. The creek bed consists of soft silt, unfrozen to a depth of at least 0.8 m..

Along the H-F pipeline between test holes 77-3-1 and 77-3-5, the terrain is flat or gently sloping 1-2% to the north, with water frequently ponded to a depth of about 0.3 m.. Test hole 77-3-5 is located 450 m. southeast of 77-3-1 and 70 m. southwest of the H-F pipeline right-of-way. It is situated in an open, poorly defined drainage course which trends northeasterly and slopes 1/2% towards the creek in the southwest. The drainage course is 20 m. wide and 0.5 m. lower than the adjacent terrain, due to permafrost degradation. It is vegetated with grass and has water ponded to a depth of 0.7 m., in contrast to the dry, moss covered terrain adjacent to the drainage

course which supports a sparse growth of spruce to 6 m..

Test hole 77-3-4 is situated 350 m. southeast of 77-3-5, 100 m. southwest of the H-F pipeline, and 7 m. east of the small tributary creek to Mirror Creek. The area slopes about 3% westerly towards the creek which has an alluvial flood plain about 20 m. across. The creek channel itself is about 3 m. across and 1 m. deep, with a bed of soft, dark brown silt. The hole elevation is about 1 m. above the creek level, whereas the banks of the southwest side of the creek, as well as on the east side of the creek 200 m. to the north, are 2 m. high and actively slumping. The slumping along the banks is partly related to both creek erosion as well as thermal degradation of permafrost in the silt soils which form the banks. The ground at the test hole is firm and moss covered, with a moderate growth of willows and spruce to 10 m..

Between test holes 77-3-4 and 77-3-3, the terrain is flat and overgrown with a moderate growth of spruce. The ground is firm, dry and moss covered. Hole 77-3-3 is located 200 m. southeast of 77-3-4, in an open swamp about 50 m. across. The ground is soft and wet, with water ponded to a depth of 0.3 m.. A few small peat mounds to a height of 0.5 m. extend above the water level in the swamp. The open area is grass covered, with sparse willows to 2 m., and a few spruce to 3 m.. The slightly higher ground surrounding the swamp has a firm moss cover, and is vegetated with a light growth of spruce to 7 m..

Test hole 77-3-2 is located 275 m. southeast of 77-3-3 in the middle of a broad open swamp along the tributary to Mirror Creek. The flat, open area adjacent to the creek is about 150 m. across, and has ponded water in excess of 1 m. deep. General drainage is into the creek which flows northwesterly into Mirror Creek. The ground beneath the swamp is soft and supports a growth of grass.

4.0 SOIL & PERMAFROST CONDITIONS

4.1 Test Hole 77-3-1

Test hole 77-3-1 was drilled to a depth of 8.5 m.. The hole was augered to 1.0 m., cored from 1.0 to 3.2 m. and rotary drilled with mud from 3.2 to 8.5 m.. The topstratum consists of peat overlying organic silt and sand to 0.75 m.. The water content of the soil varies up to 266%. From 0.75 to 2.15 the soil is a fine sand, with some silt and organic laminations. The water content varies from 30 to 40%. From 2.15 to 5.0 m. the soil grades to a coarser sand, with a little silt in pockets and a trace of organic and wood specks. The total water content varies from 20 to 70%. The upper sand strata are underlain by very dense gravel and sand soils from a depth of 5.0 to 8.5 m..

Permafrost occurs from a depth of 0.75 to 5.0 m.. The soil has low ice content (Vr, Vx, of Nbn classification) with ice lenses generally less than 1 mm. thick, comprising less than 2% of the soil by volume. A zone of more extensive visible ice occurs from the 3.0 to 3.2 m. depth, where the excess ice content is estimated to be 15% by volume.

4.2 Test Hole 77-3-2

Test Hole 77-3-2 was drilled to a depth of 8.5 m.. The hole was augered to 3 m., and drilled with mud from 3 to 8.5 m.. The site has up to 1 m. of ponded water overlying soft organic silt to a depth of 0.5 m.. The topstratum is underlain by soft, fine sand and silt, with organic laminations, to a depth of 1.5 m.. The water content averages 40%. From a depth of 1.5 to 3.4 m. the soil is medium dense sand with a little silt, becoming coarser with depth. The natural water content decreases from 35% to 25% with stratum depth. The upper fine grained strata are underlain by gravel and sand from 3.4 to 8.5 m.. The gravel and sand has a trace of silt and is fairly well graded. The natural water content is about 10%.

The entire test hole was unfrozen within the drilled depth of 8.5 m..

4.3 Test Hole 77-3-3

Test hole 77-3-3 was drilled to a depth of 8.5 m.. The hole was augered to 3 m. and drilled with mud from 3 m. to 8.5 m.. The soft upper stratum underlying the site consists of 0.5 m. of organic silt. A silt and clay laminated with organic material and a little sand, underlies the upper stratum to a depth of 3.0 m.. The silt and clay has a soft to firm consistency, a slight to low plasticity and a natural water content of 30-35%. From 3.0 to 3.45 m. the silt grades into a medium dense to dense sand, interlayered with fine gravel. This stratum is underlain by a dense to very dense gravel and sand from 3.45 m. to the maximum drilled depth of 8.5 m..

The entire test hole was unfrozen within the drilled depth of 8.5 m..

4.4 Test Hole 77-3-4

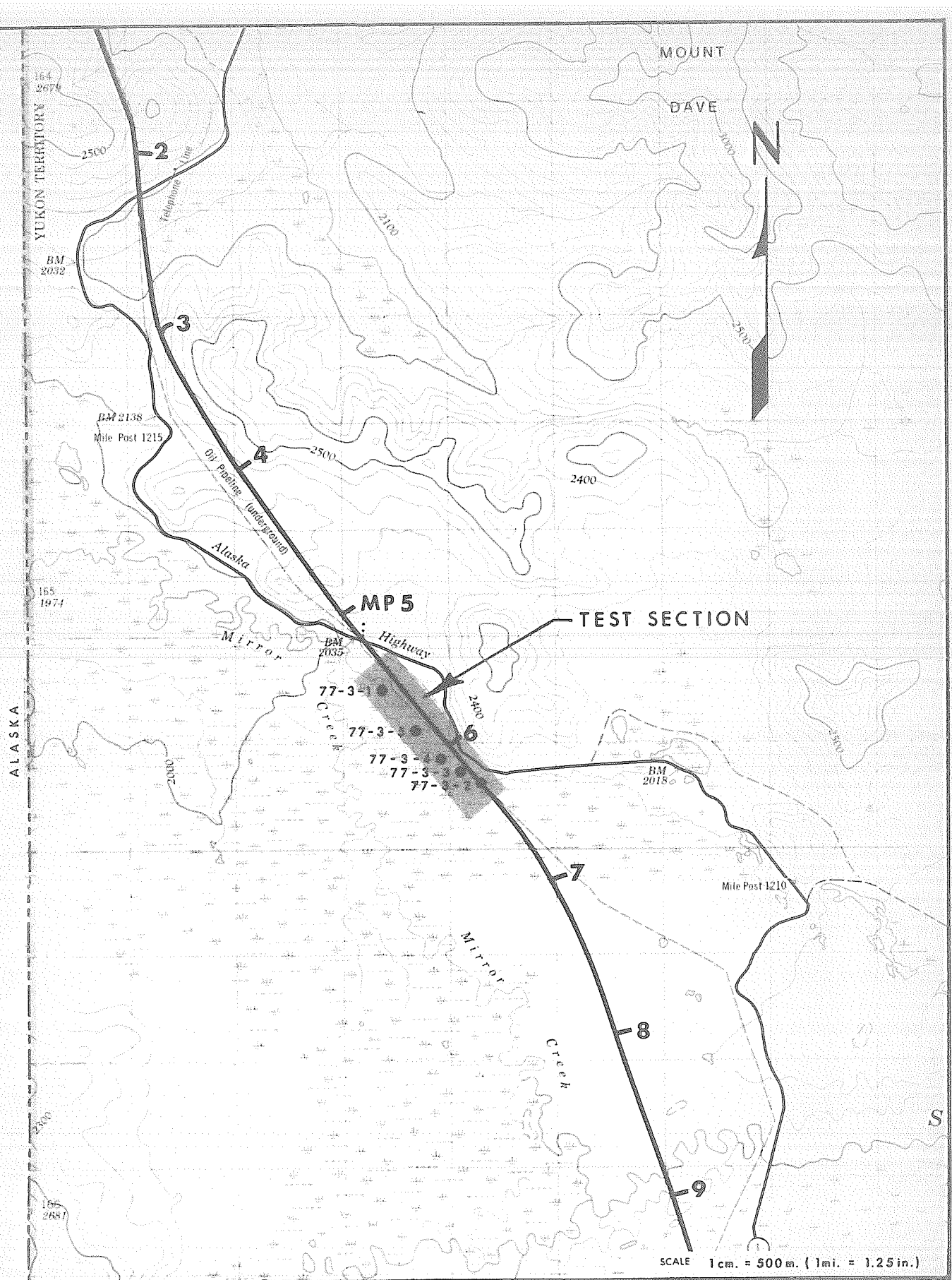
Test Hole 77-3-4 was drilled to a depth of 8.5 m.. The hole was augered to 1 m., cored from 1 to 3.45 m., and rotary drilled with mud from 3.45 to 8.5 m.. The upper strata consist of 0.2 m. of peat overlying a laminated organic silt with a little fine sand to a depth of 1.95 m.. The total water content of the organic silt averages about 110%. From 1.95 to 3.45 m. the silt is less organic, with some sand. The water content of the silt varies from 50 to 90%. Below a depth of 3.45 m. the silt overlies a dense to very dense gravel and sand stratum to the maximum drilled depth of 8.5 m.. The gravel and sand has a trace of silt and is fairly well graded.

Permafrost occurs from a depth of 0.4 to 3.2 m.. The soil has a medium to high ice content (mainly Vr, Vs, Vx classification) with extensive ice lenses 1/4 to 2 mm. thick and spaced at 1/4 to 5 mm.. The excess ice in the soil is estimated to vary from 5 to 30% by volume.

4.5 Test Hole 77-3-5

Test hole 77-3-5 was drilled to a depth of 8.5 m.. The hole was augered to 0.5 m., cored from 0.5 to 3.5 m., and rotary drilled with mud from 3.5 to 8.5 m.. The upper strata consists of 0.3 m. of soft organic silt overlying a slightly plastic silt with organic and fine sand laminations, to a depth of 2.85 m. The water content is high, varying from about 100 to 400%. From 2.85 to 3.55 m. the silt grades to a dark grey, fine to medium sand with a trace of gravel. The water content of the sand is about 20%. The sand is underlain by a gravel and sand layer to the maximum drilled depth of 8.5 m..

Permafrost occurs from a depth of 0.5 m. to the maximum drilled depth of 8.5 m.. The upper silt soils from a depth of 0.5 to 2.5 m. have a very high ice content (mainly Vx, Vr classification) with many ice lenses 1 to 4 mm. thick spaced at 1 mm. to 1 cm. The excess ice content of these soils is variable, ranging from an estimated 10 to 60% by volume. Below 2.5 m. the soils are low ice content, being mostly Nbn classification, with sparse Vx, & Vc.



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CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 3

DATE OF ISSUE: OCT. / 77.
APPROVED: R. Edgworth.

PROJECT No.: AL0890

DWG. No.: A-0890-3-1

REV.

KLOHN LEONOFF CONSULTANTS LTD.
CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No. 3

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	A L 0 8 9 0	A - 0 8 9 0 - 3 - 2	

APPROVED A. L. Hayworth

SITE 3

View northwesterly at Site 3 adjacent to both the Haines-Fairbanks pipeline right-of-way and the Alaska Highway. The site is located in flat swampy terrain along a tributary to Mirror Creek.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
					PERMAFROST		LOCATION See Plate A-0890-3-2
							ELEVATION
							0.1m ORGANIC COVER
	B		1			N.F	SILT AND SAND - organic fibres - dark brown
1.0							0.75m
	C		2		Vr, Vx, Nbn		SAND - some silt, trace clay - fine to medium - organic specks - dark grey to black
2.0	C		3		Nbn		2.15m
	C		4		Nbn Vx		SAND - trace silt, grey - fine, uniform gradation - trace fine gravel
3.0	C		5		Vr		2.75m ice lenses 1cm spaced @ 1cm
					Vx		SAND - fine to coarse - stratified - some gravel - little silt in pockets - wood pieces, grey - some gravel
4.0					Vc		
					Nbn		
5.0							5.0m
	B		6			NF	GRAVEL - fine to medium - and coarse sand - trace silt - grey
6.0							
7.0							
8.0							8.5m
							END OF HOLE @ 8.5m
9.0							

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-1
DATE	Sept. 23/77 PLATE

K.L.C - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located 7 m. east of tributary creek to Mirror Cr. Terrain slopes 3% towards creek.
2. Ground is firm, moss covered, and overgrown with spruce to 7m.
3. Thermistors installed at 0.5, 1.5, 3.0 and 6.0 m. depths. Standpipe piezometer installed.
4. Hole augered to 1 m. and cored from 1 to 3.2 m. Drilling mud was used from 3.2 to 8.5m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-1 (Continued)
DATE	Sept. 23/77 PLATE

K.L.C. - METRIC

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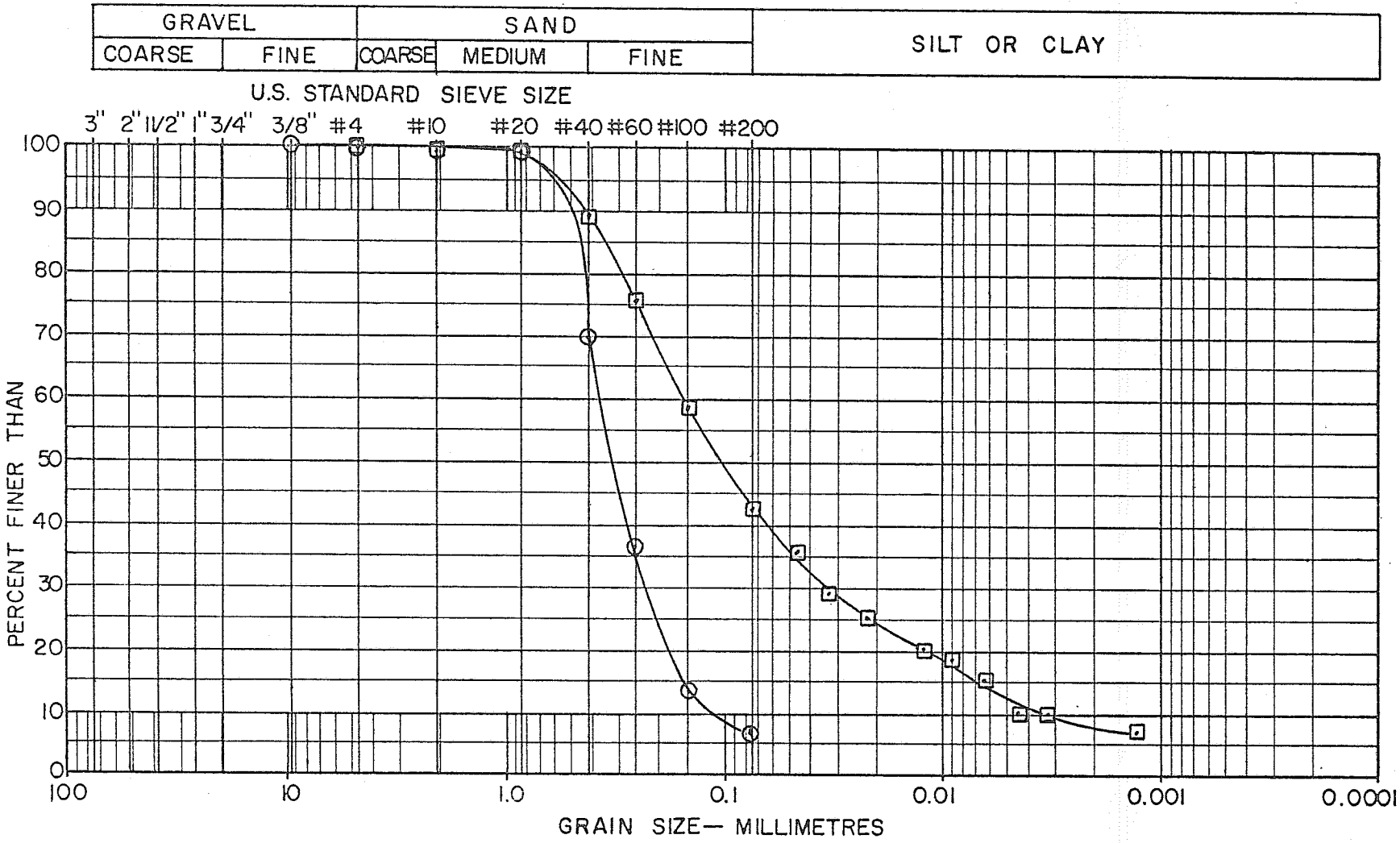
CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS: ⊡—⊡ Sa. #2 (1.0-1.45m) SAND AND SILT - trace clay

⊙—⊙ Sa. #4 (2.15-2.45m) SAND - fine uniform gradation, trace silt, trace gravel

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No. 77-3-1	DEPTH 2.15-2.45M
DATE Oct. 12/77	

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

LOCATION See Drawing A-0890-3-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
							0.3M WATER
	B						0.5M ORGANIC SILT
1.0	B		1				SAND - and silt, trace clay - fine, uniform - roots, organic specks
	B		2				- soft, black 1.5M
2.0							SAND - some silt, trace clay - wood specks - non-plastic
	B		3				- loose to med. dense - dark brown-black
	SPT	2 5 6	4				
3.0							
	B		5				3.4
4.0						NF	
	SPT	18 38 35	6				GRAVEL AND SAND - trace silt - fairly well graded - max. 5 cm. - stratified - very dense - brown and grey
5.0							
		24					
6.0	SPT	30 40	7				
	B		8				
7.0							
8.0							
							8.5M
9.0							END OF HOLE @ 8.5M

(Cont'd.)

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-2
DATE Sept. 24/77	PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA: DEPTH | TYPE | BLOW/15cm. | No.
SYMBOL
PERMAFROST: N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm. 0.2 0.6 1.0 1.4 1.8 ● FIELD VANE △ LAB VANE ▩ UNCONF.
PLASTIC LIMIT X — WATER CONTENT 0 — LIQUID LIMIT X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located in small tributary creek to Mirror Creek. Site is flat and swampy, and covered with 0.3m-0.6m standing water.
2. Open area with grass & small willows.
3. Hole augered to 3m. Drilling mud used from 3.0m to 8.5m.
4. Thermistors installed @ 0.5, 1.5, 3.0, and 6.0 M. depths.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-2 (Continued)
DATE	Sept. 24/77 PLATE

K.L.C. - METRIC

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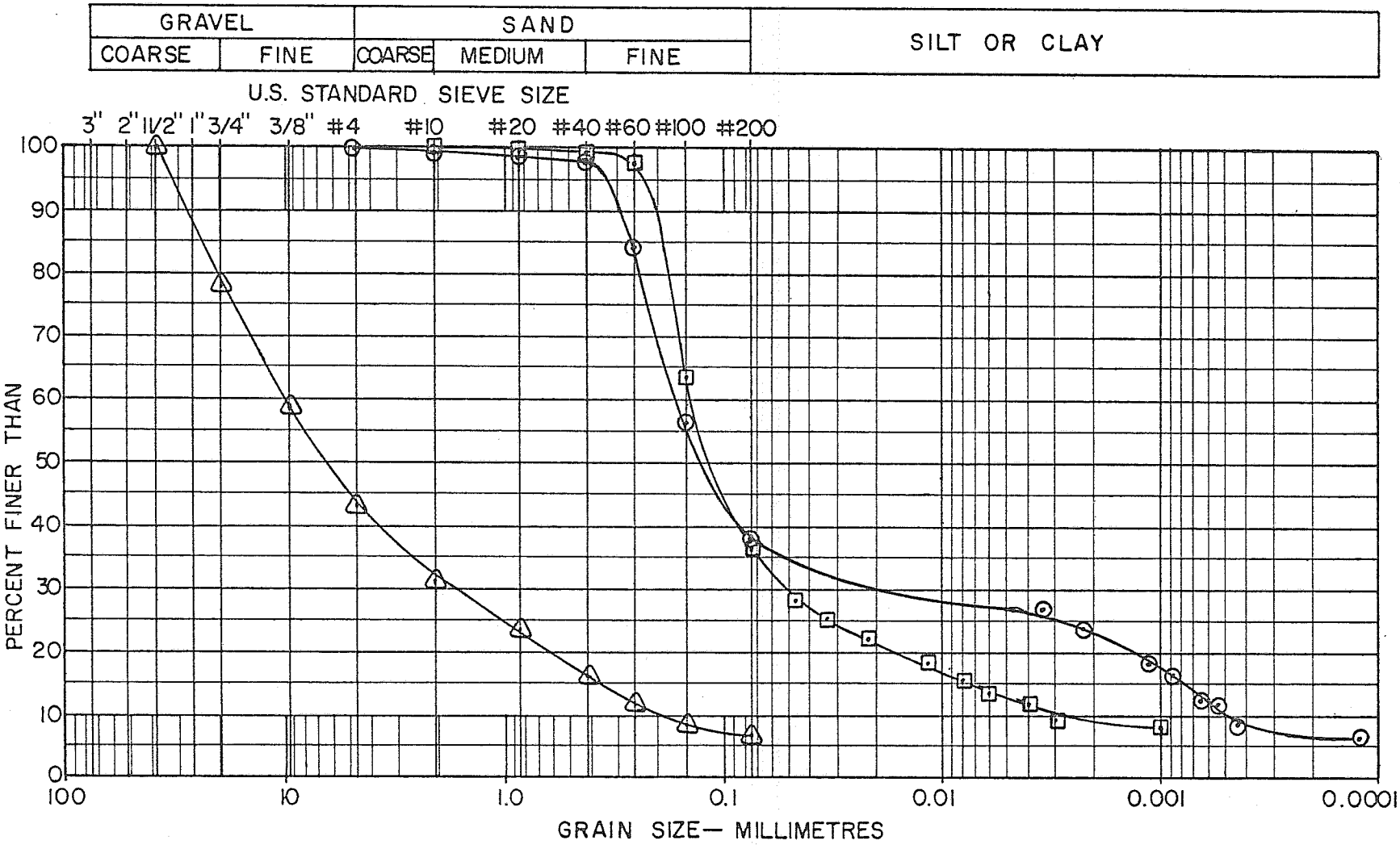
CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

- Sa. # 2 - (1.5m) Sand- and silt, fine, uniform, organic specks
- Sa. # 4 (2.3-2.75m) Sand - fine, uniform, some silt, trace clay
- Sa. # 5 (5.5-5.95m) Gravel and Sand - trace silt, fairly well graded

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-2 DEPTH
DATE	Oct. 21/77

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW / 15 cm.	No.
1.0	B		1
2.0	SPT	2 3 3	2
3.0	SPT	3 5 8	3
4.0	SPT	18 23 11	4
5.0	SPT	27 31 33	5
6.0	SPT	43 40+	6
7.0	SPT	23 18 23	7
8.0			
9.0			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF

LOCATION See Drawing A-0890-3-2
ELEVATION

DESCRIPTION OF MATERIAL

0.5M ORGANIC SILT

SILT AND CLAY
- little sand in laminations
- roots, organic specks
- laminated
- slight to low plastic
- grey

3.0M

SAND - some med. to fine gravel
- little silt, trace clay
- grey

3.45M

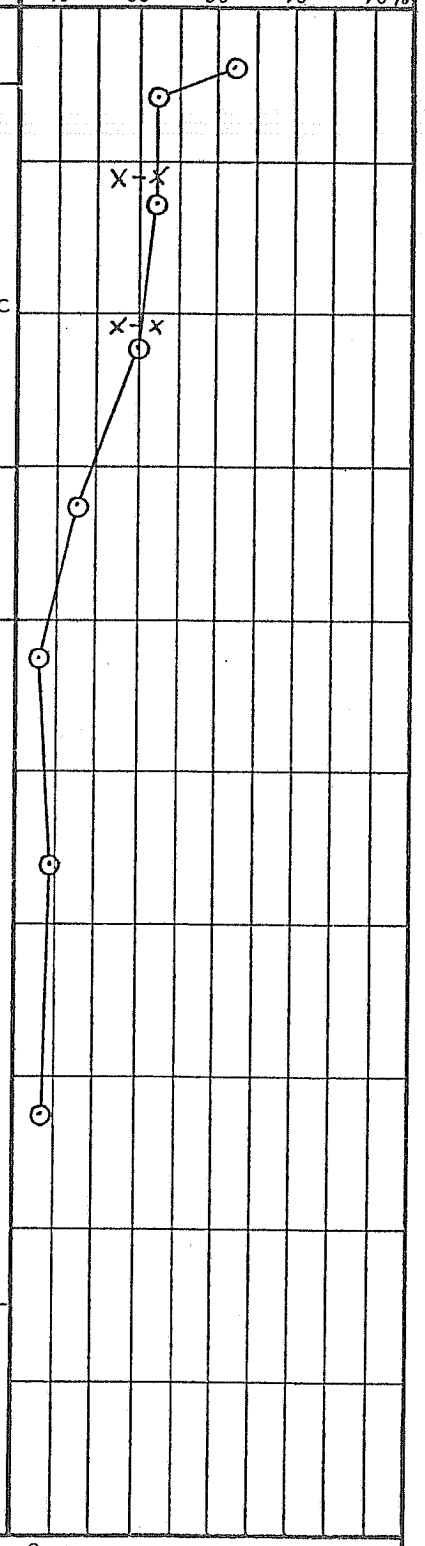
GRAVEL
- and sand
- trace silt
- fine
- grey with rusty colored layers

8.5M

END OF HOLE @ 8.5M

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-3
DATE	Sept. 26/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located in open swampy terrain 80 meters west of old Haines-Fairbanks pipeline. Ponded water to 0.5 meter deep at ground surface.

2. Ground is soft and wet, overgrown primarily with grasses.

3. Hole augered to 3M. Drilling mud used from 3M to 8.5M.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-3 (Continued)
DATE	Sept.26/77 PLATE

K.L.C. - METRIC

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JOB No. AL0890

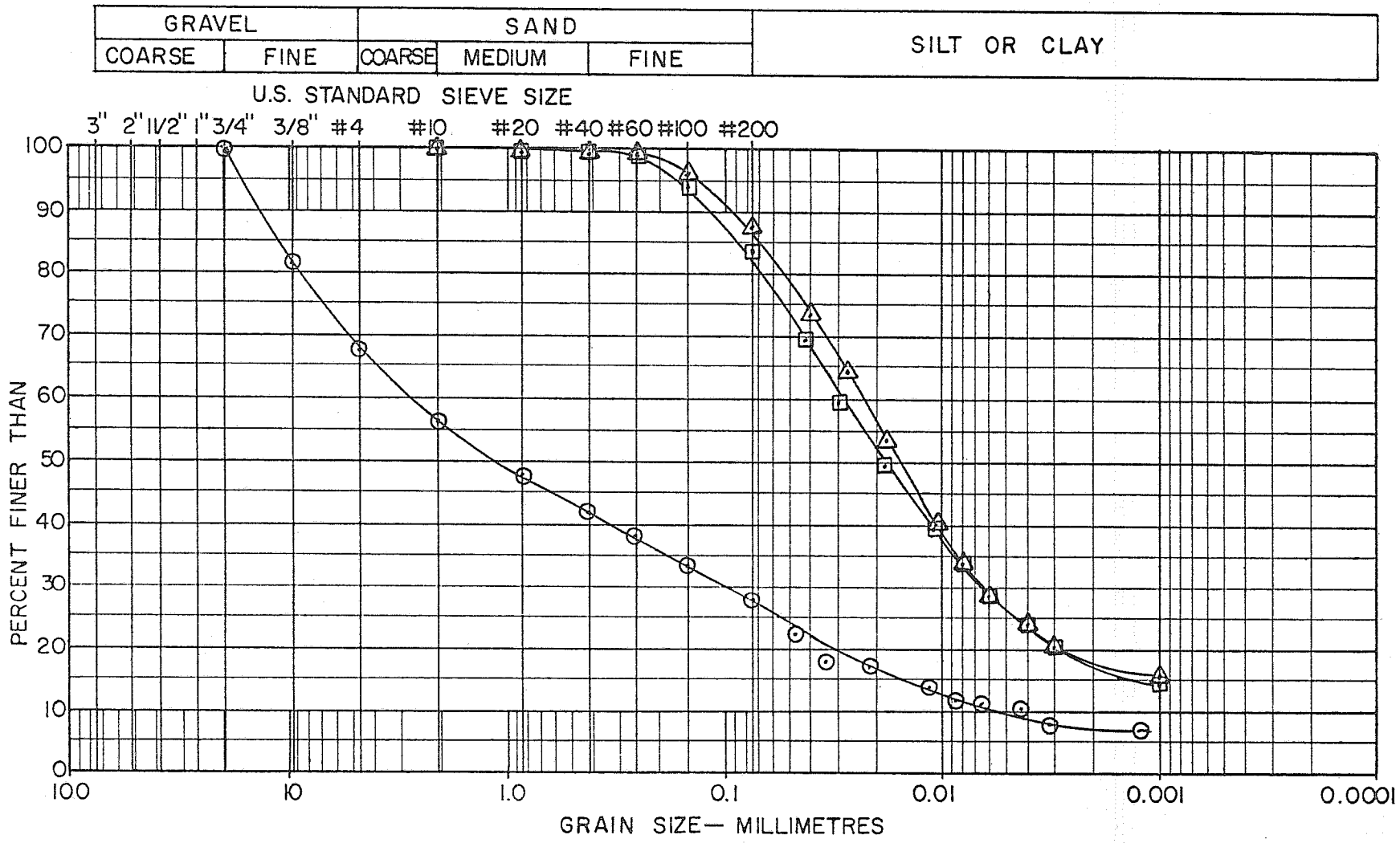
PROJECT Frost Heave Test Sites

LOCATION MP 5

HOLE No. 77-3-3 DEPTH 3-3.45M

DATEOct. 21/77

GRAIN SIZE CURVE



REMARKS:

- Sa. # 2 (1.0-1.45m) SILT & CLAY - little fine sand, low plastic
- Sa. # 3 (2.0-2.45m) SILT & CLAY - little fine sand, low plastic
- Sa. # 4 (3.0-3.45m) SAND - and gravel, some silt

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

LOCATION See Plate A-0890-3-2
ELEVATION

COHESION - Kg./5q.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
						NF 0.4	0.2 M PEAT-trace silt & sand
1.0					Nbn Vx		ORGANIC SILT - little sand - trace clay - roots, wood pieces - laminated, dk. brown - ice lenses ¼-2 mm @ ¼-5 mm spacing.
2.0	C		1		Vs, Vr		
	C		2				
	C		3		Vr, Vs, Vx, Nbn		
	C		4				1.95 M
	C		5				SILT - some sand - trace clay - organic specks - non to slight plasticity - brown and grey - ice lenses up to 4mm with ¼-10mm spacings
	C		6				
3.0	C		7		Vx, Vr		
	C		8				
	B		10			3.2	3.45 M
4.0							
	SPT	14 24 15	11				GRAVEL AND SAND - fine to coarse - layered - trace silt - very dense - grey
5.0							
	B		12				
	SPT	43 Ref	13			NF	
6.0							
7.0							
	SPT	34 33 37	14				
8.0							
	SPT	21 22 22	15				8.5 M
9.0							END OF HOLE @ 8.5 M.

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112
112
104

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-4
DATE	Sept. 27/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW 15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located 7 M east of small tributary creek to Mirror Cr. Ground slopes 3% towards creek.
2. Ground is moss covered & overgrown with moderate spruce growth to 10 M.
3. Hole augered to 1 M., then cored from 1 to 3.45 M. Drilling mud used from 3.45 to 8.5 M.
4. Water level at 3M. on completion of drilling.
5. Thermistors installed at 0.5, 1.5, 3.0 and 4.5 M depths. Standpipe piezometer installed.

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

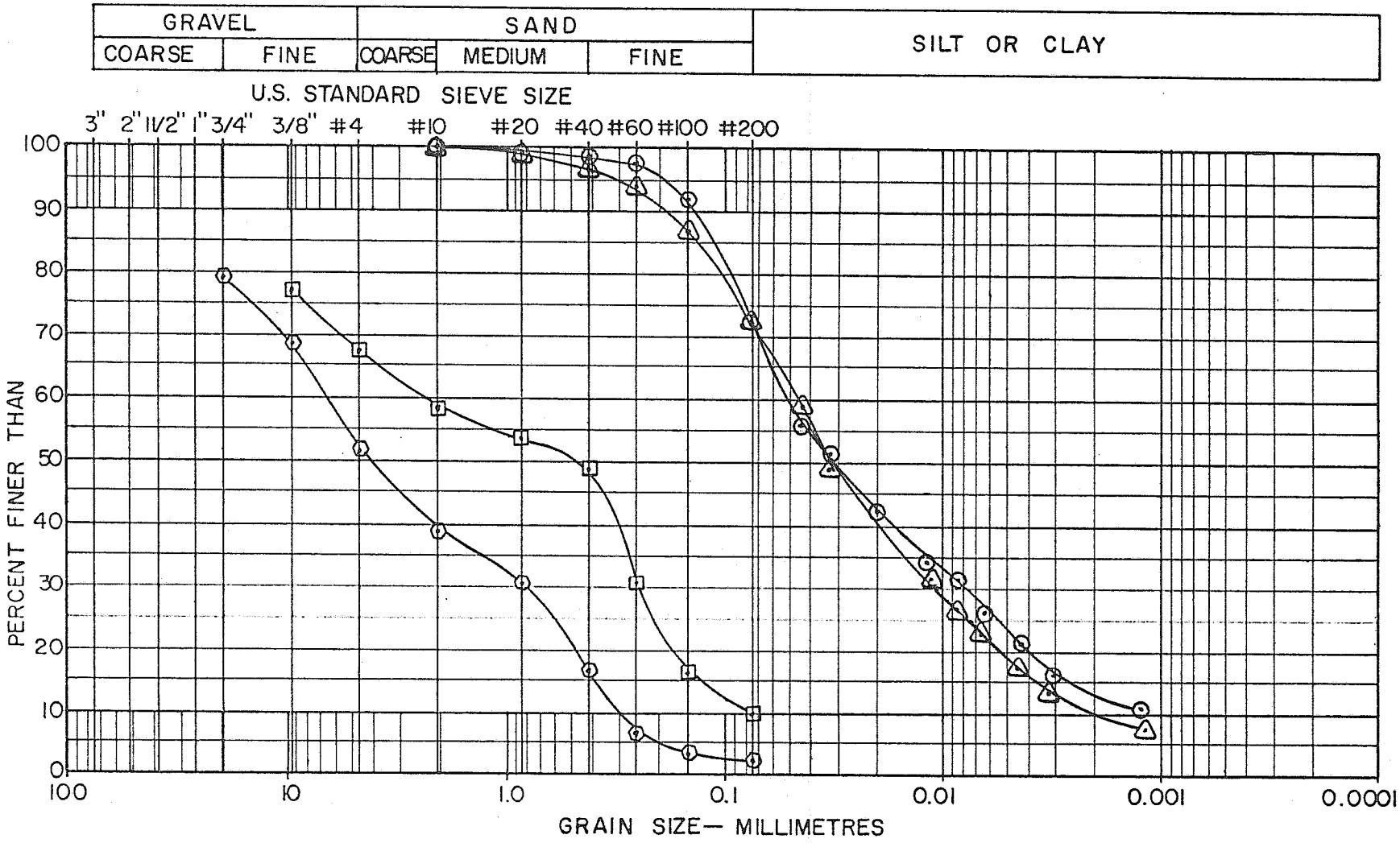
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-4 (Continued)
DATE	Sept. 27/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

- Sa. # 7 (2.5-2.8) SILT - some fine sand, trace clay.
- Sa. # 10 (3.2-3.45) SILT - some sand, trace clay.
- Sa. # 11 (4.3-4.75m) SAND - and gravel, trace silt
- Sa. # 15 (8.0-8.45m) GRAVEL & SAND - trace silt

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 5

HOLE No. 77-3-4 DEPTH 2.5-2.8M

DATE Oct. 21/77

TEST HOLE LOG

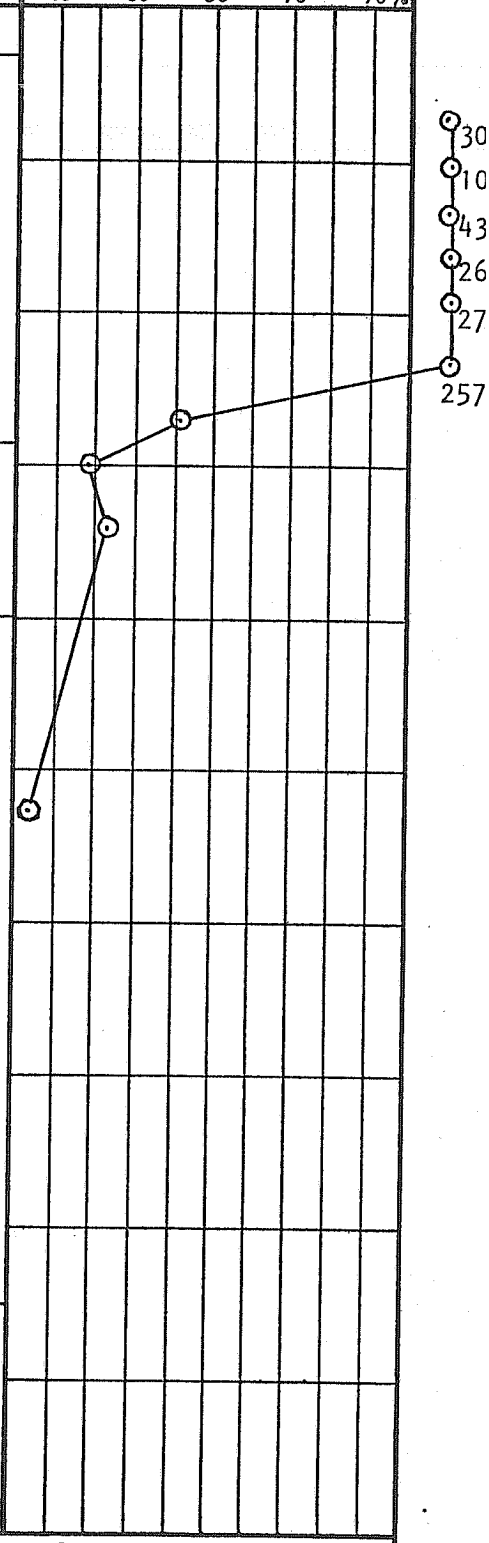
HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
						NF	0.3M ORGANIC SILT - soft
						0.5	
	C		2				SILT - trace clay
1.0	C		3		Vr		- trace sand
	C		4				- organic layers
	C		5		Vs		- slight plasticity
2.0	C		6		ICE		- brown and grey
	C		7		Vs Vr		ice lenses 1-4mm @ 1mm-1cm spacing.
3.0	C		8		Nbn		2.85M
	C		9		Vx		SAND - fine to medium
	C		10		Vc		- trace gravel, mostly shale pieces
4.0							3.55M - trace silt
5.0							- dark grey - black
	SPT-B	Ref	11		Vx Vc		GRAVEL AND SAND
6.0							- fine to medium
							- trace silt
7.0							- sub rounded
	SPT	Ref	12		Nbn		- very dense
8.0					Nbn		- grey
							8.5M
9.0							END OF HOLE @ 8.5 M.

LOCATION See Drawing A-0890-3-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-5
DATE	Sept.27/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.				SYMBOL	PERMAFROST		LOCATION	COHESION - Kg./Sq.cm. 0.2 0.6 1.0 1.4 1.8 ● FIELD VANE △ LAB VANE ■ UNCONF.
HT. DROP 76 cm.							ELEVATION	
SAMPLE DATA					N.R.C.	N.F.	DESCRIPTION OF MATERIAL	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X — — — — — 0 — — — — — X 10 30 50 70 90%
DEPTH	TYPE	BLOW 15 cm.	No.		CLASS	or F.		

Notes:

1. Hole located 50 M. west of Haines-Fairbanks pipeline R.O.W. in a swampy drainage course. Water is ponded at the hole to a depth of 0.7 M, and to a depth of 1.0 M. in a small pond where the drainage course crosses the H.F. P/L R.O.W.

2. Ground is soft and overgrown with grasses. Terrain slopes ½% westerly.

3. Hole augered to 0.5 M., then cored to 3.5 M. Drilling mud used from 3.5 to 8.5 M.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 5
HOLE No.	77-3-5 (Continued)
DATE	Sept.27/77 PLATE

K.L.C. - METRIC

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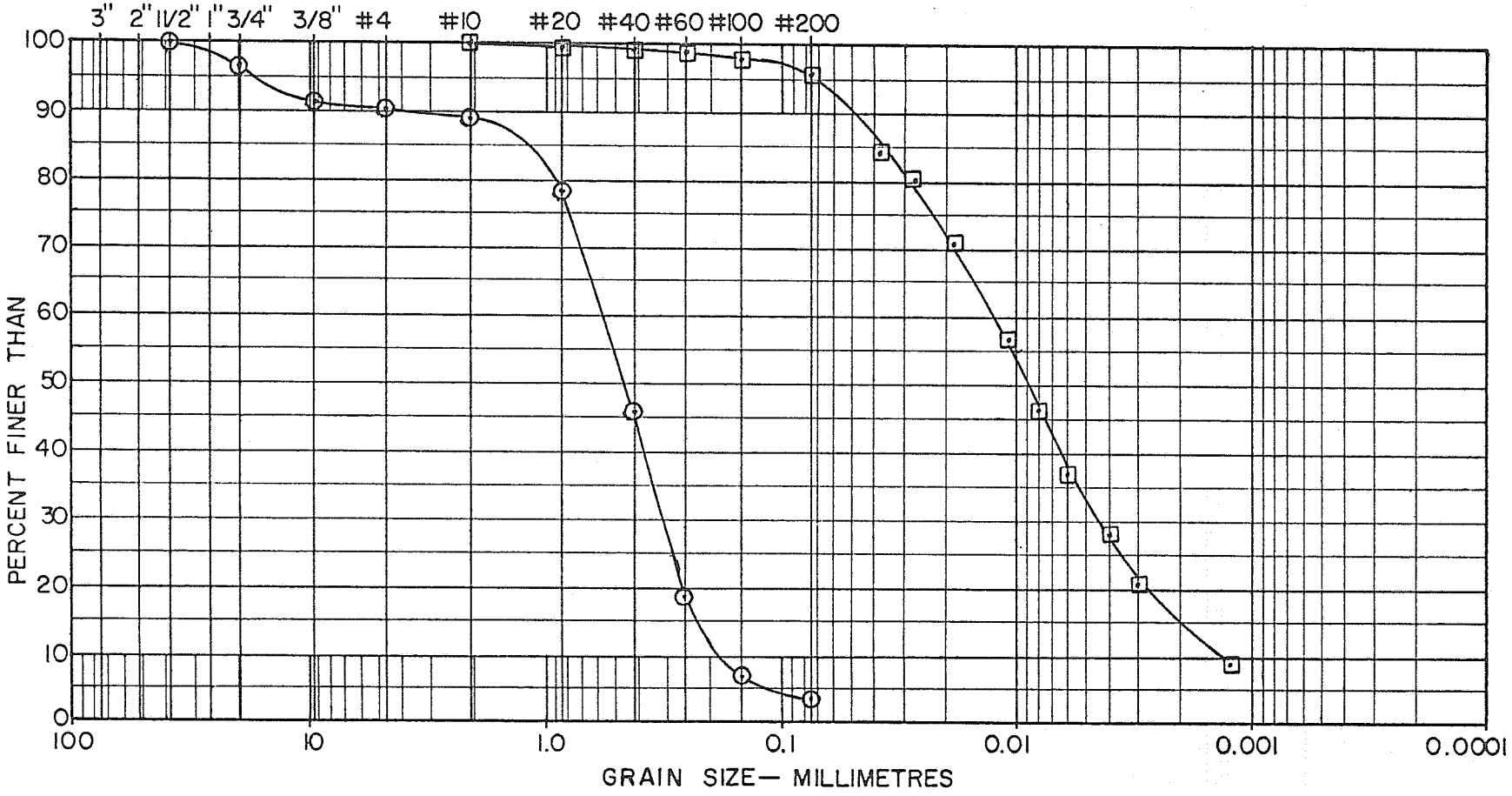
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



GRAIN SIZE CURVE

REMARKS: ⊡—⊡ Sa. # 4 (1.15-1.40m) SILT - trace clay, trace fine sand

⊙—⊙ Sa. #10 (3.25-3.55m) SAND - mostly fine to medium, trace gravel, trace silt

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 5

HOLE No. 77-3-5 DEPTH 3.25-3.55 M

DATE Oct. 12/77

SITE 4 (MP 8 - 9)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 8 and 9 along the proposed pipeline right-of-way. The Alaska Highway passes within 1000 m. to the east of the site. The reader should refer to the location plan on Plate A-0890-4-1 as well as aerial and site photographs on Plates A-0890-2 & 3.

2.0 SUMMARY

The site is located on a flat, featureless plain which was the extreme northwesterly limit of glaciation in the Yukon during the Pleistocene. The site encompasses two terrain units, namely: outwash overlain by shallow peat OW (PT) (SH), and glaciolacustrine basin terrain GLB-1 and GLB-2.

The entire site is very poorly drained with considerable ponded water in grassy swamp areas. In slightly higher terrain above the swamps, the ground is firm, moss covered, and vegetated with a light to moderate growth of spindly spruce. The local drainage is into Snag Creek which has a very mature, meandering channel. Snag Creek flows easterly, joining with Beaver Creek to the east of the site, before emptying into the White River at Snag.

Based on the six test holes drilled across the site the soil profile consists of a thin organic topstratum overlying a variable thickness of glaciolacustrine sand, silt and clay; all of which overlie outwash gravel and sand. The upper sequence of laminated and interlayered silt, organic silt, silt and clay, and sand varies from 1.4 to 5.1 m. thick. Hydrometer tests indicate these soils are usually gap graded fine sands or medium to coarse silts. Based on Atterberg Limit tests, the silt soils are generally non plastic, although the upper 2 m. in test hole 77-4-5 is low to medium plastic silt and clay. These upper fine grained glaciolacustrine soils overlie very dense gravel and sand of glacial outwash origin. The gravel and sand is well graded and

relatively clean, with a trace of silt. This stratum was penetrated in all six test holes with the maximum depth of hole to 10.0 m..

The permafrost conditions at the site are variable. Test hole 77-4-6, which was drilled in the OW (PT)(SH) terrain, has a shallow unfrozen active layer (0.7 m.) above permafrost which extends to the maximum drilled depth of 8.5 m.. Test holes 77-4-1 to 77-4-4 inclusive have a shallow unfrozen active layer above permafrost which extends to depths varying between 2.8 and 5.0 m.. Beneath this upper frozen zone or "talik" of permafrost the ground is unfrozen. Test hole 77-4-5 was drilled in a flat, open swampy area with considerable ponded water to a depth of 0.2 to 0.5 m.. No permafrost was encountered in this test hole.

Ice in the permafrost affected soils is variable, but occurs essentially as lenses and random layers in the fine grained soils, and as inclusions and coatings in the gravel and sand stratum.

The upper organic silt and sand stratum in test holes 77-4-2, 77-4-3, 77-4-4, and 77-4-6 have high ice contents. The ice generally occurs as thin, closely spaced lenses varying from 1 to 5 mm. thick. Random ice lenses up to 6 cm. also occur infrequently in these soils.

3.0 SITE DESCRIPTION

Test hole 77-4-4 is located at the northern end of the site approximately 1000 m. west of the Alaska Highway and 1300 m. north of Snag Creek. The terrain at 77-4-4 is flat and poorly drained, with a large swamp located 14 m. to the east. The hole itself is situated 0.75 m. above the water level in the swamp. The drill site is vegetated with grass, moss and peat tussocks with a sparse growth of spruce to 12 m. high.

Test hole 77-4-5 is situated about 300 m. south of 77-4-4. The terrain between these two holes is similar to that at both 77-4-4 and 77-4-5, being predominantly flat and poorly drained. Test hole 77-4-5, is located in one

of the many swampy areas characteristic of the area and poorly defined drainage flows northeasterly across the site. The ground surface is covered with extensive ponded water to 0.5 m. deep, and is vegetated with grass, moss and brush. A sparse growth of spruce and birch to 10 m. high occur predominantly in slightly higher areas where extensive ponded water is not as prevelant.

Test hole 77-4-3 lies about 300 m. southeast of 77-4-5 and is located in a treed area at the southeast corner of a broad, open swamp. The terrain is flat to gently sloping and drainage is poor. At the drill site the ground is firm, moss covered, and overgrown with a moderate growth of spruce with minor birch to 10 m. high. The broad open swamp to the north is vegetated with grass and covered with standing water at the ground surface.

Test hole 77-4-2 is located about 500 m. south of 77-4-3, in a flat area south of an old meander channel of Snag Creek and 125 m. north of the present day channel. The area is not as swampy as to the north, and the ground surface has thick moss cover. Vegetation consists of a moderate growth of spruce to 10 m. high.

Test hole 77-4-1 lies 115 m. south of 77-4-2 and 9 m. north of Snag Creek on a flat poorly drained area situated about 3 m. above the creek level. The near vertical banks along Snag Creek are comprised of silt and thaw slumps are evident at isolated locations. Water in the creek varies from 0.5 to 1.0 m. deep. The Snag Creek drainage course is mature and meanders with several ox-bow lake features and old abandoned channels. A dense growth of spruce to 20 m. high is concentrated along the banks of the creek, while shorter, sparser spruce grow in areas away from the creek. The ground surface is firm and moss covered.

Test hole 77-4-6 is located in the outwash terrain south of Snag Creek which is flat, poorly drained and void of tree cover. Vegetation consists mainly of grasses, shrubs and extensive peat tussocks. Drainage of the area is poor and ponded water generally occurs between peat tussocks.

4.0 SOIL AND PERMAFROST CONDITIONS

4.1 Test Hole 77-4-1

Test hole 77-4-1 was drilled to a total depth of 10.0 m. by dry augering to 1.1 m., coring from 1.1 to 2.85 m. and rotary drilling with mud below 2.85 m.. The subsoils consist of laminated silts of glaciolacustrine origin extending from ground surface to a depth of 3.1 m., below which sand and gravel outwash materials were encountered. The moisture content of the laminated silt varies from 30% to 55%, averaging about 35%. The underlying gravel and sand material has a moisture content of 20% at the top of the stratum and less at depth.

Permafrost exists from 0.75 to 4.0 m., while unfrozen soils occur above and below this zone. The excess ice content of the frozen interval is low and is estimated to be less than 3% by volume. Ice generally occurs as thin 1/4 to 1/2 mm. lenses and inclusions.

4.2 Test Hole 77-4-2

This test hole was drilled by augering to 0.5 m., coring from 0.5 to 2.8 m., and rotary drilling with mud from 2.8 to 10.0 m. where the hole was completed. The subsoils consist of a thin moss cover overlying silt with organic laminations to 2.65 m., all of which overlies a dense gravel and sand outwash stratum to 10.0 m.. The upper silt soils have high moisture contents ranging from 70 to 250%, due to the organic content. The underlying gravel and sand materials have a low moisture content averaging about 10%.

Permafrost exists from 0.5 to 5.0 m., with unfrozen soils above and below this zone. The estimated excess ice content of the frozen silt soils is high, varying from less than 5% to more than 50% by volume. The ice generally occurs as thin lenses 1/4 to 1 mm. thick and spaced at 1/2 to 10 mm. intervals. Due to the rotary method of drilling, the ice content of the gravel and sand soil was not ascertained.

4.3 Test Hole 77-4-3

Test hole 77-4-3 was drilled to a depth of 8.95 m.. The hole was dry

augered to 0.6 m., cored from 0.6 to 3.4 m., and rotary drilled with mud from 3.4 to 8.95 m.. The upper subsoils to a depth of 1.8 m. consist of silt laminated with sand and organic materials. The soil has a variable moisture content from 45 to 95% due to the irregular sand and organic content. Laminated silt and clay with organic pockets and seams occur from 1.8 to 3.1 m.. The moisture content is high but variable, ranging from 70 to 150%. Peat and organic silt with a high moisture content occur from 3.1 to 4.2 m.. The upper fine grained soils to a depth of 4.2 m. are underlain by fine to coarse gravel to the maximum depth drilled (8.95 m.).

Permafrost exists from 0.6 to 2.8 m., with unfrozen soils above and below this zone. The estimated excess ice content of the frozen soils is high, averaging about 20% by volume. The ice generally occurs as lenses and inclusions 1 to 2 mm. thick, spaced 1 to 5 mm. apart.

4.4 Test Hole 77-4-4

Test hole 77-4-4 was drilled to a depth of 8.95 m. by dry augering to 0.5 m., coring from 0.5 to 5.1 m., and rotary drilling with mud below 5.1 m.. The subsoils in this test hole progress from fine to coarser grained with depth. The subsoil profile consists of 1.2 m. of silt and clay, overlying sandy silt from 1.2 to 3.0 m., overlying sand from 3.0 to 4.7 m. all of which overlies a thin silt layer and a dense gravel stratum below 5.1 m.. The moisture contents of the upper silt and sand strata are variable but generally range from 30 to 60%. However, in ice rich layers and organic laminations, moisture contents vary from 70% to as high as 275%. The underlying gravel and sand stratum has a low moisture content, averaging less than 10%.

As with many of the test holes in the Snag Creek area, a talik of permafrost exists from 0.5 to 4.7 m., with unfrozen soils above and below this zone. The frozen subsoils generally have a medium ice content although some lenses are up to 6 cm. thick. The estimated excess ice content varies from 10 to 20% in the upper silt strata, to less than 10% in the sand stratum from 3.0 to 4.7 m.. Due to the rotary method of drilling, the ice content of the gravel and sand outwash stratum was not ascertained.

4.5 Test Hole 77-4-5

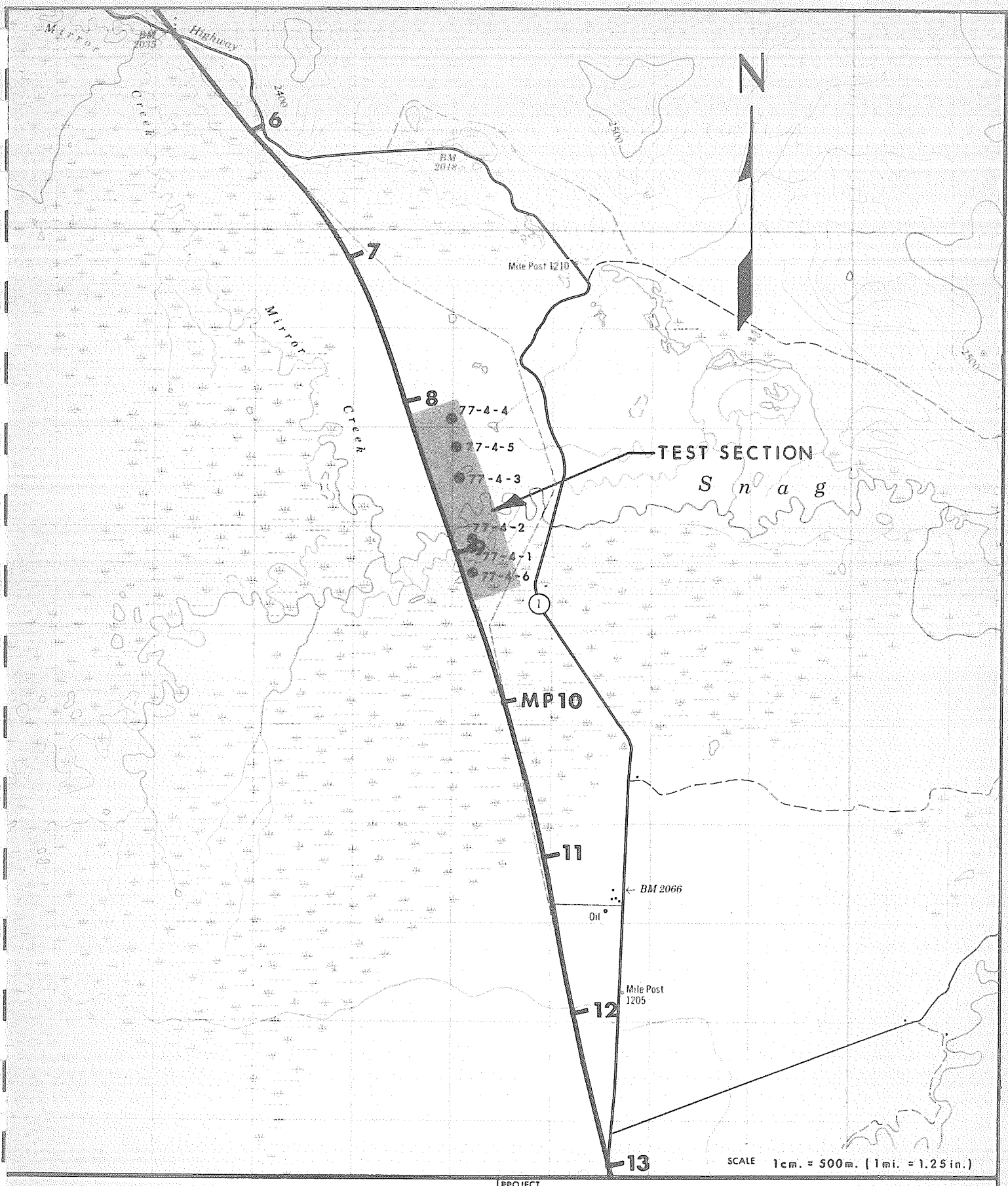
Test hole 77-4-5 was drilled to a depth of 8.6 m. by dry augering to 3.0 m. and rotary drilling with mud from 3.0 to 8.5 m.. A shallow gravel stratum was encountered at a depth of 2.0 m., beneath an upper layer of silt and clay with traces of sand and organic material. The moisture content of the silt and clay is about 50% while that of the underlying gravel is about 10%.

No permafrost was encountered in this test hole.

4.6 Test Hole 77-4-6

Test hole 77-4-6 was drilled to a depth of 8.5 m. by augering to 0.5 m., coring from 0.5 to 1.4 m., and rotary drilling with mud from 1.4 to 8.5 m.. A shallow gravel stratum was encountered at a depth of 1.4 m., beneath an upper layer of peat, ice and silt. The upper 1.4 m. of soil is comprised of 0.55 m. of peat overlying ice rich silt and organic silt. The moisture contents of these upper soils are very high, varying from 80 to more than 200%.

Permafrost occurs beneath a shallow 0.55 m. thick unfrozen active layer, to the maximum depth drilled (8.5 m.). Ice in the upper 1.4 m. occurs as horizontal lenses to 1 cm. thick. Due to the rotary method of drilling, the ice content of the gravel and sand substratum was not ascertained. However, based on drill cuttings, this material is very dense and has a negligible ice content.



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CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 4

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-4-1	

APPROVED a. Edgworth.

KLOHN LEONOFF CONSULTANTS LTD.
CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

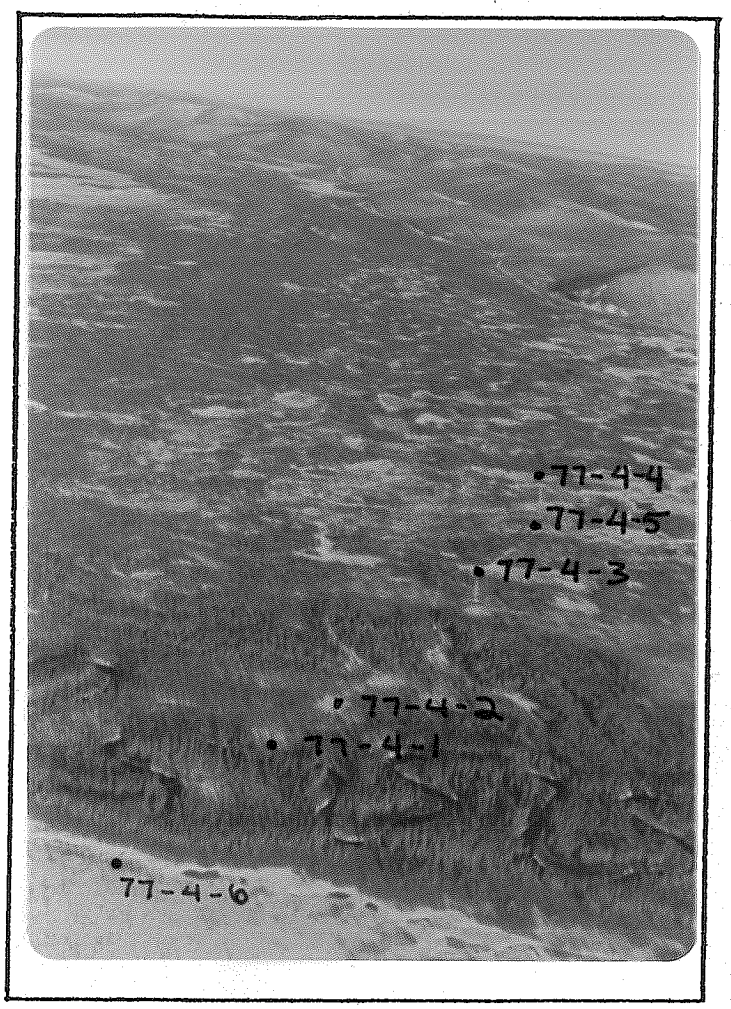
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No. 4

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-4-2	

APPROVED R. L. Edgeworth.



SITE 4

View northerly at Site 4 with Snag Creek in the foreground. The site is located on a relatively flat, featureless plain dotted with many small ponds. Note the cut line between the six test holes drilled at the site. The Alaska Highway, the Haines-Fairbanks pipeline right-of-way, and Site 3 along the tributary to Mirror Creek are visible in the upper right part of the photograph.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.
1	B		1
2	C		2
3	C		3
4	B		4
5	SPT	14 20 24	5
6	SPT	17 11 7	6
7			
8	SPT	13 11 13	7
9	B		8
10	B		9

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	N.F
	0.75
Vr	
Nbn	
Vr,Vs	
Vr	
Vs	
Nbe	
Vx	
Nbn	
	4.0
	N.F

LOCATION See Drawing A-0890-4-2
ELEVATION

DESCRIPTION OF MATERIAL

SILT
- little sand
- trace clay
- slight plasticity
- brown

1.1m

SILT- little sand, tr.clay
- laminated
- sand & organics layers and laminations
- dark grey

(Ice lenses ½mm spaced @ 10mm)
(Ice lenses ¼mm spaced @ 10mm)

3.1m

GRAVEL AND SAND
- and silt, trace clay
- layers of coarse sand
- medium dense

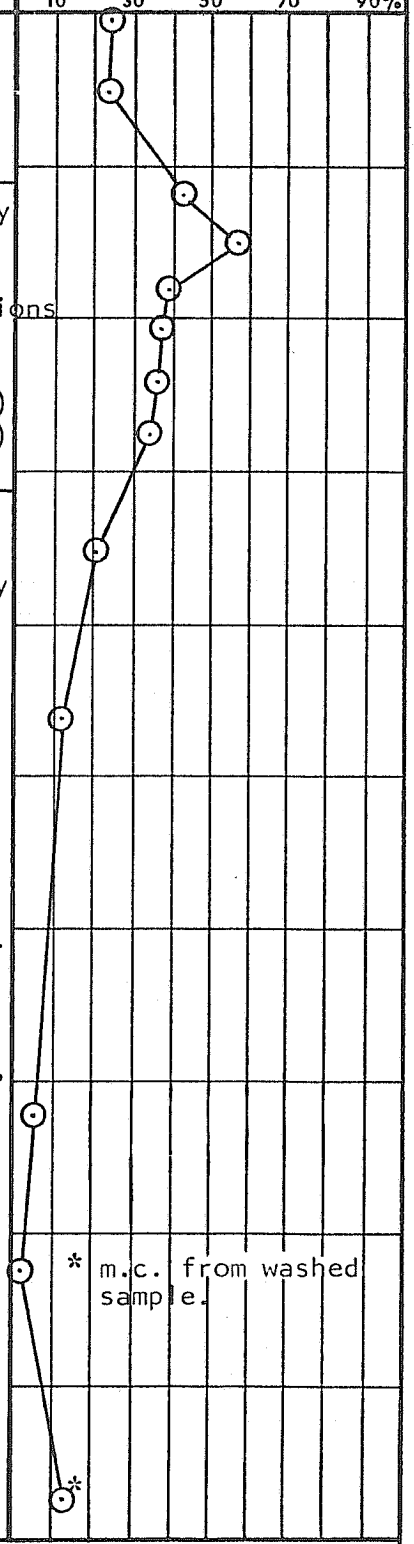
Notes:

1. Hole located 9 M north of Snag Creek on a flat and poorly drained area approx. 3 M. above creek level.
2. Dense spruce trees to 20-25M.
3. Drilling mud used from 4 to 10 M.
4. Thermistors installed at 0.5, 1.5, 3,0 and 6.0 M.

10.0 M END OF HOLE

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No.	77-4-1
DATE	Sept. 19/77 PLATE

K.L.C. - METRIC

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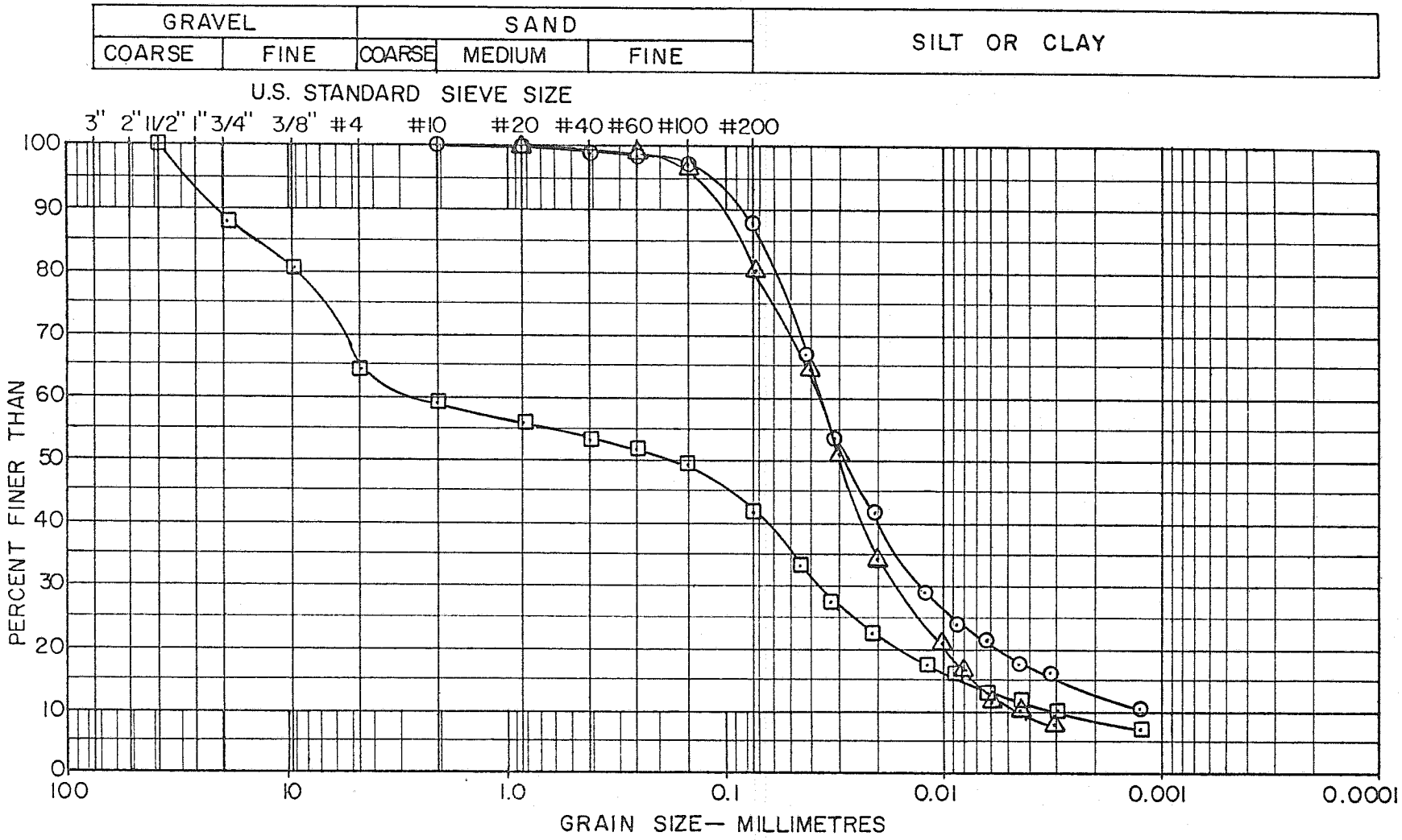
GRAIN SIZE CURVE



REMARKS:

⊙——⊙ Sample 1 at 0.5 M SILT - little sand, trace clay

△——△ Sample 3 at 2.65 - 2.85 M SILT - little sand, trace clay

⊡——⊡ Sample 4 at 3 - 4 M GRAVEL-SAND-SILT, trace clay

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No. 77-4-1	DEPTH
DATE Sept./77	

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
1	C		1
	C		2
2	C		3
	C		4
3	C		5
4			
5	B		6
6	B		7
7			
8	B		8
9			
10	B		9

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	N.F 0.5
Vr	
Vs	
Vs	
Vr	
Nbe	
N	
	5.0 N.F

LOCATION See Drawing A-0890-4-2
ELEVATION

DESCRIPTION OF MATERIAL

0.2m MOSS- organic cover
SILT- little sand
- organics lamination and layers
- dark grey
1.1 (Ice lenses 1 mm spaced @ 5mm)
(Ice lenses .5 mm spaced @ 5mm)
1.55 SILT-little clay, peat
SILT- little sand
- organic laminations and layers
- dark grey
2.65 (Ice lenses 1-2mm spaced @ 10mm)

GRAVEL AND SAND
- subangular and subrounded
- little silt

Notes:
1. Hole located 125 M north of Snag Creek on a flat poorly drained area.
2. Deep moss cover with spruce trees to 8 M.
3. Drilling mud used from 2.8 to 10 M.
4. Thermistors installed at 0.5, 1.5, 3.0 & 6.0 M.

10 M. END OF HOLE

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

254
211
206
123
235
112

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No.	77-4-2
DATE	Sept. 19/77 PLATE

K.L.C. - METRIC

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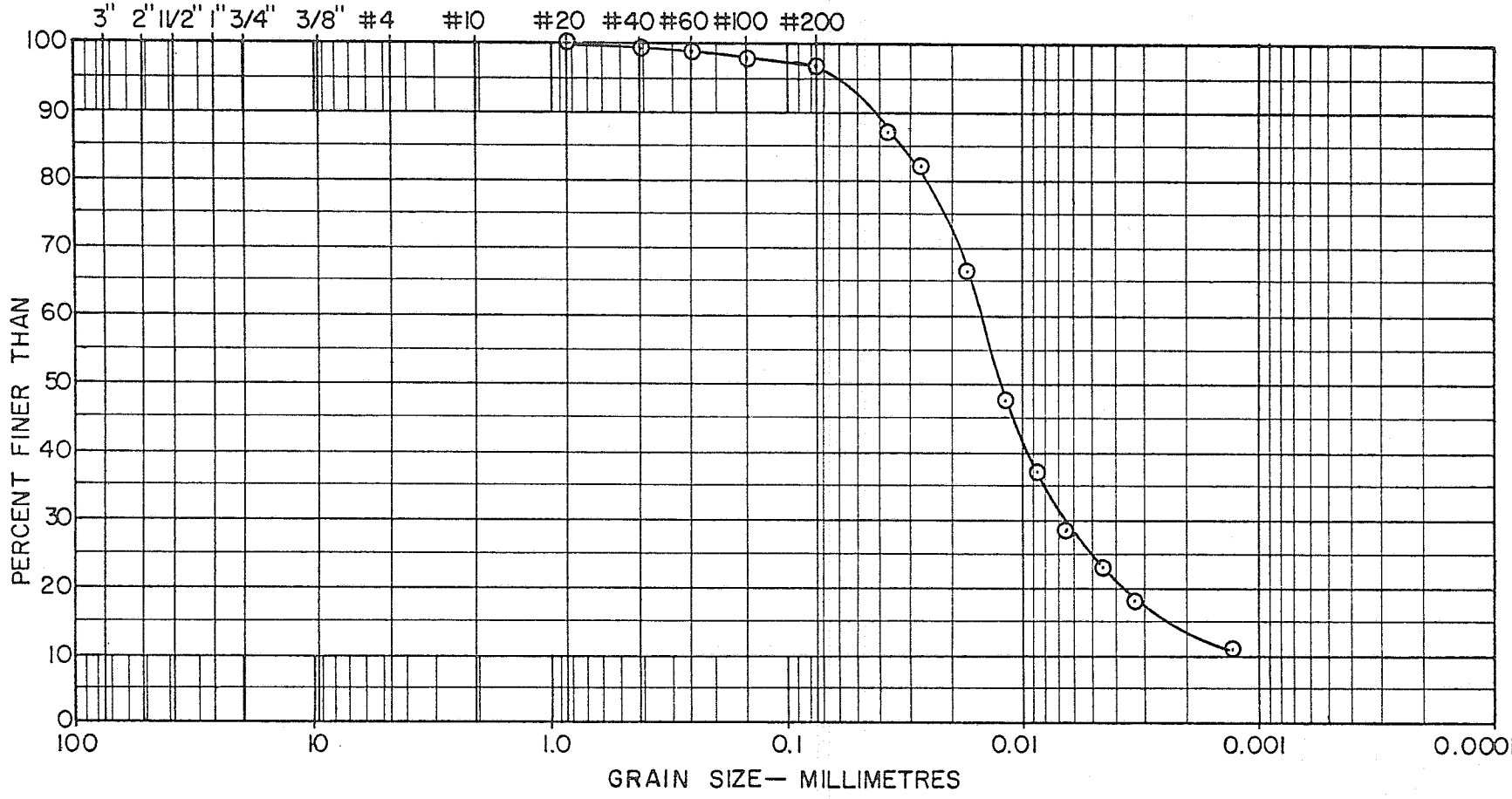
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



GRAIN SIZE CURVE

REMARKS: ⊙—⊙ Sample 2 at 1.2 - 1.55 m. SILT - organic, little clay, trace sand

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No. 77-4-2	DEPTH
DATE	Sept./77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
1	C		1
2	C		2
3	C		3
4	C		4
	SY		5
5			
6	B		6
7			
8	SPT	36 41 37	7
9	SPT	24 38 42	8
10			

SYMBOL

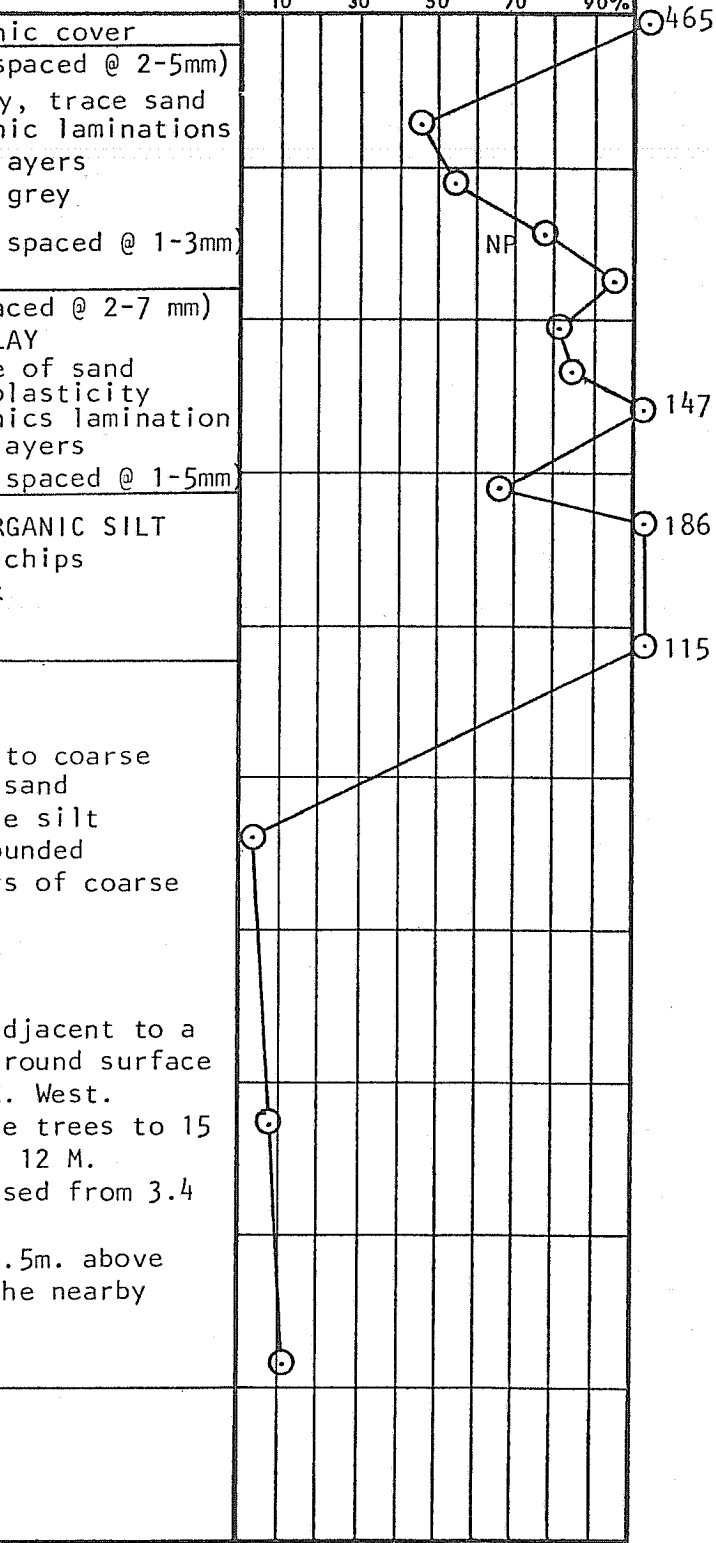
PERMAFROST

N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
	NF	0.3m MOSS- organic cover
	0.6	(Ice lenses 1-2mm spaced @ 2-5mm)
Vr Nbn		SILT - little clay, trace sand - organic laminations and layers - dark grey
silty sand		
Vr Vs Vx		(Ice lenses 1-2mm spaced @ 1-3mm)
		1.80 m.
Vx, Vr		(Ice lenses 1mm spaced @ 2-7 mm) SILT AND CLAY - trace of sand - low plasticity - organics lamination and layers
Vr Vs Vx	2.8	
		3.1m. (Ice lenses 1mm spaced @ 1-5mm
		PEAT AND ORGANIC SILT - wood chips - black
		4.2 m.
		GRAVEL - fine to coarse - some sand - little silt - subrounded - layers of coarse sand - dense
	N.F.	Notes: 1. Hole located adjacent to a swamp area. Ground surface slopes 8% to N. West. 2. Cover of spruce trees to 15 M and birch to 12 M. 3. Drilling mud used from 3.4 to 8.95 M. 4. Hole located 0.5m. above elevation of the nearby swamp.
		8.95m.
		END OF HOLE

LOCATION See Drawing A-0890-4-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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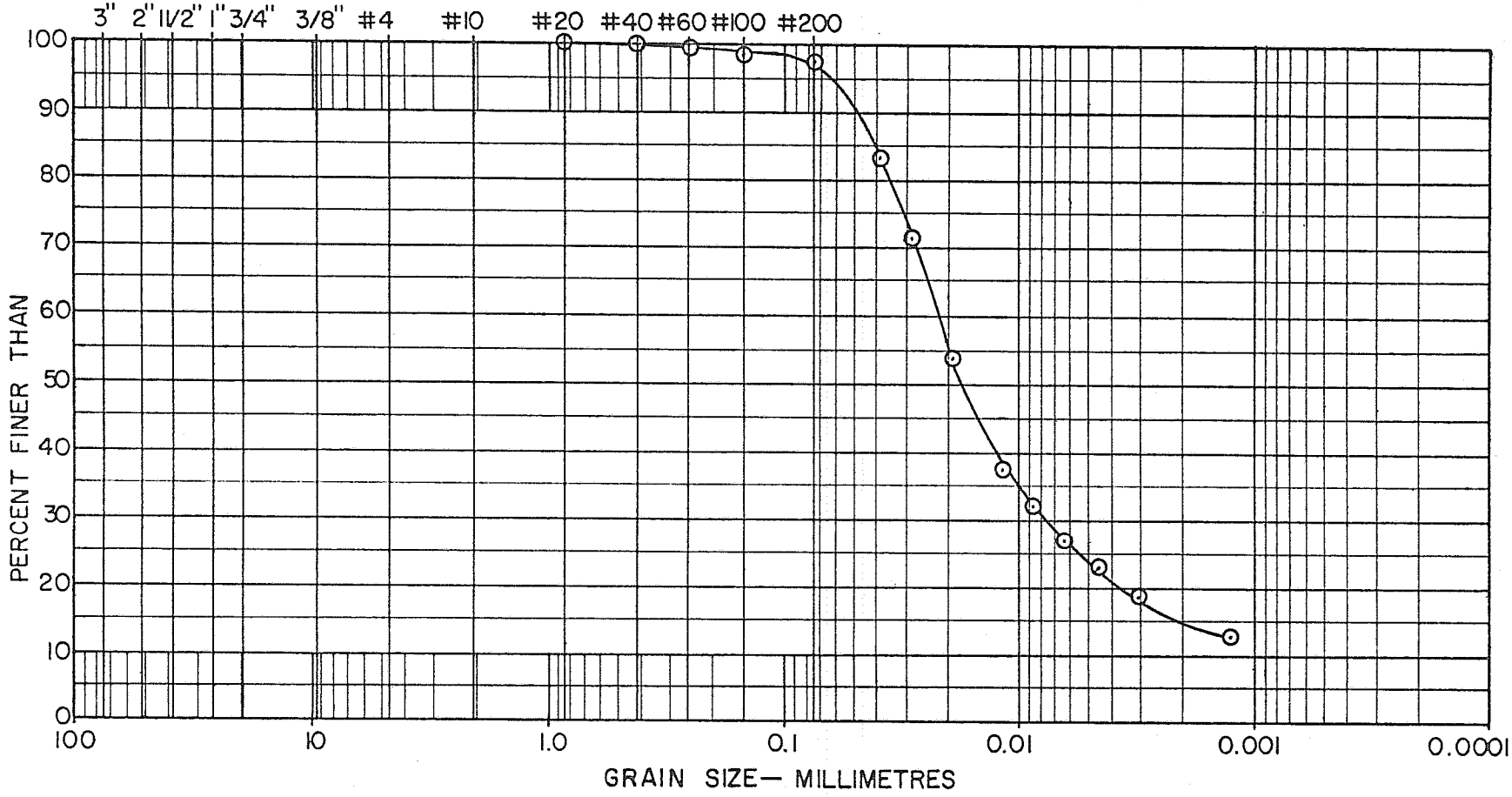
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No.	77-4-3
DATE	Sept. 20/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



GRAIN SIZE CURVE

REMARKS: ⊙—⊙ Sample 2 at 1.65 - 1.85 SILT - little clay, trace sand

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 8 to 9
HOLE No. 77-4-3 DEPTH
DATE Sept./77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.

LOCATION See Drawing A-0890-4-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

SAMPLE DATA				SYMBOL	PERMAFROST		DESCRIPTION OF MATERIAL
DEPTH	TYPE	BLOW 15 cm.	No.		N.R.C. CLASS	N.F. or F.	
						NF	0.3m. MOSS-topsoil
						0.5	SILT & CLAY -trace sand, organics -low plastic, grey
1	C		1		Vr		← (Ice lenses 1-2mm spaced @ 1mm)
					Vs		1.2m.
							← (Ice lenses 2-10mm spaced @ 10mm)
							SILT-some sand, little clay -laminations & organic layers -dark grey
2	C		2		Vx		
					Vr		← (Ice lenses 1-2mm spaced @ 1-5mm)
	C		3		Vs		← (Ice lenses to 50 mm)
3					Vr, Vx		3.0m.
	C		4		Vr		SAND-fine, uniform - some silt -layers of sand and organic -dark grey
4	C		5		Vx		4.1 (Ice lenses 1 mm spaced @ 1-5mm)
	C		6		Nbn		SAND-fine, uniform -little silt -dark grey
5	C		7			4.7	4.7m. SILT-organic
6	SPT	21 37 44	8				GRAVEL-fine to coarse -and sand -little silt -subrounded -dense
7						NF	Notes: 1. Hole located 14m. from swamp on flat area and 0.75M above swamp level. 2. Moss & grass cover with white spruces 5-12M in height. 3. Drilling mud used from 5.1 to 8.95M.
8	SPT	17 16 18	9				
9	SPT	41 30 27	10				8.95M
10							END OF HOLE

458
275
145
NP

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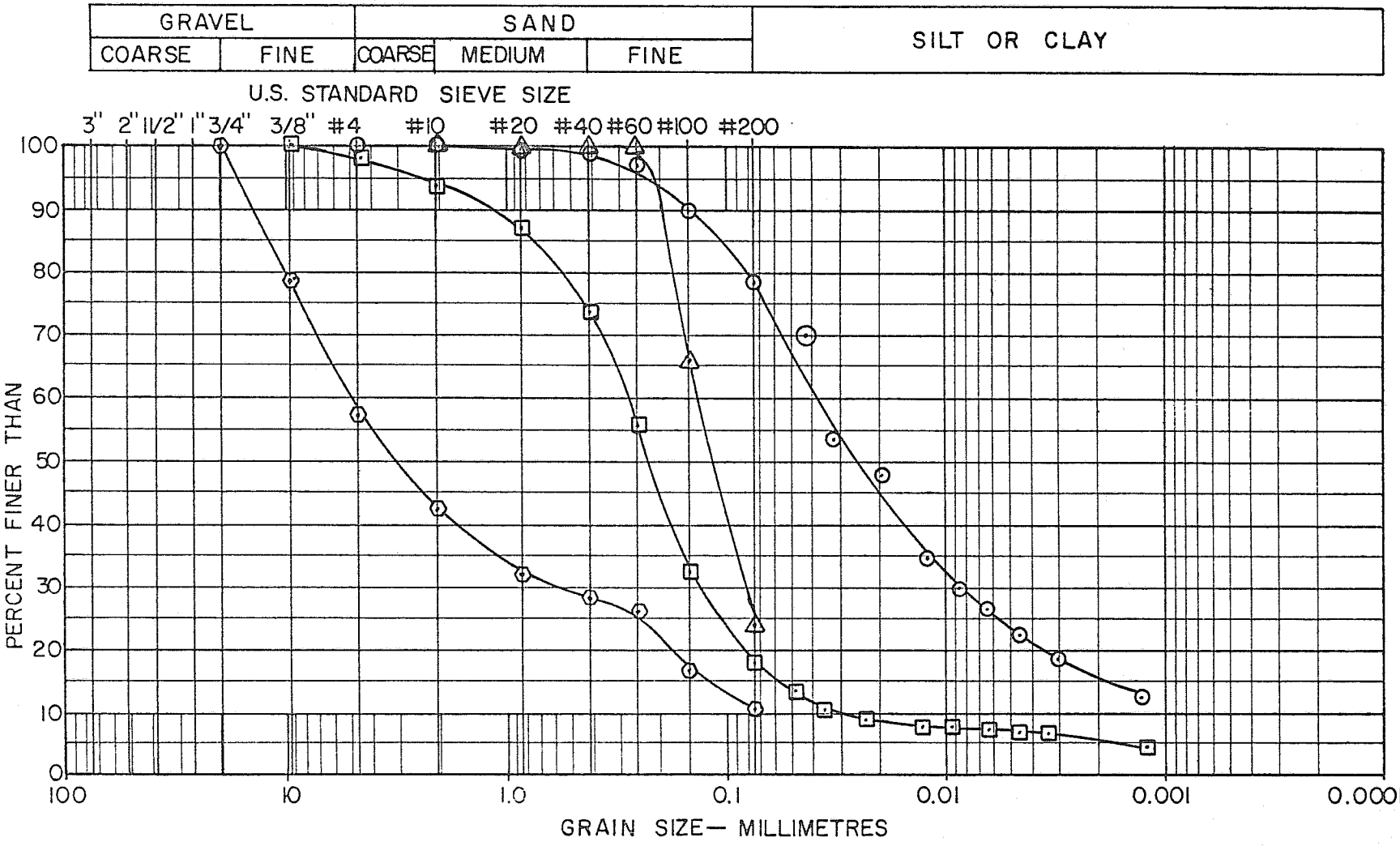
JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 8 to 9
HOLE No. 77-4-4
DATE Sept. 21/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

- Sample 3 at 2.1 to 2.3m. SILT - some fine sand, little clay
- Sample 4 at 3 - 3.2 m. SAND - fine, uniform, some silt
- Sample 5 at 3.7 - 3.9 m. SAND - little silt
- Sample 10 at 8.5 - 8.9 m. GRAVEL AND SAND - little silt

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 8 to 9

HOLE No. 77-4-4 DEPTH

DATE Sept./77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
1	B		1
	B		2
2	B		3
	B		4
3	B		5
4	SPT	18 10 9	6
5	SPT	24 23 21	7
6	SPT	17 20 24	8
7	SPT	25 Ref	9
8			
9			
10			

SYMBOL

PERMAFROST

N.R.C. CLASS | N.F. or F.

LOCATION See Drawing A-0890-4-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

0.2 m. MOSS- organic cover

SILT AND CLAY
- trace sand
- trace organics
- low plasticity
- grey

2.0 m.

GRAVEL
- fine to coarse
- some sand
- little silt
- layers of sand

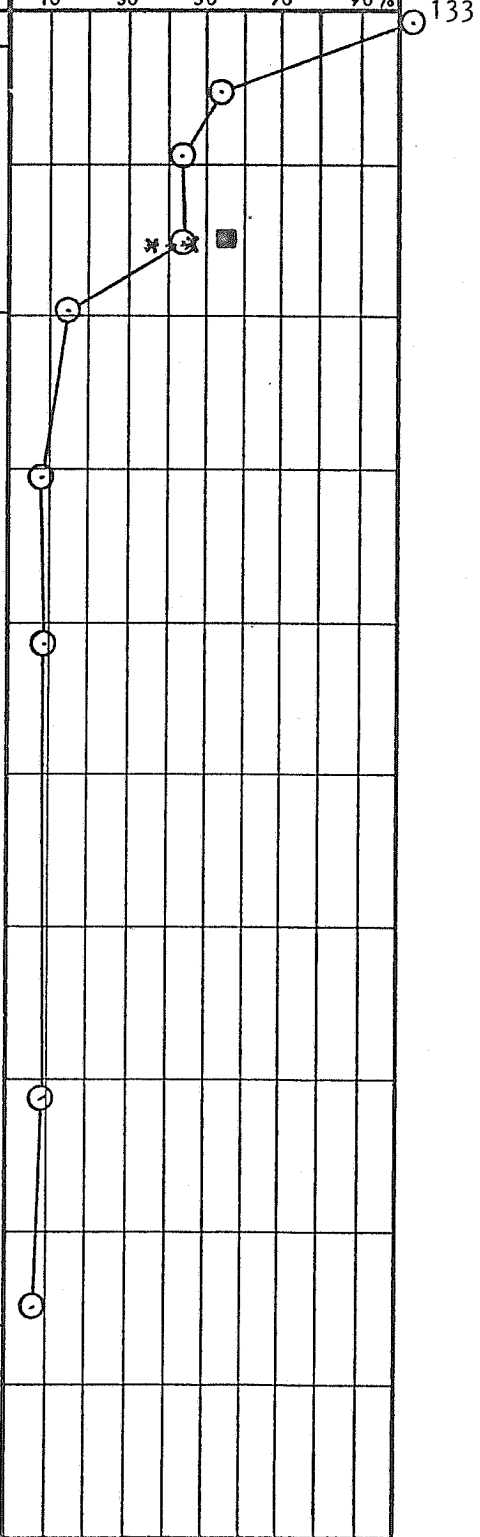
N.F.

Notes:

1. Hole located on a flat swampy area with water to a depth of 0.2 to 0.5 M.
2. Vegetation consists of shrubs with birch & white spruces in surrounding.
3. Drilling mud used from 3 to 8.6 M.
4. Thermistors installed at 0.5, 1.5, 3.0 and 6.0.
5. Piezometer installed. Water level at ground surface.

8.6 m.

END OF HOLE



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No.	77-4-5
DATE	Sept. 21/77 PLATE

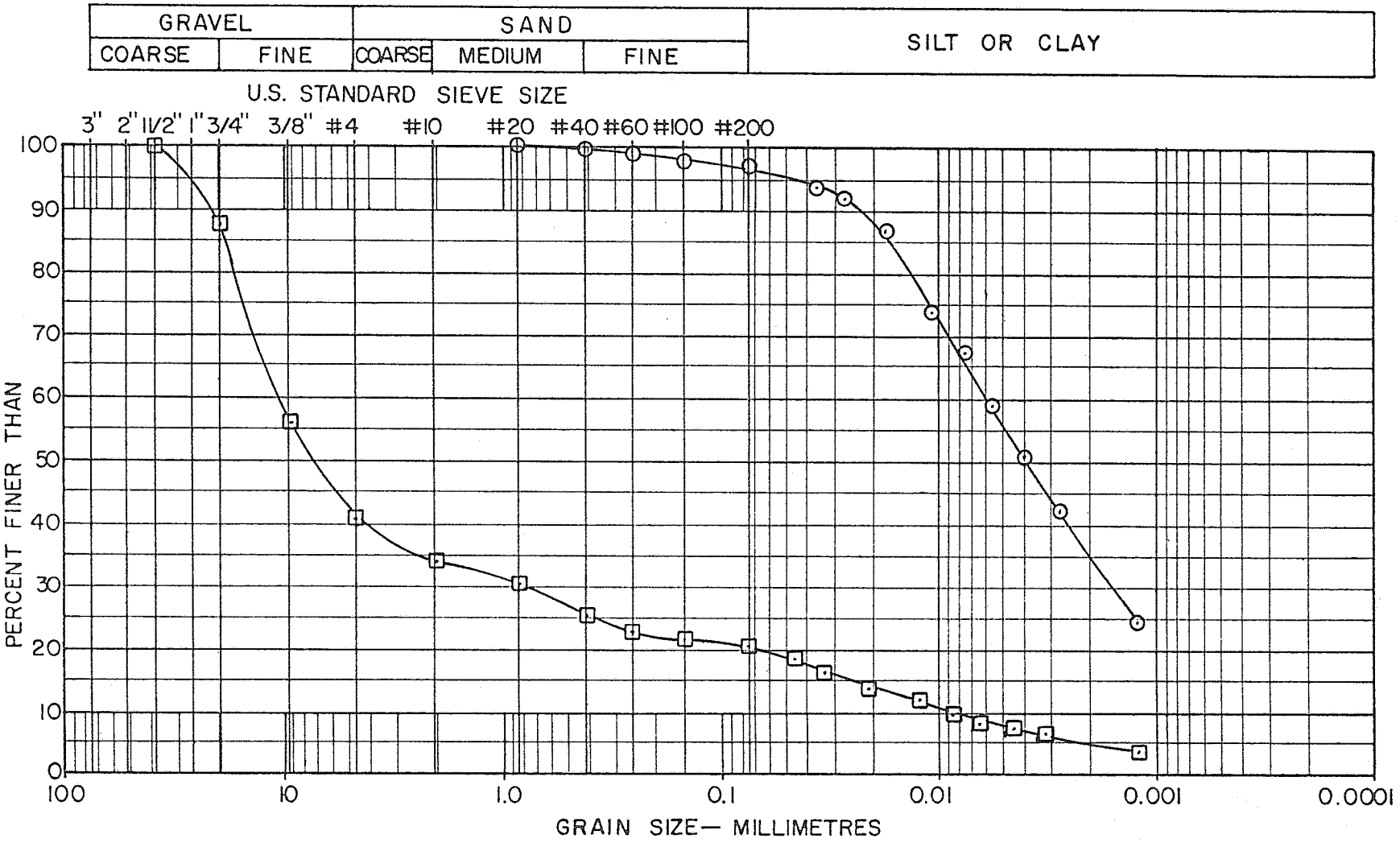
K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0390
PROJECT	Frost Heave Test Sites
LOCATION	MP 3 to 9
HOLE No.	77-4-5
DEPTH	
DATE	Sept./77

GRAIN SIZE CURVE



REMARKS:

Sample 3 at 1.5 m. SILT & CLAY - trace sand

Sample 4 at 2.0m. GRAVEL - some sand, little silt

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B		1			N.F	MOSS- grass cover PEAT
	C		2		Vs		0.55m. ICE & SILT
1					Vr		0.7m. SILT- trace sand
	C		3		Vs		1.2m. ORGANIC SILT 1.4m.
2							GRAVEL - fine to coarse - subangular - some sand - trace silt
3							
4							
5					N		
	B		4				
6							
7							
8							
							8.5 m.
9							END OF HOLE
10							

LOCATION See Drawing A-0890-4-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

669
223
154

Note:
1. Hole located on flat & poorly drained area. Free water on ground surface.
2. Vegetation consists of peat tussocks & grass with buck-brush 1-1.5m. high.
3. Drilling mud used from 1.4 to 8.5 M.

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

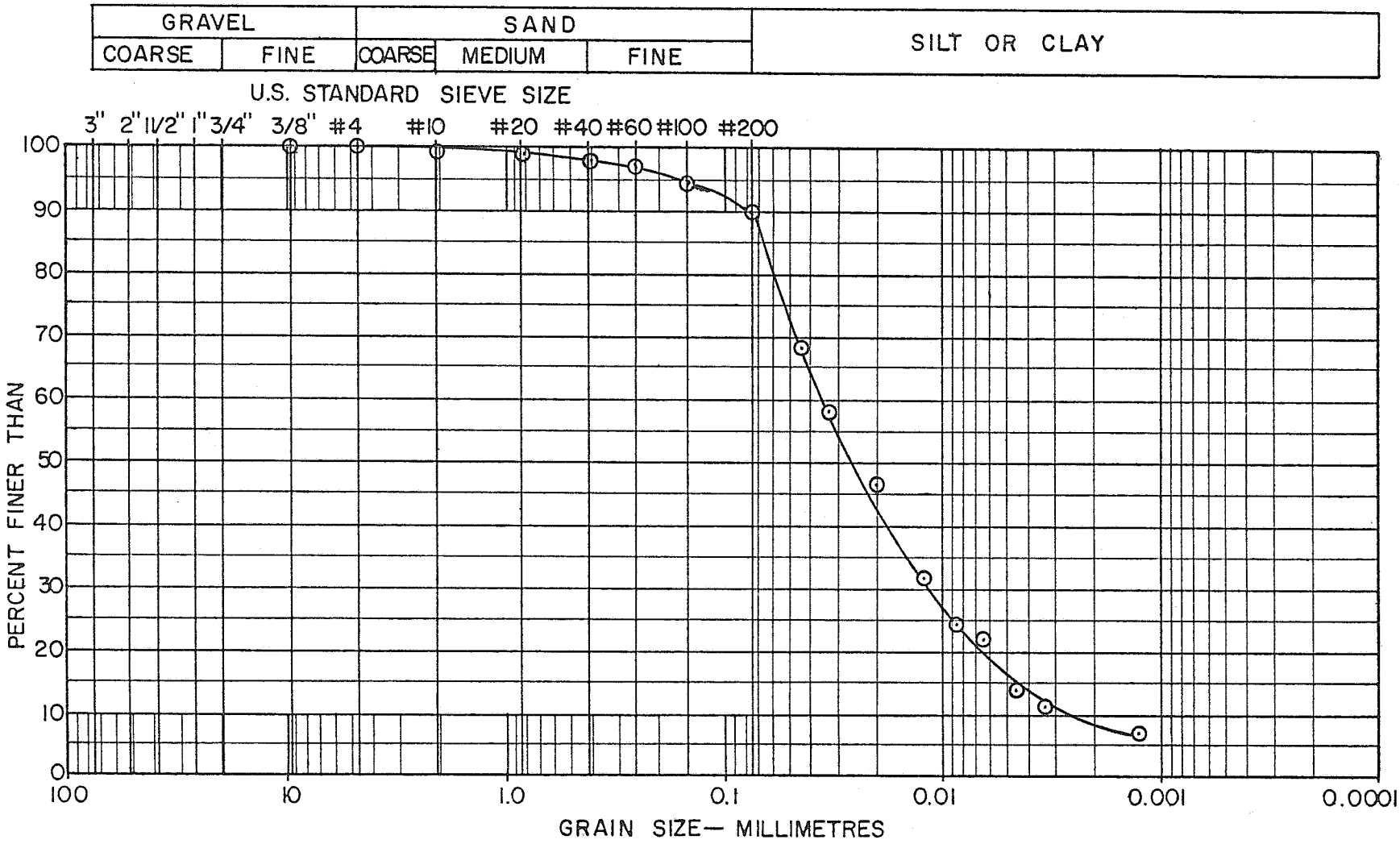
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No.	77-4-6
DATE	Sept. 23/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sample 2 at 0.7 - 1.0 m. SILT - trace sand, trace clay

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 8 to 9
HOLE No. 77-4-6	DEPTH
DATE Sept./77	

SITE 5 (MP 25 - 24.5)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 24 and 24.5 of the proposed pipeline right-of-way. The Alaska Highway passes within 150 m. of test hole 77-5-1 at the north end of the site. The reader should refer to the location plan on Plate A-0890-5-1 as well as the aerial and site photographs on Plates A-0890-5-2 & 3.

2.0 SUMMARY

The site is located in a broad, gently sloping valley bounded by a steeply sloping upland on the southeast. The valley is a former meltwater channel (MC(PT)) which is flanked by upland areas classified as outwash (OW) and moraine (RKM,HM) underlain by bedrock at shallow depths in the ridge areas.

The site is drained by Enger Creek which flows to the north and west into Beaver Creek which empties into the White River drainage system. The valley is vegetated with a very light growth of spruce and brush except along the creek where the spruce are dense and up to 20 m. high.

Based on three test holes in the valley, the soils consist of an upper sequence of fine laminated organic silts overlying a coarse gravel and sand stratum at depths between 0.6 and 4.55 m.. A fourth test hole drilled on the upper valley slopes encountered 4.9 m. of interlayered colluvial sand, silt and gravel overlying a coarse gravel stratum.

Permafrost is widespread at the site. Three test holes encountered permafrost beneath a shallow unfrozen active layer to the maximum depths drilled. Test hole 77-7-2 drilled within 5 m. of Enger Creek encountered a permafrost talik from 1.0 to 5.0 m., above and below which the ground is unfrozen.

The upper fine grained silt strata in all four test holes has a high ice content. The ice generally occurs as thin, closely spaced horizontal lenses. The ice content of the gravel underlying the

site was difficult to determine as mud was used as the drilling fluid. Based on the cuttings returned in the drilling mud, the ice content of the gravel is believed neglible.

3.0 SITE DESCRIPTION

Test hole 77-5-1 is located at the north end of the site, approximately 150 m. southwest of the Alaska Highway and 70 m. east of the H-F pipeline. The ground elevation at the test hole is about 1 m. above Enger Creek which is located 3 m. to the east of the hole. The ground at the site slopes gently towards the creek and is covered with grass, brush and scattered peat tussocks. A dense growth of spruce to 10 m. high exists along both banks of the creek.

Test hole 77-5-3 is located about 400 m. southeast of 77-5-1 and 100 m. east of the H-F pipeline. The ground between these holes is slightly dish-shaped with a large pond in the middle along the H-F pipeline. The drill site is located in a natural clearing overgrown with very sparse stunted spruce to 5 m.. A denser stand of spruce occurs southwest of the site. The terrain has a very gentle 1/2% slope to the northwest and water is ponded between peat tussocks.

Test hole 77-5-2 is located about 800 m. southeast of 77-5-3 along Enger Creek, and about 80 m. east of the H-F pipeline. The ground between these holes is gently undulating, with a maximum slope of about 2%. The creek which is situated 5 m. east of the drill hole is about 1.5 m. wide, 0.2 m. deep and had a flow of about 0.3 cms at the time of the investigation. The bed material in the creek is comprised essentially of gravel and sand. The ground at the site is firm and well drained, sloping about 8% towards the creek. A dense growth of spruce to more than 20 m. high exists along the banks of the creek.

Test hole 77-5-4 is located on a bench above the meltwater channel at the southeast end of the site. The bench slopes 8% to the northwest, whereas the nearby flanks of the meltwater channel slope at more than 20%. A bedrock cored ridge exists east of the site. The ground

surface is firm, moss covered, and supports a moderate growth of spruce to 8 m. high.

4.0 SOIL & PERMAFROST CONDITIONS

4.1 Test Hole 77-5-1

Test hole 77-5-1 was drilled to a depth of 9.0 m. by augering to 0.5 m., coring from 0.5 to 4.7 m., and rotary drilling with mud from 5.7 to 9.0 m.. The subsoils consist of 4.55 m. of silt and organic silt overlying a coarse gravel and sand stratum. From a depth of 0 to 1.75 m. the silt soils are highly organic with extensive peat layers and wood inclusions. The moisture content varies from 125% to more than 200%. The silt soils from 1.75 to 4.55 m. have a little fine and a lesser amount of organic material, with moisture contents averaging about 55%. The underlying gravel and sand is coarse and has a low moisture content of about 10%. Permafrost occurs from a depth of 0.5 to 9.0 m.. The upper fine grained soils to a depth of 4.55 m. have a low to medium ice content. The estimated excess ice content varies from about 2 to 20% by volume. The ice usually occurs in thin 1/4 - 2 cm thick lenses, with a few thicker lenses up to 1 cm.. Based on cuttings returned in the drilling mud, the gravel and sand below a depth of 4.55 m. have a low excess ice content.

4.2 Test Hole 77-5-2

Test hole 77-5-2 was drilled to a depth of 8.55 m. by augering to 1.0 m. and rotary drilling with mud from 1.0 to 8.55 m.. The subsoils consist of a thin veneer of silt and clay to a depth of 0.6 m., overlying a coarse gravel and sand stratum. The moisture content of the silt and clay is about 45%, while that of the underlying gravel and sand material is about 12%.

Based on the drill action and cuttings returned in the drilling mud, permafrost exists from a depth of 1.0 to 5.0 m.. Due to the rotary nature of drilling with mud used as a drilling fluid, representative samples of the gravel stratum were not obtained.

4.3 Test Hole 77-5-3

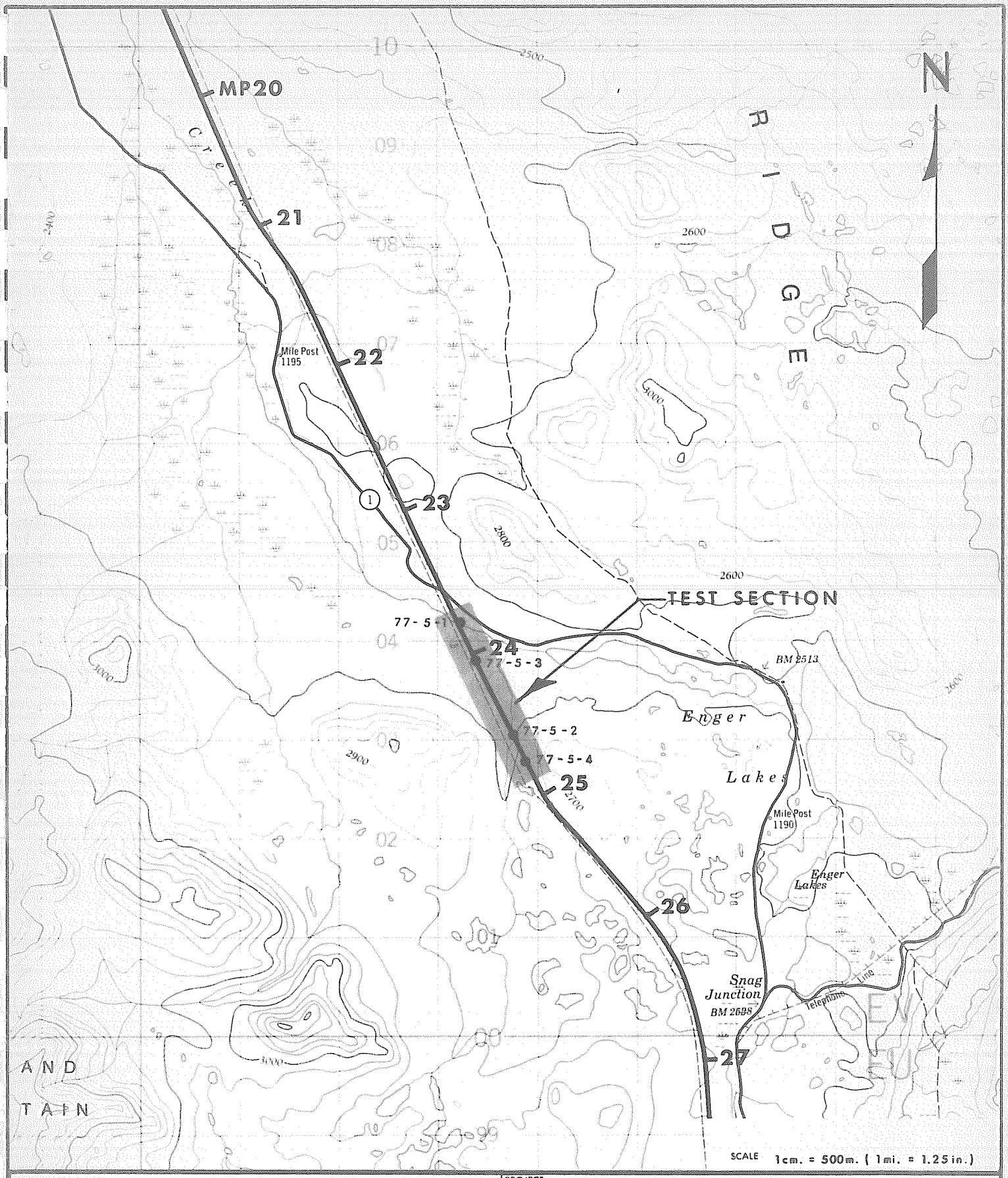
Test hole 77-5-3 was drilled to a depth of 8.5 m. by augering to 1.0 m. and rotary drilling with mud from 1.0 to 8.5 m.. From ground surface to a depth of 2.4 m., the fine grained soils consist of interlayered and laminated organic silt and clay. The moisture content of these soils is high, generally ranging from 100 to 250%. These upper fine grained soils overlie a coarse gravel and sand stratum from 2.4 to 8.5 m.. Due to the rotary nature of drilling with mud used as the drilling fluid, representative samples of the coarse gravel stratum were not obtained.

Permafrost occurs from a depth of 0.5 to 8.5 m.. The upper fine grained soils to a depth of 2.4 m. generally have a medium ice content. The estimated excess ice content varies from about 2 to 25% by volume. The ice usually occurs as random or stratified lenses from 1/4 to 7 mm. thick. Based on cuttings returned in the drilling mud, the gravel and sand stratum below a depth of 2.4 m. has a low excess ice content.

4.4 Test Hole 77-5-4

Test hole 77-5-4 was drilled to a depth of 8.5 m. by augering to 0.5 m., coring to 4.9 m., and rotary drilling with mud to 8.5 m.. The subsoils consist of 4.9 m. of interlayered silt, sand and gravel colluvium overlying a coarse gravel and sand stratum. The interlayered sandy silt and gravel soils have high moisture contents decreasing from about 100% at the top of the stratum to about 40% at a depth of 4 m.. Based on cuttings returned in the drilling mud, the underlying gravel and sand materials are coarse.

Permafrost occurs from a depth of 0.5 to 8.5 m.. The upper fine grained soils to a depth of 4.55 m. have a low ice content. The estimated excess ice content varies from about 2 to 10% by volume. Based on cuttings returned in the drilling mud, the underlying gravel and sand materials have a negligible ice content.



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VANCOUVER - CALGARY - WINNIPEG, CANADA

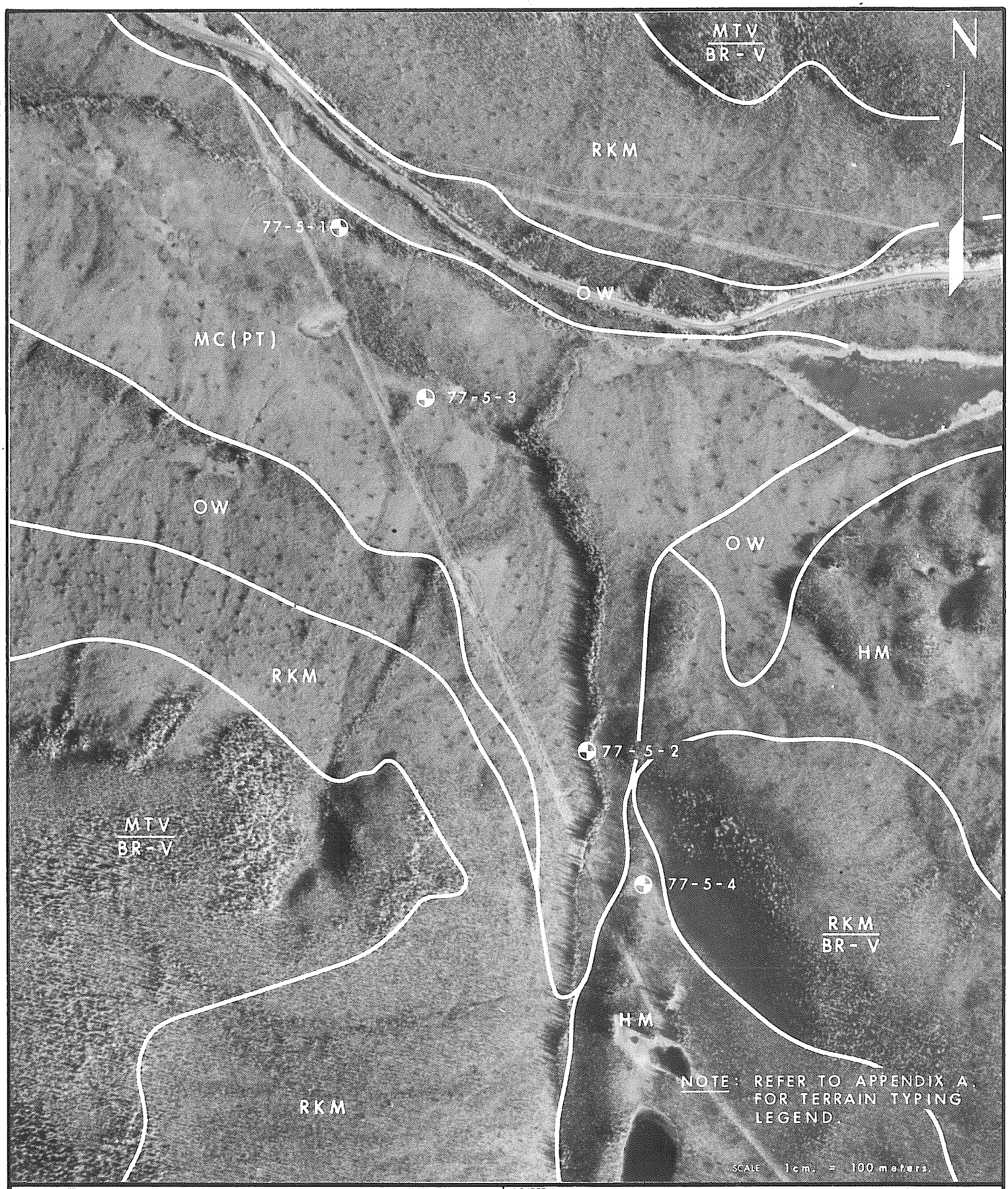
CLIENT: FOOTHILLS PIPE LINES(YUKON)LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN TEST SITE No. 5

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-5-1	

APPROVED: R. L. Edgeworth.



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VANCOUVER - CALGARY - WINNIPEG, CANADA

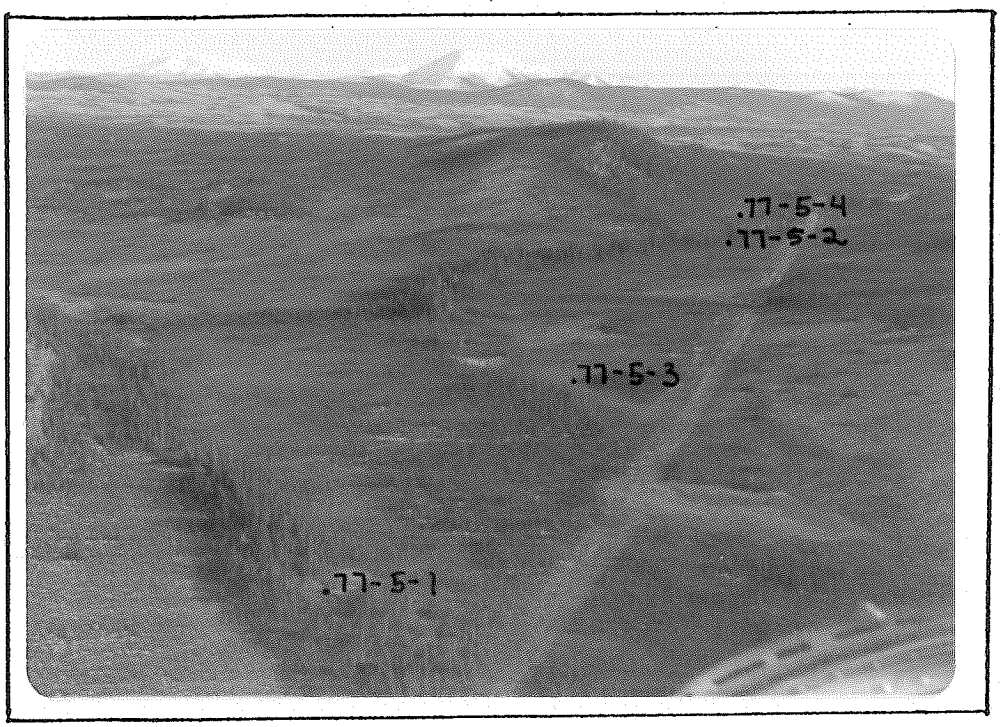
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No. 5

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-5-2	

APPROVED B. L. Edgeworth



SITE 5

View looking southerly at Site 5 along the Haines-Fairbanks pipeline-right-of-way. A heavy tree growth occurs along Enger Creek in the lower left and central parts of the photograph.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

LOCATION See Plate A-0890-5-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW 15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B		1			NF 0.5	0.3m. organic cover
1	C		2		Vr, Vs		ORGANIC SILT - little clay - trace sand - peat layers & organic laminations - slight plasticity
	C		3		Vx		
	C		4		Vr, Vs		
	C		5		Nbn		1.75m. 5cm. ice lense @ 0.95 m.
2	C		6		Vr, Vs		SILT 2.2m. - little sand in lenses
	C		7				SILT - little fine sand - trace clay - wood specks & organic layers - slight plasticity - brown
3							
	C		8		Vr, Vs		
4	C		9				
	C		10		Vx, Vr		extensive black organics 4.55m.
	C		11				GRAVEL - some sand - little silt - trace cobbles - coarser with depth
5					Vx, Vc		
6	B		12				
7							
8							
	B		13				
9							9.0m.
10							END OF HOLE @ 9.0 m.

(cont'd)

156
135
137
216
126
140

Klohn Leonoff Consultants Ltd.
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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 24 - 24.5
HOLE No. 77-5-1
DATE Oct. 3/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X – – – – – – 0 – – – – – – X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located 70 m. east of H-F pipeline and 3 m. southwest of Enger Creek. Terrain slopes 1/2% towards creek.

2. Vegetation adjacent to the creek consists of moderately dense spruce to 10 m., with extensive willows to 2 m.. An open, grassy swamp some 15 m. across is located immediately south of the creek.

3. Hole augered to 0.5 m., cored to 4.7 m., then rotary drilled with mud to 9.0 m..

4. Thermistors installed at 0.5, 1.5, 3.0, and 4.5 m.. Standpipe piezometer installed to 4.5 m..

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 24 - 24.5
HOLE No. 77-5-1
DATE Oct. 3/77 PLATE

K.L.C. - METRIC

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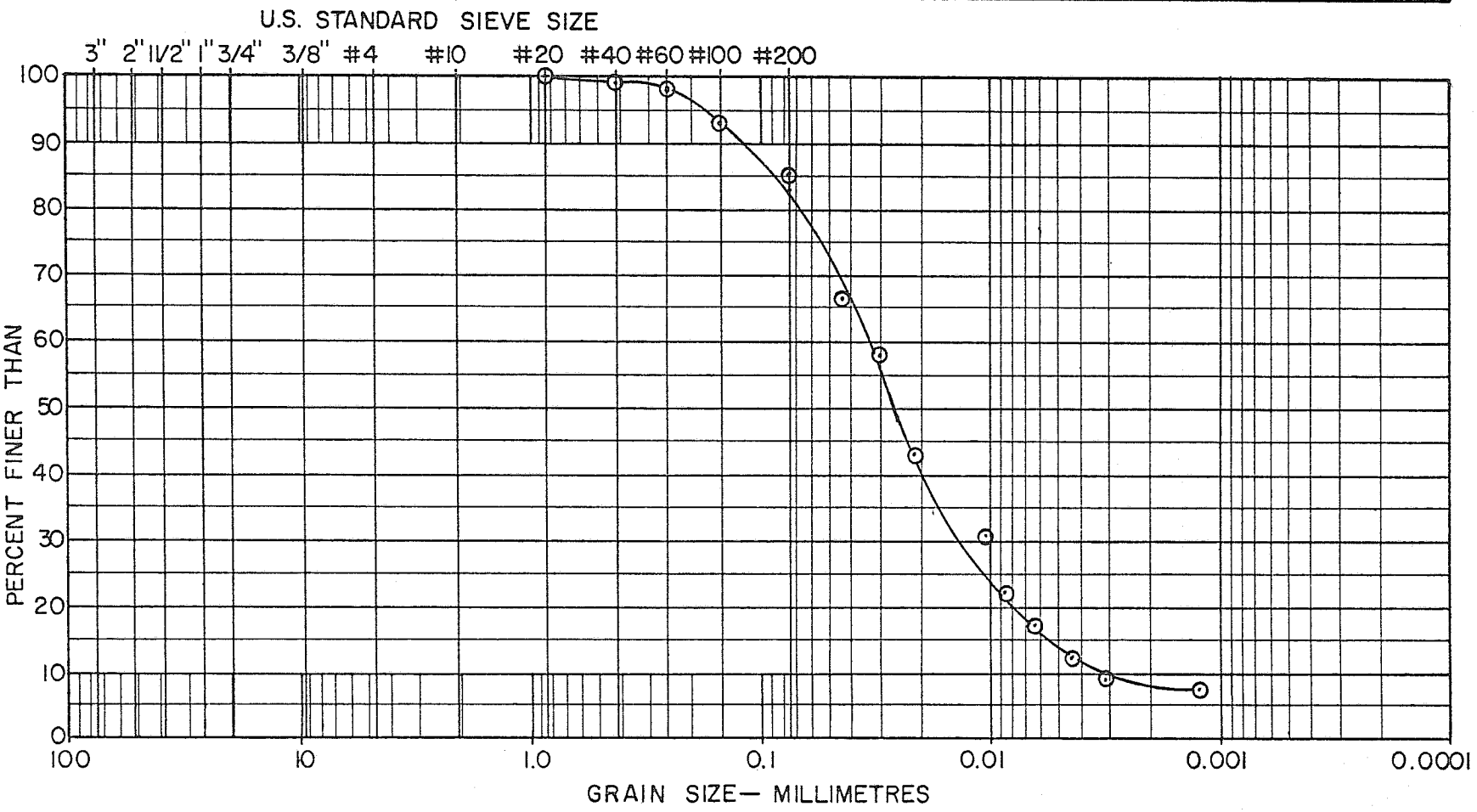
GRAIN SIZE CURVE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



REMARKS: ⊙—⊙ Sa. #9 (3.7 - 4.1 m.) SILT - little fine sand, trace clay

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 24 - 24.5
HOLE No.	77-5-1 DEPTH
DATE	Oct. 3/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 5-1

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.50-0.95	1,120	66.5
4	1.28-1.60	1,330	79.0
7	2.20-2.73	1,400	83.2
9	3.70-4.10	1,640	97.4

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.
1	B		1
	B		2
2	B		3
3			
4	B		4
5			
6			
7	B		5
8			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF 1.0
(?)	
	5.0 NF

LOCATION See Plate A-0890-5-2
ELEVATION

DESCRIPTION OF MATERIAL

0.2m. organic cover

SILT & CLAY
- little sand
- organic laminations
- wood specks

0.6m.

GRAVEL
- little sand
- little silt & clay
- brown

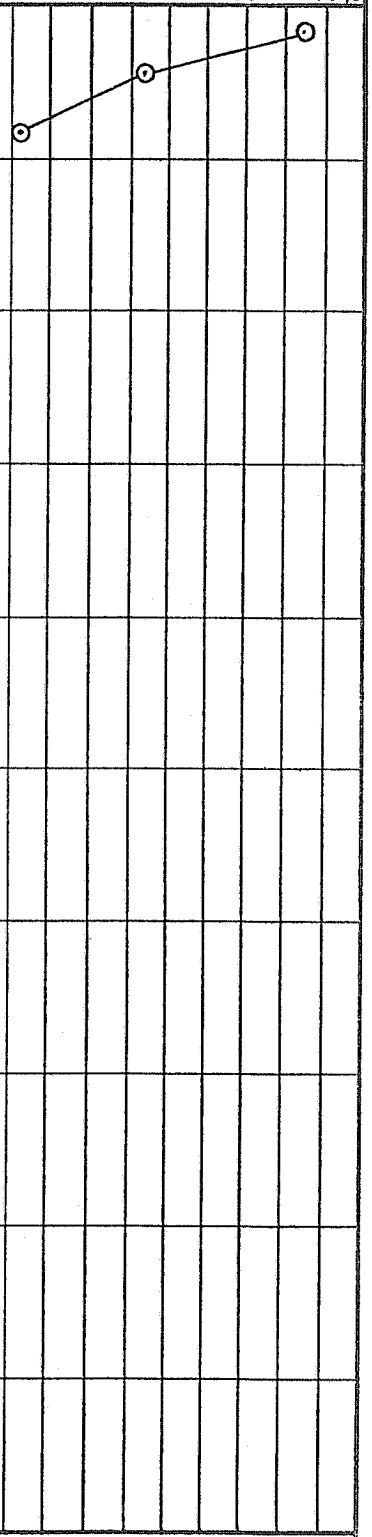
NOTES:
1. Hole located 5 m. from west bank of tributary to Enger Creek. Site is well drained & slopes gently towards the creek.
2. A dense growth of spruce to 20m occurs adjacent to the creek. The ground is firm and moss covered.
3. Hole augered to 1.0 m. and rotary drilled with mud to 8.55m.
4. Thermistors installed @ 0.5, 1.5, 3.0, and 6.0 m.. Stand-pipe piezometer installed.

8.55m.

END OF HOLE @ 8.55 m.

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 24 - 24.5
HOLE No. 77-5-2
DATE Oct. 4/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
						NF	0.25m. PEAT
						0.5	0.50m. SILT & CLAY - dark brown
1	B		1				
	C		2		Vr, Vs		ORGANIC SILT - peat in layers, wood specks - some fine sand - black white sand layer
	C		3				
	C		4				
2	C		5				1.95m. ice lenses 1/4-7mm. thick
	C		6				SILT & CLAY - trace fine sand - slight to low plasticity - dark brown
3							2.4m.
					Vx, Vc		GRAVEL - medium to coarse - some sand - little silt - layered
4	B		7				
5							
6							
7							
8	B		8				
	B		9				8.50m.
9							END OF HOLE @ 8.50 m.

(cont'd.)

LOCATION See Plate A-0890-5-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

64
15
14
27
12
11

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 24 - 24.5
HOLE No.	77-5-3
DATE	Oct. 4/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA: DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST: N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq. cm. (0.2 0.6 1.0 1.4 1.8) ● FIELD VANE △ LAB VANE ■ UNCONF.
DESCRIPTION OF MATERIAL
PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 30 50 70 90%)

NOTES:

1. Hole located 100 m. east of H-F pipeline in an open area. Terrain slopes 1/2% to the northwest.
2. Ground surface has extensive peat tussocks, with virtually no tree growth at the hole location. A dense clump of spruce occurs southwest of the site.
3. Hole augered to 1.0 m. and rotary drilled with mud to 8.5 m.

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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 24 - 24.5
HOLE No.	77-5-3
DATE	Oct. 4/77 PLATE

R.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890

PROJECT Frost Heave Test Sites

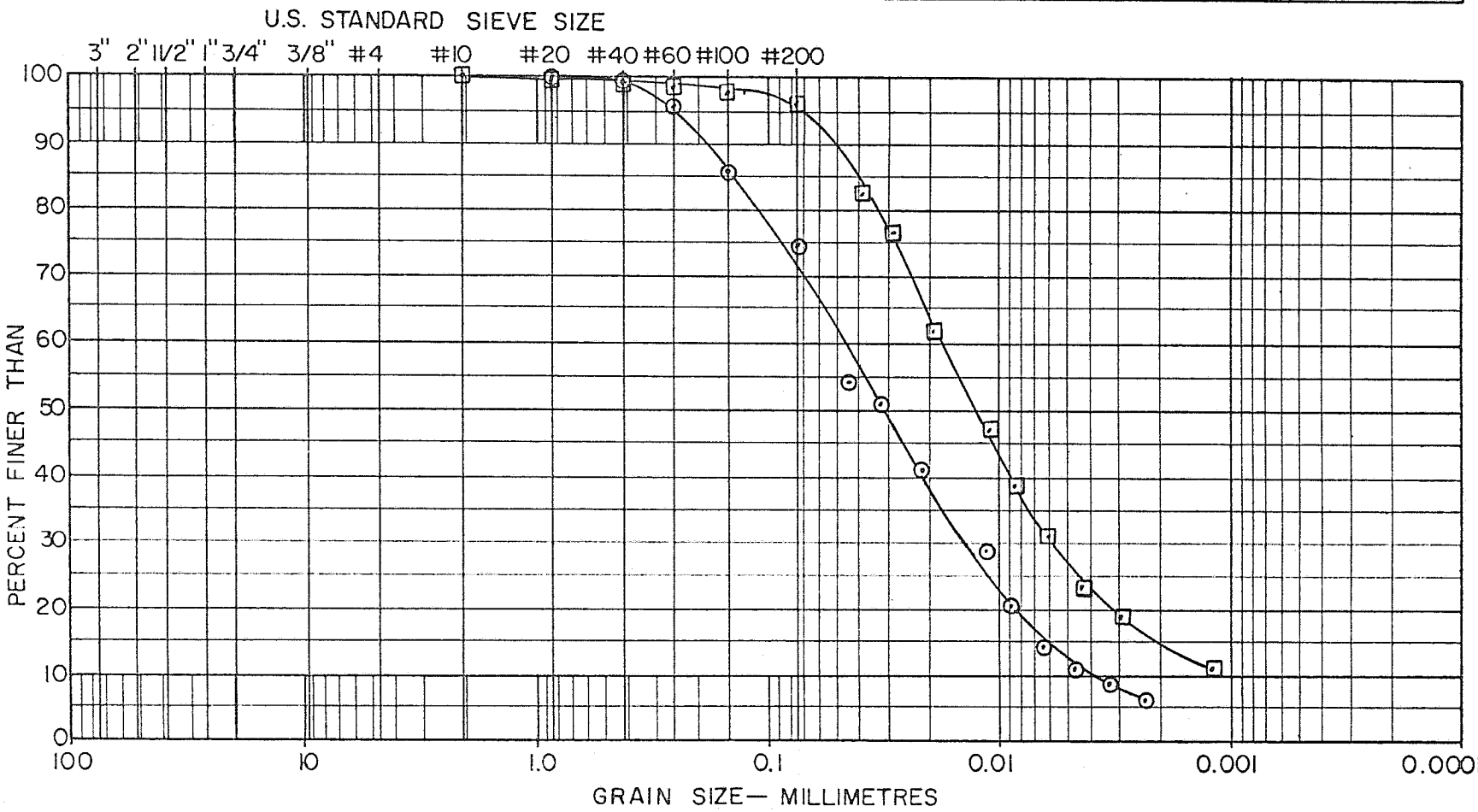
LOCATION MP 24 - 24.5

HOLE No. 77-5-3 DEPTH

DATE Oct. 4/77

GRAIN SIZE CURVE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



REMARKS: Sa. #3 (0.8 - 1.1 m.) SILT - some fine sand, trace clay, non-plastic

Sa. #6 (1.95 - 2.5 m.) SILT & CLAY - trace fine sand, slight to low plasticity

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 5-3

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
4	1.10-1.40	1,130	67.1

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
						NF	0.2m. organic cover
	B		1			0.45	SILT - little sand
1	C		2				- organic
	C		3		Vr, Vs Vx		0.6m. GRAVEL & SILT - some sand
2	C		4				1.15m. SAND - some silt - some gravel - wood specks & organic layers
	C		5				1.85m. ORGANIC SILT - trace sand - slight to low plasticity
3	C		6				2.65m.
	C		7		Vr, Vx		SILT - some sand - little gravel - gravel layers
4	C		8				3.15m. SILT - extensive gravel layers
	C		9		Nbn		4.0m.
	C		10		Vr, Vx		SILT - some sand - little gravel - organic layers
5	C		11		Nbn		4.9m.
	SPT	77 ref.	12				GRAVEL - fine to medium - some sand
6	B		13				
7					Vr, Vx Vc		
8	B		14				coarse - trace cobbles
							8.50m.
9							END OF HOLE @ 8.5m.

(cont'd.)

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

570
114

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 24 - 24.5
HOLE No.	77-5-4
DATE	Oct.5/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
DESCRIPTION OF MATERIAL
COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

NOTES:

1. Hole located on a bench above the meltwater channel. The bench slopes 8% to the northwest, whereas the nearby flanks of the meltwater channel slope at 20%.

2. The ground surface is firm and moss covered, and the area is vegetated with a moderate growth of spruce to 8m. high.

3. Hole augered to 0.5 m., cored to 4.9 m., then rotary drilled with mud to 8.5m.

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 24 - 24.5
HOLE No. 77-5-4
DATE Oct. 5/77 PLATE

K.L.C. - METRIC

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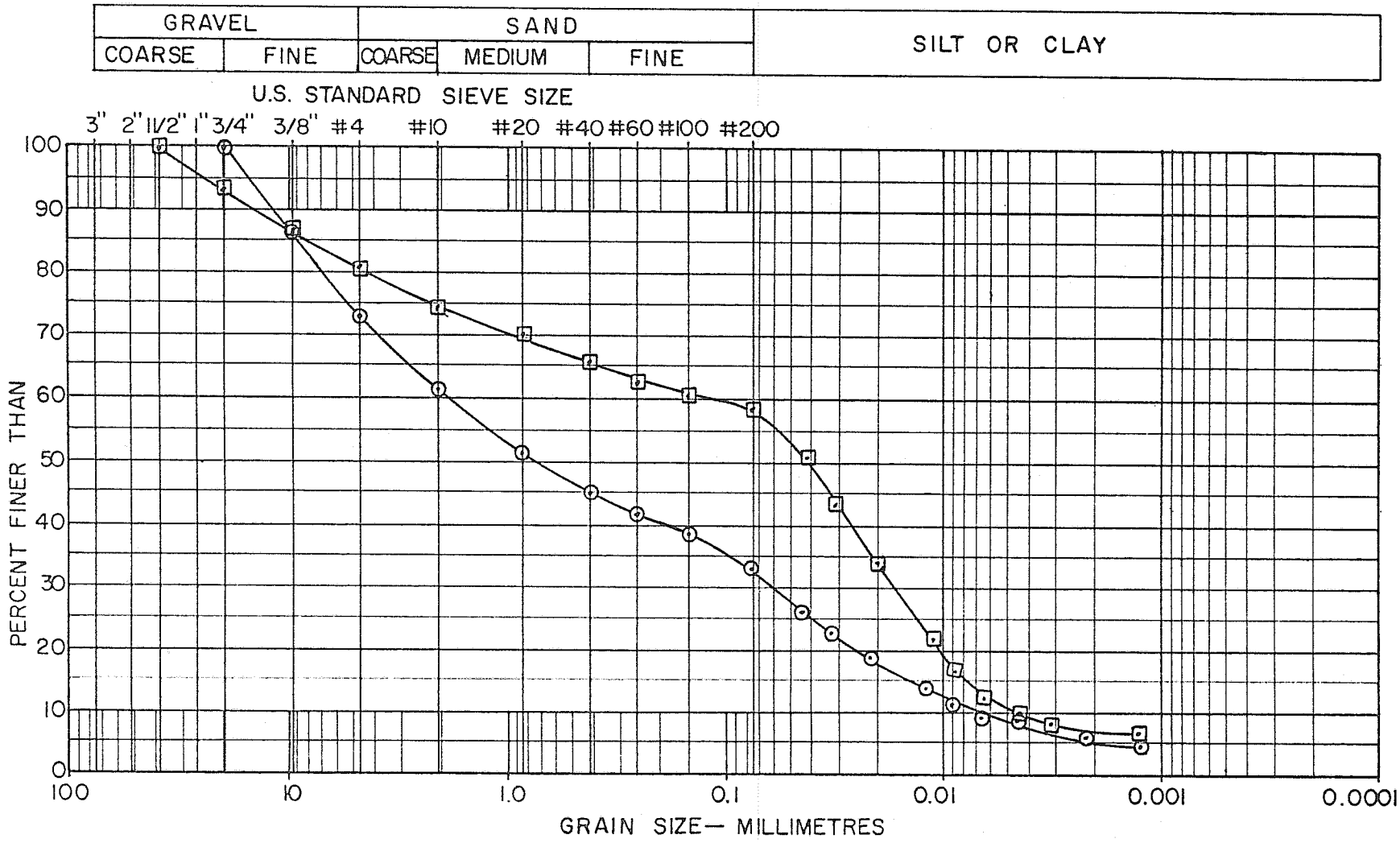
GRAIN SIZE CURVE



REMARKS: Sa. #3 (1.15 - 1.35m.) SAND - some silt, some gravel, well graded

Sa. #11 (4.75 - 4.9m.) SILT - some sand, little gravel

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 24 - 24.5

HOLE No. 77-5-4 DEPTH

DATE Nov. 16/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 5-4

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
6	2.50-3.00	1,640	97.4
9	4.00-4.35	1,590	94.4
10	4.35-4.75	1,640	97.4

SITE 6 (MP 26.5 - 27.5)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 26.5 and 27.5 along the proposed pipeline right-of-way which parallels the H-F pipeline. The Alaska Highway is 400 m. east of the southern part of the site. The reader should refer to the attached location plan on Plate A-0890-6-1 as well as the aerial and site photographs on Plates A-0890-2 & 3.

2.0 SUMMARY

This site encompasses a variety of terrain units. In the north, the terrain is rolling and locally hummocky, with many small ponds and lakes. This area is comprised of hummocky moraine and pitted outwash which marks the maximum ice advance of the Macauley glacier in the Yukon. The southern part of the site consists of low lying gently sloping terrain. This flatter, low lying terrain parallels the Alaska Highway on the west, and is flanked by gently undulating outwash and ridge and knoll moraine.

The northern portion of the site is hummocky, and locally slopes can exceed 20%. The rolling terrain is well drained into the many large water filled depressions in the area. Vegetation consists of a moderate growth of spruce and clusters of tall birch and poplar. The peat terrain in the south has a gentle 1 to 2% slope to the east. Drainage is poor and water is ponded between the extensive peat tussocks in the area. The area is void of tree cover except for a sparse growth of stunted spruce.

Seven test holes were drilled at this site. Five holes were located in the various morainal deposits at the north end of the site. The holes were drilled along or within 50 m. to the east or west of the H-F pipeline right-of-way. The subsoil conditions are relatively uniform in that they consist of an upper stratum of fine grained soils overlying interlayered gravel, sand and glacial till soils. The upper substratum varies from 0 to 3.3 m. thick and consists of variable

silt, clay, sand, and organic soils. The granular substratum which underlies the area consists of interlayered glacial till, gravel, sand and boulders with a variable silt and clay content. The coarse granular, and often unfrozen, material prevented detailed sampling with the rotary drill used for this program.

Based on the five test holes drilled in the moraine at the north end of the site, the permafrost conditions are variable. No permafrost was encountered in test holes 77-6-1, 3, & 4, and therefore large portions of this area are unfrozen. However, permafrost occurs below a depths of 5.8 and 2.5 m. respectively in test holes 77-6-6 and 7. The frozen soils in 77-6-6 are ice rich with lenses up to 4 cm. thick. These variable permafrost conditions typify those expected in the discontinuous permafrost zone.

Test holes 77-6-2 and 5 were drilled in the low lying peat terrain at the south end of the site. Permafrost was found in both test holes below a depth of 0.3 to 0.5 m.. Considerable ground probing indicates extensive permafrost in the area. The subsoils consist of a topstratum of ice rich silt, organic silt and peat varying from about 4 to 6.4 m. thick; overlying gravel and sand materials.

3.0 Site Description

Test hole 77-6-1 is located at the northern end of the site about 50 m. west of the H-F pipeline. A lake is situated 4 m. west of the test hole and the lake level is 20 cm. below the ground elevation at 77-6-1. Large boulders up to 1 m. in diameter are visible along the lakeshore. The terrain in the immediate vicinity is fairly well drained and slopes gently at about 3% into the lake on the west. The ground surface is firm and moss covered. Vegetation consists of a moderate growth of spruce to 5 m. and sparse poplars to 10 m. high.

Test hole 77-6-7 is located on the H-F pipeline right-of-way, about 150 m. south of 77-6-1. The terrain between these two test holes has

a 5% slope to the south. At the drill site the terrain slopes 5% to the east across the pipeline right-of-way. Vegetation near the site consists of a moderate growth of spruce to 10 m. and sparse poplars to 15 m. high.

Test hole 77-6-3 is located about 250 m. south of 77-6-7. The terrain between these test holes is undulating, but has an overall positive gradient to the south. At several locations along the old pipeline there are exposures of gravel and sand as well as several small glacial erratics. The H-F pipeline, which runs north-south across Site 6, is situated 40 m. east of test hole 77-6-3. The drill site is located in a natural clearing which appears to be the dried up bed of a former pond. The natural ground surface in the clearing is grass covered and some 1 to 2 m. lower in elevation than the surrounding terrain. Although local drainage is into this depression, no ponded water existed at the time of drilling. Vegetation adjacent to the clearing consists of willow, spruce and a tall growth of poplar.

Test hole 77-6-6 is located on the H-F pipeline right-of-way, about 200 m. south of 77-6-3. The terrain between these two holes is undulating but has an overall positive gradient of 2% to the south. The drill site is located in a very small drainage course which flows on a 2% gradient to the east across the pipeline right-of-way. Vegetation adjacent to the site consists of a light growth of spruce to 8 m. and sparse poplar to 15 m..

Test hole 77-6-4 is situated about 200 m. south of 77-6-3 and 30 m. west of the H-F pipeline. The hole is located on the top of a broad, low, east-west trending ridge. The terrain in the immediate vicinity of the site slopes about 3% to the east across the pipeline right-of-way. Vegetation consists of a thick growth of willows and moderately dense spruce to 5 m. high.

Test hole 77-6-5 is located about 250 m. south of 77-6-4 and 30 m. east of the H-F pipeline right-of-way. The hole is located in a low lying area about 10 m. lower in elevation than the ridge to the north. The

terrain is poorly drained and slopes gently 2% to the east. The ground surface is covered with peat tussocks and locally has standing water between the tussocks. The area is almost void of tree cover except for very sparse stunted spruce.

Test hole 77-6-2 is located 200 m. south of 77-6-5 and 30 m. east of the H-F pipeline. The poorly drained terrain slopes 2% to the east and is identical to that at 77-6-5.

4.0 SOIL & PERMAFROST CONDITIONS

4.1 Test Hole 77-6-1

This test hole was drilled to a depth of 8.5 m. by augering to 2.0 m. and rotary drilling with mud from 2.0 to 8.5 m.. The topstratum consists of 2.0 m. of silt and sand interlayered with thin gravel materials. Atterberg Limit tests indicate the soil has a non-to-slight plasticity. The moisture content is uniform at about 14%. These upper fine grained soils are underlain by very dense gravel and sand soils below a depth of 2.0 m.. This material has a variable but generally low silt and clay content and occasionally contains boulders.

The entire test hole was unfrozen within the drilled depth of 8.5 m..

4.2 Test Hole 77-6-2

This test hole was drilled to a depth of 10.0 m. by augering to 0.5 m., coring from 0.5 to 4.05 m., then rotary drilling with mud to 10.0 m.. The subsoil profile consists of peat and organic silt, overlying silt, all of which overlies a thick sandy gravel stratum. The peat and organic silt topstratum extends to a depth of 1.4 m. and has a very high moisture content in excess of 250%. The topstratum is underlain by a grey silt material from a depth of 1.4 to 3.92 m.. The silt is laminated with thin seams of sand and clay, and has a slight plasticity. The moisture content decreases from 90 to 30% with stratum depth. The basal stratum below a depth of 3.92 m. consists of gravel and sand with variable amounts of silt, clay and boulders.

Permafrost occurs from a depth of 0.3 m. to 10.0 m.. The upper peat and organic silt stratum has a high ice content with ice lenses greater than 2 cm.. The estimated excess ice content varies up to 60% by volume. The silt soils between a depth of 1.4 and 3.92 m. has a medium to high ice conetnt. Ice lenses are generally less than 5 mm. thick and the estimated excess ice content varies from 10 to 40% by volume. The ice content of the gravel and sand substratum is low based on a single core sample recovered in the upper 2 cm. of the stratum.

4.3 Test Hole 77-6-3

This test hole was drilled to a depth of 9.65 m. by augering to 1.55 m. then rotary drilling with mud below 1.55 m.. The upper 3.25 m. consists of a soft to firm, low plastic, silt and clay. Below a depth of 1.0 m. this material has some fine sand as well as layers of coarse gravel. The moisture content decreases from 50% near ground surface to 15% below a depth of 2 m.. Below a depth of 3.25 m. the subsoils consist of very dense gravelly materials. From a depth of 3.25 to 5.45 m. the soil consists of coarse gravel with both a matrix and layers of sand and silt. Below a depth of 5.45 m. the soil is a glacial till consisting of a well graded gravel, sand and silt and clay. An Atterberg Limit test on the fine matrix material indicates the plasticity index is about 7. The entire test hole was unfrozen within the total drilled depth.

4.4 Test Hole 77-6-4

This test hole was drilled to a depth of 5.5 m. where the hole was abandoned due to continuous sloughing of unfrozen gravel during drilling. The hole was augered to 1.0 m. and rotary drilled with mud from 1.0 to 5.5 m.. The subsoils consist of a 1.0 m. topstratum of silt underlain by gravel and sand (with a variable silt content and occasional boulders) to a depth of 5.5 m.. Due to the rotary nature of the drilling equipment, representative samples of the coarse, unfrozen gravel materials could not be obtained.

The entire test hole was unfrozen within the total drilled depth.

4.5 Test Hole 77-6-5

This test hole was drilled to a depth of 8.5 m. by augering to 0.5 m., coring from 0.5 to 6.4 m., then rotary drilling with mud below 6.4 m.. From ground surface to a depth of 4.9 m. the soils consist of peat and organic silt. The moisture contents in this zone are high, varying from 90 to 350% depending on the relative ice and organic content. From a depth of 4.9 to 6.4 m. the organic materials are underlain by a laminated, non plastic silt. The moisture content decreases with stratum depth from about 75 to 15%. These upper fine grained and organic soils are underlain by coarse gravel with little sand below a depth of 6.4 m..

Permafrost occurs from 0.5 m. to 8.5 m.. The upper peat and organic silt soils have an estimated average excess ice content of about 25% by volume. The silt soil from 4.9 to 6.4 m. has a low ice content. Ice lenses are generally 1/4 to 1/2 mm. thick and the estimated excess ice content is less than 5% by volume. Due to the rotary nature of the drilling equipment, representative samples of the gravel stratum could not be obtained for permafrost classification.

4.6 Test Hole 77-6-6

This test hole was drilled to 6.25 m. by augering to 2.3 m. then rotary drilling with mud below 2.3 m.. Water was encountered at 0.75 m. during drilling. Coarse unfrozen granular materials with a variable silt content were encountered from ground surface to a depth of 5.8 m.. The upper 2 m. consist of a well graded gravel, sand and silt which becomes coarser with depth. From a depth of 2.0 to 5.8 m. the material is a cleaner, medium dense to dense gravel and sand with a trace of silt and clay.

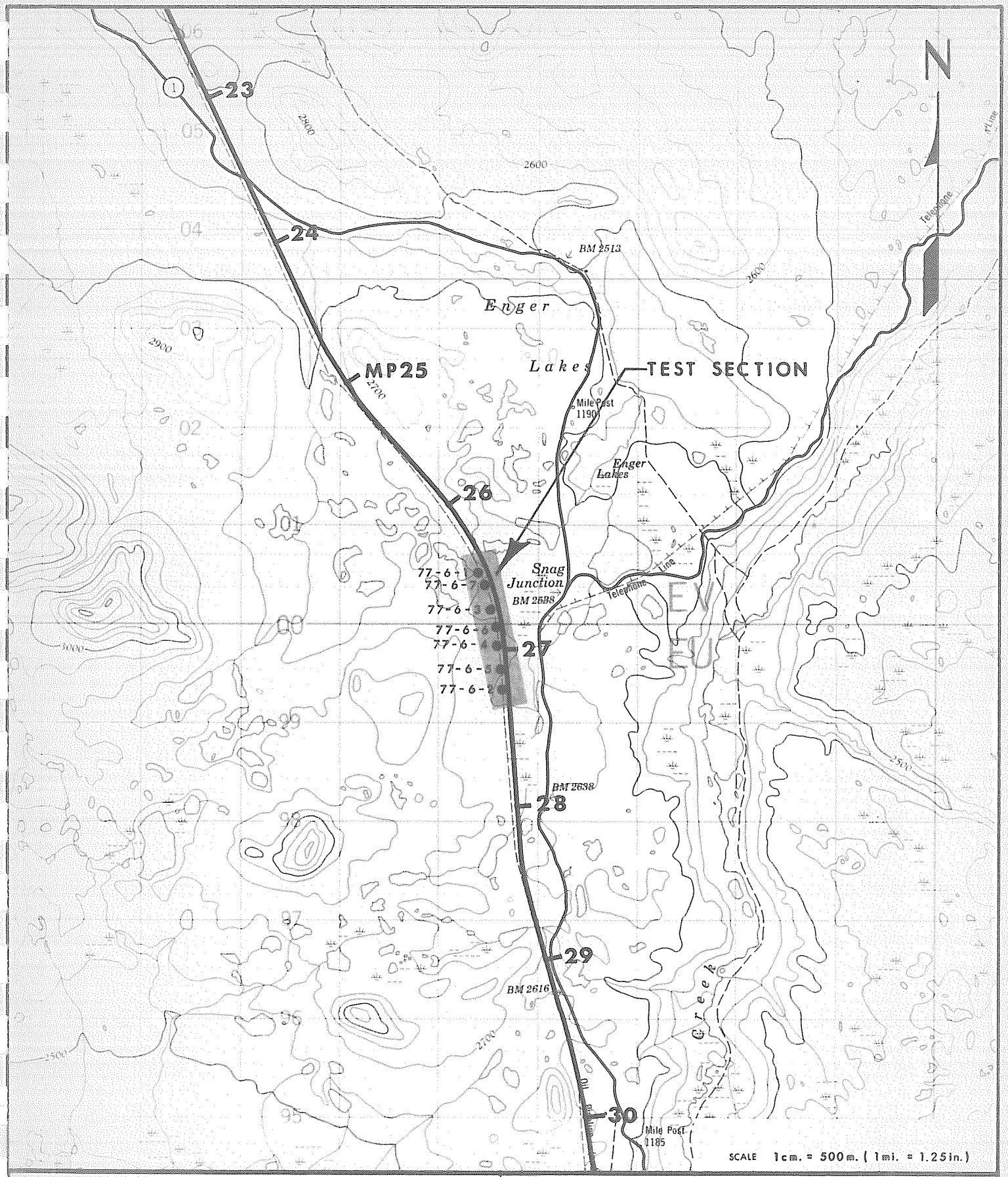
The test hole was terminated in an ice rich sand, silt and gravel layer encountered from a depth of 5.8 to 6.25 m.. Ice lenses up to 4 cm. thick exist in this permafrost-affected soil.

4.7 Test Hole 77-6-7

This test hole was drilled to 8.5 m. by augering to 3.3 m., then rotary drilling with mud below 3.3 m.. The subsoils consist of a 1.95 m.

thick topstratum of silt and clay, with a little coarse gravel and sand, and black organic laminations. The moisture content is variable from 30% to more than 200% in organic layers. This topstratum is underlain by a slightly plastic silt, sand and gravel material from a depth of 1.95 to 3.3 m.. The moisture content averages about 30%. Below a depth of 3.3 m. the subsoils consist of an interlayered gravel and sand with a variable silt content.

Permafrost occurs from 2.5 to 8.5 m.. From a depth of 2.5 to 3.3 m., ice generally occurs as thin 1/2 to 3 mm. thick lenses, although a 1 cm. thick lense occurs at a depth of 3.0 m.. The gravel and sand substratum has a low excess ice content which becomes negligible below 5.1 m..



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CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 6

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT./77.	AL0890	A-0890-6-1	

APPROVED M.L. Edgeworth.

KLOHN LEONOFF CONSULTANTS LTD.
CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No.6

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-6-2	

APPROVED A. L. Ledgerwood.

SITE 6

View southerly at Site 6 along the Haines-Fairbanks pipeline right-of-way, with the Alaska Highway to the east. The old glacial meltwater channel evident in the upper part of the photograph is the present day Dry Creek valley. The undulating and hummocky terrain in the lower part of the photograph marks the northwestern terminus of Macauley glaciation in the Yukon.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B						0.1M PEAT AND SILT - black
	B		1				SILT - and sand - little fine gravel, slight plasticity
1.0	B		2				0.5M SILT & SAND - some fine to medium gravel - gravel subangular to subrounded - slight plasticity
	B		3				
2.0	B		4				2.0M - grey-brown
3.0		34				NF	GRAVEL AND SAND - trace silt - trace clay - trace boulders - gravel fine to coarse - poorly sorted - grey
	SPT	47	5				
4.0		29					
	SPT	28					
		18					
5.0		Sa lost					loss of drilling fluid to formation
		22					
	SPT	42	6				
6.0		56					
7.0	B		7				coarse gravel
8.0							8.5M
9.0							END OF HOLE @ 8.5M

LOCATION See Drawing A-0890-6-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

289
NP
X-X

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 26.5-27.5
HOLE No.	77-6-1
DATE	Oct. 5/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA: DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST: N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located at the southeast corner of a small lake, 4 m from lake and 20 cm above water level. Ground surface is well drained and slopes into the lake. Large boulders visible along lakeshore.

2. Moderate growth of spruce to 5 m and poplars to 10 m.

3. Hole augered to 2.0 m. Drilling mud used from 2.0 to 8.5m.

4. Thermistors installed at 0.5, 1.5, 3.0 and 4.5 m depths.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-1 (Continued)
DATE	Oct. 5/77 PLATE

K.L.C. - METRIC

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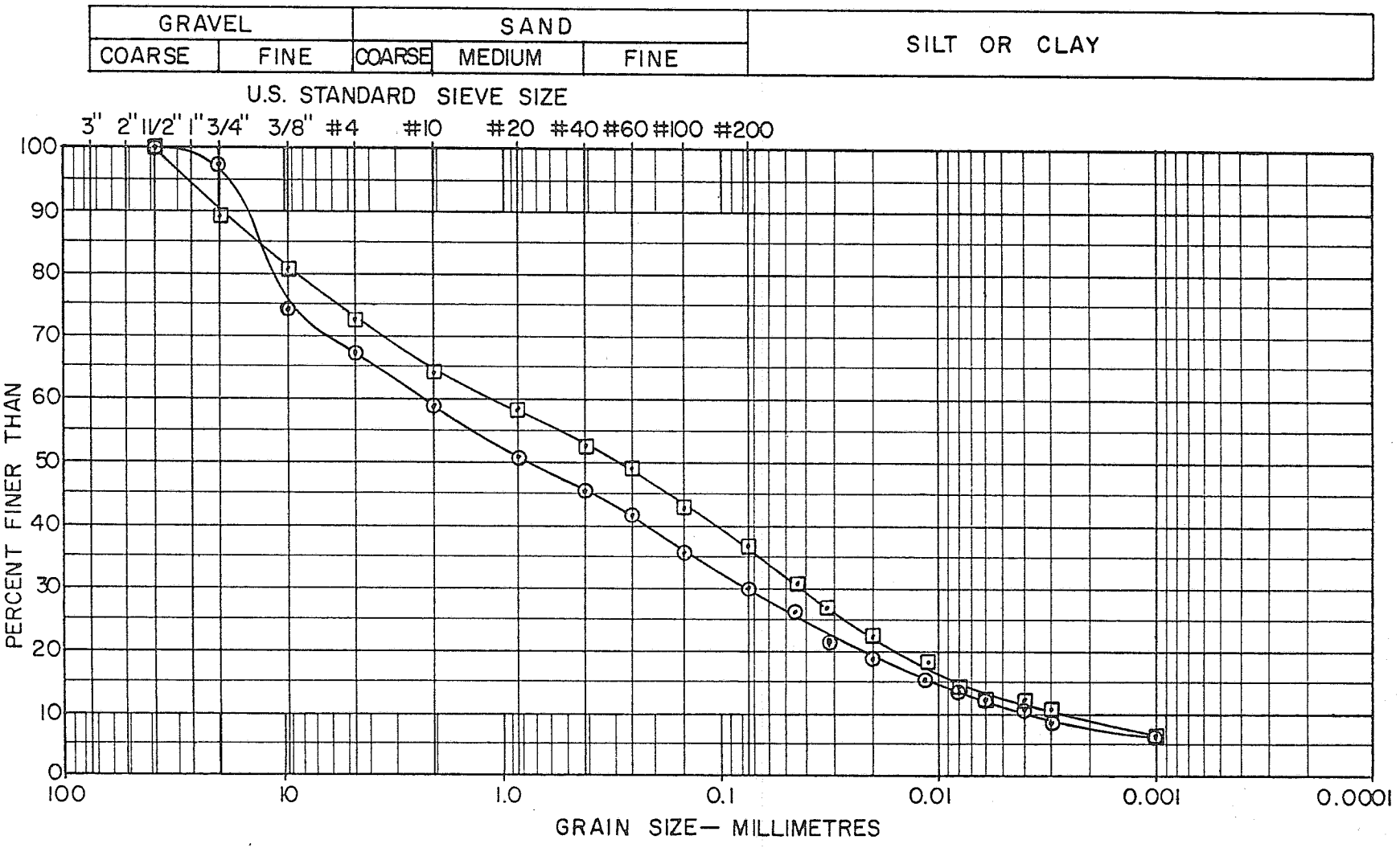
GRAIN SIZE CURVE



REMARKS: Sample 2 at 0.9 - 1.0 m. SAND & SILT - some gravel, trace clay

Sample 4 at 1.9 - 2.0 m. SAND & SILT - some gravel, trace clay, well graded

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 26.5 - 27.5

HOLE No. 77-6-1 DEPTH

DATE Oct. 24/77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.
	B					NF
	B		1		Vr, Vx	
	C		2		Vr, Vx	
1.0	C		3		Vs	
	C		4			
	C		5			
2.0	C		6		Vr,	
	C		7		Vs	
	C		8			
	C		9			
3.0	C		10		Vs	
	C		11		Vr	
	C		12		Vs	
4.0	C		13			
5.0	B		14			
6.0						
	B		15			
7.0						
8.0						
	B	17				
9.0						
10.0	B		16			

LOCATION See Plate A-0890-6-2
ELEVATION

DESCRIPTION OF MATERIAL

PEAT - moss
- considerable wood pieces
- trace silt

8 cm ice lense

1.1m

1.4m ORGANIC SILT - trace sand

SILT
- trace sand, trace clay
- organic specks
- grey

2.4m

SILT
- trace sand, trace clay
- slight plasticity
- grey

ice lenses to 15 mm

ice lenses $\frac{1}{4}$-3mm @ 1-10mm

3.92m ← and gravel and sand

GRAVEL
- some sand
- trace silt
- trace boulders
- coarse
- grey

Notes:

1. Hole located in an open, poorly drained area 30 m east of the H-F P/L. Ground surface slopes 2% easterly.
2. Vegetation consists of peat tussocks on the ground surface and sparse spruce to 3m.
3. Test hole augered to 0.5m, cored from 0.5 to 4.05m and drilled with mud from 4.05 to 10 m.

10.0m END OF HOLE AT 10.0 m

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

287
471
269
333
267

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

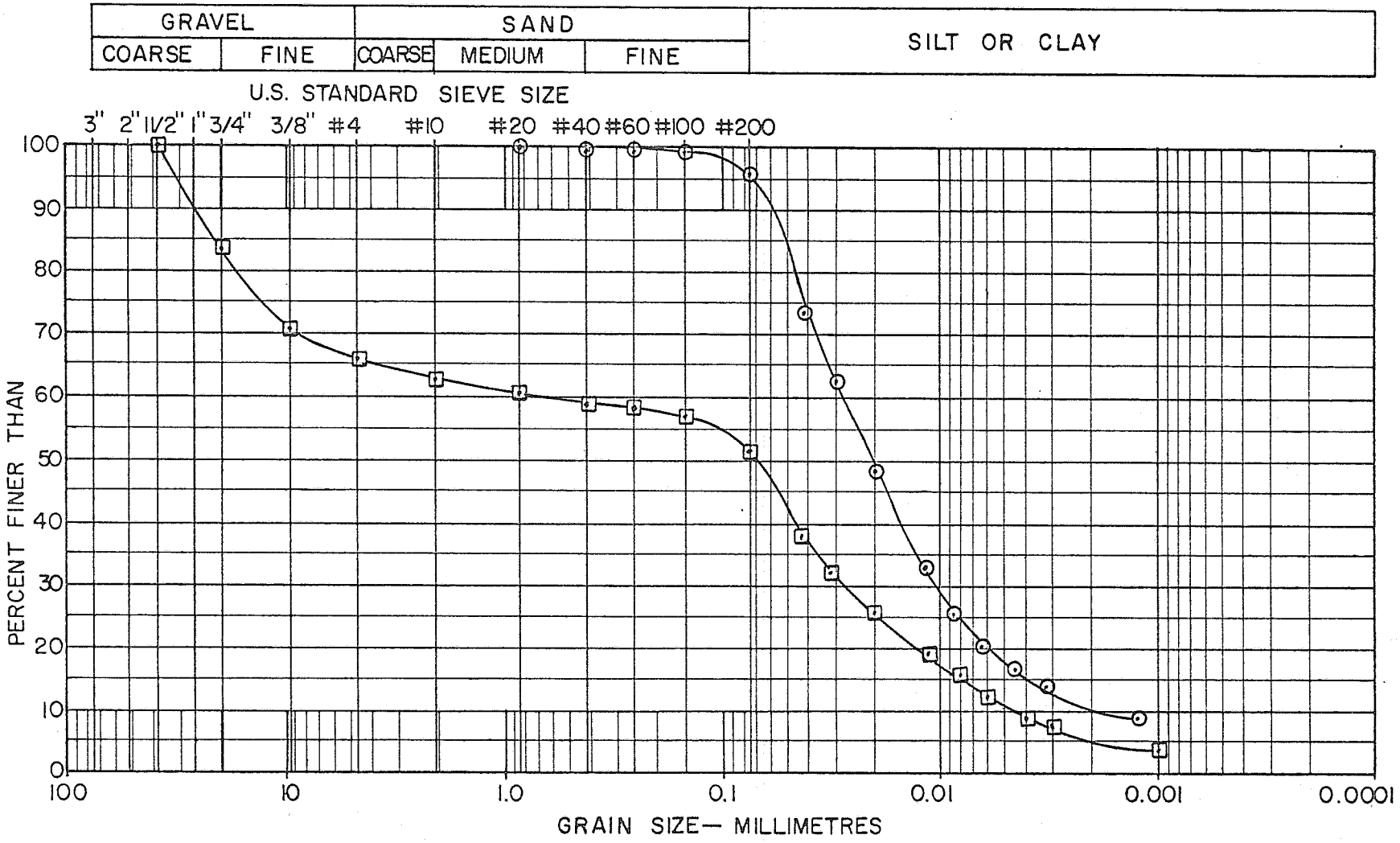
JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-2
DATE	Oct. 7/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sample 5 at 1.4 - 1.65 m. SILT - trace fine sand, trace clay

⊡—⊡ Sample 13 at 3.65 - 4.05 m. SILT - some gravel, little sand, trace clay.

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 26.5 - 27.5

HOLE No. 77-6-2 DEPTH

DATE Oct. 24/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 6-2

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.50-0.80	930	55.2
4	1.10-1.40	960	57.0
5	1.40-1.65	1,290	76.6
7	1.90-2.10	1,460	86.7
10	2.70-3.00	1,550	92.1
11	3.00-3.30	2,020	120.0
12	3.30-3.65	1,740	103.4
13	3.65-4.05	1,720	102.2

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
	B		
	B		1
1.0	B		2
	SY		3
	SPT	10	4
2.0			5
	SY		6
	SPT	9 11 14	7
3.0			
	SY		8
4.0			
5.0		10	
	SPT	18 26	9
6.0			
7.0			
	SY		10
	SPT	12 ref.	11
8.0			
	B		12
9.0			
10.0			

SYMBOL

PERMAFROST: N.R.C. CLASS | N.F. or F.

LOCATION See Plate A-0890-6-2
ELEVATION

DESCRIPTION OF MATERIAL

0.3m GRASS-COVER

SILT & CLAY
- trace sand
- low plastic

1.0m

SILT AND CLAY
- some fine sand
- little gravel and boulders
- fine laminations @ 1 to 25 mm
- discontinuous organic laminations
- slight to low plastic
- soft to firm, brown

boulder

3.25m

GRAVEL
- little silt
- little fine to coarse sand
- medium dense
- brown

NF

5.45m

SAND AND GRAVEL
- some silt & clay
- little gravel
- layers of sand and gravel
- sandier @ depth
- grey and brown

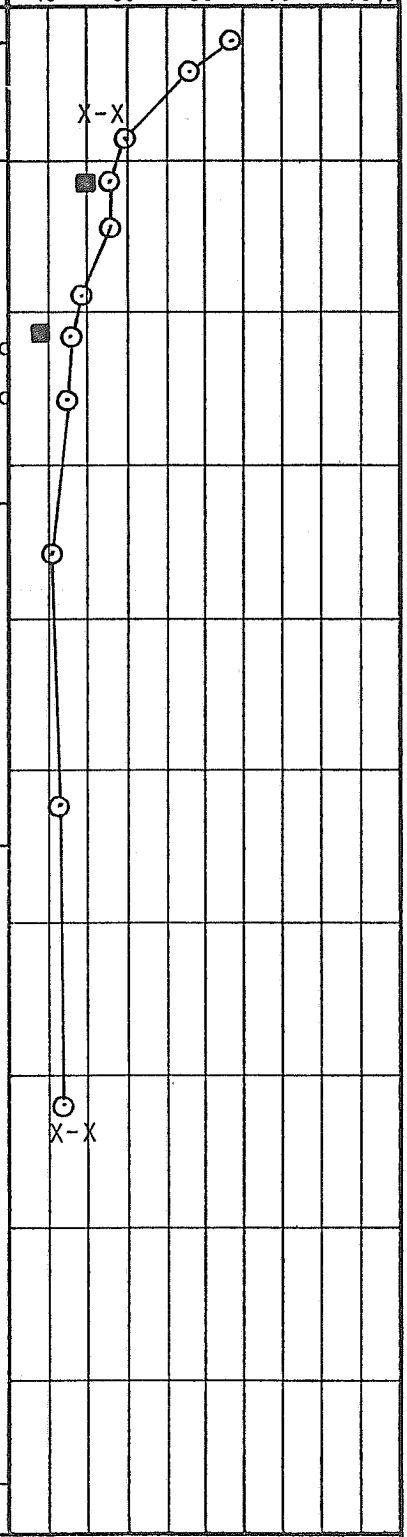
(TILL)

9.65m

END OF HOLE @ 9.65 m.

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
x — — — — — 0 — — — — — x
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-3
DATE	Oct. 7/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F
WEIGHT HAMMER 140 lb.					ELEV GROUND	0 1.0 2.0 3.0 4.0
HEIGHT DROP 30 inches					CO-ORD. LOCATION	● FIELD VANE △ LAB VANE ▩ UNCONF.
DEPTH / ELEV	O.D / I.D.	BLOWS / 6"	NO.		DESCRIPTION OF MATERIAL	PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT X — — — — 0 — — — — X 10 30 50 70 90 %

Notes:

1. Hole located in a depression which was formerly a small pond.
2. Area is grassed and open, surrounded by a dense growth of willow, poplar and spruce.
3. Test hole augered to 1.55 m. Drilling mud used from 1.55 to 9.65m.
4. Installed thermistors at 0.5, 1.5, 3.0 and 6.0 m depth. Standpipe piezometer installed.

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JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-3 (Continued)
DATE Oct. 7/77	PLATE

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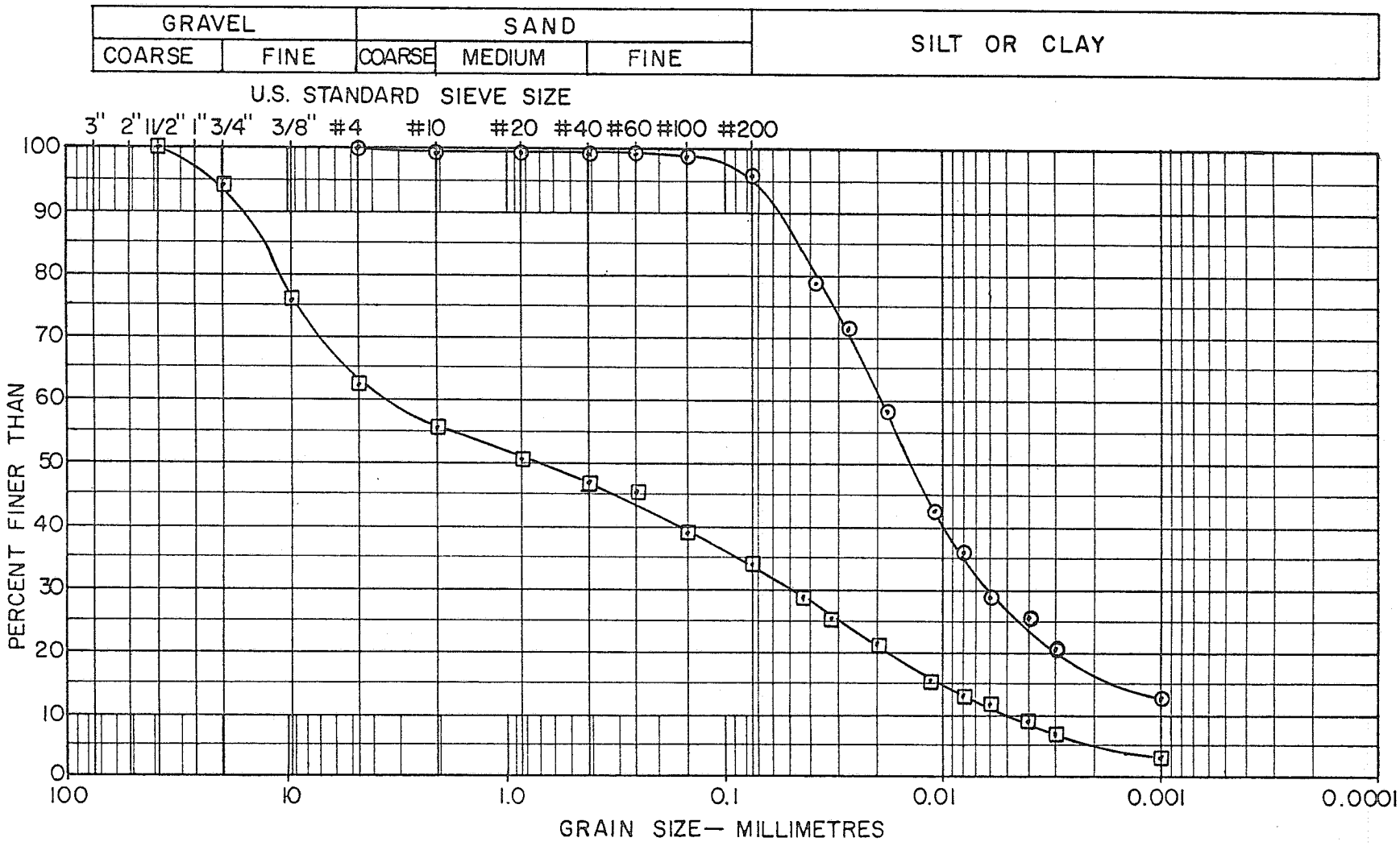
GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sample 2 at 0.75 - 1.0 m. SILT & CLAY - trace fine sand, low plastic

⊡—⊡ Sample 10 at 7.0 - 7.35 m. GRAVEL & SAND - some silt, trace clay

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 26.5 - 27.5

HOLE No. 77-6-3 DEPTH

DATE October 24/77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B		1				0.3m ORGANIC SILT & SAND-moss
	B		2				SILT - and sand, tr. clay - trace gravel - slight to low plasticity
1							1.0m
2	B		3			NF	GRAVEL AND SAND - trace cobbles and boulders - trace silt - fine to coarse gravel - poorly sorted
3							coarse gravel layer from 2 - 2.5 m depth, caving during drilling
4	B		4				
5							5.5m
6							END OF HOLE @ 5.5 m.

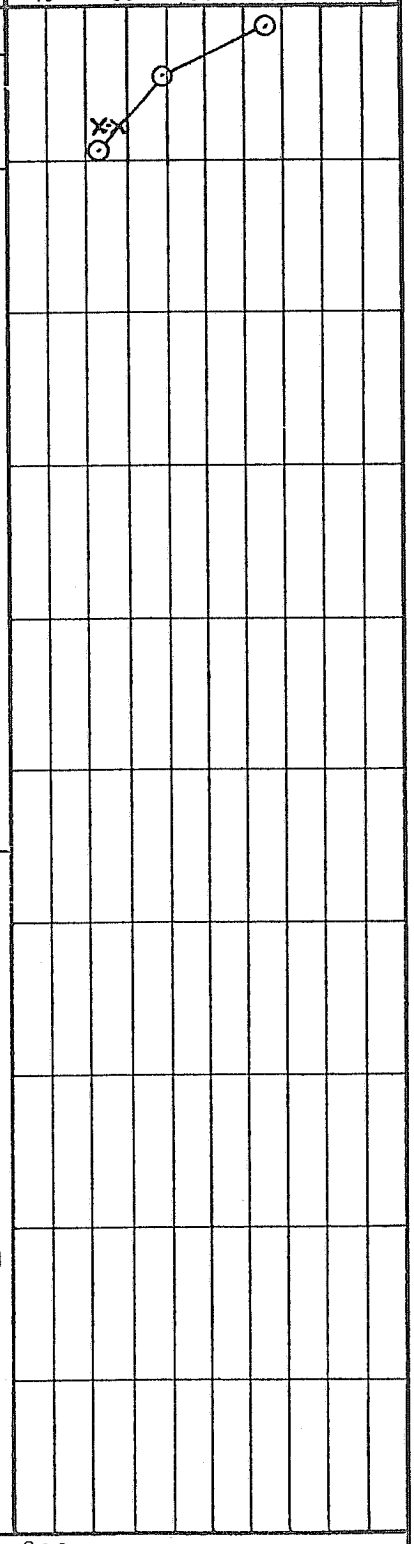
Notes:

1. Hole located 30 m west of the H-F P/L. Terrain slopes 4% to the east.
2. Site overgrown with thick willows and moderately dense spruce to 5m, few poplar to 7 m.
3. Hole augered to 1.0 m. Drilling mud used from 1 to 5.5 m
4. Hole abandoned to 5.5 due to continual caving of sand and gravel.

LOCATION See Plate A-890-6-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-4
DATE	Oct. 8/77 PLATE

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JOB No. AL0890

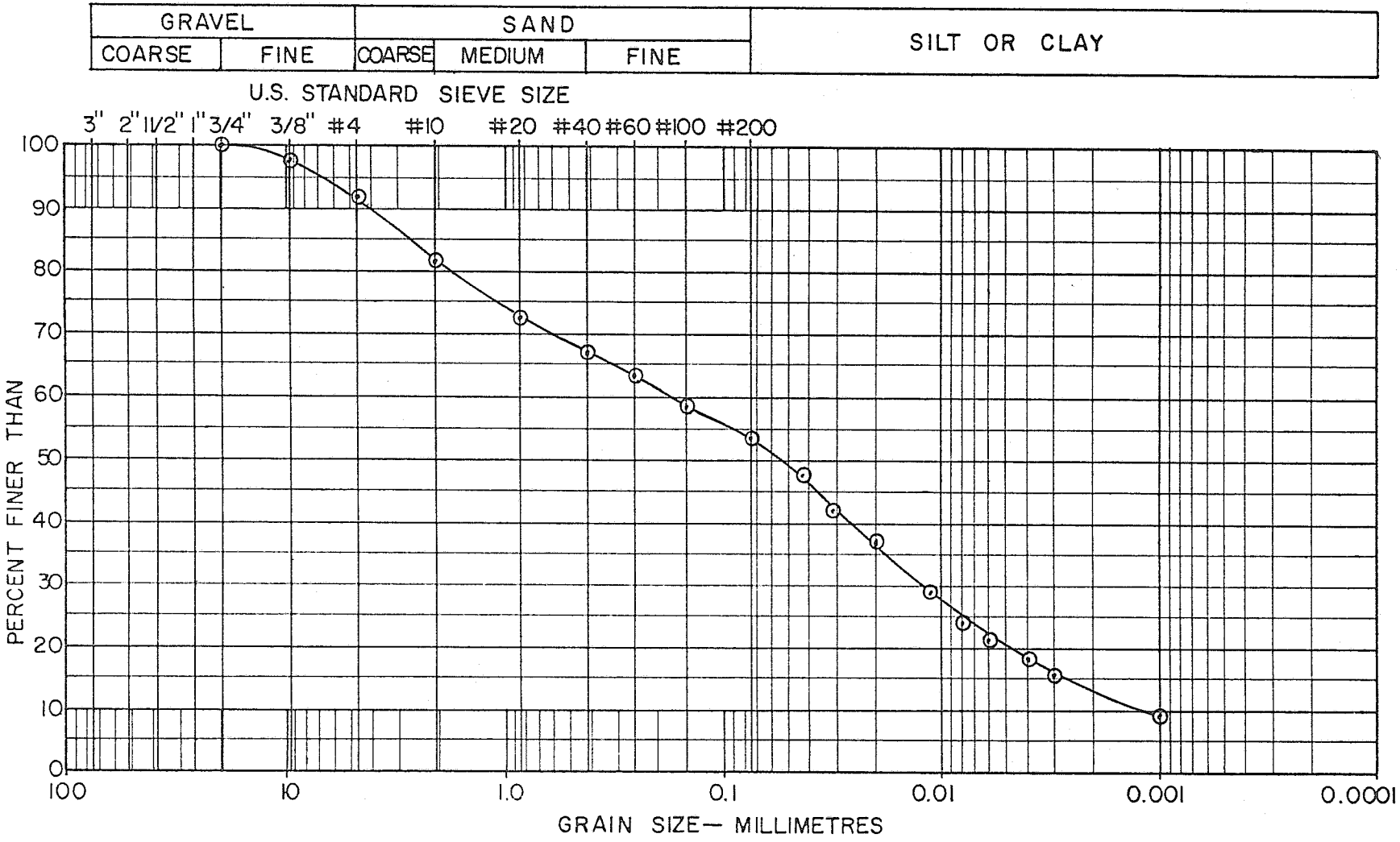
PROJECT Frost Heave Test Sites

LOCATION MP 26.5 - 27.5

HOLE No. 77-6-4 DEPTH

DATE Oct. 24/77

GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sample 2 at 1.0 m. SILT - and sand, trace clay, trace gravel

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

LOCATION See Plate A-0890-1
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B					NF	0.2m ORGANIC SILT-black, spongy
	B					0.5	0.5m SILT AND SAND - trace fine gravel - organics
	C		2		Vr, Vx		Ice lenses 1-5mm spaced @ 2-5 mm
1	C		3		Vr Vs		
	C		4				ORGANIC SILT-layers of peat - trace fine sand - dk brown to grey
2	C		5				Ice lenses 6mm spaced @ 4-5mm
	C		6		Vx, Vr		Ice inclusions to 10 mm
	C		7		Vr		Ice lenses 1-5mm spaced @ 3-5mm
	C		8		Vs		
3	C		9				
	C		10		Vr Vs		wood chunks
	C		11		Vx		Ice lense 10 mm thick
4	C		12				Ice lense 20 mm thick
	C		13				
	C		14		Vs		Ice lenses 1-3mm spaced 2-5mm
5	C		15				4.90m
	C		16		Nbn Vr		SILT - trace fine sand - trace clay - laminated - organic pockets
6	C		17		Vs		
	C		18				6.40m
7	B		19		(?)		GRAVEL - little sand - coarse
8							8.5m
9							END OF HOLE @ 8.5 m
10							

NP
NP

730 129 233 348 192 171 137 109 154 115

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JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-5
DATE	Oct. 9/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located 30 m east of H-F P/L. Area is poorly drained and slopes 2% easterly.

2. Site is open with extensive peat tussocks and ponded water to 0.3 m on ground surface. Sparse spruce to 3 m.

3. Hole cored from 0.5 to 6.4 m. Drilling mud used from 6.4 to 8.5 m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-5 (Continued)
DATE	Oct. 9/77 PLATE

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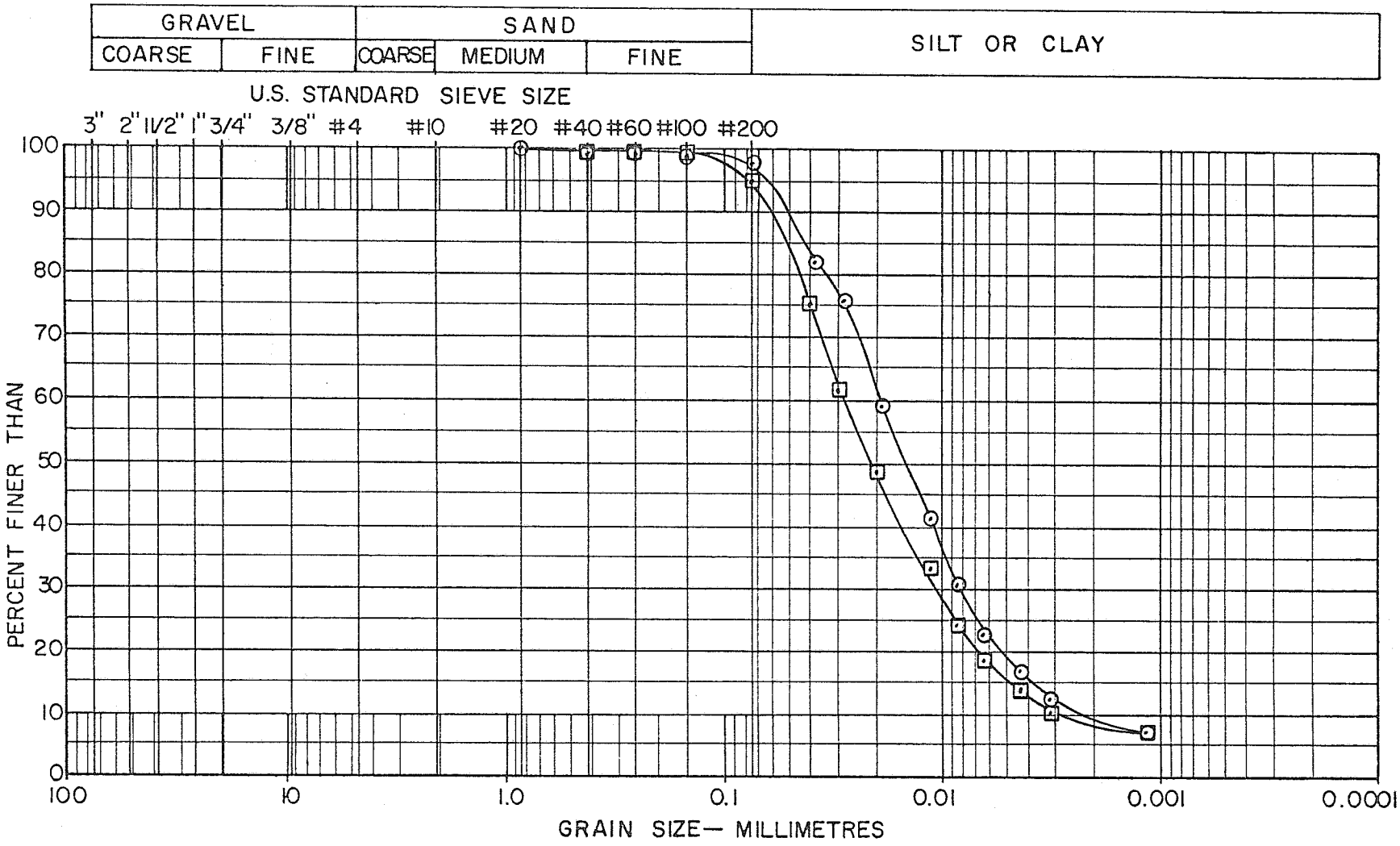
GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sample 4 at 1.2 - 1.6 m. ORGANIC SILT - trace fine sand, trace clay

⊡—⊡ Sample 16 at 5.2 - 5.5 m. SILT - trace fine sand, trace clay

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 26.5 - 27.5

HOLE No. 77-6-5 DEPTH

DATE Oct. 24/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 6-5

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	0.80-1.20	1,210	71.9
4	1.20-1.60	1,080	64.2
5	1.60-1.90	1,270	75.4
6	1.90-2.10	1,200	71.3
7	2.10-2.40	1,330	79.0
8	2.40-2.70	1,480	87.9
10	3.00-3.30	1,180	70.1
11	3.30-3.65	1,220	72.5
12	3.65-4.05	1,340	79.6
13	4.35-4.60	1,320	78.4
14	4.60-4.90	1,340	79.6
15	4.90-5.20	1,380	82.0
16	5.20-5.50	1,640	97.4
17	5.50-5.90	1,750	104.0
18	5.90-6.30	1,790	106.3

TEST HOLE LOG

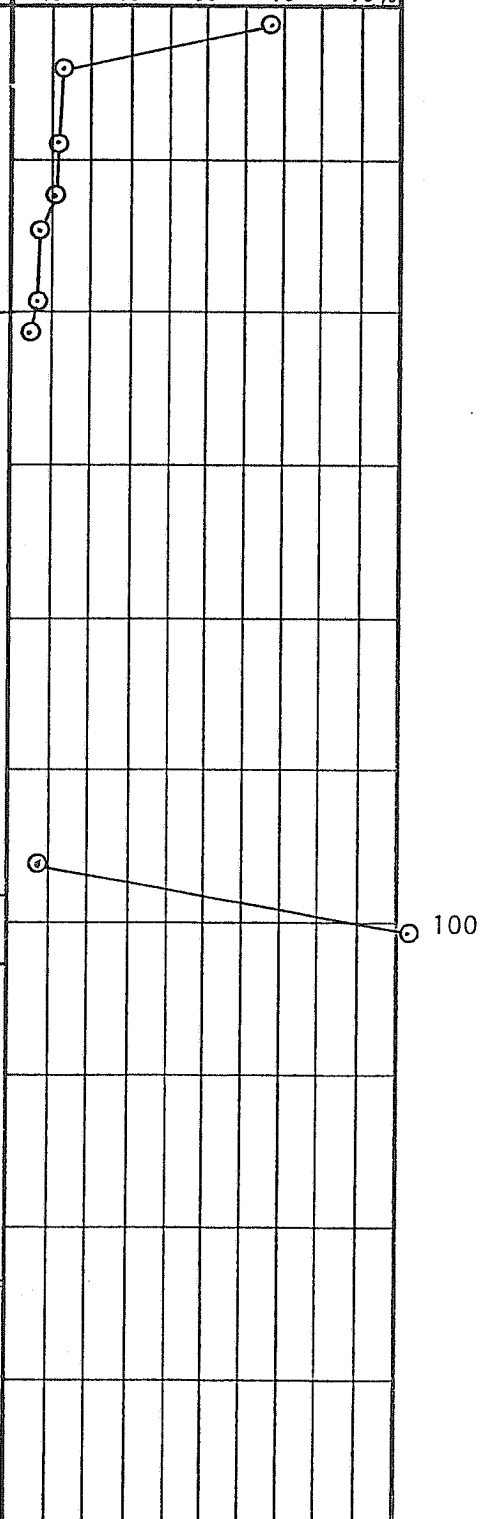
HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B		1				0.1m. organic cover GRAVEL, SAND, SILT - trace clay - trace cobbles - well graded - coarser below 1 m. - dark brown
1	B		2				
	SY		3				
	SY		4				
2	B		5				2.0m.
	SY		6			NF	GRAVEL & SAND - trace silt - organic specks - gravel rounded to subangular - medium dense to dense - grey
3							
4		15					
	SPT	17	7				coarse gravel layer
5		20					
	SY		8				5.8m.
6	SPT		9		Vs		ICE & SAND, SILT, GRAVEL 6.25m. ice lenses to 4cm.
							END OF HOLE @ 6.25 m.
7							NOTES: 1. Hole located along H-F pipeline in small drainage course mid-way between 77-6-3 and 77-6-4. Terrain slopes 2% to the east. 2. Vegetation adjacent to cleared right-of-way is a moderate growth of spruce to 8m. & sparse poplar to 15m. 3. Hole augered to 2.3m. & rotary drilled with mud from 2.3 to 6.5m.. Water encountered at 0.75m. depth during drilling.

LOCATION See Plate A-0890-6-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No. AL0890
PROJECT Frost Heave Test Site
LOCATION MP 26.5 - 27.5
HOLE No. 77-6-6
DATE Oct. 24/77 PLATE

K.L.C. - METRIC

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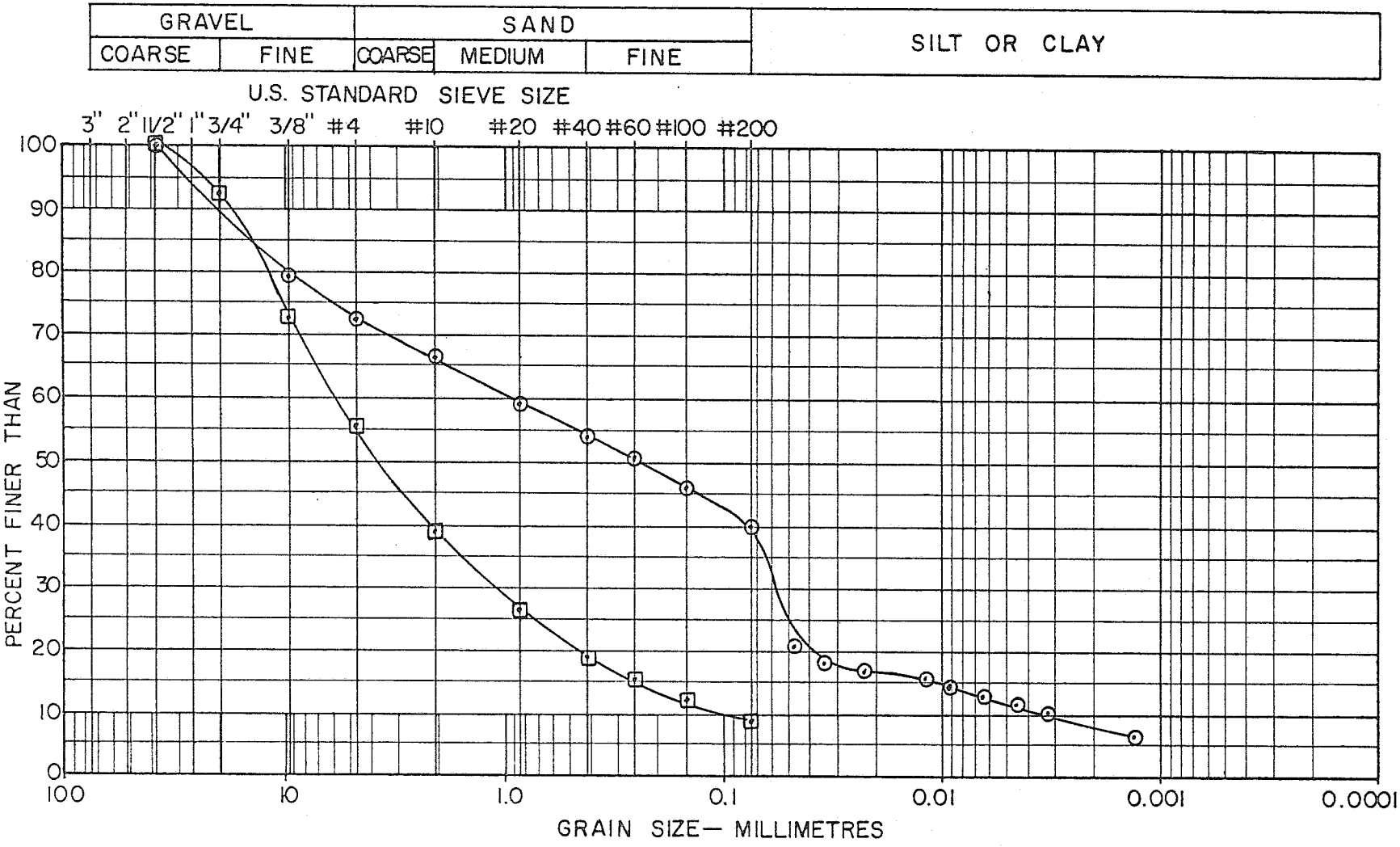
JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 26.5 - 27.5
HOLE No. 77-6-6 DEPTH
DATE Nov. 21/77



GRAIN SIZE CURVE

REMARKS: ⊙—⊙ Sa. #2 (1.0m.) GRAVEL, SAND, SILT - trace clay, trace cobbles, well graded

⊡—⊡ Sa. #6 (2.0-2.3m.) GRAVEL & SAND - trace silt, organic specks, gravel rounded to subangular, grey.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
	B		1
1	SY		2
	SY		3
2	B		4
	B		5
3	SY		6
	SPT		7
4	SPT	85 / 205	8
5			
6	SPT	112 / 223	9
7			
8			
9			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF
	2.5
Vx, Vr	
Vs, Vx	
Vr, Vx	
Vx, Vc Nbn	
(?)	

LOCATION See Plate A-0890-6-2
ELEVATION

DESCRIPTION OF MATERIAL

0.1m. organic cover
SILT & CLAY
- little coarse gravel
- little sand
- organic layers
- black & yellowish brown

1.95m. ← black organic layer

SILT, SAND & GRAVEL
- trace clay
- well graded
- slight plasticity

3.0m.

SILT & SAND
- some gravel
- trace clay
- extensive ice lenses to 1cm. thick.

3.3m.

GRAVEL & SAND
- little silt
- ice lenses up to 2cm. thick

sand layer

interbedded with fine & coarse layers

very coarse
- bouncing drill action

8.5m.

END OF HOLE @ 8.5m.

(cont'd.)

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

107
204

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-7
DATE	Oct.26/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA: DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST: N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq. cm. (0.2 0.6 1.0 1.4 1.8) ● FIELD VANE △ LAB VANE ■ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT (X — 0 — X; 10 30 50 70 90%)

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located on H-F pipeline right-of-way. Terrain is rolling and hole situated in a small saddle which slopes 5% to the east.
2. Moderate growth of spruce to 10m. and poplars to 15m. adjacent to the right-of-way.
3. Hole augered to 3.3m. and rotary drilled with mud from 3.3 to 8.5m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 26.5 to 27.5
HOLE No.	77-6-7
DATE	Oct. 26/77 PLATE

K.L.C. - METRIC

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CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890

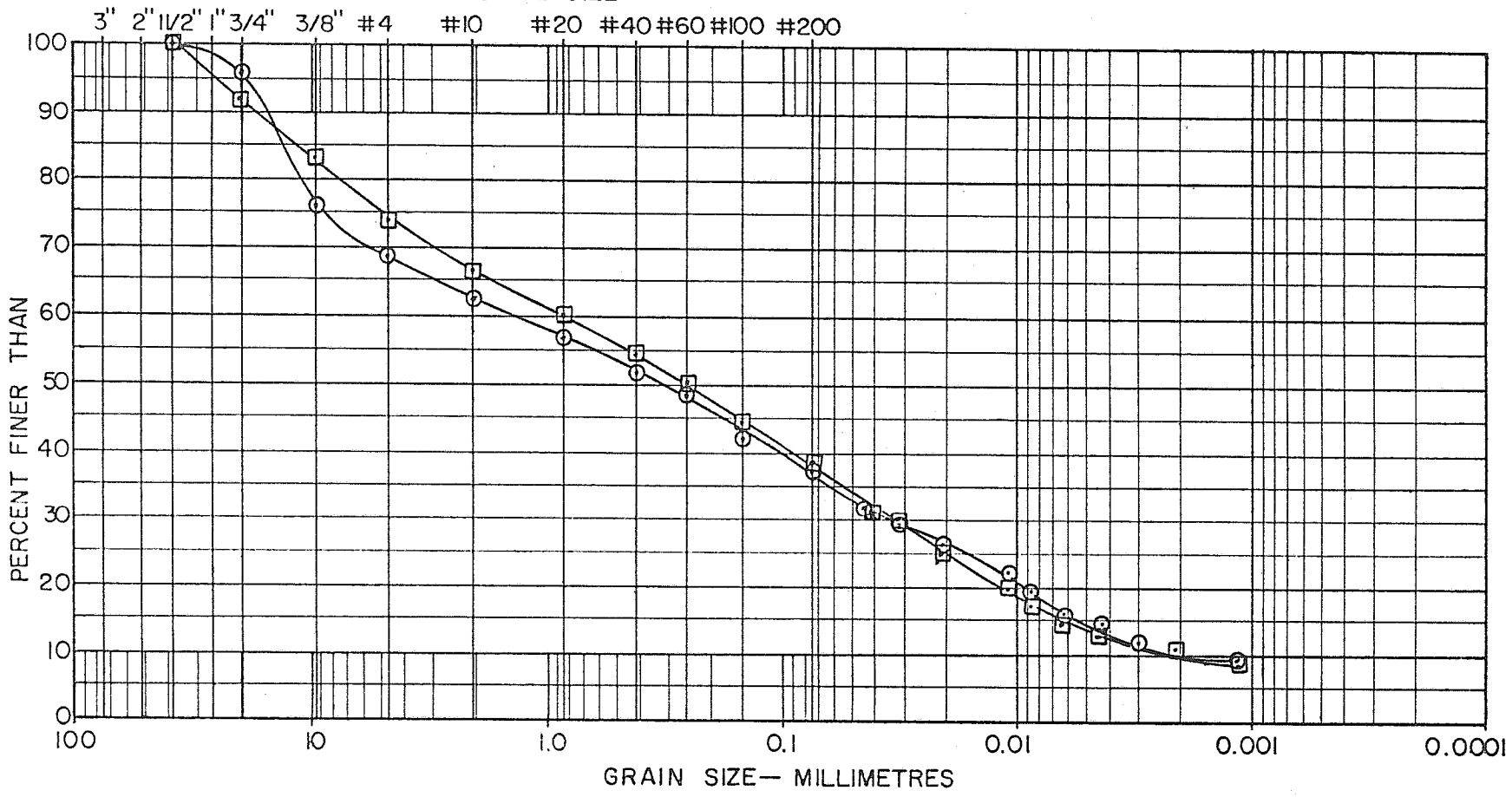
PROJECT Frost Heave Test Sites

LOCATION MP 26.5 to 27.5

HOLE No. 77-6-7 DEPTH

DATE Nov. 16/77

GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sa. #6 (2.6 - 2.95m.) GRAVEL, SAND & SILT - trace clay, well graded

⊡—⊡ Sa. #7 (2.95 - 3.3m.) SILT & SAND - some gravel, trace clay

SITE 7 (MP 31)

1.0 INTRODUCTION

The site is located at MP 31 along the proposed pipeline right-of-way which parallels the H-F pipeline. The Alaska Highway is in close proximity to the pipeline and passes within 100 meters of the site on the east side of Dry Creek. A telephone or power transmission line, which parallels the highway, also crosses the site. Four old cabins, believed to be abandoned, are also situated in the valley in the general vicinity of the site. The reader should refer to the attached drawings while reading this section. These drawings include a location plan (Plate A-0890-1), an aerial photograph (Drawing B-0890-2, a survey plan (Drawing C-0890-3), a detailed terrain interpretation map (Drawing D-0890-4), and a site photograph (Plate A-0890-5).

Initially, three preliminary test holes were located in this area. Test Hole 1 was drilled in a small open depression about 20 m. west of Dry Creek. Test hole 2 was located 8 m. east of the creek, and test hole 3 was located about 100 m. west of the creek. The subsoil and permafrost conditions in these three test holes were highly variable. However, the relatively thick, unfrozen, fine grained soil strata above a basal gravel stratum in test hole 1 were sufficiently encouraging to merit further drilling in this area.

In total, 12 additional holes were drilled at the site in those area where unfrozen soil conditions would most likely occur. Thus, the drilling was essentially confined to a narrow width adjacent to the meandering creek bed.

2.0 SITE DESCRIPTION & SUMMARY

The site is situated in a narrow, northeasterly trending valley which was a meltwater channel during deglaciation of the area. (For purposes of this report the creek is assumed to flow in a northerly direction). During a detailed terrain evaluation of airphotos for the site, the valley bottom was classified as LB+AMP(BD)/OW. (See attached drawing D-0890-7-4 for detailed terrain classification of the site and description

of the terrain typing terms). This indicates the valley bottom is comprised of reworked, thinly stratified, fine grained lacustrine basin soils interlayered with alluvial meander plain sands, silts and gravels, all of which overlie stratified outwash consisting of gravel, sand, silt, and boulders. The lower valley slopes along the east side of the creek are comprised of a series of coalescing alluvial fan deposits. These post glacial deposits are generally comprised of poorly sorted gravel, sand and silt materials eroded from upland areas which are underlain by hummocky moraine and outwash. The lower valley slopes along the west side of the creek are terrain typed as MC(SL) and LB(SL). This classification denotes a veneer of slopewash overlying the lacustrine basin and meltwater channel sediments. A gently sloping, heavily treed drainage area at the southwestern corner of the site is classified as a coarse deltaic deposit of sand, gravel and silt. The upland to the west is terrain typed as hummocky moraine (HM), ridge and knoll moraine (RKM), and outwash (OW(PT)(SH)).

The valley bottom is drained by Dry Creek which has a gradient of less than 1/2% to the northeast. The creek flows in a sinuous manner, with many tight meander loops, and drains into the White River upstream of the abandoned community of Snag. The creek occasionally displays beaded drainage and varies in width from 3 to 12 m. wide averaging 4 to 8 m. wide. The banks along the creek are generally 1 to 2 m. high, and thaw slumps are evident at several locations.

The valley bottom is "dish-shaped", with the lower valley flanks sloping at 0 to 8% towards the creek. The east valley slopes between the creek and the highway ascend to a maximum slope of about 10%. The west valley slopes are considerably steeper, with gradients on the upper slopes of more than 30%. A small erosion gulley is evident along the old pipeline right-of-way near the toe of the west valley slope. This erosional feature likely originated as a shallow surface slide which displaced the H-F pipeline 3 to 4 m. to the north. Subsequent erosion of the granular glacial subsoils has incised a gulley beneath the old pipeline to a depth of about 3 m..

A total of 15 test holes were drilled at the site. (The reader should refer to the attached test hole logs and laboratory test data for Site 7). The test drilling was confined to a zone along the creek approximately 500 m. long from north to south and 250 m. wide. Seven test holes were drilled within 5 to 20 m. from the west side of the creek. Test holes 77-7-7 and 77-7-11 were drilled further from the creek on the west side. Four test holes were drilled adjacent to the east side of the creek. Two other test holes were located at distances of 70 m. east and 100 m. west of the creek.

The subsoil and permafrost conditions underlying the site are variable. The general subsoil profile consists of interlayered, fine-grained sediments of organic silt, clay and sand from 1 to 8.5 m. thick, overlying a very dense gravel and sand substratum. Organic laminations and pieces of wood are generally widespread in the upper 1 to 3 m. of silt soils. These upper fine grained soils usually grade sequentially from slight to low plastic silt and clay near ground surface, to non plastic silt and sand, to coarser sand with gravel layers at depth. Due to the depositional mode of the sub-soils, it is impossible to correlate the micro-stratigraphy across the site without very closely spaced drill holes.

The gravel outwash stratum underlying the site is undulating, and occurs at relatively shallow depths in portions of the site. The eastern flanks of the valley are comprised of a series of moderately sloping, coalescing alluvial fans which extend almost to Dry Creek. Shallow gravel and sand soils were encountered in test hole 77-7-15 on the east side of the creek at the north end of the site. These interlayered granular materials are representative of the alluvial fan deposits which were laid down by the small tributary creeks which enter Dry Creek from the east. The stratified gravel stratum was also encountered at relatively shallow depths in test holes 77-7-2, and 4 along the east side of the creek in the south central portions of the site.

The depth to gravel is also variable on the west side of the creek. At the north end of the site, a dirty gravel stratum was encountered

below a depth of 3.25 m.. Shallow gravels were also encountered within 2.5 m. of the ground surface, in test holes 77-7-9 and 14, at the south end of the site. These shallow gravels were probably deposited as post glacial, deltaic fan materials from a drainage course entering Dry Creek on the west. In the central part of the site on the west side of Dry Creek, interlayered gravel and sand strata were encountered below a depth of 3 to 4 m. in test holes 77-7-12 and 13. The composition of the gravel strata thoughout the site is variable. The gravel is frequently layered with sand and has a silt content which varies from less than 5% to more than 30%.

The permafrost conditions underlying the site are variable. Unfrozen soils occur adjacent to the creek in a narrow zone which has its broadest extent in an area extending about 350 m. south from the H-F pipeline. The unfrozen zone closely parallels the east side of the creek and extends laterally to the east only 5 to 10 m. from the creek. The unfrozen zone along the west side of the creek is wider, and varies from about 5 to 50 m. wide. Based on considerable hand probing in this area along the west side of the creek, there are several "taliks" of permafrost in the upper soils. These taliks are likely 2-4 m. in thickness although detailed drilling is required to delineate peramfrost conditions in this zone.

On the lower valley slopes along the west side of the meltwater channel, adjacent to the unfrozen zone paralleling the creek, permafrost is widespread and has a medium to high ice content. Test holes 77-7-3, -10, -11 encountered permafrost below a thin active layer. The permafrost affected soils extend to the maximum depths drilled which vary from 5.2 to 10.0 m.. The upper, laminated organic silts in test holes 77-7-3 and 11 are ice-rich, with extensive segregated ice lenses comprising up to 50% of the soil by volume. There is also evidence of subsidence along an old trail in this area where the organic cover has been disturbed in the past.

Along the east side of the creek adjacent to the unfrozen zone,

the permafrost consists of a thin talik of frozen soil which is confined to the upper 5 m.. Test hole 77-7-9 encountered permafrost from a depth of 0.6 to 2.6 m., with unfrozen soils above and below this zone. Similarly, test hole 77-7-4 encountered permafrost from a depth of 2.15 to 5.0 m., with unfrozen soils above and below this zone.

3.0 SOIL & PERMAFROST CONDITIONS

3.1 Test Hole 77-7-1

Test hole 77-7-1 was drilled to a total depth of 9.5 m. by dry augering to 3.1 m., then rotary drilling with mud from 3.1 to 9.5 m.. Due to caving of unfrozen gravel and sand, no SPT or Shelby Tube samples were obtained below a depth of 3.1 m.. Therefore, the soil stratigraphy below 3.1 m. is based on drill action and cuttings returned in the drilling mud.

The subsoils consist of silt and clay overlying coarser, interlayered gravel and sand. The silt and clay soils extend to a depth of 2.8 m. and are laminated with organic specks, pieces of wood, and fine sand. The moisture content averages 50% in the upper 2 m., and decreases to 20% at the base of the stratum. Atterberg Limit tests indicate the material has a very low plasticity with a plasticity index of 6. The silt and clay soils overlie interlayered gravel and sand strata from 2.8 to 7.5 m.. Based on drill cuttings, these interlayered soils appear to be essentially sand. These interlayered sand soils overlie a dense sandy gravel stratum from 7.5 m. to the maximum depth drilled.

The entire test hole was unfrozen within the total depth drilled.

3.2 Test Hole 77-7-2

Test hole 77-7-2 was drilled to a total depth of 8.5 m. by dry augering to 2.15 m. and rotary drilling from 2.15 m. to the maximum depth drilled. The subsoils consist of a 0.75 m. thick peat top-stratum, overlying clay and silt from 0.75 to 1.7 m., all of which overlies a coarse, interbedded gravel and sand stratum. The clay

and silt soils are medium plastic, and two Atterberg Limit tests indicate a plasticity index of 11. Based on drill action and cuttings returned in the drilling mud, the basal gravel and sand stratum is coarse, very dense and interbedded at 0.5 to 1.0 m. intervals. Due to the rotary nature of the heli-drill, representative samples of the coarse, unfrozen gravel materials were not obtained.

The entire test hole was unfrozen within the total depth drilled.

3.3 Test Hole 77-7-3

This test hole was drilled to a depth of 10.0 m. by augering to 1.0 m., coring from 1.0 to 4.55 m., and rotary drilling with mud below 4.55 m. to the maximum depth drilled. The subsoils consist of interlayered silt and organic silt, overlying a silt and sand stratum, all of which overlies gravel and sand soils. The upper topstratum of interlayered silt and organic silt extends from ground surface to a depth of 4.2 m.. These soils are generally non plastic and have thin pockets and lenses of sand and gravel. The moisture content is variable from 30% to more than 200% in ice rich organic layers. From a depth of 4.2 to 8.5 m. the organic soils are underlain by silt and sand soils with organic inclusions, which become sandier with depth. The soil stratigraphy below 4.55 m. is, however, based on drill action and cuttings returned in the drilling mud. An interlayered gravel and sand stratum underlies the finer soils below a depth of 8.5 m..

Permafrost occurs from 0.7 m. to the maximum depth drilled in this test hole. From ground surface to a depth of about 2 m., the estimated excess ice content of the organic silt averages about 40% by volume. Ice occurs in stratified lenses generally 1/2 to 5 mm. thick spaced at 1 to 2 mm.. From a depth of 2 to 4.5 m. the ice contents of the silt and organic silt soils are lower, with the estimated excess ice content averaging about 15% by volume. The permafrost classification of the subsoils was not ascertained below a depth of 4.55 m..

3.4 Test Hole 77-7-4

This test hole was drilled to a depth of 8.0 m. by augering to 2.15 m., coring from 2.15 to 3.4 m., and rotary drilling with mud from 3.4 m. to the maximum depth drilled. The subsoils consist of interlayered peat and silt and clay from ground surface to a depth of 3.22 m., overlying interlayered gravel and sand. Peat layers in the topstratum have high moisture contents varying from 100% to more than 250%. The interlayered silt and clay soil is medium plastic, with a plasticity index of about 17. The moisture content ranges from 40 to 90%, averaging about 70%. A fine-to-coarse gravel and sand stratum occurs from a depth of 3.22 to 8.0 m..

Permafrost exists from 2.15 to 5.0 m., with unfrozen soils above and below this zone. The silt, clay and peat soils from 2.15 to 3.22 m. have a high ice content. Extensive ice lenses from 1 to 5 mm. thick are generally spaced closer than 5 mm. apart. The estimated excess ice content averages about 30% by volume. The frozen gravel and sand material from 3.22 to 5.0 m. has a low ice content.

3.5 Test Hole 77-7-5

This test hole was drilled to a depth of 7.65 by augering to 1.15 m. and coring from 1.15 m. to the maximum depth drilled. A total of ten grain size tests were made on the fine grained, unfrozen soils from 77-7-5. A silt and clay stratum occurs from ground surface to a depth of 4.2 m.. The upper 1.5 m. has many organic laminations which result in a high moisture content varying from 75 to 115%. The stratum is also laminated with fine sand which comprises about 20% of the material, but increases with depth. Four Atterberg Limit tests indicate the material has a plasticity index varying from 6 to 11, and therefore is low plastic. From a depth of 4.2 to 4.97 m. the silt and clay is underlain by a non plastic, layered sand and silt, with an average moisture content of 22%. The sand portion of this material is of a fine uniform nature. This stratum is underlain by a well graded fine to coarse sand which extends to a depth of 7.0 m.. The sand has an average moisture

content of 15%. The sand is underlain by a layer of silt and clay from 7.0 to 7.5 m., all of which overlies a very dense gravel.

Permafrost exists from 0.8 to 2.0 m., with unfrozen soils above and below this zone. The excess ice content of the frozen silt and clay is low.

3.6 Test Hole 77-7-6

This test hole was drilled to a depth of 7.8 m. by augering to 1.7 m. and coring from 1.7 m. to the maximum depth drilled. The subsoils consist of fine grained silt, sand, and clay overlying a layered gravel and sand material below a depth of 6 m.. The successful coring of fine grained unfrozen soils in this test hole yielded almost 8 m. of continuous samples which exemplify the variability of soils underlying Site 7. A total of eight grain size tests were made to assist in classification of the subsoils.

A silt and clay with sand and black organic laminations forms the topstratum from ground surface to a depth of 2 m.. An Atterberg Limit test indicates the soil is low plastic, with a plasticity index of about 7.5. The moisture content averages about 55%. From a depth of 2.0 to 2.75 m., the soil grades to a laminated silt and sand with a variable moisture content from 30 to 60%. A more uniform sand and silt occurs from a depth of 2.75 m. to 3.9 m.. The moisture content averages 25%, and Atterberg Limit tests indicate the soil is non-to-low plastic. The sand portion of all the upper strata is of a fine, uniform nature. Below a depth of 3.9 m. the soils grade into a fine to medium sand with a moisture content of 20%. A gravel and medium-to-coarse sand material occurs both from 5.0 to 5.5 m. and below a depth of 6.0 m.. The soil has an average moisture content of less than 10%. A laminated silt, sand, clay layer is interbedded in the gravel materials from 5.5 to 6.0 m..

Permafrost occurs from a depth of 0.9 to 2.0 m., with unfrozen soils above and below this zone. The excess ice content of the frozen silt and clay in this zone is low.

3.7 Test Hole 77-7-7

This test hole was drilled to a depth of 8.0 m. by augering to 4.0 m. and coring from 4.0 to 8.0 m.. The core samples from this test hole exemplify the nature of the fine grained soils underlying portions of Site 7. A total of seven grain size tests were made to assist in classification of the soils.

The subsoils consist of silt and clay with organic laminations from ground surface to a depth of 2.0 m.. Atterberg Limit tests indicate the soil is of slight-to-low plasticity, with a plasticity index varying from 2 to 7. The silt and clay overlies a sequence finely laminated sand and silt. The silt content is generally less than 25% except between a depth of 4.5 to 6.0 m.where the silt content is about 55%. The sand material generally has a fine-to-medium gradation. The moisture content of the sand and silt soils averages less than 20%.

The entire test hole was unfrozen within the total depth drilled.

3.8 Test Hole 77-7-8

This test hole was drilled to a depth of 7.6 m. by augering to 0.5 m., taking continuous Shelby Tube samples from 0.5 to 3.5 m., and coring below 3.5 m. to the maximum depth drilled. The topstratum from ground surface to a depth of 2.3 m. consists of non-to-slightly plastic silt with fine sand and organic laminations. The material has a firm to stiff consistency and a variable moisture content ranging from 35 to 80%. At a depth of 2.3 m. the silt grades into a laminated fine sand and non plastic grey silt which extends to a depth of 3.5 m.. The stratum has many organic layers with pieces of wood, which result in a variable moisture content ranging from 20 to 70%. From a depth of 3.5 to 4.9 m. the soil becomes coarser, grading from a fine-to-coarse sand with some silt, to a sand with some gravel and a trace of silt. This progression towards coarser materials at depth is a common occurence at Site 7. A gravel and sand sequence with finer sand layers occurs at the base of 77-7-8 from 4.9 to 7.6 m..

The entire test hole was unfrozen within the total depth drilled.

3.9 Test Hole 77-7-9

This test hole was augered to 0.7 m., cored from 0.7 to 4.4 m., and augered from 4.4 m. to a completion depth of 5.1 m.. The subsoils consist of organic silt, overlying silt grading into sand, all of which overlies a sandy gravel stratum. An organic silt topstratum laminated with fine sand exists from ground surface to a depth of 1.5 m.. The moisture content is high, averaging more than 100%. The organic silt overlies a silt with some fine sand from a depth of 1.5 to 2.2 m.. The moisture content is 60%. A fine-to-coarse sand layer with some silt and a trace of gravel occurs from 2.2 to 2.7 m.. The moisture content is 25%. The upper fine grained soils are underlain by a relatively fine gravel stratum below 2.7 m. to the maximum depth drilled (5.1 m.). The unfrozen gravel was successfully cored and two grain size tests on the material indicate a well graded sand content of 20 to 30%, and a silt content of about 13%, with a trace of clay. Moisture contents average about 9%.

The entire test hole was unfrozen with the total depth drilled.

3.10 Test Hole 77-7-10

This test hole was drilled to 6.5 m. by augering to 1.2 m., coring from 1.2 to 2.5 m. and rotary drilling with mud from 2.5m. to the maximum depth drilled. The subsoils consist of organic silt, clay and peat with a trace of gravel and sand, extending from ground surface to a depth of 3.25 m.. A coarse gravel layer occurs from a depth of 1.8 to 2.5 m.. The topstrata have variable moisture contents ranging from 20% in sand seams, and from 150 to 200% in organic layers. A layered gravel stratum with some silt and sand occurs from a depth of 3.25 to 6.5 m..

Permafrost occurs from a depth of 1.2 m. to the maximum depth drilled. The upper organic stratum has a medium-to-high ice content with ice lenses up to 11 cm. thick. The ice content of the gravel stratum was not ascertained due to the rotary nature of drilling using mud as the return fluid.

3.11 Test Hole 77-7-11

This test hole was drilled to a depth of 5.2 m. by augering to 0.4 m. and coring from 0.4 m. to the maximum depth drilled. An organic silt, clay and peat stratum exists from ground surface to a depth of 2.0 m.. The organic soils have high moisture contents varying from about 100 to 250%. The organic silt is underlain by a non-to-slightly plastic silt from a depth of 2.0 to 4.35 m.. The silt has fine sand laminations which are widespread from a depth of 2.65 to 2.95 m.. The average moisture content of the silt is 45%. From 4.35 to 4.75 m. the silt grades into a fine sand with some silt. The moisture content is 25%. The test hole was terminated in a gravel stratum which extends from 4.75 to 5.2 m.. Two grain size tests indicate gravel has some fine-to-coarse sand and a trace of silt. The moisture content varies from about 10 to 20%.

Permafrost occurs from 0.35 m. to the maximum depth drilled. Horizontal and randomly spaced lenses up to 5 mm. thick are widespread in the organic soils to a depth of 2.0 m.. The excess ice content of these soils averages more than 30% by volume. Below a depth of 2.5 m. the ice content is low and excess ice contents are generally less than 5% by volume.

3.12 Test Hole 77-7-12

This test hole was drilled to a depth of 8.5 m. by augering to 3.5 m., coring from 3.5 to 4.2 m., and rotary drilling with mud from 4.2 m. to the maximum depth drilled. The subsoils grade from fine to coarser grained with depth in this test hole. The topstratum to a depth of 0.95 m. consists of an organic silt with moisture contents ranging from 90 to 135%. The organic silt overlies a non organic silt laminated with some fine sand from a depth of 0.95 to 2.2 m.. The silt is of slight plasticity and has a moisture content ranging from 30 to 70%. The silt stratum grades into a fine-to-medium sand from a depth of 2.2 to 3.4 m.. The sand has a little silt and a little gravel at depth. The moisture content averages about 15%. The sand stratum grades into a sandy, silty gravel from 3.4 to 4.0 m. and overlies a dense gravel stratum.

The gravel stratum which extends from 4.0 m. to the maximum depth drilled (8.5 m.) has a thick silt layer interbedded from 6.0 to 7.5 m.. The gravel material has some sand and some silt and appears to be fairly well graded based on a sample recovered from a depth of 4.0 to 4.2 m..

Permafrost occurs as a thin talik from a depth of 1.2 to 1.75 m.. No permafrost occurs above or below this zone.

3.13 Test Hole 77-7-13

This test hole was augered and cored with virtually continuous sampling to the completion depth of 6.8 m.. The topstratum consists of an organic silt and peat which extends from ground surface to a depth of 1.0 m.. Moisture contents are well in excess of 100%. The highly organic topstratum overlies a silt with organic laminations from a depth of 1.0 to 1.6 m.. The moisture content is 40%. The silt overlies a fine-to-medium sand laminated with silt and organic material, from a depth of 1.6 to 2.7 m.. The moisture content averages 15%. The sand soils grade into a gravel and sand material from a depth of 2.7 to 3.1 m.. The gravel and sand which extends from 3.1 to 6.8 m. is interlayered with a fine-to-medium sand stratum between depths of 4.4 and 5.4 m.. Grain size tests indicate the gravel and sand materials are interlayered, medium dense-to-dense, well graded, and the gravel portion is usually fine. Moisture contents average 10 to 15%.

Permafrost occurs as a thin talik from a depth of 0.5 to 1.5 m.. No permafrost occurs above or below this zone.

3.14 Test Hole 77-7-14

This test hole was drilled to a depth of 10 m. by augering to 3.0 m., coring from 3.0 to 3.7 m., and rotary drilling with mud below 3.7 m. to the maximum depth drilled. The subsoils consist of a silt laminated with organic material and wood specks from ground surface to a depth of 2.1 m.. The silt has a stiff

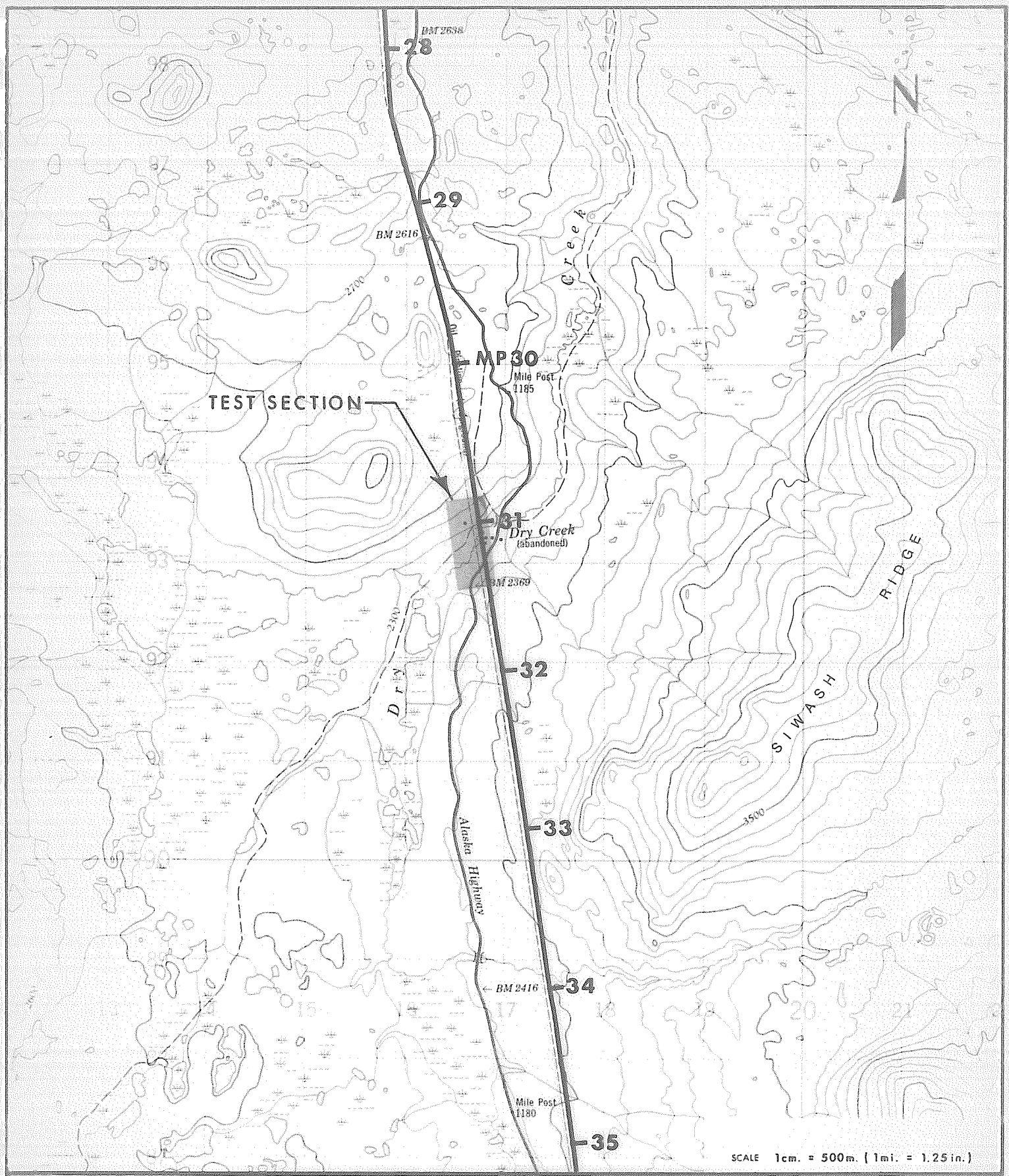
consistency and is of slight-to-low plasticity. The moisture content varies from 25 to 65%, averaging about 45%. The silt topstratum overlies a very dense gravel stratum from 2.1 m. to the maximum depth drilled. Three grain size tests indicate the gravel stratum is fine and the minor constituents are some sand, little silt, and a trace of clay. Although the gravel is fairly well graded, the stratum is interlayered with coarse gravel, sand and cobbles. The moisture content averages about 9%.

The test hole was unfrozen within the entire depth drilled.

3.15 Test Hole 77-7-15

This test hole was drilled to a depth of 5.95 m., by augering and coring to 2.5 m., then rotary drilling with mud from 2.5 m. to the maximum depth drilled. The subsoils near the ground surface are variable due to their mode of deposition as an alluvial fan. The subsoils from ground surface to a depth of 1.25 m. consist of silt with organic laminations. The silt is of slight-to-low plasticity, has a trace of clay and a moisture content of about 45%. The silt overlies a variable, interlayered sequence of gravel, sand and silt from a depth of 1.25 m. to 3.75 m.. The moisture content varies from 5 to 45% depending on the material type. These interlayered soils overlie a very dense stratum comprised of gravel and sand with a little silt. The moisture content is low, averaging less than 10%.

The entire test hole was unfrozen within the total depth drilled.



KLOHN LEONOFF CONSULTANTS LTD.
CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 7

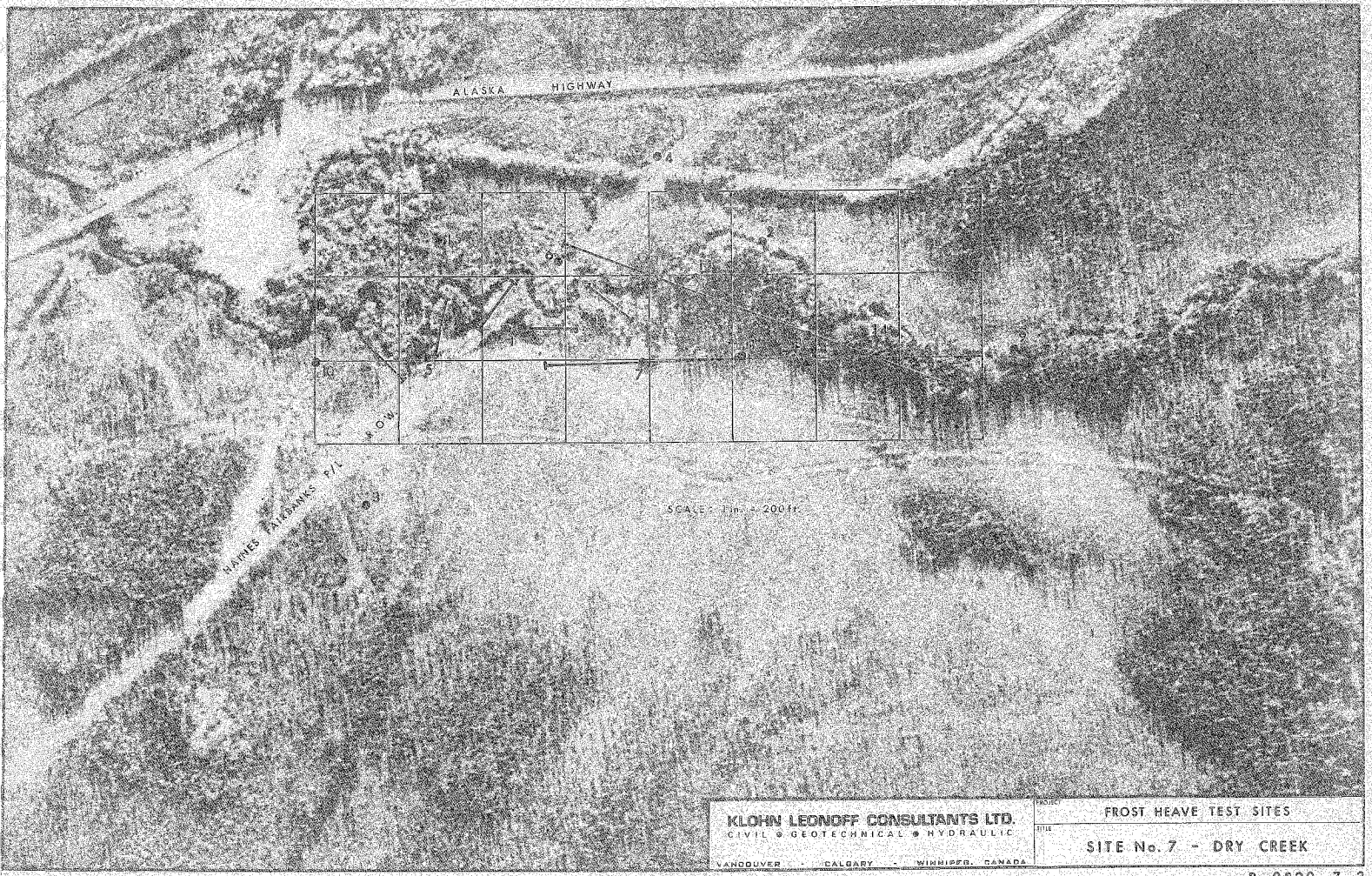
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

DATE OF ISSUE OCT. / 77.
APPROVED A. L. Edgworth.

PROJECT No. AL0890

DWG. No. A-0890-7-1

REV.



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CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER · CALGARY · WINNIPEG, CANADA

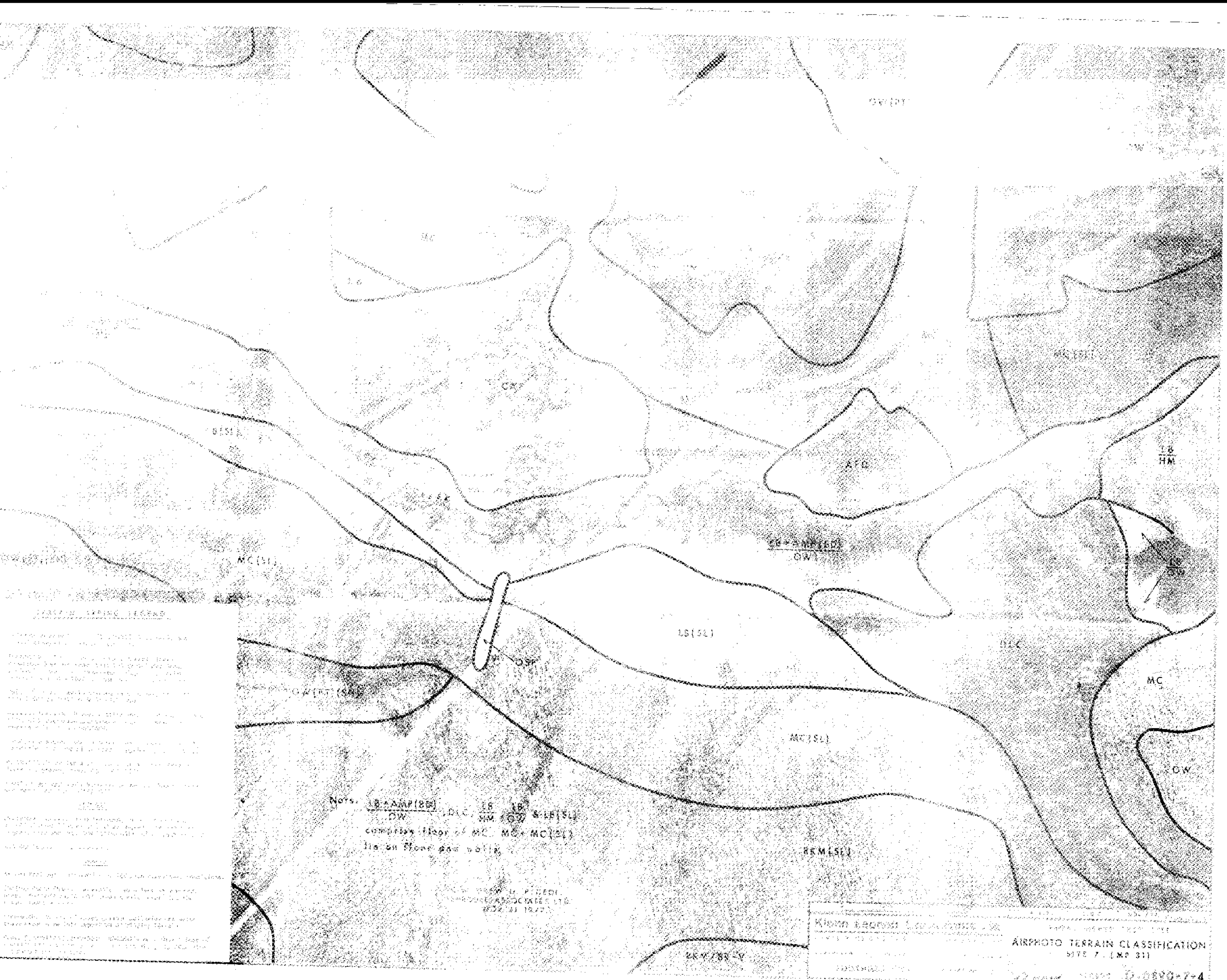
PROJECT: FROST HEAVE TEST SITES

TITLE: SITE No. 7 - DRY CREEK

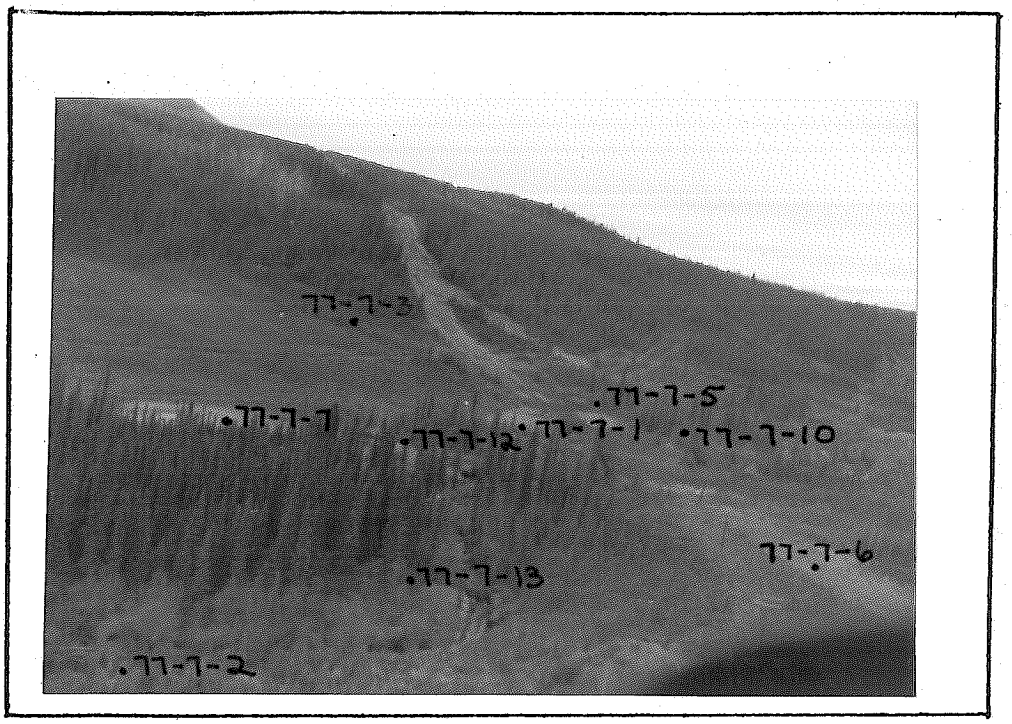
B-0890-7-2

TO BE FORWARDED BY

FOOTHILLS PIPE LINES COMPANY LTD.



CX
AFD
LB/HM
LB(SL)
MC(SL)
MC
OW
DLC
BKM(SL)
Note: LB+AMP(BD)/OW, DLC, LB/HM, LB/OW & LB(SL) comprise floor of MC. MC+MC(SL) lie on floor and walls.
AIRPHOTO TERRAIN CLASSIFICATION
SITE 7 (MP 31)



SITE 7

View northwesterly at Site 7 located in the Dry Creek meltwater channel. The proposed pipeline route parallels the Haines-Fairbanks right-of-way which cuts across the valley. A moderately dense growth of spruce occurs immediately adjacent to Dry Creek.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
	B		1
1			
	B		2
	B		3
	SY		4
2		2	
	SPT	3	5
		3	
3			
	SY		6
4			
	B		7
5			
6			
	B		8
7			
8			
9			
10			

SYMBOL | PERMAFROST: N.R.C. CLASS | N.F. or F.

LOCATION See Plate A-0890-7-2
ELEVATION 2265.21

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▣ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

0.1m ORGANIC SILT - grass

SILT & CLAY
- trace fine sand
- organics and wood
- soft to firm
- low plastic, brown

← sand & silt from 1.6-1.75m.

1.7m

SILT & CLAY
- some fine sand
- laminated @ 1-6 mm.
- black organics
- low plastic, firm
- yellowish brown

2.8m

SAND & SILT-little gravel
- trace clay

3.2m

GRAVEL AND SAND
- trace silt, brown

4.0m

SAND - little silt
- trace gravel
- caving during drilling
- loss of circulation

(based on drill action and cuttings returned in drilling mud).

6.0m

6.3m GRAVEL - fine to medium

SAND
- little silt

(based on cuttings returned in drilling mud)

7.5m

GRAVEL
- fine to medium
- some sand

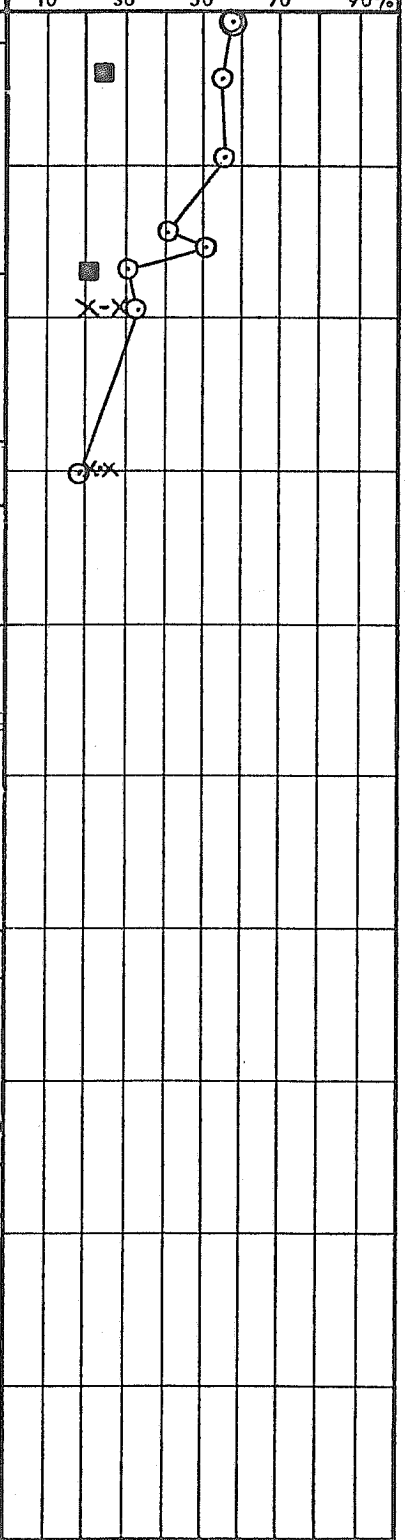
(based on drill action)

← boulder @ 9 m.

9.5m

END OF HOLE @ 9.5 m.
(Continued)

NF



Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-1
DATE	Oct. 10/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA: DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST: N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT X — WATER CONTENT — 0 — LIQUID LIMIT X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located in a small dried up slough, 20 m. west of Dry Creek. Site is approx. 1 m. below surrounding area.
2. Vegetation in dry depression is grass. Surrounding area has willow & sparse spruce to 5 m.
3. Hole augered to 3.1 m. Unable to auger further due to sloughing of gravel layer. Drilled with mud from 3.1 to 9.5 m. Unable to obtain SPT or SY samples below 3.1 m. due to caving of unfrozen sands into drill hole. Considerable loss of drilling fluid in sand layer from 4 to 6 m. The soil stratigraphy below 3.1 m. is based on drill action and cuttings returned in the drilling mud.
4. Thermistors installed @ 0.5, 1.5, 3.0 and 4.5 m. depths. Installed standpipe piezometer to 4.5 m.

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

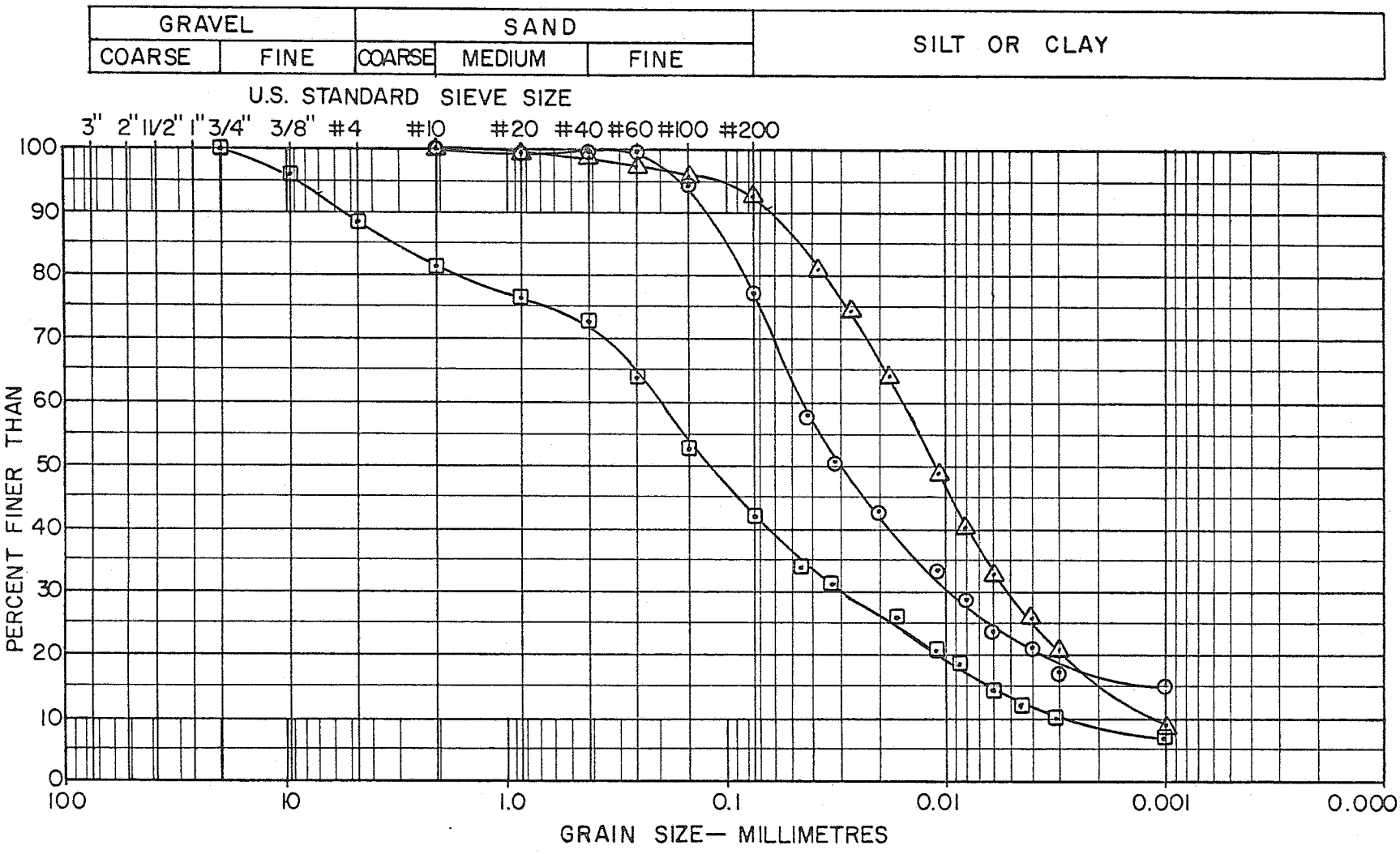
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-1 (Continued)
DATE	Oct. 10/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

- Sa #2 (@ 1 m.) SILT & CLAY - trace fine sand, low plasticity
- Sa #5 (1.75-2.2 m.) SILT & CLAY - some fine sand, slight to low plasticity
- Sa #6 (2.9-3.1 m.) SAND & SILT - little gravel, trace clay, slight plasticity

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-1 DEPTH
DATE	Oct. 24/77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
	B		
	B		1
1	B		2
	B		3
	SY		4
2	SPT	19 60 78	5
	B		6
3			
4	B		7
5			
6			
7			
8			
9			
10			

SYMBOL | PERMAFROST: N.R.C. CLASS | N.F. or F.

LOCATION See Plate A-0890-7-2
ELEVATION 2268.10

DESCRIPTION OF MATERIAL

PEAT - and silt
- trace sand
- dark brown

0.75m.

CLAY & SILT
- trace med. sand
- trace gravel
- soft to firm
- medium plastic

1.7m.

GRAVEL & SAND
- interbedded .5 to 1m.
- gravel med. to coarse subrounded to subangular
- little clay and silt in upper meter

(Based on drill action below 2.15m)

NF

sand layer

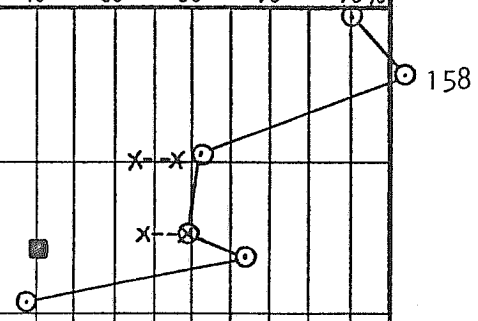
NOTES:
1. Hole located 8m. east of Dry Creek. Terrain slopes 2% towards the creek.
2. Ground surface very undulating due to peat tussocks. Vegetation mainly willows & low brush, with sparse spruce to 5m.
3. Augered to 2.15m.. Drilled with mud from 2.15 to 8.5m.. Considerable loss of drilling fluid in gravel stratum below 1.7m.

8.5m.

END OF HOLE @ 8.5m.

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-2
DATE Oct. 10/77 PLATE

K.L.C. - METRIC

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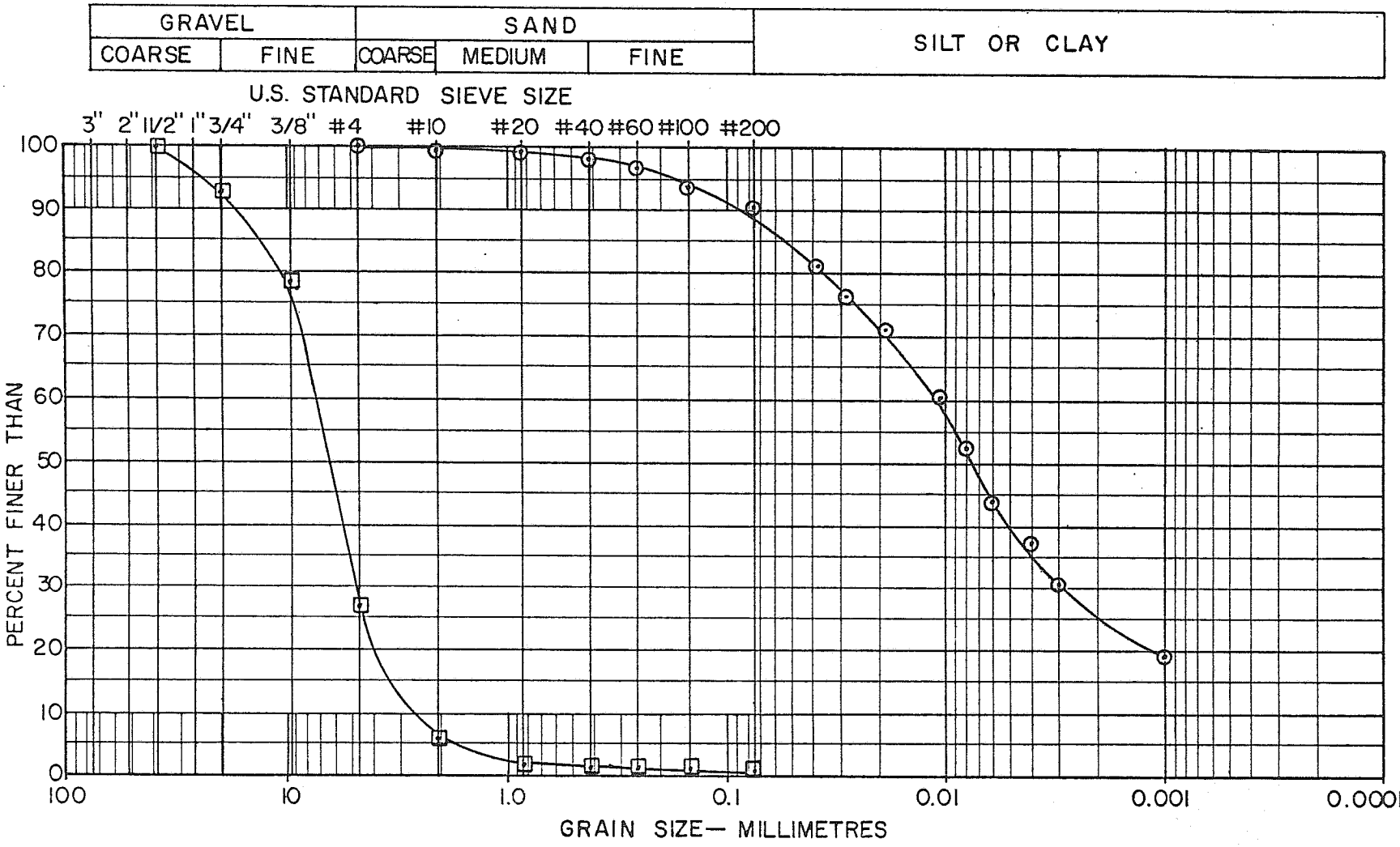
GRAIN SIZE CURVE



REMARKS: Sa # 2 (@ 1 m.) CLAY & SILT - trace fine sand, medium plastic

Sa # 6 (2.15-2.5 m) GRAVEL- some sand (N.B. gravel sample fractured due to drilling with rock bit.)

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-2
DEPTH	
DATE	Oct. 24/77

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
1	B		
	B		1
	B		2
	B		3
	C		4
2	C		5
	C		6
	C		7
	C		8
3	C		9
	C		10
	C		11
4	C		12
	C		13
	C		14
5			
6			
7			
8			
9			
	B		15
10			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
	NF	0.1m. moss cover
	0.7	ORGANIC SILT & CLAY - little sand, brown 0.6m.
Vs Vr		SILT - some sand, trace clay - organic layers 1.0m.
		ORGANIC SILT - trace sand ice lenses 1-5mm. spaced @ 2-6 mm. 1.4m.
		SILT - and sand, little clay - trace gravel - brown wood pieces ice lenses 1-5 mm. spaced @ 1-10 mm. 2.25m.
Nbn Vx		ORGANIC SILT - and med. coarse sand layers to 10 cm. - trace gravel, trace clay - extensive organics 3.2m.
Vs		SAND - and silt - little gravel - organics & wood - non plastic 3.9m.
		ORGANIC SILT - ice lenses 4-5mm. spaced @ 15mm. 4.2
Vr Vs Vx		SILT & SAND - sandier @ depth - organic inclusions - wood specks - non plastic - brown (based on drill action and cuttings returned in drilling mud). 8.5m.
		GRAVEL - fine to medium 9.0m.
		SAND 9.3m.
		GRAVEL - fine to medium 10.0m. END OF HOLE @10.0m.

LOCATION See Plate A-0890-7-2
ELEVATION 2284.58

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

315
124
132
126
NP
127
NP
203
NP

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 31
HOLE No.	77-7-3
DATE	Oct. 11/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA: DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST: N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm. 0.2 0.6 1.0 1.4 1.8 ● FIELD VANE △ LAB VANE ■ UNCONF.
DESCRIPTION OF MATERIAL
PLASTIC LIMIT X — WATER CONTENT 0 — LIQUID LIMIT X
10 30 50 70 90%

NOTES:

1. Hole located 40 m. west of H-F P/L on north side of Dry Creek valley. Terrain slopes 5% southerly towards the creek.

2. Ground is moss covered. Site vegetated with sparse spruce to 5 m.

3. Hole augered to 1 m., cored from 1 to 4.55m., and drilled with mud from 4.55 to 10.0 m.. No SPT or SY samples recovered below 4.55 m.. Soil stratigraphy below 4.55 m. is based on drill action and cuttings returned in the drilling mud.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 31
HOLE No.	77-7-3 cont'd.
DATE	Oct.11/77 PLATE

K.L.C. - METRIC

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JOB No. AL0890

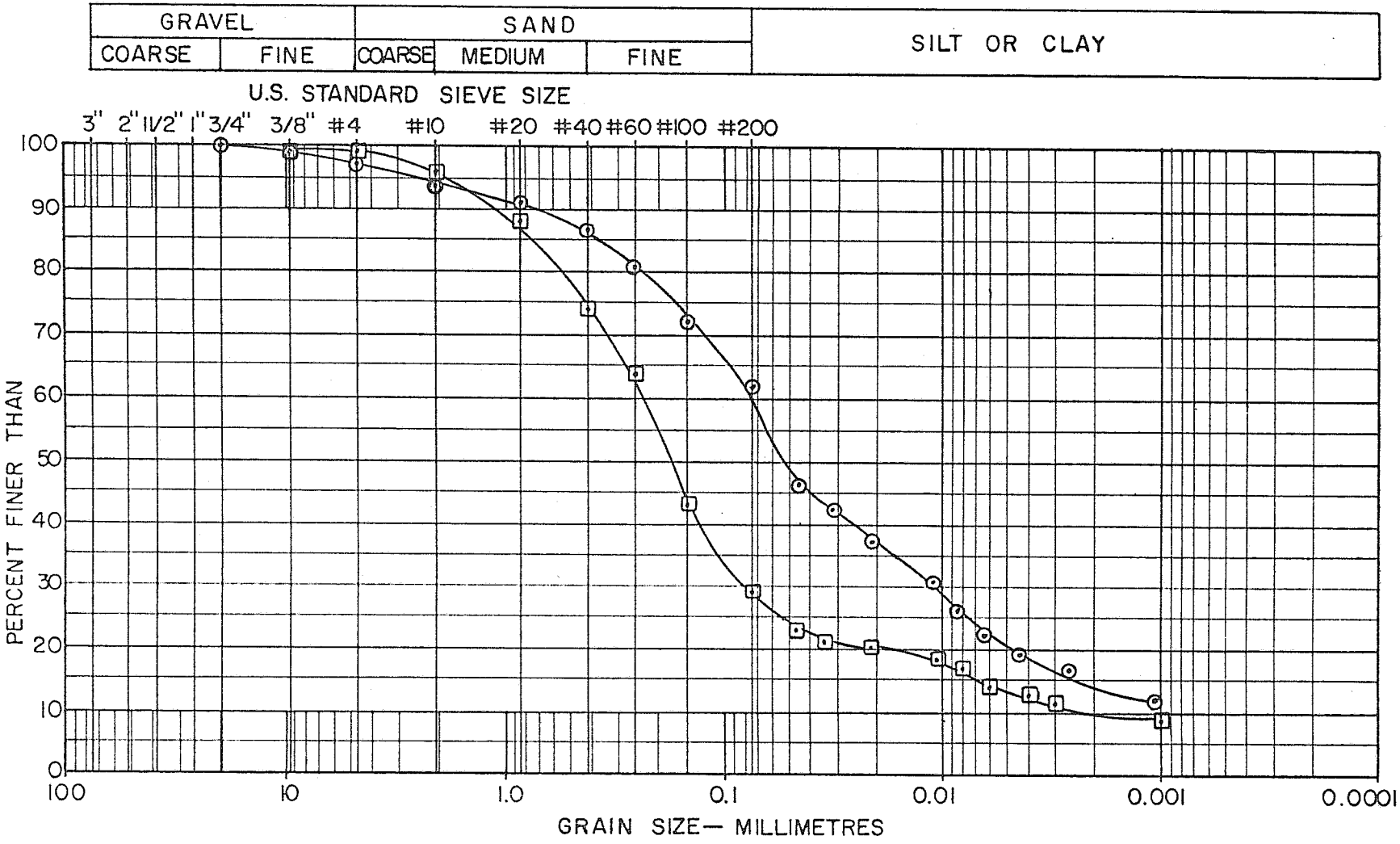
PROJECT Frost Heave Test Sites

LOCATION MP 31

HOLE No. 77-7-3 DEPTH

DATE Oct. 20/77

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa #5 (1.65-2.05 m.) SILT - and fine sand, little clay, trace gravel

⊡——⊡ Sa #8 (2.55-2.8 m.) SAND - some silt, trace clay (N.B. Sample taken from 3 cm. thick sand seam in the organic silt stratum.)

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JOB No. AL0890

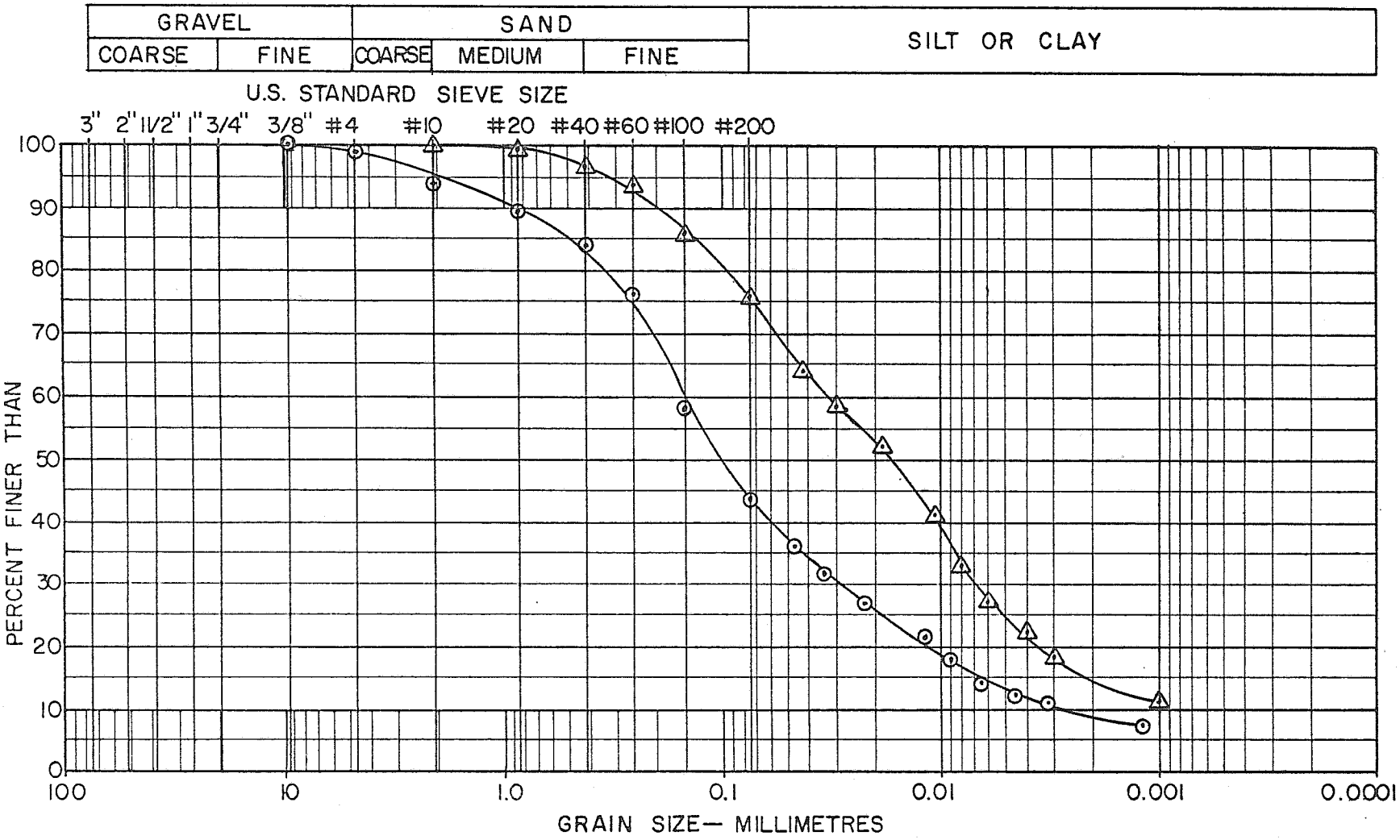
PROJECT Frost Heave Test Site

LOCATION MP 31

HOLE No. 77-7-3 DEPTH

DATE Oct 21/77

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa #10 (3.2-3.35 m.) SAND - and silt, trace gravel, trace clay

△——△ Sa #14 (4.2-4.55 m.) SILT - some sand, little clay, slight plasticity

(N.B. Sample taken from upper silty portion of stratum.)

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 7-3

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
4	1.00-1.45	1,100	65.3
5	1.65-2.05	1,190	70.7
7	2.25-2.55	1,270	75.4
8	2.55-2.80	1,290	76.6
9	2.80-3.20	1,280	76.0
11	3.35-3.70	1,720	102.2
12	3.70-3.95	1,780	105.7
13	3.95-4.20	1,450	86.1
14	4.20-4.55	1,290	76.6

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
LOCATION See Plate A-0890-7-2
ELEVATION 2276.38

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

SAMPLE DATA				SYMBOL	PERMAFROST		DESCRIPTION OF MATERIAL
DEPTH	TYPE	BLOW 15 cm.	No.		N.R.C. CLASS	N.F. or F.	
							0.3 m. peat moss cover
	B		1				CLAY & SILT - little sand
	B						- black organics
1	SY	11	2			NF	0.9 m. - medium plastic
	SPT	18	3				PEAT
		25					- and layers of clay & silt
	SY		4				1.85m. - black
2	SPT	37	5			2.15	SILT & CLAY
	C	49	6		Vr		- little sand, little gravel
	C	70+	7		Vs		- organic & wood chips
	B		8				- laminated, low plastic
3	C		9		Vx		peat layer
	C		10				3.22 gravel layer
	SY		11				
	SPT	115	12				GRAVEL & SAND
		Ref					- little to some silt
4					Vx		- subrounded to subangular
	B		13		Vc		- fine to coarse
		slough					
	SPT	5	14				
5		9					
		Ref				5.0	
6							
	B		15				
7						NF	
	B		16				
8							8.0 m.
							END OF HOLE @ 8.0 m.

NOTES:
1. Hole located 3 m. east of the Haines-Fairbanks pipeline and 90 m. north of the Alaska Hwy. Ground surface slopes 9% north.
2. Spruce and poplar to 7m., willow to 5 m.
3. Hole augered & core sampled to 3.4 m.. Drilling mud used from 3.4 to 8.0. Difficulty sampling from 5.5 to 8m. due to sloughing of gravel stratum.
4. Thermistors installed at 0.5, 1.5 3.0 and 6.0 m.. Standpipe piezometer installed

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-4
DATE Oct. 16/77 PLATE

K.L.C. - METRIC

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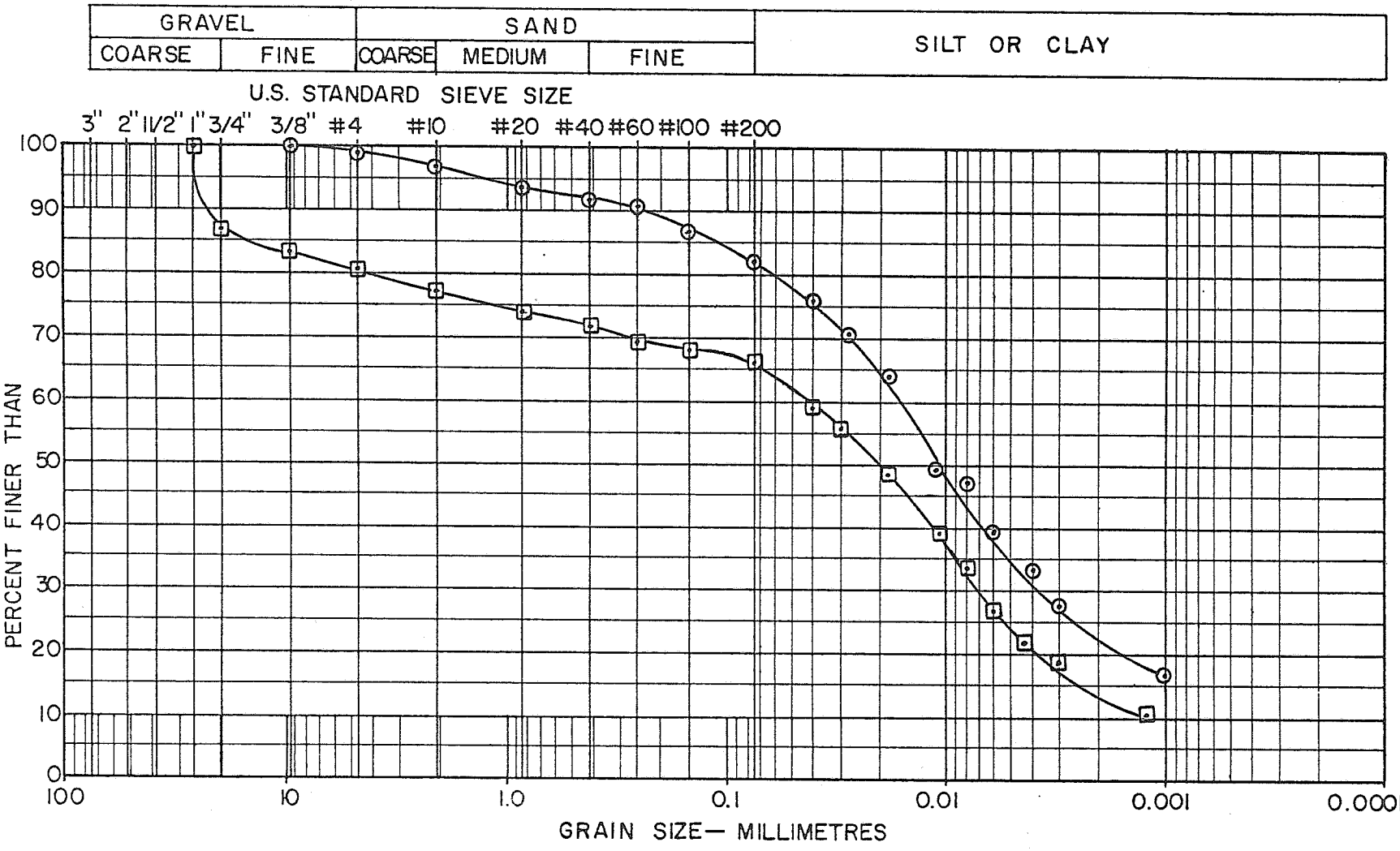
GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa #1 (0.4-0.5 m.) CLAY & SILT - little sand, organic fibres

⊡——⊡ Sa #5 (1.85-2.15 m.) SILT & CLAY - little sand, little gravel, low plastic.

JOB No. AL0890

PROJECT Frost Heave Test Site

LOCATION MP 31

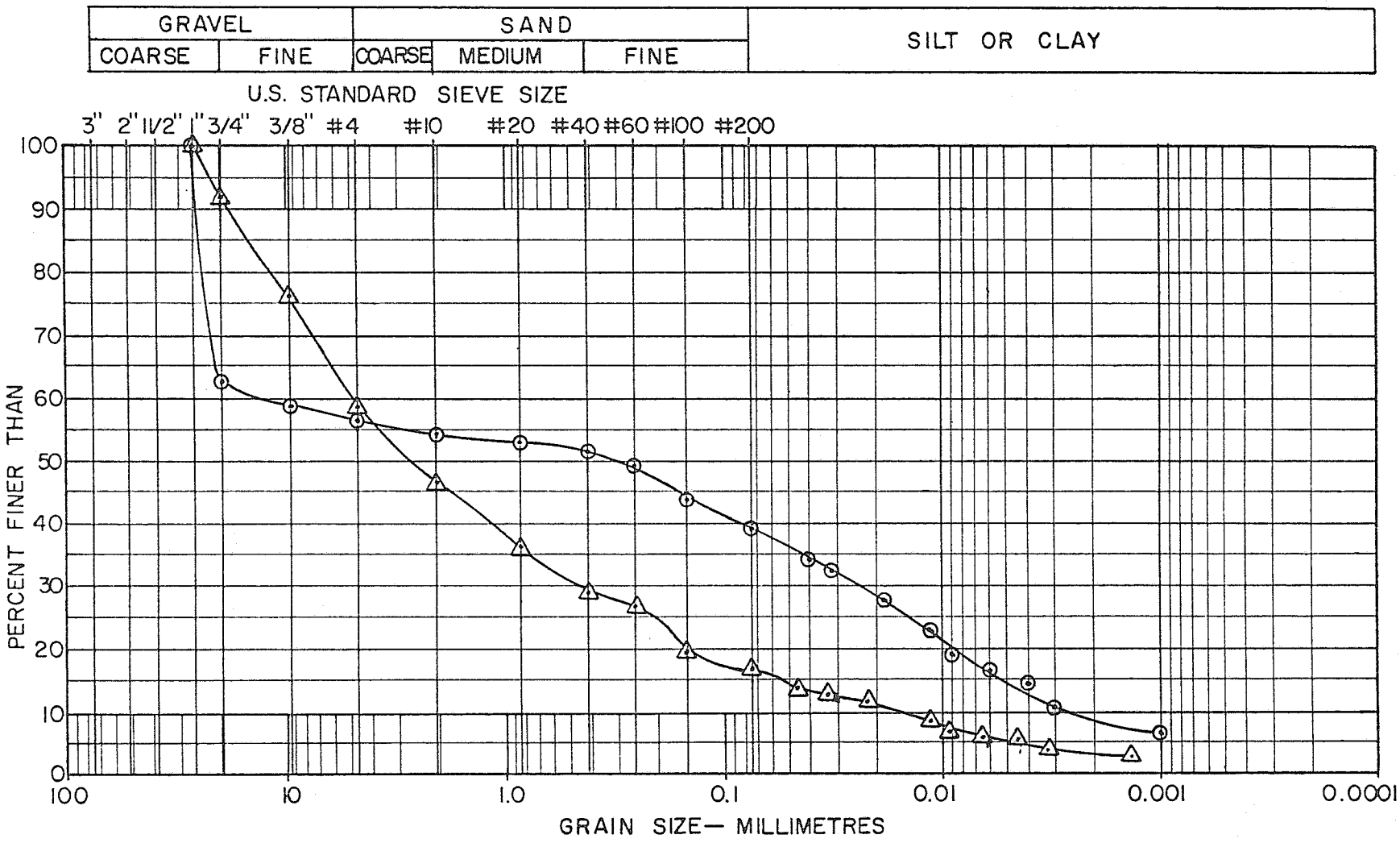
HOLE No. 77-7-4 DEPTH

DATE Oct. 26/77

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa #10 (3.0-3.2 m.) GRAVEL & SILT - little sand, trace clay

△——△ Sa #12 (3.27-3.42 m.) GRAVEL & SAND - little silt, fairly well graded.

JOB No. AL0890

PROJECT Frost Heave Test Site

LOCATION MP 31

HOLE No. 77-7-4 DEPTH

DATE Oct. 26/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 7-4

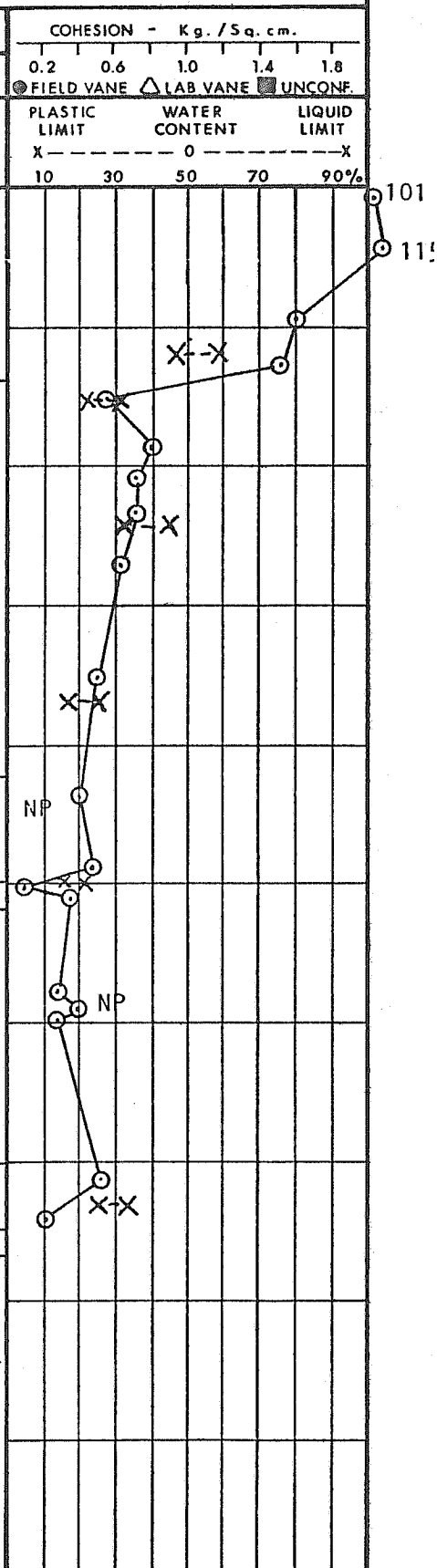
Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
7	2.35-2.60	1,120	66.5

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B						SILT & CLAY
	B		1			NF	- little sand - organic laminations - slight to low plastic - brown
						0.8	
1	B		2		Vx Vr Vs		
	C		3				1.4m.
	C		4				SILT & CLAY - little fine sand - organic specks - firm, laminated - low to medium plastic - brown
2	C		5				
	C		6			2.0	
	C	8	7				
3	SPT	9 11	8				thin gravel laminations at 2.3 m.
	C		9				some sand in laminations
4							4.2m.
	C		10				SAND & SILT- layered - trace clay - slight plasticity
5	C		11				4.97m. - light brown
	C		12				5.12m. SAND - some silt, tr. gravel
	C		13				SAND - medium to coarse - little silt - trace gravel - brown
	C		14				
6	C		15				
	C		16				
7							7.0m.
	C	16	17				SILT & CLAY - trace sand
		52					7.5m. - low plastic, grey
	SPT	93	18				7.65m. GRAVEL-some sand, little silt
8							END OF HOLE @ 7.65m.

NOTES:
1. Hole located 3m. east of Haines-Fairbanks pipeline and 8m. west of Dry Creek. Ground slopes 3% south.
2. Willows & sparse spruce to S.W.
3. Hole augered & cored to 7.65m.



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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-5
DATE Oct. 18/77 PLATE

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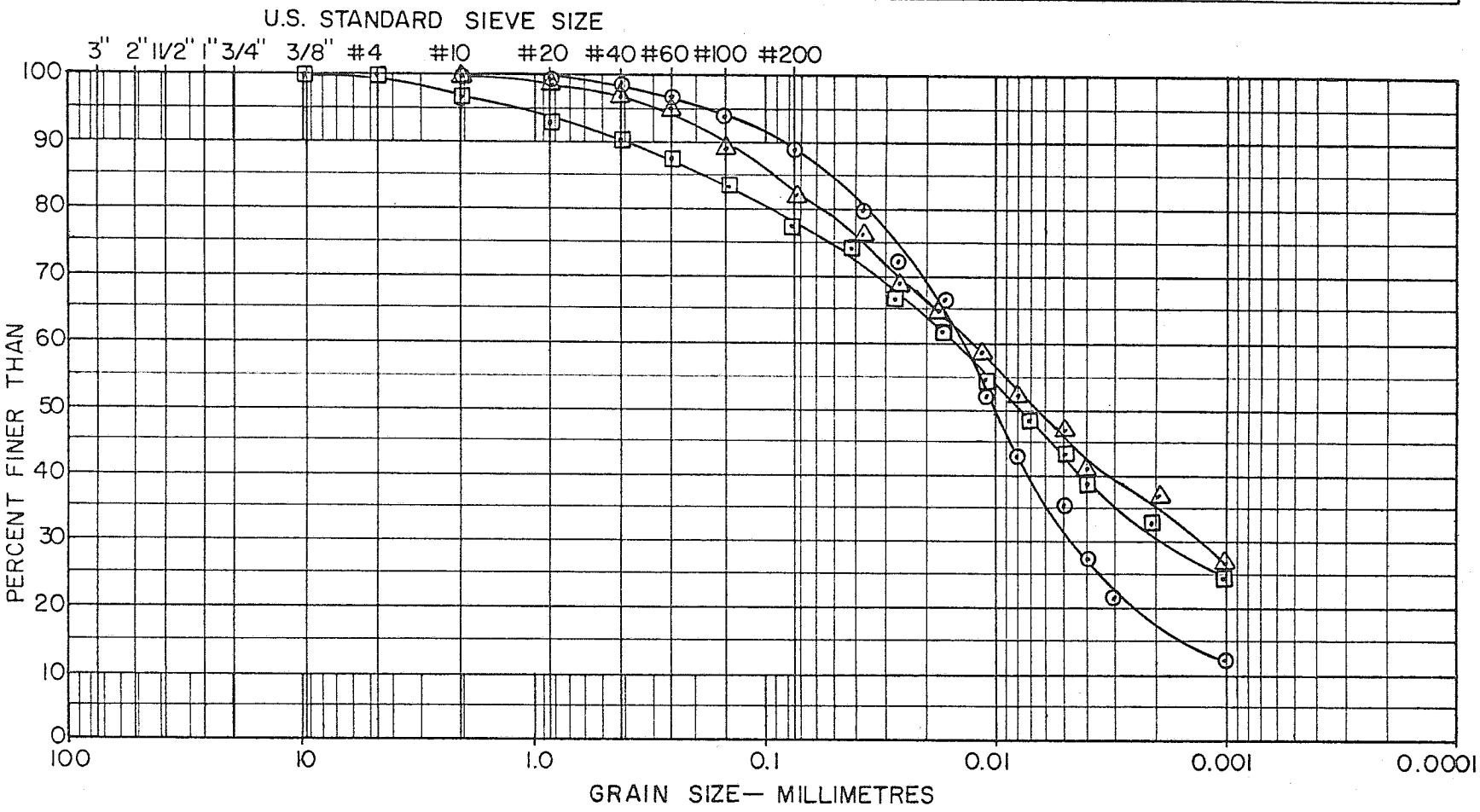
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



GRAIN SIZE CURVE

REMARKS:
- Sa. # 3 (1.15-1.35 m.) SILT & CLAY - little fine sand, low plastic
- Sa. # 4 (1.35-1.7 m.) CLAY & SILT - little fine sand, low to med. plasticity
- Sa. # 7 (2.2-2.4 m.) CLAY & SILT - some fine sand, low to med. plasticity

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 31
HOLE No. 77-7-5 DEPTH
DATE Oct. 25/77

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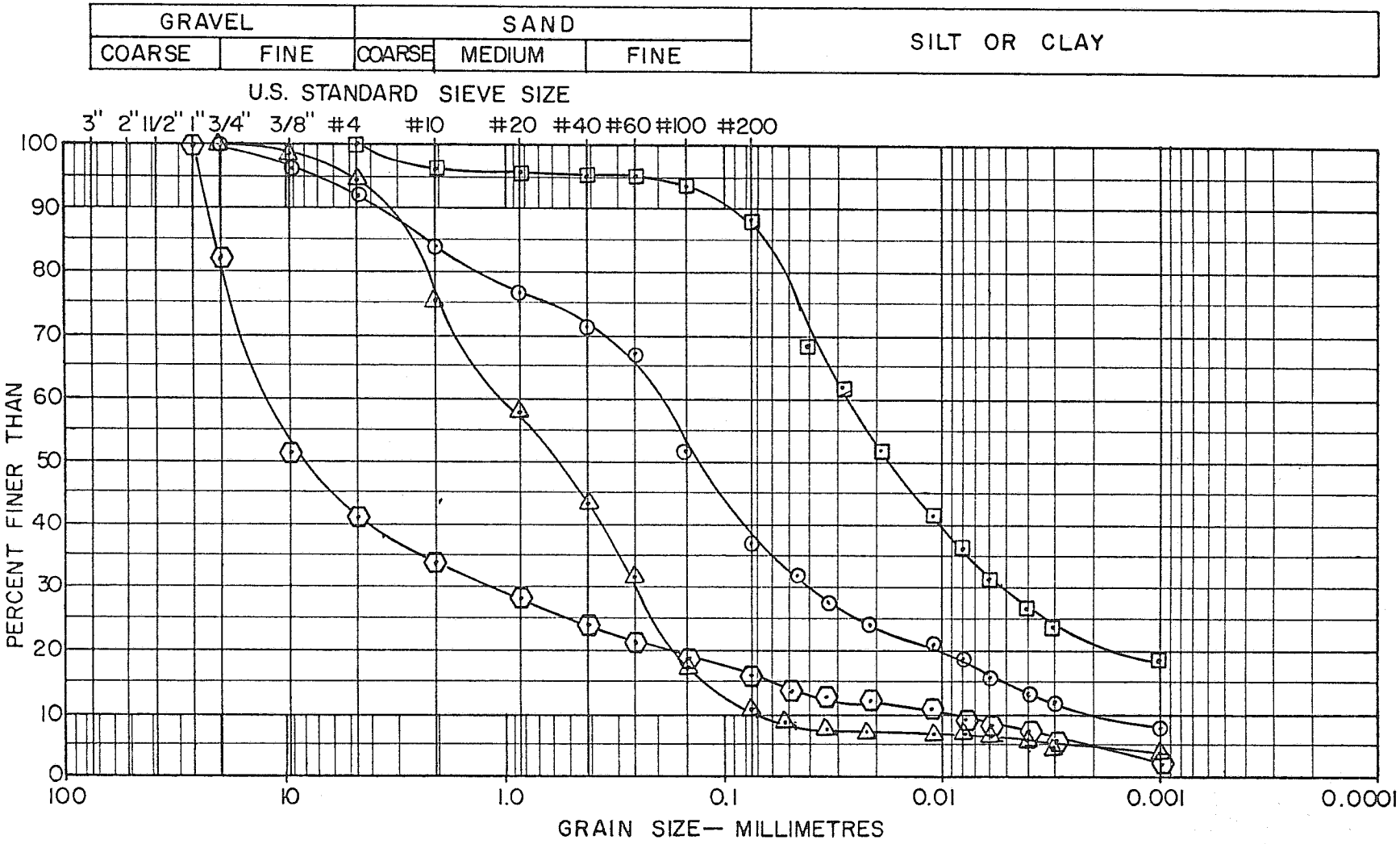
GRAIN SIZE CURVE



REMARKS:

- Sa. # 13 (5.02-5.12) SAND - fine to coarse, some silt, trace gravel
- Sa. # 14 (5.7-5.8) SAND - trace gravel, trace silt, well graded
- Sa. # 17 (7.0-7.2) SILT & CLAY - trace fine sand, low plastic
- Sa. # 18 (7.2-7.65) GRAVEL - some sand, little silt

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 31

HOLE No. 77-7-5 DEPTH

DATE Oct. 28/77

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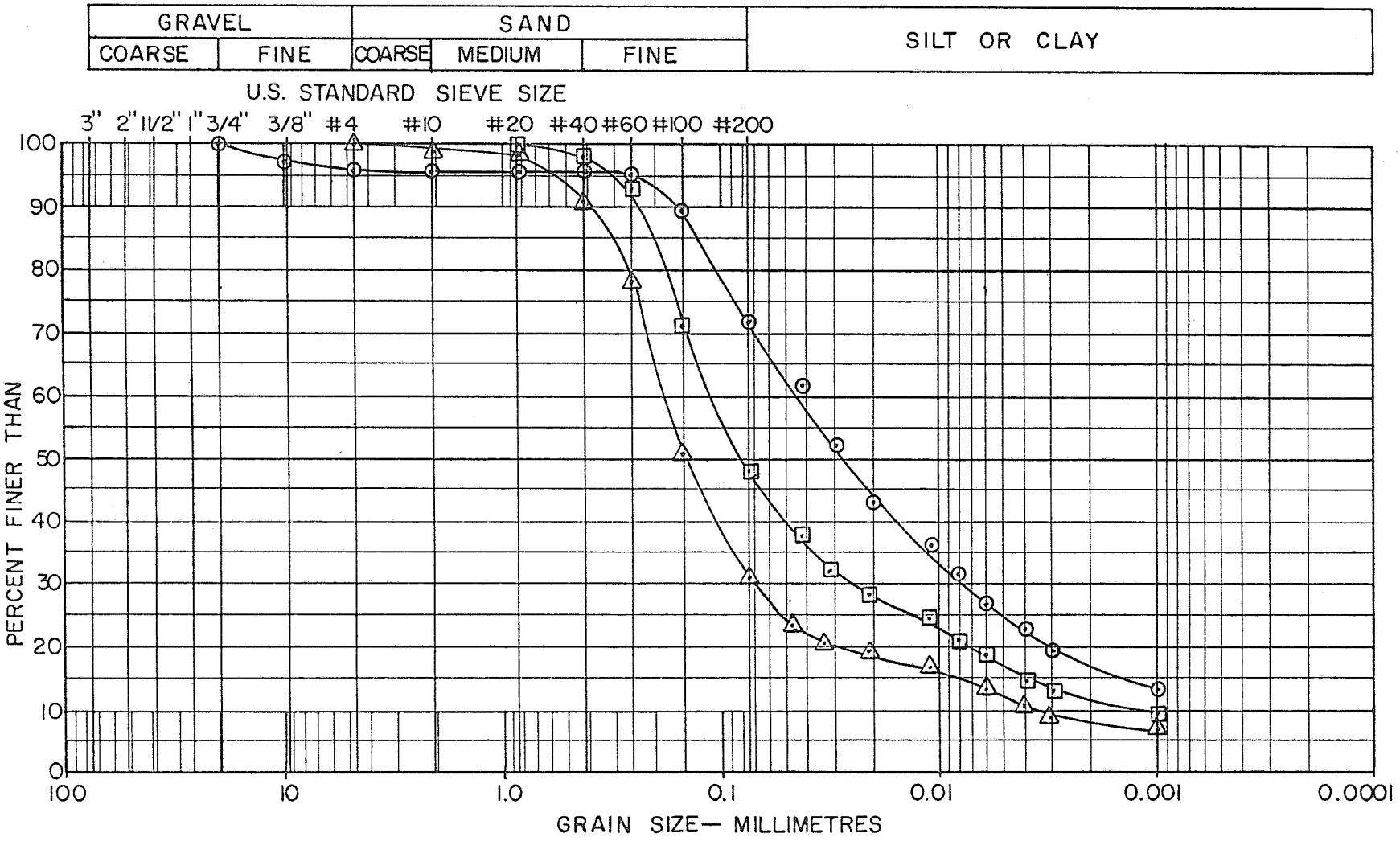
JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 31
HOLE No. 77-7-5 DEPTH
DATE Oct. 25/77

GRAIN SIZE CURVE



REMARKS:
- Sa. # 9 (3.4-3.6 m.) SILT & CLAY - some fine sand, trace gravel, low plastic
- Sa. #10 (4.2-4.3 m.) SAND & SILT - non plastic
- Sa. #10a (4.3-4.4 m.) SAND - fine, some silt, non plastic

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 7-5

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.15-1.35	1,004	59.6
4	1.35-1.70	1,840	109.3
5	1.70-2.00	1,640	97.4

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
	B		1
1	B		2
	B		3
	C		4
2	C		5
	C		6
	C		7
3	C		8
4	C		9
5	C		10
	C		11
6			
	C		12
7			
	C		13
8			

SYMBOL

PERMAFROST: N.R.C. CLASS | N.F. or F.

LOCATION See Plate A-0890-7-2
ELEVATION 2267.17

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

0.1m ORGANIC COVER

SILT AND CLAY
- some fine sand
- black organic laminations
- low plastic
- dark brown

2.0m

SILT - and sand
- wood specks
- laminated, brown

2.75m

SAND AND SILT
- fine to medium
- laminated with thin seams of silt & clay and coarse sand to 7 cm thick
- non to slight plasticity

3.9m

SAND - fine to medium
- some silt
- trace gravel

5.0m

GRAVEL- and medium to coarse sand
-little silt, trace clay

5.5

SILT & CLAY & SAND
- trace gravel
- laminated
- low plastic

6.0m

GRAVEL - and medium to coarse sand in layers
- little silt
- trace clay

@ 6.8m. 3 cm. thick grey silt and clay seam

7.8m

END OF HOLE @ 7.8 m.

(Continued)

NF
0.9
2.0
NF
NP

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-6
DATE	Oct. 19/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.				SYMBOL	PERMAFROST		LOCATION See Plate A-0890-7-2	COHESION - Kg./Sq. cm. 0.2 0.6 1.0 1.4 1.8 ● FIELD VANE △ LAB VANE ■ UNCONF.
HT. DROP 76 cm.							ELEVATION	
SAMPLE DATA					N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X — — — — — 0 — — — — — X 10 30 50 70 90%
DEPTH	TYPE	BLOW / 15 cm.	No.					

Notes:

1. Hole located along Haines-Fairbanks pipeline right-of-way immediately north of a small water filled depression, and 10 m. east of Dry Creek.
2. Vegetation mostly willows to 2 m.
3. Test hole augered to 1.7 m. and cored from 1.7 m. to 7.8 m.
4. Water encountered at 2.5 m. depth during drilling.
5. Standpipe piezometer installed to 3.2 m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-6 (Cont'd)
DATE	Oct. 19/77 PLATE

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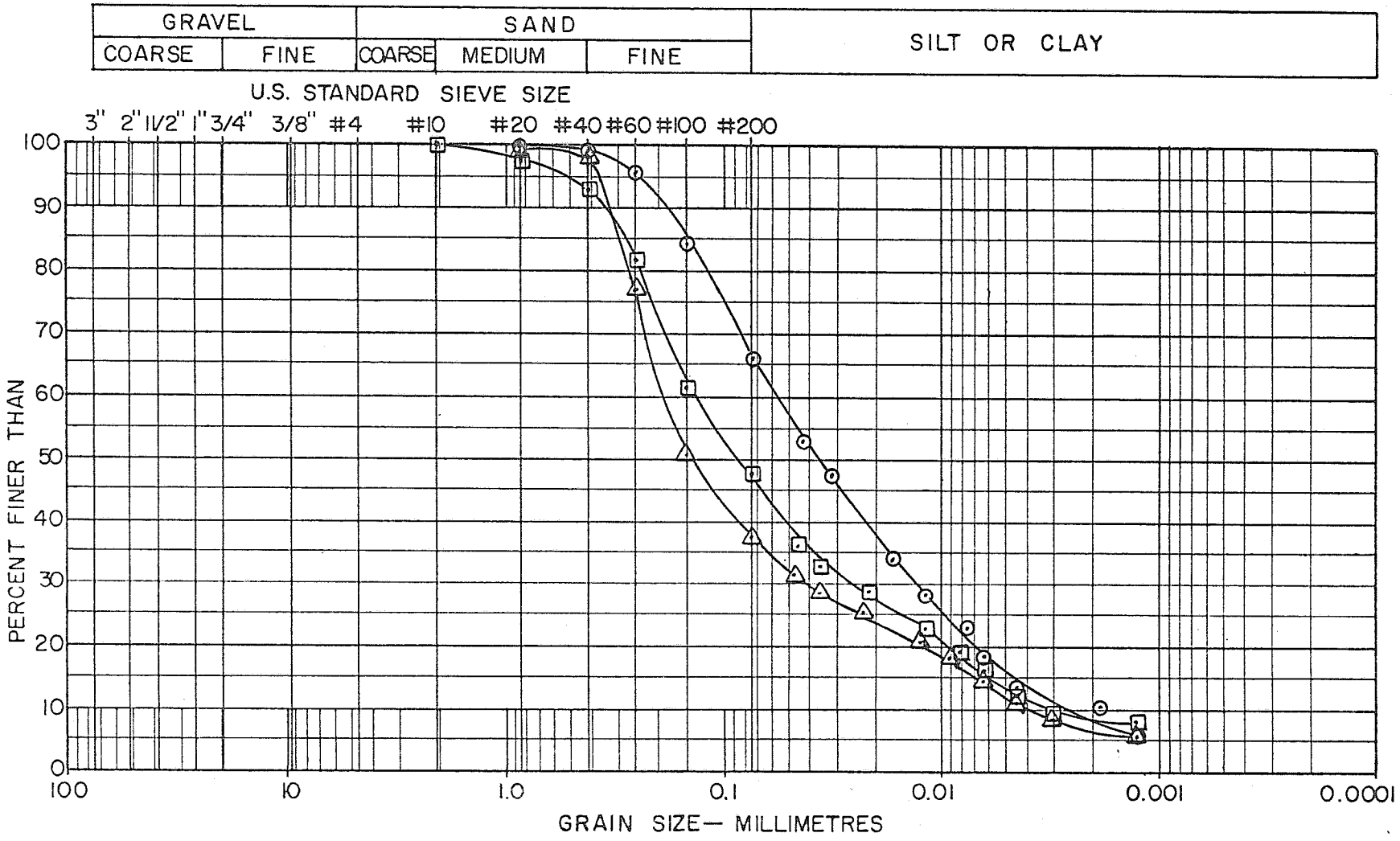
CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

- ⊙—⊙ Sa #4 (1.5-1.7 m.) SILT & CLAY - some fine sand, low plasticity
- △—△ Sa #8 (2.75-2.83 m.) SAND - fine, and silt, trace clay
- ⊡—⊡ Sa #8b (2.9-3.0 m.) SAND AND SILT - trace clay, non plastic

JOB No.	AL0890
PROJECT	Frost Heave Test Site
LOCATION	MP 31
HOLE No.	77-7-6
DEPTH	
DATE	Nov. 2/77

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JOB No. AL0890

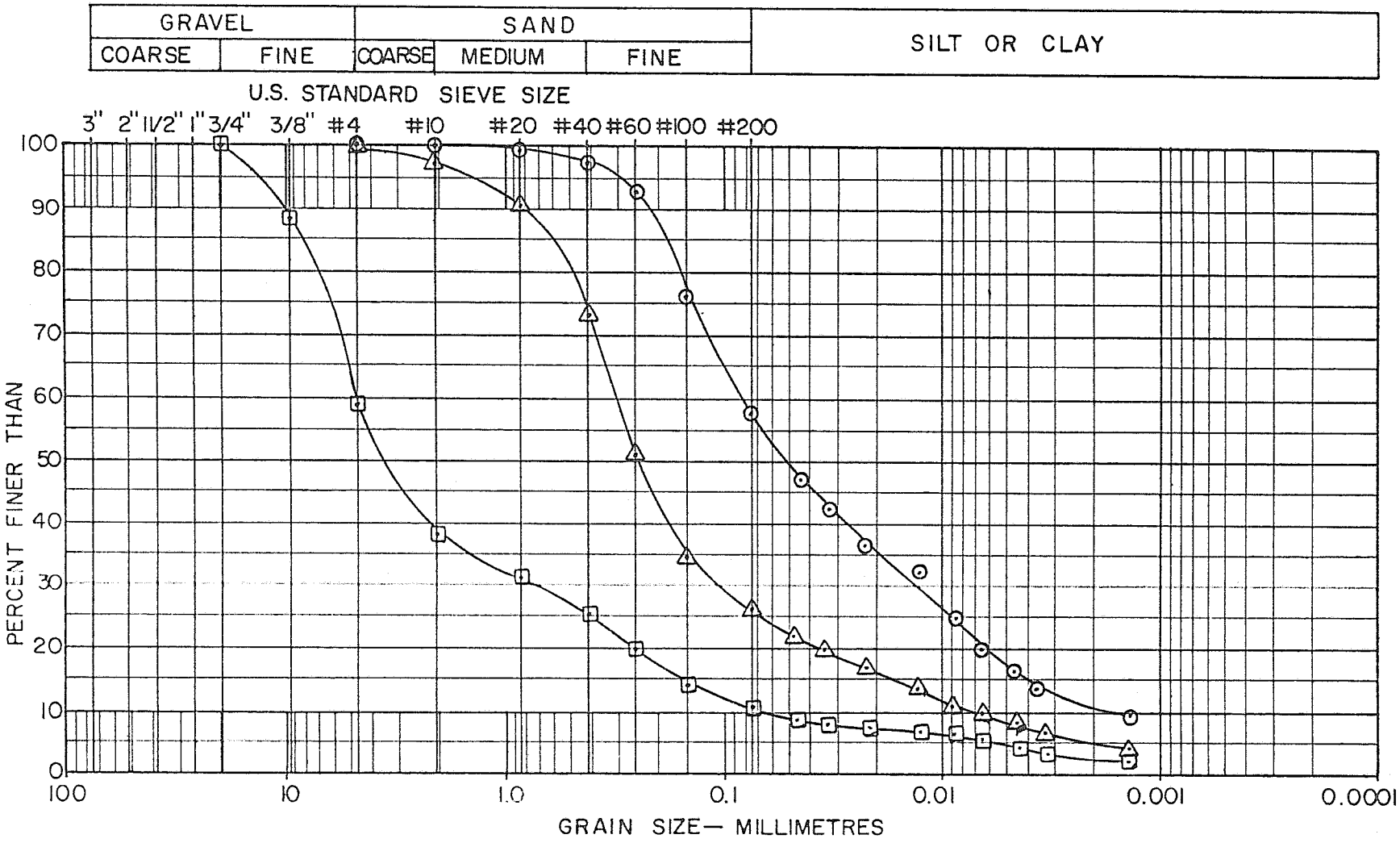
PROJECT Frost Heave Test Site

LOCATION MP 31

HOLE No. 77-7-3 DEPTH

DATE Nov. 2/77

GRAIN SIZE CURVE



REMARKS:

- Sa #9 (3.7-3.9 m.) SILT - and fine sand, trace clay, slight plasticity
- Sa #9a (3.9-4.0 m.) SAND - fine to medium, some silt, trace clay
- Sa #11 (5.0-5.5 m.) GRAVEL & SAND - little silt, trace clay

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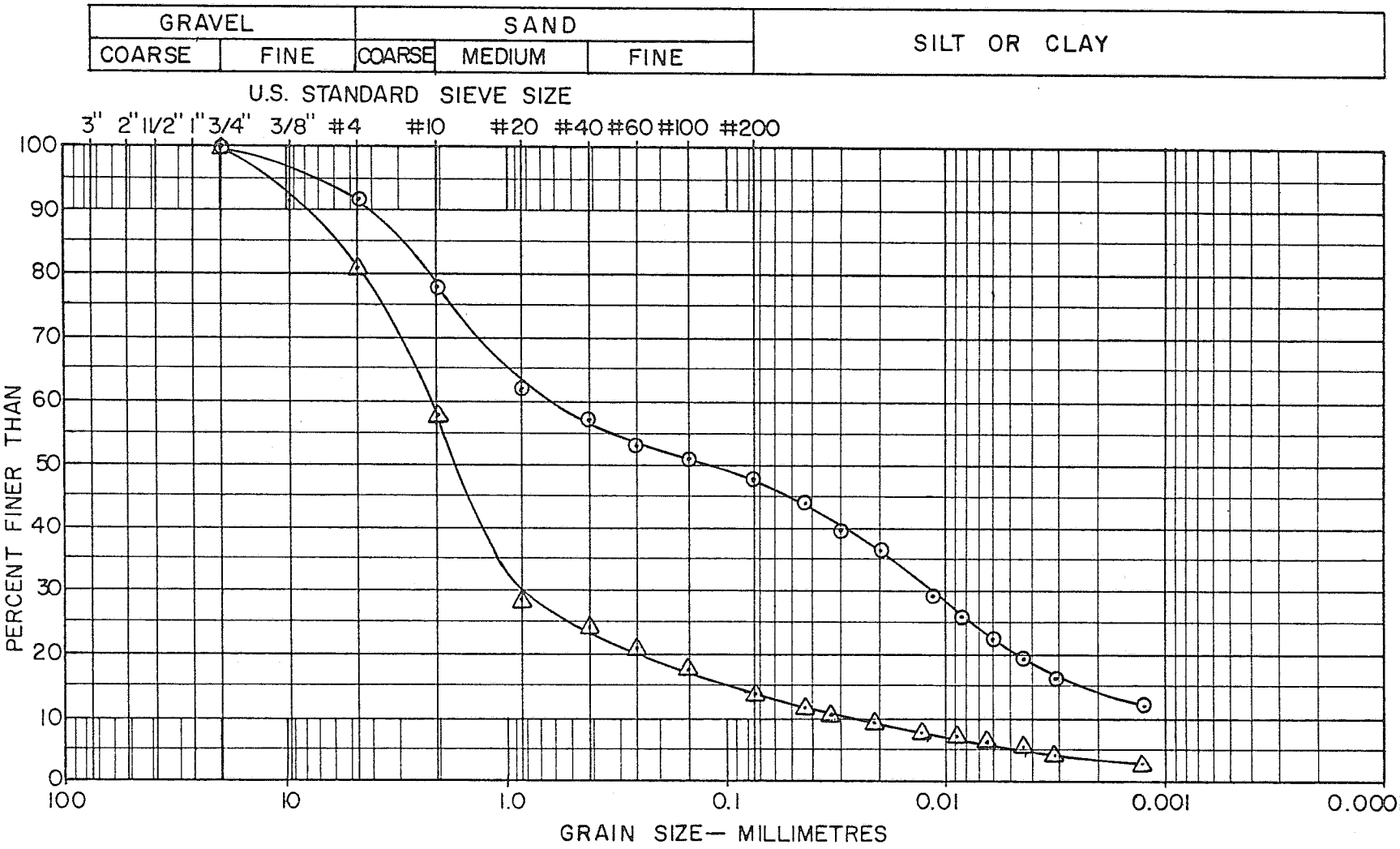
CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS: ⊙—⊙ Sa #11a (5.5-5.7 m.) SILT & CLAY AND SAND - trace gravel, low plasticity

△—△ Sa #13 (7.4-7.5 m.) SAND - medium to coarse, little gravel, little silt, trace clay (N.B. Sample taken from stratified sand layer in the gravel stratum.)

JOB No. AL0890

PROJECT Frost Heave Test Site

LOCATION MP 31

HOLE No. 77-7-6 DEPTH

DATE Nov. 2/77

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 7-6

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
4	1.50-1.70	1,620	96.2
5	1.70-2.00	1,300	77.2

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
1	B		1
	B		2
	B		3
2	B		4
	SY		4a
3	B		5
	SY		6
4			
	C		7
5			
	C		8
6			
7	C		9
	C		10
	C		10a
8			

SYMBOL

PERMAFROST
N.R.C. CLASS
N.F. or F.

LOCATION See Plate A-0890-7-2
ELEVATION 2266.73

DESCRIPTION OF MATERIAL

.15m ORGANIC COVER

SILT & CLAY
- little fine sand
- organic laminations
- rootlets
- slight to low plastic
- soft to firm, brown

and sand in laminations
2.0m slight plasticity

SAND - fine to medium
- little silt in thin 3-5 mm. laminations
- grey and brown

silt layers to 11 cm. thick @ 3.0 m. depth.

NF

4.5m

SAND AND SILT
- trace clay
- 10 cm. thick silt layer @ 4.5 m.
- silt laminations average 2-3 cm. thick

6.0m

SAND
- little laminated silt
- trace clay

little gravel to 7 cm. ø below 6.5 m. depth.

8.0m

END OF HOLE @ 8.0 m.

(Continued)

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

161
NP

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-7
DATE	Oct. 19/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

Notes:

1. Hole located on north edge of small swampy depression which is about 30 m. in diameter; & about 50 m. west of Dry Creek.
2. The swampy depression is vegetated with grass. The terrain to the west is open, with sparse spruce to 3 m. The terrain to the east adjacent to Dry Creek is more densely vegetated with spruce to 10 m.
3. Test hole augered to 4 m., & cored from 4 to 8 m.
4. Water level in test hole at 3.2 m. on completion of drilling.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-7 (Continued)
DATE	Oct. 19/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890

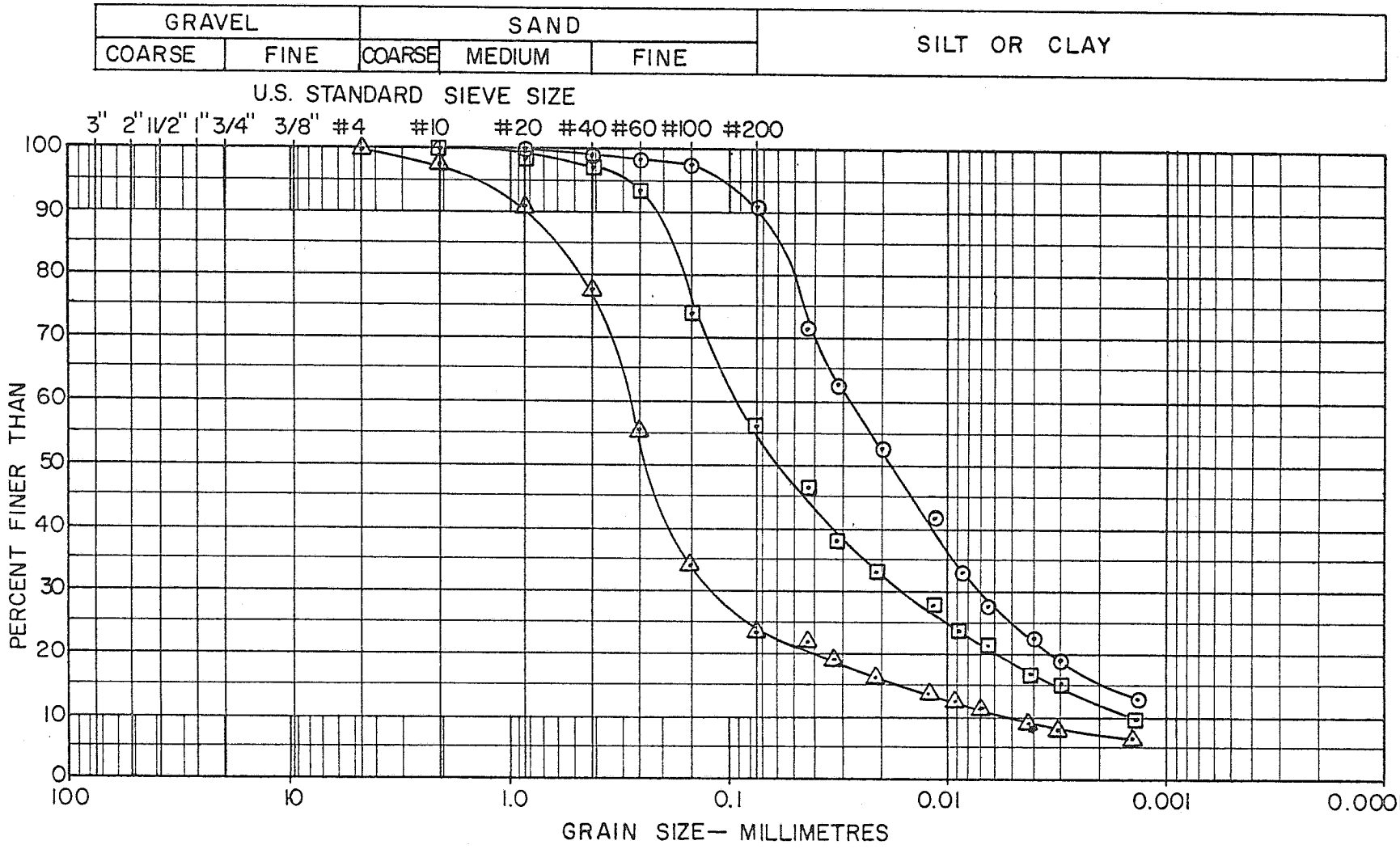
PROJECT Frost Heave Test Sites

LOCATION MP 31

HOLE No. 77-7-7 DEPTH

DATE Nov. 4/77

GRAIN SIZE CURVE



REMARKS:

- Sa. # 2 (1.0 m.) SILT & CLAY - trace fine sand, low plasticity
- Sa. # 4 (2.0 m.) SILT & CLAY AND SAND - low plasticity
- Sa. # 5 (2.8-3.0 m.) SAND - fine, little silt, trace clay

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JOB No. AL0390

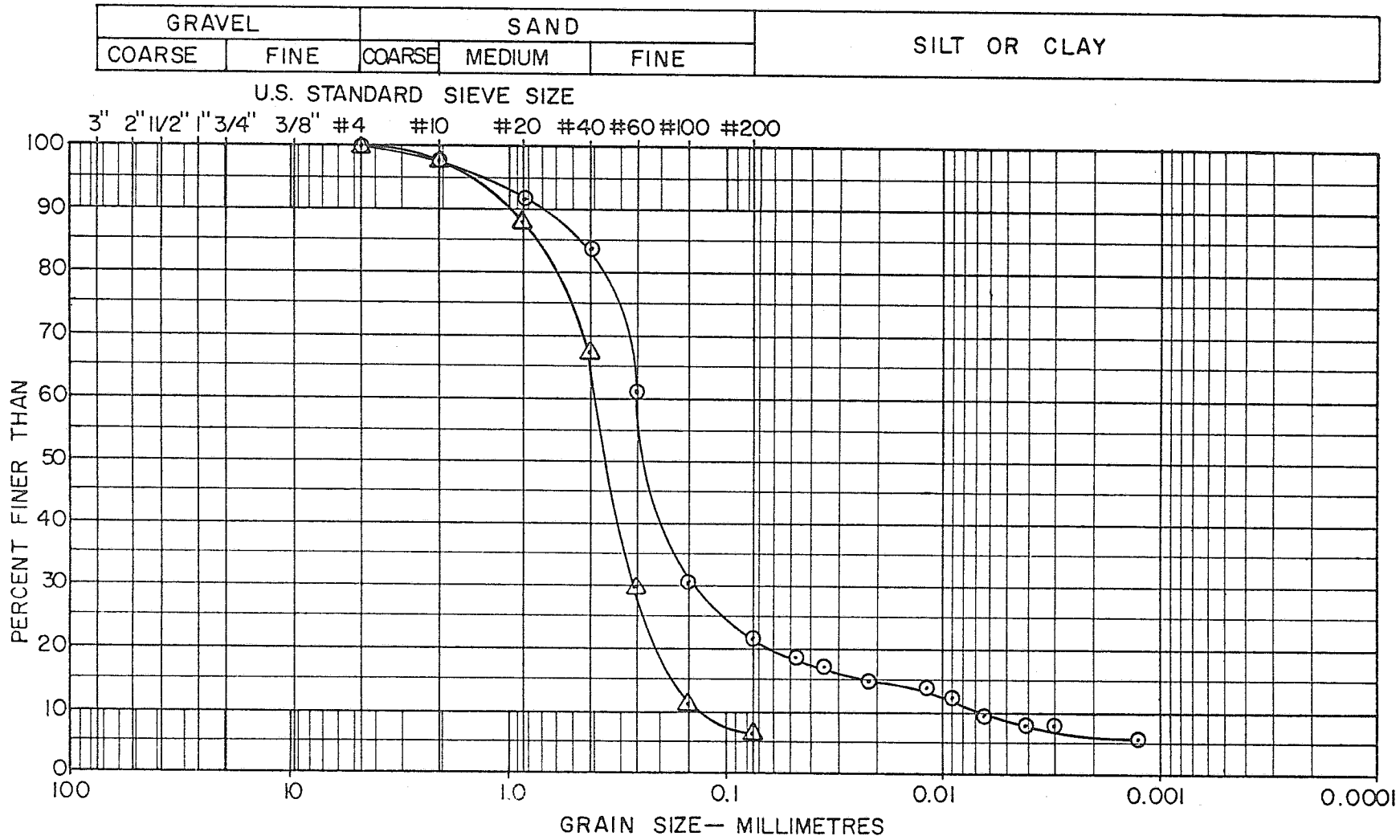
PROJECT Frost Heave Test Sites

LOCATION MP 31

HOLE No. 77-7-7 DEPTH

DATE Nov. 4/77

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa. # 6 (3.1-3.2 m.) SAND - fine, little silt, trace clay

△——△ Sa. #6a (3.2-3.3 m.) SAND - fine, trace silt

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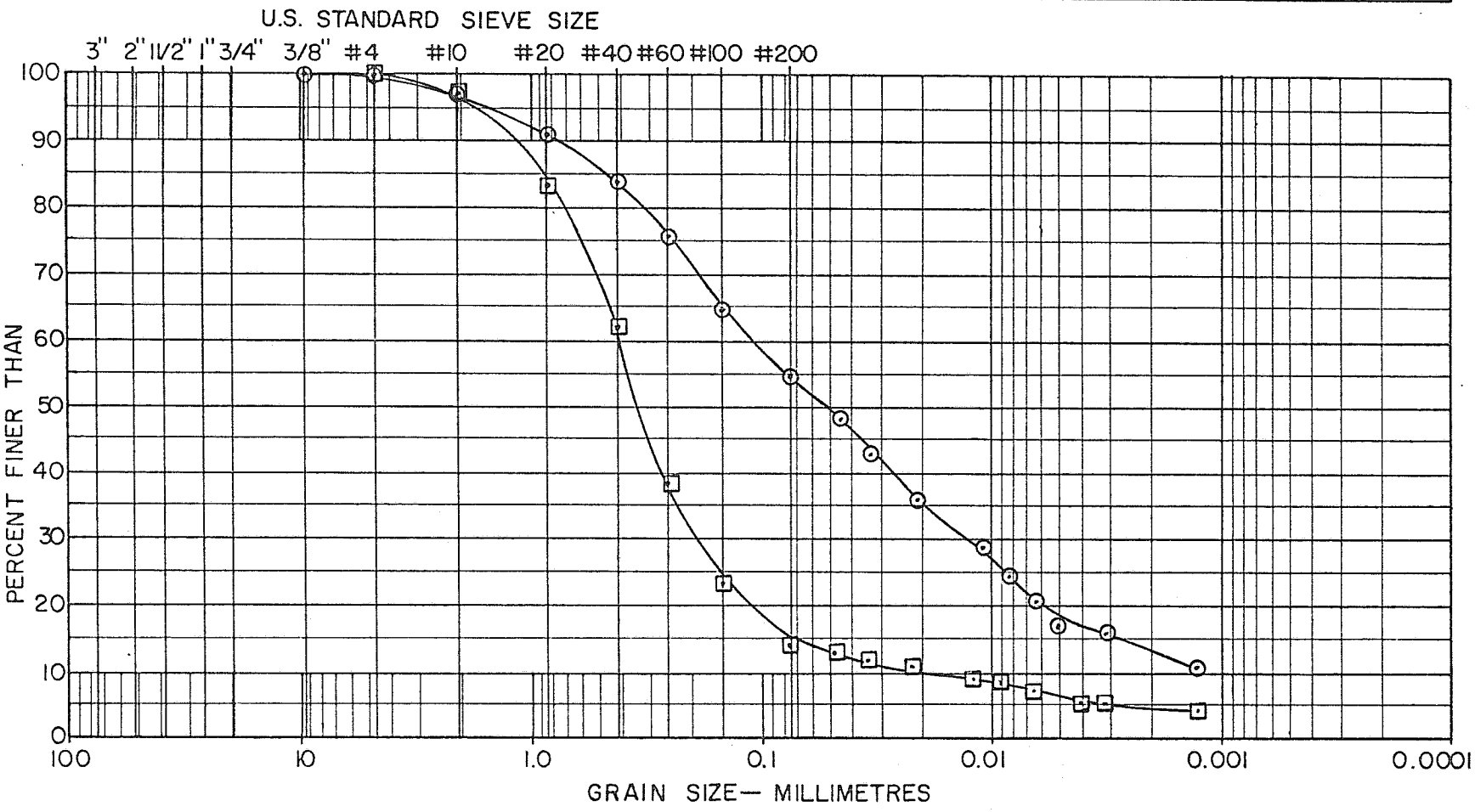
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



GRAIN SIZE CURVE

REMARKS: Sa. #8 (5.0-6.0 m.) SAND AND SILT - trace clay

Sa. #10 (7.0-7.5 m.) SAND - fine, little silt, trace clay

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 31 •

HOLE No. 77-7-7 DEPTH

DATE Nov. 4/77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

PERMAFROST

LOCATION See Plate: A-0890-7-2
ELEVATION 2270.30

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
							0.1 m. organic cover
	B		1				SILT
1	SY		2				- trace clay - trace fine sand - organic & wood specks - laminations of silt and sand @ 2-8 mm. - non to slight plasticity - firm to stiff, dk. brown
	SY		3				
	SY		4				
2							extensive organic laminations & pieces of wood
	SY		5				2.3 m.
	SY		6				SILT AND SAND - trace clay - laminated fine sand & grey silt - organic & wood layers - non to slight plasticity - firm, brown & grey
3	SY		7			NF	
	SY		8				3.5 m.
4	B		9				4.0 m. SAND - fine to coarse - some silt, little gravel - well graded, brown
	C		10				4.9 m. SAND - fine to coarse - some gravel - trace silt
5							
	C		11				5.8 m. GRAVEL - some sand, trace silt
6							
	C		12				SAND - little gravel, trace silt
7							6.5 m.
	C		13				GRAVEL - and sand, trace cobbles - trace silt
							7.6 m.
8							END OF HOLE @ 7.6 m.

(Cont'd.)

NP
NP

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 31
HOLE No.	77-7-8
DATE	Oct. 22/77 PLATE

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▣ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located 20 meters west of Dry Creek and about 20 meters east of open sparsely treed area.
2. Area adjacent to creek supports a dense spruce growth to 15 m. in height.
3. Test hole augered to 0.5 m., continuous undisturbed Shelby Tube samples taken from 0.5 to 3.5 m., and cored from 4.0 to 7.6 m..
4. Water level in test hole at 3.0 m. on completion of drilling.

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-8
DATE Oct. 22/77 PLATE

K.L.C. - METRIC

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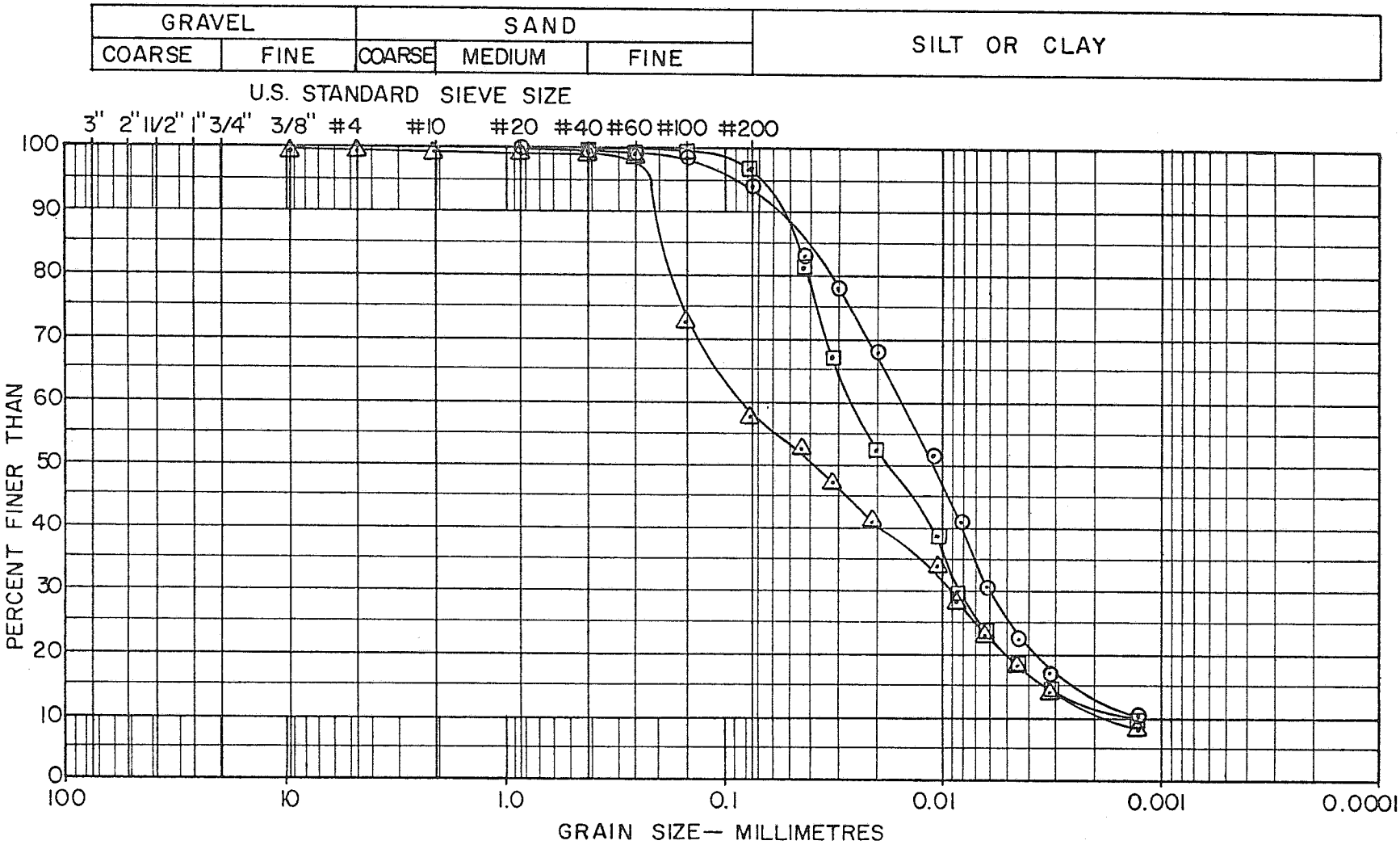
GRAIN SIZE CURVE



REMARKS:

- Sa. #2 (0.5 - 0.85 m.) SILT - trace fine sand, trace clay, non plastic
- Sa. #3 (1.0 - 1.4 m.) SILT - trace fine sand, trace clay, slight plasticity
- Sa. #6 (2.3 - 2.75 m.) SILT AND SAND - trace clay, slight plasticity

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION M.P. 31

HOLE No. 77-7-8 DEPTH

DATE Nov. 4, 1977

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JOB No. AL0890

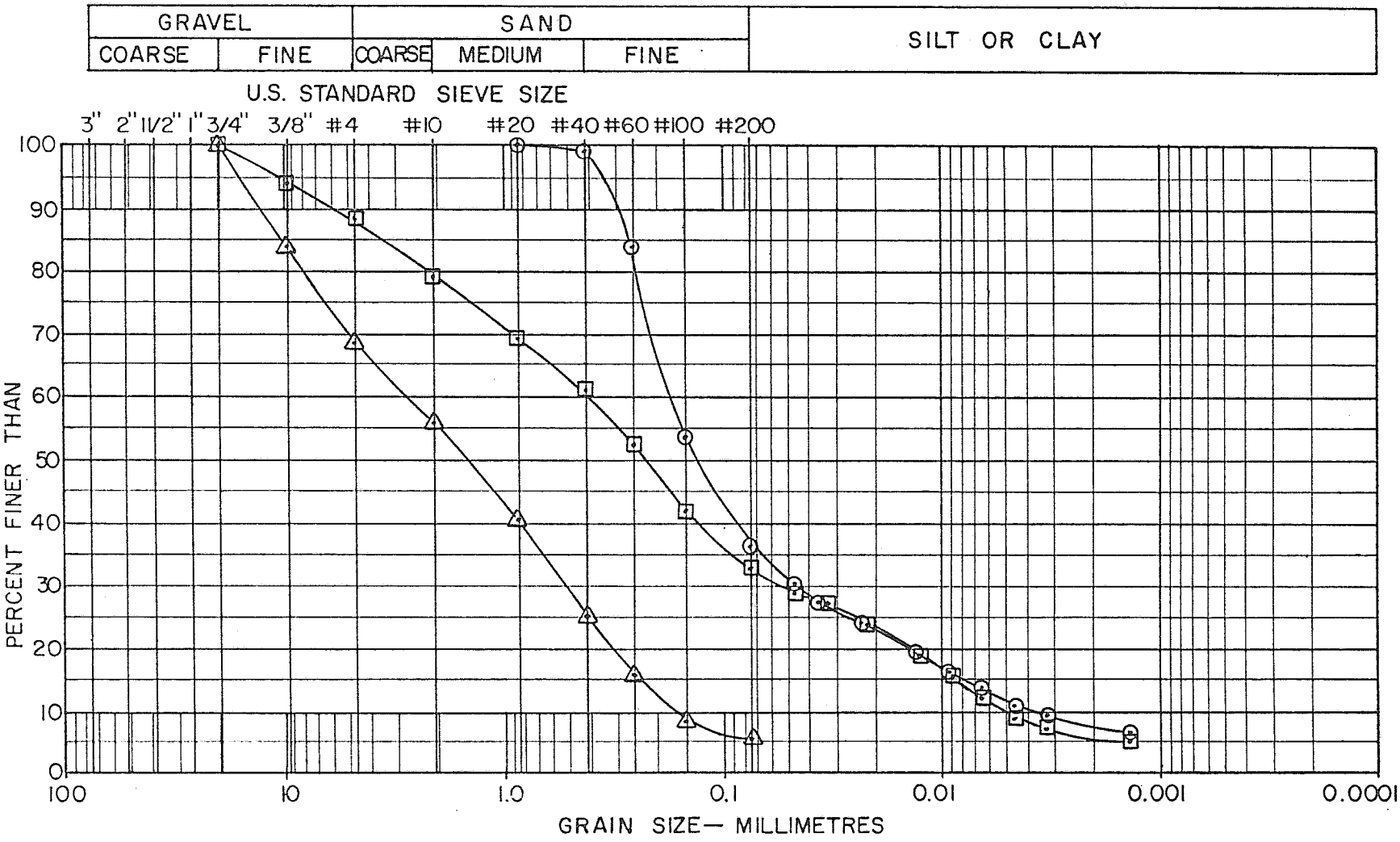
PROJECT Frost Heave Test Sites

LOCATION M.P. 31

HOLE No. 77-7-8 DEPTH

DATE Nov. 4, 1977

GRAIN SIZE CURVE



REMARKS:

⊙—⊙	Sa. #7 (2.75 - 3.2 m.)	SAND - fine, and silt, trace clay
⊡—⊡	Sa. #9 (@ 4.0 m.)	SAND - fine to coarse, some silt, little gravel, trace clay, well graded
△—△	Sa. #10 (4.4 - 4.9 m.)	SAND - fine to coarse, some gravel, trace silt, well graded.

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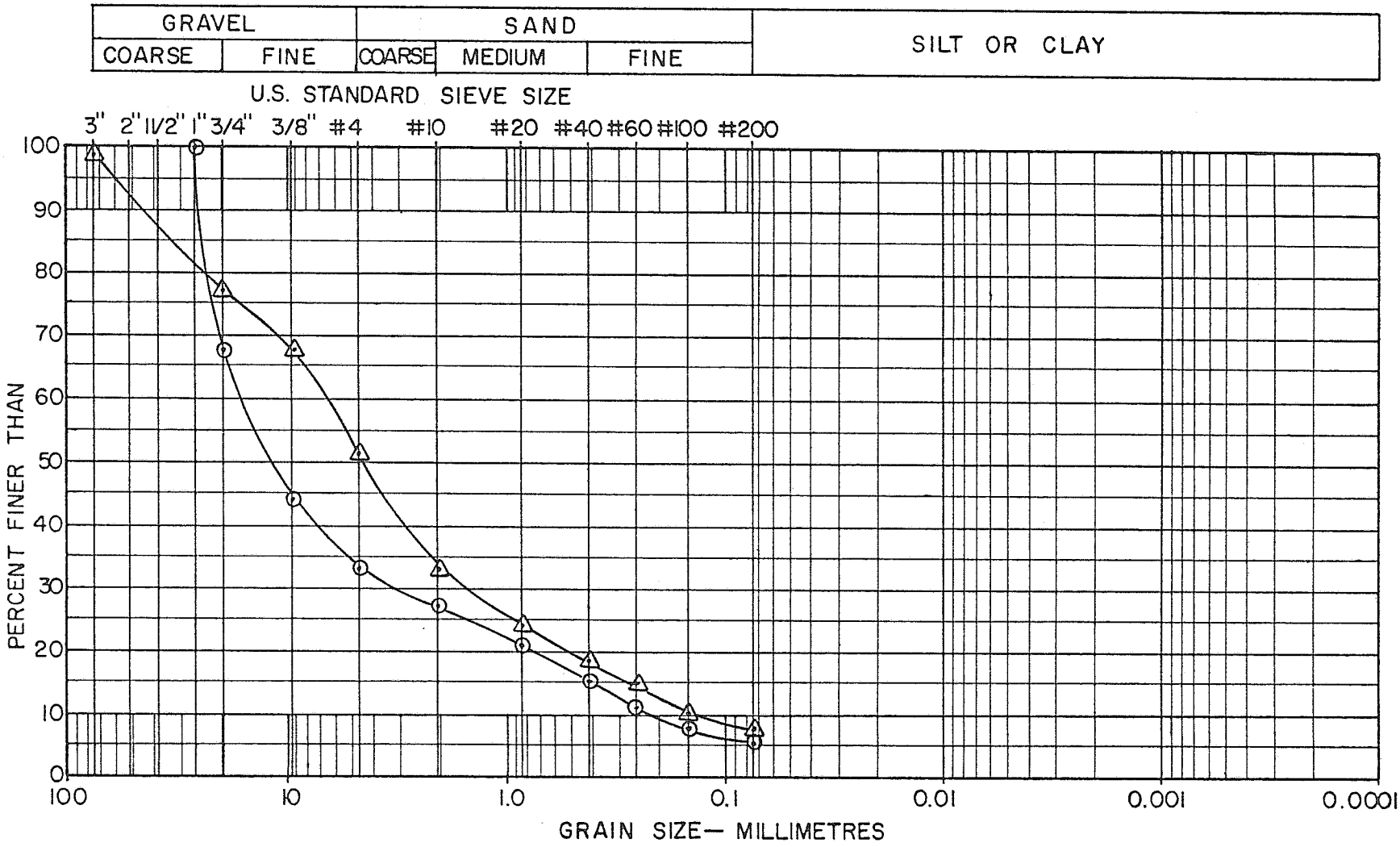
GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa. #11 (5.0 - 5.6 m) GRAVEL - some sand, trace silt

△——△ Sa. #12 (6.5 - 7.0 m) GRAVEL - and sand, trace silt, trace cobbles

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION M.P. 31

HOLE No. 77-7-8 DEPTH

DATE Nov. 8, 1977

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

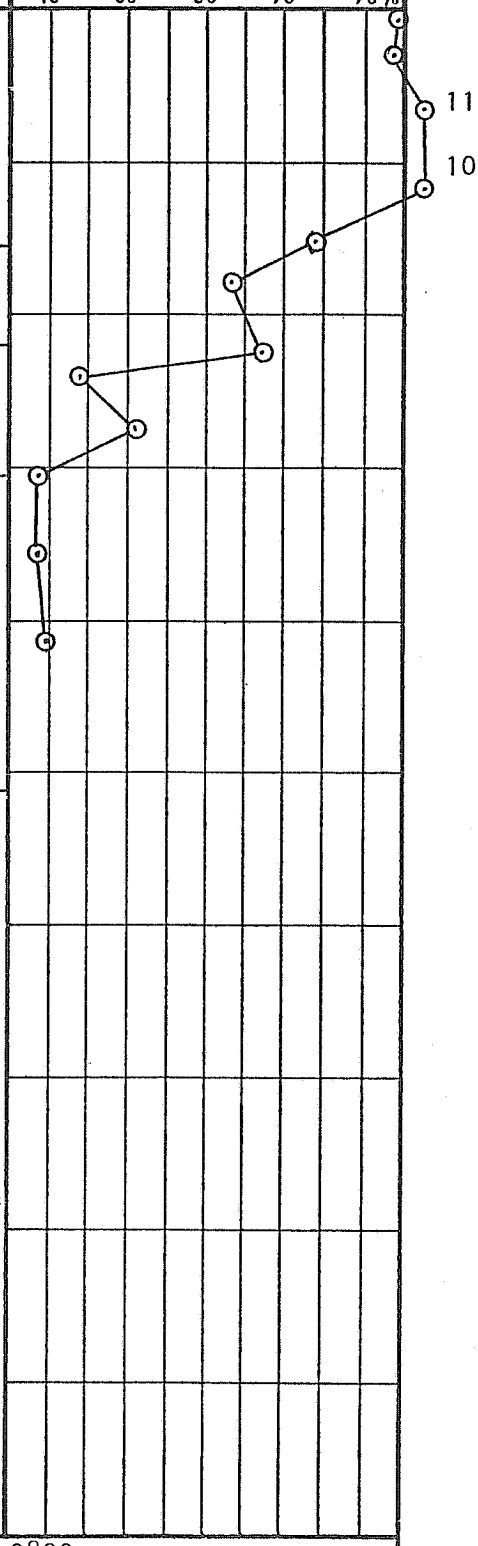
DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B		1			NF 0.6	0.1m. organic cover
1	C		2		Vr,Vs Vx		SILT - highly organic - little fine sand - trace clay - laminated
	C		3				1.5m. - slight plasiticity
2					Nbn Vs,Vx		SILT - some fine sand 2.2m. - trace gravel, trace clay
	C		4			2.6	SAND - fine to coarse 2.7m. - some silt, trace gravel - rusty brown
3	C		5				
	C		6				GRAVEL - some sand - little silt - fairly well graded - stratified - dense, brown
4							
	C		7				
5							5.1m.
6							END OF HOLE @ 5.1 m.
7							

LOCATION See Plate: A-0890-7-2
ELEVATION 2273.51

NOTES:
1. Hole located 20 m. east of Dry Creek.
2. Dense growth of spruce to 20 m. adjacent to creek. Drill site has a hummocky moss ground cover vegetated with sparse spruce to 8 m.
3. Test hole augered to 0.7 m., cored from 0.7 to 4.4 m., and augered from 4.4 to 5.1 m.. Hole terminated due to extensive sloughing of gravel.

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — 0 — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 31
HOLE No.	77-7-9
DATE	Oct. 22/77 PLATE

K.L.C. - METRIC

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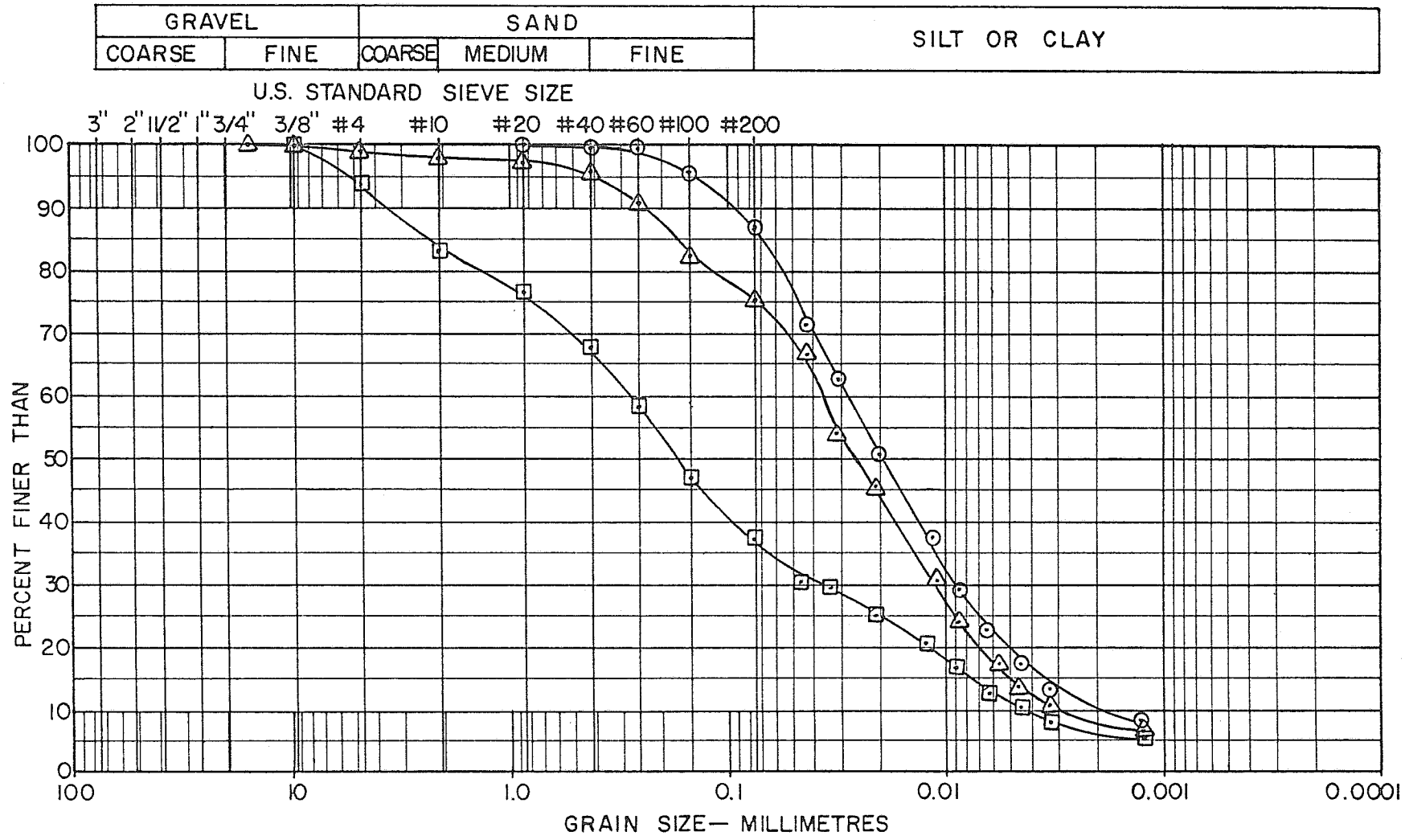
JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-9 DEPTH
DATE Nov. 4/77

GRAIN SIZE CURVE



REMARKS:
- Sa. #3 (1.0-1.5m.) SILT - little fine sand, trace clay, organic laminations
- Sa. #4 (2.0-2.2m.) SILT - some fine sand, trace clay
- Sa. #4A (2.2-2.6m.) SAND - some silt, trace clay, trace gravel

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JOB No. AL0890

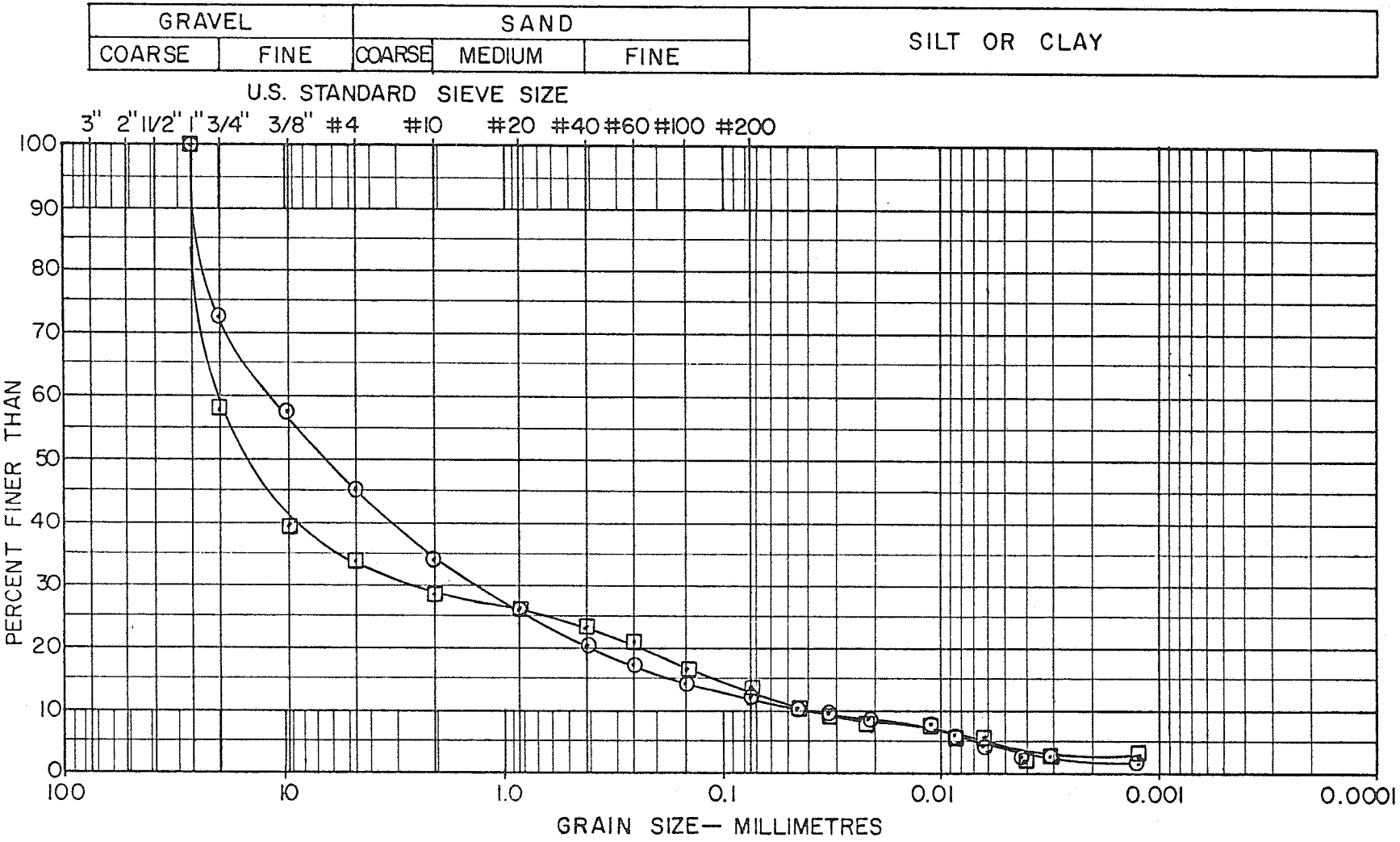
PROJECT Frost Heave Test Sites

LOCATION M.P. 31

HOLE No. 77-7-9 DEPTH

DATE Nov. 4/77

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa. #5 (2.7-3.1m.) GRAVEL - some sand, little silt

⊡——⊡ Sa. #6A (3.2-4.0m.) GRAVEL - some sand, little silt

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 7-9

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.50-2.00	1,430	84.9

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

LOCATION See Plate: A-0890-7-2
ELEVATION 2270.89

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
1	B		1			N.F	0.1m. organic cover ORGANIC SILT & CLAY & PEAT - trace fine sand in layers to 9 cm. - trace gravel, wood specks - sand layer @ 0.9 m. - black organic laminations - slight to low plasticity - dark brown ice lenses 1/4-4m. spaced @ 1/2-10mm.
	SY		2			1.2	
2	C		3		Vr, Vs Vx		1.8m.
							2.5m. GRAVEL - fine to coarse
3					Ice		ORGANIC SILT - some sand - little clay, trace gravel - brown to black ice lenses 1/4-1mm. spaced @ 1/4-1mm.
	SY		4		Vs		3.25m.
	SPT	-	5				
4		85			Vr, Vx Vc		GRAVEL - and silt - some sand - stratified (below 4.5m., based on drill action and cuttings returned in drilling mud)
5	SPT	-	6				
6		-					6.5m.
7							END OF HOLE @ 6.5 m.

NOTES:
1. Hole located 25m. west of Dry Creek
2. Light spruce growth to 6m.
3. Test hole augered & cored to 2.5m.. Drilling mud used from 2.5 to 6.5m.

151
215
170
145
160

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-10
DATE Oct. 22/77 PLATE

K.L.C. - METRIC

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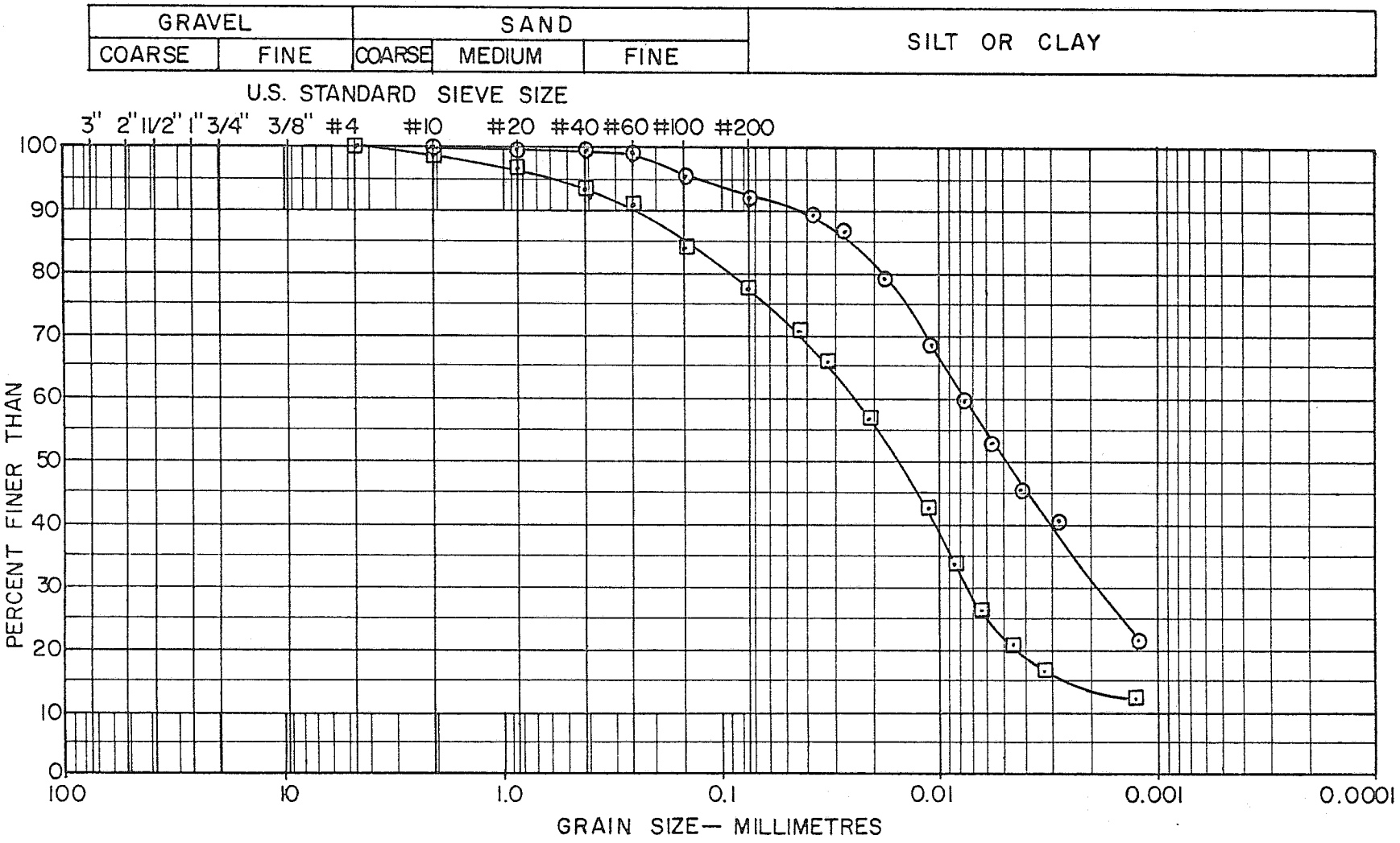
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 31
HOLE No.	77-7-10 DEPTH
DATE	Nov. 8/1977

GRAIN SIZE CURVE



REMARKS: ⊙——⊙ Sa. #3 (1.2-1.8m.) SILT & CLAY - trace fine sand, low plasticity

⊡——⊡ Sa. #4 (3.0-3.2m.) ORGANIC SILT - some sand, little clay

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

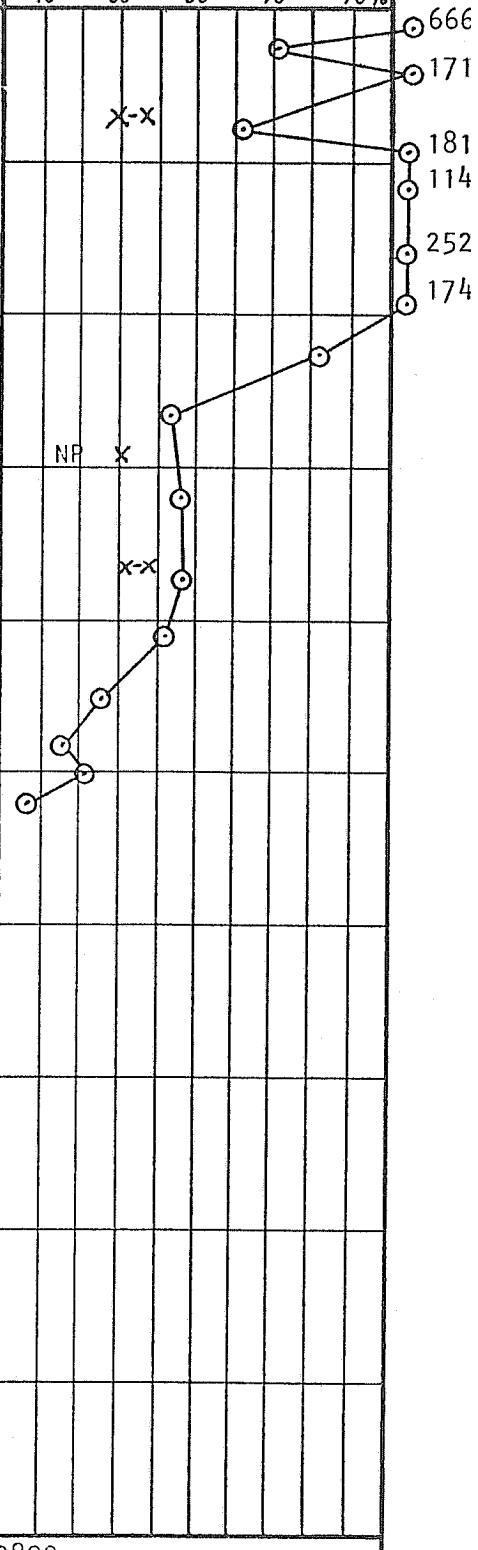
DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
						NF 0.35	0.1m. organic cover
	B		1				ORGANIC SILT & CLAY
1	C		2				- trace fine sand - extensive organic laminations
	C		3		Vr, Vs		- slight to low plasticity Ice lenses 1/4-1/2mm. spaced
							1.7m. @ 1/4-1mm.
2	C		4				ORGANIC SILT & PEAT
							2.0m. ice lenses 1/4-1mm. spaced @ 1/2-2mm.
	C		5				SILT
							2.65m. - trace fine sand
3					Vs, Nbn		- slight plasticity
							2.95m. ice lenses 1/4mm. @ 1/2-2mm.
	C		6				SILT
					Vr, Vs Nbn		- and fine sand in 1/2-2cm. laminations
4	C		7				SILT
							4.35m. - trace fine sand
							- trace clay
	C		8		Vr, Vx		4.75m. - organic layers
5	C		9				- slight plasticity
	C		10		Vx		ice lenses 1/4mm. spaced @ 2-5mm.
							5.2m. SAND
6							- fine
							- some silt, trace clay
							ice lenses 1/4mm. spaced @ 5-15mm.
7							GRAVEL
							- some sand
							- trace silt
							END OF HOLE @ 5.2 m.

NOTES:
1. Hole located 85 m. west of Dry Creek
2. Area vegetated with small grassy hummocks and a moderate spruce growth to 10m.
3. Test hole augered to 0.4 m. and cored from 0.4 to 5.2 m.

LOCATION See Plate: A-0890-7-2
ELEVATION 2272.27

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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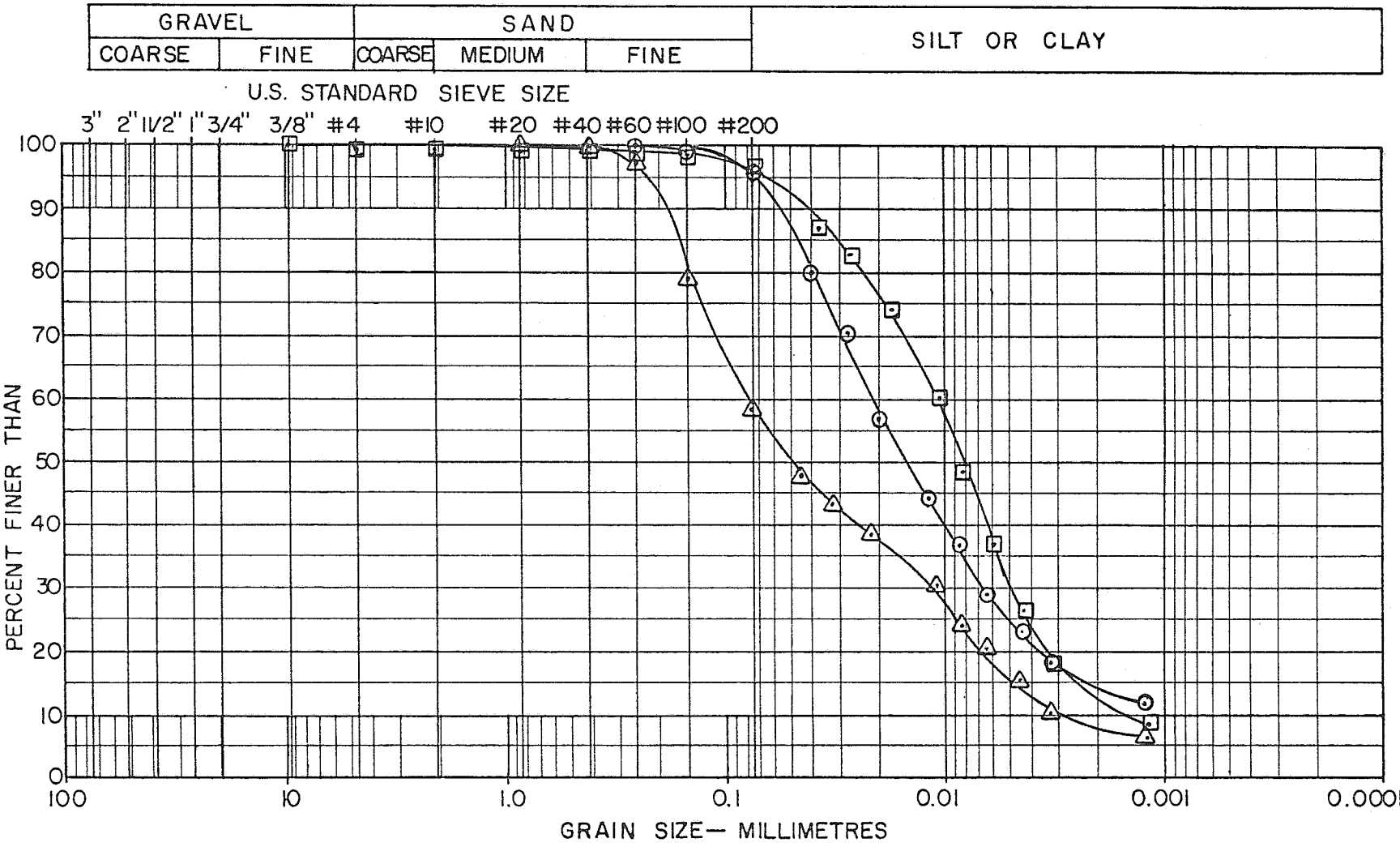
JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	M.P. 31
HOLE No.	77-7-11
DATE	Oct. 22/77 PLATE

S.I. - METRIC

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GRAIN SIZE CURVE



REMARKS:

Sa. #2 (0.7-1.0m.)	SILT & CLAY - trace fine sand, low plastic
Sa. #5 (2.0-2.5m.)	SILT & CLAY - trace sand, slight plasticity
Sa. #5A (2.5-2.95m.)	SILT - and fine sand, trace clay

JOB No. A10890

PROJECT Frost Heave Test Sites

LOCATION M.P. 31

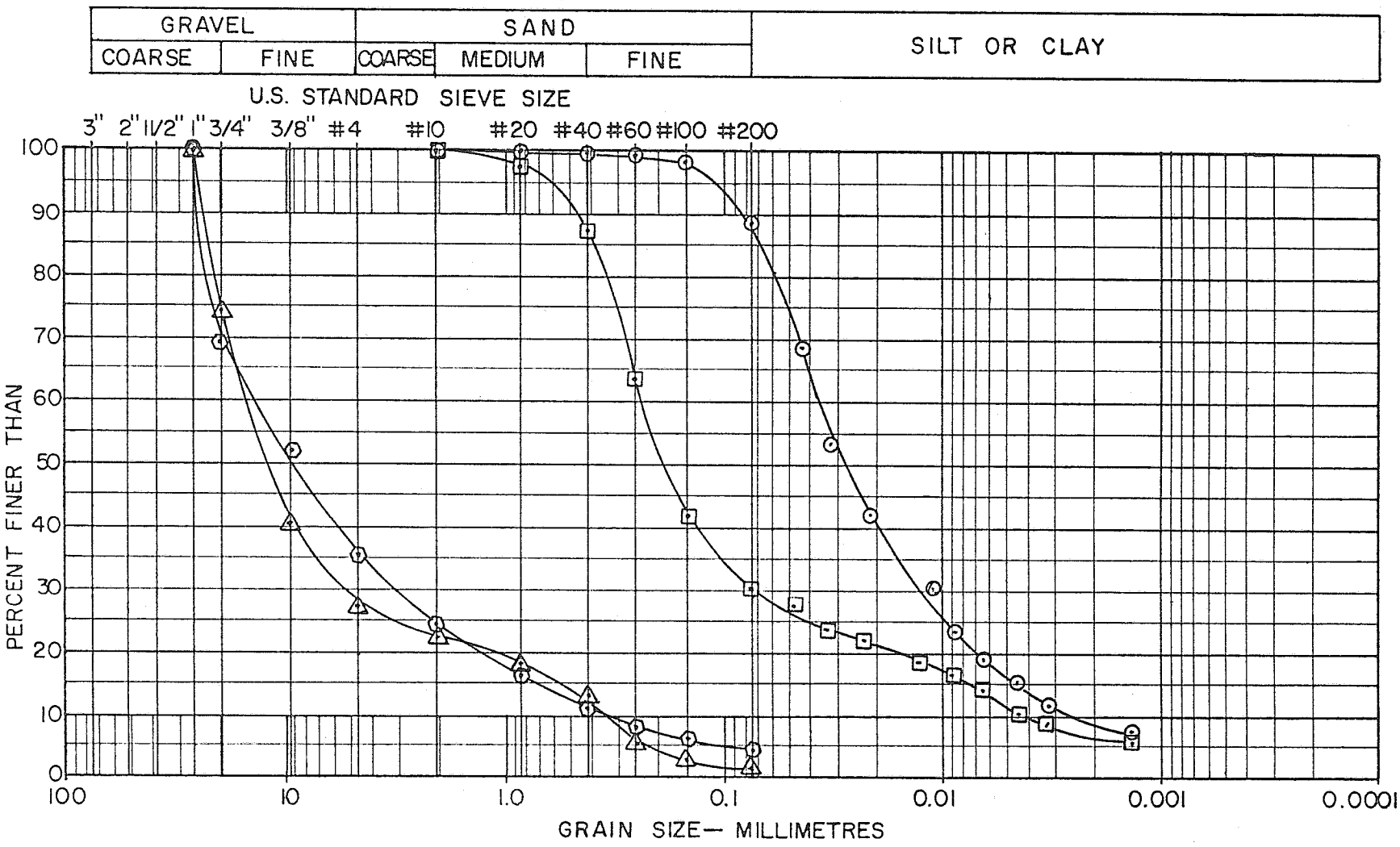
HOLE No. 77-7-11 DEPTH

DATE Nov. 8, 1977

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0390
PROJECT Frost Heave Test Sites
LOCATION M.P. 31
HOLE No. 77-7-11 DEPTH
DATE Nov. 8/77

GRAIN SIZE CURVE



REMARKS:

Sa. #7	(3.55-3.95m.)	SILT - trace fine sand, trace clay
Sa. #8	(4.35-4.75m.)	SAND - fine, some silt, trace clay
Sa. #8A	(4.75-4.90m.)	GRAVEL - some sand, trace silt
Sa. #10	(5.05-5.2m.)	GRAVEL - some sand, trace silt

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 7-11

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.70-1.00	1,440	85.5
3	1.00-1.35	1,290	76.6
4	1.70-2.00	1,130	67.1
5	2.00-2.50	1,290	76.6
5a	2.50-2.95	1,670	99.2
6	2.95-3.55	1,600	95.0
7	3.55-3.95	1,660	98.6
7a	3.95-4.35	1,640	97.4

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
1	B		1
	SY		2
2	SY		3
	SY		4
3	SY		5
	SY		6
4	B		7
	B		8
	C		9
5			
6			
7	SPT	4 5 15	10
8			
9			
10			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF
Nbn, Vr	1.2
	1.75
	NF

LOCATION See Plate A-0890-7-2
ELEVATION 2267.98

DESCRIPTION OF MATERIAL

0.1m. organic cover
ORGANIC SILT
- roots & wood specks
0.95m. - dark brown

SILT
- little to some fine sand
- trace clay
- laminated, stiff
- slight plasticity
2.2m. - grey brown
- some fine sand

SAND
- find to medium
- little silt
- trace to little gravel
3.4m. - trace clay
- light brown
silt layer @ 3.4-3.5m.

4.0m. SAND
- some gravel
- some silt, trace clay

GRAVEL
- and sand
- some silt
- trace clay
- dense
- brown
6.0m.

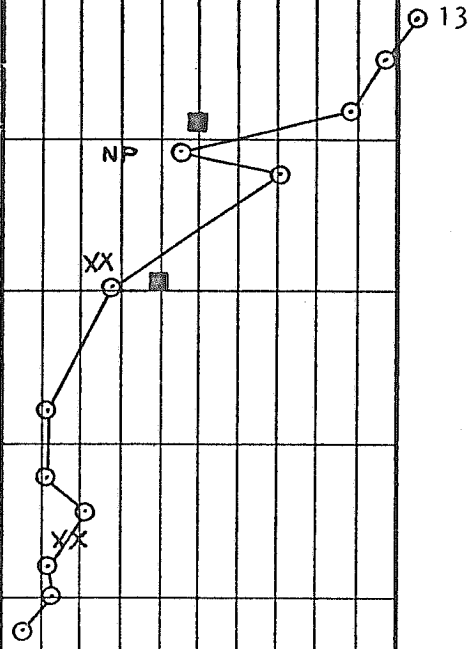
SILT
- little gravel
- little sand
- laminated & layered
- slight to low plasticity
- grey
7.5m.

GRAVEL
- some sand
- some silt
8.5m. - well graded
(based on drill action & cuttings returned in drilling mud
END OF HOLE @ 8.5m.

CONT'D.

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-12
DATE	Oct. 30/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

SAMPLE DATA				SYMBOL	ELEV COLLAR	UNCONFINED COMPRESSION T.S.F
WEIGHT HAMMER 140 lb.					ELEV GROUND	0 1.0 2.0 3.0 4.0
HEIGHT DROP 30 inches					CO-ORD. LOCATION	● FIELD VANE △ LAB VANE ▣ UNCONF.
DEPTH / ELEV	O.D / I.D.	BLOWS / 6"	NO.		DESCRIPTION OF MATERIAL	PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT X — 0 — X 10 30 50 70 90 %

Notes:

1. Hole located 22 m. northwest of Dry Creek.
2. The site is situated between a denser stand of spruce located to the east along Dry Creek, and a sparsely vegetated open area to the west.
3. Hole augered to 3.5 m., cored from 3.5 to 4.2 m., and drilled with mud from 4.2 to 8.5 m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-12 Continued
DATE	Oct. 30/77 PLATE

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890

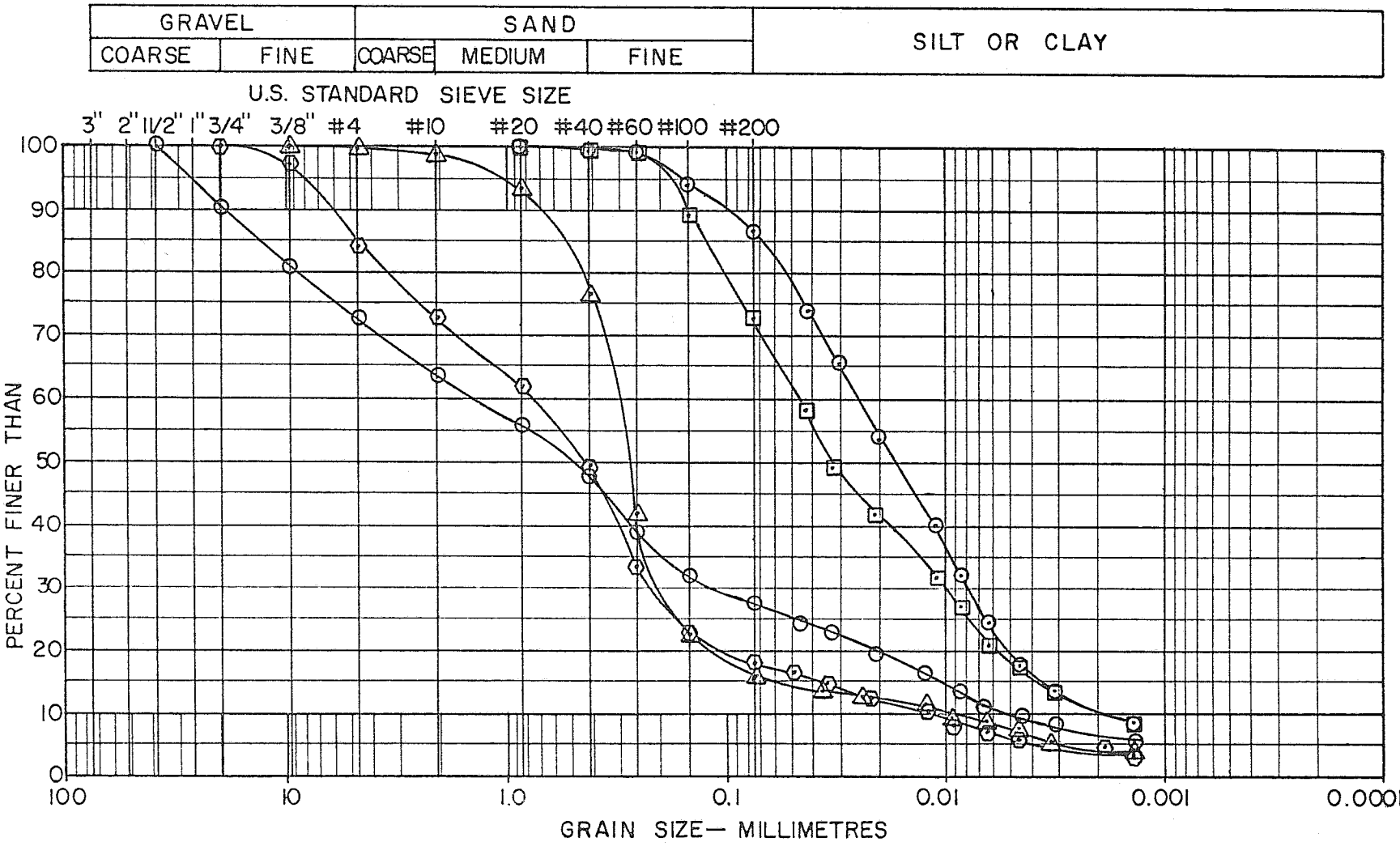
PROJECT Frost Heave Test Sites

LOCATION Mp. 31

HOLE No. 77-7-12 DEPTH

DATE Nov. 16/77

GRAIN SIZE CURVE



REMARKS:

⊙—⊙	Sa. #2 (0.95-1.13m.)	SILT - little fine sand, trace clay, non plastic.
⊡—⊡	Sa. #4 (1.75-2.2m.)	SILT - some fine sand, trace clay, slight plasticity.
△—△	Sa. #5 (2.6-3.05m.)	SAND - little silt, trace gravel
⬡—⬡	Sa. #6 (3.2-3.4m.)	SAND - fine to coarse, little silt, little gravel, trace clay
⊖—⊖	Sa. #7 (3.8m.)	SAND - some gravel, some silt, trace clay.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
1	B		1
	SY		2
2	SY		3
	SY		4
3	SY		5
	SY		6
4			
	C		7
	C		8
	C		9
5			
	C		10
	C		11
	C		12
6	C		13
	C		14
	C		15
	C		16
7			
8			
9			
10			

SYMBOL

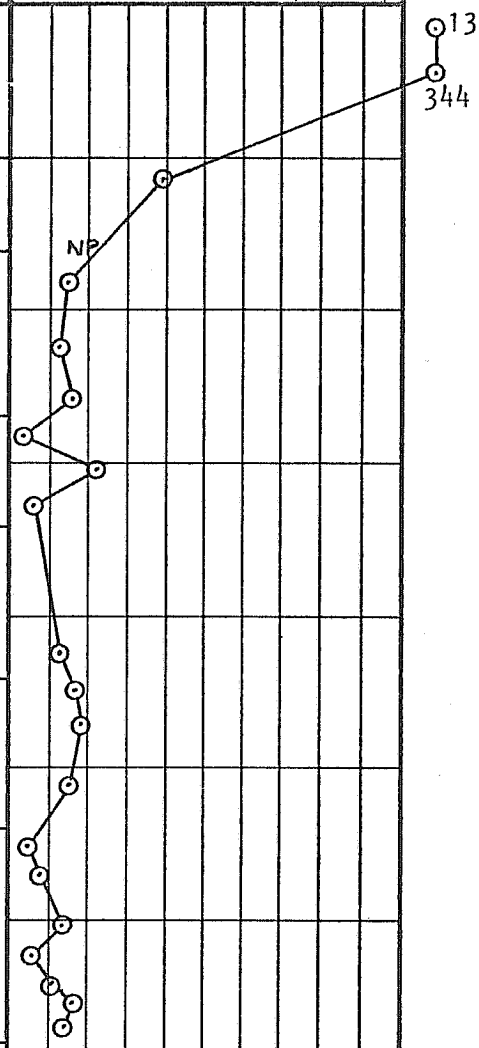
PERMAFROST

N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
	NF	0.1m ORGANIC COVER
	0.5	ORGANIC SILT & PEAT - roots & pieces of wood - dark brown to black
Vr, Vx, Nbn		1.0m SILT-organic laminations - trace fine sand 1.6m and sand @ 1.4 - 1.6 m.
	1.5	SAND - fine to medium - little silt - laminated with rusty sand, grey silt & brown organics 2.7m
	NF	SAND - and gravel, tr. silt 3.1m - well graded - trace gravel 3.0 to 3.1 m.
		GRAVEL AND SAND - trace silt, org. specks - loose to medium dense 4.4m
		SAND - fine to medium - little silt - tr. gravel, tr. clay - wood specks 5.4m - well graded
		GRAVEL - and sand - little silt - layered - wood specks - brown - sand, some gravel from 6.65 to 6.8 m. 6.8m
		END OF HOLE @ 6.8 m.

Notes:
1. Hole located 16m. n.w. of Dry Creek.
2. Dense spruce growth to 15m.
3. Hole augered & cored to refusal in dense gravel @ 6.8m. Water level @ 3.2m. during drilling.
4. Thermistors installed @ 0.5, 1.5, 3.0 & 6.0m. depth & standpipe piezometer installed.

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-13
DATE	Nov. 1/77 PLATE

K.L.C. - METRIC

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CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890

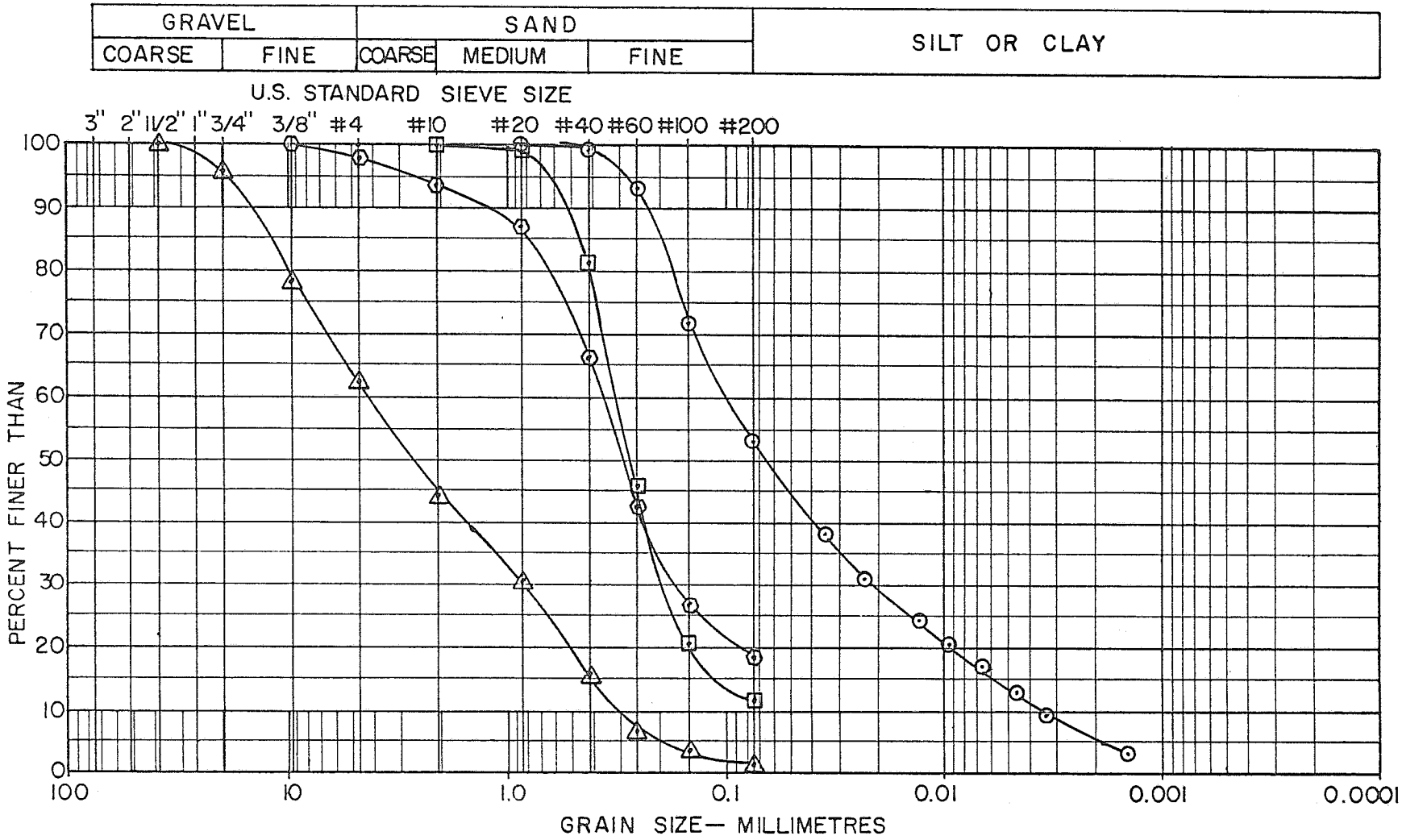
PROJECT Frost Heave Test Site

LOCATION MP 31

HOLE No. 77-7-13 DEPTH

DATE Nov. 23/77

GRAIN SIZE CURVE



REMARKS:

- Sa. # 2 (1.5-1.6m) SILT - and fine sand
- Sa. # 3 (1.6-2.05m) SAND - fine to medium, little silt
- Sa. # 5 (2.72-3.0m) SAND - and gravel, trace silt, well graded
- Sa. # 6 (3.0-3.1m) SAND - fine to medium, little silt, trace gravel

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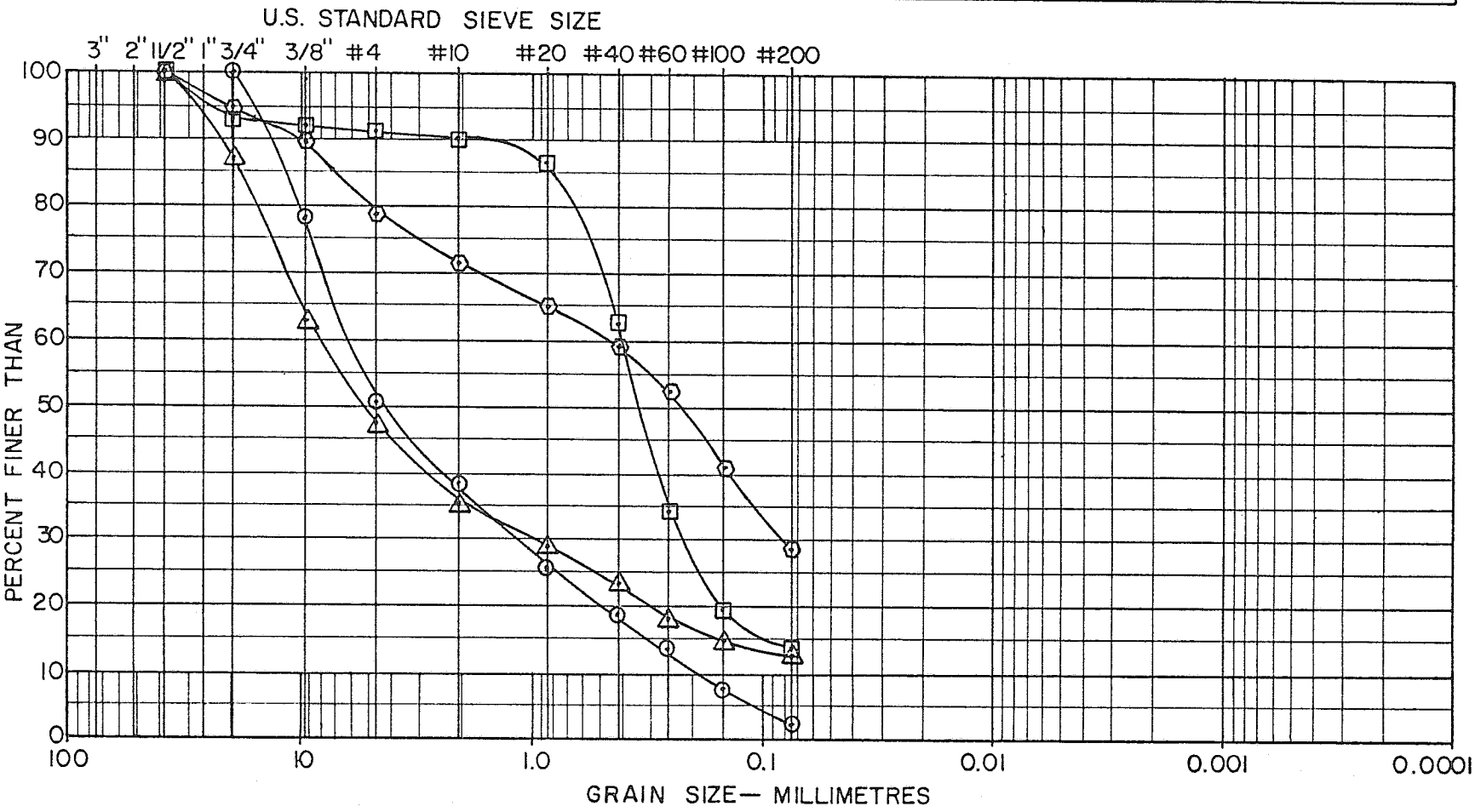
JOB No. AL0890
PROJECT Frost Heave Test Site
LOCATION MP 31
HOLE No. 77-7-13 DEPTH
DATE Nov. 18/77

GRAIN SIZE CURVE



REMARKS:

- Sa. # 7 (4.1-4.4m) GRAVEL & SAND - trace silt
- Sa. # 9 (4.6-4.85m) SAND - fine to medium, little silt, trace gravel
- Sa. #14 (6.0-6.1m) GRAVEL - and sand, little silt
- Sa. #16 (6.65-6.8m) SAND - some gravel, some silt

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
1	SY		1
	SY		2
2	SY		3
	SY		4
	SY		5
3			
	C		6
	C		7
4			
5	SPT	34 36 56	8
6	SPT	21 27 48	9
7			
	SPT	Ref	10
8			
9			
10			

SYMBOL

PERMAFROST
N.R.C. CLASS
N.F. or F.

LOCATION See Plate A-0890-7-2
ELEVATION 2272.38

DESCRIPTION OF MATERIAL

0.1m ORGANIC COVER
SILT
- trace fine sand
- trace clay
- extensive organic laminations & wood specks
- slight to low plasticity
- stiff, brown

2.1 some sand

GRAVEL - some sand
- little silt
- trace clay
- fairly well graded

NF

(drilling below 3.7m. based on SPT data, drill action, and cuttings returned in the drilling mud).

coarse gravel

sand layer

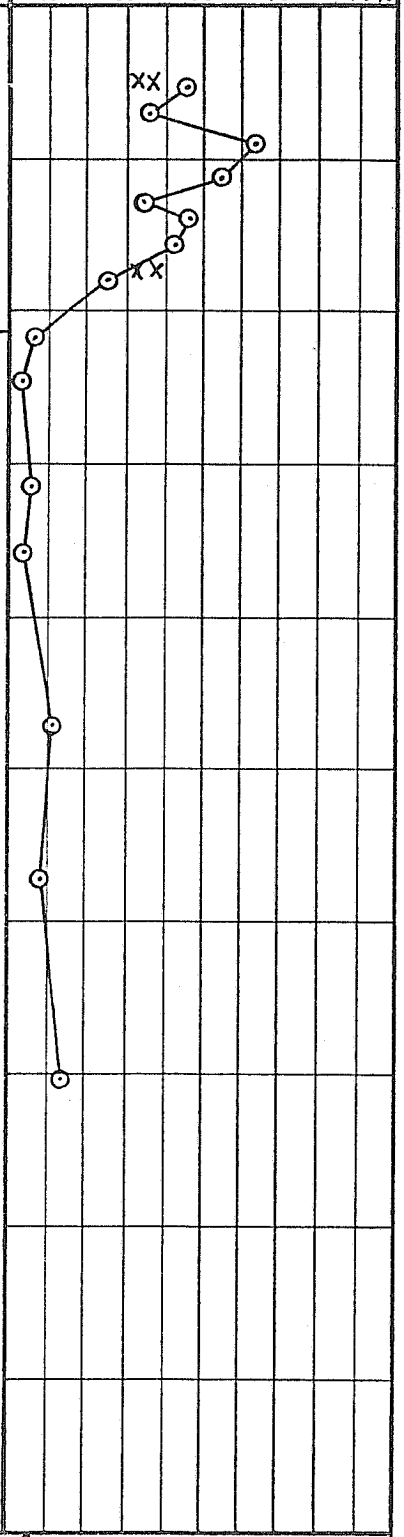
very dense gravel
- trace cobbles

sand layer

10.0m END OF HOLE @ 10.0m.

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-14
DATE	Nov. 4/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5 Kg.				SYMBOL	PERMAFROST		LOCATION
HT. DROP 76 cm.							ELEVATION
SAMPLE DATA					N.R.C.	N.F. or	DESCRIPTION OF MATERIAL
DEPTH	TYPE	BLOW / 15 cm.	No.		CLASS	F.	

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

Notes:

1. Hole located 20m. n.w. of Dry Creek.
2. Vegetation is dense spruce to 20m. Ground surface is moss covered and slightly hummocky. No free water encountered to 3.7m. during drilling.
3. Hole augered and cored to 3.7m. and drilled with mud from 3.7 to 10.0m. Hole sampled with SPT below 3.7m. and stratigraphy based on this data as well as drill action and cuttings returned in the drilling mud.
4. Thermistors installed @ 0.5, 1.5, 3.0 and 6.0m. depths.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-14 Continued
DATE	Nov. 4/77 PLATE

K.L.C. - METRIC

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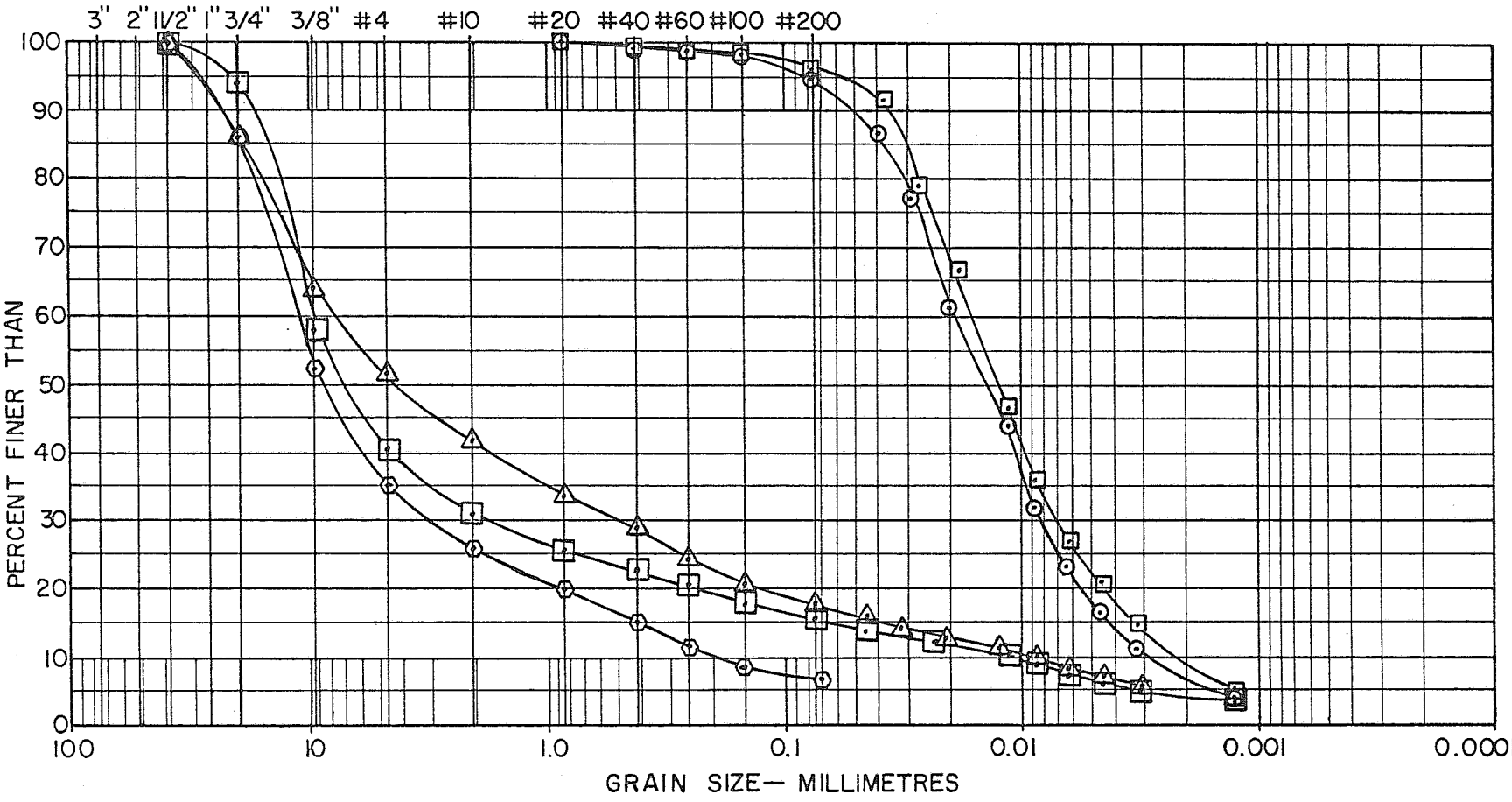
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



GRAIN SIZE CURVE

REMARKS:

- Sa. # 1(0.69-0.81m) SILT - trace fine sand, trace clay
- Sa. # 3(1.55-1.74m) SILT - trace fine sand, trace clay
- Sa. # 4(2.10-2.20m) GRAVEL - some sand, trace clay
- Sa. # 6(3.00-3.30m) GRAVEL - and sand, little silt, trace clay
- Sa. # 7(3.30-3.70m) GRAVEL - some sand, little silt

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 31
HOLE No. 77-7-14 DEPTH
DATE Nov 23/77

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

PERMAFROST

LOCATION See Plate A-0890-7-2
ELEVATION 2272.70

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
						NF	0.1m ORGANIC COVER
						0.6	SILT -organic laminations - little fine sand - slight to low plasticity - brown
1	C		1			0.7	
							1.25m
	C		2				GRAVEL- some sand - trace silt, grey
							1.75m some silt below 1.4m.
2							SAND - fine to coarse - some silt - little gravel
							2.5m - dark brown
	SY		3				SAND - SILT - GRAVEL - layered
3							
	SY		4				3.2m
							SAND & SILT
						NF	3.75m - little gravel
4							
		32					GRAVEL - and sand - little silt - interlayered - very dense - rusty brown
	SPT	33	5				
		35					
5							
		34					
	SPT	37	6				
6		22					5.95m
	Sa not rec.						END OF HOLE @ 5.95m.
7							Notes: 1. Hole located on southeast side of Dry Cr., 13m. east of old telephone line. 2. Vegetation consists of sparse spruce to 5m. and willows to 3m. 3. Hole augered & cored to 2.5m., drilled with mud from 2.5 to 5.95m. 4. Single thermistor installed @ 1.5m.
8							
9							
10							

185

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 31
HOLE No.	77-7-15
DATE	Nov. 5/77 PLATE

K.L.C - METRIC

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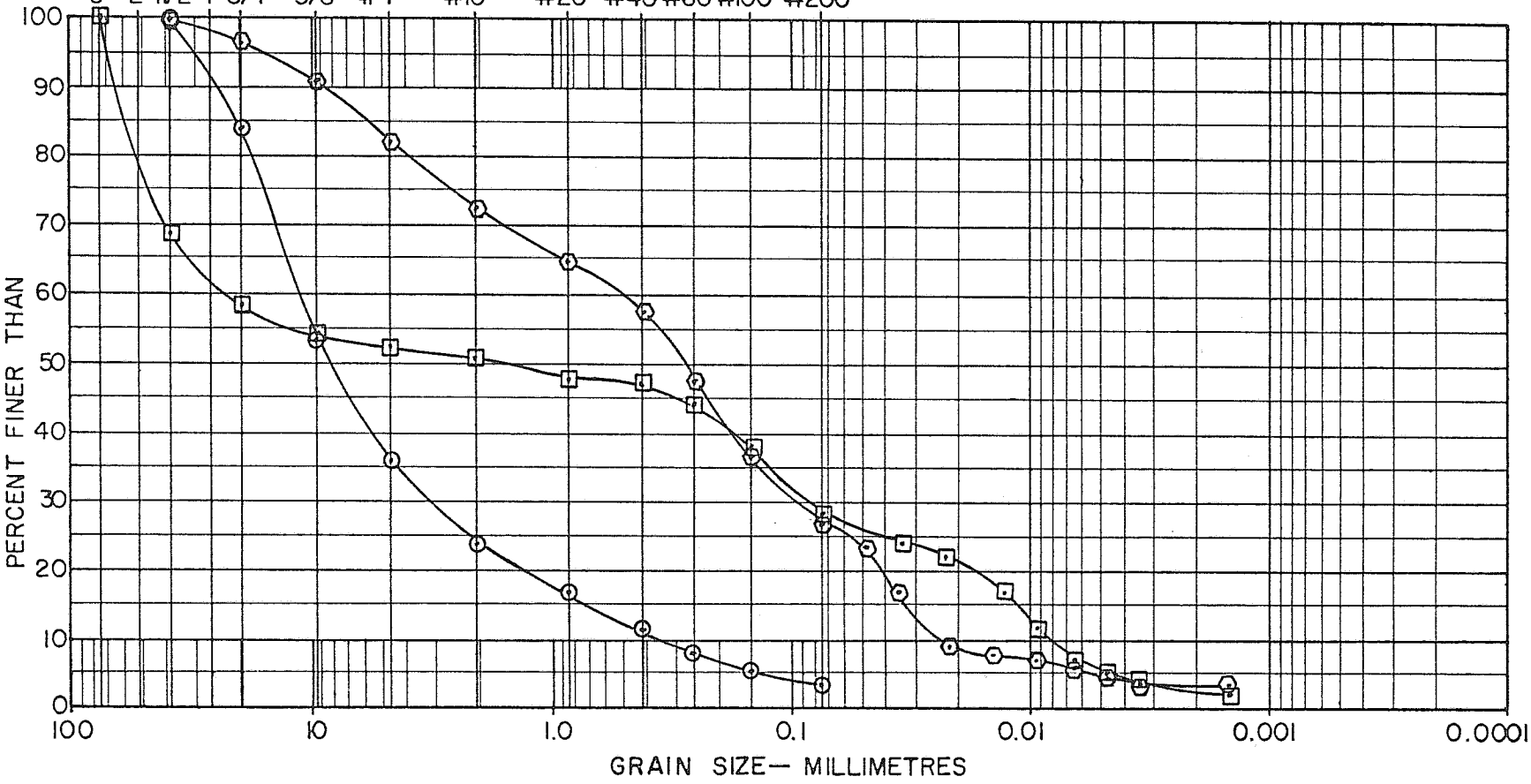
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

U.S. STANDARD SIEVE SIZE

3" 2" 1 1/2" 1" 3/4" 3/8" #4 #10 #20 #40 #60 #100 #200



GRAIN SIZE CURVE

REMARKS:

- Sa. #2a (1.25-1.4m) GRAVEL - some sand, trace silt
- Sa. #2b (1.4-1.6m) GRAVEL - some silt, some sand
- Sa. # 4 (3.2-3.3m) SAND - some silt, little gravel (sandy layer)

JOB No. AL0890

PROJECT Frost Heave Test Sites

LOCATION MP 31

HOLE No. 77-7-15 DEPTH

DATE Nov. 5/77

SITE 8 (MP 41 to 41.5)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site. The site is located between MP 41 and 41.5 along the proposed pipeline right-of-way which parallels the H-F pipeline. The Alaska Highway is located within 300 m. at the north end of the site. The reader should refer to the attached location plan on Plate A-0890-8-1 as well as the aerial and site photographs on Plates A-0890-8-2 & 3.

2.0 SUMMARY

The site is located in an old glacial meltwater channel which varies from about 100 to 300 m. wide. The valley is confined by a conspicuous upland area to the north which is underlain by outwash and hummocky moraine. In the south, the valley is bounded by a gently sloping coalescing alluvial fan deposit.

In the area adjacent to the site, the meltwater channel valley is not drained. Rather, drainage from adjacent areas flows into a number of lakes which occupy the valley floor. A large lake exists immediately northwest of the site.

Three test holes were drilled at this site - two located in the old meltwater channel and a third hole located in the coalescing alluvial fan terrain to the south. Based on two drill holes in the valley bottom, the subsoils consist of an upper fine grained strata overlying gravel and sand soils at depths between 1.5 and 3 m. below ground surface. No permafrost was encountered within the depths drilled in either test hole. Based on one and two holes respectively drilled in the coalescing alluvial fan terrain during the 1976 and 1977 programs, the soils underlying this area consist of frozen, interlayered organic silts, sands and gravels. In test hole 77-8-3, the soils consist of 5.5 m. of organic silts and clays, overlying coarse interlayered gravel and sand; and permafrost occurs below a shallow unfrozen active layer.

3.0 SITE DESCTIPTION

Test hole 77-8-1 is located at the north end of the site, about 75 m. southeast of a large lake which occupies the valley bottom. The H-F pipeline lies about 120 m. to the east. The terrain slopes gently 1 to 2% towards the lake and is relatively open with a sparse growth of willows. Locally about 10 m. north of the drill site, a small 1 m. deep drainage gulley (dry at the time of the investigation) is incised into the ground surface.

Test hole 77-8-2 is located about 250 m. southeast of 77-8-1. The terrain between these holes slopes gently 1% to the northwest and is sparsely vegetated with willow and spruce. Test hole 77-8-2 is located 30 m. west of the H-F pipeline. Vegetation at the drill site consists of a sparse growth of willow and spruce to 5 m. high.

Test hole 77-8-3 is located 500 m. south of 77-8-2 along the H-F pipeline. The terrain between these test holes is similar to the conditions at 77-8-3. The ground surface which slopes at 3% to the east is covered with peat tussocks. Ponded water occurs between the tussocks and in depressions. Vegetation consists of a light growth of spruce to 8 m. high.

4.0 SOIL AND PERMAFROST CONDITIONS

4.1 Test Hole 77-8-1

Test hole 77-8-1 was drilled to a depth of 8.5 m.. The hole was augered to 2.0 m. and rotary drilled with mud below 2.0 m.. The upper soils to a depth of 1.55 m. consist of lacustrine silt and clay. These soils are laminated with fine sand and organic materials, and have an average moisture content of 40%. These fine grained soils overlie interlayered coarse gravel and sand to the maximum depth drilled (8.5 m.).

The entire test hole was unfrozen within the total depth drilled.

4.2 Test Hole 77-8-2

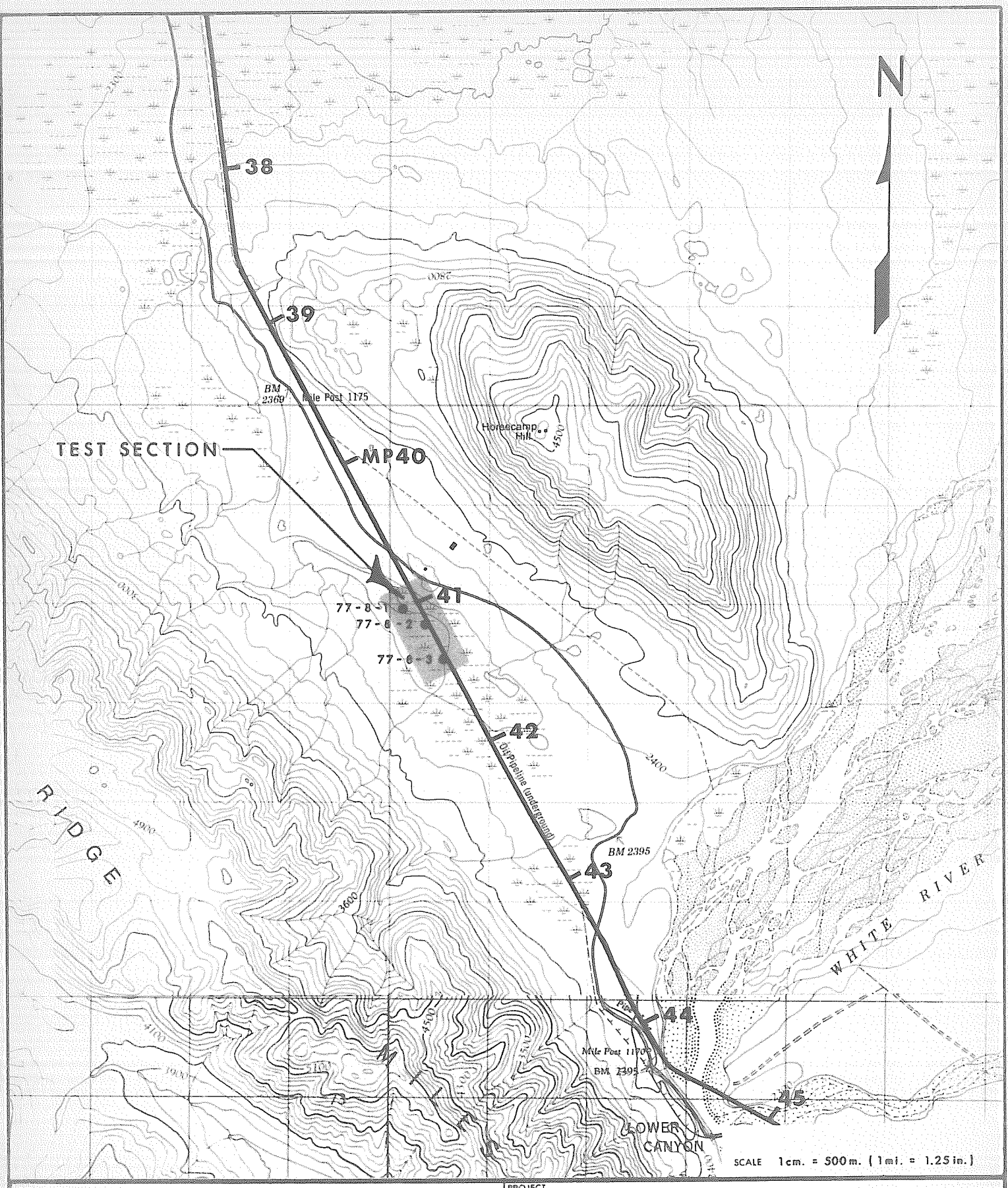
This test hole was drilled to a depth of 9.6 m. by augering to 3.64 m., then rotary drilling with mud below 3.65 m.. The topstratum consists of organic silt and clay to a depth of 0.75 m.. From a depth of 0.75 to 3.0 m., the subsoils consist of a laminated, medium plastic clay and silt. The moisture content is uniform, averaging about 35%. These upper fine grained soils overlie very dense, interlayered sand and gravel strata. From a depth of 3.0 to 5.5 m. the granular materials are comprised of fine to coarse sands with a little silt and gravel. The sand grades into an interbedded gravel and sand material at about 5.5 m. and extends to the maximum depth drilled (9.6 m.). Due to the rotary nature of the drilling equipment, no representative samples of the coarse, unfrozen gravel materials were obtained.

The entire test hole was unfrozen within the total depth drilled.

4.3 Test Hole 77-8-3

This test hole was drilled to a depth of 10.0 m. by augering to 0.6 m., coring from 0.6 m. to 5.15 m., and rotary drilling with mud below a depth of 5.15 m.. From ground surface to a depth of 5.5 m. the subsoils consist of an organic silt and clay. The moisture content of the upper 3.5 m. is high, ranging from 100% to more than 300%. From 3.5 to 5.5 m. the moisture content decreases from 80 to 50% with stratum depth. The fine grained organic soils are underlain by interlayered gravel and sand.

Permafrost occurs from a depth of 0.6 to 10.0 m.. The upper 5.5 m. has a medium to high ice content with ice lenses up to 2 cm. thick. The estimated excess ice content varies up to 30%, averaging about 15% by volume. Due to the rotary nature of the drilling equipment, representative samples of the underlying gravel stratum could not be obtained for permafrost classification.



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CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

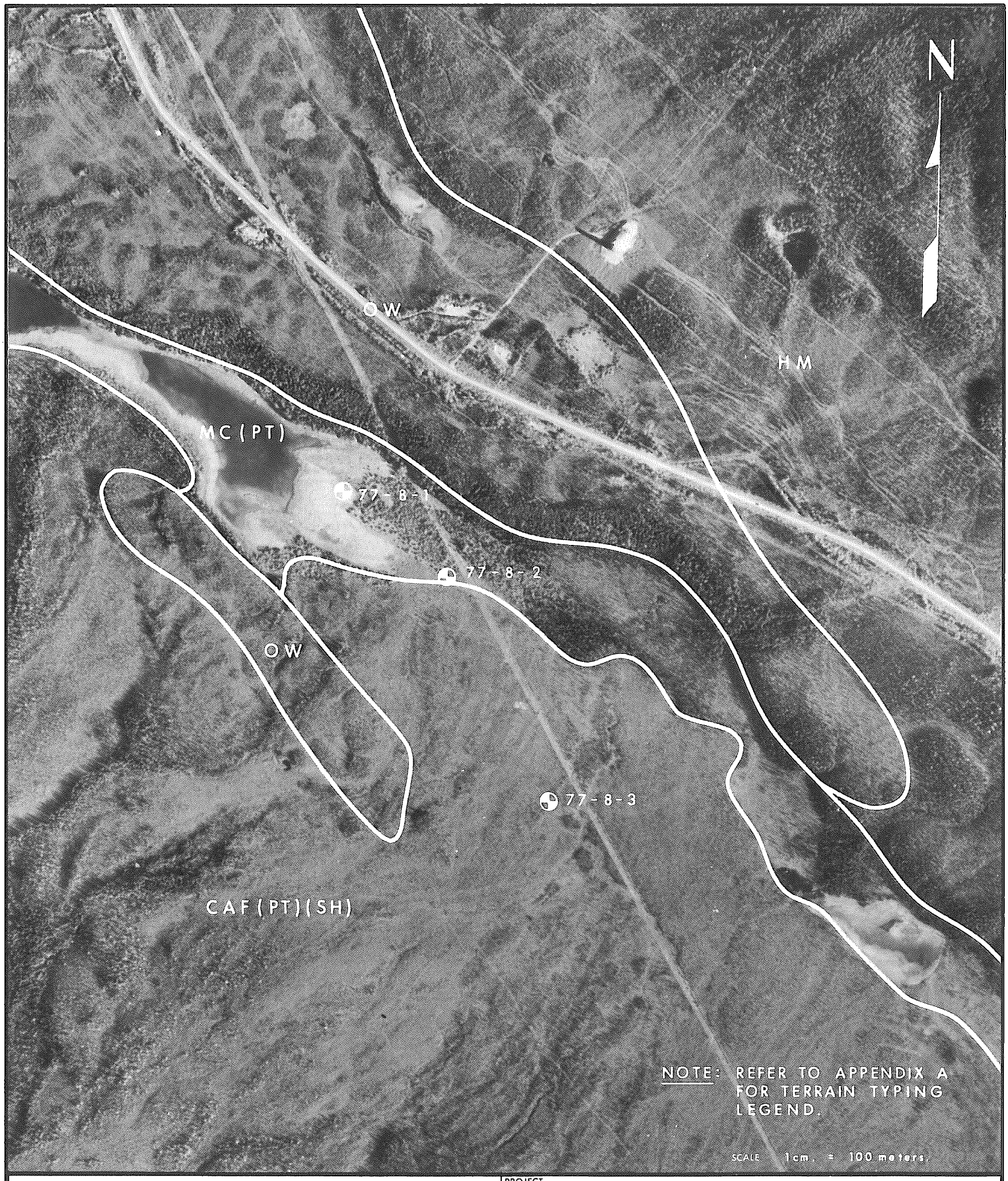
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 8

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-8-1	

APPROVED A. L. Edgeworth



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CIVIL ● GEOTECHNICAL ● HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No.8

CLIENT: FOOTHILLS PIPE LINES(YUKON) LTD.

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT./77.	AL0890	A-0890-8-2	

APPROVED R.L. Edgeworth

SITE 8

View northwesterly at Site 8 along the Haines-Fairbanks pipeline. The meltwater channel valley which is partly occupied by a lake is evident in the background. The coalescing alluvial fan terrain in the foreground is vegetated with a moderate growth of spruce.

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.

SAMPLE DATA				SYMBOL	PERMAFROST		LOCATION See Plate A-0890-8-2
DEPTH	TYPE	BLOW 15 cm.	No.		N.R.C. CLASS	N.F. or F.	ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

DEPTH	TYPE	BLOW 15 cm.	No.	Description
1	B	8	1	0.15m. organic cover
	B	16	2	SILT & CLAY
	SY	91	3	- trace fine sand
	SPT		4	- roots & organics
				- slight to low plasticity
				- light brown
				1.55m. trace gravel
2				GRAVEL
				- some sand
3				3.0m.
				3.2m. SAND
4				NF GRAVEL
				- some sand
				(classification based on drill action & cuttings returned in drilling mud).
5	B		5	
	B		6	
6				
7				
	B		7	
8				8.5m.
9				END OF HOLE @ 8.5m.

NOTES:
1. Hole located in a former lake, in a meltwater channel at the S.E. end of the present day lake. Hole is situated about 120m. west of the H-F pipeline. Terrain slopes 1-2% to N.W.
2. Site is void of forest cover and is vegetated with grass and scattered willows.
3. Hole augered to 2.0m. & drilled with mud from 2.0 to 8.5m.

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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 41 to 41.5
HOLE No.	77-8-1
DATE	Oct. 11/77 PLATE

K.L.C. - METRIC

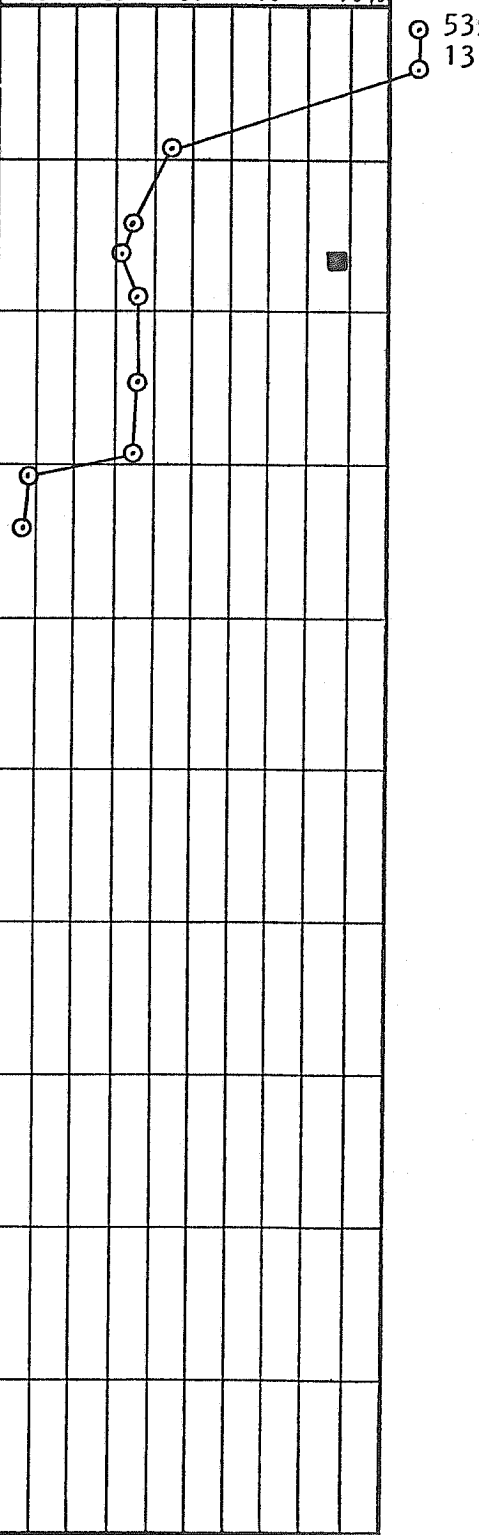
TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
							LOCATION See Plate A-0890-8-2
							ELEVATION
	B		1				ORGANIC SILT & CLAY - roots - dark brown
1	B		2				0.75m.
	B		3				CLAY & SILT - trace sand - stiff to very stiff at depth - medium to high plasticity - yellowish-rusty brown
	SY	6	4				
2	SPT	16 15	5				
	B		6				little sand - trace gravel
3	B		7				3.0m.
	SY	34	8				SAND - fine to coarse - little silt - little gravel becoming coarser with depth - grey
	SPT	55 47	9			NF	
4							
	B		10				
5							5.5m.
6							GRAVEL & SAND - interbedded @ 0.25-0.5m. (classification based on drill action and cuttings returned in the drilling mud).
7							
8							NOTES: 1. Hole located on south side of an old meltwater channel 30m. west of the H-F pipeline right-of-way. 2. Site vegetated with willow and sparse spruce to 5m. high. 3. Hole augered to 3.65m., then rotary drilled with mud.
9							
	B		11				9.6m.
10							END OF HOLE @ 9.6m.

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 41 to 41.5
HOLE No.	77-8-2
DATE	Oct. 12/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
	B		1			NF	ORGANIC SILT - peat layers - pieces of wood - little clay - trace sand - roots - dark brown
						0.6	
1	C		2				
	C		3		Vr, Vs Vx		
	C		4				
2	C		5				Ice crystals 5mm. spaced @ 5 to 10mm.
	C		6				random & stratified ice lenses to 1cm.
	C		7				some fine sand
3	C		8				
	C		9				3.25m.
	C		10		Vx, Vr Vs		ORGANIC SILT & CLAY - trace fine sand - laminated - low plastic - brown
4	C		11				
							4.5m.
	C		12		Vr, Vs Nf		CLAY & SILT - trace fine sand - organic laminations - medium plastic
5	C		13				
							5.5m.
6					Vx, Vc		GRAVEL - medium to coarse - some sand (based on drill action & cuttings returned in drilling mud).
7	B		14		(?)		
8							8.0m.
	B		15				SAND - some gravel (based on drill action & cuttings returned in drilling mud).
	B						
9							
10							10.0m. END OF HOLE @ 10.0m. (cont)

LOCATION See Plate A-0890-8-2
ELEVATION

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

721
124
339
259
326
192
279
142
188

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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION MP 41 to 41.5
HOLE No. 77-8-3
DATE Oct. 12/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X – – – – – – 0 – – – – – – X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located 50m. west of H-F pipeline. Site situated on a coalescing alluvial fan which slopes gently to the east.

2. Ground surface covered with extensive peat tussocks. Site vegetated with sparse spruce to 8m.

3. Hole augered to 0.6m., cored from 0.6 to 5.15m., and rotary drilled with mud below 5.15m.

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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 41 - 41.5
HOLE No.	77-8-3
DATE	Oct. 12/77 PLATE

K.L.C. - METRIC

Klohn Leonoff Consultants Ltd.

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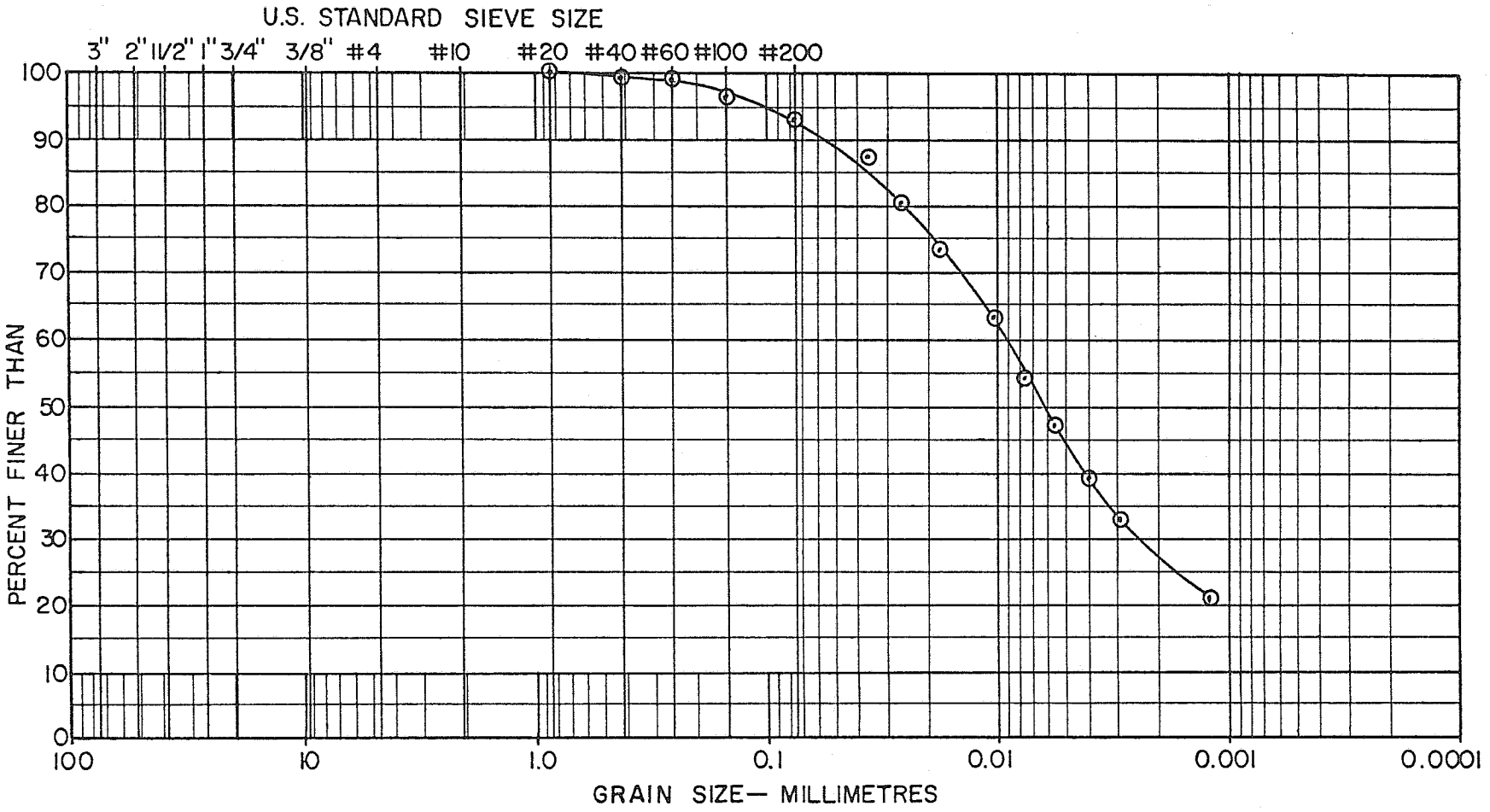
GRAIN SIZE CURVE

GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



REMARKS:

SA. #12 (4.5 - 4.72m.) CLAY & SILT - trace fine sand, medium plastic

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	MP 41 - 41.5
HOLE No.	77-8-3
DEPTH	
DATE	

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 8-3

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.60-0.85	1,040	61.8
3	0.85-1.10	1,090	64.7
4	1.10-1.45	1,120	66.5
5	1.45-1.90	1,070	63.6
6	1.90-2.30	1,080	64.2
7	2.30-2.75	1,210	71.9
8	2.75-3.10	1,250	74.3
9	3.10-3.25	1,190	70.7
10	3.25-3.70	1,230	73.1
13	4.72-5.15	1,590	94.4

SITE 9 (MP 32.5 to 33)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site subsequent to initial drilling in the Dry Creek meltwater channel at Site 7. The site is located about 1.1 km. west of the proposed pipeline right-of-way which parallels the H-F pipeline. The Alaska Highway is located within 400 m. east of the site. The reader should refer to the attached location plan on Plate A-0890-9-1 and the aerial photograph on Plate A-0890-2.

2.0 SUMMARY

This site is situated along Dry Creek in an old glacial meltwater channel. The Dry Creek valley is well defined and about 400 m. wide. It is flanked by upland areas to the east and west which are underlain by glacial outwash. The valley bottom is slightly hummocky and poorly drained, with many small thermokarst lakes. Dry Creek meanders in a sinuous manner and occaisionally displays beaded drainage which usually indicates the presence of ground ice and permafrost.

Four test holes were drilled at this site. The subsoil profile is similar across the site, consisting of an upper stratum of fine grained, highly organic soils overlying interlayered gravel and sand. The upper organic strata vary from 4.8 to 13.2 m. thick and consist essentially of peat and both organic and inorganic silt. These fine grained organic soils overlie gravels. Representative samples of the coarse gravel materials were difficult to obtain as a rotary drill was used for this program.

Permafrost is widespread at the site. All four test holes encountered permafrost to the maximum depths drilled. The ice generally occurs as thin, closely spaced horizontal or randomly oriented lenses. In test hole 77-9-4, a layer of ice and soil more than 3m. thick, has more than 50% excess ice by volume. The ice content of

of the coarse gravel substratum underlying the area was not ascertained as a rotary drill and mud was used for this program.

3.0 SITE DESCRIPTION

Test hole 77-9-1 is located at the northern end of the site, about 70 m. south of Dry Creek. The area south and west of the site is swampy and poorly drained. The ground is slightly hummocky and the terrain slopes into the swamp. The swamp is overgrown with grass, but is essentially void of forest cover. The surrounding area adjacent to the swamp is vegetated with a light to moderate growth of spruce to 8 m. high.

Test hole 77-9-2 is located about 150 m. southeast of 77-9-1. The terrain between these two test holes is low lying but slightly hummocky, and vegetated with a moderate growth of spruce to 10 m. high. At the drill site, which is located 10 m. west of Dry Creek, the ground slopes about 5% towards the creek. Vegetation at the site consists of a moderate growth of spruce to 12 m. high.

Test hole 77-9-4 is situated about 130 m. south of 77-9-2. The terrain between these holes is similar to that at 77-9-2. The drill site is located about 8 m. east of Dry Creek and is vegetated with a sparse growth of spindly spruce. The terrain slopes 3% towards the creek.

Test hole 77-9-3 is located about 150 m. south of 77-9-4. The terrain between these holes is slightly hummocky and vegetated with a moderate to dense growth of spruce to 15 m. high. The drill site is located on the east side of the Dry Creek valley, 30 m. from the toe of the east valley sideslope. A small water filled depression exists immediately east of the site. The ground surface is covered with peat tussocks and the area is essentially void of trees except for a sparse growth of stunted spruce.

4.0 SOIL & PERMAFROST CONDITIONS

4.1 Test Hole 77-9-1

This test hole was drilled to a depth of 5.0 m. by augering to 0.5 m. and coring from 0.5 to 5.0 m.. The subsoil profile consists of peat and organic silt, overlying gravel and sand materials. The interlayered peat and organic silt strata extend to a depth of 4.8 m.. The soils have a high moisture contents which generally vary from 150 to 450%. The basal granular stratum from 4.8 to 5.0 m. consists of a coarse gravel and sand with a little silt.

Permafrost occurs from a depth of 0.5 to 5.0 m.. The upper peat and organic silt soils have medium ice contents. The estimated excess ice content averages about 10% by volume. The permafrost classification of the underlying gravel was not determined.

4.2 Test Hole 77-9-2

This test hole was drilled to a depth of 11.2 m. by augering to 0.5 m., and coring from 0.5 to 11.2 m.. The subsoil profile consists of organic silts, overlying silt, all of which overlies a coarse gravel layer. From ground surface to depth of 5.9 m., the soils consist of an organic silt with peat layers. The moisture contents are high, averaging in excess of 100%. A grey silt with organic pockets and laminations of clay and sand occurs below 5.9 m. to a depth of 10.9 m.. The silt has a moisture content varying from 35 to 85%, averaging about 65%. These fine grained and organic soils overlie a gravel stratum from 10.9 to 11.2 m..

Permafrost occurs from 0.6 to the maximum depth drilled (11.2 m.). The upper peat and organic silt soils have medium-to-high ice contents. The estimated excess ice content ranges up to more than 50% in ice and soil layers, but averages about 20% by volume. Ice usually occurs in thin horizontal and randomly oriented lenses. The grey silt stratum also has ice and soil layers up to 0.4 m. thick, but the overall ice content is low-to-medium. The estimated excess ice content averages about 10% by volume in the stratum. The permafrost classification of

the underlying gravel was not determined.

4.3 Test Hole 77-9-3

This test hole was drilled to a depth of 8.5 m. by augering to 0.9 m., coring from 0.9 to 7.4 m., and rotary drilling with mud from 7.4 to 8.3 m.. The subsoil profile is consistent with the other test holes at the site. An upper organic silt stratum extends from ground surface to a depth of 2.2 m.. This soil has a high moisture content varying from 95% to more than 400%. A dark grey laminated silt underlies the organic topstratum from a depth of 2.2 to 7.4 m.. This stratum is non-to-slightly plastic and has thin laminations of sand, silt, and organic pockets. The moisture content averages about 55%. A basal gravel stratum under lies the upper fine grained soils from a depth of 7.4 to 8.3 m..

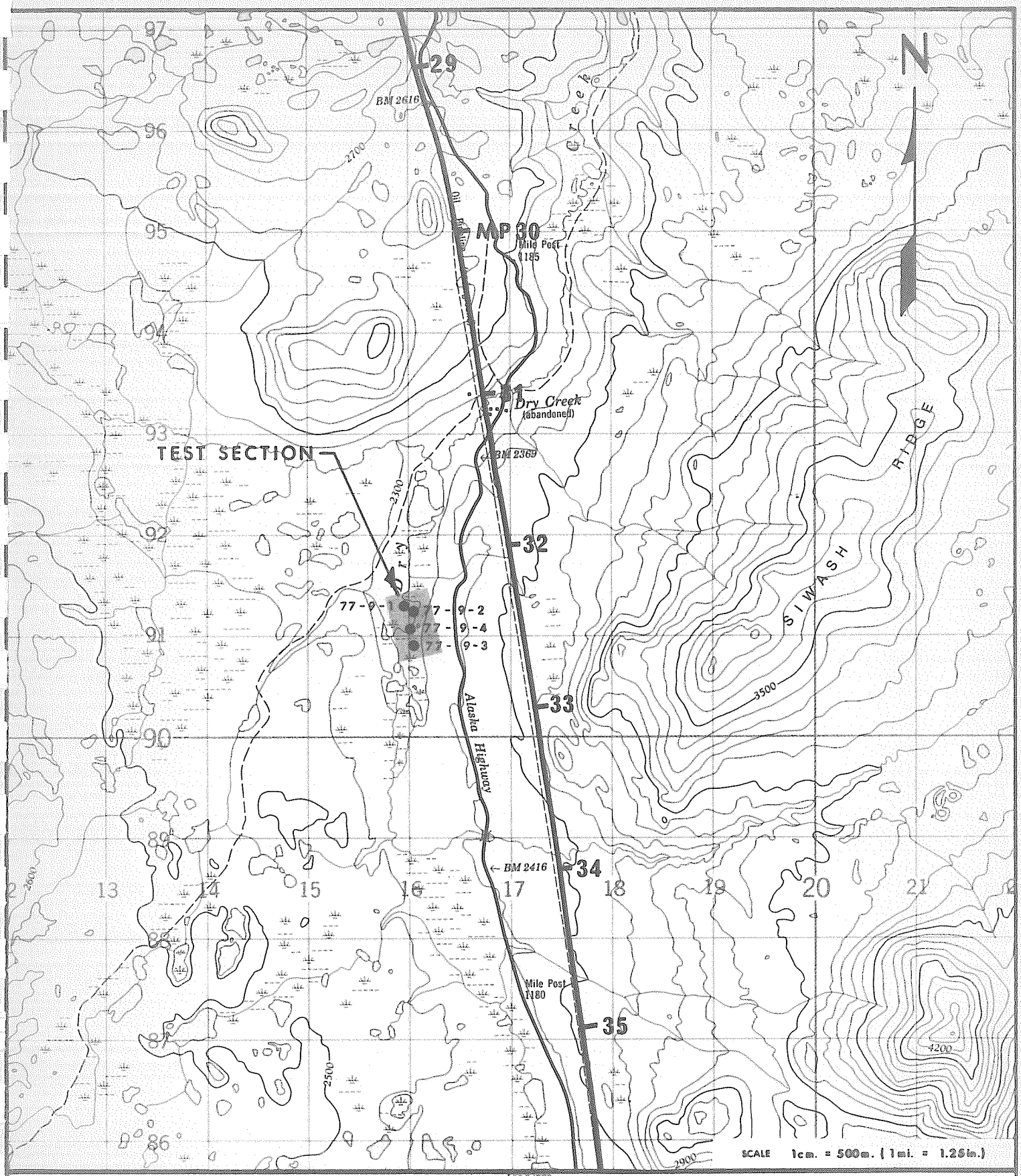
Permafrost exists from 0.7 to the maximum depth drilled (8.3 m.). The upper organic silt stratum has a medium ice content, with excess ice comprising about 10 to 20% of the soil by volume. The dark grey laminated silt generally has a low ice content except for scattered ice lenses up to 5 cm. in thickness. Ice usually occurs in horizontal and randomly oriented lenses from 1/4 to 5 mm. thick, spaced at 5 to 20 mm. apart. The permafrost classification of the underlying gravel was not determined.

4.4 Test Hole 77-9-4

This test hole was drilled to a depth of 13.3 m. by augering to 0.9 m. and coring from 0.9 to 13.3 m.. The subsoil profile is consistent with other test holes at the site. The upper 13.2 m. of soil below ground surface consists of interlayered organic silt and laminated silt of lacustrine origin. The moisture contents are high, varying from 30 to 160%, and averaging about 70%. These organic and fine grained strata are underlain by a coarse, silty, sandy gravel.

Permafrost occurs from 0.6 m. to the maximum depth drilled (13.3 m.). The ice content of the fine grained organic and silt soils varies from low to very high. A thick layer of ice and soil (with an excess ice content of more than 50% by volume) occurs from a depth of

4.95 to 8.3 m.. The permafrost classification of the underlying gravel was not determined.



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VANCOUVER - CALGARY - WINNIPEG, CANADA

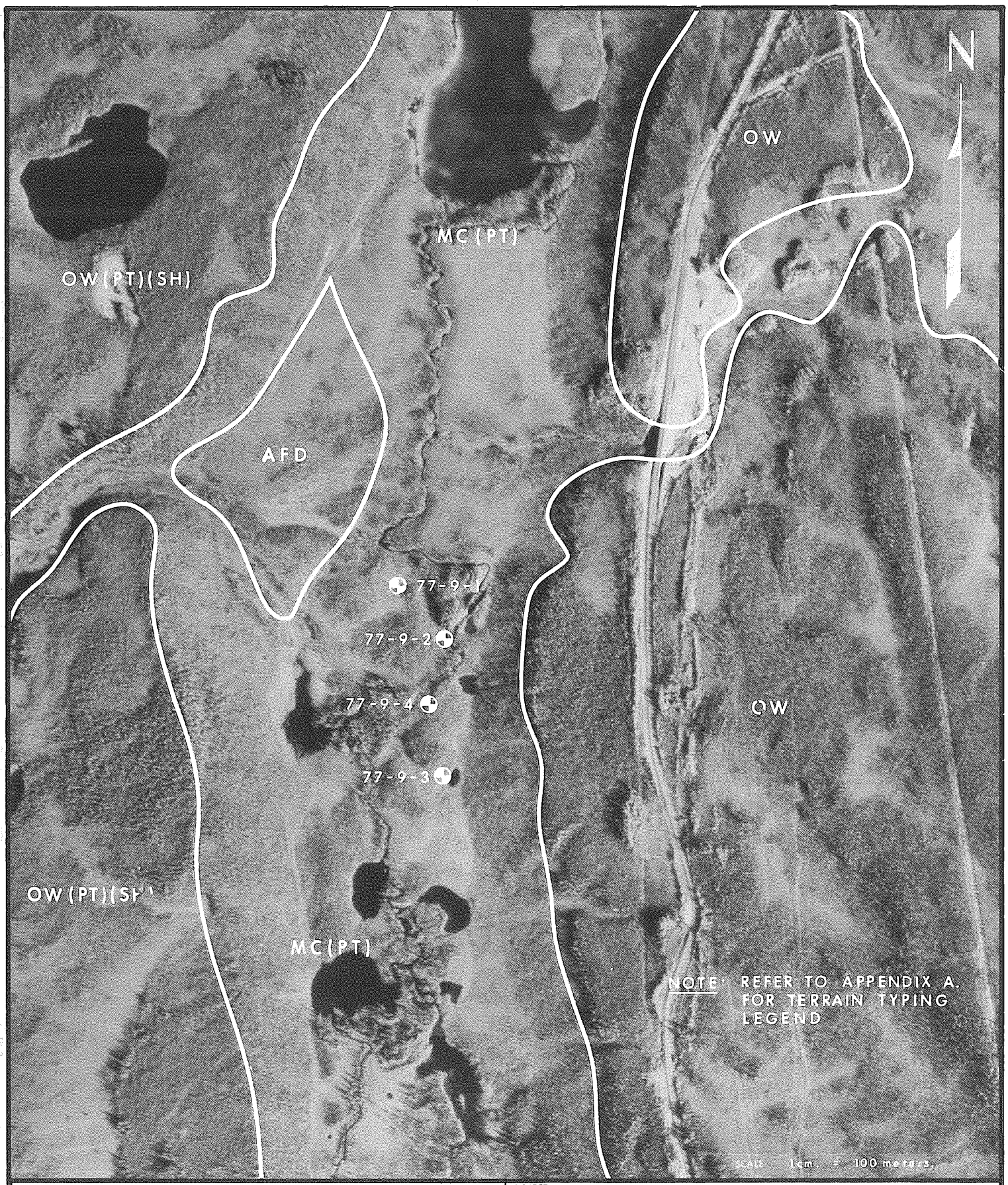
CLIENT
FOOTHILLS PIPE LINES(YUKON)LTD.

PROJECT
FROST HEAVE TEST SITES

TITLE
GENERAL LOCATION PLAN TEST SITE No. 9

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
NOV. / 77.	AL0890	A-0890-9-1	

APPROVED M. Edgewood



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VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No. 9

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	AL0890	A-0890-9-2	

APPROVED A. Edgewath

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
	B		1
1	C		2
	C		3
2	C		4
	C		4a
3	C		5
	C		6
4	C		7
	C	204	8
	C	114	8a
5	SPT	68/13cm	9
6			
7			
8			
9			
10			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
Vr, Vx Vs	NF 0.5
Vr, Vx	
Vr, Vs Vx, Nbn	
Vr, Vx	

LOCATION See Plate A-0890-9-2
ELEVATION

DESCRIPTION OF MATERIAL

PEAT & ORGANIC SILT
- laminated with silt & clay
- black

← ice lenses 1 to 5mm. thick spaced @ 5 to 10 mm.

1.7m.

ORGANIC SILT & CLAY
- wood pieces
- brown

2.4m.

PEAT & ORGANIC SILT
- laminated with silt & clay
- trace gravel
- trace sand

3.8m.

PEAT & ORGANIC SILT
- some gravel
- some sand

4.8m.

5.0m. SAND AND GRAVEL
- little silt
- grey

END OF HOLE @ 5.0m.

NOTES:
1. Hole located in the Dry Creek valley on north side of swamp. Terrain slopes into swamp.
2. Swamp is vegetated with grass. Adjacent to swamp a sparse growth of spruce to 8 m. high.
3. Hole augered to 0.5 m. & cored from 0.5 to 5.0m.

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

370
403
448
210
165
280
223
210
234
206
457
221
225
181

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION 1 mi. W. of MP 32.5 to 33
HOLE No. 77-9-1
DATE Oct. 20/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 9-1

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.50-1.00	984.8	61.4
4	2.20-2.40	1,026.0	63.9
5	2.40-3.10	1,110.2	69.2
7	3.50-3.75	1,260.0	78.5

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
	B		1		Vr,Vs Vx	NF 0.6	0.15m. Moss cover ORGANIC SILT - little clay - peat inclusions - pieces of wood - slight plasticity - dark brown
1	C		2				
	C		3				ice lenses to 1cm.
2	C		4				
					Vr,Vs		ice & soil from 2.4-2.45m. and 3.05-3.1m. depths.
3	C		4a				
	C		5		Vr,Vs Vx		ice lenses to 2cm. thick spaced @ 1.5cm.
4	C		6				
	C		7				extensive ice lenses to 1cm. thick
5	C		8				
	C		8a		Vr		5.4m.
6	C		9		ICE		ICE & SOIL 5.9m.
	C		10		Vr,Vs Vx		SILT - organic pockets & layers - trace clay - trace sand
7	C		11				7.4m.
					ICE		7.8m. ICE & SILT
8	C		12		Vr,Vs		SILT - organic pockets - trace clay, trace sand
9	C		13				
	C		14				few ice lenses up to 1.5cm. thick.
10							(cont'd.)

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

171
142
141
119
173
126
120
121
106

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION 1 mi. W. of MP 32.5 to 33
HOLE No. 77-9-2
DATE Oct. 20/77 PLATE

TEST HOLE LOG

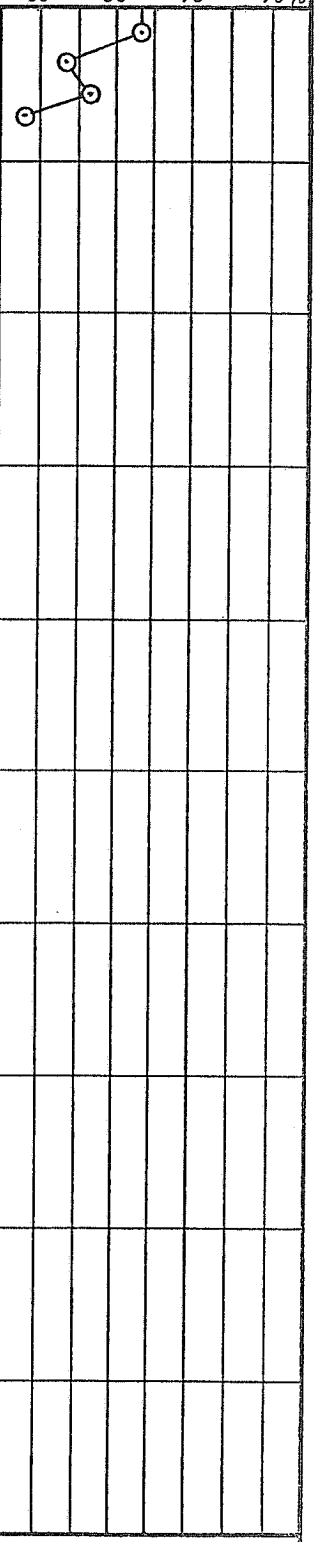
HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
11	C		15		Vr, Nbn		SILT - organic layers - trace clay, trace sand
	C		16				10.9m.
					Vx		11.2m. GRAVEL - some sand - trace silt - grey
12							END OF HOLE @ 11.2m.

LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



NOTES:
1. Hole located in an old melt-water channel, 10m. west of Dry Creek. Ground slopes at 5% towards the creek.
2. Terrain is vegetated with a moderate growth of spruce to 12m. high.
3. Hole augered to 0.5m., and cored from 0.4m. to 11.2m.

Klohn Leonoff Consultants Ltd.
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JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION 1 mi. W. of MP 32.5 to 33
HOLE No. 77-9-2 (cont'd.)
DATE Oct. 20/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 9-2

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.90-1.20	1,240	77.3
3	1.20-1.50	1,201.7	74.9
4	1.90-2.50	1,167.7	72.7
5	3.10-3.50	1,275.0	79.4
6	3.50-3.80	1,219.0	75.9
8	4.60-5.00	1,226.4	76.4
9	5.80-5.17	1,320.4	82.3
10	6.10-6.60	1,544.4	96.2
11	6.70-7.00	1,459.4	90.9
12	7.40-7.80	1,463.1	91.2
13	8.70-9.10	1,563.7	97.4
15	9.90-9.30	1,550.8	96.6

TEST HOLE LOG

HAMMER WT. 63.5 Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15 cm.	No.
1	B		1
	C		2
2	C		3
	C		4
3	C		5
	C		6
4	C		7
5	C		8
	C		9
6	C		10
7	C		11
	SPT	70 ref	12
8			
9			
10			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF
Vr, Vs Vx	0.7
Vr, Vs Nbn	7.4m.
	8.3m.

LOCATION See Plate A-0890-9-2
ELEVATION

DESCRIPTION OF MATERIAL

0.7m. peat cover
ORGANIC SILT
- little clay
- trace fine sand
- organic pockets
- slight plasticity
- grey-brown

(ice lenses 1/4 to 5mm. thick, spaced at 1 to 5mm. Few random lenses up to 1.5cm. thick)

2.2m.

SILT
- trace sand
- trace clay
- organic pockets
- blackish grey

two ice lenses to 5cm. thick

5cm. layer of white sand or volcanic ash

(ice lenses 1/4 to 5mm. thick spaced at 5 to 20mm., few lenses up to 1.5cm. thick)

ice lenses to 1.5cm. thick

some gravel

GRAVEL
- some sand
- some silt

(based on drill action & cuttings returned in the drill mud.

END OF HOLE @ 8.3m.

(cont'd.)

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ▩ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
10 30 50 70 90%

595
426
217
108

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	1 mi. W. of MP 32.5 to 33
HOLE No.	77-9-3
DATE	Oct. 21/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.
PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located in Dry Creek valley east of the creek.
2. Site is vegetated with sparse spruce
3. Hole augered to 0.9m., cored from 0.9 to 7.4m., then rotary drilled with mud from 7.4 to 8.3m.

Klohn Leonoff Consultants Ltd.
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JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	1 mi. W. of MP 32.5 to 33
HOLE No.	77-9-3
DATE	Oct. 21/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 9-3

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.30-1.90	1,238.9	77.2
4	1.90-2.20	1,300.4	81.0
7	4.00-4.60	1,459.9	91.0
8	5.00-5.50	1,427.6	88.9
10	6.00-6.70	1,615.6	100.6

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
1	B		1
	C		2
2			
	C		3
3			
	C		4
4	C		5
	C		6
5	C		7
	C		8
6	C		9
	C		10
7	C		11
	C		12
8	C		13
9	C		14
10	C		15

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF 0.6
Vr,Vs	
Vr	
Vr,Vs	
ICE & SOIL	
Nbn	
ICE	
Vr,Vs	

LOCATION See Plate A-0890-9-2
ELEVATION

DESCRIPTION OF MATERIAL

SILT
- trace sand
- organic pockets
- brown

0.9m.

ORGANIC SILT
- trace fine sand
- slight plasticity
- brown

1.9m.

SILT
- trace sand
- brown

2.55m.

ORGANIC SILT & PEAT
- trace fine sand
- brown

3.2m.

SILT
- organic pockets
- trace fine sand
- brown

4.95m.

ICE & SOIL
- soil mostly grey, low plastic, silt & clay with organic pocekts
- ice lenses are inclined or near vertical

8.3m.

8.6m. SILT & CLAY - grey

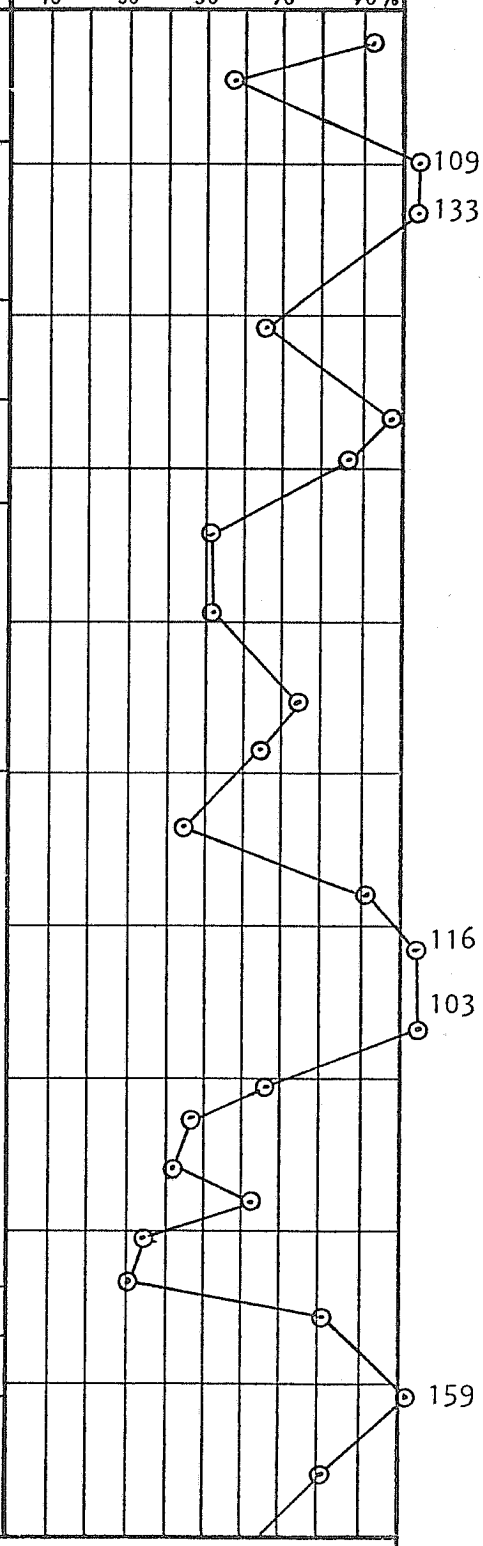
9.0m. ICE & SOIL

ORGANIC SILT
- little clay
- grey

(cont'd.)

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	1 mi. W. of MP 32.5 to 33
HOLE No.	77-9-4
DATE	Oct. 21/77 PLATE

M.I.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

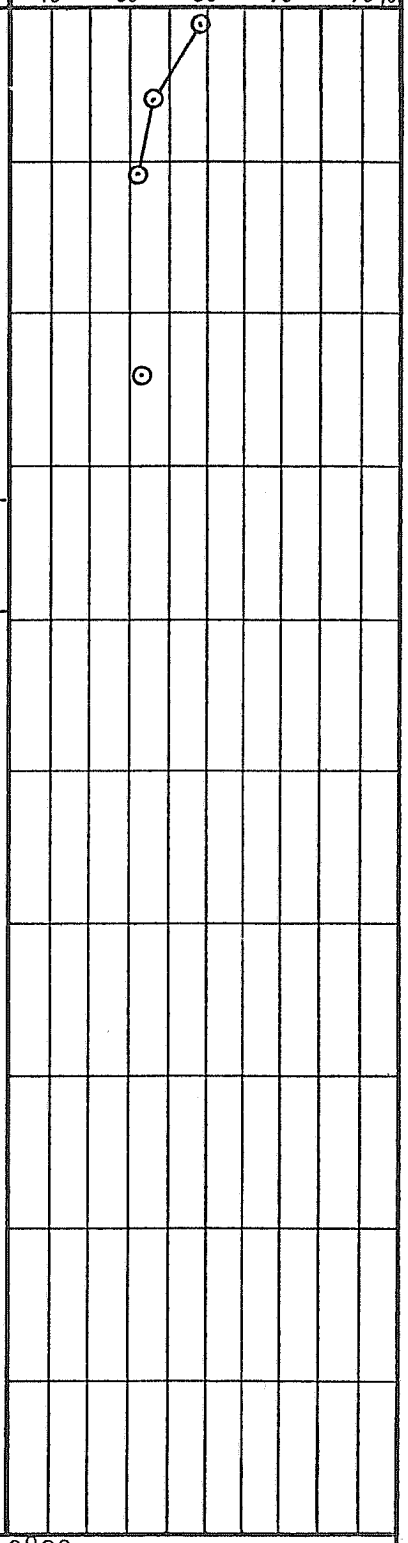
DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	C		16		Vr,Vs Nbn		SILT - little fine sand - organic pockets - rusty silt lenses - laminated - grey
11	C		17				
	C		18				
12					Vr,Vs		ice lenses to 5cm.
	C		19				
13					Nbn		13.2m.
14							GRAVEL - some silt - some sand 13.3m.

NOTES:
1. Hole located 8m. east of Dry Creek. Terrain slopes 3% to the west.
2. Ground sufrace at the site is moss covered and hummocky. Moderate growth of spruce to 15m. high.
3. Hole augered to 0.9m., then cored from 0.9 to 13.3m.

LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	1 mi. W. of MP 32.5 to 33
HOLE No.	77-9-4
DATE	Oct. 21/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.
11	C		16
	C		17
	C		18
12			
	C		19
13			
14			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.	DESCRIPTION OF MATERIAL
Vr,Vs Nbn		SILT - little fine sand - organic pockets - rusty silt lenses - laminated - grey
Vr,Vs		ice lenses to 5cm.
Nbn		13.2m.
		GRAVEL - some silt - some sand 13.3m.

LOCATION
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%

NOTES:
1. Hole located 8m. east of Dry Creek. Terrain slopes 3% to the west.
2. Ground sufrace at the site is moss covered and hummocky. Moderate growth of spruce to 15m. high.
3. Hole augered to 0.9m., then cored from 0.9 to 13.3m.

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	1 mi. W. of MP 32.5 to 33
HOLE No.	77-9-4
DATE	Oct. 21/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 9-4

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
2	0.90-1.40	1,199.4	74.7
4	2.70-3.20	1,344.7	83.8
6	3.80-4.30	1,518.7	94.6
9	5.55-6.10	1,319.9	82.2
13	7.90-8.20	1,512.3	94.2

SITE 10 (34.5 to 35.5)

1.0 INTRODUCTION

This area was selected as a potential frost heave test site subsequent to initial drilling in the Dry Creek meltwater channel at Site 7. The site is located about 700 m. west of the proposed pipeline right-of-way which parallels the H-F pipeline. The Alaska Highway is located within 200 m. east of the site. The reader should refer to the attached location plan on Plate A-0890-10-1 and the aerial photograph on Plate A-0890-10-2.

2.0 SUMMARY

The site is situated along Dry Creek in an old glacial meltwater channel. The Dry Creek valley is about 400 m. wide and flanked by upland areas to the east and west which are underlain by glacial outwash and hummocky moraine. The valley bottom is slightly hummocky and poorly drained, with a number of small lakes. Dry Creek meanders in a sinuous manner and occasionally displays beaded drainage which usually indicates the presence of ground ice and permafrost.

Two test holes were drilled at the site. The subsoil profile consists of a thick organic silt topstratum overlying interlayered silty gravel and sand materials. In test hole 77-10-2, a 3.15 m. thick layer of silt and clay overlies the gravel and underlies the organic silt. The organic silt and silt and clay soils vary from 5.65 m. thick in 77-10-1 to 8.0 m. thick in 77-10-2. These upper organic and fine grained soils overlie gravel materials. Due to use of rotary drilling equipment, representative samples of the coarse granular materials were difficult to obtain.

Permafrost was encountered to the maximum depths drilled in both test holes. The upper 4.85 m. of organic silt has a high ice content. The estimated excess ice content of these soils varies from 5 to 40%, averaging about 25% by volume. The silt and clay stratum below a depth of 5.5 m. in test hole 77-10-2 has a low excess ice content averaging less than 10% by volume. The ice content of the

gravel substratum was not ascertained.

3.0 SITE DESCRIPTION

Test hole 77-10-1 is located at the south end of the site, in a low lying poorly drained area. The terrain is flat to very gently sloping, and the ground surface is covered with peat tussocks. The area is open with no forest cover except for a sparse growth of stunted spruce.

Test hole 77-10-2 is located about 250 m. north of 77-10-1. A small lake occurs between these two test holes. The drill site is located 5 m. southeast of a small creek at its junction with Dry Creek. The water level in the creek is about 0.2 m. below the collar elevation of the test hole. The area is open with a sparse growth of spruce to 10 m. high.

4.0 SOIL & PERMAFROST CONDITIONS

4.1 Test Hole 77-10-1

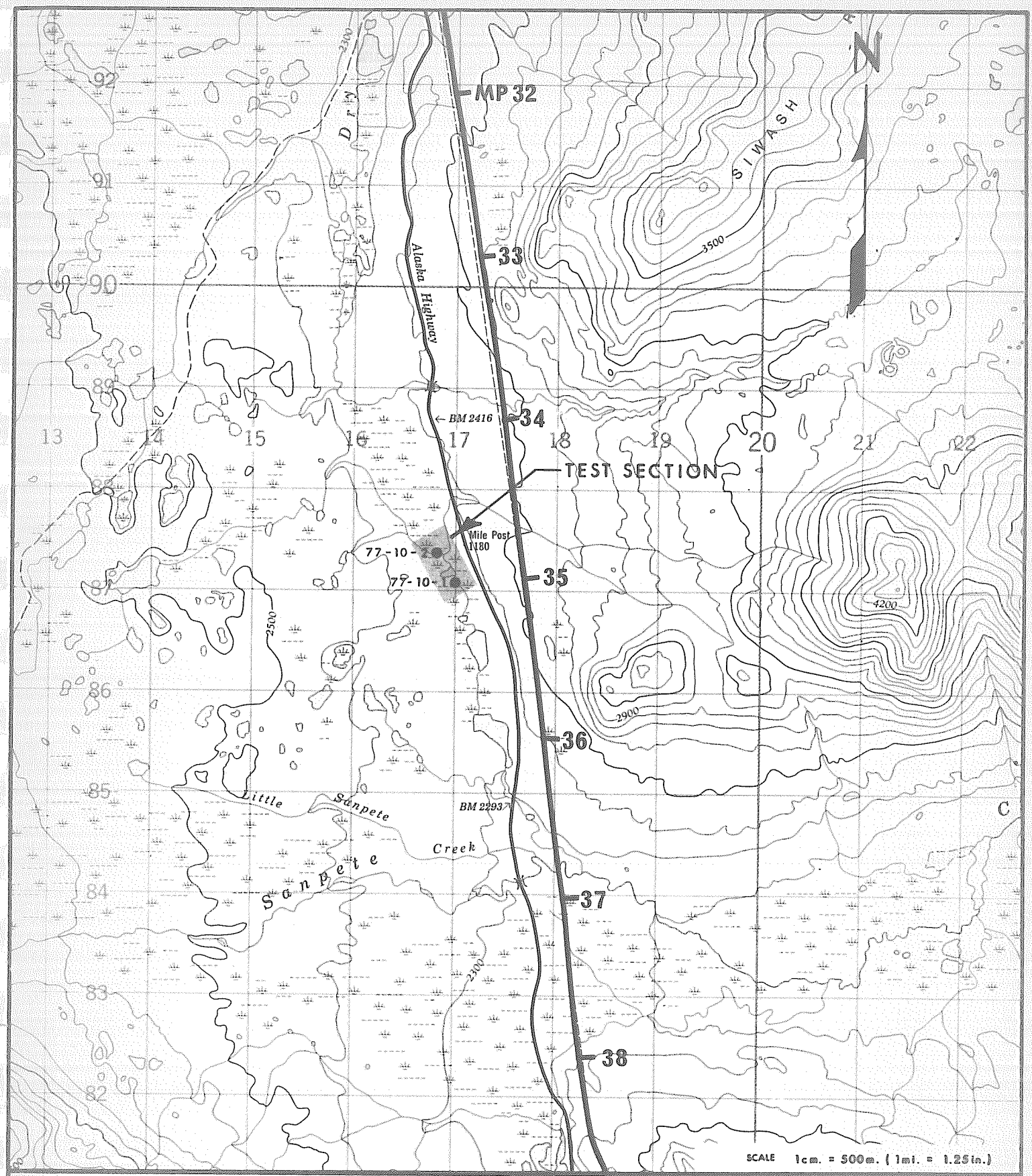
This test hole was drilled to a depth of 7.0 m. by augering to 0.85 m., coring from 0.85 to 5.7 m., and rotary drilling with mud below 5.7 m.. The subsoil profile consists of 5.65 m. of organic silt overlying gravel to the maximum depth drilled. The organic silt is laminated with peat, pieces of wood, sand and clay, and has a high moisture content varying from 100 to 300%. The basal gravel stratum from a depth of 5.65 to 7.0 m. is interlayered with silt and sand.

Permafrost occurs from 0.6 m. to the maximum depth drilled (7.0 m.). The organic silt stratum to a depth of 5.65 m. has a high ice content. The estimated excess ice content of this stratum averages about 25% by volume. Ice generally occurs in thin horizontal and randomly oriented ice lenses from 1/4 to 5 mm. thick. The ice content of the gravel substratum was not ascertained.

4.2 Test Hole 77-10-2

This test hole was augered to 0.75 m., cored from 0.75 to 8.0 m., then rotary drilled with mud from 8.0 to 9.0 m.. The subsoil profile consists of organic silt, overlying silt and clay, all of which overlies a coarse gravel stratum. The organic silt topstratum extends to a depth of 4.85 m.. The stratum is laminated with peat, pieces of wood, sand and clay, and has a high moisture content varying from 100 to 300%. The organic silt topstratum is underlain by a grey silt and clay soil of slight to low plasticity, from a depth of 4.85 to 8.0 m.. The stratum is laminated with fine sand and has scattered organic layers. The moisture content varies from 25% to a maximum of 112% in an organic layer, and averages about 55%. The basal gravel stratum is interlayered with grey silt and sand.

Permafrost occurs from 0.6 m. to the maximum depth drilled (8.9 m.). The organic silt soils to a depth of 4.85 m. have a high ice content. Ice generally occurs as horizontal lenses up to 3 cm. thick. The estimated excess ice content varies from about 20 to 50%, averaging about 30% by volume. the silt and clay soils from a depth of 4.85 to 8.0 m. have a low-to-medium ice contents except in the upper 0.6 m., where the ice content is high. The average excess ice content is less than 10% by volume. The gravel stratum from 8.0 to 8.9 m. has well bonded, non-visible ice.



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CIVIL • GEOTECHNICAL • HYDRAULIC
VANCOUVER - CALGARY - WINNIPEG, CANADA

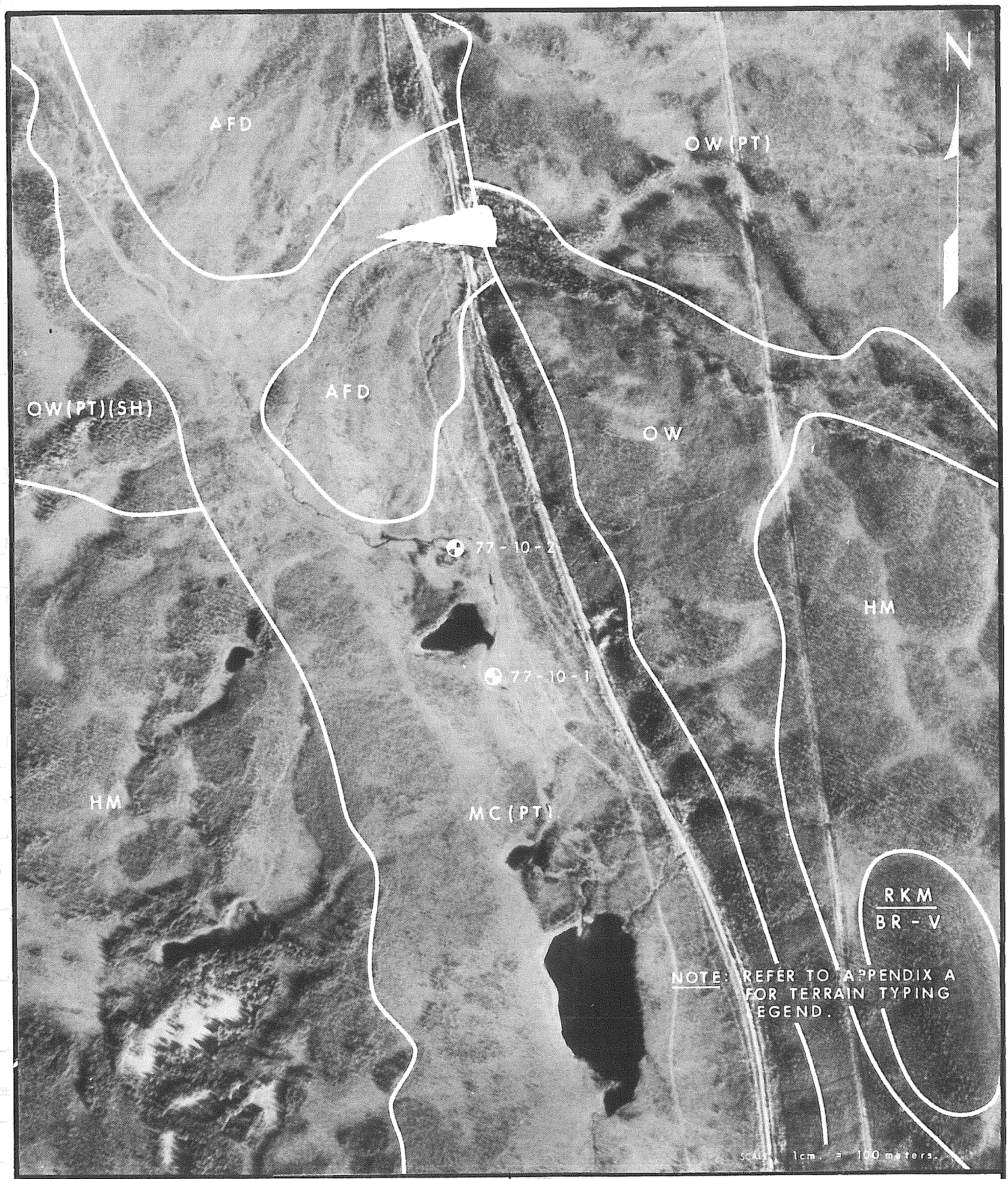
CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: GENERAL LOCATION PLAN
TEST SITE No. 10

DATE OF ISSUE	PROJECT No.	DWG. No.
NOV. / 77.	AL0890	A-0890-10-1

APPROVED: A. Edgard.



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VANCOUVER - CALGARY - WINNIPEG, CANADA

CLIENT: FOOTHILLS PIPE LINES (YUKON) LTD.

PROJECT: FROST HEAVE TEST SITES

TITLE: TEST HOLE LOCATION PHOTO MOSAIC SITE No.10

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. / 77.	A L 0 8 9 0	A-0890-10-2	

APPROVED A. Edgeworth

TEST HOLE LOG

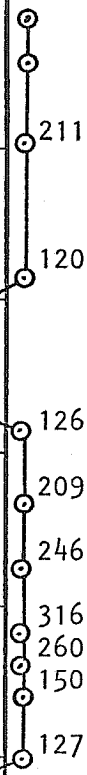
HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW/15cm.	No.	SYMBOL	PERMAFROST N.R.C. CLASS	PERMAFROST N.F. or F.	DESCRIPTION OF MATERIAL
	B		1			NF	ORGANIC SILT
						0.6	- trace sand in rusty seams
1							- trace clay
	C		2		Vr, Vx		- laminated
							- dark brown
2	C		3				
	C		4				sand lenses
3	C		4a		Vr, Vs		(ice lenses 1/4 to 5mm. thick)
	C		5				
4	C		6		Vr, Vs Vx		peat layers - pieces of wood
	C		7		Vr, Vs		
5							
	C		8				gravel seam
	C		9		NbN, Vx Vr, Vs		5.65m.
6							GRAVEL - some silt - some sand - layered, grey
7					(?)		7.0m.
							END OF HOLE @ 7.0m.
8							NOTES:
							1. Hole located in Dry Creek valley adjacent to a swamp.
9							2. Ground surface is covered with extensive peat tussocks, and vegetated by spruce to 10m.
							3. Hole augered to 0.85m., cored from 0.85 to 5.7m., then rotary drilled with water to 7.0m.
10							

LOCATION See Plate A-0890-10-2
ELEVATION

COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	0.5 mi. W. of MP. 34.5 to35.5
HOLE No.	77-10-1
DATE	Oct. 23/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 10-1

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.60-2.20	1,207.2	75.2
4	2.65-3.10	1,212.8	75.6

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA

DEPTH	TYPE	BLOW 15 cm.	No.
1	B		1
	C		2
2	C		3
3	C		4
	C		5
4	C		6
5	C		7
	C		8
6	C		9
	C		10
7	C		11
8	C		12
9			13
10			

SYMBOL

PERMAFROST

N.R.C. CLASS	N.F. or F.
	NF
	0.6
Vr, Vs Vx	
Vr, Vs	
Vr, Vs Nbn Nbe	
Nb	

LOCATION See Plate A-0890-10-2
ELEVATION

DESCRIPTION OF MATERIAL

ORGANIC SILT
- peat layers
- trace sand in lenses
- trace clay
- pieces of wood
- dark brown

(extrensive ice lenses up to 3cm. thick.)

4.85m.

SILT & CLAY
- trace fine sand
- slight-to-low plasticity
- grey

(ice lenses up to 2.5cm. thick)

organic layer

8.0m.

GRAVEL
- some silt
- some sand, grey

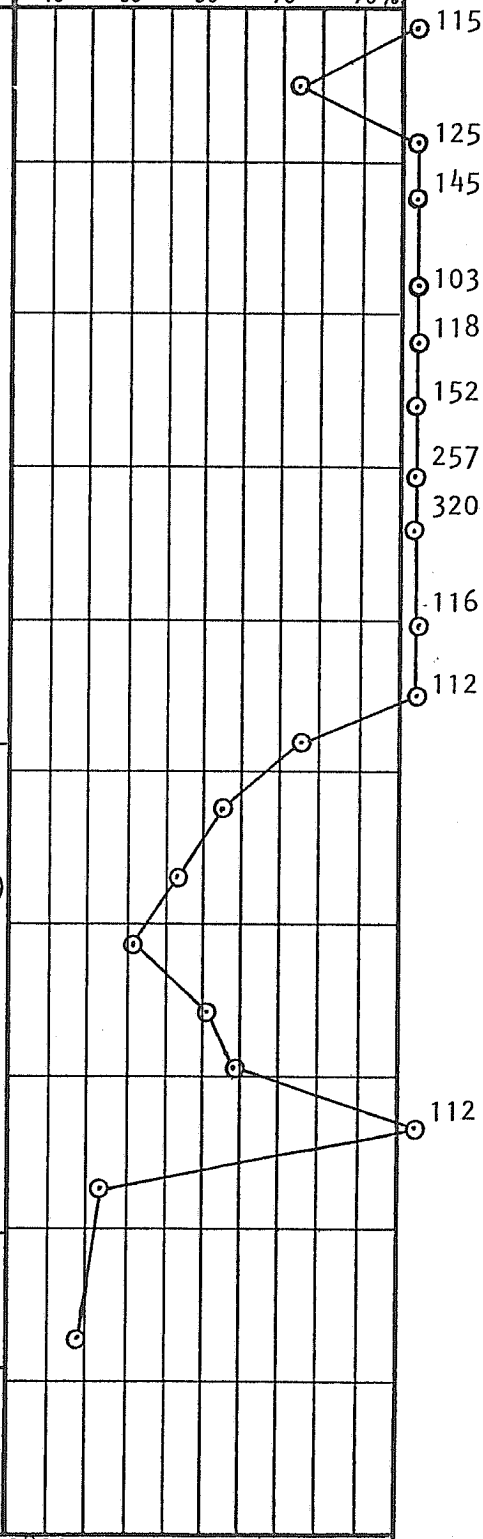
8.9m.

END OF HOLE @ 8.0m.

(cont'd.)

COHESION - Kg./Sq. cm.
0.2 0.6 1.0 1.4 1.8
● FIELD VANE △ LAB VANE ■ UNCONF.

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT
X — — — — — 0 — — — — — X
10 30 50 70 90%



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CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	AL0890
PROJECT	Frost Heave Test Sites
LOCATION	1 mi. W. of MP 34.5-35.5
HOLE No.	77-10-2
DATE	Oct. 23/77 PLATE

K.L.C. - METRIC

TEST HOLE LOG

HAMMER WT. 63.5Kg.
HT. DROP 76 cm.
SAMPLE DATA
DEPTH | TYPE | BLOW/15 cm. | No.
SYMBOL
PERMAFROST
N.R.C. CLASS | N.F. or F.
LOCATION
ELEVATION
COHESION - Kg./Sq.cm.
0.2 0.6 1.0 1.4 1.8
FIELD VANE △ LAB VANE ▩ UNCONF.
PLASTIC LIMIT X — WATER CONTENT 0 — LIQUID LIMIT X
10 30 50 70 90%

DESCRIPTION OF MATERIAL

NOTES:

1. Hole located in the Dry Creek valley, 5m. southeast of a small creek at its junction with Dry Creek.

2. Water level in creek 0.2m. below hole elevation. Sparse spruce growth to 10m. high.

3. Hole augered to 0.75m., cored from 0.75 to 8.0m., then rotary drilled with mud from 8.0 to 9.0m.

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. AL0890
PROJECT Frost Heave Test Sites
LOCATION 1 mi. W.of MP34.5 to 35.5
HOLE No. 77-10-2
DATE Oct. 23/77 PLATE

K.L.C. - METRIC

FROZEN BULK DENSITY TEST RESULTS

TEST HOLE NO. 10-2

Sample No.	Sample Depth (M)	Frozen Bulk Density KG/M^3	Frozen Bulk Density PCF
3	1.60-2.00	1,175.2	73.2
4	2.85-3.30	1,084.8	67.6
11	6.80-7.20	1,525.0	95.0

TERRAIN TYPING LEGEND

for

SITES 1, 2, 3, 4, & 5

AFD	Alluvial Fan Deposit: Poorly sorted loose, ice-rich, sand and silt with some gravel; gently sloping.
AFP	Active Flood Plain: Exposed or at least non-forested gravel, sand and minor silt with some boulders.
BR-M	Bedrock, Metamorphic: Hard schist, gneiss, quartzite, argillite, hornfels, and cherty slate forming hills.
Br-V	Bedrock, Volcanic: Hard rhyolite, latite, andesite, diabase and basal forming hills.
FFP	Fossil Flood Plain: Alluvial gravel, sand and minor silt above normal flood level of present streams; commonly forested.
GLB-1	Glacial Lake Basin, Better Drained Type: Gently sloping to flat, thinly stratified, ice-rich silt, and minor sand and clay covered by up to 14 feet of peat and organic silt.
GLB-2	Glacial Lake Basin, Thermokarst Type: Flat to gently sloping, thinly stratified, ice-rich silt, sand and clay with thermokarst ponds and lakes.
HM	Hummocky Morrain: Hilly, kettled moraine of rocky, sandy till with deep deposits of ice-rich silt, sand and clay with thermokarst ponds and lakes.
MTV	Montane Valley Colluvium: Variable but generally thin, cover of poorly sorted, commonly ice-rich, loose, colluvial boulders to silt and organic silt.
OW	Outwash Plain or Terraces: Loose stratified, locally ice-rich, gravel, sand and minor silt, sometimes covered by up to 14 feet of peat and organic silt.
RKM	Gentle Ridge and Knoll Moraine Plain: Semi-compacted ice-rich, silty till.
MC	Meltwater Channel: Flat-bottomed, steep-sided former stream courses floored with thick deposits of ice-rich organic silt and peat and having walls of outwash or till.

PHASES

DF	Discontinuous Thin Drift Cover: Zero to a few feet of ice-rich till over volcanic bedrock.
PT	Peat, Generally Unpatterned: Generally 4 to 14 feet of ice-rich peat, commonly mixed with organic silt, overlying the parent terrain type.
SH	Shallow Depth Phase: Generally 1 to 4 feet of ice-rich peat, commonly mixed with organic silt, overlying the parent terrain type.

==== Fault Lineament (Definite: Indefinite)

TERRAIN TYPING LEGEND

for

SITES 6, 7, 8, 9, & 10

AFD	Alluvial Fan Deposit: Poorly sorted, loose gravel, sand, silt, and boulders; moderately to gently sloping.
AMP	Alluvial Meander Plain: Stratified silt, sand and gravel along slowly flowing streams.
BR-BA	Bedrock, Basalt: Hard basalt lava flooring low terraces or alluvial meander plain along big creek.
BR-LS	Bedrock, Limestone: Hard quartzite forming steep covered slopes at western edge of Liard Plain.
E	Esker: Sinuous ridges of complexly stratified gravel and sand.
GLB-1	Glacial Lake Basin, Better Drained Type: Gently sloping to flat thinly stratified, sometimes peat-covered, silt, sand, and clay with occasional excess ice.
K	Kames: Variety of hills, ridges, cones and depressions composed of complexly stratified gravel and sand.
MTV	Montane Valley Colluvium: Variable but generally thin cover of poorly sorted colluvial debris of silt to rock blocks over quartzite or limestone slopes.
OW	Outwash Plain or Terraces: Loose, stratified gravel, sand, silt and boulders, locally peat-covered; sometimes containing kettles.
RKM	Gentle Ridge and Knoll Moraine or Moraine Plain: Semi-compacted boulder-silt till

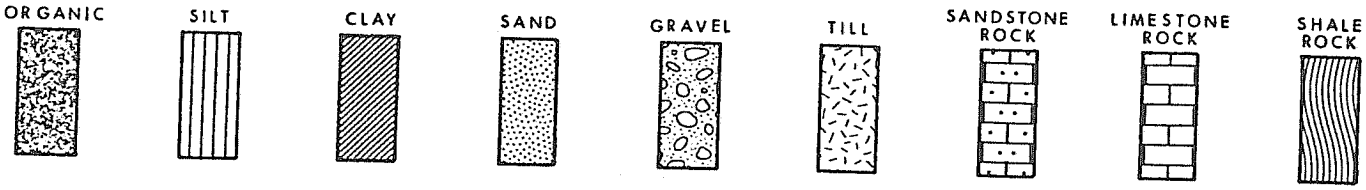
FEATURES

CF	Crevasse Fillings: Low, sub-parallel, sub-linear ridges of gravel, sand and silt on lacustrine silt.
DR	Drumlinoid and Glacial Fluting (Ice Flow) Features: Long, linear, parallel ridges and grooves of till.
EVB	Eroding Valley Banks: Mainly in loose gravel and sand with some till involved.
k	kettled: Closed depressions in outwash caused by melting of former glacial ice remnants.
MC	Meltwater Channel: Flat-bottomed, steep-sided, former stream courses generally floored with outwash, sometimes covered with peat; walls of outwash or till.

PHASES

PT	Peat, Generally Unpatterned: Peat, commonly mixed with organic silt, sometimes ice-rich, overlying outwash or lacustrine deposits.
SB	String Bogs or Reticulated Ribbed Fens: Peat and organic silt with all but the ribs normally wet all summer, overlying outwash or lacustrine deposits.
====	Fault Lineament (Definte, Indefinte).

SYMBOLS AND TERMS USED IN THE REPORT



ADDITIONAL SYMBOLS

⊙ - moisture content

■ - unconfined strength as per spring calibrated pocket penetrometer

B - disturbed bag sample

SY - undisturbed SHELBY TUBE sample

SPT - Standard Penetration Test (6 in. Blow Counts)

BURMISTER CLASSIFICATION SYSTEM

STANDARD TERMS FOR IDENTIFYING COHESIVE SOILS

DEGREE OF PLASTICITY	PLASTICITY INDEX	WRITTEN IDENTIFICATION
Non to slight plastic	0 - 5	SILT
Low	5 - 10	SILT AND CLAY
Medium High	10 - 30 30 or more	CLAY AND SILT CLAY

STANDARD TERMS FOR IDENTIFYING COHESIONLESS SOILS

MAJOR SOIL COMPONENTS >50% BY Wt.	MINOR SOIL COMPONENTS	MINOR SOIL PROPORTIONS	PROPORTION DEFINITION BY Wt.
GRAVEL SAND SILT	gravel sand silt	and	35 to 50%
		some	20 to 35%
		little	10 to 20%
		trace	1 to 10%

EXAMPLE:

	PROPORTIONS
GRAVEL	> 50%
-some sand	20 to 35%
-little silt	10 to 20%

SOIL STRENGTH GUIDELINE

POCKET PENETROMETER FOR COHESIVE SOILS	
UNCONFINED COMPRESSIVE STRENGTH T/Ft.²	CONSISTENCY
0.25	Very Soft
0.25 - 0.50	Soft
0.5 - 1.0	Firm
1.0 - 2.0	Stiff
2.0 - 4.0	Very Stiff
>4.0	Hard

STANDARD PENETRATION TEST FOR COHESIONLESS SOILS	
BLOWS / 6 inches	DENSITY
0 - 2	Very Loose
2 - 5	Loose
5 - 15	Med. Dense
15 - 25	Dense
>25	Very Dense

TERMS IDENTIFYING THE COMPOSITION OF SOILS

Component	Identification	Terms Identifying Proportions	Defining Range Percentage by Weight	Degree of Plasticity	Plasticity Index
Principal Component	GRAVEL		50 or more	non plastic	0
	SAND			non plastic	0
	SILT			non to slight plastic	0 to 5
	SILT and CLAY			low	5 to 10
	CLAY and SILT			medium	10 to 30
	CLAY			high	30 and over
Minor Component	gravel	and	35 to 50	non plastic	0
	sand	and	35 to 50	non plastic	0
	silt	and	35 to 50	non to slight plastic	0 to 5
	silt and clay	some	20 to 35	low	5 to 10
	clay and silt	little	10 to 20	medium	10 to 30
	clay	trace	1 to 10	high	30 and over

TYPES OF SAMPLES

B	disturbed sample
SPT	standard penetration test 1 3/8 inch diameter
3"SS	split tybe sample 3 inch diameter
C	core sample 3 inch diameter
SY	Shelby Tube sample 3 inch diameter

CLASSIFICATION SYSTEM FOR ICE

Non Visible Ice (N)	Nf	Poorly bonded
	Nbn	Well bonded
	Nbe	Excess Ice
Visible Ice Less than 1 inch thick	Vx	Individual ice crystals or inclusions
	Vc	Ice coatings or particles
	Vr	Random or irregularly oriented ice formation
	Vs	Stratified or distinctly oriented ice formation
Visible Ice Greater Than 1 inch thick	ICE÷	Ice with soil inclusions
	ICE	Ice without soil inclusions

GROUND ICE CONTENT - % BY VOLUME

Low $< 10\%$ Med. - 10% to 20% High $> 20\%$